



# Potenzialità dei sensori per le vibrazioni

## MUSP 10 Aprile 2013

[www.pcb.com/sure](http://www.pcb.com/sure)

The image displays four promotional panels for PCB Piezotronics sensors, each with a specific application area:

- Acoustic Measurements?** We Do! We do it all - sensors to measure vibration, acoustic, force, pressure, load, strain, shock and torque - Sure we do!
- Force Limited Vibration Measurements?** We Do! We do it all - sensors to measure vibration, acoustic, force, pressure, load, strain, shock and torque - Sure we do!
- Durability Measurements?** We Do! We do it all - sensors to measure vibration, acoustic, force, pressure, load, strain, shock and torque - Sure we do!
- Pipeline Measurements?** We Do! We do it all - sensors to measure vibration, acoustic, force, pressure, load, strain, shock and torque - Sure we do!

The panels feature images of various sensors and their applications: a microphone on a stand, a satellite in space, a vehicle on a test track, and a large industrial pipeline with a pressure gauge.

For over 40 years PCB® has been dedicated to the development of sensor technology and serving the needs of test and measurement professionals worldwide.

 **AEROSPACE & DEFENSE**  
A PCB PIEZOTRONICS DIV.

 **AUTOMOTIVE SENSORS**  
A PCB PIEZOTRONICS DIV.

 **PCB PIEZOTRONICS** INC.  
TEST & MEASUREMENT PRODUCTS

 **LARSON DAVIS**  
A PCB PIEZOTRONICS DIV.

 **IMI SENSORS**  
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PCB operations are supported by a network of international offices and distributors in all the major technology centers around the world.



- Corporate HQ/Campus – Depew, New York, USA
- PCB US Operations
- International Offices: France, Germany, Italy, UK, Sweden, China, Japan
- Major Distributors

Did you know that PCB® pioneered the integration of piezoelectric sensors and microelectronics, today ICP® sensors are used in many applications.

- Vibration Sensors
- Pressure Sensors
- Force & Strain Sensors
- Load & Torque Sensors
- Microphones
- Signal Conditioners
- MEMs Accelerometers
- Fastener Instrumentation
- Noise & Vibration Dosimeters
- Sound Level Meters



ICP® is a registered trademark of PCB Group

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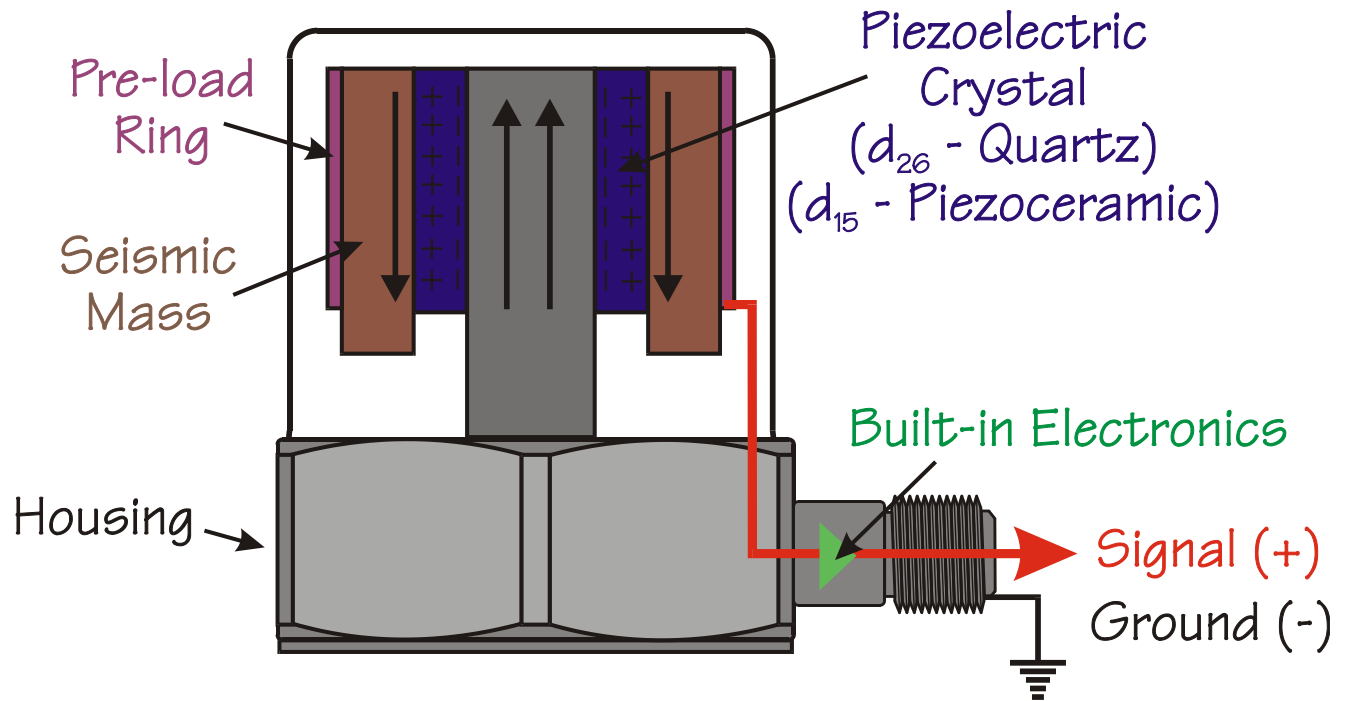
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ICP® = Integrated Circuit-Piezoelectric

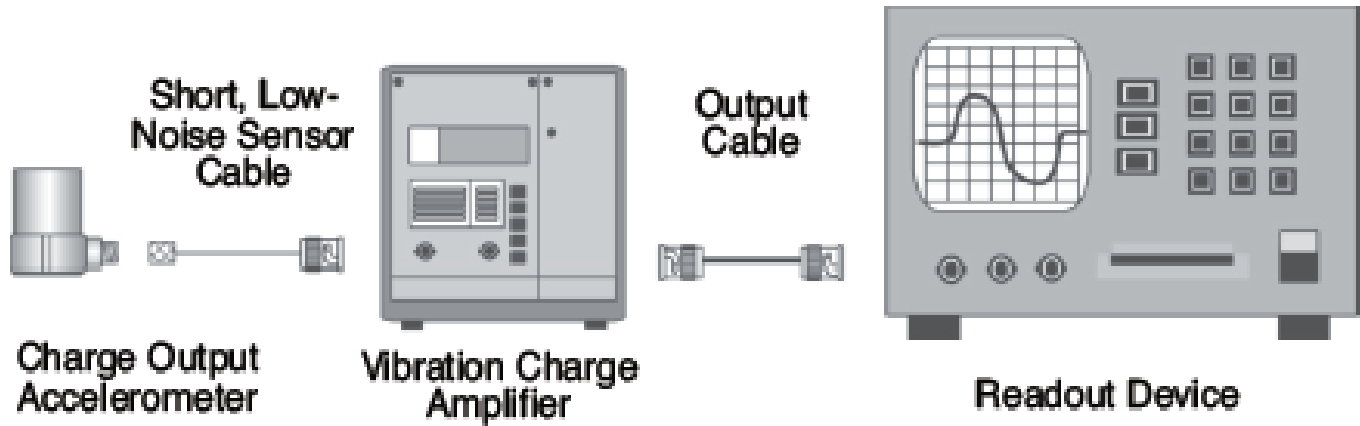
Standard Powered:

24-36VDC

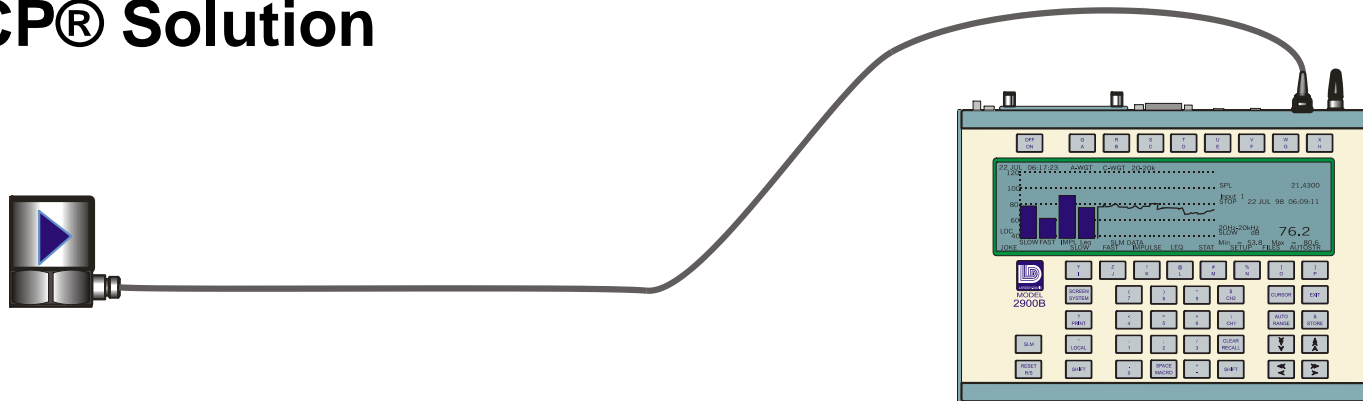
2-20mA



## Charge Solution



## ICP® Solution



PCB continually invests in people, advanced manufacturing capabilities, and state of the art facilities.



Depew, NY



High Volume Production



R&D and Custom Production



Micro Electronics



Laser Welding



Hermetic Connectors



Firing Piezo Ceramics at 1250 °C



Depew, NY

*Specializing in precision machined components for industrial, medical, aerospace, and defense applications.*



Robotic Modular Machining Cell



of North Carolina, Inc.

Roanoke, NC



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- **Types of Output**
  - Voltage 0-5 VAC
  - Current 4-20 mA
  - Switches (relays) Open/closed



- **Types of products**
  - ICP® products
  - Charge mode products
  - 4-20mA loop powered products
  - Sensor Options & News



- **Types of products**

- **ICP® products**



- Charge mode products

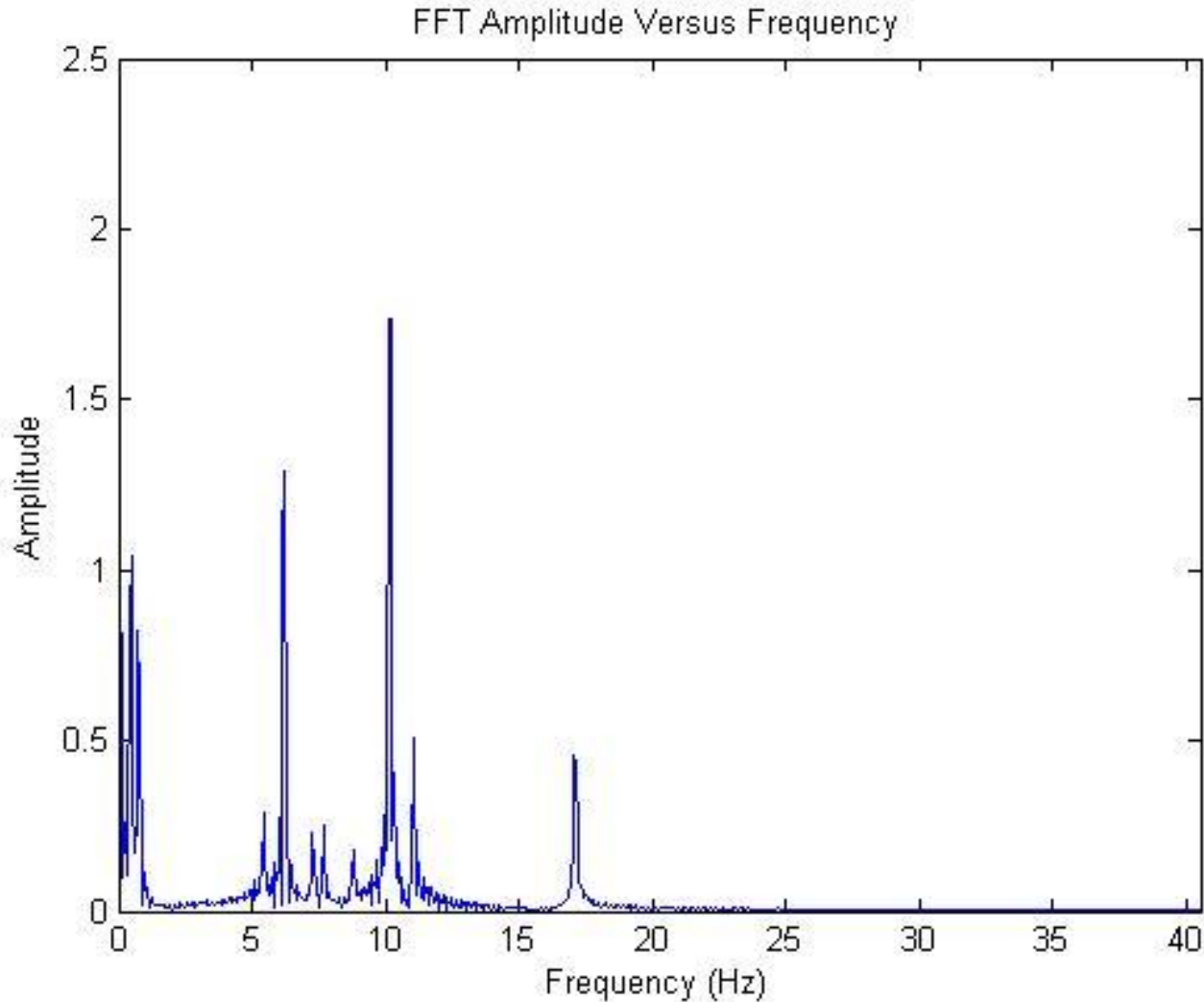
- 4-20mA loop powered products

- Sensor Options & News



- ICP is Integrated Circuit Piezoelectric
  - Freq. range 0,2Hz to 10kHz or more
  - 10/100/500 m/Vg sensitivity
  - Amp. Range 0,5/ 5/50/500 grms
- Low Cost & Precision models available
- Provide 0-5 VAC output
- Raw time waveform data
- Complete time history
  - Full spectral data
  - Allows FFT calculation



