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Information technology — Radio frequency identification for item management —

Part 2:
Parameters for air interface communications below 135 kHz

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

Partie 2: Paramètres pour les communications d'une interface d'air à moins de 135 kHz

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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 18000-2 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

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

ISO/IEC 18000 is a series of International Standards describing common communications protocols for the purpose of Radio Frequency Identification for Item Management.

This part of ISO/IEC 18000 relates to systems operating at frequencies less than 135 kHz.

It has been developed in accordance with the requirements determined in ISO 18000-1, *Information technology — Radio frequency identification for item management — Reference architecture and definition of parameters to be standardized*.

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 the table below.

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.

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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 2:
Parameters for air interface communications below 135 kHz

1 Scope

This part of ISO/IEC 18000 defines the air interface for radio frequency identification (RFID) devices operating below 135 kHz used in item management applications. Its purpose is to provide a common technical specification for RFID devices to allow for compatibility and to encourage inter-operability of products for the growing RFID market in the international marketplace. This part defines the forward and return link parameters for technical attributes including, but not limited to, operating frequency, operating channel accuracy, occupied channel bandwidth, spurious emissions, modulation, duty cycle, data coding, bit rate, bit rate accuracy, bit transmission order. It further defines the communications protocol used in the air interface.

This part contains two types. The detailed technical differences between the types are shown in the parameter tables.

This part of ISO/IEC 18000 specifies

- The physical layer that is used for communication between the interrogator and the tag.
- The protocol and the commands
- The method to detect and communicate with one tag among several tags (“anti-collision”)

It specifies two types of tags: Type A (FDX) and Type B (HDX). These two types differ only by their physical layer. Both types support the same anti-collision and protocol.

FDX tags are permanently powered by the interrogator, including during the tag-to-interrogator transmission. They operate at 125 kHz.

HDX tags are powered by the interrogator, except during the tag-to-interrogator transmission. They operate at 134,2 kHz. An alternative operating frequency is described in Annex B.

An optional anti-collision mechanism is described in Annex D.

2 Conformance

2.1 Tag

To claim conformance with this part of ISO/IEC 18000, a tag shall be of either Type A or B.

NOTE Nothing in this part of ISO/IEC 18000 prevents a tag to be of both types, although for technical reasons, it is unlikely that such tags are ever marketed.

2.2 Interrogator

To claim conformance with this part of ISO/IEC 18000, an interrogator shall support both Types A and B.

Depending on the application, it may be configured as Type A only, Type B only or Types A and B.

When configured in Types A and B, and when in the Inventory phase, the interrogator shall alternate between Type A and Type B interrogation. See Annex C.

NOTE The rules for RFID device (tag and interrogator) conformity evaluation will be given in a future Technical Report (ISO/IEC TR 18047-2).

3 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 15418, *Information technology — EAN/UCC Application Identifiers and Fact Data Identifiers and Maintenance*

ISO 11784, *Radio frequency identification of animals — Code structure*

ISO 11785, *Radio frequency identification of animals — Technical concept*

ISO/IEC 15961, *Information technology — Radio frequency identification for item management — Data protocol: application interface*[1)]

ISO/IEC 15962, *Information technology — Radio frequency identification for item management — Data protocol: data encoding rules and logical memory functions*[1)]

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 19762 (all parts), *Information technology — Automatic identification and data capture techniques — Harmonized vocabulary*[1)]

4 Terms, definitions, symbols and abbreviated terms

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

4.1 Terms and definitions

4.1.1
anti-collision loop
algorithm used to prepare for and handle a dialogue between interrogator and one or more tags out of several in its energizing field

4.1.2
byte
8 bits of data designated b1 to b8, from the most significant bit (MSB, b8) to the least significant bit (LSB, b1)

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1) To be published.

4.2 Symbols

All symbols are expressed with a letter, followed by a upper case letter (A or B or D when referring respectively to the Type A or Type B or Annex D, p when referring to the protocol), followed by letters and/or numbers as appropriate. The main symbols are listed below, where X represents A or B or D. Timings are expressed with an upper case T and according to above rule. Other symbols specific to A, B or D are specified in the relevant clauses.

f_{Xc}	Carrier frequency of the operating field
T_{Xd0}	Period of Data Symbol "0"
T_{Xd1}	Period of Data Symbol "1"
T_{Xc}	Period of carrier frequency ($T_{Xc} = 1/f_{Xc}$)
T_{Xcv}	Code Violation Duration

4.3 Abbreviated terms

ACL	Allocation class
ASK	Amplitude shift keying
AFI	Application family identifier
BSS	Block security status
BWP	Block write protection
CRC	Cyclic redundancy check
CRCT	Response cyclic redundancy check flag
DSFID	Data storage format identifier
EOF	End of frame
FDX	Full duplex
HDX	Half duplex
IRC	IC reference code
LSB	Least significant bit
MFC	Manufacturer code
MSB	Most significant bit
MSN	Manufacturer serial number
NOB	Number of blocks
NOS	Number of slots
NRZ	Non return to zero
RF	Radio frequency
RFU	Reserved for future use
SOF	Start of frame
SUID	Sub unique identifier (includes MFC and MSN)
UID	Unique Identifier (includes ACL, MFC and MSN)

5 Physical layer

5.1 Type A (FDX)

5.1.1 Power transfer

Power transfer to the tag is accomplished by radio frequency via coupling antennas in the tag and in the interrogator. The RF operating field supplies permanently power from the interrogator to the FDX tag. For communication between interrogator and tag, the field is modulated.

5.1.2 Frequency

The carrier frequency of the RF operating field is f_{Ac} = 125 kHz.

5.1.3 Communication signal interface interrogator to tag

5.1.3.1 Modulation

Communications between interrogator and tag takes place using ASK modulation with a modulation index of 100%.

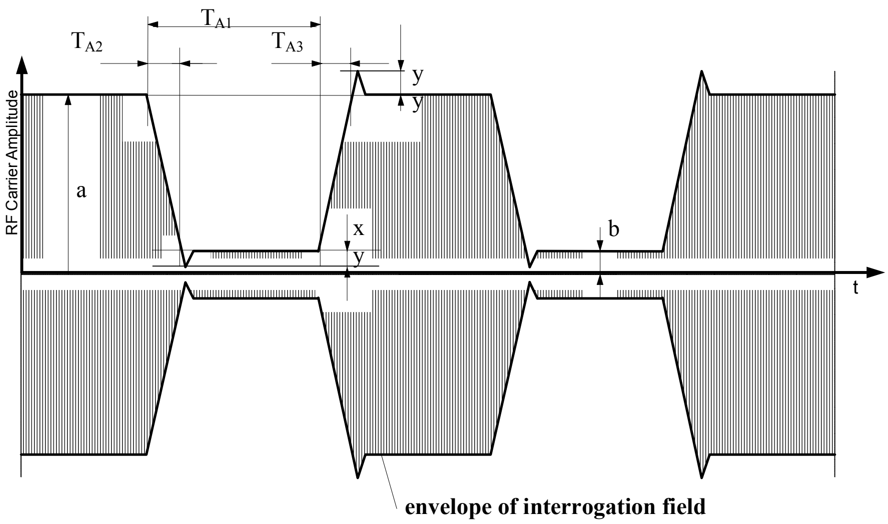


Figure 1 — Modulation details of data transmission from interrogator to tag

Table 1 — Modulation coding times

	Min	Max
m = (a-b)/(a+b)	90 %	100 %
T_{A1}	4 * T_{Ac}	10 * T_{Ac}
T_{A2}	0	0,5 * T_{A1}
T_{A3}	0	0,5 * T_{Ad0}
x	0	0,15 * a
y	0	0,05 * a

NOTE $T_{Ac} = 1/f_{Ac} \approx 8\mu s$

5.1.3.2 Data rate and data coding

The interrogator-to-tag communication uses Pulse interval encoding. The interrogator creates pulses by switching the carrier as described in Figure 1. The time between the falling edges of the pulses determines either the value of the data bit "0" and "1", a Code violation or a Stop condition.

Assuming equal distributed data bits "0" and "1", the data rate is in the range of 5,1 kbit/s.

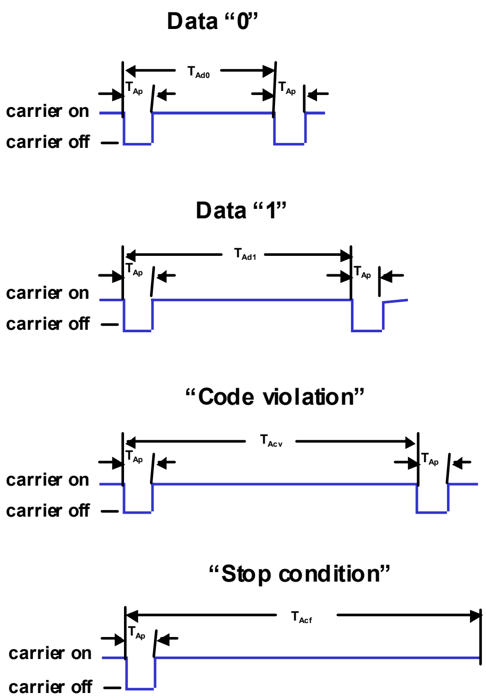


Figure 2 — Interrogator to tag: Pulse interval encoding

Table 2 — Data coding Times

Meaning	Symbol	min	max
"Carrier off" time	T_{Ap}	$4 * T_{Ac}$	$10 * T_{Ac}$
Data "0" time	T_{Ad0}	$18 * T_{Ac}$	$22 * T_{Ac}$
Data "1" time	T_{Ad1}	$26 * T_{Ac}$	$30 * T_{Ac}$
"Code violation" time	T_{Acv}	$34 * T_{Ac}$	$38 * T_{Ac}$
"Stop condition" time	T_{Asc}	$\geq 42 * T_{Ac}$	n/a

NOTE $T_{Ac} = 1/f_{Ac} \approx 8$ µs.

5.1.3.3 Start of frame pattern

The interrogator request starts always with a Start of frame pattern (SOF) for ease of synchronization. The SOF pattern consists of a data bit "0" pattern and a "Code violation" pattern.

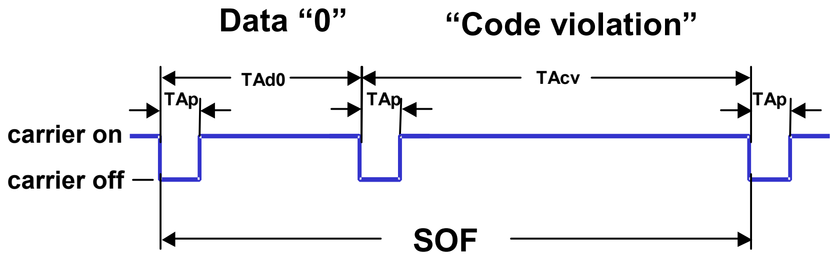


Figure 3 — Start of frame pattern

The tag shall be ready to receive a SOF from the interrogator within 1,2 ms after having sent a response to the interrogator.

The tag shall be ready to receive a SOF from the interrogator within 2,5 ms after the interrogator has established the powering field.

5.1.3.4 End of frame pattern

For slot switching during a multislot anti-collision sequence, the interrogator request is an EOF pattern. The EOF pattern is represented by a "Stop condition".

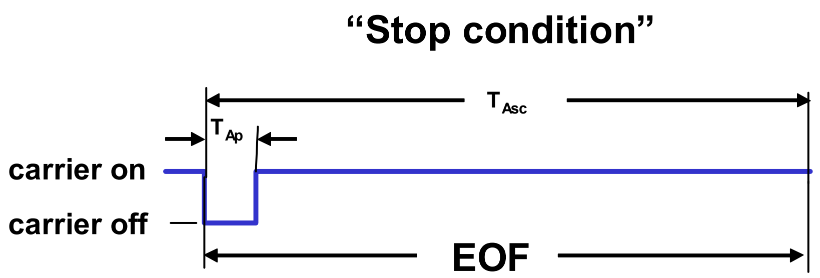


Figure 4 — End of frame pattern

5.1.4 Communication signal interface tag to interrogator

5.1.4.1 Data rate and data coding

The tag shall be capable to communicate with the interrogator via an inductive coupling, whereby the carrier is loaded with

- a 4 kbit/s Manchester coded data signal on the International Standard commands
- a 2 kbit/s dual pattern data coding on the INVENTORY command

NOTE The slower data rate used during the inventory process allows for improving the collision detection when several tags are present in the interrogator field, especially if some tags are in the near field and others in the far field.

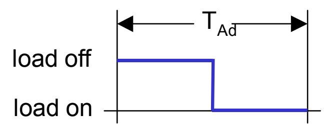
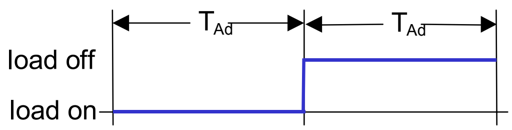
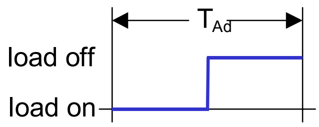
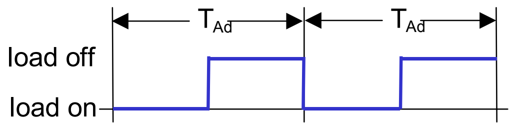
Data Element	International Standard command	Inventory command
Data "0"		
Data "1"		

Figure 5 — Tag to interrogator: load modulation coding

5.1.4.2 Start of frame pattern

The tag response starts always with a Start of frame (SOF) pattern. The SOF pattern is a Manchester coded bit sequence of "110".

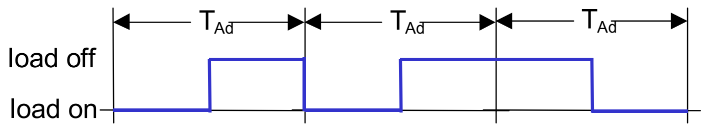


Figure 6 — Start of frame pattern

5.1.4.3 End of frame pattern

No EOF is used nor specified for the tag response.

5.2 Type B (HDX)

5.2.1 Power transfer

Power transfer to the tag is accomplished by radio frequency via coupling antennas in the tag and in the interrogator. The RF operating field supplies power at the beginning of the request from the interrogator to the HDX tag. For communication between interrogator and tag, the field is modulated.

5.2.1.1 Frequency

The carrier frequency of the RF operating field is f_{Bc} = 134,2 kHz or as described in Annex B.

5.2.2 Communication signal interface interrogator to tag

5.2.2.1 Modulation

Communication between interrogator and tag takes place using ASK modulation with a modulation index of 100%.

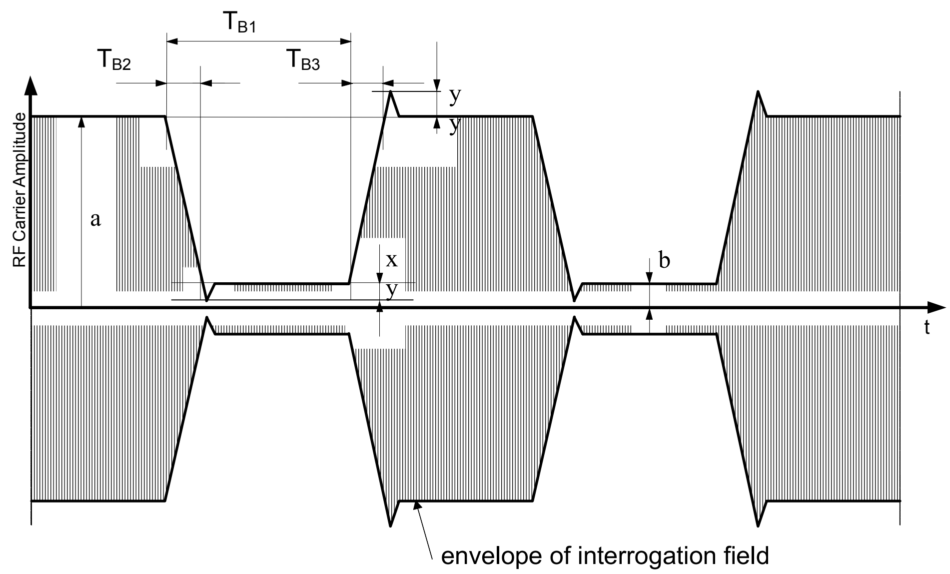


Figure 7 — Modulation details of data transmission from interrogator to tag

Table 3 — Modulation coding times

Symbol	Fast data rate			Slow data rate		
	min	nom	max	min	nom	max
T_{B1}	11 * T_{Bc}	13* T_{Bc}	18 * T_{Bc}	11 * T_{Bc}	13* T_{Bc}	25 * T_{Bc}
T_{B2}	2 * T_{Bc}	7 * T_{Bc}	10 * T_{Bc}	2 * T_{Bc}	7 * T_{Bc}	10 * T_{Bc}
T_{B3}	5 * T_{Bc}	25 * T_{Bc}	32 * T_{Bc}	5 * T_{Bc}	100 * T_{Bc}	115 * T_{Bc}
x	0	n/a	0,15 * a	0	n/a	0,15 * a
y	0	n/a	0,05 * a	0	n/a	0,05 * a

5.2.2.2 Data rate and data coding

The interrogator-to-tag communication uses Pulse interval encoding. The interrogator creates pulses by switching the carrier as described in Figure 7. The time between the falling edges of the pulses determines either the value of the data bit "0" and "1", a Code violation or a Stop condition.

Assuming equal distribution of data bits “0” and “1”, the data rates are:

Slow data rate: 1 kbit/s

Fast data rate: 2,3 kbit/s.

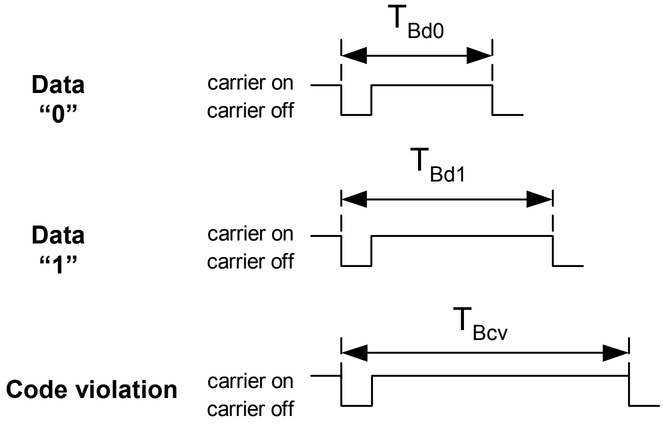


Figure 8 — Interrogator to tag: modulation and coding

Table 4 — Data coding times

Symbol	Fast data rate			Slow data rate		
	min	nom	Max	min	nom	max
T_{Bd0}	42 * T_{Bc}	47 * T_{Bc}	52 * T_{Bc}	110 * T_{Bc}	120 * T_{Bc}	130 * T_{Bc}
T_{Bd1}	62 * T_{Bc}	67 * T_{Bc}	72 * T_{Bc}	140 * T_{Bc}	150 * T_{Bc}	160 * T_{Bc}
T_{Bcv}	175 * T_{Bc}	180 * T_{Bc}	185 * T_{Bc}	200 * T_{Bc}	210 * T_{Bc}	220 * T_{Bc}

NOTE $T_{Bc} = 1/f_{Bc} \approx 7{,}452$ µs

5.2.2.3 Start of frame pattern

The interrogator request starts always with a Start of frame (SOF) pattern. The SOF pattern consists of Data "1", Data "0" and "Code violation" pattern that define a clear start of frame. The difference in duration as specified in Table 4 informs the tag about the requested data rate.

