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MIFARE ISO/IEC 14443 PICC Selection

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Document information

Information	Content
Keywords	Activate Card, MIFARE, Select Card
Abstract	This Application note shows the elementary communication for selecting a Contactless Smart Card according to the ISO/IEC 14443 and how to use this communication to guarantee proper functionality in different applications.

Revision history

Revision history

Rev	Date	Description
4.1	20200320	General update and inclusion of latest product generations
4.0	20170208	General update
3.0	20090626	Third version. Correction of wording.
2.0	20090518	Second version (supersedes AN130810 MIFARE ISO/IEC 14443 PICC Selection, Rev. 1.0, 17 October 2006)

1 Introduction

A smart card has to be properly selected, before data can be exchanged between a reader (system) and the card. This card selection process (card activation) is described in the ISO14443-3 for contactless proximity systems. The dramatic increase in contactless applications has made the correct selection of one single contactless card out of a possible number of cards in the reader field become more important. This was foreseen when the ISO standard was developed and therefore the standard describes in detail how the applications must process them.

1.1 How to use this document

The card selection process can be divided into 2 parts: at first, the communication layer describes how to select a single PICC (whatever type of card or application). This is important because the ISO standard, which specifies the contactless smartcard communication, only describes this communication layer, independent of the application. More and more different types of cards and applications can be found in the field, which all use the ISO/IEC 14443.

The second step, after a single card has been selected, is to select the correct application, to handle multiple applications (or cards), or to properly ignore foreign applications (or cards).

Section 2 of this document describes how the ISO/IEC 14443 process to select a single card. The anti-collision procedure is mandatory for both type A and type B cards.

In addition to the card activation procedure, the system itself has to ensure that the PCD can select the correct application, either with more than one application on one single card, or with different applications on different cards. In many systems, it is recommended to let the system select the correct application, but not the user, which guarantees a fast and secure transaction. This is shown in Section 3.

In this document the term „MIFARE card" refers to a contactless card using an IC out of the MIFARE Classic, MIFARE Plus or MIFARE DESFire product family.

2 Card activation according to ISO/IEC 14443

The ISO/IEC 14443-3 describes how to select ("activate") a single card. This card activation procedure is generally independent of the number of cards in the field, and of the number of applications:

- This procedure guarantees that a single card is properly selected, independent on the number of cards available in the field during the card activation.
- This procedure guarantees that a single card is properly selected, independent on the number of cards moved into the field during the whole card activation or card transaction.
- This procedure guarantees that a single card keeps being properly selected, independent on the number of cards moved into the field during the whole card activation or card transaction.

