INSTRUCTION MANUAL

MODEL 451
LVDT AND RVDT
SIGNAL CONDITIONER

Please send corrections and suggestions to howiec@ectron.com.

Ectron Corporation
9340 Hazard Way, Suite B2
San Diego, CA 92123

858-278-0600
858-732-8159

Fax: 858-278-0372

www.ectron.com
sales@ectron.com

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.

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Section I
Description

GENERAL

The Model 451 LVDT signal-conditioner produces an analog voltage that represents the displacement of the shaft of an LVDT (linear variable displacement transformer). This voltage and the displacement, in either milli-inches, millimeters, or degrees, are displayed on a backlit front-panel display. There are three independent modes of operation making it the most versatile LVDT-signal conditioner produced today.

Model 451
LVDT Signal Conditioner

MODES OF OPERATION

The Model 451 is always in one of three modes of operation: **GAIN**, **EXAMPLE**, or **SCALE**. To activate an inactive mode, the user simply dials the the knob until the desired mode is displayed and answers **YES** to a screen prompt. The unit then guides the user through the setup for that particular mode.

In the **GAIN** mode, the desired gain of the Model 451 and the transducer sensitivity are entered, and it is ready for use.

In the **EXAMPLE** mode, the user places the shaft of the LVDT at a position and "captures" that point and assigns a voltage to it. This is done a second time for another position, and after the transducer sensitivity is entered, the unit is ready for use.

In the **SCALE** mode, the user keys in two desired displacement points and corresponding voltage points, and like the other two modes, after the transducer sensitivity is entered, the unit is ready to use.

OTHER FEATURES

In addition to the mode of operation, the Model 451 offers complete control over a wide variety of functions to truly make it unique.

Zero — Two means of controlling zero are provided: manual and autozero. In manual zero, the user can dial in the amount of offset desired and either view the amount of offset or view the total offset (zero offset plus offset due to input signal) at the output. When zero is "on," the user simply presses the display once to go directly to autozero so that the unit can be quickly autozeroed. If zero is not "on," pressing the display once, turning the encoder until autozero is displayed and pressing the display again will turn zero on and initiate the autozero.

Filter Four input-filter positions are provided to aid in eliminating undesired signals. They are 1, 10, and 100 Hz in addition to wideband (WB), which is approximately 300 Hz.

Cal Both input (in terms of displacement) and output (in terms of voltage) cals are provided.

Excitation Two voltages and five frequencies are provided.

Units of Measure Three units of measure are provided: milli-inches and millimeters for linear measurements and degrees for rotational measurements.

Alignment Means to completely align the Model 451 are provided.

ENCLOSURES

Ectron manufactures several enclosures for its product line of ruggedized signal conditioners and condtioner-amplifiers. These include the Models E408-6, R408-14, R418, 4001, and 4005. The Model 451 as well as the Models 352, 418, T418, 428, and 441A will operate side by side in any of these enclosures.

ABOUT THIS MANUAL

The following sections are in this manual:

Specifications This is a complete technical description of the Model 451 and the performance that is guaranteed. While the performance specifications are the best in LVDT signal conditioning, they are conservative. The user may find that a particular unit will perform well beyond specification.

Operation Here the user will find complete instructions to use the Model 451. An operational-state diagram enhances the discussion. Also discussed are the various enclosures available for the Model 451 and other 352 and 400 Series units.

Applications Because the Model 451 is designed as a universal LVDT-signal conditioner, it would be impossible to address every possible use for this product. Rather, this section is written to help the user get the most from the data resulting from using the Model 451. Concerns about cabling, shielding, common-mode voltage, etc. are addressed.

Theory of operation

Because the Model 451 is an encapsulated unit, repair in the field is strongly discouraged. Therefore, a detailed circuit analysis is foregone in this manual. However, theory at the block-diagram level as well as a discussion of internal software is presented to further aid the user in operating the frequency-to-voltage converter for best performance.

Calibration

Step-by-step instructions are given to align the Model 451.

Parts Lists

Parts list for several enclosures are given to aid in any field repairs.

Drawings

Schematic diagrams of several enclosures are included to aid the user in instrumentation configuration. The outline-dimension drawing for the Model 451 and its operational state diagram are also provided.

Warranty

The warranty for this product is on the inside of the front cover.

Section II
SPECIFICATIONS

INPUT

Configuration	Differential.
Input Impedance	100 kΩ ±5% each input.
Common-mode-voltage Range	20 V dc or peak ac.

DYNAMIC RESPONSE

Gain Range	1 to 300, either polarity (automatically set in example and scale modes). Gains of less than unity are not supported.
Frequency Response	Selectable, 1, 10, and 100 Hz, and wideband (WB is approximately 300 Hz).
Nonlinearity	±0.1% of full scale, maximum.

OUTPUT

Full Range	±10.5 V minimum.
Current	10 mA minimum.
Impedance	2Ω maximum.
Zero-offset Range	10 V.
Offset/Zero Control	There are three zeroing modes: autozero and two manual-adjustment positions. (See Note 1)

EXCITATION

Voltage	1 or 3 V ac rms, ±1%.
Current	30 mA ac rms minimum at 2500 Hz.
Frequency	Selectable 400 Hz, 1.0, 2.5, and 10 kHz.
Output Resistance	1.0 Ω maximum at 2.5 kHz.

INPUT POWER

Voltage Range	10.5 to 32 V dc.
Current (nominal)	150 mA.
Over-voltage Protection	Up to +60 V for 15 s, +32 V and −50 V continuous.

CALIBRATION AND ALIGNMENT

Calibration	An internally generated calibration signal can be set from −10 V to +10 V in 0.01-V steps, ±0.1% of full scale,

	and from –10000 to +10000 mils, –250.0 to +250.0 mm, and –60.00 to +60.00 degrees, ±0.1% of full scale. (See Note 2.)
Alignment	An extensive software-guided, self-calibration procedure is available for the complete alignment of the instrument. (See Note 3.)
Error Indicator	Front-panel LED indicates errors. (See Note 4.)

ENVIRONMENT

Emi/rfi	Internal rfi filters are provided on all connector leads.
Operating Temperature Range	–25°C to +71°C.
Storage Temperature	–40°C to +80°C.
Altitude	No limit with adequate heat dissipation.
Static Acceleration Resistance	200 m/s^2 (approximately 20 g) for 11 ms in any plane.
Shock Resistance	200 m/s^2 (approximately 20 g) for 11 ms in any plane.
Vibration Resistance	100 m/s^2 (approximately 10 g) in any plane.

PHYSICAL PARAMETERS (DRAWING 451-900)

Height (panel)	60.2 mm (2.37″).
Height (case)	50.8 mm (2.00″).
Width	27.9 mm (1.10″).
Depth	101.6 mm (4.00″) plus front panel, front-panel controls, and connector.
Weight	255 g (9 oz) nominal.
Connector	DA-15P (mate DA-15S).

COMPATIBILITY

The Model 451 will operate in all standard Ectron enclosures designed for conditioner-amplifier Models 352, 418, T418, and 428 and the Model 441A frequency-to-voltage converter. See Table 3-2 for connection information.

NOTES

1. Zero Controls	Three zeroing modes are available when using the Model 451's output-zero circuit. Automatic zeroing can be commanded at any time, which will bring the output to zero within ±5 mV. In addition, manual zeroing allows the user to either view the amount of the offset voltage or to view the amount of the offset voltage plus output signal. The amount of offset in use can be ac-

cessed and displayed on the front panel. The zero range available is from −10 to +10 V in 0.01-V steps.

2. Calibration

Since the calibration adjustment allows the output voltage to be set in 0.01-V steps from −10 V to +10 V with an accuracy of better than ±0.1%, this output can be used to check linearity of the instrumentation following the Model 451. The output voltage can be varied also by varying the displacement reading while in the displacement part of the calibration mode.

3. Alignment

The Model 451 includes extensive self-alignment capabilities. The output stages are aligned with a voltmeter while making two adjustments via the front-panel controls. Similarly, the input stages are calibrated by applying an excitation voltage to resistive dividers connected to the input and commanding the Model 451 to self-align. Once aligned, values are stored in nonvolatile memory. Section VI details the procedure for aligning the Model 451.

4. Error Indication

The Model 451 has a front-panel LED error indicator. This LED lights for four types of error:

1. **Data-entry error** This type of error results from a front-panel entry that the hardware cannot support (such as gain beyond the range of the analog circuitry). No data entry, by itself can be invalid. However, when an entry and another entry or entries together violate preprogrammed limits, this error occurs. A simple example is if the user attempts to enter the same voltage for Point 1 and Point 2 volts in the example or scale mode.

2. **Output-overload error** This error results from a situation that produces an output outside of the ±10.5-volt range.

3. **Input-overload error** This error condition results from an input signal that is beyond the range of the unit, such as a large-scale input when a high gain is requested.

4. **Memory error** This error occurs whenever the Model 451 detects an error in its nonvolatile memory. When this occurs, an alignment of input and output is required.

In each case, the Model 451 displays a screen describing the error, and the LED remains lit as long as the error exists.

SECTION III
OPERATION

MODEL 451

GENERAL

The Model 451 operates in three completely independent measurement modes: gain, example, and scale, one of which is always active. When activating one mode, the other two are automatically deactivated. All settings in each mode are retained in nonvolatile memory, and none is used by the other two modes. For example, all three modes have a transducer-sensitivity setting, so there are three settings retained in memory.

Additionally, the Model 451 allows the user to control zero, autozero, excitation, input filter, cal, units of measure, and to perform a complete alignment, both input and output.

VIEW ANGLE

Because the temperature at which the Model 451 is operating can affect the display, the ability to quickly adjust the view angle (contrast and brightness) has been incorporated into the Model 451. When power is on, from any screen (even if the screen is blank or dark), press and hold the display for more than two seconds. Then turn the encoder (clockwise to darken, counterclockwise to lighten) until the screen is adjusted for best contrast and brightness. Thirty degrees (encoder clicks) of control are provided. When it is right, press the display. The Model 451 will not “time out” from this screen.

CONNECTIONS and ENCLOSURES

The Model 451 uses a “D” subminiature fifteen-pin connector for all input and output connections. Table 3-1 summarizes these connections, and Figure 3-1 shows a typical LVDT connection to the Model 451.

Table 3-1
Connections

Pin	Function	Pin	Function	Pin	Function
1	Plus input	6	---	11	Output low
2	Minus input	7&8*	Power	12	---
3	---			13	Case
4	Output high	9	Guard (shield)	14	Excitation common
5	Remote autozero	10	Excitation high	15	Power common

* Internally connected

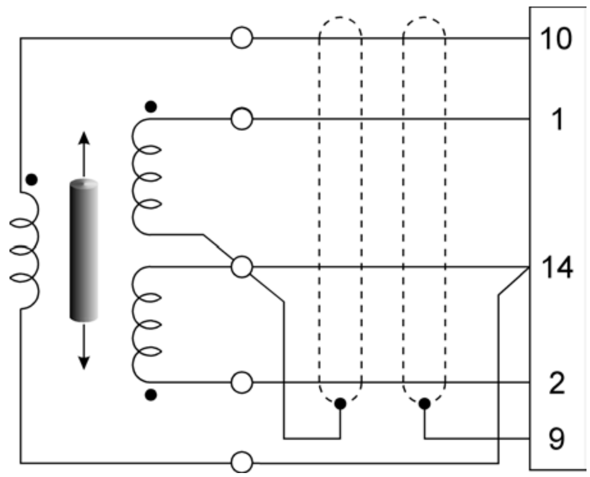

Figure 3-1 Typical LVDT Connection to the Model 451

CONTROLS

The Model 451 is operated using only the two front-panel controls: the display and the encoder.

Display

In addition to displaying the various screens, the display is used to accept the data, or settings, as they appear on the screen when it is pressed and released. This is always true, although in a few situations, the user is asked to confirm his or her intentions with an additional confirmation request. For instance, if the user answers **YES** to **RESET SYSTEM**, a confirmation will be prompted so that the user will not accidentally erase ***all*** existing settings without intending to do so. Pressing and holding the display for approximately two seconds from any screen takes the user to the **VIEW ANGLE ADJUST** screen so that the brightness and contrast can be adjusted. This is because with changes in temperature, the brightness and contrast are subject to variation.

Encoder

The encoder is used by either turning it or pressing it. Both functions control the cursor (not always displayed) on the screen. When the screen is a menu item such as **GAIN MODE SETUP** or **EXAMPLE MODE SETUP**, a cursor is not displayed because the entire screen will change when the encoder is rotated. In other words, the entire screen is the item to be accepted, so there is no need to display a cursor. When there are data points that can be changed or yes-no questions to be answered or both, the cursor is displayed. In these situations, rotating the encoder changes the setting on the screen for that data field or point. (Remember that only pressing the display places the data on the screen in memory.) Pressing the encoder will move the cursor from field to field on a screen or from digit to digit within a field on a screen.

When at the operating screen, which is normally alternating between displaying the voltage out and the input displacement, the user can select either screen full time by pressing the encoder when the desired operating screen is displayed. If the user wants to view only the input displacement, pressing the encoder when the display has alternated to the input displacement will keep the display screen in this mode. Pressing it again will return the operating screen to the alternating mode.

UPDATING MEMORY

As stated above, memory is updated when the display is pressed and released, capturing the information as it was. This is always true. However, if a screen does not require in user confirmation with a **N** or **NO** or **Y** or **YES**, then memory is updated as the data on the screen is changed. An example of this is zero offset. The zero offset actually changes as the user turns the encoder.

TIME OUT

When there has been no activity for twenty seconds at a screen, the Model 451 will revert, or "time out," to the operating screen ***without having made any updates to memory from that screen***. This is true for all screens except error screens, alignment-required screens, and several other screens only when certain conditions exist. These screens are maintained so that the user will know that action is required to return the Model 451 to a fully operational state, or it recognizes that the user probably intends to make a change.

POWER ON

When power is applied to the Model 451, diagnostics are run to ensure proper start-up. This is normally invisible to the user. However if an memory error occurs or if alignment is required, a screen other than the operating screen will appear. If the **ALIGN REQ'D** screen appears, the Model 451 must be recalibrated. If the **MEMORY ERROR** screen appears, turn the unit off and back on. If the **MEMORY ERROR** screen still appears, return the unit for repair. If, however, the unit goes to the **ALIGN REQ'D** screen, recalibrate the unit before using it.

