Application note

Augmented NDEF messages with ST25TV512C and ST25TV02KC devices

Introduction

The purpose of this document is to display practical usage of the ANDEF (augmented NDEF) feature with ST25TV512C and ST25TV02KC (hereinafter referred to as ST25TVxxxC) devices.

NDEF (NFC data exchange format) messages are stored in the EEPROM of ST25TVxxxC devices, and contain various kinds of information, such as URI, text, images, Bluetooth® or wifi credentials.

When reading an NDEF message, NFC compatible smartphones automatically trigger native actions, such as opening the web browser with an URI content, or connecting to a device with Bluetooth pairing data.

The term ANDEF stands for an NDEF message that contains data dynamically mapped from system registers of an ST25TVxxxC device, to enhance the use cases available through native actions.

1 Acronyms

Table 1. List of acronyms

Acronym	Definition
AM	ANDEF memory
AN	Application note
ANDEF	Augmented NDEF
BSS	Block security status
CC	Capability container file as defined by the NFC Forum T5T specification
CRC	Cyclic redundancy check
DS	Datasheet
EEPROM	Electrically erasable programmable read-only memory
EOF	End of frame
FID	Feature identifier
IC	Integrated circuit
IEC	International electrotechnical commission
ISO	International organization for standardization
NA	Not applicable
NDEF	NFC data exchange format defined by the NFC Forum
NFC	Near field communication
PID	Parameter identifier
RF	Radio frequency
SOF	Start of frame
TD	Tamper detection
UID	Unique identifier
UM	User memory
UTC	Unique tap code
VCD	Vicinity coupling device
VICC	Vicinity integrated circuit card

2 Conventions

The following conventions apply in this document unless otherwise stated.

- **Binary number representation**:

  Binary numbers are represented by strings of 0 and 1 digits, with the most significant bit (MSB) on the left, the least significant bit (LSB) on the right, and a **b** suffix added at the end.

  Example: 11110101b

- **Hexadecimal number representation**:

  Hexadecimal numbers are represented by strings of numbers from 0 to 9 and letters from A to F, and an **h** added at the end. The most significant byte (MSB) is shown on the left and the least significant byte (LSB) on the right.

  Example: F5h

- **Decimal number representation**:

  Decimal numbers are represented without any trailing character.

  Example: 245

- **ASCII character representation**:

  Character between single quotes.

  Example: ASCII character **"0"** corresponds to hexadecimal value 30h

3 ANDEF overview

The ANDEF feature is a contextual automatic NDEF message service, allowing the tag to respond dynamic content to read requests without an explicit update of the EEPROM by the user.

When the feature is enabled, user memory data at byte addresses ranging from ANDEF_START to ANDEF_END is replaced by the content of a virtual memory ANDEF_MEM in the response to ReadSingleBlock and ReadMultipleBlocks requests.

The content of ANDEF_MEM memory is the result of the concatenation of ANDEF fields:

- UID
- Custom message
- Unique tap code
- Tamper detection
- TruST25 signature
- Password attempt counters
- Separator

The ANDEF feature has no effect on BSS values of blocks crossing the ANDEF_START:ANDEF_END range.

Note: The ANDEF feature has no effect on the WriteSingleBlock command. When the feature is enabled, and a WriteSingleBlock command is issued on a block crossing the ANDEF_START:ANDEF_END range, the data from the command is directly written to the EEPROM at the requested block address, without replacement by volatile memory content.

Figure 1. User and ANDEF memory contents

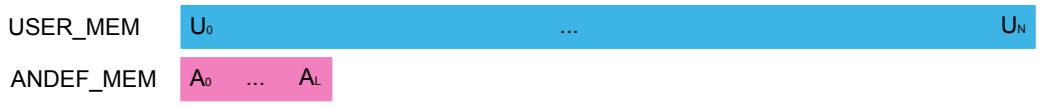
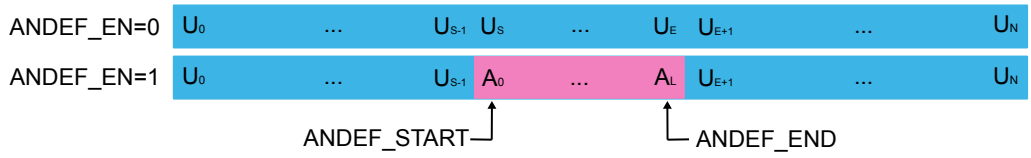


Figure 2. Data responded to user memory read request when ANDEF feature is disabled or enabled



4 ANDEF settings

The ANDEF feature is enabled or disabled when the value of register ANDEF_EN is 1b or 0b during the last RF boot sequence.

