SIcon/05– Sensors for Industry Conference
Houston Texas, USA, 8-10 February, 2005

A Minimal Dot4 NCAP with a Compatible Sensor Bus

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Abstract *- As parts of the IEEE 1451 Smart Transducer Interface Standard are completed, or approaching completion, it is desirable to build and demonstrate hardware and software which implements the standard. The purpose of this paper is to demonstrate that, while a full implementation of the standard may be complex, a minimum and useful implementation is not. It includes an NCAP (Network Capable Application Processor) and TEDS reader and writer. Also included is an a/d which converts the analog signal into digital form and a compatible sensor bus.*

I. INTRODUCTION

The IEEE 1451.4 (Dot4) version of the smart transducer standard is particularly well suited to adopt existing analog sensors to a digital format [2] since relatively little re-engineering is involved [4]. The Dot4 standard (approved 2004) differs from the other 1451 versions (Dotx's) in that it is intended only to add the Transducer Electronic Data Sheet (TEDS) to analog sensors and not specify anything concerning the digitized sensor data [3]. Its primary initial application is to add TEDS to arrays of accelerometers or vibration sensors. These are small and therefore the TEDS must be of small physical size. It is also small in capacity (typically under 16 bytes) and therefore the information is stored in a compact binary form. The TEDS differs from that used in other Dotx's, which are relatively much larger (usually over 100 bytes, possibly much larger) and has a different format.

Besides describing the TEDS, an aim of this paper is to describe a method of addressing and switching sensor analog signals on a bus, which we term the Dot4 bus.

II. DOT4 MIXED MODE TRANSDUCER INTERFACE

A block diagram of one version of the Class 2 MMI defined in the Dot4 standard is shown in Fig. 1.

The analog (sensor) and digital (TEDS) signals are the two parts of the interface. An a/d normally is present to digitize the signal but the standard does not describe the process or format.

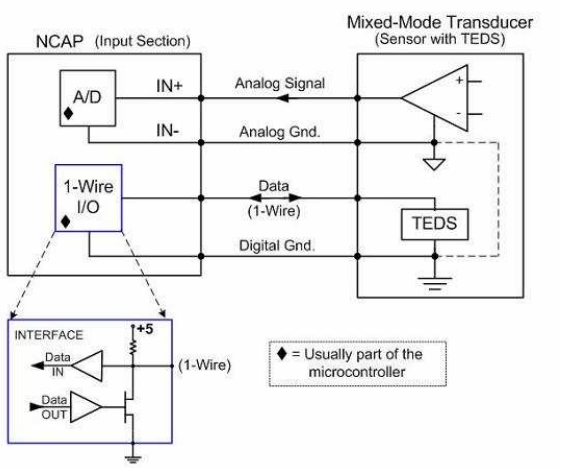

Fig.1. Dot4 Mixed Mode Interface (MMI). Note the separate analog and digital lines.

A block diagram of the Minimal NCAP system, which connects to a PC, is shown in Fig. 2. An alternative configuration has an Internet network connection instead of the PC.

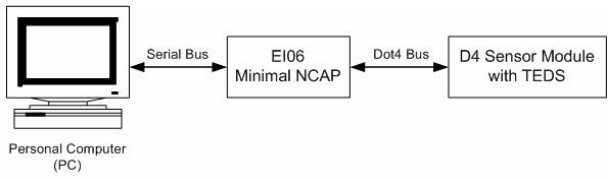

Fig. 2. System Block Diagram

The TEDS data is stored in an EPROM with a 1-wire interface which was originated, and principally available from, Dallas/Maxim [6]. We use the smallest size device (DS2430A). The data in/out and power are on the same wire (also, ground is needed). Reading or writing the memory can be done with a standard microcomputer with a switchable read/write pin (Fig. 3) and the proper software [7].

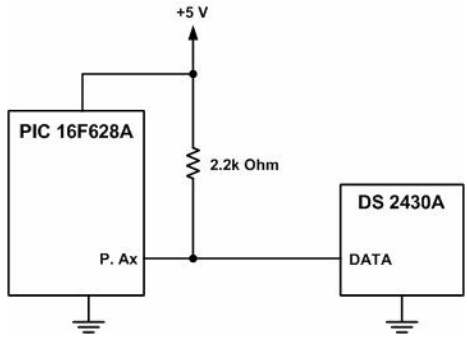

Fig. 3. A 1-Wire Interface to a Microcontroller

III. DOT4 TEDS STRUCTURE

The TEDS in divided into three parts:

A. *UUID section*

A 6-byte Universal Unique IDentifier (plus family code and CRC), a code which is supplied by the EEPROM manufacturer and controlled by the IEEE.

