

ISO/IEC JTC1/SC17 N 3613

WG8 N 1496

DOCUMENT TYPE: Notification of Ballot

TITLE: Notification of Ballot: ISO/IEC FCD 14443-3 (Revision) –
Identification Cards – Contactless integrated circuit(s) cards – Proximity cards
– Part 3: Initialization and anti-collision

BACKWARD POINTER: N 3213, N 3260, N 3388, N 3389, N 3444, N 3496
N 3547 and N 3612

SOURCE: SECRETARIAT ISO/IEC JTC1/SC17

STATUS: Disposition of comments for 17n3547 are contained in 17n3612.

This ballot has been posted to the ISO Electronic balloting application and is
available under the Balloting Portal, Committee Internal Balloting.

ACTION ID: FYI

WORK ITEM: 50942

DUE DATE: 2009-03-24

DISTRIBUTION: P and L-Members of ISO/IEC JTC1/SC17
JTC1 Secretariat
ISO/IEC ITTF

MEDIUM: SERVER

NO. OF PAGES: 64

ISO/IEC JTC 1/SC 17/WG8N1466R1

Date: 2008-11-20

ISO/IEC FCD 14443-3

ISO/IEC JTC 1/SC 17/WG 8

Secretariat: DIN

Identification cards — Contactless integrated circuit(s) cards - Proximity cards — Part 3: Initialization and anticollision

Cartes d'identification — Cartes à circuit(s) intégré(s) sans contact - Cartes de proximité — Partie 3: Initialisation et anticollision

Warning

This document is not an ISO International Standard. It is distributed for review and comment. It is subject to change without notice and may not be referred to as an International Standard.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Document type: International Standard
Document subtype:
Document stage: (40) Enquiry
Document language: E

D:\Documents and Settings\atp01074\My Documents\Work\STANDARDS\PROJECT\ISO_IEC
14443\ISO_IEC_14443-3\ISO_IEC 14443-3_Rev2\200811 FCD\14443-3FCD1_v8.doc STD Version 2.1c2

Copyright notice

This ISO document is a Draft International Standard and is copyright-protected by ISO. Except as permitted under the applicable laws of the user's country, neither this ISO draft nor any extract from it may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, photocopying, recording or otherwise, without prior written permission being secured.

Requests for permission to reproduce should be addressed to either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Reproduction may be subject to royalty payments or a licensing agreement.

Violators may be prosecuted.

Contents

Page

1	Scope	1
2	Normative references	1
3	Terms and definitions	2
4	Symbols and abbreviated terms	3
5	Alternating between Type A and Type B commands	5
5.1	Polling.....	5
5.2	Influence of Type A commands on PICC Type B operation.....	5
5.3	Influence of Type B commands on PICC Type A operation.....	5
5.4	Transition to POWER-OFF state	5
6	Type A – Initialization and anticollision	6
6.1	Bit rates	6
6.2	Frame format and timing	6
6.2.1	Frame delay time	7
6.2.2	Request Guard Time	8
6.2.3	Frame formats.....	8
6.2.4	CRC_A	11
6.3	PICC states.....	11
6.3.1	POWER-OFF state	12
6.3.2	IDLE state	13
6.3.3	READY state.....	13
6.3.4	ACTIVE state	13
6.3.5	HALT state.....	13
6.3.6	READY* state	13
6.3.7	ACTIVE* state.....	14
6.3.8	PROTOCOL state.....	14
6.4	Command set.....	14
6.4.1	REQA and WUPA commands.....	14
6.4.2	ANTICOLLISION and SELECT commands.....	15
6.4.3	HLTA command	15
6.5	Select sequence	15
6.5.1	Select sequence flowchart	15
6.5.2	ATQA - Answer To Request	16
6.5.3	Anticollision and Select	17
6.5.4	UID contents and cascade levels.....	21
7	Type B – Initialization and anticollision	23
7.1	Character, frame format and timing	23
7.1.1	Character transmission format.....	23
7.1.2	Character separation.....	23
7.1.3	Frame format.....	24
7.1.4	SOF	24
7.1.5	EOF	26
7.1.6	Timing before the PICC SOF	26
7.1.7	Timing before the PCD SOF	27
7.2	CRC_B	28
7.3	Anticollision sequence	28
7.4	PICC states description	28
7.4.1	Initialization and anticollision flowchart	30
7.4.2	General statement for state description and transitions	30
7.4.3	POWER-OFF state	31

7.4.4	IDLE state	31
7.4.5	READY-REQUESTED sub-state.....	31
7.4.6	READY-DECLARED sub-state	32
7.4.7	PROTOCOL state	32
7.4.8	HALT state	32
7.5	Command set	32
7.6	Anticollision response rules.....	33
7.6.1	PICC with initialization only	33
7.7	REQB/WUPB command	33
7.7.1	REQB/WUPB command format	33
7.7.2	Coding of Anticollision Prefix byte APf.....	34
7.7.3	Coding of AFI	34
7.7.4	Coding of PARAM	35
7.8	Slot-MARKER command	36
7.8.1	Slot-MARKER command format.....	36
7.8.2	Coding of anticollision prefix byte APn	36
7.9	ATQB Response.....	36
7.9.1	ATQB response format	36
7.9.2	PUPI (Pseudo-Unique PICC Identifier).....	37
7.9.3	Application Data.....	37
7.9.4	Protocol Info.....	38
7.10	ATTRIB command.....	41
7.10.1	ATTRIB command format	41
7.10.2	Identifier	41
7.10.3	Coding of Param 1	41
7.10.4	Coding of Param 2	43
7.10.5	Coding of Param 3	44
7.10.6	Coding of Param 4	44
7.10.7	Higher layer INF	44
7.11	Answer to ATTRIB command.....	45
7.12	HLTB command and Answer	45
Annex A	(informative) Communication example Type A	47
Annex B	(informative) CRC_A and CRC_B encoding.....	49
Annex C	(informative) Type A timeslot – Initialization and anticollision.....	53
Annex D	(informative) Example of Anticollision Sequence	57

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 14443-3 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information Technology*, Subcommittee SC 17, *Identification cards and related devices*.

This second edition cancels and replaces the first edition (2001), including its amendments. All clauses have been revised.

All annexes of this part of ISO/IEC 14443 are for information only.

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

- *Part 1: Physical characteristics*
- *Part 2: Radio frequency power and signal interface*
- *Part 3: Initialization and anticollision*
- *Part 4: Transmission protocol*

Introduction

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

This part of ISO/IEC 14443 describes 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.

ISO/IEC 14443 is intended to allow operation of proximity cards in the presence of other contactless cards conforming to ISO/IEC 10536 and ISO/IEC 15693.

Identification cards — Contactless integrated circuit(s) cards - Proximity cards — Part 3: Initialization and anticollision

1 Scope

This part of ISO/IEC 14443 describes:

- polling for proximity cards (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.

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 part of ISO/IEC 14443 is applicable to PICCs of Type A and of Type B (as described in ISO/IEC 14443-2).

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

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

2 Normative references

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

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

ISO/IEC 7816-4, *Identification cards – Integrated circuit(s) cards with contacts – Part 4: Organization, security and commands for interchange*.

ISO/IEC 7816-6, *Identification cards – Integrated circuit(s) cards with contacts – Part 6: Interindustry data elements for interchange*.

ISO/IEC 14443-2, *Identification cards – Contactless integrated circuit(s) cards – Proximity cards – Part 2: Radio frequency power and signal interface.*

ISO/IEC 14443-4, *Identification cards – Contactless integrated circuit(s) cards – Proximity cards – Part 4: Transmission protocol.*

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

ITU-T X.25, *Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data network by dedicated circuit.*

ITU-T V.41, *Code-independent error-control system.*

ITU-T V.42, *Error-correcting procedures for DLEs using asynchronous – to – synchronous conversion.*

3 Terms and definitions

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

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
a byte consists of 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
elementary time unit (etu)
calculated by the following formula:

$$1 \text{ etu} = 128 / (D \times f_c) \text{ where } D \in \{1, 2, 4, 8\}$$

The initial value of the divisor D is 1, giving the initial etu as follows:

$$1 \text{ etu} = 128 / f_c$$

where f_c is the carrier frequency as defined in ISO/IEC 14443-2.

3.5
frame
a frame is a sequence of data bits and optional error detection bits, with frame delimiters at start and end

3.6
higher layer protocol
a protocol layer (not described in this part of ISO/IEC 14443) that makes use of the protocol layer defined in this part of ISO/IEC 14443 to transfer information belonging to the application or higher layers of protocol that is not described in this part of ISO/IEC 14443

3.7**request command**

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

4 Symbols and abbreviated terms

For the purposes of this part of ISO/IEC 14443, the following abbreviations are used:

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, Type A
<i>f_c</i>	carrier frequency
FO	Frame Option, Type B
<i>f_s</i>	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
MBL	Maximum Buffer Length, Type B
MBLI	Maximum Buffer Length Index, Type B
MSB	Most Significant Bit
N	Number of anticollision slots, Type B
<i>n</i>	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
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 by ISO/IEC
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
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

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

For the purposes of this part of ISO/IEC 14443, the following notation applies:

- (xxxxx)b Data bit representation;
- 'XY' Hexadecimal notation, equal to XY to the base 16.

5 Alternating between Type A and Type B commands

5.1 Polling

In order to detect PICCs which are in the operating field, a 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 operating 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 operating 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 operating 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 operating 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 operating field.

NOTE In order to detect PICCs requiring 5 ms, PCDs should periodically present an unmodulated 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.

5.2 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 command.

5.3 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 command.

5.4 Transition to POWER-OFF state

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

6 Type A – Initialization and anticollision

This section describes the initialization and anticollision sequence applicable for PICCs of Type A.

A PICC or PCD sending RFU bits shall set these bits to the value indicated herein or to zero if no value is given. A PICC or PCD receiving RFU bits shall disregard the value of these bits and shall maintain and not change its function, unless explicitly stated otherwise.

6.1 Bit rates

Communication between PCD and PICC can be achieved with four different bit rates.

Bit rates of $f_c / 64$, $f_c / 32$ and $f_c / 16$ are optional and may be independently supported by PCD and PICC in each communication direction.

Table 1 — Bit rates

Divisor D	etu	Bit rate
1	$128 / f_c$ (~9,4 μ s)	$f_c / 128$ (~106 kbit/s)
2 (optional)	$128 / (2 f_c)$ (~4,7 μ s)	$f_c / 64$ (~212 kbit/s)
4 (optional)	$128 / (4 f_c)$ (~2,4 μ s)	$f_c / 32$ (~424 kbit/s)
8 (optional)	$128 / (8 f_c)$ (~1,2 μ s)	$f_c / 16$ (~848 kbit/s)

NOTE The initial bit rate is $f_c / 128$. This applies for the whole initialization and anticollision sequence.

6.2 Frame format and timing

This section 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 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
 - 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 FDT 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, where n is an integer value.

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.

