FLUKE®
Reliability

Wireless Sensor - MEMs Accelerometer Basics

Meet the Speaker

Steven Hudson

Director, Professional Services (2018-Present)

- Remote Vibration Analysis/Reporting
- Reciprocating Compressor Analysis
- Startup / Field Services

Background:

- 35 years in Predictive Maintenance
- ISO Cat IV Vibration Analyst
- Naval Nuclear Power (Submarines)

Joined Symphony Industrial in 2010

Roles:

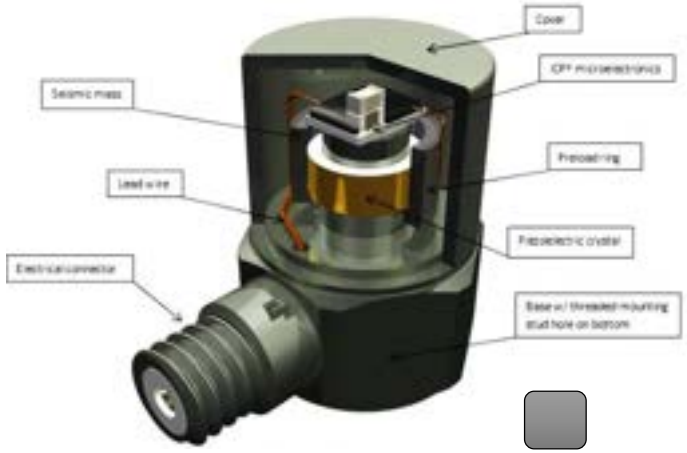
- Chief Analyst
- Strategic Account Manager / Technical Sales
- Operations

Wireless Sensor - MEMs Accelerometer Basics

This topic will discuss the use and utility of MEM's sensors for vibration analysis. It will compare attributes of legacy Piezo electric sensors vs MEM's including how each works and strengths & weakness of each. We discuss how we can leverage the MEM's sensor in a wireless sensor package and what results we see in using MEM's for impact detection.

Accelerometers

PIEZOELECTRIC ACCEL



VS

MEMS ACCEL

☐	COST	☑
☑	HIGH FREQUENCY	☐
☐	LOW FREQUENCY	☑
☑	AMPLITUDE RANGE	☐
☑	FLEXIBLE PLATFORM	☐
☐	SIMPLE PLATFORM	☑

Legacy Azima Systems use Piezo-Electric Sensors

Piezo-Electric Accelerometer

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Piezoelectricity:

The ability of a crystalline material to develop electric charge in response to the applied mechanical stress and vice-versa.

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Piezo Electric Accelerometer

Benchmark Technology

Direct Measure of Force

Pro’s

- High Dynamic Range
- Wide Frequency Range

Con’s

- Requires Unique Power Supply
- Requires Separate Signal Processing
- Requires Separate ADC
- Low Output At Low Frequency

