INTERNATIONAL STANDARD

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Second edition
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Radiofrequency identification of animals — Advanced transponders —

Part 1: Air interface

Identification des animaux par radiofréquence — Transpondeurs évolués —

Partie 1: Interface hertzienne

Reference number
ISO 14223-1:2011(E)

Contents

Page

Foreword

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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 14223-1 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics*.

This second edition cancels and replaces the first edition (ISO 14223-1:2003), which has been technically revised.

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*

Introduction

This part of ISO 14223 specifies the air interface of the radiofrequency (RF) system for advanced transponders for animals. The technical concept of advanced transponders for animal identification described is based upon the principle of radiofrequency 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 1: Air interface

1 Scope

This part of ISO 14223 specifies the air interface 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.

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 11785:1996, *Radio frequency identification of animals — Technical concept*

ISO 14223-2:2010, *Radiofrequency identification of animals — Advanced transponders — Part 2: Code and command structure*

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)*

ISO 24631-2, *Radiofrequency identification of animals — Part 2: Evaluation of conformance of RFID transceivers with ISO 11784 and ISO 11785*

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, as specified in Clauses 7 and 8, and shall be in accordance with ISO 24631-1.

NOTE Nothing in this part of ISO 14223 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, as specified in Clauses 7 and 8, and shall be in accordance with ISO 24631-2. When in the inventory mode, the transceiver shall alternate between FDX-ADV and HDX-ADV interrogation. After completion of the advanced operation, the transceiver shall move back to the mode specified by ISO 11785:1996, 6.1, for FDX systems, or ISO 11785:1996, 6.2, for HDX systems.

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
bit rate
number of bits transmitted per second

4.4
carrier off time
time interval wherein the interrogation field is switched off

4.5
charge-up time
time taken to charge the capacitor of the HDX transponder

4.6
differential bi-phase encoding
method of encoding in which data bit 0 is represented by a mid-bit transition, data bit 1 by no transition and, additionally, there is always a transition between two bits

4.7
down-link
communication process from the transceiver to the transponder

4.8
encoding
one-to-one relationship between basic information elements and modulation patterns

4.9
FDX-ADV
full duplex advanced
communication protocol for FDX advanced transponders

4.10
frequency shift keying
superimposition of binary information onto an electromagnetic field carrier by shifting between discrete frequencies of the field

4.11
full duplex
FDX
communication protocol in which information is exchanged while the transceiver transmits the interrogation field

4.12
half duplex
HDX
communication protocol in which information is exchanged after the transceiver has stopped transmitting the interrogation field (sequential method)

4.13
HDX-ADV
half duplex advanced
communication protocol for HDX advanced transponders

4.14
interrogation field
magnetic field generated by a transceiver to activate a transponder and transfer data to an advanced transponder

4.15
interrogation frequency
frequency of the magnetic field generated by the transceiver

4.16
interrogation period
time during which the magnetic field is present

4.17
Manchester encoding
method of encoding in which data bit 0 is represented by a positive mid-bit transition and data bit 1 by a negative mid-bit transition

4.18
modulation
method of superimposing information onto an interrogation field by means of varying a specific parameter of the field

4.19
non-return to zero encoding
method of encoding in which data bit 1 is a high signal and data bit 0 a low signal

4.20
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

NOTE The number of received carrier cycles defines data bit values or other code conditions.

4.21
SWITCH command
specific bit pattern which may be used by FDX-ADV transponders to switch to the advanced mode

4.22
switch window
time interval after powering up wherein an FDX-ADV transponder can be switched to the advanced mode

4.23
transceiver
device used to communicate with a transponder

4.24
transceiver request
bit pattern transmitted to the advanced transponder to modify the transponder status or to read and write information

4.25
transponder
radio frequency identification (RFID) device that transmits its stored information when activated by a transceiver and that may be able to store new information

NOTE A transponder can be characterized according to its components (chip, coil, capacitor, etc.), communication protocol, size, shape and packaging, or any additional characteristics that could change its properties. The main types are defined in ISO 24631-1:2009, 4.19.1 to 4.19.4.

[ISO 24631-1:2009, definition 4.19]

5 Abbreviated terms

ASK amplitude shift keying

CRC cyclic redundancy check

CRCT response cyclic redundancy check flag

EOF end of frame

FDX full duplex

FDX-ADV full duplex advanced

FSK frequency shift keying

HDX half duplex

HDX-ADV half duplex advanced

kbps kilobytes per second: unit for transmission speed (1 000 bit/s or 1 000 Bd)

LSB least significant bit

MSB most significant bit

NOS number of slots in the anti-collision mode

NRZ non-return to zero

RFID radio frequency identification

SOF start of frame

6 Symbols

f_C carrier frequency of the operating field

f_0 carrier frequency of HDX transponder when transmitting data symbol “0”

f_1 carrier frequency of HDX transponder when transmitting data symbol “1”

T_C period of carrier frequency ($T_C = 1/f_C \approx 7{,}452$ µs)

T_{CH} transceiver carrier frequency ON time to charge-up the storage capacitor of an HDX transponder

T_{Fd} period of data bit period of transponder to transceiver

T_{Xd0} period of data symbol “0”

T_{Xd1} period of data symbol “1”

T_{Xcv} code violation duration

T_{HcvEOF} code violation duration for HDX-ADV transceivers for the end of frame

T_{HcvSOF} code violation duration for HDX-ADV transceivers for the start of frame

T_{NRT} transponder nominal response time

T_{RCH} transceiver ON time to recharge the storage capacitor of an HDX-ADV transponder

T_{Xd} data element transmission time

T_{X1} transceiver carrier off pulse width

T_{Fsc} stop condition time (identical to T_{FpEOF})

T_{XpSOF} time duration for a transponder to transmit a SOF to the transceiver

T_{XpEOF} time duration for a transponder to transmit an EOF to the transceiver

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 the next slot during an inventory process

Subscripts

F FDX-ADV

H HDX-ADV

X either FDX-ADV or HDX-ADV

NOTE Other symbols specific to F or H are specified in the relevant clauses/subclauses.

p protocol timing (this subscript is followed by letters and/or numbers, as appropriate)

7 General requirements

The advanced transponder shall be compatible with ISO 11785. At the time the advanced transponder is placed in the interrogation field, it shall perform as per the transponders specified by ISO 11785. To identify itself as an advanced transponder, it shall send type information in the reserved bit field to the transceiver as follows:

— Bit 15 of the ISO 11784 frame shall be set to “1”, indicating an advanced transponder;

— Bit 16 of the ISO 11784 frame (additional data flag) shall be set to “1”, indicating that the transponder contains additional data.

To bring the advanced transponder into the advanced mode, the transceiver shall send a valid request or SOF. The details of this procedure for each request are described in the relevant sections of this part of ISO 14223. When the advanced transponder has detected a valid request or SOF, it shall switch to the advanced mode.

In advanced mode, the advanced transponder shall only respond when requested by the transceiver. All communication from transceiver to transponder and vice versa shall be in accordance with ISO 11785 and ISO 14223-2. The identification code, all communication from transceiver to transponder and vice versa, and the CRC error detection bits (if applicable) shall be transmitted starting with LSB first.

In the case where multiple, advanced transponders are in the interrogation field, causing collisions, the transceiver shall start the anti-collision procedure in accordance with ISO 14223-2:2010, Clause 9. Depending on the part of the total identification message, as defined in ISO 11785, in which the collision is detected, the transceiver will start with either the FDX-ADV or HDX-ADV anti-collision request.

The advanced transponder shall switch back to the mode specified in ISO 11785:1996, 6.1 (for FDX systems) or 6.2 (for HDX systems), when

a) no longer in the interrogation field,

b) it has terminated the advanced operations and the interrogation field has been switched off for at least 5 ms afterwards.

This carrier-OFF time shall be extended up to 20 ms, depending on the presence of an HDX(-ADV) transponder.

