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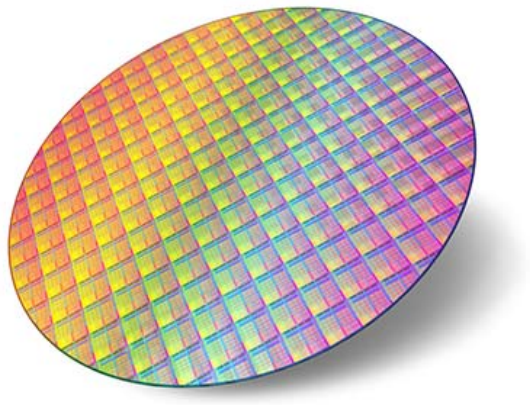
ST25TA16K

NFC Forum Type 4 Tag IC with 16-Kbit EEPROM

Datasheet - production data



Wafer (SB12I)

Description

The ST25TA16K device is an NFC tag IC embedding an EEPROM memory. It can be operated from a 13.56 MHz RFID reader or an NFC phone.

The RF protocol is compatible with ISO/IEC 14443 Type A and NFC Forum Type 4 Tag.

Features

Contactless interface

- NFC Forum Type 4 Tag
- ISO/IEC 14443 Type A
- 106 Kbps data rate
- Internal tuning capacitance: 25 pF

Memory

- 2-Kbyte (16-kbit) EEPROM
- Supports NDEF data structure
- Data retention: 200 years
- Endurance: 1 million erase-write cycles
- Reads up to 246 bytes in a single command
- Writes up to 246 bytes in a single command
- 7-byte unique identifier (UID)
- 128-bit password protection

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1 Functional description

The ST25TA16K device is a dynamic NFC/RFID tag that can be accessed from the RF interface. The RF interface is based on the ISO/IEC 14443 Type A standard.

The ST25TA16K is compatible with the NFC Forum Type 4 Tag specifications and supports all corresponding commands.

Figure 1 shows the block diagram of the ST25TA16K device.

