A FRAMEWORK FOR SMART TRANSDUCER INTERFACE SYSTEMS

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ABSTRACT

Current progress and concepts of the IEEE P1451 Draft Standards for Smart Transducer Interfacing of Sensors and Actuators will be reviewed. Topics include the Network Capable Application Processor Information Model (P1451.1), Smart Transducer Independent Interface (1451.2), Distributed Multidrop Systems (P1451.3), and Mixed-mode Communication Protocols (P1451.4).

INTRODUCTION

The rapid evolution of computer communication networks and microelectronics suitable for embedding within sensors and actuators have enabled a vast proliferation of both networks and "smart" sensor technologies and applications. An unfortunate side effect of this proliferation has been to raise the cost of supporting these technologies from both a hardware manufacturing and software applications generation viewpoint. The problem of determining which bus, or which network to support is an especially perplexing one to analog sensor companies. These companies core technologies are typically not digital, or network, but physical transduction and analog signal processing in nature.

The IEEE P1451 working groups are dedicated to the creation of a compatible family of smart transducer interface standards, which promise to significantly simplify the challenge of network to transducer interfacing. Vendor implementation of the IEEE P1451 family of standards holds the promise of simplifying connectivity of both sensors and actuators to communication networks as well as greatly simplifying the software application interface to measurement and control hardware. Support of the standard also brings the benefit of electronic identification of sensors, providing on-line documentation in the form of electronic data sheets.

ORIGINS AND OBJECTIVES

The P1451 working groups were formed out of interest and efforts on the part of the Instrumentation and Measurement Society TC-9 Committee on Sensor Technology, Institute of Electrical and Electronics Engineers (IEEE) in cooperation with The National Institute of Standards and Technology (NIST), United States Department of Commerce. The objective of this set of proposed standards is to define a uniform and consistent approach to networking sensors and actuators. Implementation of the proposed standards should lead to device and network interoperability. Systems-level implementers are then free to choose the best-in-class networks, sensors and actuators. The P1451 family of standards can be thought of as bringing "Plug and Play" to the world of sensor to network interfacing.

FAMILY MEMBERS

The IEEE P1451 [1,2] Family consists of the following standards and proposed standards as of this writing:

IEEE P1451.1 - Network Capable Application Processor (NCAP) Information Model

IEEE 1451.2-1997 - Transducer to Microprocessor Communications Protocols and Transducer Electronic Data Sheet (TEDS) Formats

IEEE P1451.3 - Digital Communication and Transducer Electronic Data Sheet (TEDS) Formats for Distributed Multidrop Systems

IEEE P1451.4 - Mixed-mode Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats

Refer to figure 1 below for a system level block diagram. Note that some of the blocks are optional, and may be collapsed into integrated subassemblies.