Note: For convenience reasons in many contactless systems the cards are continuously moved into the field and then removed from the field. So in such systems it usually cannot be **guaranteed**, that a transaction will be completed. This is not at all related to the card activation procedure or the use of multiple cards in a single reader field.
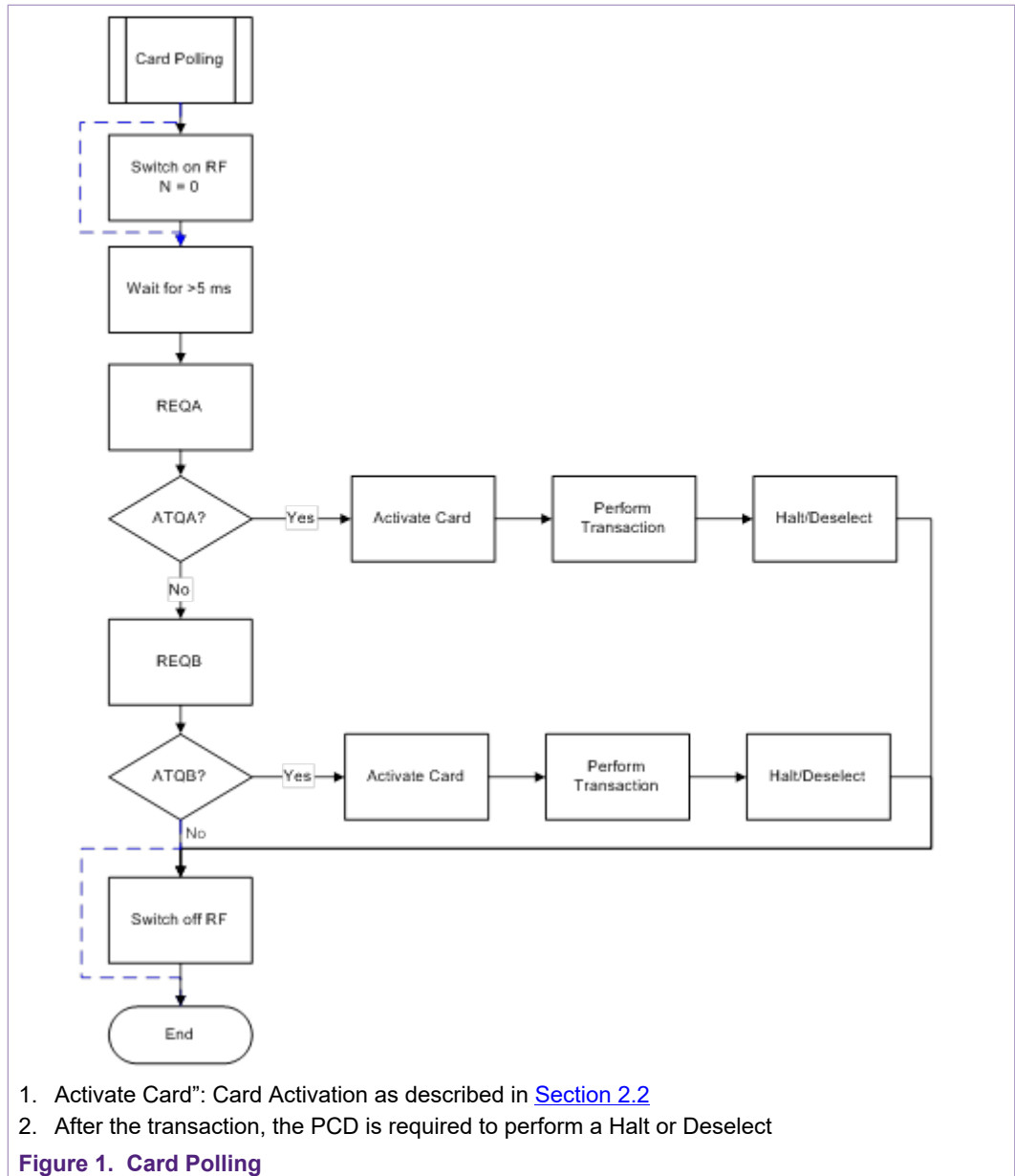
Some additional measures have to be taken into account to **guarantee** the proper function during the whole card transaction: Either a card slot has to be used similarly to the contact card reader slots, or the application (either on the card or in the system) has to offer a recovery procedure (tear protection or back-up management) for those cases, where the transaction can be interrupted.

2.1 Polling for cards

The ISO/IEC 14443 specifies that cards following the ISO/IEC 14443A shall not interfere cards following the ISO/IEC 14443B, and vice versa. In any case, the card activation procedure starts with a Request command (REQA or REQB), which is used only to check whether there is at least one card in the reader field. The REQA or REQB has to be sent after the carrier is switched on, waiting 5 ms at minimum before starting the transmission. This procedure is shown in Figure 1.

Note: The minimum required time between a REQA and REQB or REQB and REQA is 5 ms.

Note: For NFC devices, there has to be another block between "Card Polling" and "Switch on RF", because NFC devices need to check whether there is already a field available or not. If an external field is detected, the reader is not allowed to switch on its own RF field.

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1. Activate Card": Card Activation as described in Section 2.2
2. After the transaction, the PCD is required to perform a Halt or Deselect

Figure 1. Card Polling

In some applications, it might be required to reset the RF regularly, in some others the carrier is switched on only for a short time anyway. In all cases, every communication starts with a REQA (or REQB). If an ATQA (or ATQB) is received, the "Activate Card" procedure as described in Section 2.2 selects the detected card. If no ATQA (or ATQB) is received, the REQB (or REQA) is used.

