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Information technology — Radio frequency identification (RFID) for item management — Application protocol: encoding and processing rules for sensors and batteries

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National foreword

This British Standard is the UK implementation of ISO/IEC 24753:2011.

The UK participation in its preparation was entrusted to Technical Committee IST/34, Automatic identification and data capture techniques.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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INTERNATIONAL STANDARD

ISO/IEC 24753

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Information technology — Radio frequency identification (RFID) for item management — Application protocol: encoding and processing rules for sensors and batteries

Technologies de l'information — Identification par radiofréquence (RFID) pour gestion d'objets — Protocole d'application: règles de codage et de traitement pour capteurs et batteries

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Foreword

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ISO/IEC 24753 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

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Introduction

The technology of radio frequency identification (RFID) is based on non-contact electronic communication across an air interface. The structure of the bits stored in the memory of the RFID tag is invisible and accessible between the RFID tag and the interrogator only by the use of the appropriate air interface protocol, as specified in the corresponding part of ISO/IEC 18000. Since the initial publication of ISO/IEC 18000, it has become possible to add sensors to the RFID tag using various physical methods, but always using the air interface protocol as a consistent means of communicating between the RFID tag and the interrogator.

For sensor information, functional commands from the application and responses from the interrogator are processed in a standard way. This allows equipment to be interoperable and, in the special case of the sensor attached to or integrated within an RFID tag, enables configuration parameters to be encoded in one system's implementation with the resultant sensory information to be read at a later time in a completely different and unknown system's implementation. The data bits stored on each RFID tag and sensor must be formatted in such a way as to be reliably read at the point of use if the sensor is to fulfil its basic objective. The integrity of this is achieved through the use of an application protocol, for example as supported by the functional commands specified in ISO/IEC 15961 and as specified in ISO/IEC 24791.

Manufacturers of radio frequency identification equipment (interrogators, RFID tags, etc.), manufacturers of sensors, and users of RFID technology supporting sensors each require a publicly available application protocol. This International Standard specifies the sensor encoding and processing rules, which are independent of any of the air interface standards defined in the various parts of ISO/IEC 18000. As such, the sensor encoding and processing rules are consistent components in the RFID system that can, independently, evolve to support additional air interface protocols and different types of sensors.

This International Standard specifies the overall process and methodologies developed to format and process sensory information in a standardized manner and provide an interface with the appropriate air interface protocol.

The transfer of sensory information and other related data to and from the application is supported by the use of the object identifiers standard, as defined in this International Standard.

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INTERNATIONAL STANDARD ISO/IEC 24753:2011(E)

Information technology — Radio frequency identification (RFID) for item management — Application protocol: encoding and processing rules for sensors and batteries

1 Scope

This International Standard defines a minimum application protocol to support sensors and the monitoring of batteries in conjunction with RFID tags utilizing the air interface as defined in the ISO/IEC 18000 series.

This application protocol for sensors applies to RFID tags irrespective of their operating frequency. This application protocol is agnostic to how the sensor(s) are connected to or integrated within the RFID tag; however, the communication between the interrogator and the sensor(s) is always through the RFID tag. This will allow the interrogator and application to understand a compliant sensor's characteristics and process its information without prior knowledge of that sensor. This will allow sensors to announce their sense activity and the units of measurement to the interrogator.

This International Standard provides common encoding rules for identifying sensors, their functions, and their delivered measurements. It also defines the process rules to support the following functions:

— selecting and de-selecting a particular sensory function when more than one is supported by the RFID tag;

NOTE The measurement of time or battery life can be considered as separate sensory functions.

— setting sensor parameters both initially and ongoing;

— starting and stopping the monitoring function of a sensor;

— accessing sensor data; and

— carrying out basic processing of sensor data and interpreting this into a format that is meaningful for an application.

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) applies.

ISO/IEC 18000-6, *Information technology — Radio frequency identification for item management — Part 6: Parameters for air interface communications at 860 MHz to 960 MHz*

ISO/IEC 19762-1, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 1: General terms relating to AIDC*

ISO/IEC 19762-3, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 3: Radio frequency identification (RFID)*

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IEEE 1451.7, *Standard for Smart Transducer Interface for Sensors and Actuators — Transducers to Radio Frequency Identification (RFID) Systems Communication Protocols and Transducer Electronic Data Sheet Formats*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762-1, ISO/IEC 19762-3 and the following apply.

3.1.1
calibration
process used to determine the information that resides in the Calibration TEDS to support correction

3.1.2
data-set
collection of samples acquired by a sensor (or applied by an actuator) in response to a trigger command

3.1.3
event sensor
sensor that detects a state change in the physical world

NOTE The fact that a change of state has occurred and/or the instant in time of the change of state, not the state value, is the “measurement”.

3.1.4
Network Capable Application Processor
NCAP
device between the transducer modules and the network for an IEEE 1451 sensor

NOTE The NCAP performs network communications, communications, and data conversion or other processing functions.

3.1.5
Sensor Address Map
SAM
defined memory area of an RFID tag that specifies the logical location of the sensor memory

3.1.6
sensor driver
mechanism to transfer sensor-related data between the implementation of ISO/IEC 24753 and the RFID tag

3.1.7
smart transducer
transducer that provides functions beyond those necessary for generating a correct representation of a sensed or controlled quantity

NOTE This functionality typically simplifies the integration of the transducer into applications in a networked environment.

