



Model 176A04

Differential charge output pressure sensor with UHT-12™ element, 15.5 pC/psi, +662 F

Installation and Operating Manual

**For assistance with the operation of this product,
contact the PCB Piezotronics, Inc.**

**Toll-free: 716-684-0001
24-hour SensorLine: 716-684-0001
Fax: 716-684-0987
E-mail: info@pcb.com
Web: www.pcb.com**



Repair and Maintenance

PCB guarantees Total Customer Satisfaction through its “Lifetime Warranty Plus” on all Platinum Stock Products sold by PCB and through its limited warranties on all other PCB Stock, Standard and Special products. Due to the sophisticated nature of our sensors and associated instrumentation, **field servicing and repair is not recommended and, if attempted, will void the factory warranty.**

Beyond routine calibration and battery replacements where applicable, our products require no user maintenance. Clean electrical connectors, housings, and mounting surfaces with solutions and techniques that will not harm the material of construction. Observe caution when using liquids near devices that are not hermetically sealed. Such devices should only be wiped with a dampened cloth—never saturated or submerged.

In the event that equipment becomes damaged or ceases to operate, our Application Engineers are here to support your troubleshooting efforts 24 hours a day, 7 days a week. Call or email with model and serial number as well as a brief description of the problem.

Calibration

Routine calibration of sensors and associated instrumentation is necessary to maintain measurement accuracy. We recommend calibrating on an annual basis, after exposure to any extreme environmental influence, or prior to any critical test.

PCB Piezotronics is an ISO-9001 certified company whose calibration services are accredited by A2LA to ISO/IEC 17025, with full traceability to SI through N.I.S.T. In addition to our standard calibration services, we also offer specialized tests, including: sensitivity at elevated or cryogenic temperatures, phase response, extended high or low frequency response, extended range, leak testing, hydrostatic pressure testing, and others. For more information, contact your local PCB Piezotronics distributor, sales representative, or factory customer service representative.

Returning Equipment

If factory repair is required, our representatives will provide you with a Return Material Authorization (RMA) number, which we use to reference any information you have already provided and expedite the repair process. This number should be clearly marked on the outside of all returned package(s) and on any packing list(s) accompanying the shipment.

Contact Information

PCB Piezotronics, Inc.
3425 Walden Ave.
Depew, NY14043 USA
Toll-free: (800) 828-8840
24-hour SensorLine: (716) 684-0001
General inquiries: info@pcb.com
Repair inquiries: rma@pcb.com

For a complete list of distributors, global offices and sales representatives, visit our website, www.pcb.com.

Safety Considerations

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the precautions required to avoid injury. While our equipment is designed with user safety in mind, the protection provided by the equipment may be impaired if equipment is used in a manner not specified by this manual.

Discontinue use and contact our 24-Hour Sensorline if:

- Assistance is needed to safely operate equipment
- Damage is visible or suspected
- Equipment fails or malfunctions

For complete equipment ratings, refer to the enclosed specification sheet for your product.

Definition of Terms and Symbols

The following symbols may be used in this manual:



DANGER

Indicates an immediate hazardous situation, which, if not avoided, may result in death or serious injury.

**CAUTION**

Refers to hazards that could damage the instrument.

**NOTE**

Indicates tips, recommendations and important information. The notes simplify processes and contain additional information on particular operating steps.

The following symbols may be found on the equipment described in this manual:



This symbol on the unit indicates that high voltage may be present. Use standard safety precautions to avoid personal contact with this voltage.



This symbol on the unit indicates that the user should refer to the operating instructions located in the manual.



This symbol indicates safety, earth ground.



PCB工业监视和测量设备 - 中国RoHS2公布表

PCB Industrial Monitoring and Measuring Equipment - China RoHS 2 Disclosure Table

部件名称	有害物质					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
住房	O	O	O	O	O	O
PCB板	X	O	O	O	O	O
电气连接器	O	O	O	O	O	O
压电晶体	X	O	O	O	O	O
环氧	O	O	O	O	O	O
铁氟龙	O	O	O	O	O	O
电子	O	O	O	O	O	O
厚膜基板	O	O	X	O	O	O
电线	O	O	O	O	O	O
电缆	X	O	O	O	O	O
塑料	O	O	O	O	O	O
焊接	X	O	O	O	O	O
铜合金/黄铜	X	O	O	O	O	O
本表格依据 SJ/T 11364 的规定编制。						
O：表示该有害物质在该部件所有均质材料中的含量均在 GB/T 26572 规定的限量要求以下。						
X：表示该有害物质至少在该部件的某一均质材料中的含量超出 GB/T 26572 规定的限量要求。						
铅是欧洲RoHS指令2011/65/ EU附件三和附件四目前由于允许的豁免。						

