PCB PIEZOTRONICS
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TN-39

Handling Piezoresistive Shock Accelerometers

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"Hey! Be careful how you handle that shock accelerometer. You might damage it."

Sounds crazy, but piezoresistive shock accelerometers designed to measure high-g impacts can be damaged by mishandling. The small size and minimal mass required for their intended applications rule out typical design accommodations like all-welded construction for environmental protection, or bulky electronics for robust ESD, over-voltage and reverse polarity protection.

With this in mind, Endevco engineers designed a range of piezoresistive accelerometers that provide significant protection against electrical, shock and environmental threats. A quad diode was added to the boards of most Endevco piezoresistive accelerometers that provides ESD protection to Class 3B (>8000V) per Section 5.2 of MIL-STD-1686C. Exceptions include only the smallest accelerometers, like models 7270A, 7280A, 7231C, 71M, 727 and 728. These accelerometers will typically withstand an over-voltage excitation of 10% to 20% and reverse polarity for 10 to 30 seconds.

Protection against shock is accomplished through the use of mechanical stops and damping. When selecting accelerometers for your application, remember that an undamped sensor with no stops is the easiest to damage with mishandling. One step better is undamped with stops. The most rugged and resilient is a damped sensor with mechanical stops. Environmental threats are overcome by epoxy sealing which prevents the ingress of dirt. Some models are rated to IP65 (726CH) or IP67 (701AH, 757AH, 713), or are hermetic (74, 75), which speaks to their performance under high humidity.

Electrostatic Discharge (ESD) Considerations

ESD precautions should be taken when inspecting, mounting and troubleshooting piezoresistive accelerometers.

Where possible and practical, work areas where piezoresistive accelerometers are handled should be equipped with a grounded table, floor mats and wrist straps. Non-condensing relative humidity of the area should be between 20% and 80%. Keeping the sensors away from static-accumulating materials is also important. This includes Formica or finished wood surfaces, vinyl floors, personal clothing, fiberglass chairs, and spray cleaners.

It's also a good idea to ensure technicians use anti-static tools and equipment. Where grounding is not possible, consider using static eliminators (ionizers) to neutralize charges, and supply anti-static bags for packaging accelerometers when transporting or for storage.

If ESD damage does occur, it will typically result in a large shift in the zero measurand output (ZMO). If ESD damage is sufficiently high, complete accelerometer failure is likely, showing up as an extremely large ZMO or an open leg of the Wheatstone bridge.

Incoming Inspection

Upon receipt, check each accelerometer ensure thatthe calibration certificate, associated cabling/connectors and protective coverings are present. Figure 1 below presents packaging for the 7264H piezoresistive accelerometer.

Figure 1: 7264H Accelerometer and Shipping Case

Three simple tests can be performed to determine proper operation without removing the unit from its shipping container and protective sleeve.

Impedance test: Open the accelerometer shipping box and unwind a few inches of cable. Leave the accelerometer in the container. Read the input impedance (Red to Black) and output impedance (Green to White) with an ohmmeter. Refer to the accelerometer calibration data sheet that is included with the unit to determine the proper value of impedance. The measured impedance should be within ±25% of this calibrated value.

Insulation Resistance: If the input and output impedances are within acceptable limits, use a multi-meter, ohmmeter or megohmmeter set at 50 volts maximum. Measure the insulation resistance between:

a) all leads connected together and the cable shield

b) all leads connected together and the transducer case

Both readings should be 100 megohms as a minimum.

Zero Measurand Output (ZMO): After the impedance and insulation resistance tests, measure the output of the accelerometer with zero g acceleration. Turn the unit on its side so that the accelerometer mounting surface is perpendicular to the table top. Apply the specified excitation voltage to the accelerometer and measure its output with a DC millivolt meter. Allow the unit to warm up for two minutes. The accelerometer should have a zero measurand output (ZMO) within the data sheet specified limits.

