



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

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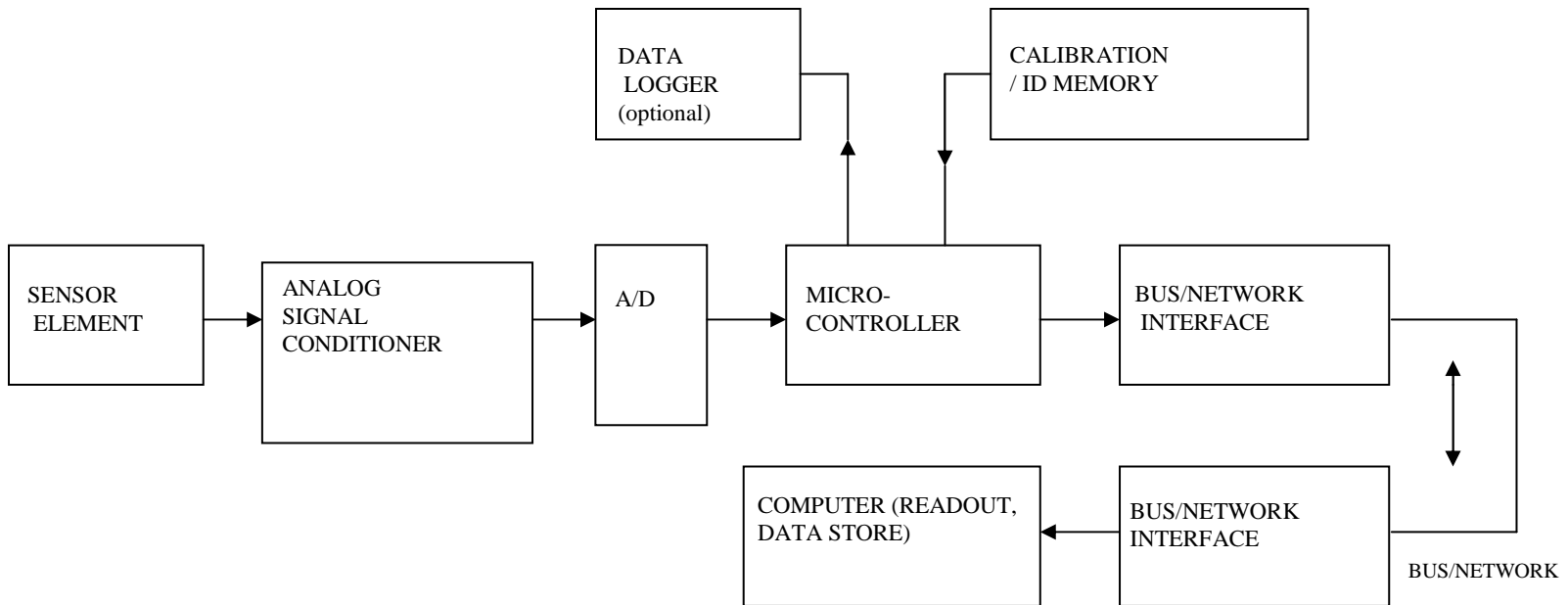
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Goals

