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

Part 3: Initialization and anticollision

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

Partie 3: Initialisation et anticollision

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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.

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).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by 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 14443-3:2016), which has been technically revised.

The following are the main changes since the last edition:

— RFU handling rules and clarifications have been added;

— Annexes D and E have been removed.

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

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Introduction

The ISO/IEC 14443 series of standards describes the parameters for identification cards or objects for international interchange.

This document describes polling for proximity cards entering the field of a proximity coupling device, the byte format and framing, the initial Request and Answer to Request command content, methods to detect and communicate with one proximity card among several proximity cards (anticollision) and other parameters required to initialize communications between a proximity card and a proximity coupling device. Protocols and commands used by higher layers and by applications and which are used after the initial phase are described in ISO/IEC 14443-4.

The ISO/IEC 14443 series of standards is intended to allow operation of proximity cards in the presence of other contactless cards or objects conforming to the ISO/IEC 10536 series of standards and the ISO/IEC 15693 series of standards and near field communication (NFC) devices conforming to ISO/IEC 18092 and ISO/IEC 21481.

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

Part 3:
Initialization and anticollision

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1 Scope

This document describes the following:

— polling for proximity cards or objects (PICCs) entering the field of a proximity coupling device (PCD);

— the byte format, the frames and timing used during the initial phase of communication between PCDs and PICCs;

— the initial Request and Answer to Request command content;

— methods to detect and communicate with one PICC among several PICCs (anticollision);

— other parameters required to initialize communications between a PICC and PCD;

— optional means to ease and speed up the selection of one PICC among several PICCs based on application criteria;

— optional capability to allow a device to alternate between the functions of a PICC and a PCD to communicate with a PCD or a PICC, respectively. A device which implements this capability is called a PXD.

Protocol and commands used by higher layers and by applications and which are used after the initial phase are described in ISO/IEC 14443-4.

This document is applicable to PICCs of Type A and of Type B (as described in ISO/IEC 14443-2), to PCDs (as described in ISO/IEC 14443-2) and to PXDs.

NOTE 1 Part of the timing of data communication is defined in ISO/IEC 14443-2.

NOTE 2 Test methods for this document are defined in ISO/IEC 10373-6.

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 7816-4, *Identification cards — Integrated circuit cards — Part 4: Organization, security and commands for interchange*

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

ISO/IEC 13239, *Information technology — Telecommunications and information exchange between systems — High-level data link control (HDLC) procedures*

ISO/IEC 14443-2, *Cards and security devices for personal identification — Contactless proximity objects —Part 2: Radio frequency power and signal interface*

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ISO/IEC 14443-4, *Cards and security devices for personal identification — Contactless proximity objects —Part 4: Transmission protocol*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 14443-2 and the following apply.

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

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

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

3.1
anticollision loop
algorithm used to prepare for dialogue between PCD and one or more PICCs out of the total number of PICCs responding to a request command

3.2
byte
8 bits of data designated b8 to b1, from the most significant bit (MSB, b8) to the least significant bit (LSB, b1)

3.3
collision
transmission by two PICCs in the same PCD energizing field and during the same time period, such that the PCD is unable to distinguish from which PICC the data originated

3.4
frame
sequence of data bits and optional error detection bits, with frame delimiters at start and end

3.5
frame error
error on SOF, start and stop bits, parity bits, EOF

3.6
higher layer protocol
protocol layer (not described in this document) that makes use of the protocol layer defined in this document to transfer information belonging to the application or higher layers of protocol that is not described in this document

3.7
PCD Mode
mode in which a PXD operates as a PCD

3.8
PICC Mode
mode in which a PXD operates as a PICC

3.9
request command
command requesting PICCs of the appropriate type to respond if they are available for initialization

3.10
transmission error
frame error or CRC_A or CRC_B error

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4 Symbols, abbreviated terms and notations

4.1 Symbols and abbreviated terms

ADC	Application Data Coding, Type B
AFI	Application Family Identifier, card preselection criteria by application, Type B
APf	anticollision prefix f, used in REQB/WUPB, Type B
APn	anticollision prefix n, used in Slot-MARKER command, Type B
ATQA	Answer to Request, Type A
ATQB	Answer to Request, Type B
ATTRIB	PICC selection command, Type B
BCC	Block Check Character (UID CL*n* check byte), Type A
CID	Card Identifier
CL*n*	cascade level *n*, Type A
CT	cascade tag, Type A
CRC_A	Cyclic Redundancy Check error detection code, Type A
CRC_B	Cyclic Redundancy Check error detection code, Type B
D	Divisor
E	end of communication, Type A
EGT	extra guard time, Type B
EOF	end of frame, Type B
etu	elementary time unit
FDT	frame delay time PCD to PICC, Type A
fc	carrier frequency
FO	Frame Option, Type B
fs	subcarrier frequency
FWI	Frame Waiting time Integer
FWT	Frame Waiting Time
HLTA	halt command, Type A
HLTB	halt command, Type B
ID	identification number, Type A
INF	information field belonging to higher layer, Type B
LSB	least significant bit

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MBL	Maximum Buffer Length, Type B
MBLI	Maximum Buffer Length Index, Type B
MSB	most significant bit
N	number of anticollision slots, Type B
n	variable integer value as defined in the specific clause
NAD	node address
NVB	number of valid bits, Type A
P	odd parity bit, Type A
PCD	proximity coupling device
PICC	proximity card or object
PUPI	Pseudo-Unique PICC Identifier, Type B
PXD	proximity extended device
R	slot number chosen by the PICC during the anticollision sequence, Type B
REQA	REQuest command, Type A
REQB	REQuest command, Type B
RFU	reserved for future use
S	start of communication, Type A
SAK	Select acknowledge, Type A
SEL	select code, Type A
SELECT	SELECT command, Type A
SFGI	Start-up Frame Guard time Integer
SFGT	Start-up Frame Guard Time
SOF	Start Of Frame, Type B
t_{cyc}	maximum automatic mode alternation cycle time
t_{diff}	minimum time difference of PICC Mode durations
$t_{\mathrm{E,\ PICC}}$	low EMD time, PICC
$t_{\mathrm{E,\ PCD}}$	low EMD time, PCD
TR0	guard time as defined in ISO/IEC 14443-2, Type B
TR1	synchronization time as defined in ISO/IEC 14443-2, Type B
TR2	frame delay time PICC to PCD, Type B
UID	unique identifier, Type A

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UID CL*n*	unique identifier of CL*n*, Type A
uid*n*	byte number *n* of unique identifier, $n \geq 0$
WUPA	Wake-UP command, Type A
WUPB	Wake-UP command, Type B

4.2 Notations

— (xxxxx)b data bit representation

— 'XY' hexadecimal notation, equal to XY to the base 16

5 General requirements

5.1 Alternating PICC and PCD support (PXD)

A proximity extended device (PXD) shall alternately support PICC requirements (PICC Mode) and PCD requirements (PCD Mode).

The alternation between the PICC Mode and the PCD Mode may be either automatic or a Mode (PICC Mode or PCD Mode) may be explicitly selected by the user.

The PICC Mode and the PCD Mode are defined as PICC and PCD in the ISO/IEC 14443 series of standards.

The automatic alternation is defined as follows:

— the PXD shall alternate between the PICC Mode and the PCD Mode with maximum cycle time $t_{cyc} = 1$ s and shall stay in PICC Mode (ready for receiving REQA/WUPA or REQB/WUPB commands, except for the first 5 ms) longer than in PCD Mode (generating operating field), until a communication to either a PICC, a PCD or another PXD is established;

— the PXD shall randomly set the PICC Mode duration for each cycle to a value chosen from a set of at least two different values differing by at least $t_{diff} = 5$ ms between each of them;

— in PICC Mode, after reception of a valid REQA/WUPA or REQB/WUPB command, the PXD shall not go in PCD Mode before a POWER-OFF state;

— when leaving the PCD Mode after processing of a PICC (or a PXD in PICC mode), the PXD shall resume its automatic mode alternation with the PICC Mode first.

The PXD may check the presence of external operating field to decide not to enter PCD Mode, i.e. to stay in PICC Mode for a further random PICC Mode duration.

The detection of the removal of a PICC (or PXD in PICC Mode) should be done by a PICC presence check method without switching off the operating field to keep the same UID/PUPI and to avoid PXD entering the PCD Mode.

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5.2 Alternating between Type A and Type B commands

5.2.1 Polling

In order to detect PICCs which are in the operating field, the PCD shall send repeated request commands. The PCD shall send REQA (or WUPA) and REQB (or WUPB) in any sequence using an equal or configurable duty cycle when polling Type A and Type B. In addition, the PCD may send other commands as described in Annex C.

When a PICC is exposed to an unmodulated RF field (see ISO/IEC 14443-2), it shall be able to accept a request within 5 ms.

EXAMPLE 1

When a PICC Type A receives any Type B command, it shall be able to accept a REQA (or WUPA) within 5 ms of unmodulated RF field.

EXAMPLE 2

When a PICC Type B receives any Type A command, it shall be able to accept a REQB (or WUPB) within 5 ms of unmodulated RF field.

EXAMPLE 3

When a PICC Type A is exposed to field activation, it shall be able to accept a REQA (or WUPA) within 5 ms of unmodulated RF field.

EXAMPLE 4

When a PICC Type B is exposed to field activation, it shall be able to accept a REQB (or WUPB) within 5 ms of unmodulated RF field.

EXAMPLE 5

When a PICC supporting Type A and Type B is exposed to field activation, it shall be able to accept a REQA (or WUPA) within 5 ms of unmodulated RF field.

EXAMPLE 6

When a PICC supporting Type A and Type B is exposed to field activation, it shall be able to accept a REQB (or WUPB) within 5 ms of unmodulated RF field.

In order to detect PICCs requiring 5 ms, the PCD should periodically present an unmodulated RF field of at least 5,1 ms duration (prior to both Type A and Type B request commands), but may poll more rapidly because PICCs may react faster.

If the PICC supports Type A and Type B, then it shall be locked in the type of the first processed request command (after Answer to Request of one type, the other type is disabled until the PICC enters POWER-OFF state).

The PCD may need to adapt its polling cycle if it wants to detect such a PICC in the disabled type.

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5.2.2 Influence of Type A commands on PICC Type B operation

A PICC Type B shall either go to IDLE state (be able to accept a REQB) or be able to continue a transaction in progress after receiving any Type A frame.

A PICC Type B should have the same behavior after receiving any frame of any other standard using the same carrier frequency.

5.2.3 Influence of Type B commands on PICC Type A operation

A PICC Type A shall either go to IDLE state (be able to accept a REQA) or be able to continue a transaction in progress after receiving any Type B frame. If the PICC Type A is in READY* or ACTIVE* state when receiving any Type B frame, it may also go to HALT state as described in Figure 7.

A PICC Type A should have the same behavior after receiving any frame of any other standard using the same carrier frequency.

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5.2.4 Transition to POWER-OFF state

The PICC shall be in POWER-OFF state no later than 5 ms after the operating field is switched off.

5.3 RFU handling

For the purposes of this document, the following general rules apply.

— A PICC or PCD sending RFU bits shall set these bits to the value indicated herein or to (0)b if no value is given.

— A PICC or PCD receiving RFU bits shall ignore the value of these bits and shall maintain and not change its function, unless explicitly stated otherwise.

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6 Type A — Initialization and anticollision

6.1 etu

The value of the etu for each bit rate is defined in Table 1.

Table 1 — etu

Bit rate		etu	
fc/128	(~ 106 kbit/s)	128/*fc*	(~ 9,4 µs)
fc/64	(~ 212 kbit/s)	64/*fc*	(~ 4,7 µs)
fc/32	(~ 424 kbit/s)	32/*fc*	(~ 2,4 µs)
fc/16	(~ 848 kbit/s)	16/*fc*	(~ 1,2 µs)
fc/8	(~ 1,70 Mbit/s)	8/*fc*	(~ 0,59 µs)
fc/4	(~ 3,39 Mbit/s)	4/*fc*	(~ 0,29 µs)
fc/2	(~ 6,78 Mbit/s)	2/*fc*	(~ 0,15 µs)
3*fc*/4	(~ 10,17 Mbit/s)	4/fc	(~ 0,29 µs)
fc	(~ 13,56 Mbit/s)	4/*fc*	(~ 0,29 µs)
3*fc*/2	(~ 20,34 Mbit/s)	2/*fc*	(~ 0,15 µs)
2*fc*	(~ 27,12 Mbit/s)	2/*fc*	(~ 0,15 µs)

6.2 Frame format and timing

This subclause defines the frame format and timing used during communication initialization and anticollision. For bit representation and coding, refer to ISO/IEC 14443-2.

Frames shall be transferred in pairs, PCD to PICC followed by PICC to PCD, using the following sequence:

— PCD frame:

  — PCD start of communication;

  — information and, where required, error detection bits sent by the PCD;

  — PCD end of communication;

— Frame delay time PCD to PICC;

— PICC frame:

  — PICC start of communication;

  — information and, where required, error detection bits sent by the PICC;

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— PICC end of communication;

— Frame delay time PICC to PCD.

NOTE The frame delay time (FDT) from PCD to PICC overlaps the PCD end of communication.

6.2.1 Frame delay time

The frame delay time is defined as the time between two frames transmitted in opposite directions.

