INTERNATIONAL STANDARD

ISO/IEC 18000-4

Second edition
2008-09-01

Information technology — Radio frequency identification for item management —

Part 4: Parameters for air interface communications at 2,45 GHz

Technologies de l'information — Identification par radiofréquence (RFID) pour la gestion d'objets —

Partie 4: Paramètres de communications d'une interface d'air à 2,45 GHz

Reference number
ISO/IEC 18000-4:2008(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

ISO/IEC 18000-4 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology* Subcommittee SC 31, *Automatic identification and data capture techniques*.

This second edition cancels and replaces the first edition (ISO/IEC 18000-4:2004), which has been technically revised.

ISO/IEC 18000 consists of the following parts, under the general title *Information technology — Radio frequency identification for item management*:

— *Part 1: Reference architecture and definition of parameters to be standardized*

— *Part 2: Parameters for air interface communications below 135 kHz*

— *Part 3: Parameters for air interface communications at 13,56 MHz*

— *Part 4: Parameters for air interface communications at 2,45 GHz*

— *Part 6: Parameters for air interface communications at 860 MHz to 960 MHz*

— *Part 7: Parameters for active air interface communications at 433 MHz*

Introduction

This part of ISO/IEC 18000 is one of a series of International Standards and Technical Reports developed by ISO/IEC JTC 1/SC 31, WG 4 for the identification of items (Item Management) using radio frequency identification (RFID) technology.

This part of ISO/IEC 18000 defines the 2,45 GHz protocols that support ISO/IEC 18000-1. Each of the specific physical/data link configurations is defined in a separate sub-clause. The configuration descriptions include a Physical Layer and a Data Link Layer.

The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning radio-frequency identification technology given in all parts of the document and especially in 5.2 and 5.3.

ISO and IEC take no position concerning the evidence, validity and scope of these patent rights.

The holders of these patent rights have assured the ISO and IEC that they are willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statements of the holders of these patent rights are registered with ISO and IEC. Information may be obtained from the following companies.

Contact details	Patent number
Intermec IP Corporation Legal Department Phyllis T.Turner-Brim, Esq. 6001 36th Ave. W Everett, Washington 98203, USA Tel.: +1(425)625-2480 Fax: +1(425)501-6587 Email: phyllis.turnerbrim@intermec.com	US 5,030,807 US 5,521,601 US 5,550,547 US 5,673,037 US 5,777,561 US 5,828,318 US 5,828,693 US 5,850,181 US 5,942,987 US 5,995,019
NXP B.V. Intellectual Property & Licensing Mr. Harald Röggla Gutheil-Schoder-Gasse 8-12 A-1102 Vienna Austria Tel.: +43(1)60870-1469 Fax: +43(1)60870-1101 Email: harald.roeggla@nxp.com	CN02811230 JP 03-502778; US6,961,829B EP02735725.0
Siemens Aktiengesellschaft, CT IP L&T Hans Joerg Mueller Otto-Hahn-Ring 6 D-81739 Munich Germany Tel: +49(89)636 82628 Fax: +49(89)636 81855 Email: hans-joerg.mueller@siemens.com	US 7289458 EP 1415263 DE 10137247 US 6944240 DE 19962458 EP 1240720

Contact details	Patent number
Zebra Technologies Corporation, Legal Department, Mr. Eric McAlpine, IP Counsel, 333 Corporate Woods Parkway, Vernon Hills, Illinois 60061-3109, USA Tel: +1(847)793-5640 Fax: +1(847)955-4514 Email: emcalpine@zebra.com	US 5519381 US 5726630 EP 0598624 EP 0789254 EP 0789253 EP 01117486.9 US 5680459 US 6198381 JP 10-272945

