How to Create an IEEE 1451.4 Sensor

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How to Create an IEEE 1451.4 Sensor

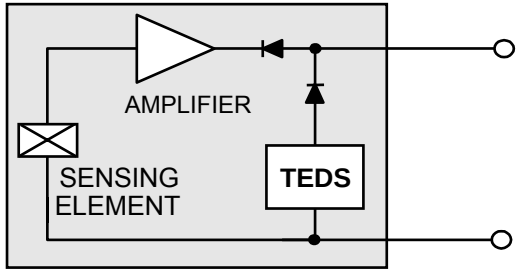
- Basics of Creating a TEDS Sensor
  - Hardware
  - Software
    - What (Content) and How (Tools, Interfaces)
- IEEE 1451.4 Instrumentation
  - A few very brief points

IEEE 1451.4 Defines Two Classes of Transducers

This presentation assumes Class 2 Sensor:

Class 1 Sensor

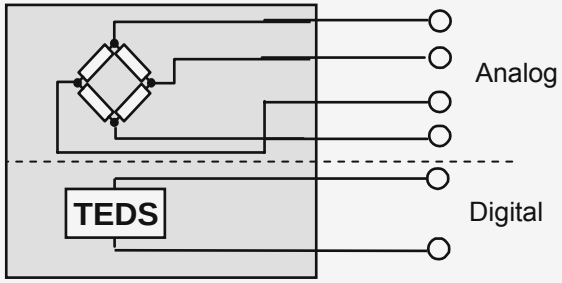
- Shared wires (no extra wires)
- Sequential access of analog and digital TEDS
- Used primarily on constant-current powered IEPE (ICP®, Piezotron®, Isotron®, DeltaTron®)) sensors (accelerometers, microphones, etc.)



Class 2 Sensor

- Separate wires
- Parallel access of analog and digital TEDS
- Can be applied to virtually any sensor type

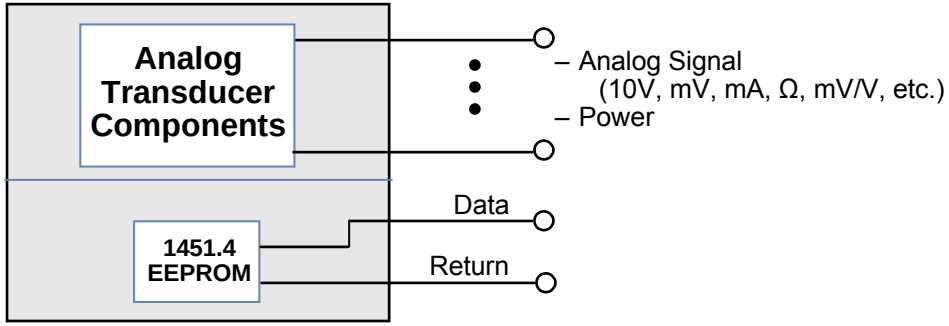
Class 2 Example: Bridge Output Sensor



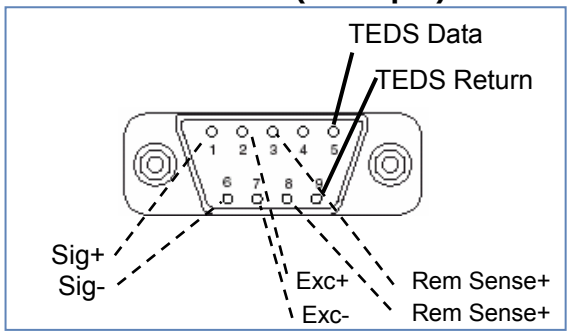
NATIONAL INSTRUMENTS

Creating a Class 2 TEDS Sensor – Hardware

- Add TEDS Node
  - Available EEPROMs (Dallas/Maxim)
    - DS2430A 256 bits
    - DS2431 (new) 1,024 bits
    - DS2433 4,096 bits
  - Alternative: purchase unique ID numbers from IEEE Registration Auth.
- Protection
  - Components protected against reverse connection
  - Consider additional high voltage protection circuitry (diodes, posisters, etc.)
- Connector?
  - IEEE 1451.4 does not address



TEDS Load Cell Connector (Example)



Creating a Class 2 Sensor – Software

Most Typical TEDS Structure:

Basic TEDS (64 bits)
Selector (2 bits)
Template ID (8 bits)
Standard Template TEDS (ID=25 to 39) (~100 to 350 bits)
Selector (2 bits)
Extended Selector (1 bit)
User Data (to end of EEPROM)

TEDS Structure with Cal Table:

Basic TEDS (64 bits)	*Required*
Selector (2 bits)	
Template ID (8 bits)	
Standard Template TEDS (ID=25 to 39) (~100 to 350 bits)	*Not Required, but <u>Expected</u>*
Selector (2 bits)	
Template ID (8 bits)	
Calibration TEDS (ID = 40-40)	*Optional*
Selector (2 bits)	
Extended Selector (1 bit)	
User Data (to end of EEPROM)	

Basic TEDS Content

	Bit Length	Allowable Range
Manufacturer ID	14	17 – 16381
Model Number	15	0-32767
Version Letter	5	A-Z (data type Chr5)
Version Number	6	0-63
Serial Number	24	0-16777215

Support files on host system can optionally be used to map:

- **Manufacturer <u>ID</u> to Manufacturer <u>Name</u>**

  78 ⇒ "Acme Sensor Co."

- **Model Number + Ver Letter + Ver Number to Model Name**

  32000, D, 23 ⇒ "BLX32000DS Series FX"

NATIONAL INSTRUMENTS

Standard IEEE Templates

Template ID	Name of template	Measurand/Sensitivity Units
25	Accelerometer/Force with constant current amplifier	V/(m/s^2)
26	Charge amplifier (incl. attached accelerometer)	V/C
43	Charge amplifier (incl. attached force transducer)	V/C
27	Microphones with built-in preamp.	V/Pa
28	Microphone preamps. w. attached microphone or system	dB
29	Microphones (capacitive)	V/Pa
30	High-Level Voltage Output sensors	Various (select from 46)*
31	Current Loop Output sensors	Various (select from 46)*
32	Resistance sensors	Various (select from 46)*
33	Bridge sensors	Various (select from 46)*
34	AC LVDT/RVDT	m, mm, in, radians, degrees
35	Strain gage	strain
36	Thermocouple	°C
37	Resistance temperature detectors (RTDs)	°C
38	Thermistor	°C
39	Potentiometric voltage divider	Various (select from 46)
40	Calibration table	—
41	Calibration curve (polynomial)	—
42	Frequency response table	—

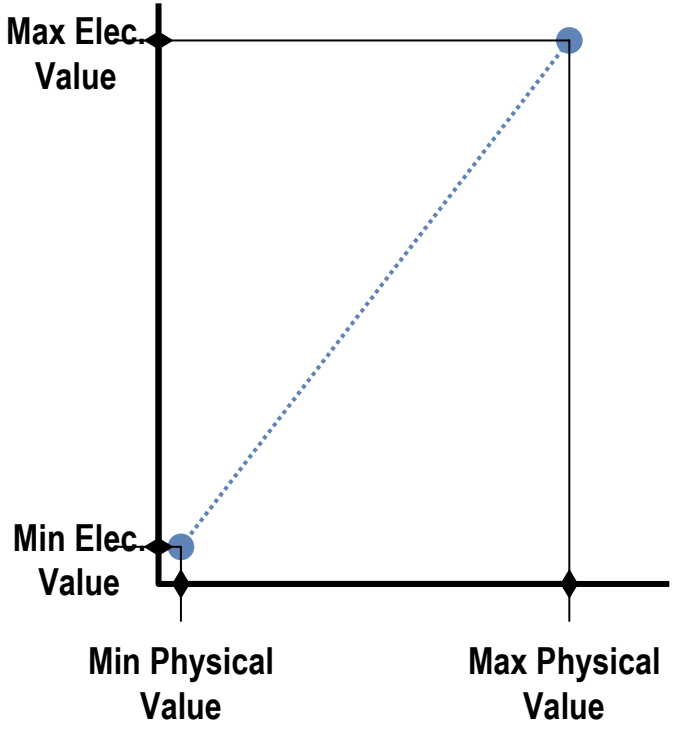
*Select : K, °C, strain, ustrain, N, lb, kgf, m/s2, ga, nM/radian, nM, oz-in, Pa, psi, Kg, G, m, mm, in, m/s, mph, fps, radians, degrees, radian/s, rpm, Hz, g/l, kg/m3, mole/ m3, mole/l, m3/ m3, l/l, m3/s, m3/hr, gpm, cfm, l/min, RH, %, Volts, Volts rms, Amperes, Amperes rms, Watts