OPERATING SCREENS

There are two operating screens for the Model 451, and they normally alternate every three seconds. One displays the analog output of the unit in volts; and the other displays the LVDT output in units of displacement, either milli-inches (**MIL**), millimeters (**MM**), or degrees (**DEG**) for RVDT's. (The transducer output is accurate only when the transducer sensitivity for the particular mode of operation has been set.)

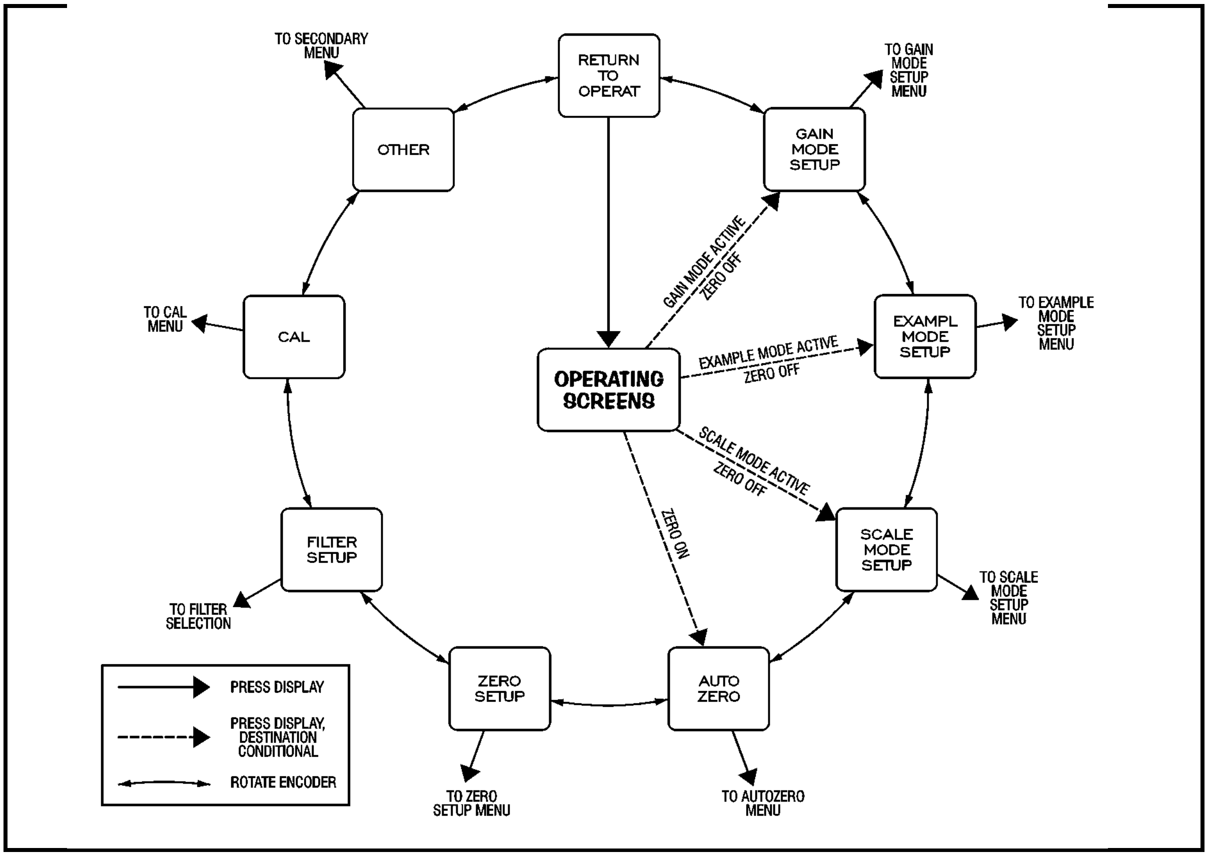

Figure 3-2 Main Menu

Either screen can be set on all the time by pressing the encoder when the desired screen is displayed. The operating screen selected will stay on until either the encoder is press again or the display is pressed taking the user to the main menu or beyond. When the Model 451 is returned to the operating screen in this situation, it will be alternating.

OPERATING SCHEME AND MAIN MENU

Although the Model 451 has more than one hundred screens, it is easily operated when the overall scheme of the screen layouts is understood.

The Model 451 normally displays the operating screen. By pressing the display from the operating screen, the main menu is displayed. On this menu are **GAIN MODE SETUP**, **EXAMPL MODE SETUP**, **SCALE MODE SETUP**, **AUTOZERO**, **ZERO SETUP**, **FILTER**, **CAL**, **RETURN TO OPERAT**, and **OTHER**. By selecting **OTHER**, a secondary menu of less frequently changed items is activated. All menus have a screen that allows the user to exit to the previous menu. Each **OTHER** menu item, when selected, goes to a menu for setting the parameters for that area of operation.

FIRST SCREEN

When the display is pressed from the operating screen, and zero is not on, the active mode will be the first screen displayed. For instance, if the active mode is example, then **EXAMPL MODE SETUP** will be displayed. When zero is on, **AUTOZERO** will be the first screen displayed. This allows the user to quickly autozero the instrument without having to navigate through other menu items.

GAIN-MODE SETUP

The gain-setup menu has three selections that allow the user to adjust gain, set transducer sensitivity for the gain mode, and exit gain-mode setup. Enter the gain, the ratio of Model 451 voltage output to LVDT voltage output, set the transducer sensitivity, and the Model 451 is ready to measure. This is the classic mode of operation for LVDT-signal conditioners.

When the gain mode is not active, the user will encounter a **GAIN ACTIVE? NO** screen that asks whether to activate this mode. If the user answers **NO**, the main menu is again displayed. When the user answers **YES**, the gain mode is activated and the gain-mode-setup menu is entered. When the gain mode is already the active mode, this preliminary screen is not displayed and the user is taken directly to the gain-mode-setup menu.

Gain Adjust Selecting this menu item allows the user to set any gain between –1.00 and –99.99 and 1 and 99.99 (less than unity gain is unavailable). This adjustment is done in real time. Therefore, the user is not required to answer yes or no to confirm the reading. When the encoder is turned the gain is changed. To exit this screen, press the display.

Gain Transducer Sensitivity Selecting this screen allows the user to enter the transducer sensitivity that is associated with the particular LVDT or RVDT transducer being used. The valid range of numbers that can be entered depend on what unit of measure is currently active. See Table 3-2. The Model 451 will "time out" from this screen unless the user has set **N** to **Y**.

Gain Setup Exit By pressing the display at this screen, the user returns to **GAIN MODE SETUP**.

Table 3-2 Transducer Sensitivity Ranges (mV/V/Unit of Displacement)

Unit of Displacement	Range
DEG (degree)	0.100 to 99.990
MIL (milli-inch)	0.0500 to 9.9999
MM (millimeter)	1.5000 to 393.70

EXAMPLE MODE SETUP

This mode of operation allows the user to physically set the LVDT transducer to two points of displacement and enter two corresponding output voltage points. For example, the core of the LVDT could be moved to its midrange, that position captured as Point 1, and a corresponding voltage (for example, 0 V) entered. Then the core could be moved a distance from Point 1, that position captured as Point 2, and a corresponding voltage (for example, 5 V) entered. It is important to note that in this example, Point 1 and Point 2 along with their corresponding voltage are not set up as end points. Rather, they define a sensitivity (or gain) at which the Model 451 operates. If the core moves beyond Point 2 or if it moves in the opposite direction, the Model 451 will continue to provide accurate data as long as built-in limits of the Model 451, such as 10.5 V output, and the LVDT (displacement range) are not violated.

When the example mode is not active, the user will encounter a screen that asks whether to activate this mode. If the user answers **NO**, the **EXAMPL MODE SETUP** screen is again displayed. When the example mode is the active mode, this screen is not displayed. When the users answers **YES** to activating the example mode or when the example mode is already active, the example-setup menu is displayed.

Example Point 1 Volts

Press this screen to go to Point 1 volts input. Then use the encoder to enter any voltage between –10.00 V and +10.00 V, and answer **Y** (yes) to confirm the setting or **N** (no) to return to the previous screen without changing the setting. When **Y** is on, "time out" is will not occur.

Example Point 2 Volts

Press this screen to go to Point 2 volts input. Then use the encoder to enter any voltage between 10.00 V and +10.00 V but not the same as the Point 1 voltage setting. As with Point 1, answer **Y** (yes) to confirm the setting or **N** (no) to return to the previous screen without having made the change. When **Y** is on, "time out" is will not occur.

Example Point 1 Displacement

Press this screen to go to Point 1 displacement input. Then physically put the LVDT core or what the core is attached to the desired position, answer **Y** (yes), and press the display to capture the position of the LVDT core as Point 1. This point must be physically different than Point 2. If **N** (no) is selected, the display will return to **EXAMPL POINT1 DISP**. When **Y** is on, "time out" will not occur.

Example Point 2 Displacement

Press this screen to go to Point 2 displacement input. Then physically put the LVDT core or what the core is attached to the desired position, answer **Y** (yes), and press the display to capture the position of the LVDT core as Point 2. This point must be physically different than Point 1. If **N** (no) is selected, the display will return to **EXAMPL POINT2 DISP**. When **Y** is on, "time out" will not occur.

Example Mode Transducer Sensitivity

Selecting this screen allows the user to enter the transducer sensitivity that is associated with the particular LVDT or RVDT transducer being used. The valid range of numbers that can be entered depend on what unit of measure is currently active. See Table 3-2.

Example Mode Exit

By pressing the display at this screen, the user returns to **EXAMPL MODE SETUP**.

SCALE MODE SETUP

This mode of operation allows the user to set both the voltage points and corresponding displacement points. It is important to note that in the scale mode, Point 1 and Point 2 along with their corresponding voltage are not set up as end points. Rather, they define a sensitivity (or gain) at which the Model 451 operates. If the core moves beyond Point 2 or if it moves in the opposite direction, the Model 451 will continue to provide accurate data as long as built-in limits of the Model 451, such as ±10.5 V output, and the LVDT are not violated.

When the scale mode is not active, the user will encounter a screen that asks whether to activate this mode. If the user answers **NO**, the **SCALE MODE SETUP** screen is again displayed. When the scale mode is the active mode, this screen is not displayed. When the users answers **YES** to activating the scale mode or when the scale mode is already active, the scale-setup menu is displayed.

Scale Point 1 Volts Press this screen to go the Point 1 volts input. Then use the encoder to enter any voltage between –10.00 V and +10.00 V, and answer **Y** (yes) to confirm the setting or **N** (no) to return to the previous screen without changing the setting. When **Y** is on, "time out" will not occur.

Scale Point 2 Volts Press this screen to go the Point 2 volts input. Then use the encoder to enter any voltage between –10.00 V and +10.00 V but not the same as the Point 1 voltage setting. As with Point 1, answer **Y** (yes) to confirm the setting or **N** (no) to return to the previous screen without having made the change. When **Y** is on, "time out" will not occur.

Scale Point 1 Displacement Press this screen to go to Point 1 displacement input. Then enter any value of displacement (–254.0 mm to +254.0 mm, –10000 mils to +10000 mils, or –60.00 degrees to +60.00 degrees), answer **Y** (yes), and press the display. This point must be different than Point 1. If **N** (no) is selected, the display will return to **SCALE POINT1 DISP**. When **Y** is on, "time out" is will not occur.

Scale Point 2 Displacement Press this screen to go to Point 1 displacement input. Then enter any value of displacement (254.0 mm to +254.0 mm, 10000 mils to +10000 mils, or –60.00 degrees to +60.00 degrees), answer **Y** (yes), and press the display. This point must be different than Point 1. If **N** (no) is selected, the display will return to **SCALE POINT2 DISP**. "Time out" will not occur when **Y** is on.

Scale Mode Transducer Sensitivity Selecting this screen allows the user to enter the transducer sensitivity that is associated with the particular LVDT or RVDT transducer being used. The valid range of numbers that can be entered depend on what unit of measure is currently active. See Table 3-2.

Scale Mode Exit

By pressing the display at this screen, the user returns to **SCALE MODE SETUP**.

AUTOZERO

Local Autozero

This main-menu selection is reached in two ways. If zero is already on, it will be the first screen seen when the display is pressed from the operate screens. When zero is off, then it is reached by pressing the display and rotating the encoder until the main-menu selection **AUTOZERO** is displayed. When the display is pressed from this screen, the user is asked to confirm an autozero by answering **YES** or **NO**. Whether **YES** or **NO** is selected, the main-menu selection **AUTOZERO** is again displayed. When the display is pressed when **YES** has been selected, an autozero is attempted. (Also if **YES** is selected, zero offset will be turned on if previously off.) If autozero is possible, the temporary screen **PLEASE WAIT** is displayed, and autozero is performed. If it is not (because the output exceeds the range of autozero), the screen **ZERO OUT OF RANGE** will displayed.

The internal microprocessor knows what the output voltage is, so when an autozero is commanded, the output is offset by that amount (up to ±10 V dc). Autozero is accomplished at the output of the Model 451; therefore, even if autozero does zero the output, the user should be aware that the usable (remaining) range of the input may be severely limited. For example, if the input voltage is 0.9 V ac, and the gain is set to 10 (thus, a 9-V-dc output), there is only 0.15 V (the voltage necessary to reach the output limit of 10.5 V dc) of range remaining for the input to operate in the positive direction, although a valid autozero can be commanded forcing the output to zero. This means that if the user now increases the input to 1.1 V ac (0.2 V ac more than the original 0.9 V ac), the screen **INPUT OUT OF RANGE** will appear even though one might expect the output to be 2 V dc (9 V minus 9 V of autozero plus the 0.2 V input times the gain of 10).

Remote Autozero

Autozero can be commanded remotely by connecting Pin 5 of the connector to any voltage between 10.5 and 32 V dc with reference to Output Low, Pin 11. If the user wishes to uses the same power supply as that which powers the Model 451, Pin 11 and Pin 15 must be connected together. When remote autozero is commanded the display will read **A-ZERO PLEASE WAIT** or **ZERO OUT OF RANGE**. Refer to the previous paragraphs for a discussion of “zero out of range.”

ZERO SETUP

ZERO SETUP allows the user to turn zero on or off, to dial in a value of zero offset, and to dial in a value for output offset. Zero offset is the amount of offset applied by the Model 451, and output offset is the zero offset plus the output due to an input to the Model 451. When zero is not on, pressing the **ZERO SETUP** screen brings the user to the screen **ZERO CONTRL ? NO**. Answering **NO** returns the user to the main-menu item **ZERO SETUP**. Answering **YES** takes the user to the zero-setup menu. When zero is on, pressing the **ZERO SETUP** screen takes you directly to the zero-setup menu.

