2461 SourceMeter® SMU Instrument

Datasheet

The 2461 High Current SourceMeter® Source Measure Unit (SMU) Instrument brings advanced Touch, Test, Invent® technology right to your fingertips. It combines an innovative graphical user interface (GUI) with capacitive touchscreen technology to make testing intuitive and minimize the learning curve to help engineers and scientists learn faster, work smarter, and invent easier. With its 10 A/1000 W pulse current and 7 A/100 W DC current capability combined with dual 18-bit 1MS/s digitizers, the 2461 is optimized for characterizing and testing high power materials, devices, and modules, such as silicon carbide (SiC), gallium nitride (GaN), DC-DC converters, circuit protection devices, solar cells and panels, high brightness LEDs and lighting systems, electrochemical cells and batteries, and much more. These new capabilities, combined with Keithley's expertise in high precision, high accuracy SMU instruments, will make the 2461 a "go-to instrument" for high current sourcing and high speed measurement applications in the lab and in the rack for years to come.

Key Features

- One tightly coupled instrument that combines the capabilities of analyzers, curve tracers, and I-V systems at a fraction of their cost
- Wide coverage up to 105 V/7 A DC 100 W, 100 V/10 A Pulse 1000 W max.
- Dual 1 MS/s digitizers for fast sampling measurements
- Five-inch, high resolution capacitive touchscreen GUI
- 0.012% DCV accuracy with 6½-digit resolution
- Source and sink (4-quadrant) operation
- Four "Quickset" modes for fast setup and measurements
- Context-sensitive help function
- Front panel input banana jacks; rear panel mass termination screw connections
- SCPI and Test Script Processor (TSP®) programming modes
- Front-panel USB 2.0 memory I/O port for transferring data, test scripts, or test configurations

The 2461's home screen makes testing intuitive and helps minimize the learning curve for new users.

Learn Faster, Work Smarter, Invent Easier

The 2461 features a five-inch, full-color, high resolution touchscreen that supports intuitive operation, helps operators become familiar with the instrument quickly, and optimizes overall speed and productivity. A simple icon-based menu structure reduces the number of steps required to configure a test by as much as 50 percent and eliminates the cumbersome multi-layer menu structures typically used on soft-key instruments. Built-in, context-sensitive help supports intuitive operation and minimizes the need to review a separate manual. These capabilities, combined with the 2461's high versatility, simplify its operation in both basic and advanced measurement applications, regardless of the user's previous experience in working with SMU instruments.
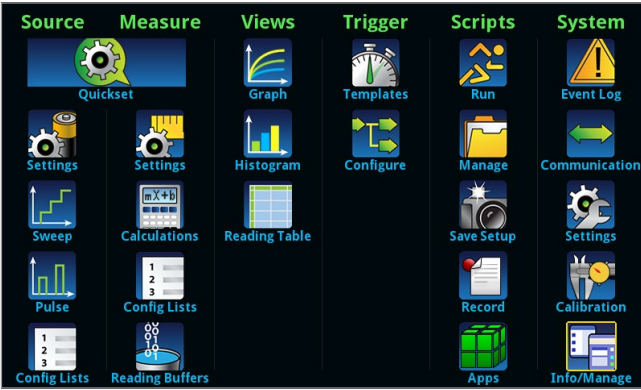
The graphical SMU's icon-based menu structure helps even novice users configure tests quickly and confidently.

Capture Real Device Operation with the Built-in Dual 1 MS/sec Digitizers

Capturing and displaying real device operation, waveforms, and transient events just got easier with the 2461's digitizing function. The two built-in 1 MS/sec, 18-bit digitizers make it possible to acquire both voltage and current waveforms simultaneously without the need to use a separate instrument. The digitizing functions employ the same DC voltage and current measure ranges that the standard A/D converter uses. In addition, the voltage digitizing function uses the same DC voltage 10 GΩ input impedance levels to reduce loading significantly on the device under test (DUT).
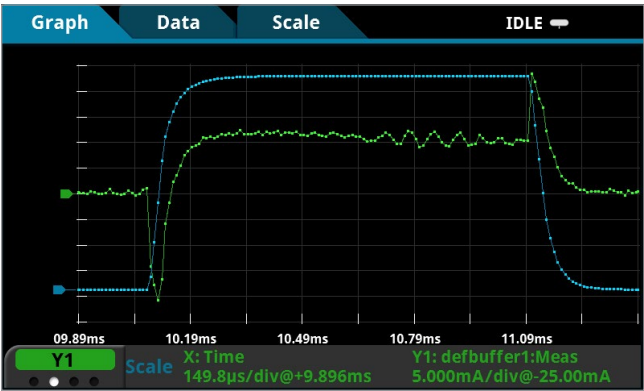
The high speed digitizing function allows capturing and displaying voltage and current measurements simultaneously.

Comparison of 2461 vs. 2420, 2425, 2430, 2440

Feature	2461	2420/2425/2440	2430
Max Voltage	100 V	60 V/100 V/40 V	100 V
Max DC Current	7 A	3 A/3 A/5 A	3 A
Max Pulse Current	10 A	NA	10 A
DC/Pulse Power	100 W/1000 W	Up to 100 W/NA	100 W/1000 W
Digitizers	Dual 18-bit 1 MS/s	None	None
Wideband Noise	<4.5 mVrms typ.	10 mVrms typ.	10 mVrms typ.
Sweep Types	Linear, Log, Dual Linear, Dual Log, Custom	Linear, Log, Custom, Source-Memory	Linear, Log, Custom, Source-Memory
Reading Buffer Size	>2 Million Point Reading Buffer	5000 Point Reading Buffer	5000 Point Reading Buffer
Programming Command Type	SCPI Programming + TSP Scripting	SCPI	SCPI
PC interface	GPIB, USB, Ethernet (LXI)	GPIB, RS-232	GPIB, RS-232
Signal Input Connections	Front: Banana Jacks Rear: Mass Screw Terminal Connection	Front/Rear Banana Jacks	Front/Rear Banana Jacks

2461 SourceMeter® SMU Instrument

All-in-One SMU Instrument

The 2461, built on the fourth generation of the award-winning SourceMeter SMU platform, leverages the proven capabilities of previously introduced high current SMU instruments from Keithley, including the 2420, 2425, and 2440. It offers a highly flexible, four-quadrant voltage and current source/load coupled with precision voltage and current measurements. This all-in-one instrument gives you the capabilities of a:

