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Identification cards — Contactless integrated circuit(s) cards - Proximity cards — Part 2: Radio frequence power and signal interface

Cartes d'identification — Carte à circuit(s) intégrés sans contacts . Cartes de proximité — Partie 2: Interface radio fréquence

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Contents

Foreword

This revision comprises the replacements and additions of ISO/IEC 14443-2:2001/Amd.2:2004(E).

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/third/... edition cancels and replaces the first/second/... edition (), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] been technically revised.

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

— *Part 1: Physical characteristics*

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

— *Part 3: Initialization and anticollision*

— *Part 4: Transmission protocol*

The Annex A of this part of ISO/IEC 14443 is for information only.

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.

This part of ISO/IEC 14443 does not preclude the incorporation of other standard technologies on the card, such as those referenced in Annex A.

Contactless card Standards cover a variety of types as embodied in ISO/IEC 10536 (Close-coupled cards), ISO/IEC 14443 (Proximity cards), 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(s) 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 (PICCs).

This part of ISO/IEC 14443 shall be used in conjunction with other parts of ISO/IEC 14443.

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 reference(s)

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO/IEC 14443. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO/IEC 14443 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to apply. Members of ISO and IEC maintain registers of currently valid International Standards.

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

ISO/IEC 7816-2, *Identification cards - Integrated circuit(s) cards with contacts - Part 2: Dimensions and location of the contacts*

ISO/IEC 14443-1, *Identification cards – Contactless integrated circuit(s) 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 Term(s) and definition(s)

For the purposes of this part of ISO/IEC 14443, 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
modulation index
defined as [a-b]/[a+b] where a and b are the peak and minimum signal amplitude respectively. The value of the index may be expressed as a percentage.

3.4
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.

3.5
subcarrier
signal of frequency *f*s used to modulate a carrier of frequency *fc.*

3.6
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 defines the logical state.

3.7
TR0
guard time between the end of a PCD transmission and the start of the PICC subcarrier generation.

3.8
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
fc	Frequency of operating field (carrier frequency)
fs	Frequency of subcarrier modulation
NRZ-L	Non-Return to Zero, (L for level)
OOK	On/Off Keying
PCD	Proximity Coupling Device
PICC	Proximity Card or object
RF	Radio Frequency

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 an energizing RF field which couples to the PICC to transfer power and which shall be 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

A PCD shall generate a field strength of at least $H_{min,}$ rms and not exceeding $H_{max,}$ rms at manufacturer specified positions (operating volume) under unmodulated conditions.

Table 1 — PCD field strength

PCD	
$H_{min,}$	$H_{max,}$
1,5 A/m	7,5 A/m

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 higher than the value specified in ISO/IEC 14443-1 (alternating magnetic field) in any possible PICC position.

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

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

Table 2 — PICC operating field

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

Note 1: Margins are effectively included by the test methods as specified in ISO/IEC 10373-6.

Note 2: In the future it is foreseen that advanced PICC technologies will require decreasing maximum operating field strength.

7 Signal interface

A PCD shall generate modulation pulses as described in the following clauses in manufacturer specified operating volume.

In addition the PCD shall be capable of receiving the minimum load modulation amplitude in manufacturer specified operating volume.

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.

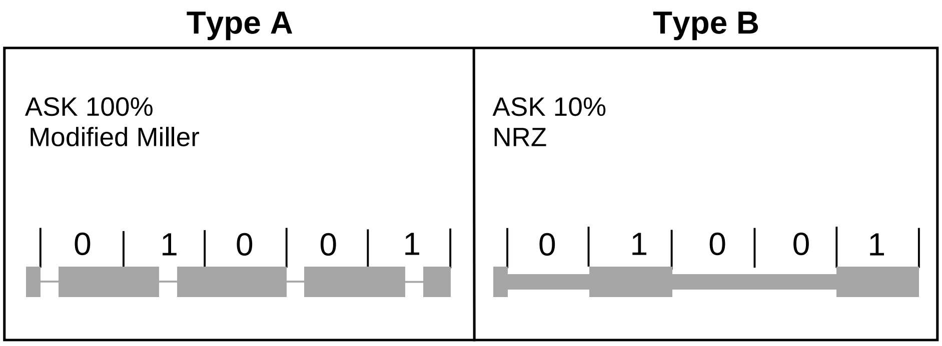

Figure 1 — Example PCD to PICC communication signals for Type A and Type B interfaces

