# INSTRUCTION MANUAL

## MODEL 428
## CONDITIONER-AMPLIFIER



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# Warranty

## GENERAL

All Ectron instruments are warranted against defects in material and workmanship for one year from the date of shipment to the original purchaser. Ectron agrees to repair or replace any assembly or components (except expendable items such as fuses, lamps, batteries, etc.) found to be defective during this period. Ectron's obligation under this warranty is limited solely to repairing or replacing, at its option, an instrument that in Ectron's sole opinion proves to be defective within the scope of the warranty when returned to the factory or to an authorized service center. Transportation to the factory or service center is to be prepaid by the purchaser. Shipment should not be made without the prior authorization of Ectron. This warranty does not apply to products repaired or altered by persons not authorized by Ectron, or not in accordance with instructions furnished by Ectron. If the instrument is defective as a result of misuse, improper repair, alteration, neglect, or abnormal conditions of operation repairs will be billed at Ectron's normal rates. Ectron assumes no liability for secondary charges of consequential damages as a result of an alleged breach of this warranty; and in any event, Ectron's liability for breach of warranty under any contract or otherwise shall not exceed the purchase price of the specific instrument shipped and against which a claim is made. This warranty is in lieu of all other warranties, expressed or implied; and no representative or person is authorized to represent or assume for Ectron any liability in connections with the sale of our products other than is set forth herein.

## PROCEDURE FOR SERVICE

If a fault develops, notify Ectron or its local representative, giving full details of the difficulty. Include the model and serial numbers. On receipt of this information, a service date or shipping instructions will be furnished. If shipment is indicated, forward the instrument, freight prepaid, to the factory or to the authorized service center indicated in the instructions.

## DAMAGE IN TRANSIT

Instruments should be tested upon receipt. If there is any damage, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and that report should be forwarded to Ectron. Ectron will advise the disposition to be made of the equipment and arrange for repair or replacement. Please include model and serial numbers in all correspondence.

Ectron® CORPORATION

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# SECTION I

# DESCRIPTION

## GENERAL

The Model 428 conditioner-amplifier is a solid-state chopper-stabilized differential dc amplifier with internal excitation voltage supply featuring complete isolation between the input, power supply, output, excitation, and case. The high input impedance permits operation with a large variety of signal sources; and the low output impedance permits operation into highly reactive loads, telemetry equipment, and most recording devices.

## STANDARD FEATURES

The Model 428 conditioner-amplifier comes standard with the following features:

- ±10-V amplifier output.
- ±40-mV RTI-zero control.
- Continuous gain in a 1-2-5 sequence from <0.1 to >2500.
- Switch-selectable excitation voltages of 5, 7, and 10.
- EMI/RFI filtering on all connector pins.
- Operation from any dc voltage from 10.5 to 32 V dc.
- Surface-mount construction.

## OPTIONAL FEATURES

Table 1-1 lists the standard options for the Model 428.

**Table 1-1**
**Model 428 Options**

| Option | Description |
|---|---|
| B | Output from 0 to +5 V |
| G | Binary gain |
| L | Overload indication with reset |
| O | Autozero |
| Options L and O are additional options, while Options B and G are alternative options. | |

## ENCLOSURES

The Model 428 operates in all Ectron enclosures that accept Models 352, 418, T418, 441A, and 451. However, unlike the other units, the Model 428 will operate whether the enclosure provides 12 or 28 volts dc power. These include Models R418, 4001, 4005, E408-6, and R408-14.


**Model 428LO**


**Model 428GLO**

## SECTION II

# SPECIFICATIONS

The Model 428 is a precision, chopper-stabilized dc amplifier with a selectable-voltage excitation power supply. The amplifier is transformer isolated from the input signal and input power. All specifications apply with a fixed source resistance of 0 Ω to 500 Ω in any unbalance over the temperature range of –25°C to +71°C unless otherwise specified. The following specifications are the maximum deviations allowed from ideal unless otherwise noted.

## INPUT

### CONFIGURATION

True differential with guard, transformer isolated. Can operate from isolated source.

### IMPEDANCE

≥ 1 MΩ with input divider deactivated.

100 kΩ ±5 kΩ with input divider activated.

### SIGNAL SOURCE

**Normal-mode voltage (without damage)**

±17 V dc or peak ac maximum with input divider out.

±150 V dc or peak ac maximum with input divider in.

**Common-mode voltage (operating)**

±100 V dc or peak ac.

**Common-mode rejection (CMR)**

| | |
|---|---|
| Dc, 100 Ω unbalance: | ≥ 140 dB. |
| Ac, 60 Hz, balanced: | ≥ 120 dB. |
| Ac, 60 Hz, 100 Ω unbalance: | ≥ 100 dB. |
| Ac, 400 Hz, balanced: | ≥ 100 dB. |
| Ac, 400 Hz, 100 Ω unbalance: | ≥ 90 dB. |

## NOISE

Noise specifications are stated with a statistical confidence of 3 sigma in peak voltage when measured in a first-order bandpass circuit with a lower frequency limit of 0.1 Hz and an upper limit as stated:

| Frequency | RTI | RTO |
|---|---|---|
| 10 Hz | ≤ 1 µV | ≤ 1 mV |
| 300 kHz | ≤ 5 µV | ≤ 2.5 mV |

## GAIN

### CONFIGURATION

**Decade**

Continuous gain from < 0.1 to > 2500 controlled by the following, the product of which (when multiplied together) is the gain setting of the amplifier:

Front-panel rotary gain switch steps of 10, 20, 50, 100, 200, 500, and 1000.

Input divider: 1⁄100 (switch-activated).

Vernier: < ×1 to > ×2.5 (switch-activated).

**Binary (Option G)**

Continuous gain from < 0.1 to > 2560 controlled by the following, the product of which (when multiplied together) is the gain setting of the amplifier:

Front-panel rotary gain switch steps of 16, 32, 64, 128, 256, 512, and 1024.

Input divider: 1⁄160 (switch-activated).

Vernier: < ×1 to > ×2.5 (switch-activated).

### ACCURACY

**Gain steps**

±0.2% of full scale.

**Input divider**

±0.1% of full scale.

### STABILITY

**Time (200 hours)**

±0.02% of full scale.

**Temperature**

±0.005% of full scale/°C with input divider out.
±0.009% of full scale/°C with input divider in.

### ZERO SHIFT WITH GAIN-STEP CHANGE

±10 mV RTO.

## DYNAMIC RESPONSE

**FREQUENCY RESPONSE (5-pole Butterworth)**

| | |
|---|---|
| Dc to 3 kHz: | ±5%. |
| Dc to 5 kHz: | –3 dB ±1 dB. |

**LINEARITY**

±0.04% of full-scale output maximum deviation from the best straight line from negative full-scale output to positive full-scale output that passes through zero.

**OVERLOAD RECOVERY**

≤ 5 ms recovery from a “10 × full scale” input (up to the maximum normal-mode voltage allowed) to 0 V ±10 mV.

## ZERO

**STABILITY**

**Time (200 hours)**

±4 µV RTI ±200 µV RTO.

**Temperature**

±1 µV/°C RTI ±50 µV/°C RTO.

**Dynamic temperature (20°C step change)**

±8 µV RTI ±400 µV RTO.

**Power-line change (30%)**

±0.5 µV RTI ±200 µV RTO.

**ADJUSTMENT RANGE (Affects amplifier input)**

**Input divider deactivated**

More than ±40 mV RTI.

**Input divider activated**

Decade gain

More than ±4 V RTI.

Binary gain

More than ±6.4 V RTI.

**CONTROLS**

Coarse: 20-turn potentiometer.

Fine: 20-turn potentiometer with a nominal range of ±1 mV RTI.

**AUTOZERO (OPTION O)**

**Capture Range**

±10 mV RTI minimum.

**Final Value**

±20 µV RTI ±10 mV RTO.

**Stability with temperature**

±0.5 µV/°C RTI. (This adds to the amplifier stability for a total of ±1.5 µV/°C.)

**Resolution**

20 µV RTI.

**Autozero-control switch**

MAN (manual) is a fixed position. In this position the amplifier zero can only be changed by the coarse and fine manual controls.

AUTO (autozero) is a momentary position. In this position the autozero signal is set to positive full scale. When the momentary switch is released to the OPR position, the autozero sequence is activated.

OPR (operate), the center position, is for normal amplifier operation with the fine and coarse RTI-zero controls active.

**Indicator**

The autozero indicator (LED) will light when the autozero switch is set to AUTO and will remain lighted after the autozero switch is released to the center position until autozero has been achieved.

**Remote Control**

Pin 5 on the output connector provides control input for remote autozero operation. The front-panel control must be in the OPR position. When the autozero command (Pin 5) is pulled high (greater than 10 V and less than 32 V), a full-scale autozero signal is placed on the input. When the command drops below 2.6 V, the autozero sequence is started.

## OUTPUT

**ISOLATION**

The output is isolated by transformer from the input and power supply. The output-to-case voltage can be up to ±50 V dc or peak ac. The capacitance from output low to case and to power common is 0.22 µF.

**LINEAR RANGE**

**Voltage**

Standard: From –10.6 V to +10.6 V.

Option B: From 0 V to +5.4 V
(–0.8 V to +6 V maximum).

**Current**

10 mA minimum. The maximum current is dependent on temperature. It is approximately 25 mA at 25°C and is inversely proportional to temperature.

**IMPEDANCE**

≤ 1 Ω (at dc).
≤ 2 Ω (at 5 kHz).

**CAPACITIVE LOAD**

The output will be stable under all normal signal conditions with a capacitive load of up to 0.02 µF.

**PROTECTION**

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

## LIMIT DETECTOR (OPTION L)

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

**Limits**

Voltage

Standard: ±10.3 V ±0.3 V.
Option B: +5.2 V ±0.2 V.

Duration

4.2 ms nominal.

## EXCITATION VOLTAGE

**VOLTAGES AVAILABLE**

Three front-panel-selectable voltages of 5 V dc, 7 V dc, and 10 V dc.

**ACCURACY**

±1% of nominal.

**OUTPUT CURRENT**

≥ 100 mA with input power from 10.5 V dc to 15 V dc, then decreasing linearly to 50 mA with input power of 32 V dc.

**Current Limit**

Output current limit is 120 mA nominal with < 10% change over full temperature range. This includes short circuit.

**REGULATION**

**Load**

±0.1% of nominal, no load to full load.

**Power**

±0.05% of nominal for a line variation of 30%.

**NOISE**

≤ 1 mV rms, 0.1 Hz to 1 MHz.

**TEMPERATURE COEFFICIENT**

±0.005% of nominal/°C.

**ISOLATION**

Excitation low is connected directly to input-power common.

## INPUT POWER

**RANGE**

≥ 10.5 V dc to ≤ 32 V dc.

**OVERVOLTAGE PROTECTION**

+60 V: For 15 s maximum.
+32 V: Continuous.
–50 V: Continuous.

**CURRENT**

Model 428: 80 mA nominal.
+ Excitation load: 100 mA maximum.
+ Amplifier load: 1.2 times nominal.

**Noise**

The maximum current noise reflected back to the source is 5 mA peak as measured across a 1-Ω resistor in a 1 MHz bandwidth.

**Maximum fault current**

230 mA.

## PHYSICAL PROPERTIES

**STORAGE TEMPERATURE**

−60°C to +125°C.

**OPERATING TEMPERATURE**

−25°C to +71°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 to 55 Hz).

20 g (55 Hz to 2 kHz).

**EMI PROTECTION**

Filters are provided in all connector leads.

**DIMENSIONS**

| Height | Width | Depth |
|---|---|---|
| 50.8 mm | 28 mm | 101.6 mm |
| (2″) | (1.1″) | (4″) |

For more information , see the outline-dimension drawing in this manual.

**WEIGHT**

255 g (9 oz) nominal.

**CONNECTOR**

DA-15P (Mate, DA-15S).

# SECTION III

# OPERATION

## GENERAL

This section discusses the operation of the Model 428. Included are elaborations of common terms used throughout this manual that are germane to amplifiers and conditioners.

## SAFETY

Because the Model 428 will operate normally with up to 100 V dc or peak ac, caution should be exercised at all times when handling input wiring (including Guard). **THIS IS TRUE EVEN IF THE MODEL 428 IS DISCONNECTED FROM ITS DC POWER SOURCE.**

Additionally, when using the Model 428 in an ac-powered enclosure, the user should ensure that the third-wire (or chassis) ground is connected to an "earth" ground. This is normally accomplished by using the ac line cord that accompanies the enclosure.

## TERMS

### GAIN

Gain is the ratio of the output to input disregarding all input and output offset, For example, if the gain switch is set to 50, then a normal-mode signal (dc or ac) will be amplified 50 times (within the input and output limits of the amplifier). If the input signal is 150 mV, then the output is 7.5 V. Gain (A) is stated either as the normalized ratio number or in decibels where:

$$A = 20 \log \frac{E_{OUT} - E_{RTO}}{E_{IN} - E_{RTI}}.$$

Unless there is a significant offset present, the user can ignore the terms $E_{RTO}$ and $E_{RTI}$.

The gain of the Model 428 is set by three front-panel controls: the gain switch, the input-divider switch, and the gain-vernier controls. Gain is the product of these three controls. The Model 428 will linearly amplify any signal of interest that is within the band pass of dc to 5 kHz and is less than 100 V dc or peak ac.

### INPUT

The input voltage is comprised of two components: normal and common mode.

Normal-mode voltage is defined as the difference signal between the two input pins of the Model 428. For example, if a signal of 1 V is applied to the inputs, then the normal-mode voltage is said to be 1 V.

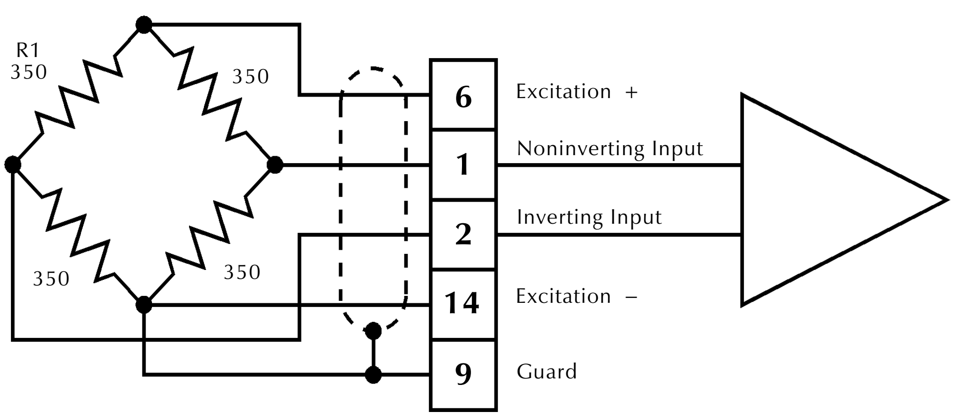



**Figure 3-1**
**Typical Bridge-input Configuration**

Common-mode voltage is defined as the average of the signals applied to the inputs with reference to a common point (usually output or excitation common):

$$CMV = \frac{E_{NONINVERTING} + E_{INVERTING}}{2}.$$

Thus a signal of 1 V at the inputs (1 V at the noninverting input, with reference to output common, and 0 V at the inverting input) produces a common-mode voltage of 0.5 V. The Model 428 discards this voltage and amplifies the normal-mode voltage.

Consider Figure 3-1, a configuration where the input to the amplifier is from a bridge (with one or more active arms). The bridge is excited by an excitation voltage of 5 V, and since both inputs are at the midpoints of each side of the bridge, each input is at 2.5 V. The common-mode component of the input signal is then 2.5 V (2.5 + 2.5 divided by 2). When the bridge is balanced, the inputs are equal, so the normal-mode voltage is zero, and there is nothing to amplify. If R1 changes resistance to 355 Ω, the bridge becomes unbalanced, and the difference between the two inputs (normal-mode voltage) is no longer zero, but ≈ 17.7 mV, and the amplifier amplifies this normal-mode signal. Note that the common-mode voltage is still approximately 2.5 V (actually ≈2.491 V). Also note that for ease of calculation, this discussion considers neither the input impedance of the amplifier nor the output impedance of the excitation supply.

**COMMON-MODE REJECTION (CMR)**

CMR is a measure of how well an amplifier discards or rejects the common-mode component of the input signal. It is a ratio of what the output would be if the amplifier amplified the common-mode voltage to what the amplifier actually puts out. For example, if the common-mode voltage is 100 V and the gain of the amplifier is 1000, then one might say that the amplifier should put out 100,000 V. Actually, the amplifier output may be 10 mV as a result of this common-mode voltage. CMR is the ratio of 100,000 V to 10 mV, stated in decibels:

$$CMR = 20 \log \frac{GAIN \times E_{CMV\ IN}}{E_{OUT}}.$$

$$CMR = 20 \log \frac{1000 \times 100\ V}{0.01\ V}.$$

$$CMR = 140\ dB.$$

**Table 3-1**
**Connector Pin Assignments**

| Pin | Function |
|---|---|
| 1 | Noninverting Input |
| 2 | Inverting Input |
| 3 | Not used |
| 4 | Output High |
| 5 | External Autozero Command |
| 6 | Excitation High |
| 7 | * Power High |
| 8 | * Power High |
| 9 | Input Guard |
| 10 | Not used |
| 11 | Output Common |
| 12 | Not used |
| 13 | Case Ground |
| 14 | ** Excitation Common |
| 15 | ** Power Common |

* Pins 7 and 8 are internally connected.
** Pins 14 and 15 are internally connected.

**RTI (REFERRED TO INPUT)**

RTI indicates that whatever is being referenced must be multiplied by the gain of the amplifier to assess the effect at the output of the amplifier. Thus, RTI effects are noticeable at high gains. For example, if the input signal is a 10-mV sine wave centered at +1 mV dc, and the gain of the amplifier is 500; the output of the Model 428 will be a 5-V sine wave centered at +0.5 V.

**RTO (REFERRED TO OUTPUT)**

RTO signifies that whatever is being referenced is independent of gain: a 10-mV RTO offset is a 10-mV offset at the output of the amplifier regardless of the gain setting.

Many specifications are stated in terms of both RTI and RTO. When this is done, multiply the RTI term by the gain of interest and add the RTO term to that product to compute the expected effect or the maximum deviation allowed at the output of the amplifier. Figure 3-2 shows the zero-offset graphs of two amplifiers, one of which has an RTI offset. Line #1 shows the zero offset of an amplifier that has been adjusted for zero RTI offset. Line #2 shows the zero offset for an amplifier

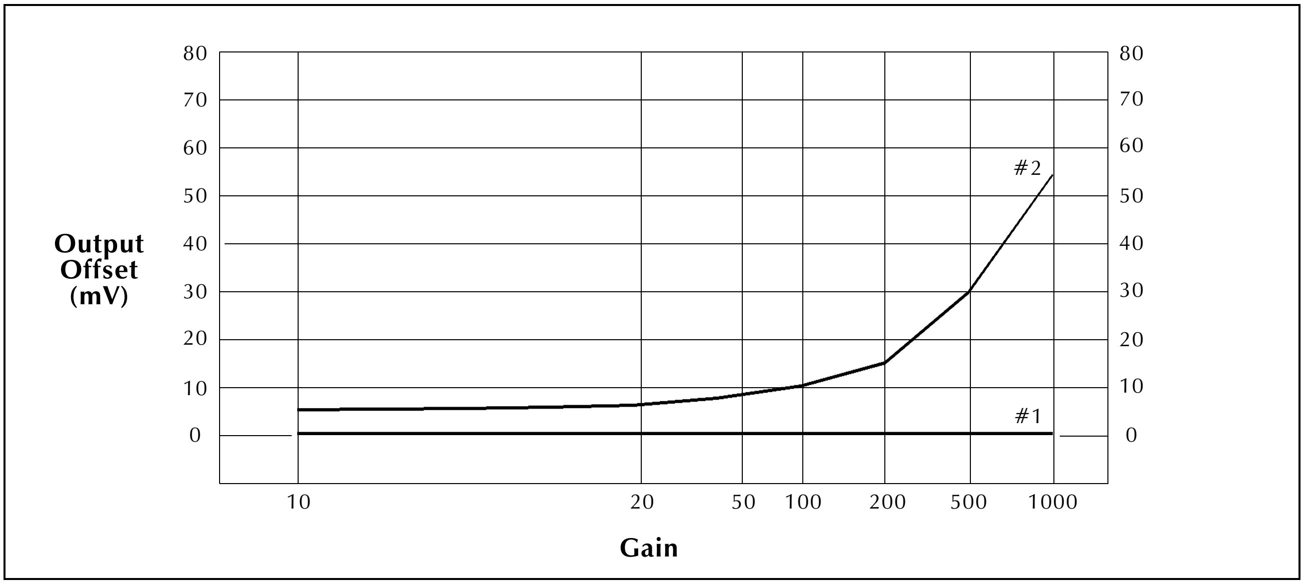



**Figure 3-2**
**RTO and RTI Zero Offsets**

that has a 50-µV RTI offset (5 mV of RTO offset separate the two graphs). Note how at higher gains, the RTI offset dominates the output.

