Smart Sensor Integration with a Wired Network

A paper in the section

IEEE 1451: Empowering the Smart Sensor Revolution

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Objectives

- Describe wired serial Transducer Interface Modules (TIMs) with IEEE 1451 protocol
- Show the 1451 data and Transducer Electronic Data Sheet (TEDS) reading process for several serial devices
- Describe integration of smart sensors into various networks

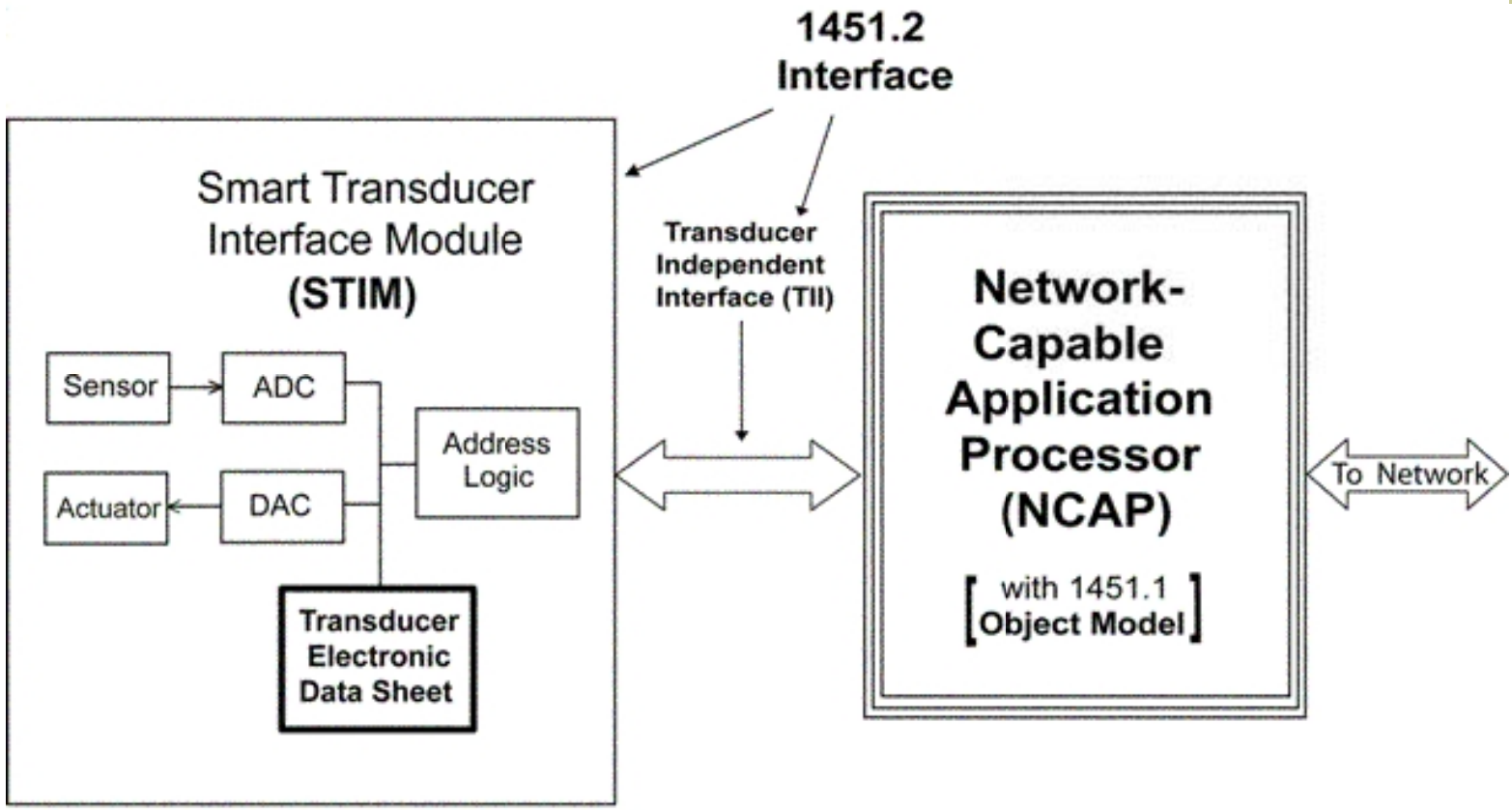
Status of

Serial IEEE 1451.x Networks

- IEEE 1451.2 TTI/RS232/RS485 (approved 1997)
  TTI approved 1997 -- Revision working group in process
- IEEE 1451.3 Multi-drop & timestamp (approved 2003)
  but no transceiver hardware yet
- IEEE 1451.4 Analog & TEDS (approved 2004)
  TEDS only, must be combined with other Dot x for digital data
- IEEE 1451.6 Open CAN (early approval process)
  Far from ready

