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System SourceMeter Instrument Specifications

SPECIFICATION CONDITIONS

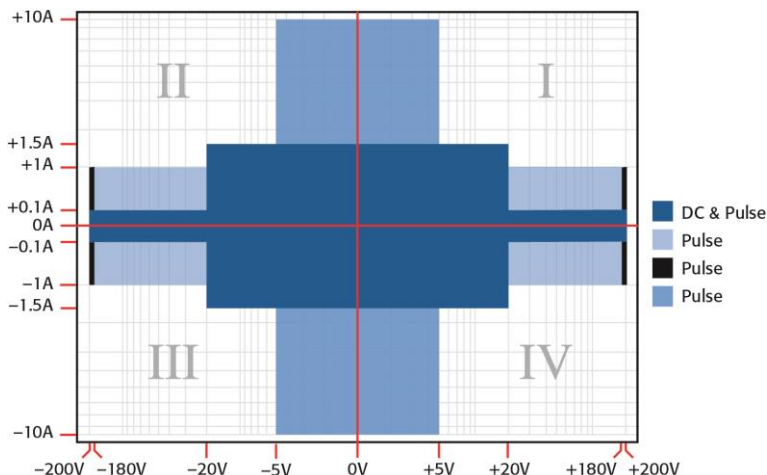
This document contains specifications and supplemental information for the Models 2611B, 2612B, and 2614B System SourceMeter™ instruments. Specifications are the standards against which the 2611B, 2612B, and 2614B are tested. Upon leaving the factory, the 2611B, 2612B, and 2614B meet these specifications. 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 2611B, 2612B, and 2614B terminals under these conditions:

- 18 °C to 28 °C, < 70 percent relative humidity
- After a two-hour warm-up period
- Speed normal (1 NPLC)
- A/D autozero enabled
- Remote sense operation or properly zeroed local operation
- Calibration period: One year

DC POWER SPECIFICATIONS

	Voltage	Current
Maximum output power and source/sink limits¹	30.3 W maximum per channel <ul style="list-style-type: none"> ▪ ± (20.2 V at 1.5 A, -1.5 A) ▪ ± (202 V at 100 mA, -100 mA) ▪ Four-quadrant source or sink operation 	30.3 W maximum per channel <ul style="list-style-type: none"> ▪ ± (1.515 A at 20 V, -20 V) ▪ ± (101 mA at 200 V, -200 V) ▪ Four-quadrant source or sink operation



Refer to [Pulse characteristics](#) for pulsing details, such as duty cycle and pulse width.

¹ Full power source operation regardless of load or number of channels used to 30 °C ambient temperature. Above 30 °C or power sink operation, refer to “Operating Boundaries” in the Series 2600B Reference Manual for additional power derating information.



VOLTAGE ACCURACY SPECIFICATIONS^{2, 3}

Range	Source			Measure	
	Programming resolution	Accuracy ± (% reading + volts)	Typical noise (peak to peak) 0.1 Hz to 10 Hz	Display resolution	Accuracy ⁴ ± (% reading + volts)
200 mV	5 µV	0.02% + 375 µV	20 µV	100 nV	0.015% + 225 µV
2 V	50 µV	0.02% + 600 µV	50 µV	1 µV	0.02% + 350 µV
20 V	500 µV	0.02% + 5 mV	300 µV	10 µV	0.015% + 5 mV
200 V	5 mV	0.02% + 50 mV	2 mV	100 µV	0.015% + 50 mV

CURRENT ACCURACY SPECIFICATIONS^{2, 5}

Range	Source			Measure	
	Programming resolution	Accuracy ± (% reading + amperes)	Typical noise (peak to peak) 0.1 Hz to 10 Hz	Display resolution	Accuracy ⁴ ± (% reading + amperes)
100 nA	2 pA	0.06% + 100 pA	5 pA	100 fA	0.06% + 100 pA
1 µA	20 pA	0.03% + 800 pA	25 pA	1 pA	0.025% + 500 pA
10 µA	200 pA	0.03% + 5 nA	60 pA	10 pA	0.025% + 1.5 nA
100 µA	2 nA	0.03% + 60 nA	3 nA	100 pA	0.02% + 25 nA
1 mA	20 nA	0.03% + 300 nA	6 nA	1 nA	0.02% + 200 nA
10 mA	200 nA	0.03% + 6 µA	200 nA	10 nA	0.02% + 2.5 µA
100 mA	2 µA	0.03% + 30 µA	600 nA	100 nA	0.02% + 20 µA
1 A	20 µA	0.05% + 1.8 mA	70 µA	1 µA	0.03% + 1.5 mA
1.5 A	50 µA	0.06% + 4 mA	150 µA	1 µA	0.05% + 3.5 mA
10 A ⁶	200 µA	0.5% + 40 mA	N/A	10 µA	0.4% + 25 mA

² For temperatures 0 °C to 18 °C and 28 °C to 50 °C, accuracy is degraded by ± (0.15 × accuracy specification)/°C. High-capacitance mode accuracy is applicable at 23 °C ± 5 °C.