If the system requires *only one card with the relevant application* to be allowed in the field, the PCD has to select all relevant cards. Then deselect the ones with foreign applications. The remaining cards with correct applications have to be checked: if more than one of such cards is presented, the PCD has to refuse the transaction. This is not part of the communication layer and is described in Section 3.
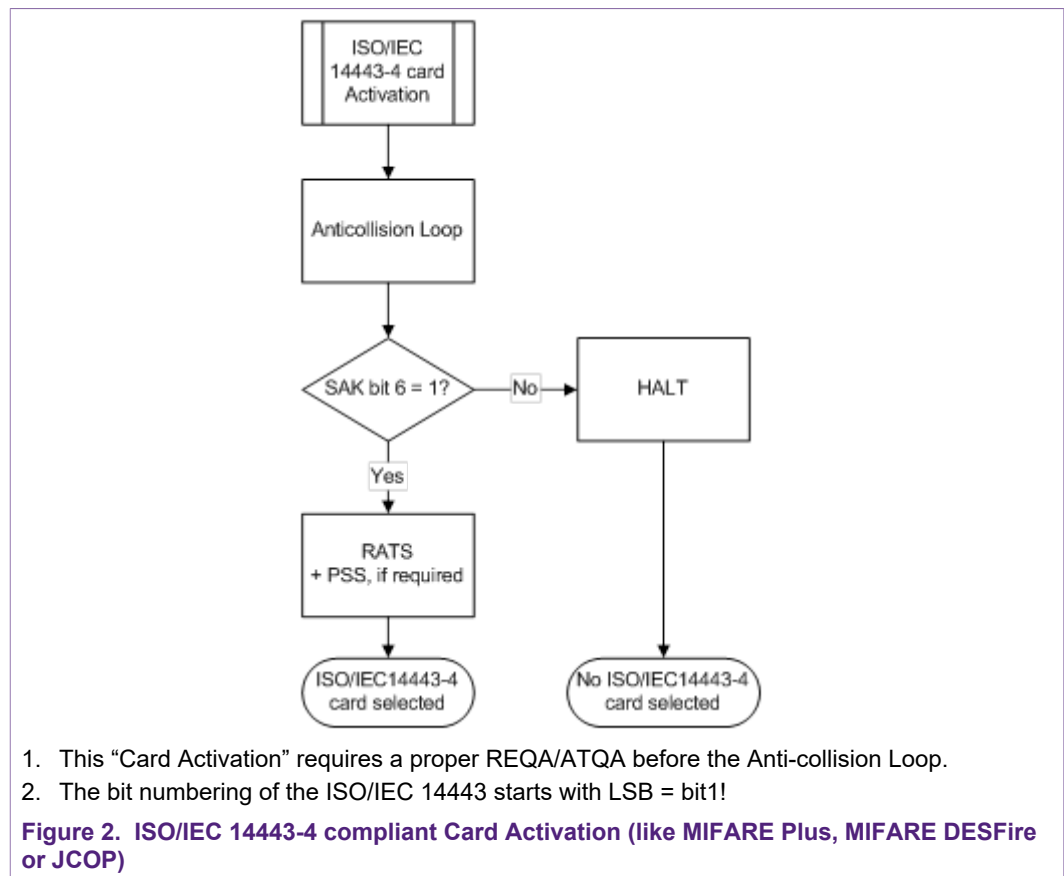
2.2 Activate card

The card activation selects a single card, after an ATQA.

2.2.1 Anti-collision procedure acc. ISO/14443A

The anti-collision procedure is mandatory for ISO/IEC 14443A compliant PICCs. All the NXP MIFARE products support the anti-collision according to ISO/IEC14443 A.

The "Activate Card" includes the anti-collision and Card selection of a single card (for both, type A or type B). For ISO/IEC 14443-4 compliant PICCs (like MIFARE DESFire, cards for contactless payment, electronic passports, etc.) the Activate Card includes the proper setup of the transmission protocol as shown in Figure 2.

1. This "Card Activation" requires a proper REQA/ATQA before the Anti-collision Loop.
2. The bit numbering of the ISO/IEC 14443 starts with LSB = bit1!

