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Radiofrequency identification of animals — Advanced transponders —

Part 2: Code and command structure

Identification des animaux par radiofréquence — Transpondeurs évolués —

Partie 2: Code et structure de commande

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Foreword

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

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

ISO 14223-2 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics*.

ISO 14223 consists of the following parts, under the general title *Radiofrequency identification of animals — Advanced transponders*:

— *Part 1: Air Interface*

— *Part 2: Code and command structure*

The following part is under preparation:

— *Part 3: Applications*

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Introduction

This part of 14223 specifies the communication interface of the radio frequency (RF) system for advanced transponders for animals. The technical concept of advanced transponders for animal identification described is based upon the principle of radio frequency identification (RFID) and is an extension of the standards ISO 11784 and ISO 11785. Apart from transmission of the (unique) identification code of animals, the application of advanced technologies facilitates the storage and retrieval of additional information (integrated database), the implementation of authentication methods and the reading of data from integrated sensors, etc.

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Radiofrequency identification of animals — Advanced transponders —

Part 2: Code and command structure

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1 Scope

This part of ISO 14223 specifies the code and command structure between the transceiver and the advanced transponder used in the radiofrequency identification of animals, this specification being fully backwards-compatible with those of ISO 11784 and ISO 11785. As a direct extension of ISO 11785, it is intended to be used in conjunction with that International Standard.

2 Normative references

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

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

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

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

ISO 24631-1, *Radiofrequency identification of animals — Part 1: Evaluation of conformance of RFID transponders with ISO 11784 and ISO 11785 (including granting and use of a manufacturer code)*

3 Conformance

3.1 Transponder

For conformance with this part of ISO 14223 to be claimed, a transponder shall be FDX-ADV or HDX-ADV.

NOTE Nothing in this International Standard prevents a transponder being of more than one type, although for technical reasons, it is unlikely that such transponders are ever marketed.

3.2 Transceiver

For conformance with this part of ISO 14223 to be claimed, a transceiver shall support both FDX-ADV and HDX-ADV. When in the inventory mode, the transceiver shall alternate between FDX-ADV and HDX-ADV interrogation. The transceiver shall move back to ISO 11785 mode after completion of the advanced operation.

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4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1
advanced transponder
transponder conforming to ISO 14223, downward compatible according to ISO 11784 and ISO 11785, with facilities for storage and retrieval of additional data, integrated sensors, etc.

4.2
advanced mode
operating method of the advanced transponder after reception of a valid command

4.3
anticollision sequence
algorithm used to prepare for and handle a dialogue between transceiver and one or more transponders out of several in its energizing field

4.4
byte
eight bits of data designated b1 to b8, from the most significant bit (MSB, b8) to the least significant bit (LSB, b1)

5 Abbreviated terms

BSS	block security status
CRC	cyclic redundancy check
CRCT	response cyclic redundancy check flag
DSFID	data storage format identifier
EOF	end of frame
FDX	full duplex
IC	integrated circuit
ICR	integrated circuit reference number
HDX	half duplex
LSB	least significant bit
MFC	integrated circuit manufacturer code
MSB	most significant bit
MSN	manufacturer serial number
NOB	number of blocks per page
NOP	number of pages
NOS	number of slots
NRZ	non-return to zero

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NSS number of sensors

RF radio frequency

RTF reader talk first

RFU reserved for future use

SOF start of frame

UID unique identifier (includes MFC and MSN)

6 Transmission protocol

6.1 Basic elements

The advanced transmission protocol defines the mechanism for exchanging instructions and data between the transceiver and the transponders, in both directions.

It is based on the following concepts.

— The transponders are by default conformant with ISO 11784 and ISO 11785. This shall be evaluated conformant with ISO 24631-1. For advanced instructions the transceiver has the ability to communicate with a transponder in the advanced mode. In this mode the transponder is communicating in RTF mode and does not start to respond unless it has received and decoded a valid request from the transceiver.

— The transponders are uniquely identified by 48 bit UID, programmed at the manufacture of the integrated circuit. The UID coding is defined in 6.2.

— An identification code of 64 bits according to ISO 11784 is stored in page 0 (the four blocks given in Table 11 can be used to store the full ISO 11785 protocol) of the user memory area (blocks 0 to 3). This identification code shall be programmed and locked by the transponder issuer in order to avoid manipulations.

The advanced mode protocol is based on

— a request from the transceiver to the transponder, and

— a response from the transponder to the transceiver.

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 format. The setting of the flags indicates either request and response variants (e.g. number of slots) or the presence of optional fields. In the 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).

6.2 Unique identifier

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

The length of the UID is 48 bits, the format of the UID is presented in Table 1. The IC manufacturer is responsible for setting the UID as defined by this part of ISO 14223 and for ensuring the uniqueness of the MSN.

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Table 1 — UID format

MSB	LSB
48 41	40 1
IC manufacturer code (MFC)	IC manufacturer serial number (MSN)

The UID shall comprise

— the 8 bit MFC, according to ISO/IEC 7816-6, and

— the 40 bit MSN, a unique serial number assigned by the IC manufacturer.

