



Model 3711E112G
DC Response Accelerometer
Installation and Operating Manual

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

Toll-free: 800-828-8840
24-hour SensorLine: 716-684-0001
Fax: 716-684-0987
E-mail: info@pcb.com
Web: www.pcb.com



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 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

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:

PCB Piezotronics, Inc.
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1.0 Introduction

This operating guide contains information that will familiarize the user with the basic operation and installation of the 3710 Series MEMS DC Accelerometers. However, it is not intended to cover all of the specific measurement challenges that one may encounter while using the device. Therefore, if you have detailed questions or are unsure of how to properly operate the sensor after reading this “Operating Guide”, please contact a PCB Application Engineer using our 24-Hour SensorLine™ at 716-684-0001.

2.0 Common Applications and Features

The 3710 Series MEMS DC Accelerometers achieve true DC response for measuring uniform (or constant) acceleration and low-frequency vibration. For this reason, they are often used to:

- Perform ride quality assessments of elevators, automobiles, trains, and amusement park rides.
- Analyze the low frequency characteristics of buildings, bridges, and large aerospace objects.
- Acquire tilt and orientation data for feedback control and stabilization purposes.

Because of the critical nature of these and similar test applications, all 3710 series MEMS DC Accelerometers have been designed and manufactured with the following common characteristics:

- Rugged, all-welded titanium housing insures reliability and durability in demanding applications and environments.
- Built-in microelectronics provide conveniently standardized sensitivities and low-noise output signals unmatched by similar sensing technologies.
- Internal voltage regulator allows sensor to be powered from virtually any unregulated DC voltage source, such as a bench-top power supply or portable battery source.
- Gas damping extends the upper frequency range, attenuates unwanted high-frequency vibration, and provides stable performance over the entire operating temperature range.
- Hermetic, multi-pin connector provides a reliable connection even under the harshest environmental conditions.

3.0 Principle of Operation

The sensor element of the 3710 series features a proof mass, ring frame, and attachment system between the two. These features are bulk micro machined from the same single-crystal silicon wafer. The movement of the proof mass is directly affected by acceleration applied in the axis of sensitivity.

The sensor element is connected as a bridge element in the circuit. The electrical characteristics of one portion of the bridge increase in value while the characteristics of the other portion decrease when exposed to acceleration. This approach minimizes common mode errors and improves non-linearity.

A selection of full scale measurement ranges is attained by modifying the stiffness of the suspension system of the proof mass. A high natural frequency is accomplished through the combination of a lightweight proof mass and suspension stiffness.

Ruggedness is enhanced through the use of mechanical stops on the two outer wafers to restrict the travel of the proof mass. Damping is used to mitigate high frequency inputs.

The sensor elements use squeeze-film gas damping that is near critically damped. This is the result of the movement of the proof mass pressing on the gas in the gap between it and the outer sensor layer. Damping helps prevent the output of the accelerometer from becoming saturated, as would happen when the resonance of an accelerometer with no damping is excited by random vibration. The advantage of gas damping over liquid damping is that it is minimally affected by temperature changes.

The 3710 series accelerometers contain conditioning circuitry that provides a high sensitivity output. This IC also provides compensation of zero bias and sensitivity errors over temperature.

An on-board voltage regulator allows a typical excitation range of 6 to 30 VDC with <30 mA current draw. The 3710 series features a ± 2 V Full Scale zero based output referenced to power ground. A negative voltage generator provides a sufficient signal swing for negative acceleration outputs with a positive voltage swing of +4.0 V accommodating positive accelerations.

An automated calibration step is conducted at the completion of the accelerometer assembly at discrete temperatures over the specified operating temperature range. The IC features an on-chip temperature sensor for accurate thermal corrections.

4.0 Typical Measurement System

The 3710 series DC Accelerometers are available in a uniaxial or triaxial package, with the uniaxial model being the 3711 version and the triaxial model being the 3713 version. The output signal is routed to follow-on signal conditioning via a hermetic four-pin receptacle and associated cable assembly; Model 010 series for the 3711 uniaxial version, and Model 037 series nine-pin cable assembly for the 3713 triaxial version. Since the High Sensitivity DC Accelerometers contain a built-in voltage regulator, they may be powered from virtually any 6 to 30 VDC power source without adversely affecting sensor performance. PCB signal conditioners available are Model 445B01, a single-channel, line powered signal conditioner for the uniaxial 3711 series DC accelerometers and Model 478A05, a three-channel, line-powered signal conditioner for the triaxial 3713 accelerometer. Consult PCB Application Engineering for additional signal conditioning options. The output from the signal conditioner is typically routed to readout instrumentation such as oscilloscopes or various model data acquisition instruments.