6.2.1.1 Frame delay time PCD to PICC

This is the time between the end of the last pause transmitted by the PCD and the first modulation edge within the start bit transmitted by the PICC and shall respect the timing defined in Figure 1 and Table 2 where n is an integer value.

For bit rates of $fc/8$, $fc/4$ and $fc/2$, the FDT starts at the end of the last modulation transmitted by the PCD.

For bit rates of $3fc/4$, fc, $3fc/2$, and $2fc$, the FDT starts at the end of the last phase modulation transmitted by the PCD.

Table 2 defines values for n and FDT depending on the command type and the logic state of the last transmitted data bit in this command.

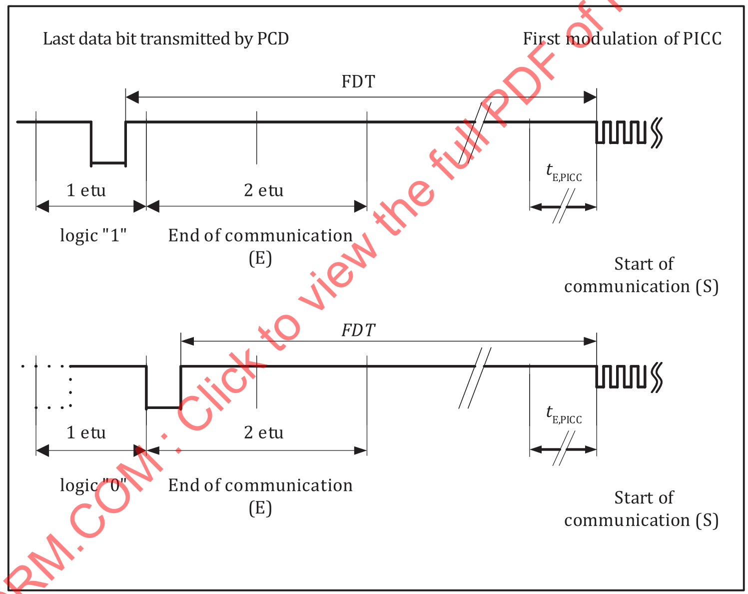

Figure 1 — Frame delay time PCD to PICC for bit rates up to $fc/16$

NOTE $t_{E,\,PICC}$ is specified in Clause 8.

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Table 2 — Frame delay time PCD to PICC

Command type		***n* (integer value)**	**FDT**	
			last bit = (1)b	**last bit = (0)b**
REQA command WUPA command ANTICOLLISION command SELECT command		9	(*n* × 128 + 84)/*fc* [= 1 236/*fc*]	(*n* × 128 + 20)/*fc* [= 1 172/*fc*]
All other commands at bit rates				
PCD to PICC	PICC to PCD			
fc/128	*fc*/128	≥9	(*n* × 128 + 84)/*fc*	(*n* × 128 + 20)/*fc*
fc/64		≥8	(*n* × 128 + 148)/*fc*	(*n* × 128 + 116)/*fc*
fc/32		≥8	(*n* × 128 + 116)/*fc*	(*n* × 128 + 100)/*fc*
fc/16		≥8	(*n* × 128 + 100)/*fc*	(*n* × 128 + 92)/*fc*
fc/128 or *fc*/64 or *fc*/32 or *fc*/16 or *fc*/8 or *fc*/4 or *fc*/2 or 3*fc*/4 or *fc* or 3*fc*/2 or 2*fc*	*fc*/64 or *fc*/32 or *fc*/16 or *fc*/8 or *fc*/4 or *fc*/2	Not applicable	≥1 116/*fc*	≥1 116/*fc*
For anticollision, all PICCs in the field shall respond in a synchronous way to the commands: REQA, WUPA, ANTICOLLISION and SELECT.				

If a bit rate higher than *fc*/16 is selected for PCD to PICC communication, then a bit rate of *fc*/128 is not allowed for PICC to PCD communication, see ISO/IEC 14443-4. This restriction is required because the necessary precise FDT is not defined for PCD NRZ-L coding which is used for bit rates higher than *fc*/16.

The FDT measurement starts at the beginning of the rising edge as specified and illustrated with small circles in the following figures of ISO/IEC 14443-2:—[1]:

— Figure titled “PauseA for a bit rate of *fc*/128” for PCD to PICC bit rate of *fc*/128;

— Figure titled “PauseA for bit rates of *fc*/64, *fc*/32, and *fc*/16” for PCD to PICC bit rates of *fc*/64, *fc*/32 and *fc*/16;

— Figure titled “Type B modulation waveform” for PCD to PICC bit rates of *fc*/8, *fc*/4 and *fc*/2.

The measured FDT shall be between the value given in Table 2 and the value given in Table 2 + 0,4 µs.

The PCD should accept a response with a FDT tolerance of −1/*fc* to (+0,4 µs + 1/*fc*).

6.2.1.2 Frame delay time PICC to PCD

This is the time between the last modulation transmitted by the PICC and the first modulation transmitted by the PCD and shall be at least 1 172/*fc*.

To enhance interoperability, an additional waiting time of 100/*fc* should be incorporated in the PCD operation.

6.2.2 Request Guard Time

The Request Guard Time is defined as the minimum time between the start bits of two consecutive REQA or WUPA commands. It has the value 7 000/*fc*.

To enhance interoperability, an additional waiting time of 100/*fc* should be incorporated in the PCD operation.

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1) Fourth edition to be published.

6.2.3 Frame formats

The following frame types are defined:

— short frames;

— standard frames;

— bit oriented anticollision frame;

— PCD standard frames for bit rates of *fc*/8, *fc*/4 and *fc*/2.

6.2.3.1 Short frame

A short frame is used to initiate communication and consists of, in the following order as illustrated in Figure 2:

— start of communication;

— 7 data bits transmitted LSB first (for coding see Table 3);

— end of communication.

No parity bit is added.

	LSB MSB	
S	b1 b2 b3 b4 b5 b6 b7	E

Figure 2 — Short frame

6.2.3.2 Standard frames

6.2.3.2.1 PCD standard frame for bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16 and PICC standard frame

Standard frames are used for data exchange and consist of, in the following order:

— start of communication;

— n × (8 data bits + odd parity bit), with $n \geq 1$. The LSB of each byte is transmitted first. Each byte is followed by an odd parity bit. The parity bit P is set such that the number of 1s is odd in (b1 to b8, P);

— end of communication.

The PCD standard frame for bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16 is illustrated in Figure 3.

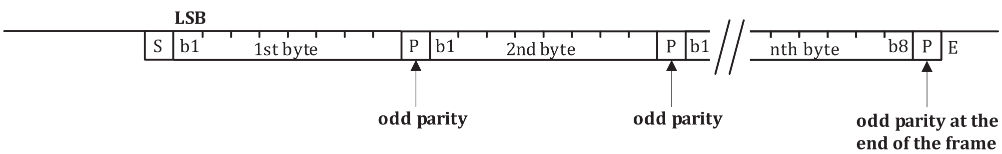

Figure 3 — PCD standard frame for bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16

As an exception, the last parity bit of a PICC standard frame shall be inverted if this frame is transmitted with a bit rate higher than *fc*/128. PICC standard frames are illustrated in Figure 4.

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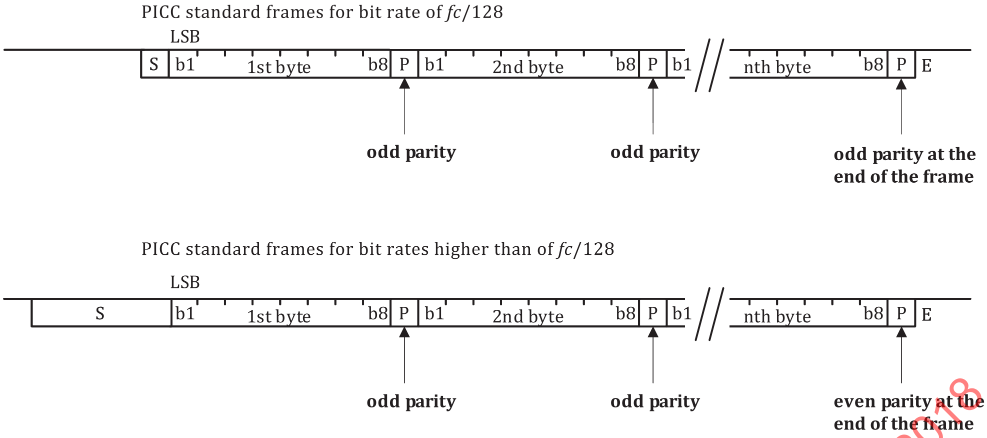

Figure 4 — PICC standard frames for all bit rates

6.2.3.2.2 PCD standard frame for bit rates of *fc*/8, *fc*/4 and *fc*/2

The character transmission format and character separation as defined in 7.1.1 and 7.1.2, respectively, shall be used.

The frame format is defined in 7.1.3.

6.2.3.2.3 PCD standard frame for PCD to PICC bit rates of 3*fc*/4, *fc*, 3*fc*/2 and 2*fc*

The standard frame format as defined in 6.2.3.2.1 shall be used.

Start and end of communication are specified in ISO/IEC 14443-2.

6.2.3.3 Bit oriented anticollision frame

The PCD shall detect a collision that occurs when at least two PICCs simultaneously transmit bit patterns with one or more bit positions in which at least two PICCs transmit complementary values. In this case, the bit patterns merge and the carrier is modulated with the subcarrier for the whole (100%) bit duration (see ISO/IEC 14443-2:—, 8.2.5.1).

Bit oriented anticollision frames shall only be used during bit frame anticollision loops and are standard frames with a length of 7 bytes, split into the following two parts:

— part 1 for transmission from PCD to PICC;

— part 2 for transmission from PICC to PCD.

For the length of part 1 and part 2, the following rules shall apply:

— Rule 1: The sum of data bits shall be 56.

— Rule 2: The minimum length of part 1 shall be 16 data bits.

— Rule 3: The maximum length of part 1 shall be 48 data bits.

Consequently, the minimum length of part 2 shall be 8 data bit and the maximum length shall be 40 data bits.

Since the split can occur at any bit position within a byte, the following two cases are defined:

— case FULL BYTE: Split after a complete byte. A parity bit is added after the last data bit of part 1;

— case SPLIT BYTE: Split within a byte. No parity bit is added after the last data bit of part 1.

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The Block Check Characters (BCC) is calculated as exclusive-or over the four previous bytes.

The following examples for case FULL BYTE and case SPLIT BYTE define the bit organization and order of bit transmission, illustrated in Figure 5 and Figure 6.

NOTE These examples include proper values for NVB and BCC.

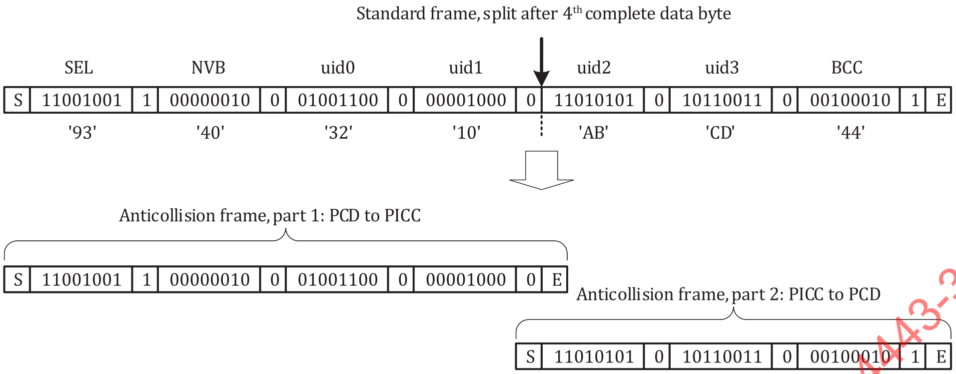

Figure 5 — Bit organization and transmission of bit oriented anticollision frame, case FULL BYTE

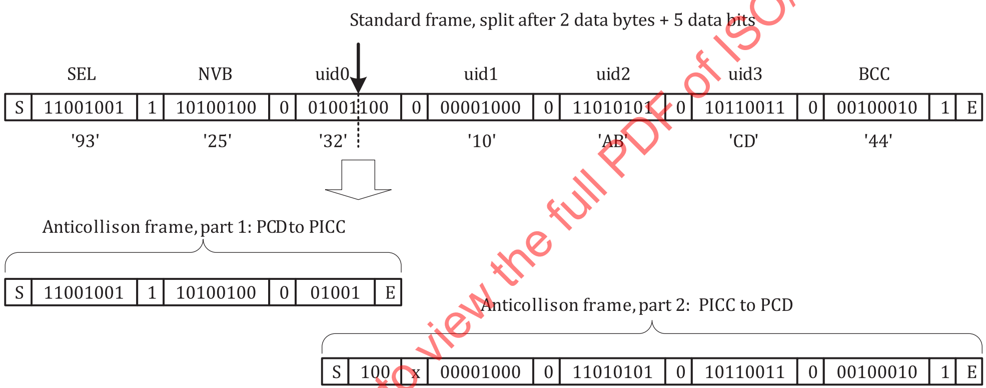

Figure 6 — Bit organization and transmission of bit oriented anticollision frame, case SPLIT BYTE

For a SPLIT BYTE, the PCD shall ignore the first parity bit of part 2.

