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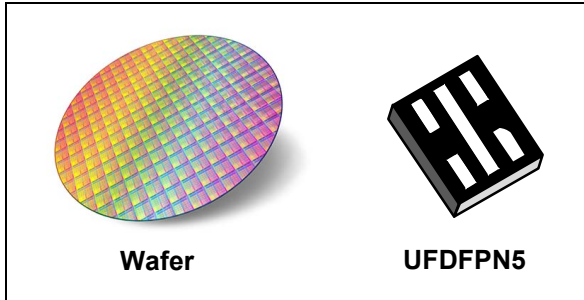
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NFC Forum Type 4 Tag IC with up to 2-Kbit EEPROM

Datasheet - production data



Features

Contactless interface

- NFC Forum Type 4 Tag, certified by the NFC Forum
- ISO/IEC 14443 Type A
- 106 kbps data rate
- Internal tuning capacitance: 50 pF

Memory

- Up to 256-byte (2-Kbit) EEPROM
- Support NDEF data structure
- Data retention: 200 years
- Endurance: 1 million erase-write cycles
- Read up to 256 bytes in a single command
- Write up to 54 bytes in a single command
- Chaining capability
- 7-byte unique identifier (UID)
- 128-bit password protection
- 20-bit event counter with anti-tearing

Product identification and protection

- TruST25™ digital signature

Package

- UDFPN5 ECOPACK®2

Digital output

- GPO: configurable general purpose output
 - driven by an open drain transistor, available on ST25TA02KB-D only
 - enabling no DC consumption (CMOS output buffer), available on ST25TA02KB-P only.

Description

The ST25TA512B and ST25TA02KB devices are NFC tag ICs, with an optional general purpose output available on ST25TA02KB-D and ST25TA02KB-P.

They embed an up to 2 -Kbit EEPROM, and can be operated from a 13.56 MHz RFID reader or an NFC phone.

The ST25TA512B, ST25TA02KB, ST25TA02KB-D and ST25TA02KB-P devices are NFC Forum Type 4 Tags.

They communicate using the ISO/IEC 14443 Type A protocol, and feature a digital signature generated by TruST25™ (a set of software and procedures) used to prove the origin of the chip in cloning detection.

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1 Functional description

The ST25TA512B, ST25TA02KB, ST25TA02KB-D and ST25TA02KB-P (hereinafter referred to as ST25TAxxxB) devices are NFC tags that can be accessed from the RF interface, based on the ISO/IEC 14443 Type A standard.

The ST25TAxxxB are compatible with the NFC Forum Type 4 Tag specifications and support all corresponding commands.

Figures 1, 2 and 3 show the block diagram, respectively, of the ST25TA02KB/ST25TA512B, ST25TA02KB-D and ST25TA02KB-P devices.

