Transducers for Data Acquisition and Testing

February 2017

VIBRATION RESEARCH

Meet VR

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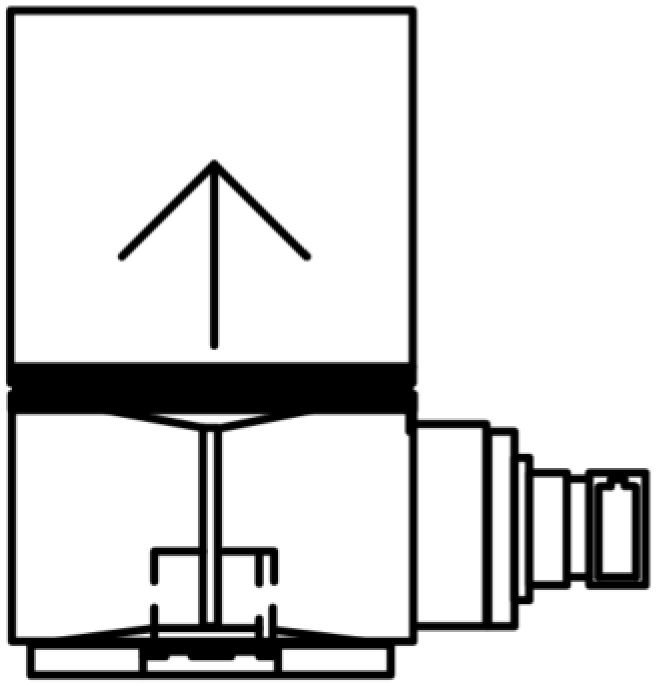
Application Engineer

Introduction

- Accelerometer Construction
- IEPE Supply and T.E.D.S.
- Selecting the right Accelerometer
- Configuring an Input
- Input Settings in VibrationVIEW

Transducer Theory

- Piezoelectric sensors
- Dynamic vs. Static Measurement
- IEPE Designs
- IEPE Transducer Characteristics
- Charge Mode Transducer Characteristics
- Mounting Considerations
- Transducer Selection
- TEDS
- Handling



Transducer Theory

- Why Piezoelectric Sensors?
  - Small Size
  - Lightweight
  - 2-Wire operation (IEPE)
  - Wide Range
    - Dynamic Range
    - Temperature Range
    - Frequency Range
  - Low Noise Floor
  - Simple Signal Conditioning
  - Cost Effective Implementation

