



# SENSORS FOR ENVIRONMENTAL TESTING

# ENVIRONMENTAL TEST

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## 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.

Founded in 1947, Endevco is one of the most trusted brands in test and measurement sensors. It was acquired by PCB in 2019. Combining Endevco's world class innovation with PCB's world class Total Customer Satisfaction (TCS) enables us to provide products and service that are unmatched in the sensor market.

## QUALITY SYSTEM CERTIFICATIONS

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

AS9100:2016 QMS Certified by DQS, Inc.:  
Requirements for Aviation, Space and Defense

ISO 9001:2015 QMS Certified by DQS, Inc.: 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). 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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# HALT/HASS ICP<sup>®</sup> TEST ACCELEROMETERS

Environmental Stress Screening (ESS) is 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:

Highly Accelerated Life Testing (HALT) is a design verification process, which exposes a product to very rapid and extreme changes in vibration in temperature in an effort to quickly uncover design and assembly flaws.

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.

CE



## ESS GENERAL PURPOSE QUARTZ SHEAR ICP<sup>®</sup> ACCELEROMETER

PCB MODEL 320C18

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 1 - 10k Hz

CE



## ESS GENERAL PURPOSE QUARTZ SHEAR ICP<sup>®</sup> ACCELEROMETER

PCB MODEL 320C03

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 1 - 6k Hz

CE



## ESS GENERAL PURPOSE QUARTZ SHEAR ICP<sup>®</sup> ACCELEROMETER

PCB MODEL 320C04

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 1 - 6k Hz

CE



## ESS GENERAL PURPOSE QUARTZ SHEAR ICP<sup>®</sup> ACCELEROMETER

PCB MODEL 320C15

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 1 - 10k Hz

CE



## ESS HIGH SENSITIVITY QUARTZ SHEAR ICP<sup>®</sup> ACCELEROMETER

PCB MODEL 320C20

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 2 - 5k Hz

CE



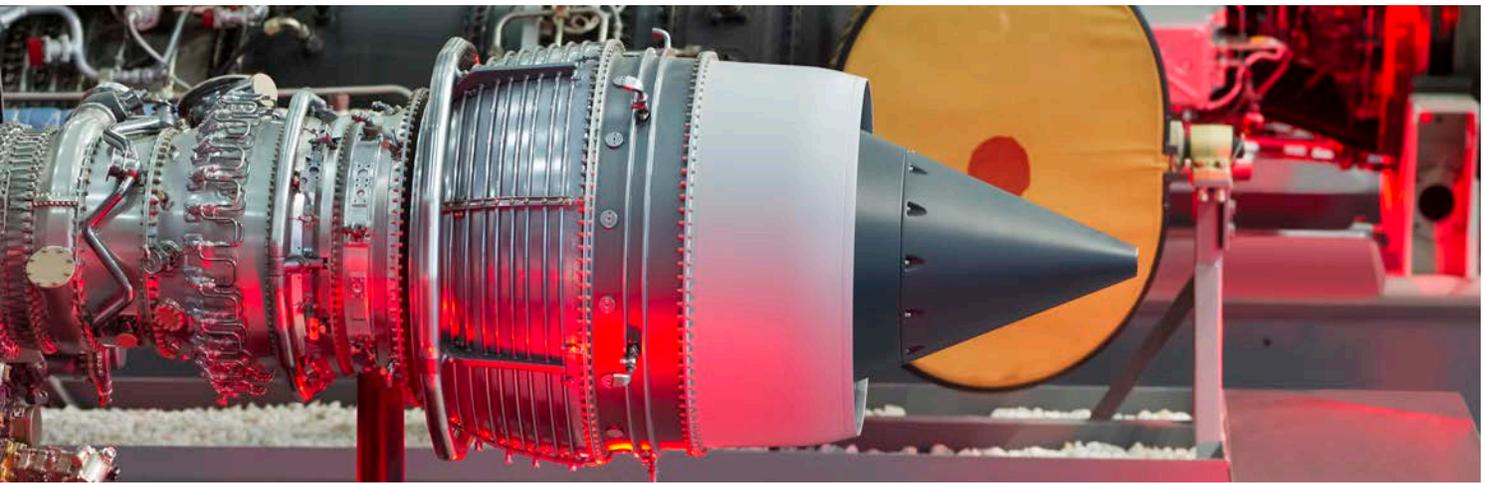
## ESS HIGH SENSITIVITY QUARTZ SHEAR ICP<sup>®</sup> ACCELEROMETER

PCB MODEL 320C33

Sensitivity: 100 mV/g

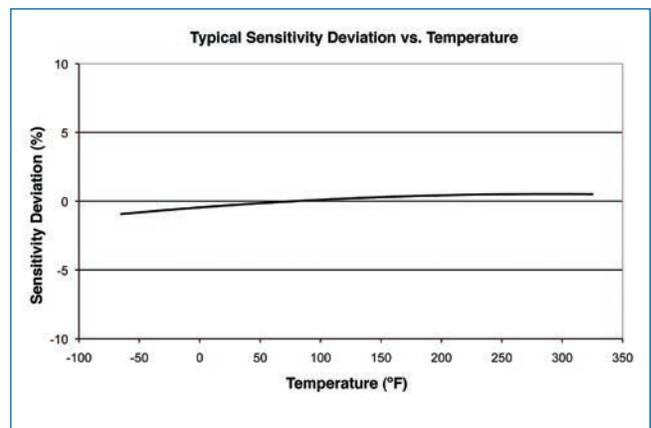
Measurement Range:  $\pm 50$  g pk

Frequency Range ( $\pm 5\%$ ): 1 - 4k Hz



## HIGH TEMPERATURE ICP® ACCELEROMETERS

PCB® single axis and triaxial ICP® accelerometers are designed with a temperature coefficient as low as 0.005% / °F (0.009% / °C), 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.



CE



**UHT-12™ MINIATURE ICP®  
ACCELEROMETER**

PCB MODEL 320C52

Sensitivity: 10 mV/g

Measurement Range: ±500 g pk

Frequency Range: (±5%) 1 - 10k Hz

CE



**UHT-12™ MINIATURE ICP®  
ACCELEROMETER**

PCB MODEL 320C53

Sensitivity: 1 mV/g

Measurement Range: ±5k g pk

Frequency Range: (±5%) 1 - 5k Hz

CE



**UHT-12™ TRIAXIAL ICP®  
ACCELEROMETER**

PCB MODEL 339A30

Sensitivity: 10 mV/g

Measurement Range: ±500 g pk

Frequency Range: (±5%) 2 - 8k Hz

CE



**UHT-12™ TRIAXIAL ICP®  
ACCELEROMETER**

PCB MODEL 339B31

Sensitivity: 10 mV/g

Measurement Range: ±500 g pk

Frequency Range: (±5%) 2 - 8k Hz

CE



**UHT-12™ LOW-PROFILE ICP®  
ACCELEROMETER**

PCB MODEL 339B32

Sensitivity: 10 mV/g

Measurement Range: ±500 g pk

Frequency Range: (±5%) 2 - 10k Hz

CE



**UHT-12™ LOW-PROFILE ICP®  
ACCELEROMETER**

PCB MODEL TLD339A34

Sensitivity: 50 mV/g

Measurement Range: ±100 g pk

Frequency Range: (±5%) 2 - 5k Hz

CE



**TRIAxIAL ICP®  
ACCELEROMETER WITH TEDS**

PCB MODEL TLD339A36

Sensitivity: 10 mV/g

Measurement Range: ±500 g pk

Frequency Range: (±5%) 2 - 5k Hz

CE



**UHT-12™ TRIAXIAL ICP®  
ACCELEROMETER WITH TEDS**

PCB MODEL TLD339A37

Sensitivity: 100 mV/g

Measurement Range: ±50 g pk

Frequency Range: (±5%) 0.3 - 4k Hz

CE



**UHT-12™ TRIAXIAL ICP®  
ACCELEROMETER**

PCB MODEL HT356B01

Sensitivity: 5 mV/g

Measurement Range: ±1k g pk

Frequency Range: (±5%) 1 - 5k Hz

# 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 regimen 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.



## CERAMIC SHEAR ICP® ACCELEROMETER

PCB MODEL 352A60

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 5 to 60k Hz



## MINIATURE LIGHTWEIGHT ICP® ACCELEROMETER

PCB MODEL 352A72

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 0.5 - 4.5k Hz



## TRIAXIAL MINIATURE ICP® ACCELEROMETER

PCB MODEL 356A63

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 2 - 4k Hz



## TRIAXIAL CERAMIC SHEAR ICP® ACCELEROMETER

PCB MODEL 356A66

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 2 - 4k Hz



## SINGLE AXIS MINIATURE ICP® ACCELEROMETER

PCB MODEL 353B77

Sensitivity: 2 mV/g

Measurement Range:  $\pm 2500$  g pk

Frequency Range: ( $\pm 5\%$ ) 1 - 10k Hz



## HIGH AMPLITUDE ICP® ACCELEROMETER

PCB MODEL 350B50

Sensitivity: 0.5 mV/g

Measurement Range:  $\pm 10k$  g pk

Frequency Range ( $\pm 1dB$ ): 3 - 10k Hz



## HIGH AMPLITUDE ICP® ACCELEROMETER

ENDEVCO MODEL 65HTLPF

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5dB$ ): 1k / 5k Hz



# HIGH AMPLITUDE ICP® SHOCK ACCELEROMETERS

Piezoelectric ICP® accelerometers afford a very high signal output (+/- 5 volts full scale) and the ease of two-wire electrical connectivity. Their inherent ruggedness enables them to be severely over ranged without damage. The addition of internal mechanical isolation minimizes the high frequency stress that is transferred to their sensing elements. This mechanical isolation, coupled with an internal 2-pole electrical filter built into the ICP® circuitry, tailors the overall accelerometer response to assure data quality to 10 kHz and up to 100k g's. Full scale linearity is verified through calibration in accordance with MIL-STD-810.