## CONNECTIONS

The Model 428 employs a "D" subminiature fifteen-pin connector for all input and output connections. Table 3-1 summarizes these connections.

## OPERATION

### POWER

Dc power to the Model 428 can be any voltage from 10.5 to 32 V dc. The power source used should provide ≈80 mA plus output and excitation supply requirements.

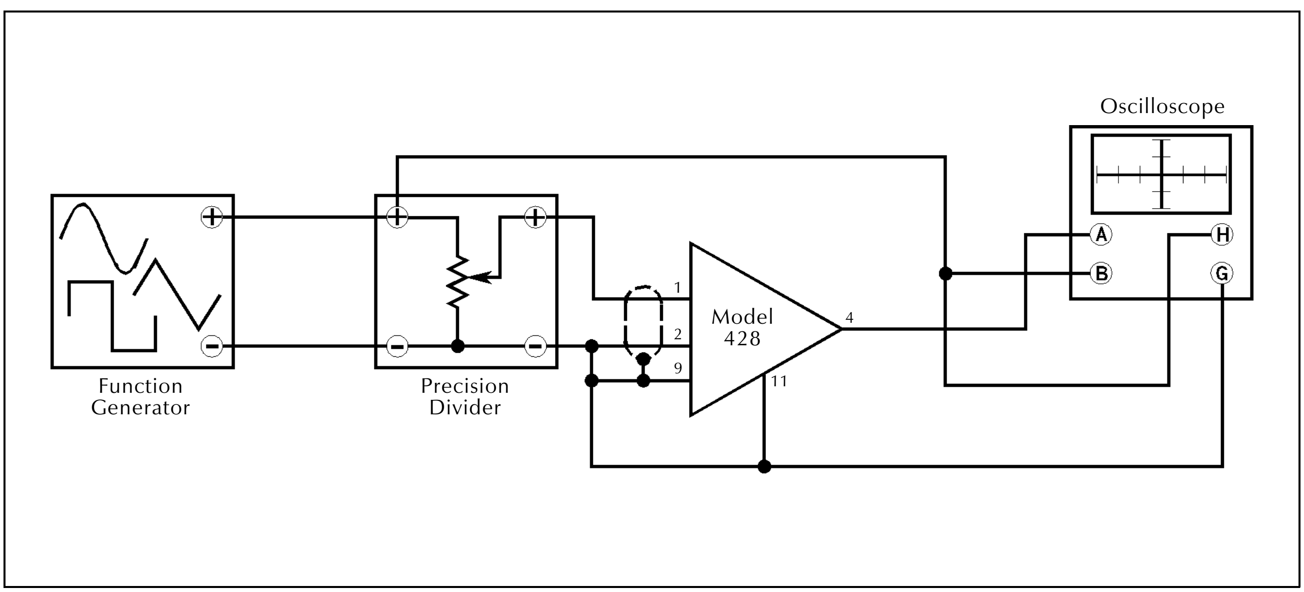



**Figure 3-3**
**Gain Determination**

For example, if the output is driving a 5-mA load and the excitation is driving a 75-mA load, then the user should provide ≈ 160 mA (80 + 5 + 75) to the power input. It is always good practice to limit the power source at slightly above the expected current requirement to prevent damage to instruments. In this example, one might limit the current at 200 mA.

The user should consider the total current load when using the Model 428 in enclosure.

**GAIN**

Normally, gain should be set to achieve the largest on-scale reading. However, the input and output limits of the amplifier as well as the output and input limits of what precedes and follows the amplifier in the system should be considered. For example, some recorders have maximum input of 1.45 V; thus, even though the maximum output of the Model 428 is 10 V, the user should reduce the gain to avoid exceeding the limits of the recorder.

For improved performance, the user should not use the divider switch when using gains of 10 and above.

If the gain vernier is not activated, then gain is simply the product of the gain-switch setting and the input-divider switch, which is either ×1 or ×0.1 (×0.0625 for Option G). This method has an uncertainty of 0.2% and is typically better than 0.1%. If more certainty is required or if the gain vernier is activated, then gain must be empirically determined.

To set gain or to determine the gain, proceed as follows:

1. Connect the unit to be tested as shown in Figure 3-3.
2. Set the ac source for a 20-V p-p (5-V p-p with a 2.5-V-dc offset for Option B) triangle wave of 0.5 Hz.
3. If the gain is to be set to a particular setting, set the decade divider to the reciprocal of the desired gain. To find gain, adjust nothing at this step and adjust the precision divider at Step 4.
4. Adjust the gain of the amplifier (or the precision divider as stated in Step 3) to achieve a straight line on the oscilloscope with the trace traveling back and forth across the display.
5. Increase the vertical gain of the oscilloscope to 10 mV/div and adjust the gain (or precision divider as stated in Step 3) of the amplifier to achieve the most horizontal trace. Characteristically, the Model 428 produces a sinusoidal wave form during this test. See Figure 5-4.
6. Gain is then the reciprocal of the setting of the precision divider.

Using this method gain accuracy of 0.05% is easily achieved.

**EXCITATION VOLTAGE**

The Model 428 can be set to one of three voltages: 5, 7, or 10 V dc, using the front-panel switch. It can then be used to excite a wide variety of transducers.

The user should calculate the load being applied to the excitation supply so that the maximum output current rating of the excitation supply is not exceeded and so that the power rating of the transducer is also not exceeded.

**ZERO**

Manual RTI zero and optionally autozero (Option O) are provided on the Model 428, and both can be used to suppress any offset (up to 40 mV RTI manually and 10 mV RTI automatically) introduced externally and internally. Because the Model 428 can be used in a variety of configurations, below are given several methods to properly zero the amplifier or the amplifier used in conjunction with the excitation supply. All procedures assume that the RTI offsets, both internal and external, do not total more than 40 mV (50 mV for units with Option O.

**Amplifier with Standard RTI Controls**

1. Connect a voltmeter or oscilloscope to the output of the amplifier.
2. Remove any input signal to the amplifier and short the three input leads together.
3. Set the gain to 1000 (1024 for Option G).
4. Adjust the FINE and COARSE controls for 0 V at the amplifier output. The output may initially be out of the linear range of the amplifier.

**Amplifier with Option O (Autozero)**

1. Connect a voltmeter or oscilloscope to the output of the amplifier.
2. Remove any input signal to the amplifier and short the input leads together.
3. Set the gain to 1000 (1024 for Option G).
4. Press the ZERO switch upward to the AUTO (autozero) position and release it. The front-panel LED will light, and if the total offset is within 10 mV RTI, then the amplifier output will automatically go to zero, and the light will extinguish.

5. If it does not, set the ZERO switch to the MAN (manual), and use the COARSE and FINE zero controls to zero the amplifier to with in 10 mV RTI of zero. If this can be achieved, then perform the previous step to complete zeroing of the amplifier.

Although autozero performs very well for most applications, the user may want to make a final zero adjustment using the RTI-zero FINE control after performing autozero.

### Remote Autozero

To externally command an autozero, set the ZERO switch to operate and apply a voltage of 10 to 32 V dc (with respect to Pin 11, output common) to Pin 5 of the amplifier connector.

### Amplifier Using Excited Bridge Configuration as Input

In this situation, one can simply use the procedures described above, but removing the bridge from the input changes the source impedance that the input "sees."

A better approach is to remove the excitation supply from the bridge so that any offset caused by a bridge imbalance is removed. The relatively low impedance of a bridge configuration will have little or no effect when compared with a direct short across the inputs, and the input then "sees" the same impedance during zeroing and operation.

## OVERLOAD (OPTION L)

The overload indicator and its attendant reset button are provided to indicate that an overload has occurred. The reset button is used to extinguish the overload indicator once the overload has been removed from the input.

# ENCLOSURES

## MODEL R418-7

The Model R418-7 is a 3½″ high 19″ rack-mount enclosure, which can accommodate up to 14 Model 428 conditioner-amplifiers (and Models 352, 418, T418, 441A, and 451 also) This enclosure comes with mating connectors for all input and output connectors and operates from a variety of power sources. See Table 3-2 for the list of all available models of the R418 with their ac and dc power voltages.

**Table 3-2**
**Model R418-7 14-Channel Enclosures**

| Model | Ac Voltage | Dc Voltage |
|---|---|---|
| R418-7AX | None | 28* |
| R418-7AY | None | 12* |
| R418-7BX | 120 | 28 |
| R418-7CY | 120 | 12 |
| R418-7DX | 240 | 28 |
| R418-7EY | 240 | 12 |
| * External input only | | |

## MODELS 4001 AND 4005

The 4000 Series Enclosures with 428 (or 418 Series, T418 Series, 352 Series, Model 441A, or Model 451) conditioner-amplifiers installed are transducer signal-conditioning systems designed for airborne, vehicular, or marine service in moderate-to-severe environments. The two enclosures in this series are the Model 4001, which accommodates fourteen conditioner-amplifiers, and the Model 4005, which accommodates twenty-two. These systems can be configured to operate with virtually any transducer from thermocouples to strain gages to RTD's (resistance temperature detectors). Separate conditioner-amplifier input and output connectors on the enclosures provide access to each channel. A switched front-panel meter plus an output connector can be used to monitor any channel in the system.

### Features

- Bipolar calibration and balance adjustment of bridge-type transducers are provided with either the Model 428, 418 or Model 352 conditioner-amplifiers. Terminals permit easy installation of calibration resistors.
- Per channel plug-in bridge-completion modules are included in the 4005, and fixed terminals for bridge-completion components are optional in the 4001.
- Thermocouple signals can be amplified using the Model T418 in conjunction with the Model 683 Universal Thermocouple Adapter (UTA).
- A monitor meter plus output signal jacks facilitate initial setup and observation of any channel.
- An output substitution calibrator is included in the Model 4005.

- The rugged construction of the 4000 Series Enclosures together with the virtual immunity to temperature and humidity extremes of the plug-in conditioner-amplifiers assure high accuracy data despite severe environments.
- The ability to operate from unregulated 12- or 28-V-dc power simplifies the logistics of on-board testing of vehicles and aircraft.
- An all-autozero switch which will initiate a zeroing sequence in all Model 428 (and 418) conditioner-amplifiers equipped with Option O.
- Modifications to the 4000 Series Enclosures can be designed to satisfy specific application requirements. If so ordered, these changes are described in an addendum inserted at the beginning of this instruction manual.

**Summary of Controls, Terminals, and Indicators**

**Model 4001:**

- DC-OFF-AC switch with red indicator lamp. Operation from the ac line requires the use of an ac power supply.
- CHANNEL selector switch with positions of 1 through 14 used to select the monitored channel.
- METER switch with positions labeled OFF, EXCITATION 10 V, AMP OUT, 10 V, 1 V, 0.1 V.
- Indicator meter.
- All-channel autozero switch, locking in the off position and momentary in the ALL AUTOZERO position.
- Fourteen CALibrate switches with positions of +, OPR (operate), and –.
- Balance-limit- and optional bridge-completion-resistor terminals are located on the side opposite the front panel.
- Calibration-resistor binding posts.

**Model 4005**

- DC-OFF-AC switch with red indicator lamp. Operation from the ac line requires the use of an ac power supply.
- CHANNEL SELECT switch with positions of 1 through 22 plus ALL.
- +, OPR (operate), – switch used in conjunction with the CHANNEL SELECT switch to perform shunt calibration.
- MONITOR CHANNEL switch with positions of 1 through 22 plus OFF, used to connect the monitor meter and the OUTPUT MONITOR jack to the output signal and excitation of any selected channel.
- Digital VOLTAGE-ADJUST switch for the voltage calibrator with a range from 0.00 to 5.00V.
- Calibrator polarity switch.
- Output calibration switch with positions of CALibrator and OPR (operate).
- MONITOR METER switch with positions of 0.1V, 1.0V, 10V, OFF, EXCIT, AND CAL.
- Indicator meter.
- Plug-in bridge-completion cards (22) containing terminals for the completion and shunt-calibration resistors.
- All-channel autozero switch, locking in the off position and momentary in the ALL-AUTOZERO position.
- ¼, ½, and FULL bridge-completion switch located above each channel.

**Available Accessories**

Line Power Supplies: Two power supplies are available to operate the 4000 Series Enclosures from the ac power line, the Model 4528 for 28-V-dc enclosures and the Model 4512 for 12-V-dc enclosures.

Mating connectors: Mating connectors for each enclosure connector are supplied unless specified otherwise.

Filler panels: A single-channel filler panel is available to fill any unused channel in the enclosures.

**MODEL E408-6**

The Model E408-6 enclosure is a six-channel bench-top unit, which will hold Models 352, 418, T418, 428, 441A, and 451 in any combination. Being small, lightweight, and powered either by ac or dc, the enclosure is well suited for use in the field as well as the laboratory.

Inside the top cover, which is held on by four captive screws, are terminals for each channel for bridge completion, CAL, and bridge balance (for Model 352 and for Model 418 with Option M).

Channel-input and dc-power connectors are PT series, and output connectors are BNC. An ac power cord and mating connectors for all but the BNC's are provided.

Front-panel controls include power on-off (for ac and externally applied dc); ALL ZERO for Models 418 and 428 equipped with autozero (Option O); and CAL with positions of +, –, and OPR (operate), which is functional when a CAL resistor and any bridge configuration are installed or connected. Calibration is input shunt calibration by means of electronically switching a customer-installed CAL resistor in parallel with selected arms of the bridge to produce either a plus or a minus calibration..

Also included are provisions for bridge balance for units so equipped and output frequency-response control for Model 352 amplifier-conditioners.

As with all Ectron enclosures, the Model E408-6 does not degrade the specifications of any plug-in amplifier or signal conditioner.

Model E408-6Y has an internal 12-V-dc power supply, and the E408-6X has a power supply of 28 V dc.

When setting up the Model E408-6 for operation, refer to either Drawing 408-600 (for 12-V systems) or 408-601 (28-V systems) at the rear of this manual for settings of plug jumper W1 (W2 is not active when using the Model 428 in this enclosure). Also depicted are typical input configurations the customer may want to use.

**MODEL R408-14**

The Model R408-14 enclosure is a 14-channel 19-inch rack-mount unit that also holds Models 352, 418, 428, 441A, and 451 in any combination. It also is powered by either dc or ac and comes in both 12-V-dc (Option Y) and 28-V-dc (Option X) versions. Model T418 is not accommodated.

Beneath the top cover are terminals for each channel for bridge completion, CAL, and bridge balance (for Model 352 and for Model 418 with Option M).

Channel-input and dc-power connectors are PT series, and output connectors are BNC. An ac power cord and mating connectors for all but the BNC's are provided.

Front-panel controls include power on-off (for ac and externally applied dc); ALL ZERO for Models 418 and 428 equipped with autozero (Option O); and CAL with positions of +, –, and OPR (operate), which is functional when a CAL resistor and any bridge configuration are installed or connected. Calibration is input shunt calibration by means of electronically switching a customer-installed CAL resistor in parallel with selected arms of the bridge to produce either a plus or a minus calibration.

Also included are provisions for bridge balance for units so equipped and output frequency-response control for Model 352 amplifier-conditioners.

As with all Ectron enclosures, the Model R408-14 does not degrade the specifications of any plug-in amplifier or signal conditioner.

Model R408-14Y has an internal 12-V-dc power supply, and the R408-14X has a power supply of 28 V dc.

When setting up the Model E408-6 for operation, refer to either Drawing 408-605 (for 12-V systems) or 408-606 (28-V systems) at the rear of this manual for settings of plug jumper W1 (W2 is not active when using the Model 428 in this enclosure). Also depicted are typical input configurations the customer may want to use.

# SECTION IV

# APPLICATIONS

## GENERAL

The Model 428 conditioner-amplifier offers excellent performance even under poor environmental conditions. Because dc drift is extremely low and the input is completely isolated, it can be used with virtually any low-impedance transducer accurately reproducing even microvolt-level signals. These characteristics make the product ideally suited for a variety of difficult applications from on-board missile testing to automotive crash testing to marine and other applications with high humidity.

## ISOLATION

Since the input is ohmically isolated from output, power, or excitation by at least 1 GΩ, ($1 \times 10^9$ Ω), noise-causing ground loops can be virtually eliminated. The input can be used in any configuration with up to 100 V common-mode (floating) voltage with no degradation of overall performance. This isolation allows the input to be connected to a signal source almost without regard to the usual grounding problems.

## INPUT AND OUTPUT CONNECTIONS

### CABLING AND SHIELDING RECOMMENDATIONS

Since any amplifier must amplify the differential (normal-mode) signal present at its input terminals, it is vital that input cabling be carefully handled so that extraneous noise signals are not introduced.

Cable selection is of considerable importance in a typical system not only because of the effect on signal quality but also because of the significant cost involved when long cable runs and numerous channels are involved.

Use of twisted-pair cables having good symmetry is important if magnetic fields exist near the cable runs. Better symmetry also helps to equalize capacitance between each lead and the shield, which is necessary to prevent “common-mode to normal-mode” conversion within the cable.

In any data system, if common-mode-voltage levels are moderate to high, it is mandatory that good shield integrity be maintained from source to conditioner-amplifier. This means that shield breaks cannot be tolerated. For example, if the input cable passes through a connector, the shell of the connector should be tied to shield potential and isolated from ground.

### SOURCE RESISTANCE

The source resistance to which the input of the amplifier is connected should not exceed 500 Ω to meet all performance specifications. If the source resistance exceeds about 5 kΩ, noise will generally increase. To accommodate sources with higher resistance, a resistive divider can be used, which can reduce the resistance coupled to the amplifier. The gain of the amplifier can then be increased to make up for the loss in the divider.

