Endevco®

INSTRUCTION MANUAL

For Model 727
PIEZORESISTIVE DROP TEST ACCELEROMETERS
IM727, Revision A (07-10-13)


(photos not to scale)

Figure 1(a): Model 727 Top View

Figure 1(b): Model 727 Side View

The Endevco® Model 727 is a family of rugged undamped piezoresistive accelerometers, offered in a variety of ranges. It is designed for shock measurements in mobile consumer electronic devices. Table 1 shows a summary of the current Endevco offering of drop-test accelerometers. This instruction manual will supply technical detail for the single-axis accelerometers in wax mount configuration.

Table 1: Endevco® Drop-Test Accelerometers.

	Wax mount, single axis
undamped	727-60K
undamped	727-20K
undamped	727-6K
undamped	727-2K

In addition to being undamped, the 727 series has no mechanical stops, maximizing both bandwidth and amplitude linearity. Its undamped characteristic allows it to be used in applications where the peak acceleration is known and there is not a significant amount of out-of-band energy that could cause enough resonance excitation to exceed the overrange limit of the accelerometer.

Due to the severe environment in which these accelerometers are tested, the user should carefully read this instruction manual in its entirety.

A Calibration Certificate is included in the shipment of your Endevco® drop-test accelerometer. Additionally, a product specification data sheet, if not already included in your shipment, can be requested by contacting Endevco's Application Engineering at +1 (866) ENDEVCO [+1 (866) 363-3826] in North America, or your local sales representative.

HANDLING PRECAUTIONS

Although undamped accelerometers are more susceptible to damage by handling, the follow precautions should be taken when handling any accelerometer, whether it is damped or undamped. The amplification factor (or Q) of the undamped accelerometer at the resonant frequency of its seismic element can approach 100 (10 for the damped accelerometers). This means that if an unmounted unit were dropped on a metal surface (such as a table or bench top) causing it to experience a shock input of 2,000 g, the high-frequency content of the metal-to-metal impact could excite the resonance frequency, resulting in an accelerometer response of 200,000 g (20,000 g for the damped accelerometers). It has been shown that the accelerometers are more vulnerable to damage in the unmounted state, as opposed to being mounted to a test subject of large mass. For this reason the unmounted unit must be handled very carefully to avoid such fast rise time impacts.

Endevco® drop-test accelerometers are shipped in electrostatic discharge (ESD) safe packaging. When handling any accelerometer it is always best practice to handle with ESD in mind. The accelerometer should only be handled by properly grounded technicians (via wrist straps or heel straps) at ESD safe work stations. 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.

INITIAL CHECKOUT

Upon receipt, the accelerometer should be checked to ensure that it was not damaged in transit. A simple resistance test is a quick way of verifying that all legs in the Wheatstone bridge sensing element are intact.

> Resistance Test – Open the accelerometer container and unwind a few inches of cable. Measure the input resistance (red to black) and output resistance (green to white while shorting red and black) with an ohmmeter and a pair of clips leads. The measured resistance should be within the specified tolerance as listed on the product specification data sheet.
>
> > Typical specification for Model 727 input/output resistance is 650Ω ±
> >
> > 300Ω

If any of the above resistance measurements are not within the noted specification there may be a problem with the accelerometer and the factory should be consulted for further troubleshooting.

MOUNTING SURFACE PREPARATION AND INSTALLATION

Special care should be taken to provide a smooth, clean mounting surface to ensure maximum transmissibility of the shock input. Any small particles or debris trapped between the mounting surface and the accelerometer will degrade the transmission of the high-frequency components of the shock input. An uneven mounting surface could also preload the accelerometer and cause unwanted static strain, resulting in possible zero shift during a shock measurement. The surface on which the accelerometer is mounted should have a surface roughness of 32 micro inches rms or better and a surface flatness tolerance of 0.0003”.

For use up to 60ºC: Aremco Crystalbond™ 509 is recommended, following this mounting procedure:

- Apply a moderate amount of Crystalbond™ 509 on the bottom of the Model 727 accelerometer
- Use a toothpick and spread the wax to form a thin, uniform layer covering area of contact, and immediately position accelerometer on mating surface
- Press down and hold accelerometer firmly in place for 30 seconds while the wax sets. Allow wax to set for at least 1 minute for maximum strength.

