INTERNATIONAL STANDARD

ISO/IEC 14443-2

Second edition
2010-09-01

Identification cards — Contactless integrated circuit cards — Proximity cards —

Part 2: Radio frequency power and signal interface

Cartes d'identification — Cartes à circuit(s) intégré(s) sans contacts — Cartes de proximité —

Partie 2: Interface radiofréquence et des signaux de communication

Reference number
ISO/IEC 14443-2:2010(E)

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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 14443-2 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 17, *Cards and personal identification*.

This second edition cancels and replaces the first edition (ISO/IEC 14443-2:2001), Clauses 6, 8 and 9 of which have been technically revised and Clause 10 removed. It also incorporates the Amendment ISO/IEC 14443-2:2001/Amd.1:2005 and the Technical Corrigendum ISO/IEC 14443-2:2001/Amd.1:2005/Cor.1:2007.

ISO/IEC 14443 consists of the following parts, under the general title *Identification cards — Contactless integrated circuit cards — Proximity cards*:

— *Part 1: Physical characteristics*

— *Part 2: Radio frequency power and signal interface*

— *Part 3: Initialization and anticollision*

— *Part 4: Transmission protocol*

Introduction

ISO/IEC 14443 is one of a series of International Standards describing the parameters for identification cards as defined in ISO/IEC 7810 and the use of such cards for international interchange.

This part of ISO/IEC 14443 describes the electrical characteristics of two types of contactless interface between a proximity card and a proximity coupling device. The interface includes both power and bi-directional communication. It is intended to be used in conjunction with other parts of ISO/IEC 14443.

Contactless card standards cover a variety of types as embodied in ISO/IEC 10536 (close-coupled cards), ISO/IEC 14443 (proximity cards) and ISO/IEC 15693 (vicinity cards). These are intended for operation when very near, nearby and at a longer distance from associated coupling devices, respectively.

Identification cards — Contactless integrated circuit cards — Proximity cards —

Part 2:
Radio frequency power and signal interface

1 Scope

This part of ISO/IEC 14443 specifies the characteristics of the fields to be provided for power and bi-directional communication between proximity coupling devices (PCDs) and proximity cards or objects (PICCs).

This part of ISO/IEC 14443 does not specify the means of generating coupling fields, nor the means of compliance with electromagnetic radiation and human exposure regulations, which can vary according to country.

2 Normative references

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

ISO/IEC 10373-6, *Identification cards — Test methods — Part 6: Proximity cards*

ISO/IEC 14443-1, *Identification cards — Contactless integrated circuit cards — Proximity cards — Part 1: Physical characteristics*

ISO/IEC 14443-3, *Identification cards — Contactless integrated circuit(s) cards — Proximity cards — Part 3: Initialization and anticollision*

3 Terms and definitions

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

3.1
bit duration
time during which a logic level is defined, at the end of which a new bit starts

3.2
binary phase shift keying
phase shift keying where the phase shift is 180°, resulting in two phase state possibilities

3.3
modified Miller
method of bit coding whereby a logic level during a bit duration is represented by the position of a pulse within the bit frame

3.4
modulation index, *m*
[1 − *b*] / [1 + *b*], where *b* is the ratio between the modulated amplitude and the initial signal amplitude

NOTE The value of the index may be expressed as a percentage.

3.5
NRZ-L
method of bit coding whereby a logic level during a bit duration is represented by one of two defined physical states of a communication medium

3.6
subcarrier
signal of frequency *fs* used to modulate a carrier of frequency *fc*

3.7
Manchester
method of bit coding whereby a logic level during a bit duration is represented by a sequence of two defined physical states of a communication medium, the order of the physical states within the sequence defining the logical state

3.8
TR0
guard time between the end of a PCD transmission and the start of the PICC subcarrier generation

3.9
TR1
synchronization time between the start of the PICC subcarrier generation and the start of the PICC subcarrier modulation

4 Symbols and abbreviated terms

ASK	amplitude shift keying
BPSK	binary phase shift keying
NRZ-L	non-return to zero, (L for level)
OOK	on/off keying
PauseA	PCD modulation pulse, Type A
PCD	proximity coupling device
PICC	proximity card or object
RF	radio frequency
a	pulse shape factor, Type A
b	ratio between the modulated and initial signal amplitude, Type B
fc	frequency of operating field (carrier frequency)
fs	frequency of subcarrier
H	equivalent homogenous magnetic field strength

$H_{INITIAL}$	field strength of the unmodulated RF field
h_{ovs}	envelope overshoot for bit rates of *fc*/16, *fc*/32, *fc*/64, Type A
h_f	envelope undershoot, Type B
h_r	envelope overshoot, Type B
Ø0	initial phase of the subcarrier
t_1	PauseA length
t_2	PauseA "Low" time for a bit rate of *fc*/128
t_3	PauseA rise time for a bit rate of *fc*/128
t_4	PauseA rise time section for a bit rate of *fc*/128
t_5	PauseA "Low" time for bit rates of *fc*/64, *fc*/32 and *fc*/16
t_6	PauseA rise time for bit rates of *fc*/64, *fc*/32 and *fc*/16
$t_{6,\ max,\ PCD}$	maximum value of t_6 for PCD transmission
$t_{6,\ max,\ PICC}$	maximum value of t_6 for PICC reception
t_b	bit duration, Type A
t_f	envelope fall time, Type B
$t_{f,\ max,\ PCD}$	maximum fall time for PCD transmission, Type B
$t_{f,\ max,\ PICC}$	maximum fall time for PICC reception, Type B
t_r	envelope rise time, Type B
$t_{r,\ max,\ PCD}$	maximum rise time for PCD transmission, Type B
$t_{r,\ max,\ PICC}$	maximum rise time for PICC reception, Type B
t_x	pulse position, Type A
V_{LMA}	load modulation amplitude

5 Initial dialogue for proximity cards

The initial dialogue between the PCD and the PICC shall be conducted through the following consecutive operations:

— activation of the PICC by the RF operating field of the PCD,

— the PICC shall wait silently for a command from the PCD,

— transmission of a command by the PCD,

— transmission of a response by the PICC.

These operations shall use the RF power and signal interface specified in the following clauses.

6 Power transfer

The PCD shall produce a high frequency alternating magnetic field. This field inductively couples to the PICC to transfer power and is modulated for communication.

6.1 Frequency

The frequency *fc* of the RF operating field shall be 13,56 MHz ±7 kHz.

6.2 Operating field strength

The PCD shall generate a field strength of at least H_{min} and not exceeding H_{max} at manufacturer specified positions (operating volume) under unmodulated conditions, as defined in Table 1.

Table 1 — PCD field strength

PCD	
H_{min}	H_{max}
1,5 A/m (rms)	7,5 A/m (rms)

In addition, the PCD shall be capable of powering any single reference PICC (defined in ISO/IEC 10373-6) at manufacturer specified positions (operating volume).

The PCD shall not generate a field strength higher than the value specified in ISO/IEC 14443-1:2008, 4.4 (alternating magnetic field) in any possible PICC position and orientation.

Test methods for the PCD operating field strength are defined in ISO/IEC 10373-6.

The PICC shall operate as intended continuously between H_{min} and H_{max}, as defined in Table 2. This includes all PICC requirements defined in this standard and processing of the manufacturer specified set of commands.

Table 2 — PICC operating field strength

PICC	
H_{min}	H_{max}
1,5 A/m (rms)	7,5 A/m (rms)

NOTE Margins are effectively included by the test methods as specified in ISO/IEC 10373-6.

7 Signal interface

The PCD modulates the amplitude of the alternating magnetic field strength with modulation pulses in order to transmit data from the PCD to the PICC.

The PICC loads the alternating magnetic field with a modulated subcarrier signal (load modulation) in order to transmit data from the PICC to the PCD.

Within manufacturer specified operating volume the PCD shall generate modulation pulses as described in the following clauses and shall be capable of receiving the minimum load modulation amplitude.

NOTE As an indication of the operating volume, the manufacturer may give the operating range (e.g. 0 to X cm) within which all ISO/IEC 14443-2 requirements are fulfilled.

Test methods for the PCD communication signal interface are defined in ISO/IEC 10373-6.

Two communication signal interfaces, Type A and Type B, are described in the following clauses. The PCD shall alternate between modulation methods when idling before detecting the presence of a PICC of Type A or Type B.

Only one communication signal interface may be active during a communication session until deactivation by the PCD or removal of the PICC. Subsequent session(s) may then proceed with either modulation method.

Figures 1 and 2 illustrate the concepts described in the following clauses.