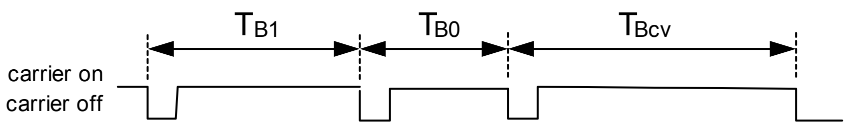


Figure 9 — Start of frame pattern

5.2.2.4 End of frame

The EOF of an interrogator request is defined as the falling edge of the field followed by a delay time longer than T_{B1}.

For the 16 slots inventory sequence, the EOF that instructs the tags to switch to the next slot is defined as the rising edge of the interrogator field followed by a time t_{RCH}.

In both cases, the tag shall receive this sequence before transmitting its response SOF.

5.2.3 Communication signal interface tag to interrogator

5.2.3.1 Data rate and data coding

The tag shall be capable to communicate with the interrogator via an inductive coupling, whereby the power is switched off and the data are FSK modulated using the frequencies:

- f_{Bc} = 134,2 kHz for the “Low Bit” encoding
- f_{B1} = 123,7 ± 4,2 kHz for the “High Bit” encoding

The data coding is based on the NRZ method.

The average data rate is 8 kbit/s.

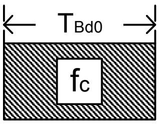
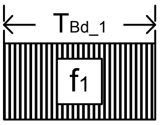
Data Element	International Standard command	Comment
Data "0"		$T_{Bd0} = 16/f_{Bc}$
Data "1"		$T_{Bd1} = 16/f_{B1}$

Figure 10 — Tag to interrogator: modulation and coding

5.2.3.2 Start of frame pattern

The tag response starts always with a Start of frame (SOF) pattern. The SOF pattern is coded with a bit pattern of "111101".

f_{B1} represents the frequency for data bit “1” (T_{Bd1}) and f_{Bc} for data bit “0” (T_{Bd0}).

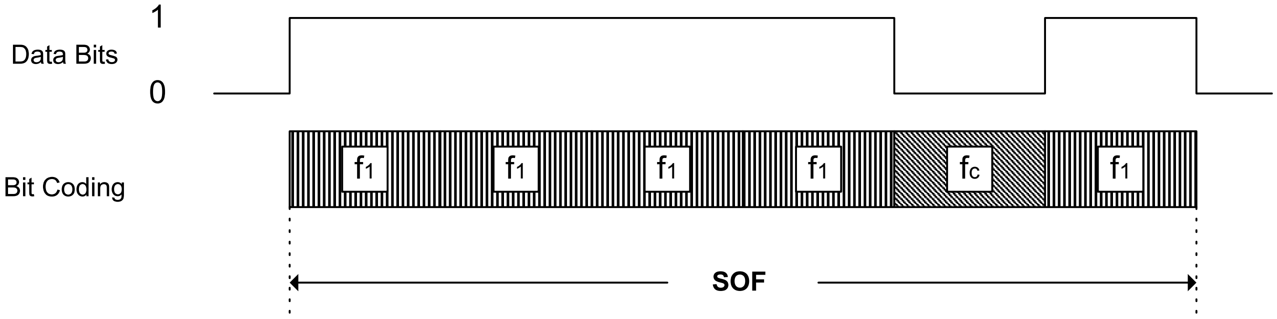


Figure 11 — Start of frame pattern

5.2.3.3 End of frame pattern

The tag response ends always with an End of frame (EOF) pattern. The EOF pattern is coded with a bit pattern of "101111".

f_{B1} represents the frequency for data bit “1” (T_{Bd1}) and f_{Bc} for data bit “0” (T_{Bd0}).

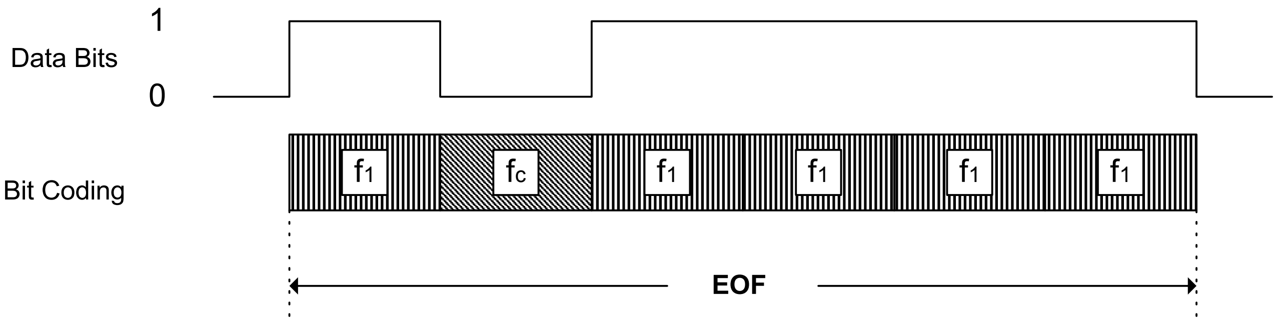


Figure 12 — End of frame pattern

5.3 Physical and Media Access Control (MAC) Parameters

5.3.1 Interrogator to tag link

Ref.	Parameter	Description Type A	Description Type B	Options/Comments
M1-INT: 1	Operating Frequency Range	One interrogator to tag link channel at 125 kHz	One interrogator to tag link channel at 134,2 kHz	
M1-INT: 1a	Default Operating Frequency	125 kHz	134,2 kHz	
M1-INT: 1b	Operating Channels (for Spread Spectrum systems)	Not appropriate for this MODE		
M1-INT: 1c	Operating Frequency Accuracy	Within ± 0,1 kHz		
M1-INT: 1d	Frequency Hop Rate (for Frequency Hopping [FHSS] systems)	Not appropriate for this MODE		
M1-INT: 1e	Frequency Hop Sequence (for Frequency Hopping [FHSS] systems)	Not appropriate for this MODE		
M1-INT: 2	Occupied Channel Bandwidth	± 4 kHz	± 8 kHz	3 dB Bandwidth
M1-INT: 2a	Minimum Receiver Bandwidth	± 10 kHz	± 8 kHz	3 dB Bandwidth
M1-INT: 3	Interrogator Transmit Maximum EIRP Power Limits within Communication Zone	65,5 dBµA/m		@ d = 10m see ITUR 012E-WB9
M1-INT: 3	Interrogator Transmit Spurious Emissions	27 dBµA/m		@9 kHz descending 3dB/octave, until 10 MHz

Ref.	Parameter	Description Type A	Description Type B	Options/Comments
M1-INT: 4a	Interrogator Transmit Spurious Emissions, In-Band (for Spread Spectrum systems)	Not appropriate for this MODE		
M1-INT: 4b	Interrogator Transmit Spurious Emissions, Out-of-Band	See M1A-F3		
M1-INT: 5	Interrogator Transmitter Spectrum Mask	Emissions below 135 kHz 65,5 dBµA/m @ f<135kHz	65,5 dBµA/m @ f<135kHz 50 dBµA/m @ f<135-140kHz 30 dBµA/m @ f<140-148,5kHz	
M1-INT: 6	Timing			
M1-INT: 6a	Transmit to Receive Turn Around Time	1,2 ms		Interrogator has to wait min. 1,2 ms before sending next command
M1-INT: 6b	Receive to Transmit Turn Around Time	2 ms		Interrogator has to wait min 2 ms for answer of tag before signalizing a timeout error.
M1-INT: 6c	Dwell Time or Interrogator Transmit Power On Ramp	< 2 ms	< 2ms	
M1-INT: 6d	Decay Time or Interrogator Transmit Power Down Ramp	Not appropriate for this MODE		
M1-INT: 7	Modulation	OOK (100% ASK)		
M1-INT: 7a	Spreading Sequence (for Frequency Hopping [FHSS] systems)	Not appropriate for this MODE		
M1-INT: 7b	Chip Rate (for Spread Spectrum systems)	Not appropriate for this MODE		
M1-INT: 7c	Chip Rate Accuracy (for Spread Spectrum systems)	Not appropriate for this MODE		
M1-INT: 7d	Modulation Index	100%		
M1-INT: 7e	Duty Cycle	Not appropriate for this MODE		
M1-INT: 7f	FM Deviation	Not appropriate for this MODE		

Ref.	Parameter	Description Type A	Description Type B	Options/Comments
M1-INT: 8	Data Coding	Pulse interval encoding (PIE)		
M1-INT: 9	Bit Rate	Average 5,2 kbit/s	1 to 2,3 kbit/s (optional)	
M1-INT: 9a	Bit Rate Accuracy	Synchronous to the carrier frequency		
M1-INT: 10	Interrogator Transmit Modulation Accuracy	Not appropriate for this MODE		
M1-INT: 11	Preamble	No Preamble		
M1-INT: 11a	Preamble Length			
M1-INT: 11b	Preamble Waveform			
M1-INT: 11c	Bit Sync Sequence			
M1-INT: 11d	Frame Sync Sequence	Start Of Frame pattern (SOF)		
M1-INT: 11e	Postamble	none	End Of Frame pattern (EOF), 6 bits	
M1-INT: 12	Scrambling (for Spread Spectrum systems)	Not appropriate for this MODE		
M1-INT: 13	Bit Transmission Order	Least significant bit (LSB) first.		
M1-INT: 14	Wake-up process	The dialogue between the Interrogator and the RF tag (one or more RF tags may be present at the same time) is conducted through the following consecutive operations: - activation of the RF tag by the RF operating field of the interrogator, - RFID tag waits silently for a command from the interrogator, - transmission of a command by the interrogator, - transmission of a response by the RFID tag. .		
M1-INT: 15	Polarization	Not Applicable (near field)		

5.3.2 Tag to interrogator link

Ref.	Parameter Name	Description Type A	Description Type B	Options/Comments
M1-TAG: 1	Operating Frequency Range Sub-carrier Frequencies	See M1-INT: 1 No subcarrier	See M1-INT: 1 134,2/123,7 ± 4 kHz using FSK technique	
M1-TAG: 1a	Default Operating Frequency	See M1-INT: 1a		
M1-TAG: 1b	Operating Channels (for Spread Spectrum systems)	Not appropriate for this MODE		
M1-TAG: 1c	Operating Frequency Accuracy	see M1-INT: 1c		
M1-TAG: 1d	Frequency Hop Rate (for Frequency Hopping [FHSS] systems)	Not appropriate for this MODE		
M1-TAG: 1e	Frequency Hop Sequence (for Frequency Hopping [FHSS] systems)	Not appropriate for this MODE		
M1-TAG: 2	Occupied Channel Bandwidth	± 10 kHz	± 15 kHz	
M1-TAG: 3	Transmit Maximum EIRP	Not appropriate for this MODE		
M1-TAG: 4	Transmit Spurious Emissions	Not appropriate for this MODE		
M1-TAG: 4a	Transmit Spurious Emissions, In-Band (for Spread Spectrum systems)	Not appropriate for this MODE		
M1-TAG: 4b	Transmit Spurious Emissions, Out-of-Band	Not appropriate for this MODE		
M1-TAG: 5	Transmit Spectrum Mask	Not appropriate for this MODE		
M1-TAG: 6a	Transmit to Receive Turn Around Time	see M1-INT: 6b		
M1-TAG: 6b	Receive to Transmit Turn Around Time	see M1-INT: 6a		
M1-TAG: 6c	Dwell Time or Transmit Power On Ramp	Not appropriate for this MODE		
M1-TAG: 6d	Decay Time or Transmit Power Down Ramp	Not appropriate for this MODE		

Ref.	Parameter Name	Description Type A	Description Type B	Options/Comments
M1-TAG: 7	Modulation (on the carrier)	The RF tag shall be capable to communicate with the interrogator via an inductive coupling area, whereby the carrier frequency is modulated by switching a load in the RF tag.	Not appropriate for this type	
M1-TAG: 7a	Spreading Sequence (for Frequency Hopping [FHSS] systems)	Not appropriate for this MODE		
M1-TAG: 7b	Chip Rate (for Spread Spectrum systems)	Not appropriate for this MODE		
M1-TAG: 7c	Chip Rate Accuracy (for Spread Spectrum systems)	Not appropriate for this MODE		
M1-TAG: 7d	On-Off Ratio	Not appropriate for this MODE		Load modulation
M1-TAG: 7e	Sub-carrier Frequency	Not appropriate for this MODE	134,2 /123,7 ± 4 kHz using FSK technique	
M1-TAG: 7f	Sub-carrier Frequency Accuracy Tolerance of Direct Generated tag to interrogator Link Carrier	Not appropriate for this MODE		
M1-TAG: 7g	Sub-Carrier Modulation	Not appropriate for this MODE		
M1-TAG:7h	Duty Cycle	Not appropriate for this MODE		
M1-TAG: 7 I	FM Deviation	Not appropriate for this MODE		
M1-TAG: 8	Data Coding	Manchester Code or Dual Pattern Code	NRZ	
M1-TAG: 9	Bit Rate	Manchester Code : 4 kbit/s (f_{Ac}/32) Dual Pattern Code: 2 kbit/s (f_{Ac}/64) during inventory	NRZ “0” : 8,2 kbit/s NRZ “1” : 7,7 kbit/s	
M1-TAG: 9a	Bit Rate Accuracy	Derived from the carrier		
M1-TAG: 10	Tag Transmit Modulation Accuracy (for Frequency Hopping [FHSS] systems)	Not applicable for this MODE		
M1-TAG: 11	Preamble	No Preamble		
M1-TAG: 11a	Preamble Length			

Ref.	Parameter Name	Description Type A	Description Type B	Options/Comments
M1-TAG: 11b	Preamble Waveform			
M1-TAG: 11c	Bit Sync Sequence	Start Of Frame pattern (SOF), 3 bits	Start Of Frame pattern (SOF), 6 bits End Of Frame pattern (EOF), 6 bits	
M1-TAG: 12	Scrambling (for Spread Spectrum systems)	Not appropriate for this MODE		
M1-TAG: 13	Bit Transmission Order	Least Significant bit (LSB) first		
M1-TAG: 14	Reserved			
M1-TAG: 15	Polarization	Not Applicable(Near Field)		
M1-TAG: 16	Minimum tag Receiver Bandwidth	± 10 kHz	± 15 kHz	

6 Transmission Protocol

6.1 Basic elements

The transmission protocol defines the mechanism to exchange instructions and data between the interrogator and the tags, in both directions. The interrogator shall be capable to communicate with tags of both Type A (FDX) and Type B (HDX).

It is based on the following concepts:

- "Interrogator Talks First". This means that any tag does not start transmitting, unless it has received and properly decoded an instruction sent by the interrogator.
- Tags are uniquely identified by a 64 bit Unique Identifier (UID). See clause 6.2.
- The protocol consists of an exchange of
  - a request from the interrogator to the tag
  - a response from the tag(s) to the interrogator
- The protocol is bit-oriented. The number of bits transmitted after a SOF depends on the respective request and response.

Flags are used for the control of request and response. The setting of the flags indicates either request and response variants (e.g. number of slots) or the presence of optional fields (e.g. AFI). When the flag is set to one (1), the field is present. When the flag is reset to zero (0), the field is absent.

RFU flags shall be set to zero (0).

6.2 Unique identifier

6.2.1 Unique identifier (UID)

The tags are uniquely identified by a 64 bit unique identifier (UID). The UID shall be set permanently by the IC manufacturer in accordance with Figure 13.

The UID is used for addressing each tag uniquely and individually.

MSB		LSB
64 57	56 49	48 1
'E0'	IC Mfg code	IC manufacturer serial number

Figure 13 — UID format

The UID shall comprise

- The allocation class on 8 bits defined as 'E0',
- The MFC (IC manufacturer code) on 8 bits according to ISO/IEC 7816-6,
- The MSN, a unique serial number of 48 bits assigned by the IC manufacturer.

6.2.2 Sub-UID

In order to improve the system performances, only a part of the UID, called Sub-UID (SUID) is transmitted in most commands and in the tag response during a collision arbitration process. The SUID consists in 48 bits: the 8 bit manufacturer code followed by the 40 LSBs of the manufacturer serial number.

The 8 MSBs (bits 41 to 48) of the serial number shall be set to 0.

The mapping of the 64 UID to the transmitted 48 bits and back is described in Figure 14.

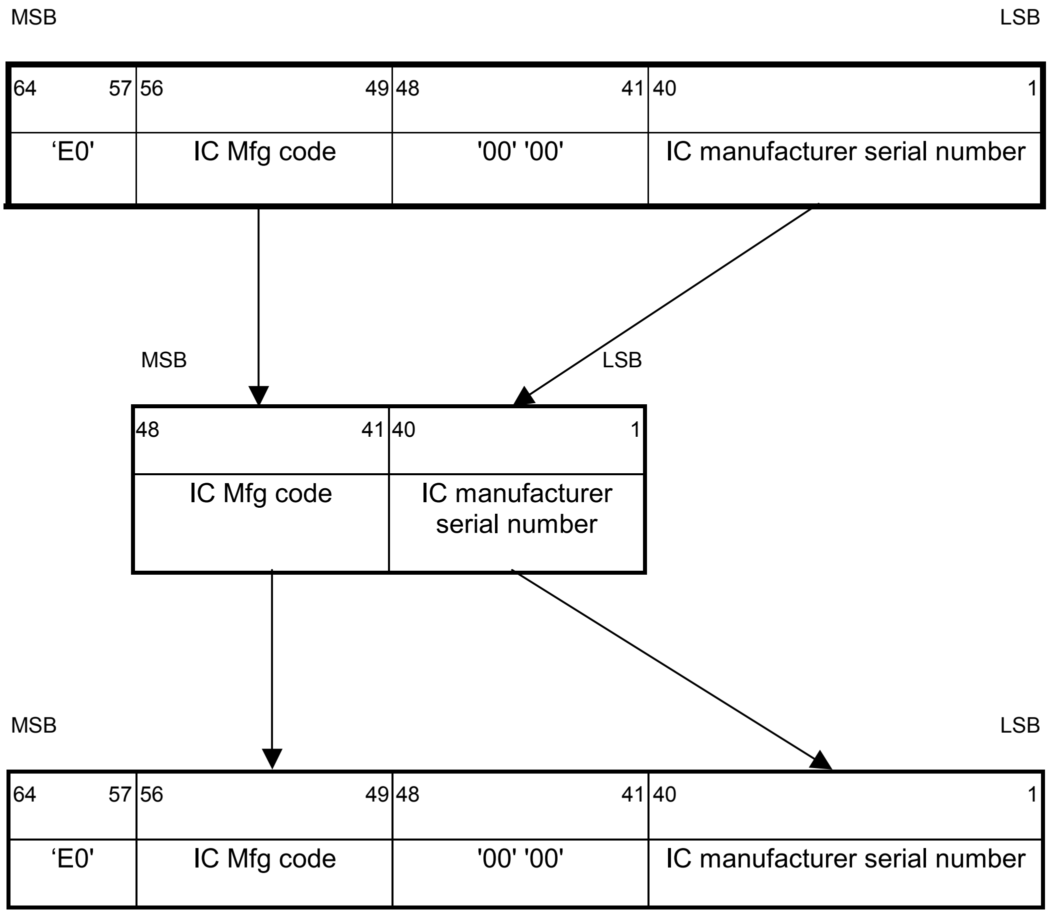


Figure 14 — UID/SUID mapping from 64 to 48 and from 48 to 64

The interrogator shall use the 64 bit format specified in clause 6.2.1 when exchanging the UID with the application. It shall perform the required mapping described in Figure 14.