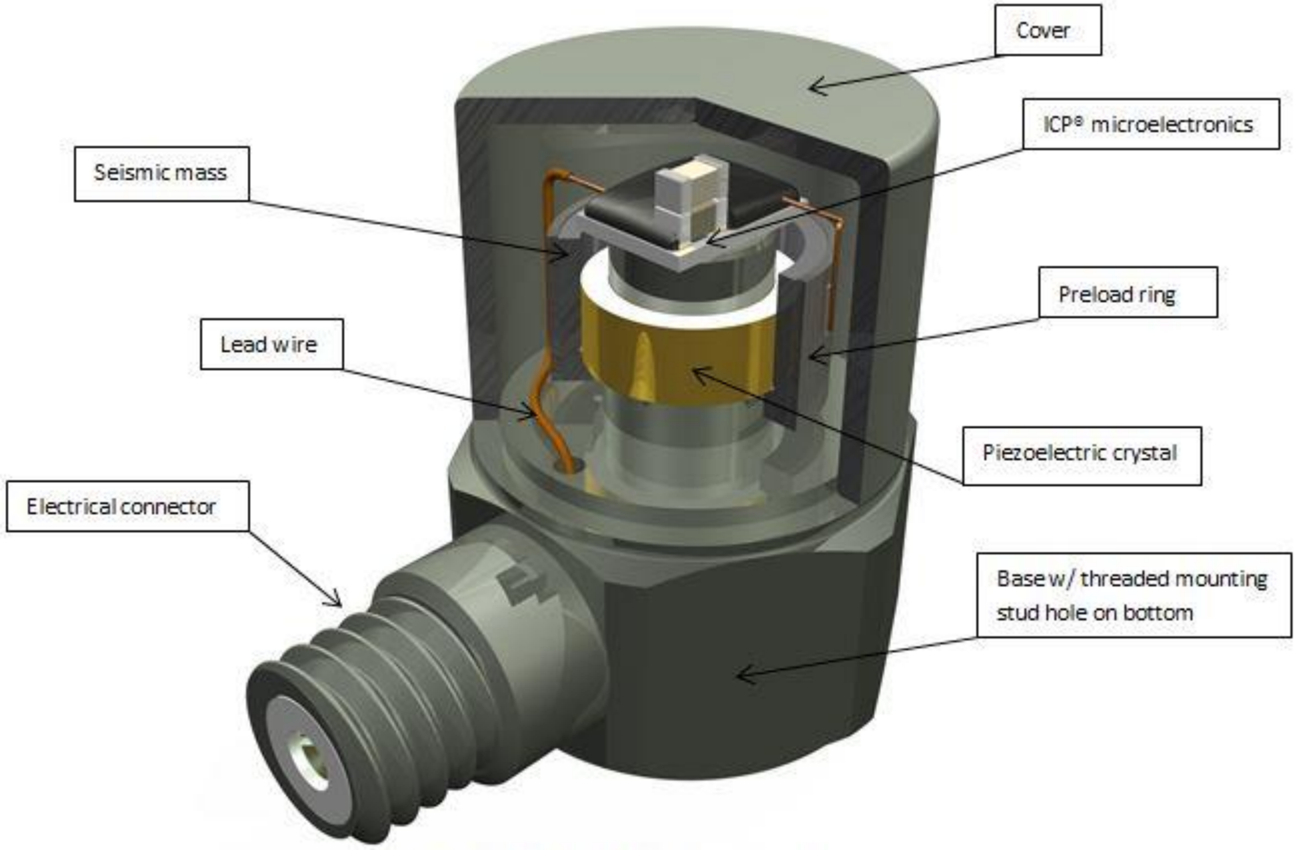


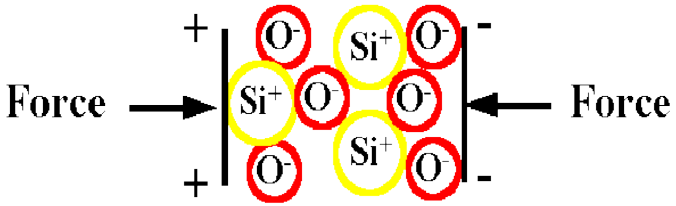
Figure 1: Typical ICP® Accelerometer

Transducer Theory

- Common Testing Environments for Piezoelectric Sensors:
  - Modal Analysis
  - Environmental Stress Screening (ESS)
  - Health and Usage Monitoring Systems (HUMS)
  - Predictive/Preventative Maintenance
  - Pyrotechnic Events
  - Aircraft Flight Monitoring
  - Vibration Testing