- Precision power supply with V and I readback

- True current source

- Digital multimeter (DCV, DCI, ohms, and power with 6½-digit resolution)

- Precision electronic load

- Pulse generator

- Trigger controller
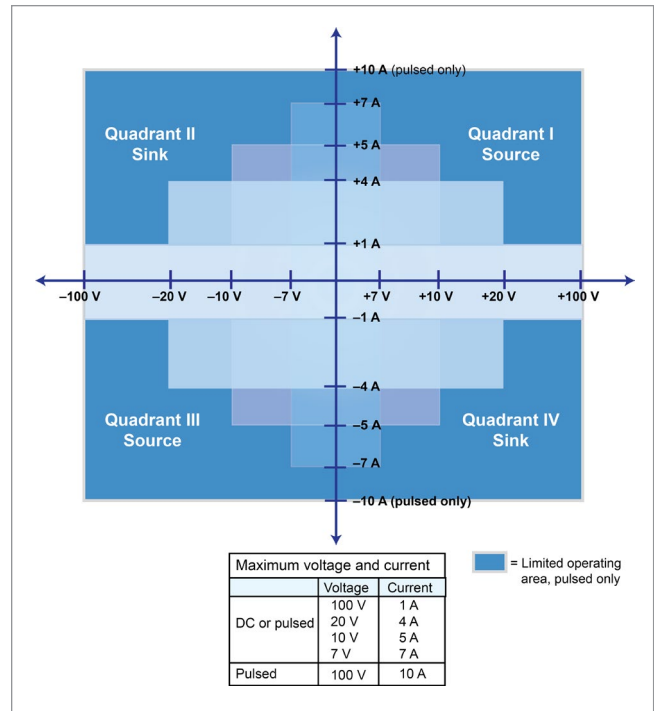
2461 Power Envelope

Ease of Use Beyond the Touchscreen

In addition to its five-inch color touchscreen, the 2461 Graphical SourceMeter front panel offers a variety of features that enhance its speed, user-friendliness, and learnability, including a USB 2.0 memory I/O port, a HELP key, a rotary navigation/control knob, a front/rear input selector button, and banana jacks for basic bench applications. The USB 2.0 memory port simplifies storing test results and instrument configurations, uploading test scripts into the instrument, and installing system upgrades. All front-panel buttons are backlit to enhance visibility in low-light environments.
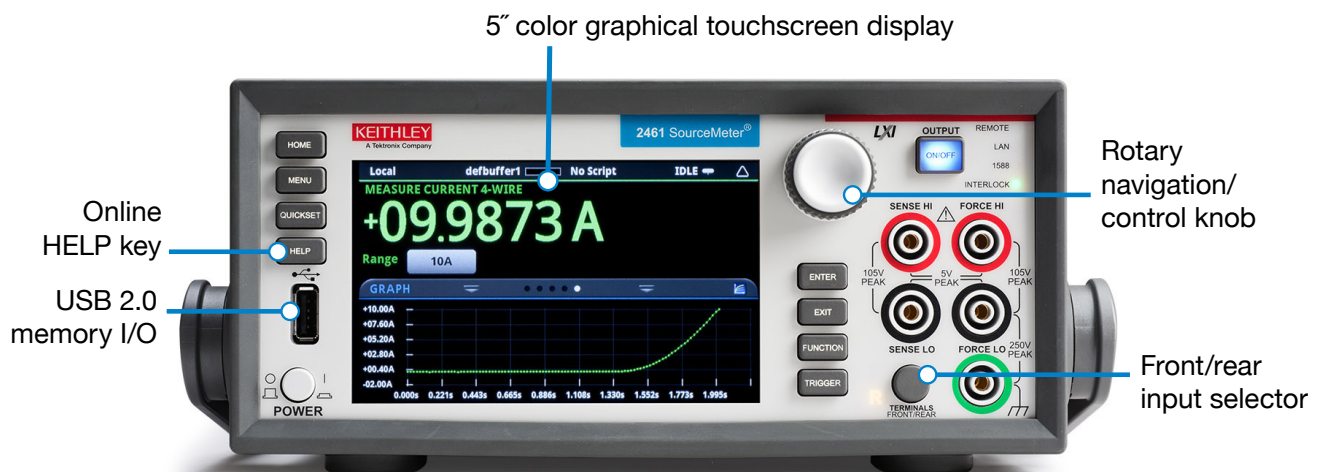

The 2461's high resolution, capacitive touchscreen and front panel controls allow for intuitive operation, even by novice users.

Mass screw terminal connections
Interlock
Ethernet
USB   Digital I/O   TSP-Link
GPIB
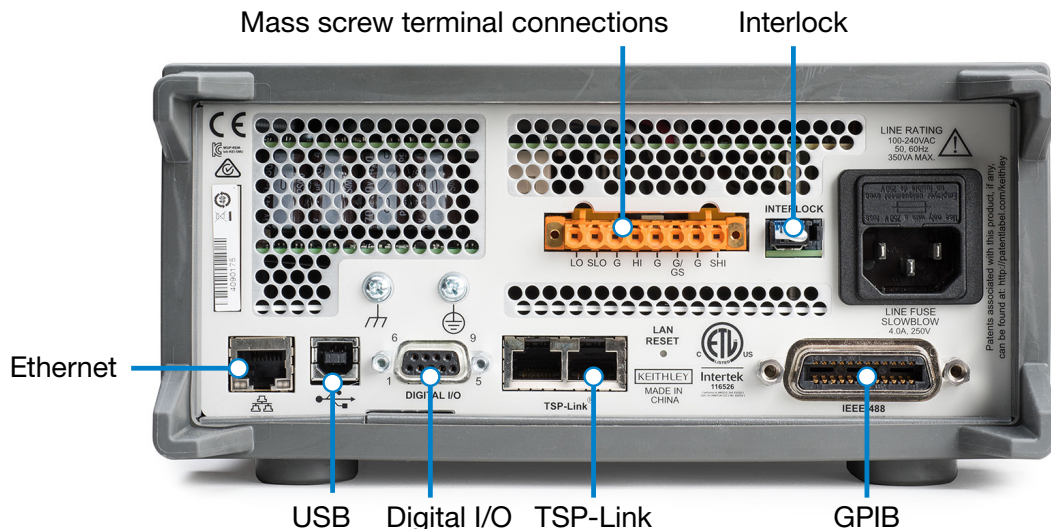
2461 rear panel connections are optimized to maintain signal integrity and speed system setup.