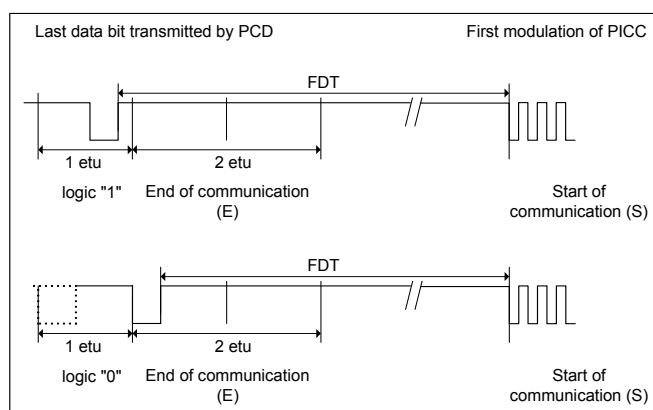


Figure 1 — Frame delay time PCD to PICC

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	$(n \times 128 + 84) / fc$ [= 1236 / fc]	$(n \times 128 + 20) / fc$ [= 1172 / fc]
All other commands at bit rates				
PCD to PICC	PICC to PCD			
$fc / 128$	$fc / 128$	≥ 9	$(n \times 128 + 84) / fc$	$(n \times 128 + 20) / fc$
$fc / 64$		≥ 8	$(n \times 128 + 148) / fc$	$(n \times 128 + 116) / fc$
$fc / 32$		≥ 8	$(n \times 128 + 116) / fc$	$(n \times 128 + 100) / fc$
$fc / 16$		≥ 8	$(n \times 128 + 100) / fc$	$(n \times 128 + 92) / fc$
$fc / 128$ or $fc / 64$ or $fc / 32$ or $fc / 16$	$fc / 64$ or $fc / 32$ or $fc / 16$	Not applicable	$\geq 1116 / fc$	$\geq 1116 / fc$
All PICCs in the field shall respond in a synchronous way to the commands: REQA, WUPA, ANTICOLLISION and SELECT. This is needed for anticollision.				

The FDT measurement starts at the beginning of the rising edge as specified in ISO/IEC 14443-2 and illustrated with small circles in Figure 3 for $f_c / 128$ and Figure 6 for other bit rates.

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

NOTE The PCD should accept a response with a FDT tolerance of $-1 / f_c$ to $(+0,4 \mu\text{s} + 1 / f_c)$.

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 pause transmitted by the PCD and shall be at least $1172 / f_c$.

NOTE To enhance interoperability it is recommended that an additional waiting time of $10 / f_c$ is 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 $7000 / f_c$.

NOTE To enhance interoperability it is recommended that an additional waiting time of $10 / f_c$ is incorporated in the PCD operation.

6.2.3 Frame formats

The following frame types are defined:

- short frames;
- standard frames;
- bit oriented anticollision frame.

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 frame

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

- start of communication;

$n \times (8 \text{ data bits} + \text{odd parity bit})$, 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 (b_1 to b_8 , P);

— end of communication.

The PCD standard frame is illustrated in Figure 3.

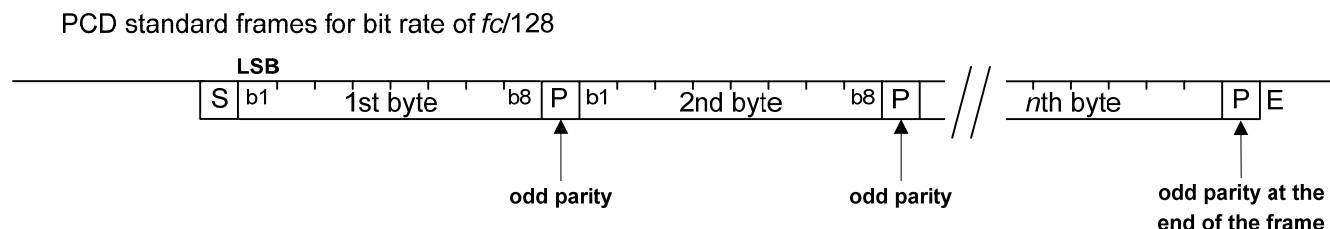


Figure 3 — PCD standard frame

As an exception the last parity bit of a PICC standard frame shall be inverted if this frame is transmitted with bit rate of $fc/64$, $fc/32$ or $fc/16$. PICC standard frames are illustrated in Figure 4.

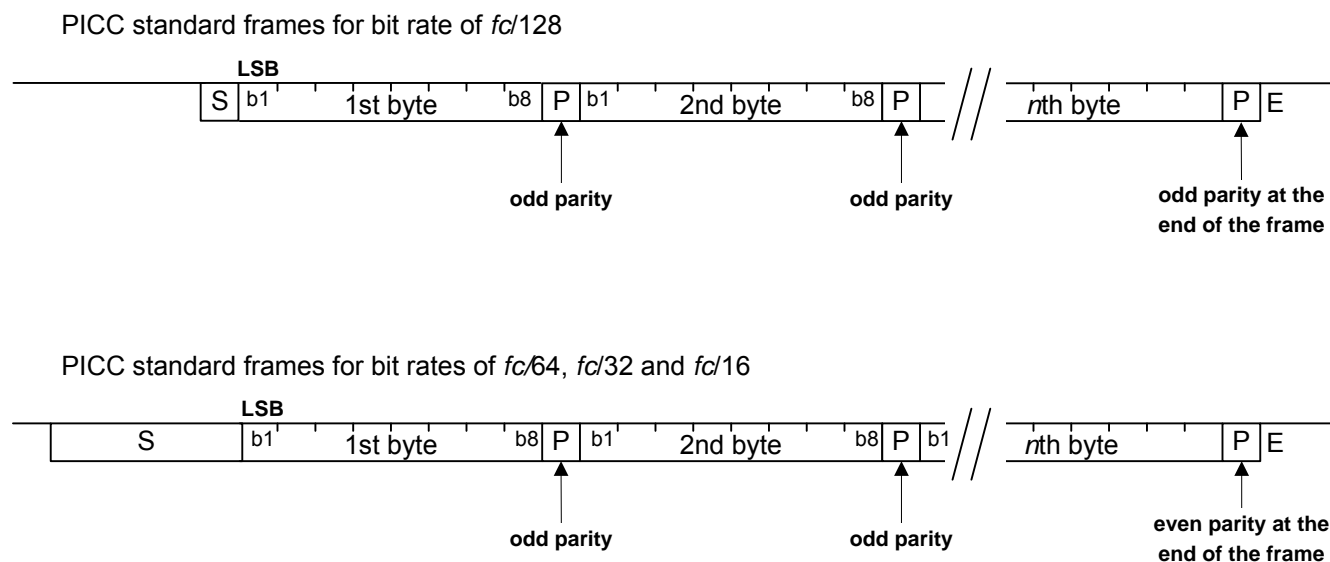


Figure 4 — PICC standard frames

6.2.3.3 Bit oriented anticollision frame

The PCD shall be designed to 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 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, 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.

The Block Check Character (BCC) is calculated as exclusive-or over the 4 previous bytes.

The following examples for case FULL BYTE and case SPLIT BYTE define the bit organization and order of bit transmission.

NOTE These examples include proper values for NVB and BCC.

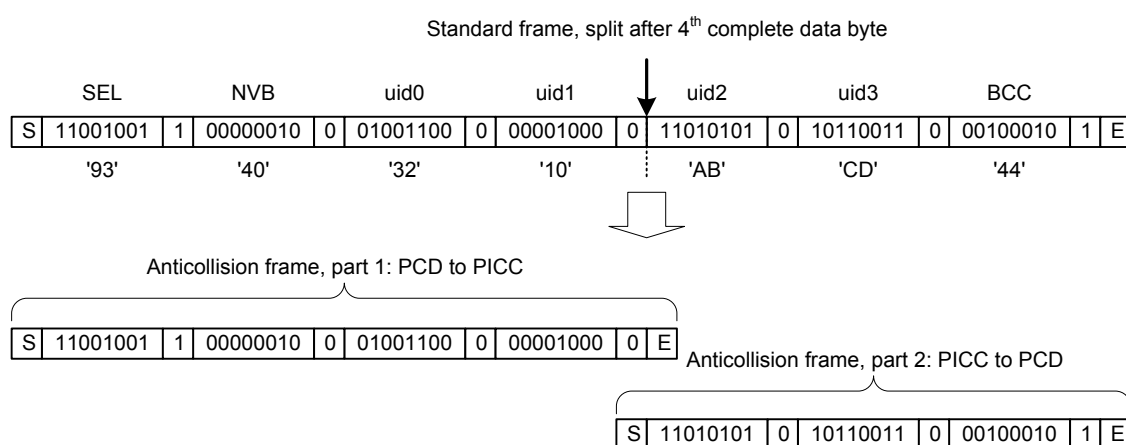


Figure 5 —Bit organization and transmission of bit oriented anticollision frame, case FULL BYTE

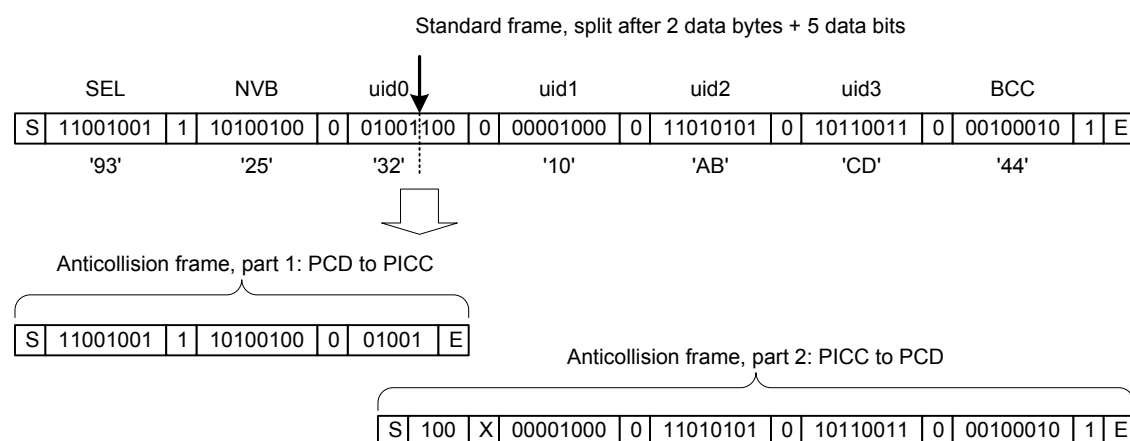


Figure 6 — Bit organization and transmission of bit oriented anticollision frame, case SPLIT BYTE

For a SPLIT BYTE, the first parity bit of part 2 shall be ignored by the PCD.

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 bytes and before the E. The CRC_A is 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 sections provide descriptions of the states for a PICC of Type A specific to the anticollision sequence.

The following 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.

