

## ULTRA-SENSITIVE MEASUREMENT SELECTION

## ULTRA-SENSITIVE MEASUREMENT INSTRUMENTS

Scientists and researchers worldwide rely on Keithley Electrometers, Picoammeters, and Nanovoltmeters for making low-level measurements beyond the capabilities of a typical digital multimeter. Keithley Electrometers and Picoammeters provide low current and high resistance measurements and Keithley Nanovoltmeters measure low voltages.



	2182A NANOVOLTMETER	6220 / 6221 CURRENT SOURCES	6485 / 6487 / 6482 PICOAMMETERS / PICOAMMETER & VOLTAGE SOURCE	6514 / 6517B / 6430 ELECTROMETERS
<b>Current Min/Max</b>	—	100fA / 100mA	1fA / 20mA	1aA/100mA
<b>Voltage Min/Max</b>	1nV / 100V	—	—	1μV / 200V
<b>Resistance Min/Max</b>	10nΩ / 1GΩ (with Model 6220 or 6221)	10nΩ/1GΩ (with Model 2182A)	10Ω/1PΩ (with Model 6487)	1μΩ - 1000PΩ
<b>Resolution</b>	7½ Digits	4½ Digits	5½ Digits (6485, 6487) 6½ Digits (6482)	5½ Digits (6514) 6½ Digits (6517B, 6430)
<b>Input Connection / Interface</b>	Low Thermal / GPIB, RS-232	3 Slot Triax / GPIB, RS-232 (LAN on 6221)	BNC (6485) 3 Slot Triax (6482, 6487) / GPIB, RS-232	3 Slot Triax / GPIB, RS-232

## CHOOSING YOUR SPECIALIZED LOW LEVEL INSTRUMENT

To help you choose the appropriate specialized low level instrument for your application, the most common selection criteria are listed below, including helpful tips for determining the correct specialized low level instrument for your requirements.

### 1 Resolution

Resolution means how fine a meter's measurement is and lets you determine if it's possible to see a small change in the signal. Resolution is described by digits and counts. A 6.5-digit instrument can display six full digits ranging from 0 to 9, and one "half" digit that displays either a 1 or is left blank. A 6.5-digit instrument can display up to 1,999,999 counts of resolution.

### 2 Accuracy

Accuracy is the largest allowable error that will occur under specific operating conditions and is an indication of how close the instrument's displayed measurement is to the actual value of the signal measured. Accuracy is typically expressed as a percent of reading. For example, an accuracy of 1% of reading means that, for a displayed reading of 100 volts, the actual value of the voltage is between 99 volts and 101 volts.

### 3 Low Current/High Resistance Measurements

Low current/high resistance measurements evaluate the insulation qualities of materials or components. Typically, a voltage up to 500 or 1000 volts is applied and the resulting current is measured, which can be in the range of picoamperes (10E-12A) or lower. A digital multimeter may seem like the right instrument for these measurements. But if the current is below 1μA or the resistance is above 10MΩ, the correct solution is an Electrometer or Picoammeter.

### 4 Low Voltage/Low Resistance Measurements

Low resistance/low voltage measurements evaluate the conduction or contact qualities of materials or components. Typically, a current under 100mA but as low as 1μA is applied and the resulting voltage is measured, which can be in the range of microvolts and even nanovolts. For low voltage, choose a Nanovoltmeter or low noise multimeter. For low resistance, a Nanovoltmeter/current source combination or switch/multimeter is the correct solution.

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## 2182A Nanovoltmeter

The two-channel Model 2182A Nanovoltmeter is optimized for making stable, low noise voltage measurements and for characterizing low resistance materials and devices reliably and repeatably. It provides higher measurement speed and significantly better noise performance for voltage meters than alternative low voltage measurement solutions.

MODEL	2182A	6220/2182A	6221/2182A
Voltage	1 nV – 100 V	1 nV – 100 V	1 nV – 100 V
Temperature	-200°C – 1820°C	-200°C – 1820°C	-200°C – 1820°C
Resistance		10 nΩ – 1 GΩ	10 nΩ – 1 GΩ
Channels	2	—	—
Current Source	—	±100 fA – 100 mA	±100 fA – 100 mA, with 1 mHz – 100 kHz, 10 Msamples/s, 64k arbitrary waveform generator

\*Delta Mode Resistance Measurement System

- Low noise voltage measurements at high speeds
- Delta mode coordinates measurements with a reversing current source at up to 24 Hz with 30 nV p-p noise (typical) for one reading. Averages multiple readings for greater noise reduction
- Built-in thermocouple linearization and cold junction compensation
- Dual channels



- Comparison of the 2182A's DC noise performance with a nanovolt/micro-ohmmeter's.

