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System SourceMeter® Instrument Specifications

SPECIFICATION CONDITIONS

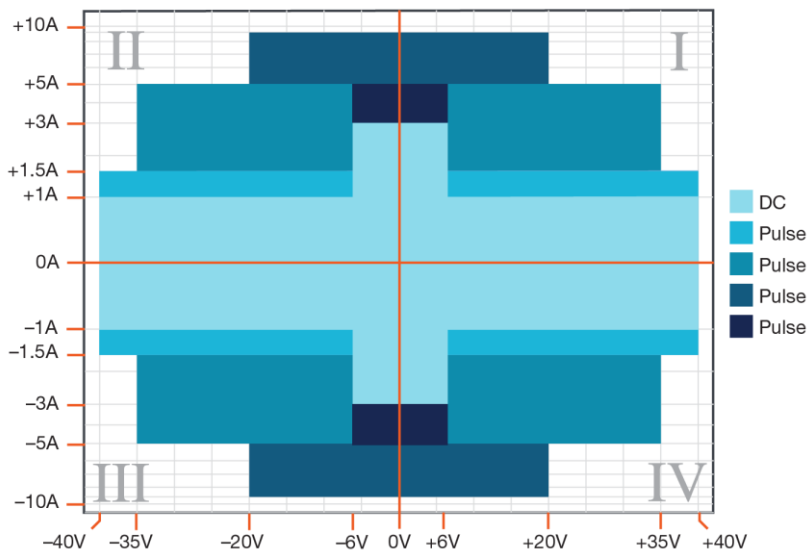
This document contains specifications and supplemental information for the Models 2601B, 2602B, and 2604B System SourceMeter® instrument. Specifications are the standards against which the Models 2601B, 2602B, and 2604B are tested. Upon leaving the factory, the Models 2601B, 2602B, and 2604B meet these 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 Models 2601B, 2602B, and 2604B 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 | 40.4 W maximum <ul style="list-style-type: none"> ▪ ± (40.4 V at 1.0 A, -1.0 A) ▪ ± (6.06 V at 3.0 A, -3.0 A) ▪ Four-quadrant source or sink operation | 40.4 W maximum <ul style="list-style-type: none"> ▪ ± (1.01 A at 40 V, -40 V) ▪ ± (3.03 A at 6 V, -6 V) ▪ Four-quadrant source or sink operation |



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



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

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) |
| 100 mV | 5 µV | 0.02% + 250 µV | 20 µV | 100 nV | 0.015% + 150 µV |
| 1 V | 50 µV | 0.02% + 400 µV | 50 µV | 1 µV | 0.015% + 200 µV |
| 6 V | 50 µV | 0.02% + 1.8 mV | 100 µV | 1 µV | 0.015% + 1 mV |
| 40 V | 500 µV | 0.02% + 12 mV | 500 µV | 10 µV | 0.015% + 8 mV |

CURRENT ACCURACY SPECIFICATIONS²

| 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 | 0.1% + 100 pA | 5 pA | 100 fA | 0.08% + 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 |
| 3 A | 20 µA | 0.06% + 4 mA | 150 µA | 1 µA | 0.05% + 3.5 mA |
| 10 A ⁵ | 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.