8 FDX-ADV transponder

8.1 FDX-ADV down-link description

After receiving and decoding the total identification message, as defined in ISO 11785, of the transponder code, the transceiver shall detect the presence of an advanced transponder in the interrogation field. To transfer the FDX-ADV transponder into the advanced mode, the transceiver's interrogation field shall be switched off. After this OFF period, the interrogation field shall be switched on again, and either the SOF at the start of a valid request or the special SWITCH command shall be sent to the transponder within the specified switch time window. The transponder shall switch itself into the advanced mode upon reception of any SWITCH command. In this advanced mode, the FDX-ADV transponder shall respond when requested by the transceiver (transceiver-driven protocol).

As specified above, the advanced transponder switches back to the ISO 11785-specified mode for FDX or HDX after the interrogation field has been switched off for at least 5 ms. The steps necessary for transferring the FDX-ADV transponder into the advanced mode are shown in Figure 1. The down-link communication takes place in the periods of Cycles C and D (the letters A to E represent the cycles described below). The example illustrated by Figure 1 shows two data blocks (#1 and #2) being selected by the transceiver; these are then transmitted by the FDX-ADV transponder.

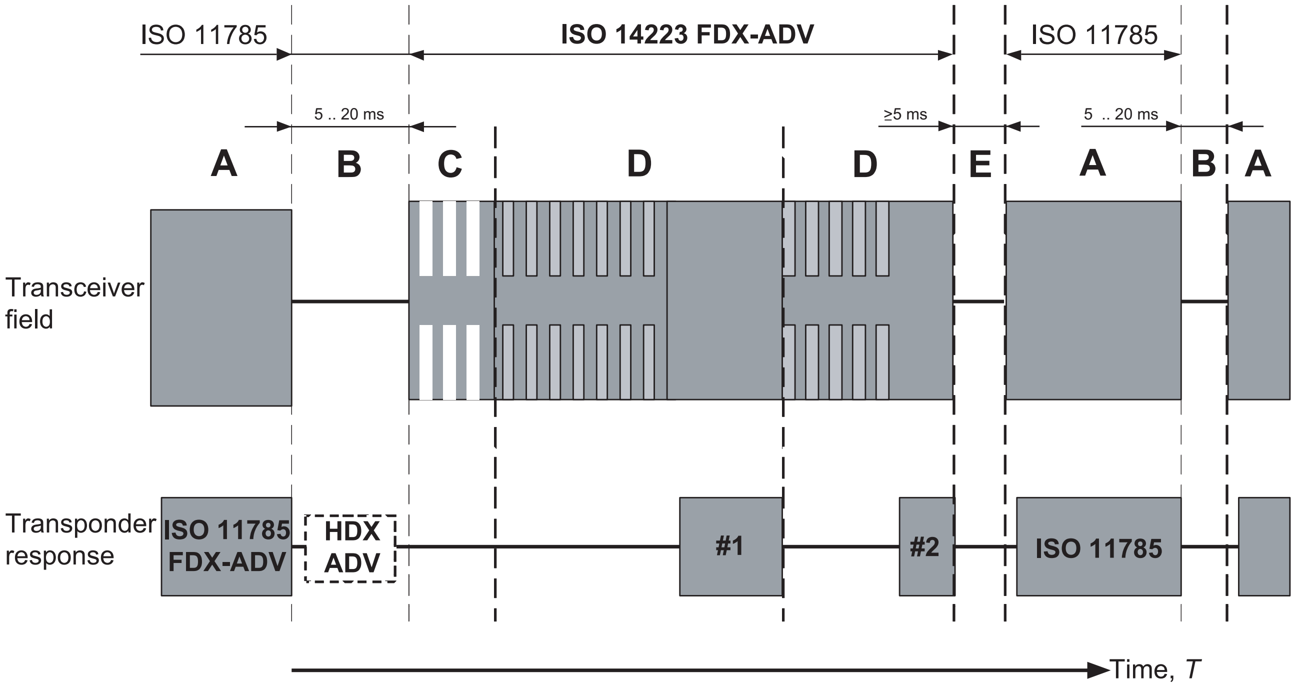


Figure 1 — RF interface for FDX-ADV transponders

Cycle A The transceiver reads the total identification message, as defined in ISO 11785. With the bits defined in the reserved field, the transceiver detects that an FDX-ADV transponder is in the interrogation field.

Cycle B The transceiver switches off the interrogation field for at least 5 ms in order to reset the transponder.

Cycle C The transceiver sends either the SOF at the start of a valid request or the SWITCH command to the transponder in order to put it into the advanced mode. Any of these has to be issued within the switch window after reset — as defined in Table 1 and Figure 2.

Cycle D Read/write or inventory operation in the advanced mode.

Cycle E After all operations are finished or the transponder has left the antenna field, the transceiver switches off the field for at least 5 ms in order to poll for new incoming transponders (compatible with ISO 11785).

8.2 FDX-ADV transponder — Mode-switching protocol

After powering, the FDX-ADV transponder shall switch to the advanced mode after receiving one of the two possible SWITCH commands from the transceiver during the specified switch window. See Table 1 and Figure 2.

The transceiver sends either the SOF at the start of a valid request or a special SWITCH command to the transponder, as shown in Figure 2, in order to transfer it into the advanced mode. Any of these has to be issued within the switch window after reset, as defined in Table 1 and as shown Figure 2.

Table 1 — FDX-ADV transponder — Air interface parameters

Interrogation field modulation	Amplitude modulation (ASK), 90–100 %
Encoding	Pulse interval encoding, LSB first
Bit rate	Typically 5,5 kbps
Mode switching	Either a specific 5 bit SWITCH command or the detection of the SOF as part of a valid advanced transponder command, transmitted after the interruption of the interrogation field for at least 5 ms.
Mode switch timing	Transponder settling time: 312,5 T_C SWITCH command window after transponder settling: 232,5 T_C. All within Cycle C in Figure 1.
Mode SWITCH command	000 11 or SOF sequence

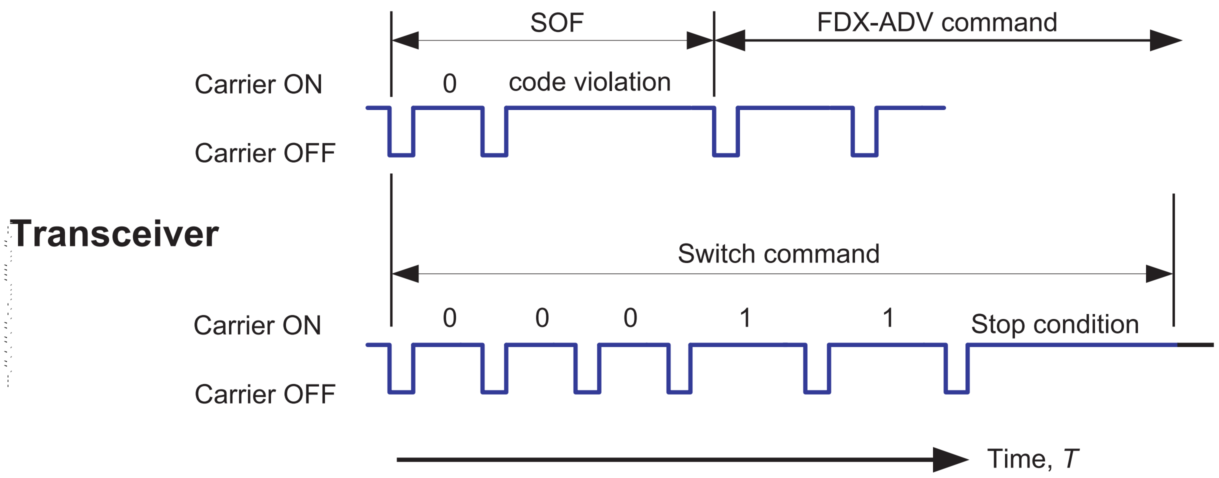


Figure 2 — Transceiver down-link modulation for advanced mode SWITCH command

8.3 Down-link communication signal interface — Transceiver to transponder

8.3.1 Modulation parameters

Communications between transceiver and transponder take place using ASK modulation with a modulation index of >90 %. See Figure 3 and Table 2.