Figure 1. ST25TA16K block diagram

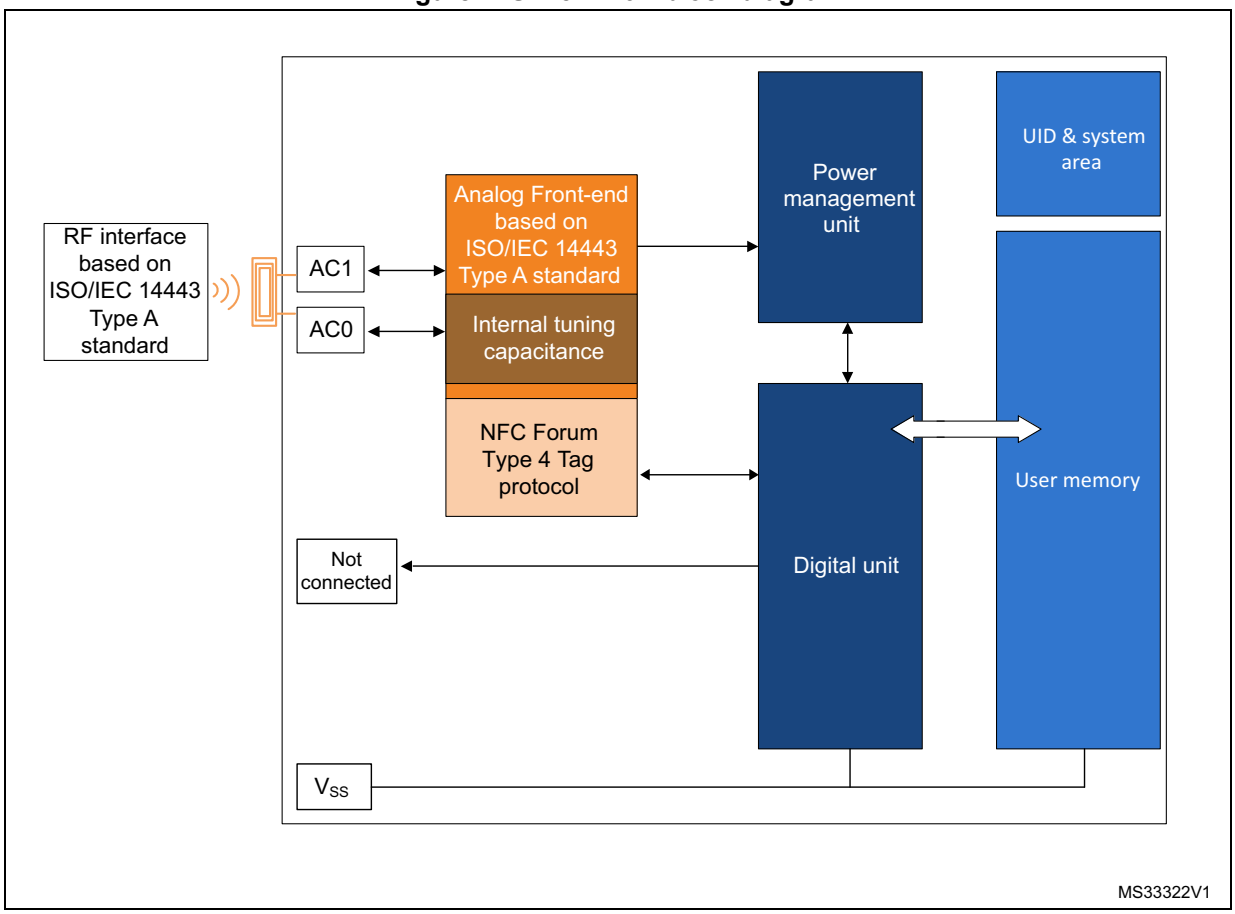


Table 1. Signal names

Signal name	Function	Direction
AC0, AC1	Antenna coils	-

1.1 Functional modes

The ST25TA16K has just one functional mode (see *Table 2*).

Table 2. Functional mode

Mode	Supply source	Comments
Tag mode	RF field only	The interface is connected

1.1.1 Tag mode

The ST25TA16K is supplied by the RF field and can communicate with an RF host (RFID reader or an NFC phone). The User memory can only be accessed by the RF commands.

2 Signal descriptions

2.1 Antenna coil (AC0, AC1)

These inputs are used to connect the device to an external coil exclusively. It is advised not to connect any other DC or AC path to AC0 or AC1.

When correctly tuned, the coil is used to access the device using NFC Forum Type 4 commands.

3 ST25TA16K memory management

3.1 Memory structure

The ST25TA16K supports the NDEF Tag Application as defined in the NFC Forum Type 4 Tag. The ST25TA16K is composed of three files:

- one Capability Container file;
- one NDEF file;
- one System file: this is an ST-proprietary file.

The System file contains some information on the configuration of the ST25TA16K device. The CC file gives some information about the ST25TA16K itself and the NDEF file. The NDEF file contains the User data.

3.1.1 File identifier

The file identifier is the value used in the Select command to select a file.

Table 3. File identifier

File identifier	Meaning
0xE101	System file
0xE103	CC file
0x0001	NDEF file

3.1.2 CC file layout

The CC file gives some information about the ST25TA16K and the NDEF file. This file is a read-only file for the RF host and cannot be modified by issuing a write command.

The T, Read Access and Write Access fields can be changed by the RF host through a specific process (refer to *Section 7: Functional procedures*).

Table 4. CC file layout for one NDEF file

File offset	Meaning	Value	Comments
0x0000	Number of bytes of CC file	0x000F	15 bytes
0x0002	Mapping version(1)	0x20 or 0x10	V 2.0 or V 1.0
0x0003	Maximum number of bytes that can be read	0x00F6	246 bytes
0x0005	Maximum number of bytes that can be written	0x00F6	246 bytes

Table 4. CC file layout for one NDEF file (continued)

File offset	Meaning	Value	Comments
0x0007	NDEF file control TLV	0x04 (2)	T field
0x0008		0x06	L field
0x0009		0x0001	FileID
0x000B		0x0800	Maximum NDEF file size
0x000D		0x00(2)	Read access
0x000E		0x00(2)	Write access

1. According to the reader.
2. Delivery state.

3.1.3 NDEF file layout

The NDEF file contains the NDEF message that contains the User data. The RF host can read and write data inside the file. The first two bytes named NDEF Message Length define the size of the NDEF message. The NDEF Message Length shall be managed by the application and the ST25TA16K device does not check if its value is relevant vs the data written by the RF host. The ST25TA16K device uses the NDEF Message Length, e. g. the standard read can be processed only inside the NDEF message; otherwise, the ST25TA16K device returns an error code. For more details about the read command, refer to *Section 5.6.7: ReadBinary command*.