Figure 2. ISO/IEC 14443-4 compliant Card Activation (like MIFARE Plus, MIFARE DESFire or JCOP)

According to the SAK coding the MIFARE cards like MIFARE Mini, MIFARE 1K, MIFARE 4K, MIFARE Ultralight or Ultralight C (and MIFARE Plus in Security Level 1 or 2) can be clearly separated and selected as shown in Figure 3.
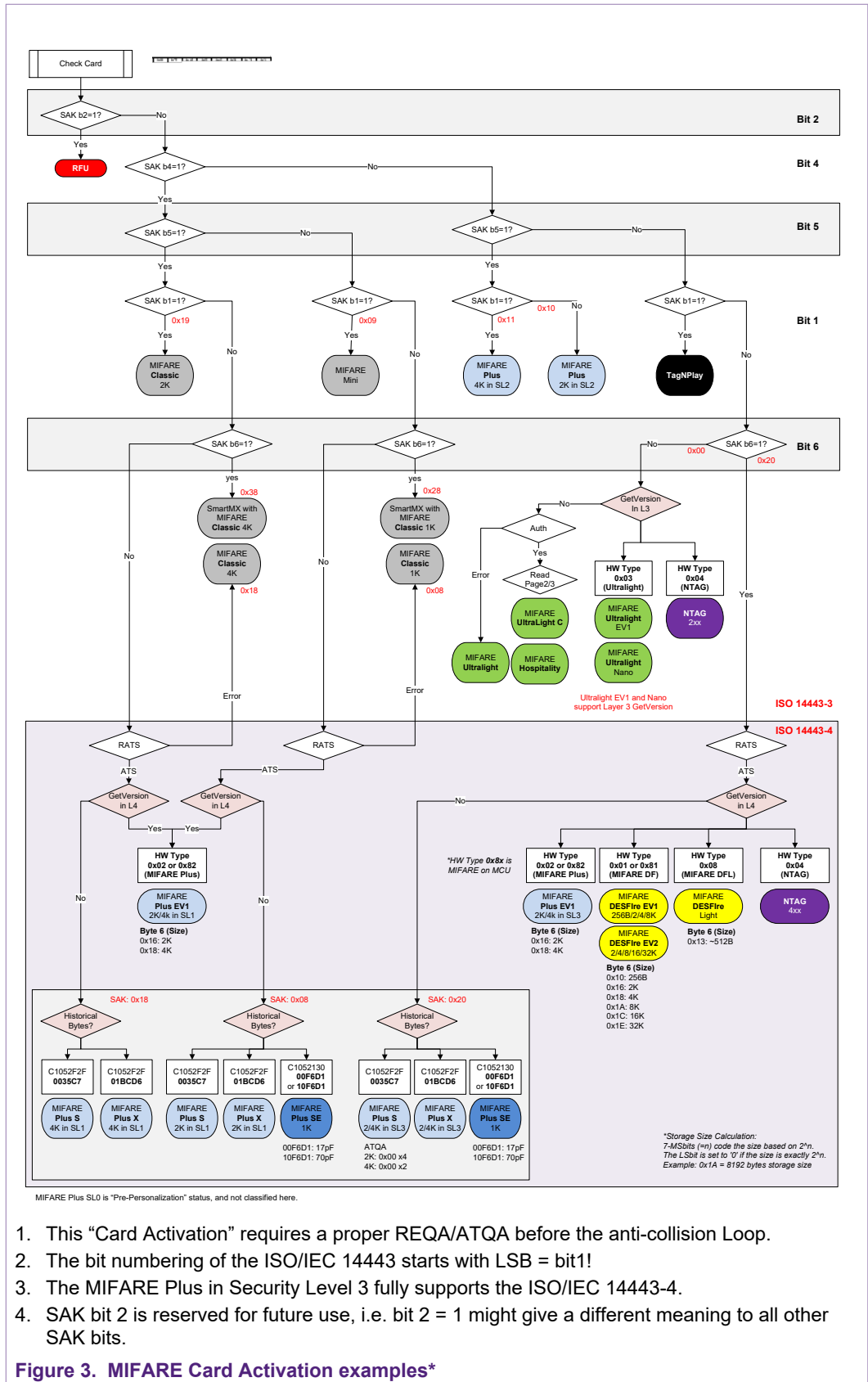
Figure 3. MIFARE Card Activation examples*

1. This "Card Activation" requires a proper REQA/ATQA before the anti-collision Loop.
2. The bit numbering of the ISO/IEC 14443 starts with LSB = bit1!
3. The MIFARE Plus in Security Level 3 fully supports the ISO/IEC 14443-4.
4. SAK bit 2 is reserved for future use, i.e. bit 2 = 1 might give a different meaning to all other SAK bits.

