

Series 2600 System SourceMeter®

User's Manual

2600S-900-01 Rev. C / January 2008

WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of one (1) year from date of shipment.

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, software, rechargeable batteries, diskettes, and documentation.

During the warranty period, Keithley Instruments will, at its option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local Keithley Instruments representative, or contact Keithley Instruments headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

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KEITHLEY

A G R E A T E R M E A S U R E O F C O N F I D E N C E

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Series 2600
System SourceMeter® Instruments
User's Manual

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Cleveland, Ohio, U.S.A.

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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 non-hazardous voltages, there are situations where hazardous conditions may be present.

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

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

The types of product users are:

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

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

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

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

Keithley Instruments products are designed for use with electrical signals that are rated Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Measurement Category II connections require protection for high transient over-voltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the user documentation.

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 30V RMS, 42.4V peak, or 60VDC 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 1000V, 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.


The instrument and accessories must be used in accordance with its specifications and operating instructions, or the safety of the equipment may be impaired.


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


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

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth 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 safety earth ground using the wire recommended in the user documentation.

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the user documentation.

The  symbol on an instrument shows that it can source or measure 1000V or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

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

The  symbol indicates a connection terminal to the equipment frame.

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

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

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

Instrumentation and accessories shall not be connected to humans.

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

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

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

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Front and Rear Panel Operation

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Front and rear panel familiarization

Front panel summaries


The front panels of the Keithley Instruments Series 2600 System SourceMeter® are shown in [Figure 1-1](#). The descriptions of the front panel controls follow [Figure 1-1](#).


Rear panel summaries


The rear panels of the Models 2601/2602 and 2611/2612 are shown in [Figure 1-2 on page 1-6](#). The rear panels of the Models 2635 and 2636 are shown in [Figure 1-3 on page 1-8](#). The descriptions of the rear panel components follow [Figure 1-2](#) and [Figure 1-3](#).

Safety symbols and terms

The following symbols and terms may be found on the instrument or used in this manual:

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The  symbol on the instrument shows that high voltage may be present on the terminal(s). Use standard safety precautions to avoid personal contact with these voltages.

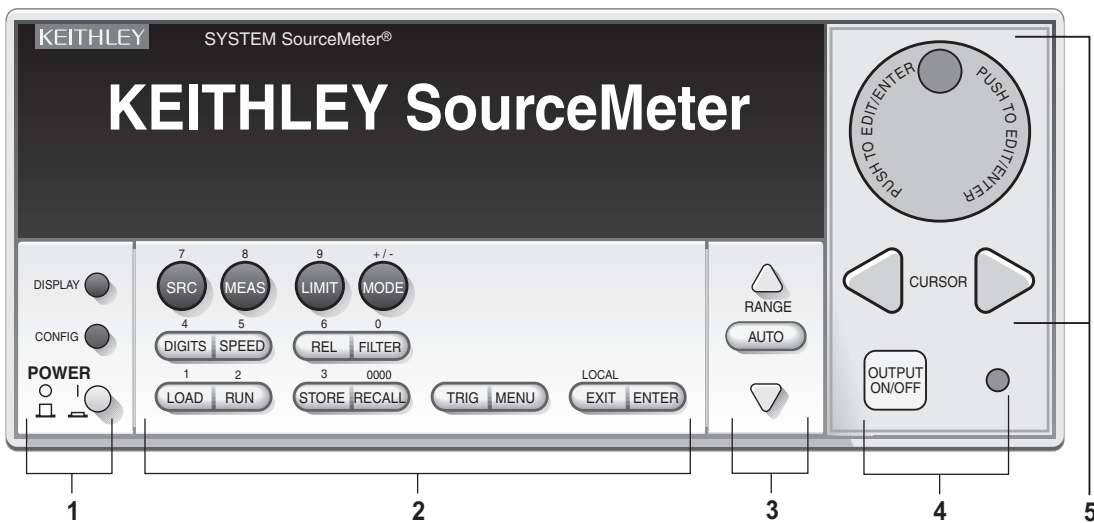
The  symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

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

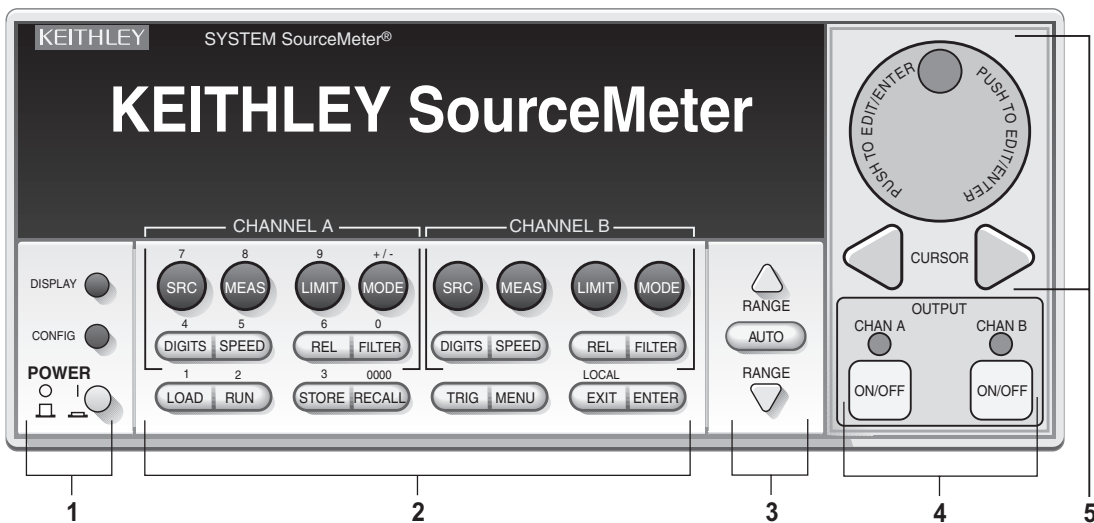
The **CAUTION** heading used in this manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Figure 1-1
Models 2601, 2611, 2602, 2612, 2635, and 2636 front panels

Model 2601, Model 2611, and Model 2635



Model 2602, Model 2612, and Model 2636



NOTE The Models 2601, 2611, and 2635 have one SourceMeter channel (Channel A) and the Models 2602, 2612, and 2636 have two SourceMeter channels (Channel A and Channel B).

1. Special keys and power switch:

- | | |
|-------------|--|
| DISPLAY | Toggles between the various source-measure displays and the user message mode. Selects Models 2602/2612/2636 single or dual-channel display. |
| CONFIG | Used to configure a function or operation. |
| POWER | Power switch – In position turns SourceMeter on (I), out position turns SourceMeter off (O). |
| Number keys | The Number Keys (0-9, +/-, 0000) allow direct numeric entry in the EDIT mode. |

2. Source-measure setup, performance control and special operation:

Top Row – Source-measure setup

Model 2601/2611/2635 and Model 2602/2612/2636:

SRC	Channel A – Selects the source function (V or A) and places cursor in the source field for editing.
MEAS	Channel A – Cycles through measure functions (V, A, Ω or W).
LIMIT	Channel A – Places the cursor in the compliance limit field for editing.
MODE	Channel A – Directly chooses the measurement function (V, A, Ω or W).

Model 2602/2612/2636 only:

SRC	Channel B – Selects the source function (V or A) and places cursor in the source field.
MEAS	Channel B – Cycles through measure functions (V, A, Ω or W).
LIMIT	Channel B – Places the cursor in the compliance limit field for editing.
MODE	Channel B – Directly chooses the measurement function (V, A, Ω or W).

Middle Row – Source-measure setup

Model 2601/2611/2635 and Model 2602/2612/2636:

DIGITS	Channel A – Changes display resolution to 4-1/2, 5-1/2, or 6-1/2 digits.
SPEED	Channel A – Sets the measurement speed by controlling the A/D converter measurement aperture.
REL	Channel A – Controls relative, which allows a baseline value to be subtracted from a reading.
FILTER	Channel A – Controls the digital filter, which can be used to reduce reading noise.

Model 2602/2612/2636 only:

DIGITS	Channel B – Changes display resolution to 4-1/2, 5-1/2, or 6-1/2 digits.
SPEED	Channel B – Sets the measurement speed by controlling the A/D converter measurement aperture.
REL	Channel B – Controls relative, which allows a baseline value to be subtracted from a reading.
FILTER	Channel B – Controls the digital filter, which can be used to reduce reading noise.

Bottom Row – Source-measure setup

LOAD	Loads factory or user-defined scripts for execution.
RUN	Runs last selected factory or user-defined scripts.
STORE	Stores readings, source values, and timestamp values in one of two internal buffers per channel for later recall.
RECALL	Recalls stored readings, source values, and timestamp values from either of the two buffers.
TRIG	Triggers readings.
MENU	Accesses the Main Menu for saving and recalling setups, selecting remote interface, line frequency, self-tests, serial number and beeper control.
EXIT	Cancels selection, and backs out of menu structure. Used as a LOCAL key to take the unit out of remote.
ENTER	Accepts selection, moves to next choice or exits menu.

3. Range keys:

△ and ▽	Selects the next higher or lower source or measure range.
AUTO	Enables or disables source or measure auto range.

4. Output control and LED status indicator:

OUTPUT ON/OFF	Turns source output on or off.
LED indicator	Turns on when output is on.

5. navigation wheel and CURSOR keys:

When in source edit, use **CURSOR** keys for cursor control and then turn the to change a source or compliance value. The can also be used to enable or disable the source edit mode.

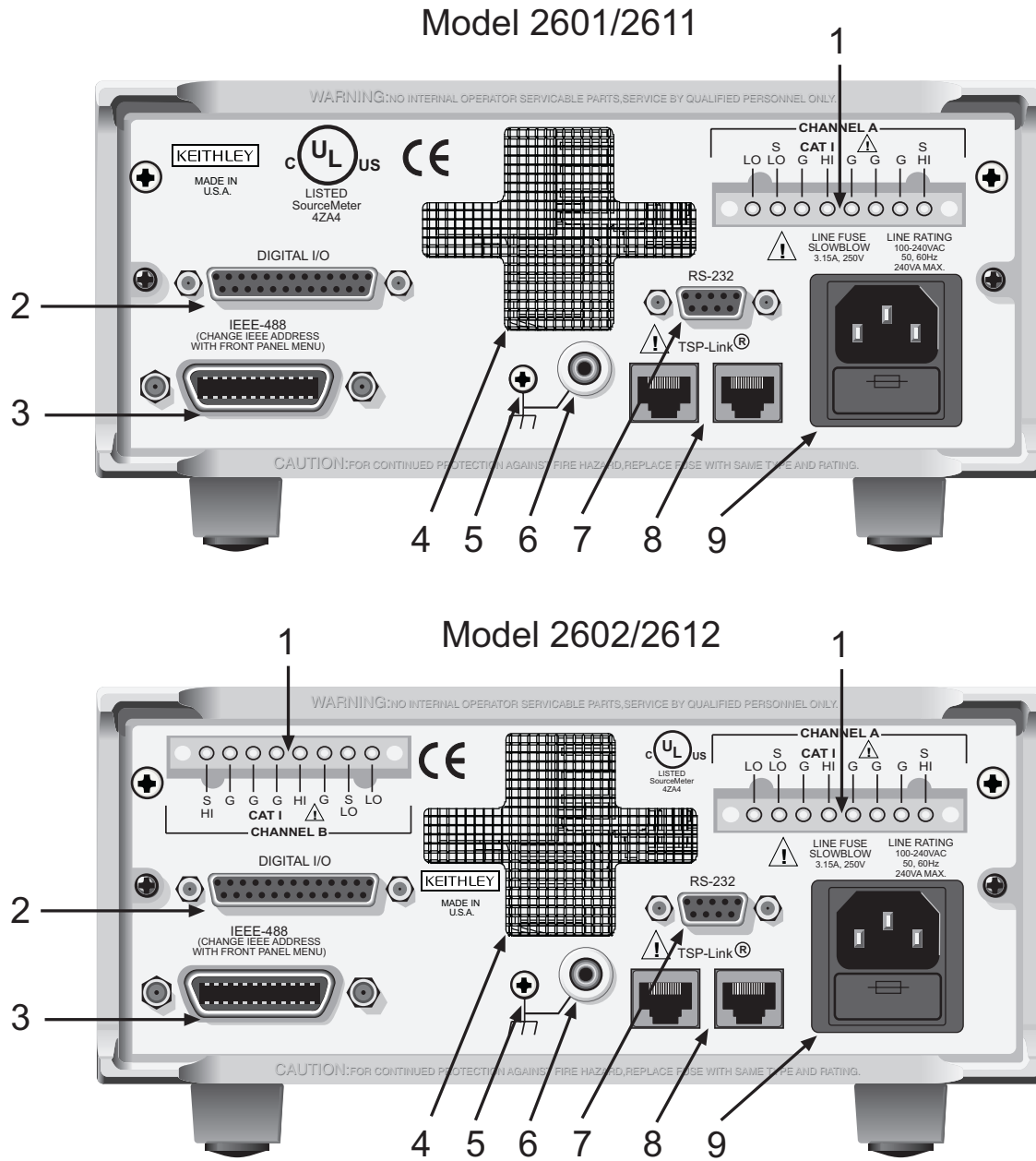
When in a menu, use the **CURSOR** keys or for menu item cursor control. When displaying a menu value, use the **CURSOR** keys for cursor control and turn the to change the value. Pressing the opens a menu item, or selects a menu option or value.

6. Display indicators (not shown):

EDIT	Unit is in the source editing mode.
ERR	Questionable reading or invalid cal step.
REM	Unit in remote mode.
TALK	Unit addressed to talk.
LSTN	Unit addressed to listen.
SRQ	Service request.
REL	Relative mode enabled.
FILT	Analog filter or Averaging filter is enabled.
AUTO	Auto source or measure range selected.
ARM	Unit armed and ready to run.
TRIG	External triggering selected.

* (asterisk) Readings being stored in buffer.

Figure 1-2
Model 2601/2602/2611/2612 rear panels



Model 2601/2602 and Model 2611/2612 rear panels

1. CHANNEL A and CHANNEL B (Channel B on Model 2602/2612 only)

Input/output connections for source, sense, and guard.

2. DIGITAL I/O

Female DB-25 connector. Fourteen pins for digital input or output, one pin for Output Enable. Use a cable equipped with a male DB-25 connector (Keithley Instruments part number CA-126-1CA).

3. IEEE-488

Connector for IEEE-488 (GPIB) operation. Use a shielded cable, such as the Model 7007-1 or Model 7007-2.

4. Cooling exhaust vent

Exhaust vent for internal cooling fan. Keep vent free of obstructions to prevent overheating.

5. Chassis ground

Ground screw for connections to chassis ground.

6. Low noise chassis ground

Ground jack for connecting Output HI or LO to chassis.

7. RS-232

Female DB-9 connector. For RS-232 operation, use a straight-through (not null modem) DB-9 shielded cable for connection to the PC (Keithley Instruments Model 7009-5).

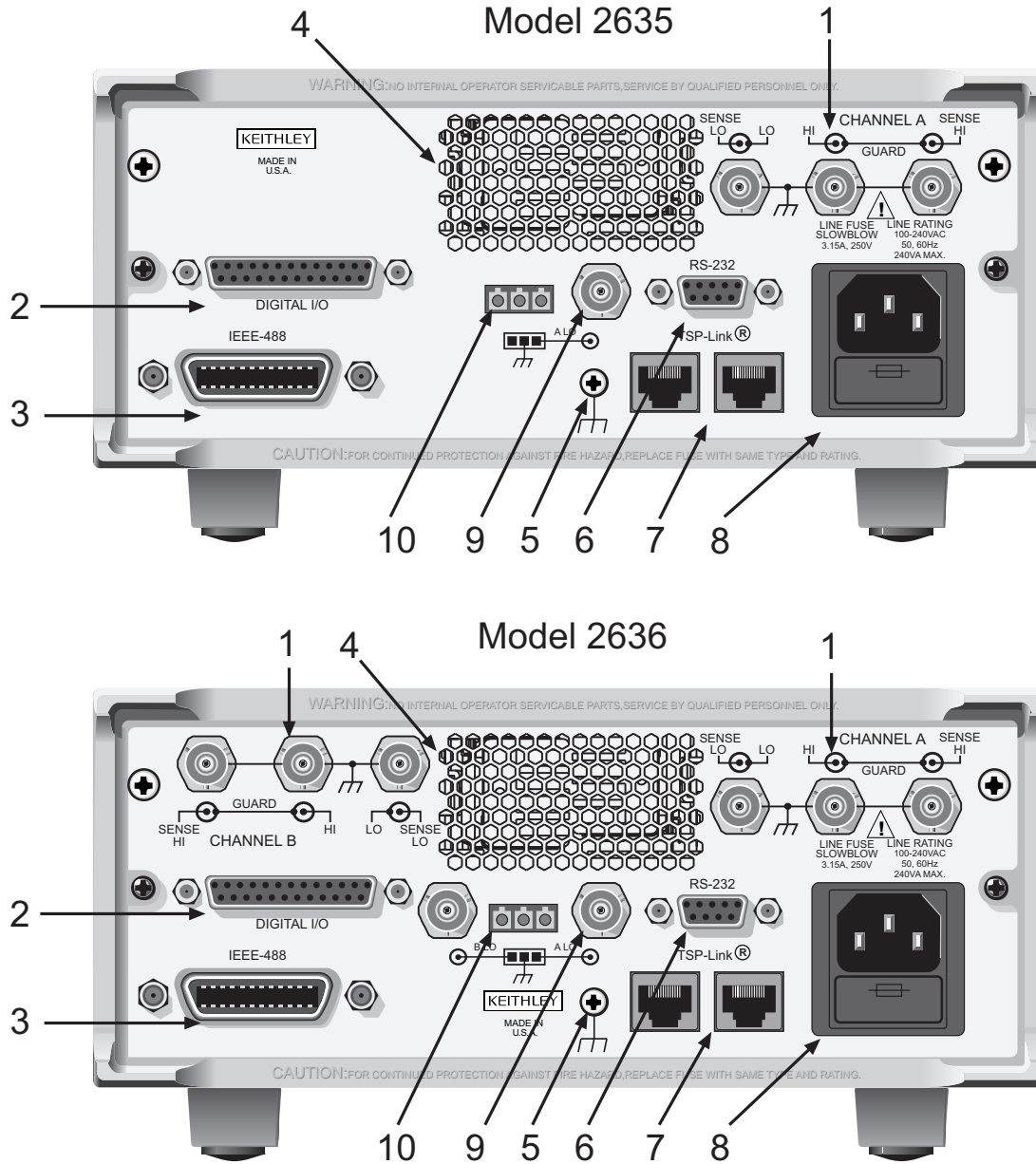
8. TSP-Link

Expansion interface that allows a Series 2600 and other TSP-enabled instruments to trigger and communicate with each other. Use a category 5e or higher LAN crossover cable (Keithley Instruments part number CA-180-3A).

9. Power module

Contains the AC line receptacle and power line fuse. The instrument can operate on line voltages of 100V to 240VAC at line frequencies of 50Hz or 60Hz. See Section 17 of the Series 2600 Reference Manual for line fuse replacement instructions.

Figure 1-3
Model 2635 and 2636 rear panels



Model 2635/2636 rear panels

1. CHANNEL A and CHANNEL B (Channel B on Model 2636 only)

Triax connectors for Input/output, guard, and sense connections. Use only low-noise triax cables such as the Keithley Model 7078-TRX (available in several lengths). Connector terminals and associated triax cable conductors are as follows:

Table 1-1

Connectors and triax cable conductors

Connector	Center conductor	Inner ring	Outer ring
LO	Sense LO	Input/Output LO	Chassis ground
HI	Input/Output HI	Guard	Chassis ground
SENSE HI	Sense HI	Guard	Chassis ground
Triax cable	Center conductor	Inner shield	Outer shield

2. DIGITAL I/O

Female DB-25 connector. Fourteen pins for digital input or output, one pin for safety interlock. Use a cable equipped with a male DB-25 connector (Keithley Instruments part number CA-126-1CA).

3. IEEE-488

Connector for IEEE-488 (GPIB) operation. Use a shielded cable, such as the Model 7007-1 or Model 7007-2.

4. Cooling exhaust vent

Exhaust vent for internal cooling fan. Keep vent free of obstructions to prevent overheating.

5. Chassis ground

Ground screw for connections to chassis ground.

6. RS-232

Female DB-9 connector. For RS-232 operation, use a straight-through (not null modem) DB-9 shielded cable for connection to the PC (Keithley Instruments Model 7009-5).

7. TSP-Link

Expansion interface that allows a Series 2600 and other TSP-enabled instruments to trigger and communicate with each other. Use a category 5e or higher LAN crossover cable (Keithley Instruments part number CA-180-3A).

8. Power module

Contains the AC line receptacle and power line fuse. The instrument can operate on line voltages of 100V to 240VAC at line frequencies of 50Hz or 60Hz. See Section 17 of the Series 2600 Reference Manual for line fuse replacement instructions.

9. Ground / LO (Triax connector)

Channel A and Channel B low noise chassis ground triax connectors. Use only low-noise triax cables such as the Keithley Model 7078-TRX. Connector terminals and associated triax cable connectors are as follows:

Table 1-2

Triax connector on ground module

Connector	Center conductor	Inner ring	Outer ring
LO	Output Lo	Floating	Chassis Ground
Triax cable	Center conductor	Inner shield	Outer shield

10. Ground / LO (Phoenix connector)

Channel A and Channel B Low noise chassis ground Phoenix connector.

What are the source-measure capabilities?

Reference See the specifications in Appendix A of this manual as well as Sections 4 and 8 of the Series 2600 Reference Manual for more detailed information.

Model 2601 and Model 2602

Basic DC source-measure capabilities for the Models 2601 and 2602 are listed in [Table 1-3](#).

Table 1-3

Model 2601 and 2602 source-measure capabilities

Function	Capabilities
Source \pm DC voltage	1 μ V to 40.4V
Source \pm DC current	1pA to 3.03A ¹
Measure \pm DC voltage	1 μ V to 40.8V
Measure \pm DC current	1pA to 3.06A ¹

1. 10A maximum available in pulse mode only.

Model 2611 and Model 2612

Basic DC source-measure capabilities for the Models 2611 and 2612 are listed in [Table 1-4](#).

Table 1-4

Model 2611 and 2612 source-measure capabilities

Function	Capabilities
Source \pm DC voltage	1 μ V to 202V
Source \pm DC current	1pA to 1.515A ¹
Measure \pm DC voltage	1 μ V to 204V
Measure \pm DC current	1pA to 1.53A ¹

1. 10A maximum available in pulse mode only.

Model 2635 and Model 2636

Basic DC source-measure capabilities for the Models 2635 and 2636 are listed in [Table 1-5](#).

Table 1-5

Model 2635 and 2636 source-measure capabilities

Function	Capabilities
Source \pm DC voltage	1 μ V to 202V
Source \pm DC current	20fA to 1.515A
Measure \pm DC voltage	1 μ V to 204V
Measure \pm DC current	1fA to 1.53A

How do I power-up the instrument?

Reference See “Power-up” in Section 1 of the Series 2600 Reference Manual for more information on line power.

Step 1: Connect to line power

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

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. Connect the other end of the power cord to a grounded AC outlet.

WARNING *Failure to use a grounded outlet may result in personal injury or death due to electric shock.*

Step 2: Turn on power

Turn on the instrument by pressing the front panel power switch to the on (I) position. Assuming no errors occur, the Series 2600 will power-up as follows:

- After a few seconds with the OUTPUT indicators and display pixels on, the instrument model number and firmware revision levels are briefly displayed.
- The node and the GPIB address are displayed briefly as follows:

```
KEITHLEY MODEL 26xx1
NODE = 1           GPIB = 26
```

- The TSP-Link node and serial port parameters are displayed briefly:

```
KEITHLEY MODEL 26xx2
NODE = 1           SERIAL = 9600,8,N,1,NONE
```

Step 3: Set line frequency

The Series 2600 will operate at line frequencies of either 50Hz or 60Hz. For best measurement noise performance, the unit should be configured to match the actual line frequency used by selecting MENU > LINE-FREQ > 50Hz, 60Hz, or AUTO. (When set to AUTO, the SourceMeter will automatically detect the power line frequency at power-up.)

1. Instrument will display actual model number: 2601, 2602, 2611, 2612, 2635, or 2636.

2. Instrument will display actual model number: 2601, 2602, 2611, 2612, 2635, or 2636.

How do I make measurements?

Reference For more detailed information, see the following information in Section 4 of the Series 2600 Reference Manual:

- "Basic source-measure procedure"
- "Ohms measurements"
- "Power measurements"

The measurement procedure below demonstrates how to set up the Series 2600 to source 10V and measure current through a 10kΩ resistor.

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 Series 2600 while the output is on. Power off the equipment from the front panel or disconnect the main power cord from the rear of the SourceMeter 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.*

Step 1: Connect the DUT

Connect a 10kΩ resistor to the SourceMeter Channel A HI and LO terminals as shown in [Figure 1-4 on page 1-14](#) (Models 2601/2602/2611/2612) or [Figure 1-5 on page 1-15](#) (Models 2635/2636). See Section 3 of the Series 2600 Reference Manual for complete information.

Step 2: Select source and set source level

Perform the following steps to select the voltage source and set the source value to 10V:

1. Press **Channel A SRC** to select the V-Source as indicated by the "V" units in the source field on the display. The flashing cursor indicates which value is presently selected for editing.
2. Press the up **RANGE** key, and select the 20V source range (Model 2611/2612/2635/2636) or 40V source range (Model 2601/2602). Use the lowest possible source range for best accuracy.
3. Use the **CURSOR** keys to move the cursor to the 10s digit, then press the **navigation wheel** to enter the EDIT mode (EDIT indicator displays).
4. Using either the numeric keys or the **navigation wheel**, set the source value to 10.0000V, then press **ENTER** or the **navigation wheel**.