6.2.4 CRC_A

A frame that includes CRC_A shall only be considered correct if it is received with a valid CRC_A value.

The frame CRC_A is a function of *k* data bits, which consist of all the data bits in the frame, excluding parity bits, S and E, and the CRC_A itself. Since data is encoded in bytes, the number of bits *k* is a multiple of 8.

For error checking, the two CRC_A bytes are sent in the standard frame, after the data bytes and before the E. The CRC_A shall be as defined in ISO/IEC 13239 but the initial register content shall be '6363' and the register content shall not be inverted after calculation.

For examples, refer to Annex B.

6.3 PICC states

The following subclauses provide descriptions of the states for a PICC Type A specific to the anticollision sequence.

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The state diagram in Figure 7 specifies all possible state transitions caused by commands of this part of ISO/IEC 14443. PICCs shall react to valid received frames only. No response shall be sent when transmission errors are detected except for PICCs in ACTIVE or ACTIVE* state.

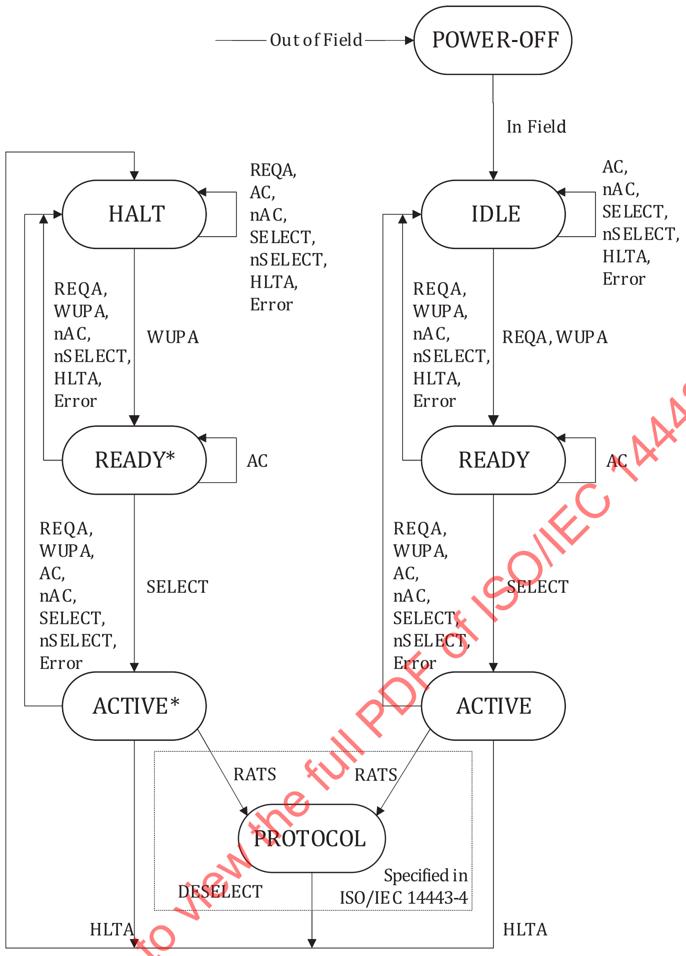

Figure 7 — PICC Type A state diagram

The following symbols apply for the state diagram shown in Figure 7:

AC: ANTICOLLISION command (matched UID)

nAC: ANTICOLLISION command (not matched UID)

SELECT: SELECT command (matched UID)

nSELECT: SELECT command (not matched UID)

RATS: RATS command, defined in ISO/IEC 14443-4

DESELECT: DESELECT command, defined in ISO/IEC 14443-4

Error: transmission error detected or unexpected Type A command

PICCs being compliant with ISO/IEC 14443-3 but not selected with RATS from ISO/IEC 14443-4 may leave ACTIVE or ACTIVE* state by proprietary commands.

6.3.1 POWER-OFF state

Description:

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In POWER-OFF state, the PICC is not powered by a PCD operating field.

State exit conditions and transitions:

If the PICC is in an energizing magnetic field greater than H_{min} (see ISO/IEC 14443-2), it shall enter its IDLE state within a delay not greater than defined in 6.2.

6.3.2 IDLE state

Description:

In IDLE state, the PICC is powered. It listens for commands and shall recognize REQA and WUPA commands.

State exit conditions and transitions:

The PICC enters READY state after it has received a valid REQA or WUPA command and transmitted its ATQA.

6.3.3 READY state

Description:

In READY state, the bit frame anticollision method shall be applied. Cascade levels are handled inside this state to get the complete UID.

State exit conditions and transitions:

The PICC enters ACTIVE state when it is selected with its complete UID.

6.3.4 ACTIVE state

Description:

If the PICC complies with ISO/IEC 14443-4 then the PICC shall be ready to accept the protocol activation command (RATS) as specified in ISO/IEC 14443-4. Otherwise, it may proceed with non ISO/IEC 14443-4 protocol.

State exit conditions and transitions:

The PICC enters HALT state when a valid HLTA command is received.

NOTE In the higher layer protocol, specific commands can be defined to return the PICC to its HALT state.

6.3.5 HALT state

Description:

In HALT state, the PICC shall respond only to a WUPA command.

State exit conditions and transitions:

The PICC enters READY* state after it has received a valid WUPA command and transmitted its ATQA.

6.3.6 READY* state

Description:

READY* state is similar to READY state. The differences are the transitions specified in Figure 7. The bit frame anticollision method shall be applied. Cascade levels are handled inside this state to get complete UID.

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State exit conditions and transitions:

The PICC enters ACTIVE* state when it is selected with its complete UID.

6.3.7 ACTIVE* state

Description:

ACTIVE* state is similar to ACTIVE state. The differences are the transitions specified in Figure 7. If the PICC complies with ISO/IEC 14443-4, then the PICC shall be ready to accept the protocol activation command (RATS) as specified in ISO/IEC 14443-4. Otherwise it may proceed with non ISO/IEC 14443-4 protocol.

State exit conditions and transitions:

The PICC enters HALT state when a valid HLTA command is received.

6.3.8 PROTOCOL state

Description:

In PROTOCOL state, the PICC behaves in accordance with ISO/IEC 14443-4.

6.4 Command set

The commands used by the PCD to manage communication with several PICCs are as follows:

— REQA;

— WUPA;

— ANTICOLLISION;

— SELECT;

— HLTA.

The commands use the byte and frame formats described above.

6.4.1 REQA and WUPA commands

The REQA and WUPA commands are sent by the PCD to probe the field for PICCs of Type A. They are transmitted within a short frame. See Figure 7 to check in which cases PICCs actually have to answer to these respective commands.

Particularly, the WUPA command is sent by the PCD to put PICCs which have entered HALT state back into READY* state. They shall then participate in further anticollision and selection procedures.

Table 3 shows the coding of REQA and WUPA commands which use the short frame format.

Table 3 — Coding of short frame

b7	b6	b5	b4	b3	b2	b1	Meaning
0	1	0	0	1	1	0	'26' = REQA
1	0	1	0	0	1	0	'52' = WUPA
0	1	1	0	1	0	1	'35' = Optional timeslot method; see Annex C
1	0	0	x	x	x	x	'40' to '4F' = Proprietary

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Table 3 *(continued)*

b7	b6	b5	b4	b3	b2	b1	Meaning
1	1	1	1	x	x	x	'78' to '7F' = Proprietary
all other values							RFU
"x" means a "don't care" value.							

A PICC receiving a short frame containing an RFU value shall interpret this as Error (see Figure 7) and shall not send a response.

6.4.2 ANTICOLLISION and SELECT commands

These commands are used during an anticollision loop (see Figures 5 and 6). The ANTICOLLISION and SELECT commands consist of the following:

— select code SEL (1 byte);

— number of valid bits NVB (1 byte, for coding see Table 8);

— 0 to 40 data bits of UID CL*n* according to the value of NVB.

NOTE The composition of UID CL*n* for the different UID sizes is shown in Figure 12.

SEL specifies the cascade level CL*n*.

The ANTICOLLISION command is transmitted within bit oriented anticollision frame.

The SELECT command is transmitted within standard frame.

As long as NVB does not specify 40 valid bits, the command is called ANTICOLLISION command, where the PICC remains in READY or READY* state.

If NVB specifies 40 data bits of UID CL*n* (NVB = '70'), a CRC_A shall be appended. This command is called SELECT command.

If the PICC has transmitted the complete UID, it transits from READY state to ACTIVE state or from READY* state to ACTIVE* state and indicates in its SAK response that UID is complete.

Otherwise, the PICC remains in READY or READY* state and the PCD shall initiate a new anticollision loop with increased cascade level.

6.4.3 HLTA command

The HLTA command consists of two bytes followed by CRC_A and shall be transmitted within a standard frame, defined in Figure 8.

S	´50´	´00´	CRC_A	E

Figure 8 — Standard frame containing HLTA command

When receiving a valid HLTA command in any state, the PICC shall not respond. The PCD shall not interpret any modulation received during a period of 1 ms after the end of the frame containing the HLTA command.

In ACTIVE or ACTIVE* states, the PICC may respond to an invalid HLTA command.

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6.5 Select sequence

The purpose of the select sequence is to get the UID from one PICC and to select this PICC for further communication.

6.5.1 Select sequence flowchart

The select sequence is specified in Figure 9.

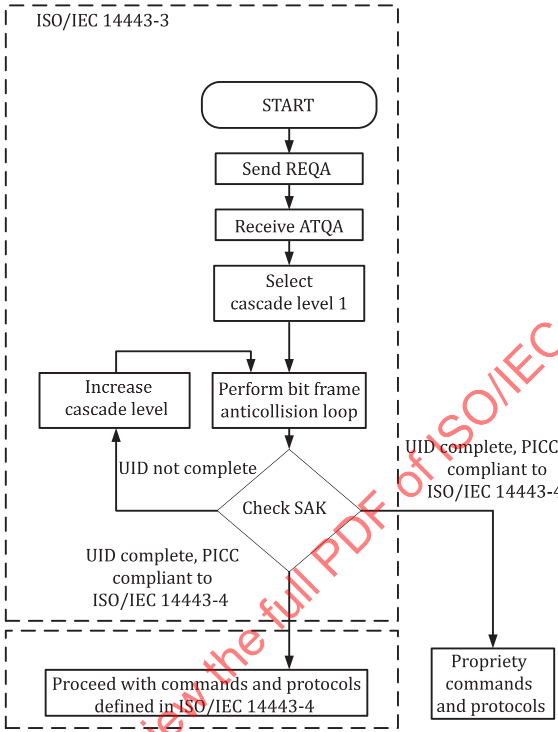

Figure 9 — Initialization and anticollision flowchart for PCD

The PICC may use ATQA bit combinations of b9 to b12 for indication of proprietary methods.

Type A PICCs that do not support the mandatory bit frame anticollision are not compliant with this document.

6.5.2 ATQA — Answer to Request

After a REQA command is transmitted by the PCD, all PICCs in IDLE state shall respond synchronously with ATQA.

After a WUPA command is transmitted by the PCD, all PICCs in IDLE or HALT state shall respond synchronously with ATQA.

The PCD shall detect any collision that may occur when multiple PICCs respond.

An example is given in Annex A.

6.5.2.1 Coding of ATQA

Table 4 specifies the coding of ATQA.

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Table 4 — Coding of ATQA

MSB															LSB
b16	**b15**	**b14**	**b13**	**b12**	**b11**	**b10**	**b9**	**b8**	**b7**	**b6**	**b5**	**b4**	**b3**	**b2**	**b1**
Each bit RFU				Proprietary coding				UID size		RFU	Bit frame anticollision				

The PICC shall send the byte consisting of (b1 to b8) first and then the byte consisting of (b9 to b16) in a PICC standard frame.

A PCD detecting a collision in any bit of (b16 to b1) shall commence with the first step of the anticollision loop (see 6.5.3.1). The PCD shall commence with the first step of the anticollision loop regardless of any value in the proprietary field b12 to b9.

6.5.2.2 Coding rules for bit frame anticollision

— Rule 1: b7 and b8 code the UID size (single, double or triple, see Table 5).

— Rule 2: Only one out of the five bits b1, b2, b3, b4 or b5 shall be set to (1)b to indicate bit frame anticollision (see Table 6).

Table 5 — UID size coding

b8	b7	Meaning
0	0	UID size: single
0	1	UID size: double
1	0	UID size: triple
1	1	RFU

Table 6 — Coding of b5 to b1 for bit frame anticollision

b5	b4	b3	b2	b1	Meaning
1	0	0	0	0	bit frame anticollision
0	1	0	0	0	bit frame anticollision
0	0	1	0	0	bit frame anticollision
0	0	0	1	0	bit frame anticollision
0	0	0	0	1	bit frame anticollision

6.5.3 Anticollision and Select

6.5.3.1 Anticollision loop within each cascade level

The following algorithm shall apply to the anticollision loop.

Step 1	The PCD shall assign SEL with the code for the selected anticollision cascade level.
Step 2	The PCD shall assign NVB with the value of '20'. NOTE 1 This value defines that the PCD will transmit no part of UID CL*n*. Consequently, this command forces all PICCs in the field to respond with their complete UID CL*n*.
Step 3	The PCD shall transmit SEL and NVB.
Step 4	All PICCs in the field shall respond with their complete UID CL*n*.
Step 5	If more than one PICC responds, a collision may occur. If no collision occurs, steps 6 to 10 shall be skipped.
Step 6	The PCD shall recognize the position of the first collision.