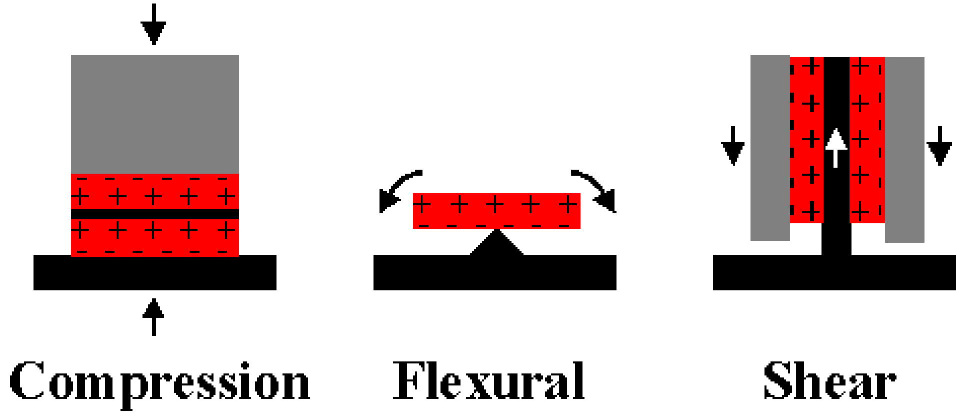
Transducer Theory

- Piezoelectricity
  - Definition:
    - Piezoelectricity is the ability of some materials (notably crystals and some ceramics) to generate an electrical potential in response to applied mechanical stress. This may take the form of a separation of electrical charge across the crystal lattice. If the material is not short-circuited, the applied charge induces a voltage across the material. The word is derived from the Greek word piezien, which means to squeeze or press
  - The crystal converts mechanical energy into electrical energy
  - Types of piezoelectric materials:
    - Quartz, Tourmaline, Ceramic (PZT), GAP04….



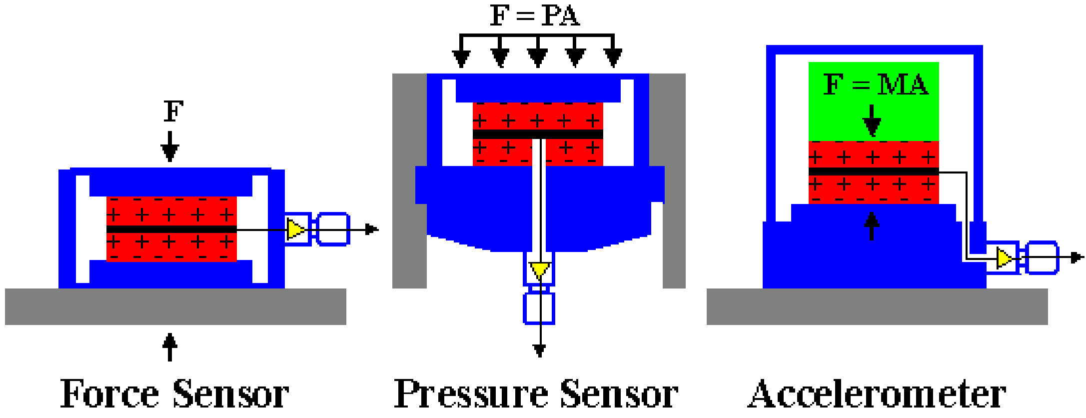
Transducer Theory

- Transducers come in many different sizes and shapes.
- Red → Piezoelectric Crystals
- Grey → Seismic Mass
- Arrows indicate direction of stress
- Shear Configuration
  - Most common for accelerometers
  - Wide frequency range
  - Low off axis sensitivity
  - Low sensitivity to base strain
  - Low sensitivity to thermal input



Transducer Theory

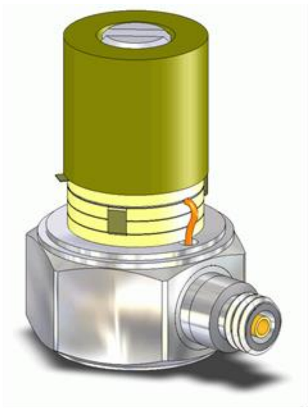
- Force, Pressure and Acceleration
  - Blue → Sensor Housing
  - Red → Piezoelectric Crystals
  - Black → Electrode, where charge builds
  - Yellow → Microcircuit
  - Green → Seismic Mas



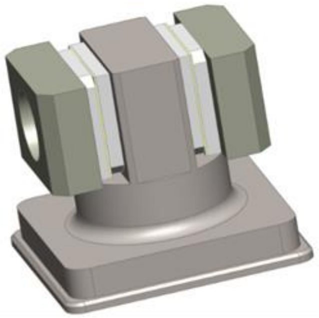
- Seismic mass is forced to follow the motion of the base. Resulting force on the crystals is calculated by Newtons Second Law of Motion: F=MA

Transducer Theory

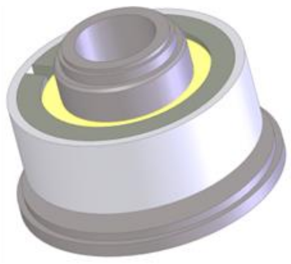
- Piezoelectric Transducers
  - The active element is a piece of piezoelectric material. When compressed a particular voltage output can be measured based on the amount of force being applied to the material.
  - Common types of Piezo Sensors:
    - Voltage Mode (IEPE, LIVM, ICP, Piezotron, Isotron)
    - Charge Mode