Adjust Zero Offset Selecting this screen takes the user to the **ZERO OFFSET +NN.NN** screen, where **+NN.NN** is any number between –10.00 and +10.00 V dc. When this screen is pressed, the amount of zero offset displayed is applied to the output. This adjustment is done in "real time." Therefore, the user is not required to answer yes or no to confirm the reading. When the encoder is turned clockwise the zero offset is changed in a positive direction and negative when turned counter-clockwise. To exit this screen, press the display.

Adjust Output Offset Selecting this screen takes the user to the **OUTPUT OFFSET +NN.NN** screen, where **+NN.NN** is any number between –10.00 and +10.00 V dc. When this screen is pressed, the output is with the offset applied to the output. This adjustment is done in "real time." Therefore, the user is not required to answer yes or no to confirm the reading. When the encoder is turned clockwise the output offset is changed in a positive direction and negative when turned counter-clockwise. To exit this screen, press the display.

Zero Control Off This screen allows the user to turn off the zero control of the Model 451. By pressing the display at this screen, the user turns off zero control and is returned to **ZERO SETUP**.

Zero Setup Exit Pressing the display, at this screen, returns the user to **ZERO SETUP**.

FILTER SETUP

Pressing the **FILTER SETUP** screen takes the user to the **FILTER FREQ NNN HZ** screen. Rotating the knob increments through the four available two-pole low-pass input-filter positions, which are: **1 HZ**, **10 HZ**, **100 HZ** and **WB**, which is approximately 300 Hz. To exit this screen, press the display, The Model 451 then returns the user to the main-menu **FILTER SETUP** screen.

CAL

Two methods of cal are provided: voltage and displacement. Voltage cal produces a user-selected voltage at the output of the Model 451, which would normally be used to calibrate instrumentation following the unit. Displacement cal produces a voltage at the output of the

Model 451 that would be produced if the dialed-in displacement were at the input of Model 451, taking gain, transducer sensitivity, and unit of measure currently active into account.

Pressing the **CAL** screen brings the user to the cal setup menu.

Cal Volts

Selecting this screen takes the user to the **CALOFF NN.NN VOLTS** screen. position. Enter any voltage from –10.00 to +10.00 V and change **OFF** to **ON**. (Because of space restrictions on the screen, **CALOFF** is written as one word but in fact, the **OFF** part is changeable to **ON** by rotating the encoder.) While cal is **ON**, pressing the display has no effect. Only when cal is turned **OFF** can one return to the **CAL VOLT** screen. The selected cal voltage will remain in nonvolatile ram.

Cal Displacement

Selecting this screen takes the user to the **CALOFF NNNNN ***** screen (******* equals the current unit of displacement; i.e., **DEG**, **MIL**, or **MM**). Enter the desired displacement 10000 to +10000 mils, 254.0 to +254.0 mm, or 60.00 to +60.00 deg) and turn **OFF** to **ON**. (Because of space restrictions on the screen, **CALOFF** is written as one word but in fact, the **OFF** part is changeable to **ON** by rotating the encoder.) While cal is **ON**, pressing the display has no effect. Only when cal is turned **OFF** can one return to the **CAL DISP** screen. The selected cal displacement will remain in nonvolatile ram.

Cal Exit

Pressing the display, at this screen, returns the user to the main-menu (**CAL**).

OTHER

This main-menu selection takes the user to the secondary menu.

SECONDARY MENU (Figure 3-3)

The secondary menu consists of five additional menus plus an exit screen to return to the main menu. The Model 451 is configured this way to prevent accidental change of parameters that are changed less frequently during its operation. Included on the secondary menu are excitation setup (**EXCIT SETUP**), units of measure (**UNITS OF MEASUR**), system reset (**RESET SYSTEM**), alignment (**ALIGN**), system information (**SYSTEM INFO**), and exit to the main menu (**OTHER EXIT**).

EXCITATION SETUP

In the excitation-setup menu, the user can select both the excitation voltage and the excitation frequency. From **EXCIT SETUP**, press the display to go to excitation voltage setup (**EXCIT VOLTS SETUP**).

Excitation Voltage Setup

From this screen press the display, select either 1 V ac or 3 V ac as the excitation voltage, and press the display to accept that setting. Excitation voltage is in real time meaning that the voltage will change from 1 V ac to 3 V ac or vice versa as soon as the encoder is turned.

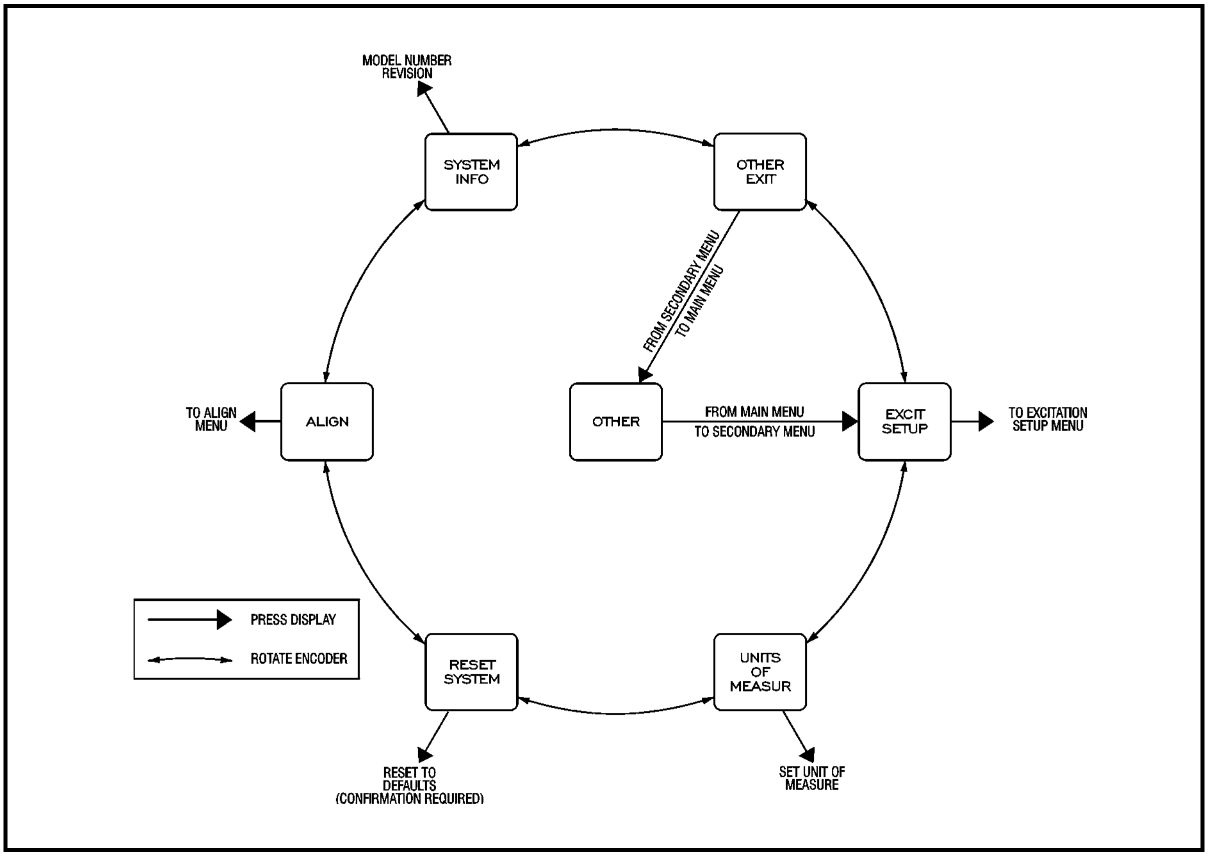

Figure 3-3 Secondary Menu

See also the discussion in Section IV, Applications regarding the maximum input allowed by the Model 451.

Excitation Frequency Setup From the **EXCIT VOLTS SETUP** screen turn the encoder one click to go to **EXCIT FREQ SETUP**. Press the display, select an excitation frequency of **400 HZ**, **1000 HZ**, **2500 HZ**, **5000 HZ**, **or 10000 HZ**, and press the display again to accept that setting. Like excitation voltage, excitation frequency is in real time.

Excitation Setup Exit Press the display at this screen to return to excitation setup (**EXCIT SETUP**) on the secondary menu.

UNITS OF MEASURE

The units-of-measure screen allows the user to select milli-inches (**MIL**), millimeters (**MM**), or degrees (**DEG**). The user is asked to confirm the setting by answering **Y** (yes). If the user does not want to change units of measure at this time, set **Y** to **N** (no) and press the display. In either situation, the secondary menu item of **UNITS OF MEASUR** is again displayed. When **Y** is on, the Model 451 will not "time out."

RESET SYSTEM

The reset-system command allows the user to reset all parameters (in all three modes of operation) the default settings. Pressing the display when at **RESET SYSTEM** takes the user to the screen **RESET ? NO**. If **NO** is not changed to **YES** and the display is pressed, the secondary-menu item **RESET SYSTEM** is again displayed. "time out" will occur from this screen under both **NO** and **YES** conditions.

When **NO** is changed to **YES** and the display is pressed, the screen **RESET AREYOU SURE N** is displayed. Only when **N** is changed to **Y** and the display is pressed will a system reset occur. "time out" will occur from this screen under both **N** and **Y** conditions.

ALIGN

The alignment menu allows the user to align both the input and output of the Model 451. This operation is fully discussed in Section VI, Alignment.

SYSTEM INFO

The system-info screens tell the user the model number, the software revision, and the date of that revision. Press the display at system info to go to **ECTRON 451 LVDT**. Press it again to display the software revision level and the date of the revision. The date is in year-month-day format.

OTHER EXIT

Press the display at this screen to exit to the main-menu item **OTHER**.

ENCLOSURES

The pin assignments (Table 3-1) for the Model 451 are the same as for Ectron Models 352, 418, and 428 conditioner-amplifiers (except for excitation high) and Model 441A frequency-to-voltage converter. Therefore, unless special features have been incorporated that would preclude using the Model 451, enclosures, including Models E408, R408, R418, 4001 and 4005, designed for these models are compatible with the Model 451. Table 3-3 lists these enclosures and what special connections must be made for the Model 451 to operate properly in them. The Model 451 accepts power from 10.5 V dc to 32 V dc, so enclosures designed for either 12 V or 28 V can be used.

Table 3-3 Adapting Ectron Enclosures for Model 451 Operation

Enclosure	Changes Necessary
E408-6	Install jumpers for balance-limit resistor R5 (for each channel of Model 451 operation) and connect the LVDT excitation-input lead to J1-6, Pin F.
R408-14	Install jumpers for balance-limit resistor R5 (for each channel of Model 451 operation) and connect the LVDT excitation-input lead to J1-14, Pin F.
R418	Install jumpers for balance-limit resistor R1-14 (for each channel of Model 451 operation) and connect the LVDT excitation-input lead to J1-14, Pin H.
R418-M1028	Install jumpers for balance-limit resistor R4 (for each channel of Model 451 operation) and connect the LVDT excitation-input lead to J1-14, Pin F.
4001	See the particular schematic for the Model 4001 in use and install the appropriate jumper to connect the Model 451 Pin 10 to the LVDT excitation-input lead for each channel of Model 451 Operation.
4005	See the particular schematic for the Model 4001 in use and install the appropriate jumper to connect the Model 451 Pin 10 to the LVDT excitation-input lead for each channel of Model 451 Operation.

MODEL R418-7

The Model R418-7 is a 3½″-high 19″-wide rack-mount enclosure, which can accommodate up to 14 units such as Models 352, 418, T418, 428, 441A, and 451). The Model R418-7 is intended for use with units such as the Model 451 or general-purpose amplifiers or thermocouple amplifiers or conditioner-amplifiers employing full external bridges. Provision is made for balance-limit resistors for each channel. This enclosure comes with mating connectors for all input and output connectors and operates from a variety of power sources. See Table 3-4 for the list of all available models of the R418 with their ac and dc power voltages.

Table 3-4
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 are 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 or frequency-to-voltage converters, 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 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 V to 5.00 V.
- Calibrator polarity switch.
- Output calibration switch with positions of CALibrator and OPR (operate).
- MONITOR METER switch with positions of 0.1 V, 1.0 V, 10 V, 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.
- $\frac{1}{4}$, $\frac{1}{2}$, 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.

Model E408-6

The Model E408-6 enclosure is a six-channel bench-top unit, which will hold Models 352, 418, 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. Model T418 is not accommodated without modification to the enclosure.

Features

- 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 any plug-in unit's specifications.
- 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.

Model R408-14

The Model R408-14 enclosure is a 14-channel 19-inch-wide rack-mount unit that 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 without modification to the enclosure.

Features

- 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 unit.
- 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 R408-14 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..

Section IV
APPLICATIONS

GENERAL

Cabling to the Transducer

With some LVDT and RVDT transducers, crosstalk in the cabling between the excitation drive voltage and the output signal from the transducer can cause nonlinearity errors in the signal reaching the Model 451. Transducers that are most susceptible to this problem are those with a higher output impedance. Note that this effect is independent of the conditioner used and is simply a loading effect between the cable capacity and the output impedance of the transducer. It is complicated by the fact that the output impedance of most of these devices varies with the position of the transducer's core, so linearity is usually quite good until near the end of the core's travel.

For example, a Schaevitz Model GCA-121 LVDT was measured. This is a ±1″ model, hermetically sealed, spring loaded, with a linearity specification of ±0.25%. Its output (secondary) impedance is 2100 Ω. When tested with a short cable, a linearity of 0.25% was measured over the full plus to minus range. Then, a 25-foot, four-wire shielded cable was used, and linearity fell to almost 3%. (This cable provided one shield for all four wires, so the excitation wires were in close proximity with the output signal wires.) Replacing the single cable with two 25-foot, shielded, twisted-pair cables, one for excitation and the other for the output, signal linearity was improved to 0.3%.

CAUTION

Unless the cable distance is short (10 feet or less), the excitation should be separated from the signal wires by using different cables. If one cable is used, the signal wires should be contained within a separate two-wire twisted, shielded section of the cable.