Cyanoacrylate (super glue) is not recommended as a temporary adhesive unless an appropriate solvent (such as acetone) is used to weaken the glue joint before attempting to remove the accelerometer. The solvent should be swabbed around the base of the accelerometer; under no circumstances should the accelerometer be soaked or immersed in any liquid. Similarly, if wax is used as a temporary adhesive, always remove the unit using the appropriate amount of heat. Trying to remove the accelerometer by shearing or twisting will excite the resonance and could cause permanent damage to the accelerometer.

Mounting to low strength material (such as aluminum) is not recommended. Additionally, adhesive must always be used between the transducer and any low-strength mounting surface.

CABLE HANDLING

The 727 series of drop-test accelerometers are supplied with integral cables, which are terminated in pigtails. The user can select an appropriate end-connector.

There are two important considerations regarding the integral cable when installing the accelerometer. First, since the cable will be exposed to the same high level shocks as the accelerometer, care needs to be taken to prevent damage to the cable. Relative motion between the cable and the accelerometer can cause cable failure and/or a significantly shortened life. Second, the signal voltage on the leads of the cable will be at a very low level and any excessive movement of the cable could cause noise on the signal lines. Because of the above factors, it is important that the following cable recommendations be observed.

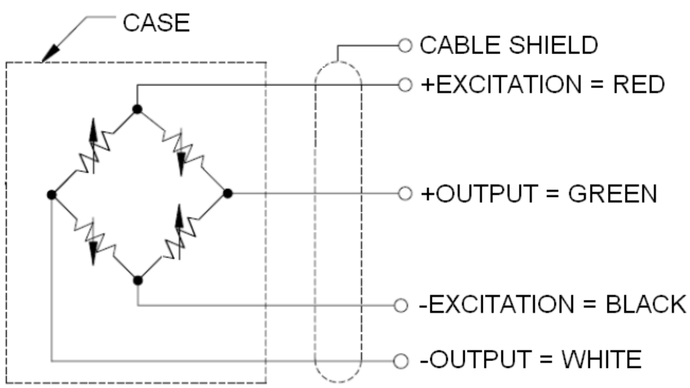
If possible, the mounting preparation should allow for the cable to be routed perpendicular to the primary shock direction to reduce the amount of tensile stress on the cable. To strain relieve the cable close to the accelerometer, form a small bend (~¼” radius) in the cable within two inches of the case and then tack the cable to the mounting surface with tape. Next, completely secure the cable between the accelerometer case and the tape to the mounting surface by encapsulating with a silicone RTV. A recommended silicone RTV is Loctite® item number 37463, an air curing RTV which will be tack-free in 15-20 minutes, test-ready in roughly an hour and fully cured in 24 hours (assuming 70ºF and 50% relative humidity). In routing the remaining portion of the cable to the signal conditioner, it is important that there be sufficient slack in the cable, i.e. the cable should not be pulled tight between the test specimen and the signal conditioner.

ELECTRICAL CONSIDERATIONS

1. Excitation Voltage – The drop-test accelerometers are calibrated using an excitation voltage of 10.000±0.005 Vdc, unless otherwise specified at the time of order (the maximum excitation voltage without damage is 12 Vdc). If a voltage other than the voltage used at the time of calibration is applied to the unit, the ZMO and sensitivity will differ from the specified value on the Calibration Certificate, thus excitation voltages other than 10 Vdc should be specified at the time of order. The accelerometer requires a clean, well-regulated, constant voltage power supply.

   Endevco offers a wide range of signal conditioners that ensure optimal performance from Endevco® piezoresistive accelerometers, including the 126, 136 and 4430A. Contact Applications Engineering to discuss your specific signal conditioning needs.

2. Power and Signal Leads – The cable leads are assigned as follows:



   The cable shield is not connected to the accelerometer case. It is recommended that the shield be connected to the power supply ground.

