

**Keithley Instruments**  
28775 Aurora Road  
Cleveland, Ohio 44139  
1-800-833-9200  
[tek.com/keithley](http://tek.com/keithley)

### SPECIFICATION CONDITIONS

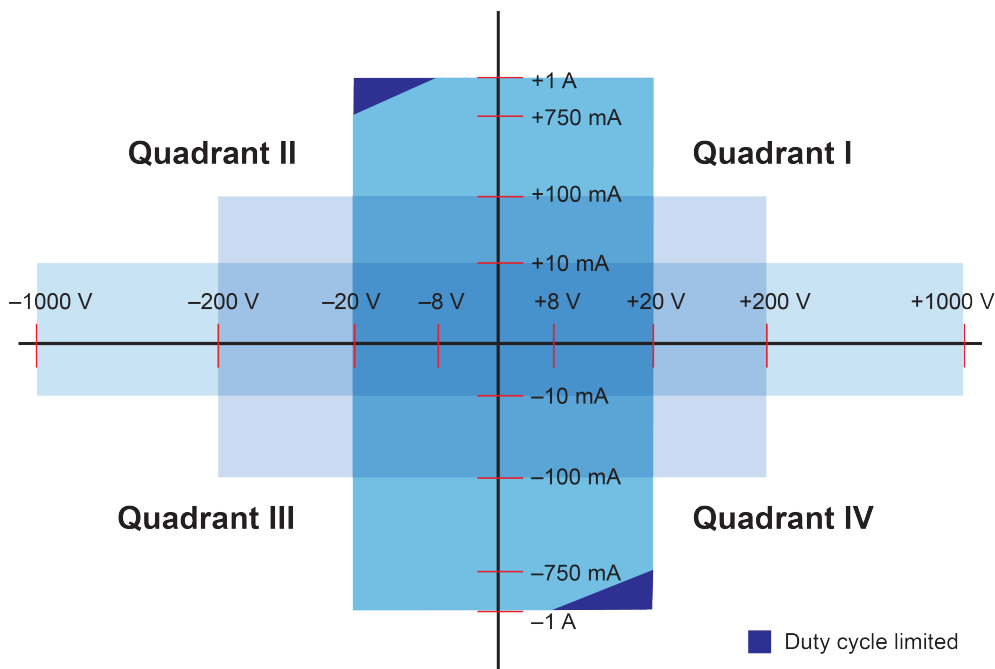
This document contains specifications and supplemental information for the Model 2470 High Voltage SourceMeter® SMU instrument. Specifications are the standards against which the 2470 is tested. Upon leaving the factory, the 2470 meets these specifications. Supplemental and typical values are nonwarranted, apply at 23 °C, and are provided solely as useful information.

Source and measurement accuracies are specified at the 2470 terminals with A/D autozero enabled.

Calibration period: One year.

### DC POWER SPECIFICATIONS

	Voltage	Current
<b>Maximum output power and source limits<sup>1</sup></b>	20 W maximum <ul style="list-style-type: none"> <li>▪ ± 21 V (≤ 1 A range)</li> <li>▪ ± 210 V (≤ 100 mA range)</li> <li>▪ ± 1100 V (≤ 10 mA range)</li> <li>▪ Four-quadrant source or sink operation</li> </ul>	20 W maximum <ul style="list-style-type: none"> <li>▪ ± 1.05 A (≤ 20 V range)</li> <li>▪ ± 105 mA (≤ 200 V range)</li> <li>▪ ± 10.5 mA (≤ 1000 V range)</li> <li>▪ Four-quadrant source or sink operation</li> </ul>



<sup>1</sup> Maximum display and programming ranges are 5% overrange for voltage, except for the 1000 V range, which is 10% overrange (1100 V) and 5% overrange for current (for example, 1.05 A on the 1 A range). Full power source operation regardless of load to 23 °C ambient temperature. Above 23 °C, refer to "Operating Boundaries" in the *Model 2470 Reference Manual* for additional power derating information.