Figure 1. Block diagram - ST25TA02KB and ST25TA512B

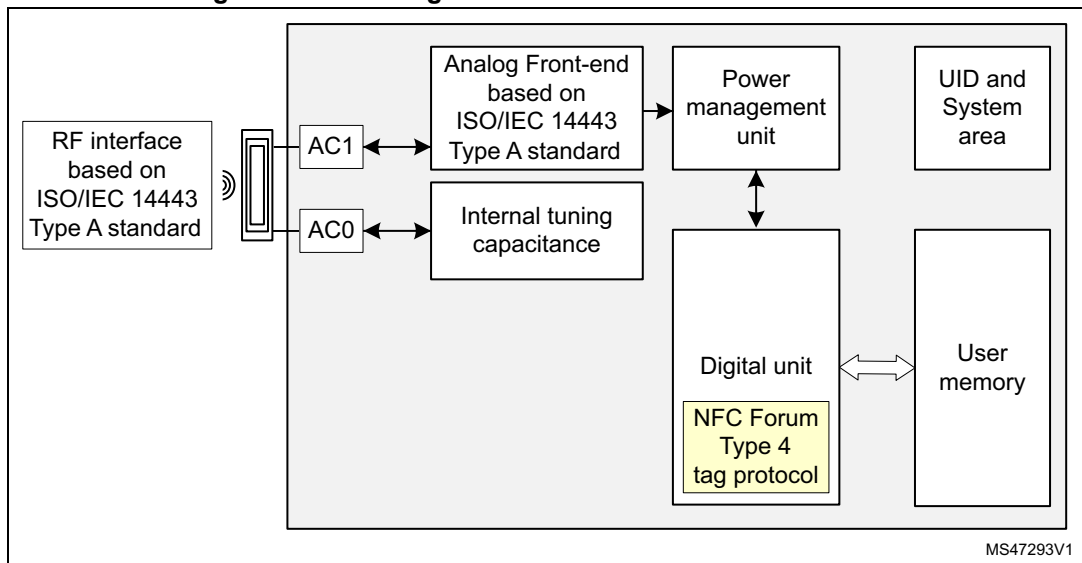


Figure 2. Block diagram - ST25TA02KB-D

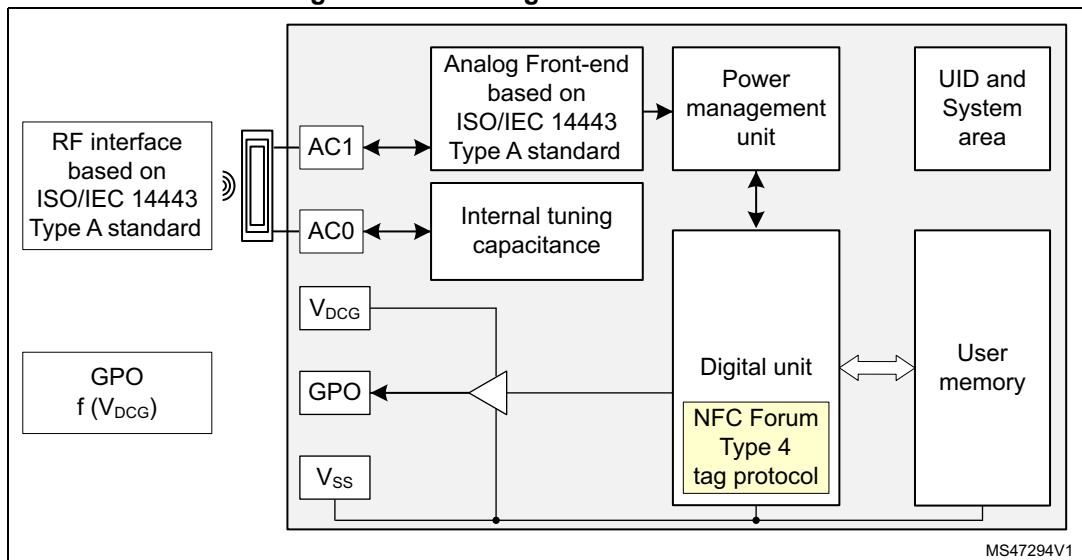


Figure 3. Block diagram - ST25TA02KB-P

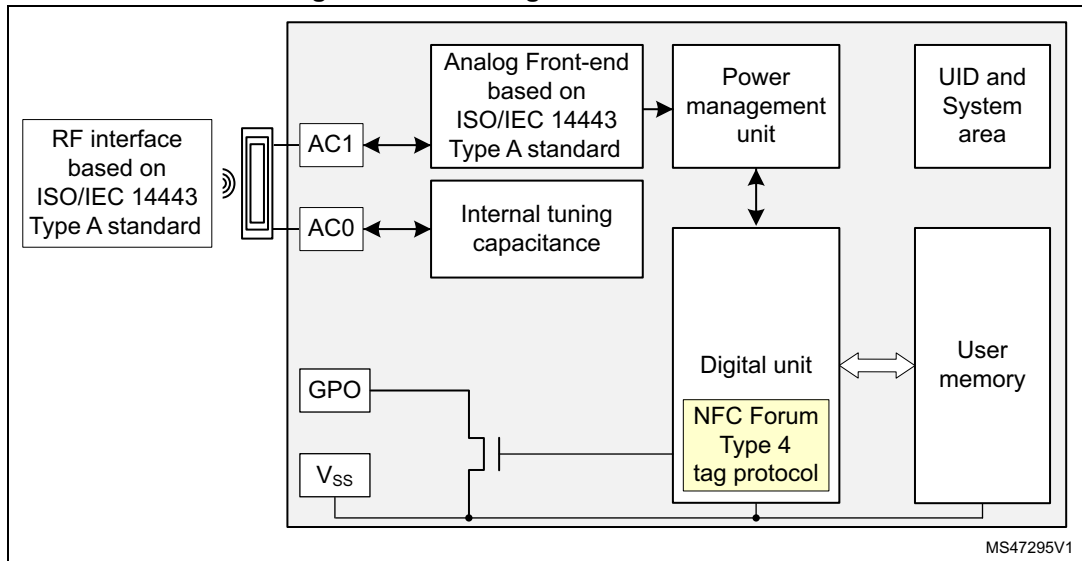
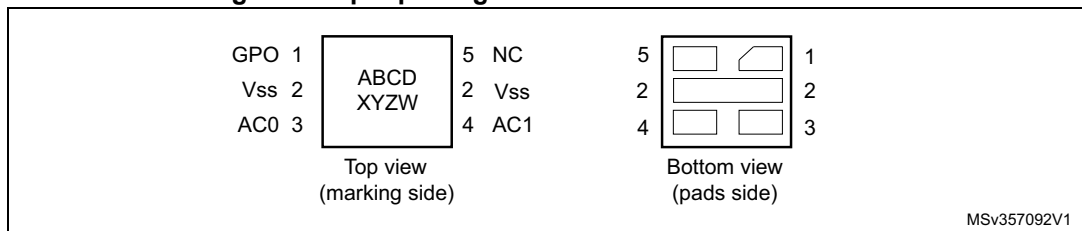


Table 1. Signal names

Signal name	Function	Direction
AC0, AC1	Antenna coils	-
V _{DCG} ⁽¹⁾	Supply voltage for CMOS GPO driver	Power
V _{SS} ⁽²⁾	Ground	-
GPO ⁽²⁾	Interrupt output	CMOS or Open drain output

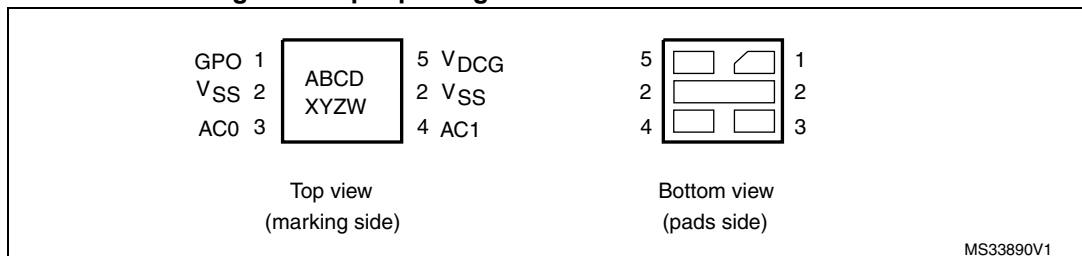
1. Only available on ST25TA02KB-P.
2. Only available on ST25TA02KB-P and ST25TA02KB-D.

