BS ISO/IEC 14443-2:2020+A1:2021
Incorporating corrigenda July 2021 and September 2023

BSI Standards Publication

Cards and security devices for personal identification — Contactless proximity objects

Part 2: Radio frequency power and signal interface

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National foreword

This British Standard is the UK implementation of ISO/IEC 14443-2:2020+A1:2021, incorporating corrigenda July 2021 and September 2023. It supersedes BS ISO/IEC 14443-2:2020, which is withdrawn.

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A list of organizations represented on this committee can be obtained on request to its committee manager.

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INTERNATIONAL STANDARD

ISO 14443-2

Fourth edition
2020-07-22

Cards and security devices for personal identification — Contactless proximity objects —

Part 2: Radio frequency power and signal interface

Cartes et dispositifs de sécurité pour l'identification personnelle — Objets sans contact de proximité —

Partie 2: Interface radiofréquence et des signaux de communication

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see http://patents.iec.ch).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 17, *Cards and security devices for personal identification*.

This fourth edition cancels and replaces the third edition (ISO/IEC 14443-2:2016), which has been technically revised.

The main changes compared to the previous edition are as follows:

— amendment of active and passive PICC transmissions;

— amendment of electromagnetic disturbance levels for all PICC classes.

A list of all parts in the ISO/IEC 14443 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

ISO/IEC 14443 (all parts) is one of a group 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 document 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 the ISO/IEC 14443series.

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

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Cards and security devices for personal identification — Contactless proximity objects —

Part 2: Radio frequency power and signal interface

1 Scope

This document 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 document does not specify the means of generating coupling fields, nor the means of compliance with electromagnetic radiation and human exposure regulations, which can vary depending on the country.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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, *Cards and security devices for personal identification — Test methods — Part 6: Contactless proximity objects*

ISO/IEC 14443-1:2018, *Cards and security devices for personal identification — Contactless proximity objects — Part 1: Physical characteristics*

ISO/IEC 14443-3:2018, *Cards and security devices for personal identification — Contactless proximity objects — Part 3: Initialization and anticollision*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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

3.2
BPSK
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* (3.1) is represented by the position of a pulse within the bit frame

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

Note 1 to entry: 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* (3.1) is represented by one of two defined physical states of a communication medium

3.6
operating volume
positions, for each PICC class, where the corresponding Reference PICC and Active Reference PICC show PCD compliance with all requirements of this document for this class

3.7
subcarrier
signal of frequency, f_s, used to modulate a carrier of frequency, f_c

3.8
Manchester
method of bit coding whereby a logic level during a *bit duration* (3.1) 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

3.9
TR0
guard time between the end of a PCD transmission and the start of the PICC *subcarrier* (3.7) generation

3.10
TR1
synchronization time between the start of the PICC *subcarrier* (3.7) generation and the start of the PICC subcarrier modulation

4 Symbols and abbreviated terms

a	pulse shape factor, Type A
ACP	actual constellation point
AP	actual phase value
ASK	amplitude shift keying
b	ratio between the modulated and initial signal amplitude, Type B
BPSK	binary phase shift keying
EMD	electromagnetic disturbance, parasitically generated by the PICC
EPI	elementary phase interval
etu	elementary time unit
f_c	frequency of operating field (carrier frequency)
f_s	frequency of subcarrier

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H	equivalent homogenous magnetic field strength
$H_{INITIAL}$	field strength of the unmodulated RF field
A1 H_{LP}	minimum requested field strength A1
h_{ovs}	envelope overshoot for bit rates of $f_c/64$, $f_c/32$, and $f_c/16$, Type A
h_f	envelope undershoot, Type B
h_r	envelope overshoot, Type B
A1 $H_{step,max}$	PCD maximum field strength step increase or step decrease A1
ISI	inter symbol interference
ISI_d	inter symbol interference angle
ISI_m	inter symbol interference magnitude
MS1	first modulated state
MS2	second modulated state
NP	nominal phase value
NRZ-L	non-return to zero (L for level)
OOK	on/off keying
PauseA	PCD modulation pulse, Type A
$Ø_0$	initial phase of the subcarrier
$Ø_{LM}$	load modulation phase
$Ø_{LM, INIT}$	initial value of $Ø_{LM, MEAN}$
$Ø_{LM, INTER}$	load modulation interstate phase drift
$Ø_{LM, INTER, PCD}$	limit of $Ø_{LM, INTER}$ for PCD reception
$Ø_{LM, INTER, PICC}$	limit of $Ø_{LM, INTER}$ for PICC transmission
$Ø_{LM, INTRA}$	load modulation intrastate phase drift
$Ø_{LM, INTRA, PCD}$	limit of $Ø_{LM, INTRA}$ for PCD reception
$Ø_{LM, INTRA, PICC}$	limit of $Ø_{LM, INTRA}$ for PICC transmission
$Ø_{LM, MEAN}$	interstate phase
PCD	proximity coupling device
PICC	proximity card or object