6.3 Request format

A request consists of the following elements:

— SOF;

— flags;

— command;

— parameters (depending on the command);

— data (depending on the command);

— CRC (optional);

— EOF.

The general request format is presented in Table 2.

Table 2 — General request format

SOF	flags	command	parameters	data	CRC	EOF

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

The allocation of the LSB and MSB for each field of the request format is shown in Table 3.

Table 3 — Allocation of LSB and MSB to the request fields

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

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6.4 Response format

A response consists of the following elements:

— SOF pattern;

— error flag;

— error code;

— data (depending on the command);

— CRC (is optional depending on command and flag settings);

— EOF pattern.

The format of the general response if there is no error is presented in Table 4 and that of the general response if there is an error in Table 5.

Table 4 — General response format if no error

SOF	Error flag 0	Data	CRC	EOF

Table 5 — General response format if error

SOF	Error flag 1	Error code	CRC	EOF

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

The allocation of the LSB and MSB for each field of the response format is shown in Table 6.

Table 6 — Allocation of LSB and MSB to response fields

	LSB MSB	LSB MSB	LSB MSB	
SOF	Field 1 (1 bit) (Error flag)	Field 2 (⩾3 bits) (Error code or data)	Field 3 (16 bits) (CRC)	EOF

6.5 Request flags

6.5.1 General

In each request, five flags are used, with flag b1 to be transmitted first. The specific meaning of the request flags depends on the context. The meaning of request flags b1 to b3 is explained in Table 7, that of b4 and b5 where the inventory flag is *not* set in Table 8 and that where the inventory flag *is* set in Table 9.

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Table 7 — Meaning of request flags b1 to b3

Bit	Flag name	Value	Description
b1	PEXT (protocol extension) flag	0	No protocol format extension
		1	RFU
b2	INV (inventory) flag	0	The meaning of flags b4 to b5 is according to Table 8
		1	The meaning of flags b4 to b5 is according to Table 9
b3	CRCT	0	CRC shall *not* be appended to the transponder response
		1	CRC shall be appended to the transponder response

Table 8 — Request flags b4 to b5 definition when inventory flag is *not* set

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

Table 9 — Request flags b4 to b5 definition when the inventory flag is set

Bit	Flag name	Value	Description
b4	RFU	0	—
b5	NOS flag	0	16 slots
		1	1 slot

A further description of these flags is given in 6.5.2 to 6.5.4.

6.5.2 NOS flag

The NOS flag (see Table 10) is used by the INVENTORY command to select the number of slots during execution of the anticollision sequence.

Table 10 — Meaning of NOS flag

NOS flag	Meaning only for INVENTORY command
0	16 slots
1	1 slot

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6.5.3 SEL flag and ADR flag

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

When both the ADR flag and the SEL flag are set to 0, the request shall not contain a UID. Any transponder in the ready state receiving such a request shall execute it (if possible) and shall return a response to the transceiver as specified by the command description.

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

When the SEL flag is set to 1 (selected mode), the request shall not contain a transponder UID. Only the transponder in the selected state receiving such a request shall execute it (if possible) and shall return a response to the transceiver as specified by the command description. Other transponders not in the selected state shall keep their current state and be silent. The combination of ADR and SEL flag is not supported.

Table 11 gives an overview of the meaning of the SEL flag and ADR flag.

Table 11 — Meaning of SEL flag and ADR flag

SEL	ADR	Meaning for all commands except INVENTORY and READ UID
0	0	No UID is attached. All transponders in the ready state shall execute this command.
0	1	The UID is attached. Only the transponder with corresponding UID shall execute this command.
1	0	No UID is attached. Only the transponder in the selected state shall execute this command.
1	1	RFU

6.5.4 CRCT flag

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

6.6 Response flag and error code

The error flag indicates whether or not the transponder has detected an error (see Table 12). If it is set to 1, the response error field shall be returned according to Table 13.

If the transponder does not support specific error codes (as listed in Table 13) it shall answer with the error code 7 “unknown error”.

Table 12 — Error flag

Error flag	Meaning
0	No error
1	Error detected

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Table 13 — 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 response shall be according to the Table 14 format; commands not supporting error responses are excluded. In the case of an unsupported command there will be no response.

Table 14 — General response format (with error)

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

6.7 Error handling

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

— unsupported command;

— the inventory flag is set to 1;

— wrong manufacturer code in a customer command;

— CRC error;

— RFU bit ≠ 0;

— command format error.

6.8 Block security status (BSS)

The BSS is sent back by the transponder as a parameter in the response to a transceiver request as specified in 10.4 (e.g. READ SINGLE BLOCK WITH SECURITY STATUS). It is coded on four bits, as explained by Table 15.

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

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Table 15 — Block security status

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

6.9 Start of frame pattern (SOF)

6.9.1 Transceiver request

The transceiver request always starts with a SOF pattern. The SOF pattern is defined in ISO 14223-1.

6.9.2 Transponder response

The transponder response in the advanced mode always starts with a SOF pattern. The SOF pattern is defined in ISO 14223-1.

6.10 Cyclic redundancy check (CRC)

The CRC is according to ISO 11785. The initial register content shall be all zeros: “0000”. The CRC length is 16 bits.