Figure 4. 5-pin package connections - ST25TA02KB-D



1. See Package mechanical data section for package dimensions, and how to identify pin 1.

Figure 5. 5-pin package connections - ST25TA02KB-P



1. See Package mechanical data section for package dimensions, and how to identify pin 1.

1.1 Functional mode

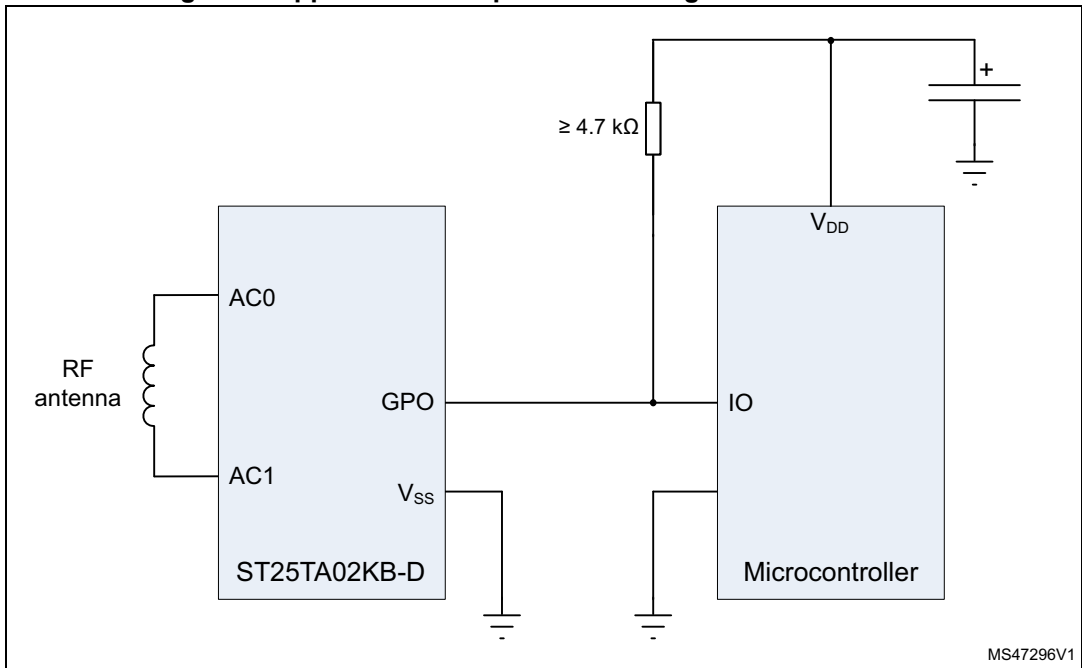
The ST25TxxxB have only one functional mode available (see [Table 2](#)).

Table 2. Functional mode

Mode	Supply source	Comments
Tag mode	RF field only	The RF interface operates only when RF field level is sufficient.

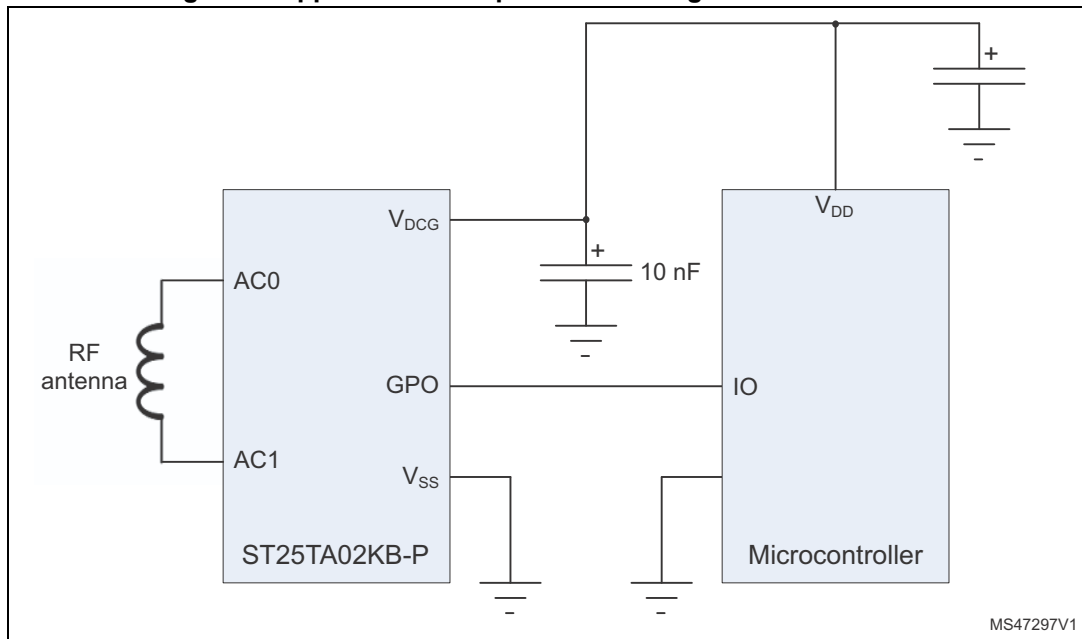
The optional GPO open drain transistor requests an external pull-up ($> 4.7\text{ k}\Omega$) to operate (see [Figure 6](#)).

Figure 6. Applicative example of GPO usage - ST25TA02KB-D



The optional GPO CMOS driver requests an external supply to operate (see [Figure 7](#)).

Figure 7. Applicative example of GPO usage - ST25TA02KB-P



1.1.1 Tag mode

The ST25TAxxxB are supplied by the RF field and can communicate with an RF host (RFID reader or NFC phone). The User memory can be accessed by the RF commands.

2 Signal description

2.1 Antenna coil (AC0, AC1)

These inputs are used to connect the ST25TAxxxB devices to an external coil exclusively. It is advised not to connect any other DC or AC path to neither AC0 nor AC1.

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

2.2 Ground (V_{SS}), only available on ST25TA02KB-P and ST25TA02KB-D

V_{SS} , when connected, is the reference for the V_{DCG} supply voltage and for all pads, including AC0 and AC1.

2.3 GPO supply voltage (V_{DCG}), only available on ST25TA02KB-P

This pin can be connected to an external DC supply voltage. It only supplies the GPO driver block.

2.3.1 Operating supply voltage V_{DCG}

Before checking ST25TA02KB-P GPO, a valid and stable V_{DCG} voltage within the specified [$V_{DCG(min)}$, $V_{DCG(max)}$] range must be applied.

To maintain a stable DC supply voltage, it is recommended to decouple the V_{DCG} line with suitable capacitors (usually of the order of 10 nF and 100 pF) close to the V_{DCG} / V_{SS} package pins.

This voltage must remain stable and valid until the end of the GPO usage by the ST25TA02KB-P.

2.3.2 Power-up conditions

The V_{DCG} rise time must not vary faster than 1 V / μ s.

2.4 General purpose output (GPO), only available on ST25TA02KB-P and ST25TA02KB-D

The GPO pad is either an open drain pad on which an external pull-up resistor shall be connected, or a CMOS pad with default polarity set to 0.

This pad is a configurable output signal, driven to active level when configured events occur. Its behavior is consistent with the RF session activated and with the mode chosen by the user, see [Section 7: Functional procedures](#) for more details.

