



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

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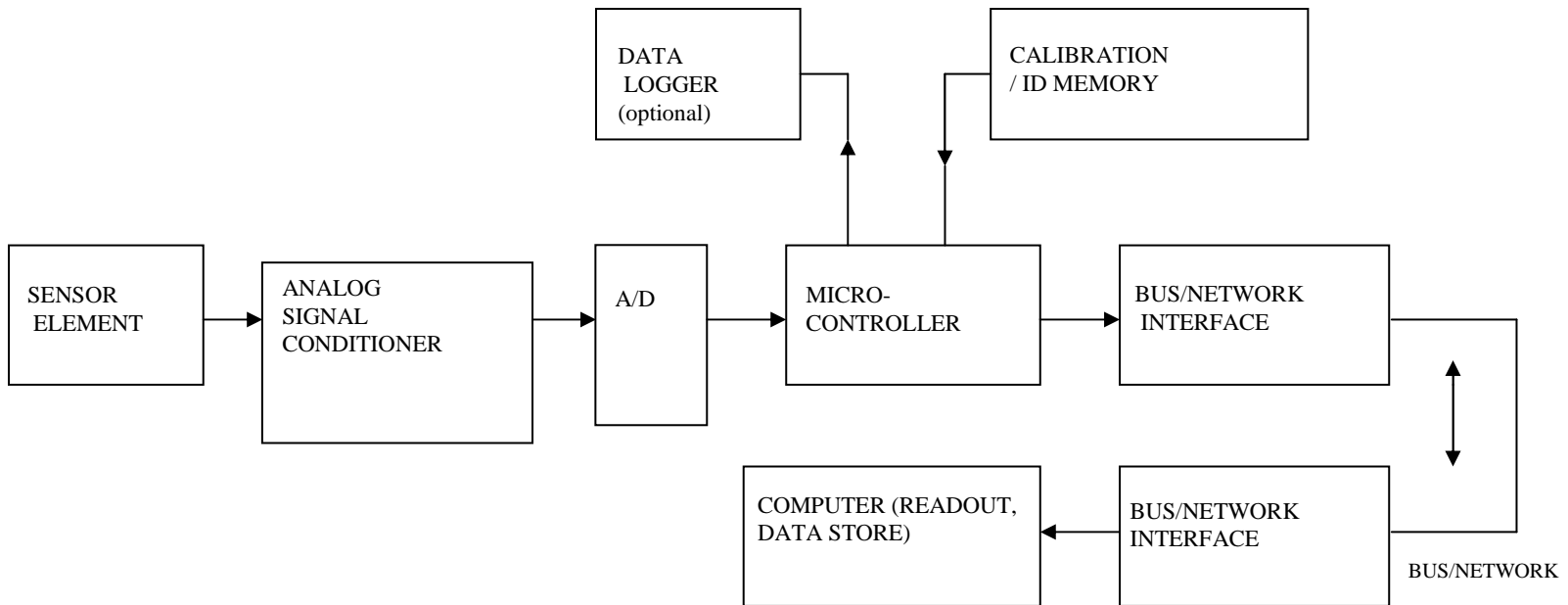
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# Goals

