

# MODEL 428 PRECISION DIFFERENTIAL DC AMPLIFIER AND SIGNAL CONDITIONER

## SENSOR COMPATIBILITY

- Strain Gages
- Pressure Transducers
- Thermocouples
- Accelerometers
- Piezoresistive Sensors

## RUGGED APPLICATIONS

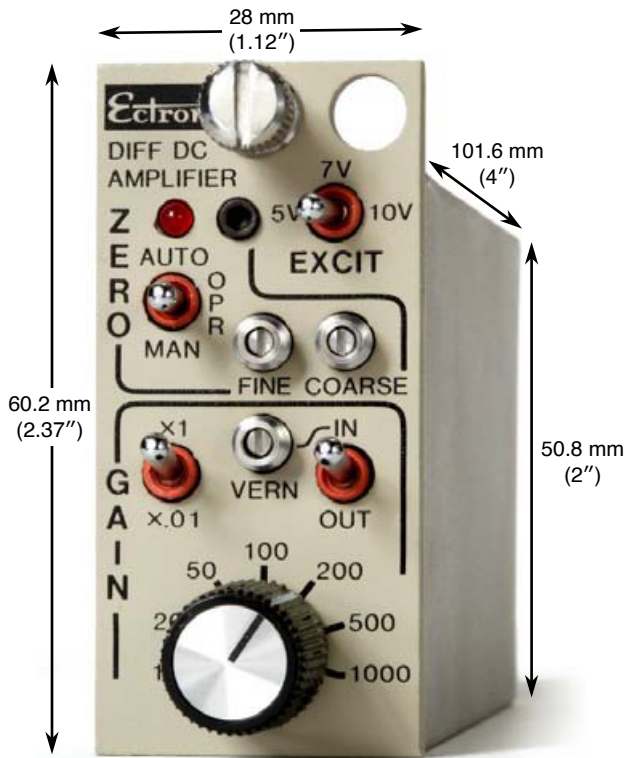
- Vehicle Crash Testing
- Helicopter Mast Safety
- Flight Testing
- Shipboard Analysis
- Rocketry/Missile Testing
- Automobile Design R&D

## ENVIRONMENTAL RATINGS

- 100 g Shock
- 20 g Continuous Vibration
- -25°C to +71°C
- 90% Relative Humidity
- Thermal Shock Resistant

## PERFORMANCE HIGHLIGHTS

- Isolated True Differential Input
- Miniature Size
- 0.5  $\mu\text{V}/^\circ\text{C}$  Stability
- Bridge Excitation
- Autozero
- Zero Suppression
- Dual Gain Ranges



Model 428 with Option 0



Model E408-1D Single-unit Mount,  
including DIN-rail adapter



# Model 428 Differential Dc Amplifier and Signal Conditioner

**E**ctron Corporation has been building small, rugged, reliable instrumentation amplifiers for over 35 years. Primary emphasis has always been reliability and accuracy under poor environmental operating conditions. Over the years the Ectron 400 Series has been the established leader in both the auto and aerospace industries for on-board vehicle test.

Because of recent technological advances, including surface-mount construction, Ectron embarked on a major design effort to further improve this product. This culminated in the development of the Model 428.

Retaining the basic form and design of the Model 418, including chopper stabilization and transformer isolation, the Model 428 is a direct replacement for most Model 418's including operation in most existing Model R418, 4001, and 4005 enclosures.

The Model 428, however, offers improved performance and operator conveniences such as increased input impedance, increased signal bandwidth, dual gain ranges, and front-panel-selectable excitation as standard features. Also standard is EMI/RFI filtering (option I in the Model 418) and operation from any dc-power voltage from 10.5 to 32 volts with power consumption reduced by almost 50% over that of the Model 418.

## GENERAL DESCRIPTION

The Model 428 is a true differential amplifier with transformer isolation between input, output, and the power source. An internal dc-to-dc converter provides bipolar voltages for the internal circuitry while accepting power from a single external dc power supply or battery. In addition to the high-performance amplifier, the unit includes an integral excitation power supply. Transformer coupling contributes to high common-mode rejection, and the chopper design results in superior zero stability, both short term and long term.

