Model 2450 SourceMeter SMU Instrument

Specifications

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SPECIFICATION CONDITIONS

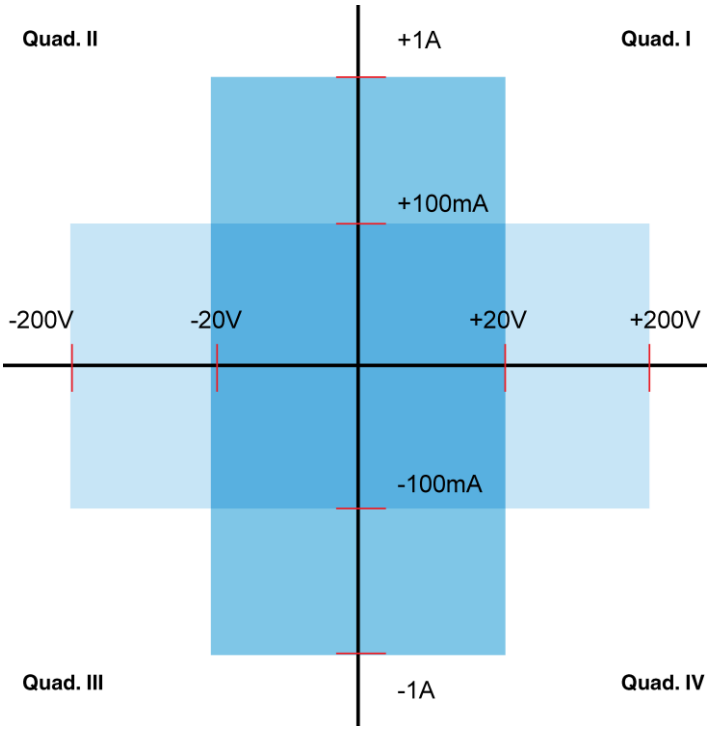
This document contains specifications and supplemental information for the Model 2450 SourceMeter® SMU instrument. Specifications are the standards against which the 2450 is tested. Upon leaving the factory, the 2450 meets these specifications. Supplemental and typical values are nonwarranted, apply at 23 °C, and are provided solely as useful information.

Source and measurement accuracies are specified at the 2450 terminals with A/D autozero enabled.

Calibration period: One year.

DC POWER SPECIFICATIONS

	Voltage	Current
Maximum output power and source limits	20 W maximum ▪ ± 21 V (≤ 1 A range) ▪ ± 210 V (≤ 100 mA range) ▪ Four-quadrant source or sink operation	20 W maximum ▪ ± 1.05 A (≤ 20 V range) ▪ ± 105 mA (≤ 200 V range) ▪ Four-quadrant source or sink operation



VOLTAGE SPECIFICATIONS[1,2]

Source				Measure[3]		
Range	**Resolution**	**Accuracy 23 °C ± 5 °C 1 year ± (% setting + volts)**	**Noise (RMS) <10Hz**	**Resolution**	**Input resistance**	**Accuracy 23 °C ± 5 °C 1 year ± (% reading + volts)**
20.00000 mV	500 nV	0.100% + 200 µV	1 µV	10 nV	> 10 GΩ	0.100% + 150 µV
200.0000 mV	5 µV	0.015% + 200 µV	1 µV	100 nV	> 10 GΩ	0.012% + 200 µV
2.000000 V	50 µV	0.020% + 300 µV	10 µV	1 µV	> 10 GΩ	0.012% + 300 µV
20.00000 V	500 µV	0.015% + 2.4 mV	100 µV	10 µV	> 10 GΩ	0.015% + 1 mV
200.0000 V	5 mV	0.015% + 24 mV	1 mV	100 µV	> 10 GΩ	0.015% + 10 mV
Temperature coefficient: ± (0.15 × accuracy specification)/°C, 0 °C to 18 °C and 28 °C to 50 °C						

CURRENT SPECIFICATIONS[1,2]