3 ST25TxxxB memory management

3.1 Memory structure

The ST25TxxxB support the NDEF Tag Application as defined in the NFC Forum Type 4 Tag. They are composed of three files:

- a Capability Container (CC) file
- an NDEF file
- a System file: this file is an ST-proprietary file

The System file contains some information on the configuration of the ST25TxxxB devices. The CC file gives some information about the ST25TxxxB 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 ST25TxxxB 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 field, Read Access and Write Access fields can be changed by the RF host by issuing a specific process (refer to [Section 7: Functional procedures](#)).

Table 4. CC file layout

File offset	Meaning	Value	Comments
0x0000	Length CC file	0x000F	15 bytes
0x0002	Mapping version ⁽¹⁾	0x20 or 0x10	V 2.0 or V 1.0
0x0003	MLe: Maximum number of bytes that can be read	0x00FF ⁽²⁾	255 bytes ⁽²⁾
		0x0040 ⁽³⁾	64 bytes ⁽³⁾
0x0005	MLc: Maximum number of bytes that can be written	0x0036	54 bytes

Table 4. CC file layout (continued)

File offset	Meaning	Value	Comments
0x0007	NDEF file control TLV	0x04 ⁽⁴⁾	T field
0x0008		0x06	L field
0x0009		0x0001	FileID
0x000B		0x0100 ⁽²⁾	FLEN: Maximum NDEF file size in Bytes
		0x0040 ⁽³⁾	
0x000D		0x00 ⁽⁴⁾	CCRD: Read access condition
0x000E		0x00 ⁽⁴⁾	CCWR: Write access condition

1. According to the reader command format the ST25TxxxxB devices will automatically align to the corresponding NFC Forum version.
2. ST25TA02KB, ST25TA02KB-D and ST25TA02KB-P.
3. ST25TA512B.
4. 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 ST25TxxxxB devices do not check if its value is relevant vs. the data written by the RF host. If the NDEF Message Length value stored in the file is greater than FLEN-2^(a) the tag handles it as an invalid case and returns 0x00 for the byte values at offsets 0x0000 and 0x0001 in the response to a ReadBinary command.

For more details about the read command, refer to [Section 6.7.5: 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
...
...
...
0x003C ⁽¹⁾ or 0x00FC ⁽²⁾	User data

1. ST25TA512B.
2. ST25TA02KB, ST25TA02KB-D and ST25TA02KB-P.

a. NDEF Message Length > FLEN-2 can occur because of a successful UpdateBinary command with wrong value, or because of a corrupted UpdateBinary command.

3.1.4 System file layout

The system file specifies the configuration of the ST25TAxxxB devices. [Table 6](#) lists the different fields.

Table 6. Field list

File offset	Field name	No. of bytes	Read access	Write access	Device(s)	Delivery state
0x0000	Length system file	2	Yes	-	ST25TA512B ST25TA02KB ST25TA02KB-D ST25TA02KB-P	0x0012
0x0002	ST reserved	1	Yes	None	ST25TA512B ST25TA02KB	0x80
	GPO Config			Yes ⁽¹⁾	ST25TA02KB-D ST25TA02KB-P	0x70 ⁽²⁾
0x0003	Event Counter Config	1	Yes	Yes ⁽¹⁾	ST25TA512B ST25TA02KB ST25TA02KB-D ST25TA02KB-P	0x00
0x0004	20-bit counter (MS nibble 0x0)	3	Yes	None		0x000000
0x0007	Product version	1	Yes	None		0x22 ⁽³⁾
0x0008	UID	7	Yes	None	ST25TA512B	0x02E4 xx xx xx xx xx ⁽⁴⁾
					ST25TA02KB	0x02E3 xx xx xx xx xx ⁽⁴⁾
					ST25TA02KB-D	0x02F3 xx xx xx xx xx ⁽⁴⁾
					ST25TA02KB-P	0x02A3 xx xx xx xx xx ⁽⁴⁾
0x000F	Memory Size - 1	2	Yes	None	ST25TA512B	0x003F
					ST25TA02KB ST25TA02KB-D ST25TA02KB-P	0x00FF
0x0011	IC reference code	1	Yes	None	ST25TA512B	0xE5
					ST25TA02KB	0xE2
					ST25TA02KB-D	0xF2
					ST25TA02KB-P	0xA2

1. Configuration bytes can be locked by setting the Most significant bit to 1. Once locked, these bytes cannot be changed anymore.
2. Field detect as GPO configuration.
3. ST reserved.
4. x values are defined by ST to ensure UID uniqueness.

Table 7. Details about the Counter configuration field

File offset	b7	b6-b2	b1	b0
0x0003				
Counter configuration lock bit: 0b0: unlocked 0b1: locked				
0b00000: ST reserved				
Counter enable: 0b0: disable 0b1: enable				
Counter increment: 0b0: on Read 0b1: on Write				

Table 8. Details about the GPO field

File offset	b7	b6-b4	b3-b0
0x0002			
GPO config lock bit: 0b0: unlocked 0b1: locked			
GPO configuration: 0b000: Not used 0b001: Session opened 0b010: WIP 0b011: MIP 0b100: Interrupt 0b101: State Control 0b110: RF Busy 0b111: Field Detect			
0b0000 ST Reserved			

3.2 Read and write access rights to the NDEF file

The NDEF file can be protected for read or write accesses with passwords 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 also be locked for read or write accesses. Thus, the host cannot access the NDEF file.

The read password shall be sent to the ST25TxxxB devices before reading a read-protected NDEF file.

The write password shall be sent to the ST25TxxxB devices before writing a write-protected NDEF file. The write password shall be sent to change the read or write

protection mode. The access rights are only relevant for the NDEF file. If the Verify command is used with the CC, System or no file selected, an error is responded by the tag.

3.2.1 Read and Write protection modes

Three protection modes are defined for each of the Read and Write access rights to the NDEF file:

- UNPROTECTED
- PROTECTED
- FORBIDDEN

The Read/Write protection mode is identified by the R-APDU value responded to a Verify command (see [Section 6.8.1: Verify command](#)).

