Model EX611A20

Charge Output Accelerometer

Installation and Operating Manual

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

Toll-free: 800-828-8840
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Warranty, Service, Repair, and Return Policies and Instructions

The information contained in this document supersedes all similar information that may be found elsewhere in this manual.

Total Customer Satisfaction – PCB Piezotronics guarantees Total Customer Satisfaction. If, at any time, for any reason, you are not completely satisfied with any PCB product, PCB will repair, replace, or exchange it at no charge. You may also choose to have your purchase price refunded in lieu of the repair, replacement, or exchange of the product.

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 insure 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 insure 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.

Warranty – All equipment and repair services provided by PCB Piezotronics, Inc. are covered by a limited warranty against defective material and workmanship for a period of one year from date of original purchase. Contact PCB for a complete statement of our warranty. Expendable items, such as batteries and mounting hardware, are not covered by warranty. Mechanical damage to equipment due to improper use is not covered by warranty. Electronic circuitry failure caused by the introduction of unregulated or improper excitation power or electrostatic discharge is not covered by warranty.

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. 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. 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:

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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.

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General

OPERATING GUIDE

for use with

PIEZOELECTRIC CHARGE MODE ACCELEROMETERS

SPECIFICATION SHEET, INSTALLATION DRAWING
AND CALIBRATION INFORMATION ENCLOSED

PCB ASSUMES NO RESPONSIBILITY FOR DAMAGE CAUSED TO THIS PRODUCT AS A RESULT OF PROCEDURES THAT ARE INCONSISTENT WITH THIS OPERATING GUIDE.

DOC: 55308
REV: NR
ECO:41036

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INTRODUCTION
Congratulations on the purchase of a quality PCB charge mode accelerometer. In order to ensure the highest level of performance for this product, it is imperative that you properly familiarize yourself with the correct mounting and installation techniques before attempting to operate this device. If, after reading this manual, you have any additional questions concerning this sensor or its application, feel free to call an Application Engineer at 716-684-0001 or the closest PCB representative.

1.1 Cables in Explosive Atmospheres

The cable lengths (Integral and Cable and Cable Assemblies) INSTALLED IN AN EXPLOSIVE ATMOSPHERE IS DEFINED IN THE ATEX, IECEx, CSA, ETC. APPROVAL CERTIFICATES.

1.2 High Temperature Differential Charge Output Sensor

Ceramic or Single crystal shear-structured accelerometers offer high performance for precision vibration measurements in high-temperature environments. The use of ceramic or single crystal sensing crystals, operating in the shear mode, reduces erroneous output due to base strain, thermal transients, and transverse motion.

Charge mode accelerometers output a strong, high-impedance charge signal directly from their piezoelectric sensing element. They do not contain built-in signal conditioning electronics; the signal is conditioned externally by either a laboratory-style charge amplifier or in-line charge converter prior to being analyzed by a readout or recording device. The absence of built-in electronics permits operation to elevated temperatures of 500 °F (260 °C) for most models or up to 1300 °F (700 °C) for special applications.

These accelerometers are ideal for structural testing, machine monitoring, ~~and~~ vehicular shock, high temperature machinery and power generation turbine and other vibration measurement tasks where high temperatures preclude the use of accelerometers with built-in microelectronics.

Enclosed is a **Specification Sheet**, which lists the complete performance characteristics of the particular accelerometer.

2 CABLING

2.1 General Precautions and Considerations

2.1.1 Proper Cable Type and Care

Ascertain that you have ordered the correct cable type. Due to the high-impedance nature of the output signal generated by charge mode accelerometers, several important precautionary measures must be followed. When using soft-line cable always use special low-noise PCB Series 045 Low-Noise Cable (or equivalent) for connecting to the input of the differential charge-output accelerometers. For extremely high temperature charge mode applications use mineral insulated (MI) hard-line.

Care and attention to installation is essential, as the reliability and accuracy of your system is no better than that of the output cable. Cables and connectors must be kept clean and dry to maintain high insulation resistance and low frequency responce. In the event that the insulation resistance is compromised, inspect, clean, and bake cables and connectors to restore insulation resistance.

2.2 Softline Cable

Special high temperature low-noise, shielded cable 2-wire cable assembly is required with charge mode sensors for applications up to 500°F to connect the transducer to the charge amp. When additional mechanical protection is required a stainless steel armor can be used.

The shield acts as a Faraday cage to reduce electrical noise from corrupting the signals, and minimizes capacitively coupled noise from other electrical sources.

Standard, two-wire, or coaxial cable, when flexed, generates a charge between the conductors. This is referred to as triboelectric noise and cannot be distinguished from the sensor's charge output. Low-noise cables have a special graphite lubricant between the dielectric and the braided shield, which minimizes the triboelectric effect and improves the quality of the sensor's charge output signal.

When using separate cables connect the cable to the accelerometer. A small amount of thread-locking compound placed on the connector prior to attachment helps secure the cable during testing. In harsh environments, the connection can be sealed with silicone rubber, O-rings, and flexible heat-shrink tubing.

2.3 Integral Hardline Cable

For extremely high temperature (>500°F) charge mode applications use mineral insulated (MI) hardline. Keep cable clean to maintain insulation resistance and good low-frequency response

2.4 Hardline Connection Type

2.4.1 PCB / Lemo type connector

The Lemo connector is PCA.0S.302.CLAC42 that is specially adapted for use with hardline cable. The connector is a self-latching system that allows the connector to be mated by simply pushing the plug axially into the socket. When required the connector is disengage by a single axial pull on the outer release sleeve.

2.4.2 High Temperature 2 –pin 7/16-27 UNS connector

This connector is a Model GP, 2 Pin Jack, 7/16-27 thread. The connector is welded to the hardline to provide a high temperature, hermetic connection. The GP connector uses a threaded connction to mate with a GN or ET 2-Socket plug and torqued to 5 ft*lbs +/- 1 ft*lb

2.5 In Line Differential Charge Amplifier

The differential in line charge amplifier is purchased separately

A conventional method for conditioning the high-impedance signal generated by a charge output sensor is to use a differential 422 series in-line charge amplifiers operate from an ICP ® signal conditioner. The unit employs a high gain amplifier to perform the impedance transformation. The charge output of the transducers may be scaled in terms of acceleration, pressure or force. The output is then mV/g, mV/psi or mV/lb, respectively.