**SHOCK ICP® ACCELEROMETER**

PCB MODEL 350C23

Sensitivity: 0.5 mV/g

Measurement Range: ±10k g pk

Frequency Range (±1dB): 0.4 - 10k Hz



**SHOCK ICP® ACCELEROMETER**

PCB MODEL 350C24

Sensitivity: 1 mV/g

Measurement Range: ±5k g pk

Frequency Range (±1dB): 0.4 - 10k Hz



**SHOCK ICP® ACCELEROMETER**

PCB MODEL 350B01

Sensitivity: 0.05 mV/g

Measurement Range: ±100k g pk

Frequency Range (±1dB): 4 - 10k Hz



**SHOCK ICP® ACCELEROMETER**

PCB MODEL 350D02

Sensitivity: 0.1 mV/g

Measurement Range: ±50k g pk

Frequency Range (±1db): 4 - 10k Hz



**TRIAXIAL SHOCK ICP® ACCELEROMETER**

PCB MODEL 350B41

Sensitivity: 0.05 mV/g

Measurement Range: ±100k g pk

Frequency Range (±1dB): 0.4 - 10k Hz



**TRIAXIAL SHOCK ICP® ACCELEROMETER**

PCB MODEL 350B42

Sensitivity: 0.1 mV/g

Measurement Range: ±50k g pk

Frequency Range (±1dB): 0.4 - 10k Hz



**TRIAXIAL SHOCK ICP® ACCELEROMETER**

PCB MODEL 350B43

Sensitivity: 0.5 mV/g

Measurement Range: ±10k g pk

Frequency Range (±1dB): 0.4 - 10k Hz



**TRIAXIAL SHOCK ICP® ACCELEROMETER**

PCB MODEL 350B44

Sensitivity: 1 mV/g

Measurement Range: ±5k g pk

Frequency Range (±1dB): 0.4 - 10k Hz



## PIEZORESISTIVE ACCELEROMETERS

Piezoresistive high g shock accelerometers are available in both undamped and lightly damped models to provide high-reliability shock and vibration measurements in extreme environments. With available measurement ranges from 2k to 200k g, these accelerometers feature rugged piezoresistive MEMS sensing elements.

Our in-house MEMS manufacturing techniques allow us to offer a product with compact size, high sensitivity, and exceptional overrange, while ensuring the repeatability and reliability required for mission critical applications. Product variations include single axis or triaxial configurations and screw, stud, and surface mounting options.

### APPLICATIONS:

- Mechanical shock testing
- Shock wave monitoring
- Drop and impact testing
- Portable electronic device testing
- High-shock data recorders
- Near and far-field pyroshock testing
- Weapons and rocket testing
- Fuze/safe and arm

### HIGHLIGHTS:

- Multiple mounting configurations
- Minimal zero shift after shock
- High survivability in overrange environments
- DC response for long duration transient events
- Ranges up to 200k g
- Undamped for broad frequency response or damped for exceptional survivability
- Miniature SMT versions for embedded applications

# UNDAMPED PIEZORESISTIVE ACCELEROMETERS

The Endevco brand of undamped shock accelerometers dates back over four decades and are used on many long standing programs that require high frequency. They are used by our most experienced customers primarily engaged in research and development applications, where careful preparation of the experiment is performed and attention is given to minute instrumentation details such as sample rate, anti-aliasing filter selection and detailed post process analysis.



## HIGH RESONANCE UNDAMPED PIEZORESISTIVE ACCELEROMETER

ENDEVCO MODEL 7270A

Sensitivity: 10 / 3 / 1 / .3 / .1 uV/V/g

Measurement Range:  
±2K / ±6K / ±20K / ±60K / ±200K g

Frequency Range (+/-5%):  
10 / 20 / 50 / 100/ 150 kHz



## HIGH RESONANCE UNDAMPED PIEZORESISTIVE ACCELEROMETER

ENDEVCO MODEL 7270AM4

Sensitivity: 10 / 3 / 1 / .3 / .1 uV/V/g

Measurement Range:  
±2K / ±6K / ±20K / ±60K / ±200K g

Frequency Range (+/-5%):  
10 / 20 / 50 / 100/ 150 kHz



## RUGGED UNDAMPED PIEZORESISTIVE ACCELEROMETER

ENDEVCO MODEL 7270AM6

Sensitivity: 10 / 3 / 1 / .3 uV/V/g

Measurement Range:  
±2K / ±6K / ±20K / ±60K g

Frequency Range (+/-5%): 10 kHz



## EXTREMELY RUGGED UNDAMPED PIEZORESISTIVE ACCELEROMETER

ENDEVCO MODEL 7270AM7

Sensitivity: 10 / 3 / 1 / .3 / .1 uV/V/g

Measurement Range:  
±2K / ±6K / ±20K / ±60K / ±200K g

Frequency Range (+/-5%):  
10 / 20 / 50 / 100/ 150 kHz



## HIGH RESONANCE UNDAMPED PIEZORESISTIVE TRIAXIAL ACCELEROMETER

ENDEVCO MODEL 7274A

Sensitivity: 10 / 3 / 1 / .3 uV/V/g

Measurement Range:  
±2K / ±6K / ±20K / ±60K g

Frequency Range (+/-5%):  
18 / 36 / 70 / 140 kHz

# UNDAMPED PIEZORESISTIVE SURFACE MOUNT ACCELEROMETERS

Endevco undamped surface mount configurations allow for use in circuit board OEM applications.



## UNDAMPED PIEZORESISTIVE SURFACE MOUNT ACCELEROMETER

ENDEVCO MODEL 71M

Sensitivity: 10 / 3 / 1 / .3 uV/V/g

Measurement Range:  
±2K / ±6K / ±20K / ±60K g

Frequency Range (+/-5%):  
10 / 20 / 50 / 100 kHz



## UNDAMPED PIEZORESISTIVE SURFACE MOUNT TRIAXIAL ACCELEROMETER

ENDEVCO MODEL 75

Sensitivity: 10 / 3 / 1 / .3 uV/V/g

Measurement Range:  
±2K / ±6K / ±20K / ±60K g

Frequency Range (+/-5%):  
18 / 36 / 70 / 140kHz

# LIGHTLY DAMPED PIEZORESISTIVE SURFACE MOUNT SHOCK ACCELEROMETERS

The PCB and Endevco brands of lightly damped shock accelerometers feature over range stops for improved survivability. Damping also helps improve data recorder resolution compared to undamped versions.



## LIGHTLY DAMPED PIEZORESISTIVE SURFACE MOUNT SHOCK ACCELEROMETER

PCB MODEL 3501A20XXKG

Sensitivity: 1 / .3 uV/V/g

Measurement Range: 20K / 60K g

Frequency Range (+/-5%): 10 / 20 kHz



## LIGHTLY DAMPED PIEZORESISTIVE SURFACE MOUNT SHOCK ACCELEROMETER

ENDEVCO MODEL 72

Sensitivity: 30 / 1.6 / .6 uV/V/g

Measurement Range: 2K / 20K / 60K g

Frequency Range (+/-5%):  
10 / 10 / 20 kHz



## LIGHTLY DAMPED PIEZORESISTIVE SURFACE MOUNT SHOCK ACCELEROMETER

ENDEVCO MODEL 74

Sensitivity: 30 / 1.6 / .5 uV/V/g

Measurement Range: 2K / 20K / 60K g

Frequency Range (+/-5%):  
5 / 10 / 13 kHz

# DAMPED PIEZORESISTIVE ACCELEROMETERS

The PCB and Endevco brands of damped shock accelerometers feature over range stops for improved survivability. Damping also helps improve data recorder resolution compared to undamped versions.