Table 9. Read protection modes

Mode	Verify (P1P2=0x0001) R-APDU	Meaning
READ UNPROTECTED	0x9000	Read access without any security (delivery state)
READ PROTECTED	0x6300	Read access protected by password
READ FORBIDDEN	0x6984	Read access forbidden (permanent state)

Table 10. Write protection modes

Mode	Verify (P1P2=0x0002) R-APDU	Meaning
WRITE UNPROTECTED	0x9000	Write access without any security (delivery state)
WRITE PROTECTED	0x6300	Write access protected by password
WRITE FORBIDDEN	0x6984	Write access forbidden (permanent state)

3.2.2 Read and Write access conditions

The CCRD and CCWR bytes (see [Table 3](#)) in the CC file are used to identify the Read and Write access conditions for the NDEF message as defined in the NFC Forum Type 4 Tag specification. The ST25TAxxxB support one read condition value and two write condition values.

Tables [11](#) and [12](#) show how these condition values are mapped to the read and write protection modes defined in [Section 3.2.1](#).

Warning: As several protection modes may be mapped to a single condition value, the Read and Write access condition values are not to be used to identify the protection modes.

Table 11. Read access conditions (CCRD values)

Value	Read protection modes
0x00	UNPROTECTED ⁽¹⁾ , PROTECTED ⁽¹⁾ , FORBIDDEN ⁽¹⁾

1. Refer to [Section 3.2.1](#) to discriminate between the protection modes.

Table 12. Write access conditions (CCWR)

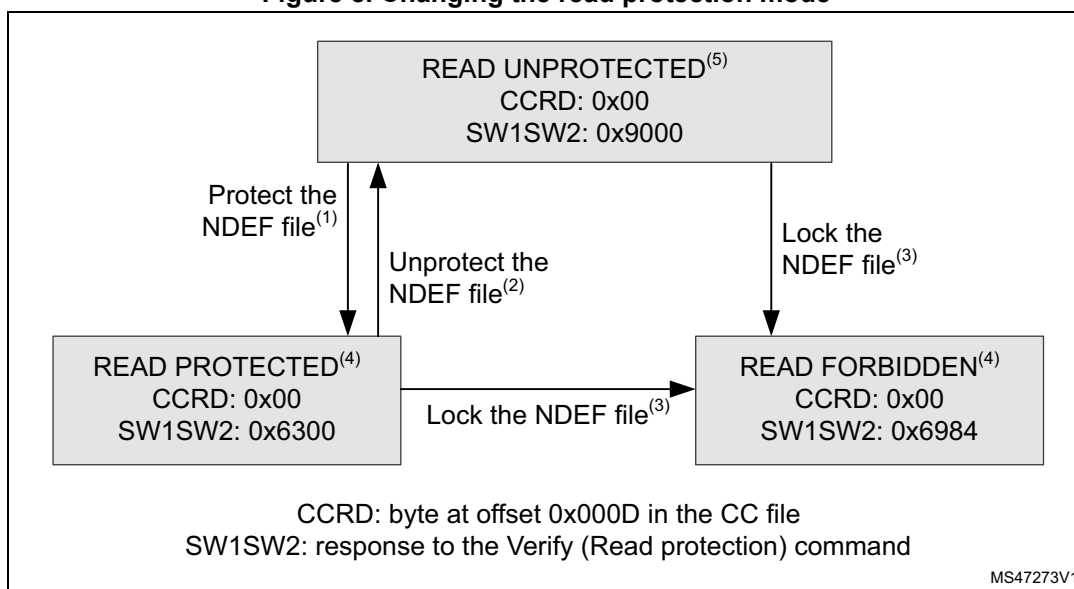
Value	Write protection modes
0x00	UNPROTECTED
0xFF	PROTECTED ⁽¹⁾ , FORBIDDEN ⁽¹⁾

1. Refer to [Section 3.2.1](#) to discriminate between the protection modes.

3.2.3 Changing the read protection mode

The state diagram of [Figure 8](#) shows how to change the read protection mode of the NDEF file.

Figure 8. Changing the read protection mode

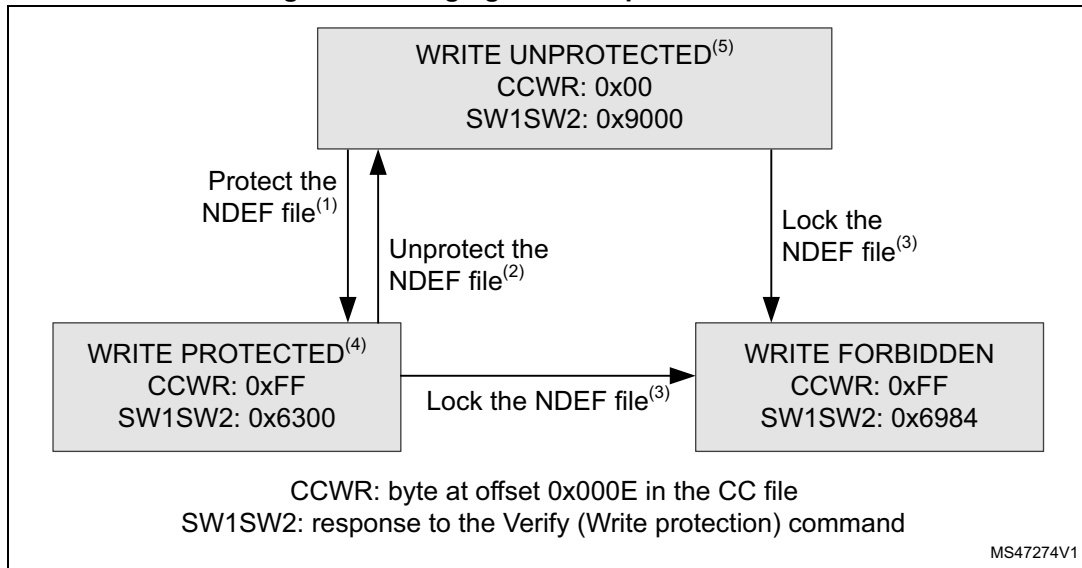


1. See the procedure to protect the read access ([Section 7.1: Protecting an NDEF file](#)).
2. See the procedure to unprotect the read access ([Section 7.3: Unprotecting an NDEF file](#)).
3. See the procedure to forbid the read access ([Section 7.4: Locking an NDEF file](#)).
4. Proprietary state, not defined by NFC Forum Type 4 Tag.
5. Delivery state.