6.3 Request format

A request consists of

- Start of frame pattern
- Flags
- Command
- Parameters (depending on the command)
- Data (depending on the command)
- CRC (optional)
- End of frame pattern

SOF	Flags	Command	Parameters	Data	CRC	EOF

Figure 15 — General request format

Each request starts with a SOF. The subsequent fields are transmitted successively from the first field (Flags) to the last field (e.g. CRC). All fields are transmitted LSB first. At the end of a request, an EOF is appended.

The allocation of the least significant bit (LSB) and the most significant bit (MSB) for each field of the request format is shown in Figure 16.

	LSB MSB	LSB MSB	LSB MSB	LSB MSB	LSB MSB	
SOF	Field 1 (Flags 1..5)	Field 2 (Command)	Field 3 (Parameters)	Field 4 (Data)	Field 5 (CRC)	EOF

Figure 16 — Allocation of LSB and MSB to the request fields

6.4 Response format

A response consists of

- Start of frame pattern
- Flags (not used by the INVENTORY command)
- Error code (not used by the INVENTORY command)
- Data (depending on the command)
- CRC (optional)
- End of frame pattern

SOF	Error flag '0'	Data	CRC	EOF

Figure 17 — General response format if no error

SOF	Error flag '1'	Error code	CRC	EOF

Figure 18 — General response format if error

Each response begins with a SOF. The subsequent fields are transmitted successively from the first field (Flag) to the last field (e.g. CRC). All fields are transmitted LSB first. At the end of a response, an EOF is appended.

The allocation of the least significant bit (LSB) and the most significant bit (MSB) for each field of the response format is shown in Figure 19.

	LSB MSB	LSB MSB	LSB MSB	LSB MSB	
SOF	Field 1 (Flag)	Field 2 (Status)	Field 3 (Data)	Field 4 (CRC)	EOF

Figure 19 — Allocation of LSB and MSB to the response fields

6.5 Request flags

In each request, five flags are used with flag 1 to be transmitted first. The specific meaning of the flags depends on the context.

Table 5 — Meaning of the request flags 1 to 3

Bit	Flag name	Value	Description
b1	PEXT (Protocol Extension) flag	0	No protocol format extension
		1	Protocol format is extended. Reserved for future use
b2	INV (Inventory) flag	0	Flags 4 to 5 meaning is according to Table 6
		1	Flags 4 to 5 meaning is according to Table 7
b3	CRCT	0	CRC shall NOT be appended to the tag response
		1	CRC shall be appended to the tag response

Table 6 — Request flags 4 to 5 definition when Inventory flag is NOT set

Bit	Flag name	Value	Description
b4	SEL (Select) flag	0	Request shall be executed by any tag according to the setting of Address_flag
		1	Request shall be executed only by tag in selected state. The Address_flag shall be set to 0 and the SUID field shall not be included in the request.
b5	ADR (Address) flag	0	Request is not addressed. SUID field is not included. It shall be executed by any tag.
		1	Request is addressed. SUID field is included. It shall be executed only by the tag whose SUID matches the SUID specified in the request.

Table 7 — Request flags 4 to 5 definition when inventory flag is set

Bit	Flag name	Value	Description
b4	AFI flag	0	AFI field is not present
		1	AFI field is present
b5	NOS flag	0	16 slots
		1	1 slot

A further description of these flags is given in the five following subclauses.

6.5.1 AFI flag

The AFI flag is used by the INVENTORY command to differentiate between a general request (AFI = 0) and an AFI request (AFI = 1). If the AFI flag is set to 1, the AFI of the application family shall be attached to the request. AFI operation is explained in clause 6.13.

6.5.2 NOS flag

The NOS flag is used by the INVENTORY command or any other command when the Inventory flag is set to select the number of slots while performing the anti-collision sequence.

6.5.3 SEL flag and ADR flag

The SEL flag and ADR flag are used by all commands except the INVENTORY command and any other command where the Inventory flag is set.

When both the ADR flag and the SEL flag are set to 0, the request shall not contain a unique sub-ID. Any tag in the Ready state receiving such a request shall execute it (if possible) and shall return a response to the interrogator as specified by the command description.

When the ADR flag is set to 1 (addressed mode), the request shall contain the unique sub-ID (SUID) of the addressed tag. Independent of the state, any tag receiving such a request shall compare the received unique SUID (address) to its own SUID. If it matches, it shall execute it (if possible) and return a response to the interrogator as specified by the command description. If it does not match, it shall remain silent.

When the SEL flag is set to 1 (selected mode), the request shall not contain a tag SUID. Only the tag in the Selected state receiving such a request shall execute it (if possible) and shall return a response to the interrogator as specified by the command description.

Table 8 — Meaning of the SEL flag and ADR flag

SEL	ADR	Meaning for all commands except INVENTORY and READ SUID
0	0	No SUID is attached. All tags in the Ready state shall execute this command
0	1	The SUID is attached. Only the tag with corresponding SUID shall execute this command
1	0	No SUID is attached. Only a tag in the Selected state shall execute this command
1	1	RFU

6.5.4 CRCT flag

The CRCT flag specifies whether the tag shall attach a CRC in its response or not. The CRC implementation on the tag is mandatory.

Table 9 — Meaning of the CRCT flag

CRCT	Meaning for all commands
0	No CRC shall be attached to the response
1	A CRC shall be attached to the response

6.5.5 PEXT flag

The PEXT flag is reserved for future protocol extension by ISO. It shall be set to 0.

6.6 Error flag

The error flag indicates whether the tag has detected an error or not. If it is set to 1, the response error field shall be returned according to Table 11.

Table 10 — Error flag

Error flag	Meaning
0	No error
1	Error detected

Table 11 — Error Code

Code	Description
0	No error
1	The command is not supported, i.e. the request code is not recognized
2	The command is not recognized, for example: a format error occurred
3	The specified block is not available (doesn't exist)
4	The specified block is secured and its content cannot be accessed
5	The specified block was not successfully programmed / locked
6	RFU
7	Unknown error

6.7 Block security status

The block security status (BSS) is sent back by the tag as a parameter in the response to an interrogator request as specified in clause 10 (e.g. READ SINGLE BLOCK WITH SECURITY STATUS). It is coded on four bits for each existing block.

It is an element of the protocol. There is no implicit or explicit assumption that the 4 bits are actually implemented in the physical memory structure of the tag.

Table 12 — Block security status

Bit	Meaning	Value	Description
Bit 1	Block lock bit	0	Not locked
		1	Locked
Bit 2 to Bit 4	Reserved for future use	0	

6.8 AFI security status

The AFI security status is sent back by the tag as a parameter in the response to an interrogator request as specified in clause 10.5.8 (Get system information). It is coded on four bits.

It is an element of the protocol. There is no implicit or explicit assumption that the 4 bits are actually implemented in the physical memory structure of the tag.

Table 13 — AFI security status

Bit	Meaning	Value	Description
Bit 1	AFI lock bit	0	Not locked
		1	Locked
Bit 2 to Bit 4	Reserved for future use	0	

6.9 DSFID security status

The DSFID security status is sent back by the tag as a parameter in the response to an interrogator request as specified in clause 10.5.8 (Get system information). It is coded on four bits.

It is an element of the protocol. There is no implicit or explicit assumption that the 4 bits are actually implemented in the physical memory structure of the tag.

Table 14 — DSFID security status

Bit	Meaning	Value	Description
Bit 1	DSFID lock bit	0	Not locked
		1	Locked
Bit 2 to Bit 4	Reserved for future use	0	

6.10 Start of frame pattern (SOF)

6.10.1 Interrogator request

The interrogator request shall start always with a SOF pattern. The SOF pattern is defined in clauses 5.1.3.3 (Type A) and 5.2.2.3 (Type B).

6.10.2 Tag response

The tag response shall start always with a SOF pattern. The SOF pattern is defined in clauses 5.1.4.2 (Type A) and 5.2.3.2 (Type B).

6.11 End of frame pattern (EOF)

6.11.1 Interrogator request

The interrogator request shall end always with an EOF pattern. The EOF pattern is defined in clauses 5.1.3.4 (Type A) and 5.2.2.4 (Type B).

6.11.2 Tag response

The tag response shall end always with an EOF pattern. The EOF pattern is defined in clauses 5.1.4.3 (Type A) and 5.2.3.3 (Type B).

6.12 CRC

The CRC ensures the integrity of transmitted and received data packets. This part of ISO/IEC 18000 uses the reverse CRC specified by the CCITT (Consultative Committee for International Telegraph and Telephone) for error detection. The 16-bit cyclic redundancy code is calculated using the following polynomial with an initial value of 0x0000:

$$P(X) = x^{16} + x^{12} + x^{5} + x^{0}$$

The initial register content shall be all zeros: "0000" .The CRC length is 16 bits.

The CRC check has the following characteristics:

Reverse CRC-CCITT 16 as used in ISO/IEC 11784 or ISO/IEC 11785

Reversibility - The original data together with associated CRC, when fed back into the same CRC generator will regenerate the initial value (all zero’s).

The request CRC is calculated on all bits of the request after the SOF up to the CRC field. The tag shall detect the presence of the request CRC by the number of transmitted bits.

The request CRC is calculated on all bits of the request after the SOF up to the CRC field. The response CRC is calculated on all bits of the response after the SOF up to the CRC field. If the CRCT flag is set in the request, the tag shall generate and include the CRC in its response.

Upon reception of a request from the interrogator, if the tag detects that a CRC is present, the tag shall verify the CRC value. If it is invalid, it shall discard the frame and remain silent.

Upon reception of a response from the tag, the interrogator shall verify the CRC value. If it is invalid, actions to be performed are left to the responsibility of the interrogator designer.

Examples of possible implementations are given in Annex A.

6.13 Application family identifier (AFI)

AFI (Application family identifier) represents the type of application targeted by the interrogator and is used to extract from all the tags present only the tags meeting the required application criteria.

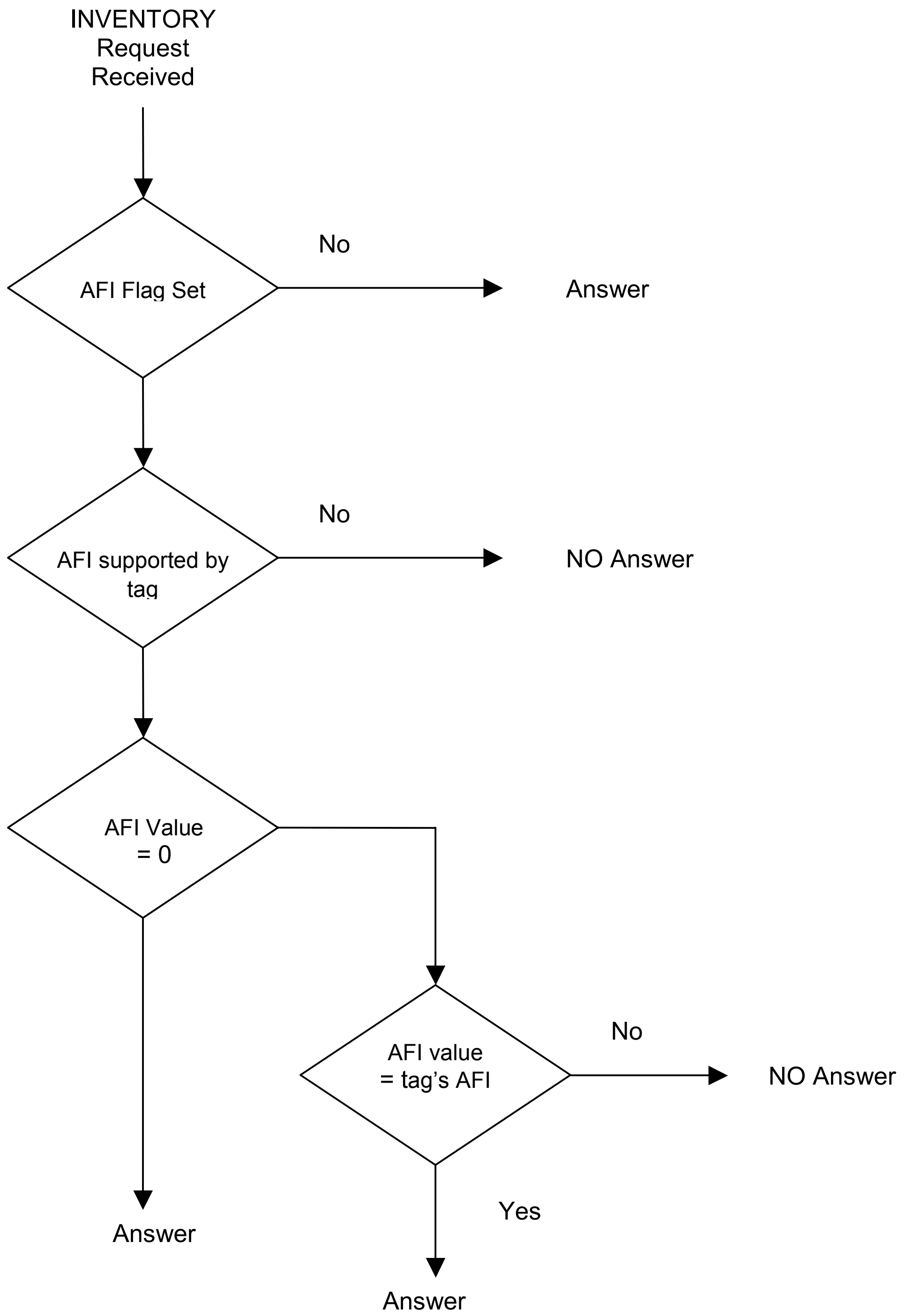
It may be programmed and locked by the respective commands.

AFI is coded on one byte, which constitutes 2 nibbles of 4 bits each. The most significant nibble of AFI is used to code one specific or all application families, as defined in ISO/IEC 15961 and ISO/IEC 15962. The least significant nibble of AFI is used to code one specific or all application sub-families. Sub-family codes different from 0 are proprietary.

The support of AFI by the tag is optional.

If AFI is not supported by the tag and if the AFI flag is set, the tag shall not answer whatever the AFI value is in the request.

If AFI is supported by the tag, it shall answer according to the matching rules described in Figure 20.



NOTE "Answer" means that the tag shall respond to the INVENTORY request.

Figure 20 — Tag decision tree for AFI

6.14 Data storage format identifier (DSFID)

The Data storage format identifier indicates how the data is structured in the tag memory.

It may be programmed and locked by the respective commands. It is coded on one byte. It allows for instant knowledge on the logical organisation of the data.

If the programming and locking commands are not supported by the tag, the tag shall answer to these commands with the error flag set and the error code "1".

If it is not supported or has not been programmed, the tag shall return the default value "00" in answer to the commands requesting its value.

7 User memory organisation

The user memory is accessed in blocks of 32 bits.

Up to 256 blocks can be addressed. This leads to a maximum user data memory capacity of up to 1024 bits.

Table 15 — User data memory organization

Block Address	Size	Description
0	32 bits	User data
...	...	…
255	32 bits	User data

8 Tag states

A tag can be in one of the four following states:

- Power-Off
- Ready
- Selected
- Quiet

The support of Power-Off, Ready and Quiet states is mandatory. The support of the Selected state is optional.

After powering up, the tag enters the Ready state. A change between states takes place via a field change (on/off) or via the commands SELECT, STAY QUIET and RESET TO READY, respectively. When the tag cannot process an interrogator request (e.g. CRC error etc...), it shall stay in its current state.

8.1 Power-off state

The tag is in the Power-off state when it cannot be activated by the interrogator.

8.2 Ready state

The tag is in the Ready state when it is activated by the interrogator.

8.3 Quiet state

A tag enters the Quiet state after receiving the STAY QUIET command issued to the tag. In the Quiet state, the tag shall process any request where the ADR flag is set.

The tags shall enter the Quiet state if it is in Selected state and receives a SELECT command addressed to another tag.