If any of these initial checks do not give proper readings, indicating a possible malfunction, and the reason for the erroneous reading cannot be found, contact Endevco.

Turn-over test for incoming or field use

Piezoresistive accelerometers are DC response, thus they can measure acceleration due to gravity. This characteristic is advantageous when checking the accelerometer's sensitivity for troubleshooting purposes. Orient the sensor with its mounting surface in contact with a level tabletop. The sensitive axis should be oriented straight up and down relative to level ground. Assuming the sensor has a nominal sensitivity of 0.20 mV/g (for a 2000 g full scale unit) in this orientation, the sensor's output should read 0.20 mV plus the ZMO (which could be in the 10's of mV).

Now rotate the sensor 180° (turn the sensor over), making sure the sensitive axis is parallel to level ground. The sensor's output should now be reading -0.20 mV plus the ZMO. The value is negative because of the polarity feature of the sensor. Polarity simply means the output of the sensor is positive when exposed to a positive-going acceleration and negative when exposed to a negative-going acceleration. Subtracting the two values read yields 0.40 mV (ZMO subtracts out).

This is the value expected for the 2 g change to which the accelerometer was exposed (positive 1 g to negative 1 g) If we do the math: 2 g x 0.20 mV/g = 0.40 mV. If your sensor deviates significantly from this value, it is likely the sensor has been damaged.

The turn-over test is very effective when testing high sensitivity accelerometers. Low sensitivity accelerometers, as described in the above paragraph, may give ambiguous readings due to noise pick-up. The same turn-over test can be performed with triaxial sensors as well. Use the markings on the unit or refer to the datasheet to determine the orientation of the X, Y, and Z axes.

Mounting

There are various mounting techniques commonly employed for piezoresistive shock accelerometers. Whatever type is chosen, it is essential to utilize proper procedures and tools.

Adhesive Mounting

When adhesively mounting accelerometers, the amount (thickness) of adhesive may play a critical role in achieving good frequency response. A thin film or minimal amount of adhesive promotes higher transmissibility, and hence, a broader frequency response. Prior to mounting accelerometers, clean the mating surfaces with a hydrocarbon solvent such as Loctite™ X-NMS. For the most part, cyanoacrylate, double-sided tape or petrowax may be used, resulting in a uniform thickness that will provide good results. Hot glue, on the other hand, requires more attention in its application. This is due to the limited time for application before glue hardens.

Cyanoacrylate: Tests performed at Endevco indicate that for an accelerometer weighing ≤ 10 grams, cyanoacrylate has the highest merit. Cyanoacrylates are liquid monomers that polymerize, forming a hard plastic. This plastic adheres to metal, rubber, glass and various plastics. The thinner the layer of cyanoacrylate, the quicker the cure time.

Generally, for accelerometers with aluminum or stainless steel outer cases, a methyl-based cyanoacrylate is recommended which bonds metal and glass well. When uncertain whether cyanoacrylates are compatible with a particular surface material, separately test a sample piece first.

Advantages: Room temperature cure, fast cure time, broad frequency response and good temperature range.

Disadvantages: Difficult to set on rough surfaces, need for a solvent (such as Loctite™ X-NMS or equiv.) to break glue bond down before removing accelerometer,and removal is time consuming,

Double-sided tape: This approach has a fairly broad temperature range.

Advantages: Ease of application and removal, wide temperature range.

Disadvantages: Limited amplitude range.

Hot glue: This approach requires more attention than other adhesive mounting methods, particularly when trying to optimize for higher frequency applications.

Advantages: Ready supply of adhesive (glue sticks), rapid cure time, easy removal.

Disadvantages: Very rapid cure time, which must be taken into consideration to ensure good adhesion and proper frequency response. The user should be prepared to mount the accelerometer as soon as the glue is applied to the mounting surface.

