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Information Technology — Radio frequency identification for item management — Part 2: Parameters for air interface communications below 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.

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

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 automatic identification and data capture techniques — 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

The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this part of ISO/IEC 18000may involve the use of patents.

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Patent number	Patent title	Patent holder	Contact	Affected sub clause
		ATMEL Germany GmbH	Leo Merken, Director of Intellectual Property 2325 Orchard Parkway, San Jose, CA, 95131 USA Phone 408-436-4251 Fax 408-487-2615 Email leo.merken@atmel.com	
		NXP B.V.	Harald Roeggla, Intellectual Property & Licensing Gutheil-Schoder-Gasse 8-12 1102 Vienna, Austria Phone 43-1-60-970-1469 Fax 43-1-60-870-1101 harald.roeggla@nxp.com	
US 6 177 858 Application 96 402556.3-Patent EP 0 777 194 CA 2 191 787 CA 2 191 788 US 5 923 251 Application 96 402554.8 Patent EP 0 777 192 US 5 808 550 Appication 96 402555.5-Patent EP 0 777 193		Winstead Assets Ltd	Craig Cook, director 12 rue des petits ruisseaux-91370 Verrieres le Buisson France Phone +33(0) 169 752 170 Fax +33(0) 160 110 031 contact@spacecode-rfid.com	

CA 2 191 794 Application 90 909459.1-Patent EP 0 476 026 US 5426423 CA 2058 947				
EP 0640939,US 5430447,DE P69428309 EP831618, US5929801 (claims 1-15 and corresponding claims of other patents based on this patent) US 5793324 US 5053774 excluding claims 14-17 and 20 (and corresponding claims of other patents based on this patent)	Protection Against Manipulation of Batteryless Read/Write Transponders Method for Repeating Interrogations Until Failing to Receive Unintelligible Responses to Identify Plurality of Transponders by an Interrogator Transponder Signal Collision Avoidance System Transponder Arrangement	Texas Instruments Inc	Robby Holland Licensing Manager, Law Department P.o. Box 660199, MS 3999 Dallas, TX 75266-0199 Phone 1-972-917-4367 Fax 1-972-917-4418 Email r-holland3@ti.com	

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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. The purpose of this part of ISO/IEC 18000 is to provide a common technical specification for RFID devices that may be used by ISO committees developing RFID application standards. This part of ISO/IEC 18000 is intended to allow for compatibility and to encourage inter-operability of products in the international marketplace. This part of ISO/IEC 18000 defines the physical layer used for communication between the interrogator and the tag and further defines the communications protocol used in the air interface.

Two types of tags are defined by this part of ISO/IEC 18000- Type A and Type B which differ only by their physical layer. Both support the same inventory (anti-collision) and protocol.

Type A tags are permanently powered by the interrogator, including during the tag-to-interrogator transmission, and operate at 125 kHz.

Type B tags are powered by the interrogator, except during the tag-to-interrogator transmission, and operate at 125 kHz or 134.2 kHz.

2 Conformance

In order to claim conformance it is necessary to comply to all of the relevant clauses of this specification except those marked 'optional'. It is also necessary to operate within the local national radio regulations (which may require further restrictions).

The rules for RFID device conformity evaluation are defined in ISO/IEC TR 18047-2.

The tag shall be of either Type A or B.

NOTE: Nothing in this International Standard prevents a tag to be of both types, although for technical reasons, it is unlikely that such tags are ever marketed.

The interrogator shall support both Types A and B.

The interrogator 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 B

2.1 RF emissions general population

Device manufacturers claiming conformance to this part of ISO/IEC 18000 shall certify that RF emissions do not exceed the maximum permitted exposure limits recommended by either IEEE C95.1:2005 or ICNIRP according to IEC 62369-1. If a device manufacturer is unsure as to which recommendation to be cited for compliance the manufacturer shall certify to ICNIRP limits.

2.2 RF emissions and susceptibility health care setting

Device manufacturers claiming conformance to this part of ISO/IEC 18000 shall certify that RF emissions and susceptibility comply with IEC 60601-1-2.

3 Normative references

The following referenced documents are indispensable for the application of this part of ISO/IEC 18000. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62369-1 *Evaluation of human exposure to electromagnetic fields from short range devices (SRDs) in various applications over the frequency range 0 GHz to 300 GHz - Part 1: Fields produced by devices used for electronic article surveillance, radio frequency identification and similar systems*

IEC 60601-1-2 *Medical electrical equipment - Part 1-2: General requirements for safety - Collateral standard: Electromagnetic compatibility - Requirements and tests*

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

4 Terms and definitions

For the purposes of this part of ISO/IEC 18000t, the terms and definitions given in ISO/IEC 19762 (all parts) and the following apply.

4.1

anti-collision sequence

algorithm used to prepare for and handle a dialogue between interrogator and one or more tags out of several in its energizing field.

4.2

bit rate

number of bits transmitted per second.

4.3

byte

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

4.4

carrier off time

time interval when the interrogation field is switched off.

4.5

charge up time

time to charge the capacitor of the HDX tag

4.6

commands

interrogator to tag communication

note: 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 International Standard. Custom and Proprietary commands should be used only to perform functions that are not defined in this International Standard. If a custom or proprietary command solely duplicates the functionality of a mandatory or optional command specified in this International Standard, the corresponding mandatory or optional command shall be supported by the tag

4.7

differential bi-phase encoding

method of encoding in which data bit 0 is represented by a mid-bit transition; data bit 1 is represented by no transition; additionally there is always a transition in between two bits.

4.8

down-link

communication process from the interrogator to the tag

4.9

encoding

the one to one relationship between basic information elements and modulation patterns.

4.10

elementary time unit (etu)

elementary time unit (etu) =16/62,5kHz.

4.11

FDX

communication protocol for Type A or FDX tags.

4.12

frequency shift keying

binary information is superimposed onto an electromagnetic field carrier by shifting between discrete frequencies of the field.

4.13

full duplex

communication protocol in which information is exchanged while the interrogator transmits the interrogation field.

4.14

half duplex

communication protocol in which information is exchanged after the interrogator has stopped transmitting the interrogation field (sequential method).

4.15

HDX

communication protocol for Type B or HDX tags.

4.16

interrogation field

magnetic field generated by an interrogator to activate a tag and to transfer data to an advanced tag.

4.17

interrogation frequency

frequency of the magnetic field generated by the interrogator.

4.18

interrogation period

the time duration the magnetic field is present.

4.19

interrogator request

bit pattern transmitted to the advanced tag to modify the tag status or to read and write information.

4.20

manchester encoding

method of encoding in which data bit 0 is represented by a positive mid-bit transition; data bit 1 is represented by a negative mid-bit transition

4.21

modulation

method of superimposing information onto an interrogation field by means of varying a specific parameter of the field.

4.23

non-return to zero encoding

method of encoding in which data bit 1 is a high signal; and data bit 0 is a low signal.

4.24

pulse interval encoding

method of data encoding in which the transmitted information is represented by the time between the falling edges of fixed length pulses. The number of received carrier cycles defines data bit values or other code conditions.

4.25

interrogator

device used to communicate with a tag.

4.26

tag

electronic device which is activated by the interrogator and communicates with it.

4.27

unique item identifier

an identification that uniquely identifies a specific entity during its life; a unique permanent ID of the integrated circuit in an RF tag

5 Symbols (and abbreviated terms)

5.1 Symbols

All symbols are expressed with a letter, followed by a upper case letter (A or B or C when referring respectively to the Type A or Type B or Annex C, 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 C. Timings are expressed with an upper case T and according to above rule. Other symbols specific to A, B or C are specified in the relevant clauses.

$\mathbf{f_{Xc}}$ Carrier frequency of the operating field

$\mathbf{T_{Xd0}}$ Period of Data Symbol "0"

$\mathbf{T_{Xd1}}$ Period of Data Symbol "1"

$\mathbf{T_{Xc}}$ Period of carrier frequency ($T_{Xc} = 1/f_{Xc}$)

$\mathbf{T_{Xcv}}$ Code Violation Duration

T_{Apx} Tag wait time before transmitting response after end of frame

T_{Ad} Modulation Coding Time where $T_{Ad} = 32 / f_{Ac}$

etu elementary time unit

5.2 Abbreviated terms

AFI Application family identifier

ASK Amplitude shift keying

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 (pattern)

ETU Elementary time unit

FDX Full duplex- Type A tag

HDX Half duplex – Type B tag

IRC IC reference number

kbps Unit for transmission speed: 1000 bit/s or 1000 Baud

LSB Least significant bit

MFC Manufacturer code

MSB Most significant bit

MSN Manufacturer serial number

NOB Number of Blocks-1

NOS Number Of Slots (in the anti-collision mode)

NRZ Non return to zero

RF Radio frequency

RFID Radio Frequency Identification

RFU Reserved for future use

SOF Start of frame (pattern)

UII Unique Item Identifier (includes ICR, MFC and MSN)

UMS User Data Memory Structure

6 Physical layer

6.1 Type A (FDX)

6.1.1 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.

6.1.2 Frequency

The carrier frequency of the RF operating field is f_{Ac} = 125 ±0,1 kHz.

6.1.3 Communication signal interface interrogator to tag

6.1.3.1 Modulation

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

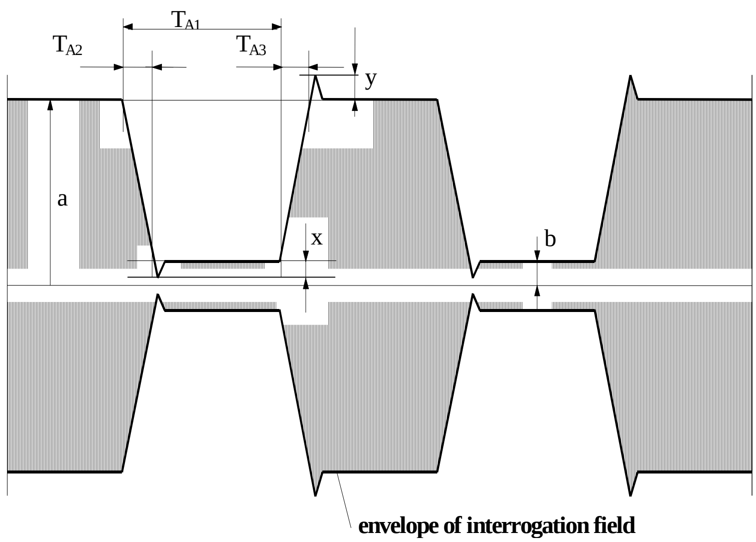


Figure 1 — Modulation details of data transmission from interrogator to tag

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	0,05 * a
y	0	0,05 * a

Notes:

$T_{A1}+T_{A3}+3*T_c < T_{Ad0}$

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

6.1.3.2 Data rate and data coding

The interrogator-to-tag communication uses Pulse Interval Encoding (Figure 2). 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.(note: with equal distributed data bits "0" and "1", the data rate is in the range of 5,1 kbps). Data coding Times are shown in Table 2

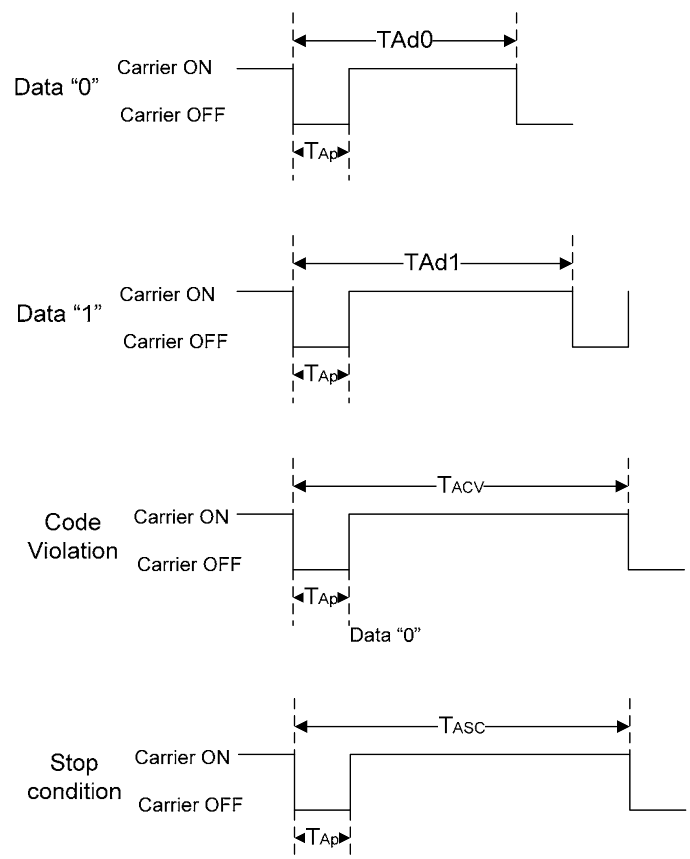


Figure 2 — Interrogator to tag: Pulse interval encoding

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 $T_{Ac}=1/f_{Ac}$ = 8 μs.

6.1.3.3 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.

