
**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

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Foreword

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

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In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. 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.

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

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*

Annexes A, B, C and D of this part of ISO/IEC 14443 are for information only.

Introduction

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

This part of ISO/IEC 14443 describes 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.

The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this part of ISO/IEC 14443 may involve the use of patents.

ISO and IEC take no position concerning the evidence, validity and scope of this patent right.

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US Patent 4,810,862 and JP 2564480
"System for judging propriety of use of an integrated circuit card with a card terminal", issued on March 07, 1989

Japan Patent No. 2564480
US Patent No. 4810862
British Patent No. 209092
German Patent No. P 3689089.8
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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 Part of the timing of data communication is defined in ISO/IEC 14443-2.

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 7816-3:1997, *Information technology — Identification cards — Integrated circuit(s) cards with contacts — Part 3: Electronic signals and transmission protocols.*

ISO/IEC 7816-5, *Identification cards — Integrated circuit(s) cards with contacts — Part 5: Numbering system and registration procedure for application identifiers.*

ISO/IEC 7816-6:1996/Amd.1:2000, *Identification cards — Integrated circuit(s) cards with contacts — Part 6: Interindustry data elements — Amendment 1: IC manufacturer registration.*

ISO/IEC 14443-3:2001(E)

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

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.*

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 networks by dedicated circuit.*

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

ITU-T V.42, *Error-correcting procedures for DCEs 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, ISO/IEC 7816-3 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

bit collision detection protocol

anticollision method for PICCs of Type A, employing collision detection at bit level within a frame

3.3

byte

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

3.4

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

3.5

elementary time unit

etu

for this part of ISO/IEC 14443, one etu is defined as $1 \text{ etu} = 128/f_c$ (i.e. 9,4 μs nominal)

3.6

frame

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

3.7

higher layer protocol

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

3.8

timeslot protocol

method whereby a PCD establishes logical channels with one or more PICCs of Type B, which makes use of timeslot allocation for PICC response

3.9**request command**

command requesting PICC 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	UID CLn check byte, calculated as exclusive-or over the 4 previous bytes, Type A
CID	Card IDentifier
CLn	Cascade Level n, Type A
CT	Cascade Tag, Type A
CRC_A	Cyclic Redundancy Check error detection code A
CRC_B	Cyclic Redundancy Check error detection code B
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>fc</i>	Carrier frequency
FO	Frame Option
<i>fs</i>	Subcarrier frequency
FWI	Frame Waiting time Integer
FWT	Frame Waiting Time
HLTA	Halt Command, Type A
HLTB	Halt Command, Type B

ISO/IEC 14443-3:2001(E)

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 or PICC response probability in each slot, Type B
n	Variable integer value as defined in the specific clause
NAD	Node ADdress
NVB	Number of Valid Bits, Type A
P	Odd Parity bit, Type A
PCD	Proximity Coupling Device
PICC	Proximity Card
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 ISO/IEC Use
S	Start of communication, Type A
SAK	Select Acknowledge, Type A
SEL	SElect code, Type A
SELECT	Select Command, Type A
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
UID	Unique Identifier, Type A
uidn	Byte number <i>n</i> 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 Polling

In order to detect PICCs which are in the operating field, a PCD shall send repeated Request commands. The PCD shall send REQA and REQB described herein in any sequence and in addition 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 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 within 5 ms of unmodulated operating field.

6 Type A – Initialization and anticollision

This section describes the initialization and collision detection protocol applicable for PICCs of Type A.

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).

6.1 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

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

6.1.1 Frame delay time

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

6.1.2 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 1 defines values for n and FDT depending on the command type and the logic state of the last transmitted data bit in this command.

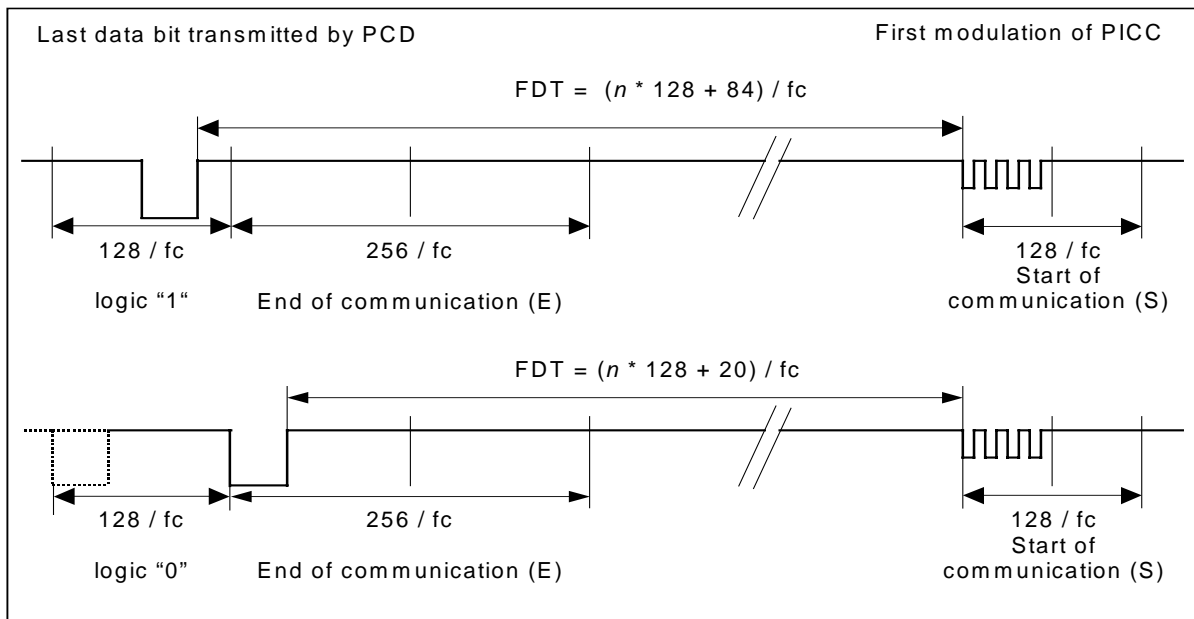


Figure 1 — Frame delay time PCD to PICC

Table 1 — 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	$1236 / fc$	$1172 / fc$
All other commands	≥ 9	$(n * 128 + 84) / fc$	$(n * 128 + 20) / fc$

The value $n = 9$ means that all PICCs in the field shall respond in a synchronous way which is needed for anticollision.

