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## DESIGN OF TEDS OF INTELLIGENT SENSOR BASED ON IEEE1451.2 STANDARD

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**Abstract.** One of the directions of modern sensor development is the intelligent sensor based on IEEE1451.2 standard. The paper illustrates it on the example of an intelligent humidity sensor. It also introduces a technique for designing the meta-TEDS and humidity TEDS, which are necessary for a humidity intelligent sensor.

**Keywords:** IEEE1451; intelligent sensor.

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**Problem statement.** The traditional sensor with analog signal output cannot meet the requirements of modern measurement-control systems. Since NASA put forward the concept of intelligent sensor based on MCU in 1978, many scientists have conducted abundant research and development work [1–6]. However, because of the disunion of the format of the digital signal

output, the non-compatibility of the products from different manufacturers restricts further development of intelligent sensor. Kang Lee and coauthors began to advance the current intelligent transducer standard in 1993, and their endeavor was accepted by IEEE in 1997 [7]. Thus, IEEE recommended the standard IEEE1451.2 based on their work.

According to IEEE1451.2, a TEDS (Transducer Electronic Data Sheet) is the hard core of the STIM (Smart Transducer Interface Module), and it can be stored in firmware or E2PROM. There are eight different TEDS formats defined in this standard: two necessary and six optional ones. TEDS can well describe the parameters related to sensor type, action, performance attributes and indicates its manufacturer, model, and serial number. In such a way, the sensors have self-describing and self-identifying abilities. Thus, selection of different intelligent devices and networks can be separated, and the compatibility of an intelligent sensor and a control network is not a problem for users. This can be called plug-and-play.

**Basic material.**

**1. Hardware basis**

According to IEEE1451.2, the single chip PIC16F873 was selected, which has a 10-bit ADC. This chip supports I2C communication model, so it can be directly connected to the chip 24LC256 and E2PROM, which also supports I2C (RC0 is linked to SCK, RC1 is linked to SDA). The type of humidity sensor is HIH4000, which is designed by Honeywell. The ICSP debugging socket can be used for writing the program. The frequency of exterior crystal is 4M. The principles of electric circuits are shown in Fig. 1.

**2. Design of TEDS**

The IEEE1451.2 standard [7; 8] explains the general concept, TEDS design and TII (Transducer Independent Interface) design; the latter is a communication interface between STIM (Smart Transducer Interface Module) and NCAP (Net Capable Application Processor) [1–2;

8–12]. In the case of humidity sensor, a Meta TEDS data block and a channel TEDS data block are introduced. Let us regard the Type-Length-Value format of TEDS as TLV in this design.

*2.1. Data of Meta TEDS in TLV format*

First TLV	Second TLV	Third TLV	Fourth TLV
01030 20101	040A03B0 C8755781F 59528E0	090103	1D024955

The Meta TEDS consists of 4 TLV. As shown in Table 1, the first TLV comprises 5 bytes, which is the Identification Header of this TEDS. Based on the descriptions of the IEEE1451.2 standard, let us present Meta TEDS via the TLV method (Table 1).

There are 12 bytes in the second TLV of Meta TEDS, which shows detailed information of UUID. This UUID provides the latitude and longitude of manufacture, and the date and year when the STIM is manufactured. The information in the STIM of the intelligent sensor is as follows: latitude = 30233 ARC-SEC to north, longitude = 120158 ARC-SEC to east in Hangzhou, manufactured on June10th 2006, 12:00 PM. It has past 160.5(day)·24(hour)/(day)·3600(second)/ hour = 1386720·10 (seconds), from January 1st 2006, 00:00 PM (Table 2).

There are 3 bytes in the third TLV of Meta TEDS, which shows the numbers of channels implemented in the STIM. There is only one sensor in this design, so the number is 1 (Table 3).

There are 4 bytes in the fourth TLV of Meta TEDS, which is used to check the data of Meta TEDS. The summation of the front 16 bytes is 34953, so 4953 is the checksum (Table 4).