- ◆ 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

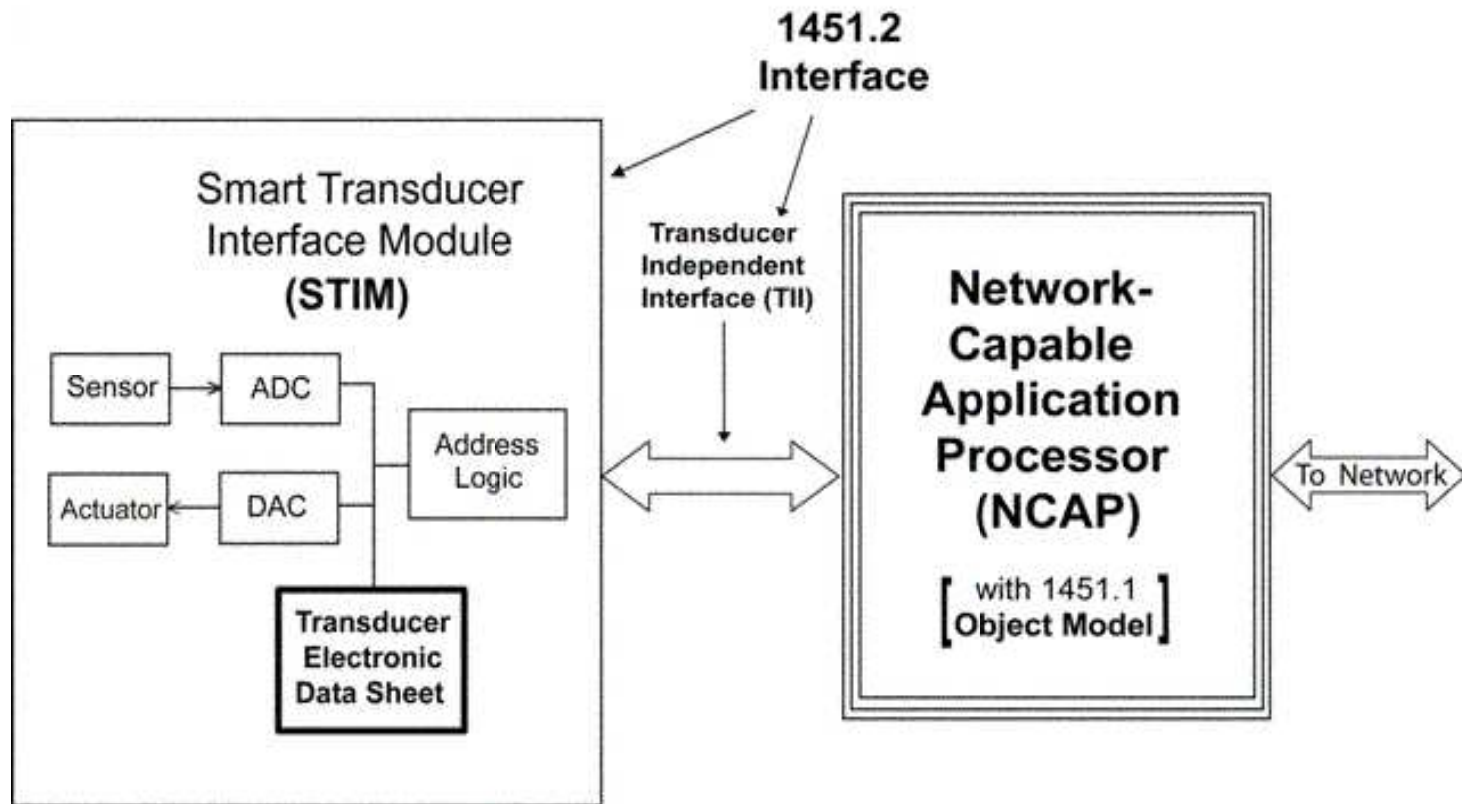
# Advantages of IEEE 1451 Standard

- ◆ 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

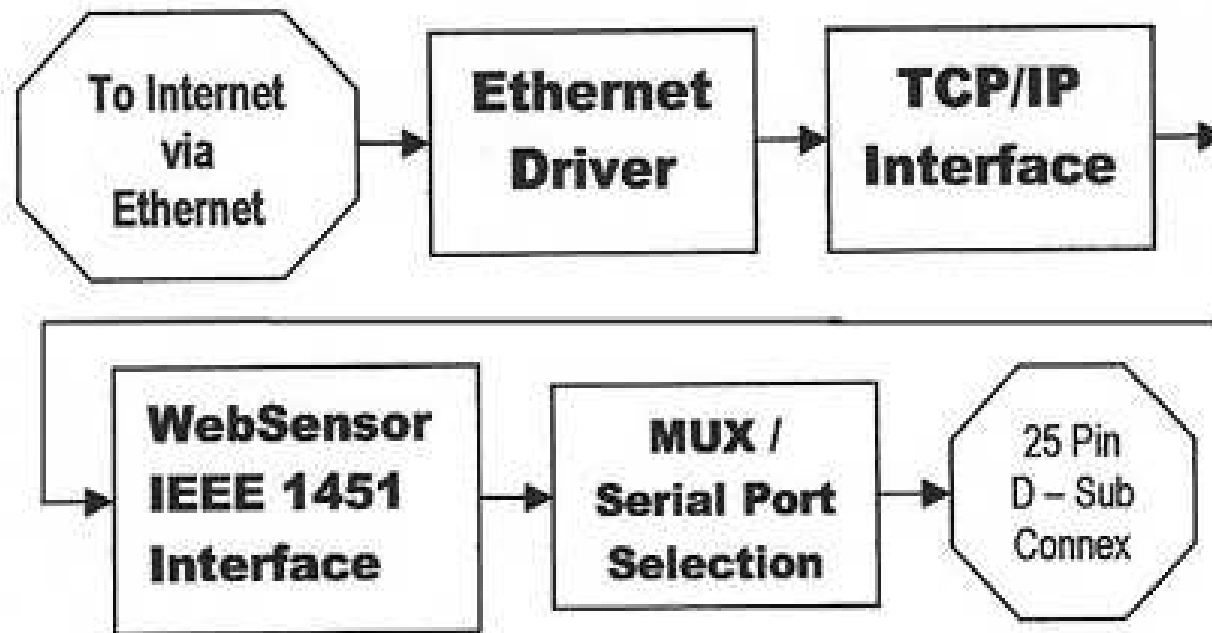
•  
Dot2

# 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

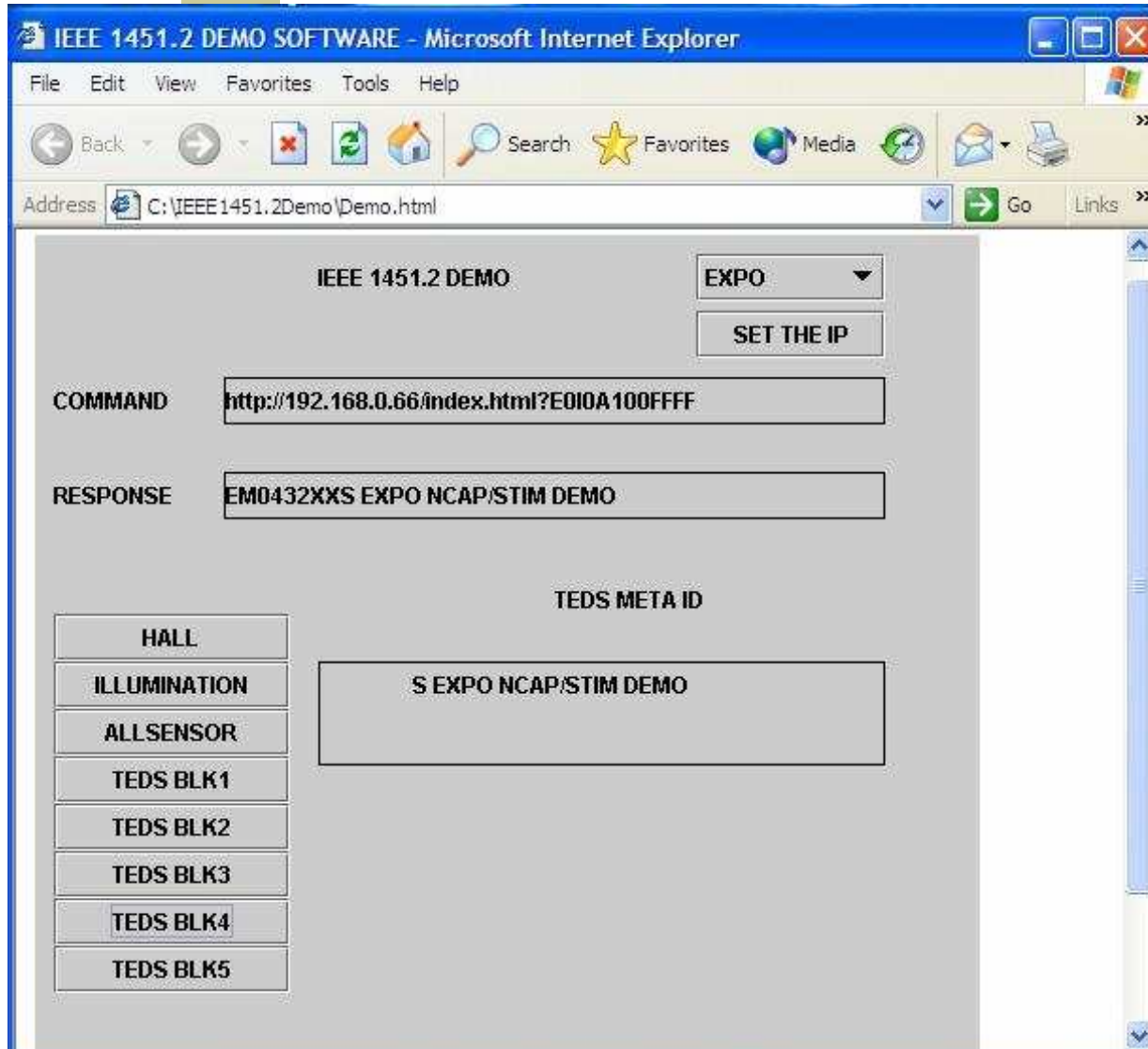


# Serial Port Selection

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