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P_H	complex constellation point of the maximum NP
P_L	complex constellation point of the minimum NP
PNP	previous nominal phase
PR	phase range
PSK	phase shift keying
RF	radio frequency
t_1	PauseA length
t_2	PauseA "Low" time for a bit rate of $f_c/128$
t_3	PauseA rise time for a bit rate of $f_c/128$
t_4	PauseA rise time section for a bit rate of $f_c/128$
t_5	PauseA "Low" time for bit rates of $f_c/64$, $f_c/32$, and $f_c/16$
t_6	PauseA rise time for bit rates of $f_c/64$, $f_c/32$, and $f_c/16$
$t_{6, max, PCD}$	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
US	unmodulated state
$V_{\|MS1-US\|}$	modulus of the difference between US and any MS1
$V_{E, PCD}$	EMD limit, PCD
$V_{E, PICC}$	EMD limit, PICC
V_{LMA}	load modulation amplitude
$V_{LMA, min, PCD}$	minimum limit of V_{LMA} for PCD reception
$V_{LMA, min, PICC}$	minimum limit of V_{LMA} for PICC transmission
$V_{LMA, max, PCD}$	maximum limit of V_{LMA} for PCD reception
$V_{LMA, max, PICC}$	maximum limit of V_{LMA} for PICC transmission

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Number

5 General considerations

5.1 Initial dialogue

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 Clauses 6 to 10.

5.2 Compliance

5.2.1 PICC compliance

The PICC shall comply with all mandatory requirements of this document and may support optional requirements (bit rate, class, etc.). The PICC should fulfill all the requirements of one particular class in order to improve interoperability.

5.2.2 PCD compliance

5.2.2.1 General

The PCD shall comply with all mandatory requirements of this document and may support optional requirements (bit rate, support of PICCs of optional classes, etc.).

The PCD

— shall support PICCs of "Class 1", "Class 2", and "Class 3",

— may optionally support PICCs of "Class 4",

— may optionally support PICCs of "Class 5", and

— may optionally support PICCs of "Class 6".

PCD requirements measured with Reference PICCs 1, 2, and 3 and Active Reference PICCs 1, 2, and 3 are mandatory for all PCDs.

PCD requirements measured with Reference PICC 4 and Active Reference PICC 4 are only mandatory for PCDs supporting operation with "Class 4" PICCs.

PCD requirements measured with Reference PICC 5 and Active Reference PICC 5 are only mandatory for PCDs supporting operation with "Class 5" PICCs.

PCD requirements measured with Reference PICC 6 and Active Reference PICC 6 are only mandatory for PCDs supporting operation with "Class 6" PICCs.

For each supported PICC class, the PCD manufacturer shall indicate the operating volume within which the PCD fulfills all requirements of this document.

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5.2.2.2 PCD supporting PICCs of particular class(es

If a PCD is expected to operate with PICCs of only particular class(es), it is not mandatory for this PCD to support PICCs of other classes. This PCD shall comply with all requirements of this document non-specific to one class. The PCD manufacturer shall clearly state which class(es) are supported.

NOTE A PCD which does not support all mandatory classes 1, 2, and 3 is not fully compliant with this document. It can be advertised as "supporting 'Class X' PICCs only" or "compliant with Class(es) X requirements only".

6 Power transfer

6.1 General

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.

6.2 Frequency

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

6.3 Operating field strength

〚A1〛Within the manufacturer specified operating volumes (see 3.6),

— the PCD shall generate a field strength of at least H_{min} and not exceeding H_{max} under unmodulated conditions, see Table 1;

— the PCD may generate a field strength lower than H_{min} only in case the PICC allows a decrease in the PCD field strength as specified in other parts of ISO/IEC 14443 and only for the processing of that PICC.

The PCD field strength step increase and step decrease shall be less than $H_{step,\ max}$ = 3 dB (a factor of ~1,4) and may be achieved by any wave shape, e.g., by several increments.