3 INSTALLATION OVERVIEW

3.1 Equipment Inspection

Before installing the accelerometer, verify the insulation resistance (I/R) of the sensor is per specification. I/R can be out of specification due to mishandling and/or damage.

3.2 Polarity Test

Use this test to verify the proper polarity response. Improper polarity will adversely affect the use of the sensor for machinery diagnostics such as balancing.

Step 1 – Connect the sensor to a 422 style charge amp and any ICP ® signal conditioner. Using standard cable, connect the powered sensor to an oscilloscope.

Step 2 – Set the time scale to 20 milliseconds/division

Step 3 – Hold the transducer in hand and tap the bottom. The wavefrom on the oscilloscope first goes positive as shown in Figure 1. If the waveform goes negative the wiring is reversed, contact PCB for technical support.

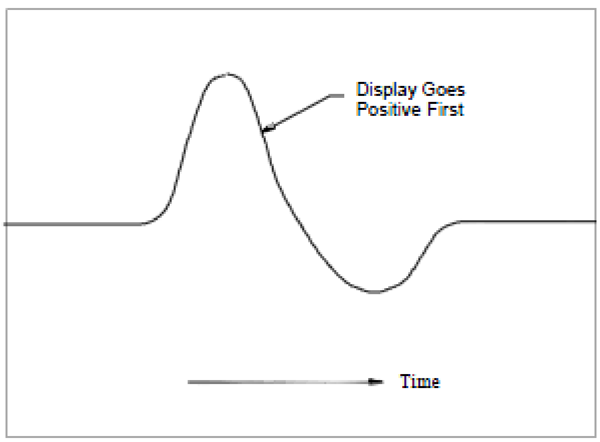


FIGURE 1

3.3 Sensor Location

Characteristics like location, ruggedness, amplitude range, accessibility, temperature, and portability are extremely critical.

For optimum performance and measurement find a rigid location on the machine casing that most accurately represents the vibration of the rotor, bearing, fan, etc. to be measured.).

3.4 Mounting Sensor

Bolt mounting requires smooth, flat contact surfaces for proper operation and is recommended for permanent and/or secure installations. Stud or bolt mounting is also recommended when testing at high frequencies.

Note: *Do NOT attempt mounting on curved, rough, or uneven surfaces, as the potential for misalignment and limited contact surface may significantly reduce the sensor's upper operating frequency range.*

STEP 1: Verify that the ambient and surface temperature of the mounting location are within the temperature range of the sensor.

Step 2: Prepare a smooth, flat mounting surface on the machine casing. Then drill and tap a mounting hole in the center or on the corresponding bolt circle of the sensor–as shown in Figure 2 and in accordance with the **Installation Drawing** for the specific sensor that is being mounted**.**

A precision-machined mounting surface with a minimum finish of 63 μin (0.00016 mm) and flatness of at least .001" (25.4μm) is recommended. Inspect the area, checking that there are no burrs or other foreign particles interfering with the contact surface.

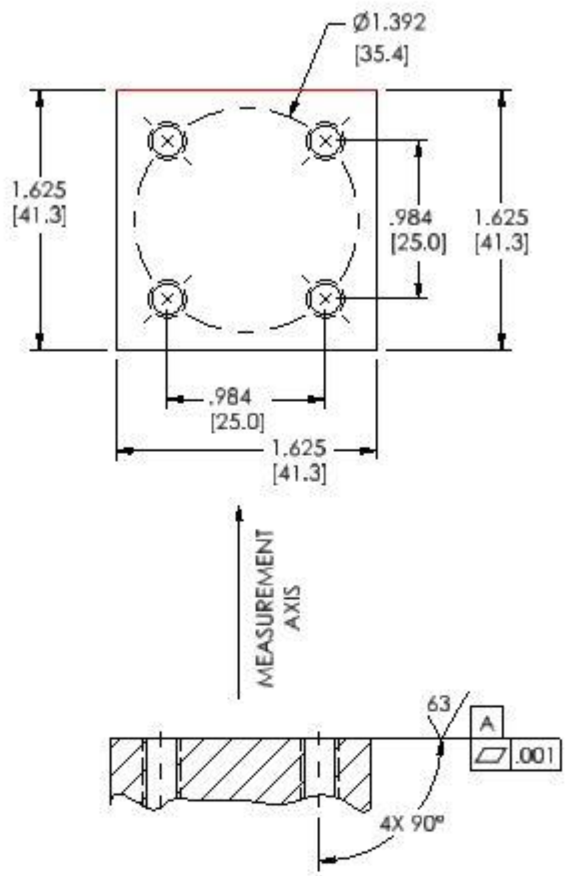


Figure 2. Mounting Surface Preparation

STEP 3: Wipe the mounting surface clean, prior to installation.

STEP 4: Place the sensor on the mounting surface and attach with mounting bolts and tighten to the recommended torque as indicated on the specification.

Note: *It is important to use a torque wrench during this step. Under-torquing the sensor may not adequately couple the device; over-torquing may result in bolt failure.*

3.5 Route Mineral Insulated Hardline Cable

3.5.1 Care

Certain precautions should be used to avoid physical damage and minimize electrical noise. For instance, route the cables away from points that may exceed its operating temperature, avoid routing cables near high-voltage wires. Do not route cables along floors or walkways where they may be stepped on or become damaged or contaminated. Avoid twisting, kinking, or straining the cable. Shielded cables should have the shield grounded at one end only.