Table 2. Content of ANDEF_EN register

Bit	Name	Function	Factory value
b0	ANDEF_EN	0: ANDEF feature is disabled 1: ANDEF feature is enabled	0b
b7-b1	RFU	-	0000000b

Byte addresses ANDEF_START and ANDEF_END depend on the value of configuration register ANDEF_CFG (see) during the last RF boot sequence:

- ANDEF_START = ANDEF_BLOCK * 4 + ANDEF_BYTE
- ANDEF_END = min (END_MEM * 4 + 3, ANDEF_START + ANDEF_LEN - 1)

where:

- END_MEM is the address of the last block available from the user memory (0Fh and 4Fh on ST25TV512C and ST25TV02KC devices, respectively)
- ANDEF_LEN is the number of bytes available from ANDEF_MEM memory: ANDEF_LEN = ANDEF_UID_EN * 16 + ANDEF_CUS_EN * 8 + ANDEF_UTC_EN * 3 + ANDEF_TD_EN * 3 + ANDEF_SEP_EN * (ANDEF_UID_EN + ANDEF_CUS_EN + ANDEF_UTC_EN + ANDEF_TD_EN - 1)

Table 3. ANDEF_CFG content

Bit	Name	Function	Factory value
b0	ANDEF_UID_EN	0: UID field disabled in ANDEF feature 1: UID field enabled in ANDEF feature	0b
b1	ANDEF_CUS_EN	0: Custom field disabled in ANDEF feature 1: Custom field enabled in ANDEF feature	0b
b2	ANDEF_UTC_EN	0: Unique tap code field disabled in ANDEF feature 1: Unique tap code field enabled in ANDEF feature	0b
b3	RFU	-	0b
b4	ANDEF_TD_EN (1)	0: Tamper detection field disabled in ANDEF feature 1: Tamper detection field enabled in ANDEF feature	0b
b5	ANDEF_SEP_EN	0: ANDEF field separator disabled 1: ANDEF field separator enabled	1b
b7- b6	ANDEF_BYTE	Byte offset in block ANDEF_BLOCK where the ANDEF feature starts operating	00b
b15-b8	ANDEF_BLOCK	Block address where the ANDEF feature starts operating	00h

1. *Relevant on ST25TV02KC-T devices only, forced to 0b on ST25TVxxxC-A devices*

Note: Refer to the datasheet for details on ANDEF_EN and ANDEF_CFG configuration registers.

4.1 ANDEF fields

Each ANDEF field corresponds to a system register of the ST25TVxxxC device. Each field may be enabled independently, and its order of appearance in the ANDEF_MEM memory is fixed (see Section 4.2 ANDEF_MEM memory content).

4.1.1 UID

The UID field is 16 bytes wide and contains the value of the ANDEF_UID system register. It holds a static value corresponding to the ASCII translation of the binary UID value returned by commands like Inventory or GetSystemInfo. It is present when ANDEF_UID_EN = 1b in the ANDEF_CFG configuration register.

Table 4. ANDEF_UID content

Bit	Name	Function	Factory value
b127-b0	ANDEF_UID	Value displayed in the UID field of the ANDEF feature	UID in ASCII format starting with **E0**

Each 4-bit nibble of the binary UID is translated to an ASCII character representing its hexadecimal value. The ANDEF_UID register is formatted to display the hexadecimal nibble values in a reversed order with regard to the binary value: the magic number E0h (which is the trailing byte of the binary UID) is translated as the heading characters "E" and "0" in the ANDEF_UID register.