Four "Quickset" modes simplify instrument setup. With one touch, the instrument can be quickly configured for various operating modes without the need to configure the instrument indirectly for this operation.
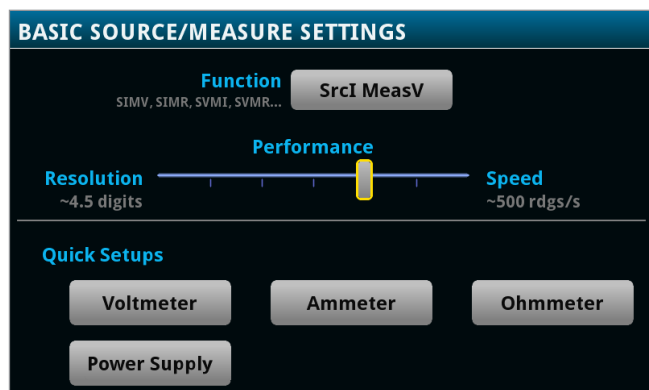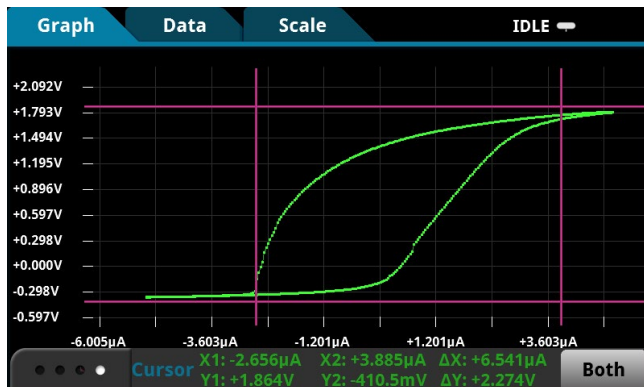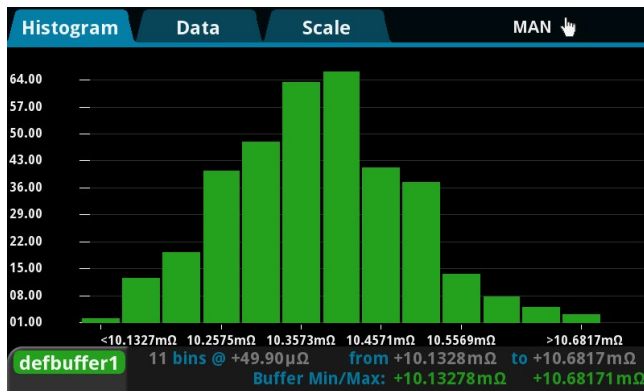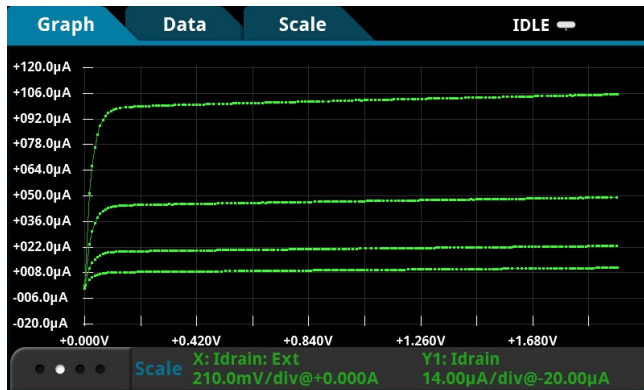

One-touch Quickset modes speed measurement setups and minimize the time to measurements.

Comprehensive Built-in Connectivity

Rear panel access to rear-input connectors, remote control interfaces (GPIB, USB 2.0, and LXI/Ethernet), D-sub 9-pin digital I/O port (for internal/external trigger signals and handler control), instrument interlock control, and TSP-Link® jacks make it simple to configure multiple instrument test solutions and eliminate the need to invest in additional adapter accessories..

Convert Raw Data to Information

A full graphical plotting window converts raw data and displays it immediately as useful information, such as semiconductor I-V curves and digitized waveforms. The touchscreen interface makes it easy to observe, interact with, and explore measurements with "pinch and zoom" simplicity. By using the built-in graphing cursors, you can immediately analyze your data without a PC. All graphic screens can be saved to a USB thumb drive for incorporation into reports and journals. Using the graphical SMU's Sheet view, test data can also be displayed in tabular form. The instrument supports exporting data to a spreadsheet for further analysis, dramatically improving productivity for research, benchtop testing, device qualification, and debugging. This combination of high performance and high ease of use offers unparalleled insight into your test results.

Graph	Data	Scale		IDLE

```
+120.0µA ─
+106.0µA ─
+092.0µA ─
+078.0µA ─
+064.0µA ─
+050.0µA ─
+036.0µA ─
+022.0µA ─
+008.0µA ─
-006.0µA ─
-020.0µA ─
        +0.000V    +0.420V    +0.840V    +1.260V    +1.680V
```

Scale	X: Idrain: Ext	Y1: Idrain
	210.0mV/div@+0.000A	14.00µA/div@-20.00µA

Histogram	Data	Scale		MAN

```
64.00 ─
57.00 ─
50.00 ─
43.00 ─
36.00 ─
29.00 ─
22.00 ─
15.00 ─
08.00 ─
01.00 ─
      <10.1327mΩ  10.2575mΩ  10.3573mΩ  10.4571mΩ  10.5569mΩ   >10.6817mΩ
```

defbuffer1   11 bins @ +49.90µΩ   from +10.1328mΩ   to +10.6817mΩ
Buffer Min/Max: +10.13278mΩ   +10.68171mΩ

Graph	Data	Scale		IDLE

```
+2.092V ─
+1.793V ─
+1.494V ─
+1.195V ─
+0.896V ─
+0.597V ─
+0.298V ─
+0.000V ─
-0.298V ─
-0.597V ─
     -6.005µA   -3.603µA   -1.201µA   +1.201µA   +3.603µA
```

Cursor	X1: -2.656µA	X2: +3.885µA	ΔX: +6.541µA		Both
	Y1: +1.864V	Y2: -410.5mV	ΔY: +2.274V		

READING TABLE

Buffer | Active (defbuffer1)

Buffer Index	Time	Source	Reading
1	04/14 12:56:46.766230	+6.000000 A	+5.98635 V
2	04/14 12:56:46.770194	+6.000000 A	+5.98594 V
3	04/14 12:56:46.774216	+6.000000 A	+5.98594 V
4	04/14 12:56:46.778194	+6.000000 A	+5.98594 V
5	04/14 12:56:46.782211	+6.000000 A	+5.98580 V
6	04/14 12:56:46.786198	+6.000000 A	+5.98649 V
7	04/14 12:56:46.790208	+6.000000 A	+5.98566 V
8	04/14 12:56:46.794203	+6.000000 A	+5.98484 V
9	04/14 12:56:46.798219	+6.000000 A	+5.98594 V
10	04/14 12:56:46.802194	+6.000000 A	+5.98566 V

Built-in functions like real-time graphing, charting, scope-like cursors, and data display spreadsheet for export simplify converting test results into useful information.