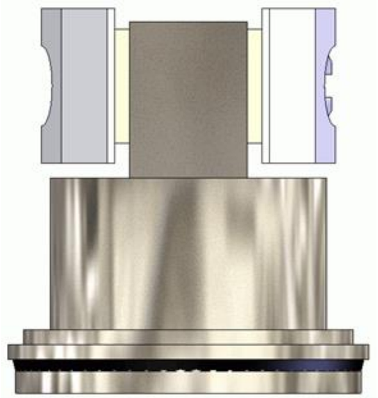
Compression



Planar Shear



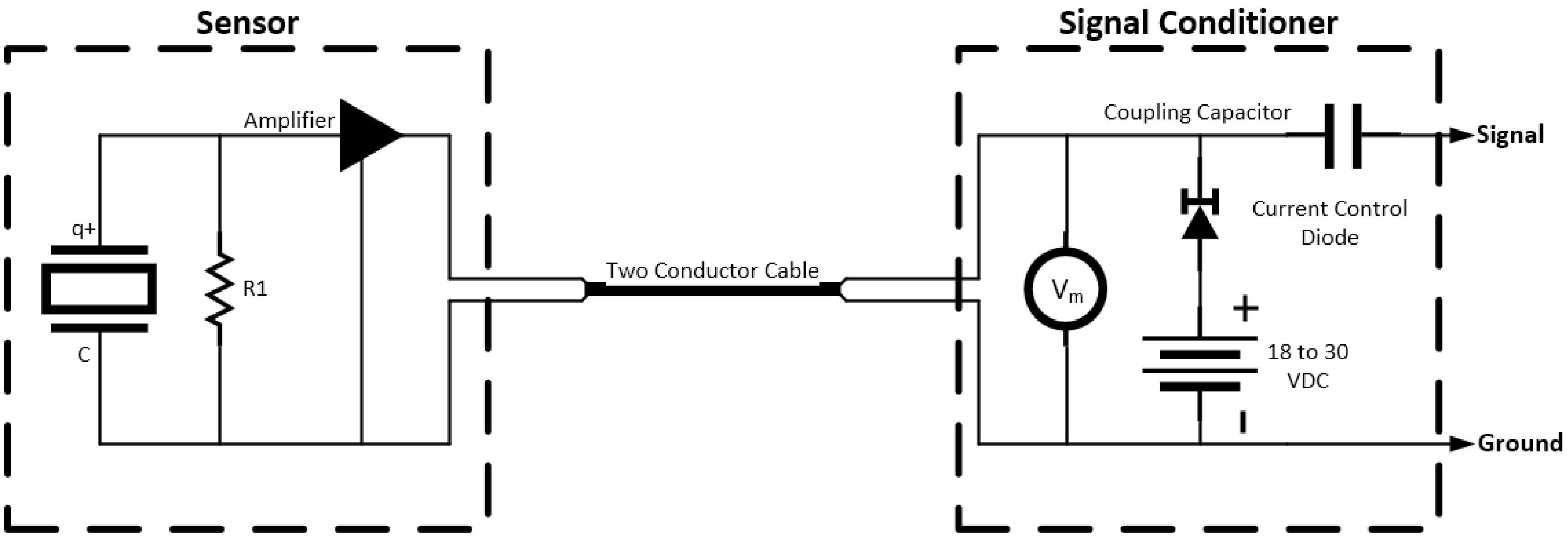
Annular Shear



Shear

Transducer Theory

- IEPE/ICP Power Supply
  - 2 Wire System
  - Common wire for power and signal
  - Additional conductor for signal ground
- Supply Specs
  - 18-30 VDC
  - 2 – 4 mA DC
  - Constant Current supply



Transducer Theory

- Transducer Electronic Data Sheet (TEDS)