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

The response CRC is calculated on all bits of the response after the SOF up to the CRC field. Whether the response CRC is appended to a response depends on the setting of the CRCT flag.

Upon reception of a request from the transceiver containing the CRC, the transponder shall verify the CRC value. If it is invalid, it shall discard the frame and remain silent.

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

An example of CRC calculation is given in of ISO 11785:1996, Annex B.

6.11 Data storage format identifier (DSFID)

The DSFID indicates how the data is structured in the transponder memory. The different data structures will be defined in ISO 14223-3.

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

If the programming and locking commands are not supported by the transponder, the transponder shall not respond to these commands.

If the DSFID is not supported or has not been programmed, the transponder shall return the default value “00” in answer to the commands requesting its value.

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7 Memory organization

7.1 General

The physical transponder memory is divided into three logical sections.

— The first logical memory section contains the system data (see 10.4.5).

— The second logical memory section contains the ISO 11784 and ISO 11785 code (see Table 16) and user data. These memory blocks are part of the user memory page 0.

— The third logical memory section contains user data (see Table 17). These memory blocks are part of the user memory page ⩾ 1.

The user memory is organized in pages, each page containing up to 256 blocks; the number of blocks per page shall be the same for all pages. Block size is 32 bits, with up to 256 pages, each with up to 256 blocks; a maximum user memory of 256 kByte can be addressed.

7.2 User data memory — Page 0

Blocks 0 to 3 of the user memory Page 0 are used to store the ISO 11784 and ISO 11785 code (see Table 16). It shall be locked just after programming to ensure any manipulation of this code after programming during the lifetime of the animal transponder. The first block accessible for users is block 4.

Table 16 — User data memory organization (page 0)

Block Address	Size	Description
0 to 3	4 times 32 bits	User data (Bits 1 to 128 reserved for ISO 11785 identification data or frame)
4	32 bits	User data
...	...	…
NOB	32 bits	User data

7.3 User data memory — Extended memory (⩾ page 1)

In the case of an advanced transponder having the means to handle sensor data, the blocks in the upper user memory are reserved for sensor data. The sensor hardware information is defined in the highest block (NOB). The meaning of the sensor data is defined in ISO 14223-3. The size of the sensor data area, i, is defined through the DSFID. In that case, the user data memory organization is described in Table 17. This memory can be addressed by extended memory commands.

Table 17 — User data memory organization (page 1 to NOP)

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]

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8 Transponder states

8.1 General

A transponder can be in one of the six following states:

— RF-off;

— wait;

— ISO 11785;

— ready;

— selected (optional);

— quiet.

The support of the RF-off, wait, ISO 11785, ready and quiet states is mandatory. The support of the selected state is optional.

After powering up, the FDX-ADV transponder stays in the wait state for a defined time-out period.

For advanced transponders, a change from the wait stage to the ready state takes place on SOF.

When the transponder cannot process a transceiver request (e.g. CRC error), it shall stay in its current state.

8.2 RF-off state

The transponder is in the RF-off state when it is not activated by the transceiver.

8.3 ISO 11785 state

This is the state where the ISO 11785 protocol is executed.

8.4 Wait state

The wait represents a transition phase in which the transponder can be switched to the advanced mode.

8.5 Ready state

The transponder moves to the ready state after receiving a valid request; in this way it is switched to advanced mode.

8.6 Quiet state

A transponder enters the quiet state after receiving the STAY QUIET command issued to the transponder. In the quiet state, the transponder shall process any request for which the ADR flag is set.

The transponders shall enter the quiet state if it is in the selected state and receives a SELECT command addressed to another transponder.

8.7 Selected state

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

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Only one transponder shall be in the selected state at any time. If a first transponder is in the selected state, and a second transponder will be selected by the SELECT command, the first transponder shall enter automatically the quiet state.

8.8 State diagram

In each of the states, except for the wait state, the transponder accepts only dedicated commands. All other commands are ignored. Figure 1 presents the transponder state diagram.