3.2.4 Changing the write protection mode

The state diagram on [Figure 9](#) shows how to change the write protection mode of the NDEF file.

Figure 9. Changing the write protection mode



1. See the procedure to protect the write access ([Section 7.1: Protecting an NDEF file](#)).
2. See the procedure to unprotect the write access ([Section 7.3: Unprotecting an NDEF file](#)).
3. See the procedure to forbid the write access ([Section 7.4: Locking an NDEF file](#)).
4. Proprietary state, not defined by NFC Forum Type 4 Tag.
5. Delivery state.

3.3 Granted access life time

When the NDEF file is in a READ or WRITE PROTECTED state, the corresponding file access is granted starting from the first successful password presentation (see [Section 7.1](#)), and until one of the following events occurs:

- an RF field shutdown
- a successful DESELECT command
- a successful NDEF Tag Application Select command (no file selected)
- successful Capability Container Select or System File Select command (other file selected)
- a wrong password presentation (security session closed)

When the NDEF file is in a READ or WRITE FORBIDDEN state, the corresponding file access is never granted.

3.4 NDEF file passwords

Two passwords are available on the ST25TAxxxB devices:

- Read password: protects the read access to the NDEF file
- Write password: protect the write access to the NDEF file and the setting of the read and write protection modes (see [Section 7.1](#) and [Section 7.2](#))

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

A password is presented using the Verify command (see [Section 6.8.1: Verify command](#)).

After three consecutive authentication failures for a given password, further attempts will fail until the following sequence of events occurs:

- tag set in Standby power mode (RF field shutdown or DESELECT command)
- tag activation (anticollision and RATS commands)
- successful NDEF Tag Application Select command
- successful NDEF Select command

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

4 Specific features

4.1 Read/Write counter

A 20-bit counter can track the read or write events on the NDEF file.

It benefits from an anti-tearing mechanism, that ensures the consistency of the counter, even if there has been an electrical problem during its increment.

The value of the Read/Write counter can be checked by any application, by reading suitable bytes in System file (see [Section 3.1.4](#)).

If enabled, the Read/Write counter will be incremented on the first event (exclusively read / write) performed on the NDEF File, after a successful NDEF Tag Application Select command. Following read/write events will not modify the counter value until a new successful NDEF Tag Application Select command is issued.

The counter is reset when it is disabled.

Apart from these procedures, there is no way to act on the value of this counter.

The Read/Write counter can be configured through a specific byte in System file (see [Section 3.1.4](#)).

This configuration byte allows to:

- Enable or disable this counter
- Define if the counter must be incremented on a read or write sequence
- Definitively lock this configuration byte

Warning: Once this configuration byte is locked, it cannot be changed anymore: the counter will behave accordingly.

If enabled, the Read/Write counter will have an impact on the execution time of the event being countered: the counter increment needs some write cycles of specific EEPROM cells automatically managed by ST25TAxxxB, which increase the total time before the response is sent to the reader.

As a consequence, an S(WTX) request can be issued on the command that will increment the counter (see [Section 6.4: S-Block format](#)).

4.2 General purpose output (GPO), only available on ST25TA02KB-D/P

The GPO pad is either a CMOS pad (ST25TA02KB-P) or an open drain pad (ST25TA02KB-D).

In case of CMOS GPO active state is 1 and inactive state is 0.

In case of open drain an external pull-up shall be connected to it. In this case, active state is 0 and inactive state is 1. If no pull-up is used the active state is 0, but inactive state is HZ.

This pad is a configurable output signal, driven to the alternate polarity when configured event occur. Its behavior is consistent with the RF session activated and with the mode chosen by the user.

The user can select one of these configurations (*Table 68: GPO timings measurement*):

- SessionOpen: an RF session is ongoing.
- MIP (NDEF Message updating In Progress): the RF host is writing an NDEF length different from 0x0000. This mode can be used to detect when the RF host changes the NDEF message as defined by the NFC Forum.
- WIP (Writing In Progress): the ST25TA02KB-D/P is executing a writing operation.
- INT (interrupt): the RF host can force the ST25TA02KB-D/P to send an alternate pulse on the GPO pin.
- State mode: the RF host can control the state of the GPO pad during the RF session.
- RF busy: an RF host is communicating with the ST25TA02KB-P.
- Field detection: the RF field is sufficient to establish an RF communication with the ST25TA02KB-P.

GPO configuration byte can be locked, by setting its Most Significant Bit to 1 (1xxx 0000 b). Once locked, this byte cannot be changed anymore.

4.2.1 Session Open configuration (GPO field = 0x10 or 0x90)

When the GPO is configured as “Session Open”, it goes to the active state when an RF session is ongoing (see *Figure 10*).

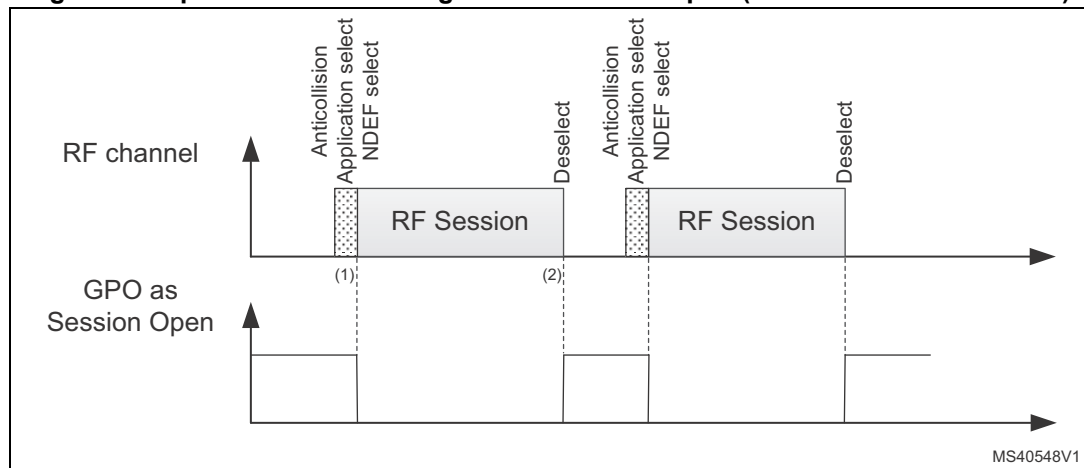
An RF session is taken when the ST25TA02KB-D/P receives a valid Select Application. The session is released when:

- ST25TA02KB-D/P receives a valid Deselect command
- RF field becomes OFF

GPO is driven to active state after a delay (1) when the session is open.