These will use the recently approved IEEE 1451.0 Protocols & formats

Original IEEE 1451.2 (Dot 2)
With 10-pin Transducer Independent Interface (TII)



Note: New name is TIM (Transducer Interface Module)

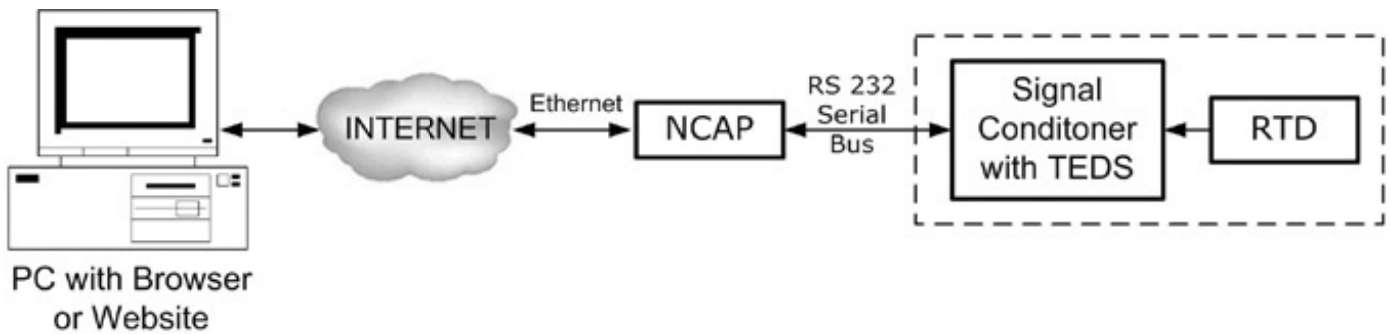
Original IEEE 1451.2 TII (SPI) Interface

* SPI line

	Line	Logic	Driven By	Function
*	2 DIN	Positive logic	NCAP	Address and data from NCAP to STIM
*	3 DOUT	Positive logic	STIM	Data transport from STIM to NCAP
*	1 CLK	Positive logic	NCAP	Positive-going edge latches data on DIN and DOUT
	6 NIOE	Active low	NCAP	Signals that data transport is active
	8 NTRIG	Negative logic	NCAP	Performs triggering function
	4 NACK	Negative logic	STIM	Trigger acknowledge and data transport acknowledge
	7 NINT	Negative logic	STIM	Used by the STIM to request service from the NCAP
	10 NSDET	Active low	STIM	Used by the NCAP to detect the presence of a STIM
	9 POWER	N/A	NCAP	Nominal 5-V power supply
	5 COM	N/A	NCAP	Signal common or ground

RS232 version of IEEE 1451.2 (proposed)

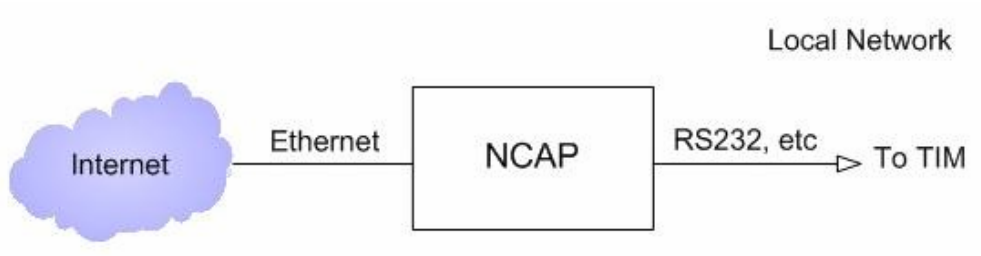
- Point-to-point serial format
- Standard 9-pin connector and +/- 10 volt level data lines
- RS485 multi-drop is likely extension to standard
- USB under consideration
- Advantage is compatibility with small microcontrollers commonly used with sensor electronics (UART or TX/RX interface)