Table 5. ANDEF_UID value (UID=E00208000ED1E016h)

Bytes	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Hex	36h	31h	30h	45h	31h	44h	45h	30h	30h	30h	38h	30h	32h	30h	30h	45h
Char	"6"	"1"	"0"	"E"	"1"	"D"	"E"	"0"	"0"	"0"	"8"	"0"	"2"	"0"	"0"	"E"

Note: Registers containing multiple bytes are transmitted in LSB to MSB byte order in responses to ISO15693 requests. Consequently, the first two characters displayed from the UID ANDEF field are "E" and "0".

4.1.2 Custom message

The custom message field is 8 bytes wide and contains the concatenation of the ANDEF_CUSTOM_LSB and ANDEF_CUSTOM_MSB configuration registers. It is present when ANDEF_CUS_EN = 1b in the ANDEF_CFG configuration register.

Table 6. ANDEF_CUSTOM_LSB content

Bit	Name	Function	Factory value
b31-b0	ANDEF_CUSTOM_LSB	First 4 characters of the ANDEF custom field	2E2E2E2Eh

Table 7. ANDEF_CUSTOM_MSB content

Bit	Name	Function	Factory value
b31-b0	ANDEF_CUSTOM_MSB	Last 4 characters of the ANDEF custom field	2E2E2E2Eh

Note: Refer to the datasheet for details on access to the ANDEF_CUSTOM_LSB and ANDEF_CUSTOM_MSB configuration registers.

The Table 8 shows the values of ANDEF_CUSTOM_LSB and ANDEF_CUSTOM_MSB registers to display the string PERFUME1 in the custom message field.

Table 8. Register content to display PERFUME1 string in the custom message field

Bytes	ANDEF_CUSTOM_MSB				ANDEF_CUSTOM_LSB			
	B3	B2	B1	B0	B3	B2	B1	B0
Hex	31h	45h	4Dh	66h	46h	52h	45h	50h
Char	"1"	"E"	"M"	"U"	"F"	"R"	"E"	"P"

4.1.3 Unique tap code

The unique tap code field is 3 bytes wide and contains the value of the UTC configuration register. It is present when ANDEF_UTC_EN = 1b in the ANDEF_CFG configuration register.

The value of the UTC register is automatically updated during the RF boot sequence of the ST25TVxxxC device if the value of the UTC_EN configuration register is set to 1b.

Table 9. UTC content

Bit	Name	Function	Factory value
b23-b0	UTC	Unique tap code value	Not applicable

Table 10. UTC_EN content

Bit	Name	Function	Factory value
b0	UTC_EN	0: Unique tap code is disabled 1: Unique tap code is enabled	0b
b7-b1	RFU	-	0000000b

Note: Refer to DS13304 the datasheet for details on access to the UTC and UTC_EN configuration registers.

Note: The unique tap code is meant to be used in NFC Forum usecases. When the unique tap code is enabled, the duration of the RF boot sequence is:

- *compliant with the 5 ms guard-time value defined by the NFC Forum DIGITAL specification*
- *not compliant with the 1 ms guard-time value defined by the ISO15693 standard*

When the UTC register is updated, the new value is different from its preceding values, allowing to uniquely identify a RF session for this ST25TVxxxC device.

4.1.4 Tamper detection

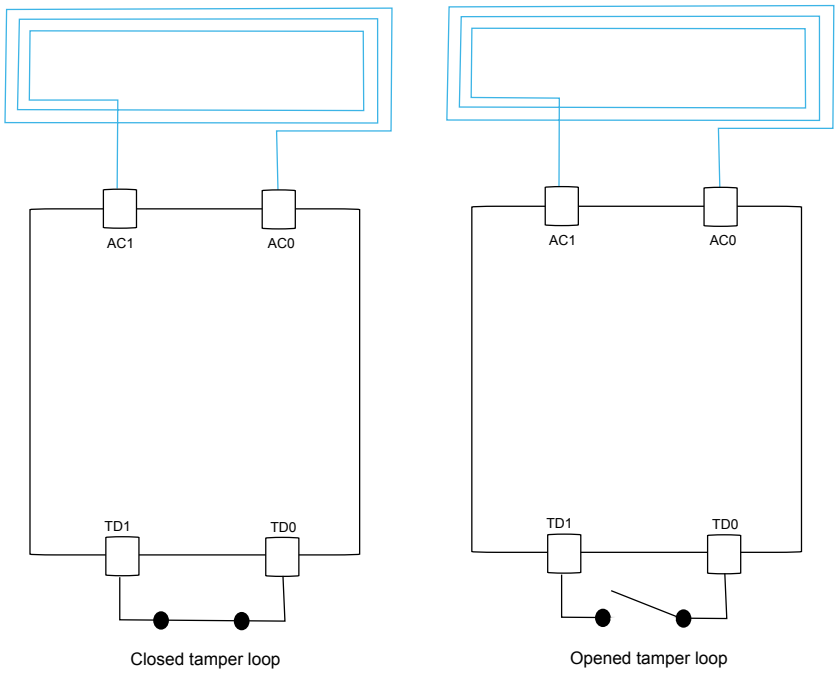
The tamper detection field is available on ST25TV02KC-T (see ordering information section in DS13304).