DEFINITION: ADC = Analog to Digital Converter

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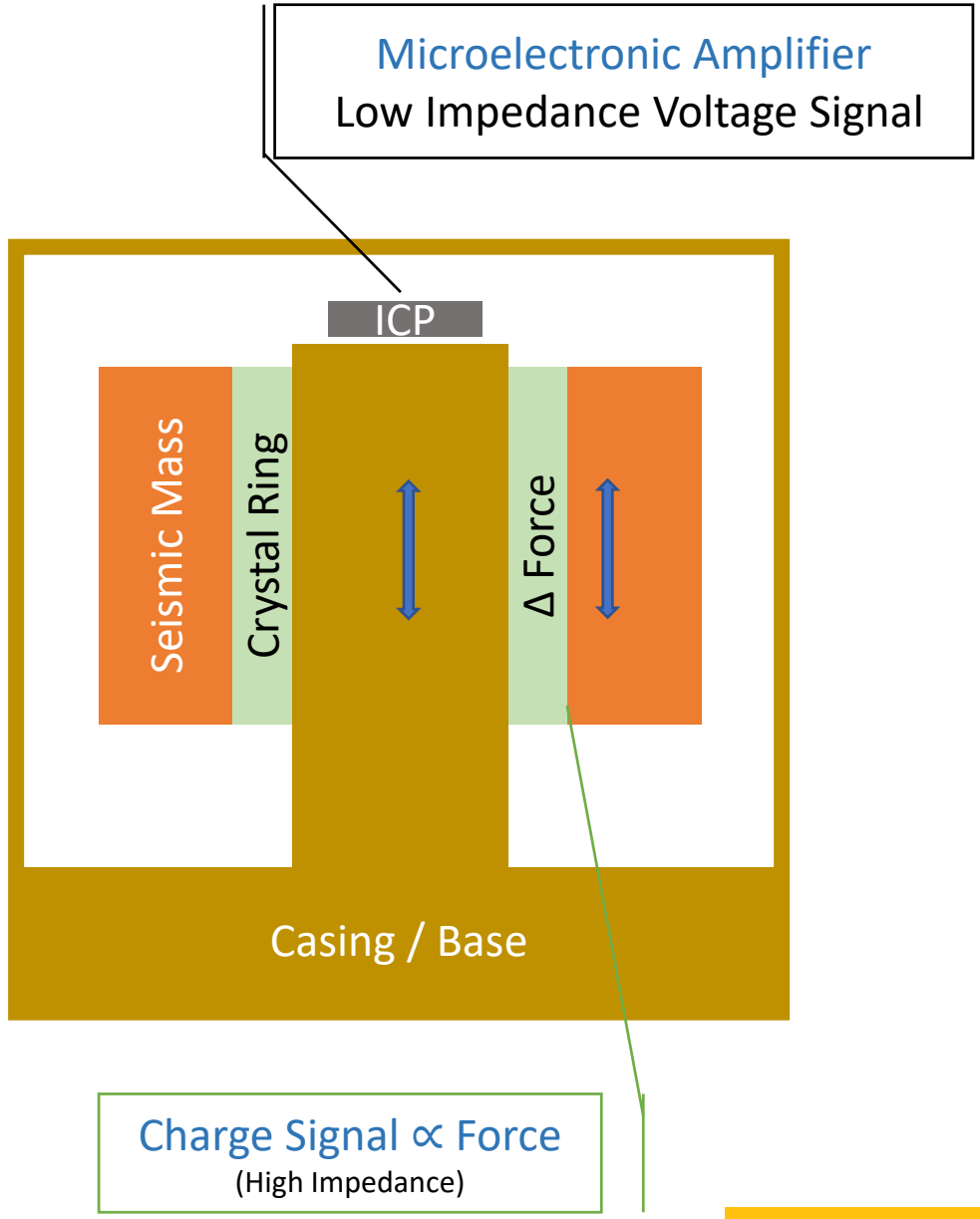
Piezo Electric Accelerometer

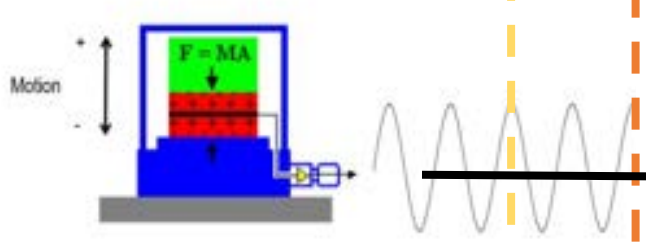
- Piezo Electric Affect of Crystalline Element

- ΔVoltage ∝ ΔForce
- F=MA (known mass)
  - Shear Mode / Compression Mode
    - (Shear Mode Shown)
  - Seismic Mass Supported By Crystal
  - Sensing Element Is Rigid
  - Varying Stress Across Crystal Creates Varying Charge
  - Converted To Analog Voltage By Amplifier
  - Requires External Signal Processing And Digitization