Table 5. NDEF file layout

File offset	Byte 0	Byte 1	Byte 2	Byte 3
0x0000	NDEF message length		User data	User data
0x0004	User data	User data	User data	User data
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
0x07FC	...	...	...	User data

3.1.4 System file layout

The system file specifies the configuration of the ST25TA16K. *Table 6* lists the different fields.

Table 6. Field list

File offset	Field name	Number of bytes	Read access	Write access	Delivery state
0x0000	Length system file	2	RF	-	0x0012
0x0002	ST reserved	1	RF	none	0x01
0x0003	ST reserved	1	RF	none	0x00

Table 6. Field list (continued)

File offset	Field name	Number of bytes	Read access	Write access	Delivery state
0x0004	ST reserved	1	RF	none	0x11
0x0005	ST reserved	1	RF	none	0x00
0x0006	ST reserved	1	RF	none	0x01
0x0007	NDEF File number (RFU)	1	RF	none	0x00
0x0008	UID	7	RF	none	0x02C5 xx xx xx xx xx(1)
0x000F	Memory Size	2	RF	none	0x07FF
0x0011	Product Code	1	RF	none	0xC5

1. x values are defined by ST to insure UID unicity.

3.2 Read and write access rights to the memory

An NDEF file can be locked for read or write accesses. It is also protected by a 128-bit password that the host shall present before accessing the NDEF file. There are two 128-bit passwords, one for the read access and the other one for the write access.

An NDEF file can be permanently locked for read or write accesses. Thus, the host cannot access the NDEF file.

The read password shall be sent to the ST25TA16K device before reading a read-locked NDEF file.

The write password shall be present on the ST25TA16K device before writing a write-locked NDEF file. The write password shall be sent to change the read or write access. The read or write access right is defined for the NDEF file.

3.2.1 State of the Read and Write access rights

Two bytes in the CC file are used to define the Read and Write access rights to the NDEF file. For more details, refer to *Section 3.1.2: CC file layout*.

Table 7. Read access right

Value	Meaning
0x00	Read access without any security
0x80	Locked (1)
0xFE	Read not authorized

1. The read password shall be sent before reading in the NDEF file.

Table 8. Write access right

Value	Meaning
0x00	Write access without any security
0x80	Locked (1)
0xFF	Write not authorized

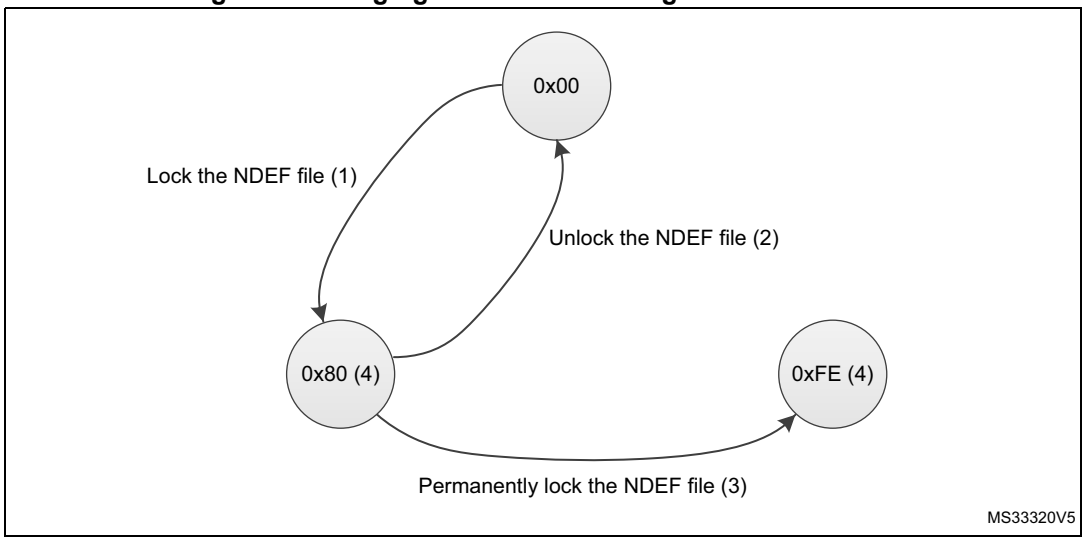
1. The write password shall be sent before writing in the NDEF file.

