# ICP® FORCE SENSOR

## OPERATING MANUAL

Model 208 B02 & B03

****** CAUTION ******

Use sensor with PCB Power Supply or PCB-approved equal.

Damage to built-in amplifier by incorrect power is not covered by warranty.

A data sheet on standard PCB power supplies, available from stock, is included in back of manual.

PCB PIEZOTRONICS

PCB PIEZOTRONICS, INC. 3425 WALDEN AVENUE DEPEW, NY 14043-2495 PHONE 716-684-0001 FAX 716-684-0987

208 B02 + B03

PCB®
PIEZOTRONICS

# PREFIX GUIDE

REVISIONS
8/95 - TMS

SHEET 1 OF 1

## Letter Prefix Codes for Product Model Numbers
### (define options and system kits)

Letter prefixes often appear in model numbers of PCB products. These prefixes refer to various options available with standard products. More than one prefix may appear in a product model number, for example: HSM113A21 (Model 113A21 pressure sensor with 'H' hermetic seal, 'S' stainless steel diaphragm and 'M' metric mounting thread). Letter prefixes may also indicate a sensor is being supplied in a system kit with power unit, cables and accessory hardware items - complete, ready to connect and operate (e.g: K353B01 accelerometer kit includes sensor, battery powered signal conditioner, cables and accessories).

| PREFIX | DESIGNATION |
|---|---|
| A | Adhesive mount version of sensor. Supplied with mounting base, Petro Wax and "quick bonding" gel. (Miniature accelerometers have the integral stud removed.) |
| B | Low bias sensor for reduced voltage and current levels (e.g. B353A04) |
| D | Dummy sensor for display purposes (e.g. D339A01) |
| DKL | 484B06 line power supply with DC coupling sensor kit (e.g. DKL208A05) |
| E | Emralon coated sensor for ground isolation or corrosion resistance. |
| F | Operates with 210V to 240V (50 to 500 Hz) line power (e.g. F482A16) |
| FM | Factory Mutual Approved (Intrinsically safe.) (e.g. FM328D04) |
| GK | 480E09 battery power supply with gain x1, x10, x100 sensor kit (e.g. GK302B) |
| GKL | 482B11 line power supply with gain x1, x10, x100 sensor kit (e.g. GKL338A04) |
| GKR | Rechargeable 480E09 w/NiCad batteries and 488A02 charger sensor kit |
| GDKL | 484B11 line power ( DC coupling and gain x1, x10, x 100) sensor kit |
| H | Hermetically sealed sensor (e.g. H112A) |
| J | Ground Isolated - Single Axis accels with 10-32 tapped hole (e.g. J353B33)<br>Ground Isolated - Integral stud types (e.g. J353B68) |
| K | 480C02 battery power supply sensor kit (e.g. K359B33) |
| KL | 482A06 basic line power supply sensor kit (e.g. KL338A35) |
| KR | Rechargeable 480C02 w/NiCad batteries and 488A02 Charger sensor kit |
| M* | Metric mounting thread or metric adaptor stud (e.g. M338A24) |
| N | Negative polarity output |
| P | Positive polarity output |
| Q | Extended time constant. (≥10 DTC) for low frequency and/or shock applications |
| R | Recharge option. Includes 488A02 Charger and NiCad batteries (e.g. R480E06) |
| S | Stainless steel diaphragm (e.g. S112A) |
| T | Momentum trap for some pressure transducers (e.g. T102A). Acts as a stress wave absorber to prevent connector damage. |
| U | Useable demonstration sensor. (Performance does not meet specifications) |
| V | Indicates version of a standard model number (e.g. V337D22/050-C is a Model 337D22 with a 50 ft integral cable terminating in a BNC Plug) |
| W | Waterproof cable attachment. (e.g. W353B41/002A100C is a 100 ft. type 002 cable with a standard 10-32 coaxial plug sealed to the sensor and terminates as a BNC plug.) |

NOTE: Prefixes including the letter 'K' are transducer and power kits supplied with a 10 ft. input cable, power unit with 3 ft. output cable terminating in BNC and vinyl kit storage case. Input cable lengths up to 50 ft. of cable styles 002, 007, 012, 015 and 031 may be specified at no additional charge.

* When the letter 'M' appears in the middle of a model number, it designates a special or modified version of a standard product (e.g: 353M204)

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# SPECIFICATIONS

## Voltage Output Force Transducer

**Model No.**
**208B02**

**Revisions**
**-A- Rev # 5527**
DM 1/2/95

| | | | | |
|---|---|---|---|---|
| **DYNAMIC PERFORMANCE** | | | | |
| Range: | Compression | lb [kN] | 100 [0,4448] | |
| | Tension | lb [kN] | 100 [0,4448] | |
| Maximum Force: | Compression | lb [kN] | 1000 [4,448] | |
| | Tension | lb [kN] | 500 [2,224] | |
| Resolution | | lb [kN] | 0.002 [8,896 E-6] | |
| Sensitivity | | mV/lb [mV/kN] | 50 [11 241] | |
| Resonant Frequency | | kHz | 70 | [5] |
| Rise Time | | µ sec | 10 | |
| Discharge Time Constant | | sec | ≥500 | [1] |
| Low Frequency Response (-5%) | | Hz | 0.001 | [3] |
| Amplitude Non-Linearity | | % F.S. | 1 | [2] |
| Stiffness | | lb/µin [kN/µm] | 10 [1,75] | |
| **ENVIRONMENTAL** | | | | |
| Temperature Range | | °F [°C] | -65 to +250 [-54 to +121] | |
| Temperature Coefficient | | %/°F [%/°C] | ≤0.03 [≤0,054] | |
| Vibration | | ±g pk [±m/s² pk] | 2000 [19 620] | [4] |
| Shock | | ±g pk [±m/s² pk] | 10000 [98 100] | [4] |
| **ELECTRICAL** | | | | |
| Full Scale Output | | + volt | 5 | [6] |
| Output Impedance | | ohm | ≤100 | |
| Output Bias | | + volt | 8 to 14 | |
| Excitation: | Voltage | + VDC | 24 to 27 | |
| | Constant Current | mA | 2 to 20 | |
| Polarity | | compression | Positive | |
| Ground Isolation | | ohms | | |
| **MECHANICAL** | | | | |
| Dimensions | | in [mm] | 0.625 x 0.625 [15,88 x 15,88] | |
| Weight | | oz [grams] | 0.93 [26] | |
| Housing | | material | Stainless Steel | |
| Connector | | type | 10-32 Coaxial Jack | |
| Connector Orientation | | position | Side | |
| Mating Connector Required | | type | 10-32 Coaxial Plug | |
| Sealing | | type | Epoxy | |

**NOTES:**

[1] At room temperature.
[2] Zero based best straight line.
[3] Calculated from discharge time constant.
[4] Maximum without mass load.
[5] Measured, mounted and unloaded.
[6] At specified measurement range.

