Transducers for Data Acquisition and Testing

February 2017
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
• 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
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
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….
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
• 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
• 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
**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)

<table>
<thead>
<tr>
<th>Basic TEDS</th>
<th>Manufacturer ID</th>
<th>43 (Accel MFG 123)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Number</td>
<td>7115</td>
<td></td>
</tr>
<tr>
<td>Version Letter</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Serial Number</td>
<td>X001891</td>
<td></td>
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<tr>
<td>Calibration Date</td>
<td>Feb 29, 2016</td>
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<tr>
<td>Sensitivity @ ref. condition (S ref)</td>
<td>10.123 mV/G</td>
<td></td>
</tr>
<tr>
<td>Physical measurement range</td>
<td>± 500G</td>
<td></td>
</tr>
<tr>
<td>Electrical output range</td>
<td>± 10V</td>
<td></td>
</tr>
<tr>
<td>Reference frequency (F ref)</td>
<td>100.0 Hz</td>
<td></td>
</tr>
<tr>
<td>Quality factor @ Fref (Q)</td>
<td>300 E-3</td>
<td></td>
</tr>
<tr>
<td>Temperature Coefficient</td>
<td>-0.48 %/°C</td>
<td></td>
</tr>
<tr>
<td>Reference temperature</td>
<td>23°C</td>
<td></td>
</tr>
<tr>
<td>Sensitivity direction (x,y,z)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>User Area</td>
<td>Sensor Location</td>
<td>Strut AB12</td>
</tr>
<tr>
<td></td>
<td>Calibration due date</td>
<td>Feb 28, 2017</td>
</tr>
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</table>
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
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!
• Mounting Considerations
  – Probe Tip
  – 2-Pole Magnet
  – Flat Magnet
  – Adhesive Mounting Pad
  – Adhesive
  – Stud
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**
## Input Configuration

![Input Configuration Window](image_url)

The Input Configuration window for VibrationVIEW shows the configuration of input channels. The table displays the following information for each channel:

- **Channel Label**: The label for each channel.
- **ID**: The identification number for the channel.
- **Serial Number**: The serial number associated with the channel.
- **Sensitivity**: The sensitivity of the channel in mV/G.
- **Unit**: The unit of measurement for the channel.
- **Calibration Date**: The date when the channel was last calibrated.
- **Accel Power**: The acceleration power for the channel.
- **TEDS**: The TEDS (Type Identification and Data Sheet) information for the channel.

The window includes buttons for **Load Configuration**, **Save Configuration**, **Read All TEDS**, **Database Selector**, and **Advanced Settings**.

The configuration appears to be for four channels, with each channel having a sensitivity of 10 mV/G and calibrated on the same date. The TEDS information is currently not available or is not shown in the window.
Input Settings in VibrationVIEW

<table>
<thead>
<tr>
<th>Channel Label</th>
<th>ID</th>
<th>Serial Number</th>
<th>Axis</th>
<th>Transducer Sensitivity</th>
<th>Calibration Date</th>
<th>Accel Power</th>
<th>TEDS</th>
<th>Low</th>
<th>Cap</th>
<th>Diff</th>
<th>DC</th>
<th>Invert</th>
<th>Range (units)</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Type</th>
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<tbody>
<tr>
<td>Ch1</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔ 10</td>
<td>✔</td>
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<td>✔</td>
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</tr>
<tr>
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<td>✔</td>
<td>✔ 10</td>
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<td>✔</td>
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<td>✔</td>
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</tr>
<tr>
<td>Ch3</td>
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<td>✔</td>
<td>✔</td>
<td>✔ 10</td>
<td>✔</td>
<td>✔</td>
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<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Ch4</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔ 10</td>
<td>✔</td>
<td>✔</td>
<td></td>
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<td></td>
<td></td>
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<td>✔</td>
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</tbody>
</table>
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!