Step 3: Set compliance limit

Perform the following steps to set the current compliance limit value to 10mA:

1. Put the Model 2602/2612/2636 in the single-channel display mode with the **DISPLAY** key.
2. Press the **LIMIT** key, then press **ENTER** or the **navigation wheel**.
3. Move the cursor to the 10s digit, then press the **navigation wheel** to enter the **EDIT** mode.
4. Using the numeric keys or the **navigation wheel**, set the limit value to 10.000mA, then press **ENTER** or the **navigation wheel**.

Step 4: Select measurement function and range

1. Put the Model 2602/2612/2636 in the single-channel display mode with the **DISPLAY** key, then select the current measurement function by pressing **MEAS** or **MODE**.
2. Select the measurement range with the **RANGE** keys. For the purposes of this example, press **AUTO RANGE**, and note the **AUTO** indicator displays. The instrument will automatically select the best range based on the measured value. You can also use manual ranging by pressing the up or down **RANGE** key, but be sure to use the lowest possible range for best accuracy.

Step 5: Turn output on

Turn the output on by pressing the appropriate **OUTPUT ON/OFF** key. The **ON/OFF** indicator LED will turn on when the channel output is on.

NOTE The Models 2611, 2612, 2635, and 2636 are equipped with a safety interlock circuit that prevents operation on the 200V range if the circuit is not energized. This circuit is illustrated in [Figure 1-5 on page 1-15](#). Refer to Section 10 of the Series 2600 Reference manual for more information.

Step 6: Make measurements

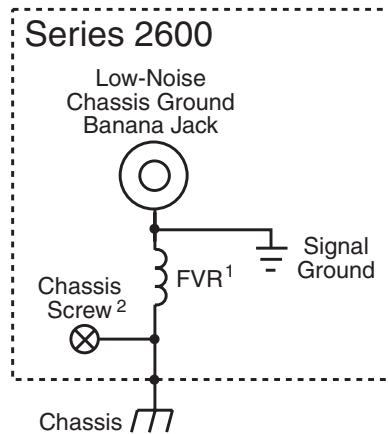
1. Observe the readings on the display. (Press **TRIG** if necessary to trigger the unit to begin taking readings.) For the single-channel display mode, the readings will appear on the top line, while source and limit values are on the bottom line. For the 10k Ω resistor under test, typical display values are:
1.00000mA
SrcA: +10.0000 VLimA:010.0000mA
2. Use the **DISPLAY** key to cycle through the various display modes shown in [Figure 1-6 on page 1-15](#). (The User State display messages are defined with specific display commands; see Section 14 of the Series 2600 Reference manual.)
3. Press the **MEAS** key several times to display measured voltage, resistance, and power. Typical values for the 10k Ω resistor are: 10.0000V, 10.0000k Ω , and 10.0000mW.

Step 7: Turn output off

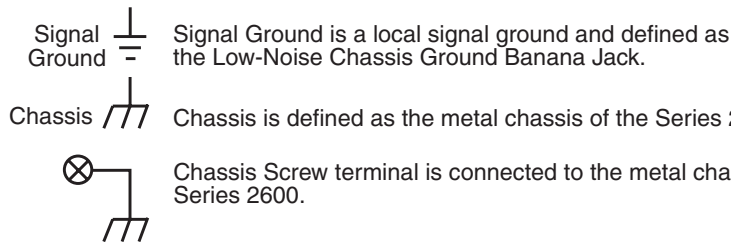
When finished making measurements, turn the output off by pressing the **OUTPUT ON/OFF** key. The **OUTPUT** indicator light will turn off.

Figure 1-4

Model 2602/2612 Low-Noise Chassis Ground Banana Jack and Chassis Screw



- 1) Frequency Variable Resistor (FVR) – Isolates the SMUs from high frequencies on the chassis. For DC to 60Hz, the FVR is a virtual short (zero ohms).
- 2) **DO NOT** use the Chassis Screw terminal to make signal connections to external circuitry. High frequency (>1MHz) on the chassis may result in higher noise at the output.



Model 2636

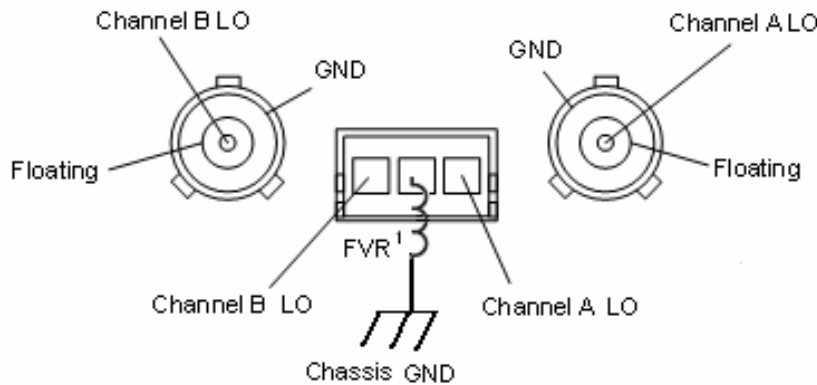


Figure 1-5
Interlock circuit

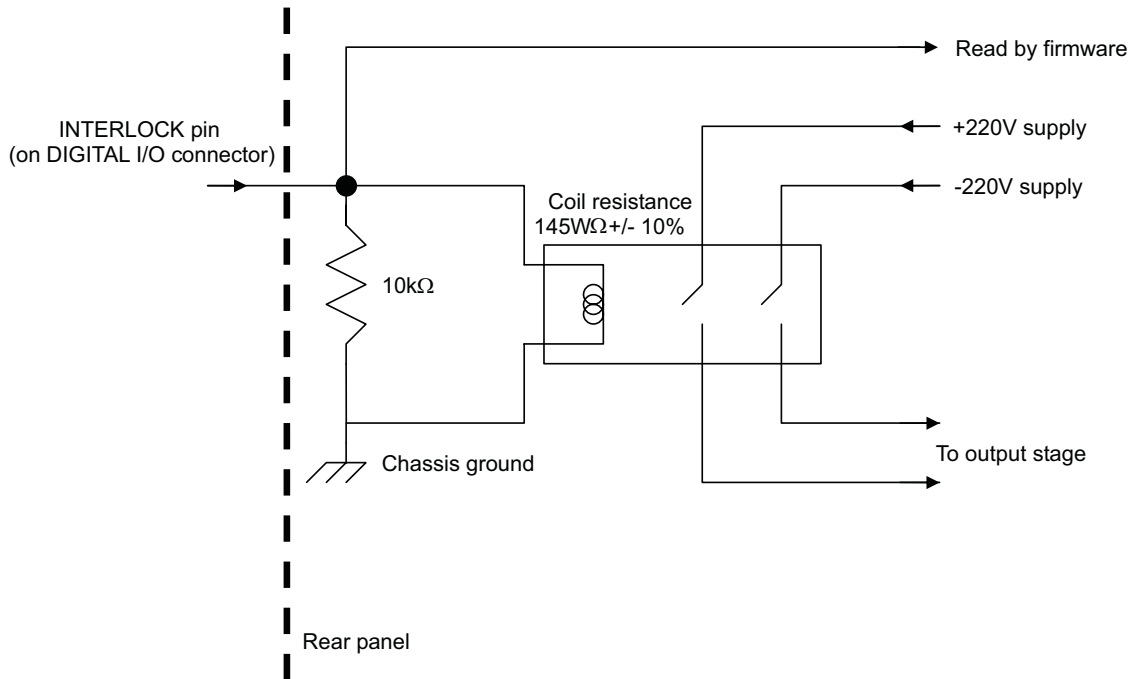
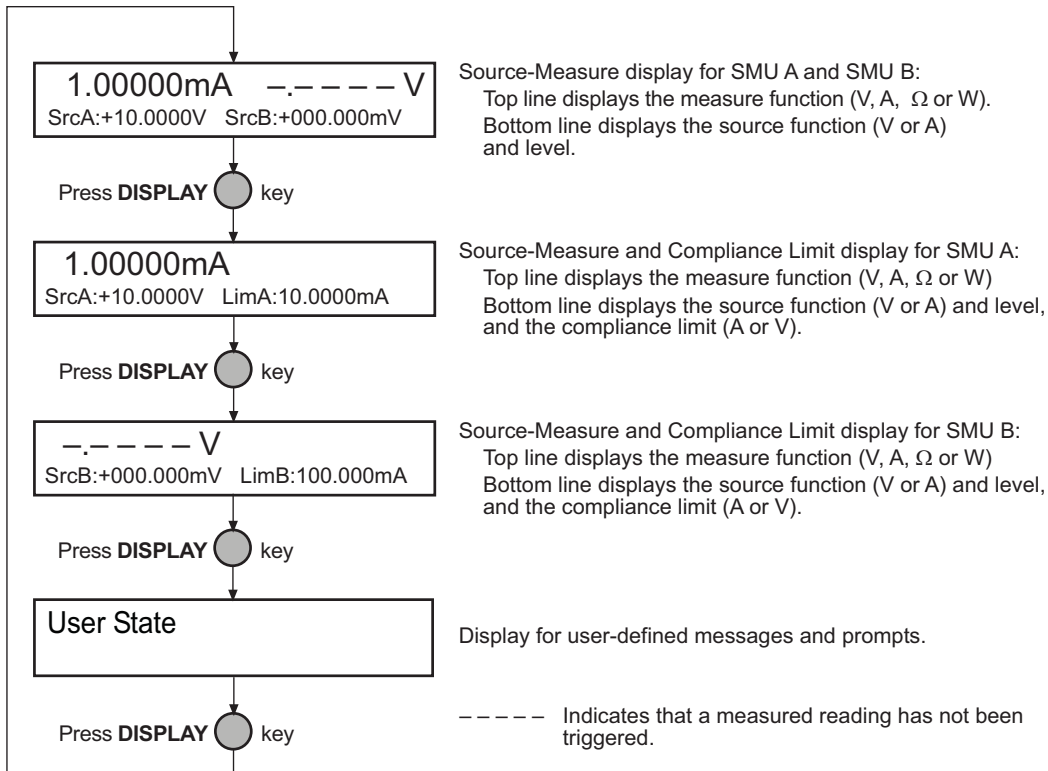


Figure 1-6
Display modes



How do I use the buffer?

Reference See Section 7 of the Series 2600 Reference Manual for more detailed information on using the buffer.

The instrument has two buffers per channel that can store from 1 to more than 100,000 readings. Each buffer reading is numbered and can also include the source value and a timestamp.

The following example shows how to store 100 readings, source values, and timestamps in Channel A, Buffer 1 and recall them from the front panel.

Step 1: Connect the DUT

Connect a 10kΩ resistor to the Channel A HI and LO terminals (see [Figure 1-4 on page 1-14](#)).

Step 2: Set up source and measure functions

Using the procedure described in [“How do I make measurements?” on page 1-12](#), set up source and measure functions:

- Source function: volts
- Source range: 20V (2611/2612/2635/2636) or 40V (2601/2602)
- Source value: 10V
- Measure function: current
- Measure range: auto

Step 3: Configure the buffer

1. From the front panel, press the **STORE** key.
The Count screen displays.
2. Use the **navigation wheel** to select the number of readings and then press **ENTER**.

NOTE You can store up to 100.

3. Choose **CONFIG > STORE > CHANA_BUFF**, then the press the navigation wheel to select Channel A.
4. Select **DEST > CHANA_BUFFER1**, and then press **ENTER**.

NOTE The message *“Cant’ change dest buffers” while storing* displays if the instrument is in store mode.

5. Choose **CHANA-BUFF1**, then press the **navigation wheel** to set up Buffer 1.

Complete the following steps to clear the Buffer 1.

1. Select **BUFFER1 > CLEAR**.
2. Select **YES**.
3. Choose **ELEMENTS**.
4. Select **SRC-VAL** and then choose **ON** to enable the source value.
5. Select **TSTAMP** and then choose **ON** to enable timestamps.
6. Press **EXIT** until the normal display.

Step 4: Turn on the output

Press the **CHAN A** (Model 2602/2612/2636) **OUTPUT ON/OFF** key to turn on the source output.

Step 5: Store readings

1. Press the **STORE** key to enable storage.
The * (asterisk) indicator displays.
2. Press **EXIT** to stop data storage.

Step 6: Turn off the output

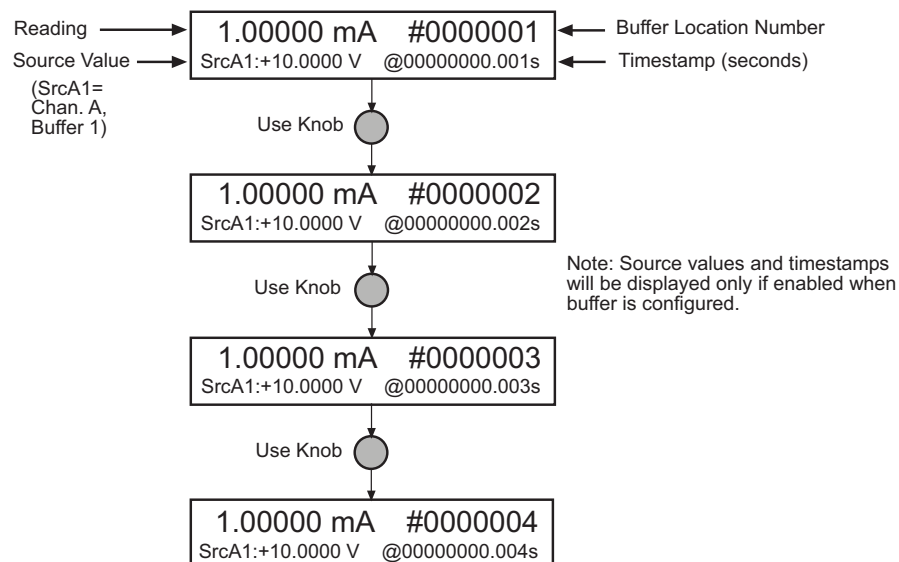
- Press the **OUTPUT ON/OFF** key to turn off the output after storage has completed.

Step 7: Recall readings

1. Press the **RECALL** key to access buffer readings. (Repeatedly pressing **RECALL** will cycle through Buffer 1 then Buffer 2 for Channel A and then Channel B). A message will be displayed if a buffer is empty.
2. Note the buffer display data (see [Figure 1-7](#)):
 - The reading is on the top display at the left.
 - The buffer location number is on the right. For example, location #000001 indicates that the displayed reading is stored at the first memory location.
 - The source value is positioned at the lower left side of the display.
 - The timestamp is positioned at the lower right side. The first source-measure reading stored in the buffer (#000001) is time stamped at 00000000.001 seconds. Subsequent readings are time stamped relative to when the time storage was started. The interval between readings will depend on the reading rate.
3. To display the other readings stored in the buffer, choose the desired memory location number:
 - Use the **+** to increment and **-** to decrement the selected digit of the location number.
 - Set the cursor position with the **←** or **→** **CURSOR** keys.
4. To exit from the data store recall mode, press **EXIT**.

Figure 1-7

Buffer display format



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Remote Operation**In this section:**

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How do I use the remote interface?

Reference See Section 11 of the Keithley Instruments Series 2600 System Series 2600® Reference Manual for detailed information on communications interfaces.

Step 1: Connect to the interface

See [Figure 1-2 on page 1-6](#) for the locations of the GPIB (IEEE-488) and RS-232 connectors, and make connections as follows:

- GPIB – Use a shielded IEEE-488 cable such as the Keithley Instruments Model 7007 to connect the Series 2600 IEEE-488 connector to the GPIB connector on the computer (see [Figure 2-1](#)).
- RS-232 – Use a shielded 9-pin RS-232 cable like the Keithley Instruments Model 7009-5 to connect the Series 2600 RS-232 connector to the serial port of the computer (see [Figure 2-2](#)).

Figure 2-1
GPIB cable

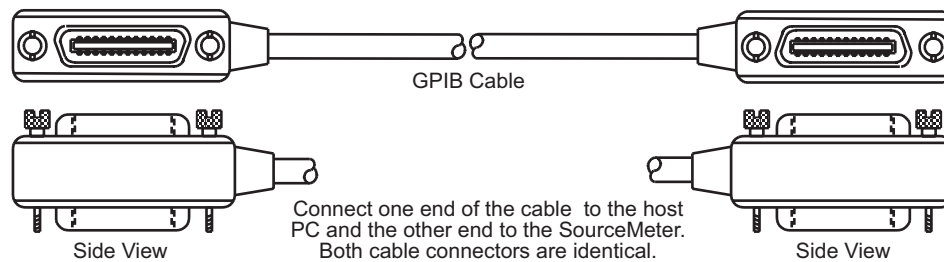
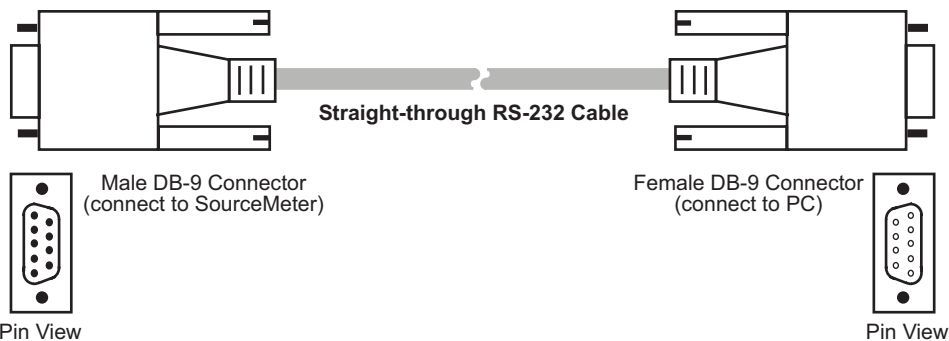


Figure 2-2
RS-232 cable



Step 2: Select the interface

1. Press **MENU** and then choose one of the following:
 - GPIB
 - RS-232
 - AUTO

Step 3: Configure the interface

GPIB interface configuration

Set the primary address using the following procedure. The Series 2600 primary address must be the same as that specified in your program, or the two devices will not be able to communicate.

1. Press **MENU > GPIB** and then press the **ENTER**.
2. Select **ADDRESS** and then press the **ENTER**.
The Address screen displays.
3. Turn the navigation wheel to the right or to the left to select the desired number.
4. Push in on the **navigation wheel** and then turn the **navigation wheel** to the left or to the right to choose an address.

NOTE The address can range from 1-30.

5. Press the **navigation wheel** to set the address.
6. Press **EXIT** to until the Main Menu displays.

RS-232 interface configuration

Set RS-232 parameters as covered below. The Series 2600 RS-232 parameters must agree with those of the computer serial port, or the two devices will not be able communicate.

1. Press **MENU** to view the main menu.
2. Choose **RS-232**, then press **ENTER**.
3. Choose the following options:
 - Select **BAUD** and then choose the desired option.
 - Choose **BITS** and then select the appropriate option.
 - Select **PARITY** and then choose the desired.
 - Choose **FLOW-CTRL** and then select the appropriate option.
6. Press **EXIT** until the Main Menu displays.

How do I use Test Script Builder?

Reference See Section 2 of the Series 2600 Reference Manual for complete details on using the Test Script Builder.

Step 1: Run Test Script Builder

Run the Test Script Builder program in the Keithley Instruments folder in the usual manner. The initial startup screen shown in [Figure 2-3 on page 2-5](#) will be displayed. The main sections of the screen are briefly described below.

Main Bar

The menu contain following options:

File – Use this option to control projects and files.

Edit – Performs a number of editing functions on script files.

Navigate – Navigates through projects.

Project – Opens, closes, and builds projects.

Run – Runs scripts.

Window – Selects which window to display.

Help – Provides access to online help files.

Project Navigator pane

The window pane on the left side is where the Project Navigator resides. The navigator consists of created project folders and the script files (.tsp) created for each project. Each project folder can have one or more script files.

Script Development pane

The script chunk is written in the upper window pane. It is in this area that scripts are written and/or modified. Notice that there is a tab available for each opened script file. A script project is then downloaded to the Series 2600 and run.

Series 2600/Script Interaction pane

A number of tabs in the lower window pane provide additional interaction between the Test Script Builder, the Series 2600 and the opened script (the tabs displayed will depend on those selected in the menu).

Key tabs include:

Instrument Console – The Instrument Console is used to send commands to the connected Series 2600. Retrieved data (e.g., readings) from commands and scripts appear in the console.

Problems – When a script is saved, error checking is performed. If a script error is detected, an “X” will appear in the script at or near the corrupt line of code. The Problems tab in the lower window pane will open automatically and provide a description of the error.

Tasks – When writing a script, a double dash (--) is used to designate that the text that follows is a comment and not script code. When using the "--TODO" comment in a script, it will also appear in the Tasks tab, where additional information can be added.

Command Help – Provides online help to the Instrument Command Library (ICL).

Language Help – Provides online help to the TSL programming language.

Control icons

Control icons (shown in [Figure 2-4 on page 2-6](#)) include:









- 1. Open/Close Instrument**  – Opens instrument resource if closed. Closes instrument resource if open.
- 2. Clear Console Window**  – Clears instrument console window.
- 3. Abort Execution**  – Halts execution of commands or scripts.
- 4. Reset**  – Aborts whatever the unit is doing and resets everything to the default state with the output off.
- 5. Send Software Trigger**  – Sends a software trigger to take readings.
- 6. Delete a Script From NVRAM**  – Brings up a window that lists the scripts stored in the unit's non-volatile memory, and allows you to remove scripts.
- 7. Menu**  – Accesses the console menu.
- 8. Minimize/Maximize**  – Minimizes or maximizes the console window.