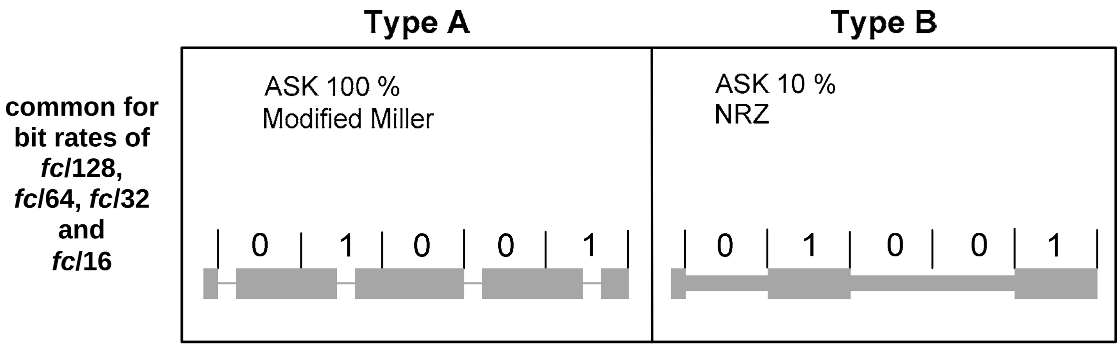

Figure 1 — Example PCD to PICC communication signals for Type A and Type B interfaces

NOTE For the coding of modified Miller, see 8.1.3.

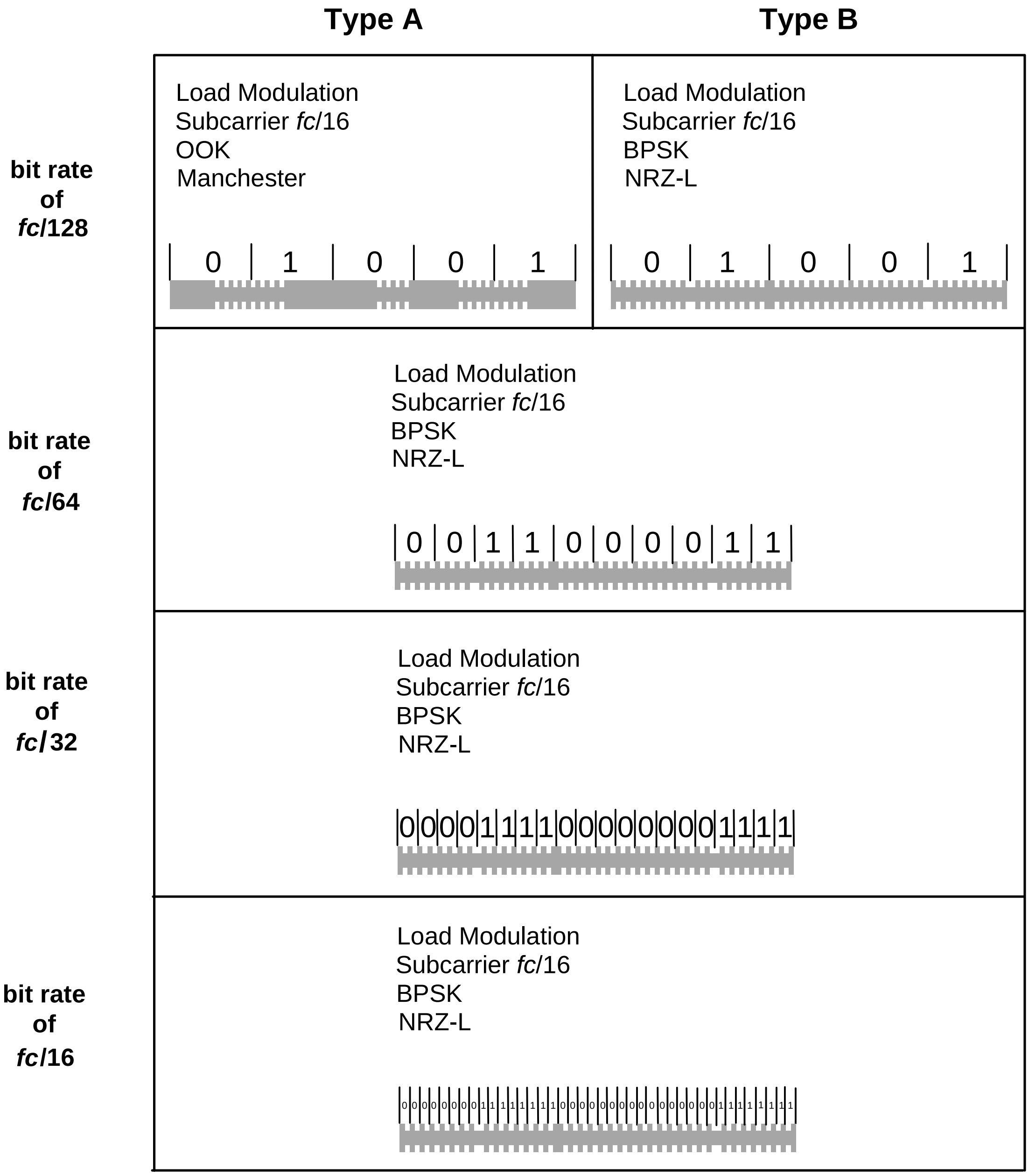

Figure 2 — Example PICC to PCD communication signals for Type A and Type B interfaces

8 Communication signal interface Type A

8.1 Communication PCD to PICC

8.1.1 Bit rate

The bit rate for the transmission during initialization and anticollision shall be *fc*/128 (~106 kbit/s).

The bit rate for the transmission after initialization and anticollision shall be one of the following:

— *fc*/128 (~106 kbit/s),

— *fc*/64 (~212 kbit/s),

— *fc*/32 (~424 kbit/s),

— *fc*/16 (~848 kbit/s).

8.1.2 Modulation

8.1.2.1 Modulation for a bit rate of *fc*/128

Communication from PCD to PICC for a bit rate of *fc*/128 shall use the modulation principle of ASK 100 % of the RF operating field to create a PauseA as shown in Figure 3.

The envelope of the PCD field shall decrease monotonically to less than 5 % of its initial value H_{INITIAL} and remain less than 5 % for more than t_2. This envelope shall comply with Figure 3.

If the envelope of the PCD field does not decrease monotonically, the time between a local maximum and the time of passing the same value before the local maximum shall not exceed 0,5 µs. This shall only apply if the local maximum is greater than 5 % of H_{INITIAL}.

The PauseA length t_1 is the time between 90 % of the falling edge and 5 % of the rising edge of the *H*-field signal envelope.

In case of an overshoot the field shall remain within 90 % of H_{INITIAL} and 110 % of H_{INITIAL}.

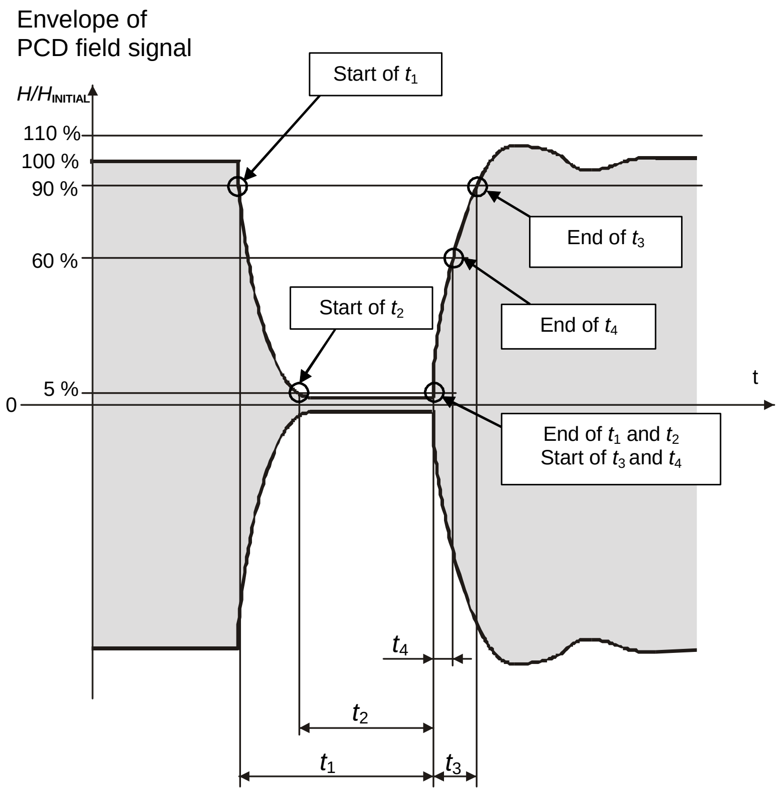

Figure 3 — PauseA for a bit rate of *fc*/128

The PCD shall generate a PauseA with timing parameters defined in Table 3.

