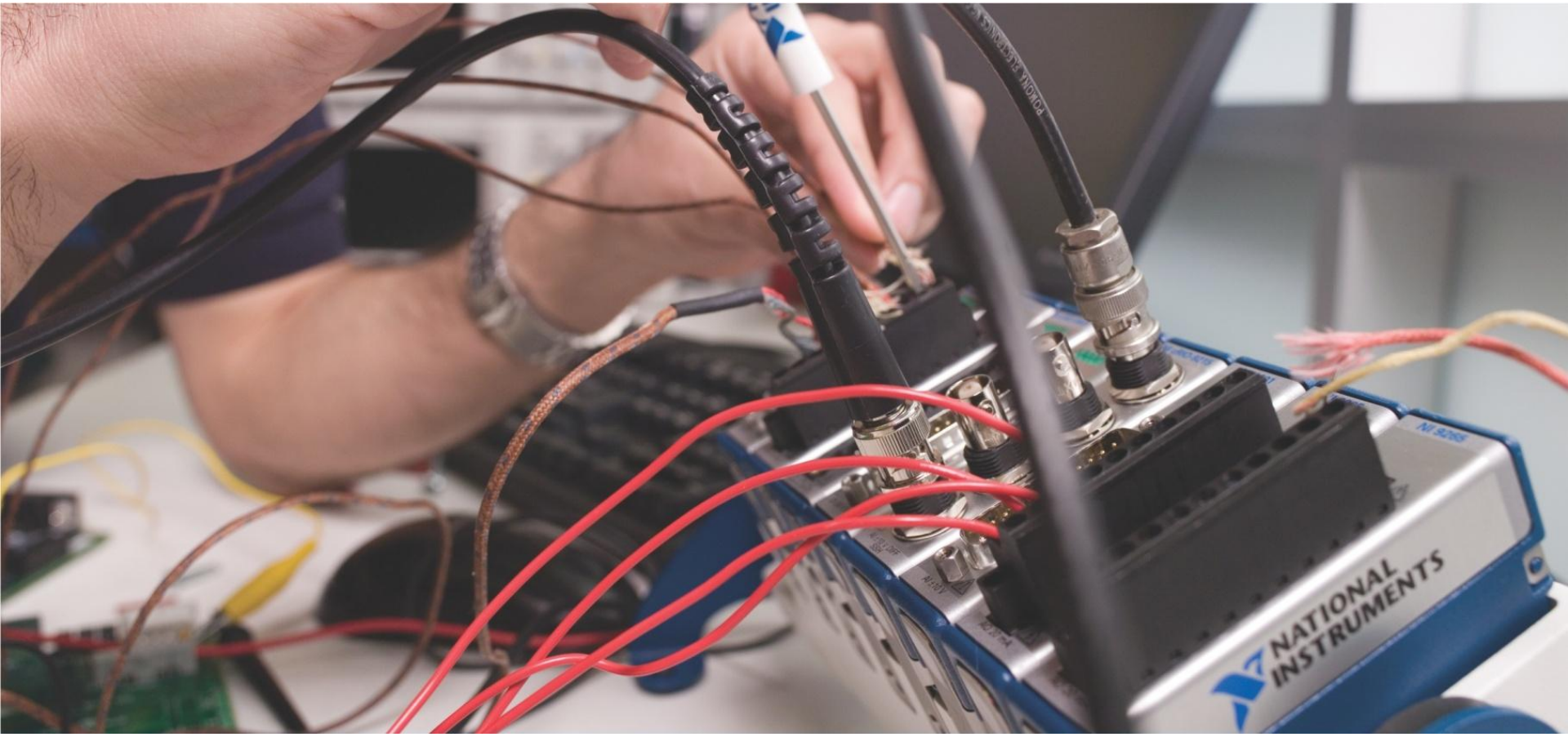


Sensor Measurement Fundamentals Series

Vibration Measurements

Doug Farrell

Product Manager

National Instruments

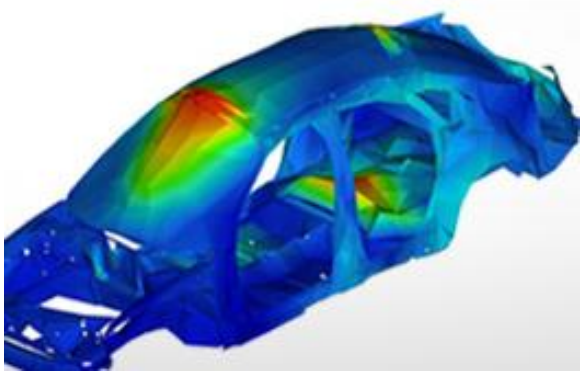
NATIONAL INSTRUMENTS

Key takeaways

- Vibration fundamentals
- Vibration sensors
- Data acquisition system requirements
- Signal processing techniques
- NI's vibration solution

Why measure vibration?

Machine Health



Noise and Vibration

Structural Health

Vibration applications

Engine NVH

Consumer Electronic Test

Road Dynamometer

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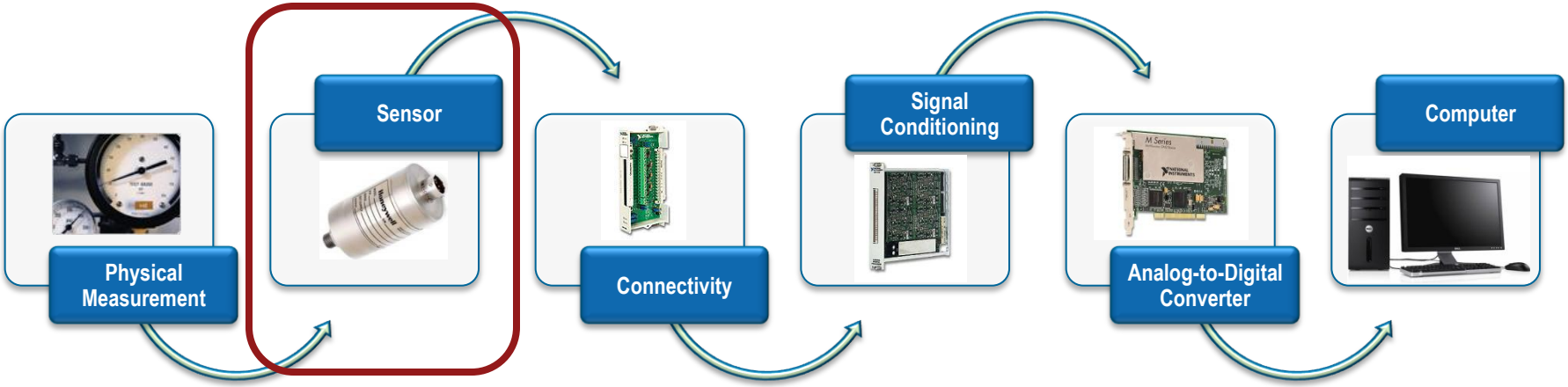
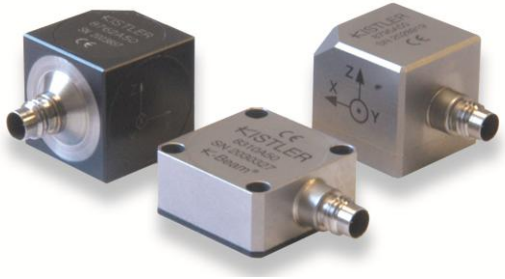
Measurement components



NATIONAL INSTRUMENTS

Accelerometers

- Measure
  - Acceleration
  - Velocity and displacement (via integration versus time)
- Result is expressed in units of *g* or m/s^2
  - 1 g = acceleration at the surface of the earth
  - 1 g = 9.81 m/s^2