## HIGH SENSITIVITY MULTI-MODE DAMPING PIEZORESISTIVE ACCELEROMETER

ENDEVCO MODEL 2262B

Sensitivity: 0.45 / 0.3 / 0.015 uV/V/g

Measurement Range:  
±1K / ±2K / ±6K g

Frequency Range (+/-5%): 3000 kHz



## LIGHTLY DAMPED STUD MOUNT PIEZORESISTIVE ACCELEROMETER

PCB MODEL 3501B12XXKG

Sensitivity: 1 / .3 uV/V/g

Measurement Range: ±20K / ±60K g

Frequency Range (+/-5%): 10/20 kHz



## EXTREMELY RUGGED LIGHTLY DAMPED PIEZORESISTIVE ACCELEROMETER

ENDEVCO MODEL 7280AM4

Sensitivity: 30 / 1.6 / .5 uV/V/g

Measurement Range:  
±2K / ±20K / ±60K g

Frequency Range (+/-5%):  
5 / 10 / 13 kHz



## LIGHTLY DAMPED THRU HOLE MOUNT PIEZORESISTIVE ACCELEROMETER

PCB MODEL 3991B12XXKG

Sensitivity: 1 / .3 uV/V/g

Measurement Range: ±20K / ±60K g

Frequency Range (+/-5%):  
10 / 20 kHz



## EXTREMELY RUGGED LIGHTLY DAMPED PIEZORESISTIVE ACCELEROMETER

ENDEVCO MODEL 7280AM7

Sensitivity: 30 / 1.6 / .5 uV/V/g

Measurement Range:  
±2K / ±20K / ±60K g

Frequency Range (+/-5%):  
5 / 10 / 13 kHz



## LOW POWER LIGHTLY DAMPED PIEZORESISTIVE ACCELEROMETER

ENDEVCO MODEL 7280A

Sensitivity: 30 / 1.6 / .5 uV/V/g

Measurement Range:  
±2K / ±20K / ±60K g

Frequency Range (+/-5%):  
5 / 10 / 13 kHz



## LIGHTLY DAMPED THRU HOLE MOUNT PIEZORESISTIVE ACCELEROMETER

PCB MODEL 3503A11XXKG

Sensitivity: 1 / .3 uV/V/g

Measurement Range: 20K / 60K g

Frequency Range (+/-5%):  
10 / 20 kHz



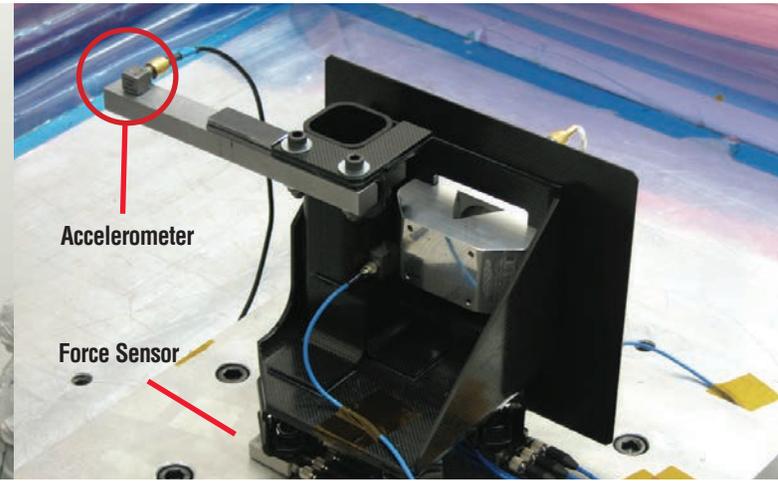
## LIGHTLY DAMPED THRU HOLE MOUNT PIEZORESISTIVE ACCELEROMETER

ENDEVCO MODEL 7284A

Sensitivity: 30 / 1.6 / .5 uV/V/g

Measurement Range:  
2K / 20K / 60K g

Frequency Range (+/-5%):  
10 / 10 / 20 kHz



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

## LOW OUTGASSING ICP® ACCELEROMETERS AND CABLES

PCB's low outgassing accelerometers and cables are standard products whose specifications are designed for use in high-vacuum applications such as satellite ground testing and in space.

### 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 CVCM (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 CVCM values, and leak testing services for low outgas verification of accelerometers.

#### Highlights:

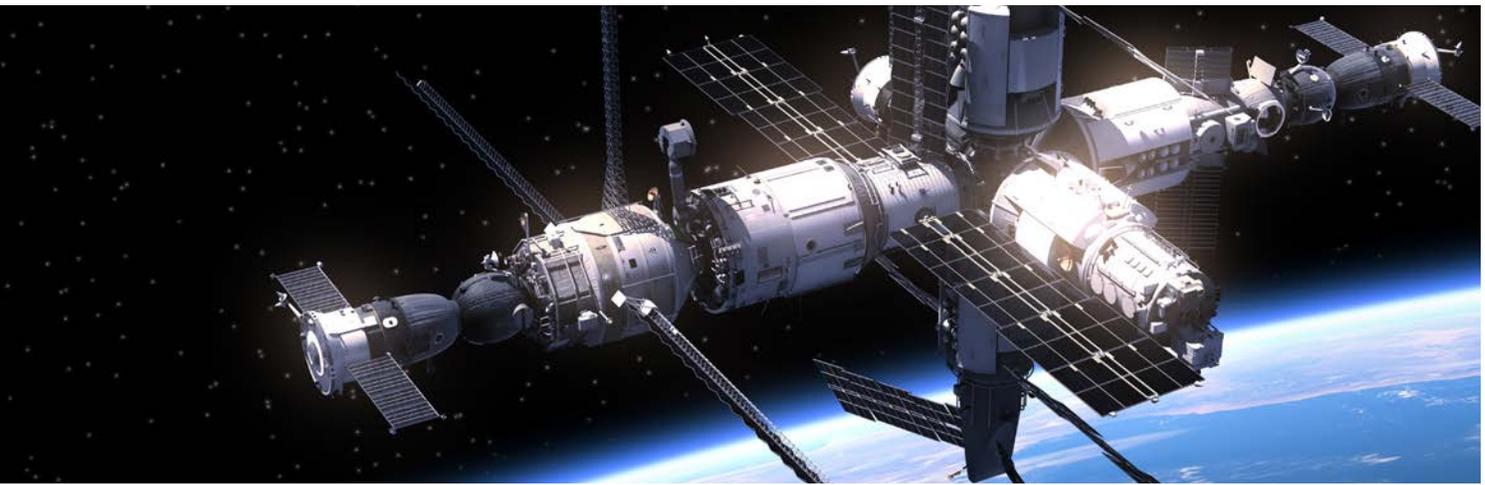
Vibration measurements in thermal vacuum or space environment

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 ACCELEROMETERS



### LOW OUTGASSING MINIATURE CHARGE OUTPUT ACCELEROMETER

PCB MODEL 357A07

Sensitivity: 1.7 pC/g

Measurement Range:  $\pm 2k$  g pk

Frequency Range ( $\pm 5\%$ ): 15k Hz



### MINIATURE CHARGE OUTPUT ACCELEROMETER WITH CABLE

PCB MODEL P357A09/030EK001PH

Sensitivity: 1.7 pC/g

Measurement Range:  
 $\pm 2k$  g pk

Frequency Range ( $\pm 5\%$ ): 10k Hz



### LOW OUTGASSING SHOCK ICP® ACCELEROMETER

PCB MODEL 350M88A

Sensitivity: 0.5 mV/g

Measurement Range:  $\pm 10k$  g pk

Frequency Range ( $\pm 1dB$ ): 0.4 - 10k Hz



### LOW OUTGASSING TEARDROP ICP® ACCELEROMETER

PCB MODEL 352M212

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 0.5 - 10k Hz



**LOW OUTGASSING  
MINIATURE ICP® TRIAXIAL  
ACCELEROMETER**

PCB MODEL 356M57

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ):

2 - 10k Hz (y or z axis)

2 - 7k Hz (x axis)



**LOW OUTGASSING MINIATURE  
LIGHTWEIGHT ICP® TRIAXIAL  
ACCELEROMETER**

PCB MODEL 356A06/NC & 356A09/NC

Sensitivity: Available in 5 mV/g  
and 10 mV/g

Measurement Range:  
 $\pm 1k$  g pk

Frequency Range ( $\pm 5\%$ ):

2 - 8k Hz (y or z axis)

2 - 5k Hz (x axis)



**LOW OUTGASSING MINIATURE  
LIGHTWEIGHT ICP® TRIAXIAL  
ACCELEROMETER**

PCB MODEL 356M208/NC & 356M239

Sensitivity: Available in 5 mV/g  
and 10 mV/g

Measurement Range:  
 $\pm 1k$  g pk

Frequency Range ( $\pm 5\%$ ):

2 - 8k Hz (y or z axis)

2 - 5k Hz (x axis)



**LOW OUTGASSING ICP®  
TRIAxIAL ACCELEROMETER  
WITH LOW MASS CABLE**

PCB MODEL 356M234

Sensitivity: 5 mV/g

Measurement Range:  $\pm 1k$  g pk

Frequency Range ( $\pm 5\%$ ):

