# Series 2400

# SourceMeter® SMU Instruments

- Five instruments in one (IV Source, IVR Measure)
- Seven models: 20–100W DC, 1000W pulsed, 1100V to 1µV, 10A to 10pA
- Source and sink (4-quadrant) operation
- 0.012% basic measure accuracy with 6½-digit resolution
- 2-, 4-, and 6-wire remote V-source and measure sensing
- 1700 readings/second at 4½ digits via GPIB
- Pass/Fail comparator for fast sorting/binning
- Available high speed sense lead contact check function
- Programmable DIO port for automation/handler/prober control (except Model 2401)
- Standard SCPI GPIB, RS-232 and Keithley Trigger Link interfaces
- Keithley LabTracer 2.0 I-V curve tracing application software (download)

Keithley's Series 2400 Source Measure Unit (SMU) Instruments are designed specifically for test applications that demand tightly coupled sourcing and measurement. All SourceMeter models provide precision voltage and current sourcing as well as measurement capabilities. Each SourceMeter SMU instrument is both a highly stable DC power source and a true instrument-grade 6½-digit multimeter. The power source characteristics include low noise, precision, and readback. The multimeter capabilities include high repeatability and low noise. The result is a compact, single-channel, DC parametric tester. In operation, these instruments can act as a voltage source, a current source, a voltage meter, a current meter, and an ohmmeter. Manufacturers of components and modules for the communications, semiconductor, computer, automotive, and medical industries will find the SourceMeter SMU instruments invaluable for a wide range of characterization and production test applications.

## Advantages of a Tightly Integrated Instrument

By linking source and measurement circuitry in a single unit, these instruments offer a variety of advantages over systems configured with separate source and measurement instruments. For example, they minimize the time required for test station development, setup, and maintenance, while lowering the overall cost of system ownership. They simplify the test process itself by eliminating many of the complex synchronization and connection issues associated with using multiple instruments. And, their compact half-rack size conserves precious "real estate" in the test rack or bench.

## Power of Five Instruments in One (IV Source, IVR Measure)

The tightly coupled nature of a SourceMeter SMU instrument provides many advantages over solutions configured from separate instruments, such as a precision power supply and a digital multimeter. For example, it provides faster test times by reducing GPIB traffic and simplifies the remote programming interface. It also protects the device under test from damage due to accidental overloads, thermal runaway, etc. Both the current and voltage source are programmable with readback to help maximize device measurement integrity. If the readback reaches a programmed compliance limit, then the source is clamped at the limit, providing fault protection.

## ACCESSORIES AVAILABLE

### TEST LEADS AND PROBES

| | |
|---|---|
| 1754 | 2-Wire Universal 10-Piece Test Lead Kit |
| 5804 | Kelvin (4-Wire) Universal 10-Piece Test Lead Kit |
| 5805 | Kelvin (4-Wire) Spring-Loaded Probes |
| 5808 | Low Cost Single-pin Kelvin Probe Set |
| 5809 | Low Cost Kelvin Clip Lead Set |
| 8607 | 2-Wire, 1000V Banana Cables, 1m (3.3 ft) |
| CA-18-1 | Shielded Dual Banana Cable, 1.2m (4 ft) |

### SWITCHING HARDWARE

| | |
|---|---|
| 7001 | Two-Slot Switch System |
| 7002 | Ten-Slot Switch System |
| 7019-C | 6-Wire Ohms Switch Card |
| 7053 | High-Current Switch Card |

### CABLES/ADAPTERS

| | |
|---|---|
| 7007-1 | Shielded GPIB Cable, 1m (3.3 ft) |
| 7007-2 | Shielded GPIB Cable, 2m (6.6 ft) |
| 7009-5 | RS-232 Cable |
| 8620 | Shorting Plug |

### COMMUNICATION INTERFACE

| | |
|---|---|
| KPCI-488LPA | IEEE-488 Interface/Controller for the PCI Bus |
| KUSB-488B | IEEE-488 USB-to-GPIB Interface Adapter |

### TRIGGERING AND CONTROL

| | |
|---|---|
| 2499-DIGIO | Digital I/O Expander Assembly (not for Model 2401) |
| 8501-1 | Trigger Link Cable, DIN-to-DIN, 1m (3.3 ft) |
| 8501-2 | Trigger Link Cable, DIN-to-DIN, 2m (6.6 ft) |
| 8502 | Trigger Link to BNC Breakout Box |
| 8503 | Trigger Link Cable, DIN-to-Dual BNC, 1m (3.3 ft) |
| 8505 | Male to 2-Female Y-DIN Cable for Trigger Link |

### RACK MOUNT KITS

| | |
|---|---|
| 4288-1 | Single Fixed Rack Mount Kit |
| 4288-2 | Dual Fixed Rack Mount Kit |
| 4288-4 | Dual Fixed Rack Mount Kit |
| 4288-5 | Shelf Type Side by Side Rack Mounting Kit |
| 4288-9 | Dual Fixed Rack Mounting Kit |

