IEEE 1451 Prototype Dot 2 and Dot 4 NCAPs with Internet Access

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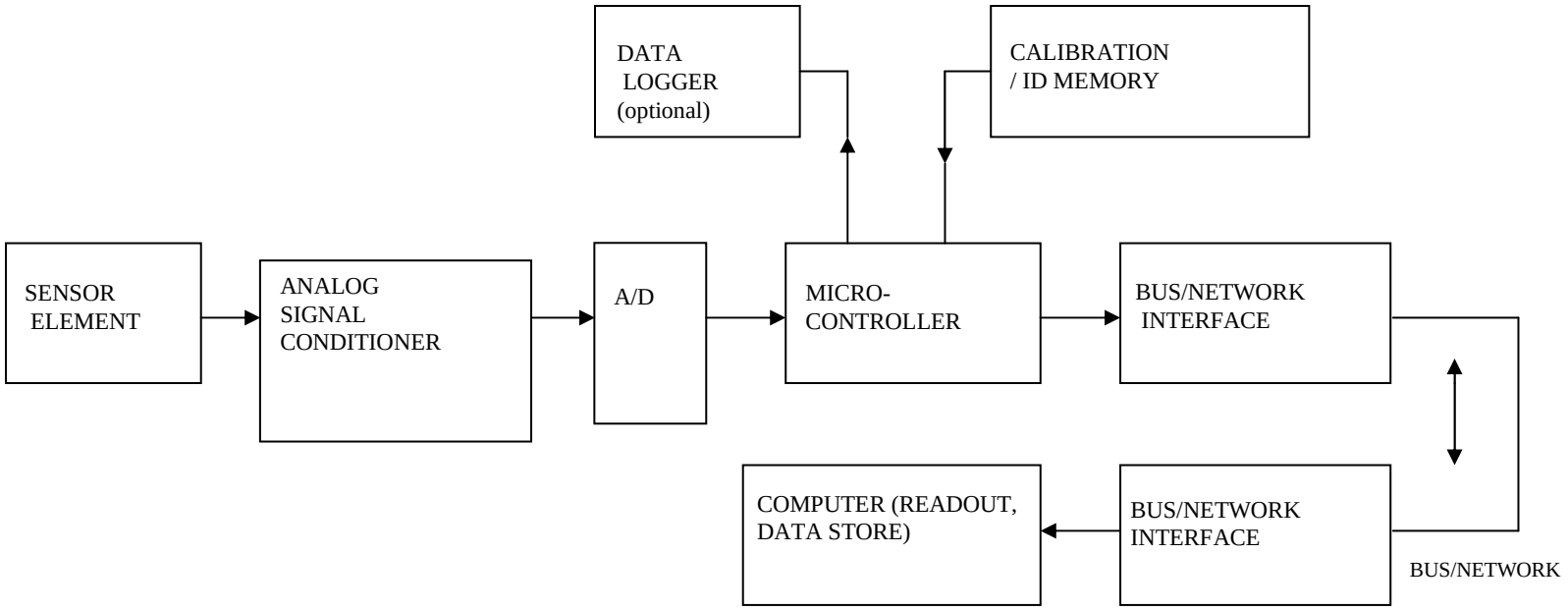
Goals

- Develop hardware and software for three IEEE 1451 compatible Network Capable Application Processors (NCAP)
- Test the RS232 serial interface as a possible new Dot2 option.
- Test a minimal Dot4 NCAP
- Test a split Dot4 NCAP
- Provide direct Internet access via Ethernet for sensors

Generic Smart Sensor Block Diagram



Need for Network Standards

- Smart sensors require a digital network
- Over 50 sensor networks and busses in common use
- Users want one standard to reduce manufacturing and installation costs, and for plug&play capability
- No single local network is likely to dominate in near future due to divergent needs
- The Internet via Ethernet will likely be one of the dominate networks (cost/ complexity are problems)
- The IEEE 1451 standard for sensor interfacing overcomes many of the complications of multiple networks

IEEE 1451 Parts

- IEEE 1451.0 Protocols & formats (early approval process)
- IEEE 1451.1 Object model (approved 1999)
- IEEE 1451.2 Interface (approved 1997)*
- IEEE 1451.3 Local network (just approved)
- IEEE 1451.4 Analog & TEDS (final approval process)
- IEEE 1451.5 Wireless (early approval process)

* Enhancement /revision working group in process

Advantages of IEEE 1451 Standard

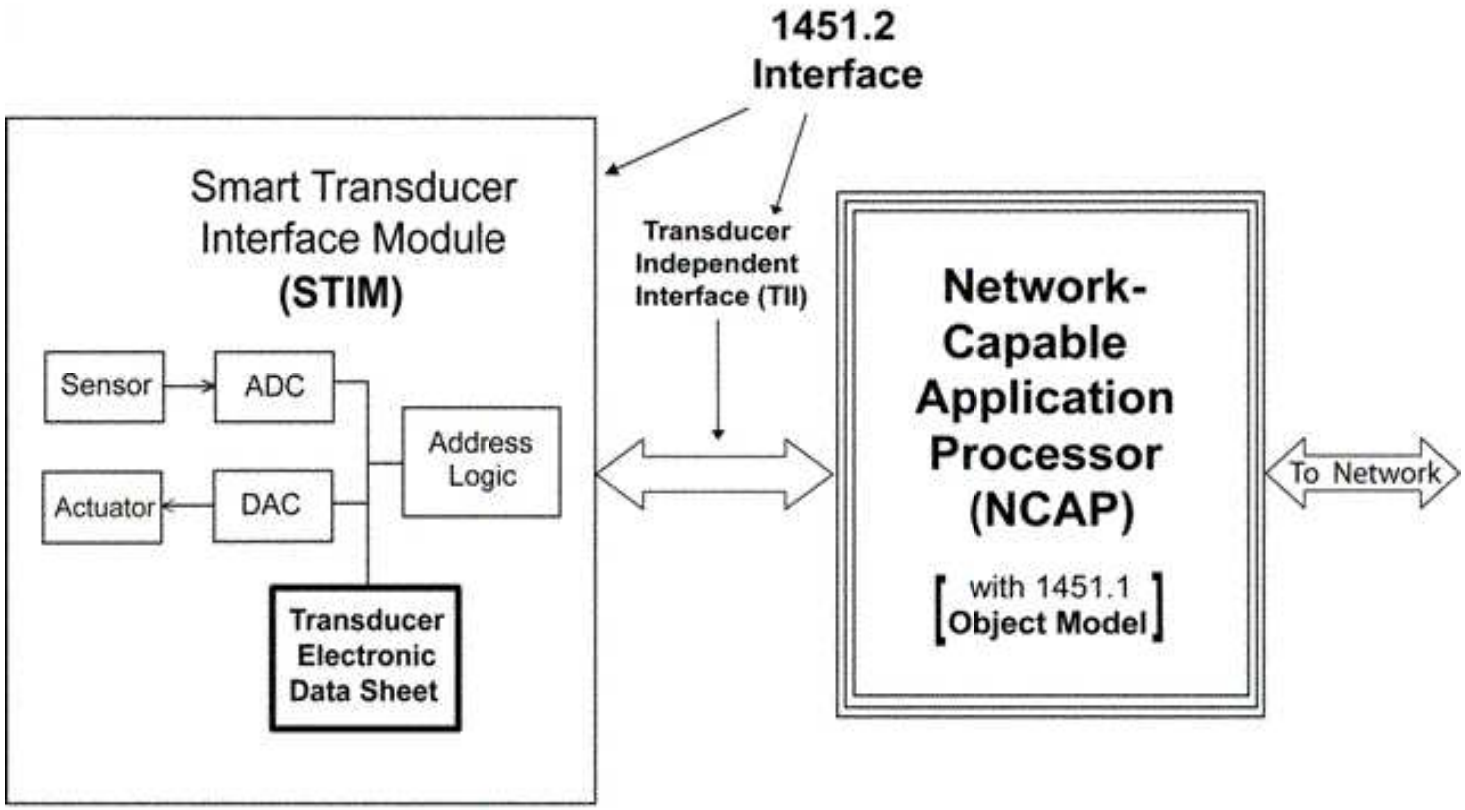
- Continuing network interface and microcontroller cost reductions have made interface more attractive.
- The sensor industry is closer to recognizing the necessity for a sensor network standard.
- The general concept of the IEEE 1451 approach, especially TEDS, is supported by many.
- Working groups are addressing the dot2 problems and expanding the standard via dot3, dot4, and dot5.