**SUPPLIED ACCESSORIES: English Installation**

Model 081B05 Mounting Stud (2)
Model 084A03 Impact Cap (1)
Model 080A81 Thread Locker (1)

**SUPPLIED ACCESSORIES: Metric Installation**

Model M081B05 Mounting Stud (2)
Model 084A03 Impact Cap (1)
Model 080A81 Thread Locker (1)

| | | | |
|---|---|---|---|
| Drawn | [signature] | FEB 1, '95 | Spec No. 2244 |
| Engineer | [signature] | 2-1-95 | |
| Sales | [signature] | 2-1-95 | |
| Approved | EJL | 2-2-95 | Sheet 1 of 1 |

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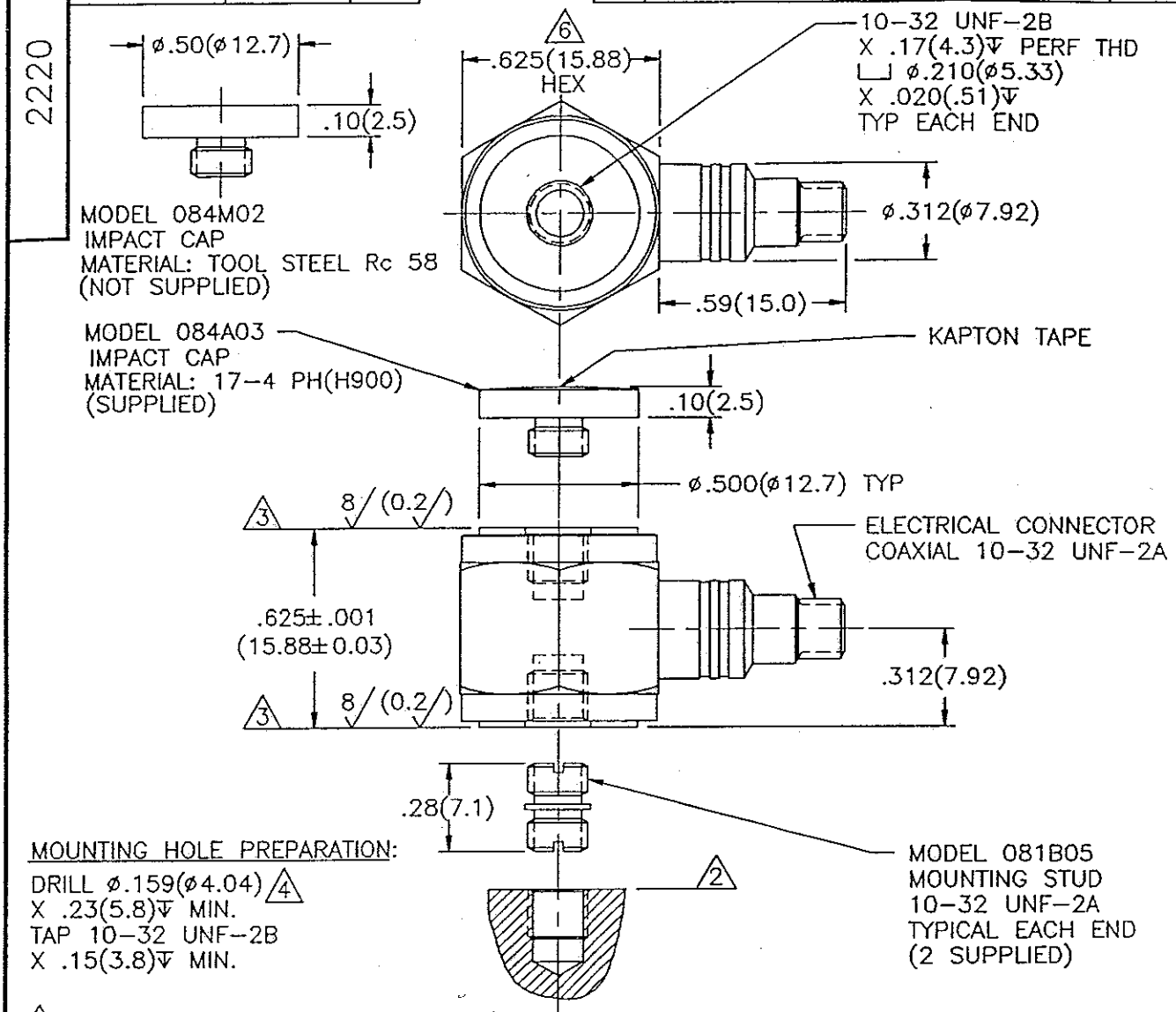
| APPLICATION | | |
|---|---|---|
| NEXT ASS'Y | USED ON | VAR |
| | | |

| REVISIONS | | | | |
|---|---|---|---|---|
| REV | DESCRIPTION | ECN | DATE | APP'D |
| 1 | | | | |




MOUNTING HOLE PREPARATION:
DRILL ø.159(ø4.04) 4
X .23(5.8)↧ MIN.
TAP 10-32 UNF-2B
X .15(3.8)↧ MIN.

6 MOUNTING TORQUE ON .625(15.88) HEX, 16-20 INCH POUNDS (181-226 NEWTON CENTIMETERS).

5.) COMPRESSIVE FORCE ON CELL YIELDS POSITIVE OUTPUT VOLTAGE.

4 DRILL PERPENDICULAR TO MOUNTING SURFACE TO WITHIN ± 1°.

3 THESE SURFACES GROUND FLAT AND PARALLEL TO WITHIN .001(0.03) TIR.

2 MOUNTING SURFACE TO BE FLAT TO WITHIN .001(0.03) TIR WITH A MIN 125/(3.2/).

1.) CASE MATERIAL-STAINLESS STEEL.

| UNLESS SPECIFIED TOLERANCES | |
|---|---|
| DIMENSIONS IN INCHES | DIMENSIONS IN MILLIMETERS (IN PARENTHESIS) |
| DECIMALS XX ±.01<br>XXX ±.005 | DECIMALS XX ±0.3<br>XXX ±0.13 |
| ANGLES ±2 DEGREES | ANGLES ±2 DEGREES |
| FILLETS AND RADII .003 - .005 | FILLETS AND RADII (0.07 - 0.13) |
| DD011 REV. NR 10/25/94 | |

| | | | | | |
|---|---|---|---|---|---|
| DRAWN | [illegible] | 1/26/95 | MFG | D.B.L. | 1/26/95 |
| CHK'D | D.M. | 1/26/95 | ENGR | [illegible] | 1-30-95 |
| APP'D | [illegible] | 1/31/95 | [illegible] | [illegible] | 1-30-95 |