B. *Basic TEDS section*

An 8-byte section prepared by the sensor manufacturer with the following parts:

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

C. *IEEE or Manufacturer TEDS section*

The IEEE version TEDS provides data (binary) for a variety of sensor templates (e.g. bridge). A specialized program (normally in a PC, not illustrated here) is needed to parse this TEDS and expand it into a specification sheet form. Typically, this TEDS section is under 32 bytes for the IEEE version, but the standard does not give a limit.

The manufacturer version format is not specified and therefore is under the control of the manufacturer.

An example of Dot4 TEDS displayed on a PC is given in Fig. 4. It is often used for calibration data.

For many applications we prefer to convert the Dot4 TEDS into the more complete Dot2 (Dot0) format but we are not describing the process here.

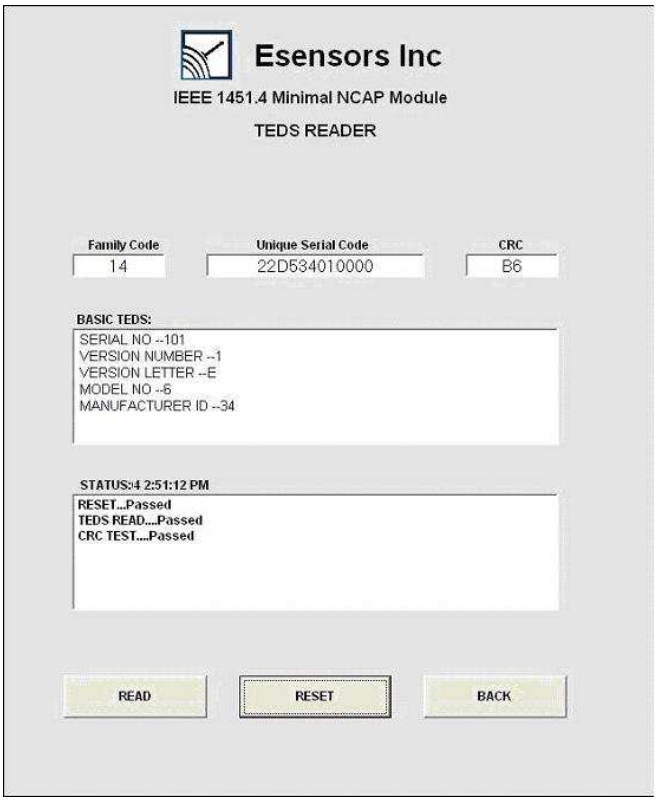

Fig. 4. TEDS Data Screen Display

A separate program (Fig. 5) writes data to the TEDS (1-wire EEPROM). Normally this is done only by the manufacturer. Data, e.g. serial number, is entered into the program which converts it into the proper binary form and writes it to the EEPROM.

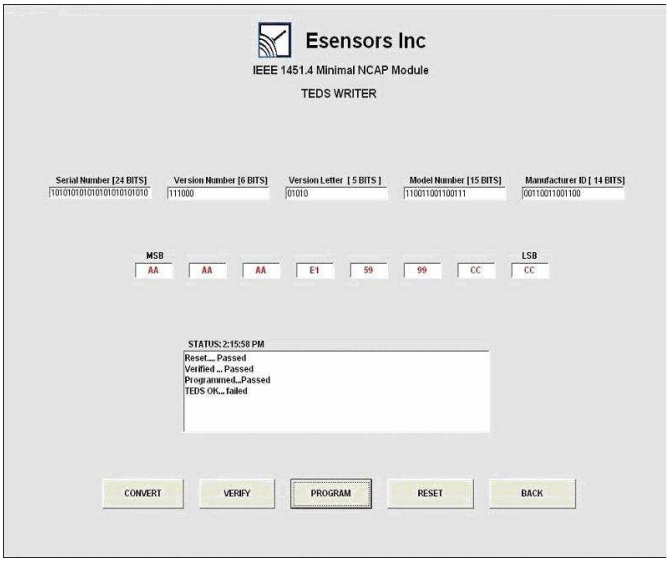

Fig. 5. TEDS Writer Screen

IV. MINIMAL DOT4 NCAP

A minimal NCAP (Network Capable Application Processor was built and tested (see Fig 6). The NCAP can read and write the TEDS (or any 1-wire device) with a PC (Personal Computer) via the RS232 serial link. While the TEDS writing is needed only by manufacturers, TEDS reading is needed by all users. The plug and play software, including display of the TEDS information in a convenient form, recognizes when a sensor is added or removed.

