

6430 Sub-Femtoamp Remote SourceMeter® SMU Instrument

DATASHEET



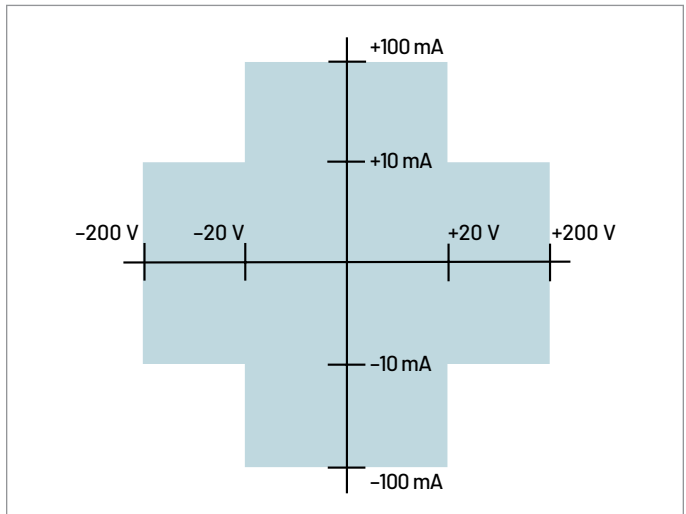
The 6430 Sub-Femtoamp Remote SourceMeter SMU Instrument combines the voltage and current sourcing and measurement functions of Keithley’s popular SourceMeter SMU instruments with sensitivity, noise, and input resistance specifications superior to electrometers. This unique combination of broad functionality and exceptional measurement integrity is made possible by the 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 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 5 ms on the 100 nA range, decreasing to just a few hundred microseconds on the higher ranges.

Key Features

- 0.4 fA p-p (4E-16 A) 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 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 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.



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

Applications

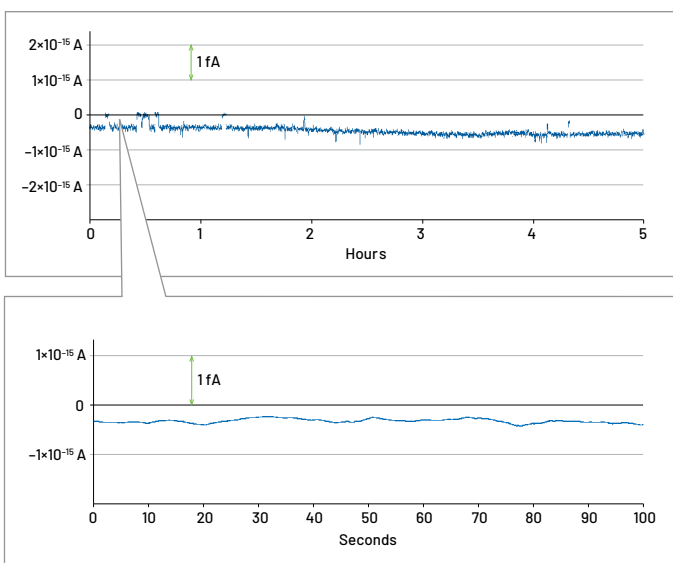
The 6430's capabilities make it equally useful for research work and for evaluating sophisticated components in test labs for low-current, high-resistance, or sensitive semiconductor measurements. The low noise and drift performance of the 6430 also makes it well suited for research studies in single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

High Speed Data Handling

The 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 Measurement Industry's Lowest Noise and Drift

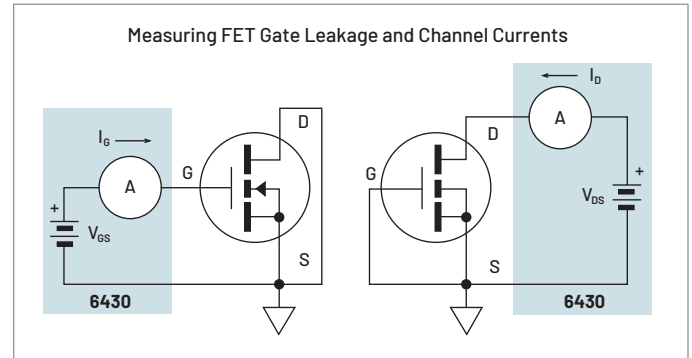
This data illustrates the 6430's impressive stability over a five-hour period, as well as its low short-term noise performance. This signal trace was acquired using the instrument's AUTOFILTER with a 5-second rise time on the 1 pA range. The inset close-up is a snapshot of the filtered signal, showing the 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.



Typical Applications

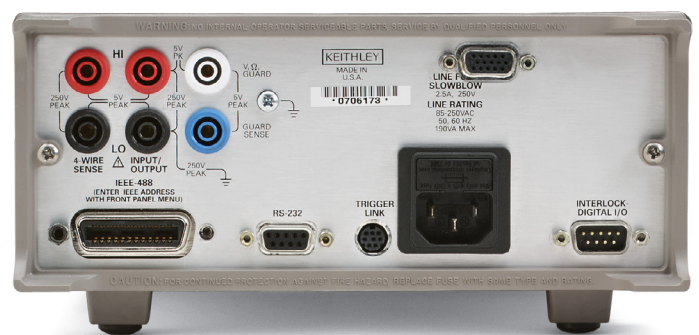
Semiconductor measurements

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 6430 can help them understand the design limitations of these components and investigate alternative device structures or materials.



SET research

The 6430's superior low current measurement ability (0.4 fA 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).



6430 rear panel.