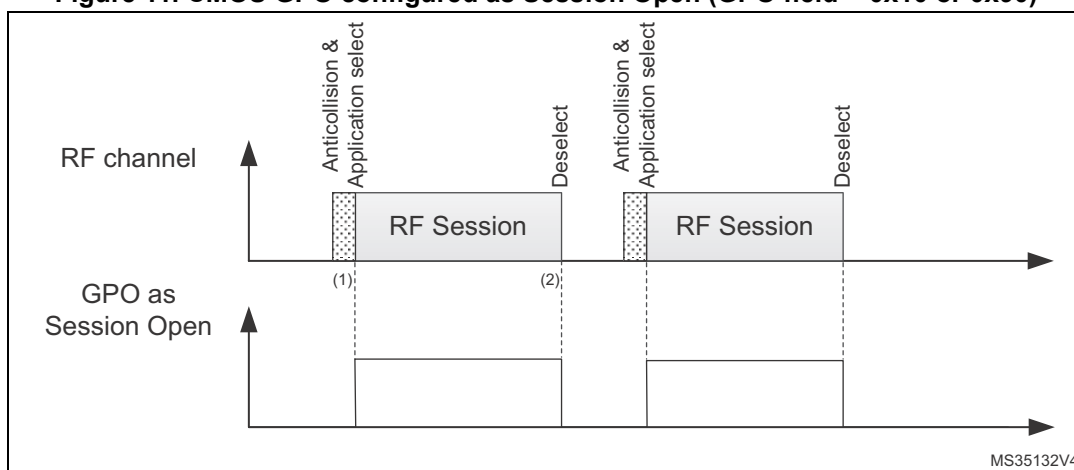
GPO is released after a delay (2) when the session is released.

Figure 10. Open drain GPO configured as Session Open (GPO field = 0x10 or 0x90)



1. CmdEOFtoGPlow (RF command End of frame to GPORF Session pad low).
2. CmdEOFtoGPHZ (RF command End of frame to GPORF Session pad HZ).

Figure 11. CMOS GPO configured as Session Open (GPO field = 0x10 or 0x90)



1. CmdEOFToGPhigh (RF command End of frame to GPORF Session pad high).
2. CmdEOFToGPlow (RF command End of frame to GPORF Session pad low).

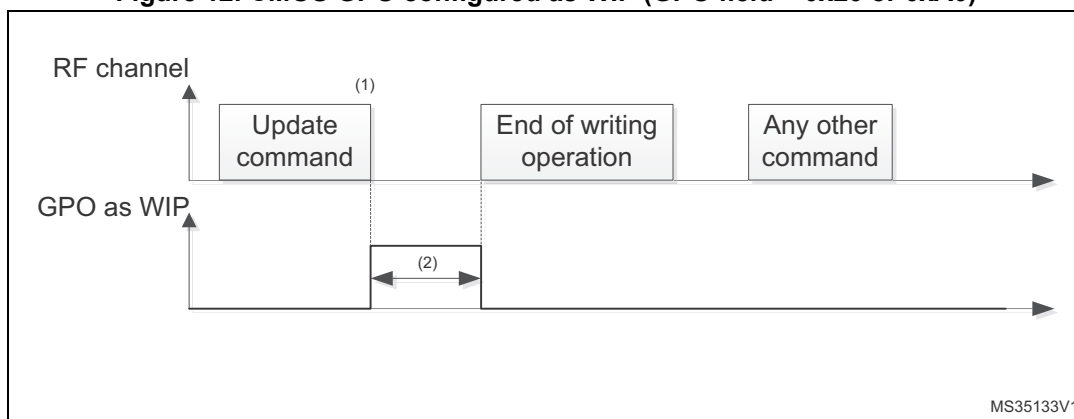
4.2.2 WIP Writing in Progress configuration (GPO field = 0x20 or 0xA0)

When the GPO is configured as “WIP”, it goes to the active state state during an RF writing operation (see [Figure 12](#)).

During an RF session, when the ST25TA02KB-D/P updates a file, the GPO is driven in active state after a delay (1) following the beginning of the correspondent UpdateBinary command execution.

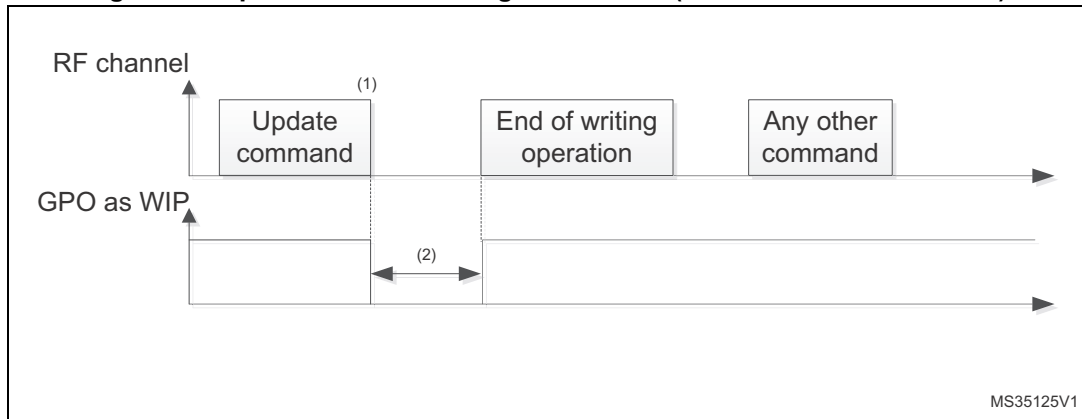
GPO will remain in active state during the writing time (2), before being released.