³ Add 50 µV to source accuracy specifications per volt of HI lead drop.

⁴ Derate accuracy specification for NPLC setting < 1 by increasing the error term. Add appropriate typical percent of reading term for resistive loads using the table below.

NPLC setting	200 mV range	2 V and 200 V ranges	100 nA range	1 µA to 100 mA ranges	1 A to 1.5 A ranges
0.1	0.01%	0.01%	0.01%	0.01%	0.01%
0.01	0.08%	0.07%	0.1%	0.05%	0.05%
0.001	0.8%	0.6%	1%	0.5%	1.1%

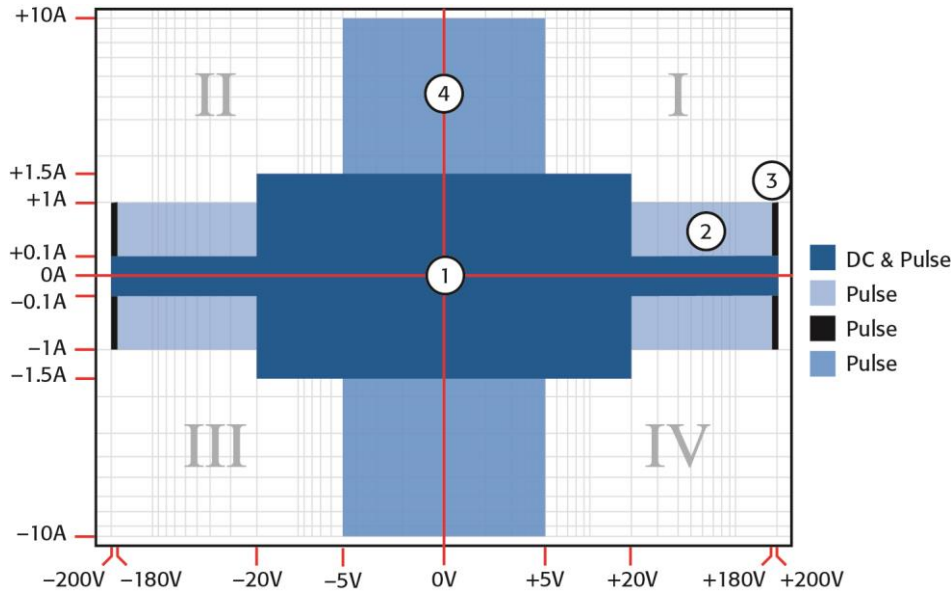
⁵ Accuracy specifications do not include connector leakage. Derate accuracy by $V_{OUT}/2E11$ per °C when operating between 18 °C and 28 °C. Derate accuracy by $V_{OUT}/2E11 + (0.15 \cdot V_{OUT}/2E11)$ per °C when operating < 18 °C and > 28 °C.

⁶ 10 A range is accessible in pulse mode only. Accuracy specifications for 10 A range are typical.

SUPPLEMENTAL CHARACTERISTICS

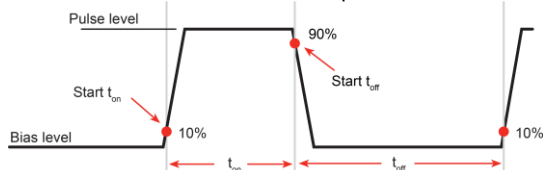
The following specifications are supplemental characteristics that provide additional information about instrument functions and performance. These characteristics are nonwarranted specifications; they describe the typical performance of the 2611B, 2612B, and 2614B.

PULSE CHARACTERISTICS



Pulse region specifications			
Region quadrant diagram	Region maximums	Maximum pulse width ⁷	Maximum duty cycle ⁸
1	100 mA at 200 V	DC, no limit	100%
1	1.5 A at 20 V	DC, no limit	100%
2	1 A at 180 V	8.5 ms	1%
3 ⁹	1 A at 200 V	2.2 ms	1%
4	10 A at 5 V	1 ms	2.2%

⁷ Times measured from the start of pulse to the start off-time; see figure below.