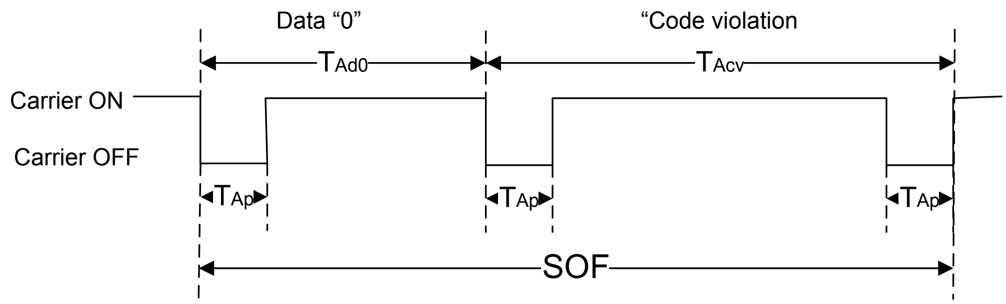


Figure 3 — Start of frame pattern

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.

6.1.3.4 End of frame pattern

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

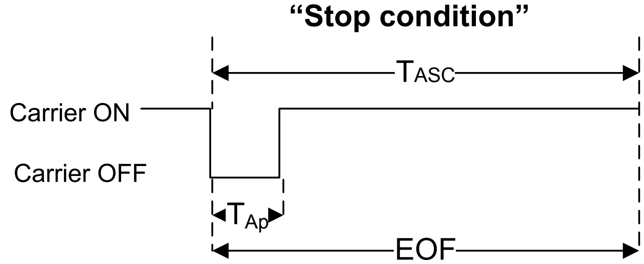


Figure 4 — End of frame pattern

6.1.4 Communication signal interface tag to interrogator

6.1.4.1 Data rate and data coding

The tag shall communicate with the interrogator via an inductive coupling, where the interrogator carrier is load modulated as follows:

- $1/T_{Ad}$ Manchester coded data signal of the tag response
- $1/(2*T_{Ad})$ dual pattern data coding when responding within the INVENTORY process

Where $T_{Ad} = 32 / f_{Ac}$ and f_{Ac} is the carrier frequency of the operating field

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.

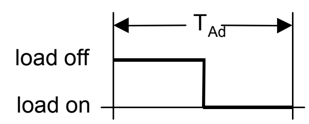
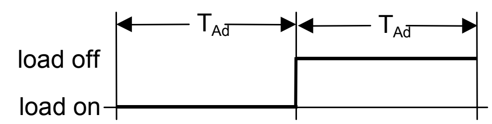
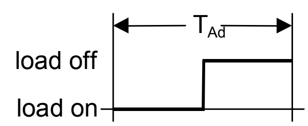
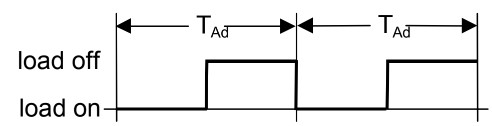
Data Element	International Standard command	Inventory command
Data "0"		
Data "1"		

Figure 5 — Tag to interrogator: load modulation coding

6.1.4.2 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".

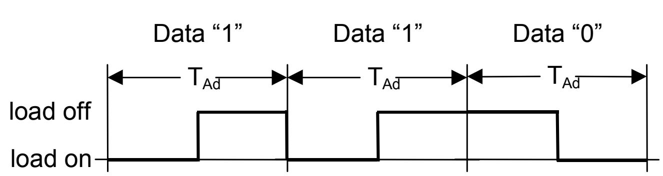


Figure 6 — Start of frame pattern

6.1.4.3 End of frame pattern

A specific EOF pattern is neither used nor specified for the FDX tag response. An EOF is detected by the interrogator if there is no load modulation for more than two data bit periods (T_{Ad}).

6.1.5 General Protocol Timing Specifications

For write like requests where an erase and or programming operation is required, the tag shall return its response when it has completed the write/lock operation and latest either after 20 ms upon detection of the last falling edge of the interrogator request.

T_{AP1} is not applicable for write like requests.

6.1.5.1 Waiting Time before Transmitting its Response after an EOF from the Interrogator

When the FDX 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 T_{Ap1} before starting to transmit its response to an interrogator request or when switching to the next slot in an inventory process.

T_{Ap1} starts from the detection of the falling edge of the EOF received from the interrogator.

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

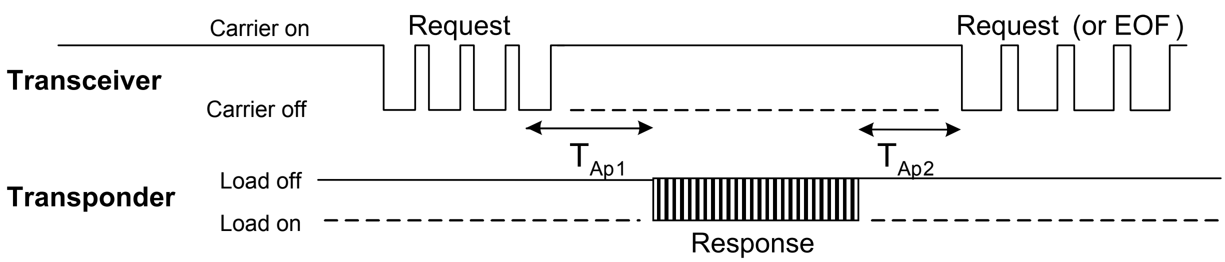


Figure 7 — FDX - General Protocol Timing Diagram

The minimum value of T_{Ap1} is T_{Ap1min} = 204 T_{Ac}

The typical value of T_{Ap1} is T_{Ap1typ} = 209 T_{Ac}

The maximum value of T_{Ap1} is T_{Ap1max} = 213 T_{Ac}

If the FDX 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.

6.1.5.2 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's EOF (falling edge of EOF pulse + 42 T_{Ac}).

The minimum value of T_{Ap2} is T_{Ap2min} = 150 T_{Ac}. It ensures that the tags are ready to receive a subsequent request.

NOTE The interrogator should wait at least 2.5 ms after it has activated the electromagnetic field before sending the first request, to ensure that the tag(s) are ready to receive a request.

c) When the interrogator has sent an inventory request, it is in an inventory process. See the subsequent clause 6.1.5.3.

6.1.5.3 Interrogator Waiting Time Before Switching to Next Inventory Slot

An inventory process is started when the interrogator sends an inventory request.

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

6.1.5.4 Interrogator Started to Receive One or More FDX 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's 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, if a 16 slot anti-collision request is processed, or send a subsequent request (which could be again an inventory request).

T_{Ap2} 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}.

T_{ANRT} is dependant on the anti-collisions current mask value and on the setting of the CRCT flag.

6.1.5.5 Interrogator Receives no FDX 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, if a 16 slot anti-collision request is processed, 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 $T_{Ap3min} = T_{Ap1max} + T_{ApSOF}$

T_{ApSOF} is the time duration for a tag to transmit an SOF to the interrogator.

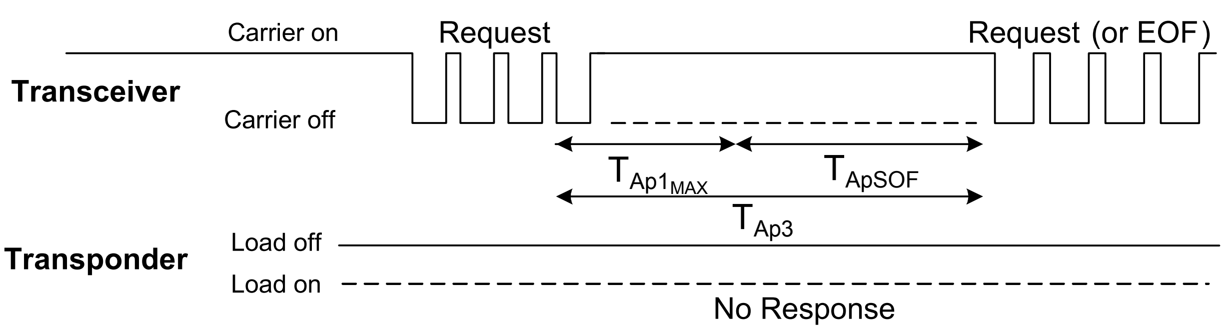


Figure 8 — FDX - Protocol Timing Diagram without Tag Response

Table 3 — Overview timing parameters FDX

Symbol	Minimum	Maximum
T_{ApSOF}	3 * T_{Ad}	3 * T_{Ad}
T_{Ap1}	204 T_{Ac}	213 T_{Ac}
T_{Ap2}	150 T_{Ac}	
T_{Ap3}	T_{Ap1max} + T_{ApSOF}	

6.2 Type B (HDX)

6.2.1 Power transfer

HDX tags have to be charged before operation which is done by switching on the interrogator's field for a defined time (Charge time). This charge phase is executed at the beginning of every request and the duration of the Charge time depends on the system parameters and distance to the interrogator.

During the execution of the INVENTORY request, the tags shall be charged at the beginning as already defined above. Between the inventory slots the tags shall be re-charged. This re-charge time is depending on the amount of additional data requested in an inventory request and the physical parameters.

Table 4 — HDX, Charge and Re-charge Times

Meaning	Symbol	min	max
Charge time	T_{CH} [ms]	20	
Re-charge time	T_{RCH} [ms]	5	

6.2.1.1 Frequency

The carrier frequency of the RF operating field is f_{Bc} =125 kHz ±0,1 kHz or 134,2 ±0,1 kHz.

6.2.2 Communication signal interface interrogator to tag

6.2.2.1 Modulation

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

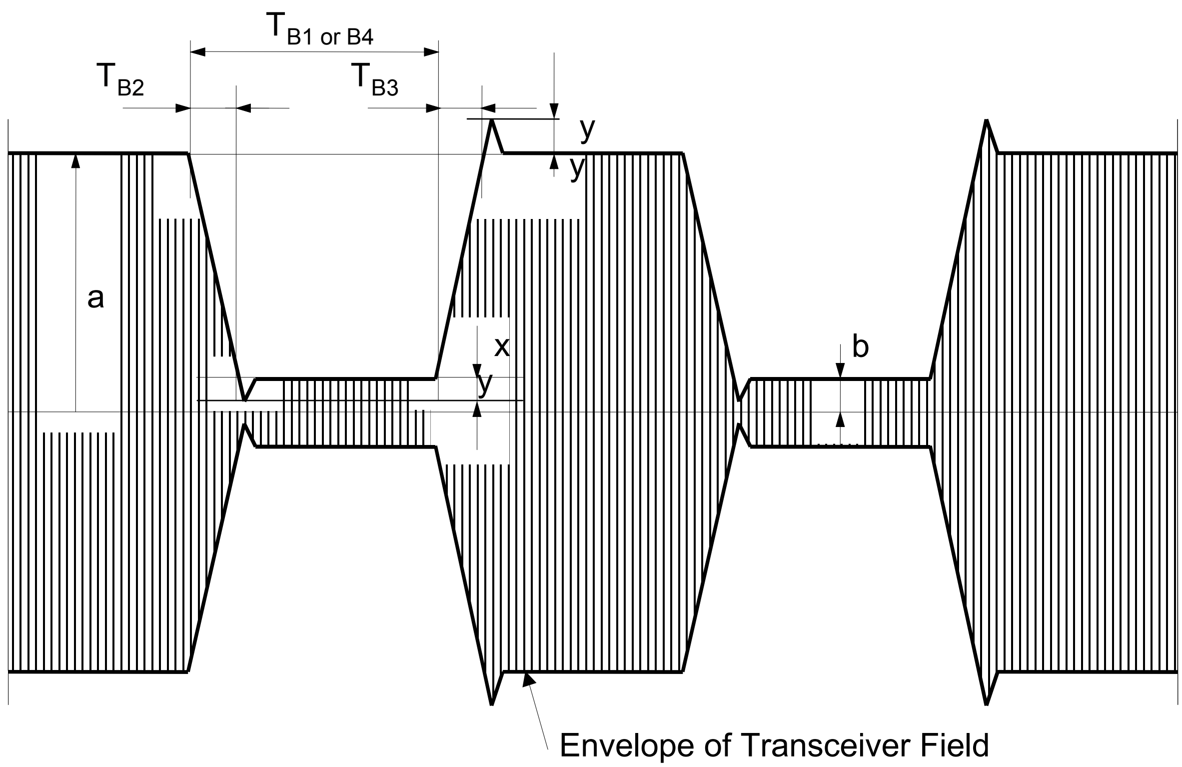


Figure 9 — Modulation details of data transmission from interrogator to tag

Table 5 — Modulation coding times

	Min	nom	max
T_{B1}	14 * $T_{\mathbf{Bc}}$	20* $T_{\mathbf{Bc}}$	26 * $T_{\mathbf{Bc}}$
T_{B2}	2 * $T_{\mathbf{Bc}}$	7 * $T_{\mathbf{Bc}}$	10 * $T_{\mathbf{Bc}}$
T_{B3}	5 * $T_{\mathbf{Bc}}$	13 * $T_{\mathbf{Bc}}$	20 * $T_{\mathbf{Bc}}$
T_{B4}	34 * $T_{\mathbf{Bc}}$	40 * $T_{\mathbf{Bc}}$	46 * $T_{\mathbf{Bc}}$
X	0	n/a	0,05 * a
Y	0	n/a	0,05 * a

6.2.2.2 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 9. 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:

- Data rate: 2,83 kbps (nominal)