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Step 7	The PCD shall assign NVB with a value that specifies the number of valid bits of UID CL*n*. The valid bits shall be part of the UID CL*n* that was received before a collision occurred followed by a (0)b or (1)b, decided by the PCD. A typical implementation adds a (1)b.
Step 8	The PCD shall transmit SEL and NVB, followed by the valid bits.
Step 9	Only PICCs of which the part of UID CL*n* is equal to the valid bits transmitted by the PCD shall transmit their remaining bits of the UID CL*n*.
Step 10	If further collisions occur, steps 6 to 9 shall be repeated. The maximum number of loops is 32.
Step 11	If no further collision occurs, the PCD shall assign NVB with the value of '70'. NOTE 2 This value defines that the PCD will transmit the complete UID CL*n*.
Step 12	The PCD shall transmit SEL and NVB, followed by all 40 bits of UID CL*n*, followed by CRC_A.
Step 13	The PICCs which UID CL*n* matches the 40 bits shall respond with their SAK.
Step 14	If the UID is complete, the PICC shall transmit SAK with cleared cascade bit and shall transit from READY state to ACTIVE state or from READY* state to ACTIVE* state.
Step 15	The PCD shall check if the cascade bit of SAK is set to decide whether further anticollision loops with increased cascade level shall follow.

If the UID of a PICC is complete and known by the PCD, the PCD may skip step 2 to step 10 to select this PICC without performing the anticollision loop.

NOTE 3 Figure 10 explains steps 1 to 13.

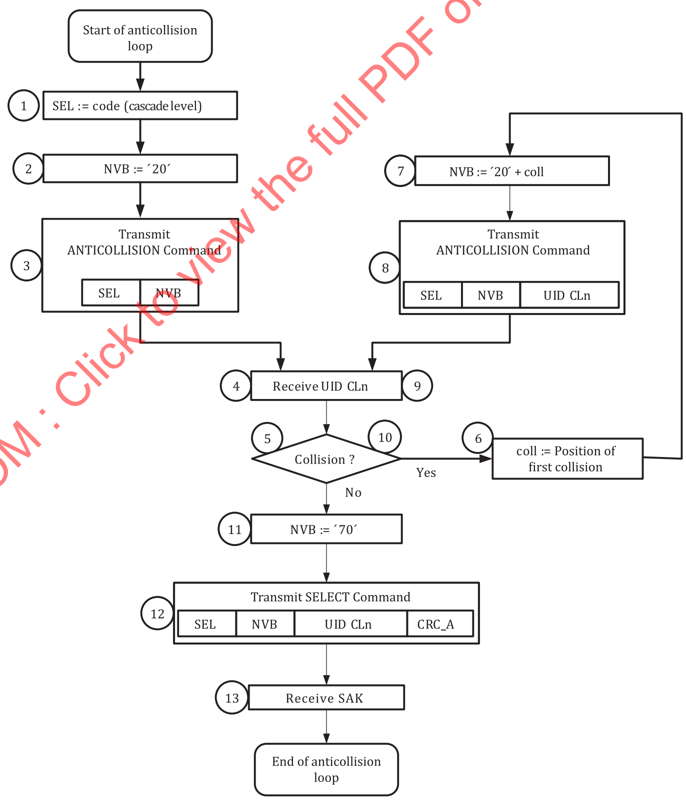

Figure 10 — Anticollision loop, flowchart for PCD

NOTE 4 The circled numbers correspond to the steps of the algorithm.

6.5.3.2 Coding of SEL (select code)

Table 7 specifies the coding of SEL.

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Table 7 — Coding of SEL

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
1	0	0	1	0	0	1	1	'93': Select cascade level 1
1	0	0	1	0	1	0	1	'95': Select cascade level 2
1	0	0	1	0	1	1	1	'97': Select cascade level 3
1	0	0	1	other values except those above				RFU

A PICC receiving an RFU value should interpret it as Error (see Figure 7) and should not send a response.

6.5.3.3 Coding of NVB (number of valid bits)

Length: 1 byte

The upper 4 bits are called “byte count” and specify the integer part of the number of all valid data bits transmitted by the PCD (including SEL and NVB) divided by 8. Consequently, the minimum value of “byte count” is 2 and the maximum value is 7.

The lower 4 bits are called “bit count” and specify the number of all valid data bits transmitted by the PCD (including SEL and NVB) modulo 8.

Table 8 — Coding of NVB

b8	b7	b6	b5	Meaning
0	0	1	0	byte count = 2
0	0	1	1	byte count = 3
0	1	0	0	byte count = 4
0	1	0	1	byte count = 5
0	1	1	0	byte count = 6
0	1	1	1	byte count = 7

b4	b3	b2	b1	Meaning
0	0	0	0	bit count = 0
0	0	0	1	bit count = 1
0	0	1	0	bit count = 2
0	0	1	1	bit count = 3
0	1	0	0	bit count = 4
0	1	0	1	bit count = 5
0	1	1	0	bit count = 6
0	1	1	1	bit count = 7

The PCD shall set NVB only to values defined in Table 8 except that for byte counts 6 and 7, only a bit count of 0 is allowed. A PICC receiving a byte count value not specified in Table 8 (b8 to b5), or receiving a bit count value not specified in Table 8 (b4 to b1) for byte count equal 2 to 5 or set to any value other than 0 for byte count equal 6 or 7, should interpret it as Error (see Figure 7) and should not send a response.

6.5.3.4 Coding of SAK (Select acknowledge)

SAK, as defined in Figure 11, is transmitted by the PICC when NVB has specified 40 valid data bits and when all these data bits match with UID CL*n*.

1st byte	2nd, 3rd bytes
SAK (1 byte)	**CRC_A** (2 bytes)

Figure 11 — Select acknowledge (SAK)

The coding of bits b3 (cascade bit), b6 and b7 is given in Table 9.

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Table 9 — Coding of SAK

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
x	x	x	x	x	1	x	x	Cascade bit set: UID not complete
x	x	1	x	x	0	x	x	UID complete, PICC compliant with ISO/IEC 14443-4
x	x	0	x	x	0	x	x	UID complete, PICC not compliant with ISO/IEC 14443-4
x	1	x	x	x	0	x	x	UID complete; see b7 coding in Table 2 of ISO/IEC 18092
x	0	x	x	x	0	x	x	UID complete; see b7 coding in Table 2 of ISO/IEC 18092
"x" means a "don't care" value.								

For b3 = (1)b, the PCD shall ignore any other bit of SAK. For b3 = (0)b, the supported transmission protocols are indicated as shown in Table 9 independently of any "don't care" value.

When setting b3 to (1)b, the PICC should set all other bits of SAK to (0)b.

6.5.4 UID contents and cascade levels

The UID consists of 4, 7 or 10 UID bytes. Consequently, the PICC shall handle up to 3 cascade levels to get all UID bytes. Within each cascade level, a part of UID shall be transmitted to the PCD. The relationship between the UID size (see Table 5), the numbers of UID bytes and cascade levels is given in Table 10.

Table 10 — UID size

UID size	Number of UID bytes	Cascade levels
single	4	1
double	7	2
triple	10	3

The UID is

— either a fixed unique number,

— a random number which is dynamically generated by the PICC (only allowed for single size UID), or

— a fixed non-unique number (only allowed for single size UID).

The first byte (uid0) of the UID assigns the content of the following bytes of the UID as defined in Table 11 and Table 12.

Table 11 — Single size UIDs

uid0	Description
'08'	uid1 to uid3 is a random number which is dynamically generated
'x0' - 'x7', 'x9' - 'xE', '18', '28', '38', '48', '58', '68', '78', '98', 'A8', 'B8', 'C8', 'D8', 'E8'	Proprietary number
'F8'	RFU
'xF'	Fixed number, non-unique

The PICC shall generate a random UID only on state transition from POWER-OFF state to IDLE state.

The PICC shall not use the value '88' of the cascade tag CT for uid0 in single size UID.

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Table 12 — Double and triple size UIDs

uid0	Description
Manufacturer ID in accordance with ISO/IEC 7816-6[a]	Each manufacturer is responsible for the uniqueness of the value of the other bytes of the unique number.

[a] The values '81' to 'FE', which are marked for "Proprietary" in ISO/IEC 7816-6 shall not be allowed in this context.

The value '88' of the cascade tag CT shall not be used for uid3 in double size UID.

Figure 12 defines the usage of cascade levels

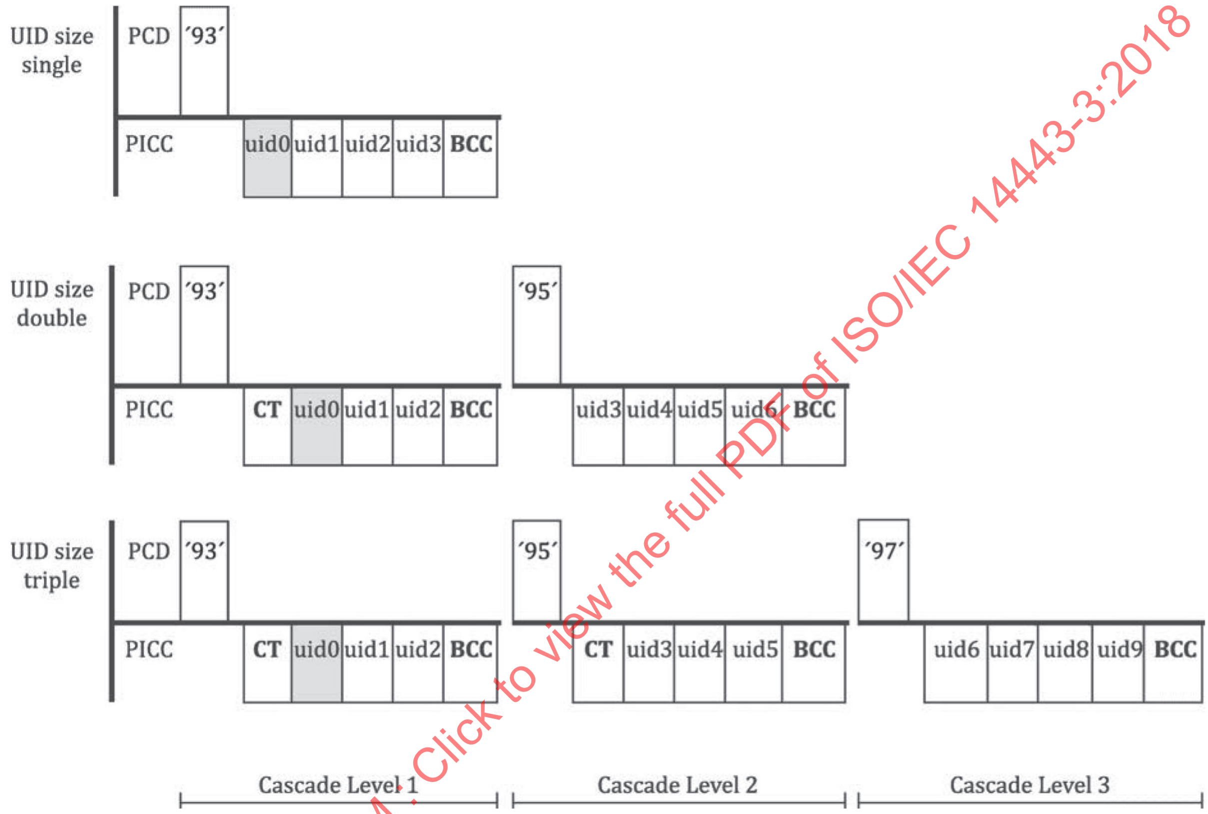

Figure 12 — Usage of cascade levels

NOTE The purpose of the cascade tag is to force a collision with PICCs that have a smaller UID size.

The following algorithm shall apply to the PCD to get the complete UID:

Step 1	The PCD selects cascade level 1.
Step 2	The anticollision loop shall be performed.
Step 3	The PCD shall check the cascade bit of SAK.
Step 4	If the cascade bit is set, the PCD shall increase the cascade level and initiate a new anticollision loop.

A PICC sending a proprietary number shall fulfil all other requirements of the anticollision sequence including CT.

During the anticollision, the PCD shall regard uid0 with RFU or proprietary values as a regular uid0.

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7 Type B — Initialization and anticollision

7.1 Character, frame format and timing

This subclause defines the character, frame format and timing used during communication initialization and anticollision for PICCs of Type B. For bit representation and coding, refer to ISO/IEC 14443-2.

etu is defined in 6.1.

7.1.1 Character transmission format

Bytes are transmitted and received between PICCs and a PCD by characters, the format of which during the anticollision sequence is as follows:

— 1 start bit at logic "0";

— 8 data bits transmitted, LSB first;

— 1 stop bit at logic "1".

The transmission of one byte is performed with a character requiring 10 etu as illustrated in Figure 13.

