AN5399
Application note

Migrating from M24LRxxE-R to ST25DV02K-Wx

Introduction

The purpose of this document is to explain how to migrate from the M24LRxxE-R dynamic tag to the new ST25DV02K-Wx dynamic tag.

M24LRxxE-R is an ISO/IEC 15693 NFC/RFID tag, with EEPROM memory and supporting I^2C interface.

ST25DV02K-Wx is an ISO/IEC 15693 NFC/RFID tag, with EEPROM memory and supporting PWM output(s).

The ST25DV02K-Wx is a natural evolution of the M24LRxxE-R with a microcontroller, for applications requiring PWM signal(s). It delivers a highly integrated solution to generate PWM signal(s).

Table 1. Applicable products

Type	Part number
Dual Interface EEPROM	M24LR04E-R M24LR16E-R M24LR64E-R ST25DV02K-W1 ST25DV02K-W2

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1 Acronyms and notational conventions

Table 2. List of acronyms

Acronym	Definition
CC File	Capability container file as defined by the NFC Forum
EEPROM	Electrically-erasable programmable read-only memory
EOF	End of frame
I^2C	Inter-integrated circuit
IC	Integrated circuit
IC Ref	Integrated circuit reference
ISO	International organization for standardization
IEC	International electro-technical commission
NFC	Near field communication standard defined by the NFC Forum
PWM	Pulse width modulation
RF	Radio frequency
SOF	Start of frame
UID	Unique identifier
VCD	Vicinity coupling device
VICC	Vicinity integrated circuit card

1.1 Conventions

The following conventions and notations apply in this document unless otherwise stated.

1.1.1 Product family denomination

Product families are abbreviated as follows:

- **M24LR** refers to the complete family of products: M24LR04E-R, M24LR16E-R and M24LR64E-R.
- **ST25DV-PWM** refers to the complete family of products: ST25DV02K-W1 and ST25DV02K-W2

1.1.2 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

1.1.3 Hexadecimal number representation

Hexadecimal numbers are represented by strings of numbers from 0 to 9 and letters from A to F, and an ‘h’ suffix 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

1.1.4 Decimal number representation

Decimal numbers are represented without any trailing character.

Example: 245

2 M24LR and ST25DV-PWM product feature comparison

Table 3 lists the features of M24LR and ST25DV-PWM products (For full details, refer also to the M24LR *[1]*, *[2]*, *[3]* and ST25DV-PWM *[4]* product datasheets).

Table 3. Feature comparison summary

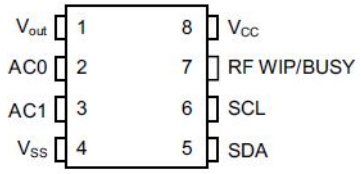
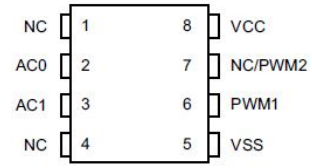
Feature	M24LR	ST25DV-PWM
Pinout		
Packages	SO8	
	TSSPO8	
	UFDFPN8	NA
	Wafer	NA
Tuning capacitance	Same tuning capacitance. M24LR datasheet tuning cap is 27.5 pF, whereas ST25DV-PWM Datasheet tuning cap is 28.5 pF, but there is no need to re-tune the antenna when moving from one device to the other. The datasheet differences are coming from different measurement methodologies. Refer to AN3249 for more details.	
Wired power supply	1.8 to 5.5 V	
I^2C interface	Yes -400 kHz -4 bytes page write -32 bits dedicated password	NA
PWM	NA	Yes - x1/x2 PWM outputs - From 488 to 31250 Hz - Live update by NFC interface
TruST25™	NA	Yes Digital signature for authentication

Table 3. Feature comparison summary (continued)

