Model 2400, 2400-LV, 2400-C, and 2401 SourceMeter® Specifications

SOURCE SPECIFICATIONS[1]

VOLTAGE PROGRAMMING ACCURACY (LOCAL OR REMOTE SENSE)

MODEL	RANGE	PROGRAMMING RESOLUTION	ACCURACY (1 Year) 23°C ±5°C ±(% rdg. + volts)	NOISE (peak-peak) 0.1Hz – 10Hz
	200.00 mV	5 µV	0.02% + 600 µV	5 µV
	2.00000 V	50 µV	0.02% + 600 µV	50 µV
	20.0000 V	500 µV	0.02% + 2.4 mV	500 µV
2400-C and 2400 Only:	200.00 V	5 mV	0.02% + 24 mV	5 mV

TEMPERATURE COEFFICIENT (0°-18°C & 28°-50°C): ±(0.15 × accuracy specification)/ °C.

MAX. OUTPUT POWER: 22W, four quadrant source or sink operation.

SOURCE/SINK LIMITS:

MODEL 2400, 2400-C: ±21V @ ±1.05A, ±210V @ ±105 mA.

MODEL 2400-LV, 2401: ±21V @ ±1.05A.

VOLTAGE REGULATION: Line: 0.01% of range. **Load:** 0.01% of range + 100µV.

NOISE 10Hz – 1MHz (p-p): 20mV typical into a resistive load.

OVERVOLTAGE PROTECTION: User selectable values, 5% tolerance. Factory default = none.

CURRENT LIMIT: Bipolar current limit (compliance) set with single value. Min. 0.1% of range.

OVERSHOOT: <0.1% typical (full scale step, resistive load, 10mA range).

CURRENT PROGRAMMING ACCURACY (LOCAL OR REMOTE SENSE)

RANGE	PROGRAMMING RESOLUTION	ACCURACY (1 Year)[3] 23°C ±5°C ±(% rdg. + amps)	NOISE (peak-peak) 0.1Hz – 10Hz
1.00000 µA	50 pA	0.035% + 600 pA	5 pA
10.0000 µA	500 pA	0.033% + 2 nA	50 pA
100.000 µA	5 nA	0.031% + 20 nA	500 pA
1.00000 mA	50 nA	0.034% + 200 nA	5 nA
10.0000 mA	500 nA	0.045% + 2 µA	50 nA
100.000 mA	5 µA	0.066% + 20 µA	500 nA
1.00000 A[2]	50 µA	0.27% + 900 µA	25 µA

TEMPERATURE COEFFICIENT (0°-18°C & 28°-50°C): ±(0.15 × accuracy specification)/ °C.

MAX. OUTPUT POWER: 22W, four quadrant source or sink operation.

SOURCE/SINK LIMITS:

MODEL 2400, 2400-C: ±21V @ ±1.05A, ±210V @ ±105 mA.

MODEL 2400-LV, 2401: ±21V @ ±1.05A.

CURRENT REGULATION: Line: 0.01% of range. **Load:** 0.01% of range + 100pA.

VOLTAGE LIMIT: Bipolar voltage limit (compliance) set with single value. Min. 0.1% of range.

OVERSHOOT: <0.1% typical (1mA step, RL = 10kΩ, 20V range).

ADDITIONAL SOURCE SPECIFICATIONS

TRANSIENT RESPONSE TIME: 30µs minimum for the output to recover to its spec. following a step change in load.

COMMAND PROCESSING TIME: Maximum time required for the output to begin to change following the receipt of :SOURce:VOLTage|CURRent <nrf> command. **Autorange On:** 10ms. **Autorange Off:** 7ms.

OUTPUT SETTLING TIME: Time required to reach 0.1% of final value after command is processed and output slew. 100µs typical. Resistive load. 10µA to 100mA range.

OUTPUT SLEW RATE (±30%): 0.5V/µs, 200V range, 100mA compliance. (2400 and 2400-C only) 0.08V/µs, 20V range, 100mA compliance.

DC FLOATING VOLTAGE: Output can be floated up to ±250VDC from chassis ground.

REMOTE SENSE: Up to 1V drop per load lead.

COMPLIANCE ACCURACY: Add 0.3% of range and ±0.02% of reading to base specification.

OVER TEMPERATURE PROTECTION: Internally sensed temperature overload puts unit in standby mode.

