Model 2680B
Airborne Amplifier

Instruction Manual # 77079

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Piezoelectric accelerometers | Piezoresistive accelerometers | IEPE accelerometers | Variable capacitance accelerometers | Piezoresistive pressure sensors | Piezoelectric pressure sensors | High intensity microphones | Inertial sensors | Signal conditioners and supportive instrumentation | Cable assemblies

CONTENTS

01 PRODUCTS COVERED

This manual covers the model 2680B charge amplifier and applicable accessories. The full model number is printed on the label located on the top of the unit. The tables below describe the numbering system and applicable parameters.

"M" number	Gain range (mV/pC)	Input pulse (pC)	Output Coupling
M1	0.1 to 1	50000 to 5000	Biased & Unbiased
M3	0.5 to 5	10000 to 1000	Biased & Unbiased
M5	2 to 20	2500 to 250	Biased & Unbiased
M7	10 to 100	500 to 50	Biased & Unbiased
M12	1 to 10, 10 to 100	5000 to 50	Biased
M14	1 to 10, 10 to 100	5000 to 50	Unbiased

Table 1: "M" number nomenclature for the 2680B

1.1 Low-Pass Filters

The 2680B includes a three-pole Butterworth low-pass filter. The model number will contain a three-digit suffix (dash number) to indicate the filter's -5% frequency in Hz. The first two digits are significant numbers, and the third indicates the numbers of zeroes.

As an example, the 2680BM7-103 has a flat response from 5 Hz (-5%) to 10 kHz (-5%). Table 2 provides a list of the various filters by dash number, and frequency response of each.

Lower Cutoff		Upper Cutoff		
Dash number	-5% frequency	-5% frequency	-3 dB typical	-12 dB typical
-501	5 Hz	500 Hz	775 Hz	1150 Hz
-202	5 Hz	2 kHz	3.1 kHz	4.6 kHz
-502	5 Hz	5 kHz	7.75 kHz	11.5 kHz
-103	5 Hz	10 kHz	15.5kHz	23 kHz
-203	5 Hz	20 kHz	31 kHz	46 kHz

Table 2: Frequency response based on "dash" number

02 PRODUCT DESCRIPTION

The Endevco Model 2680B Series of airborne charge amplifiers are solid-state devices, designed for use with charge-mode piezoelectric transducers. Units contain a front-end circuit to receive the transducer signal, a filter to select the flat frequency response range, and a digitally programmable gain.

The 2680B's front end has a charge converter, followed by a voltage amplifier at the output. The charge amplifier produces an output voltage proportional to the charge at the input, thus minimizing the effect of input cable length.
The 2680B is designed to accommodate single-ended charge mode piezoelectric accelerometers and microphones.

The airborne amplifiers have small size, low weight, and low power consumption. The case of the amplifier is completely isolated from the circuit.

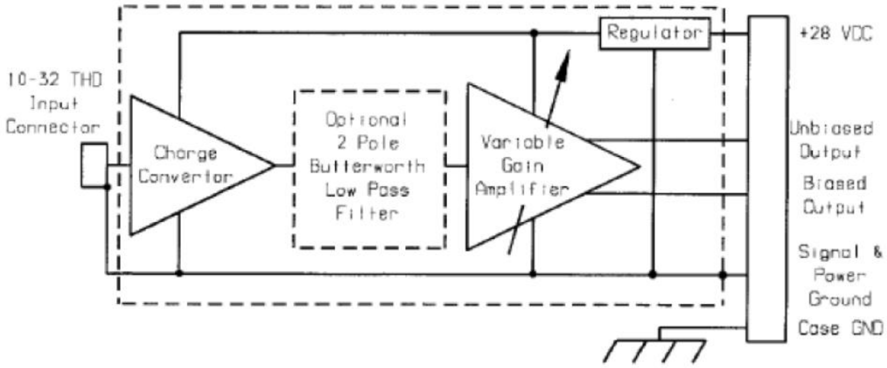


Figure 1: Functional block diagram of 2680B airborne charge amplifier

03 INITIAL INSPECTION

The charge amplifier is packed in a protective bag and packaged in shipping cartons containing shock-absorbent materials to prevent in-transit damage. However, upon receipt of the units, the customer should make an inspection to be certain that no damage has occurred during shipment. Obvious damage should be reported immediately to the carrier.

Inspect the contents of the shipping carton and verify that the applicable accessories listed in Table 3 are included in the shipment with each airborne amplifier.

Should it be necessary to return the amplifier to the factory, follow the instructions in section 7.1 of this manual. It is recommended that an applications engineer be contacted prior to returning the unit, since many problems can be resolved via telephone or email.

04 INSTALLATION

The charge amplifier’s case is drilled with two holes for mounting the unit to the test specimen. The mounting holes are drilled and counterbored to accommodate a 6-32 cap screw. The user should refer to figure 2 for measurement information. The mounting hardware is listed in Table 3.