Table 3 — PCD transmission: PauseA timing parameters for a bit rate of *fc*/128

Parameter	Condition	Min	Max
t_1		28/*fc*	40,5/*fc*
t_2	$t_1 > 34/fc$	7/*fc*	t_1
	$t_1 \leq 34/fc$	10/*fc*	
t_3		$1,5 \times t_4$	16/*fc*
t_4		0	6/*fc*

NOTE 1 PCD implementations may be restricted to generate a PauseA with values of $t_1 = n/fc$ (n = integer). Therefore measurement of t_1 should be rounded to the closest n in the unit 1/*fc.*

NOTE 2 The maximum value of t_2 is a function of the measured value of t_1.

NOTE 3 The minimum value of t_3 is a function of the measured value of t_4.

The PICC shall be able to receive a PauseA with timing parameters defined in Table 4.

Table 4 — PICC reception: PauseA timing parameters for a bit rate of *fc*/128

Parameter	Condition	Min	Max
t_1		27,5/*fc*	41/*fc*
t_2	$t_1 > 34/fc$	6/*fc*	t_1
	$t_1 \leq 34/fc$	9/*fc*	
t_3		$1,5 \times t_4$	17/*fc*
t_4		0	7/*fc*

NOTE 4 The maximum value of t_2 is a function of the set value of t_1.

NOTE 5 The minimum value of t_3 is a function of the set value of t_4.

For a bit rate of *fc*/128 the PCD shall generate a PauseA with a rise time t_3

— greater than both 0/*fc* and $(t_1 - t_2) - 24,5/fc$,

— and less than both $(t_1 - t_2) + 7/fc$ and 16/*fc*.

For a bit rate of *fc*/128 the PICC shall be able to receive a PauseA with a rise time t_3

— greater than both 0/*fc* and $(t_1 - t_2) - 26/fc$,

— and less than both $(t_1 - t_2) + 8/fc$ and 17/*fc*.

NOTE 6 Minimum and maximum values of $(t_1 - t_2)$ are derived from minimum and maximum values of t_1 and t_2 defined in Table 3 and Table 4.

The timing parameters for PCD and PICC are illustrated in Figure 4.

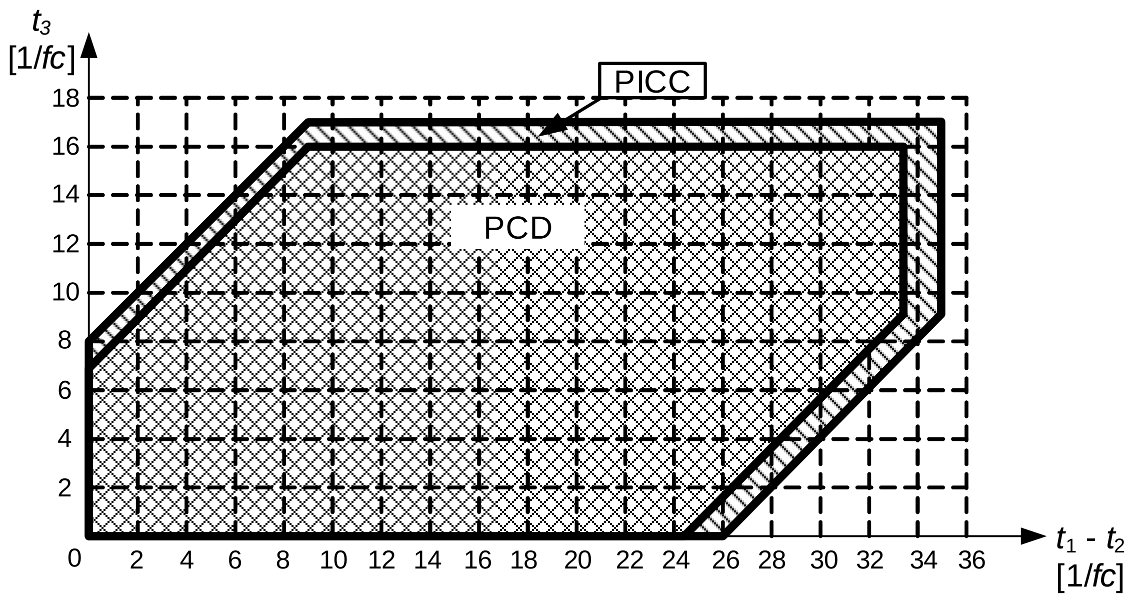

Figure 4 — PauseA timing parameters for a bit rate of *fc*/128

The PICC shall detect the end of PauseA after the field exceeds 5 % of $H_{INITIAL}$ and before it exceeds 60 % of $H_{INITIAL}$. Figure 5 shows the definition of the end of PauseA. This definition applies to all modulation envelope timings.

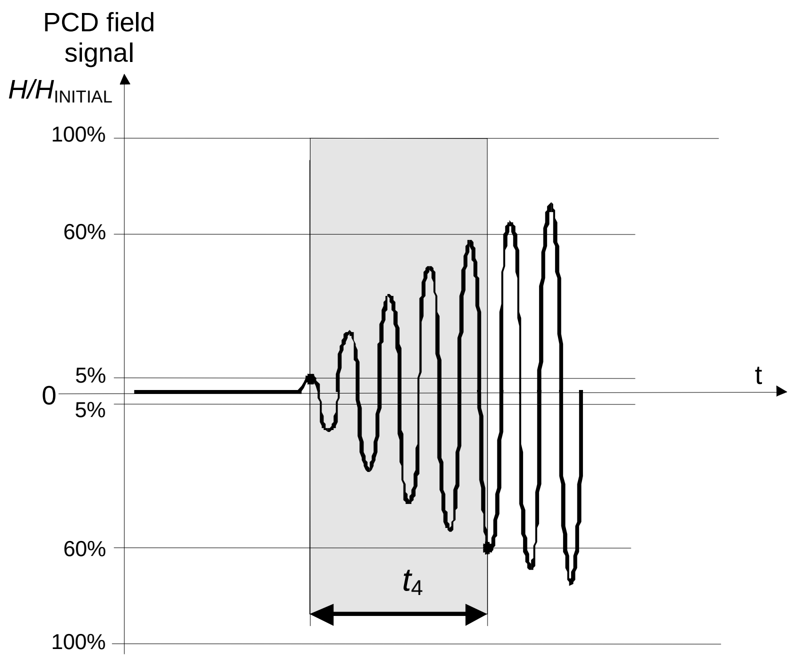

Figure 5 — End of PauseA for a bit rate of *fc*/128

8.1.2.2 Modulation for bit rates of fc/64, *fc*/32 and *fc*/16

Communication from PCD to PICC for bit rates of *fc*/64 (~212 kbit/s), *fc*/32 (~424 kbit/s) and *fc*/16 (~848 kbit/s) shall use the modulation principle of ASK (with different values for '*a*') of the operating field strength to create a PauseA as shown in Figure 6.

The envelope of the PCD field shall decrease monotonically to the maximum value of parameter '*a*' as defined in Table 5. Then, if the envelope evolution becomes non-monotonic, the difference between any local maximum and the lowest previous minimum (within the same PauseA) shall not exceed 0,09 times the difference between the initial amplitude and the previous lowest minimum.

The parameter '*a*' is the lowest minimum within PauseA.

Figure 6 is an illustration of PauseA for bit rates of *fc*/64, *fc*/32 and *fc*/16.

In case of an overshoot the field shall remain within $H_{\text{INITIAL}} \times (1 - h_{\text{ovs}})$ and $H_{\text{INITIAL}} \times (1 + h_{\text{ovs}})$.

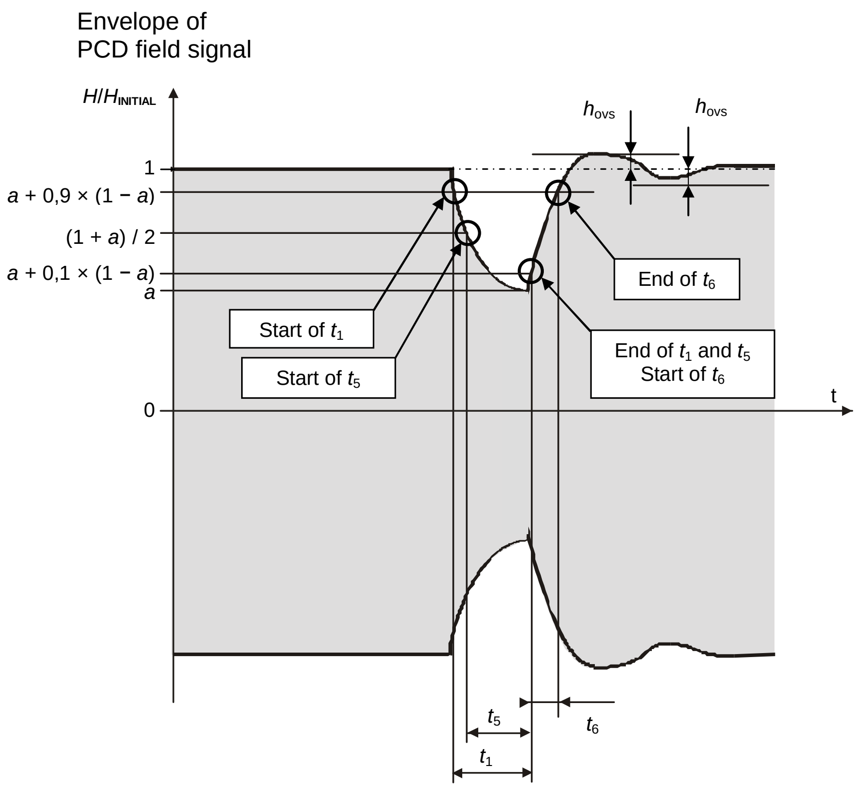

Figure 6 — PauseA for bit rates of fc/64, fc/32 and fc/16

The PCD shall generate a PauseA with timing and amplitude parameters defined in Table 5.