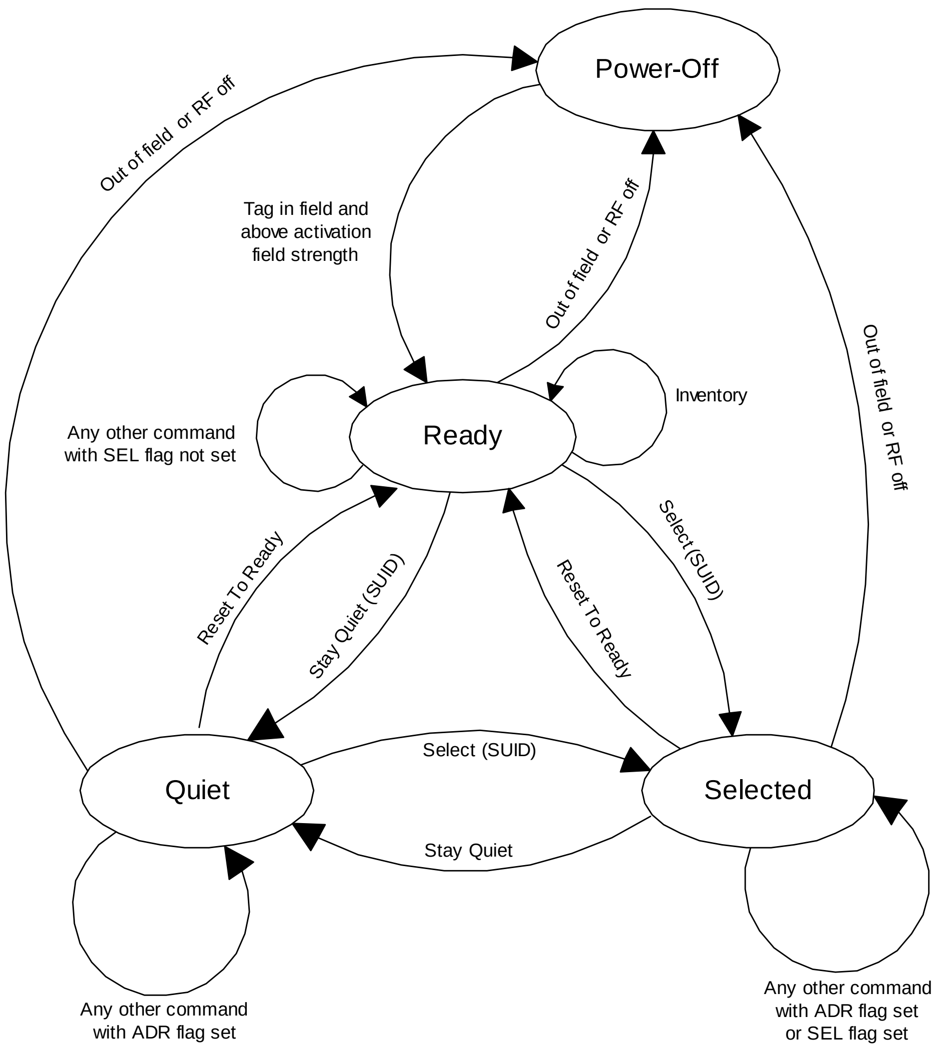
8.4 Selected state

A tag enters the Selected state after receiving the SELECT command with matching SUID. In the Selected state, the respective commands with SEL flag = 1 are valid only for the selected tag.

Only one tag should be in the Selected state at a time. If a first tag is in the Selected state and a second tag will be selected by the SELECT command, the first tag shall enter automatically the Quiet state.

8.5 State diagram

In each state, the tag accepts only special commands. All other commands are ignored.



NOTE Entering the Power-off state after the tag is out of field or RF field has been switched off might not be immediate as in some implementations a capacitor may allow to remember the state for a few milliseconds, typically 20ms.

Figure 21 — Tag state diagram

9 Anti-collision

The purpose of the anti-collision sequence is to make an inventory of the tags present in the interrogator field by their unique sub-ID (SUID).

The interrogator is the master of the communication with one or multiple tags. It initiates communication by issuing the INVENTORY request.

The tag shall send its response in the slot determined or shall not respond, according to the algorithm described in clause 9.2.

9.1 Request parameters

When issuing the INVENTORY request, the interrogator shall set the NOS flag to the desired setting (1 or 16 slots) and add after the command field the mask length and the mask value.

The mask length n indicates the number of significant bits of the mask value. It can have any value between 0 and 44 when 16 slots are used and any value between 0 and 47 when 1 slot is used.

SOF	Flags	Command	AFI (optional)	Mask length(n), $0 \le n \le 47$	Mask value	CRC (optional)	EOF
	5 bits	6 bits	8 bits	6 bits	n bits	16 bits	

Figure 22 — Inventory request format

The AFI field shall be present if the AFI flag is set.

To switch to the next slot, the interrogator sends an EOF.

9.2 Request processing by the tag

Upon reception of a valid request, the tag shall process it by executing the operation sequence specified in the following text in italics. The step sequence is also graphically represented.

NbS is the total number of slots (1 or 16)

SN is the current slot number (0 to 15)

SN_length is set to 0 when 1 slot is used and set to 4 when 16 slots are used

LSB (value, n) function returns the n least significant bits of value

"&" is the concatenation operator

Slot_Frame is either a SOF or an EOF

SN= 0

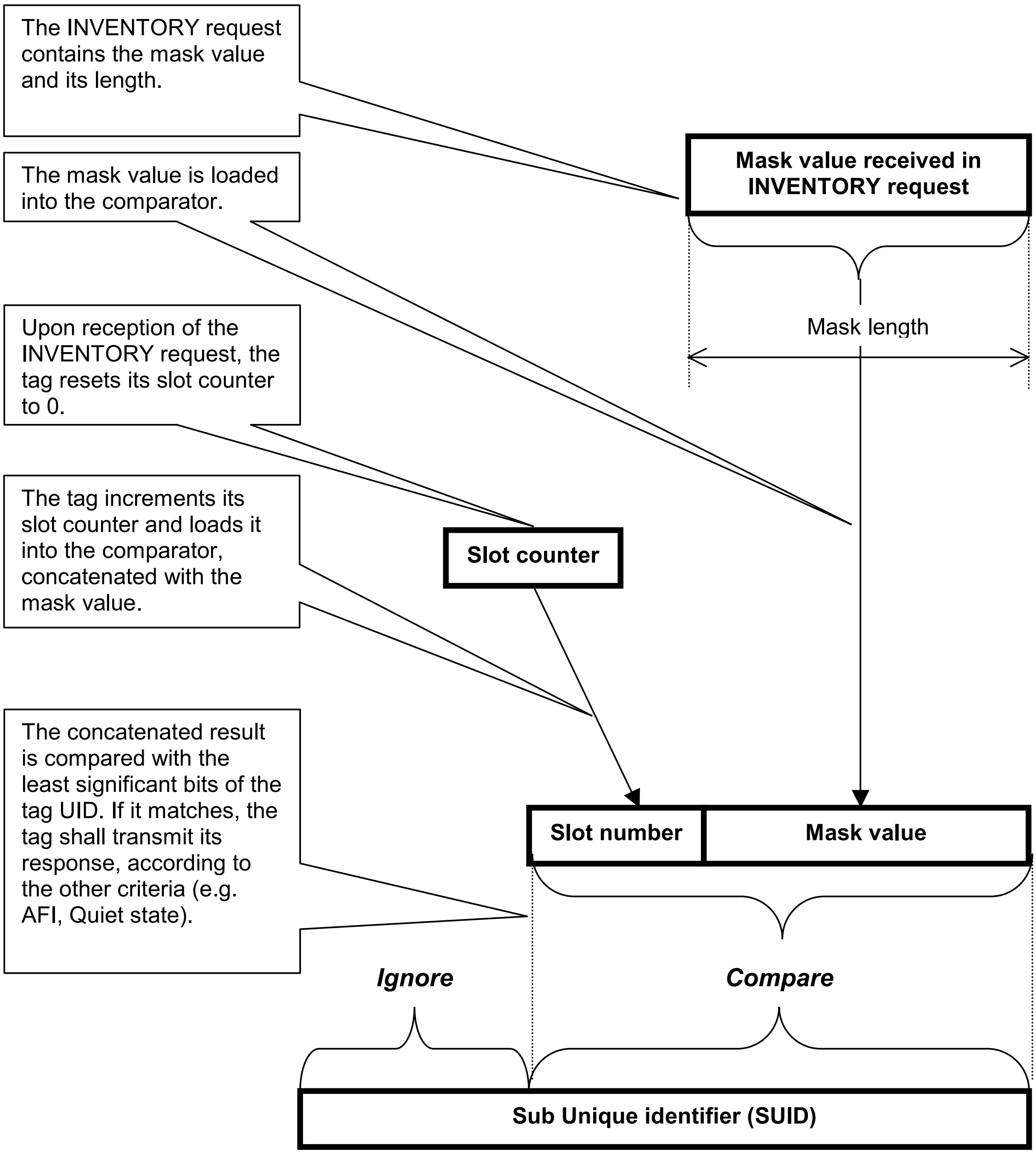
if NOS flag then

NbS =1 SN_length=0

Else NbS = 16 SN_length = 4

endif

```
label1:  if LSB(UID, SN_length + Mask_length) = LSB(SN, SN_length) & LSB(Mask, Mask_length) then
             transmit response to inventory request
         endif
         wait (Slot_Frame)
         if Slot_Frame= SOF then
             Stop anticollision and decode/process request
             Exit
         Endif
         if SN<NbS-1 then
             SN = SN +1
             Goto label1
             Exit
         Endif
         exit
```



NOTE When the slot number is 1 (NOS flag is set to 1), the comparison is made only on the mask (without padding).

Figure 23 — Principle of comparison between the mask value, slot number and SUID

9.3 Explanation of anti-collision sequences

9.3.1 Anti-collision sequence with 1 slot

The following description explains a typical anti-collision sequence where the number of slots is 1.

a) The interrogator sends an INVENTORY request.

   If the SUID of the tag is completely unknown, the value of the Mask length is set to 0 and the Mask value is omitted. After a precisely defined time, all tags in the Ready state transmit simultaneously their responses.

   If the least significant part of the tag SUID is partly known, the attached parameters consist of the Mask length n and of the Mask value. After a precisely defined time, all tags in the Ready state that have the least significant part of their SUID equal to the mask value sent in the INVENTORY request transmit simultaneously their responses.

b) The interrogator checks the tag responses bitwise.

   If there is no tag responding, continue at a).

   If there is only one tag responding, no collision occurs and the tag SUID is received and registered by the interrogator. Continue at c).

   If there are more than one tags responding, the interrogator reads additional SUID bits of the tags and expands the Mask value with these bits, until the first collision occurs. The interrogator recognizes the bit position of this collision and expands the Mask value to 0 or 1, respectively, dependent on which serial number branch should be selected. Continue at a).

c) The interrogator can communicate with the respective tag by sending requests issued to that tag. If the interrogator sends another INVENTORY request, continue at a)

9.3.2 Anti-collision sequence with 16 slots

Figure 24 summarises the main cases that can occur during a typical anti-collision sequence where the number of slots is 16.

The different steps are:

a) the interrogator sends an INVENTORY request, in a frame, terminated by a EOF. The number of slots is 16.

b) tag 1 transmits its response in slot 0. It is the only one to do so, therefore no collision occurs and its SUID is received and registered by the interrogator.

c) the interrogator sends an EOF, meaning to switch to the next slot.

d) in slot 1, two tags 2 and 3 transmits their response, this generates a collision. The interrogator detects it and remembers that a collision was detected in slot 1.

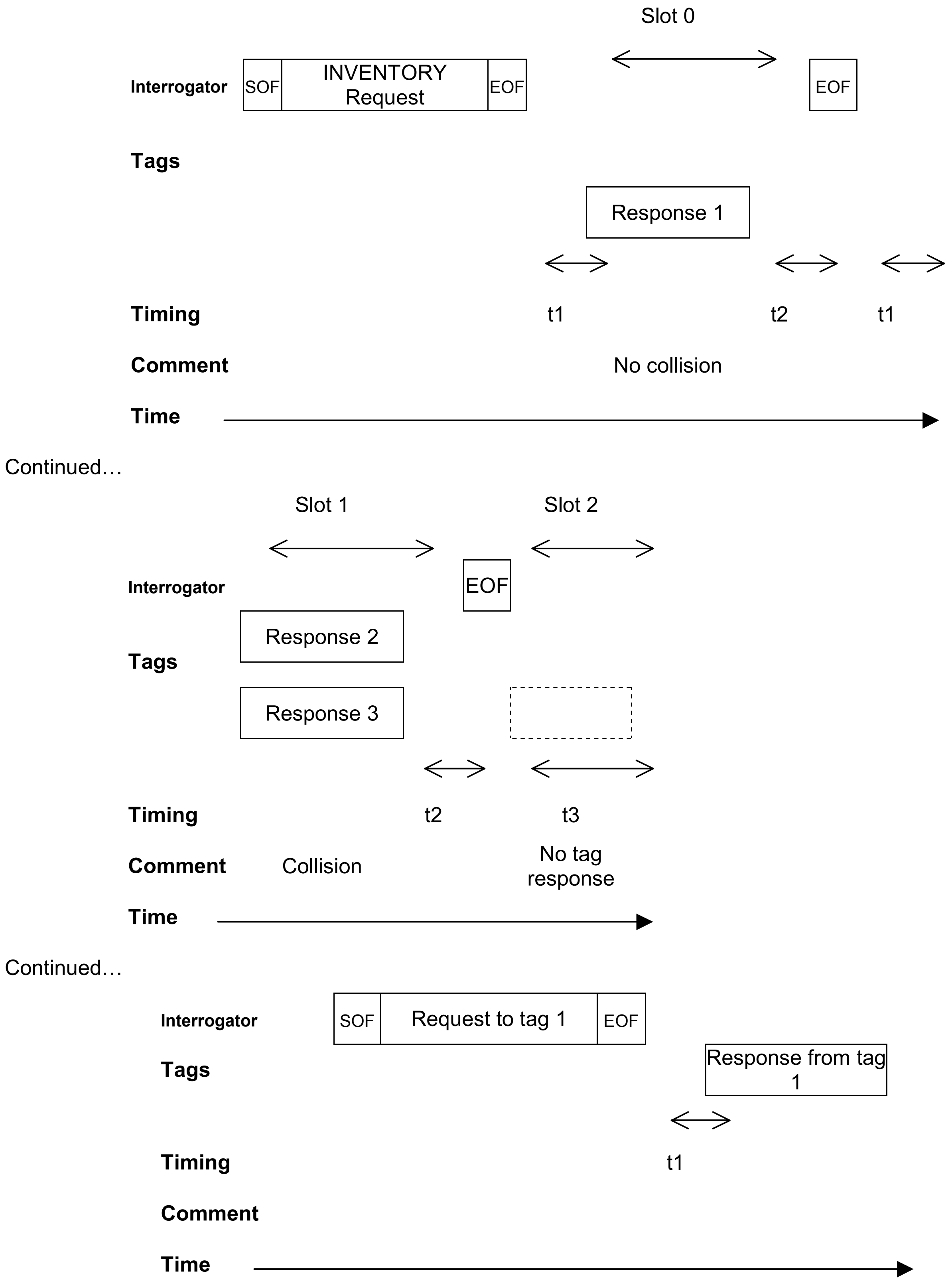
e) the interrogator sends an EOF, meaning to switch to the next slot.

f) in slot 2, no tag transmits a response. Therefore the interrogator does not detect a tag SOF and decides to send an addressed request (for instance a Read Block) to tag 1, which SUID was already correctly received.

g) all tags detect a SOF and exit the anti-collision sequence. They process this request and since the request is addressed to tag 1, only tag 1 transmit its response.

h) all tags are ready to receive another request. If it is an INVENTORY command, the slot numbering sequence restarts from 0.

NOTE The decision to interrupt the anti-collision sequence is up to the interrogator. It could have continued to send EOF's till slot 16 and then send the request to tag 1.



NOTE t1, t2 and t3 are specified in the timing specifications.

Figure 24 — Description of a possible anti-collision sequence

9.3.3 Mixed population with tags of type A and B

The following description explains a typical anti-collision sequence when tags of both type A and type B are in the interrogator field (or expected to be).

a) the interrogator switches on the RF field with f_{Ac} and waits the power up time of approximately 2,5 ms.

b) the interrogator performs an anti-collision sequence according to clause 9.3.1 (1 slot) or clause 9.3.2 (16 slots).

c) the interrogator switches off the RF field.

d) the interrogator switches on the RF field with f_{Bc} and charges the tag during 10ms to 50 ms.

e) the interrogator performs an anti-collision sequence according to clause 9.3.1 (1 slot) or clause 9.3.2 (16 slots).

f) the interrogator switches off the RF field.

NOTE The order can be swapped from a), b), c), d), e), f) to d), e), f), a), b), c).

A more detailed example of a mixed population is given in Annex C.

10 Commands

10.1 Command classification

10.1.1 Mandatory commands

A Mandatory command shall be supported by tags and interrogators.

Mandatory commands shall be implemented as specified in this part of ISO/IEC 18000.

10.1.2 Optional commands

Optional commands are specified in this part of ISO/IEC 18000. Interrogators shall be technically capable of supporting all optional commands that are specified in this part of ISO/IEC 18000 (although need not be set up to do so).

Tags may or may not support optional commands.

Optional commands shall be implemented as specified in this part of ISO/IEC 18000.

10.1.3 Custom commands

Custom commands are not specified in this part of ISO/IEC 18000.

10.1.4 Proprietary commands

Proprietary commands are not specified in this part of ISO/IEC 18000.

In order to ensure tags interoperability, the International Standardized functions (e.g. Read, Write) shall be implemented in the tags using mandatory and optional commands as defined in this part of ISO/IEC 18000.

Custom and Proprietary commands should be used only to perform functions that are not defined in this part of ISO/IEC 18000.

If a custom or proprietary command solely duplicates the functionality of a mandatory or optional command specified in this part of ISO/IEC 18000, the corresponding mandatory or optional command shall be supported by the tag.

10.2 Command code structure

The command code is on 6 bits.

Table 16 — Command classes

Code	Class
'00' – '0F'	Mandatory
'10' – '27'	Optional
'28' – '37'	Customer
'38' – '3F'	Proprietary

All tags with the same IC Manufacturer code and same IC reference code (IRC) shall behave the same.

Tags that do not support the Multi-Read command specified in Annex D shall remain silent on receiving the Multi-read command.

NOTE This is required to ensure interoperability by avoiding collisions between tags of type A or B with tags specified in Annex D.

NOTE The attention of interrogator designers is drawn on the possibility that tag manufacturers may implement Custom Commands and/or Proprietary Commands, if not disabled, in quite different ways for the same Command Code, which may lead to errors whose consequences cannot be predicted. It is therefore recommended that Custom Commands and/or Proprietary Commands, if not disabled, are performed only after having requested from the tags the IC Manufacturer Code and the IC version. These two parameters, linked with the IC manufacturer information, will inform the interrogator on the supported commands and their syntax.

10.3 Command list

Table 17 — Command list

Command	Code	Type	Function	Valid in state
Inventory	'00'	Mandatory	Anti-collision loop	Ready
Stay quiet	'01'	Mandatory	Forces a tag into the Quiet state	Ready, Selected
RFU	'02' – 0F'	Mandatory	Reserved for future use	
Read single block	'10'	Optional	Reads a single user memory block	Ready, Quiet, Selected
Read single block with security status	'11'	Optional	Reads a single user memory block with security status	Ready, Quiet, Selected
Read multiple blocks	'12'	Optional	Reads multiple user memory blocks	Ready, Quiet, Selected
Read multiple blocks with security status	'13'	Optional	Reads multiple user memory blocks with security status	Ready, Quiet, Selected
Write single block	'14'	Optional	Writes a single user memory block	Ready, Quiet, Selected
Write multiple blocks	'15'	Optional	Writes multiple user memory blocks	Ready, Quiet, Selected
Lock block	'16'	Optional	Locks a single user memory block	Ready, Quiet, Selected
Get system information	'17'	Optional	Reads specified system memory data	Ready, Quiet, Selected
Select	'18'	Optional	Forces a tag into the Selected state	Ready, Quiet, Selected
Reset to ready	'19'	Optional	Forces a selected tag into the Ready state	Quiet, Selected
Write system data	'1A'	Optional	Writes specified system data (e.g. AFI or DSFID)	Ready, Quiet, Selected
Lock system data	'1B'	Optional	Locks specified system data (e.g. AFI or DSFID	Ready, Quiet, Selected
RFU	'1C'	Optional	Multi-Read – see Annex D	
RFU	'1C' – '27'	Optional	Reserved for future use	
NN	'28' – '37'	Custom	IC Manufacturer specific commands	
NN	'38' – '3F'	Proprietary	IC Manufacturer specific commands	

10.4 Mandatory commands

10.4.1 INVENTORY

The formats of the request parameters and of the response depend on the setting of the Inventory flag.