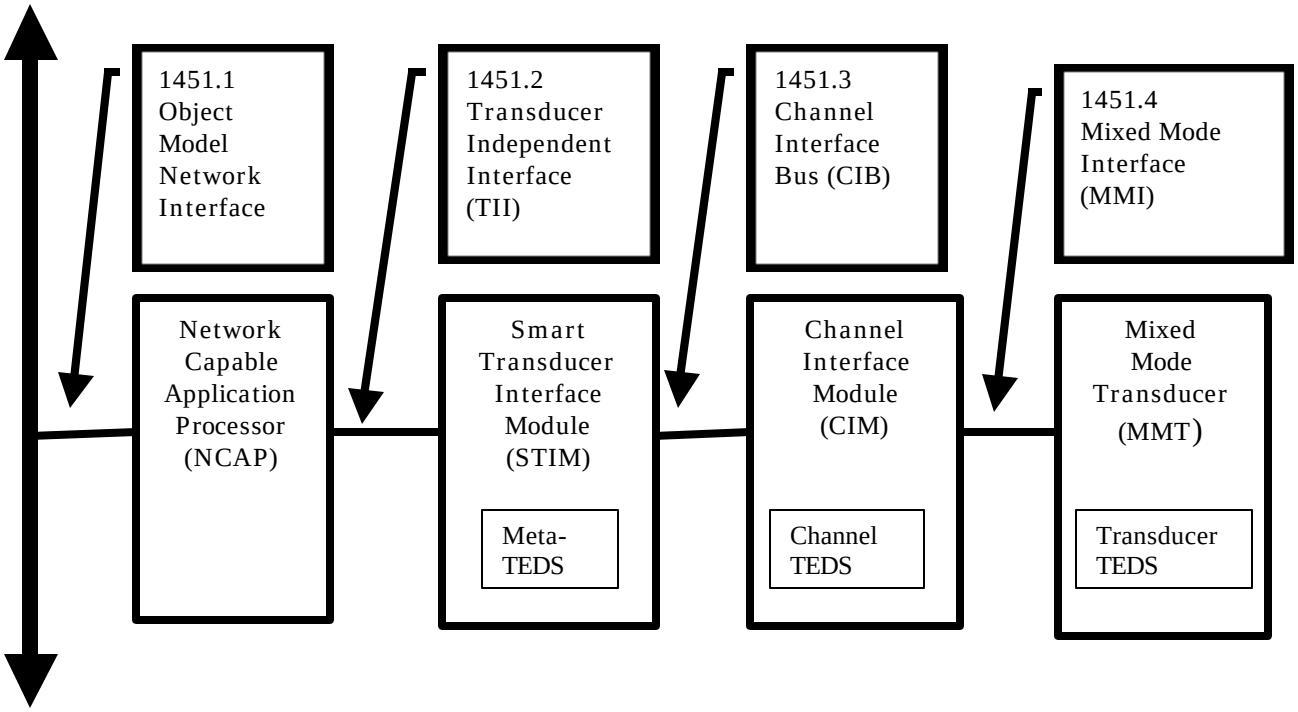

Figure 1 – IEEE P1451 Family Architecture

IEEE P1451.1

The objective of the P1451.1 working group is to utilize existing networking technology and develop standardized methods for connection of Smart Transducers to networks. Adoption of such a standard should require little or no changes to use different methods of analog to digital conversion, different microprocessors, or different network protocols and transceivers. This objective is achieved through the definition of a common object model for the components of a Networked Smart Transducer, together with Interface Specifications to these components. This working group has submitted its draft specification for first round IEEE balloting and is currently revising the draft specification (current revision D2.19 as of this writing) in preparation for balloting in the fall of 1998.

IEEE 1451.2-1997

The second working group has successfully completed its activities, resulting in the approval of full use IEEE Std. 1451.2-1997. This group's focus was definition of TEDS, and a Transducer Independent Interface (TII) to a Network Capable Applications Processor. The resulting TEDS definition ranging in size from 256 bytes upwards fully describes the type, operational characteristics, calibration, attributes, and data format aspects of transducers. The TEDS is intended to be stored in electrically erasable programmable read-only memory (EEPROM) so as

to be field updated when transducer sensitivity or any other aspect of the physical measurement and control changes. The 1451.2 standard also requires that the TEDS shall be physically inseparable from the transducer. This and the fact that TEDS are readable by upper levels of the standard ensure that critical transducer information such as calibration constants is maintained with the transducer.

The 1451.2 TII consists of a set of 10 signal wires, which are responsible for connecting the Smart Transducer Interface Module (STIM) to the NCAP. This TII is intended to behave as an internal point to point communications, power and timing bus, facilitating bi-directional communication of TEDS information as well as sensor or actuator data in various operational modes. The TII specifies only a minimum communications speed between a STIM and NCAP. The TEDS, and what the capabilities of the individual NCAP can support determine the maximum communications speed between NCAP and STIM. The TII also supports features such as hot swap, and power-down, thus enabling upper level components to detect transducer or STIM swaps, as well as power saving operations.

