Current Status of IEEE 1451.4 Transducer Electronic Data Sheet (TEDS)

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For dissemination of IEEE 1451.4 info only
1451.4™ Standard

Motivation for 1451.4 TEDS

- Plug and Play for instrumentation
- Electronic Data Sheet
  - Sensitivity, model number, serial number, etc.
- Simplification of cable identification
- Elimination of data entry error and system setup
- Participation in 1451 vision
- Legacy compatibility
  - Existing accelerometer (sensor) users
History

- NIST TC9 sponsorship
- 1993-1996 IEEE 1451.1 & .2 formed
- 1996 IEEE 1451.3 WG (multi-drop)
- 1997 IEEE 1451.4 WG formed
- Balloted and accepted May 2004
- Corrigendum in late 2005
- Up for review in 2009
1451.4 Participants

Mostly everybody in the accelerometer community:
- PCB, B&K, Endevco, Kistler, Wilcoxon
- The Modal Shop
- Oak Ridge National Labs
- National Instruments
- Dallas Semiconductor
  - 1-wire technology (key piece of technology that allowed implementation of the memory in the sensor)
Implementation

- Electrical reprogrammable memory added to sensor/actuator
- Memory contains ROM (permanent) and RAM (alterable)
- Information out is serial bit-stream
- Operations limited to $-40^\circ \text{C}$ to $85^\circ \text{C}$
- Based on Maxim/Dallas 1-wire (DS2430A)
IEEE 1451.4 Architecture

IEEE 1451.4 System Architecture

1451.1 NCAP

IEEE 1451.4 COMMON OBJECT MODEL

NETWORK LAYER
FUNCTION LAYER
INTERFACE LAYER
VIRTUAL BACKPLANE

IEEE 1451.4 TEMPLATE LIBRARY

IEEE 1451.4 TRANSDUCER BLOCK

IEEE 1451.4 MIXED MODE INTERFACE

IEEE 1451.4 TEDS per TEMPLATE

IEEE 1451.4 TEMPLATE DESCRIPTION LANGUAGE

IEEE 1451.4 TEDS per TEDS

IEEE 1451.4 Sensors and Actuators TEDS

IEEE 1451.4 Mixed Mode Interface

The Modal Shop, Inc.
A PCB Group Company

IMAC XXVII February 9-12 2009
Class of interface

IEEE 1451.4 Class 1 and 2 MMI Details

IMAC XXVII February 9-12 2009
TEDS Bitmaps

IEEE 1451.4 Basic TEDS

- Manufacturer ID [7:0]
- Model # [1:0]
- Model # [9:2]
- Version Letter [2:0]
- Version # [5:0]
- Serial # [7:0]
- Serial # [15:8]
- Serial # [23:16]

IEEE 1451.4 TEDS

- Check Sum [7:0]
- TEDS Data [7:0]
- TEDS Data [239:8]
- TEDS Data [247:240]

64 bit

256 bit

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Differences

- The early producers agreed not to utilize the ROM memory
- Early templates crude (TEDS v0.9 vs TEDS v1.0)
- v1.0 incorporates TEDS Development Language (TDL) concept
- TDL development is encouraged
- IEEE is registration authority
Example: Accelerometer programmed per IEEE P1451.4 (template 0)

<table>
<thead>
<tr>
<th>label</th>
<th>Data</th>
<th>Units</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model number</td>
<td>333</td>
<td></td>
<td>0</td>
<td>65535</td>
</tr>
<tr>
<td>Version letter</td>
<td>B</td>
<td>A</td>
<td></td>
<td>Z</td>
</tr>
<tr>
<td>Version number</td>
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<td></td>
<td>0</td>
<td>63</td>
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<tr>
<td>Serial no.</td>
<td>25451</td>
<td></td>
<td>0</td>
<td>33554431</td>
</tr>
<tr>
<td>Calibration Date</td>
<td>5/28/2007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity @ reference condition</td>
<td>0.010198</td>
<td>V/(m/s²)</td>
<td>1.00E-04</td>
<td>49.17322</td>
</tr>
<tr>
<td>Reference frequency (F ref)</td>
<td>159.753479</td>
<td>Hz</td>
<td>10.17502</td>
<td>1.91E+04</td>
</tr>
<tr>
<td>High pass cut-off frequency (F hp)</td>
<td>0.010061</td>
<td>Hz</td>
<td>0.01</td>
<td>35.75359</td>
</tr>
<tr>
<td>Polarity (Sign)</td>
<td>0</td>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Sensitivity direction (x,y,z)</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement location ID</td>
<td>0</td>
<td></td>
<td>0</td>
<td>511</td>
</tr>
<tr>
<td>User data (ascii)</td>
<td>template 0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Example: Accelerometer programmed per IEEE 1451.4 (template 25)