In Type A(FDX) the response to the Inventory request consists of

- A 2 kbit/s dual pattern if the inventory flag is set
- A 4 kbit/s Manchester coded data signal if the inventory flag is not set

10.4.1.1 Inventory when the inventory flag is set

Upon reception of this command without error,

- If the AFI flag is set to 0, all tags in the Ready state shall perform the anti-collision sequence (see clause 9).
- If the AFI flag is set to 1, only the tag(s) with corresponding AFI (parameter 1) shall perform the anti-collision sequence (see clause 6.13).

The NOS flag determines whether 1 or 16 slots are used.

If a tag detects an error, it shall remain silent.

SOF	Flags	Command	Parameter 1	Parameter 2	Parameter 3	CRC	EOF
	01xxx	INVENTORY	AFI (optional)	Mask length(n) $0 \leq n \leq$ SUID length	Mask value	(optional)	
	5 bits	6 bits	8 bits	6 bits	n bits	16 bits	

Figure 25 — INVENTORY request format when inventory flag is set

SOF	Data	CRC	EOF
	Remaining section of the SUID (SUID without Mask value)	(optional)	
	48 - n bits	16 bits	

Figure 26 — INVENTORY response format when inventory flag was set in the request

10.4.1.2 Inventory when the inventory flag is NOT set

When the inventory flag is not set, the NOS flag shall be set to 1 to indicate only one slot. This will cause the tag to answer immediately by transmitting its SUID.

Upon reception of this command without error,

- If the AFI flag is set to 0, the tag shall answer by transmitting its SUID.
- If the AFI flag is set to 1, the tag shall answer by transmitting its SUID only if its AFI matches the requested AFI (see clause 6.13).

SOF	Flags	Command	Parameter 1	CRC	EOF
	00xx1	INVENTORY	AFI (optional)	(optional)	
	5 bits	6 bits	8 bits	16 bits	

Figure 27 — INVENTORY request format when inventory flag is NOT set

SOF	Data	CRC	EOF
	SUID	(optional)	
	48 bits	16 bits	

Figure 28 — INVENTORY response format when inventory flag was NOT set in the request

10.4.2 STAY QUIET

Upon reception of this command without error, a tag in either Ready state or Selected state shall enter the Quiet state and shall NOT send back a response.

A STAY QUIET command with both SEL and ADR flag set to 0 or both set to 1 is not allowed.

There is NO response to the STAY QUIET request, even if the tag detects an error.

SOF	Flags	Command	Parameter	CRC	EOF
		STAY QUIET	SUID (optional)	(optional)	
	5 bits	6 bits	48 bits	16 bits	

Figure 29 — STAY QUIET request format

10.5 Optional commands

10.5.1 READ SINGLE BLOCK

Upon reception of this command without error, a tag shall respond with the content of the respective user memory block.

SOF	Flags	Command	Parameter 1	Parameter 2	CRC	EOF
		READ SINGLE BLOCK	SUID (optional)	Block address	(optional)	
	5 bits	6 bits	48 bits	6 bits	16 bits	

Figure 30 — READ SINGLE BLOCK request format

SOF	Error flag	Data	CRC	EOF
	0	User memory block data	(optional)	
	1 bit	32 bits	16 bits	

Figure 31 — READ SINGLE BLOCK response format if no error

SOF	Error flag	Error code	CRC	EOF
			(optional)	
	1 bit	3 bits	16 bits	

Figure 32 — READ SINGLE BLOCK response format

10.5.2 READ SINGLE BLOCK WITH SECURITY STATUS

Upon reception of this command without error, the tag shall read the requested block and the block security status and send back their value in the response

SOF	Flags	Command	Parameter 1	Parameter 2	CRC	EOF
		READ SINGLE BLOCK WITH SECURITY STATUS	SUID (optional)	Block address	(optional)	
	5 bits	6 bits	48 bits	8 bits	16 bits	

Figure 33 — READ SINGLE BLOCK WITH SECURITY STATUS request format

SOF	Error flag	Data1	Data2	CRC	EOF
	0	Security status	User memory block data (depending on security status)	(optional)	
	1 bit	4 bits	32 bits	16 bits	

Figure 34 — READ SINGLE BLOCK WITH SECURITY STATUS response format if no error

SOF	Error flag	Error code	CRC	EOF
	1		(optional)	
	1 bit	3 bits	16 bits	

Figure 35 — READ SINGLE BLOCK WITH SECURITY STATUS response format if error

10.5.3 READ MULTIPLE BLOCKS

Upon reception of this command without error, the tag shall read the requested block(s) and send back their value in the response. The blocks are numbered from 0 to 255.

The number of blocks in the request is one less than the number of blocks that the tag shall return in its response. E.g. a value of 6 in the "Number of blocks" field requests to read 7 blocks. A value of 0 requests to read a single block.

SOF	Flags	Command	Parameter 1	Parameter 2	Parameter 3	CRC	EOF
		READ MULTIPLE BLOCKS	SUID (optional)	First block number	Number of blocks	(optional)	
	5 bits	6 bits	48 bits	8 bits	8 bits	16 bits	

Figure 36 — READ MULTIPLE BLOCKS request format

SOF	Error flag	Data	CRC	EOF
	0	User memory block data (not present on error)	(optional)	
	1 bit	32 bits	16 bits	
		Repeated as needed		

Figure 37 — READ MULTIPLE BLOCKS response format if no error

SOF	Error flag	Error code	CRC	EOF
	1		(optional)	
	1 bit	3 bits	16 bits	

Figure 38 — READ MULTIPLE BLOCKS response format if error

10.5.4 READ MULTIPLE BLOCKS WITH SECURITY STATUS

Upon reception of this command without error, the tag shall read the requested block(s) and the block(s) security status and send back their value in the response sequentially block by block. The blocks are numbered from 0 to 255.

The number of blocks in the request is one less than the number of blocks that the tag shall return in its response. E.g. a value of 6 in the "Number of blocks" field requests to read 7 blocks. A value of 0 requests to read a single block.

SOF	Flags	Command	Parameter 1	Parameter 2	Parameter 3	CRC	EOF
		READ MULTIPLE BLOCKS WITH SECURITY STATUS	SUID (optional)	First block number	Number of blocks	(optional)	
	5 bits	6 bits	48 bits	8 bits	8 bits	16 bits	

Figure 39 — READ MULTIPLE BLOCKS WITH SECURITY STATUS request format

SOF	Error flag	Data 1	Data 2	CRC	EOF
	0	Security status	User memory block data (depending on security status)	(optional)	
	1 bit	4 bits	32 bits	16 bits	
		Repeated as needed			

Figure 40 — READ MULTIPLE BLOCKS WITH SECURITY STATUS response format if no error

SOF	Error flag	Error code	CRC	EOF
	1		(optional)	
	1 bit	3 bits	16 bits	

Figure 41 — READ MULTIPLE BLOCKS WITH SECURITY STATUS response format if error

10.5.5 WRITE SINGLE BLOCK

Upon reception of this command without error, the tag shall write the requested block with the data contained in the request and report the success of the operation in the response. The tag shall return its response when it has completed the write operation and latest either after 20ms upon detection of the last falling edge of the interrogator request (Type A) or after the interrogator has switched off the field (Type B).

If the tag cannot perform the requested operation, it shall return an error code as specified in clause 6.6.

NOTE For Type B tags, the interrogator shall keep the field on after the EOF for a time long enough to perform the memory programming so that the tag is powered. This time depends of the type of memory used by the tag and may be determined from the IC reference code. Switching off the field triggers the tag response.

SOF	Flags	Command	Parameter 1	Parameter 2	Data	CRC	EOF
		WRITE SINGLE BLOCK	SUID (optional)	Block number	Block data	(optional)	
	5 bits	6 bits	48 bits	8 bits	32 bits	16 bits	

Figure 42 — WRITE SINGLE BLOCK request format

SOF	Error flag	CRC	EOF
	0	(optional)	
	1 bit	16 bits	

Figure 43 — WRITE SINGLE BLOCK response format if no error

SOF	Error flag	Error code	CRC	EOF
	1		(optional)	
	1 bit	3 bits	16 bits	

Figure 44 — WRITE SINGLE BLOCK response format if error

10.5.6 WRITE MULTIPLE BLOCKS

Upon reception of this command without error, the tag shall write the requested block(s) with the data contained in the request and report the success of the operation in the response. The tag shall return its response when it has completed the write operation and latest either after 20ms upon detection of the last falling edge of the interrogator request (Type A) or after the interrogator has switched off the field (Type B).

If the tag cannot perform the requested operation, it shall return an error code as specified in clause 6.6.

NOTE For Type B tags, the interrogator shall keep the field on after the EOF for a time long enough to perform the memory programming so that the tag is powered. This time depends of the type of memory used by the tag and may be determined from the IC reference code. Switching off the field triggers the tag response.

The blocks are numbered from 0 to 255. The number of blocks in the request is one less than the number of blocks that the tag shall write. E.g. a value of 6 in the "Number of blocks" field requests to write 7 blocks. The "Data" field shall contain 7 blocks. A value of 0 in the "Number of blocks" field requests to write 1 block. The "Data" field shall contain 1 block.

SOF	Flags	Command	Parameter 1	Parameter 2	Parameter 3	Data	CRC	EOF
		WRITE MULTIPLE BLOCKS	SUID (optional)	First block number	Number of blocks	Block data	(optional)	
	5 bits	6 bits	48 bits	8 bits	8 bits	32 bits	16 bits	
						Repeated as needed		

Figure 45 — WRITE MULTIPLE BLOCKS request format

SOF	Error flag	CRC	EOF
	0	(optional)	
	1 bit	16 bits	

Figure 46 — WRITE MULTIPLE BLOCKS response format if no error

SOF	Error flag	Error code	CRC	EOF
	1		(optional)	
	1 bit	3 bits	16 bits	

Figure 47 — WRITE SINGLE BLOCK response format if error

10.5.7 LOCK BLOCK

Upon reception of this command without error, the tag shall lock permanently the requested block. The tag shall return its response when it has completed the lock operation and latest either after 20ms upon detection of the last falling edge of the interrogator request (Type A) or after the interrogator has switched off the field (Type B).

If the tag cannot perform the requested operation, it shall return an error code as specified in clause 6.6.

NOTE For Type B tags, the interrogator shall keep the field on after the EOF for a time long enough to perform the memory programming so that the tag is powered. This time depends of the type of memory used by the tag and may be determined from the IC reference code. Switching off the field triggers the tag response.

SOF	Flags	Command	Parameter 1	Parameter 2	CRC	EOF
		LOCK BLOCK	SUID (optional)	Block number	(optional)	
	5 bits	6 bits	48 bits	8 bits	16 bits	

Figure 48 — LOCK BLOCK request format

SOF	Error flag	CRC	EOF
	0	(optional)	
	1 bit	16 bits	

Figure 49 — LOCK BLOCK response format if no error

SOF	Error flag	Error code	CRC	EOF
	1		(optional)	
	1 bit	3 bits	16 bits	

Figure 50 — LOCK BLOCK response format if error

10.5.8 GET SYSTEM INFORMATION

Upon reception of this command without error, the tag shall read the requested system memory block(s) and send back their value in the response.

SOF	Flags	Command	Parameter 1	Parameter 2	CRC	EOF
		GET SYSTEM INFORMATION	SUID (optional)	System memory selector (see Table 18)	(optional)	
	5 bits	6 bits	48 bits	8 bits	16 bits	

Figure 51 — GET SYSTEM INFORMATION request format

Each system memory block is selected with the system memory selector. If no bit of the System memory selector is set, no data are transmitted. If more than one bit of the System memory selector is set, the respective system memory blocks are transmitted successively.

Table 18 — System Memory Selector

Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
MSN	ACL + MFC	IRC	NOB	BSS	AFI + AFI security status	DSFID + DSFID security status	RFU

Table 19 — System Memory Blocks

System data	Size	Description
MSN	40 bits	Manufacturer Serial Number (see Note), mandatory
ACL + MFC	16 bits	Allocation Class + Manufacturer Code (see Note)
IRC	8 bits	IC Reference Code
NOB	9 bits	Number of blocks (0 to 256)
BSS	0 to 1024 bits, dependent on the user data memory block number	User Data Memory Block Security Status 4 bits for each existing block, the least significant 4 bits correspond to block 0, the most significant 4 bits correspond to last existing block
AFI	12 bits	Application Family Identifier (8 bits) LSB + AFI security status (4 bits) MSB
DSFID	12 bits	Data Storage Format Identifier (8 bits) LSB + DSFID security status (4 bits) MSB

SOF	Error flag	Data	CRC	EOF
	0	System memory blocks	(optional)	
	1 bit	0 bit to 1024 bits (dependent on system memory selector)	16 bits	
		Repeated as needed		

Figure 52 — GET SYSTEM INFORMATION response format if no error

SOF	Error flag	Error code	CRC	EOF
	1		(optional)	
	1 bit	3 bits	16 bits	

Figure 53 — GET SYSTEM INFORMATION response format if error

10.5.9 SELECT

The Select command shall always be executed with SEL flag set to 0 and ADR flag set to 1. Upon reception of this command without error

- If the SUID is equal to its own SUID, the tag shall enter the Selected state and shall send a response.
- If it is different,
  - A tag in a non Selected state (Quiet or Ready) shall keep its state and shall not send a response.
  - The tag in the Selected state shall enter the Quiet state and shall not send a response.

SOF	Flags	Command	Parameter	CRC	EOF
		SELECT	SUID	(optional)	
	5 bits	6 bits	48 bits	16 bits	

Figure 54 — SELECT request format

SOF	Error flag	CRC	EOF
	0	(optional)	
	1 bit	16 bits	

Figure 55 — SELECT response format if no error

SOF	Error flag	Error code	CRC	EOF
	1		(optional)	
	1 bit	3 bits	16 bits	

Figure 56 — SELECT response format if error

10.5.10 RESET TO READY

Upon reception of this command without error, a tag in the Quiet or Selected state shall enter the Ready state.

In Quiet state, an attached UID leads to the change of only one tag from Quiet to Ready state, while not attaching an UID leads to the change of all tags in Quiet state to Ready state.

SOF	Flags	Command	Parameter	CRC	EOF
		RESET TO READY	SUID (optional)	(optional)	
	5 bits	6 bits	48 bits	16 bits	

Figure 57 — RESET TO READY

SOF	Error flag	CRC	EOF
	0	(optional)	
	1 bit	16 bits	

Figure 58 — RESET TO READY response format if no error

SOF	Error flag	Error code	CRC	EOF
	1		(optional)	
	1 bit	3 bits	16 bits	

Figure 59 — RESET TO READY response format if error

10.5.11 WRITE SYSTEM DATA

Upon reception of this command without error, the tag shall write the AFI or DSFID value (dependent on System data selector, see Table 20) into its memory and report the success of the operation in the response. The tag shall return its response when it has completed the write operation and latest either after 20ms upon detection of the last falling edge of the interrogator request (Type A) or after the interrogator has switched off the field (Type B).

If the tag cannot perform the requested operation, it shall return an error code as specified in clause 6.6.

NOTE For Type B tags, the interrogator shall keep the field on after the EOF for a time long enough to perform the memory programming so that the tag is powered. This time depends of the type of memory used by the tag and may be determined from the IC reference code. Switching off the field triggers the tag response.

SOF	Flags	Command	Parameter 1	Parameter 2	Parameter 3	CRC	EOF
		WRITE SYSTEM DATA	SUID (optional)	System data selector (see Table 20)	System data (see Table 14)	(optional)	
	5 bits	6 bits	48 bits	2 bits	8 bits	16 bits	

Figure 60 — WRITE SYSTEM DATA request format

Table 20 — System data selector

System data selector	System data
00	AFI
01	DSFID
10	RFU
11	RFU

SOF	Error flag	CRC	EOF
	0	(optional)	
	1 bit	16 bits	

Figure 61 — WRITE SYSTEM DATA response format if no error

SOF	Error flag	Error code	CRC	EOF
	1		(optional)	
	1 bit	3 bits	16 bits	

Figure 62 — WRITE SYSTEM DATA response format if error

10.5.12 LOCK SYSTEM DATA

Upon reception of this command without error, the tag shall lock the AFI or DSFID value (dependent on system memory selector, see Table 20) permanently into its memory. The tag shall return its response when it has completed the lock operation and latest either after 20ms upon detection of the last falling edge of the interrogator request (Type A) or after the interrogator has switched off the field (Type B).

If the tag cannot perform the requested operation, it shall return an error code as specified in clause 6.6.

NOTE For Type B tags, the interrogator shall keep the field on after the EOF for a time long enough to perform the memory programming so that the tag is powered. This time depends of the type of memory used by the tag and may be determined from the IC reference code. Switching off the field triggers the tag response.

SOF	Flags	Command	Parameter 1	Parameter 2	CRC	EOF
		LOCK SYSTEM DATA	SUID (optional)	System data selector (see Table 20)	(optional)	
	5 bits	6 bits	48 bits	2 bits	16 bits	

Figure 63 — LOCK SYSTEM DATA request format

SOF	Error flag	CRC	EOF
	0	(optional)	
	1 bit	16 bits	

Figure 64 — LOCK SYSTEM DATA response format if no error

SOF	Error flag	Error code	CRC	EOF
	1		(optional)	
	1 bit	3 bits	16 bits	

Figure 65 — LOCK SYSTEM DATA response format if error

10.5.13 Optional command execution in inventory mode

Some commands may be executed in inventory mode by setting the inventory flag to 1. The support of this mechanism by the tag is optional.

The list of command codes that can be executed in inventory mode is specified in Table 21.

When receiving a request with the Inventory flag set to "1", the tag shall perform the inventory sequence. The inventory mode related fields that are "Mask Length" and "Mask Value" followed by the requested command related parameters (in non addressed mode) shall be contained in the Request. See Figure 66.

If the tag detects an error during the inventory sequence, it shall remain silent.

The syntax of the returned data in the response shall be according to the command code. See Figure 67.

If the tag detects an error during this sequence, it shall set the error flag and return the corresponding error code.

The AFI mechanism, if supported by the tag, shall be implemented as specified in clause 6.13.

Type A tags transmit the remaining section of the SUID in dual pattern code. The following data (Error Flag, Data 2, optional CRC in no error case; Error Flag, Error Code, optional CRC in error case) is transmitted in Manchester Code.