CHINA RoHS COMPLIANCE

Component Name	Hazardous Substances					
	Lead (Pb)	Mercury (Hg)	Cadmium (Cd)	Chromium VI Compounds (Cr(VI))	Polybrominated Biphenyls (PBB)	Polybrominated Diphenyl Ethers (PBDE)
Housing	O	O	O	O	O	O
PCB Board	X	O	O	O	O	O
Electrical Connectors	O	O	O	O	O	O
Piezoelectric Crystals	X	O	O	O	O	O
Epoxy	O	O	O	O	O	O
Teflon	O	O	O	O	O	O
Electronics	O	O	O	O	O	O
Thick Film Substrate	O	O	X	O	O	O
Wires	O	O	O	O	O	O
Cables	X	O	O	O	O	O
Plastic	O	O	O	O	O	O
Solder	X	O	O	O	O	O
Copper Alloy/Brass	X	O	O	O	O	O

This table is prepared in accordance with the provisions of SJ/T 11364.

O: Indicates that said hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement of GB/T 26572.

X: Indicates that said hazardous substance contained in at least one of the homogeneous materials for this part is above the limit requirement of GB/T 26572.

Lead is present due to allowed exemption in Annex III or Annex IV of the European RoHS Directive 2011/65/EU.

1.0 INTRODUCTION

Charge mode pressure sensors offer high performance for precise pressure measurements over a wide range of near-static and dynamic pressures. The sensors use piezoelectric properties to convert an applied pressure into an analogous electrical charge.

The internal design of a sensor incorporates a sensing element that provides high sensitivity over a wide range of pressures. As pressure is applied to the diaphragm of the sensor, a charge is generated in the crystals. The high-impedance electrostatic charge is then conditioned externally by either a laboratory-style charge amplifier or in-line charge converter prior to being sent to a readout or recording device.

Charge mode sensors are ideally suited for applications where wide dynamic range is needed. Such applications include compressors, engines, blast, ballistic, pneumatic, hydraulic, and fluid pressures. Enclosed is a Specification Sheet that lists the complete performance characteristics of the sensor purchased.

2.0 Series 176 High Temperature Differential Output Sensor

The Series 176 High temperature differential output sensor is a special-purpose high temperature charge mode pressure sensor designed specifically to measure low-level pressures in severe environments. The unit is most frequently used in engines, hydraulic and pneumatic devices, compressors and turbines. Ideal for sound pressure measurements, microphones and small pressure agitations, its maximum dynamic pressure range is 100 psi (689 kPa). It is acceleration compensated to minimize vibration sensitivity and is capable of a five-microsecond rise time.

This sensor measures transient or repetitive phenomena relative to the initial or average pressure level, over a wide amplitude range and a usable frequency range near DC to 10 000 Hz; the resonant frequency is 50 000 Hz. The operating temperature for the Series 176 ranges from 0°F to 1000°F. This hermetically sealed sensor contains extremely rigid compression-mode crystals with an integral acceleration compensating crystal to reduce vibration sensitivity and partially suppress internal resonance effects.

Manual Number: 30737
Revision: A
ECR Number: 24690

3.0 Installation

3.1 Overview

When choosing an installation method, the advantages and disadvantages of each method must be carefully weighed. Characteristics like location, ruggedness, amplitude range, accessibility, temperature and portability may be greatly affected by the installation configuration and technique. Often, the most important and overlooked consideration is the affect the mounting technique has on the frequency of the pressure being measured by the sensor.

Two basic mounting techniques are recommended for pressure sensors: the recess mount and the flush mount. The technique used is determined by the specifics of the individual application. See the Installation Drawing in this manual for additional details on the individual sensor series.

3.2 Recess Mount

A recess mount protects the sensor diaphragm from the effect of high flash temperature and particle impingement. This method is often selected because it can prolong sensor life and increase data integrity by reducing thermal effects. See Figure 3.1.

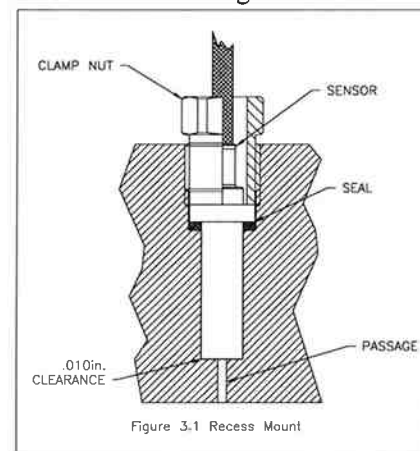


Figure 3.1 Recess Mount

When using a recess mount, note that the length of the passage may limit the frequency range of the measurement. The effect the passage has is similar to that of an under-damped second order system, with the resonant frequency determined by passage length. The passage length thus limits pressure pulse rise time and may also cause passage ringing.