Websensor design

- Developed at Esensors before this NCAP
- Has Internet/Ethernet interface (TCP/IP)
- Sensors are built-in (direct Internet connection)
- 8-byte command and 32 byte response
- Similar to a NCAP with sensors

  (but without TEDS and uses ASCII commands & data)

Present (1997) IEEE 1451.2 System Block Diagram



Dot2

IEEE 1451.2 TEDS Blocks
--Transducer Electronic Data Sheet --

Machine Readable

- Meta-TEDS (mandatory)
- Channel TEDS (mandatory)
- Calibration
- Physical Layer Meta (proposed)
- Physical Layer Channel (proposed)

  Note: One TEDS per channel for Calibration

Human Readable

- Meta-ID TEDS
- Channel-ID TEDS
- Calibration-ID TEDS
- Application Specific

  End Users' Application-Specific TEDS
- Future Extensions

  Industry Extension TEDS

Simplified TEDS under discussion in Dot 2 revision working group

Dot2

Drawbacks to Present IEEE 1451.2 Standard

List compiled from comments at meetings

- Few NCAP suppliers
- TII interface unpopular (few STIMs also made)
- Does not support standard serial interfaces
- No standard connector option
- TEDS large and complex, yet not complete

  but Dot4 has basic TEDS and extensions using T-block
- Plug-and-play has been demonstrated, but difficult

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Dot2

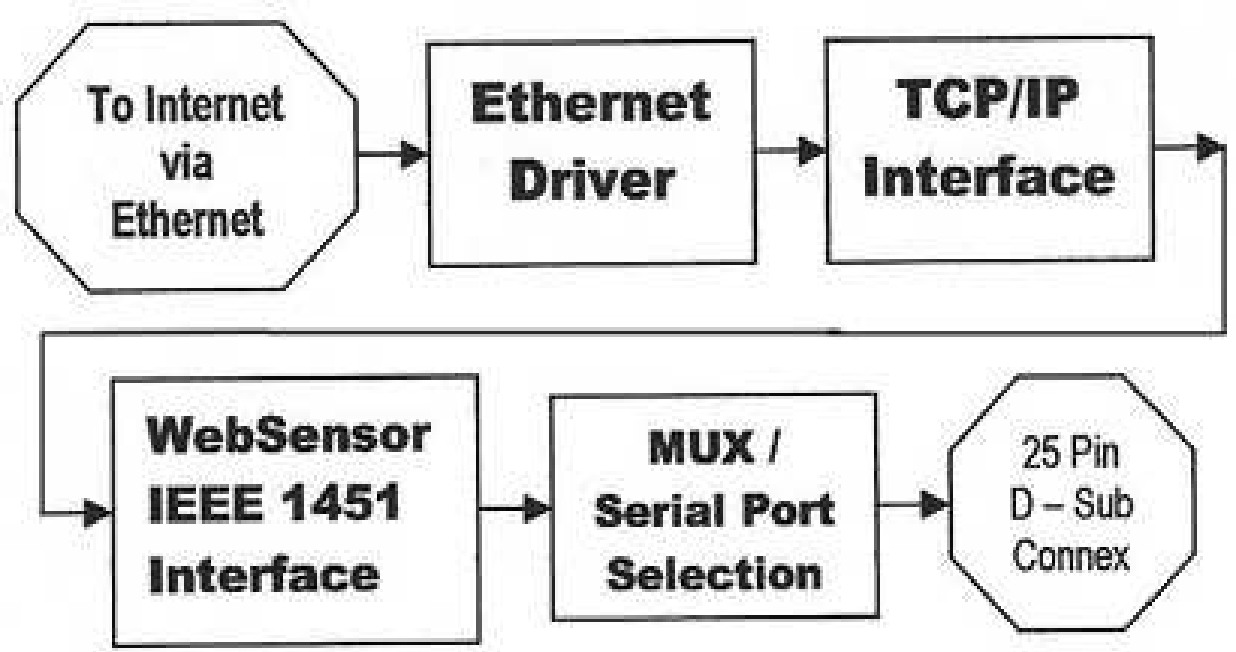
Multi-serial port NCAP
(a prototype Dot2/Dot4)

- Similar to Dot2 NCAP but has additional options
- Hardware is initial design focus of prototype
- Has different options for the serial port
- Has internal TEDS storage memory (option)
- Only basic software supplied

  (IEEE 1451 TEDS is large, complex and changing)
- I-Format protocol currently used (ASCII encoded binary)
- Demo with RS232 STIM available
- H-format protocol under development

  (mostly IEEE 1451.2 compatible and includes Dot2 commands)