### SOFTWARE

| | |
|---|---|
| LabTracer 2.0 | Curve Tracing Software (downloadable) |

# Series 2400

# SourceMeter® SMU Instruments

## Ordering Information

**2400** 200V, 1A, 20W SourceMeter SMU Instrument

**2400-C** 200V, 1A, 20W SourceMeter SMU Instrument with Contact Check

**2401** 20V, 1A, 20W SourceMeter SMU Instrument

**2410** 1100V, 1A, 20W SourceMeter SMU Instrument

**2410-C** 1100V, 1A, 20W SourceMeter SMU Instrument with Contact Check

**2420** 60V, 3A, 60W SourceMeter SMU Instrument

**2420-C** 60V, 3A, 60W SourceMeter SMU Instrument with Contact Check

**2425** 100V, 3A, 100W SourceMeter SMU Instrument

**2425-C** 100V, 3A, 100W SourceMeter SMU Instrument with Contact Check

**2430** 100V, 10A, 1000W Pulse Mode SourceMeter SMU Instrument

**2430-C** 100V, 10A, 1000W Pulse Mode SourceMeter SMU Instrument with Contact Check

**2440** 40V, 5A, 50W SourceMeter SMU Instrument

**2440-C** 40V, 5A, 50W SourceMeter SMU Instrument with Contact Check

**Accessories Supplied**

**Model 8605 Test Leads**

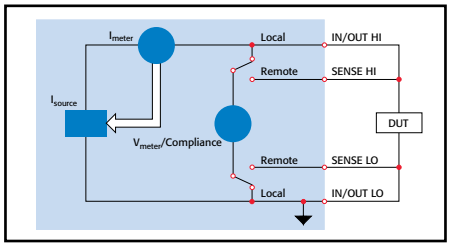
**LabVIEW Software Driver (downloadable)**

**LabTracer Software (downloadable)**

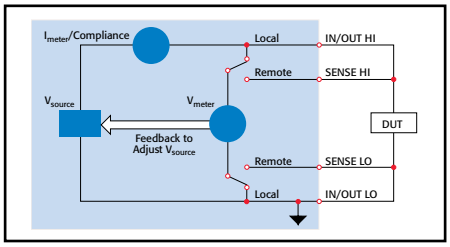


## I-V Characteristics

All SourceMeter SMU instruments provide four-quadrant operation. In the first and third quadrants they operate as a source, delivering power to a load. In the second and fourth quadrants they operate as a sink, dissipating power internally. Voltage, current, and resistance can be measured during source or sink operation.

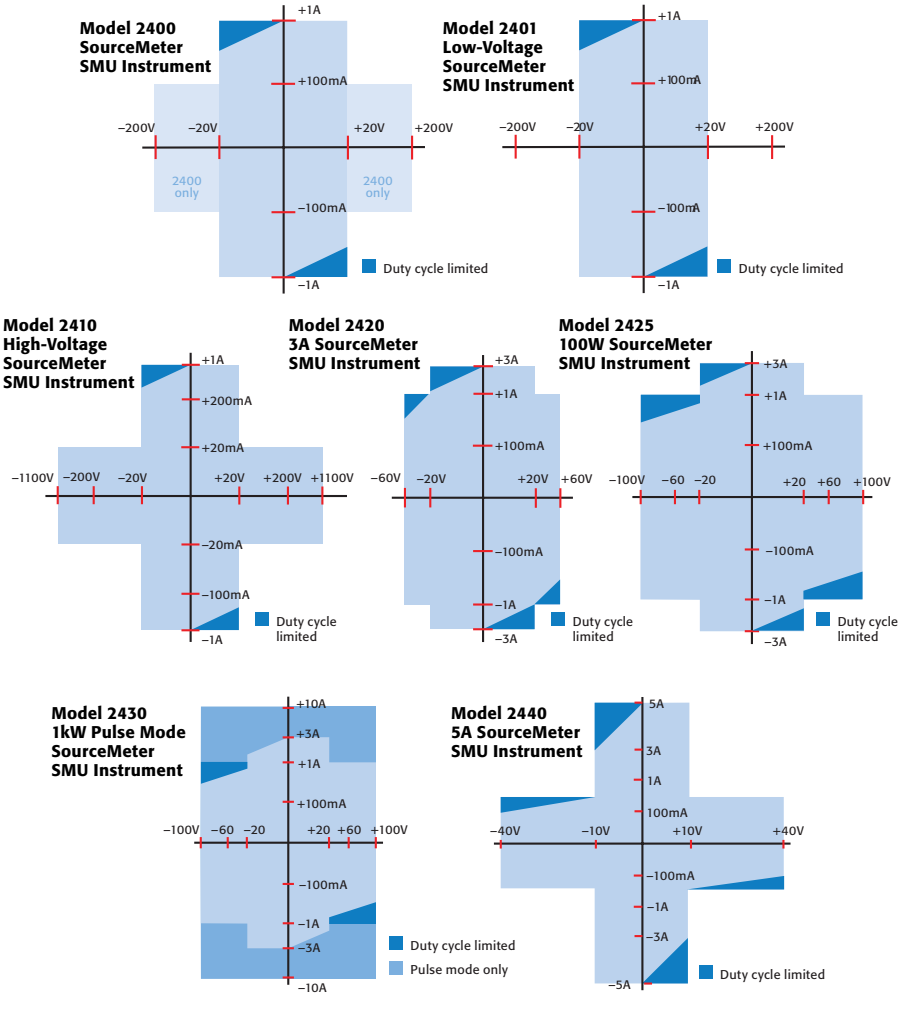



**Source I–Measure V, I, or Ω configuration**




**Source V–Measure I, V, or Ω configuration**

**Series 2400 SourceMeter SMU Instruments**

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# Series 2400 SourceMeter® SMU Instruments

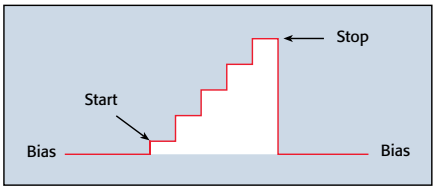
## Automation for Speed

A SourceMeter SMU instrument streamlines production testing. It sources voltage or current while making measurements without needing to change connections. It is designed for reliable operation in non-stop production environments. To provide the throughput demanded by production applications, the SourceMeter SMU instrument offers many built-in features that allow it to run complex test sequences without computer control or GPIB communications slowing things down.