Feature	M24LR	ST25DV-PWM
Contact-less interface (RF)	Based on ISO/IEC 15693	Based on ISO/IEC 15693 (including amendments 3 and 4) and NFC Forum Type 5 tag
	M24LR16E-R and M24LR64E-R only: Non ISO 15693 compliant commands for reading and writing block memory access	NA
	M24LR16E-R and M24LR64E-R only: Non ISO 15693 compliant command for retrieving memory size	NA
	M24LR16E-R and M24LR64E-R only: Non ISO 15693 compliant response of Get Multiple Blocks Security Status command.	NA
	Inventory-Initiated feature (custom command) for faster inventory sequence	NA
	Proprietary Fast Read commands (downlink 53 Kbits/s)	NA
	4-byte size RF block	
Memory organization	1 Kbit sectors	Up to 4 independent areas: – AREA0 (4 bytes) dedicated to CC file – AREA1 (124 or 252 bytes) for user1 data – AREA2 (128bytes) for user2 data (applies only if area1=124 bytes length) – PWM_CTRL area for PWM settings
User memory protection	From RF: each sector individually protected in reading or writing by one of three possible RF passwords	Each area individually protected in reading or writing by its own password
	From I^2C: Write protection with one I^2C password	NA
	32-bit RF and I^2C passwords	32-bit passwords. 64-bit password on AREA1, when AREA1 length is 252 bytes (AREA2=0 bytes)
	NA	Each block can be individually locked by Lock Block feature, including CC file (AREA0)

Table 3. Feature comparison summary (continued)

Feature	M24LR	ST25DV-PWM
System configuration protection	NA	Write protection with password
	NA	32-bit passwords
	NA	Possible definitive lock of configuration for RF write access
System configuration	From RF: custom commands to read and write configuration register and control byte	Same RF command codes as M24LR. However, command addressing is different between the two devices.
	From I^2C: range address 2304-2336 with E2=1	NA
Interrupt on RF events	Digital output pin (RFWIP/RF Busy) Open drain active low	NA
	RF Busy: IT when M24LR is busy in RF mode (VCD SOF to M24LR EOF)	NA
	RF Write: IT during M24LR internal write time	NA
	The status bit indicates correct completion of the write cycle.	NA
Energy harvesting	Power delivered on Vout output pin is limited depending on configuration	NA
	4 sink current level configurations	NA

The following chapters focus on the differences between each device.

Features that are only available in one device (M24LR or ST25DV-PWM) are not further analyzed (I²C, PWM, TruST25™, Interrupts, Energy harvesting,...). Refer to device datasheets for more details on those features.

3 Hardware considerations

M24LR and ST25DV-PWM products are available in the following package versions:

Table 4. M24LR and ST25DV-PWM product package availability

Product	Package		
	SO8	TSSOP8	UFDFPN8
M24LR	X	X	X
ST25DV-PWM	X	X	-

ST25DV-PWM and M24LR chips are not pin-to-pin compatible, because they do not supply the same functionalities (PWM = Outputs vs. I^2C = Input and Output).

However, the sensitive RF interface does not need to be redone, thanks to the same positioning of antenna connection pins.

Note also that 'NC' pins of ST25DV-PWM can be used to ease board layout, with no impact on-chip functionality and performances.

Table 5. M24LR and ST25DV-PWM pinout

Pin number	M24LR Signal name	ST25DV-PWM Signal name	Function	Direction
1	Vout	NC	Energy Harvesting / NC	Analog output / -
2	AC0	AC0	Antenna coil	IO
3	AC1	AC1	Antenna coil	IO
4	Vss	NC	Ground / NC	Power / -
5	SDA	VSS	Serial data / Ground	IO / Power
6	SCL	PWM1	Serial clock / PWM #1	Input / Output
7	RF WIP/BUSY	NC / PWM2	Interrupt / PWM #2	Output
8	Vcc	VCC	Supply voltage	Power

The M24LR and ST25DV-PWM products support the same power supply voltage range, as shown in *Table 6*.

Table 6. Supported power supply range

Power supply	M24LR	ST25DV-PWM	Unit
Vcc min.	1.8		V
Vcc max.	5.5		

The internal tuning capacitance of the M24LR and ST25DV-PWM products is shown in *Table 7*. Migrating from M24LR to ST25DV-PWM products does not require modification of antenna design.

Note: The typical 28.5 pF value for the ST25DV-PWM is equivalent to the M24LR data-sheet value of 27.5 pF. This change is due to a different measurement methodology between M24LR and ST25DV-PWM products. Refer to the application note AN3249 for more details.