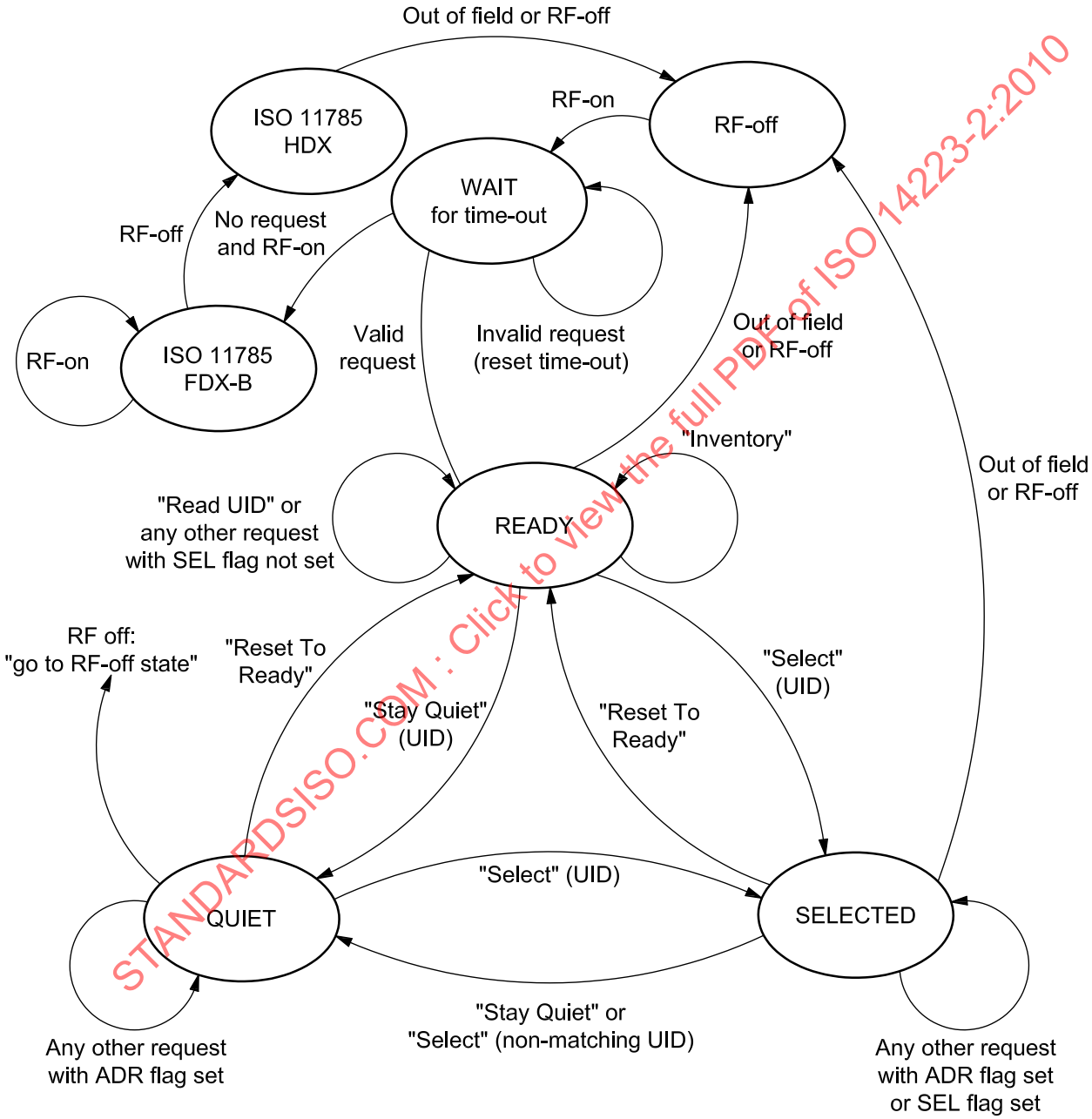

Figure 1 — Transponder state diagram

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9 Anticollision

9.1 General

The purpose of the anticollision sequence is to make an inventory of the transponders present in the transceiver field by their UID.

The transceiver is the master of the communication with one or multiple transponders. It starts the anticollision sequence by issuing the INVENTORY request.

The transponder shall send its response in the slot determined or shall not respond, according to the algorithm described in 9.3.

9.2 Request parameters

When issuing the INVENTORY command, the transceiver 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 (see Table 19) and any value between 0 and 48 when 1 slot is used (see Table 18).

Table 18 — Inventory request format (mask length 1 slot)

SOF	Flags	Command	Mask length, n 1 slot $0 \leqslant n < 48$	Mask value	CRC (optional)	EOF
	5 bits	6 bits	6 bits	n bits	16 bits	

Table 19 — Inventory request format (mask length 16 slots)

SOF	Flags	Command	Mask length, n 16 slots $0 \leqslant n < 44$	Mask value	CRC (optional)	EOF
	5 bits	6 bits	6 bits	n bits	16 bits	

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

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9.3 Request processing by the transponder

Upon reception of a valid request, the transponder shall process it by executing the operation sequence specified in italics as below. The step sequence is also graphically represented in Figure 2.

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

end if

label1: if LSB(UID, SN_length + Mask_length) = LSB(SN, SN_length) & LSB(Mask, Mask_length) then

transmit response to inventory request

end if

wait (Slot_Frame)