It is 3 bytes wide and contains the value of the TD_STATUS configuration register depicted in Table 11. It is present when ANDEF_TD_EN = 1b in the ANDEF_CFG configuration register.

Table 11. TD_STATUS content

Bit	Name	Function	Factory value
b15-b0	TD_EVENT	TD_SEAL_MSG, TD_UNSEAL_MSG or TD_RESEAL_MSG according to result of tamper event detection	Not applicable
b23-b16	TD_LOOP	TD_SHORT_MSG or TD_OPEN_MSG according to the status of the tamper loop during the last boot sequence	Not applicable

Figure 3. **Tamper loop status**



The TD_LOOP value displayed when the tamper pins are connected/disconnected can be configured with the TD_SHORT_MSG/TD_OPEN_MSG registers, respectively.

Table 12. **TD_SHORT_MSG content**

Bit	Name	Function	Factory value
b7- b0	TD_SHORT_MSG	Message displayed when the tamper loop is in closed status during the last boot sequence	63h

Table 13. **TD_OPEN_MSG content**

Bit	Name	Function	Factory value
b7- b0	TD_OPEN_MSG	Message displayed when the tamper loop is in open status during the last boot sequence	6Fh

The TD_EVENT bytes of the TD_STATUS register reflects one of the following states for the ST25TV02KC-T device:

- TD_SEAL: the disconnection of the tamper pins TD0 and TD1 is never registered.
- TD_UNSEAL: the disconnection of pins TD0 and TD1 is registered once, and their reconnection is never registered ever since.
- TD_RESEAL: a reconnection of pins TD0 and TD1 is registered once (implying the device is in TD_UNSEAL state before switching to the TD_RESEAL state).

The TD_EVENT value displayed when the device is in TD_SEAL/TD_UNSEAL/TD_RESEAL state can be configured with the TD_SEAL_MSG/TD_UNSEAL_MSG/TD_RESEAL_MSG configuration register respectively.

The value of TD_EVENT is updated during the boot sequence of the ST25TV02KC-T device when the TD_EVENT_UPDATE_EN configuration register is set to 1b and a switch to TD_UNSEAL or TD_RESEAL state is detected.

Note: At delivery of the ST25TV02KC-T device, the TD_EVENT_UPDATE_EN configuration register is set to 0b, and the value of TD_EVENT reflects the TD_SEAL state regardless of the tamper loop status, until the TD_EVENT_UPDATE_EN register is set to 1b.

Note: After switching from TD_SEAL to TD_UNSEAL state, the state cannot be reverted to TD_SEAL. After switching from TD_UNSEAL to TD_RESEAL state, the state cannot be reverted to TD_UNSEAL.

