Combines broad functionality with exceptional measurement integrity

SMU INSTRUMENTS

6430

Sub-femtoamp Remote SourceMeter® SMU Instrument

- **0.4fA p-p (4E–16A) noise (typical)**
- **Remote PreAmp can be located at the signal source to minimize cable noise**
- **>$10^{16}\Omega$ input resistance on voltage measurements**
- **High speed — up to 2000 readings/second**
- **Up to 6½-digit resolution**
- **Fast characterization of components with programmable digital I/O and interfaces**

The Model 6430 Sub-Femtoamp Remote SourceMeter SMU Instrument combines the voltage and current sourcing and measurement functions of Keithley's popular SourceMeter SMU instruments with sensitivity, noise, and input resistance specifications superior to electrometers. This unique combination of broad functionality and exceptional measurement integrity is made possible by the Model 6430's Remote PreAmp, which offers a very sensitive bi-directional amplifier with sensitive feedback elements for measuring or sourcing currents at the device being tested. The high level signals output by the Remote PreAmp are sent to the controlling mainframe via a two-meter cable. This allows the user to make a direct or very short connection to the signal, minimizing the effects of cable noise.

The Model 6430 makes voltage, current, and resistance measurements at speeds no electrometer can match. It can read up to 2000 source/measure readings per second into internal memory. Currents can be measured in as little as 5ms on the 100nA range, decreasing to just a few hundred microseconds on the higher ranges.

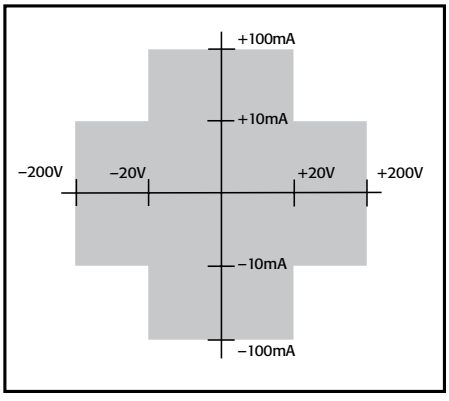
The Model 6430's distinguishing features include its excellent low current sensitivity and the Remote PreAmp, which makes this sensitivity useful by eliminating long input cables. The Remote PreAmp is an integral part of the Model 6430's feedback measuring system that cannot be operated independently from the measurement mainframe, although it can be separated from the mainframe by up to two meters of connection cable carrying high level signals.

Applications

The Model 6430's capabilities make it equally useful for research work and for evaluating sophisticated components in test labs for low-current, high-resistance, or sensitive semiconductor measurements. The low noise and drift performance of the Model 6430 also makes it well suited for research studies in single electron devices, highly resistive nanowires and nanotubes, polymers, highly resistive nanomaterials, and electrochemical amperometry applications.

High Speed Data Handling

The Model 6430 can read more than 2000 readings per second into its internal memory buffer. The IEEE-488 bus output can transmit up to 75 source/measure readings per second to an external computer controller, including pass/fail indication.



The Model 6430 provides four-quadrant sourcing of up to 2.2W, as well as measurement sensitivity down to sub-femtoamp and microvolt levels. It can measure currents from the 1pA range (with just 0.4fA p-p noise typical) up to the 100mA range at up to 20V. Voltage ranges from 200mV to 200V are available. Current and voltage range settings define the maximum source or sink voltage or current.

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Ordering Information

6430 Sub-femtoamp Remote SourceMeter SMU Instrument

Accessories Supplied

6430-322-1B Low Noise Triax Cable, 3-slot triax to alligator clips, 20cm (8 in)

8607 Safety High Voltage Dual Test Leads

CA-176-1E PreAmp Cable, 2m (6.6 ft)

CA-186-1B Banana Lead to Screw Terminal Adapter

CAP-31 3-lug Protective Cap (2)