5.0 Sensor Installation

When choosing an installation technique, be certain to carefully examine the different application characteristics that may affect sensor performance. Characteristics such as mounting location may limit the use of large mounting blocks or the amplitude range may necessitate the use of a stud mount rather than using adhesive. A summary of the recommended mounting methods is provided below.

Stud Mount: Recommended for permanent mount applications or in test situations that require a rugged or secure installation. The necessary information, including surface finish, mounting hole dimensions, and recommended mounting torque for installing the sensor is listed on the enclosed Sensor Installation Drawing. It is recommended that an experienced technician or machinist with good machining capabilities adequately prepare the surface.

Adhesive Mount: Recommended for temporary mounting of the sensor or when the test object surface cannot be properly prepared for stud mounting. Wax works well for temporary mount applications under conditions where the operating temperature will not melt the wax or the acceleration levels will not dislodge the sensor from the test object. Cyanoacrylate-based, “quick-bonding” adhesives provide a quick mounting method, while two-part epoxies can be used for a more secure mount. To remove an adhesively mounted sensor, it is best to place an open-ended wrench over the sensor and twist it to shear the adhesive bond. Striking the sensor with a hammer or other object may permanently damage the sensor.

Easy Mount Clip: Recommended when frequent installation and removal of Series 3710 series accelerometers is desired. The Easy-Mount Clip can either be stud mounted or adhesively mounted to the test structure. (If adhesively mounting the clip, detach the sensor from the clip first, as excessive adhesive may creep through the mounting holes and adhere to the sensor. This will make separation and removal from the clip difficult.) Once the Easy-Mount Clip has been attached to the test structure, the sensor can be easily snapped into and out of the clip. Over time, the Easy-Mount Clip must be replaced as it will “wear-out” and eventually lose its ability to securely hold the sensor.

6.0 Powering

The 3710 Series contains built-in microelectronics that will operate from any PCB Series 445 or Series 478 Sensor Signal Conditioner. These signal conditioners provide the necessary voltage and current required for all of the powering options available on the 3710 series.

The 3710 series may also be powered by other voltage sources such as DC voltage laboratory supplies, automotive or marine batteries, or low-voltage supplies designed for powering PC Board components. If you decide to not use a Series 445 or 478 Series Signal Conditioner, insure that the source provides power within the excitation voltage range listed on the specification sheet for that model. It is important to note that since the accelerometers contain a built-in voltage regulator, precise calibration of the power source is generally not required.

7.0 Operation

After the sensor has been installed and the cable connected for proper operation, there are a couple of measurement points to take note of:

- To take advantage of the DC response of the accelerometer, the readout device must be in a DC coupled state. Consult the appropriate manufacturer or product manual for your readout device for details.
- Because the 3710 series can measure static (constant) accelerations, the DC offset voltage will be affected by the positional alignment relative to the Earth’s gravity. In other words, when the sensor is mounted perpendicular with the Earth’s surface, the offset will equal that as specified on the calibration certificate for “zero-g offset voltage.” If the sensor is mounted parallel with the Earth’s surface, the sensor will be experiencing 1 g of acceleration and the offset voltage will increase by the sensitivity of the accelerometer.

- If the sensor is extended, in the case of an integral cable sensor, or a cable length other than 10 ft is used, in the case of sensor with an integral connector, the offset voltage will change. To determine the accelerometer's offset, rotate the unit 90° so that the sensor is on its side with the sensing axis perpendicular to Earth's gravity and record the DC output. This value is the new "zero-g offset voltage."
- To insure that ground loops are not induced, the shield should only be terminated at one end. Typically, the shield of the cable is tied to the sensor housing. If the sensor is mounted with an isolation pad (or other form of electrical isolation) from the test structure, then the shield should be tied to signal ground at the instrumentation end. Otherwise, leave the cable shield floating or not connected at the instrumentation end.