Note: The memorization of tamper events is meant to be used in NFC Forum usecases. When the value of TD_EVENT is updated, the duration of the RF boot sequence is:

- *compliant with the 5 ms guard-time value defined by the NFC Forum DIGITAL specification.*
- *not compliant with the 1 ms guard-time value defined by the ISO15693 standard.*

Table 14. TD_SEAL_MSG content

Bit	Name	Function	Factory value
b15-b0	TD_SEAL_MSG	Value of TD_EVENT displayed before first occurence of a TD_UNSEAL event	3030h

Table 15. TD_UNSEAL_MSG content

Bit	Name	Function	Factory value
b15-b0	TD_UNSEAL_MSG	Value of TD_EVENT displayed after first occurrence of a TD_UNSEAL event	5555h

Table 16. TD_RESEAL_MSG content

Bit	Name	Function	Factory value
b15-b0	TD_RESEAL_MSG	Value of TD_EVENT displayed after occurrence of a TD_RESEAL event	5252h

Table 17. TD_EVENT_UPDATE_EN content

Bit	Name	Function	Factory value
b0	TD_EVENT_UPDATE_EN	0: memorization of tamper events disabled 1: memorization of tamper events enabled	0b
b7- b1	RFU	-	0000000b

4.1.5 Separator

The separator field is 1 byte wide and contains the value of the ANDEF_SEP configuration register. It is inserted between each ANDEF fields when ANDEF_SEP_EN = 1b in the ANDEF_CFG configuration register, and more than one of these fields are enabled.

Table 18. ANDEF_SEP content

Bit	Name	Function	Factory value
b7- b0	ANDEF_SEP	Character used as ANDEF field separator when ANDEF_SEP_EN = 1b	78h

Note: Refer to the datasheet for details on access to the ANDEF_SEP configuration register.

4.1.6 TruST25 signature

An additional TruST25 signature field can be configured for the ANDEF feature of ST25TV02KC devices.

Refer to AN5578, for more details on this field. Contact your STMicroelectronics sales office to get this document.

4.1.7 Password attempt counters

An additional password attempt counters field can be configured for the ANDEF feature in ST25TV02KC. Refer to AN5577, for more details on this field. Contact your STMicroelectronics sales office to get this document.

4.2 ANDEF_MEM memory content

For each field from UID to Separator, the order of appearance, register content, and condition of presence in the ANDEF_MEM memory are listed in Table 19.

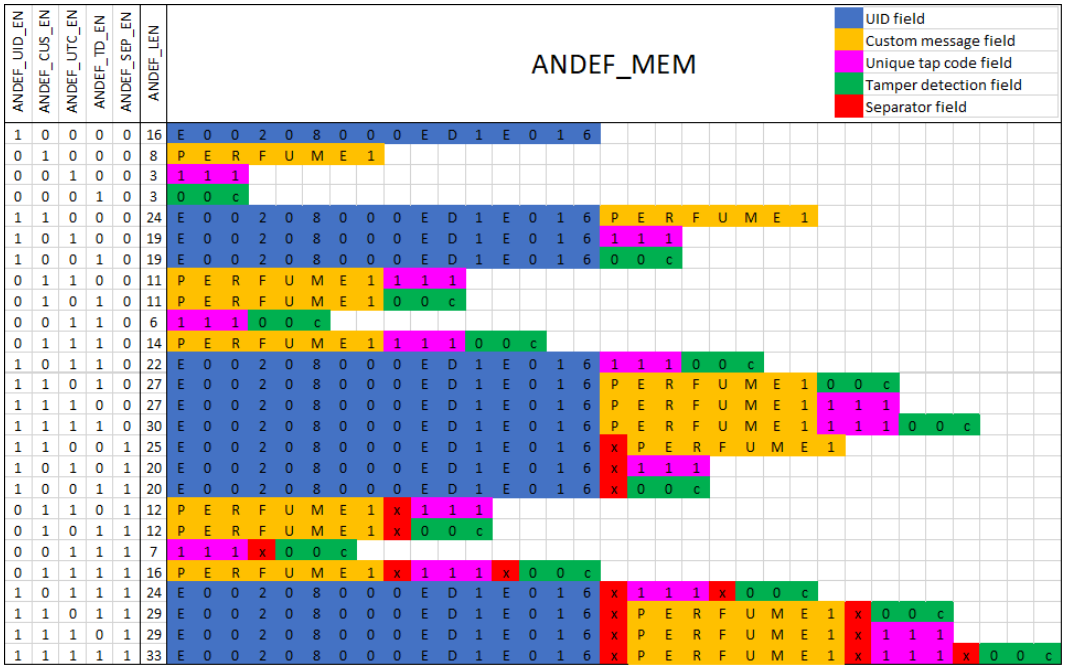
Table 19. ANDEF fields concatenated in ANDEF_MEM