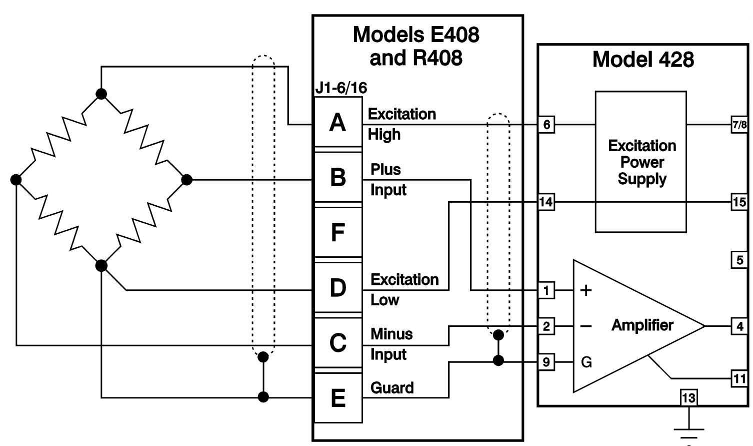



**Figure 4-1**
**Full External Bridge**

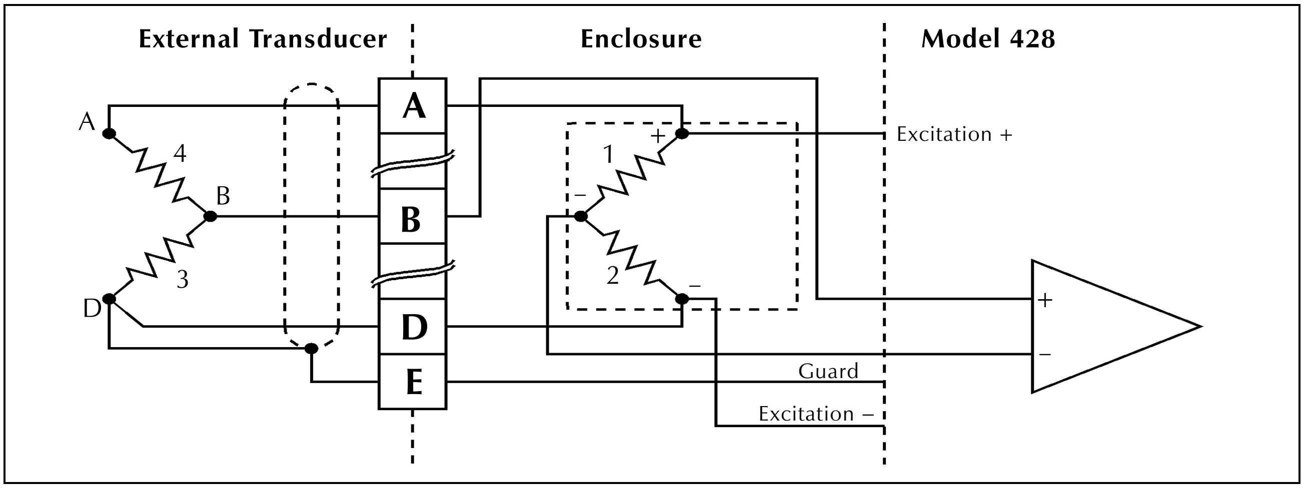



**Figure 4-2**
**Half Bridge**

## AMPLIFIER LOADING

Although the input impedance of the 400 Series amplifiers exceeds 1 MΩ; under some circumstances, the input impedance appears to be much lower. This occurs when an average-measuring instrument such as a DVM is paralleled across the amplifier inputs, the source R is high (several hundred ohms), and the gain setting is low. The cause of this loading effect is the make-before-break action of the chopper which presents a momentary low impedance at the amplifier input every time the chopper switches. The amplifier ignores this loading effect because the demodulator is timed to measure only the trailing end of the chopper interval. However, an average-reading instrument measuring the signal at the input to the amplifier will read low. The loading effect will be increased if the measuring instrument includes capacitance as is usually the case. To minimize this loading effect, the following recommendations should be considered in using these amplifiers:

- Do not attempt to measure amplifier gain by measuring input and output signal levels. Instead, follow the procedures in Section V.
- If another instrument is to be paralleled across the amplifier input, isolate the amplifier by adding an attenuator and increasing the amplifier gain.
- If paralleling another instrument across the input of the amplifier cannot be avoided, the following precautions are recommended:
- The source resistance of the signal should be as low as possible.

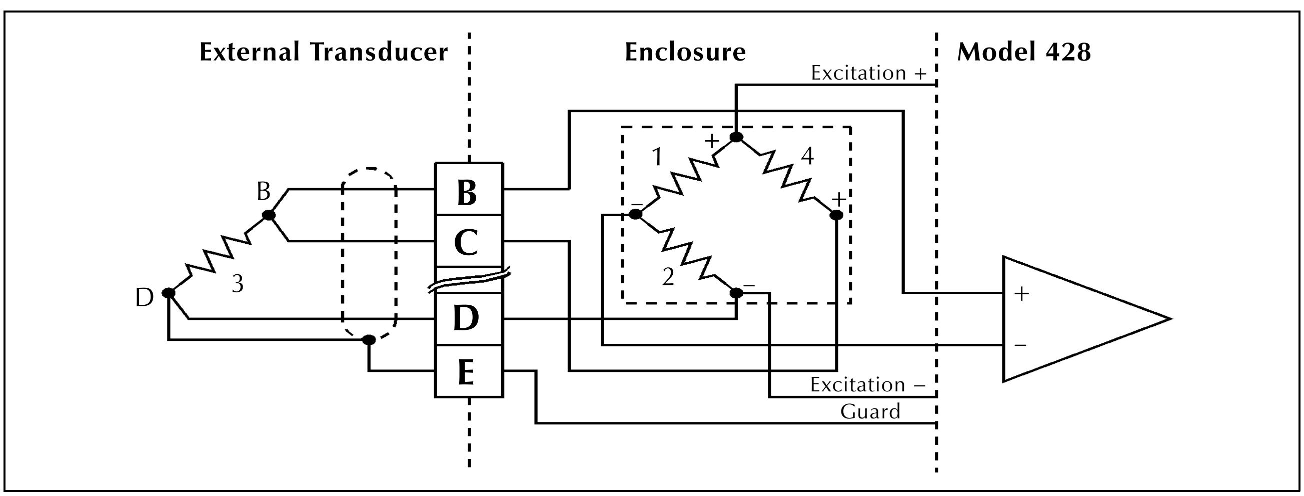



**Figure 4-3**

- The signal level should be as low as possible.
- The capacity of the input circuit should be minimized.
- Since the amplifier loading effect is relatively constant, the differential could be noted, and a correction factor applied.

### Table 4-1
### Cabling Recommendations

| |
|---|
| Use twisted-pair, foil-shielded cable for signal input. Another shielded-pair cable can be used for excitation or both input and excitation signals may be included within a single shielded cable |
| Keep shield inductance and resistance to a minimum when pulse or thansient common-mode signals may be present. |
| For best CMR, capacitance between each conductor and shield should be equal. |
| Avoid areas of high magnetic fields when routing cable. |

## NOISE

There are no 60-Hz or 400-Hz sources within the amplifier. Any such line-frequency signals that appear on the output are due to pickup on the input, or output leads. Such signals can appear like wideband noise when only the higher frequencies are coupled into the amplifier wiring.

To minimize pickup, the signal input leads must be shielded as close as possible to the input connector and routed away from external wiring or equipment which radiate electrostatic or electromagnetic noise. (See Tables 4-1 and 4-2.)

The internal dc-to-dc converter operates at 20 kHz, and some small amount of residual noise at this frequency will appear on the output along with pulses at 40kHz. The amplitude of this noise depend on the resistance of the signal source and on the grounding of the output versus the power source. To meet the noise specifications of the amplifier, the signal-source resistance should be less than 500 Ω, and the output should be directly connected to power common or interconnected with a low-impedance path such as a 0.1-µF capacitor.

## OUTPUT CONNECTIONS

## TRANSDUCER APPLICATIONS

### General

The Model 428 amplifier can condition almost any type of transducer including load cells, pressure transducers, thermistors, potentiometer transducers, resistance temperature detectors (RTD's), and semiconductor sensors. Because of size limitations, the Model 428 does not include bridge completion or calibration components. Rather, these parts are normally added to the enclosures. (See the paragraphs on enclosures in section III and the instruction manual for the enclosure in use.) The front-panel FINE and COARSE RTI zero controls normally obviate the need for a bridge-balance control.

### Table 4-2
### Shielding Recommendations

| |
|---|
| Maintain total shield integrity from source to amplifier. |
| Connect the shield to a zero-signal point having low source impedance. |
| Use only a single ground point for the input signal system. |
| Minimize shield current. Use drain wire or second shield when shield currents may be high. |

### Strain Gages

Strain gages are small passive devices that change resistance when subjected to a dimensional change. They are normally used in a bridge configuration having one, two, or four active elements. Figures 4-1, 4-2, and 4-3 show the proper connections for the Model 428 using one, two, or four active elements. A calibration resistor is also selected by the user to provide the proper degree of calibration. Using one or two active elements requires the addition of three or two bridge-completion resistors, which should have a temperature coefficient better than 25ppm/°C and an accuracy within 0.1%. Strain-gage elements are commonly 120 Ω or 350 Ω. Normally a bridge-balance control is not needed because of the wide range available in the RTI-zero controls of the Model 428.

Refer to the enclosure manual for details on connector pin assignments and bridge-completion circuitry.

### Resistance Temperature Detectors

Resistance temperature detectors (RTD's) are devices that depend on the change in resistance of a sensing element with a change in temperature to function.

RTD's require external excitation to function; and because they measure temperature, the excitation must be limited to minimize self-heating. Refer to the manufacturer's recommendations for allowable excitation voltage.

The typical resistance change with temperature characteristic of an RTD is nonlinear. Consequently, when put into a bridge circuit the curve of voltage output versus temperature becomes very nonlinear because of the large resistance variation of the RTD for a large temperature change. (A typical platinum RTD that has a resistance of 100 Ω at 25°C varies from 18 Ω at −200°C to 375Ω at 800°C.) A further effect of the large resistance change is that the excitation voltage across the RTD will increase at low temperatures which can affect self-heating. A solution here is to use larger (but equal) upper resistors when completing the bridge (resistors 1 and 4 in drawing 4-3). In so doing, however, lead-resistance compensation will suffer.

RTD's are supplied in two-, three-, and four-wire configurations with the three-wire type being the most common. Figure 4-3 shows the recommended connections for a three-wire sensor.

### Thermistors

Thermistors are temperature-sensitive devices frequently made of semiconductor materials. Although most have a negative temperature coefficient, devices are available that have a positive temperature coefficient. Thermistors are characterized by small size, rapid response, high sensitivity, and low cost; but they have a fairly limited temperature range. Because of their high sensitivity, these devices also suffer from the same nonlinearity problems as RTD's. Also, they can reach high values of resistance, which could affect the noise and stability of the Model 428. Compensated- and linearized-thermistor assemblies that offer interchangeability and moderately high accuracy are available. For these specialized assemblies, the manufacturer's recommendations should be followed.

## LEAD-RESISTANCE COMPENSATION

One problem that may arise when using a transducer having a low-resistance sensing element is the voltage drop in the connecting leads. If the leads are long, the variation in resistance of the leads during the measurement period can degrade the accuracy of the measurement. To compensate for this, the leads can be connected so that the lead resistance will cancel. Refer to the schematic of the enclosure being used to determine if lead cancellation is possible. Of course, the use of a full-bridge sensor virtually eliminates the problem of lead resistance. However, shunt-calibration accuracy will be affected by lead resistance.

## SIGNAL GROUND POINTS

Four independent and isolated ground circuits exist within the Model 428. As a result, great flexibility exists in adapting this amplifier-conditioner to almost any application. The available ground systems include

- the input (two input leads and guard shield)
- the output (output high and low)
- the dc power (plus and common)
- the case.

Proper use of these grounds will result in low noise and highly accurate data. However, incorrect grounding will increase noise and degrade data accuracy. Some grounding recommendations follow.

### Input

In any signal system, use only one ground point. This applies to the input and output signal systems. Signal input is ohmically isolated from any other ground so it can be floated off ground (to 100 V dc or peak ac), and grounded anywhere that suits the application. However, since the excitation power supply is not isolated but instead is connected to the input dc power common, no other ground point is allowed. (See Excitation Grounding below.) The input guard shield should be tied to the signal-source common. In a bridge circuit, the point where the negative excitation lead is tied is where the shield lead should be tied. This point would then tie to the input cable shield (and drain wire if any) and continue on to the amplifier's guard shield at the amplifier end.

### Output

The high- and low-output leads can and usually should be grounded at the load device. Depending on the load device, connecting this common on to earth ground or dc-power supply ground can minimize noise.

### Power

The negative of the dc-power source should be connected to earth or power line ground. In Ectron enclosures this is accomplished by proper use of the third-wire-ground pin on the power cord.

### Case

The case-ground pin should be connected to earth or power ground. This is also taken care of in Ectron enclosures.

## EXCITATION-SUPPLY GROUNDING

Although each Model 428 has a separate excitation regulator, all amplifiers in any one enclosure are fed by one excitation supply and have a single common point.

Therefore, the signal leads of the transducer connected to the excitation supply cannot be grounded. Normally this does not cause any problems since the circuitry of most transducers is “floating” off ground. If noise problems exist, the user should see if there are multiple grounds and, if possible, remove the ground connection causing the problem.

## OTHER APPLICATION NOTES

### LOADS

Because of its isolation, low output impedance, and the “±10 V at 10 mA” output capability, the Model 428 can satisfy most load requirements. Amplifier output can be short circuited indefinitely without damage.

### MAXIMUM VOLTAGES

The maximum input voltage to the amplifier should not exceed ±17 V dc or peak ac (±150 V with the input divider switch in), and the maximum common-mode voltage should not exceed 100 V dc or peak ac. The input impedance of the amplifier will be reduced as the input voltage exceeds full-scale output. No external signal voltage should be fed into the amplifier’s output.

### EMI PROTECTION

All leads into and out of the Model 428 have individual rf filters in series with them. As a result, most moderate level rf signals will have an insignificant affect on signal integrity. Because of the nature of the input chopper, the input is inherently immune to out-of-band effects except near the harmonic frequencies of the chopper. (See the paragraph on aliasing effects in this section.)

### ALIASING EFFECTS

Since the chopper operates at 20 kHz, it is possible that strong signals at a frequency close to that of the chopper or its harmonics will be passed on to the carrier amplifier. Although some filtering at these frequencies exists, if there is a possibility of this type of interference, external input filtering is recommended. Consult the factory for advice.

### SURFACE-MOUNT CONSTRUCTION

Much of the internal circuitry of this amplifier is made up of surface-mount components. Because the size and weight of these components is less than that of equivalent through-hole devices, the ruggedness and reliability of the Model 428 is enhanced by their use.

# SECTION V

# CALIBRATION

## GENERAL

This section gives the test procedures that allow the user to test any of the 428 Series products to validate the instrument's performance and compare it to that of the Ectron specification. Because these instruments are encapsulated in a protective material within a sealed metal case, repairs should not be attempted in the field.

## PRECAUTIONS

The following precautions must be observed when testing these conditioner/amplifiers:

- The power supplies should be current limited to protect them and other instruments.
- The input signal leads, switches, and any input resistors must be well shielded, particularly for CMR tests.
- The following tests are based on the premise that the amplifier has ±10-V-dc output capability. Option B and certain special products will modify this premise. The test procedure may have to be altered to accommodate the change.
- Remove power to the unit before connecting it to or disconnecting it from the test fixture.
- All shields, grounds, and common wiring should be connected to one terminal, which should be connected to a ground system.
- **DO NOT** make gain or linearity measurements using a voltmeter to measure input and output voltages. Few meters have the required microvolt-level accuracy; and because of their capacitive loading on the input to the amplifier, these instruments can modify the input to the amplifier. The procedure in this section describes a method to accurately measure gain and linearity that depends only on the precision of a resistive divider and an oscilloscope.
- Allow 30 minutes warmup for temperature stabilization unless otherwise specified.
- **DO NOT** exceed the maximum input common- and normal-mode voltages.

## EQUIPMENT REQUIRED

### VARIABLE DC-VOLTAGE SUPPLY

0-100 V dc. Must have low noise with current-limiting characteristics.

### PRECISION VOLTAGE DIVIDER

Electro Scientific Instruments (ESI) Model RV622A or equivalent. The voltage divider must have 10 kΩ or less input resistance, and the division accuracy at a ratio of 1:1000 must be better than 0.025%.

### POWER SUPPLY

Any dc power supply with a dc voltage that is variable between 10.5-32 V dc, 100 mA minimum, and with current limiting.

### DIFFERENTIAL OSCILLOSCOPE

Tektronix Model 5110 with a Model 5A22N plug-in or equivalent. The oscilloscope must have 10-V-dc common-mode-voltage capability. Ensure that the Model 5A22N has been adjusted for maximum common-mode rejection.

### DIGITAL MULTIMETER (DMM)

Hewlett Packard Model 3478A or equivalent.

### FUNCTION GENERATOR

Wavetek Model 180 or equivalent

### AC VOLTMETER

Hewlett Packard Model 400E or equivalent.

### MISCELLANEOUS RESISTORS AND CAPACITORS

These tests require one or more resistors and capacitors. The full description of these components is specified in the individual test procedures or in the figures.

### SWITCHES

The only type switch used in these procedures is a single-pole double-throw switch, such as a C&K Components Model 7101. The user may choose not to use switches and instead make wiring connections.

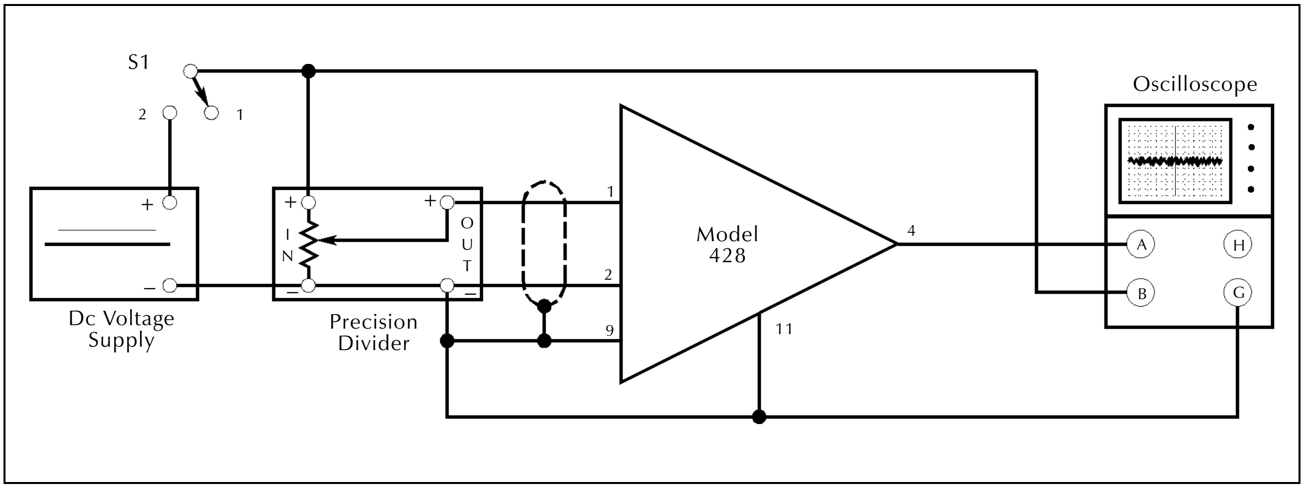



**Figure 5-1**
**Gain-accuracy Test for Gains of 1 and Above**

## GAIN ACCURACY

Gain is the ratio of the output voltage to the input voltage, RTI and RTO zeroes notwithstanding. It is measured at the positive full-scale limit of the amplifier. The method used for this test is to precisely divide a dc voltage, amplify it using the Model 428 under test, and then compare the dc voltage and the output of the Model 428. Any difference is gain error of the Model 428.

### GAINS OF 1 AND GREATER

1. Connect the amplifier to be tested as shown in Figure 5-1.
2. Set the amplifier gain switches to the desired gain (with the GAIN VERNIER switch in the OUT position).
3. Use the front-panel zero-adjust controls to remove any offset at the amplifier output as viewed on the oscilloscope.
4. Set S1 to 2.
5. Using the precision divider, restore the trace to the same position (within 5 mV) as in Step 3.

The gain is the reciprocal of the reading on the precision divider. Therefore gain accuracy $A_A$, in percent, is computed as follows:

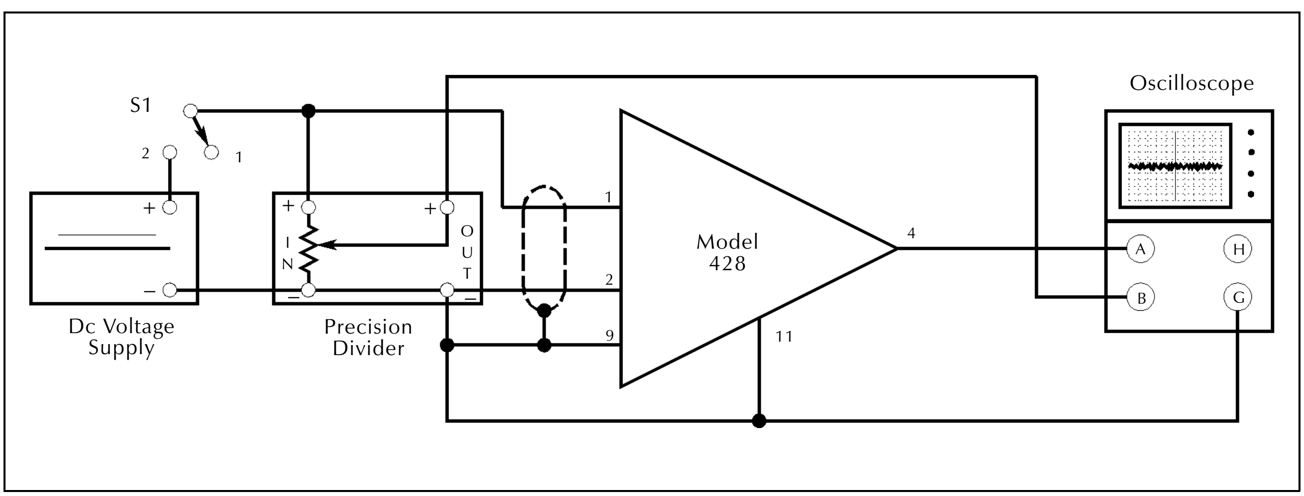



**Figure 5-2**
**Gain-accuracy Test for Gains Below 1**

$$A_A = \frac{(A_S - \frac{1}{R})}{A_S} \times 100.$$

where $A_S$ is the gain setting of the amplifier, and $R$ is the setting of the precision divider.