Quantity	Description	Endevco Part Number	Manufacturer Part Number
1	6-32 x ¼” cap screw, SS	EDVEH535	McMaster-Carr 92185A144
1	6-32 x ¾” cap screw, SS	EDVEH293	McMaster-Carr 92185A151
2	#6 Lock washer, SS	EDVEHW172	McMaster-Carr 92147A420
0	Optional mating connector	EDVEJ1125	Glenair 800-008-06Z16-7SN
0	Optional EMI band	EDVEP636	Glenair 600-057-1

Table 3: Standard accessories supplied

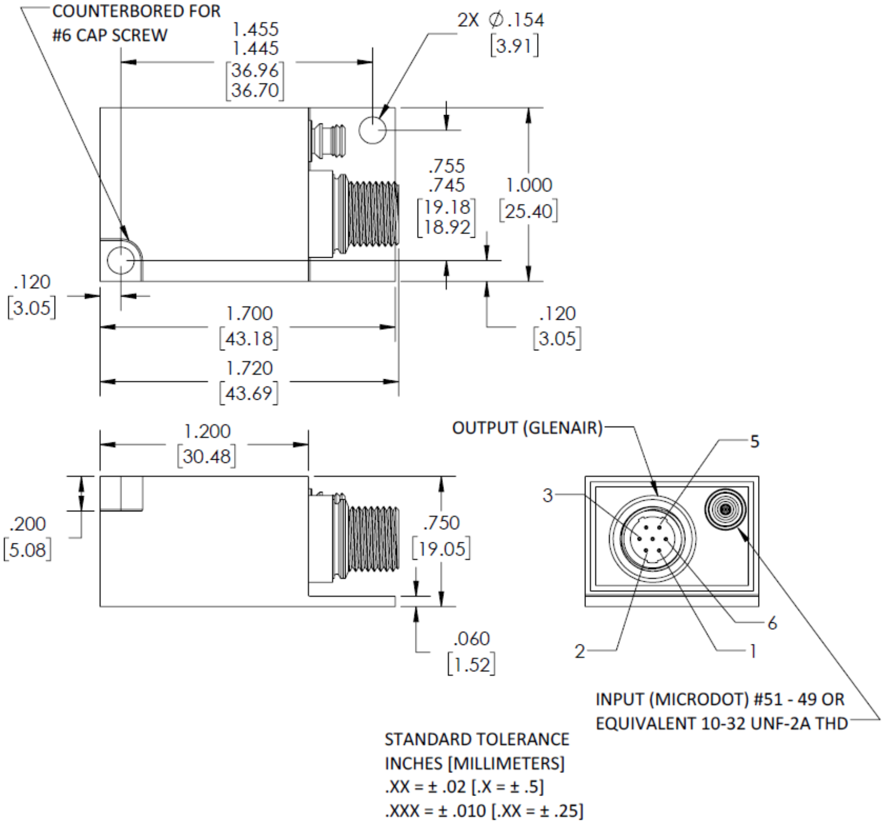


Figure 2: Outline drawing of the 2680B charge amplifier

04.1 Grounding

Case and signal grounds are available as pins in the output connector. The case of the 2680B is completely isolated from the circuit's signal/power ground. Signal/power grounds and case ground are available in the output connector as pins 2 and 3, respectively (reference Table 4 pinout). To prevent ground loops, the case ground should be connected to the signal/power ground at a single point.

For best performance, use a high-quality instrumentation ground for the case ground reference, either through the mounting hardware or, if the case is isolated from the test article, through pin 3 of the 2680B output connector or via the overall cable shield connected to the output connector housing.

If the case is grounded to the frame of the test article, it is advisable to reference the signal/power ground to this same frame ground. This can be achieved by connecting pin 3 to pin 2 in the 2680B output connector and tying pin 2 to the return of a floating power source. If the power source is not floating (referenced to the frame ground), then the power source ground should connect to pin 2 of the output connector but NOT be connected to pin 3 to avoid a ground loop.

If the case is floating, it is advisable to ground the case either through the shield of the 2680B output cable or by tying pins 2 and 3 together and connecting a single wire to a grounded power source that is referenced via a low-noise instrumentation ground.

04.2 Input Installation

This section covers the connections between the transducer and the airborne amplifiers.

04.2.1 Input Cable

The 2680B airborne amplifier is configured to operate with charge-mode transducers thus the input cable must be low-noise treated. Cable assemblies such as the Endevco 3090C is recommended. The input connector on the airborne amplifier is a 10-32 type.

04.2.2 Input Cable Length

Since the 2680B amplifier supports high impedance charge-mode accelerometers, it is important that the cable be as short as possible. While cable length has no practical effect on sensitivity, the high impedance characteristics make the system susceptible to noise pick-up. The model 2680B has an input source capacitance of 10000 pF, maximum. Thus, the capacitance of the accelerometer plus the cable's capacitance must not exceed 10000pf.