- ◆ 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

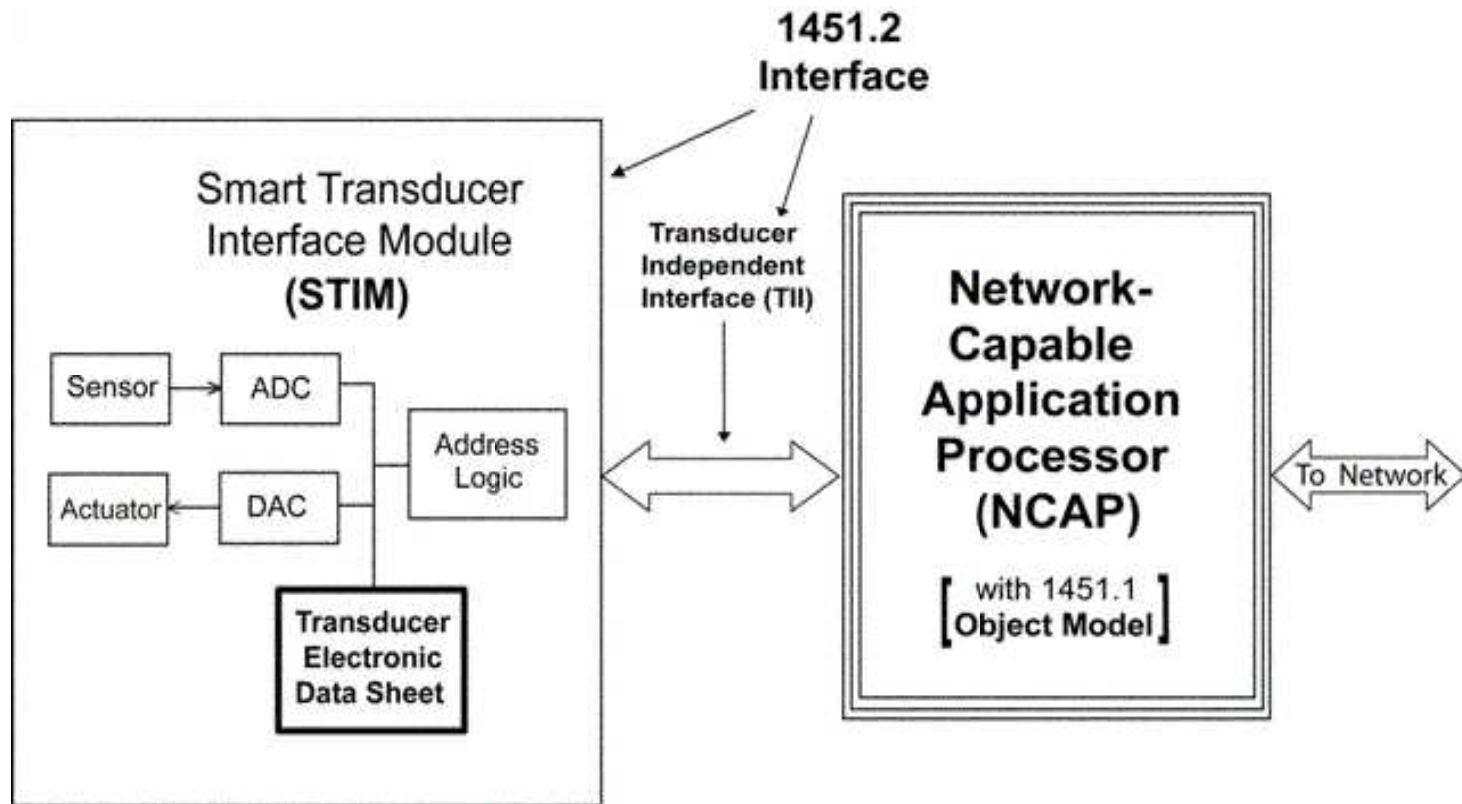
Advantages of IEEE 1451 Standard

- ◆ 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

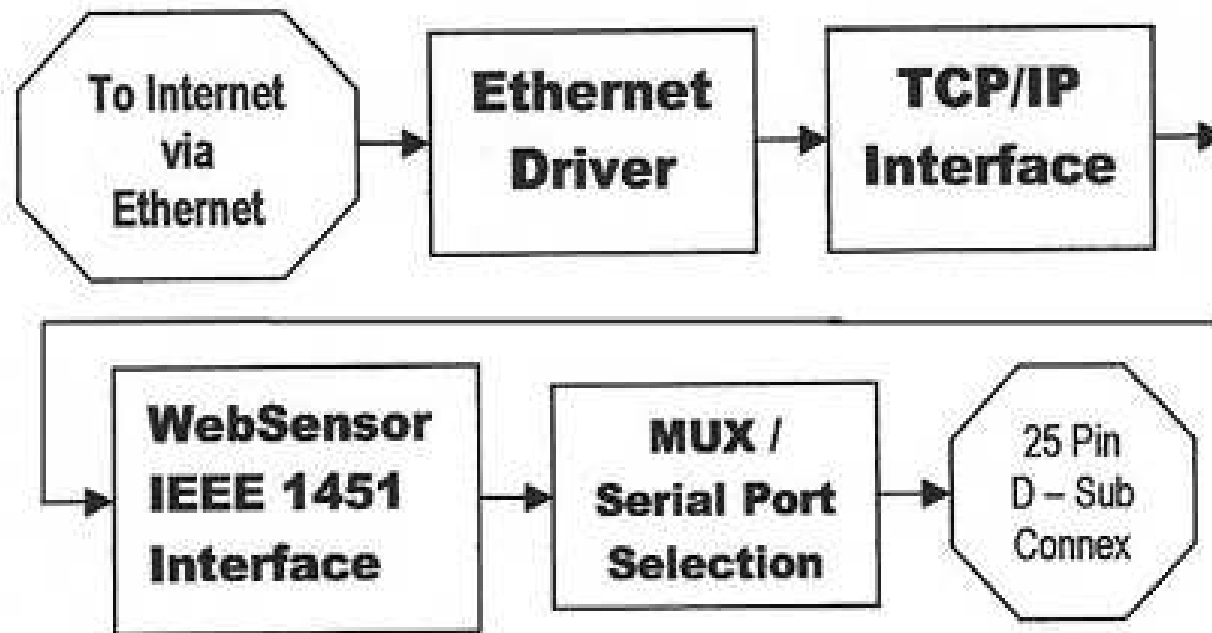
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Dot2