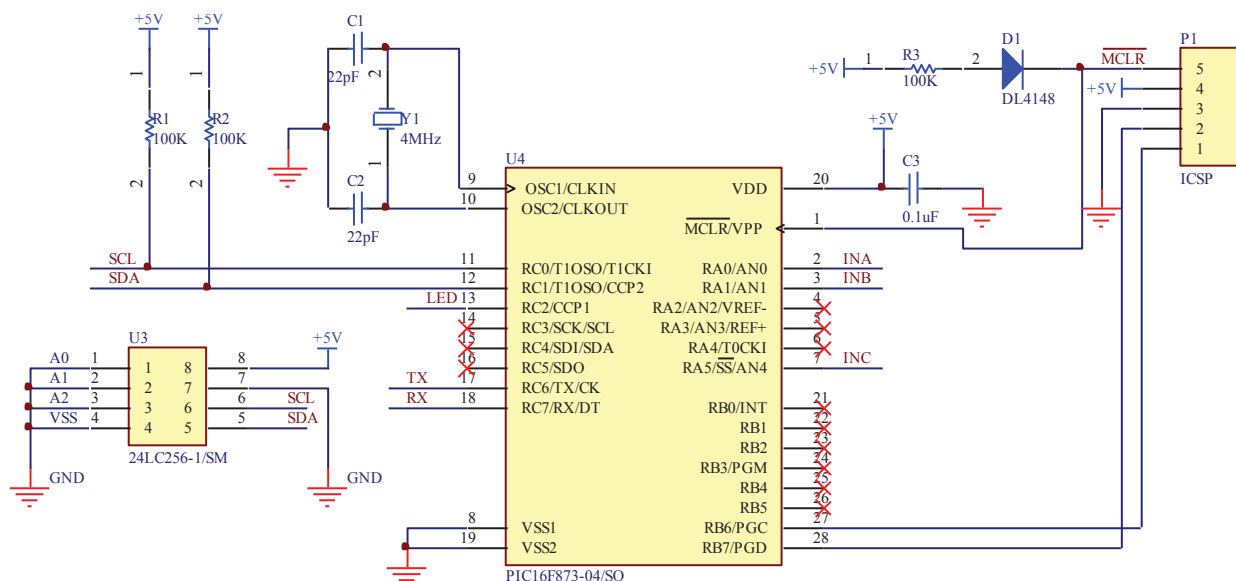


Fig. 1. Principles of the electric circuit

**Table 1.** The first TLV of Meta TEDS

TLV	Data format	Byte number	Data	Data description
Type	Decimal	1	01	TEDS Identification Header
Length		2	03	Length of value (03 = Length of value is 3)
Value		3	02	IEEE1451 standard family working group number (02 = 1451.2)
		4	01	Type of TEDS (01 = Meta-TEDS)
		5	01	TEDS version number (01 = version 1 in 1997)

**Table 2.** The second TLV of Meta TEDS

TLV	Data format	Byte number	Data	Data description
Type	Decimal	1	04	Universal Unique Identification (UUID)
Length	Decimal	2	0A	Length of value (0A = Length of value is 10)
Value	Hex	3	03	Data location: bit 1 = 0 (north), bit 2-bit 21, Hangzhou latitude = 30233 ARC-SEC to north = 000 0011 1011 0000 1100 1 (binary: 2-21 bit)
		4	B0	
		5	C8	
		6	75	
		7	57	Data location: bit 23-bit 42, bit 22 = 0 (east) Hangzhou longitude = 120158 ARC-SEC to east = 000 0111 0101 0101 0111 10 (binary: 22-42 bit)
		8	81	Data location: bit 43-bit 46 Void bits: 00 00 (binary)
		9	F5	Data location: bit 47-bit 58 Year: 2006 = 01 1111 0101 10 (binary)
		10	95	Data location: bit 59-bit 80; time=2006/6/10 12:00:00 PM; 160.5°24'3600/10 = 1386720 01 0101 0010 1000 1110 0000 (Binary)

**Table 3.** The third TLV of Meta TEDS

TLV	Data format	Byte number	Data	Data description
Type	Decimal	1	09	Number of implemented channels
Length	Decimal	2	01	Length of value, 01 = 1 byte
Value	Decimal	3	01	Total number channels implemented, 01 = 1