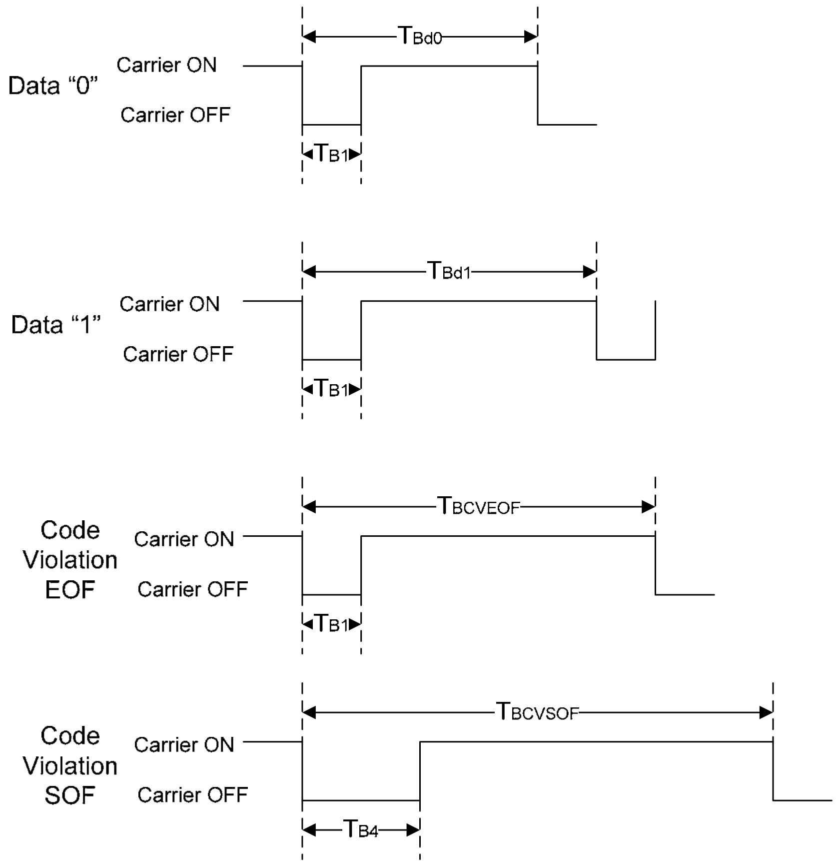


Figure 10 — Interrogator to tag: modulation and coding

Table 6 — Data coding times

Symbol	min	Nom	Max
T_{Bd0}	40 * T_C	43 * T_C	46 * T_C
T_{Bd1}	50 * T_C	52 * T_C	54 * T_C
T_{BCVEOF}	70 * T_C		
T_{BCVSOF}	100 * T_C	107 * T_C	114 * T_C

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

6.2.2.3 Start of frame pattern

The interrogator request starts always with a Start of frame (SOF) pattern (Figure 9). The SOF consists of a "Code violation a Data "1" and a Data "0"" pattern that defines a clear start of frame.

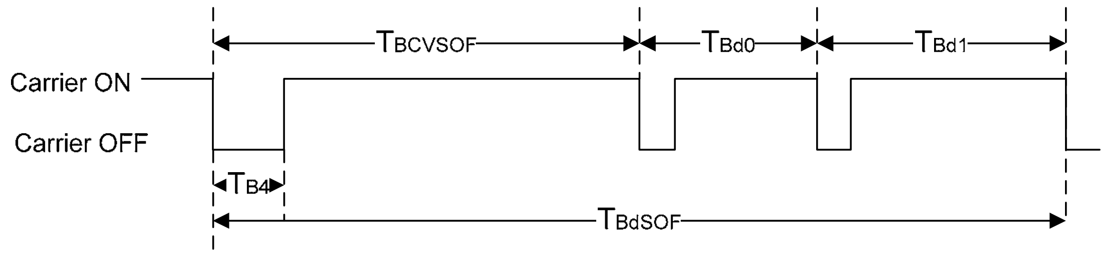


Figure 11 — HDX - Start of frame pattern (SOF) Pattern

6.2.2.4 End of frame

For EOF of the HDX-ADV interrogator request the code violation pattern T_{BcvEOF} is used (Figure 10).

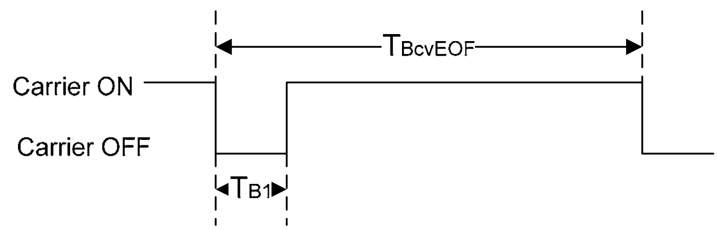


Figure 12 — HDX - End of Frame (EOF) Pattern

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.

6.2.3 Communication Signal Interface tag to interrogator

6.2.3.1 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_{B0} = 134,2 ±3 kHz for the data bit “0” encoding

- f_{B1} = 123,7 ±3 kHz for the data bit “1” encoding

The data coding is based on the NRZ method.

The average data rate is 8 kbit/s.

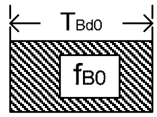
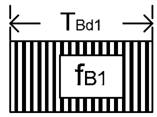
Data Element	International Standard command	Comment
Data bit "0"		**$T_{Bd0} = 16/f_{B0}$**
Data bit "1"		**$T_{Bd1} = 16/f_{B1}$**

Figure 13 — Tag to interrogator: modulation and coding

6.2.3.2 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 "011101".

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

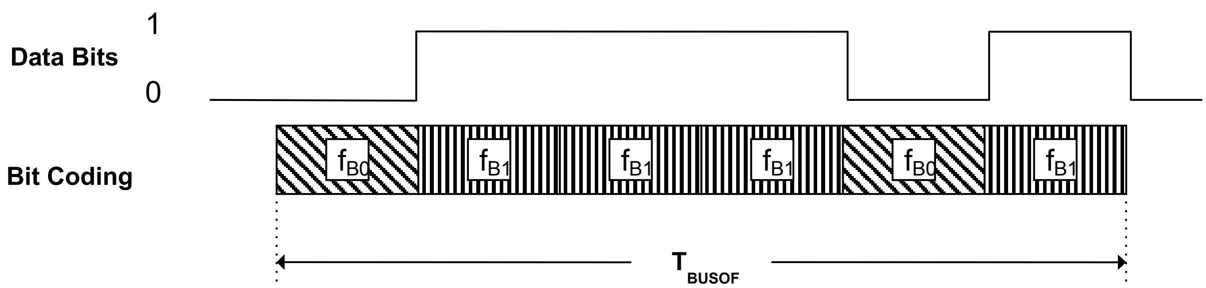


Figure 14 — HDX - Start of frame pattern

6.2.3.3 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 "101110".

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

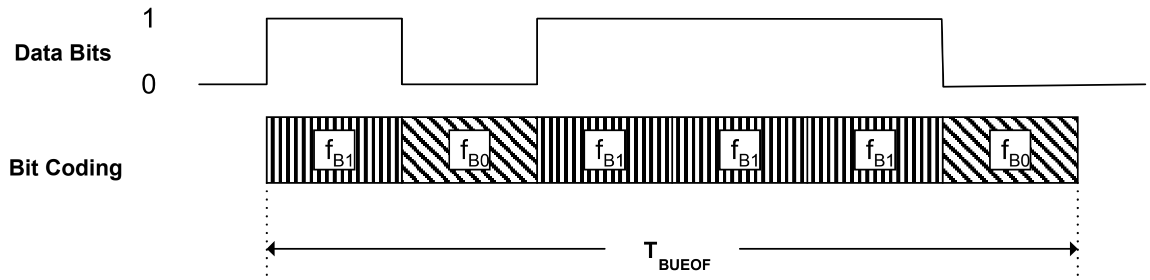


Figure 15 — HDX - End of frame pattern

6.2.4 General protocol Timing Specification

For write like requests where an erase and or programming operation is required a programming time of < 20ms shall be used. The tag shall return its response after switching off the transmitter field.

6.2.4.1 Waiting Time Before Transmitting its Response After Receipt of an EOF from the Interrogator

After the transmission of the request frame the interrogator switches off the field. When the tag has detected the 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 by the tag.

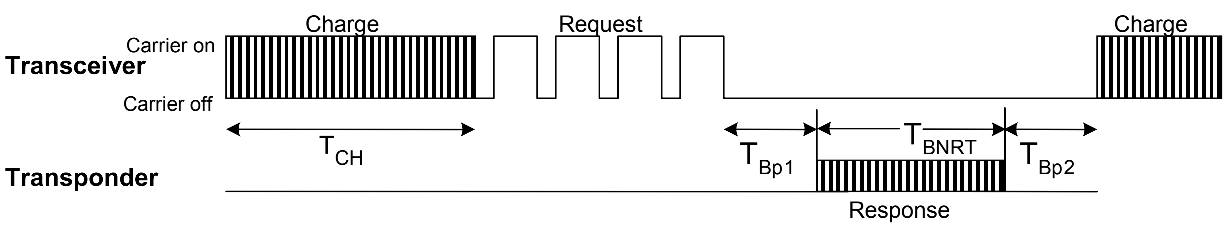


Figure 16 — Protocol Timing Diagram Including Charge-Up Phase

The minimum and maximum values of T_{Bp1} are given in Table .

If the HDX-ADV tag detects a carrier modulation during this time T_{Hp1}, it shall reset its T_{Hp1} timer and wait for a further time T_{Hp1} before starting to transmit its response to an interrogator request or to switch to the next slot when in an inventory process.

6.2.4.2 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 switch on the carrier signal to re-charge the tag, timing according to Table .

6.2.4.3 Interrogator Waiting Time Before Switching to Next Inventory Slot

An inventory process is started when the interrogator sends an inventory request.

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_{RCH} triggers the tag to switch to the next slot.

6.2.4.4 Interrogator 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), or
- send a subsequent request.

T_{BNRT} depends on the current mask value and of the CRCT flag setting.

6.2.4.5 Interrogator Received no Tag Response

During an inventory process, when the interrogator has received no tag response (empty slot), it shall wait at least a time of T_{Bp3} before starting to recharge the tag and switch to the next slot (during a 16 slot anti-collision request) or sending a subsequent request (which could be again an inventory request).

T_{Bp3} starts from the time the interrogator has switched off the field and has generated the falling edge of the last sent EOF. See Figure 17 and Table for an overview.

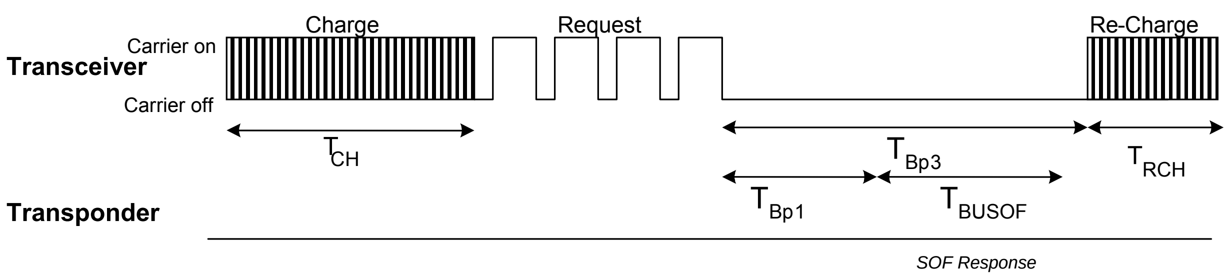


Figure 17 — Protocol Timing Diagram Including Charge and Re-Charge Time Period

The minimum value of T_{Bp3} is $T_{Bp3min} = T_{Bp1max} + T_{BUSOF}$

T_{BUSOF} is the time duration for a HDX tag to transmit a SOF to the interrogator (see clause 6.2.2.3).

Table 7 — Overview timing parameters HDX

Symbol	Minimum	Nominal	Maximum
T_{BUSOF}		0.75 ms	
T_{Bp1}	1,9 ms		3 ms
T_{Bp2}	2,2 ms		
T_{Bp3}	T_{Bp1max} + T_{BUSOF}		

T_{BNRT}	Depends on the requested data and options. Must be calculated in the interrogator for every request and flag setting combination.		