Basic TEDS	Manufacturer ID	43 (Accel MFG 123)
	Model Number	7115
	Version Letter	B
	Serial Number	X001891
Standard and Extended TEDS (fields will vary according to transducer type)	Calibration Date	Feb 29, 2016
	Sensitivity @ ref. condition (S ref)	10.123 mV/G
	Physical measurement range	± 500G
	Electrical output range	± 10V
	Reference frequency (F ref)	100.0 Hz
	Quality factor @ Fref (Q)	300 E-3
	Temperature Coefficient	-0.48 %/°C
	Reference temperature	23°C
	Sensitivity direction (x,y,z)	X
User Area	Sensor Location	Strut AB12
	Calibration due date	Feb 28, 2017

Transducer Theory

- Voltage Mode Transducers
  - Utilize some type of quartz or ceramic piezo material
  - Built in Electronics
  - Low Cost Signal Conditioning
  - Limited upper temperature range due to onboard electronics
  - Modern analyzers, DAQ's, and controllers have IEPE power built in
  - Available with TEDS (Transducer Electronic Data Sheet)
  - Easy to configure, connect, and use

DYTRAN INSTRUMENTS, INC.

PCB PIEZOTRONICS INC.

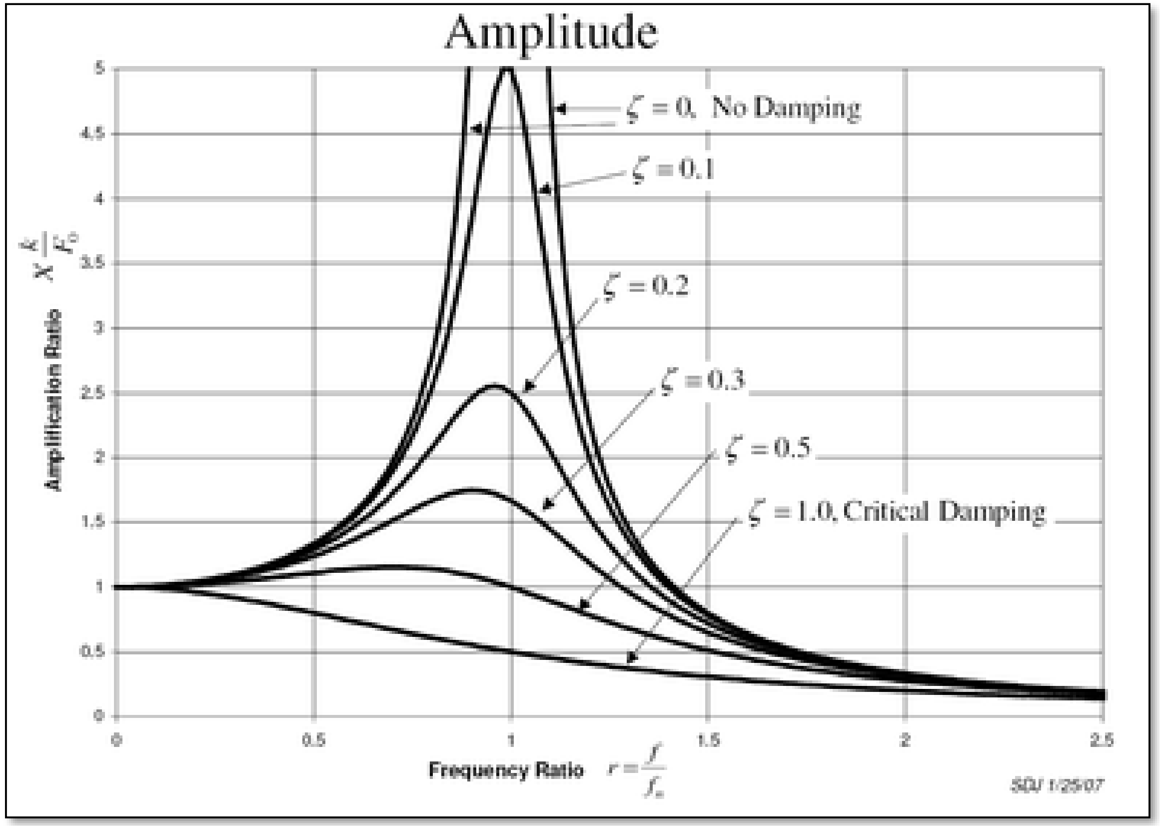
KISTLER measure. analyze. innovate.

