

4428 Pressure indicator Instruction manual

IM4428, Revision E1

**ENDEVCO 4428A
INSTRUCTION MANUAL**

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**SECTION 1:
DESCRIPTION**

1. INTRODUCTION

This manual describes the Model 4428A Pressure Indicator designed specifically to operate with ENDEVCO Model 8500 series piezoresistive full bridge, pressure transducers. The Model 4428A is a self contained minisystem that includes a built-in power supply, signal conditioning amplifier, and 4 1/2 digit LED display.

Figure 1-1 shows the Model 4428A with the unique multi-position, adjustable handle that allows easy observation of the LED display during bench top operation.

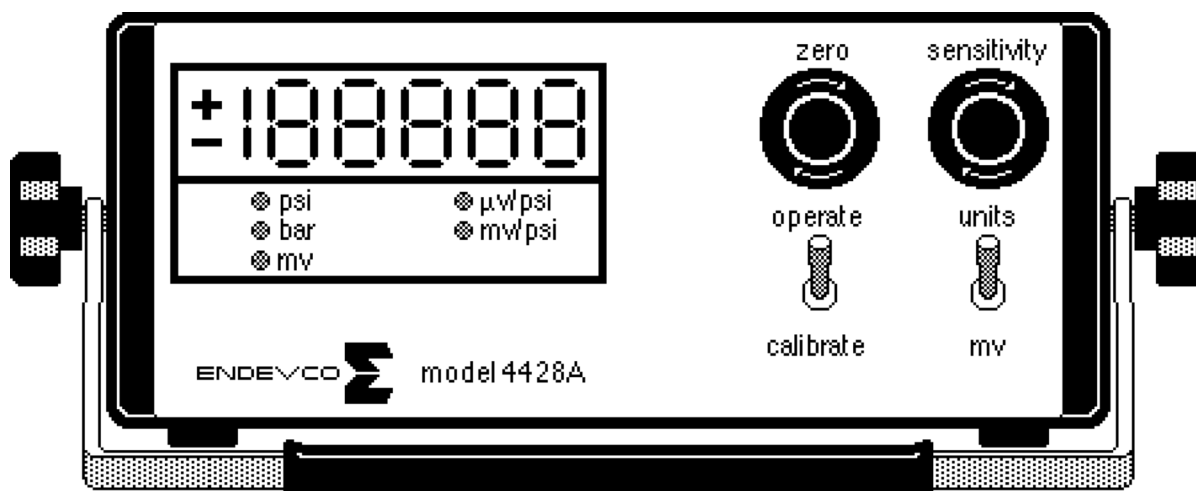


Figure 1-1. Model 4428A Pressure Indicator Minisystem

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2. FEATURES

The following features make the Model 4428A simple to operate, easy to calibrate, and user friendly.

- * Large (1/2" high) 7-segment digital display characters for easy readout observation.
- * All calibration and operation controls are easily accessible on the front and rear panels. No internal adjustments, calibrations, or alignments are required.
- * ZERO and SENSITIVITY adjustment potentiometers are lock protected against accidental movement after calibration settings have been made.
- * Switch selectable digital display mode for units or mV readout of the input signal.
- * Eleven full scale ranges (1 psi to 20 k psi), thumb wheel selectable from the back panel.
- * Convenient (5 V full scale) analog output signal available from a BNC rear panel connector.
- * AC main power input switch selectable (screwdriver slide switch) for 115 or 230 VAC operation.
- * 5-Pin Lemo connector furnished with unit for easy transducer connection to rear panel input terminal.
- * Housing case handle doubles as stand which locks position to allow selection of viewing angles of the digital display.

3. SPECIFICATIONS

The following specifications for the Model 4428A assume that the unit has been plugged into the proper AC power source and allowed to warm up for a minimum of 10 minutes (30 minutes to guarantee all specifications).

A. INPUT CHARACTERISTICS

Connection Type	Fully differential. Signal ground isolated from case ground.
Differential Resistance	>1000 M Ω
Common Mode Rejection	>60 db with <1000 ohms input and imbalance at < 100 Hz with gain set to 50 and measured at the analog output.
Source Resistance	300 to 3000 Ω
Transducer Excitation	10.0 V or 15.0 V +0.005 V, rear panel selectable
Transducer Excitation Voltage Stability	± 20 PPM/ $^{\circ}$ C max. Within 250PPM for 3 months at 25 $^{\circ}$ C \pm 5 $^{\circ}$ C.

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Transducer Excitation
Current

30 mA max., limited at <50 mA.

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B. OUTPUT CHARACTERISTICS

Analog Connection	Single sided. One side connected to ground.
Analog Impedance	100 Ω max.
Analog Voltage	5 V full scale. Linear to 10 V.
Analog Current	5 mA min. to 30 kHz.
Analog Noise	<400 μ V rms at a gain of 50 and < 5 mV peak-to-peak (0.1 Hz to 100 kHz).
Digital Display	4 1/2 digit LED segmented display of full scale pressure (psi or mV).
Display Noise	± 1 count at a gain of 50.