Typical Applications

Ideal for current/voltage (I-V) characterization and functional test of a wide range of today's modern electronics and devices, including:

- Power semiconductors and materials
  - SiC, GaN
  - IGBTs, Power MOSFETs, HBLEDs
  - Thyristors
- Power management and protection devices
  - Telecom power management chipsets
  - DC-DC converters
  - Metal-oxide varistors (MOV), transient voltage suppressors (TVS)
- Electrochemistry
  - Galvanic cycling
  - Cyclic voltammetry
  - Electro-deposition
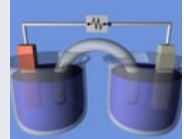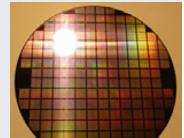
TriggerFlow® Building Blocks for Instrument Control and Execution

The 2461 incorporates Keithley's TriggerFlow triggering system, which provides user control over instrument execution. TriggerFlow diagrams are created in much the same way that flow charts are developed, using four fundamental building block types::

- Wait – Waits for an event to occur before the flow continues

- Branch – Branches when a condition has been satisfied

- Action – Initiates an action in the instrument, for example, measure, source, delay, set digital I/O, etc.

- Notify – Notifies other equipment that an event has occurred
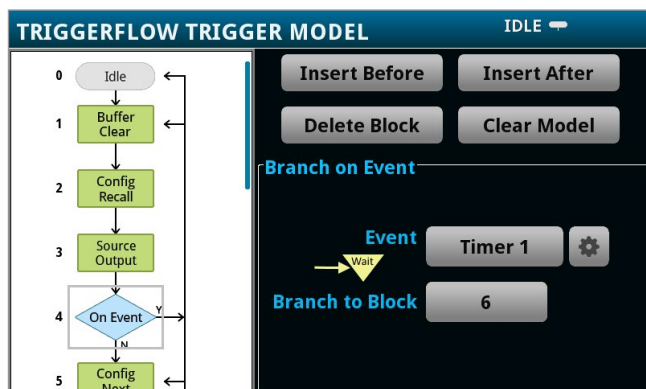
TriggerFlow building blocks allow creating triggering models that range from very simple to highly complex.

A TriggerFlow model using a combination of these building blocks can be created from the front panel or by sending remote commands. With the TriggerFlow system, users can build triggering models from very simple to complex with up to 255 block levels. The 2461 also includes basic triggering functions, including immediate, timer, and manual triggering.

Contact Check Function

The Contact Check function makes it simple to verify good connections quickly and easily before an automated test sequence begins. This eliminates measurement errors and false failures associated with contact fatigue, breakage, contamination, loose or broken connection, relay failures, etc. Some capabilities of this function are:

- <100 µs verification and notification process time

- 3 pass/fail threshold values: 2 Ω, 15 Ω, and 50 Ω

- Enabled remotely over the GPIB, USB, or Ethernet (LXI) interfaces

Unmatched System Integration and Programming Flexibility

When a 2461 is configured into a multi-channel I-V test system, its embedded Test Script Processor (TSP®) allows it to run test scripts, so users can create powerful measurement applications with significantly reduced development times. TSP technology also offers channel expansion without a mainframe. Keithley's TSP-Link® channel expansion bus, which uses a 100 Base T Ethernet cable, can connect multiple graphical SourceMeter SMUs (2450, 2460, 2461), and other TSP instruments such as Keithley's DMM7510 7½-Digit Graphical Sampling Multimeter, Series 2600B System SourceMeter SMU instruments, and Series 3700A Switch/Multimeter systems in a master-slave configuration that operates as one integrated system. The TSP-Link expansion bus supports up to 32 units per GPIB or IP address, making it easy to scale a system to fit an application's particular requirements. The 2461 also includes a SCPI programming mode that takes advantage of all of the instrument's capabilities.

Parallel Test Capability

The TSP technology in the 2461 supports testing multiple devices in parallel to meet the needs of device research, advanced semiconductor lab applications, and even high throughput production test. This parallel testing capability allows each instrument in the system to run its own complete test sequence, creating a fully multi-threaded test environment. The number of tests that can be run in parallel on a graphical SourceMeter can be as high as the number of instruments in the system.
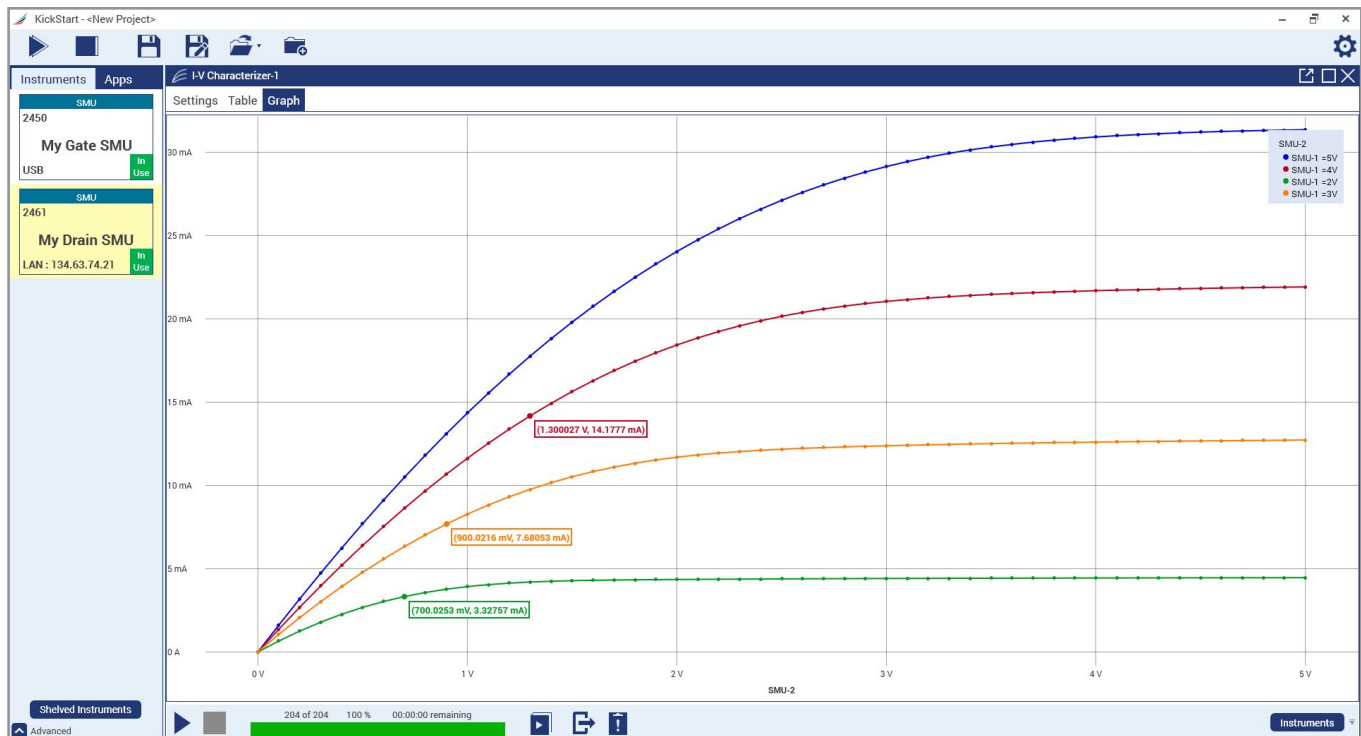
KickStart start-up software lets users be ready to make measurements in minutes.