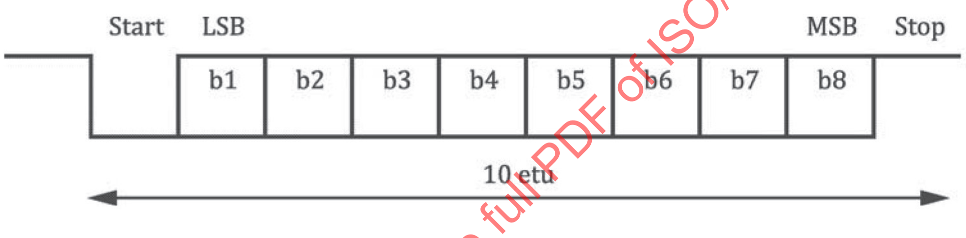

Figure 13 — Character transmission format

For PCD to PICC bit rates of 3*fc*/4, *fc*, 3*fc*/2 and 2*fc* the start and stop bits shall be omitted and no character separation shall be applied.

From PCD to PICC, bit boundaries within a character shall occur as defined in Table 13, where *n* is the number of bit boundaries after the start bit falling edge ($1 \leq n \leq 9$).

Table 13 — Bit boundaries from PCD to PICC

	PCD to PICC bit rate			
	fc/128	*fc*/64	*fc*/32	*fc*/16
Bit boundaries from PCD to PICC for the falling edge(s)	*n* etu ± 8/*fc*	*n* etu ± 1/*fc*	*n* etu ± 1/*fc*	*n* etu ± 1/*fc*
Bit boundaries from PCD to PICC for the rising edge(s)	*n* etu ± 8/*fc*	*n* etu ± 4/*fc*	*n* etu ± 2/*fc*	*n* etu ± 1/*fc*

For PCD to PICC bit rates of *fc*/8, *fc*/4 and *fc*/2, bit boundaries shall occur at nominal bit positions.

7.1.2 Character separation

7.1.2.1 Character separation for bit rates up to *fc*/16

A character may be separated from the next one by the extra guard time (EGT).

The EGT between two consecutive characters sent by the PCD to the PICC shall be between 0 and 5,875 etu (not necessarily an integer number of etu), as defined in Table 14.

The EGT between two consecutive characters sent by the PICC to the PCD shall be between 0 and 2 etu (not necessarily an integer number of etu), as defined in Table 15.

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Table 14 — EGT from PCD to PICC

EGT PCD to PICC			
PCD shall use EGT between		PICC shall accept EGT between	
Min	Max	Min	Max
0 etu	5,875 etu	0 etu	6 etu

Table 15 — EGT from PICC to PCD

EGT PICC to PCD			
PICC shall use EGT between		PCD shall accept EGT between	
Min	Max	Min	Max
0 etu	2 etu	0 etu	2,125 etu

An integer number of etu for EGT should be used for all bit rates. Non integer values may not be accepted in future revisions of this document.

7.1.2.2 Character separation for bit rates of *fc*/8, *fc*/4 and *fc*/2

No character separation shall be applied.

7.1.3 Frame format

PCDs and PICCs shall send characters as frames. The frame is delimited by SOF and by EOF, as defined in Figure 14, unless suppressed in accordance with 7.10.3.3.

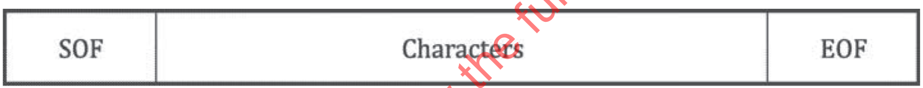

Figure 14 — Frame Format

For PCD to PICC bit rates of 3*fc*/4, *fc*, 3*fc*/2 and 2*fc* the PCD frame shall be delimited by start and end of communication as specified in ISO/IEC 14443-2.

7.1.4 SOF

SOF, as illustrated in Figure 15 and defined in Tables 16, 17 and 18, is composed of the following:

- one falling edge;
- followed by 10 to 11 etu with a logic "0" (SOF low);
- followed by one single rising edge;
- followed by 2 to 3 etu with a logic "1" (SOF high).

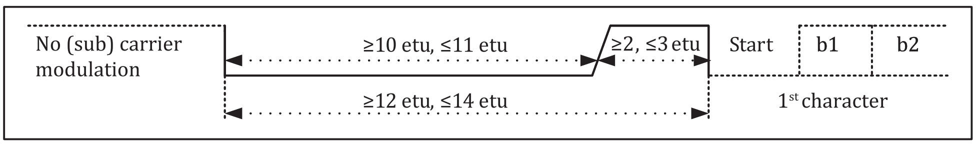

Figure 15 — SOF

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Table 16 — SOF of PCD transmission

	PCD shall use time between		PICC shall accept time between	
	Min	Max	Min	Max
PCD SOF low	10 etu	11 etu + 1/16 etu	10 etu – 1/16 etu	11 etu + 1/8 etu
PCD SOF high	2 etu – 1/16 etu	3 etu + 1/16 etu	2 etu – 1/8 etu	3 etu + 1/8 etu

Table 17 — SOF low of PICC transmission

Bit rate	PICC shall use SOF low time between		PCD shall accept SOF low time between	
	Min	Max	Min	Max
fc/128	10 etu – 0,5/*fs*	11 etu + 0,5/*fs*	10 etu – 1/*fs*	11 etu + 1/*fs*
fc/64	10 etu	11 etu	10 etu – 0,5/*fs*	11 etu + 0,5/*fs*
fc/32	10 etu	11 etu	10 etu	11 etu
>*fc*/32	10 etu	11 etu	10 etu	11 etu

Table 18 — SOF high of PICC transmission

Bit rate	PICC shall use SOF high time between		PCD shall accept SOF high time between	
	Min	Max	Min	Max
fc/128	2 etu – 0,5/*fs*	3 etu + 0,5/*fs*	2 etu – 1/*fs*	3 etu + 1/*fs*
fc/64	2 etu	3 etu	2 etu – 0,5/*fs*	3 etu + 0,5/*fs*
fc/32	2 etu	3 etu	2 etu	3 etu
>*fc*/32	2 etu	3 etu	2 etu	3 etu

NOTE All values in Tables 17 and 18 are in accordance with the phase shifts requirements of ISO/IEC 14443-2:—, 9.2.4.

For PCD to PICC bit rates of 3*fc*/4, *fc*, 3*fc*/2 and 2*fc* the start of communication is specified in ISO/IEC 14443-2.

7.1.5 EOF

EOF, as illustrated in Figure 16 and defined in Tables 19 and 20, is composed of the following:

— one falling edge;

— followed by 10 to 11 etu with a logic "0" (EOF low);

— followed by one single rising edge.

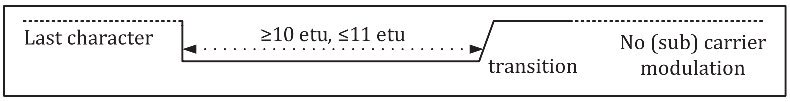

Figure 16 — EOF

Table 19 — EOF of PCD transmission

PCD shall use EOF time between		PICC shall accept EOF time between	
Min	Max	Min	Max
10 etu	11 etu + 1/16 etu	10 etu – 1/16 etu	11 etu + 1/8 etu

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Table 20 — EOF of PICC transmission

Bit rate	PICC shall use EOF time between		PCD shall accept EOF time between	
	Min	Max	Min	Max
$fc/128$	10 etu – 0,5/fs	11 etu + 0,5/fs	10 etu – 1/fs	11 etu + 1/fs
$fc/64$	10 etu	11 etu	10 etu – 0,5/fs	11 etu + 0,5/fs
$fc/32$	10 etu	11 etu	10 etu	11 etu
>$fc/32$	10 etu	11 etu	10 etu	11 etu

NOTE All values in Table 20 are in accordance with the phase shifts requirements of ISO/IEC 14443-2:—, 9.2.4.

For PCD to PICC bit rates of 3fc/4, fc, 3fc/2 and 2fc the end of communication is specified in ISO/IEC 14443-2.

7.1.6 Timing before the PICC SOF

PICC start of communication after a PCD data transmission shall respect the timing defined in Figure 17.

The default minimum values of TR0 and TR1 are defined in ISO/IEC 14443-2 and may be reduced by the PCD; see 7.10.3.

The maximum value of TR0 is as follows:

— 4 096/fc (~ 302 µs) for ATQB;

— 65 536/fc – TR1 for S(DESELECT) blocks (see ISO/IEC 14443-4:2018, 8.1), for S(PARAMETERS) blocks and for ATTRIB in case extended ATQB is supported by both the PICC and the PCD;

— (4 096/fc) × 2^{FWI} – TR1 for all other frames (see 7.9.4.3).

The maximum value of TR1 is 200/fs.

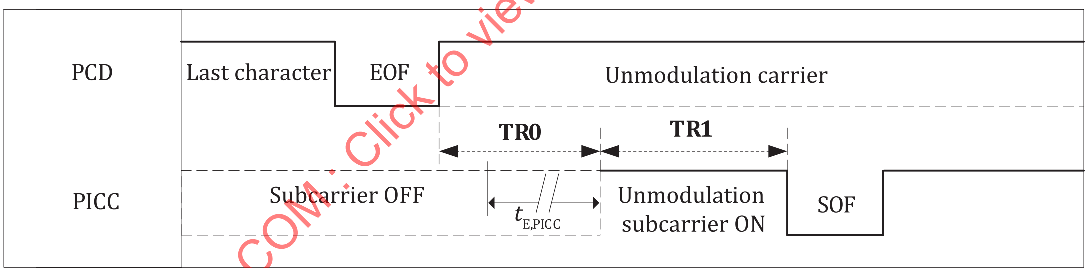

Figure 17 — Timing before the PICC SOF

NOTE $t_{E, PICC}$ is specified in Clause 8.

A PICC may turn on the subcarrier only if it intends to begin transmitting information.

The minimal and maximal values of TR0 and TR1 are applicable to PICCs. PCDs shall accept minimal and maximal values of TR0 with a margin of 16/fc and of TR1 with a margin of 1/fs.

7.1.7 Timing before the PCD SOF

PCD start of communication after a PICC data transmission and EOF shall respect the timing in Figure 18.

The PICC shall turn off its subcarrier after the transmission of the EOF and respect the timing in Table 21. The subcarrier signal shall

— not be stopped before the end of the EOF, and

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— be stopped no later than 2 etu after the end of the EOF.

NOTE If the subcarrier is turned off at the same time as the rising edge of the PICC EOF, then the stopping of the subcarrier represents the rising edge of the PICC EOF.

The minimum value of TR2 is coded in ATQB by Protocol_Type in “Protocol Info” field (see 7.9.4.4).

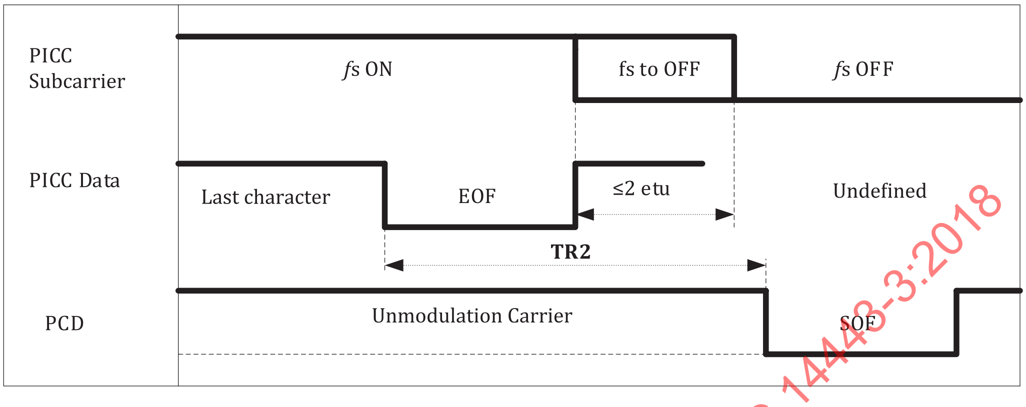

Figure 18 — Timing before the PCD SOF

Table 21 — Timing (*fs* to OFF) before PCD SOF

PICC shall use time between		PCD shall accept time between	
Min	**Max**	**Min**	**Max**
0 etu	2 etu	0 etu	2 etu + 1/*fs*

The minimal value of TR2 is applicable to PICCs. PCDs shall respect minimal value of TR2 with a margin of 100/*fc*.

For bit rates of 3*fc*/4, *fc*, 3*fc*/2 and 2*fc*, this is the time between the end of the last character transmitted by the PICC and the beginning of the first phase modulation transmitted by the PCD.

7.2 CRC_B

A frame shall only be considered correct if it is received with a valid CRC_B value.

The frame CRC_B is a function of *k* data bits, which consist of all the data bits in the frame, excluding start bits, stop bits, delays between bytes, SOF and EOF, and the CRC_B itself. Since data is encoded in bytes, the number of bits *k* is a multiple of 8.

For error checking, the two CRC_B bytes are included in the frame, after the data bits and before the EOF. The CRC_B shall be as defined in ISO/IEC 13239. The initial register content shall be all ones: 'FFFF'.

For examples, refer to Annex B.

7.3 Anticollision sequence

An anticollision sequence is managed by the PCD through a set of commands detailed in this subclause.

The PCD is the master of the communication with one or more PICCs. It initiates PICC communication activity by issuing a REQB/WUPB command to prompt for PICCs to respond.

During the anticollision sequence, it may happen that two or more PICCs respond simultaneously: this is a collision. The command set allows the PCD to handle sequences to separate PICC transmissions in time. The PCD may repeat its anticollision procedure until it finds all PICCs in the operating volume.

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Having completed the anticollision sequence, PICC communication will be under control of the PCD, allowing only one PICC to talk at a time.