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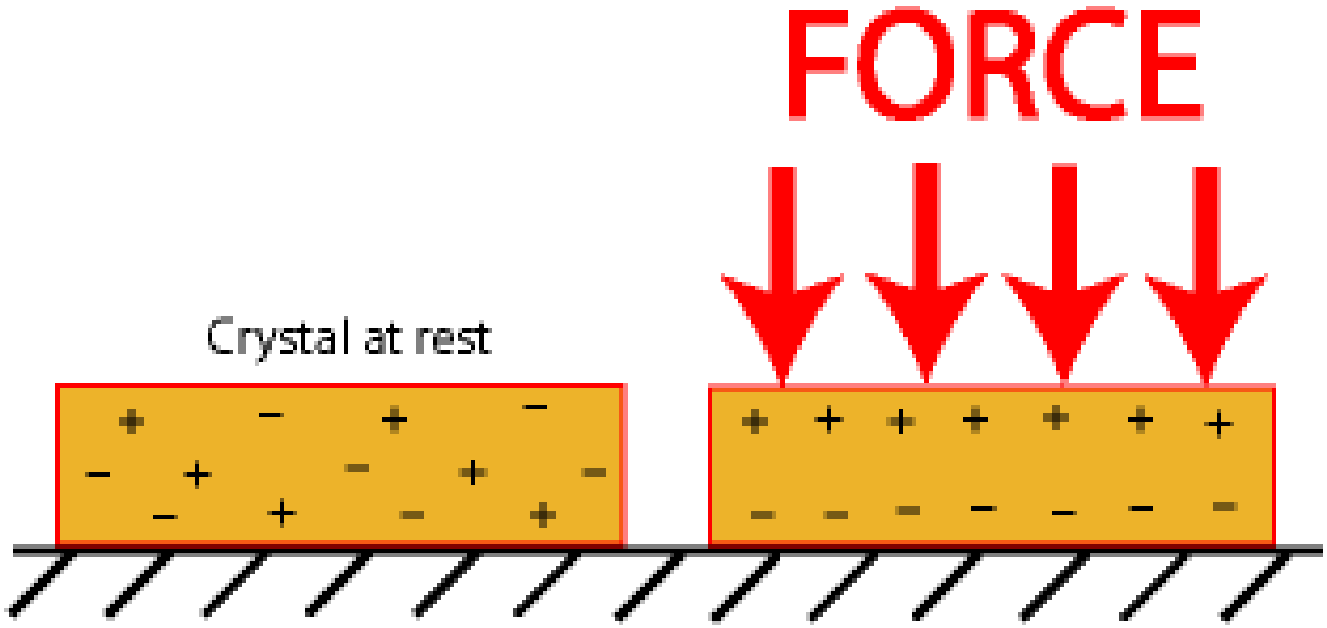
Accelerometers use the properties of piezoelectric crystals to change force into voltage



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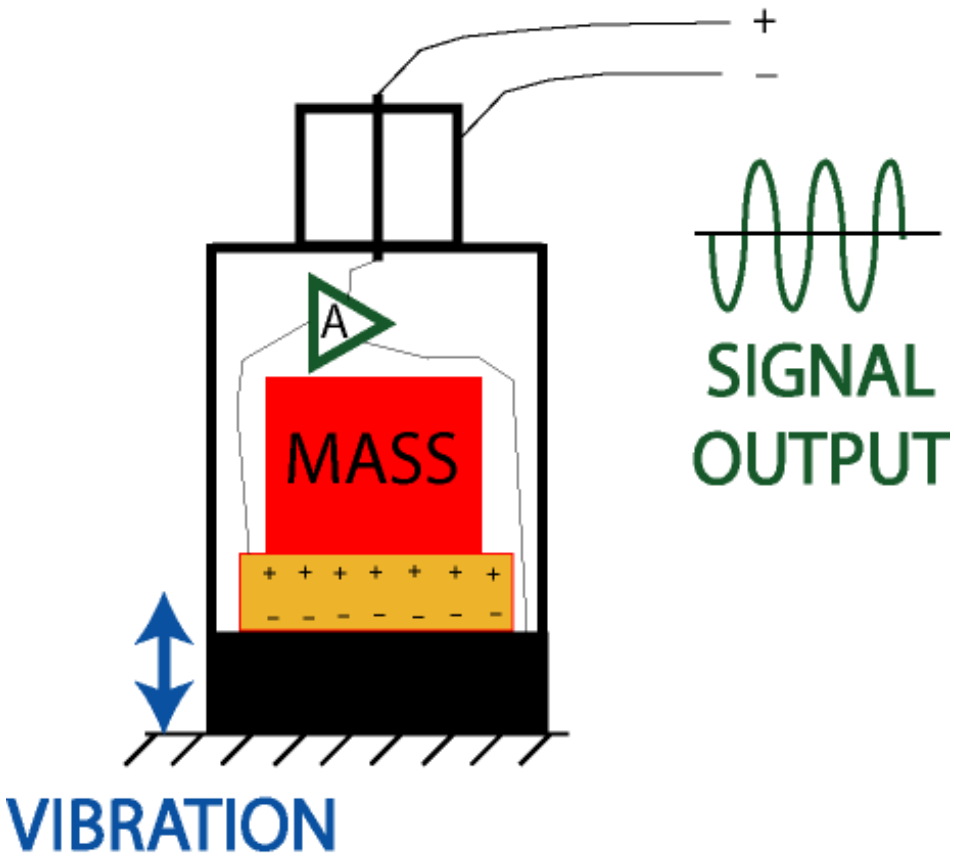
Vibration generates analog output voltage proportional to the acceleration of vibration



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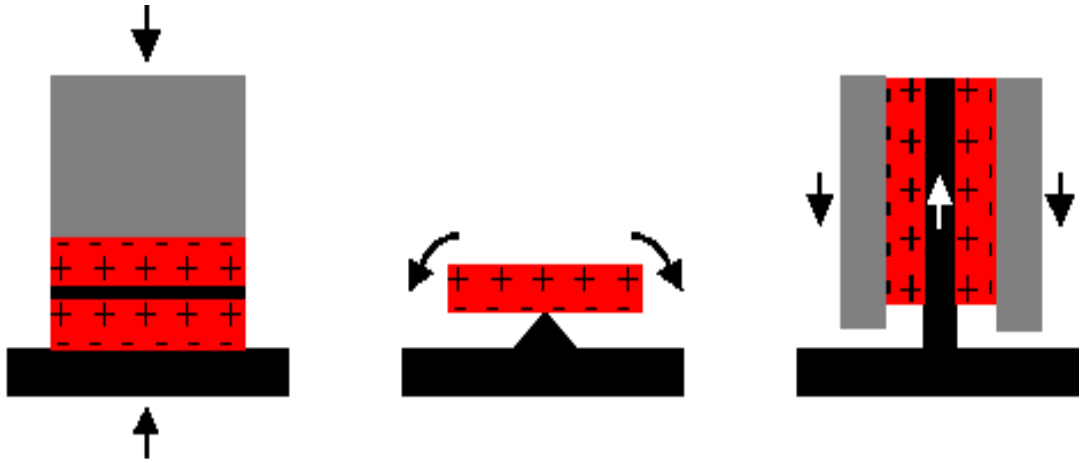
Accelerometer materials can be oriented for different measurements



Charge mode accelerometers are ideal for extreme temperature environments

Advantages

- High temperature survivability

Disadvantages

- External conditioning required
- Need low noise cabling
- Sensitive to environmental influences

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IEPE accelerometers are easy to connect, simple to set up

Direct Connection

Advantages

- Simple and easy to use
- Built-in microelectronics

Disadvantages

- Lower temperature range
- Fixed sensitivity

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Transducer Electronic Data Sheet (TEDS)

TEDS Info

- Calibration
- Sensitivity
- Sensor model
- Filter information
- And more

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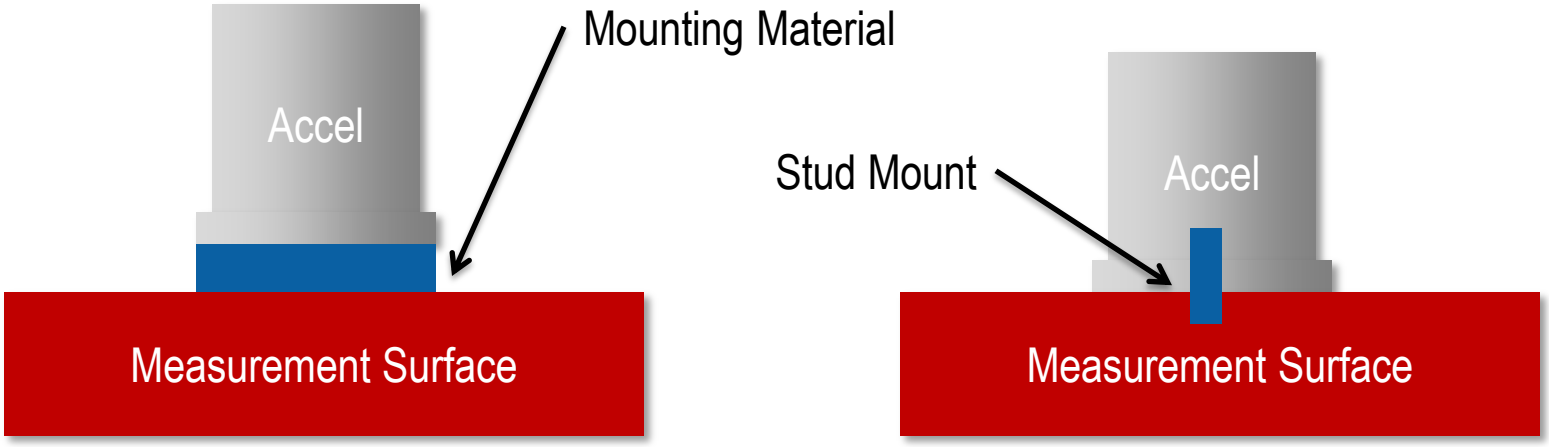
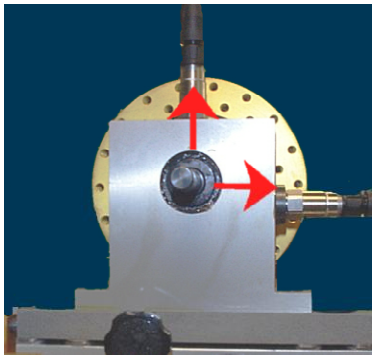
Accelerometer mounting options