C. TRANSFER CHARACTERISTICS

Gain	10 to 100, continuously adjustable.
Gain Error	$\pm 0.5\%$ of full scale display at 25°C for 30 days max. ($\pm 0.2\%$ typical).
Gain Stability	$\pm 0.2\%$ of full scale 0° C to 55° C.
Zero Stability	$\pm 5.0 \mu$ V/° C (RTI).
Zero Adjust Range	± 30 mV min.
Frequency Response	DC to 30 kHz -5% max., -3dB @ 60 kHz or greater
Digital Amplitude Linearity	0.01% max.
Analog Amplitude Linearity	0.1% max.

D. POWER REQUIREMENTS

AC Input Power	Selectable on back panel as: 115 VAC +10% 50-60 HZ, or 230 VAC +10% 50-60 HZ
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E. ENVIRONMENT

Operating Temperature	0° C to +55° C
Storage Temperature	-40° C to +85° C
System Warm Up Time	30 minutes to guarantee all spec's.

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4. ACCESSORIES SUPPLIED

The following accessories are supplied with the Model 4428A.

One, power cord, p/n EW599 (115 VAC), or p/n EW599V (230 Vac).
One, 5-pin Lemo connector P/N EP531.

5. RECOMMENDED CALIBRATION TEST EQUIPMENT

Table 1-1 lists the recommended test equipment and accessories referenced in this manual. Equivalents are acceptable.

<u>QTY.</u>	<u>MODEL NO.</u>	<u>DESCRIPTION</u>	<u>MANUFACTURER</u>
1	8375A	Digital Voltmeter (DVM)	Fluke
1	2213	Oscilloscope	Tektronix
4	RN55C1001F or 0309-1001	1k ohm, 1/4 W, 0.1% resistors, matched to within 0.1% each.	RCD Components or Endevco

Table 1-1. List of Recommended Test Equipment and Accessories

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SECTION 2: CONTROLS AND INDICATORS

1. INTRODUCTION

This section describes the controls, indicators, and connectors mounted on the front and rear panels of the Model 4428A Pressure Indicator.

Figure 2-1 shows the front and rear panels with each control, indicator, or connector identified with an assigned mnemonic. These mnemonics are listed under an ITEM column in Table 2-1 where each control, indicator, or connector is described and its function is identified.

<u>ITEM</u>	<u>PANEL</u>	<u>DESCRIPTION</u>	<u>FUNCTION</u>
R1	Front	ZERO - 10 revolution vernier potentiometer with lock knob.	Adjusts the input for zero volts +30 mV.
R2	Front	SENSITIVITY-10 turn vernier potentiometer lock knob.	Allows adjustment of the input sensitivity during with instrument calibration. While adjusting input sensitivity, the gain is automatically adjusted to provide a 5 volt full scale analog output.
S3	Front	OPERATE/CALIBRATE - a two position toggle switch that is spring loaded to stay in OPERATE position.	Normally selects OPERATE position and can be held in CALIBRATE position when adjusting the input sensitivity by the SPAN potentiometer (R2).
S4	Front	Units/mV - a two-position toggle switch.	Selects whether the LED display is in pounds-per-square-inch (psi), bars or millivolts (mV)>.
DS1	Front	A 4 1/2 digit display with 7-segment LED characters.	Displays full scale pressure in psi or mV.
S2	Rear	230V/115V - Recessed, screw driver notched, slide switch.	Selects main AC poser to be connected to P1 as either 230 or 115 VAC.
F1	Rear	FUSE - Twist-cap, fuse holder and fuse.	Main AC power fuse. 1/4 amp for 115 VAC and 1/8 amp for 230 VAC (fast-blo only).
P1	Rear	POWER - 3-prong, recessed, male connector.	Main AC power input connector.
J2	Rear	GRN/WHT/RED/BLK - 5-pin, Lemo or equiv. connector.	Input connection for transducers under test or precision resistors during calibration.
S1	Rear	16 position thumb-wheel sw.	Selects one of fifteen input full scale psi ranges for the transducer selected as shown in the following table. One position of the thumbwell switch is not used (15).
S1 SETTING		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14	
FULL SCALE PSI RANGE PSI		1 2 5 10 15 20 50 100 200 500 1k 2k 5k 10k 20k	
J1	Rear	Analog output.	Provides ±5.0 volt analog output at full range output of transducer.