Table 5 — PCD transmission: PauseA parameters for bit rates of *fc*/64, *fc*/32 and *fc*/16

Parameter	Bit rate	Min	Max
a	$fc/64$	0	0,18
	$fc/32$	0	0,38
	$fc/16$	0,22	0,58
t_1	$fc/64$	$16{,}5/fc$	$20/fc$
	$fc/32$	$8{,}0/fc$	$10/fc$
	$fc/16$	$4{,}0/fc$	$5/fc$
t_5	$fc/64$	$t_1/2 + 4/fc$	t_1
	$fc/32$	$t_1/2 + 1/fc$	t_1
	$fc/16$	$t_1/2$	t_1
t_6	$fc/64$	see requirements above Figure 7	
	$fc/32$	see requirements above Figure 8	
	$fc/16$	see requirements above Figure 9	
h_{ovs}	$fc/64$, $fc/32$ and $fc/16$	0	$(1 - t_6 / (2 \times t_{6,\ max,\ PCD})) \times 0{,}10 \times (1 - a)$

NOTE 1 The minimum and maximum value of t_5 are functions of the measured value of t_1.

NOTE 2 The maximum value of h_{ovs} for PCD transmission is a function of the measured value of t_6 and of $t_{6,\ max,\ PCD}$ (see requirements above Figure 7, 8 or 9).

NOTE 3 PCD implementations may be restricted to generate a PauseA with values of $t_1 = n/fc$ (n = integer). Therefore measurement of t_1 should be rounded to the closest n in the unit $1/fc$.

The PICC shall be able to receive a PauseA with timing and amplitude parameters defined in Table 6.

Table 6 — PICC reception: PauseA parameters for bit rates of *fc*/64, *fc*/32 and *fc*/16

Parameter	Bit rate	Min	Max
a	$fc/64$	0	0,2
	$fc/32$	0	0,4
	$fc/16$	0,2	0,6
t_1	$fc/64$	$16/fc$	$20/fc$
	$fc/32$	$8/fc$	$10/fc$
	$fc/16$	$4/fc$	$5/fc$
t_5	$fc/64$	$t_1/2 + 3/fc$	t_1
	$fc/32$	$t_1/2 + 1/fc$	t_1
	$fc/16$	$t_1/2$	t_1
t_6	$fc/64$	see requirements above Figure 7	
	$fc/32$	see requirements above Figure 8	
	$fc/16$	see requirements above Figure 9	
h_{ovs}	$fc/64$, $fc/32$ and $fc/16$	0	$(1 - t_6 / (2 \times t_{6,\ max,\ PICC})) \times 0{,}11 \times (1 - a)$

NOTE 4 The minimum and maximum values of t_5 are functions of the set value of t_1.

NOTE 5 The maximum value of h_{ovs} for PICC reception is a function of the set value of t_6 and of $t_{6,\ max,\ PICC}$ (see requirements above Figure 7, 8 or 9).

NOTE 6 The PauseA length t_1 is the time between an envelope amplitude of (a + 0,9 × (1 − a)) on the falling edge and (a + 0,1 × (1 − a)) on the rising edge.

For a bit rate of *fc*/64 the PCD shall generate a PauseA with a rise time t_6

— greater than both 0/*fc* and ($t_1 - t_5$) − 3/*fc*,

— and less than both ($t_1 - t_5$) + 8/*fc* and $t_{6,\ max,\ PCD}$ = 11/*fc*.

For a bit rate of *fc*/64 the PICC shall be able to receive a PauseA with a rise time t_6

— greater than both 0/*fc* and ($t_1 - t_5$) − 4/*fc*,

— and less than both ($t_1 - t_5$) + 9/*fc* and $t_{6,\ max,\ PICC}$ = 12/*fc*.

NOTE 7 Minimum and maximum values of ($t_1 - t_5$) are derived from minimum and maximum values of t_1 and t_5 defined in Table 5 and Table 6.

The timing parameters for PCD and PICC are illustrated in Figure 7.

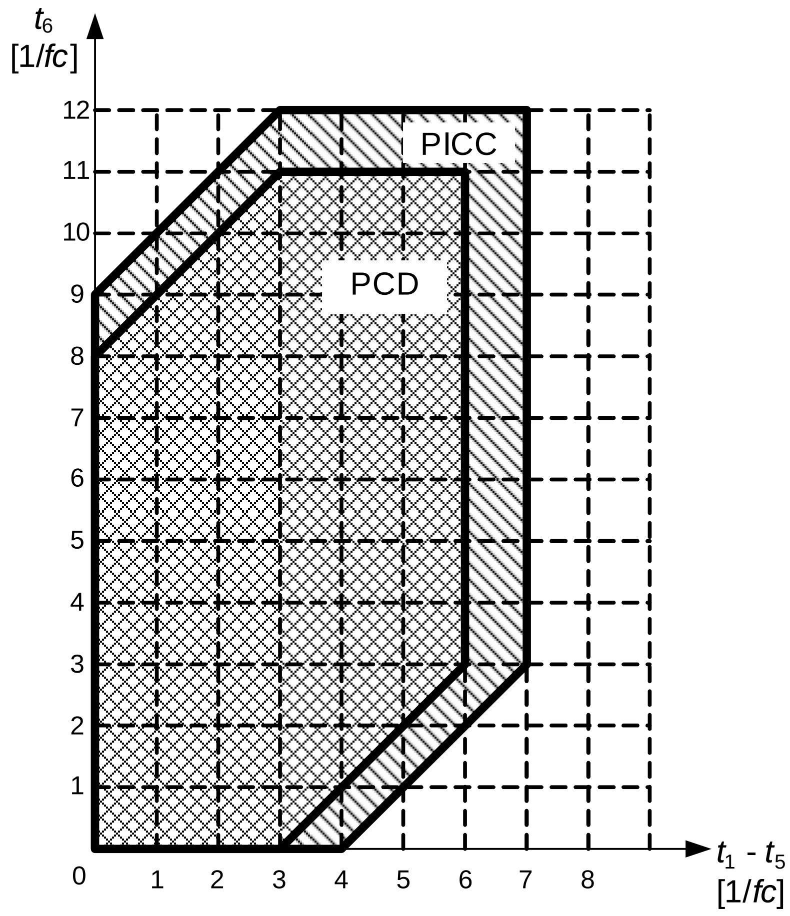

Figure 7 — PauseA timing parameters for a bit rate of *fc*/64

For a bit rate of *fc*/32 the PCD shall generate a PauseA with a rise time t_6

— greater than 0/*fc,*

— and less than both $(t_1 - t_5)$ + 8/*fc* and $t_{6,\ max,\ PCD}$ = 9/*fc*.

For a bit rate of *fc*/32 the PICC shall be able to receive a PauseA with a rise time t_6

— greater than 0/*fc,*

— and less than both $(t_1 - t_5)$ + 8/*fc* and $t_{6,\ max,\ PICC}$ = 10/*fc*.

The timing parameters for PCD and PICC are illustrated in Figure 8.

NOTE 8 Minimum and maximum values of $(t_1 - t_5)$ are derived from minimum and maximum values of t_1 and t_5 defined in Table 5 and Table 6.