RANGE CHANGE OVERSHOOT: Overshoot into a fully resistive 100kΩ load, 10Hz to 1MHz BW, adjacent range changes between 200mV, 2V and 20V ranges, 100mV typical.

MINIMUM COMPLIANCE VALUE: 0.1% of range.

1. Specifications valid for continuous output currents below 105mA. For operation above 105mA continuous for > 1 minute, derate accuracy 10%/35mA above 105mA.
2. Full operation (1A) regardless of load to 30°C. Above 30°C ambient, derate 35mA/°C and prorate 35mA/Ω load. 4-wire mode. For current sink operation on 1A range, maximum continuous power is limited to approximately 1/2 rated power or less, depending on current, up to 30°C ambient. See power equations in the User's Manual to calculate allowable duty cycle for specific conditions.
3. For sink mode, 1µA to 100mA range, accuracy is: ±(0.15% + offset*4)
   For 1A range, accuracy is: ±(1.5% + offset*8)

Model 2400, 2400-LV, 2400-C, and 2401 SourceMeter® Specifications

MEASURE SPECIFICATIONS[1,2]

VOLTAGE MEASUREMENT ACCURACY (LOCAL OR REMOTE SENSE)

MODEL	RANGE	DEFAULT RESOLUTION	INPUT RESISTANCE	ACCURACY (1 Year) 23°C ±5°C ±(% rdg. + volts)
	200.00 mV	1 µV	>10 GΩ	0.012% + 300 µV
	2.00000 V	10 µV	>10 GΩ	0.012% + 300 µV
	20.0000 V	100 µV	>10 GΩ	0.015% + 1.5 mV
2400-C and 2400 Only:	200.000 V	1 mV	>10 GΩ	0.015% + 10 mV

TEMPERATURE COEFFICIENT (0°-18°C & 28°-50°C): ±(0.15 × accuracy specification)/ °C.

CURRENT MEASUREMENT ACCURACY (LOCAL OR REMOTE SENSE)

RANGE	DEFAULT RESOLUTION	VOLTAGE BURDEN[3]	ACCURACY (1 Year) 23°C ±5°C ±(% rdg. + amps)
1.00000 µA	10 pA	<1 mV	0.029% + 300 pA
10.0000 µA	100 pA	<1 mV	0.027% + 700 pA
100.000 µA	1 nA	<1 mV	0.025% + 6 nA
1.00000 mA	10 nA	<1 mV	0.027% + 60 nA
10.0000 mA	100 nA	<1 mV	0.035% + 600 nA
100.000 mA	1 µA	<1 mV	0.055% + 6 µA
1.00000 A	10 µA	<1 mV	0.22% + 570 µA

TEMPERATURE COEFFICIENT (0°-18°C & 28°-50°C): ±(0.10 × accuracy specification)/ °C.

RESISTANCE MEASUREMENT ACCURACY (LOCAL OR REMOTE SENSE)

RANGE	DEFAULT RESOLUTION	DEFAULT TEST CURRENT	NORMAL ACCURACY (23°C ±5°C) 1 YEAR, ±(% rdg. + ohms)	ENHANCED ACCURACY (23°C ±5°C)[5] 1 YEAR, ±(% rdg. + ohms)
<2.00000 Ω[4]	10 µΩ	-	Source I_{ACC} + Meas. V_{ACC}	Meas I_{ACC} + Meas. V_{ACC}
20.0000 Ω	100 µΩ	100 mA	0.10% + 0.003 Ω	0.07% + 0.001 Ω
200.000 Ω	1 mΩ	10 mA	0.08% + 0.03 Ω	0.05% + 0.01 Ω
2.00000 kΩ	10 mΩ	1 mA	0.07% + 0.3 Ω	0.05% + 0.1 Ω
20.0000 kΩ	100 mΩ	100 µA	0.06% + 3 Ω	0.04% + 1 Ω
200.000 kΩ	1 Ω	10 µA	0.07% + 30 Ω	0.05% + 10 Ω
2.00000 MΩ	10 Ω	1 µA	0.11% + 300 Ω	0.05% + 100 Ω
20.0000 MΩ	100 Ω	1 µA	0.11% + 1 kΩ	0.05% + 500 Ω
200.000 MΩ	1 kΩ	100 nA	0.66% + 10 kΩ	0.35% + 5 kΩ
>200.000 MΩ[4]	-	-	Source I_{ACC} + Meas. V_{ACC}	Meas I_{ACC} + Meas. V_{ACC}

TEMPERATURE COEFFICIENT (0°-18°C & 28°-50°C): ±(0.15 × accuracy specification)/ °C.