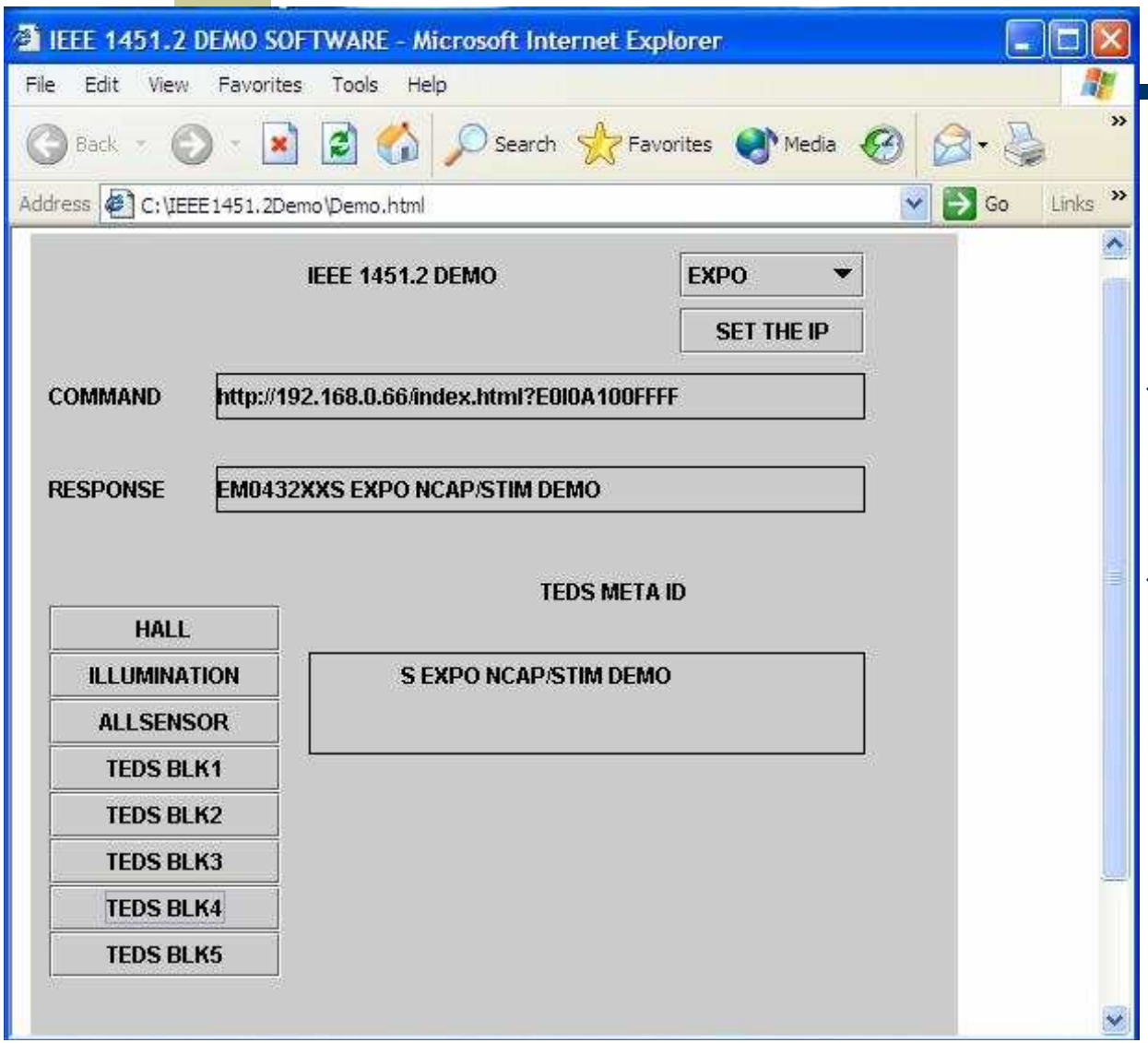
NCAP Block Diagram



Serial Port Selection

•RS232	000	New Dot2
•RS485/Modbus	001	
•TII (original IEEE-1451.2)	010	
•Microlan/1-wire	011	
•IEEE-1451.4	100	
•Esbus	101	
•I^2C	110	
•General (individual I/O lines)	111	

Internet Command/Response Screen
-- I Format (experimental) --

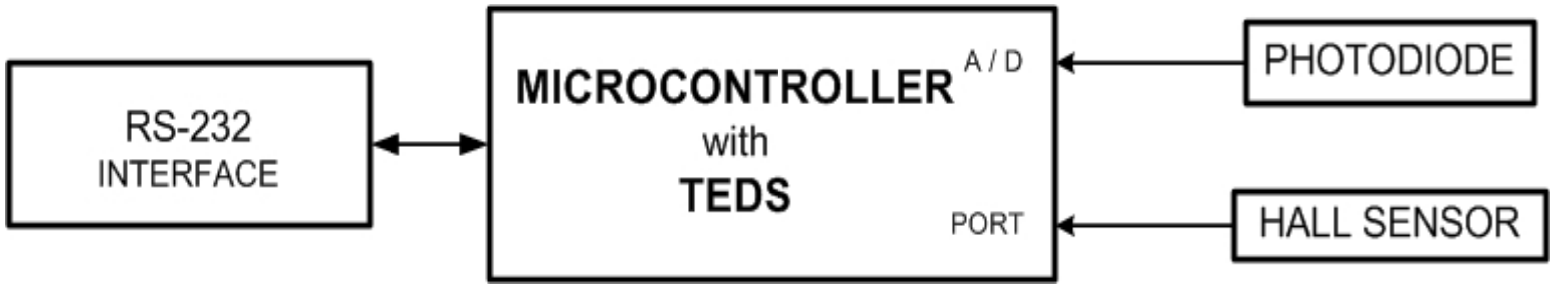


- Some binary words cannot easily be transmitted over Internet
- I format uses Dot2 binary commands converted to hex
  [e.g. A6 transmitted as ASCII "a" + ASCII "6"]

Dot2

Block Diagram of STIM for Dot2 NCAP Testing

- PIC 16F783 used for microcontroller
- TEDS (mini-version) in 128 byte EEPEOM
- Sensors for illumination and magnet proximity
- Standard RS232 (+/- 10v) rather than TTL/CMOS level



Dot2

Internet commands -- h format
(under development – all ASCII)

Command Header (8 bytes)

echybbbb

where e is ASCII “e” and h is ASCII “h”
c is the channel number, 0 to 9 (a to f)
y is command (see below)
bbbb is data, data block #, or subchannel
[set bbbb to zero if unused]

Command list

R: Read sensor data, result in decimal (ASCII)
r: Read sensor data, result in hex
W: Write actuator (or sensor setup), data in decimal
w: Write actuator, data in hexadecimal
U: Report sensor units
T: Send TEDS data (where bbbb is data block #)
I: Send ID information (short form of TEDS)

Dot2

Internet Data Transfer – h format
(continued)

Data Format Header (1st 8 bytes)
EM04achw
where c is channel # (0 to 9, a to f)
and w is status (unspecified)
Remaining bits (EM04a + h) are fixed

Time Stamp (2nd 8 bytes) -- optional
Cdhhmmss
where hh= hour
mm=min
ss=sec
d=day of month (last digit)
Data (2 [or 3] sets of 8 bytes, total 16 or 24)
TC123.45 example of temperature data

Total data transmitted is 32 bytes (http)

Dot2

TEDS Memory Types

Option #1 – Standard dot2 TEDS

* Meta-TEDS (binary/machine readable)

[Meta is all channel]

* Meta-ID-TEDS (ASCII)
* Channel-TEDS (binary)

Option #2 – Modified dot4

* Basic TEDS (8 bytes, binary)
* ID TEDS (user provided 24 bytes ASCII)
* Several templates implemented