The state 0xFF and 0xFE cannot be changed by using the Read or Write passwords.

3.2.2 Changing the read access right to NDEF files

The state diagram on *Figure 2* shows how to change the access right to read an NDEF file.

Figure 2. Changing the read access right to an NDEF file

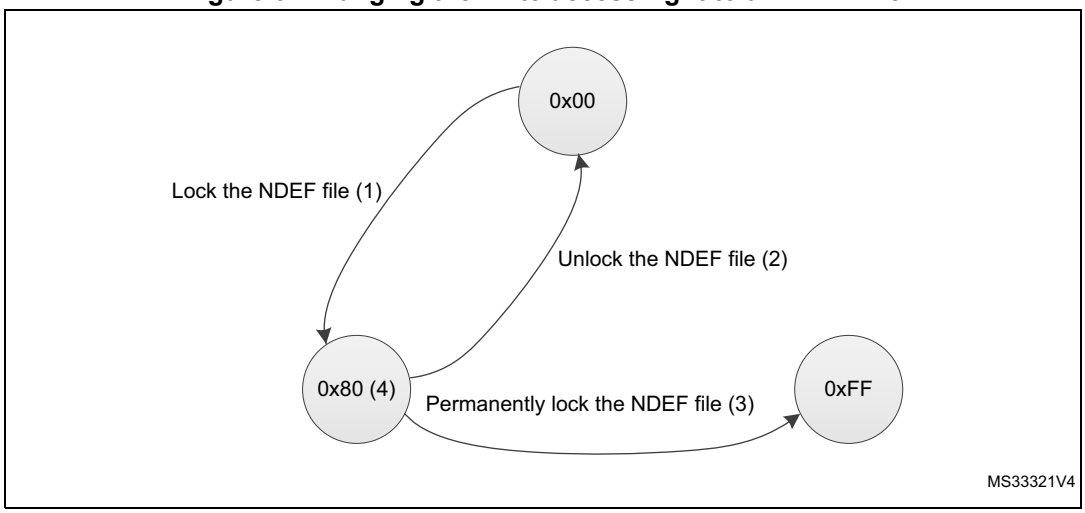


1. See the procedure to lock the read access (*Section 7.4: Locking an NDEF file*).
2. See the procedure to unlock the read access (*Section 7.5: Unlocking an NDEF file*).
3. See the procedure to permanently lock the read access (*Section 7.6: Reaching the read-only state for an NDEF file*).
4. Proprietary state, not defined by NFC Forum Type 4 Tag.

3.2.3 Changing the write access right to NDEF files

The state diagram on *Figure 3* shows how to change the write access right to an NDEF file.

Figure 3. Changing the write access right to an NDEF file



1. See the procedure to lock the write access.
2. See the procedure to unlock the write access.
3. See the procedure to permanently lock the write access (*Section 7.6: Reaching the read-only state for an NDEF file*).
4. Proprietary state, not defined by NFC Forum Type 4 Tag.

3.3 Access right life time

The access right life time is validated while the NDEF file is selected or until the end of the RF session. Once the read or write access right is granted, the host can send one or more ReadBinary or UpdateBinary commands.

At the end of a session or when the host selects another file, the read and write access rights are initialized.

3.4 NDEF file passwords

The NDEF file passwords protect the read or write access from an RF interface from/to an NDEF file.

Two NDEF file passwords are available for each NDEF file:

- Read password
- Write password

The length of a password is 128 bits (16 bytes).

Note: The delivery state for all passwords is 0x00000000000000000000000000000000.