8.0 Sensor Verification

If the sensor has been handled in a rough manner or before using a sensor for a critical measurement application, it is a good idea to verify that the sensor's sensitivity is still within specification. An accurate static calibration of the 3710 series can be performed using the Earth's Gravitational Field as a reference. The sensor can simply be "flipped" (rotated 180°) in the Earth's Gravity to obtain the scaling factor (sensitivity) and DC offset. First, place the accelerometer in a +1g orientation so that the base is resting on the table and the model number is facing up. The sensing axis will be parallel with the Earth's gravity with the sensor experiencing +1g acceleration. Record the DC output by using a DVM. Then rotate the sensor 180° so that the sensor is inverted (the top of the sensor is resting on the table) and the sensor is experiencing -1g acceleration. Record the DC output. To calculate the sensitivity of the accelerometer, refer to equation 8.1.

$$\text{Sensitivity} = \frac{(+1g) - (-1g)}{2} \quad \text{Eq 8.1}$$

9.0 Sensor Calibration

Due to ISO 9001, ISO Guide 25, or other contractual requirements, it may become necessary to send the accelerometer back to PCB for recalibration. In this case, a complete back-to-back frequency response test will be performed and the "zero-g" offset voltage will be checked with NIST traceable equipment.

10.0 Maintenance and Repair

Because of the sophisticated nature of PCB instrumentation, field repair of the equipment is not recommended. Most PCB sensors are of modular construction and are factory repairable. A repair or replacement quotation is available at no charge. Before returning equipment for repair, it is recommended that the user confer with a factory application engineer (or international representative) to first troubleshoot the problem.

11.0 Return Procedure

To expedite the repair process, contact a factory Application Engineer to obtain a Return Material Authorization (RMA) number prior to sending equipment to the factory. Please have information, such as model number, serial number and description of the problem, available.



Customers outside the U.S. should consult their local PCB distributor for information on returning equipment. For exceptions to this guideline, please contact the International Sales department to request shipping instructions and an RMA.

For further assistance, please call (716) 684-0001 or fax us at (716) 684-0987. You may also receive assistance via e-mail at info@pcb.com or visit our web site at www.pcb.com.

12.0 Customer Service / Warranty

The employees of PCB strive to provide superior, unmatched customer service. Should you at any time find yourself dissatisfied with any PCB product for any reason, consult a factory Application Engineer or local representative/distributor to discuss repair, refund, or exchange procedures.

When unexpected measurement problems arise, call our 24-hour SensorLine™ at (716) 684-0001 to discuss your immediate dynamic instrumentation needs with a PCB Application Engineer.