Dot2

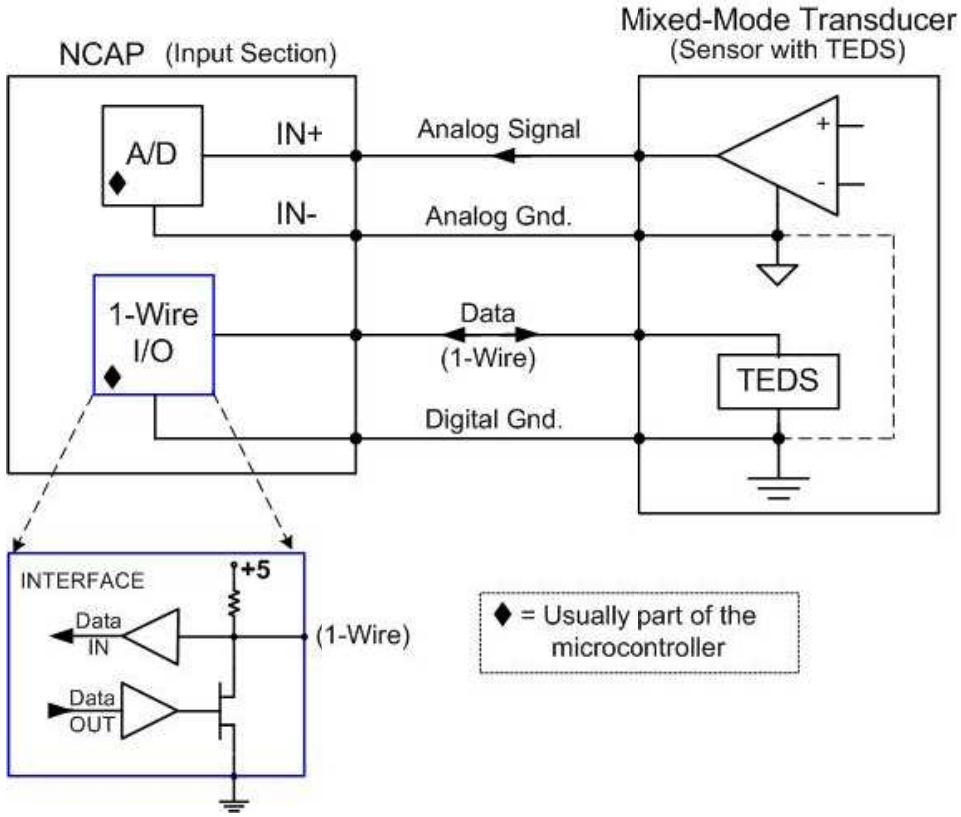
TEDS Read Commands
(standard/original IEEE 1451.2 format)

Command *hex*	Function	# bytes
8000	Meta-TEDS	80
A000	Meta-TEDS-ID	16
B001	Chan 1-TEDS	48
B101	Chan 1-TEDS-ID	16
B002	Chan 2-TEDS	48
B102	Chan 2-TEDS-ID	16

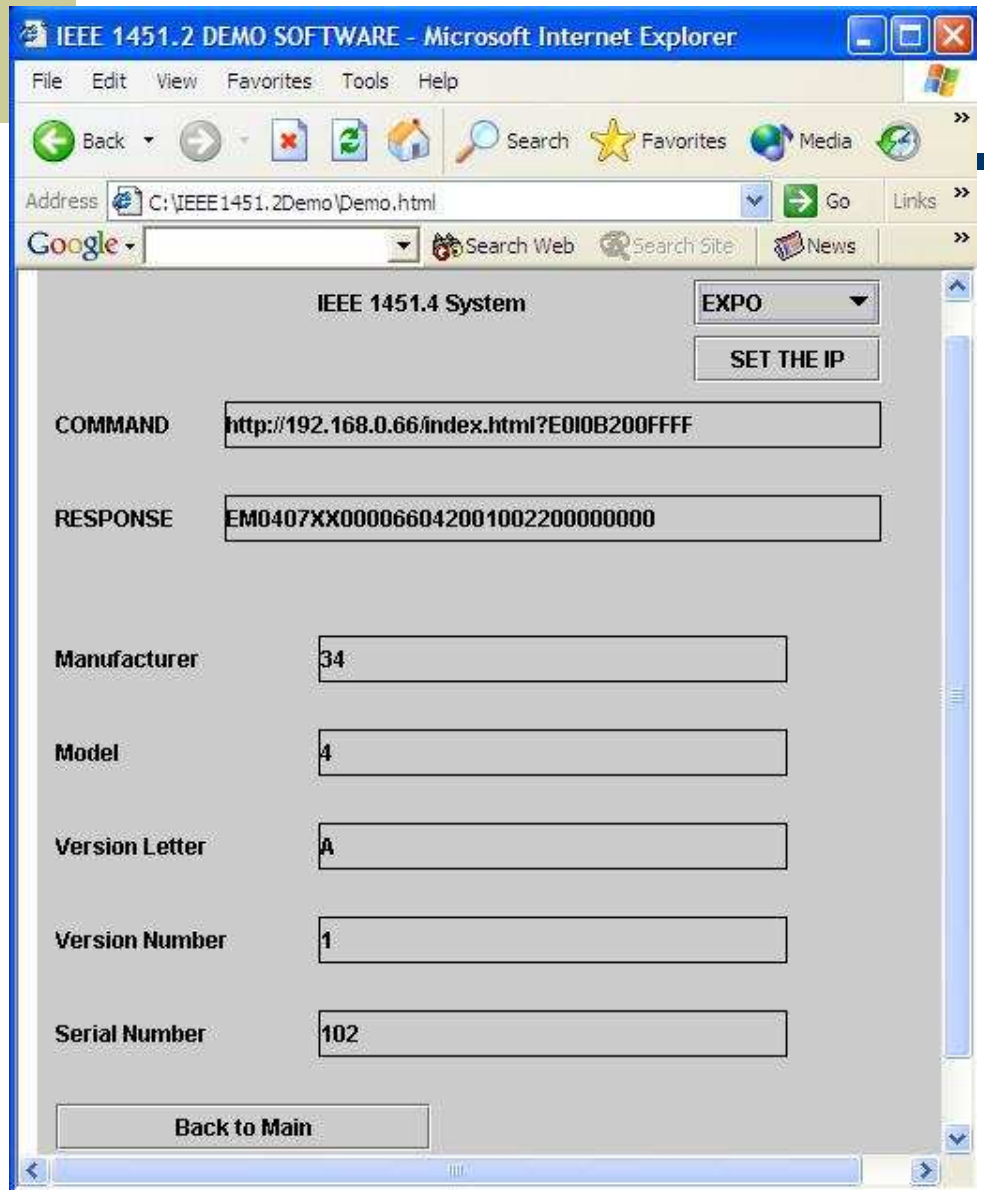
Because of experimental 24 byte (12 byte binary) limitation, commands are subdivided

Dot2

IEEE 1451.4 (Dot4) Interface
(Class 2)