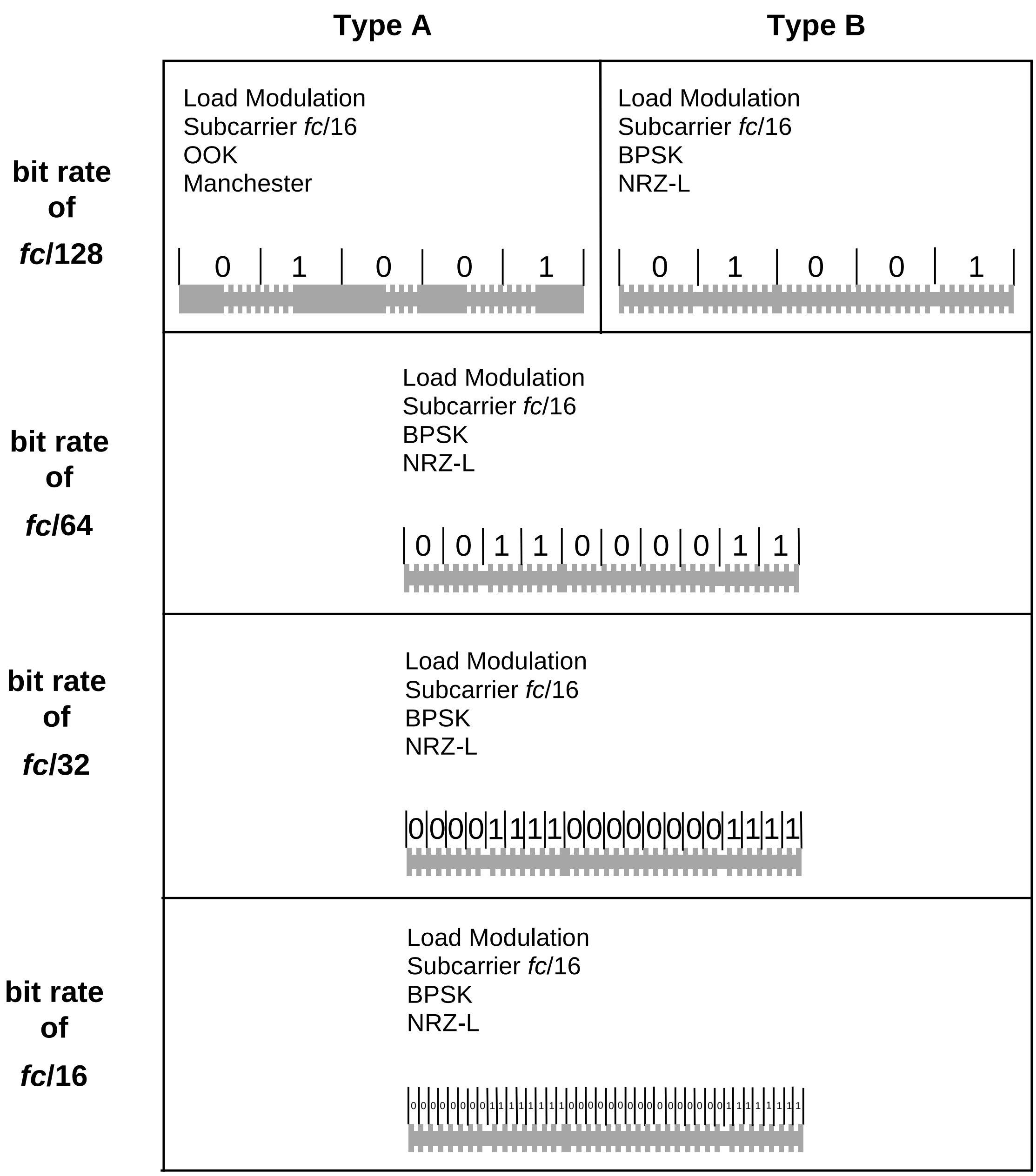

Figure 2 — Example PICC to PCD communication signals for Type A and Type B interfaces

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 (~847 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 “Pause” 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 to 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 pause length t1 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 $H_{INITIAL}$.

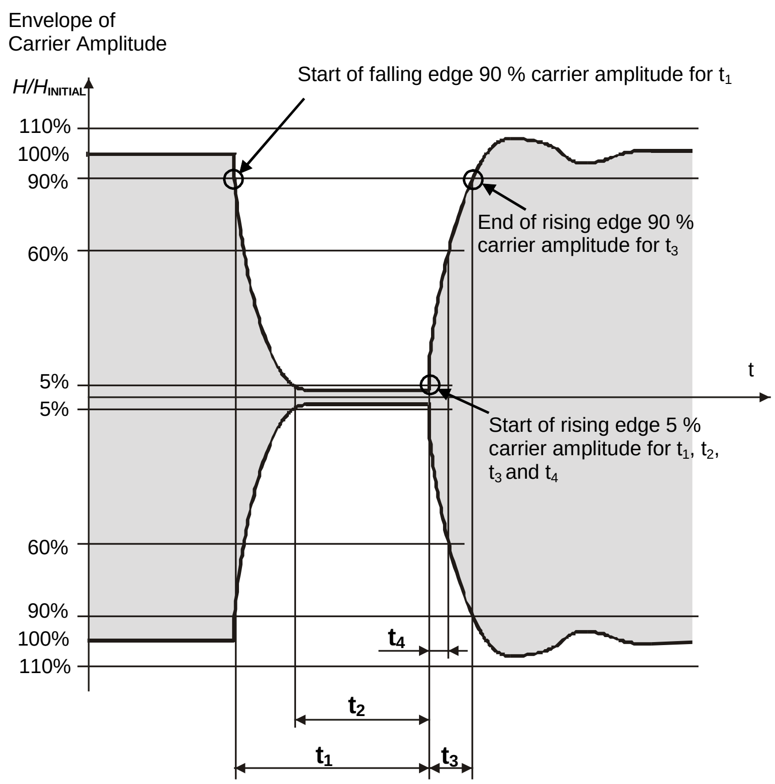

Figure 3 — Pause for a bit rate of fc/128

The PCD shall generate a Pause with timing parameter defined in Table 3

Table 3 — PCD transmission: Pause timing parameter for bit rate of fc/128

Parameter	Min	Max
t_1	38/fc	40/fc
t_2	7/fc	t_1 - 2/fc
t_3	1,5 × t_4	16/fc
t_4	2/fc	6/fc

The PICC shall be able to receive a Pause with timing parameter defined in Table 4.

Table 4 — PICC reception: Pause timing parameter for bit rate of fc/128

Parameter	Min	Max
t_1	37,5/fc	40,5/fc
t_2	6/fc	t_1 - 1/fc
t_3	1,5 × t_4	17/fc
t_4	1/fc	7/fc

The rise time t_3 is dependent on the fall time characterized by (t_1 - t_2) as defined in Figure 4.