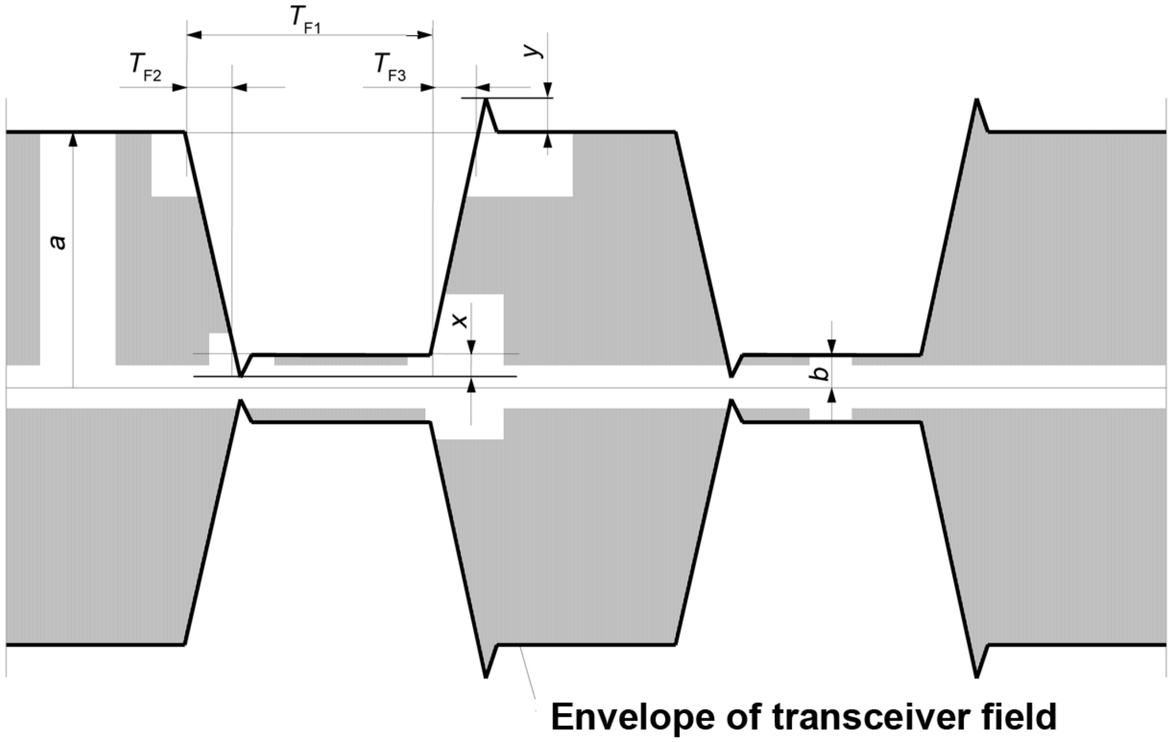


Figure 3 — Modulation details of data transmission from transceiver to FDX-ADV transponder

Table 2 — FDX-ADV — Modulation coding times

Symbol	Minimum	Maximum
$m = (a - b)/(a + b)$	90 %	100 %
T_{F1}	4 * T_C	10 * T_C
T_{F2}	0	0,5 * T_{F1}
T_{F3}	0	0,5 * T_{Fd0}
x	0	0,05 * a
y	0	0,05 * a

T_{F3} shall not exceed $T_{Fd0} - T_{F1} - 3*T_C$.

8.3.2 Data rate and data coding

The transceiver-to-transponder communication uses pulse interval encoding. The transceiver creates pulses by switching the carrier off as described in Figure 4. The time between the falling edges of the pulses determines either the value of the data bits “0” and “1”, a code violation or a stop condition.

Assuming equal distributed data bits “0” and “1”, the data rate is in the range of about 5,5 kbps.

The data coding times are presented in Table 3.

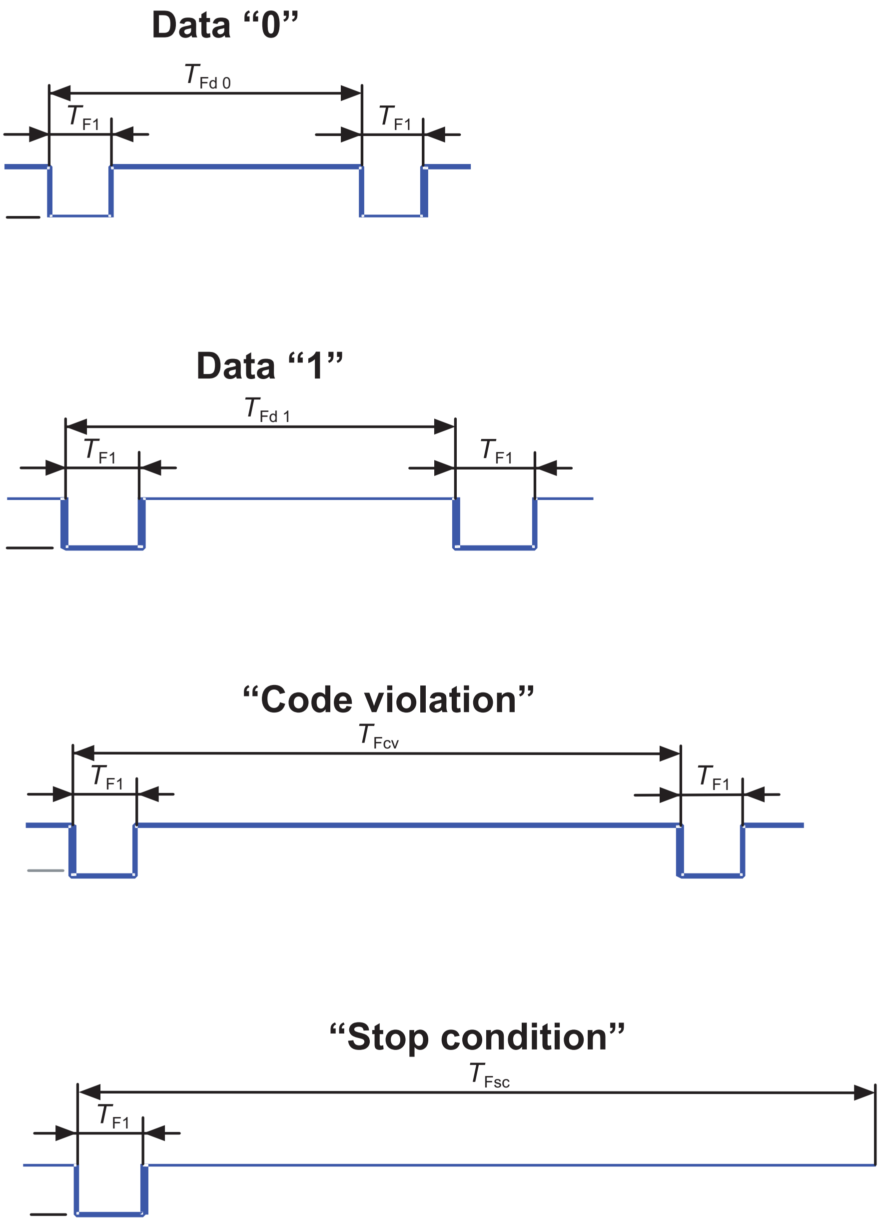


Figure 4 — Transceiver to transponder — Pulse interval encoding

Table 3 — FDX-ADV — Data coding times

Time	Symbol	Minimum	Maximum
Carrier OFF time	T_{F1}	4 * T_C	10 * T_C
Data "0" time	T_{Fd0}	18 * T_C	22 * T_C
Data "1" time	T_{Fd1}	26 * T_C	30 * T_C
Code violation time	T_{Fcv}	34 * T_C	38 * T_C
Stop condition time	T_{Fsc}	$\geqslant$42 * T_C	—

8.3.3 Transceiver — Start of frame (SOF) pattern

The transceiver request in the advanced mode always starts with a SOF pattern for ease of synchronisation. The SOF consists of an encoded data bit “0” and a “code violation” pattern.

The transponder shall be ready to receive a SOF from the transceiver within 1,2 ms of having sent a response to the transceiver.