The function is described by the following equation:

$$F_r = \frac{V}{4L}$$

Where: F_r = resonant frequency passage (Hz)
 V = velocity of sound in air (feet/second)
 L = length of column (feet)

For air at room temperature, the equation becomes:

$$F_r = \frac{3300}{L}$$

Where: L = passage length (inches)

The natural frequency and approximately fastest pressure step rise time for various length passages are shown in the following chart, using a medium of air at 77°F (25°C).

Selected Values for 77°F (25°C)

Passage length (inches)	Passage resonance (kHz)	Approx. fastest pulse rise time (microseconds)
.050	66	5
.100	33	10
.200	16.5	20
.50	6.6	50
1.0	3.3	100

Measured resonant frequencies may differ slightly from the chart values due to variations in the velocity of sound in the air from changes in temperature and pressure of the air in the passage.

To ensure diaphragm integrity, maintain .006 inches (.153 mm) of clearance ahead of the diaphragm as shown in Figure 3.1.

3.3 Flush Mount

In a flush mount installation, there is no reduced area passage from the sensor diaphragm to the test chamber. Instead, the sensor diaphragm is mounted flush with, or slightly recessed from, the inside surface of the test chamber. See Figure 3.2.

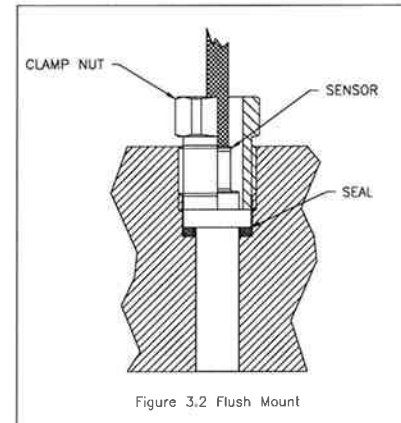


Figure 3.2 Flush Mount

If thermal transients or diaphragm impingement are concerns, use the flush mount technique only when space or frequency response considerations preclude the use of the recess mount installation.

In severe or pyrotechnic environments, sensor life may be seriously curtailed when using this mounting method.

3.4 Cabling

Care and attention to cable attachment is essential, as the reliability and accuracy of your system is no better than that of the output cable. First, check that you have ordered the correct cable type. As with sensors, no cable can satisfy all applications. Special low-noise cabling shielded twisted pair should be used with high-impedance, charge output devices.

Plug the connector on the cable into the mating connector on the sensor. Then, holding the sensor stationary, secure the connector in place by tightening down the attached cable sleeve.

Route the cable to a charge amplifier or in-line charge converter, making certain to strain relieve the sensor/cable connection and minimize motion by clamping the cable at regular intervals. Common sense must be used to avoid physical damage and minimize electrical noise. Avoid routing cables near high voltage wires. Do not route cables along floors or walkways where they may be stepped on or become contaminated. Shielded cable should have the shield grounded at one end only.

To dissipate any charge that may have accumulated in the cable, short the pins to ground prior to attachment to the charge amplifier or charge converter.

4.0 CALIBRATION

These sensors may be calibrated using static hydraulic techniques, such as dead-weight testers, or by comparison with a reference gage.

When calibrating with a laboratory-style charge amplifier, set the charge amplifier to LONG, for the time constant setting, and allow the sensor to stabilize before applying pressure. If slow drift is apparent, apply the pressure to the desired level, and immediately take a reading. Release the pressure and take another reading at zero pressure to obtain the difference between the readings at the desired present level and zero pressure. If the drift is too fast to take a reading, clean the cable connections according to the procedures out-lined in Section 7.0, Maintenance.

NOTE: Do not attempt to use a charge amplifier which, in the long time constant position, has less than a 5 000-second time constant for quasi-static calibration of charge sensors. Any drift may cause error.

A factory-supplied, NIST-traceable calibration graph is provided with each sensor, certifying its charge sensitivity in pC/psi, or when used with an in-line amplifier, in mV/psi.

5.0 Normal Operation

The high impedance signal generated by a charge output sensor is usually conditioned with a laboratory-style charge amplifier. The charge amplifier converts the high-impedance charge signal generated by the sensor into a low-impedance voltage signal. This signal may then be transmitted to a readout or recording device for analysis. See Figure 5.1 for a drawing of a typical system connection.

NOTE: When using charge-amplified systems, the noise floor of the system is dependent on the input capacitance to the charge amplifier. To minimize noise, keep the cable length between the pressure sensor and the charge amplifier to a minimum. Cable length does not affect the system sensitivity.