2 - 8k Hz (y or z axis)

2 - 5k Hz (x axis)



**HIGH AMPLITUDE ICP®  
TRIAxIAL ACCELEROMETER  
WITH LOW-PASS FILTER**

PCB MODEL 350B50/XXXBZ/NC

Sensitivity: ( $\pm 30\%$ ) 0.5 mV/g

Measurement Range:  $\pm 10k$  g pk

Frequency Range ( $\pm 1$  dB): 3 to 10k Hz



**LOW OUTGASSING ICP®  
TRIAxIAL ACCELEROMETER**

PCB MODEL TLD356M131

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 2 - 3k Hz



**LOW OUTGASSING  
TITANIUM ICP® TRIAXIAL  
ACCELEROMETER**

PCB MODEL 356M98

Sensitivity: 1k mV/g

Measurement Range:  $\pm 5$  g pk

Frequency Range ( $\pm 5\%$ ): 0.5 - 3k Hz



**LOW OUTGASSING HIGH  
SENSITIVITY ICP® TRIAXIAL  
ACCELEROMETER**

PCB MODEL 356M132

Sensitivity: 500 mV/g

Measurement Range:  $\pm 10$  g pk

Frequency Range ( $\pm 5\%$ ): 0.5 - 3k Hz



**LOW OUTGASSING  
MINIATURE ICP® TRIAXIAL  
ACCELEROMETER**

PCB MODEL 354M56

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ): 2 - 8k Hz



**LOW OUTGASSING ICP®  
TRIAXIAL ACCELEROMETER  
WITH TEDS**

PCB MODEL TLD356M155

Sensitivity: 2.5 mV/g

Measurement Range:  $\pm 2k$  g pk

Frequency Range ( $\pm 5\%$ ):  
1 - 10k Hz (y or z axis)  
1 - 6k Hz (x axis)



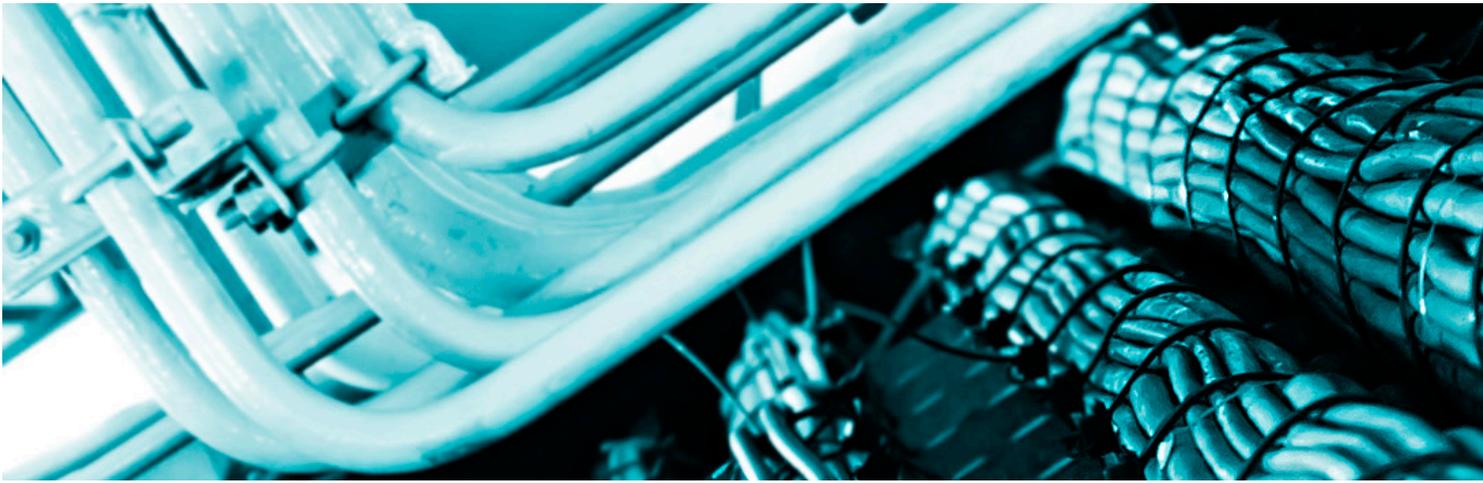
**LOW OUTGASSING ICP®  
TRIAXIAL ACCELEROMETER  
WITH TEDS**

PCB MODEL 356A19

Sensitivity: 10 mV/g

Measurement Range:  $\pm 500$  g pk

Frequency Range ( $\pm 5\%$ ):  
1 - 13k Hz (all axis)



## LOW OUTGASSING CABLES FOR SINGLE AXIS ACCELEROMETERS



PCB MODEL 002A10

Sensor connecting cable for ICP®  
General purpose, coaxial FEP  
10-ft, 10-32 plug to 10-32 plug



PCB MODEL 003A10

Sensor connecting cable  
Low-noise, coaxial TFE  
10-ft, 10-32 plug to 10-32 plug



PCB MODEL 003M208

Sensor connecting cable  
Low-noise, coaxial TFE  
10-ft, 5-44 plug to 10-32 plug



PCB MODEL 003M269/010

Connecting cable  
Low-noise, coaxial TFE  
10-ft, 10-32 plug to BNC plug



PCB MODEL 030B10

Sensor connecting cable  
Low-noise, coaxial FEP  
10-ft, M3 plug to 10-32 jack



PCB MODEL 030A10

Sensor connecting cable  
Low-noise, coaxial FEP  
10-ft, 3-56 plug to 10-32 plug



PCB MODEL 030EK010PH

Sensor connecting cable  
Low-noise, coaxial FEP  
10-ft, 3-56 plug to 10-32 jack



PCB MODEL 098EB010EB

Extension cable  
Low-noise, coaxial TFE  
10-ft, 10-32 plug to 10-32 plug



PCB MODEL 098PW010PW

Connecting cable  
Low-noise, green, coaxial, TFE cable  
with stranded conductor  
10 ft, BNC plug to BNC plug  
(both with gold plated pins)



## LOW OUTGASSING CABLES FOR TRIAXIAL ACCELEROMETERS



PCB MODEL 034M22

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



PCB MODEL 034M51

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



PCB MODEL 034M28/020

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



PCB MODEL 034M21

Sensor connecting cable  
 4-conductor shielded, FEP  
 10-ft, mini 4-pin 8-36 plug to (3) BNC plugs



PCB MODEL 010M128/040

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



PCB MODEL 068M01/020

Sensor connecting cable  
 4-conductor, 85% shield for low mass  
 20-ft, 4 pin 1/4-28 plug to blunt cut  
 Also available to (3) BNC or (3) 10-32 plugs



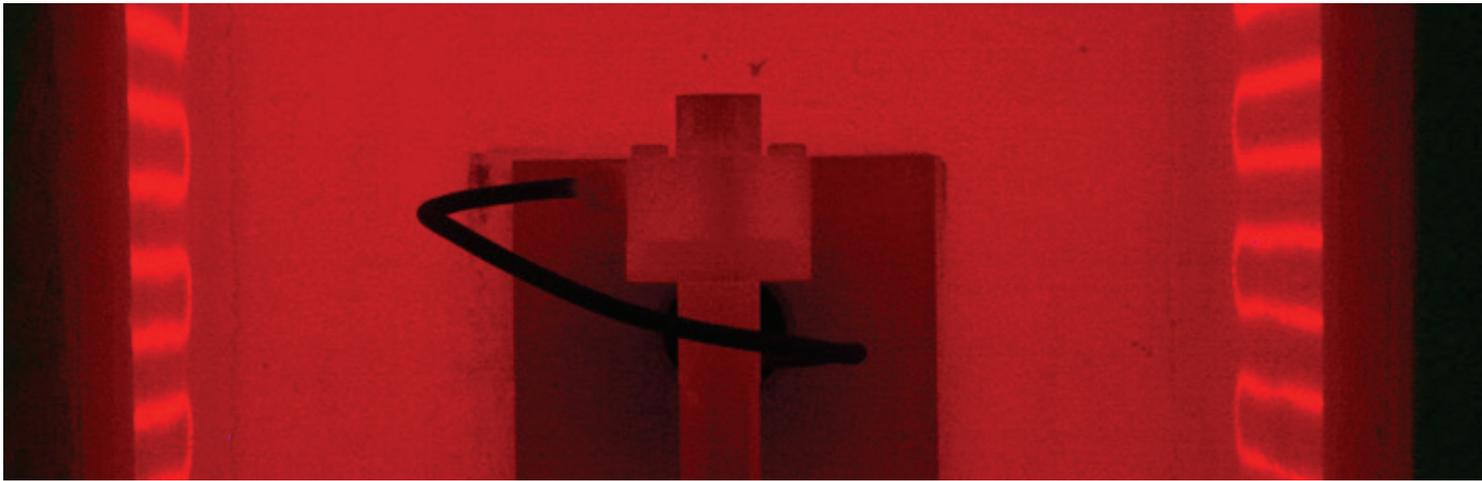
PCB MODEL 070B14

Hermetic bulkhead feed-thru adaptor  
 Low outgassing  
 10-32 jack to 10-32 jack



PCB MODEL 080M233

Hermetic bulkhead feed-thru adaptor  
 Low outgassing  
 4-pin 1/4-28 jack to 1/4-28 jack



## HIGH TEMPERATURE CHARGE MODE ACCELEROMETERS

Vibration testing of aircraft gas turbine engines, industrial turbines, rocket propulsion systems, and exhaust systems requires accelerometers that are designed to withstand very high temperature environments.