SOURCE I MODE, MANUAL OHMS: Total uncertainty = I source accuracy + V measure accuracy (4-wire remote sense).

SOURCE V MODE, MANUAL OHMS: Total uncertainty = V source accuracy + I measure accuracy (4-wire remote sense).

6-WIRE OHMS MODE: Available using active ohms guard and guard sense. Max. Guard Output Current: 50mA (except 1A range). Accuracy is load dependent. Refer to White Paper no. 2033 for calculation formula.

GUARD OUTPUT IMPEDANCE: <0.1Ω in ohms mode.

CONTACT CHECK SPECIFICATIONS

SPEED: 350µs for verification and notification.

CONTACT CHECK:	2Ω	15Ω	50Ω
No contact check failure	<1.00Ω	<13.5Ω	<47.5Ω
Always contact check failure	>3.00Ω	>16.5Ω	>52.5Ω

1. Speed = Normal (1 PLC). For 0.1 PLC, add 0.005% of range to offset specifications, except 200mV, 1A ranges, add 0.05%. For 0.01 PLC, add 0.05% of range to offset specifications, except 200mV and 1A ranges, add 0.5%.
2. Accuracies apply to 2- or 4-wire mode when properly zeroed.
3. 4-wire mode.
4. Manual ohms only.
5. Source readback ON, offset compensation ON, add system noise but don't include offsets.

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SYSTEM SPEEDS

MEASUREMENT[1]

MAXIMUM RANGE CHANGE RATE: 75/second.

MAXIMUM MEASURE AUTORANGE TIME: 40ms (fixed source)[2].

SWEEP OPERATION[3] READING RATES (rdg./second) FOR 60Hz (50Hz):

SPEED	NPLC/TRIGGER ORIGIN	MEASURE		SOURCE-MEASURE[5]		SOURCE-MEASURE PASS/FAIL TEST[4,5]		SOURCE-MEMORY[4,5]	
		TO MEM.	TO GPIB	TO MEM	TO GPIB	TO MEM.	TO GPIB	TO MEM.	TO GPIB
Fast	0.01 / internal	2081 (2030)	1754	1551 (1515)	1369	902 (900)	981	165 (162)	165
IEEE-488.1 Mode	0.01 / external	1239 (1200)	1254	1018 (990)	1035	830 (830)	886	163 (160)	163
Fast	0.01 / internal	2801 (2030)	1198 (1210)	1551 (1515)	1000 (900)	902 (900)	809 (840)	165 (162)	164 (162)
IEEE-488.2 Mode	0.01 / external	1239 (1200)	1079 (1050)	1018 (990)	916 (835)	830 (830)	756 (780)	163 (160)	162 (160)
Medium	0.10 / internal	510 (433)	509 (433)	470 (405)	470 (410)	389 (343)	388 (343)	133 (126)	132 (126)
IEEE-488.2 Mode	0.10 / external	438 (380)	438 (380)	409 (360)	409 (365)	374 (333)	374 (333)	131 (125)	131 (125)
Normal	1.00 / internal	59 (49)	59 (49)	58 (48)	58 (48)	56 (47)	56 (47)	44 (38)	44 (38)
IEEE-488.2 Mode	1.00 / external	57 (48)	57 (48)	57 (48)	57 (47)	56 (47)	56 (47)	44 (38)	44 (38)

SINGLE READING OPERATION READINGRATES (rdg./second) FOR 60Hz (50Hz):

SPEED	NPLC/TRIGGER ORIGIN	MEASURE TO GPIB	SOURCE-MEASURE TO GPIB[5]	SOURCE-MEASURE PASS/FAIL TEST[4,5] TO GPIB
Fast (488.1)	0.01 / internal	537	140	135
Fast (488.2)	0.01 / internal	256 (256)	79 (83)	79 (83)
Medium (488.2)	0.10 / internal	167 (166)	72 (70)	69 (70)
Normal (488.2)	1.00 / internal	49 (42)	34 (31)	35 (30)

COMPONENT INTERFACE HANDLER TIME FOR 60Hz (50Hz):[4,6,8]