# Internet Command/Response Screen

-- I Format (experimental) --

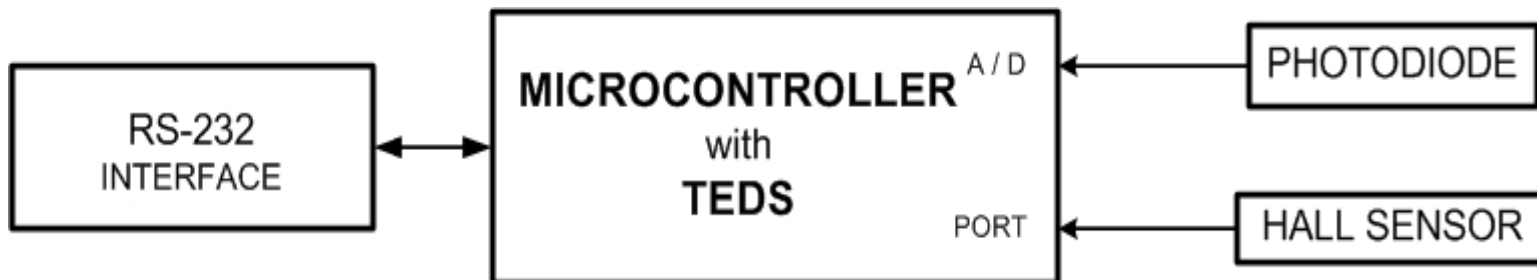


- ◆ Some binary words cannot easily be transmitted over Internet
- ◆ I format uses Dot2 binary commands converted to hex [e.g. A6 transmitted as ASCII “a” + ASCII “6”]

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 (1<sup>st</sup> 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 (2<sup>nd</sup> 8 bytes) -- optional*