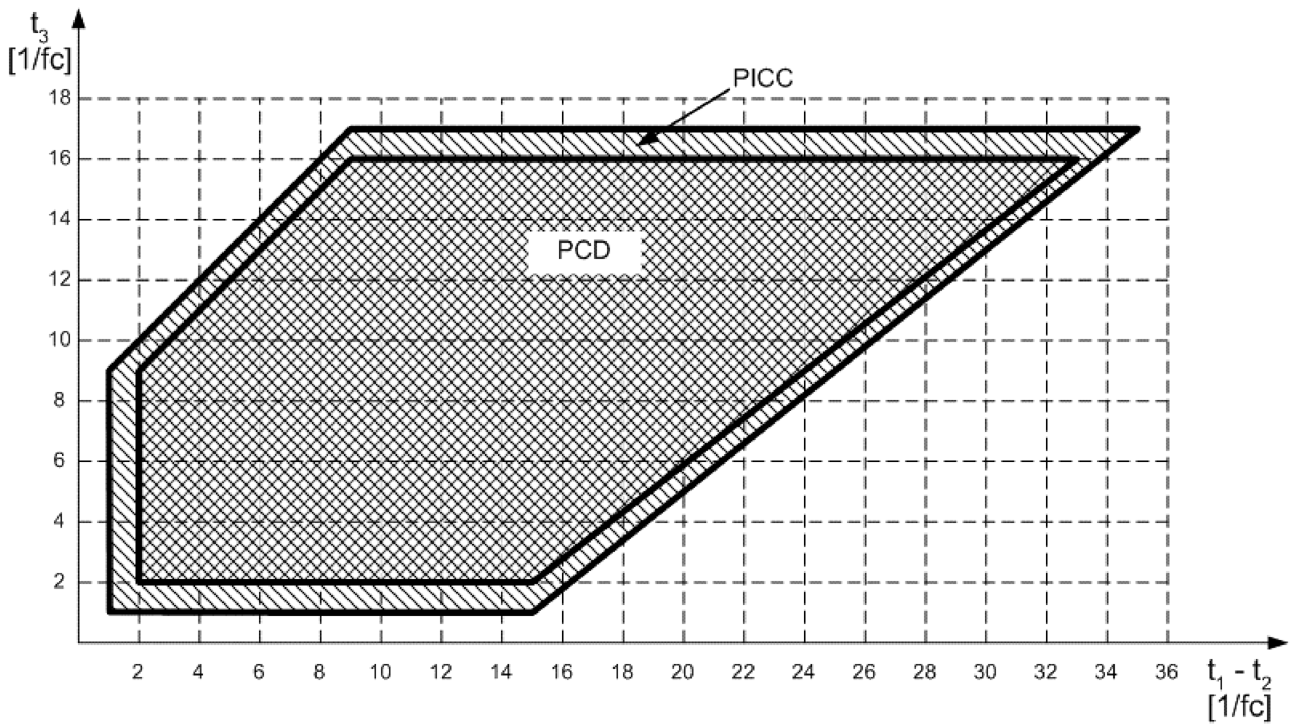

Figure 4 — Rise – fall time dependency for a for bit rate of fc/128

The PICC shall detect the ”End of Pause” 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 Pause". This definition applies to all modulation envelope timings.

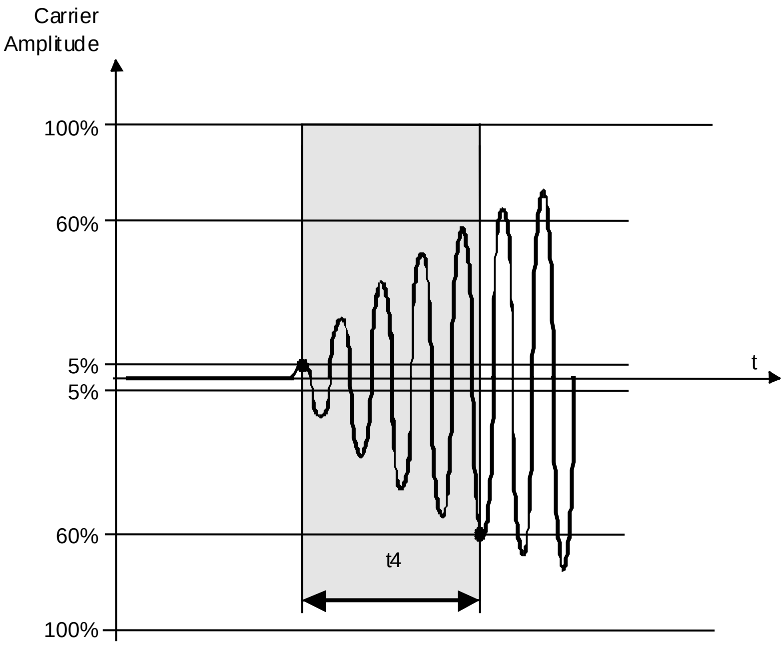

Figure 5 — Definition of "End of Pause" for a bit rate of fc/128

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 (~847 kbit/s) shall use the modulation principle of ASK of the RF operating field to create a pause as shown in Figure 6.

The envelope of the PCD field shall decrease monotonically to less than the values of parameter 'a' and shall comply with Figure 6.