Figure 12. CMOS GPO configured as WIP (GPO field = 0x20 or 0xA0)



1. CmdEOFToGPhigh (RF Command End of frame to GPO high).
2. Writing time duration.

Figure 13. Open drain GPO configured as WIP (GPO field = 0x20 or 0xA0)



- 1. CmdEOFtoGPlow (RF Command End of frame to GPO low).
- 2. Writing time duration.

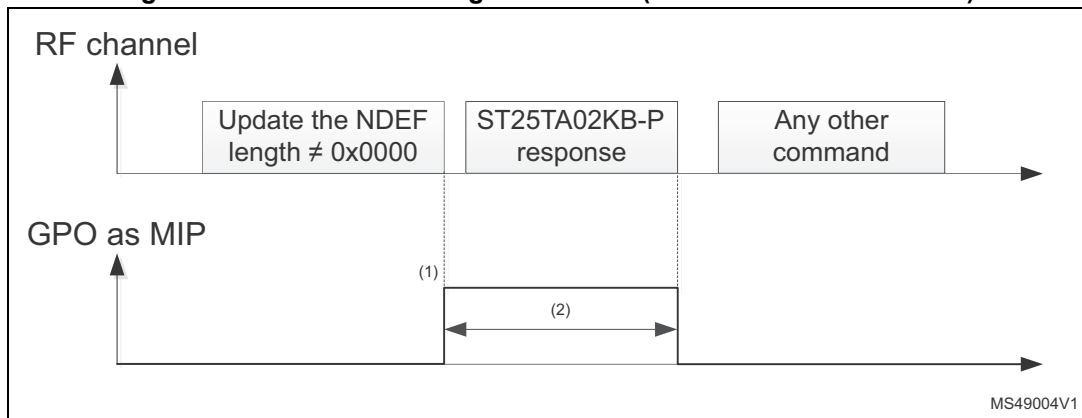
4.2.3 MIP NDEF Message writing in Progress configuration (GPO field = 0x30 or 0xB0)

When the GPO is configured as MIP, its state goes to the active state when the RF host writes the NDEF length to another value than 0x0000 (see [Figure 14](#)).

During an RF session, when the ST25TA02KB-D/P changes an NDEF file and updates the NDEF length with a value different from 0x0000, the GPO is driven in active state after a delay (1) following the beginning of the correspondent UpdateBinary command execution.

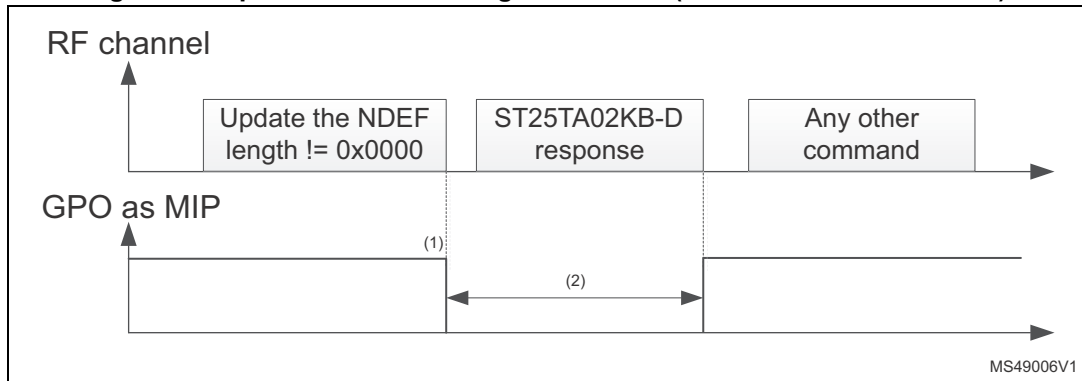
GPO will remain in active state during the writing time (2), before being released.

Figure 14. CMOS GPO configured as MIP (GPO field = 0x30 or 0xB0)



- 1. CmdEOFtoGPhigh (RF command End of frame to GPO high).
- 2. Writing time duration.

Figure 15. Open drain GPO configured as WIP (GPO field = 0x30 or 0xB0)



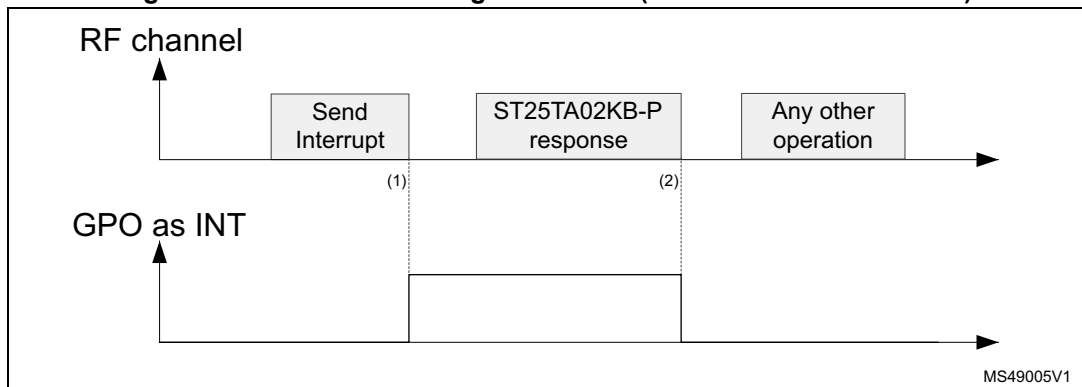
1. CmdEOFtoGPlow (RF command End of frame to GPO low).
2. Writing time duration.

4.2.4 INT Interrupt configuration (GPO field = 0x40 or 0xC0)

The RF host can send a pulse on the GPO pad. The GPO pad goes to active state at the end of the command and goes to the inactive state at the end of the ST25TA02KB-D/P response (see [Figure 16](#)).

During an RF session, when the ST25TA02KB-D/P receives a valid SendInterrupt command, the GPO pin is driven in active state (1). Then the GPO pin is released at the end of the response (2).

Figure 16. CMOS GPO configured as INT (GPO field = 0x40 or 0xC0)



1. CmdEOFtoGPhigh (RF command End of frame to GPO high).
2. RespEOFtoGPlow.