



Environmental Test

Piezoelectric MEMS Response Accelerometers, Shock Sensors, Force Sensors, Pressure Sensors, Acoustic Microphones & Torque Sensors





Environmental Test



Introduction

PCB Piezotronics was founded in 1967 as a manufacturer of piezoelectric quartz sensors, and associated electronics for the measurement of dynamic pressure, force, and acceleration. The unique expertise of the company was the incorporation of microelectronic signal conditioning circuitry within these sensors to make them easier to use and more environmentally compatible. These ICP® sensors gained wide popularity and became the foundation for the company's success.

Subsequent growth and steady investment in facilities, machinery, and equipment permitted a constant broadening of the product offering. Measurement capabilities expanded with the addition of piezoceramic, tourmaline, capacitive, piezoresistive, and metal strain gage sensing technologies. Ensuing products include industrial accelerometers, DC MEMS accelerometers, load cells, torque sensors, microphones, pressure transmitters, and calibration equipment.

The backbone of the company is its mission statement: Total Customer Satisfaction. This mission is not only supported by products that offer great value, but also backed by our industry exclusive Lifetime Warranty Plus. Factory applications engineering and a worldwide network of sales offices and representatives are readily available to assist with customer requests.

Quality System Certifications

PCB® Quality Systems are certified to the requirements of the following International Standards:

- AS9100 Revision B: Requirements for Aviation, Space and Defense
- ISO9001:2000: Quality Management Systems requirements
- ISO17025 and ANSI-Z-540-1: Requirements for Competence of Testing & Calibration Laboratories
- EN13980 & Directive 94/9/EC: Quality Systems for Potentially Explosive Atmospheres

These standards strive for process consistency and provide a means for continuous improvement while covering the entire product cycle, which includes contracting, product design control, manufacturing process control and inspection and test. In-house calibration of PCB® sensors is conducted with full traceability to National and International Institutes of Standards and Technology (N.I.S.T., P.T.B). In addition, a complete listing of A2LA accredited calibration services is documented on PCB's "Scope of Calibration" document(s).

The purpose of these standards is to facilitate trade, exchange and technology transfer through:

- Enhanced product quality and reliability at a reasonable price
- Improved health, safety and environmental protection
- Greater compatibility and interoperability of goods and services
- Simplification for improved usability,
- Increased distribution efficiency, and ease of maintenance

Assurance of quality system conformity is provided by certifying bodies and through our internal auditing system.

In addition, our system remains compliant with obsolete or superseded standards such as: ISO 10012-1 (former MIL-STD-45662A), Guide 25, MIL-Q-9858 and MIL-I-45208. PCB is also compliant to nuclear power plant specification 10CFR50 Appendix B. PCB sensors are capable of testing MIL-STD-810 and MIL-STD-461. If you require compliance to a product or application specific standard (such as RoHS, European CE Marking, or US test requirement MIL-STD-740-2) which was not mentioned, please contact the factory for additional information.

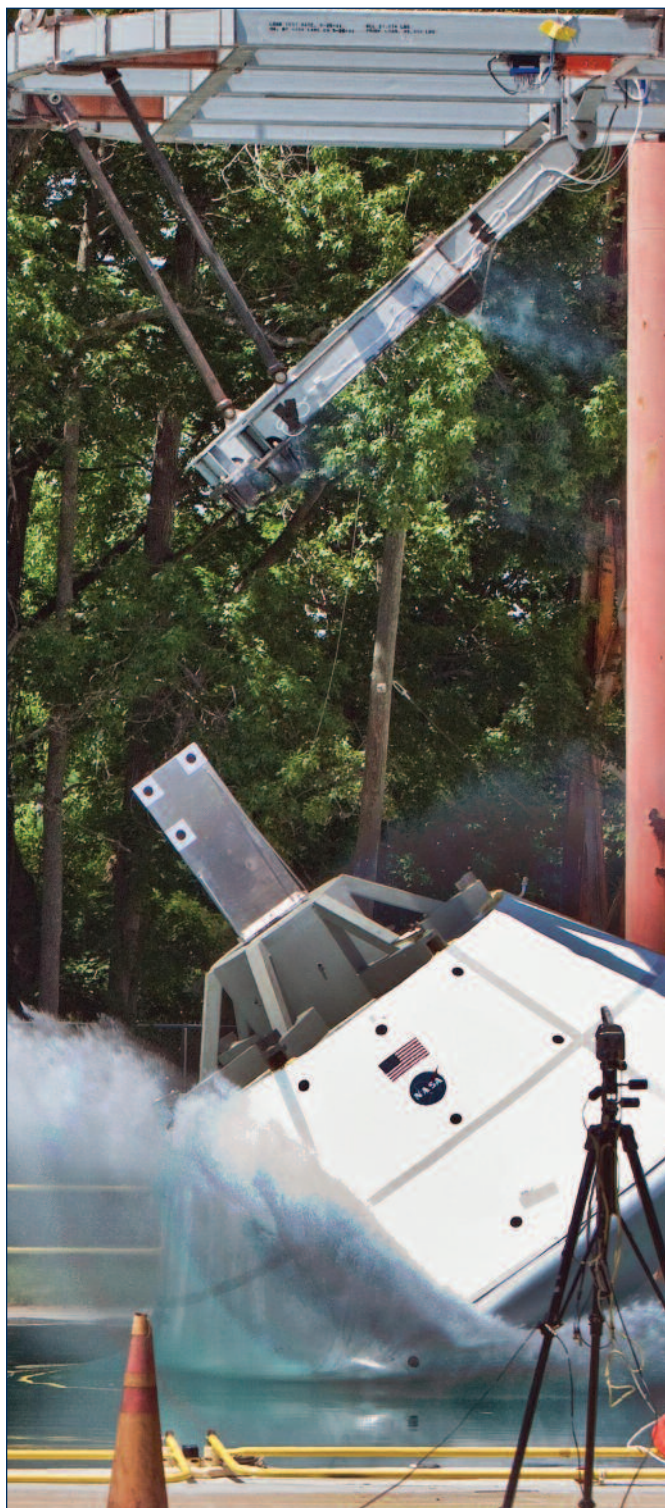


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The Modal Shop, Inc. (www.modalshop.com) specializes in multi-channel sound and vibration sensing systems for lab measurements and industrial process monitoring, including calibration systems and test and measurement equipment rental. Also, smart sensing systems applied to parts quality NDT analysis, process monitoring and machinery gauging. Toll-free in USA: 800-860-4867, Phone: 513-351-9919



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PCB Load & Torque, Inc., a wholly-owned subsidiary of PCB Piezotronics, is a manufacturer of high quality, precision load cells, torque transducers, and telemetry units. In addition to the quality products produced, PCB Load & Torque's customer support services mirror those of PCB Piezotronics.



Photo Courtesy of Sun Microsystems
Advanced Product Testing Laboratory

HALT/HASS ICP® Test Accelerometers




Environmental Stress Screening (ESS) is a general reliability testing term used to define the practice of exposing primarily electronic products to environmental stresses in an attempt to create failures and expose defects. HALT and HASS represent two types of ESS, each with different goals.

Highly Accelerated Life Testing (HALT) is a design verification process, which exposes a product to very rapid and extreme changes in vibration and temperature in an effort to quickly uncover design and assembly flaws. The stress level to which the product is subjected is usually much higher than would normally be anticipated during use. Subsequent improvements in design or assembly techniques can then be undertaken to ensure that a higher quality product is manufactured.

Highly Accelerated Stress Screening (HASS) is a weeding-out process that involves testing 100 percent of final products in an effort to identify those which may possess a higher probability of early failure. Only products that pass the testing are sent along to end users. The result is a better quality product that has already demonstrated to be less prone to failure. HASS involves exposure to environmental influences including vibration, temperature, humidity, and pressure.

Applications:

- Quality Assurance (HALT, HASS, ESS)
- Vibration Testing
- Combined Environments (-100 to 325 °F)

HALT/HASS Test Accelerometers					
					
Model Number	320C03	320C04	320C15	320C20	320C33
Performance					
Sensitivity (± 10 %)	10 mV/g 1.02 mV/(m/s ²)	10 mV/g 1.02 mV/(m/s ²)	10 mV/g 1.02 mV/(m/s ²)	10 mV/g 1.02 mV/(m/s ²)	100 mV/g 10.2 mV/(m/s ²)
Measurement Range	± 500 g pk ±4900 m/s ² pk	± 500 g pk ±4900 m/s ² pk	± 500 g pk ±4900 m/s ² pk	± 500 g pk ±4900 m/s ² pk	± 50 g pk ± 490 m/s ² pk
Frequency Range (± 5 %)	1 to 6000 Hz	1 to 6000 Hz	1.0 to 10,000 Hz	2.0 to 5000 Hz	1 to 4000 Hz
Resonant Frequency	≥ 35 kHz	≥ 35 kHz	≥ 60 kHz	≥ 60 kHz	≥ 22 kHz
Broadband Resolution (1 to 10,000 Hz)	0.003 g rms 0.03 m/s ² rms	0.003 g rms 0.03 m/s ² rms	0.005 g rms 0.05 m/s ² rms	0.006 g rms 0.06 m/s ² rms	0.0003 g rms 0.003 m/s ² rms
Filter Type	—	—	—	Low Pass	—
Electrical Filter Corner Frequency	—	—	—	13 kHz	—
Electrical Filter Roll-off	—	—	—	6 dB/octave	—
Environmental					
Overload Limit (Shock)	± 10,000 g pk ± 98,100 m/s ² pk	± 10,000 g pk ± 98,100 m/s ² pk	± 10,000 g pk ± 98,100 m/s ² pk	± 10,000 g pk ± 98,100 m/s ² pk	± 2000 g pk ± 19,620 m/s ² pk
Temperature Range (Operating)	-100 to +325 °F -73 to +163 °C	-100 to +325 °F -73 to +163 °C	-100 to +325 °F -73 to +163 °C	-100 to +325 °F -73 to +163 °C	-100 to +325 °F -73 to +163 °C
Physical					
Size (Height x Hex)	0.81 in x 0.50 in 20.6 mm x 12.7 mm	1.14 in x 0.50 in 29.0 mm x 12.7 mm	0.43 in x 5/16 in 10.9 mm x 5/16 in	0.87 in x 0.38 in 22.1 mm x 9.7	0.85 in x 0.75 in 21.6 mm x 19.1 mm
Weight	0.38 oz 10.5 gm	0.38 oz 10.5 gm	0.07 oz 2.0 gm	0.23 oz 6.5 gm	0.7 oz 20 gm
Sensing Element	Quartz	Quartz	Quartz	Quartz	Quartz
Sensing Geometry	Shear	Shear	Shear	Shear	Shear
Housing Material	Titanium	Titanium	Titanium	Titanium	Titanium
Electrical Connector	10-32 Coaxial Jack	10-32 Coaxial Jack	5-44 Coaxial	10-32 Coaxial Jack	10-32 Coaxial Jack
Electrical Connector Position	Side	Top	Side	Top	Side
Mounting Thread	10-32 Female	10-32 Female	5-40 Male	10-32 Male	10-32 Female



ICP® Accelerometers with Excellent Thermal Stability

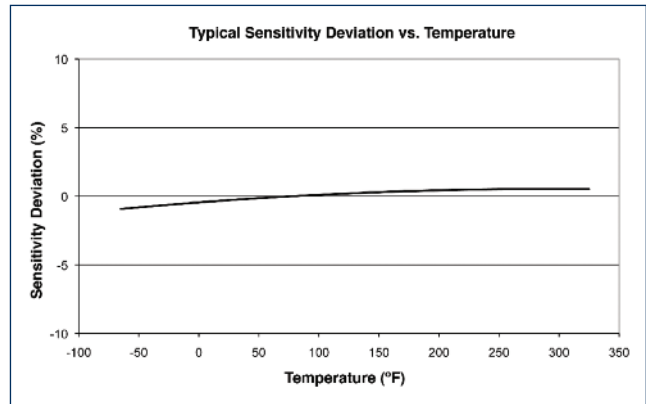
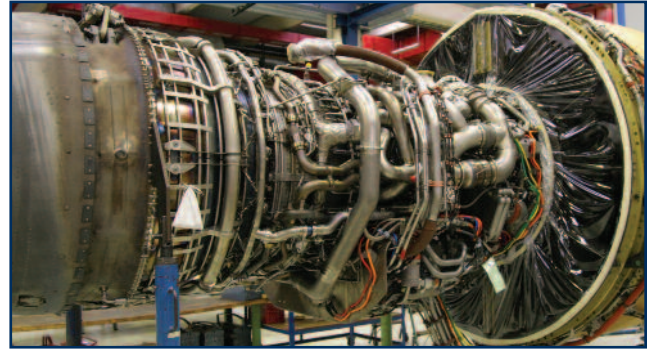
PCB® single axis and triaxial ICP® accelerometers are designed with a low temperature coefficient, wide operating temperature range, and good broadband measurement resolution, making them ideal for any vibration measurement requiring tight control of amplitude sensitivity over a wide thermal gradient. To alleviate the effects of high frequency overloads some models have a low pass filter incorporated, ensuring accurate data in the frequency range of interest.