Order	Content(1)	Bytes	Condition of presence
1	ANDEF_UID	16	ANDEF_UID_EN = 1b
2	ANDEF_SEP	1	ANDEF_UID_EN = 1b and ANDEF_CUS_EN = 1b and ANDEF_SEP_EN = 1b
3	ANDEF_CUSTOM_LSB	4	ANDEF_CUS_EN = 1b
4	ANDEF_CUSTOM_MSB	4	ANDEF_CUS_EN = 1b
5	ANDEF_SEP	1	(ANDEF_UID_EN = 1b or ANDEF_CUS_EN = 1b) and ANDEF_UTC_EN = 1b and ANDEF_SEP_EN = 1b
6	UTC	3	ANDEF_UTC_EN = 1b
7	ANDEF_SEP	1	(ANDEF_UID_EN = 1b or ANDEF_CUS_EN=1b or ANDEF_UTC_EN = 1b) and ANDEF_TD_EN = 1b(2) and ANDEF_SEP_EN = 1b
8	TD_STATUS	3	ANDEF_TD_EN = 1b(2)

1. *When a register value is coded on several bytes, it is copied in LSB to MSB byte order in the ANDEF_MEM memory.*
2. *TD_STATUS field available on ST25TV02KC-T devices only.*

Figure 4 lists the possible combination of ANDEF fields from UID to Separator in the ANDEF_MEM memory according to the rules from Table 19.

Figure 4. Possible combinations of ANDEF fields in ANDEF_MEM memory



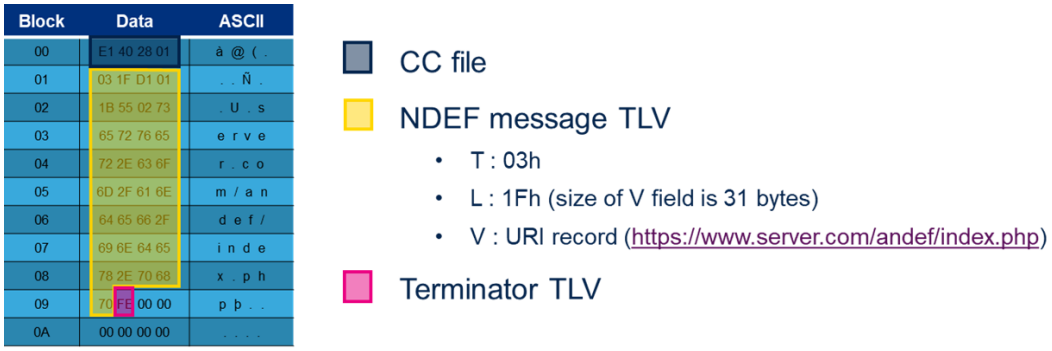
5 ANDEF message

This section shows a practical usage of the ANDEF feature with the example of a dynamic NDEF URI message.

5.1 Basic NDEF URI message

Figure 5 shows the content of the user memory when an ST25TV02KC is configured as an NFC Forum T5T device containing an NDEF message with one URI record. The formatting of the user memory follows the guidelines defined in AN5608.

Figure 5. USER_MEM content in case of basic NDEF URI message



In this basic case, the content of the URI record is static and the ANDEF feature of the ST25TV02KC device is not used (the value of the ANDEF_EN register is 0b).

5.2 ANDEF URI message

5.2.1 ST25TV02KC-T configuration

Figure 6 shows the content of the ANDEF_MEM memory for a ST25TV02KC-T device when UID, Custom message, Unique tap code, Tamper detection and Separator fields are enabled.

Figure 6. ANDEF_MEM content (ANDEF_LEN = 33)

As two of these ANDEF fields are dynamic (unique tap code and tamper detection), the content of ANDEF_MEM can be used to generate dynamic content in an URI record.