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 frame

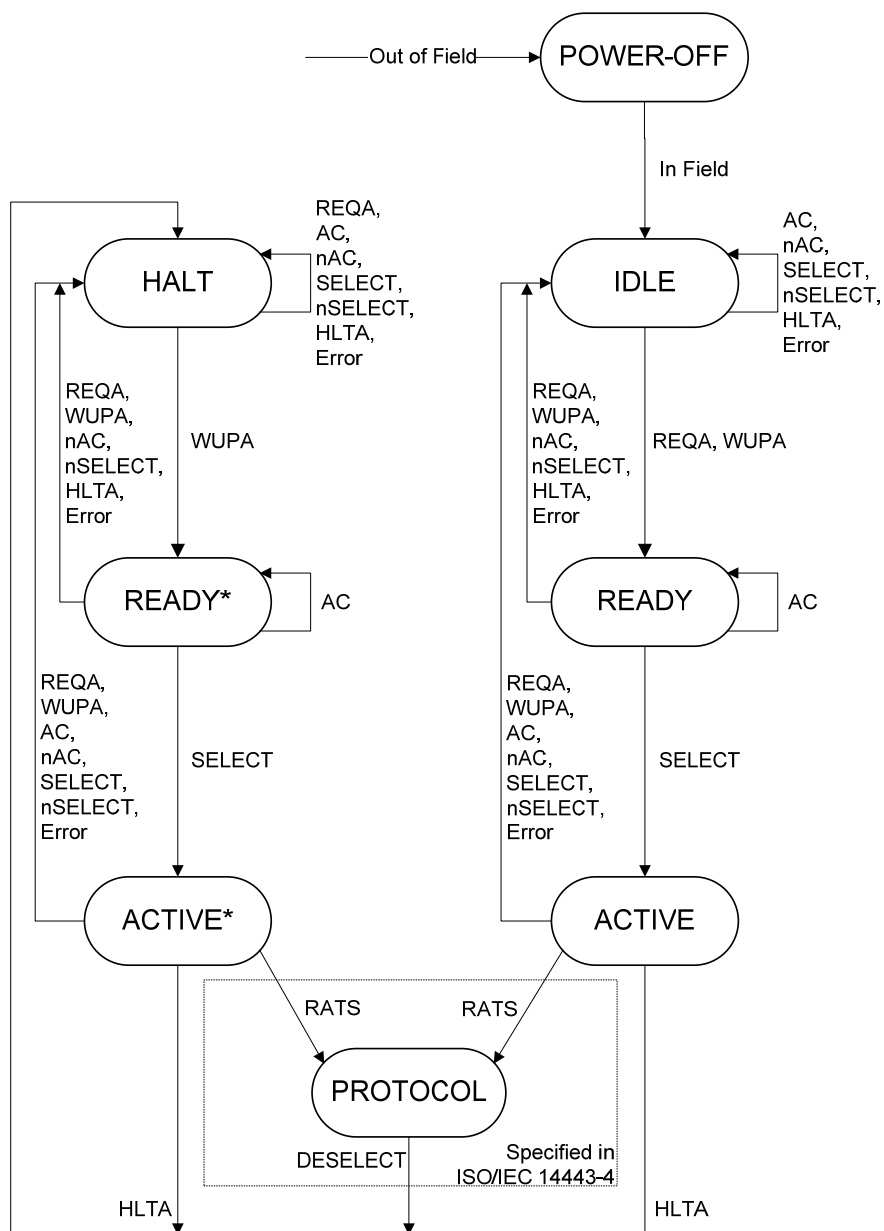


Figure 7 — PICC Type A state diagram

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

6.3.1 POWER-OFF state

Description:

In the 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 clause 5.

6.3.2 IDLE state

Description:

In the 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 the READY state after it has received a valid REQA or WUPA command and transmitted its ATQA.

6.3.3 READY state

Description:

In the 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 the 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, else it may proceed with non ISO/IEC 14443-4 protocol.

State exit conditions and transitions:

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

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

6.3.5 HALT state

Description:

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

State exit conditions and transitions:

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

6.3.6 READY* state

Description:

The READY* state is similar to the 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.

State exit conditions and transitions:

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

6.3.7 ACTIVE* state

Description:

The ACTIVE* state is similar to the 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, else it may proceed with non ISO/IEC 14443-4 protocol.

State exit conditions and transitions:

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

6.3.8 PROTOCOL state

Description:

In the PROTOCOL state the PICC behaves according to ISO/IEC 14443-4.

6.4 Command set

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

- 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 the HALT state back into the 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
1	1	1	1	x	x	x	'78' to '7F' = Proprietary
all other values							RFU

A PCD sending an RFU value is not compliant with this standard.

A PICC receiving an RFU value should consider the short frame as an error (see Figure 7) and should 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:

- 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 standard frame.



Figure 8 — Standard frame containing HLTA command

If the PICC responds with any modulation during a period of 1 ms after the end of the frame containing the HLTA command, this response shall be interpreted as 'not acknowledge'.

NOTE The PCD should apply an additional waiting time margin of 0,1 ms.

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.

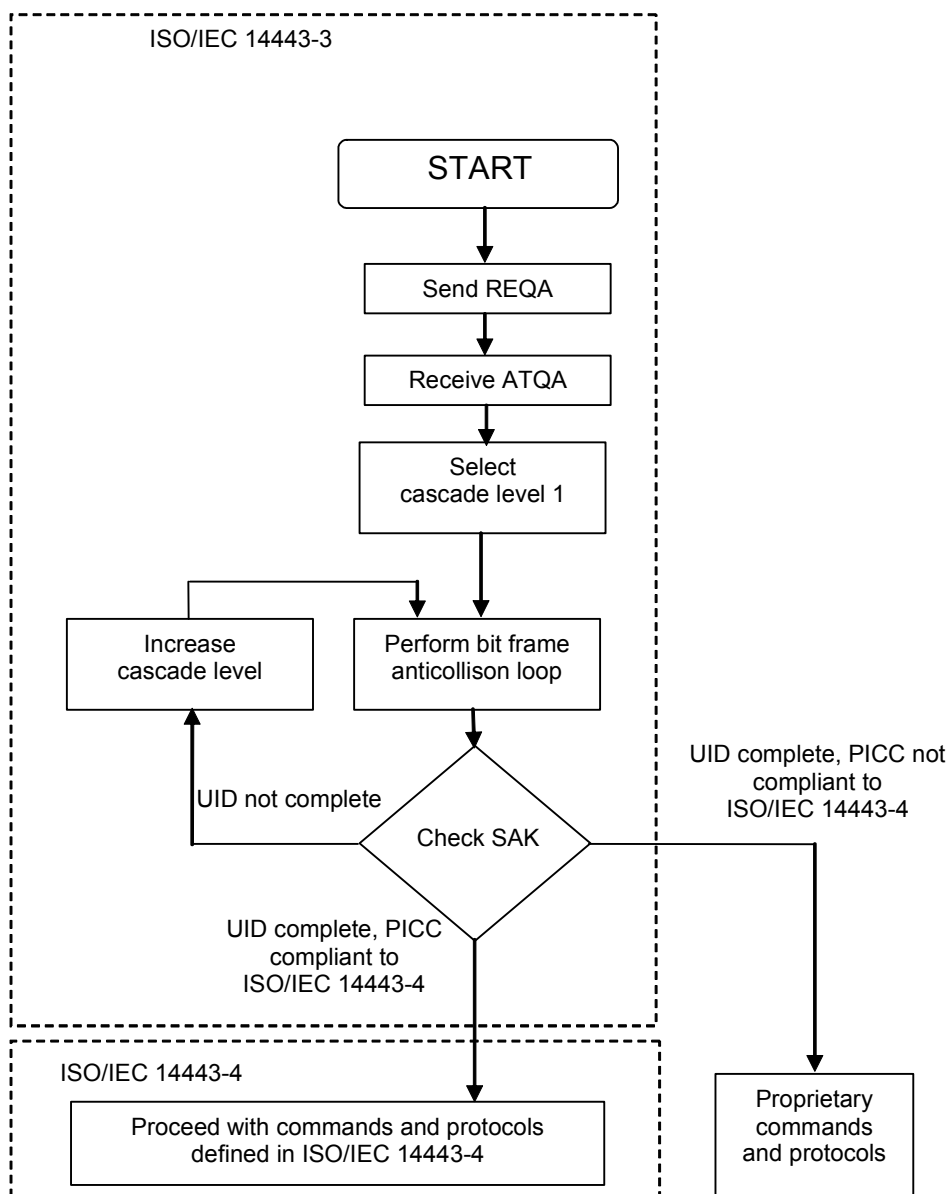


Figure 9 — Initialization and anticollision flowchart for PCD

NOTE PICCs may use ATQA bit combinations of b9 to b12 for indication of proprietary methods.

PICCs that do not support the mandatory bit frame anticollision are not compliant with this standard.

6.5.2 ATQA - Answer To Request

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

After a WUPA command is transmitted by the PCD, all PICCs in the 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 — Coding of ATQA

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

All RFU bits shall be set to 0.

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 PICC sending an ATQA with (b8,b7) = (11)b or (b16 to b13) \neq (0000)b or b6 \neq (0)b is not compliant with this standard.

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.

A PCD receiving (b8,b7) = (11)b or (b16 to b13) \neq (0000)b or b6 \neq (0)b should ignore the values and should commence with the first step of the anticollision loop (see 6.5.3.1).

6.5.2.2 Coding rules for bit frame anticollision

- Rule 1: Bits 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 — Coding of b7, b8 for bit frame anticollision

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 b1 to b5 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 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.
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 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 - step 10 to select this PICC without performing the anticollision loop.

NOTE Figure 10 explains steps 1 to 13.

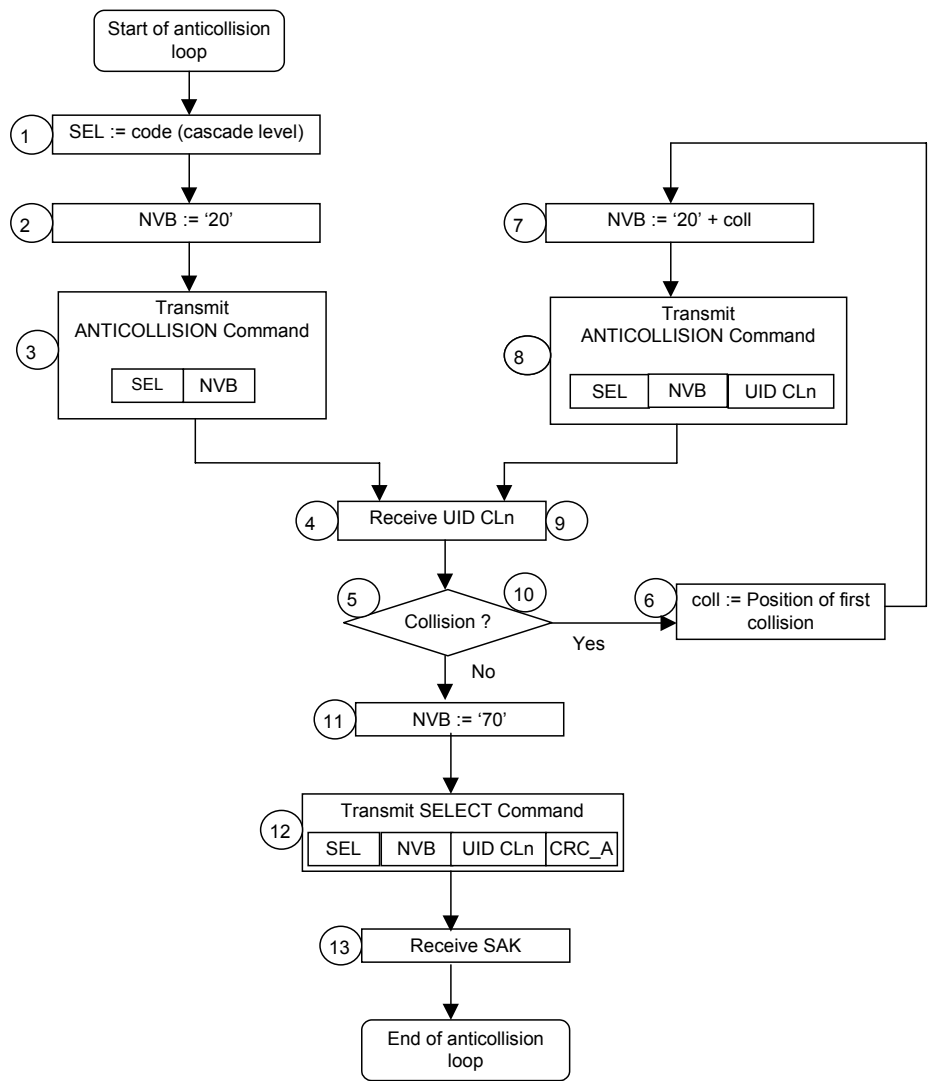


Figure 10 — Anticollision loop, flowchart for PCD

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

6.5.3.2 Coding of SEL (Select code)

Length: 1 byte
Possible values: '93', '95', '97'

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 here above				RFU

NOTE Only three SEL codings are defined and the PICC behaviour when receiving undefined codings is unpredictable.

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 bit count of 0 is allowed. A PCD setting NVB to any forbidden value is not compliant with this standard.

A PCD setting the byte count (b8 to b5) to any value outside the range 2 to 7 is not compliant with this standard.