Instruction Manual

ACCESSORIES AVAILABLE

7007-1	Shielded GPIB Cable, 1m (3.3 ft)
7007-2	Shielded GPIB Cable, 2m (6.6 ft)
7007-4	Shielded GPIB Cable, 4m (13.1 ft)
7007-05	Shielded GPIB Cable, 0.5m (1.6 ft)
7078-TRX-6IN	3-slot, Low Noise, 0.15m (0.5 ft) Guarded Triax Cable
8501-1	Trigger Link Cable, 1m (3.3 ft.)
8501-2	Trigger Link Cable, 2m (6.6 ft.)
8502	Trigger Link Adapter Box
8503	Trigger Link DIN-to-BNC Trigger Cable
KPCI-488LPA	IEEE-488 Interface/Controller for the PCI Bus
KUSB-488B	IEEE-488 USB-to-GPIB Interface Adapter

SERVICES AVAILABLE

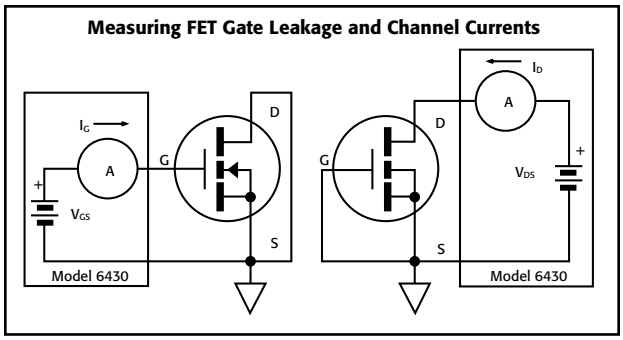
TRN-2400-1-C	Course: Unleashing the Power of Your SourceMeter SMU Instrument
6430-3Y-EW	1-year factory warranty extended to 3 years from date of shipment
C/6430-3Y-ISO	3 (ISO-17025 accredited) calibrations within 3 years of purchase*

*Not available in all countries

Typical applications:

Semiconductor measurements

Gate leakage or channel leakage in FET-based components can generate errors in MOSFETs, JFETs, analog switches, and many other circuits. By allowing researchers to measure extremely low-level currents and voltages, the Model 6430 can help them understand the design limitations of these components and investigate alternative device structures or materials.

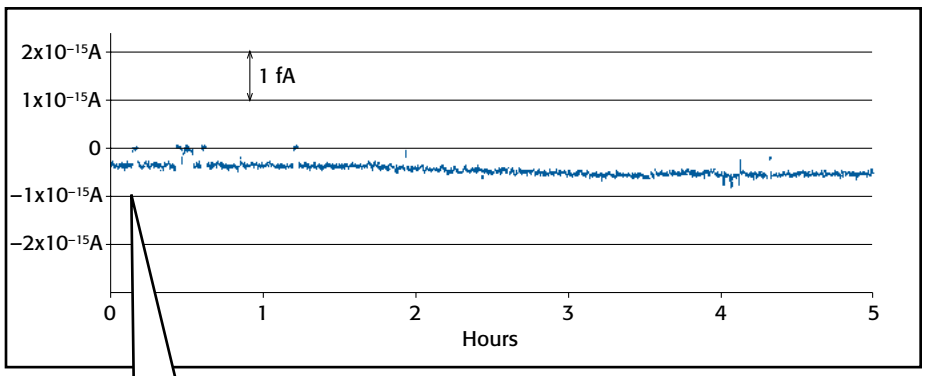


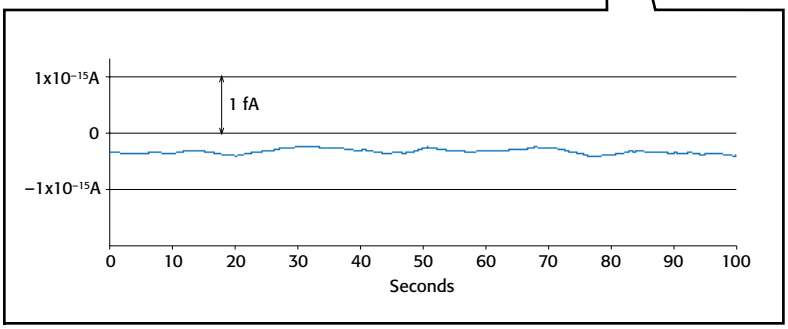
SET research

The Model 6430's superior low current measurement ability (0.4fA p-p noise typical) makes it extremely useful for single electron transistor (SET) and quantum-dot research. Using a technique similar to a lock-in, the 6430 can measure currents with 1aA sensitivity (10^{-18}A = 6 electrons/second).