Table 21— Commands executable in Inventory mode

Command	Code	Function
Read single block	‘10’	Reads a single user memory block
Read single block with security status	'11'	Reads a single user memory block with security status
Read multiple blocks	'12'	Reads multiple user memory blocks
Read multiple blocks with security status	'13'	Reads multiple user memory blocks with security status
Get system information	'17'	Reads specified system memory data

SOF	Flags	Command	Parameter 1	Parameter 2	Parameter 3	Parameter 4	CRC	EOF
		See Table 21	AFI (optional)	Mask length(n) $0 \leq n \leq$ SUID length	Mask value	Command Parameter	(optional)	
	0**1**xxx							
	5 bits	6 bits	8 bits	6 bits	n bits	see relevant command	16 bits	

Figure 66— Request format of commands executed in inventory mode

SOF	Data 1	Error Flag	Data 2	CRC	EOF
	Remaining section of the SUID (SUID without Mask value)	0	Response Data as defined in the executed command	(optional)	
	48 - n bits	1 bit	xx bits	16 bits	

Figure 67 — Response format to command in inventory mode if no error in Data 2 section

SOF	Data 1	Error Flag	Error Code	CRC	EOF
	Remaining section of the SUID (SUID without Mask value)	1		(optional)	
	48 - n bits	1 bit	3 bits	16 bits	

Figure 68 — Response format to command in inventory mode if error in Data 2 section

10.6 Custom commands

This part of ISO/IEC 18000 does not specify custom commands by definition.

10.7 Proprietary commands

This part of ISO/IEC 18000 does not specify proprietary commands by definition.

11 Protocol timing specifications

The interrogator and the tag shall comply with the following protocol timing specifications.

11.1 Type A (FDX)

11.1.1 Tag waiting time before transmitting its response after reception of an EOF from the interrogator

When the tag has detected an EOF of a valid interrogator request or when this EOF is in the normal sequence of a valid interrogator request, it shall wait for a time Tp1 before starting to transmit its response to an interrogator request or before switching to the next slot when in an inventory process (see clauses 9.2 and 9.3).

T_{Ap1} starts from the detection of the falling edge of the EOF received from the interrogator (see clause 5.1.3.4).

NOTE The synchronisation on the falling edge of the interrogator-to-tag EOF is needed for ensuring the required synchronisation of the tag responses.

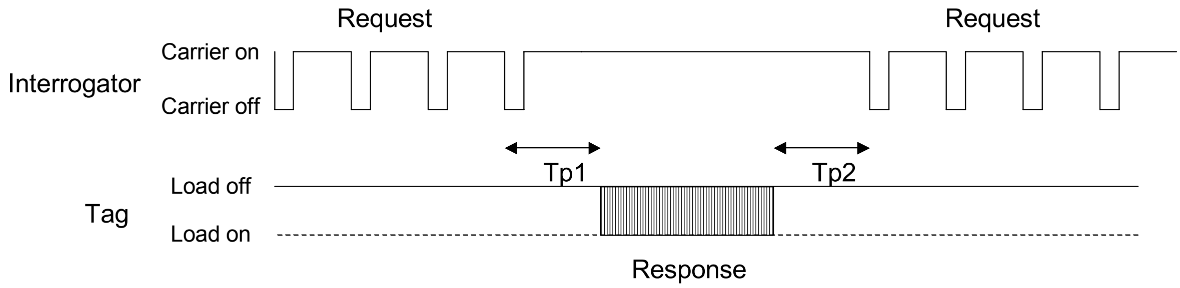


Figure 69 — Protocol timing diagram

The minimum value of T_{Ap1} is T_{Ap1min} = 204 T_{Ac} (1,632 ms).

The typical value of T_{Ap1} is T_{Ap1typ} = 209 T_{Ac} (1,672 ms).

The maximum value of T_{Ap1} is T_{Ap1max} = 213 T_c (1,704 ms).

If the tag detects a carrier modulation during this time T_{Ap1}, it shall reset its T_{Ap1} timer and wait for a further time T_{Ap1} before starting to transmit its response to an interrogator request or to switch to the next slot when in an inventory process.

11.1.2 Interrogator waiting time before sending a subsequent request

a) When the interrogator has received a tag response to a previous request other than INVENTORY and QUIET, it shall wait a time T_{Ap2} before sending a subsequent request. T_{Ap2} starts from the time the last bit has been received from the tag.

b) When the interrogator has sent a QUIET request (which causes no tag response), it shall wait a time T_{Ap2} before sending a subsequent request. T_{Ap2} starts from the end of the QUIET request EOF (falling edge of the EOF plus 0,336 ms (42 T_{Ac}), see clause 5.1.3.2).

The minimum value of T_{Ap2} is T_{Ap2min} = 150 Tac (1,2 ms).

NOTE 1 This ensures that the tags are ready to receive this subsequent request (see clause 5.1.3.2).

NOTE 2 The interrogator should wait at least 2,5 ms after it activated the powering field before sending the first request, to ensure that the tags are ready to receive it (see clause 5.1.3.2).

c) When the interrogator has sent an INVENTORY request, it is in an inventory process. See clause 11.1.3.

11.1.3 Interrogator waiting time before switching to the next slot during an inventory process

An inventory process is started when the interrogator sends an INVENTORY request. (see clauses 9.2 and 9.3).

To switch to the next slot, the interrogator sends an EOF after waiting a time specified in the following sub-clauses.

11.1.3.1 When the interrogator has started to receive one or more tag responses

During an inventory process, when the interrogator has started to receive one or more tag responses (i.e. it has detected a tag SOF and/or a collision), it shall

- wait for the complete reception of the tag responses (i.e. when a tag last bit has been received or when the tag nominal response time t_{Anrt} has elapsed),
- wait an additional time T_{Ap2}
- and then send an EOF to switch to the next slot (choice selection if NOS flag was set to 0, see clause 6.5.2) or send a subsequent request (which could be again an INVENTORY request).

t2 starts from the time the last bit has been received from the tag.

The minimum value of T_{Ap2} is T_{Ap2min} = 150 T_{Ac} (1,2 ms).

t_{Art} is dependent on the current mask value and of the CRCT setting (see clauses 6.5.4 and 10.4.1).

11.1.3.2 When the interrogator has received no tag response

During an inventory process, when the interrogator has received no tag response, it shall wait a time T_{Ap3} before sending a subsequent EOF to switch to the next slot (choice selection if NOS flag was set to 0, see clause 6.5.2) or sending a subsequent request (which could be again an INVENTORY request).

T_{Ap3} starts from the time the interrogator has generated the falling edge of the last sent EOF.

The minimum value of T_{Ap3} is T_{Ap3min} = T_{Ap1max} (1,704 ms) + t_{Asof} (0,768 ms)

T_{Asof} is the time duration for a tag to transmit an SOF to the interrogator (see clause 5.1.4.2).

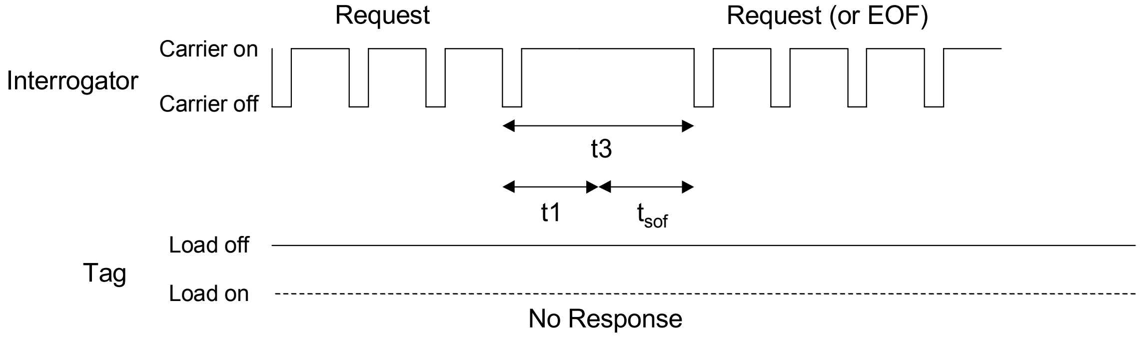


Figure 70 — Protocol timing diagram

11.2 Type B (HDX)

11.2.1 Tag waiting time before transmitting its response after reception of an EOF from the interrogator

After the transmission of the request frame the interrogator switches off the field. When the tag has detected a falling edge of the field after a valid interrogator request, it shall wait for a time t_{Bp1} before transmitting its response to an interrogator request.

T_{Bp1} starts from the detection of the falling edge of the field (see clause 5.1.3.4).

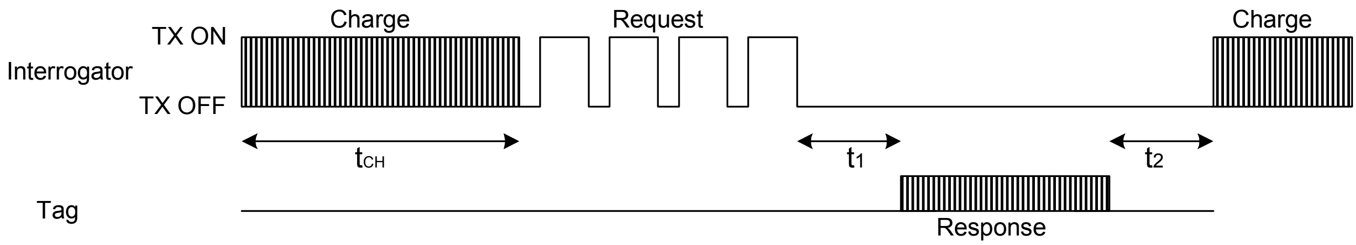


Figure 71 — Protocol timing diagram including charging

The minimum value of T_{Bp1} is T_{Bp1min} = 208 T_{Bc} (1,55ms)

The maximum value of T_{Bp1} is T_{Bp1max} = t3

If the tag detects a carrier modulation during this time T_{Bp1}, it shall reset its T_{Bp1} timer and wait for a further time T_{Bp1} before starting to transmit its response to a interrogator request or to switch to the next slot when in an inventory process.

11.2.2 Interrogator waiting time before sending a subsequent request

When the interrogator has received the last bit of a tag response to a previous request, the interrogator can immediately switch on the carrier signal to re-charge the tag, T_{Bp2min} =0.

11.2.3 Interrogator waiting time before switching to the next slot during an inventory process

An inventory process is started when the interrogator sends an INVENTORY request. (see clauses 9.2 and 9.3).

To switch to the next slot, the interrogator switches on the field to re-charge the tags in the field. The rising edge of the field followed by the time T_{BRCH} triggers the tag to switch to the next slot.

11.2.3.1 When the interrogator has started to receive one or more tag responses

During an inventory process, when the interrogator has started to receive one or more tag responses (i.e. it has detected a tag SOF and/or a collision), it may

- wait for the complete reception of the tag responses (i.e. when a tag last bit has been received or when the tag nominal response time T_{Bnrt} has elapsed),
- or switch on the field to re-charge the tags and switch to the next slot (choice selection if NOS flag was set to 0, see clause 6.5.2),
- or send a subsequent request.

T_{Bnrt} is dependent on the current mask value and of the CRCT setting (see clauses 6.5.4 and 10.4.1).

11.2.3.2 When the interrogator has received no tag response

During an inventory process, when the interrogator has received no tag response, it shall wait a time T_{B3} before switching on the field to re-charge the tags in the field and to switch to the next slot (choice selection if NOS flag was set to 0, see clause 6.5.2) or sending a subsequent request (which could be again an INVENTORY request).

T_{B3} starts from the time the interrogator has switched off the field and has generated the falling edge of the last sent EOF.

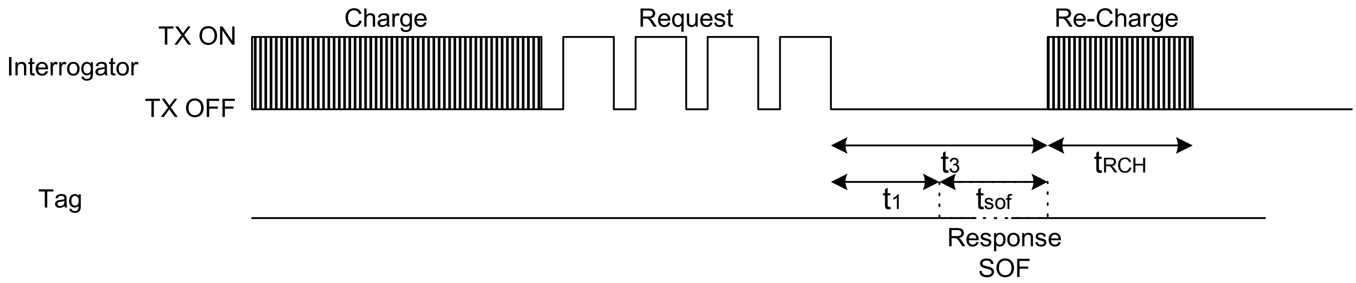


Figure 72 — Protocol timing diagram including charging and re-charging

The minimum value of T_{B3} is $T_{B3min} = T_{B1max} + T_{Bsof}$

T_{Bsof} is the time duration for a tag to transmit an SOF to the interrogator (see clause 5.1.4.2).

11.2.4 Tag charge and re-charge

The HDX tags have to be charged before operation. This is done by switching on the power for a defined time.

The charge phase is executed at the beginning of every request and depends on the system parameters and distance to the interrogator.

$T_{Brch_{min}} = 10ms$

$T_{Brch_{max}} = 50ms$

During the execution of the INVENTORY request, the tags shall be charged at the beginning as already defined above. Between the slots the tags shall be re-charged.

$T_{Bich_{min}} = 5ms$

$T_{Bich_{max}} = 20ms$

12 Protocol parameters

Ref.	Parameter	Description	Comment/Option
M1-P:1	Who talks first	Interrogator talks first	
M1-P:2	Tag addressing capability	Yes	
M1-P:3	Tag ID	Yes	

Ref.	Parameter	Description	Comment/Option
M1-P:3a	UID Length	The UID consists of 64 bits	
M1-P:3b	UID Format	8 bit Allocation Class 8 bit Manufacturer Code 48 bit Manufacturer Serial Number	

Ref.	Parameter	Description Type A	Description Type B	Comment/Option
M1-P:4	Read size	Minimum read size is 4 bytes Maximum read size is 1Kbyte (in multiple of 4 bytes)		
M1-P:5	Write Size	Same as above M1A-P:4		
M1-P:6	Read Transaction Time	About 28 ms	Fast data rate : About 57ms Slow data rate: About 97ms	Assumptions: One Read single block request with attached SUID, medium PWM times, tag CRC attached
M1-P:7	Write Transaction Time	About 25 ms	Fast data rate : About 81ms Slow data rate: About 141ms	Assumptions: One Write single block request with attached SUID, medium PWM times, interrogator CRC attached, EEPROM programming time not considered

Ref.	Parameter	Description	Comment/Option
M1-P:8	Error detection	Tag to interrogator: CRC with length 16 (dependent on request flag CRCT setting) Interrogator to tag: CRC with length 16 (at the option of the interrogator)	
M1-P:9	Error correction	No	
M1-P:10	Memory size	The maximum memory size is 1024 bits.	
M1-P:11	Command structure and extensibility	The maximum number of commands is 64 (6 bits). 3 mandatory and 13 optional commands are specified. Thus, 48 commands are available for future extensions, custom and proprietary commands. See Table 17.	

13 Anti-collision parameters

The purpose of the anti-collision sequence is to inventory the tags present in the interrogator field by their unique ID.

The interrogator is the master of the communication with one or multiple tags. It initiates tag communication by issuing the INVENTORY request.

The tag shall send its response in the slot determined or shall not respond.

Ref.	Parameter	Description	Comment/Options
M1-A:1	**Type** **(Probabilistic or Deterministic)**	Deterministic	
M1-A:2	**Linearity**	Approximately	
M1-A:3	**Tag inventory capacity**	Theoretically 2^{48} (SUID length is 48 bits)	The number of tags that can be actually inventoried is limited by the mutual detuning of the tags.

Annex A
(informative)

CRC Check for Error Detection

A.1 Description

The CRC error checking circuitry generates a 16 bits CRC to ensure the integrity of transmitted and received data packets The tag uses the reverse CRC-CCITT (Consultative Committee for International Telegraph and Telephone) for error detection. The 16-bit cyclic redundancy code is calculated using the following polynomial with an initial value of 0x0000:

$$P(X) = x^{16} + x^{12} + x^{5} + x^{0}$$

The CRC check has the following characteristics:

Reverse CRC-CCITT 16 as used in ISO/IEC 11784/11785

The CRC 16 bit shift register is initialised to all zeros at the beginning of a command

The incoming data bits are XOR-ed with the MSB of the CRC register and is shifted into the register's LSB

After all data bits have been processed, the CRC register contains the CRC-16 code.

Reversibility - The original data together with associated CRC, when fed back into the same CRC generator will regenerate the initial value (all zero's).

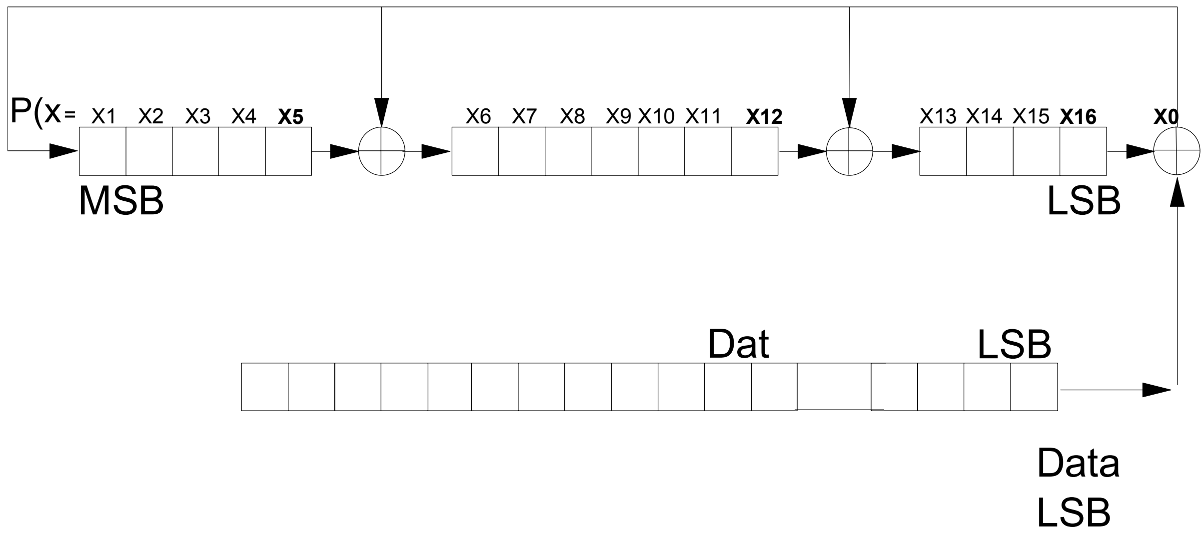


Figure A.1 — Schematic diagram of the CRC check.