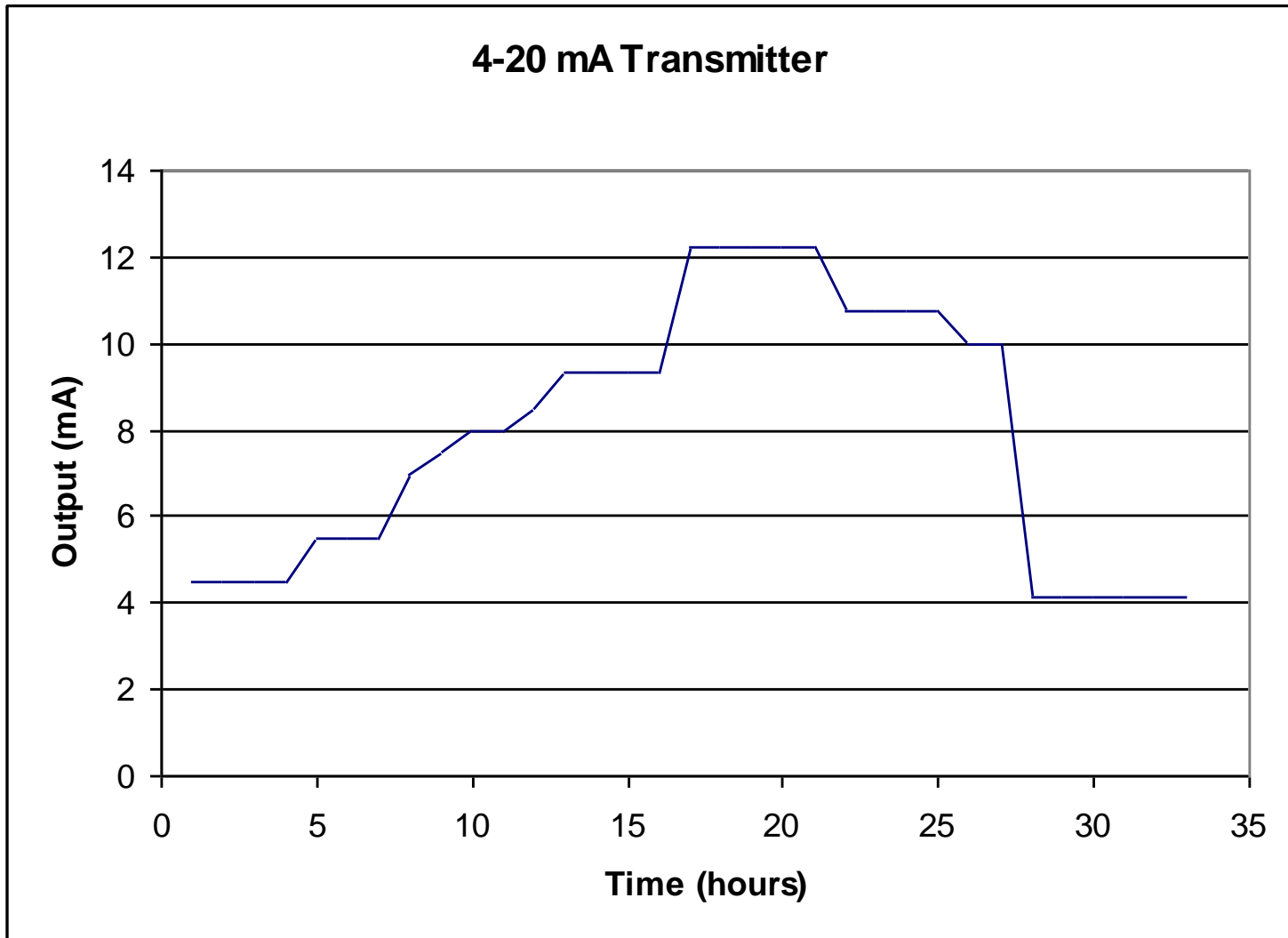


- **Types of products**
  - ICP® products
  - Charge mode products
  - **4-20mA loop powered products**
  - Sensor Options & News



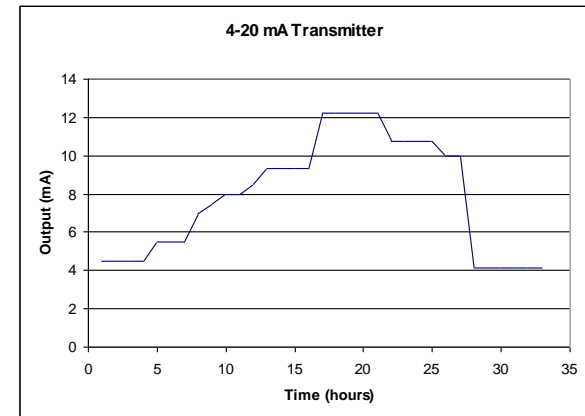
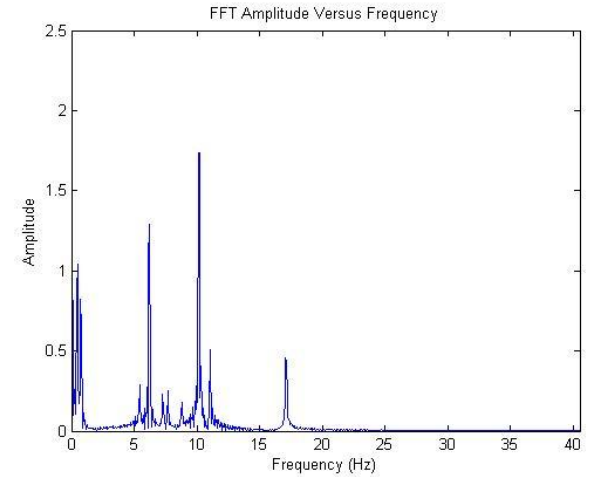
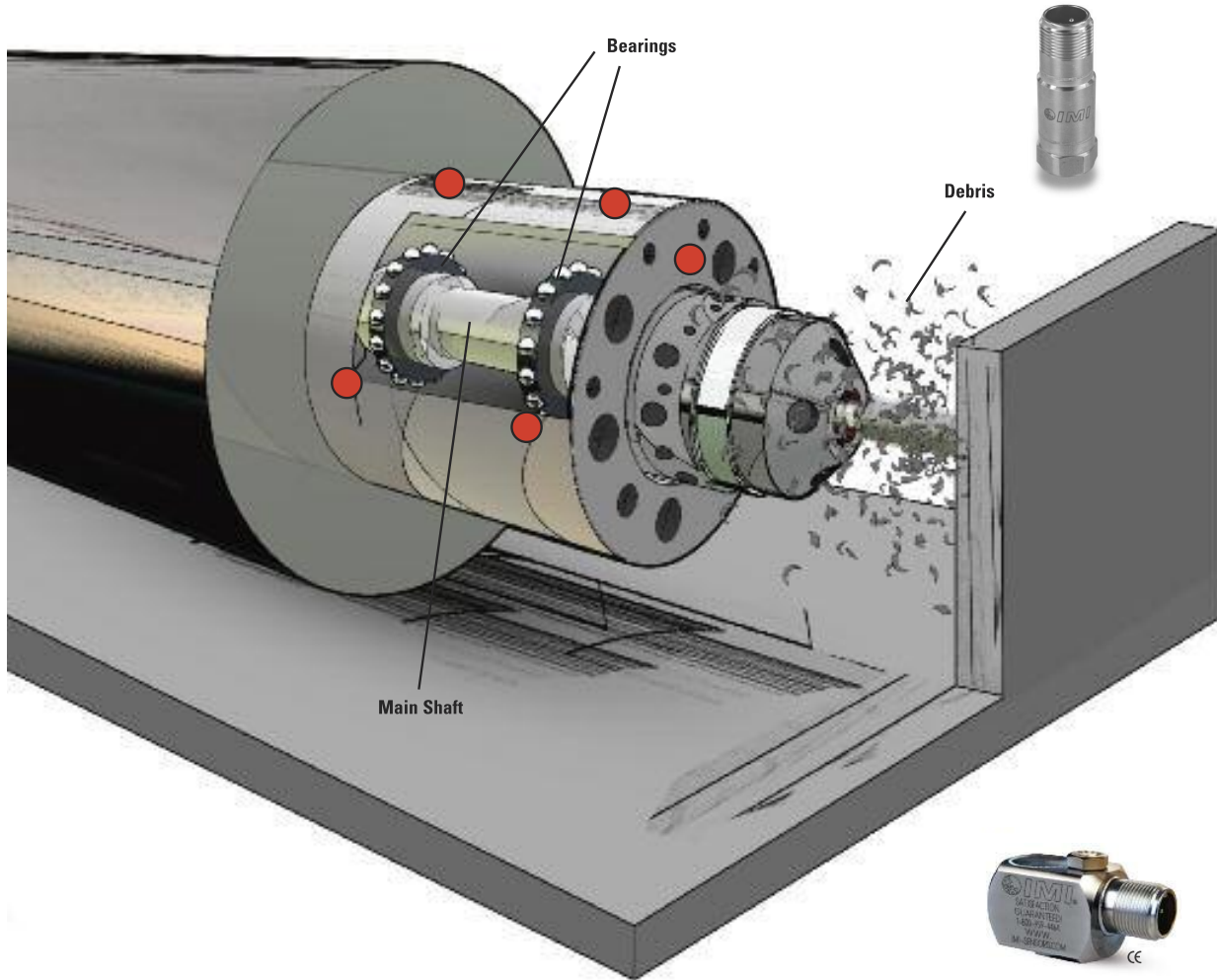
- IMI offers vibration transmitters which are loop powered and have a 4-20 mA output.
- The 4-20 mA output is proportional to OVERALL or AVERAGE vibration (RMS or PEAK).
- RMS or Peak 4-20 mA signals are just numbers, they provide no raw time history or spectral data.
- Main Advantages
  - Easily integrate with PLC/SCADA, DCS
  - Does not require signal conditioning
  - Loop power is industry standard