The anticollision scheme is based on definition of slots in which PICCs are invited to answer with minimum identification data. The number of slots is parameterized in the REQB/WUPB and can vary from one to some integer number. PICC response probability in each slot is also controllable. PICCs are allowed to answer only once in the anticollision sequence.

Consequently, even in case of multiple PICCs present in the PCD field, there will probably be a slot in which only one PICC answers and where the PCD is able to capture the identification data. Based on the identification data, the PCD is able to establish a communication channel with the identified PICC.

An anticollision sequence allows selection of one or more PICCs for further communication at any time.

7.4 PICC states description

Different states and transition conditions between states describe the PICC detailed behavior during the anticollision sequence.

The following symbols apply for Figures 19 and 20.

REQB(AFI/nAFI, N, R)/WUPB(AFI/nAFI, N, R)	REQB/WUPB commands with matched/unmatched AFI
AFI	matched AFI
nAFI	unmatched AFI
Slot-MARKER	Slot-MARKER command with matched slot number
nSlot-MARKER	Slot-MARKER command with unmatched slot number
HLTB(PUPI)	HLTB command with matched PUPI
HLTB(nPUPI)	HLTB command with unmatched PUPI
ATTRIB(PUPI)	ATTRIB command with matched PUPI
ATTRIB(nPUPI)	ATTRIB command with unmatched PUPI
Error	transmission error detected or unexpected Type B command

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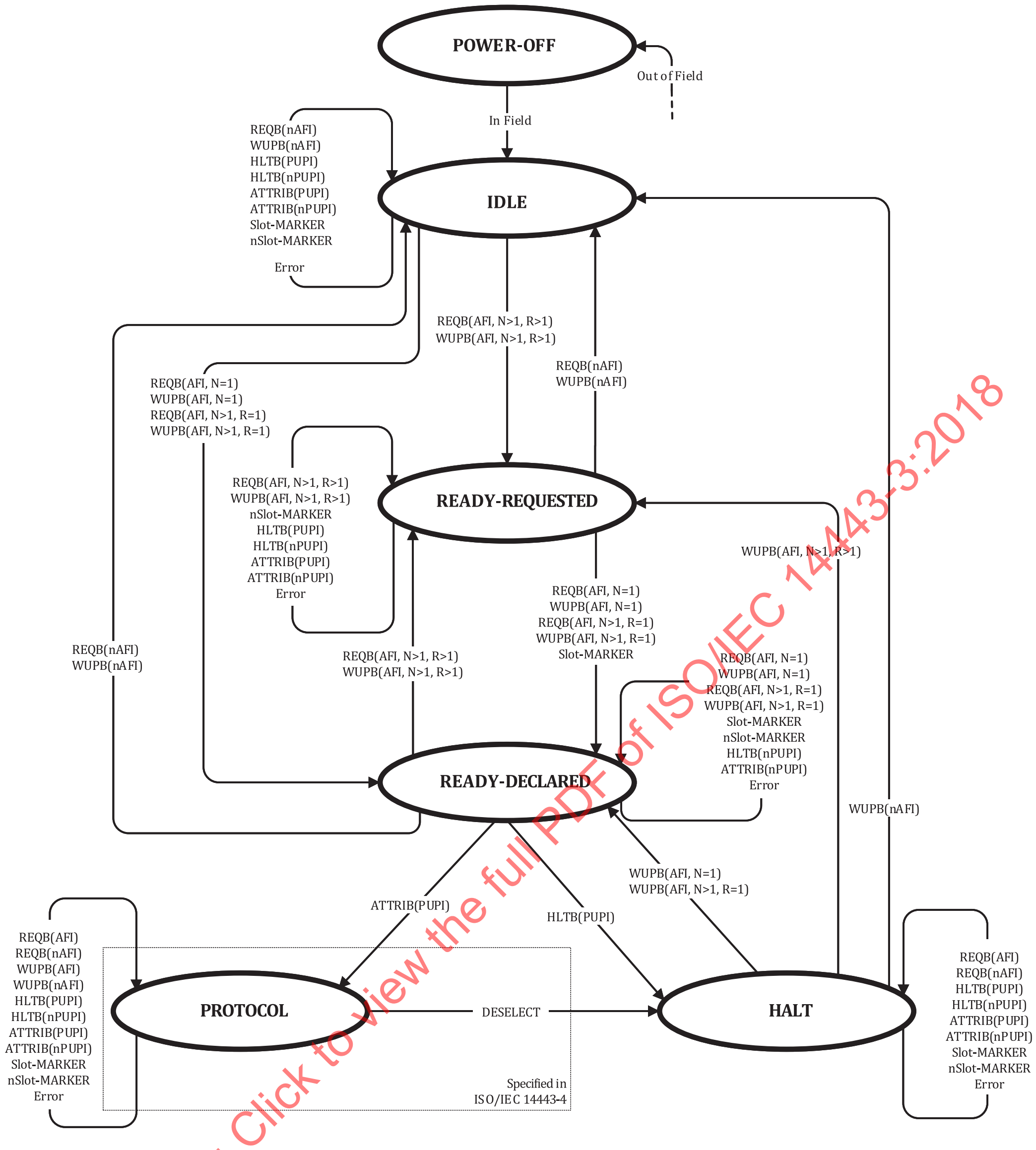

Figure 19 — PICC Type B state diagram

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7.4.1 Initialization and anticollision flowchart

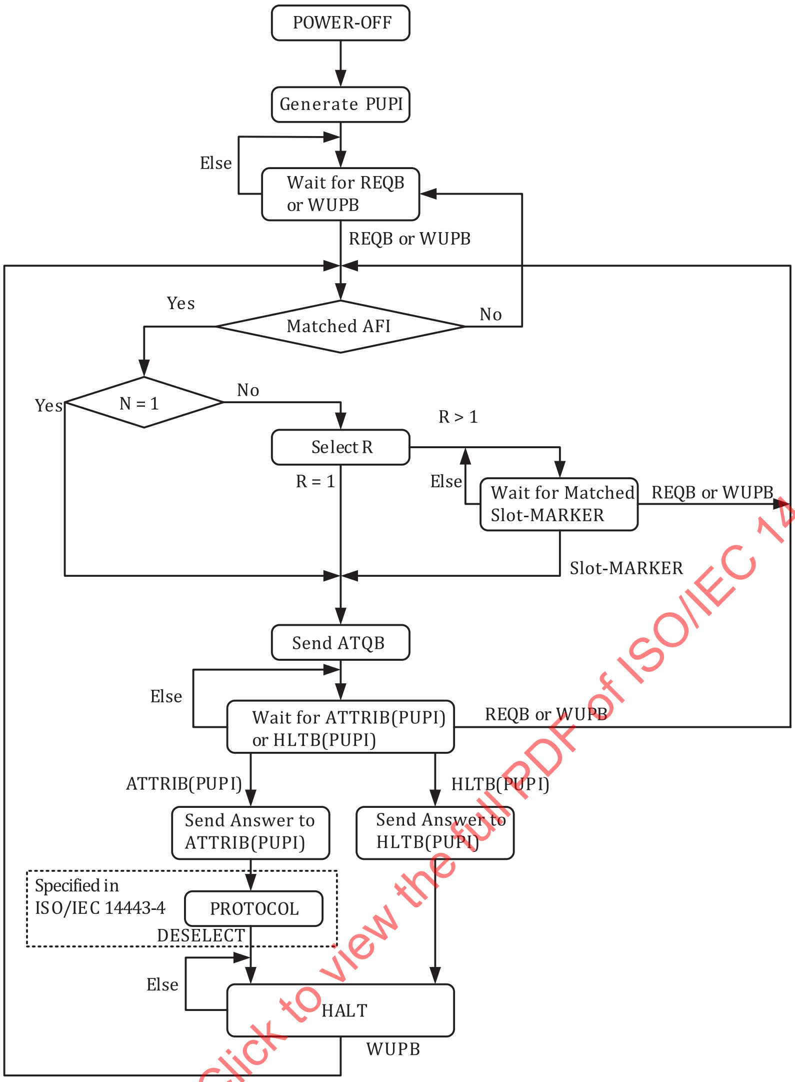

Figure 20 — PICC initialization and anticollision flowchart

NOTE R is a random number chosen by the PICC in the range from 1 to N (for coding of N, see 7.7.4).

7.4.2 General statement for state description and transitions

To any state, the following shall apply:

— the PICC shall return to POWER-OFF state if the RF field disappears.

To any state specific to the anticollision sequence (except PROTOCOL state), the following shall apply:

— default communication parameters as defined in ISO/IEC 14443-2 and in the previous sections shall be used;

— the PICC shall not emit subcarrier except to transmit response frames as specified in the previous sections;

— if a frame from the PCD is valid (correct CRC_B), the PICC shall perform the required action and/or response depending on its state;

— as in anticollision commands the first three bits of the data in a frame are (101)b (three first bits of anticollision Prefix byte) the PICC shall not answer to any command frame not starting with (101)b;

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— the PICC shall only react to valid frames received (no response sent when transmission errors are detected).

7.4.3 POWER-OFF state

Description:

In POWER-OFF state, the PICC is not be powered by a PCD operating field.

State exit conditions and transitions:

If the PICC is in an energizing magnetic field greater than $H_{\min}$ (see ISO/IEC 14443-2), it shall enter its IDLE state within a delay not greater than defined in 5.2.

7.4.4 IDLE state

Description:

In IDLE state, the PICC is powered. It listens for frames and shall recognize REQB and WUPB commands.

State exit conditions and transitions:

On reception of a valid REQB or WUPB command frame, the PICC shall enter READY-REQUESTED or READY-DECLARED sub-state, depending on values of N and if necessary R, as defined in 7.6. (Valid REQB/WUPB means a valid frame with REQB/WUPB command and a matched AFI. See REQB/WUPB command specification for more details.)

7.4.5 READY-REQUESTED sub-state

Description:

In READY-REQUESTED sub-state, the PICC is powered and has received a valid REQB or WUPB command with a control parameter N (not equal to 1). The PICC has a random number R (not equal to 1) which is used to control its subsequent operation as described in 7.6. It listens for frames and shall recognize REQB, WUPB and Slot-MARKER commands.

State exit conditions and transitions:

See 7.6 for details.

Specific remark:

In this state, the ATQB has not yet been sent.

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7.4.6 READY-DECLARED sub-state

Description:

In READY-DECLARED sub-state, the PICC is powered and has sent its ATQB corresponding to the last valid REQB/WUPB/Slot-MARKER command received. It listens for frames and shall recognize REQB/WUPB, ATTRIB and HLTB commands.

State exit conditions and transitions:

On reception of a valid ATTRIB command, the PICC shall enter PROTOCOL state if the PUPI in the ATTRIB command matches the PICC PUPI.

If the PUPI in the ATTRIB command does not match the PICC PUPI, the PICC shall remain in READY-DECLARED sub-state.

On reception of a valid REQB/WUPB command frame, the same conditions and transitions shall apply as on reception of a valid REQB/WUPB command frame in IDLE state.

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On reception of a matched HLTB command, the PICC shall enter HALT state.

7.4.7 PROTOCOL state

Description:

In PROTOCOL state, the PICC is powered and has sent its answer to ATTRIB command.

If the PICC was selected for the ISO/IEC 14443-4 protocol with the ATTRIB command, then the PICC shall operate in accordance with ISO/IEC 14443-4. Otherwise it may proceed with non ISO/IEC 14443-4 protocol.

Specific remarks:

Valid REQB/WUPB or Slot-MARKER frames shall not be answered.

A valid frame with an ATTRIB command shall not be answered.

In the higher layer protocol, specific commands may be defined to return the PICC to other states (IDLE or HALT). The PICC may return to these states only following reception of such commands.

7.4.8 HALT state

Description:

In HALT state, the PICC is powered. It listens for frames and shall recognize WUPB commands.

The PUPI shall not change (see 7.9.2) when entering or leaving HALT state.

State exit conditions and transitions:

On reception of a valid WUPB command, the PICC shall enter READY-REQUESTED or READY-DECLARED sub-state, depending on values of N and if necessary R, as defined in 7.6. (Valid REQB/WUPB means a valid frame with REQB/WUPB command and a matched AFI. See REQB/WUPB command specification for more details.) If the AFI does not match, then the PICC moves to IDLE state.

7.5 Command set

The following four primitive commands are used to manage multi-node communication channels:

— REQB/WUPB;

— Slot-MARKER;

— ATTRIB;

— HLTB.

All four commands use the character, frame format and timing detailed in 7.1.

The commands and the responses of the PICC to these commands are described in the following sections. Any frame received with a wrong format (wrong frame identifiers or invalid CRC_B) shall be ignored.

7.6 Anticollision response rules

A PICC which is in IDLE state or READY-REQUESTED sub-state or READY-DECLARED sub-state and receives a valid REQB/WUPB command (AFI = '00' or AFI matched with an internal application), or which is in HALT state and receives a valid WUPB command (AFI = '00' or AFI matched with an internal

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application), shall respond according to the following rules, where the parameter N has been given in the REQB/WUPB command:

— if N = 1, the PICC shall send an ATQB and shall move to READY-DECLARED sub-state;

— if N > 1, the PICC shall internally generate a random number R which shall be evenly distributed between 1 and N;

  — if R = 1, the PICC shall send an ATQB and shall move to READY-DECLARED sub-state;

  — if R > 1, the PICC shall wait until it has received a Slot-MARKER command with a matched slot number (slot number = R) before sending the ATQB and moving to READY-DECLARED sub-state.