Instrument Control Start-up Software

KickStart instrument control/start-up software enables users to start making measurements in minutes without programming. In most cases, users merely need to make some quick measurements, graph the data, and store the data to disk for later analysis in software environments such as Excel. KickStart offers:

- Instrument configuration control to perform I-V characterization

- Native X-Y graphing, panning, and zooming

- Spreadsheet/tabular viewing of data

- Saving and exporting of data for further analysis

- Saving of test setups

- Screenshot capturing of graphs

- Annotating of tests

- GPIB, USB 2.0, Ethernet compliance

Optional Apps Tailored for your Characterization Needs

The 2461 is an excellent tool to define nearly any DC test you choose for characterizing materials, electronic devices and modules. For more specific needs, Keithley offers on-instrument software apps that alter the 2461's behavior, fitting your instrument to your needs. These apps can be installed directly to your 2461 by connecting to Keithley's KickStart instrument control software and opening the relevant app in KickStart.

I-V Tracer App

Curve tracing analysis is a critical task for many users in the semiconductor development supply chain. Engineers and technicians both hold the traditional curve tracer as the simplest, fastest method for generating characteristic I-V curves on a device. They are heavily used by engineers in failure analysis and incoming inspection to qualify parts, identify counterfeit devices, and to quickly identify the location of a failure on damaged devices. SMUs have typically been limited to predefined sweeps with longer set up times than curve tracers — until I-V Tracer.

Keithley's I-V Tracer app leverages the touchscreen and front-panel knob of the 2461 to allow precise, live control over the SMU output while viewing I-V results of 2 terminal

devices. At each individual output level current and voltage are measured and plotted. The small footprint of the SMU enables portable bench top use, reserving high power (kW) traditional curve tracers for special cases. The power envelope of the 2461 allows it to comfortably operate in the low power range of traditional curve tracers like the Tektronix 576 and Tektronix 370A, while offering enhanced low current measurements.

AC mode with I-V Tracer, available on the 2461.

Once installed, I-V Tracer exists on the SMU itself, meaning I-V tracer can be used wherever your SMU can go, without a continuous remote connection. It can also integrate with KickStart to enable simple data collection and comparison on the PC, simplifying the preparation of reports used in failure analysis or teaching labs at colleges and universities.

I-V Tracer capabilities with the 2461:

- Use the full DC power envelope of the 2461 (max 100 V or 7 A)

- Trace by sourcing voltage or current, positive or negative

- Use AC polarity to continuously sweep positive and negative about 0 to see the full behavior of your device

- Pulse mode with adjustable pulse width to limit self-heating effects

- 2 or 4-wire sense

- Compare mode for verifying against a reference device

- Reading table view to see exact measurements

- Easily copy curves and settings to your PC with KickStart

Simplified Programming with Ready-to-Use Instrument Drivers

For those who prefer to create their own customized application software, native National Instruments LabVIEW® drivers, as well as IVI-C and IVI-COM drivers, are available at www.keithley.com.

Specifications

Voltage Specifications [1, 2]

Range	Max. DC Current	Source			Measure [3]		
		Resolution	Accuracy (23° ± 5°C) 1 Year ±(% setting + volts)	Noise (RMS) (<10 Hz)	Resolution [4]	Accuracy (23° ± 5°C) 1 Year ±(% rdg. + volts)	Digitizer Accuracy [5] (23° ± 5°C) 1 Year ±(% rdg. + volts)
200.0000 mV	7.35 A	5 µV	0.015% + 200 µV	1 µV	100 nV	0.012% + 200 µV	0.05% + 1.2 mV
2.000000 V	7.35 A	50 µV	0.015% + 300 µV	2 µV	1 µV	0.012% + 300 µV	0.05% + 1.2 mV
7.000000 V	7.35 A	250 µV	0.015% + 2.4 mV	20 µV	1 µV	0.015% + 1 mV	0.05% + 8 mV
10.00000 V	5.25 A	250 µV	0.015% + 2.4 mV	20 µV	10 µV	0.015% + 1 mV	0.05% + 8 mV
20.00000 V	4.20 A	500 µV	0.015% + 2.4 mV	20 µV	10 µV	0.015% + 1 mV	0.05% + 8 mV
100.0000 V	1.05 A	2.5 mV	0.015% + 15 mV	100 µV	100 µV	0.015% + 5 mV	0.05% + 40 mV

Current Specifications [1, 2, 6]