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* Product-specific details can be found in the data sheet of the specific product.

Note: It is not recommended to use the ATQA to determine card parameters due to possible collisions.

Note: The MIFARE Ultralight C uses the same ATQA and SAK as the MIFARE Ultralight.

Note: The MIFARE Plus in the SL3 uses the ATS or the card capabilities to distinguish between different card types.

3 Selecting the correct application

Due to the fact, that in a standard system can be more than one PICC in the active PCD field, the system has to select the right one – and has to deselect all the other ones.

In any case, the system has to be able to separate cards with foreign applications from card with the own application – and properly exclude the "foreign card" from the own selection process. The system has to be able to exclude cards containing foreign applications especially in those cases, where the system requires the operation being limited to "**one single card"**.

Note: This selection process is related to the application, but not to the communication!

The principle of this selection is always the same: every card in the field is selected and queried to check if it contains the relevant application or not. If more than one card in the field contains the relevant application, the system either has to prioritize the cards or refuse the transaction.

If only one card contains the relevant application, the system has to perform the transaction – independent of the number of cards in the field.

The following sections describe how to properly select the relevant application, if only one type of cards is used in the system (e.g. MIFARE product only). However, the process can of course be extended to operate applications using different type of cards, too.

## 3.1 Selecting a MIFARE product application

In many cases, the system needs to select one MIFARE product card (like MIFARE 1K or MIFARE 4K or MIFARE Ultralight). In all those cases the PCD does not use the transmission protocol, but just selects the card according to ISO/IEC 14443-3. Afterwards the application runs the application-related commands (like the Authentication for the MIFARE 1K or MIFARE 4K or Read for the MIFARE Ultralight).

The process for selecting a MIFARE 1K or 4K as shown in Figure 4 (without MAD) or Figure 5 (using MAD) uses the Activate Card without activating the transmission protocol. Every ISO/IEC14443-4 compliant card is selected and properly halted in this process. A dual interface card providing both a MIFARE Emulation as well as an ISO/IEC14443-4 protocol layer is automatically correctly activated as a MIFARE product card here.

This process returns an error if more than one MIFARE product card with the relevant application is in the field.

"Reactivate Card" uses the WUPA, and the Select command.