Cdhmmss

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

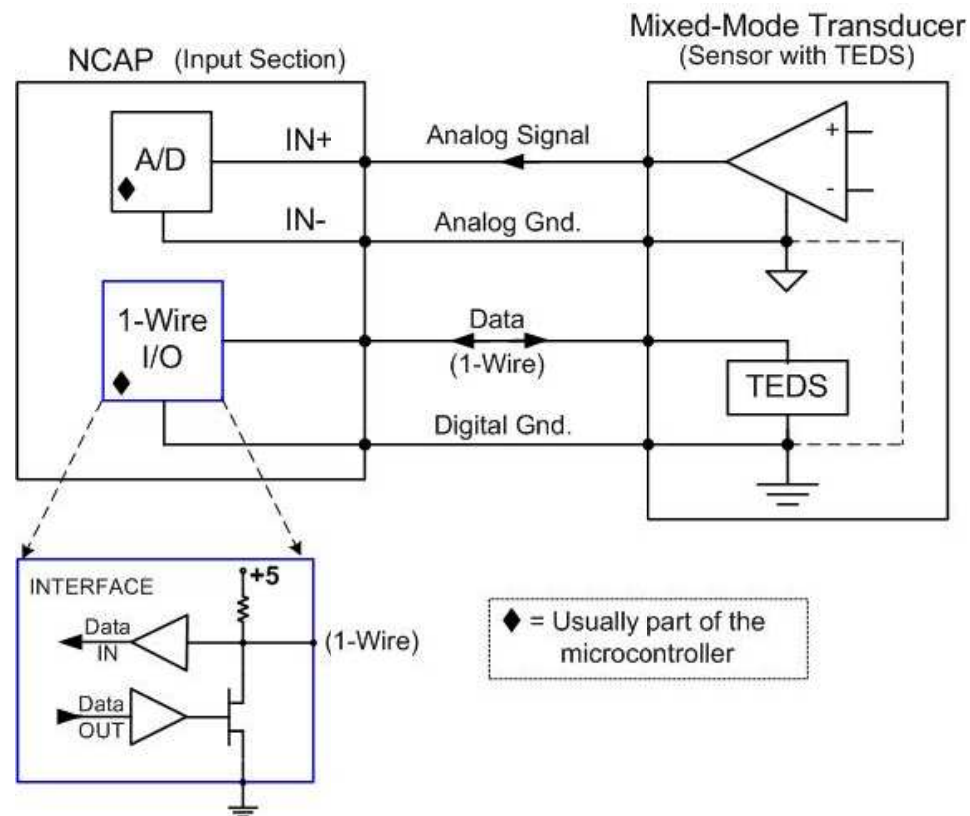
(standard/original IEEE 1451.2 format)

Command	Function	# bytes
<i>hex</i>		
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

IEEE 1451.2 DEMO SOFTWARE - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Media

Address C:\IEEE1451.2Demo\Demo.html Go Links

Google Search Web Search Site News

IEEE 1451.4 System EXPO

SET THE IP

COMMAND

RESPONSE

Manufacturer

Model

Version Letter

Version Number

Serial Number

Back to Main

## 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

The screenshot shows a web browser window titled "C:\IEEE 1451.4 Demo\MainDot4.html - Microsoft Internet Explorer". The browser's address bar shows "C:\IEEE 1451.4 Demo\MainDot4.html". The main content area displays the "IEEE 1451.4 Standard System" interface, which is titled "Esensors Inc".

On the left side of the interface, there is a list of TEDS blocks with addresses 000001 through 000005. Below this list is a dropdown menu labeled "Enter TEDS Block" with the value "0". There are three buttons: "READ SENSOR", "REFRESH SENSORS", and "READ TEDS".

The central part of the interface is titled "Standard TEDS Interpreter BLK 1". It contains a table with the following columns: "Description", "No. Of Bits", and "Value".

