



<b>Service, Repair, and Return Policies and Instructions</b>
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**The information contained in this document supersedes all similar information that may be found elsewhere in this manual.**

**Service** – Due to the sophisticated nature of the sensors and associated instrumentation provided by PCB Piezotronics, user servicing or repair is not recommended and, if attempted, may void the factory warranty. Routine maintenance, such as the cleaning of electrical connectors, housings, and mounting surfaces with solutions and techniques that will not harm the physical material of construction, is acceptable. Caution should be observed to ensure that liquids are not permitted to migrate into devices that are not hermetically sealed. Such devices should only be wiped with a dampened cloth and never submerged or have liquids poured upon them.

**Repair** – In the event that equipment becomes damaged or ceases to operate, arrangements should be made to return the equipment to PCB Piezotronics for repair. User servicing or repair is not recommended and, if attempted, may void the factory warranty.

**Calibration** – Routine calibration of sensors and associated instrumentation is recommended as this helps build confidence in measurement accuracy and acquired data. Equipment calibration cycles are typically established by the users own quality regimen. When in doubt about a calibration cycle, a good “rule of thumb” is to recalibrate on an annual basis. It is

also good practice to recalibrate after exposure to any severe temperature extreme, shock, load, or other environmental influence, or prior to any critical test.

PCB Piezotronics maintains an ISO-9001 certified metrology laboratory and offers calibration services, which are accredited by A2LA to ISO/IEC 17025, with full traceability to SI through N.I.S.T. In addition to the normally supplied calibration, special testing is also available, such as: sensitivity at elevated or cryogenic temperatures, phase response, extended high or low frequency response, extended range, leak testing, hydrostatic pressure testing, and others. For information on standard recalibration services or special testing, contact your local PCB Piezotronics distributor, sales representative, or factory customer service representative.

**Returning Equipment** – *Following these procedures will ensure that your returned materials are handled in the most expedient manner.* Before returning any equipment to PCB Piezotronics, contact your local distributor, sales representative, or factory customer service representative to obtain a Return **Warranty, Service, Repair, and Return Policies and Instructions** Materials Authorization (RMA) Number. This RMA number should be clearly marked on the outside of all package(s) and on the packing

list(s) accompanying the shipment. A detailed account of the nature of the problem(s) being experienced with the equipment should also be included inside the package(s) containing any returned materials.

A Purchase Order, included with the returned materials, will expedite the turn-around of serviced equipment. It is recommended to include authorization on the Purchase Order for PCB to proceed with any repairs, as long as they do not exceed 50% of the replacement cost of the returned item(s). PCB will provide a price quotation or replacement recommendation for any item whose repair costs would exceed 50% of replacement cost, or any item that is not economically feasible to repair. For routine calibration services, the Purchase Order should include authorization to proceed and return at current pricing, which can be obtained from a factory customer service representative.

**Contact Information** – International customers should direct all inquiries to their local distributor or sales office. A

complete list of distributors and offices can be found at [www.pcb.com](http://www.pcb.com). Customers within the United States may contact their local sales representative or a factory customer service representative. A complete list of sales representatives can be found at [www.pcb.com](http://www.pcb.com). Toll-free telephone numbers for a factory customer service representative, in the division responsible for this product, can be found on the title page at the front of this manual. Our ship to address and general contact numbers are:

PCB Piezotronics, Inc.  
3425 Walden Ave.  
Depew, NY14043 USA  
Toll-free: (800) 828-8840  
24-hour SensorLine<sup>SM</sup>: (716) 684-0001  
Website: [www.pcb.com](http://www.pcb.com)  
E-mail: [info@pcb.com](mailto:info@pcb.com)



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	○	○	○	○	○	○
PCB板	X	○	○	○	○	○
电气连接器	○	○	○	○	○	○
压电晶体	X	○	○	○	○	○
环氧	○	○	○	○	○	○
铁氟龙	○	○	○	○	○	○
电子	○	○	○	○	○	○
厚膜基板	○	○	X	○	○	○
电线	○	○	○	○	○	○
电缆	X	○	○	○	○	○
塑料	○	○	○	○	○	○
焊接	X	○	○	○	○	○
铜合金/黄铜	X	○	○	○	○	○
本表格依据 SJ/T 11364 的规定编制。						
○：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.