A.2 CRC check source code example

```
; BCCH and BCCL contain the 16 bit CRC. Both must be initialized to 0.
; GPR is a general purpose register for temporary storage (scratch register)
; A = Accumulator
; BTJZ    Bit Test Jump Zero
; SETC    Set Carry Flag
; CLRC    Clear Carry Flag
; RRC     Rotate Right Through Carry


; loop start
; test databit for high or low
         BTJZ     %RXDAT,DALOW            ; RXDAT=LOW
         SETC                             ; RXDAT=HIGH
         JMP      BCCGEN
DALOW    CLRC
BCCGEN   RRC      BCCH                    ; Shift
         RRC      BCCL
         JNC      Q1L                     ; C=0
         XOR      %?10000000,BCCH         ; C=1 --> Toggle Q16
Q1L      MOV      BCCH,GPR                ; Q16=0 ?
         AND      %?10000000,GPR
         JZ       D16L
         XOR      %?00001000,BCCL         ; Toggle Q4
         XOR      %?00000100,BCCH         ; Toggle Q11
D16L continue with Program

; repeat loop for n bits
```

Annex B
(informative)

Alternative carrier frequency for Type B operating fields

B.1 Description

An alternative carrier frequency of the RF operating field for type B systems is 125 kHz.

Annex C
(informative)

Description of a typical anti-collision sequence with tags of types A and B

C.1 Description

Table C.1 shows an example of a mixed population with 2 tags of Type A (A1, A2) and 2 tags of Type B (B1, B2). The interrogator performs the anti-collision sequence row by row, whereby the decision to start with type A or type B is with the interrogator.

In the example, the interrogator chooses the slot number to 1. The interrogator detects a collision and decides to proceed with the tags having a 0 at the UID collision position. After recognizing the complete UID of the first tag (A1, B1), the interrogator proceeds with the tags having a 1 at the UID collision position (A2, B2).

The timings are specified in clause 11.

Table C.1— Anti-collision sequence example of a mixed population with 2 tags of Type A (A1, A2) and 2 tags of Type B (B1, B2)

Performer	Type A	Type B
Interrogator	Field ON (125 kHz)	Field ON (134,2 kHz)
Interrogator	Wait for power on time (min. 2,5 ms)	Charge tag for max. 50 ms
Interrogator	INVENTORY request (NOS=1, no mask value)	INVENTORY request (NOS=1, no mask value)
Interrogator	-	Field OFF
Tag	Wait t1 (max. 1,704 ms)	Wait for max 2 ms
Tag	Response of UID (with collision)	Response of UID (with collision)
Interrogator	Wait t2 (min. 1,2 ms)	Field ON with charge for max. 50 ms
Interrogator	INVENTORY request (NOS=1, mask value + 0)	INVENTORY request (NOS=1, mask value + 0)
Interrogator	-	Field OFF
Tag	Wait t1 (max. 1,704 ms)	Wait for max. 2 ms
Tag	Response of remaining UID [A1]	Response of remaining UID [B1]
Interrogator	Wait t2 (min. 1,2 ms)	Field ON with recharge for max. 20 ms
Interrogator	INVENTORY request (NOS=1, mask value + 1)	INVENTORY request (NOS=1, mask value + 1)
Interrogator	-	Field OFF
Tag	Wait t1 (max. 1,704 ms)	Wait for max. 2 ms
Tag	Response of remaining UID [A2]	Response of remaining UID [B2]
Interrogator	Field OFF (125 kHz)	-

NOTE All times are worst case times.

Annex D
(informative)

Optional anti-collision mechanism

D.1 Introduction

This annex describes an optional anti-collision mechanism. It may be implemented optionally in the interrogator and in the tag.

The tag shall conform to either Type A or B and may optionally support this mechanism.

The interrogator shall conform to Types A and B and may optionally support this mechanism.

When this mechanism is supported, request and response shall comply with the definition given in this annex. Furthermore the physical layer shall comply with the definition in this annex.

If the tag does not support the anti-collision protocol extension, it shall remain silent (and therefore not return an error code).

D.2 Description

This optional anti-collision mechanism consists of:

— An interrogator-to-tag command and a tag-to-interrogator response. The code of the interrogator-to-tag command is reserved in this part of ISO/IEC 18000. See clause 10.3. The command and the response formats are specified in this annex.

— To send this command to the tag, the interrogator-to-tag shall use the Type A physical layer. See clause 5.1.3.

— To respond to this command, the tag shall use the physical layer specified in this annex. See clause D.3.4.

— All other commands and responses shall conform to this part of ISO/IEC 18000. In particular, the tag-to-interrogator physical layer described in this annex shall be used for the response to the optional anti-collision command. When the optional anti-collision command is decoded by the tag, the tag shall respond using the sub-carrier (fc/2) and the coding method specified in this annex.

— All responses to normative commands shall be done using the normative physical layer Type A.

D.3 Physical layer for the Multi-read command

This clause and its sub clauses apply only to the execution of the Multi-read command (see clause D.4).

All other commands and responses shall conform to this part of ISO/IEC 18000. See clause 5.

D.3.1 Power transfer

Power transfer to the tag is accomplished by radio frequency via coupling antennas in the tag and in the interrogator. The RF operating field supplies permanently power from the interrogator to the FDX tag. For communication between interrogator and tag, the field is modulated.

D.3.2 Frequency

The carrier frequency of the RF operating field is f_c = 125 kHz.

D.3.3 Interrogator to tag

The interrogator-to-tag link shall comply with the normative Type A (ASK 100%, 125kHz). See clause 5.1.

D.3.4 Tag to interrogator

The tag shall send its answer to the Multi-read command using a sub-carrier (62,5 kHz) modulated with a 1,9 kbit/s ASK coded signal.

In the anti-collision sequence, the tag transmits an acknowledgement (ACK) to the interrogator commands by modulating its sub-carrier during 768µs (48 cycles of sub-carrier).

The response timing is described in Figure D.3.

D.3.4.1 Data coding

A period consists of 16 cycles of sub-carrier. The data modulation is encoded by every two bits, and needs four periods per two 2bits as shown in Figure D.1

The tags complying with this annex shall be able to generate such modulation. Once such modulation is selected in the MULTI-READ command, the tag shall continue to use it until it is powered off.

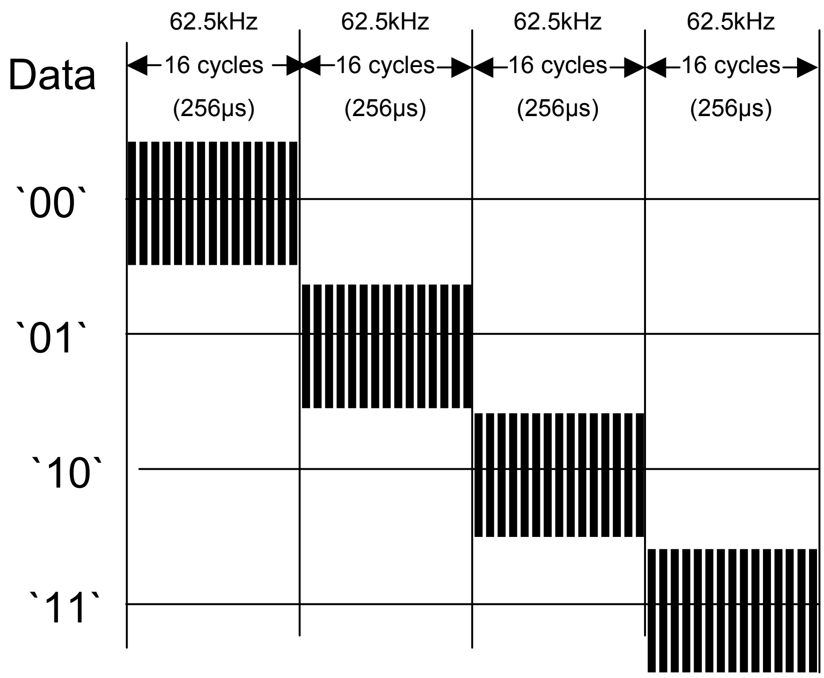


Figure D.1 — Tag ASK Modulation

D.3.4.2 Start of frame pattern of ASK

The tag response shall start with the following six bits sequence: '100100'.

D.3.5 Parameters for optional Multi-read command

D.3.5.1 Interrogator to tag link

See clause 5.3.1 Type A.

D.3.5.2 Tag to interrogator link

Ref.	Parameter Name	Description
M1-R1	Operating Frequency Range Sub-carrier Frequencies	A sub-carrier is used . The frequency (fs) of the sub-carrier load modulation shall be- $f_c/2$(62,5 kHz).
M1-R1a	Default Operating Frequency	125 kHz ± 0,05 kHz
M1-R1b	Operating Channels (for Spread Spectrum systems)	Not appropriate--for this MODE
M1-R1c	Operating Frequency Accuracy	± 0,05 kHz
M1A-R1d	Frequency Hop Rate (for Frequency Hopping [FHSS] systems)	Not appropriate for this MODE
M1A-R:1e	Frequency Hop Sequence (for Frequency Hopping [FHSS] systems)	Not appropriate for this MODE
M1A-R:2	Occupied Channel Bandwidth	± 62,5 kHz
M1A-R:3	Transmit Maximum EIRP	Not appropriate for this MODE
M1A-R:4	Transmit Spurious Emissions	Not appropriate for this MODE
M1A-R:4a	Transmit Spurious Emissions, In-Band (for Spread Spectrum systems)	Not appropriate for this MODE
M1A-R:4b	Transmit Spurious Emissions, Out-of-Band	Not appropriate for this MODE
M1A-R:5	Transmit Spectrum Mask	Not appropriate for this MODE
M1-R6a	Transmit to Receive Turn Around Time	Minimum 0,75 ms
M1A-R6b	Receive to Transmit Turn Around Time	Minimum 0,25 ms
M1A-R6c	Dwell Time or Transmit Power On Ramp	Not appropriate for this MODE
M1A-R6d	Decay Time or Transmit Power Down Ramp	Not appropriate for this MODE
M1A-R7	Modulation (on the carrier)	The RF tag shall be capable of communication to the interrogator via an inductive coupling area whereby the carrier frequency is modulated to generate sub-carrier. The sub-carrier shall be generated by switching a load in the RF tag.
M1A-R7a	Spreading Sequence (for Frequency Hopping [FHSS] systems)	Not appropriate for this MODE
M1A-R7b	Chip Rate (for Spread Spectrum systems)	Not appropriate for this MODE

Ref.	Parameter Name	Description
M1A-R7c	Chip Rate Accuracy (for Spread Spectrum systems)	Not appropriate for this MODE
M1A-R7d	On-Off Ratio	Not appropriate for this MODE
M1A-R7e	Sub-carrier Frequency	See M1A-R 1 above.
M1A-R7f	Sub-carrier Frequency Accuracy Tolerance of Direct Generated tag to interrogator Link Carrier	Derived from the carrier.
M1A-R7g	Sub-Carrier Modulation	The frequency of the sub-carrier (fs) shall be fc/2. Namely, during the response period from the tag, one bit duration is equal to 16 periods of the sub-carrier wave. The tag shall generate a sub-carrier when data is to be transmitted. The sub-carrier is modulated using ASK (OOK:On Off Keying).
M1A-R7h	Duty Cycle	Not appropriate for this MODE
M1A-R7 i	FM Deviation	Not appropriate for this MODE
M1A-R8	Data Coding	Tag to interrogator: ASK, Load Modulation, NRZ See Figure D.1
M1A-R9	Bit Rate	The data bit rate for the transmission during read and write. Anti-collision shall be nominally fc/64 (~1,95 kbit/s)
M1A-R9a	Bit Rate Accuracy	Derived from the carrier
M1A-R10	Tag Transmit Modulation Accuracy (for Frequency Hopping [FHSS] systems)	Not applicable for this MODE
M1A-R11	Preamble	Preamble is mandatory Framing has been chosen for ease of synchronization and independence of protocol.
M1A-R11a	Preamble Length	Start of Frame(SOF) 12 etu (1 etu = 16/62,5 kHz)
M1A-R11b	Preamble Waveform	SOF is '100100' (12 etu) in ASK modulation.
M1A-R 11c	Bit Sync Sequence	
M1A-R12	Scrambling (for Spread Spectrum systems)	Not appropriate for this MODE
M1A-R13	Bit Transmission Order	Least significant bit (LSB) first
M1A-R14	Reserved	
M1A-R15	Polarization	Not Applicable(Near field)
M1A-R16	Minimum Tag Receiver Bandwidth	± 10 kHz

D.4 Multi-read command

D.4.1 Multi-read request format

The Multi-read command has the general request format specified in clause 6.3.

The command code is '1C'. See clause 10.3.

The meaning of some flags is different from the normative part (see clause 6.5). The meaning of the flags for the Multi-read request is specified in clause D.4.2.

SOF	Flags	Command	AFI (optional)	CRC (optional)
	5 bits	6 bits (`1C`)	8 bits	16 bits

Figure D.2 — Multi-Read request format

D.4.2 Request flags

In the Multi-read command, four flags are used, which meaning depends on the context.

Table D.1 — Multi-read command flags

Command	Flag 1	Flag 2	Flag 3	Flag 4	Flag 5
MULTI-READ	PEXT	INV	ASK Select	AFI	SUID/MUID Select

These flags are described in the subsequent clauses.

D.4.2.1 AFI flag

The meaning of the AFI flag conforms to the normative part. See clause 6.5.1.

D.4.2.2 UID/MID Select flag

The SUID/MID Select flag allows to select whether the SUID (Sub Unique Identifier) or the MID (Multi-read Identifier) is used during the Multi-read anti-collision sequence.

The UID conforms to the normative part. See clause 6.2.2.

The MID consists of 32bits. The MID is programmed by the tag issuer. The MID is different from the SUID. The MID is used in closed systems (that are separated from open systems) where the tag issuer or user control the tag individually.

Table D.2 — Meaning of the SUID/MID Select flag

SUID/MID Select	Meaning the Multi-read command
0	SUID
1	MID

D.4.2.3 ASK Select flag

The ASK Select flag specifies the modulation method that the tag shall use to transmit its response to the Multi-read command. Default value is `0`.

Table D.3 — Meaning of the ASK Select flag

ASK Select	Meaning for the Multi-read command
0	ASK modulation (sub-carrier fc/2). See clause D.3.4
1	RFU

D.5 Anti-collision mechanism

The anti-collision mechanism consists of a sequence of

- A Multi-read command sent by the interrogator
- Responses by the tags, referred to as tag-acknowledgments
- Acknowledgments by the interrogator to tag responses, referred to as interrogator-acknowledgements

D.5.1 Acknowledgement by the interrogator

The interrogator issues the five kinds of acknowledges for separating slot in anti-collision sequence. The time of acknowledge of interrogator shall have a range according to the ASK modulation in Type A.

Table D.4 — Acknowledgement by the interrogator

Interrogator acknowledgement	Slot number	Acknowledge(3 bits)
ACK00	Slot 00	100(608us)
ACK01	Slot 01	101
ACK10	Slot 10	110
ACK11	Slot 11	111

D.5.2 Acknowledgement by the tag

The acknowledgement by the tag consists in modulating the sub-carrier (fs=fc/2) during 768µs.

The tag shall send this acknowledgement when its ID matches the slot number. When another tag sends the acknowledgement just before the response, the tag shall not send the acknowledgement and shall wait the next MULTI-READ command.

The phase of sub-carrier shall be not fixed due to escape methodology for collision.

D.5.3 Timing

The tag and the interrogator shall conform to the following timings. Their values are specified in Table D.5.

- t_{D1} is the time after which the tag shall send its acknowledgement. It starts from the end of MULTI-READ command or the end of interrogator acknowledgement.
- t_{D2} is the time after which the interrogator shall send its acknowledgement. It starts from the end of the reception of the tag acknowledgement.
- t_{D3} is the duration of the tag acknowledgement . See clause D.5.2
- t_{D4} is the duration of the interrogator acknowledgement, that consists of 3 bits. See clause D.5.1
- t_{D5} is the time after which the tag shall send its acknowledgement if no interrogator acknowledgement has been received.

Table D.5 — Timings

Time	Min	Nominal	Max
T_{D1}	752 µs (94/f_{Dc})	768 µs (96/ f_{Dc})	784 µs (98/ f_{Dc})
T_{D2}	240 µs (30/ f_{Dc})	256µs (32/ f_{Dc})	272 µs (34/ f_{Dc})
T_{D3}	752 µs (94/ f_{Dc})	768 µs (96/ f_{Dc})	784 µs (98/ f_{Dc})
T_{D4}	N/a	3 bits	N/a
T_{D5}	752 µs (94/ f_{Dc})	768 µs (96/ f_{Dc})	784 µs (98/ f_{Dc})

Where f_{Dc} =125kHz (1/ f_{Dc} =8µs)

D.5.4 Explanation of an anti-collision sequence

Figure D.3 summarizes the main cases that can occur during a typical anti-collision sequence where the UID is 8 bits.

For illustration, there are four RFID tags in the field.