⁸ Thermally limited in sink mode (quadrants 2 and 4) and ambient temperatures above 30° C. See power equations in the Series 2600B Reference Manual for more information.

⁹ Voltage source operation with 1.5 A current limit.

Minimum programmable pulse width⁷	100 μ s			
	<ul style="list-style-type: none"> Note: Minimum pulse width for settled source at a given I-V output and load can be longer than 100 μs. 			
	Source value	Load	Source settling time (% of range)	Minimum pulse width
	5 V	0.5 Ω	1%	300 μ s
	20 V	200 Ω	0.2%	200 μ s
	180 V	180 Ω	0.2%	5 ms
	200 V (1.5 A limit)	200 Ω	0.2%	1.5 ms
	100 mA	200 Ω	1%	200 μ s
	1 A	200 Ω	1%	500 μ s
1 A	180 Ω	0.2%	5 ms	
10 A	0.5 Ω	0.5%	300 μ s	
Pulse width programming resolution	1 μ s			
Pulse width programming accuracy	\pm 5 μ s			
Pulse width jitter	2 μ s			

ADDITIONAL SOURCE CHARACTERISTICS

Noise 10 Hz to 20 MHz	<p>< 20 mV peak-peak, < 3 mV_{RMS}</p> <ul style="list-style-type: none"> 20 V range
Transient response time	< 70 μ s for the output to recover to within 0.1% for a 10% to 90% step change in load
Overshoot	<p>Voltage:</p> <ul style="list-style-type: none"> < \pm0.1% + 10 mV Step size = 10% to 90% of range, resistive load, maximum current limit/compliance <p>Current:</p> <ul style="list-style-type: none"> < \pm0.1% Step size = 10% to 90% of range, resistive load See Current source output settling time for additional test conditions
Range change overshoot	<p>Voltage:</p> <ul style="list-style-type: none"> < 300 mV + 0.1% of larger range Overshoot into a 200 kΩ load, 20 MHz bandwidth <p>Current:¹⁰</p> <ul style="list-style-type: none"> < 300 mV/R_{LOAD} + 5% of larger range
Guard offset voltage	<p>< 4 mV</p> <ul style="list-style-type: none"> Current < 10 mA
Remote sense operating range¹¹	<p>Maximum voltage between HI and SENSE HI = 3 V</p> <p>Maximum voltage between LO and SENSE LO = 3 V</p>

¹⁰ With source settling set to SETTLE_SMOOTH_100NA

Voltage output headroom	200 V range <ul style="list-style-type: none"> ▪ Maximum output voltage = 202.3 V – (total voltage drop across source leads). Maximum 1 Ω source lead. 20 V range <ul style="list-style-type: none"> ▪ Maximum output voltage = 23.3 V – (total voltage drop across source leads). Maximum 1 Ω source lead. 	
Over-temperature protection	Internally sensed temperature overload puts the instrument in standby mode	
Limit/compliance	Bipolar limit (compliance) set with a single value Voltage: ¹² <ul style="list-style-type: none"> ▪ Minimum value is 20 mV; accuracy is the same as voltage source Current: ¹³ <ul style="list-style-type: none"> ▪ Minimum value is 10 nA; accuracy is the same as current source 	
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.	
	Voltage range	Settling time
	200 mV	< 50 μs
	2 V	< 50 μs
	20 V	< 110 μs
200 V	< 700 μs	
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	
	<ul style="list-style-type: none"> ▪ Values below for $I_{OUT} \times R_{LOAD} = 2 V$ 	
	Current range	Settling time
	1.5 A and 1 A	< 120 μs ($R_{LOAD} > 6 \Omega$)
	100 mA and 10 mA	< 80 μs
	1 mA	< 100 μs
	100 μA	< 150 μs
	10 μA	< 500 μs
	1 μA	< 2 ms
100 nA	< 20 ms	

¹¹ Add 50 μV to source accuracy specifications per volt of HI lead drop.

¹² For sink operation (quadrants II and IV) without sink mode enabled, add 10% of compliance range and ±0.02% of limit settling to the corresponding voltage source accuracy specifications. For 200 mV range, add an additional 120 mV of uncertainty. Specifications apply with sink mode enabled.

¹³ For sink operation (quadrants II and IV) without sink mode enabled, add 0.06% of limit range to the corresponding current limit accuracy specifications. Specifications apply with sink mode enabled.