Basic TEDS

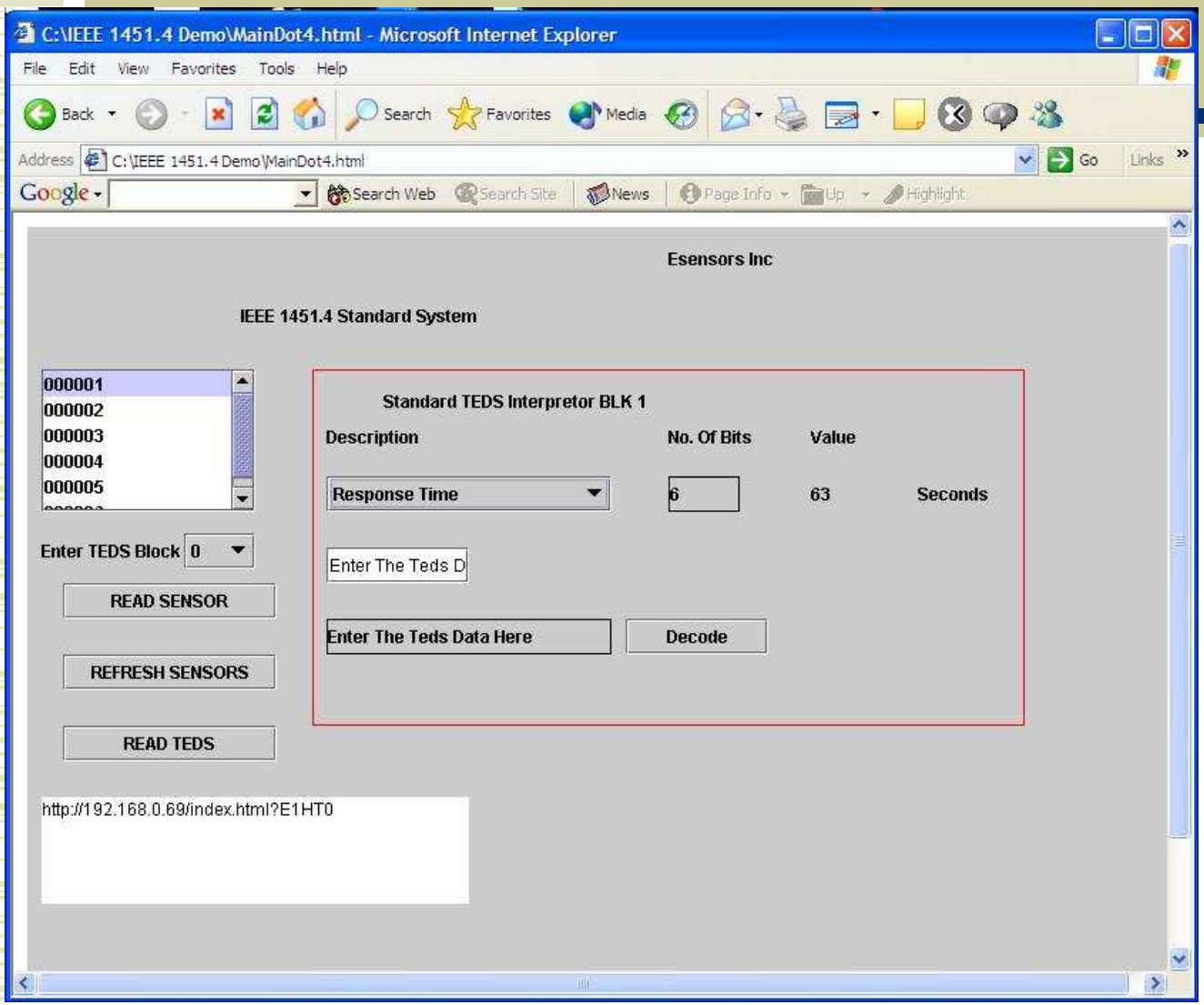


Basic TEDS (8 bytes)

- Manufacturer ID (14 bits)
- Model Number (15 bits)
- Version Letter (5 bits, A-Z)
- Version Number (6 bits)
- Serial Number (24 bits)