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

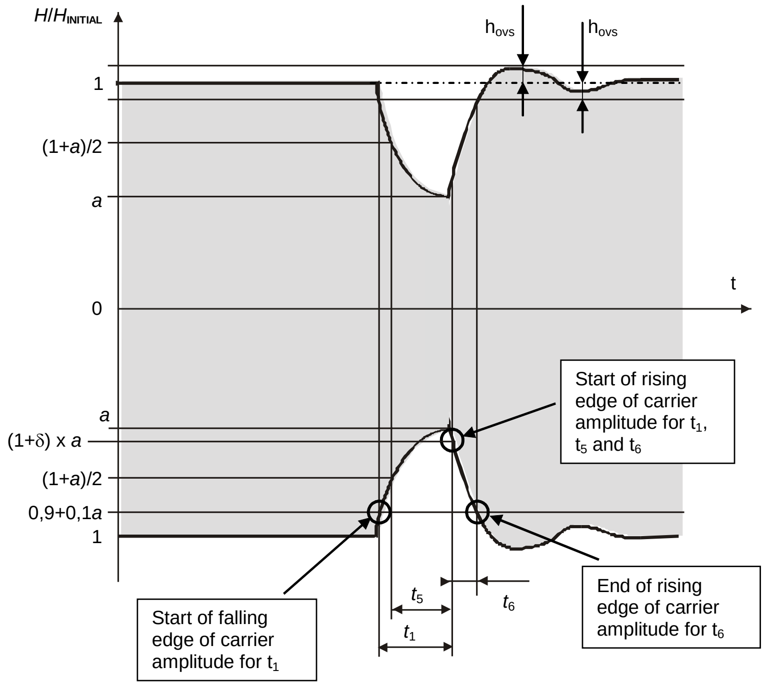

Figure 6 — Pause for bit rates of fc/64, fc/32 and fc/16

The PCD shall generate a Pause with timing and amplitude parameter defined in Table 5

Table 5 — PCD transmission: Pause parameter 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	0,35
	fc/16	0,22	0,55
t_1	fc/64	16,5/fc	18,5/fc
	fc/32	8,0/fc	9,0/fc
	fc/16	4,0/fc	5,0/fc
t_5	fc/64	$t_1/2$ + 4/fc	t_1 - 2/fc
	fc/32	$t_1/2$ + 1/fc	t_1 – 1/fc
	fc/16	$t_1/2$	t_1 – 1/fc
t_6	fc/64	2/fc	11/fc
	fc/32	2/fc	9/fc
	fc/16	2/fc	6/fc
h_{ovs}	fc/64, fc/32, fc/16	n.a.	$(1 – t6 / t6_{max, PCD})$ x 0,10 x (1-a)

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

Table 6 — PICC reception: Pause parameter 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	19/fc
	fc/32	8/fc	9,5/fc
	fc/16	4/fc	5,5/fc
t_5	fc/64	t_1/2 + 3/fc	t_1 - 1/fc
	fc/32	t_1/2 + 1/fc	t_1 - 1/fc
	fc/16	t_1/2	t_1 - 1/fc
t_6	fc/64	1/fc	12/fc
	fc/32	1/fc	10/fc
	fc/16	1/fc	6/fc
h_{ovs}	fc/64, fc/32, fc/16	n.a.	$(1 – t6 / t6_{max, PICC})$ x 0,11 x (1-a)

The pause length t1 is the time between an envelope amplitude of (0,9 + 0,1 x a) on the falling edge and (1 + δ) x a on the rising edge. δ is defined to be 0,025.

Editor's note: (1 + δ) x a should be replaced by parameter a plus a fixed value (percentage of the carrier) and the expression (0,9 + 0,1 x a) should be replaced by 0,9.

Figure 7 defines the rise time (t_6) dependency on the fall time (t_1 - t_5) for a bit rate of fc/64.

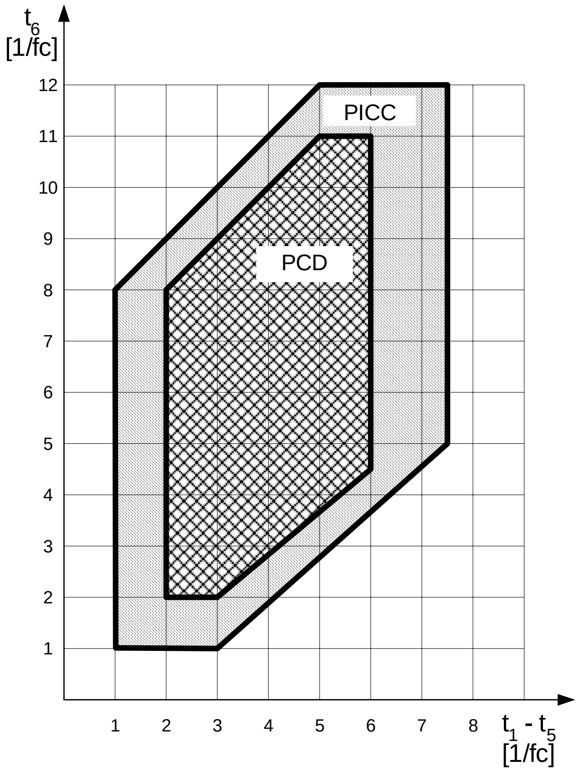

Figure 7 — Rise – fall time dependency for a for bit rate of fc/64

Figure 8 defines the rise time (t_6) dependency on the fall time (t_1 - t_5) for a bit rate of fc/32.

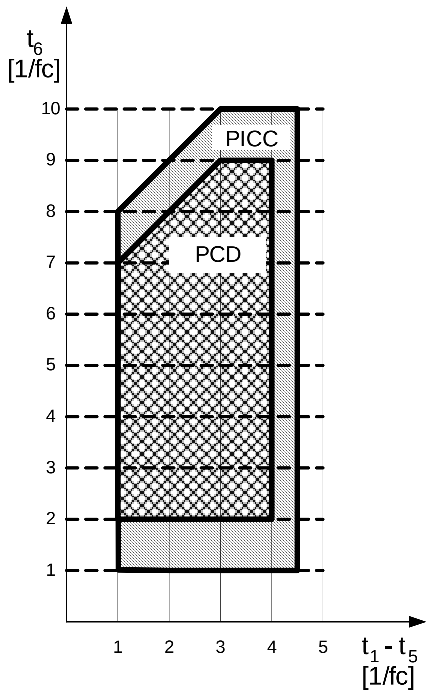

Figure 8 — Rise – fall time dependency for a for bit rate of fc/32

Figure 9 defines the rise time (t_6) dependency on the fall time (t_1 - t_5) for a bit rate of fc/16.