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

Information technology — Radio frequency identification for item management —

Part 4:
Parameters for air interface communications at 2,45 GHz

1 Scope

This part of ISO/IEC 18000 defines the air interface for radio frequency identification (RFID) devices operating in the 2,45 GHz Industrial, Scientific, and Medical (ISM) band used in item management applications. This part of ISO/IEC 18000 provides a common technical specification for RFID devices that can be used by ISO committees developing RFID application standards. This part of ISO/IEC 18000 is intended to allow for compatibility and to encourage inter-operability of products for the growing RFID market in the international marketplace. This part of ISO/IEC 18000 defines the forward and return link parameters for technical attributes including, but not limited to, operating frequency, operating channel accuracy, occupied channel bandwidth, maximum equivalent isotropically radiated power (EIRP), spurious emissions, modulation, duty cycle, data coding, bit rate, bit rate accuracy, bit transmission order, and where appropriate operating channels, frequency hop rate, hop sequence, spreading sequence, and chip rate. This part of ISO/IEC 18000 further defines the communications protocol used in the air interface.

This part of ISO/IEC 18000 contains two modes. The first is a passive tag operating as an interrogator talks first and the second is a battery-assisted tag operating as a tag talks first. The detailed technical differences between the modes are shown in the parameter tables.

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 7816-6, *Identification cards — Integrated circuit cards — Part 6: Interindustry data elements for interchange*

ISO/IEC 15963, *Information technology — Radio frequency identification for item management — Unique identification for RF tags*

ISO/IEC 18000-1, *Information technology — Radio frequency identification for item management — Part 1: Reference architecture and definition of parameters to be standardized*

ISO/IEC TR 18047-4, *Information technology — Radio frequency identification device conformance test methods — Part 4: Test methods for air interface communications at 2,45 GHz*

ISO/IEC 19762 (all parts), *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762 (all parts) apply.

4 Symbols and abbreviated terms

Cht	Carrier high level tolerance
Clt	Carrier low level tolerance
$f_{bitrate}$	base frequency of the bit rate of Manchester code without bit changes
f_c	frequency of operating field (carrier frequency)
FHSS	Frequency Hopping Spread Spectrum
M	Modulation
Ma	Modulation overshoot
Mb	Modulation undershoot
Mlt	Modulation lower tolerance
Mut	Modulation upper tolerance
Tbmf	Manchester fall time
Tbmr	Manchester rise time
Tcf	carrier fall time
Tcr	carrier rise time
Tcs	carrier steady time
Tf	fall time
Tfhf	carrier FHSS fall time
Tfhr	carrier FHSS rise time
Tfhs	carrier FHSS steady time
Tflb	forward link bit time
Tr	rise time
Trlb	return link bit time

5 2,45 GHz RFID protocols that support this part of ISO/IEC 18000

5.1 General

5.1.1 Protocols

Clause 5 defines the ISO/IEC 18000-4 2,45 GHz RFID command/data level communication protocols. These protocols facilitate communication between compliant tag and compliant interrogator. The timing parameters and signal characteristics for the protocols are defined in the physical link specifications in each mode.

5.1.2 Frequency

This part of ISO/IEC 18000 is intended to address RFID devices operating in the 2 450 MHz Industrial, Scientific and Medical (ISM) frequency band.

5.1.2.1 Interface definitions

This part of ISO/IEC 18000 supports standard parameters as described in ISO/IEC 18000-1 and standard air interface implementations for wireless, non-contact information system equipment for Item Management applications. Typical applications operate at ranges greater than one meter.

5.1.2.1.1 RFID system definition

The radio-frequency identification (RFID) system shall include a host system and RFID equipment (interrogator and tags). The host system runs an application program, which controls interfaces with the RFID. The RFID equipment shall be composed of two principal components: tags and interrogators. The tag is intended for attachment to an item, which a user wishes to manage. It is capable of storing a tag ID number and other data regarding the tag or item and of communicating this information to the interrogator. The interrogator is a device, which communicates to tags in its field of view. Additionally, the interrogator can use its transmitted RF carrier to power the tag. Systems, which rely on the transmitted interrogator carrier for powering the tag, are typically referred to as passive tag systems. The interrogator controls the protocol, reads information from the tag, directs the tag to store data in some cases, and ensures message delivery and validity.