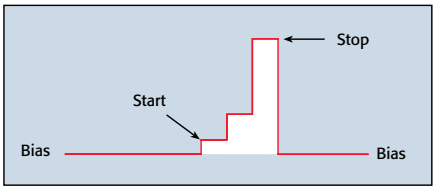
## Standard and Custom Sweeps

Sweep solutions greatly accelerate testing with automation hooks. Three basic sweep waveforms are provided that can be programmed for single-event or continuous operation. They are ideal for I/V, I/R, V/I, and V/R characterization.

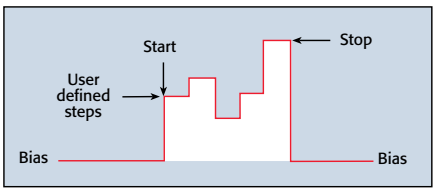
- Linear Staircase Sweep: Moves from the start level to the stop level in equal linear steps
- Logarithmic Staircase Sweep: Done on a log scale with a specified number of steps per decade
- Custom Sweep: Allows construction of special sweeps by specifying the number of measurement points and the source level at each point
- Up to 1700 readings/second at 4½ digits to the GPIB bus
- 5000 readings can be stored in the non-volatile buffer memory




**Linear staircase sweep**




**Logarithmic staircase sweep**




**Custom sweep**

## Built-In Test Sequencer (Source Memory List)

The Source Memory list provides faster and easier testing by allowing you to setup and execute up to 100 different tests that run without PC intervention.

- Stores up to 100 instrument configurations, each containing source settings, measurement settings, pass/fail criteria, etc.
- Pass/fail limit test as fast as 500μs per point
- Onboard comparator eliminates the delay caused when sending data to the computer for analysis
- Built-in, user definable math functions to calculate derived parameters

## TYPICAL APPLICATIONS

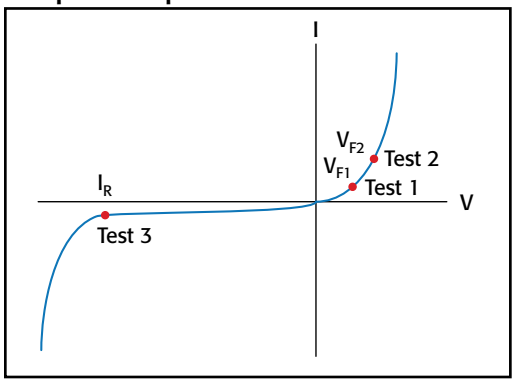
**Devices:**

- **Discrete semiconductor devices**
- **Passive devices**
- **Transient suppression devices**
- **ICs, RFICs, MMICs**
- **Laser diodes, laser diode modules, LEDs, photodetectors**
- **Circuit protection devices: TVS, MOV, Fuses, etc.**
- **Airbags**
- **Connectors, switches, relays**
- **High brightness LEDs (DC and pulse)**

**Tests:**

- **Leakage**
- **Low voltage/resistances**
- **LIV**
- **IDDQ**
- **I-V characterization**
- **Isolation and trace resistance**
- **Temperature coefficient**
- **Forward voltage, reverse breakdown, leakage current**
- **DC parametric test**
- **DC power source**
- **HIPOT**
- **Photovoltaic cell efficiency (source and sink)**
- **Dielectric withstanding**

**Example Test Sequence**




| Test | Pass/Fail Test | If Passes Test | If Fails Test |
|---|---|---|---|
| Test 1 | Check $V_{F1}$ at 100mA against pass/fail limits | Go to Test 2 | 1. Bin part to bad bin<br>2. Transmit data to computer while handler is placing new part<br>3. Return to Test 1 |
| Test 2 | Check $V_{F2}$ at 1A against pass/fail limits | Go to Test 3 | |
| Test 3 | Check leakage current at –500V and test against pass/fail limits | 1. Bin part to good bin<br>2. Transmit readings to computer while handler is placing new part<br>3. Return to Test 1 | |

# Series 2400 SourceMeter® SMU Instruments

## Digital I/O Interface

The digital I/O interface can link a SourceMeter SMU instrument to many popular component handlers, including Aetrium, Aeco, and Robotronics. Other capabilities of the interface include:

- Tight systems integration for applications such as binning and sorting
- Built-in component handler interface
- Start of test and end of test signals
- 5V, 300mA power supply
- Optional expander accessory (Model 2499-DIGIO) adds 16 digital I/O lines

The digital I/O interface is available on all Series 2400 SoourceMeter instruments except the Model 2401.

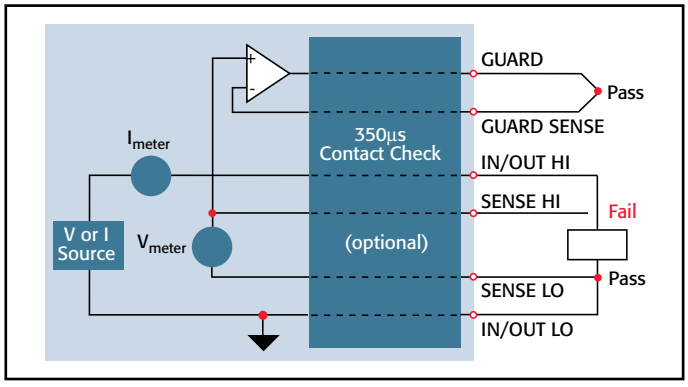
## Trigger Link Interface

All SourceMeter SMU instruments include Keithley's unique Trigger Link interface which provides high-speed, seamless communications with many of Keithley's other instruments. For example, use the Trigger Link interface to connect a SourceMeter SMU instrument with a Series 7000 Switching System for a complete multi-point test solution. With Trigger Link, the Series 7000 Switching Systems can be controlled by a SourceMeter SMU instrument during a high-speed test sequence independent of a computer and GPIB.