Campatible Transducers

The Model 451 is compatible with nearly all ac transducers of the linear (LVDT), rotary (RVDT), and resistive (strain-gage) types. Those transducers that include conversion to dc are not compatible with the Ectron conditioner. Resistive sensors that incorporate semiconductor elements will operate well with the Ectron instrument. Strain-gage sensors using wire- or filmsensing elements are more suited to Ectron's dc conditioner-amplifiers such as the Model 428. Ectron enclosures such as Models E408-6, R408-14, R418, 4001, and 4005) will accommodate a mix of Models 451, 428, and 441A (frequency-to-voltage) conditioners.

Excitation

Excitation frequency and amplitude should follow the manufacturer's recommendations. When in doubt, use a frequency of 2.5 kHz and 3 V ac amplitude. The Model 451 provides a choice of either 1 V or 3 V amplitude and frequencies of 400, 1 kHz, 2.5 kHz, 5 kHz, and 10 kHz. The user should remember that the maximum input to the Model 451 is 0.5 V.

Excitation from another source

The Model 451 can be used with an external excitation. However, reduced output accuracy will usually result because while the Model 451 moniters and adjusts for its own oscillator, it does not do so for external oscillators. Also, any noise or jitter of the external excitation will increase output noise.

Output-voltage Display

The front-panel display of output voltage is determined by user settings in the gain, example, and scale modes. Below 10 volts, resolution is 1 mV; and above, 10 mV. Polarity is also indicated. If the reading exceeds ±10.49 V the display changes to either ++.+++ or —.———, depending on the polarity of the signal.

Input-displacement Display

The displacement display indicates the position of the transducer and is displayed in the selected units: **MIL** (milli-inches), **MM** (millimeters), or **DEG** (degrees). For this display to be correct, the transducer sensitivity (as stated by the LVDT or RVDT manufacturer) must be entered for the mode of operation in use. For a linear LVDT, the transducer sensitivity is given in terms of millivolts of output per volt of excitation per mil (or mm) of movement of the core.

The displacement display can be used to determine the actual null point of the transducer. Simply move the core of the transducer until the displacement display reads zero, and this will be the physical null point of the device. If it is necessary to find this point with a high degree of precision, reduce the transducer sensitivity to minimum (See Table 3-3). The displacement display will be very sensitive, so a precise null point can be determined. After making this measurement, return the transducer sensitivity setting to its correct value.

If the transducer sensitivity is unknown, it can be measured using the Model 451 and a device that can accurately measure the transducer's displacement.

SELECTING THE OPERATING MODE TO USE

There are three operating modes to choose from: gain, example, and scale. The choice of which mode to use depends on several factors: whether the transducer sensitivity of the transducer is known, whether physical measurements can be made on the movement of the transducer when it is in place, the desired accuracy of the resulting data, etc.

Gain Mode

This mode can be used if the transducer sensitivity of the LVDT or RVDT and the gain needed for the test are known, or if experimentation with gain settings to see if the resulting output swing fits the intended application can be done.

Enter the transducer sensitivity and set the gain to the specified value (these two steps can be done in either order). If possible, do a preliminary test to determine if the output fits the required output range. Note: if the output polarity is the reverse of that which is expected, change the polarity of the gain setting. The allowable gain range is from –1 to –300 and +1 to +300 (less than unity gain is not supported).

Example Mode

To set up this mode of operation requires that data for two values of output voltage are entered along with the corresponding positions of the apparatus under test. For instance, if an output of 00.00 to +10.00 volts is required for a movement of the apparatus from its minimum to its maximum displacement, then from **EXAMPL POINT1 VOLTS**, press the display, enter 00.00, change the **N** (no) to **Y** (yes) and press the display. Repeat this process for **EXAMPL POINT2 VOLTS** entering 10.00. Next, you will be asked for two displacements. Move the apparatus to its position where an output voltage of 00.00 is desired, select **EXAMPLE POINT1 DISP**, press the display to **PT1 D EXAMPL SET N**, change the **N** (no) to a **Y** (yes), and push the display. Point 1 displacement has been "captured." In a similar fashion "capture" Point 2 displacement.

This procedure equates the output voltages for Points 1 and 2 with the displacements for Points 1 and 2. The processor precisely calculates the gain and offset values necessary to match the Model 451 to the voltage and displacement values entered.

It is not necessary to use the extremes of the displacement values for the capture points. In the above example, we could have used voltage points of 1.00 V and 9.00 V as long as the capture points were similarly modified. Note, too, that Point 1 could be the higher voltage with the lower displacement point; and Point 2, the lower voltage with the higher displacement point.

To have the output voltage correspond to engineering units or if exact values of voltage versus displacement are required, then measurements of displacement values will have to be made. If this is done with high accuracy then precise displacement-versus-voltage results can be obtained. These results can have a much higher accuracy than with a procedure of calibrating the LVDT with the conditioner in the cal lab, mounting the device to apparatus under test and then taking the data. For instance, the example mode allows the displacement measurements to be made on the apparatus under test rather than on the LVDT. This can eliminate the errors of the mechanical connection between the apparatus and the transducer.

Conventional applications of LVDTs usually depended on calibrating the transducer with the conditioner in a cal lab, mounting the device where it will be used, and then running the test. If conditions change between calibration and the test, (temperature changes, excitation voltage or frequency change, the transducer is dropped) the calibration values will no longer be valid.

Scale Mode

Choose scale mode if the transducer sensitivity is accurately known and the numerical values of output voltage and the corresponding values of transducer displacement (in mil's, mm's, or deg's) are known.

For example, if a one-inch LVDT is being used, and an output of from –5 V to +5 V is required for the transducer going from –500 to +500 mils, just enter these values, and the conditioner is set up. So, first set the units to inches and the transducer sensitivity to its predetermined value. In scale mode, set Point 1 V to –5 V, Point 2 V to +5 V, Point 1 displacement to –500 mils and Point 2 displacement to +500 mils. This procedure will set up the conditioner to the transducer. If the polarity is backwards, reverse the signal leads to the Model 451.)

DETERMINING THE ACTIVE MODE

To determine which operating mode is active, press the display. If zero control is off, the first screen to appear is the active mode. If zero control is on, the first screen to appear is the autozero screen. (Zero control will be on if an autozero has been set or if zero control has been actively turned on.)

If zero is on, to determine the active mode, press the display and rotate the knob until you reach **GAIN MODE SETUP**. Pressing the display will show the **GAIN ADJUST** display if the gain mode is active. If the gain mode is not active, the screen **GAIN ACTIVE ? NO** will be displayed.

Similarly, when at the **EXAMPL MODE SETUP** screen, pressing the screen will display **EXAMPL POINT1 VOLTS** if the Example mode is active or it will display **EXAMPL ACTIVE ? NO** if it is not active.

To determine if the scale mode is active, go to the **SCALE MODE SETUP** screen. Pushing this display will show the screen **SCALE POINT1 VOLTS** if scale mode is active. If it is not active, **SCALE ACTIVE ? NO** will be shown.

CROSSTALK

Crosstalk between LVDT/RVDT transducers occurs when the excitation from one sensor mixes with the data signal from another. The result is that the output dc signal is modulated, usually by the difference frequency of the two excitation supplies. Depending on the difference frequency, the modulation can be a very low frequency. For unshielded sensors, when crosstalk occurs, the output signal will vary by this difference frequency.

Since the excitation supply of the Model 451 can provide 30 mA of current, generally two or three LVDT or RVDT transducers can be connected in parallel and excited by one Model 451. This would eliminate the cross talk problem. Check primary impedance to determine how many loads can be supported by a single excitation supply. A higher excitation frequency or a lower voltage would increase the impedance thereby reducing the current required by each transducer.

If it is necessary to operate the sensors in close proximity to different excitation supplies, shielding can be added to the transducers to minimize the crosstalk effect. A single wrap of a good shielding material will usually reduce the crosstalk to an acceptable level. For additional help, consult factory.

OUTPUT NOISE

The filter settings of WB (wideband), 100 Hz, 10 Hz, and 1 Hz can be used to reduce input signal noise but will not help reduce output noise. If speed of response is not required, output noise can be reduced by adding an output filter following the Model 451. An rc filter consisting of a 10 kΩ series resistor and a 1 μF shunt capacitor to common will reduce any noise considerably. See Figure 4-1.

PHASE CONTROL

One of the design features of the Model 451 is that it does not require a phase control. The phase of the incoming signal is derived from the signal applied to the differential amplifier. Thus, this conditioner is not susceptible to phase changes of the cabling or the phase non-linearity of the transducer.

GROUND CONNECTIONS

Case ground (Pin 13) should be connected to the common of the input power (Pin 15) and, if possible, to earth ground. (This is automatically taken care of in Ectron enclosures.) This connection will allow the emi (rfi) filters of the Model 451 to maximize the rejection of high-frequency noise signals. It is further recommended that excitation low (Pin 14) and output common (Pin 11) be connected to this point. However, output common can be floated; so if the load has a different grounding point, Pin 11 should be connected to load common. Whether this common point should then be connected to earth or power ground depends on where output noise is minimized.

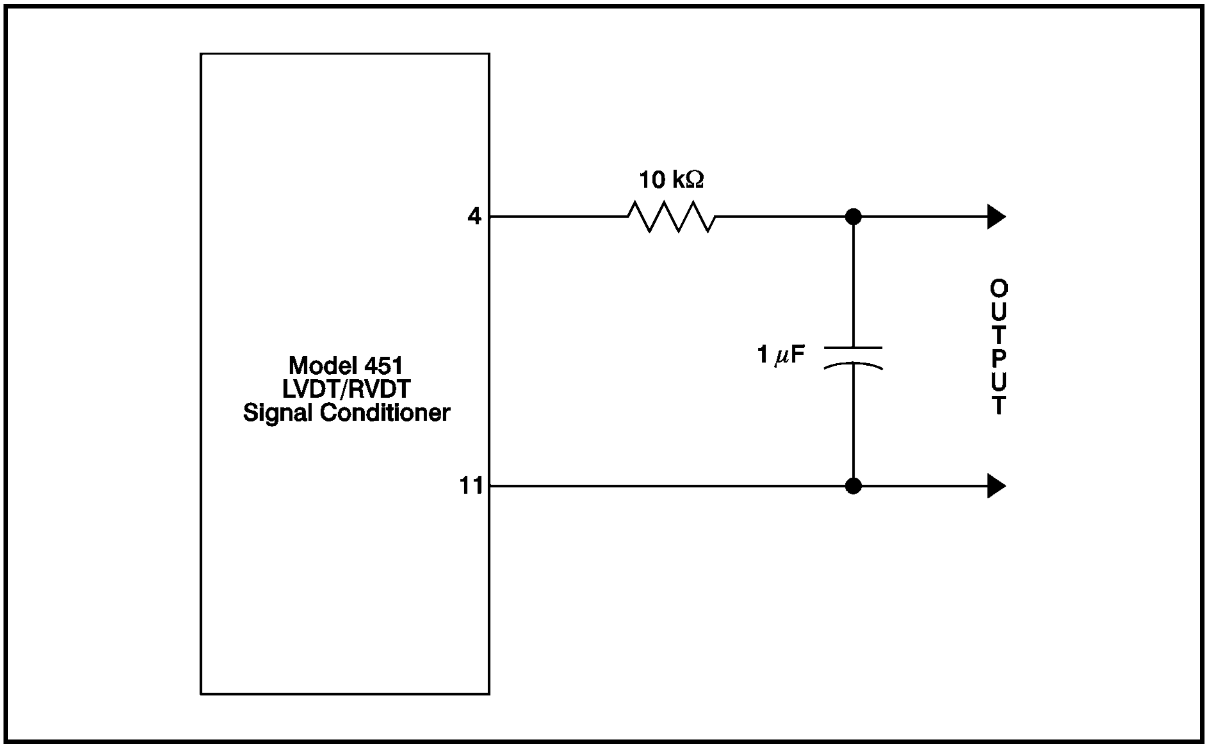

Figure 4-1 Typical Output Filter

EMI PROTECTION

All connections to the converter go through EMI filters to minimize the effects of RF noise. The filter-frequency coverage starts with about –3 dB attenuation at 1 MHz, increasing to –66 dB at 200 MHz and beyond.

VEHICLE APPLICATIONS

Because the modern automobile generates a great variety of sometimes intense noise signals, acquiring good data especially from low-level signals sometimes requires extraordinary measures. Vehicle noise usually involves both electromagnetic and electrostatic signals covering the spectrum from subaudio to many-megahertz frequencies. Signal and power leads involved with signals generated in the engine compartment usually require filtering for both normal-mode and common-mode components ahead of the instrumentation involved. Leads carrying battery power will be contaminated when exposed to engine-compartment noise for even a few inches unless appropriate precautions are taken.

For this reason Ectron instrumentation products intended for vehicle applications include EMI filtering in all leads feeding to or from the instrument. Although LVDT and RVDT signals are higher level than those from thermocouples or strain gages, for best accuracy and least noise, precautions must be taken against noise interference.

RESPONSE TIME

Response time depends on the setting of the filter and, to some degree, the excitation frequency. The filter settings will allow a reduction of noise in the output, but at a sacrifice of response time. Using the frequency setting of 1 Hz, the 10-to-90% response time at the output will be approximately 2.6 s assuming a step function signal at the input. Response time will increase linearly as the frequency setting is increased.

UPDATE RATE

The update rate of the microcontroller and A-to-D converter is 2 kHz, so their influence on the response of the conditioner is minimal.

OUTPUT POLARITY

The polarity of the output signal can be reversed by changing the polarity of the gain setting. This avoids the need to reverse the leads of the transducer to accomplish this reversal. To get exactly the same operation, be sure to change only the polarity and not the numerical gain setting. Direct gain control is only available when using the gain mode.

NULL IMPROVEMENT

Some LVDT or RVDT transducers have a null signal that is not well defined. As a result, linearity in the null area can be poor. To some extent, the null area can be degraded further by adding cabling with high capacitance.

Some improvement in the null area can be made by shunting the transducer's secondary windings with resistance. If the application requires better sensitivity and linearity in the null area, this method should be attempted. For further information contact the transducer's manufacturer. Also, see "Cabling to the Transducer" on Page 4-1.

SECTION V
THEORY of OPERATION

ANALOG INPUT

The two signal inputs from the LVDT feed a differential, programmable-gain amplifier stage, which can be set to any of three gains. This is followed by a demodulator that is synchronized to the phase of the input signal. This synchronozation allows the Model 451 to operate with a wide variety of LVDT's and cabling arrangements without the need for phase adjustment. The output of the demodulator is voltage proportional to the difference between the two LVDT secondary voltages multiplied by the gain of the programmable-gain amplifier.