**VOLTAGE SPECIFICATIONS<sup>2,3</sup>**

Range <sup>5</sup>	Source			Measure <sup>4</sup>		
	Resolution	Accuracy <sup>6</sup> 23 °C ± 5 °C 1 year ± (% setting + volts)	Noise (RMS) <10 Hz	Resolution	Input resistance	Accuracy 23 °C ± 5 °C 1 year ± (% reading + volts)
200.0000 mV	5 µV	0.015% + 200 µV	2 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
1000.000 V	50 mV	0.02% + 100 mV	20 mV	10 mV	> 10 GΩ	0.015% + 50 mV

**Temperature coefficient:** ± (0.15 × accuracy specification)/°C, 0 °C to 18 °C and 28 °C to 50 °C

**CURRENT SPECIFICATIONS<sup>2,3</sup>**

Range <sup>5</sup>	Source			Measure <sup>4</sup>		
	Resolution	Accuracy <sup>6</sup> 23 °C ± 5 °C 1 year ± (% setting + amps)	Noise (RMS) <10 Hz	Resolution	Voltage burden	Accuracy 23 °C ± 5 °C 1 year ± (% reading + amps)
10.00000 nA <sup>7</sup>	500 fA	0.100% + 200 pA	500 fA	10 fA	< 100 µV	0.10% + 250 pA
100.0000 nA <sup>7</sup>	5 pA	0.060% + 250 pA	500 fA	100 fA	< 100 µV	0.060% + 300 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	10 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

<sup>2</sup> Speed = 1 PLC.

<sup>3</sup> All specifications are guaranteed with output ON.

<sup>4</sup> Accuracies apply to 2-wire and 4-wire modes when properly zeroed. For the 200 mV and 1 A ranges, the voltage burden may exceed the specification in 2-wire mode.

<sup>5</sup> Maximum display and programming ranges are 5% overrange for voltage, except for the 1000 V range, which is 10% overrange (1100 V), and 5% overrange for current (for example, 1.05 A on the 1 A range).

<sup>6</sup> For sink mode, accuracy is ± (0.15% + offset × 4) except for 1 A range, accuracy is: ± (1.5% + offset × 8).

<sup>7</sup> Rear-panel triaxial connections only.

**RESISTANCE MEASUREMENT ACCURACY (LOCAL OR REMOTE SENSE)<sup>8,9,10</sup>**

Range	Default resolution <sup>11</sup>	Default test current	Normal accuracy 23 °C ± 5 °C 1 year ± (% reading + ohms)	Enhanced accuracy <sup>12</sup> 23 °C ± 5 °C 1 year ± (% reading + ohms)
< 2.000000 Ω <sup>13</sup>	1 μΩ	User-defined	Source I <sub>ACC</sub> + Meas V <sub>ACC</sub>	Meas I <sub>ACC</sub> + Meas V <sub>ACC</sub>
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 <sup>14</sup>	100 Ω	100 nA	0.655% + 10 kΩ	0.349% + 5 kΩ
> 200.0000 MΩ <sup>13, 14</sup>	—	User-defined	Source I <sub>ACC</sub> + Meas V <sub>ACC</sub>	Meas I <sub>ACC</sub> + Meas V <sub>ACC</sub>
<b>Temperature coefficient:</b> ± (0.15 × accuracy specification)/°C 0 °C to 18 °C and 28 °C to 50 °C				
<b>Source current, measure resistance mode</b>		Total uncertainty = I source accuracy + V measure accuracy (4-wire remote sense)		
<b>Source voltage, measure resistance mode</b>		Total uncertainty = V source accuracy + I measure accuracy (4-wire remote sense)		
<b>Guard output impedance</b>		≥ 300 Ω typical		

**SUPPLEMENTAL SPECIFICATIONS**

<b>Overrange</b>	105% of range for 200 mV to 200 V, source and measure ranges 110% of range for 1000 V, source and measure ranges
<b>Regulation</b>	<p><b>Voltage</b></p> <ul style="list-style-type: none"> <li>▪ Line: 0.01% of range</li> <li>▪ Load: 0.01% of range + 100 μV</li> </ul> <p><b>Current</b></p> <ul style="list-style-type: none"> <li>▪ Line: 0.01% of range</li> <li>▪ Load: 0.01% of range + 100 pA</li> </ul>

<sup>8</sup> Speed = 1 PLC.

<sup>9</sup> All specifications are guaranteed with output ON.

<sup>10</sup> Accuracies apply to 2-wire and 4-wire modes when properly zeroed.