Dot4

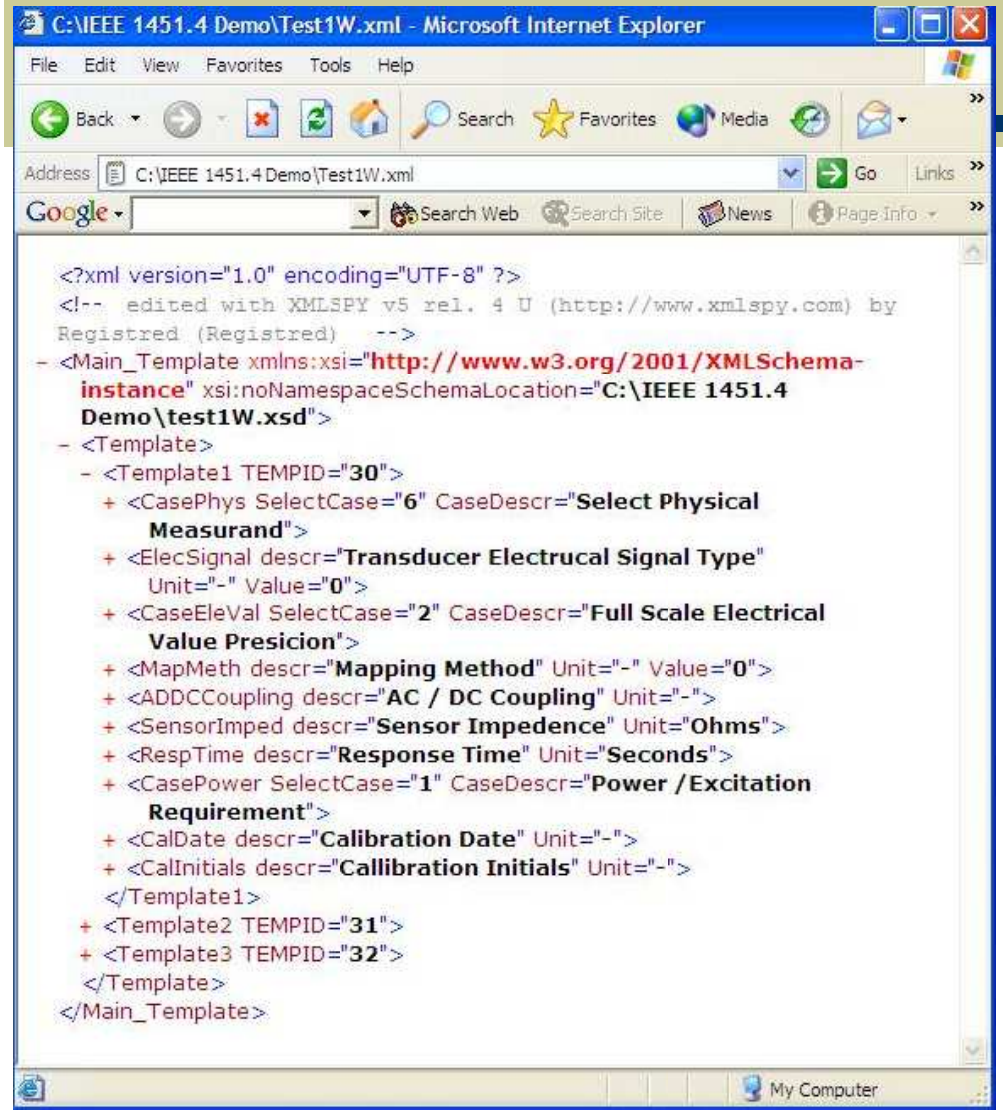
Standard Template TEDS



Contains binary data for specific templates

Dot4

Dot 4 XML Program

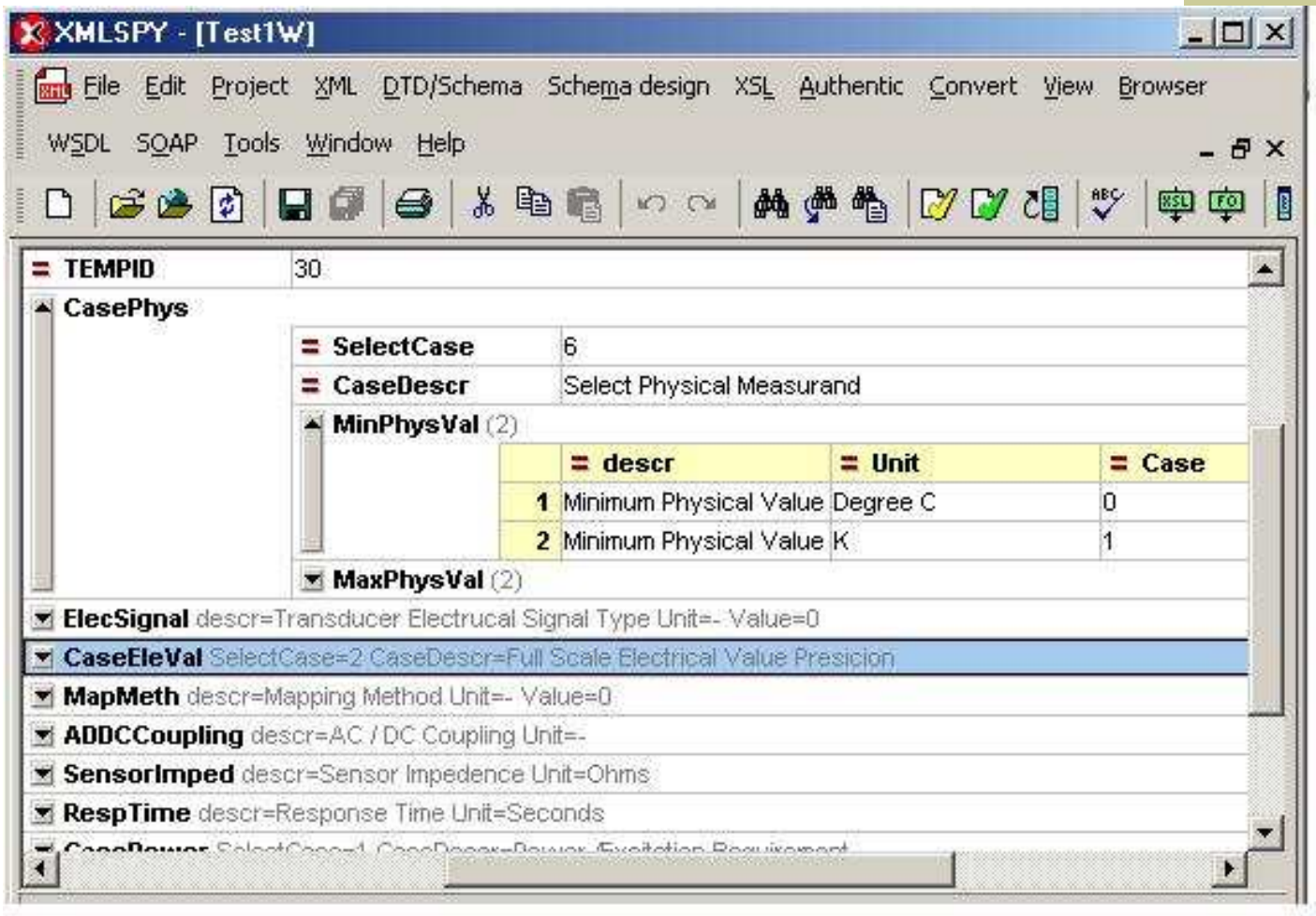


Example of

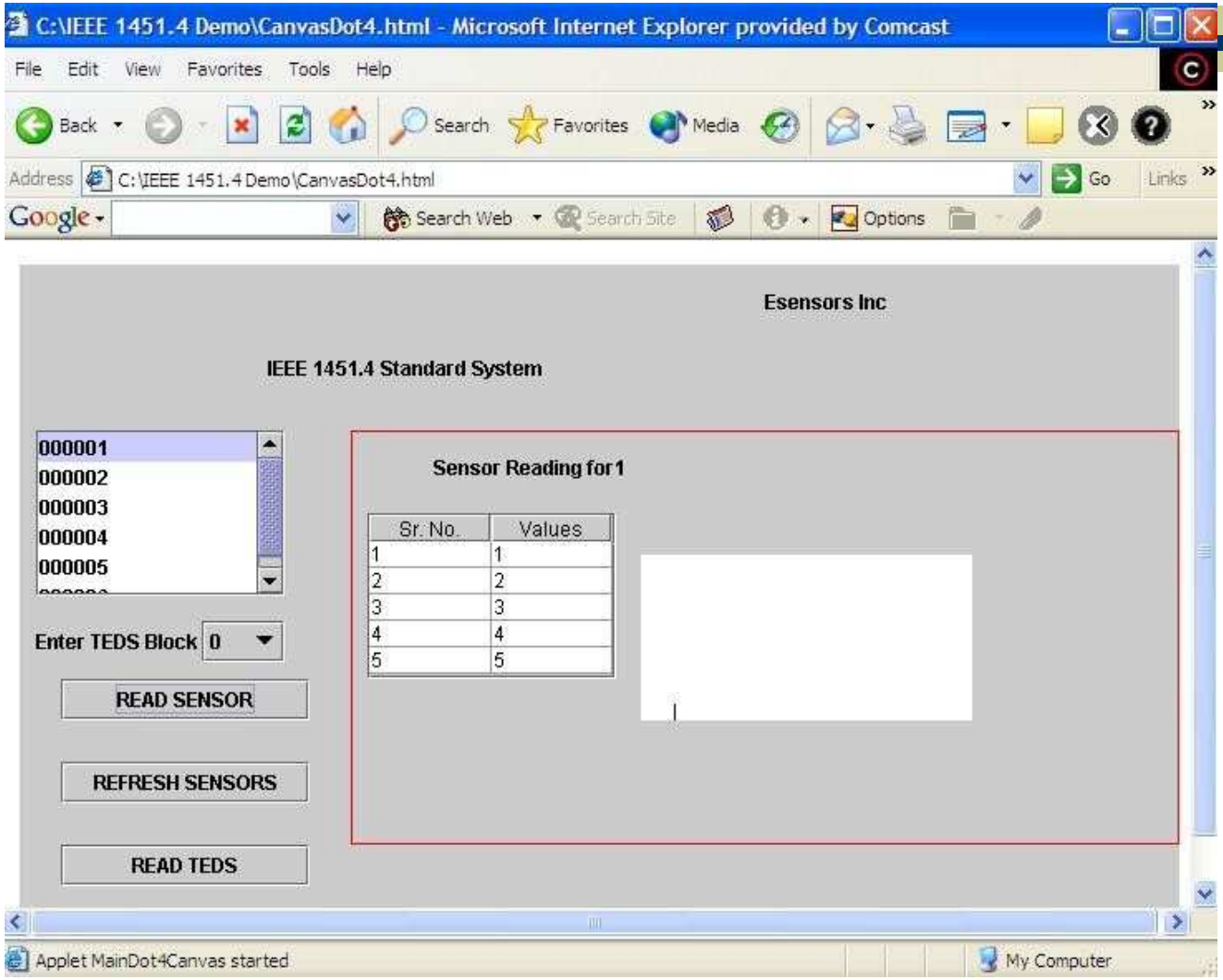
T-block program to parse standard TEDS

[Uses XML-SPI]

TEDS Template # 30
(4 – 20 Ma)



Analog data readout screen
(4-20 mA interface)