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

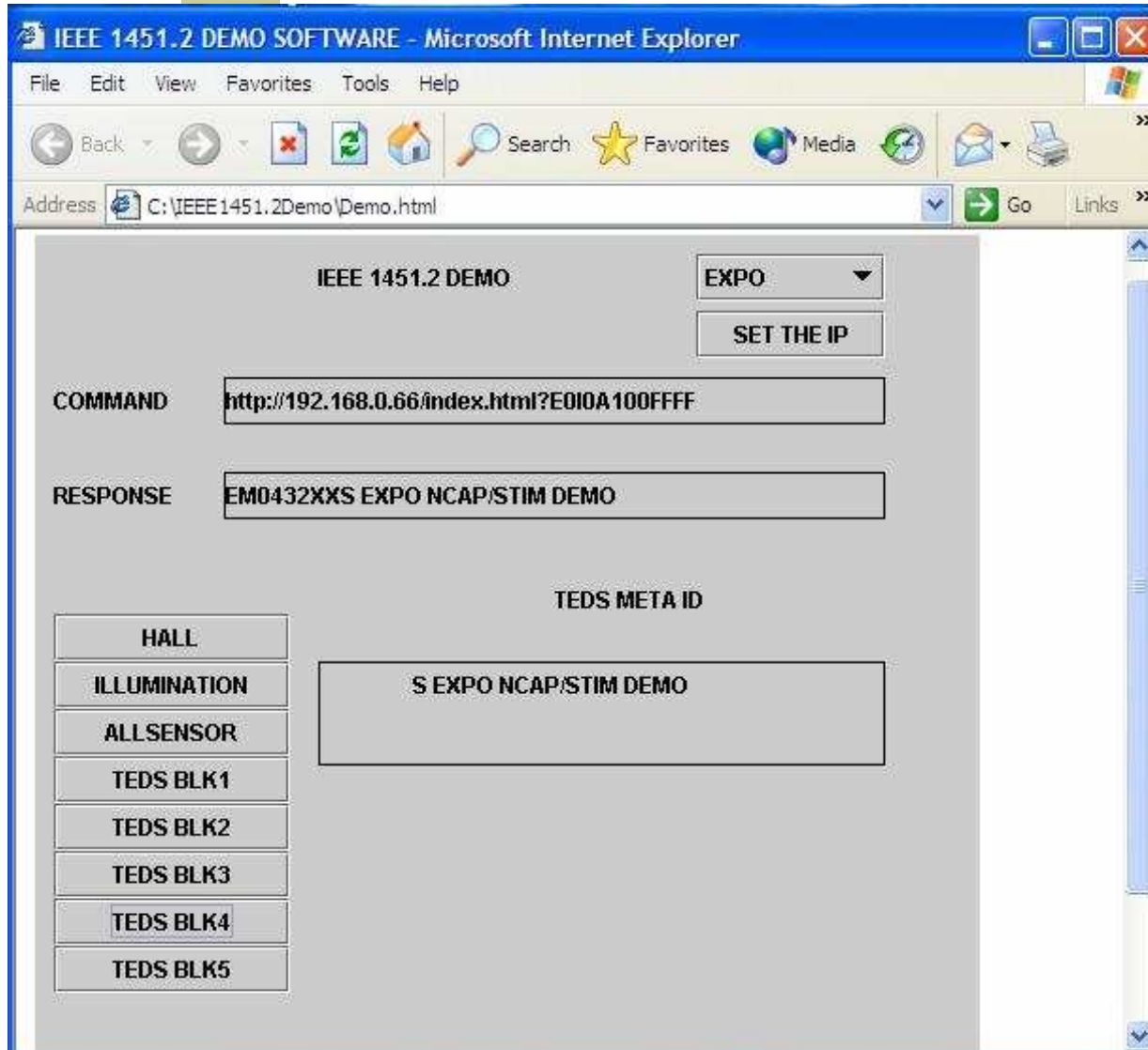


Serial Port Selection

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

Internet Command/Response Screen

-- I Format (experimental) --

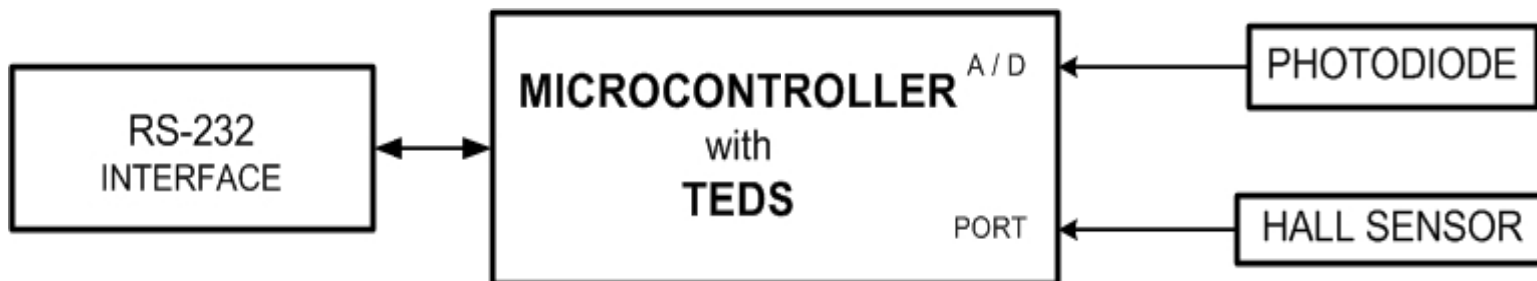


- ◆ Some binary words cannot easily be transmitted over Internet
- ◆ I format uses Dot2 binary commands converted to hex [e.g. A6 transmitted as ASCII “a” + ASCII “6”]

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 (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