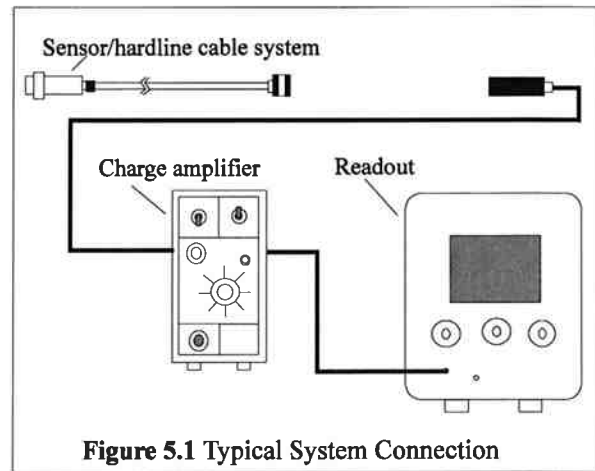


Figure 5.1 Typical System Connection

Before connecting the low-noise cable from the pressure sensor to the charge amplifier, be certain to ground the charge amplifier. This ensures that any excessive accumulated static charges across the sensor/cable combination are harmlessly discharged. If this precaution is not observed, the input FET of certain amplifiers may be destroyed. Press the ground button of the charge amplifier and adjust electrical zero if necessary.

Once system components are connected, wait a few minutes for the system to thermally stabilize. Place the switch in the OPR (operate) position and proceed with the measurement. Refer to the charge amplifier operating manual for further operating details.

For fixed sensitivity in-line charge amplifiers, the system sensitivity (mV/psi) is determined as the product of the charge amplifier sensitivity (mV/pC) and the sensor sensitivity (pC/psi).

6.0 HIGH-TEMPERATURE OPERATION

6.1 Introduction

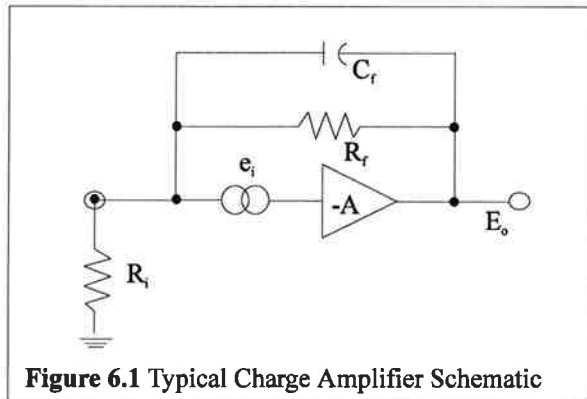
When subjected to elevated temperature, all piezoelectric sensors/hardline cable systems exhibit decreased insulation resistance, due in part to the piezoelectric element, but due mostly to the hardline cable necessary to withstand the high temperatures. This situation can cause serious voltage offset problems in direct-coupled charge amplifiers. To solve this problem, the user must AC couple (capacitor) the charge amplifier

to the sensor/cable system. See Section 6.3, Solution to Reduced Resistance, for complete details, or use different amplifiers.

6.2 Reduced Resistance at Charge Amplifier Input

Figure 6.1 illustrates a simplified schematic of a typical direct-coupled charge amplifier where:

- R_f = Feedback resistor (ohms)
- R_i = Input leakage resistance (ohms)
- E_o = Steady-state output voltage (volts)
- e_i = Offset voltage: FET leakage (volts)
- C_f = Feedback capacitor (farads)



The feedback capacitor C_f comes into play only in the dynamic situation and its influence does not affect the steady-state situation. The voltage e_i is a DC offset voltage, usually very tiny (microvolts), that exists at the input gate of the MOSFET circuit. This minute leakage current exists in all real devices.

As demonstrated in Equation 1, the steady-state (DC) output voltage E_o is:

Equation 1

$$E_o = e_i \left(1 + \frac{R_f}{R_i} \right)$$

This equation shows that if the input (leakage) resistance at the charge amplifier is extremely high (approaching infinity), the output DC voltage approaches e_i , usually a very tiny voltage. However, as R_i decreases, the term

$$1 + \frac{R_f}{R_i}$$

increases, such that the output voltage can, with large ratios of R_f / R_i , become large enough to result in a large E_o , perhaps large enough to be outside the normal output voltage range of the charge amplifier.

Because of the feedback capacitor C_f , this output voltage change usually does not occur rapidly but rather, it manifests itself as a slow drift in the output voltage level. If R_i is low enough with respect to R_f , the voltage drift may continue until saturation of the charge amplifier occurs.

6.3 Solution to Reduced Resistance

Since the drift or offset problem is caused by a static or steady-state imbalance at the input of the charge amplifier, the solution involves blocking this steady-state effect while allowing the desired dynamic phenomena to pass. This may be accomplished by installing a series capacitor at the input of the charge amplifier, between the offending sensor (or low-impedance hardline) and the input.