Source				Measure[3]		
Range	**Resolution**	**Accuracy[4] 23 °C ± 5 °C 1 year ± (% setting + amps)**	**Noise (RMS) <10Hz**	**Resolution**	**Voltage burden**	**Accuracy 23 °C ± 5 °C 1 year ± (% reading + amps)**
10.00000 nA[5]	500 fA	0.100% + 100 pA	500 fA	10 fA	< 100 µV	0.10% + 50 pA
100.0000 nA[5]	5 pA	0.060% + 150 pA	500 fA	100 fA	< 100 µV	0.060% + 100 pA
1.000000 µA	50 pA	0.025% + 400 pA	5 pA	1 pA	< 100 µV	0.025% + 300 pA
10.00000 µA	500 pA	0.025% + 1.5 nA	40 pA	10 pA	< 100 µV	0.025% + 700 pA
100.0000 µA	5 nA	0.020% + 15 nA	400 pA	100 pA	< 100 µV	0.02% + 6 nA
1.000000 mA	50 nA	0.020% + 150 nA	5 nA	1 nA	< 100 µV	0.02% + 60 nA
10.00000 mA	500 nA	0.020% + 1.5 µA	40 nA	10 nA	< 100 µV	0.02% + 600 nA
100.0000 mA	5 µA	0.025% + 15 µA	100 nA	100 nA	< 100 µV	0.025% + 6 µA
1.000000 A	50 µA	0.067% + 900 µA	3 µA	1 µA	< 100 µV	0.03% + 500 µA
Temperature coefficient: ± (0.15 × accuracy specification)/°C, 0 °C to 18 °C and 28 °C to 50 °C						

[1] Speed = 1 PLC.
[2] All specifications are guaranteed with output ON.
[3] Accuracies apply to 2-wire and 4-wire modes when properly zeroed.
[4] For sink mode, 1 µA to 100 mA range accuracy is: ± (0.15% + offset × 4). For 1 A range, accuracy is: ± (1.5% + offset × 8).
[5] Rear-panel triaxial connections only.

RESISTANCE MEASUREMENT ACCURACY (LOCAL OR REMOTE SENSE)[6,7,8]

Range	Default resolution[9]	Default test current	Normal accuracy 23 °C ± 5 °C 1 year ± (% reading + ohms)	Enhanced accuracy[10] 23 °C ± 5 °C 1 year ± (% reading + ohms)
< 2.000000 Ω[11]	1 µΩ	User-defined	Source I_{ACC} + Meas V_{ACC}	Meas I_{ACC} + Meas V_{ACC}
20.00000 Ω	10 µΩ	100 mA	0.098% + 0.003 Ω	0.073% + 0.001 Ω
200.0000 Ω	100 µΩ	10 mA	0.077% + 0.03 Ω	0.053% + 0.01 Ω
2.000000 kΩ	1 mΩ	1 mA	0.066% + 0.3 Ω	0.045% + 0.1 Ω
20.00000 kΩ	10 mΩ	100 µA	0.063% + 3 Ω	0.043% + 1 Ω
200.0000 kΩ	100 mΩ	10 µA	0.065% + 30 Ω	0.046% + 10 Ω
2.000000 MΩ	1 Ω	1 µA	0.11% + 300 Ω	0.049% + 100 Ω
20.00000 MΩ	10 Ω	1 µA	0.11% + 1 kΩ	0.052% + 500 Ω
200.0000 MΩ	100 Ω	100 nA	0.655% + 10 kΩ	0.349% + 5 kΩ
> 200.0000 MΩ[11]	—	User-defined	Source I_{ACC} + Meas V_{ACC}	Meas I_{ACC} + Meas V_{ACC}
Temperature coefficient: ± (0.15 × accuracy specification)/°C 0 °C to 18 °C and 28 °C to 50 °C				
Source current, measure resistance mode	Total uncertainty = I source accuracy + V measure accuracy (4-wire remote sense)			
Source voltage, measure resistance mode	Total uncertainty = V source accuracy + I measure accuracy (4-wire remote sense)			
Guard output impedance	0.5 Ω (DC) in ohms mode			

SUPPLEMENTAL SPECIFICATIONS

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

[6] Speed = 1 PLC.
[7] All specifications are guaranteed with output ON.
[8] Accuracies apply to 2-wire and 4-wire modes when properly zeroed.
[9] Measure resolution 6.5 digits.
[10] Source readback enabled; offset compensation on.
[11] Source current, measure resistance or source voltage, measure resistance only.