For example, using an Endevco 2276 piezoelectric accelerometer over a distance of 80 feet (24 meters) between the accelerometer and the airborne amplifier. The coaxial cable between the accelerometer and airborne amplifier has a nominal capacitance of 30 pF/foot (92 pF/meter):

Therefore: 80ft X 30pF/ft = 2400 pF

2400 pF is well within the capacitance range and will work OK, but there might be some added noise.

04.3 Output Connector

A 7-pin threaded connector is provided for the output signals, ground and power. A mating connector is not supplied with the amplifier due to the large variety of possible configurations. See Table 4 below for the output connector pinout.

Pinout	M1-M7	M12	M14
5	+28V DC	+28V DC	+28V DC
2	SIG & PWR GND	SIG & PWR GND	SIG & PWR GND
3	CASE GND	CASE GND	CASE GND
6	UNBIASED OUTPUT	X1-10 BIASED OUTPUT	X1-10 UNBIASED OUTPUT
1	BIASED OUTPUT	X10-100 BIASED OUTPUT	X10-100 UNBIASED OUTPUT
7	Gain prog. TX	Gain prog. TX	Gain prog. TX
4	Gain prog. RX	Gain prog. RX	Gain prog. RX

Table 4: Output connector pinout

04.4 Powering

Power is applied to pins 5 (+28V) and 2 (ground) of the 7-pin connector. Power should be from a clean DC source of 20 to 32 VDC (28 VDC, nominal). The power input circuit includes reverse polarity protection; thus a reversed connection will not damage the airborne amplifier.

The nominal current requirements are per the following table:

Quiescent	Quiescent + Signal	Quiescent + Signal (MAX)
4 mA	6 mA	15 mA

Table 5: Typical operating current

04.5 Signal Outputs

Each airborne amplifier has two outputs, biased and/or unbiased. Both outputs are single-ended, with one side connected to circuit ground. When both outputs are used simultaneously, the parallel combination of both load resistances must be 10kΩ or greater to meet all specifications.

Maximum output voltage is approximately 0 to 7.5 Vpk. The output circuits are short-circuit protected; thus the outputs will withstand an indefinite short without damage.

04.5.1 Biased Output

The biased output is available from pin 1 (signal) and pin 2 (signal ground). This output is direct-coupled with an output impedance under 50Ω. With no input, the airborne amplifier produces +2.5 VDC, ±3% at the output. Output voltage will be approximately +/- 2.5 Vpk around this bias level. Clipping will occur slightly above the 0V level and also at +7.5 Vpk.

04.5.2 Unbiased Output

The unbiased output is available from pin 6 (signal) and pin 2 (ground). This output is taken from the same source as the biased, except a series decoupling capacitor blocks the DC bias, only allowing only the AC signal to be available at pin 6. With the addition of the series capacitor and bleed resistor at the output, a 0.00 VDC bias level is established. The unbiased output is linear from approximately 0 to 4.65 Vpp.

04.6 Adjustable Gain/Sensitivity

The airborne amplifier's gain/sensitivity can be adjusted digitally; either at the factory, or using Endevco Model 4876 Handheld Gain Programmer.

By default, units will have the gain set to the minimum rated gain. See Table 1 for all available gain options.

There is no limit on *temporary* gain adjustments (resets after a power cycle). However, gain can only be "burned in" a finite number of times (persists through power cycles). 15 "burns" are guaranteed; up to 19 burns may be possible depending on the manufacturing process.

This is due to the more robust fusing method of storage. After all gain burns are used up, the gain can no longer be permanently fused. It can still be set temporarily, but will default to the last burned value on power-up.

04.7 Final Electrical and Mechanical Installation

Once a mounting surface has been determined, drill two holes per the outline drawing (Figure 2). Drill and tap the holes to accommodate the two 6-32 cap screws. When securing the cap screws, consider the recommended torque for the screw (8 in-lb / 0.9 Nm) and the material of the mounting surface.

The accelerometer input cable should be installed finger tight (1.5 in-lb / 0.169 Nm).

04.8 How to Calculate Gain and Output Level

Any of the methods described in section 6 may be used. It is necessary to know the following factors:

-Accelerometer's sensitivity in pC/g

-Desired full-scale output from the airborne amplifier

Determine the amplifier's peak sensitivity in pC/g or mV/g: (1)

$$As = \frac{Eo}{Fs}$$

Where: As = Amplifier's charge sensitivity or voltage sensitivity in mV/g.

Eo = Amplifier's peak full-scale output in mV peak

FS = Amplifier's desired peak full-scale output in g peak

The next step is to compute the required gain (Aq): (2)

$$Aq = \frac{As}{Sq}$$

Where: Sq = Sensor's sensitivity in pC/g or mV/g

Make sure that the output signal amplitude is compatible with the readout equipment: (3)

$$As = \frac{Eo}{Fs}$$

Where: As = System sensitivity:

Eo = Output in mV peak

Fs = Desired full scale (g peak)

Using one of the signal sources described in section 6, a DMM and/or an oscilloscope, make the necessary adjustment of the potentiometer. The signal source should be set to 100Hz.