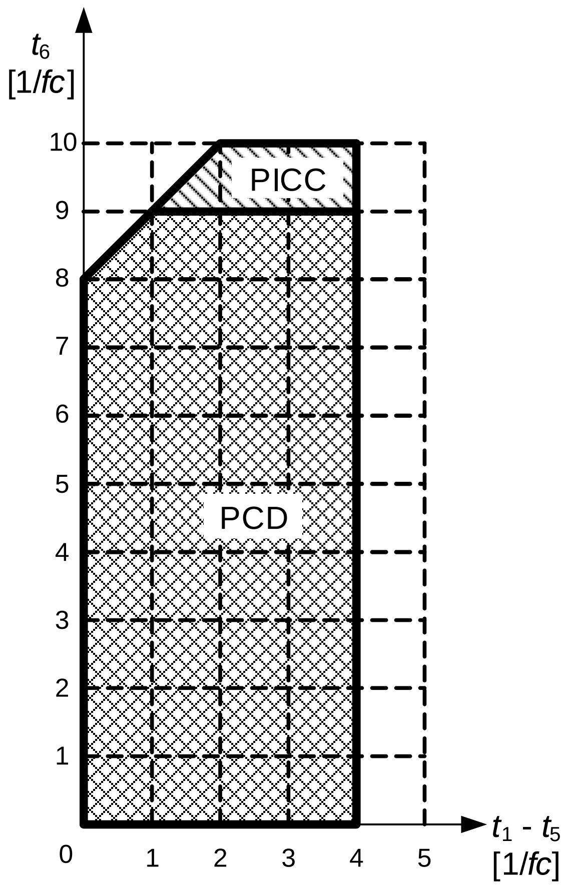

Figure 8 — PauseA timing parameters for a bit rate of *fc*/32

For a bit rate of *fc*/16 the PCD shall generate a PauseA with a rise time t_6

— greater than 0/*fc*,

— and less than both $(t_1 - t_5)$ + 4/*fc* and $t_{6,\ max,\ PCD}$ = 5,5/*fc*.

For a bit rate of *fc*/16 the PICC shall be able to receive a PauseA with a rise time t_6

— greater than 0/*fc*,

— and less than both $(t_1 - t_5) + 4{,}5/fc$ and $t_{6,\ \max,\ \mathrm{PICC}} = 6/fc$.

NOTE 9 Minimum and maximum values of $(t_1 - t_5)$ are derived from minimum and maximum values of t_1 and t_5 defined in Table 5 and Table 6.

The timing parameters for PCD and PICC are illustrated in Figure 9.

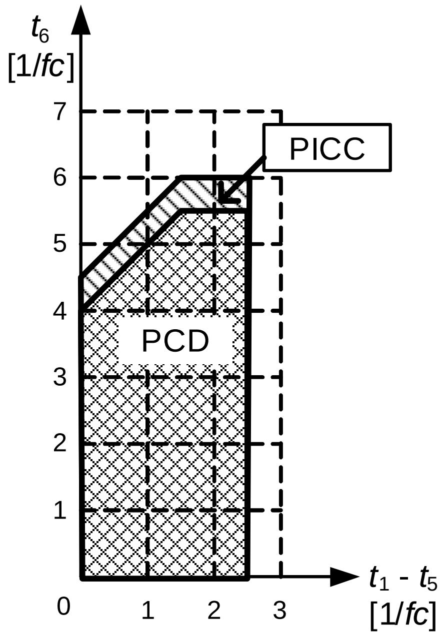

Figure 9 — PauseA timing parameters for a bit rate of *fc*/16

8.1.3 Bit representation and coding

The following sequences are defined:

— sequence X: after a time of half the bit duration (t_x) a PauseA shall occur,

— sequence Y: for the full bit duration (t_b) no modulation shall occur,

— sequence Z: at the beginning of the bit duration (t_b) a PauseA shall occur.

Figure 10, together with the timing parameters in Table 7, illustrates sequences X, Y and Z.

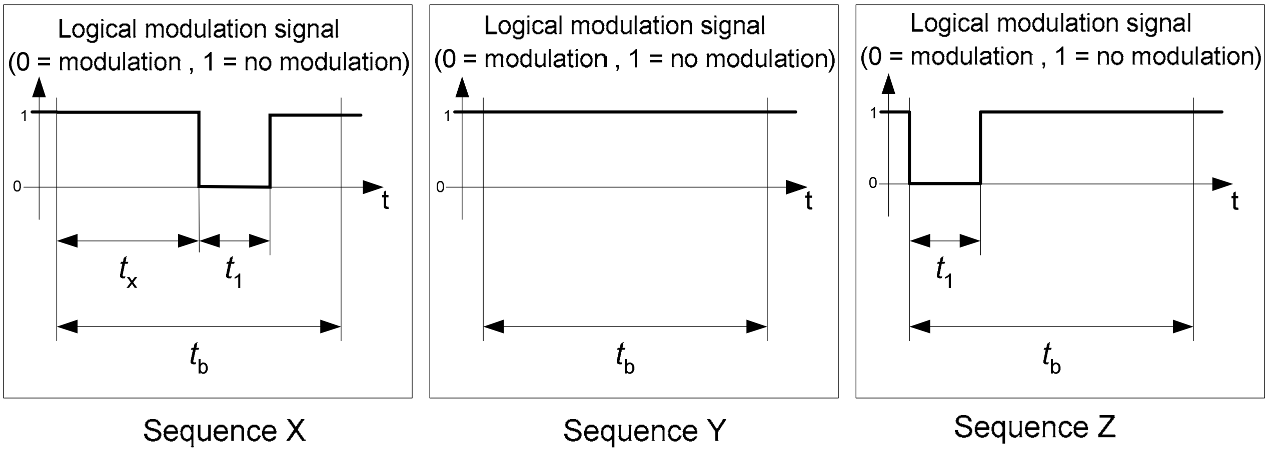

Figure 10 — Sequences for Type A communication PCD to PICC

Table 7 — Parameters for sequences

Parameter	**Bit rate**			
	***fc*/128**	***fc*/64**	***fc*/32**	***fc*/16**
t_b	128/*fc*	64/*fc*	32/*fc*	16/*fc*
t_x	64/*fc*	32/*fc*	16/*fc*	8/*fc*
t_1	see t_1 of Table 3	see t_1 of Table 5		

The above sequences shall be used to code the following information:

— logic "1": sequence X,

— logic "0": sequence Y with the following two exceptions:

i) If there are two or more contiguous "0"s, sequence Z shall be used from the second "0" on,

ii) If the first bit after a "start of communication" is "0", sequence Z shall be used to represent this and any "0"s which follow directly thereafter,

— start of communication: sequence Z,

— end of communication: logic "0" followed by sequence Y,

— no information: at least two sequences Y.

8.2 Communication PICC to PCD

8.2.1 Bit rate

See 8.1.1.

8.2.2 Load modulation

The PICC shall be capable of communication to the PCD via an inductive coupling area where the carrier frequency is loaded to generate a subcarrier with frequency *fs*. The subcarrier shall be generated by switching a load in the PICC.

The load modulation amplitude V_{LMA} of the PICC shall be at least $22/H^{0,5}$ [mV (peak)] when measured as described in ISO/IEC 10373-6, where *H* is the (rms) value of magnetic field strength in A/m. The PCD shall be able to receive a V_{LMA} of at least $18/H^{0,5}$ [mV (peak)] when measured as described in ISO/IEC 10373-6, where *H* is the (rms) value of magnetic field strength in A/m.

Figure 11 is an illustration of the PCD and PICC load modulation amplitude limits.

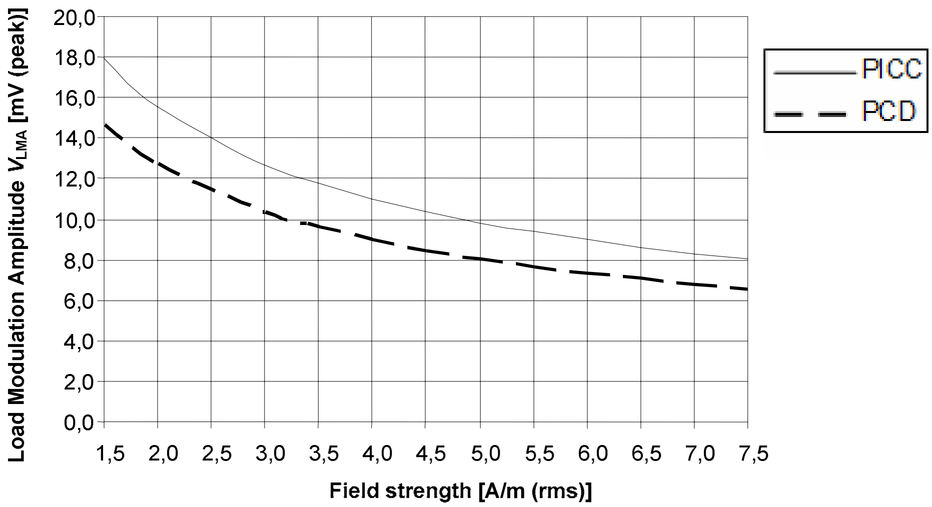

Figure 11 — Load modulation amplitude

NOTE This PICC limit is stricter than in ISO/IEC 14443-2:2001 and may be too strict for PICCs whose antenna is much smaller than "Class 1" size (due to the size of the sense coils in ISO/IEC 10373-6). Future revisions of ISO/IEC 14443 and ISO/IEC 10373-6 may specify new limits and/or test methods adapted to these PICCs.