DJB Instruments

MEGGITT Endevco

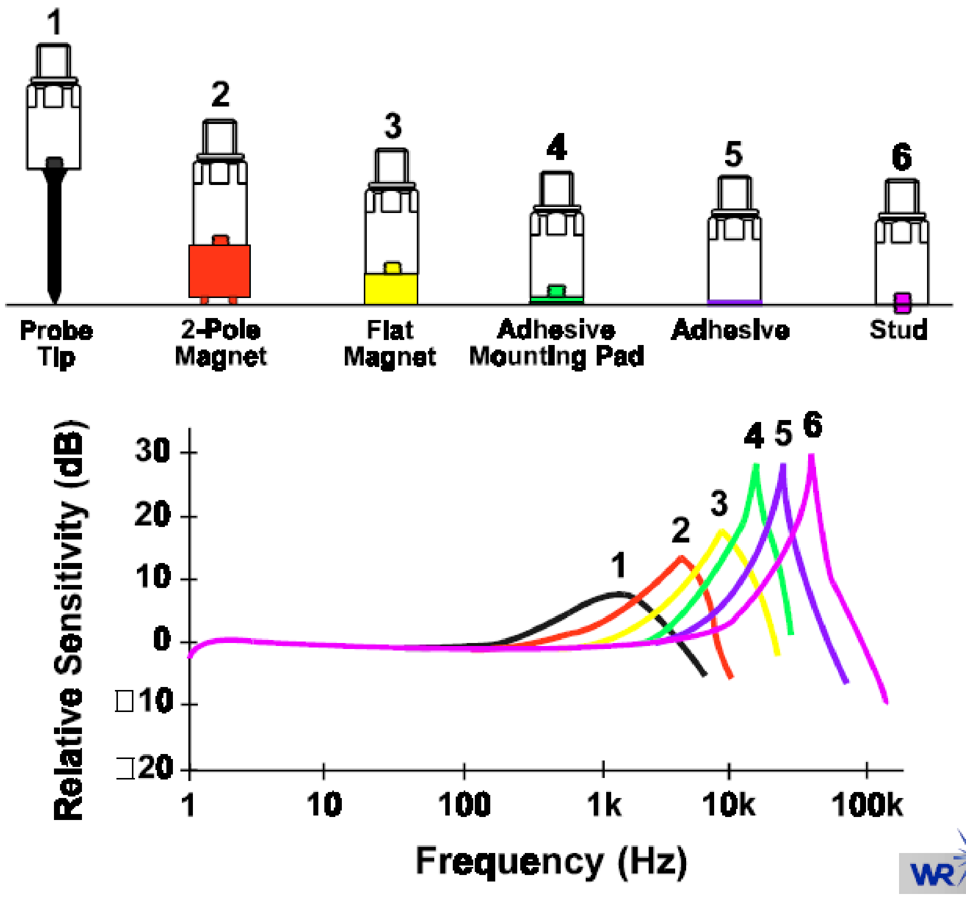
Transducer Theory

- Sensor Resonance
  - Accelerometers are a spring mass system
    - Has a natural resonance
  - When selecting an accelerometer:
    - For Error < 4% ensure the natural frequency is AT LEAST 5x greater than the highest frequency measured
    - For Error < 1% ensure the natural frequency is 10x greater!



Transducer Theory

- Mounting Considerations
  - Probe Tip
  - 2-Pole Magnet
  - Flat Magnet
  - Adhesive Mounting Pad
  - Adhesive
  - Stud



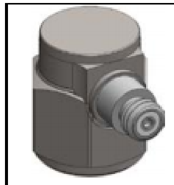
WILCOXON RESEARCH
Precisely what you need