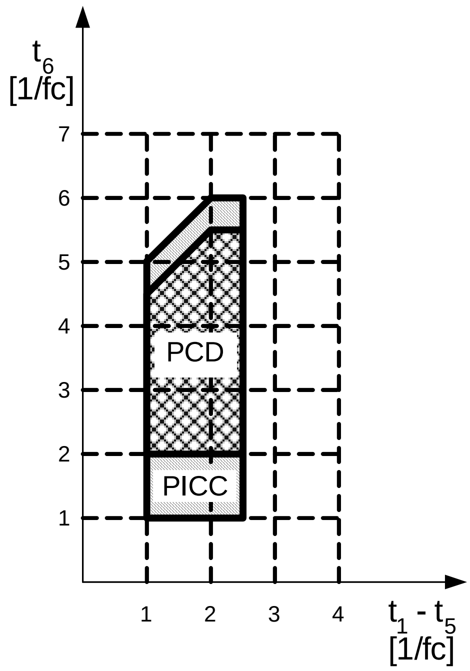

Figure 9 — Rise – fall time dependency for a for bit rate of fc/16

8.1.3 Bit representation and coding

The following sequences are defined:

— sequence X: after a time of half the bit duration a "Pause" shall occur.

— sequence Y: for the full bit duration no modulation shall occur.

— sequence Z: at the beginning of the bit duration a “Pause” shall occur.

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

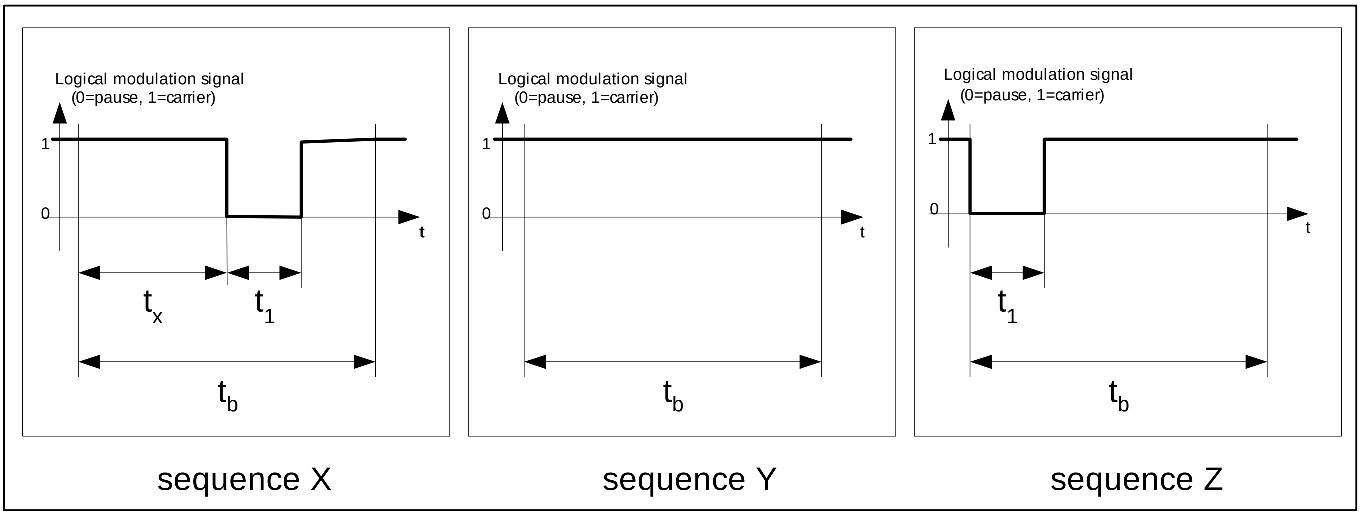

Figure 10 — Signal shapes for sequences

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 figure 3	see t_1 of figure 6		

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 frame” 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

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 (~847 kbit/s).

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.

