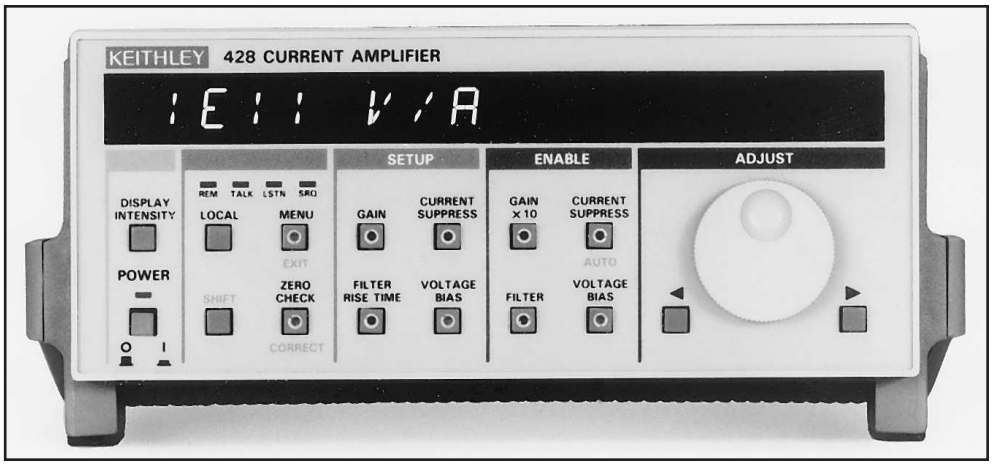
428 Current Amplifier

- 2µs rise time
- 1.2fA rms noise
- Up to 10^{11} V/A gain
- IEEE-488 interface available



ACCESSORIES AVAILABLE

CABLES

4801 Low Noise BNC Input Cable, 1.2m (4 ft)

ADAPTERS

4804 Male BNC to 2-Lug Female Triax Adapter

6147 2-Slot Male Triax to Female BNC Adapter

7078-TRX-BNC 3-Slot Male Triax to Female BNC Adapter

RACK MOUNTS

4288-1 Single Fixed Rack Mount Kit

4288-2 Dual Fixed Rack Mount Kit

4288-4 Dual Fixed Rack Mount Kit

See page A-231 for descriptions of all accessories.

The Model 428 Current Amplifier converts fast, small currents to a voltage, which can be easily digitized or displayed by an oscilloscope, wave-form analyzer, or data acquisition system. It uses a sophisticated "feedback current" circuit to achieve both fast rise times and sub-picoamp noise. The gain of the 428 is adjustable in decade increments from 10^3V/A to 10^{11}V/A, with selectable rise times from 2µs to 300ms.

The 428 incorporates a second-order Bessel-function filter that minimizes noise without increasing rise time on high-gain ranges. This may be defeated in situations where 6dB/octave roll-off is desired, as in control loops of scanning tunnel electron microscopes.

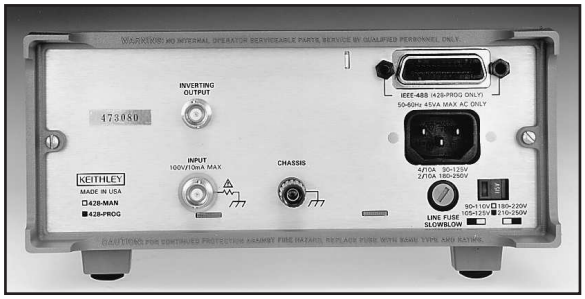
Input and output connections to the 428 are made with BNC connectors. INPUT HI is connected to a programmable ±5V supply, which permits suitable bias voltages to be applied to devices-under-test or current collectors. This eliminates the need for a separate bias supply.

ORDERING INFORMATION

428-MAN	Manual Current Amplifier
428-PROG	Programmable Current Amplifier with IEEE-488 Interface

This product is available with an **Extended Warranty.** See section C for complete ordering information.

For applications where voltage offset errors exist, the ZERO CHECK and OFFSET functions can be used, thereby maintaining maximum instrument accuracy. Current suppression is also available up to 5mA, useful for suppressing background currents, such as dark currents.



The 428 also incorporates a new exterior design with simplified front panel operation, improved display, and convenient system integration. Pushbutton controls have an LED in the center to indicate if that function is activated. The display features three selectable intensities (bright, dim, and off) for use in light-sensitive environments. All set-up values can be displayed from the front panel.

The Model 428-MAN is a manual version with no IEEE-488 interface capabilities. The Model 428-PROG includes the IEEE-488 interface.

Applications

The 428 satisfies a broad range of applications in research and device labs due to its cost-effective ability to amplify fast, low currents. A few of these applications include:

Surface Science Studies:

- Scanning Tunneling Electron Microscope system amplifier.
- Observation of secondary electron emission, as in X-ray and beam line currents.

QUESTIONS?

1-800-552-1115 (U.S. only)

Call toll free for technical assistance, product support or ordering information.

428 Current Amplifier

Laser and Light Measurements:

- Fast, sensitive amplifier for use with PMTs and photodiodes.
- Analysis of fast photoconductive materials.
- IR detector amplifier.

Transient Phenomena:

- Current DLTS studies.
- Breakdown in devices and dielectric materials

The 428 as Preamplifier to an Oscilloscope

In this widespread application, the 428 is connected to an oscilloscope or waveform digitizer and very low currents are amplified, converted to a voltage, and sent into the scope to be displayed in real time.