if Slot_Frame = SOF then

stop anticollision and decode/process request

exit

end if

if SN<NbS-1 then

SN = SN +1

go to label1

exit

end if

exit

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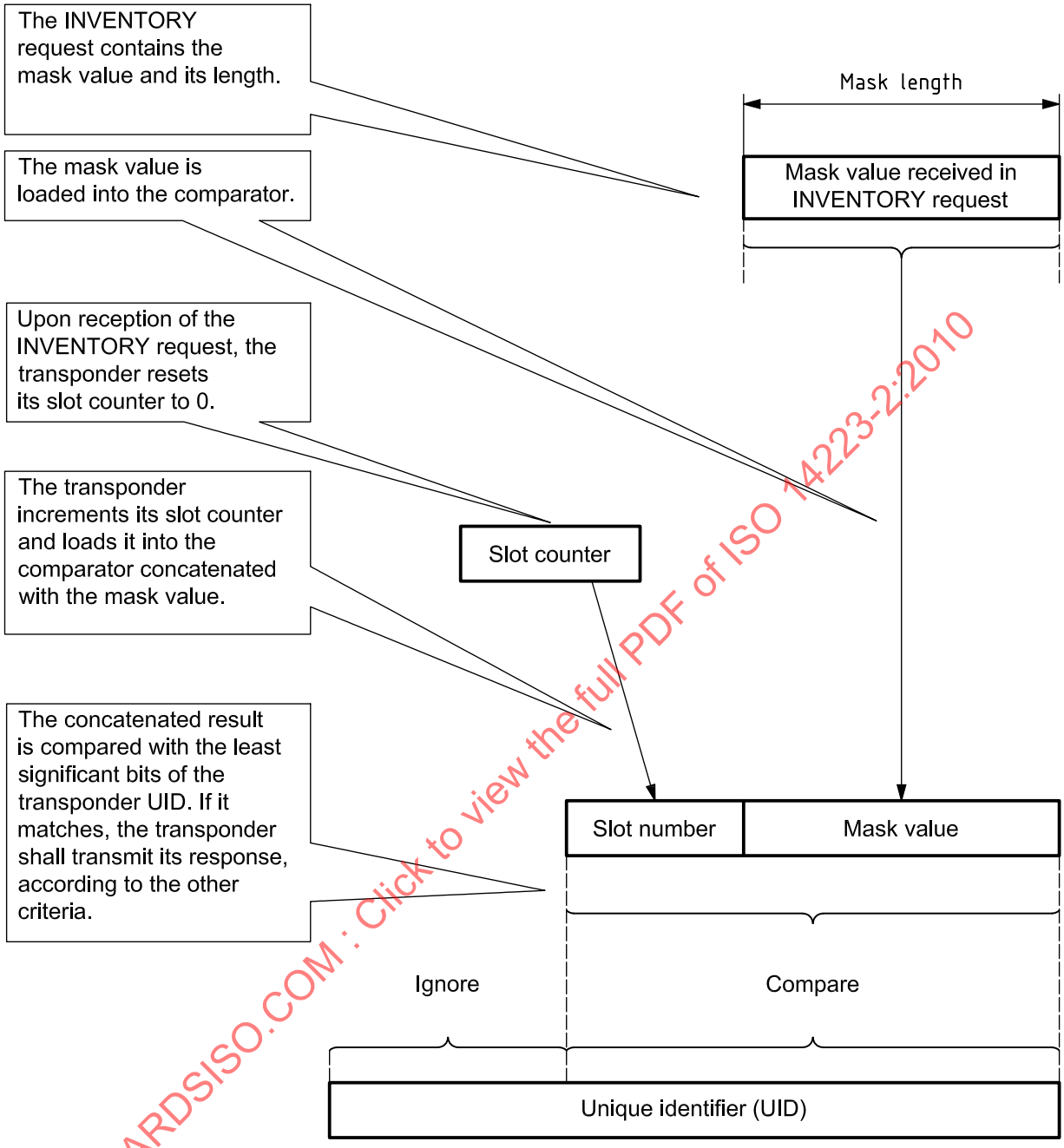

Figure 2 — Principle of comparison between mask value, slot number and UID

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

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9.4 Explanation of anticollision sequences

9.4.1 General

FDX transponders shall transmit the remaining section of the UID in dual pattern code. The following data (error flag, data block where an ISO 11785 number is requested, optional CRC) shall be transmitted in Manchester code.

9.4.2 Anticollision sequence with one slot

The following description explains a typical anticollision sequence where the number of slots is 1.

a) The transceiver sends an INVENTORY request.

   If the UID of the transponder 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 transponders in the ready state simultaneously transmit their responses.

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

b) The transceiver checks the transponder responses bitwise.

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

   If there is only one transponder responding, no collision occurs and the transponder UID is received and registered by the transceiver. Continue at c).

   If there is more than one transponder responding, the transceiver reads additional UID bits of the transponders and expands the mask value with these bits until the first collision occurs. The transceiver recognizes the bit position of this collision and expands the mask value to 0 or 1, depending on which serial number branch is to be selected. Continue at a).

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

9.4.3 Anticollision sequence with 16 slots

Figure 3 summarises the main cases that can occur during a typical anticollision sequence where the number of slots is 16.

The different steps are the following.

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

b) Transponder 1 transmits its response in slot 0. It is the only one to do so, consequently, no collision occurs and its UID is received and registered by the transceiver.

c) The transceiver sends an EOF or recharge for HDX-ADV, meaning to switch to the next slot.

d) In slot 1, two transponders, 2 and 3, transmit their responses, this generates a collision. The transceiver detects it and remembers that a collision was detected in slot 1.

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e) The transceiver sends an EOF or recharge for HDX-ADV, meaning to switch to the next slot.

f) In slot 2, no transponder transmits a response. Consequently, the transceiver does not detect a transponder SOF and decides to send an addressed request (for example, a read block) to transponder 1, which UID was already correctly received.

g) All transponders detect a SOF and exit the anticollision sequence. They process this request and since the request is addressed to transponder 1, only transponder 1 transmits its response.

h) All transponders are ready to receive another request. If it is an INVENTORY command, the slot numbering sequence restarts from 0 (slot numbering 0 to 15).