3.1.8
timestamp
unambiguous representation of some instant in time

3.1.9
transducer
sensor or actuator device that converts energy from one domain into another

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3.1.10
Transducer Electronic Data Sheet
TEDS
electronic data sheet describing a transducer

3.1.11
trigger
signal or command that is used to start an action

3.2 Abbreviations

ASIC	Application-specific Integrated circuit
LSB	Least Significant Bit
MSB	Most Significant Bit
NCAP	Network Capable Application Processor
RTC	Real Time Clock
SAM	Sensor Address Map
SI	international system of units, reference *The International System of Units (SI)*
TEDS	Transducer Electronic Data Sheet
UTC	Co-ordinated Universal Time

4 Conformance

To claim conformance with this International Standard, an implementation shall support one or both of the following:

a) All the processes that are required to support all aspects of full function sensors for configuration and interpretation of sensor data.

b) All the processes that are required to support all aspects of simple sensors for configuration and interpretation of sensor data.

5 Basic Model

5.1 Logical interface model

5.1.1 General

The processes defined in this International Standard are implemented between the application and the air interface protocol. This International Standard performs similar functions for sensory data as ISO/IEC 15962 does for item-related data. The relationship and basic functions of the standards are illustrated in Figure 1 — Basic application interface model.

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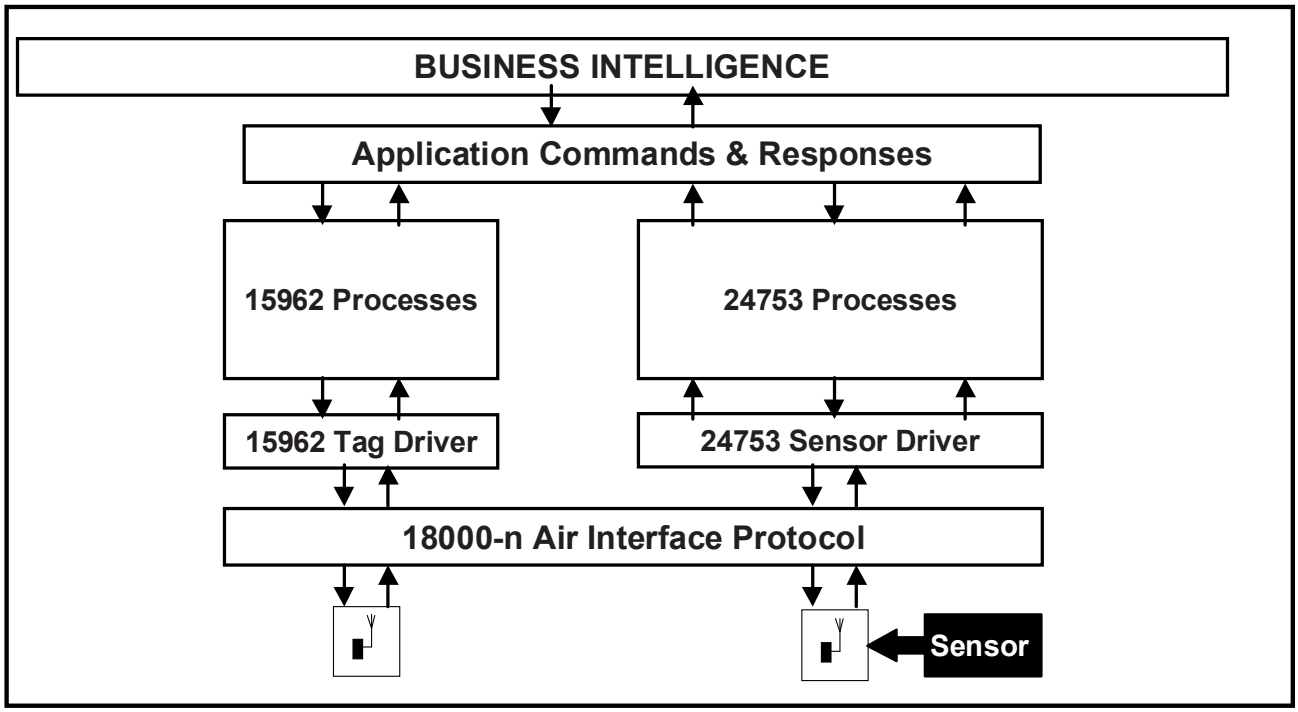

Figure 1 — Basic application interface model

Each of the component parts of the model relevant to sensors and batteries is described below.

5.1.2 Functional application commands

A set of functional application commands are required to enable the application to identify what sensor functions are supported, to access data from sensors, to access the status of the battery power, and to reset values such as alarm values for the sensor activity. The structure of these commands may be derived from the set of object identifiers used, or from future standards as these are developed.

5.1.3 ISO/IEC 24753 processes

This International Standard specifies a set of encoding and processing rules that address the following:

— Reading sensor identifiers

— Reading sensor characteristics and converting this from the bit based encoding on the sensor to a format more appropriate for business processing

— Reading (and encoding when permitted by the sensor) configuration parameters

— Reading event data captured by the sensor and converting this from the bit based encoding on the sensor to a format more appropriate for business processing

— Reading alarm data provided by the sensor

These processes are applied in different manners depending on the whether the sensor is a full function sensor (as specified in IEEE 1451.7) or a simple sensor (as specified in ISO/IEC 18000-6).

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5.1.4 Sensor driver

The sensor driver provides two main functions:

— It provides the rules for identifying how a particular air interface protocol supports sensors. Typically, this would be one of the following: the sensor is integrated within the RFID ASIC or attached through a serial or parallel port, or internal analogue to digital conversion incorporated into the RFID ASIC. A sensor driver may define that an air interface supports one of these types, or if more than one option is possible, it will need to clearly differentiate the type of interface between the sensor and the RFID tag.

— It provides facilities that accept the application commands and converts them to a format that results in calls to command codes supported by the particular RFID tag. In some instances, the air interface protocol might have a specific command such as "read port n" whereas in other cases an air interface command might simply act as a transport mechanism to embed command understood by the sensor.