**GAIN OF LESS THAN 1.**

In this test, a voltage is applied to the input of the Model 428 and to the precision divider. The output of the precision divider is then compared to the output of the Model 428. Any difference is the gain error of the Model 428.

**WARNING**

**Voltage that can be lethal is used in this procedure. Use extreme care when performing the test.**

1. Connect the amplifier to be tested as shown in Figure 5-2.
2. Set the amplifier gain switches to the desired gain (with the GAIN VERNIER switch in the OUT position).
3. Use the front-panel zero-adjust controls to remove any offset at the amplifier output as viewed on the oscilloscope.
4. Set the variable dc-voltage supply to the voltage that will produce the maximum on-scale reading from the amplifier. (Do not exceed the maximum input for the amplifier.)
5. Set S1 to 2.
6. Using the precision divider, restore the trace to the same position (within 5 mV) as in Step 5.

Compute the gain and gain accuracy as defined for gains of 1 and above.

**GAIN SHIFT WITH TEMPERATURE**

1. Connect the amplifier to be tested as shown in Figure 5-1 or 5-2.
2. Set the amplifier to the desired gain.
3. Place the amplifier in an environmental chamber adjusted to −25°C.
4. After stabilization (approximately 30 minutes), position the trace on the oscilloscope on the center line using the vertical position control.
5. Set S1 to 2.
6. Restore the trace to the center line within 1 mV using the precision divider. Record the setting as $R_1$.
7. Set S1 to 1.
8. Raise the temperature of the environmental chamber to +71°C.
9. After stabilization (approximately 45 minutes), restore the trace to the center line of the oscilloscope using the vertical position control.
10. Set S1 to 2.
11. Using only the precision divider, restore the trace to the centerline (within 1 mV). Record the reading of the precision divider as $R_2$.

Compute the temperature coefficient of gain $A_{TC}$ in percent as follows:

$$A_{TC} = \frac{\frac{R_1}{R_2} - 1}{96°C} \times 100.$$

**LINEARITY**

LInearity is the measure of how well the output of the amplifier matches a perfect output regarding output voltage level. This test applies a very-low-frequency triangle wave to the input of the amplifier and the “B” and external horizontal “H” inputs of the oscilloscope. It then measures any vertical deflection, which is directly attributable to nonlinearity of the amplifier.

1. Connect the amplifier to be tested as shown in Figure 5-3. For R1 and R2, use either metal-film or carbon-film or carbon-composition resistors. R2 should not be less than 100 Ω.
2. Set the Model 428 gain controls to the desired gain.
3. Adjust the zero control(s) to position the trace in the center of the oscilloscope.
4. Set the function generator for a 0.5-Hz triangle waveform of 20 V p-p.
5. Adjust the external horizontal input sensitivity of the oscilloscope to 2 V/div.
6. Adjust the precision divider to restore the trace to the center of the oscilloscope. It may also be necessary to adjust the vernier-gain potentiometer of the amplifier to achieve an exactly horizontal trace on the oscilloscope. The trace will be moving from left to right and back at a 0.5-Hz rate. Adjust the oscilloscope controls so that the trace passes through zero (the origin of the oscilloscope face) and travels to both ends of the graticule (indicating that the output of the amplifier is swinging from −10 V to +10 V.
7. Increase the vertical sensitivity of the oscilloscope until measurable vertical deviation from the center

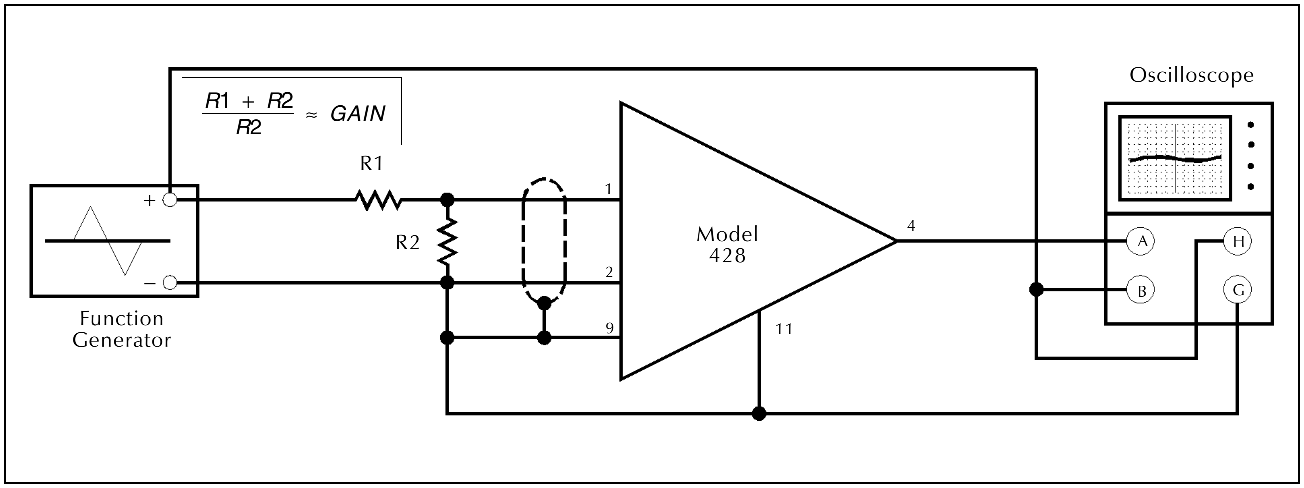



**Figure 5-3**
**Linearity Test**

horizontal graticule to the trace can be attained. It may be necessary to adjust the gain of the amplifier slightly to obtain the best straight line through zero (the origin). See Figure 5-4.

Linearity is defined as follows:

$$Linearity = \frac{vertical\ deviation\ (in\ V)}{20V} \times 100.$$

## INPUT IMPEDANCE

Input impedance, that which is present between the two inputs, is measured by applying an ac signal to the input, first through no resistance and then through a resistor. The difference in voltage at the output of the amplifier is then used to calculate the input impedance.

1. Connect the Model 428 as is shown in Figure 5-5. For R1, R2, and R3 use either metal-film or carbon-film or carbon-composition resistors. R2 should not be less than 100 Ω.
2. Set the Model 428 gain controls to the desired gain.
3. Set the DMM to measure ac voltage.
4. Adjust the function generator (and if necessary, the gain-vernier control of the amplifier) for a 1.000-V-rms sine wave of 100 Hz at the amplifier output.

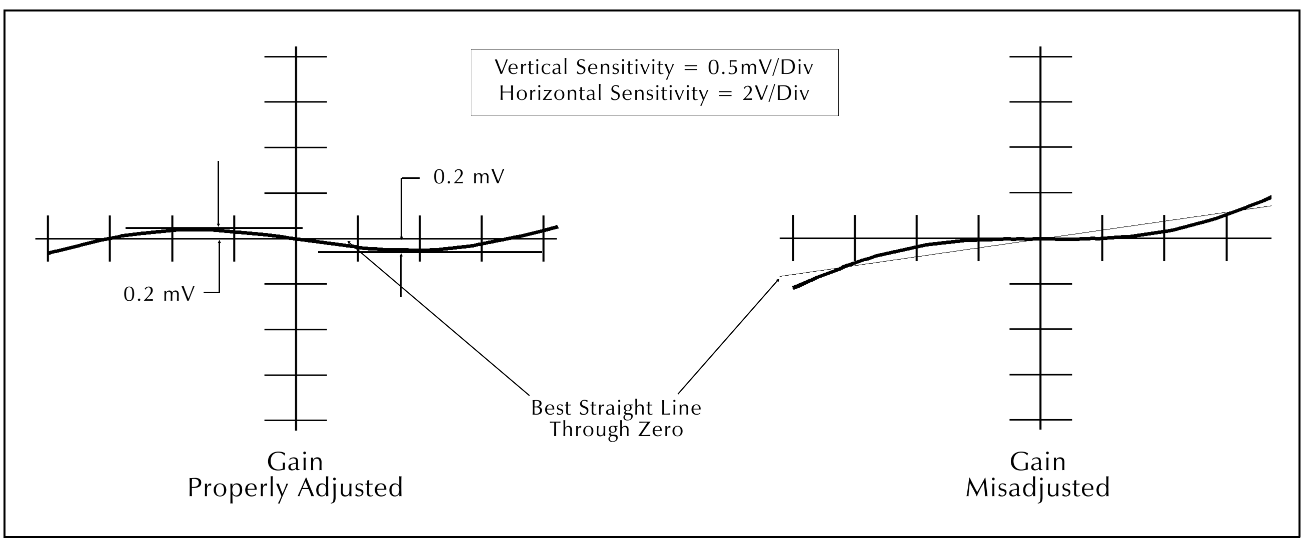



**Figure 5-4**
**Linearity Displays**

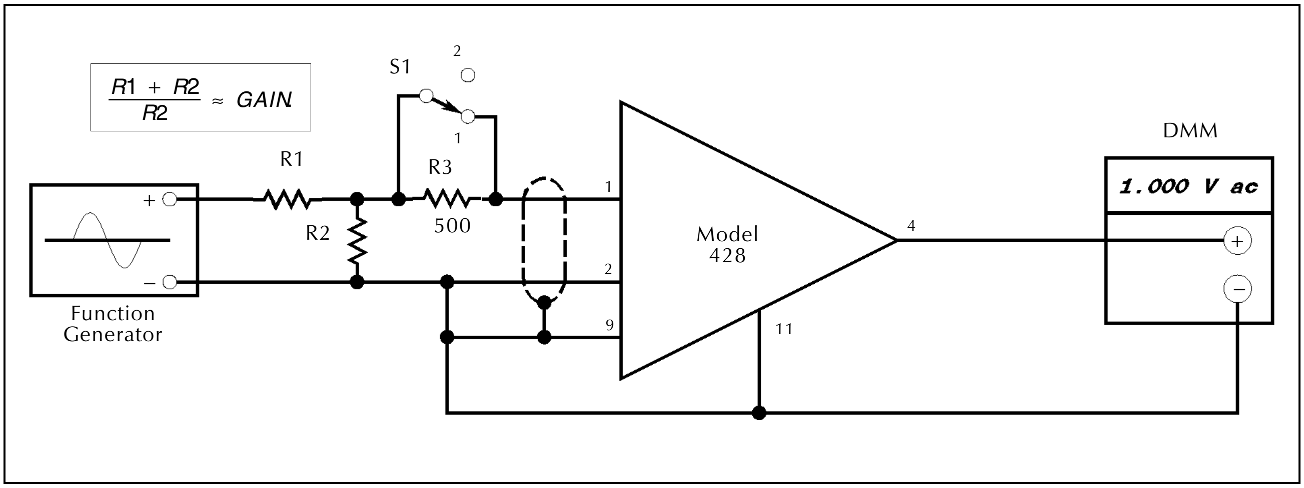



**Figure 5-5**
**Input-impedance Test**

5. Set S1 to 2.
6. Record the change in the amplifier output voltage, ΔV.

The input resistance $R_{IN}$ is defined as follows:

$$Z_{IN} = \frac{500}{\Delta V}.$$

## OUTPUT IMPEDANCE

The output impedance, which is directly in series with the output-high lead, is measured by reading the output of the amplifier without and then with a known resistance across the output and with that data, computing the output impedance of the amplifier.

1. Connect the Model 428 as is shown in Figure 5-6. For R1, R2, and R3 use either metal-film or carbon-film or carbon-composition resistors. R2 should not be less than 100 Ω. Install a 1-kΩ ¼-watt resistor for R3.
2. Set the Model 428 gain controls to the desired gain.
3. Set the DMM to measure ac volts.
4. Adjust the function generator (and if necessary, the gain vernier control of the amplifier) for a 1.000-V rms sine wave of 100 Hz at the amplifier output terminals.
5. Set S1 to 2.
6. Record the change in volts in the amplifier output as e.

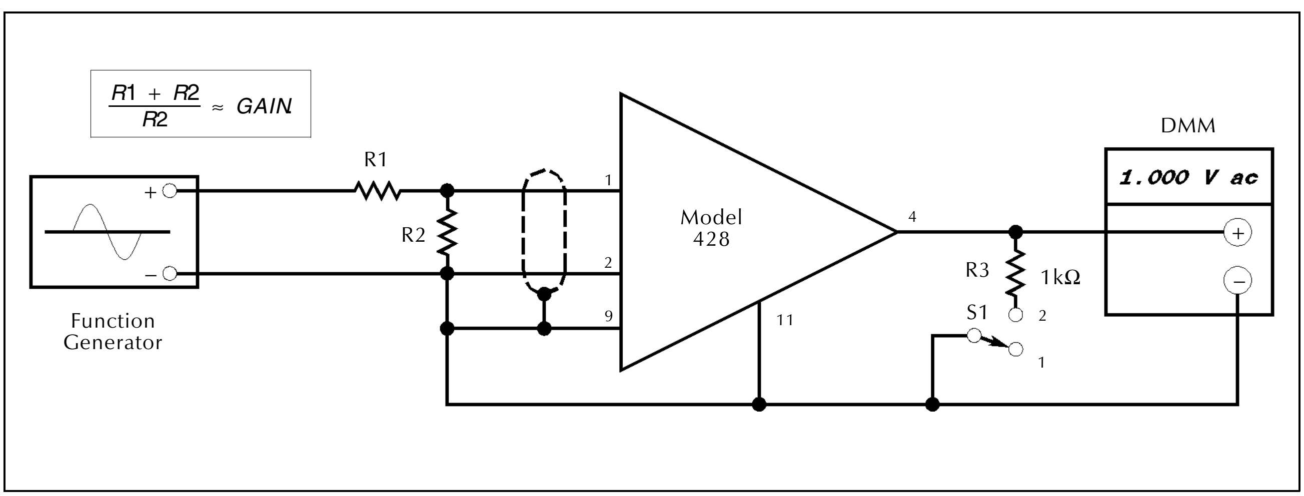



**Figure 5-6**
**Output-impedance Test**

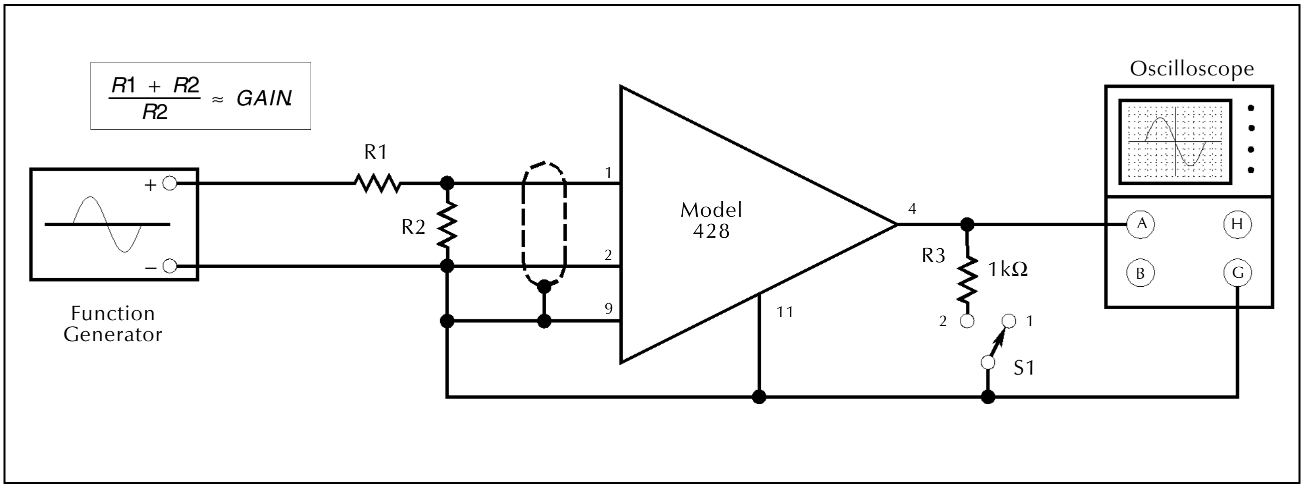



**Figure 5-7**
**Output-capability Test**

Output impedance $Z_{OUT}$ is defined as follows:

$$Z_{OUT} = 1000 \times e.$$

## OUTPUT CAPABILITY

1. Connect the Model 428 as is shown in Figure 5-7. For R1, R2, and R3 use either metal-film or carbon-film or carbon-composition resistors. R2 should not be less than 100 Ω. Install a 1-kΩ 1/4-watt resistor for R3.
2. Set the oscilloscope to display A only.
3. Set the function generator to 100 Hz and adjust it and the Model 428 gain controls to obtain a sine wave of greater than 20 V p-p as viewed on the oscilloscope.
4. Set S1 to 2. There should be no visible clipping of the sine wave, which indicates that the amplifier is capable of delivering 10 mA at ±10 V.
5. To perform this test with Option B installed, replace R3 with a 250-Ω resistor and offset the input wave form so that a 5-V p-p sine wave centered about +2.5 V dc is visible. Then set S1 to 2 and verify that no clipping of the wave form is visible.

## COMMON-MODE REJECTION (CMR)

CMR is the measure of how well an amplifier rejects a signal that is common to both inputs. The following tests apply various voltages, both ac and dc to the inputs (including guard) and measure the change in the output attributable to that common-mode voltage. A balanced

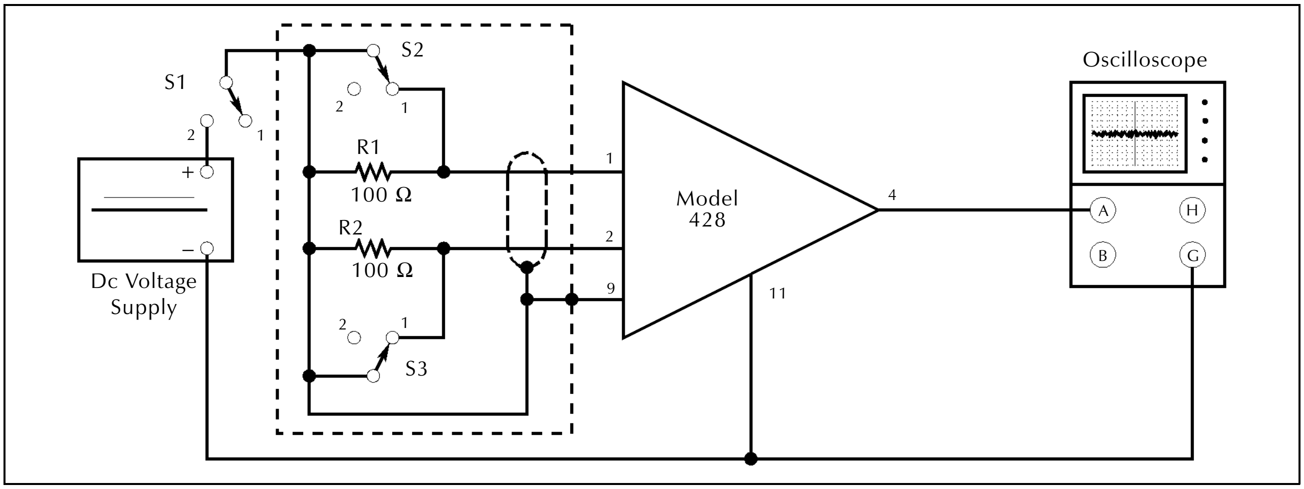



**Figure 5-8**
**Dc Common-mode-rejection Test**

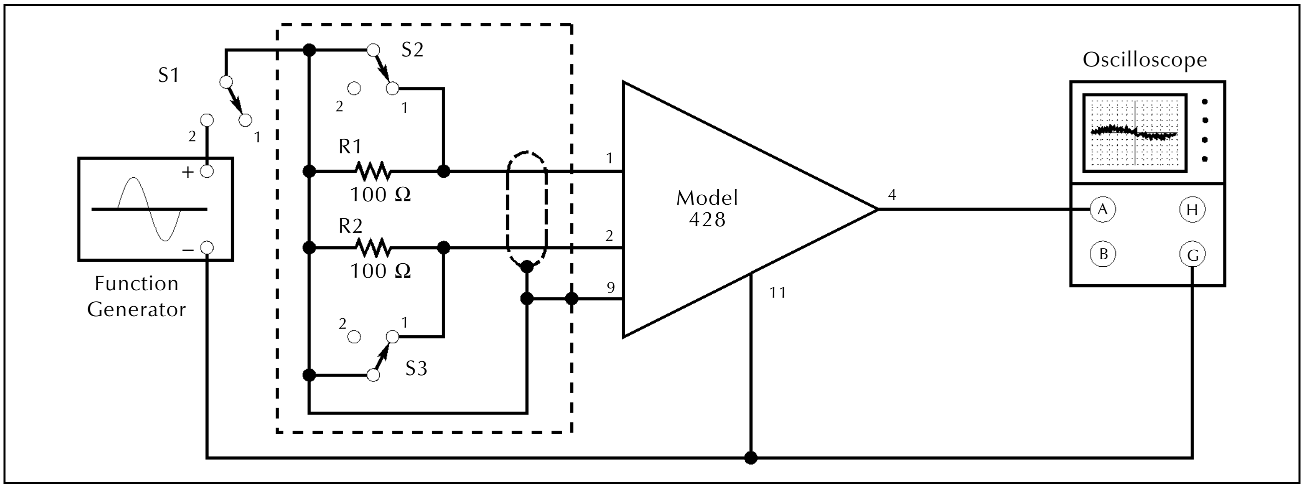



**Figure 5-9**
**Ac Common-mode-rejection Test**

input is one that has an equal impedance in series with both inputs. This includes no resistance. An unbalance of a specified resistance means that one or the other input has more series resistance than does the other input.