Note: The same process as shown in Figure 4 can be used for the MIFARE Ultralight, if a Read command instead of the Authentication is used.
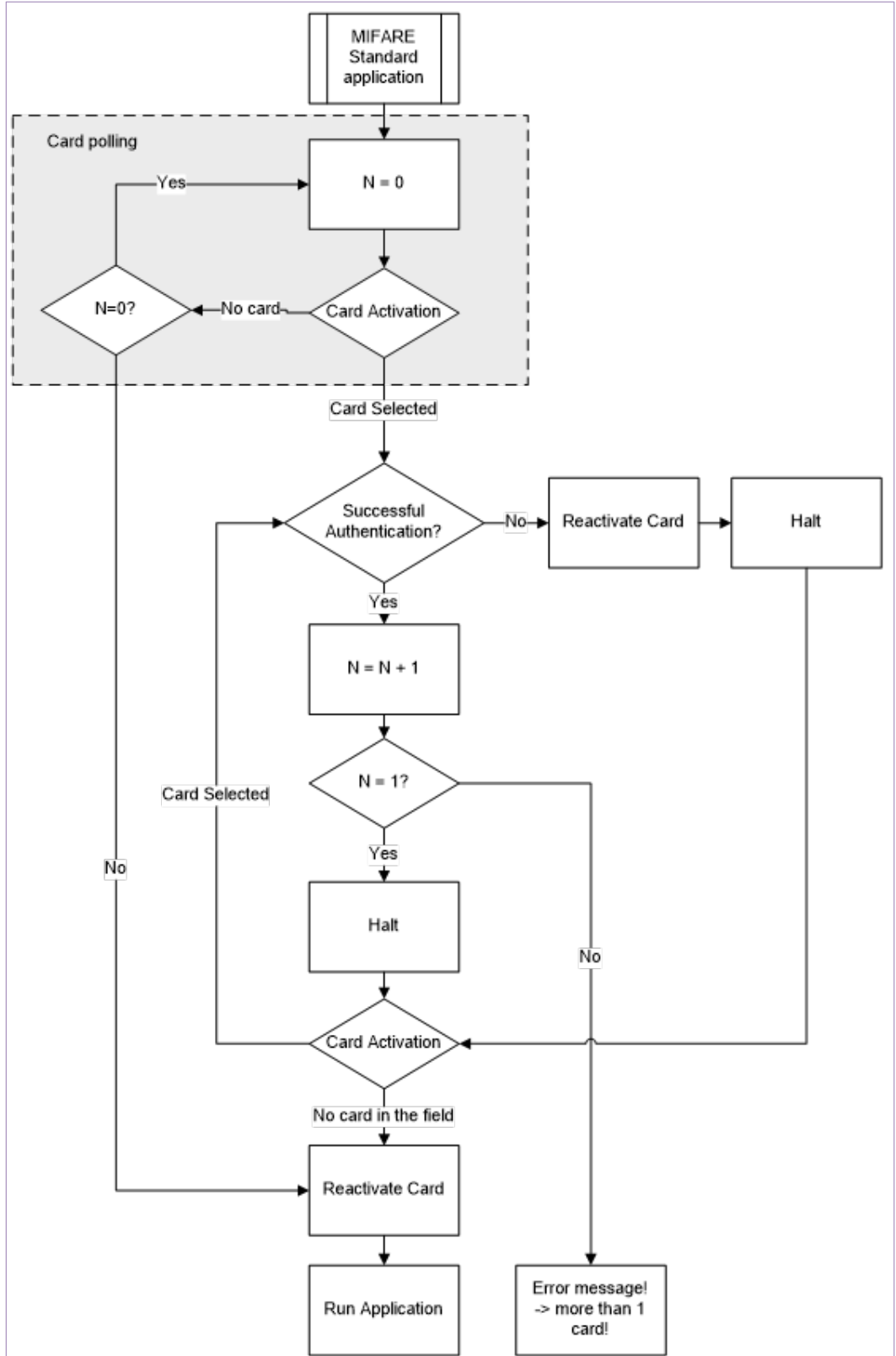
1. "Card Activation" is shown in Section 2 (incl. the REQA).

Figure 4. Selecting one single MIFARE Mini, 1K or 4K application without MAD

1. "Card Activation" is shown in Section 2 (incl. the REQA).