For example, suppose a system consisting of a charge-mode piezoelectric accelerometer is used to measure ± 50g peak, full scale with a 2680B amplifier (which has a 2500 mV full-scale output).

Using the previous equation:

$$As = \frac{2500mV}{50g}$$

$$= 50 \text{ mV/g}$$

04.9 What to Look For

Exercise caution and do not operate too close to the full-scale output. Clipping can occur (Figure 3D) once the signal reaches 0 Volts or the maximum voltage. In the region just prior to clipping, the amplitude is non-linear.

An oscilloscope with an FFT function is an excellent tool for checking signals close to the full-scale output. When using the FFT mode, a Hanning window is recommended.

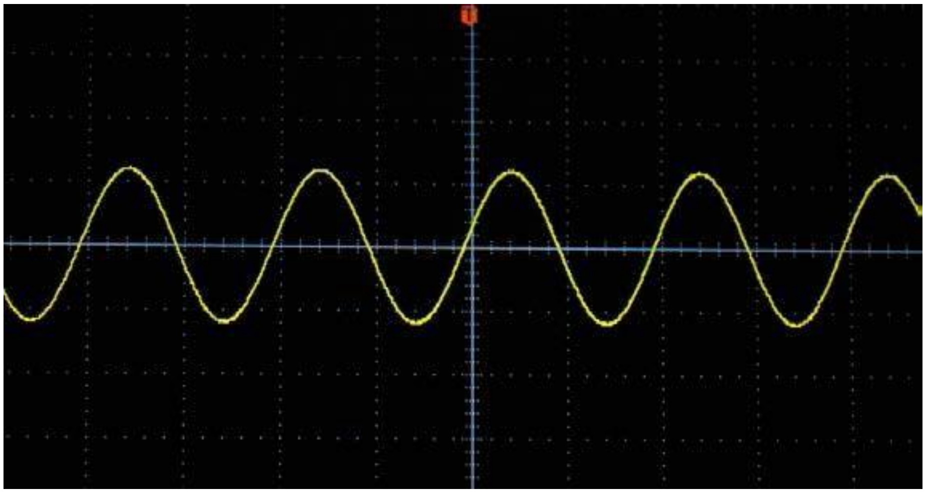


Figure 3A: A clean sine wave in the time domain

Using the FFT mode on the oscilloscope, view the frequency domain and observe the presence of harmonics. The below image shows the spectrum of an undistorted sine wave. Only a single frequency is present.

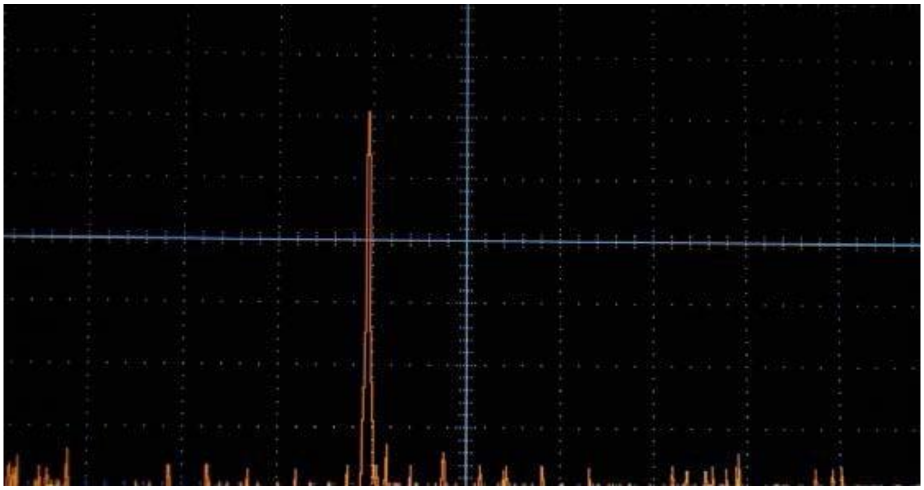


Figure 3B: FFT showing a clean sine wave in the frequency domain

In some cases, the time domain display on the oscilloscope can appear as clean as figure 3A, but there may be distortion present that will only be detectable in the frequency domain or on a harmonic distortion analyzer. Notice the fundamental frequency, on the left, and the presence of harmonics below in figure 3C.