## RUGGED CONSTRUCTION

The Model 428 is designed for reliable operation in the most severe and dramatically changing environments. The amplifiers have produced uninterrupted data while subjected to the vibration of helicopters, the impact of rocket test sleds, the abrupt temperature and altitude shifts of supersonic aircraft, and the general abuse encountered on automotive proving grounds.

The amplifiers are housed in a steel casing and fully protected from moisture, including condensation. One-hundred-percent factory testing assures normal operation over the ambient temperature range of  $-25^{\circ}\text{C}$  to  $+71^{\circ}\text{C}$ , with extremes of  $-55^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$  certified on special order.

## ISOLATION

True ohmic isolation is provided between input, output, and power source by means of transformer coupling (see block diagram, Figure 1). This results in excellent common-mode rejection and the ability to operate with common-mode potentials of 100 V dc or peak ac.

Figure 1 shows operation from a single dc-power source. For operation in conventional, industrial, and laboratory applications, the R408 series rack-mount enclosures are equipped with heavy-duty 120 V ac (or 240 V ac) power supplies to provide dc power to all amplifiers within the enclosure.

## TEMPERATURE STABILITY

The Model 428 has an inherent temperature stability that does not require delicate balancing of offset-producing components.

Direct-coupled amplifiers, by contrast, depend on temperature-compensation circuits to balance the characteristics of

transistor pairs. The technique is reasonably effective for gradual temperature changes, but does not provide an effective solution to the problems that occur when the operating environment is changing rapidly.

Temperature shifts of this type can occur during warmup, with changes in altitude, or even when a single amplifier is removed from the rack and there is a resulting change in the airflow through the system.

The recording below (Figure 2) compares the zero stability of a Model 428 amplifier with a direct-coupled amplifier when the temperature is changed abruptly from  $23^{\circ}\text{C}$  to  $0^{\circ}\text{C}$ . This illustrates why direct-coupled amplifiers do not include "dynamic zero stability" as a specification item.

## LOW 1/F NOISE

In very low-level high-resolution systems, the noise generated by the amplifier becomes a significant factor in determining the accuracy that can be achieved. In narrow-band systems, the use of low-pass filtering is helpful, but its effectiveness in amplifiers is limited by a low-frequency component referred to