# Traditional Solution: IMI Sensor



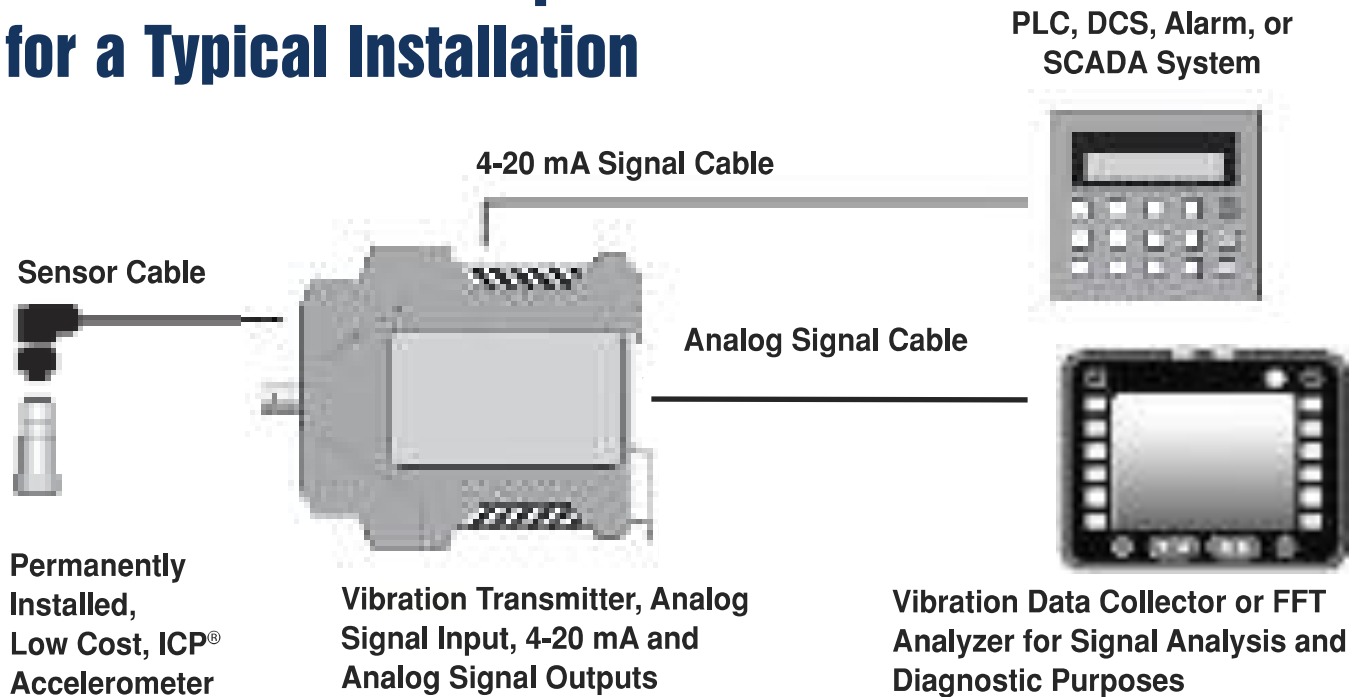
● Suggested Sensor Placement

- Provides both 4-20mA overall vibration and raw vibration
- 4-20 mA output features
- Acceleration, Velocity, or Displacement
- Adjustable Range
- Filters can be altered
- Customer can have the best of both!



## Tips From Techs

### Recommended Components for a Typical Installation



- **Types of Output**

- Voltage 0-5 VAC
- Current 4-20 mA
- **Switches (relays) Open/closed**

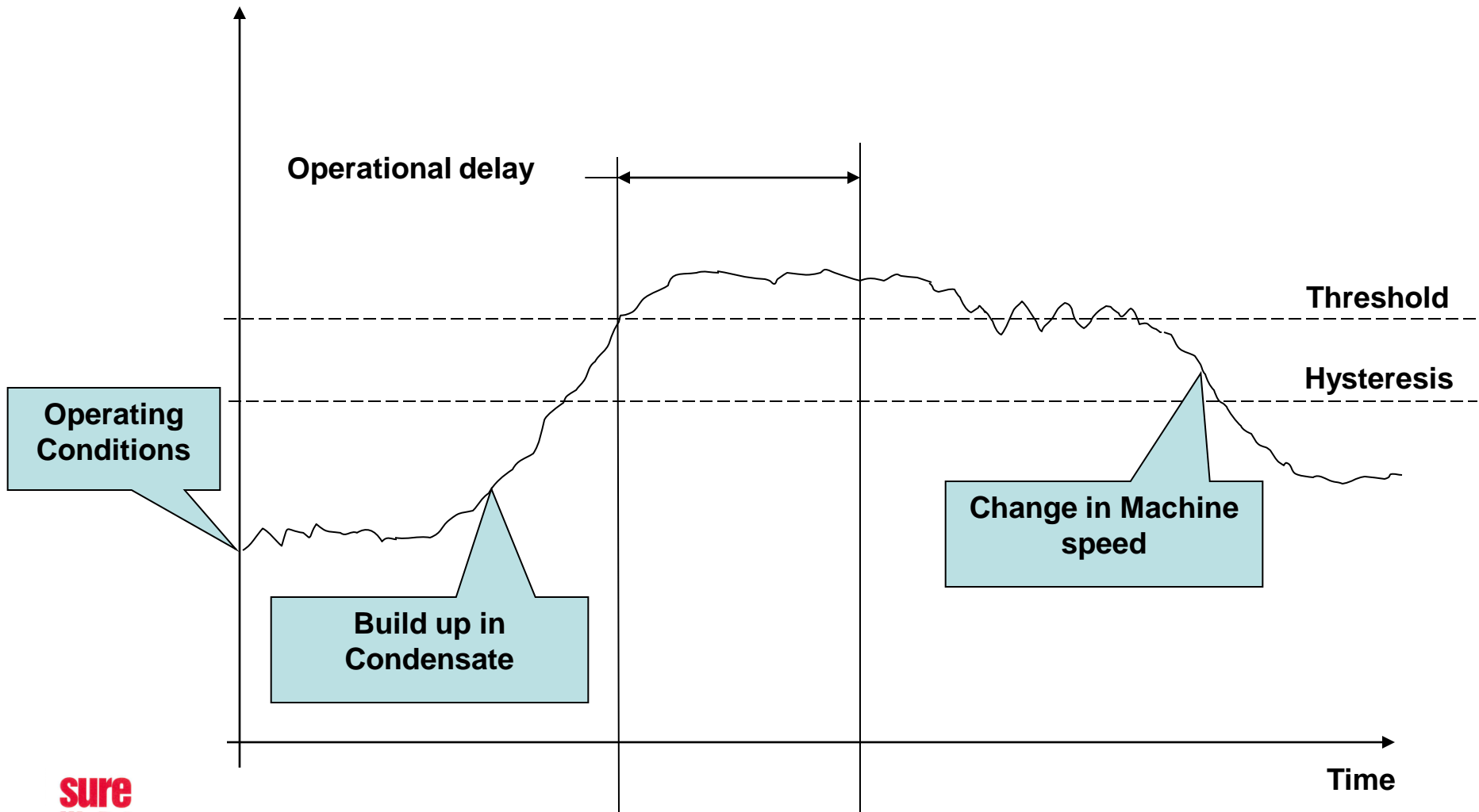


- Highlights:
  - Relay – Open/Closed
  - Low Cost
  - Extremely Accurate
  - Time Delay
  - USB Programmable
  - Leaks power from circuit
- THIS IS JUST A SWITCH
  - NO VIBRATION OUTPUT
  - NO VIBRATION OUTPUT
  - NO VIBRATION OUTPUT
- Best Application:
  - Prevents accidents
  - The customer only needs a switch



## Threshold and Hysteresis

Vibration Level



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- **Types of products**
  - ICP® products
  - Charge mode products
  - 4-20mA loop powered products
  - **Sensor Options & News**



- Alternative Mounting Method
- Submersible/Waterproof
- Embeddable
- High Temperature
- Strain & Force
- Modal & Structural Analysis





- Noise
- Calibration & Alarm



- **Alternative Mounting Method**
- Submersible/Waterproof
- Embeddable
- High Temperature
- Strain & Force
- Modal & Structural Analysis



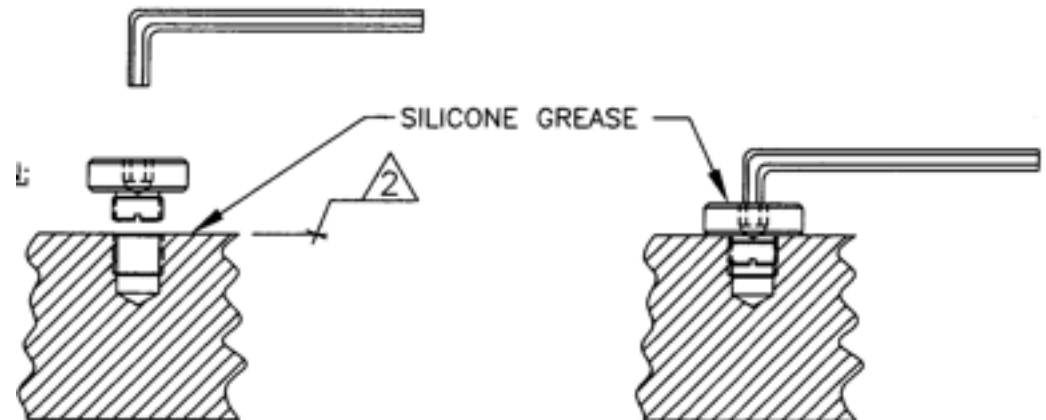
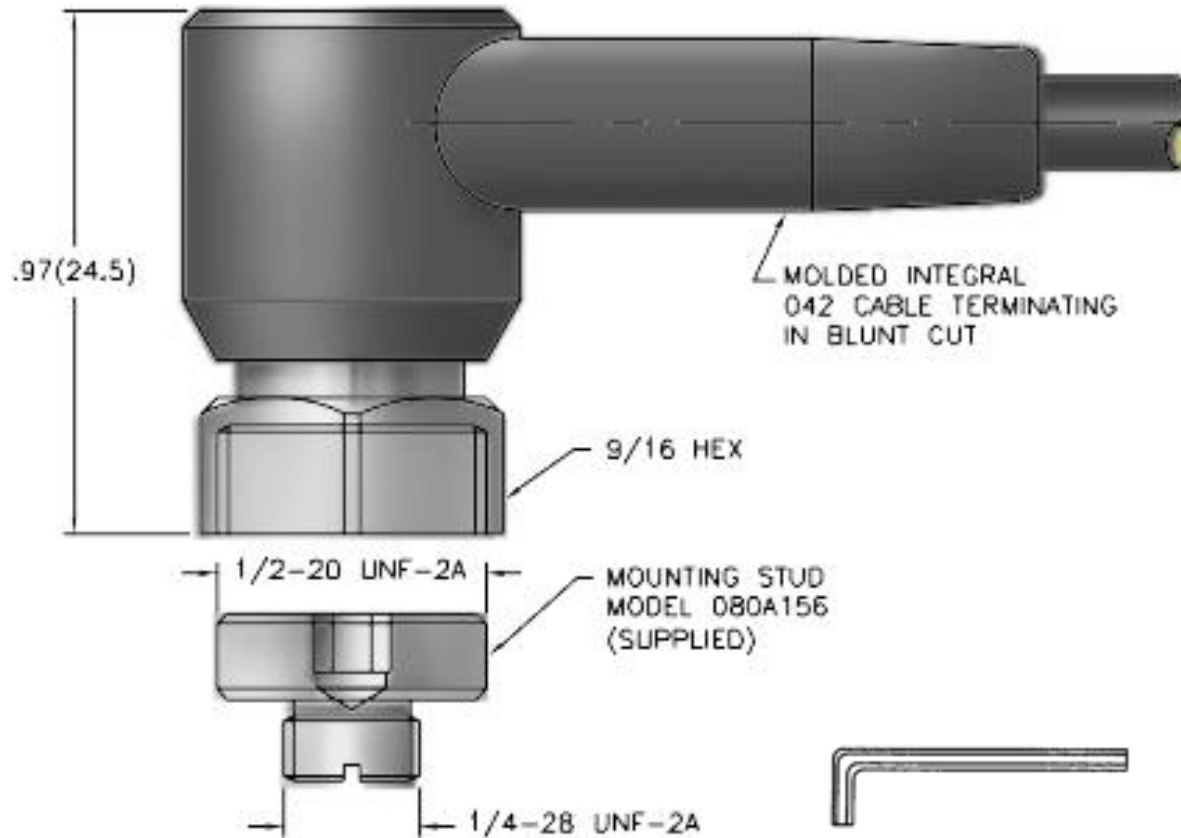
## Swiveler® & Spindler® Accelerometers