A PCD setting the bit count (b4 to b1) > 7 for byte count equal 2 to 5 or setting the bit count (b4 to b1) to any value other than 0 for byte count equal 6 or 7 is not compliant with this standard.

6.5.3.4 Coding of SAK (Select acknowledge)

SAK is transmitted by the PICC when NVB has specified 40 valid data bits and when all these data bits match with UID CL_n.

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

Figure 11 — Select acknowledge (SAK)

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

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" means a "don't care" value.								

For b3 = (1)b the PCD shall ignore any other bit of SAK. For b3 = (0)b the PCD shall interpret b6 and shall ignore any of the remaining bits of SAK. A PCD behaving differently is not compliant with this standard.

NOTE When b3 is set to 1, all other bits of SAK should be set to 0.

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 number of UID bytes and the number of 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 a fixed unique number or a random number which is dynamically generated by the PICC. The first byte (uid0) of the UID assigns the content of the following bytes of the UID.

Table 11 — Single size UIDs

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

A random UID shall be generated only on state transition from POWER-OFF state to IDLE state.

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

Table 12 — Double and triple size UIDs

uid0	Description
Manufacturer ID according to ISO/IEC 7816-6*	Each manufacturer is responsible for the uniqueness of the value of the other bytes of the unique number.
* 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.

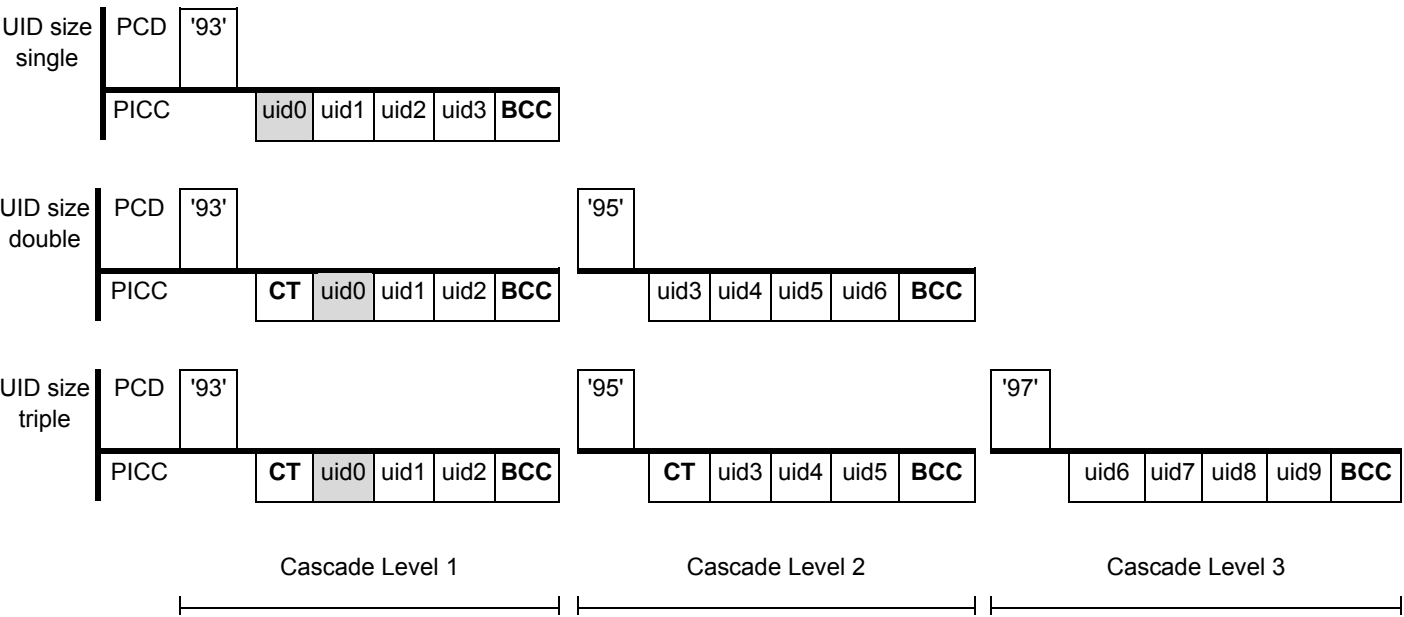


Figure 12 — Usage of cascade levels

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 uid0 with an RFU value is not compliant with this standard. A PICC sending a proprietary number shall fulfil all other requirements of the anticollision sequence including CT otherwise such a PICC is not compliant with this standard.

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

7 Type B – Initialization and anticollision

This section describes the initialization and anticollision sequence applicable for PICCs of Type B.

A PICC or PCD sending RFU bits shall set these bits to the value indicated herein or to zero if no value is given. A PICC or PCD receiving RFU bits shall disregard the value of these bits and shall maintain and not change its function, unless explicitly stated otherwise.

7.1 Character, frame format and timing

This section 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.

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 below.

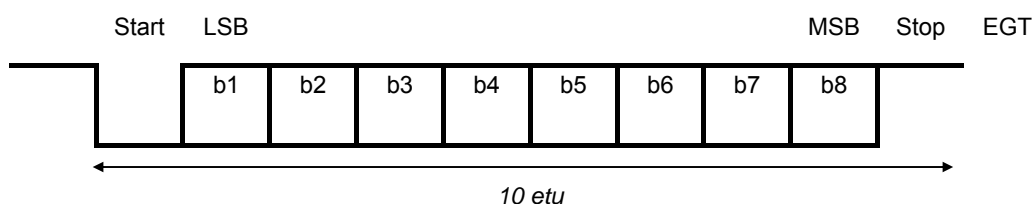


Figure 13 — Character format

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)	$n \text{ etu} \pm 8 / fc$	$n \text{ etu} \pm 1 / fc$	$n \text{ etu} \pm 1 / fc$	$n \text{ etu} \pm 1 / fc$
Bit boundaries from PCD to PICC for the rising edge(s)	$n \text{ etu} \pm 8 / fc$	$n \text{ etu} \pm 4 / fc$	$n \text{ etu} \pm 2 / fc$	$n \text{ etu} \pm 1 / fc$

7.1.2 Character separation

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

The EGT between 2 consecutive characters sent by the PCD to the PICC shall be between 0 and 5,875 etu (not necessarily an integer number of etu).

The EGT between 2 consecutive characters sent by the PICC to the PCD shall be between 0 and 2 etu (not necessarily an integer number of etu).

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

7.1.3 Frame format

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

SOF	Characters	EOF
-----	------------	-----

Figure 14 — Frame Format

7.1.4 SOF

SOF is composed of:

- 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).

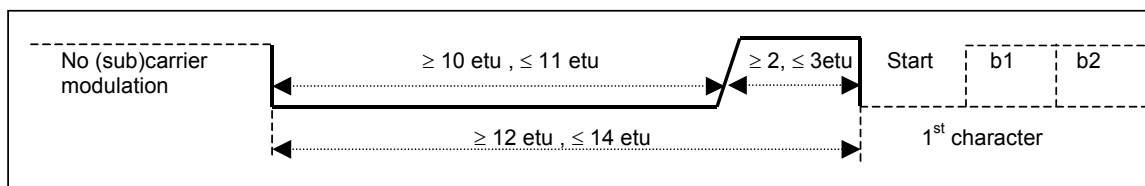


Figure 15 — SOF

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	$11 \text{ etu} + 1 / 16 \text{ etu}$	$10 \text{ etu} - 1 / 16 \text{ etu}$	$11 \text{ etu} + 1 / 8 \text{ etu}$
PCD SOF high	$2 \text{ etu} - 1 / 16 \text{ etu}$	$3 \text{ etu} + 1 / 16 \text{ etu}$	$2 \text{ etu} - 1 / 8 \text{ etu}$	$3 \text{ etu} + 1 / 8 \text{ etu}$

Table 17 — SOF low of PICC transmission

	PICC shall use SOF low time between		PCD shall accept SOF low time between	
	Min	Max	Min	Max
Bit rate				
$fc / 128$	$10 \text{ etu} - 0,5 / fs$	$11 \text{ etu} + 0,5 / fs$	$10 \text{ etu} - 1 / fs$	$11 \text{ etu} + 1 / fs$
$fc / 64$	10 etu	11 etu	$10 \text{ etu} - 0,5 / fs$	$11 \text{ etu} + 0,5 / fs$
$fc / 32$	10 etu	11 etu	10 etu	11 etu
$fc / 16$	10 etu	11 etu	10 etu	11 etu

Table 18 — SOF high of PICC transmission

	PICC shall use SOF high time between		PCD shall accept SOF high time between	
	Min	Max	Min	Max
Bit rate				
$fc / 128$	$2 \text{ etu} - 0,5 / fs$	$3 \text{ etu} + 0,5 / fs$	$2 \text{ etu} - 1 / fs$	$3 \text{ etu} + 1 / fs$
$fc / 64$	2 etu	3 etu	$2 \text{ etu} - 0,5 / fs$	$3 \text{ etu} + 0,5 / fs$
$fc / 32$	2 etu	3 etu	2 etu	3 etu
$fc / 16$	2 etu	3 etu	2 etu	3 etu

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

7.1.5 EOF

EOF is composed of:

- one falling edge;
- followed by 10 to 11 etu with a logic "0" (EOF low);
- followed by one single rising edge.

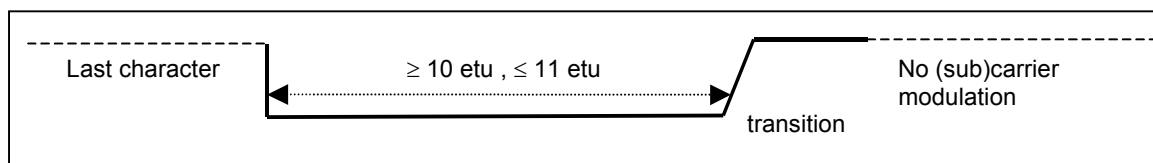


Figure 16 — EOF

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

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
$fc / 16$	10 etu	11 etu	10 etu	11 etu

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

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:

- $256 / fs$ for ATQB
- $65536 / fc$ for S(DESELECT) (see ISO/IEC 14443-4, 8.1)

- $(256 / f_s) \times 2^{FWI} - TR1$ for all other frames (see 7.9.4.3).

The maximum value of TR1 is $200 / f_s$.

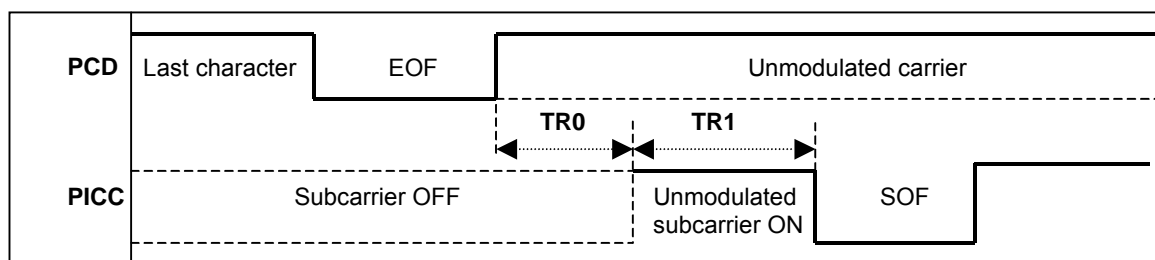


Figure 17 — Timing before the PICC SOF

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 and TR1 with a margin of $1 / f_s$.

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. The subcarrier signal shall:

- not be stopped before the end of the EOF;
- 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).