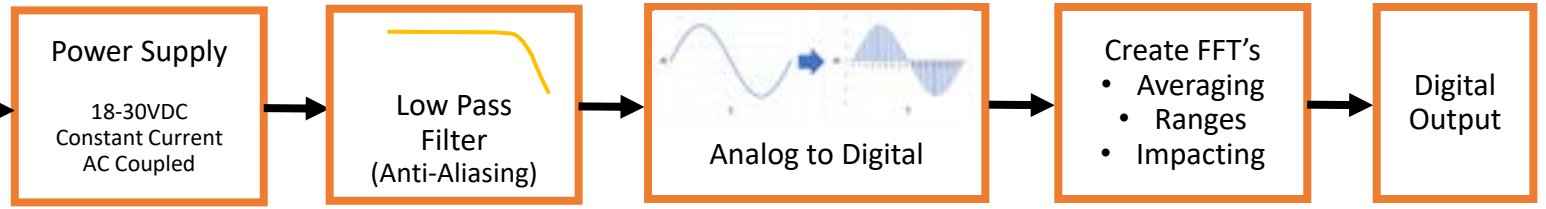


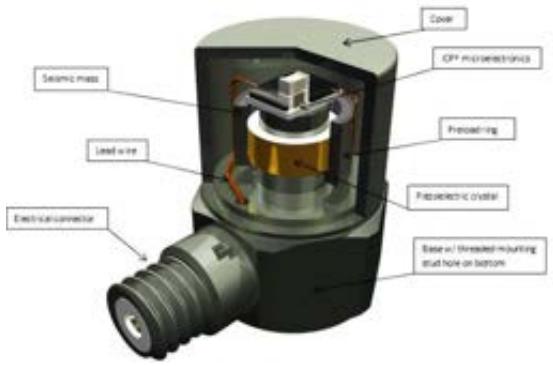
Example Signal Path

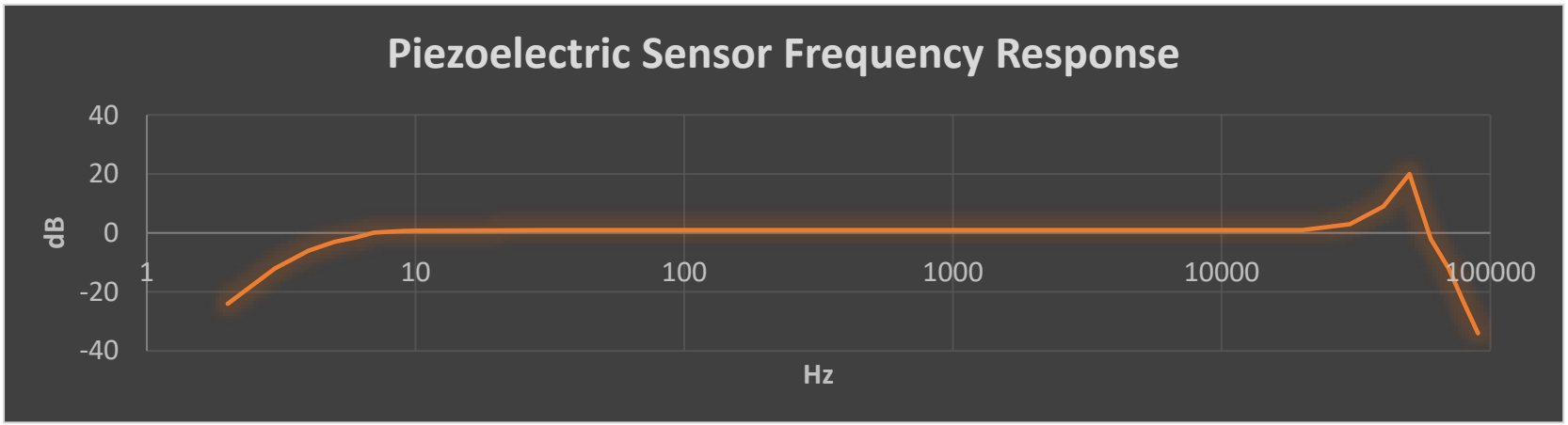
Sensor



Signal Path (1CH) / Analyzer

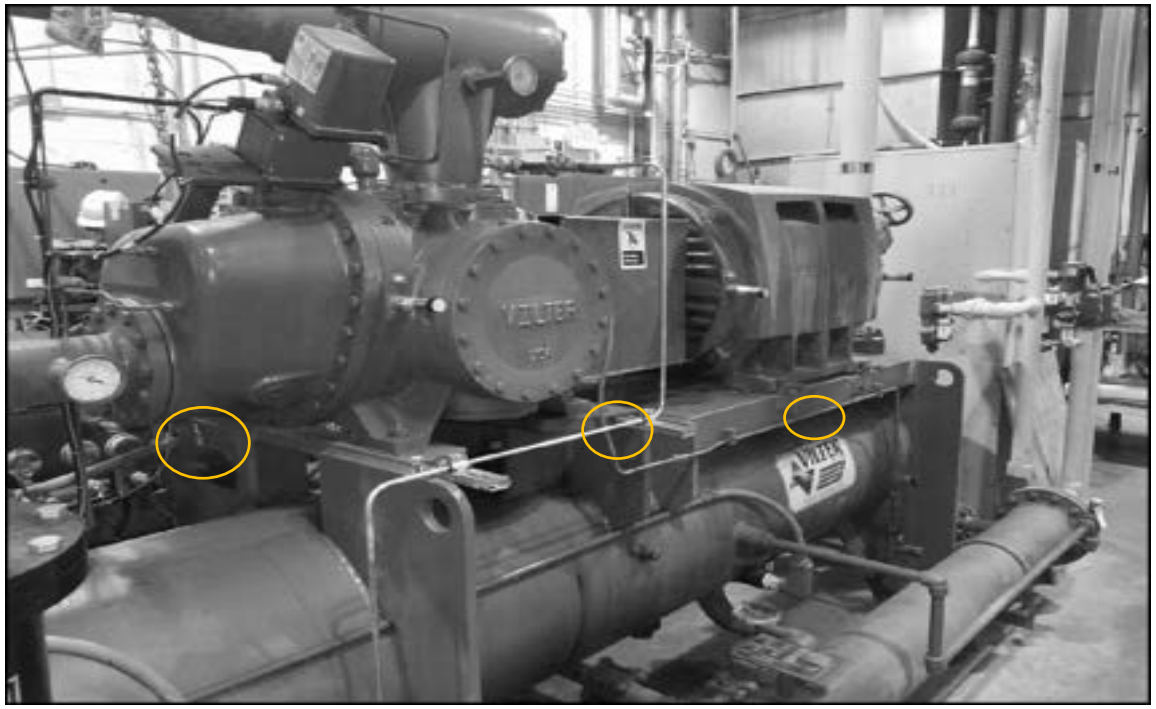






Watchman AIR™

Uses MEMS Accelerometer Technology



✓Supports Expert Automated Diagnostic System