Transducer Theory

- Handling of Transducers
  - Do NOT!:
    - Drop the sensor on the floor
    - Connect a bench power supply to the sensor
    - Remove the sensor with a hammer
    - Use Un-Calibrated Sensors
    - Apply static discharge to accelerometers
  - DO:
    - Store the sensor in the box it came in
    - Connect a constant current supply
    - Remove the sensor using solvent or the proper tool
    - Re-calibrate the sensors
    - Properly ground before handling the sensor

Selecting the Right Accelerometer

- 10mV/G Accelerometer
  - Max Acceleration
- 100 mv/G Accelerometer
- 1000 mv/G Accelerometer

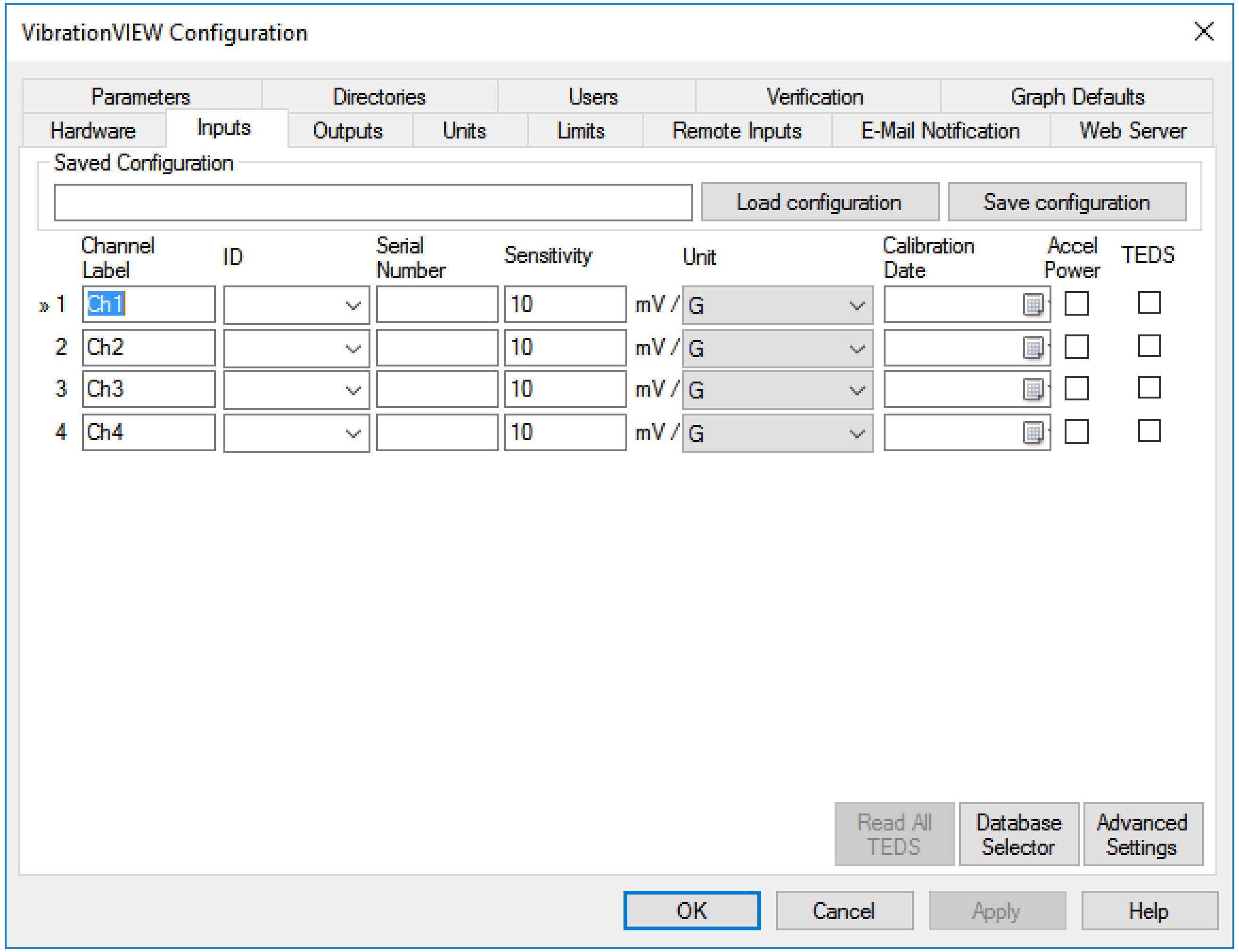


- HERMETICALLY SEALED
- BASE ISOLATED
- IDEAL LOW FREQUENCY RESPONSE
- TEDS

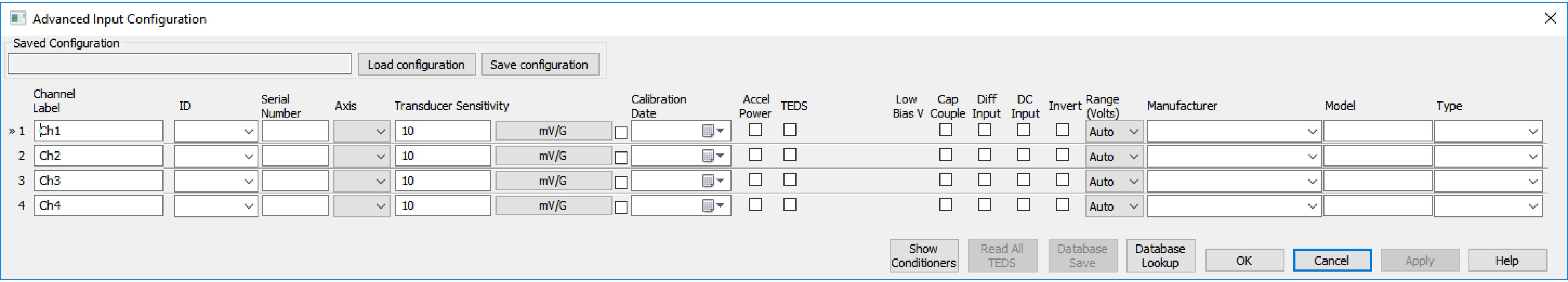
		ENGLISH		SI	
PHYSICAL					
Weight		0.35	oz	10	grams
Connector	Type	10-32		10-32	
Mounting Provision	Tapped Hole	10-32 X .150 ↓		10-32 X .150 ↓	
Material, Housing/Connector		Titanium		Titanium	
Sensing Element		Ceramic		Ceramic	
Element Style		Planar Shear		Planar Shear	
PERFORMANCE					
Sensitivity, ± 5% [1]		10	mV/g	1	$mV/m/s^2$
Range for ± 5 Volts Output		500	g	4905	m/s^2
