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Specifications

SPECIFICATION CONDITIONS

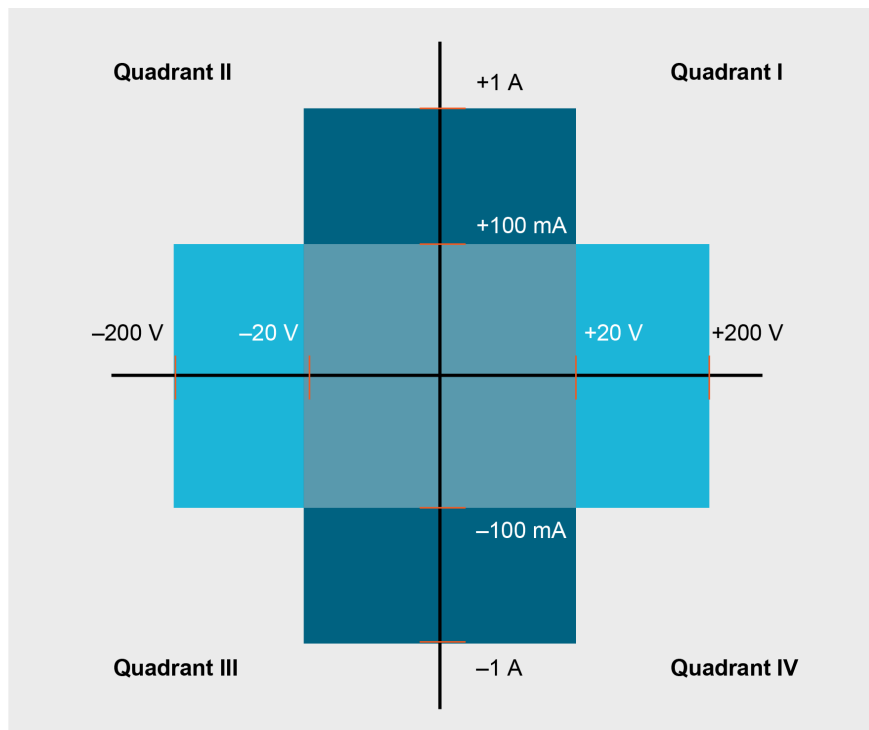
This document contains specifications and supplemental information for the Model 2450 SourceMeter® SMU instrument. Specifications are the standards against which the 2450 is tested. Upon leaving the factory, the 2450 meets these specifications. Supplemental and typical values are nonwarranted, apply 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 <ul style="list-style-type: none"> ▪ $\pm 21\text{ V}$ ($\leq 1\text{ A}$ range) ▪ $\pm 210\text{ V}$ ($\leq 100\text{ mA}$ range) ▪ Four-quadrant source or sink operation 	20 W maximum <ul style="list-style-type: none"> ▪ $\pm 1.05\text{ A}$ ($\leq 20\text{ V}$ range) ▪ $\pm 105\text{ mA}$ ($\leq 200\text{ V}$ 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) < 10 Hz (typical)	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 (typical)	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	<p>Voltage</p> <ul style="list-style-type: none"> ▪ Line: 0.01% of range ▪ Load: 0.01% of range + 100 μV <p>Current</p> <ul style="list-style-type: none"> ▪ 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.

Source limits	Voltage source current limit: <ul style="list-style-type: none"> ▪ Bipolar current limit set with a single value ▪ Minimum value is 10% of range Current source voltage limit: <ul style="list-style-type: none"> ▪ Bipolar voltage limit set with a single value ▪ Minimum value is 10% of range 		
V-limit/I-limit accuracy	Add 0.3% of range and $\pm 0.02\%$ of reading to base specification		
Overshoot	Voltage source: <ul style="list-style-type: none"> ▪ < 0.1% typical ▪ Step size = Full scale, resistive load, 20 V range, 10 mA I-limit Current source: <ul style="list-style-type: none"> ▪ < 0.1% typical ▪ Step size = 1 mA, $R_{LOAD} = 10\text{ k}\Omega$, 20 V range 		
Range change overshoot	Overshoot into a fully resistive 100 k Ω 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 after command is processed and output slew: 20 V range, 100 mA I-limit: < 200 μs typical		
Maximum slew rate	0.2 V per μs , 200 V range, 100 mA limit into a 20 k Ω load (typical)		
Overvoltage protection	User-selectable values, 5% tolerance; factory default = none		
Typical voltage source noise	10 Hz to 1 MHz (RMS): 2 mV typical into a resistive load		
Common mode voltage	250 V dc		
Common mode isolation	> 1 G Ω , < 1000 pF		
Noise rejection (typical)	NPLC	NMRR	CMRR
	0.01	—	60 dB
	0.1	—	60 dB
	1	60 dB	100 dB*
* Except lowest two current ranges ~90 dB			
Load impedance	Normal mode		High-capacitance mode
	<ul style="list-style-type: none"> ▪ 20 nF typical 		<ul style="list-style-type: none"> ▪ Stable into 50 μF typical ▪ High-capacitance mode valid for $\geq 100\text{ }\mu\text{A}$ ranges, $\geq 200\text{ mV}$ ranges
Maximum voltage drop between force and sense terminals	5 V		
Maximum sense lead resistance	1 M Ω for rated accuracy		
Sense input impedance	> 10 G Ω		
Guard offset voltage	< 300 μV typical		

SYSTEM MEASUREMENT SPEEDS¹²**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 programmed¹³

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	<ul style="list-style-type: none"> ▪ 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	<p>GPIO: IEEE Std 488.1 compliant; supports IEEE Std 488.2 common commands and status model topology</p> <p>USB device (rear panel, type B): 2.0 full-speed USBTMC</p> <p>USB host (front panel, type A): USB 2.0, support for flash drives, FAT32</p> <p>Ethernet: RJ-45 connector, 10/100 BT</p>	
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	<p>Front: Banana</p> <p>Rear: Triaxial (3-lug)</p>	
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

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