NOTE The decision to interrupt the anticollision sequence is up to the transceiver. It could have continued to send EOFs until slot 15 and then send the request to transponder 1.

9.4.4 Mixed population with transponders of type FDX-ADV and HDX-ADV

The following description explains a typical anticollision sequence when transponders of both types (FDX and HDX) are in the transceiver field (or expected to be).

a) The transceiver switches on the RF field and awaits the power-up time.

b) The transceiver performs an anticollision sequence according to 9.4.2 (one slot) or 9.4.3 (16 slots).

c) The transceiver may switch off the RF field.

d) The transceiver switches on the RF field and charges the transponder during 10 ms to 50 ms.

e) The transceiver performs an anticollision sequence according to 9.4.2 (one slot) or 9.4.3 (16 slots).

f) The transceiver switches off the RF field.

NOTE The order of sequence a), b), c), d), e), f) can be replaced by d), e), f), a), b), c).

9.4.5 Advanced anticollision mode

This mode is used to access the code conforming to ISO 11784 and ISO 11785 during the anticollision process. It can be accessed by setting the inventory flag in multiple block command.

Parameters are:

— read multiple block command with parameter block 0 to 3;

— inventory flag set to 1.

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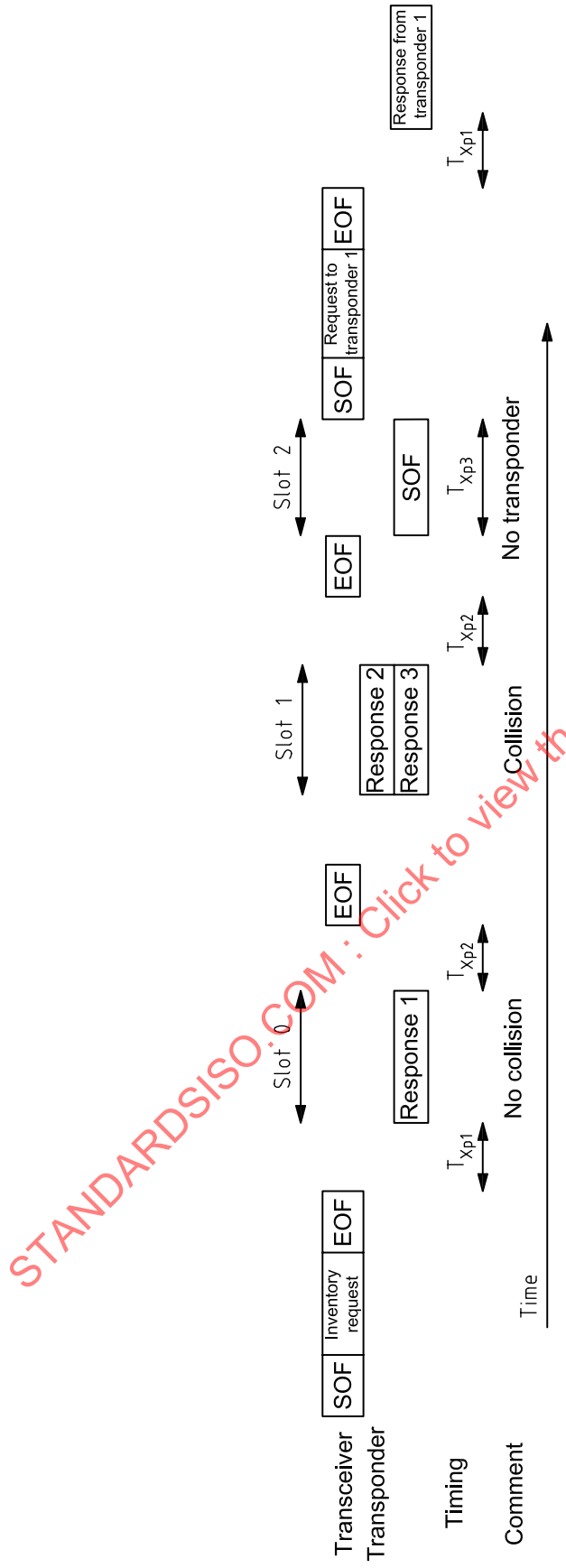

Key

T_{Xp1} transponder waiting time before starting to transmit response after detection of valid transceiver request

T_{Xp2} transceiver waiting time before starting to transmit subsequent request after receiving transponder response

T_{Xp3} transceiver waiting time before switching to next slot during inventory process

Figure 3 — Description of a possible anticollision sequence

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10 Commands

10.1 Command classification

Four sets of commands are defined as follows (see Table 20).

a) **Mandatory**

All transponders and transceivers shall support them.

b) **Optional**

Transponders may support them, at their option. If not supported, the transponder shall remain silent. If supported, request and response formats shall comply with the definition given in this part of ISO 14223.

c) **Custom**

Transponders support them, at their option, to implement manufacturer specific functions. 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. If not supported, a correct error code ("Not supported") or, if no specific error code is supported, error code '7', shall be returned.

d) **Proprietary**

These commands are used by IC and transponder manufacturers for different purposes, such as testing and the programming of system information. They are not specified in this part of ISO 14223. The IC manufacturer may, at his option, document them or not. It is likely that these commands will be disabled after IC and/or transponder manufacturing.

