Building Plug-and-Play Networked Smart Transducers

The Proposed IEEE P1451.2 Standard Enables Transducer Manufacturers to Support Multiple Fieldbuses

1. INTRODUCTION

The current fragmented fieldbus market, with multiple buses each with their own physical interface and communications protocol, is a barrier to the development of smart, network-capable transducers.

Transducer manufacturers are overwhelmed by the sheer number of buses, and are unsure of which to select to support.

IEEE and NIST held workshops in 1994 and 1995 to characterize problem and develop solutions.

The proposed solution was to prepare an open standard for network-independent smart transducers.

2. IEEE P1451.2

IEEE P1451 is a family of standards covering network-capable transducers from the raw transducer itself to a high-level, object-model representation of behavior, attributes and data communications.

Covers both sensors and actuators.

IEEE P1451.2 is ahead. Successful ballot, will be submitted to IEEE for standardization.

Defines Transducer Electronic Data Sheet (TEDS), channel models (sensor, actuator, buffered, event sensor, etc.), and general-purpose correction engine. Output is in IEEE standard floating-point numbers using standard SI units.

Block diagram of IEEE P1451 network system shown figure 1.

Physical connection is the 10-pin Transducer Independent Interface (TII). Synchronous serial communications based on SPI (Serial Peripheral Interface). Also includes power, ground, and control lines.

Definition of TII pins in table 1.

NCAP supplies up to 75 mA at 5 V to power STIM. Provision is made for supplemental power if needed.

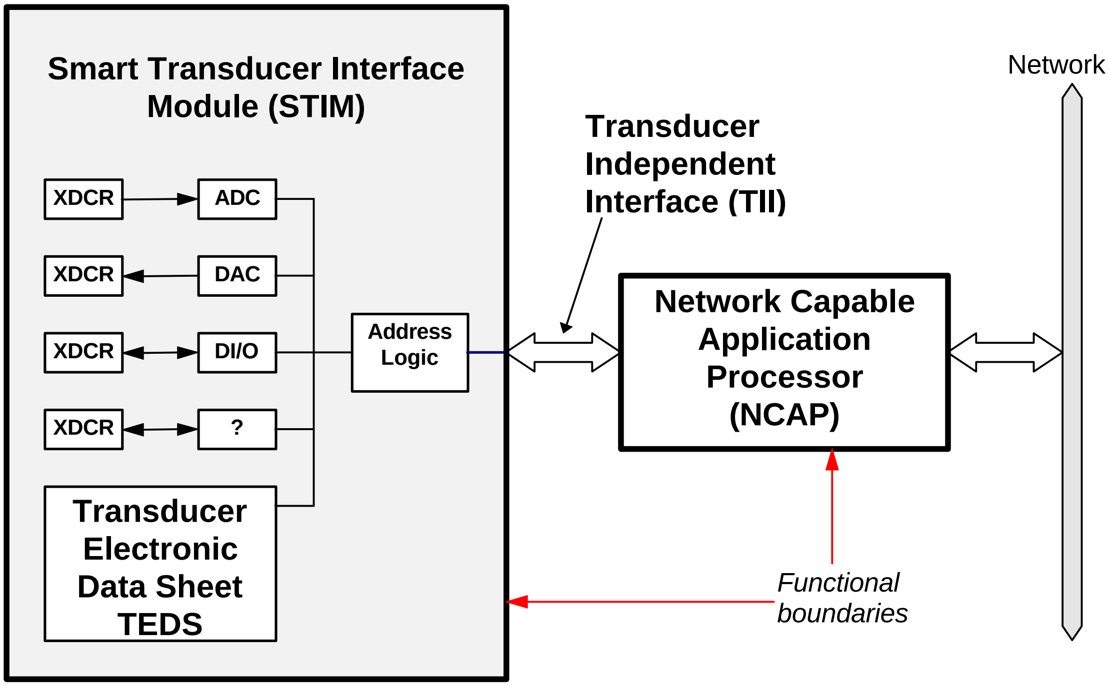

Figure 1. IEEE P1451 system block diagram

Table 1. TII Pin assignments

Pin number	Signal name	Wire color	Direction for NCAP	Direction for STIM
1	DCLK	brown	OUT	IN
2	DIN	red	OUT	IN
3	DOUT	orange	IN	OUT
4	NACK	yellow	IN	OUT
5	COMMON (GROUND)	green	POWER	POWER
6	NIOE	blue	OUT	IN
7	NINT	violet	IN	OUT
8	NTRIG	gray	OUT	IN
9	POWER (+5 VDC)	white	POWER	POWER
10	NSDET	black	IN	OUT

TII signal definitions and functions are shown in table 2.

Table 2. TII signal definitions.