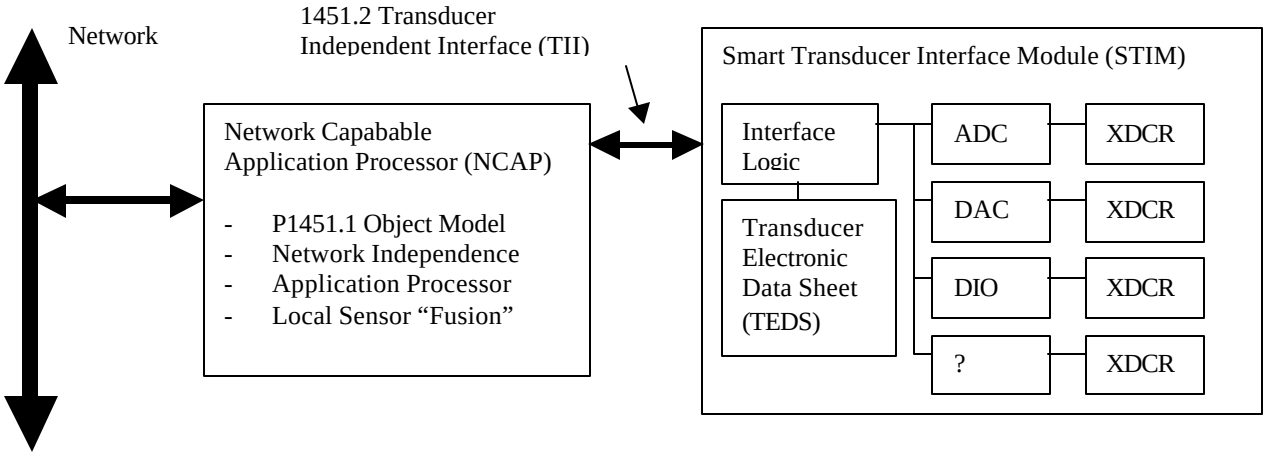

Figure 2 – System block diagram showing a 1451.1 and 1451.2 interface to an integrated STIM

IEEE P1451.3

The third working group IEEE P1451.3 grew out of the recognition of a need for low cost and size deployments of spatially separated transducers. The group intends to leverage off of and be compatible with the P1451.1 and IEEE 1451.2 standards. Excellent examples of requirements for spatial separation would be modal measurements along a wing spar, or along a bridge span. In both of these cases traditional hub and spoke wiring, characteristic of traditional measurement approaches becomes space and cost prohibitive.

To date, this working group has focused on a specification of TEDS, and communication protocols, which are independent of physical bus implementation to date. The current "straw man" draft specification incorporates such concepts as hot swap, channel identification, synchronization and read-write logic functions used to access TEDS and transducer data. Most read-write functions are quite similar to if not an identical copy of those used in the 1451.2 standard for purposes of compatibility. The standard will not, however specify signal conditioning, or the method by which an application uses the TEDS data fields.

The physical bus implementation currently under consideration is a two wire spread spectrum multidrop scheme. This could also be thought of as "wireless" on a wire. A conceptual block diagram of a 1451.3 type interface is shown in figure (3).