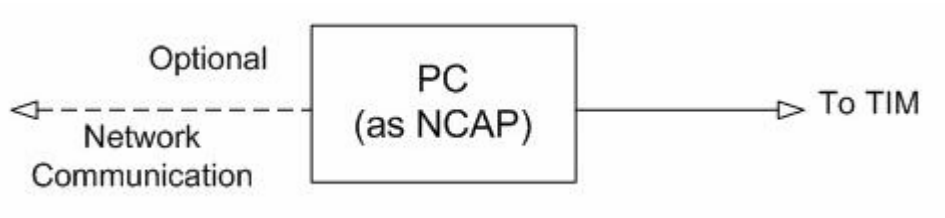
Example of a Dot 2 (RS232) TIM

Network side (NCAP) options (wired)

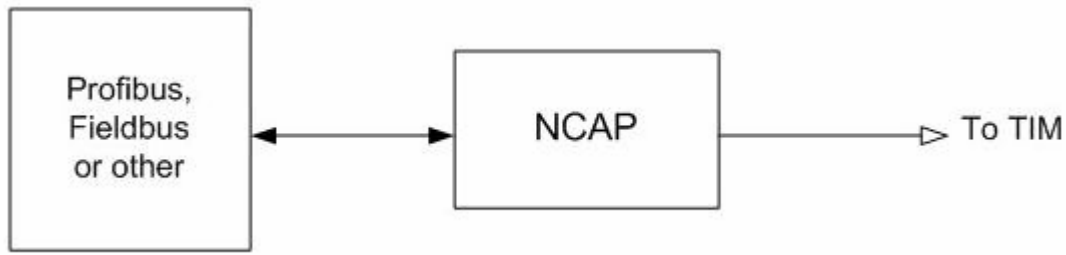
- Internet/Ethernet



- PC Readout



- Industrial network

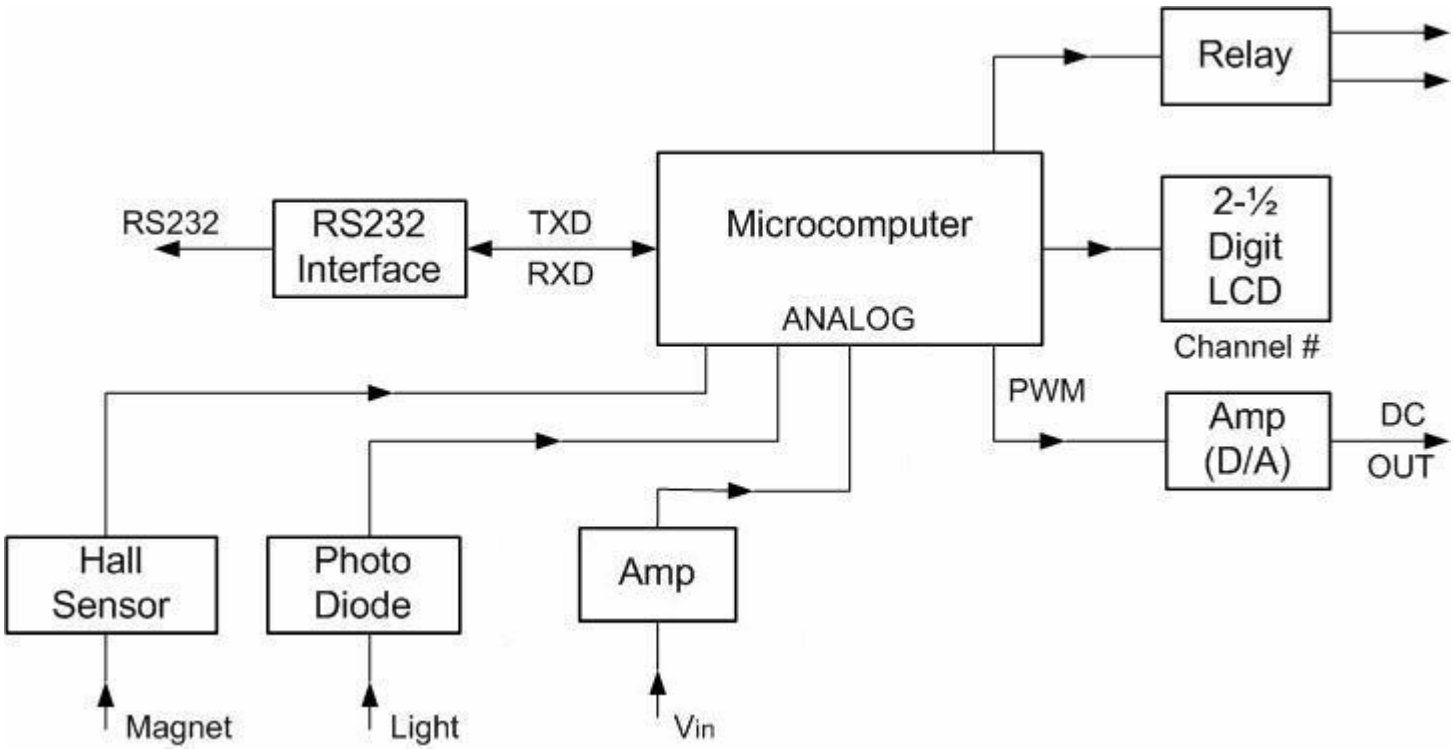


Basic Requirements for IEEE 1451Capable TIMs

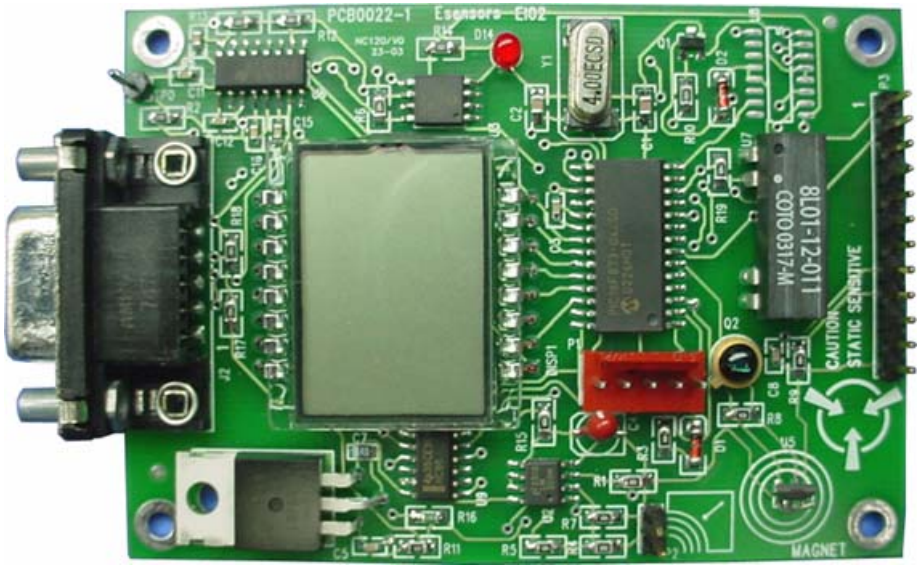
- TIM must recognize and respond to standard (Dot 0) commands (some required and some optional).
- Data must be returned in proper format, specifically the header (6 bytes) and variables [e.g. Integer (16-bit) or IEEE floating point (32 bits)].
- The Transducer Electronic Data Sheet (TEDS) must be present and in the proper format.

  [Our demo has 3 required TEDS and an optional TEDS (50-200 bytes)]
- Physical layer (Dot x) must be compatible with existing external standard

Block Diagram of a Prototype Dot 2 TIM or Smart Transducer



Prototype Dot 2 (RS232) TIM
(with 2 sensors and 1 actuator)