The Measurement Industry's Lowest Noise and Drift

This data illustrates the Model 6430's impressive stability over a five-hour period, as well as its low short-term noise performance. This signal trace was acquired using the instrument's AUTOFILTER with a 5-second rise time on the 1pA range. The inset close-up is a snapshot of the filtered signal, showing the Model 6430's low noise during the first 100-second period. The data was taken in a laboratory environment where temperature varied about 1°C, with the instrument's IN/OUT HI and SENSE leads capped.





Combines broad functionality with exceptional measurement integrity

SMU INSTRUMENTS

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Sub-Femtoamp Remote SourceMeter® SMU Instrument

CONDENSED MEASURE SPECIFICATIONS [1]

VOLTAGE MEASUREMENT ACCURACY (4-WIRE SENSE)[3]

Range	Max. Resolution	Input[2] Resistance	Accuracy (23°C ± 5°C) 1 Year, ±(%rdg + volts)
200.000 mV	1 μV	>10^{16}Ω	0.012% + 350 μV
2.00000 V	10 μV	>10^{16}Ω	0.012% + 350 μV
20.0000 V	100 μV	>10^{16}Ω	0.015% + 1.5 mV
200.000 V	1 mV	>10^{16}Ω	0.015% + 10 mV

TEMPERATURE COEFFICIENT (0°–18°C and 28°–40°C): ±(0.15 × accuracy specification)/°C.

ADDITIONAL MEASURE SPECIFICATIONS

OUTPUT SETTLING TIME (typical to 10% of final value): <2s, 1pA and 10pA ranges; <50ms, 100pA through 10nA ranges; <5ms, 100nA through 100mA ranges.

CURRENT NOISE: When observed over 1 minute intervals, peak to peak noise will be within 400aA (typical) during 90% of the intervals using Autofilter (5s 10% to 90% rise time), with triax connectors capped, Autozero OFF, Source Delay = 0, on the 1pA range for at least 3 minutes.

CURRENT MEASUREMENT ACCURACY (2- OR 4-WIRE SENSE)[4]

Range	Max. Resolution	Voltage Burden[5]	Accuracy (23°C ± 5°C) 1 Year ±(%rdg + amps)
1.00000 pA	10 aA	< 1mV	1.0 % + 7 fA
10.0000 pA	100 aA	< 1mV	0.50 % + 7 fA
100.000 pA	1 fA	< 1mV	0.15 % + 30 fA
1.00000 nA	10 fA	< 1mV	0.050 % + 200 fA
10.0000 nA	100 fA	< 1mV	0.050 % + 2 pA
100.000 nA	1 pA	< 1mV	0.050 % + 20 pA
1.00000 μA	10 pA	< 1mV	0.050 % + 300 pA
10.0000 μA	100 pA	< 1mV	0.050 % + 2 nA
100.000 μA	1 nA	< 1mV	0.025 % + 6 nA
1.00000 mA	10 nA	< 1mV	0.027 % + 60 nA
10.0000 mA	100 nA	< 1mV	0.035 % + 600 nA
100.000 mA	1 μA	< 1mV	0.055 % + 6 μA

TEMPERATURE COEFFICIENT (0°–18°C and 28°–40°C): ±[(0.15 × accuracy specification) + 1fA]/°C.

INPUT CURRENT: <3fA at 23°C, <40% RH; typically ±0.5fA/°C around 23°C, <40% RH.