## DC UNBALANCED

**WARNING**

**Voltage that can be lethal is used in this procedure. This voltage will be present on all three amplifier input pins as well as all shielding. Use extreme care when performing the test.**

1. Connect the amplifier to be tested as shown in Figure 5-8, and set its gain to 1000 (1024 for Option G). For R1 and R2, use either metal-film or carbon-film or carbon-composition resistors. Set the dc voltage supply for 100 V.
2. Adjust the oscilloscope to display A only.
3. Adjust the zero control(s) for zero output from the amplifier and center the trace on the oscilloscope.
4. Set S1 to 2.
5. Set S2 to 2 and note the change in voltage from Step 3 as e.
6. Set S2 to 1 and S3 to 2 and again note change in voltage from Step 3 as e.
7. Using the larger voltage of Steps 5 and 6, compute the CMR where common-mode rejection (in dB) is defined as follows:

$$CMR = 20 \log \frac{100\ V \times GAIN}{e\ (in\ volts)}.$$

## AC BALANCED

1. Connect the amplifier to be tested as shown in Figure 5-9, and set the gain to 1000 (1024 for Option G). For R1 and R2, use either metal-film or carbon-film or carbon-composition resistors.
2. Adjust the oscilloscope to display A only.
3. Adjust the function generator for a 20-V p-p sine wave at 60 Hz.
4. Set S1 to 2.
5. Note the peak-to-peak signal displayed on the oscilloscope as *e*.

Compute CMR where common-mode rejection (in dB) is defined as follows:

$$CMR = 20 \log \frac{20\ V \times GAIN}{e\ (in\ volts)}.$$

## AC UNBALANCED

1. Connect the amplifier to be tested as shown in Figure 5-9, and set its gain to 1000 (1024 for Option G).
2. Adjust the oscilloscope to display A only.
3. Adjust the generator for a 20-V p-p sine wave at 60 Hz.
4. Set S1 and S2 to 2 and note the peak-to-peak voltage displayed on the oscilloscope as e.
5. Set S2 to 1 and S3 to 2 and again note the peak-to-peak voltage displayed on the oscilloscope as e.

Using the larger voltage of Steps 4 and 5, compute the CMR where common-mode rejection in dB as follows:

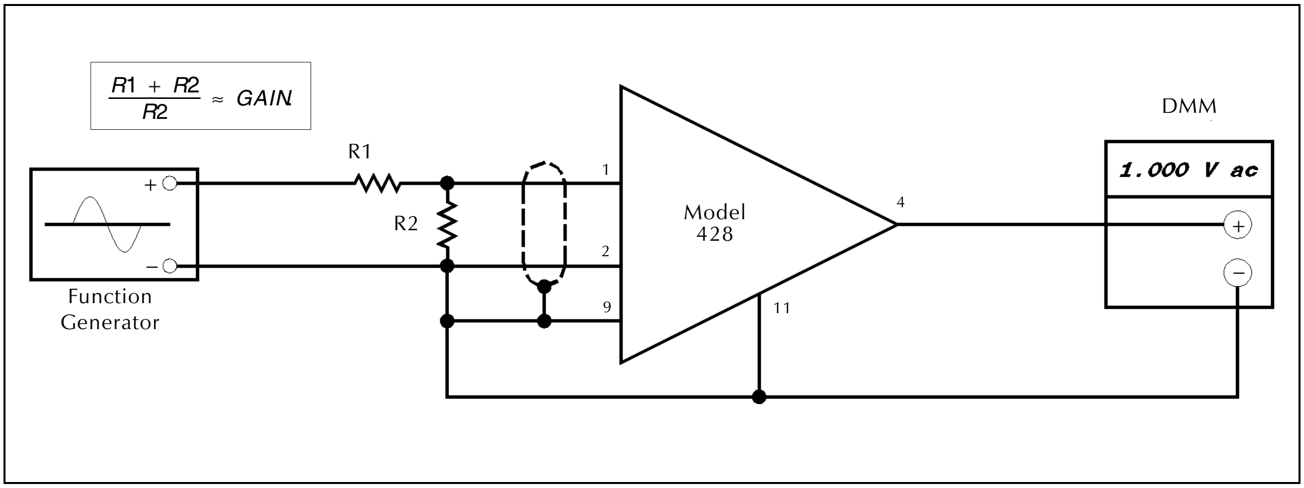



**Figure 5-10**
**Frequency-response Test**

$$CMR = 20 \log \frac{20 \ V \times GAIN}{e \ (in \ volts)}.$$

## FREQUENCY RESPONSE

In this test, a sine wave is applied to the input, and the response of the amplifier is noted on the DMM. The signal of 1 V rms is used for ease of measurement. The user may wish to use another voltage. When doing so, make sure that the full signal is within the linear range of the amplifier input and output.

1. Connect the amplifier as shown in Figure 5-10. For R1 and R2, use either metal-film or carbon-film or carbon-composition resistors. R2 should not be less than 100 Ω.
2. Set the DMM to measure ac voltage.
3. Adjust the function generator for a 1-V p-p sine wave of 100 Hz on the digital voltmeter. (If the unit under test has Option B, an input offset (using the front-panel zero controls or an external input offset) must be introduced to avoid clipping.
4. Vary the frequency of the function generator from 100 Hz to 5 kHz to verify compliance with the frequency-response specifications.

## NOISE

Noise is broken into two components for these tests: RTI, or input noise; and RTO, or output noise. The RTI-noise specification is stated as an input, so it must

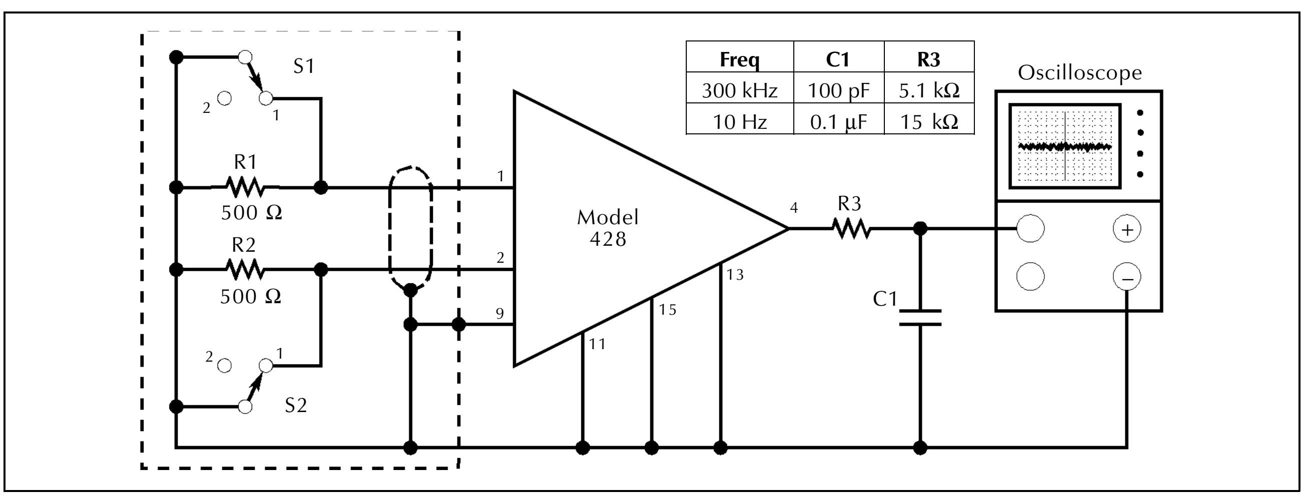



**Figure 5-11**
**Noise Test**

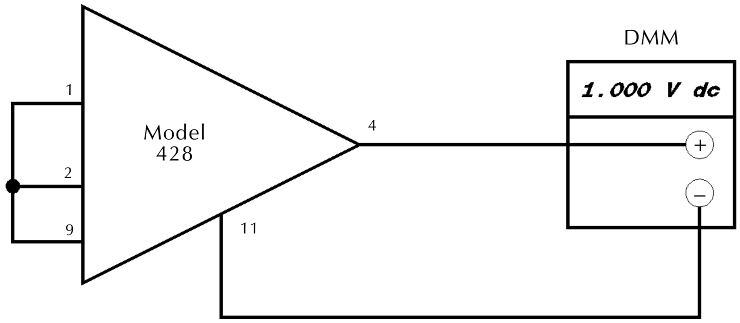



**Figure 5-12**
**Zero Tests**

be multiplied by the gain of the amplifier to determine its effect at the output. And since this is true for RTI noise, RTO noise can be measured at a low gain to effectively eliminate RTI noise from the measurement.

With a measurement bandwidth of 300 kHz, the maximum allowable noise at a gain of 10 is ≤2.55 mV peak (2.5 mV peak RTO plus 5 µV peak RTI times the gain of 10), and the maximum allowable noise at a gain of 1000 is ≤.7.5 mV peak (2.5 mV peak RTO plus 5µV peak RTI times the gain of 1000).

To measure the noise attributalbe to the Model 428, it is necessary to isolate its inputs from outside sources and to connect guard (Pin 9), output common (Pin 11, case (pin 13), and power common (Pin 15) to a single point. The two 500-Ω resistors and two toggle switches shown in Figure 5-11 should be housed completely within a "guarded" box. The Model 428 does not generate any 60-Hz signals. If 60 Hz is present on the oscilloscope display, it is being introduced externally and should not be included in the measurement.

1. Connect the amplifier as shown in Figure 5-11. For R1 and R2, use either metal-film or carbon-film or carbon-composition resistors. To measure RTO noise, set the amplifier gain to 10; RTI noise, 1000.
2. Set the oscilloscope low-pass filter for 300 kHz. If a switchable filter is not present on the oscilloscope, install one as is shown with R3 and C1.
3. Note the largest peak voltage (The user may find it more convenient to make the measurements in peak-to-peak in which case the specifications must by multiplied by 2 to determine whether the amplifier is within specification.) as displayed on the oscilloscope when S1 and S2 are both in 1 and in 1 and 2 alternately.
4. Switch in a 10-Hz filter and repeat Step 3. Values for R3 and C1 are shown in Figure 5-11.

## ZERO

### RTI ZERO

1. Connect the amplifier to be tested as shown in Figure 5-12.
2. Adjust the gain to 100 (128 for units equipped with Option G).
3. Adjust the coarse- and fine-zero controls counter-clockwise until the stops are reached.
4. The reading on the DMM should be more negative than −4 V (–5.12 V for units with Option G).
5. Adjust the COARSE- and FINE-zero controls fully clockwise.
6. Note and record the reading on the DMM, which, should be more positive than +4 V (+5.12 V for units with Option G).
7. Adjust the coarse and fine zero control potentiometers for zero output from the amplifier.

### OPTION O (AUTOZERO)

Option O allows the operator to command the amplifier to zero itself either by front-panel or remote control.

1. Connect the amplifier under test as shown in Figure 5-12. Set its gain to 100 (128 for units equipped with Option G).
2. Using the front-panel zero controls, offset the output of the amplifier to 1 V (1.28 V for units with

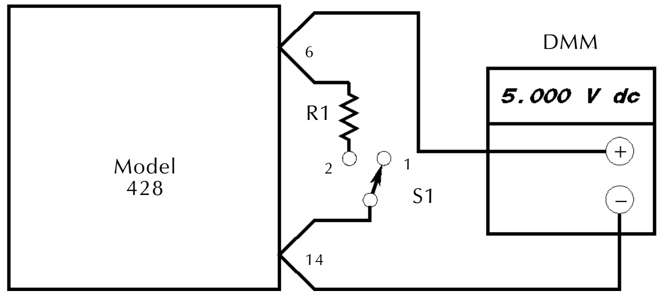



**Figure 5-13**
**Excitation-voltage Accuracy Tests**

Option G).

3. Set the momentary autozero switch to ZERO and release. Verify that the amplifier output returns to 0 ±12 mV (±12.6 mV for units with Option G) and that the light extinguishes.
4. Set the autozero switch to MAN, adjust the COARSE- and FINE-control potentiometers for zero output from the amplifier, and set the autozero switch to OPR.

## ZERO SHIFT WITH TEMPERATURE

This test measures the shift in zero due to temperature changes, by subjecting the Model 428 to the extremes of its temperature range, measuring the output at those extremes, and computing the zero temperature coefficient. This test is run at only one gain. However, the user may want to perform it a low gain (10) and a high gain (1000) to obtain data for RTO as well as RTI zero shift. At low gains, nearly all of the shift in zero is RTO; and at high gains, RTI zero is the main contributor. For example, if the total zero drift at a gain of 10 is 15 mV and 50 mV at a gain of 1000, then RTO is contributing nearly all of the 15 mV noted at a gain of 10, and RTI is contributing slightly more than the 35-mV difference between the two readings. With these two readings then, one can compute the contribution of both RTO and RTI zero.

1. Connect the amplifier to be tested as shown in Figure 5-12, and set gain to the desired gain.
2. Adjust the zero controls for zero output from the amplifier.
3. Place the amplifier in an environmental chamber and reduce the temperature to −25°C.
4. Record the output as $V_1$ ( in volts) after the amplifier has stabilized (approximately 30 minutes).
5. Increase the temperature in the environmental chamber to +71°C.
6. Record the output after the amplifier has stabilized (approximately 45 minutes) as $V_2$ (in volts).

The temperature change of zero per °C is computed as follows:

$$Z_{TC} = \frac{(V_2 - V_1)}{96°C}.$$

To compare this reading with the specification, multiply the maximum allowable RTI shift (taking into account not only the basic amplifier specification but also the specification for Option O if it is installed), in microvolts per degrees centigrade, by the gain of the amplifier. Then add to that the maximum allowable RTO shift in microvolts per degree centigrade. Finally, compare that sum with the result obtained in Step 6 to determine whether the unit under test is within specification.

For example, assume the following:

$$V_1 = 0.01\ V\ dc.$$

$$V_2 = 0.04\ V\ dc.$$

$$GAIN = 500.$$

$$OPTION\ O: \quad INSTALLED$$

First compute the results of the test using the formula:

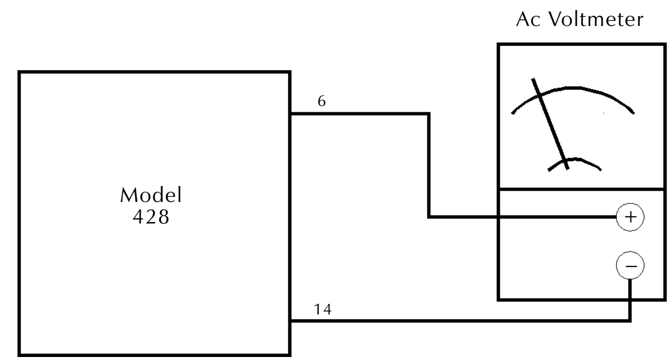



**Figure 5-14**
**Excitation-voltage Noise Tests**

$$Z_{TC} = \frac{(0.04\ V - 0.01\ V)}{96°C}.$$

$$= 312.5\ \mu V/°C.$$

Next, compute the maximum allowable RTI change ($V_{RTI\ MAX}$):

$$V_{RTI\ MAX} = \pm 1.5\ \mu V/°C \times GAIN$$

$$= \pm 1.5\ \mu V/°C \times 500.$$

$$= \pm 750\ \mu V/°C.$$

Next add the maximum allowable RTI specification to the maximum allowable RTO specification:

$$750\ \mu V/°C + 50\ \mu V/°C = 800\ \mu V/°C.$$

Finally, compare the results of the test with the maximum allowable zero shift to ascertain whether the unit under tests conforms to the specification for zero shift with temperature:

$$312.5\ \mu V/°C < 800\ \mu V/°C.$$

## EXCITATION SUPPLY

### VOLTAGE ACCURACY

This test measures the excitation voltages with no load applied. The readings will be used in the next test, load regulation.

1. Connect the Model 428 as is shown in Figure 5-13 and set the DMM for dc volts.
2. Switch the Model 428 Excitation switch to the three voltages and verify that they are within specification.

### LOAD REGULATION

In this test a resistive load is placed “across” the excitation-output pins, and the voltage is compared to that of the previous test to ensure that the excitation supply is capable of delivering its rated power.

1. Connect the Model 428 as is shown is Figure 5-13, Install an appropriate resistor (see Table 5-1) for R1. The resistor should be connected as close to the connector pins as is possible to avoid IR losses in the measurement.
2. Set S1 to 2.
3. Referring to the voltages noted in the voltage-accuracy test above, verify that when S1 is switched to 2, the voltage change is within specification.

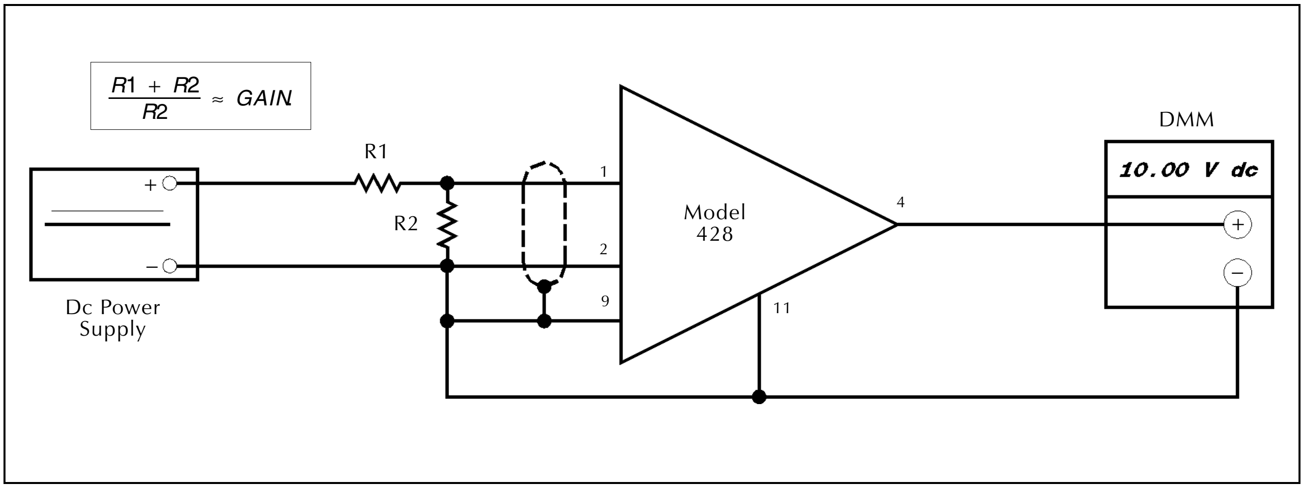



**Figure 5-15**
**Overload Indicator and Reset Test**

### Table 5-1
### Load Resistors for Excitation Load Tests

| Excitation V | Loads (in Ω)* | | |
|---|---|---|---|
| | @ 50 mA | @ 75 mA | @ 100 mA |
| **5** | 100 | 67 | 50 |
| **7** | 140 | 93 | 70 |
| **10** | 200 | 133 | 100 |
| * Worst-case load-resistor wattage is 1 W. Use 2-W resistors. | | | |

**TEMPERATURE COEFFICIENT**

This test measures the temperature coefficient of the excitation supply by subjecting the Model 428 to the extremes of its rated temperature range, measuring the excitation supplies at those extremes, and computing the percent error per degree centigrade.