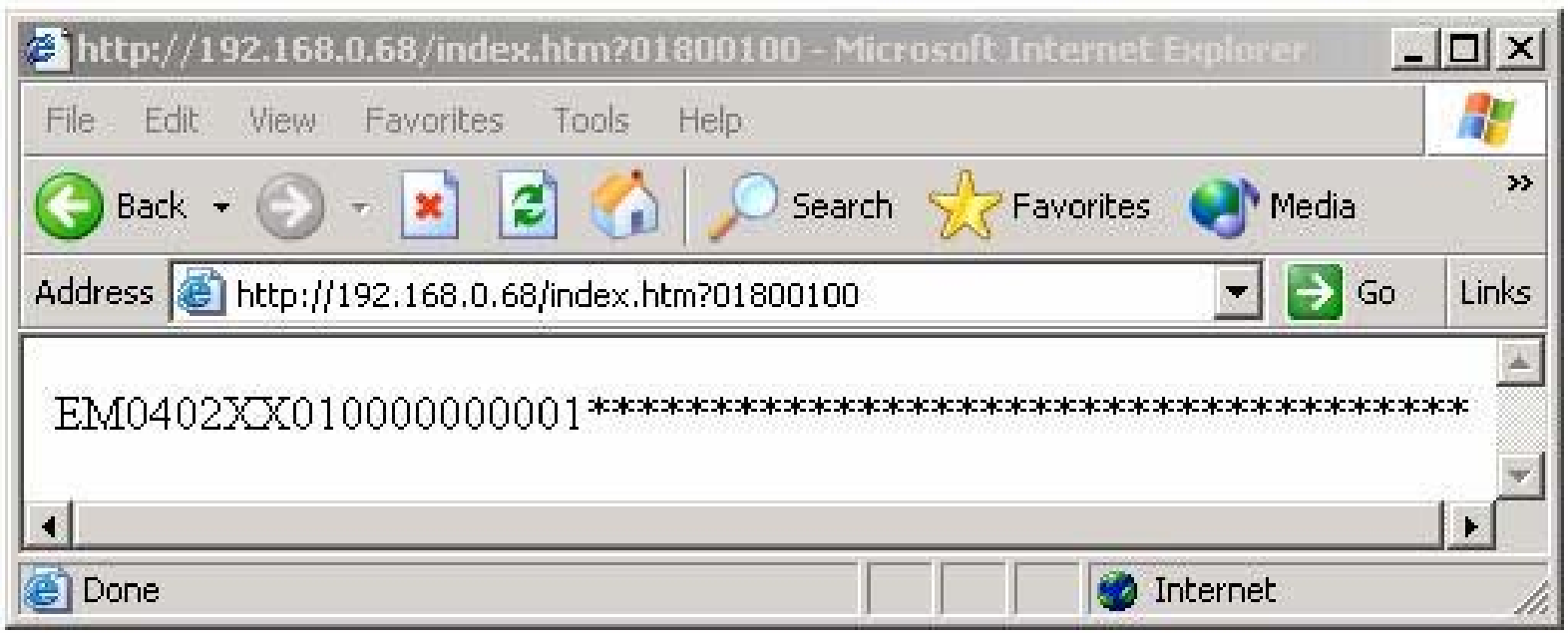
Relay

Photo

Hall effect

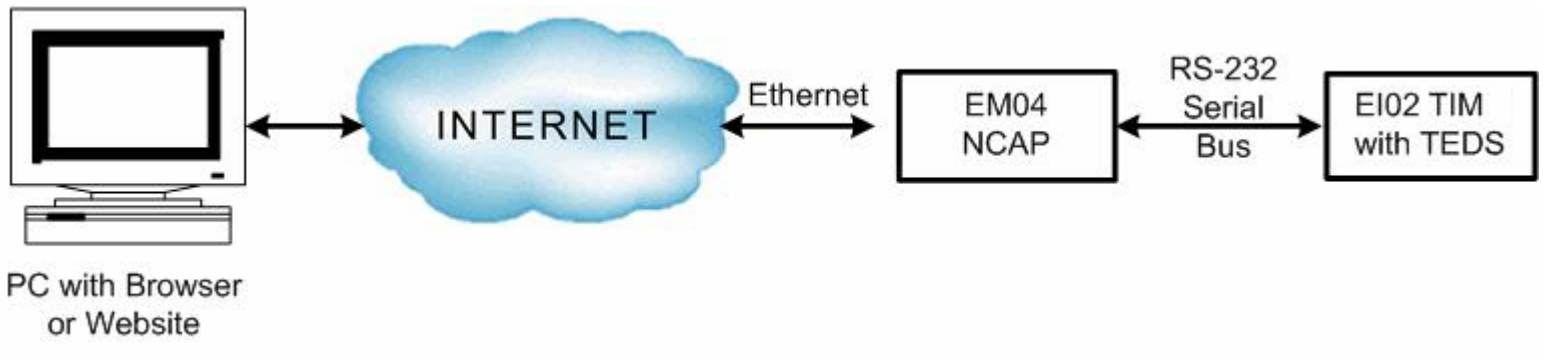
Data Readout Example

- Sensor data converted to ASCII for display