Figure 7 shows the content of the user memory ST25TV02KC containing an NDEF URI record, where a placeholder of ANDEF_LEN (33) bytes is set at bytes addresses 43 to 75 (string of "0" highlighted in purple). ANDEF feature is configured as follows:

- ANDEF_EN = 1b
- ANDEF_CFG = 0AF7h
  - ANDEF_UID_EN = 1b
  - ANDEF_CUS_EN = 1b
  - ANDEF_UTC_EN = 1b
  - ANDEF_TD_EN = 1b
  - ANDEF_SEP_EN = 1b
  - ANDEF_BYTE = 11b
  - ANDEF_BLOCK = 0Ah → ANDEF_START = 43
- ANDEF_CUSTOM_LSB = 46524550h
- ANDEF_CUSTOM_MSB = 31454D66h → Custom message = "PERFUME1"

Figure 8 shows the mapping of ANDEF_MEM content at placeholder location in the data responded to read requests.

Note: Refer to the datasheet for details on access to the ANDEF_EN, ANDEF_CFG, ANDEF_CUSTOM_LSB and ANDEF_CUSTOM_MSB configuration registers.

Note: When the configuration registers of the ANDEF feature are updated, the new values take effect at the next boot of the ST25TV02KC-T device.

Note: The UTC_EN register should be set to 1b to enable the automatic update of the unique tap code field

Figure 7. USER_MEM content in case of ANDEF URI message

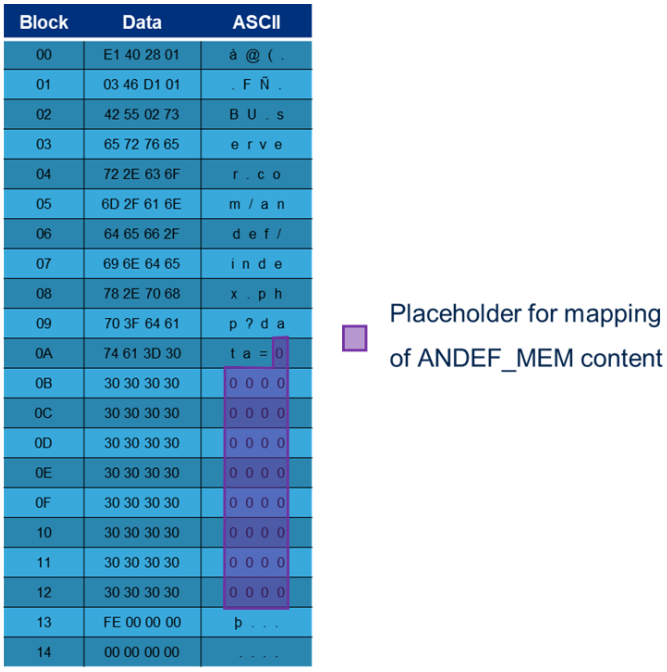
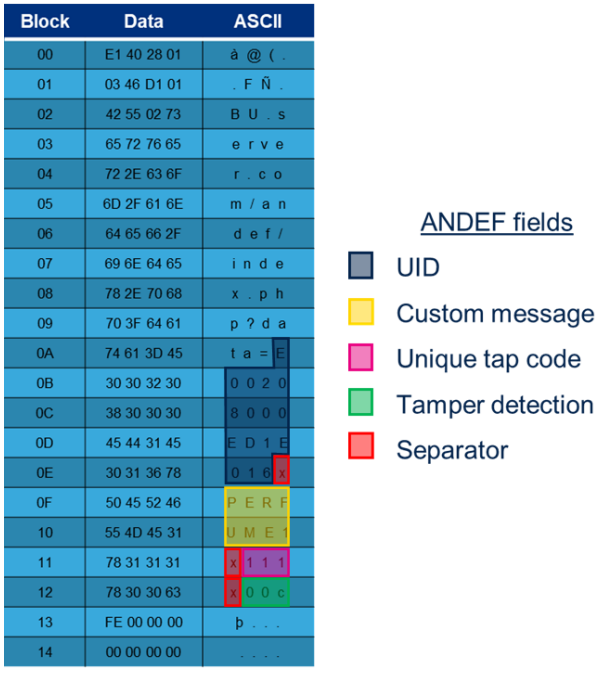


Figure 8. Data responded to ReadSingleBlock or ReadMultipleBlocks requests



While the user memory holds the following basic NDEF URI message

https://www.server.com/andef/index.php?data=00000000000000000000000000000000

the actual URI retrieved by the NFC reader is:

https://www.server.com/andef/index.php?data=E00208000ED1E016xPERFUME1x111x00c

As some of the ANDEF fields mapped in the URI record are dynamic, a smartphone will natively launch its web browser with an updated URI in subsequent read access to this ST25TV02KC-T device.