Frequency Response, ± 10%		1 to 10000	Hz	1 to 10000	Hz
Resonant Frequency		> 32	kHz	> 32	kHz
Broad Band Resolution		0.0040	Grms	0.039	m/s^2 rms
Linearity [2]		± 1	% F.S.	± 1	% F.S.
Maximum Transverse sensitivity		5	%	5	%
Strain Sensitivity @ 250με		0.002	g/με	0.02	$m/s^2/\mu\varepsilon$
ENVIRONMENTAL					
Maximum Vibration		600	Gpeak	5886	m/s^2 peak
Maximum Shock		3000	Gpeak	29430	m/s^2 peak
Operating Temperature Range		-60 to +250	°F	-51 to 121	°C
TEDS Operating Temperature		-40 to +185	°F	-40 to +85	°C
Seal		Hermetic		Hermetic	
ELECTRICAL					
Supply Current Range [3]		2 to 20	mA	2 to 20	mA
Compliance Voltage Range		18 to +30	Volts	18 to +30	Volts
Output Impedence,Typ		20	Ω	20	Ω
Bias Voltage		11 to 13	VDC	11 to 13	VDC
Discharge Time Constant		0.5 to 1.5	Sec	0.5 to 1.5	Sec
Electrical Isolation		10	GΩ,min	10	GΩ,min
TEDS		IEEE 1451.4		IEEE 1451.4	

VIBRATION RESEARCH

Input Configuration



Input Settings in VibrationVIEW



Conclusion

- Questions?

- If you want the slides or want to ask questions at a later time, please email in to vrsales@vibrationresearch.com or feel free to call in at 616-669-3028

- Thanks!