The high power Model 2651A is the newest addition to the Series 2600A family of System SourceMeter instruments. Specifically designed to characterize and test high power electronics, these source measurement unit (SMU) instruments can help you improve productivity in applications across the R&D, reliability, and production spectrums, including high brightness LEDs, power semiconductors, DC-DC converters, batteries, and other high power materials, components, modules, and subassemblies.

The Model 2651A, like every Series 2600A SourceMeter instrument, offers a highly flexible, four-quadrant voltage and current source/load coupled with precision voltage and current meters. It can be used as:

- Semiconductor characterization instrument
- V or I waveform generator
- V or I pulse generator
- Precision power supply
- True current source
- Digital multimeter (DCV, DCI, ohms, and power with 6½-digit resolution)
- Precision electronic load

The Model 2651A can source or sink up to ±40V and ±50A.

**Two Measurement Modes: Digitizing or Integrating**

Precisely characterize transient and steady-state behavior, including rapidly changing thermal effects, with the two measurement modes in the Model 2651A. Each mode is defined by its independent analog-to-digital (A/D) converters.

The Digitizing Measurement mode enables 1µs per point measurements. Its 18-bit A/D converters allow you to precisely measure transient characteristics. For more accurate measurements, use its Integrating Measurement mode, which is based on 22-bit A/D converters. The Integrating Measurement mode is provided in all Series 2600A instruments.

**APPLICATIONS**

- Power semiconductor, HBLED, and optical device characterization and testing
- Characterization of GaN, SiC, and other compound materials and devices
- Semiconductor junction temperature characterization
- High speed, high precision digitization
- Electromigration studies
- High current, high power device testing
High power System SourceMeter instrument

50A, High Power System SourceMeter® Instrument

Expansion Capabilities

Through TSP-Link® technology, multiple Model 2651As and other Series 2600A instruments can be combined to form a larger integrated system with up to 64 channels. Precision timing and tight channel synchronization are guaranteed with built-in 500ns trigger controllers. True SMU instrument-per-pin testing is assured with the fully isolated, independent channels of the SourceMeter instruments.

1µV measurement resolution and current sourcing up to 50A (100A with two units) enable low-level Rds measurements to support next-generation devices.

Standard Capabilities of Series 2600A Instruments

Each Model 2651A includes all the features and capabilities provided in the other Series 2600A instruments, such as:

- Ability to be used as either a bench-top I-V characterization tool or as a building block component of multiple-channel I-V test systems
- TSP Express software to quickly and easily perform common I-V tests without programming or installing software
- ACS Basic Edition software for semiconductor characterization (optional). ACS Basic now features a Trace mode for generating a suite of characteristic curves.
- Keithley’s Test Script Processor (TSP®), which enables creation of custom user test scripts to further automate testing, and also supports the creation of programming sequences that allow the instrument to operate asynchronously without direct PC control.
- Parallel test execution and precision timing when multiple Series 2600A instruments are connected together in a system
- LXI Class C compliance
- 14 digital I/O lines for direct interaction with probe stations, component handlers, or other automation tools
- USB port for extra data and test program storage via USB memory device

Accessories Supplied

2651A-KIT-1A: Low Impedance Cable Assembly (1m)
CS-1592-2: High Current Phoenix Connector (male)
CS-1626-2: High Current Phoenix Connector (female)
CA-557-1: Sense Line Phoenix Connector (female)
CA-180-3A: TSP-Link/Ethernet Cable Assembly (1m)
CA-1592-2: High Current Cable Assembly (1m)
CS-1626-2: High Current Cable Assembly (1m)
CS-1592-2: High Current Cable Assembly (1m)

1µV measurement resolution and current sourcing up to 50A (100A with two units) enable low-level Rds measurements to support next-generation devices.