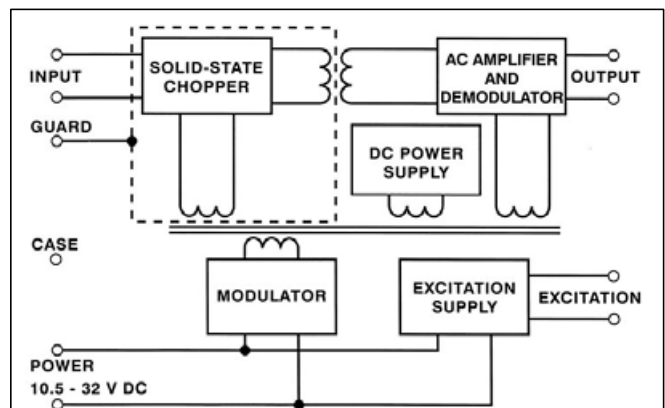


FIG. 1 MODEL 428 BLOCK DIAGRAM

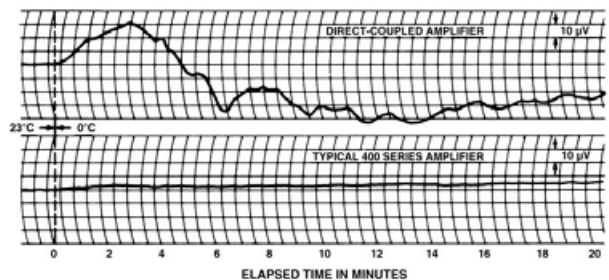


FIG. 2 EFFECT OF ABRUPT TEMPERATURE CHANGE

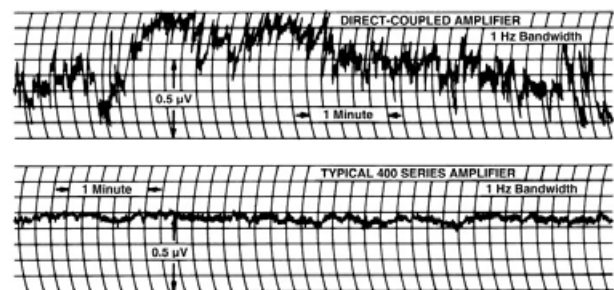


FIG. 3 LOW FREQUENCY (1/F) NOISE

# Model 428 Differential Dc Amplifier and Signal Conditioner

as 1/F noise. Well-designed chopper amplifiers such as the Model 428 are significantly superior in this area. Usable sensitivity extends to well under one microvolt.

A comparative recording of the Model 428 and a direct-coupled amplifier is shown in Figure 3. Since very-low-frequency phenomena is illustrated, the chart speed is slow, and both outputs are prefiltered with a low-pass 1 Hz filter.

## EMI/RFI

All dc amplifiers produce some error when subjected to conducted or radiated rf signals of sufficient magnitude. If this error appears in the form of spikes or an ac waveform at the output, it is readily recognized. Unfortunately, the error is often a dc offset which changes in magnitude as the level or frequency of the interference signal changes. This is because the signals are internally rectified by the amplifiers.

In a direct-coupled amplifier, any dc level produced by this rectification is amplified and appears as an error signal at the output. On the other hand, a chopper amplifier will not necessarily do this. Referring to the Model 428 block diagram, note that the design incorporates an "ac" amplifier which is capacitively coupled to the output demodulator. This means that RFI can produce a dc level shift in the amplifier without affecting the output.

Although the standard Model 428 can outperform most other types of amplifiers in side-by-side comparisons, it is not totally immune to EMI/RFI. Therefore, special models (or sys-

tems) can be provided that include supplementary protection. When so equipped, these amplifiers have demonstrated their ability to function properly in rf environments that cause other amplifiers to "lock up" at full-scale output.

## MODEL 428

The standard, without options, Model 428 operates from dc power within the range of 10.5 to 32 volts. All units include EMI/RFI protection and front-panel toggle switch selection of a constant-voltage excitation of 5 V, 7 V, or 10 V. Another front-panel toggle switch selects one of the two gain step ranges, i.e. 10, 20, 50, 100, 200, 500, 1000 or 0.1, 0.2, 0.5, 1, 2, 5, 10. Additionally,  $\pm 40$  mV of input zero suppression is provided by front-panel screwdriver multiturn coarse and fine zero controls. Amplifier output is  $\pm 10$  volts.

## MODEL 428 OPTIONS

**Option B** changes the amplifier output capability from  $\pm 10$  volts to a limited 0 to +5 volt output.

**Option G** changes the dual gain-step ranges to binary, i.e. 16, 32, 64, 128, 256, 512, 1024 and 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4.

**Option L** adds latched front-panel LED indication of output overvoltage with a front-panel reset switch.

**Option O** adds autozero with front-panel manual control and remote control capability.

## SPECIFICATIONS

The following specifications are the maximum deviation from the ideal permitted in this Ectron instrument. All specifications apply with a fixed source resistance of 0  $\Omega$  to 500  $\Omega$  in any unbalance over the temperature range of  $-25^{\circ}\text{C}$  to  $+71^{\circ}\text{C}$ , unless otherwise stated. RTI means referred to input; RTO, referred to output.

## INPUT CHARACTERISTICS

**Configuration:** True differential with guard, transformer isolated. Can operate from isolated source. May be used inverting, noninverting, differential or single-ended.

**Impedance:**  $\geq 1$  M $\Omega$ ; high gain range.  
100 k $\Omega$   $\pm 5\%$ ; low gain range.

## GAIN

**Decimal (standard)** 0.1 to 2500 in seven front-panel switch-selectable calibrated gain steps of 10, 20, 50, 100, 200, 500, and 1000 plus a switch selectable 100:1 input divider and a vernier gain,  $< x1$  to  $> x2.5$ , with in-out switch.