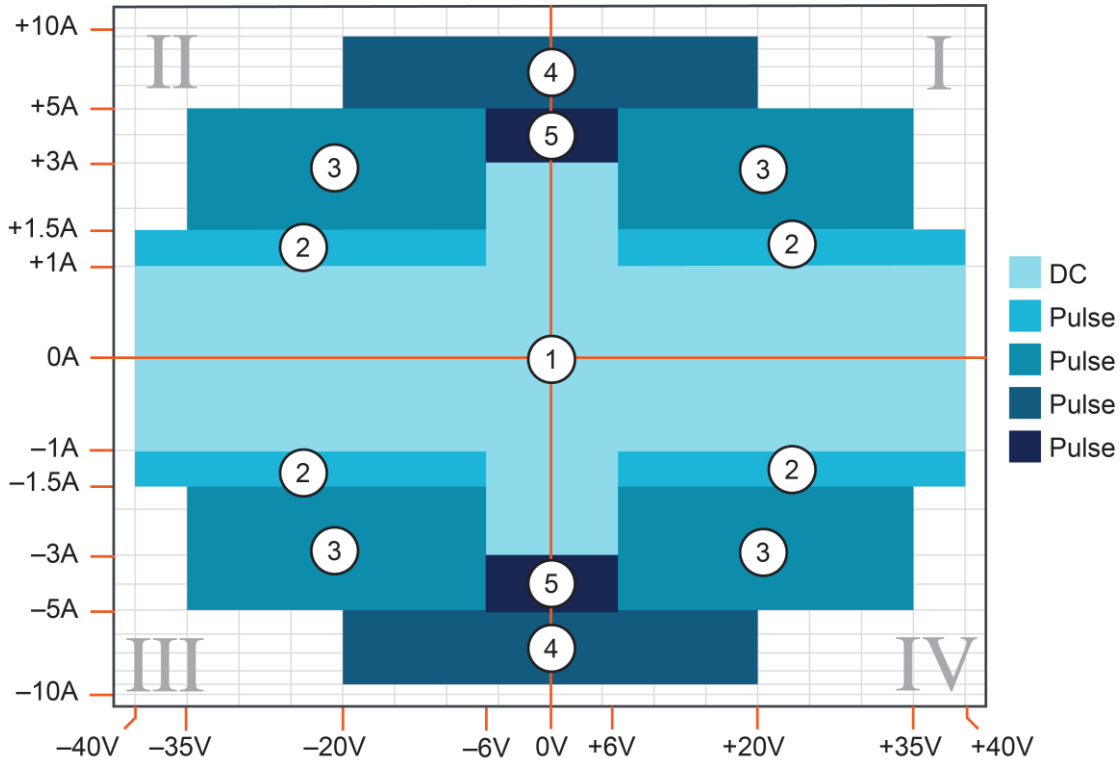
| NPLC setting | 100 mV range | 1 V and 40 V ranges | 100 nA range | 1 µA to 100 mA ranges | 1 A to 3 A ranges |
|--------------|--------------|---------------------|--------------|-----------------------|-------------------|
| 0.1 | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% |
| 0.01 | 0.08% | 0.07% | 0.1% | 0.05% | 0.05% |
| 0.001 | 0.8% | 0.6% | 1% | 0.5% | 1.1% |

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

SUPPLEMENTAL CHARACTERISTICS

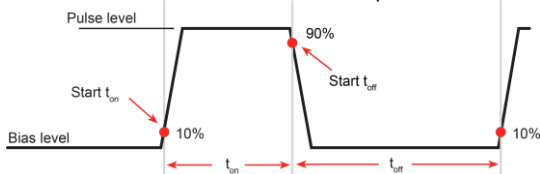
The following specifications are supplemental characteristics that provide additional information about instrument functions and performance. These characteristics are nonwarranted specifications; they describe the typical performance of the Models 2601B, 2602B and 2604B.

PULSE CHARACTERISTICS



| Pulse region specifications | | | |
|-----------------------------|-----------------|----------------------------------|---------------------------------|
| Region quadrant diagram | Region maximums | Maximum pulse width ⁶ | Maximum duty cycle ⁷ |
| 1 | 1 A at 40 V | DC, no limit | 100% |
| 1 | 3 A at 6 V | DC, no limit | 100% |
| 2 | 1.5 A at 40 V | 100 ms | 25% |
| 3 | 5 A at 35 V | 4 ms | 4% |
| 4 | 10 A at 20 V | 1.8 ms | 1% |
| 5 | 5 A at 6 V | 10 ms | 10% |

⁶ Times measured from the start of the pulse to the start of the off-time; see figure below.