Condensed Source Specifications¹

Voltage Programming Accuracy (4-wire sense)²

Range	Programming Resolution	Accuracy (1 Year) 23°C ±5°C ±(% rdg. + volts)	Typical Noise (peak-peak) 0.1 Hz – 10 Hz
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 2.2 W (four quadrant source or sink operation).

Source/Sink Limits ±21 V @ ±105 mA, ±210 V @ ±10.5 mA.

Voltage Regulation **Line:** 0.01% of range. **Load:** 0.01% of range + 100 µV.

Noise 10 Hz–1 MHz (p-p) 10 mV (typical).

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) ² 23°C ±5°C ±(% rdg. + amps)	Typical Noise (peak-peak) 0.1 Hz – 10 Hz
1.00000 pA	50 aA	1.0 % + 10 fA	7 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 fA	80 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 2.2 W (four quadrant source or sink operation).

Source/Sink Limits ±10.5 mA @ ±210 V, ±105 mA @ ±21 V.

Current Regulation **Line:** 0.01% of range. **Load:** 0.01% of range + 1 fA.

Voltage Limit Bipolar voltage limit (compliance) set with single value. Min. 0.1% of range.

NOTES

- For sink mode, 1 pA to 100 mA range, accuracy is ±(0.15% + offset*4).
- Voltage source accuracies are not affected by remote preamp.

Condensed Measure Specifications¹

Voltage Measurement Accuracy (4-wire sense)³

Range	Max. Resolution	Input Resistance ²	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)

<2 s, 1 pA, and 10 pA ranges; <50 ms, 100 pA through 10 nA ranges; <5 ms, 100 nA through 100 mA ranges.

Current Noise

When observed over 1 minute intervals, peak to peak noise will be within 400 aA (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 1 pA 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	<1 mV	1.0 % + 7 fA
10.0000 pA	100 aA	<1 mV	0.50 % + 7 fA
100.000 pA	1 fA	<1 mV	0.15 % + 30 fA
1.00000 nA	10 fA	<1 mV	0.050 % + 200 fA
10.0000 nA	100 fA	<1 mV	0.050 % + 2 pA
100.000 nA	1 pA	<1 mV	0.050 % + 20 pA
1.00000 µA	10 pA	<1 mV	0.050 % + 300 pA
10.0000 µA	100 pA	<1 mV	0.050 % + 2 nA
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

Temperature Coefficient (0°–18°C and 28°–40°C)

±[(0.15 × accuracy specification) + 1 fA]/°C.

Input Current

<3 fA at 23°C, <40% RH; typically ±0.5 fA/°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 0.1 Ω in ohms mode.

NOTES

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

Condensed System Speeds

Measurement¹

Maximum Range Change Rate 75/second.

Single Reading Operation Reading Rates (rdg/second) for 60 Hz (50 Hz)

Speed	NPLC/Trigger Origin	Measure To GPIB	Source-Measure ³ 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)

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.

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 20,000 pF on the 100 mA through 100 μ A ranges, 470 pF on the 10 μ A and 1 μ A ranges, and 100 pF on the nA and pA ranges. Refer to the User's Manual for details on measuring large capacitive loads.
Common Mode Voltage	\pm 42 VDC maximum.
Common Mode Isolation	$>10^9 \Omega$, <1000 pF.
Overrange	105% of range, source and measure.
Max. Voltage Drop Between Input/Output and Sense Terminals	5 V. (To meet specified accuracy with 4-wire sense, refer to the User's Manual.)
Max. Sense Lead Resistance	10 Ω for rated accuracy.
Sense Input Resistance	1 M Ω .
Mainframe Guard Offset Voltage	300 μ V, typical.
Preamp Guard Offset Voltage	1 mV, typical.
Preamp Guard Output Resistance	110 k Ω .
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. +5 V @ 300 mA supply.
Digital I/O	1 trigger input, 4 TTL/Relay Drive outputs (33 V @ 500 mA sink, diode clamped).
Programmability	IEEE-488 (SCPI-1995.0), RS-232, 5 user-definable power-up states plus factory default and *RST.
Power Supply	100 V–240 V rms, 50–60 Hz (automatically detected at power up), 100 VA 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	89 mm high × 213 mm wide × 370 mm deep (3½ in × 8⅜ in × 14⅞ in). Bench Configuration (with handle and feet): 104 mm high × 238 mm wide × 370 mm deep (4⅛ in × 9⅝ in × 14⅞ in). Amplifier: 20 mm high × 57 mm wide × 97 mm deep (0.783 in × 2.225 in × 3.75 in).
Weight	5.9 kg (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.

Ordering Information

6430	Sub-femtoamp Remote SourceMeter SMU Instrument
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Supplied Accessories

6430-322-1B	Low Noise Triax Cable, 3-slot triax to alligator clips, 20 cm (8 in)
8607	Safety High Voltage Dual Test Leads
CA-176-1E	PreAmp Cable, 2 m (6.6 ft)
CA-186-1B	Banana Lead to Screw Terminal Adapter
CAP-31	3-lug Protective Cap (2)

Instruction Manual

Available Accessories

7007-1	Shielded GPIB Cable, 1 m (3.3 ft)
7007-2	Shielded GPIB Cable, 2 m (6.6 ft)
7007-4	Shielded GPIB Cable, 4 m (13.1 ft)
7007-05	Shielded GPIB Cable, 0.5 m (1.6 ft)
7078-TRX-6IN	3-slot, Low Noise, 0.15 m (0.5 ft) Guarded Triax Cable
8501-1	Trigger Link Cable, 1 m (3.3 ft.)
8501-2	Trigger Link Cable, 2 m (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

Available Services

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

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