Highlights:

- Temperature coefficient as low as 0.005% / °F (0.009% / °C)
- Titanium housed and hermetically sealed
- Stud, adhesive and through hole mounting configurations

Applications:

- Engine Systems and Exhaust
- Component and System Dynamic Performance
- ESS and Durability Testing in Climatic Chambers



Technical Specifications

Model Number	NEW! 320C52	339A30	339A31	339A32	NEW! T339A34 [1]
Sensitivity	10 mV/g	10 mV/g	10 mV/g	10 mV/g	50 mV/g
Measurement Range	± 500 g pk	± 500 g pk	± 500 g pk	± 500 g pk	± 100 g pk
Broadband Resolution	0.004 g rms	0.008 g rms	0.008 g rms	0.003 g rms	0.005 g rms
Frequency Range (± 5 %)	1 to 10 kHz	2 to 8 kHz	2 to 8 kHz	2 to 8 kHz	2 to 5 kHz
Resonant Frequency (x or y axis)	≥ 50 kHz	≥ 25 kHz	≥ 25 kHz	≥ 45 kHz	≥ 35 kHz
Resonant Frequency (z axis)	—	≥ 55 kHz	≥ 25 kHz	≥ 45 kHz	—
Environmental					
Overload Limit (Shock)	± 5000 g pk	± 5000 g pk	± 5000 g pk	± 5000 g pk	± 5000 g pk
Temperature Range	-100 to +325 °F -73 to +163 °C	-65 to +325 °F -54 to +163 °C	-65 to +325 °F -54 to +163 °C	-65 to +325 °F -54 to +163 °C	-65 to +325 °F -54 to +163 °C
Temperature Coefficient of Sensitivity	≤ 0.005 %/°F ≤ 0.009 %/°C	≤ 0.011 %/°F ≤ 0.020 %/°C	≤ 0.011 %/°F ≤ 0.020 %/°C	≤ 0.011 %/°F ≤ 0.020 %/°C	≤ 0.03 %/°F ≤ 0.06 %/°C
Physical					
Housing Material	Titanium	Titanium	Titanium	Titanium	Titanium
Sealing	Hermetic	Hermetic	Hermetic	Hermetic	Hermetic
Size (H x L x W)	0.23 x 0.65 x 0.38 in 5.84 x 16.4 x 9.6 mm	0.4 in Cube 10.2 mm Cube	0.55 x 0.4 x 0.4 in 14 x 10.2 x 10.2 mm	0.28 x 0.47 x 0.47 in 7.0 x 12.0 x 12.0 mm	0.55 x 0.80 x 0.55 in 14.0 x 23.3 x 14.0 mm
Weight	1.85 gm	4.0 gm	5.5 gm	3.6 gm	10.5 gm
Electrical Connector	5-44 Coaxial	8-36 4-Pin	8-36 4-Pin	8-36 4-Pin	1/4-28 4-Pin
Mounting	Through Hole	Adhesive	5-40 Stud	Adhesive	5-40 Stud
Notes					
[1] TEDS Capable of Digital Memory and Communication compliant with IEEE1451.4					



Photo Courtesy of Sun Microsystems Advanced Product Testing Laboratory





Filtered ICP® Accelerometers

Impact testing of aerospace components often involves exposing the test specimen to dynamic stimuli, which include high levels of broadband excitation. This testing regiment can cause resonant behavior in brackets or other subassemblies that may be mounted to the component under test. A resonating component can cause vibration energy to be transmitted throughout the test structure, which can potentially corrupt or mask the measurement data of interest. Internal LP filtering is used to eliminate unwanted high magnitude high frequency signals that are above the structural frequency range of interest.

Highlights:

- Qualification testing during high random excitation
- Minimize the possibility of amplifier saturation
- Extend the usable high frequency range of data acquisition

Filtered Accelerometers

				
Model Number	352B70	352A72	356A63	356A66
Performance				
Sensitivity(± 15 %)	1 mV/g 0.1 mV/(m/s ²)	10 mV/g 1.02 mV/(m/s ²)	10 mV/g 1.02 mV/(m/s ²)	10 mV/g 1.02 mV/(m/s ²) (± 10 %)
Measurement Range	± 5000 g pk ± 49,000 m/s ² pk	± 500 g pk ± 4905 m/s ² pk	± 500 g pk ± 4905 m/s ² pk	± 500 g pk ± 4905 m/s ² pk
Frequency Range(± 5 %)	0.7 to 9000 Hz	0.5 to 4500 Hz	2 to 4000 Hz	2 to 4000 Hz
Electrical Filter Corner Frequency	23 kHz	15 kHz	15 kHz	16 kHz
Electrical Filter Roll-off	12 dB/octave	6 dB/octave	6 dB/octave	6 dB/octave
Resonant Frequency	≥ 55 kHz	≥ 65 kHz	≥ 55 kHz	≥ 35 kHz
Broadband Resolution (1 to 10,000 Hz)	0.025 g rms 0.25 m/s ² rms	0.003 g rms 0.03 m/s ² rms	0.008 g rms 0.08 m/s ² rms	0.002 g rms 0.02 m/s ² rms
Environmental				
Overload Limit (Shock)	± 10,000 g pk ± 98,000 m/s ² pk	± 10,000 g pk ± 98,000 m/s ² pk	± 10,000 g pk ± 98,000 m/s ² pk	± 10,000 g pk ± 98,000 m/s ² pk
Temperature Range (Operating)	-65 to +250 °F -54 to +121 °C	-65 to +250 °F -54 to +121 °C	-65 to +250 °F -54 to +121 °C	-65 to +250 °F -54 to +121 °C
Physical				
Size (Height x Length x Width)	0.90 x 3/8 in 22.9 mm x 3/8 in (Height x Hex)	0.14 in x 0.41 in x 0.25 in 3.6 mm x 10.4 mm x 6.4 mm	0.40 in x 0.77 in x 0.40 in 10.2 mm x 19.6 mm x 10.2 mm	0.55 in x 0.80 in x 0.55 in 14.0 mm x 20.3 mm x 14.0 mm
Weight (without cable)	0.15 oz 4.3 gm	0.023 oz 0.64 gm	0.19 oz 5.3 gm	0.32 oz 9.0 gm
Sensing Element	Ceramic	Ceramic	Ceramic	Ceramic
Sensing Geometry	Shear	Shear	Shear	Shear
Housing Material	Titanium	Titanium	Titanium	Titanium
Electrical Connector	10-32 Coaxial Jack	Solder pins, 10 ft. attached cable, 10-32 plug	1/4-28 4-Pin	1/4-28 4-Pin
Electrical Connector Position	Top	Side	Side	Side
Mounting Thread	10-32 Female	Adhesive	5-40 Female	10-32 Female



High Amplitude ICP® Shock Accelerometers

Shock accelerometers are specifically designed to withstand and measure extreme, high amplitude, short-duration, transient accelerations. Such accelerations characteristically exceed the 1000 g boundary imposed on other typical accelerometer designs. Shock acceleration events may reach 100,000 g or more with pulse durations of less than 10 microseconds. The extremely fast transient and volatile nature of a shock event imposes special demands on the design.

PCB® shock accelerometers represent extensive research in materials, assembly techniques, and testing techniques to insure survivability and faithful representation of the shock event. PCB® invested in an automated Hopkinson Bar Calibration Station to evaluate shock sensor performance by simulating, high amplitude measurement conditions. This allows PCB® to assess and improve upon individual sensor characteristics, such as zero shift, ringing and non-linearity.



Highlights:

- Mechanically isolated and electrically filtered, which avoids ringing and minimizes zero shift
- Lightweight titanium construction
- Hermetically sealed for harsh environments
- Provides high voltage, low impedance output

Applications:

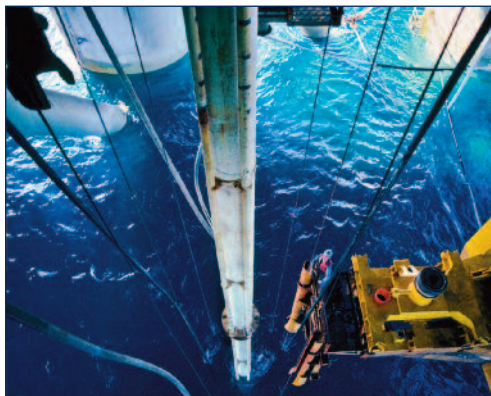
- Pyroshock Events
- Recoil and Penetration
- Impact Press Monitoring
- Explosive Studies
- Shaker Shock



Models
350B23
350D02
350B21

350B50

High Amplitude ICP® Shock Response Accelerometers				
	Single Axis			Triaxial
Model Number	350B23	350D02	350B21	350B50
Performance				
Sensitivity ($\pm 30\%$)	0.5 mV/g 0.05 mV/(m/s ²)	0.1 mV/g 0.01 mV/(m/s ²)	0.05 mV/g 0.005 mV/(m/s ²)	0.5 mV/g 0.05 mV/(m/s ²)
Measurement Range	$\pm 10,000$ g pk $\pm 98,000$ m/s ² pk	$\pm 50,000$ g pk $\pm 490,000$ m/s ² pk	$\pm 100,000$ g pk $\pm 980,000$ m/s ² pk	$\pm 10,000$ g pk $\pm 98,000$ m/s ² pk
Frequency Range (± 1 dB)	0.4 to 10,000 Hz	4 to 10,000 Hz	1 to 10,000 Hz	3 to 10,000 Hz
Frequency Range (-3 dB)	0.2 to 25,000 Hz	2 to 25,000 Hz	0.5 to 35,000 Hz	1.5 to 20,000 Hz
Electrical Filter Corner Frequency (-3 dB)	13 kHz	17 kHz	NA	20 kHz
Mechanical Filter Resonant Frequency	23 kHz	45 kHz	NA	NA
Resonant Frequency	≥ 100 kHz	≥ 100 kHz	≥ 200 kHz	≥ 60 kHz
Environmental				
Overload Limit (Shock)	$\pm 50,000$ g pk $\pm 490,000$ m/s ² pk	$\pm 150,000$ g pk $\pm 1,471,500$ m/s ² pk	$\pm 200,000$ g pk $\pm 1,960,000$ m/s ² pk	$\pm 25,000$ g pk $\pm 245,000$ m/s ² pk
Temperature Range (Operating)	0 to +150 °F -18 to +66 °C	0 to +150 °F -18 to +66 °C	-65 to +200 °F -54 to +93 °C	-65 to +250 °F -54 to +121 °C
Physical				
Sensing Element	Ceramic	Ceramic	Ceramic	Ceramic
Sensing Geometry	Shear	Shear	Shear	Shear
Sealing	Hermetic	Hermetic	Hermetic	Hermetic
Housing Material	Titanium	Titanium	Titanium	Titanium
Size (Hex x Height)	0.375 in x 0.75 in 9.5 mm x 19.1 mm	0.375 in x 0.87 in 9.5 mm x 19.1 mm	0.375 in x 0.75 in 9.5 mm x 19.1 mm	0.32 in x 0.72 in x 0.72 in 8.2 mm x 18.3 mm x 18.3 mm (Height x Length x Width)
Weight	0.16 oz 4.5 gm	0.15 oz 4.2 gm	0.15 oz 4.2 gm	0.3 oz 8.0 gm
Electrical Connector	Integral Cable	Integral Cable	Integral Cable	Integral Cable
Cable Length	10 ft 3.05 m	10 ft 3.05 m	10 ft 3.05 m	5.0 ft 1.52 m
Mounting Thread	1/4-28 Male	1/4-28 Male	1/4-28 Male	Through Hole



MEMS Piezoresistive High-G Shock Accelerometers DC Reponse, Four-wire Full Bridge

MEMS high-amplitude shock accelerometers, from PCB Piezotronics, represent state-of-the-art industry technology for miniature, high amplitude, DC response acceleration sensors, capable of measuring long duration transient motion, as well as responding to and surviving extremely fast rise times, typical of a High-G shock event. Both packaged and OEM configurations are offered, to fulfill a variety of installation requirements.

The lightly air-damped acceleration sensing element, which is micromachined from silicon, is manufactured with the latest advances in etching techniques and equipment. This tiny element measures just 2.5 x 1.7 x 0.9 mm (L x W x H), and incorporates a seismic mass, protective over-range stops, and a full-active, piezoresistive Wheatstone bridge.

This Series is intended to fulfill the most demanding aerospace, industrial, and commercial application requirements. Their design concepts were born from more than 20 years of PCB® expertise in High-G shock ($\geq 20,000$ g) measurement applications and sensor development. Our process engineers utilized the latest and most sophisticated techniques and equipment to achieve the desired performance levels that previously have not been attainable. Utilizing deep reactive ion etching (DRIE) equipment and techniques, PCB® can micromachine in-house, from extremely strong single crystal silicon, the industry's smallest, most accurate and durable shock accelerometer.