3.5.2 Bend Radius

The minimum bend radius (r) for both soft-line and hardline cable is determined by the cable diameter as shown below:

Bends Allowed	Cable Diameter	Minimum Bending Radius
Total	d	r
1	0.125" (3.2 mm)	0.60" (16 mm)
20	0.125" (3.2 mm)	2.0" (50 mm)

3.5.3 Clamp Cable

To minimize triboelectric (motion-induced) noise from the cable interfering with the sensors high impedance charge output cable clamps must be used. Clamp the cable as close to the transducer as possible and should be attached to the same surface that the head is mounted (See Figure 3) taking care not to induce stress into the cable and possibly leading to intermittent or broken connections. Continue to clamp the cable at regular intervals of approximately 1.5 ft (0.5 m)

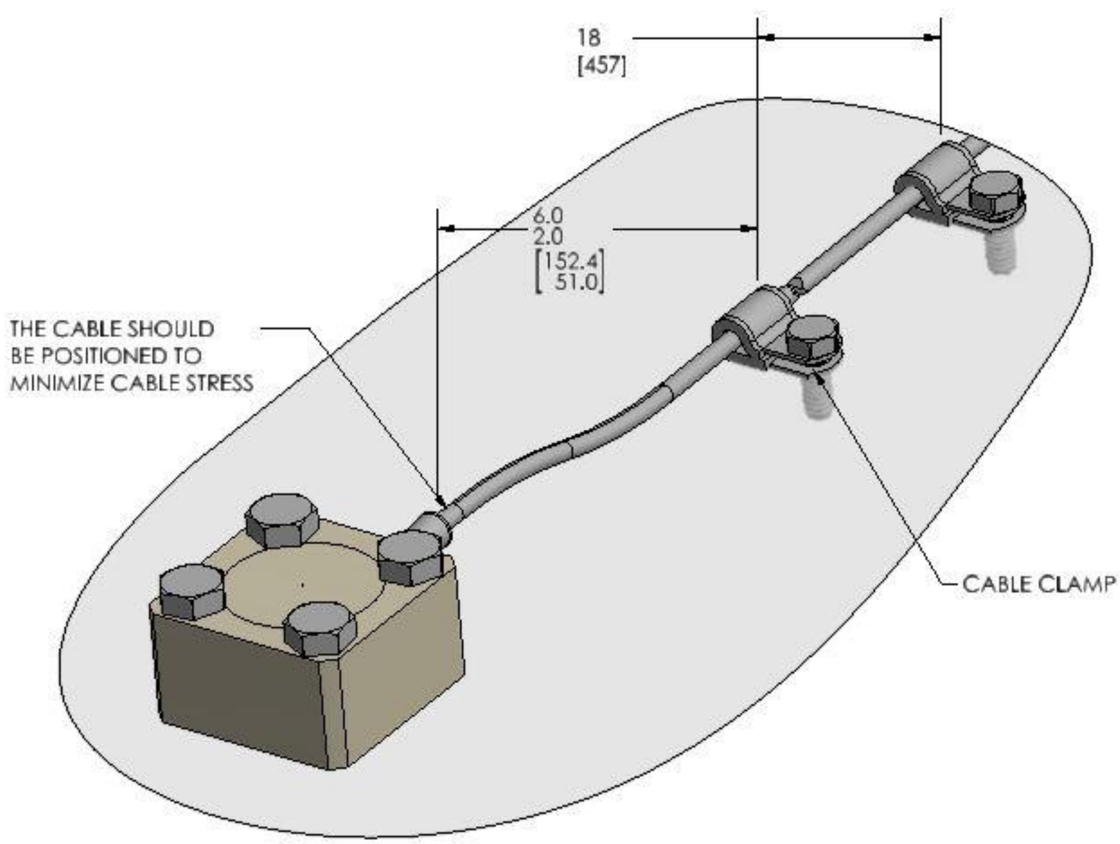
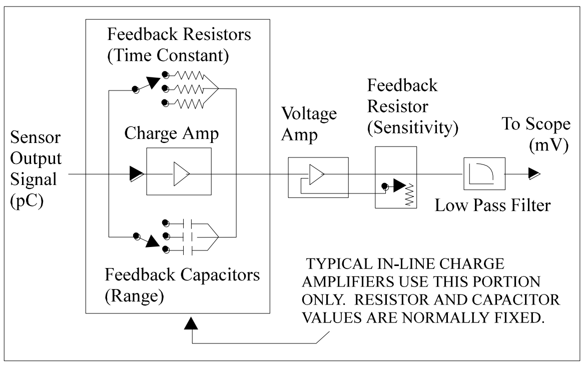


Figure 3

4 POWERING

4.1 Installation

Before connecting the low-noise cable from the accelerometer to the charge amplifier, be sure to ground both the charge amplifier and the cable. This ensures that an excessive static charge that may have accumulated across the accelerometer or cable is harmlessly discharged. Failure to observe this precaution can result in the destruction of the input FET of certain amplifiers.



Connect the transducer to the input of a PCB differential 422 series or equivalent charge amp using low noise cable. ***Note:*** *For optimum noise performance, the cable length between the sensor and the 422 should be minimized.*

Connect the output of the 422 to any ICP ® signal conditioner using standard cable. Finally, the output of the signal conditioner may then be connected to an oscilloscope or other monitoring device. This output will be an AC signal (see ***specification*** for actual frequency response) with a DC bias. Many PCB signal conditioners remove the bias via an AC coupling circuit.

4.2 Operation

Once each element is connected, allow a few minutes for the system to thermally stabilize. Place the switch on the charge amplifier in the OPERATE position and proceed with the measurement.

It is often convenient to normalize the accelerometer and charge amplifier system to a precise sensitivity, such as 10.0 or 100.0 mV/g for ease of data analysis. This is accomplished with most PCB laboratory charge amplifiers and some miniature in-line units as well.

For fixed sensitivity in-line charge converters, such as the PCB Series 422, the system sensitivity (mV/g) is determined as the product of the charge amplifier sensitivity (mV/pC) and the charge sensitivity of the accelerometer (pC/g).

Note: *When using charge-amplified systems, the noise floor of the system is dependent on the input capacitance to the charge amplifier. Since the cable adds to the capacitance and to minimize the noise threshold, keep the cable length between the accelerometer and the charge amplifier to a minimum. Cable length does not affect the system sensitivity of charge-amplified systems.*

Since charge amplifier operation varies, please contact the respective signal conditioner manufacturer or check the product manual for additional information.

5 HIGH-TEMPERATURE OPERATION

5.1 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 5.3 Solution to Reduced Resistance , for complete details, or use different amplifiers.

5.2 Reduced Resistance at Charge Amplifier Input

Figure 5.1 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)

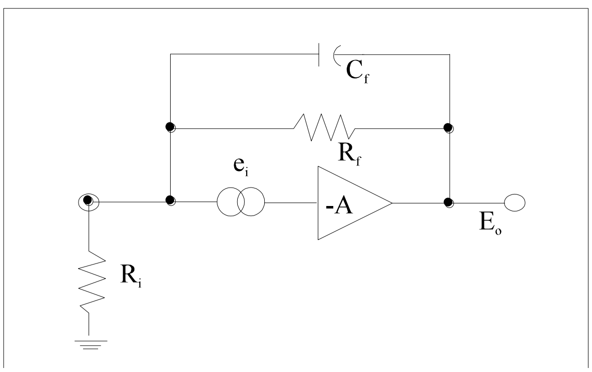


Figure 5.1 Typical Charge Amplifier Schematic

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.

