428-PROG

Programmable Current Amplifier

The Model 428-PROG Programmable Current Amplifier converts fast, small currents to a voltage, which can be easily digitized or displayed by an oscilloscope, waveform 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 Model 428-PROG is adjustable in decade increments from 10^3V/A to 10^{11}V/A, with selectable rise times from 2μs to 300ms.

The Model 428-PROG offers fast response at low current levels, which is unmatched by either electrometers or picoammeters. The nine current amplification ranges allow the greatest flexibility in making speed/noise tradeoffs. The Model 428-PROG can be used with any of Keithley's data acquisition boards to implement a very cost-effective, low current measurement system with wide bandwidth and fast response.

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

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

Input and output connections to the Model 428-PROG 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.

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 Model 428-PROG also incorporates an exterior design with simple front panel operation, improved display, and convenient system integration. Pushbutton controls have an LED to indicate if that function is activated. The display features three selectable intensities (bright, dim, and off) for use in light-sensitive environments. All setup values can be displayed from the front panel. An IEEE-488 interface is included.

The Model 428-PROG as Preamplifier to an Oscilloscope

The Model 428-PROG can be connected to an oscilloscope or waveform digitizer to display very low currents in real time.

APPLICATIONS

The Model 428-PROG 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:

Biochemistry Measurements:

- Ion channel currents through cell walls and membranes

Beam Position Monitoring:

- Used on electron storage rings and synchrotrons

Surface Science Studies:

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

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

Ordering Information

428-PROG
Programmable Current Amplifier with IEEE-488 Interface

Extended warranty, service, and calibration contracts are available.

Converts small, fast currents to a voltage

LOW LEVEL MEASURE & SOURCE

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A GREATER MEASURE OF CONFIDENCE

428-PROG Programmable Current Amplifier

GAIN SETTING V/A	ACCURACY[1] 18°–28°C ±(% input + offset)	ACCURACY[1] TEMPERATURE COEFFICIENT ±(% input + offset)/°C	LOW NOISE[2] RISE TIME[3] (10%–90%) ms	LOW NOISE[2] NOISE rms	MAXIMUM SPEED RISE TIME[3] (10%–90%) µs[4]	MAXIMUM SPEED NOISE rms[4]	DC INPUT RESISTANCE
10^3	0.45 + 1.2 µA	0.01 + 40 nA	0.1	90 nA	2	100 nA	< 0.6Ω
10^4	0.31 + 120 nA	0.01 + 4 nA	0.1	9 nA	2	15 nA	< 0.7Ω
10^5	0.31 + 12 nA	0.01 + 400 pA	0.1	900 pA	5	2 nA	< 1.6Ω
10^6	0.34 + 1.2 nA	0.01 + 40 pA	0.1	90 pA	10	500 pA	< 10 Ω
10^7	0.5 + 122 pA	0.015 + 4.3 pA	0.1	9 pA	15	200 pA	< 100 Ω
10^8	1.4 + 14 pA	0.015 + 700 fA	1	0.5 pA	40	30 pA	< 1kΩ
10^9	2.5 + 3 pA	0.025 + 300 fA	10	50 fA	100	10 pA	< 10kΩ
10^{10}	2.5 + 1.6 pA	0.025 + 250 fA	100	4 fA	250	2 pA	< 100kΩ
10^{11}*	2.7 + 1.6 pA	0.028 + 250 fA	300	1.2 fA	250	2 pA	< 100kΩ

[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 + 100 pA
±500 nA	100 pA	0.8 + 1 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

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.

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

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

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

DIMENSIONS: 90mm high × 213mm wide × 397mm deep (3½ in × 8⅜ in × 15⅝ in).

IEEE-488 BUS IMPLEMENTATION

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: <500ms.

All other commands: <40ms.

ACCESSORIES AVAILABLE

CABLES

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

ADAPTERS

7078-TRX-BNC	3-Slot Male Triax to Female BNC Adapter
KUSB-488	USB-to-GPIB Interface Adapter for USB Port (requires 7010 Adapter)

RACK MOUNTS

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