Typical Frequency Limits for Various Mounting Options

Method	Frequency Limit
Handheld	500 Hz
Magnet	2,000 Hz
Adhesive	2,500–4,000 Hz
Beeswax	5,000 Hz
Stud	6,000–10,000 Hz

Monitoring of roller bearings in machines is performed with accelerometers



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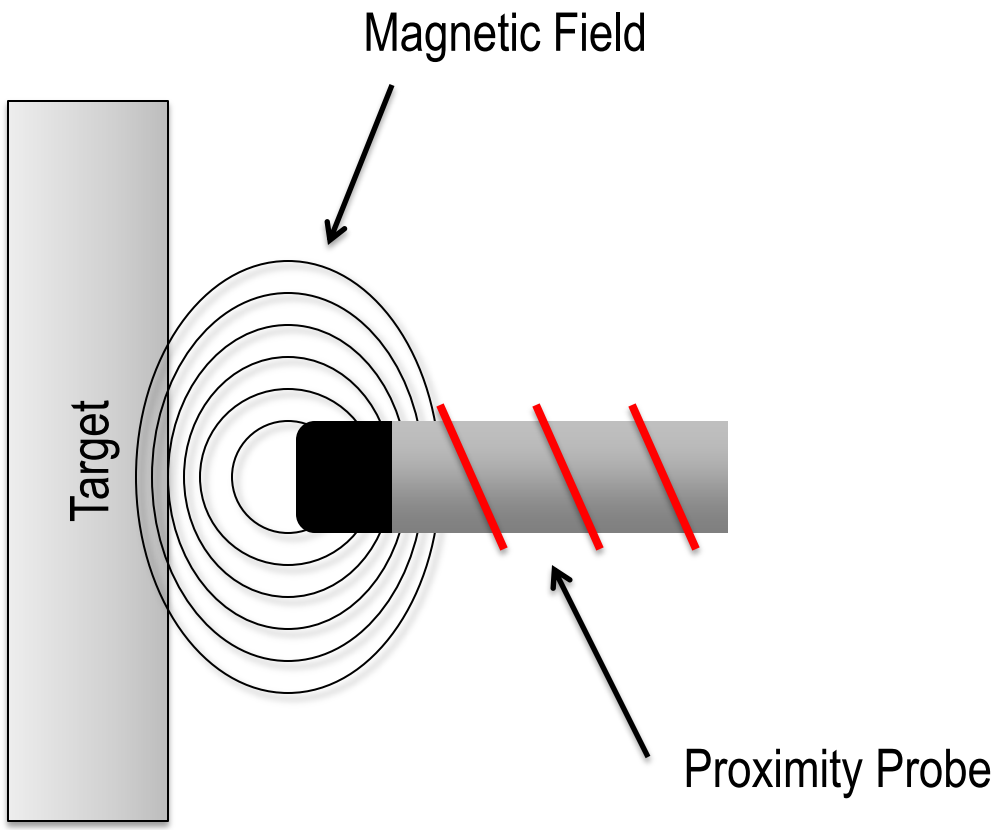
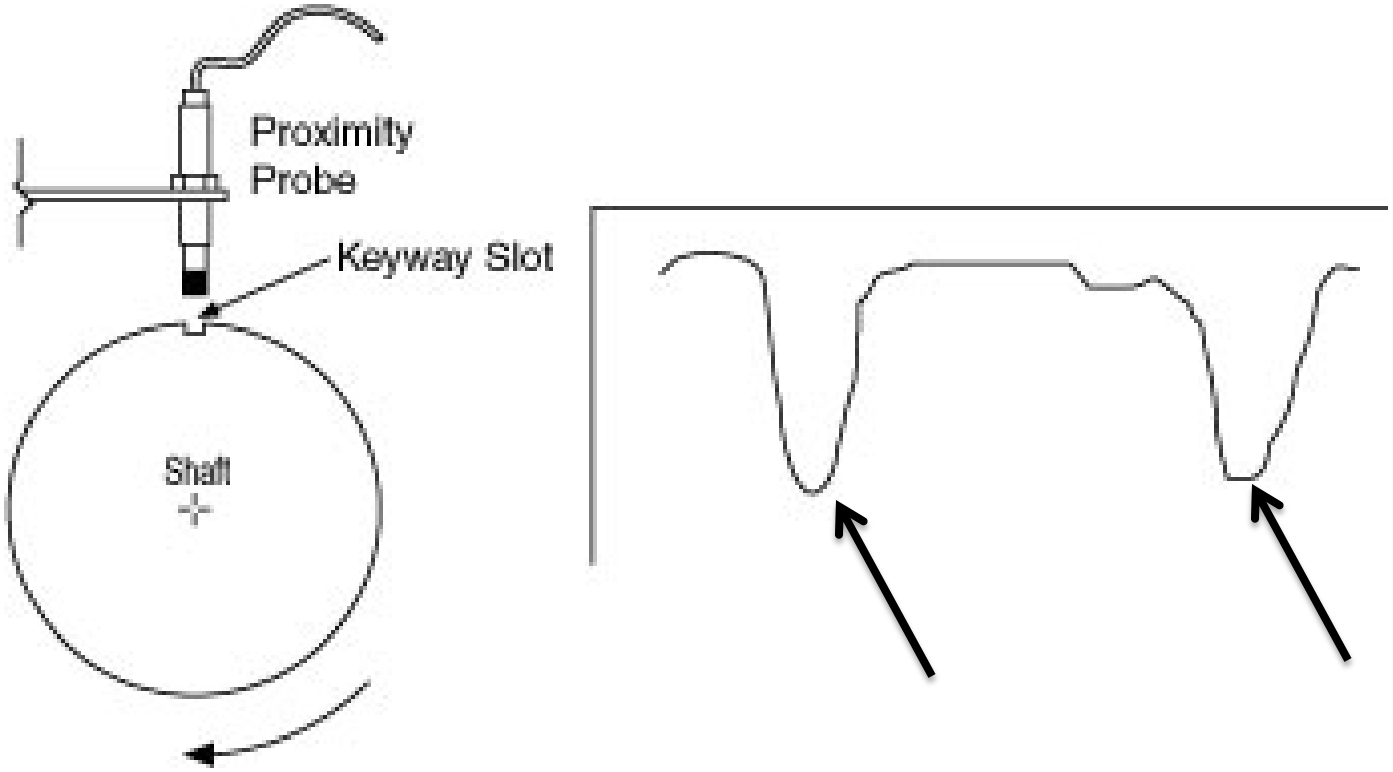
Proximity (eddy current) probes



Proximity (eddy current) probes



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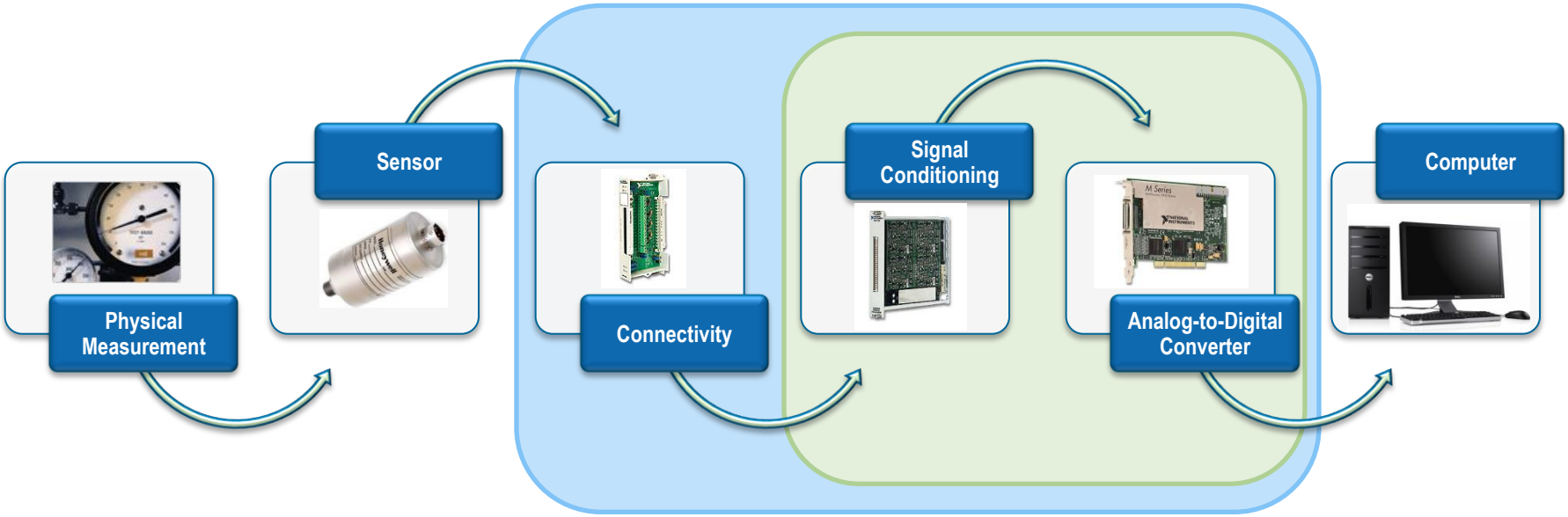
Measurement components