Following the demodulator is a two-pole, selectable, low-pass filter with bandwidths of 1 Hz, 10 Hz, 100 Hz, and a wideband position (which filters the signal to about 600 Hz). Following the filter is a 14-bit analog-to-digital converter (ADC). This ADC operates at approximately 2000 samples per second and feeds its output to the microcontroller.

FIRMWARE

The Model 451 firmware provides the front-panel user interface, calculation of the constants needed for real-time operation, processing of the real-time input-to-output data stream, and monitoring for out-of-range and other error conditions. The Model 451 is programmed to provide extensive configuration capabilities that allow the user to adjust many parameters used in operating an LVDT, as well as calibration of its own input and output circuitry.

The Model 451 has an overall gain range of 1 to 300, both positive and negative. Specifying negative gain will result in inversion of the output signal, which is useful since it is often rather tedious to predict the polarity of an LVDT system in advance. The input programmable-gain amplifier provides part of the needed gain, and real-time multiplication of the signal-in firmware provides the remainder.

Real-time operation involves reading the input voltage x from the ADC, multiplying that input voltage by a gain factor m, adding an offset value b, and feeding the result y to the output DAC. Calculation of the m and b values is done during setup, so the Model 451 only evaluates the equation $y = mx + b$ in real time, about 2000 times per second.

The front-panel display shows LVDT displacement, updated about three times per second. This display is calculated from the input voltage and the transducer sensitivity and depends on the accuracy of the transducer sensitivity. In GAIN and EXAMPLE modes, the transducer sensitivity is not needed for calculation of the output, so the display of displacement may not agree with the output if the transducer sensitivity does not match the transducer in use.

Three modes of operation are provided: **GAIN**, **EXAMPLE**, and **SCALE**. The operation of each will be described separately.

GAIN MODE

In the gain mode, m and b (from above) are the gain and offset, respectively, entered from the front panel. The range of gain is 1 to 300, positive and negative, where negative gain will invert polarity of the output compared to the input. In **GAIN** mode, the Model 451 operates much like a conventional LVDT conditioner.

EXAMPLE MODE

In **EXAMPLE** mode, *m* and *b* are calculated from measurements taken at the two input conditions, Point 1 and Point 2. The output voltage is given by the following equation:

$$y = \left(\frac{Pt\ 1\ output - Pt\ 2\ output}{Pt\ 1\ input - Pt\ 2\ input} \right) x + (Pt\ 1\ output + zero\ offset).$$

As explained in the OPERATION section of this manual, the *Pt 1 output* and *Pt 2 output* are entered from the front panel, and *Pt 1 input* and *Pt 2 input* are input voltages measured by the Model 451.

SCALE MODE

In **SCALE** mode, *m* and *b* are calculated from values entered via the front panel. The output voltage is given by the following equation:

$$y = \left(\frac{Pt\ 1\ output - Pt\ 2\ output}{(Pt\ 1\ disp - Pt\ 2\ disp) \times transducer\ sensitivity} \right) x + (Pt\ 1\ output + zero\ offset).$$

Pt 1 disp, *Point 2 disp*, *Pt 1 output*, *Pt 2 output*, and *transducer sensitivity* are entered from the front panel.

CALIBRATION

The Model 451 stores calibration information in nonvolatile memory and uses it to compensate for inaccuracies in its internal circuitry. Two types of calibration are performed: input and output.

Input calibration involves connecting the Model 451 to a set of precision dividers and executing a calibration procedure. This calibration includes the Model 451's excitation supply and input circuitry. During this calibration, the Model 451 measures its A/D output with various combinations of input gains and excitation voltages to arrive at a set of correction factors that are used to improve accuracy during normal operation.

Output calibration requires the user to connect a digital voltmeter to the Model 451's output. The user then adjusts the front-panel controls to set the Model 451's output to +10 volts, then −10 volts.

SECTION VI
ALIGNMENT

GENERAL

The Model 451 is easily aligned in two steps: output alignment and input alignment. Prior to aligning the Model 451, the user should read Section III, Operation, to become familiar with its operation.

EQUIPMENT REQUIRED

Digital multimeter Hewlett Packard Model 3478A or equivalent.

Matched resistor set Two 5-kΩ metal film resistors, each with an absolute tolerance of ±0.1% and ratio-matched to each other to within ±0.005%.

Precision resistive divider ESI Model 622A or equivalent.

Dual operational amplifier Analog Devices Model OP270FZ or equivalent.

Dc power supply (PS1) This power supply will be used to power the Model 451. Requirements are 10.5 to 32 V dc @ 80 mA nominal.

Plus-and-minus dc power supply (PS2) This power supply must be capable of supplying 10 V dc (±0.5 V dc) to the dual operational amplifier.

Hookup wires and cables as required.

PROCEDURES

Output Alignment

The output alignment consists of going to the two output-alignment screens for voltage and setting the output (Pins 4 and 11) to ±10 V dc. The numbers on the bottom line of the two alignment screens are provided so that the user can retain the setting for future reference should it be needed.

1. Connect the Model 451 and dc voltmeter as is shown in Figure 6-1. Set PS1 to any voltage between 10.5 and 32 V dc and set the dc voltmeter to measure 10 V dc with 1-mV resolution.

2. From the operating screen press the display once to go to the main menu. turn the encoder until **OTHER** is displayed, then press the display.

3. Turn the encoder until **ALIGN** is displayed and again press the display. At this point the display should read **ALIGN +10V**.

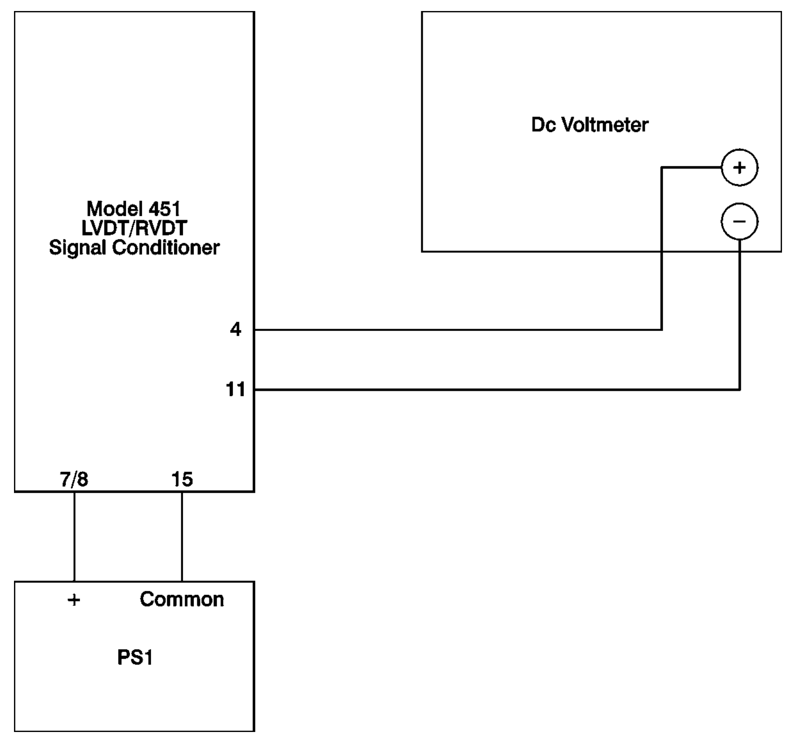

Figure 6-1 Output Alignment

4. Press the display, and the display should now read **ALIGN +10 NNNNN** where **NNNNN** is a five-digit number from 14848 to 16383.
5. Using the encoder, adjust the reading on the dc voltmeter until it is +10 V dc, ±0.003 V dc.
6. When this has been achieved, press the display to accept the reading. The user may want to record the actual number **NNNNN** for future reference.
7. The display should now read **ALIGN +10V**. Turn the encoder so that the display reads **ALIGN −10V** and press the display.
8. The display should now read **ALIGN −10 NNNN** where **NNNN** is a four-digit number from 0000 to 1499.
9. Using the encoder, adjust the reading on the dc voltmeter until it is −10 V dc, ±0.003 V dc.
10. When this has been achieved, press the display to accept the reading. The user may want record the actual number **NNNN** for future reference.

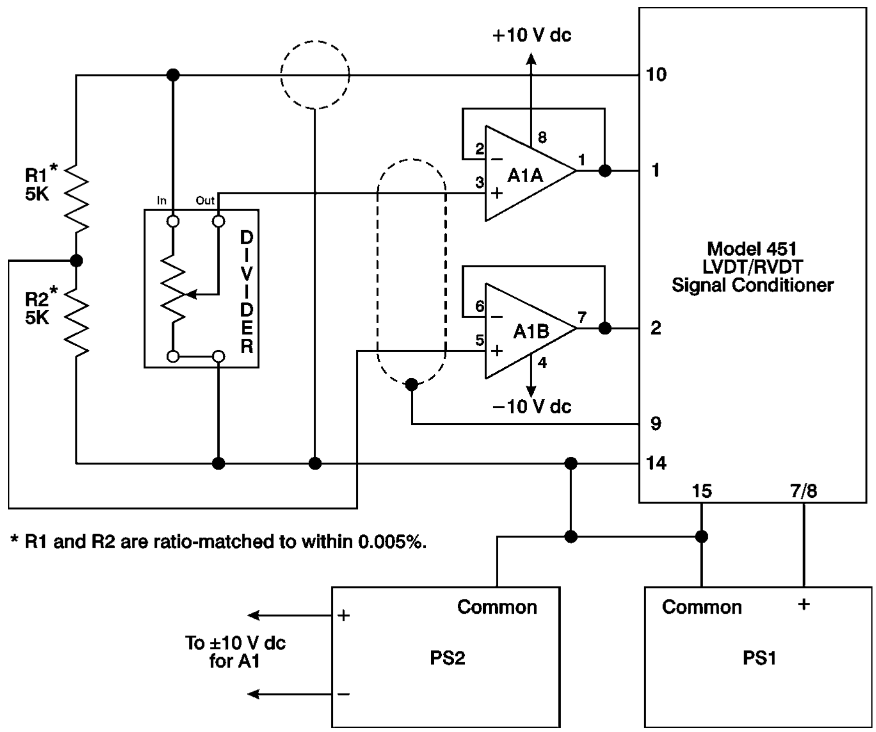

Figure 6-2 Input Alignment

Input Alignment.

Input alignment is accomplished in three steps called **DIV 1**, **DIV 2**, and **DIV 3**.

1. Connect the Model 451 and dc voltmeter as is shown in Figure 6-2. Make sure to provide shielding where indicated. Set PS1 to any voltage between 10.5 and 32 V dc and PS2 to 10 V dc.
2. Set the divider to 4-9-9-9-9-10
3. From the operating screen press the display once to go to the main menu. turn the encoder until **OTHER** is displayed, then press the display.
4. Turn the encoder until **ALIGN** is displayed and again press the display.
5. Rotate the encoder until the display reads **ALIGN INPUT** and press the display. The screen should read **ALIGN WITH DIV 1**.
6. Press the display. The screen should read **DIV 1 SET N**. Turn the encoder until the **N** is **Y** and press the display. At this point the display will request **PLEASE WAIT** while the unit begins the input

alignment. When this part of the alignment is finished, the display will automatically be returned to **ALIGN WITH DIV 1**. If during this step the screen **INPUT OUT OF RANGE** is encountered, check the setup, including measuring the two inputs with an ac voltmeter to ascertain that they are equal. Repeat this step as necessary if the error screen occurs.

7. Set the divider to 8-9-9-9-9-10.

8. Turn the encoder to **ALIGN WITH DIV 2** and press the display.

9. The screen should now display **DIV 2 SET N**. Turn the encoder until the **N** is **Y** and press the display. At this point the display will request **PLEASE WAIT** while the unit begins the second part of the input alignment. When this part of the alignment is finished, the display will automatically be returned to **ALIGN WITH DIV 2**. If during this step the screen **INPUT OUT OF RANGE** is encountered, check the setup, including measuring the two inputs with an ac voltmeter to ensure that the input to the Model 451 (Pin 1 to Pin 2) is 40% of the excitation (Pin 10 to Pin 14). Repeat this step as necessary if the error screen occurs.

10. Set the divider to 6-4-9-9-9-10.

11. Turn the encoder until the display reads **ALIGN WITH DIV 3** and press the display.

12. The screen should now display **DIV 3 SET N**. Turn the encoder until the **N** is **Y** and press the display. At this point the display will request **PLEASE WAIT** while the unit begins the third and last part of the input alignment. When it is finished, the display will automatically be returned to **ALIGN WITH DIV 3**. If during this step the screen **INPUT OUT OF RANGE** is encountered, check the setup, including measuring the input with an ac voltmeter to ensure that the input to the Model 451 (Pin 1 to Pin 2) is 15% of the excitation voltage (Pin 10 to Pin 14). Repeat this step as necessary if the error screen occurs.

This completes the alignment of the Model 451. The user can return to the operate screen by waiting 20 seconds for a "time out" or by turning the encoder to **ALIGN EXIT**, pressing the display, turning the encoder to **OTHER EXIT**, pressing the display, turning the encoder to **RETURN TO OPERAT**, and pressing the display.

SECTION VI
ALIGNMENT

GENERAL

The Model 451 is easily aligned in two steps: output alignment and input alignment. Prior to aligning the Model 451, the user should read Section III, Operation, to become familiar with its operation.

EQUIPMENT REQUIRED

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Matched resistor set — Two 5-kΩ metal film resistors, each with an absolute tolerance of ±0.1% and ratio-matched to each other to within ±0.005%.

Precision resistive divider — ESI Model RV622A or equivalent.

Dual operational amplifier — Analog Devices Model OP270FZ or equivalent.

Dc power supply (PS1) — This power supply will be used to power the Model 451. Requirements are 10.5 to 32 V dc @ 80 mA nominal.

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Hookup wires and cables as required.

PROCEDURES

Output Alignment

The output alignment consists of going to the two output-alignment screens for voltage and setting the output (Pins 4 and 11) to ±10 V dc. The numbers on the bottom line of the two alignment screens are provided so that the user can retain the setting for future reference should it be needed.

1. Connect the Model 451 and dc voltmeter as is shown in Figure 6-1. Set PS1 to any voltage between 10.5 and 32 V dc and set the dc voltmeter to measure 10 V dc with 1-mV resolution.

2. From the operating screen press the display once to go to the main menu. turn the encoder until **OTHER** is displayed, then press the display.