Series 3501 & 3503

MEMS High-G Shock Accelerometers

	Surface Mount	Packaged	
Model Number	3501A2020KG Single Axis	3501A1220KG Single Axis	3503A1020KG Triaxial
Performance			
Sensitivity ($\pm 50\%$) (at 10 VDC excitation)	0.010 mV/g 0.001 mV/(m/s ²)	0.010 mV/g 0.001 mV/(m/s ²)	0.010 mV/g 0.001 mV/(m/s ²)
Sensitivity	0.001 mV/V/g 0.0001 mV/V/(m/s ²)	0.001 mV/V/g 0.0001 mV/V/(m/s ²)	0.001 mV/V/g 0.0001 mV/V/(m/s ²)
Measurement Range	$\pm 20,000$ g $\pm 196,100$ m/s ² pk	$\pm 20,000$ g $\pm 196,100$ m/s ² pk	$\pm 20,000$ g $\pm 196,100$ m/s ² pk
Frequency Range(± 1 dB)	0 to 10,000 Hz	0 to 10,000 Hz	0 to 10,000 Hz
Resonant Frequency	>60 kHz	>60 kHz	>60 kHz
Environmental			
Overload Limit (Shock)	$\pm 60,000$ g pk $\pm 588,000$ m/s ² pk	$\pm 60,000$ g pk $\pm 588,000$ m/s ² pk	$\pm 60,000$ g pk $\pm 588,000$ m/s ² pk
Overload Limit (Mechanical Stops)	≥ 30 Kg $\geq 294,200$ m/s ² pk	≥ 30 Kg $\geq 294,200$ m/s ² pk	≥ 30 Kg $\geq 294,200$ m/s ² pk
Temperature Range (Operating)	-65 to 250 °F -54 to 121 °C	-65 to 250 °F -54 to 121 °C	-65 to 250 °F -54 to 121 °C
Electrical			
Excitation Voltage (Maximum)	15 VDC	15 VDC	15 VDC
Current Consumption	< 3 mA	< 3 mA	< 3 mA
Offset Voltage	-40 to +40 mVDC	-40 to +40 mVDC	-40 to +40 mVDC
Physical			
Sensing Element	Piezoresistive MEMS	Piezoresistive MEMS	Piezoresistive MEMS
Sensing Geometry	Full Active	Full Active	Full Active
Housing Material	Ceramic	Titanium	Titanium
Size (Height x Length x Width)	0.085 in x 0.236 in x 0.138 in 2.16 mm x 6.00 mm x 3.50 mm	3/8 in x 0.5 in 3/8 in x 12.7 mm (Hex x Height)	0.25 in x 0.47 in x 0.47 in 6.35 mm x 11.81 mm x 11.81 mm
Weight	0.005 oz 0.15 gm	0.088 oz 2.5 gm	0.1 oz 2.83 gm
Electrical Connector	Solder Tabs	10-ft / 3.05 m Integral Type 034 Cable with Pigtail Ends	10-ft / 3.05 m Integral Type 026 Cable with Pigtail Ends
Mounting	Surface Mount	1/4-28 Integral Stud	Through Holes (2)



Highlights:



- Packaged and OEM Configurations
- Single axis and triaxial arrangements
- Wide band frequency response
- No zero-shift
- Mechanical over-range stops improves survivability
- Slight damping reduces resonance amplification
- 20 KG and 60 KG ranges available

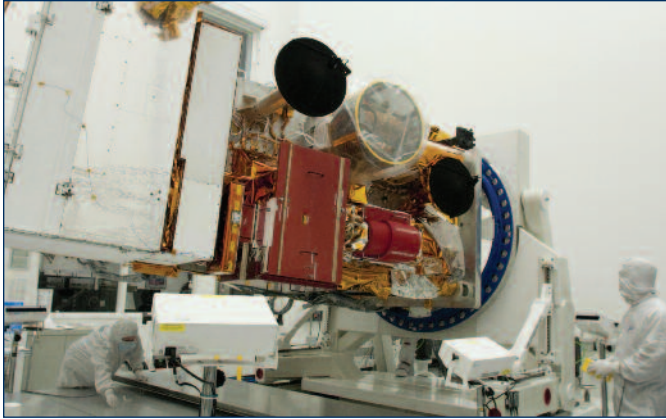
Applications

- Consumer Electronics Drop Testing
- Down-hole Oil Exploration
- Shot Counting for Rifles and Handguns
- Tool Manufacturers
- Pyroshock
- Crash and Impact Environments



MEMS High-G Shock Accelerometers

	Surface Mount	Packaged
		
Model Number	3501A2060KG Single Axis	3501A1260KG Single Axis
Performance		
Sensitivity ($\pm 50\%$) (at 10 VDC excitation)	0.003 mV/g 0.0003 mV/(m/s ²)	0.003 mV/g 0.0003 mV/(m/s ²)
Sensitivity	0.0003 mV/V/g 0.00003 mV/V/(m/s ²)	0.0003 mV/V/g 0.00003 mV/V/(m/s ²)
Measurement Range	$\pm 60,000$ g pk $\pm 588,400$ m/s ² pk	$\pm 60,000$ g pk $\pm 588,400$ m/s ² pk
Frequency Range(± 1 dB)	0 to 20,000 Hz $\pm 588,400$ m/s ² pk	0 to 20,000 Hz $\pm 588,400$ m/s ² pk
Resonant Frequency	>120 kHz	>120 kHz
Environmental		
Overload Limit (Shock)	$\pm 100,000$ g pk $\pm 980,665$ m/s ² pk	$\pm 100,000$ g pk $\pm 980,665$ m/s ² pk
Overload Limit (Mechanical Stops)	≥ 80 Kg $\geq 782,534$ m/s ² pk	≥ 80 Kg $\geq 782,534$ m/s ² pk
Temperature Range (Operating)	-65 to 250 °F -54 to 121 °C	-65 to 250 °F -54 to 121 °C
Electrical		
Excitation Voltage (Maximum)	15.0 VDC	15.0 VDC
Current Consumption	<3 mA	<3 mA
Offset Voltage	-40 to +40 mVDC	-40 to +40 mVDC
Physical		
Sensing Element	Piezoresistive MEMS	Piezoresistive MEMS
Sensing Geometry	Full Active	Full Active
Housing Material	Ceramic	Titanium
Size (Height x Length x Width)	0.085 in x 0.236 in x 0.138 in 2.16 mm x 6.00 mm x 3.50 mm	3/8 in x 0.5 in 3/8 in x 12.7 mm (Hex x Height)
Weight	0.005 oz 0.15 gm	0.005 oz 0.15 gm
Electrical Connector	Solder Tabs	10-ft / 3.05 m Integral Type 034 Cable with Pigtail Ends
Mounting	Surface Mount	1/4-28 Integral Stud



Low Outgassing ICP® & Charge Mode Accelerometers and Cables

Thermal Vacuum Vibration Testing

Exposure to the high vacuum level of a space environment induces material outgassing in ordinary accelerometers and cables. Any substance subjected to a vacuum has the potential to release trapped gasses. Contaminants from outgassing can condense onto nearby surfaces obscuring them, rendering them useless during their intended application.

Many hermetic accelerometer designs have inherent low outgassing qualities. Cables with rubberized boots or shrink tubing typically do not have low outgassing qualities.

For all non-metallic materials outside of a hermetic package required for an application in a vacuum environment, PCB® verifies that the material has less than or equal to 1% TML (total mass loss) and a CVCMM (collected volatile condensable mass material) less than or equal to 0.1%. This is verified either using NASA documentation or test results from an outside laboratory.

In any application involving a vacuum environment, the important things to consider when selecting low outgassing accelerometers and cables are: welded hermetic housings, polymers and epoxies that have low TML and CVCMM values, and leak testing services for low outgas verification of accelerometers.

Highlights

- Vibration measurements in Thermal Vacuum or Space environment
- Welded hermetic accelerometer designs have low outgassing qualities
- Hermeticity testing is performed on all hermetic products at PCB®
- Cables with strain relief use polymers are verified for Total Mass Loss and Collected Volatile Condensable Material
- Materials selected using NASA guidelines

Low Outgassing ICP® & Charge Mode Accelerometers

				
Model Number	350M72	352M212	357A07	357A09
Performance				
Sensitivity (± 10 %)	0.5 mV/g 0.05 mV/(m/s ²)	10 mV/g 1.02 mV/(m/s ²)	1.7 pC/g 0.17 pC/(m/s ²) (± 20 %)	1.7 pC/g 0.17 pC/(m/s ²) (± 20 %)
Measurement Range	± 10,000 g pk ± 98,000 m/s ² pk	± 500 g pk ± 4905 m/s ² pk	± 2000 g pk ± 19,620 m/s ² pk	± 2000 g pk ± 19,620 m/s ² pk
Frequency Range (± 1 dB)	0.4 to 10,000 Hz	0.5 to 10,000 Hz (± 5 %)	15,000 Hz (+5 %)	10,000 Hz (+5 %)
Resonant Frequency	≥ 100 kHz	≥ 65 kHz	≥ 60 kHz	≥ 50 kHz
Environmental				
Overload Limit (Shock)	± 50,000 g pk ± 490,000 m/s ² pk	± 10,000 g pk ± 98,100 m/s ² pk	± 10,000 g pk ± 98,100 m/s ² pk	± 10,000 g pk ± 98,100 m/s ² pk
Temperature Range (Operating)	0 to +150 °F -18 to +66 °C	-65 to +250 °F -54 to +121 °C	-100 to 500 °F -73 to 260 °C	-100 to 350 °F -73 to 177 °C
Physical				
Sensing Element	Ceramic	Ceramic	Ceramic	Ceramic
Sensing Geometry	Shear	Shear	Shear	Shear
Sealing	Hermetic	Hermetic	Hermetic	Hermetic
Housing Material	Titanium	Titanium	Titanium	Titanium
Size (Height x Length x Width)	0.375 in x 0.95 in 9.5 mm x 24.1 mm (Hex x Height)	0.14 in x 0.41 in x 0.25 in 3.6 mm x 10.4 mm x 6.4 mm	0.195 in x 0.420 in x 0.250 in 4.9 mm x 10.7 mm x 6.4 mm	0.14 in x 0.45 in x 0.25 in 3.6 mm x 11.4 mm x 6.4 mm
Weight	0.17 oz 4.8 gm	0.023 oz 0.64 gm	0.03 oz 0.7 gm	0.02 oz 0.6 gm
Mounting	1/4-28 Male	Adhesive	Adhesive	Adhesive



Accelerometer Types & Their Applications

Mini-triaxial accelerometers

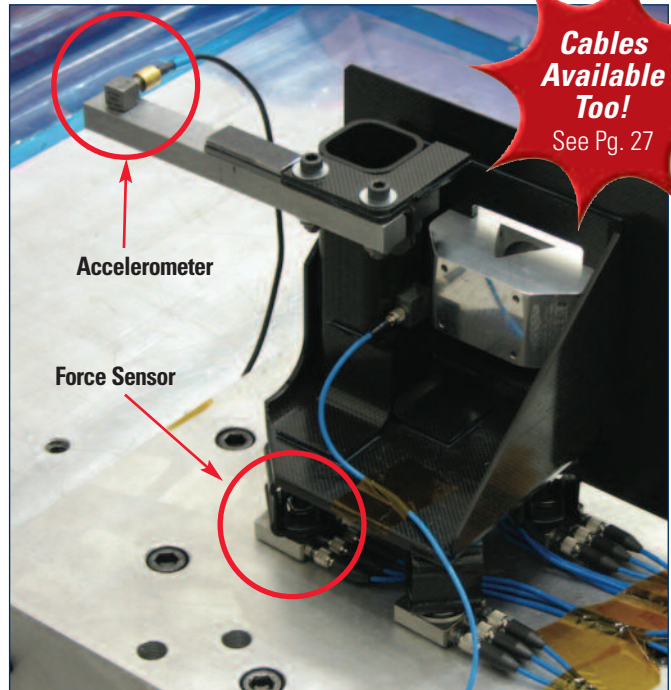
Spacecraft structures are often made of thin, light-weight materials and require low mass accelerometers. Full-scale spacecraft random vibration responses are three-dimensional, so the combination of a triaxial, low-mass ICP® accelerometer with low outgassing properties is recommended. PCB® Model 356M208 meets this requirement with a low mass of one gram and low outgassing characteristics.

Shock accelerometers

Separation of booster stages cause shock events that may be transmitted to the spacecraft payload. Low outgassing ICP® accelerometers such as PCB® Model 350M72 may be launched with the payload or used in a vacuum chamber to simulate launch conditions.





High temperature accelerometers

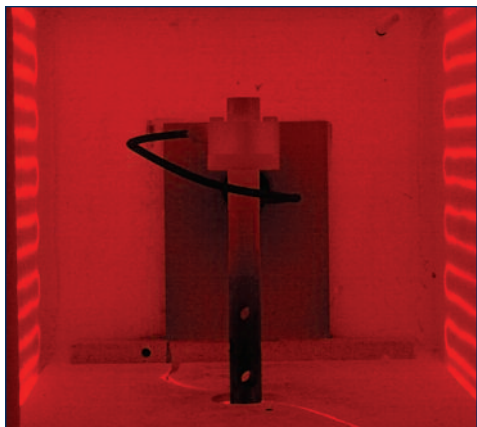
Environmental stress screening is often performed in thermal vacuum chambers to verify operating characteristics. PCB® Model 357A07, (p. 10) offers a hermetic, low-mass package with a wide operating temperature range from -100 to +500 °F (-73 to +260 °C).