RESISTANCE MEASUREMENT ACCURACY (4-WIRE SENSE WITH REMOTE PREAMP)

Source I Mode, Auto Ohms

Range	Max. Resolution	Default Test Current	Normal Accuracy (23°C ± 5°C) 1 Year, ±(%rdg + ohms)	Enhanced Accuracy (23°C ± 5°C) [7] 1 Year, ±(%rdg + ohms)
<2.00000 Ω [6]	1 μΩ	—	Source I_{ACC} + Measure V_{ACC}	Measure I_{ACC} + Measure V_{ACC}
20.0000 Ω	100 μΩ	100 mA	0.098% + 0.003 Ω	0.068% + 0.001 Ω
200.000 Ω	1 mΩ	10 mA	0.077% + 0.03 Ω	0.048% + 0.01 Ω
2.00000 kΩ	10 mΩ	1 mA	0.066% + 0.3 Ω	0.040% + 0.1 Ω
20.0000 kΩ	100 mΩ	100 μA	0.063% + 3 Ω	0.038% + 1 Ω
200.000 kΩ	1 Ω	10 μA	0.082% + 30 Ω	0.064% + 10 Ω
2.00000 MΩ	10 Ω	1 μA	0.082% + 300 Ω	0.064% + 100 Ω
20.0000 MΩ	100 Ω	1 μA	0.085% + 1 kΩ	0.067% + 500 Ω
200.000 MΩ	1 kΩ	100 nA	0.085% + 10 kΩ	0.068% + 5 kΩ
2.00000 GΩ	10 kΩ	10 nA	0.085% + 100 kΩ	0.070% + 50 kΩ
20.0000 GΩ	100 kΩ	1 nA	0.085% + 1 MΩ	0.070% + 500 kΩ
200.000 GΩ	1 MΩ	100 pA	0.205% + 10 MΩ	0.185% + 5 MΩ
2.00000 TΩ	10 MΩ	10 pA	0.822% + 100 MΩ	0.619% + 50 MΩ
20.0000 TΩ	100 MΩ	1 pA	2.06% + 1 GΩ	1.54% + 500 MΩ
>20.0000 TΩ [6]	—	—	Source I_{ACC} + Measure V_{ACC}	Measure I_{ACC} + Measure V_{ACC}

TEMPERATURE COEFFICIENT (0°–18°C and 28°–40°C): ±(0.15 × accuracy specification)/°C.

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

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

6-WIRE OHMS MODE: Available using active ohms guard and guard sense (mainframe rear panel ONLY). **Max. Guard Output Current:** 50 mA. Accuracy is load dependent. Refer to manual for calculation formula.

MAINFRAME GUARD OUTPUT RESISTANCE: 0.1Ω in ohms mode.

NOTES

1. Speed = 10 PLC, Autofilter ON, properly zeroed and settled.
2. Source I mode, I = 0.
3. Voltage measurement accuracy is not affected by the remote preamp.
4. Current measurement accuracy is not affected by the remote preamp; however, the 1pA through 100nA ranges are available only when using a preamp.
5. 4-wire mode.
6. Manual ohms mode only.
7. Source readback enabled, offset compensation ON. Source delay must be programmed such that the source is fully settled for each reading.

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Sub-Femtoamp Remote SourceMeter® SMU Instrument

CONDENSED SYSTEM SPEEDS

MEASUREMENT[1]

MAXIMUM RANGE CHANGE RATE: 75/second.

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[2, 3] To GPIB
Fast	0.01 / internal	256 (256)	83 (83)	83 (83)
Medium	0.10 / internal	181 (166)	73 (70)	73 (70)
Normal	1.00 / internal	49 (42)	35 (31)	34 (30)

CONDENSED SOURCE SPECIFICATIONS[4]

VOLTAGE PROGRAMMING ACCURACY (4-WIRE SENSE)[5]

Range	Programming Resolution	Accuracy (1 Year) 23°C ±5°C ±(% rdg. + volts)	Noise (peak-peak) 0.1Hz – 10Hz
200.000 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
200.000 V	5 mV	0.02% + 24 mV	5 mV

TEMPERATURE COEFFICIENT (0°–18°C and 28°–40°C): ±(0.15 × accuracy specification)/°C.

MAX. OUTPUT POWER: 2.2W (four quadrant source or sink operation).

SOURCE/SINK LIMITS: ±21V @ ±105mA, ±210V @ ±10.5mA.

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

NOISE 10Hz–1MHz (p-p): 10mV.

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.