6.3 Physical and Media Access Control (MAC) Parameters

6.3.1 Interrogator to tag link

Table 8 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	± 8 kHz	± 4 kHz	3 dB Bandwidth
M1-INT: 2a	Minimum Receiver Bandwidth	± 10 kHz		3 dB Bandwidth
M1-INT: 3	Interrogator Transmit Maximum EIRP Power Limits within Communication Zone	65,5 dBµA/m		at d = 10m see ITUR 012E-WB9
M1-INT: 3a	Interrogator Transmit Spurious Emissions	27 dBµA/m		at 9 kHz descending 3dB/octave, until 10 MHz
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 M1-INT-3		

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	

Ref.	Parameter	Description Type A	Description Type B	Options/Comments
M1-INT: 6	Timing			
M1-INT: 6a	Transmit to Receive Turn Around Time	1,6 ms	1,9 ms	Interrogator has to wait min. before receiving the tag response (Txp1)
M1-INT: 6b	Receive to Transmit Turn Around Time	1,2 ms	2,2 ms	Interrogator has to wait the min time after tag response before sending a subsequent command (Txp2).
M1-INT: 6c	Dwell Time or Interrogator Transmit Power On Ramp	< 2 ms	<1ms	
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		
M1-INT: 8	Data Coding	Pulse interval encoding (PIE)		
M1-INT: 9	Bit Rate Average	5,2 kbps	2,8 kbps	

M1-INT: 9a	Bit Rate Accuracy	Synchronous to the carrier frequency	
M1-INT: 10	Interrogator Transmit Modulation Accuracy	Not appropriate for this MODE	

Ref.	Parameter	Description Type A	Description Type B	Options/Comments
M1-INT: 11	Preamble	No Preamble		
M1-INT: 11a	Preamble Length	Not appropriate for this MODE		
M1-INT: 11b	Preamble Waveform	Not appropriate for this MODE		
M1-INT: 11c	Bit Sync Sequence	Not appropriate for this MODE		
M1-INT: 11d	Frame Sync Sequence	Start Of Frame pattern (SOF)		
M1-INT: 11e	Post amble	none	6 bits End Of Frame pattern (EOF)	

Ref.	Parameter	Description Type A	Description Type B	Options/Comments
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)		

6.3.2 Tag to interrogator link

Table 9 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 sub-carrier	See M1-INT: 1 134,2 ±3/123,7 ±3 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	

Ref.	Parameter	Description Type A	Description Type B	Options/Comments
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		

Ref.	Parameter	Description Type A	Description Type B	Options/Comments
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		
M1-TAG: 7	Modulation (on the carrier)	The carrier frequency is modulated by switching a load in the RF tag. The level of the tag response signal is defined by the difference of the magnetic dipole moment for the bit 1 and the bit 0. The level of the tag response signal shall be declared by the tag manufacturer	The tag generates a field through its antenna. The level of the tag response signal is defined by the average value of the magnetic dipole moment values measured for the bit q and the bit 0. The level of the tag response signal shall be declared by the tag manufacturer	Resolution: WG3/SG1N0159

Ref.	Parameter	Description Type A	Description Type B	Options/Comments
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		
M1-TAG: 7e	Sub-carrier Frequency	Not appropriate for this MODE	134,2 ±3/123,7 ±3 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	see M1-TAG: 7e	
M1-TAG: 7g	Sub-Carrier Modulation	Not appropriate for this MODE		

Ref.	Parameter	Description Type A	Description Type B	Options/Comments
M1-TAG:7h	Duty Cycle	Not appropriate for this MODE		
M1-TAG: 7 l	FM Deviation	Not appropriate for this MODE		
M1-TAG: 8	Data Coding	Manchester Code or Dual Pattern Code	NRZ	

Ref.	Parameter	Description Type A	Description Type B	Options/ Comments
M1-TAG: 9	Bit Rate	Manchester Code : ≈4 kbps (f_{Ac}/32) Dual Pattern Code: ≈2 kbps (f_{Ac}/64) during inventory	NRZ “0” : 8,2 kbps NRZ “1” : 7,7 kbps	
M1-TAG: 9a	Bit Rate Accuracy	Derived from the carrier	see M1-TAG: 7f	
M1-TAG: 10	Tag Transmit Modulation Accuracy (for Frequency Hopping [FHSS] systems)	Not applicable for this MODE		
M1-TAG: 11	Preamble	No Preamble		

Ref.	Parameter	Description Type A	Description Type B	Options/ Comments
M1-TAG: 11a	Preamble Length			
M1-TAG: 11b	Preamble Waveform			

Ref.	Parameter	Description Type A	Description Type B	Options/Comments
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	

6.3.3 Protocol parameters

Table 10 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	UII Length	IC Identifier of 64 bits The UII consists of 48 bits	
M1-P:3b	UII Format	8 bit Manufacturer Code 40 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	4 byte: about 32 ms 8 byte: about 40 ms 12 byte: about 48 ms 16 byte: about 56 ms		Assumptions: tag UII is known and transmitted, tag block size corresponds to the respective data size (one READ SINGLE BLOCK request), medium PWM times, tag CRC used

M1-P:7	Write Transaction Time	4 byte: about 29 ms 8 byte: about 36 ms 12 byte: about 42 ms 16 byte: about 48 ms		Assumptions: tag UII is known and transmitted, tag block size corresponds to the respective data size (one WRITE SINGLE BLOCK request), medium PWM times, interrogator CRC used, EEPROM programming time not considered
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)	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	No	
M1-P:10	Memory size	max 256 Blocks and option for extended memory.	max 256 Blocks and option for extended memory.	
M1-P:11	Command structure and extensibility	The maximum number of commands is 32 (5 bit) Extensibility using protocol extension bit	The maximum number of commands is 32 (5 bit) Extensibility using protocol extension bit	

6.3.4 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

Table 11 Anti-collision parameters

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

7 Transmission Protocol

7.1 Basic elements

The transmission protocol defines the mechanism to exchange instructions and data between the interrogator and the tags, in both directions.

It is based on the following concepts:

- "Reader Talks First" (RTF). This means that any tag does not start responding, unless it has received and properly decoded an instruction sent by the interrogator.

- The Tags are uniquely identified by a 48 bit UII, part of the 64 bit IC Identifier, programmed at manufacturing of the integrated circuit. The UII coding is defined in clause 7.2.
- 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). In case of optional fields 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).

7.2 IC Identifier and Unique Item Identifier (UII)

The tags are uniquely identified by a 64 bit IC identifier. The IC Identifier consists of the data elements described in Figure 18.

The IC identifier shall be set permanently by the IC manufacturer.

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

MSB LSB

		UII	
64 57	56 49	48 41	40 1
RFU	ICR code	IC Mfg code	IC manufacturer serial number (MSN)

Figure 18 — IC Identifier format

The IC Identifier comprises:

- The MSN, a unique serial number of 40 bits assigned by the IC manufacture
- The MFC (IC manufacturer code) on 8 bits according to ISO/IEC 7816-6/AM1,
- Bit 49-56 ICR (Integrated Circuit Reference Number)
- Bit 57-64: RFU

7.3 Request format

A request consists of

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

SOF	Flags	Command	Parameters	Data	CRC	EOF

Figure 19 — 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. These fields are shown in Figure 19.

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 20

	LSB MSB	LSB MSB	LSB MSB	LSB MSB	LSB MSB	
	5 bits	6 bits			16 bits	
SOF	Field 1 (Flags 1..5)	Field 2 (Command)	Field 3 (Parameters)	Field 4 (Data)	Field 5 (CRC)	EOF

Figure 20 — Allocation of LSB and MSB to the request fields

7.4 Response format

A Response consists of

- Start of frame pattern (SOF)
- Error Flag
- Error Code
- Data (depending on the command)
- CRC (optional depending on command and flag settings)
- End of frame pattern (EOF)

SOF	Error flag '0'	Data	CRC	EOF

Figure 21 — General response format if no error

SOF	Error flag '1'	Error code	CRC	EOF

Figure 22 — 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 response fields are shown in Figures 21 and 22.

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 23.

	LSB MSB	LSB MSB	LSB MSB	
	1 bit	≥ 3 bits	16 bits	
SOF	Field 1 (Flag)	Field 2 (Error code or Data)	Field 3 (CRC)	EOF

Figure 23 — Allocation of LSB and MSB to the response fields

7.5 Request flags

In each request, five flags are used with flag b1 to be transmitted first. The specific meaning of the flags depends on the context.

Table 12— 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 13
		1	Flags 4 to 5 meaning is according to Table 14
b3	CRCT	0	CRC shall NOT be appended to the tag response
		1	CRC shall be appended to the tag response

Table 13 — 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 UII field shall not be included in the request.
b5	ADR (Address) flag	0	Request is not addressed. UII field is not included. It shall be executed by any tag.
		1	Request is addressed. UII field is included. It shall be executed only by the tag who's UII matches the UII specified in the request. The SEL_Flag shall be set to "0"

Table 14 — 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 following.

7.5.1 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 7.12.

7.5.2 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.

7.5.3 SEL flag and ADR flag

The SEL flag and ADR flag are used by all commands except the INVENTORY and READ UII command.

When both the ADR flag and the SEL flag are set to 0, the request shall not contain a UII. 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 UII of the addressed tag. Independent of the state, any tag receiving such a request shall compare the received UII (address) to its own UII. 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 not execute the Request, shall remain silent and keep its current State.

When the SEL flag is set to 1 (selected mode), the request shall not contain a tag UII. 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. Other tags not in the selected state, shall not execute the Request, shall keep its current state and be silent.

Table 15— Meaning of the SEL flag and ADR flag

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

7.5.4 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 16— 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

7.5.5 PEXT flag

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

7.6 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 17.

If the tag does not support specific error codes (as listed in Table 18) it shall answer with the error code 7 ‘unknown error’.

Table 17— Error flag

Error flag	Meaning
0	No error
1	Error detected

Table 18— Error Code

Code	Description
0	RFU
1	RFU
2	RFU
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

The general response format in case of an error shall be according to the figure 7. Commands not supporting error responses are excluded.

In case of an unsupported command there will be no response.

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

Figure 24 —General response format (with error)

7.7 Error handling

In case of the following errors case there will be no response:

- An unsupported command
- If the inventory flag is set to '1'
- A CRC error
- RFU bit ≠ '0'
- Request format error
- A wrong manufacturer code in a customer command

7.8 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 11.5.3 (e.g. READ SINGLE BLOCK WITH SECURITY STATUS). It is coded in 4 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 19— Block security status

Bit	Meaning	Value	Description
Bit 1	Block lock bit	0	Not locked
		1	Locked
Bit 2 to Bit 4	RFU	0	

7.9 Start of frame pattern (SOF)

7.9.1 Interrogator request

The interrogator request shall start always with a SOF pattern. The SOF pattern is defined in clauses 6.1.3.3 (Type A) and 6.2.2.3 (Type B).

7.9.2 Tag response

The tag response shall start always with a SOF pattern. The SOF pattern is defined in clauses 6.1.4.2 (Type A) and 6.2.3.2 (Type B).

7.10 End of frame pattern (EOF)

7.10.1 Interrogator request

The interrogator request shall end always with an EOF pattern. The EOF pattern is defined in clauses 6.1.3.4 (Type A) and 0 (Type B).

7.10.2 Tag response

The tag response shall end always with an EOF pattern. The EOF pattern is defined in clauses 6.1.4.3 (Type A) and 6.2.3.3 (Type B).

7.11 CRC

The CRC ensures the integrity of transmitted and received data packets. This International Standard uses the reverse CRC specified by the CCITT (Consultative Committee for International Telegraph and Telephone) for error detection.

The 16-bit cyclic redundancy code (CRC) is calculated using the following polynomial:

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

The initial register content shall be all zeros: "0000".

The CRC length is 16 bit.

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 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 containing CRC, 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 containing the CRC, 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.

7.12 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 1 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 Table 20 (see also ISO/IEC 15961 and 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.