<table>
<tr><td>Source limits</td><td colspan="3">Voltage source current limit:
▪ Bipolar current limit set with a single value
▪ Minimum value is 10% of range
Current source voltage limit:
▪ Bipolar voltage limit set with a single value
▪ Minimum value is 10% of range</td></tr>
<tr><td>V-limit/I-limit accuracy</td><td colspan="3">Add 0.3% of range and ±0.02% of reading to base specification</td></tr>
<tr><td>Overshoot</td><td colspan="3">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 = 1 mA, R_{Load} = 10 kΩ, 20 V range</td></tr>
<tr><td>Range change overshoot</td><td colspan="3">Overshoot into a fully resistive 100 kΩ load, 10 Hz to 20 MHz bandwidth, adjacent ranges: 250 mV typical</td></tr>
<tr><td>Output settling time</td><td colspan="3">Time required to reach within 0.1% of final value after command is processed and output slew:
20 V range, 100 mA I-limit: < 200 µs typical</td></tr>
<tr><td>Maximum slew rate</td><td colspan="3">0.2 V per µs, 200 V range, 100 mA limit into a 20 KΩ load (typical)</td></tr>
<tr><td>Overvoltage protection</td><td colspan="3">User-selectable values, 5% tolerance; factory default = none</td></tr>
<tr><td>Voltage source noise</td><td colspan="3">10 Hz to 1 MHz (RMS): 2 mV typical into a resistive load</td></tr>
<tr><td>Common mode voltage</td><td colspan="3">250 V DC</td></tr>
<tr><td>Common mode isolation</td><td colspan="3">> 1 GΩ, < 1000 pF</td></tr>
<tr><td rowspan="5">Noise rejection (typical)</td><td>NPLC</td><td>NMRR</td><td>CMRR</td></tr>
<tr><td>0.01</td><td>—</td><td>60 dB</td></tr>
<tr><td>0.1</td><td>—</td><td>60 dB</td></tr>
<tr><td>1</td><td>60 dB</td><td>100 dB*</td></tr>
<tr><td colspan="3">* Except lowest two current ranges ~90 dB</td></tr>
<tr><td>Load impedance</td><td colspan="2">Normal mode
▪ 20 nF typical</td><td>High-capacitance mode
▪ Stable into 50 µF typical
▪ High-capacitance mode valid for ≥ 100 µA ranges, ≥ 200 mV ranges</td></tr>
<tr><td>Maximum voltage drop between force and sense terminals</td><td colspan="3">5 V</td></tr>
<tr><td>Maximum sense lead resistance</td><td colspan="3">1 MΩ for rated accuracy</td></tr>
<tr><td>Sense input impedance</td><td colspan="3">> 10 GΩ</td></tr>
<tr><td>Guard offset voltage</td><td colspan="3">< 300 µV typical</td></tr>
</table>

SYSTEM MEASUREMENT SPEEDS[12]

Reading rates (readings per second) typical for 60 Hz (50 Hz), script (TSP) programmed

NPLC	Trigger origin	Measure to memory	Measure to GPIB	Measure to USB	Measure to LAN	Source measure sweep to memory	Source measure sweep to GPIB	Source measure sweep to USB	Source measure sweep to LAN
0.01	Internal	3130 (2800)	2830 (2570)	2825 (2600)	2790 (2530)	1710 (1620)	1620 (1540)	1630 (1540)	1620 (1540)
0.01	External	2170 (2050)	2150 (2030)	2170 (2040)	2160 (1990)	1670 (1590)	1580 (1500)	1590 (1510)	1580 (1510)
0.10	Internal	540 (460)	530 (450)	530 (450)	530 (450)	470 (410)	460 (400)	470 (400)	470 (400)
0.10	External	500 (430)	490 (420)	500 (430)	500 (420)	470 (400)	460 (390)	460 (400)	460 (400)
1.00	Internal	59 (49)	58 (49)	59 (49)	59 (49)	58 (48)	58 (48)	58 (48)	58 (48)
1.00	External	58 (48)	57 (48)	58 (48)	58 (48)	57 (48)	57 (48)	57 (48)	57 (48)