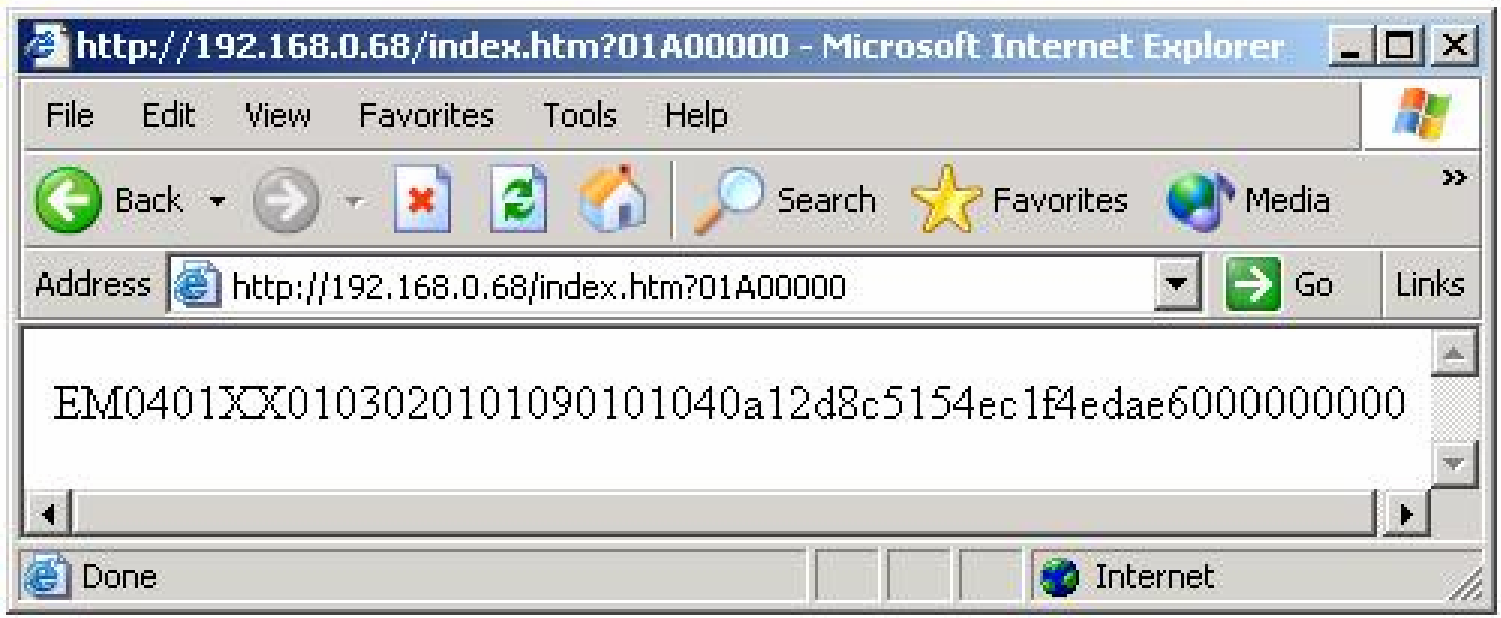
Prototype TIM and NCAP

- NCAP interfaces to Internet via Ethernet

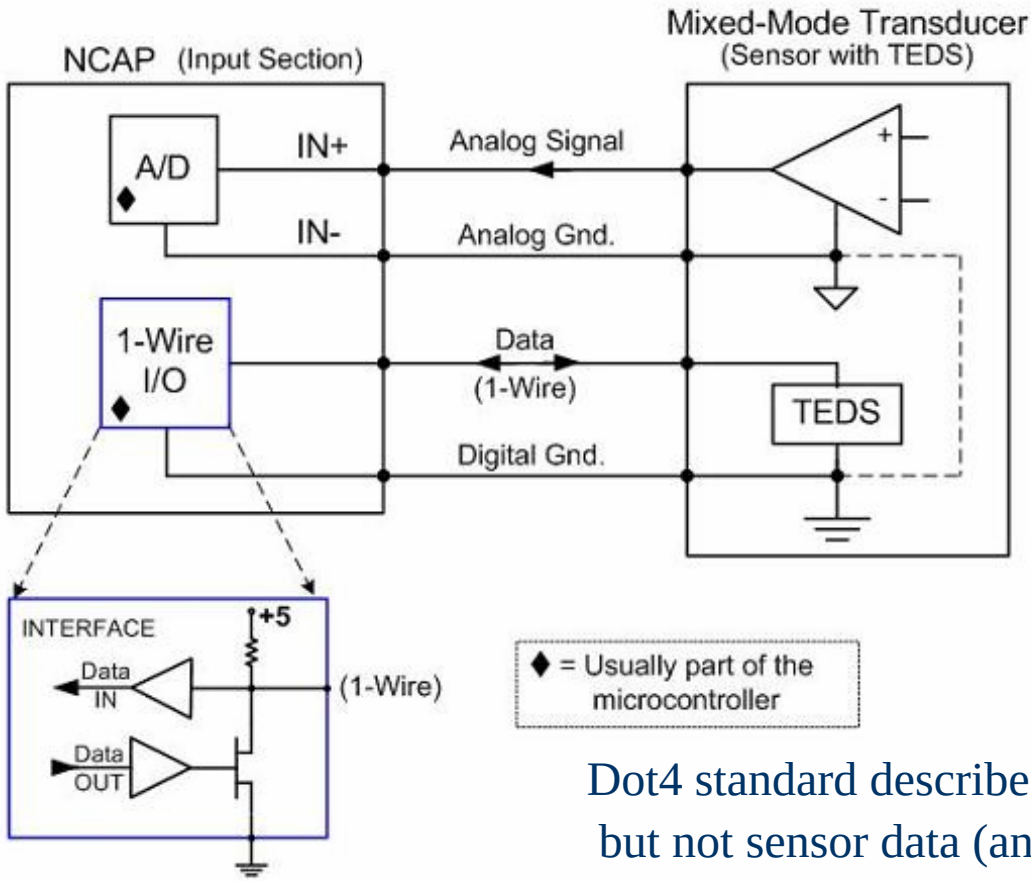


TEDS Readout Example