For all other commands the PICC shall ensure that the first modulation edge within the start bit is aligned to the bit-grid defined in Figure 1.

6.1.3 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 $1172 / fc$.

6.1.4 Request Guard Time

The Request Guard Time is defined as the minimum time between the start bits of two consecutive REQA commands. It has the value $7000 / f_c$.

6.1.5 Frame formats

The following frame types are defined:

- short frames for commands defined in Table 2;
- standard frames for regular commands;
- bit oriented anticollision frame for anticollision command.

6.1.5.1 Short frame

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

- start of communication;
- 7 data bits transmitted LSB first (for coding see Table 2);
- end of communication.

No parity bit is added.

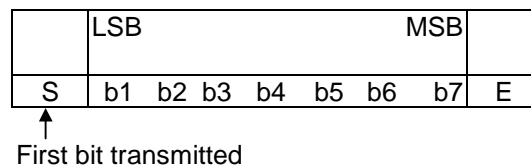


Figure 2 — Short frame

6.1.5.2 Standard frame

Standard frames are used for data exchange and consist of:

- start of communication;
- $n * (8 \text{ data bits} + \text{odd parity bit})$, 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 (b1 to b8, P);
- end of communication.

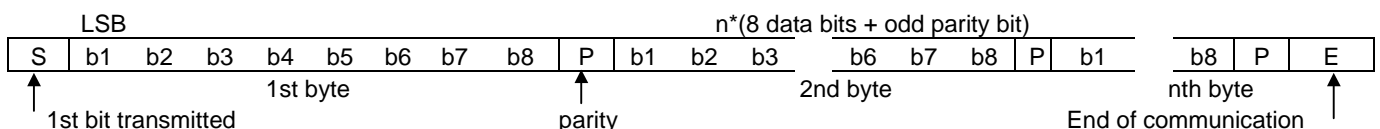


Figure 3 — Standard Frame

6.1.5.3 Bit oriented anticollision frame

A collision is detected when at least two PICCs transmit different bit patterns to the PCD. In this case the carrier is modulated with the subcarrier for the whole bit duration for at least one bit.

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 55 data bits.

Consequently, the minimum length of part 2 shall be 1 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 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.

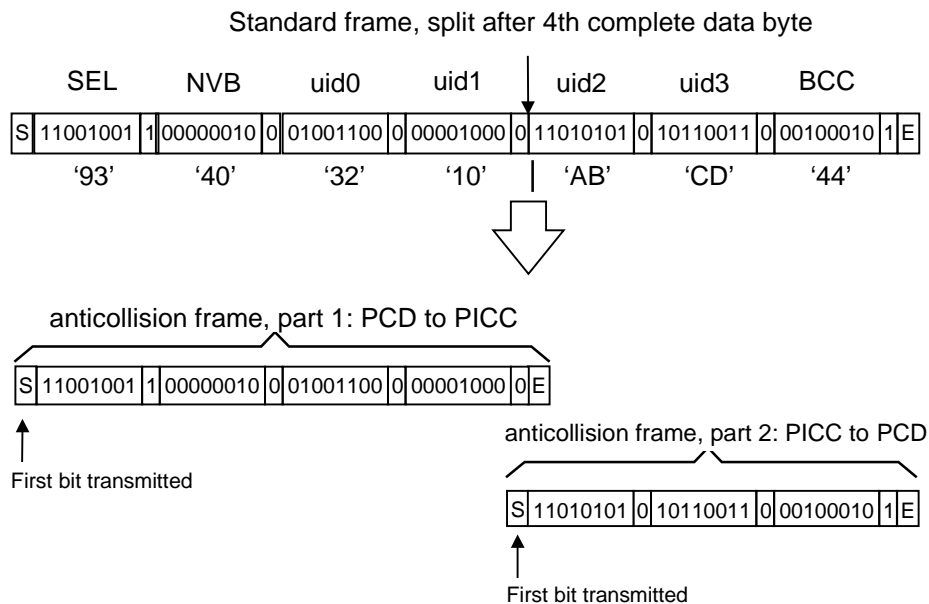


Figure 4 — Bit organization and transmission of bit oriented anticollision frame, case FULL BYTE

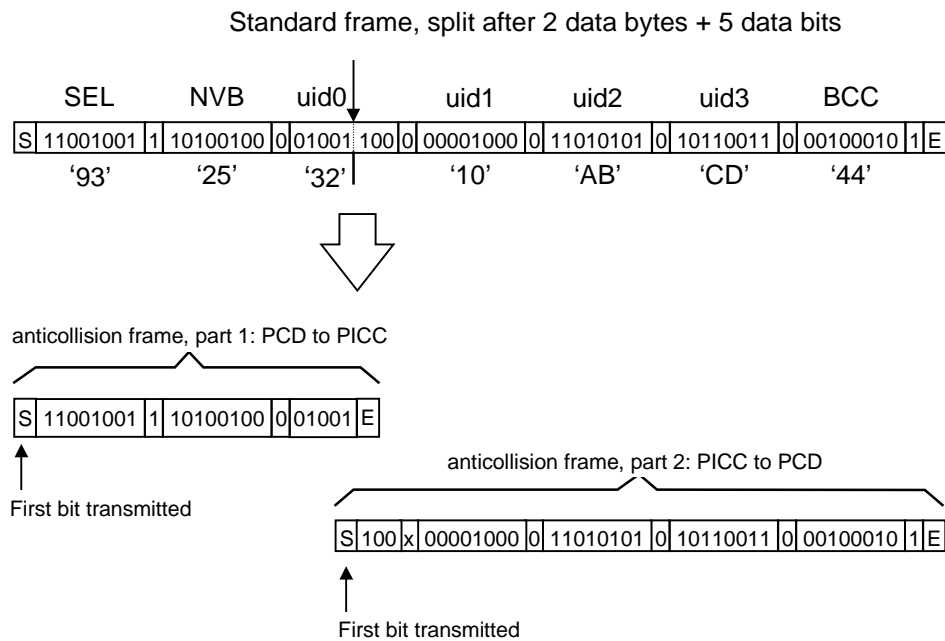


Figure 5 — Bit organization and transmission of bit oriented anticollision frame, case SPLIT BYTE

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

6.1.6 CRC_A

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 an example refer to annex B.