- Results from a 2182A and 6220 using the delta mode to measure a 10 mΩ resistor with a 20 μA test current.



## SHIPS WITH PRODUCT

2107-4: Low Thermal Input Cable with Spade Lugs, 1.2 m (4 ft)  
 User Documentation  
 Contact Cleaner  
 Power Cord  
 Alligator Clips

## RECOMMENDED ACCESSORIES

4288-1: Single Fixed Rack Mounting Kit  
 4288-2: Dual Fixed Rack Mounting Kit  
 KPCL-488LPA: IEEE-488 Interface/Controller for the PCI Bus  
 KUSB-488B: IEEE-488 USB-to-GPIB Interface Adapter  
 2107-30: Low Thermal Input Cable with spade lugs, 9.1 m (30 ft)  
 2182-KIT: Low Thermal Test Lead Kit  
 2187-4: Input Cable with safety banana plugs  
 2188: Low Thermal Calibration Shorting Plug  
 7007-1: Shielded GPIB Cable, 1 m (3.2 ft)  
 7007-2: Shielded GPIB Cable, 2 m (6.5 ft)  
 7009-5: Shielded RS-232 Cable, 1.5 m (5 ft)  
 8501-1: Trigger Link Cable, 1 m (3.2 ft)  
 8501-2: Trigger Link Cable, 2 m (6.5 ft)  
 8503: Trigger Link Cable to 2 male BNC connectors

**LEARN MORE** 📄 Download the Application Note "Low-Level Pulsed Electrical Characterization using Model 6221/2182A Combination."

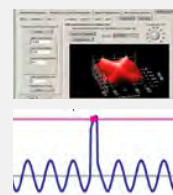


## 6220 / 6221 Current Sources

Keithley precision current sources include both broad-purpose 6220 and high-performance 6221. Their high sourcing accuracy and built-in control functions make them ideal for Hall Effect, resistance (using delta mode), pulsed, and differential conductance measurements. Programmable pulse widths limit power dissipation.

MODEL	6220	6221	6220/2182A	6221/2182A
Current Source	±100 fA – 100 mA	±100 fA – 100 mA	±100 fA – 100 mA	±100 fA – 100 mA
Arbitrary Waveform Generator	—	1 mHz – 100 kHz, 10 Msamples/s sample rate, 64k point waveform length	—	1 mHz – 100 kHz, 10 Msamples/s sample rate, 64k point waveform length
Pulse Generator	—	Programmable, 5 μs min. width	—	Programmable, 50 μs min. width, for pulsed I-V measurements
Resistance	—	—	10 nΩ – 1 GΩ	10 nΩ – 1 GΩ
PC Interface	GPIB, RS-232	GPIB, RS-232, Ethernet	GPIB, RS-232	GPIB, RS-232, Ethernet

- Measure low current & high voltage, resistance, and charge
- Resistance measurements to 1000P± (6517B)
- Current sensitivity as low as 1aA (6430)
- Voltage burden as low as 200μV
- Superior accuracy and sensitivity
- Perform insulation resistivity measurements in accordance with ASTM D257 standard
- Measurements are line synchronized to minimize 50/60Hz interference.



## SHIPS WITH PRODUCT

237-ALG-2: Low Noise, Input Cable with Triax-to-Alligator Clips 6.6 ft (2 m)  
 8501-2: Trigger Link Cable to connect 622x to 2182A, 6.6 ft (2 m)  
 174694600: Ethernet Crossover Cable (1.5 m) (6221 only)  
 CA-351: Communication Cable between 2182A and 622x  
 CS-1195-2: Safety Interlock Connector  
 User Documentation  
 Getting Started manual (hardcopy)  
 Software (downloadable)