Table 7. Internal tuning capacitance

M24LR04E-R, M24LE16E-R, M24LR64E-R	ST25DV02K-W1, ST25DV02K-W2	Unit
27.5	28.5	pF

4 RF operations

The M24LR and ST25DV-PWM products are based on the ISO/IEC 15693 standard. In addition, ST25DV-PWM products are compatible with ISO/IEC 15693 amendments 3 and 4, and with NFC Forum Type 5 Tag.

The M24LR and ST25DV-PWM products both address 4-byte RF blocks.

The M24LR and ST25DV-PWM products are similar in their RF operations (protocol, modulations, and timings), but they differ in their ISO/IEC 15693 standard command support and in their custom commands.

4.1 RF command list

Table 8 shows the differences in ISO/IEC 15693 standard commands supported by M24LR and ST25DV-PWM products.

Table 8. ISO/IEC 15693 Mandatory and Optional commands support

Command code	M24LR commands	ST25DV-PWM commands	Comment
01h	Inventory	Inventory	-
02h	Stay Quiet	Stay Quiet	-
20h	Read Single Block	Read Single Block	In M24LR16E-R and M24LR64E-R, this command request has a custom format.
21h	Write Single Block	Write Single Block	In M24LR16E-R and M24LR64E-R, this command request has a custom format.
22h	-	Lock Block	Lock Block command is replaced by Lock Sector custom command in M24LR
23h	Read Multiple Blocks	Read Multiple Blocks	In M24LR16E-R and M24LR64E-R, this command request has a custom format. Limited to 32 blocks maximum in all M24LR versions.
24h	-	Write Multiple Blocks	-
25h	Select	Select	-
26h	Reset to Ready	Reset to Ready	-
27h	Write AFI	Write AFI	-
28h	Lock AFI	Lock AFI	-
29h	Write DSFID	Write DSFID	-
2Ah	Lock DSFID	Lock DSFID	-

Table 8. ISO/IEC 15693 Mandatory and Optional commands support (continued)

Command code	M24LR commands	ST25DV-PWM commands	Comment
2Bh	Get System Info	Get System Info	In M24LR16E-R and M24LR64E-R, the answer is formatted differently if Protocol_extenstion_flag = 1.
2Ch	Get Multiple Block SS	Get Multiple Block SS	In M24LR16E-R and M24LR64E-R, this command request has a custom format.

Table 9 shows the differences in custom commands supported by M24LR and ST25DV-PWM products.

Table 9. Custom command support

Cmd code	M24LR commands	ST25DV-PWM commands	Comment
A0h	Read Configuration	Read Configuration	The command format and purpose are different between M24LR and ST25DV-PWM.
A1h	Write EH Configuration	Write Configuration	The command format and purpose are different between M24LR and ST25DV-PWM.
A2h	Set Reset EH configuration	-	-
A3h	Check EH Enable	-	-
A4h	Write DO Configuration	-	-
B1h	Write Sector Password-	Write Password	The command format and purpose are different between M24LR and ST25DV-PWM.
B2h	Lock Sector Password	-	-
B3h	Present Sector Password	Present Password	The command format and purpose are different between M24LR and ST25DV-PWM.
C0h	Fast Read Single block	-	-
C1h	Fast Inventory Initiate	-	-
C2h	Fast Initiate	-	-
C3h	Fast Read Multiple blocks	-	-
D1h	Inventory Initiate	-	-
D2h	Initiate	-	-
D8h	-	Read Signature	

5 User memory access from RF reader

RF user memory is addressed by blocks of 32 bits (4 bytes), both in M24LR and ST25DV-PWM products.

The maximum block address of RF user memory depends on the device's memory size. Depending on the number of blocks, one or two bytes are needed to code the block's memory address as shown in *Table 10*.