Table 20 — Command classes

Code	Class
"00" to "27"	Mandatory or optional
"28" to "37"	Custom
"38" to "3F"	Proprietary

All transponders with the same MFC and ICR shall behave in the same manner.

In the case of the implementation of a custom command having a logical function already covered by one of the defined optional commands, it is mandatory that the optional command concerned be implemented.

The attention of transceiver designers is drawn to the possibility that transponder manufacturers can implement custom commands and/or proprietary commands, if not disabled, in quite different ways for the same command code, which can lead to errors whose consequences cannot be predicted. It is therefore recommended that custom commands and/or proprietary commands, if not disabled, be performed only after the IC manufacturer code and IC version has been requested from the transponders. These two parameters, linked with the IC manufacturer information, will inform the transceiver of the supported commands and their syntax.

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10.2 Command list

Table 21 gives an overview of the command list.

Table 21 — Command list

Command	Code	Type	Function	Valid in state
Inventory	“00”	Mandatory	Anticollision loop	Ready
Stay quiet	“01”	Mandatory	Forces a transponder into the quiet state	Ready, quiet, selected
Read UID	“02”	Mandatory	Fast reading of the transponders UID 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 transponder into the selected state	Ready, quiet, selected
Reset to ready	“19”	Optional	Forces a selected transponder into the ready state	Ready, quiet, selected
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
Reserved (ISO/IEC 18000-2)	“1C”	Not available in ISO 14223	—	—
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	—
Inventory ISO 11785 code	“23”	Mandatory	Inventory command including ISO 11785 code	Ready
RFU	“24” to “27”	Optional	—	—
	“28” to “37”	Custom	IC manufacturer specific commands	—
	“38” to “3F”	Proprietary	IC manufacturer specific commands	—

Execution of the lock/write commands shall be completed and acknowledged within 20 ms of the detection of the last falling edge of the transceiver request (FDX) or after the transceiver has switched off the field (HDX).

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10.3 Mandatory commands

10.3.1 INVENTORY

Upon reception of this command without error, all transponders in the ready state shall perform the anticollision sequence. The inventory (INV) flag shall be set to 1. The NOS flag determines whether one or 16 slots are used.

If a transponder detects any error, it shall remain silent.

The INVENTORY request format is given in Table 22, the INVENTORY response format in Table 23, the INVENTORY request format with ISO 11785 code is given in Table 24 and the INVENTORY response format with ISO 11785 code in Table 25.

Table 22 — INVENTORY request format

SOF	Flags	Command	Parameter 1	Parameter 2	CRC	EOF
		INVENTORY	Mask length n	Mask value	(Optional)	
	5 bits	6 bits	6 bits	n bits	16 bits	

Table 23 — INVENTORY response format

SOF	Error flag	Data	CRC	EOF
	0	Remaining section of the UID (UID without mask value)	(Optional)	
	1 bit	48 – n bits	16 bits	

Table 24 — INVENTORY request format with ISO 11785 code

SOF	Flags	Command	Parameter 1	Parameter 2	CRC	EOF
		Inventory ISO 11785 code	Mask length n	Mask value	(Optional)	
	5 bits	6 bits	6 bits	n bits	16 bits	

Table 25 — INVENTORY response format with ISO 11785 code

SOF	Error flag	Data	Data block	CRC	EOF
	0	Remaining section of the UID (UID without mask value)	ISO 11785 number	(Optional)	
	1 bit	48 – n bits	64 bits	16 bits	

The allowed values of n depend on the number of slots and are defined in 9.2.

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10.3.2 READ UID

Upon reception of this command without error, all transponders in the ready state shall send their UID. The READ UID request format is shown in Table 26 and the READ UID response format in Table 27.

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

Table 26 — READ UID request format

SOF	Flags	Command	CRC	EOF
		READ UID	(Optional)	
	5 bits	6 bits	16 bits	

Table 27 — READ UID response format

SOF	Error flag	Data	CRC	EOF
	0	UID	(Optional)	
	1 bit	48 bits	16 bits	

10.3.3 READ MULTIPLE BLOCKS

Upon reception of this command without error, the transponder shall read the requested block(s) and send back their value in the response. The blocks are numbered from 0 to 255. The format for the READ MULTIPLE BLOCKS request is given in Table 28 and the format for the READ MULTIPLE BLOCKS response in Table 29.

The number of blocks in the request is 1 less than the number of blocks that the transponder shall return in its response. For example, a value of 6 in the "Number of blocks" field is needed to request that seven blocks be read, and a value of 0 to request that a single block be read.

Table 28 — READ MULTIPLE BLOCKS request format

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

Table 29 — READ MULTIPLE BLOCKS response format

SOF	Error flag	Data	CRC	EOF
	0	User memory block data	(Optional)	
	1 bit	32 bits	16 bits	
		Repeated as needed		

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10.3.4 STAY QUIET

Upon reception of this command without error, a transponder in either the ready or the selected state shall enter the quiet state and shall NOT send back a response.

The 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 transponder detects an error.

The format of the STAY QUIET request format is presented in Table 30.