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Model 2651A specifications

**Specification Conditions**

This document contains specifications and supplemental information for the Model 2651A High Power System SourceMeter instrument. Specifications are the standards against which the Model 2651A is tested. Upon leaving the factory, the Model 2651A meets these specifications. Supplemental and typical values are non-warranted, apply at 23°C, and are provided solely as useful information.

Accuracy specifications are applicable for both normal and high-capacitance modes.

**VOLTAGE ACCURACY SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Range</th>
<th>Programming Resolution</th>
<th>Accuracy</th>
<th>Noise (Vpp) (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.000 mV</td>
<td>5 µV</td>
<td>±0.02% + 500 µV</td>
<td>100 µV</td>
</tr>
<tr>
<td>10.0000 V</td>
<td>50 µV</td>
<td>±0.02% + 500 µV</td>
<td>500 µV</td>
</tr>
<tr>
<td>20.0000 V</td>
<td>500 µV</td>
<td>±0.02% + 5 mV</td>
<td>1 mV</td>
</tr>
<tr>
<td>40.0000 V</td>
<td>5000 µV</td>
<td>±0.02% + 12 mV</td>
<td>2 mV</td>
</tr>
</tbody>
</table>

**MEASURE**

<table>
<thead>
<tr>
<th>Default Display Resolution</th>
<th>Integrating ADC Accuracy</th>
<th>High-Speed ADC Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 µA</td>
<td>±0.02% + 500 µV</td>
<td>±0.05% + 600 µV</td>
</tr>
<tr>
<td>10 µA</td>
<td>±0.02% + 500 µV</td>
<td>±0.05% + 600 µV</td>
</tr>
<tr>
<td>100 µA</td>
<td>±0.02% + 5 mV</td>
<td>±0.05% + 8 mV</td>
</tr>
<tr>
<td>1000 µA</td>
<td>±0.02% + 5 mV</td>
<td>±0.05% + 8 mV</td>
</tr>
<tr>
<td>10,000 µA</td>
<td>±0.02% + 12 mV</td>
<td>±0.05% + 15 mV</td>
</tr>
</tbody>
</table>

**CURRENT ACCURACY SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Range</th>
<th>Programming Resolution</th>
<th>Accuracy</th>
<th>Noise (ppp) (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.000 nA</td>
<td>2 pA</td>
<td>±0.1% + 500 pA</td>
<td>50 pA</td>
</tr>
<tr>
<td>1.00000 µA</td>
<td>20 pA</td>
<td>±0.1% + 2 nA</td>
<td>250 pA</td>
</tr>
<tr>
<td>10.0000 µA</td>
<td>200 pA</td>
<td>±0.1% + 10 nA</td>
<td>500 pA</td>
</tr>
<tr>
<td>100.000 µA</td>
<td>2 nA</td>
<td>±0.03% + 60 nA</td>
<td>5 nA</td>
</tr>
<tr>
<td>1.00000 mA</td>
<td>20 nA</td>
<td>±0.03% + 300 nA</td>
<td>10 nA</td>
</tr>
<tr>
<td>10.0000 mA</td>
<td>200 nA</td>
<td>±0.03% + 8 µA</td>
<td>500 nA</td>
</tr>
<tr>
<td>100.000 mA</td>
<td>2 µA</td>
<td>±0.03% + 50 µA</td>
<td>1 µA</td>
</tr>
<tr>
<td>1.00000 A</td>
<td>20 µA</td>
<td>±0.08% + 35 mA</td>
<td>300 µA</td>
</tr>
<tr>
<td>10.0000 A</td>
<td>200 µA</td>
<td>±0.08% + 3.5 mA</td>
<td>300 µA</td>
</tr>
<tr>
<td>5.00000 A</td>
<td>500 µA</td>
<td>±0.15% + 6 mA</td>
<td>500 µA</td>
</tr>
<tr>
<td>10.0000 A</td>
<td>500 µA</td>
<td>±0.15% + 8 mA</td>
<td>500 µA</td>
</tr>
<tr>
<td>50.0000 A</td>
<td>2 mA</td>
<td>±0.15% + 80 mA</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**MEASURE**