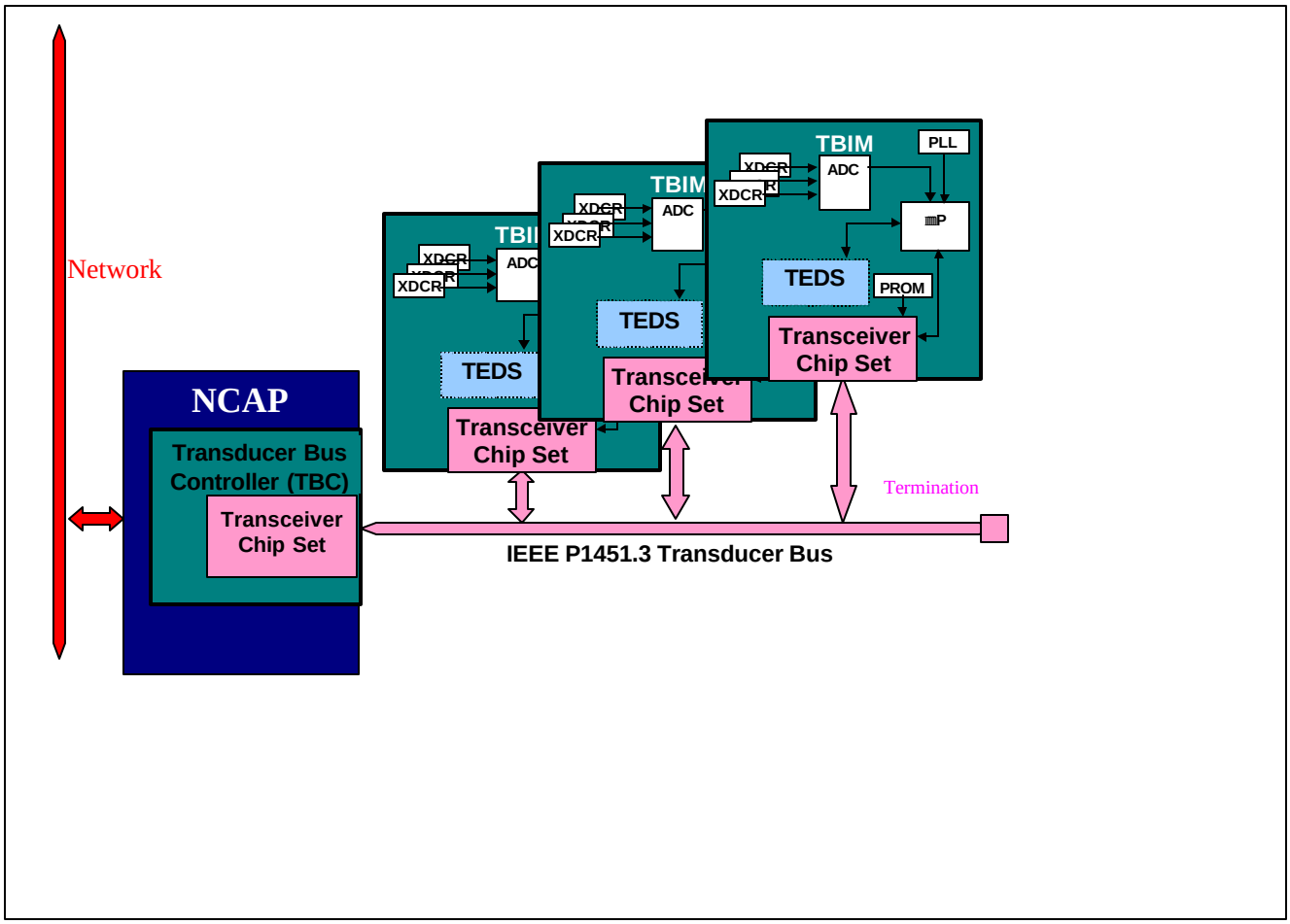

Figure 3 – Proposed 1451.3 Radio Frequency spread spectrum architecture utilizing integral transducers.

IEEE P1451.4

The fourth working group grew out of the P1451.3 working group, and at present is quite heavily represented by manufacturers of traditional dynamic analog sensors. This group desires to define a standard which would allow analog transducers to digitally communicate their data qualification information for purposes of self-identification and configuration.

The group recognizes that each type or class of analog transducer will most probably require its own electrical interface in terms of wire count and signaling mechanism. The group is currently focused upon definition of the two and seven wire implementations. The two wire implementation is for supporting constant current accelerometers and microphones, and the seven wire is for support of precision microphones.