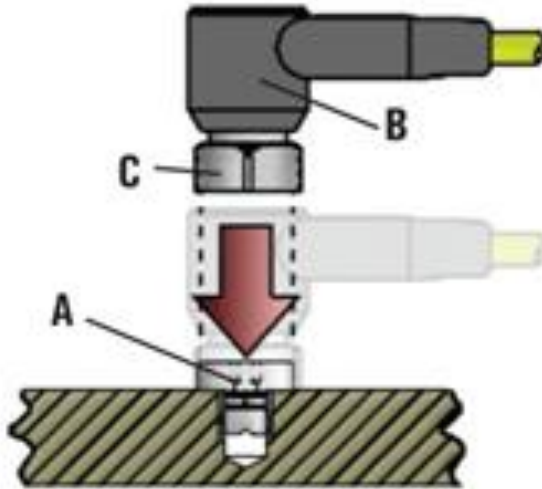
Get them from every angle



- Patented 360° swivel mount allows for convenient cable orientation (USA Patent #6,435,902)
- Lower cost alternative to through-bolt sensors
- Small footprint & very low profile for installation in tight spaces

# Alternative Mounting Method





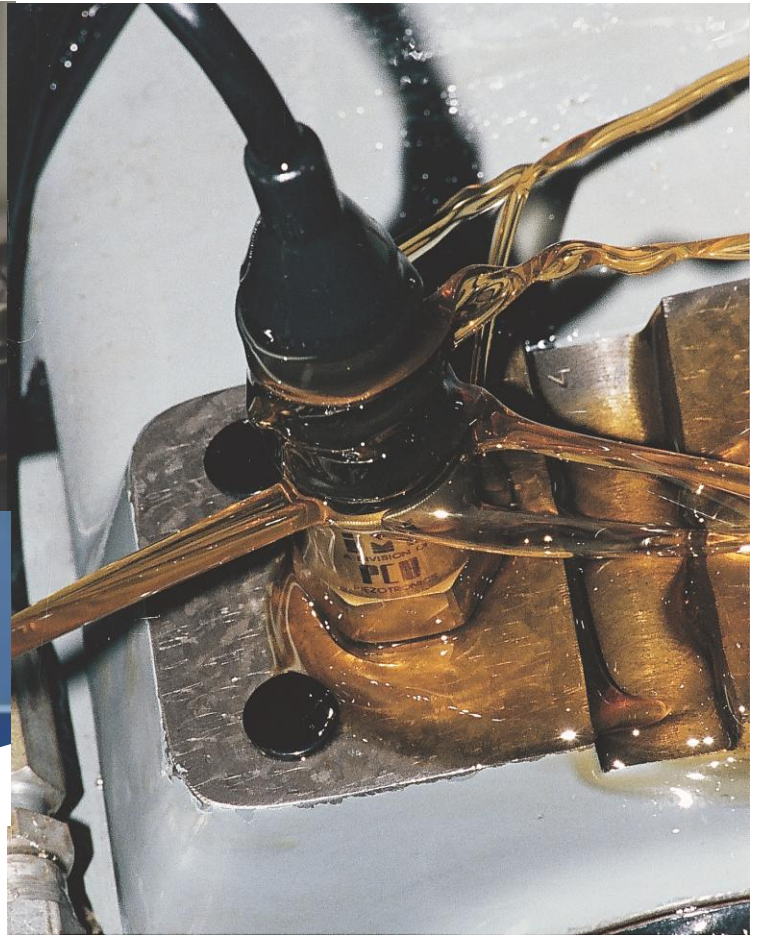
Mounting hole is prepared into machine surface to accept sensor's mounting stud (A). Stud is then tightened to recommended torque with hex Allen key. Sensor (B) hex nut (C) is threaded onto mounting stud.



Using the 360° capabilities of the Swiveler<sup>®</sup>, the cable is positioned into desired orientation & temporarily hand tightened. Using a wrench, the hex nut is tightened to the recommended torque while holding the cable or connector in the desired location.

- Alternative Mounting Method
- **Submersible/Waterproof**
- Embeddable
- High Temperature
- Strain & Force
- Modal & Structural Analysis







- Waterproof
  - IP 68
- Integral cable
  - Armed cable
- Survive in Corrosive environments
  - Atex
  - CSA



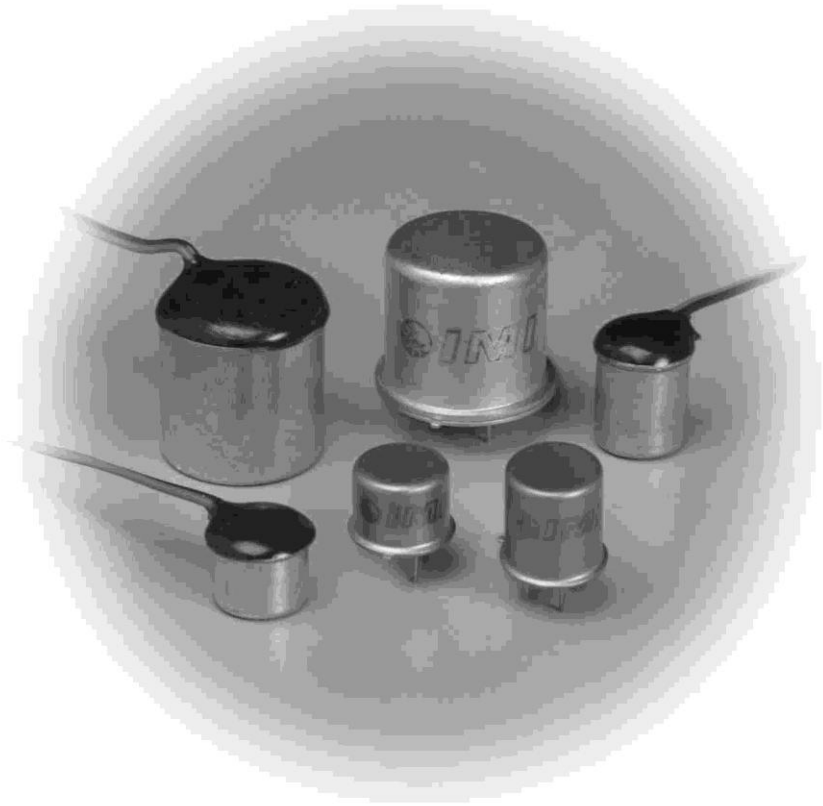


- Alternative Mounting Method
- Submersible/Waterproof
- **Embeddable**
- High Temperature
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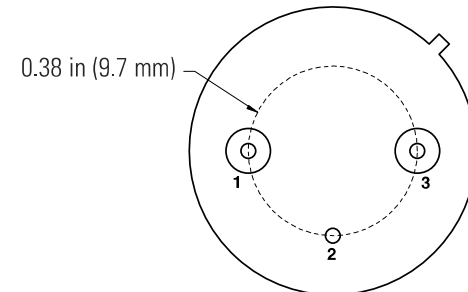
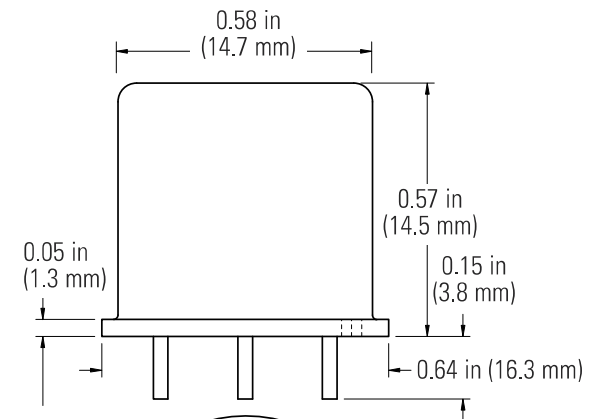
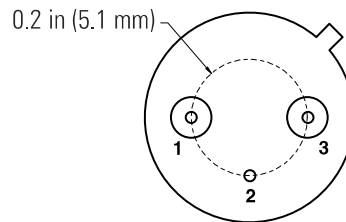
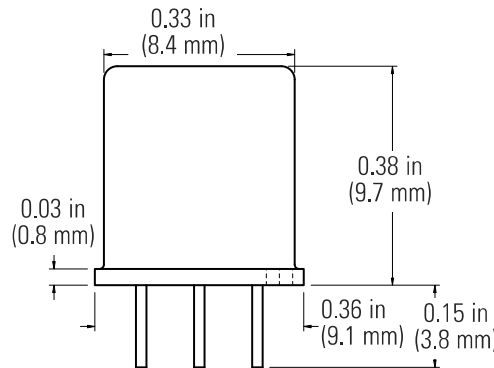
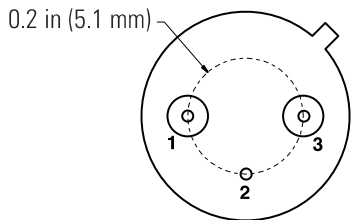
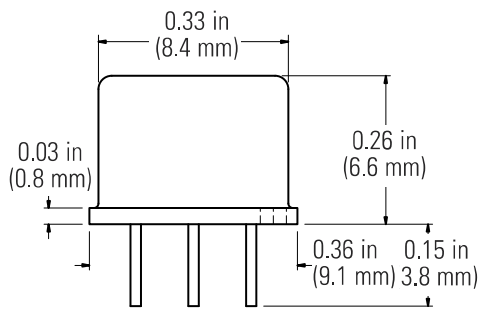
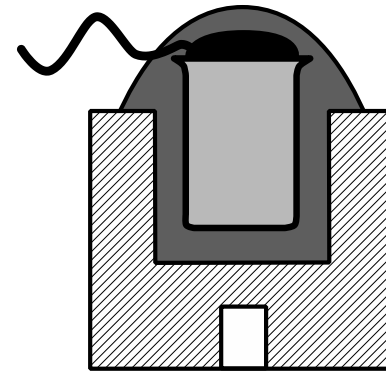
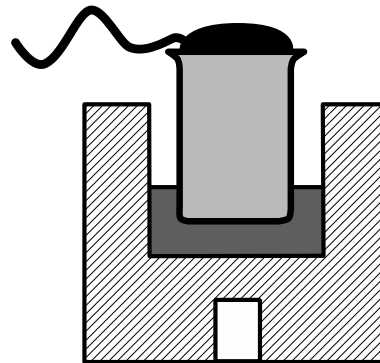
- **Applications:**

- Stabilization
- Intrusion monitoring
- Vibration monitoring
- Black Box
- OEM
- Custom



## Mounting Example:

- Potted
- Encapsulated
- Welded



## Available:

- ICP®<sup>®</sup>, Charge, voltage, 3-wire versions
- Variety of sensitivities
- Temperature Output
- Solder pin or integral cable
- Positive or Negative output



- Alternative Mounting Method
- Submersible/Waterproof
- Embeddable
- **High Temperature**
- Strain & Force
- Modal & Structural Analysis



# High Temperature Accelerometers



**High Temperature Accelerometer  
with Teflon® Jacketed Cable**  
Model HT602D11  
See page 100 for more information

**NEW!**

**High Temperature Accelerometer  
with Armored Integral Cable**  
Model HT602D61  
See page 100 for more information

**High Temperature Accelerometer**  
Model HT602D01  
See page 100 for more information

**High Temperature Accelerometer**  
Model EX600B13  
See page 106 for more information

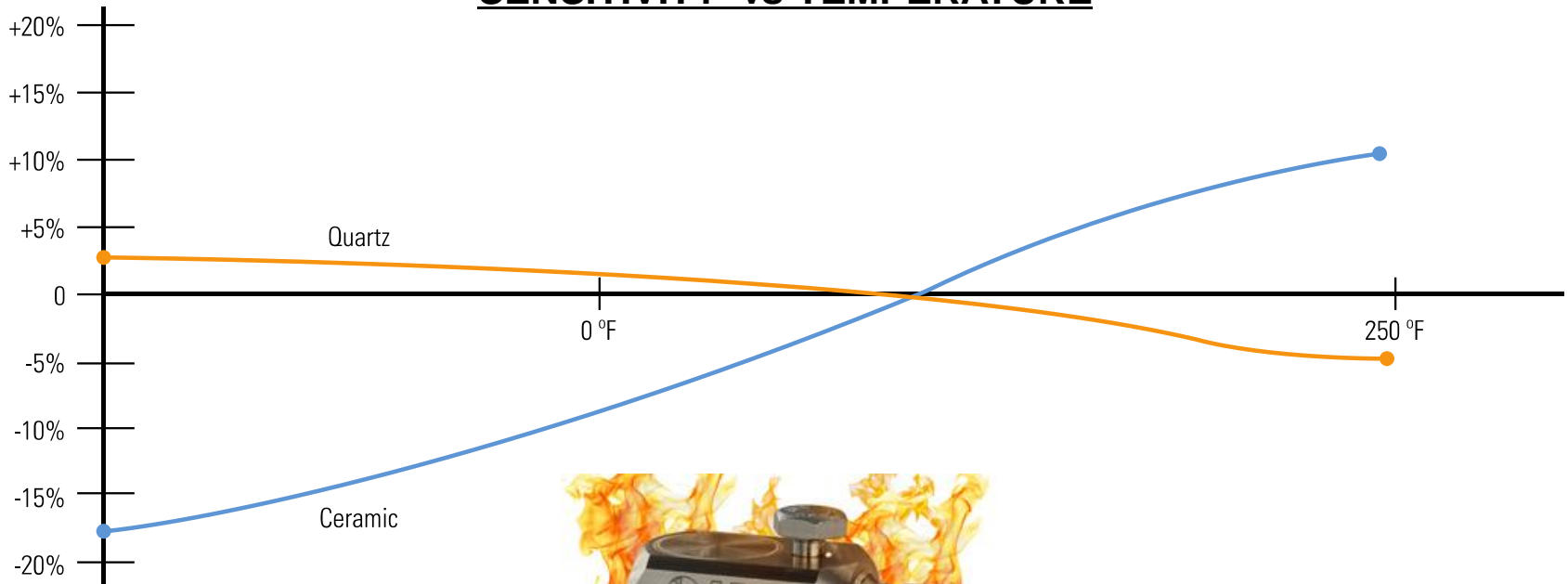
Teflon® is a registered  
trademark of DuPont