PCB® Model 356M208 accelerometer & force sensors used during vibration testing of bracket assembly at Utah State Space Dynamics Lab

Low Outgassing ICP® Accelerometers

				
Model Number	356M208	356M57	356M132	356M98
Performance				
Sensitivity (± 20 %)	5 mV/g 0.51 mV/(m/s²)	10 mV/g 1.02 mV/(m/s²) (± 10 %)	500 mV/g 51 mV/(m/s²) (± 10 %)	1000 mV/g 102 mV/(m/s²) (± 10 %)
Measurement Range	± 1000 g pk ± 9810 m/s² pk	± 500 g pk ± 4905 m/s² pk	± 10 g pk ± 98 m/s² pk	± 5 g pk ± 49 m/s² pk
Frequency Range (± 5 %) (y or z axis)	2 to 8000 Hz	2 to 10,000 Hz	0.5 to 3000 Hz	0.5 to 3000 Hz
Resonant Frequency	≥ 50 kHz	≥ 55 kHz	≥ 14 kHz	≥ 20 kHz
Environmental				
Overload Limit (Shock)	± 10,000 g pk ± 98,100 m/s² pk	± 10,000 g pk ± 98,100 m/s² pk	± 5000 g pk ± 49,000 m/s² pk	± 5000 g pk ± 49,000 m/s² pk
Temperature Range (Operating)	-65 to +250 °F -54 to +121 °C	-65 to +250 °F -54 to +121 °C	-65 to +176 °F -54 to +80 °C	-20 to +170 °F -29 to +77 °C
Electrical				
Excitation Voltage	18 to 30 VDC	18 to 30 VDC	18 to 30 VDC	20 to 30 VDC
Output Impedance	≤ 200 Ohm	≤ 200 Ohm	≤ 300 Ohm	≤ 600 Ohm
Output Bias Voltage	7 to 11 VDC	7 to 11 VDC	8 to 12 VDC	8 to 12 VDC
Physical				
Sensing Element	Ceramic	Ceramic	Ceramic	Ceramic
Sensing Geometry	Shear	Shear	Shear	Shear
Housing Material	Titanium	Titanium	Titanium	Titanium
Size (Height x Length x Width)	0.25 in x 0.25 in x 0.25 in 6.35 mm x 6.35 mm x 6.35 mm	0.4 in x 0.4 in x 0.4 in 10.2 mm x 10.2 mm x 10.2 mm	0.55 in x 0.80 in x 0.55 in 14.0 mm x 20.3 mm x 14.0 mm	0.80 in x 1.03 in x 0.80 in 20.3 mm x 26.1 mm x 20.3 mm



High Temperature Charge Mode Accelerometers

Many operating engine environments generate temperatures in excess of 550 °F (288 °C). Above this temperature, many of the design features and materials used in high temperature accelerometers change considerably.

For 550 °F to 1,200 °F (288 °C to 650 °C) operating environments, PCB® offers a range of both single-ended (measurement output as a signal and ground) and differential (measurement output as a plus and minus signal) sensors. The former tend to be smaller and more suitable for short-term testing needs, while the latter are more appropriate for long-term monitoring applications.

Obviously, the environments in which these sensors operate are challenging. In fact, in some of the highest temperature operating environments, the operating sensor measures vibration signatures while glowing red hot!

Since PCB® manufactures the majority of its own piezoelectric materials, we offer an extensive array of charge mode accelerometer form factors, sensitivities, frequency ranges and sizes. A few of the single-ended accelerometers for use in up to 288 °C (500 °F) environments are presented below. Complementing this range of sensors is a variety of in-line and laboratory grade bench top and rack mounted charge amplifiers.

The accelerometers summarized here are only a subset of the available. Please reference PCB's Test and Measurement Catalog or our web site at www.pcb.com for additional product offerings. Of course, custom designed accelerometers are available.

Applications

- Quality Assurance
- Thermal Stress Screening
- Environmental Testing
- High Temperature Vibration Measurements
- Engine Vibration Analysis
- Exhaust Component Vibration Tests

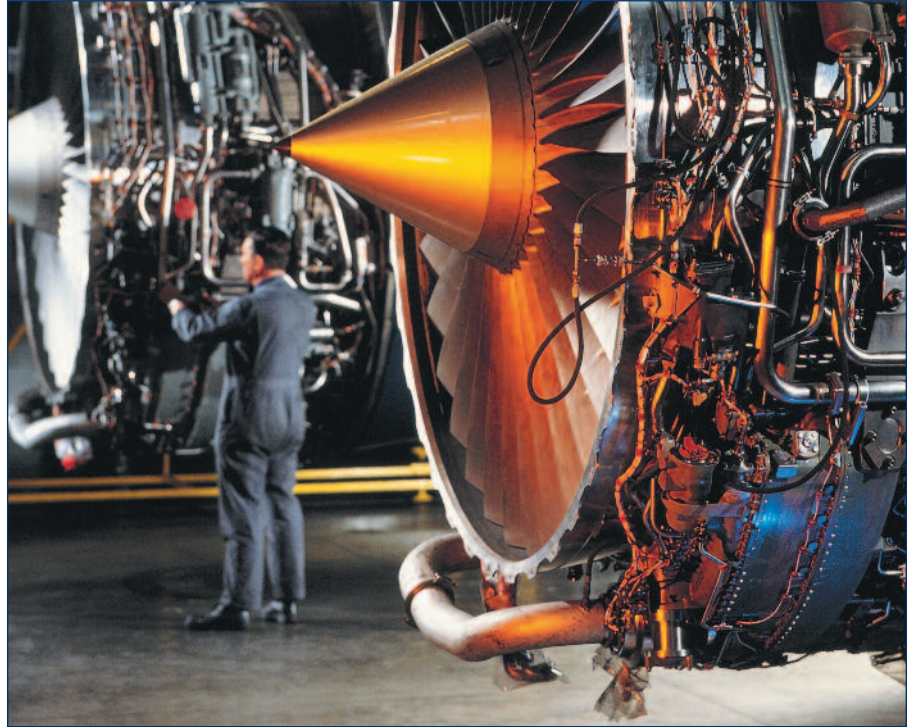
High Temperature Charge Mode Accelerometers

				
Model Number	357B11	357B06	357B21	357B22
Performance				
Sensitivity (± 10 %)	3 pC/g 0.31 pC/(m/s ²)	5 pC/g (± 20 %) 0.51 pC/(m/s ²)	30 pC/g (± 15 %) 3.1 pC/(m/s ²)	30 pC/g (± 15 %) 3.1 pC/(m/s ²)
Measurement Range	± 2300 g pk ± 22,600 m/s ² pk	± 500 g pk ± 4905 m/s ² pk	± 1500 g pk ± 14,700 m/s ² pk	± 1500 g pk ± 14,700 m/s ² pk
Frequency Range (+5 %)	12,000 Hz	10,000 Hz	6000 Hz	6000 Hz
Resonant Frequency	≥ 50 kHz	≥ 50 kHz	≥ 23 kHz	≥ 23 kHz
Environmental				
Overload Limit (Shock)	± 10,000 g pk ± 98,100 m/s ² pk	± 10,000 g pk ± 98,100 m/s ² pk	± 6000 g pk ± 58,860 m/s ² pk	± 6000 g pk ± 58,860 m/s ² pk
Operating Temperature	-95 °F to +500 °F -70 °C to +260 °C	-95 °F to +500 °F -70 °C to +260 °C	-95 °F to +500 °F -70 °C to +260 °C	-95 °F to +500 °F -70 °C to +260 °C
Electrical				
Capacitance	485 pF	700 pF	930 pF	930 pF
Output Polarity	Negative	Negative	Negative	Negative
Physical				
Sensing Element	Ceramic	Ceramic	Ceramic	Ceramic
Sensing Geometry	Shear	Shear	Shear	Shear
Housing Material	Titanium	Titanium	Titanium	Titanium
Size (Hex x Height)	0.28 in x 0.33 in 7.1 mm x 8.4 mm	0.23 in x .65 in x 0.38 in 5.8 mm x 16.4 mm x 9.6 mm (Height x Length x Width)	5/8 in x 0.85 in 5/8 in x 21.6 mm	5/8 in x 1.16 in 5/8 in x 29.3 mm
Weight	0.071 oz 2.0 gm	0.08 oz 2.3 gm	0.73 oz 21 gm	0.73 oz 21 gm
Electrical Connector	5-44 Coaxial	5-44 Coaxial	10-32 Coaxial Jack	10-32 Coaxial Jack
Electrical Connector Position	Side	Side	Side	Top
Mounting Thread	5-40 Male	Through Hole	10-32 Female	10-32 Female





High Temperature Charge Mode Accelerometers

Because of its temperature and high/complex vibration environment, the turbine engine measurement environment is perhaps the most demanding application for accelerometers. With 30 years of high temperature measurement experience, PCB® has developed a range of piezoelectric materials and technologies that provide accurate, reliable measurements in this challenging environment. With the cost (and non-repeatability) of each turbine engine test, PCB's customers have come to expect and rely on this accuracy and reliability of our sensors.



High Temperature Charge Mode Accelerometers

					
Model Number	356A70	356A71	357B69	357B61	357D90
Performance					
Sensitivity(± 30 %)	2.7 pC/g 0.28 pC/(m/s²)	10 pC/g 1.02 pC/(m/s²)	3.5 pC/g (± 10 %) 0.357 pC/(m/s²)	10 pC/g 1.02 pC/(m/s²)	5 pC/g (± 10 %) 0.51 pC/(m/s²)
Measurement Range	± 500 g pk ± 4905 m/s² pk	± 500 g pk ± 4905 m/s² pk	± 500 g pk ± 4905 m/s² pk	± 1000 g pk ± 9810 m/s² pk	± 1000 g pk ± 9800 m/s² pk
Frequency Range(+5 %)	5000 kHz	5000 Hz	6000 Hz	5000 Hz	2500 Hz
Environmental					
Overload Limit (Shock)	± 5000 g pk ± 49,000 m/s² pk	± 5000 g pk ± 49,000 m/s² pk	± 3000 g pk ± 29,420 m/s² pk	± 5000 g pk ± 49,000 m/s² pk	± 2000 g pk ± 19,600 m/s² pk
Temperature Range	-95 to +490 °F -70 to +254 °C	-95 to +490 °F -70 to +254 °C	-65 to +900 °F -54 to +482 °C	-65 to +900 °F -54 to +482 °C	-67 to +1200 °F -55 to +649 °C
Electrical					
Capacitance	240 pF	690 pF	196 pF	630 pF	990 pF
Insulation Resistance (at 70° F [21° C])	>10 ¹² Ohm	>10 ¹² Ohm	>10 ⁹ Ohm	>10 ⁹ Ohm	≥ 10 ⁷ Ohm
Output Polarity	Negative	Negative	Negative	Negative	Negative
Physical					
Sensing Geometry	Shear	Shear	Compression	Compression	Shear
Housing Material	Titanium	Titanium	Inconel	Inconel	Inconel
Size (Length x Width x Height)	0.73 in x 0.90 in x 0.40 in 18.5 mm x 22.9 mm x 10.2 mm	0.96 in x 1.00 in x 0.50 in 24.4 mm x 25.4 mm x 12.7 mm	0.875 in x 0.45 in 22.2 mm x 11.4 mm (Hex x Dia)	5/8 in x 1.0 in 5/8 in x 25.4 mm (Hex x Height)	0.66 in x 1.26 in x 0.66 in 16.7 mm x 32.0 mm x 16.7 mm (Height x Length x Width)
Weight	0.28 oz 7.9 gm	0.8 oz 22.7 gm	0.56 oz 16 gm	1.1 oz 30 gm	1.8 oz 50 gm
Electrical Connector	5-44 Coaxial	10-32 Coaxial Jack	10-32 Coaxial Jack	10-32 Coaxial Jack	Integral Hardline Cable
Mounting	Through Hole	Through Hole	10-32 Female	10-32 Female	Through Hole








Cryogenic ICP® Accelerometers

PCB® offers specially designed and tested ICP® accelerometers for conducting vibration measurements under demanding conditions. Laser welded, hermetically sealed housings offer further protection from the environment. Series 351 accelerometers address cryogenic applications to - 320 °F (- 196 °C). Prior to shipment, each sensor undergoes a series of temperature cycling tests in addition to a final calibration.

Applications:

- Cryogenic Pumps
- Rocket Motors
- Refrigerant Handling

Cryogenic ICP® Accelerometers

					
Model Number	351B03	351B04	351B11	351B41	351B42
Performance					
Sensitivity (± 10 %)	10 mV/g 1.02 mV/(m/s²)	10 mV/g 1.02 mV/(m/s²)	5 mV/g 0.51 mV/(m/s²)	100 mV/g 10.2 mV/(m/s²)	100 mV/g 10.2 mV/(m/s²)
Measurement Range	± 150 g pk ± 1472 m/s² pk	± 150 g pk ± 1472 m/s² pk	± 300 g pk ± 2943 m/s² pk	± 15 g pk ± 147 m/s² pk	± 15 g pk ± 147 m/s² pk
Frequency Range (± 5 %)	1 to 6000 Hz	1 to 6000 Hz	1 to 10,000 Hz	1 to 2000 Hz	1 to 2000 Hz
Resonant Frequency	≥ 35 kHz	≥ 35 kHz	≥ 40 kHz	≥ 15 kHz	≥ 15 kHz
Broadband Resolution	0.01 g rms 0.1 m/s² rms	0.01 g rms 0.1 m/s² rms	0.01 g rms 0.1 m/s² rms	0.0005 g rms 0.005 m/s² rms	0.0005 g rms 0.005 m/s² rms
Environmental					
Overload Limit (Shock)	± 5000 g pk ± 49,050 m/s² pk	± 5000 g pk ± 49,050 m/s² pk	± 10,000 g pk ± 98,100 m/s² pk	± 1000 g pk ± 9810 m/s² pk	± 1000 g pk ± 9810 m/s² pk
Temperature Range (Operating)	-320 to +250 °F -196 to +121 °C	-320 to +250 °F -196 to +121 °C	-320 to +250 °F -196 to +121 °C	-320 to +250 °F -196 to +121 °C	-320 to +250 °F -196 to +121 °C
Electrical					
Excitation Voltage	20 to 30 VDC	20 to 30 VDC	20 to 30 VDC	20 to 30 VDC	20 to 30 VDC
Output Impedance	≤ 100 Ohm	≤ 100 Ohm	≤ 100 Ohm	≤ 100 Ohm	≤ 100 Ohm
Output Bias Voltage	3 to 10 VDC	3 to 10 VDC	3 to 10 VDC	3 to 10 VDC	3 to 10 VDC
Physical					
Weight	0.38 oz 10.5 gm	0.38 oz 10.5 gm	0.07 oz 2.0 gm	1.4 oz 40 gm	1.4 oz 40 gm
Sensing Element	Quartz	Quartz	Quartz	Quartz	Quartz
Sensing Geometry	Shear	Shear	Shear	Shear	Shear
Housing Material	Titanium	Titanium	Titanium	Titanium	Titanium
Electrical Connector	10-32 Coaxial Jack	10-32 Coaxial Jack	5-44 Coaxial Jack	10-32 Coaxial Jack	10-32 Coaxial Jack

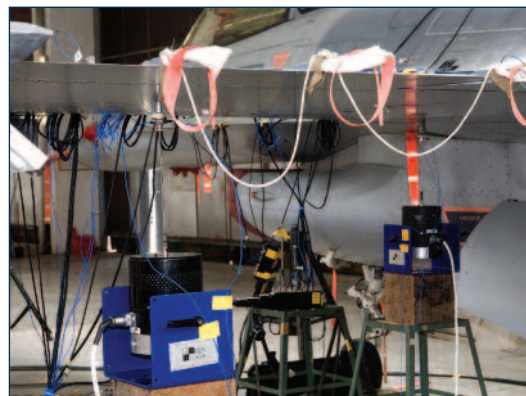


The Modal Shop, a PCB Group Company based in Cincinnati, Ohio, USA, offers a complete line of electrodynamic modal and vibration shakers ideal for applications ranging from experimental modal analysis and general vibration testing to accelerometer calibration. Shakers are also available through the TMS Rental Program in addition to accelerometers, force sensors, hammers, microphones and sound level meters. As a global leader in sound and vibration, The Modal Shop is PCB Group's focal point for a comprehensive product range of dynamic calibration systems. Visit www.modalshop.com for more information. Toll-free in USA (800)-860-4867.