The transponder shall be ready to receive a SOF or SWITCH command from the transceiver within 2,33 ms after the transceiver has established the powering field.

See Figure 5.

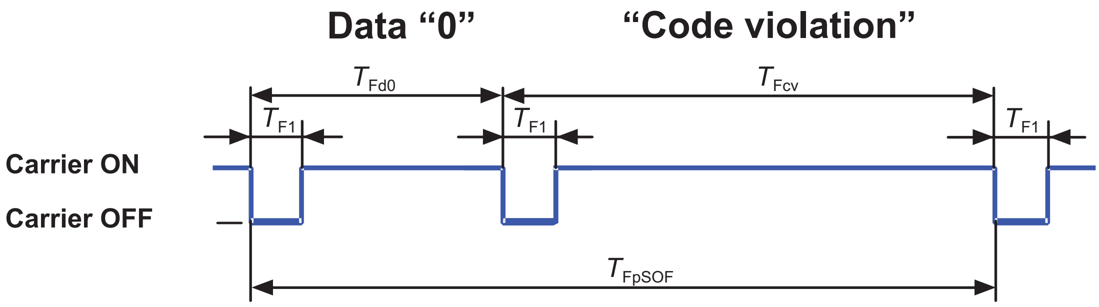


Figure 5 — SOF pattern

8.3.4 Transceiver — End of frame (EOF) pattern

For slot switching during a multi-slot anti-collision sequence, the transceiver request is an EOF pattern. The EOF pattern is represented by a transceiver “Stop condition”. See Figure 6.

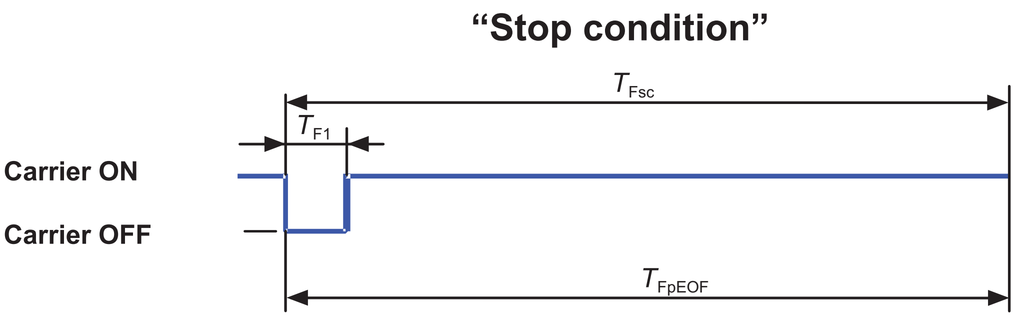


Figure 6 — EOF pattern

8.4 Communication signal interface — Transponder to transceiver

8.4.1 Data rate and data coding

The transponder shall be capable of communicating with the transceiver via an inductive coupling, whereby the carrier is loaded with

— $1/T_{Fd}$ differential bi-phase coded data signal in the ISO 11785 mode, without SOF and EOF,

— $1/T_{Fd}$ Manchester coded data signal on the response to the advanced transponder commands, and

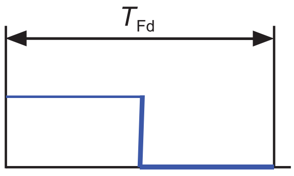
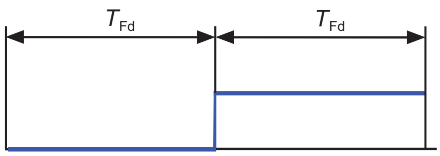
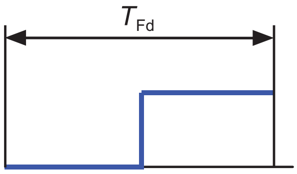
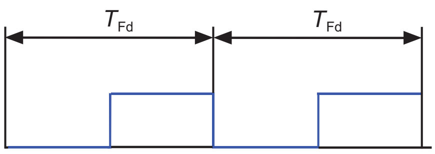
— $1/(2 * T_{Fd})$ dual pattern data coding when responding within the inventory process,

where $T_{Fd} = 32/f_C$.

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

See Table 4.

Table 4 — FDX-ADV transponder — Load modulation coding

Data element	Response encoding to advanced transceiver request	Response encoding in INVENTORY mode
Data "0"	Load off Load on 	Load off Load on 
Data "1"	Load off Load on 	Load off Load on 

8.4.2 Start of frame (SOF) pattern

The transponder response — if not in ISO 11785-compliant mode — always starts with a SOF pattern. The SOF is a Manchester encoded bit sequence of "110". See Figure 7.

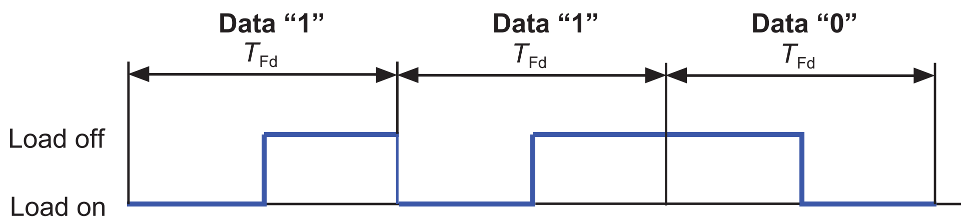


Figure 7 — FDX-ADV — SOF pattern

8.4.3 End of frame (EOF) pattern

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

9 HDX-ADV transponder

9.1 Transponder charge and recharge times

HDX transponders must be charged to operate and this is done by switching on the transceiver's field for a defined time. This charge phase is executed at the beginning of every request and the duration depends on the system parameters and distance to the transceiver. After the power is switched on, the charge phase as defined by the ISO 11785 timing frame is of 50 ms duration.

During the execution of the INVENTORY request, the transponders shall be charged at the beginning, as stated above. Between the inventory slots, the transponders shall be recharged. This recharge time also depends on the amount of additional data requested in an inventory request and physical parameters.

See Table 5.

Table 5 — HDX-ADV — Charge and recharge times

Time	Symbol	Min.	Max.
Charge time, ms	T_{CH}	20	50
Recharge time, ms	T_{RCH}	5	20

9.2 HDX-ADV down-link description

The HDX-ADV transponder uses the half-duplex communication protocol. It can be switched into the advanced mode at every charging cycle. In order to bring the transponder into the advanced mode, after the charge-up period, the transceiver shall send a valid request. After receiving a valid request, the transponder shall respond with the data according to this request in the subsequent off time of the field (response interval). The down-link communication takes place in the period of Cycle C (the letters A to E represent the cycles described below). The example illustrated by Figure 8 shows two data blocks (#1 and #2) being addressed by the transceiver, which are then transmitted by the transponder.

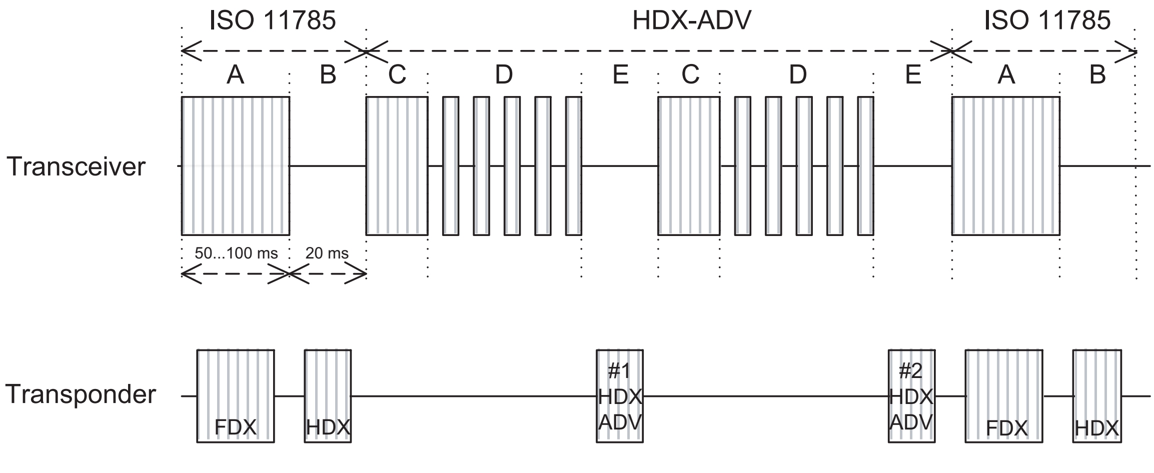


Figure 8 — RF interface for HDX-ADV transponders

Cycle A The transceiver switches on the RF field to charge the ISO 11785 HDX, HDX-ADV, FDX or FDX-ADV transponders for a time of 50–100 ms, depending on whether an FDX transponder is present.