The description of the sensor drivers for particular RFID tags is provided in Annex A. The sensor driver is unique to the particular air interface type of RFID tag as specified in the appropriate part of ISO/IEC 18000. This is a logical representation, and a physical implementation could combine features of different logical tag drivers. The interrogator may support one or many sensor drivers.

Generally speaking, the sensor driver will be logically independent from the tag driver, as specified in ISO/IEC 15962, but physical implementations could combine the functionality of the tag driver and sensor driver.

5.1.5 ISO/IEC 18000 air interface functions

This International Standard can only be prescriptive on how the air interface functions insofar as the sensor driver needs to represent the capabilities of the air interface protocols. However, some attempts at standardisation can prove useful. Such standardisation can include having reasonably consistent:

— command structures

— response structures

— rules for defining ports or memory mapped locations

The prime requirement for consistency is with respect to the sensor and also between the application and this International Standard. So, any variation on the common approach for a particular air interface should be addressable through the rules of the sensor driver. As air interface protocols are developed to support sensors and batteries, consideration should be given to the manner that previous implementations have been incorporated into ISO/IEC 18000 standards.

5.1.6 The sensor

Full function sensors supported by this International Standard shall be compliant with IEEE 1451.7.

Simple sensors supported by this International Standard shall be as specified in ISO/IEC 18000-6.

In either case, the focus for this International Standard is on the data encoded about the sensor or generated by the sensor during its monitoring process. The functional processes of the sensor or the interface or integration method with the RFID tag component are beyond the scope of this International Standard.

No constraints are placed on what environmental features are monitored because this is a matter for sensor design to meet market requirements, with the exception that the unit of measure shall be basic SI units, derived SI units, or integer values (for example for counts). This open-ended approach enables this International Standard to maintain similar processes for sensor types that have yet to be developed, or to require minimal changes to support an increased variety of sensor capabilities.

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5.2 The sensor information model for full function sensors

5.2.1 General

The sensor information model (Figure 2 — Sensor information model for full function sensors) shows the relationship between component processes and structures described later in this International Standard for full function sensors specified in IEEE 1451.7. A physical sensor is defined as one that monitors a particular environmental feature capable of being expressed in terms of an SI unit or derived SI unit. A given physical sensor may support a number of logical sensors, each of which specifies a method of event data output, e.g. maximum value, observed value below a threshold qualified by a timestamp, count of events observed that are above a threshold.