Table 20— AFI coding

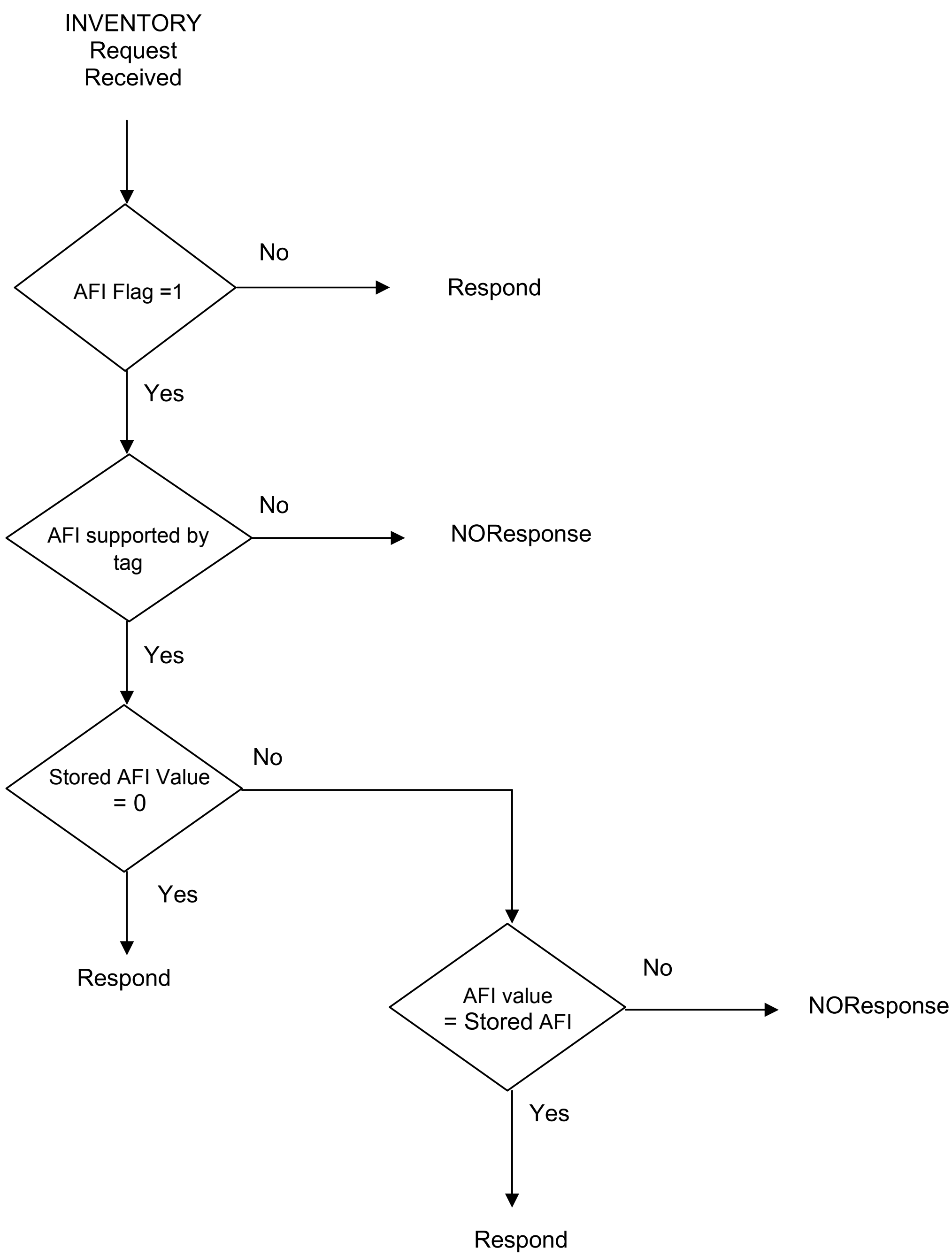
AFI most significant nibble	AFI least significant nibble	Meaning Tags respond from	Examples / note
‘0’	‘0’	All families and sub-families	No applicative pre-selection
X	'0'	All sub-families of family X	Wide applicative pre-selection
X	Y	Only the Yth sub-family of family X	
‘0’	Y	Proprietary sub-family Y only	
‘1'	‘0’, Y	Transport	Mass transit, Bus, Airline
'2'	‘0’, Y	Financial	IEP, Banking, Retail
'3'	‘0’, Y	Identification	Access control
'4'	‘0’, Y	Telecommunication	Public telephony, GSM
‘5’	‘0’, Y	Medical	
'6'	‘0’, Y	Multimedia	Internet services
'7'	‘0’, Y	Gaming	
'8'	‘0’, Y	Data storage	Portable files
'9'	‘0’, Y	GS1	The sub-family shall be registered by GS1.
'A'	‘0’, Y	Data Identifiers as defined in ISO/IEC 15418	
'B'	‘0’, Y	UPU	The sub-family shall be registered by UPU.
'C'	‘0’, Y	IATA	The sub-family shall be registered by IATA.
'D'	‘0’, Y	Reserved for future use	
'E'	‘0’, Y	Reserved for future use	
‘F’	‘0’, Y	Reserved for future use	

NOTE X = ‘1’ to ‘F’, Y = ‘1’ to ‘F’

The support of AFI by the tag is optional.

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

If AFI is supported by the tag, it shall answer according to the matching rules described in Figure 31.



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

Figure 31 — Tag decision tree for AFI

7.13 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 not Respond to these commands.

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.

8 User memory organisation

8.1 User memory organisation (Page 0)

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 1 kB.

Table 21— User data memory organization

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

8.2 Extended User memory organisation (Page ≥ 1)

In case of tag having means to handle sensor data, the blocks in upper user memory are reserved for sensor data. The sensor hardware information is defined in highest block (NOB). The size of the sensor data area (i) is defined through the DSFID. In that case, the user data memory organisation is described in Table 22. This memory can be addressed by extended memory commands.

Block Address	Size	Description
0	32 bits	User data
...	...	…
NOB-i-1	32 bits	User Data
NOB-i	32 bits	User Data [sensor data]
…	…	
NOB-1	32 bits	User Data [sensor data]
NOB	32 bits	User Data [sensor hardware information]

Table 22— User data memory organization (page 1 to NOP)

9 Tag states

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

- RF-Off
- Ready
- Selected
- Quiet

The support of RF-Off, Ready and Quiet states is mandatory.

The support of the Selected state is optional.

After powering up, the tag enters the Ready state. When the tag cannot process an interrogator request (e.g. CRC error etc.), it shall stay in its current state.

9.1 RF-Off State

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

9.2 Ready State

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

9.3 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.

9.4 Selected state

A tag enters the Selected State after receiving the SELECT command with matching UII. 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 (different UII), the first tag shall enter automatically the Quiet state.

9.5 State diagram

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

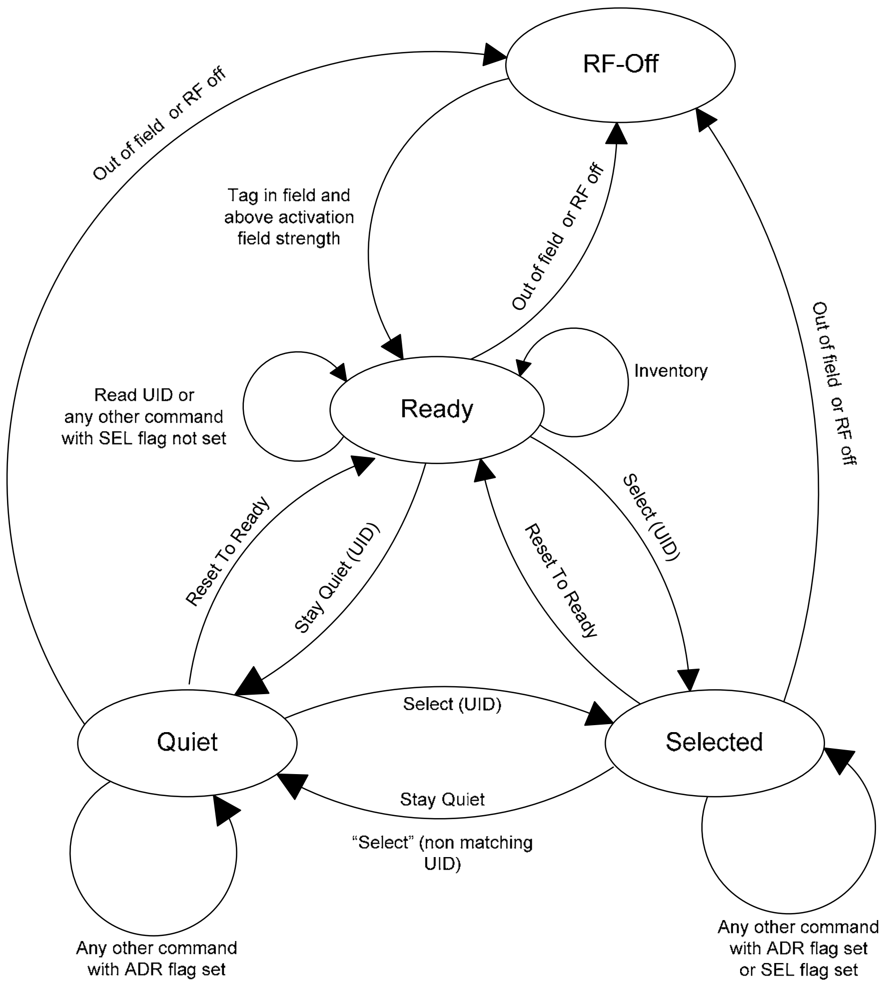


Figure 32 — Tag state diagram

10 Anti-collision

The purpose of the anti-collision sequence is to make an inventory of the tags present in the interrogator field by their UII.

The interrogator is the master of the communication with one or multiple tags. It starts the anti-collision sequence 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 10.2.

10.1 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 48 when 1 slot is used.

SOF	Flags	Command	AFI (Optional)	Mask length(n), 1 slot: 0 <= n < 48	Mask value	CRC (optional)	EOF
	5 bits	6 bits	8 bits	6 bits	n bits	16 bits	

SOF	Flags	Command	AFI (Optional)	Mask length(n), 16 slots: 0 <= n < 44	Mask value	CRC (optional)	EOF
	5 bits	6 bits	8 bits	6 bits	n bits	16 bits	

Figure 33 — 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 or Re-Charge (for HDX).

10.2 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)

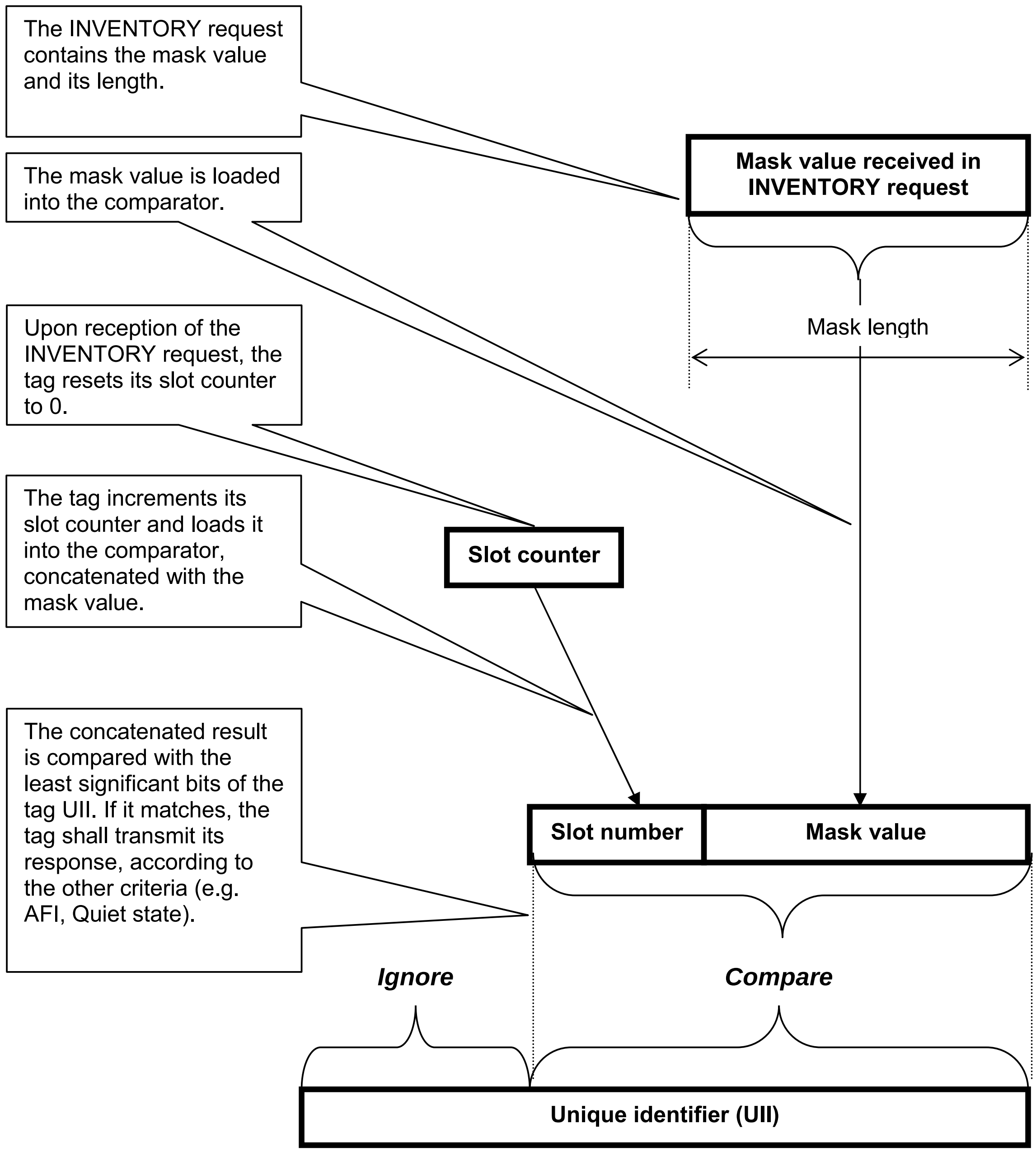
SN_length is set to 0 when 1 slot is used and set to 4 when 16 slots are used