<table>
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<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
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<td>Model number</td>
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<td>0</td>
<td>32767</td>
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<tr>
<td>Version letter</td>
<td>B</td>
<td>A</td>
<td></td>
<td>Z</td>
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<tr>
<td>Version number</td>
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<td>0</td>
<td>0</td>
<td>63</td>
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<tr>
<td>Serial no.</td>
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<td>0</td>
<td>0</td>
<td>16777215</td>
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<tr>
<td>Sensitivity @ reference condition</td>
<td>0.010198</td>
<td>V/(m/s²)</td>
<td>5.00E-07</td>
<td>172.2408</td>
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<tr>
<td>High pass cut-off frequency (F hp)</td>
<td>0.010061</td>
<td>Hz</td>
<td>0.005</td>
<td>1.42E+04</td>
</tr>
<tr>
<td>Sensitivity direction (x,y,z)</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transducer weight</td>
<td>3.83376</td>
<td>g</td>
<td>0.1</td>
<td>9.74E+03</td>
</tr>
<tr>
<td>Polarity (Sign)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Reference frequency (F ref)</td>
<td>159.753479</td>
<td>Hz</td>
<td>0.35</td>
<td>2.26E+03</td>
</tr>
<tr>
<td>Reference temperature (T ref)</td>
<td>25</td>
<td>°C</td>
<td>15</td>
<td>30.5</td>
</tr>
<tr>
<td>Calibration Date</td>
<td>5/28/2007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calibration Initials</td>
<td>MAP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calibration Period (Days)</td>
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<td>days</td>
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<td>4095</td>
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</tr>
<tr>
<td>User data (ascii)</td>
<td>template 25</td>
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</tr>
</tbody>
</table>
What are accelerometer vendors supporting?

- All support 1.0, it is the default
- Most moving to 1.0 after testing
- All will offer “both” for quite some time
- Most require customer to specify
- Electronics / Software level is important
- Once you go 1.0, you don’t go back!
TEDS Sensors – all types

- Accelerometers – Uni-axial, Tri-axial
- Impact hammers, force sensors, impedance heads
- Microphones - all types
- Load Cells, Strain Gauges, Impedance
- Thermocouples, Pressure sensors
- Extended Functionality
- Charge converters (in-line)
- Legacy - “TEDS in a Tube”
What does TEDS cost?

- Microphones - standard in most
- Accelerometers - US$25-55 additional
- Electronics – standard to US$1500
- Migration is $0 (with cal) to US$55
- Savings is justification for cost
TEDS Sensors Manufactures

- **Accelerometers**
  - PCB, B&K, Dytran, Endevco, Kistler, Wilcoxon, etc

- **Microphones**
  - PCB, B&K, GRAS, etc

- **Strain Gage load cells**
  - Lebow, HBM, Futek
Electronics & Hand Held Devices

- PCB / The Modal Shop
- Dytran
- Endevco
- ATA
- NI PDA Toolkit is an enabler
PC based Readers/Writers

- The Modal Shop: 400B76 (USB)
- B&K: BZ 5294 (RS-232)
- Endevco
- Dytran
- Kistler 5000M04
Electronics - PC Cards

National Instruments
- PXI-4462, PCI-4461, NI 9233,9234
- SCXI-1314T, Compact RIO NI 9237

VXI Technology
- VT1435
- VT1436
Electronics - Analyzers

- LMS: SCADAS III
- M+P International
- B&K: Pulse
- Oros
- Data Physics: Quattro, Abacus
- IOtech Wavebook
- LDS Dactron Focus II (only support to preliminary templates – TEDS v0.9 – at this time)
- Etc.

Should always check with analyzer manufacturer on what TEDS sensors and templates are supported
Electronics – Signal
Conditioners & Recorders

- PCB - 481, 498, 440 series
- NI - SC-3250, BNC-2096
- B&K - Deltatron, Nexus
- Endevco - OASIS
- Sensotec - SC2000, SC3400
- Precision Filters
- TEAC LX10, Sony EX Series
TEDS and Calibration Systems

What about re-calibration?

- Does your calibration system support TEDS?
- Does your calibration house support TEDS?
Applications

- Geometry Information
- Sound Contour w/ phase
- Large Channel count mapping
- Channel Identification
- Vibration controller security
LMS (Geometry) Format

- IEEE 1451 Standard permits “private”
- LMS (Daimler, Airbus) needed geometry
- IEEE Working group didn’t support
- Work progressing on defining 1.0 TDL
- Currently represents single largest channel count of installed 1451 sensors
Additional Information

- **IEEE**
  http://standards.ieee.org/regauth/1451

- **National Instruments**
  http://www.ni.com/teds/

- **TMS** - TEDS FAQ

- **Wilcoxon** - Multiple TEDS papers

- **B&K** - extensive TEDS material

- **Maxim/Dallas** - 1 wire products
Summary

- IEEE 1451 is well-entrenched in market
- Est over 150,000 1451 sensors shipped
- More than 100 sensors type, 8+ vendors
- More than 20 electronics, 6+ vendors
- IEEE Manufacturer ID Public Listing
  - 71 registered manufacturers
- IEEE 1451.4 continues to gain acceptance in the marketplace