- Industry leading high temperature performance in ICP® designs
- Variety of rugged connector and integral cable option
- Ceramic or Quartz
- Top or side exit versions for easy installation
- ICP® version up to 163° C
- Charge version up to 649° C



## Benefits of Quartz vs. Ceramic

### SENSITIVITY vs TEMPERATURE



**NO Sensitivity  
Variation**



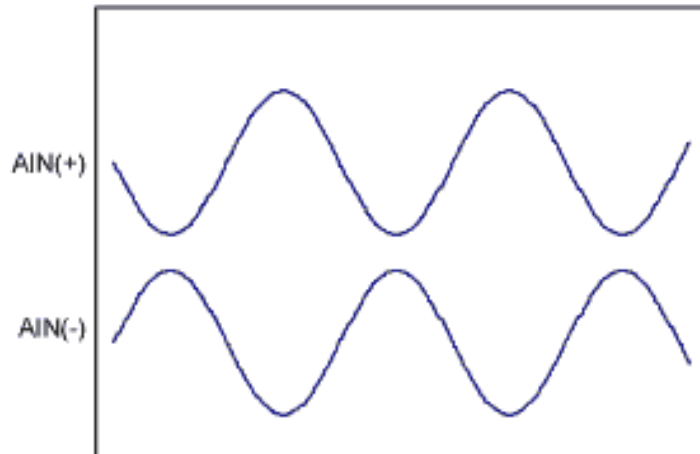


**UP to 649° C**

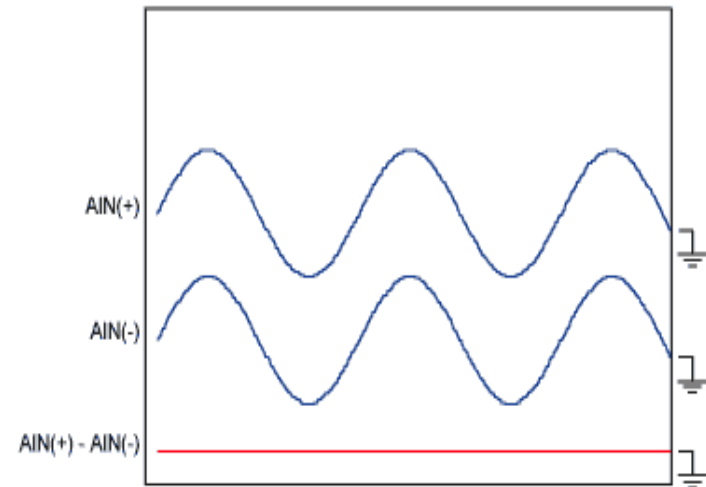
- Combines a high temperature differential charge output accelerometer with a 10 ft. (3 m) welded integral hardline cable and an ICP® powered in-line charge converter.
- Attractive choice for industrial machinery vibration monitoring applications with ICP® capable data collectors

## Differential Charge Output

- Common mode noise elimination
  - Taking the difference between the two signals creates a doubling of the measurement signal and elimination of the common mode noise.



Measurement Signals are Opposed

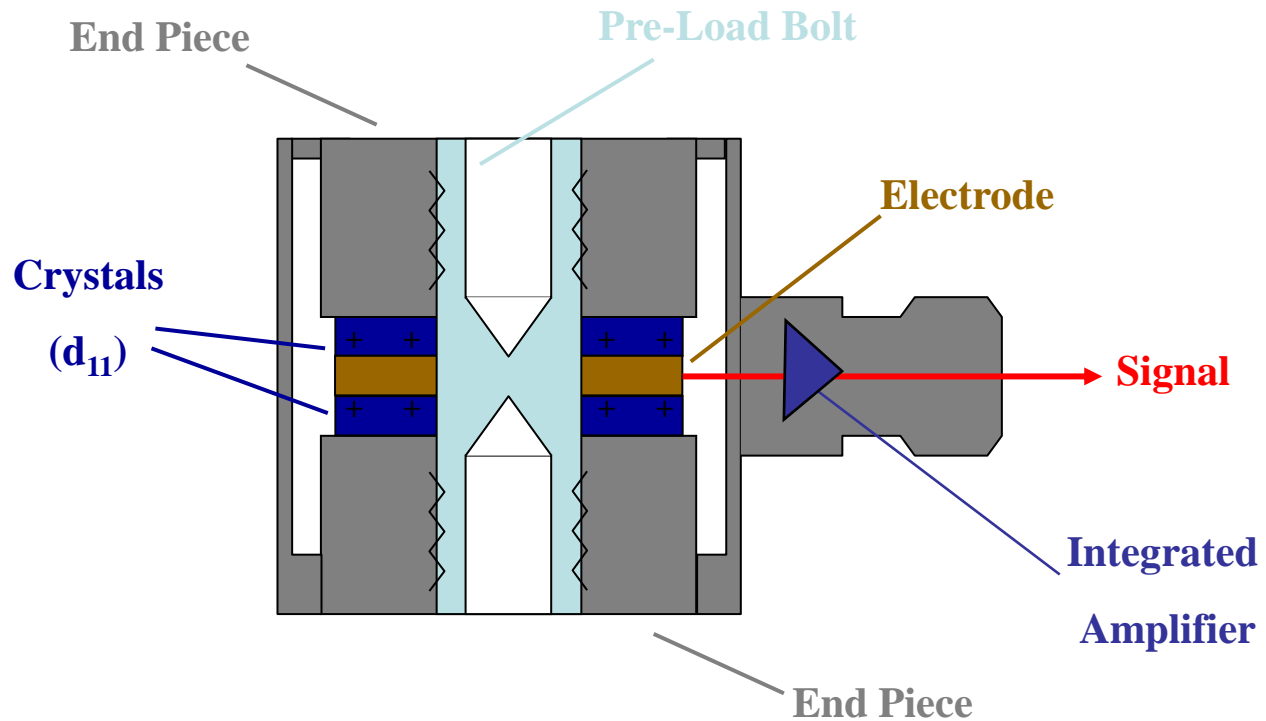


Noise Signals are Common

- Alternative Mounting Method
- Submersible/Waterproof
- Embeddable
- High Temperature
- **Strain & Force**
- Modal & Structural Analysis



## Force Sensor Feature:



## Force Sensor Feature:

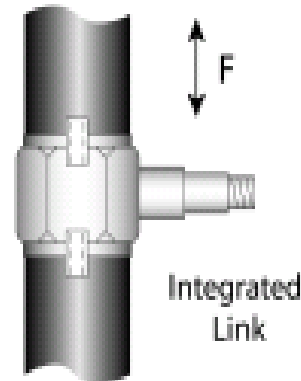
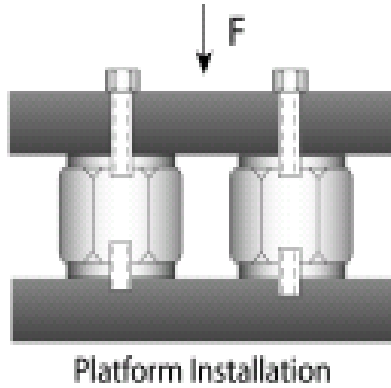
- Hermetically Sealed
- Laser-Welded Stainless Steel Construction
- Quartz Sensing Element
- Solid State Construction for Long Term Durability
- 10/32 Electrical Connector on all Single Axis Models
- ICP® and Charge Output Availability



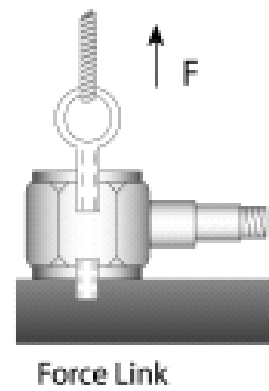
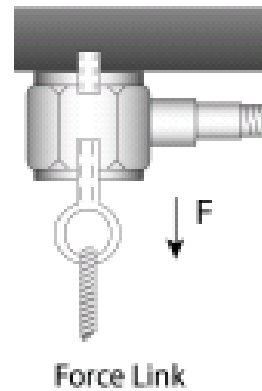
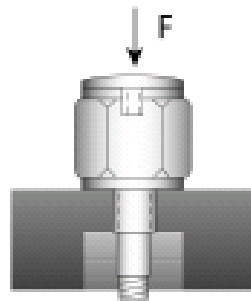
## Typical PE Force Sensor Applications

- Dynamic compression and tension
- Reaction & actuation force
- Impact testing
- Punching and forming
- Press force monitoring
- Drop testing
- Materials testing, fatigue testing, material fracture
- Machinery studies
- Modal analysis force input, biomechanics, mechanical impedance, matrix print head
- Testing of plastics and polymers

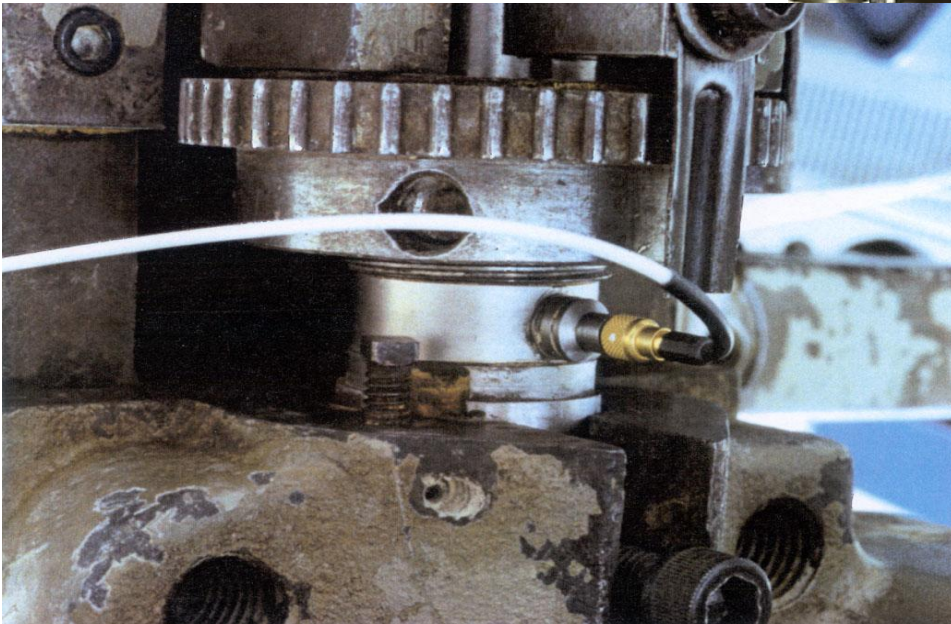




- ⇒ Flat & Parallel
- ⇒ Ground Surfaces



- Invasive mounting method
- Part of machine's layout



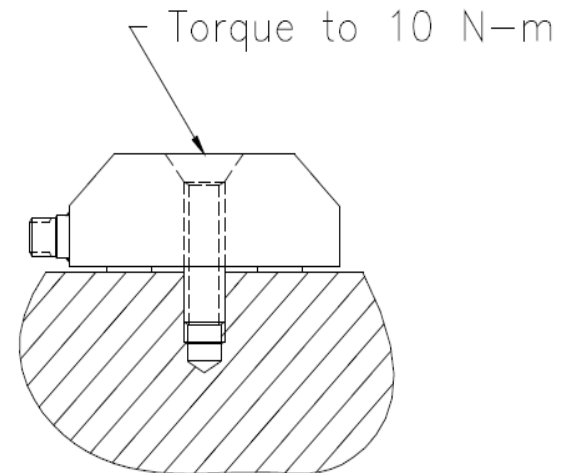


## Strain ICP® Sensor

- Dynamic Strain Measurements
- In-Direct Force Measurements
- ICP® Sensors
- Stud Mounted (M6 x 1.00-6g)
- Ground Isolated