- High resolution, high sampling rate, Impact Demod™

✓ Supports frequent data collection

- Sustain 3-year battery guarantee

✓ Easy to setup, easy to train

- Simple configuration, plus mesh

✓ Various network options

- IT approved

✓ Affordable at scale

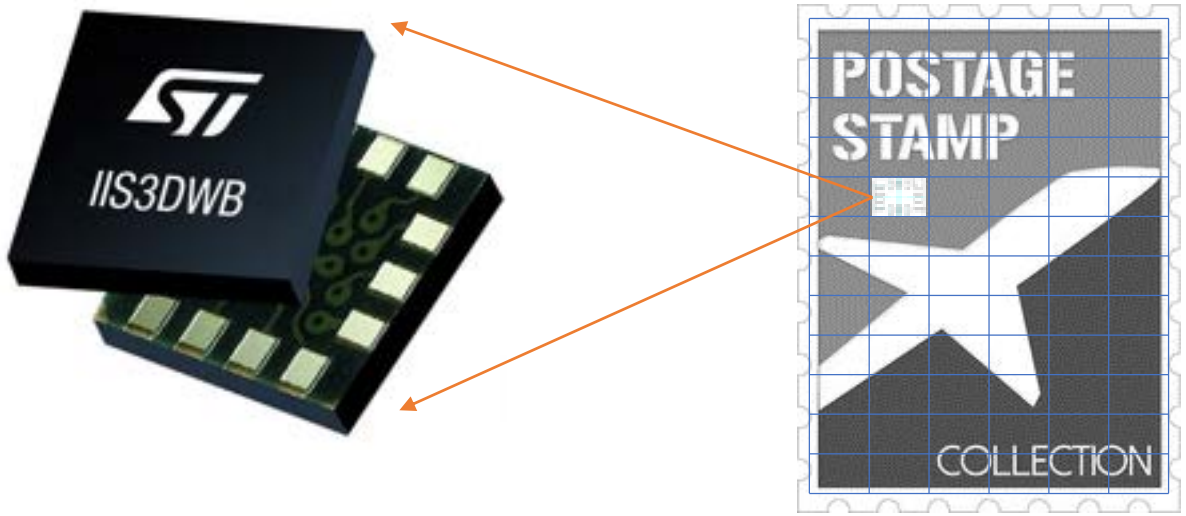