3. Turn the encoder until **ALIGN** is displayed and again press the display. At this point the display should read **ALIGN +10V**.

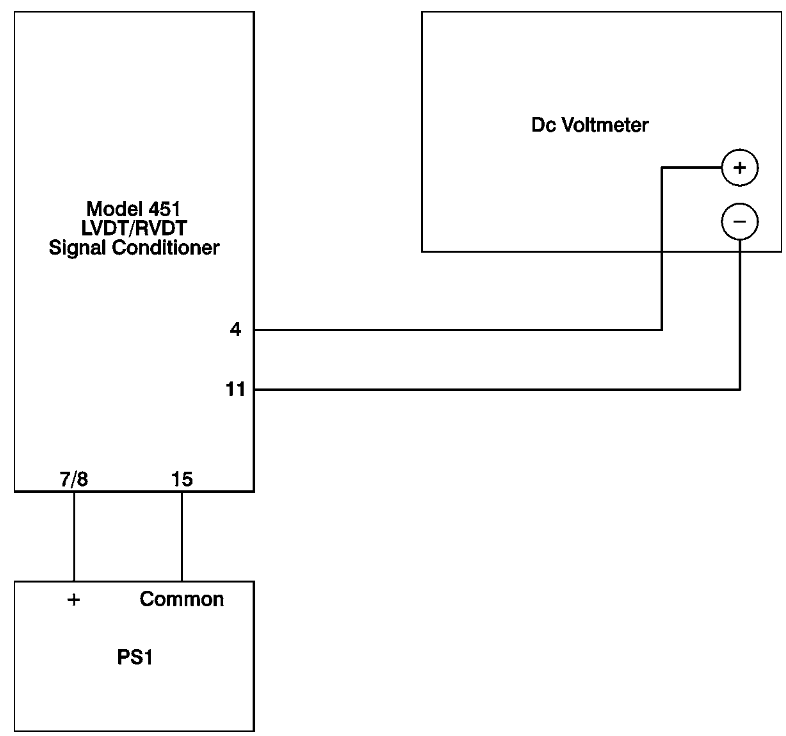


Figure 6-1 Output Alignment

4. Press the display, and the display should now read **ALIGN +10 NNNNN** where **NNNNN** is a five-digit number from 14848 to 16383.

5. Using the encoder, adjust the reading on the dc voltmeter until it is +10 V dc, ±0.003 V dc.

6. When this has been achieved, press the display to accept the reading. The user may want to record the actual number **NNNNN** for future reference.

7. The display should now read **ALIGN +10V**. Turn the encoder so that the display reads **ALIGN −10V** and press the display.

8. The display should now read **ALIGN −10 NNNN** where **NNNN** is a four-digit number from 0000 to 1499.

9. Using the encoder, adjust the reading on the dc voltmeter until it is −10 V dc, ±0.003 V dc.

10. When this has been achieved, press the display to accept the reading. The user may want record the actual number **NNNN** for future reference.

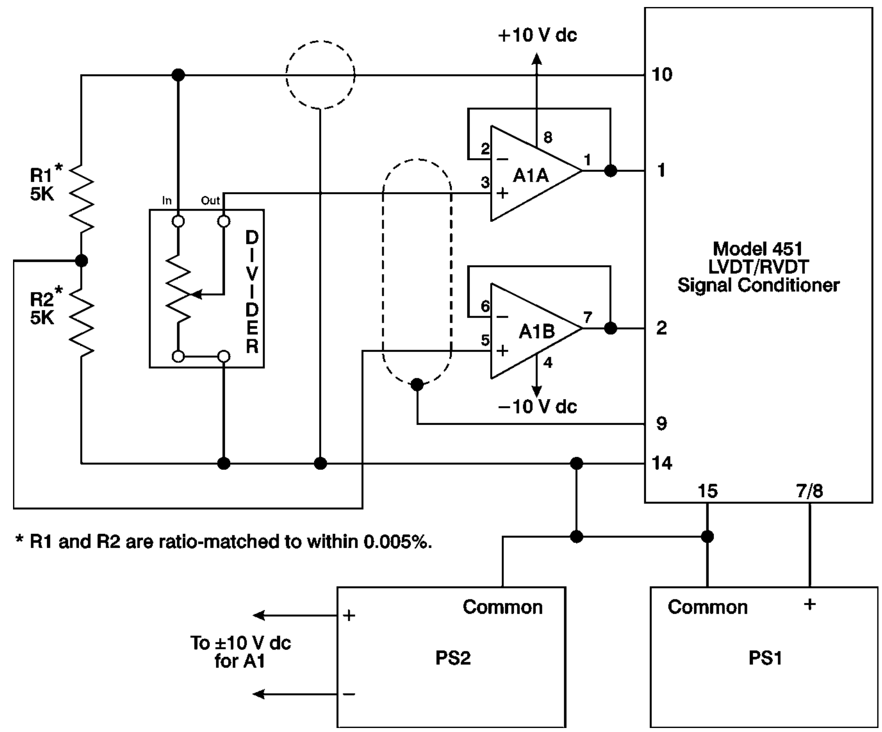


Figure 6-2 Input Alignment

Input Alignment.

Input alignment is accomplished in three steps called **DIV 1**, **DIV 2**, and **DIV 3**.

1. Connect the Model 451 and dc voltmeter as is shown in Figure 6-2. Make sure to provide shielding where indicated. Set PS1 to any voltage between 10.5 and 32 V dc and PS2 to 10 V dc.
2. Set the divider to 4-9-9-9-9-10
3. From the operating screen press the display once to go to the main menu. turn the encoder until **OTHER** is displayed, then press the display.
4. Turn the encoder until **ALIGN** is displayed and again press the display.
5. Rotate the encoder until the display reads **ALIGN INPUT** and press the display. The screen should read **ALIGN WITH DIV 1**.
6. Press the display. The screen should read **DIV 1 SET N**. Turn the encoder until the **N** is **Y** and press the display. At this point the display will request **PLEASE WAIT** while the unit begins the input

alignment. When this part of the alignment is finished, the display will automatically be returned to **ALIGN WITH DIV 1**. If during this step the screen **INPUT OUT OF RANGE** is encountered, check the setup, including measuring the two inputs with an ac voltmeter to ascertain that they are equal. Repeat this step as necessary if the error screen occurs.

7. Set the divider to 8-9-9-9-9-10.

8. Turn the encoder to **ALIGN WITH DIV 2** and press the display.

9. The screen should now display **DIV 2 SET N**. Turn the encoder until the **N** is **Y** and press the display. At this point the display will request **PLEASE WAIT** while the unit begins the second part of the input alignment. When this part of the alignment is finished, the display will automatically be returned to **ALIGN WITH DIV 2**. If during this step the screen **INPUT OUT OF RANGE** is encountered, check the setup, including measuring the two inputs with an ac voltmeter to ensure that the input to the Model 451 (Pin 1 to Pin 2) is 40% of the excitation (Pin 10 to Pin 14). Repeat this step as necessary if the error screen occurs.

10. Set the divider to 6-4-9-9-9-10.

11. Turn the encoder until the display reads **ALIGN WITH DIV 3** and press the display.

12. The screen should now display **DIV 3 SET N**. Turn the encoder until the **N** is **Y** and press the display. At this point the display will request **PLEASE WAIT** while the unit begins the third and last part of the input alignment. When it is finished, the display will automatically be returned to **ALIGN WITH DIV 3**. If during this step the screen **INPUT OUT OF RANGE** is encountered, check the setup, including measuring the input with an ac voltmeter to ensure that the input to the Model 451 (Pin 1 to Pin 2) is 15% of the excitation voltage (Pin 10 to Pin 14). Repeat this step as necessary if the error screen occurs.

This completes the alignment of the Model 451. The user can return to the operate screen by waiting 20 seconds for a "time out" or by turning the encoder to **ALIGN EXIT**, pressing the display, turning the encoder to **OTHER EXIT**, pressing the display, turning the encoder to **RETURN TO OPERAT**, and pressing the display.

SECTION VII
PARTS LISTS

NAMES OF MANUFACTURERS

The table below lists the manufacturers of the components used by Ectron in the products for which parts lists and scematics are provided. They are listed numerically for easy cross reference to the parts lists.

List of Manufacturers

Number	Manufacturer	Number	Manufacturer
00027	Allen-Bradley Co.	00726	Rohm
00044	Amphenol	00763	Samtec
00060	Aries Electronics	00808	Siliconix Inc.
00074	Augat Interconnection	00834	Sprague Electric Co.
00091	Bendix Corp.	00845	Standard Power Inc.
00127	Bussmann Div.	00863	Switchcraft Inc.
00128	C&K Components Inc.	00949	Useco
00166	Circuit Assembly Corp.	00987	Winslow International
00206	Data Display Products	01094	Central Semiconductor
00336	Fairchild	01152	TRW-cinch
00464	ITT Cannon	01164	PEM
00493	Kemet, Union Carbide Corp	01166	Kulka Smith
00503	KOA Speer Electronics	01176	Belden
00532	Littelfuse Inc.	01177	Keystone
00564	Philips	01230	Ectron Corporation
00616	Motorola Semiconductor	01264	IRC-(Int'l. Resistive Co.)
00628	National Semiconductor	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-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	JUMPER			
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-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 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	FET, MOS VN 30V 1.2-OHM	00808	VN0300L	1-240030-0
Q3	TRANSISTOR, PNP	00628	2N3702	1-213702-0
R5	JUMPER			
R6	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

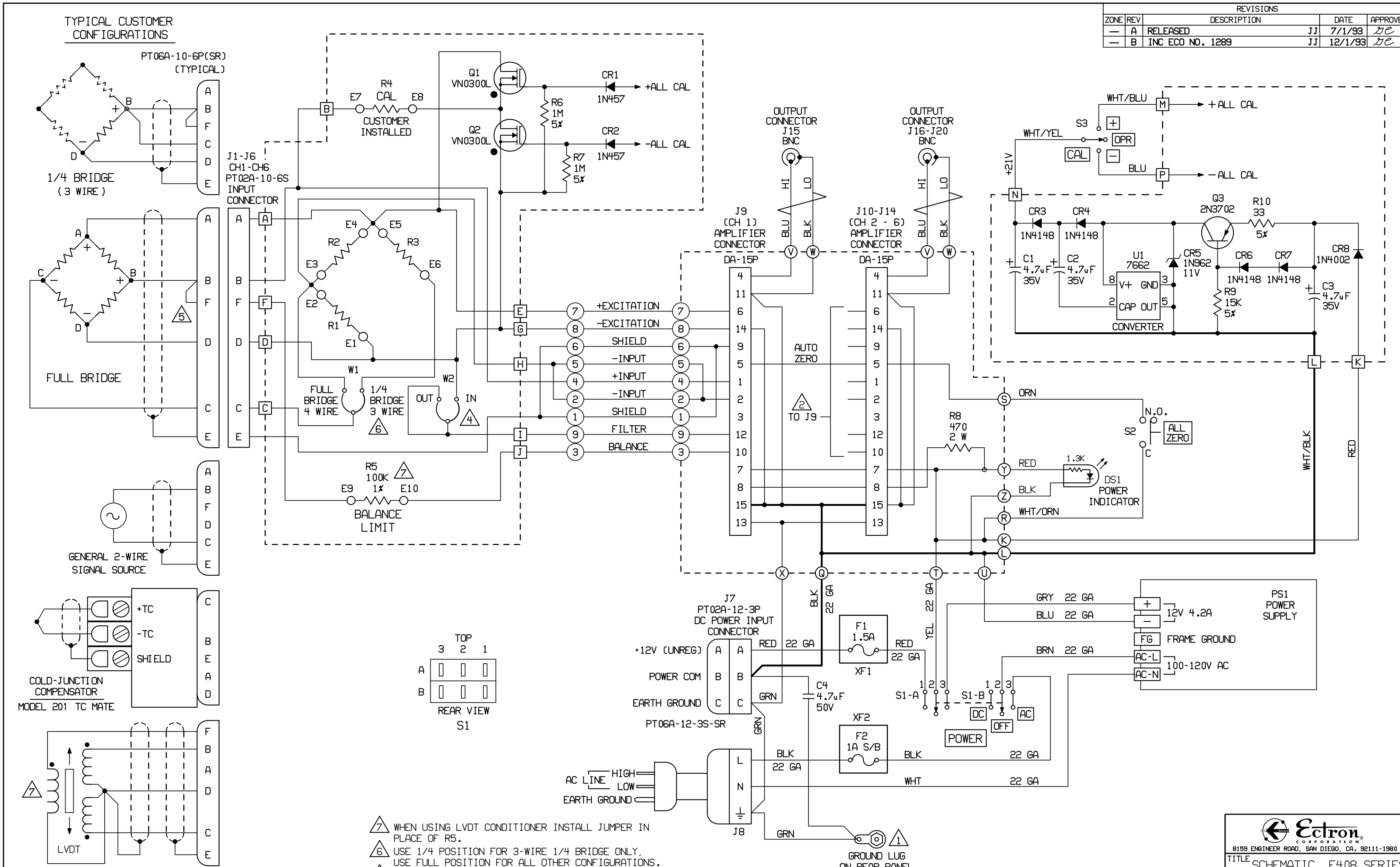
MODEL R418-7 ENCLOSURE
(Drawing 418-627)

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	JUMPER			
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-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)	JUMPER			
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
REVISIONS					
—	A	RELEASED	JJ	7/1/93	GC
—	B	INC ECO NO. 1289	JJ	12/1/93	GC



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.