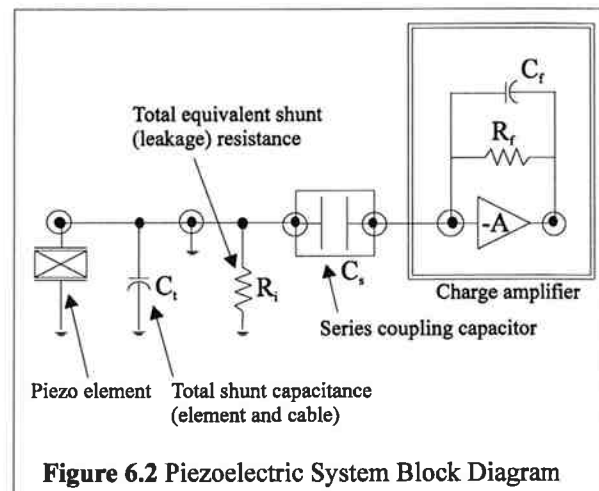


Figure 6.2 illustrates a block diagram of the piezoelectric system where:

- C_t = Shunt capacitor
- C_s = Series blocking capacitor

With the series blocking capacitor C_s in place as shown, the dynamic charge (Q) generated by the sensor element is distributed across the two capacitors, C_t and C_s , in proportion to the size (capacitance) of each. If C_s , for example, is equal to 100 times C_t , 99% of the charge appears at the input of the charge amplifier, while 1% is

across the shunt capacitor C_i . This results in a 1% decrease in apparent sensitivity of the system.

This therefore demonstrates the importance of selecting the series blocking capacitor at least two orders of magnitude higher than the total shunt capacitance C_i across the input of the charge amplifier.

It is also important that this capacitor be of high quality, with a leakage resistance of greater than 10^{12} ohms, to avoid the DC offset discussed previously in 6.1, Introduction.

6.4 Low-Frequency Response Limitations

In a normal charge amplifier, the low-frequency response is set by the RC time constant, as established by the product of C_f and R_f . The system acts like a high-pass first order RC filter with a -3 dB frequency established by the relationship:

Equation 2

$$f_o = \frac{.16}{R_f C_f}$$

where:

$$\begin{aligned} f_o &= \text{-3 dB Frequency (Hz)} \\ R_f &= \text{Feedback resistor (ohms)} \\ C_f &= \text{Feedback capacitor (farads)} \end{aligned}$$

However, after the addition of the series blocking capacitor C_s , the system becomes the equivalent of two high-pass filters in series, one as previously mentioned and one comprised of series capacitor C_s and total equivalent shunt resistance R_i . This new cutoff frequency is:

Equation 3

$$f_o = \frac{.16}{R_i C_s}$$

To avoid compromise of the low-frequency response established by the charge amplifier parameters and illustrated by Equation 2, the product of $R_i C_s$ should be several orders of magnitude higher than $R_f C_f$.

The approximate final system discharge time constant becomes:

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Equation 4a

$$TC = \frac{1}{\frac{1}{R_i C_s} + \frac{1}{R_f C_f}} \quad \text{seconds}$$

If the input coupling time constant ($R_i C_s$) is very much greater than the discharge time constant of the charge amplifier ($R_f C_f$), Equation 4a then becomes:

Equation 4b

$$\frac{1}{R_i C_s} \Rightarrow 0 \text{ Seconds}$$

Equation 5

$$TC = R_f C_f$$

With the product $R_i C_s$ chosen to be much greater than $R_f C_f$, the system discharge time constant is simply $R_f C_f$ (seconds). The feedback parameters of the charge amplifier establish the low frequency characteristics of the system, unaffected by the degraded input resistance parameters of the test sensor and/or cable.

6.5 Other Precautions

Always remember to keep the OPR-GND switch on the charge amplifier in the GND position while connecting or disconnecting sensors, cable, or capacitor to the input connector. Stray or accumulated electrostatic charges may build to the point that they may saturate or even damage the input circuitry of the charge amplifier.

Operate the charge amplifier in the SHORT time constant while the sensor is subject to elevated or changing temperatures.


If it is not necessary to procure data during the transition from room temperature to operating temperature, place the OPR-GND switch in the GND position to keep spurious, thermally generated charges grounded.

It is prudent to momentarily switch to the GND position even during the measurement period to ensure that excess charges do not accumulate at the input of the charge amplifier.