TITLE: INSTALLATION DRAWING
MODEL 208B02
LOAD CELL


PCB PIEZOTRONICS, INC.
3425 WALDEN AVE. DEPEW, NEW YORK 14043
PHONE: (716) 684-0001


CODE IDENT. NO. 52681

DWG. NO. 2220

SCALE: 2X

SHEET 1 OF 1

PIEZOTRONICS

# SPECIFICATIONS

## Voltage Output Force Transducer

**Model No.** 208B03

**Revisions**

| | | | | |
|---|---|---|---|---|
| **DYNAMIC PERFORMANCE** | | | | |
| Range: | Compression | lb [kN] | 500 [2,224] | |
| | Tension | lb [kN] | 500 [2,224] | |
| Maximum Force: | Compression | lb [kN] | 5000 [22,24] | |
| | Tension | lb [kN] | 750 [3,336] | |
| Resolution | | lb [kN] | 0.01 [4,48 E-5] | |
| Sensitivity | | mV/lb [mV/kN] | 10 [2248,2] | |
| Resonant Frequency | | kHz | 70 | [5] |
| Rise Time | | µ sec | 10 | |
| Discharge Time Constant | | sec | ≥2000 | [1] |
| Low Frequency Response (-5%) | | Hz | 0.0003 | [3] |
| Amplitude Non-Linearity | | % F.S. | 1 | [2] |
| Stiffness | | lb/µin [kN/µm] | 10 [1,75] | |
| **ENVIRONMENTAL** | | | | |
| Temperature Range | | °F [°C] | -65 to +250 [-54 to +121] | |
| Temperature Coefficient | | %/°F [%/°C] | ≤0.03 [≤0,054] | |
| Vibration | | ±g pk [±m/s² pk] | 2000 [19 620] | [4] |
| Shock | | ±g pk [±m/s² pk] | 10000 [98 100] | [4] |
| **ELECTRICAL** | | | | |
| Full Scale Output | | + volt | 5 | [6] |
| Output Impedance | | ohm | ≤100 | |
| Output Bias | | + volt | 8 to 14 | |
| Excitation: | Voltage | + VDC | 24 to 27 | |
| | Constant Current | mA | 2 to 20 | |
| Polarity | | compression | Positive | |
| **MECHANICAL** | | | | |
| Dimensions | | in [mm] | 0.625 x 0.625 [15,88 x 15,88] | |
| Weight | | oz [grams] | 0.93 [26] | |
| Housing | | material | Stainless Steel | |
| Connector | | type | 10-32 Coaxial Jack | |
| Connector Orientation | | position | Side | |
| Mating Connector Required | | type | 10-32 Coaxial Plug | |
| Sealing | | type | Epoxy | |

**NOTES:**

[1] At room temperature.
[2] Zero based best straight line.
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**SUPPLIED ACCESSORIES: Metric Installation**

Model M081B05 Mounting Stud (2)
Model 084A03 Impact Cap (1)
Model 080A81 Thread Locker (1)

| | | | |
|---|---|---|---|
| Drawn | | FEB 6, '95 | Spec No. 2283 |
| Engineer | | 2-6-95 | |
| Sales | SGC | 2-6-95 | |
| Approved | EJT | 2-6-95 | Sheet 1 of 1 |

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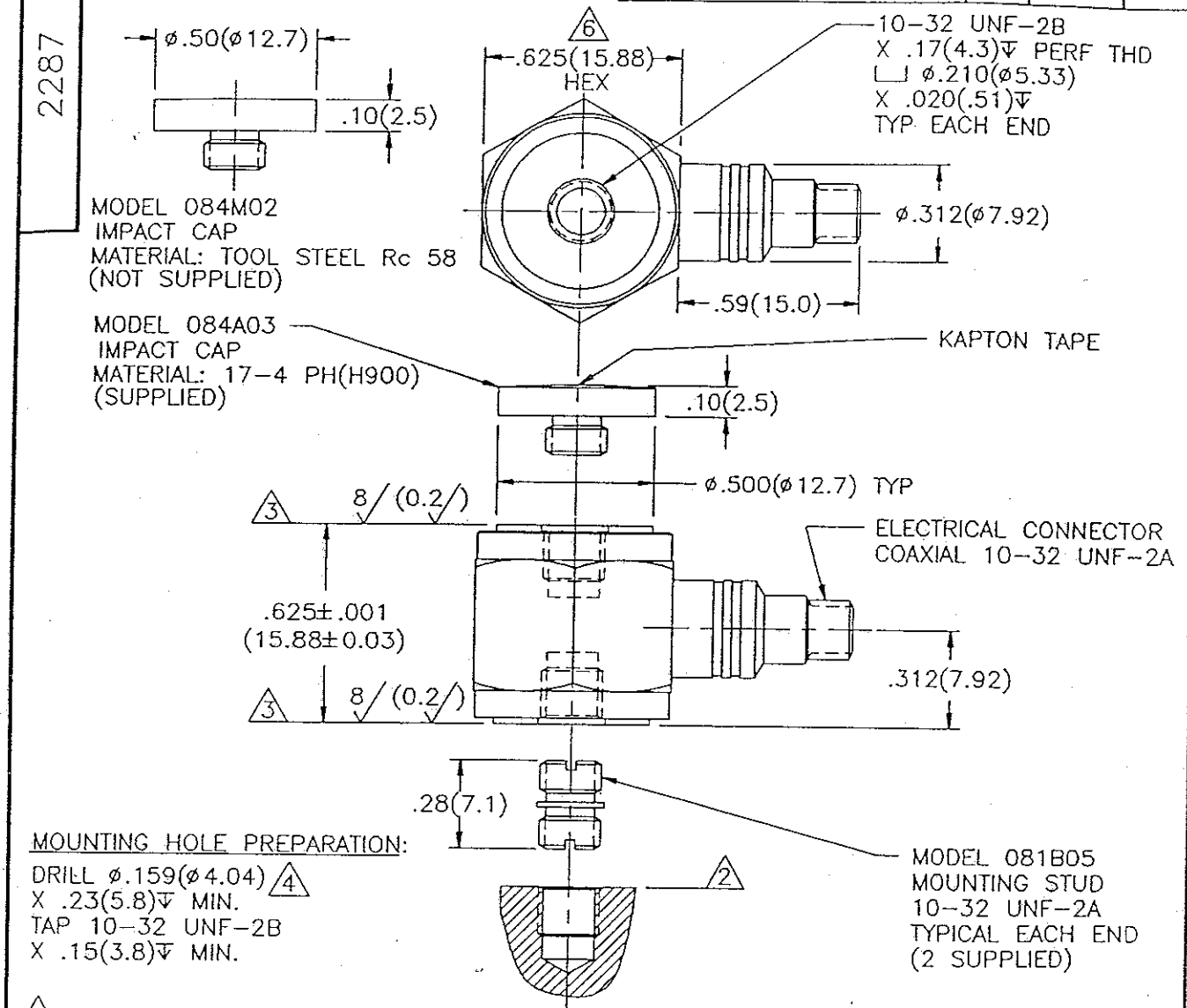
| APPLICATION | | |
|---|---|---|
| NEXT ASS'Y | USED ON | VAR |
| | | |

| REVISIONS | | | | |
|---|---|---|---|---|
| REV | DESCRIPTION | ECN | DATE | APP'D |
| | | | | |




MOUNTING HOLE PREPARATION:

DRILL ø.159(ø4.04) 4
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TAP 10-32 UNF-2B
X .15(3.8)↧ MIN.

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| ANGLES ±2 DEGREES | ANGLES ±2 DEGREES |
| FILLETS AND RADII .003 - .005 | FILLETS AND RADII (0.07 - 0.13) |
| DD011 REV. NR 10/25/94 | |

| | | | | | |
|---|---|---|---|---|---|
| DRAWN | | | MFG | | |
| CHK'D | DM | 8/24/95 | ENGR | | |
| APP'D | | | | | |

TITLE: INSTALLATION DRAWING
MODEL 208B03
LOAD CELL

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3425 WALDEN AVE. DEPEW, NEW YORK 14043
PHONE: (716) 684-0001

| CODE IDENT. NO. | DWG. NO. |
|---|---|
| 52681 | 2287 |
| SCALE: 2X | SHEET 1 OF 1 |

## 1.0 Introduction

PCB Quartz ICP® Force Sensors are designed to measure rapidly changing compression, tensile and impact forces for wide dynamic ranges from 0.00005 to 100,000 lbs (0,00022 N to 444,8 kN). Most sensors feature all-welded construction and incorporate built-in ICP microelectronics to provide a clean, low-impedance voltage output signal. Options on various models include hermetic seal, special ranging, extended frequency response and temperature range. Charge mode versions with low-impedance output are also available for higher temperature applications.

PCB manufactures various standard sensor configurations that allow ease of installation for nearly any application. These configurations include impact, rings, general purpose, axial, penetration, miniature/high sensitivity and links. In addition, custom units can be manufactured for specific requirements.