6.2 PICC states

The following sections provide descriptions of the states for a PICC of Type A specific to the bit collision detection protocol.

The following state diagram takes all possible state transitions caused by commands of this part of ISO/IEC 14443 into account.

PICCs react to valid received frames only. No response is sent when transmission errors are detected.

The following symbols apply for the state diagram shown in Figure 6 below.

AC	ANTICOLLISION Command (matched UID)
nAC	ANTICOLLISION Command (not matched UID)
SELECT	SELECT Command (matched UID)
nSELECT	SELECT Command (not matched UID)

DESELECT DESELECT Command, defined in ISO/IEC 14443-4

Error transmission error detected

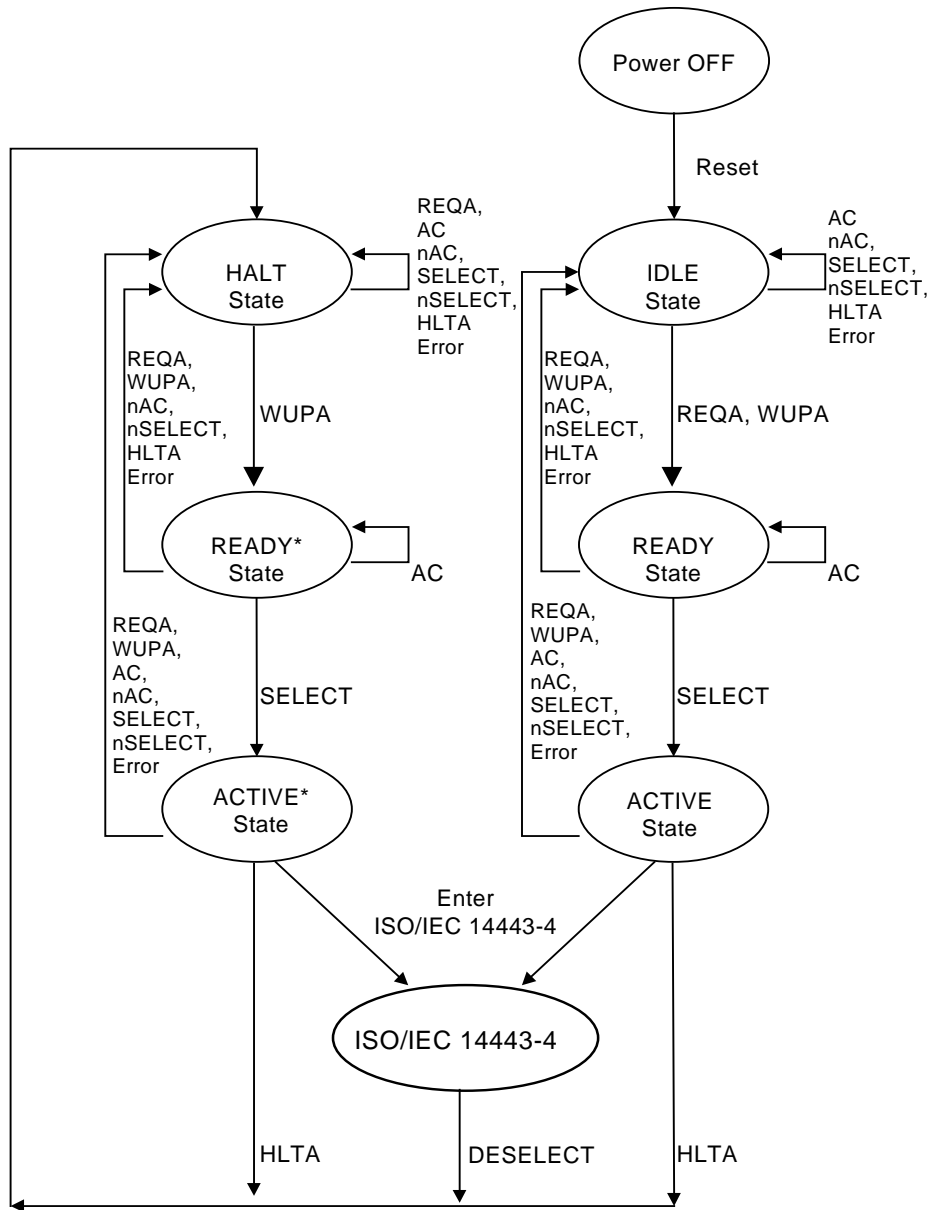


Figure 6 — PICC Type A state diagram

PICCs being compliant with ISO/IEC 14443-3 but not using ISO/IEC 14443-4 may leave the ACTIVE or ACTIVE* State by proprietary commands.

6.2.1 POWER-OFF State

Description:

In the POWER-OFF State, the PICC is not powered due to a lack of carrier energy.

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.

6.2.2 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.

6.2.3 READY State**Description:**

In the READY State, either the bit frame anticollision or a proprietary anticollision method can 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.

6.2.4 ACTIVE State**Description:**

In the ACTIVE State, the PICC listens to any higher layer message.

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.

6.2.5 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.

6.2.6 READY* State**Description:**

The READY* State is similar to the READY State, either the bit frame anticollision or a proprietary anticollision method can 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.

6.2.7 ACTIVE* State

Description:

The ACTIVE* State is similar to the ACTIVE State, the PICC is selected and listens to any higher layer message.

State exit conditions and transitions:

The PICC enters the HALT State when a valid HLTA Command is received.

6.3 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.

6.3.1 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 6 to check in which cases PICC 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 2 shows the coding of REQA and WUPA Commands which use the Short frame format.

Table 2 — 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

6.3.2 ANTICOLLISION and SELECT Commands

These commands are used during an anticollision loop (see Figure 4 and 5). The ANTICOLLISION and SELECT Commands consist of:

- select code SEL (1 byte);
- number of valid bits NVB (1 byte, for coding see Table 7);
- 0 to 40 data bits of UID CL_n according to the value of NVB.