- Finance approved

MEMs Accelerometer

Micro Electro-Mechanical System

System-in-Package / Triaxial Accel / Digital Output

Tiny Microchip
72 on stamp

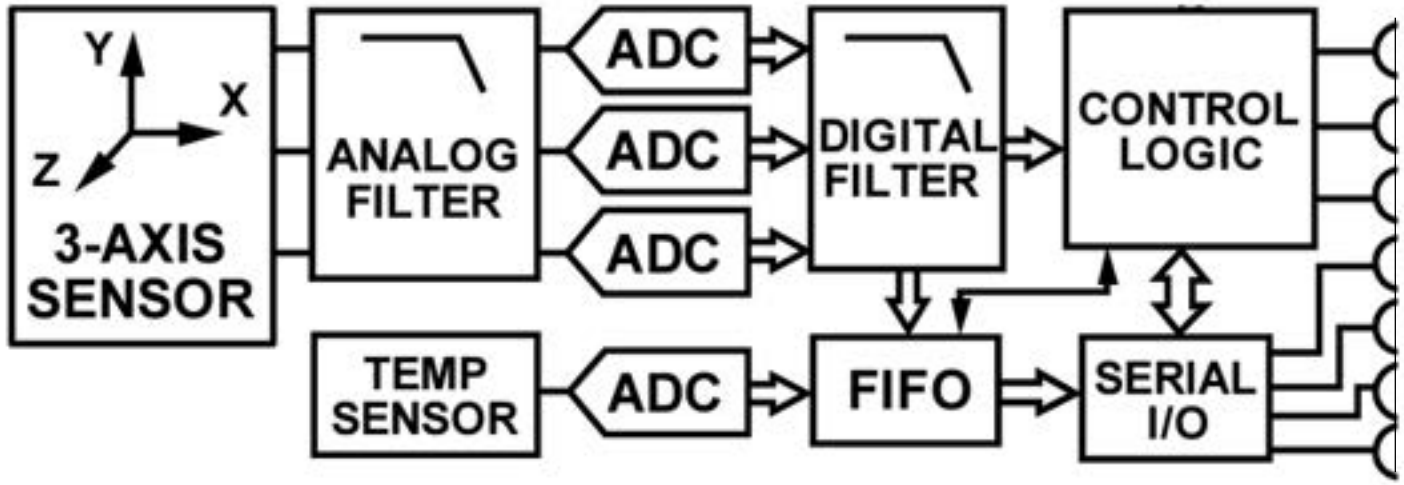


MEMs Accelerometer

Sensor, Signal Processing, ADC, Buffer, Logic

Pro's

- Compact
- Low Power
- Low Cost
- DC Coupled (0Hz)