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.

UHT-12™ is a proprietary crystal designed for more accurate, lower noise measurements at elevated temperatures and trusted in the most demanding test environments. PCB® sensors made with UHT-12™ technology have an improved data quality compared to ceramic crystal designs.

The main technical advantages include:

- Absence of pyroelectric noise spikes up to 1200 °F (649 °C)

- Sensitivity that remains more consistent over a wide temperature change

- Shear mode crystals isolated from base strain & transverse measurement errors

- Proprietary crystal technology comes sealed in a hermetic package and has proven reliable performance in hundreds of gas turbine installations for research and monitoring

### Applications:

- High temperature vibration measurements

- Engine compartment studies

- Exhaust component vibration tests

- Steam turbine testing

- Engine vibration analysis



**MINIATURE TRIAXIAL  
CHARGE OUTPUT  
ACCELEROMETER**

PCB MODEL 356A70 & 356A71

Temperature: -94 to +490 °F  
(-70 to +254 °C)

Sensitivity: 2.7 to 10 pC/g

Measuring range: 1500 g

Weight: 8 grams

CE



**MINIATURE RING-STYLE  
CHARGE OUTPUT  
ACCELEROMETER**

PCB MODEL 357B06

Temperature: -65 to +500 °F  
(-54 to +260 °C)

Sensitivity: 5 pC/g

Measuring range: 500 g

Weight: 2.3 grams

CE



**HIGH TEMPERATURE  
MINIATURE CHARGE OUTPUT  
ACCELEROMETER**

PCB MODEL 357B11

Temperature: -95 to +500 °F  
(-71 to +260 °C)

Sensitivity: 3 pC/g

Measuring range: 2300 g

Weight: 2 grams



**CHARGE OUTPUT TRIAXIAL  
ACCELEROMETER  
WITH UHT-12™**

PCB MODEL EX356A73

Temperature: -67 to +900 °F  
(-55 to +482 °C)

Sensitivity: 3.2 pC/g

Measuring range: ±500 g

Weight: 150 grams

CE



**UHT-12™ HIGH TEMPERATURE  
CHARGE OUTPUT  
ACCELEROMETER**

PCB MODEL 357A63

Temperature: -65 to +900 °F  
(-54 to +482 °C)

Sensitivity: 0.53 pC/g

Measuring range: ±5000 g

Weight: 8.7 grams

CE



**HIGH TEMPERATURE  
CHARGE OUTPUT  
ACCELEROMETER**

PCB MODEL 357B69

Temperature: -65 to +900 °F  
(-54 to +482 °C)

Sensitivity: 3.5 pC/g

Measuring range: ±500 g

Weight: 16.0 grams

CE



**MINIATURE CHARGE OUTPUT ACCELEROMETER**

ENDEVCO MODEL 7240C

Temperature: -67 to +500 °F

Sensitivity: 3 pC/g

Measuring range: 5k g pk

Weight: 4.8 grams

CE



**MINIATURE CHARGE OUTPUT ACCELEROMETER**

ENDEVCO MODEL 2220E

Temperature: -67 to +500 °F

Sensitivity: 3 pC/g

Measuring range: 5k g pk

Weight: 3.1 grams

CE



**MINIATURE CHARGE OUTPUT ACCELEROMETER**

ENDEVCO MODEL 2230E

Temperature: -67 to +500 °F

Sensitivity: 2.8 pC/g

Measuring range: 2kg pk

Weight: 17 grams

CE



**CHARGE OUTPUT ACCELEROMETER**

ENDEVCO MODEL 2221F

Temperature: -67 to +500 °F

Sensitivity: 10 pC/g

Measuring range: 2k g pk

Weight: 11 grams

CE



**CHARGE OUTPUT ACCELEROMETER**

ENDEVCO MODEL 7201-10

Temperature: -67 to +500 °F

Sensitivity: 10 pC/g

Measuring range: 2k g pk

Weight: 18 grams

CE



**CHARGE OUTPUT ACCELEROMETER**

ENDEVCO MODEL 7221A

Temperature: -67 to +500 °F

Sensitivity: 10 pC/g

Measuring range: 2k g pk

Weight: 0.37 grams

CE



**CHARGE OUTPUT ACCELEROMETER**

ENDEVCO MODEL 7703A-50

Temperature: -67 to +550 °F  
(-55 to +288 °C)

Sensitivity: 300 pC/g

Measuring range: 2k g pk

Weight: 25 grams

CE



**CHARGE OUTPUT ACCELEROMETER**

ENDEVCO MODEL 7704A-50

Temperature: -67 to +550 °F  
(-55 to +288 °C)

Sensitivity: 50 pC/g

Measuring range: 2k g pk

Weight: 0.9 grams

CE



**TRIAXIAL CHARGE OUTPUT ACCELEROMETER**

ENDEVCO MODEL 2230EM1

Temperature: -67 to +500 °F

Sensitivity: 3 pC/g

Measuring range: 2k g pk

Weight: 17 grams



**900°F**  
(482 °C)

### HIGH TEMPERATURE CHARGE OUTPUT ACCELEROMETER

PCB MODEL 357B69

Sensitivity: 3 pC/g

Measurement Range:  $\pm 500$  g pk

Frequency Response (+5%): 6k Hz



**900°F**  
(482 °C)

### HIGH TEMPERATURE CHARGE OUTPUT ACCELEROMETER

PCB MODEL 357B61

Sensitivity: 10 pC/g

Measurement Range:  $\pm 1k$  g pk

Frequency Response (+5%): 5k Hz



**1200°F**  
(649 °C)

### UHT-12™ CHARGE OUTPUT ACCELEROMETER

PCB MODELS 357E90/91/92/93

357E90/91 Sensitivity: 5.0 pC/g

357E92/93 Sensitivity: 2.3 pC/g

Measurement Range:  $\pm 1k$  g pk

Frequency Response (+5%): 3k Hz



**900°F**  
(482 °C)

### UHT-12™ CHARGE OUTPUT ACCELEROMETER

PCB MODEL 357A63

Sensitivity: 0.53 pC/g

Measurement Range:  $\pm 5k$  g pk

Frequency Response (+10%): 10k Hz



**1200°F**  
(649 °C)

### UHT-12™ CHARGE OUTPUT ACCELEROMETER

PCB MODEL 357A64

Sensitivity: 0.53 pC/g

Measurement Range:  $\pm 5k$  g pk

Frequency Response (+10%): 10k Hz



**1200°F**  
(649 °C)

### UHT-12™ CHARGE OUTPUT DIFFERENTIAL ACCELEROMETER

PCB MODELS 357A94/95

Sensitivity: 3.3 pC/g

Measurement Range:  $\pm 1k$  g pk

Frequency Response (+5%): 3k Hz



## CRYOGENIC ICP® ACCELEROMETERS

Cryogenic ICP® accelerometers are specifically designed to operate at temperatures below the typical -65 °F (-54 °C) temperature limit of most voltage mode sensors. The use of specialized, built-in, cryogenic ICP® circuitry and quartz shear sensing technology provides survivability in demanding environments such as liquid nitrogen. Each sensor is hermetically sealed and individually tested to determine the thermal coefficient of sensitivity at -320 °F (-196 °C) ensuring reliable operation and accurate measurements. Choose from a variety accelerometers ranging from lightweight units for minimizing mass loading effects to high sensitivity versions for sensing low-level vibrations.