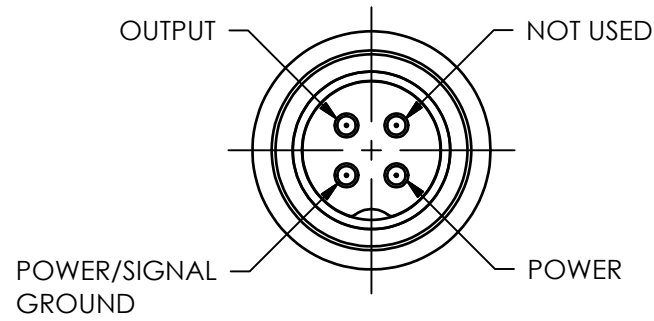
Model Number 3711E112G		DC RESPONSE ACCELEROMETER		Revision: A ECN #: 44033
Performance	ENGLISH	SI		OPTIONAL VERSIONS
Sensitivity(± 3 %)	1000 mV/g	101.9 mV/(m/s ²)		Optional versions have identical specifications and accessories as listed for the standard model except where noted below. More than one option may be used.
Measurement Range	± 2 g pk	± 19.6 m/s ² pk		
Frequency Range(± 3 dB)	0 to 400 Hz	0 to 400 Hz	[2]	
Frequency Range(± 3 dB)	0 to 200 Hz	0 to 200 Hz	[5]	
Phase Response(10 Hz)	<2.5 °	<2.5 °		
Broadband Resolution(0.5 to 100 Hz)	.1 mg rms	.001 m/s ² rms	[2]	
Non-Linearity	≤ 1 %	≤ 1 %	[6]	
Transverse Sensitivity	≤ 5 %	≤ 5 %		
Environmental				
Overload Limit(Shock)	± 2000 g pk	± 19,620 m/s ² pk		
Temperature Range(Operating)	-65 to +250 °F	-54.0 to +121 °C		
Temperature Range(Storage)	-65 to +250 °F	-54.0 to +121 °C		
Temperature Coefficient of Sensitivity	± 5 %	± 5 %	[3]	
Zero g Offset Temperature Coefficient	± 4 % FSO	± 4 % FSO	[3][4]	
Base Strain Sensitivity(Measured at 250 µε)	.0002 g/µε	.002 (m/s ²)/µε	[2]	
Magnetic Sensitivity	100 µg/gauss	9.8 (m/s ²)/Tesla	[2]	
Electrical				
Excitation Voltage	6 to 30 VDC	6 to 30 VDC		
Current Consumption	≤ 10 mA	≤ 10 mA		
Output Impedance	≤ 120 Ohm	≤ 120 Ohm		
Offset Voltage(0 g)	± 160 mVDC	± 160 mVDC	[1]	
Spectral Noise(1 to 100 Hz)	15 µg/√Hz	147 (µm/sec ²)/√Hz	[2]	
Electrical Isolation(Case)	>10 ⁸ Ohm	>10 ⁸ Ohm		
Physical				
Housing Material	Titanium	Titanium		