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.

6.3.3 HLTA Command

The HLTA Command consists of two bytes followed by CRC_A and shall be transmitted within Standard Frame.

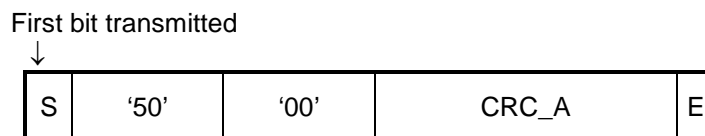


Figure 7 — Standard frame containing HLTA Command

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'.

6.4 Select sequence

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

6.4.1 Select sequence flowchart

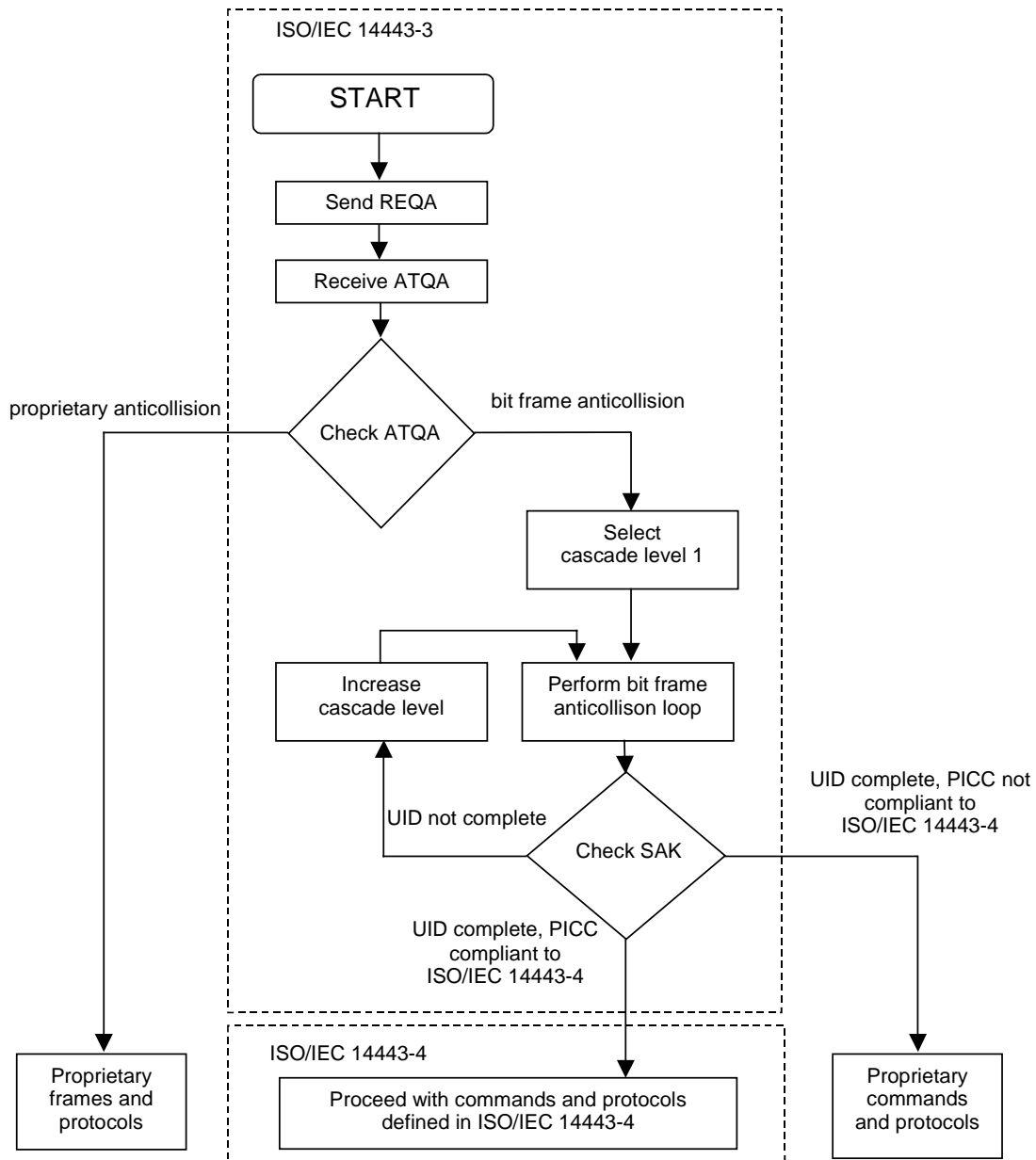


Figure 8 — Initialization and anticollision flowchart for PCD

6.4.2 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.

6.4.2.1 Coding of ATQA

Table 3 — 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.

6.4.2.2 Coding rules for bit frame anticollision

- Rule 1: Bits b7 and b8 code the UID size (single, double or triple, see Table 4).
- Rule 2: 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 5)

NOTE Bit 9 to bit 12 indicate additional and proprietary methods

Table 4 — 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 5 — Coding of b1 - 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

6.4.3 Anticollision and Select

6.4.3.1 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 type and 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 CLn. Consequently this command forces all PICCs in the field to respond with their complete UID CLn.
Step 3	The PCD shall transmit SEL and NVB.
Step 4	All PICCs in the field shall respond with their complete UID CLn.
Step 5	Assuming the PICCs in the field have unique serial numbers, then if more than one PICC responds, a collision occurs. 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 CLn. The valid bits shall be part of the UID CLn 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 CLn is equal to the valid bits transmitted by the PCD shall transmit their remaining bits of the UID CLn.
Step 10	If further collisions occur, steps 6 to 9 shall be repeated. The maximum number of loops will be 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 CLn.
Step 12	The PCD shall transmit SEL and NVB, followed by all 40 bits of UID CLn, followed by CRC_A checksum.
Step 13	The PICC which UID CLn matches the 40 bits shall respond with its 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 9 explains steps 1 to 13.