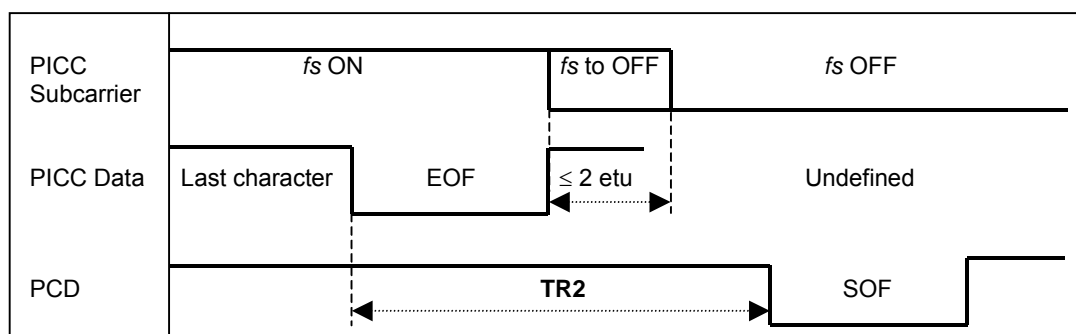


Figure 18 — Timing before the PCD SOF

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	$2 \text{ etu} + 1 / f_s$

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

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 is 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 section.

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.

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 behaviour 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 frame

Else any other command

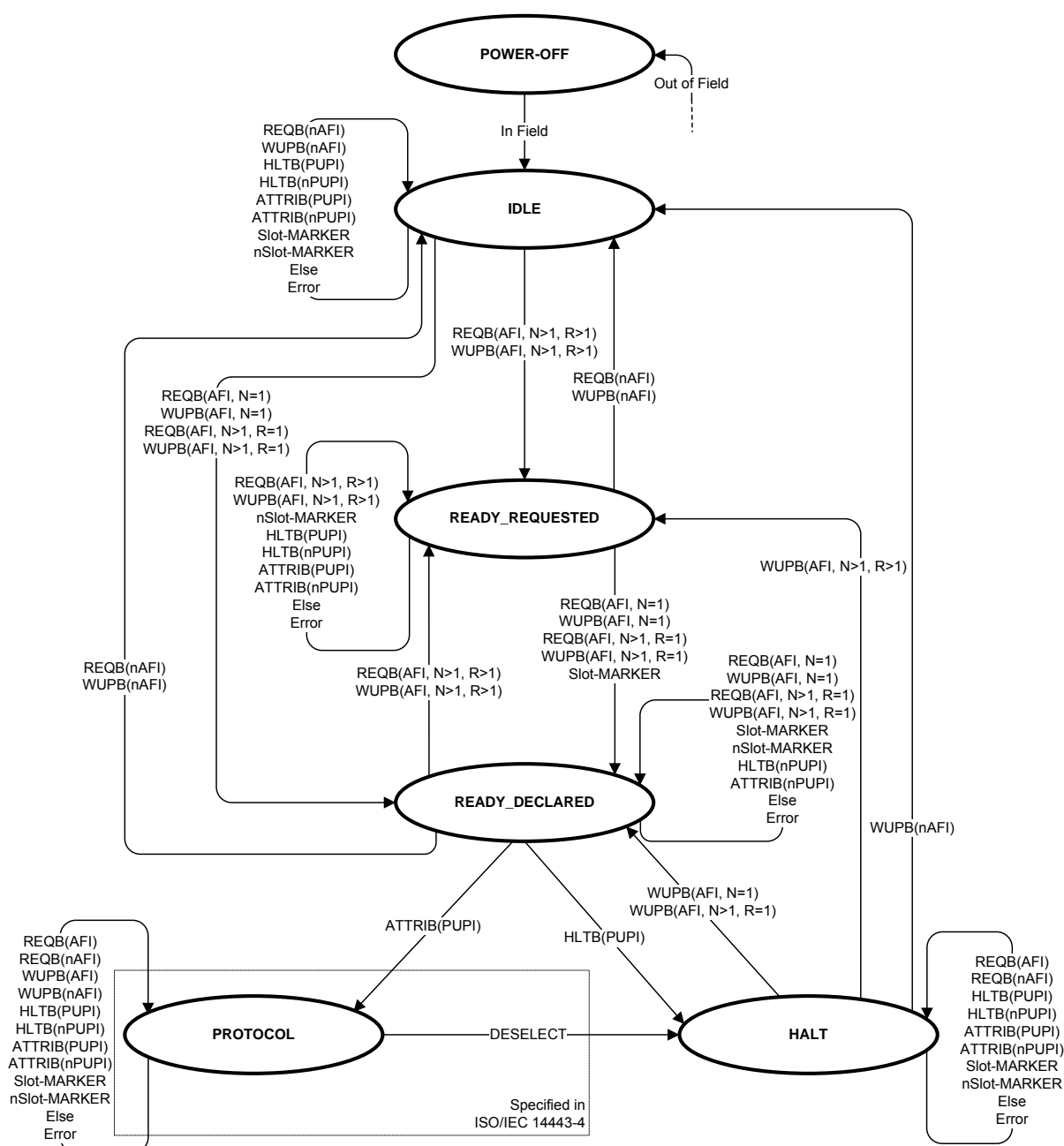


Figure 19 — PICC Type B state diagram

7.4.1 Initialization and anticollision flowchart

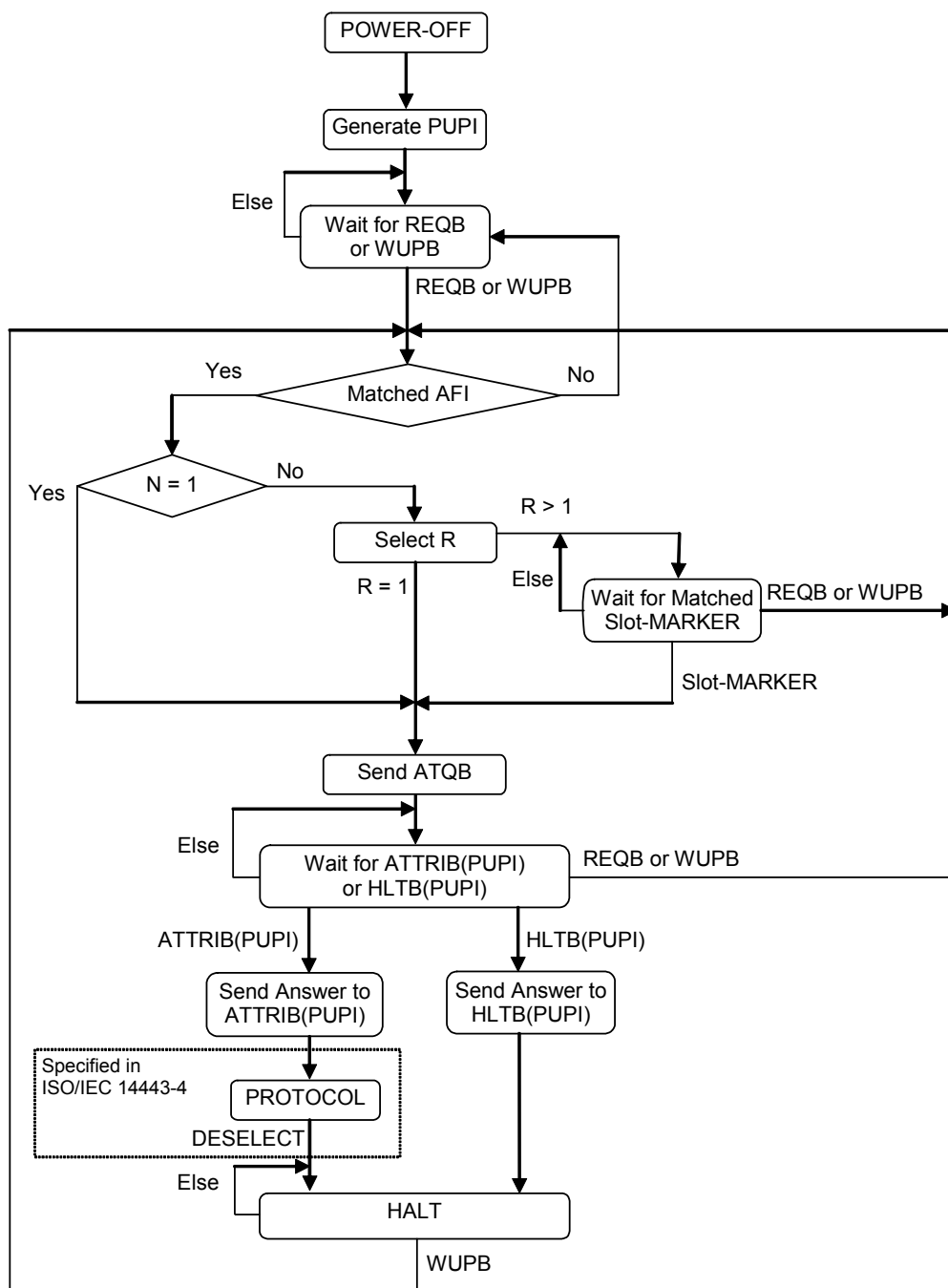


Figure 20 — PICC initialization and anticollision flowchart

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 3 bits of the data in a frame are (101)b (3 first bits of anticollision Prefix byte) the PICC shall not answer to any command frame not starting with (101)b;
- 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 the 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 clause 5.

7.4.4 IDLE state

Description:

In the 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 the 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 the 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.

7.4.6 READY-DECLARED sub-state

Description:

In the 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 the 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 the 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 the IDLE state.

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

7.4.7 PROTOCOL state

Description:

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

If the PICC was selected for the 14443-4 protocol with the ATTRIB command, then the PICC shall operate according to ISO/IEC 14443-4 else 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 the 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 the HALT state.

State exit conditions and transitions:

On reception of a valid WUPB command the PICC shall enter the 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 the IDLE state.

7.5 Command set

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 the IDLE state or READY-REQUESTED sub-state or READY-DECLARED sub-state and receives a valid REQB/WUPB command (AFI=0 or AFI matched with an internal application), or which is in the HALT state and receives a valid WUPB command (AFI=0 or AFI matched with an internal 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 the 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 the 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 the READY-DECLARED sub-state

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 standard.

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 following format:

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

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

AFI (Application Family Identifier) represents the type of application targeted by the PCD and is used to preselect PICCs before the ATQB. Only PICCs with applications of the type indicated by the AFI may answer to a REQb/WUPb command with AFI different to '00'. When AFI equals '00', all PICCs shall process the REQb/WUPb.

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,...
'2'	'0', Y	Financial	IEP, Banking, Retail,...
'3'	'0', Y	Identification	Access Control,...
'4'	'0', Y	Telecommunication	Public Telephony, GSM,...
'5'	'0', Y	Medical	
'6'	'0', Y	Multimedia	Internet services....
'7'	'0', Y	Gaming	
'8'	'0', Y	Data Storage	Portable Files, ...
'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'

A PCD sending a REQb/WUPb command with an AFI field set to an RFU value is not compliant with this standard. The PICC shall not respond when the AFI field is set to a value which is RFU.

7.7.4 Coding of PARAM

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

Figure 22 — Coding of PARAM

All RFU bits shall be set to 0.

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

b4 = 1 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 according to 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 defines: extended ATQB defined in 7.9.4.7 is not supported by the PCD,
- b5 = 1 defines: extended ATQB defined in 7.9.4.7 is supported by the PCD.

WARNING — PCD manufacturers should take care that b5 was RFU in ISO/IEC 14443-3:2001 and the PICC behaviour with b5 = 1 was not specified.

A PCD sending a REQB/WUPB command with (b8 to b6) \neq (000)b is not compliant with this standard.

The PICC should ignore (b8 to b6) and its interpretation of any other field of the whole frame shall not change.

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 by ISO, a PICC receiving (b3 to b1) = (101)b or (11x)b should interpret it as (b3 to b1) = (100)b (16 slots).