## Optional Contact Check Function

The Contact Check function makes it simple to verify good connections quickly and easily before an automated test sequence begins. This eliminates measurement errors and false product failures associated with contact fatigue, breakage, contamination, loose or broken connection, relay failures, etc. Some capabilities of this function are:

- 350µs verification and notification process time
- The output of the SourceMeter SMU instrument is automatically shut off after a fault and is not re-activated until good contact is verified, protecting the device under test from damage and the operator from potential safety hazards.
- 3 pass/fail threshold values: 2Ω, 15Ω, and 50Ω
- No energy passes through the device under test during the operation.
- Enabled either from the front panel or remotely over the GPIB
- 3 fault notification methods

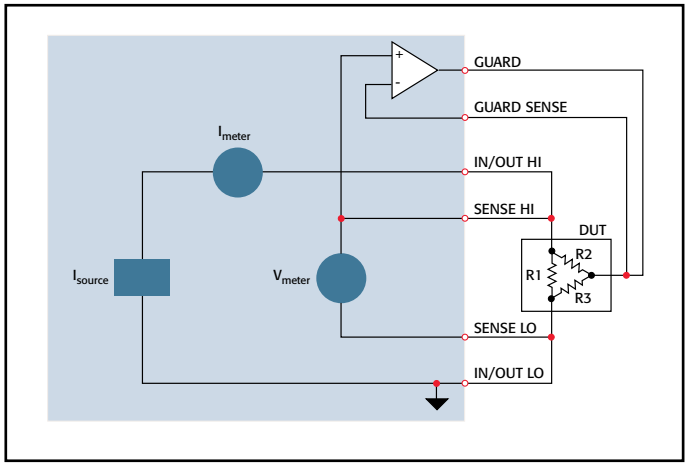



**Contact check option for 4-wire or 6-wire applications**

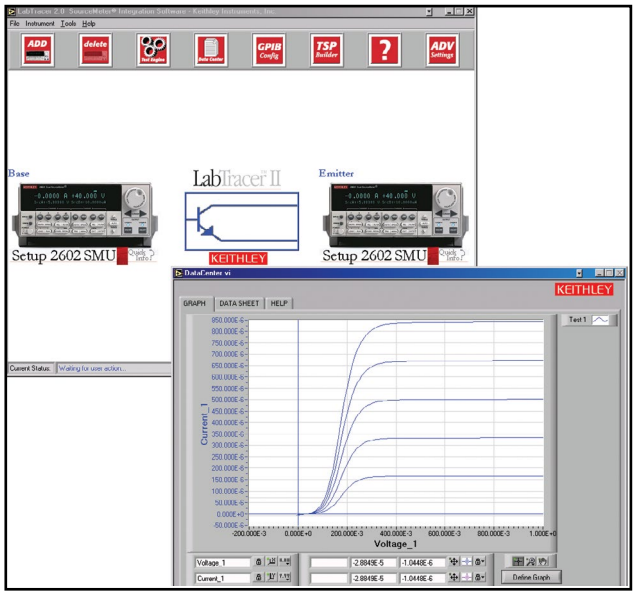
## Unique 6-Wire Ohms Technique

SourceMeter SMU instruments can make standard 4-wire, split Kelvin, and 6-wire, guarded ohms measurements and can be configured for either the constant current or constant voltage method. The 6-wire ohms technique:

- Uses guard and guard sense leads in addition to the 4-wire sense and source leads.
- Locks out parallel current paths when measuring resistor networks or hybrid circuits to isolate the component under test.
- Allows users to configure and plot data easily from Series 2400 SourceMeter SMU instruments, making characterization of two, three, and four terminal devices a snap.




**6-Wire Ohms Circuit. All test current flows through R1 because the high current guard drives the voltage across R2 to 0V.**




**Free LabTracer 2.0 device characterization software (downloadable)**



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## Voltage Accuracy (Local or Remote Sense)