<table>
<thead>
<tr>
<th>Default Display Resolution</th>
<th>Integrating ADC Accuracy</th>
<th>High-Speed ADC Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 pA</td>
<td>±0.08% + 500 pA</td>
<td>±0.08% + 800 pA</td>
</tr>
<tr>
<td>10 pA</td>
<td>±0.08% + 2 nA</td>
<td>±0.08% + 4 nA</td>
</tr>
<tr>
<td>100 pA</td>
<td>±0.08% + 8 nA</td>
<td>±0.08% + 10 nA</td>
</tr>
<tr>
<td>1000 pA</td>
<td>±0.08% + 20 nA</td>
<td>±0.08% + 10 nA</td>
</tr>
<tr>
<td>10,000 pA</td>
<td>±0.08% + 200 nA</td>
<td>±0.08% + 100 nA</td>
</tr>
<tr>
<td>100,000 pA</td>
<td>±0.08% + 2000 nA</td>
<td>±0.08% + 1000 nA</td>
</tr>
<tr>
<td>1,000,000 pA</td>
<td>±0.08% + 10000 nA</td>
<td>±0.08% + 10000 nA</td>
</tr>
</tbody>
</table>

**NOTES**

1. Add 50 µV to source accuracy specifications per volt of HI lead drop.
2. For temperatures 0° to 18°C and 28° to 50°C, accuracy is degraded by ±(0.15 × accuracy specification)/°C.
3. High-capacitance mode accuracy is applicable at 23° ±5°C only.
4. Derate accuracy specification for NPLC setting <1 by increasing error term.
5. Add appropriate typical percent of range term for resistive loads using the table below.

<table>
<thead>
<tr>
<th>NPLC Setting</th>
<th>100µV Range</th>
<th>1V to 40V Ranges</th>
<th>100mA Range</th>
<th>1µA to 100mA Ranges</th>
<th>1A to 20A Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>0.01%</td>
<td>0.01%</td>
<td>0.01%</td>
<td>0.01%</td>
<td>0.01%</td>
</tr>
<tr>
<td>0.001</td>
<td>0.8%</td>
<td>0.07%</td>
<td>0.1%</td>
<td>0.09%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

4. 18-bit ADC. Average of 1000 samples taken at 1µs intervals.
5. At temperatures 0° to 18°C and 28° to 50°C, 100mA to 50A accuracy is degraded by ±(0.35 × accuracy specification)/°C.
6. 30A range accuracy is applicable at 23° ±5°C only.
7. 50A range accuracy measurements are taken at 0.008 NPLC.
8. Average of 100 samples taken at 1µs intervals.
DC POWER SPECIFICATIONS

MAXIMUM OUTPUT POWER: 202W maximum.

SOURCE/SINK LIMITS:
- Voltage: ±10.1V at ±20.0A, ±20.2V at ±10.0A, ±40.4V at ±5.0A
  Four-quadrant source or sink operation.
- Current: ±5.0A at ±40V, ±10.1A at ±20V, ±20.2A at ±10V
  Four-quadrant source or sink operation.

CAUTION: Carefully consider and configure the appropriate output-off state and source and compliance levels before connecting the Model 2651A to a device that can deliver energy. Failure to consider the output-off state and source and compliance levels may result in damage to the instrument or to the device under test.

PULSE SPECIFICATIONS

MINIMUM PROGRAMMABLE PULSE WIDTH: 100µs. Note: Minimum pulse width for settled source at a given I/V output and load can be longer than 100µs.

PULSE WIDTH PROGRAMMING RESOLUTION: ±4µs.

PULSE WIDTH PROGRAMMING ACCURACY: ±5µs.

PULSE WIDTH JITTER: ±2µs (typical).