5.3 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.

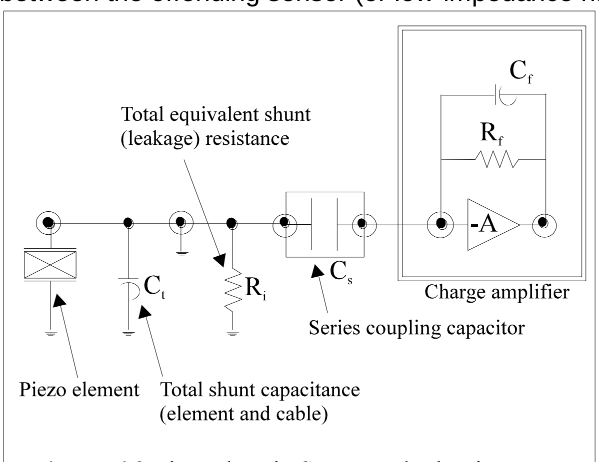


Figure 5.2 Piezoelectric System Block Diagram

Figure 5.2 illustrates a block diagram of the piezo-electric 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_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 that 10^{12} ohms, to avoid the DC offset discussed previously in 5.1, Introduction.

5.4 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_t = 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_iC_s should be several orders of magnitude higher than R_fC_f.

The approximate final system discharge time constant becomes:

Equation 4a

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

If the input coupling time constant (R_iC_s) is very much greater than the discharge time constant of the charge amplifier (R_fC_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_iC_s chosen to be much greater than R_fC_f , the system discharge time constant is simply R_fC_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.

5.5 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.

6 ACCELEROMETER CALIBRATION

Accelerometer calibration provides, with a definable degree of accuracy, the necessary link between the physical quantity being measured and the electrical signal generated by the sensor. In addition, other useful information concerning operational limits, physical parameters, electrical characteristics, or environmental influences may also be determined. Without this link, analyzing data becomes a nearly impossible task. PCB provides a calibration record that documents the exact characteristics of each sensor. (The type and amount of data varies depending on the sensor type, contractual regulations, and other special requirements.)

Under normal operating conditions, piezoelectric sensors are extremely stable, and their calibrated performance characteristics do not change over time. However, harsh environments or other unusual conditions that cause the sensor to experience dynamic phenomena outside of its specified operating range may temporarily or permanently affect the sensor. This change manifests itself in a variety of ways, including a shift of the sensor resonance due to a cracked crystal, or a temporary loss of low-frequency measuring capability due to a drop in insulation resistance.

For these reasons, it is recommended that a recalibration cycle be established for each accelerometer. This schedule is unique and is based on a variety of factors, such as extent of use, environmental conditions, accuracy requirements, trend information obtained from previous calibration records, contractual regulations, frequency of “cross-checking” against other equipment, manufacturer recommendation, and any risk associated with incorrect readings. International standards, such as ISO 10012-1, provide insight and suggested methods for determining recalibration intervals for most measuring equipment. With the above information in mind and under “normal” circumstances, PCB conservatively suggests a 12- to 24-month recalibration cycle for most piezoelectric accelerometers.

Note: *It is good measurement practice to verify the performance of each accelerometer with a Handheld Shaker or other calibration device before and after each measurement. The PCB Model 394C06 Handheld Shaker operates at a fixed frequency and known amplitude (1.0 g) to provide a quick check of sensor sensitivity.*

6.1.1 SENSOR RECALIBRATION

Accelerometer recalibration services are typically performed by PCB’s internal metrology laboratory. (Other international and private laboratories are also available.) The PCB laboratory is certified to ISO 9001, accredited by A2LA to ISO 17025, complies with ISO 10012-1 (and former MIL-STD-45662A), and uses equipment directly traceable to N.I.S.T. This assures an accurate calibration of relevant specifications.

In addition, many companies choose to purchase the equipment necessary to perform the recalibration procedure themselves. While this may result in both a savings of time and money, it has also been attributed to incorrect readings and costly errors. Therefore, in an effort to prevent the common mistakes associated with customer-performed calibration, this document includes a broad overview of the Back-to-Back Calibration technique. This technique provides a quick and easy method for determining the sensitivity of a test accelerometer over a wide frequency range.

6.1.2 BACK-TO-BACK CALIBRATION THEORY

Back-to-Back Calibration is perhaps the most common method for determining the sensitivity of piezoelectric accelerometers. This method relies on a simple comparison to a previously calibrated accelerometer, typically referred to as a reference standard.

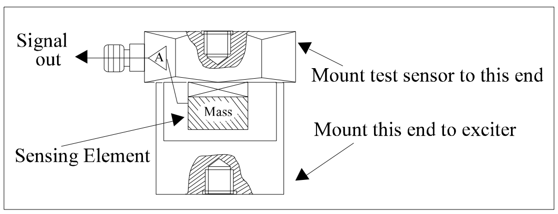


Figure 1. Reference Standard Accelerometer

These high-accuracy devices, which are directly traceable to a recognized standards laboratory, are designed for stability, as well as configured to accept a test accelerometer. By mounting a test accelerometer to the reference standard and then connecting this combination to a suitable vibration source, it is possible to vibrate both devices and compare the data as shown in Figure 2. (Test set-ups may be automated and vary, depending on the type and number of accelerometers being calibrated.)

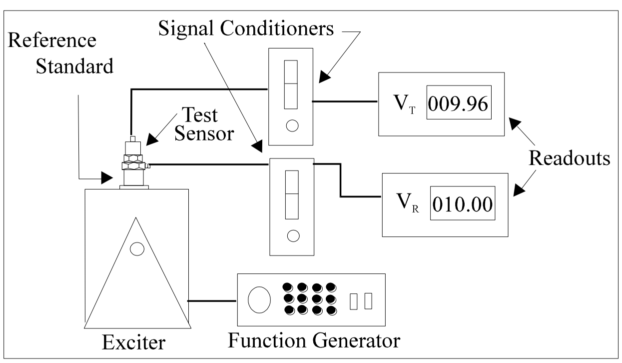


Figure 2. Typical Back-to-Back Calibration System

Because the acceleration is the same on both sensors, the ratio of their outputs (V_T/V_R) must also be the ratio of their sensitivities. With the sensitivity of the reference standard (S_R) known, the exact sensitivity of the test sensor (S_T) is easily calculated by using the following equation:

$$S_T = S_R \, (V_T/V_R)$$

By varying the frequency of the vibration, the sensor may be calibrated over its entire operating frequency range. The typical response of an unfiltered accelerometer is shown in Figure 3.