The PICC shall not respond to a REQB/WUPB command with AFI different to ‘00’ and not matching any of its applications.

NOTE AFI with RFU values do not match.

Figure 19 illustrates the various state transitions.

7.6.1 PICC with initialization only

If anticollision resolution is not required (e.g. only one PICC is expected in the PCD field), it is not mandatory for a PICC to support either the REQB/WUPB command with N > 1 or the Slot-MARKER command. It is not mandatory for PCDs, especially those not using REQB/WUPB with N = 1, or in multiple PICC situations, to support such PICCs. These Type B PICCs shall comply with all other relevant clauses of this document.

7.7 REQB/WUPB command

The REQB and WUPB commands sent by the PCD are used to probe the field for PICCs of Type B. In addition, WUPB is particularly used to also wake up PICCs which are in HALT state.

The number of slots N is included in the command as a parameter to optimize the anticollision algorithm for a given application. See Figures 19 and 20 for detailed description of when the PICC shall respond to these respective commands.

7.7.1 REQB/WUPB command format

REQB/WUPB command has the format defined in Figure 21.

1st byte	2nd byte	3rd byte	4th, 5th bytes
APf (1 byte)	AFI (1 byte)	PARAM (1 byte)	CRC_B (2 bytes)

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Figure 21 — REQB/WUPB command format

7.7.2 Coding of anticollision prefix byte APf

The anticollision prefix byte is APf = '05' = (0000 0101)b.

7.7.3 Coding of AFI

Application Family Identifier (AFI) represents the type of application targeted by the PCD and is used to preselect PICCs before the ATQB.

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The most significant half byte of AFI is used to code one specific or all application families, as defined in Table 22. The least significant half byte of AFI is used to code one specific or all application sub-families. Sub-family codes different from 0 are proprietary unless defined in Table 22.

Table 22 — AFI coding

AFI most significant half byte	AFI least significant half byte	Meaning – PICCs respond from	Examples/Note
'0'	'0'	All families and sub-families	No application preselection
X	'0'	All sub-families of family X	Wide application preselection
X	Y	Only the Yth sub-family of family X	
'0'	Y	Proprietary sub-family Y only	
'1'	'0', Y	Transport	Mass transit, bus, airline, etc.
'2'	'0', Y	Financial	IEP, banking, retail, etc.
'3'	'0', Y	Identification	Access control, etc.
'4'	'0', Y	Telecommunication	Public telephony, GSM, etc.
'5'	'0', Y	Medical	
'6'	'0', Y	Multimedia	Internet services, etc.
'7'	'0', Y	Gaming	
'8'	'0', Y	Data Storage	Portable files, etc.
'9' - 'D'	'0', Y	RFU	
'E'	'0', Y = 1, Y = 2, Other Y values are RFU	Machine Readable Travel Documents (MRTDs)	Y = 1 ePassport Y = 2 eVisa
'F'	'0', Y	RFU	

NOTE X = '1' to 'F', Y = '1' to 'F'

7.7.4 Coding of PARAM

The coding of PARAM is defined in Figure 22.

b8	b7	b6	b5	b4	b3	b2	b1
Each bit RFU			Extended ATQB supported	REQB / WUPB	N		

Figure 22 — Coding of PARAM

b4 = (0)b defines REQB: PICCs in IDLE state or READY state shall process this command.

b4 = (1)b defines WUPB: PICCs in IDLE state or READY state or HALT state shall process this command.

b1, b2 and b3 are used to code N in accordance with Table 23.

b5 indicates the PCD capability to support extended ATQB response from the PICC. The use of extended ATQB is optional for the PICC. The coding of b5 is as follows:

— b5 = (0)b defines: extended ATQB defined in 7.9.4.7 is not supported by the PCD;

— b5 = (1)b defines: extended ATQB defined in 7.9.4.7 is supported by the PCD.

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Table 23 — Coding of N

b3	b2	b1	N
0	0	0	$1 = 2^0$
0	0	1	$2 = 2^1$
0	1	0	$4 = 2^2$
0	1	1	$8 = 2^3$
1	0	0	$16 = 2^4$
1	0	1	RFU
1	1	x	RFU

Until the RFU values (101)b or (11x)b are assigned, a PICC receiving (b3 to b1) = (101)b or (11x)b shall interpret it as (b3 to b1) = (100)b (16 slots).

NOTE For each PICC, the probability of response (ATQB) in the first slot is 1/N.

7.8 Slot-MARKER command

After a REQB/WUPB command, the PCD may send up to (N – 1) Slot-MARKER commands to define the start of each slot.

Slot-MARKER commands may be sent

— after the end of an ATQB message received by the PCD, or

— earlier if no ATQB is received.

7.8.1 Slot-MARKER command format

Slot-MARKER command has the format defined in Figure 23.

1st byte	2nd, 3rd bytes
APn (1 byte)	**CRC_B** (2 bytes)

Figure 23 — Slot-MARKER command format

7.8.2 Coding of anticollision prefix byte APn

APn = (xxxx0101)b where n = (xxxx)b codes the slot number as defined in Table 24.

Table 24 — Coding of slot number

n	Slot number
(0000)b	2
(0001)b	3
(0011)b	4

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Table 24 *(continued)*

n	Slot number
....	....
(1110)b	15
(1111)b	16

NOTE It is not mandatory that the Slot-MARKER commands are sent sequentially with incremental slot numbers.

7.9 ATQB Response

The response to both REQB/WUPB and Slot-MARKER commands is named ATQB.

7.9.1 ATQB response format

ATQB response has one of the two formats defined in Figure 24.

Basic ATQB format:

1st byte	2nd, 3rd, 4th, 5th bytes	6th, 7th, 8th, 9th bytes	10th, 11th, 12th bytes	13th, 14th bytes
'50' (1 byte)	PUPI (4 bytes)	Application Data (4 bytes)	Protocol Info (3 bytes)	CRC_B (2 bytes)

Extended ATQB format:

1st byte	2nd, 3rd, 4th, 5th bytes	6th, 7th, 8th, 9th bytes	10th, 11th, 12th, 13th bytes	14th, 15th bytes
'50' (1 byte)	PUPI (4 bytes)	Application Data (4 bytes)	Protocol Info (4 bytes)	CRC_B (2 bytes)

Figure 24 — ATQB response formats

The PICC shall send the basic ATQB format if the extended ATQB is not supported by the PCD (see 7.7.4).

The PICC may send the extended ATQB format if the extended ATQB is supported by the PCD (see 7.7.4).

7.9.2 Pseudo-Unique PICC Identifier (PUPI)

A Pseudo-Unique PICC Identifier (PUPI) is used to differentiate PICCs during anticollision. This four-byte number may be either a number dynamically generated by the PICC or a diversified fixed number. The PUPI shall only be generated by a state transition from POWER-OFF to IDLE state.

7.9.3 Application data

The Application data field is used to inform the PCD which applications are currently installed in the PICC. This information allows the PCD to select the desired PICC in the presence of more than one PICC.

The Application data is defined dependent upon the ADC (Application Data Coding) field in the Protocol Info field (see 7.9.4), which defines if either the CRC_B compressing method described below or proprietary coding is used.

When the CRC_B compressing coding is used, Application data field contents is defined in Figure 25.

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1st byte	2nd, 3rd bytes	4th byte
AFI (1 byte)	CRC_B (AID) (2 bytes)	Number of Applications (1 byte)

Figure 25 — Application data format

NOTE The two bytes of CRC_B (AID) are sent in the same order as other CRC_B.

7.9.3.1 AFI

For mono application PICCs AFI gives the family of the application (see AFI coding in Table 22).

For multi application PICCs AFI gives the family of the application described in CRC_B (AID).

7.9.3.2 CRC_B(AID)

CRC_B(AID) is the result of calculation of CRC_B of the AID, as specified in ISO/IEC 7816-4 of an application in the PICC matching the AFI given in the REQB/WUPB command.

7.9.3.3 Number of applications

The number of applications field specifies how many applications reside in the PICC.

The most significant half byte value gives the number of applications corresponding to the AFI given in application data with '0' meaning no application and 'F' meaning 15 applications or more.

The least significant half byte value gives the total number of applications in the PICC with '0' meaning no application and 'F' meaning 15 applications or more.

7.9.4 Protocol Info

The Protocol Info field indicates the parameters supported by the PICC. It is formatted as specified in Figure 26.

1st byte	2nd byte		3rd byte			4th byte (optional) Extended ATQB	
Bit_Rate_capability (8 bits)	Max_Frame_Size (4 bits)	Protocol_Type (4 bits)	FWI (4 bits)	ADC (2 bits)	FO (2 bits)	SFGI (4 bits)	RFU (4 bits)

Figure 26 — Protocol Info format

7.9.4.1 FO

The Frame Option supported by the PICC is defined in Table 25.

Table 25 — Frame Option supported by the PICC

b2	b1	Meaning
1	x	NAD supported by the PICC
x	1	CID supported by the PICC

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7.9.4.2 ADC

ADC consists of the two bits b3 and b4. b4 is RFU.

b3 = (0)b means Application Data Coding is proprietary.

b3 = (1)b means Application Data Coding is as described in 7.9.3.

7.9.4.3 FWI

Frame Waiting time Integer (4 bits) is coded with b8 to b5:

FWI codes an integer value used to define the FWT.

The FWT defines the maximum time for a PICC to start its response after the end of a PCD frame.

FWT is calculated by Formula (1):

$$FWT = (256 \times 16/fc) \times 2^{FWI} \quad (1)$$

where the value of FWI has the range from 0 to 14 and the value of 15 is RFU.

For FWI = 0, FWT is minimal (~ 302 µs).

For FWI = 14, FWT is maximal (~ 4 949 ms).

Until the RFU value 15 is assigned, a PCD receiving FWI = 15 shall interpret it as FWI = 4.

NOTE This requirement is added for PCD's compatibility with future PICCs when ISO/IEC further defines the behavior for an RFU value of 15.

7.9.4.4 Protocol_Type

The protocol type supported by the PICC is defined by Protocol_Type bit b1, as specified in Table 26.

Table 26 — Protocol type coding

b1	Meaning
1	PICC compliant with ISO/IEC 14443-4
0	PICC not compliant with ISO/IEC 14443-4

The minimum value of TR2 (delay between PICC EOF start and PCD SOF start) is defined by Protocol_Type bits (b3, b2), as specified in Table 27.

Table 27 — Minimum TR2 coding

b3	b2	Minimum TR2
0	0	10 etu + 512/*fc*
0	1	10 etu + 2 048/*fc*
1	0	10 etu + 4 096/*fc*
1	1	10 etu + 8 192/*fc*

b4 is RFU.

The PCD shall not continue communicating with a PICC that sets b4 to (1)b.

7.9.4.5 Max_Frame_Size

Table 28 defines the maximum frame size.

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Table 28 — Maximum frame size

Maximum Frame Size Code in ATQB	'0'	'1'	'2'	'3'	'4'	'5'	'6'	'7'	'8'	'9'	'A'	'B'	'C'	'D' – 'F'
Maximum frame size (bytes)	16	24	32	40	48	64	96	128	256	512	1 024	2 048	4 096	RFU

Until the RFU values 'D' - 'F' are assigned, a PCD receiving Maximum Frame Size Code = 'D' - 'F' shall interpret it as Maximum Frame Size Code = 'C' (maximum frame size 4 096 bytes).

NOTE This PCD requirement is added for PCD's compatibility with future PICCs when ISO/IEC further defines the behavior for the RFU values of 'D' - 'F'.

7.9.4.6 Bit_Rate_capability

Table 29 defines the bit rates supported by the PICC up to $fc/16$.

Table 29 — Bit rates supported by the PICC

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
0	0	0	0	0	0	0	0	PICC supports only $fc/128$ (~ 106 kbit/s) in both directions
1	x	x	x	0	x	x	x	Same bit rate from PCD to PICC and from PICC to PCD compulsory
x	x	x	1	0	x	x	x	PICC to PCD, 1 etu = $64/fc$, bit rate supported is $fc/64$ (~ 212 kbit/s)
x	x	1	x	0	x	x	x	PICC to PCD, 1 etu = $32/fc$, bit rate supported is $fc/32$ (~ 424 kbit/s)
x	1	x	x	0	x	x	x	PICC to PCD, 1 etu = $16/fc$, bit rate supported is $fc/16$ (~ 848 kbit/s)
x	x	x	x	0	x	x	1	PCD to PICC, 1 etu = $64/fc$, bit rate supported is $fc/64$ (~ 212 kbit/s)
x	x	x	x	0	x	1	x	PCD to PICC, 1 etu = $32/fc$, bit rate supported is $fc/32$ (~ 424 kbit/s)
x	x	x	x	0	1	x	x	PCD to PICC, 1 etu = $16/fc$, bit rate supported is $fc/16$ (~ 848 kbit/s)
Other values (with b4 = (1)b) are RFU.								

Until the RFU values with b4 = (1)b are assigned, a PCD receiving Bit_Rate_capability with b4 = (1)b shall interpret the Bit_Rate_capability byte as if (b8 to b1) = (00000000)b (only $fc/128$ in both directions).