A PCD sending (b3 to b1) = (101)b or (11x)b is not compliant with this standard.

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

7.8 Slot-MARKER command

After a REQ_B/WUP_B 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 following format:

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

Figure 23 — Slot-MARKER command format

7.8.2 Coding of anticollision prefix byte AP_n

AP_n = (nnnn 0101)_b where nnnn codes the slot number as defined in the Table 24.

Table 24 — Coding of slot number

nnnn	Slot number
0001	2
0010	3
0011	4
.....
1110	15
1111	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 REQ_B/WUP_B 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:

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

Extended ATQB format:

1 st byte	2 nd , 3 rd , 4 th , 5 th bytes	6 th , 7 th , 8 th , 9 th bytes	10 th , 11 th , 12 th , 13 th bytes	14 th , 15 th 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 PUPI (Pseudo-Unique PICC Identifier)

A Pseudo-Unique PICC Identifier (PUPI) is used to differentiate PICCs during anticollision. This 4-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 the POWER-OFF to the IDLE state.

WARNING — PICCs based on ISO/IEC 14443:2001 may change their PUPI when leaving HALT state and/or in the 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 contains the following:

1 st byte	2 nd , 3 rd bytes	4 th 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 defined in ISO/IEC 7816-4, 8.2.1.2) 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.

1 st byte	2 nd byte		3 rd byte			4 th 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

The RFU bits in Figure 26 shall be set to 0.

7.9.4.1 FO

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

7.9.4.2 ADC

ADC consists of the two bits b3 and b4.

b3 = 0 means Application Data Coding is proprietary.

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

b4 is RFU and shall be set to 0.

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 the formula:

$$\text{FWT} = (256 \times 16 / f_c) \times 2^{\text{FWI}}$$

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 (~ 4949 ms).

In case of extended ATQB supported by the PICC and the PCD:

- FWT applies after the Answer to ATTRIB command,
- the waiting time for the Answer to ATTRIB command is a fixed value given by the following formula:
Answer to ATTRIB waiting time = $(256 \times 16 / f_c) \times 2^4$ (~ 4,8 ms)

NOTE 1 It is strongly recommended to use a FWT as low as possible to protect communications speed when retry occurs.

A PICC setting FWI = 15 is not compliant with this standard.

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

NOTE 2 This requirement is added for PCD's compatibility with future PICCs when ISO defines the behaviour for an RFU value of 15.

7.9.4.4 Protocol_Type

Table 26 — Protocol_Type supported by the PICC

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 + 32 / fs
0	1	10 etu + 128 / fs
1	0	10 etu + 256 / fs
1	1	10 etu + 512 / fs

The bit b4 is RFU and shall be set to 0.

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

7.9.4.5 Max_Frame_Size

Table 28 — Maximum frame size

Maximum Frame Size Code in ATQB	0	1	2	3	4	5	6	7	8	9-F
Maximum Frame Size (bytes)	16	24	32	40	48	64	96	128	256	RFU > 256

A PICC setting Maximum Frame Size Code = '9'-F' is not compliant with this standard.

Until the RFU values '9'-F' are assigned by ISO, a PCD receiving Maximum Frame Size Code = '9'-F' should interpret it as Maximum Frame Size Code = '8' (256 bytes).

NOTE This clause is added for PCD's compatibility with future PICCs when ISO defines the behaviour for the RFU values of '9'-F'.

7.9.4.6 Bit_Rate_capability

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, $1etu = 64 / fc$, bit rate supported is $fc / 64$ (~212 kbit/s)
x	x	1	x	0	x	x	x	PICC to PCD, $1etu = 32 / fc$, bit rate supported is $fc / 32$ (~424 kbit/s)
x	1	x	x	0	x	x	x	PICC to PCD, $1etu = 16 / fc$, bit rate supported is $fc / 16$ (~848 kbit/s)
x	x	x	x	0	x	x	1	PCD to PICC, $1etu = 64 / fc$, bit rate supported is $fc / 64$ (~212 kbit/s)
x	x	x	x	0	x	1	x	PCD to PICC, $1etu = 32 / fc$, bit rate supported is $fc / 32$ (~424 kbit/s)
x	x	x	x	0	1	x	x	PCD to PICC, $1etu = 16 / fc$, bit rate supported is $fc / 16$ (~848 kbit/s)
Other values (with b4 = 1) are RFU.								

A PICC setting b4 = 1 is not compliant with this standard.

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

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 and shall be set to (0000)b;
- 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 the formula given below. The default value of SFGI is 0.

$$\text{SFGT} = (256 \times 16 / f_c) \times 2^{\text{SFGI}}.$$

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

For SFGI = 14, SFGT is maximal (~ 4949 ms).

A PICC setting SFGI = 15 is not compliant with this standard.

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

A PICC sending a ATQB response with (b4 to b1) <> (0000)b is not compliant with this standard.

The PCD shall ignore (b4 to b1) and its interpretation of any other field of the whole frame shall not change. A PCD changing its interpretation of any other field of the whole frame when (b4 to b1) <> (0000)b is not compliant with this standard.

When answering a REQB/WUPB command with bit b5 set to 0 (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 only responds 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

ATTRIB command has the following format:

1 st byte	2 nd , 3 rd , 4 th , 5 th bytes	6 th byte	7 th byte	8 th byte	9 th byte	10 thbytes	
'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

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

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

Figure 28 — Coding of Param 1

All RFU bits shall be set to 0 if not otherwise specified. A PCD setting (b2,b1) \neq (00)b is not compliant with this standard. The PICC should ignore any value (b2,b1) and its interpretation of any other field of the whole frame shall not change.

7.10.3.1 Minimum TR0

Minimum TR0 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.

Table 30 — Minimum TR0 coding

b8	b7	Minimum TR0 for a PCD to PICC bit rate of			
		$fc / 128$	$fc / 64$	$fc / 32$	$fc / 16$
0	0	64 / f_s	64 / f_s	64 / f_s	64 / f_s
0	1	48 / f_s	32 / f_s	16 / f_s	16 / f_s
1	0	16 / f_s	8 / f_s	4 / f_s	4 / f_s
1	1	RFU	RFU	RFU	RFU

NOTE Minimum TR0 is required by the PCD when switching from transmit to receive and its value depends on the PCD performance.

A PCD setting (b8,b7) = (11)b is not compliant with this standard. Until the RFU value (11)b is assigned by ISO, a PICC receiving (b8,b7) = (11)b should interpret it as (b8,b7) = (00)b, the default value.

7.10.3.2 Minimum TR1

Minimum TR1 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			
		$fc / 128$	$fc / 64$	$fc / 32$	$fc / 16$
0	0	80 / f_s	80 / f_s	80 / f_s	80 / f_s
0	1	64 / f_s	32 / f_s	32 / f_s	32 / f_s
1	0	16 / f_s	8 / f_s	8 / f_s	8 / f_s
1	1	RFU	RFU	RFU	RFU

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

A PCD setting $(b6, b5) = (11)b$ is not compliant with this standard. Until the RFU value $(11)b$ is assigned by ISO, a PICC receiving $(b6, b5) = (11)b$ should 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 $f_c / 128$ (~106kbit/s). For bit rates higher than $f_c / 128$ (~106 kbit/s) the PICC shall always provide SOF and EOF.

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-F
Maximum Frame Size (bytes)	16	24	32	40	48	64	96	128	256	RFU > 256

The most significant half byte (b8 to b5) is used for bit rate selection, as specified in Tables 36 and 37.

Table 35 — Coding of b6 and b5 of Param 2

b6	b5	Meaning
0	0	PCD to PICC, $1\text{etu} = 128 / f_c$, bit rate is $f_c / 128$ (~106 kbit/s)
0	1	PCD to PICC, $1\text{etu} = 64 / f_c$, bit rate is $f_c / 64$ (~212 kbit/s)
1	0	PCD to PICC, $1\text{etu} = 32 / f_c$, bit rate is $f_c / 32$ (~424 kbit/s)
1	1	PCD to PICC, $1\text{etu} = 16 / f_c$, bit rate is $f_c / 16$ (~848 kbit/s)

Table 36 — Coding of b8 and b7 of Param 2

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

A PCD setting Maximum Frame Size Code = '9'-'F' is not compliant with this standard.

Until the RFU values '9'-'F' are assigned by ISO, a PICC receiving Maximum Frame Size Code = '9'-'F' should interpret it as Maximum Frame Size Code = '8' (256 bytes).

7.10.5 Coding of Param 3

The least significant half byte (b4 to b1) is used for confirmation of the protocol type as specified in Table 26 and of the minimum TR2, as specified in Table 27. b4 is RFU and shall be set to 0.

The PICC should ignore (b4 to b2) and the interpretation of any other field of the whole frame shall not change.

The most significant half byte (b8 to b5) is set to (0000)b, all other values are RFU.

A PCD setting (b8 to b4) \neq (00000)b is not compliant with this standard.

The PICC should ignore and not answer the ATTRIB command when (b8 to b5) \neq (0000)b.

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, code value (0000)b shall be used;
- the most significant half byte (b8 to b5) is set to (0000)b, all other values are RFU.

A PCD setting CID = 15 is not compliant with this standard.

The PICC should ignore and not answer the ATTRIB command when received value of CID = 15 as any action in the PICC for CID = 15 may be decided in the future by ISO.

A PCD setting (b8 to b5) \neq (0000)b is not compliant with this standard.

The PICC should ignore (b8 to b5) and its interpretation of any other field of the whole frame shall not change.

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.

1 st byte		2 ndbytes	
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. If the PICC does not support CID, code value (0000)b is returned;
- 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: $MBL = (\text{PICC Maximum Frame Size}) \times 2^{(\text{MBLI}-1)}$ 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, a PICC shall answer the empty (no higher layer INF field) ATTRIB command with an empty higher layer response:

1 st byte		2 nd , 3 rd 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 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)

HLTB command has the following format:

1 st byte	2 nd , 3 rd , 4 th , 5 th bytes	6 th , 7 th 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 as follows:

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

Figure 32 — Format of PICC Answer to HLTB command

Annex A
(informative)

Communication example Type A

This example shows the select sequence with 2 PICCs in the field on the assumption of:

- PICC #1 with UID size: single, value of uid0 is '10';
- PICC #2 with UID size: double.