Example of Standard Template (Bridge Type)

Property	Descriptiond	Access	Bits	Data Type (& Range)	Units	TEDS Value Example
TEMPLATE	Template ID	–	8	Integer (value = 33)	–	33
%ElecSigType	Electrical signal type	ID	-	Assign = 3, “Bridge Sensor”	–	
%MinPhysVal	Minimum physical value	CAL	32	Single	Various	0.00
%MaxPhysVal	Maximum physical value	CAL	32	Single	Various	1000.00
%MinElecVal	Minimum electrical output	CAL	32	Single	V/V	0.00
%MaxElecVal	Maximum electrical output	CAL	32	Single	V/V	3.0012E-3
%MapMeth	Mapping Method	ID	-	Assign = 0, “Linear”	–	0.110E-6
%BridgeType	Bridge type	ID	2	Enumeration: Quarter | Half | Full	–	2 (Full)
%SensorImped	Bridge element impedance	ID	18	ConRes (1 to 26.2k, step 0.1)	Ohms	350.0
%RespTime	Response time	ID	6	ConRelRes (1E-6 to 7.9, ±15%)	seconds	1E-3
%ExciteAmplNom	Excitation level, nominal	ID	9	ConRes (0.1 to 51.1, step 0.1)	Volts	10.0
%ExciteAmplMin	Excitation level, min.	ID	9	ConRes (0.1 to 51.1, step 0.1)	Volts	1.0
%ExciteAmplMax	Excitation level, max.	ID	9	ConRes (0.1 to 51.1, step 0.1)	Volts	50.0
%CalDate	Calibration date	CAL	16	DATE	–	Mar 10, ‘04
%CalInitials	Calibration initials	CAL	15	CHR5	–	GWF
%CalPeriod	Calibration period	CAL	12	UNINT	days	365
%MeasID	Measurement location ID	USR	11	UNINT	–	0

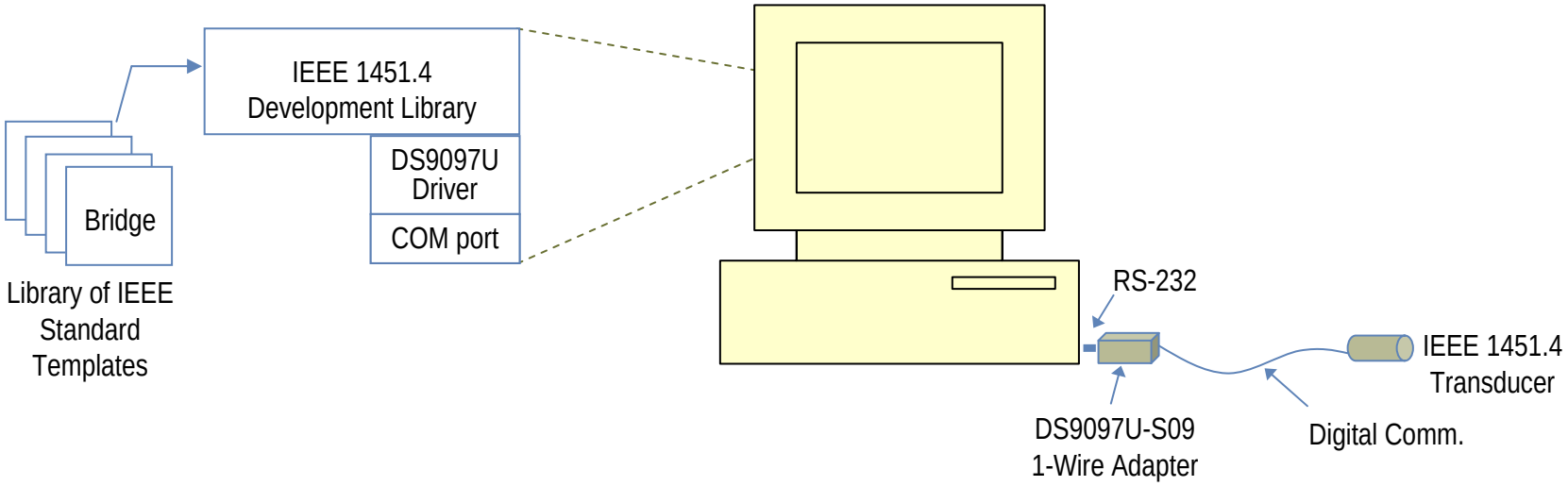
Physical and Electrical ranges

- Most templates define a 2-point mapping between the physical measurand and the electrical output
- This means that offset/gain calibration can be handled with these two points