Other: In emergencies, when “push comes to shove,” even duct tape and Velcro strips are reported to have been used in field testing. No data is available that allows an assessment of the reliability of data obtained by these means, and we do not recommend this.

Note: For adhesively mounted accelerometers, the complete accelerometer must be clean. If there is adhesive left on the base, there will be a base-to-device coupling problem. If there is glue elsewhere, the characteristics of the transducer's sides and top could change and result in additional crosstalk.

Screw and Stud Mounting

Technicians should refer to manuals and datasheets for each accelerometer requiring screw or stud mounting, as various mounting instructions (such as torque and mating connection on the test object) may vary. Generally, for screw or stud-mounted devices, the mounting surface must be very flat, with low roughness, and must be perpendicular to the threaded hole(s) used to mount the accelerometer. If there was adhesive used on any of the surfaces, a thorough cleaning is absolutely necessary to remove all traces of the adhesive. Any aberrations on the mounting surface will produce base strain, causing errors in the reading.

Additional tips:

- Do not cement the unit to the mounting structure; instead, use the supplied mounting accessories.
- If the unit was packaged with a protective sleeve or tube around the housing, keep the sleeve on as much as possible before sensor installation. The sleeve protects against impact between the sensor housing and other hard surfaces, which can induce high-frequency resonance and damage. After removing the sleeve, it is recommended that the unit be handled by the case, and not the cable. This is another measure to prevent the unit from slapping against hard surfaces during installation.
- For screw mounted accelerometers, use the supplied tools to turn the screws into the mounting holes to the recommended torque. (This is roughly equivalent to finger tight.) Installation of the unit with higher torque values, dry threads, or thread adhesives is not recommended, as excessive torque will be required to break the screw loose when the accelerometer is dismounted. Do not use snap-type torque wrenches.
- As practical, tie down the cable within 2 to 3 inches (4 to 6 cm) from the unit. Whipping of the cable during vibration and shock will strain the cable unnecessarily at the unit, and produce noise
- Connect the unit to the signal conditioner and check for proper functioning through the use of standard techniques.

Cables

Connection errors can be a problem with piezoresistive accelerometers due to fine gage wiring and the multitude of wires used. Connecting wires to the wrong pins or solder bridges between connector pins is among the most common wiring errors. Endevco products follow the industry standard for wire colors; however, one should confirm the color codes when using non-Endevco products. (Red for + excitation, black for - excitation, green for + signal output, and white for – signal output).

Troubleshooting

During setup, technicians sometimes report high voltage outputs or no voltage output. For purposes of our discussion, assume that a connector has been attached to one end of the sensor cable and the power has been applied between the red and black wires. There are now three conditions that can exist: open resistor, shorted resistor and normal. The more common problem is an open resistor caused by excessive current.

Table 1: Examples of Common Malfunctions

Parameter	Normal bridge	Open arm	Shorted arm
Input resistance	500 Ω	1k Ω	512 Ω
Output resistance	1k Ω	1k Ω	343 Ω
Supply current	20 mA	5mA	20mA
ZMO	43 mV	5 Volts	0 Volts

Most problems that technicians report are due to intermittent connections causing signal noise. This may be caused by worn contacts, mismatched pins and sockets, damaged or fatigued conductors and shield wires, moisture, corrosion or improper mating of connectors. In addition, a long length of cable makes a very efficient antenna for receiving any kind of electromagnetic energy. The very shock and vibration being measured may cause intermittent contacts or loosen coupling devices.

Recalibration

Sensitivity and ZMO calibration are suggested to be performed at 6 to 12 month intervals, depending on usage. Ordinarily, recalibration need be performed only at 12 month intervals, if it is known that the accelerometer has not been used beyond its rated specifications. If the unit is operated in severe environments, it may be desirable to use shorter calibration intervals. Your company's quality system is the final determination of the frequency needed for calibration. **Contact Endevco for local calibration facility information, or return the unit to Endevco for calibration.**

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