WARNING — The PCD design shall take into account the field strength variation caused by the two different loading effects used in the associated test.〚/A1〛

The PCD

— shall support PICCs of "Class 1", "Class 2", and "Class 3",

— may optionally support PICCs of "Class 4",

— may optionally support PICCs of "Class 5", and

— may optionally support PICCs of "Class 6".

PCD requirements measured with Reference PICCs 1, 2, and 3 are mandatory for all PCDs.

PCD requirements measured with Reference PICC 4 are only mandatory for PCDs supporting operation with "Class 4" PICCs.

PCD requirements measured with Reference PICC 5 are only mandatory for PCDs supporting operation with "Class 5" PICCs.

PCD requirements measured with Reference PICC 6 are only mandatory for PCDs supporting operation with "Class 6" PICCs.

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Table 1 — PCD field strength

	H_{min} A/m (rms)	H_{max} A/m (rms)
Measured with Reference PICC 1	1,5	7,5
Measured with Reference PICC 2	1,5	8,5
Measured with Reference PICC 3	1,5	8,5
Measured with Reference PICC 4 (optional)	2,0	12
Measured with Reference PICC 5 (optional)	2,5	14
Measured with Reference PICC 6 (optional)	4,5	18

The PCD shall not generate a field strength higher than the average and maximum levels specified for all mandatory and optional classes in ISO/IEC 14443-1:2018, 4.4 (alternating magnetic field) in any possible PICC position and orientation, measured with the associated Reference PICCs.

Test methods for the PCD operating field are defined in ISO/IEC 10373-6 and use a dedicated Reference PICC for each class.

If the PICC meets the requirements of one particular class as specified in ISO/IEC 14443-1, then the PICC shall operate as intended continuously between H_{min} and H_{max} defined for its class, see Table 2; this includes all PICC requirements defined in this document and processing of the manufacturer specified set of commands.

If the PICC does not claim to meet the requirements of one particular class as specified in ISO/IEC 14443-1, then:

— if the PICC antenna fits within the external rectangle defined in "Class 2" as specified in ISO/IEC 14443-1, then

  — the PICC shall operate as intended continuously between H_{min} and H_{max} defined for "Class 2", see Table 2,

  — the PICC shall pass the loading effect test defined for "Class 2";

— if the PICC antenna fits within the external rectangle or external circle defined in "Class 3" as specified in ISO/IEC 14443-1, then

  — the PICC shall operate as intended continuously between H_{min} and H_{max} defined for "Class 3", see Table 2,

  — the PICC shall pass the loading effect test defined for "Class 3";

— if the PICC antenna does not claim to fit within the external rectangle or external circle defined in "Class 2" or "Class 3" as specified in ISO/IEC 14443-1, then

  — the PICC shall operate as intended continuously between H_{min} and H_{max} defined for "Class 1", see Table 2,

  — the PICC shall pass the loading effect test defined for "Class 1".

NOTE 1 If the PICC does not claim to meet the requirements of one particular class, then the requirements defined above are sufficient to guarantee proper operation and interoperability with PCDs.

〈A1〉 Additionally, if the PICC allows a decrease in the PCD field strength down to a value less than H_{min}, then the PICC shall be able to operate as intended continuously between that value and H_{min} defined for its class, see Table 2.

The minimum requested field strength H_{LP} is $H_{step,\ max}$ below the lowest field strength at which the PICC indicates PLI_{ATQ} = (11)b or PLI_{CID} = (10)b or (11)b (see ISO/IEC 14443-3:2018/Amd 1 and ISO/IEC 14443-4:2018/Amd 1). 〈A1〉

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Table 2 — PICC operating field strength

	H_{min} A/m (rms)	H_{max} A/m (rms)
"Class 1" PICC	1,5	7,5
"Class 2" PICC	1,5	8,5
"Class 3" PICC	1,5	8,5
"Class 4" PICC	2,0	12
"Class 5" PICC	2,5	14
"Class 6" PICC	4,5	18

NOTE 2 Margins of field strength are effectively included by the test methods as specified in ISO/IEC 10373-6.

7 Signal interface

In order to transmit data to the PICC, the PCD modulates the amplitude of its alternating magnetic field strength with modulation pulses.

In order to transmit data to the PCD, the PICC passively loads the PCD alternating magnetic field and/or actively contributes with its own alternating magnetic field. This is called load modulation.