Table 10. Number of blocks per device in M24LR and ST25DV-PWM product families

Parameter	ST25DV02K-Wx	M24LR04E-R	M24LR16E-R	M24LR64E-R
Memory size	2 Kbits	4 Kbits	16 Kbits	64 Kbits
Block size	4 bytes			
Max block address	3Fh	7Fh	1FFh	7FFh
Number of bytes used to code the block addresses	1 byte		2 bytes	
Product type	Low-density		High-density	

The ISO/IEC 15693 specification defines the reading and writing commands with a block number coded on one byte for low-density devices (memory smaller than 256 blocks).

The third amendment of ISO/IEC 15693 defines the extended read and write commands with a block number coded on two bytes for high-density devices (memory larger than 256 blocks).

M24LR16E-R and M24LR64E-R are high-density devices, but have been released before ISO/IEC 15693 amendment 3 publication and do not integrate extended read and write commands. Instead, they use custom read and write commands with block numbers coded on two bytes and the proprietary Protocol_extension_flag to address all memory blocks (see *Table 11*).

Table 11. Addressing modes of M24LR and ST25DV-PWM devices

Parameter	M24LR04E-R ST25DV-PWM	M24LR16E-R M24LR64E-R
Addressing mode	Standard (1 byte)	Custom (2 bytes)
Protocol_extension_flag	0	1

In consequence, two migration paths exist, as shown in *Table 12*.

Table 12. Memory addressing migration paths

Original device	New device	Changes in reading and writing user memory blocks
M24LR04E-R	ST25DV-PWM	No change
M24LR16E-R M24LR64E-R	ST25DV-PWM	Different commands must be used for reading and writing blocks, whatever the address

Following *Section 5.1: Read_Single_Block command* to *Section 5.4: Get_Multiple_Blocks_Security_Status command* describe differences of user memory access commands between the M24LR and ST25DV-PWM products.

5.1 Read_Single_Block command

Command format:

Table 13. ST25DV-PWM and M24LR04KE-R Read Single Block

SOF	Request_flags	Read Single Block	UID (optional)	Block number	CRC16	EOF
-	xxxx0xxxb	20h	8 bytes	1 byte	2 bytes	-

Table 14. M24LR16E-R and M24LR64E-R Read Single Block

SOF	Request_flags	Read Single Block	UID (optional)	Block number	CRC16	EOF
-	xxxx1xxxb	20h	8 bytes	2 bytes	2 bytes	-

Response:

If the option flag is not set, the response to a Read Single Block command is identical between M24LR and ST25DV-PWM products.

If the option flag is set, the Block Security Status byte of the response is different. Refer to *Table 33: M24LR RF block security status response* and *Table 34: ST25DV-PWM RF block security status response*.

Note: The ST25DV-PWM device does not support the Fast Read Single Block command.

5.2 Write_Single_Block command

Command format:

Table 15. ST25DV-PWM and M24LR04KE-R Write Single Block

SOF	Request_flags	Write Single Block	UID (optional)	Block number	Data	CRC16	EOF
-	xxxx0xxxb	21h	8 bytes	1 byte	4 bytes	2 bytes	-

Table 16. M24LR16E-R and M24LR64E-R Write Single Block

SOF	Request_flags	Write Single Block	UID (optional)	Block number	Data	CRC16	EOF
-	xxxx1xxxb	21h	8 bytes	2 bytes	4 bytes	2 bytes	-

Response:

The response to a Write command is identical between M24LR and ST25DV-PWM products.

5.3 Read_Multiple_Block command

Command format:

Table 17. ST25DV-PWM and M24LR04KE-R Read Multiple Blocks

SOF	Request_flags	Read Multiple Blocks	UID (optional)	First Block	Number of blocks	CRC16	EOF
-	xxxx0xxxb	23h	8 bytes	1 byte	1 byte(1)(2)	2 bytes	-

1. M24LR: The number of blocks is limited to 32 and all blocks must belong to the same sector. Otherwise, an error 0Fh is returned.
2. ST25DV-PWM: In case the requested blocks belong to different areas, bytes are returned as long as they are not locked. When a locked area is encountered, the device stops sending bytes.