Figure 2-3
Test Script Builder initial startup screen

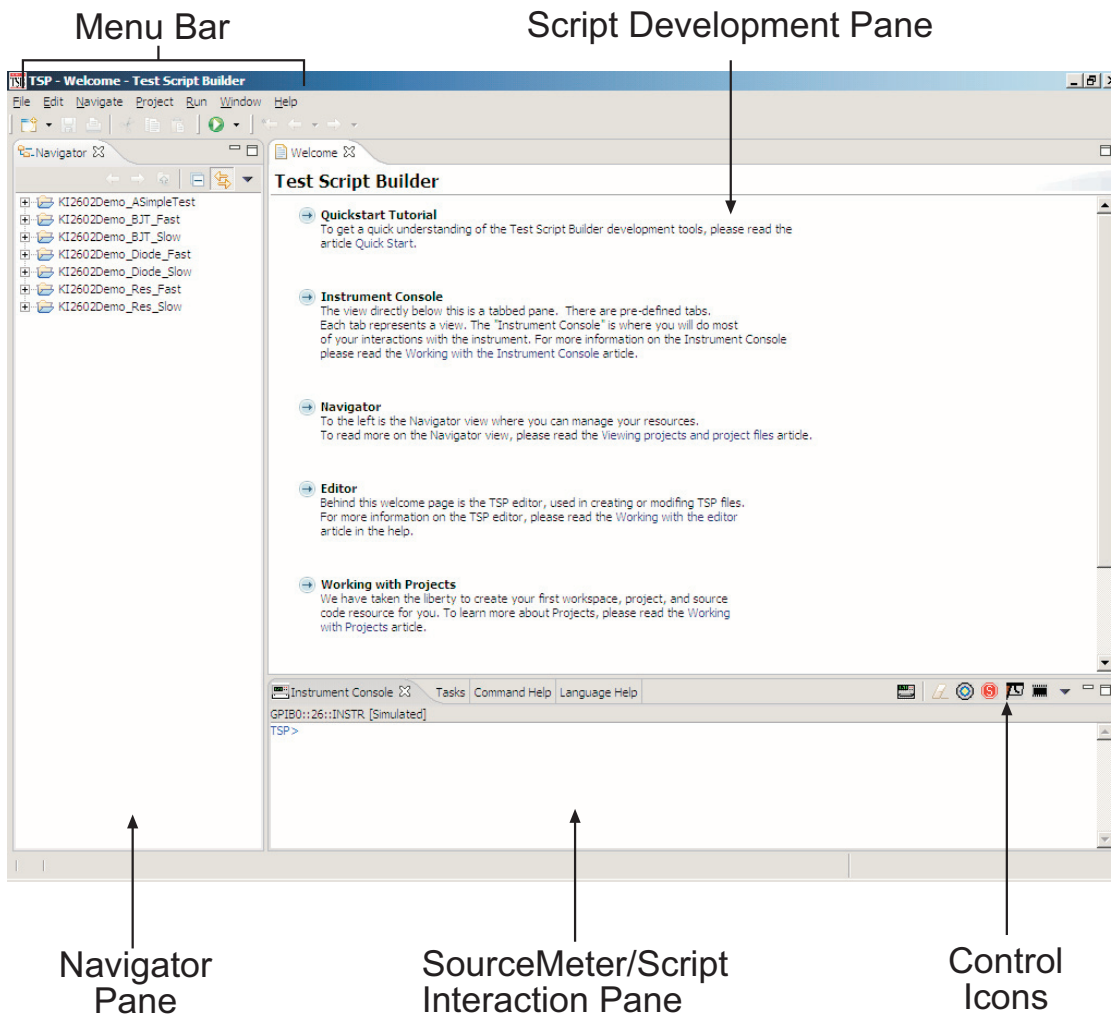
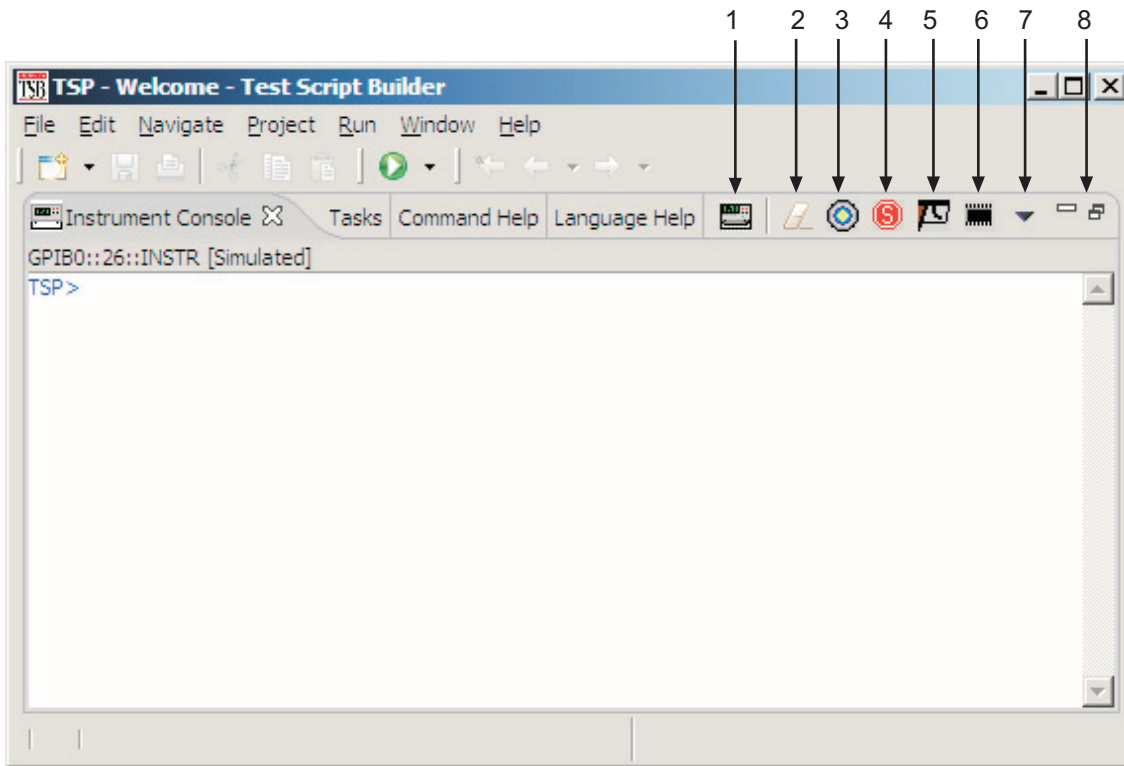


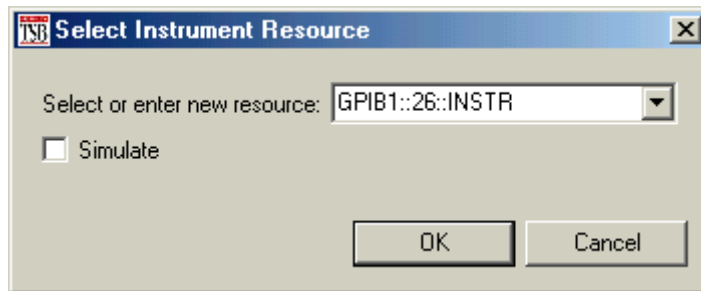
Figure 2-4

Instrument console control icons**Step 2: Open and close an instrument resource**

Before you can send commands or run scripts to control the Series 2600, you must first open the instrument resource as follows:

1. Click on the **Open Instrument** icon (see [Figure 2-4](#)).
2. Choose the desired instrument from the dialog box (see [Figure 2-5](#)) drop-down menu to select a communications resource:
 - **GPIB** – At the factory, the GPIB address for the Series 2600 is set to 26. If using the GPIB interface board 0 and address 26, the resource setting should be **GPIB0::26::INSTR**. Resource settings for other GPIB board numbers and primary addresses are available from the dialog box.
 - **RS-232** – Typically, the COM1 serial port of the PC is used for RS-232 communications. For COM1, use the **ASRL1::INSTR** resource setting. Resource settings for other COM ports are available from the dialog box.
3. If you select the **Simulate** option, the Instrument Console will become active even though there will be no actual communication with the Series 2600. You can simulate running a script or sending a command, but the Series 2600 will not respond.
4. To close the resource, click on the **Instrument** icon again. The resource will close, and the console window will become inactive.

Figure 2-5
Select Instrument Resource dialog box



Step 3: Save and clear console window

You can save and clear the console window as follows:

- **Save console** – Click on the **Menu** arrow (Figure 2-3), choose **Save Console**, then choose the folder and filename desired.
- **Clear console** – Click on the **Clear Console** icon (Figure 2-3) to clear the console window.

Step 4: Select command and language reference views

You can access online help for the ICL (Instrument Control Library) and TSL (Test Script Language) as follows:

- **ICL:** Click on the **Command Help** tab at the top, then click the **Maximize** icon. You can then quickly get information on all commands in the library.
- **TSL:** Click on the **Language Help** tab at the top, then click the **Maximize** icon to quickly access details on the script language.

How do I use TSB to make measurements?

Reference See “Remote source-measure procedure” in Section 4 and Section 12 of the Series 2600 Reference Manual for details on instrument commands.

The following procedure uses the TSB Instrument Console to send commands to source voltage and measure current on Channel A using a 10kΩ resistor as the DUT. The complete command sequence as it would appear in the console window is shown in Figure 2-6 on page 2-9 along with instrument responses.

The procedure assumes the DUT (10kΩ resistor) is already connected to the Series 2600 (Figure 1-4 on page 1-14), and that the instrument resource has already been opened (“Open and close an instrument resource” on page 2-6).

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 Series 2600 while the output is on. Power off the equipment from the front panel or disconnect the main power cord from the rear of the Series 2600 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.*

Step 1: Reset instrument

A good practice is to reset the instrument to its default settings before the start of a test. To reset the Series 2600, type the following command into the console window, then press the Return key:

```
reset ()
```

For a Model 2602, 2612, or 2636 you can restore defaults of Channel A or Channel B respectively as follows:

```
smua.reset ()
```

```
smub.reset ()
```

Step 2: Select source function and set output value

Enter the following commands to select the source voltage function, set the source range to 20V (Model 2611/2612/2635/2636) or 40V Model 2601/2602), and set the source value to 10V:

```
smua.source.func = smua.OUTPUT_DCVOLTS
```

```
smua.source.rangev = 40 (Use for Model 2601/2602)
```

```
smua.source.rangev = 20 (Use for Model 2611/2612/2635/2636)
```

```
smua.source.levelv = 10
```

Step 3: Set compliance value and measure range

Enter the following commands to set the compliance limit and measure range to 10mA:

```
smua.source.limiti = 10e-3
```

```
smua.measure.rangei = 10e-3
```

Step 4: Turn on output

Send the following command to turn on the output:

```
smua.source.output =smua.OUTPUT_ON
```

Step 5: Make a measurement

Enter the following command to take a current measurement:

```
reading = smua.measure.i ()
```

Step 6: Print the result

Print the result in the console window with the following command:

```
print (reading)
```


Note that the reading response will appear in the console window (Figure 2-6).

Alternatively, you can also take and print readings by including the appropriate `measure` command as the argument in the `print` command. For example, the following commands will take and print ohms and power readings respectively:

```
print(smua.measure.r())
print(smua.measure.p())
```

Again, readings will be displayed in the console window.

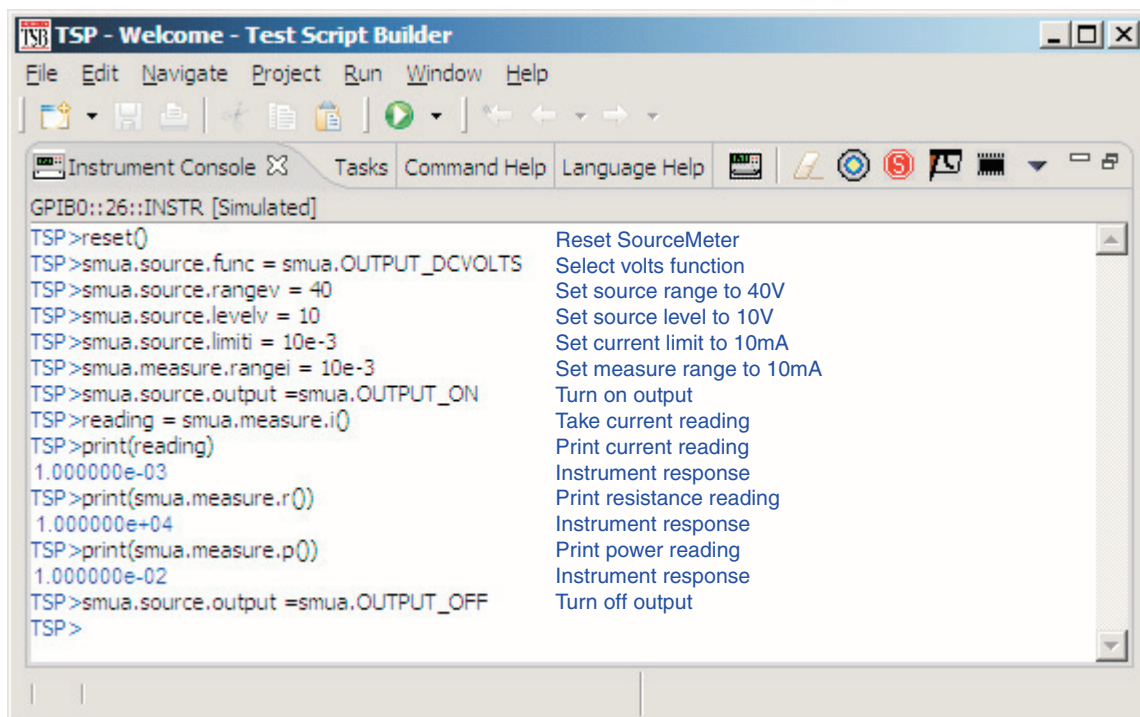
Step 7: Turn off output

Send the following command to turn off the output when measurements are complete:

```
smua.source.output =smua.OUTPUT_OFF
```

Figure 2-6

Source-measure command sequence in console window (2601/2602 version shown)



How do I use other programs?

Reference See the LabVIEW and Visual Basic documentation for details on using those programs.

Basic source-measure examples using LabVIEW and Visual Basic are shown below. See also Section 3 for more examples to load and run scripts.

Using LabVIEW

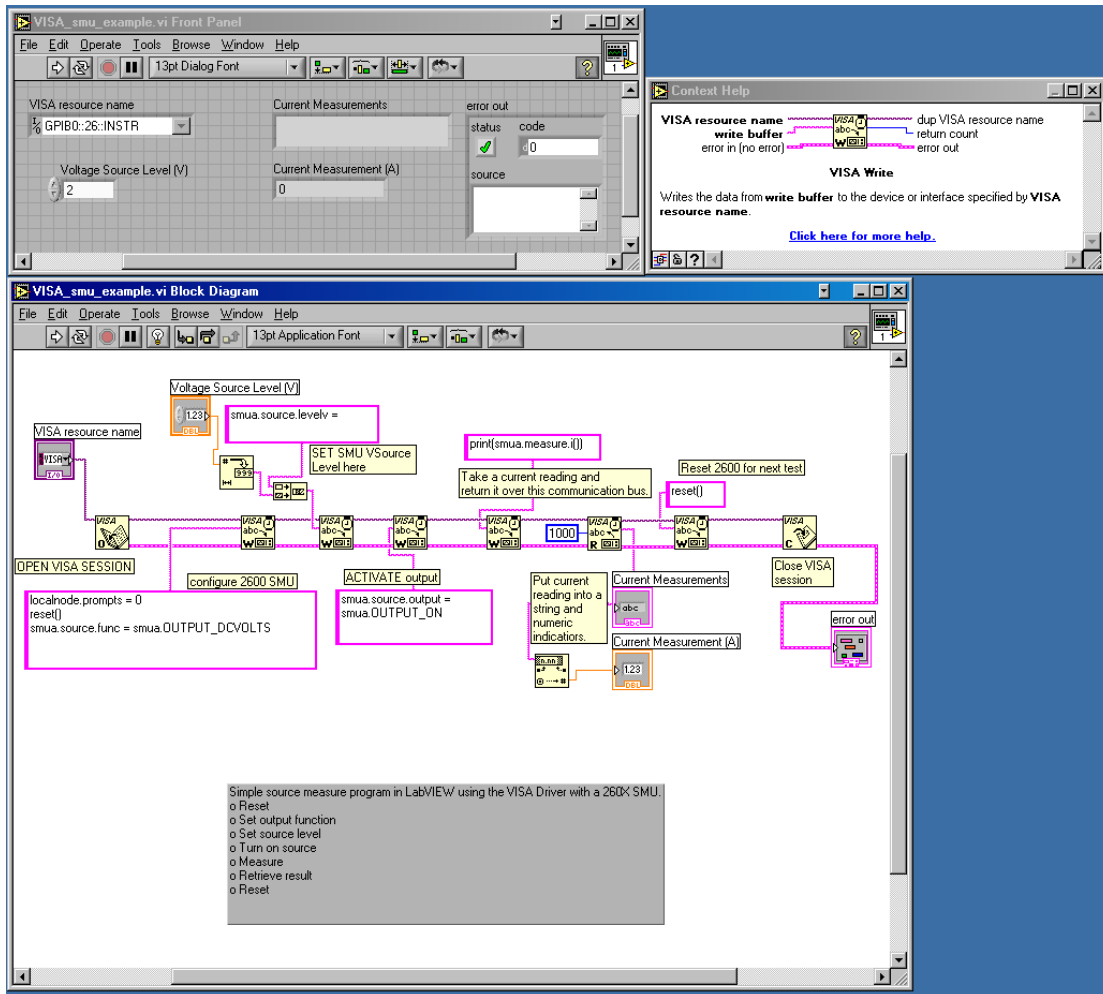
The source-measure example using LabVIEW is shown in [Figure 2-7](#). The test steps are:

1. Reset instrument.
2. Select source voltage function.
3. Set source output voltage.
4. Turn on output.
5. Take current measurement.
6. Reset instrument.

The command sequence for this source-measure example is shown below:

```
localnode.prompts = 0           - Disable prompts.
reset ()                        -
                                - Reset Series 2600.
smua.source.func = smua.OUTPUT_DCVOLTS - Select voltage source function.
smua.source.levelv = volts      -
                                - Set voltage source level.
smua.source.output = smua.OUTPUT_ON - Turn on source output.
print (smua.measurei ())        -
                                - Take and return current reading.
reset ()                        -
                                - Reset Series 2600.
```

Figure 2-7
LabVIEW source-measure example block diagram

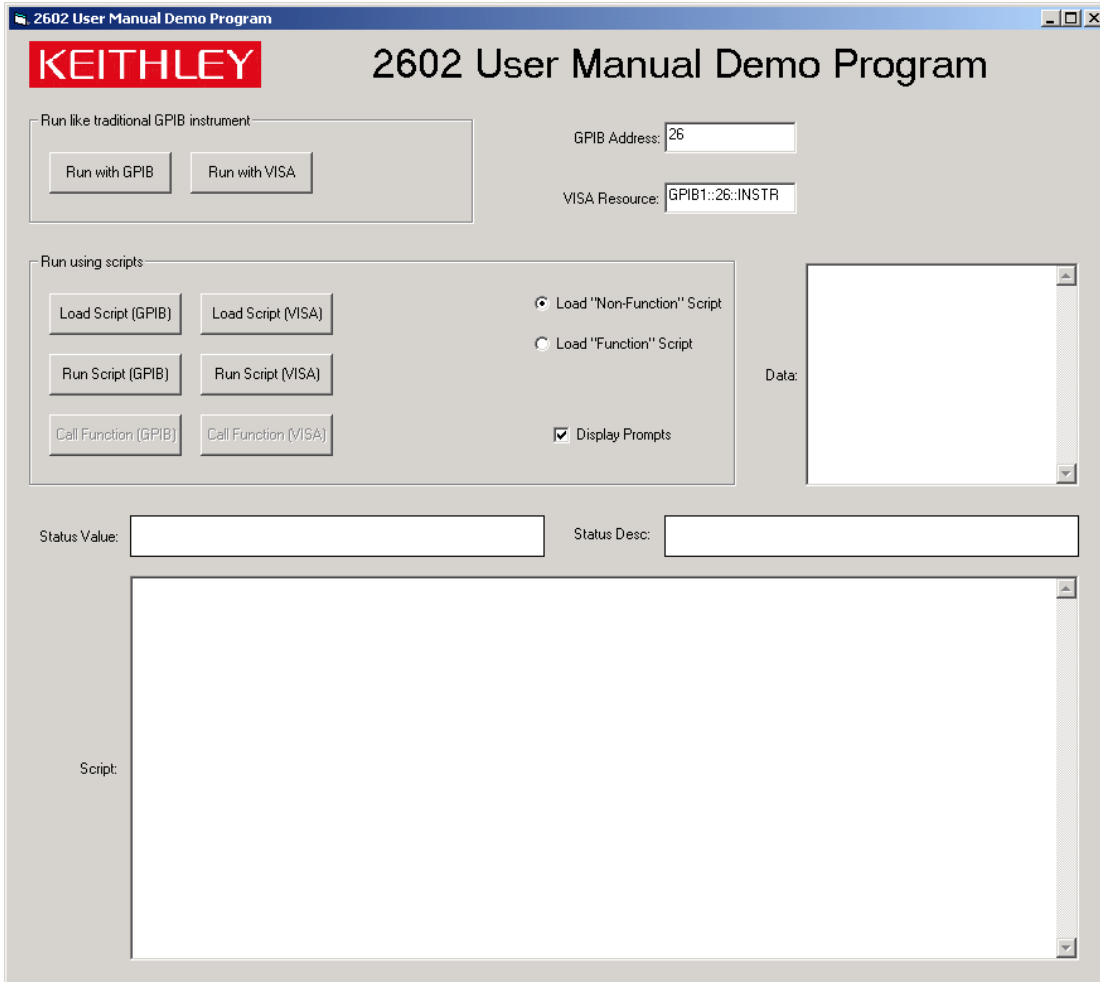


Using Visual Basic

User interface

The GUI (graphical user interface) shown in [Figure 2-8](#) was created to demonstrate how to control a Keithley Instruments Series 2600 instrument SourceMeter using Visual Basic 6.0. Source code for this example program can be downloaded from the Keithley Instruments internet site, www.keithley.com.

Figure 2-8
Visual Basic example user interface



Using the Series 2600 as a traditional GPIB instrument

The following pseudocode describes how the Series 2600 will be configured and controlled to source voltage and measure current for this example. Some of the settings are default values restored by resetting the instrument, but they are included to show a typical setup and measure sequence that might be used for such a test.

1. Reset Series 2600 to default settings.
2. Set display to show SMU A source and limit settings.
3. Set display to show current measurement.
4. Set source function to DCV.

5. Enable source autorange.
6. Set source level to 5V.
7. Set current compliance to 100mA.
8. Set current measurement range to 100mA.
9. Set integration time to 1PLC.
10. Turn on SMU A output.
11. Measure the current and put reading in instrument output queue. This step is similar to using a SCPI "READ?" query to take a single reading.
12. Turn off SMU A output.

Command sequence

The commands that implement the pseudocode are listed below. The syntax for the "send" and "enter" commands is for a Keithley Instruments GPIB card. To use a Keithley Instruments GPIB card in Visual Basic, you must include the "ieeevb.bas" module in your project. This module is included on the CD that comes with your GPIB card.

When you click the "Run with GPIB" button on the GUI, the commands are sent to the Series 2600 and executed. The single reading returned by these commands is displayed in the Data text box as shown in [Figure 2-9 on page 2-14](#).

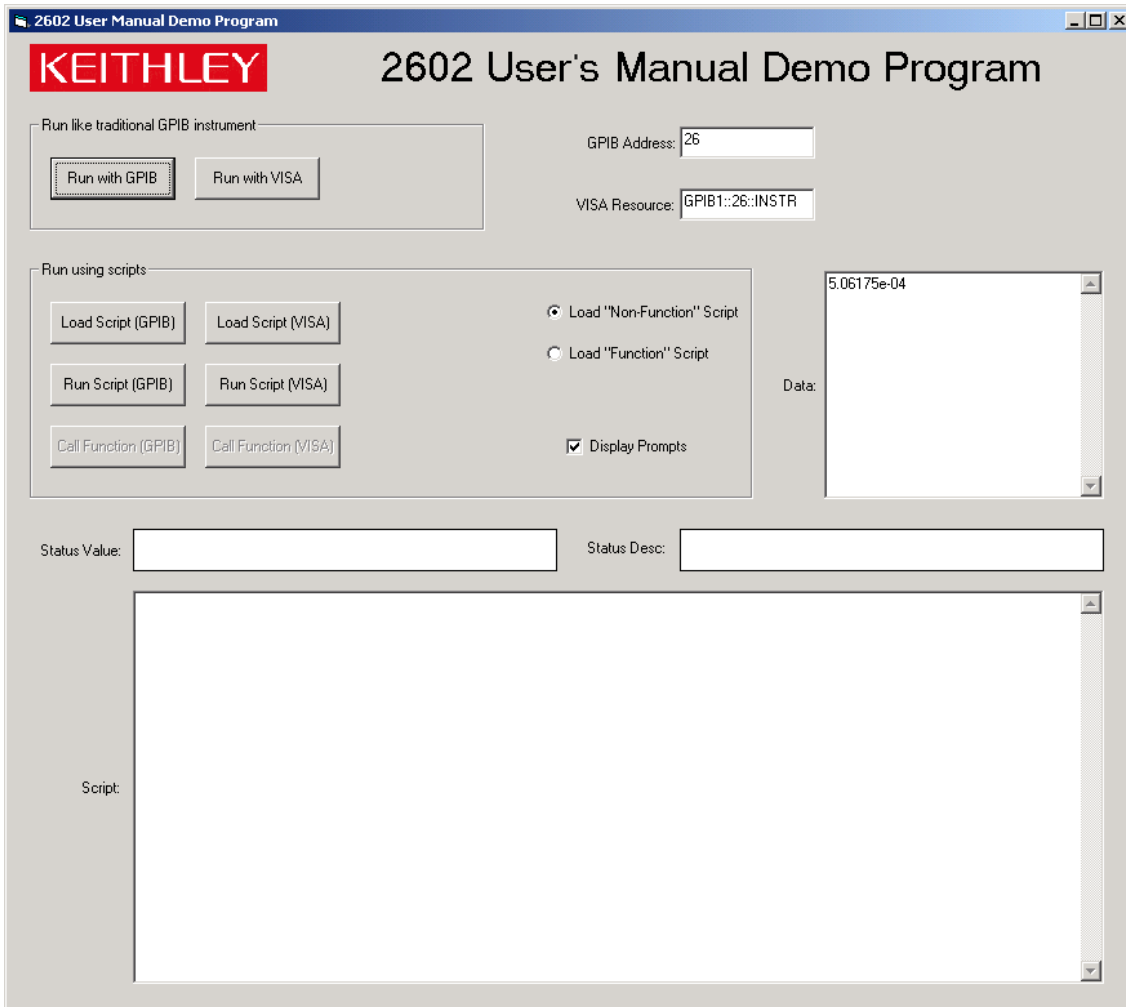
NOTE Addr% is the GPIB address of the instrument and is assigned the value of 26.

```
Call send(Addr%, "localnode.prompts = 0", intStatus)
Call send(Addr%, "reset()", intStatus)
Call send(Addr%, "display.screen = display.SMUA", intStatus)
Call send(Addr%, "display.smua.measure.func = display.MEASURE_DCAMPS",
  intStatus)
Call send(Addr%, "smua.source.func = smua.OUTPUT_DCVOLTS", intStatus)
Call send(Addr%, "smua.source.autorangev = smua.AUTORANGE_ON", intStatus)
Call send(Addr%, "smua.source.levelv = 5", intStatus)
Call send(Addr%, "smua.source.limiti = 0.1", intStatus)
Call send(Addr%, "smua.measure.rangei = 0.1", intStatus)
Call send(Addr%, "smua.measure.nplc = 1", intStatus)
Call send(Addr%, "smua.source.output = smua.OUTPUT_ON", intStatus)
Call send(Addr%, "print(smua.measure.i())", intStatus)
Call send(Addr%, "smua.source.output = smua.OUTPUT_OFF", intStatus)
Call enter(strBuffer, 256, intNbytes, Addr%, intStatus)
txtData.Text = strBuffer
```

Using VISA

Clicking on the "Run with VISA" button will send the same commands to the Series 2600 using National Instruments® (NI) VISA. The VISA resource is for an instrument at address 26 connected to GPIB interface #1. Once again, a Keithley Instruments GPIB card was used for this example. However, VISA allows the same code to be used with GPIB cards made by other manufacturers, or with altogether different interfaces such as the RS-232 or the Ethernet.

Figure 2-9
Example program test results



Test Script Processor Interaction

In this section:

Topic	Page
What is a script?	3-2
Factory scripts	3-2
User scripts.....	3-2
How do I run a script from the front panel?	3-2
How do I interact with scripts using Test Script Builder?	3-3
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What is a script?

Reference See “Programming overview” in Section 2 of the Keithley Instruments Series 2600 System Series 2600® Instruments Reference Manual for more information on script fundamentals.