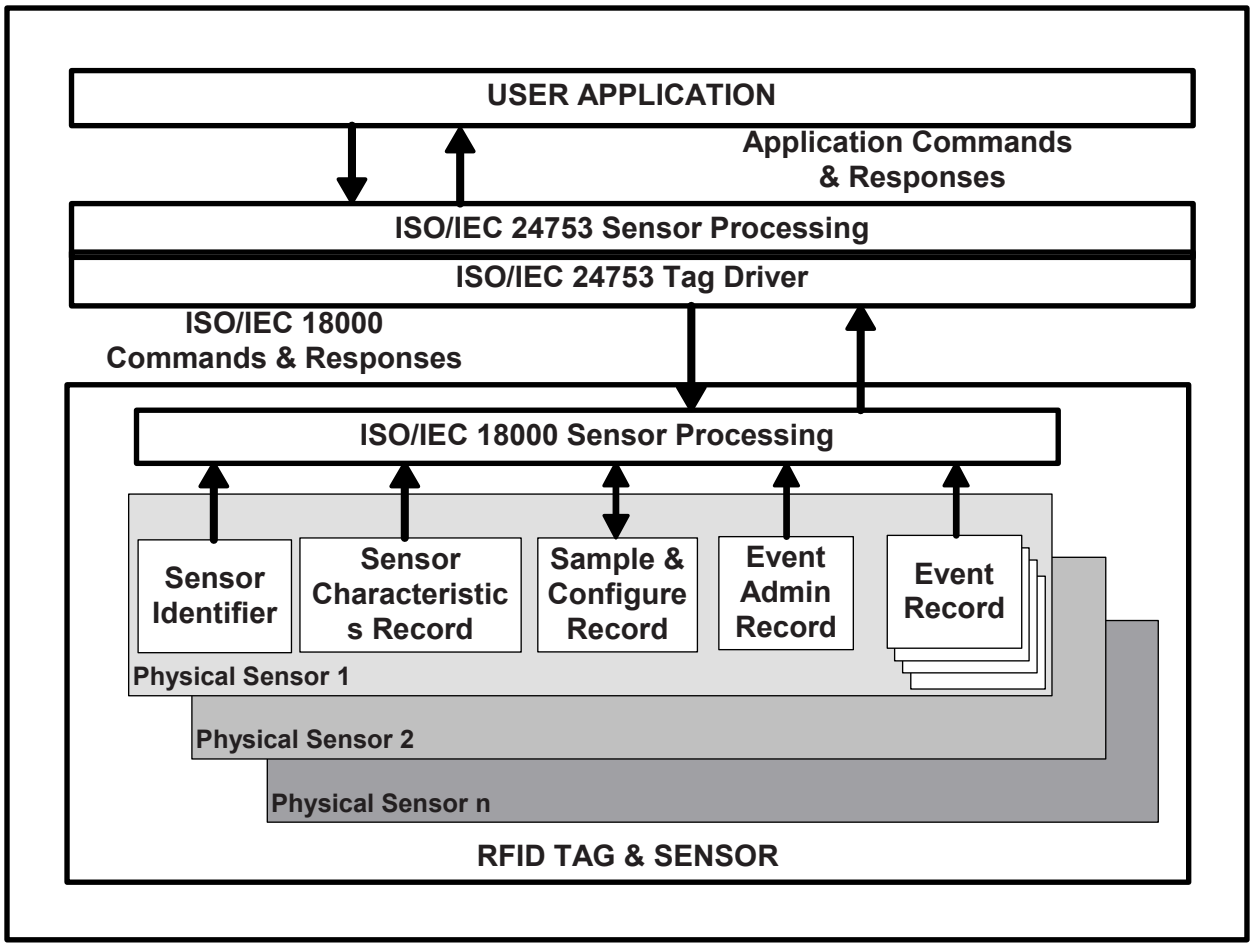

Figure 2 — Sensor information model for full function sensors

5.2.2 Sensor identifier

The sensor identifier enables the sensor manufacturer to uniquely identify a sensor to provide information about the sensor that is additional to that encoded in the sensor characteristic record (e.g. batch number, date of manufacturer, and any other feature that is potentially relevant to the unique sensor. The sensor identifier also provides a mechanism for RFID communications that may be used if more than one sensor can be incorporated on the RFID tag, or if sensor functions can be changed (e.g. through a port connection).

5.2.3 Sensor characteristics

There is a fundamental requirement to be able to identify the sensor characteristics in a consistent manner on the RFID tag, through the processes of this International Standard, and in turn from IEEE 1451.7 for full

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function sensors so that the application receives meaningful information. This requirement has to apply irrespective of air interface protocol and RFID tag architecture, how the sensory function is incorporated with the RFID tag, and even irrespective of the capabilities of the sensors. This does not mean that all encoding and processes have to be achieved in exactly the same manner, just that there shall be no ambiguity with the processing of sensor characteristics.

This International Standard converts the code structures specified in IEEE 1451.7 for the type of sensor, additional attribute features such as whether the sensor is recording a minimum value, a maximum value or an average value. In addition, all of the characteristics of the sensor are defined in a manner that enables their information to be processed unambiguously, so that the outputs from a temperature sensor cannot be confused with the outputs of a strain sensor.

5.2.4 Sampling and configuration

The capability of sensors will differ considerably from the simplest that only outputs a single item of data, through to more complicated devices where threshold values can be set to trigger monitoring of event data, or the delivery of an alarm. To enable sensors with different data capture and processing capabilities to be supported, similar configuration rules are applied in IEEE 1451.7, but where specific parameters are not relevant, they can be encoded in a manner that the sensor can ignore.

In its turn, this International Standard has process rules that enable the configuration parameters to be converted to an application level interpretation, or for the inverse procedure to be used to set configuration parameters on the sensor.

To ensure that the sampling and configuration values remain set by an authorised user, the air interface protocols may impose additional security features so that only those with permission to change the configuration in the sampling may do so.

5.2.5 Event administration record

The event records can vary from a simple single record to multiple records. In addition for the multiple records, the sensor can provide the option of rollover where the earliest records get overwritten when the memory becomes full. To manage all this, the sensor holds an event administration record that contains information about the size of memory and the number of sensor words that can be stored on the memory. It also contains information that enables the reconstruction of the observation history.

5.2.6 Event record

The event records encode the digital output from the sensor in a binary format specified in IEEE 1451.7. Each physical sensor (e.g. temperature ºC, relative humidity %) supports one or more logical sensors that provide the application with a particular form of event record (e.g. current value, maximum value, data log of observations above a threshold, count of observations below a threshold). The flexibility of the logical memory structure enables more rapid access to some data with a more detailed subsequent RFID transaction for detailed data.

5.3 The sensor information model for simple sensors

5.3.1 General

A simple sensor provides limited functional support to determine whether the temperature or other environmental conditions have gone outside some allowable limits. These sensors are defined as factory programmed, which restricts parameter setting from a fully open systems application, but allows data to be captured using open system air interface commands and processes.

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5.3.2 Simple sensor data block

The prime operating mode of a simple sensor is to provide the simple sensor data block using some delivery mechanism defined by the air protocol interface. The simple sensor data block is a short bit-based code that provides sensor characteristics, configuration and alarm data.

5.3.3 Other simple sensor memory

Implementation of the simple sensor may use additional memory as defined in 8.3, which specifies the structure of different record blocks. Access to this additional memory is through commands as defined in ISO/IEC 18000-6.

6 Real time clock (RTC)

6.1 General requirements

The RFID tag shall have an RTC and it shall be used as the source of UTC timestamps for sensor related data. Timestamps shall be based on the UTC time epoch beginning at 1970-01-01 00:00:00. At configuration of a sensor, the RTC shall be set to the current 32-bit UTC time precise to 1 second.

6.2 Presentation of time to the application

All time stamps shall be presented to the application in the UTC format of:

year-month-day hour:minute:second

More precisely the format defined by RFC 3339 is presented as yyyy-mm-ddThh:mm:ssZ.

6.3 Encoding of the time stamp

All time stamps shall be stored on the RFID tag as a 32-bit value precise to 1 second.

NOTE This time stamp can be achieved by taking the most significant 32-bit from the IEEE 1588 synchronised time stamp.

The number of 32 bit time stamps that are required to be stored on the RFID tag are kept to a minimum by using the ordinal number of the sample to reduce the use of memory and air interface transmission.

6.4 Converting between the two time presentations

During the decode process, the 32-bit timestamp needs to be converted into the UTC format to provide better human understanding for interpreting an observation at particular points in time. As a number of computer program languages have mechanisms to carry out such a conversion, specifying a detailed algorithm is beyond the scope of this International Standard. However, there are two points of guidance that are provided to assist with implementing this conversion:

— Different program languages use different epochs, and it essential that the epoch for this International Standard begins on 1st January 1970. If the program language uses a different epoch, then an offset value will need to be used to correct the output UTC date and time.