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(UII, 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 anti-collision and decode/process request
               Exit
        Endif
        if SN<NbS-1 then
               SN = SN +1
               Goto label1
               Exit
        Endif
        exit
```



When the number of slots is 1 (NOS flag is set to 1), the comparison is made only on the mask.

Figure 34— Principle of comparison between the mask value, slot number and UII

10.3 Explanation of anti-collision sequences

FDX tags transmit the remaining section of the UII in dual pattern code. The following data (Error Flag, optional CRC) is transmitted in Manchester Code.

10.3.1 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 UII 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 UII 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 UII 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 UII is received and registered by the interrogator. Continue at c).

   If there are more than one tags responding, the interrogator reads additional UII 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)

10.3.2 Anti-collision sequence with 16 slots

Figure 35 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 an 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 UII 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.

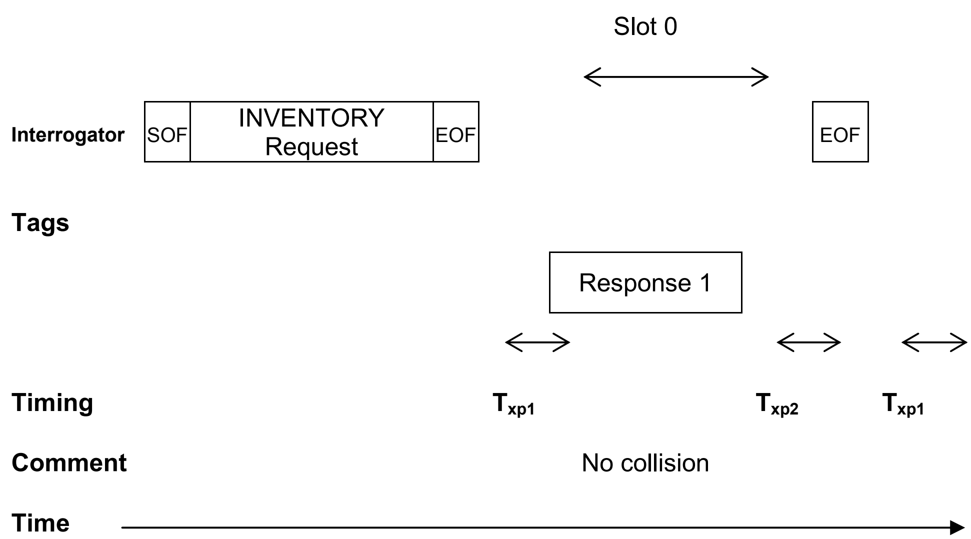
e) the interrogator sends an EOF, meaning to switch to the next slot.

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 UII was already correctly received.

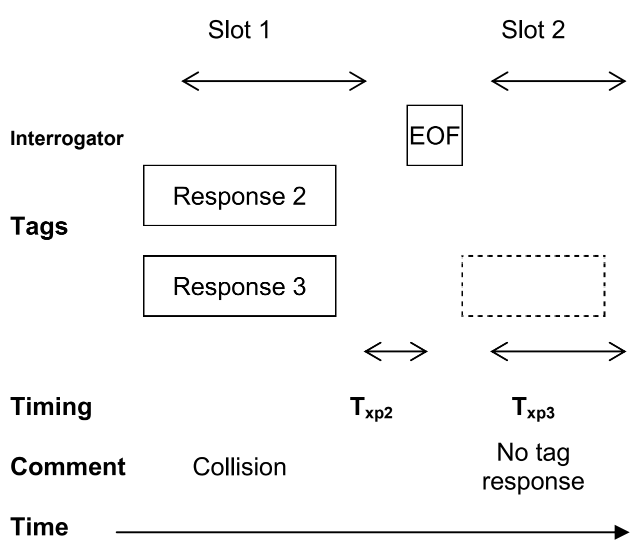
g) all tags detect a SOF and exit the anti-collision sequence. They process this request and since the request is addressed to tag 1, only tag 1 transmit its response.

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

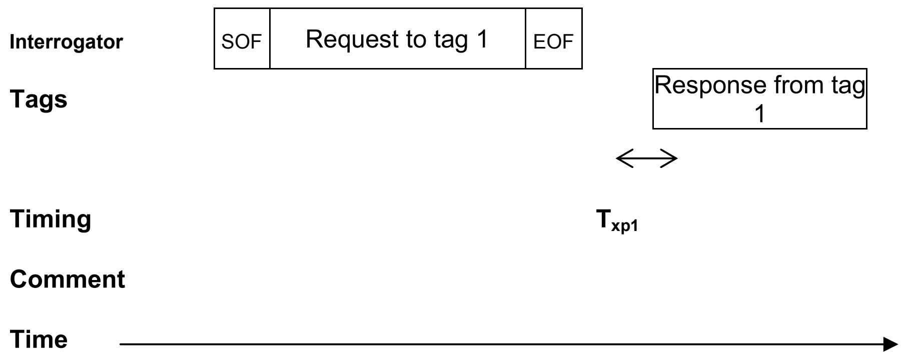
NOTE The decision to interrupt the anti-collision sequence is up to the interrogator. It could have continued to send EOF's till slot 16 and then send the request to tag 1.



Continued…



Continued…



NOTE T_{xp1}, $T_{xp2}$and T_{xp3} are specified in the timing specifications.

Figure 35 — Description of a possible anti-collision sequence

10.3.3 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 10.3.1 (1 slot) or clause 10.3.2 (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 min 20ms.

e) the interrogator performs an anti-collision sequence according to clause 10.3.1 (1 slot) or clause 10.3.2 (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.

11 Commands

11.1 Command classification

11.1.1 Mandatory commands

Mandatory commands shall be supported by all tags and interrogators.

Mandatory commands shall be implemented as specified in this International Standard.

11.1.2 Optional commands

Tags may support them at their option. If not supported the tag shall not execute and remain silent and keep its current State. If supported Request and Response formats shall comply with the definition given in this part of ISO/IEC 18000.

11.1.3 Custom commands

Tags may support Custom commands. The implementation and functionality is up to the manufacturer. The function of flags (including reserved bits) shall not be modified. The only fields that can be customized are the parameters and the data fields.

Any custom command contains as its first parameter the IC manufacturer code. This allows IC manufacturers to implement custom commands without risking duplication of command codes and thus misinterpretation.

If the tag does not support a custom command, it shall not execute the Request, remain silent and not change the current State.

11.1.4 Proprietary commands

Proprietary commands are not specified in this International Standard.

11.2 Command code structure

The command code is on 6 bits.

Table 23 — Command classes

Code	Class
'00' – '27'	Mandatory and 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 informative annex C shall remain silent on receiving the Multi-read command.

NOTE 1) This is required to ensure interoperability by avoiding collisions between tags of type A or B with tags specified in informative annex C.

2) The attention of interrogator designers is drawn on the possibility that tag manufacturers may implement 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 Proprietary Commands, if not disabled, are performed only after having requested from the tags the IC Manufacturer Code and the IC Reference number. These two parameters, linked with the IC manufacturer information, will inform the interrogator on the supported commands and their syntax.

11.3 Command list

Table 24— 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,Quiet
Read UII	‘02’	***Mandatory***	Fast reading of the tags UII without collision protection	Ready
RFU	’03-0F’			
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'	***Mandatory***	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'	***Mandatory***	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'	***Mandatory***	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,Ready
Write system data	'1A’	Optional	Writes specified system data (e.g. DSFID)	Ready, Quiet, Selected
Lock system data	'1B'	Optional	Locks specified system data (e.g. DSFID)	Ready, Quiet, Selected
Multi Read Command	‘1C’	Optional	Annex C	
Read extended multiple blocks	'1D'	Optional	Reads multiple user memory blocks in pages 1 to 255	Ready, Quiet, Selected
Write extended multiple blocks	'1E'	Optional	Write multiple user memory blocks in pages 1 to 255	Ready, Quiet, Selected
Lock extended block	'1F'	Optional	Lock user memory block in pages 1 to 255	Ready, Quiet, Selected
Login	‘20	Optional	RFU	
Change Password	‘21’	Optional	RFU	
Lock Password	‘22’	Optional	RFU	
Reserved for ISO14223	‘23’	***Reserved***	Reserved Inventory command for ISO 14223	
RFU	‘24’ – ‘27’	Optional		
	'28' – '37'	Custom	IC Manufacturer specific commands	
	'38' – '3F'	Proprietary	IC Manufacturer specific commands	

11.4 Mandatory commands

11.4.1 INVENTORY

For the execution of this command, the INV flag shall be set to 1.

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 Clause10).
- If the AFI flag is set to 1, only the tag(s) with matching AFI (parameter 1) shall perform the anti-collision sequence (see clause 7.12).

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
		INVENTORY	AFI (optional)	Mask length(n) n	Mask value	(optional)	
	5 bits	6 bits	8 bits	6 bits	n bits	16 bits	

Figure 36— INVENTORY request format when inventory flag is set

SOF	Error flag	Data	CRC	EOF
	0	Remaining section of the UII (UII without Mask value)	(optional)	
	1 bit	48 - n bits	16 bits	

Figure 37— INVENTORY response format when inventory flag was set in the request

The allowed values of n are depending on the number of slots and are defined in clause 10.1.

11.4.2 READ UII

Upon reception of this command without error all tags in the Ready state shall send their UII.

The inventory (INV), the addressed (ADR) and the select (SEL) flags shall be set to ‘0’.

SOF	Flags	Command	CRC	EOF
		READ UII	(optional)	
	5 bits	6 bits	16 bits	

Figure 38— READ UII Request format

SOF	Error flag	Data	CRC	EOF
	0	UII	(optional)	
	1 bit	48 bits	16 bits	

Figure 39 — READ UII Response format

11.4.3 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	UII (optional)	First block number	Number of blocks	(optional)	
	5 bits	6 bits	48 bits	8 bits	8 bits	16 bits	

Figure 40 — 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 41 — READ MULTIPLE BLOCKS response format

11.4.4 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	UII (optional)	(optional)	
	5 bits	6 bits	48 bits	16 bits	

Figure 42 — STAY QUIET request format

11.4.5 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).

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

Figure 43 — WRITE SINGLE BLOCK request format

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

Figure 44 — WRITE SINGLE BLOCK response format

11.4.6 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).

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

Figure 45 — LOCK BLOCK request format

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

Figure 46 — LOCK BLOCK response format

11.5 Optional commands

11.5.1 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	UII (optional)	Block address	(optional)	
	5 bits	6 bits	48 bits	8 bits	16 bits	

Figure 47 — READ SINGLE BLOCK request format

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

Figure 48 — READ SINGLE BLOCK response format

11.5.2 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	UII (optional)	Block address	(optional)	
	5 bits	6 bits	48 bits	8 bits	16 bits	

Figure 49 — READ SINGLE BLOCK WITH SECURITY STATUS request format

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

Figure 50 — READ SINGLE BLOCK WITH SECURITY STATUS response format

11.5.3 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 BLOCK WITH SECURITY STATUS	UII (optional)	First block number	Number of blocks	(optional)	
	5 bits	6 bits	48 bits	8 bits	8 bits	16 bits	

Figure 51 — READ MULTIPLE BLOCKS WITH SECURITY STATUS request format

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

Figure 52 — READ MULTIPLE BLOCKS WITH SECURITY STATUS response format

11.5.4 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 7.6.