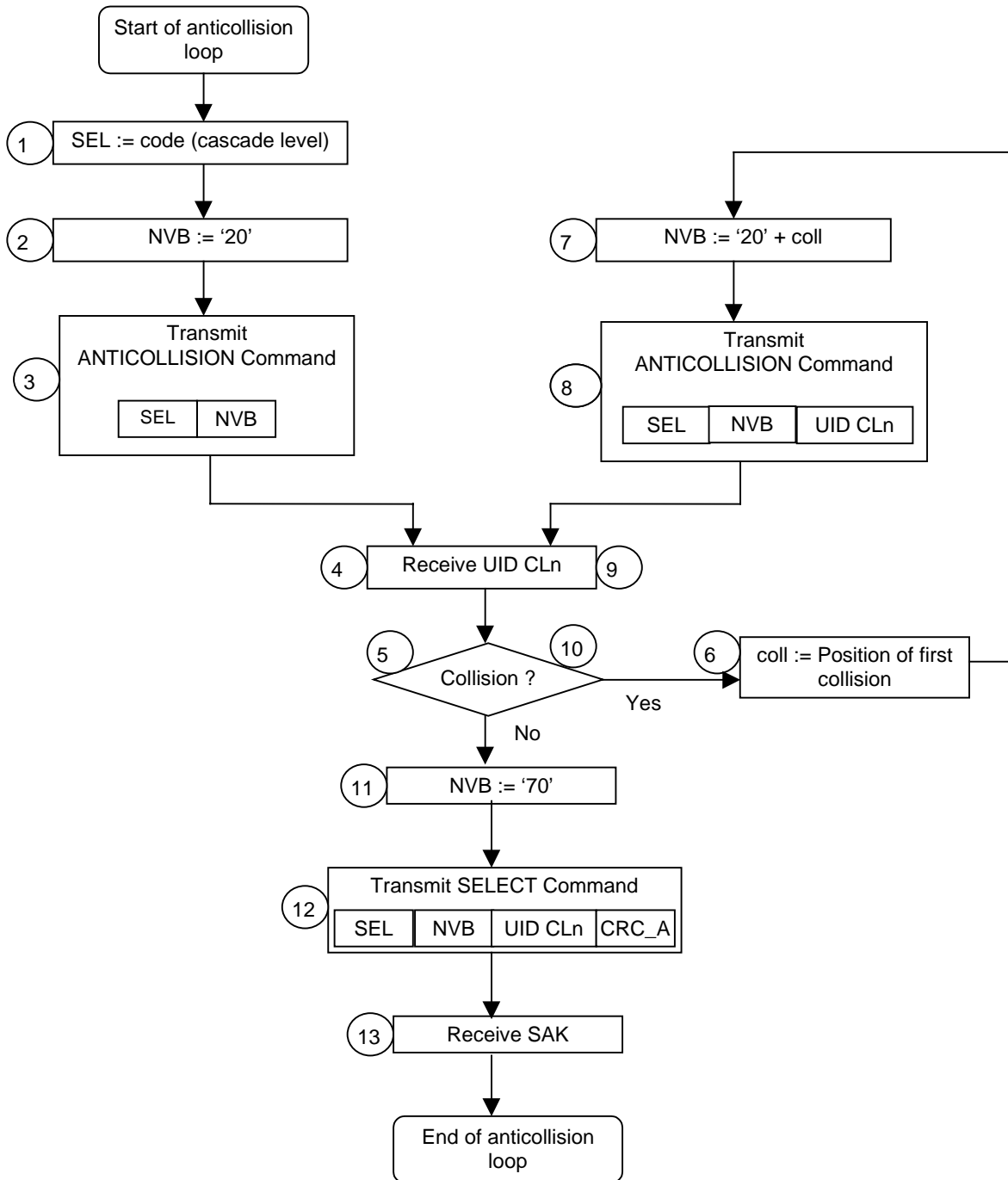


Figure 9 — Anticollision loop, flowchart for PCD

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

6.4.3.2 Coding of SEL (Select code)

Length: 1 byte

Possible values: '93', '95', '97'

Table 6 — 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

6.4.3.3 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 7 — 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

6.4.3.4 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 CLn.

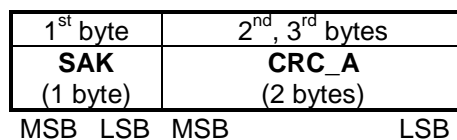


Figure 10 — Select acknowledge (SAK)

The coding of bits b3 (cascade bit) and b6 is given in Table 8.

Table 8 — 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

6.4.4 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. According to the cascade level, three types of UID size are defined. This UID size shall be consistent with Table 4.

Table 9 — UID size

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

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 10 — Single size UIDs

uid0	Description
'08'	uid1 to uid3 is a random number which is dynamically generated
'x0' - 'x7'	proprietary fixed number
'x9' - 'xE'	
'18' - 'F8'	RFU
'xF'	

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

Table 11 — Double and triple size UIDs

uid0	Description
Manufacturer ID according to ISO/IEC 7816-6/AM1*	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 'Private use' in ISO/IEC 7816-6/AM1 shall not be allowed in this context.	