A script is a collection of instrument control commands and programming statements to perform one or more operations or tasks. A script is stored in a Series 2600 and is run by its Test Script Processor (TSP).

Factory scripts

The Series 2600 is shipped from the factory with at least one factory script stored in its non-volatile memory. Each factory script is made up of a series of functions to perform specific tests. A factory script function can be called (run) from the front panel or called using remote programming. A factory script cannot be deleted from non-volatile memory.

User scripts

A user script is a script created by a user using the Test Script Builder or an external program. The user script is loaded in the Series 2600 and stored in volatile or non-volatile memory. If stored in non-volatile memory, the script will not be lost when the instrument is turned off.

Keithley Instruments will be posting approved user scripts donated by registered users on its web site. You will be able to download these user scripts into your Series 2600. Visit www.keithley.com for details.

How do I run a script from the front panel?

Reference See “Factory scripts” and “User Scripts” in Section 2 of the Series 2600 Reference Manual for details on running scripts.

Choose to run scripts from the following options:

- Factory
- Users
- Scripts

All factory script functions are interactive if accessed from the front panel. This means you must manually enter the parameters.

A user script can be non-interactive or interactive. A non-interactive script does not require user input.

NOTE If the Series 2600 is in remote operation, press the LOCAL key to return control to the front panel.

To run the script from the front panel:

1. Press the **LOAD** key to display the LOAD TEST menu.
2. Position the blinking cursor on the **FACTORY** or **USER** menu item and press **ENTER** (or the navigation wheel). Keep in mind that the Series 2600 is shipped with no user scripts loaded.
3. Position the blinking cursor on the test to be run, and then press **ENTER**.
4. Press the **RUN** key to start the test.
5. Enter required test parameters using the front panel controls.

Reading the buffer – Test data is stored in a buffer. See [“How do I use the buffer?”](#) on page 1-16 for details on recalling test data.

How do I interact with scripts using Test Script Builder?

Reference See “Using the Test Script Builder” in Section 2 of the Series 2600 Reference Manual for details on the Test Script Builder.

The following function for factory script “KIGeneral” is stored in the non-volatile memory of the Series 2600:

```
PulseVMeasureI(smu, bias, level, ton, toff, points)
```

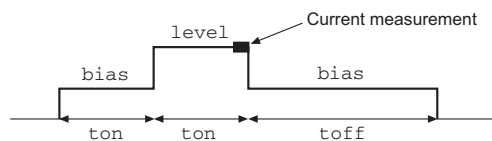
The above function performs a specified number of pulse V, measure I cycles:

- Sets the `smu` to output `bias` volts and dwell for `ton` seconds.
- Sets the `smu` to output `level` volts and dwell for `ton` seconds.
- Performs current measurement with the source at `level` volts.
- Sets the `smu` to output `bias` volts for `toff` seconds.
- Repeats the above sequence for `points` pulse-measure cycles.

[Figure 3-1](#) shows one pulse-measure cycle for the function.

Figure 3-1

Pulse-measure cycle for the PulseVMeasureI function



Running a factory script

Reference See “Factory scripts” in Section 2 of the Series 2600 Reference Manual for details on running factory scripts.

NOTE All commands to run a factory script are to be executed from the Instrument Console of the Test Script Builder.

The following steps explain how to run the `PulseVMeasureI` function and read the data stored in the buffer.

NOTE The “KIGeneral” factory script is an autorun script. The script runs automatically when the Series 2600 is turned on. The functions of the script are ready to be called.

Step 1: Call the function

The following are example parameters for the `PulseVMeasureI` function which will perform three pulse voltage, measure current cycles:

```
smu      SMU A
bias     -1V
level    1V
ton      1ms
toff     2ms
```

```
points      3
```

The following command will execute the `PulseVMeasureI` function using the above parameters:
`PulseVMeasureI(smua, -1, 1, 1E-3, 2E-3, 3)`

Step 2: Read the buffer

Reference See in Section 7 of the Series 2600 Reference Manual for more details on the reading buffers.

The above function stores the three current measurements in the reading buffer (`smua.nvbuffer1`). Also stored in the buffer are the voltage source settings and timestamps for the measurements. The timestamps (in seconds) are referenced to the start of the test. The timer for the timestamps starts at zero seconds when the test is started.

The `printbuffer` function is used to print (output) measured readings, timestamps and/or source values stored in the buffers.

Print readings – The following code will return the three measured current readings stored in `nvbuffer1`:

```
rb1 = smua.nvbuffer1
printbuffer(1, rb1.n, rb1)
```

Example output: `1.234567e-03, 2.362360e-03, 2.362368e-03`

For the above `printbuffer` function, 1 is the starting index for values to print, `rb1.n` is the ending index (for this function, `n = 3`), and `rb1` is the reading buffer (`smua.nvbuffer1`).

Print time stamps – The following command will print the time stamps for the three measured current readings:

```
printbuffer(1, rb1.n, rb1.timestamps)
```

Example output: `5.555555e-02, 8.888888e-02, 1.111111e-01`

Print source values – The following command will print the voltage source values for the three measured current readings:

```
printbuffer(1, rb1.n, rb1.sourcevalues)
```

Output: `1.000000e+00, 1.000000e+00, 1.000000e+00`

Print readings, time stamps and source values – The following command will return the three sets of data (nine values) in the same message:

```
printbuffer(1, rb1.n, rb1, rb1.timestamps, rb1.sourcevalues)
```

Example output:

```
1.234567e-03, 5.555555e-02, 1.000000e+00, 2.362360e-03, 8.888888e-02,
1.000000e+00, 2.362368e-03, 1.111111e-01, 1.000000e+00
```

The above output is returned in the following order:

```
reading1, timestamp1, sourcevalue1, reading2, timestamp2, sourcevalue2, reading3, timestamp3,
sourcevalue3
```

Calling a function without parameters

When the command to call a script function is sent without parameters, input value fields and messages will appear on the display to prompt the operator to input the parameters using the front panel controls.

The following command will call the `SourceVMeasureI` function and then require operator interaction:

```
PulseVMeasureI()
```

After sending the above command, the Series 2600 display will prompt the operator to input the following parameters from the front panel:

- Enter BIAS voltage.
- Enter PULSE (level) voltage.
- Enter pulse ON time.
- Enter pulse OFF time.
- Enter number of pulses (points).

After the operator keys in each parameter and presses the **ENTER** key (or the navigation wheel), the display will proceed to the next input prompt. After the last parameter (number of pulses) is entered, the test will continue.

The following message will be displayed when the test is finished:

```
PulseVMeasureI
```

```
Test complete.
```

Modifying a factory script

Reference See “Factory scripts” in Section 2 of the Series 2600 Reference Manual for more information on modifying a factory script.

A factory script can be imported from the Series 2600 into the Test Script Builder where it can be modified. The modified script can then be loaded back into the Series 2600 and saved as a user script.

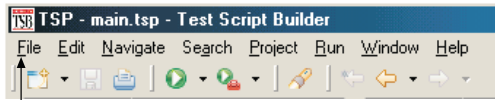
The following procedure will import the KIGeneral factory script into the Test Script Builder, modify code for the SourceVMeasureI function, load the script in the Series 2600 as a user script under a different name, and then configure the test to call the SourceVMeasureI function.

Step 1: Importing a factory script project

A factory script project is made of many executable functions. The `SourceVMeasureI` function is one of the functions that make up the KIGeneral factory script that is stored in the Series 2600.

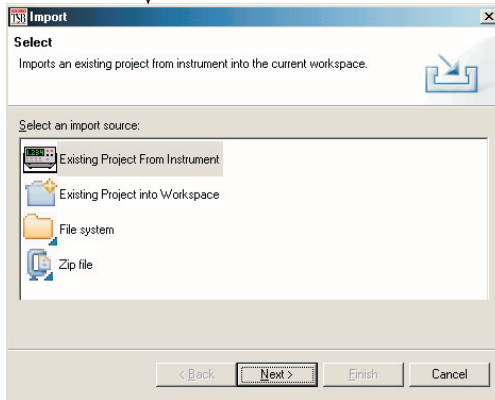
[Figure 3-2](#) shows how to import the KIGeneral factory script project from the Series 2600 into the Test Script Builder. After importing the script, the project will appear as a folder in the Project Navigator with a script file named “main.tst” (see [Figure 3-3](#)).

Figure 3-2
Importing a factory script project from the Series 2600

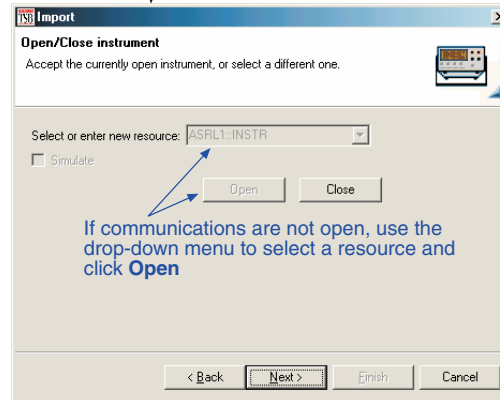


A) Click **File** to display the drop-down file menu and click **Import** to open the Import wizard.

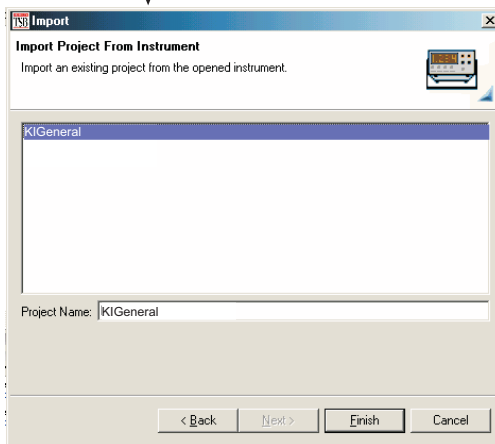
B) In the **Import Select** box, click **Existing Project From Instrument** and then click **Next**.



C) **Import Open/Close instrument** box – With communications to the Series 2600 open, click **Next**.



D) In the **Import Project From Instrument** box, click the **KIGeneral** project, and then click **Finish**.



Step 2: Modifying the test code for the SourceVMeasureI function

As shown in [Figure 3-3](#), the test code for the script functions is contained in the tab for the “main.tsp” script file. The test code for all of the functions of the KIGeneral factory script are in this tab. Use the scroll buttons on the right side of the tab to view more code.

Editing example

The following line of code in the “main.tsp” script file applies to the `SourceVMeasureI` function:

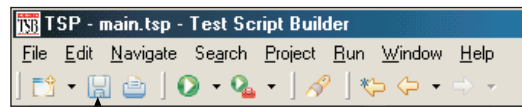
```
92bias = display.prompt("+00.000", " Seconds", "Enter BIAS Voltage.", 0, -
    40, 40)
```

The above command defines a display input field and message prompt for entering the bias voltage. The `-40` parameter sets the minimum voltage that can be entered, and the `40` parameter sets the maximum voltage that can be entered.

Now assume you wish to change the bias input limits to $\pm 10V$. Edit the line of code to the following:

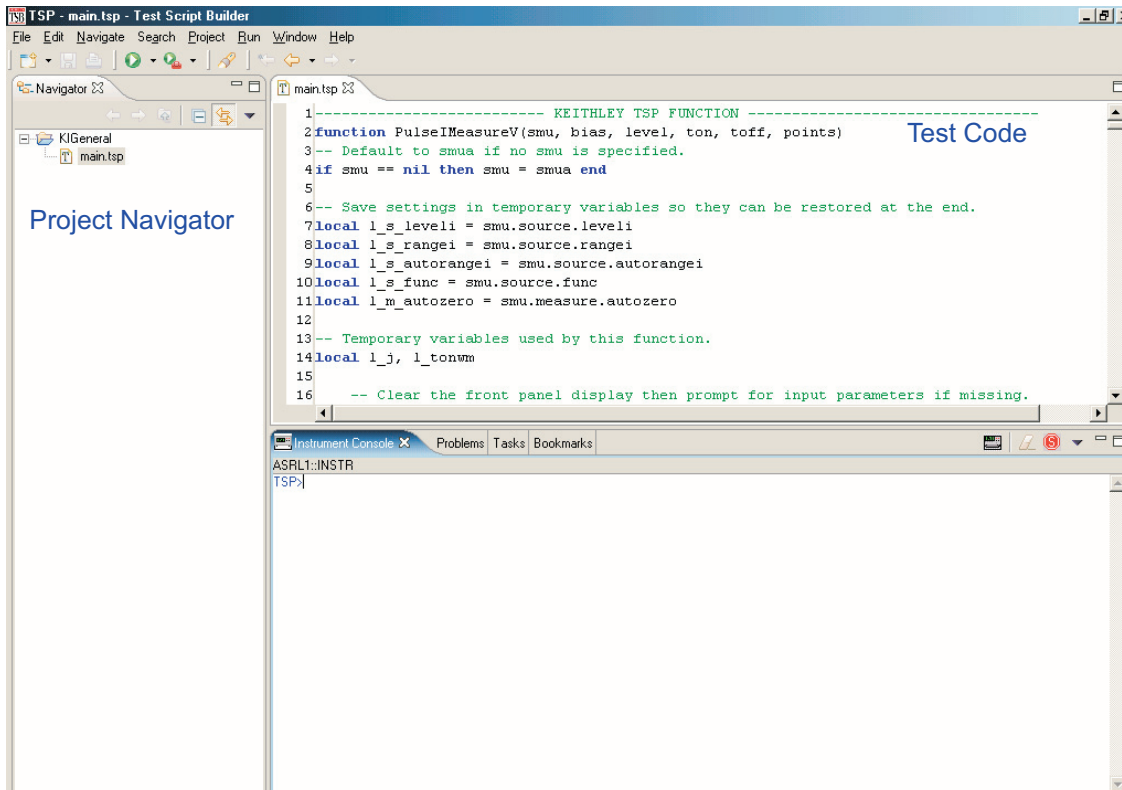
```
92bias = display.prompt("+00.000", " Seconds", "Enter BIAS Voltage.", 0, -
    10, 10)
```

Saving the script – After modifying the script file, it must be saved by clicking the save icon on the toolbar of the Test Script Builder as follows:



Click to save the "main.tsp" script file

Figure 3-3
KIGeneral project imported into the Test Script Builder

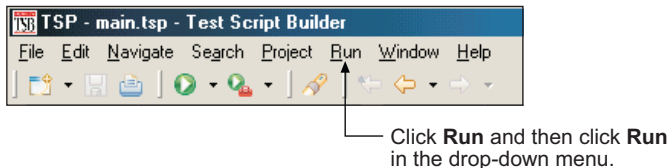


Step 3: Storing the script in non-volatile memory of the Series 2600

Reference See "User scripts" in Section 2 of the Series 2600 Reference Manual for more information on storing user scripts in non-volatile memory.

After modifying a factory script, it can be loaded back into the Series 2600 and saved in non-volatile memory as a user script.

1. The **Run** configuration box is used to launch (load) a user script into the Series 2600 and save it in non-volatile memory. As shown below, open the **Run** box and then click **Run** in the drop-down menu:

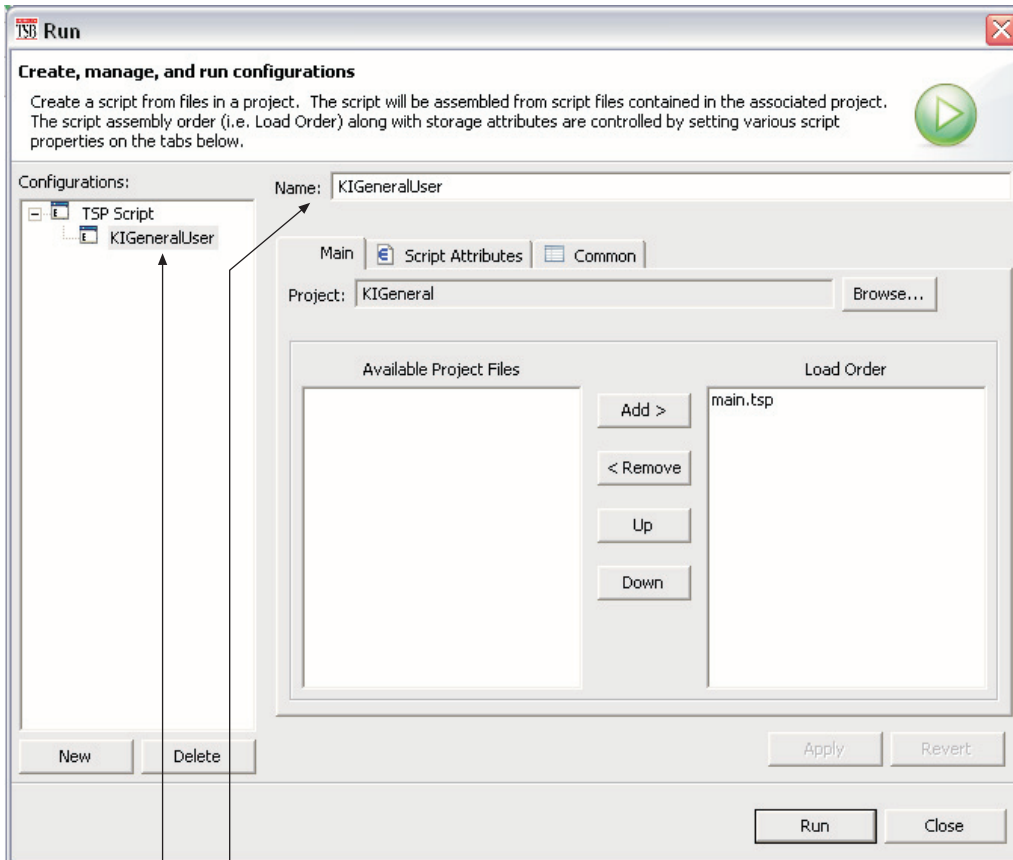


NOTE [Figure 3-4](#) and [Figure 3-5](#) show how the Run box will look after the launch is configured.

2. In the Configurations area of the Run box, select the KIGeneral script. The launch configuration tabs for that script will appear in the Run box.
3. Presently, the Name of the script is KIGeneral. You should change the name so the script is not confused with the factory script of the same name that resides in the Series 2600. Change the script Name to KIGeneralUser and click the Apply button.
4. As shown in [Figure 3-4](#), the main.tsp file must be in the Load Order area of the Run box. If it is in the Available Project Files area, double-click main.tsp to move the file over.
5. Click the Script Attributes tab to display the load and store options and select the LoadOnly run action and Non-volatile storage as shown in [Figure 3-5](#).
6. Click the Apply button to set the run configuration.
7. Click the Run key to load the user script into non-volatile memory of the Series 2600.

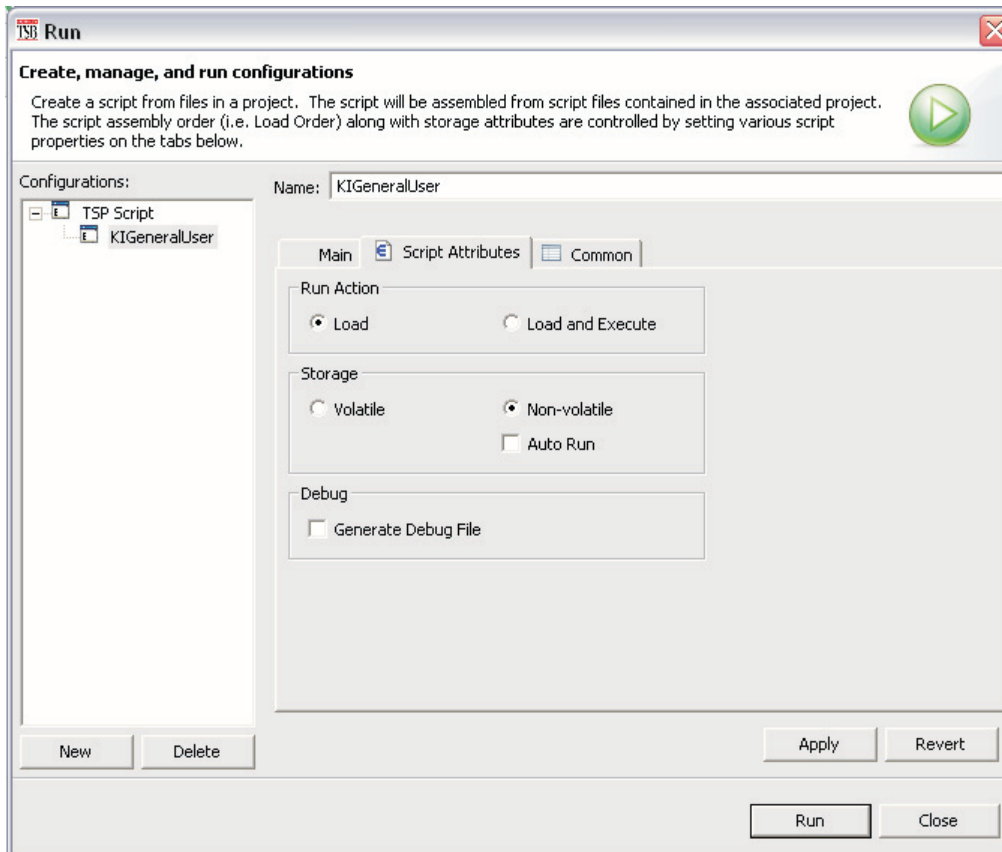
NOTE There is small bar graph at the bottom-right of the Test Script Builder that will appear while a script is loading. The bar graph will continuously sequence through its segments while the script is loading.

Figure 3-4
Run configuration example - Main tab shown



Changing the script **Name** from **KIGeneral** to **KIGeneralUser** also changes the name in the **Configurations** area.

Figure 3-5
Run configuration example - Script Attributes tab shown



Running the user script

Reference See “User scripts” in Section 2 of the Series 2600 Reference Manual for details on running a user script.

Remote programming

The functions for the KIGeneralUser user script can be called after the script is run as follows:

```
KIGeneralUser()
```

After the above command is executed, any of the functions that make up the user script can be called in the same manner that factory script functions are called (see “[Step 1: Call the function](#)” on [page 3-3](#)).

Front panel operation

To run the script from the front panel, a test name has to be added to the **USER TESTS** submenu of the **LOAD TEST** menu. Since the KIGeneralUser script is made up of eight functions, a front panel user test must run the script and also call a function. The following command will add the test name “PulseVMeasI” to the menu. It will also configure the test to run the KIGeneralUser script and call the PulseVMeasureI function:

```
display.loadmenu.add("PulseVMeasI", "KIGeneralUser() PulseVMeasureI()",  
display.SAVE)
```


Since no parameters are used in the function (`PulseVMeasureI()`), the test will be interactive and require the operator to input the test parameters using the front panel controls. See [“How do I run a script from the front panel?”](#) on [page 3-2](#) for details on running a user script from the front panel.

The command `display.loadmenu.add` can be used to configure front panel user tests for the other functions of the script. Make sure to use a different menu name for each function. For example, the following command will add the name “PulseIMeasV” for a test to call the `PulseIMeasureV` function.

```
display.loadmenu.add("PulseIMeasV", "KIGeneralUser() PulseIMeasureV()",
display.SAVE)
```

Reference See “Load test menu” in Section 14 of the Series 2600 Reference Manual for details on the `display.loadmenu.add` function.

Deleting a user script and user tests

Deleting a user script

A user script can be deleted from non-volatile memory of the Series 2600. The following command will delete the `KIGeneralUser` user script:

```
script.delete("KIGeneralUser")
```

Deleting a user test

After deleting a script, you should also delete the test from the USER TESTS menu since it no longer exists. The following command deletes the “PulseVMeasI” test from the menu:

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

Reference See “User scripts” in Section 2 of the Series 2600 Reference Manual for more information on deleting a user script. See “Load test menu” in Section 14 of the Series 2600 Reference Manual for details on deleting user tests from the front panel USER TESTS menu.

How do I use other programs?

Reference See the LabVIEW and Visual Basic documentation for details on using those programs.

Using LabVIEW

Source step example

The source step example is shown in [Figure 3-6](#). The example steps the source voltage from 1V to 10V in 1V steps, measures the current at each step, and stores the result in a table. Once all steps are completed, the stored table current values are printed.