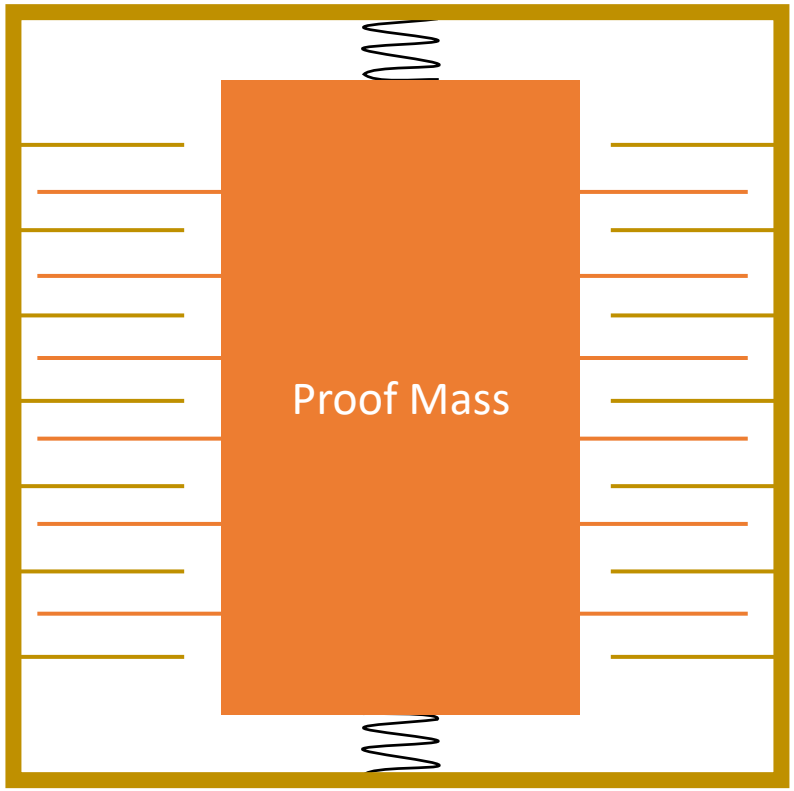
Con's

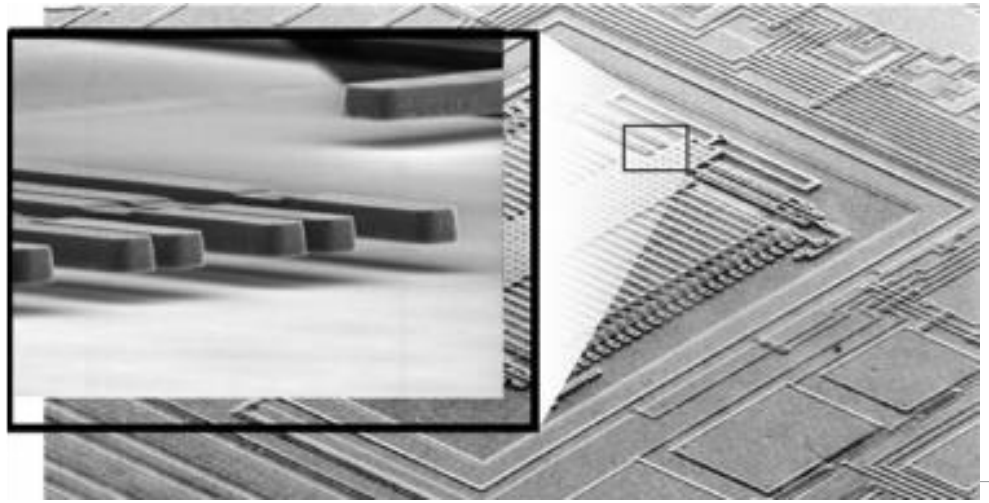
- Limited Bandwidth
- Limited Amplitude Range (often)

MEMs Acceleration Sensor

Variable Capacitance of Moving Proof Mass

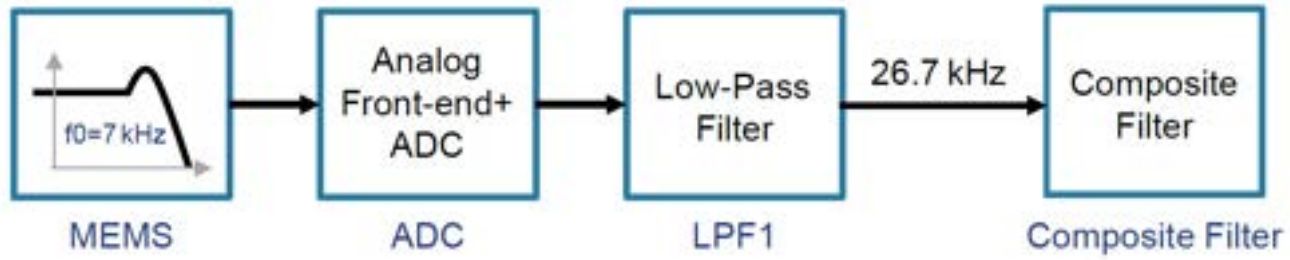
- ΔCapacitance ∝ ΔAcceleration
  - Comb Fingers create Variable Capacitor
  - Proof Mass Spring Supported
  - Displacement of Proof Mass Varies Finger Capacitance

