

# 6517A

# Electrometer/High Resistance Meter



- Measures resistances up to  $10^{16}\Omega$
- 1fA–20mA current measurement range
- $<20\mu\text{V}$  burden voltage on lowest current ranges
- $200\text{T}\Omega$  input impedance
- $<3\text{fA}$  bias current
- Up to 125 rdgs/s
- 0.75fA p-p noise
- Built-in  $\pm 1\text{kV}$  voltage source
- Unique voltage reversal method for high resistance measurements
- Optional plug-in scanner cards

## Ordering Information

**6517A Electrometer/High Resistance Meter**

### Accessories Supplied

**237-ALG-2 Low Noise Triax Cable, 3-slot Triax to Alligator Clips, 2m (6.6 ft)**

**8607 Safety High Voltage Dual Test Leads**

**6517-TP Thermocouple Bead Probe**

**CS-1305 Interlock Connector**

ideal circuit loading. These specifications ensure the accuracy and sensitivity needed for accurate low current and high impedance voltage, resistance, and charge measurements in areas of research such as physics, optics, nanotechnology, and materials science. A built-in  $\pm 1\text{kV}$  voltage source with sweep capability simplifies performing leakage, breakdown, and resistance testing, as well as volume ( $\Omega\text{-cm}$ ) and surface resistivity ( $\Omega/\text{square}$ ) measurements on insulating materials.

### Wide Measurement Ranges

The Model 6517A offers full autoranging over the full span of ranges on current, resistance, voltage, and charge measurements:

- Current measurements from 1fA to 20mA
- Voltage measurements from  $10\mu\text{V}$  to 200V
- Resistance measurements from  $50\Omega$  to  $10^{16}\Omega$
- Charge measurements from 10fC to  $2\mu\text{C}$

Keithley's 5½-digit Model 6517A Electrometer/High Resistance Meter offers accuracy and sensitivity specifications unmatched by any other meter of this type. It also offers a variety of features that simplify measuring high resistances and the resistivity of insulating materials. With reading rates of up to 125 readings/second, the Model 6517A is also significantly faster than competitive electrometers, so it offers a quick, easy way to measure low-level currents.

### Exceptional Performance Specifications

The half-rack-sized Model 6517A has a special low current input amplifier with an input bias current of  $<3\text{fA}$  with just 0.75fA p-p (peak-to-peak) noise and  $<20\mu\text{V}$  burden voltage on the lowest range. The input impedance for voltage and resistance measurements is  $200\text{T}\Omega$  for near-

## ACCESSORIES AVAILABLE

### CABLES

6517A-ILC-3	Interlock Cable
7007-1	Shielded IEEE-488 Cable, 1m (3.2 ft)
7007-2	Shielded IEEE-488 Cable, 2m (6.5 ft)
7009-5	RS-232 Cable
7078-TRX-3	Low Noise Triax Cable, 3-Slot Triax Connectors, 0.9m (3 ft)
7078-TRX-10	Low Noise Triax Cable, 3-Slot Triax Connectors, 3m (10 ft)
7078-TRX-20	Low Noise Triax Cable, 3-Slot Triax Connectors, 6m (20 ft)
8501-1	Trigger Link Cable, 1m (3.3 ft)
8501-2	Trigger Link Cable, 2m (6.6 ft)
8503	Trigger Link Cable to 2 male BNCs, 1m (3.3 ft)
8607	1kV Source Banana Cables

### PROBES

6103C	Voltage Divider Probe
6517-RH	Humidity Probe with Extension Cable
6517-TP	Temperature Bead Probe (included with 6517A)

### TEST FIXTURE

8009	Resistivity Test Fixture
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### ADAPTERS

237-BNC-TRX	Male BNC to 3-Lug Female Triax Adapter
237-TRX-NG	Triax Male-Female Adapter with Guard Disconnected
237-TRX-T	3-Slot Male Triax to Dual 3-Lug Female Triax Tee Adapter
237-TRX-TBC	3-Lug Female Triax Bulkhead Connector (1.1kV rated)
7078-TRX-BNC	3-Slot Male Triax to BNC Adapter
7078-TRX-GND	3-Slot Male Triax to BNC Adapter with guard removed
7078-TRX-TBC	3-Lug Female Triax Bulkhead Connector with Cap