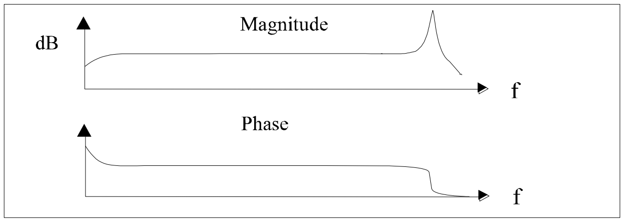


Figure 3. Typical Test Accelerometer Response

6.1.3 PCB CALIBRATION PROCEDURE

Numerous precautions are taken at PCB to insure accurate and repeatable results. This section provides a brief overview of the primary areas of concern.

Since the Back-to-Back Calibration technique relies on each sensor experiencing an identical acceleration level, proper mounting of the test sensor to the reference standard is imperative. Sensors with mounting holes are attached directly to the reference standard with a stud tightened to the recommended mounting torque. A shouldered mounting stud is typically used to prevent the stud from "bottoming out" in the hole.

Both mounting surfaces are precision-machined and lapped to provide a smooth, flat interface according to the manufacturer's specification. A thin layer of silicone grease is placed between the mating surfaces to fill any imperfections and increase the mounting stiffness. The cables are stress-relieved by first routing them to the shaker head, securing them with tape or cable ties, then routing them to a nearby stationary location. This reduces cable motion, which is especially important when testing charge output sensors and helps to prevent extraneous noise or stresses from being imparted into the system. A typical set-up is shown in Figure 4.

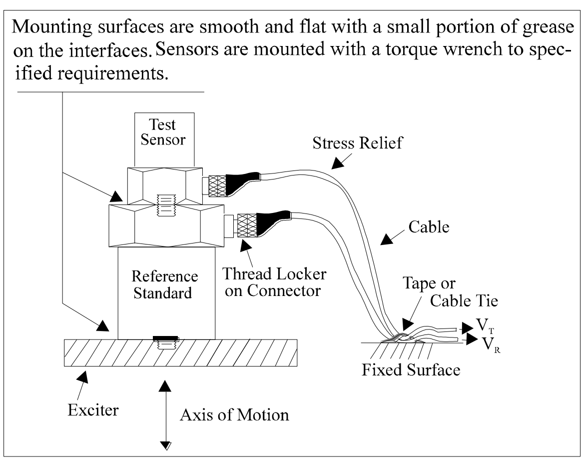


Figure 4. Typical Calibration Set-Up

Adhesively mounted sensors use similar practices. However, in this case, a small portion of quick-bonding gel or similar temporary adhesive is used to attach the test sensor to a reference standard designed with a smooth, flat mounting surface.

In addition to mounting, the selection of the proper equipment is critical. Some of the more important considerations include: 1) the reference standard must be specified and previously calibrated over the frequency and/or amplitude range of interest; 2) the shaker should be selected to provide minimal transverse (lateral) motion and minimal distortion; and 3) the quality of the meters, signal generator, and other devices should be selected so as to operate within the limits of permissible error.

7.4 COMMON MISTAKES

Most calibration errors are caused by simply overlooking some of the fundamental principals of dynamics. This section attempts to address some of the more common concerns.

For stud-mount sensors, always mount the accelerometer directly to the reference standard. Ensure that the mounting surfaces are smooth, flat, and free of any burrs. Always use a coupling fluid, such as silicone grease, in the mounting interface to maintain a high mounting stiffness. Mount the sensor according to the manufacturer's recommended mounting torque. DO NOT use any intermediate mounting adaptors, as the mounted resonant frequency may be reduced and thereby compromise the high-frequency performance. If necessary, use adaptor studs.

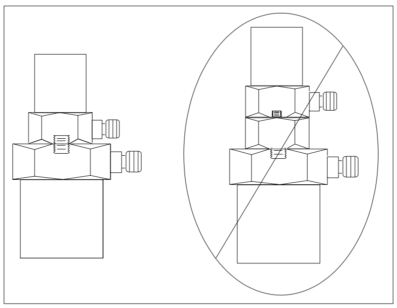


Figure 5. Stud Mounting

Understand Back-to-Back Calibration limitations. Do not expect the uncertainty of calibration to be any better than ±2%. (In fact, the uncertainty may be as high as ±3% or ±4% for frequencies <10 Hz or >2 kHz.) Since large sensors may affect high-frequency accuracy, verify that the test sensor does not mass load the reference standard. Validate your calibration system with another accelerometer prior to each calibration session. Check with the manufacturer for exact system specifications.

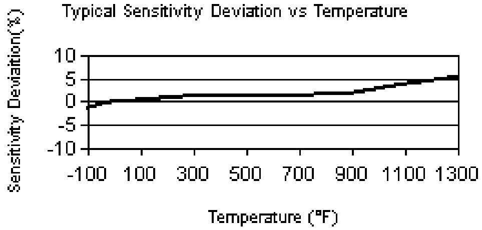
7.5 CONCLUSIONS

Without an adequate understanding of dynamics, determining what, when, and how to test a sensor is a difficult task. Therefore, each user must weigh the cost, time, and risk associated with self-calibration versus the services of an accredited laboratory.

