



**SEQUOIA**  
Technology Ltd

**WHITE PAPER**

## **IEEE p1451.2 Smart Sensor Interfaces**

### **A Brief Discussion of the 1451 Standard and a Description of Related Esensors Interfaces**

**August 2004**

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The main sections of this white paper are laid out follows:

**Section 1**

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# Section 1

## Introduction

A major inhibiting factor to the development of networked digital (smart) sensors is the lack of a single sensor network /bus standard. Over fifty networks are in common use and no single standard is likely to emerge in the near future. In response, a NIST-sponsored initiative has developed the IEEE 1451 sensor interface standard which can be considered a universal interface between digital sensors/actuators and the network interface/driver, together with a standard electronic data sheet format. To date there has been little implementation of the standard by the sensor industry, probably due to dissatisfaction with the original IEEE 1451.2 hardware interface (10-line), the complex software features, and the limited availability of a compatible commercial network interfaces. Changes to the standard are being considered, including changing the sensor interface to the RS232 serial bus. In anticipation of these changes Esensors has developed a prototype interface which is compatible with most of the IEEE 1451 NCAP hardware standard under consideration. The network side of the interface handles the TCP/IP protocol and this is able to receive commands and sent email over the Internet. The route to the Internet is through Ethernet (10 Mbit rate).

## Section 2

### IEEE 1451 Standard Subdivision (Dots)

The IEEE 1451 Smart Sensor Interface Standard consist the sub division listed below.

<b>Dot Standard</b>	<b>Status (1st February, 2004)</b>
• IEEE 1451.0 Protocols & Format	Early approval process
• IEEE 1451.1 Object Model	Approved 1999
• IEEE 1451.2 Interface	Approved 1997 but being significantly revised
• IEEE 1451.3 Local Network	Just approved
• IEEE 1451.4 Analog & TEDS	Final approval process
• IEEE 1451.5 Wireless	Early approval process
• IEEE 1451.6 CAN	Proposed

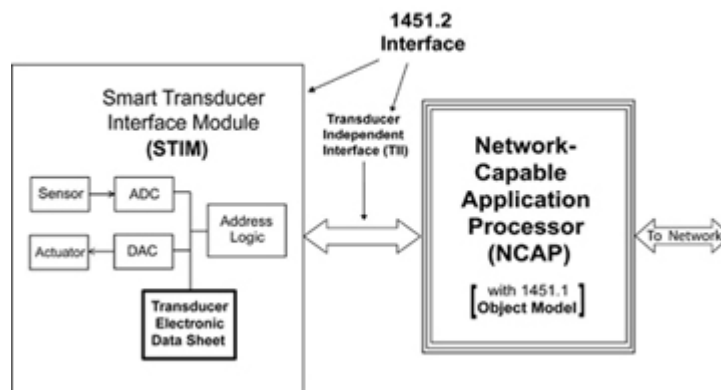
Esensors has developed devices for the Dot2 and Dot4 standard and expects to introduce wireless devices compatible with the Dot5 standard during 2004.

### **IEEE 1451.2 INTERFACE**

The Dot2 protocol consists primarily of these parts:

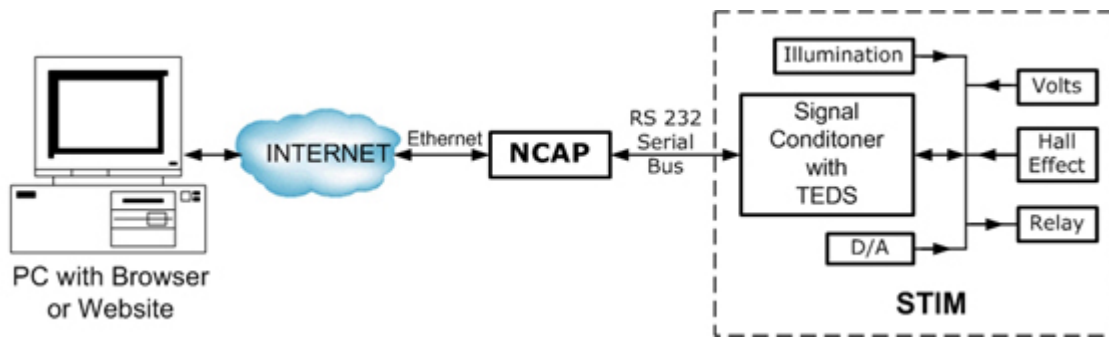
- Physical layer (originally TII, to be replaced by RS232)
- Communications protocol (address, handshaking)
- Transducer Electronic Data Sheet (TEDS)
- Command protocol
- Data format

A block diagram of the original and modified IEEE 1451.2 Interface is given below.



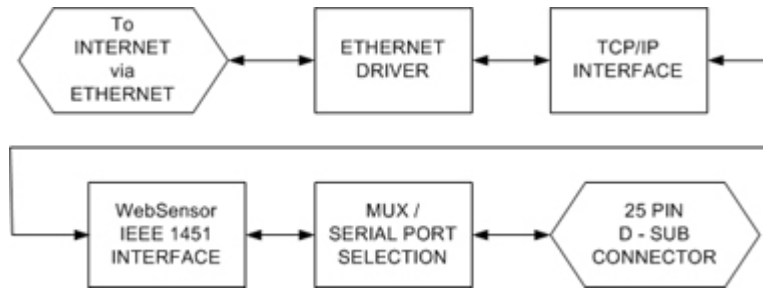
### **SYSTEM BLOCK DIAGRAM**

A block diagram of the system is shown below. It consists of an NCAP and a STIM with multi-function sensors.