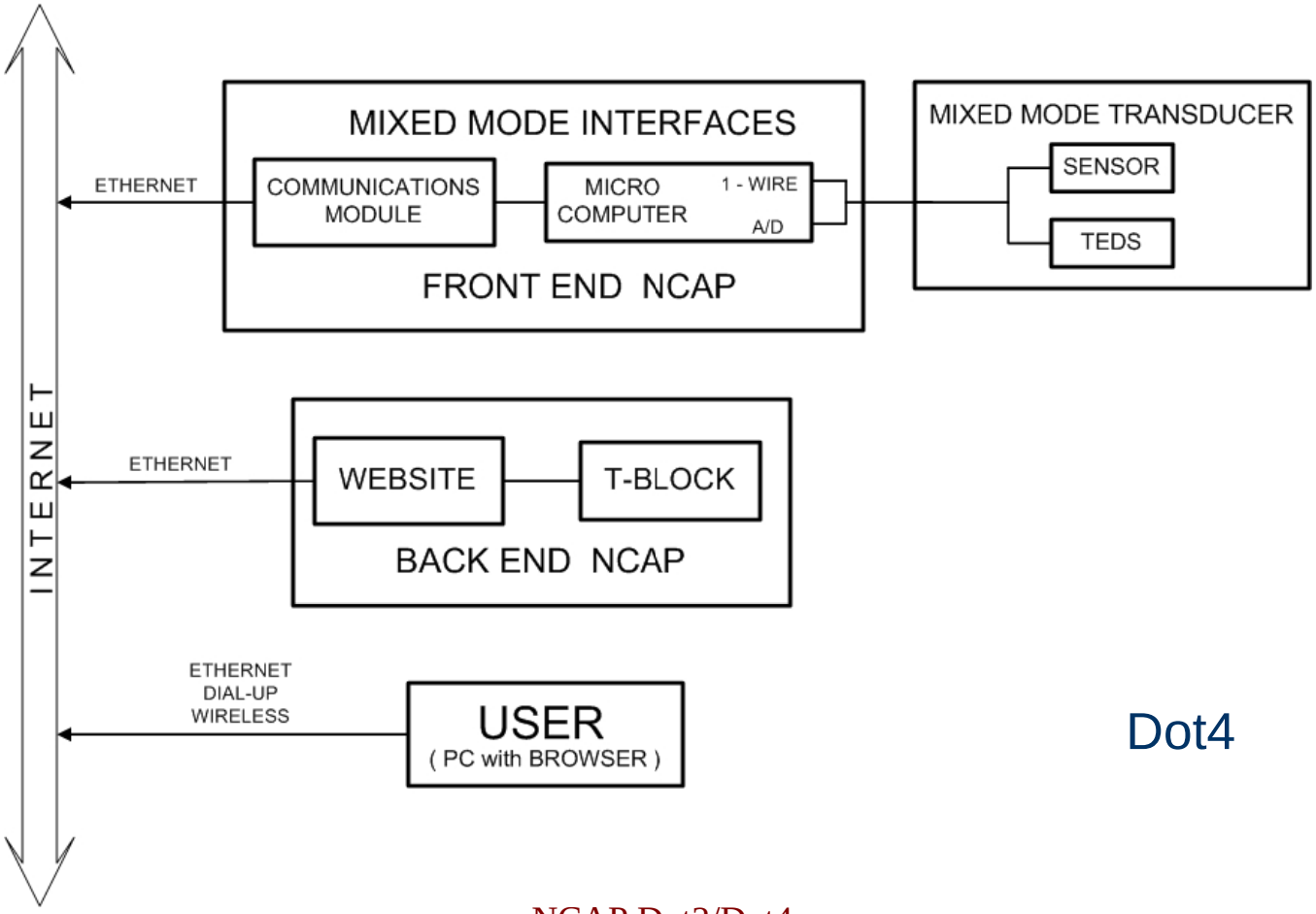


Split NCAP
(Dot4 NCAP Partitioning)

- Sensor data is transmitted over Internet via Ethernet to Website for further processing (speed limited)
- Needed because full Dot4 Software too complex for a small NCAP at sensor end (Front-end)
- Complex section (T-block) is moved to PC/Website (Back-end)
- Fully processed data is available over Internet from any Internet browser
- System is compatible with appended (virtual) TEDS