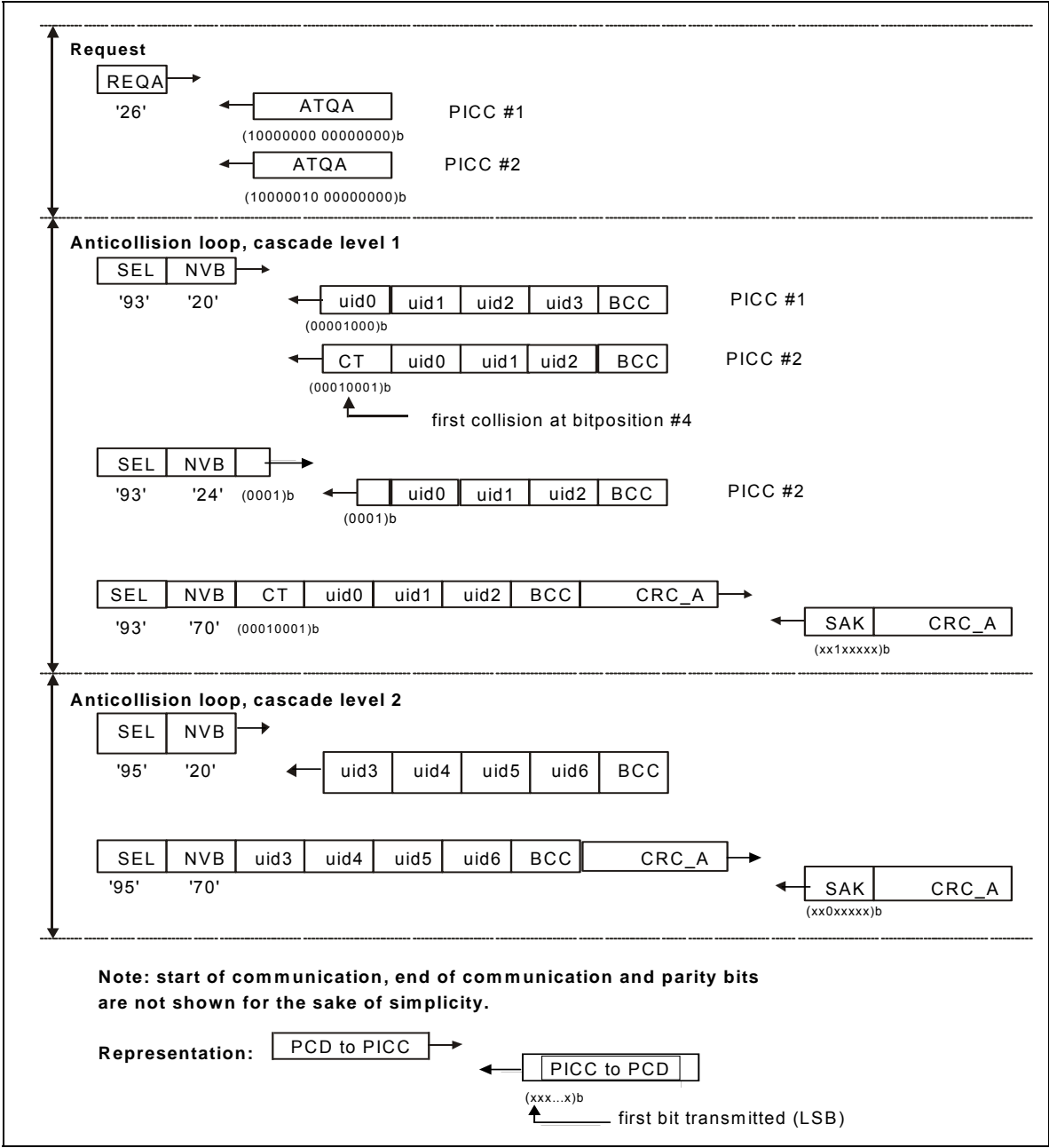


Figure A.1 —Select sequence with bit frame anticollision

Explanations to Figure A.1:

Request	<ul style="list-style-type: none"> — PCD transmits the REQA command — All PICCs respond with their ATQA: <ul style="list-style-type: none"> — PICC #1 indicates bit frame anticollision and UID size: single; — PICC #2 indicates bit frame anticollision and UID size: double.
Anticollision loop, cascade level 1	<ul style="list-style-type: none"> — PCD transmits an ANTICOLLISION command: <ul style="list-style-type: none"> — SEL specifies bit frame anticollision and cascade level 1; — the value '20' of NVB specifies that the PCD will transmit no part of UID CL1; — consequently all PICCs in the field respond with their complete UID CL1; — due to the value '88' of the cascade tag, the first collision occurs at bit position #4; — PCD transmits another ANTICOLLISION command that includes the first 3 bits of UID CL1 that were received before the collision occurs, followed by a (1)b. Consequently the PCD assigns NVB with the value '24'; — these 4 bits correspond to the first bits of UID CL1 of PICC #2; — PICC #2 responds with its 36 remaining bits of UID CL1. Since PICC #1 does not respond, no collision occurs; — since the PCD "knows" all bits of UID CL1 of PICC #2, it transmits a SELECT command for PICC #2; — PICC #2 responds with SAK, indicating that UID is not complete; — consequently, the PCD increases the cascade level.
Anticollision loop, cascade level 2	<ul style="list-style-type: none"> — PCD transmits another ANTICOLLISION command: <ul style="list-style-type: none"> — SEL specifies bit frame anticollision and cascade level 2; — NVB is reset to '20' to force PICC #2 to respond with its complete UID CL2; — PICC #2 responds with all 40 bits of its UID CL2; — PCD transmits the SELECT command for PICC #2, cascade level 2; — PICC #2 responds with SAK, indicating that UID is complete, and transits from READY state to PROTOCOL state.

Annex B (informative)

CRC_A and CRC_B encoding

B.1 CRC_A encoding

This Annex is provided for explanatory purposes and indicates the bit patterns that will exist in the physical layer. It is included for the purpose of checking an ISO/IEC 14443-3 Type A implementation of CRC_A encoding.

The process of encoding and decoding may be conveniently carried out by a 16-stage cyclic shift register with appropriate feedback gates. According to ITU-T Recommendation V.41, ANNEX I, Figures I-1/V.41 and I-2/V.41 the flip-flops of the register shall be numbered from FF0 to FF15. FF0 shall be the leftmost flip-flop where data is shifted in. FF15 shall be the rightmost flip-flop where data is shifted out.

Table B.1 defines the initial content of the register.

Table B.1 — Initial content of 16-stage shift register according to value '6363'

FF0	FF1	FF2	FF3	FF4	FF5	FF6	FF7	FF8	FF9	FF10	FF11	FF12	FF13	FF14	FF15
0	1	1	0	0	0	1	1	0	1	1	0	0	0	1	1

Consequently, FF0 corresponds to the MSB and FF15 to the LSB.

Examples of bit patterns that will be transmitted via standard frames

EXAMPLE 1 Transmission of data, first byte = '00', second byte = '00', CRC_A appended.

Calculated CRC_A = '1EA0'

S	0000 0000	1	0000 0000	1	0000 0101	1	0111 1000	1	E
	'00'	P	'00'	P	'A0'	P	'1E'	P	

Figure B.1 — Example 1 for CRC_A encoding

Table B.2 — Content of 16-stage shift register according to value '1EA0'

FF0	FF1	FF2	FF3	FF4	FF5	FF6	FF7	FF8	FF9	FF10	FF11	FF12	FF13	FF14	FF15
0	0	0	1	1	1	1	0	1	0	1	0	0	0	0	0

EXAMPLE 2 Transmission of data block, first byte = '12', second byte = '34', CRC_A appended.

Calculated CRC_A = 'CF26'

S	0100 1000	1	0010 1100	0	0110 0100	0	1111 0011	1	E
	'12'	P	'34'	P	'26'	P	'CF'	P	

Figure B.2 — Example 2 for CRC_A encoding

Table B.3 — Content of 16-stage shift register according to value 'CF26'

FF0	FF1	FF2	FF3	FF4	FF5	FF6	FF7	FF8	FF9	FF10	FF11	FF12	FF13	FF14	FF15
1	1	0	0	1	1	1	1	0	0	1	0	0	1	1	0

B.2 CRC_B encoding

This Annex is provided for explanatory purposes and indicates the bit patterns that will exist in the physical layer. It is included for the purpose of checking an ISO/IEC 14443-3 Type B implementation of CRC_B encoding. Refer to ISO/IEC 13239 and ITU-T X.25 #2.2.7 and V.42 #8.1.1.6.1 for further details.

Initial Value = 'FFFF'.

Examples of bit patterns that will be transmitted via standard frames

EXAMPLE 1 Transmission of first byte = '00', second byte = '00', third byte = '00', CRC_B appended. Calculated CRC_B = 'C6CC'

		1st byte	2nd byte	3rd byte	CRC_B		
Frame =	SOF	'00'	'00'	'00'	'CC'	'C6'	EOF

Figure B.3 — Example 1 for CRC_B encoding

EXAMPLE 2 Transmission of first byte = '0F', second byte = 'AA', third byte = 'FF', CRC_B appended. Calculated CRC_B = 'D1FC'

		1st byte	2nd byte	3rd byte	CRC_B		
Frame =	SOF	'0F'	'AA'	'FF'	'FC'	'D1'	EOF

Figure B.4 — Example 2 for CRC_B encoding

EXAMPLE 3 Transmission of first byte = '0A', second byte = '12', third byte = '34', fourth byte = '56', CRC_B appended. Calculated CRC_B = 'F62C'

		1st byte	2nd byte	3rd byte	4th byte	CRC_B		
Frame =	SOF	'0A'	'12'	'34'	'56'	'2C'	'F6'	EOF

Figure B.5 — Example 3 for CRC_B encoding

B.3 Code sample written in C language for CRC calculation

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <ctype.h>

#define CRC_A 1
#define CRC_B 2
#define BYTE unsigned char
```

```

unsigned short UpdateCrc(unsigned char ch, unsigned short *lpwCrc)
{
    ch = (ch^(unsigned char)((*lpwCrc) & 0x00FF));

    ch = (ch^(ch<<4));

    *lpwCrc = (*lpwCrc >> 8)^((unsigned short)ch << 8)^((unsigned short)ch<<3)^((unsigned short)ch>>4);

    return(*lpwCrc);
}

void ComputeCrc(int CRCType, char *Data, int Length,
    BYTE *TransmitFirst, BYTE *TransmitSecond)
{
    unsigned char chBlock;
    unsigned short wCrc;

    switch(CRCType) {
        case CRC_A:
            wCrc = 0x6363; /* ITU-V.41 */
            break;
        case CRC_B:
            wCrc = 0xFFFF; /* ISO/IEC 13239 (formerly ISO/IEC 3309) */
            break;
        default:
            return;
    }

    do {
        chBlock = *Data++;
        UpdateCrc(chBlock, &wCrc);
    } while (--Length);
    if (CRCType == CRC_B)
        wCrc = ~wCrc; /* ISO/IEC 13239 (formerly ISO/IEC 3309) */

    *TransmitFirst = (BYTE) (wCrc & 0xFF);
    *TransmitSecond = (BYTE) ((wCrc >> 8) & 0xFF);

    return;
}

BYTE BuffCRC_A[10] = {0x12, 0x34};
BYTE BuffCRC_B[10] = {0x0A, 0x12, 0x34, 0x56};
unsigned short Crc;
BYTE First, Second;
FILE *OutFd;
int i;

int main(void)
{
    printf("CRC-16 reference results ISO/IEC 14443-3\n");
    printf("Crc-16 G(x) = x^16 + x^12 + x^5 + 1\n\n");
    printf("CRC_A of [ ");
    for(i=0; i<2; i++) printf("%02X ",BuffCRC_A[i]);
    ComputeCrc(CRC_A, BuffCRC_A, 2, &First, &Second);
    printf("] Transmitted: %02X then %02X.\n", First, Second);
    printf("CRC_B of [ ");
    for(i=0; i<4; i++) printf("%02X ",BuffCRC_B[i]);

```