Line	Logic	Driven by	Function
DIN	positive logic	NCAP	Address and data transport from NCAP to STIM

DOUT	positive logic	STIM	Data transport from STIM to NCAP
DCLK	positive edge	NCAP	Positive-going edge latches data on both DIN and DOUT
NIOE	active low	NCAP	Signals that the data transport is active and delimits data transport framing.
NTRIG	negative edge	NCAP	Performs triggering function
NACK	negative edge	STIM	Serves two functions: 1. trigger acknowledge 2. data transport acknowledge
NINT	negative edge	STIM	Used by the STIM to request service from the NCAP
NSDET	active low	STIM	Used by the NCAP to detect the presence of a STIM
POWER	N/A	NCAP	Nominal 5 V power supply
COMMON	N/A	NCAP	Signal common or ground

The NCAP is the communications master and always controls DCLK. The basic interface communications protocol is that the NCAP clocks an address into the STIM using the DIN and DCLK signal lines. For a write, the NCAP keeps clocking DCLK and places the data on DIN. For a read, the NCAP keep clocking DCLK looks for the data on DOUT.

Originally, an acknowledgment was not required between bytes. This meant that the DCLK rate had to be slow enough that the STIM could prepare to receive or transmit the next byte within a single DCLK period. As will be discussed, changing this to require acknowledging each byte had a dramatic effect on the data transfer rate.

Working group attempted to standardize on a connector, but that was too application-dependent to get consensus. Simple 5 x 2 headers have been used for demonstration systems. Other connectors, such as 15-pin sub-miniature “D”-shell commonly used for computer video cables, have also been used.

3. REPRESENTATIVE STIM IMPLEMENTATION

For the Sensors Expo Boston show in May of 1997, working group put together a joint booth to demonstrate aspects of IEEE P1451.2. Hewlett-Packard provided network backbone, NCAPs, and STIM developers kits to participants.

(Trying to get HP photo of NCAP and/or developers kit)

Electronics Development Corporation was invited to build and demonstrate a miniature STIM based on our CogniSense™ EDI520 Smart Sensor Module.

The CogniSense EDI520 shown in figure 2 is a small (0.5 x 1.0 inch) multichip module containing mixed-signal ASIC for transducer interface and microcontroller for communications and local decision-making capability. (sidebar for description?)

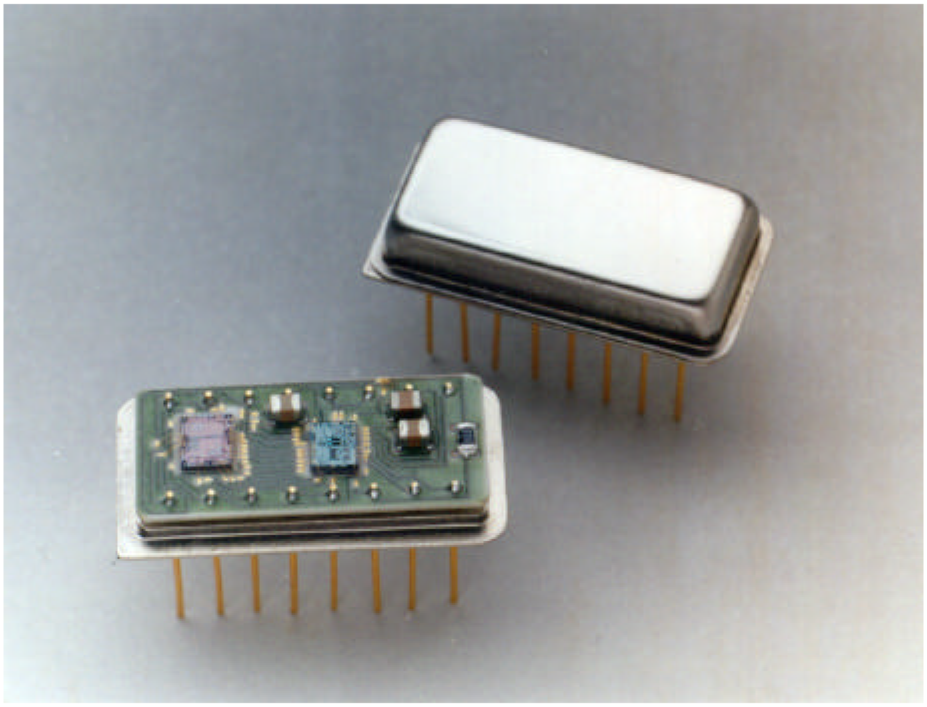

Figure 2. CogniSense EDI520 Smart Sensor Module

A STIM must include a transducer. We selected an accelerometer because it is easy to provide excitation.

The resulting miniature STIM required approximately one square inch of printed wiring board, including the surface mounted accelerometer.

The prototype STIM is shown in figure 3.