SPEED	NPLC/TRIGGER ORIGIN	MEASURE TO GPIB	SOURCE PASS/FAIL TEST	SOURCE-MEASURE PASS/FAIL TEST[5,7] TO GPIB
Fast	0.01/ external	1.04 ms (1.08 ms)	0.5 ms (0.5 ms)	4.82 ms (5.3 ms)
Medium	0.10 / external	2.55 ms (2.9 ms)	0.5 ms (0.5 ms)	6.27 ms (7.1 ms)
Normal	1.00 / external	17.53 ms (20.9 ms)	0.5 ms (0.5 ms)	21.31 ms (25.0 ms)

1. Reading rates applicable for voltage or current measurements. Auto zero off, autorange off, filter off, display off, trigger delay = 0, binary reading format, and source auto-clear off.
2. Purely resistive load. 1µA and 10µA ranges <65ms.
3. 1000 point sweep was characterized with the source on a fixed range.
4. Pass/Fail test performed using one high limit and one low math limit.
5. Includes time to re-program source to a new level before making measurement.
6. Time from falling edge of START OF TEST signal to falling edge of END OF TEST signal.
7. Command processing time of :SOURce:VOLTage|CURRent:TRIGgered <nrf> command not included.
8. Models 2400, 2400-LV, and 2400-C.

GENERAL

NOISE REJECTION:

	NPLC	NMRR	CMRR
Fast	0.01	-	80 dB
Medium	0.1	-	80 dB
Slow	1	60 dB	100 dB[1]

1. Except lowest 2 current ranges – 90dB.

LOAD IMPEDANCE: Stable into 20,000pF typical.

COMMON MODE VOLTAGE: 250V DC.

COMMON MODE ISOLATION: $>10^9\Omega$, <1000pF.

OVERRANGE: 105% of range, source and measure.

MAX. VOLTAGE DROP BETWEEN INPUT/OUTPUT AND SENSE TERMINALS: 5V.

MAX. SENSE LEAD RESISTANCE: 1MΩ for rated accuracy.

SENSE INPUT IMPEDANCE: $>10^{10}\Omega$.

GUARD OFFSET VOLTAGE: <300µV, typical.

SOURCE OUTPUT MODES:
Fixed DC level
Memory List (mixed function)
Stair (linear and log)

SOURCE MEMORY LIST: 100 points max.

MEMORY BUFFER: 5,000 readings @ 5.5 digits (two 2,500 point buffers). Includes selected measured value(s) and time stamp. Lithium battery backup (3 yr+ battery life).

PROGRAMMABILITY: IEEE-488 (SCPI-1996.0), RS-232, 5 user-definable power-up states plus factory default and *RST.

DIGITAL INTERFACE:
Output Enable: Active low input.
Handler Interface: Start of test, end of test, 3 category bits. +5V@ 300mA supply. Model 2400, 2400-LV, 2400-C only.
Digital I/O: 1 trigger input, 4 TTL/Relay Drive outputs (33V @ 500mA, diode clamped). Model 2400, 2400-LV, 2400-C only. Model 2401 uses the trigger input (SOT) line but not the four digital output lines.

POWER SUPPLY: 100V to 240V rms, 50–60Hz (automatically detected at power up). 190VA.

WARRANTY: 1 year.

EMC: Conforms to European Union EMC Directive.

SAFETY: UL listed to UL 61010B-1:2003. Conforms to European Union Low Voltage Directive.

WARM-UP: 1 hour to rated accuracies.

DIMENSIONS: 89mm high × 213mm wide × 370mm deep (3 1/2 in × 8 3/8 in × 14 9/16 in). Bench Configuration (with handle & feet):104mm high × 238mm wide × 370mm deep (4 1/8 in × 9 3/8 in × 14 9/16 in).

WEIGHT: 3.21kg (7.08 lbs).

ENVIRONMENT:
For Indoor Use Only: Maximum 2000m above Sea Level
Operating: 0°–50°C, 70%R.H. up to 35°C. Derate 3% R.H./°C, 35°–50°C.
Storage: –25°C to 65°C.

ACCESSORIES SUPPLIED: Test Leads, User's Manual, Quick Start Guide, Service Manual (downloadable), LabVIEW Drivers (downloadable for Models 2400 and 2400-C only).

Specifications subject to change without notice.