### SOFTWARE

6524	High Resistance Measurement Software
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### RACK MOUNT KITS

4288-1	Single Fixed Rack Mounting Kit
4288-2	Dual Fixed Rack Mounting Kit

### SCANNER CARDS

6521	Low Current Scanner Card
6522	Voltage/Low Current Scanner Card

### GPIB INTERFACES

KPCI-488LP	IEEE-488 Interface/Controller for the PCI Bus
KPXI-488	IEEE-488 Interface Board for the PXI Bus
KUSB-488A	IEEE-488 USB-to-GPIB Interface Adapter

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**KEITHLEY**

Simplifies measuring high resistances and the resistivity of insulating materials

LOW LEVEL MEASURE & SOURCE

## 6517A

## Electrometer/High Resistance Meter

**Simple DMM-like Operation**

The Model 6517A is designed for easy, DMM-like operation via the front panel, with single-button control of important functions such as resistance measurement. It can also be controlled via a built-in IEEE-488 interface, which makes it possible to program all functions over the bus through a computer controller.

**High Accuracy High Resistance Measurements**

The Model 6517A offers a number of features and capabilities that help ensure the accuracy of high resistance measurement applications. For example, the built-in voltage source simplifies determining the relationship between an insulator's resistivity and the level of source voltage used. It is well suited for capacitor leakage and insulation resistance measurements, tests of the surface insulation resistance of printed circuit boards, voltage coefficient testing of resistors, and diode leakage characterization.

A test sequence in the Model 6517A incorporates a new voltage reversal method for measuring very high resistances, especially in materials and devices where the inherent background currents in the sample previously made accurate measurements impossible. The optional Model 6524 software package simplifies operating the Model 6517A via a computer controller and makes it easy to optimize the test parameters (delay time, voltage, etc.) for the specific material or device under test. The Model 6517A meter, the software, and a resistivity fixture are available as a combination for specific material or device testing applications. Refer to the Model 65 for more information.

**Temperature and Humidity Stamping**

Humidity and temperature can influence the resistivity values of materials significantly. To help you make accurate comparisons of readings acquired under varying conditions, the Model 6517A offers a built-in type K thermocouple and an optional Model 6517-RH Relative Humidity Probe. A built-in

data storage buffer allows recording and recalling readings stamped with the time, temperature, and relative humidity at which they were acquired.

**Accessories Extend Measurement Capabilities**

A variety of optional accessories can be used to extend the Model 6517A's applications and enhance its performance.

**Scanner Cards.** Two scanner cards are available to simplify scanning multiple signals. Either card can be easily inserted in the option slot of the instrument's back panel. The Model 6521 Scanner Card offers ten channels of low-level current scanning. The Model 6522 Scanner Card provides ten channels of high impedance voltage switching or low current switching.

**Test Fixture.** The Model 8009 Resistivity Chamber is a guarded test fixture for measuring volume and surface resistivities of sample materials. It has stainless-steel electrodes built to ASTM standards. The fixture's electrode dimensions are pre-programmed into the Model 6517A, so there's no need to calculate those values then enter them manually. This accessory is designed to protect you from contact with potentially hazardous voltages—opening the lid of the chamber automatically turns off the Model 6517A's voltage source.

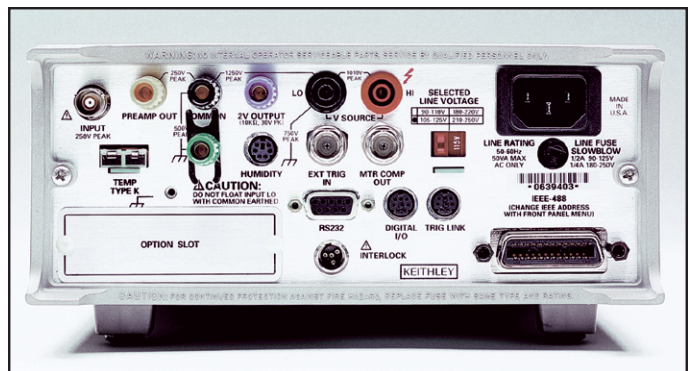
**Applications**

The Model 6517A is well suited for low current and high impedance voltage, resistance, and charge measurements in areas of research such as physics, optics, and materials science. Its extremely low voltage burden makes it particularly appropriate for use in solar cell applications, and its built-in voltage source and low current sensitivity make it an excellent solution for high resistance measurements of nanomaterials such as polymer based nanowires. Its high speed and ease of use also make it an excellent choice for quality control, product engineering, and production test applications involving leakage, breakdown, and resistance testing. Volume and surface resistivity measurements on non-conductive materials are particularly enhanced by the Model 6517A's voltage reversal method.