Figure 5. Selecting one single MIFARE Mini, 1K or 4K application with MAD
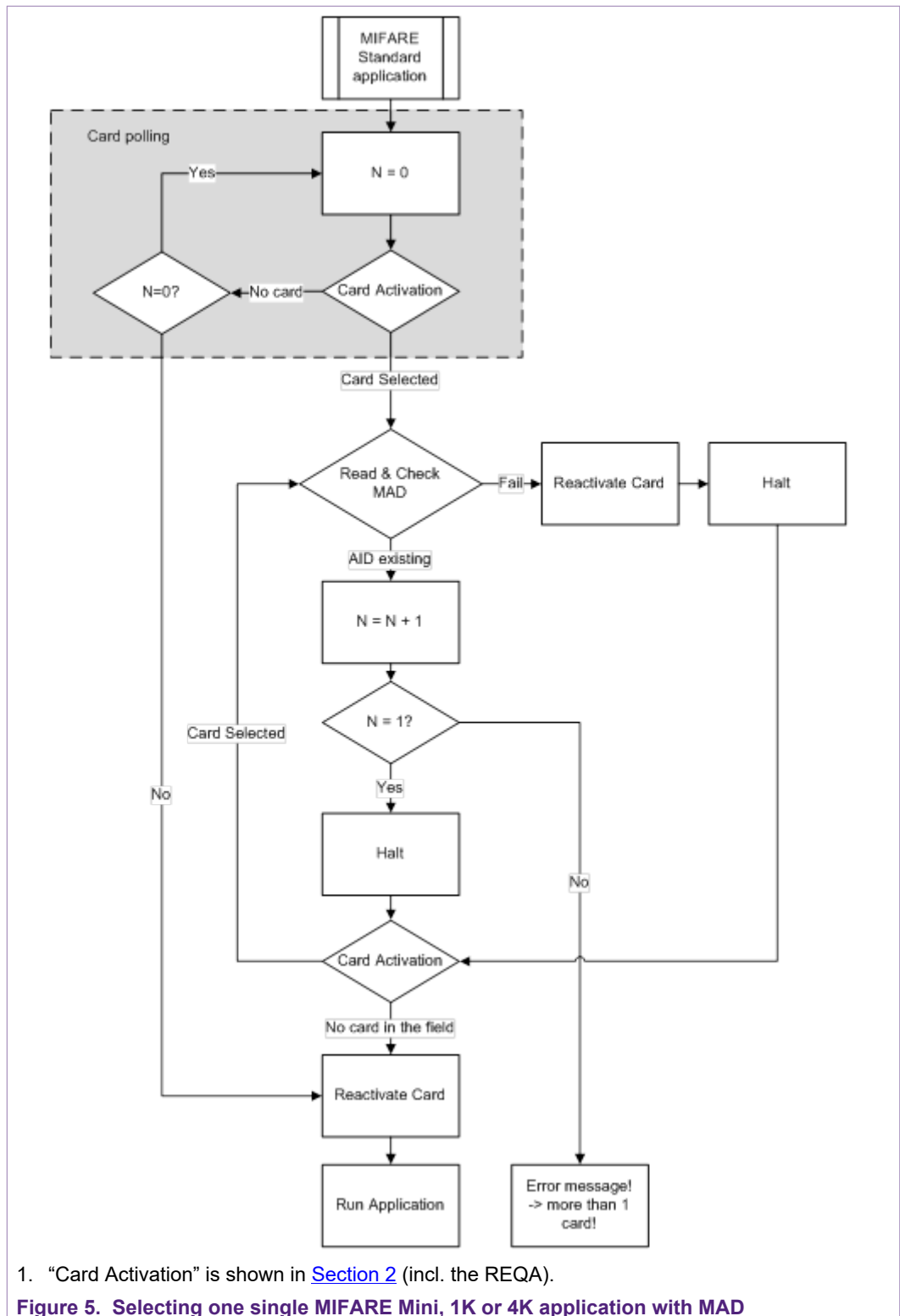
3.2 Selecting an ISO14443-4 complaint application

In many applications using ISO/IEC 14443-4 compliant cards the proper selection of one card out of a number of cards is required. Even if the transaction requires more than one card to be addressed, usually every system uses a transaction flow which addresses cards sequentially. So every card should be activated (and deactivated) separately, even though the ISO/IEC 14443 protocol activation allows the use of CIDs and several cards in parallel.

Note: For better communication stability, it is recommended to only activate and select the card that is being used in the current transaction, if not otherwise required.

Figure 6 shows the selection of an application on a DESFire card as an example. Every other card that does not contain the relevant application is ignored from the system (i.e. properly deselected). If more than one DESFire card with such a relevant application is presented to the reader, the system refuses the transaction.

"Reactivate Card" uses the WUPA, and the Select command.