5.1.2.1.2 Minimum features

RFID systems defined by this part of ISO/IEC 18000 provide the following minimum features:

- identify tag in range,
- read data,
- write data or handle read only systems gracefully,
- selection by group or address,
- graceful handling of multiple tags in the field of view,
- error detection.

5.1.2.1.3 Conformance

To claim conformance with this part of ISO/IEC 18000, an RFID system shall comply with one of the physical/data link implementations described in 5.2 and 5.3.

The rules for RFID device conformity evaluation are given in ISO/IEC TR 18047-4.

5.1.3 Tag identification number

A tag identification number shall be included in commands directed to a specific tag unless the protocol provides other means like TTF (Tag Talks First) protocols. This part of ISO/IEC 18000 mandates that each tag shall include a manufacturer's tag identification number as defined in Annex A for mode 1 and in Annex C for mode 2.

A separate User Tag Identification is not mandatory, but is an option. When a UserTagID is used, it shall consist of the number of bytes required by the user application. This number and other application data shall be accessed as user data fields on the tag. These fields can be accessed via the API using the driver's field name resolution mechanism. The UserTagID is a user-defined tag identifier and is not necessarily unique.

5.1.4 Potential interference

Standards developers have a duty to ensure that no "significant interference" exists between Standardized modes. "Significant Interference" exists if a system of one Standardized mode (working within the most widespread regulated power emissions) is likely to impede the successful operation of a system of another Standardized mode (working within the most widespread regulated power emissions), *in likely expected operating situations.*

Marginal measurable interference that does not impede operation *in likely expected operating situations*, or that could be avoided by simple and inexpensive design improvement, shall not be considered cause to reject a mode.

- Therefore, TTF modes are clearly identified as such in this part of ISO/IEC 18000.
- Therefore, installers of RFID systems are advised that they should make best efforts to be a good neighbour in installing any systems, bearing in mind that there may be other systems sharing the same bandwidth and are advised to take precautions to minimise interference to other systems. Installers are equally advised to be prepared to handle interference within the bandwidth from other users up to transmission powers permitted by local regulations.

5.2 MODE 1: Passive backscatter RFID system

The FHSS backscatter option or the narrow band operation RFID system shall include an interrogator that runs the FHSS backscatter option 1 RFID protocol or in narrow band operation, as well as one or more tags within the interrogation zone.

When placed in the RF field of an interrogator, the tag shall begin to power up. If the field is adequate, the tag shall execute a power-on reset and shall be ready to receive commands. Each command shall begin with a preamble and start delimiters that, taken together, enable the tag to perform clock and data recovery on the incoming signal. Data to and from the tag is checked for errors using a Cyclic Redundancy Code (CRC). Therefore, CRC fields are present in all interrogator interrogations and in all tag responses. Additional data protection is provided by Manchester encoding on the forward (interrogator to tag link) and FM0 encoding on the return (tag to interrogator) link.

By using the FHSS backscatter option 1 RFID command set or in narrow band operation, the interrogator can execute a number of functions on tags in its field. For example, the interrogator can send a command sequence, which allows it to identify multiple tags simultaneously in its RF field. Alternately, it can select a subset of the tags in the field based on tag memory contents. It can also read data stored on a tag in its field, as well as write or lock data to such a tag.

The description of the RFID tag command set in the following clause shall provide detail regarding the command field and return data/acknowledgement fields, if any. In addition, it shall cover additional high-level elements of the FHSS backscatter option RFID protocol, including how the multiple item identification algorithm works and byte ordering requirements. The more general aspects of the protocol (preambles, CRC-16, etc.) are covered in detail in 5.2.2.7.