## RECOMMENDED ACCESSORIES

237-ALG-2: Low Noise Triax Cable, 3-slot triax to alligator clips  
 7007-1: Shielded GPIB Cable, 1 m (3.2 ft)  
 7007-2: Shielded GPIB Cable, 2 m (6.5 ft)  
 7007-4: Shielded IEEE-488 Cable, 4 m (13.1 ft)  
 7009-5: Shielded RS-232 Cable, 1.5 m (5 ft)  
 7078-TRX-3: Low Noise Triax Cable, 3-Slot Triax Connectors, 0.9 m (3 ft)  
 7078-TRX-5: Low Noise Triax Cable, 3-Slot Triax Connectors, 1.5 m (5 ft)  
 7078-TRX-10: Low Noise Triax Cable, 3-Slot Triax Connectors, 3 m (10 ft)  
 7078-TRX-20: Low Noise Triax Cable, 3-Slot Triax Connectors, 6 m (20 ft)  
 174694600: LAN Crossover Cable (3 m)  
 8501-1: Trigger Link Cable with male Micro-DIN connectors at each end, 1 m (3.3 ft)  
 4288-1: Single Fixed Rack Mounting Kit  
 4288-2: Dual Fixed Rack Mounting Kit  
 KPCL-488LPA: IEEE-488 Interface/Controller for the PCI Bus  
 KUSB-488B: IEEE-488 USB-to-GPIB Interface Adapter

**LEARN MORE** 📄 Download "Determining Resistivity and Conductivity Type using a Four-Point Collinear Probe and the Model 6221 Current Source".

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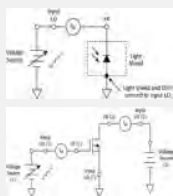
### 6485 Picoammeter, 6487/6482 Picoammeter & Voltage Sources

6485 6487 6482

Keithley Picoammeters combine sensitive current measurement with high speed. The 6485 Picoammeter offers fast, sensitive current measurement. The 6487 offers improved measurement capability, and adds a high resolution 500 V source. The 6482 offers two independent picoammeter/voltage source channels.

MODEL	6482	6487	6485
Channels	2	1	2
Current	1 fA – 20 mA (2 ch)	10 fA – 20 mA	10 fA – 20 mA
Resistance	N/A	Up to $10^{15} \Omega$	N/A
Reading Rate	900 rdgs/s	1000 rdgs/s	1000 rdgs/s
Voltage Source	2, $\pm 30$ V	$\pm 500$ V	—

- Measure currents down to 1 fA
- Voltage and resistance measurement options
- Voltage burden <200  $\mu$ V (most models)
- 5½- to 6½-digit resolution (most models)
- Feedback ammeter design for higher accuracy
- Dark current characterization of a photodiode using picoammeter and voltage source (such as the 6482)
- MOSFET sub-threshold voltage test using picoammeters and voltage sources (such as the 6482)



## SHIPS WITH PRODUCT

7078-TRX-BNC: Triax-to-BNC Connector (2x) (6482)  
 CA-186-1B: Ground Connection Cable, Banana to Screw-Lug (6487)  
 CAP-31: Protective Shield/Cap (3-lug) (6487)  
 CS-459: Safety Interlock Plug (6487)  
 7078-TRX-3: Low Noise Triax Input Cable, 1 m (3 ft) (6487)  
 8607: High Voltage Banana Cable Set for Voltage Source Output (6487)  
 CAP-18: Protective Shield/Cap (2-lug) (6485)  
 4801: Low Noise BNC Input (6485)  
 User Documentation

## RECOMMENDED ACCESSORIES

4802-10: Low noise BNC Input Cable, 3 m (10 ft) (for 6485)  
 4803: Low Noise Cable Kit (for 6485)  
 6517-ILC-3: Interlock Cable for 8009 Resistivity Test Fixture (6487 Only)  
 7007-1: Shielded IEEE-488 Cable, 1 m (3.3 ft)  
 7007-2: Shielded IEEE-488 Cable, 2 m (6.6 ft)  
 7007-4: Shielded IEEE-488 Cable, 4 m (13.1 ft)  
 7009-5: RS-232 Cable  
 7078-TRX-10: Low Noise Triax Cable, 3.0 m (10 ft) (6487 Only)  
 7078-TRX-20: Low Noise Triax Cable, 6.0 m (20 ft) (6487 Only)  
 7754-3: BNC to Alligator Cable (for 6485)  
 8501-1: Trigger Link Cable with male Micro-DIN connectors at each end, 1 m (3.3 ft)  
 CS-565: BNC Barrel (for 6485)  
 237-TRX-BAR: Triax Barrel (for 6487)  
 7078-TRX-BNC: Triax-to-BNC Adapter  
 8009: Resistivity Test Fixture (for 6487)  
 4288-1: Single Fixed Rack Mounting Kit  
 4288-2: Dual Fixed Rack Mounting Kit  
 KPCI-488LPA: IEEE-488 Interface/Controller for the PCI Bus  
 KUSB-488B: IEEE-488 USB-to-GPIB Interface Adapter