```
    ComputeCrc(CRC_B, BuffCRC_B, 4, &First, &Second);  
    printf("] Transmitted: %02X then %02X.\n", First, Second);  
  
    return(0);  
}
```

Annex C (informative)

Type A timeslot – Initialization and anticollision

This Annex describes the timeslot anticollision sequence applicable for PICCs of Type A. A PCD supporting Polling for both of Type A and Type B is not required to support this sequence as a mandatory anticollision sequence as described in clause 5.

C.1. Terms and abbreviations

The following are specific to this section of ISO/IEC 14443-3.

ATQA_t	Answer To reQuest of Type A_ timeslot
ATQ-ID	Answer To REQ-ID
CID_t	Card IDentifier of Type A_ timeslot
HLTA_t	HALT command of Type A_ timeslot
REQA_t	REQuest command of Type A_ timeslot
REQ-ID	REQuest-ID command
SAK_t	Select AKnowledge of Type A_ timeslot
SEL_t	SElect command of Type A_ timeslot

C.2. Timing and frame format

C.2.1. Timing definitions

Polling reset time

Polling reset times of Type A_ timeslot are equal to those of Type A in clause 5.

Time interval from REQA_t to ATQA_t

PICC returns ATQA_t after waiting for 32 +/- 2 etu upon receiving REQA_t. The PCD may not recognize the coding of the ATQA_t.

Request Guard Time

The Request Guard Time is defined as the minimum time between the start of bits of two consecutive Request commands. Its value shall be 0,5 ms.

Frame Guard Time

The Frame Guard Time is defined as the minimum time between the rising edge of the last bit and the falling edge of the start bit of two consecutive frames in opposite direction. Its value shall be 10 etu.

Timeslot length

The first timeslot starts in 32 etu after REQ-ID. Each timeslot length is 104 etu consisting of 94 etu for ATQ-ID reception and 10 etu frame guard time succeeding.

C.2.2. Frame formats

REQA_t frame

See 6.1.5.1 and Table 2. The data content is '35' for a REQA_t.

Standard frame

The LSB of each byte is transmitted first. Each byte has no parity. CRC_B is defined in 7.2.

S	data: $n \cdot (8 \text{ data bits} + \text{no parity})$				CRC_B	E
	1byte	(0 or 1byte)	(0 or 1 byte)	(0 or 8 bytes)	2 bytes	
	command or response	(parameter 1)	(parameter 2)	(UID)		

C.3. PICC states

The following clauses provide the states for a PICC, Type A_timeslot.

POWER-OFF state

In the POWER-OFF state, the PICC is not energized due to lack of carrier and shall not emit subcarrier.

IDLE state

This state is entered after the field has been active within a 5 ms delay. The PICC recognizes REQA_t.

READY state

This state is entered by REQA_t. The PICC recognizes REQA_t, REQ-ID and SEL_t.

ACTIVE state

This state has two substates. The first sub-state is entered by SEL_t with its complete UID and CID_t. In this sub-state, the PICC recognizes HLTA_t and proprietary higher layer commands. The second substate is in ISO/IEC 14443-4 and entered from the first sub-state by a command defined in ISO/IEC 14443-4.

HALT state

This state is entered by HLTA_t from ACTIVE state. In this state, the PICC is mute.

C.4. Command/response set

Four sets of command and response are used.

Type	Name	Coding (b8-b1)	Meaning
Command	REQA_t	(b7-b1) (0110101)b (= '35')	Request PICC Type A timeslot to answer ATQA_t.
Response	ATQA_t	any one-byte content of '00' to 'FF'	Answer to REQA_t. PCD can recognize the existence of Type A timeslot PICC. However, the PCD is not required to recognize the coding of the ATQA_t.
Command	REQ-ID	(00001000)b (= '08')	Request the PICC to answer its UID to one of timeslots. REQ-ID is followed by two parameters.
Response	ATQ-ID	(00000110)b (= '06')	Answer 8-byte UID to one of 4 timeslots. ATQ-ID is followed by its 8-byte UID.
Command	SEL_t	(01000NNN)b, (NNN=CID_t No.(0-7)) (01100NNN)b, (NNN+8=CID_t No.(8-15))	Select the PICC with its UID and set the CID_t. SEL_t is followed by 8-byte UID.
Response	SAK_t	b8-b5 (1000)b: Additional information available in protocols b8-b5 (1100)b: Default mode in protocols b4-b1(0000)b: Other than ISO/IEC 14443-4 b4-b1(0001)b: PICC supports ISO/IEC 14443-4	Acknowledge SEL_t.
Command	HLTA_t	(00011NNN)b, (NNN=CID_t No.(0-7)) (00111NNN)b, (NNN+8=CID_t No.(8-15))	Halt the PICC with its CID_t.
Response	Answer to HLTA_t	(00000110)b (= '06')	Acknowledge HLTA_t.

Parameters of REQ-ID command

Parameters		Meaning
P1	b8-b7	Timeslot length, b7=1: for 8-byte UID, b8=0
	b6-b1	Number of timeslots, b3=1: for 4 timeslots, Others=0
P2		'00'

C.5. Timeslot anticollision sequence

The flow chart of PICC anticollision sequence is shown as below in Figure C.1.

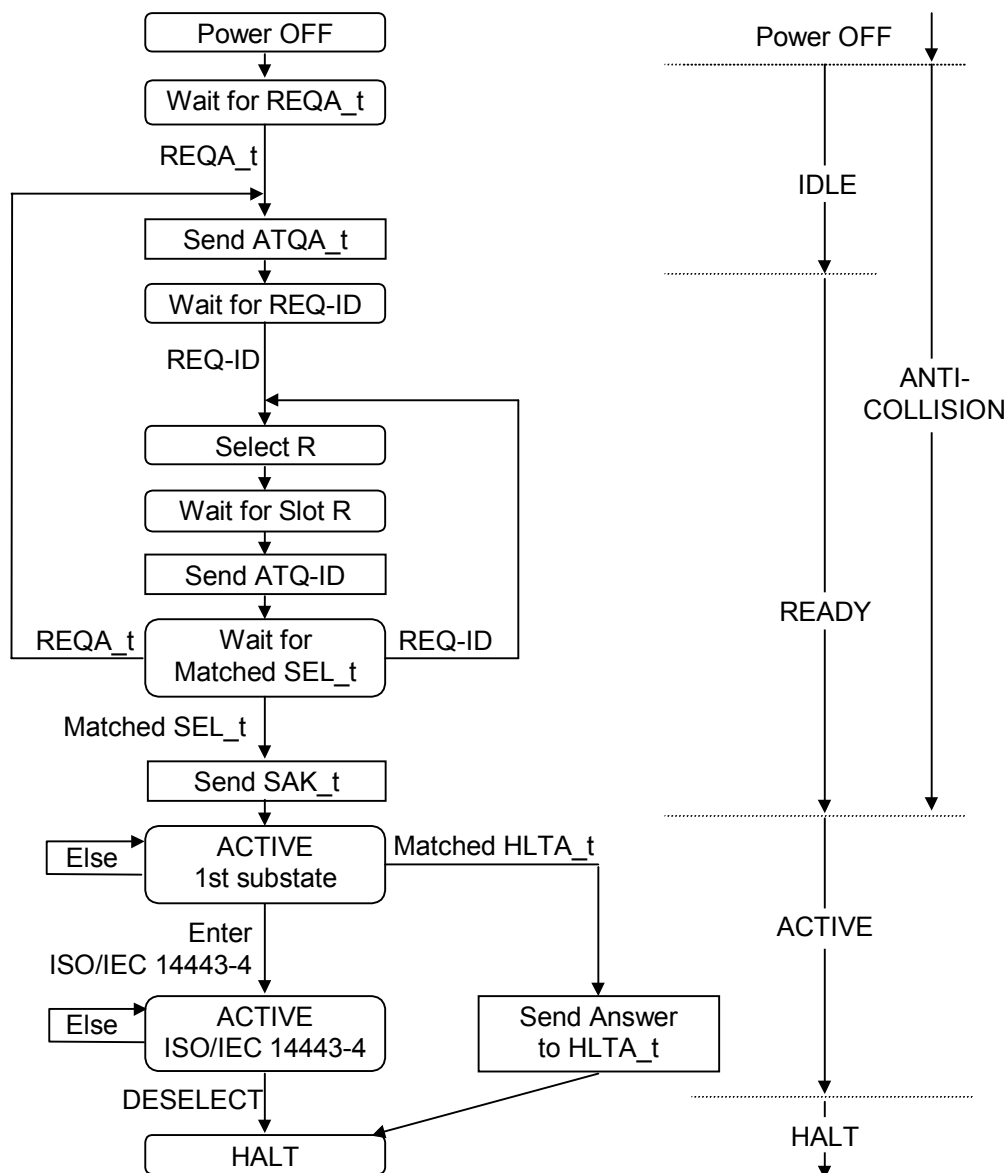
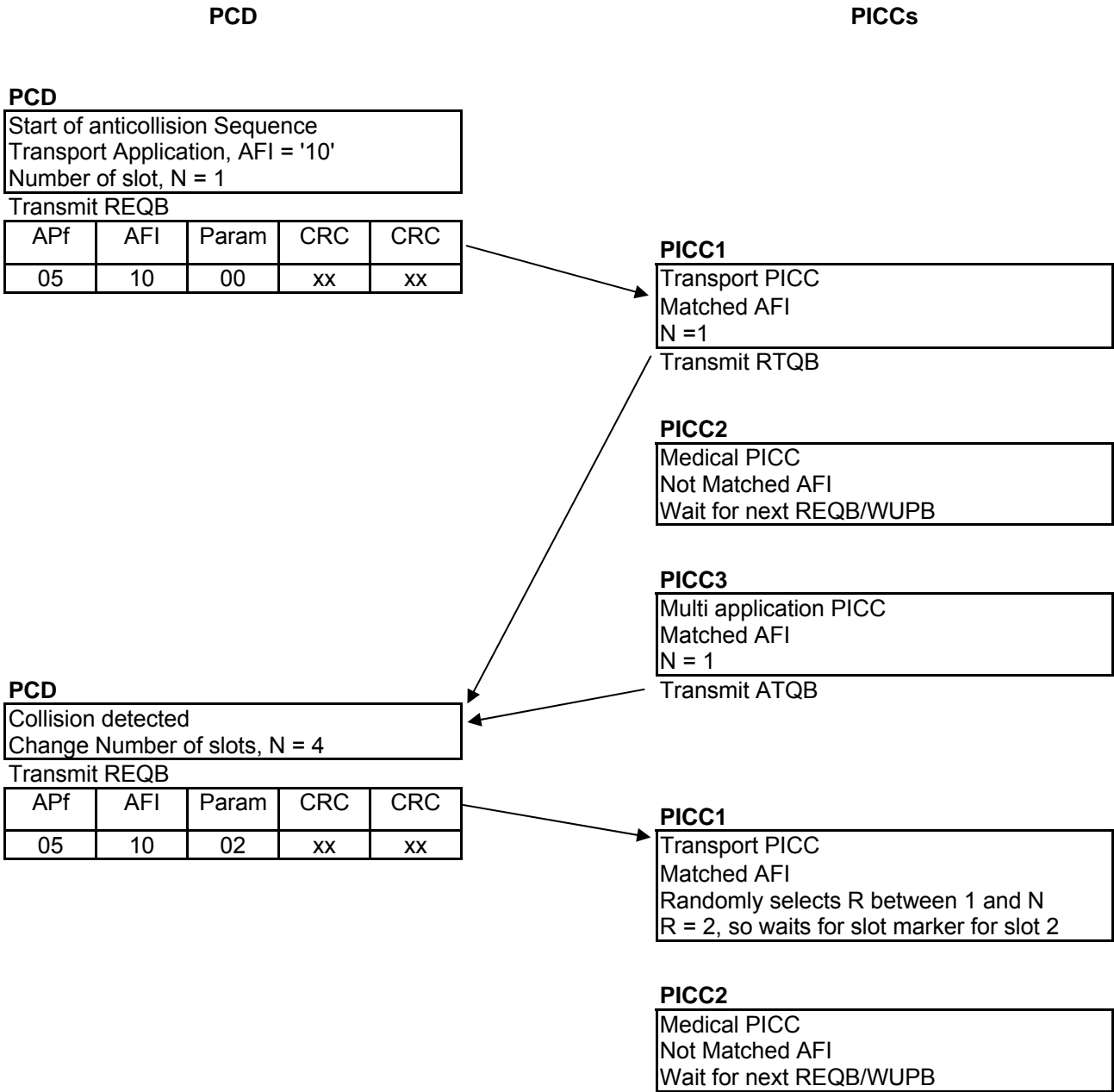


Figure C.1 — Flow chart of PICC anticollision sequence

Annex D
(informative)

Example of Anticollision Sequence

NOTE Type B anticollision is a flexible set of commands to allow the anticollision strategy to be developed for the application.



Continued next page