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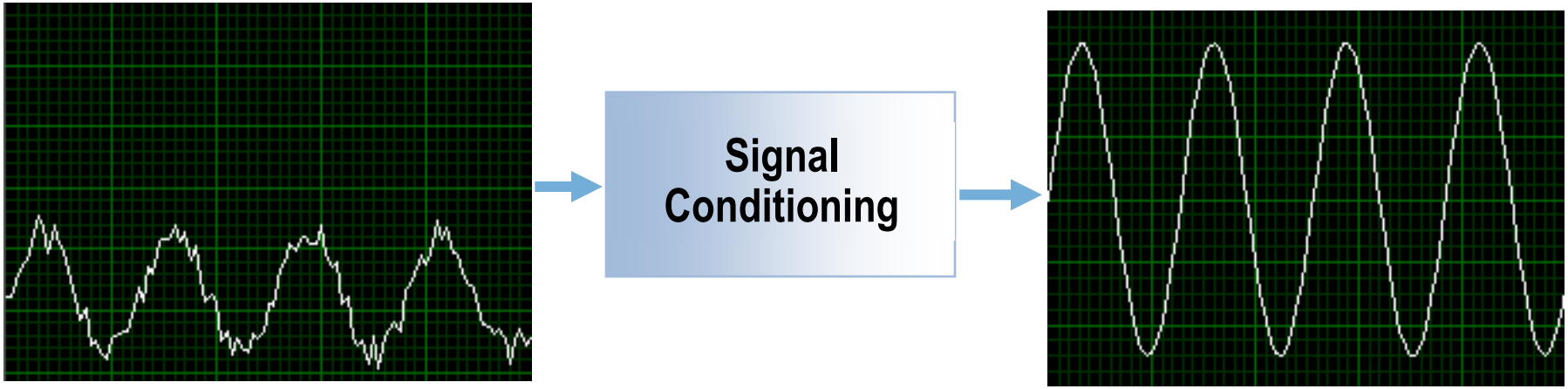
Measurement requirements

- Sensor excitation
- AC coupling
- Anti-aliasing
- High resolution
- Synchronous measurements

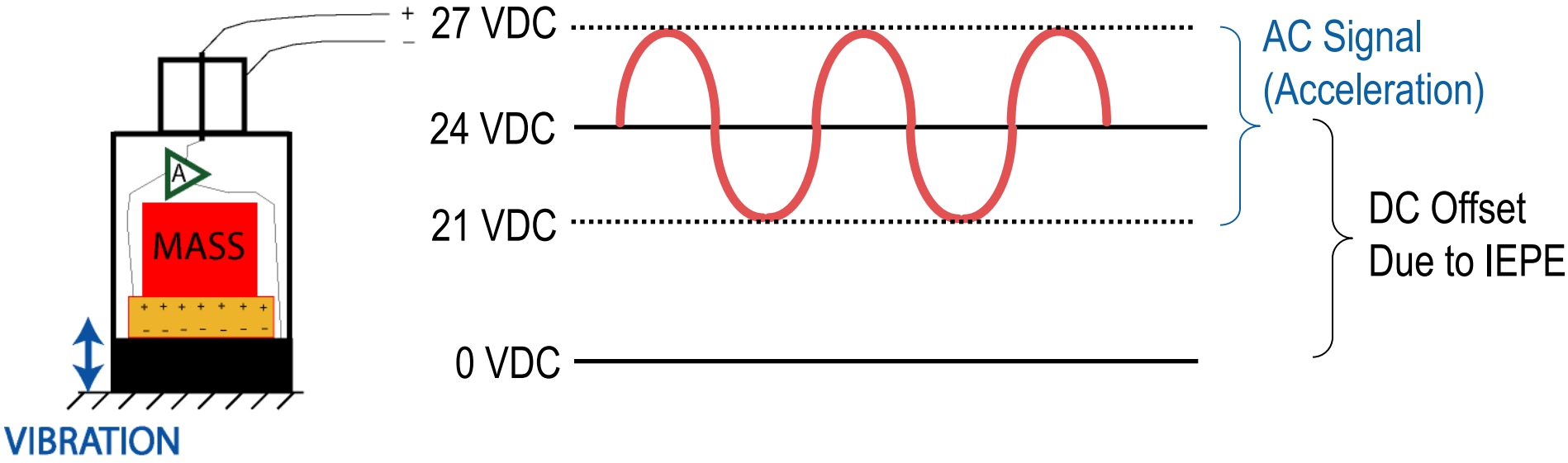
Signal conditioning removes artifacts and noise from the signal



Noisy, Low-Level Signal

Filtered, Amplified Signal

Powering IEPE sensors means AC coupling is needed for best measurement resolution



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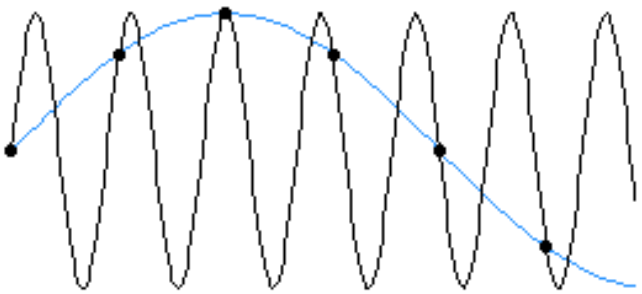
Aliasing

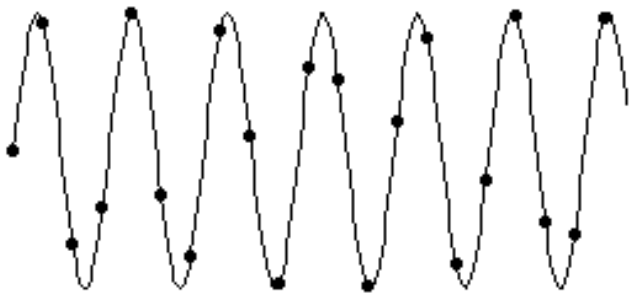
- Shannon sampling theorem
  - The maximum frequency (Nyquist frequency: f_N) that can be analyzed is given by