PULSE RISE TIME (TYPICAL):

<table>
<thead>
<tr>
<th>Current Range</th>
<th>Rmin</th>
<th>Rise Time (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 A</td>
<td>0.05 Ω</td>
<td>25 µs</td>
</tr>
<tr>
<td>50 A</td>
<td>0.2 Ω</td>
<td>57 µs</td>
</tr>
<tr>
<td>50 A</td>
<td>0.4 Ω</td>
<td>85 µs</td>
</tr>
<tr>
<td>20 A</td>
<td>0.5 Ω</td>
<td>95 µs</td>
</tr>
<tr>
<td>20 A</td>
<td>1 Ω</td>
<td>180 µs</td>
</tr>
<tr>
<td>10 A</td>
<td>2 Ω</td>
<td>330 µs</td>
</tr>
<tr>
<td>5 A</td>
<td>8.2 Ω</td>
<td>400 µs</td>
</tr>
</tbody>
</table>

NOTES

1. Full power source operation regardless of load to 30°C ambient. Above 30°C or power sink operation, refer to “Operating Boundaries” in the Model 2651A Reference manual for additional power derating information.
2. Quadrants 2 and 4 power envelope is trimmed at 36V and 4.5A.
3. Times measured from the start of pulse to the start offtime; see figure below.
4. Thermally limited in sink mode (quadrants 2 and 4) and ambient temperatures above 30°C. See power equations in the Model 2651A Reference Manual for more information.

**ADDITIONAL SOURCE SPECIFICATIONS**

NOISE (10Hz to 20MHz): <100nV peak-peak (typical), <30nV RMS (typical), 10V range with a 20A limit.

**OVERSHOOT:**
Voltage: \( \pm 0.1\% + 10\text{mV} \) (typical). Step size = 10% to 90% of range, resistive load, maximum current limit/compliance.

**Current:** \( \pm 0.1\% + 10\text{mV} \) (typical). Step Size = 10% to 90% of range, resistive load. See Current Source Output Settling Time specifications for additional test conditions.

**RANGE CHANGE OVERSHOOT:**
Voltage: <300mV + 0.1% of larger range (for <20V ranges) (typical).
<400mV + 0.1% of larger range (for ≥20V ranges) (typical).
Overshoot into a 100kΩ load, 20MHz bandwidth.

Current: <5% of larger range + 160mV/Rload (for >10µA ranges) (typical). \( I_{max} \times R_{load} = 1\text{V} \).

**VOLTAGE SOURCE OUTPUT SETTLING TIME:** Time required to reach within 0.1% of final value after source level command is processed on a fixed range. \(^4\)

<table>
<thead>
<tr>
<th>Range</th>
<th>Settling Time (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 V</td>
<td>&lt; 70 µs</td>
</tr>
<tr>
<td>10 V</td>
<td>&lt;160 µs</td>
</tr>
<tr>
<td>20 V</td>
<td>&lt;190 µs</td>
</tr>
<tr>
<td>40 V</td>
<td>&lt;175 µs</td>
</tr>
</tbody>
</table>

**CURRENT SOURCE OUTPUT SETTLING TIME:** Time required to reach within 0.1% of final value after source level command is processed on a fixed range. Values below for \( I_{max} \times R_{load} \).

<table>
<thead>
<tr>
<th>Current Range</th>
<th>( R_{load} )</th>
<th>Settling Time (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 A</td>
<td>0.5 Ω</td>
<td>&lt;195 µs</td>
</tr>
<tr>
<td>10 A</td>
<td>1.5 Ω</td>
<td>&lt;560 µs</td>
</tr>
<tr>
<td>5 A</td>
<td>5 Ω</td>
<td>&lt;560 µs</td>
</tr>
<tr>
<td>1 A</td>
<td>10 Ω</td>
<td>&lt; 80 µs</td>
</tr>
<tr>
<td>100 mA</td>
<td>1 Ω</td>
<td>&lt; 80 µs</td>
</tr>
<tr>
<td>10 mA</td>
<td>100 Ω</td>
<td>&lt;210 µs</td>
</tr>
<tr>
<td>1 mA</td>
<td>1 kΩ</td>
<td>&lt;300 µs</td>
</tr>
<tr>
<td>100 µA</td>
<td>10 Ω</td>
<td>&lt;500 µs</td>
</tr>
<tr>
<td>10 µA</td>
<td>100 Ω</td>
<td>&lt; 15 ms</td>
</tr>
<tr>
<td>1 µA</td>
<td>1 MΩ</td>
<td>&lt; 35 ms</td>
</tr>
<tr>
<td>100 nA</td>
<td>10 MΩ</td>
<td>&lt;110 ms</td>
</tr>
</tbody>
</table>