### CRYOGENIC ICP® ACCELEROMETERS

PCB MODEL 351B03/04

Sensitivity: 10 mV/g

Measurement Range: ±150 g pk

Frequency Range (±5%): 6k Hz

Available with ground isolation



### CRYOGENIC ICP® ACCELEROMETER

PCB MODEL 351B31

Sensitivity: 50 mV/g

Measurement Range: ±30 g pk

Frequency Range (±5%): 4k Hz

Available with ground isolation



### CRYOGENIC ICP® ACCELEROMETER

PCB MODEL 351B41/42

Sensitivity: 100 mV/g

Measurement Range: ±15 g pk

Frequency Range (±5%): 2k Hz

Available with ground isolation



### CRYOGENIC MINIATURE ICP® ACCELEROMETER

PCB MODEL 351B11

Sensitivity: 5 mV/g

Measurement Range: ±300 g pk

Frequency Range (±5%): 10k Hz

Available with ground isolation  
& in metric



### CRYOGENIC MINIATURE ICP® ACCELEROMETER

PCB MODEL 351B14

Sensitivity: 5 mV/g

Measurement Range: ±300 g pk

Frequency Range (±5%): 8k Hz

Available with ground isolation  
& in metric



### MINIATURE CRYOGENIC ICP® ACCELEROMETER

PCB MODEL 351A15

Sensitivity: 5.5 mV/g

Measurement Range: ±1k g pk

Frequency Range (±5%): 6.5k Hz



## CRYOGENIC CHARGE OUTPUT PIEZOELECTRIC ACCELEROMETERS

Endevco® cryogenic piezoelectric accelerometers are built specifically for measuring vibration under cryogenic conditions down to -452 °F (-269 °C). Signal outputs of these units are very stable even at extremely low temperatures. Their rugged internal construction is designed to withstand multiple cycles of thermal shock with steep temperature gradient. The accelerometers are self-generating devices that require no external power source for operation and contain no electronics. This allows them to operate below the -320 °F (-196 °C) limit of ICP accelerometers, down to -452 °F (-269 °C).

CE



### CRYOGENIC CHARGE PIEZOELECTRIC ACCELEROMETERS

ENDEVCO MODEL 7722

Sensitivity: 3.7 pC/g

Shock Limit: 2.5k g

Frequency Response ( $\pm 1$  dB Hz): 6k Hz

CE



### CRYOGENIC CHARGE PIEZOELECTRIC ACCELEROMETERS

ENDEVCO MODEL 7724

Sensitivity: 3.7 pC/g

Shock Limit: 2.5k g

Frequency Response ( $\pm 1$  dB Hz): 6k Hz

CE



### CRYOGENIC CHARGE PIEZOELECTRIC ACCELEROMETERS

ENDEVCO MODEL 2271A / 2271AM20

Sensitivity: 11.5 pC/g

Shock Limit: 10k g

Frequency Response ( $\pm 1$  dB Hz): 8k Hz

CE



### REMOTE CHARGER CONVERTERS WITH TEDS

ENDEVCO MODEL 2771C-01

Gain: .1 mV/pC

Input Type: Single-ended piezoelectric

Number of channels: 1

Configuration: In-line

CE



### REMOTE CHARGER CONVERTERS WITH TEDS

ENDEVCO MODEL 2771C-01

Gain: 1 mV/pC

Input Type: Single-ended piezoelectric

Number of channels: 1

Configuration: In-line

CE



### REMOTE CHARGER CONVERTERS WITH TEDS

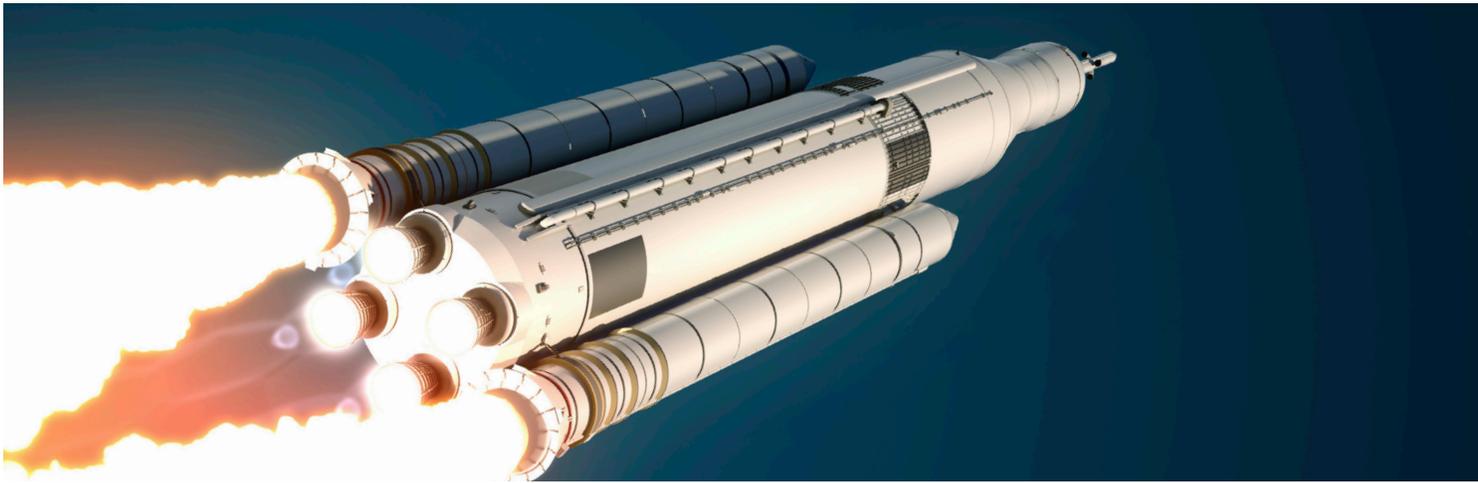
ENDEVCO MODEL 2771C-5

Gain: 5 mV/pC

Input Type: Single-ended piezoelectric

Number of channels: 1

Configuration: In-line



## EXTREME ENVIRONMENT ICP® & CHARGE OUTPUT PRESSURE SENSORS

CE



### ROCKET MOTOR ICP® PRESSURE SENSOR

PCB MODEL 123B22 / 23 / 24

Sensitivity: 1.0 / 0.5 / 5.0 mV/psi

Measurement Range:  
3k / 10k / 1k psi

Temperature Range: -100 to +250 °F  
(-73 to +121 °C)

CE



### CHARGE OUTPUT ROCKET MOTOR PRESSURE SENSOR

PCB MODEL 123B

Sensitivity: 1.1 pC/psi

Measurement Range: 3k psi

Temperature Range  
(with water cooling on):  
-450 to +500 °F (-268 to +260 °C)

CE



### ROCKET MOTOR ICP® PRESSURE SENSOR

PCB MODEL 124A24

Sensitivity: 5.0 mV/psi

Measurement Range: 1 kpsi

Temperature Range: -100 to +250 °F  
(-73 to +121 °C)



## 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 1200 °F (650 °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.

### 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 1200 °F (650 °C)

## 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:

- 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 at -320 °F (-196 °C)



### WIDE TEMPERATURE RANGE CHARGE PRESSURE SENSORS

PCB MODELS 112B05/112A06

Sensitivity: 1.1 / 2.6 pC/psi

Measurement Range: 5k psi

Temperature Range: -400 to +500 °F (-240 to +260 °C)



### WATER-COOLED ADAPTOR

PCB MODEL 064B01

1/2-20 External thread

1.0" hex (for PCB Model 112A05)

PCB MODEL 064B06

M20 x 1.5 External thread

1.25" hex (for PCB Model 112B05)



### HIGH TEMPERATURE PRESSURE SENSOR

PCB MODEL 116B

Sensitivity: 6 pC/psi

Measurement Range: 100 psi

Temperature Range: -400 to +650 °F (-240 to +345 °C)



### CRYOGENIC ICP® PRESSURE SENSOR

PCB MODEL 102B10 / 102B11

Sensitivity: 50 / 5.0 mV/psi

Measurement Range: 100 psi / 1k psi

Temperature Range: -320 to +212 °F (-196 to +100 °C)



### CRYOGENIC ICP® PRESSURE SENSOR

PCB MODEL 102B13 / 102B14

Sensitivity: 0.5 / 1 mV/psi

Measurement Range: 10k / 5k psi

Temperature Range: -320 to +212 °F (-196 to +100 °C)



### CHARGE OUTPUT PRESSURE SENSOR

PCB MODEL 176A07

Sensitivity: 7 pC/psi

Measurement Range: 725 psi

Temperature Range: -94 to +1200 °F (-70 to +650 °C)



### CHARGE DIFFERENTIAL OUTPUT PRESSURE SENSOR

PCB MODEL 176A31

Sensitivity: 6 pC/psi

Measurement Range: 3k psi

Temperature Range: -94 to +1400 °F (-70 to +760 °C)



### CHARGE SINGLE ENDED OUTPUT PRESSURE SENSOR

PCB MODEL 176A33

Sensitivity: 6 pC/psi

Measurement Range: 3k psi

Temperature Range: -94 to +1400 °F (-70 to +760 °C)



### CHARGE OUTPUT PRESSURE SENSOR

PCB MODEL 176M47

Sensitivity: 15 pC/psi

Measurement Range: 500 psi

Temperature Range: -70 to +1200 °F (-57 to 650 °C)



The Modal Shop's family of shakers includes small-sized shakers rated from 2 lbf (9 N) to 500 lbf (2224 N). Available designs include the revolutionary SmartShaker™ with integrated power amplifier, the mini inertial shaker, a variety of mini, through-hole modal, dual purpose, and platform shakers. These exciters are ideal for applications ranging from experimental modal analysis to general vibration testing of small components and sub-assemblies. The shaker systems are also available through the TMS Rental Program in addition to accelerometers, force sensors, hammers, microphones and sound level meters. Visit [www.modalshop.com](http://www.modalshop.com) for more information, or reach TMS at +1-513-351-9919 or [info@modalshop.com](mailto:info@modalshop.com).