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S5	Rear	Excitation adjust.	Permits excitation of 10.0 Vdc or 15.0 Vdc.
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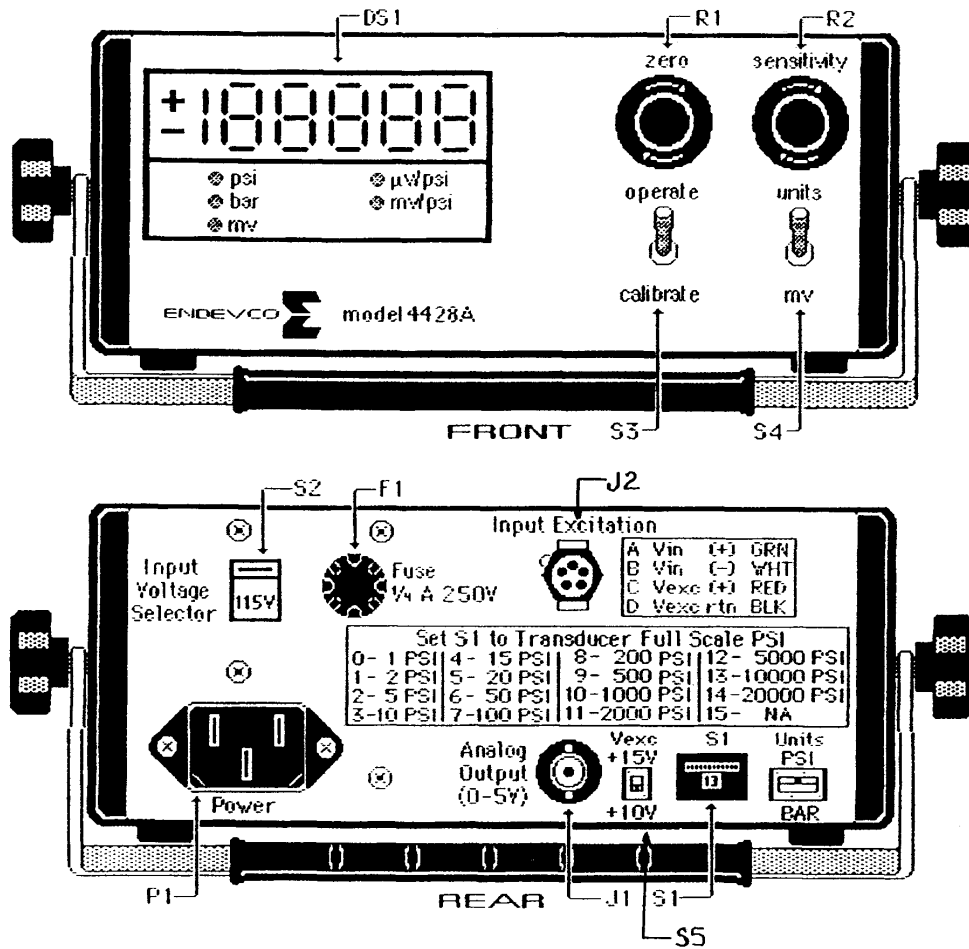
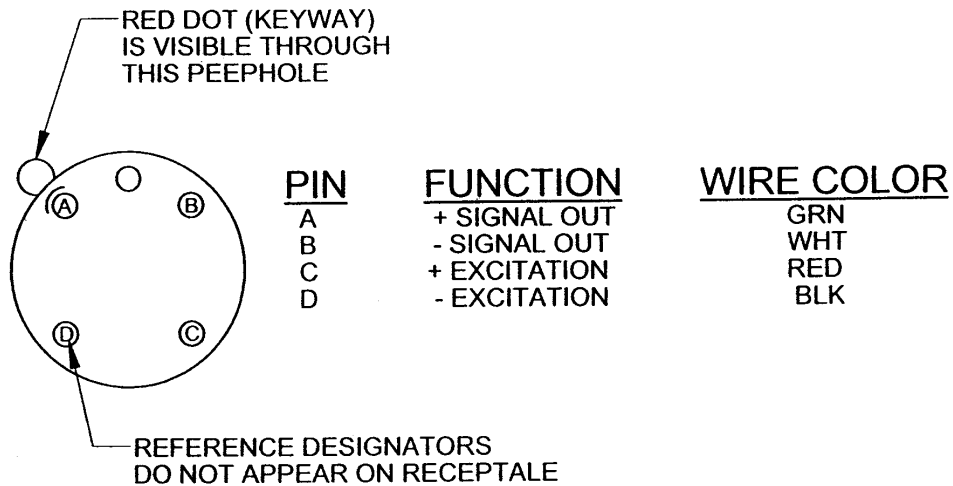


Figure 2-1. Model 4428A Front and Rear Panels



DETAIL OF J2

Figure 2-1. Model 4428A Front and Rear Panels

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**SECTION 3:
INSTALLATION AND CHECKOUT**

1. INTRODUCTION

This section contains information on the incoming inspection, installation, and checkout of the Model 4428A Pressure Indicator.

Careful adherence to the procedures discussed in this section will ensure proper operation and accurate test readings obtained from the Model 4428A Pressure Indicator.

2. UNPACKING AND INSPECTION

The Model 4428A Pressure Indicator has been thoroughly tested at the factory before shipment and should be ready for operation when received. However, an inspection should be made to ensure that no damage occurred during shipment. Any obvious damage should be immediately reported to the carrier and no attempt should be made to operate the equipment. Also, carefully compare each item shipped in its packing box against the Packing List and notify the factory if any discrepancies are discovered.