**SERVICES AVAILABLE**

6517A-3Y-EW	1-year factory warranty extended to 3 years from date of shipment
C/6517A-3Y-ISO	3 (ISO-17025 accredited) calibrations within 3 years of purchase*
TRN-LLM-1-C	Course: Making Accurate Low-Level Measurements

\*Not available in all countries



Model 6517A rear panel

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VOLTS			
Range	5½-Digit Resolution	Accuracy (1 Year) <sup>1</sup> 18°–28°C ±(%rdg+counts)	Temperature Coefficient 0°–18°C & 28°–50°C ±(%rdg+counts)/°C
2 V	10 μV	0.025 + 4	0.003 + 2
20 V	100 μV	0.025 + 3	0.002 + 1
200 V	1 mV	0.06 + 3	0.002 + 1

<sup>1</sup> When properly zeroed, 5½-digit, 1 PLC (power line cycle), median filter on, digital filter = 10 readings.

NMRR: 60dB on 2V, 20V, >55dB on 200V, at 50Hz or 60Hz ±0.1%.

CMRR: >120dB at DC, 50Hz or 60Hz.

INPUT IMPEDANCE: >200TΩ in parallel with 20pF, <2pF guarded (1MΩ with zero check on).

SMALL SIGNAL BANDWIDTH AT PREAMP OUTPUT: Typically 100kHz (–3dB).

AMPS			
Range	5½-Digit Resolution	Accuracy (1 Year) <sup>1</sup> 18°–28°C ±(%rdg+counts)	Temperature Coefficient 0°–18°C & 28°–50°C ±(%rdg+counts)/°C
20 pA	100 aA <sup>2</sup>	1 + 30	0.1 + 5
200 pA	1 fA <sup>2</sup>	1 + 5	0.1 + 1
2 nA	10 fA	0.2 + 30	0.1 + 2
20 nA	100 fA	0.2 + 5	0.03 + 1
200 nA	1 pA	0.2 + 5	0.03 + 1
2 μA	10 pA	0.1 + 10	0.005 + 2
20 μA	100 pA	0.1 + 5	0.005 + 1
200 μA	1 nA	0.1 + 5	0.005 + 1
2 mA	10 nA	0.1 + 10	0.008 + 2
20 mA	100 nA	0.1 + 5	0.008 + 1

<sup>1</sup> When properly zeroed, 5½-digit, 1PLC (power line cycle), median filter on, digital filter = 10 readings.

<sup>2</sup> aA = 10–18A, fA = 10–15A.

INPUT BIAS CURRENT: <3fA at T<sub>CAL</sub>. Temperature coefficient = 0.5fA/°C.

INPUT BIAS CURRENT NOISE: <750aA p-p (capped input), 0.1Hz to 10Hz bandwidth, damping on. Digital filter = 40 readings.

INPUT VOLTAGE BURDEN at T<sub>CAL</sub> ±1°C: <20μV on 20pA, 2nA, 20nA, 2μA, 20μA ranges. <100μV on 200pA, 200nA, 200μA ranges. <2mV on 2mA range. <4mV on 20mA range.

TEMPERATURE COEFFICIENT OF INPUT VOLTAGE BURDEN: <10μV/°C on pA, nA, μA ranges.

PREAMP SETTLING TIME (to 10% of final value): 2.5s typical on pA ranges, damping off, 4s typical on pA ranges damping on, 15ms on nA ranges, 2ms on μA and mA ranges.

NMRR: >95dB on pA, 60dB on nA, μA, and mA ranges at 50Hz or 60Hz ±0.1%.