4 Communication mechanism

This chapter describes the principle of communication between an RF host and the ST25TA16K device.

4.1 Master and slave

The ST25TA16K acts as a slave device on the RF channel and therefore waits for a command from the RF host before sending its response.

The RF host shall generate the RF field and the RF commands.

5 RF command sets

This section describes the ST25TA16K command sets that can be issued by the RF host.

There are three command families:

- the NFC Forum Type 4 Tag command set
- the ISO/IEC 7816-4 command set
- the proprietary command set

The NFC Forum Type 4 Tag command set and the ISO/IEC 7816-4 command set use the I-Block format. For more details about the I-Block format, refer to *Section 5.2: I-Block format*.

Two other command formats exist:

- the commands using the R-Block format
- the commands using the S-Block format

For more details about these formats, refer to the corresponding sections: *Section 5.3: R-Block format* and *Section 5.4: S-Block format*.

This section gives a brief description of the RF host commands. The format of these command sets is the I-Block format.

Table 9 lists the RF command sets.

Table 9. RF command sets

Family command set	Command name	Class byte	Instruction code	Brief description
NFC Forum Type 4 Tag	NDEF Tag Application Select	0x00	0xA4	NDEF Tag Application Select
	CC select	0x00	0xA4	Selects the CC file
	NDEF select	0x00	0xA4	Selects the NDEF file
	System select	0x00	0xA4	Selects the system file
	ReadBinary	0x00	0xB0	Reads data from file
	UpdateBinary	0x00	0xD6	Writes or erases data to a NDEF file
ISO/IEC 7816-4	Verify	0x00	0x20	Checks the right access of a NDEF file or sends a password
	ChangeReferenceData	0x00	0x24	Changes a Read or write password
	EnableVerificationRequirement	0x00	0x28	Activates the password security
	DisableVerificationRequirement	0x00	0x26	Disables the password security

Table 9. RF command sets (continued)

Family command set	Command name	Class byte	Instruction code	Brief description
ST proprietary	EnablePermanentState	0xA2	0x28	Enables the Read Only or Write Only security state
	ExtendedReadBinary	0xA2	0xB0	Reads data from file
	UpdateFileType	0xA2	0xD6	Sets file type to NDEF or proprietary

5.1 Structure of the command sets

The exchange of data between the RF host and the ST25TA16K uses three kinds of data formats, called blocks:

- I-Block: to exchange the command and the response
- R-Block: to exchange positive or negative acknowledgment
- S-Block: to use either the Deselect command or the Frame Waiting eXtension (WTX) command or response

This section describes the structure of the I-Block, R-block and S-Block. This format is used for the application command set.

5.2 I-Block format

The I-Block is used to exchange data between the RF host and the ST25TA16K. It is composed of three fields. *Table 10* details the I-Block format.

Table 10. I-Block format

Name	SoD		Payload	EoD
	PCB	DID	-	CRC
Length	1 byte	1 byte	1 to 251 bytes	2 bytes
PCB field				
DID field (optional)				
RF host to ST25TA16K: C-APDU ST25TA16K to RF host: R-APDU				
2 CRC bytes				

Table 11. PCB field of the I-Block format

	b7-b6	b5	b4	b3	b2	b1	b0
	0b00	0	0	X	0	1	X
I-Block							
RFU							
Must be set to 0							
DID field, if bit is set							
Must be set to 0							
Must be set to 1							
Block number							

When the RF host sends a command to the ST25TA16K the format of the payload is the C-APDU.

When the ST25TA16K sends a command to the RF host, the format of the payload is the R-APDU.

5.2.1 C-APDU: payload format of a command

The C-APDU format is used by the RF host to send a command to the ST25TA16K. *Table 12* describes its format.

Table 12. C-APDU format

Name	Payload field						
	CLA	INS	P1	P2	LC	Data	Le
Length	1 byte	1 byte	1 byte	1 byte	1 byte	Lc byte	1 byte
Class byte 0x00: standard command 0xA2: ST command							
Instruction byte							
Param Byte 1							
Param Byte 2							
Number of bytes of the Data field							
Data bytes							
Number of bytes to be read in the ST25TA16K memory							

5.2.2 R-APDU: payload format of a response

The ST25TA16K uses the I-Block format to reply to a command that used the I-Block format. This format is described in *Table 13*.