— Although not critical to overall precision, different conversion processes either take into account the leap second or ignore the leap second. Annex B.1 provides information about leap seconds, and sources of information for these.

Annex B.2 also includes references to internet-based conversion calculators that can be used to benchmark any program output, but obviously cannot be incorporated within the process of this International Standard.

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For encoding, there are two options available. The first is to apply an inverse algorithm to take the UTC date and time and convert it to a 32-bit value. The second is to access this 32-bit value directly from a network service. Some services compliant with IEEE 1588 can deliver a 64-bit time stamp, where the MSB 32 bits identify time to a second. Services compliant with the Internet Simple Network Time Protocol, as defined in IETF RFC 1769, might also be able to provide the time as a 32-bit value that can be directly used. If encoders are part of a network that has access to the Internet, then time stamps (for example for configuration) can be delivered via the network rather than through the command structure. The choice of providing a program conversion so that UTC is addressed through the application commands, or using a network time based on the correct epoch, is a matter of implementation.

6.5 Setting the RTC

6.5.1 General

The current 32-bit UTC timestamp shall be transmitted across the air interface between the interrogator and the RFID tag to set the RTC during sensor configuration and at other times to maintain time synchronisation.

The 32-bit UTC timestamp may be taken from the interrogator if it supports UTC time as specified in this clause. Timestamps that are not in seconds and of a 32-bit format are not suitable. Timestamps that are based on local time are not acceptable and shall not be used.

If the interrogator is not capable of providing a timestamp in the specified format, then this should be provided using some accurate network-based UTC time.

The RFID tag shall implement a method to determine the memory address of the RTC.

6.5.2 Write-RTC command

This command is intended to be used to set the RTC by writing the current UTC time into the RTC within the RFID tag memory. If the air interface protocol supports it, this command may be encapsulated in an air interface broadcast command, which simply sends out a UTC timestamp to all RFID tags having an RTC within the reading zone. As the RTC has to be integrated with the tag compliant with a particular air interface, it should be possible to implement the RTC such that a response is not necessary to a broadcast command.

Write operations to the RTC may be restricted by the use of memory locking, permalocking, password authorisation, or other means implemented by the RFID tag. It shall not be permitted to write a UTC time of zero into the RTC nor set the RTC when an alarm condition is present other than the low battery alarm.

6.5.3 Read-RTC command

This command is intended to be used to read the current time of the RTC within the RFID tag memory. The current time may be obtained by directly reading from the RTC address. Read operations to the current time may be restricted by the use of memory locking, permalocking, password authorisation, or other means implemented by the RFID tag.

6.6 Time synchronisation

6.6.1 General

The RTC mechanism on an RFID tag might not be able to maintain an accurate record of time. This is partly a factor of the cost of providing additional accuracy and the impact on temperature variation to which the RTC is exposed. If the RFID tag implements sensor event records, then it shall also implement a time synchronisation record block to enable the application to reconstruct a more accurate time line.

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The time synchronisation record block enables a UTC timestamp to be recorded against the most recent sample count value. Each recorded time synchronisation record shall comprise, in sequence:

— The prevailing time as recorded by the RFID tag. This may be a 32-bit RTC value maintained since the time of configuration, or the 16-bit sample count value. The 32-bit structure is recommended where time accuracy is important or where there is a large sample interval.

— The 32-bit UTC timestamp.

The number of time synchronisation records contained within the time synchronisation record block shall be vendor defined and consistent with the vendor defined timestamp accuracy at the application level. The timestamp accuracy at the application level shall be achieved provided that a sufficient time synchronisation update rate is maintained. The time synchronisation update rate should define a maximum time interval between updates necessary to maintain timestamp accuracy as well as a minimum time interval between updates necessary to generate a time synchronisation record. When the allocated memory for the time synchronisation block becomes full no further records are possible, but no error shall be indicated.

6.6.2 Reconciling UTC with the 32-bit RTC time

As both the RTC and UTC timestamps have the same common datum, the UTC timestamp at configuration, it is possible to determine the extent of the difference in time at each point when time synchronisation took place. The extent of any difference might vary over the sample period and because of different causes, the RTC could be 'fast' or 'slow' without any pattern. Any time correction can only be applied more accurately close to the time of synchronisation, and be less certain at a point midway between two time synchronisation events.

6.6.3 Reconciling UTC with the 16-bit sample count

In this simpler approach, the best level of synchronisation that can be achieved is to write the UTC timestamp against the most recent sample count value. This means that time synchronisation is also a factor of the size of the sample interval. The larger the sample interval, the more likely that the UTC timestamp will represent a time that is between the most recently recorded sample count value and the projected next (future) sample count value. This provides a simple indication:

— that the RTC and UTC are within the same time period as determined by the sample interval, or

— if the UTC indicates an earlier time than the sample count, then the RTC is 'fast', or

— if the UTC indicates a later time than sample count + 1, then the RTC is 'slow'.

It is only when the synchronisation is at these outer limits that any inaccuracy can be corrected.

7 Full function sensors

7.1 General

Full function sensors shall be compliant with IEEE 1451.7 Type 1. They contain five records:

1) Sensor identifier
2) Sensor characteristics record (Type 1)
3) Sampling and configuration record
4) Event administration record
5) Event records

The numbers in the list are used as record references for full function sensors in this International Standard. Each record is described in the following sub-clauses.

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7.2 Sensor identifier

Each IEEE 1451.7 sensor is identified with a unique 64-bit identifier. This value is encoded and locked by the sensor manufacturer. It has two potential functions with respect to this International Standard:

— The unique sensor identifier may be used by an air interface protocol sensor driver as a means of precisely identifying a particular physical sensor.