**Series M240**  
**Industrial ICP® Strain Sensors**



- Conditions ICP Force and Strain sensors
- Analog and peak hold outputs allow real-time monitoring
- Synchronizes with machine cycles through reset feature
- Selectable DC or AC coupled output
- Auto bias zero feature for DC coupling
- Includes selectable gain and attenuation
- Easy, DIN rail mount



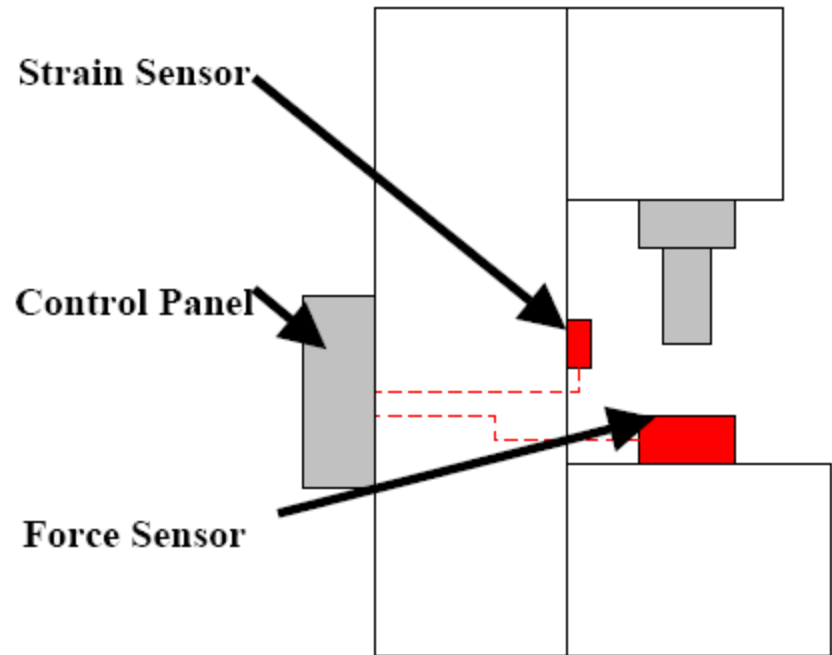
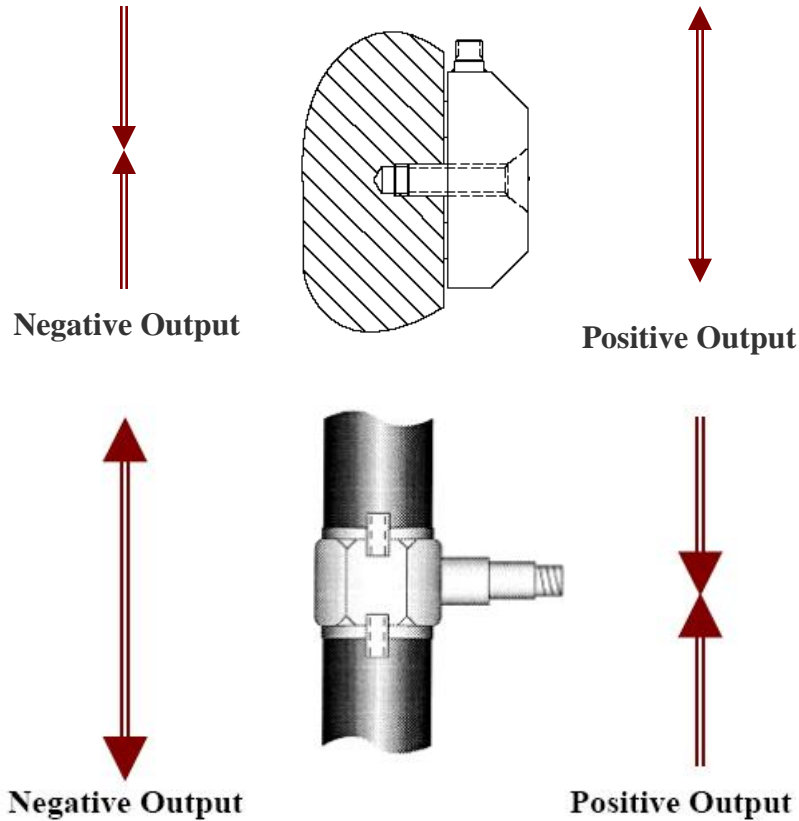
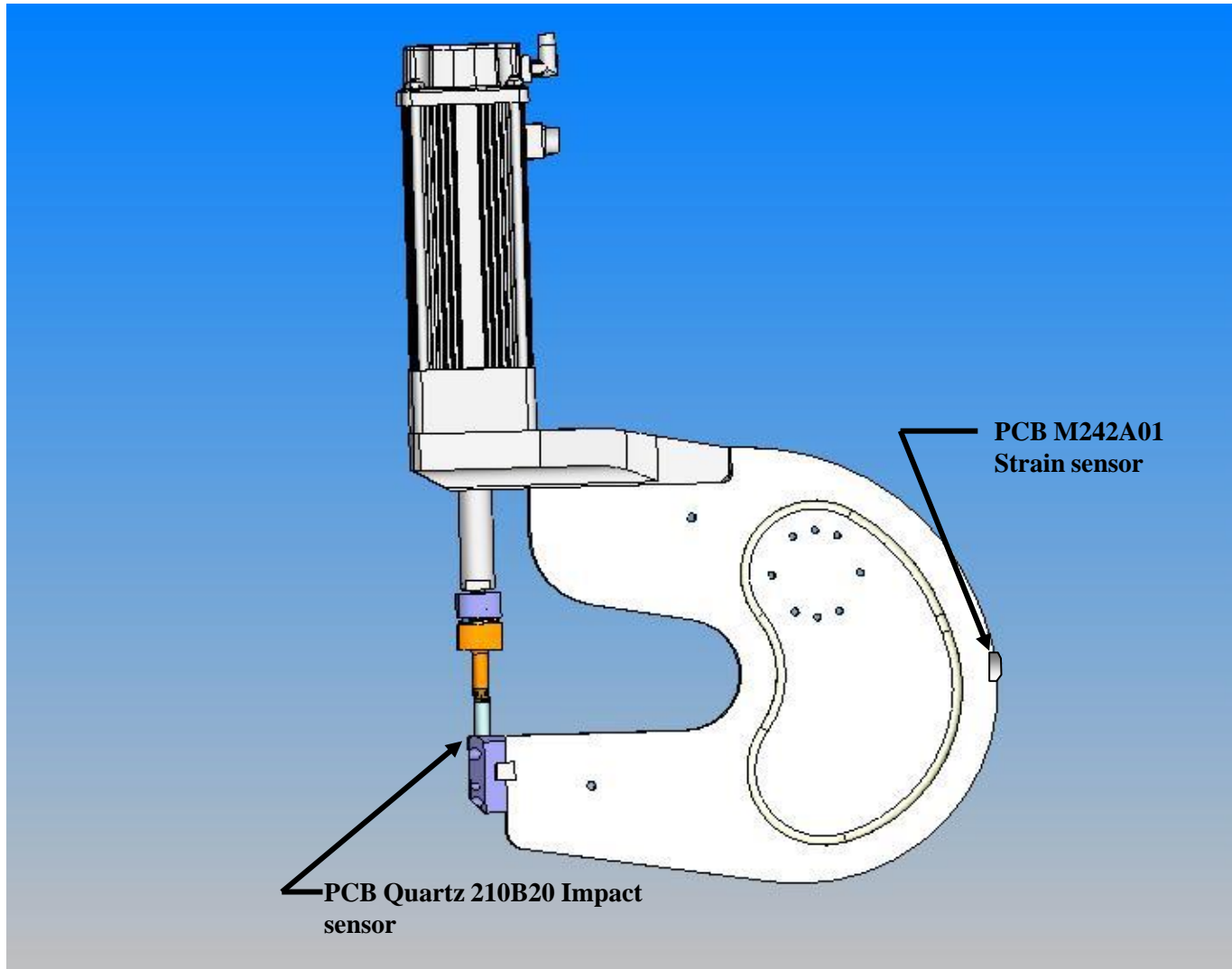
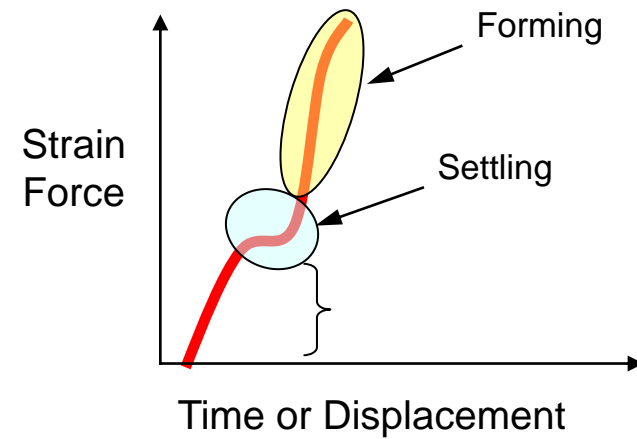
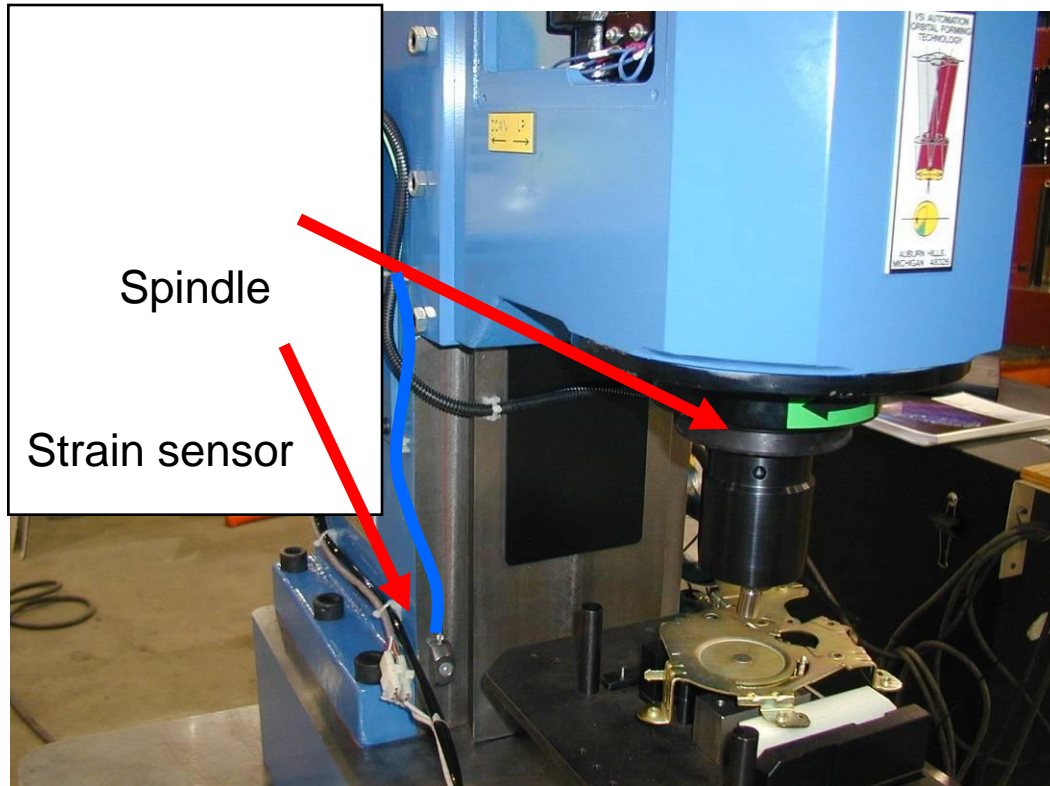


Figure 10 – ICP<sup>®</sup> Force Sensor





- Monitors Force During Manufacturing
- Avoids Damage & Detects Tool Wear
- Monitors Process Deviations
- Helps Ensure Quality & Zero Defects
- Easy Installation