⁷ Thermally limited in sink mode (quadrants 2 and 4) and ambient temperatures above 30 °C. See power equations in the *Series 2600B System SourceMeter Instrument Reference Manual* for more information.

| | | | | |
|---|--|-------------|-------------------------------------|-------------------------------------|
| Minimum programmable pulse width⁶ | 100 μ s Note: Minimum pulse width for settled source at a given I/V output and load can be longer than 100 μ s. | | | |
| | Source value | Load | Source settling (% of range) | Minimum pulse time to settle |
| | 6 V | 2 Ω | 0.2% | 150 μ s |
| | 20 V | 2 Ω | 1% | 200 μ s |
| | 35 V | 7 Ω | 0.5% | 500 μ s |
| | 40 V | 27 Ω | 0.1% | 400 μ s |
| | 1.5 A | 27 Ω | 0.1% | 1.5 ms |
| | 3 A | 2 Ω | 0.2% | 150 μ s |
| | 5 A | 7 Ω | 0.5% | 500 μ s |
| 10 A | 2 Ω | 0.5% | 200 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 | < 20 mV peak-peak, < 3 mV RMS <ul style="list-style-type: none"> ▪ 6 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 | Voltage: <ul style="list-style-type: none"> ▪ < \pm0.1% + 10 mV ▪ Step size = 10% to 90% of range, resistive load, maximum current limit/compliance Current: <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 | Voltage: ⁸ <ul style="list-style-type: none"> ▪ < 500 mV + 0.1% of larger range or < 300 mV + 0.5% of larger range ▪ Overshoot into a 100 kΩ load, 20 MHz bandwidth Current: ⁹ <ul style="list-style-type: none"> ▪ < 300 mV/R_{LOAD} + 5% of larger range |
| Guard offset voltage | < 4 mV <ul style="list-style-type: none"> ▪ Current < 10 mA |

⁸ Add 180 mV for the 6 V to 20 V change (500 mA).⁹ With source settling set to SETTLE_SMOOTH_100NA.

| | | |
|--|---|---|
| Remote sense operating range¹⁰ | Maximum voltage between HI and SENSE HI = 3 V Maximum voltage between LO and SENSE LO = 3 V | |
| Voltage output headroom | 40 V range <ul style="list-style-type: none"> Maximum output voltage = 42 V – (total voltage drop across source leads); maximum 1 Ω source lead 6 V range <ul style="list-style-type: none"> Maximum output voltage = 8 V – (total voltage drop across source leads); maximum 1 Ω source lead | |
| Overtemperature protection | Internally sensed overtemperature condition puts the instrument in standby mode | |
| Limit/compliance | Bipolar limit (compliance) set with a single value Voltage: ¹¹ <ul style="list-style-type: none"> Minimum value is 10 mV; accuracy is the same as voltage source Current: ¹² <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 |
| | 100 mV | < 50 μs |
| | 1 V | < 50 μs |
| | 6 V | < 110 μs |
| 40 V ¹³ | < 150 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 $I_{OUT} \times R_{LOAD} = 1 V$ | |
| | Current range | Settling time |
| | 100 nA | < 20 ms |
| | 1 μA | < 2 ms |
| | 10 μA | < 500 μs |
| | 100 μA | < 150 μs |
| | 1 mA | < 100 μs |
| | 1 A to 10 mA | < 80 μs ($R_{LOAD} > 6 \Omega$) |
| | 3 A | < 80 μs (Current < 2.5 A, $R_{LOAD} > 2 \Omega$) |

¹⁰ Add 50 μV to source accuracy specifications per volt of HI lead drop.

¹¹ 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 100 mV range add an additional 60 mV of uncertainty. Specifications apply with sink mode enabled.

¹² 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.

¹³ Add 150 μs when measuring on the 1 A range.

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} = 1 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 2604B.

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 |
| | 100 mV | < 200 μ s |
| | 1 V | < 200 μ s |
| | 6 V | < 200 μ s |
| | 40 V | < 7 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} = 1 V unless noted | |
| | Current range | Settling time |
| | 1 μ A | < 230 ms |
| | 10 μ A | < 230 ms |
| | 100 μ A | < 3 ms |
| | 1 mA | < 3 ms |
| | 100 mA and 10 mA | < 100 μ s |
| | 3 A and 1 A | < 120 μ s (R _{LOAD} > 2 Ω) |
| Capacitor leakage performance using the KIHighC factory script²⁰ | 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 | 10 G Ω in parallel with 3300 pF | |
| Noise 10 Hz to 20 MHz | < 30 mV peak-peak <ul style="list-style-type: none"> ▪ 6 V range | |
| Range change overshoot | Voltage: <ul style="list-style-type: none"> ▪ < 400 mV + 0.1% of larger range ▪ Overshoot into a 100 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 utilizes locked ranges. Autorange is disabled.²⁰ Part of KI Factory scripts. See the *Series 2600B System SourceMeter Instrument 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) |

²¹ Tests performed with a Model 2602B 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.

| | |
|--|--|
| 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. |

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 |

²³ Fixed source range with no polarity change.