Table 13. R-APDU format

Name	Payload field		
	Data (optional)	SW1	SW2
Length	Le byte	1 byte	1 byte
Data			
Status byte 1			
Status byte 2			

5.3 R-Block format

The R-Block is used to convey positive or negative acknowledgment between the RF host and the ST25TA16K.

Table 14. R-Block format

PCB	CRC
R(ACK) without the DID field: 0xA2 or 0xA3 R(ACK) with the DID field: 0xAA or 0xAB R(NAK) without the DID field: 0xB2 0xB3 R(NAK) with the DID field: 0xBA 0xBB	2 CRC bytes

There are two kinds of R-Blocks:

- R(ACK): the acknowledgment block sent by the RF host or by the ST25TA16K
- R(NAK): the non-acknowledgment block sent by the RF host or by the ST25TA16K

Table 15. R-Block detailed format

b7-b6	b5	b4	b3	b2	b1	b0
0b10	1	X	X	0	0	X
R-Block						
RFU						
0: NAK 1: ACK						
0: DID field is not present 1: DID field is present						
Must be set to 0						
RFU						
Block number						

5.4 S-Block format

The S-Block is used to exchange control information between a reader and a contactless tag.

Table 16. S-Block format

NFC frame	SoD		Payload	EoD
	PCB	DID	-	CRC
Length	1 byte	1 byte	0 to 1 byte	2 bytes
0xC2: for S(DES) when the DID field is not present 0xCA: for S(DES) when the DID field is present 0xF2: for S(WTX) when the DID field is not present 0xFA: for S(WTX) when the DID field is present				
DID field (optional)				
WTX field (1)				
2 CRC bytes				

1. This field is present when b5-b4 bits are set to 0b11 (S-Block is a WTX). see *Table 17: S-Block detailed format*.

There are two requests using the S-Block format:

- S(DES): the deselect command
- S(WTX): the Waiting Frame eXtension command or response.

Table 17. S-Block detailed format

	b7-b6	b5-b4	b3	b2	b1	b0
	0b11	X	X	0	1	0
S-Block						
0b00: Deselect 0b11: WTX						
0: DID field is not present 1: DID field is present						
-						
RFU						
RFU						

Note: After receiving the deselect command, the session is released and ST25TA16K enters the Standby power mode.

*In response to a RATS command, ST25TA16K returns FWI parameter (default frame waiting time used); when ST25TA16K needs more time for a command execution, it requests a frame waiting time extension by responding 0xF2 0xWTX (Request waiting time = FWI * WTX). If the reader accepts ST25TA16K request, it acknowledges by sending the command 0xF2 0xWTX. The frame waiting time becomes FWI * WTX for the current command only.*

5.5 CRC of the RF frame

The two CRC bytes check the data transmission between the RF host and the ST25TA16K. For the RF frame, the CRC is computed on all the data bits in the frame, excluding parity bits, SOF and EOF, and the CRC itself.

The CRC is as defined in ISO/IEC 13239. The initial register content shall be 0x6363 and the register content shall not be inverted after calculation.

5.6 NFC Forum Type 4 Tag protocol

5.6.1 Commands set

Table 18. Command set overview

Command name	Brief description
NDEF Tag Application Select	Select the NDEF Tag Application
Capability Container Select	Select the capability container (CC) file using the Select command
NDEF Select	Select the NDEF file
System File Select	Select the system file
ReadBinary	Read data from a file
UpdateBinary	Write new data to a file

5.6.2 Status and error codes

This section lists the status and the error code of the ST25TA16K.