5.2.2 Character set constraint

When the placeholder of the ANDEF_MEM memory belongs to an URI record, the following configuration registers must be encoded using only characters from Section 4.1.3 Unique tap code:

- ANDEF_CUSTOM_LSB and ANDEF_CUSTOM_LSB (when ANDEF_CUS_EN = 1b)
- TD_SHORT_MSG, TD_OPEN_MSG, TD_SEAL_MSG, TD_UNSEAL_MSG and TD_RESEAL_MSG (when ANDEF_TD_EN = 1b)
- ANDEF_SEP (when ANDEF_SEP_EN = 1b and two or more fields are enabled)

Table 20. List of ASCII characters safe for encoding of URI

Hex	Char	Hex	Char	Hex	Char	Hex	Char	Hex	Char	Hex	Char
-		30h	0	-		50h	P	-		70h	p
21h	!	31h	1	41h	A	51h	Q	61h	a	71h	q
-		32h	2	42h	B	52h	R	62h	b	72h	r
23h	#	33h	3	43h	C	53h	S	63h	c	73h	s
24h	$	34h	4	44h	D	54h	T	64h	d	74h	t
25h	%	35h	5	45h	E	66h	U	65h	e	75h	u
-		36h	6	46h	F	56h	V	66h	f	76h	v
		37h	7	47h	G	57h	W	67h	g	77h	w
28h	(	38h	8	48h	H	58h	X	68h	h	78h	x
29h	)	39h	9	49h	I	59h	Y	69h	i	79h	y
2Ah	*	-		4Ah	J	5Ah	Z	6Ah	j	7Ah	z
2Bh	+			4Bh	K	-		6Bh	k	-	
2Ch	,			4Ch	L	5Ch	\	6Ch	l		
2Dh	-			4Dh	M	-		6Dh	m		
2Eh	.			4Eh	N			6Eh	n	7Eh	~
2Fh	/			4Fh	O	5Fh	_	6Fh	o	-	

Note: Refer to AN5580 for more details on the content of the UTC register. Contact your STMicroelectronics sales office to get this document.

5.2.3 Dynamic ANDEF fields

The unique tap code and tamper detection ANDEF fields are dynamic: their values may change between two consecutive RF sessions of an ST25TVxxxC device.

Note: An RF session starts with the activation of an ST25TVxxxC device on RF field power-up and ends with the deactivation of the device on RF field power-down.

The unique tap code ANDEF field value is updated during the RF boot sequence if the value of the UTC_EN configuration register is 1b (see Section 4.1.3 Unique tap code).

The tamper detection ANDEF field value is updated during the boot sequence if the status of the tamper loop changes with regard to the previous boot sequence (see Section 4.1.4 Tamper detection).

Note: The unique tap code and memorization of tamper event are features designed for NFC Forum usecases. The update of the UTC or TD_EVENT configuration registers during the boot sequence is:

- *compliant with the 5 ms guard time defined by the NFC Forum DIGITAL specification.*
- *not compliant with the 1 ms guard time defined in the ISO15693 standard.*

5.2.4 Webserver application

Considering the use case of an ANDEF URI message, the webserver targeted by this URI may keep track of the unique tap code and tamper detection status of a ST25TVxxxC device, and interpret the sequence of values to determine the integrity of a product and consequently display appropriate information on the generated webpage.

A demonstration of such webserver application is available on demand. Contact you STMicroelectronics sales office for further information.

Note:

- *See AN5580 for detailed information on the content of the UTC register and how to check its integrity. Contact your STMicroelectronics sales office to get this document.*

Revision history

Table 21. **Document revision history**

Date	Version	Changes
20-May-2021	1	Initial release.

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