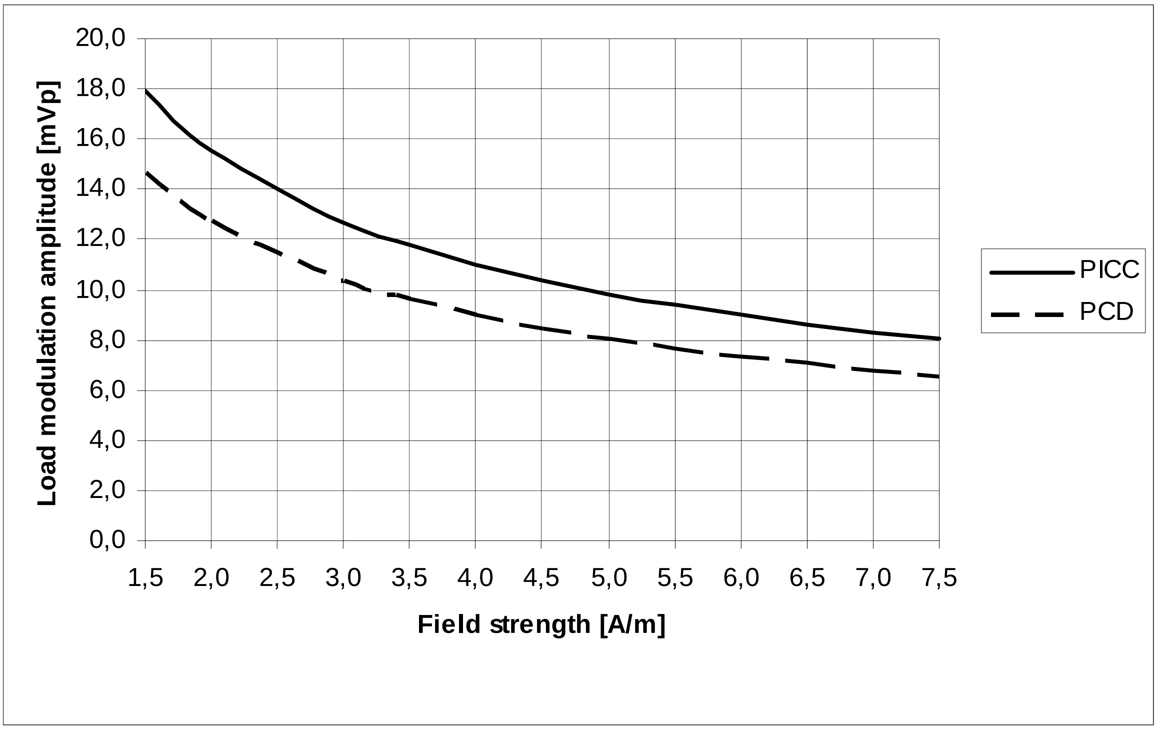

Figure 11 — Load modulation amplitude

The load modulation amplitude of the PICC shall be at least $22/H^{0,5}$ (mVpeak) 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 load modulation amplitude of at least $18/H^{0,5}$ (mVpeak) when measured as described in ISO/IEC 10373-6, where *H* is the (rms) value of magnetic field strength in A/m.

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 coil in the testing standard)

Future revision of 14443 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 (~847 kHz). Consequently, during initialization and anticollision, one bit duration is equivalent to 8 periods of the subcarrier.

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.

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 (~847 kbit/s).

Tolerance and bit boundaries are defined in ISO/IEC 14443-3.

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 to 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 (y=0,1 x (a-b)).

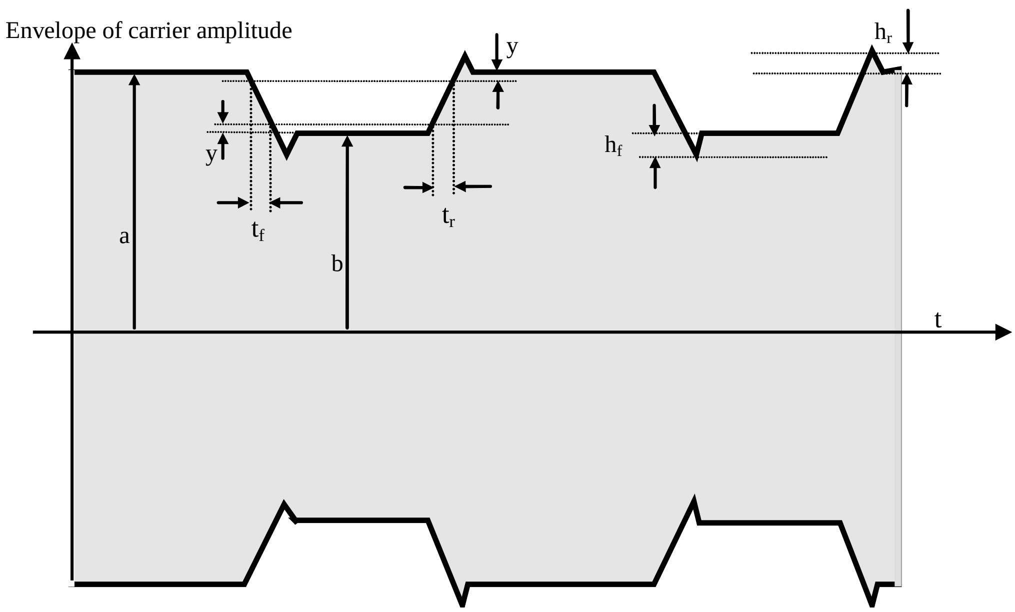

Figure 12 — Type B modulation waveform

The overshoots of the PCD modulation waveform shall remain within limits specified in Table 8.

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

Parameter	Min	Max
h_f	0	$(1{,}0 - t_f / t_{r\_max\_PCD}) \times 0{,}09 \times (a - b)$
h_r	0	$(1{,}0 - t_r / t_{f\_max\_PCD}) \cdot \times 0{,}09 \times \cdot (a - b)$

The PICC shall be able to receive a modulation waveform with overshoots defined in Table 10.

Table 9 — PCD transmission: Maximum rise an fall times for bit rates of fc/128, fc/64, fc/32 and fc/16

bit rates	tr_max_PCD	tf_max_PCD
fc/128	16 / fc	16 / fc
fc/64	13/ fc	13/ fc
fc/32	10 / fc	10 / fc
fc/16	7 / fc	7 / fc

Table 10 — PICC reception: Overshoots for Bit Rates fc/128, fc/64, fc/32 and fc/16

Parameter	Min	Max
h_f	0	$(1{,}0 - t_f / t_{f\_max\_PICC}) \times 0{,}11 \times (a - b)$
h_r	0	$(1{,}0 - t_r / t_{r\_max\_PICC}) \cdot \times 0{,}11 \times \cdot (a - b)$

Table 11 — PICC transmission: Maximum rise an fall times for bit rates of fc/128, fc/64, fc/32 and fc/16

bit rates	tr_max_PICC	tf_max_PICC
fc/128	17 / fc	17 / fc
fc/64	14 / fc	14 / fc
fc/32	11 / fc	11 / fc
fc/16	8 / fc	8 / fc

The modulation index m of the PCD modulation waveform shall remain within limits specified in Figure 13.