COULOMBS			
Range	5½-Digit Resolution	Accuracy (1 Year) <sup>1,2</sup> 18°–28°C ±(%rdg+counts)	Temperature Coefficient 0°–18°C & 28°–50°C ±(%rdg+counts)/°C
2 nC	10 fC	0.4 + 5	0.04 + 3
20 nC	100 fC	0.4 + 5	0.04 + 1
200 nC	1 pC	0.4 + 5	0.04 + 1
2 μC	10 pC	0.4 + 5	0.04 + 1

<sup>1</sup> Specifications apply immediately after charge acquisition. Add

$$\left(4fA + \frac{|Q_w|}{RC}\right) T_x$$

where T<sub>x</sub> = period of time in seconds between the coulombs zero and measurement  
Q<sub>w</sub> = average charge measured over T<sub>x</sub>, and RC = 300,000 typical.

<sup>2</sup> When properly zeroed, 5½-digit, 1PLC (power line cycle), median filter on, digital filter = 10 readings.

INPUT BIAS CURRENT: <4fA at T<sub>CAL</sub>. Temperature coefficient = 0.5fA/°C.

OHMS (Normal Method)						
Range	5½-Digit Resolution	Accuracy <sup>1</sup> 18°–28°C (1 Yr.) ±(% rdg+counts)	Temperature Coefficient (10–100% Range) 0°–18°C & 28°–50°C ±(% rdg+counts)	Auto V Source	Amps Range	
					Ω	μA
2 MΩ	10 Ω	0.125 + 1	0.01 + 1	40 V	200 μA	20 μA
20 MΩ	100 Ω	0.125 + 1	0.01 + 1	40 V	20 μA	2 μA
200 MΩ	1 kΩ	0.15 + 1	0.015 + 1	40 V	2 μA	20 nA
2 GΩ	10 kΩ	0.225 + 1	0.035 + 1	40 V	200 nA	20 nA
20 GΩ	100 kΩ	0.225 + 1	0.035 + 1	40 V	20 nA	2 nA
200 GΩ	1 MΩ	0.35 + 1	0.110 + 1	40 V	2 nA	2 nA
2 TΩ	10 MΩ	0.35 + 1	0.110 + 1	400 V	2 nA	200 pA
20 TΩ	100 MΩ	1.025 + 1	0.105 + 1	400 V	200 pA	20 pA
200 TΩ	1 GΩ	1.15 + 1	0.125 + 1	400 V	20 pA	20 pA

<sup>1</sup> Specifications are for auto V-source ohms, when properly zeroed, 5½-digit, 1PLC, median filter on, digital filter = 10 readings. If user selectable voltage is required, use manual mode. Manual mode displays resistance (up to 10<sup>18</sup>Ω) calculated from measured current. Accuracy is equal to accuracy of V-source plus accuracy of selected Amps range.

PREAMP SETTLING TIME: Add voltage source settling time to preamp settling time in Amps specification.

## OHMS (ALTERNATING POLARITY METHOD)

The alternating polarity sequence compensates for the background (offset) currents of the material or device under test. Maximum tolerable offset up to full scale of the current range used.

Using Keithley 8009 fixture

REPEATABILITY: ΔI<sub>BG</sub> × R/V<sub>ALT</sub> + 0.1% (1σ) (instrument temperature constant ±1°C).

ACCURACY: (V<sub>SRC</sub>Err + I<sub>MEAS</sub>Err × R)/V<sub>ALT</sub>

where: ΔI<sub>BG</sub> is a measured, typical background current noise from the sample and fixture.

V<sub>ALT</sub> is the alternating polarity voltage used.

V<sub>SRC</sub>Err is the accuracy (in volts) of the voltage source using V<sub>ALT</sub> as the setting.

I<sub>MEAS</sub>Err is the accuracy (in amps) of the ammeter using V<sub>ALT</sub>/R as the rdg.

VOLTAGE SOURCE			
Range	5½-Digit Resolution	Accuracy (1 Year) 18°–28°C ±(% setting + offset)	Temperature Coefficient 0°–18°C & 28°–50°C ±(% setting+offset)/°C
100 V	5 mV	0.15 + 10 mV	0.005 + 1 mV
1000 V	50 mV	0.15 + 100 mV	0.005 + 10 mV

MAXIMUM OUTPUT CURRENT:

±10mA; active current limit at <11.5mA for 100V range.

±1mA; active current limit at <1.15mA for 1000V range.

SETTLING TIME: <8ms to rated accuracy for 100V range.

<50ms to rated accuracy for 1000V range.