Sealing	Hermetic	Hermetic		
Size (Height x Length x Width)	0.45 in x 0.85 in x 0.85 in	11.4 mm x 21.6 mm x 21.6 mm		
Weight	0.58 oz	16.3 gm		
Electrical Connector	4-Pin	4-Pin		
Electrical Connection Position	Side	Side		
Mounting	Through Holes (2)	Through Holes (2)		
 <p>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. ICP® is a registered trademark of PCB Group, Inc.</p>				NOTES:
				[1]Offset tolerance is based on 10 ft of 010 test cable. [2]Typical. [3]-65 to +250 °F, ref. 75 °F (-54 to +121 °C, ref. 24 °C) [4]FSO = Full Scale Output over the Measurement Range (4VDC). [5]Minimum, verified with Calibration data. [6]Least-squares, straight line method, % FSO. [7]See PCB Declaration of Conformance PS027 for details.
SUPPLIED ACCESSORIES: Model 080A152 Easy Mount Clip (1) Model 081A113 Mounting screw assembly (2) Model ACS-145 Phase and Amplitude Calibration from 2 Hz to ±3 dB of frequency range (1) Model M081A113 Mounting screw assembly (2)				Entered: AP
				Engineer: JJD
Date: 3/27/2015		Sales: RWM	Approved: NJF	Spec Number:
Date: 3/27/2015		Date: 3/27/2015	Date: 3/27/2015	60024
				Phone: 716-684-0001 Fax: 716-684-0987 E-Mail: info@pcb.com
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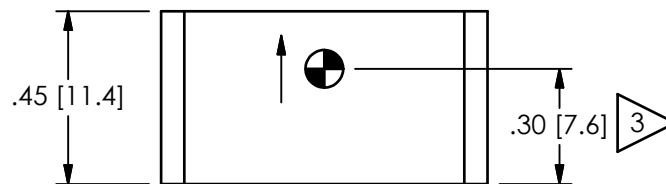
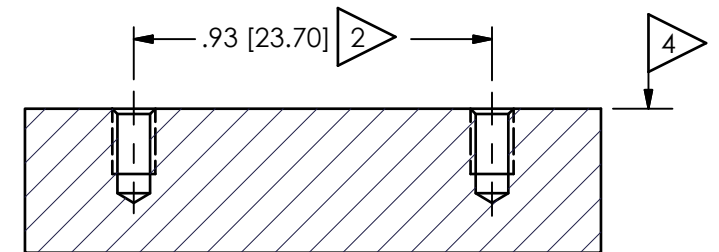
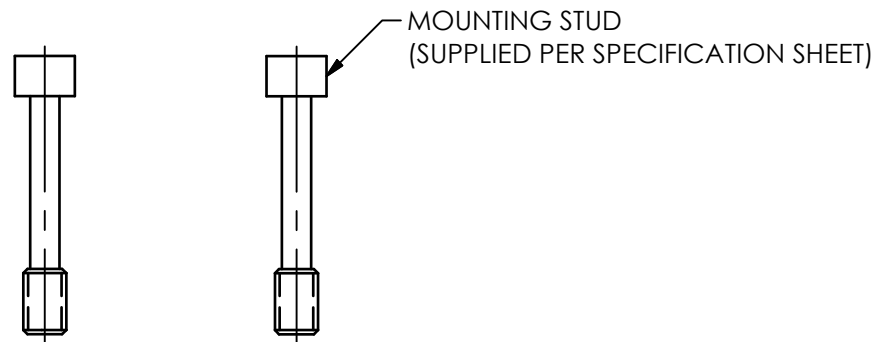
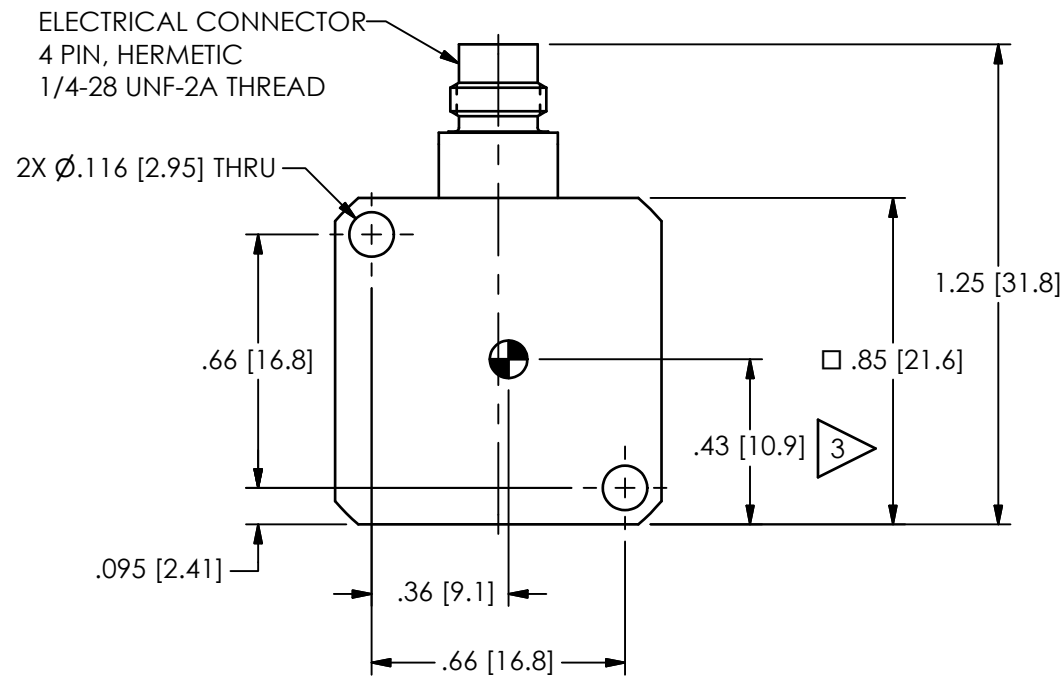
REVISIONS		
REV	DESCRIPTION	DIN
NR	RELEASED TO DRAFTING	43293