DOCUMENT NUMBER: 21354

DOCUMENT REVISION: **D**

ECN: 46162

## 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.

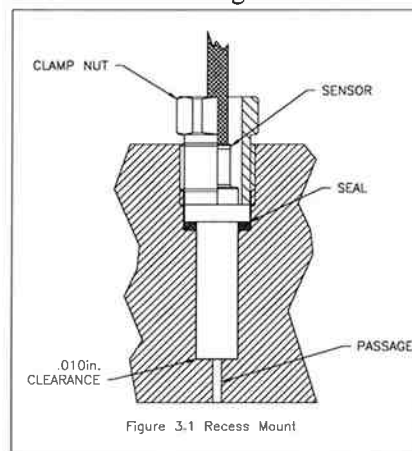


Figure 3.1 Recess Mount

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.

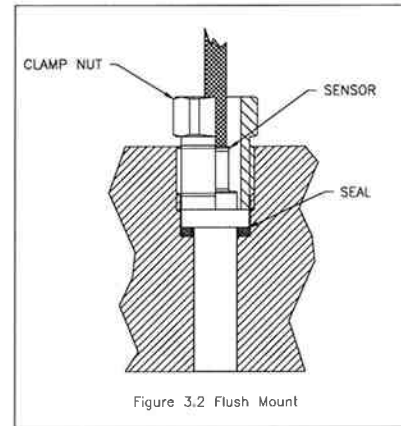


Figure 3.2 Flush Mount

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.

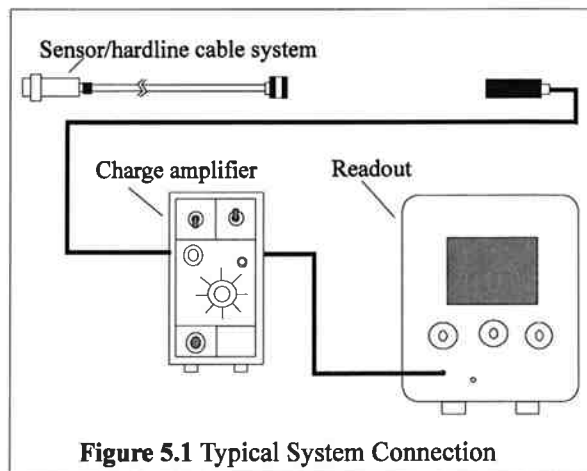
**NOTE:** Do not attempt to use a charge amplifier which, in the long time constant position, has less than a 5 000-second time constant for quasi-static calibration of charge sensors. Any drift may cause error.

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**

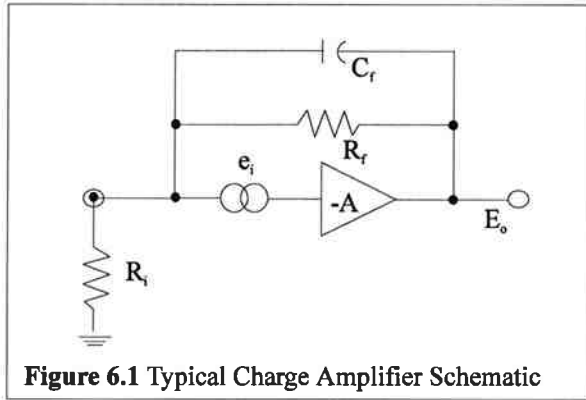
When subjected to elevated temperature, all piezoelectric sensors/hardline cable systems exhibit decreased insulation resistance, due in part to the piezoelectric element, but due mostly to the hardline cable necessary to withstand the high temperatures. This situation can cause serious voltage offset 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.