Electrodynamic Exciter Family

The electrodynamic exciter family from The Modal Shop includes compact size shakers rated from 110 lbf (489 N) down to 4.5 lbf (20 N). Available designs include the revolutionary new SmartShaker™ with integrated power amplifier, a variety of mini, through-hole modal and dual purpose platform shakers, and the new SmartAmp™ power amplifiers. These shakers are ideal for applications ranging from general vibration testing of small components and sub-assemblies to experimental modal analysis.

All shakers are supplied with stingers, trunnion bases, cables and other accessories. Shaker system kits make product selection easy; configuring each shaker with an appropriate amplifier and cooling package (if required). Dual purpose platform shakers offer the best of both worlds, a through-hole armature for easy stinger setup on modal applications, as well as a table top for mounting the test articles during testing.



Electrodynamic Exciter Family

Model Number	K2004E01	K2007E01	2004E	2007E	2060E	2075E	2110E	2100E
	SmartShaker (Integrated Amplifier)		Mini Shaker		Modal Shaker	Vibration Shaker	Vibration Shaker	Modal Shaker
Max. Force pk [1]	4.5 lbf 20 N	7 lbf 31 N	4.5 lbf 20 N	7 lbf 31 N	60 lbf 267 N	75 lbf 334 N	110 lbf 489 N	100 lbf 440 N
Stroke in pk-pk	0.2	0.5	0.2	0.5	1.4	1	1	1
Weight	7 lb 3.10 kg	7 lb 3.10 kg	6 lb 2.72 kg	6 lb 2.72 kg	37 lb 17 kg	35 lb 16 kg	56 lb 25 kg	33 lb 15 kg
Max Freq	11,000 Hz	9000 Hz	11,000 Hz	9000 Hz	6000 Hz	6500 Hz	6500 kHz	5400 kHz
Note								
[1] Maximum force dependent on shaker, amplifier and cooling package								

Horizontal Table Kits

Model K2075E-HT and K2110E-HT Horizontal Tables are specially designed to support loads not suitable for direct shaker attachment. Test objects may be larger or heavier than what can be directly mounted to a particular shaker or test specifications may require test objects be oriented in a specific direction relative to gravity. In any of these situations, the Horizontal Table offers an easy to use, versatile solution. The Horizontal Table has a 6 x 7.5 inch (15 x 19 cm) platform and can operate both horizontally and vertically.

Model K2075E-HT

Horizontal Table Kits include either the 2075E or 2110E Shaker, horizontal table, shaker mounting base for horizontal or vertical testing, power amplifier, cooling package, and accessory kit.

Head Expander

Model 2000X01 Head Expander, offers the ability to expand the mounting surface of the 2075E and 2110E vibration shakers. By providing a broader mounting surface, the Head Expander allows shaker users to test objects larger than those that can be attached directly to the shaker platform. Head Expanders offer an intermediate solution for testing larger objects.

Model K2075E-HT and K2110E-HT Horizontal Table and Vibration Shaker

General Specifications

Flexure Table Weight	2.8 lbs (1.27 kg)
Shaker Armature Weight	1.0 lb (0.45 kg)
Total Moving Element Weight	3.8 lbs (1.72 kg)
Maximum Vertical/Horizontal Load Capacity	40 lbs (18 kg)
Maximum Table Mounting CG Moment	20 in lbf (2.2 N m)
Table Mounting Surface	6L x 7.5W in (15L x 19W cm)
2075E Max. Bare Table Acceleration	20 g pk (20 g pk)
2110E Max. Bare Table Acceleration	29 g pk (29 g pk)
Bare Table Resonance Frequency	3000 Hz (3000 Hz)
Maximum Useable Frequency	4500 Hz (4500 Hz)
Displacement	1.0 inch pk-pk (25.4 mm)
Table Mounting Hole Pattern	Same as shaker
2075E Complete Base + Shaker Weight	70 lbs (32 kg)
2110E Complete Base + Shaker Weight	100 lbs (45 kg)
Overall Dimensions	18.4L x 9.1H x 7.5W in (47L x 23H x 19W cm)



Force Limited Vibration Testing Systems

Easy and Accurate Measurement of the Input Force

Due to the high cost, long development times, and uniqueness of sophisticated aerospace and other high-tech equipment, it has become imperative to implement techniques that ensure the safety of such items during vibration qualification testing.

Conventional control using acceleration has been shown to cause significant over-testing that may result in damage to the unit under test (UUT). In force limited vibration testing, the total input force to the UUT is measured and controlled, thereby limiting the “quasi-static” acceleration of the center-of-gravity and ensuring the integrity of the equipment.

The PCB® Force Limited Vibration Testing System meets the requirements for limiting the reaction force between the shaker and unit under test in random vibration testing. The use of piezo-electric, 3-component force sensors facilitates easy and accurate measurement of the input force. This force relates directly, using Newton’s Second Law, $F=ma$, to the “quasi-static” acceleration of the structure’s center-of-gravity. Since design loads for aerospace equipment are often given in terms of the “quasi-static” acceleration, the use of force sensors represents an ideal measurement approach for this application.

Force sensors may also be used with low outgassing accelerometers in thermal vacuum chambers.

Highlights:






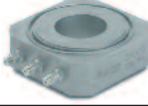
- Minimizes over-testing
- Reduces risk of damage to critical structures
- Measures summed forces
- Measures force differences (moments)
- Simplifies and expedites the test process
- Convenient and easy to implement
- ICP® & Charge Output

Applications:

- Force Limited Vibration Testing
- Cutting Tool Forces
- Force Dynamometer
- Engine Mount Analysis
- Biomechanics
- Modal Analysis

3-Component ICP® & Charge Output Quartz Force Rings

3-Component ICP® & Charge Output Quartz Force Rings

						
Model Number	260A01	260A02	260A03	260A11	260A12	260A13
Measurement Range (z axis)	± 1000 lb ± 4.45 kN	± 1000 lb ± 4.45 kN	± 10,000 lb ± 44.48 kN	± 1000 lb ± 4.45 kN	± 1000 lb ± 4.45 kN	± 10,000 lb ± 44.48 kN
Measurement Range (x or y axis)	± 500 lb ± 2.22 kN	± 1000 lb ± 4.45 kN	± 4000 lb ± 17.79 kN	± 500 lb ± 2.22 kN	± 1000 lb ± 4.45 kN	± 4000 lb ± 17.7 kN
Sensitivity (z axis)	2.5 mV/lb 0.56 mV/N	2.5 mV/lb 0.56 mV/N	0.25 mV/lb 0.06 mV/N	15 pC/lb 3.37 pC/N	15 pC/lb 3.37 pC/N	15 pC/lb 3.37 pC/N
Sensitivity (x or y axis)	10 mV/lb 2.25 mV/N	5 mV/lb 1.12 mV/N	1.25 mV/lb 0.28 mV/N	32 pC/lb 7.19 pC/N	32 pC/lb 7.19 pC/N	32 pC/lb 7.19 pC/N
Maximum Force (z axis)	1320 lb 5.87 kN	1320 lb 5.87 kN	11,000 lb 48.93 kN	1320 lb 5.87 kN	1320 lb 5.87 kN	11,000 lb 48.93 kN
Maximum Force (x or y axis)	660 lb 2.94 kN	1000 lb 4.45 kN	4400 lb 19.57 kN	660 lb 2.94 kN	1000 lb 4.45 kN	4400 lb 19.57 kN
Maximum Moment (z axis)	14 ft-lb 18.98 N-m	40 ft-lb 54.23 N-m	240 ft-lb 325.4 N-m	14 ft-lb 18.98 N-m	40 ft-lb 54.23 N-m	240 ft-lb 325.4 N-m
Maximum Moment (x or y axis)	13 ft-lb 17.63 N-m	70 ft-lb 94.91 N-m	325 ft-lb 440.7 N-m	13 ft-lb 17.63 N-m	70 ft-lb 94.91 N-m	325 ft-lb 440.7 N-m
Broadband Resolution (z axis)	0.006 lb-rms 0.027 N-rms	0.006 lb-rms 0.027 N-rms	0.05 lb-rms 0.222 N-rms	[1]	[1]	[1]
Broadband Resolution (x or y axis)	0.002 lb-rms 0.0089 N-rms	0.006 lb-rms 0.027 N-rms	0.01 lb-rms 0.04 N-rms	[1]	[1]	[1]
Note						
[1] Resolution is dependent upon cable length and charge amplifier characteristics						



3-Component ICP® & Charge Output Quartz Force Links

3-Component ICP® & Charge Output Quartz Force Links

	CE	CE	CE			
Model Number	261A01	261A02	261A03	261A11	261A12	261A13
Measurement Range (z axis)	± 1000 lb ± 4.45 kN	± 1000 lb ± 4.45 kN	± 10,000 lb ± 44.48 kN	± 1000 lb ± 4.45 kN	± 1000 lb ± 4.45 kN	± 10,000 lb ± 44.48 kN
Measurement Range (x or y axis)	± 500 lb ± 2.22 kN	± 1000 lb ± 4.45 kN	± 4000 lb ± 17.79 kN	± 500 lb ± 2.22 kN	± 1000 lb ± 4.45 kN	± 4000 lb ± 17.7 kN
Sensitivity (z axis)	2.5 mV/lb 0.56 mV/N	2.5 mV/lb 0.56 mV/N	0.25 mV/lb 0.06 mV/N	15 pC/lb 3.37 pC/N	15 pC/lb 3.37 pC/N	15 pC/lb 3.37 pC/N
Sensitivity (x or y axis)	10 mV/lb 2.25 mV/N	5 mV/lb 1.12 mV/N	1.25 mV/lb 0.28 mV/N	32 pC/lb 7.19 pC/N	32 pC/lb 7.19 pC/N	32 pC/lb 7.19 pC/N
Maximum Force (z axis)	1320 lb 5.87 kN	1320 lb 5.87 kN	11,000 lb 48.93 kN	1320 lb 5.87 kN	1320 lb 5.87 kN	11,000 lb 48.93 kN
Maximum Force (x or y axis)	660 lb 2.94 kN	1000 lb 4.45 kN	4400 lb 19.57 kN	660 lb 2.94 kN	1000 lb 4.45 kN	4400 lb 19.57 kN
Maximum Moment (z axis)	14 ft-lb 18.98 N-m	40 ft-lb 54.23 N-m	240 ft-lb 325.4 N-m	14 ft-lb 18.98 N-m	40 ft-lb 54.23 N-m	240 ft-lb 325.4 N-m
Maximum Moment (x or y axis)	13 ft-lb 17.63 N-m	70 ft-lb 94.91 N-m	325 ft-lb 440.7 N-m	13 ft-lb 17.63 N-m	70 ft-lb 94.91 N-m	325 ft-lb 440.7 N-m
Broadband Resolution (z axis)	0.006 lb-rms 0.027 N-rms	0.006 lb-rms 0.027 N-rms	0.05 lb-rms 0.222 N-rms	[1]	[1]	[1]
Broadband Resolution (x or y axis)	0.002 lb-rms 0.0089 N-rms	0.006 lb-rms 0.027 N-rms	0.01 lb-rms 0.04 N-rms	[1]	[1]	[1]
Note						
[1] Resolution is dependent upon cable length and charge amplifier characteristics						

Signal Conditioning System Component Specifications

Model 443B102 Dual-Mode Amplifier Module		Model 070M69 Computational Signal Conditioner	
Channels	1	Input	8-Channels of ICP® sensor or voltage signals
Display (Menu Driven)	Backlit 2 × 16 character LCD	Computational Function	[(A-B) + (C-D) + (E-F) + (G-H)] × Gain
Voltage Gain (ICP® Sensor Mode)	×0.1 to ×1000 (4-digit resolution)	Excitation Voltage (for ICP® Sensors)	24 VDC
Charge Gain (Charge Mode)	0.1 to 10 000 mV/pC (4-digit resolution)	Excitation Current (Selectable)	0, 2, 4, 8, 12, 20 mA
Discharge Time Constant	0.18, 1.8, 10, 100, 1000, > 100k sec	Differenced Output	4-Channels: (A-B), (C-D), (E-F), (G-H)
Drift [1]	< 0.03 pC/sec	Function Output	1-Channel
Broadband Noise (ICP® Sensor Mode) [2] (2 Hz to 22.4 kHz)	< 3 μV (< -110.5 dB)	Gain	×0.1, ×1, ×10
Broadband Noise (Charge Mode) [3] (2 Hz to 22.4 kHz)	< 5 fC (< 0.005 pC)	Model 070M90 12-Channel Summing Amplifier	
Low Frequency Response (-10%)	2, 0.2, 0.03, 0.003, 0.0003 ~0 Hz	Input	12-Channels of ICP® signals
High Frequency Response (-10%)	0.1, 1, 3, 10, 100, >200 kHz	Excitation Voltage (for ICP® Sensors)	24 VDC
Model 070A15 Summing Block		Excitation Current	2 to 20 mA adjustable
Input	4-Channels of Charge Input	Output	1-Channel
Output	1-Channel of Summed Charge Output	Gain	×0.1, ×1, ×10
Model 070M70 Charge Summation Node Module		Notes:	
Input	8-Channels of charge mode sensor signals	[1] Long discharge time constant mode.	
Summed Output (Charge Mode)	1-Channel (A + B + C + D + E + F + G + H)	[2] Measured at gain of 1000 (60 dB), input referred.	
		[3] Measured at gain of 10 V/pC (80 dB) with a 1 nF source capacitance, input referred.	