**Binary (Option G)** 0.1 to 2560 in seven front-panel switch-selectable calibrated gain steps of 16, 32, 64, 128, 256, 512, and 1024 plus a switch selectable 160:1 input divider and a vernier gain,  $< x1$  to  $> x2.5$ , with in-out switch.

**Accuracy:** Steps  $\pm 0.2\%$ , Input divider  $\pm 0.1\%$ .

**Stability:** Time (200 hours)  $\pm 0.02\%$ ,  
Temperature (steps)  $\pm 0.005\%/^{\circ}\text{C}$ , (Input divider)  $\pm 0.004\%/^{\circ}\text{C}$ .

**Zero Shift with Gain Change:**  $\pm 10$  mV RTO maximum.

## VOLTAGE RANGE

**Normal-mode voltage (without damage):**  
 $\pm 17$  V dc or peak ac maximum, high gain range.

$\pm 150$  V dc or peak ac maximum, low gain range.

**Common-mode voltage (operating):**  
 $\pm 100$  V dc or peak ac maximum.

**Common-mode rejection (CMR):**  
 $\geq 140$  dB, dc, 100  $\Omega$  unbalance.  
 $\geq 120$  dB, ac, 60 Hz, balanced.  
 $\geq 100$  dB, ac, 60 Hz, 100  $\Omega$  unbalance.  
 $\geq 100$  dB, ac, 400 Hz, balanced.  
 $\geq 90$  dB, ac, 400 Hz, 100  $\Omega$  unbalance.

## Noise (peak, 3 sigma)

0.1 Hz – 10 Hz,  $\leq 1$  V RTI + 1 mV RTO.

0.1 Hz – 300 kHz,  $\leq 5$   $\mu\text{V}$  RTI + 2.5 mV RTO.

## ZERO

### Stability:

Time (200 hours):  $\pm 4$   $\mu\text{V}$  RTI  $\pm 200$   $\mu\text{V}$  RTO.

Temperature:  $\pm 1$   $\mu\text{V}/^{\circ}\text{C}$  RTI  $\pm 50$   $\mu\text{V}/^{\circ}\text{C}$  RTO.

Dynamic temperature (20 $^{\circ}$  step change):

$\pm 8$   $\mu\text{V}$  RTI  $\pm 400$   $\mu\text{V}$  RTO.

### Adjustment Range (affects amplifier input):

High gain range:  $\pm 40$  mV RTI.

Low gain range: Decimal gain  $\pm 4$  V RTI,

Binary gain  $\pm 6.4$  V RTI.

### Controls:

Coarse: 20-turn potentiometer with a nominal resolution of better than 150  $\mu\text{V}$  RTI.

Fine: 20-turn potentiometer with a nominal resolution of better than 10  $\mu\text{V}$  RTI.

## DYNAMIC RESPONSE

### Frequency Response (5-pole Butterworth):

Dc to 3 kHz  $\pm 5\%$ ,  $-3 \pm 1$  dB at 5 kHz.

**Linearity:**  $\pm 0.04\%$  of full-scale output maximum deviation from the best straight line through zero.

**Overload Recovery:**  $\leq 5$  ms recovery from a "10 x full scale" input (up to the maximum normal-mode voltage allowed) to within  $\pm 0.1\%$  of the rated full-scale output.

### Autozero (Option O):

Capture Range:  $\pm 10$  mV RTI.

Final Value:  $\pm 20$   $\mu\text{V}$  RTI  $\pm 10$  mV RTO.

Temperature Stability:  $\pm 0.5$   $\mu\text{V}/^{\circ}\text{C}$  RTI.

Resolution: 20  $\mu\text{V}$  RTI.

## OUTPUT CHARACTERISTICS

**Isolation:** The output is transformer isolated from the input and power supply. The output-to-case voltage can be up to  $\pm 50$  V dc or peak ac. The capacitance from output low to case and to power common is 0.22  $\mu\text{F}$ .