3. INSTALLATION

Installation of the Model 4428A Pressure Indicator is extremely easy since it has been designed with no internal calibration or configuration adjustments and it has an internal regulated power supply so that no external power source, other than main AC power is required.

A. AC POWER SOURCE/CORD

The Model 4428A has been designed to operate with nominal AC power source voltages of 115 VAC or 230 VAC depending upon the setting of the POWER selection switch (S2) on the back panel.

If not specified otherwise in the order, the Model 4428A is shipped from the factory with S2 set for 115 VAC and a power cord with a three blade, female connector on one end and a U.S. standard three prong, male connector on the other end (p/n EW599). SWITCH S2 SHOULD BE SET TO 115V.

If, however, 230 VAC operation is required, the Model 4428A is shipped with the POWER selection switch set accordingly and a power cord with the three blade female connector on one end and no plug on the other end (p/n EW599V).

The wires at the end with no connector are stripped and tinned for installation of an appropriate AC outlet plug.

For 230 VAC operation of the Model 4428A Pressure Indicator, it is necessary to obtain the proper AC power cord plug from a local supplier and install the plug in accordance with local codes as follows: Brown wire = AC hot line, Blue wire = AC common line, Green wire = earth ground. CHECK THE SETTING OF SWITCH S2. IT SHOULD BE SET FOR 230V.

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CAUTION: REGARDLESS OF THE POWER SOURCE TO BE USED, DO NOT PLUG THE AC CORD INTO A TWO PRONG OUT-LET UNLESS A THIRD WIRE GROUND ADAPTER IS USED. DO NOT, IN ANY WAY, DEFEAT THE 3-WIRE FUNCTION.

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B. TEST SET UP PLANNING

Before beginning with the system checkout procedures or attempting actual pressure measurements, you should be thoroughly familiar with the controls and indicators, as well as the signal levels the Model 4428A Pressure Indicator will be receiving and transmitting. Complete knowledge of the Model 4428A now, will ensure that meaningful data will be obtained later. It is recommended that Sections 1 through 4 of this manual (with special attention being given to the SPECIFICATIONS in Section 1) be understood before attempting any checkout tests or actual accelerometer measurements.

C. CHECKOUT OF THE MODEL 4428A

NOTE: These procedures need only be run as an initial checkout of the Model 4428A or if the Model 4428A has not been used for an extended period of time and therefore, verification of proper operation is desirable.

The Model 4428A has been designed to be self contained and simple to operate. There are very few calibration adjustments required for using the Model 4428A in a Model 8500 series pressure transducer environment. However, the following simple checkout test procedure should be run as part of the INSTALLATION procedures to ensure that the Model 4428A is operating as designed and has not encountered any damage during shipment.

- 1) Check the setting of the POWER selection switch (S2) to be certain that it agrees with the AC power source voltage to be applied. If the switch setting does not agree with the power source voltage, use a narrow blade screw driver to slide the switch to the proper setting.
- 2) Locate four precision 1k ohm, 1/4 W, 0.1% resistors, (ENDEVCO p/n 0329-1001, or equivalent) and connect them to the input terminal strip as shown in Figure 3-1. These resistors must be matched with each other to within 0.1%. The resistor leads are slipped into the terminal strip square openings and then secured by screwing the terminal lugs in until tight.
- 3) Plug the female connector of the AC power cord into P1 on the back panel of the Model 4428A and the other end of the cord into the proper AC power source.
- 4) The LED display (DS1) on the front panel should light, displaying numbers whose least-significant-digit is constantly changing. At this point in the procedures, it is not important what digits appear on the display.
- 5) Let the Model 4428A warm up for at least 10 minutes (30 minutes to guarantee all specifications) before continuing with the checkout procedures.
- 6) After the allowed warm up time, set the Units/mV switch on the front panel (S4) to units and the full scale range selection thumbwheel switch (S1) on the back panel to 0. Set PSI/BAR switch on back panel to PSI.

NOTE: In the following steps where the front panel potentiometers are being adjusted, if the knob does not want to turn the LOCK knob is engaged and must be turned to the counter-clockwise position to disengage the lock.

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- 7) Check that the SENSITIVITY potentiometer (R2) on the front panel is set to the fully counter-clockwise position and adjust the ZERO potentiometer (R1) until the display reads 0.000 (+001). Lock the R1 potentiometer knob at this setting with the LOCK knob.
- 8) Change the settings of the full scale range selection thumbwheel switch (S1) on the back panel to 1, and then 2, 3, etc., until 14 is reached while observing the display. The display should read within $\pm 0.5\%$ of full scale ranges in PSI which is set by switch (S1) on the rear panel.

NOTE: Thumbwheel setting number 15 is not used by the Model 4428A and therefore will result in an unbalanced input producing random and erroneous reading on the display.

When these steps have been successfully completed, you can be confident that the bridge balance circuitry within the Model 4428A is functioning properly.