<sup>11</sup> Measure resolution 6.5 digits.

<sup>12</sup> Source readback enabled; offset compensation on.

<sup>13</sup> Source current, measure resistance or source voltage, measure resistance only.

<sup>14</sup> Rear-panel triaxial connections only.

<b>Source limits</b>	<b>Voltage source current limit:</b> <ul style="list-style-type: none"> <li>▪ Bipolar current limit set with a single value</li> <li>▪ Minimum value is 10% of range</li> </ul> <b>Current source voltage limit:</b> <ul style="list-style-type: none"> <li>▪ Bipolar voltage limit set with a single value</li> <li>▪ Minimum value is 10% of range</li> </ul>		
<b>Voltage limit/Current limit accuracy</b>	Add 0.3% of range and $\pm 0.02\%$ of reading to base specification		
<b>Overshoot</b>	<b>Voltage source:</b> <ul style="list-style-type: none"> <li>▪ &lt; 0.1% typical</li> <li>▪ Step size = Full scale, resistive load, 20 V range, 10 mA current limit</li> </ul> <b>Current source:</b> <ul style="list-style-type: none"> <li>▪ &lt; 0.1% typical</li> <li>▪ Step size = Full scale, resistive load of 10 k<math>\Omega</math>, 1 mA range, 20 V voltage limit</li> </ul>		
<b>Range change overshoot</b>	Overshoot into a fully resistive 100 k $\Omega$ load, 10 Hz to 20 MHz bandwidth, adjacent ranges: 250 mV typical		
<b>Output settling time</b>	Time required to reach 0.1% of final value after command is processed and output slew: 20 V range, 100 mA current limit: < 200 $\mu$ s typical		
<b>Maximum slew rate<sup>15</sup></b>	0.2 V/ $\mu$ s, 200 V range, 100 mA limit into a 2 k $\Omega$ load (typical) 0.5 V/ $\mu$ s, 1000 V range, 10 mA limit into a 100 k $\Omega$ load (typical)		
<b>Overvoltage protection</b>	User-selectable values, 10% tolerance; factory default = none		
<b>Voltage source noise</b>	10 Hz to 20 MHz (RMS): 4 mV typical into a resistive load		
<b>Common mode voltage</b>	250 V DC		
<b>Common mode isolation</b>	> 1 G $\Omega$ , < 1000 pF		
<b>Noise rejection (typical)</b>	<b>NPLC</b>	<b>NMRR</b>	<b>CMRR</b>
	0.01	—	60 dB
	0.1	—	60 dB
	1	60 dB	100 dB*
* Except 10 nA and 100 nA current ranges ~90 dB			
<b>Load impedance</b>	<b>Normal mode</b>		<b>High-capacitance mode</b>
	20 nF typical		Stable into 1 $\mu$ F typical (specification only valid for ranges $\geq$ 100 $\mu$ A)
<b>Maximum voltage drop between force and sense terminals</b>	5 V		
<b>Maximum sense lead resistance</b>	1 M $\Omega$ for rated accuracy		
<b>Sense input impedance</b>	> 10 G $\Omega$		
<b>Guard offset voltage</b>	< 300 $\mu$ V typical		

<sup>15</sup> High-capacitance mode off.

**SYSTEM MEASUREMENT SPEEDS<sup>16</sup>****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	3150 (2800)	2760 (2570)	2825 (2570)	2740 (2530)	1710 (1620)	1620 (1540)	1630 (1540)	1620 (1540)
0.01	External	2170 (2050)	2120 (2003)	2170 (2010)	2100 (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 (425)	480 (420)	470 (400)	450 (390)	460 (390)	410 (350)
1.00	Internal	59 (49)	58 (49)	59 (49)	59 (49)	58 (48)	58 (48)	58 (48)	57 (48)
1.00	External	58 (48)	57 (48)	58 (48)	58 (48)	57 (48)	57 (48)	57 (48)	55 (48)

**Reading rates (readings per second) typical for 60 Hz (50 Hz), SCPI programmed<sup>17</sup>**

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	3040 (2800)	3000 (2760)	3000 (2760)	3010 (2710)	1710 (1630)	1610 (1544)	1440 (1380)	1690 (1590)
0.01	External	2320 (2165)	2290 (2140)	2340 (2150)	2290 (2130)	1680 (1590)	1560 (1525)	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)

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

<sup>17</sup> SCPI programming mode.