Range	Max. DC Voltage	Source			Measure [3]		
		Resolution	Accuracy (23° ±5°C) 1 Year ±(% setting + amps)	Noise (RMS) (<10 Hz)	Resolution [4]	Accuracy (23° ± 5°C) 1 Year ±(% rdg. + volts)	Digitizer Accuracy [5] (23° ±5°C) 1 Year ±(% rdg. + amps)
1.000000 µA	105 V	50 pA	0.025% + 1 nA	40 pA	1 pA	0.025% + 700 pA	0.05% + 4 nA
10.00000 µA	105 V	500 pA	0.025% + 1.5 nA	40 pA	10 pA	0.025% + 1 nA	0.05% + 8 nA
100.0000 µA	105 V	5 nA	0.020% + 15 nA	100 pA	100 pA	0.020% + 10 nA	0.05% + 80 nA
1.000000 mA	105 V	50 nA	0.020% + 150 nA	1 nA	1 nA	0.020% + 100 nA	0.05% + 800 nA
10.00000 mA	105 V	500 nA	0.020% + 1.5 µA	10 nA	10 nA	0.020% + 1 µA	0.05% + 8 µA
100.0000 mA	105 V	5 µA	0.020% + 15 µA	100 nA	100 nA	0.020% + 10 µA	0.05% + 80 µA
1.000000 A	105 V	50 µA	0.050% + 750 µA	5 µA	1 µA	0.050% + 500 µA	0.05% + 1 mA
4.000000 A	21 V	250 µA	0.100% + 3 mA	25 µA	1 µA	0.100% + 2.5 mA	0.10% + 5 mA
5.000000 A	10.5 V	250 µA	0.100% + 3 mA	25 µA	1 µA	0.100% + 2.5 mA	0.10% + 5 mA
7.000000 A	7.35 V	500 µA	0.150% + 6 mA	125 µA	1 µA	0.150% + 5 mA	0.15% + 10 mA
10.000000 A [7]	7.35 V	500 µA	0.150% + 6 mA	125 µA	10 µA	0.150% + 5 mA	0.15% + 10 mA

Voltage Burden [8]   <100 µV all ranges.

Temperature Coefficient   ±(0.10 × accuracy specification)/°C, 0° to 18 °C and 28° to 50 °C.

Notes

1. Speed = 1 PLC.
2. All specifications guaranteed with output ON.
3. Accuracies apply to 2-wire and 4-wire modes when properly zeroed.
4. Measure resolution 6.5 digits. Digitizer resolution limited by noise.
5. 18-bit ADC. Average of 1000 samples taken at 1 µs intervals. Internal temperature within ±5°C and 1 week of ACAL.
6. Accuracy specifications guaranteed when using 2461-KIT screw terminal accessory for 2461.
7. 10 A range DC specifications valid up to 7.35 A. Operation >7.35 A only in pulse mode. Pulse width and duty cycle limits apply. See Pulse Specifications and Typical Pulse Performance sections for more details on pulse operation.
8. 4-wire mode.

Resistance Measurement Accuracy (Local or Remote Sense) [9, 10, 11]

Range	Resolution [12]	Default Test Current	Normal Accuracy (23°C ±5°C), 1 Year ±(% rdg. + ohms)	Enhanced Accuracy [13] (23°C ±5°C), 1 Year ±(% rdg. + ohms)
<2.000000 Ω [14]	1 µΩ	User defined	Source I_{ACC} + Meas. V_{ACC}	Meas. I_{ACC} + Meas. V_{ACC}
2.000000Ω	1 µΩ	100 mA	0.05 % +0.003Ω	0.04 % +0.001Ω
20.00000Ω	10 µΩ	100 mA	0.05 % +0.003Ω	0.04 % +0.001Ω
200.0000Ω	100 µΩ	10 mA	0.05 % +0.03Ω	0.04 % +0.01Ω
2.000000kΩ	1 mΩ	1 mA	0.05 % +0.3Ω	0.04 % +0.1Ω
20.00000kΩ	10 mΩ	100 µA	0.05 % +3Ω	0.04 % +1Ω
200.0000kΩ	100 mΩ	10 µA	0.05 % +30Ω	0.05 % +10Ω
2.000000 MΩ	1Ω	10 µA	0.06 % +100Ω	0.06 % +50Ω
20.00000 MΩ	10Ω	1 µA	0.14 % +1kΩ	0.12 % +500Ω
200.0000 MΩ	100Ω	100 nA	1.04 % +10kΩ	0.74 % +5kΩ
>200.0000 MΩ [14]	—	User defined	Source I_{ACC} + Meas. V_{ACC}	Meas. I_{ACC} + Meas. V_{ACC}

Temperature Coefficient (0°–18 °C and 28°–50 °C)	±(0.10 × accuracy specification)/°C.
Source Current, Measure Resistance Mode	Total uncertainty = Isource accuracy + Vmeasure accuracy (4-wire remote sense).
Source Voltage, Measure Resistance Mode	Total uncertainty = Vsource accuracy + Imeasure accuracy (4-wire remote sense).

Notes

9. Speed = 1 PLC.
10. All specifications are guaranteed with output ON.
11. Accuracies apply to 2- and 4-wire mode when properly zeroed.
12. 6.5-digit measure resolution.
13. Source readback enabled. Offset compensation ON.
14. Source current, measure resistance or source voltage, measure resistance only

Additional Pulse Mode Source Specifications

Minimum Programmable Pulse Width	150 µs. **Note:** Time for settling and/or measuring may be longer than 150 µs.
Maximum Extended Range Pulse Width	2.5 ms for 7 A and lower ranges, 1ms for 10 A range.
Maximum DC Pulse Width	10,000 seconds.
Pulse Width Programming Resolution	Variable, limited by Pulse Width and Pulse Width Jitter.
Pulse Width Jitter	<(50 µs + 10% of pulse width), typical, A_{CQIN} Readings = OFF.
Maximum Pulse Duty Cycle	10% for 20 V and lower ranges, 5% for 100 V range.

Typical Pulse Performance (Best fixed range, 4W sense)

Source Value	Limit Range and Value	Load	Rise Time (10% to 90%)	Settling Time (1% of range)
100 V	10.5 A	10 Ω	300 µs	520 µs
100 V	1.05 A	200 Ω	180 µs	320 µs
20 V	10 A	2 Ω	150 µs	340 µs
10 A	105 V	10 Ω	300 µs	700 µs
7 A	7.35 V	1 Ω	120 µs	360 µs
5 A	10.5 V	2 Ω	110 µs	280 µs

Contact Check

Contact Check Speed   <100 µs for verification and notification

Resistance Settings	2 Ω	15 Ω	50 Ω
No contact check failure	<1.0 Ω	<10.0 Ω	<40.0 Ω
Always contact check failure	>6.0 Ω	>20.0 Ω	>60.0 Ω

Digitizer Characteristics

Maximum Resolution   18 bits.