| Model | Range | Programming Resolution | Source[1] Accuracy (1 Year) 23°C ±5°C ±(% rdg. + volts) | Default Measurement Resolution | Measurement[2, 3, 4] Accuracy (1 Year) 23°C ±5°C ±(% rdg. + volts) | Output Slew Rate (±30%) | Source/Sink Limit |
|---|---|---|---|---|---|---|---|
| 2400, 2400-C, 2401 | 200.000 mV | 5 µV | 0.02% + 600 µV | 1 µV | 0.012% + 300 µV | | ±21 V @ ±1.05 A<br>±210 V @ ±105 mA* |
| | 2.00000 V | 50 µV | 0.02% + 600 µV | 10 µV | 0.012% + 300 µV | | |
| | 20.0000 V | 500 µV | 0.02% + 2.4 mV | 100 µV | 0.015% + 1.5 mV | 0.08 V/µs | |
| | 200.000 V* | 5 mV | 0.02% + 24 mV | 1 mV | 0.015% + 10 mV | 0.5 V/µs | |
| 2410, 2410-C | 200.000 mV | 5 µV | 0.02% + 600 µV | 1 µV | 0.012% + 300 µV | | ±21 V @ ±1.05 A<br>±1100 V @ ±21 mA |
| | 2.00000 V | 50 µV | 0.02% + 600 µV | 10 µV | 0.012% + 300 µV | | |
| | 20.0000 V | 500 µV | 0.02% + 2.4 mV | 100 µV | 0.015% + 1 mV | 0.15 V/µs | |
| | 1000.00 V | 50 mV | 0.02% + 100 mV | 10 mV | 0.015% + 50 mV | 0.5 V/µs | |
| 2420, 2420-C | 200.000 mV | 5 µV | 0.02% + 600 µV | 1 µV | 0.012% + 300 µV | | ±21 V @ ±3.15 A<br>±63 V @ ±1.05 A |
| | 2.00000 V | 50 µV | 0.02% + 600 µV | 10 µV | 0.012% + 300 µV | | |
| | 20.0000 V | 500 µV | 0.02% + 2.4 mV | 100 µV | 0.015% + 1 mV | 0.08 V/µs | |
| | 60.0000 V | 1.5 mV | 0.02% + 7.2 mV | 1 mV | 0.015% + 3 mV | 0.14 V/µs | |
| 2425, 2425-C | 200.000 mV | 5 µV | 0.02% + 600 µV | 1 µV | 0.012% + 300 µV | | ±21 V @ ±3.15 A<br>±105 V @ ±1.05 A |
| | 2.00000 V | 50 µV | 0.02% + 600 µV | 10 µV | 0.012% + 300 µV | | |
| | 20.0000 V | 500 µV | 0.02% + 2.4 mV | 100 µV | 0.015% + 1 mV | 0.08 V/µs | |
| | 100.0000 V | 2.5 mV | 0.02% + 12 mV | 1 mV | 0.015% + 5 mV | 0.25 V/µs | |
| 2430, 2430-C | 200.000 mV | 5 µV | 0.02% + 600 µV | 1 µV | 0.012% + 300 µV | | ±105 V @ ±1.05 A<br>±105 V @ ±10.5 A (pulse mode only) |
| | 2.00000 V | 50 µV | 0.02% + 600 µV | 10 µV | 0.012% + 300 µV | | |
| | 20.0000 V | 500 µV | 0.02% + 2.4 mV | 100 µV | 0.015% + 1 mV | 0.08 V/µs | |
| | 100.0000 V | 2.5 mV | 0.02% + 12 mV | 1 mV | 0.015% + 5 mV | 0.25 V/µs | |
| 2440, 2440-C | 200.000 mV | 5 µV | 0.02% + 600 µV | 1 µV | 0.012% + 300 µV | | ±10.5 V @ ±5.25 A<br>±42 V @ ±1.05 A |
| | 2.00000 V | 50 µV | 0.02% + 600 µV | 10 µV | 0.012% + 300 µV | | |
| | 10.0000 V | 500 µV | 0.02% + 1.2 mV | 100 µV | 0.015% + 750 µV | 0.08 V/µs | |
| | 40.0000 V | 5 mV | 0.02% + 4.8 mV | 1 mV | 0.015% + 3 mV | 0.25 V/µs | |

***Not available on Model 2401.**

**TEMPERATURE COEFFICIENT (0°–18°C and 28°–50°C):** ±(0.15 × accuracy specification)/°C.

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

**OVER VOLTAGE 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).

## ADDITIONAL SOURCE SPECIFICATIONS (All Models)

**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. 100µs typical. Resistive load. 10µA to 100mA range.

**DC FLOATING VOLTAGE:** Output can be floated up to ±250VDC (Model 2440 ±40VDC) 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 ranges: 100mV typical, except 20V/200V (20V/60V on Model 2420), 20V/100V on Model 2425 and 2430, range boundary, and Model 2440.

**MINIMUM COMPLIANCE VALUE:** 0.1% of range.

## ADDITIONAL PULSE MODE SOURCE SPECIFICATIONS (2430 and 2430-C only)

**MAXIMUM DUTY CYCLE:** 8%, hardware limited, 10A range only. All other ranges 100%.

**MAXIMUM PULSE WIDTH:** 5ms from 90% rising to 90% falling edge, 2.5ms 10A range.

**MINIMUM PULSE WIDTH:** 150µs.

**MINIMUM PULSE RESOLUTION:** 50µs typical, 70µs max., limited by system jitter.

**SOURCE ACCURACY:** Determined by settling time and source range specifications.

**OUTPUT SETTLING TIME 0.1%:**
800µs typ., source I = 10A into 10Ω, limited by voltage slew rate.
500µs typ., source I = 10A into 1Ω, limited by voltage slew rate.

**OUTPUT SLEW RATE:**
**Voltage (10Ω load):** 0.25V/µs ±30% on 100V range. 0.08V/µs ±30% on 20V range, 10A range.
**Current (0Ω load):** 0.25A/µs ±30% on 100V range. 0.08A/µs ±30% on 20V range, 10A range.

### NOTES

1. **2400, 2401, 2410 Only:** Specifications valid for continuous output currents below 105mA. For operation above 105mA continuous for >1 minute, derate accuracy 10%/35mA above 105mA.
2. Speed = Normal (1 PLC). For 0.1 PLC, add 0.005% of range to offset specifications, except 200mV, 1A, 10A ranges, add 0.05%. For 0.01 PLC, add 0.05% of range to offset specifications, except 200mV, 1A, 10A ranges, add 0.5%.
3. Accuracies apply to 2- or 4-wire mode when properly zeroed.
4. In pulse mode, limited to 0.1 PLC measurement.