## SHAKERS FOR MODAL TESTING

The Modal Shop's modal shakers are a proven solution in test laboratories throughout the world. With force ratings from 2 to 60 lbf (9 to 133 N), these shakers are suitable for a wide range of modal analysis applications. When performing experimental modal analysis and structural testing, the choice of excitation function and system will make the difference between a good measurement and a poor one. For many applications, an electrodynamic shaker system is the ideal choice.

The Modal Shop's modal shakers are designed to be highly portable, rugged, and easy to set up in order to facilitate the best testing results. The smallest Model 2002E Inertial Shaker is well suited for testing applications in confined locations that a stinger or modal hammer could not normally be used. The compact, all-in-one Models K2007E01 and K2004E01 SmartShakers™ with built-in power amplifier makes modal test set up quick and easy, whether a single or multiple input (SIMO or MIMO) test. The Model 2060E shaker with extended 1.4 in (36 mm) stroke is particularly useful for GVT applications enhancing input levels at low frequencies. All shaker systems are supplied complete and ready to use with appropriate amplifier, trunnion base, cables, stingers, and other accessories.



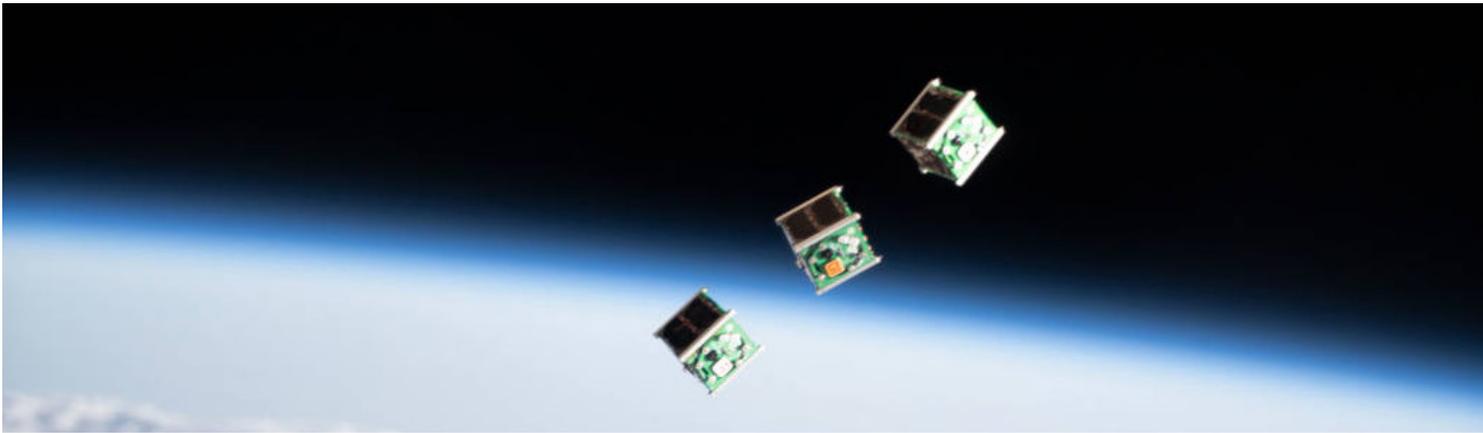
MODEL 2060E

MODEL 2025E

MODELS 2004E & 2007E

SMARTSHAKER™  
MODELS K2004E01 & K2007E01

MODEL 2002E



## CUBESAT VIBRATION TESTING WITH MODAL-POD™

Streamline your CubeSat vibration testing with The Modal Shop's Electrodynamic Shaker Model 2500E using the Modal-Pod™ Model 2000X15. The 2500E shaker is a 500 lbf pk sine force shaker with a 6 in (15.2 cm) diameter mounting platform designed for general-purpose vibration testing of small components, as well as stress screening of electronic and mechanical sub-assemblies for R&D, reliability, and quality assurance applications.

The 2000X15 Modal-Pod™ is a CubeSat test fixture specific for use with the 2500E shaker providing a standard mounting fixture to meet the standardized sizing of 1U, 2U, and 3U CubeSats. The user can quickly mount up to 3U size satellites in horizontal or vertical configurations for critical vibration qualification and acceptance testing based on NASA or other standards to ensure survivability during launch.



Model 2500E Shaker with 2000X15 Mounted

## SHAKERS FOR VIBRATION TESTING

Vibration shakers from The Modal Shop offer a wide range of options from miniature inertial shakers to large vibration test shakers. Designed for applications ranging from laboratory research to automotive and aerospace component testing, this versatile line of shakers offers force ratings from 4.5 lbf (20 N) to 500 lbf (2224 N).

The miniature SmartShaker™ Series, Models K2007E01 and K2004E01, serves as an all-in-one modal and vibration shaker with built-in power amplifier. The Model 2025E-HF with its 2.125 in (5.4 cm) diameter table offers an extended high frequency capability of 20 kHz. Dual Purpose Vibration Test Shaker Models 2075E and 2110E are designed with a 3.25 in (8.3 cm) diameter platform for vibration testing and through-hole armature for modal testing, delivering a unique solution for a variety of applications. The 2500E, 2075E, and 2110E shakers are also available with Head Expanders and in Horizontal Table configurations to support vibration testing of payloads that are not suitable for direct shaker attachment, or need to be tested in a specific orientation.



MODEL 2110E



MODEL 2075E



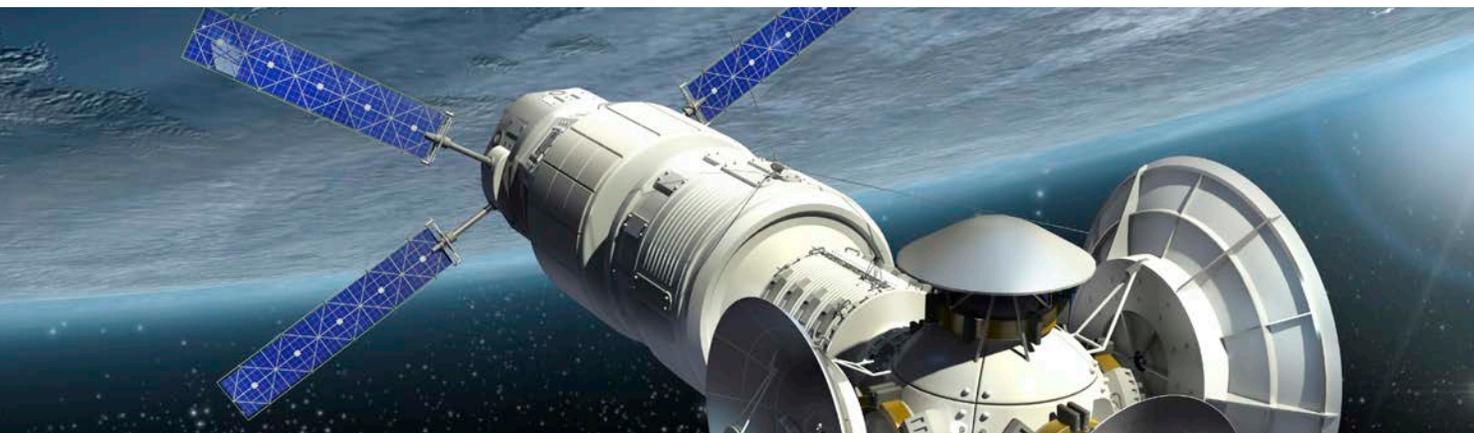
MODEL 2025E-HF



MODELS 2004E & 2007E



SMARTSHAKER™  
MODELS K2004E01 & K2007E01



## FORCE LIMITED VIBRATION TESTING SYSTEMS

Force limited vibration testing system for easy and accurate measurement of the input force. Optimizing 3 component force sensor installation for satellite force limited vibration testing.

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 most requirements for limiting the reaction force between the shaker and unit under test in random vibration testing. The use of piezoelectric, 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.