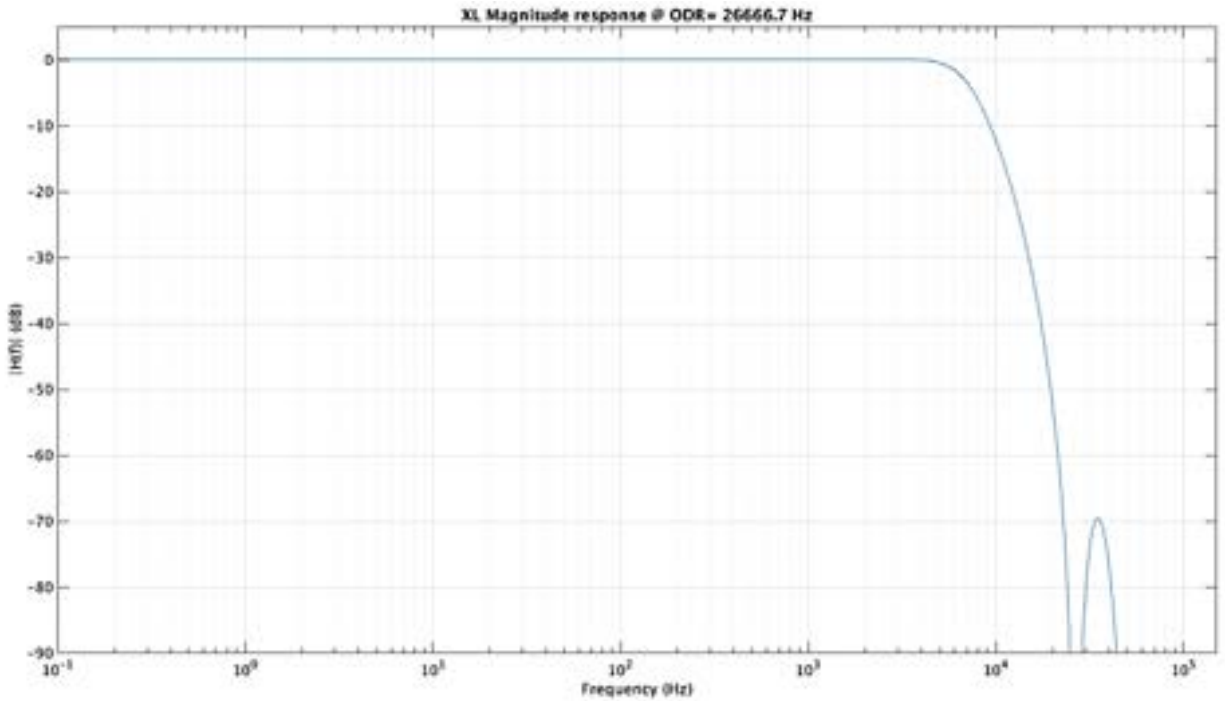




Accelerometer Performance

Filter Chain





PIEZO ACCEL

MEMS ACCEL

VS

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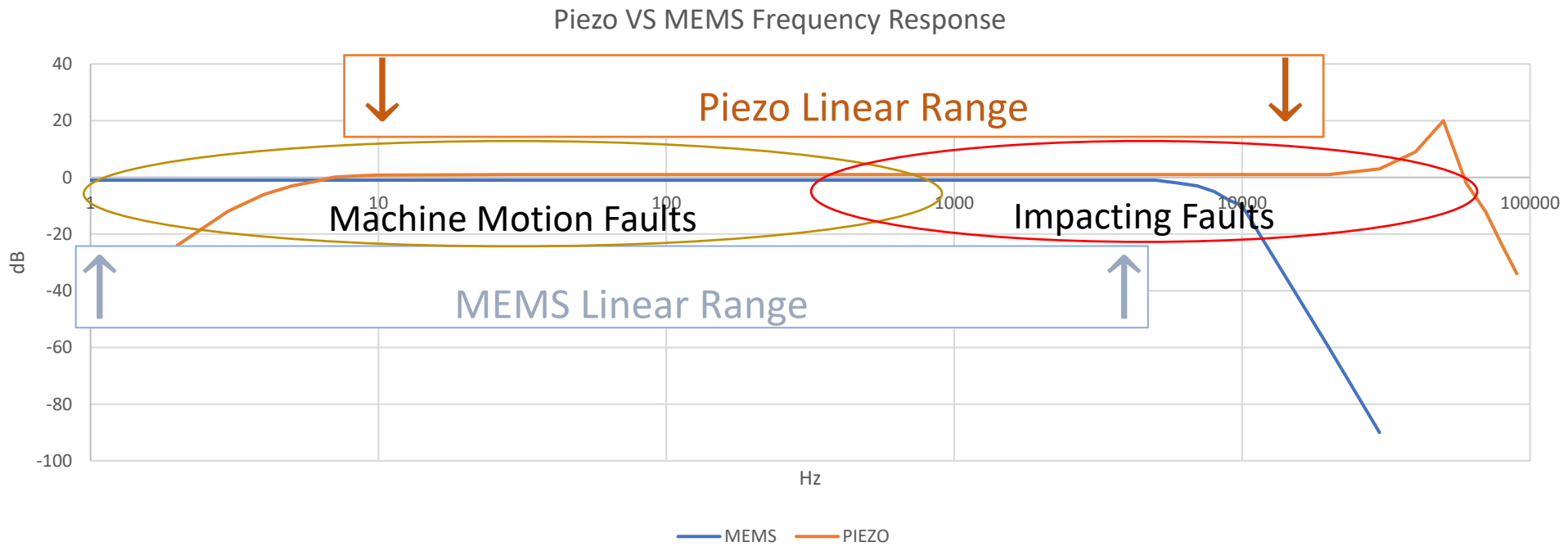
PIEZO

VS

MEMS



Low Speed and Wireless

Question:

If MEMs sensor goes down to Zero RPM, why do you limit your wireless sensor to 600 RPM and above machines?

Simple Answer:

Battery Life

FLUKE Reliability

Example Data Set

Best practice

Sample for 15 revolutions

4 averages +50% overlap

600 RPM Example

1 Test = 4.25 Sec producing 113,000 Samples

Battery life ~ 3 yr.