**GENERAL CHARACTERISTICS**

(Default mode unless specified)

<b>Factory default standard power-up setting</b>	SCPI mode	
<b>Source output modes</b>	<ul style="list-style-type: none"> <li>▪ Fixed DC level</li> <li>▪ Memory/configuration list (mixed function)</li> <li>▪ Stair (linear and logarithmic)</li> </ul>	
<b>Memory buffer</b>	> 5,000,000 readings with selected measured values and timestamp	
<b>Real-time clock</b>	Lithium battery backup (more than 3 years of battery life)	
<b>Remote interfaces</b>	<p><b>GPIO:</b> IEEE Std 488.1 compliant; supports IEEE Std 488.2 common commands and status model topology</p> <p><b>USB device (rear panel, type B):</b> 2.0 full-speed USBTMC</p> <p><b>USB host (front panel, type A):</b> USB 2.0, support for flash drives, FAT32</p> <p><b>Ethernet:</b> RJ-45 connector, 10/100 BT</p>	
<b>IP configuration</b>	Static or DHCP	
<b>Expansion interface</b>	The TSP-Link® expansion interface allows TSP-enabled instruments to trigger and communicate with each other	
<b>LXI compliance</b>	1.5 LXI Device Specification 2016	
<b>TSP mode</b>	Embedded Test Script Processor (TSP) accessible from any host interface	
<b>Display</b>	Five-inch capacitive touch, color TFT WVGA (800 × 480) with LED backlight	
<b>Input signal connections</b>	<p><b>Front:</b> Banana</p> <p><b>Rear:</b> High-voltage triaxial</p>	
<b>Programmability</b>	SCPI or TSP command sets	
<b>Interlock</b>	Active high-input	
<b>Digital I/O</b>	<b>Lines</b>	Six input/output, user-defined, for digital I/O or triggering
	<b>Connector</b>	9-pin female D
	<b>Input signal levels</b>	0.7 V (maximum logic low), 3.7 V (minimum logic high)
	<b>Input voltage limits</b>	−0.25 V (absolute minimum), +5.25 V (absolute maximum)
	<b>Maximum source current</b>	+2.0 mA at > 2.7 V (per pin)
	<b>Maximum sink current</b>	−50 mA at 0.7 V (per pin, solid-state fuse protected)
	<b>5 V power supply pin</b>	Limited to 500 mA at > 4 V (solid-state fuse protected)
	<b>Handler</b>	User-definable start of test, end of test, four category bits
<b>Cooling</b>	Forced air, variable speed	
<b>Overtemperature protection</b>	Internally sensed temperature overload puts instrument in standby mode	
<b>Power supply</b>	100 V <sub>RMS</sub> to 240 V <sub>RMS</sub> , 50 Hz or 60 Hz (automatically detected at power up)	
<b>VA rating</b>	220 VA maximum	
<b>Altitude</b>	Maximum 2000 meters (6562 feet) above sea level	
<b>EMC</b>	Conforms to European Union EMC Directive	

<b>Safety</b>	NRTL listed to UL61010-1 and UL61010-2-30 Conforms to European Union Low Voltage Directive
<b>RoHS</b>	Conforms to European Union Restriction on Hazardous Substances Directive
<b>Vibration</b>	MIL-PRF-28800F Class 3 Random
<b>Warm up</b>	One hour to rated accuracies
<b>Dimensions</b>	<b>With handle and bumpers:</b> 106 mm x 255 mm x 425 mm (4.18 in. high x 10.05 in. wide x 16.75 in. deep) <b>Without handle and bumpers:</b> 88 mm x 213 mm x 403 mm (3.46 in. high x 8.39 in. wide x 15.87 in. deep)
<b>Weight</b>	<b>With handle and bumpers:</b> 4.54 kg (10.0 lb) <b>Without handle and bumpers:</b> 4.08 kg (9.0 lb)
<b>Environment</b>	<b>Operating:</b> 0 °C to 50 °C, 70% relative humidity up to 35 °C; derate 3% relative humidity/°C, 35 °C to 50 °C <b>Storage:</b> -25 °C to 65 °C <b>Pollution Category:</b> 2

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