1. Connect the amplifier to be tested as shown in Figure 5-13.
2. Set the excitation voltage to the desired setting.
3. Place the amplifier in an environmental chamber adjusted to −25°C.
4. Record the excitation supply voltage after it has stabilized (≈30 minutes) as $V_1$.
5. Raise the temperature of the environmental chamber to +71°C.
6. Record the excitation supply voltage after it has stabilized (≈45 minutes) as $V_2$.

Compute the temperature coefficient for excitation voltage in percent as follows:

$$ExV_{TC} = \frac{V_2 - V_1}{96°C} \times 100.$$

**EXCITATION NOISE**

This tests measures the noise generated by the excitation supply using an ac voltmeter capable of measuring less than 1 mV rms.

1. Connect the amplifier to be tested as shown in Figure 5-14.
2. Set the excitation voltage to the desired setting and verify that the noise as read on the ac voltmeter is within specification.

**OVERLOAD INDICATION AND RESET**
**OPTION L**

This test verifies that the overload indicator lights within the specificied range and that the reset switch is functional.

1. Connect the amplifier to be tested as shown in Figure 5-15 and set the DMM to measure 10 V dc.
2. Set the gain as desired, and slowly increase the dc voltage while monitoring the DMM until to overload indicator lights.
3. Verify that the indicator turns on within the specificied range and remains on.
4. Decrease the dc voltage to a level below the rated full-scale output (as displayed on the DMM), press the Reset button, and verify that the overload indicator turns off and remains off.

## SECTION VI
# PARTS LISTS

## NAMES OF MANUFACTURERS

Following is the list of manufacturers of the components used by Ectron in the products for which parts lists and schematics are provided. They are listed numerically for easy cross reference to the parts lists.

| | |
|---|---|
| 00027 | ALLEN-BRADLEY CO. |
| 00044 | AMPHENOL |
| 00060 | ARIES ELECTRONICS |
| 00074 | AUGAT INTERCONNECTION |
| 00091 | BENDIX CORP. |
| 00127 | BUSSMANN DIV. |
| 00128 | C&K COMPONENTS INC. |
| 00166 | CIRCUIT ASSEMBLY CORP. |
| 00206 | DATA DISPLAY PRODUCTS |
| 00336 | FAIRCHILD |
| 00464 | ITT CANNON |
| 00493 | KEMET, UNION CARBIDE CORP |
| 00503 | KOA SPEER ELECTRONICS |
| 00532 | LITTELFUSE INC. |
| 00564 | PHILIPS |
| 00616 | MOTOROLA SEMICONDUCTOR |
| 00628 | NATIONAL SEMICONDUCTOR |
| 00726 | ROHM |
| 00763 | SAMTEC |
| 00808 | SILICONIX INC. |
| 00834 | SPRAGUE ELECTRIC CO. |
| 00845 | STANDARD POWER INC. |
| 00863 | SWITCHCRAFT INC. |
| 00949 | USECO |
| 00987 | WINSLOW INTERNATIONAL |
| 01094 | CENTRAL SEMICONDUCTOR |
| 01152 | TRW-CINCH |
| 01164 | PEM |
| 01166 | KULKA SMITH |
| 01176 | BELDEN |
| 01177 | KEYSTONE |
| 01230 | ECTRON CORPORATION |
| 01264 | IRC-(INT'L. RESITIVE CO.) |
| 01302 | ELCO (COSEL) |

# MODEL E408-6 ENCLOSURE

## (Drawings 408-600 and 408-601)

| REFERENCE DESIGNATOR | DESCRIPTION | MFR | MANUFACTURER'S P/N | ECTRON P/N |
|---|---|---|---|---|
| C1,C2,C3 | CAPACITOR, 4.7UF/35V TANTALUM | 00834 | 199D475X9035CA2 | 1-444700-1 |
| C4 | CAPACITOR, 4.7UF/50V CERAMIC | 00493 | C340C475M5U5CA | 1-444709-0 |
| CR1, CR2 | DIODE, SIGNAL | 01094 | 1N457 | 1-190457-0 |
| CR3,CR4,CR6,CR7 | DIODE, SIGNAL | 00628 | 1N4148 | 1-194148-0 |
| CR5 | ZENER, 11V 11.5MA 500MW | 00616 | 1N962B | 1-190962-0 |
| CR8 | DIODE, POWER | 00336 | 1N4002 | 1-194002-0 |
| DS1 | LAMP | 00206 | 91W-EWR24H-CR0 | 4-121007-0 |
| F1 | FUSE, 1.5A NORMAL BLOW | 00532 | 31201.5 | 2-161500-0 |
| F2 | FUSE, 1A SLOW BLOW | 00532 | 313001 | 2-161000-1 |
| J1-J6 | CONNECTOR, 6-PIN | 00091 | PT02A-10-6S | 1-310506-1 |
| J7 | CONNECTOR, 3-PIN | 00091 | PT02A-12-3P | 1-310103-0 |
| J8 | RECEPTACLE, POWER | 00863 | EAC-309 | 3-840043-0 |
| J9-J14 | CONNECTOR, 15-PIN D | 01152 | DA-15-SV | 1-310015-6 |
| J15-J20 | CONNECTOR, BNC | 00044 | 31-010 | 1-311102-0 |
| P1-P6 | CONNECTOR, 6-PIN | 00091 | PT06A-10-6P(SR) | 1-310506-0 |
| P7 | CONNECTOR, 3-PIN | 00091 | PTO6A-12-3S(SR) | 1-310103-1 |
| PS1, OPTION X | POWER SUPPLY, 28 V | 01302 | R50U-24-N | 5-120026-0 |
| PS1, OPTION Y | POWER SUPPLY, 12 V | 01302 | R50U-12-N | 5-120025-0 |
| Q1,Q2 | FET, MOS 1.2-OHM | 00808 | VN0300L | 1-240030-0 |
| Q3 | TRANSISTOR, PNP | 00628 | 2N3702 | 1-213702-0 |
| R5 | RESISTOR, 100K/1% | 00726 | CRB1/4FY100K | 6-103100-0 |
| R6,R7 | RESISTOR, 1MEG/5% 1/4W | 00564 | 5043EM1M000JB | 6-174100-0 |
| R8 | RESISTOR, 470 OHM 5% 2W | 01264 | SPH 470 OHM 5% 2W | 6-200470-0 |
| R9 | RESISTOR, 15K 1/4W 5% | 00564 | 5043CX15K00J | 6-172150-0 |
| R10 | RESISTOR, 100/5% 1/4W | 00564 | 5043CX100R0J | 6-170100-0 |
| S1 | SWITCH, TOGGLE | 00128 | 7203-K-Z-G-E | 7-110059-0 |
| S2 | SWITCH, PUSHBUTTON | 00128 | 8121-J83-Z-G-E-3-2 | 7-120012-0 |
| S3 | SWITCH, TOGGLE | 00128 | 7103-K-Z-G-E | 7-110048-0 |
| U1 | IC | 00808 | 7661CJ | 1-147661-0 |
| XF1,XF2 | FUSEHOLDER | 00532 | 342004 | 2-170006-0 |
| W1, W2 | JUMPER, PLUG | 00166 | CA-02-SJOB | 1-319921-0 |
| FOR TOP COVER | SCREW, 6-32 CAPTIVE PANEL | 01164 | PS10-632-40 | 3-905032-1 |
| | FERRULE | 01166 | 1670 | 3-905010-0 |
| | FOOT | 01166 | 2192 | 3-840008-0 |
| | HANDLE | 00949 | B1073-12 BRASS CHRM PLT | 3-820019-0 |
| | POWER CORD, USA/CANADA | 01176 | 17250B | 3-840026-0 |

# MODEL R408-14 ENCLOSURE
## (Drawings 408-605 and 408-606)

| REFERENCE DESIGNATOR | DESCRIPTION | MFR | MANUFACTURER'S P/N | ECTRON P/N |
|---|---|---|---|---|
| C1, C2, C3 | CAPACITOR, 4.7UF/35V TANTALUM | 00834 | 199D475X9035CA2 | 1-444700-1 |
| C4 | CAPACITOR, 4.7UF/50V CERAMIC | 00493 | C340C475M5U5CA | 1-444709-0 |
| CR1, CR2 EACH CHANNEL | DIODE, SIGNAL | 01094 | 1N457 | 1-190457-0 |
| CR3, CR4, CR6, CR7 | DIODE, SIGNAL | 00628 | 1N4148 | 1-194148-0 |
| CR5 | ZENER, 11V 11.5MA 500MW | 00616 | 1N962B | 1-190962-0 |
| CR8 | DIODE, POWER | 00336 | 1N4002 | 1-194002-0 |
| DS1 | LAMP 12-40V | 00206 | 91W-EWR24H-CR0 | 4-121007-0 |
| F1 | FUSE, 5A/32V 3AG | 00127 | BK/AGC-5X | 2-165000-0 |
| F2 | FUSE, 1A/25OV 3AG SLOBLO | 00532 | 313001 | 2-161000-1 |
| J1-J14 | CONNECTOR, 6-PIN | 00091 | PT02A-10-6S | 1-310506-1 |
| J15-J28 | CONNECTOR, BNC | 00044 | 31-010 | 1-311102-0 |
| J29-J42 | CONNECTOR, 15-PIN | 01152 | DA-15-SV | 1-310015-6 |
| J43 | CONNECTOR, 3-P | 00091 | PT02A-12-3P | 1-310103-0 |
| J44 | RECEPTACLE, POWER | 00863 | EAC-309 | 3-840043-0 |
| P1-P14 | CONNECTOR, 6-PIN | 00091 | PT06A-10-6P(SR) | 1-310506-0 |
| P43 | CONNECTOR, 3-PIN | 00091 | PTO6A-12-3S(SR) | 1-310103-1 |
| PS1, OPTION Y | POWER SUPPLY | 01302 | R50U-12-N | 5-120025-0 |
| PS1, OPTION X | POWER SUPPLY | 01302 | R50U-24-N | 5-120026-0 |
| Q1, Q2 EACH CHANNEL | FET, MOS VN 30V 1.2-OHM | 00808 | VN0300L | 1-240030-0 |
| Q3 | TRANSISTOR, PNP | 00628 | 2N3702 | 1-213702-0 |
| R5 EACH CHANNEL | RESISTOR,100K 1% 1/4W 50PPM/TC | 00726 | CRB1/4FY100K | 6-103100-0 |
| R6, R7 EACH CHANNEL | RESISTOR, 1MEG 1/4W 5% | 00564 | 5043EM1M000JB | 6-174100-0 |
| R9 | RESISTOR, 15K 1/4W 5% | 00564 | 5043CX15K00J | 6-172150-0 |
| R10 | RESISTOR, 100 1/4W 5% | 00564 | 5043CX100R0J | 6-170100-0 |
| S1 | SWITCH, TOGGLE | 00128 | 7303KYZGE | 7-110024-0 |
| S2 | SWITCH, PUSH-BUTTON | 00128 | 8125SHZBE | 7-120002-0 |
| S3 | SWITCH, TOGGLE | 00128 | 7103KZGE | 7-110048-0 |
| U1 | IC, VOLTAGE CONVERTER | 00808 | 7661CJ | 1-147661-0 |
| W1, W2 | JUMPER | 00166 | CA-02-SJOB | 1-319921-0 |
| XF1, XF2 | FUSEHOLDER | 00532 | 342004 | 2-170006-0 |
| | FERRULE | 01166 | 1670 | 3-905010-0 |
| | GROMMET, 3/8DIA 7/16MOUNT | 01166 | 91107 | 3-801412-0 |
| | HANDLE, 3 INCH MOD R418-7 | 01166 | 1622 OR 1620 | 3-820002-0 |
| | POWER CORD, USA AND CANADA | 01176 | 17250B | 3-840026-0 |

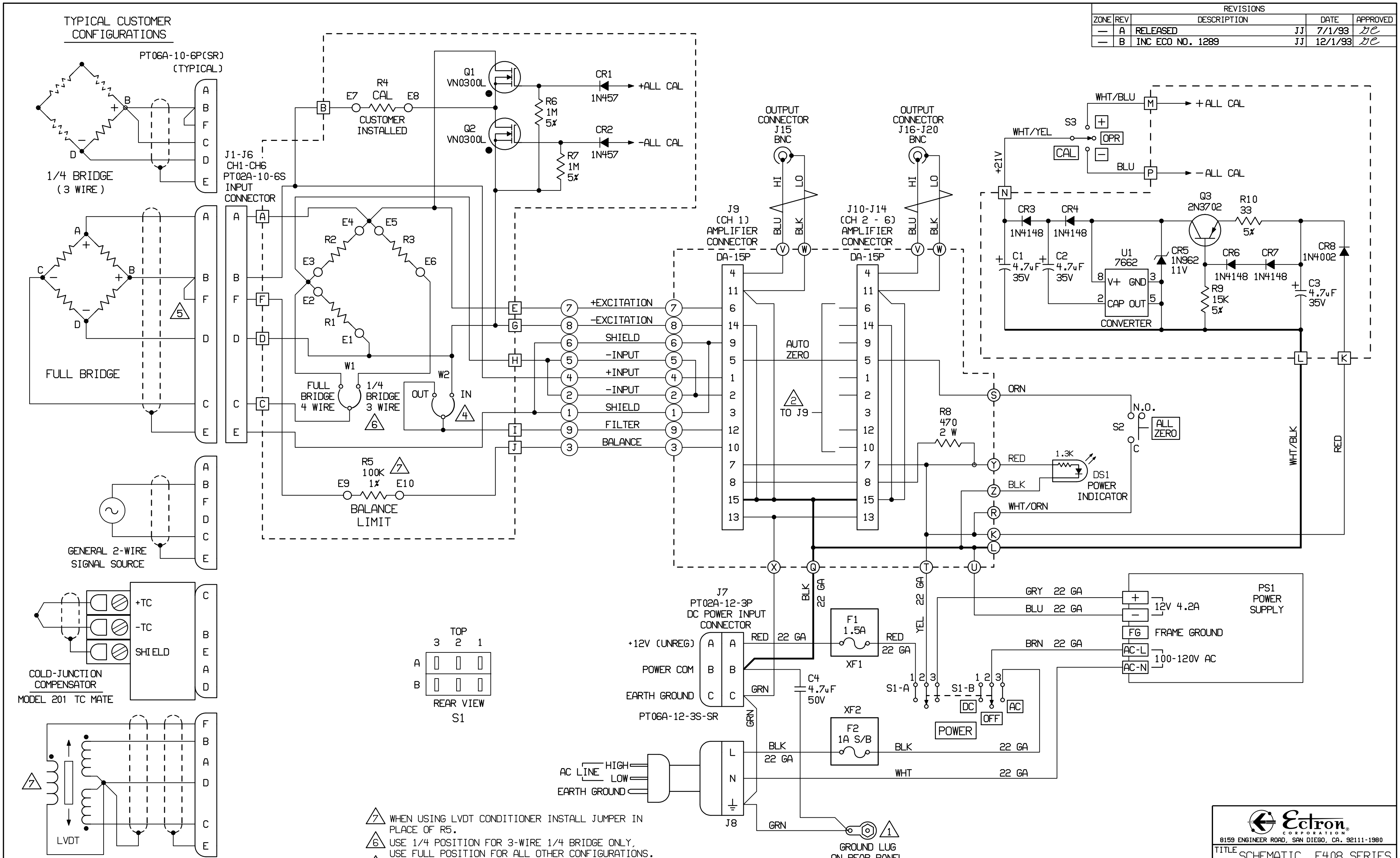
# MODEL R418-7 ENCLOSURE

## (Drawing 418-627)

| REFERENCE DESIGNATOR | DESCRIPTION | MFR | MANUFACTURER'S P/N | ECTRON P/N |
|---|---|---|---|---|
| C1 | CAPACITOR,4.7UF/50V CERAMIC | 00493 | C340C475M5U5CA | 1-444709-0 |
| DS1 | LAMP | 00206 | 91W-EWR24H-CR0 | 4-121007-0 |
| J1-J14 | CONNECTOR,8-PIN | 00044 | MS3102A-18-8P | 1-310008-0 |
| J15 | CONNECTOR,36-PIN | 00044 | 57-30360 | 1-310136-0 |
| J16 | CONNECTOR,3-PIN | 00044 | MS-3102A-14S-7P | 1-310003-0 |
| J17 | RECEPTACLE,POWER | 00863 | EAC-309 | 3-840043-0 |
| J18-J31 | CONNECTOR,15-PIN | 00464 | DAF-15-S | 1-310515-0 |
| P1-P14 | CONNECTOR,8-PIN | 00044 | MS3106A-18-8S | 1-310008-1 |
| P15 | CONNECTOR,36-PIN | 00044 | 57-40360 | 1-310136-1 |
| P16 | CONNECTOR,3-PIN | 00044 | MS-3106A-14S-7S | 1-310003-1 |
| PS1, PS2, OPTION Y | POWER SUPPLY, 12 V | 00845 | SPS30-12 | 5-120003-0 |
| PS1, PS2, OPTION X | POWER SUPPLY, 28 V | 00845 | SPS30-24/28 | 5-120002-0 |
| R1-R14 | RESISTOR,100K/1% | 00726 | CRB14FY100K | 6-103100-0 |
| R15 | RESISTOR,470/5% 1/2W | 00027 | RC20GF471J | 6-180470-0 |
| S1, R418-7A | SWITCH,TOGGLE | 00128 | 7201-S-Y-Z-G-E | 7-110006-0 |
| S1, R418-7B-E | SWITCH,TOGGLE | 00128 | 7303-S-Y-Z-G-E | 7-110011-0 |
| XF1, XF2 | FUSEHOLDER,1.25IN PANEL MOUNT | 00532 | 342004 | 2-170006-0 |
| 'FOR P1-P14 | BUSHING | 00044 | 9779-513-10 | 1-319008-1 |
| FOR P1-P14 | CLAMP | 00044 | 97-3057-10 | 1-319002-1 |
| FOR P16 | CLAMP & BUSHING | 00044 | 97-3057-1007-1 | 1-319004-0 |
| | FERRULE | 01166 | 1670 | 3-905010-0 |
| | HANDLE | 01166 | 1622 OR 1620 | 3-820002-0 |
| | POWER CORD, USA/CANADA | 01176 | 17250B | 3-840026-0 |