Combined System



Model 443B102
Dual-Mode Amplifier Module



Model 070A15
Summing Block for
Charge Mode Sensors



Model 070M70
Charge Summation
Node Module



Model 070M69
Computational Signal
Conditioner



Model 070M90
Summing Amplifier
for ICP® Sensors



Extreme Environment ICP® & Charge Output Pressure Sensors

Water Cooled, Helium Bleed Pressure Sensors

Series 123 rocket motor sensors are designed for measuring dynamic combustion instability pressures in intense heat flow associated with high temperature rocket motor environments. The sensors are suited for long duration measurements in environments where a severe and rapid temperature increase in the sensor mounting location or high soaking temperature after rocket motor shut down exists.

Sensors incorporate helium bleed, water cooling construction. The helium bleed design involves enveloping the case and diaphragm of a miniature quartz sensor with a cool flow of helium gas. The gas cools the sensor and insulates the unit from hot combustion gases, while cleaning and improving the frequency response of the connecting passage. Available in ICP® and charge designs, a ceramic-coated end piece protects the sensor from the intense flow and combustion gasses.

Highlights:

- Ability to withstand intense heat at sensor tip [1]
- Sensor diaphragm enveloped in cool, helium gas
- Water cooling adaptor for greater thermal stability
- Integral acceleration compensation to reduce unwanted vibration sensitivity
- Helium flow increases frequency response of the short connecting passage
- Ceramic coated diaphragm for thermal protection

Applications

- Combustion Dynamics
- Instabilities
- Pulsations



Water Cooled, Helium Bleed Pressure Sensors

Model Number	123A	123A21	123A22	123A23	123A24
Performance	CE		CE	CE	CE
Sensitivity (± 15 %)	1.0 pC/psi 0.145 mV/kPa	20 mV/psi 2.90 mV/kPa	1.0 mV/psi 0.145 mV/kPa	0.5 mV/psi 0.07 mV/kPa	5.0 mV/psi 0.725 mV/kPa
Measurement Range	3 kpsi 20,685 kPa	250 psi 1724 kPa (for ±5V output)	3 kpsi 20,685 kPa (for ± 3V output)	10 kpsi 68,950 kPa	1 kpsi 6895, kPa (for ±5V output)
Maximum Pressure	5 kpsi 34,475 kPa	5 kpsi 34,475 kPa	5 kpsi 34,475 kPa	20 kpsi 137,900 kPa	5 kpsi 34,475 kPa
Environmental					
Acceleration Sensitivity	≤ 0.002 psi/g ≤ 0.0014 kPa/(m/s²)	≤ 0.002 psi/g ≤ 0.0014 kPa/(m/s²)	≤ 0.002 psi/g ≤ 0.0014 kPa/(m/s²)	≤ 0.002 psi/g ≤ 0.0014 kPa/(m/s²)	≤ 0.002 psi/g ≤ 0.0014 kPa/(m/s²)
Temperature Range (Operating) [1]	-450 to +500 °F -73 to +121 °C	-100 to +250 °F -73 to +121 °C	-100 to +250 °F -73 to +121 °C	-100 to +250 °F -73 to +121 °C	-100 to +250 °F -73 to +121 °C
Maximum Shock	10,000 g pk 98,070 m/s² pk	10,000 g pk 98,070 m/s² pk	10,000 g pk 98,070 m/s² pk	10,000 g pk 98,070 m/s² pk	10,000 g pk 98,070 m/s² pk
Electrical					
Output Polarity (Positive Pressure)	Negative	Positive	Positive	Positive	Positive
Physical					
Housing Material	17-4 Stainless Steel	17-4 Stainless Steel	17-4 Stainless Steel	17-4 Stainless Steel	17-4 Stainless Steel
Diaphragm	Invar	Invar	Invar	Invar	Invar
Electrical Connector	Integral Cable	Integral Cable	Integral Cable	Integral Cable	Integral Cable
Cable Length	4 ft 1.2 m	4 ft 1.2 m	4 ft 1.2 m	4 ft 1.2 m	4 ft 1.2 m
Weight	4.23 oz 120 gm	4.23 oz 120 gm	4.23 oz 120 gm	4.23 oz 120 gm	4.23 oz 120 gm

Note

[1] When maintained with water cooling flow and helium bleed per factory specification.



PCB® High Temperature Charge Output Sensors

PCB® High Temperature quartz dynamic pressure sensors are designed for operation at the highest temperatures. They are structured with quartz crystals and operate, without cooling, up to +750 °F (+399 °C) on compressors and pumps. Special mounting adaptors can be supplied to fit existing mounting holes. Water cooled adaptors are available to provide a lower temperature thermally stable environment that allow sensors to operate in applications above their normal operating range.

Hard-line cables are recommended for operating temperatures above +500 °F (+260 °C). The cable can be welded to the sensor for operation in pressurized environments. All of these features ensure reliable operation in high temperature environments.



PCB® Cryogenic ICP® Pressure Sensors

PCB® Cryogenic quartz dynamic pressure sensors are a high resolution ICP® pressure sensor design, specially made for cryogenic environments. They consistently follow dynamic events found in cryogenic turbo pumps for liquid fuel handling systems or biomedical research.

Highlights:

- Laser welded, hermetically sealed quartz sensing elements
- Fused ceramic insulation connectors
- Internal acceleration compensation minimizes vibration sensitivity
- Calibration supplied at room temperature with thermal coefficients up to +750 °F (+399 °C)

Highlights:

- Fast rise time of $\leq 2 \mu\text{sec}$ from quartz element, with high resonant frequency $\geq 250 \text{ kHz}$
- Welded, hermetically sealed, stainless steel construction
- Electrically ground isolated, which helps prevent ground loop challenges
- Calibration supplied at room temperature with thermal coefficients down to -320 °F (-196 °C)



Model 064B01





Product Type: Accessory, Thread Adaptor

Water-cooled adaptor, sensor recess mount, 1/2-20 External thd, 1.0" hex (for Model 112A05)

Model 064B06

Product Type: Accessory, Thread Adaptor

Water-cooled adaptor, sensor recess mount, M20 x 1.5 External thd, 1.25" hex (for Model 116B) Other versions are available

	High Temperature			Cryogenic	
					
Model Number	112A05	116B	176M03	102A10	102A14
Performance					
Sensitivity ($\pm 15\%$)	1.1 pC/psi 0.160 pC/kPa (-10 to +25 %)	6 pC/psi 0.870 pC/kPa	17 pC/psi 2.47 pC/kPa ($\pm 20\%$)	50 mV/psi 7.25 mV/kPa	1.0 mV/psi 0.145 mV/kPa
Measurement Range	5,000 psi 34,475 kPa	100 psi 690 kPa	20 psi 137.9 kPa	100 psi 690 kPa	5,000 psi 34,475 kPa
Maximum Pressure (static)	10,000 psi 68,950 kPa	3,000 psi 20,685 kPa	400 psi 2758 kPa	15,000 psi 103,425 kPa	15,000 psi 103,425 kPa
Resonant Frequency	$\geq 200 \text{ kHz}$	$\geq 55 \text{ kHz}$	$>50 \text{ kHz}$	$\geq 250 \text{ kHz}$	$\geq 250 \text{ kHz}$
Environmental					
Acceleration Sensitivity	$\leq 0.003 \text{ psi/g}$ $\leq 0.0021 \text{ kPa/(m/s}^2\text{)}$	$\leq .002 \text{ psi/g}$ $\leq 0.014 \text{ kPa/(m/s}^2\text{)}$	$\leq 0.01 \text{ psi/g}$ $\leq 0.007 \text{ kPa/(m/s}^2\text{)}$	$\leq 0.002 \text{ psi/g}$ $\leq 0.0014 \text{ kPa/(m/s}^2\text{)}$	$\leq 0.002 \text{ psi/g}$ $\leq 0.0014 \text{ kPa/(m/s}^2\text{)}$
Temperature Range (Operating)	-400 to +600 °F -240 to +316 °C	-400 to 650 °F -240 to 345 °C	986 °F 530 °C	-320 to +212 °F -196 to +100 °C	-320 to +212 °F -196 to +100 °C
Physical					
Housing Material	17-4 Stainless Steel	316L Stainless Steel	Inconel	Stainless Steel	Stainless Steel
Electrical Connector	10-32 Coaxial Jack	10-32 Coaxial Jack	2-Pin	10-32 Coaxial Jack	10-32 Coaxial Jack
Weight	0.212 oz 6.0 gm	0.717 oz 20.3 gm	4.9 oz 140 gm	0.388 oz 11.00 gm	0.388 oz 11.00 gm



Underwater Sensors

Noise source detection and identification methods are used to determine the acoustic stealth of underwater vessels. All of a vessel's noise sources must be measured and identified, including on-board equipment, cavitation of the propulsion system, personnel and other sources of radiated noise.

PCB® has extensive experience with underwater noise, vibration and pressure measurements. Our experience with underwater testing can be used in specific applications for measuring and identifying noise sources, such as:





- Interior and exterior noise identification
- Noise and vibration monitoring
- Noise level assessment of vessels
- Acoustic pressure sensor arrays

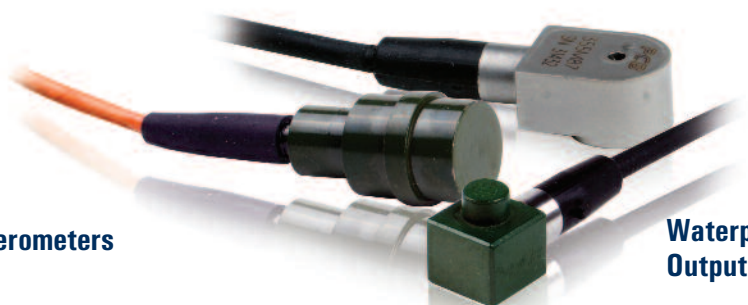
High Intensity Acoustic ICP® Pressure Sensors

Highlights:

- Waterproof, pressure tested cables can be over-molded directly to the sensor
- ICP® voltage output or constant voltage line driver (CVLD) current output operates through long cables with low noise
- Electrical case isolation for the lowest possible noise
- Corrosion resistant construction





Underwater High Intensity Acoustic ICP® Pressure Sensors

				
Model Number	103B01	106B	112A22	113B28
Performance				
Measurement Range(± 5 V output)	3.33 psi 181 dB	8.3 psi 57.2 kPa (for ±2.5V output)	50 psi 345 kPa	50 psi 345 kPa
Sensitivity(± 15 %)	1500 mV/psi 217.5 mV/kPa	300 mV/psi 43.5 mV/kPa	100 mV/psi 14.5 mV/kPa	100 mV/psi 14.5 mV/kPa
Maximum Pressure	250 psi 1725 kPa	200 psi 1379 kPa	500 psi 3450 kPa	1,000 psi 690 kPa
Resonant Frequency	≥ 13 kHz	≥ 60 kHz	≥ 250 kHz	≥ 500 kHz
Rise Time	≤ 25 µ sec	≤ 9 µ sec	≤ 2.0 µ sec	≤ 1.0 µ sec
Low Frequency Response(-5 %)	5 Hz	0.5 Hz	0.5 Hz	0.5 Hz
Environmental				
Acceleration Sensitivity	≤ 0.0005 psi/g ≤ 0.0035 psi/(m/s²)	≤ 0.002 psi/g ≤ 0.0014 psi/(m/s²)	≤ 0.002 psi/g ≤ 0.0014 psi/(m/s²)	≤ 0.002 psi/g ≤ 0.0014 psi/(m/s²)
Temperature Range (Operating)	-100 to 250 °F -73 to +121°C	-65 to +250 °F -54 to +121°C	-100 to +275 °F -73 to +135°C	-100 to +275 °F -73 to +135°C
Maximum Shock	1000 g pk	2000 g pk	20,000 g pk	20,000 g pk
Electrical				
Output Polarity (Positive Pressure)	Positive	Positive	Positive	Positive
Excitation Voltage	20 to 30 VDC	12 to 30 VDC	22 to 30 VDC	22 to 30 VDC
Output Impedance	≤ 100 Ohm	≤ 100 Ohm	< 100 Ohm	< 100 Ohm
Physical				
Sensing Element	Ceramic	Quartz	Quartz	Quartz
Diaphragm	316L Stainless Steel	316L Stainless Steel	Invar	Invar
Electrical Connector	Integral Cable	10-32 Coaxial Jack	10-32 Coaxial Jack	10-32 Coaxial Jack
Weight	0.115 oz 3.260 gm	0.63 oz 18.0 gm	0.21 oz 6.0 gm	0.16 oz 4.5 gm



