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Information technology — Smart transducer interface for sensors and actuators — Common functions, communication protocols, and Transducer Electronic Data Sheet (TEDS) formats

Technologies de l'information — Interface de transducteurs intelligente pour capteurs et actuateurs — Fonctions communes, protocoles de communication et formats des feuilles de données électroniques du transducteur (TEDS)

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IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Common Functions, Communication Protocols, and Transducer Electronic Data Sheet (TEDS) Formats

1451.0™

IEEE Instrumentation and Measurement Society

Sponsored by the
Technical Committee on Sensor Technology (TC-9)

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Sponsor

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Abstract: This standard provides a common basis for members of the IEEE 1451 family of standards to be interoperable. It defines the functions that are to be performed by a transducer interface module (TIM) and the common characteristics for all devices that implement the TIM. It specifies the formats for Transducer Electronic Data Sheets (TEDS). It defines a set of commands to facilitate the setup and control of the TIM as well as reading and writing the data used by the system. Application programming interfaces (APIs) are defined to facilitate communications with the TIM and with applications.

Keywords: actuator, application programming interface, communication protocol, network-capable application processor, sensor, smart transducer, transducer electronic data sheet, transducer interface module

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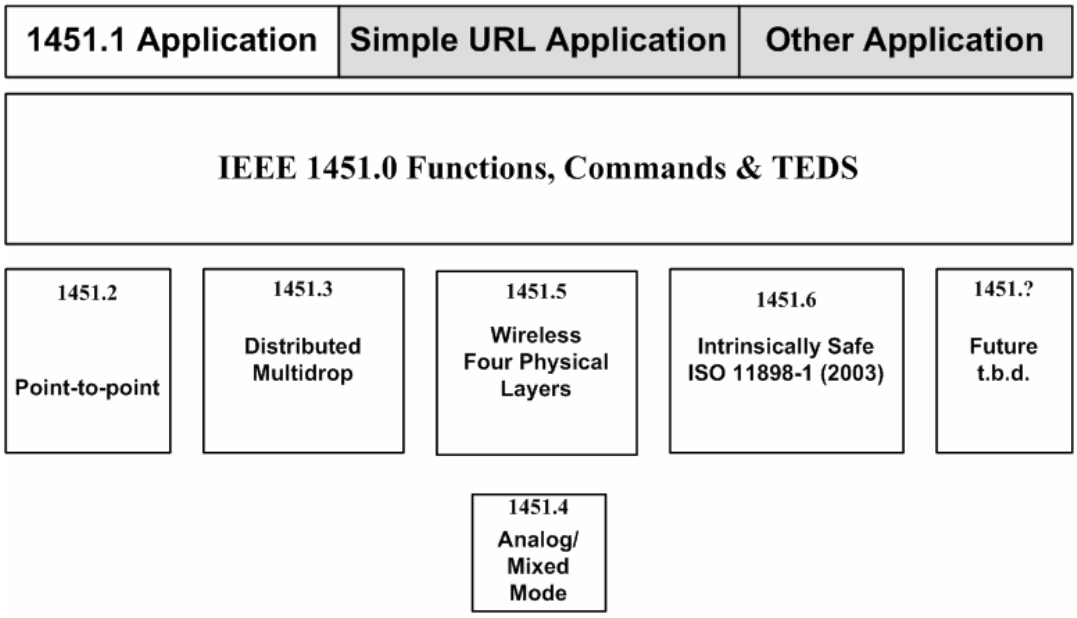
Introduction

This introduction is not part of IEEE Std 1451.0-2007, IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Common Functions, Communication Protocols, and Transducer Electronic Data Sheet (TEDS) Formats.

This standard is intended to provide a basis for all future members of the IEEE 1451 family of standards that use digital interfaces. It should also be adopted by the existing members of the IEEE 1451 family of standards as they are revised in the future in order to provide the highest degree of compatibility among the members of the family. This standard does not apply to IEEE Std 1451.4™-2004, which only provides a size-constrained TEDS and an analog interface.