CURRENT PROGRAMMING ACCURACY (WITH REMOTE PREAMP)

Range	Programming Resolution	Accuracy (1 Year)[4] 23°C ±5°C ±(% rdg. + amps)	Noise (peak-peak) 0.1Hz – 10Hz
1.00000 pA	50 aA	1.0 % + 10 fA	5 fA
10.0000 pA	500 aA	0.50 % + 30 fA	10 fA
100.000 pA	5 fA	0.15 % + 40 fA	20 fA
1.00000 nA	50 fA	0.050 % + 200 f A	50 fA
10.0000 nA	500 fA	0.050 % + 2 pA	500 fA
100.000 nA	5 pA	0.050 % + 20 pA	3 pA
1.00000 µA	50 pA	0.050 % + 300 pA	20 pA
10.0000 µA	500 pA	0.050 % + 2 nA	200 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

TEMPERATURE COEFFICIENT (0°–18°C and 28°–40°C): ±(0.15 × accuracy specification)/°C.

MAX. OUTPUT POWER: 2.2W (four quadrant source or sink operation).

SOURCE/SINK LIMITS: ±10.5mA @ ±210V, ±105mA @ ±21V.

CURRENT REGULATION: Line: 0.01% of range. **Load:** 0.01% of range + 1fA.

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

NOTES

1. Reading rates applicable for voltage or current measurements. Auto zero off, autorange off, filter off, display off, trigger delay = 0, source auto clear off, and binary reading format.
2. Pass/Fail test performed using one high limit and one low math limit.
3. Includes time to re-program source to a new level before making measurement.
4. For sink mode, 1pA to 100mA range, accuracy is ±(0.15% + offset*4).
5. Voltage source accuracies are not affected by the remote preamp.

GENERAL

Noise Rejection:	NPLC	NMRR	CMRR
Fast	0.01	—	80 dB
Medium	0.1	—	80 dB
Normal	1	60 dB	90 dB

LOAD IMPEDANCE: Stable into 20,000pF on the 100mA through 100µA ranges, 470pF on the 10µA and 1µA ranges, and 100pF on the nA and pA ranges. Refer to the User's Manual for details on measuring large capacitive loads.

COMMON MODE VOLTAGE: ±42VDC maximum.

COMMON MODE ISOLATION: >10^9Ω, <1000pF.

OVERRANGE: 105% of range, source and measure.

MAX. VOLTAGE DROP BETWEEN INPUT/OUTPUT AND SENSE TERMINALS: 5V. (To meet specified accuracy with 4-wire sense, refer to the User's Manual.)

MAX. SENSE LEAD RESISTANCE: 10Ω for rated accuracy.

SENSE INPUT RESISTANCE: 1MΩ.

MAINFRAME GUARD OFFSET VOLTAGE: 300µV, typical.

PREAMP GUARD OFFSET VOLTAGE: 1mV, typical.

PREAMP GUARD OUTPUT RESISTANCE: 110kΩ.

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 @ 5½ digits (two 2,500 point buffers). Includes selected measured value(s) and time stamp. Lithium battery backup (3 yr+ battery life).

DIGITAL INTERFACE:

Safety Interlock: Active low input.

Handler Interface: Start of test, end of test, 3 category bits. +5V @ 300mA supply.

Digital I/O: 1 trigger input, 4 TTL/Relay Drive outputs (33V @ 500mA sink, diode clamped).

PROGRAMMABILITY: IEEE-488 (SCPI-1995.0), RS-232, 5 user-definable power-up states plus factory default and *RST.

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

EMC: Conforms with European Union Directive 89/336/EEC EN 55011, EN 50082-1, EN 61000-3-2 and 61000-3-3, FCC part 15 class B.

SAFETY: Conforms with European Union Directive 73/23/EEC EN 61010-1.

VIBRATION: MIL-PRF-28800F, Class 3.

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).
Amplifier: 20mm high × 57mm wide × 97mm deep (0.783 in × 2.225 in × 3.75 in).

WEIGHT: 5.9kg (13 lbs).

ENVIRONMENT: Operating: 0°–40°C, 60% R.H. (non-condensing) up to 35°C. Derate 5% R.H./°C, 35°–40°C. **Storage:** –25°C to 65°C. Non-condensing humidity.