This portion of the International Standard describes a passive backscatter RFID system that supports the following system capabilities:

System protocol

- Identify and communicate with multiple tags in the field
- Select a subgroup of tags to identify or communicate with based on information that the user has stored in the tag
- Read from and write or rewrite data many times to individual tags
- User controlled permanent lock memory

Data integrity protection

- Manchester bit-wise encoding and CRC-16 packet-level protection is applied to the forward link (interrogator-to-tag) data.
- FM0 bit-wise encoding and CRC-16 packet-level protection is applied to the return link (tag-to-interrogator) data.

In this RFID system, interrogators both power and communicate with the tags that are within their range. Tags receive data as on-off key amplitude modulation of the power/data signal from the interrogator. During the time that the tag communicates back to the interrogator, the interrogator broadcasts a steady radio frequency power level, and the tag modulates the impedance of its radio frequency load attached to the tag antenna terminals. The interrogator then receives the data back from the tag as a variation in reflection of its transmitted power.

5.2.1 MODE 1: Physical and media access control (MAC) parameters

5.2.1.1 MODE 1: Interrogator to tag link

Table 1 — Physical link specifications - forward link

Ref.	Parameter name	Description
M1-Int:1:	Operating Frequency Range	As permitted by local radio regulations in the band from 2 400 to 2 483,5 MHz.
M1-Int: 1a	Default Operating Frequency	2 450 MHz
M1-Int: 1b	Operating Channels	As required by local radio regulations. *As an example in the US 79 channels from 2 422,5 to 2 461,5 in 0,5 MHz increments may be used.*
M1-Int: 1c	Operating Frequency Accuracy	Maximum tolerance is ±50 ppm, however local tolerance may apply in case required by local regulations.
M1-Int: 1d	Frequency Hop Rate	The hop rate, if applicable, is determined by each country's regulatory authority in which the system is being operated. *As an example, within the US the maximum time at any frequency as set by FCC, clause 15,247 of FCC part 15 is 0,4 s.*
M1-Int: 1e	Frequency Hop Sequences	Pseudo-random hopping patterns uniformly utilising the designated frequency band.
M1-Int: 2	Occupied Channel Bandwidth	Maximum 0,5 MHz. Bandwidth specification according definition of local radio regulations. *As an example, within the US the 20 dB bandwidth is regulated by reference document 1.2.2, clause 15.247 of FCC part 15.*

Table 1 *(continued)*

Ref.	Parameter name	Description
M1-Int: 3	Interrogator Transmit Maximum EIRP	The maximum output power is regulated by each country's regulatory authority in which the system is being operated. *As an example, within the US reference document, clause 15.247 of FCC part 15 at the time of drafting of this part of ISO/IEC 18000, has as a maximum 30 dBm output from the interrogator, and 4W (36 dBm) EIRP from the interrogator transmit antenna.* *As an example, within the Japan reference document, for a fixed frequency (i.e. narrowband) mode of operation in the ISM band the system may operate as "licensed" providing 300 mW of conductive power into a directional antenna of gain below 20 dBi. Channel definition under FHSS "unlicensed" operation may be used for this mode of operation.*
M1-Int: 4	Interrogator Spurious Emissions	Covered in M1-Int: 4a and M1-Int 4b
M1-Int: 4a	Interrogator Transmit Spurious Emissions, In Band (for Spread Spectrum systems)	not applicable
M1-Int: 4b	Interrogator Transmit Spurious Emissions, Out of Band	The interrogator shall transmit in conformance with spurious emissions requirements defined by the country's regulatory authority within which the system is operated. *As an example, within the US reference, clause 15.205 and 15.209 of FCC part 15 sets the limit at the time of drafting of this document at 500 μV/m @ 3 m*
M1-Int: 5	Interrogator Transmitter Spectrum Mask	Communication carrier: ASK
M1-Int: 6	Timing	Covered in M1-Int: 6a to M1-Int 6d
M1-Int: 6a	Transmit to Receive Turn Around Time	See 5.2.2.9.2
M1-Int: 6b	Receive to Transmit Turn Around Time	As determined by the communication protocol – refer to tag 6a.
M1-Int: 6c	Dwell time or Interrogator Transmit Power-On Ramp	< 5 % of bit period
M1-Int: 6d	Decay time or Interrogator Transmit Power-Down Ramp	< 5 % of bit period
M1-Int: 7	Modulation	ASK. Details are described in 5.2.2.4
M1-Int: 7a	Spreading sequence (for Direct Sequence Spread Spectrum [DSSS] systems)	Not applicable
M1-Int 7b	Chip Rate (for Spread Spectrum systems)	Not applicable
M1-Int 7c	Chip Rate Accuracy (for Spread Spectrum systems)	Not applicable
M1-Int 7d	Modulation Index	99 %. For details see 5.2.2.4.1
M1-Int 7e	Duty Cycle	50 % ±5 %
M1-Int:7f	FM Deviation	Not applicable