The relationships between this standard and the other members of the family are shown in the following diagram. Three of these standards were complete before this standard was started and do not comply with this standard but will in the future as they are revised. They are IEEE Std 1451.1™-1999, IEEE Std 1451.2™-1997, and IEEE Std 1451.3™-2003. IEEE Std 1451.1 is an application that, in the future, will fit between the user's network and this standard. IEEE Std 1451.2 and IEEE Std 1451.3 will also be modified to interface with this standard. When these changes are made, the functions of an IEEE 1451 transducer will be as defined in this standard as will be the commands and TEDS. IEEE 1451.5™-2007, which uses any of several different wireless communications media, and IEEE P1451.6™ have been written around the functions, commands, and TEDS as described in this standard. IEEE Std 1451.4 uses an analog signal interface and a TEDS that is not the same as that used by other members of the family. It may be used as the input to any of the other standards in the family but does not comply with the functions, commands, and TEDS defined in this standard. Items shown with a gray background are items that are not covered by any of the IEEE 1451 family of standards but that may be used.



The underlying purpose of this family of standards is to allow manufacturers to build elements of a system that are interoperable. To accomplish this goal, the IEEE 1451 family of standards divides the parts of a system into two general categories of devices. One is the network capable application processor (NCAP) that functions as a gateway between the users' network and the transducer interface modules (TIMs). The NCAP is a processor-based device that has two interfaces. The physical interface to the users' network is not specified in any of this family of standards. IEEE Std 1451.1 provides a logical object model for this

interface. Other applications may also be used at the manufacturer's discretion. The communications interface between the NCAP and the TIMs is defined in the remaining members of the family of standards. Different manufacturers may build the NCAPs and TIMs, and if both comply with this standard, they should be interoperable.

This standard provides a description of the functions that are to be performed by a transducer interface module or TIM. Provisions are made for a high level of addressing that is independent of the physical medium-level and low-level protocols that are used to implement the communications. It defines the common characteristics for all devices that implement the transducer modules. The timing of the acquiring or processing of the data samples is described. Methods of grouping the outputs from multiple transducers within one TIM are defined. Common status words are also defined.

A standard set of commands are defined to facilitate the setup and control of the transducer modules as well as to read and write the data used by the system. Commands are also provided for reading and writing the TEDS that supply the system with the operating characteristics that are needed to use the transducer modules. A method of adding manufacturer unique commands is included.

In addition, this standard provides formats for the TEDS. Several TEDS are defined in the standard. Four of these TEDS are required, and the remaining TEDS are optional. Some TEDS are provided to allow the user to define information and to store it in the TEDS.

This standard provides areas that are "open to manufacturers." It should be noted that any use of these areas may compromise the "plug-and-play" potential of controllers and TIMs.

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Contents

IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Common Functions, Communication Protocols, and Transducer Electronic Data Sheet (TEDS) Formats

1. Overview

This standard introduces the concept of a transducer interface module (TIM) and a network capable application processor (NCAP) connected by a media specified by another member of the IEEE 1451 family of standards. A TIM is a module that contains the interface, signal conditioning, analog-to-digital and/or digital-to-analog conversion and, in many cases, the transducer. A TIM may range in complexity from a single sensor or actuator to units containing many transducers (sensors and actuators). An NCAP is the hardware and software that provides the gateway function between the TIMs and the user network or host processor. Another member of the standards family provides the communications interface between an NCAP or host processor and one or more TIMs. Three types of transducers are recognized by this standard. They are sensors, event sensors, and actuators.

A transducer is denoted "smart" in this context because of three features:

— It is described by a machine-readable Transducer Electronic Data Sheet (TEDS).

— The control and data associated with the transducer are digital.

— Triggering, status, and control are provided to support the proper functioning of the transducer.

An NCAP or a host processor controls a TIM by means of a digital interface medium. The NCAP mediates between the TIM and a higher level digital network and may provide local intelligence.

This standard defines an application program interface (API) for applications that provide communications between the users' network and the IEEE 1451.0 layer. An API is also provided between the IEEE 1451.0 layer and the underlying physical communications layers usually referred to in this standard as IEEE 1451.X. These API definitions are provided for systems that have visible interfaces. For TIMs and

NCAPs with a single set of hardware and software without regard to distinguishing separate interfaces between IEEE 1451.0 functionality and IEEE 1451.X functionality, the API is optional as long as the messages at visible interfaces conform to the rest of the standard. The definition of these APIs is to facilitate modular design to the extent that multiple suppliers can provide different functionality and yet have the various parts integrate seamlessly.