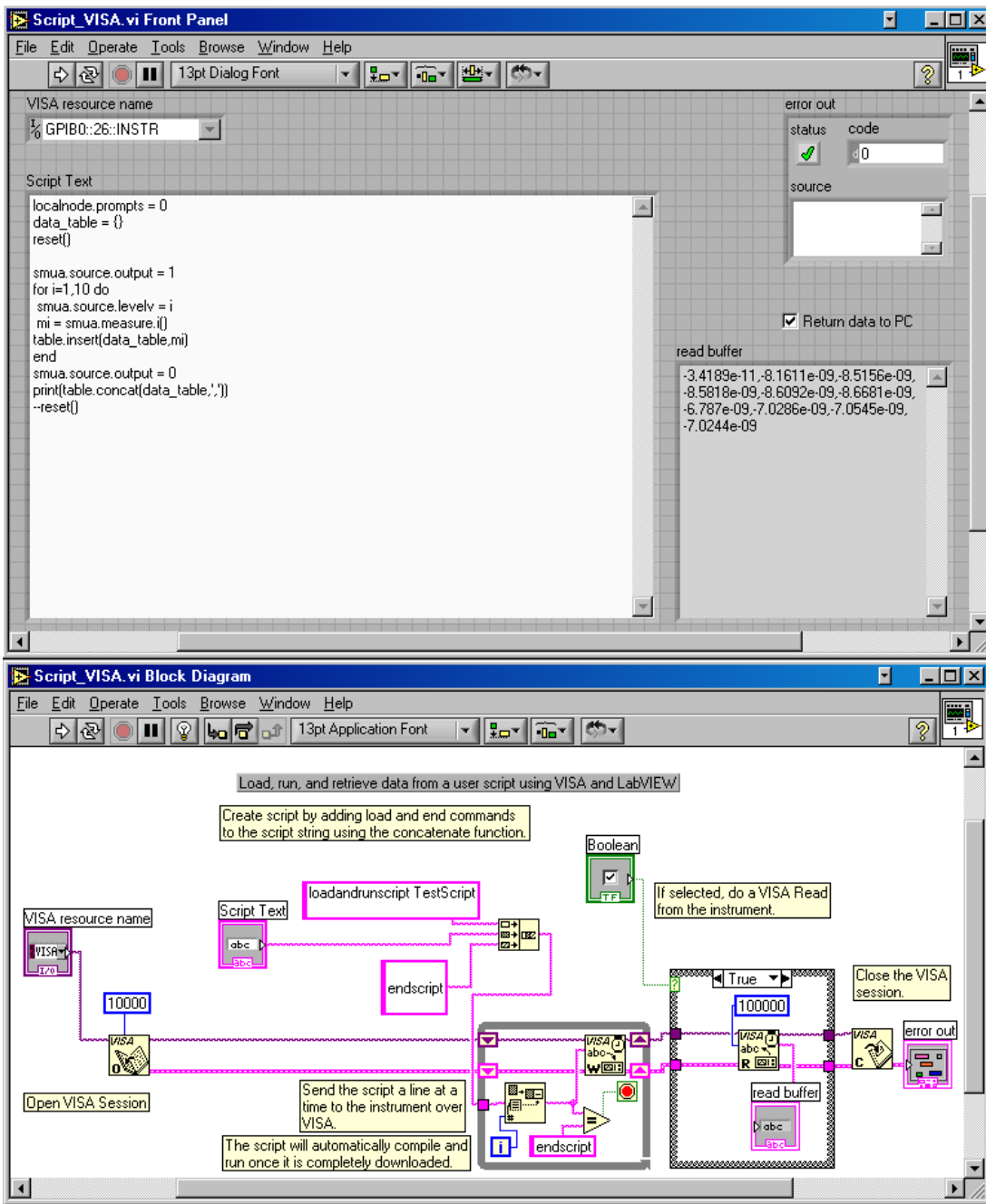
The Series 2600 command sequence:

```

localnode.prompts = 0
data_table = {}
reset()
smua.source.output = 1
for i=1,10 do
  smua.source.levelv = i
  mi = smua.measure.i()
  table.insert(data_table,mi)
end
smua.source.output = 0
print(table.concat(data_table,','))
reset()
    
```

- Disable prompts.
- Clear table.
- Reset Series 2600.
- Turn on source output.
- Loop for 10 steps.
- Set source level.
- Take a current measurement.
- Store measurement in table.
- End of loop.
- Turn off output.
- Print table of current values.
- Reset instrument.

Figure 3-6
LabVIEW source step example



Using Visual Basic

NOTE The form file (UserManualExample.frm) can be opened using any text editor to view the code executed by the various command buttons.

The following examples look at how you can download and run Model 2600 Series scripts using Visual Basic. Two scripts were created for these examples. Both scripts are based on the pseudocode and instrument commands presented in [Section 2](#) on using the Series 2600 as a traditional GPIB instrument while they perform multiple measurements. Source code for this example program can be downloaded from the Keithley Instruments internet site, www.keithley.com.

Example script 1 – script that does not use functions

The following script is in the file named “MeasCurrScript.tsp.” Note that the actual script contains additional comments, which have not been included here. Comments are identified by double dashes (--).

```
reset()
display.screen = display.SMUA
display.smua.measure.func = display.MEASURE_DCAMPS
smua.source.func = smua.OUTPUT_DCVOLTS
smua.source.autorangev = smua.AUTORANGE_ON
smua.source.levelv = 5
smua.source.limiti = 0.1
smua.measure.rangei = 0.1
smua.measure.nplc = 1
smua.source.output = smua.OUTPUT_ON
ntimes = 10
for i = 1, ntimes do           -- Perform following command(s) ntimes.
    print(smua.measure.i())   -- Measure current and put reading in output queue.
end --for
smua.source.output = smua.OUTPUT_OFF
```

The primary code that reads the file and downloads the script to the Series 2600 is listed below. This code is executed when you select the **Load “Non-Function” Script** option, and then click the **Load Script (GPIB)** command button. Although not required, TSP prompts are enabled for this example because they provide useful test script processor status information when loading and running scripts. See the Series 2600 System Series 2600 Instruments Series 2600 Reference Manual for more information about using prompts. As the script is being downloaded, it is displayed in the **Script** text box of the GUI (Graphical User Interface), as shown in [Figure 3-7](#).

```

Call send(Addr%, "localnode.showerrors = 0", intStatus)
Call send(Addr%, "localnode.prompts = 1", intStatus)
strReturnMessage = udfGetTspResponse()
Open App.Path & "\" & "MeasCurrScript.tsp" For Input As #1
Call send(Addr%, "loadscript MeasCurrScript", intStatus)
strReturnMessage = udfGetTspResponse()

Do While Not EOF(1)

Line Input #1, strScriptline
Call send(Addr%, strScriptline, intStatus)

strReturnMessage = udfGetTspResponse()
strReturnMessage = Left(strReturnMessage, 4)
Select Case strReturnMessage
    Case ">>>>"

        Case "TSP>"

Exit Do
Case "TSP?"

Case Else

End Select
Loop
Close #1
Call send(Addr%, "endscript", intStatus)
strReturnMessage = udfGetTspResponse()
Call send(Addr%, "localnode.prompts = 0", intStatus)

```

--Disable automatic display of errors - leave error messages in queue and enable Error Prompt. The "localnode" is unit being communicated with via GPIB or RS-232.

--Turn on prompts; need to start handling the prompts as soon as this command is sent.

--Open the script file for sequential input.

--"loadscript" identifies the beginning of the script. "MeasCurrScript" is the name assigned to the script.

--Read the file.

--Loop until the end of the script file.

--Read a line from the script file.

--Send script line to Series 2600.

--Continuation prompt. TSP received script line successfully; waiting for next line.

--Ready prompt. TSP received script successfully; ready for next command.

--Error prompt. Error occurred; handle as desired. Use "errorqueue" commands to read and clear errors.

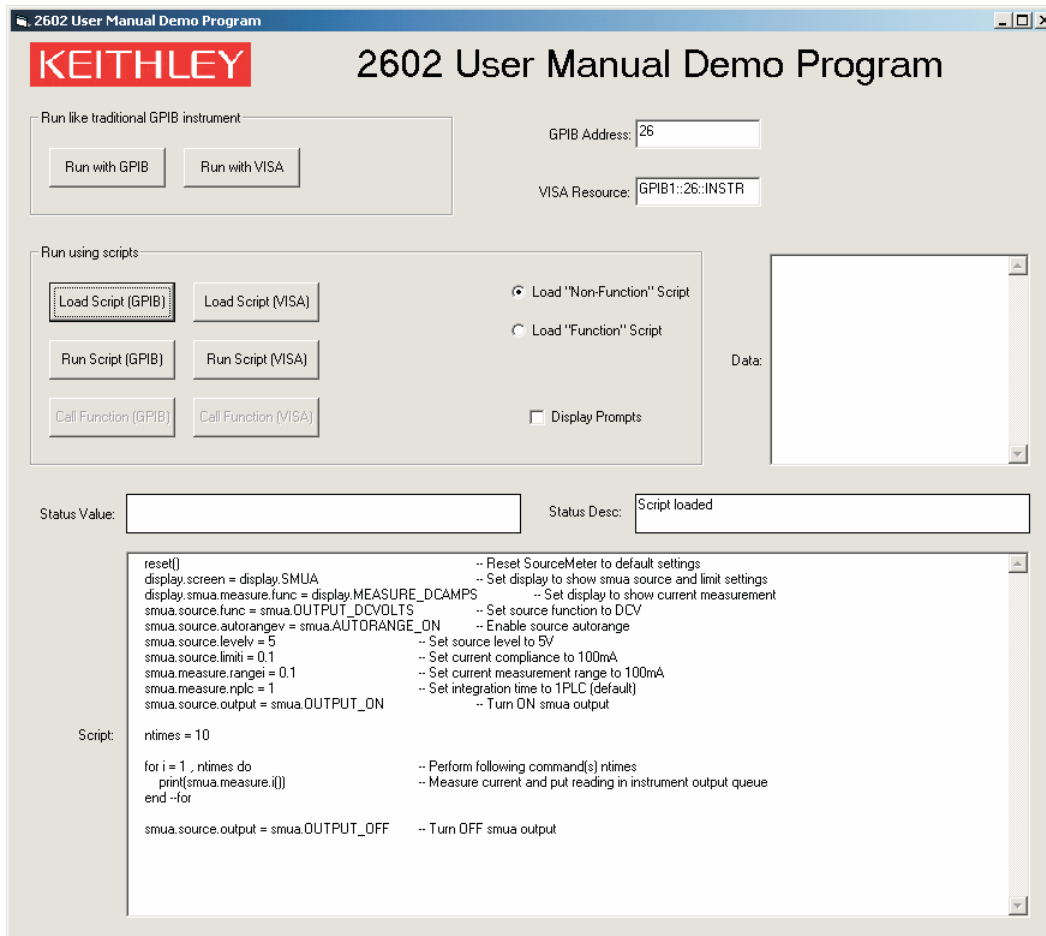
--No prompt received. Response other than shell prompt was received; handle as desired.

--Close the script file.

--Tell TSP complete script has been downloaded.

--Disable prompts.

Figure 3-7
GUI after loading the non-function script (GPIB)



The primary code that runs the script and retrieves the measurement results is listed below. This code is executed when you click the **Run Script (GPIB)** command button. When you run this script it will perform ten measurements and send the readings to the PC. The results are displayed in the **Data** text box of the GUI as shown in [Figure 3-8](#). TSP prompts are enabled prior to running the script.

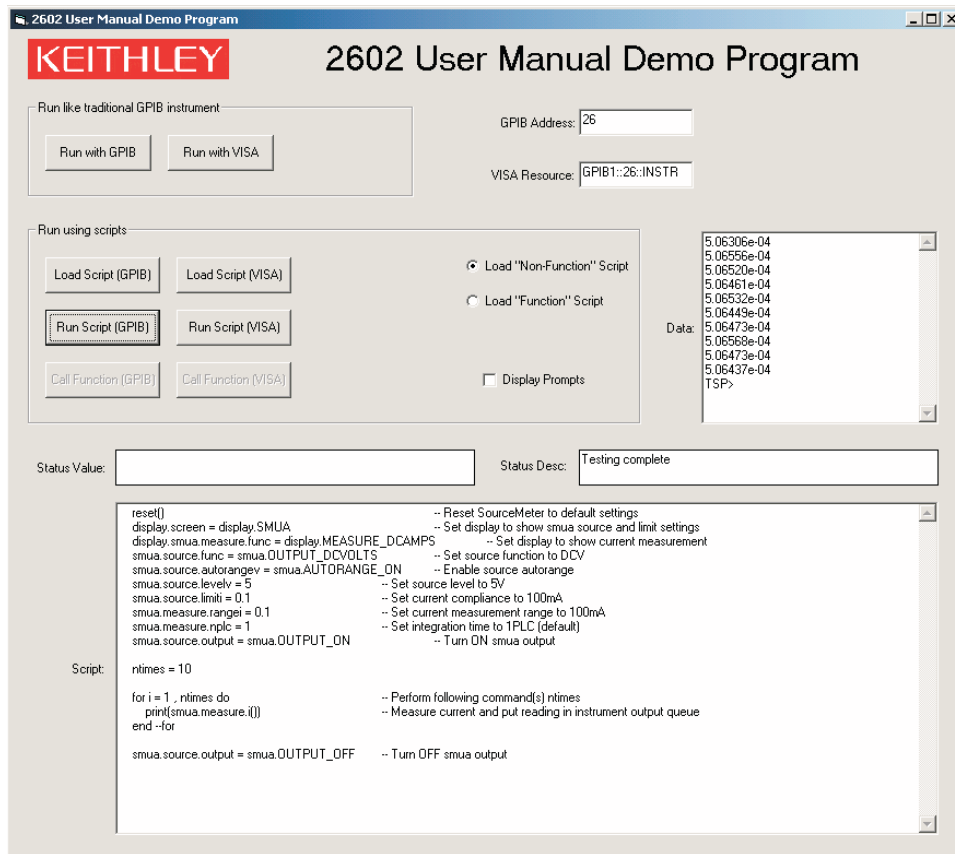
```
Call send(Addr%, "MeasCurrScript.run()", intStatus) --The following command runs the
                                                    script; you can also use
                                                    MeasCurrScript() form of the
                                                    command.
```

```
Do
strReturnMessage = udfGetTspResponse()
txtData.Text = txtData.Text & strReturnMessage
Loop Until Left(strReturnMessage, 3) = "TSP"
If strReturnMessage = "TSP?" Then
txtStatusDesc.Text = "Error Occurred"
Call send(Addr%, "print(errorqueue.next()",
intStatus)
strReturnMessage = udfGetTspResponse()
txtStatusDesc.Text = txtStatusDesc.Text & strRe-
turnMessage & vbCrLf
```

```
End If
```

```
--Get output from script.
```

Figure 3-8
GUI after running the non-function script (GPIB)



Example script 2 – script that uses functions

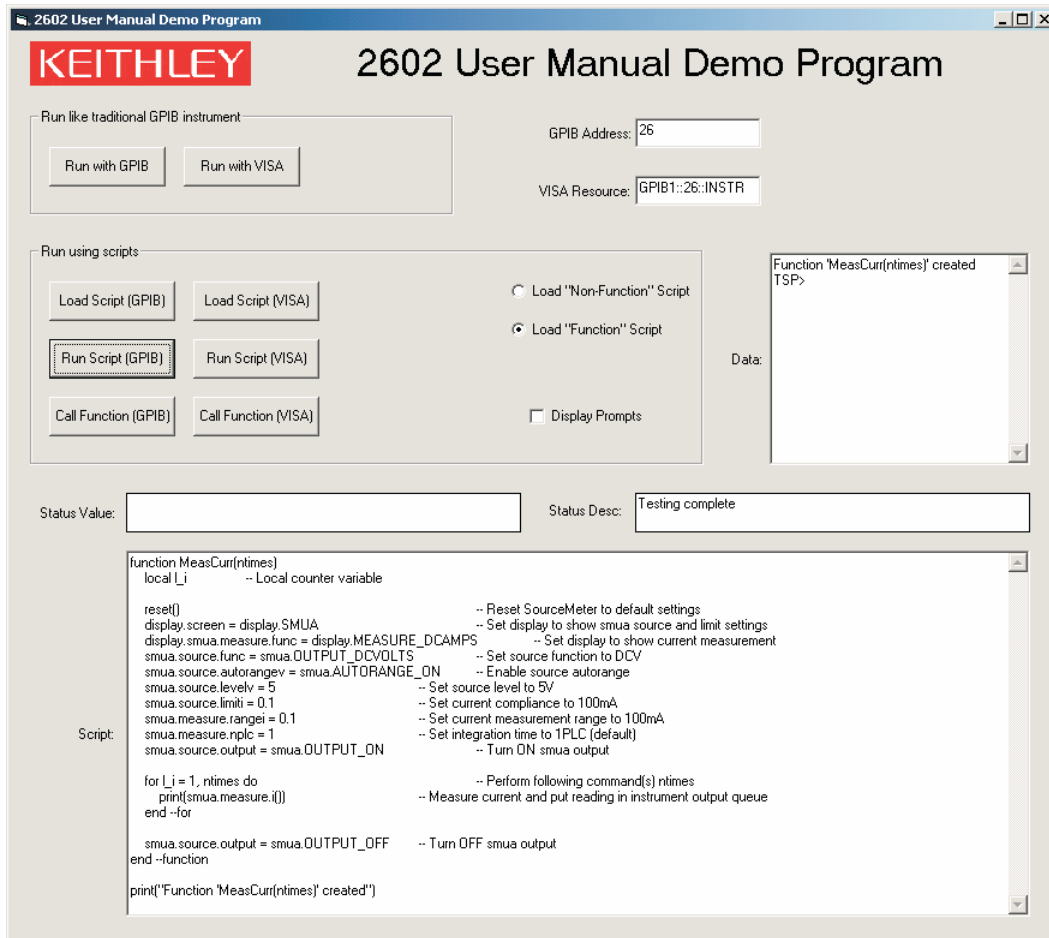
The script used in this example is in the file named “MeasCurrFunctionScript.tsp.” This script is downloaded to the Series 2600 by selecting the **Load “Function” Script** option, and then clicking the **Load Script (GPIB)** command button. The script is downloaded exactly as shown in the previous example, except the “open file” and “loadscript” commands reflect the different script name as shown below.

```
Open App.Path & "\" & "MeasCurrFunctionScript.tsp" For Input As #1
Call send(Addr%, "loadscript MeasCurrFunctionScript", intStatus)
```

The other difference is in the script itself, which is listed below. This script does not perform multiple current measurements, but rather it creates a function named “MeasCurr,” which performs one or more current measurements when it is called. The number of measurements depends on the value of “ntimes,” which is passed to the function when it is called. [Figure 3-9](#) shows the GUI (Graphical User Interface) after loading and running the script. Note that the **Data** text box does not contain any readings as in the previous example; it simply indicates that the “MeasCurr(ntimes)” function has been created.

```
function MeasCurr(ntimes)
    local l_i -- Local counter variable
    reset()
    display.screen = display.SMUA
    display.smua.measure.func = display.MEASURE_DCAMPS
    smua.source.func = smua.OUTPUT_DCVOLTS
    smua.source.autorangev = smua.AUTORANGE_ON
    smua.source.levelv = 5
    smua.source.limiti = 0.1
    smua.measure.rangei = 0.1
    smua.measure.nplc = 1
    smua.source.output = smua.OUTPUT_ON
    for l_i = 1, ntimes do
        print(smua.measure.i())
    end --for
    smua.source.output = smua.OUTPUT_OFF
end --function
print("Function 'MeasCurr(ntimes)' created")
```

Figure 3-9
GUI after loading and running the function script (GPIB)



The primary code that calls the function and retrieves the measurement results is listed below. TSP prompts are enabled prior to calling the function. This code is executed when you click the Call Function (GPIB) command button. In this example, the function performs ten current measurements and sends the readings to the PC because “ntimes” is set to 10 when the function is called. The results are displayed in the Data text box as shown in [Figure 3-10](#). Note that it would be just as easy to take one or 100 readings simply by calling the function with a different value for “ntimes,” e.g. MeasCurr(100). You can pass parameters to a function, but not to a script. However, you must initially run a script to create a function. See the Series 2600 Series 2600 Reference Manual for more information about scripts and functions.


```

Call send(Addr%, "MeasCurr(10)", intStatus)

Do
  strReturnMessage = udfGetTspResponse()
  txtData.Text = txtData.Text & strReturnMessage &
  vbCrLf
Loop Until Left(strReturnMessage, 3) = "TSP"
If strReturnMessage = "TSP?" Then
  txtStatusDesc.Text = "Error Occurred"
  Call send(Addr%, "print(errorqueue.next())", intStatus)
  strReturnMessage = udfGetTspResponse()
  txtStatusDesc.Text = txtStatusDesc.Text &
  strReturnMessage & vbCrLf

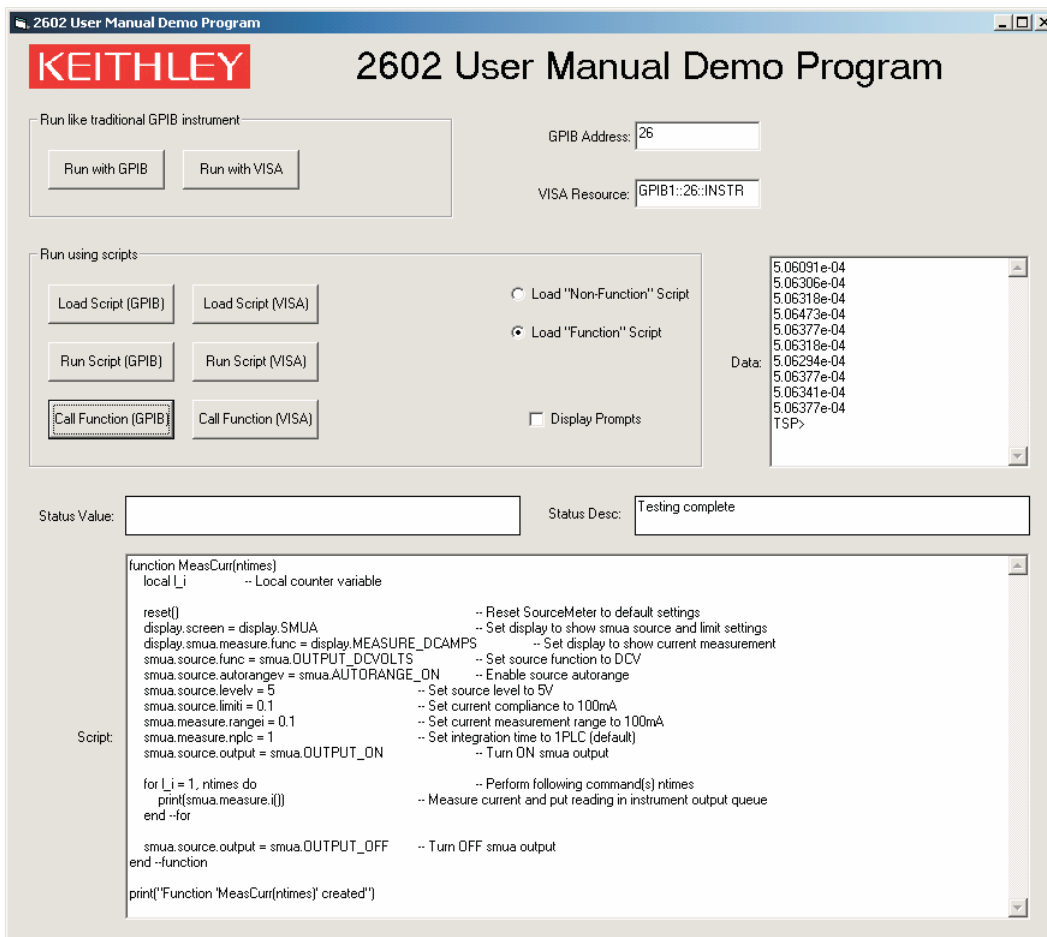
End If

```

--Call function with ntimes=10 and then enter data.
--Get output from function.

--Take appropriate action based on error message.

Figure 3-10
GUI after calling the function (GPIB)



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Controlling Multiple Series 2600s (TSP-Link)

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How do I set up the TSP-Link system?

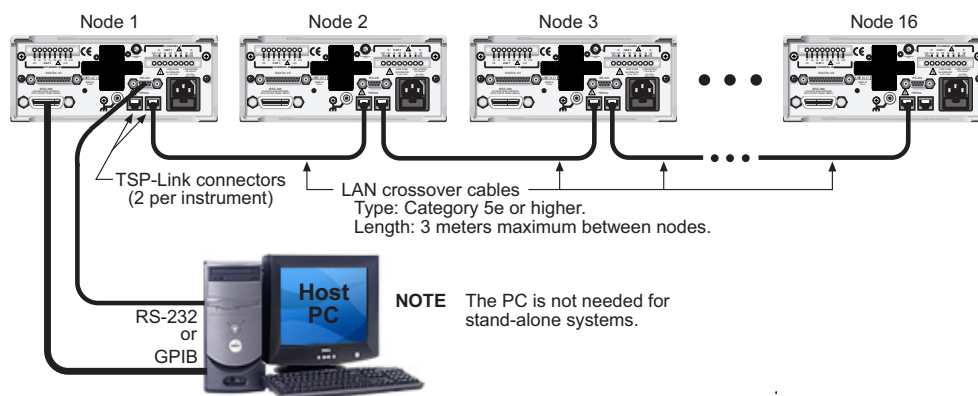
Up to 16 TSP-Link enabled instruments (e.g., Series 2600 System Series 2600s™ instruments) can be connected together to form a TSP-Link system.

Step 1: Connect the TSP-Link system

Reference See “Connections” in Section 9 of the Series 2600 Reference Manual for more information on TSP-Link connections.

A connection example for an expanded system is shown in [Figure 4-1](#). All the TSP-Link-enabled instruments in the system are daisy-chained together using LAN crossover cables. In this example, the unit connected to the PC is the Master and the other units are its Slaves. Note that the Master does not have to be assigned as Node 1, nor does it have to be at the end of the node chain.

Figure 4-1
TSP-Link connections



Step 2: Assign node numbers

Reference See “Initialization” in Section 9 of the Series 2600 Reference Manual for more information on assigning node numbers.

Each instrument in the TSP-Link system must have a unique node number assigned to it. The node number for each instrument is stored in its non-volatile memory and will not be lost when the instrument is turned off.

Complete the following steps to assign a node number.

1. From the front panel, press the **MENU > TSPLINK**.
2. Select **NODE** and then use the navigation wheel to assign the node number.
Note: The node number can range from 1 - 64.

For remote programming, the `tsplink.node` attribute is used to set the node number for an instrument:

```
tsplink.node = N
```

where: N = 1 to 16 The node number of an instrument can be determined by reading the `tsplink.node` attribute as follows:

```
nodenumber = tsplink.node
```

```
print (nodenumber)
```

The above `print` command will return the node number. For example, if the node number is 1, the value `1.000000e00` will be returned.