Within the manufacturer specified operating volumes (see 3.6), the PCD shall generate modulation pulses as described in Clauses 8 and 9 and shall be capable of receiving the minimum load modulation amplitude.

NOTE 1 As an indication of the operating volume, the manufacturer can give the operating range (e.g. 0 to X cm) within which all requirements of this document 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 Clauses 8 and 9. 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.

Table 3 and Table 4 illustrate the concepts described in Clauses 8 and 9.

Table 3 — Example PCD to PICC communication signals for Type A and Type B interfaces

	Type A	Type B
bit rates of $f_c/128$, $f_c/64$, $f_c/32$, and $f_c/16$	ASK ~ 100 % modified Miller	ASK ~ 10 % NRZ-L
bit rates of $f_c/8$, $f_c/4$, and $f_c/2$	ASK ~ 10 % NRZ–L	

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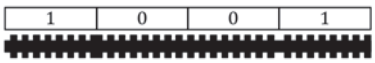
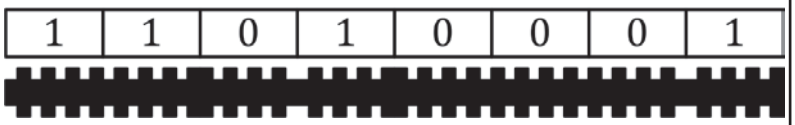
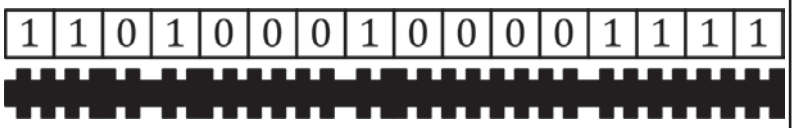
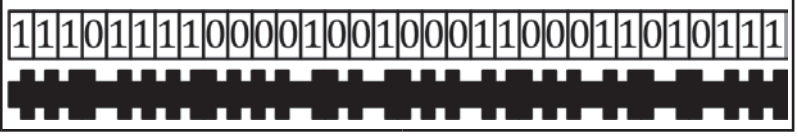
	Type A	Type B
bit rates of $3f_c/4$, f_c, $3f_c/2$, and $2f_c$	PSK, see 8.1.2.5.	

NOTE 2 For the coding of modified Miller, see 8.1.3.1.

Table 4 — Example PICC to PCD communication signals for Type A and Type B interfaces

	Type A	Type B
bit rate of $f_c/128$	Load modulation Subcarrier $f_c/16$ OOK Manchester 	Load modulation Subcarrier $f_c/16$ BPSK NRZ-L 
bit rate of $f_c/64$	Load modulation Subcarrier $f_c/16$ BPSK NRZ-L 	
bit rate of $f_c/32$	Load modulation Subcarrier $f_c/16$ BPSK NRZ-L 	
bit rates of $f_c/16$, $f_c/8$, $f_c/4$, and $f_c/2$	Load modulation Subcarrier equals the bit rate BPSK NRZ-L 	

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 $f_c/128$ (~106 kbit/s).

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

— $f_c/128$ (~106 kbit/s);

— $f_c/64$ (~212 kbit/s);

— $f_c/32$ (~424 kbit/s);

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— $f_c/16$ (~848 kbit/s);

— $f_c/8$ (~1,70 Mbit/s);

— $f_c/4$ (~3,39 Mbit/s);

— $f_c/2$ (~6,78 Mbit/s);

— $3f_c/4$ (~10,17 Mbit/s);

— f_c (~13,56 Mbit/s);

— $3f_c/2$ (~20,34 Mbit/s);

— $2f_c$ (~27,12 Mbit/s).

8.1.2 Modulation

8.1.2.1 General

8.1.2.2 to 8.1.2.5 describe the modulation waveform requirements for all bit rates.

NOTE Filtering of the PCD modulation is defined in ISO/IEC 10373-6. Some extreme values can be filtered out. This can affect the relevant timing parameter associated with the fall and rise timings as well as overshoot and undershoot values.

8.1.2.2 Modulation for a bit rate of $f_c/128$

Communication from PCD to PICC for a bit rate of $f_c/128$ shall use the modulation principle of ASK 100 % of the RF operating field to create a PauseA as shown in Figure 1.

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 t_2. This envelope shall comply with Figure 1.

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 $H_{INITIAL}$.