- Alternative Mounting Method
- Submersible/Waterproof
- Embeddable
- High Temperature
- Strain & Force
- **Modal & Structural Analysis**





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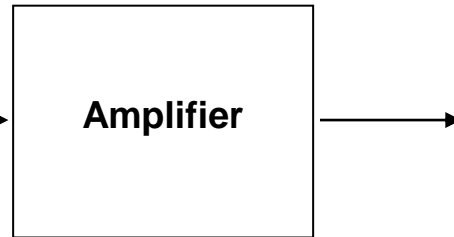
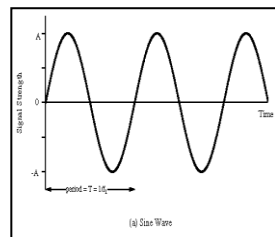
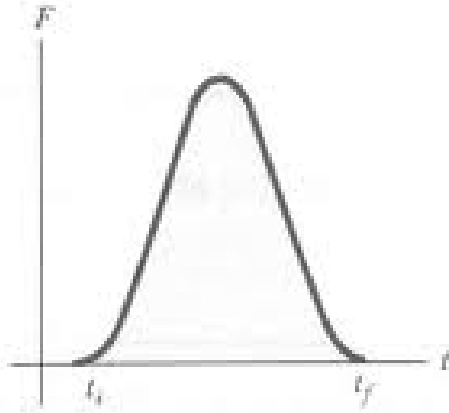


## Impact Hammers

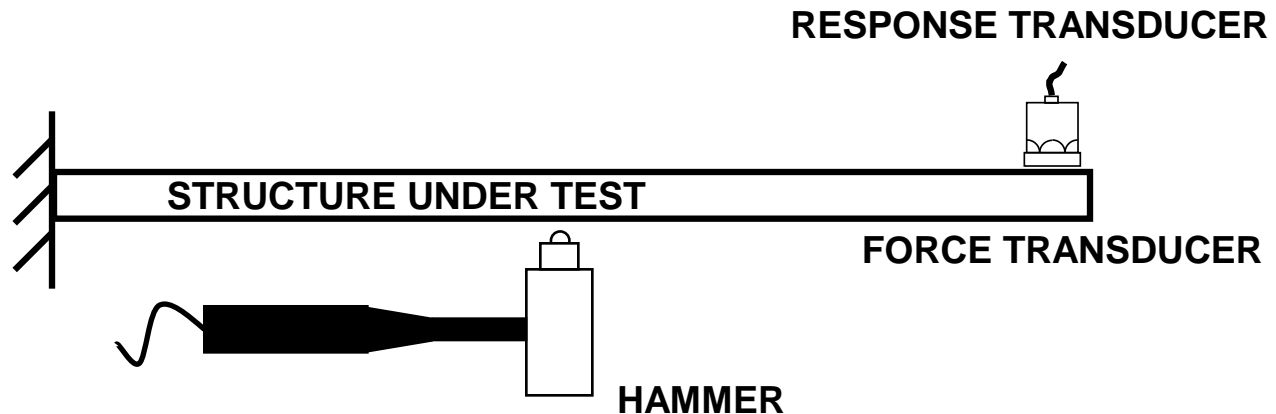


## Modal Shakers

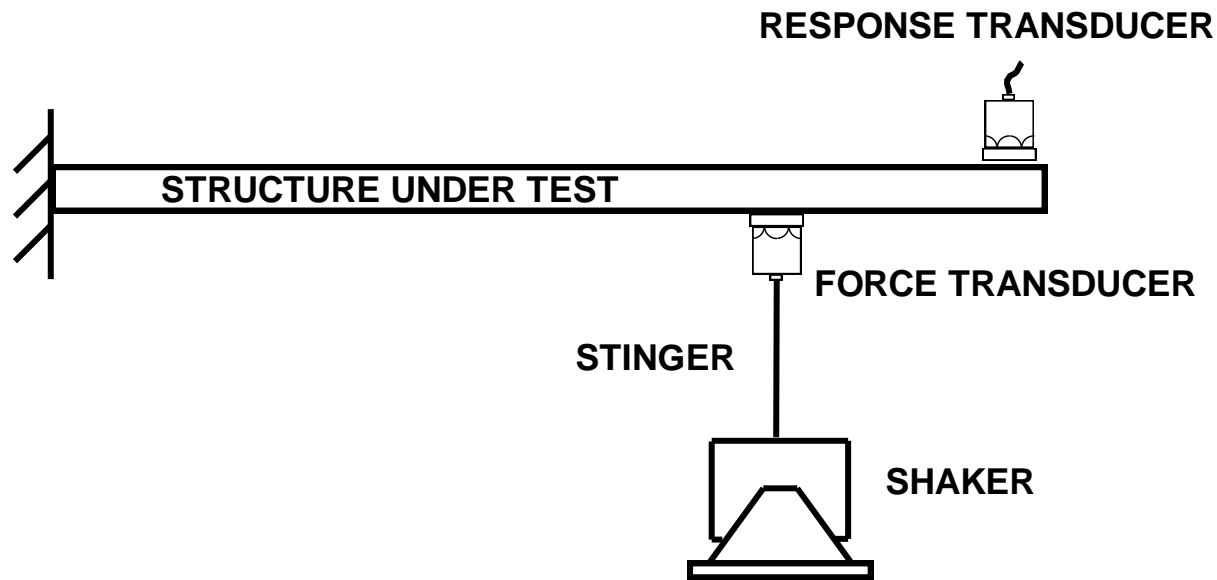




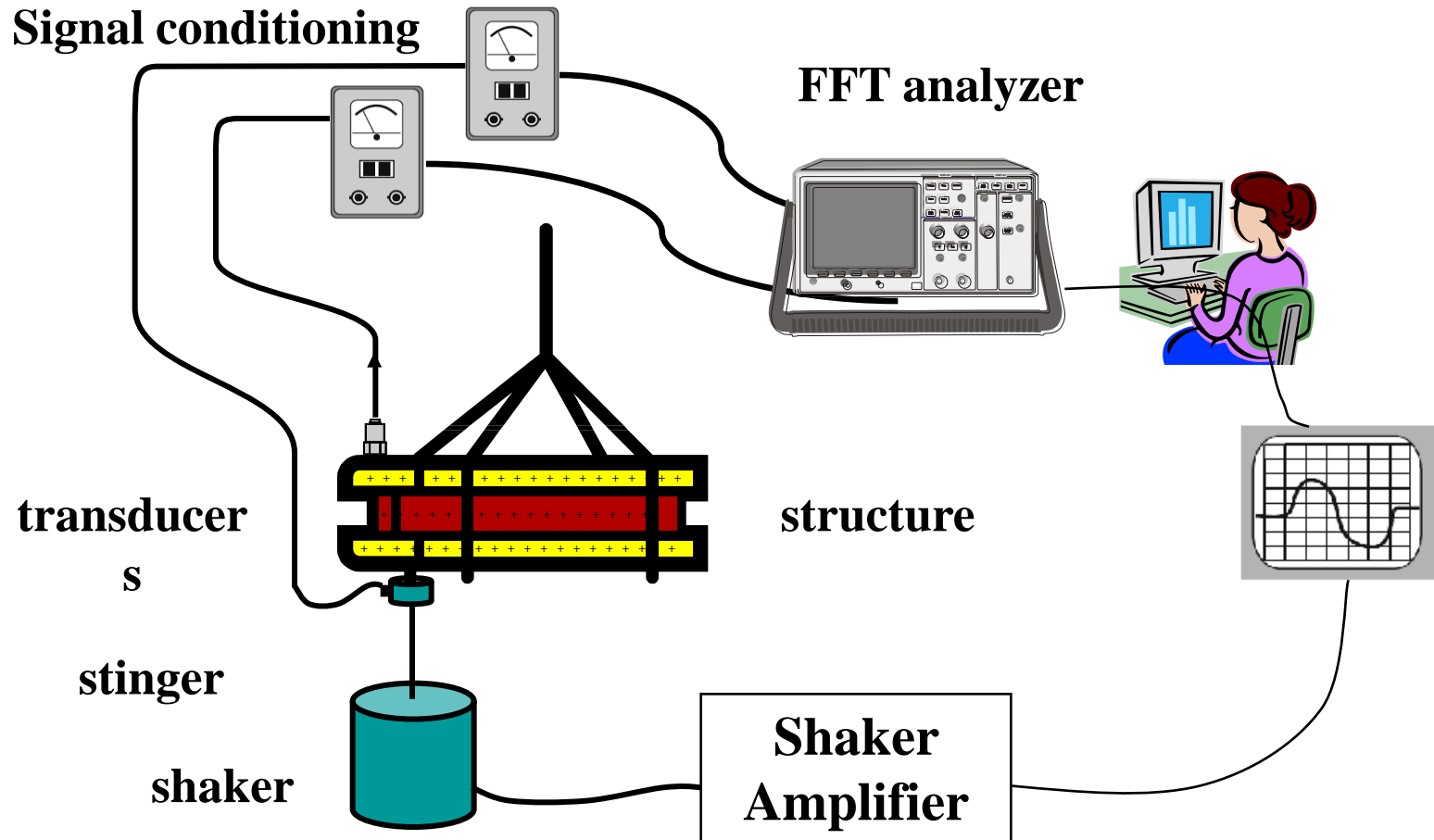
- Impact Testing
  - *Hammer used to apply excitation*
  - *Accelerometers typically used to measure response*
  - *Limited bandwidth – can use different hammer tips*
  - *Difficult to apply consistent excitation*



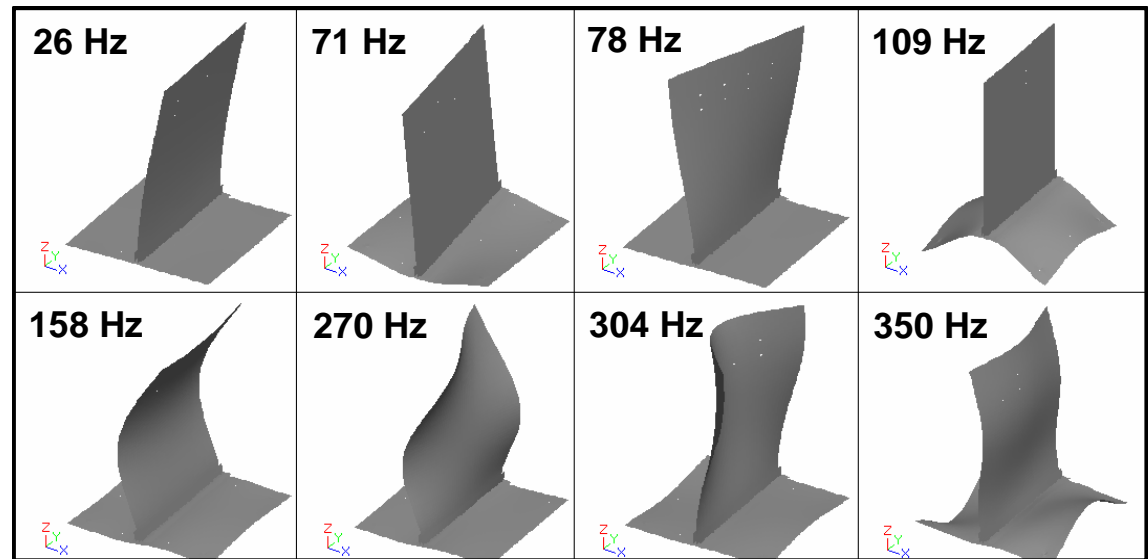
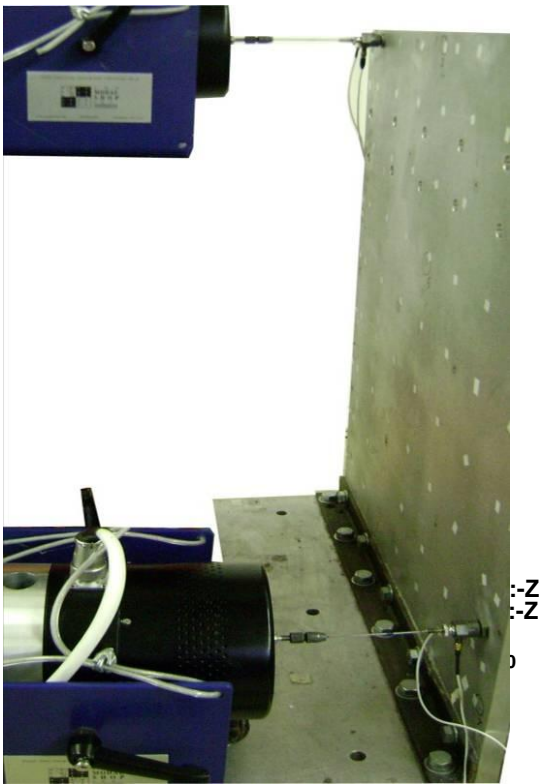
- Shaker Testing
  - *Shaker applies excitation through stinger*
  - *Control on frequency range and force levels*
  - *Able to apply excitation simultaneously at multiple points*
  - *More consistent measurements*