Cycle B The transceiver switches off the RF field for 20 ms in order to read the ISO 11785-compliant response of the HDX or HDX-ADV transponder.

Cycle C Recharging of the HDX transponders in the field.

Cycle D The transceiver modulates the RF field according to the encoded down-link data, to transmit commands and data to the HDX-ADV transponder.

Cycle E The transceiver switches off the RF field in order to receive the corresponding response frame of the HDX-ADV transponder.

9.3 HDX-ADV — Mode switching protocol

The HDX-ADV transponder shall switch to the advanced mode upon reception of a valid request after the charge phase. The valid request has simultaneously a switch function and defines for the transponder how to respond. At every charging cycle, the transponder starts up again in the default ISO 11785 mode if no further request is transmitted by the transceiver.

9.4 Down-link communication signal interface — Transceiver to HDX-ADV transponder

9.4.1 Modulation parameters

Communication between transceiver and transponder takes place using ASK modulation with a modulation index of >90 %. See Figure 9 and Table 6.

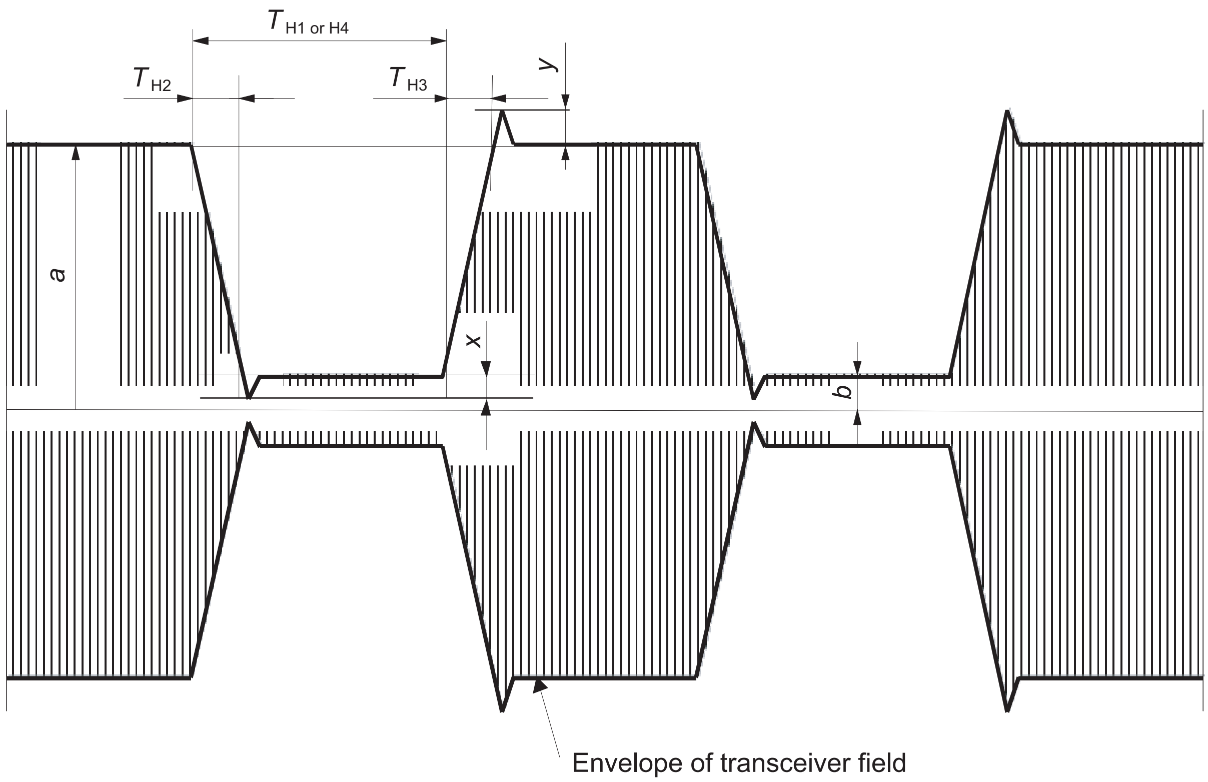


Figure 9 — Modulation details of HDX-ADV data transmission from transceiver to transponder

Table 6 — HDX-ADV — Modulation coding times

Symbol	Minimum	Nominal	Maximum
T_{H1}	14 * T_C	20 * T_C	26 * T_C
T_{H2}	2 * T_C	7 * T_C	10 * T_C
T_{H3}	5 * T_C	13 * T_C	20 * T_C
T_{H4}	34 * T_C	40 * T_C	46 * T_C
x	0	—	0,05 * a
y	0	—	0,05 * a

9.4.2 Data rate and data coding

The transceiver-to-transponder communication uses pulse interval encoding. The transceiver generates pulses by switching the carrier on and off as described in Figure 10. 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.

See Figure 10.