8.2.3 Subcarrier

The frequency *fs* of the subcarrier shall be *fc*/16 (~848 kHz). Consequently, during initialization and anticollision, one bit duration is equivalent to 8 periods of the subcarrier. After initialization and anticollision, the number of subcarrier periods is determined by the bit rate.

The PICC shall generate a subcarrier only when data is to be transmitted.

8.2.4 Subcarrier modulation

Every bit period shall start with a defined phase relation to the subcarrier. The bit period shall start with the loaded state of the subcarrier (the unloaded state of the subcarrier is the stable state when the PICC is not sending bits).

At the bit rate of *fc*/128 the subcarrier is modulated using OOK with the sequences defined in 8.2.5.1. At bit rates of *fc*/64, *fc*/32 and *fc*/16 the subcarrier is modulated using BPSK with the sequences defined in 8.2.5.2.

8.2.5 Bit representation and coding

8.2.5.1 Bit representation and coding for a bit rate of *fc*/128

The following sequences are defined:

— sequence D: the carrier shall be modulated with the subcarrier for the first half (50 %) of the bit duration,

— sequence E: the carrier shall be modulated with the subcarrier for the second half (50 %) of the bit duration,

— sequence F: the carrier is not modulated with the subcarrier for one bit duration.

Bit coding shall be Manchester with the following definitions:

— logic "1": sequence D,

— logic "0": sequence E,

— start of communication: sequence D,

— end of communication: sequence F,

— no information: no subcarrier.

8.2.5.2 Bit representation and coding for bit rates of *fc*/64, *fc*/32 and *fc*/16

Bit coding shall be NRZ-L with the following definitions:

— logic "1": the carrier shall be modulated with the subcarrier for one bit duration,

— logic "0": the carrier shall be modulated with the inverted subcarrier for one bit duration,

— start of communication: burst of 32 subcarrier cycles (phase as logic "1") followed by inverted subcarrier for one bit duration (phase as logic "0"),

— end of communication: the carrier is not modulated with the subcarrier for one bit duration,

— no information: the carrier is not modulated with the subcarrier.

9 Communication signal interface Type B

9.1 Communication PCD to PICC

9.1.1 Bit rate

The bit rate for the transmission during initialization and anticollision shall be nominally *fc*/128 (~106 kbit/s).

The bit rate for the transmission after initialization and anticollision shall be one of the following:

— *fc*/128 (~106 kbit/s),

— *fc*/64 (~212 kbit/s),

— $fc/32$ (~424 kbit/s),

— $fc/16$ (~848 kbit/s).

Bit boundary tolerances are defined in ISO/IEC 14443-3:—[1] , 7.1.1 and 7.1.2, respectively.

9.1.2 Modulation

Communication from PCD to PICC shall use the modulation principle of ASK 10 % of the RF operating field.

The modulation waveform shall comply with Figure 12. The rising and falling edges of the modulation shall be monotonic. The rise and fall times (t_r, t_f) shall be measured between 10 % and 90 % of the actual modulation step.

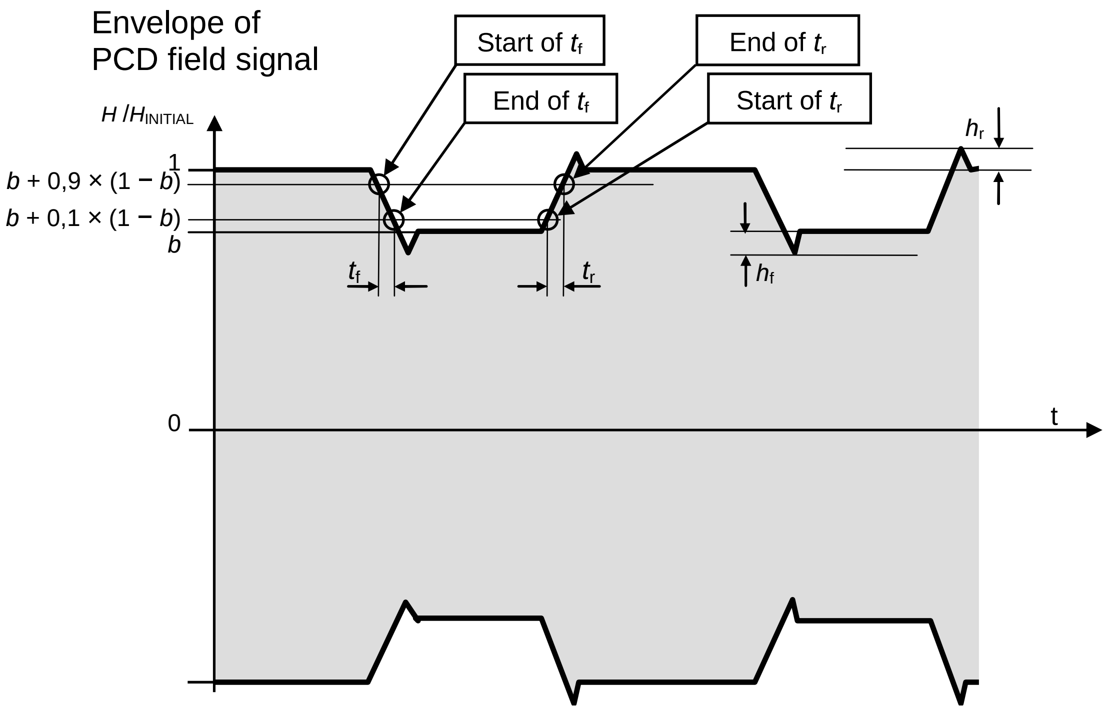

Figure 12 — Type B modulation waveform

For all supported bit rates the PCD shall generate a modulation waveform with a modulation index m between 8 % and 14 %.

For all supported bit rates the PICC shall be able to receive a modulation waveform with a modulation index m

— greater than both $(9,5 - H)$ % and 7 %

— and less than 15 %.

NOTE Minimum and maximum values of H are defined in Table 1 and Table 2.

The limits for the modulation index m are illustrated in Figure 13.

1) To be published. Revision of ISO/IEC 14443-3:2001.

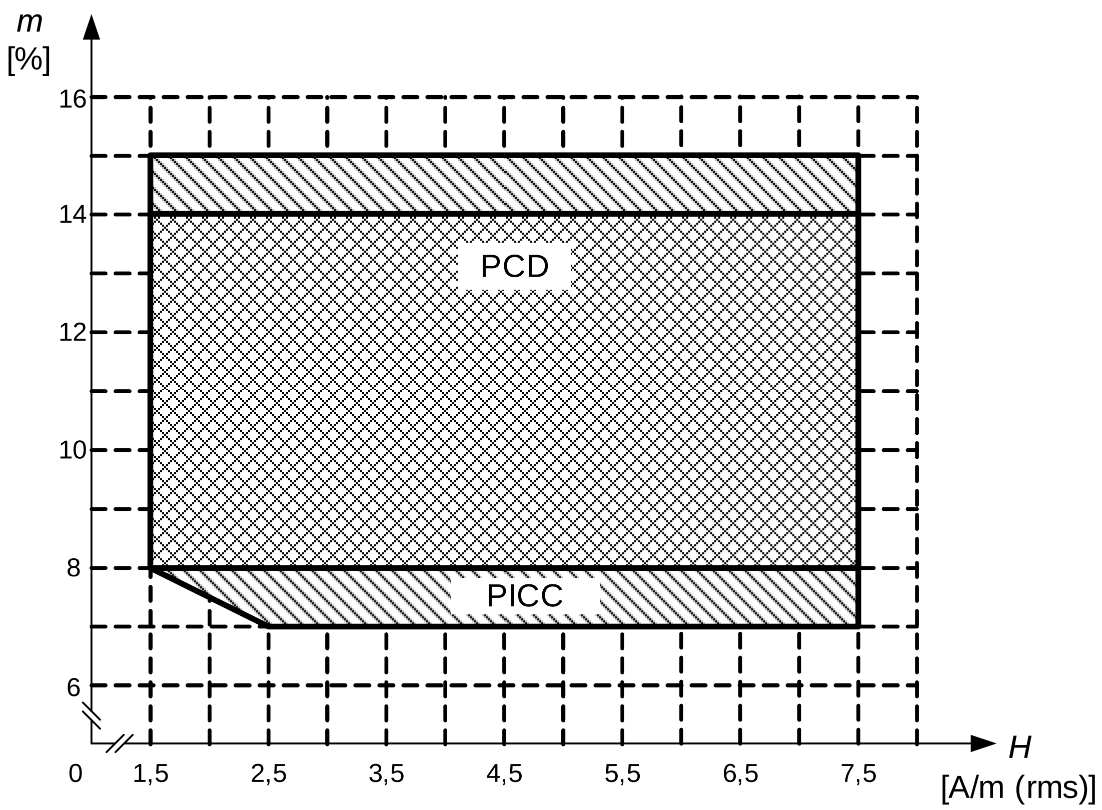

Figure 13 — Type B modulation index *m* for bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16

The overshoot and undershoot of the PCD modulation waveform shall remain within limits specified in Table 8.