- Typical modal shaker set up



- Example: TMS model T-Plate
  - *Natural frequencies, mode shapes, damping*



- **Noise**
- Calibration & Alarm



If your machine makes  
**Noise**  
you can measure it

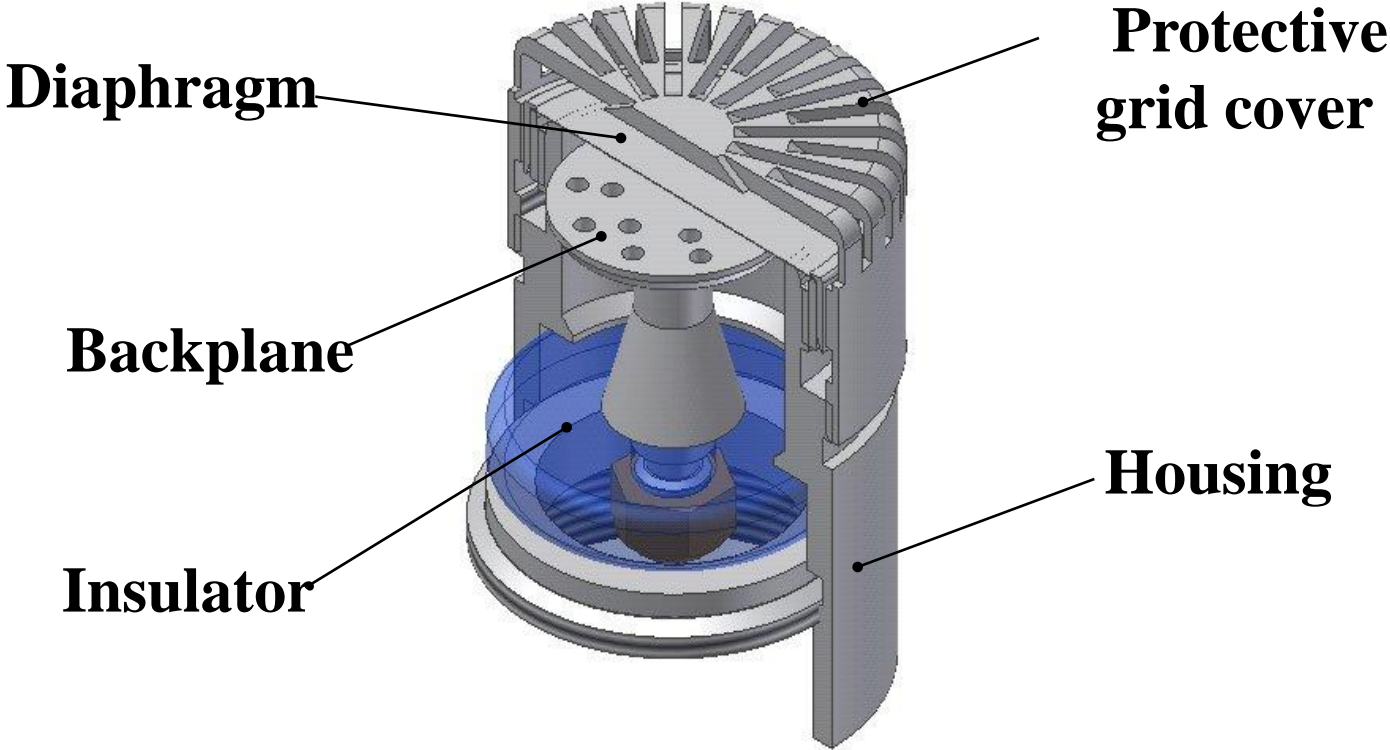




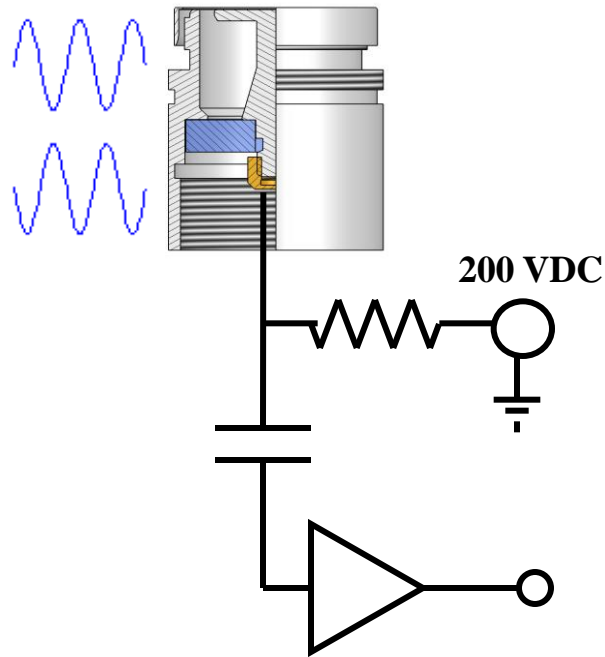
## Microphone

- ¼” microphones industrial application
- 45 mV/Pa nominal sensitivity
- Microphone and preamplifier in one unit
- Low Cost
- ICP®

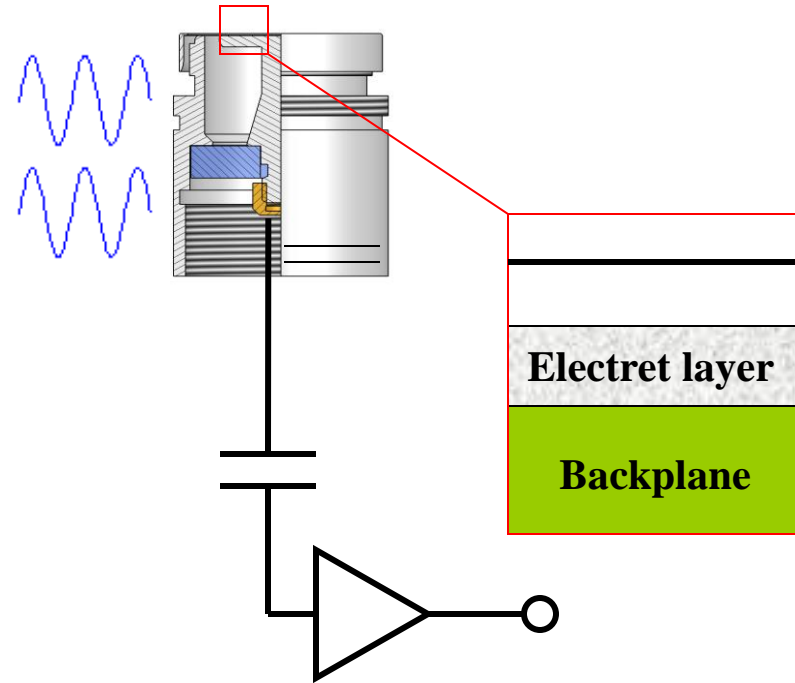




## Externally polarized

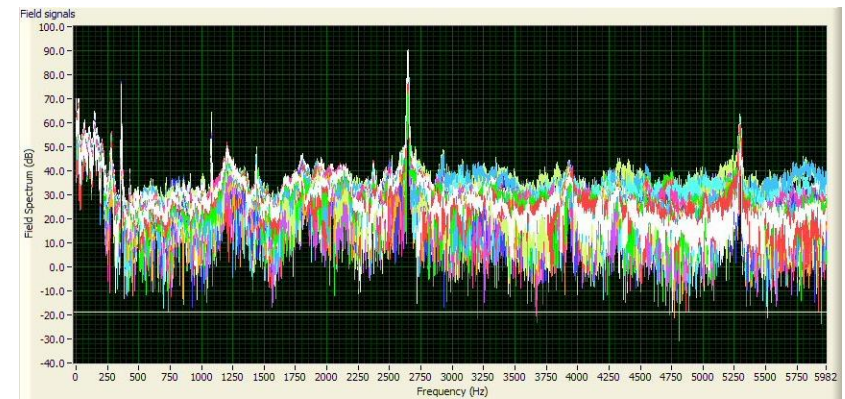


## Prepolarized





## Cross-Correlation of Vibration Signal Vs Noise Signal



- Noise
- **Calibration & Alarm**





- Calibrate
- Check Alarms & alert trip point
  - Verify System Performance
  - Confirms operation of cables

## PERFORMANCE

- From 7Hz to 10kHz
  - From 0g to 10g
    - RMS/peak
- Acceleration/Velocity/Displacement

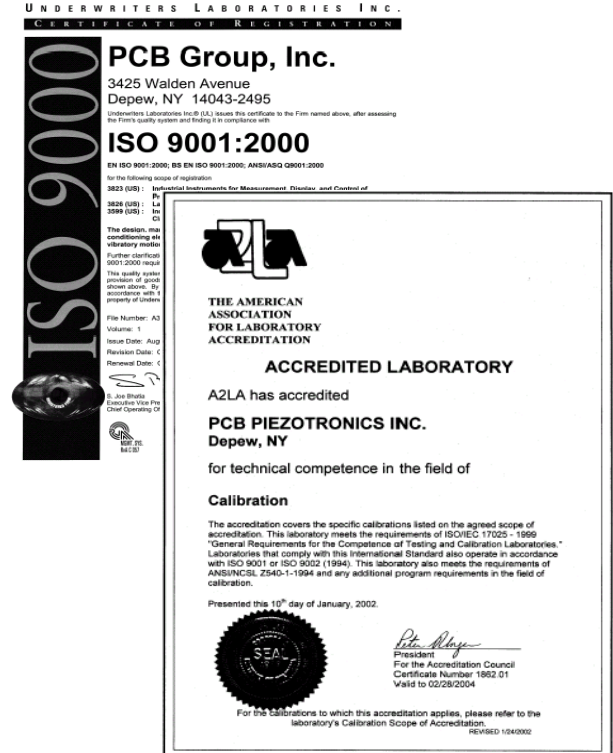
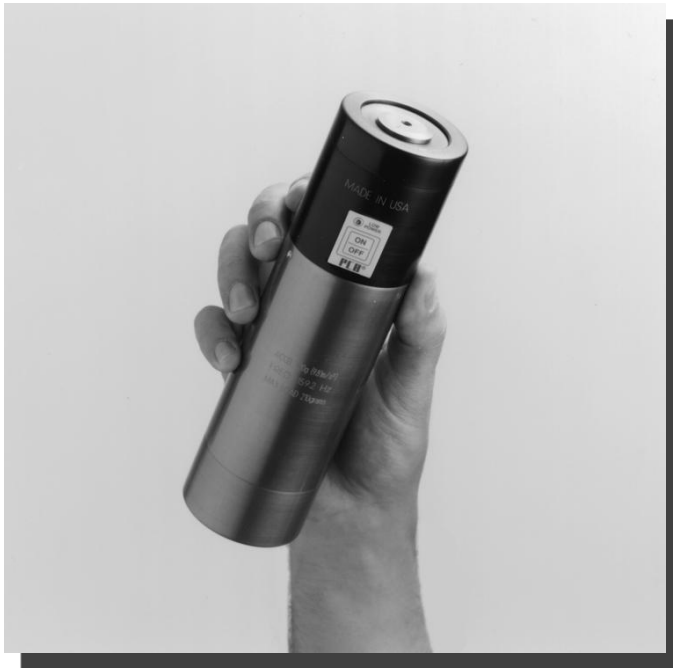
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**We Do!**

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## Portable Handheld Calibrator

- 1g @ 159,2 Hz
- 210 gm. Sensor
- Powered by “alkaline” batteries



- TCS – Total Customer Satisfaction
- Platinum Stock Product – Immediate delivery
- Worldwide Network
- Custom Sensors Program
- 24-hour SensorLine<sup>SM</sup>
- Quality & Certification





Thanks !

**Stefano PRIOLETTA**

**Sales Engineer**

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