# Series 2400 SourceMeter® SMU Instruments

## Current Accuracy (Local or Remote Sense)

| Model | Range | Programming Resolution | Source [1, 3] Accuracy (1 Year) 23°C ±5°C ±(% rdg. + amps) | Default Measurement Resolution | Measurement [5, 6, 7] Accuracy (1 Year) 23°C ±5°C ±(% rdg. + amps) | Source/Sink Limit |
|---|---|---|---|---|---|---|
| 2400, 2400-C, 2401 | 1.00000 µA | 50 pA | 0.035% + 600 pA | 10 pA | 0.029% + 300 pA | ±1.05A @ ±21 V<br>±105 mA @ ±210 V[8] |
| | 10.0000 µA | 500 pA | 0.033% + 2 nA | 100 pA | 0.027% + 700 pA | |
| | 100.000 µA | 5 nA | 0.031% + 20 nA | 1 nA | 0.025% + 6 nA | |
| | 1.00000 mA | 50 nA | 0.034% + 200 nA | 10 nA | 0.027% + 60 nA | |
| | 10.0000 mA | 500 nA | 0.045% + 2 µA | 100 nA | 0.035% + 600 nA | |
| | 100.000 mA | 5 µA | 0.066% + 20 µA | 1 µA | 0.055% + 6 µA | |
| | 1.00000 A[2] | 50 µA | 0.27 % + 900 µA | 10 µA | 0.22 % + 570 µA | |
| 2410, 2410-C | 1.00000 µA | 50 pA | 0.035% + 600 pA | 10 pA | 0.029% + 300 pA | ±1.05A @ ±21 V<br>±21 mA @ ±1100 V |
| | 10.0000 µA | 500 pA | 0.033% + 2 nA | 100 pA | 0.027% + 700 pA | |
| | 100.000 µA | 5 nA | 0.031% + 20 nA | 1 nA | 0.025% + 6 nA | |
| | 1.00000 mA | 50 nA | 0.034% + 200 nA | 10 nA | 0.027% + 60 nA | |
| | 20.0000 mA | 500 nA | 0.045% + 4 µA | 100 nA | 0.035% + 1.2 µA | |
| | 100.000 mA | 5 µA | 0.066% + 20 µA | 1 µA | 0.055% + 6 µA | |
| | 1.00000 A[2] | 50 µA | 0.27 % + 900 µA | 10 µA | 0.22 % + 570 µA | |
| 2420, 2420-C | 10.0000 µA | 500 pA | 0.033% + 2 nA | 100 pA | 0.027% + 700 pA | ±3.15A @ ±21 V<br>±1.05 A @ ±63 V |
| | 100.000 µA | 5 nA | 0.031% + 20 nA | 1 nA | 0.025% + 6 nA | |
| | 1.00000 mA | 50 nA | 0.034% + 200 nA | 10 nA | 0.027% + 60 nA | |
| | 10.0000 mA | 500 nA | 0.045% + 2 µA | 100 nA | 0.035% + 600 nA | |
| | 100.000 mA | 5 µA | 0.066% + 20 µA | 1 µA | 0.055% + 6 µA | |
| | 1.00000 A[2] | 50 µA | 0.067% + 900 µA | 10 µA | 0.066% + 570 µA | |
| | 3.00000 A[2] | 50 µA | 0.059% + 2.7 mA | 10 µA | 0.052% + 1.71 mA | |
| 2425, 2425-C | 10.0000 µA | 500 pA | 0.033% + 2 nA | 100 pA | 0.027% + 700 pA | ±3.15A @ ±21 V<br>±1.05 A @ ±105 V |
| | 100.000 µA | 5 nA | 0.031% + 20 nA | 1 nA | 0.025% + 6 nA | |
| | 1.00000 mA | 50 nA | 0.034% + 200 nA | 10 nA | 0.027% + 60 nA | |
| | 10.0000 mA | 500 nA | 0.045% + 2 µA | 100 nA | 0.035% + 600 nA | |
| | 100.000 mA | 5 µA | 0.066% + 20 µA | 1 µA | 0.055% + 6 µA | |
| | 1.00000 A[2] | 50 µA | 0.067% + 900 µA | 10 µA | 0.060% + 570 µA | |
| | 3.00000 A[2] | 50 µA | 0.059% + 2.8 mA | 10 µA | 0.052% + 1.71 mA | |
| 2430, 2430-C | 10.0000 µA | 500 pA | 0.033% + 2 nA | 100 pA | 0.027% + 700 pA | ±1.05A @ ±105 V<br><br>±10.5 A @ ±105 V<br>(pulse mode only) |
| | 100.000 µA | 5 nA | 0.031% + 20 nA | 1 nA | 0.025% + 6 nA | |
| | 1.00000 mA | 50 nA | 0.034% + 200 nA | 10 nA | 0.027% + 60 nA | |
| | 10.0000 mA | 500 nA | 0.045% + 2 µA | 100 nA | 0.035% + 600 nA | |
| | 100.000 mA | 5 µA | 0.066% + 20 µA | 1 µA | 0.055% + 6 µA | |
| | 1.00000 A | 50 µA | 0.067% + 900 µA | 10 µA | 0.060% + 570 µA | |
| | 3.00000 A[2] | 500 µA | 0.059% + 2.8 mA | 10 µA | 0.052% + 1.71 mA | |
| | 10.00000 A[4] | 500 µA | 0.089% + 5.9 mA | 10 µA | 0.082% + 1.71 mA | |
| 2440, 2440-C | 10.0000 µA | 500 pA | 0.033% + 2 nA | 100 pA | 0.027% + 700 pA | ±5.25A @ ±10.5 V<br>±1.05 A @ ±42 V |
| | 100.000 µA | 5 nA | 0.031% + 20 nA | 1 nA | 0.025% + 6 nA | |
| | 1.00000 mA | 50 nA | 0.034% + 200 nA | 10 nA | 0.027% + 60 nA | |
| | 10.0000 mA | 500 nA | 0.045% + 2 µA | 100 nA | 0.035% + 600 nA | |
| | 100.000 mA | 5 µA | 0.066% + 20 µA | 1 µA | 0.055% + 6 µA | |
| | 1.00000 A | 50 µA | 0.067% + 900 µA | 10 µA | 0.060% + 570 µA | |
| | 5.00000 A | 50 µA | 0.10 % + 5.4 mA | 10 µA | 0.10 % + 3.42 mA | |