Description	No. Of Bits	Value
Response Time	6	63 Seconds

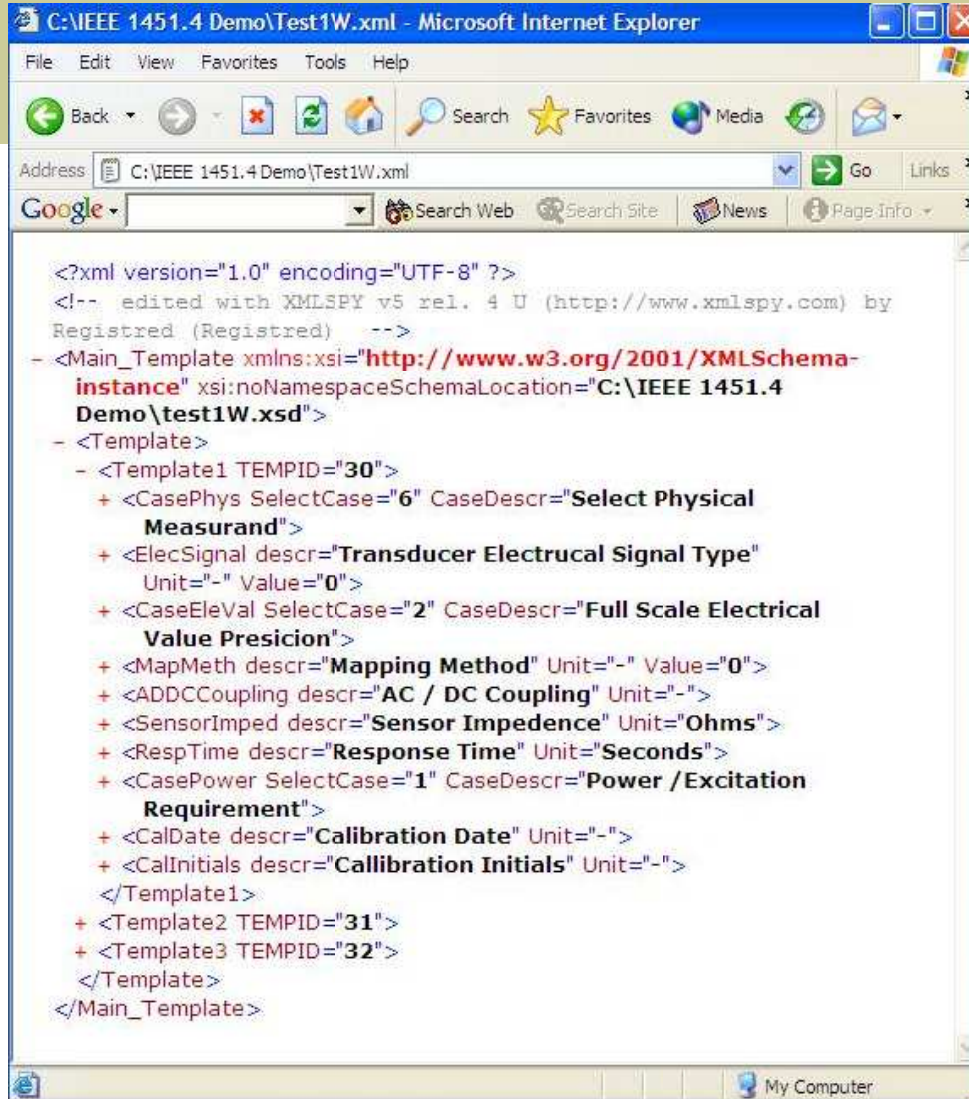
Below the table, there is a text input field labeled "Enter The Teds D". At the bottom of this section, there are two buttons: "Enter The Teds Data Here" and "Decode".

At the bottom of the browser window, the status bar shows the URL "http://192.168.0.69/index.html?E1HT0".

Contains binary data for specific templates

Dot4

# Dot 4 XML Program



```
<?xml version="1.0" encoding="UTF-8" ?>
<!-- edited with XMLSPY v5 rel. 4 U (http://www.xmlspy.com) by
Registered (Registered) -->
- <Main_Template xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:noNamespaceSchemaLocation="C:\IEEE 1451.4
Demo\test1W.xsd">
- <Template>
- <Template1 TEMPID="30">
+ <CasePhys SelectCase="6" CaseDescr="Select Physical
Measurand">
+ <ElecSignal descr="Transducer Electrual Signal Type"
Unit="-" Value="0">
+ <CaseEleVal SelectCase="2" CaseDescr="Full Scale Electrical
Value Presicion">
+ <MapMeth descr="Mapping Method" Unit="-" Value="0">
+ <ADDCCoupling descr="AC / DC Coupling" Unit="-">
+ <SensorImped descr="Sensor Impedence" Unit="Ohms">
+ <RespTime descr="Response Time" Unit="Seconds">
+ <CasePower SelectCase="1" CaseDescr="Power /Excitation
Requirement">
+ <CalDate descr="Calibration Date" Unit="-">
+ <CalInitials descr="Callibration Initials" Unit="-">
</Template1>
+ <Template2 TEMPID="31">
+ <Template3 TEMPID="32">
</Template>
</Main_Template>
```

Example of  
T-block program  
to parse standard  
TEDS  
[Uses XML-SPI]

# TEDS Template # 30 (4 – 20 Ma)

The screenshot shows the XMLSPY application window titled "XMLSPY - [Test1W]". The menu bar includes File, Edit, Project, XML, DTD/Schema, Schema design, XSL, Authentic, Convert, View, and Browser. The toolbar contains various icons for file operations and XML processing. The main workspace displays a configuration for a TEDS template with ID 30.

**TEMPID** 30

**CasePhys**

- SelectCase** 6
- CaseDescr** Select Physical Measurand
- MinPhysVal (2)**

	descr	Unit	Case
1	Minimum Physical Value	Degree C	0
2	Minimum Physical Value	K	1
- MaxPhysVal (2)**
- ElecSignal** descr=Transducer Electrical Signal Type Unit=- Value=0
- CaseEleVal** SelectCase=2 CaseDescr=Full Scale Electrical Value Precision
- MapMeth** descr=Mapping Method Unit=- Value=0
- ADDCoupling** descr=AC / DC Coupling Unit=-
- SensorImped** descr=Sensor Impedence Unit=Ohms
- RespTime** descr=Response Time Unit=Seconds
- CasePower** SelectCase=1 CaseDescr=Power Excitation Requirement