ICP® Accelerometers

Waterproofing and Alternate Electrical Output Options Are Available

Underwater ICP® Accelerometers				
				
	For Dry Areas		For Wet Areas	
Model Number	355B02	355B03	625B11	629A11
Performance				
Sensitivity(± 10 %)	10 mV/g 1.02 mV/(m/s²)	100 mV/g 10.19 mV/(m/s²)	100 mV/g 10.19 mV/(m/s²) (± 5 %)	100 mV/g 10.19 mV/(m/s²) (± 5 %)
Measurement Range	± 500 g pk ±4900 m/s² pk	± 50 g pk ±490 m/s² pk	± 50 g pk ±490 m/s² pk	± 50 g pk ±490 m/s² pk
Frequency Range(± 5 %)	1 to 10,000 Hz	1 to 10,000 Hz	0.5 to 5000 Hz	0.8 to 8000 Hz
Resonant Frequency	≥ 35 kHz	≥ 35 kHz	25 kHz	20 kHz
Environmental				
Overload Limit	± 5000 g pk	± 5000 g pk	5000 g pk	5000 g pk
Temperature Range	-65 to +250 °F -54 to +121 °F	-65 to +250 °F -54 to +121 °F	-65 to +250 °F -54 to +121 °F	-65 to +250 °F -54 to +121 °F
Electrical				
Excitation Voltage	22 to 30 VDC	18 to 30 VDC	18 to 28 VDC	18 to 28 VDC
Output Impedance	≤ 100 Ohm	≤ 200 Ohm	< 100 Ohm	< 100 Ohm
Output Bias Voltage	7 to 15 VDC	7 to 13 VDC	8 to 12 VDC	8 to 12 VDC
Physical				
Size (Height x Length x Width)	0.40 in x 0.95 in x 0.63 in 10.2 mm x 24.1 mm x 16.0 mm	0.40 in x 0.95 in x 0.63 in 10.2 mm x 24.1 mm x 16.0 mm	1.38 in x 1.13 in 35.1 mm x 28.7 mm (Diameter x Height)	0.82 in x 1.5 in x 1.5 in 20.8 mm x 38.1 mm x 38.1 mm
Weight	0.35 oz 10 gm	0.35 oz 10 gm	4.7 oz 133 gm	4.9 oz 139 gm
Sensing Element	Ceramic	Ceramic	Ceramic	Ceramic
Housing Material	Titanium	Titanium	Stainless Steel	Stainless Steel
Mounting	Through Hole	Through Hole	Through Hole	1/4-28 Male



Highlights:

- DC to ≤ 1 msec response time
- Stainless steel wetted parts
- All welded construction with no adhesives, seals, or fluid filling
- Gage, sealed gage, absolute, or compound pressure versions

Applications:

- Iron Bird Testing
- Landing Gear Actuation Tests
- Hydraulic Pump Verification
- Pneumatic System Monitoring



Series 100A02

Recommended Indicator / Power Supply

- 4-Digit indicator with sensor power supply
- Provides 24 VDC excitation for voltage output pressure transducers or current output pressure transmitters
- High visibility, 4-digit, fully scalable, LED display
- Straight forward, menu-driven set-up
- Optional user-programmable set points with relays and LED alarm status indicators
- Optional 4-20 mA output for process recorder or PLC

Pressure Transmitters & Transducers

Manufactured with an unique thin-film process to “atomically fuse” sensitive resistive material behind a recessed diaphragm, Series 1500 Pressure Transmitters and Transducers achieve accuracy, repeatability, and stability required of today’s measurement and control requirements.

Choose gage, absolute, sealed-gage, or compound pressure ranges that span from vacuum up to 6000 psi (400 bar). Configured with a variety of threaded, cavity-style pressure ports, an assortment of electrical connectors, or submersible integral cables. Select from versions with amplified 0-5 VDC, 0-10 VDC, or loop-powered 4-20mA outputs for interface with a wide range of analyzers, readout instruments, and process controllers.



Pressure Transmitters & Transducers

			
Series Number	1501	1502	1503
Output	0 to 5 VDC FS	0 to 10 VDC FS	4-20 mA FS
Supply Voltage (Vs)	6.5 to 30 VDC	11.5 to 30 VDC	8 to 30 VDC
Pressure Ranges [1]	From 0 to 10 psi (69 kPa) FS up to 0 to 5000 psi (34,473 kPa) FS		
Accuracy [1][2]	≤ ±0.25% FS		
Response Time	≤ 1 m sec		
Burst Pressure	> 35x for ≤ 100 psi (≤ 670 kPa) > 20x for ≤ 1000 psi (≤ 6,890 kPa) > 5x for ≤ 6000 psi (≤ 41,370 kPa)		
Operating Temperature [1]	-40 to +260 °F -40 to +125 °C		
Compensated Temperature Range	-5 to +180 °F -20 to +80 °C		
Thermal Error over Compensated Range	≤ 1.5% FS		
Acceleration Sensitivity	≤ ±0.03% FS/g		
Vibration Survivability Rating	35 g peak sinusoidal (5 to 2000 Hz)		
Pressure Ports [1]	English, NPT, SI, and "M" Threads		
Materials:			
Wetted parts	17-4 PH SS		
Housing	316/316L SS		
Electrical Connection [1]	Screw Terminals (Mini-DIN), Connector or Integral Cable		
Notes			
[1] Consult your PCB Piezotronics representative for specific ordering information and options.			
[2] Accuracy is calculated as the square root of the sum of the squares of non-linearity, non-repeatability and hysteresis.			



The Modal Shop, a PCB Group Company based in Cincinnati, Ohio, USA, offers a complete line of electrodynamic modal and vibration shakers ideal for applications ranging from experimental modal analysis and general vibration testing to accelerometer calibration. Shakers are also available through the TMS Rental Program in addition to accelerometers, force sensors, hammers, microphones and sound level meters. As a global leader in sound and vibration, The Modal Shop is PCB Group's focal point for a comprehensive product range of dynamic calibration systems. Visit www.modalshop.com for more information. Toll-free in USA (800)-860-4867.

Calibration of Sensors for Environmental Test

Model 9155 Accelerometer Calibration Workstation

The Accelerometer Calibration Workstation, Model 9155, from The Modal Shop features accurate back-to-back comparison calibration of ICP® (IEPE), and charge mode piezoelectric accelerometers in accordance with ISO 16063. The 9155 system can also calibrate piezoresistive, capacitive, and velocity sensors via available options. Other configurations offer automated TEDS sensor updating, linearity checking, low frequency calibration down to 0.1 Hz, shock calibration, resonance, dynamic pressure and a host of shaker options.



Precision Calibration Grade Air-bearing Model 9155D-830

- Precision air-bearing shaker with usable frequency range of 5 Hz to 15 kHz
- Ultra-low transverse motion per ISO 16063-21 recommendations



Low Frequency Long Stroke Model 9155D-771

- Allows low frequency calibration data to 0.5 Hz
- Calibrate high sensitivity sensors to lower frequencies with industry leading usable stroke of 25 cm
- Precision air-bearing long stroke shaker



High-G Shock Calibration Model 9155D-525

- Provides calibration and linearity check from 20 g-pk to 10,000 g-pk per ISO 16062-22 (2005).
- Pneumatically actuated excited provides controlled and consistent impacts
- Compatible with standard back-to-back shock reference accelerometer

Model 9100D Portable Vibration Calibrator

Ideal for checking accelerometers, velocity transducers and proximity probes over a wide frequency and amplitude operating range, the Model 9100D Portable Vibration Calibrator from The Modal Shop is rugged throughout, with simple and elegant usability and robust internal components. In contrast to more elaborate laboratory style systems, the 9100D is a portable vibration shaker and calibrator, making it perfect for testing in the field or at a customer's site.

- Small and completely self-contained
- Amplitude up to 20 g's with frequency range of 7 Hz to 10 kHz
- Supports calibration for sensors up to 800 grams
- Battery powered with extensive life
- Ruggedized, weatherproof enclosure dramatically improves durability and portability
- Precision quartz reference accelerometer and conditioning electronics for superior control and stability
- Rugged carbon fiber composite armature flexures
- Provides NIST/PTB traceable transducer verification



PCB® Model 394C06 Handheld Shaker

The Model 394C06 Handheld Shaker from PCB Piezotronics is a small, self-contained, battery powered vibration exciter specifically designed to conveniently verify accelerometer and vibration system performance. It accepts sensors weighing up to 210 grams and delivers a controlled 1 g mechanical excitation.



Platinum Stock Product
LIFETIME WARRANTY
Delivery Now!

CE





Environmental Test



PCB Load & Torque, Inc., a wholly-owned subsidiary of PCB Piezotronics, is a manufacturer of high quality, precision load cells, torque transducers, and telemetry units. In addition to the quality products produced, PCB Load & Torque's customer support services mirror those of PCB Piezotronics. Visit www.pcbloadtorque.com for more information. Toll-free in USA (866)-684-7107.

PCB Load & Torque, Inc. Torque Sensors

Flange-shaft Rotary Transformer Torque Sensors

Aerospace hydraulic pumps and motors require an end-of-line production test for torque to ensure flight worthiness prior to installation on aircraft. These pumps are responsible for providing highly reliable hydraulic pressure required for control surface and landing gear actuation. Other common applications include landing gear retraction system torque, ball screw and gearbox torque for wing flaps and leading edge slat actuation testing, aircraft starter testing, cross-bleed system testing, and high speed fuel pump testing. For example, gearboxes and their output drives used in flap actuation or landing gear retraction must meet stringent life cycle and wear requirements. Such gearboxes have to be 100% tested end-of-line for specific load profiles to simulate realistic control surface actuation.

PCB Load & Torque, Inc. Series 4115K Rotary Torque Transducers use non-contact rotary transformer technology for sending excitation to and receiving measurement signals from a strain gage instrumented rotating shaft. Their unique flange and splined shaft design, which conforms to AND 10262 & 20002 standards, mate directly to aerospace industry standard hydraulic pumps and accessories. These units feature high torsional stiffness and low rotating inertia. Models are available with several measurement ranges and standard operating speeds up to 15,000 rpm.

To enable reliability assessment the input torque is measured as a function of speed. So, in addition to the torque output signal, optional speed sensors provide an output proportional to rotational speed. Optional K-type thermocouples monitor internal bearing temperature.

Highlights:

- Capacities from 50 to 10k in-lb FS (5.6 to 1130 Nm FS)
- 2.5 mV/V output sensitivity
- Splined shaft drive
- High signal-to-noise ratio
- High torsional stiffness



Shown with Optional Speed Sensor Installed

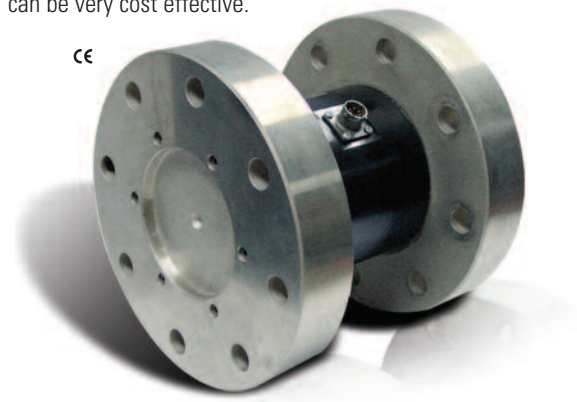
Flange-shaft Rotary Transformer Torque Sensors

Model Number	4115K-04A	4115K-06A	4115K-08A	4115K-11A	4115K-13A
Performance					
Measurement Range (Full Scale Capacity)	500 in-lb 55 Nm	1000 in-lb 115 Nm	2000 in-lb 225 Nm	5000 in-lb 565 Nm	10,000 in-lb 1,130 Nm
Sensitivity(±15%) (output at rated capacity)	2.5 mV/V	2.5 mV/V	2.5 mV/V	2.5 mV/V	2.5 mV/V
Hysteresis	≤ 0.05 % FS	≤ 0.05 % FS	≤ 0.05 % FS	≤ 0.05 % FS	≤ 0.05 % FS
Environmental					
Overload Limit	1500 in-lb 170 Nm	3000 in-lb 340 Nm	6000 in-lb 675 Nm	15,000 in-lb 1700 Nm	15,000 in-lb 1700 Nm
Temperature Range (Operating)	-65 to +285 °F -54 to 141 °C	-65 to +285 °F -54 to 141 °C	-65 to +285 °F -54 to 141 °C	-65 to 225 °F -54 to 107 °C	-65 to 225 °F -54 to 107 °C
Electrical					
Bridge Resistance	350 Ohm	350 Ohm	350 Ohm	350 Ohm	350 Ohm
Excitation Frequency	3,280 Hz	3,280 Hz	3,280 Hz	3,280 Hz	3,280 Hz
Bridge Current (at 5 VAC)	50 mA	50 mA	50 mA	50 mA	50 mA
Physical					
Size (Shaft Length x Housing Length x Housing Height)	9.56 in x 8.25 in x 6.00 in 242.82 mm x 209.55 mm x 152.40 mm	9.56 in x 8.25 in x 6.00 in 242.82 mm x 209.55 mm x 152.40 mm	9.56 in x 8.25 in x 6.00 in 242.82 mm x 209.55 mm x 152.40 mm	9.56 in x 8.25 in x 6.00 in 242.82 mm x 209.55 mm x 152.40 mm	9.56 in x 8.25 in x 6.00 in 242.82 mm x 209.55 mm x 152.40 mm
Weight	47 lb 21.3 Kg	47 lb 21.3 Kg	47 lb 21.3 Kg	47 lb 21.3 Kg	47 lb 21.3 Kg
Mounting	Flange w/ Splined Shaft	Flange w/ Splined Shaft	Flange w/ Splined Shaft	Flange w/ Splined Shaft	Flange w/ Splined Shaft
Sensing Element	Strain Gage	Strain Gage	Strain Gage	Strain Gage	Strain Gage
Shaft Material	Steel	Steel	Steel	Steel	Steel
Electrical Connector	MS3102A-14S-5P	MS3102A-14S-5P	MS3102A-14S-5P	MS3102A-14S-5P	MS3102A-14S-5P
Maximum Speed	15,000 RPM	15,000 RPM	15,000 RPM	15,000 RPM	15,000 RPM



Reaction Torque Sensors

Reaction Torque sensors are suitable for a wide array of torque measurement applications. They are typically used in torsional test machines, motor dynamometers, or in any application where rotation is limited to 360° or less. Due to the fact that these sensors do not utilize bearings, slip rings, or other rotating elements, their installation and use can be very cost effective.