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

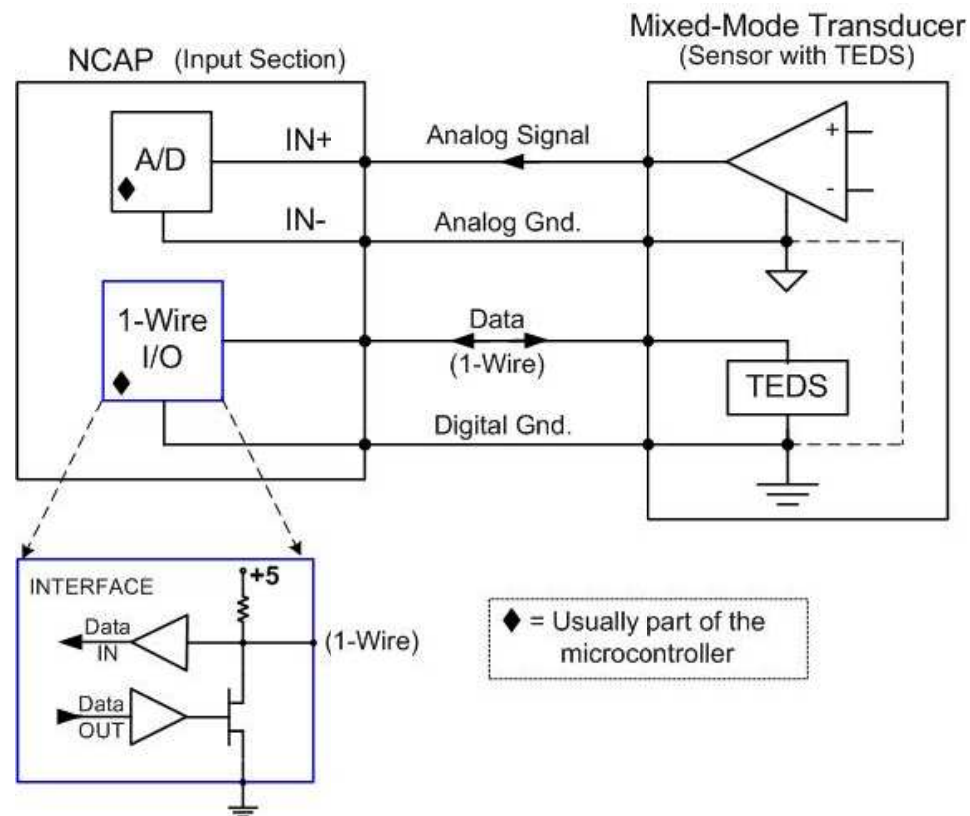
(standard/original IEEE 1451.2 format)

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 part of the "Esensors Inc" application. On the left side, there is a list of TEDS blocks with addresses 000001 through 000005. Below this list are three buttons: "READ SENSOR", "REFRESH SENSORS", and "READ TEDS". The "Enter TEDS Block" dropdown is set to "0". The main area features a "Standard TEDS Interpreter BLK 1" section, which is highlighted with a red border. This section contains a table with the following data:

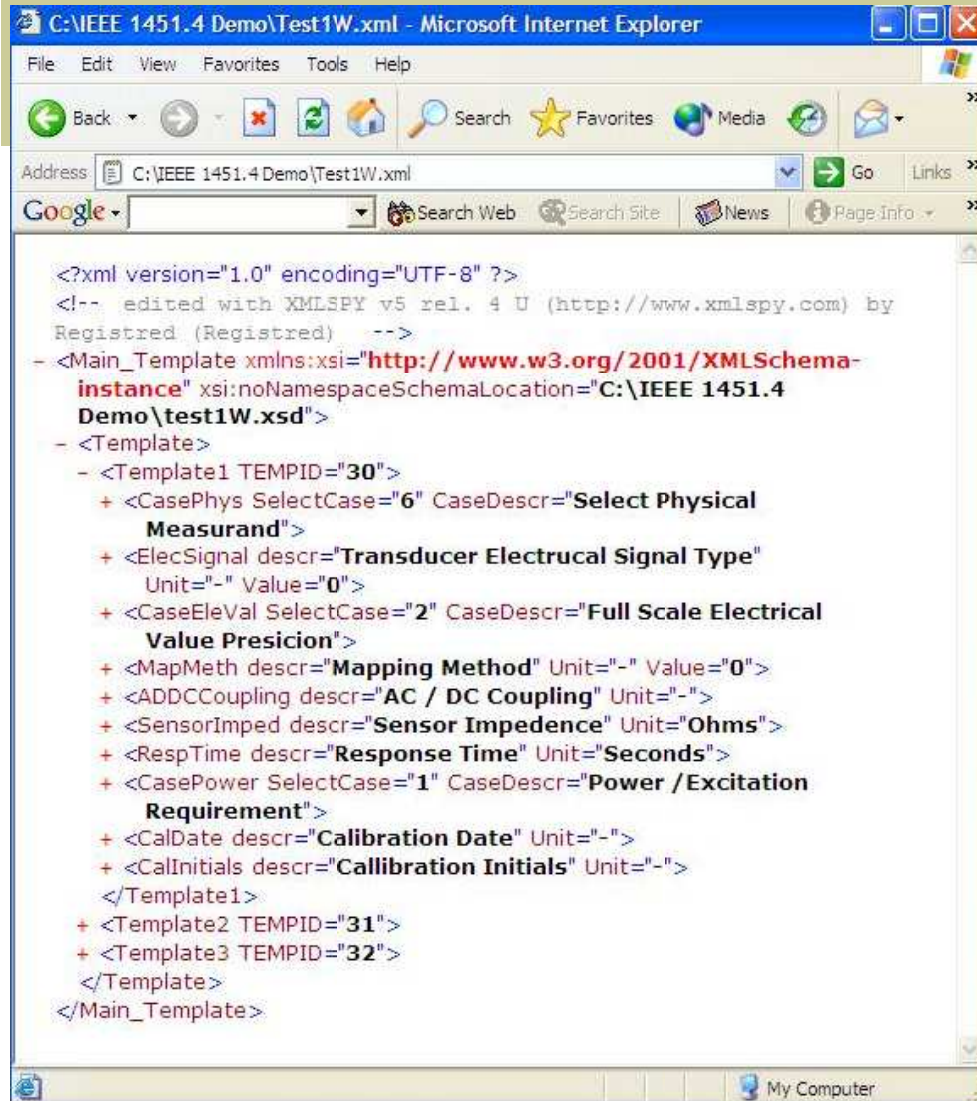
Description	No. Of Bits	Value
Response Time	6	63 Seconds

Below the table, there is a text input field labeled "Enter The Teds D" and a button labeled "Decode". At the bottom of the interface, there is a text area containing 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">
+ <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">
+ <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 elements:

- Browser Title Bar:** C:\IEEE 1451.4 Demo\CanvasDot4.html - Microsoft Internet Explorer provided by Comcast
- Address Bar:** C:\IEEE 1451.4 Demo\CanvasDot4.html
- Page Content:**
 - Eensors Inc**
 - IEEE 1451.4 Standard System**
 - Sensor Reading for 1**
 - Table:**

Sr. No.	Values
1	1
2	2
3	3
4	4
5	5
 - Control Panel:**
 - Enter TEDS Block: 0
 - Buttons: READ SENSOR, REFRESH SENSORS, READ TEDS
- Status Bar:** Applet MainDot4Canvas started