— With supportive middleware access to the Internet, it can provide additional information about the sensor that is not possible to convey with the sensor characteristics record. For example, a unique sensor identifier may convey information about batch number, manufacturing data and further details for interpreting the data uncertainty and remaining battery life. A procedure to resolve these details is currently beyond the scope of this International Standard.

7.3 Sensor characteristics record (Type 1)

The sensor characteristics record, or more properly called the Transducer Electronic Data Sheet (TEDS) in IEEE 1451, defines all the capabilities of the sensor and this record is permanently encoded on the sensor by the sensor manufacturer. This International Standard only supports IEEE 1451.7 Type 1 sensors; it might need to be amended if a new Type is introduced.

This record is 128 bits long, and provides all the basic characteristics necessary to define the sensor functionality. The first 111 bits of the Type 1 sensor characteristics record are defined in the first edition of IEEE 1451.7. As any of the reserved 17 bits are assigned a function, this International Standard might need to be amended. The sensor characteristics record comprises 22 fields, which are identified by their ordinal number in this International Standard:

1 TEDS type
2 Sensor Type
3 Units extension
4 Sensor map
5 Data resolution
6 Scale Factor Significand
7 Scale Factor Exponent
8 Scale Offset Significand
9 Scale Offset Exponent
10 Data uncertainty
11 Sensor Reconfiguration Capability
12 Memory Rollover Capability
13 Air Interface Security Capability Code
14 Sensor Security Capability Code
15 Sensor Authentication Encryption Capability Map
16 Sensor Data Encryption Capability Map
17 Sensor Authentication Password/Key Size
18 Sensor Data Encryption Key Size
19 Random Number Sizes Supported
20 Continuing Authentication Capability Field
21 Data Encryption Capability Field
22 Clock Accuracy
23 RFU

Procedures to encode and decode the sample and configuration record are specified in 10.3.

7.4 Sampling and configuration record

The IEEE 1451.7 sampling and configuration record is a re-writable record encoded on the sensor. Permission to make changes may be restricted by invoking passwords and other features supported by the air interface protocol standards and the application commands.

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The sampling and configuration record comprises of the following 13 fields, which are identified by their ordinal number:

1 UTC timestamp at configuration, or upon successfully beginning a mission.
2 Sample interval
3 Monitor delay
4 Alarm values set
5 Memory rollover enabled
6 Air Interface Security Function Code
7 Sensor Security Function Code
8 Sensor Authentication Encryption Function Code
9 Sensor Data Encryption Function Code
10 Security Timer Duration
11 Begin-End-Mission Authority
12 Upper alarm threshold
13 Lower alarm threshold

This record is of various pre-determined lengths depending on whether none, one, or both alarm levels are set.

Procedures to encode and decode the sample and configuration record are specified in 10.4.

7.5 Event administration record

The event administration record is a read-only record that identifies, for those multiple sample measurement types, the capacity of those event records and other associated parameters.

The event administration record comprises of the following 12 fields, which are identified by their ordinal number:

1 Code 10 Sample capacity
2 Code 11 Sample capacity
3 Code 12 Sample capacity
4 Code 13 Sample capacity
5 Sample count
6 Alarm triggered
7 Sample count at predetermined time
8 Sample count at critical event
9 Sample count of events outside either threshold
10 Sample count at the first threshold event
11 Password/key(s) Read-Lock and Write-Lock status flags
12 Mission in Progress

Procedures to encode and decode the event administration record are specified in 10.5.

7.6 Event records

The event records supported by a particular physical sensor are declared by bit values on the logical sensor map field of the sensor characteristics record. If a bit position is 1_2, then that measurement code is supported and used as the basis for the event record. Any measurement type is addressable by using a 4-bit code as defined in 7.3.

Procedures to encode and decode the event record are specified in 10.6.

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8 Simple sensors

8.1 General

This clause specifies the basic functionality, record structures, sensor commands, and processes for simple sensors. Because of their intended functionality, their integrated design with the RFID ASIC and their sensitivity to power consumption, form-factor and cost, only a limited number of simple sensor types are specified. The basic output is a simple sensor data block, where a 32-bit string (or possibly longer) declares information about a simple sensor and reports basic sensor observations using a minimum number of data bits. Simple sensors include:

— Temperature sensor having a high and/or a low out-of-range temperature alarm.

— Relative Humidity sensor having a high and/or a low out-of-range relative humidity alarm.

— Impact sensor with an instance of_out-of-range impact alarm.

— Tilt sensor with an instance of_out-of-range tilt

Although called "simple sensors", the devices are required to support features common to any type of sensor device. The simple sensor has to monitor the environmental characteristic for which it is designed, take samples at defined intervals, compare and process against criteria, and report output in terms of the simple sensor data and additionally in a more detailed diagnostic structure. The following sub-clauses specify all the requirements.

8.2 Implementations

Simple sensors shall be implemented either as a memory mapped simple sensor (see 8.4) or as a ported simple sensor (see 8.5).

8.3 Record structures

Each simple sensor shall support a simple sensor data block. Details of the data blocks for the simple sensor types so far defined are in an annex in ISO/IEC 18000-6. Each of the simple sensors only requires a 32-bit structure, but future simple sensors might require a slightly larger data block size. As additional simple sensors are specified they will be added by amendment to this International Standard.

The ported simple sensor supports additional mandatory and optional records, as detailed in the list. An annex of ISO/IEC 18000-6 defines the requirements for processing these records if present on the ported simple sensor.