# Analog data readout screen (4-20 mA interface)

The screenshot shows a web browser window with the following content:

**Eensors Inc**

**IEEE 1451.4 Standard System**

000001  
000002  
000003  
000004  
000005  
000006

Enter TEDS Block **0**

**READ SENSOR**

**REFRESH SENSORS**

**READ TEDS**

**Sensor Reading for 1**

Sr. No.	Values
1	1
2	2
3	3
4	4
5	5

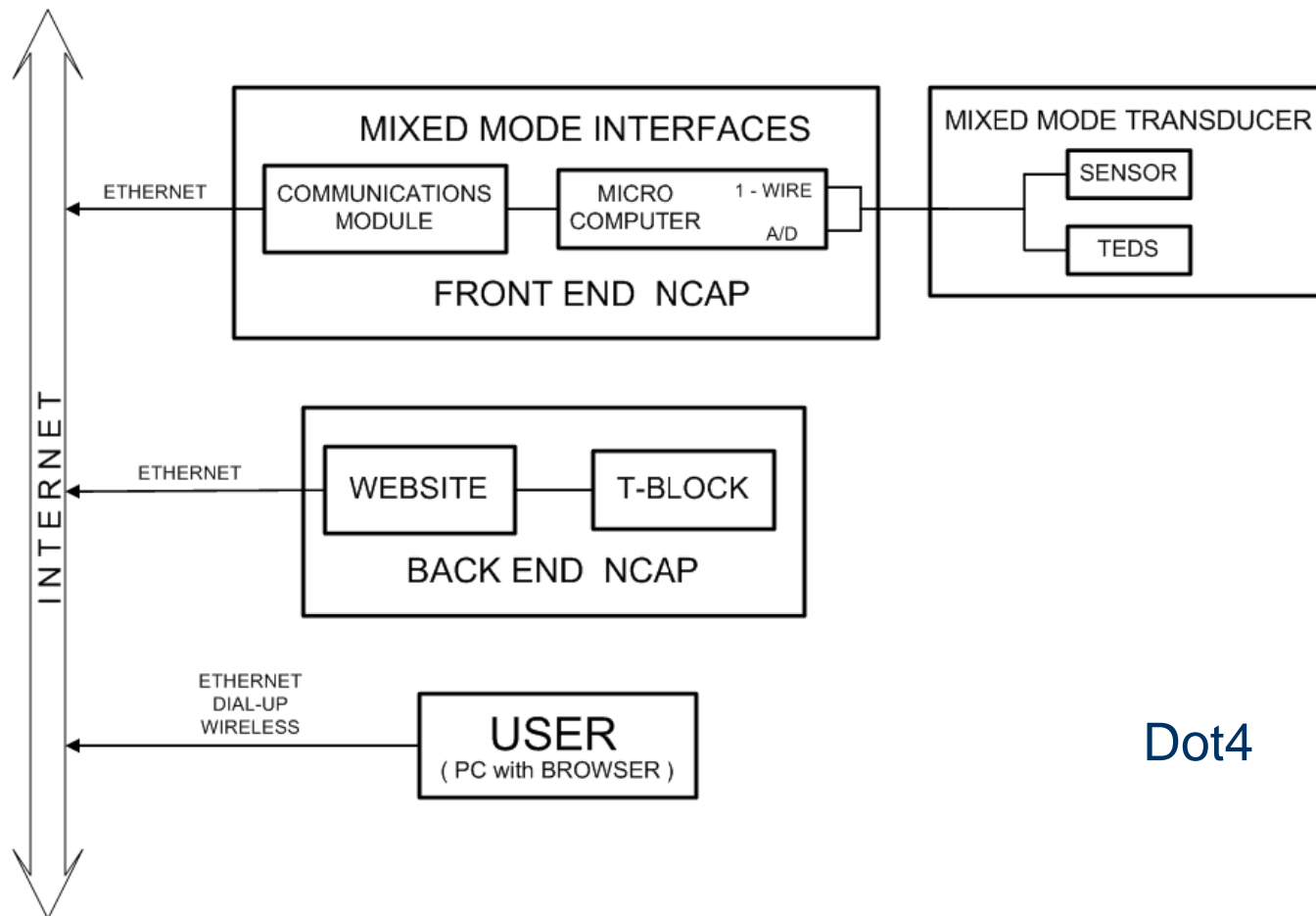
Applet MainDot4Canvas started. My Computer