*Refer to the installation drawing and specification sheet at the front of this manual for details and dimensions of the particular sensor model number(s) purchased.* The following pages give a brief description of the various sensor series available, recommended mounting procedures, operation and recommended calibration.

If you wish to learn more about sensors with built-in microelectronic circuitry, known as ICP sensors, consult PCB's "General Operating Guide for use with Piezoelectric ICP® Accelerometers," a brochure outlining the technical specifics associated with piezoelectric sensors. Topics covered include charge versus voltage mode systems, sensor time constants, effect of discharge time constant on low frequency response, and power requirements. PCB's Force Product Catalog also contains technical information.

If questions arise regarding the operation or characteristics of the Force Sensor products as outlined in this manual, feel free to contact PCB and discuss your concerns with an experienced applications engineer.

## 2.0 Description

### 2.1 Impact

Series 200 ICP Impact Sensors are designed to measure compression and impact forces from 0.0002 to over 50,000 lbs (0,0089 N to 222,4 kN). These low-profile sensors are hermetically sealed to permit operation in wet, dirty environments. The flat sensing surface is located on the top of the sensor and is designed to measure force as it is applied axially to the sensor.

Model 200B01 through 200B05 accommodate forces ranging from 0.0002 to 5000 lbs (0,0089 N to 22,24 kN). They measure 0.65 inches (1,65 cm) in diameter and are just 0.36 inches (0,91 cm) high. Larger Models 200B20 and 200B50 operate to 20,000 and 50,000 lbs (88,96 kN and 222,4 kN), respectively. Models 200B01 through 200B05 are equipped with 10-32 electrical connectors, while Models 200B20 and 200B50 are equipped with 5/16-32 electrical connectors. Models 200B20 and 200B50 are equipped with replaceable impact caps. Each sensor is supplied with one mounting stud.

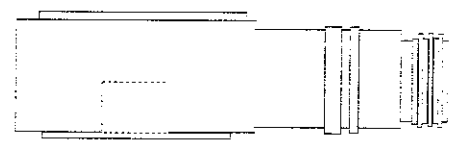


**Figure 2.1 Series 200 ICP® Impact Sensor**

### 2.2 Rings

Series 201 ICP Ring Sensors are designed to measure compression and tensile forces from 0.0002 to over 100,000 lbs (0,0089 N to 444,8 kN). Rings are hermetically sealed and are installed by means of a removable, beryllium-copper mounting bolt.

Designed in the shape of a thick ring, Models 201B01 through 201B05 feature an operating

range from 0.0002 to 5000 lbs (0,0089 N to 22,24 kN). In addition, seven larger rings are available to handle forces to 100,000 lbs (444,8 kN). These sensors vary in size from 0.65 to 3.00 inches (1,65 to 7,62 cm) in diameter.

Each sensor is provided with a NIST-traceable calibration certificate reflecting the sensitivity of the sensor. It is recommended that the system in which the sensor is operating be calibrated after sensor installation. Please consult the factory regarding calibration procedures. PCB can provide custom calibration if needed.

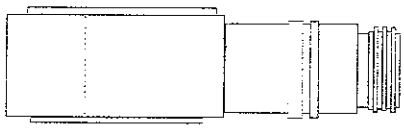


**Figure 2.2 Series 201B01 to 207B ICP® Ring Force Sensor**

The tension range of the force ring is dependent on the amount of preload administered to the sensor during installation. For improved linearity, preload forces should exceed levels desired to be monitored. Tension is monitored as a relaxation (negative output) for applied compression (positive output) preload forces. Refer to Section 3.1, page 5 for recommended force ring mounting and preload requirements.

## 2.3 General Purpose

Series 208 General Purpose ICP Sensors are designed to measure compression and impact forces from 0.0002 to over 5000 lbs (0,0089 N to 22,24 kN). This model measures 0.625 inches (1,587 cm) in both diameter across hex flats and height. Model 084A03, a convex, stainless steel impact cap with integral 10-32 mounting stud is supplied. This cap is used for impact measurements. Kapton tape covers the cap surface to reduce high-frequency ringing associated with metal-to-metal impacts. The Series 208 sensor is equipped with a 10-32 radial electrical cable connector. Internal mounting holes with uniform 10-32 threads are prepared on each end of the sensor. Two Model 081B05 mounting studs (M081B05 for metric installation) are supplied.

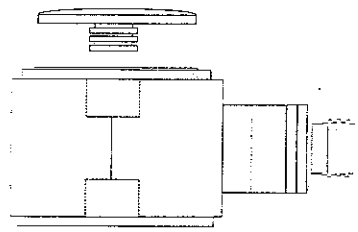


**Figure 2.3 Series 208 General Purpose ICP® Force Sensor**

## 2.4 Axial

Series 208A10 hermetically-sealed Axial ICP Sensors provide performance and possess specifications similar to General Purpose 208 Series units. They are designed primarily to measure tensile, compression and impact forces from 0.0002 to 5000 lbs ((0,0089 N to 22,24 kN). The 10-32 axial electrical connector orientation associated with these sensors makes them ideal for installations where radial space is restricted or where physical connector damage may occur due to the nature of a specific application. The M7 x 0.75-6g connector mounting threads may be installed directly into a test structure. The 10-32 electrical connector exits from the opposite side of the mounting fixture, away from any possible application-caused damage. Series 208A10 measures 0.625 inches (1,87 cm) across the flats and is supplied with a Model 084A03 convex, stainless steel impact cap and one Model 081B05 mounting stud (Model M081B05 for metric thread).

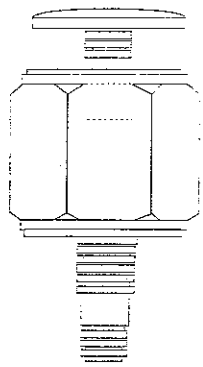


**Figure 2.4 Series 208A10 General Purpose, Axial Connector ICP® Force Sensor**

## 2.5 Penetration

Series 208A20 ICP Penetration Sensors are designed to measure compression and impact forces during drop and penetration testing. Bullet shaped, the Series 208A20 is a modified version of the Series 208A10 Axial Sensor. Composite-material strength testing associated with plastics, rubber and polymers represent an ideal application for this sensor. The welded, hemispherical impact cap allows for testing materials without risk of damage from sharp edges or corners. The design of the cap also directs forces toward the axis of the sensor. Penetration sensors can measure forces from 0.0002 to 5000 lbs (0,0089 N to 22, 24 kN).

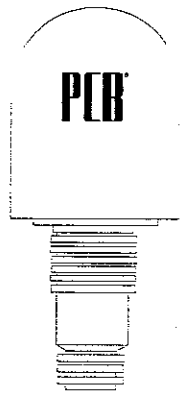



**Figure 2.5 Series 208A20 ICP® Penetration Force Sensor**

## 2.6 Miniature/High Sensitivity

The smallest of PCB's line of standard force products, Series 209 Miniature/High Sensitivity ICP Sensor is designed for measuring small compression and impact forces from 0.00005 to 2.2 lbs (0,02 to 1000 gm). Model 209B01 has a discharge time constant of one second. Model 209B02 has a 10-second discharge time constant for extended low-frequency response. Both sensors are 0.60 inches tall (1,52 cm) and 0.375 inches (0,95 cm) in diameter across the hex. A 10-32 mounting hole is provided at the base for installation ease. Series 209 sensors are supplied with one Model 081A05 mounting stud.