	ACCURACY[1]		LOW NOISE[2]		MAXIMUM SPEED		
GAIN SETTING V/A	18°–28°C ±(% input + offset)	TEMPERATURE COEFFICIENT ±(% input + offset)/°C	RISE TIME[3] (10%–90%) ms	NOISE RMS	RISE TIME[3] (10%–90%) µs[4]	NOISE RMS[4]	DC INPUT RESISTANCE
10^3	0.45 + 1.2 µA	0.01 + 40 nA	0.1	90 nA	2	100 nA	< 0.6 Ω
10^4	0.31 + 120 nA	0.01 + 4 nA	0.1	9 nA	2	15 nA	< 0.7 Ω
10^5	0.31 + 12 nA	0.01 + 400 pA	0.1	900 pA	5	2 nA	< 1.6 Ω
10^6	0.34 + 1.2 nA	0.01 + 40 pA	0.1	90 pA	10	50 pA	< 10 Ω
10^7	0.5 + 122 pA	0.015 + 4.3 pA	0.1	9 pA	15	20 pA	< 100 Ω
10^8	1.4 + 14 pA	0.015 + 700 fA	1	0.5 pA	40	30 pA	< 1 kΩ
10^9	2.5 + 3 pA	0.025 + 300 fA	10	50 fA	100	10 pA	< 10 kΩ
10^{10}	2.5 + 1.6 pA	0.025 + 250 fA	100	4 fA	250	2 pA	< 100 kΩ
10^{11}*	2.7 + 1.6 pA	0.028 + 50 fA	300	1.2 fA	250	2 pA	< 100 kΩ

[1] When properly zeroed using zero correct.
[2] Selectable filtering will improve noise specifications; see operator's manual for details (typical value shown).
[3] Bandwidth = 0.35/rise time.
[4] With up to 100pF shunt capacitance; autofilter on; low pass filter off.
* 10^{11} setting is 10^{10} setting with GAIN ×10 enabled; other entries are for GAIN ×10 disabled.

SPECIFICATIONS

INPUT:

Voltage Burden: <200µV (18°–28°C) for inputs <100µA; <10mV for inputs ≥ 100µA; 20µV/°C temperature coefficient.

Maximum Overload: 100V on 10^4 to 10^{11}V/A ranges; 10V on 10^3V/A range. Higher voltage sources must be current limited at 10mA.

OUTPUT:

Range: ±10V, 1mA; bias voltage off.

Impedance: <100Ω DC–175kHz.

LOW PASS FILTER:

Ranges: 10µs to 300ms (±25%) in 1, 3, 10 sequence or OFF.

Attenuation: 12dB/octave.

GAIN ×10: Rise time, noise, and input resistance are unchanged when selecting GAIN ×10; gain accuracy and temperature coefficient are degraded by 0.2% and 0.003%/°C respectively.

CURRENT SUPPRESSION

RANGE	RESOLUTION	ACCURACY ±(%setting + offset)
±5 nA	1 pA	3.0 + 10 pA
±50 nA	10 pA	1.6 + 10 pA
±500 nA	100 pA	0.8 + nA
±5 µA	1 nA	0.7 + 10 nA
±50 µA	10 nA	0.6 + 100 nA
±500 µA	100 nA	0.6 + 1 µA
±5 mA	1 µA	0.6 + 10 µA

BIAS VOLTAGE:

Range: ±5V.

Resolution: 2.5mV.

Accuracy: ±(1.1%rdg + 25mV).

GENERAL

DISPLAY: Ten character alphanumeric LED display with normal/dim/off intensity control.

REAR PANEL CONNECTORS:

Input BNC: Common connected to chassis through 1kΩ.

Output BNC: Common connected to chassis.

IEEE-488 Connector: 428-PROG only.

5-Way Binding Post: Connected to chassis.

EMI/RFI: Complies with the RF interference limits of FCC Part 15 Class B and VDE 0871 Class B.

WARM-UP: 1 hour to rated accuracy.

ENVIRONMENT: Operating: 0°–50°C, <70% R.H. up to 35°C; linearly derate R.H. 3%/°C up to 50°C. **Storage:** –25°C to 65°C.

POWER: 105–125 VAC or 210–250 VAC, switch selected. (90–110/180–220 VAC available.) 50Hz or 60Hz. 45VA maximum.

DIMENSIONS, WEIGHT: 90mm high × 213mm wide × 397mm deep (3½ in × 8⅜ in × 15⅝ in). Net weight 3.4kg (7.4 lb).

IEEE-488 BUS IMPLEMENTATION (428-PROG)

MULTILINE COMMANDS: DCL, LLO, SDC, GTL, UNT, UNL, SPE, SPD.

UNILINE COMMANDS: IFC, REN, EOI, SRQ, ATN.

INTERFACE FUNCTIONS: SH1, AH1, T6, L4, LE0, SR1, RL1, PP0, DC1, DT0, C0, E1.

PROGRAMMABLE PARAMETERS: All parameters and controls programmable except for IEEE-488 bus address.

EXECUTION SPEED: (measured from DAV true to RFD true on bus).
Zero correct & auto suppression commands: <3s
Save/Recall Configuration commands:<500 ms
All other commands:<40ms