This standard defines TIMs that can be plugged into a system and can be used without having to add special drivers, profiles, or make any other changes to the system. This process is referred to as a "plug-and-play" operation. The primary features that enable a plug-and-play operation are the TEDS and the command set. A TIM may be added to or removed from an active IEEE 1451 physical layer with no more than a momentary impact on the data being transferred over the bus. "Hot swap" is the term used to refer to this feature.

This standard is organized as follows:

Clause 1: "Overview" provides the scope of this standard.

Clause 2: "Normative references" lists references to other standards and documents that are useful in applying this standard.

Clause 3: "Definitions, acronyms, and abbreviations" provides definitions that are either not found in other standards or have been modified for use with this standard.

Clause 4: "Data types" defines the data types used in the standard.

Clause 5: "Smart transducer functional specification" specifies the functions required of a TIM and of each TransducerChannel it comprises.

Clause 6: "Message structures" specifies the message structures that are used to encapsulate the information being passed between an NCAP and TIMs.

Clause 7: "Commands" provides the command syntax and the expected replies.

Clause 8: "TEDS specification" specifies the transducer electronic data sheet structure and content.

Clause 9: "Introduction to the IEEE 1451.0 API" gives the common features of the two APIs.

Clause 10: "Transducer services API" gives the API that an application would use to utilize this standard.

Clause 11: "Module communications API" gives the API that this standard would use to communicate to the TIMs using the communications features of a physical interface defined by another member of the IEEE 1451 family of standards.

Clause 12: "HTTP protocol" is used to transfer or convey information on the World Wide Web. It is intended to provide a simpler protocol than is currently supplied by IEEE Std 1451.1-1999.

Annex: A: "Bibliography" provides references for additional information about topics referred to in this document.

Annex B: "Guidance to Transducer Services Interface" gives examples of the use of this interface for measurement and control applications that interact with the IEEE 1451.0 layer using the Transducer Services interface.

Annex C: "Guidance to Module Communication Interface" gives additional guidance for the logical communication between the NCAP and TIMs or between TIMs using the Module Communication API.

Annex D: "XML Schema for Text-based TEDS" gives the basic schemas for the Text-based TEDS defined in this standard.

Annex E: "Example Meta-Identification TEDS" gives an example of a possible Meta-Identification TEDS.

Annex F: “Example TransducerChannel Identification TEDS” gives an example of a possible TransducerChannel Identification TEDS.

Annex G: “Example Calibration Identification TEDS” gives an example of a possible Calibration Identification TEDS.

Annex H: “Example Commands TEDS” gives an example of a possible Commands TEDS.

Annex I: “Example Location and Title TEDS” gives an example of a possible Location and Title TEDS.

Annex J: “Example Units Extension TEDS” gives an example of a possible Units Extension TEDS.

Annex K: “Examples of Physical Units” gives a series of examples of implementations of Physical Units using the representation specified in this standard.

Annex L: “TEDS read and write protocols” describes processes that may be used to write or read the TEDS.

Annex M: “Trigger logic configurations” shows some possible configurations of the trigger logic allowed in this standard.

Annex N: “Notation summary for IDL” is intended to give guidance on the use of IDL notation in this standard.

Annex O: “TEDS implementation of a simple sensor” is an example of a simple sensor implemented using the structures defined in this standard.

1.1 Scope

This project develops a set of common functionality for the family of IEEE 1451 smart transducer interface standards. This functionality is independent of the physical communications media. It includes the basic functions required to control and manage smart transducers, common communications protocols, and media-independent TEDS formats. It defines a set of implementation-independent APIs. This project does not specify signal conditioning and conversion, physical media, or how the TEDS data are used in applications.

1.2 Purpose

There are currently three approved and three proposed smart transducer interface standards in the IEEE 1451 family of standards. They all share certain characteristics, but no common set of functions, communications protocols, and TEDS formats provides interoperability among these standards. This standard will provide that commonality and will simplify the creation of future standards for different physical layers that are interoperable within the family.