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	UII (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 53 — WRITE MULTIPLE BLOCKS request format

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

Figure 54 — WRITE MULTIPLE BLOCKS response format

11.5.5 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	CRC	EOF
		GET SYSTEM INFORMATION	UII (optional)	(optional)	
	5 bits	6 bits	48 bits	16 bits	

Figure 55 — GET SYSTEM INFORMATION request format

SOF	Error flag	Data									CRC	EOF
	0	System memory block data									(optional)	
	1 bit	40 bits	8 bits	8 bits	8 bits	8 bits	8 bits	8 bits	8 bits	8 bits	16 bits	
		MSN	MFC	ICR	Info	NSS	NOB	NOP	DSFID	AFI		

Figure 56 — GET SYSTEM INFORMATION response format

Table 25 — System data description

System data	Size	Type	Description
MSN	40 bits	Mandatory	Manufacturer Serial Number
MFC	8 bits	Mandatory	IC Manufacturer Code
ICR	8 bits	Optional	IC Reference Number
Info	8 bits	Mandatory	IC configuration: b0=0’ ISO14223 b0=1: ISO18000-2 b1-b3: RFU b4-b7: xxxx Manufacturer specific data
NSS	8 bits	Optional	Number of sensors
NOB	8 bits	Optional	Number of blocks per page
NOP	8 bits	Optional	Number of pages - 1
DSFID	8 bits	Optional	Data Storage Format Identifier
AFI	8 bits	Optional	Application Family Identifier

If an optional System Data element is not supported, “0” value has to be included in the response.

11.5.6 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 UII is equal to its own UII, 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	UII	(optional)	
	5 bits	6 bits	48 bits	16 bits	

Figure 57 — SELECT request format

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

Figure 58 — SELECT response format

11.5.7 RESET TO READY

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

If the command is executed in addressed mode, it shall send a response as defined in Figure 60. If it is executed in NON Addressed mode no response shall be sent.

In Quiet state,

- if the UII is attached in the command, only one tag moves from Quiet to Ready state, and transmits a response.

- If no UII is attached to the command, all tags move from Quiet state to Ready state without sending a response.

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

Figure 59 — RESET TO READY

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

Figure 60 — RESET TO READY response format

11.5.8 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 26) 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).

SOF	Flags	Command	Parameter 1	Parameter 2	Parameter 3	CRC	EOF
		WRITE SYSTEM DATA	UII (optional)	System data selector (see Table 26)	System data (see Table 14)	(optional)	
	5 bits	6 bits	48 bits	2 bits	8 bits	16 bits	

Figure 61 — WRITE SYSTEM DATA request format

Table 26 — 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 62 — WRITE SYSTEM DATA response format

11.5.9 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 26) 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).

SOF	Flags	Command	Parameter 1	Parameter 2	CRC	EOF
		LOCK SYSTEM DATA	UII (optional)	System data selector (see Table 26)	(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

11.5.10 READ EXTENDED MULTIPLE BLOCKS

Upon reception of this command without error, the tag shall read the Requested block(s) from the page specified in parameter 2 of the Request and send back their data in the Response. The blocks and pages 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	Parameter 4	CRC	EOF
		READ EXT MULTIPLE BLOCKS	UII (optional)	Page number	First block number	Number of blocks	(optional)	
	5 bits	6 bits	48 bits	8 bits	8 bits	8 bits	16 bits	

Figure 65 — READ EXTENDED MULTIPLE BLOCKS Request format

SOF	Error flag	Data	CRC	EOF
	0	User memory block data from page number specified in parameter 2	(optional)	
	1 bits	32 bits	16 bits	
		Repeated as needed		

Figure 66 — READ EXTENDED MULTIPLE BLOCKS Response format

11.5.11 WRITE EXTENDED MULTIPLE BLOCK

Upon reception of this command without error, the tag shall write the Requested blocks within the page specified in parameter 2 with the data contained in the Request and report the success of the operation in the Response.

The blocks and pages are numbered from 0 to 255.

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.

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).

SOF	Flags	Command	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Data	CRC	EOF
		WRITE EXT MULTIPLE BLOCKS	UII (optional)	Page number	First block number	Number of blocks	Block data	(optional)	
	5 bits	6 bits	48 bits	8 bits	8 bits	8 bits	32 bits	16 bits	
							Repeated as needed		

Figure 67 — WRITE EXTENDED MULTIPLE BLOCK Request format

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

Figure 68 — WRITE EXTENDED MULTIPLE BLOCK Response format

NOTE: The number of blocks may be implementation dependent.

11.5.12 LOCK EXTENDED BLOCK

Upon reception of this command without error, the tag shall lock the Requested block within the page specified in parameter 2 and report the success of the operation in the Response.

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).

The blocks and pages are numbered from 0 to 255.

SOF	Flags	Command	Parameter 1	Parameter 2	Parameter 3	CRC	EOF
		LOCK EXT BLOCK	UII (optional)	Page number	block number	(optional)	
	5 bits	6 bits	48 bits	8 bits	8 bits	16 bits	

Figure 69 — LOCK EXTENDED BLOCK Request format

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

Figure 70 — LOCK EXTENDED BLOCK Response format

11.5.13 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 27.

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 71.

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

The syntax of the returned data in the Response will be according to the command code. See Figure 72.

The AFI mechanism, if supported by the tag, shall be implemented as specified in clause 7.12.

FDX tags transmit the remaining section of the UII 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 27— 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 27	AFI (optional)	Mask length(n) n	Mask value	Command Parameter	(optional)	
	01xxx							
	5 bits	6 bits	8 bits	6 bits	n bits	see relevant command	16 bits	

Figure 71— Request format of commands executed in inventory mode

The allowed values of n are depending on the number of slots and are defined in clause 10.1.

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

Figure 72— Response format to command in inventory mode

11.6 Custom commands

The format of custom command is generic and allows unambiguous attribution of custom command codes to each tag manufacturer.

The custom command code is the combination of a custom command code and of the IC manufacturer code.

The custom request parameters definition is the responsibility of the IC manufacturer and is the IC manufacturer code according to ISO/IEC 7816-6/AM1.

SOF	Flags	Command	IC MFC	Custom request parameters	CRC	EOF
		See Table 24		Custom defined	(optional)	
	5 bits	6 bits	8 bits	Custom defined	16 bits	

Figure 73 — Custom request format

SOF	Flags	Error code	CRC16 (Optional)	EOF
	1 bit	8 bits	16 bits	

Figure 74 — Custom response format when Error_flag is set

SOF	Flags	Custom response parameters	CRC16 (Optional)	EOF

	1 bit	Custom defined	16 bits	

Figure 75 — Custom response format when Error_flag is NOT set

11.7 Proprietary commands

This International Standard does not specify proprietary commands by definition.

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 zeros).

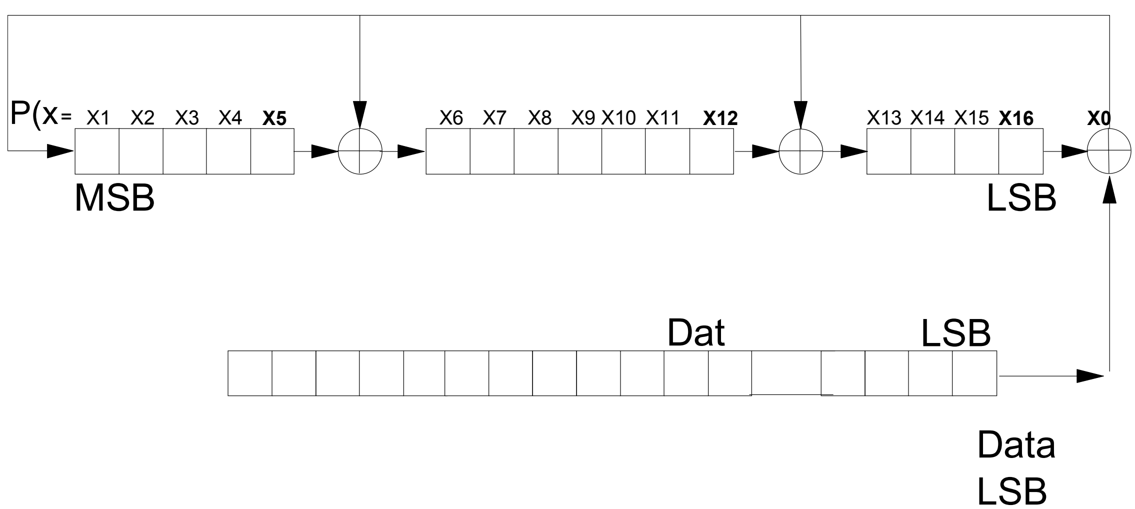


Figure A.1— Schematic diagram of the CRC check.

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)

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

B.1 Description

Table B.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 UII collision position. After recognizing the complete UII of the first tag (A1, B1) the interrogator proceeds with the tags having a 1 at the UII collision position (A2, B2).

The timings are specified in clause 6.1.5.

Table B.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 UII (with collision)	Response of UII (with collision)
Interrogator	Wait t2 (min 1.2 ms)	Field ON with recharge for max. 10 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 UII [A1]	Response of remaining UII [B1]
Interrogator	Wait t2 (min 1.2 ms)	Field ON with recharge for max. 10 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 UII [A2]	Response of remaining UII [B2]
Interrogator	Field OFF	Field OFF

NOTE All times are worst case times.

Annex C

Optional anti-collision mechanism

C.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 informative annex. Furthermore the physical layer shall comply with the definition in this informative annex.

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

C.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 the normative part of this International Standard. See clause 11.3. 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 6.1.3.

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

— All other commands and responses shall conform to the normative part of this International Standard. 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.

C.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 C.4).