The same principle can be used to select other applications on other type of cards, e.g. a ticketing application on a MIFARE Plus SL3 card, a payment application on a JCOP card or an electronic passport application on an eMRTD.
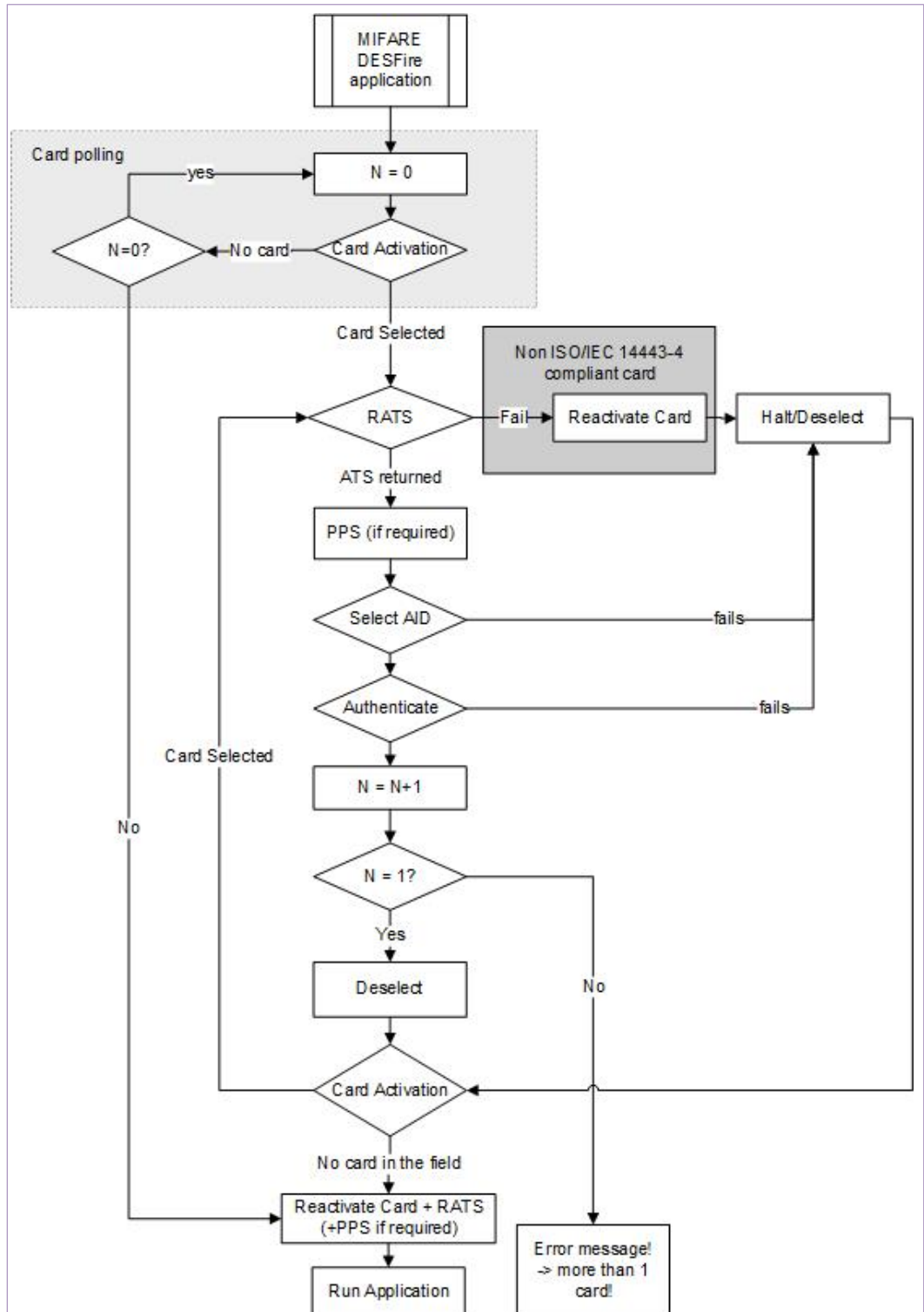
1. "Card Activation" is shown in Section 2 (incl. the REQA).
2. The same principle applies for MIFARE Plus SL3 and other ISO/IEC 14443-4 compliant cards.

Figure 6. Selecting one single MIFARE DESFire card

3.3 Using multiple cards during one transaction

In some cases, the system might require to handle two or more cards in parallel during the same transaction. In such a case the system can use the CID of the protocol to activate and address each card during one transaction.

The selection process is the same as shown in Figure 6, and can be processed as many times as cards are in the field, using different CIDs to select each card.

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4 Terms and Abbreviations

Table 1. Abbreviations

Acronym	Description
Application	Here: the application on the card
ATQA	Answer To re-Quest type A
ATQB	Answer To re-Quest type B
Card	Here: PICC acc. to the ISO/IEC 14443 (contactless proximity smart card)
CID	Card IDentifier
eMRTD	electronic Machine-Readable Travel Document ("ICAO-compliant ePassport")
ICAO	International Civil Aviation Organization
MAD	MIFARE Multi Application Directory
NFC	Near Field Communication
PCD	Proximity Coupling Device ("Reader")
PPS	Protocol Parameter Selection
RATS	Request for Answer To Select
Reader	Here: PCD acc. to the ISO/IEC 14443
SL	MIFARE Plus Security Level (0, 1, 2 or 3)
SAK	Select AcKnowledge
System	Here: the system application

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5 References

1. ISO/IEC14443 Identification cards – Contactless integrated circuit(s) cards – Proximity cards
2. ISO10373-6 Identification cards – Test methods part 6: Proximity cards
3. AN10787 MIFARE Application Directory (MAD)

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