12 RPM Example

1 Test = 188 Sec producing 4,800,000 Samples

Battery life ~ 45 days

Asset Applicability

Common Identifiable Fault Types	1kHz Wireless	2kHz Wireless	Wireless Accel 310	Portable TRIO	Online SPRITE
Rotating Looseness	Limited	Yes	Yes	Yes	Yes
Soft Foot / Mounting Flexibility	Yes	Yes	Yes	Yes	Yes
Imbalance	Yes	Yes	Yes	Yes	Yes
Angular / Parallel Misalignment	Yes	Yes	Yes	Yes	Yes
Belt Faults	Yes	Yes	Yes	Yes	Yes
Sheaves Faults	Yes	Yes	Yes	Yes	Yes
Late Stage Bearing Wear	Yes	Yes	Yes	Yes	Yes
Early Stage Bearing Wear - Spectrum	No	Limited	Yes	Better	Best
Early Stage Ball Bearing Wear - Impact Demod	No	No	Yes	Better	Best
Impeller Vane Faults	Limited	Limited	Yes	Yes	Yes
Axial Flow Propellor Faults	Limited	Limited	Yes	Yes	Yes
Rotary Gear / Screw / Thread Faults	No	Limited	Yes	Yes	Yes
Fan Blade Faults	Limited	Limited	Yes	Yes	Yes
Blower Lobe Faults	No	Limited	Yes	Yes	Yes
Compressor Piston Faults	No	No	Yes	Yes	Yes
Compressor Screw Faults	No	No	Yes	Yes	Yes
VFD Motor Faults	No	No	Most	Yes	Yes
Motor Rotor Bar Faults	No	Limited	Most	Yes	Yes
Gearbox Faults	No	No	Most	Yes	Yes
Journal Bearing Faults	No	No	Most	Most	Most
Centrifugal (Centac) Compressor Faults	No	No	Limited	Better	Best
High-speed Gear Mesh Faults	No	No	Limited	Better	Best
Turbines	No	No	Limited	Better	Best
Turbochargers	No	No	No	Yes	Yes
Expanders	No	No	No	Yes	Yes
Conveyors	No	No	No	Yes	Yes
Slow Speed Shaft Faults, 60-350 RPM	No	No	No	Yes	Yes
Slow Speed Shaft Faults, 5-60 RPM	No	No	No	No	Yes

- 6.3kHz - 10kHz Fmax
- 26.7kHz sample rate
- +/-16g input range
- 1,600 lines of resolution
- 110,000 sample buffer

- 40kHz Fmax
- 102.4kHz sample rate
- 100g (w/ 100mV/g sensor)
- 25,600 lines of resolution
- 525,000 sample buffer

- 40kHz Fmax
- 102.4kHz sample rate
- 100g (w/ 100mV/g sensor)
- 51,200 lines of resolution
- >14M sample buffer

Piezoelectric

Portable, Manual Acquisition

TRIO – DP-2

- 4 simultaneous channels

Largest asset coverage

- All accessible, industrial, rotating assets

Tech Specs:

- 40kHz Fmax
- 102.4kHz sample rate
- 100g (w/ 100mV/g sensor)
- 25,600 lines of resolution

Permanent, Auto Acquisition

Online i110 / i120

- 16 multiplexed or 8+8 simultaneous channels

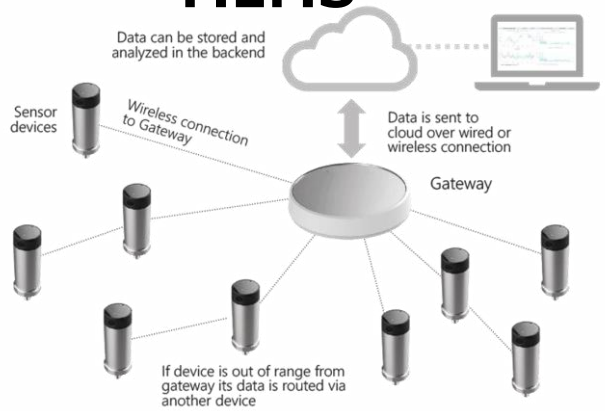
Monitoring down to 5 RPM

- Paper & metals machinery
- Slow speed gearboxes

Tech Specs:

- 40kHz Fmax
- 102.4kHz sample rate
- 100g (w/ 100mV/g sensor)
- 51,200 lines of resolution
- >14M sample buffer
- Wireless or wired

MEMS



Permanent, Fully Wireless

Wireless Accel™ 310

- Hi-res, triaxial + temp

Most connected program

- Most common, industrial rotating assets
- Continuous running assets

Tech Specs:

- 6.3kHz - 10kHz Fmax
- 26.7kHz sample rate
- +/-16g input range
- 1,600 lines of resolution
- 3-year battery, fixed
- Mesh + gateway

FLUKE Reliability

QUESTIONS ?

THANK YOU!