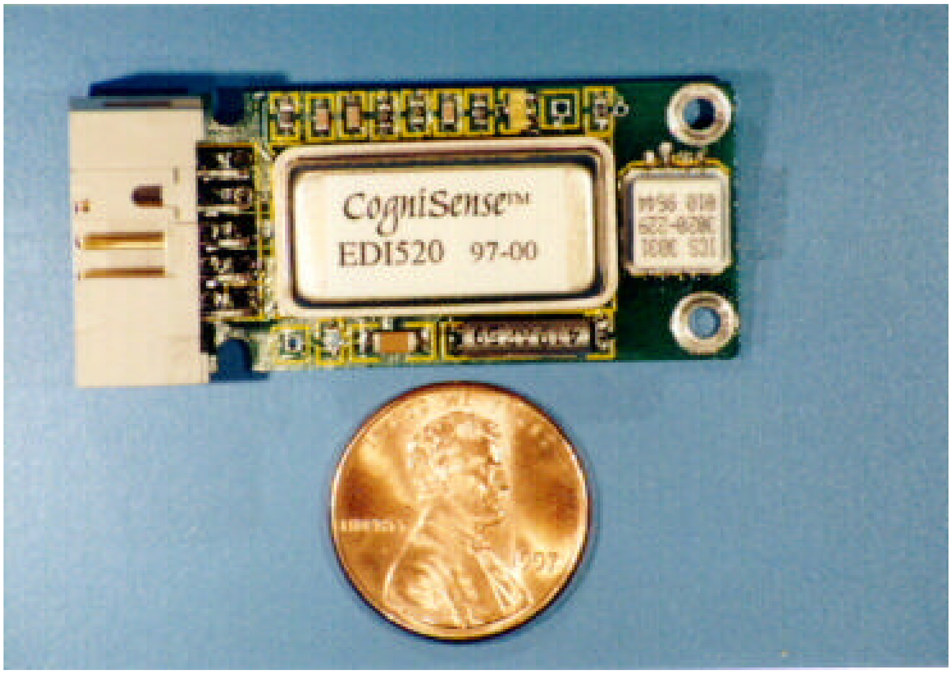

Figure 3. Miniature Accelerometer STIM

A block diagram (schematic?) of the STIM is shown in figure x.

(Need Microsoft Word compatible diagram)

From the time we received a copy of the draft standard and the Hewlett-Packard NCAP until we had a prototype communicating with the Hewlett-Packard NCAP over the TII was a little over one week.

Final demonstration was an accelerometer STIM mounted on a “wave machine” (long tube filled with two heavy liquids with tilt mechanism to produce waves in the liquids).

The accelerometer was mounted with the sensitive axis horizontal so that it read the sine of tilt angle. Accelerometers are commonly used as inclinometers in this way.

It took approximately one month total for delivery of the miniature STIMs for the demonstration.

This speaks well of the quality and maturity of the IEEE P1451.2 standard. It really can be used by transducer manufacturers to produce working, network-capable but network-independent STIMs.

The byte pacing protocol for the TII communications interface changed during the implementation of the miniature STIM to include an acknowledgment of each byte of data. For the miniature STIM, this increased the serial clock rate capability from less than 10,000 bits per second, to over 500,000 bits per second. This increase is due to relaxing the interrupt latency time requirement for making the transition from receiving the address to sending out the data.

The actual data throughput rate is lower than 500,000 bits per second due to the few microseconds required at the end of each byte to empty or reload the serial buffer, but the increase was dramatic.

This section can be filled out to almost any length with a more detailed description of the STIM design. For example, a description of the embedded firmware, a discussion of the use of interrupts versus polling loops for the communications interface, etc.

4. FUTURE PLANS

The standard is being submitted to IEEE for approval. May have happened by the time of this publication. Once that happens…

It is anticipated that a significant number of sensors will become available with the IEEE P1451.2 interface. Transducer manufacturers will need assistance, at least at first, in applying this new, exciting, technology.

More than one of the members of the working group are planning to offer assistance to transducer manufacturers for developing STIMs.

For example, Electronics Development Corporation plans to offer a complete “STIM Developers Kit” for resistive or voltage output transducers, which will include the tools to develop and manage the TEDS data, including calibration factors.

Other sensor interface and microcontroller companies can be expected to some form of assistance to transducer manufacturers.

This section can be toned down if it is starting to sound too much like a commercial.

5. SUMMARY

IEEE P1451.2 is here at last. May have been approved by the time of publication.

Provides ability to produce network-capable, but network-independent smart transducers.

Sometimes overlooked benefit is that it allows system integrators to upgrade the network, without changing the sensors. Not only the transducer manufacturers but also the integrators have more freedom from the details of the exact fieldbus implementations.

The standard has been implemented by more than one company and compatibility demonstrated. By the time of this publication, we anticipate that commercial hardware will be available that is directed toward specific real-world applications.

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