7.0 MAINTENANCE

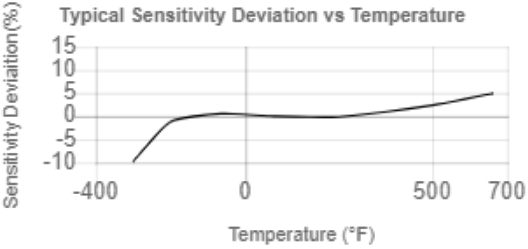
The only maintenance required on the pressure sensor is to keep the connector clean. If it is operating in a dirty environment, protect the cable connections with heat-shrink tubing or similar material.

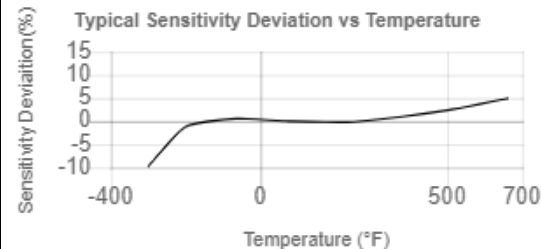
In the event that the electrical connection of the pressure sensor becomes contaminated with dirt or moisture, the insulation resistance degrades. This may cause a reduction of sensitivity or excessive drifting when connected to the charge amplifier. If this happens, brush off the connector with no-residue solvent or other approved cleaning solutions. To restore insulation, bake the sensor in a vacuum oven at 250°F for about four hours. If the condition persists even after cleaning and/or baking, please contact a PCB applications engineer for further assistance. The sensor is hermetically sealed; it must therefore be returned to the factory if the aforementioned measures fail to restore performance.

Model Number 176A04		CHARGE OUTPUT PRESSURE SENSOR			Revision: E ECN #: 54257	
Performance		ENGLISH	SI	OPTIONAL VERSIONS		
Sensitivity(± 20 %)		15.5 pC/psi	225 pC/bar	Optional versions have identical specifications and accessories as listed for the standard model except where noted below. More than one option may be used.		
Measurement Range		300 psi	20.7 bar			
Maximum Pressure(Total)		1,450 psi	100 bar			
Resonant Frequency		≥ 50 kHz	≥ 50 kHz			
Transverse Resonance		10 kHz	10 kHz			
Frequency Response		10 kHz	10 kHz	[2][3]		
Non-Linearity		≤ 1 % FS	≤ 1 % FS	[4]		
Environmental						
Acceleration Sensitivity		≤ 0.01 psi/g	≤ .00069 bar/g			
Temperature Range(Continuous)		-65 to 662 °F	-54 to 350 °C			
Temperature Range(Intermittent)		-320 to 752 °F	-196 to 400 °C			
Temperature Response		See Graph	See Graph	[1]		
Radiation Exposure Limit(Integrated Neutron Flux)		1E10 N/cm ²	1E10 N/cm ²			
Radiation Exposure Limit(Integrated Gamma Flux)		1E8 rad	1E8 rad			
Electrical						
Output Polarity		Differential	Differential			
Capacitance		45 pF	45 pF	[5]		
Resistance(Pin-Pin)(Room Temp)		≥ 10 ⁹ Ohm	≥ 10 ⁹ Ohm			
Resistance(Pin-Case)(Room Temp)		≥ 10 ⁹ Ohm	≥ 10 ⁹ Ohm			
Resistance(Pin-Pin)(572°F/300°C)		≥ 10 ⁷ Ohm	≥ 10 ⁷ Ohm			
Resistance(Pin-Case)(572°F/300°C)		≥ 10 ⁷ Ohm	≥ 10 ⁷ Ohm			
Physical						
Sensing Element		UHT-12™	UHT-12™			
Sensing Geometry		Compression	Compression			
Housing Material		Nickel Alloy	Nickel Alloy			
Sealing		Welded Hermetic	Welded Hermetic			
Electrical Connector		2-Pin	2-Pin			
Weight		3.9 oz	122 g			
NOTES:						
[1]Typical.						
[2]Upper frequency response is calculated from Resonant Frequency.						
[3]Low frequency response is determined by external signal conditioning electronics.						
[4]Zero-based, least-squares, straight line method.						
[5]Nominal.						
SUPPLIED ACCESSORIES:						
Model 100-15954-30 Metric Mounting screws (M5 x 0.8mm x 18mm long) (3)						
Entered: ND		Engineer: RPF		Sales: DPC		
Approved: RPF		Spec Number:				
Date: 10/12/2023		Date: 10/12/2023		Date: 10/12/2023		
Date: 10/12/2023		Date: 10/12/2023		59473		
<div><div>PCB PIEZOTRONICS AN AMPHENOL COMPANY</div><div>Phone: 716-684-0001 Fax: 716-684-0987 E-Mail: info@pcb.com</div></div>						
3425 Walden Avenue, Depew, NY 14043						