Creating a Class 2 Sensor
How to Program and Interface the EEPROM

- Development Example
  - DS9097U-S09 COM adapter for 1-Wire
  - IEEE 1451.4 Development Library in LabVIEW



Example of Standard Template TEDS Software

EXAMPLE Create and Write TEDS to EEPROM (serial).vi Front Panel *

File Edit Operate Tools Browse Window Help

13pt Application Font

Strain Gauge | Thermocouple | RTD | Thermistor

Accelerometer | High-Level Voltage Output | Current Loop Output | Bridge

Physical Measurand: Force/Weight (pounds)

Maximum Physical Value: 0

Minimum Physical Value: 1000

Full Scale Electrical Value Precision: Full precision (32 bits)

Maximum Electrical Value (V/V): 0.0030012 V/V

Minimum Electrical Value (V/V): 110E-9 V/V

Bridge Type: Full

Bridge Impedance (Ohms): 350 Ohms

Transducer Response Time (sec): 0.001 sec

Excitation Level (Nom) (Volts): 10 V

Excitation Level (Min) (Volts): 1 V

Excitation Level (Max) (Volts): 50 V

Calibration Date: 3/10/2004

Calibration Initials (3): GWF

Calibration Period (days): 365 days

Measurement Location ID: 0

Basic TEDS

Manufacturer ID: National Instruments 30

Model Number: 32000

Version Letter: D

Version Number: 23

Serial Number: 123456

User ASCII Data

Users can write ASCII data in this area...

Target Location: Hardware TEDS

Serial COM Port: 1

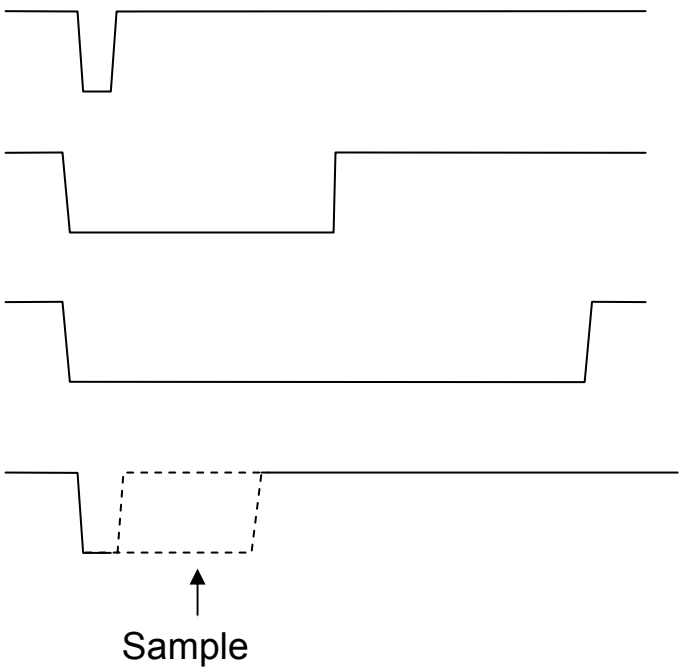
Path (for Virtual TEDS)

Write TEDS Data

IEEE 1451.4 Instrumentation

What is Required to Build IEEE 1451.4 "Readers"

- Pulses/reads with microsecond resolution
- Bidirectional line
- Example implementations
  - FPGA
  - Digital I/O port of microcontroller
- Timing requirements:
  - Writing a "1"
    - 1 to 15 us pulse
  - Writing a "0"
    - 60 to 120 us pulse
  - Reset/Synch pulse
    - 480 to 5000 us pulse
  - Reading a bit
    - 1 to 5 us pulse, sample bit after exactly 15 us



Creating a Class 2 IEEE 1451.4 Sensor - Review

- Add EEPROM to Transducer
  - as simple as 1 additional chip; two-pin connection
- Obtain Manufacturer ID from IEEE
- Programming Interface to EEPROM
  - Serial/USB adapters (example)
- Software