$f_N = f_s/2$

f_s: sampling frequency

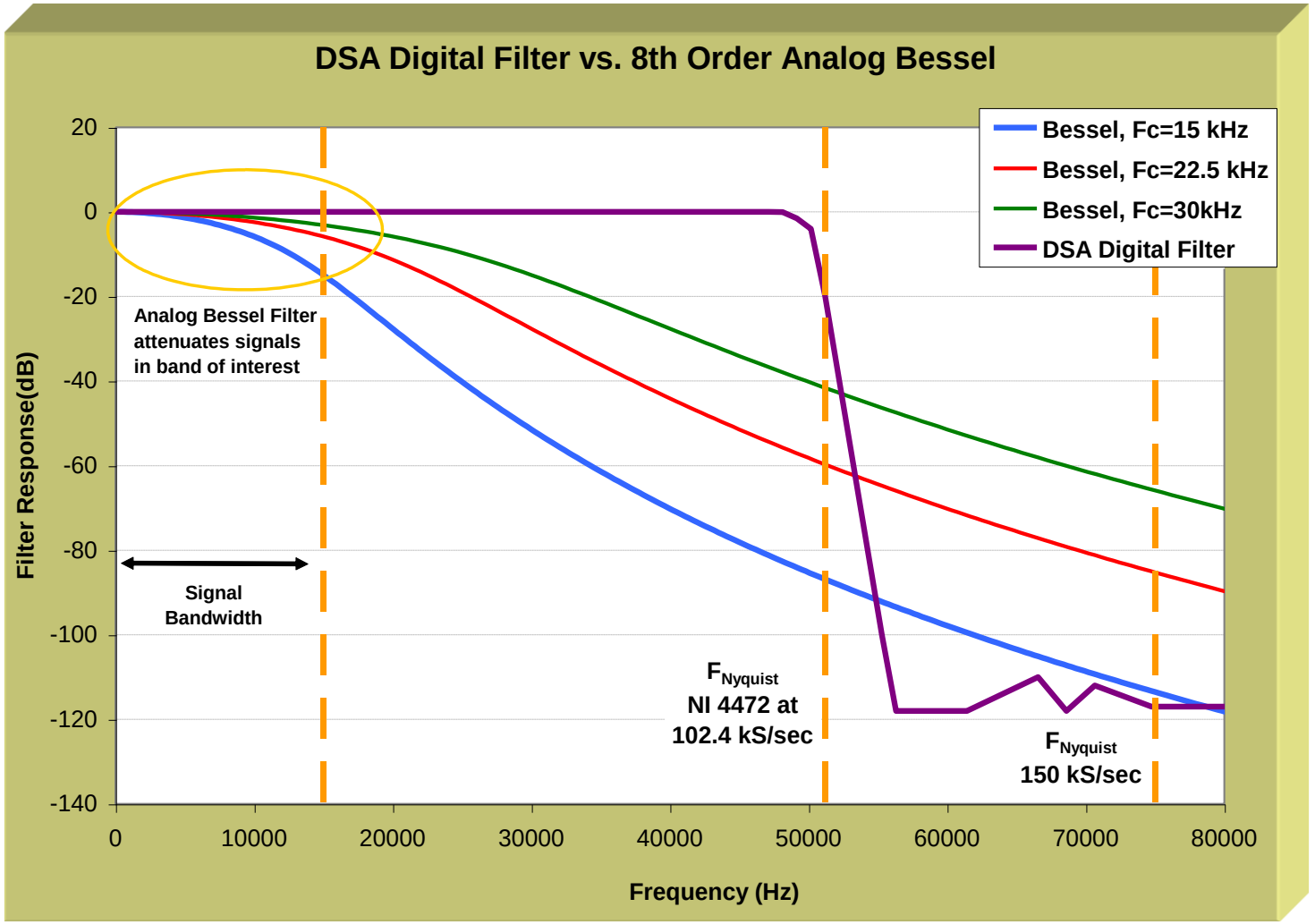


Improperly sampled



Properly sampled

Anti-aliasing filter in ADCs



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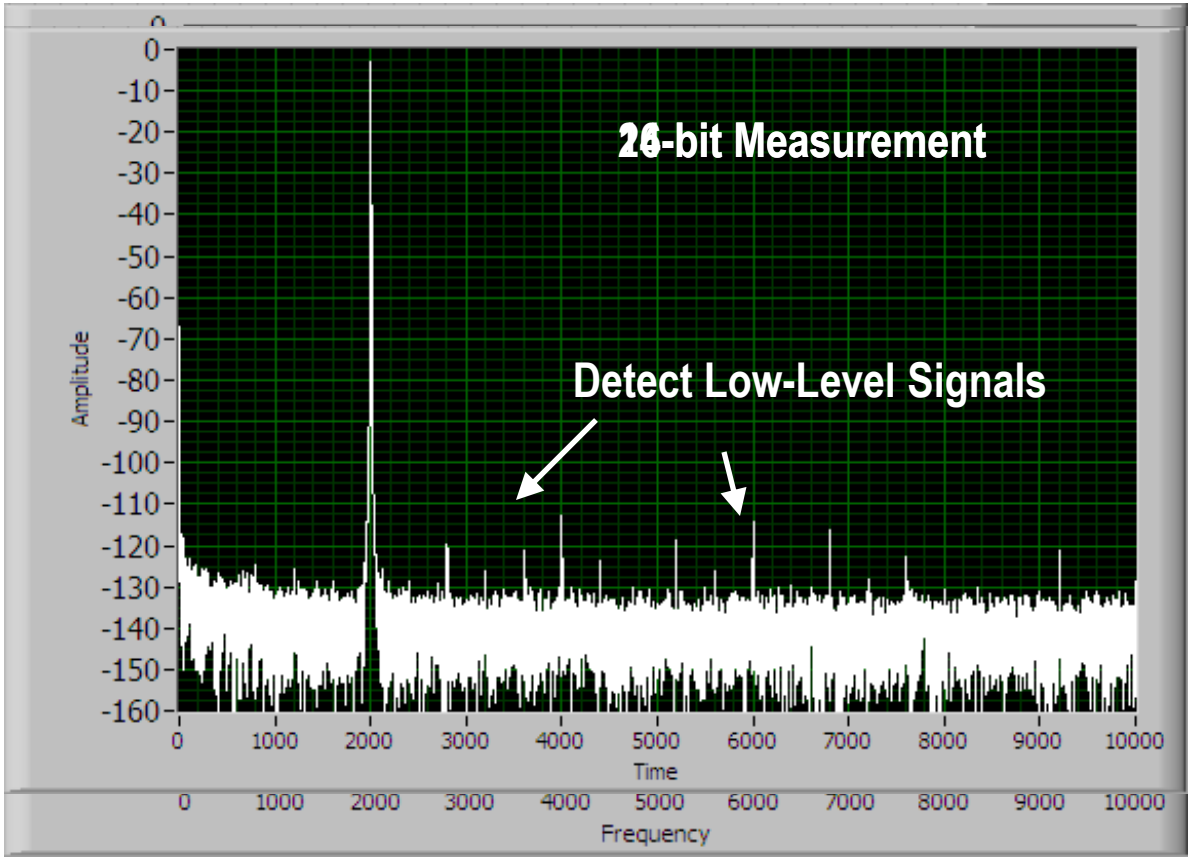
Effect of ADC resolution

With high-resolution ADCs, you can detect both strong and weak signal components at the same time.

90 dB →

140 dB →



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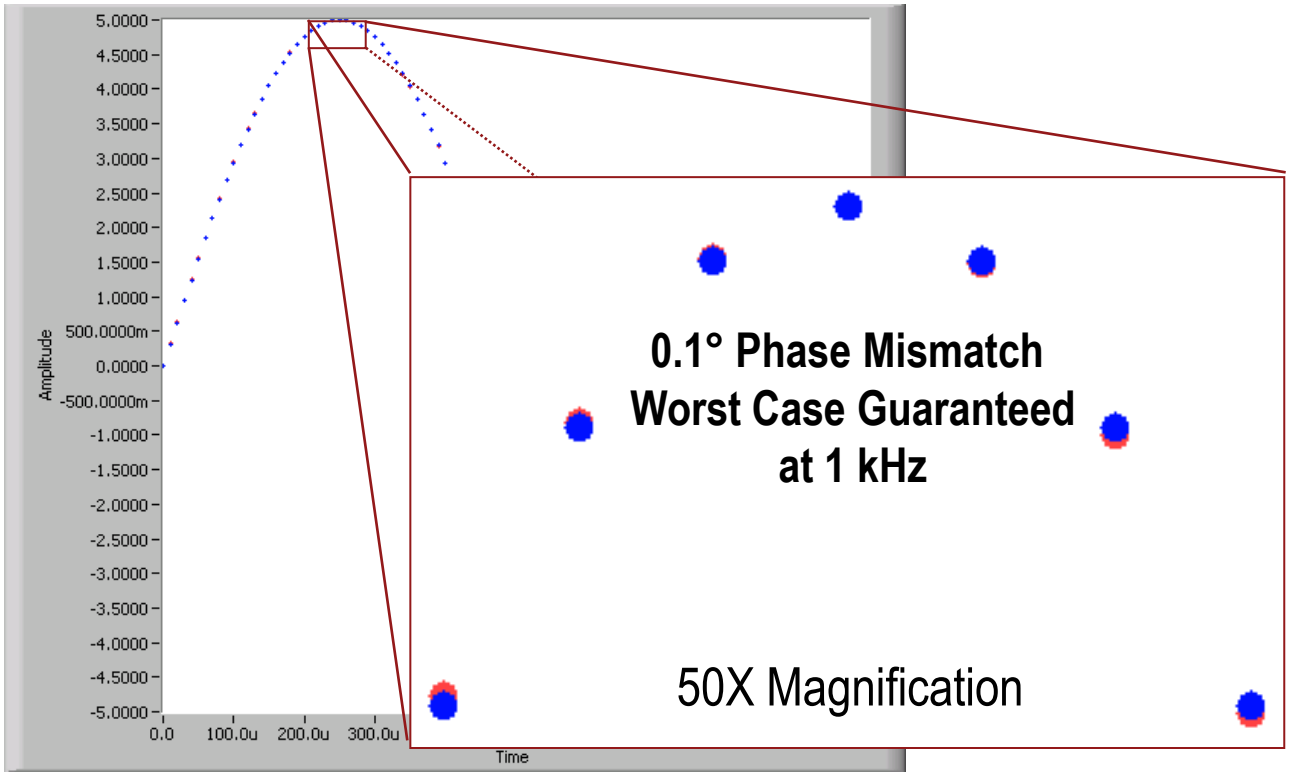
NI synchronization technology ensures phase synchronous measurements