3. Cable Length Considerations – The 727 accelerometers are calibrated with 120 inches of cable, unless otherwise specified at the time of order. When using cables longer than 10 – 20 feet , three effects must be taken into account:

   a. *Input Voltage Attenuation*: Resistance in the excitation voltage wires may reduce the voltage to the sensor, resulting in a loss of sensitivity. The reduced sensitivity can be calculated as follows:

$$E_{OL} = E_O \left(\frac{R_L}{R_O + R_L} \right)$$

E_{OL} = loaded output sensitivity
E_o = sensitivity into an infinite load (from Cal. Cert.)
R_O = output bridge resistance (from Cal. Cert.), includes cable
R_L = load resistance

If cable lengths longer than 20 feet are required then it is recommended to use a signal conditioner with an excitation sense (remote sense) feature. In brief, to use excitation sense a secondary cable (longer) is spliced to the existing accelerometer cable (shorter). The extension cable has two extra wires; one wire is connected to the accelerometer's positive input lead and the other to the accelerometer's negative input lead. The two extra wires are used to measure the actual voltage at the accelerometer and adjust the supplied excitation voltage accordingly until the target value is achieved. The effect of the voltage drop due to the series resistance in the wires is eliminated by measuring the voltage using a high input impedance voltmeter.

b. *Signal Attenuation:* Similar to the input voltage attenuation discussion, the resistance in the output leads will also cause attenuation of the output signal. The reduced sensitivity is calculated as follows:

$$E_{OL} = E_O \left(\frac{R_L}{R_O + R_L + R_{CO}} \right)$$

E_O = sensitivity into an infinite load (from Cal. Cert.)
E_{OL} = loaded output sensitivity
R_O = output bridge resistance (from Cal. Cert.), including cable.
R_L = load resistance
R_{CO} = resistance of the spliced output wire

c. *Cable Capacitance*: Long cable leads act as an RC filter, which can cause significant attenuation of high frequencies. A rough calculation for the cut-off frequency of such a filter is as follows:

$$fc = \frac{1}{2\pi RC}$$

fc = cut-off frequency, in Hertz (-3 dB)
R = output resistance, in Ohm
C = cable capacitance, in Farad

In general, the above effects are insignificant when cable length is 20 feet (6 meters) or less. The effects discussed in sections (a) and (b) above are typically accounted for in any factory calibration, so they must only be considered when longer extension cables are installed by the customer. Contact Applications Engineering for more information, if required.

OPERATING PRECAUTIONS

While these drop-test accelerometers can be extremely rugged, they can also be extremely fragile under very specific operating conditions, namely under resonance excitation. Due to the extremely high levels of shock encountered and the potential for resonance excitation, the user should **read this section carefully** before operating.

RESONANT FREQUENCY EXCITATION

The 727 series utilizes an undamped sensing element which means its resonant frequency is excited more easily as compared to a damped device. Additionally, the 727 series does not incorporate any mechanical overtravel stops, which means the displacement of the proof mass is not restricted. Since the amplification factor for an undamped accelerometer can be up to 100, if there is sufficiently high frequency content in the shock event, the excessive amplitude of the seismic mass can be well over the overrange capability and cause permanent damage to the accelerometer.

Another thing to note is that each seismic element used on the 727 series includes two masses, each with its own resonant frequency. If both resonant frequencies are excited, a beat frequency may appear in your data that will be at a frequency equivalent to the difference between the two resonant frequencies. Although the beat frequency will be apparent in the time history it will not translate to the Fourier transform. Although resonance excitation cannot always be avoided, it possible for the user to take measures to reduce the amount of high-frequency energy the accelerometer will be subjected to.

BANDWIDTH AND AMPLITUDE LINEARITY

Because the 727 series is undamped and does not use mechanical over travel stops, accurate measurements are permitted over a wide frequency and amplitude range. Undamped accelerometer data are typically considered accurate (±5%) to one-fifth of the resonant frequency and, because there are no overtravel stops to limit the displacement of the proof mass, reasonable amplitude linearity can be observed well beyond the rated full-scale range.