**LEARN MORE** 📄 Download the “Low Current Measurements” Application Note.



6514

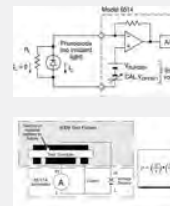
### 6514/6517B/6430 Electrometers

6517 6430

Our Electrometers provide a voltage source and the most current sensitivity to make extremely high resistivity measurements. They combine flexible interfacing capabilities with high impedance voltage measurement, charge measurement capabilities, resolution, and speed. The 6430 offers unmatched low current sensitivity.

MODEL	6517B	6514	6430
Current	10 aA – 20 mA	100 aA – 20 mA	1 aA – 100 mA
Voltage	1 $\mu$ V – 200 V	10 $\mu$ V – 200 V	100 nV – 200 V
Resistance	1 $\Omega$ – 1000 P $\Omega$	10 m $\Omega$ – 200 G $\Omega$	1 $\mu\Omega$ – >20 T $\Omega$
Charge	1 fC – 2 $\mu$ C	10 fC – 20 $\mu$ C	—
Sources	$\pm 5$ mV – 1000 V	—	$\pm 5$ $\mu$ V – 200 V, $\pm 50$ aA – 100 mA

- Measure low current & high voltage, resistance, and charge
- Resistance measurements to 1000 P $\Omega$  (6517B)
- Current sensitivity as low as 1 aA (6430)
- Voltage burden as low as 200  $\mu$ V
- Superior accuracy and sensitivity
- Perform insulation resistivity measurements in accordance with ASTM D257 standard
- The 6514's measurement can be adjusted to reflect the true dark current of a photodiode.
- A 6517B is well suited for applications where the volume resistivity needs to be measured.



## SHIPS WITH PRODUCT

237-ALG-2: Low Noise Triax Cable, 3-slot triax to alligator clips (2 m) (6514, 6517B)  
 6430-322-1B: Low noise Triax Cable, 3-slot triax to alligator clips (20 cm) (6430)  
 8607: Safety High Voltage Dual Test Leads (6430, 6517B)  
 6517-TP: Thermocouple Bead Probe (6517B)  
 CS-1305: Interlock Connector (6517B)  
 PreAmp Cable, 2 m (6.6 ft) (6430)  
 User Documentation

## RECOMMENDED ACCESSORIES

237-ALG-2: Low Noise Triax Cable, 3-slot triax to alligator clips  
 6517B-ILC-3: Interlock Cable (6517B only)  
 7078-TRX-3: Low Noise Triax Cable, 3-Slot Triax Connectors, 0.9 m (3 ft)  
 7007-1: Shielded IEEE-488 Cable, 1 m (3.2 ft)  
 8501-1: Trigger Link Cable, 1 m (3.3 ft)  
 8503: Trigger Link DIN-to-BNC Trigger Cable  
 8607: 1kV Source Banana Cables (for 6517B only)  
 6517-RH: Humidity Probe with Extension Cable (6517B only)  
 6517-TP: Temperature Bead Probe (included with 6517B) (6517B only)  
 8009: Resistivity Test Fixture (6517B Only)  
 KICKSTARTFL-HRMA: High Resistance Measurement Application for KickStart Instrument Control Software (6517B)  
 237-BNC-TRX: Male BNC to 3-Lug Female Triax Adapter (6517B)  
 237-TRX-NG: Triax Male-Female Adapter with Guard Disconnected  
 7078-TRX-BNC: 3-Slot Male Triax to BNC Adapter  
 7078-TRX-GND: 3-Slot Male Triax to BNC Adapter with guard removed (6517B)  
 4288-1: Single Fixed Rack Mounting Kit  
 4288-2: Dual Fixed Rack Mounting Kit  
 6521: Low Current Scanner Card (6517B)  
 6522: Voltage/Low Current Scanner Card (6517B)  
 KPCI-488LPA: IEEE-488 Interface/Controller for the PCI Bus  
 KUSB-488B: IEEE-488 USB-to-GPIB Interface Adapter

**LEARN MORE** 📄 Download the Application Note “Volume and Surface Resistivity Measurements of Insulating Materials”.

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