- Data in is hexadecimal form



IEEE 1451.4 (Dot4) Mixed Mode Interface (MMI)



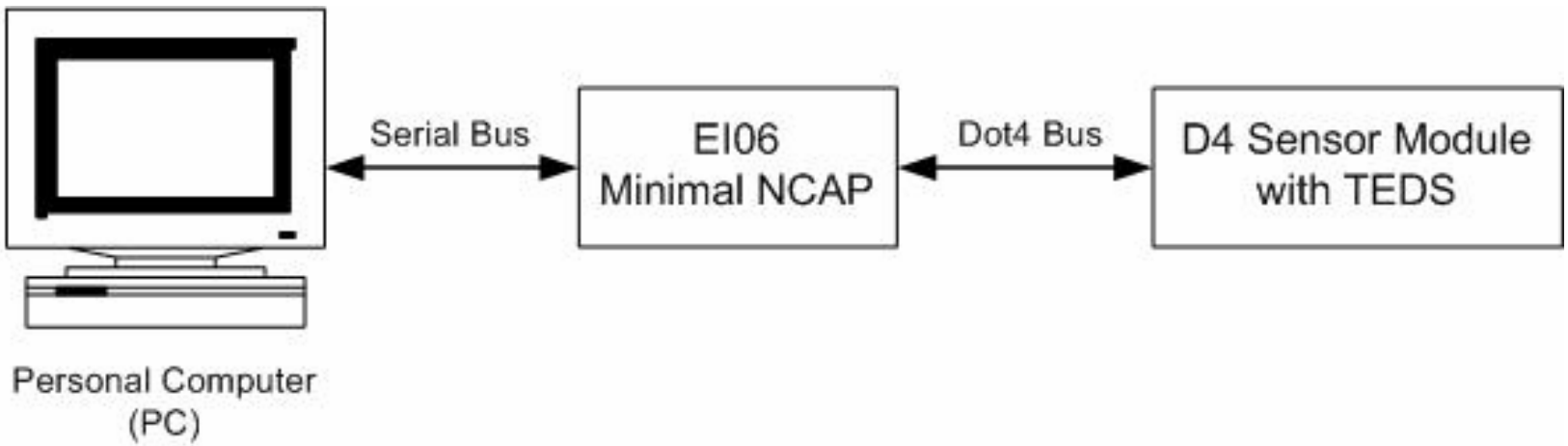
Dot4 standard describes TEDS
but not sensor data (analog) signal