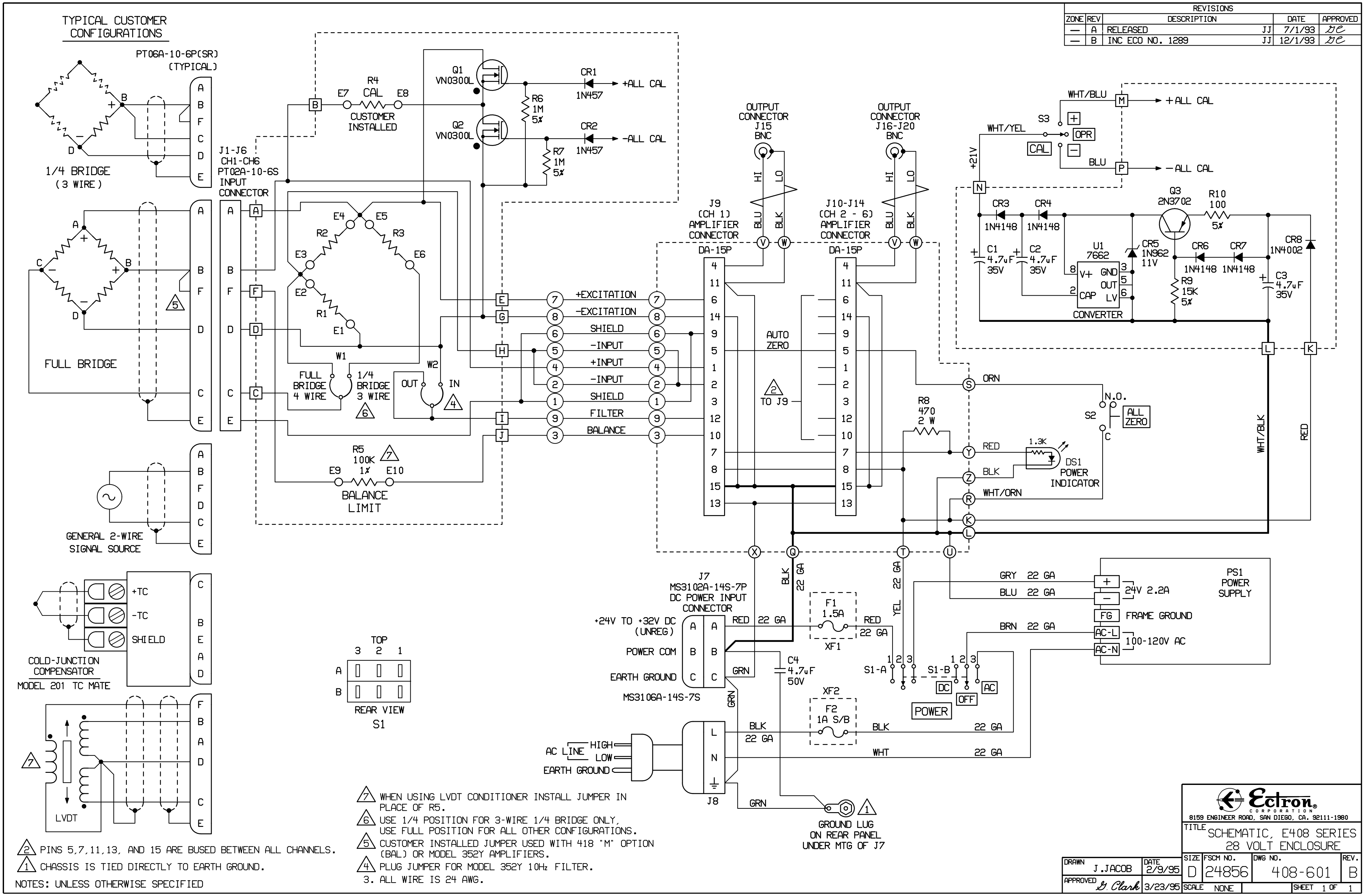
Ectron CORPORATION, 8159 ENGINEER ROAD, SAN DIEGO, CA. 92111-1980

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

TITLE: SCHEMATIC, E408 SERIES 12 VOLT ENCLOSURE

SIZE	FSCM NO.	DWG NO.	REV.
D	24856	408-600	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.

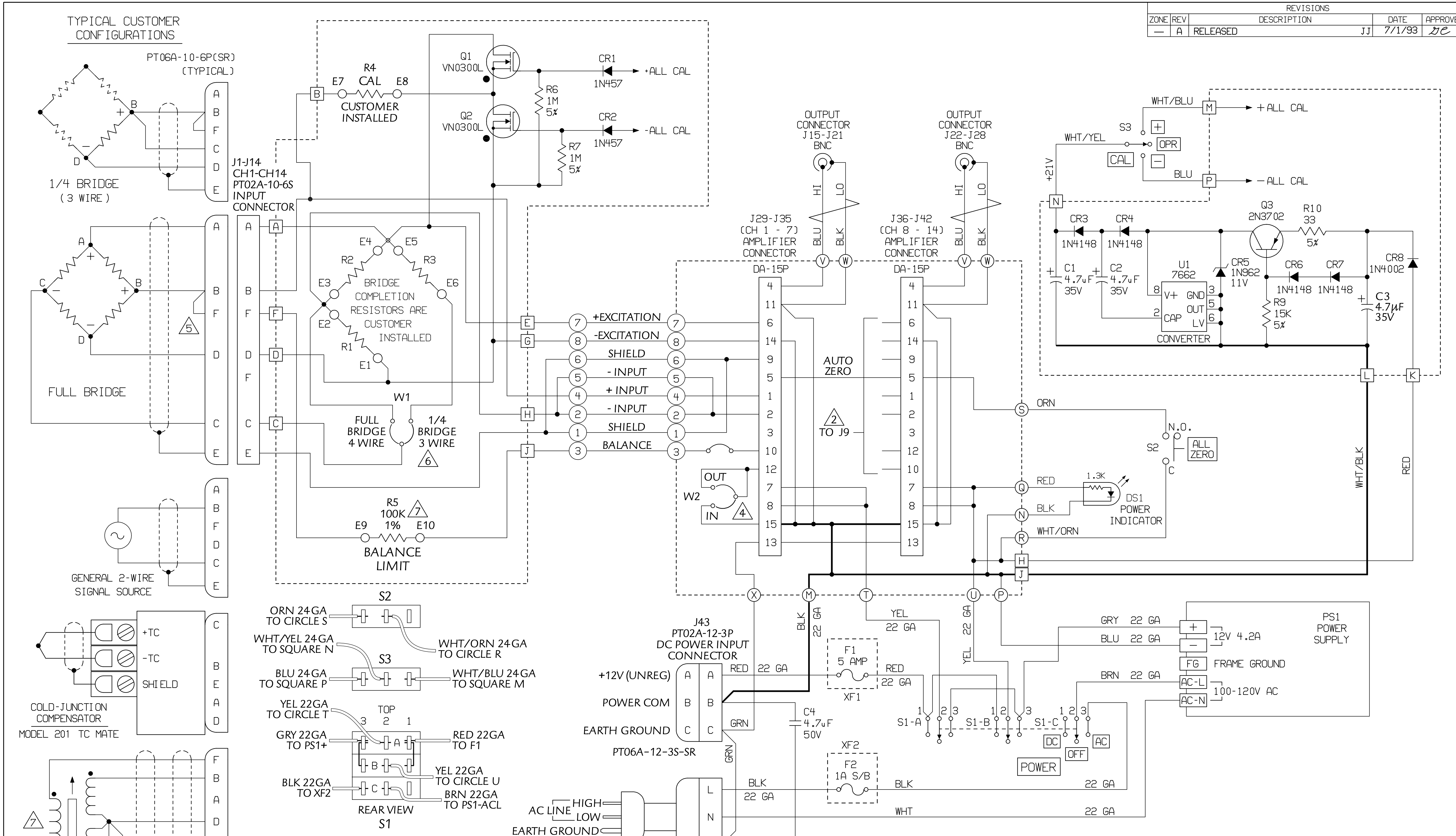
REVISIONS

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

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

TITLE: SCHEMATIC, E408 SERIES 28 VOLT ENCLOSURE

DRAWN	J.JACOB	DATE 2/9/95	SIZE D	FSCM NO. 24856	DWG NO. 408-601	REV. B
APPROVED	G. Clark	3/23/95	SCALE NONE		SHEET 1 OF 1	



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

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

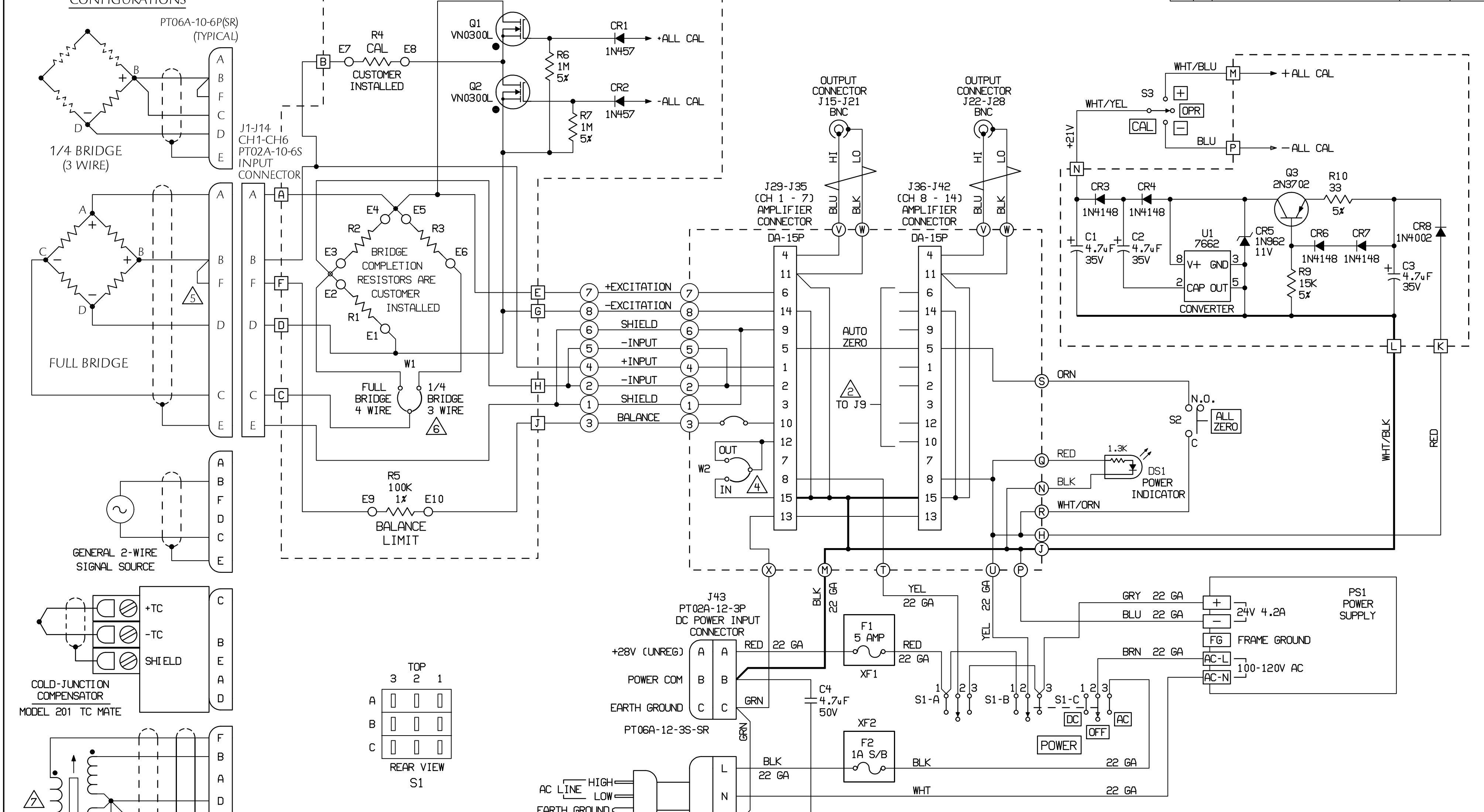
Ectron CORPORATION
8159 ENGINEER ROAD, SAN DIEGO, CA. 92111-1980

TITLE SCHEMATIC, R408-14 12 VOLT ENCLOSURE

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

SCALE NONE SHEET 1 OF 1

ZONE	REV	DESCRIPTION		DATE	APPROVED
—	A	RELEASED	JJ	2/20/96	[illegible]



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

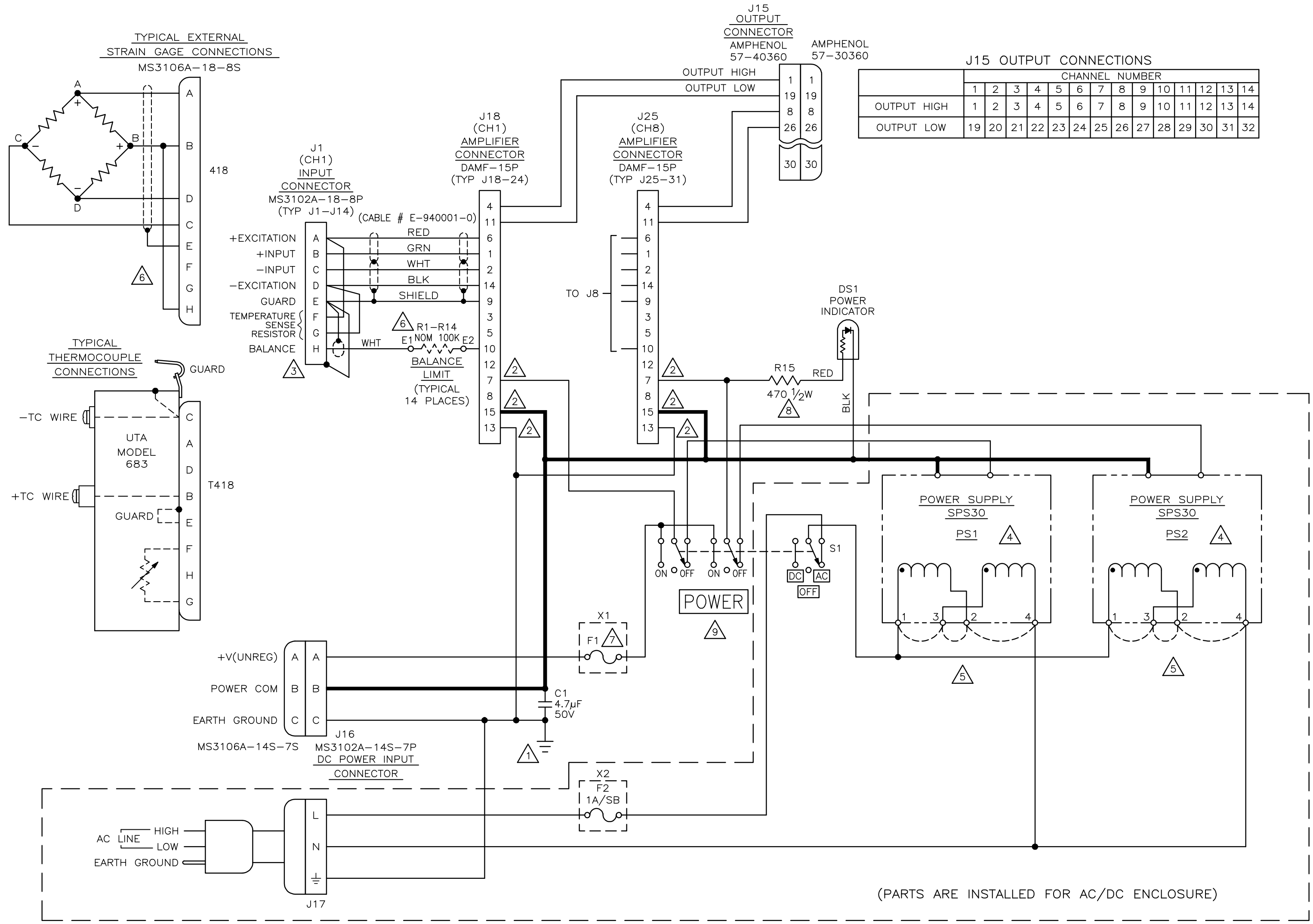
DRAWN	J.JACOB	1/23/96
CHECKED	G. Clark	2/20/96
APPROVED		