Table 19. Status code of the ST25TA16K

	SW1	SW2	Comment
Value	0x90	0x00	Command completed successfully

Table 20. Error codes of the ST25TA16K

	SW1	SW2	Comment
Length	1 byte	1 byte	
Value	0x62	0x80	File overflow (Le error)
Value	0x62	0x82	End of file or record reached before reading Le bytes
Value	0x63	0x00	Password is required
Value	0x63	0xCX	Password is incorrect, X further retries allowed (X can take value 0,1, 2)
Value	0x65	0x81	Unsuccessful updating

Table 20. Error codes of the ST25TA16K (continued)

	SW1	SW2	Comment
Length	1 byte	1 byte	
Value	0x67	0x00	Wrong length
Value	0x69	0x81	Command is incompatible with the file structure
Value	0x69	0x82	Security status not satisfied
Value	0x69	0x84	Reference data not usable
Value	0x6A	0x80	Incorrect parameters Le or Lc
Value	0x6A	0x82	File or application not found
Value	0x6A	0x84	File overflow (Lc error)
Value	0x6A	0x86	Incorrect P1 or P2 values
Value	0x6D	0x00	INS field not supported
Value	0x6E	0x00	Class not supported

5.6.3 NDEF Tag Application Select command

the RF host shall send this command to activate the NDEF Tag Application.

To activate the NDEF Tag Application, the RF host sends the Select command (see *Table 21*) in addition to the sequence defined in the NFC Forum digital protocol.

Table 21 defines the C-APDU of the Select command to select the NDEF Tag Application (called NDEF Tag Application Select).

Table 21. C-APDU of the NDEF Tag Application Select command

Name	CLA	INS	P1	P2	Lc	Data	Le
-	0x00	0xA4	0x04	0x00	0x07	0xD27600 00850101	0x00
Class byte							
Select instruction code							
P1 field							
P2 field							
Number of bytes of data							
Application ID							
Le field							

Table 22 defines the R-APDU of the NDEF Tag Application Select command.

Table 22. R-APDU of the NDEF Tag Application Select command

	Data	SW1	SW2	Comment
Length	-	1 byte	1 byte	-
Value	-	0x90	0x00	Command completed
Value	-	0x6A	0x82	NDEF Tag Application not found
Value	-	0x6D	0x00	Class not supported

5.6.4 Capability Container Select command

The RF host uses the Capability Container Select procedure to select the capability container (CC) file.

The CC file is selected when this command returns "command completed" in the R-APDU. *Table 23* defines the C-APDU of the Select command to select the CC file (called Capability Container Select).

Table 23. C-APDU of the Capability Container Select command

Name	CLA	INS	P1	P2	Lc	Data	Le
-	0x00	0xA4	0x00	0x0C	0x02	0xE103	-
Class byte							
Select instruction code							
P1 field							
P2 field							
Number of bytes of data							
CC file ID							
-							

Table 24 defines the R-APDU of the CC Select command.

Table 24. R-APDU of the Capability Container Select command

	Data	SW1	SW2	Comment
Length	-	1 byte	1 byte	-
Value	-	0x90	0x00	Command completed
Value	-	0x6A	0x82	File or application not found
Value	-	0x6D	0x00	Class not supported

5.6.5 NDEF Select command

The RF host uses the NDEF Select command to select the NDEF file.

The NDEF file is selected when this command returns "command completed" in the R-APDU. *Table 25* defines the C-APDU of the Select command to select the NDEF file (called NDEF Select).

Table 25. C-APDU of the NDEF Select command

Name	CLA	INS	P1	P2	Lc	Data	Le
-	0x00	0xA4	0x00	0x0C	0x02	0x000X	-
Class byte							
Select instruction code							
P1 field							
P2 field							
Number of bytes of data							
0x0001: first NDEF file							
-							

Table 26 defines the R-APDU of the NDEF Select command.

Table 26. R-APDU of the NDEF Select command

	Data	SW1	SW2	Comment
Length	-	1 byte	1 byte	-
Value	-	0x90	0x00	Command completed
Value	-	0x6A	0x82	File or application not found

5.6.6 System File Select command

The RF host uses this command to select the system file.

The System file is selected when this command returns "command completed" in the R-APDU.

Table 27 defines the C-APDU of the command to select the System file (called System Select).

Table 27. C-APDU of the System File Select command

Name	CLA	INS	P1	P2	Lc	Data	Le
-	0x00	0xA4	0x00	0x0C	0x02	0xE101	-
Class byte							
Select instruction code							
P1 field							
P2 field							
Number of bytes of data							
System file ID							
-							