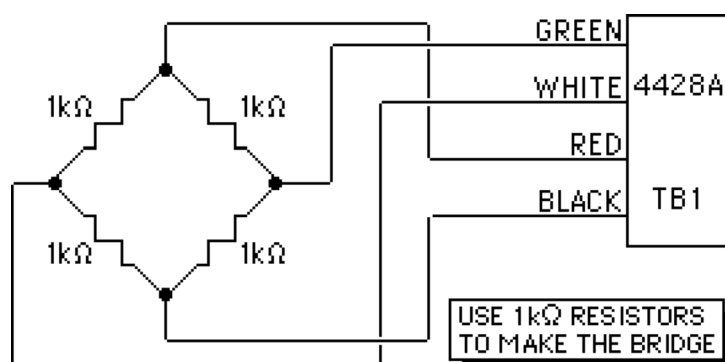


Figure 3-1. Balanced Bridge Simulation Circuit

D. TEST

The following steps will ensure that the input sensitivity and calibration circuitry are functioning properly.

- 1) Leave the precision resistors installed on the input terminals, S4 set to PSI, R1 LOCKED as before, R2 fully counter-clockwise, and set S1 to 0.
- 2) Press and hold down the OPERATE/CALIBRATE switch (S3) and observe a reading of 100 or less on the display.
- 3) While still holding down S3, turn the SENSITIVITY potentiometer (R2) clockwise until it stops. Observe that the display increases in value to a final 400 or greater.
- 4) Still holding down S3, set SENSITIVITY (R2) for a reading of 300 on the display.
- 5) Release S3, then turn the ZERO potentiometer (R1) as far as it will go counter-clockwise while observing the display. When R1 stops, the display will show a number from -0.1 to 0.0.

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- 6) Again adjust R1 (ZERO) full clockwise. The display will show a number from 0.0 to +0.1.

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- 7) Adjust the ZERO potentiometer (R1) for a reading of 0.000 (+001).
- 8) Press and hold down the CALIBRATE switch and observe a reading on the display of approximately 300.
- 9) While still holding down the CALIBRATE switch, change the S1 thumbwheel switch to 1, then 2, etc., and notice that the display changes with each new S1 setting as shown in table 3-1. Notice also, if the CALIBRATE switch is released (OPERATE mode), the ZERO value displayed also changes with each setting of switch S1.

S1 SETTING	FULL SCALE PSI	R2 (SENS) CENTER	< LOW	> HIGH	R1 (ZERO) RANGE +15% F.S.
0	1	300	200	400	± 0.15
1	2	150	100	200	± 0.300
2	5	60	40	80	± 0.75
3	10	30	20	40	± 1.5
4	15	20	13.3	26.7	± 2.25
5	20	15	10	20	± 3.00
6	50	6	4	8	± 7.50
7	100	3	2	4	± 15.0
8	200	1.5	1.0	2.0	± 30.0
9	500	0.6	0.4	0.8	± 75.00
10	1K	0.3	0.2	0.4	± 150.0
11	2K	0.15	0.1	0.2	± 300.0
12	5K	*60	*40	*80	± 750.0
13	**10K	*30	*20	*40	**± 1500
14	**20K	*15	*10	*20	**± 3000

Table 3-1. S1 Setting Versus R2 (SENS) and R1 (ZERO) Readings

* Displayed in microvolts/psi

** Displayed with dummy zero

- 10) With the SENS potentiometer set at mid range (300 mV/psi when S1 is set to 0), use an oscilloscope to measure the noise level at the ANALOG output connector. The noise level should be < 400 μ V rms and any noise spikes observed should be < 5 mV peak-to-peak (0.1 Hz to 100 kHz).

4. SUMMARY

These procedures have accomplished the following as a preliminary checkout of the Model 4428A Pressure Indicator:

- You can be confident that the calibration circuitry is functioning properly,

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- You can be confident that the input sensitivity adjustment circuitry is functioning within specifications, and

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- You have established that the gain circuitry in the Model 4428A is operating to specifications.

Another benefit can be gained from these checkout procedures. An explanation, at this point, as to exactly what was happening when the R1 and R2 potentiometers were adjusted will be helpful in understanding the operation procedures to be discussed in the next section of this manual.

Adjusting R1 (ZERO) for a display of zero was really balancing the bridge network to a zero reference for the voltage differential between the inverting and non-inverting inputs from the transducer.

Adjusting R2 (SENSITIVITY) from minimum to maximum was really changing the input sensitivity setting while at the same time changing the gain of the Model 4428A from a maximum of 50 to a minimum of 25. When observing the display while holding down the CALIBRATE switch, you were reading the input sensitivity setting in mV/psi.

You observed, during these checkout procedures, the interactive relationship between changes to the SENSITIVITY and the affects on the zero reference setting. Also demonstrated was, how changing of the full scale ranges with S1 affects the input sensitivity range selected by R2 (SENSITIVITY) but does not affect the R1 (ZERO).