Optional Series 209B10 incorporate a small threaded "hat" that is epoxied to the top sensing surface to provide for small tension measurements. Axial application of forces is critical during such tension measurements, as these sensors can be very sensitive to bending moments.

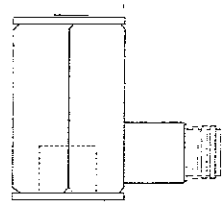


**Figure 2.6 Series 209 Miniature/High Sensitivity ICP® Force Sensor**

## 2.7 Links

Series 221 to 227B ICP Link Sensors are designed for measuring compression and tension forces from 0.0002 to over 50,000 lbs (0,0089 N to 222,4 kN). A link consists of a standard PCB ring sensor, preloaded between two hex end nuts. The high stiffness characteristics of the quartz sensing element (one-third as elastic as steel) and the ruggedness of the force link assembly make this unit ideal for installing into machines to measure forces generated from rods, rams and mechanical linkages, without affecting the strength or rigidity

of the original structure. Various standard sizes are available with varying ranges. The smallest units are 1.25 inches (3,18 cm) high with a diameter of 0.65 inches (1,65 cm), and can monitor to 5000 lbs (22,24 kN) compression. Larger ranges are available to measure to 50,000 lbs (222,4 kN) compression. All hex caps are threaded for mounting ease. External preloads are not required with these sensors, as they are internally preloaded during manufacture.

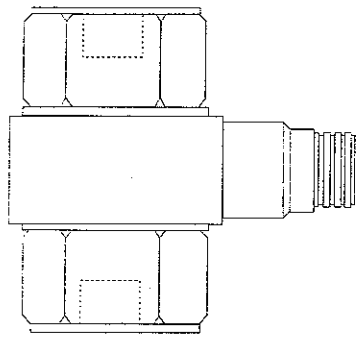


**Figure 2.7 Series 221B01 to 227B ICP® Force Link Sensor**

## 2.8 Press Monitoring

Model 229A ICP Press Monitoring Force Sensor is an exceptionally rugged, hermetically-sealed design that can be permanently installed in machinery to measure punch or press operations up to 50,000 lbs (222,4 kN). The removable impact cap, Model 084A02, may be replaced easily by removing three socket head cap screws. The punch surface is made from Type 440C hardenable stainless steel, heat-treated to a hardness of 53 to 54 Rockwell C. A captivated 10-32 steel socket head cap screw holds the sensor to the test structure. An access hole is provided in the top cap for a sufficiently long Allen wrench to engage the cap screw. The proper orientation of the electrical connector is ensured by a 0.125 inch (0,318 cm) diameter roll-pin protruding from the mounting surface, located exactly opposite and on the center line of the connector (see Installation Drawing).

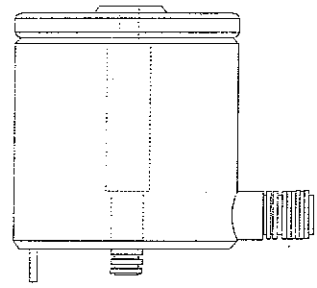


**Figure 2.8 Model 229A ICP® Press Monitoring Force Sensor**

## 3.0 Installation

Refer to the Installation Drawing supplied with this manual for specific outline dimensions and installation details for your particular model.

It is important that the surface to which each sensor is mounted be perfectly flat to avoid flexing of the base, which could affect sensor sensitivity and result in erroneous data (see Figure 3.1). A good mating surface may be obtained by lapping, turning, spotfacing, or surface grinding. Surface flatness should be held to within 0.001 (TIR) over the entire mating surface.

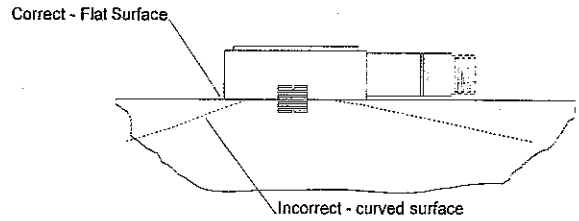



**Figure 3.1 Force Sensor Installation**

A light coating of silicon grease (DC-4 or equivalent) on the mating surface enhances the coupling between the mounting base and mounting surface and provides the best high-frequency response.

Connect one end of the coaxial cable to the sensor connector and the other end to the XDCR jack on the signal conditioner. Make sure to tighten the

cable connector to the sensor. DO NOT spin the sensor onto the cable, as this fatigues the cable's center pin, resulting in a shorted signal and a damaged cable.

For installation in dirty, humid, or rugged environments, it is suggested that the connection be shielded against dust or moisture with shrink tubing or other protective material. Strain relieving the cable/sensor connection can also prolong cable life. Mounting cables to a test structure with tape, clamps, or adhesives minimizes cable whip. (See Figure 3.2 for an example of a sensor installation with a securely fastened cable.)

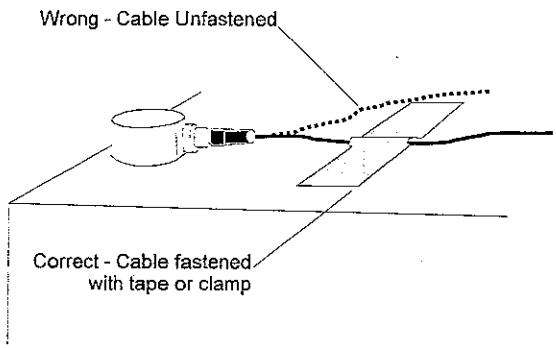



**Figure 3.2 Cable Strain Relief**

## 3.1 Force Ring Preload Requirements

When installing PCB ICP Force Rings (Models 201B01 through 207B), it is recommended that the sensor be preloaded prior to operation. This preload is necessary to ensure good output linearity at the sensor's lower operating range. Suggested pre-load required is 20% of the 5 volt dynamic operating range. Lower-range sensors, such as Series 201, should have a minimum of 100 lbs (444,8 kN) preload applied.

The force sensor senses the tension measurement as a relaxation of the preload. Therefore, for tension measurements, it is necessary to apply a preload greater than the desired tension range.

## 4.0 Operation

Sensors with built-in ICP circuitry require a constant-current excitation voltage for operation. The enclosed Specification Sheet provides specific power requirements. Required supply voltage is normally 24 to 27 VDC, while the constant current required ranges from 2 to 20 mA.

PCB standard battery-powered signal conditioners are factory set at 2 mA and may be used to adequately drive a signal for 100 feet. PCB line signal supplies are factory set at 4 mA (and adjustable from 2 to 20 mA), enabling signals to be transmitted over hundreds of feet.

Should it be required to drive a signal over an extended cable length (>200 feet), it may be necessary to increase the current of the line signal conditioner. A current adjustment potentiometer is located inside most line conditioners for easy field adjustment.

Operation requires the connection of the force sensor first to a signal conditioner, such as PCB Series 480, 484, or 482, then to a readout device (oscilloscope, meter, recorder, or A-to-D board). Tighten the coaxial cable to the sensor by hand to ensure good electrical contact. DO NOT spin the sensor onto the mating cable connector, as this fatigues the cable's center pin, resulting in a shorted signal and a damaged cable. See Figure 4.1 for a typical system connection set-up.