Step 3: Reset the TSP-Link

Reference See “Initialization” in Section 9 of the Series 2600 Reference Manual for more information on resetting the TSP-Link.

After all the node numbers are set, you must reset (initialize) the TSP-Link interface system. For initialization to succeed, all units must be powered on when the TSP-Link reset is performed.

Complete the following steps to reset the TSP-Link.

1. From the front panel, press **MENU > TSPLINK**.
2. Choose Reset.

For remote programming, the following command initializes the TSP-Link:

```
tsplink.reset()
```

Step 4: Check the state of the TSP-Link system

Reference See “Initialization” in Section 9 of the Series 2600 Reference Manual for more information on checking the state of the TSP-Link.

The `tsplink.state` read-only attribute is used to determine whether or not the TSP-Link reset routine was completed successfully. The returned value `online` indicates that the reset was successful for all instruments (nodes) in the system. The value `offline` indicates that the reset has failed.

A few typical reasons for a reset failure include the following:

- Two or more instruments in the system have the same node number.
- There are no other instruments connected to the unit performing the reset.
- One of the units in a properly connected system isn't powered on.

Programming example – After assigning node numbers to the instruments in the system, the following command checks the state of the TSP-Link:

```
print (tsplink.state)
```

If the reset is successful, `online` will be the output to indicate that communication to all nodes is established.

How do I use the expanded system?

Reference See “Using the expanded system” in Section 9 of the Series 2600 Reference Manual for more information on using the system.

Accessing resources of TSP-Link nodes

After a successful TSP-Link reset, the `node` and `localnode` variables can be used to access resources of any node in the system.

Using node[N]

The `node[N]` variable (where `N = 1 to 16`) is used to send a command to any node in the system. The node can be the Master or a Slave. Examples:

```
node [4] .smua.reset ()      -- Resets SMU A of Node 4.  
node [1] .smua.reset ()      -- Resets SMU A of Node 1.
```

Using the alias (`localnode`)

The variable `localnode` is an alias for `node [N]`, where `N` is the node number of the Master.

For example, assume that Node 1 is the Master in a TSP-Link system. To send a command to Node 1, you can use `node [1]` or `localnode` as follows:

```
node [1] .smua.reset ()      -- Resets SMU A of the Master (Node 1).  
localnode.smua.reset ()      -- Resets SMU A of the Master (Node 1).
```

Running scripts in a TSP-Link system

For remote programming, only a script stored in the Master can be run. Scripts in the Slaves cannot be accessed. See [“How do I interact with scripts using Test Script Builder?”](#) on [page 3-3](#).

For front panel operation, a script in any node can be run from its front panel. For details, see [“How do I run a script from the front panel?”](#) on [page 3-2](#).

In this appendix:

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1. SPECIFICATION CONDITIONS

This document contains specifications and supplemental information for the Keithley Instruments Models 2601 and 2602 System SourceMeters[®]. Specifications are the standards against which the Models 2601 and 2602 are tested. Upon leaving the factory, the Models 2601 and 2602 meet these specifications. Supplemental and typical values are nonwarranted, apply at 23°C, and are provided solely as useful information.

The source and measurement accuracies are specified at the SourceMeter CHANNEL A (2601 and 2602) or SourceMeter CHANNEL B (2602) terminals under the following conditions:

1. 23°C ± 5°C, <70% relative humidity.
2. After two-hour warm-up.
3. Speed normal (1 NPLC).
4. A/D auto-zero enabled.
5. Remote sense operation or properly zeroed local operation.
6. Calibration period: one year.

2. SOURCE SPECIFICATIONS**Voltage Programming Accuracy¹**

Range	Programming resolution	Accuracy (1 year) 23°C ± 5°C ± (% rdg.+ volts)	Typical noise (peak-peak) 0.1Hz-10Hz
100.000mV	5µV	0.02% + 250µV	20µV
1.00000V	50µV	0.02% + 400µV	50µV
6.00000V	50µV	0.02% + 1.8mV	100µV
40.0000V	500µV	0.02% + 12mV	500µV

Temperature coefficient (0°C–18°C and 28°C–50°C): ±(0.15 × accuracy specification)/°C.

Maximum output power and source/sink limits:² 40.4W per channel maximum. ±40.4V at ±1.0A, ±6.06V at ±3.0A, four-quadrant source or sink operation.

Voltage regulation: Line: 0.01% of range. **Load:** ±(0.01% of range + 100µV).

Noise 10Hz–20MHz (peak-peak): 25mV typical into a resistive load.

Current limit/compliance:³ Bipolar current limit (compliance) set with single value. Minimum value is 10nA. Accuracy same as current source.

Overshoot: <±(0.1% + 10mV) typical (step size = 10% to 90% of range, resistive load, maximum current limit/compliance).

Guard offset voltage: <10mV typical (I_{out} ≤ 100mA).

1 Add 50µV to source accuracy specifications per volt of HI lead drop.

2 Full power source operation regardless of load to 30°C ambient. Above 30°C and/or power sink operation, refer to Section 8, "Operating boundaries" in the Series 2600 Reference Manual for additional power derating information.

3 For sink mode operation (quadrants II and IV), add 12% of limit range and ±0.02% of limit setting to corresponding current limit accuracy specifications. For 1A range, add an additional 40mA of uncertainty.

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System SourceMeter® Specifications

Current Programming Accuracy

Range	Programming resolution	Accuracy (1 year) 23°C ± 5°C ± (% rdg.+amps)	Typical noise (peak-peak) 0.1Hz-10Hz
100.000nA	1pA	0.06% + 100pA	5pA
1.00000µA	10pA	0.03% + 800pA	25pA
10.0000µA	100pA	0.03% + 5nA	60pA
100.000µA	1nA	0.03% + 60nA	3nA
1.00000mA	10nA	0.03% + 300nA	6nA
10.0000mA	100nA	0.03% + 6µA	200nA
100.000mA	1µA	0.03% + 30µA	600nA
1.00000A	10µA	0.05% + 1.8mA	70µA
3.00000A	10µA	0.06% + 4.0mA	150µA

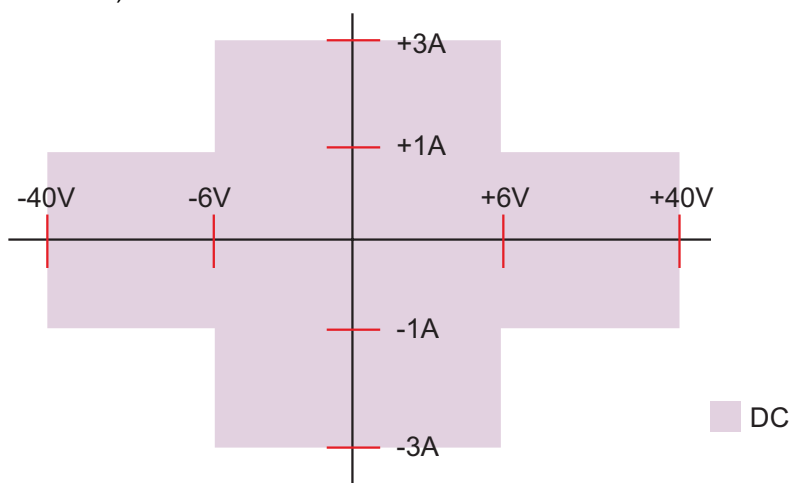
Temperature coefficient (0°C–18°C and 28°C–50°C): ±(0.15 × accuracy specification)/°C.

Maximum output power and source/sink limits:² 40.4W per channel maximum. ±1.01A at ±40.0V, ±3.03A at ±6.0V, four quadrant source or sink operation.

Current regulation: Line: 0.01% of range. **Load:** ±(0.01% of range + 100pA).

Voltage limit/compliance:⁴ Bipolar voltage limit (compliance) set with a single value. Minimum value is 10mV. Accuracy same as voltage source.

Overshoot: <0.1% typical (step size = 10% to 90% of range, resistive load; see “Current source output settling time” for additional test conditions).



Models 2601 and 2602 I-V capability

⁴ For sink mode operation (quadrants II and IV), add 10% of compliance range and ±0.02% of limit setting to corresponding voltage source specification. For 100mV range, add an additional 60mV of uncertainty.

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Additional Source Specifications

Transient response time: <70 μ s for the output to recover to 0.1% for a 10% to 90% step change in load.

Voltage source output settling time: Time required to reach 0.1% of final value, when changing from 10% to 90% of range, after source level command is processed on a fixed range.

100mV, 1V ranges: <50 μ s typical.

6V Range: <100 μ s typical.

40V Range: <150 μ s typical.⁵

Current source output settling time: Time required to reach 0.1% of final value, when changing from 10% to 90% of range, after source level command is processed on a fixed range. Values below for I_{out} · R_{load} = 1V unless noted.

3A–10mA ranges: <80 μ s typical (current less than 2.5A, R_{load} >1.5 Ω).

1mA range: <100 μ s typical.

100 μ A range: <150 μ s typical.

10 μ A range: <500 μ s typical.

1 μ A range: <2.5ms typical.

100nA range: <25ms typical.

DC floating voltage: Output can be floated up to \pm 250VDC from chassis ground.

Remote sense operating range:¹

Maximum voltage between HI and SENSE HI = 3V.

Maximum voltage between LO and SENSE LO = 3V.

Voltage output headroom:

40V range: Max. output voltage = 42V – total voltage drop across source leads (maximum 1 Ω per source lead).

6V range: Max. output voltage = 8V – total voltage drop across source leads.

Over temperature protection: Internally sensed temperature overload puts unit in standby mode.

Voltage source range change overshoot: Overshoot into a 100k Ω load, 20MHz BW, 300mV typical.

Current source range change overshoot: <5% of larger range + 300mV/R_{load} typical.

(see "CURRENT SOURCE OUTPUT SETTLING TIME" for additional test conditions).

⁵ Add 150 μ s when measuring on the 1A range.

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3. METER SPECIFICATIONS**Voltage Measurement Accuracy⁶**

Range	Display resolution ⁷	Input resistance	Accuracy (1 year) 23°C ± 5°C ± (% rdg.+ volts)
100.000mV	1µV	>10GΩ	0.015% + 150µV
1.00000V	10µV	>10GΩ	0.015% + 200µV
6.00000V	10µV	>10GΩ	0.015% + 1mV
40.0000V	100µV	>10GΩ	0.015% + 8mV

Temperature coefficient (0°C–18°C and 28°C–50°C): ±(0.15 × accuracy specification)/°C.

Current Measurement Accuracy

Range	Display resolution ⁷	Voltage burden ⁸	Accuracy (1 year) 23°C ± 5°C ± (% rdg.+amps)
100.000nA	1pA	<1mV	0.05% + 100pA
1.00000µA	10pA	<1mV	0.025% + 300pA
10.0000µA	100pA	<1mV	0.025% + 1.5nA
100.000µA	1nA	<1mV	0.02% + 25nA
1.00000mA	10nA	<1mV	0.02% + 200nA
10.0000mA	100nA	<1mV	0.02% + 2.5µA
100.000mA	1µA	<1mV	0.02% + 20µA
1.00000A	10µA	<1mV	0.03% + 1.5mA
3.00000A	10µA	<1mV	0.05% + 3.5mA

Temperature coefficient (0°C–18°C and 28°C–50°C): ±(0.15 × accuracy specification)/°C.

6 Add 50µV to source accuracy specifications per volt of HI lead drop.

7 Applies when in single channel display mode.

8 Four-wire remote sense only.

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System SourceMeter[®] Specifications**Contact Check⁹**

Speed	Maximum measurement time to memory for 60Hz (50Hz)⁹	Accuracy (1 year) 23°C ± 5°C ± (% rdg.+ ohms)
Fast	1 (1.2)ms	5% + 10
Medium	4 (5)ms	5% + 1
Slow	36 (42)ms	5% + 0.3

Additional Meter Specifications

Load impedance: Stable into 10,000pF typical.

Common mode voltage: 250VDC.

Common mode isolation: >1GΩ, <4500pF.

Over-range: 101% of source range, 102% of measure range.

Maximum sense lead resistance: 1kΩ for rated accuracy.

Sense input impedance: >10GΩ.

⁹ Includes measurement of SENSE HI to HI and SENSE LO to LO contact resistances.

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System SourceMeter® Specifications

4. GENERAL

Host Interfaces: Computer control interfaces.

IEEE-488: IEEE-488.1 compliant. Supports IEEE-488.2 common commands and status model topology.

RS-232: Baud rates from 300 bps to 115200 bps. Programmable number of data bits, parity type, and flow control (RTS/CTS hardware or none). When not programmed as the active host interface, the SourceMeter can use the RS-232 interface to control other instrumentation.

Expansion interface: The TSP-Link expansion interface allows TSP-enabled instruments to trigger and communicate with each other.

Cable type: Category 5e or higher LAN crossover cable.

Length: 3 meters maximum between each TSP-enabled instrument.

Digital I/O interface:

Connector: 25-pin female D.

Input/Output pins: 14 open drain I/O bits.

Absolute maximum input voltage: 5.25V.

Absolute minimum input voltage: -0.25V.

Maximum logic low input voltage: 0.7V, +850 μ A max.

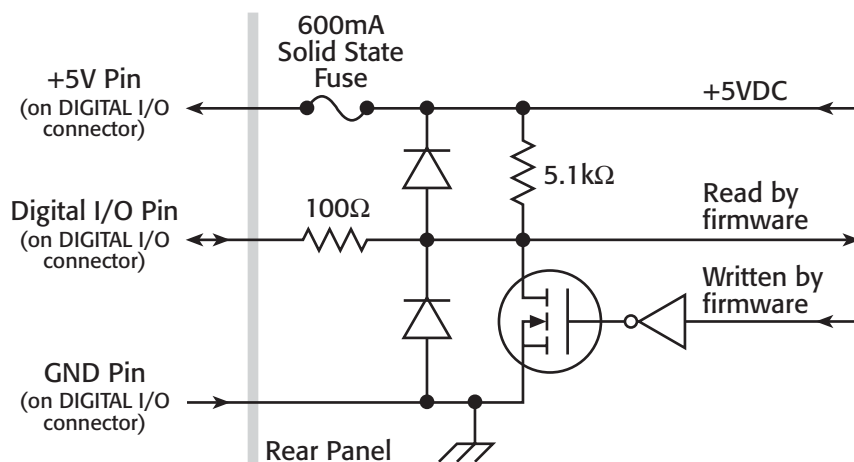
Minimum logic high input voltage: 2.1V, +570 μ A.

Maximum source current (flowing out of digital I/O bit): +960 μ A.

Maximum sink current at maximum logic low voltage (0.7V): -5.0mA.

Absolute maximum sink current (flowing into digital I/O pin): -11mA.

5V power supply pin: Limited to 600mA, solid state fuse protected.



Output enable pin: Active high input pulled down internally to ground with 10k Ω resistor. When the Output Enable input function has been activated, each SourceMeter channel will not turn on unless the output enable pin is driven to >2.1V (nominal current = 2.1V / 10k Ω = 210 μ A).

Power Supply: 100V to 250VAC, 50Hz-60Hz (auto sensing), 250VA max.

Cooling: Forced air. Side intake and rear exhaust. One side must be unobstructed when rack-mounted.

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System SourceMeter[®] Specifications

Warranty: 1 year.

EMC: Conforms to European Union Directive 89/336/EEC, EN 61326-1.

Safety: Conforms to European Union Directive 73/23/EEC, EN 61010-1, and UL 61010-1.

Dimensions: 89mm high × 213mm wide × 460mm deep (3 1/2 in × 8 3/8 in × 17 1/2 in). Bench configuration (with handle & feet): 104mm high × 238mm wide × 460mm deep (4 1/8 in × 9 3/8 in × 17 1/2 in).

Weight: 2601: 4.75kg (10.4 lbs). **2602:** 5.50kg (12.0 lbs).

Environment: For indoor use only.

Altitude: Maximum 2000 meters above sea level.

Operating: 0°C–50°C, 70% R.H. up to 35°C. Derate 3% R.H./°C, 35°C–50°C.

Storage: –25°C to 65°C.

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1. SPECIFICATION CONDITIONS

This document contains specifications and supplemental information for the Keithley Instruments Models 2611 and 2612 System SourceMeters®. Specifications are the standards against which the Models 2611 and 2612 are tested. Upon leaving the factory, the Models 2611 and 2612 meet these specifications. Supplemental and typical values are non-warranted, apply at 23°C, and are provided solely as useful information.

The source and measurement accuracies are specified at the SourceMeter CHANNEL A (Models 2611 and 2612) or SourceMeter CHANNEL B (Model 2612) terminals under the following conditions:

1. 23°C ± 5°C, <70% relative humidity.
2. After two-hour warm-up.
3. Speed normal (1 NPLC).
4. A/D auto-zero enabled.
5. Remote sense operation or properly zeroed local sense operation.
6. Calibration period: one year.

2. SOURCE SPECIFICATIONS**Voltage Programming Accuracy¹**

Range	Programming resolution	Accuracy (1 year) 23°C ± 5°C ± (% rdg.+ volts)	Typical noise (peak-peak) 0.1Hz-10Hz
200.000mV	5µV	0.02% + 375µV	20µV
2.00000V	50µV	0.02% + 600µV	50µV
20.0000V	500µV	0.02% + 5mV	300µV
200.000V	5mV	0.02% + 50mV	2mV

Temperature coefficient (0°C–18°C and 28°C–50°C): ±(0.15 × accuracy specification)/°C.

Maximum output power and source/sink limits:² 30.603W per channel maximum. ±20.2V at ±1.515A, ±202V at ±101mA, four quadrant source or sink operation.

Voltage regulation: Line: 0.01% of range. **Load:** ±(0.01% of range + 100µV).

Noise 10Hz–20MHz: <5mV RMS typical, 20V range, 1A limit.

Current limit/compliance:³ Bipolar current limit (compliance) set with single value. Minimum value is 10nA. Accuracy same as current source.

Overshoot: <±(0.1% + 10mV) typical (step size = 10% to 90% of range, resistive load, maximum current limit/compliance).

Guard offset voltage: <4mV (current ≤10mA).

1 Add 50µV to source accuracy specifications per volt of HI lead drop.

2 Full power source operation regardless of load to 30°C ambient. Above 30°C and/or power sink operation, refer to Section 8, "Operating boundaries" in the Series 2600 Reference Manual for additional power derating information.

3 For sink mode operation (quadrants II and IV), add 12% of limit range and ±0.02% of limit setting to corresponding current limit accuracy specifications. For 1A range add an additional 40mA of uncertainty.

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System SourceMeter[®] Specifications
Current Programming Accuracy⁴

Range	Programming resolution	Accuracy (1 year) 23°C ± 5°C ± (% rdg.+amps)	Typical noise (peak-peak) 0.1Hz-10Hz
100.000nA	2pA	0.06% + 100pA	5pA
1.00000µA	20pA	0.03% + 800pA	25pA
10.0000µA	200pA	0.03% + 5nA	60pA
100.000µA	2nA	0.03% + 60nA	3nA
1.00000mA	20nA	0.03% + 300nA	6nA
10.0000mA	200nA	0.03% + 6µA	200nA
100.000mA	2µA	0.03% + 30µA	600nA
1.00000A ²	20µA	0.05% + 1.8mA	70µA
1.50000A ²	50µA	0.06% + 4mA	150µA
10.0000A ^{2,5}	200µA	0.5% + 40mA	

Temperature coefficient (0°C–18°C and 28°C–50°C): ±(0.15 × accuracy specification)/°C.

Maximum output power and source/sink limits:² 30.603W per channel maximum. ±1.515A at ±20.2V, ±101mA at ±202V, four-quadrant source or sink operation.

Current regulation: Line: 0.01% of range. **Load:** ±(0.01% of range + 100pA).

Voltage limit/compliance:⁶ Bipolar voltage limit (compliance) set with a single value. Minimum value is 10mV. Accuracy same as voltage source.

Overshoot: <0.1% typical (step size = 10% to 90% of range, resistive load; see “Current source output settling time” for additional test conditions).

Additional Source Specifications

Transient response time: <70µs for the output to recover to 0.1% for a 10% to 90% step change in load.

Voltage source output settling time: Time required to reach 0.1% of final value after source level command is processed on a fixed range.

200mV, 2V ranges: <50µs typical. **20V range:** <110µs typical. **200V range:** <700µs typical.

Current source output settling time: Time required to reach 0.1% of final value after source level command is processed on a fixed range. Values below for I_{out} · R_{load} = 2V unless noted.

1.5A–1A ranges: <120µs typical (R_{load} >6Ω).

100mA–10mA ranges: <80µs typical.

1mA range: <100µs typical.

100µA range: <150µs typical.

4 Accuracy specifications do not include connector leakage. Derate accuracy by V_{out}/2E11 per °C when operating between 18°C–28°C. Derate accuracy by V_{out}/2E11 + (0.15 * V_{out}/2E11) per °C when operating <18°C and >28°C.

5 10A range accessible only in pulse mode.

6 For sink mode operation (quadrants II and IV), add 10% of compliance range and ±0.02% of limit setting to corresponding voltage source specification. For 200mV range add an additional 120mV of uncertainty.

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10µA range: <500µs typical.
1µA range: <2ms typical.
100nA range: <20ms typical.

DC floating voltage: Output can be floated up to ±250VDC from chassis ground.

Remote sense operating range:¹ Maximum voltage between HI and SENSE HI = 3V. Maximum voltage between LO and SENSE LO = 3V.

Voltage output headroom:

200V range: Max. output voltage = 202.3V; total voltage drop across source leads (maximum 1Ω per source lead).
20V range: Max. output voltage = 23.3V; total voltage drop across source leads (maximum 1Ω per source lead).

Over temperature protection: Internally-sensed temperature overload puts unit in standby mode.

Voltage source range change overshoot: Overshoot into a 200k load, 20MHz BW, 300mV typical.

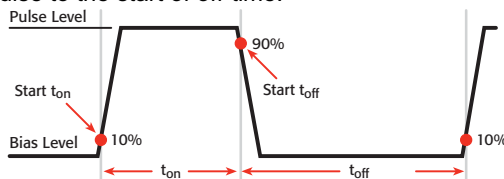
Current source range change overshoot: <5% of larger range + 300mV/Rload + 60nA typical (see “Current source output settling time” for additional test conditions).

Pulse Specifications

Region	Maximum current limit	Maximum pulse width ⁷	Maximum duty cycle ⁸
1	100mA at 200V	DC, no limit	100%
1	1.5A at 20V	DC, no limit	100%
2	1A at 180V	8.5ms	1%
3 ⁹	1A at 200V	2.2ms	1%
4	10A at 5V	1ms	2.2%

Minimum programmable pulse width:⁷ 200µs. NOTE: Minimum pulse width for settled source at a given I/V output and load can be longer than 200µs. See note 10 for typical settling times.¹⁰

7 Times measured from the start of pulse to the start of off-time:



8 Thermally limited in sink mode (quadrants 2 and 4) and ambient temperatures above 30°C. See power equations in the Reference Manual for more information.

9 Voltage source operation with 1.5A current limit.

10 Typical performance for minimum settled pulse widths:

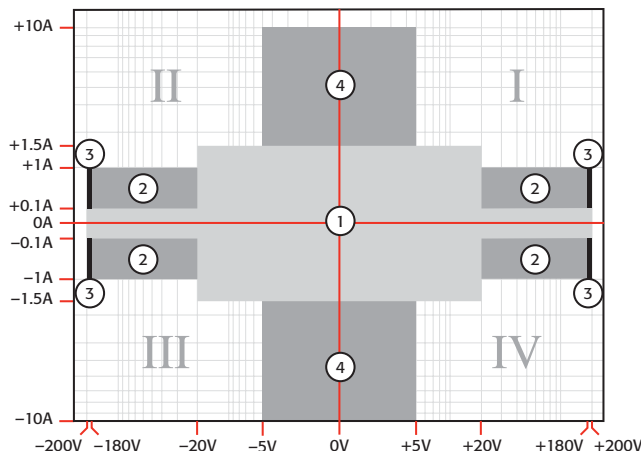
Source value	Load	Source settling (% of range)	Min. pulse width
5V	0.5Ω	1%	300µs
20V	200Ω	0.2%	200µs
180V	180Ω	0.2%	5ms
200V (1.5A limit)	200Ω	0.2%	1.5ms
100 mA	200Ω	1%	200µs
1A	20Ω	1%	500µs
1A	180Ω	0.2%	5ms
10A	0.5Ω	0.5%	300µs

Typical tests were performed using remote operation, 4W sense, Keithley 2600 ban cables and best fixed measurement range. For more information on pulse scripts, see the Series 2600 Reference Manual.

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System SourceMeter[®] Specifications

Pulse width programming resolution: 1 μ s.
Pulse width programming accuracy:⁷ $\pm 25\mu$ s.
Typical pulse width jitter: 50 μ s.



3. METER SPECIFICATIONS

Voltage Measurement Accuracy^{11, 12}

Range	Display resolution ¹³	Input resistance	Accuracy (1 year) 23°C \pm 5°C \pm (% rdg.+ volts)
200.000mV	1 μ V	>10G Ω	0.015% + 225 μ V
2.00000V	10 μ V	>10G Ω	0.02% + 350 μ V
20.0000V	100 μ V	>10G Ω	0.015% + 5mV
200.000V	1mV	>10G Ω	0.015% + 50mV

Temperature coefficient (0°C–18°C and 28°C–50°C): $\pm(0.15 \times \text{accuracy specification})/^\circ\text{C}$.

¹¹ Add 50 μ V to source accuracy specifications per volt of HI lead drop.