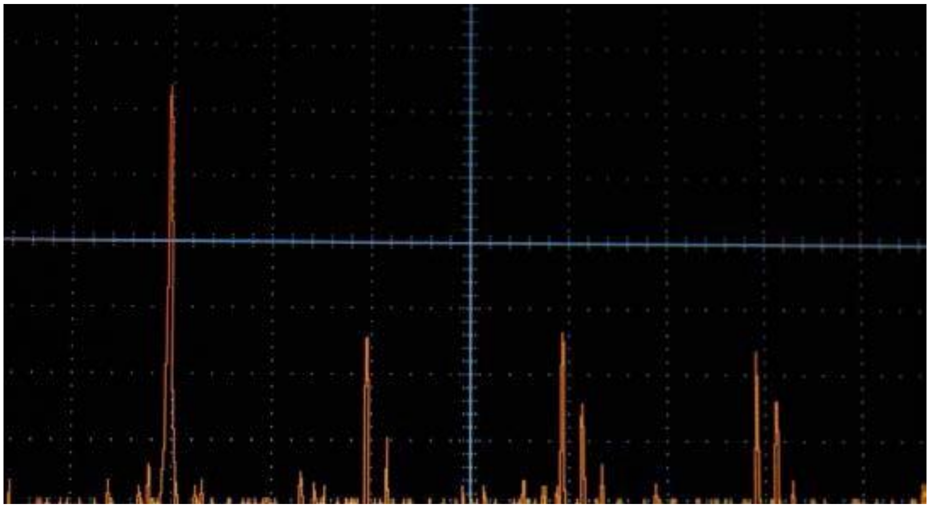


Figure 3C: FFT showing a distorted sine wave in the frequency domain

Figure 3D is an example of the presence of clipping as seen in the time domain. In this case, further analysis using the FFT mode is unnecessary since the problem is obvious.

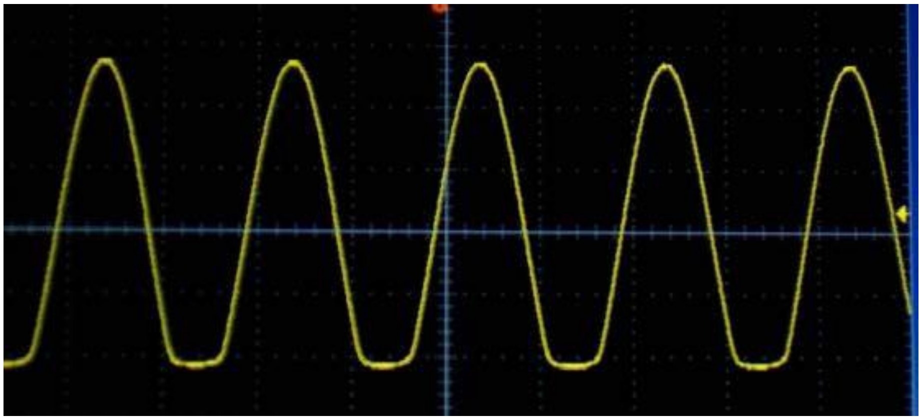


Figure 3D: A distorted sine wave in the time domain

5.0 ENVIRONMENTAL CONSIDERATIONS

See the applicable product datasheet for applicable environmental specifications, and ensure that the airborne amplifiers are operating within these specifications.

5.1 Hermeticity

The 2680B is hermetically sealed in accordance with MIL-STD-202G, Method 112E, Test Condition C, Procedure IIIC.

5.2 EMC Capability

The 2680B meets the requirements of EN 61326-1 “Electrical Equipment for Measurement, Control and Laboratory Use – Electromagnetic Compatibility (EMC) Requirements: Part 1 – General Requirements (2021).”

The 2680B is also in compliance with MIL-STD-461G “Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment (11 December 2015).”

5.3 Operating Temperature

Airborne amplifiers can be operated over a temperature range of -67° F to 212° F (-55° C to 100° C).

5.4 High Temperature Accelerometers

Charge amplifiers, including the 2680B, exhibit low-frequency peaking when the source resistance is low.

When accelerometers are exposed to high temperature extremes, the internal resistance decreases. High temperature accelerometers usually specify resistance at room temperature and at the maximum temperature.

The 2680B begins to exhibit low-frequency peaking when the source resistance drops below ~300kΩ (reference plots available on datasheet).

As an example, let’s assume that we are going to use a model 2230 high- temperature accelerometer. The room temperature resistance is 1GΩ, which would work well with the 2680B. However, the resistance drops to 100kΩ when the accelerometer reaches 900°F (482°C). The system is now starting to become susceptible to low-frequency peaking.

6.0 PERFORMANCE TESTING

It is sometimes desirable (or required) to test the integrity of a system after installation. This section will provide both a quick test and an in-depth test for the 2680B. The quick test might be conducted prior to installation to verify the unit is operational.

The most efficient way to test the performance is described in section 6.1. If these instruments are unavailable, section 6.2 suggests methods where standard laboratory instrumentation can be used to effectively perform the tests. See the appropriate Endevco technical paper for further tests, if required.

6.1 Preferred Method

Using one of the Endevco test instruments discussed herein is the easiest and most effective way to conduct a performance test on the airborne amplifiers. The two instruments and their applications are discussed below.