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	REVISION 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



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

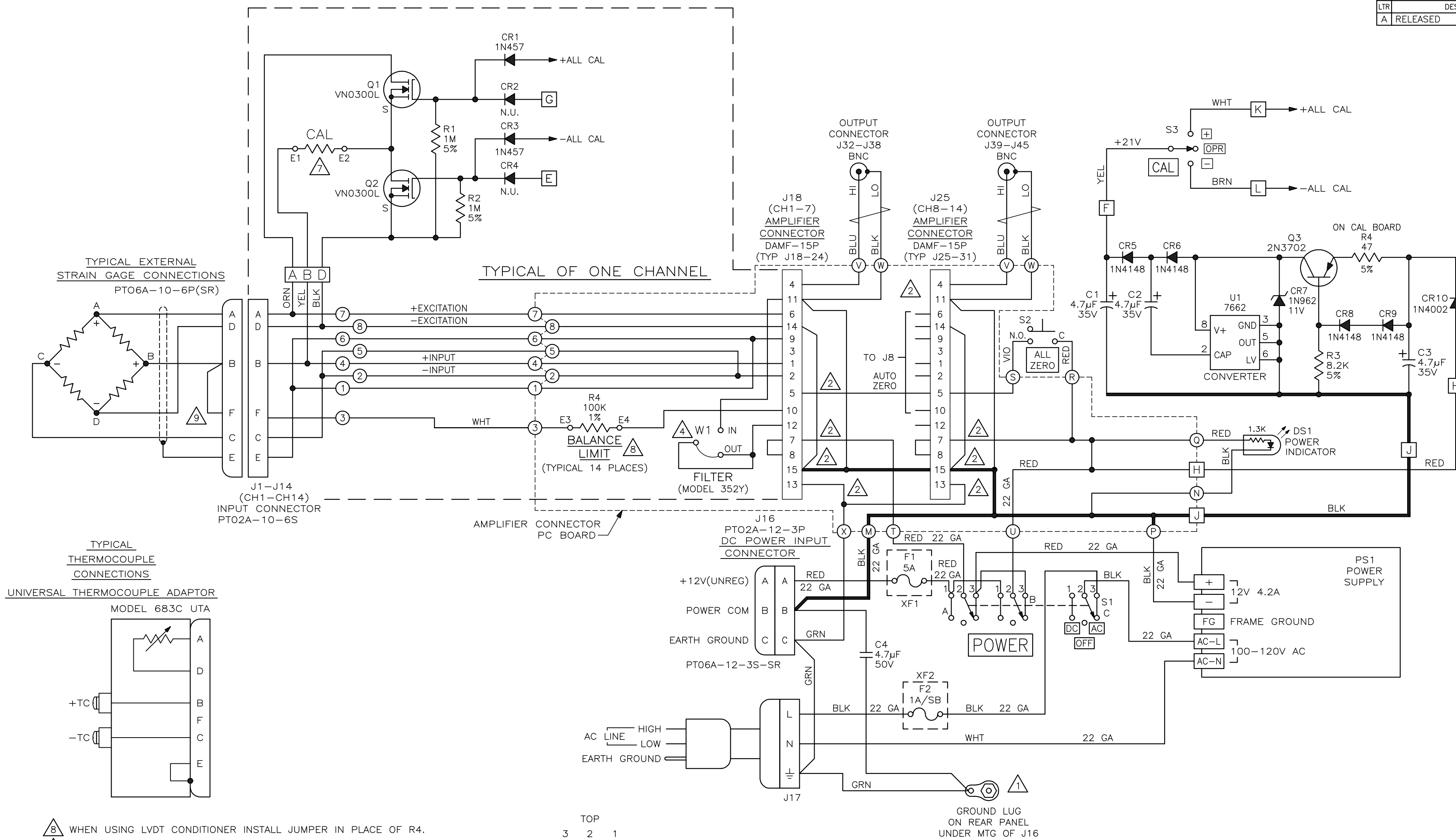
TITLE SCHEMATIC, R418–7 ENCLOSURE

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

SCALE NONE — SHEET 1 OF 1

DWG. NO. 418–627 REV. G

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.

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

DRAWN	J.JACOB	11/29/93
CHECKED	G. Clark	11/30/93
APPROVED		

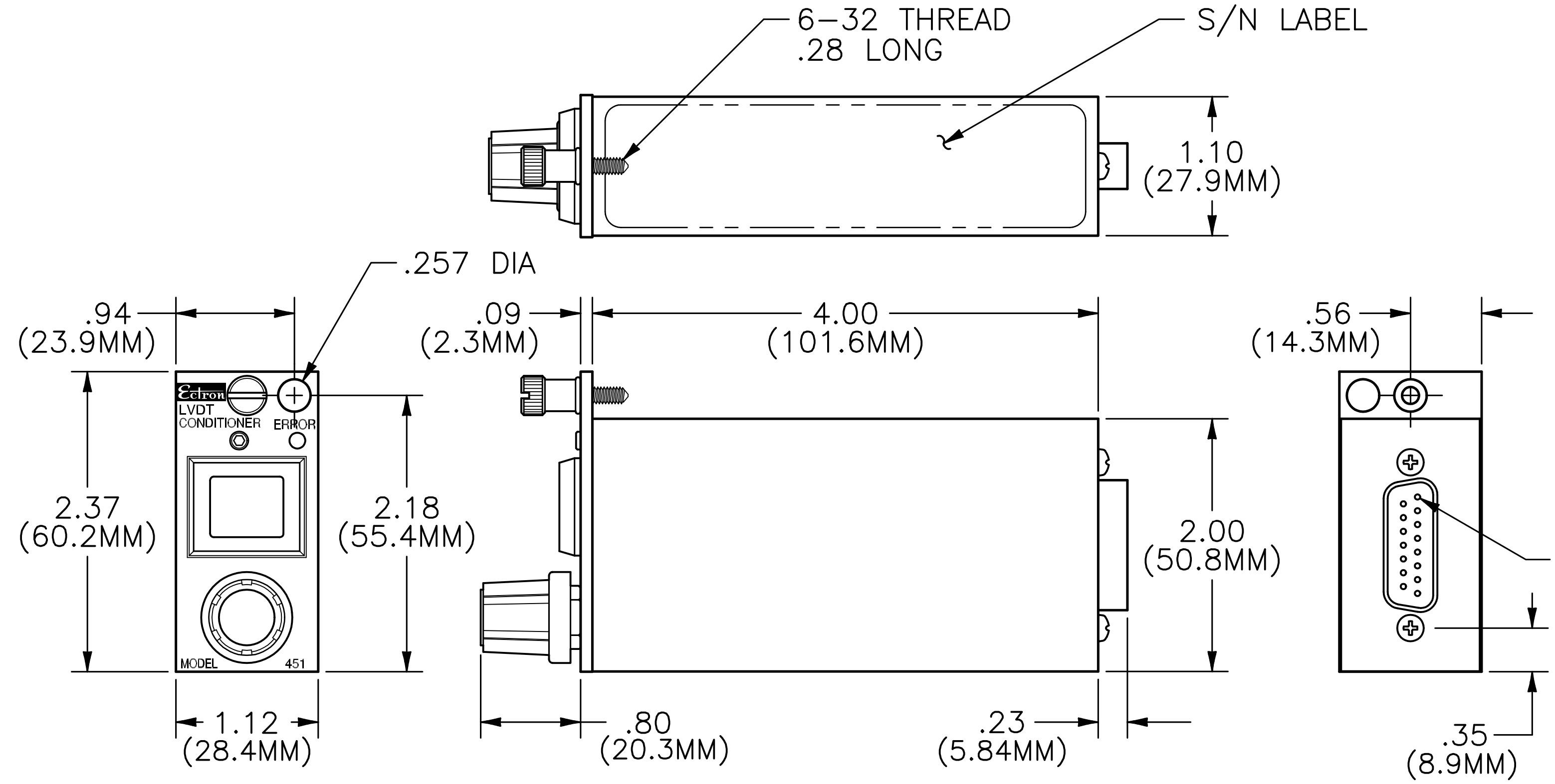
TITLE: SCHEMATIC, R418-M1028C ENCLOSURE

SIZE	FSCM NO.	DWG NO.	REV
D	24856	419-605	A

SCALE NONE — SHEET 1 OF 1

DWG. NO. 419-605 REV. A

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
–	A	INITIAL RELEASE JJ	8/4/98	GC



PIN	FUNCTION
1	INPUT HIGH
2	INPUT LOW
3	NOT USED
4	OUTPUT HI
5	REMOTE AUTO ZERO
6	NOT USED
7	POWER HI
8	POWER HI
9	GUARD
10	+EXCITATION
11	OUTPUT LO
12	NOT USED
13	CASE GND
14	–EXCITATION
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:

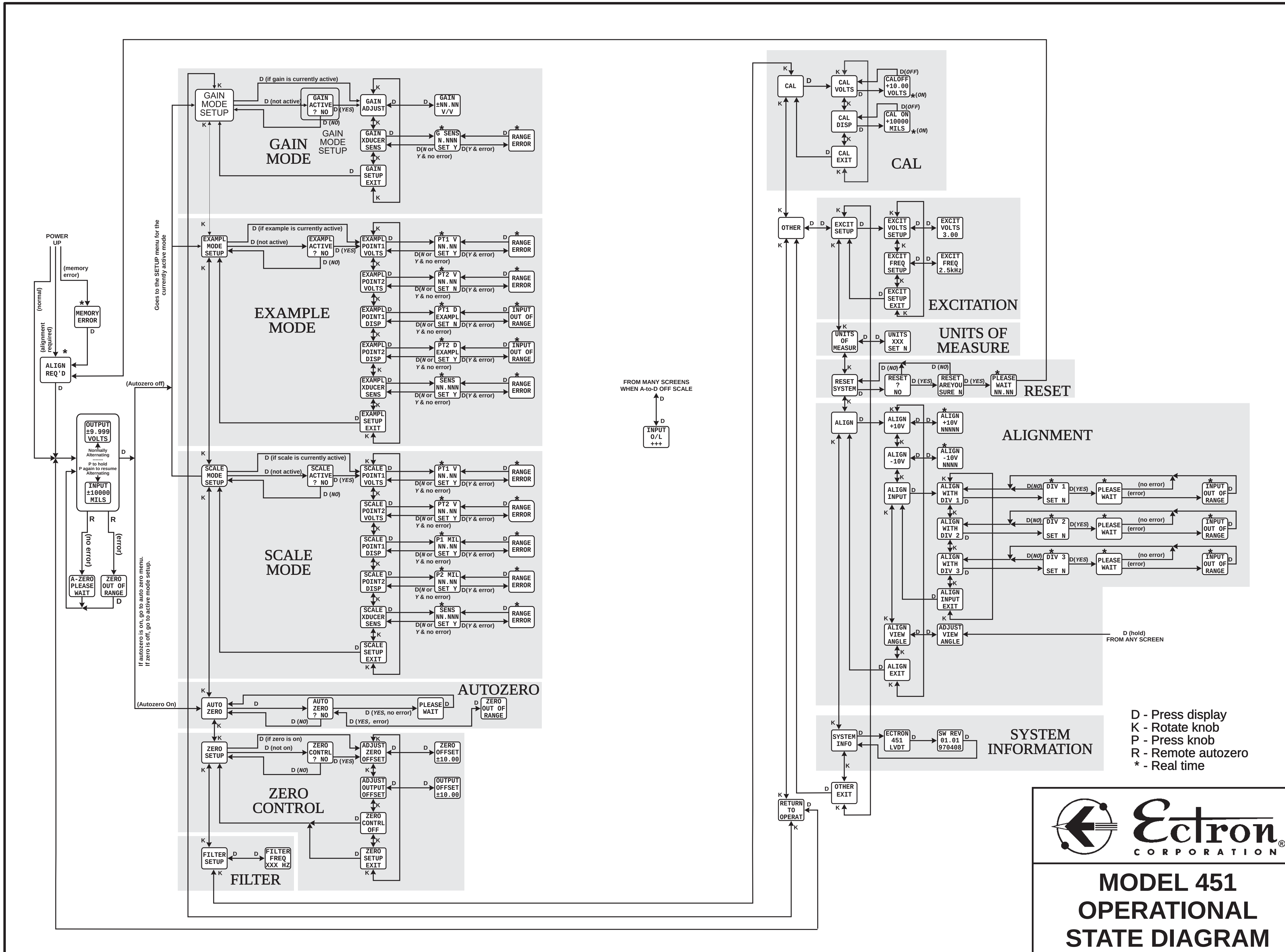
HOLE DIAMETERS	DIMENSIONS
.0135 THRU .125 +.004/–.001	FRACTIONS ±1/16
.126 THRU .250 +.005/–.001	DEC .X ±.030
.251 THRU .500 +.006/–.001	DEC .XX ±.020
.501 THRU .750 +.008/–.001	DEC .XXX ±.010
.751 THRU 1.000 +.010/–.001	ANGULAR ±2°0'
1.001 THRU 2.000 +.012/–.001	

MATERIAL		
FINISH		
DRAWN	J.JACOB	DATE 8/4/98
CHECKED	G. Clark	8/4/98
APPROVED		

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

TITLE DIMENSIONAL OUTLINE, LVDT CONDITIONER

SIZE	FSCM NO.	DWG NO.	REV
B	24856	451–900	A
SCALE 1/1		SHEET 1 OF 1	



MODEL 451 OPERATIONAL STATE DIAGRAM