Reaction Torque Sensors / Series 2300

- Conduct friction & viscosity studies
- No moving parts
- Responds to torsional loads
- Braking system test
- Capacities from 50 to 300k in-lb (5.6 to 33.9k Nm)



Signal Conditioner / Series 8120

- Provides required carrier based sensor excitation
- Recommended for use with PCB Load & Torque, Inc. Series 4100, 4115K & 4200 rotary transformer torque sensors
- AC bridge excitation
- ± 5 V analog output
- Shunt calibration
- 6 digit LED display
- Auxiliary ± 10 V & 4-20 mA outputs
- HI-LO set points
- Peak capture
- RS-232 interface



Rotary Torque Sensors

A primary challenge for Rotary Torque sensors is transferring the measurement signal from the rotating portion to the stationary portion of the sensor. Techniques are used by PCB Load & Torque, Inc. for Rotary Torque sensor signal transmission or rotary transformer, and digital telemetry. The rotary transformer is a non-contacting technique providing low maintenance and quiet operation. Digital telemetry offers noise-free operation. For installations where space is a premium, the TORKDISC®, with digital telemetry, provides higher frequency dynamic response and a shorter coupled installation.



TORKDISC® / Series 5300

- 16-bit digital telemetry style
- Compact & lightweight
- Capacities from 250 to 225k in-lb (28 to 25.4 Nm)
- Combined accuracy to 0.1% FSO
- Flange mount
- Immune to RF interference
- DC to 8500 Hz
- AC Coupled Output
- DC Coupled Output

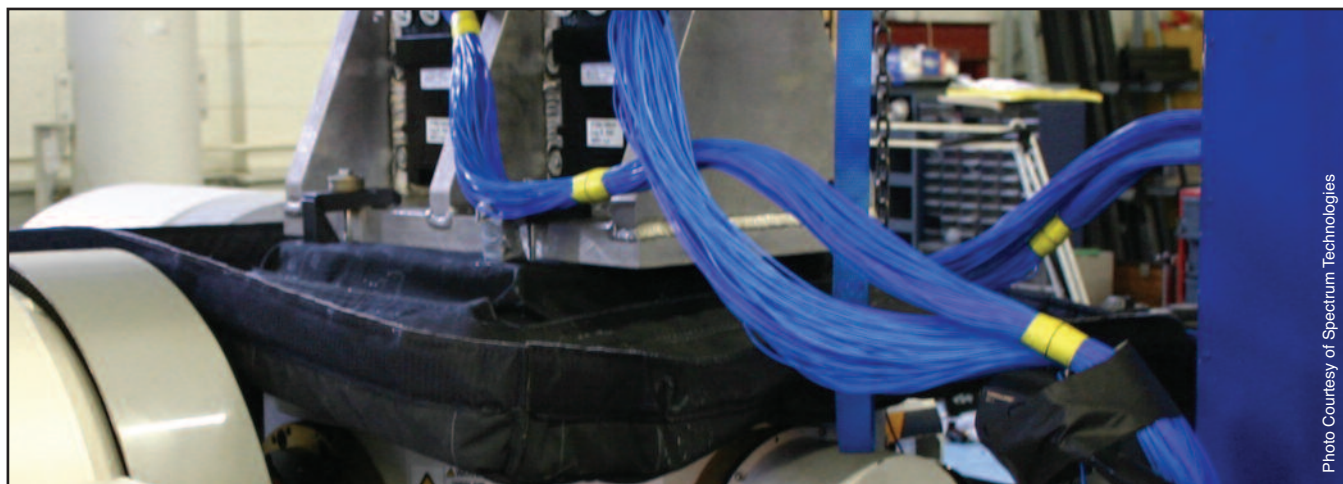


Photo Courtesy of Spectrum Technologies

Stock Cables



Coaxial Cable Specifications

Model	002	003	012	018	030
Cable Style	General Purpose	Low Noise	General Purpose	General Purpose	Low Noise
Temperature Range	-130 to +400 °F -90 to +204 °C	-320 to +500 °F -196 to +260 °C	-40 to +176 °F -40 to +80 °C	-22 to +221 °F -30 to +105 °C	-130 to +500 °F -90 to +260 °C
Impedance	50 Ohm	50 Ohm	52 Ohm	32 Ohm	50 Ohm
Capacitance	29 pF/ft 95 pF/m	30 pF/ft 98 pF/m	29 pF/ft 95 pF/m	55 pF/ft 180 pF/m	30 pF/ft 98 pF/m
Cable Jacket Material	FEP	TFE	PVC	PVC	FEP
Cable Jacket Diameter	0.075 in 1.9 mm	0.079 in 2.01 mm	0.193 in 4.9 mm	0.054 in 1.37 mm	0.042 in 1.09 mm



Series 010G



Series 034K



Series 034D

Series 036



Series 019



Series 010F

4-Conductor Cable Specifications

Model	010	034	019	036	078
Cable Style	General Purpose	Low Noise	Flexible Lightweight	Flexible	Flexible
Temperature Range	-130 to +392 °F -90 to +200 °C	-130 to +392 °F -90 to +200 °C	-76 to +500 °F -60 to +260 °C	-76 to +392 °F -60 to +200 °C	-58 to +185 °F -50 to +85 °C
Capacitance	16 pF/ft 52.4 pF/m	14 pF/ft 46 pF/m	15 pF/ft 49.2 pF/m	15 pF/ft 48 pF/m	25 pF/ft 81 pF/m
Cable Jacket Material	FEP	FEP	Silicone	Silicone	Polyurethane
Cable Jacket (Diameter)	0.1 in 2.54 mm	0.077 in 1.96 mm	0.070 in 1.77 mm	0.104 in 2.64 mm	0.119 in 3.02 mm

Industrial Cable Configurations*

* Stock Cables are not covered under the Platinum Stock Product Lifetime Warranty + Delivery Now Program.



052BR

Two-conductor shielded twisted pair cable with polyurethane jacket, molded-composite 2-socket MIL to blunt cut



052BQ

Two-conductor shielded twisted pair cable with polyurethane jacket, right-angle molded composite 2-socket MIL to blunt cut



052AE

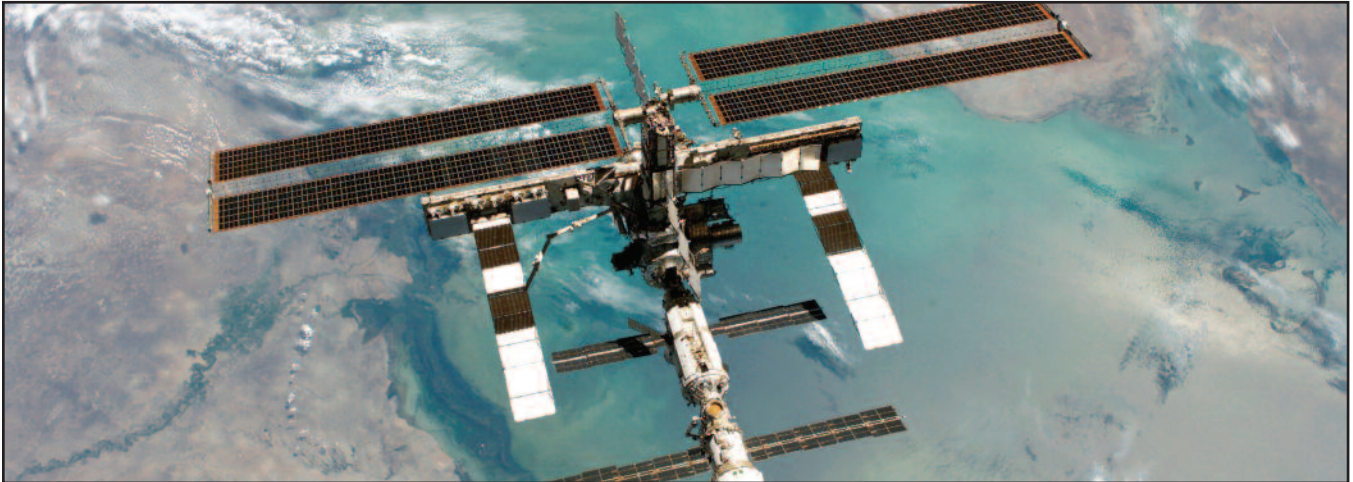
Two-conductor shielded twisted pair cable with polyurethane jacket, push-on 2-socket MIL with environmental boot to blunt cut



053BR

High temperature FEP cable, composite 2-socket MIL to blunt cut

Please contact PCB® for information on cable and connector configurations. All may be supplied at your desired length.



Low Outgassing Cables Suitable for Thermal Vacuum Chamber Exposure

Contact the factory for additional cable lengths

Cables for Single Axis Accelerometers



- 003A10**
- Connecting cable
 - Low-noise, coaxial TFE
 - 10-ft, 10-32 plug to 10-32 plug



- 003M269/010**
- Connecting cable
 - Low-noise, coaxial TFE
 - 10-ft, 10-32 plug to BNC plug



- 003M208**
- Connecting cable
 - Low-noise, coaxial TFE
 - 10-ft, 5-44 plug to 10-32 plug



- 003M252**
- Low-noise, coaxial TFE
 - 2-meter, 2-socket MS3106 to BNC plug
 - For 2-pin MIL connectors



- 003M204**
- Low-noise, coaxial TFE
 - 5-ft, 2-socket MS3106 to pigtails
 - For 2-pin MIL connectors



- 030A10**
- Connecting cable
 - Low-noise, coaxial FEP
 - 10-ft, 3-56 plug to 10-32 plug



- 030B10**
- Connecting cable
 - Low-noise, coaxial FEP
 - 10-ft, M3 plug to 10-32 jack



- 030EK010PH**
- Connecting cable
 - Low-noise, coaxial FEP
 - 10-ft, 3-56 plug to 10-32 jack

Cables for Triaxial Accelerometers



- 034M22**
- Sensor connecting cable
 - 4-conductor shielded, FEP
 - 20-ft, 4-pin 1/4-28 plug to (3) BNC plugs



- 034M51**
- Extension cable
 - 4-conductor shielded, FEP
 - 40 ft, 4-pin 1/4-28 plug to 4-pin 1/4-28 plug



- 034M28/020**
- Sensor connecting cable
 - 4-conductor shielded, FEP
 - 20-ft, 4 pin 1/4-28 plug to (3) 10-32 plugs

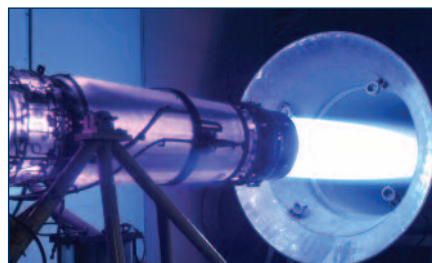
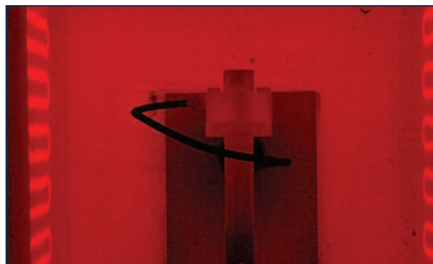


- 034M21**
- Sensor connecting cable
 - 4-conductor shielded, FEP
 - 20-ft, mini 4-pin 3-36 plug to (3) BNC plugs



- 010M128/040**
- Extension cable
 - 4-conductor shielded, FEP
 - 40-ft, 4-pin 1/4-28 plug to 4-pin 1/4-28 jack





Please see these PCB Piezotronics catalogs for your other Aerospace & Defense applications:

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