DATA ACQUISITION AND ANTI-ALIASING PRECAUTIONS

With any shock testing it is always best practice to use recording equipment with enough bandwidth to resolve the highest frequency component present, which is usually the resonant frequency of the accelerometer. Even with the excitation of resonance, if linear filtering is used and the amplitude during resonance does not cause saturation to the signal conditioning (or go beyond the linear range of the damped accelerometer), the high amplitudes experienced during resonance will not degrade the accuracy of the actual shock data recorded at lower frequencies.

The user should also be aware of aliasing and its effect on the data. A simple, and by no means complete, explanation of aliasing is as follows. Aliasing occurs during digitization when you have energy in the analog time history at a frequency higher than one-half of the sampling rate (the

Nyquist frequency). Once digitized, the aliased frequencies will fold back over the Nyquist frequency into the frequency range of interest resulting in errors in the data. To prevent aliasing, the sampling rate should be at least two times (and preferably ten times) the highest frequency present. The highest frequency present in almost all situations will be the resonant frequency of the high shock accelerometer. Better yet, an analog anti-aliasing filter should be placed before digitization with a cutoff frequency of at least one-half (and preferably one-tenth) the sampling rate. The anti-aliasing filter safeguards against any unpredictable out-of-band energy and is the most reliable approach to acquiring good quality, non-aliased data.

See Endevco Technical Paper TP284 for further information on high-frequency, high-level testing and calibration.

REMOVAL OF THE ACCELEROMETER

To remove the 727 accelerometer from your application, please use the supplied removal tool, Endevco® part number 42894. The tool should be placed over the accelerometer with the cable positioned away from the tool to shear the accelerometer off the surface of your application by gently wriggling the tool in clockwise and counterclockwise directions.

CLEANING

If desired, dirty accelerometers may be wiped clean using a damp cloth and a solvent such as acetone. **Do not soak or immerse** the unit in any solvent or water. Do not use any sharp tool such as a screwdriver to remove dirt or contaminants. Any temporary adhesives, such as wax or cyanoacrylate, used to mount the accelerometer, should be cleaned with an appropriate solvent (such as acetone).

RECALIBRATION

As with any measuring device, optimum accuracy is maintained by periodic recalibration. Sensitivity and ZMO calibration should be performed at 6 to 12 month intervals depending on usage. Ordinarily, recalibration need only be performed at 12 month intervals if it is known that the accelerometer has not been used beyond its rated specifications. If the unit is used under severe environments, it may be desirable to use shorter calibration intervals. When testing at high levels (levels exceeding the accelerometer's full-scale range) it is recommended that calibration be performed every six months or after each high-amplitude test.

The general health of the accelerometer can be assessed by measuring the ZMO and comparing the value to the most recent calibration certificate. The ZMO can be checked by applying a well-regulated excitation voltage (10 Vdc in most cases, unless otherwise specified at time of order) to the red-black leads and reading out the differential voltage between the green-white leads. Changes in ZMO of up to ±20mV with time and usage are not uncommon and are not necessarily a sign of a damaged accelerometer. Changes of greater than ±20mV may indicate damage to the sensor and the accuracy of subsequent measurements is in question. If possible, an accelerometer that has experienced a large ZMO shift should be replaced or returned for recalibration. Any ZMO reading approaching one-half of the excitation voltage up to the excitation voltage is a sure sign of accelerometer failure. The simple resistance check described in the "Initial Checkout" section above can also be used to evaluate accelerometer health.

After performing the above tests, if you are still uncertain about the health of your accelerometer please contact Applications Engineering. An Application Engineer will be able to discuss the health of your accelerometer in more detail and suggest if it is healthy, needs recalibration or needs replacement. Endevco maintains an accelerometer recalibration service with NIST traceability in the United States. Endevco European Regional offices maintain accelerometer recalibration services with traceability to applicable national standards.

QUESTIONS

If you have any questions regarding the use of these accelerometers (or any other Endevco® product) please contact Endevco's Application Engineering at +1 (866) ENDEVCO [+1 (866) 363-3826] in North America, or your local sales representative.