¹² De-rate accuracy specifications for NPLC setting <1 by increasing error term. Add appropriate % of range term using table below:

NPLC setting	200mV range	2V–200V ranges	100nA range	1 μ A–100mA ranges	1A–1.5A ranges
0.1	0.01%	0.01%	0.01%	0.01%	0.01%
0.01	0.08%	0.07%	0.1 %	0.05%	0.05%
0.001	0.8 %	0.6 %	1 %	0.5 %	1.1 %

¹³ Applies when in single channel display mode.

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System SourceMeter[®] Specifications
Current measurement accuracy^{14,12}

Range	Display resolution ¹³	Voltage burden ¹⁵	Accuracy (1 year) 23°C ± 5°C ± (% rdg.+amps)
100.000nA	1pA	<1mV	0.05% + 100pA
1.00000µA	10pA	<1mV	0.025% + 500pA
10.0000µA	100pA	<1mV	0.025% + 1.5nA
100.000µA	1nA	<1mV	0.02% + 25nA
1.00000mA	10nA	<1mV	0.02% + 200nA
10.0000mA	100nA	<1mV	0.02% + 2.5µA
100.000mA	1µA	<1mV	0.02% + 20µA
1.00000A	10µA	<1mV	0.03% + 1.5mA
1.50000A	10µA	<1mV	0.05% + 3.5mA
10.0000A ¹⁶	100µA	<1mV	0.4% + 25mA

Temperature Coefficient (0°C–18°C and 28°C–50°C): ±(0.15 × accuracy specification)/°C.

Contact Check¹⁷

Speed	Maximum measurement time to memory for 60Hz (50Hz) ¹⁷	Accuracy (1 year) 23°C ± 5°C ± (% rdg.+ohms)
Fast	1 (1.2)ms	5% + 10
Medium	4 (5)ms	5% + 1
Slow	36 (42)ms	5% + 0.3

Additional Meter Specifications

Load impedance: Stable into 10,000pF typical.

Common mode voltage: 250VDC.

Common mode isolation: >1GΩ, <4500pF.

Over-range: 101% of source range, 102% of measure range.

Maximum sense lead resistance: 1kΩ for rated accuracy.

Sense input impedance: >10GΩ.

14 De-rate accuracy by $V_{out}/2E11$ per °C when operating between 18°C–28°C. Derate accuracy by $V_{out}/2E11 + (0.15 * V_{out}/2E11)$ per °C when operating <18°C and >28°C.

15 Four-wire remote sense only.

16 10A range accessible only in pulse mode.

17 Includes measurement of SENSE HI to HI and SENSE LO to LO contact resistances.

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4. GENERAL

Host interfaces: Computer control interfaces.

IEEE-488: IEEE-488.1 compliant. Supports IEEE-488.2 common commands and status model topology.

RS-232: Baud rates from 300 bps to 115200 bps. Programmable number of data bits, parity type, and flow control (RTS/CTS hardware or none). When not programmed as the active host interface, the SourceMeter can use the RS-232 interface to control other instrumentation.

Expansion interface: The TSP-Link expansion interface allows TSP-enabled instruments to trigger and communicate with each other.

Cable type: Category 5e or higher LAN crossover cable.

Length: 3 meters maximum between each TSP-enabled instrument.

Digital I/O interface (see Models 2601 and 2602 GENERAL specifications for circuit diagram):

Connector: 25-pin female D.

Input/output pins: 14 open drain I/O bits.

Absolute maximum input voltage: 5.25V.

Absolute minimum input voltage: -0.25V.

Maximum logic low input voltage: 0.7V, +850 μ A max.

Minimum logic high input voltage: 2.1V, +570 μ A.

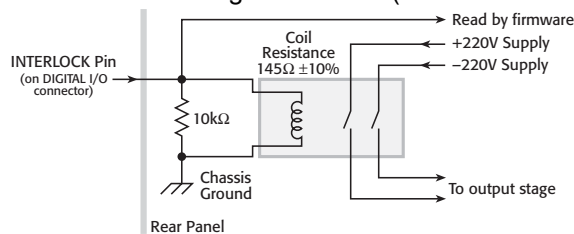
Maximum source current (flowing out of digital I/O bit): +960 μ A.

Maximum sink current at maximum logic low voltage (0.7V): -5.0mA.

Absolute maximum sink current (flowing into digital I/O pin): -11mA.

5V Power supply pin: Limited to 600mA, solid state fuse protected.

Safety interlock pin: Active high input. >3.4V at 24mA (absolute maximum of 6V) must be externally applied to this pin to ensure 200V operation. This signal is pulled down to chassis ground with a 10k Ω resistor. 200V operation will be blocked when the INTERLOCK signal is <0.4V (absolute minimum of -0.4V). See figure below:



Power supply: 100V to 240VAC, 50–60Hz (manual setting), 240VA max.

Cooling: Forced air. Side intake and rear exhaust. One side must be unobstructed when rack-mounted.

Warranty: One year.

EMC: Conforms to European Union Directive 89/336/EEC, EN 61326-1.

Safety: Conforms to European Union Directive 73/23/EEC, EN 61010-1, and UL 61010-1.

Dimensions: 89mm high × 213mm wide × 460mm deep (3 1/2 in × 8 3/8 in × 17 1/2 in). Bench configuration (with handle and feet): 104mm high × 238mm wide × 460mm deep (4 1/8 in × 9 3/8 in × 17 1/2 in).

Weight: Model 2611: 4.75kg (10.4 lbs). Model 2612: 5.50kg (12.0 lbs).

Environment: For indoor use only.

Altitude: Maximum 2000 meters above sea level.

Operating: 0°C–50°C, 70% R.H. up to 35°C. Derate 3% R.H./°C, 35°C–50°C.

Storage: -25°C to 65°C.

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System SourceMeter® Specifications

1. SPECIFICATION CONDITIONS

This document contains specifications and supplemental information for the Models 2635 and 2636 System SourceMeters®. Specifications are the standards against which the Models 2635 and 2636 are tested. Upon leaving the factory the 2635 and 2636 meet these specifications. Supplemental and typical values are non-warranted, apply at 23°C, and are provided solely as useful information.

The source and measurement accuracies are specified at the SourceMeters® CHANNEL A (2635 and 2636) or SourceMeters® B (2636) terminals under the following conditions:

1. 23°C ± 5°C, < 70% relative humidity.
2. After two-hour warm-up.
3. Speed normal (1 NPLC).
4. A/D auto-zero enabled.
5. Remote sense operation or properly zeroed local operation.
6. Calibration period: one year.

2. SOURCE SPECIFICATIONS

VOLTAGE SOURCE SPECIFICATIONS

Specifications Category	Specifications			
	RANGE	PROGRAMMING RESOLUTION	ACCURACY (1 Year) 23°C ± 5°C ± (% rdg. + volts)	TYPICAL NOISE (peak-peak) 0.1 Hz–10 Hz
Voltage Programming Accuracy ¹	200.000 mV	5 µV	0.02% + 375 µV	20 µV
	2.00000 V	50 µV	0.02% + 600 µV	50 µV
	20.0000 V	500 µV	0.02% + 5 mV	300 µV
	200.000 V	5 mV	0.02% + 50 mV	2 mV
Temperature Coefficient	± (0.15 × accuracy specification)/°C • For temperatures (0°–18°C & 28°–50°C)			
Maximum Output Power and Source/Sink Limits ²	30.3 W per channel maximum. • ± 20.2 V @ ± 1.5 A • ± 202 V @ ± 100 mA • Four-quadrant source or sink operation.			
Voltage Regulation	Line: 0.01% of range Load: ± (0.01% of range + 100 µV).			
Noise 10 Hz – 20 MHz	< 20 mV peak-peak (typical), < 3 mV RMS (typical) • 20 V range			
Current Limit/Compliance ³	Bipolar current limit (compliance) set with single value. Minimum value is 100 pA. Accuracy is the same as current source.			

¹ Add 50 µV to source accuracy specifications per volt of HI lead drop.

² Full power source operation regardless of load to 30°C ambient. Above 30°C and/or power sink operation, refer to Section 8 – “Operating Boundaries” in the Series 2600 Reference Manual for additional power derating information.

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System SourceMeter® Specifications

Specifications Category	Specifications
Overshoot	$< \pm (0.1\% + 10 \text{ mV})$ (typical) • Step size = 10% to 90% of range, resistive load, maximum - current limit/compliance.
Guard Offset Voltage	$< 4 \text{ mV}$ • Current $< 10 \text{ mA}$

CURRENT SOURCE SPECIFICATIONS

Specifications Category	Specifications			
	RANGE	PROGRAMMING RESOLUTION	ACCURACY (1 Year) 23°C ± 5°C ± (% rdg. + amps)	TYPICAL NOISE (peak-peak) 0.1 Hz–10 Hz
Current Programming Accuracy	1.00000 nA	20 fA	0.15% + 2 pA	800 fA
	10.0000 nA	200 fA	0.15% + 5 pA	2 pA
	100.000 nA	2 pA	0.06% + 50 pA	5 pA
	1.00000 µA	20 pA	0.03% + 700 pA	25 pA
	10.0000 µA	200 pA	0.03% + 5 nA	60 pA
	100.000 µA	2 nA	0.03% + 60 nA	3 nA
	1.00000 mA	20 nA	0.03% + 300 nA	6 nA
	10.0000 mA	200 nA	0.03% + 6 µA	200 nA
	100.000 mA	2 µA	0.03% + 30 µA	600 nA
	1.00000 A ⁴	20 µA	0.05% + 1.8 mA	70 µA
1.50000 A ⁴	50 µA	0.06% + 4 mA	150 µA	
Temperature Coefficient	$\pm (0.15 \times \text{accuracy specification})/^{\circ}\text{C}$ • For temperatures (0° – 18°C & 28° – 50°C)			
Maximum Output Power and Source/Sink Limits ⁴	30.3 W per channel maximum. • $\pm 1.515 \text{ A @ } \pm 20 \text{ V}$ • $\pm 101 \text{ mA @ } \pm 200 \text{ V}$ • Four-quadrant source or sink operation.			
Current Regulation	Line: 0.01% of range Load: $\pm (0.01\% \text{ of range} + 100\text{pA})$.			
Voltage Limit/Compliance ⁵	Bipolar voltage limit (compliance) set with single value. Minimum value is 10 mV. Accuracy is the same as current source.			

³ For sink mode operation (quadrants II and IV), add 12% of limit range and $\pm 0.02\%$ of limit setting to corresponding current limit accuracy specifications. For 1A range add an additional 40mA of uncertainty.

⁴ Full power source operation regardless of load to 30°C ambient. Above 30°C and/or power sink operation, refer to Section 8 – “Operating Boundaries” in the Series 2600 Reference Manual for additional power derating information

⁵ For sink mode operation (quadrants II and IV), add 10% of compliance range and $\pm 0.02\%$ of limit setting to corresponding voltage source specification. For 200mV range add an additional 120mV of uncertainty.

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System SourceMeter® Specifications

Specifications Category	Specifications
Overshoot	$< \pm 0.1\%$ (typical) <ul style="list-style-type: none"> • step size = 10% to 90% of range, resistive load, maximum - current limit/compliance • See CURRENT SOURCE OUTPUT SETTLING TIME for additional test conditions

ADDITIONAL SOURCE SPECIFICATIONS

Specifications Category	Specifications	
Transient Response Time	$< 70 \mu\text{s}$ for the output to recover to 0.1% for a 10% to 90% step change in load.	
Voltage Source Output Settling Time	Time required to reach 0.1% of final value after source level command is processed on a fixed range.	
	Range	Settling Time
	200 mV	$< 50 \mu\text{s}$ (typical)
	2 V	$< 50 \mu\text{s}$ (typical)
	20 V	$< 110 \mu\text{s}$ (typical)
Current Source Output Settling Time	200 V	$< 700 \mu\text{s}$ (typical)
	Time required to reach 0.1% of final value after source level command is processed on a fixed range.	
	• Values below for $I_{\text{out}} \times R_{\text{load}} = 2 \text{ V}$ unless noted	
	Current Range	Settling Time
	1.5 A – 1 A	$< 120 \mu\text{s}$ (typical) ($R_{\text{load}} > 6 \Omega$)
	100 mA – 10 mA	$< 80 \mu\text{s}$ (typical)
	1 mA	$< 100 \mu\text{s}$ (typical)
	100 μA	$< 150 \mu\text{s}$ (typical)
	10 μA	$< 500 \mu\text{s}$ (typical)
	1 μA	$< 2 \text{ ms}$ (typical)
100 nA	$< 20 \text{ ms}$ (typical)	
10 nA	$< 40 \text{ ms}$ (typical)	
1 nA	$< 150 \text{ ms}$ (typical)	
DC Floating Voltage	Output can be floated up to $\pm 250 \text{ VDC}$	
Remote Sense Operating Range ⁶	Maximum voltage between HI and SENSE HI = 3 V Maximum voltage between LO and SENSE LO = 3 V	
Voltage Output Headroom	200 V Range	
	<ul style="list-style-type: none"> • Maximum output voltage = 202.3 V – total voltage drop across source leads. (maximum 1 μV per source lead) 	
Voltage Output Headroom	20 V Range	
	<ul style="list-style-type: none"> • Maximum output voltage = 23.3 V – total voltage drop across source leads. (maximum 1 μV per source lead) 	

⁶ Add 50 μV to source accuracy specifications per volt of HI lead drop.

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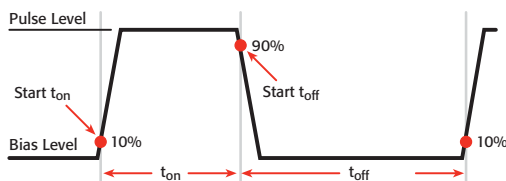
System SourceMeter® Specifications

Specifications Category	Specifications
Over Temperature Protection	Internally sensed temperature overload puts unit in standby mode.
Voltage Source Range Change Overshoot	300 mV + 0.1% of larger range (typical) <ul style="list-style-type: none"> • Overshoot into a 200 K load, 20 MHz BW
Current Source Range Change Overshoot	< 5% of larger range + 300 mV/Rload + 60 nA (typical) <ul style="list-style-type: none"> • See CURRENT SOURCE OUTPUT SETTLING TIME for additional test conditions.

PULSE SPECIFICATIONS

Specifications Category	Specifications
Minimum Programmable Pulse Width ⁷	200 μ s <ul style="list-style-type: none"> • Note: Minimum pulse width for settled source at a given I/V output and load can be longer than 200 μs.
Pulse Width Programming Resolution	1 μ s
Pulse Width Programming Accuracy	\pm 25 μ s
Pulse Width Jitter	50 μ s (typical)
Quadrant Diagram	

⁷ Times measured from the start of pulse to the start off-time; see figure below.



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System SourceMeter® Specifications
3. METER SPECIFICATIONS
VOLTAGE MEASUREMENT SPECIFICATIONS

Specifications Category	Specifications			
Voltage Measurement Accuracy ^{8,9}	RANGE	DISPLAY RESOLUTION⁹	INPUT IMPEDENCE	ACCURACY (1 Year) 23°C ± 5°C ± (% rdg. + volts)
	200.00 mV	1 µV	> 10 GΩ	0.015% + 225 µV
	2.00000 V	10 µV	> 10 GΩ	0.02% + 350 µV
	20.0000 V	100 µV	> 10 GΩ	0.015% + 5 mV
	200.000 V	1 mV	> 10 GΩ	0.015% + 50 mV
Temperature Coefficient	± (0.15 × accuracy specification)/°C • For temperatures (0°–18°C & 28°–50°C)			

CURRENT MEASUREMENT SPECIFICATIONS⁹

Specifications Category	Specifications			
Current Measurement Accuracy	RANGE	DISPLAY RESOLUTION¹⁰	VOLTAGE BURDEN¹¹	ACCURACY (1 Year) 23°C ± 5°C ± (% rdg. + amps)
	100.00 pA ^{12,13}	1 fA	< 1 mV	0.15% + 120 fA
	1.00000 nA ^{12,14}	10 fA	< 1 mV	0.15% + 240 fA
	10.0000 nA	100 fA	< 1 mV	0.15% + 3 pA
	100.000 nA	1 pA	< 1 mV	0.06% + 40 pA
	1.00000 µA	10 pA	< 1 mV	0.025% + 400 pA
	10.0000 µA	100 pA	< 1 mV	0.025% + 1.5 nA

⁸ Add 50µV to source accuracy specifications per volt of HI lead drop

⁹ De-rate accuracy specifications for NPLC setting < 1 by increasing error term. Add appropriate % of range term using table below

NPLC Setting	200 mV Range	2 V – 200 V Ranges	100 nA Range	1 µA – 100 mA Ranges	1 A – 1.5 A Ranges
0.1	0.01%	0.01%	0.01%	0.01%	0.01%
0.01	0.08 %	0.07%	0.1 %	0.05%	0.05%
0.001	0.8 %	0.6 %	1 %	0.5 %	1.1 %

¹⁰ Applies when in single channel display mode.

¹¹ Four-wire remote sense only.

¹² 10-NPLC, 11-Point Median Filter, < 200V range, measurements made within 1 hour after zeroing. 23°C ± 1°C

¹³ Under default specification conditions: ±(0.15% + 750 fA).

¹⁴ Under default specification conditions: ±(0.15% + 1 pA).

Specifications are subject to change without notice.

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System SourceMeter® Specifications

Specifications Category	Specifications			
	RANGE	DISPLAY RESOLUTION¹⁵	VOLTAGE BURDEN¹⁶	ACCURACY (1 Year) 23°C ± 5°C ± (% rdg. + amps)
	100.000 µA	1 nA	< 1 mV	0.02% + 25 nA
	1.00000 mA	10 nA	< 1 mV	0.02% +200 nA
	10.0000 mA	100 nA	< 1 mV	0.02% + 2.5 µA
	100.000 mA	1 µA	< 1 mV	0.02% +20 µA
	1.00000 A	10 µA	< 1 mV	0.03% +1.5 mA
	1.50000 A	10 µA	< 1 mV	0.05% + 3.5 mA
Current Measure ¹⁷ Settling Time	Time required to reach 0.1% of final value:			
	Current Range		Settling Time	
	1 mA		< 100 µs (typical)	
Temperature Coefficient	± (0.15 × accuracy specification)/°C • For temperatures (0°–18°C & 28°–50°C)			

ADDITIONAL METER SPECIFICATIONS

Specifications Category	Specifications
Load Impedance	Stable into 10,000 pF (typical)
Common Mode Voltage	250 VDC
Common Mode Isolation	> 1 GΩ < 4500 pF
Ovrange	101% of source range 102% of measure range
Maximum Sense Lead Resistance	1 KΩ for rated accuracy
Sense Input Impedance	> 10 GΩ

¹⁵ Applies when in single channel display mode.

¹⁶ Four-wire remote sense only.

¹⁷ See series 2600 SourceMeter Reference Manual Section 8 for more information.

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System SourceMeter® Specifications**4. GENERAL**

Specifications Category	Specifications
Host Interfaces	Computer control interfaces
IEEE-488	IEEE-488.1 compliant. Supports IEEE-488.2 common commands and status model topology
RS-232	Baud rates from 300bps to 115200bps. Programmable number of data bits, parity type, and flow control (RTS/CTS hardware or none). When not programmed as the active host interface, the SourceMeter can use the RS-232 interface to control other – instrumentation
Expansion Interface	The TSP-Link expansion interface allows TSP enabled instruments to trigger and communicate with each other.
Cable Type	Category 5e or higher LAN crossover cable
Length	3 meters maximum between each TSP enabled instrument
Digital I/O Interface	See 2601/02 GENERAL specifications for circuit diagram
Connector	25-pin female D
Input/Output Pins	14 open drain I/O bits
Absolute Maximum Input Voltage	5.25 V
Absolute Minimum Input Voltage	– 0.25 V
Maximum Logic Low Input Voltage	0.7V, +850 μ A max
Minimum Logic High Input Voltage	2.1V, + 570 μ A
Maximum Source Current (flowing out of Digital I/O bit)	+ 960 μ A
Maximum Sink Current @ Maximum Logic Low Voltage (0.7V)	– 5.0 mA
Absolute Maximum Sink Current (flowing into Digital I/O pin)	– 11 mA
5V Power Supply Pin	Limited to 600 mA, solid state fuse protected
Safety Interlock Pin	Active high input. > 3.4 V @ 24 mA (absolute maximum of 6 V) must be externally applied to this pin to insure 200 V operation. This signal is pulled down to chassis ground with a 10 K resistor. 200 V operation will be blocked when the INTERLOCK signal is < 0.4 V (absolute minimum –0.4 V). See figure below:

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System SourceMeter® Specifications

Specifications Category	Specifications
Host Interfaces	Computer control interfaces
IEEE-488	IEEE-488.1 compliant. Supports IEEE-488.2 common commands and status model topology
RS-232	Baud rates from 300bps to 115200bps. Programmable number of data bits, parity type, and flow control (RTS/CTS hardware or none). When not programmed as the active host interface, the SourceMeter can use the RS-232 interface to control other – instrumentation
Power Supply	100 V to 240 VAC, 50 Hz – 60 Hz (manual setting), 240 VA max
Cooling	Forced air. Side intake and rear exhaust. One side must be unobstructed when rack mounted
Warranty	1 year
EMC	Conforms to European Union Directive 2004/108/EEC, EN 61326-1
Safety	Conforms to European Union Directive 73/23/EEC, EN 61010-1, and UL 61010-1
Dimensions	89 mm high × 213 mm wide × 460 mm deep (3½ in × 8¾ in × 17½ in). Bench Configuration (with handle & feet): 104 mm high × 238 mm wide × 460 mm deep (4⅛ in × 9¾ in × 17½ in)
Weight	2635: 4.75 Kg (10.4 lbs). 2636: 5.50 Kg (12.0 lbs).
Environment	For indoor use only
Altitude	Maximum 2000 meters above sea level
Operating	0° – 50°C, 70% R.H. up to 35°C. Derate 3% R.H./°C, 35° – 50°C
Storage	– 25°C to 65°C

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System SourceMeter® Specifications
1. SPEED SPECIFICATIONS^{1,2,3}
Maximum Sweep Operation Rates (operations per second) for 60Hz (50Hz):

A/D converter speed	Trigger origin	Measure to memory	Measure to GPIB	Source measure to memory	Source measure to GPIB	Source measure pass/fail to memory	Source measure pass/fail to GPIB
0.001 NPLC	Internal	10000 (10000)	8000 (8000)	5500 (5500)	3600 (3600)	4900 (4900)	3100 (3100)
0.001 NPLC	Digital I/O	2700 (2650)	2100 (2100)	2300 (2300)	1900 (1875)	2200 (2150)	1800 (1775)
0.01 NPLC	Internal	4000 (3500)	3600 (3200)	2750 (2700)	2300 (2100)	2800 (2500)	2100 (1975)
0.01 NPLC	Digital I/O	1900 (1775)	1600 (1500)	1700 (1600)	1450 (1400)	1600 (1500)	1400 (1325)
0.1 NPLC	Internal	565 (475)	555 (470)	540 (450)	510 (440)	535 (455)	505 (430)
0.1 NPLC	Digital I/O	490 (420)	470 (405)	470 (410)	450 (390)	470 (400)	450 (390)
1.0 NPLC	Internal	59 (49)	59 (49)	58 (49)	58 (48)	58 (49)	58 (48)
1.0 NPLC	Digital I/O	58 (48)	58 (48)	58 (48)	57 (48)	57 (48)	57 (48)

Maximum Single Measurement Rates (operations per second) for 60Hz (50Hz):

A/D converter speed	Trigger origin	Measure to GPIB	Source measure to GPIB	Source measure pass/fail to GPIB
0.001 NPLC	Internal	1110 (1000)	880 (880)	840 (840)
0.01 NPLC	Internal	950 (900)	780 (760)	730 (710)
0.1 NPLC	Internal	390 (345)	355 (320)	340 (305)
1.0 NPLC	Internal	57 (48)	56 (47)	56 (47)

Maximum measurement range change rate: >4500/second typical. When changing to or from a range $\geq 1A$, maximum rate is >2000/second typical.

Maximum source range change rate: >400/second, typical.

Maximum source function change rate: >500/second, typical.

External trigger input: The digital I/O interface signals can be configured to operate as trigger inputs.

Input latency (time from trigger input to start of measurement or source change): <150 μ s, typical.

Input jitter: <100 μ s, typical.

Command processing time: Maximum time required for the output to begin to change following the receipt of the smux.source.levelv or smux.source.leveli command. <1ms typical.

¹ See the Speed Specifications Test Conditions Appendix in the Series 2600 Reference Manual for more information regarding test conditions.

² Exclude current measurement ranges less than 1mA.

³ 2635/2636 with default measurement delays and filters disabled.

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2. SUPPLEMENTAL INFORMATION

Front Panel Interface:

Two-line vacuum fluorescent display (VFD) with keypad and rotary knob.

Display:

- Show error messages and user-defined messages
- Display source and limit settings
- Show current and voltage measurements
- View measurements stored in non-volatile reading buffers

Keypad operations:

- Change host interface settings
- Save and restore instrument setups
- Load and run factory and user-defined test scripts (i.e., sequences) that prompt for input and send results to the display
- Store measurements into non-volatile reading buffers

Programming:

Embedded Test Script Processor (TSP) accessible from any host interface. Responds to individual instrument control commands. Responds to high-speed test scripts comprised of instrument control commands and Test Script Language (TSL) statements (e.g., branching, looping, math, etc.). Able to execute high-speed test scripts stored in memory without host intervention.

Minimum memory available: 3Mb (approximately 50,000 lines of TSL code).