**TRANSIENT RESPONSE TIME:**
10V and 20V Ranges: <70µs for the output to recover to within 0.1% for a 10% to 90% step change in load.
40V Range: <110µs for the output to recover to within 0.1% for a 10% to 90% step change in load.

**GUARD OFFSET VOLTAGE:** <4mV, current <10mA.

**REMOTE SENSE OPERATING RANGE:**
Minimum Voltage between HI and SENSE HI: 3V.
Maximum Voltage between LO and SENSE LO: 5V.

**MAXIMUM IMPEDANCE PER SOURCE LEAD:**
Maximum impedance limited by 3V drop by remote sense operating range.
Maximum resistance = \( 3\text{V} / \text{source current value (amperes)} \) (maximum of 10A).\(^2\)

**VOLTAGE OUTPUT HEADROOM:**
Maximum Voltage between HI and SENSE HI: 3V.
Maximum Voltage between LO and SENSE LO: 5V.

**MAXIMUM LOAD IMPEDANCE:**
Normal Mode: 10Ω (typical), 3µH (typical).
High-Capacitance Mode: 50µ (typical), 3µH (typical).
Common Mode Voltage: 250V DC.
Common Mode Isolation: >10GΩ, <4500pF.

**MEASURE INPUT IMPEDANCE:** >10GΩ.

**SENSE HIGH INPUT IMPEDANCE:** >10GΩ.

**MAXIMUM SENSE LEAD RESISTANCE:** 1kΩ for rated accuracy.

**OVER-RANGE:** 10% of sense range, 10% of measure range.

**HIGH-CAPACITANCE MODE** \(^1,2\)

**ACCURACY SPECIFICATIONS:** Accuracy specifications are applicable in both normal and high-capacitance modes.

**VOLTAGE SOURCE OUTPUT SETTLING TIME:** Time required to reach within 0.1% of final value after source level command is processed on a fixed range. \(^4\)

<table>
<thead>
<tr>
<th>Voltage Source Range</th>
<th>Setting Time with ( C_{load} = 4.7\text{µF} ) (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 V</td>
<td>79 µs</td>
</tr>
<tr>
<td>10 V</td>
<td>170 µs</td>
</tr>
<tr>
<td>20 V</td>
<td>200 µs</td>
</tr>
<tr>
<td>40 V</td>
<td>180 µs</td>
</tr>
</tbody>
</table>

**MODE CHANGE DELAY:**
100 µA Current Range and Above:
- Delay into High-Capacitance Mode: 11ms.
- Delay out of High-Capacitance Mode: 11ms.
- Delay into High-Capacitance Mode: 250ms.
- Delay out of High-Capacitance Mode: 11ms.

**MEASURE INPUT IMPEDANCE:** >10GΩ in parallel with 25nF.

**VOLTAGE SOURCE RANGE CHANGE OVERSHOOT:** <100mV + 0.1% of larger range (typical).
Overshoot into a 100kΩ load, 20MHz bandwidth.

**NOTES**
1. High-capacitance mode specifications are for DC measurements only and use locked ranges. Autorange is disabled.
2. 100mA range is not available in high-capacitance mode.
3. Add an additional 2nA to the source current accuracy and measure current accuracy offset for the 1µA range.
4. With measure and compliance set to the maximum current for the specified voltage range.