The P1451.4 proposals considered to date fundamentally assume an absolute minimum of electronics in the transducer. This is driven by the sensitivity of these applications to transducer mass and size. Typically this involves only a diode (switch) or two, and a memory component. This implementation has come to be known as the two-wire current reversal scheme and allows both reading and writing of a memory component located within the transducer. An example of a two wire constant current accelerometer implementation is shown in figure 4.

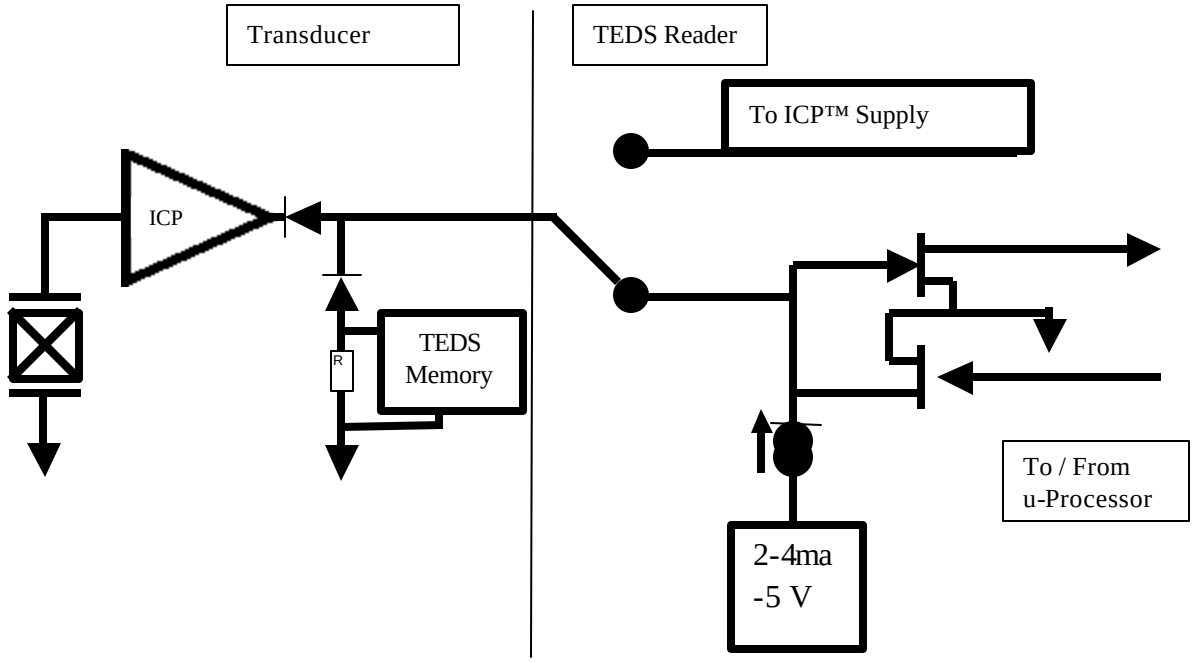

Figure 4 Example of a two wire constant current ICP™ 1451.4 implementation

FOR MORE INFORMATION

Copies of the IEEE P1451.1 draft standard and IEEE 1451.2 – 1997 standard may be purchased by contacting IEEE directly. Information on participation in the IEEE P1451.3 and P1451.4 working groups may be obtained at www.ic.ornl.gov/p1451. Some information on this site is restricted to working group members only. Additional information about the P1451 working groups may also be obtained by contacting the authors or the TC9 sponsor of the 1451 activities:

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REFERENCES

[1] IEEE P1451.1/D2.19 Draft Standard for a Smart Transducer Interface for Sensors and Actuators - Network Capable Application Processor (NCAP) Information Model

[2] IEEE 1451.2-1977 IEEE STANDARD for
A SMART TRANSDUCER INTERFACE
For SENSORS and ACTUATORS Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet
(TEDS) Formats.