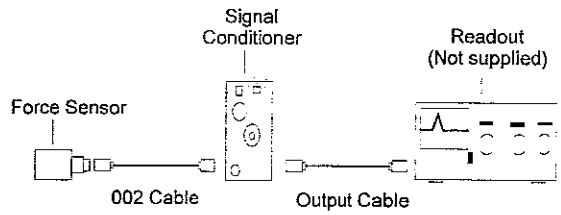



**Figure 4.1 Typical ICP® System Connection**

If you are using a PCB Series 480 Signal Conditioner, switch the power on and observe the bias monitoring voltmeter on the front panel of the signal conditioner. If the indicator registers in

the green area, the ICP amplifier is producing proper bias (generally +8 to +12 VDC); cable connections are normal and the system is ready to operate.

If the indicator moves to the red area of the fault monitor meter, the voltage output is zero, and a short in the system is indicated. The short may be in the amplifier or cable, or in the cable connectors. The other possible cause of trouble is a faulty power supply.

If the pointer moves into the yellow area of the fault monitor meter, an open circuit is indicated. This opening could be the result of a faulty amplifier, an open cable, or open connectors.

## 5.0 Polarity

Compressive forces upon an ICP force sensor produce a positive-going voltage output. Tensile forces produce a negative-going voltage output.

## 6.0 Low-Frequency Monitoring

Force sensors used for applications in short term, steady-state monitoring, such as sensor calibration, or short term, quasi-static testing should be powered by signal conditioners that operate in DC mode. PCB Series 484 Signal Conditioner operates in either AC or DC mode and may be supplied with gain features or a zero "clamped" output often necessary in repetitive, positive polarity pulse train applications.

If you wish to learn more about ICP sensors, consult PCB's "General Operation Guide for use with Piezoelectric ICP® Accelerometers," a brochure outlining the technical specifics associated with piezoelectric sensors. This brochure is available from PCB by request, free of charge.

## 7.0 Discharge Time Constant

The discharge time constant (TC) of the entire transduction system from sensor to readout must be considered when attempting to calibrate an ICP force sensor by static methods.

In order to take full advantage of the long TC built into the force sensor, it is best to DC couple from the sensor to the readout device. Several dual-mode PCB signal conditioners (e.g., Series 484) use direct coupling techniques to decouple the output signal from the sensor bias voltage. With the output of the signal conditioner coupled to a DC readout, such as a digital voltmeter (DVM) or oscilloscope, the time constant of the sensor is not compromised by AC coupling elsewhere in the system.

When DC coupling to a system, it is important to DC couple the entire system and not just from the sensor to the signal conditioner. The system time constant is determined by the shortest time constant in the system. For this reason, the signal conditioner, as well as the readout device, must be DC coupled.

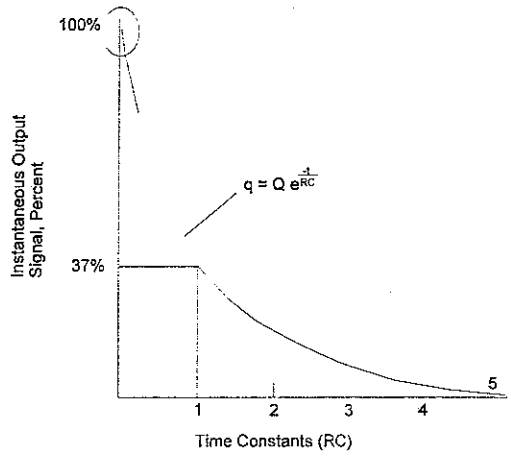



**Figure 7.1 Characteristic Discharge Time Constant Curve**

The discharge time constant represents the decay rate of an input signal. One TC represents the amount of time taken for the signal to decay to 37% of the initial peak value. As illustrated in Figure 7.1, this is an exponential decay.

Approximately five TC intervals are needed for a peak signal to naturally decay back to zero.

The rule of thumb for signal discharge, as outlined in Figure 7.2, is this: for the first 10% of the discharge TC, the signal lost is approximately proportional to the time elapsed.

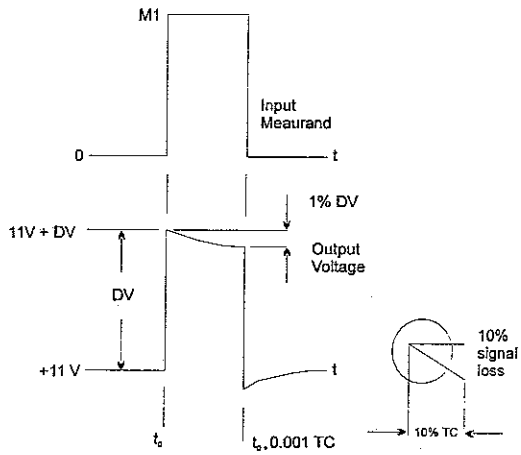



**Figure 7.2 Step Function Response**

For example, a sensor with a 500-second discharge TC loses approximately 1% of its output level the first five seconds (1% of 500) after the application of a steady state force within the measuring range. In this case, the output reading must be taken within five seconds of the force application for 1% accuracy.

If it is impossible to avoid AC coupling somewhere in the sensing system, try to keep the coupling TC at least an order of magnitude longer than the discharge TC of the force sensor. This avoids compromising the sensor TC.

## 8.0 Calibration

A NIST-traceable calibration graph is supplied with each force sensor certifying its voltage sensitivity (mV/lb). Static calibration methods are generally used, provided discharge TCs are sufficiently long (greater than 1000 seconds). For certain applications, in-place calibration is recommended. This may be done with proving rings, dead weights, or by comparison with a reference sensor.

As performed at PCB, the following is a laboratory procedure suggested for calibration of a force sensor, using a hydraulic jack stand with a force ring gauge and a traceable proving ring.

## 8.1 Suggested Calibration Procedure for Time Constant Greater Than 1000 Seconds

A. Place the test sensor in mechanical series with a proving ring on a hydraulic force stand.

B. Take the zero force reading from the readout device.

C. Apply a known force ($\Delta F$) to the test sensor by pumping a hydraulic cylinder. Use the proving ring gauge as a reference standard. Read the corresponding output voltage ($\Delta V$) from the readout device.

D. Repeat procedure steps B and C in 20% increments to the full scale of the test sensor.

E. Repeat procedure steps B through D three (3) times and take average reading at each 20% interval.

F. Plot the readings on an X-Y scale.

G. Sensor sensitivity is $\Delta V/\Delta F$.

## 8.2 Suggested Calibration Procedure for Time Constant Less Than 1000 Seconds

A. Place the test sensor in mechanical series with a proving ring on a hydraulic force stand.

B. Apply a known force (ΔF) to the test sensor by pumping a hydraulic cylinder, using a reference standard proving ring.

C. Note the reading from the readout device.

D. Release the force quickly.

E. Note the reading from the readout device.

F. Subtract the value obtained in Step C from the value of Step E to ΔV.

G. Plot the readings on an X-Y scale.

H. Sensor sensitivity is ΔV/ ΔF.

## 9.0 Maintenance and Repair

The sensor connector must be kept clean, especially if it is operating in a dusty and/or wet environment. Because the force sensor is of welded construction, it should be returned to the factory for servicing in the event of serious malfunction.

Observe the following precautions in using the sensor:

A. Do not exceed the maximum load levels for the force sensor (see specification sheet).

B. Do not subject the sensor to temperatures exceeding that of the specification, normally 250°F (121°C).

C. Do not apply voltage to the sensor without current-limiting diodes or other current protection.

D. Do not apply more than 20 mA of current to the force sensor.

E. When mounting the force sensor, observe installation procedures detailed in Section 3.0 and as outlined on the specific sensor Installation Drawing to avoid overtorquing when mounting.