Available Measurement Functions   Voltage, Current, Simultaneous Voltage and Current, Resistance, Power.

Sampling Rate [15]   Programmable 1 k through 1 million samples per second .

Volatile Sample Memory with Timestamp   27.5 million.

Minimum Record Time   1 µs.

Timestamp Resolution   1 ns with standard or full buffer style. 1 µs with compact buffer style.

Maximum Record Length   5 million.

Range Selection   Fixed-range required for digitizer measurements.

Measurement Settling Time   Range and load dependent. Accuracy limited by settling time for 10 mA and lower current ranges.

Notes

15. Sample rate is not continuously adjustable. For valid discrete settings, see the Model 2461 Reference Manual.

Supplemental Characteristics

Max. Output Power   1050 W pulse, 105 W DC, four quadrant source or sink operation.

Overrange   105% of range, source and measure.

Regulation   **Voltage:** Line: 0.01% of range. **Load:** 0.01% of range + 100 µV.
Current: Line: 0.01% of range. **Load:** 0.01% of range + 100 pA.

Source Limits

Voltage Source Current Limit   Bipolar current limit set with single value. Min. 10% of range.

Current Source Voltage Limit   Bipolar voltage limit set with single value. Min. 10% of range.

V/I-Limit Accuracy   Add 0.3% of setting and ±0.02% of reading to base specification.

Overshoot

Voltage Source   <0.1% typical. Step size = Full scale, resistive load, 20 V range, 10 mA I-limit).

Current Source   <0.1% typical. Step size = 1mA step, R_{Load} = 10 kΩ, 20 V range)

Range Change Overshoot   Overshoot into a fully resistive 100 kΩ load, 10 Hz to 20 MHz bandwidth, adjacent ranges:
<250 mV typical.

Output Settling Time   Time required to reach within 0.1 % of final value: 20 V range, 100 mA I-limit: <200 µs typical.

Maximum Slew Rate   1 V per µs, 100 V range, 100 mA limit into a 20 kΩ load (typical). 0.6 V per µs, 20 V range, 100 mA limit into a 20 kΩ load (typical).

Over Voltage Protection   User selectable values, 5% ±0.5 V tolerance. Factory default = none.

Voltage Source Noise   10 Hz to 20 MHz (RMS): <4.5m V typical into a resistive load.

Common Mode Voltage   250 V DC.

Common Mode Isolation   >1 GΩ, <1000 pF.

Noise Rejection (typical)

NPLC	NMRR	CMRR
0.01	—	60 dB
0.1	—	60 dB
1	60 dB	100 dB

Load Impedance	**Normal Mode:** 20 nF typical. **High Capacitance Mode:** Stable into 50 µF typical. High-C mode valid for ≥100 µA ranges.
Max. Voltage Drop Between Force and Sense Terminals	5 V.
Max. Sense Lead Resistance	1 MΩ for rated accuracy.
Sense Input Impedance	>10 GΩ.
Guard Offset Voltage	<300 µV, typical

System Measurement Speeds [16]

Reading Rates (readings/second) typical for 60 Hz (50 Hz), script (TSP®) programmed

NPLC	Trigger Origin	Measure to Memory	Measure to GPIB/USB/LAN	Source-Measure to Memory	Source-Measure to GPIB/USB/LAN
0.01	Internal	3050 (2800)	2800 (2500)	1700 (1600)	1650 (1550)
0.01	External	2300 (2100)	2150 (2000)	1650 (1550)	1600 (1450)
0.1	Internal	540 (460)	530 (450)	470 (410)	470 (400)
0.1	External	500 (420)	500 (420)	460 (390)	450 (350)
1	Internal	59 (49)	59 (49)	58 (48)	58 (48)
1	External	58 (48)	58 (48)	57 (48)	57 (46)

Reading Rates (readings/second) typical for 60 Hz (50 Hz), SCPI programmed

NPLC	Trigger Origin	Measure to Memory	Measure to GPIB/USB/LAN	Source-Measure to Memory	Source-Measure to GPIB/USB/LAN
0.01	Internal	3000 (2800)	3000 (2790)	1700 (1600)	1550 (1500)
0.01	External	2330 (2150)	2330 (2150)	1650 (1550)	1500 (1450)
0.1	Internal	540 (460)	540 (460)	470 (410)	460 (400)
0.1	External	510 (430)	510 (430)	470 (400)	460 (390)
1	Internal	59 (49)	59 (49)	58 (48)	58 (48)
1	External	58 (49)	58 (49)	58 (48)	58 (48)

Notes

16. Reading rates applicable for voltage or current measurements, autozero off, autorange off, filter off, binary reading format, and source readback off.

Digitize, Typical

Sampling Rate	Digits	Resolution, Bits	Measure to USB
10 kS/s	5½	18	Up to 10 kS/s
20 kS/s	4½	16	Up to 20 kS/s
50 kS/s	4½	16	Up to 50 kS/s
100 kS/s	4½	15	Up to 100 kS/s
1 MS/s	3½	12	At least 100 kS/s

SCPI Programmed. Buffer style is compact.

General Characteristics (default mode unless specified)