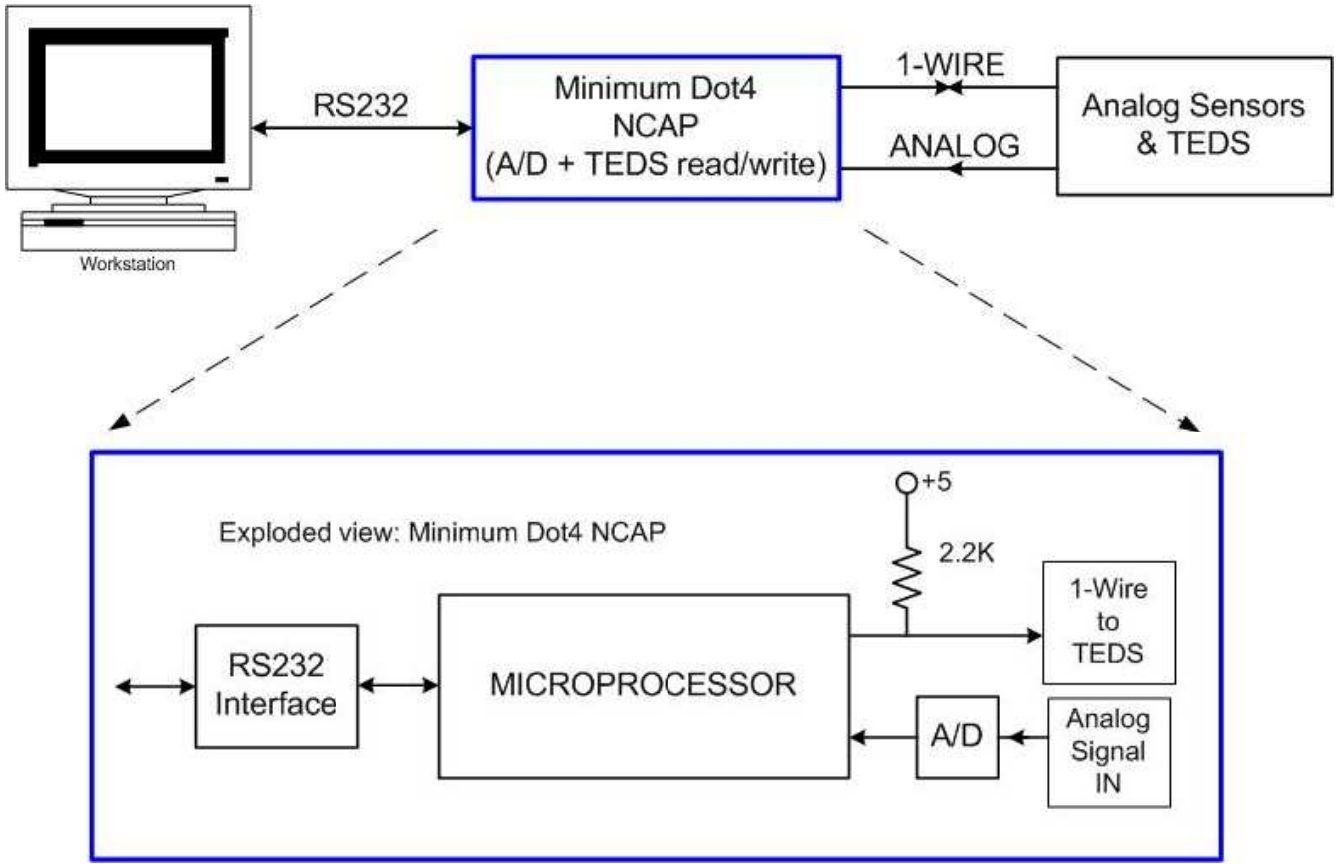
Dot4

Split Dot4 NCAP Block Diagram

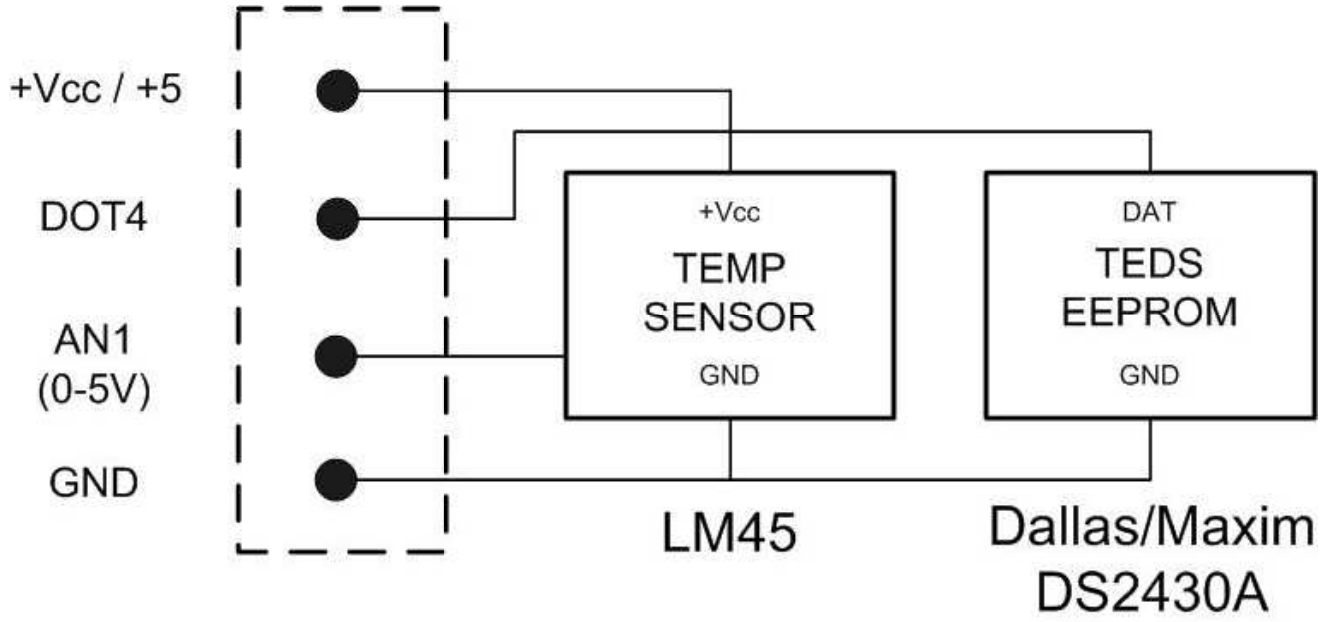


Dot4

Minimal Dot 4 (PC) NCAP
Block Diagram



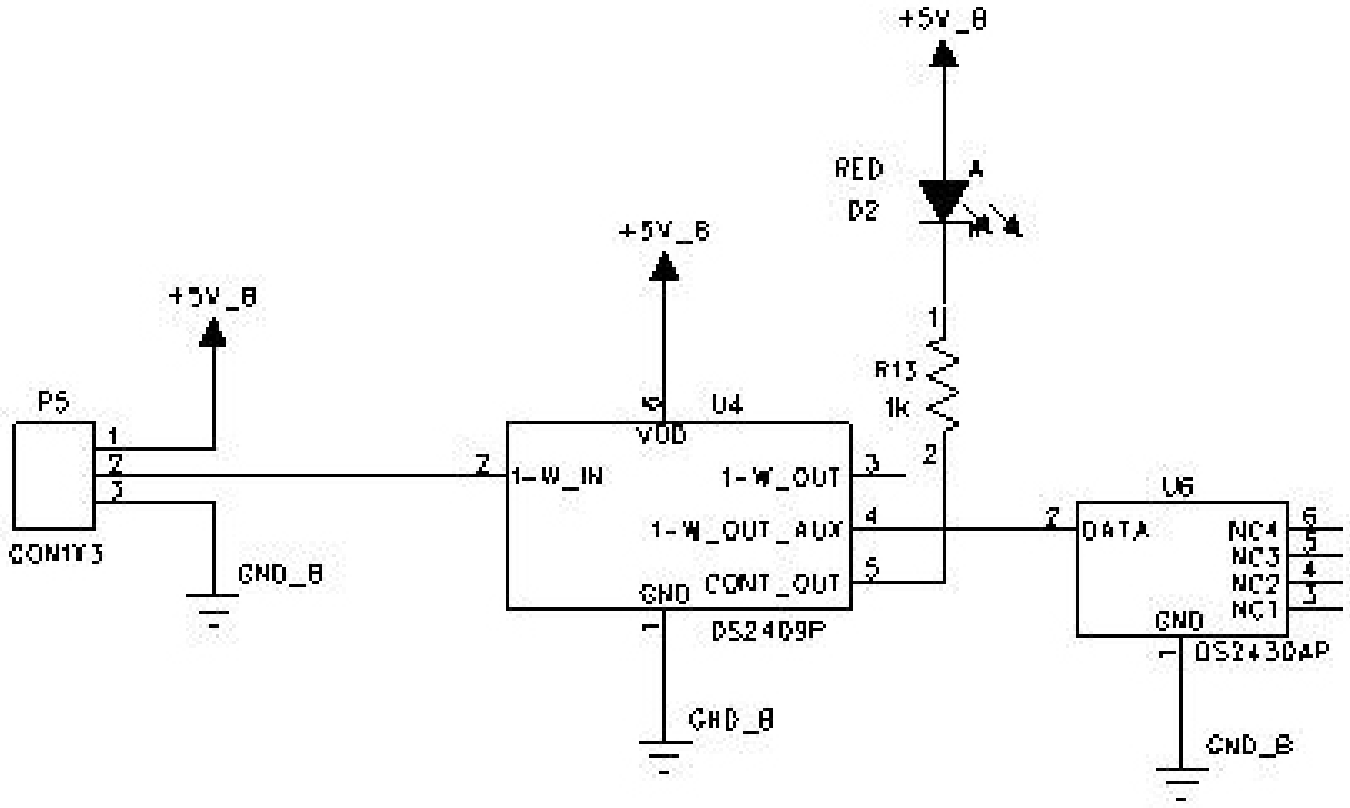
Simple Dot4 Sensor Circuit
(Single TEDS and analog signal)



Dot4

Note: Not block diagram

TEDS Tag
(multi-drop version)



References

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- 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 ed, Artech House (2000)
- D. Wobschall, “Websensor Design – Smart sensors with an Internet Address” Proceeding Sensors Expo (Philadelphia, Oct. 2001)
- T. Licht, “The IEEE P1451.4 Templates”, Proceedings Sensors Expo (Chicago, June 2003)
- www.eesensors.com/IEEE1451
- ***Experimental NCAP demo at mini-pavilion***

Summary

- Multiple serial port NCAP (hardware) for use with the Internet (via Ethernet) has been developed
- Simple IEEE 1451.2 command/data software (and STIM) with RS232 interface has been demonstrated
- Dot 4 Basic and Standard Template TEDS retrieval has been shown
- Minimal and Split Dot4 NCAP described

Further information: designer@eesensors.com