NOISE: <150μV p-p from 0.1Hz to 10Hz for 100V range.  
<1.5mV p-p from 0.1Hz to 10Hz for 1000V range.

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## TEMPERATURE (Thermocouple)

Thermocouple Type	Range	Accuracy (1 Year) <sup>1</sup> 18°–28°C ±(% rdg + °C)
K	–25°C to 150°C	± (0.3% + 1.5°C)

<sup>1</sup> Excluding probe errors,  $T_{cal} \pm 5^\circ\text{C}$ , 1 PLC integration time.

## HUMIDITY

Range	Accuracy (1 Year) <sup>1</sup> 18°–28°C, ±(% rdg + % RH)
0–100%	± (0.3% + 0.5)

<sup>1</sup> Humidity probe accuracy must be added. This is  $\pm 3\%$  RH for Model 6517-RH, up to 65°C probe environment, not to exceed 85°C.

## IEEE-488 BUS IMPLEMENTATION

**IMPLEMENTATION:** SCPI (IEEE-488.2, SCPI-1993).

**TRIGGER TO READING DONE:** 150ms typical, with external trigger.

**RS-232 IMPLEMENTATION: Supports:** SCPI 1991.0.

**Baud Rates:** 300, 600, 1200, 2400, 4800, 9600, 19.2k.

**PROTOCOLS:** Xon/Xoff, 7- or 8-bit ASCII, parity-odd/even/none.

**CONNECTOR:** DB-9 TXD/RXD/GND.

## GENERAL

**DISPLAY:** 6½-digit vacuum fluorescent multiline.

**RANGING:** Automatic or manual.

**CONVERSION TIME:** Selectable 0.01PLC to 10PLC.

**MAXIMUM INPUT:** 250V peak, DC to 60Hz sine wave; 10s per minute maximum on mA ranges.

**MAXIMUM COMMON MODE VOLTAGE (DC to 60Hz sine wave):**  
Electrometer, 500V peak; V Source, 750V peak.

**ISOLATION (Meter COMMON to chassis):** Typically  $10^{10}\Omega$  in parallel with 500pF.

**INPUT CONNECTOR:** Three lug triaxial on rear panel.

**2V ANALOG OUTPUT:** 2V for full range input. Non-inverting in Volts mode, inverting when measuring Amps, Ohms, or Coulombs. Output impedance 10k $\Omega$ .

**PREAMP OUTPUT:** Provides a guard output for Volts measurements. Can be used as an inverting output or with external feedback in Amps and Coulombs modes.

**EXTERNAL TRIGGER:** TTL compatible External Trigger and Electrometer Complete.

**GUARD:** Switchable voltage guard available.

**DIGITAL I/O AND TRIGGER LINE:** Available, see manual for usage.

**EMI/RFI:** Meets VDE-0871 and FCC Class B limits.

**EMC:** Conforms to European Union Directive 89/336/EEC.

**SAFETY:** Conforms to European Union Directive 73/23/EEC (meets EN61010-1/IEC 1010).

**READING STORAGE:** 50,000 max. readings (SCPI mode).

**READING RATE:**

To internal buffer 125 readings/second<sup>1</sup>

To IEEE-488 bus 115 readings/second<sup>1,2</sup>

Bus transfer 2500 readings/second<sup>2</sup>

<sup>1</sup> 0.01PLC, digital filters off, front panel off, temperature + RH off.

<sup>2</sup> Binary transfer mode.

**DIGITAL FILTER:** Median and averaging.

**ENVIRONMENT: Operating:** 0°–50°C; relative humidity 70% non-condensing, up to 35°C. **Storage:** –25° to +65°C.

**WARM-UP:** 1 hour to rated accuracy (see manual for recommended procedure).

**POWER:** 105–125V or 210–250V (external switch selected), 90–110V (internal switch selected), 50–60Hz, 50VA.

**PHYSICAL: Case Dimensions:** 90mm high  $\times$  214mm wide  $\times$  369mm deep (3½ in.  $\times$  8½ in.  $\times$  14½ in.).

**Working Dimensions:** From front of case to rear including power cord and IEEE-488 connector: 15.5 inches.

**Net Weight:** <4.6kg (<10.1 lbs.).

**Shipping Weight:** <9.5kg (<21 lbs.).

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