### 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

### 3-COMPONENT ICP® & CHARGE OUTPUT QUARTZ FORCE RINGS



#### TRIAxIAL ICP® FORCE SENSOR

PCB MODEL 260A01

Sensitivity (z-axis): 2.5 mV/lb

Sensitivity (x or y axis): 10 mV/lb

Measurement Range (z-axis): 1k lb

Measurement Range (x or y axis):  
±500 lb

Temperature Range: -65 to +250 °F  
(-54 to +121 °C)



#### TRIAxIAL ICP® FORCE SENSOR

PCB MODEL 260A02

Sensitivity (z-axis): 2.5 mV/lb

Sensitivity (x or y axis): 5 mV/lb

Measurement Range (z-axis): ±1k lb

Measurement Range (x or y axis):  
±1k lb

Temperature Range: -65 to +250 °F  
(-54 to +121 °C)



#### TRIAxIAL ICP® FORCE SENSOR

PCB MODEL 260A03

Sensitivity (z-axis): 0.25 mV/lb

Sensitivity (x or y axis): 1.25 mV/lb

Measurement Range (z-axis): ±10k lb

Measurement Range (x or y axis):  
±4k lb

Temperature Range: -65 to +250 °F  
(-54 to +121 °C)



#### TRIAxIAL CHARGE OUTPUT FORCE SENSOR

PCB MODEL 260A11

Sensitivity (z-axis): 15 pC/lb

Sensitivity (x or y axis): 32 pC/lb

Measurement Range (z-axis): ±1k lb

Measurement Range (x or y axis):  
±500 lb

Temperature Range: -100 to +350 °F  
(-73 to +177 °C)



#### TRIAxIAL CHARGE OUTPUT FORCE SENSOR

PCB MODEL 260A12

Sensitivity (z-axis): 15 pC/lb

Sensitivity (x or y axis): 32 pC/lb

Measurement Range (z-axis): ±1k lb

Measurement Range (x or y axis):  
±1k lb

Temperature Range: -100 to +350 °F  
(-73 to +177 °C)



#### TRIAxIAL CHARGE OUTPUT FORCE SENSOR

PCB MODEL 260A13

Sensitivity (z-axis): 15 pC/lb

Sensitivity (x or y axis): 32 pC/lb

Measurement Range (z-axis): ±10k lb

Measurement Range (x or y axis):  
±4k lb

Temperature Range: -100 to +350 °F  
(-73 to +177 °C)

### 3-COMPONENT ICP® & CHARGE OUTPUT QUARTZ FORCE LINKS



#### TRIAxIAL ICP® FORCE LINK

PCB MODEL 261B01

- Sensitivity (z-axis): 2.5 mV/lb
- Sensitivity (x or y axis): 10 mV/lb
- Measurement Range (z-axis):  $\pm 1k$  lb
- Measurement Range (x or y axis):  $\pm 500$  lb
- Temperature Range: -65 to +250 °F (-54 to +121 °C)



#### TRIAxIAL ICP® FORCE LINK

PCB MODEL 261B02

- Sensitivity (z-axis): 2.5 mV/lb
- Sensitivity (x or y axis): 5 mV/lb
- Measurement Range (z-axis):  $\pm 1k$  lb
- Measurement Range (x or y axis):  $\pm 1k$  lb
- Temperature Range: -65 to +250 °F (-54 to +121 °C)



#### TRIAxIAL ICP® FORCE LINK

PCB MODEL 261B03

- Sensitivity (z-axis): 0.25 mV/lb
- Sensitivity (x or y axis): 1.25 mV/lb
- Measurement Range (z-axis):  $\pm 10k$  lb
- Measurement Range (x or y axis):  $\pm 4k$  lb
- Temperature Range: -65 to +250 °F (-54 to +121 °C)



#### TRIAxIAL CHARGE OUTPUT FORCE LINK

PCB MODEL 261B11

- Sensitivity (z-axis): 15 pC/lb
- Sensitivity (x or y axis): 32 pC/lb
- Measurement Range (z-axis):  $\pm 1k$  lb
- Measurement Range (x or y axis):  $\pm 500$  lb
- Temperature Range: -100 to +350 °F (-73 to +177 °C)



#### TRIAxIAL CHARGE OUTPUT FORCE LINK

PCB MODEL 261B12

- Sensitivity (z-axis): 15 pC/lb
- Sensitivity (x or y axis): 32 pC/lb
- Measurement Range (z-axis):  $\pm 1k$  lb
- Measurement Range (x or y axis):  $\pm 1k$  lb
- Temperature Range: -100 to +350 °F (-73 to +177 °C)



#### TRIAxIAL CHARGE OUTPUT FORCE LINK

PCB MODEL 261B13

- Sensitivity (z-axis): 15 pC/lb
- Sensitivity (x or y axis): 32 pC/lb
- Measurement Range (z-axis):  $\pm 10k$  lb
- Measurement Range (x or y axis):  $\pm 4k$  lb
- Temperature Range: -100 to +350 °F (-73 to +177 °C)



## SIGNAL CONDITIONING SYSTEM COMPONENT SPECIFICATIONS



### SUMMING BLOCK FOR CHARGE MODE SENSORS

PCB MODEL 070A15

Input: 4-Channels of charge input

Output: 1-Channel of summed charge output



### DUAL-MODE CHARGE AMPLIFIER

PCB MODEL 443B102

1-channel

Voltage Gain (ICP® sensor mode):  
x0.1 to x1k

Voltage Gain (charge mode):  
x0.1 to 10k mV/pC



### CHARGE SUMMATION NODE MODULE

PCB MODEL 070M70

Input: 8-Channels of charge mode

Output: 1-Channel of summed charge output



### COMPUTATIONAL SIGNAL CONDITIONER

PCB MODEL 070M69

Input: 4 to 8-Channels of ICP® sensor or voltage signals

Output: 1-Channel

For summing or moment calculations



### SUMMING AMPLIFIER FOR ICP® SENSORS

PCB MODEL 070M90

Input: 12-Channels of ICP® signals

Output: 1-Channel

Gain: x0.1, x1, x10



### PE/IEPE SIGNAL CONDITIONER

ENDEVCO MODEL 2775C

Input: 1-Channel Piezoelectric (PE), Integrated Electronics PE (IEPE), or in-line Remote Charge Converter (RCC)

Output: AC, DC, or SERVO

Gain up to 10,000



## RAPIDLY FLUCTUATING PRESSURE, FLOW, SCREW CAVITATION, & WAVE SLAP

Piezoelectric pressure & force sensors are suited for dynamic pressure measurements including turbulence and cavitation. These measurements require a fast response or rise time, ruggedness, and high stiffness in order to obtain a high frequency response.



### HIGH RESOLUTION ICP® PRESSURE PROBE

PCB MODEL S112A22

100 mV/psi, 50 psi

Stainless steel for corrosion  
protection

Acceleration compensated



### ICP® QUARTZ FORCE RINGS

PCB MODEL 202M44

±100 lbs

Measures dynamic excitation  
or reaction forces

Integral waterproof cable

## VIBRATION

Shear mode accelerometers isolate the sensing crystals from the base and housing, lowering thermal transients and signal noise resulting from base bending effects. This is a very important feature when attaching them to relatively thin walled vessel hull models during wave slap applications.



### ICP® UNDERWATER ACCELEROMETER

PCB MODEL 352M221

10 mV/g,  $\pm 500$  g

2nd order LP filter

Frequency response:  
1 Hz to 6k Hz

Integral waterproof cable



### MINIATURE RING-STYLE, CERAMIC SHEAR CVLD ACCELEROMETER

PCB MODEL 355M87A

100  $\mu$ A/g,  $\pm 50$  g

Frequency response:  
7 Hz to 9k Hz

Integral waterproof cable

Case isolated



### MINIATURE RING-STYLE, CERAMIC SHEAR ICP® ACCELEROMETER

PCB MODEL 355M73

100 mV/g,  $\pm 50$  g range

Frequency response:  
7 Hz to 9k Hz

Integral waterproof cable

Case isolated



### TEARDROP ICP® ACCELEROMETER WITH FLEXIBLE, INTEGRAL CABLE

PCB MODEL 352A74

100 mV/g,  $\pm 50$  g range

Frequency response:  
1 Hz to 8k Hz

Hermetic housing



### RING-STYLE SEISMIC SHEAR CVLD ACCELEROMETER

PCB MODEL 631M21

1k  $\mu$ A/g,  $\pm 2.5$  g range

Frequency response:  
1 Hz to 4k Hz

Integral waterproof cable

Case isolated



## UNDERWATER BLAST

Piezoelectric pressure sensors measure shock waves and bubble energy associated with underwater explosion testing. Sensors structured with volumetrically sensitive, omnidirectional tourmaline crystal and ICP® microelectronics provide a high frequency, low impedance output in underwater test environments. Waterproof cables of customer requested lengths are factory installed.



### TOURMALINE ICP® UNDERWATER BLAST SENSOR

PCB SERIES 138A

ICP® underwater blast pressure probes

Ranges from 1k to 50k psi

Rise time 1.5  $\mu$  sec

Resonant frequency  $\geq$  1 MHz

Approximate max depth 1k ft.



Photo Courtesy of Siemens and Belgian Defense

## PORTABLE SYSTEM VERIFICATION INSTRUMENTS

### 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.



### ACCELEROMETER SIMULATOR ENDEVCO MODEL 4830B

The 4830B accelerometer simulator is a hand held battery operated signal generator designed specifically to simulate the electrical output of common types of accelerometers. The instrument contains a highly accurate oscillator with an adjustable output level and is ideal for setting up, testing and the diagnosis of faults within data acquisition systems, environmental test systems, or simply as a flexible signal generator.







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