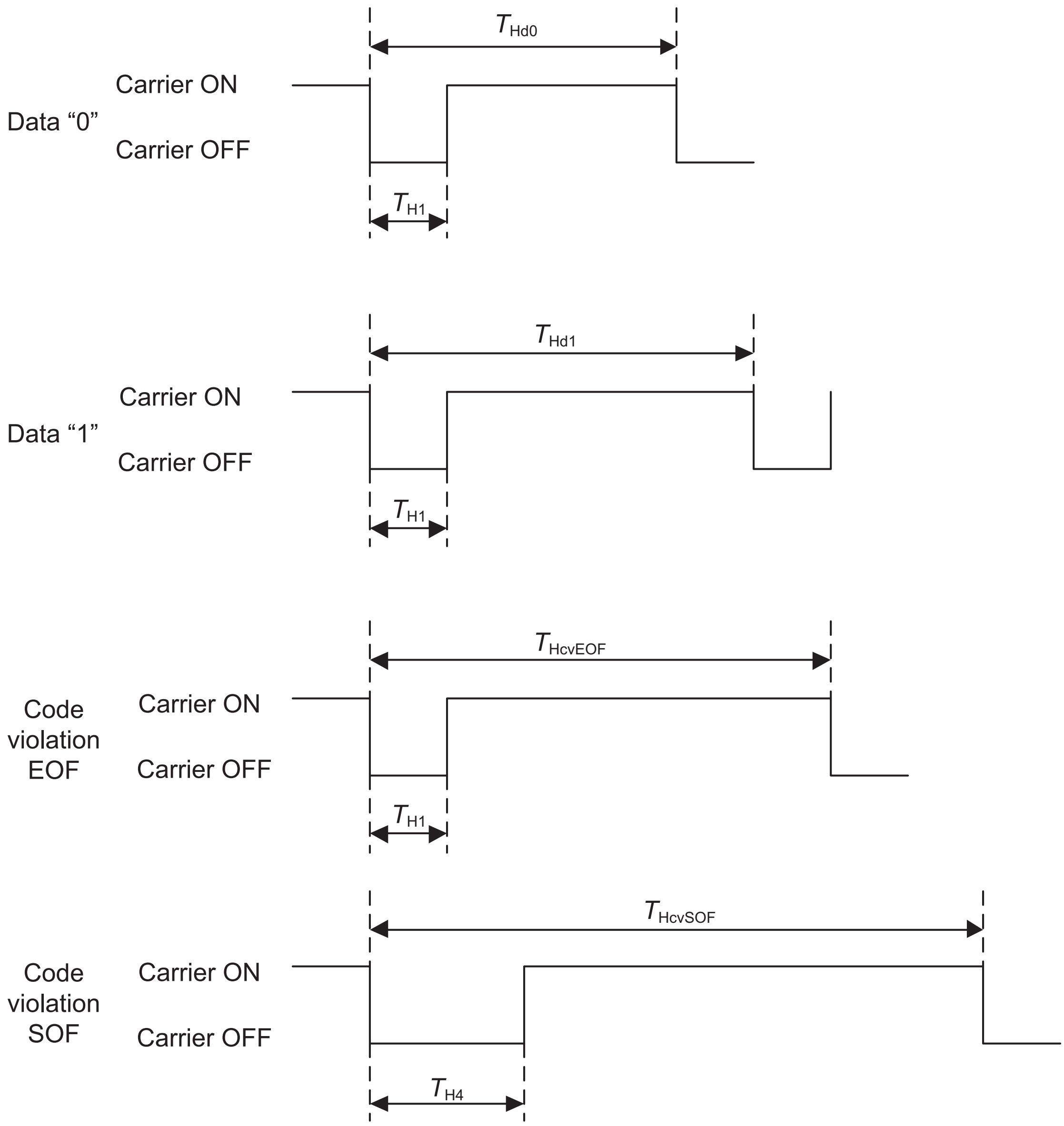


Figure 10 — Transceiver to transponder — Modulation and coding

Assuming equal distribution of data bits “0” and “1”, the data rate is 2,83 kbps (nominal). The data coding times are presented in Table 7.

Table 7 — HDX-ADV — Data coding times

Symbol	Minimum	Nominal	Maximum
T_{Hd0}	40 * T_C	43 * T_C	46 * T_C
T_{Hd1}	50 * T_C	52 * T_C	54 * T_C
T_{HcvEOF}	70 * T_C	—	—
T_{HcvSOF}	100 * T_C	107 * T_C	114 * T_C

9.4.3 Start of frame (SOF) pattern

The transceiver request always starts with a SOF pattern (see Figure 11). The SOF consists of a data "1", data "0" and "code violation" pattern that defines a clear start of frame.

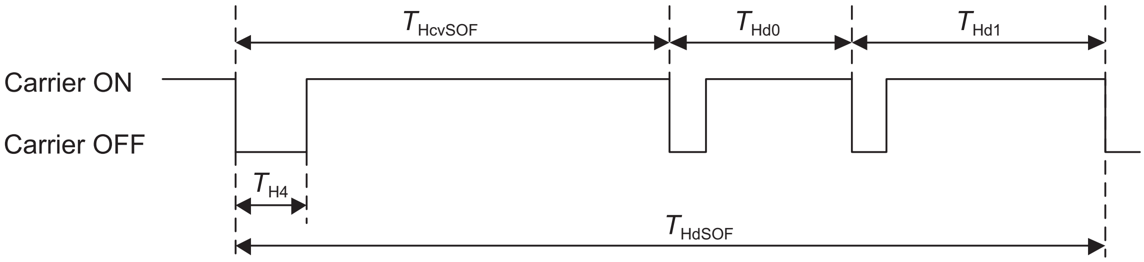


Figure 11 — HDX-ADV — SOF pattern

9.4.4 End of frame (EOF)

For the EOF of the HDX-ADV transceiver request, the code violation pattern, T_{HcvEOF}, is used (see Figure 12).

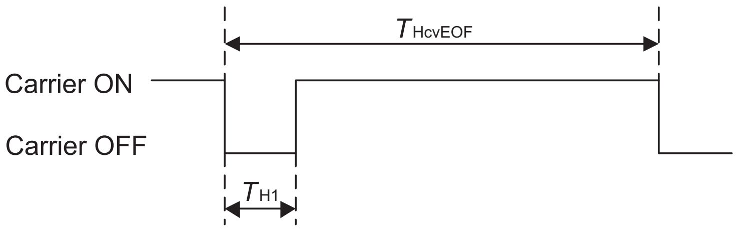


Figure 12 — HDX-ADV — EOF pattern

9.5 Communication signal interface — Transponder to transceiver

9.5.1 Data rate and data coding

The transponder shall be capable of communication with the transceiver via an inductive coupling, whereby the power is switched off and the response data are FSK-modulated using the following frequencies:

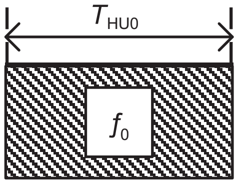
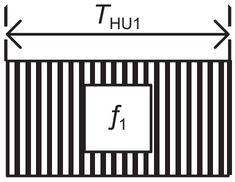
— f_0 = 134,2 ± 3 kHz for the data bit "0" encoding;

— f_1 = 123,7 ± 3 kHz for the data bit "1" encoding.

The data coding is based on the NRZ method. The average data rate is about 8 kbps.

See Table 8.

Table 8 — Transponder to transceiver — HDX-ADV modulation and data coding

Data element	Command	Comment
Data “0”		$T_{HU0} = 16/f_0$
Data “1”		$T_{HU1} = 16/f_1$

9.5.2 Start of frame (SOF) pattern

The transponder response — if not in ISO 11785-compliant mode — always starts with a SOF pattern. The SOF is coded with a bit pattern of “011101”.

f_1 represents the frequency for data bit “1” (T_{HU1}) and f_0 the frequency for data bit “0” (T_{HU0}).

See Figure 13.

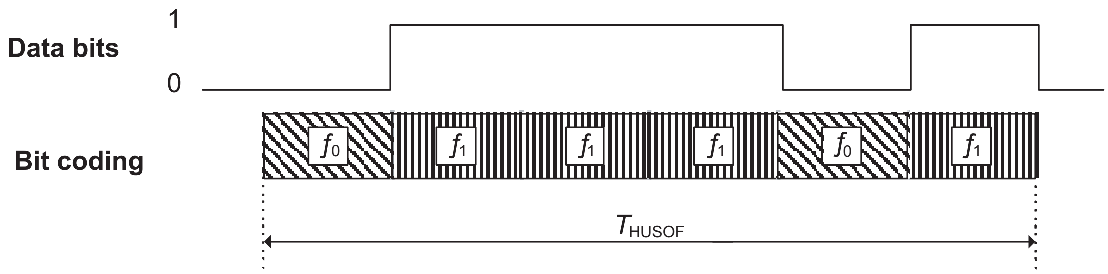


Figure 13 — HDX-ADV SOF pattern

9.5.3 End of frame (EOF) pattern

The transponder response — if not in ISO 11785-compliant mode — always ends with an EOF. The EOF is coded “101110”.

f_1 represents the frequency for data bit “1” (T_{HU1}) and f_0 the frequency for data bit “0” (T_{HU0}).

See Figure 14.

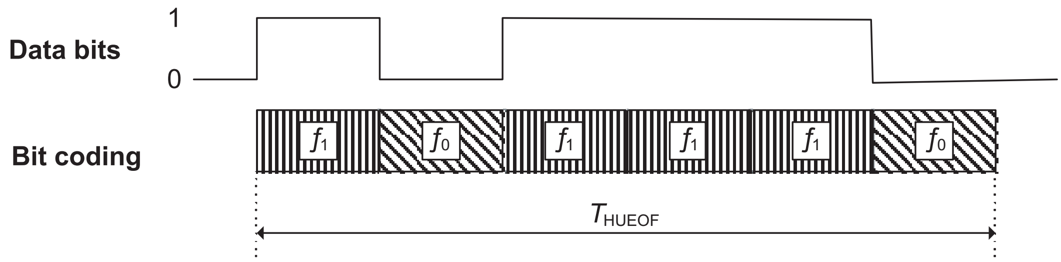


Figure 14 — HDX-ADV EOF pattern

10 General protocol timing specification

10.1 General considerations

The transceiver and the transponder shall comply with the protocol timing specifications given in this clause, which is intended to be used in conjunction with ISO 14223-2.

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, at the latest either

— after 20 ms upon detection of the last falling edge of the interrogator request (Type A), or

— after the interrogator has switched off the field (Type B).

T_{Fp1} and T_{Hp1} are not applicable for write-like requests.