Table 8 — PCD transmission: Overshoot and undershoot for bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16

Parameter	Min	Max
h_f	0	$(1 - t_f / (2 \times t_{f,\ max,\ PCD})) \times 0{,}10 \times (1 - b)$
h_r	0	$(1 - t_r / (2 \times t_{r,\ max,\ PCD})) \times 0{,}10 \times (1 - b)$

NOTE 1 The maximum value of h_f / h_r is a function of the measured value of t_f / t_r and of $t_{f,\ max,\ PCD} / t_{r,\ max,\ PCD}$ (see requirements above Figure 14, 15, 16 or 17).

The PICC shall be able to receive a modulation waveform with overshoot and undershoot defined in Table 9.

Table 9 — PICC reception: Overshoot and undershoot for bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16

Parameter	Min	Max
h_f	0	$(1 - t_f / (2 \times t_{f,\ max,\ PICC})) \times 0{,}11 \times (1 - b)$
h_r	0	$(1 - t_r / (2 \times t_{r,\ max,\ PICC})) \times 0{,}11 \times (1 - b)$

NOTE 2 The maximum value of h_f / h_r is a function of the set value of t_f / t_r and of $t_{f,\ max,\ PICC}$ / $t_{r,\ max,\ PICC}$ (see requirements above Figure 14, 15, 16 or 17).

For a bit rate of *fc*/128 the PCD shall generate a modulation waveform with

- a fall time t_f between 0/*fc* and $t_{f,\ max,\ PCD}$ = 16/*fc*,
- and a rise time t_r
  - greater than both 0/*fc* and t_f − 8/*fc*,
  - and less than both t_f + 8/*fc* and and $t_{r,\ max,\ PCD}$ = 16/*fc*.

For a bit rate of *fc*/128 the PICC shall be able to receive a modulation waveform with

- a fall time t_f between 0/*fc* and $t_{f,\ max,\ PICC}$ = 17/*fc,*
- and a rise time t_r
  - greater than both 0/*fc* and t_f − 9/*fc*,
  - and less than both t_f + 9/*fc* and $t_{r,\ max,\ PICC}$ = 17/*fc*.

The timing parameters for PCD and PICC are illustrated in Figure 14.

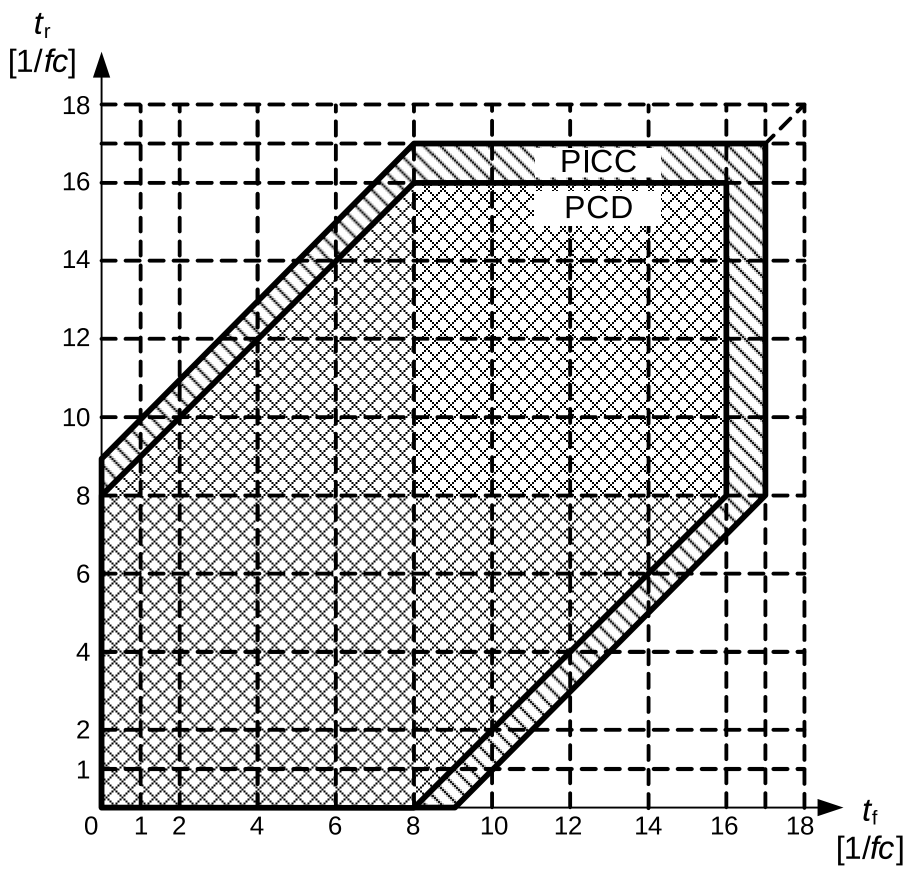

Figure 14 — Type B modulation waveform timing parameters for a bit rate of *fc*/128

For a bit rate of *fc*/64 the PCD shall generate a modulation waveform with

— a fall time t_f between 0/*fc* and $t_{f,\ max,\ PCD}$ = 14/*fc*,

— and a rise time t_r

  — greater than both 0/*fc* and t_f − 6/*fc*,

  — and less than both t_f + 6/*fc* and and $t_{r,\ max,\ PCD}$ = 14/*fc*.

For a bit rate of *fc*/64 the PICC shall be able to receive a modulation waveform with

— a fall time t_f between 0/*fc* and $t_{f,\ max,\ PICC}$ = 14/*fc*,

— and a rise time t_r

  — greater than both 0/*fc* and t_f − 7/*fc*,

  — and less than both t_f + 7/*fc* and $t_{r,\ max,\ PICC}$ = 14/*fc*.

The timing parameters for PCD and PICC are illustrated in Figure 15.

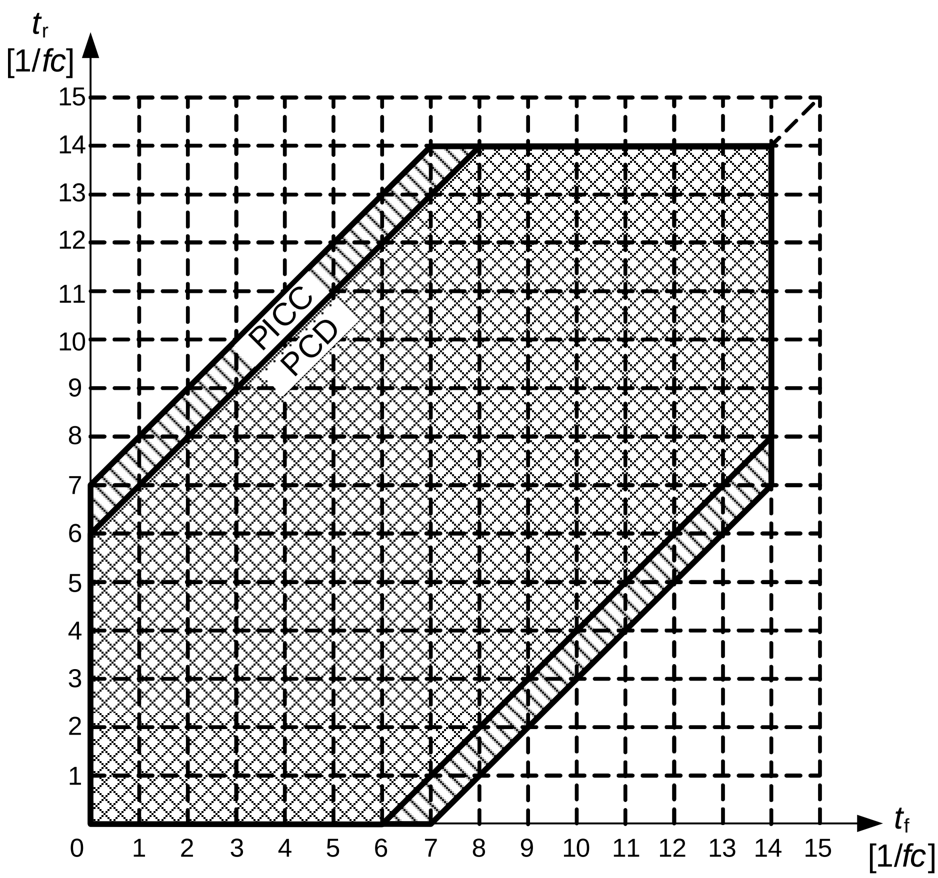

Figure 15 — Type B modulation waveform timing parameters for a bit rate of *fc*/64

For a bit rate of *fc*/32 the PCD shall generate a modulation waveform with

— a fall time t_f between 0/*fc* and $t_{f,\ max,\ PCD}$ = 11/*fc*,

— and a rise time t_r

 — greater than both 0/*fc* and t_f − 4,5/*fc*,

 — and less than both t_f + 4,5/*fc* and and $t_{r,\ max,\ PCD}$ = 11/*fc*.