ADDITIONAL MEASUREMENT CHARACTERISTICS

Contact check specifications ^{14, 15}	Speed	Maximum measurement time to memory for 60 Hz (50 Hz)	Accuracy (1 year) 23° C ± 5° C ± (% reading + ohms)
	Fast	1.1 ms (1.2 ms)	5% + 10 Ω
	Medium	4.1 ms (5 ms)	5% + 1 Ω
	Slow	36 ms (42 ms)	5% + 0.3 Ω
Current measure settling time ¹⁶	Time required to reach within 0.1% of final value after source level command is processed on a fixed range Values below for $V_{OUT} = 2\text{ V}$		
	Current range	Settling time	
	1 mA	< 100 μs	
Input impedance	> 10 GΩ		

ADDITIONAL CHARACTERISTICS

Maximum load impedance	Normal mode 10 nF	High-capacitance mode 50 μF
Common mode voltage	250 V dc	
Common mode isolation	> 1 GΩ < 4500 pF	
Sense high input impedance	> 10 GΩ	
Maximum sense lead resistance	1 kΩ for rated accuracy	
Overrange	101% of source range 102% of measure range	

¹⁴ Includes measurement of SENSE HI to HI and SENSE LO to LO contact resistances.¹⁵ Contact check is not available with the Model 2614B.¹⁶ Compliance equal to 100 mA

HIGH CAPACITANCE MODE^{17, 18, 19}

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 Current limit = 1 A	
	Voltage range	Settling time with C_{LOAD} = 4.7 μF
	200 mV	< 600 μ s
	2 V	< 600 μ s
	20 V	< 1.5 ms
	200 V	< 20 ms
Current measure 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 V _{OUT} = 2 V unless noted	
	Current range	Settling time
	1.5 A and 1A	< 120 μ s (R _{LOAD} > 6 Ω)
	100 mA and 10 mA	< 100 μ s
	1 mA	< 3 ms
	100 μ A	< 3 ms
	10 μ A	< 230 ms
	1 μ A	< 230 ms
Capacitor leakage performance using the KIHighC factory scripts²⁰	200 ms at 50 nA <ul style="list-style-type: none"> ▪ Load = 5 μF in parallel with 10 MΩ ▪ Test: 5 V step and measure 	
Mode change delay	Current ranges of 100 μ A and above: <ul style="list-style-type: none"> ▪ 11 ms delay for both in and out of high-capacitance mode Current ranges below 100 μ A: <ul style="list-style-type: none"> ▪ 250 ms delay into high-capacitance mode ▪ 11 ms delay out of high-capacitance mode 	
Voltmeter input impedance	30 G Ω in parallel with 3300 pF	
Noise 10 Hz to 20 MHz	< 30 mV peak-peak <ul style="list-style-type: none"> ▪ 20 V range 	
Range change overshoot	Voltage: <ul style="list-style-type: none"> ▪ < 400 mV + 0.1% of larger range ▪ For 20 V range and below ▪ Overshoot into a 200 kΩ load, 20 MHz bandwidth 	

¹⁷ High Capacitance Mode specifications are for DC measurements only.¹⁸ 100 nA range is not available in High Capacitance Mode.¹⁹ High Capacitance Mode uses locked ranges. Autorange is disabled.²⁰ Part of KI Factory scripts. See the *Series 2600B Reference Manual* for details.

MEASUREMENT SPEED CHARACTERISTICS^{21, 22}

Maximum sweep operation rates (operations per second) for 60 Hz (50 Hz):

A/D converter speed	Trigger origin	Measure to memory (using user scripts)	Measure to GPIB (using user scripts)	Source measure to memory (using user scripts)	Source measure to GPIB (using user scripts)	Source measure to memory (using sweep API)	Source measure to GPIB (using sweep API)
0.001 NPLC	Internal	20000 (20000)	9800 (9800)	7000 (7000)	6200 (6200)	12000 (12000)	5900 (5900)
0.001 NPLC	Digital I/O	8100 (8100)	7100 (7100)	5500 (5500)	5100 (5100)	11200 (11200)	5700 (5700)
0.01 NPLC	Internal	4900 (4000)	3900 (3400)	3400 (3000)	3200 (2900)	4200 (3700)	4000 (3500)
0.01 NPLC	Digital I/O	3500 (3100)	3400 (3000)	3000 (2700)	2900 (2600)	4150 (3650)	3800 (3400)
0.1 NPLC	Internal	580 (480)	560 (470)	550 (465)	550 (460)	560 (470)	545 (460)
0.1 NPLC	Digital I/O	550 (460)	550 (460)	540 (450)	540 (450)	560 (470)	545 (460)
1.0 NPLC	Internal	59 (49)	59 (49)	59 (49)	59 (49)	59 (49)	59 (49)
1.0 NPLC	Digital I/O	59 (49)	59 (49)	59 (49)	59 (49)	59 (49)	59 (49)