As the final portion of the initial checkout procedures, use the DVM to measure the transducer excitation voltage as following:

- A. Place the negative lead of the DVM on the BLK terminal and the positive lead of the DVM on the RED terminal.
- B. Read a voltage of 10 VDC (± 0.1). This measurement represents the +5 volt range of each leg of the balanced bridge.

Make certain that the following items are available, as preparation for actual balanced bridge transducer testing using the Model 4428A.

- A. RECOMMENDED TEST EQUIPMENT listed in Section 1.
- B. All required cabling from the transducer test bed and to the recommended test equipment.
- C. Calibration record card supplied with the transducer.

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**SECTION 4:
OPERATION AND THEORY**

1. INTRODUCTION

This section of the manual discusses the operation of the Model 4428A and presents typical preparation procedures when using a Model 8500 series pressure transducer with the Pressure Indicator.

In order for the discussion of a typical operation to have more meaning it will be helpful to first discuss the internal functional operation of the Model 4428A. A simplified block diagram level explanation of the Model 4428A is therefore given first.

2. THEORY OF OPERATION

Figure 4-1 shows a simplified block diagram layout of the Model 4428A. In this diagram, only the main functional elements of the Model 4428A are shown. It is these main elements that are discussed in the following paragraphs. They are:

Excitation Voltage Source

Differential Input Amplifier

Bridge Balance Circuit (ZERO Adjustment)

Buffer Stage

A/D Converter and Display Logic, Digital Display

Gain Amplifier and Output Buffer

Gain/Calibration Control (SPAN Adjustment)

Full Scale Range Circuit

A. EXCITATION VOLTAGE SOURCE

This circuit maintains a constant 10 Vdc (+0.1) transducer excitation voltage that is supplied to the RED (+) and BLK (-) terminals of J2 on the back panel.

B. DIFFERENTIAL INPUT AMPLIFIER AND BUFFER STAGE

The two inputs of this differential amplifier circuit are connected to the full bridge pressure transducer outputs through the GRN (+) and WHT (-) terminals of TB1. It is these input signals that are analyzed, amplified, displayed, and output by the Model 4428A. A resistive feedback circuit (the ZERO front panel potentiometer) from the output to the (+) input of the differential amplifier balances the bridge input and allows for zero input adjustment during calibration.

The output of the differential amplifier is connected to a buffer stage that has a split output.

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C. A/D CONVERTER AND DISPLAY LOGIC

One output of the buffer stage is connected to an analog-to-digital (A/D) converter. The analog signal from the output of the differential amplifier is converted to a digital value which is then fed to the digital display logic and is displayed by the 4 1/2 digit LEDs.

D. DIGITAL DISPLAY

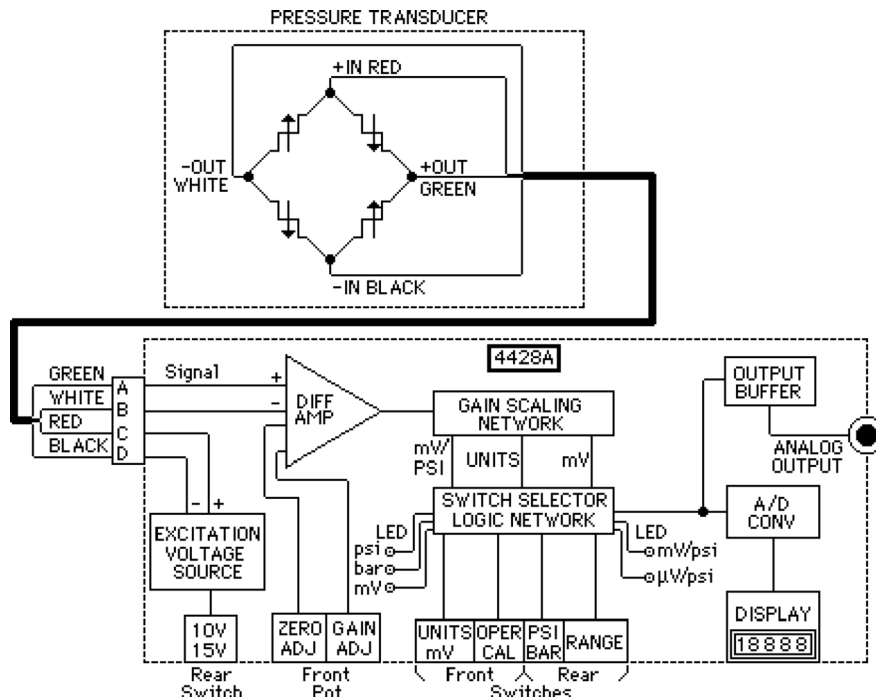
The digital display is a 4 1/2 digit, 7-segment, LED display with floating decimal point and + notation. In OPERATE mode this display shows the output of the transducer (GRN and WHT leads) after the output of the differential amplifier in psi or mV as selected by the front panel switch S4. In CALIBRATE mode the display shows the input sensitivity setting selected by the full scale range switch S1 and the SPAN potentiometer.