S(PARAMETERS), as defined in ISO/IEC 14443-4, is the only way to negotiate bit rates higher than $fc/16$ and may also be used to negotiate any specified bit rate.

7.9.4.7 Extended ATQB (optional)

The optional Extended ATQB byte (optional 4th byte of Protocol Info field) consists of two parts:

— the least significant half byte (b4 to b1) is RFU;

— the most significant half byte (b8 to b5) defines the Start-up Frame Guard time Integer (SFGI).

The SFGI codes an integer value used to define the Start-up Frame Guard Time (SFGT).

The SFGT defines a specific guard time replacing TR2 which is needed by the PICC before it is ready to receive the next frame after it has sent the Answer to ATTRIB command. SFGI is coded in the range from 0 to 14. The value of 15 is RFU. The values in the range from 0 to 14 are used to calculate the SFGT with Formula (3). The default value of SFGI is 0.

$$SFGT = (256 \times 16/fc) \times 2^{SFGI} \quad (2)$$

For SFGI = 0, SFGT is minimal (~ 302 µs).

For SFGI = 14, SFGT is maximal (~ 4 949 ms).

Until the RFU value 15 is assigned, a PCD receiving SFGI = 15 shall interpret it as SFGI = 0.

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The PCD shall ignore (b4 to b1) and its interpretation of any other field of the whole frame shall not change.

When answering a REQB/WUPB command with bit b5 set to (0)b (no extended ATQB supported), the PICC shall not send the optional 4th byte in its ATQB response.

7.10 ATTRIB command

The ATTRIB command sent by the PCD shall include information required to select a single PICC.

A PICC receiving an ATTRIB command with its identifier becomes selected and assigned to a dedicated channel. After being selected, this PICC shall only respond to commands defined in the higher layer protocol which include its unique CID.

The parameters selected in the ATTRIB command shall apply after the Answer to ATTRIB.

7.10.1 ATTRIB command format

The ATTRIB command format is defined in Figure 27.

1st byte	2nd, 3rd, 4th 5th, bytes	6th byte	7th byte	8th byte	9th byte	10th ....bytes	
´1D´ (1 byte)	Identifier (4 bytes)	Param 1 (1 byte)	Param 2 (1 byte)	Param 3 (1 byte)	Param 4 (1 byte)	Higher layer INF (optional – 0 or more bytes)	CRC_B (2 bytes)

Figure 27 — ATTRIB command format

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7.10.2 Identifier

This identifier is the value of the PUPI sent by the PICC in the ATQB.

7.10.3 Coding of Param 1

Figure 28 defines the Coding of Param 1.

b8	b7	b6	b5	b4	b3	b2	b1
Minimum TR0		Minimum TR1		EOF	SOF	Each bit RFU	

Figure 28 — Coding of Param 1

7.10.3.1 Minimum TR0

The minimum TR0 coding is defined in Table 30. It indicates to the PICC the minimum delay before responding after the end of a command sent by a PCD. The default value has been defined in ISO/IEC 14443-2:—, 9.2.5.

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Table 30 — Minimum TR0 coding

b8	b7	Minimum TR0 for a PCD to PICC bit rate of	
		fc/128	>*fc*/128
0	0	1 024/*fc*	1 024/*fc*
0	1	768/*fc*	512/*fc*
1	0	256/*fc*	256/*fc*
1	1	RFU	RFU

NOTE Minimum TR1 is required by the PCD for synchronization with the PICC and its value depends on the PCD performance.

Until the RFU value (11)b is assigned, a PICC receiving (b8,b7) = (11)b shall interpret it as (b8,b7) = (00) b, the default value.

7.10.3.2 Minimum TR1

The minimum TR1 coding is defined in Table 31. It indicates to the PICC the minimum delay between subcarrier modulation start and beginning of data transmission. The default value has been defined in ISO/IEC 14443-2:—, 9.2.5.

Table 31 — Minimum TR1 coding

b6	b5	Minimum TR1 for a PICC to PCD bit rate of	
		fc/128	> *fc*/128
0	0	80/*fs*	80/*fs*
0	1	64/*fs*	32/*fs*
1	0	16/*fs*	8/*fs*
1	1	RFU	RFU

NOTE Minimum TR1 is required by the PCD for synchronization with the PICC and its value depends on the PCD performance.

Until the RFU value (11)b is assigned, a PICC receiving (b6,b5) = (11)b shall interpret it as (b6,b5) = (00) b, the default value.

7.10.3.3 EOF/SOF

b3 and b4 indicate the PCD capability to support suppression of the EOF and/or SOF from PICC to PCD, which may reduce communication overhead. The suppression of EOF and/or SOF is optional for the PICC. The coding of b3 and b4 is specified in Tables 32 and 33.

Table 32 — SOF handling

b3	SOF required
0	Yes
1	No

Table 33 — EOF handling

b4	EOF required
0	Yes
1	No

SOF/EOF suppression applies only for communications at *fc*/128 (~ 106 kbit/s). For bit rates higher than *fc*/128 (~ 106 kbit/s) up to *fc*/16 (~ 848 kbit/s), the PICC shall always provide SOF and EOF.

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7.10.4 Coding of Param 2

The least significant half byte (b4 to b1) is used to code the maximum frame size that can be received by the PCD as specified in Table 34.

Table 34 — Coding of b4 to b1 of Param 2

Maximum Frame Size Code in ATTRIB	'0'	'1'	'2'	'3'	'4'	'5'	'6'	'7'	'8'	'9'	'A'	'B'	'C'	'D' - 'F'
Maximum frame size (bytes)	16	24	32	40	48	64	96	128	256	512	1 024	2 048	4 096	RFU

The most significant half byte (b8 to b5) is used for bit rate selection, as specified in Table 35 and Table 36.

Table 35 — Coding of b6 and b5 of Param 2

b6	b5	Meaning
0	0	PCD to PICC, 1 etu = 128/*fc*, bit rate is *fc*/128 (~ 106 kbit/s)
0	1	PCD to PICC, 1 etu = 64/*fc*, bit rate is *fc*/64 (~ 212 kbit/s)
1	0	PCD to PICC, 1 etu = 32/*fc*, bit rate is *fc*/32 (~ 424 kbit/s)
1	1	PCD to PICC, 1 etu = 16/*fc*, bit rate is *fc*/16 (~ 848 kbit/s)

Table 36 — Coding of b8 and b7 of Param 2

b8	b7	Meaning
0	0	PICC to PCD, 1 etu = 128/*fc*, bit rate is *fc*/128 (~ 106 kbit/s)
0	1	PICC to PCD, 1 etu = 64/*fc*, bit rate is *fc*/64 (~ 212 kbit/s)
1	0	PICC to PCD, 1 etu = 32/*fc*, bit rate is *fc*/32 (~ 424 kbit/s)
1	1	PICC to PCD, 1 etu = 16/*fc*, bit rate is *fc*/16 (~ 848 kbit/s)

S(PARAMETERS), as defined in ISO/IEC 14443-4, is the only way to negotiate bit rates higher than *fc*/16 and may also be used to negotiate any specified bit rate.

Until the RFU values 'D' - 'F' are assigned, a PICC receiving Maximum Frame Size Code = 'D' - 'F' shall interpret it as Maximum Frame Size Code = 'C (maximum frame size = 4 096 bytes).

NOTE This PICC requirement is added for PICC's compatibility with future PCDs when ISO/IEC further defines the behavior for the RFU values of 'D' – 'F'.

7.10.5 Coding of Param 3

The PCD shall use b1 for the confirmation of the protocol type as specified in Table 26 and should use (b3,b2) for confirmation of minimum TR2, as specified in Table 27. b4 is RFU.

The PICC shall ignore (b3,b2) and the interpretation of any other field of the whole frame shall not change.

NOTE When b4 <> (0)b, the rule in 5.3 applies.

b8, b7, b6 and b5 are each RFU.

The PICC shall not respond to the ATTRIB command when b8 or b7 or b6 or b5 <> (0)b.

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7.10.6 Coding of Param 4

The Param 4 byte consists of two parts:

— the least significant half byte (b4 to b1) is named Card Identifier (CID) and defines the logical number of the addressed PICC in the range from 0 to 14. The value 15 is RFU. The CID is specified by the PCD and shall be unique for each active PICC. If the PICC does not support CID, the PCD shall use CID = (0000)b and the PICC shall not respond to an ATTRIB command using CID <> (0000)b;

— b8, b7, b6 and b5 are each RFU.

Until the RFU value of CID = 15 is assigned, a PICC receiving CID = 15 shall not respond to the ATTRIB command.

7.10.7 Higher layer INF

The higher layer INF field may include any data. The PICC need not process this data.

The PICC processing of the ATTRIB command shall not be altered by the inclusion of those data.

7.11 Answer to ATTRIB command

The PICC shall answer to any valid ATTRIB command (correct PUPI and valid CRC_B) with the format described in Figure 29.

1st byte		2nd ....bytes	
MBLI	CID	Higher layer Response	CRC_B
(1 byte)		(optional 0 or more bytes)	(2 bytes)

Figure 29 — Format of the Answer to an ATTRIB command

The first byte consists of two parts:

— the least significant half byte (b4 to b1) contains the returned CID. When answering to a valid ATTRIB command, the PICC shall return the CID value received in the ATTRIB command, else the PCD shall consider the PICC response as a protocol error;

— the most significant half byte (b8 to b5) is called the Maximum Buffer Length Index (MBLI). It is used by the PICC to let the PCD know the limit of its internal buffer to received chained frames. The coding of MBLI is as follows:

  — MBLI = 0 means that the PICC provides no information on its internal input buffer size;

  — MBLI > 0 is used to calculate the actual internal Maximum Buffer Length (MBL) according to the following formula: MBL = (PICC Maximum Frame Size) × $2^{(\mathrm{MBLI} - 1)}$ where the PICC maximum frame size is returned by the PICC in its ATQB. When it sends chained frames to a PICC, the PCD shall ensure that the accumulated length is never greater than MBL.

Remaining bytes are optional and used for higher layer response.

As illustrated in Figure 30, the PICC shall answer the empty (no higher layer INF field) ATTRIB command with an empty higher layer response.

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1st byte		2nd, 3rd bytes
MBLI	CID	CRC_B
(1 byte)		(2 bytes)

Figure 30 — PICC Answer to ATTRIB format without higher layer response

NOTE A valid Answer (same CID and valid CRC_B) to an ATTRIB command (as defined in Figure 29 or Figure 30) is the means for a PCD to verify that PICC selection has been successful.

7.12 HLTB command and Answer

The HLTB command is used to set a PICC in HALT state and stop responding to a REQB.

After answering to this command, the PICC shall ignore any commands except the WUPB command (see 7.7).

The HLTB command format is defined in Figure 31.

1st byte	2nd, 3rd, 4th 5th, bytes	6th 7th, bytes
′50′ (1 byte)	Identifier (4 bytes)	CRC_B (2 bytes)

Figure 31 — Format of the HLTB command

The 4 bytes identifier is the value of the PUPI sent by the PICC in the ATQB.

The format of Answer to a HLTB command from the PICC is defined in Figure 32.

1st byte	2nd, 3rd, bytes
′00′ (1 byte)	CRC_B (2 bytes)

Figure 32 — Format of PICC Answer to HLTB command

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8 Electromagnetic disturbance handling

8.1 General

Electromagnetic disturbance handling enhances the robustness of the contactless communication between PCD and PICC against PICC generated electromagnetic disturbance (EMD).

While the PCD is waiting for the PICC response, the PICC is processing the requested command. The PICC dynamic current consumption during execution time may cause an arbitrary load (which may not be purely resistive) modulation effect on the magnetic field. In some cases, the PCD may misinterpret EMD as data sent by the PICC and this may negatively impact proper reception of the PICC response.

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The effect of the EMD on the PCD reception may depend on

— the PICC operation and speed,

— the PCD and PICC antenna geometries and relative distance (coupling factor), and

— the sensitivity of PCD receiver channel.

EMD handling also improves the robustness of the contactless communication from PICC to PCD by

— defining EMD timing constraints for PICC and for PCD, and

— recommending a PCD algorithm for EMD handling.

8.2 EMD timing constraints

The low EMD time $t_{E,\ PICC}$ is the time period before the start of PICC data transmission, when the PICC shall not produce an EMD level higher than the EMD limit as defined in ISO/IEC 14443-2.

This low EMD time $t_{E,\ PICC}$ has a value of F – 1 024/*fc* with a maximum value of 1 408/*fc* where F equals FDT for Type A and TR0 for Type B. The value is 0/*fc* for TR0 ≤ 1 024/*fc*.

The low EMD time $t_{E,\ PCD}$ is the time period to allow the PCD to recover from electromagnetic disturbances.

The PCD shall be ready to process a PICC frame no later than $t_{E,\ PCD}$ after the last time the EMD level was above the EMD limit as defined in ISO/IEC 14443-2.

This low EMD time $t_{E,\ PCD}$ has a value of F – 1 044/*fc* with a maximum value of 1 388/*fc* where F equals FDT for Type A and TR0 for Type B. The value is 0/*fc* for TR0 ≤ 1 044/*fc*.

The minimum value of 0 for $t_{E,\ PICC}$ and $t_{E,\ PCD}$ may only be reached when the PCD indicates support of a TR0 shorter than the default value (see 7.10.3.1).

The low EMD time for PCD and PICC are illustrated in Figure 33.

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