---

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www.keithley.com
MEASUREMENT SPEED SPECIFICATIONS 1, 2

MAXIMUM SWEEP OPERATION RATES (operations per second) FOR 60Hz (50Hz):

<table>
<thead>
<tr>
<th>A/D Converter Speed</th>
<th>Trigger Origin</th>
<th>Measure To Memory Using User Scripts</th>
<th>Measure To GPIB Using User Scripts</th>
<th>Source Measure To Memory Using User Scripts</th>
<th>Source Measure To GPIB Using User Scripts</th>
<th>Source Measure To Memory Using Sweep API</th>
<th>Source Measure To GPIB Using Sweep API</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001 NPLC</td>
<td>Internal</td>
<td>20000 (20000)</td>
<td>9800 (9800)</td>
<td>7000 (7000)</td>
<td>6200 (6200)</td>
<td>12000 (12000)</td>
<td>5900 (5900)</td>
</tr>
<tr>
<td>0.001 NPLC</td>
<td>Digital I/O</td>
<td>8100 (8100)</td>
<td>7100 (7100)</td>
<td>5500 (5500)</td>
<td>5100 (5100)</td>
<td>11200 (11200)</td>
<td>5700 (5700)</td>
</tr>
<tr>
<td>0.01 NPLC</td>
<td>Internal</td>
<td>4900 (4000)</td>
<td>3900 (3400)</td>
<td>3400 (3000)</td>
<td>3200 (2900)</td>
<td>4200 (3700)</td>
<td>4600 (3500)</td>
</tr>
<tr>
<td>0.01 NPLC</td>
<td>Digital I/O</td>
<td>3500 (4100)</td>
<td>5400 (3800)</td>
<td>3000 (2700)</td>
<td>2900 (2600)</td>
<td>1150 (3650)</td>
<td>3800 (3400)</td>
</tr>
<tr>
<td>0.1 NPLC</td>
<td>Internal</td>
<td>580 (48)</td>
<td>560 (370)</td>
<td>550 (465)</td>
<td>550 (460)</td>
<td>560 (470)</td>
<td>545 (460)</td>
</tr>
<tr>
<td>0.1 NPLC</td>
<td>Digital I/O</td>
<td>550 (460)</td>
<td>550 (460)</td>
<td>540 (450)</td>
<td>540 (450)</td>
<td>560 (470)</td>
<td>545 (460)</td>
</tr>
<tr>
<td>1.0 NPLC</td>
<td>Internal</td>
<td>59 (49)</td>
<td>59 (49)</td>
<td>59 (49)</td>
<td>59 (49)</td>
<td>59 (49)</td>
<td>59 (49)</td>
</tr>
<tr>
<td>1.0 NPLC</td>
<td>Digital I/O</td>
<td>58 (48)</td>
<td>58 (49)</td>
<td>59 (49)</td>
<td>59 (49)</td>
<td>59 (49)</td>
<td>59 (49)</td>
</tr>
<tr>
<td>HS ADC</td>
<td>Internal</td>
<td>38500 (35800)</td>
<td>18000 (18000)</td>
<td>10000 (10000)</td>
<td>9500 (9950)</td>
<td>14500 (14500)</td>
<td>6300 (6300)</td>
</tr>
<tr>
<td>HS ADC</td>
<td>Digital I/O</td>
<td>12500 (12500)</td>
<td>11500 (11500)</td>
<td>7500 (7500)</td>
<td>7000 (7000)</td>
<td>15200 (13200)</td>
<td>6000 (6000)</td>
</tr>
</tbody>
</table>