FRONT VIEW OF CONNECTOR
SCALE 4:1



OUTPUT SIGNAL:
REFERENCE TO GROUND.

POWER:
CONNECT TO DC VOLTAGE POWER SUPPLY. SEE SPECIFICATION SHEET FOR PROPER EXCITATION VOLTAGE.



MOUNTING HOLE PREPARATION:
Ø.089 [2.26] ∇ .220 [5.59] MIN
4-40 UNC-2B ∇ .170 [4.32] MIN

METRIC MOUNTING HOLE PREPARATION:
Ø.081 [2.05] ∇ .180 [4.57] MIN
M2.5 X .45-6H ∇ .130 [3.30] MIN

5.) SEE SHEET 2 OF 2 FOR CABLE STRAIN RELIEF INFORMATION.

4 RECOMMENDED MOUNTING SURFACE SHOULD BE FLAT TO WITHIN .003 [.08] TIR OVER Ø1.21 [30.5] WITH A 32[.08] ∇ FINISH FOR BEST RESULTS.

3 CG-CENTER OF SEISMIC MEASUREMENT

2 DIAGONAL MOUNTING DIMENSION BETWEEN HOLES.

1 RECOMMENDED MOUNTING TORQUE ON MOUNTING STUD, 4-5 IN-LBS [45-55 N-CM].

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:		DRAWN		CHECKED		ENGINEER	
DIMENSIONS IN INCHES	DIMENSIONS IN MILLIMETERS [IN BRACKETS]	JDM	8/28/14	ECB	8/28/14	JJD	8/28/14
DECIMALS XX ±.01 XXX ±.005	DECIMALS X ±.03 XX ±.013	TITLE INSTALLATION DRAWING MODEL 3711 SERIES DC ACCELEROMETER					
ANGLES ± 2 DEGREES	ANGLES ± 2 DEGREES						
FILLETS AND RADII .003 - .005	FILLETS AND RADII 0.07 - 0.13	CODE IDENT. NO. 52681		DWG. NO. 59773		SCALE: 2X SHEET 1 OF 2	



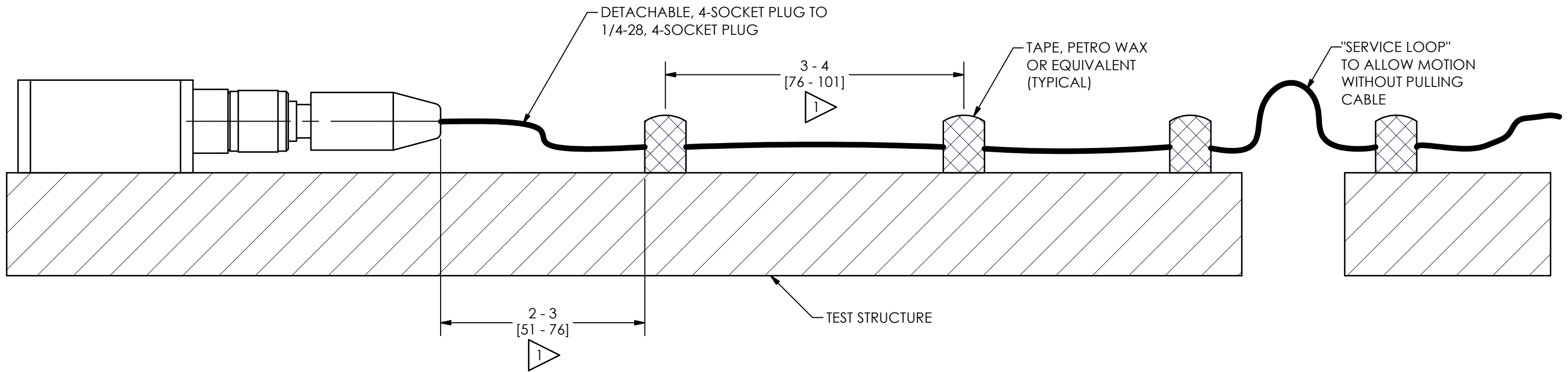
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REVISIONS

REV	DESCRIPTION	DIN
	- SEE SHEET ONE -	



FASTEN CABLE TO TEST STRUCTURE TYPICALLY WITHIN 2-3" [51-76] OF SENSOR. THEN FASTEN AGAIN WITHIN 3-4" [76-101] OF PREVIOUS ATTACHMENT. BETWEEN THE TEST STRUCTURE AND A FIXED STRUCTURE, ALLOW A SERVICE LOOP LARGE ENOUGH TO PREVENT PULLING OF THE CABLE WHEN SHAKING. MORE ATTACHMENT POINTS WILL PROVIDE LESS NOISE IN THE RESULTING DATA. LOOSE CABLES OR PARTS ELSEWHERE ON THE TEST STRUCTURE CAN ALSO GENERATE "NOISE" ON THE SIGNAL RECEIVED FROM THE MODEL 3711 SERIES.

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:		DRAWN		CHECKED		ENGINEER	
DIMENSIONS IN INCHES	DIMENSIONS IN MILLIMETERS [IN BRACKETS]	JDM	8/28/14	ECB	8/28/14	JJD	8/28/14
DECIMALS XX ±.01 XXX ±.005	DECIMALS X ±.03 XX ±.013	TITLE INSTALLATION DRAWING MODEL 3711 SERIES DC ACCELEROMETER					
ANGLES ± 2 DEGREES	ANGLES ± 2 DEGREES						
FILLETS AND RADII .003 - .005	FILLETS AND RADII 0.07 - 0.13	CODE IDENT. NO. 52681		DWG. NO. 59773		SCALE: 2 X SHEET 2 OF 2	

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