The sequence of records is as follows:

— Record 1: Simple sensor data block (mandatory for both implementations), with the following fields:

1 Sensor type
2 Measurement span
3 Accuracy
4 Sampling regime
5 High on-range limit
6 Low in-range limit
7 Monitor delay
8 High out-of-range alarm delay
9 Low out-of-range alarm delay
10 Alarms

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— Record 2: Manufacturer record (mandatory only for the ported simple sensor), with the following fields:

1 Data transmission size (bits)
2 Password indicator and size
3 Calibration record indicator
4 Transfer packet size (in bytes)
5 Diagnostic memory capacity (in terms of transfer packets)
6 Configuration history indicator
7 Time synchronisation type
8 Number of time synchronisation records

— Record 3: Authorisation password record (optional for the ported simple sensor)

— Record 4: Calibration record (recommended for the ported simple sensor), which holds three values for temperature, 17 values for humidity, and none for impact and tilt

— Record 5: Sample and configuration record (mandatory only for the ported simple sensor), with the following fields:

1 UTC timestamp at point of manufacture
2 Number of configuration records
3 UTC timestamp at configuration and activation
4 Sampling regime
5 High in-range limit
6 Low in-range limit
7 Monitor delay
8 High out-of-range limit alarm delay
9 Low out-of-range limit alarm delay

The simple sensor may have the facility to store a sequence of Fields 3 to 9. This is declared the configuration history indicator (Field 6 of the Manufacturer record).

— Record 6: Event record (recommended for the ported simple sensor), with the following fields:

1 Current sample count
2 Packet count
3 Sample count at observation
4 Observed sample data

Fields 3 and 4 may be repeated a number of times equivalent to the packet count.

— Record 7: Time synchronisation record (mandatory only for the ported simple sensor and only if the event record is present), with the following fields:

1 RTC time or sample count value
2 UTC timestamp

These fields are may be repeated a number of times

The sequence of the set of records numbered 2 to 7 and the size of each memory is specified in logical terms leaving the physical structure a matter of implementation.

The numbers in the list are used as record references for simple sensors in this International Standard. Each record is described in the following sub-clauses.

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8.4 Memory mapped simple sensor

8.4.1 Air interface access method

A memory mapped simple sensor is accessed via memory read and write operations to the RFID tag.

8.4.2 Simple sensor data block address

The RFID tag shall implement a method to determine the memory address of the simple sensor data block. Details of the data blocks for the simple sensor types so far defined are in an annex of ISO/IEC 18000-6. Each of these only requires a 32-bit structure, but future simple sensors might require a slightly larger data block size. As additional simple sensors are specified they will be added by amendment to this International Standard.

8.4.2.1 Write-Simple-Sensor-Data-Block Command

This command is intended to be used to configure the simple sensor by writing the entire simple sensor data block into the RFID tag memory. The processes defined in this International Standard ensure that various bit fields are logically structured in accordance with the capabilities of the sensor, as defined by the structure of the simple sensor data block.

The command is used in two distinctly different manners:

— Sensor manufacturers and RFID tag manufacturers may use it to set the first three fields of the record (sensor type, measurement span, and accuracy). These fields should be locked to ensure that the manufacturer settings are not changed. The remaining fields should be zero filled for subsequent configuration by the user or for the alarm states to be set by the sensor. The RFID tag shall not permit setting alarm conditions when processing this command.

— The command is used by users for operational control of the configuration parameters (fields 4 to 9). Access may be restricted by the need for password authorisation. The command shall have the following structure, applied to memory mapped and ported simple sensors to ensure a compliant structure in the air interface commands:

  i) 9 bits zero filled. This covers the three fields encoded by the manufacturer, and the sensor ignores this bit string because the fields are already locked.

  ii) 19 bits for the configuration parameters.

  iii) 4 bits zero filled. This covers the alarm bits, and the sensor ignores this bit string because the fields are reserved to be set automatically by the sensor.

Write operations to the simple sensor data block may be restricted by the use of memory locking, permalocking, password authorisation, or other means implemented by the RFID tag. The RFID tag may be implemented such that some parameter fields (e.g. sensor type, span, accuracy) are not writeable by an interrogator and these bits shall be ignored by the RFID tag when processing this command. The RFID tag shall not permit setting alarm conditions when processing this command.

8.4.2.2 Read-Simple-Sensor-Data-Block Command

This command is intended to be used to obtain the status of a memory mapped simple sensor by reading the simple sensor data block within the RFID tag memory. The simple sensor data block may be obtained by directly reading from the simple sensor data block address. Read operations to the simple sensor data block may be restricted by the use of memory locking, permalocking, password authorisation, or other means implemented by the RFID tag. Other mechanisms specified by an air interface protocol may exist that capture the simple sensor data block such as having a procedure that appends the simple sensor data block to the unique item identifier.

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8.4.3 Memory mapped simple sensor operation

Configuring the memory mapped simple sensor shall reset all the alarms within the simple sensor data block, stop the RTC, and initialise the RTC to zero. The memory mapped simple sensor is disarmed when the RTC has a zero value. Writing the current time to the RTC shall then start the RTC running and arm the memory mapped simple sensor. Once armed, the sensor shall be monitored as configured and check for the event conditions required to declare an alarm condition. If an alarm condition other than low battery is declared, then the RTC shall be stopped and its current time retained as a timestamp for when the event occurred.

8.5 Ported simple sensor

8.5.1 Air interface access method

A ported simple sensor is accessed via dedicated sensor commands to the RFID tag.

8.5.2 Record structures

Various records are defined for inclusion on a mandatory or optional basis to support the processing, encoding and subsequent diagnostics of a simple sensor. These are as defined in 8.3.

8.5.3 "Payload" commands

Various simple sensor commands for ported simple sensors are specified in an annex of ISO/IEC 18000-6. These commands (as listed in Table 1 — Payload commands for ported simple sensors) are embedded in the ISO/IEC 18000-6 Type C *HandleSensor* command.