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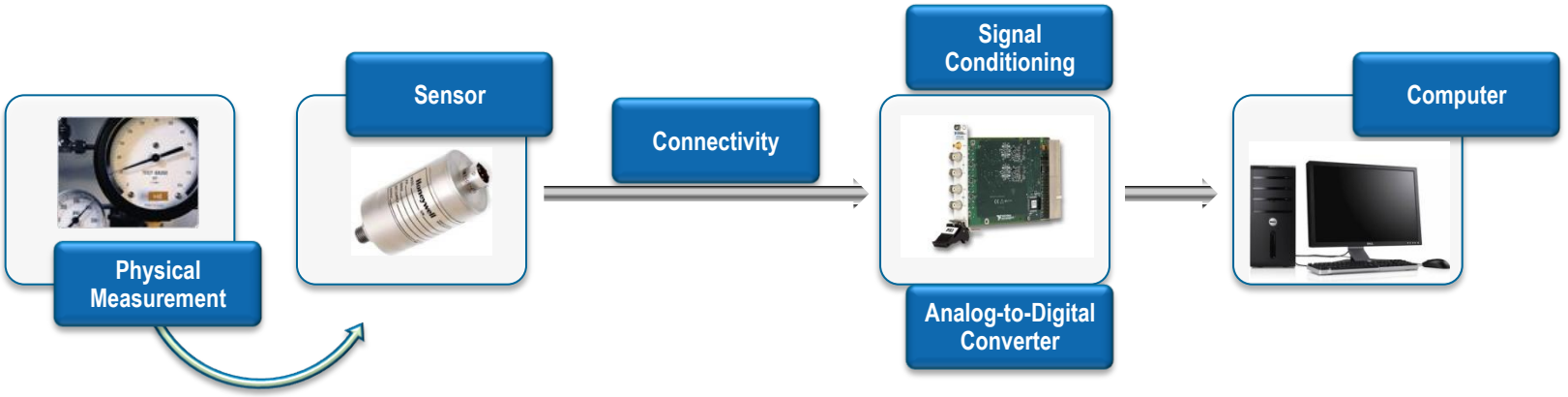
NI dynamic signal acquisition devices simplify acquisition from IEPE sensors



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NI has many solutions for accelerometer measurements

Portable

NI 9234: WiFi, ENET, USB
NI 443x: 24-bit analog output

- Rugged, compact
- USB, wireless, Ethernet
- Synchronized

High Channel Count

NI 4498: 16 channels

- Better dynamic range
- Variable input ranges
- Highest sample rate

High Performance

NI 446x analog out and in

- Best dynamic range (118)
- Best AC coupling
- PCI or PXI bus

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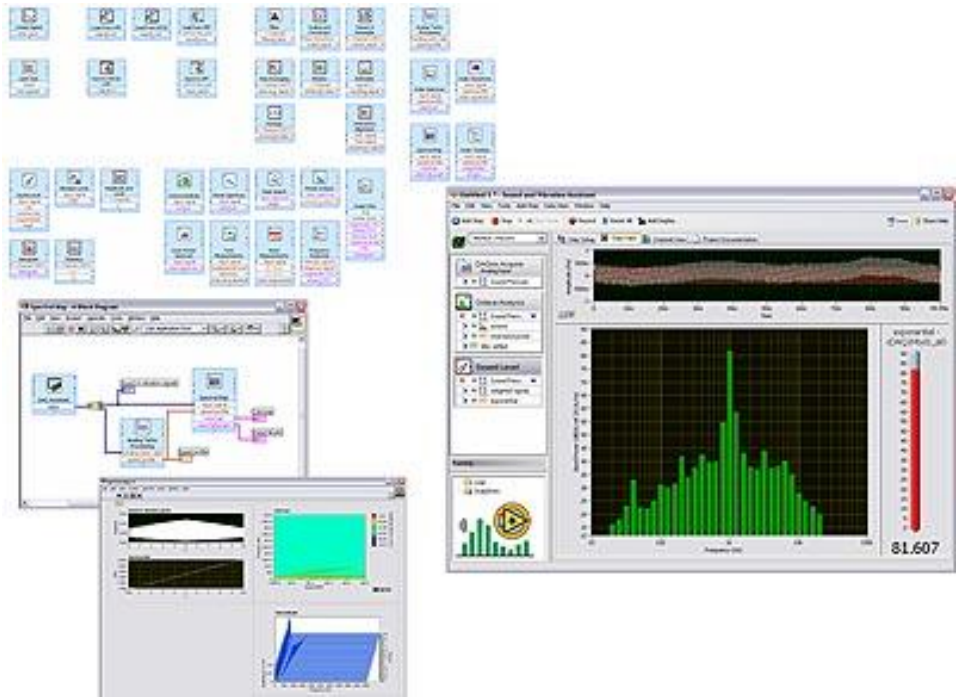
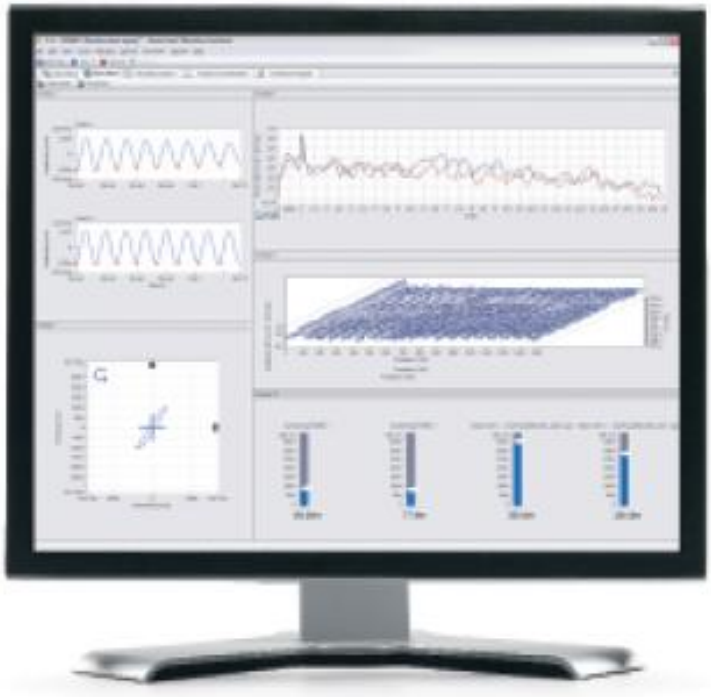
The Sound and Vibration Measurement Suite for LabVIEW simplifies vibration measurements