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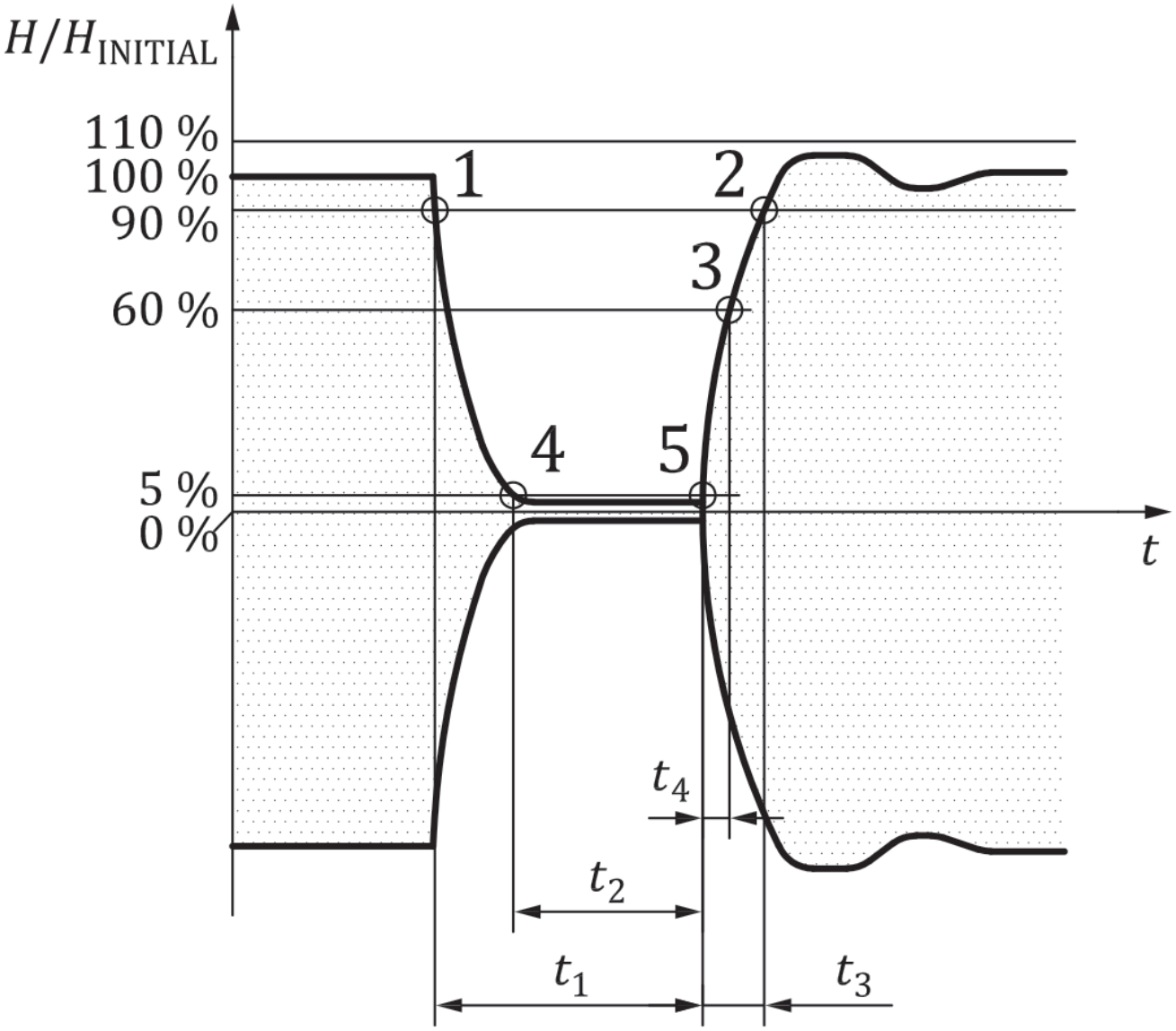

Key

1 start of t_1
2 end of t_3
3 end of t_4
4 start of t_2
5 end of t_1 and t_2, start of t_3 and t_4

Figure 1 — PauseA for a bit rate of $f_c/128$

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

Table 5 — PCD transmission: PauseA timing parameters for a bit rate of $f_c/128$

Parameter	Condition	Minimum	Maximum
t_1		$28/f_c$	$40{,}5/f_c$
t_2	$t_1 > 34/f_c$	$7/f_c$	t_1
	$t_1 \leq 34/f_c$	$10/f_c$	
t_3		$1{,}5 \times t_4$	$16/f_c$

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