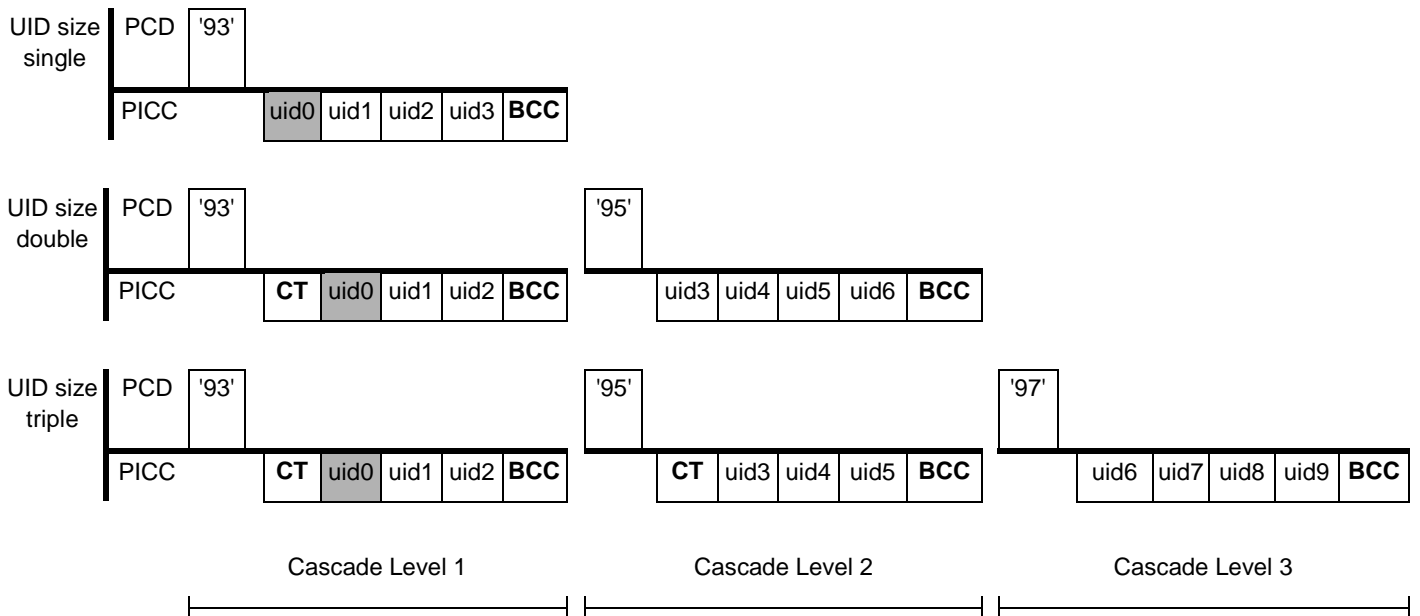


Figure 11 — Usage of cascade levels

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

7 Type B – Initialization and anticollision

This section describes the initialization and collision detection protocol applicable for PICCs of Type B.

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 Anti-collision 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.

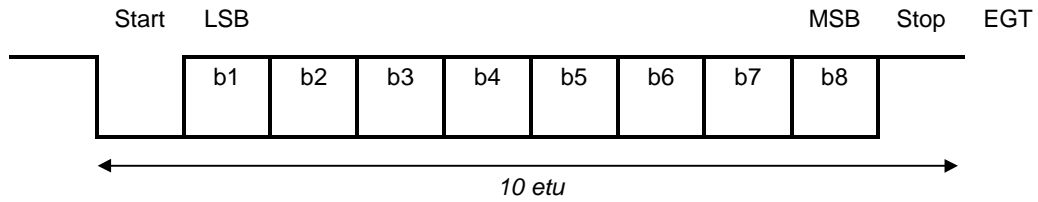


Figure 12 — Character format

Bit boundaries within a character shall occur between $(n - 0,125)$ etu and $(n + 0,125)$ etu where n is the number of bit boundaries after the start bit falling edge ($1 \leq n \leq 9$).

7.1.2 Character separation

A character is 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 57 μ s.

The EGT between 2 consecutive characters sent by the PICC to the PCD shall be between 0 and 19 μ s.

7.1.3 Frame format

PCDs and PICCs shall send characters as frames. The frame is normally delimited by SOF and by EOF. See 7.10.3 for exceptions.

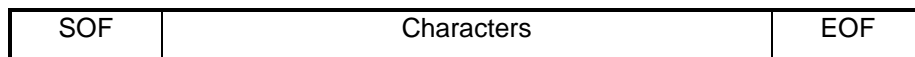


Figure 13 — Frame Format

7.1.4 SOF

SOF is composed of:

- one falling edge;
- followed by 10 etu with a logic "0";
- followed by one single rising edge located anywhere within the following etu;
- followed by at least 2 etu (but no more than 3 etu) with a logic "1".

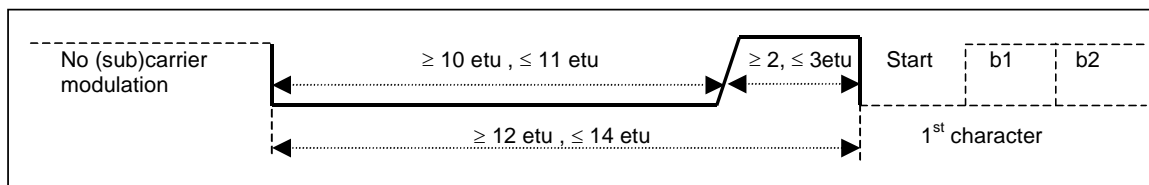


Figure 14 — SOF

7.1.5 EOF

EOF is composed of:

- one falling edge;
- followed by 10 etu with a logic "0";
- followed by one single rising edge located anywhere within the following etu.

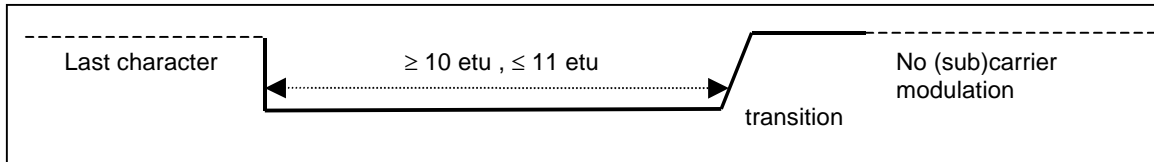


Figure 15 — EOF

NOTE The probability of receiving a false EOF is low and corresponds to the transmission of a '00' character with a wrong reception of the stop bit.

7.1.6 Timing before the PICC SOF

PICC start of communication after a PCD data transmission shall respect the timing defined in Figure 16.

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 $256/f_s$ for ATQB only and $(256/f_s) \cdot 2^{FWI}$ for all other frames (see 7.9.4.3).