# R418-M1028C ENCLOSURE
## (Drawing 419-605)

| REFERENCE DESIGNATOR | DESCRIPTION | MFR | MANUFACTURER'S P/N | ECTRON P/N |
|---|---|---|---|---|
| C1, C2, C3 | CAPACITOR,4.7UF/35V TANTALUM | 00834 | 199D475X9035CA2 | 1-444700-1 |
| C4 | CAPACITOR,4.7UF 20% 50V | 00493 | C340C475M5U5CA | 1-444709-0 |
| CR1, CR3 PER CHANNEL | DIODE,SIGNAL | 01094 | 1N457 | 1-190457-0 |
| CR5, CR6, CR8, CR9 | DIODE,1N4148 | 00628 | 1N4148 | 1-194148-0 |
| CR7 | ZENER,11V 11.5MA 500MW | 00616 | 1N962B | 1-190962-0 |
| CR10 | DIODE,POWER | 00336 | 1N4002 | 1-194002-0 |
| DS1 | LAMP | 00206 | 91W-EWR24H-CR0 | 4-121007-0 |
| F1 | FUSE,5A/32V 3AG | 00127 | BK/AGC-5X | 2-165000-0 |
| F2 | FUSE | 00532 | 313.500 | 2-160500-1 |
| J1-J14 | CONNECTOR, 6-PIN | 00091 | PT02A-10-6S | 1-310506-1 |
| J16 | CONNECTOR, 3-PIN | 00091 | PT02A-12-3P | 1-310103-0 |
| J17 | RECEPTACLE | 00863 | EAC-309 | 3-840043-0 |
| J18-J31 | CONNECTOR,15-PIN D-SUB | 01152 | DA-15-SV | 1-310015-6 |
| J32-J45 | CONNECTOR, BNC | 00044 | 31-010 | 1-311102-0 |
| P1-P14 | CONNECTOR, 6-PIN | 00091 | PT06A-10-6P(SR) | 1-310506-0 |
| P16 | CONNECTOR, 3-PIN | 00091 | PTO6A-12-3S(SR) | 1-310103-1 |
| PS1 | POWER SUPPLY,12V/4.2A | 01302 | R50U-12-N | 5-120025-0 |
| Q1, 2 PER CHANNEL | FET,MOS 1.2-OHM | 00808 | VN0300L | 1-240030-0 |
| Q3 | TRANSISTOR,PNP | 00628 | 2N3702 | 1-213702-0 |
| R1, 2 PER CHANNEL | RESISTOR,1MEG 1/4W 5% | 00564 | 5043EM1M000JB | 6-174100-0 |
| R3 | RESISTOR,8.2K 1/4W 5% | 00564 | 5043CX8K200J | 6-171820-0 |
| R4 PER CHANNEL (BAL LIMIT) | RESISTOR,100K/1% | 00726 | CRB14FY100K | 6-103100-0 |
| R4 | RESISTOR,47 1/4W 5% | 00503 | 47 OHM 5% | 6-170047-0 |
| S1 | SWITCH,TOGGLE | 00128 | 7303 K-Y-Z-G-E | 7-110024-0 |
| S2 | SWITCH,PUSH-BUTTON | 00128 | 8125-S-H-Z-B-E | 7-120002-0 |
| S3 | SWITCH,TOGGLE | 00128 | 7103-K-Z-G-E | 7-110048-0 |
| U1 | VOLTAGE CONVERTER | 00808 | 7661CJ | 1-147661-0 |
| | FERRULE | 01166 | 1670 | 3-905010-0 |
| | HANDLE | 01166 | 1622 OR 1620 | 3-820002-0 |
| | JUMPER,PLUG | 00166 | CA-02-SJOB | 1-319921-0 |
| | POWER CORD | 01176 | 17250B | 3-840026-0 |




| ZONE | REV | DESCRIPTION | | DATE | APPROVED |
|---|---|---|---|---|---|
| — | A | RELEASED | JJ | 7/1/93 | GC |
| — | B | INC ECO NO. 1289 | JJ | 12/1/93 | GC |

Ectron Corporation
8159 ENGINEER ROAD, SAN DIEGO, CA. 92111-1980

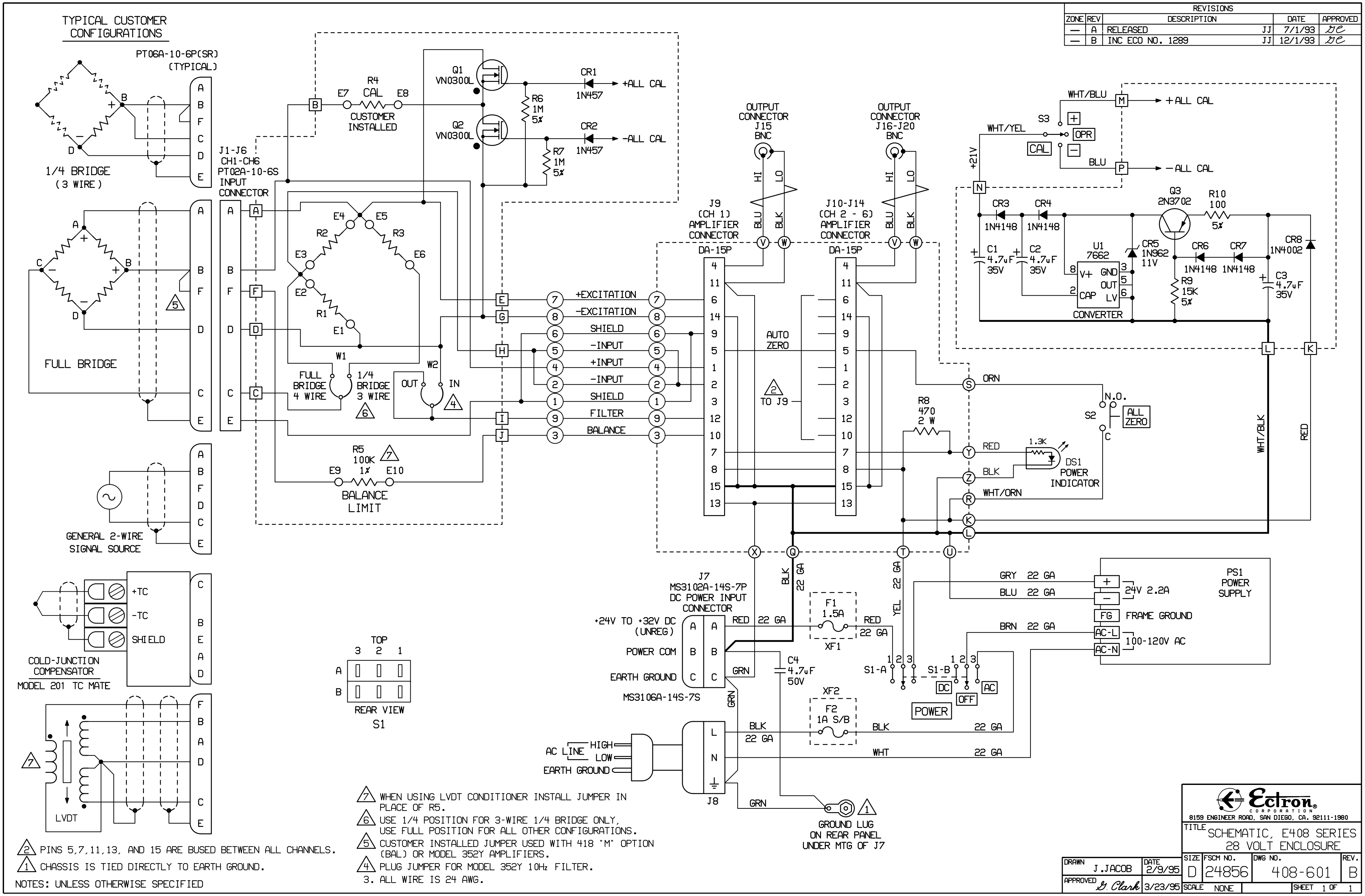
TITLE SCHEMATIC, E408 SERIES 12 VOLT ENCLOSURE

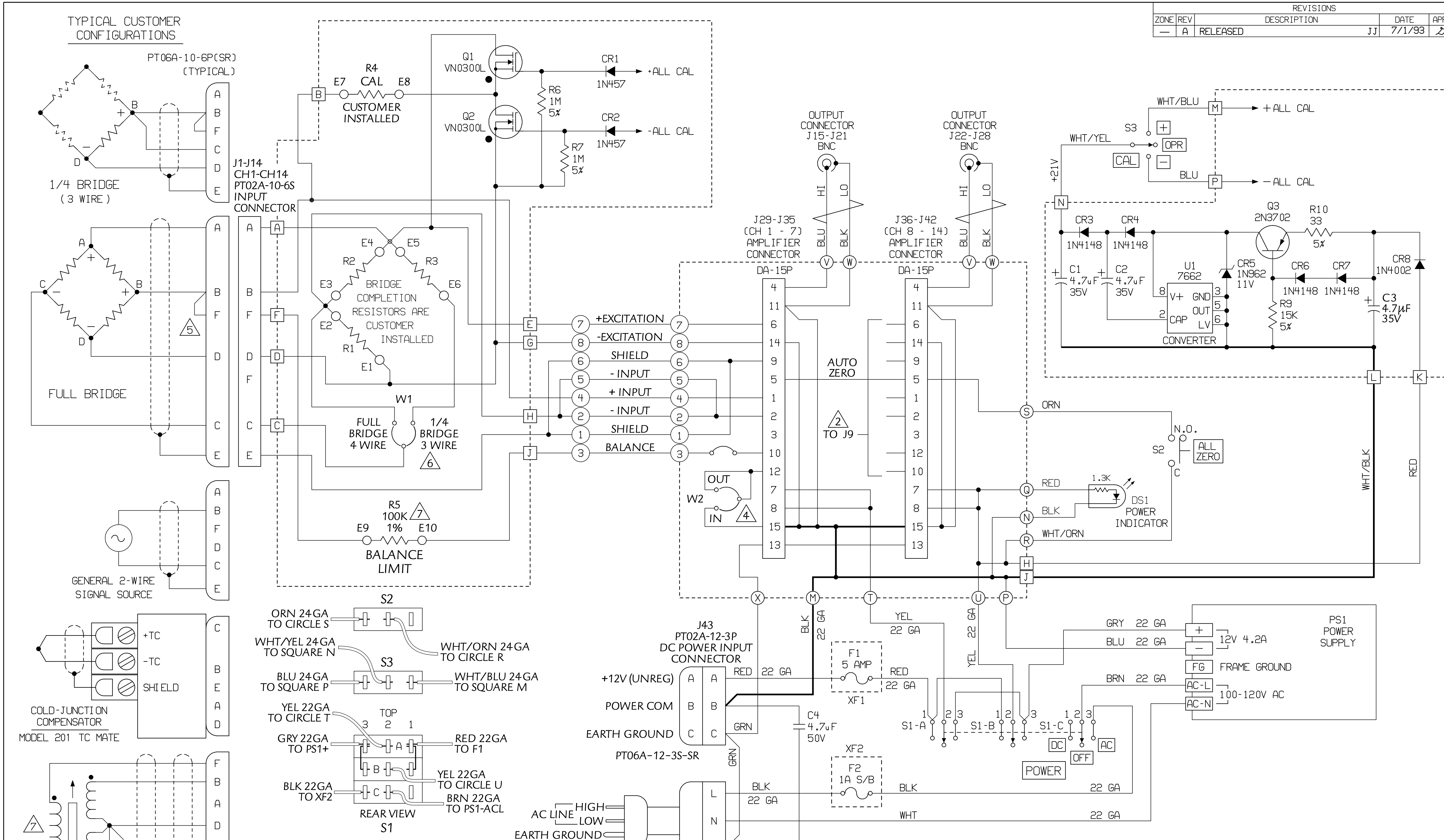
DRAWN J.JACOB — DATE 2/9/95
CHECKED G. Clark — 3/23/95
APPROVED

SIZE D — FSCM NO. 24856 — DWG NO. 408-600 — REV. B
SCALE NONE — SHEET 1 OF 1

NOTES: UNLESS OTHERWISE SPECIFIED

1. CHASSIS IS TIED DIRECTLY TO EARTH GROUND.
2. PINS 5,7,11,13, AND 15 ARE BUSED BETWEEN ALL CHANNELS.
3. ALL WIRE IS 24 AWG.
4. PLUG JUMPER FOR MODEL 352Y 10Hz FILTER.
5. CUSTOMER INSTALLED JUMPER USED WITH 418 "M" OPTION (BAL) OR MODEL 352Y AMPLIFIERS.
6. USE 1/4 POSITION FOR 3-WIRE 1/4 BRIDGE ONLY. USE FULL POSITION FOR ALL OTHER CONFIGURATIONS.
7. WHEN USING LVDT CONDITIONER INSTALL JUMPER IN PLACE OF R5.


REVISIONS
ZONE | REV | DESCRIPTION | DATE | APPROVED
— | A | RELEASED JJ | 7/1/93 | GC
— | B | INC ECO NO. 1289 JJ | 12/1/93 | GC
TYPICAL CUSTOMER CONFIGURATIONS
PT06A-10-6P(SR) (TYPICAL)
1/4 BRIDGE (3 WIRE)
FULL BRIDGE
GENERAL 2-WIRE SIGNAL SOURCE
COLD-JUNCTION COMPENSATOR
MODEL 201 TC MATE
+TC
-TC
SHIELD
LVDT
J1-J6 CH1-CH6 PT02A-10-6S INPUT CONNECTOR
R4 CAL CUSTOMER INSTALLED
Q1 VN0300L
Q2 VN0300L
CR1 1N457
CR2 1N457
R6 1M 5%
R7 1M 5%
+ALL CAL
-ALL CAL
W1
FULL BRIDGE 4 WIRE
1/4 BRIDGE 3 WIRE
W2
OUT
IN
R5 100K 1%
BALANCE LIMIT
+EXCITATION
-EXCITATION
SHIELD
-INPUT
+INPUT
-INPUT
SHIELD
FILTER
BALANCE
OUTPUT CONNECTOR J15 BNC
OUTPUT CONNECTOR J16-J20 BNC
J9 (CH 1) AMPLIFIER CONNECTOR DA-15P
J10-J14 (CH 2 - 6) AMPLIFIER CONNECTOR DA-15P
AUTO ZERO
TO J9
R8 470 2 W
S2 N.O. C
ALL ZERO
DS1 POWER INDICATOR
1.3K
S3
OPR
CAL
+21V
CR3 1N4148
CR4 1N4148
C1 4.7uF 35V
C2 4.7uF 35V
U1 7662
CONVERTER
CR5 1N962 11V
Q3 2N3702
R10 100 5%
CR6 1N4148
CR7 1N4148
R9 15K 5%
CR8 1N4002
C3 4.7uF 35V
WHT/BLU
WHT/YEL
BLU
ORN
RED
BLK
WHT/ORN
WHT/BLK
J7 MS3102A-14S-7P DC POWER INPUT CONNECTOR
+24V TO +32V DC (UNREG)
POWER COM
EARTH GROUND
MS3106A-14S-7S
F1 1.5A
XF1
C4 4.7uF 50V
F2 1A S/B
XF2
S1-A
S1-B
DC
OFF
AC
POWER
PS1 POWER SUPPLY
GRY 22 GA
BLU 22 GA
24V 2.2A
FG FRAME GROUND
BRN 22 GA
AC-L
AC-N
100-120V AC
AC LINE HIGH LOW
EARTH GROUND
J8
GROUND LUG ON REAR PANEL UNDER MTG OF J7
TOP
REAR VIEW
S1
7 WHEN USING LVDT CONDITIONER INSTALL JUMPER IN PLACE OF R5.
6 USE 1/4 POSITION FOR 3-WIRE 1/4 BRIDGE ONLY. USE FULL POSITION FOR ALL OTHER CONFIGURATIONS.
5 CUSTOMER INSTALLED JUMPER USED WITH 418 "M" OPTION (BAL) OR MODEL 352Y AMPLIFIERS.
4 PLUG JUMPER FOR MODEL 352Y 10Hz FILTER.
3. ALL WIRE IS 24 AWG.
2 PINS 5,7,11,13, AND 15 ARE BUSED BETWEEN ALL CHANNELS.
1 CHASSIS IS TIED DIRECTLY TO EARTH GROUND.
NOTES: UNLESS OTHERWISE SPECIFIED
Ectron CORPORATION
8159 ENGINEER ROAD, SAN DIEGO, CA. 92111-1980
TITLE SCHEMATIC, E408 SERIES 28 VOLT ENCLOSURE
DRAWN J.JACOB DATE 2/9/95
APPROVED G. Clark 3/23/95
SIZE D FSCM NO. 24856 DWG NO. 408-601 REV. B
SCALE NONE SHEET 1 OF 1




| ZONE | REV | DESCRIPTION | | DATE | APPROVED |
|---|---|---|---|---|---|
| — | A | RELEASED | JJ | 7/1/93 | ge |

REVISIONS

7. WHEN USING LVDT CONDITIONER INSTALL JUMPER IN PLACE OF R5.
6. USE 1/4 POSITION FOR 3-WIRE 1/4 BRIDGE ONLY. USE FULL POSITION FOR ALL OTHER CONFIGURATIONS.
5. CUSTOMER INSTALLED JUMPER USED WITH 418 "M" OPTION (BAL) OR MODEL 352Y AMPLIFIERS.
4. PLUG JUMPER FOR MODEL 352Y 10Hz FILTER.
3. ALL WIRE IS 24 AWG.
2. PINS 5,7,11,13, AND 15 ARE BUSED BETWEEN ALL CHANNELS.
1. CHASSIS IS TIED DIRECTLY TO EARTH GROUND.

NOTES: UNLESS OTHERWISE SPECIFIED

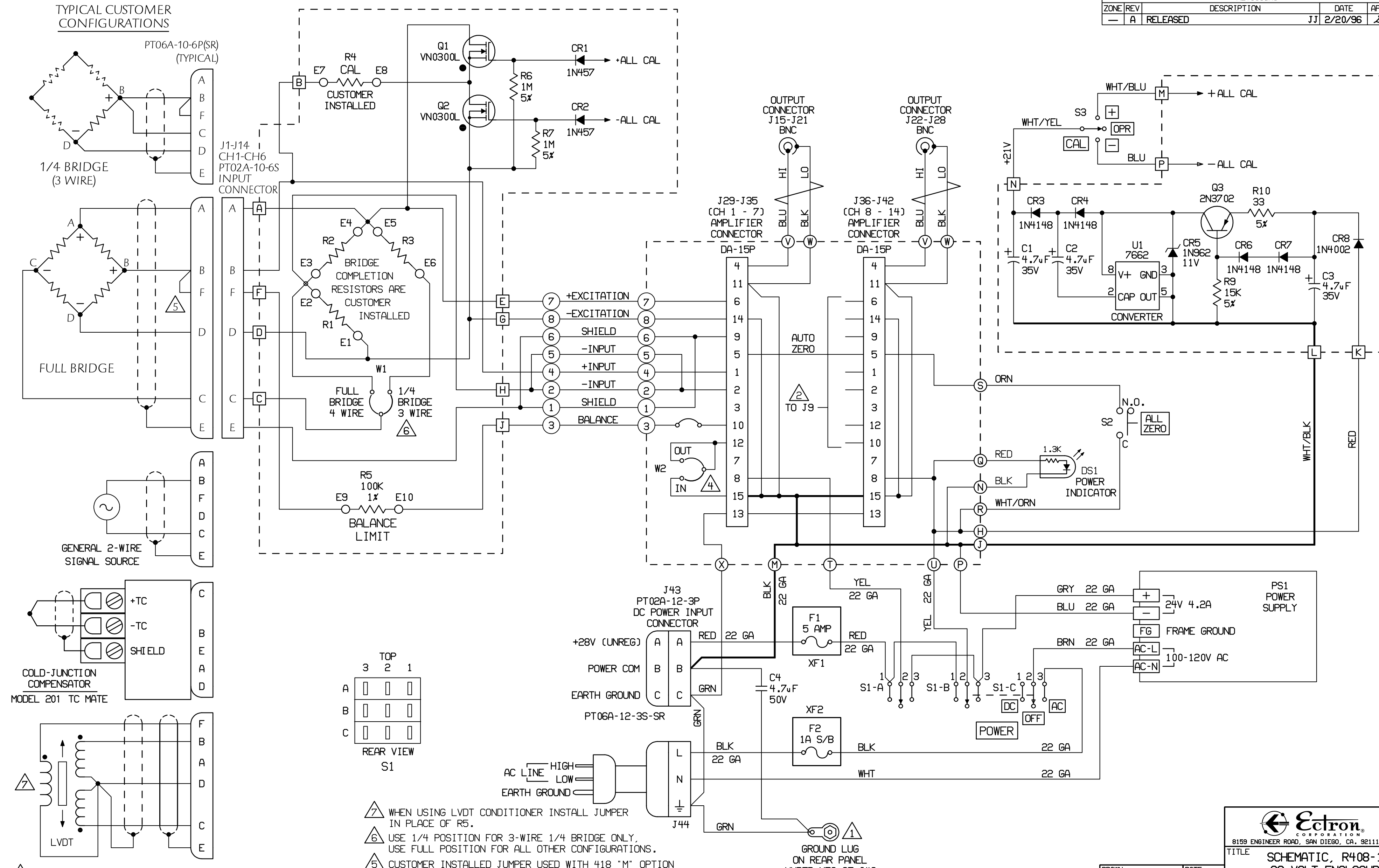
Ectron CORPORATION
8159 ENGINEER ROAD, SAN DIEGO, CA. 92111-1980

| | | |
|---|---|---|
| DRAWN | J.JACOB | 1/2/96 |
| CHECKED | G. Clark | 2/20/96 |
| APPROVED | | |

TITLE: SCHEMATIC, R408-14 12 VOLT ENCLOSURE

| SIZE | FSCM NO. | DWG NO. | REV. |
|---|---|---|---|
| D | 24856 | 408-605 | A |

SCALE NONE — SHEET 1 OF 1




NOTES: UNLESS OTHERWISE SPECIFIED

1. CHASSIS IS TIED DIRECTLY TO EARTH GROUND.
2. PINS 5,7,11,13, AND 15 ARE BUSED BETWEEN ALL CHANNELS.
3. ALL WIRE IS 24 AWG.
4. PLUG JUMPER FOR MODEL 352Y 10Hz FILTER.
5. CUSTOMER INSTALLED JUMPER USED WITH 418 "M" OPTION (BAL) OR MODEL 352Y AMPLIFIERS.
6. USE 1/4 POSITION FOR 3-WIRE 1/4 BRIDGE ONLY. USE FULL POSITION FOR ALL OTHER CONFIGURATIONS.
7. WHEN USING LVDT CONDITIONER INSTALL JUMPER IN PLACE OF R5.