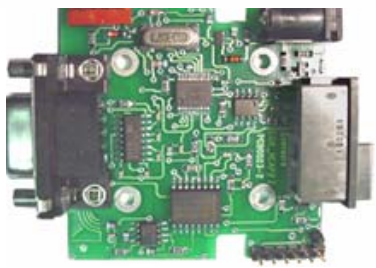
Dot4 TEDS

- Dot4 TEDS differs from standard IEEE 1451.0 TEDS.
  It has three parts:
- UUID (Universal Unique Identifier) identifies sensor. Every sensor (and manufacturer) has unique number 6-byte binary code
  (supplied by the EEPROM manufacturer and controlled by the IEEE).
- Basic TEDS section
  Manufacturer ID (14 bits), Model No. (15 bits), Version Letter (5 bits), Version Number (6 bits), Serial Number (24 bits)
- IEEE Standard Template or Manufacturers TEDS section
- Translation from Dot4 TEDS to Dot0 TEDS (described elsewhere) possible (likewise sensor data is sent in Dot 0 format)

Dot4 System Block Diagram

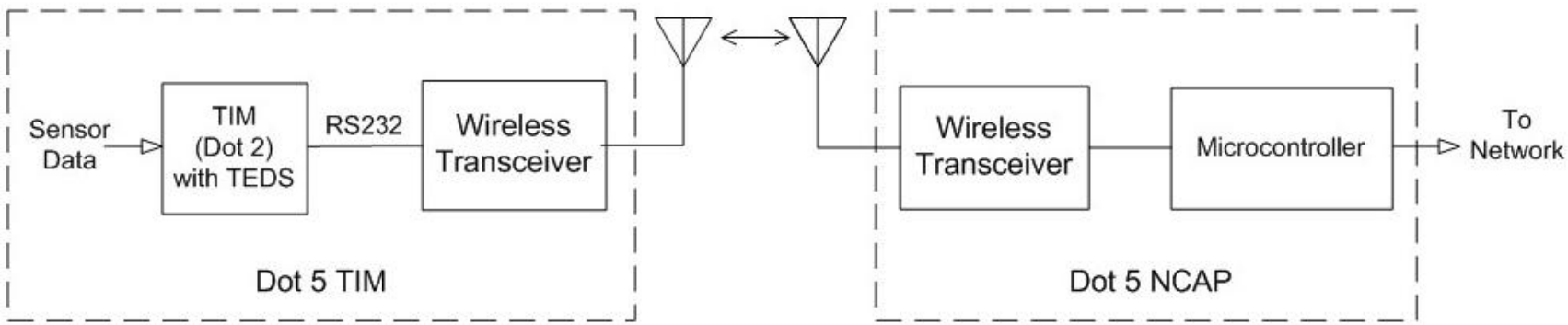
- Minimal NCAP converts analog data to digital form (Dot0/Dot2 format) and D0t4 TEDS to Dot0 format.





Wireless Connection

- Wireless modules with RS232 I/O when connected to Dot 2 TIMS are similar to IEEE 1451.5 TIMs (wireless version of IEEE 1451).
- Data format and TEDS are the same (both follow the Dot 0 standard).
- Demo at IEEE 1451 booth.



Dot 5 TIM built from a Dot 2 TIM and wireless transceiver

References

- R. Johnson, et al “A Standard Smart Transducer Interface” http://ieee1451.nist.gov/Workshop_04Oct01/1451_overview.pdf
- IEEE Std. 1451.2-1907 “IEEE Standard for a Smart Transducer Interface for Sensors and Actuators – Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Format” http://ihome.ust.hk/~yangrd/pdf/ieee14512.pdf
- R. Frank “Understanding Smart Sensors”, 2nd edition, Artech House (2000)
- D. Wobschall, “Websensor Design – Smart sensors with an Internet Address” Proceeding Sensors Expo (Philadelphia, Oct. 2001)
- D. Wobschall, “A Minimal Dot4 NCAP with a Compatible Sensor Bus”, SiCon/05 (Houston).
- www.eesensors.com/IEEE1451

Summary

- The overall architecture of smart sensors (IEEE 1451.2 TIMs) is described.
- A specific example of a TIM using an RS232 serial bus was demonstrated.
- The command and response for data and TEDS on an RS232 line were illustrated.
- Integration of Dot 2 TIMs into Dot 4 and Dot 5 networks were shown.

Further information: designer@eesensors.com