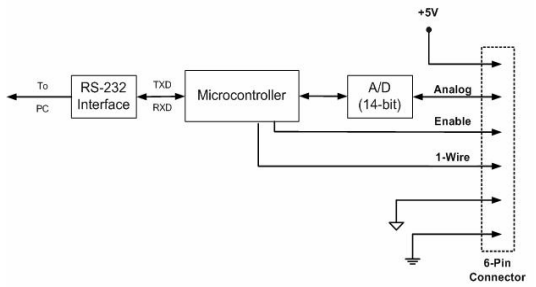

Fig. 6. Block Diagram of Minimal (RS232 type) NCAP

A 14-bit analog to digital (a/d) converter (-2 to +2 v) converts the analog signal (a part of the Dot4 Class 2 mixed mode interface) into digital form. The circuit diagram of the NCAP is given in Fig. 7.

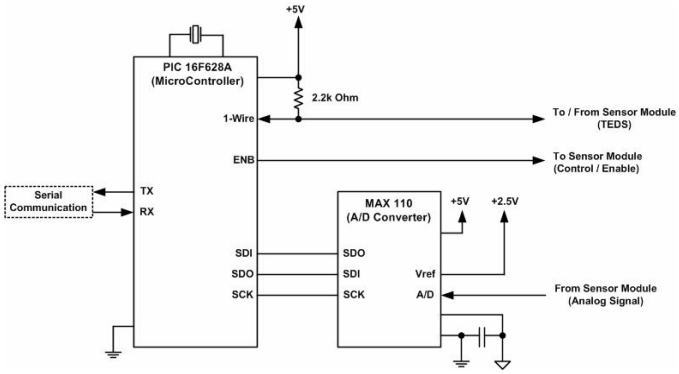

Fig. 7. NCAP Circuit Diagram

The sensor data is converted to decimal form (ASCII), transmitted through the RS232 serial link (9600 Baud) and displayed on a PC using visual Basic. (Fig. 8). The display format was devised for convenience and is not a part of the standard.

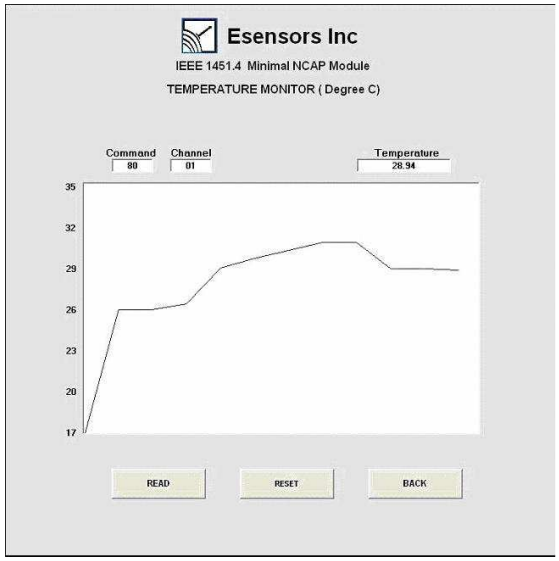

Fig. 8. Display of Sensor Data on a PC

V. DOT4 SENSOR BUS

The Dot4 standard does not specify a connector. We chose a standard 6-pin modular connector as the sensor/actuation module connector. (Figs. 6, 9 & 10). It has lines for (a) TEDS, (b) analog signal input, and (c) power. A separate analog ground is provided to reduce noise and zero offsets. An optional control line (for actuators or selection) is also provided.

With one mode of operation (Fig. 9), a single sensor with TEDS is connected. Various types of sensors can be used (e.g. temperature, photo-detector, Hall/magnetic).. The TEDS provides the ID for the specific sensor option and, if desired, the calibration data. The TEDS data is transmitted through the NCAP to the PC Fig. 4).

For retrofit applications, where the sensor and a/d are already present, only the TEDS need be added. It may be attached to the sensor housing and only two wires (1-wire and ground) are needed.