### Linear Range:

Voltage:

Standard: From  $-10$  V to  $+10$  V dc or peak ac.

Option B: From 0 V to  $+5$  V ( $-0.8$  V to  $+6$  V maximum).

**Current:** 10 mA. The maximum fault current is dependent on temperature. It is approximately 25 mA at  $25^{\circ}\text{C}$  and varies inversely with temperature.

**Impedance:**  $\leq 1$   $\Omega$  (dc),  $\leq 2$   $\Omega$  (at 5 kHz).

**Capacitive Load:** The output will be stable under all normal signal conditions with a capacitive load of up to 0.02  $\mu\text{F}$ .

**Protection:** No damage will occur with a continuous short on the output.

*Continued on back page*

**LIMIT DETECTOR (Option L)**

If the amplifier output exceeds the rated full-scale output voltage, a front-panel LED will energize and stay on until manually turned off with the front-panel RESET pushbutton.

Limits: Standard:  $\pm 10.3\text{ V} \pm 0.3\text{ V}$   
 Option B:  $+5.2\text{ V} \pm 0.2\text{ V}$

**TRANSDUCER EXCITATION**

**Voltages Available:**

Three front-panel-selectable voltages of 5 V dc, 7 V dc, and 10 V dc (other voltages optional).

**Accuracy:**  $\pm 1\%$ .

**Output Current:**  $\geq 100\text{ mA}$  with power supply voltage from 10.5 V dc to 15 V dc, then derated linearly to 50 mA at 32 V dc.

**Current Limit:** Output current limit is 120 mA nominal with  $< 10\%$  change over full temperature range. No damage from short circuit.

**Regulation:**

Load:  $\pm 0.1\%$  no load to full load.  
 Line:  $\pm 0.05\%$  for a 30% line variation.

**Noise:** 1 mV rms, 0.1 Hz to 1 MHz.

**Temperature Coefficient:**  $\pm 0.005\%/^{\circ}\text{C}$ .

**Isolation:** Excitation low is connected directly to input-power common.

**INPUT POWER**

**Range:** 10.5 V dc to 32 V dc.

**Overvoltage Protection:** Up to +60 V for 15 s maximum. Reverse-voltage protected to  $-50\text{ V}$  continuous.

**Current (nominal):** 80 mA plus excitation load plus 1.2 times amplifier load. Maximum 280 mA.

**ENVIRONMENT**

**Storage Temperature:**  $-60^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

**Operating Temperature:**  $-25^{\circ}\text{C}$  to  $+71^{\circ}\text{C}$ .

**Relative Humidity:** 90% noncondensing.

**Altitude:** No limit with adequate heat dissipation.

**Static Acceleration:** 100 g (20 g when installed in an Ectron enclosure).

**Shock (6 ms sawtooth):** 100 g (20 g when installed in an Ectron enclosure).

**Vibration:** 0.12" DA (5 Hz to 55 Hz).  
 20 g (55 Hz to 2 kHz).

**EMI/RFI Protection:** Filters are provided in all connector leads.

**DIMENSIONS**

Height (panel)	Height (case)	Width	Depth
60.2 mm (2.37")	50.8 mm (2")	28 mm (1.12")	101.6 mm (4")

**Weight:** 255 g (9 oz) nominal.

**Connector:** DA-15P (Mate, DA-15S).

**ENCLOSURES**

**COMPATIBILITY**

The Model 428 will operate in all standard Ectron enclosures designed for Model 352 Conditioner-Amplifiers, Model 441A/AL Frequency-to-Voltage Converters, and Model 451 LVDT Signal Conditioners. These include Models E408-1, E408-6, and R408-14 enclosures.



Model E408-6 Six-channel Portable Enclosure



Model R408-14 Fourteen-channel Rack-mount Enclosure

**ORDERING INFORMATION**

**Model 428 Standard Conditioner-Amplifier.**

- Option B Output limited to 0 V to 5 V.
- Option G Binary Gain.
- Option L Output limit detector & reset.
- Option O Autozero.

For price and delivery information, please contact the factory or the Ectron representative in your area.



Model 428 Rear View with Connector

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