F. Do not apply more than 30 volts to the sensor.

G. *Avoid metal-to-metal impacts* during applications, which can produce a high-frequency ringing. Electrical low-pass filtering or a damping material can help reduce such effects.

E. *Do not spin the sensor onto the cable.* This may fatigue the cable center pin, causing cable damage. Always insert the cable pin into the sensor and tighten the knurled cable nut to the sensor.

A.C. MODE, BASIC

# LINE POWER UNIT

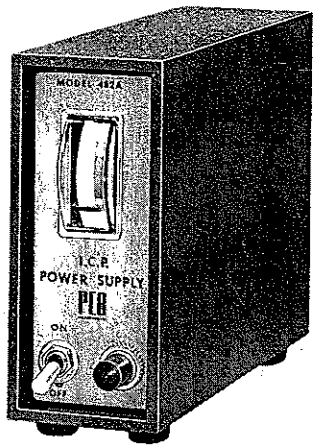
for voltage-mode transducers

## Model 482A

PCB PIEZOTRONICS

ELECTRONICS

- powers transducers with built-in or attached amplifiers
- supplies power over signal lead
- eliminates bias on output
- monitors normal or faulty system operation
- provides adjustable constant-current excitation




For powering low-impedance piezoelectric transducers with built-in or attached amplifiers and coupling them to versatile readout instruments; and especially for driving long transducer cables.

Model 482A Line Power Unit powers the transducer over the signal lead and couples self-amplifying PCB transducers to oscilloscopes, recorders or other readout instruments. In the coupling process, it eliminates D.C. power bias from the output by means of a coupling capacitor. It also monitors normal operation of the system with a meter that detects such faults as cable and connector open or short circuits and transducer amplifier trouble. With a 24V D.C. regulator, Model 482A provides an output signal range linear to ± 10 volts. Constant current excitation adjustable from 2 to 20 mA (factory set at 4 mA) is supplied to transducer to improve linearity and cable driving capabilities. Higher supply currents drive longer cables at higher frequencies. The factory set 4 mA CC is adequate for most lower frequency dynamic measurements (to approx. 10 kHz) with several hundred feet of input cable. When ultra-high frequency data (micro-seconds) is to be transmitted through long cables (100 ft.), use 20 mA constant current and the 073A Impedance Matching resistor.

Like the transducer discharge circuit, the capacitive coupling circuit to the readout instrument also eliminates D.C. signal components at an exponential rate. When the readout load impedance is one megohm or more, the coupling time constant exceeds 10 seconds, which is sufficiently long for most applications. If good low frequency response is required into low impedance recorders (<100 kΩ), the Models 484B or 494A are recommended.

For static calibrating or other purposes, Model 482A can be operated in a D.C. mode by taking the output signal directly off the transducer lead through a "T" connector or by shorting across the internal coupling capacitor. The resulting 11V D.C. bias on the output lead can be eliminated, if necessary, by a series battery or floating D.C. supply. Model 484B has an active D.C. mode, which maintains transducer time constant into any load impedance.

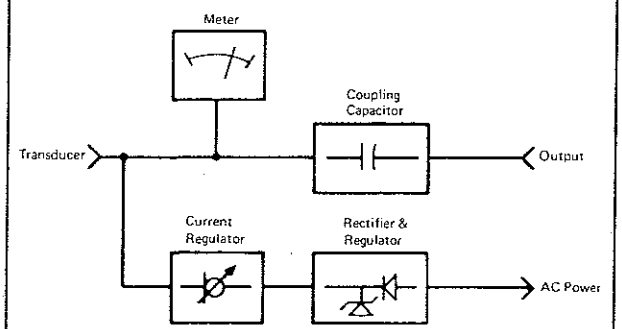
| SPECIFICATIONS: Model No. | | 482A |
|---|---|---|
| Transducer Excitation | VDC | +24 |
| Excitation Current (adjustable)(1) | mA | 2 to 20 |
| Voltage Gain | | 1 |
| Coupling Capacitor | μF | 10 |
| Output Signal, F.S. | ± volts | 10 |
| Output Current | mA | Supply –2 mA |
| Noise, Wideband (pk – pk max.) | μV | 300 |
| Size (2) | in | 1.8x4.3x6 |
| Weight | lb | 2 |
| Transducer Connector | micro | 10-32 |
| Output Connector | | BNC |
| Power Cord (3-wire) | ft | 6 |
| Power Required (50-400 Hz) | V/A | 105–125/0.3 |

| OPTIONAL MODELS: | |
|---|---|
| Four Channel Version | 482A04 |
| BNC Input/Output: Single Channel | 482A06 |
| Four Channel | 482A05 |
| Gain Version (X1, X10, X20) Single Channel | 482A10 |

To specify 220V operation, add prefix 'F' to model number, e.g. F482A.

NOTES: (1) Factory set at 4 mA.
(2) 8-unit rack mounting adaptor available, Model 400A03.

BLOCK DIAGRAM:




**PCB PIEZOTRONICS, INC.** 3425 WALDEN AVENUE DEPEW, NEW YORK 14043-2495 TELEPHONE 716-684-0001 TWX. 710-263-1371

AC & DC MODE

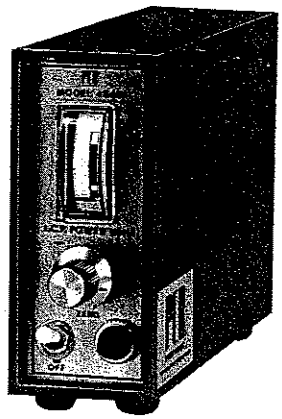
# LINE POWER UNIT

## Model 484B

PCB® ELECTRONICS
PIEZOTRONICS

for voltage-mode transducers

- calibrate long TC transducers in DC mode
- operate drift free in dynamic AC mode
- power transducers with built-in or attached amplifiers
- monitor normal operation; indicate faults
- supply adjustable constant-current transducer excitation
- isolate coupling circuit from load impedance



See Optional Models below Specifications.

**For powering low-impedance piezoelectric transducers with built-in amplifiers and coupling them to versatile readout instruments; and especially for statically calibrating transducers with long discharge time constants or for coupling to low input impedance recorders.**

Model 484B, AC and DC mode Line Power Unit, supplies transducer excitation over the signal lead and couples self-amplifying PCB transducers to oscilloscopes, recorders or other readout instruments. In the coupling process it eliminates DC power bias from the output by means of a coupling capacitor or level-shifter of the floating DC power supply type. In addition a unity-gain operational amplifier isolates the coupling circuits from the readout load impedance.

A 24V DC regulator within the Model 484B provides an output signal range linear to ±10V. Constant-current excitation adjustable from 2 to 20 mA (factory set at 4 mA) is supplied to the transducer to improve linearity and cable driving ability. Higher magnitude supply currents drive longer cables or provide more available output current.