# Split NCAP (Dot4 NCAP Partitioning)

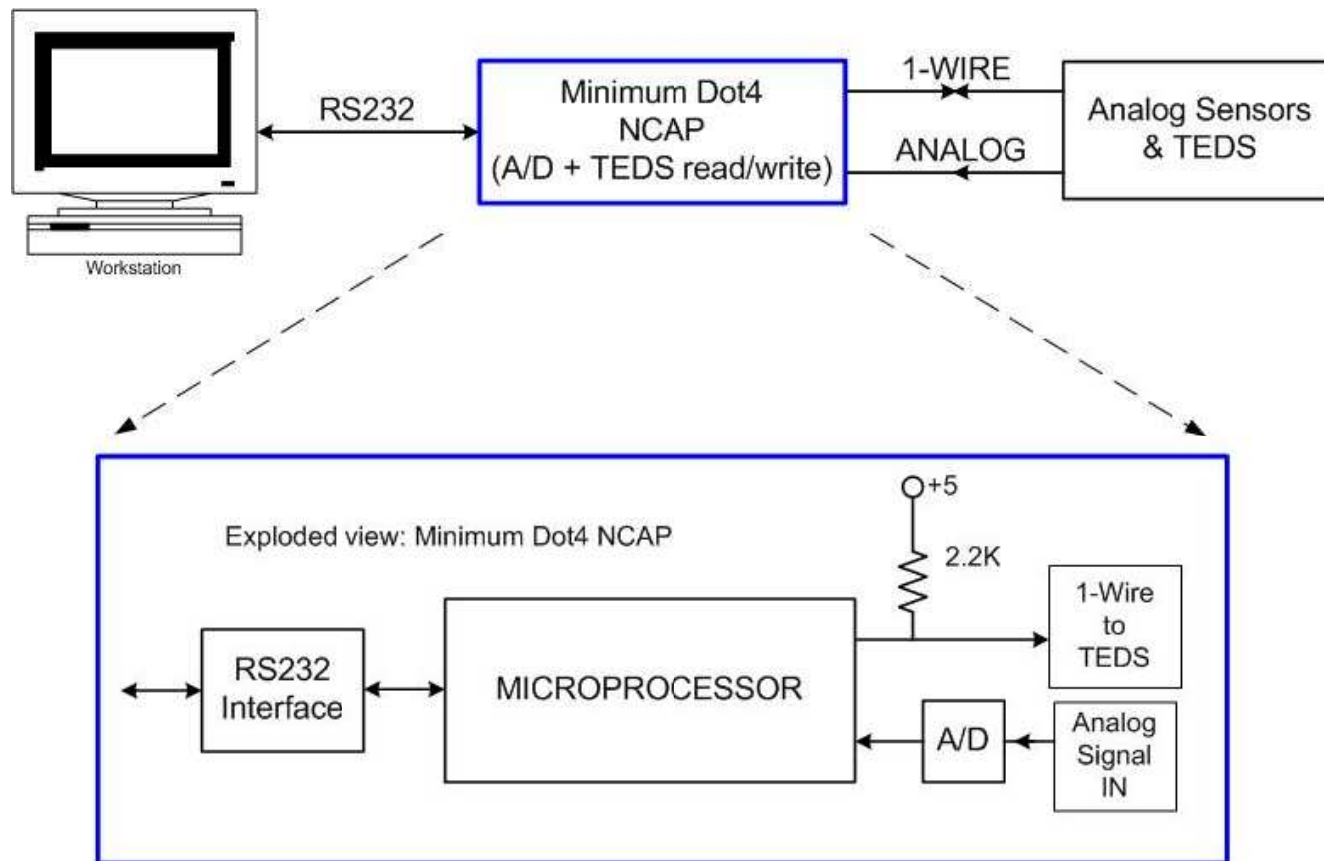
- ◆ Sensor data is transmitted over Internet via Ethernet to Website for further processing (speed limited)
- ◆ Needed because full Dot4 Software too complex for a small NCAP at sensor end (Front-end)
- ◆ Complex section (T-block) is moved to PC/Website (Back-end)
- ◆ Fully processed data is available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