**Table 4.** The fourth TLV of Meta TEDS

TLV	Data format	Byte number	Data	Data description
Type	Decimal	1	1D	Checksum for Meta-TEDS
Length	Decimal	2	02	Length of value, 02 = 2 bytes
Value	Decimal	3	49	First byte of checksum
			53	Second byte of checksum

2.2. Data of Humidity Channel TEDS

0103020201	080100	090A808080808080808082	1E02AE9B
First TLV	Second TLV	Third TLV	Fourth TLV

There are four TLVs in Humidity Channel TEDS. The first TLV part consists of 5 bytes (see Table 5), which is Identification Header of Meta TEDS. The description of the Meta TEDS in this TLV method is also based on the descriptions provided in the IEEE1451.2 standard.

There are 3 bytes in the second TLV of Humidity Channel TEDS, which shows the number of the implemented channels. According to the description given in IEEE1451.2, when the type of implemented channel is sensor, the value in this TLV should be 00 (Table 6).

There are 12 bytes in the third TLV of Humidity Channel TEDS, which shows the detailed information of the units of sensor. A unit shall be represented as a product of the SI base units, plus radians and steradians, each raised to a rational power (Table 7).

There are 4 bytes in the fourth TLV of Humidity channel TEDS, which is used to check the value of Meta TEDS. The summation of the front 16 bytes is 2AE9B, so AE9B is the checksum (Table 8).

**Table 5.** The first TLV of Humidity Channel TEDS

TLV	Data format	Byte number	Data	Data description
Type	Decimal	1	01	Identification Header of TEDS
Length		2	03	Length of value (03 = 3)
Value		3	02	IEEE1451 standard family working group number (02 = 1451.2)
		4	02	Type of TEDS (02 = Channel TEDS)
		5	01	TEDS version number (01 = version 1 in 1997)

**Table 6.** The second TLV of Humidity Channel TEDS

TLV	Data format	Byte number	Data	Data description
Type	Decimal	1	08	Channel type key
Length		2	01	Length of value, 01 = 1 byte
Value		3	00	Implemented channel type key, 00 = sensor

**Table 7.** The third TLV of Humidity channel TEDS

TLV	Data format	Byte number	Data	Data description
Type	Decimal	1	09	Physical Units
Length	Decimal	2	0A	Length of value (0A = 10 bytes)
Value	Hex	3	82	Enumeration (enum), 82 means 1
		4	80	Exponent of radians (rad), 80 means 0
		5	80	Exponent of steradians (sr), 80 means 0
		6	80	Exponent of meters (m), 80 means 0
		7	80	Exponent of kilograms (kg), 80 means 0
		8	80	Exponent of seconds (s), 8080 means 0
		9	80	Exponent of amperes (A), 80 means 0
		10	80	Exponent of kelvins (K), 80 means 0
		11	80	Exponent of moles (mol), 80 means 0
		12	80	Exponent of candelas (cd), 80 means 0

**Table 8.** The fourth TLV of Humidity channel TEDS

TLV	Data format	Byte number	Data	Data description
Type	Decimal	1	1E	Checksum for Meta-TEDS
Length	Decimal	2	02	Length of value, 02 = 2 bytes
Value	Decimal	3	AE	First byte of checksum
			9B	Second byte of checksum

**CONCLUSIONS.** After Industrial and Information Revolutions, the upcoming automation revolution requires abundant sensors. Standardizing the output signal of these electric character-different sensors is very important to enhance measurement-control systems. Design of the data acquisition module based on IEEE1451.2 is going to be a developing direction for the years to come. Thus, it is advisable to reduce the cost and improve the

technology of modern measurement-control systems. The paper introduces two obligatory TEDS; there are six more TEDS, but they may be regarded as optional. There are 29 TLV parts in Meta TEDS, and 30 TLV parts in channel TEDS, all complying with IEEE1451.2. It is impossible to show all the TLV parts in this paper, but considering some TLV are relative, designing the whole TLV in a STIM is not necessary.

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