For a bit rate of *fc*/32 the PICC shall be able to receive a modulation waveform with

— a fall time t_f between 0/*fc* and $t_{f,\ max,\ PICC}$ = 11/*fc*,

— and a rise time t_r

 — greater than both 0/*fc* and t_f − 5,5/*fc*,

 — and less than both t_f + 5,5/*fc* and $t_{r,\ max,\ PICC}$ = 11/*fc*.

The timing parameters for PCD and PICC are illustrated in Figure 16.

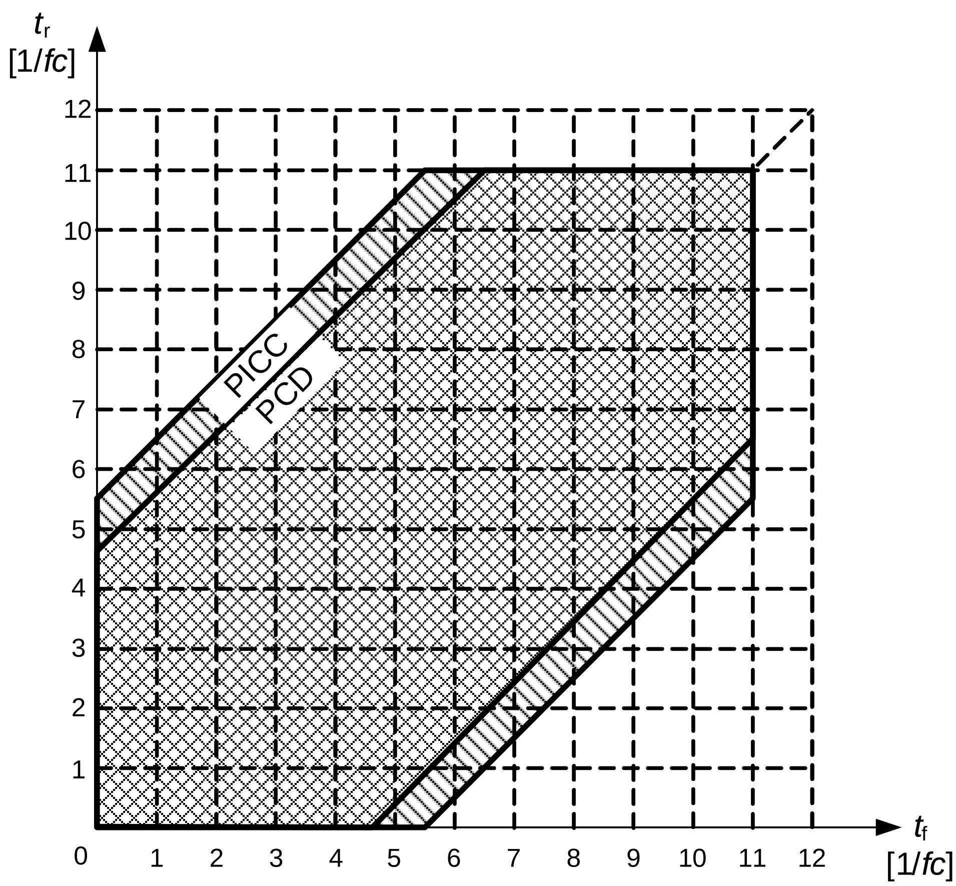

Figure 16 — Type B modulation waveform timing parameters for a bit rate of *fc*/32

For a bit rate of *fc*/16 the PCD shall generate a modulation waveform with

— a fall time t_f between 0/*fc* and $t_{f,\ max,\ PCD}$ = 8/*fc*,

— and a rise time t_r

  — greater than both 0/*fc* and t_f − 4/*fc*,

  — and less than both t_f + 4/*fc* and and $t_{r,\ max,\ PCD}$ = 8/*fc*.

For a bit rate of *fc*/16 the PICC shall be able to receive a modulation waveform with

— a fall time t_f between 0/*fc* and $t_{f,\ max,\ PICC}$ = 8/*fc*,

— and a rise time t_r:

  — greater than both 0/*fc* and t_f − 4/*fc*,

  — and less than both t_f + 4/*fc* and and $t_{r,\ max,\ PICC}$ = 8/*fc*.

The timing parameters for PCD and PICC are illustrated in Figure 17.

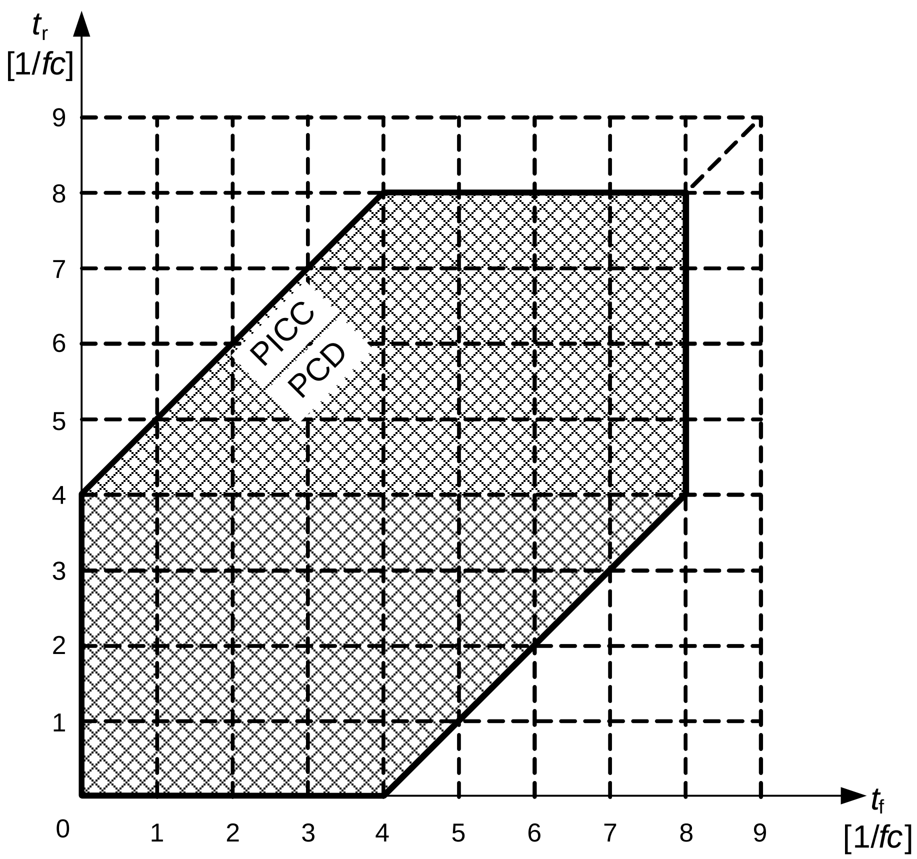

Figure 17 — Type B modulation waveform timing parameters for a bit rate of *fc*/16

9.1.3 Bit representation and coding

Bit coding format shall be NRZ-L with logic levels defined as follows:

— logic "1": carrier high field amplitude (no modulation applied),

— logic "0": carrier low field amplitude.

9.2 Communication PICC to PCD

9.2.1 Bit rate

See 8.1.1.

9.2.2 Load modulation

See 8.2.2 including the note.

9.2.3 Subcarrier

See 8.2.3.

9.2.4 Subcarrier modulation

The subcarrier shall be BPSK modulated. Phase shifts shall only occur at nominal positions of rising or falling edges of the subcarrier.

9.2.5 Bit representation and coding

Bit coding shall be NRZ-L where a change of logic level shall be denoted by a phase shift (180°) of the subcarrier.

The initial logic level for NRZ-L at the start of a PICC frame shall be established by the following sequence:

— After any command from the PCD a guard time TR0 shall apply in which the PICC shall not generate a subcarrier. TR0 shall be greater than 64/*fs* (~75,5 µs).

— The PICC shall then generate a subcarrier with no phase transition for a synchronization time TR1. This establishes an initial subcarrier phase reference *Ø0*. TR1 shall be greater than 80/*fs* (~94,4 µs).

— This initial phase state *Ø0* of the subcarrier shall be defined as logic "1" so that the first phase transition represents a change from logic "1" to logic "0".

— Subsequently the logic level is defined according to the initial phase of the subcarrier.

Ø0: represents logic "1",

Ø0 + 180°: represents logic "0".

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