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

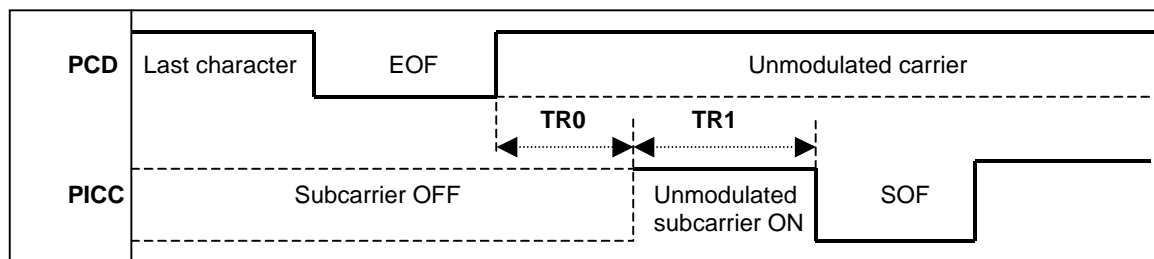


Figure 16 — PICC subcarrier SOF

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

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 17.

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.

The minimum delay between the PICC EOF start (falling edge) and the PCD SOF start (falling edge) is $10 \text{ etu} + 32 / f_s$.

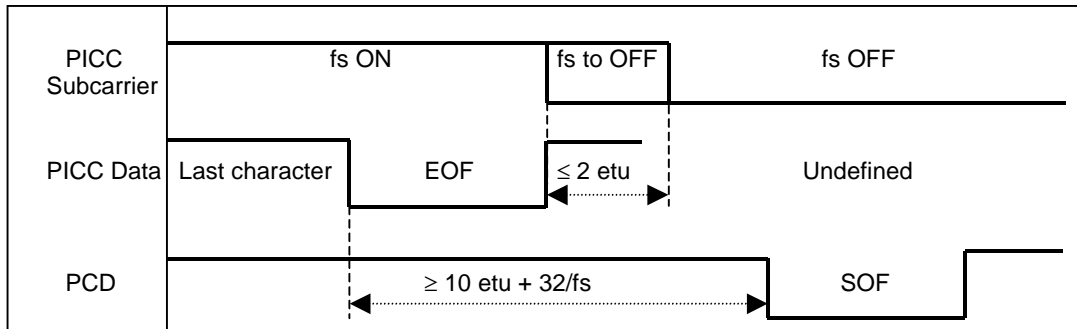


Figure 17 — PICC to PCD EOF

7.2 CRC_B

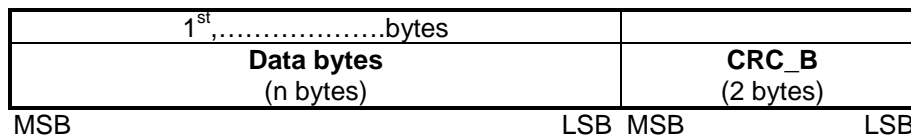


Figure 18 — Position of a CRC_B within a frame

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 example 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 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 timeslots 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 timeslot 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.

The set of commands allows implementation of different anticollision management strategies at the PCD level. This strategy is under the control of the application designer and can include:

- probabilistic (repetitive single slot prompt with response probability less than or equal to 1);
- pseudo-deterministic (multiple slots with scanning of them during the anticollision sequence to have the maximum probability that all present PICCs answer);
- any combination of these methods that can be conducted dynamically.

7.4 PICC states description

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

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

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 CCITT 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