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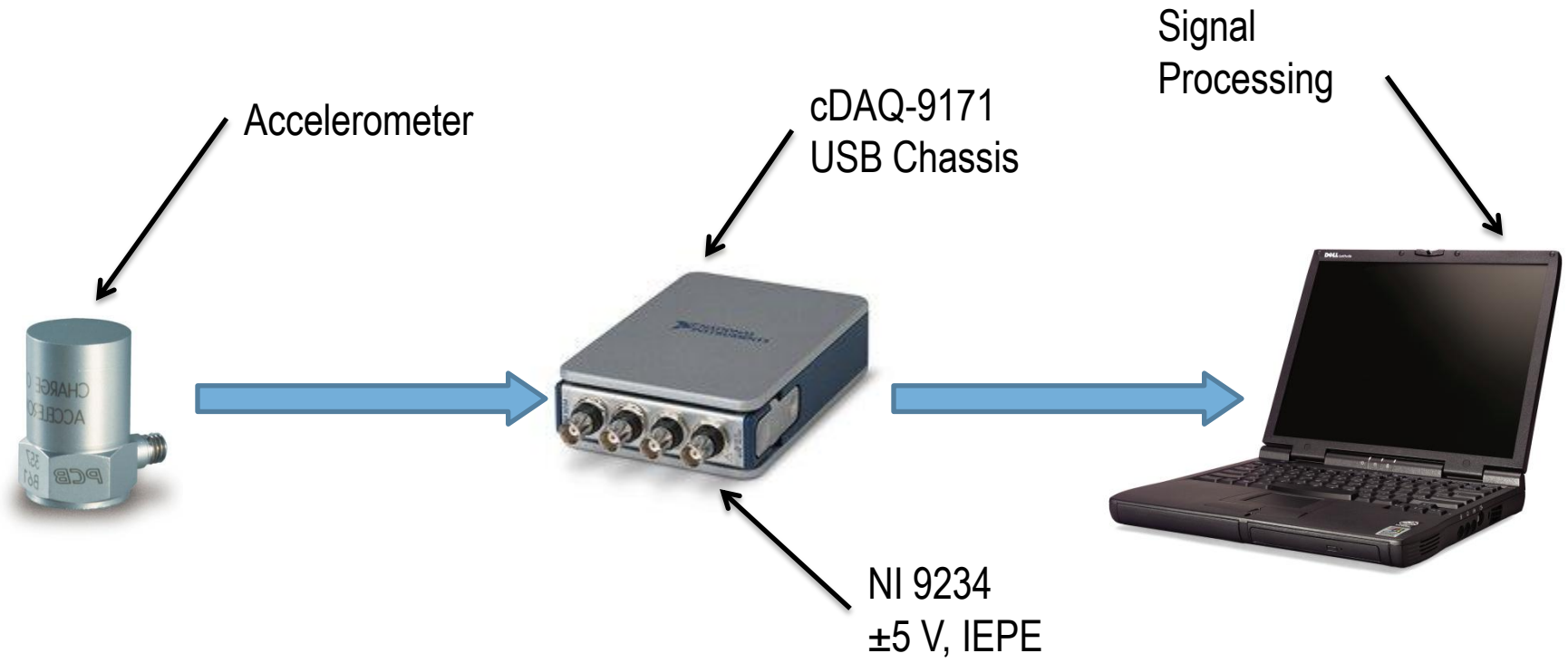
Vibration demo



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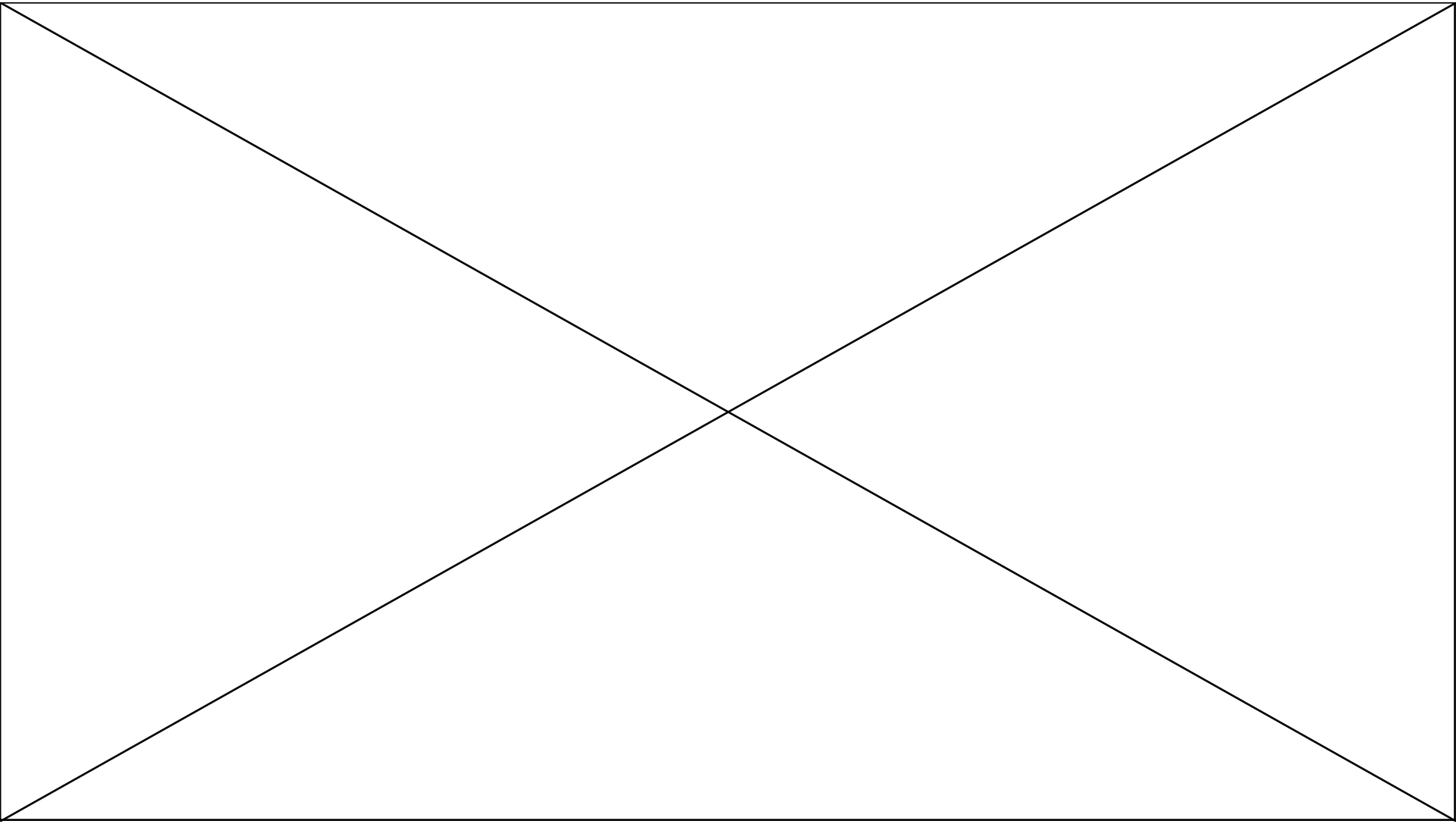
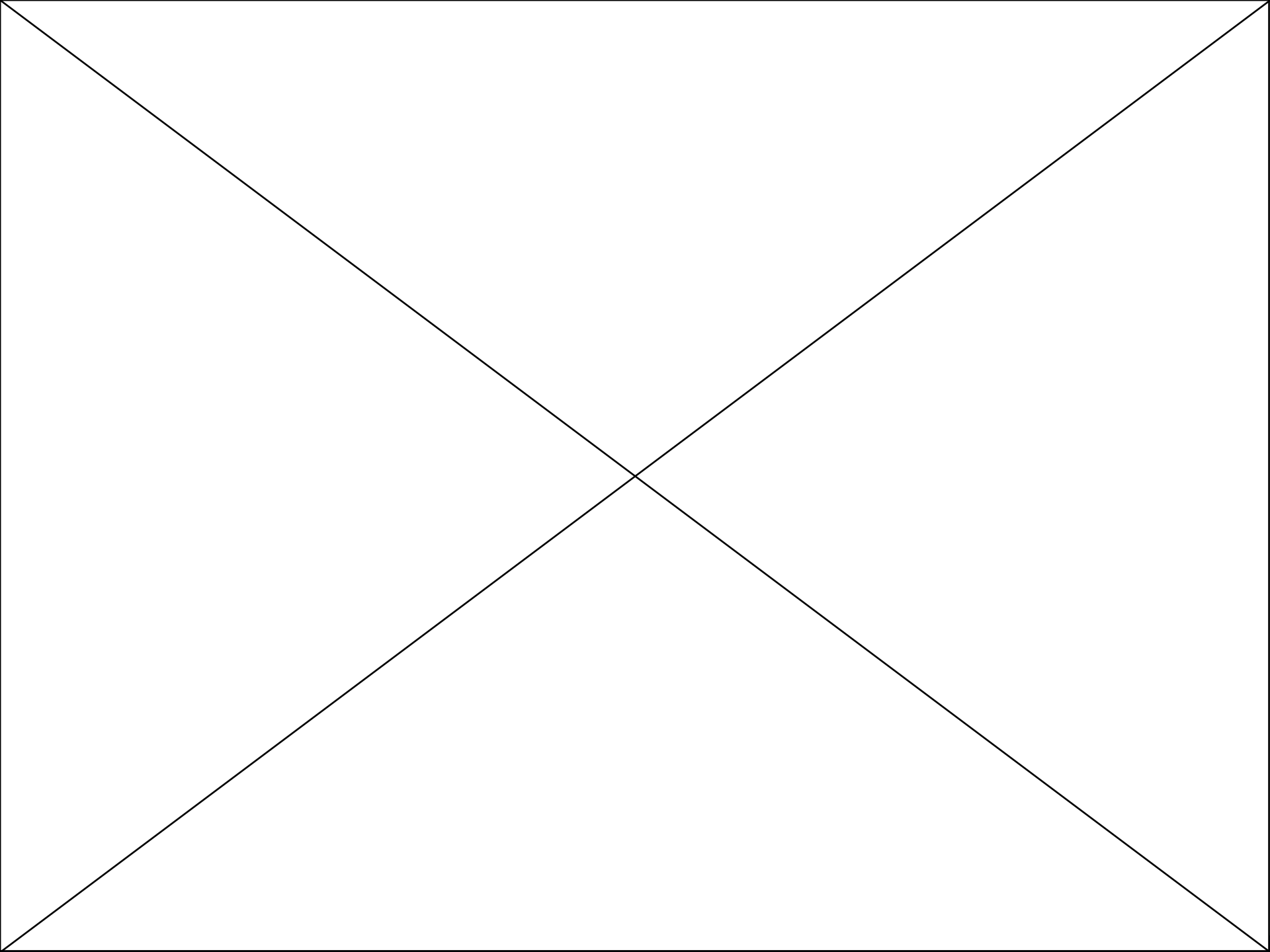
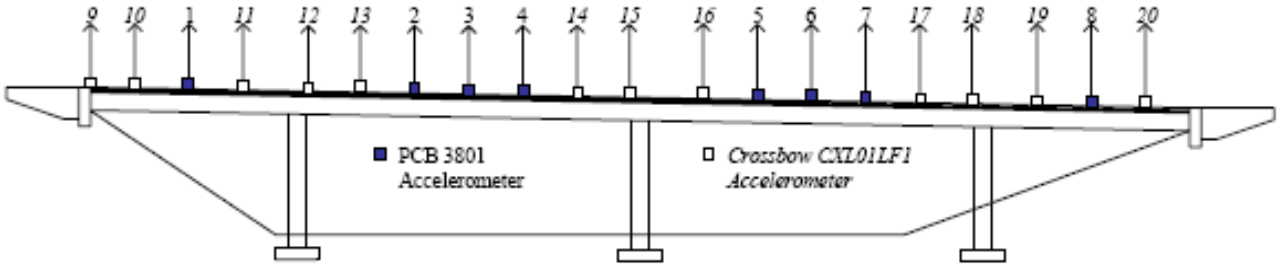
Hardware Demonstration