E. GAIN AMPLIFIER AND OUTPUT BUFFER

The other output of the buffer stage is connected to a gain amplifier and output buffer stage that supplies a 5 volt, full scale, analog voltage to the output at J1. A resistive feedback stage controls the gain of this amplifier and the input to the buffer stage from the differential amplifier.

F. GAIN/CALIBRATION CONTROL (SPAN ADJUSTMENT)

The front panel SPAN potentiometer adjusts the gain of the gain amplifier over a range of 25 to 50. At the same time, this pot is also adjusting the input sensitivity level at the differential amplifier. This input sensitivity level, in mV/psi, is displayed when the OPERATE/ CALIBRATE switch is held in the CALIBRATE position. This gain control circuit interacts with the full scale range circuit to set the input sensitivity level to match the transducer used in the tests and also set the gain to provide a 5 volt analog output at J1.



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Figure 4-1: Model 4428A Simplified Block Diagram

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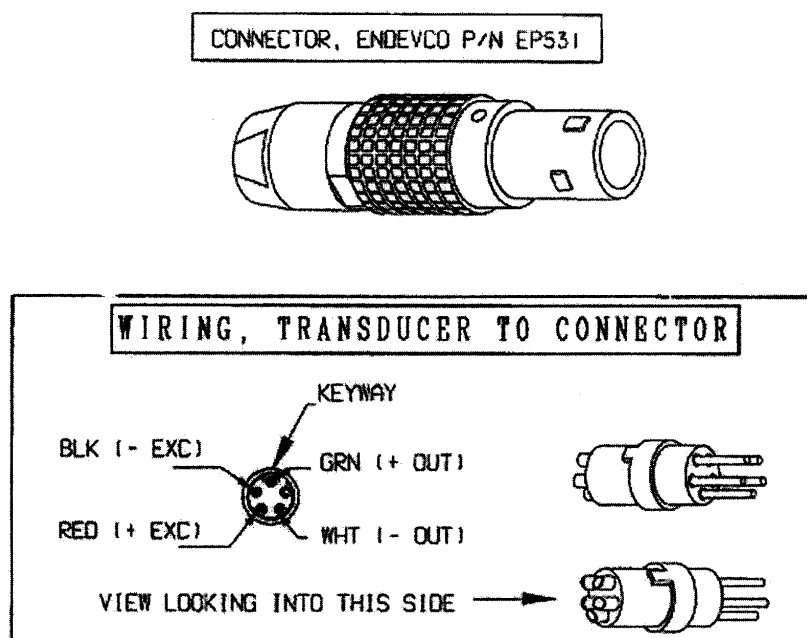
3. OPERATION

Before actually running a functional test, it is necessary to prepare the transducer cable leads, connect all test equipment as required, connect the transducer to the Model 4428A TB input terminal, and calibrate the Model 4428A.

A. PREPARING THE TRANSDUCER LEADS

Attach the wires to the sockets in the following order: BLK (-OUT), RED (+OUT), WHT (-IN), GRN (+IN), reading counter clockwise.

NOTE: Green wire is soldered into keyway socket.



B. CONNECTING ALL REQUIRED TEST EQUIPMENT

As a minimum you will want an oscilloscope and DVM connected to the Model 4428A ANALOG OUTPUT J1. Connect a single coaxial cable to J1 and use a coaxial tee at the input of the DVM or oscilloscope to connect the other device.

Make certain that all equipment required for the test bed set up are available, interconnected, and turned on if long warm up times are required.

C. CALIBRATING THE MODEL 4428A

When all connections have been made, plug the Model 4428A into the AC power source and allow it to warm up for at least 10 minutes (30 minutes to guarantee all specifications). During this warm up period, locate the Endevco Model 8500 series transducer (or its equivalent) specification calibration sheet. This sheet will define the Full Scale Range of the transducer and the Sensitivity specifications (in mV/psi). When this information has been located on the specification sheet, and the Model 4428A has warmed up for at least 30 minutes, do the following steps to calibrate the system:

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- 1) Set the S1 thumbwheel on the back panel to the number that corresponds to the full scale range of the transducer,

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- 2) Press down and hold the CALIBRATE switch to observe numbers on display panel,
- 3) Adjust the SPAN potentiometer (R2) until the display reading agrees with the sensitivity (in mV/psi) on the transducer specification sheet,
NOTE: As an example, an Endevco transducer with a full scale range of 2 psi would show a sensitivity rating of 150 mV/psi + 50 mV. For this transducer you would set the thumbwheel S1 to 0 and the SPAN potentiometer would be adjusted to show a reading of 150 on the display panel of the Model 4428A.
- 4) When the sensitivity reading has been set by the SPAN potentiometer, lock the knob by turning the inner ring as far as it will go to the right (clockwise).
- 5) With the OPERATE/CALIBRATE switch released (OPERATE mode), adjust the ZERO potentiometer until the display reads as close to all zeros as can be achieved. The three MSD must be zero and the LSD should be flashing around zero +1.
- 6) When satisfied that the best zero setting has been reached, lock the ZERO knob in the same manner as was used earlier for the SPAN knob.