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

TIMING

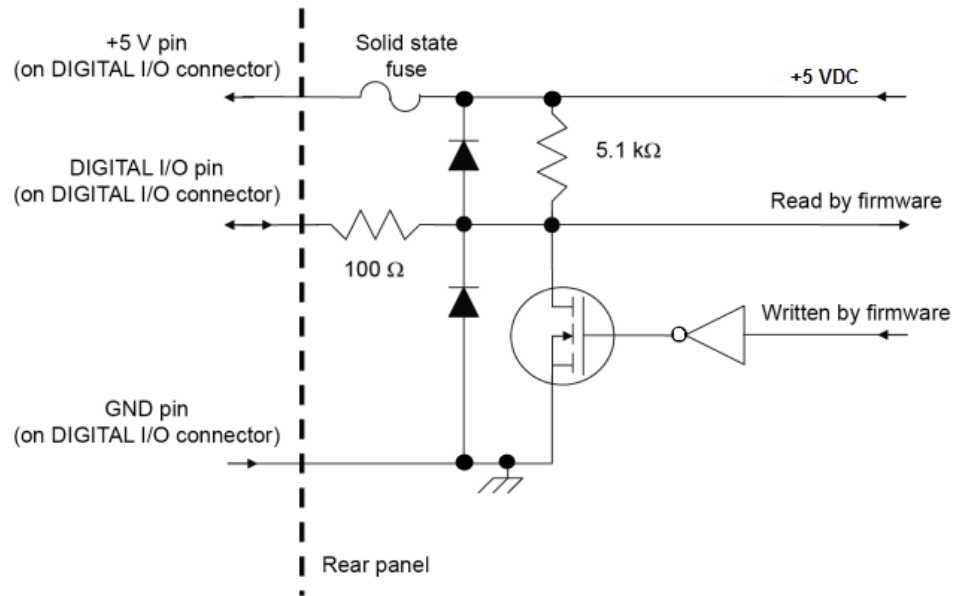
| | |
|---------------------------|--|
| Timer | Free-running 47-bit counter with 1 MHz clock input. Reset each time instrument power is turned on. If the instrument is not turned off, the timer is automatically reset to zero (0) every four years. |
| Timestamp | TIMER value is automatically saved when 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 2601B, 2602B and 2604B can use the RS-232 interface to control other instruments |
| Ethernet | RJ-45 connector, LXI version 1.4 Core 2011, 10/100BaseT, 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 |
| EMC | Conforms to European Union EMC Directive |
| Safety | NRTL listed to UL61010-1:2008 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 × 213 mm wide × 460 mm deep (3.5 in. × 8.4 in. × 17.5 in.) Bench configuration (with handle and feet): 104 mm high × 238 mm wide × 460 mm deep (4.1 in. × 9.4 in. × 17.5 in.) |
| Weight | 2601B: 4.75 kg (10.4 lb) 2602B and 2604B: 5.50 kg (12.0 lb) |

²⁴ TSP-Link is not available with the Model 2604B.

Digital I/O interface²⁵



Connector: 25-pin female D

Input/output pins: 14 open drain I/O bits

Absolute maximum input voltage: 5.25 V

Absolute minimum input voltage: -0.25 V

Maximum logic low input voltage: 0.7 V, +850 μA maximum

Minimum logic high input voltage: 2.1 V, +570 μA

Maximum source current (flowing out of digital I/O bit): +960 μA

Maximum sink current at maximum logic low voltage (0.7 V): -5.0 mA

Absolute maximum sink current (flowing into digital I/O pin): -11 mA

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

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

²⁵ The Digital I/O feature is not available with the Model 2604B. Only +5 V, GND and INTERLOCK pins are available with the Model 2604B