Table 1 — Payload commands for ported simple sensors

Code	Description
00001	Read-Simple-Sensor-Data-Block
00010	Read-Manufacturer-Record
00011	Write-Password
00100	Read-Calibration-Record
00101	Write-Sample-And-Configuration-Record
00110	Initialise-Sensor-Monitoring
00111	Read-Sample-And-Configuration-Record
01000	Read-Event-Record
01001	Write-UTC-Timestamp
01010	Read-Time-Synchronisation-Record
01011	Erase-Monitored-Data
01100	Activate-Simple-Sensor
01101	Deactivate-Simple-Sensor
01110 to 11111	RFU

The construction of the "payload" of these sensor commands and the deconstruction of their responses are specified in 9.3 and Clause 11 of this International Standard.

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9 Processing functional application commands and responses

9.1 General

Application interface command may specify a set of functional commands and their associated responses used to configure sensors, initiate processes, and read sampling data from the sensors. The sensor commands can be applied in parallel to the data commands as specified in ISO/IEC 15961-1. This will allow interoperability between item-related data and sensor-related data.

Unlike the data-related commands, all the sensor commands can be more explicitly specified because ISO/IEC 18000-6 (for simple sensors) and IEEE 1451.7 (for full function sensors) prescribe the data content in the sensor memory. Because of this, each data element on a sensor has been assigned an object identifier to align with the command arguments.

The following root-OIDs apply:

1.0.24753.0.r.f	Simple sensors, where the {arc = r} refers to a record number, and {arc = f} refers to a field number
1.0.24753.0.126	Simple sensor command, where the next arc = command number (1..13), and others are reserved
1.0.24753.0.127	Simple sensor response, where the next arc = response number (1..13), and others are reserved
1.0.24753.7.r.f	IEEE 1451.7 full function sensors, the {arc = r} refers to a record number, and {arc = f} refers to a field number
1.0.24753.7.126	IEEE 1451.7 command, where the next arc = command number (1..21), and others are reserved
1.0.24753.7.127	IEEE 1451.7 response, where the next arc = response number (1..21), and others are reserved

NOTE: In ISO/IEC 15961-1, the object identifiers are, by necessity, defined by the application. Another difference is that the sensor commands do not have qualifying arguments that determine the sequence, compaction scheme, or whether the data is locked. Everything is prescribed by the relevant sensor record structure.

Using the object identifier structure also enables greater integration with this standard and ISO/IEC 24791-5 (for device interfaces) and 24791-2 (for data management).

This International Standard uses two slightly different approaches to the use of object identifiers. For simple sensors the data elements identified as arguments in the commands and responses are assigned object identifiers based on the root-OID of the command or response. This is because of the optional nature of some of the associated records and their fields. For full function sensors, the records and their inherent fields are mandatory. This enables each field to be assigned a unique object identifier. Object identifiers based on a root-OID for IEEE 1451.7 commands and responses are only applied where a field name is not applied (for example for a response code).

9.2 Processing full function sensors functional application commands and responses

9.2.1 General

The command and response names used in the following sub-clauses align with the same names as used in IEEE 1451.7. The 5-bit code that identifies the command and response is converted to and from the object identifier.

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Many of the commands and responses contain fields for security functions that are not supported by ISO/IEC 18000-6, which is the only 18000 series air interface protocol standard that supports sensors. As theses fields are required for the payload sensor command detailed advice is provided in the sub-clauses below of how to address the issue.

In addition many of the IEEE 1451.7 commands have two additional arguments *Reader-Security-Token* and *New-Reader-RN* that are present at the end of the command. It is not possible to support these arguments by processes in this International Standard because they are outside the scope of being defined by the application. Most of the IEEE 1451.7 responses have the arguments *Sensor-Security-Token* and *New-Sensor-RN*. These arguments are created in the IEEE 1451.7 commands by the sensor driver, with the default value 0_2. Where these arguments are also in the IEEE 1451.7 responses, the sensor driver shall remove them prior to transferring to the processes defined in this International Standard.

9.2.2 Common command-based object Identifiers

The following command-based object identifiers apply to all commands except: Read-Sensor-Identifier (see 9.2.4).

Sensor-Address-Type [OID ref: 1 0 24753 7 126 {command code} 1]
Sensor interface:
00 = no sub-addressing
01 = use 7-bit sub-addressing
10 = use sensor type sub-addressing
11 = use sensor ID sub-addressing

App-interface: INTEGER (0..3)

Sensor-Comms-Id [OID ref: 1 0 24753 7 126 {command code} 2]
Sensor interface and App-interface: BIT STRING (0, or 7, or 15, or 64)
If Sensor-Address-Type = 00 then this field is empty
01 then this field is the 7-bit sensor sub-address
10 then this field is the 15-bit concatenation of: TEDS-Type, Sensor-Type, and Units-Extension
11 then this field is the 64-bit Sensor-Id

9.2.3 Common response-based object identifiers

The following response-based object identifiers apply to all responses.

Response-Code [OID ref: 1 0 24753 7 127 {response code} 1]
Sensor interface: 3-bit code, as defined in the IEEE 1451.7 Read-Sensor-Identifier response in the current versions of IEEE 1451.7. Only code 111 provides a full response

App-interface: INTEGER (0..7), where the following codes result in a truncated response caused by some sensor error:
0, 1, 3, 4, and 5 - truncated at this point
2 - truncated after the next field

Battery-Status-Code [OID ref: 1 0 24753 7 127 {response code} 2]:
Sensor interface and App-interface:
0 = Battery OK
1 = Battery low

9.2.4 Read-Sensor-Identifier

This command is used to return the different identifiers used for subsequent communication with the sensor if this is not achieved by using a port number on the RFID tag itself.

Sensor interface for command and response: 5-bit code = 00001

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