1.3 Conformance

The philosophy underlying the conformance requirements of this subclause is to provide the structure necessary to raise the level of interoperability of transducers and systems built to this standard, while leaving open opportunity for continued technical improvement and differentiation.

TIM implementation shall be deemed in conformance with this standard provided the following requirements are met:

a) The TIM supports the required functional specifications identified in Clause 5.

b) The TIM supports the message structures specified in Clause 6.

c) The TIM supports the required commands specified in Clause 7.

d) The TIM supports required TEDS that have the format and content specified in Clause 8.

e) The TIM supports one of the communications protocols and physical media defined by another member of the IEEE 1451 family of standards.

NOTE—Several features are highly desirable and are supported by this standard, but they are not practical to make into hard requirements. It is desirable that the sense element for a sensor be an integral part of the TIM, but for sensing elements like structural strain gages and thermocouples, this is not practical, so it has not been made into a hard requirement. In addition, it is very desirable that the TEDS be located within the TIM, but there are systems where the environment and/or the physical size make this impractical so the standard allows the TEDS to be located remote from the TIM..[1]

An NCAP implementation shall be deemed in conformance with this standard provided the following requirements are met:

— The NCAP supports the required functional specifications identified in Clause 5.

— The NCAP supports the message structures specified in Clause 6.

— The NCAP supports the required commands specified in Clause 7.

— The NCAP supports one of the communications protocols and physical media defined by another member of the IEEE 1451 family of standards.

1.3.1 Conformance keywords

Several keywords are used to differentiate among various levels of requirements and optionality, as follows.

1.3.1.1 Shall

The keyword “shall” indicates a mandatory requirement. Designers are required to implement all such mandatory requirements to ensure interoperability with other products that conform to this standard.

1.3.1.2 Shall not

The keyword “shall not” indicates a mandatory exclusion. Designers are required NOT to implement all such exclusions to ensure interoperability with other products that conform to this standard.

1.3.1.3 Recommended

“Recommended” is a keyword indicating flexibility of choice with a strong preference alternative. The word “should” has the same meaning.

[1] Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

1.3.1.4 Should

"Should" is a keyword indicating flexibility of choice with a strong preference alternative. The phrase *it is recommended* has the same meaning.

1.3.1.5 Should not

"Should not" is a keyword indicating flexibility of choice with a strong preference that a given alternative not be implemented.

1.3.1.6 May

"May" is a keyword that indicates flexibility of choice with no implied preference.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI X3.4-1986 (Reaff 1992), Coded Character Sets—7-bit American National Standard Code For Information Interchange.[2]

Extensible Markup Language (XML) 1.0 (Second Edition), W3C Recommendation, 6 October 2000.[3]

HTTP URL syntax (RFC 2616), HyperText Transfer Protocol (W3C).[4]

IEEE Std 754™-1985 (Reaff 1990), IEEE Standard for Binary Floating-Point Arithmetic.[5, 6]

IEEE Std 802.3™-2002, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications.

IEEE Std 1451.1™-1999, IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Network Capable Application Processor (NCAP) Information Model.

IEEE Std 1451.2™-1997, IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats.

[2] ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).
[3] Documents on the eXtensible Markup language can be downloaded from http://www.w3.org/TR/2000/REC-xml-20001006 or ordered from the World Wide Web Consortium, c/o MIT, 32 Vassar Street, Room 32-G515, Cambridge, MA 02139 USA.
[4] Documents describing the HTTP 1.1 Protocol can be downloaded from http://www.w3.org/Protocols/ or ordered from the World Wide Web Consortium, c/o MIT, 32 Vassar Street, Room 32-G515, Cambridge, MA 02139 USA.
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IEEE Std 1451.3™-2003, IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Digital Communication and Transducer Electronic Data Sheet (TEDS) Formats for Distributed Multidrop Systems.

IEEE Std 1451.4™-2004, IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Mixed-Mode Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats.

IEEE Std 1588™-2002, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.

ISO 639: 1988-04-01 (E/F), Codes for the Representation of Names of Languages.[7]

ISO 19136, Geographic information—Geography Markup Language (GML).

ISO/IEC 14750: 1999-03-15, Information technology—Open Distributed Processing—Interface Definition Language.[8]

[7] ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/ Suisse (http://www.iso.ch/). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

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