HIGH SPEED ADC BURST MEASUREMENT RATES 3

<table>
<thead>
<tr>
<th>Burst Length (readings)</th>
<th>Readings per Second</th>
<th>Bursts per Second</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1,000,000</td>
<td>400</td>
</tr>
<tr>
<td>500</td>
<td>1,000,000</td>
<td>80</td>
</tr>
<tr>
<td>1000</td>
<td>1,000,000</td>
<td>40</td>
</tr>
<tr>
<td>2500</td>
<td>1,000,000</td>
<td>16</td>
</tr>
<tr>
<td>5000</td>
<td>1,000,000</td>
<td>8</td>
</tr>
</tbody>
</table>

MAXIMUM SINGLE MEASUREMENT RATES (operations per second) FOR 60Hz (50Hz)

<table>
<thead>
<tr>
<th>A/D Converter Speed</th>
<th>Trigger Origin</th>
<th>Measure To GPIB</th>
<th>Source Measure To GPIB</th>
<th>Source Measure Pass/Fail To GPIB</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001 NPLC</td>
<td>Internal</td>
<td>1900 (1800)</td>
<td>1400 (1400)</td>
<td>1400 (1400)</td>
</tr>
<tr>
<td>0.01 NPLC</td>
<td>Internal</td>
<td>1650 (1400)</td>
<td>1200 (1100)</td>
<td>1100 (1100)</td>
</tr>
<tr>
<td>0.1 NPLC</td>
<td>Internal</td>
<td>450 (390)</td>
<td>425 (370)</td>
<td>425 (375)</td>
</tr>
<tr>
<td>1.0 NPLC</td>
<td>Internal</td>
<td>58 (48)</td>
<td>57 (48)</td>
<td>57 (48)</td>
</tr>
</tbody>
</table>

MAXIMUM MEASUREMENT RANGE CHANGE RATE: >4000 per second for >10µA (typical).
MAXIMUM SOURCE RANGE CHANGE RATE: >325 per second for >10µA, typical. When chang- ing to or from a range ≥ 1A, maximum rate is >250 per second, typical.

COMMAND PROCESSING TIME: Maximum time required for the output to begin to change following the receipt of the smua.source.levelv or smua.source.level command. <1ms typical.

NOTES
1. Fixed source range with no polarity change.

TRIGGERING AND SYNCHRONIZATION SPECIFICATIONS

TRIGGERING:
- Trigger In to Trigger Out: 0.5µs (typical).
- Trigger In to Source Change: 1; 0.5µs (typical).
- Trigger Timer Accuracy: ±2µs (typical).
- Source Change 3 After LXI Trigger: 20µs (typical).

SYNCHRONIZATION:
- Single-Node Synchronized Source Change: 1; <0.5µs (typical).
- Multi-Node Synchronized Source Change: 1; <0.5µs (typical).

NOTES
1. Tests performed with a Model 2651A on channel A using the following equipment: Computer hardware (Intel® Pentium® 4 2.4GHz, 2GB RAM, National Instruments™ PCI-GPIB), Driver (NI-488.2 Version 2.2 PCI-GPIB).
3. Tested with a Model 2651A on channel A using the following equipment: Computer hardware (Intel® Pentium® 4 2.4GHz, 2GB RAM, National Instruments™ PCI-GPIB), Driver (NI-488.2 Version 2.2 PCI-GPIB).
4. Excluding current measurement ranges less than 1mA.
5. smua.measure.adc has to be enabled and the smua.measure.count set to the burst length.
SUPPLEMENTAL INFORMATION

FRONT PANEL INTERFACE: Two-line vacuum fluorescent display (VFD) with keypad and navigation wheel.

DISPLAY:
- Show error messages and user defined messages
- Display source and limit settings
- Show current and voltage measurements (6½-digit to 4½-digit)
- View measurements stored in dedicated reading buffers

KEYPAD OPERATIONS:
- Change host interface settings
- Save and restore instrument setups
- Load and run factory and user defined test scripts that prompt for input and send results to the display
- Store measurements into dedicated reading buffers

PROGRAMMING: Embedded Test Script Processor (TSP®) scripting engine is 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 (for example, branching, looping, and math).
- Able to execute high speed test scripts stored in memory without host intervention.