PCB PIEZOTRONICS INC.
VIBRATION DIVISION
3425 Walden Avenue, Depew, NY 14043
Toll Free: 888-684-0013 • 24-hour SensorLine[SM]: 716-684-0001 • FAX: 716-685-3886
E-mail: vibration@pcb.com • Website: www.pcb.com

Model Number EX611A20	CHARGE OUTPUT ACCELEROMETER	Revision: A ECN #: 41807

Performance	ENGLISH	SI	
Sensitivity(± 5 %)	10 pC/g	1.02 pC/(m/s²)	
Measurement Range	± 200 g pk	± 1962 m/s² pk	
Frequency Range(± 5 %)	2800 Hz	2800 Hz	[4]
Frequency Range(+10 %)	3700 Hz	3700 Hz	[4]
Resonant Frequency	>17 kHz	>17 kHz	[1]
Non-Linearity	≤ 1 %	≤ 1 %	[5]
Transverse Sensitivity	≤ 5 %	≤ 5 %	[6]
Environmental			
Overload Limit(Shock)	± 5000 g pk	± 49,050 m/s² pk	
Temperature Range	-65 to +900 °F	-54 to +482 °C	
Temperature Range	-65 to +1200 °F	-54 to +650 °C	[2]
Temperature Range	-165 to +1300 °F	-109 to +704 °C	[3]
Temperature Response	See Graph	See Graph	[1]
Temperature Response	See Graph	See Graph	
Temperature Response	See Graph	See Graph	
Base Strain Sensitivity	0.005 g/με	0.05 (m/s²)/με	[1]
Radiation Exposure Limit(Integrated Neutron Flux)	1 E10 N/cm²	1 E10 N/cm²	
Radiation Exposure Limit(Integrated Gamma Flux)	1 E8 rad	1 E8 rad	
Hazardous Area Approval	Ex ia IIC T6 . . . T 710°C Ga	Ex ia IIC T6 . . . T 710°C Ga	
Hazardous Area Approval	IECEx Ex ia IIC T6 . . . T 710°C Ga	IECEx Ex ia IIC T6 . . . T 710°C Ga	
Electrical			
Capacitance(Pin to Pin)	320 pF	320 pF	[1]
Capacitance(Pin to Case)	360 pF	360 pF	[1]
Insulation Resistance(Pin to Case 70° F)	>10^9 Ohm	>10^9 Ohm	[1]
Insulation Resistance(Pin to Pin 70° F)	>10^9 Ohm	>10^9 Ohm	
Insulation Resistance(Pin to Pin 900° F)	>100 kohm	>100 kohm	
Insulation Resistance(Pin to Pin 1200° F)	>20 kohm	>20 kohm	
Output Polarity	Differential	Differential	
Physical			
Sensing Element	Single Crystal	Single Crystal	
Sensing Geometry	Shear	Shear	
Housing Material	Inconel	Inconel	
Sealing	Hermetic	Hermetic	
Size (Height x Length x Width)	.787 in x 1.465 in x 1.456 in	20 mm x 37 mm x 37 mm	
Weight(without cable)	6.3 oz	180 gm	[1]
Electrical Connector	LEMO PCA.0S.302.CLLC42	LEMO PCA.0S.302.CLLC42	
Electrical Connection Position	Side	Side	
Cable Length	10 ft	3 m	
Cable Type	MI Hardline Cable	MI Hardline Cable	
Mounting	Through Hole	Through Hole	



CE [7]

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.

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] Typical.
[2] Continuous
[3] Extreme
[4] Low frequency response is determined by external signal conditioning electronics.
[5] Zero-based, least-squares, straight line method.
[6] Transverse sensitivity is typically ≤ 3%.
[7] See PCB Declaration of Conformance PS122 for details.

SUPPLIED ACCESSORIES:

Model 081A115 M6 x 1 x 25 mm long (1)
Model ICS-1 NIST-traceable single-axis amplitude response calibration from 600 cpm (10 Hz) to upper 5% frequency

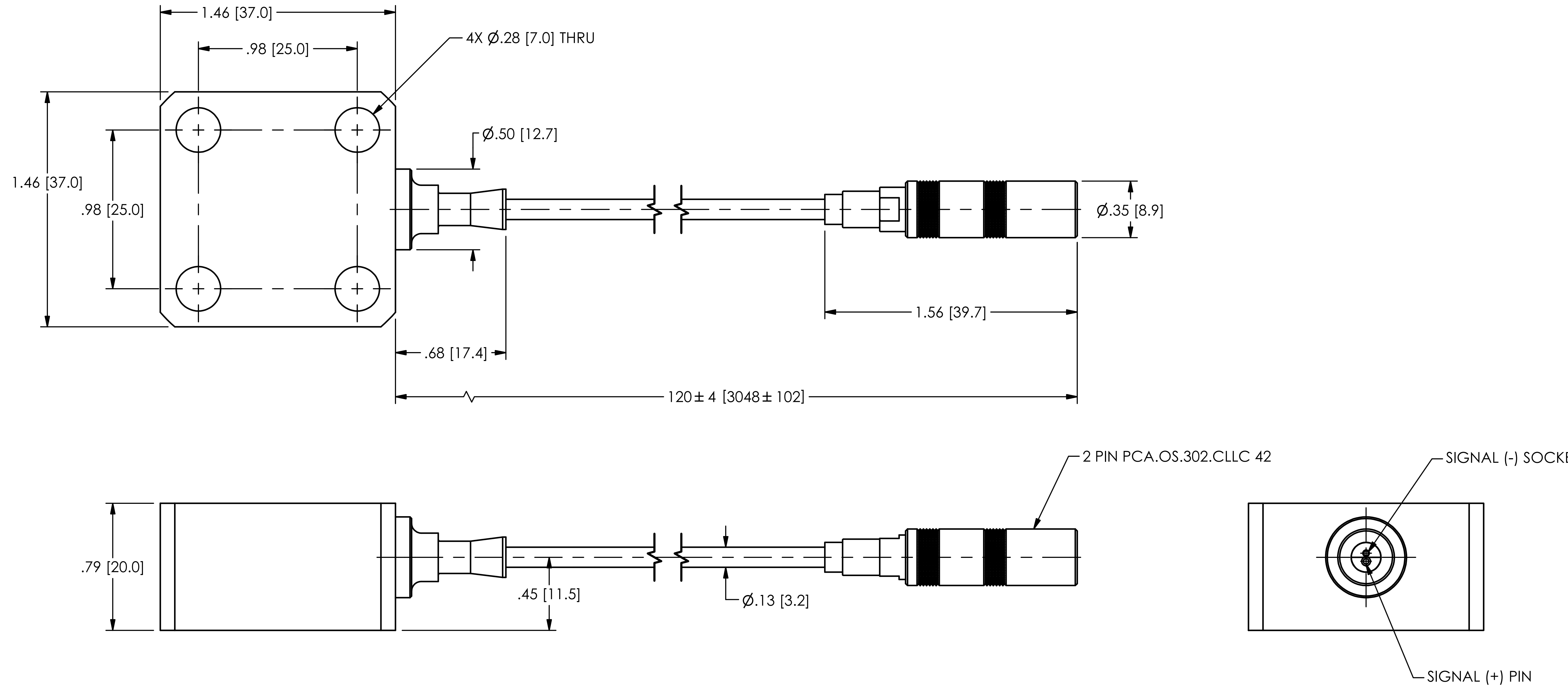
Entered: AP	Engineer: JJD	Sales: EGY	Approved: NJF	Spec Number:
Date: 9/12/2013	Date: 9/12/2013	Date: 9/12/2013	Date: 9/12/2013	**50208**