## Dot 2 NCAP Block Diagram

A block diagram of the NCAP is shown below



The communication section is based on the Ubicom SX stack and is a modified version of the Ubicom evaluation board. Also the TCP/IP software is based on that provided by Ubicom to users of their chips. Esensors has modified the software for its websensor series and considers the software proprietary. The function of the communication board is to receive and send email in blocks of predetermined length, suitable for sensor data communication. Network data is transmitted through a standard Ethernet interface (8 pin modular connector, RJ45). The HTTP command in and email out is transferred to the master board through a SPI (3-wire) bus operating at a clock frequency of 100 KHz. Data is always transferred in 8-byte blocks, a total of 64 bytes are transferred (after stripping off the standard Internet/Ethernet headers). Data exchange on the SPI bus between the two boards is controlled by two hand-shaking lines. Also there are timing restrictions but the data transfer is handled by a subroutine provided with the master microprocessor (PIC) software and users preparing need not be concerned with this. A more detailed description is given in the EM04 specification sheet xxxx and operating manual yyyy.

## Section 3

### TEDS Description

The Transducer Electronic Data Sheet (TEDS) is a particularly useful feature of the IEEE 1451 standard. The formats for the various Dots differ and the goal of the Dot0 effort is to unify them. The 1997 Dot2 TEDS is the original version and the recently approved Dot3 can be considered an improved and expanded version of this original Dot2. The Dot0 TEDS, now under consideration, is similar to the Dot3 except for the format (tuple vs. fixed) and optional parts. The revised Dot2 and Dot5 are likely to adopt the Dot0 format, except for the Dot4 (which is described here). The TEDS types are:

Type of TEDS	TEDS Function
<i>Meta TEDS*</i>	Contains the mandatory machine-readable data that describes the entire STIM. The data may include information such as the revision of the IEEE standard, version of the TEDS, number of channels and timing restriction.
<i>Channel TEDS*</i>	Contains the mandatory machine-readable data that describe each transducer channel in the STIM. The data may include information such as the transducer type, calibration model, physical units, limits range, data format and the timing restriction for the relevant transducer channel.
<i>Meta-Identification TEDS *</i>	Provides the optional human-readable (Text/ASCII) data for the overall STIM. Data may include information such as manufacturer's name, model number, serial number, version codes, date codes and product description.
<i>Calibration TEDS</i>	Contains the optional machine-readable data when a correction engine is used in the STIM. The data may include information such as the calibration coefficients, intervals, date and time for the each transducer channel that requires calibration.
<i>Channel-Identification TEDS</i>	Provides the optional human-readable data similar to Meta-Identification TEDS, except that it is for an individual channel. This data is used when a STIM is built with multi-channel transducers from different manufacturers.
<i>Calibration-Identification TEDS</i>	Provides the optional human-readable data when a correction engine is used in the STIM. The data may include information such as the calibrator id and the calibration standard used.
<i>End-User's Application-Specific</i>	Provides the additional human-readable data not

<i>TEDS</i>	covered by the specific TEDS described above. The data may include information such as the location of the STIM and the contact information for the technical inquiry.
<i>Generic Extensions TEDS</i>	Allows an option for the future extension to the TEDS described above

- *Included in the Esensors prototype*

## DOT2 COMMANDS

While the commands for the revised Dot2 standard have not been approved, we expect them to be similar to the following and therefore we have used them in our current prototype:

<i>Command Sent</i>	<Address><Function><Channel><Data>			
<i>Number of Byte</i>	1	1	1	1

<i>Data Returned</i>	<Address><Data><Status>		
<i>Number of Byte</i>	1	4	1

## Section 4

### More IEEE 1451 Information

#### *National Institute of Standards and Technology (NIST) Site*

<http://www.motion.aptd.nist.gov/>

<http://ieee1451.nist.gov/intro.htm>

[http://www.bfrl.nist.gov/861/CMAG/CMAG\\_workshop/lee.pdf](http://www.bfrl.nist.gov/861/CMAG/CMAG_workshop/lee.pdf)

#### *IEEE 1451 Commercial Site*

[http://www-2.cs.cmu.edu/~sensing-sensors/S2004/L2004-03-data\\_acquisition/L2004-03-IEEE\\_1451-Anna\\_Liao.pdf](http://www-2.cs.cmu.edu/~sensing-sensors/S2004/L2004-03-data_acquisition/L2004-03-IEEE_1451-Anna_Liao.pdf)

[http://www.ni.com/devzone/advisors/sensor\\_pnp.htm](http://www.ni.com/devzone/advisors/sensor_pnp.htm) (National Instruments)

<http://www.telemonitor.com/ieee1451.html> (Telemonitor)

[http://www.kistler.com/web/article.nsf/KIWEBArticlesByNumber/000-276/\\$File/000-276e-06.01.pdf](http://www.kistler.com/web/article.nsf/KIWEBArticlesByNumber/000-276/$File/000-276e-06.01.pdf) (Kistler) <http://www.watlow.com/> (Watlow)

#### *Sensors Magazine Site*

<http://www.sensormag.com/articles/1202/14/main.shtml>

[http://www.sensormag.com/articles/0901/74/pf\\_main.shtml](http://www.sensormag.com/articles/0901/74/pf_main.shtml)

<http://www.sensormag.com/articles/0603/14/main.shtml>

#### *Sensors Expo Site*

<http://www.sensorexpo.com/spring04/V40/index.cvn>

#### *IEEE P1451 Compatible Sensors Site*

<http://www.sensorsportal.com/>