This completes the calibration procedures for the Model 4428A. After running any functional test and collecting the data, the calibration procedures should be performed again to instill confidence in the data gathered.

D. FURTHER INFORMATION

After completing all operation preparation procedures and the calibration procedures, you are ready to run actual functional tests. If you are not familiar with the disciplines of pressure testing using piezoresistive transducers, there are several Endevco Technical Papers available which can be requested through any Endevco Sales Office or the San Juan Capistrano Corporate Office or from the Endevco website www.endevco.com (after you register). (Offices are listed on a separate insert sheet at the back of this manual.) The following Endevco Technical Papers are recommended:

- 1) TP268 - Compendium on Endevco Diffused Piezoresistive Transducers.
- 2) TP269 - Measurement of Local Pressures Resulting From Hydrodynamic Impact.
- 3) TP277 - Basic Advantages of the Anisotropic Etched, Transverse Gage Pressure Transducer.
- 4) TP280 - Application of Silicon Strain Gauge Technology to Aerospace Acceleration and Pressure Measurements.
- 5) TP281 - Miniature Pressure Transducers for Use to 300°C. As a further aid in planning a functional test set up, Figure 4-2 shows a typical stress analysis test bed set up using Model 8500 series Endevco Pressure Transducers and the Model 4428A. In this figure, actual transducer numbers are used, the full scale range numbers and input sensitivity are identified, and the Model 4428A switch setting is noted.

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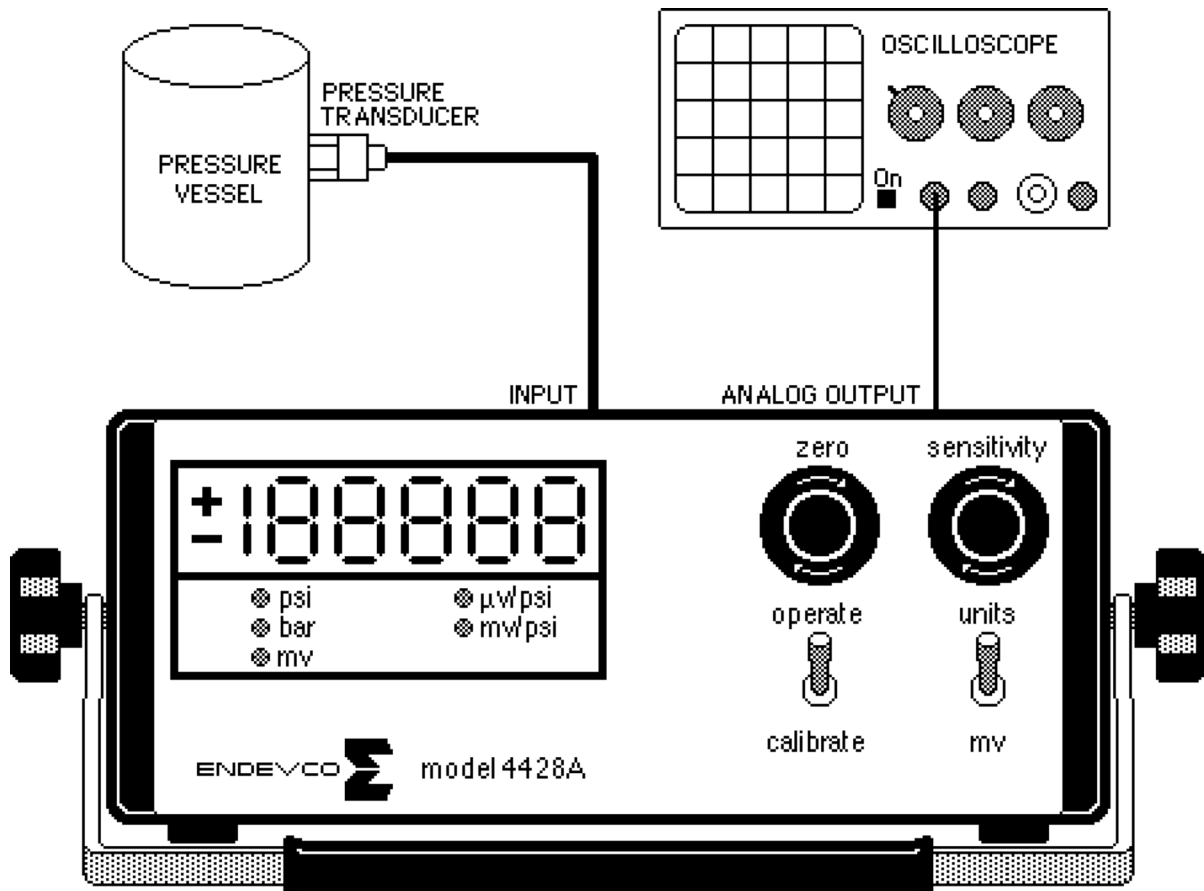


Figure 4-2. Typical Pressure Analysis Test Set Up