All other commands and responses shall conform to the normative part of this International Standard. See clause 6.

C.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.

C.3.2 Frequency

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

C.3.3 Interrogator to tag

The interrogator-to-tag link shall comply with the normative Type A (ASK 100%, 125 kHz). See clause 6.1.

C.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 Kbps 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 C.6.

C.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 C.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.

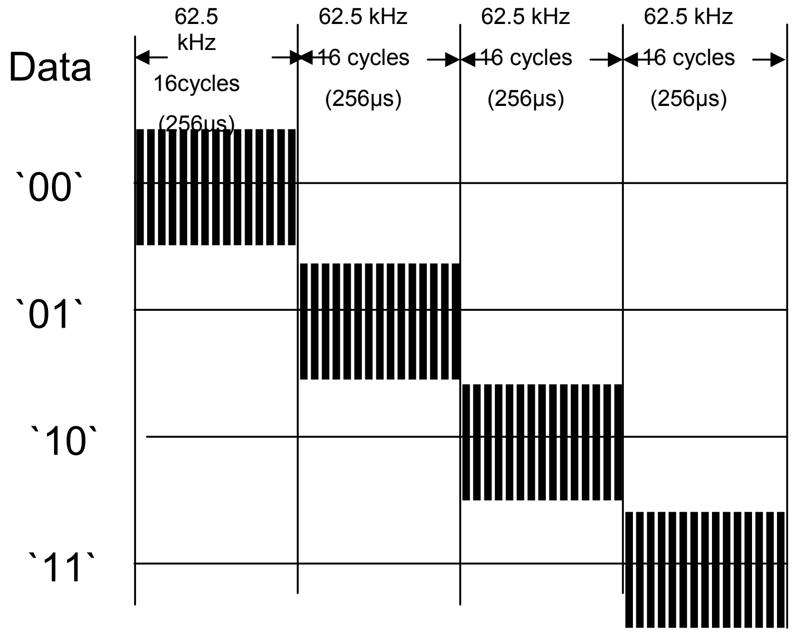


Figure C.1 — Tag ASK Modulation

C.3.4.2 Start of frame pattern of ASK

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

C.3.5 Parameters for optional Multi-read command

C.3.5.1 Interrogator to tag link

See clause 6.3.1 Type A.

C.3.5.2 Tag to interrogator link

Table C. 1 — Tag to Interrogators parameters

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	125kHz $\pm$ 0.05kHz

M1-R1b	Operating Channels (for Spread Spectrum systems)	Not appropriate--for this MODE
M1-R1c	Operating Frequency Accuracy	± 0.05kHz
Ref.	Parameter	Description
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
Ref.	Parameter	Description
M1-R6a	Transmit to Receive Turn Around Time	Minimum 0.75ms

M1A-R6b	Receive to Transmit Turn Around Time	Minimum 0.25ms
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.
Ref.	Parameter	Description
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
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).
Ref.	Parameter	Description Type
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
Ref.	Parameter	Description
M1A-R9	Bit Rate	The data bit rate for the transmission during read and write. anti-collision shall be nominally fc/64 (~1.95Kbit/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.
Ref.	Parameter	Description
M1A-R11a	Preamble Length	Start of Frame(SOF) 12 etu (1etu=16/62.5kHz)
M1A-R11b	Preamble Waveform	SOF is '100100' (12 etu) in ASK modulation.
Ref.	Parameter	Description
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

C.4 Multi-read command

C.4.1.1 Multi-read request format

The Multi-read command has the general request format specified in clause 7.3 and shown in figure C 2.

The command code is '1C'. See clause 11.3

The meaning of some flags is different from the normative part (see clause 7.5). The meaning of the flags for the Multi-read request is specified in clause C.4.2.

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

Figure C. 2— Multi-Read request format

C.4.2 Request flags

In the Multi-read command, four flags are used, which meaning depends on the context (Table C.2).

Table C. 2 — Multi-read command flags

Command	Flag 1	Flag 2	Flag 3	Flag 4	Flag 5
MULTI-READ	PEXT	INV	ASK Select	AFI	UII/MUI I Select

These flags are described in the subsequent clauses.

C.4.2.1 AFI flag

The meaning of the AFI flag conforms to the normative part. See clause 7.5.1.

C.4.2.2 UII/MID Select flag

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

The UII conforms to the normative part. See clause 7.2.

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

Table C.3 — Meaning of the UII/MID Select flag

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

C.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 C.4— Meaning of the ASK Select flag

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

C.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

C.5.1 Acknowledgement by the interrogator

The interrogator issues the five kinds of acknowledges for separating slot in anti-collision sequence as shown in Table C5. The time of acknowledge of interrogator shall have a range according to the ASK modulation in Type A.

Table C.5 — 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

C.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.

C.5.3 Timing

The tag and the interrogator shall conform to the following timings. Their values are specified in Table 6

- 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 C.5.2
- t_{D4} is the duration of the interrogator acknowledgement that consists of 3 bits. See clause C.5.1
- t_{D5} is the time after which the tag shall send its acknowledgement if no interrogator acknowledgement has been received.

Table C.6 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 ($98/ f_{Dc}$)

Note: f_{Dc} =125 kHz ($1/ f_{Dc}$ =8µs)

C.5.4 Explanation of an anti-collision sequence

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

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

UII of RF tag 1=`FFh`, UII of RF tag 2 =`00h`, UII 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 UII 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 UII of RF tag2 is also `00b`. Therefore RF tag2 transmits its response in slot 00. No collision occurs and its UII 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 UII of RF tag2 is also `00b`. Therefore RF tag2 transmits its response in slot 00. No collision occurs and its UII 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 UII of RF tag2 is also `00b`. Therefore RF tag2 transmits its response in slot 00. No collision occurs and its UII is received and registered by the interrogator.

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

k) The RF tag2 is completed the response of its UII, 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 UII 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 UII of RF tag3 is `01b`. Therefore RF tag3 transmits it's response in slot 01. No collision occurs and its UII 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 UII of RF tag3 is '10b'. Therefore RF tag2 transmits it's response in slot 10. No collision occurs and its UII 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 UII of RF tag3 is also `10b`. Therefore RF tag 3 transmits it's response in slot 10. No collision occurs and its UII is received and registered by the interrogator.

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

v) The RF tag3 has completed the response of its UII, 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 UII 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 UII of RF tag1 is also `11b`. Therefore RF tag 2 transmits it's response in slot 11. No collision occurs and its UII is received and registered by the interrogator.

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

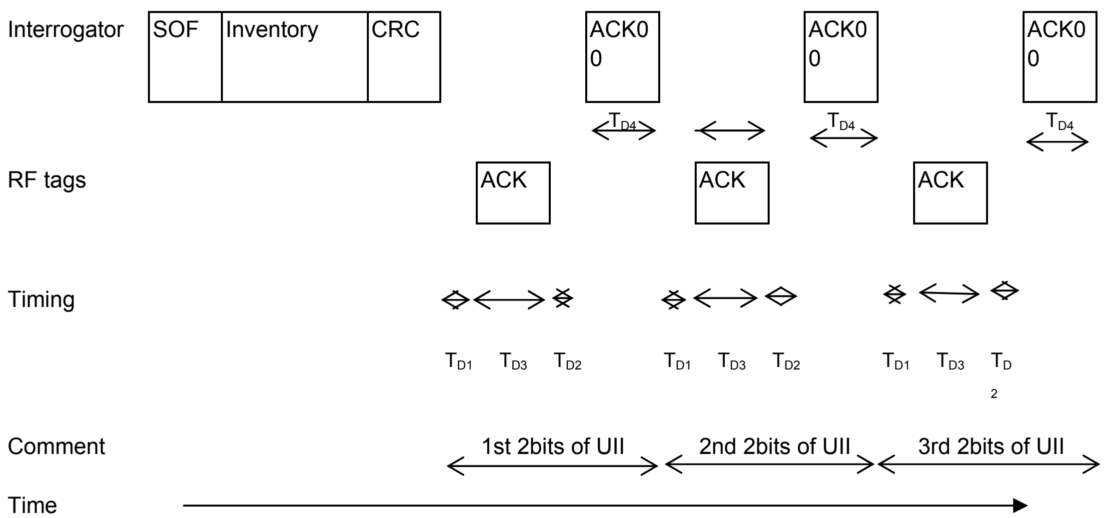
bb) In 3rd 2bit (b4b5), the UII of RF tag1 is also `11b`. Therefore RF tag1 transmits it's response in slot 11. No collision occurs and its UII is received and registered by the interrogator.

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

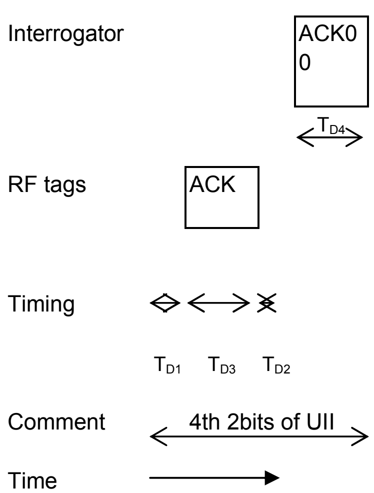
dd) In 4th 2bit (b6b7), the UII of RF tag1 is also `11b`. Therefore RF tag 2 transmits it's response in slot 11. No collision occurs and its UII is received and registered by the interrogator.

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

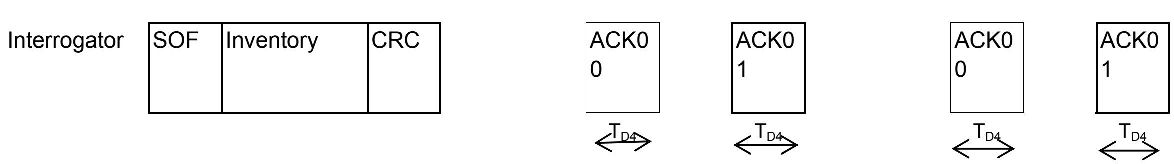
UII of RF TAG= \`00h\`

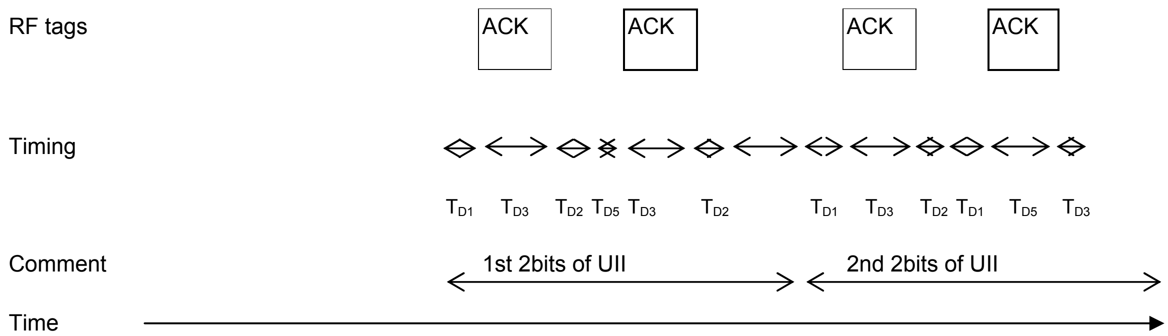


Continued…

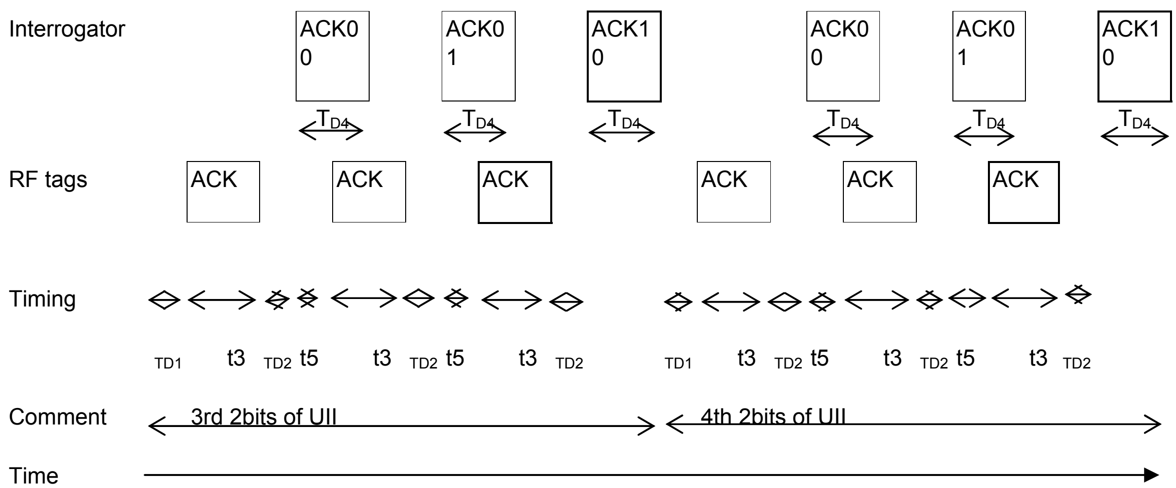


UII of RF TAG= \`5Ah\`

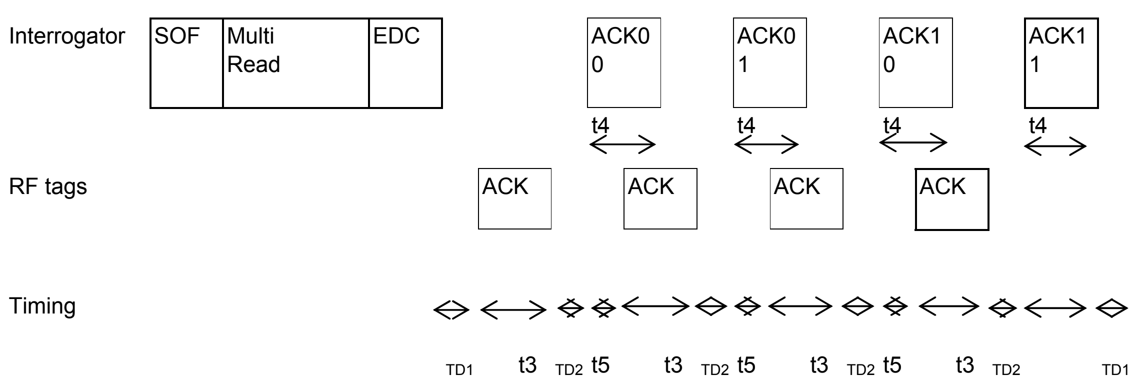




Continued…



UII of RF TAG= `FFh`



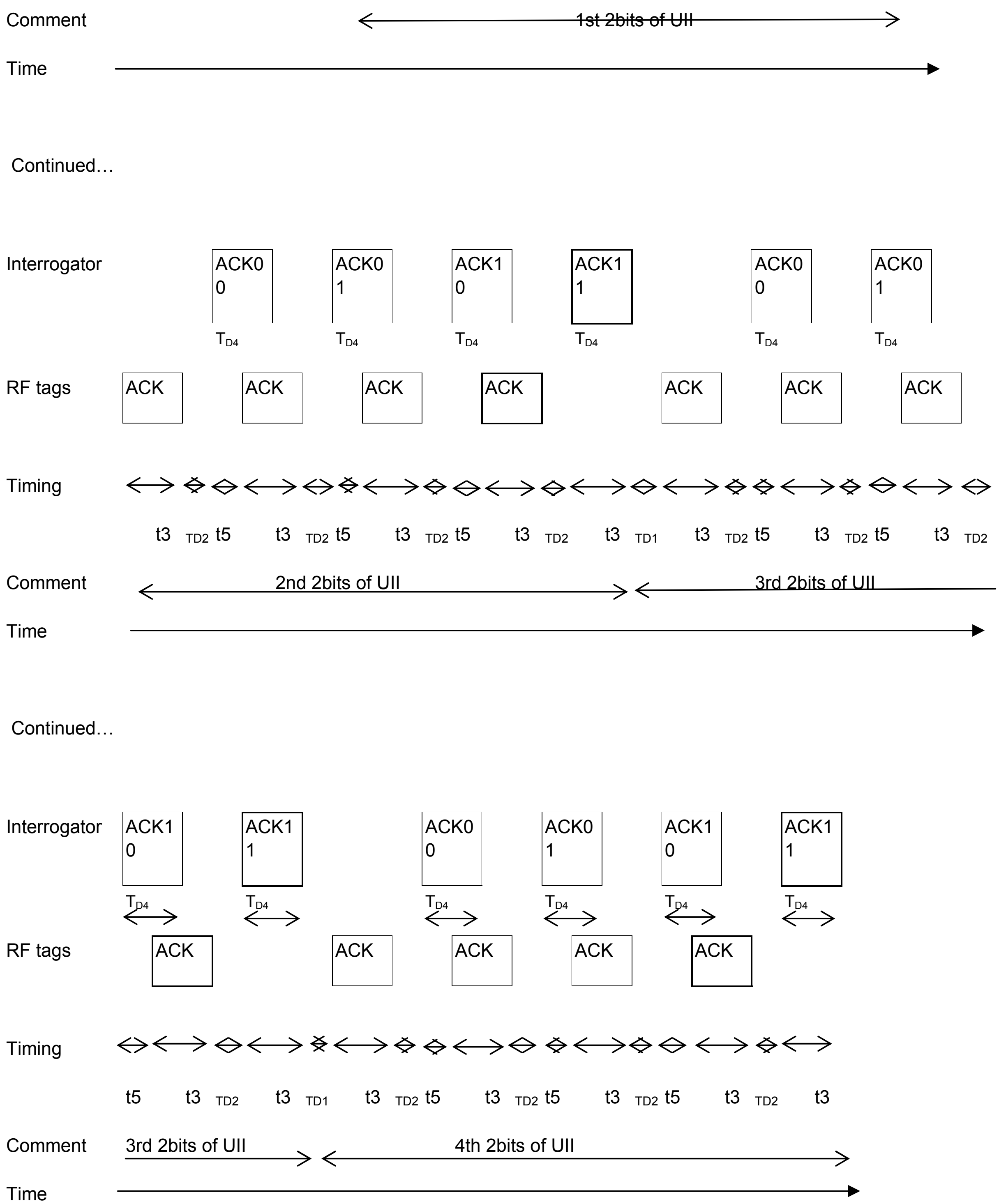


Figure C. 3— Description of a possible anti-collision sequence (ex. 4 tags)

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 to prevent the recurrence of collisions the phase of sub-carrier may be changed from previous response by tag.

C.5.4.1 Explanation of the collision

In the explanation in Figure C.3, the collision may occur between tag3 and tag1 if tag3 UII 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.

C.6 Protocol and anti-collision Parameters

C.6.1 Protocol Parameters

Table C.7 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	
Ref.	Parameter	Description	Comment/Option
M1A-P:3a	UII Length	The UII consists of 64 bits The UII consists of 48 bits The MID consists of 32bits	
M1A-P:3b	UII Format	UII: 8 bits Allocation Class 8 bits Manufacturer Code 16 bits reserved 40 bits Manufacturer Serial Number UII: 8 bits Manufacturer Code 40 bits Manufacturer Serial Number MID: programmed by tag Issuer	
Ref.	Parameter	Description	Comment/Option
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, UII=48bits, CRC=16bits) 4bytes: about 27ms (flag: 5bits, command: 6bits, no UII, no CRC)	
M1A-P:7	Write Transaction Time	4bytes: about 38ms (flag: 5bits, command: 6bits, UII=48bits, CRC=16bits) 4bytes: about 17ms (flag: 5bits, command: 6bits, no UII, no CRC)	
Ref.	Parameter	Description	Comment/Option
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 1Kbyte The typical memory size is 256byte	
M1A-P:11	Command structure and extensibility	The maximum number of commands is 64 (6 bits) See clause 11.3	

C.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.

Table C.8 Anti-collision protocol

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} (UII 48 bits) or 2^{32}(MID 32 bits)	In practice the tag capacity is limited by mutual detuning of the tags.

Annex D

(informative)

Bibliography

The following referenced documents are informative 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.

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