Dot4

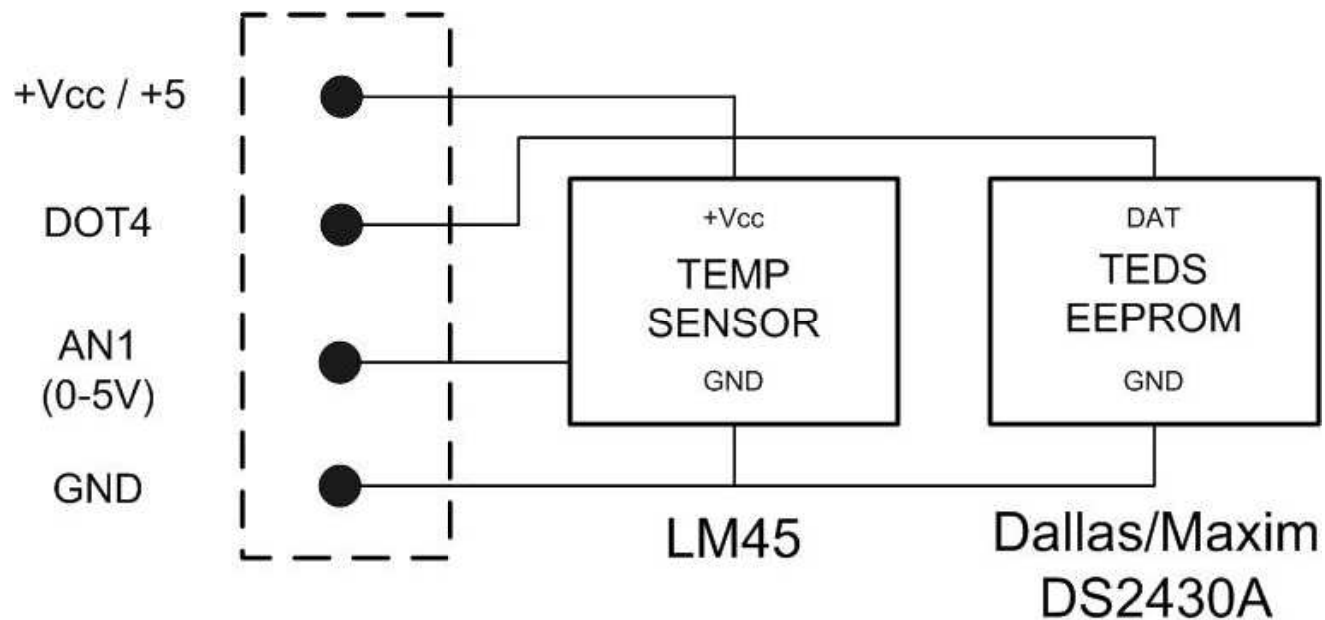
# Split Dot4 NCAP Block Diagram



# Minimal Dot 4 (PC) NCAP Block Diagram



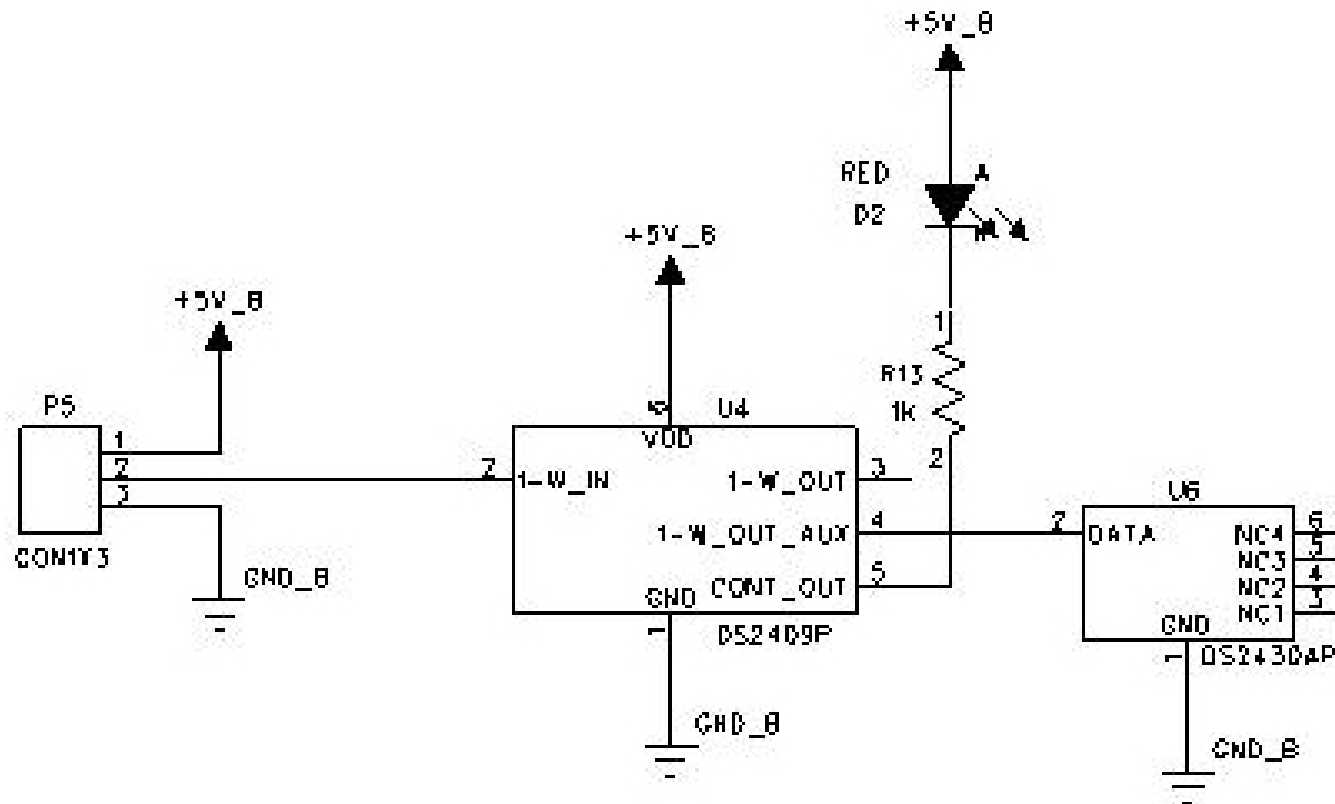
# Simple Dot4 Sensor Circuit (Single TEDS and analog signal)



Dot4

**Note: Not block diagram**

# TEDS Tag (multi-drop version)



# References

- ◆ R. Johnson, et al “A Standard Smart Transducer Interface”  
[http://ieee1451.nist.gov/Workshop\\_04Oct01/1451\\_overview.pdf](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”, 2<sup>nd</sup> 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](http://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](mailto:designer@eesensors.com)*