REVISIONS

| ZONE | REV | DESCRIPTION | | DATE | APPROVED |
|---|---|---|---|---|---|
| — | A | RELEASED | JJ | 2/20/96 | [signature] |

Ectron Corporation, 8159 Engineer Road, San Diego, CA. 92111-1980

| | | |
|---|---|---|
| DRAWN | J.JACOB | 1/23/96 |
| CHECKED | G. Clark | 2/20/96 |
| APPROVED | | |

TITLE: SCHEMATIC, R408-14 28 VOLT ENCLOSURE

| SIZE | FSCM NO. | DWG NO. | REV. |
|---|---|---|---|
| D | 24856 | 408-606 | A |

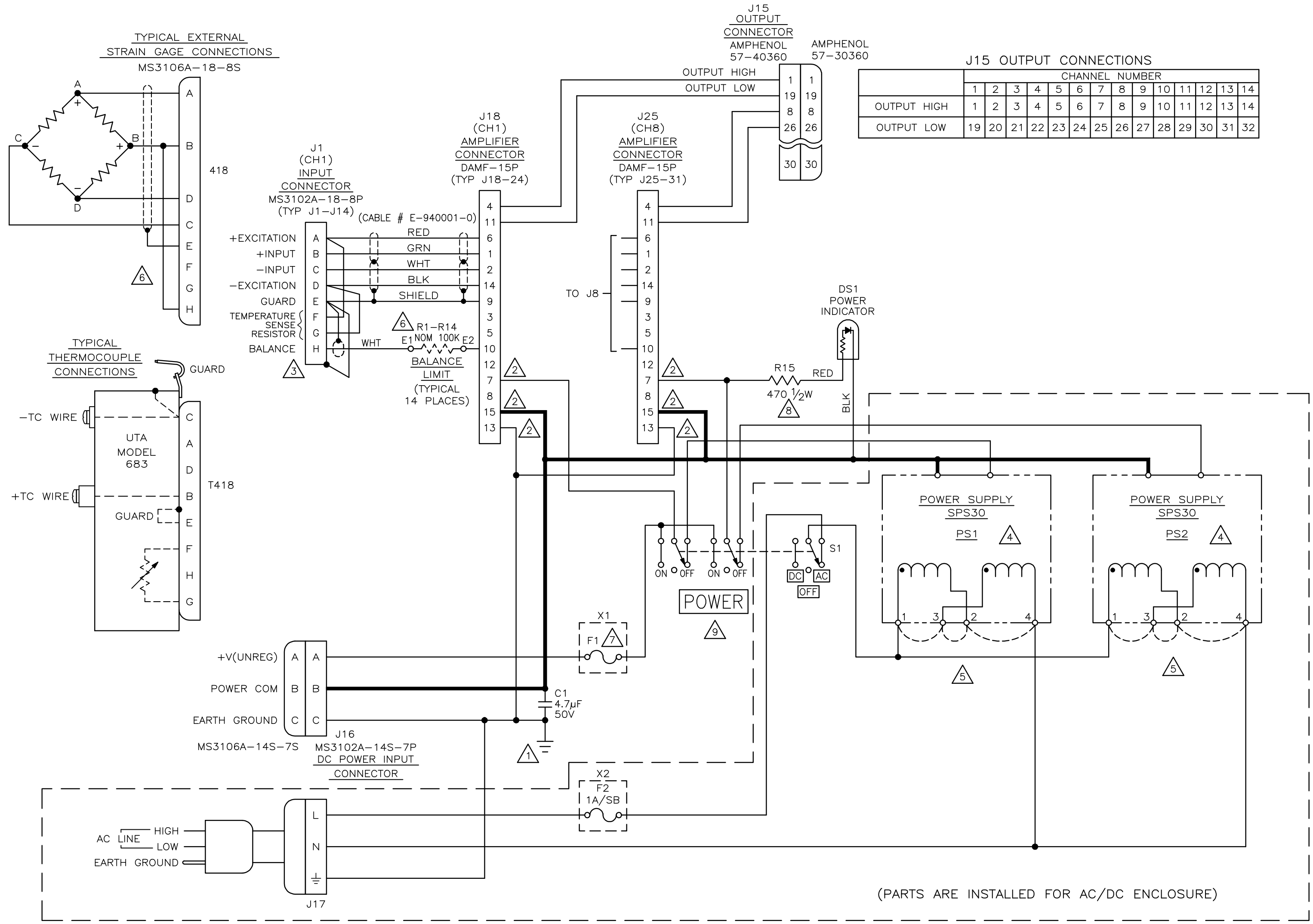
SCALE: NONE — SHEET 1 OF 1

| LTR | DESCRIPTION | BY | DATE | APPD |
|---|---|---|---|---|
| A | ADD OUTLINE & NOTE | JM | 5/8/81 | GC |
| B | INC ECR 491 (ADD CABLE P/N) | LCN | 7/30/82 | GC |
| C | R1–R14 WAS R1, R15 WAS R2 | BW | 4/18/83 | GC |
| D | ADD 352 TO FLAG NOTE 6 | EB | 3/28/85 | GC |
| E | ADDED SHIELD TO H OF J1–J14 | JJ | 9/19/90 | GC |
| F | INC ECO 1245 | JJ | 9/22/91 | GC |
| G | INC ECO 1284 | JJ | 5/20/93 | GC |

REVISION

J15 OUTPUT CONNECTIONS

| | CHANNEL NUMBER | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| OUTPUT HIGH | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| OUTPUT LOW | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |




NOTES: UNLESS OTHERWISE SPECIFIED

1. CHASSIS IS TIED DIRECTLY TO EARTH GROUND.
2. PINS 7 AND 15 ARE BUSED BETWEEN CH1–7 AND CH8–14 FOR 12V (PINS 8 AND 15 FOR 28V). PIN 13 IS BUSED BETWEEN ALL CHANNELS.
3. CAUTION– CONNECTOR SHELL IS AT COMMON–MODE POTENTIAL.
4. PS1 & PS2 ARE "SPS30–10" FOR 12V (SET TO 11V DC) AND "SPS30–24/28" FOR 28V OPER. (SET TO 24V DC).
5. FOR 115V OPERATION JUMPER 1 TO 3 & 2 TO 4, FOR 230V OPERATION JUMPER 2 TO 3 ONLY.
6. CUSTOMER INSTALLED RESISTOR & JUMPER FOR USE WITH 418 "M" OPTION (BAL) OR MODEL 352 AMPLIFIERS; MUST BE JUMPERED FOR MODEL 451 OPERATION.
7. SELECTED FOR SUM OF AMPLIFIER POWER REQUIREMENTS.
8. RESISTOR AS SHOWN FOR 28V JUMPER FOR 12V OPERATION.
9. ON "DC ONLY" ENCLOSURES, S1 IS A DPDT SWITCH INDICATING POWER "ON" & "OFF."

| DRAWN | JHM | DATE 6/21/77 |
|---|---|---|
| CHECKED | G. Clark | 6/21/77 |
| APPROVED | | |

Ectron CORPORATION
8159 ENGINEER ROAD, SAN DIEGO, CA. 92111–1980

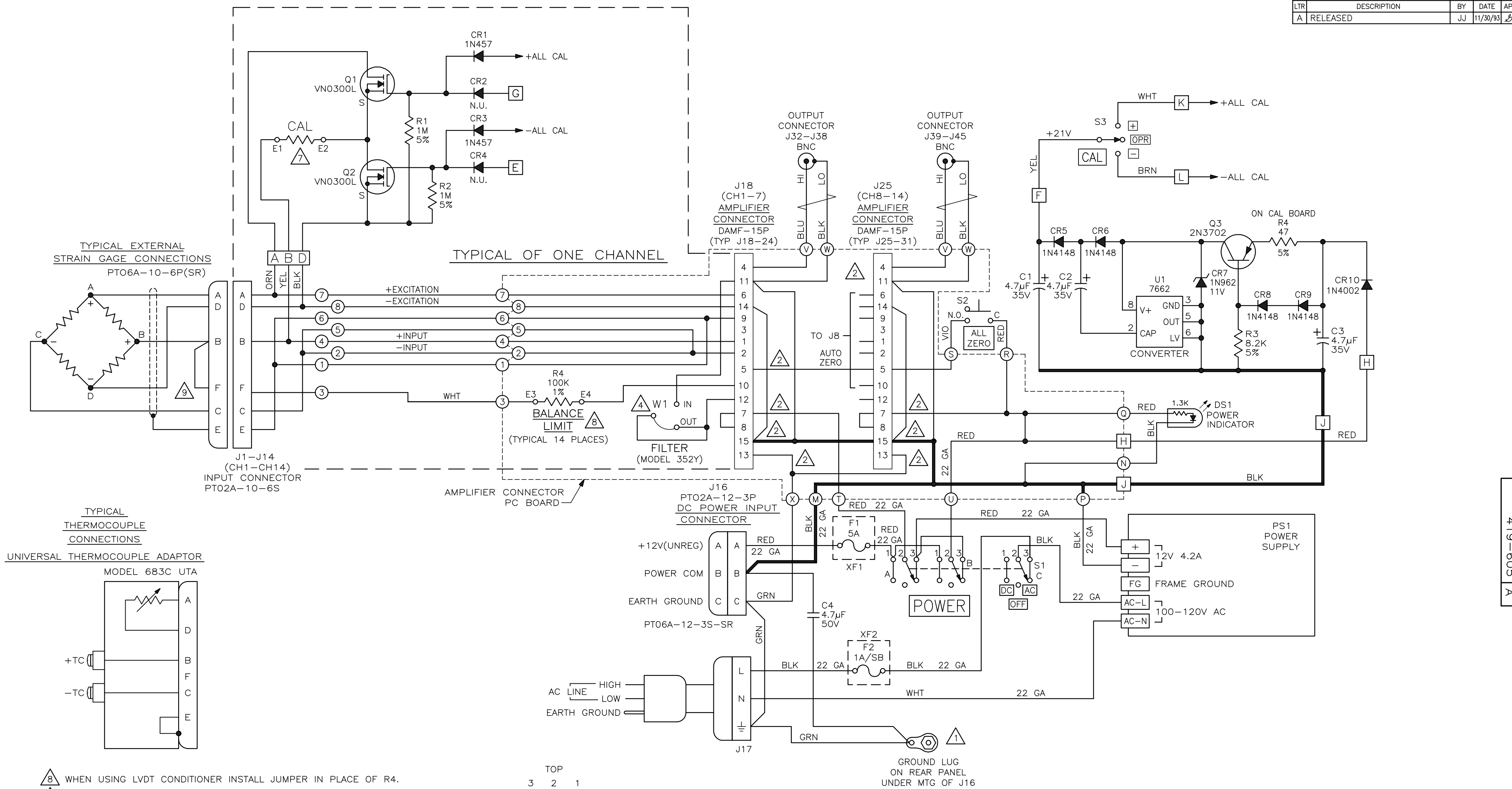
TITLE SCHEMATIC, R418–7 ENCLOSURE

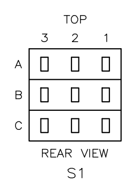
| SIZE | FSCM NO. | DWG NO. | REV |
|---|---|---|---|
| D | 24856 | 418–627 | G |

SCALE NONE — SHEET 1 OF 1

DWG. NO. 418–627 REV. G

| REVISION | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | BY | DATE | APPD |
| A | RELEASED | JJ | 11/30/93 | GC |




NOTES: UNLESS OTHERWISE SPECIFIED

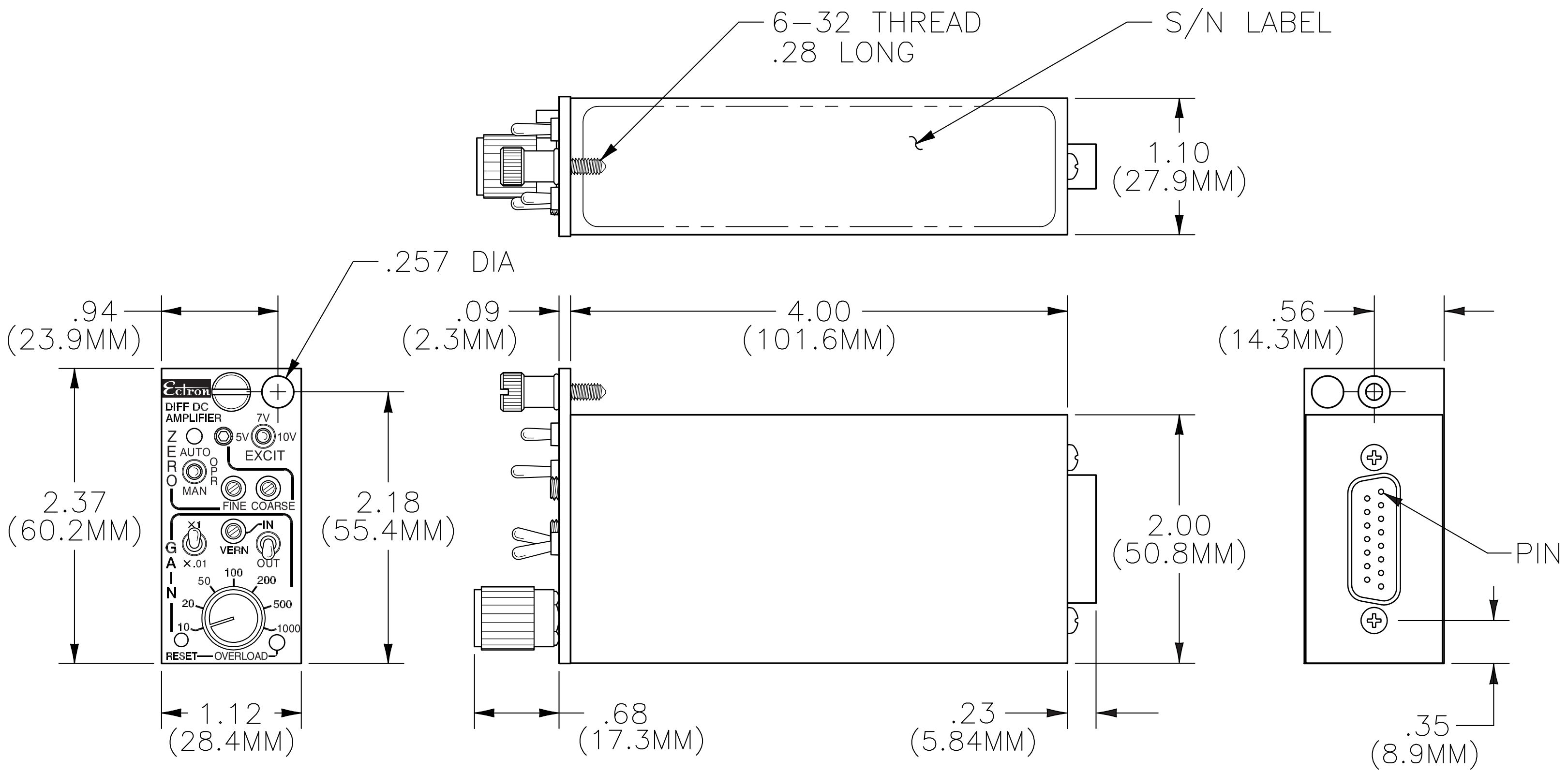
1. (△) CHASSIS IS TIED DIRECTLY TO EARTH GROUND.
2. (△) PIN 7 OF J18-J31 IS BUSED BETWEEN CH1-7 AND CH8-14. PINS 5,11,13 AND 15 ARE BUSED BETWEEN ALL CHANNELS.
3. NOT USED.
4. (△) PLUG JUMPER FOR 352Y 10Hz FILTER.
5. NOT USED.
6. ALL WIRE IS 24 AWG.
7. (△) CAL RESISTOR IS CUSTOMER INSTALLED.
8. (△) WHEN USING LVDT CONDITIONER INSTALL JUMPER IN PLACE OF R4.
9. (△) CUSTOMER-INSTALLED JUMPER USED WITH 418 "M" OPTION (BAL) OR MODEL 352 AMPLIFIERS.

DWG. NO. 419-605 REV. A

Ectron CORPORATION
8159 ENGINEER ROAD, SAN DIEGO, CA. 92111-1980

| | | |
|---|---|---|
| DRAWN J.JACOB | DATE 11/29/93 | TITLE SCHEMATIC, R418-M1028C ENCLOSURE |
| CHECKED G. Clark | 11/30/93 | SIZE D · FSCM NO. 24856 · DWG NO. 419-605 · REV A |
| APPROVED | | SCALE NONE · SHEET 1 OF 1 |

| REVISIONS | | | | |
|---|---|---|---|---|
| ZONE | LTR | DESCRIPTION | DATE | APPROVED |
| — | A | INITIAL RELEASE JJ | 8/3/95 | GC |




| PIN | FUNCTION |
|---|---|
| 1 | + INPUT |
| 2 | – INPUT |
| 3 | NOT USED |
| 4 | OUTPUT HI |
| 5 | AUTOZERO |
| 6 | EXCIT HI |
| 7 | POWER HI |
| 8 | POWER HI |
| 9 | GUARD |
| 10 | NOT USED |
| 11 | OUTPUT LO |
| 12 | NOT USED |
| 13 | CASE GND |
| 14 | EXCIT LO |
| 15 | POWER LO |

NOTES: UNLESS OTHERWISE SPECIFIED

1. MATING CONNECTOR: SOCKET TYPE, 15–PIN, D–SUBMINIATURE CONNECTOR.

UNLESS OTHERWISE SPECIFIED:
- ALL DIMENSIONS ARE IN INCHES
- DO NOT SCALE DRAWING
- REMOVE BURRS
- BREAK SHARP EDGES .005 TO .010
- 63√ ALL MACHINED SURFACES
- TOLERANCES:

| HOLE DIAMETERS | DIMENSIONS |
|---|---|
| .0135 THRU .125 +.004/–.001 | |
| .126 THRU .250 +.005/–.001 | FRACTIONS ±1/16 |
| .251 THRU .500 +.006/–.001 | DEC .X ±.030 |
| .501 THRU .750 +.008/–.001 | DEC .XX ±.020 |
| .751 THRU 1.000 +.010/–.001 | DEC .XXX ±.010 |
| 1.001 THRU 2.000 +.012/–.001 | ANGULAR ±2°0' |

| | | |
|---|---|---|
| MATERIAL | | |
| FINISH | | |
| DRAWN | J.JACOB | DATE 7/11/95 |
| CHECKED | G. Clark | 8/3/95 |
| APPROVED | | |

Ectron CORPORATION
8159 ENGINEER ROAD, SAN DIEGO, CA. 92111–1980

TITLE DIMENSIONAL OUTLINE, 428 AMPLIFIER

| SIZE | FSCM NO. | DWG NO. | REV |
|---|---|---|---|
| B | 24856 | 428–900 | A |
| SCALE 1/1 | | SHEET 1 OF 1 | |