The PICC shall be able to receive a modulation waveform with modulation index defined in Figure 13.

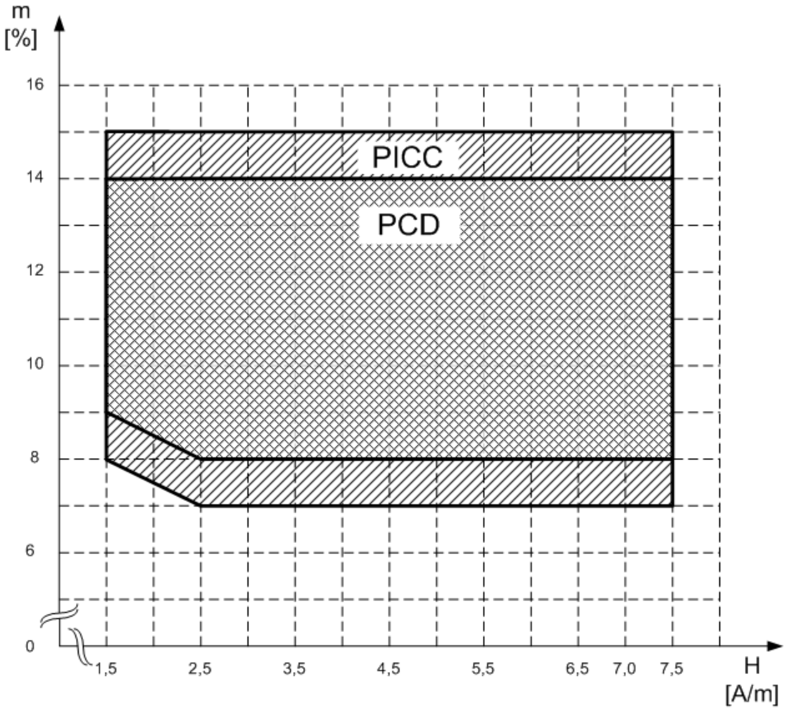

Figure 13 — Type B modulation index for bit rates of fc/128, fc/64, fc/32 and fc/16

Fehler! Verweisquelle konnte nicht gefunden werden. defines modulation waveform timing parameter for a bit rate of fc/128.

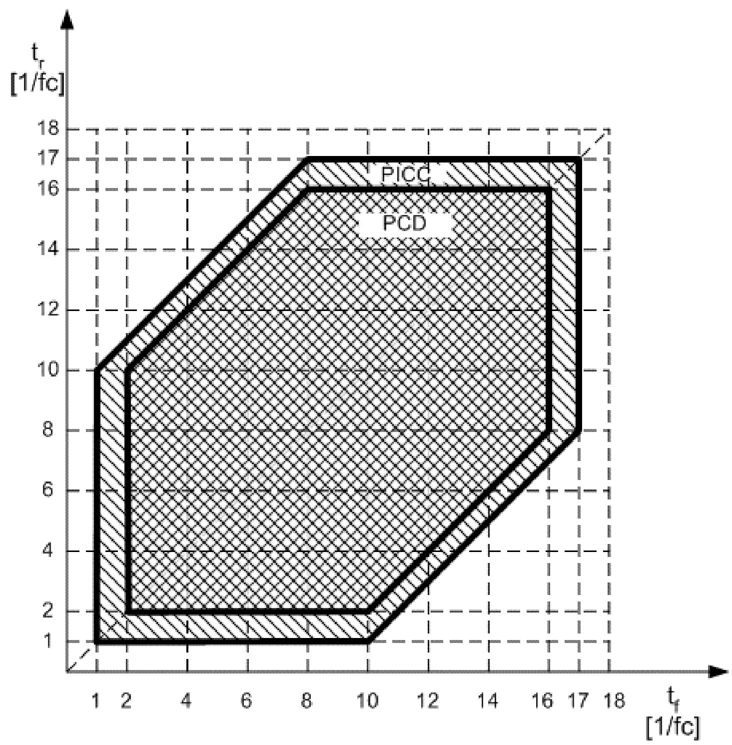

Figure 14 — Type B modulation waveform timing parameter for bit rate fc/128

Figure 15 defines modulation waveform timing parameter for a bit rate of fc/64.

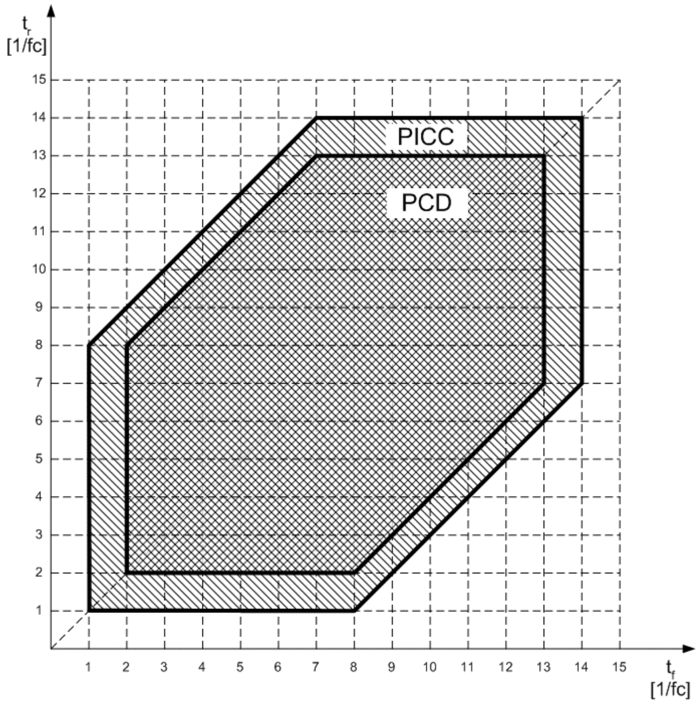

Figure 15 — Type B modulation waveform timing parameter for bit rate fc/64

Figure 16 defines modulation waveform timing parameter for a bit rate of fc/32.