Maximum single measurement rates (operations per second) for 60 Hz (50 Hz)

A/D converter speed	Trigger origin	Measure to GPIB	Source measure to GPIB	Source measure pass/fail to GPIB
0.001 NPLC	Internal	1900 (1800)	1400 (1400)	1400 (1400)
0.01 NPLC	Internal	1450 (1400)	1200 (1200)	1100 (1100)
0.1 NPLC	Internal	450 (390)	425 (370)	425 (375)
1.0 NPLC	Internal	58 (48)	57 (48)	57 (48)

Maximum measurement range change rate	> 7000 per second for > 10 μ A. When changing to or from a range \geq 1 A, maximum rate is > 2200/second.
Maximum source range change rate	> 400 per second > 10 μ A. When changing to or from a range \geq 1 A, maximum rate is > 190/second.
Maximum source function change rate	> 1000 per second
Command processing time	< 1 ms <ul style="list-style-type: none"> ▪ Maximum time required for the output to begin to change after receiving the <code>smua.source.levelv</code> or <code>smua.source.leveli</code> command.

²¹ Tests performed with a Model 2612B using the following equipment: Computer hardware (Intel® Pentium® 4 2.4 GHz, 2 GB RAM, National Instruments™ PCI-GPIB); driver (NI-488.2 Version 2.2 PCI-GPIB); software (Microsoft® Windows® XP, Microsoft® Visual Studio® 2010, VISA™ version 4.1).

²² Exclude current measurement ranges less than 1 mA.

TRIGGERING AND SYNCHRONIZATION CHARACTERISTICS**Triggering**

Trigger in to trigger out	0.5 μ s
Trigger in to source change²³	10 μ s
Trigger timer accuracy	\pm 2 μ s
Source change²³ after LXI trigger	280 μ s

Synchronization

Multi-node synchronized source change²³	< 0.5 μ s
Single-node synchronized source change²³	< 0.5 μ s

SUPPLEMENTAL INFORMATION

Front-panel interface	Two-line vacuum fluorescent display (VFD) with keypad and navigation wheel
Display	<ul style="list-style-type: none"> ▪ Show error messages and user-defined messages ▪ Display source and limit settings ▪ Show current and voltage measurements ▪ View measurements stored in dedicated reading buffers
Keypad operations	<ul style="list-style-type: none"> ▪ 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™) accessible from any host interface; responds to high-speed test scripts comprised of remote commands and statements (for example, branching, looping, and math); able to execute test scripts stored in memory without host intervention.
Minimum user memory available	16 MB (approximately 250,000 lines of TSP code)
Reading buffers	<p>Nonvolatile memory uses dedicated storage areas reserved for measurement data. Reading buffers are arrays of measurement elements. Each element can store the following items:</p> <ul style="list-style-type: none"> ▪ Measurement ▪ Source setting (at the time the measurement was taken) ▪ Measurement status ▪ Range information ▪ Timestamp <p>Reading buffers can be filled using the front-panel STORE key, and retrieved using the RECALL key or host interface.</p>

²³ Fixed source range with no polarity change.

Buffer size, with timestamp and source setting	> 60,000 samples
Buffer size, without timestamp and source setting	> 140,000 samples