**TEMPERATURE COEFFICIENT (0°–18°C and 28°–50°C):** ±(0.15 × accuracy specification)/°C.

**CURRENT REGULATION: Line:** 0.01% of range. **Load:** 0.01% of range (except Model 2440 5A range 0.05%) + 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 for Model 2400, 2401, 2410, 2420, 2425, 2430), (10V range for Model 2440).

## CONTACT CHECK SPECIFICATIONS (requires -C version)

(Not available for Model 2401)

**SPEED:** 350µs for verification and notification.

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

### NOTES

1. **2400, 2401, 2410 Only:** 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 (50°C for Model 2420 and 2440). Above 30°C (50°C for Model 2420 and 2440) ambient, derate 35mA/°C and prorate 35mA/Ω load. 4-wire mode. For current sink operation on 1A, 3A, or 5A ranges, 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:
   **Model 2400, 2401:** ±(0.15% + offset*4). **Models 2410, 2420, 2425, 2430, 2440:** ±(0.5% + offset*3).
   For 1A range, accuracy is:
   **Model 2400, 2401:** ±(1.5% + offset*8). **Models 2410, 2420, 2425, 2430, 2440:** ±(1.5% + offset*3).
4. 10A range only in pulse mode. Limited to 2.5ms pulse width maximum. 10% duty cycle maximum.
5. Speed = Normal (1 PLC). For 0.1 PLC, add 0.005% of range to offset specifications, except 200mV, 1A, 10A ranges, add 0.05%. For 0.01 PLC, add 0.05% of range to offset specifications, except 200mV, 1A, 10A ranges, add 0.5%.
6. Accuracies apply to 2- or 4-wire mode when properly zeroed.
7. In pulse mode, limited to 0.1 PLC measurement.
8. Model 2400 and 2400-C only.

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## Resistance Measurement Accuracy (Local or Remote Sense)[1, 2, 5]

| Range | Default Resolution | Default Test Current 2400, 2401, 2410 | Default Test Current 2420, 2425, 2430, 2440 | Normal Accuracy (23°C ±5°C) 1 Year, ±(% rdg. + ohms) 2400, 2401 | 2410 | 2420, 2425, 2430, 2440 | Enhanced Accuracy (23°C ±5°C)[4] 1 Year, ±(% rdg. + ohms) 2400, 2401 |
|---|---|---|---|---|---|---|---|
| <0.20000 Ω[3] | – | – | – | Source $I_{ACC}$ + Meas. $V_{ACC}$ | Source $I_{ACC}$ + Meas. $V_{ACC}$ | Source $I_{ACC}$ + Meas. $V_{ACC}$ | Source $I_{ACC}$ + Meas. $V_{ACC}$ |
| 2.00000 Ω[3] | 10 μΩ | – | 1 A | Source $I_{ACC}$ + Meas $V_{ACC}$ | Source $I_{ACC}$ + Meas. $V_{ACC}$ | 0.17% + 0.0003 Ω | Source $I_{ACC}$ + Meas. $V_{ACC}$ |
| 20.0000 Ω | 100 μΩ | 100 mA | 100 mA | 0.10% + 0.003 Ω | 0.11% + 0.006 Ω | 0.10% + 0.003 Ω | 0.07% + 0.001 Ω |
| 200.000 Ω | 1 mΩ | 10 mA | 10 mA | 0.08% + 0.03 Ω | 0.09% + 0.1 Ω | 0.08% + 0.03 Ω | 0.05% + 0.01 Ω |
| 2.00000 kΩ | 10 mΩ | 1 mA | 1 mA | 0.07% + 0.3 Ω | 0.08% + 0.6 Ω | 0.07% + 0.3 Ω | 0.05% + 0.1 Ω |
| 20.0000 kΩ | 100 mΩ | 100 μA | 100 μA | 0.06% + 3 Ω | 0.07% + 6 Ω | 0.06% + 3 Ω | 0.04% + 1 Ω |
| 200.000 kΩ | 1 Ω | 10 μA | 10 μA | 0.07% + 30 Ω | 0.07% + 60 Ω | 0.07% + 30 Ω | 0.05% + 10 Ω |
| 2.00000 MΩ[6] | 10 Ω | 1 μA | 1 μA | 0.11% + 300 Ω | 0.12% + 600 Ω | 0.11% + 300 Ω | 0.05% + 100 Ω |
| 20.0000 MΩ[7] | 100 Ω | 1 μA | 1 μA | 0.11% + 1 kΩ | 0.12% + 2.4 kΩ | 0.11% + 1 kΩ | 0.05% + 500 Ω |
| 200.000 MΩ[3] | 1 kΩ | 100 nA | – | 0.66% + 10 kΩ | 0.66% + 24 kΩ | Source $I_{ACC}$ + Meas. $V_{ACC}$ | 0.35% + 5 kΩ |
| >200.000 MΩ[3] | – | – | – | Source $I_{ACC}$ + Meas. $V_{ACC}$ | Source $I_{ACC}$ + Meas. $V_{ACC}$ | Source $I_{ACC}$ + Meas. $V_{ACC}$ | Source $I_{ACC}$ + Meas. $V_{ACC}$ |