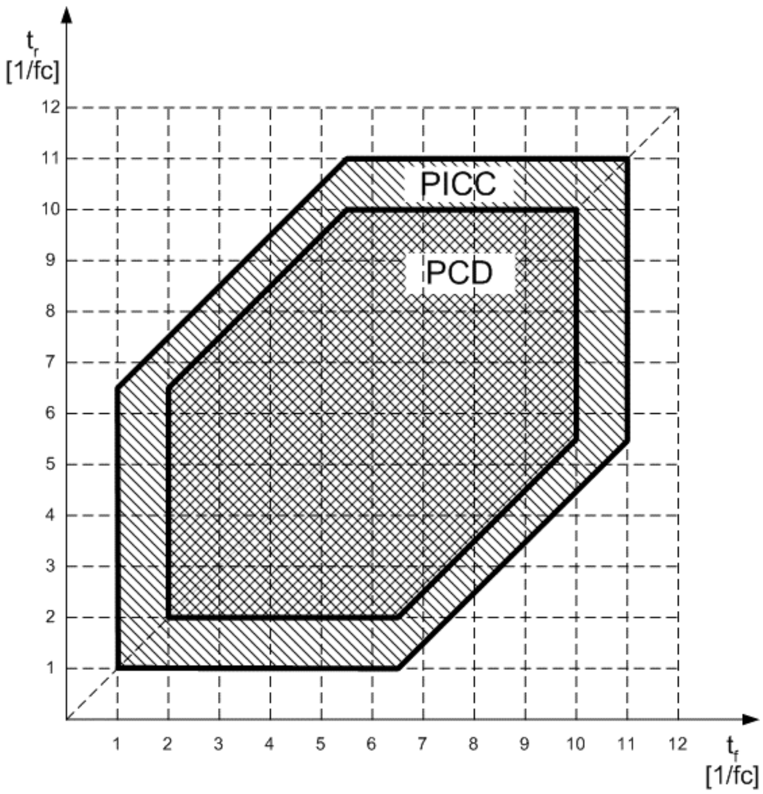

Figure 16 — Type B modulation waveform timing parameter for bit rate fc/32

Figure 17 defines modulation waveform timing parameter for a bit rate of fc/16.

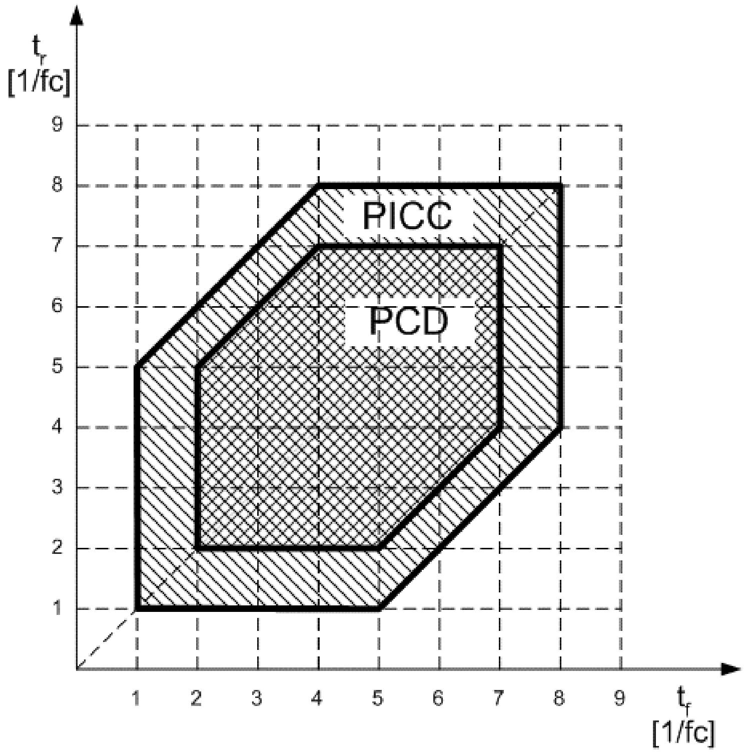

Figure 17 — Type B modulation waveform timing parameter for bit rate fc/16

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

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 (~847 kbit/s).

9.2.2 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 of the PICC shall be at least $22/H^{0,5}$ (mVpeak) 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 load modulation amplitude of at least $18/H^{0,5}$ (mVpeak) when measured as described in ISO/IEC 10373-6, where *H* is the (rms) value of magnetic field strength in A/m.

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 coil in the testing standard).

Future revision of 14443 may specify new limits and/or test methods adapted to these PICCs.

9.2.3 Subcarrier

The frequency *fs* of the subcarrier shall be *fc*/16 (~847 kHz). Consequently, during initialization and anticollision, one bit period is equivalent to 8 periods of the subcarrier. After initialisation 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.

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/*f*s.

— The PICC shall then generate a subcarrier with no phase transition for a synchronization time TR1. This establishes a subcarrier phase reference Ø0. TR1 shall be greater than 80/*f*s.

— 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 subcarrier phase reference:

Ø0: represents logic "1"

Ø0 + 180°: represents logic "0".

NOTE Clause 10 has been removed.