Reading rates (readings per second) typical for 60 Hz (50 Hz), SCPI programmed[13]

NPLC	Trigger origin	Measure to memory	Measure to GPIB	Measure to USB	Measure to LAN	Source measure sweep to memory	Source measure sweep to GPIB	Source measure sweep to USB	Source measure sweep to LAN
0.01	Internal	3130 (2800)	3060 (2760)	3000 (2790)	3010 (2710)	1710 (1630)	1610 (1600)	1440 (1380)	1690 (1590)
0.01	External	2350 (2200)	2320 (2170)	2340 (2190)	2320 (2130)	1680 (1590)	1560 (1570)	1410 (1360)	1660 (1560)
0.10	Internal	540 (460)	540 (450)	540 (460)	540 (450)	470 (410)	470 (410)	450 (390)	470 (410)
0.10	External	510 (440)	510 (430)	510 (440)	510 (430)	470 (400)	470 (400)	450 (390)	470 (400)
1.00	Internal	59 (49)	59 (49)	59 (49)	59 (49)	58 (48)	58 (48)	57 (48)	58 (48)
1.00	External	58 (49)	58 (49)	58 (49)	58 (49)	58 (48)	58 (48)	57 (47)	58 (48)

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

[13] SCPI programming mode. Speeds do not apply to SCPI 2400 mode.

GENERAL CHARACTERISTICS

(Default mode unless specified)

Factory default standard power-up setting	SCPI mode	
Source output modes	▪ Fixed DC level ▪ Memory/configuration list (mixed function) ▪ Stair (linear and logarithmic)	
Source memory list	100 points maximum (SCPI 2400 command set only)	
Memory buffer	> 250,000 readings with selected measured values and timestamp	
Real-time clock	Lithium battery backup (more than 3 years of battery life)	
Remote interfaces	**GPIB:** IEEE Std 488.1 compliant; supports IEEE Std 488.2 common commands and status model topology **USB device (rear panel, type B):** 2.0 full-speed USBTMC **USB host (front panel, type A):** USB 2.0, support for flash drives, FAT32 **Ethernet:** RJ-45 connector, 10/100 BT	
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	1.5 LXI Device Specification 2016	
TSP mode	Embedded Test Script Processor (TSP) accessible from any host interface	
Display	Five-inch capacitive touch, color TFT WVGA (800 × 480) with LED backlight	
Input signal connections	**Front:** Banana **Rear:** Triaxial (3-lug)	
Programmability	SCPI or TSP command sets	
Interlock	Active high-input	
Digital I/O	**Lines**	Six 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 (absolute minimum), +5.25 V (absolute maximum)
	Maximum source current	+2.0 mA at > 2.7 V (per pin)
	Maximum sink current	−50 mA at 0.7 V (per pin, solid-state fuse protected)
	5 V power supply pin	Limited to 500 mA at > 4 V (solid-state fuse protected)
	Handler	User-definable start of test, end of test, four category bits

Cooling	Forced air, variable speed
Overtemperature protection	Internally sensed temperature overload puts instrument in standby mode
Power supply	100 V to 240 V_{RMS}, 50 Hz to 60 Hz (automatically detected at power up)
VA rating	190 VA maximum
Altitude	Maximum 6562 feet (2000 meters) above sea level
EMC	Conforms to European Union EMC Directive
Safety	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	One hour to rated accuracies
Dimensions	**With handle and bumpers:** 106 mm × 255 mm × 425 mm (4.18 in. high × 10.05 in. wide × 16.75 in. deep) **Without handle and bumpers:** 88 mm × 213 mm × 403 mm (3.46 in. high × 8.39 in. wide × 15.87 in. deep)
Weight	**With handle and bumpers:** 4.04 kg (8.9 lb) **Without handle and bumpers:** 3.58 kg (7.9 lb)
Environment	**Operating:** 0 °C to 50 °C, 70% relative humidity up to 35 °C; derate 3% relative humidity/°C, 35 °C to 50 °C **Storage:** −25 °C to 65 °C