6.1.1 Handheld Shaker Method

The PCB 394C06 (figure 5) reference shaker is a highly convenient way to test and confirm the calibration and performance of the accelerometer, cable and amplifier with one simple test. The vibration level is limited to 1g peak.

Figure 5: 394C06 Handheld Shaker

Equipment required:

- 28 volt power supply with an output mA meter
- Oscilloscope
- Digital multimeter

Follow the below steps:

1. Apply 28 VDC between pins 5 (+28V) and 2 (signal ground). Confirm that the current is within the specifications in Table 5. Allow about >3 minutes for warm-up.
2. Install a 10kΩ, ¼ watt resistor between pins 1 (biased output) and 2 (ground).
3. Attach an oscilloscope to pins 1 (biased output) and 2 (ground).
4. Set the reference shaker frequency to 100Hz.
5. Observe a 100 Hz undistorted sine wave on the oscilloscope. If the oscilloscope is DC coupled, a DC bias of 2.50 VDC (±3%) should also be observed.

6.1.2 Accelerometer Simulator Method

An accelerometer simulator is also a good source for testing the performance of the 2680B. In this instance, the accelerometer is absent from the circuit. The Endevco model 4830B (figure 6) is an example of an accelerometer simulator.

Figure 6: Endevco model 4630B hand-held accelerometer simulator

Equipment required:

- 28 volt power supply with an output mA meter
- Digital storage oscilloscope
- Digital multimeter

When using a simulator, follow the below steps:

1. Apply 28 VDC between pins 5 (+28V) and 2 (signal ground). Confirm that the current is within the specifications in Table 5. Allow about >3 minutes for warm-up.
2. Install a 10kΩ, ¼ watt resistor between pins 1 (biased output) and 2 (ground).
3. Attach an oscilloscope to pins 1 (biased output) and 2 (ground).
4. Use the charge output for testing the 2680B.
5. Set the simulator frequency to 100Hz.
6. Observe a 100 Hz undistorted sine wave on the oscilloscope. If the oscilloscope is DC coupled, a DC bias of 2.50 VDC (±3%) should be observed.

6.1.3 Quick Test

This section provides a method to perform a quick functional test using common laboratory measurement equipment.

Equipment required:

- 28 volt power supply with an output mA meter
- Digital storage oscilloscope
- Digital multimeter

1. Apply 28 VDC between pins 5 (+28V) and 2 (signal ground). Confirm that the current is within the specifications in Table 5.
2. Install a 10kΩ, ¼ watt resistor between pins 1 (biased output) and 2 (ground).
3. With a DMM, measure the DC voltage across the 10kΩ resistor. The voltage should read 2.50 VDC ±3%.
4. Connect a charge-mode piezoelectric accelerometer to the 10-32 input connector using low-noise cable.
5. Connect an oscilloscope to either pins 6 & 2, or 1 & 2. AC coupling is recommended if using "biased" pins 1 & 2.
6. Tap the base of the accelerometer with a wooden pencil, or a plastic screwdriver handle.
7. Look for an output response on the oscilloscope screen. Figure 7 is an example of a response from a hard strike.
8. If a suitable response is observed on the oscilloscope, the test is complete.

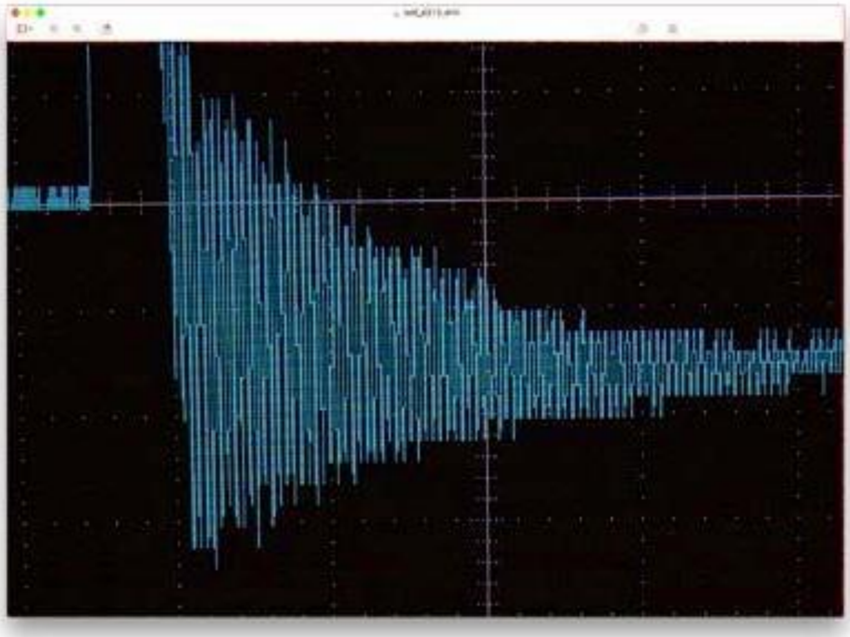


Figure 7: The left side of the trace shows the initial strike followed by the "ring" from the accelerometer's resonance. Other patterns are possible from a "good" system.