Table 30 — STAY QUIET request format

SOF	Flags	Command	Parameter	CRC	EOF
		STAY QUIET	UID (Optional)	(Optional)	
	5 bits	6 bits	48 bits	16 bits	

10.3.5 WRITE SINGLE BLOCK

Upon reception of this command without error, the transponder shall write the requested block with the data contained in the request and report the success of the operation in the response. The WRITE SINGLE BLOCK request is presented in Table 31 and the WRITE SINGLE BLOCK response in Table 32.

Table 31 — WRITE SINGLE BLOCK request format

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

Table 32 — WRITE SINGLE BLOCK response format

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

10.3.6 LOCK BLOCK

Upon reception of the LOCK BLOCK command without error, the transponder shall lock permanently the requested block. The LOCK BLOCK request format is given in Table 33 and the LOCK BLOCK response format in Table 34.

Table 33 — LOCK BLOCK request format

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

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Table 34 — LOCK BLOCK response format

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

10.4 Optional commands

10.4.1 READ SINGLE BLOCK

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

The READ SINGLE BLOCK request format is presented in Table 35 and the READ SINGLE BLOCK response format in Table 36.

Table 35 — READ SINGLE BLOCK request format

SOF	Flags	Command	Parameter 1	Parameter 2	CRC	EOF
		READ SINGLE BLOCK	UID (Optional)	Block address	(Optional)	
	5 bits	6 bits	48 bits	8 bits	16 bits	

Table 36 — READ SINGLE BLOCK response format

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

10.4.2 READ SINGLE BLOCK WITH SECURITY STATUS

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

The READ SINGLE BLOCK WITH SECURITY STATUS request format is presented in Table 37 and the READ SINGLE BLOCK WITH SECURITY STATUS response format in Table 38.

Table 37 — READ SINGLE BLOCK WITH SECURITY STATUS request format

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

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Table 38 — READ SINGLE BLOCK WITH SECURITY STATUS response format

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

10.4.3 READ MULTIPLE BLOCKS WITH SECURITY STATUS

Upon reception of this command without error, the transponder 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 transponder is to return in its response. For example, a value of 6 in the "Number of blocks" field is needed to request that seven blocks be read, and a value of 0 to request that a single block be read.

The READ MULTIPLE BLOCKS WITH SECURITY STATUS request format is presented in Table 39 and the READ MULTIPLE BLOCKS WITH SECURITY STATUS response format in Table 40.

Table 39 — READ MULTIPLE BLOCKS WITH SECURITY STATUS request format

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

Table 40 — READ MULTIPLE BLOCKS WITH SECURITY STATUS response 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			

10.4.4 WRITE MULTIPLE BLOCKS

Upon reception of this command without error, the transponder shall write the requested block(s) with the data contained in the request and report the success of the operation in the response.

For HDX transponders, the transceiver shall keep the field on after the EOF for a period sufficient for the memory programming to be performed, so that the transponder is powered.

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 transponder is to write. For example, a value of 6 in the "Number of blocks" field is needed to request that seven blocks be written. The "Data" field shall contain seven blocks. A value of 0 in the "Number of blocks" field is needed to request that a single block be written. The "Data" field shall contain one block.

The WRITE MULTIPLE BLOCKS request format is presented in Table 41 and the WRITE MULTIPLE BLOCKS response format in Table 42.

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Table 41 — WRITE MULTIPLE BLOCKS request format

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

Table 42 — WRITE MULTIPLE BLOCKS response format

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

10.4.5 GET SYSTEM INFORMATION

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

The GET SYSTEM INFORMATION request format is presented in Table 43, the GET SYSTEM INFORMATION response format in Table 44 and the system data description in Table 45.

Table 43 — GET SYSTEM INFORMATION request format

SOF	Flags	Command	Parameter 1	CRC	EOF
		GET SYSTEM INFORMATION	UID (Optional)	(Optional)	
	5 bits	6 bits	48 bits	16 bits	

Table 44 — GET SYSTEM INFORMATION response 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	RFU	NSS	NOB	NOP	DSFID	RFU		

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Table 45 — System data description

System data	Size	Type	Description
MFC	8 bits	Mandatory	IC manufacturer code
ICR	8 bits	Optional	IC reference code
MSN	40 bits	Mandatory	Manufacturer serial number
DSFID	8 bits	Optional	Data storage format identifier
NOP	8 bits	Optional	Number of pages – 1 (0 to 255)
NOB	8 bits	Optional	Number of blocks per page – 1 (0 to 255)
NSS	8 bits	Optional	Number of sensors

10.4.6 SELECT

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

a) if the UID is equal to its own UID, the transponder shall enter the selected state and shall send a response, or

b) if it is different,

— a transponder in a non-selected state (quiet or ready) shall keep its state and shall not send a response, and

— the transponder in the selected state shall enter the quiet state and shall not send a response.

The SELECT request format is presented in Table 46 and the SELECT response format in Table 47.

Table 46 — SELECT request format

SOF	Flags	Command	Parameter	CRC	EOF
		SELECT	UID	(Optional)	
	5 bits	6 bits	48 bits	16 bits	

Table 47 — SELECT response format

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

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