10.2 FDX-ADV transponder

10.2.1 Waiting time before transmitting a response after EOF from the transceiver

When the FDX-ADV transponder has detected an EOF of a valid transceiver request or when this EOF is in the normal sequence of a valid transceiver request, it shall wait for the duration of time T_{Fp1} before starting to transmit its response to a transceiver request or switching to the next slot in an inventory process. T_{Fp1} starts from the detection of the falling edge of the EOF received from the transceiver.

NOTE 1 For a detailed explanation of the inventory process, see ISO 14223-2:2010, Clause 9.

NOTE 2 The synchronisation on the falling edge of the transceiver to transponder EOF is necessary to ensure the required synchronisation of the transponder responses.

See Figure 15.

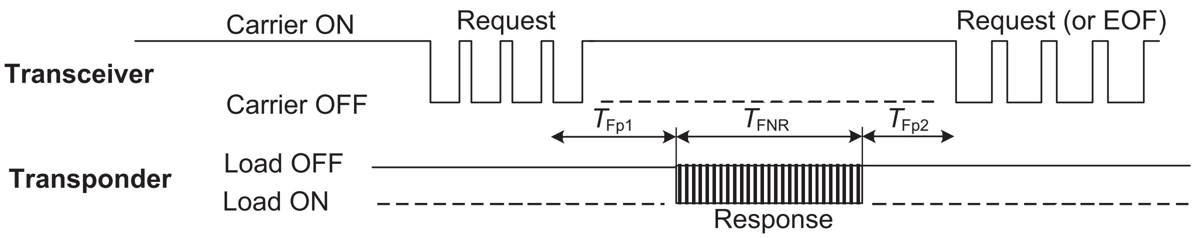


Figure 15 — FDX-ADV — General protocol timing diagram

The minimum value of T_{Fp1} is $T_{Fp1min} = 204\ T_C$.

The typical value of T_{Fp1} is $T_{Fp1typ} = 209\ T_C$.

The maximum value of T_{Fp1} is $T_{Fp1max} = 213\ T_C$.

If the FDX-ADV transponder detects a carrier modulation during T_{Fp1}, it shall reset its T_{Fp1} timer and wait for a further duration of T_{Fp1} before starting to transmit its response to a transceiver request or switch to the next slot in an inventory process.

10.2.2 Transceiver waiting time before sending a subsequent request

10.2.2.1 When the transceiver has received a transponder response to a previous request other than INVENTORY or QUIET, it shall wait for the duration of time T_{Fp2} before sending a subsequent request. T_{Fp2} starts from the time the last bit has been received from the transponder.

10.2.2.2 When the transceiver has sent a QUIET request (transponder arrest command), it shall wait for the duration of time T_{Fp2} before sending a subsequent request. T_{Fp2} starts from the end of the QUIET request's EOF (falling edge of EOF pulse + 42 T_C).

The minimum value of T_{Fp2} is $T_{Fp2min} = 150\ T_C$. This ensures that the transponders are ready to receive a subsequent request.

10.2.2.3 The transceiver shall wait at least 2,33 ms after it has activated the electromagnetic field before sending the first request, in order to ensure that the transponder(s) are ready to receive a request (see 9.4.3).

When the transceiver has sent an inventory request, it is in an inventory process. See 10.2.3.

10.2.3 Transceiver waiting time before switching to the next inventory slot

10.2.3.1 General

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

NOTE For a detailed explanation of the inventory process, see ISO 14223-2:2010, Clause 9.

To switch to the next slot, the transceiver sends an EOF after waiting for the duration of the times specified in 10.2.3.2 and 10.2.3.3.

10.2.3.2 Transceiver starts to receive one or more FDX-ADV transponder responses

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

— wait for the complete reception of the transponder responses (i.e. when the transponder's last bit has been received or when its nominal response time, T_{NRT}, has elapsed),

— wait an additional time, T_{Fp2}, 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_{Fp2} starts from the time the last bit has been received from the transponder.

The minimum value of T_{Fp2} is $T_{Fp2min} = 150\ T_C$.

T_{NRT} is dependant on the anti-collision current mask value and on the setting of the CRCT.

10.2.3.3 Transceiver received no FDX-ADV transponder response

During an inventory process, when the transceiver has received no transponder response, it shall wait for the duration of time T_{Fp3} before sending a subsequent 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_{Fp3} starts from the time the transceiver has generated the falling edge of the last sent EOF.

The minimum value of T_{Fp3} is $T_{Fp3min} = T_{Fp1max} + T_{FpSOF}$.

T_{FpSOF} is the time duration for a transponder to transmit a SOF to the transceiver.

See Figure 16 and Table 9 for an overview.

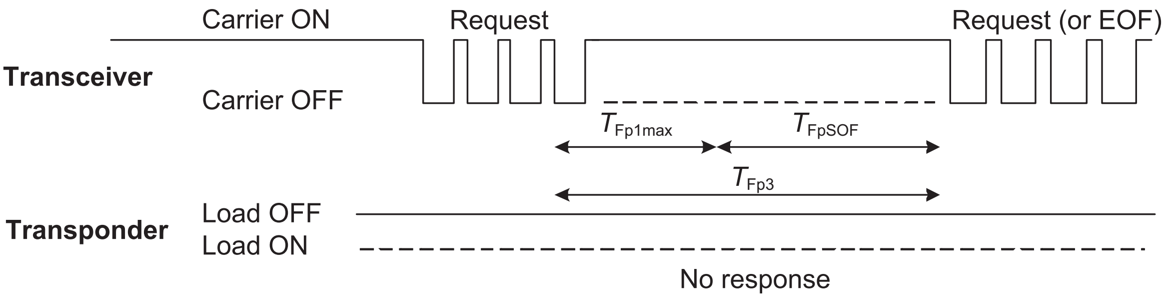


Figure 16 — FDX-ADV — Protocol timing diagram without transponder response

Table 9 — FDX-ADV — Overview of timing parameters

Symbol	Minimum	Maximum
T_{FpSOF}	3 * T_{Fd}	3 * T_{Fd}
T_{Fp1}	204 T_C	213 T_C
T_{Fp2}	150 T_C	—
T_{Fp3}	$T_{Fp1max} + T_{FpSOF}$	—

10.3 HDX-ADV transponder

10.3.1 Waiting time before transmitting its response after receipt of an EOF from the transceiver

After the transmission of the request frame, the transceiver switches off the field. When the transponder has detected the falling edge of the field after a valid transceiver request, it shall wait for the duration of time T_{Hp1} before transmitting its response to a transceiver request.

T_{Hp1} starts from the detection of the falling edge of the field by the transponder. For the duration of T_{Hp1}, the transponder shall continuously send the frequency, f_0 = 134,2 kHz, representing the presence of logic data bits “0”.

See Figure 17.

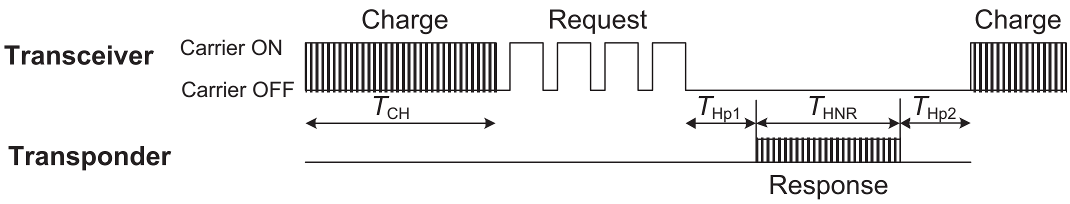


Figure 17 — Protocol timing diagram, including charge-up phase

The minimum and maximum values of T_{Hp1} are given in Table 10.

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

10.3.2 Transceiver waiting time before sending a subsequent request

When the transceiver has received the last bit of a transponder response to a previous request, it can switch on the carrier signal to recharge the tag, with timing according to Table 10.

10.3.3 Transceiver waiting time before switching to next inventory slot

10.3.3.1 General

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

NOTE For a detailed explanation of the inventory process, see ISO 14223-2:2010, Clause 9.