6.2 Testing Without a Sensor

Testing with high accuracy is possible using common laboratory instruments and an Endevco model 2947C Calibration Capacitor. The 2947C is simply a stable, well-shielded 1000pF capacitor that is placed between the signal generator and the 2680B charge amplifier. Its purpose is to convert the signal generators output voltage to a charge (pC) signal. When using a 1000 pF capacitor, charge = voltage. The accuracy is dependent on the tolerance of the capacitor and the accuracy of the signal generators output level. The 2947C's internal capacitor is measured and the actual capacitance is marked on the case.

Figure 8: Endevco model 2947C calibration capacitor

Equipment required:

- Function generator
- Endevco 2947 Calibration capacitor
- Oscilloscope
- Digital multimeter

1. Apply 28 VDC between pins 5 (+28V) and 2 (signal ground).
   Confirm that the current is within the specifications in Table 5.
2. Install a 10kΩ, ¼ watt resistor between pins 1 (biased output) and 2 (ground).
3. With a DMM, measure the DC voltage across the 10kΩ resistor. The voltage should read 2.50 VDC ±3%.
4. Connect the 2947C to the 10-32 connector and the BNC end to a function generator (see figure 9 below).
5. Connect an oscilloscope to either pins 6 & 2, or 1 & 2. AC coupling is recommended if using "biased" pins 1 & 2.
6. Set the sine wave frequency to 100 Hz.
7. Set the amplitude to a level that will produce 10 g.
8. Look for an output response on the oscilloscope screen. The user should see a pure sine wave with no distortion or clipping. If the oscilloscope has an FFT function, observe the frequency domain response that should be free of harmonics. Confirm that there are no 50 Hz / 60 Hz lines present in the spectrum.

9. If a suitable response is observed on the oscilloscope, the test is complete.

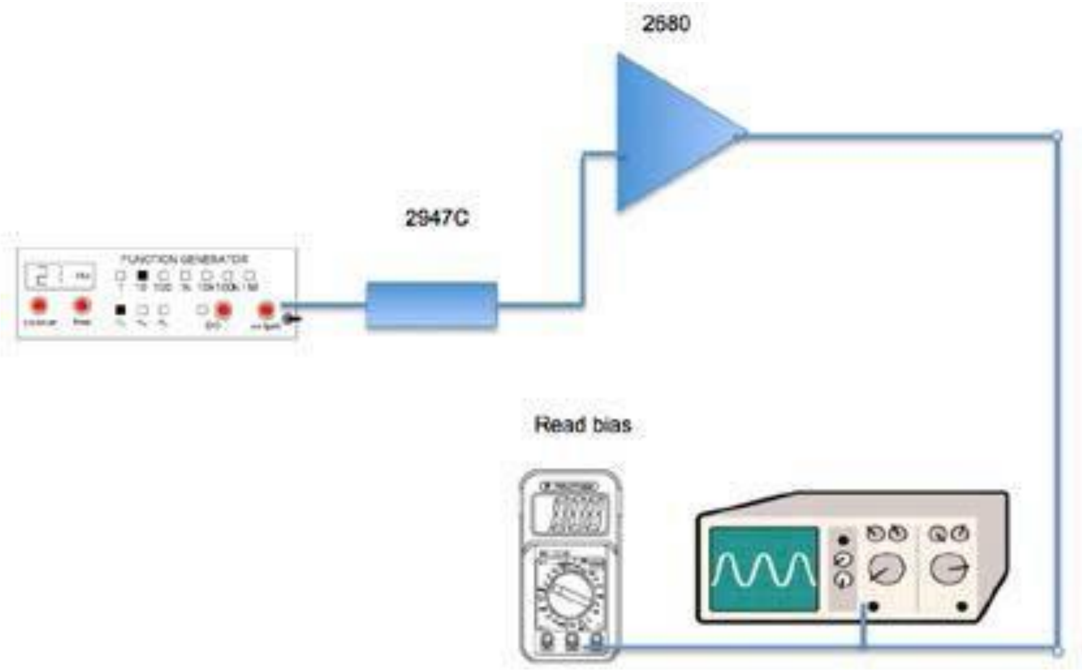


Figure 9: Test set- up using a sine wave voltage signal. The 2947C converts the voltage (mV) signal to a charge signal (pC). The output wave is displayed on the oscilloscope and the bias voltage is read on the DMM.

07 MAINTENANCE AND CALIBRATION

The airborne amplifiers are sealed, and there are no user serviceable parts. Cleaning the connectors is important to maintain noise-free operation. Annual calibration using sources traceable to the National Institute of Standards and Technology (USA) or other recognized standards organizations is recommended.