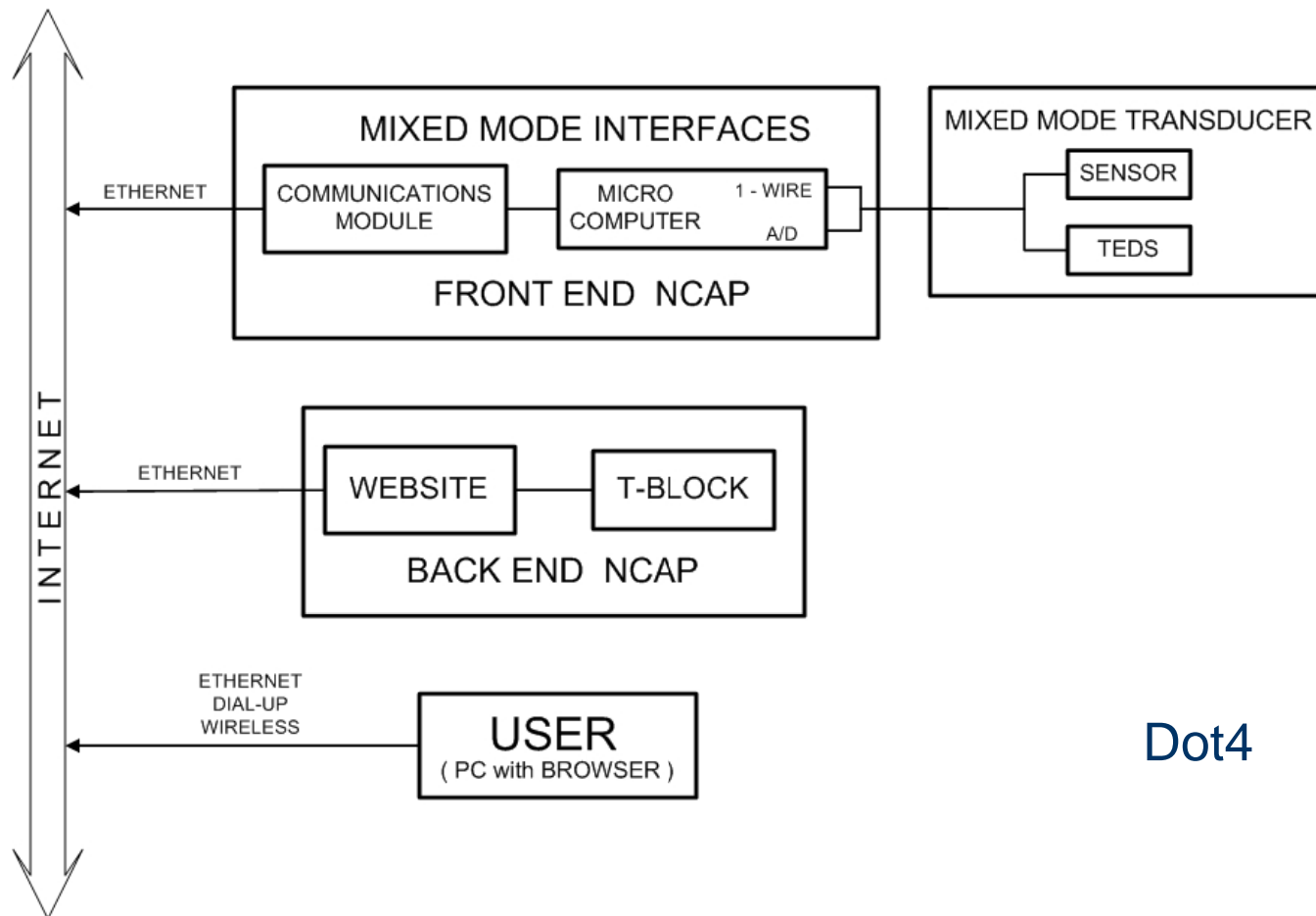
Split NCAP

(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

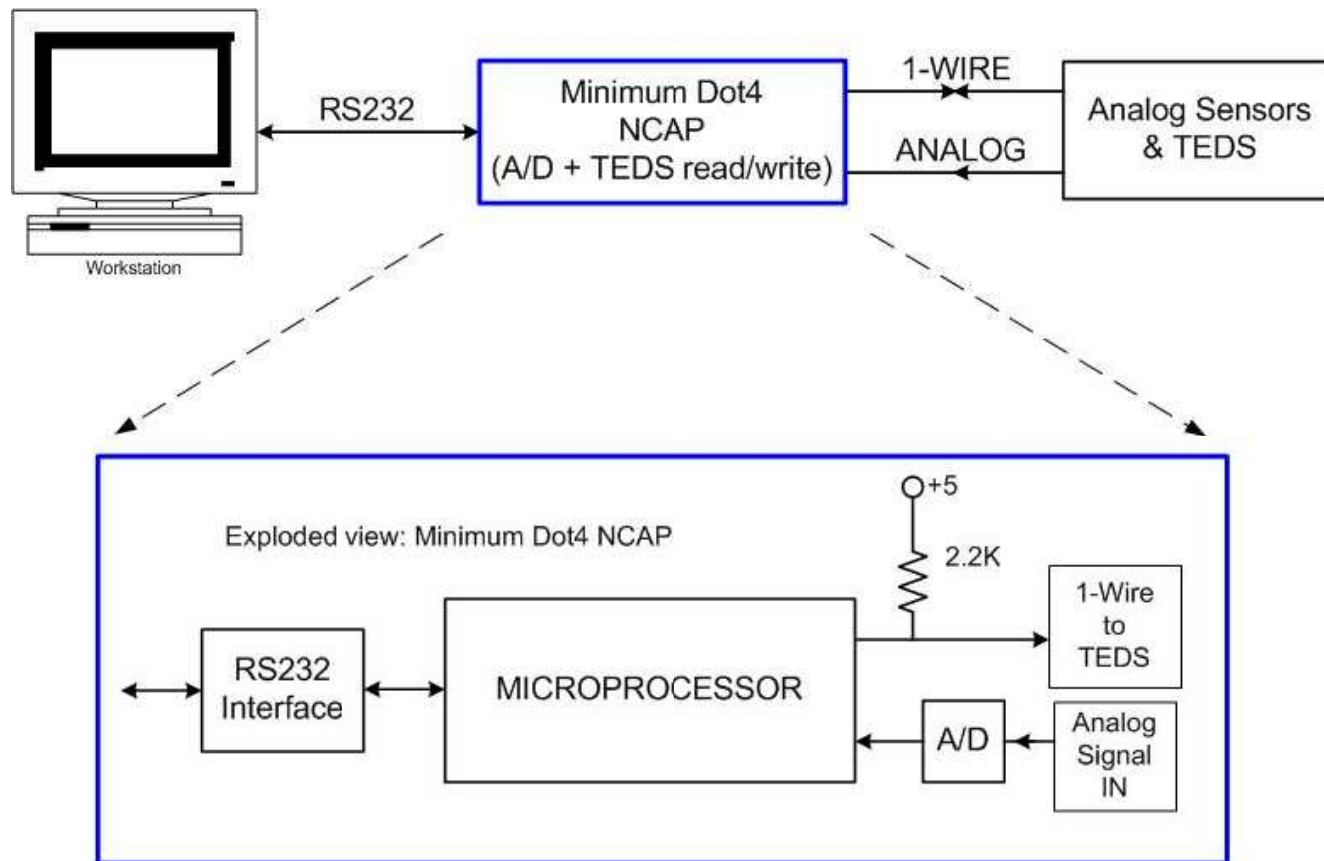
Dot4

Split Dot4 NCAP Block Diagram