MINIMUM USER MEMORY AVAILABLE: 16MB (approximately 250,000 lines of TSP 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)
- Intel® Pentium III 800MHz or faster personal computer
- Microsoft Windows® 2000, XP, Vista®, or 7

TSP EXPRESS (embedded): Tool that allows users to quickly and easily perform common I-V tests without programming or installing software. To run TSP Express, you need:
- Java™ Platform, Standard Edition 6
- Microsoft Internet Explorer®, Mozilla® Firefox®, or another Java-compatible web browser

SOFTWARE INTERFACE: TSP Express (embedded), direct GPIB/VISA, read/write with Microsoft Visual Basic®, Visual C++, Visual C#, LabVIEW™, CEC TestPoint™ Data Acquisition Software Package, NI LabWindows®, CVI, etc.

READING BUFFERS: Nonvolatile memory uses dedicated storage areas reserved for measurement data. Reading buffers are arrays of measurement elements. Each element can hold the following items:
- Measurement
- Source setting (at the time the measurement was taken)
- Measurement status
- Range information
- Timestamp

Two reading buffers are reserved for each Model 2651A 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:
- >140,000 samples.
- >10,000 samples.

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

Each Model 2651A has two TSP-Link connectors to make it easier to connect instruments together in sequence.
- Once source-measure instruments are interconnected through the TSP-Link expansion interface, a computer can access all of the resources of each source-measure instrument through the host interface of any Model 2651A
- A maximum of 32 TSP-Link nodes can be interconnected. Each source-measure instrument consumes one TSP-Link node.

TIMER: Free-running 47-bit counter with 1MHz clock input. Resets each time instrument power is turned on. If the instrument is not turned off, the timer is reset to zero every 4 years.

Resolution: 1µs

Timestep Accuracy: ±100ppm.

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www.keithley.com

A GREATER MEASURE OF CONFIDENCE

GENERAL

DIGITAL I/O INTERFACE:

+5VDC

Digital I/O Pin (on DIGITAL I/O connector)

600mA Sold State Fuse

+5VDC

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: +850µA max.

Minimum Logic High Input Voltage: 2.4V: +570µA

Maximum Source Current (flowing out of digital I/O pin): +960µA

Maximum Sink Current At Maximum Logic Low Voltage (0.7V): –5.0mA

5V Power Supply Pin: Limited to 250mA, solid-state fuse protected.

Output Enable Pin: Active high input pulled down internally to ground with a 10kΩ resistor, when the output enable input function has been activated, the Model 2651A channel will not turn on unless the output enable pin is driven to >2.4V (nominal current = 2.1V/10kΩ = 210µA).


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 Model 2651A can use the RS-232 interface to control other instrumentation.

ETHERNET: RJ-45 connector, LXI Class C, 10/100BT, Auto MDIX.

LXI COMPLIANCE: LXI Class C.1.2

Total Output Trigger Response Time: 245µs minimum, 280µs (typical), (not specified) maximum.


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. 3 meters maximum between each TSP-enabled instrument.

USB: USB 2.0 host controller.

POWER SUPPLY: 100V to 250V AC, 50Hz to 60Hz (autosensing). 550VA maximum.

COOLING: Forced air; side and top intake and rear exhaust.

WARRANTY: 1 year.

EMC: Conforms to European Union EMC Directive.


DIMENSIONS: 89mm high × 435mm wide × 549mm deep (3.5 in. × 17.1 in. × 21.6 in.).

BENCH CONFIGURATION (with handle and feet): 104mm high × 483mm wide × 620mm deep (4.1 in. × 19 in. × 24.4 in.).

WEIGHT: 9.98kg (22 lb).

ENVIRONMENT: For indoor use only

ALTIMETER: Maximum 2000 meters above sea level.

OPERATING: 0° to 50°C, 70% relative humidity up to 35°C. Derate 3% relative humidity/°C, 3° to 50°C.

STORAGE: –25° to 65°C.