**TEMPERATURE COEFFICIENT (0°–18°C and 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.

### NOTES

1. Speed = Normal (1 PLC). For 0.1 PLC, add 0.005% of range to offset specifications, except 200mV, 1A, 10A ranges, add 0.05%. For 0.01 PLC, add 0.05% of range to offset specifications, except 200mV, 1A, 10A ranges, add 0.5%.
2. Accuracies apply to 2- or 4-wire mode when properly zeroed.
3. Manual ohms only – except 2420, 2425, 2430, 2440 for 2Ω range and 2400, 2401, or 2410 for 200MΩ range.
4. Source readback enabled, offset compensation ON. Also available on 2410, 2420, 2425, 2430, and 2440 with similar accuracy enhancement.
5. In pulse mode, limited to 0.1 PLC measurement.
6. Except 2440; default test current is 5μA.
7. Except 2440; default test current is 0.5μA.

## SERVICES AVAILABLE

| | |
|---|---|
| 2400-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2400-C-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2401-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2410-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2410-C-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2420-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2420-C-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2425-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2425-C-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2430-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2430-C-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2440-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| 2440-C-3Y-EW | 1-year factory warranty extended to 3 years from date of shipment |
| C/2400-3Y-ISO | 3 (ISO-17025 accredited) calibrations within 3 years of purchase for Models 2400, 2400-C, 2400-LV* |
| C/2401-3Y-ISO | 3 (ISO-17025 accredited) calibrations within 3 years of purchase for Model 2401* |
| C/2410-3Y-ISO | 3 (ISO-17025 accredited) calibrations within 3 years of purchase for Models 2410, 2410-C* |
| C/2420-3Y-ISO | 3 (ISO-17025 accredited) calibrations within 3 years of purchase for Models 2420, 2420-C* |
| C/2425-3Y-ISO | 3 (ISO-17025 accredited) calibrations within 3 years of purchase for Models 2425, 2425-C* |
| C/2430-3Y-ISO | 3 (ISO-17025 accredited) calibrations within 3 years of purchase for Models 2430, 2430-C* |
| C/2440-3Y-ISO | 3 (ISO-17025 accredited) calibrations within 3 years of purchase for Models 2440, 2440-C* |
| TRN-2400-1-C | Course: Unleashing the Power of Your SourceMeter SMU Instrument |

*Not available in all countries

# Series 2400 SourceMeter® SMU Instruments

## 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 To Mem. | Measure To GPIB | Source-Measure To Mem. | Source-Measure To GPIB | Source-Measure Pass/Fail Test[4, 5] To Mem. | Source-Measure Pass/Fail Test[4, 5] To GPIB | Source-Memory[4] To Mem. | Source-Memory[4] 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 | 2081 (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 Reading Rates (rdg./second) for 60Hz (50Hz):

| Speed | NPLC/Trigger Origin | Measure To GPIB | Source-Measure[5] To GPIB | 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 for 60Hz (50Hz):[4, 6]

| 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) |

### NOTES

[1] Reading rates applicable for voltage or current measurements. Auto zero off, autorange off, filter off, display off, trigger delay = 0, and binary reading format.

[2] Purely resistive lead. 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.

## 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 (40V DC for Model 2440).

**COMMON MODE ISOLATION:** >$10^9$Ω, <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:** >$10^{10}$Ω.

**GUARD OFFSET VOLTAGE:** <150μV, typical (300μV for Models 2430, 2440).

**SOURCE OUTPUT MODES:**
Pulse (Model 2430 only)
Fixed DC level
Memory List (mixed function)
Stair (linear and log)

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

**SOURCE MEMORY LIST:** 100 points max.

**PROGRAMMABILITY:** IEEE-488 (SCPI-1995.0), 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. Not available on Model 2401.
**Digital I/O:** 1 trigger input, 4 TTL/Relay Drive outputs (33V @ 500mA, diode clamped). Not available on Model 2401.

**POWER SUPPLY:** 100V to 240V rms, 50–60Hz (automatically detected at power up). **Model 2400, 2401:** 190VA. **Model 2410:** 210VA. **Model 2420:** 220VA. **Model 2425, 2430:** 250VA. **Model 2440:** 240VA.

**COOLING: Model 2401:** Convection. **Model 2410, 2420, 2425, 2430, 2440:** Forced air, variable speed.

**EMC:** Conforms to European Union Directive 89/336/EEC, EN 61326-1.

**SAFETY:** Conforms to European Union Low Voltage Directive. Models 2400 and 2401 UL listed to UL 61010-1:2012 and UL 61010-2-30: 2012.

**VIBRATION:** MIL-PRF-28800F Class 3 Random.

**WARM-UP:** 1 hour to rated accuracies.

**DIMENSIONS:** 89mm high × 213mm wide × 370mm deep (3½ in × 8⅜ in × 14⅝ in). **Bench Configuration (with handle and feet):**104mm high × 238mm wide × 370mm deep (4⅛ in × 9⅜ in × 14⅝ in).

**WEIGHT:** 3.21kg (7.08 lbs) (Model 2425, 2430, 2440: 4.1kg, 9.0 lbs).

**ENVIRONMENT: 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.

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