PCB PIEZOTRONICS
3425 Walden Avenue, Depew, NY 14043
Phone: 716-684-0001
Fax: 716-684-0987
E-Mail: info@pcb.com

49582

REVISIONS

REV	DESCRIPTION	DIN
B	UPDATED CABLE LENGTH	44951



UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:	
DIMENSIONS IN INCHES	DIMENSIONS IN MILLIMETERS [IN BRACKETS]
DECIMALS XX ±.03 XXX ±.010	DECIMALS X ± 0.8 XX ± 0.25
ANGLES ± 2 DEGREES	ANGLES ± 2 DEGREES
FILLETS AND RADII .003 - .005	FILLETS AND RADII 0.07 - 0.13

DRAWN		CHECKED		ENGINEER	
BB	1/18/16	ECB	1/18/16	JJD	1/18/16

TITLE

OUTLINE DRAWING
MODEL EX611A20

PCB PIEZOTRONICS
3425 WALDEN AVE. DEPEW, NY 14043
(716) 684-0001 E-MAIL: sales@pcb.com

CODE IDENT. NO. 52681

DWG. NO. 49582

SCALE: 1.5X SHEET 1 OF 1

PCB PIEZOTRONICS
IMI SENSORS
A PCB PIEZOTRONICS DIV.

EC Declaration of Conformity PS122

In Accordance with ISO/IEC 17050

Manufacturer: PCB Piezotronics, Inc. 3425 Walden Avenue Depew, New York 14043 USA	**Authorized European Representative:** PCB Piezotronics Europe GmbH PO Box 1148 D-52473 Linnich, Germany

Certifies that type of equipment: **High Temperature Accelerometer(s)**

Whose Product Models Include: **EX611XXX Series**

This declaration is applicable to all High Temperature Accelerometer(s) of the above series which have the CE & ATEX mark on their data sheets and where those data sheets refer to this declaration of conformity. The data sheets for all model numbers referenced above, which include the CE & ATEX mark on such data sheets and refer to this Declaration of Conformity are hereby incorporated by reference into this Declaration.

Conform to the following EC Directive(s) when installed per product documentation:	94/9/EC	ATEX

Standards to which Conformity is Declared:

Harmonized Standards	EN60079-0 (2009) EN60079-11 (2012) IEC60079-0 Ed 5 IEC60079-11 Ed 6	General Explosive Atmosphere Intrinsic safe, I General Explosive Atmosphere Intrinsic safe, I
	ATEX Cert IECEx Cert	LCIE 12 ATEX 3053x Ex ia II C T6 ...710ºC Ga, II 1G Ex ia II C T6 ...710ºC Ga
Notified Body Name		Laboratoire Central des Industries Electriques (0081)
Notified Body's Address		**FONTENAY-AUX-ROSES (Head Office)** 33, avenue du Général Leclerc FR- 92260 Fontenay-aux-Roses Tel. : + 33 1 40 95 60 60 Fax : + 33 1 40 95 86 56

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) Standard(s)

Place: Depew, NY **Date:** 02/27/2013

Signature: Kenneth J. Gonyea Jr

Name: Kenneth J. Gonyea Jr.

Title: V.P. Manufacturing

ITEM # 54998
REV: NR
ECO: 41036

L C I E

1 **ATTESTATION D'EXAMEN CE DE TYPE**

1 **EC TYPE EXAMINATION CERTIFICATE**

2 **Appareil ou système de protection** destiné à être utilisé en atmosphères explosibles **(Directive 94/9/CE)**

2 **Equipment or protective system** intended for use in potentially explosive atmospheres **(Directive 94/9/EC)**

3 Numéro de l'attestation d'examen CE de type
LCIE 12 ATEX 3053 X

3 EC type examination certificate number
LCIE 12 ATEX 3053 X

4 Appareil ou système de protection :
Capteurs de vibrations
Type : EX611xxx/xxxxx

4 Equipment or protective system :
Vibration sensors
Type : EX611xxx/xxxxx

5 Demandeur : IMI
Adresse : A PCB Piezotronics Div.
3425 Walden Avenue
Depew, New York, 14043 USA

5 Applicant : IMI
Address : A PCB Piezotronics Div.
3425 Walden Avenue
Depew, New York, 14043 USA

6 Fabricant : IMI
Adresse : A PCB Piezotronics Div.
3425 Walden Avenue
Depew, New York, 14043 USA

6 Manufacturer : IMI
Address : A PCB Piezotronics Div.
3425 Walden Avenue
Depew, New York, 14043 USA

7 Cet appareil ou système de protection et ses variantes éventuelles acceptées sont décrits dans l'annexe de la présente attestation et dans les documents descriptifs cités en référence.

7 This equipment or protective system and any acceptable variation thereto are specified in the schedule to this certificate and the documents therein referred to.

8 Le LCIE, organisme notifié sous la référence 0081 conformément à l'article 9 de la directive 94/9/CE du Parlement européen et du Conseil du 23 mars 1994, certifie que cet appareil ou système de protection est conforme aux exigences essentielles de sécurité et de santé pour la conception et la construction d'appareils et de systèmes de protection destinés à être utilisés en atmosphères explosibles, données dans l'annexe II de la directive.
Les résultats des vérifications et essais figurent dans le rapport confidentiel N°113365-625323.

8 LCIE, notified body number 0081 in accordance with article 9 of the Directive 94/9/EC of the European Parliament and the Council of 23 March 1994, certifies that this equipment or protective system has been found to comply with the essential Health and Safety Requirements relating to the design and construction of equipment and protective systems intended for use in potentially explosive atmospheres, given in Annex II to the Directive.
The examination and test results are recorded in confidential report N°113365-625323.