Below is a list of checks to perform prior to returning the unit or contacting an applications engineer:

- Check the connector wiring, making sure that pin 5 (+28V) is at the proper polarity. Look for possible shorted pin connections.
- Check for damaged cables on the input and output.
- Using a DMM, measure the DC bias between pins 1 & 2. This should read approximately 2.5 VDC.
- Measure input current from the power supply. See Table 5 for the expected current values.

7.1 Returning the Unit

Prior to returning the unit to the factory, contact the applications engineering department. Let the applications engineer know the results of any of the above tests. If it is necessary to return the unit to the factory, follow the below procedure:

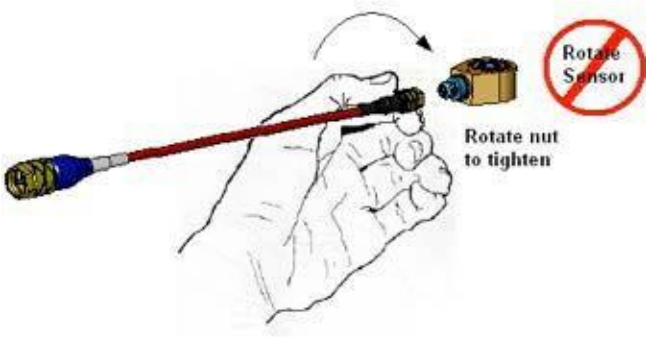
USA: Contact the customer service department, at the factory, and obtain an RMA number. Include the RMA number on the enclosed documentation and the outside of the shipping box. Include a description of the problem encountered and the unit serial number and your contact information.

Outside USA: Contact your local representative or distributor and follow their instructions.

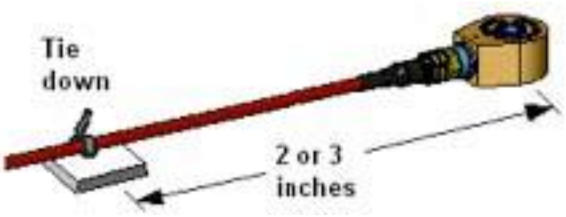
APPENDIX A: CABLE INSTALLATION RECOMMENDATIONS

The following recommendations are provided to help the users of Endevco cables and assemblies.

1. When attaching a coaxial cable assembly to a transducer or the amplifier, always turn the connector nut onto the transducer. Turning the transducer or amplifier into the cable connector may damage the pin, the cable, or the transducer. Only finger tighten to 1.5 in-lbs. (0.169 Nm).



2. Always tie down the cable within 2 or 3 inches of the transducer. Whipping of the cable will generate cable noise, strain the cable unnecessarily at the connector, and cause spurious signals in strain sensitive transducers.



3. Always be certain that the cable connector is screwed finger tight, or to specifications. Do not loose critical data because of a loose connector.
4. When testing in a high humidity environment, curl the cable into a drip loop near the transducer and the airborne amplifier. Any condensation that occurs will then be drawn away from the connector. Apply Dow-Corning Silastic 732RTV adhesive sealant) to connector threads and outer joints to prevent moisture from entering the connector.
5. Keep cable connectors and transducer receptacle clean by dipping them in a volatile solvent before use. Freon, acetone, trichlorothane, or similar solvents may be used. Connector contamination caused by ordinary handling can create low impedance paths between signal and ground, increasing noise and affecting the low frequency response of the connected amplifier.
6. If an intermittent signal is encountered and the cable is suspect, check the transducer/cable interface. Flex the cable all along its length, particularly near the connector, and observe the effect on the signal. Check center conductor and cable shield continuity with an ohmmeter.
7. Replace any noisy cables.
8. If you make your own connector-coaxial cable assemblies, cut and strip the cable carefully. When using low-noise cable on the 2680B, don’t smear the electrically conductive coating across the dielectric.
9. Do not allow cable to be dropped, contaminated, stepped on or otherwise abused. Treat it as carefully as you would treat your transducer.

APPENDIX B: WHY A CALIBRATION CAPACITOR?

A calibration capacitor allows for the testing of a charge amplifier without an accelerometer attached to the amplifier's input. Common electronic laboratory test instruments may be used to simulate the input charge signal.

A voltage signal from an audio signal generator is fed into the charge amplifier's input via a 1000pF series capacitor (see figure 9). The voltage signal is thus converted to a charge signal.

The transfer function is: Q = EC; where:

Q= Charge in picocoulombs (pC)
E= Voltage in volts (V)
C= Capacitance in picofarads (pF)

Since the capacitor is 1000 pF, the transfer function simplifies to Q (pC) = E (mV). The charge must be expressed in pC peak if the voltage is expressed in peak units. The calibration reference frequency is 100 Hz; thus this frequency is the recommended input to be used for this test.

The uncertainty will be that of the signal source and the capacitor. The Endevco 2947C has an uncertainty of ±1%. Adequate shielding is required for optimum accuracy. The amplifier, being a high impedance device, is sensitive to ambient noise.