Test Script Builder: Integrated development environment for building, running, and managing TSP scripts. Includes an instrument console for communicating with any TSP-enabled instrument in an interactive manner.

Requires:

- VISA (NI-VISA included on CD)
- Microsoft .NET Framework (included on CD)
- Keithley I/O Layer (included on CD)
- Pentium III 800MHz or faster personal computer
- Microsoft[®] Windows[®] 98, NT, 2000, or XP

Software Interface: Direct GPIB/VISA, Read/Write with VB, VC/C++, LabVIEW, TestPoint, LabWindows/CVI, etc.

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System SourceMeter[®] Specifications

Reading Buffers:

Non-volatile storage area(s) reserved for measurement data. Reading buffers are arrays of measurement elements. Each element can hold the following items:

- Measurement
- Measurement status
- Timestamp
- Source setting (at the time the measurement was taken)
- Range information

Two reading buffers are reserved for each SourceMeter channel. Reading buffers can be filled using the front panel STORE key, and retrieved using the RECALL key or host interface.

Buffer Size, with timestamp and source setting: >50,000 samples.

Buffer Size, without timestamp and source setting: >100,000 samples.

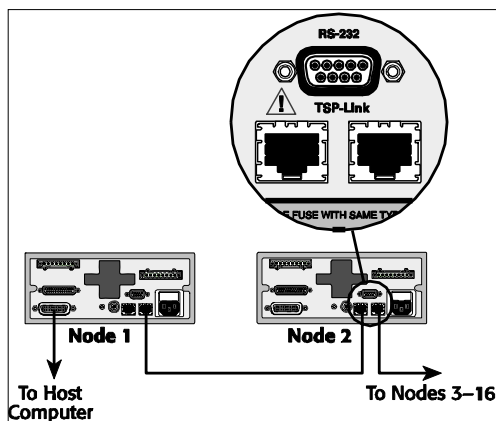
Battery Backup: Lithium-ion battery backup; 30 days of non-volatile storage. Typical battery life is 1 year.

Factory TSP Scripts:

See www.keithley.com for Keithley-supported application-specific scripts.

System Expansion:

The TSP-Link expansion interface allows TSP-enabled instruments to trigger and communicate with each other. See figure below:



Each SourceMeter has two TSP-Link connectors to facilitate chaining instruments together.

- Once SourceMeter instruments are interconnected via TSP-Link, a computer can access all of the resources of each SourceMeter via the host interface of any SourceMeter.
- A maximum of 16 TSP-Link nodes can be interconnected. Each SourceMeter consumes one TSP-Link node.

TIMER:

Free-running 47-bit counter with 1MHz clock input. Reset each time instrument powers up. Rolls over every 4 years.

Timestamp: TIMER value automatically saved when each measurement is triggered.

Resolution: 1 μ s.

Accuracy: 100ppm.

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Frequently Asked Questions

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NOTE Visit the Keithley Instruments website at www.keithley.com for more information on Frequently Asked Questions.

How do I optimize performance?

Reference See “Operation considerations” in Section 4 and “Speed” in Section 6 of the Series 2600 Reference Manual for detailed information on performance factors that affect measurement speed and accuracy.

There are three primary factors that affect measurement accuracy and speed:

- Warm-up – For rated measurement accuracy, allow the Series 2600 to warm up for at least one hour before use.
- Speed setting – The Speed setting affects both speed and accuracy.
- Auto zero – Auto zero can be disabled to increase speed at the expense of accuracy.

Setting speed

Press the SPEED key, then choose the setting based on your requirements:

- Choose the FAST setting for the fastest measurements, but measurement accuracy will be reduced.
- For best accuracy, use the HI ACCURACY setting, but speed will be reduced.
- To compromise between accuracy and speed, use the MED or NORMAL setting.

Disabling auto zero to increase speed

In certain measuring situations, disabling auto zero can increase measurement speed, but accuracy will drift with time. To disable auto zero, select CONFIG > MEAS > AUTO-ZERO, then set to OFF. To minimize drift with auto zero disabled, use the ONCE selection just before measuring.

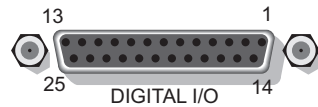
How do I use the Digital I/O port?

Reference See Section 10 of the Series 2600 Reference Manual for complete details on the Digital I/O port.

Digital I/O port terminals

The Digital I/O port, located on the rear panel ([Figure 1-2 on page 1-6](#)), provides 14 digital I/O lines ([Figure B-1](#)). Each output can be set high (+5V) or low (0V), read high or low logic levels, and can be set up for triggering. Make connections using a cable with a Male DB-25 connector (Keithley Instruments part number CA-126-1).

Figure B-1
Digital I/O port terminals



1 = Digital I/O #1	11 = Digital I/O #11
2 = Digital I/O #2	12 = Digital I/O #12
3 = Digital I/O #3	13 = Digital I/O #13
4 = Digital I/O #4	14 = Digital I/O #14
5 = Digital I/O #5	15-21 = Ground
6 = Digital I/O #6	22 = +5V
7 = Digital I/O #7	23 = +5V
8 = Digital I/O #8	24 = Output Enable (OE); 2601/2602
9 = Digital I/O #9	24 = Interlock (INT); 2611/2612/2635/2636
10 = Digital I/O #10	25 = +5V

Controlling the Digital I/O port

From the front panel, select MENU > GENERAL > DIGOUT > DIG_IO_OUTPUT, then enter the decimal value to set I/O lines high or low (16,383 maximum). Commands for basic I/O are summarized in [Table B-1](#). For example, to set all 14 lines high, send:
`digio.write.port(16383).`

Table B-1
Commands for basic I/O port

Command	Description
<code>digio.readbit(bit)</code>	Read one digital I/O input line.
<code>digio.readport()</code>	Read digital I/O port.
<code>digio.writebit(bit, data)</code>	Write data to one digital I/O output line.
<code>digio.writeport(data)</code>	Write data to digital I/O port.

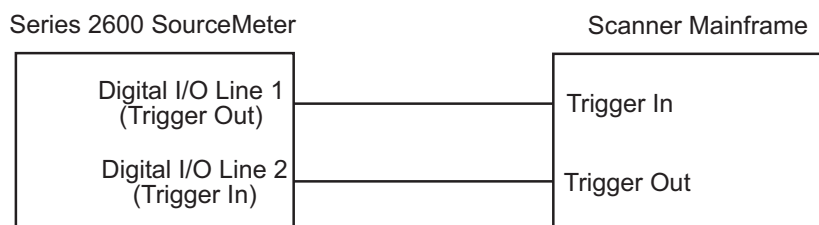
How do I trigger other instruments?

Reference See “Triggering” in Section 4, “Remote digital I/O commands” in Section 11, and Section 12 of the Series 2600 Reference Manual for triggering and Digital I/O port command details.

Triggering a scanner

A typical test scenario might call for using the Series 2600 with a scanner to test a number of DUTs in sequence. A basic example that uses the Series 2600 Digital I/O port to trigger a scanner is shown in [Figure B-2](#). In this case, line 1 of the I/O port is used as a trigger output and connected to the scanner mainframe trigger input, while line 2 of the I/O port is used as a trigger input.

Figure B-2
Triggering a scanner



Programming triggering

A simple command sequence that sets up triggering is shown below. The first two commands set the output pulse width on line 1 and program line 2 for falling edge input triggers. The second two commands assert and then wait for a trigger on lines 1 and 2 respectively.

```

digio.trigger[1].pulsewidth = 1e-5 - Set line 1 pulse width to 10µs.
-
digio.trigger[2].mode =           - Set line 2 mode to falling edge.
digio.TRIG_FALLING               -
digio.trigger[1].assert()        - Assert trigger on line 1.
-
digio.trigger[2].wait(timeout)    - Wait for trigger on line 2.
-

```

How do I generate a service request?

Reference See “Status byte and service request (SRQ)” and additional information in Appendix D of the Series 2600 Reference Manual for status model and service request details.

Setting up a service request

The exact programming steps necessary to generate a GPIB service request (SRQ) will vary somewhat depending on the event(s) intended to generate the SRQ. In general, the steps used will be as follows:

- Clear all status registers to prevent anomalous events from generating an SRQ.
- Set bits in the appropriate operation: questionable, measurement enable, or transition register(s).
- Set the proper summary bit in the service request enable register. At least one bit in this register must always be set, but the exact bit(s) to be set will depend on the desired SRQ event(s).

Service request programming example

The example below shows how to program the SourceMeter to generate an SRQ when the current limit on Channel A is exceeded.

```

status.reset()                    - Clear all registers.
-
status.measurement.current_limit.enable = - Enable current limit bit in
status.measurement.current_limit.SMUA   - current limit register.
status.measurement.enable =           - Enable status measure
status.measurement.ILMT                - current limit bit.
status.request_enable = status.MSB     - Enable status SRQ MSB.

```

Polling for SRQs

To determine if the SourceMeter is the GPIB device that generated the SRQ, simply serial poll the unit for the status byte, and test to see if the corresponding summary bit or bits are set. For example, the following commands request the status byte and prints the result:

```

status_byte = status.condition
print(status_byte)

```

How do I store measurements in non-volatile memory?

A Series 2600 SourceMeter has two non-volatile buffers for measured readings, source values, and timestamps: NV Buffer 1 (`nvbuffer1`) and NV Buffer 2 (`nvbuffer2`). Data stored in these buffers will not be lost when the Series 2600 is turned off.

Reference See Section 7 of the Series 2600 Reference Manual for details on the buffer (data store).

Front panel operation

See “[How do I use the buffer?](#)” on page 1-16 of this manual for details on storing data from the front panel of the Series 2600.

Remote programming

The following example demonstrates a typical way to use a reading buffer. The commands in the following steps will perform three SMU A voltage measurements, store them in `nvbuffer1`, and then read the buffer:

Step 1: Clear and configure the buffer

The following command sequence will clear the buffer of all readings, and configure the buffer to store timestamps and source values:

```
smua.nvbuffer1.clear()
smua.nvbuffer1.collecttimestamps = 1
smua.nvbuffer1.collectsourcevalues = 1
```

NOTE Setting `collecttimestamps` to 0 and `collectsourcevalues` to 0 will disable the storage of timestamps and source values.

Step 2: Perform measurements

The following command sequence sets the measure count to three, turns on the output, performs the three measurements, and then turns off the output:

```
smua.measure.count = 3
smua.source.output = smua.OUTPUT_ON
smua.measure.v(smua.nvbuffer1)
smua.source.output = smua.OUTPUT_OFF
```

The three measure readings, timestamps, and source values will be stored in the buffer.

Step 3: Read the buffer

The following code will output the three sets of data (nine values) in the same message:

```
rb1 = smua.nvbuffer1
printbuffer(1, rb1.n, rb1, rb1.timestamps, rb1.sourcevalues)
```

For the above `printbuffer` function, 1 is the starting index for values to output, `rb1.n` is the ending index (`n` = the number of readings in the buffer, which in this case is 3), `rb1` includes the measured readings, `rb1.timestamps` includes the timestamps, and `rb1.sourcevalues` includes the source values.

Example output:

```
1.234567e-03, 5.555555e-02, 1.000000e+00, 2.362360e-03, 8.888888e-02,  
1.000000e+00, 2.362368e-03, 1.111111e-01, 1.000000e+00
```

The above output is returned in the following order:

```
reading1, timestamp1, sourcevalue1, reading2, timestamp2, sourcevalue2, reading3, timestamp3,  
sourcevalue3
```

See Step 3 of “[Running a factory script](#)” on [page 3-3](#) for more examples on reading the buffer.

How do I stack channels to output higher voltage?

The maximum output voltage of a Model 2601 or Model 2602 channel is 40.4, and the maximum output voltage of a Model 2611/2612 or 2635/2636 channel is 202V. Higher voltage can be output by stacking (connecting in series) channels.

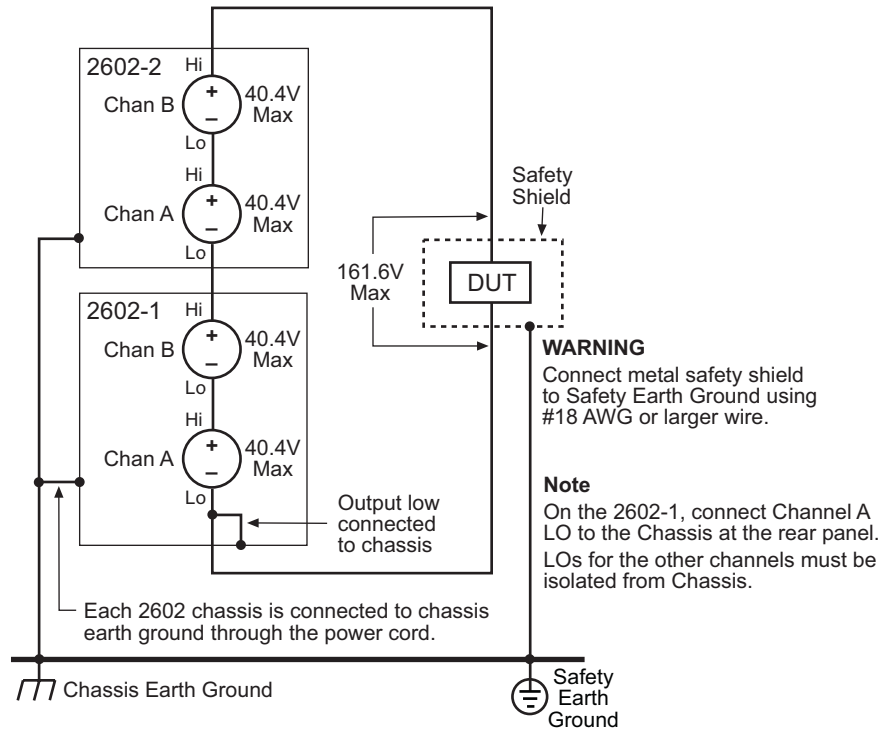
Stacking channels requires that all SMU channels (except one) float off earth ground. [Figure B-3](#) shows two Model 2602s configured with the four channels connected in series to output up to 161.6V (40.4V per channel). Additional channels can be added (stacked), but the LO terminal of any SMU channel in the stack must never exceed 250V with respect to earth ground.

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

Whenever hazardous voltage (>30Vrms, 42Vpeak) will be output, a safety shield must completely surround the DUT test circuit. When using a metal safety shield, it must be connected to a known safety earth ground and chassis ground.

Reference See “Floating a SMU” in Section 3 of the Reference Manual for details on floating SMU channels.

Figure B-3

Stacking channels for higher voltage

NOTE Each stacked channel adds approximately $100\mu\text{A}$ of common mode current that is seen by the channels below it. Therefore, in the example above, Model 2602-1 Chan A will measure approximately $100\mu\text{A} \times 3 = 300\mu\text{A}$ higher than Model 2602-2 Chan B. Similarly, Model 2602-1 Chan B will measure approximately $100\mu\text{A} \times 2 = 200\mu\text{A}$ higher than Model 2602-2 Chan B. The most accurate measurement of actual current flowing through the DUT will be obtained from Model 2602-2 Chan B.

How do I parallel channels to output higher current?

Reference See Section 3 of the Series 2600 Reference Manual for details on SMU connections.

The maximum DC output current of a Model 2601 or Model 2602 channel is as follows:

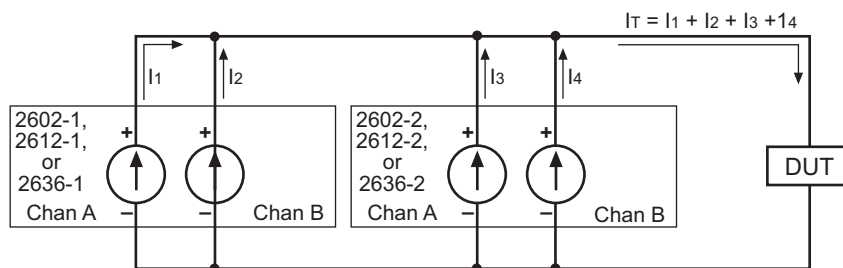
- 1.01A @ up to 40.4V
- 3.03A @ up to 6.06V

The maximum DC output current of a Model 2611/2612 or Model 2635/2636 channel is as follows:

- 101mA @ up to 202V
- 1.515A @ up to 20.2V

Higher current can be output by connecting channels in parallel. Figure B-4 shows four channels of two Model 2602s, 2612s, or 2636s connected in parallel. Two Model 2602s can output up to 4.04A at up to 40.4V and 12.12A at up to 6.06V, while two Model 2612s and Model 2636s can output up to 404mA at up to 202V and 6.06A at up to 20.2V. The current delivered to the DUT is the sum of currents output by the four SMU channels. More current can be output by connecting additional channels in parallel.

Figure B-4
Connecting channels in parallel for higher current



How do I make contact check measurements?

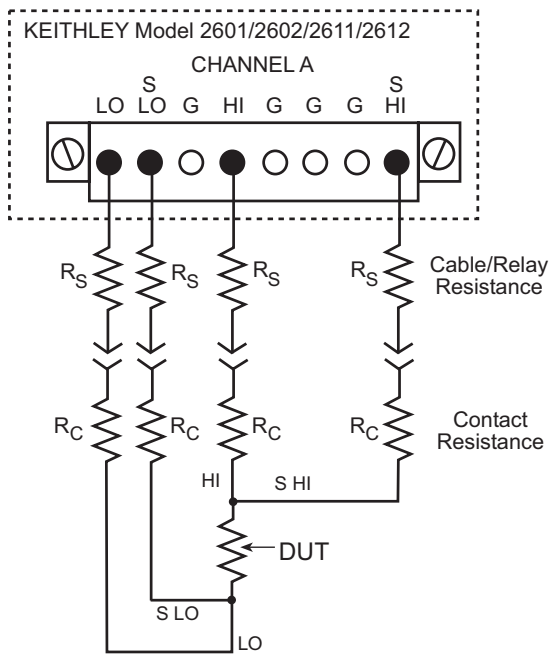
Reference See “Contact check measurements” in Section 4 and command information in Section 12 of the Series 2600 Reference Manual for contact check details.

Contact check connections

The contact check function¹ prevents measurement errors due to excessive resistance in the force or sense leads caused by poor contact at the DUT, failing relay contacts on a switching card, or wires that are too long or thin. The contact check function will also detect an open circuit that may occur with a four-point probe is misplaced or misaligned. Figure B-5 shows Model 2601/2602/ 2611/2612 contact check connections, and Figure B-6 shows Model 2635/2636 contact check connections. R_C is the resistance of the mechanical contact at the DUT, and R_S is the series resistance of relays and cables.

1. All Model 2611/2612s manufactured by Keithley Instruments support the contact check function. Only Model 2601/2602s with firmware revision 1.1.0 or later and SMU hardware revision E or later support the contact check function. To determine the firmware and SMU hardware revisions, inspect the data returned by the `print(localnode.info())` command. The `InstFwRev` and `SMUBrdRev` keys contain the necessary information (contact check is NOT on 2635/2636).

Figure B-5
Model 2601/2602/2611/2612 contact check connections



Contact check programming example

The command sequence for a typical contact measurements is shown below. These commands set the contact check speed to fast and the threshold to 10Ω. A contact check measurement against the threshold is then 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.

Figure B-6

Model 2635/2636 contact check connections

```

smua.reset()
smua.contact.speed = smua.CONTACT_FAST
smua.contact.threshold = 10
if (not smua.contact.check()) then
  --One/both contact resistances are not
  --below the programmed threshold.
  smua.contact.speed = smua.CONTACT_SLOW
  rhi, rlo = smua.contact.r()
  print(rhi, rlo)
  exit()
end
smua.source.output = smua.OUTPUT_ON

```

- Restore defaults.
-
- Set speed to fast.
-
- Set threshold to 10Ω.
-
- Check contacts against threshold.
-
- Set speed to slow.
- Get resistance readings.
- Return contact resistances to the host.
- Terminate execution.
-
- Turn on output and continue.

How do I make low-current measurements?

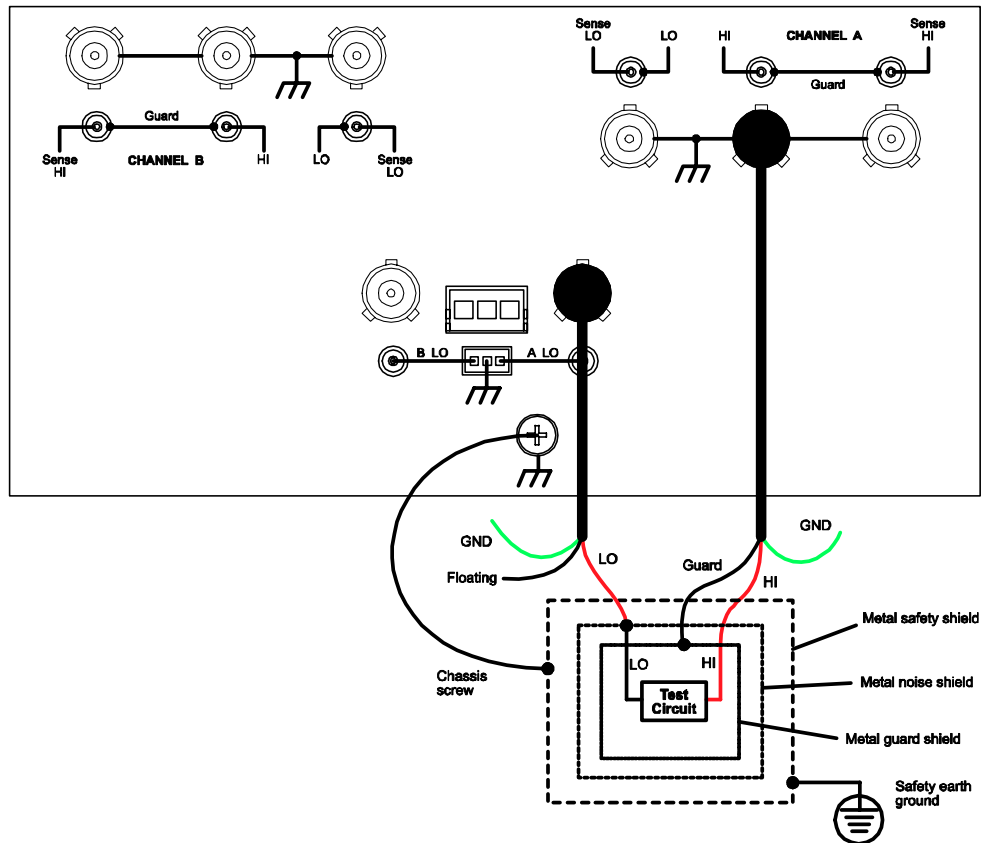
Reference See Section 3 for more connection information, and Section 12 of the Series 2600 Reference Manual for command details.

Low-current connections

Low-current measurements ($<1\mu\text{A}$) are subject to errors caused by leakage currents and leakage resistances in the signal path. For that reason, Model 2635 and 2636 SourceMeters are equipped with triax connectors to minimize these problems. To assure accurate low-level measurements, the integrity of the signal path must be maintained to the DUT, including using both low-noise triax cables and a suitable test fixture.

Figure B-7 shows typical connections for low-current measurements. The DUT in this example could be a low-current semiconductor device, a high-megohm resistor, or any other passive or active electronic device requiring low-current measurements. Note that the DUT is enclosed in both a guard shield and a safety shield, which is necessary when hazardous voltages are used. The inner shield (guard) of the HI triax cable is connected to the test fixture guard shield, and the outer cable shield (chassis ground) is connected to the safety shield.

Figure B-7
Model 2635/2636 low-current connections



Low-current measurement programming example

The command sequence for typical low-current measurements is shown below. The sequence assumes that a 100G Ω resistor is being tested. These commands set the output voltage to 100V and then measure and display both the current through the device as well as the resistance.

<code>smua.reset()</code>	- Restore defaults.
<code>smua.source.func = smua.OUTPUT_DCVOLTS</code>	- Set source to DCV.
<code>smua.source.rangev = 200</code>	- Select 200V source range
<code>smua.source.levelv = 100</code>	- Output 100V DC.
<code>smua.measure.rangei = 1e-9</code>	- Select 1nA range.
<code>smua.source.limiti = 1e-9</code>	- Set current limit to 1nA
<code>smua.source.output = smua.OUTPUT_ON</code>	- Turn on output.
<code>print(smua.measure.i())</code>	- Display current reading.
<code>print(smua.measure.r())</code>	- Display resistance reading.
<code>smua.source.output = smua.OUTPUT_OFF</code>	- Turn off output.

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Model No. _____ Serial No. _____ Date _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

- | | | |
|--|--|--|
| <input type="checkbox"/> Intermittent | <input type="checkbox"/> Analog output follows display | <input type="checkbox"/> Particular range or function bad; specify _____ |
| <input type="checkbox"/> IEEE failure | <input type="checkbox"/> Obvious problem on power-up | <input type="checkbox"/> Batteries and fuses are OK |
| <input type="checkbox"/> Front panel operational | <input type="checkbox"/> All ranges or functions are bad | <input type="checkbox"/> Checked all cables |

Display or output (check one)

- | | |
|---|--|
| <input type="checkbox"/> Drifts | <input type="checkbox"/> Unable to zero |
| <input type="checkbox"/> Unstable | <input type="checkbox"/> Will not read applied input |
| <input type="checkbox"/> Overload | |
| <input type="checkbox"/> Calibration only | <input type="checkbox"/> Certificate of calibration required |
| <input type="checkbox"/> Data required | |

(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

What power line voltage is used? _____ Ambient temperature? F _____

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

Be sure to include your name and phone number on this service form.

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A G R E A T E R M E A S U R E O F C O N F I D E N C E

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