9 Le respect des exigences essentielles de sécurité et de santé est assuré par la conformité à :

9 Compliance with the Essential Health and Safety Requirements has been assured by compliance with :

EN 60079-0:2009, EN 60079-11:2012

10 Le signe X lorsqu'il est placé à la suite du numéro de l'attestation, indique que cet appareil ou système de protection est soumis aux conditions spéciales pour une utilisation sûre, mentionnées dans l'annexe de la présente attestation.

10 If the sign X is placed after the certificate number, it indicates that the equipment or protective system is subject to special conditions for safe use specified in the schedule to this certificate.

11 Cette attestation d'examen CE de type concerne uniquement la conception et la construction de l'appareil ou du système de protection spécifié, conformément à l'annexe III de la directive 94/9/CE.
Des exigences supplémentaires de la directive sont applicables pour la fabrication et la fourniture de l'appareil ou du système de protection. Ces dernières ne sont pas couvertes par la présente attestation.

11 This EC type examination certificate relates only to the design and construction of this specified equipment or protective system in accordance with annex III to the directive 94/9/EC.

Further requirements of the directive apply to the manufacturing process and supply of this equipment or protective system. These are not covered by this certificate.

12 Le marquage de l'appareil ou du système de protection doit comporter les informations détaillées au point 15.

12 The marking of the equipment or protective system shall include information as detailed at 15.

Fontenay-aux-Roses, le 30 août 2012

Le Responsable de Certification ATEX
ATEX Certification Officer
Michel BRENON

LCIE 33, av du Général Leclerc Tél : +33 1 40 95 60 60 Société par Actions Simplifiée
Laboratoire Central BP 8 Fax : +33 1 40 95 86 56 au capital de 15 745 984 €

13 **ANNEXE**

14 **ATTESTATION D'EXAMEN CE DE TYPE**

LCIE 12 ATEX 3053 X

15 **DESCRIPTION DE L'APPAREIL OU DU SYSTEME DE PROTECTION**

Capteurs de vibrations
Type : EX611xxx/xxxxx

L'appareil est un capteur de vibration haute température avec un câble intégré et une sortie par connecteur.
Le capteur de vibration fournit un signal lorsqu'il est soumis à un mouvement.
Le capteur est fabriqué en acier inoxydable.

Paramètres spécifiques du ou des modes de protection concernés :
Ui ≤ 30V, Ii ≤ 100mA, Pi ≤ 0,7W, Ci ≤ 3300pF, Li ≤ 30µH

Le marquage doit être :
IMI Adresse :
Type : 611xxx/xxxxx (1)
N° de fabrication : ... Année de fabrication : ...
Ex II 1G Ex ia IIC T6...T710°C Ga (2)
LCIE 12 ATEX 3053 X
Ui ≤ 30V, Ii ≤ 100mA, Pi ≤ 0,7W, Ci ≤ 3300pF, Li ≤ 30µH
(1)complété avec le modèle
(2)température coté capteur et câble

L'appareil doit également comporter le marquage normalement prévu par les normes de construction qui le concerne.

16 **DOCUMENTS DESCRIPTIFS**
Dossier technique n°52740 rev.NR du 03/08/2012.
Ce document comprend 5 rubriques (7 pages).

17 **CONDITIONS SPECIALES POUR UNE UTILISATION SÛRE**
L'appareil ne peut être raccordé qu'à des équipements certifiés de sécurité intrinsèque. Ces associations doivent être compatibles vis-à-vis de la sécurité intrinsèque (voir les paramètres électriques au paragraphe 15 et le plan n°52744).
Température ambiante d'utilisation : - 196°C à + 700°C.
Classement en température : T6 à +80°C, T5 à +95°C, T4 à +130°C, T3 à +190°C, T2 à +290°C, T1 à +440°C, T710°C à +700°C.

18 **EXIGENCES ESSENTIELLES DE SECURITE ET DE SANTE**
Couvertes par les normes listées au point 9.

19 **VERIFICATIONS ET ESSAIS INDIVIDUELS**
Néant.

20 **CONDITIONS DE CERTIFICATION**
Les détenteurs d'attestations d'examen CE de type doivent également satisfaire les exigences de contrôle de production telles que définies à l'article 8 de la directive 94/9/CE.

13 **SCHEDULE**

14 **EC TYPE EXAMINATION CERTIFICATE**

LCIE 12 ATEX 3053 X

15 **DESCRIPTION OF EQUIPMENT OR PROTECTIVE SYSTEM**

Vibration sensors
Type : EX611xxx/xxxxx

The apparatus is a vibration sensor, series high temperature sensor with integral cable and connector output.
The vibration sensors provide a charge output when subjected to mechanical motion.
The sensors have stainless steel housings.

Specific parameters of the concerned protection mode:
Ui ≤ 30V, Ii ≤ 100mA, Pi ≤ 0,7W, Ci ≤ 3300pF, Li ≤ 30µH

The marking shall be :
IMI Address : ...
Type : 611xxx/xxxxx (1)
Serial number : ... Year of construction : ...
Ex II 1G Ex ia IIC T6...T710°C Ga (2)
LCIE 12 ATEX 3053 X
Ui ≤ 30V, Ii ≤ 100mA, Pi ≤ 0,7W, Ci ≤ 3300pF, Li ≤ 30µH
(1)completed by the model
(2)temperature sensor and cable side

The equipment shall also bear the usual marking required by the manufacturing standards applying to such equipment.

16 **DESCRIPTIVE DOCUMENTS**
Certification file n°52740 rev.NR dated 2012/08/03.
This file includes 5 items (7 pages).

17 **SPECIAL CONDITIONS FOR SAFE USE**
The apparatus can be only connected to intrinsically safe certified equipment. These combinations shall be compatible as regard intrinsic safety rules (see electrical parameters clause 15 and drawing n°52744).
Ambient temperature of use : - 196°C to + 700°C.
Temperature classification : T6 at +80°C, T5 at +95°C, T4 at +130°C, T3 at +190°C, T2 at +290°C, T1 at +440°C, T710°C at +700°C.

18 **ESSENTIAL HEALTH AND SAFETY REQUIREMENTS**
Covered by standards listed at 9.

19 **ROUTINE VERIFICATIONS AND TESTS**
None.

20 **CONDITIONS OF CERTIFICATION**
Holders of EC type examination certificates are also required to comply with the production control requirements defined in article 8 of directive 94/9/EC.