UID of RF tag 1=`FFh`, UID of RF tag 2 =`00h`, UID of RF tag 3=`5Ah`,

The different steps are:

a) The interrogator sends a MULTI-READ Command, in a frame.

b) RF tag2 transmits its response in slot 00 because its 1st 2 bits (b0B1) is `00b` , therefore no collision occurs and its UID is received and registered by the interrogator;

c) the interrogator sends an ACK00, meaning to switch to the next 2 bits

d) The RF tag 1 and the RF tag 3 are recognized that they have to stop the response for multi read command in this time by receiving ACK00 from the interrogator.

e) In 2nd 2bit(b2b3), the UID of RF tag2 is also `00b`. Therefore RF tag2 transmits its response in slot 00. No collision occurs and its UID is received and registered by the interrogator.

f) the interrogator sends an ACK00, meaning to switch to the next 2 bit

g) In 3rd 2bit(b4b5), the UID of RF tag2 is also `00b`. Therefore RF tag2 transmits its response in slot 00. No collision occurs and its UID is received and registered by the interrogator.

h) the interrogator sends an ACK00, meaning to switch to the next 2 bit

i) In 4th 2bit(b6b7), the UID of RF tag2 is also `00b`. Therefore RF tag2 transmits its response in slot 00. No collision occurs and its UID is received and registered by the interrogator.

j) the interrogator sends an ACK00,meaning to finish the recognition of UID (for illustration, UID is 8bit)

k) The RF tag2 is completed the response of its UID, and responses to following MULTI- READ command no more.

l) The interrogator sends a MULTI-READ Command, in a frame.

m) The RF tag3 transmits there response in slot 01 because its 1st 2 bits (b0b1) is `01b`, therefore no collision occurs and its UID is received and registered by the interrogator;

n) the interrogator sends an ACK01, meaning to switch to the next 2 bit

o) The RF tag 1 is recognized that it have to stop the response for MULTI-READ command in this time by receiving ACK01 from the interrogator.

p) In 2nd 2bit(b2b3), the UID of RF tag3 is `01b`. Therefore RF tag3 transmits its response in slot 01. No collision occurs and its UID is received and registered by the interrogator.

q) the interrogator sends an ACK01, meaning to switch to the next 2 bits.

r) In 3rd 2bit(b4b5), the UID of RF tag3 is '10b'. Therefore RF tag2 transmits its response in slot 10. No collision occurs and its UID is received and registered by the interrogator.

s) the interrogator sends an ACK10, meaning to switch to the next 2 bit

t) In 4th 2bit(b6b7), the UID of RF tag3 is also `10b`. Therefore RF tag 3 transmits its response in slot 10. No collision occurs and its UID is received and registered by the interrogator.

u) the interrogator sends an ACK10,meaning to finish the recognition of UID (for illustration, UID is 8bits)

v) The RF tag3 has completed the response of its UID, and responses to following MULTI- READ command no more

w) The interrogator sends a Multi Read Command, in a frame.

x) RF tag1 transmits there response in slot 11 because its 1st 2 bits (b0B1) is '1b', therefore no collision occurs and its UID is received and registered by the interrogator;

y) the interrogator sends an ACK11, meaning to switch to the next 2 bits

z) In 2nd 2bit(b2b3), the UID of RF tag1 is also `11b`. Therefore RF tag 2 transmits there response in slot 11. No collision occurs and its UID is received and registered by the interrogator.

aa) the interrogator sends an ACK11, meaning to switch to the next 2 bit

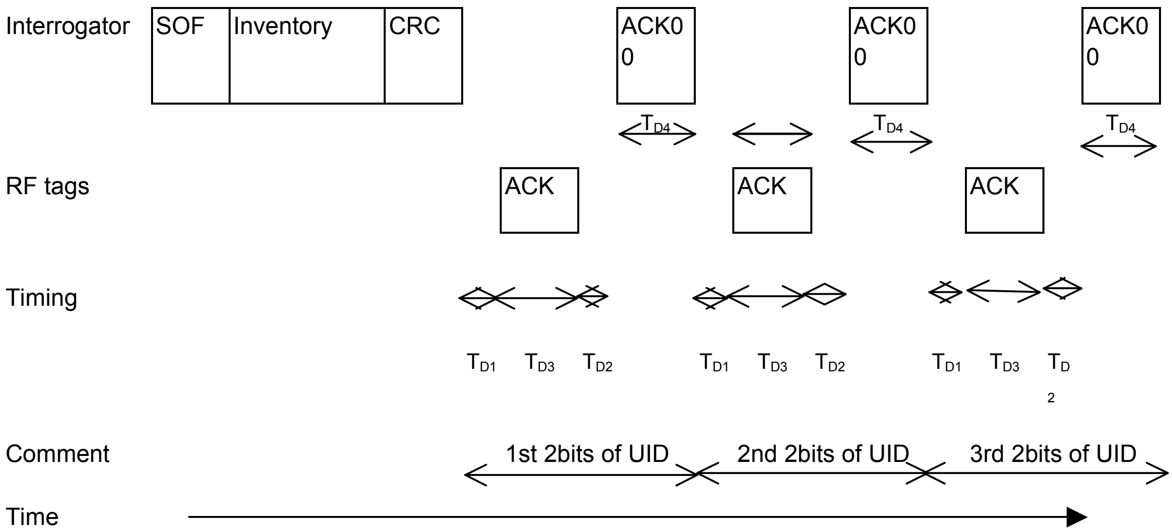
bb) In 3rd 2bit(b4b5), the UID of RF tag1 is also `11b`. Therefore RF tag1 transmits its response in slot 11. No collision occurs and its UID is received and registered by the interrogator.

cc) the interrogator sends an ACK11, meaning to switch to the next 2 bit

dd) In 4th 2bit(b6b7), the UID of RF tag1 is also `11b`. Therefore RF tag 2 transmits there response in slot 11. No collision occurs and its UID is received and registered by the interrogator.

ee) the interrogator sends an ACK11,meaning to finish the recognition of UID (for illustration, UID is 8bits)

UID of RF TAG= `00h`



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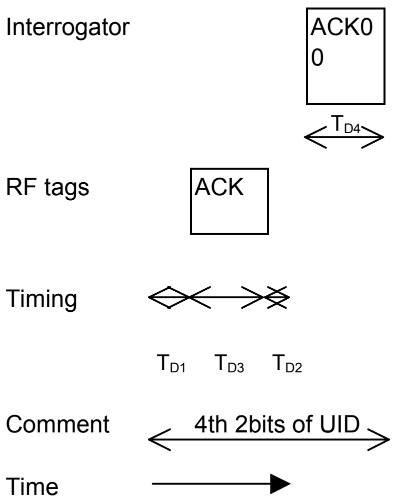
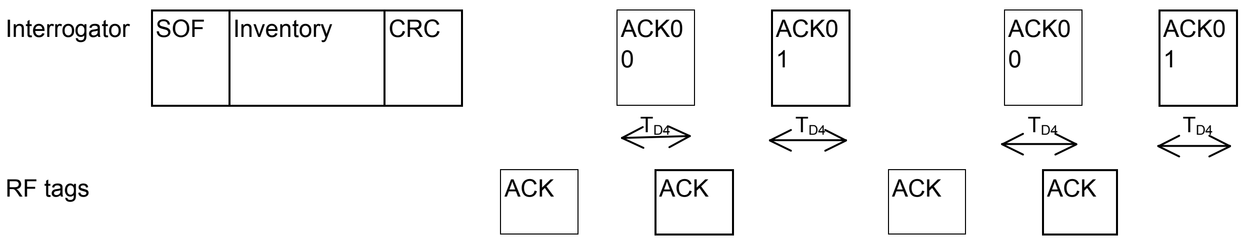
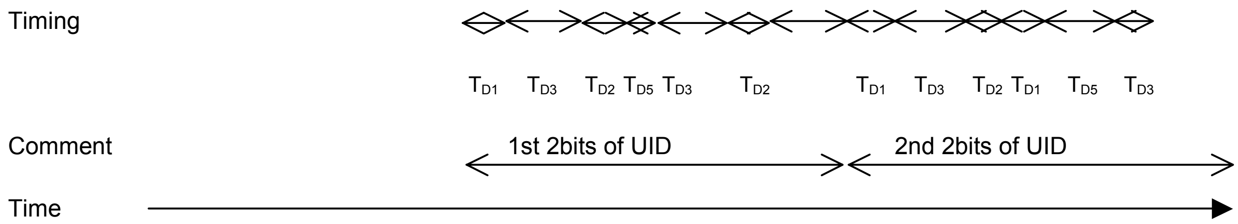


UID of RF TAG= `5Ah`





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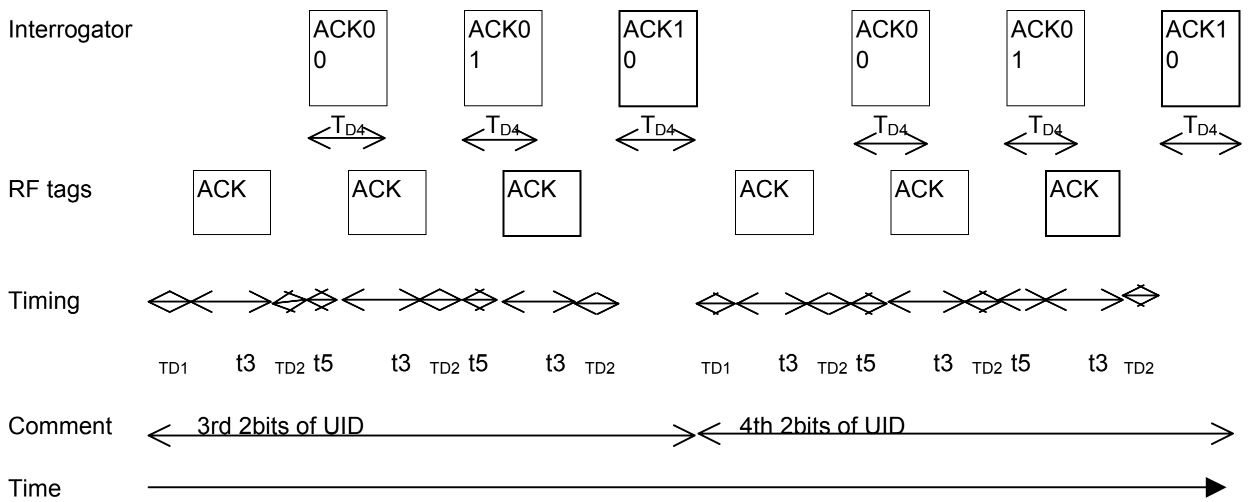

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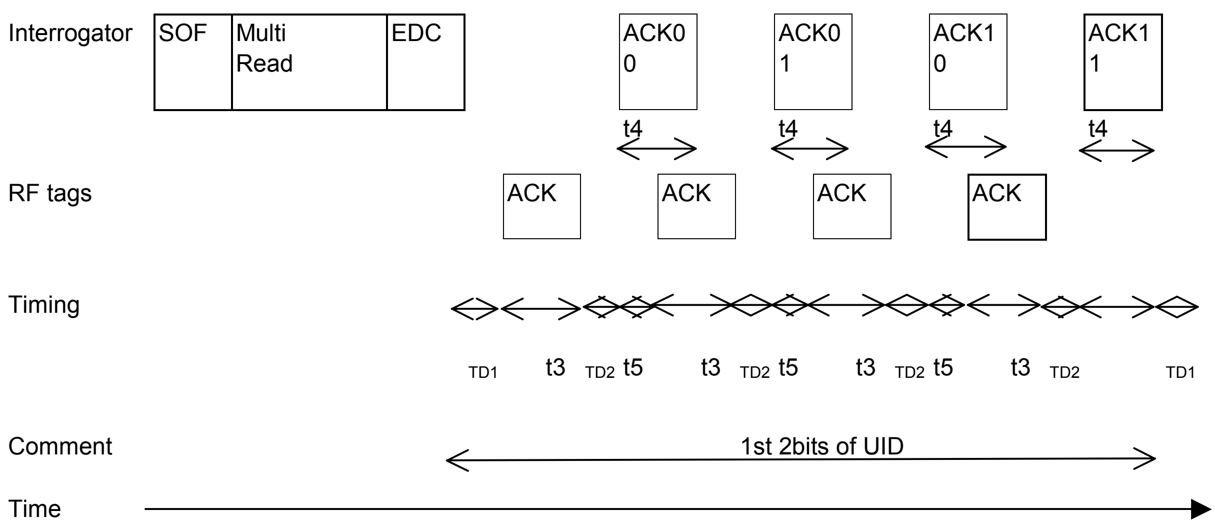

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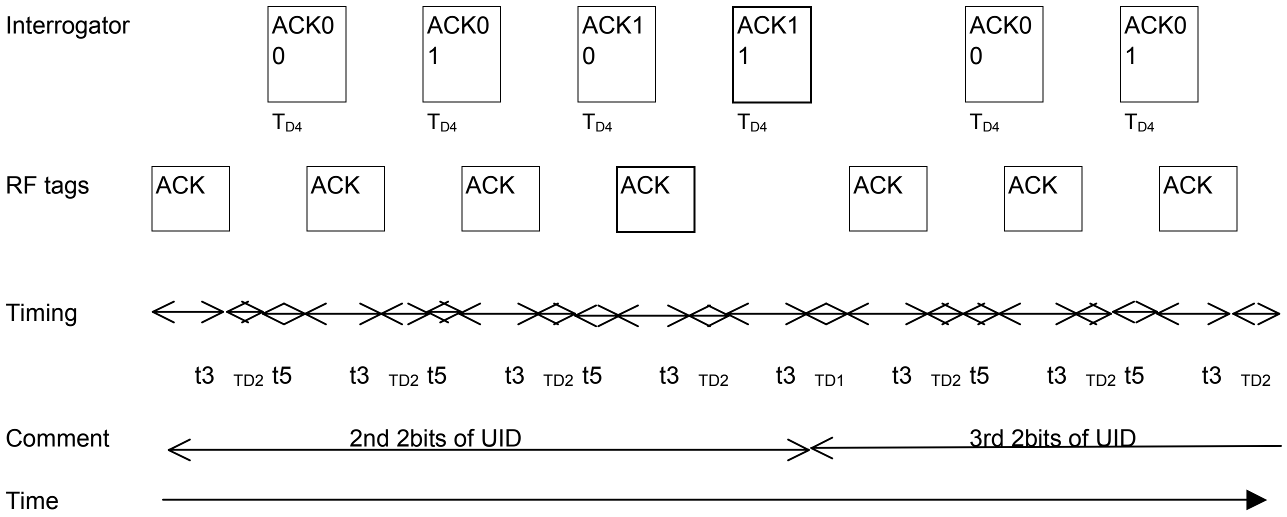

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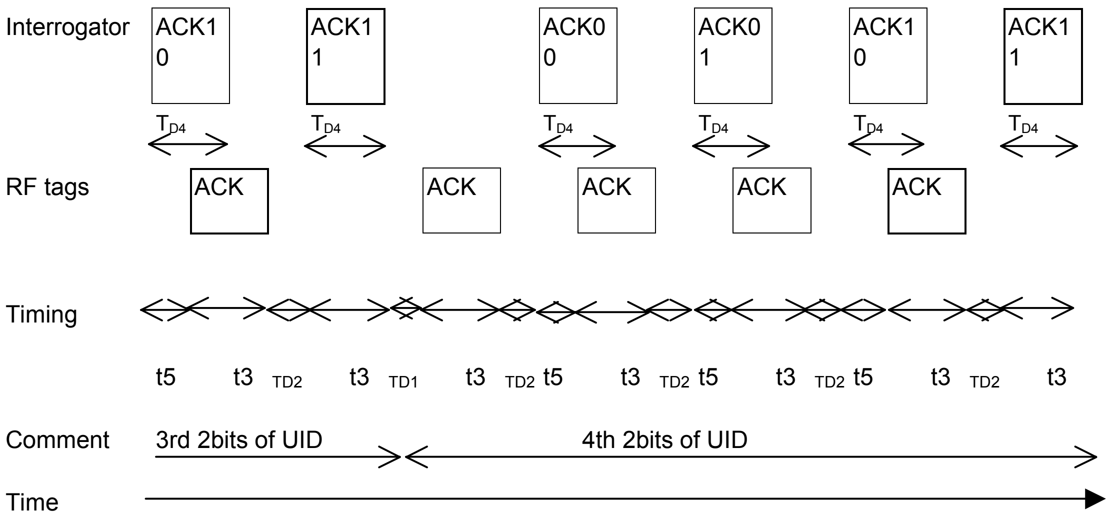

Figure D.3 — Description of a possible anti-collision sequence (ex. 4 tags)

In above explanation, the true acknowledgement is drawn by heavy dark square box. The other light dark square boxes are not real which is shall suspend the present anti-collision sequence, and shall wait the next MULTI-READ command. And moreover, to prevent the recurrence of collision. The phase of sub-carrier may be changed from previous response by tag.described those acknowledgements for the understanding of response timing.

D.5.4.1 Explanation of the collision

In the explanation in Figure D.3, the collision may occur between tag3 and tag1 if tag3 UID changes to 'Fa'. In this condition, two tags answer simultaneously in the slot 11.

In that case, there are two possibilities as follows.

a) The interrogator can recognize the sub-carrier (two tags responded),

b) The interrogator cannot recognize the sub-carrier due to cancel each sub-carrier phase.

In case of a), the interrogator shall send the acknowledgment (ACK11) of next slot. Both tags shall continue the present anti-collision sequence.

In case of b), the interrogator can not send the acknowledgment, however, TAG3 and TAG1 shall understand the incidence of collision because the interrogator acknowledgement does not return. In case of such collision, both collision tags shall suspend the present anti-collision sequence, and shall wait the next MULTI-READ command. To prevent the recurrence of collision, the phase of sub-carrier may be changed from previous response by tag.

D.6 Protocol and anti-collision Parameters

D.6.1 Protocol Parameters

Ref.	Parameter	Description	Comment/Option
M1A-P:1	Who talks first	Interrogator talks first	
M1A-P:2	Tag addressing capability	Yes	
M1A-P:3	Tag ID	Yes	
M1A-P:3a	UID Length	The UID consists of 64 bits The SUID consists of 48 bits The MID consists of 32bits	
M1A-P:3b	UID Format	UID: 8 bits Allocation Class 8 bits Manufacturer Code 16 bits reserved 40 bits Manufacturer Serial Number SUID: 8 bits Manufacturer Code 40 bits Manufacturer Serial Number MID: programmed by tag Issuer	
M1A-P:4	Read size	Fixed read/write block size is 4 bytes	
M1A-P:5	Write Size	Same as above M1A-P:4	
M1A-P:6	Read Transaction Time	4bytes: about 48ms (flag: 5bits, command: 6bits, SUID=48bits, CRC=16bits) 4bytes: about 27ms (flag: 5bits, command: 6bits, no SUID, no CRC)	

Ref.	Parameter	Description	Comment/Option
M1A-P:7	Write Transaction Time	4bytes: about 38ms (flag: 5bits, command: 6bits, SUID=48bits, CRC=16bits) 4bytes: about 17ms (flag: 5bits, command: 6bits, no SUID, no CRC)	
M1A-P:8	Error detection	Tag to interrogator: CRC with length 16 (optional) Interrogator to tag: CRC with length 16 (optional)	
M1A-P:9	Error correction	No	
M1A-P:10	Memory size	The maximum memory size is 1024 bits The typical memory size is 256 bits	
M1A-P:11	Command structure and extensibility	The maximum number of commands is 64 (6 bits) See clause 10.3	

D.6.2 Anti-collision Protocol

The purpose of the anti-collision sequence is to inventory the tags present in the interrogator field by their unique ID.

The interrogator is the master of the communication with one or multiple tags. It initiates tag communication by issuing the MULTI-READ request.

The tag shall send its response in the slot determined or shall not respond.

Ref.	Parameter	Description	Comment/Options
M1A-A:1	**Type** **(Probabilistic or Deterministic)**	Deterministic	
M1A-A:2	**Linearity**	Yes	
M1A-A:3	**Tag inventory capacity**	Theoretically 2^{48} (SUID 48 bits) or 2^{32}(MID 32 bits)	In practice the tag capacity is limited by mutual detuning of the tags.

Bibliography

[1] ISO/IEC TR 18047-2[2)], *Information technology — Radio frequency identification device conformance test methods — Part 2: Test methods for air interface communications below 135 kHz*

2) To be published.

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