To switch to the next slot, the transceiver switches on the field to recharge the transponders in the field. The rising edge of the field followed by the time T_{RCH} triggers the transponder to switch to the next slot.

10.3.3.2 Transceiver starts to receive one or more transponder responses

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

- wait for the complete reception of the transponder responses (i.e. when a transponder last bit has been received or when the transponder nominal response time T_{HNR} has elapsed), or
- switch on the field to recharge the transponders and switch to the next slot (choice selection if NOS flag was set to "0"), or
- send a subsequent request.

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

10.3.3.3 Transceiver received no transponder response

During an inventory process, when the transceiver has received no transponder response (empty slot), it shall wait at least for the duration of time T_{Hp3} before starting to recharge the transponder and switching to the next slot (during a 16 slot anti-collision request), or before sending a subsequent request (which could be again an inventory request).

T_{Hp3} starts from the time the transceiver has switched off the field and has generated the falling edge of the last-sent EOF. See Figure 18 and Table 10 for an overview.

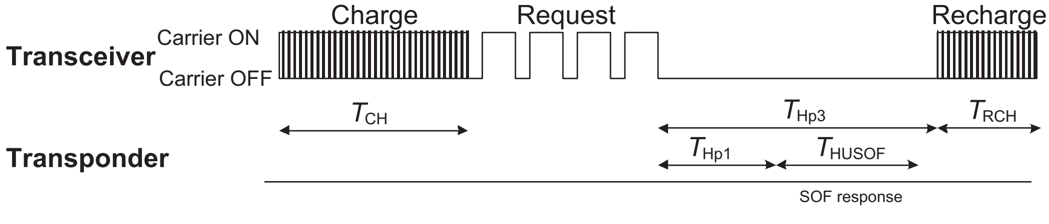


Figure 18 — Protocol timing diagram including charge and recharge time period

The minimum value of T_{Hp3} is $T_{Hp3min} = T_{Hp1max} + T_{HUSOF}$.

T_{HUSOF} is the time duration for an HDX-ADV transponder to transmit a SOF to the transceiver (see 9.4.3).

Table 10 — HDX-ADV — Overview of timing parameters

Symbol	Minimum	Nominal	Maximum
T_{HUSOF}	—	0,75 ms	—
T_{Hp1}	1,9 ms	—	4 ms
T_{Hp2}	2,2 ms	—	—
T_{Hp3}	$T_{Hp1max} + T_{HUSOF}$	—	—
T_{HNR}	Depends on the requested data and options. Must be calculated in the transceiver for every request and flag setting combination.	—	—

Annex A
(informative)

Synchronisation of advanced transceivers

A number of methods are available for co-ordinating the operations of multiple readers and for minimising mutual interaction when readers must operate in close vicinity.

a) **Software synchronisation**

This method can be used when multiple readers are connected to the same communications bus. As readers are individually addressable, the controlling (host) computer is able to command each reader to transmit at a separate time, so that it is not possible for more than one reader to be transmitting at the same time. This technique can also be used when individual readers are connected point-to-point to separate communication ports on a host computer.

b) **Antenna multiplexing**

In this method, a single reader is connected through a switching box to multiple antennas. The reader output is directed to each antenna in turn, again ensuring that only one antenna is ever transmitting at the same time. Multiplexers need to have solid state switching because of the frequency of operation. Unfortunately, solid state switching introduces losses and the reader power output is normally increased to compensate. As multiplexing divides the time available to read an animal by the number of channels on the multiplexor, it needs to be checked that there is enough time for a complete interrogation if there are moving animals in the application.

c) **Shielding**

Shielding does more than just prevent interference between readers. It is commonly employed when higher than normal power outputs are used. Shielding can attenuate the signals that would otherwise exceed those allowed under ETSI/FCC regulations[1)].

It also serves to prevent animals that are passing outside the reading system from being read and, when antennas are close together, the same animal from being picked up on an adjacent antenna. Shielding can also act as a barrier to prevent metal sheets or other objects that have been left next to an antenna from affecting performance. Because of the shape of an antenna's RF field (i.e. side lobes), the shielding has to be larger than the antenna. The metal sheet used for shielding will need to be approximately twice as high and wide as the antenna. It is not recommended to have the shielding too close to an antenna (less than 10 cm), as two unwanted features will occur:

1) the antenna will be detuned;

2) the metal will absorb some of the power that should be radiating.

d) **Cascaded synchronisation with buffered read mode**

One mode of operation for the reader is the so-called *buffered read mode*. In this mode, the reader is "free-running" — extracting and buffering the required data from transponders that pass the antenna. To avoid mutual interference between readers, this mode also incorporates a cascaded synchronisation. Using the reader's SYNC I/O, the output from a designated master reader is connected to the input of the next slave unit, whose output is connected to the next slave, and so on, with the last slave's output being coupled back to the master's input. See Figure A.1.

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1) European Telecommunications Standards Institute/Federal Communications Commission (USA).

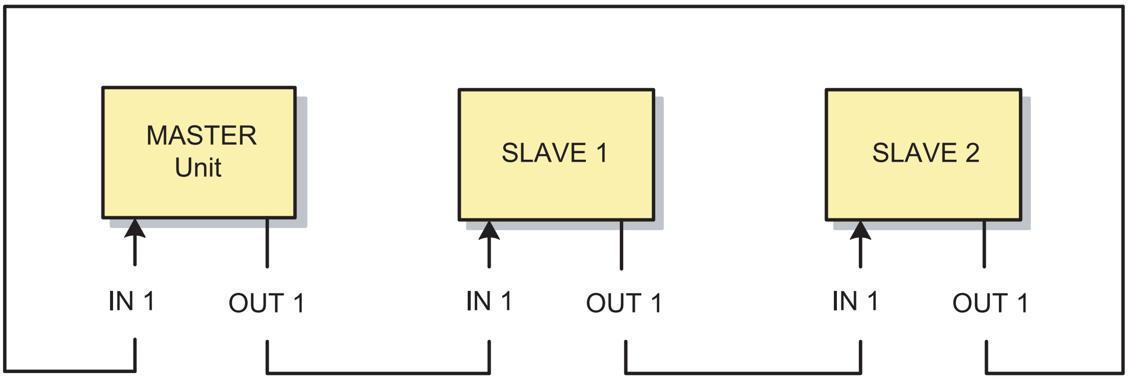

Figure A.1 — Configuration of cascaded synchronisation

Cascaded synchronisation can be enabled and a reader defined as master or slave. Any reader on the network can be the master, but, conventionally, it is normally the first reader on the network. Each cascaded group of readers needs a master to initiate the “round-robin” procedure following a manual reset or a power reset cycle. The master will complete its down-link protocol and immediately pass control to the next slave, which in turn will pass on control. This is the fastest method of operation involving multiple readers and ensures that only one reader is ever transmitting.

The user has to define, for each transceiver, the data required and enable the cascaded synchronisation with buffered read mode. Once buffered read mode is selected, as soon as the reader is reset manually or enters the power reset cycle, the reader will start operating autonomously, assembling successful readings in its buffer. If multiple animals are expected to be present in the antenna field at the same time, the anti-collision mode shall also be enabled.

Some antenna systems do not have homogeneous RF fields and the animals may move in and out of reading zones as they pass through. If, during a read operation, the reading of a data block fails, the transceiver will retry to read this block a defined number of times. A different strategy of the advanced transceiver may try to locate missing blocks of data until a time-out period has expired.

Annex B
(informative)

FDX-ADV and HDX-ADV down-link interfaces

See Table B.1.

NOTE In most countries, the use of the transceivers specified in this part of ISO 14223 is subject to national or regional regulations. Type approval from the national regulatory agencies may be required before a transceiver can be operated or traded in those countries.

Table B.1 — Summary of down-link air interfaces in FDX-ADV and HDX-ADV systems

Parameter	FDX-ADV	HDX-ADV
Down-link frequency	134,2 kHz	
Modulation (depth)	ASK (90–100 %)	
Encoding	Pulse interval encoding	
Bit rate	Typically 5,5 kbps	2,8 kbps
Switch command or SOF encoding	Binary pulse length	

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