All specifications are at room temperature unless otherwise specified.
In the interest of constant product improvement, we reserve the right to change specifications without notice.
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Typical Sensitivity Deviation vs Temperature

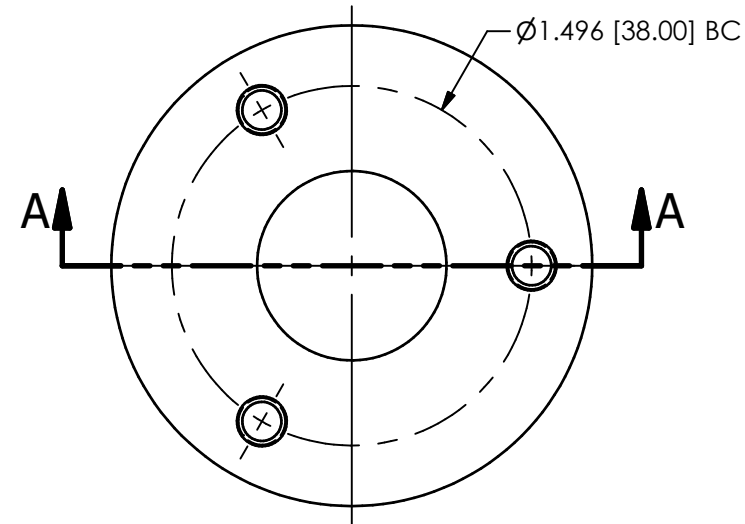
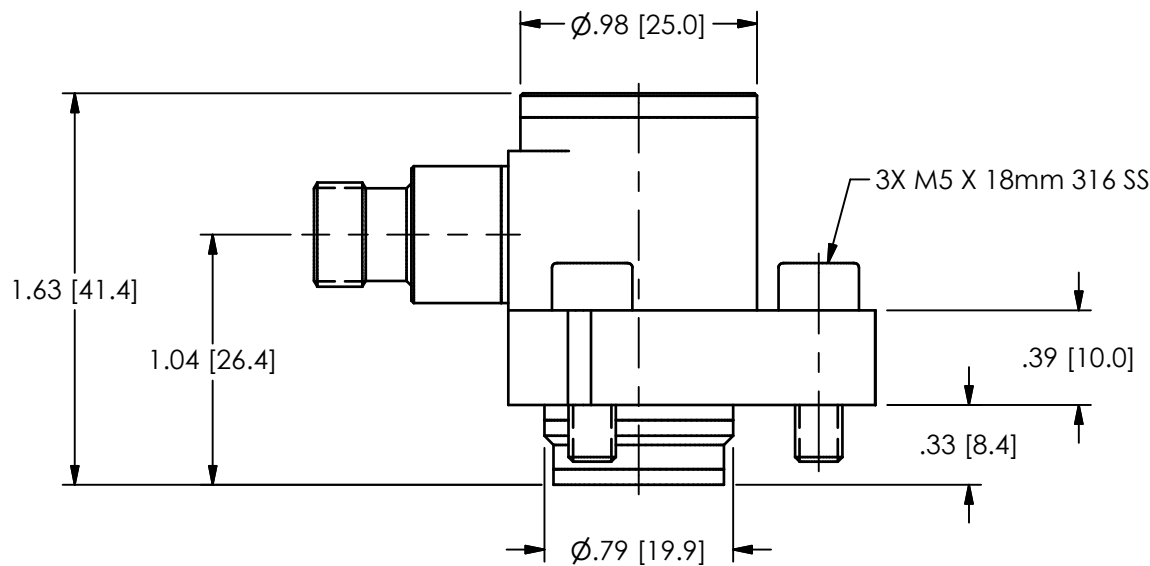
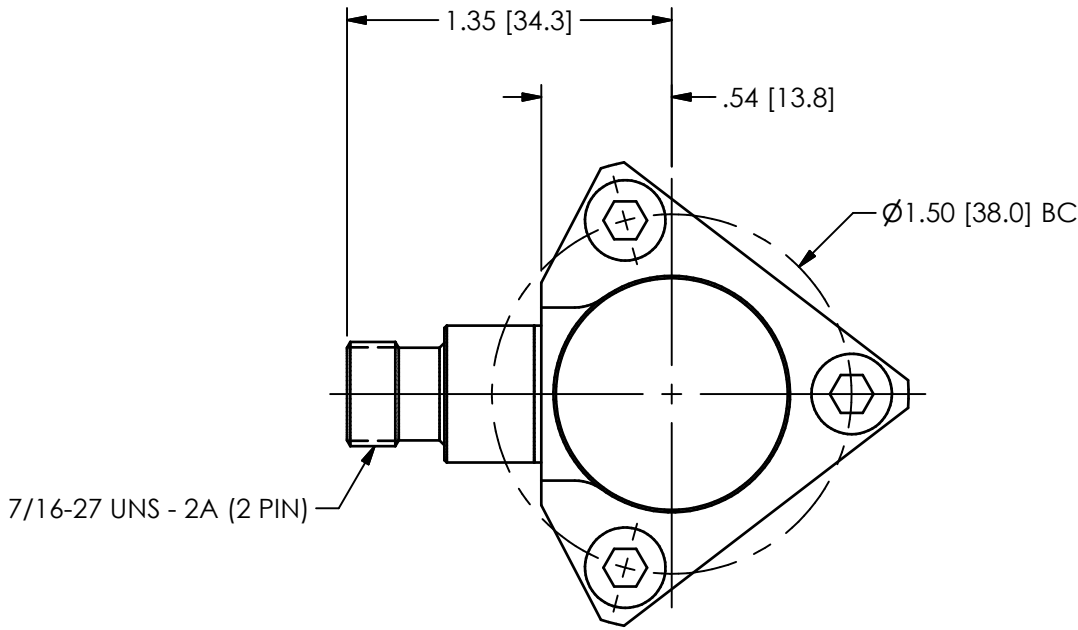