NI hardware is frequently used in structural test



UCSD

UCSD: Bridge Testbed for Health Monitoring Technologies

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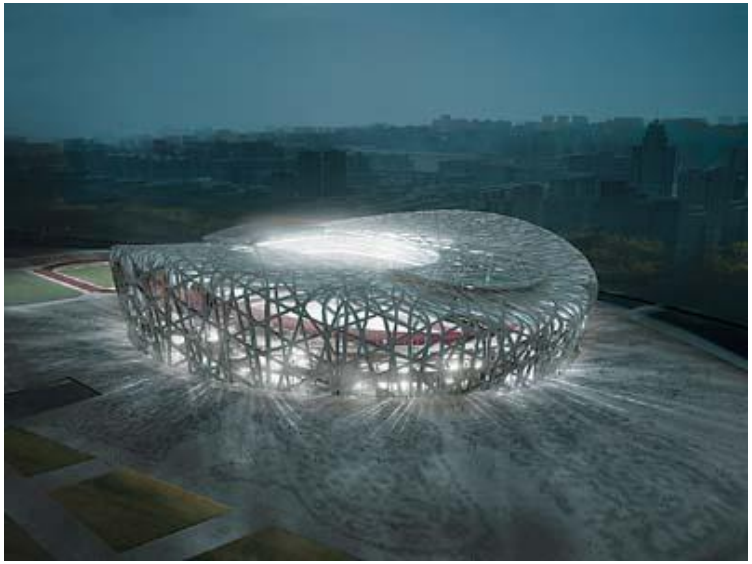
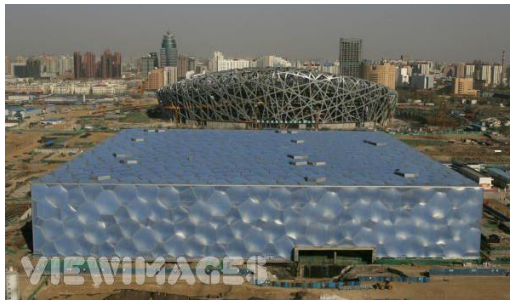
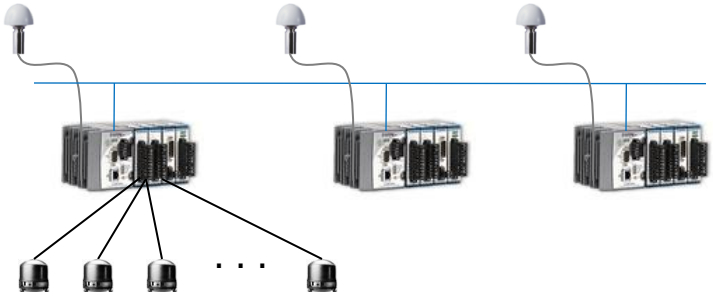
Continuous monitoring of seismic activity at the Beijing National Stadium and Aquatics Center

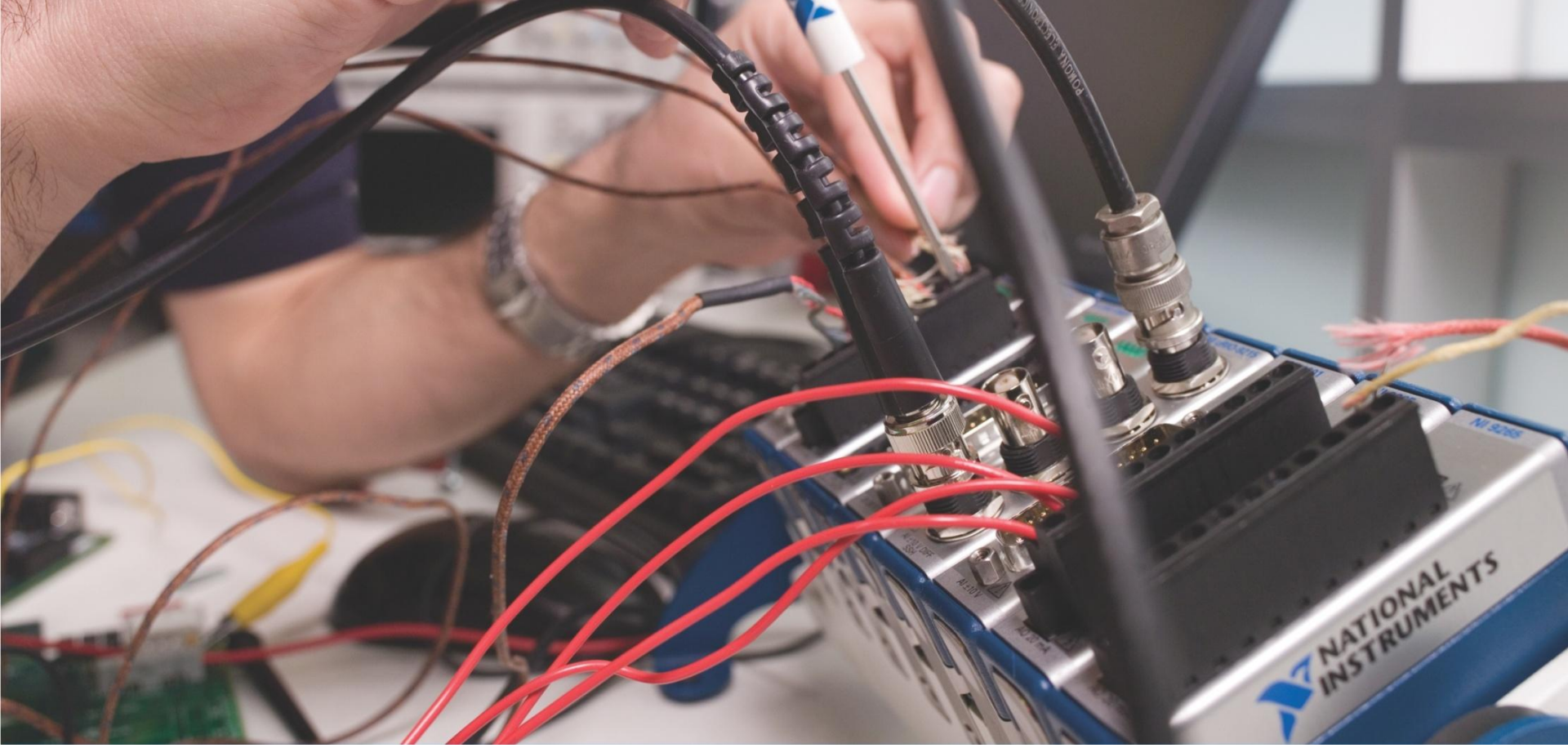






CGM Engineering, Inc.

National Instruments



ni.com/soundandvibration

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