Table 1 *(continued)*

Ref.	Parameter name	Description
M1-Int: 8	Data Coding	Manchester
M1-Int: 9	Bit Rate	30 – 40 kbit/s
M1-Int: 9a	Bit Rate Accuracy	100 ppm
M1-Int: 10	Interrogator Transmit Modulation Accuracy	See 5.2.2.4.1
M1-Int: 11	Preamble	Yes, see 5.2.2.8.3
M1-Int: 11a	Preamble length	9 bits, see 5.2.2.8.3
M1-Int: 11b	Preamble Waveform	See 5.2.2.8.3
M1-Int: 11c	Bit Sync Sequence	Yes, see 5.2.2.8.4
M1-Int: 11d	Frame Sync Sequence	Yes, see 5.2.2.8.4
M1-Int: 12	Scrambling (for Spread Spectrum Systems)	Not applicable
M1-Int: 13	Bit transmission order	MSB first
M1-Int: 14	Wake-up process	Presence of an appropriate RF signal at the tag followed by a wake-up command as required by the tag type.
M1-Int: 15	Polarisation	Interrogator dependent. Not defined in this part of ISO/IEC 18000.

5.2.1.2 MODE 1: Tag to interrogator link

Table 2 — Physical link specifications — backscatter return link

Ref.	Parameter name	Description
M1-Tag: 1	Operating Frequency Range	As permitted by local radio regulations in the band from 2 400 to 2 483,5 MHz.
M1-Tag: 1a	Default Operating Frequency	2 450 MHz
M1-Tag: 1b	Operating Channels (for Spread Spectrum systems)	As required by local radio regulations. See M1-Int: 1b.
M1-Tag: 1c	Operating Frequency Accuracy	Maximum tolerance is ± 50 ppm, however local tolerance may apply in case required by local regulations.
M1-Tag: 1d	Frequency Hop Rate (for Frequency Hopping [FHSS] systems)	The hop rate is set the regulatory authority within the country in which the system is operated.
M1-Tag: 1e	Frequency Hop Sequence (for Frequency Hopping [FHSS] systems)	Driven by Interrogator. See M1-Int: 1e
M1-Tag: 2	Occupied Channel Bandwidth	See M1-Int: 2
M1-Tag: 3	Transmit Maximum EIRP	The maximum output power transmitted by the interrogator during backscatter operation is regulated by the country's regulatory authority in which the system is operated. Examples are mentioned under M1-Int: 3