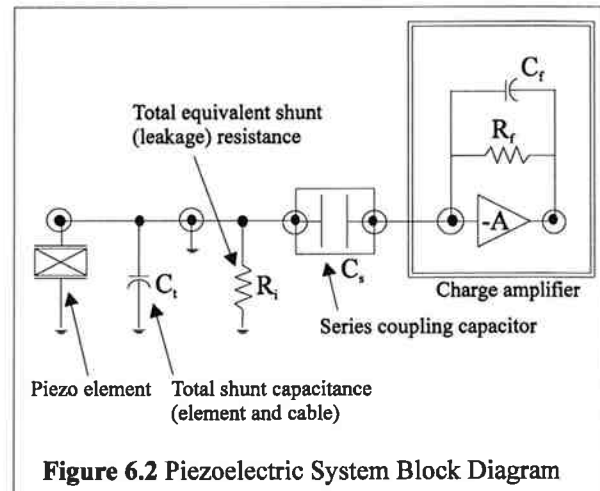


Figure 6.2 illustrates a block diagram of the piezoelectric system where:

- $C_1$  = 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,  $C_1$  and  $C_s$ , in proportion to the size (capacitance) of each. If  $C_s$ , for example, is equal to 100 times  $C_1$ , 99% of the charge appears at the input of the charge amplifier, while 1% is



across the shunt capacitor  $C_t$ . 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  $C_t$  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:

$f_o$  = -3 dB Frequency (Hz)  
 $R_f$  = Feedback resistor (ohms)  
 $C_f$  = Feedback capacitor (farads)

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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Revision: A

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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 <b>176A04</b>	<b>CHARGE OUTPUT PRESSURE SENSOR</b>	Revision: A ECN #: 46623
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	<u>ENGLISH</u>	<u>SI</u>	
<b>Performance</b>			
Sensitivity(± 20 %)	15.5 pC/psi	2.25 pC/kPa	
Measurement Range	300 psi	2070 kPa	
Maximum Pressure(Total)	1.45 kpsi	10,000 kPa	
Resonant Frequency	≥ 50 kHz	≥ 50 kHz	
Transverse Resonance	≥ 10 kHz	≥ 10 kHz	
Frequency Response	10 kHz	10 kHz	[3][4]
Non-Linearity	≤ 1 % FS	≤ 1 % FS	[5]
<b>Environmental</b>			
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	[2]
Radiation Exposure Limit(Integrated Neutron Flux)	1E10 N/cm <sup>2</sup>	1E10 N/cm <sup>2</sup>	
Radiation Exposure Limit(Integrated Gamma Flux)	1E8 rad	1E8 rad	
<b>Electrical</b>			
Output Polarity	Differential	Differential	
Capacitance	45 pF	45 pF	[1]
Internal Resistance(room temp)	≥ 10 <sup>9</sup> Ohm	≥ 10 <sup>9</sup> Ohm	
Insulation Resistance(room temp)	≥ 10 <sup>9</sup> Ohm	≥ 10 <sup>9</sup> Ohm	
Internal Resistance(572°F/300°C)	≥ 10 <sup>7</sup> Ohm	≥ 10 <sup>7</sup> Ohm	
Insulation Resistance(572°F/300°C)	≥ 10 <sup>7</sup> Ohm	≥ 10 <sup>7</sup> Ohm	
<b>Physical</b>			
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	

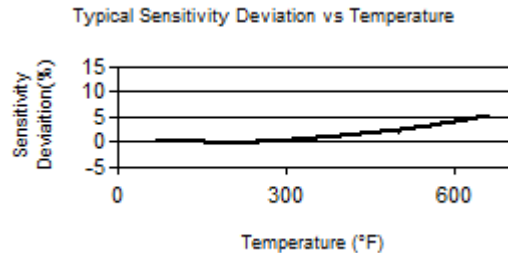
**OPTIONAL VERSIONS**

Optional versions have identical specifications and accessories as listed for the standard model except where noted below. More than one option may be used.

**NOTES:**

[1] Nominal.  
 [2] Typical.  
 [3] Upper frequency response is calculated from Resonant Frequency.  
 [4] Low frequency response is determined by external signal conditioning electronics.  
 [5] Zero-based, least-squares, straight line method.