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);
}
```

Only

KATS Internal User

Annex C (informative)

Type A timeslot – Initialization and anticollision

This annex describes the timeslot detection protocol applicable for PICCs of Type A. A PCD supporting Polling for both of Type A and Type B is not required to support this detection protocol as a mandatory anticollision protocol 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 *(8 data bits +no parity)				CRC_B 2 bytes	E
	1byte command or response	(0 or 1byte) (parameter 1)	(0 or 1 byte) (parameter 2)	(0 or 8 bytes) (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 sub-state 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.

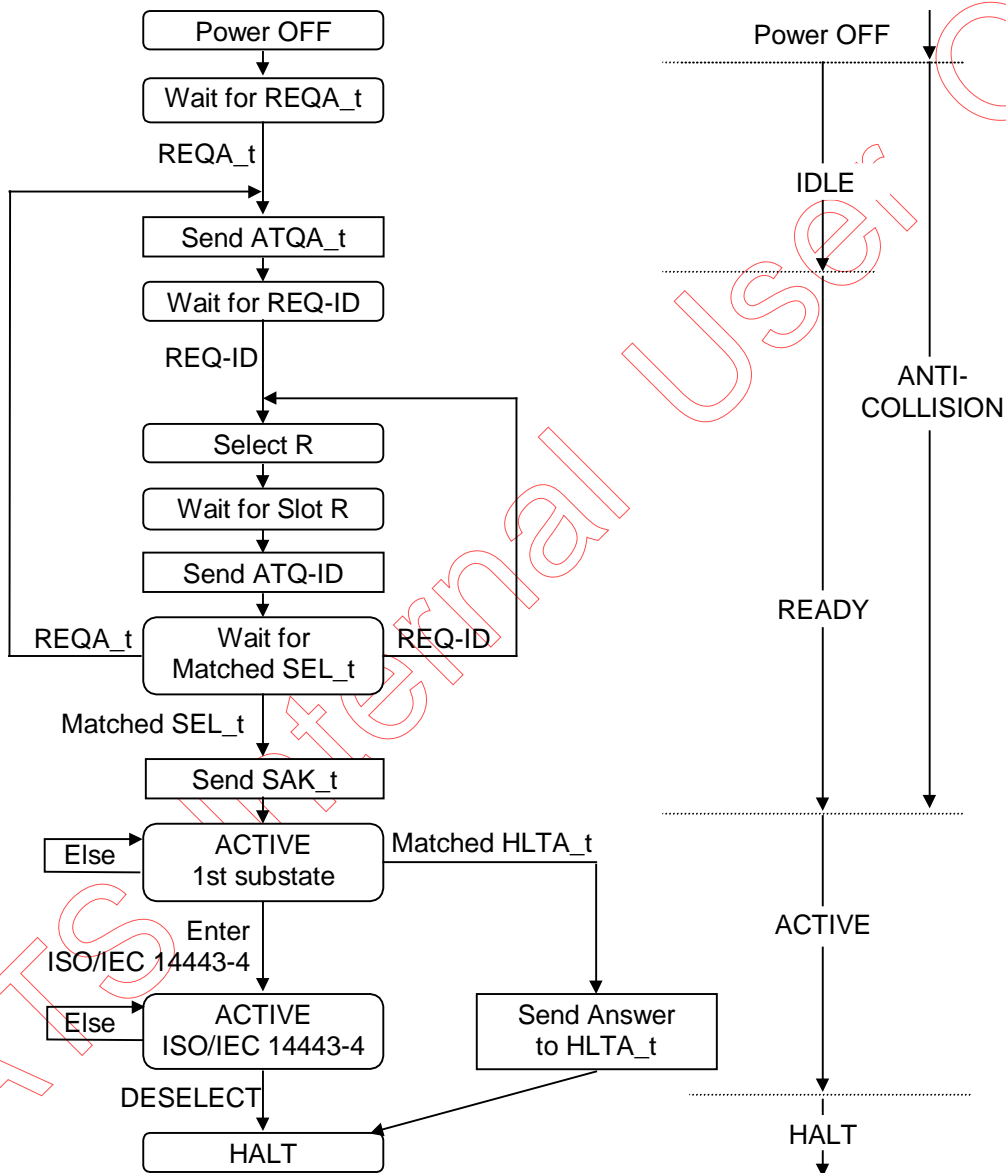


Figure C.1 — Flow chart of PICC anticollision sequence

Annex D (informative)

Type B - 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.

PCD

PICCs

PCD

Start of anticollision Sequence
Transport Application, AFI = `10`
Number of slot, N = 1

Transmit `REQB`

APf	AFI	Param	CRC	CRC
05	10	00	xx	xx

PICC1

Transport PICC

Matched AFI

N = 1

Transmit `ATQB`

PICC2

Medical PICC

Not Matched AFI

Wait for next REQB/WUPB

PICC3

Multi application PICC

Matched AFI

N = 1

Transmit `ATQB`

PCD

Collision detected
Change Number of slots, N = 4

Transmit `REQB`

APf	AFI	Param	CRC	CRC
05	10	02	xx	xx

PICC1

Transport PICC

Matched AFI

Randomly selects R between 1 and N

R = 2, so waits for slot marker for slot 2

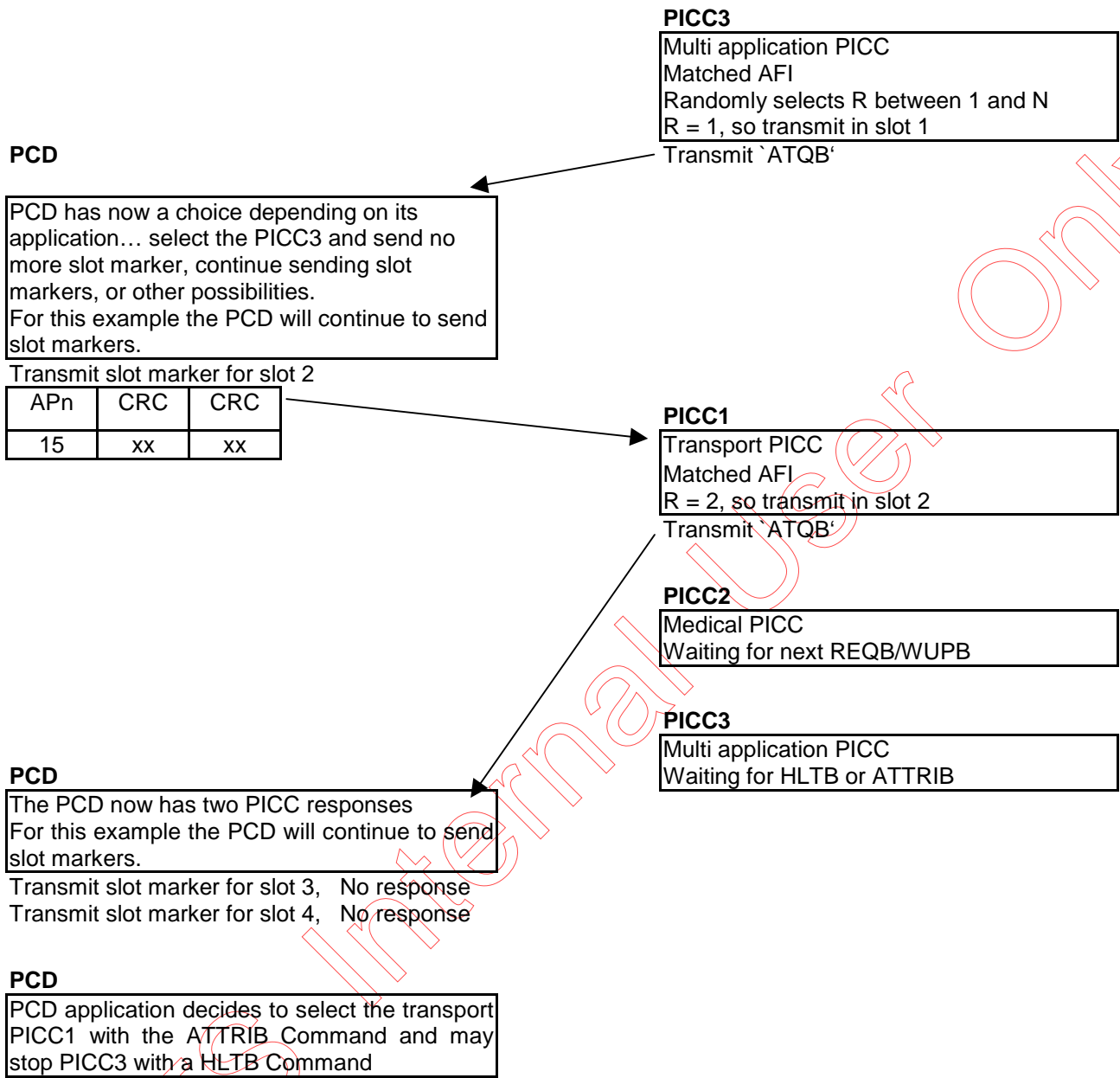
PICC2

Medical PICC

Not Matched AFI

Wait for next REQB/WUPB

Continued next page



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