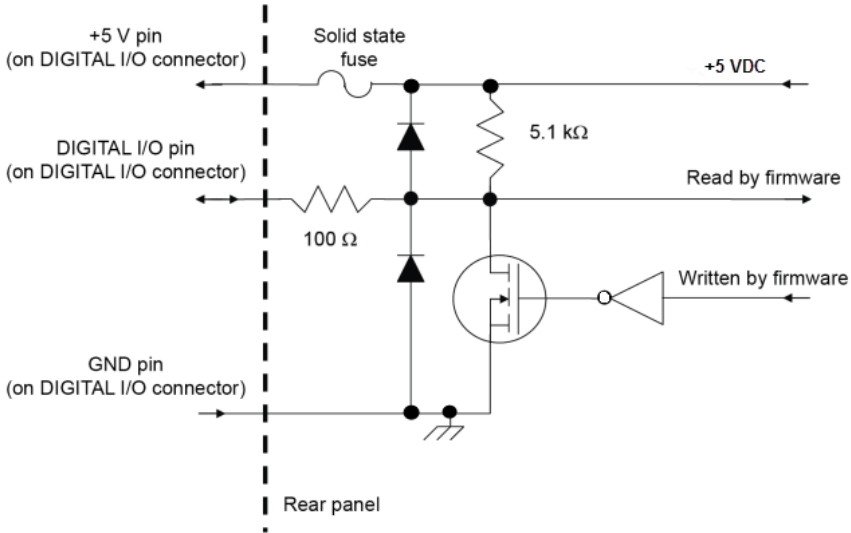
Timing

Timer	Free-running 47-bit counter with 1 MHz clock input. Reset each time instrument power is turned on. If the instrument is not turned off, the timer is automatically reset to zero (0) every four years.
Timestamp	TIMER value is automatically saved when each measurement is triggered
Resolution	1 μ s
Timestamp accuracy	\pm 100 ppm

GENERAL SPECIFICATIONS

IEEE-488	IEEE Std 488.1 compliant. Supports IEEE Std 488.2 common commands and status model topology.
RS-232	<ul style="list-style-type: none"> ▪ Baud rates from 300 bps to 115,200 bps ▪ Programmable number of data bits, parity type, and flow control (RTS/CTS hardware or none) ▪ When not programmed as the active host interface, the Models 2611B, 2612B and 2614B can use the RS-232 interface to control other instruments
Ethernet	RJ-45 connector, LXI version 1.4 Core 2011, 10/100Base-T, Auto-MDIX
LXI compliance	LXI version 1.4 Core 2011
Expansion interface²⁴	<ul style="list-style-type: none"> ▪ 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 ▪ Three meter (9.84 ft) maximum between each TSP-enabled instrument ▪ A maximum of 32 TSP-Link nodes can be interconnected ▪ Each source-measure instrument uses one TSP-Link node
USB Control (Rear)	USB 2.0 Device: USB-TMC488 protocol
USB File System (Front)	USB 2.0 Host: Mass storage class device
Power supply	100 V ac to 240 V ac, 50 Hz or 60 Hz (autosensing), 240 VA maximum
Cooling	Forced air; side intake and rear exhaust; one side must be unobstructed when rack mounted
Warranty	1 year

²⁴ TSP-Link is not available with the Model 2614B.

EMC	Conforms to European Union EMC Directive
Safety	NRTL listed to UL61010-1 and CSA C22.2 No. 61010-1 Conforms to European Union Low Voltage Directive
Environment	For indoor use only Altitude: Maximum 2000 m (6562 ft) above sea level 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
Dimensions	Rack mount: 89 mm high x 213 mm wide x 460 mm deep (3.5 in. x 8.4 in. x 17.5 in.) Bench configuration (with handle and feet): 104 mm high x 238 mm wide x 460 mm deep (4.1 in. x 9.4 in. x 17.5 in.)
Weight	2611B: 4.75 kg (10.4 lb) 2612B and 2614B: 15.50 kg (2.0 lb)
Digital I/O interface²⁵	 <p>Connector: 25-pin female D</p> <p>Input/output pins: 14 open drain I/O bits</p> <p>Absolute maximum input voltage: 5.25 V</p> <p>Absolute minimum input voltage: -0.25 V</p> <p>Maximum logic low input voltage: 0.7 V, +850 μA maximum</p> <p>Minimum logic high input voltage: 2.1 V, +570 μA</p> <p>Maximum source current (flowing out of digital I/O bit): +960 μA</p> <p>Maximum sink current at maximum logic low voltage (0.7): -5.0 mA</p> <p>Absolute maximum sink current (flowing into digital I/O pin): -11 mA</p>

²⁵ The Digital I/O feature is not available with the 2614B. Only +5 V, GND and INTERLOCK pins are available with the Model 2614B.

5 V power supply pins: Limited to 250 mA total, solid-state fuse protected

Safety interlock pin:

A signal of > 3.4 V at 24 mA (at an absolute maximum of 6 V) must be externally applied to this pin to ensure 200 V operation. Connect the 5 V output and the interlock input of the 25-pin digital I/O connector on the back of the 2611B, 2612B, or 2614B to the switch in your fixture. The output is disabled when the interlock signal is < 0.45 V. Absolute maximum input is -0.4 V to +6.0 V.