**SUPPLIED ACCESSORIES:**  
 Model 100-15954-30 Metric Mounting screws (M5 x 0.8mm x 18mm long) (3)



Entered: LK	Engineer: GJR	Sales: JC	Approved: BAM	Spec Number:
Date: 3/30/2017	Date: 3/30/2017	Date: 3/30/2017	Date: 3/30/2017	<b>59473</b>

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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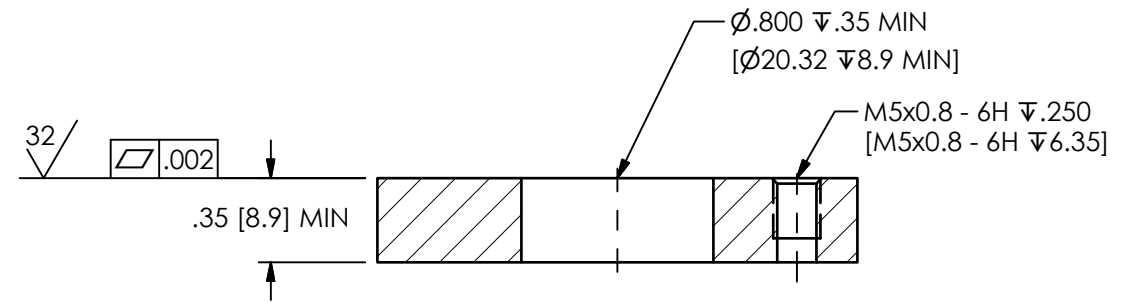
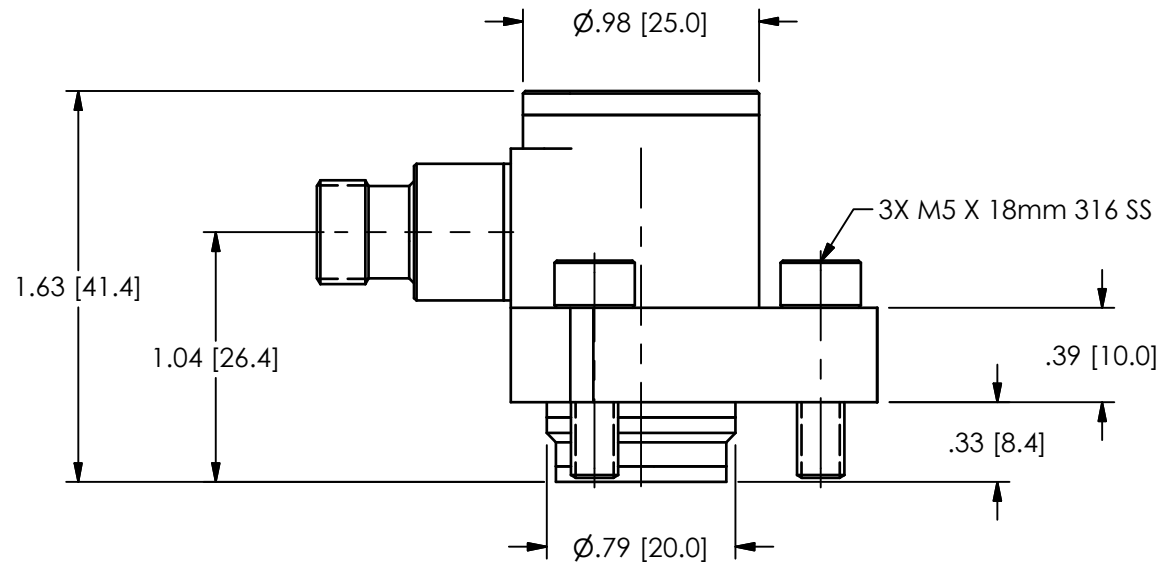
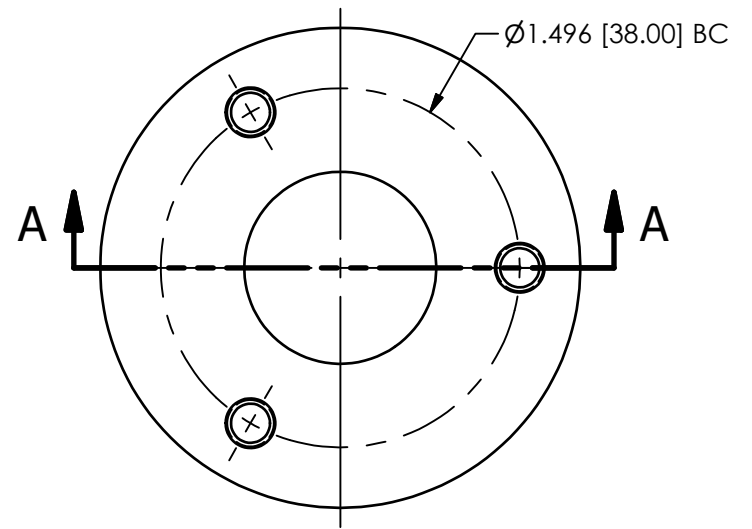
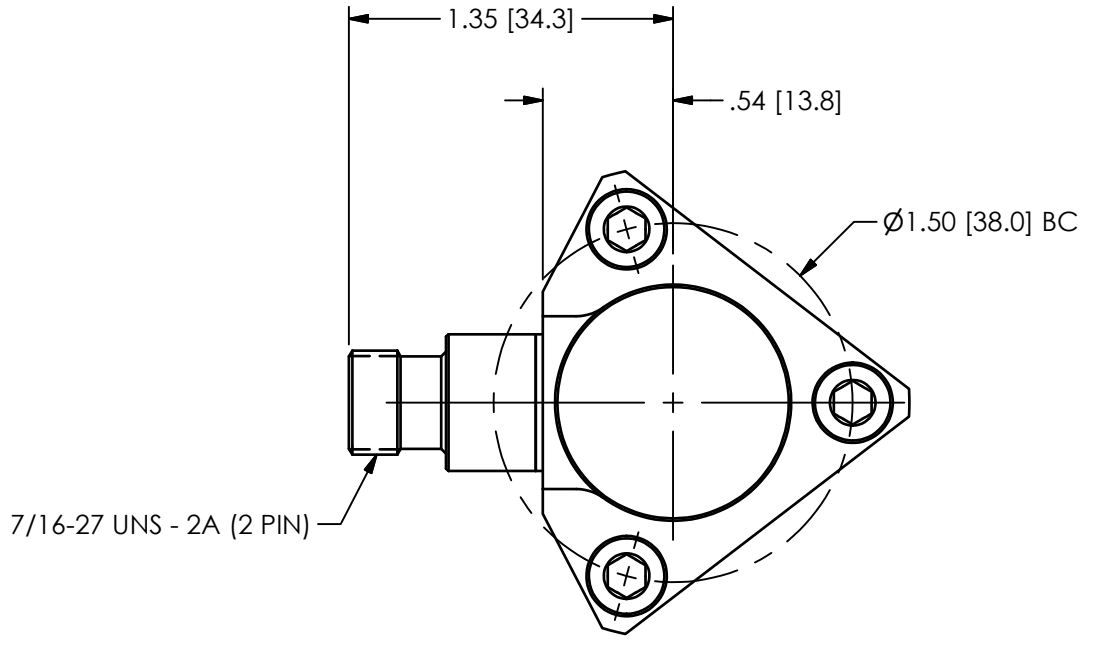
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59472

REVISIONS		
REV	DESCRIPTION	DIN
NR	RELEASED TO DRAFTING	46135



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

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:		DRAWN		CHECKED		ENGINEER	
DIMENSIONS IN INCHES	DIMENSIONS IN MILLIMETERS [IN BRACKETS]	KRM	2/20/17	ECB	2/20/17	AJA	2/20/17
DECIMALS XX $\pm$ .01 XXX $\pm$ .005	DECIMALS X $\pm$ .3 XX $\pm$ .13	TITLE INSTALLATION DRAWING PRESSURE TRANSDUCER MODEL 176A04					
ANGLES $\pm$ 2 DEGREES	ANGLES $\pm$ 2 DEGREES						
FILLETS AND RADII .003 - .005	FILLETS AND RADII 0.07 - 0.13	CODE IDENT. NO. 52681		DWG. NO. 59472		SCALE: 1.25X SHEET 1 OF 1	

**PCB PIEZOTRONICS™**  
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