Factory Default Standard Power-Up	SCPI Mode.
Source Output Modes	Fixed DC Level, Memory/Configuration List (mixed function), Sweep (linear and logarithmic), Sweep (dual linear and dual logarithmic.
Memory Buffer	>2 million readings, user adjustable. Includes selected measured value(s) and time stamp.
Real-Time Clock	Lithium battery backup (3 yr.+ battery life).
Remote Interfaces	
GPIB	IEEE-488.2.
USB Device (rear panel, type B)	2.0 Full Speed USBTMC.
USB Device (front panel, type A)	USB 2.0, support for thumb drives.
Ethernet	RJ-45 (10/100BT)
Digital I/O Interface	
Lines	6 Input/Output user defined for digital I/O or triggering.
Connector	9-pin female D.
Input Signal Levels	0.7 V (maximum logic low), 3.7 V (minimum logic high).
Input Voltage Limits	−0.25 V (Abs. minimum), +5.25 V (Abs. maximum).
Maximum Source Current	+2.0 mA @ >2.7 V (per pin).
Maximum Sink Current	−50 mA @ 0.7 V (per pin, solid-state fuse protected).
5 V Power Supply Pin	Limited to 500 mA @ >4 V (solid-state fuse protected).
Handler Interface	Start of test, end of test, 4 category bits.
Programmability	SCPI or TSP command sets.
TSP Mode	Embedded Test Script Processor (TSP) accessible from any host interface.
IP Configuration	Static or DHCP.
Expansion Interface	The TSP-Link expansion interface allows TSP enabled instruments to trigger and communicate with each other.
LXI Compliance	1.4 LXI Core 2011.
Display	5 inch capacitive touch, color TFT WVGA (800×480) with LED backlight.
Input Signal Connections	**Front:** Banana. **Rear:** Mass termination screw terminal.
Interlock	Active High Input.
Cooling	Forced air, variable speed.
Over Temperature Protection	Internally sensed temperature overload puts unit in standby mode.
Power Supply	100 V to 240 V RMS, 50–60 Hz (automatically detected at power up).
VA Rating	350 volt-amps max.
Altitude	Maximum 2000 meters above sea level.
EMC	Conforms to European Union EMC Directive.
Safety	Compliance with CE and NRTL listed to UL61010-1 and UL61010-2-30. Conforms with European Union Low Voltage Directive.
Vibration	MIL-PRF-28800F Class 3 Random.
Warm-Up	1 hour to rated accuracies.
Dimensions	**With bumpers and handle:** 106 mm high × 255 mm wide × 425 mm deep (4.18 in × 10.05 in × 16.75 in). **Without bumpers and handle:** 88 mm high × 213 mm wide × 397 mm deep (3.46 in × 8.39 in × 15.63 in.)
Weight	**With bumpers and handle:** 4.75 kg (10.5 lbs.). **Without bumpers and handle:** 4.55 kg (10.0 lbs.).
Environment	**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.

Ordering Information

2461	100 V, 10 A, 1000 W SourceMeter Instrument

Supplied Accessories

2460-KIT	Rear Panel Mating Mass Terminated Screw Connector
8608	High Performance Test Leads
USB-B-1	USB Cable, Type A to Type B, 1 m (3.3 ft)
CS-1616-3	Safety Interlock Mating Connector
CA-180-3A	TSP-Link/Ethernet Cable
	Documentation CD
	2461 QuickStart Guide
	Test Script Builder Software (available at www.keithley.com)
	KickStart Startup Software (available at www.keithley.com)
	LabVIEW and IVI Drivers (available at www.keithley.com)

Available Accessories

Test Leads and Probes

1754	2-wire Universal 10-Piece Test Lead Kit
5805	Kelvin (4-Wire) Spring-Loaded Probes
5808	Low Cost Single-pin Kelvin Probe Set
5809	Low Cost Kelvin Clip Lead Set
8605	High Performance Modular Test Leads
8606	High Performance Modular Probe Kit
8608	High Performance Clip Lead Set

Cables, Connectors, Adapters

2461-BAN	Screw Terminal Connector to Banana Cable
2461-KIT	Mating Mass Termination Connector
8607	2-Wire, 1000 V Banana Cables, 1 m (3.3 ft.)
CS-1616-3	Safety Interlock Mating Connector

Communication Interfaces & Cables

7007-1	Shielded GPIB Cable, 1 m (3.3 ft)
7007-2	Shielded GPIB Cable, 1 m (6.6 ft)
CA-180-3A	CAT5 Crossover Cable for TSP-Link/Ethernet
KPCI-488LPA	IEEE-488 Interface for PCI Bus
KUSB-488B	IEEE-488 USB-to-GPIB Interface Adapter
USB-B-1	USB Cable, Type A to Type B, 1 m (3.3 ft)

Triggering and Control

2450-TLINK	DB-9 to Trigger Link Connector Adapter.
8501-1	Trigger Link Cable, DIN-to-DIN, 1 m (3.3 ft)
8501-2	Trigger Link Cable, DIN-to-DIN, 2 m (6.6 ft)

Rack Mount Kits

4299-8	Single Fixed Rack Mount Kit
4299-9	Dual Fixed Rack Mount Kit
4299-10	Dual Fixed Rack Mount Kit. Mount one 2461 and one Series 26xxB
4299-11	Dual Fixed Rack Mount Kit. Mount one 2461 and one Series 2400, Series 2000, etc.

Software Options

EC-UPGRADE	Upgrade 2461 SMU to 2461-EC Graphical Potentiostat
Kickstart	Instrument Control Software
ACS Basic Edition	Semiconductor Parametric Test Software for Component and Discrete Devices

Available Services

2461-3Y-EW	1 Year Factory Warranty extended to 3 years from date of shipment
2461-5Y-EW	1 Year Factory Warranty extended to 5 years from date of shipment
C/2461-3Y-17025	KeithleyCare® 3 Year ISO 17025 Calibration Plan
C/2461-3Y-DATA	KeithleyCare 3 Year Calibration w/Data Plan
C/2461-3Y-STD	KeithleyCare 3 Year Std. Calibration Plan
C/2461-5Y-17025	KeithleyCare 5 Year ISO 17025 Calibration Plan
C/2461-5Y-DATA	KeithleyCare 5 Year Calibration w/Data Plan
C/2461-5Y-STD	KeithleyCare 5 Year Std. Calibration Plan
C/NEW DATA	Calibration Data for New Units
C/NEW DATA ISO	ISO-17025 Calibration Data for New Units

Warranty Information

Warranty Summary	This section summarizes the warranties of the 2461. For complete warranty information, refer to the 2461 Reference Manual. Any portion of the product that is not manufactured by Keithley is not covered by this warranty and Keithley will have no duty to enforce any other manufacturer's warranties.
Hardware Warranty	Keithley Instruments, Inc. warrants the Keithley manufactured portion of the hardware for a period of one year from defects in materials or workmanship; provided that such defect has not been caused by use of the Keithley hardware which is not in accordance with the hardware instructions. The warranty does not apply upon any modification of Keithley hardware made by the customer or operation of the hardware outside the environmental specifications.
Software Warranty	Keithley warrants for the Keithley produced portion of the software or firmware will conform in all material respects with the published specifications for a period of ninety (90) days; provided the software is used on the product for which it is intended in accordance with the software instructions. Keithley does not warrant that operation of the software will be uninterrupted or error-free, or that the software will be adequate for the customer's intended application. The warranty does not apply upon any modification of the software made by the customer.

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