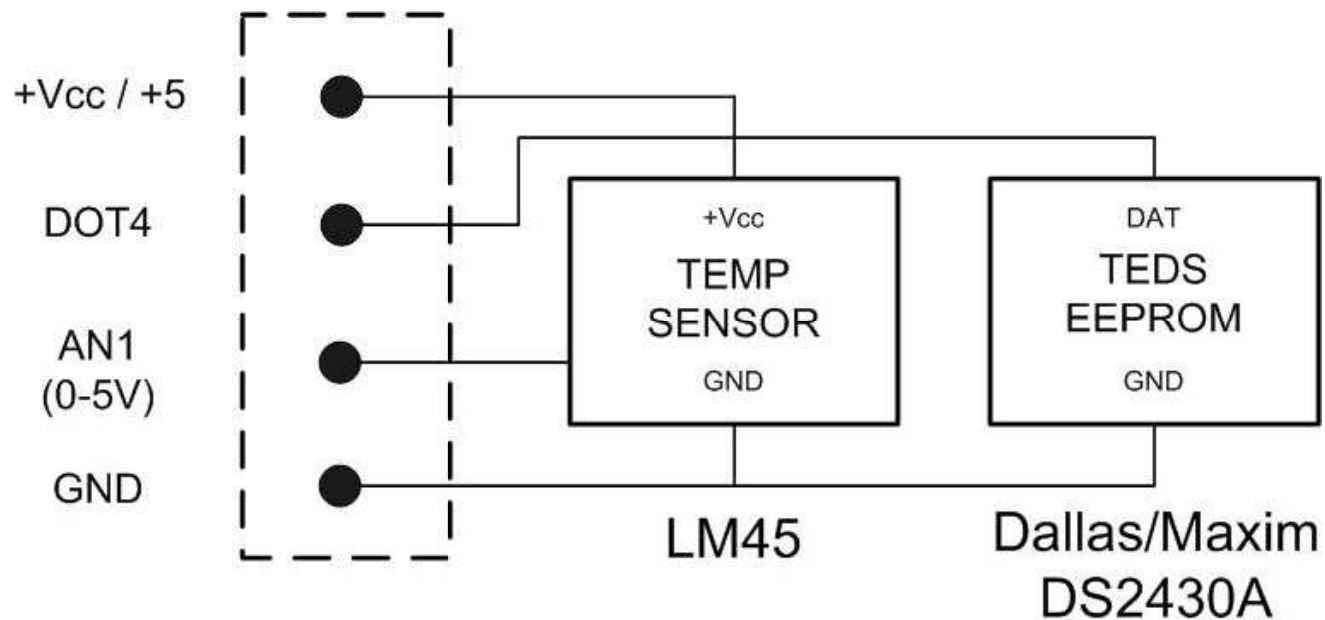


Dot4

Minimal Dot 4 (PC) NCAP Block Diagram



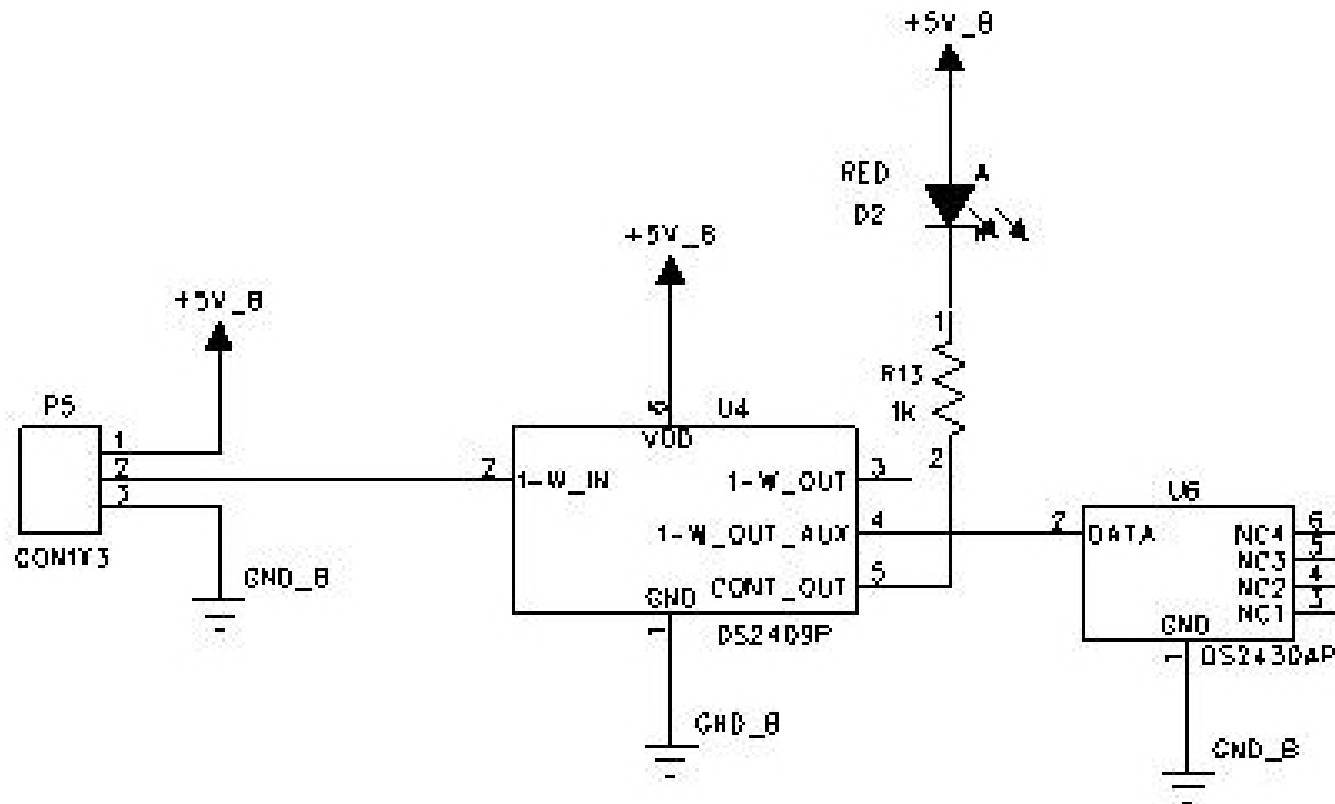
Simple Dot4 Sensor Circuit (Single TEDS and analog signal)



Dot4

Note: Not block diagram

TEDS Tag (multi-drop version)



References

- ◆ 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 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