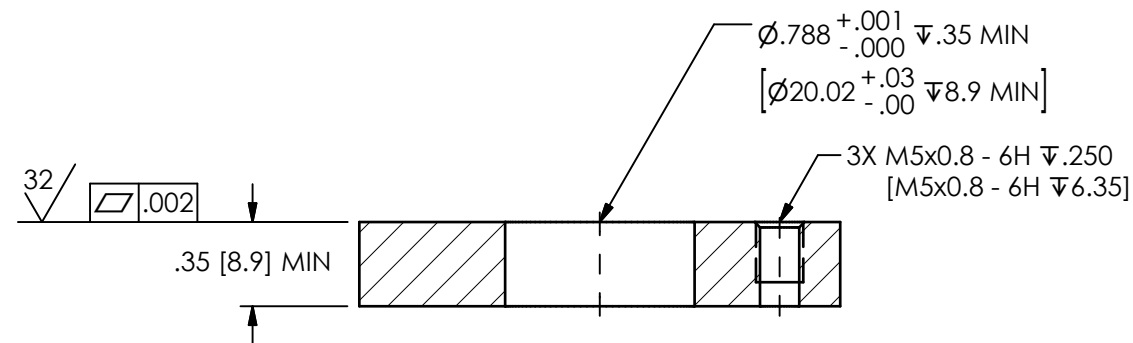
All specifications are at room temperature unless otherwise specified.
In the interest of constant product improvement, we reserve the right to change specifications without notice.
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A

7/16-27 UNS - 2A (2 PIN)




MOUNTING DETAIL



SECTION A-A

REVISIONS		
REV	DESCRIPTION	DIN
B	UPDATED TITLE	54467

1.) RECOMMENDED MOUNTING TORQUE: 3.4 ft-lb [10Nm]

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:		DRAWN		CHECKED		ENGINEER		<div> PCB PIEZOTRONICS AN AMPHENOL COMPANY 3425 WALDEN AVE. DEPEW, NY 14043 (716) 684-0001 E-MAIL: sales@pcb.com</div>		
DIMENSIONS IN INCHES	DIMENSIONS IN MILLIMETERS [IN BRACKETS]	JJF	12/18/23	JJF	12/18/23	NJL	12/18/23			
DECIMALS $\begin{matrix} XX \\ XXX \end{matrix} \pm .01 \\ \pm .005$	DECIMALS $\begin{matrix} X \\ XX \end{matrix} \pm 0.3 \\ \pm 0.13$	TITLE						INSTALLATION DRAWING HIGH TEMPERATURE PRESSURE SENSOR		
ANGLES ± 2 DEGREES	ANGLES ± 2 DEGREES									
CABLE TOLERANCES IN ENGLISH 1" \leq LENGTH < 1' = +1" / - 0 5' \leq LENGTH < 5' = +2" / - 0 15' \leq LENGTH < 100' = +6" / - 0 100' \leq LENGTH = +1' / - 0	CABLE TOLERANCES IN METRIC 2.54cm \leq LENGTH < 30.5cm = +2.54cm / - 0 30.5cm \leq LENGTH < 1.5m = +5.1cm / - 0 1.5m \leq LENGTH < 30.5m = +15.2cm / - 0 30.5m \leq LENGTH = +30.5cm / - 0							CODE IDENT. NO. 52681		
FILLETES AND RADII .003 - .005	FILLETES AND RADII 0.07 - 0.13							SCALE: 1.25X		
					SHEET B			DWG. NO. 59472		