Table 2 *(continued)*

Ref.	Parameter name	Description
M1-Tag: 4	Transmit Spurious Emissions	Covered in M1-Int: 4a and M1-Int 4b
M1-Tag: 4a	Transmit Spurious Emissions, In-Band (for Spread Spectrum systems)	As permitted by local radio regulations.
M1-Tag: 4b	Transmit Spurious Emissions, Out of Band	During backscatter return link operation, the interrogator shall transmit in conformance with spurious emissions requirements set by the country's regulatory authority. *As an example, within the US reference, 15.205 and 15.209 of FCC part 15 limits the at the time of drafting this document the level to 500 µV/m @ 3 m*
M1-Tag: 5	Transmit Spectrum Mask	As permitted by local radio regulations.
M1-Tag: 6a	Transmit to Receive Turn Around Time	< 1 ms. For details see 5.2.2.8.2
M1-Tag: 6b	Receive to Transmit Turn Around Time	As determined by the communication protocol – refer to interrogator 6a.
M1-Tag: 6c	Dwell Time or Transmit Power On Ramp	Not applicable
M1-Tag: 6d	Decay Time or Transmit Power Down Ramp	Not applicable
M1-Tag: 7	Modulation	Backscatter. Details are defined in 5.2.2.5.2
M1-Tag: 7a	Spreading Sequence (for Direct Sequence Spread Spectrum [DSSS] systems)	Not applicable
M1-Tag: 7b	Chip Rate (for Spread Spectrum systems)	Not applicable
M1-Tag: 7c	Chip Rate Accuracy (for Spread Spectrum systems)	Not applicable
M1-Tag: 7d	On-Off Ratio	Not applicable
M1-Tag: 7e	Sub-carrier Frequency	Not applicable
M1-Tag: 7f	Sub-carrier Frequency Accuracy	Not applicable
M1-Tag: 7g	Sub-Carrier Modulation	Not applicable
M1-Tag: 7h	Duty Cycle	50 % ± 5 %
M1-Tag: 7i	FM Deviation	Not applicable
M1-Tag: 8	Data Coding	FM0
M1-Tag: 9	Bit Rate	30 – 40 kbit/s
M1-Tag: 9a	Bit Rate Accuracy	± 15 %
M1-Tag: 10	Tag Transmit Modulation Accuracy (for Frequency Hopping [FHSS] systems)	Not applicable

Table 2 *(continued)*

Ref.	Parameter name	Description
M1-Tag: 11	Preamble	See 5.2.2.5.6
M1-Tag: 11a	Preamble Length	16 bit made up of a quiet period, followed by sync. followed by a code violation followed by an orthogonal code
M1-Tag: 11b	Preamble Waveform	Bi-phase encoded data '1'
M1-Tag: 11c	Bit Sync Sequence	Yes, included in the preamble
M1-Tag: 11d	Frame Sync Sequence	Yes, included in the preamble
M1-Tag: 12	Scrambling (for Spread Spectrum systems)	Not applicable
M1-Tag: 13	Bit Transmission Order	MSB first
M1-Tag: 14	Reserved	Reserved
M1-Tag: 15	Polarisation	Product design feature. Not defined in this part of ISO/IEC 18000.
M1-Tag: 16	Minimum Tag Receiver Bandwidth	2 400 – 2 483,5 MHz

5.2.1.3 MODE 1: Protocol parameters

Table 3 — Protocol parameters

Ref.	Parameter name	Description
M1-P: 1	Who talks first	Interrogator talks first
M1-P: 2	Tag addressing capability	Yes
M1-P: 3	Tag UID	Contained in tag memory and accessible by means of commands
M1-P: 3a	UID Length	64 bit
M1-P: 3b	UID Format	See Annex A
M1-P: 4	Read size	Addressable in byte blocks
M1-P: 5	Write Size	Addressable in byte blocks. Writing in blocks of 1, 2, 3 or 4 bytes. (See details in 5.2.3.6.2.5)
M1-P: 6	Read Transaction Time	Once a tag has been identified and selected, a 64 bit data block can typically be read in less than 10 ms. This time may vary depending on data rate used as constrained by the local radio regulations.
M1-P: 7	Write Transaction Time	Once a tag has been identified and selected, an 8 to 32 bit data block can typically be written in less than 20 ms. This time may vary depending on data rate used as constrained by the local radio regulations.
M1-P: 8	Error detection	CRC-16
M1-P: 9	Error correction	No forward error correction code used. Errors are handled by signalling an error to the interrogator that then repeats its last transmission.
M1-P: 10	Memory size	Minimum memory size of 64 bits. Recommended minimum memory size of 18 bytes.
M1-P: 11	Command structure and extensibility	Several command codes are reserved for future use.