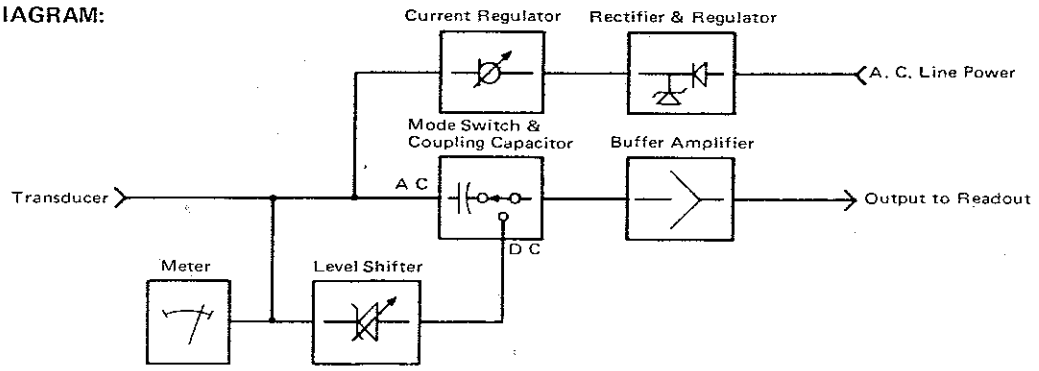
For applications involving repetitive pulses that must be ground based, positive polarity for peak meter or computer recording, Model 484B02 Power Unit with clamped output is recommended.

Operating in a capacitive coupled AC mode eliminates the annoying drift usually present in DC coupled instruments.

| SPECIFICATIONS: Model No. | | 484B |
|---|---|---|
| Excitation, CC (set at 4) | mA<br>VDC | 2 to 20 (adj.)<br>+24 |
| Voltage Gain (non-inverting) | | 1.0 |
| Coupling Capacitor | μF | 10 |
| Coupling Time Constant (AC mode) | s | 10 |
| Bias Elimination Range (DC mode) | 6V<br>11V | 3 to 8<br>7.5 to 14.5 |
| Frequency Response (±5%, DC mode) | Hz | DC to 200000 |
| Frequency Response (±5%, AC mode) | Hz | 0.05 to 200000 |
| Output Current | mA | ±10 |
| Output Impedance | ohm | 50 |
| Noise (pk-to-pk) | μV | 600 |
| Size (hxwxd) | in | 1.8x4.3x6 |
| Weight | lb | 2 |
| Transducer Connector | coaxial | 10-32 |
| Output Connector | | BNC |
| Power Cord (3-wire) | ft | 6 |
| Power Required (50-400 Hz) | V/A | 105-125/0.12 |
| Optional Models: | | |
| With BNC input/output conn. | | 484B06 |
| With gain X1, X10, X20 | | 484B10 |
| With clamped output | | 484B02 |
| Rack adaptor (holds 8 units) | | 400A03 |

To specify 220V operation, add prefix 'F' to model number, e.g. F484B

BLOCK DIAGRAM:

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AC & DC MODE

# LINE POWER UNIT

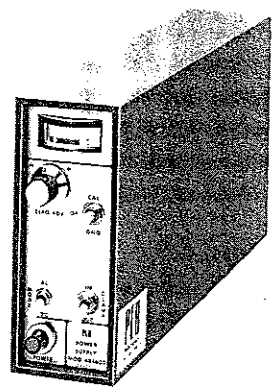
with clamped output

## Model 484B02

PCB PIEZOTRONICS — ELECTRONICS

for voltage-mode sensors

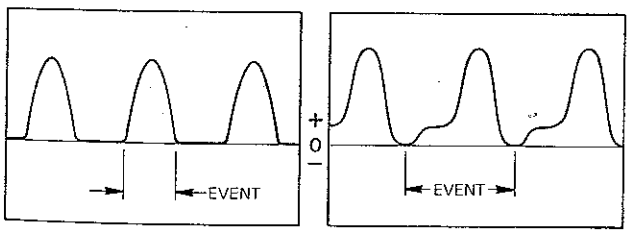
- resets automatically or manually in AC mode
- keeps pulse train ground based positive polarity
- operates drift-free in AC mode
- calibrates internally or externally in AC or DC mode
- calibrates sensors with long discharge TC
- supplies adjustable constant-current sensor excitation
- monitors normal sensor operation; indicates faults
- provides low-impedance OP amp output



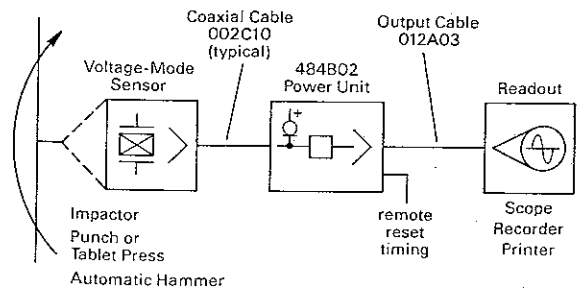
**Model 484B02 functions to power voltage-mode sensors, monitor their operation, debias the output signal and, in the AC mode, automatically, remotely or manually rezeros the output between repetitive events. Operation in the DC mode is the same as for Model 484B.**

The structure of the Model 484B02 includes an internal calibration feature, provision for injecting an external CAL signal, relay switch for zeroing output and automatic rezeroing circuit in addition to the normal components of the Model 484B.

These special circuits, in the AC mode, function to position the output signal relative to zero. This behavior keeps a repetitive pulse train ground-based and at positive polarity as required by many peak meters, computers and controllers. These special circuits also keep the display on an oscilloscope or recorder from drifting. Standard circuits accommodate events lasting up to a few seconds duration. Typical results are pictured below.



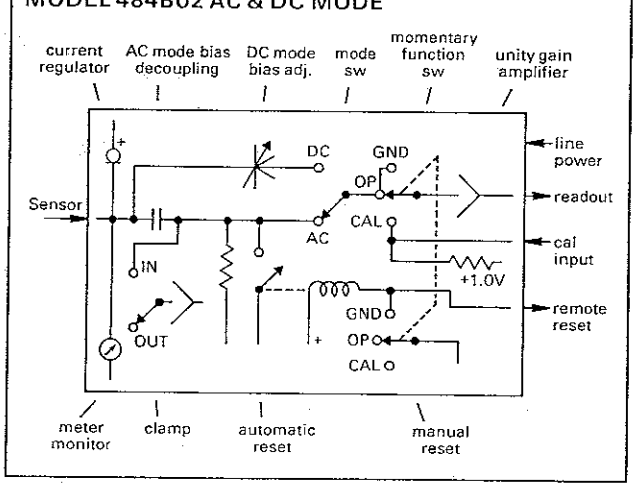

**TYPICAL SYSTEM**




| SPECIFICATIONS: Model No. | | 484B02 |
|---|---|---|
| Sensor Excitation VDC | | +24 |
| Excitation Current(1) | mA | 2 to 20 |
| Voltage Gain (noninverting) | | 1.0 |
| Coupling Time Constant (AC mode) | s | 1000 |
| Frequency Response (±5%, DC mode)(2) | Hz | DC to 100 000 |
| Frequency Response (±5%, AC mode)(2) | Hz | 0.001 to 100 000 |
| Output Current | ±mA | 10 |
| Output Voltage | ±V | 10 |
| Output Impedance | ohm | <10 |
| Output Noise (PK to PK) | mV | 0.6 |
| Size (W, H, D) | in | 2x5x10.5 |
| Weight | lb | 2 |
| Sensor Connector | | BNC |
| Output Connector | | BNC |
| CAL Input Connector | | BNC |
| Remote Reset Connector | | BNC |
| Power Connector | | 3 pin socket |
| Power Cord (3 wire plug-in) | ft | 8 |
| Power (60 Hz) | V/A | 105 to 125/0.25 |

Note: 1. Factory set at 4 mA.
2. Low frequency response determined by sensor discharge time constant.
3. Output cable not supplied. Order Model 012A03.

**MODEL 484B02 AC & DC MODE**

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