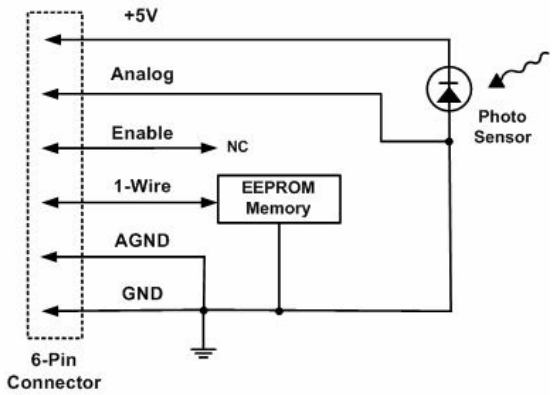

Fig. 9. Single Sensor Module

VI. MULTI-DROP BUS

To input data from more than one sensor, a switching device is connected to each sensor module to enable the analog line for that sensor. The switching device (1-wire net coupler) has a specific address or UUID on the 1-wire bus. During a discovery process the addresses of all 1-wire devices on the bus are found and these correspond to the sensor module addresses. The NCAP keeps track of these locally only. The coupler has an output (CONT) line which is turned on (active low) when the UUID of the TEDS attached to it matches an address sent on the 1-wire bus. The coupler then switches the sensor analog signal so that it is connected to the analog signal line on the Dot4 bus. Only the signal for the addressed TEDS is switched on and therefore multiple sensor modules can be connected to the Dot4 bus, that is the bus is multi-drop.

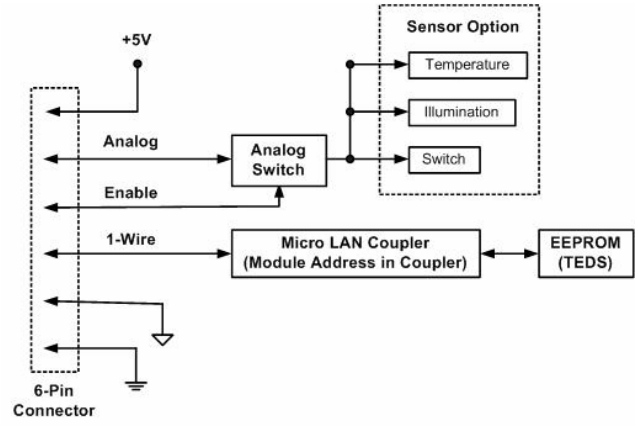

Fig. 9. Block Diagram of Multi-drop Sensor Module. One 1-wire EEPROM is used for the module ID while the other is the TEDS.

A circuit diagram of the coupler and analog switch sections of the module are given in Fig. 10.

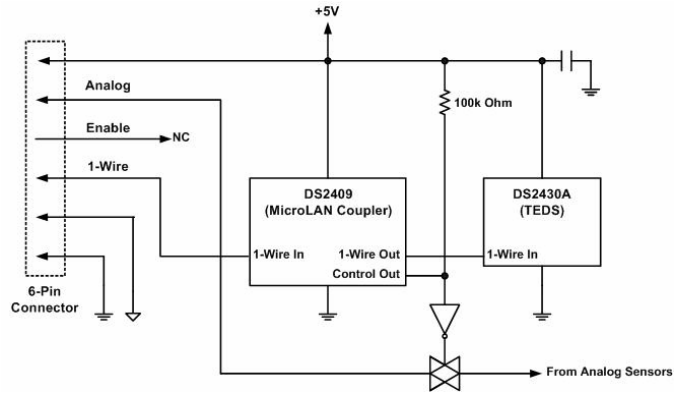

Fig. 10. Circuit Diagram of Multi-drop Sensor Module

VII. PRINTED CIRCUIT BOARDS

The NCAP and Sensor modules in printed circuit board form are shown in Fig. 11. Note the 6-pin modular connector for the Dot4 sensor bus and the 9-pin D connector for the RS232.

Fig. 11. Minimal Dot4 NCAP (top) and Sensor Module (bottom) Boards

VIII. INTERNET GATEWAY NCAP

An alternative NCAP that connects directly to the Internet, and which has an IP address, has been described previously [5].

IX. CONCLUSIONS

The minimal Dot4 interface was shown to be effective in inputting data from analog sensor with a TEDS. It is expected that this interface will be useful in retrofitting existing analog sensors to networks with the IEEE 1451 format.

REFERENCES

[1] John Webster and R. Pallas-Areny "Sensors and Signal Conditioning", 2nd Ed., John Wiley & Sons, (2001)

[2] R. Frank "Understanding Smart Sensors", 2nd edition, Artech House (2000)

[3] IEEE 1451 information http://ieee1451.nist.gov

[4] D. Potter "Overview of IEEE 1451.4", Proc. Sensors Expo (June 2004)

[5] D. Wobschall "IEEE 1451 Prototype Dot 2 and Dot 4 NCAPs with Internet Access", Proc. Sensors Expo (Sept 2003)

[6] Info on 1-wire: http://www.maxim-ic.com/1-Wire.cfm

[7] And: http://www.maxim-ic.com/appnotes.cfm/appnote_number/1796