Table 18. M24LR16E-R and M24LR64E-R Read Multiple Blocks

SOF	Request_flags	Read Multiple Blocks	UID (optional)	First Block	Number of blocks	CRC16	EOF
-	xxxx1xxxb	23h	8 bytes	2 bytes	1 byte(1)	2 bytes	-

1. The number of blocks is limited to 32 and all blocks must belong to the same sector. Otherwise, an error 0Fh is returned.

Response:

If the option flag is not set, the response to a Read Multiple Block command is identical between M24LR and ST25DV-PWM products.

If the option flag is set, the Block Security Status byte of the response is different. Refer to *Table 33: M24LR RF block security status response* and *Table 34: ST25DV-PWM RF block security status response*.

Note: The ST25DV-PWM device does not support the Fast Read Multiple Block command.

5.4 Get_Multiple_Blocks_Security_Status command

Command format:

Table 19. ST25DV-PWM and M24LR04KE-R Get Multiple Blocks Security Status

SOF	Request_flags	Get Multiple Blocks SS	UID (optional)	First Block	Number of blocks	CRC16	EOF
-	xxxx0xxxb	2Ch	8 bytes	1 byte	1 byte	2 bytes	-

Table 20. M24LR16E-R and M24LR64E-R Get Multiple Blocks Security Status

SOF	Request_flags	Get Multiple Blocks SS	UID (optional)	First Block	Number of blocks	CRC16	EOF
-	xxxx1xxxb	2Ch	8 bytes	2 bytes	2 bytes	2 bytes	-

Response:

The Block Security Status byte response of a Multiple Block Security Status command is different between M24LR and ST25DV-PWM products. Refer to *Table 33: M24LR RF block security status response* and *Table 34: ST25DV-PWM RF block security status response*.

6 User memory organization and protection

M24LR and ST25DV-PWM products have different user memory organization and use different memory protection methods. This chapter focuses on memory organization and protection as viewed from the RF side only (I^2C is supported by M24LR device only).

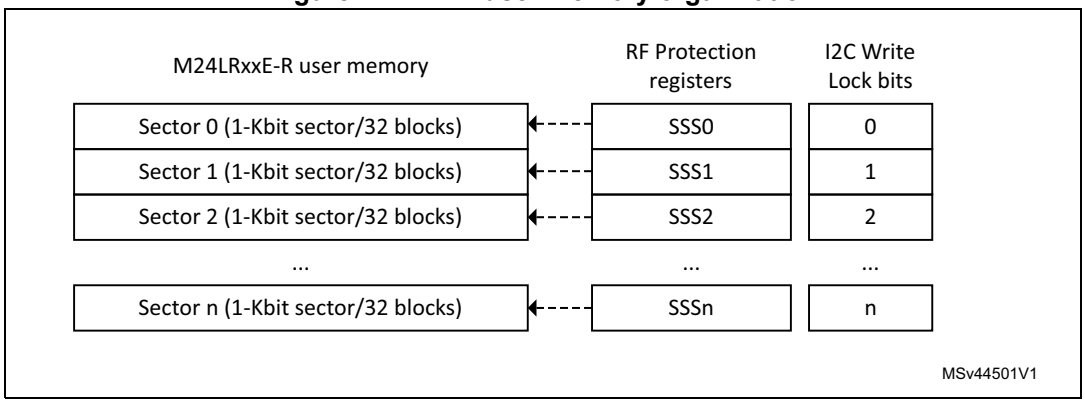
6.1 M24LR user memory organization and protection overview

M24LR product user memory is organized in sectors of 32 blocks (of 1 Kbits).

For RF access, each sector is assigned to a security status register (From SSS0 to SSSn) and can be individually read and/or write access protected by one of three available 32-bit RF passwords.

For I^2C accesses, each sector can be write-protected with a write-lock bit and a 32-bit I^2C password.

Figure 1. M24LR user memory organization



6.2 ST25DV-PWM user memory organization and protection overview

The ST25DV-PWM user memory is organized in three or four areas.

Area0 always starts at the first block of the memory and is one block long. It is dedicated to the CC-file according to NFC Type5 formalism. However, it can be used for any other purpose, if the tag is not required to be NFC Type5 compliant. Area0 can always be Read. It can be permanently locked in Write by issuing a Lock Block command on its address.

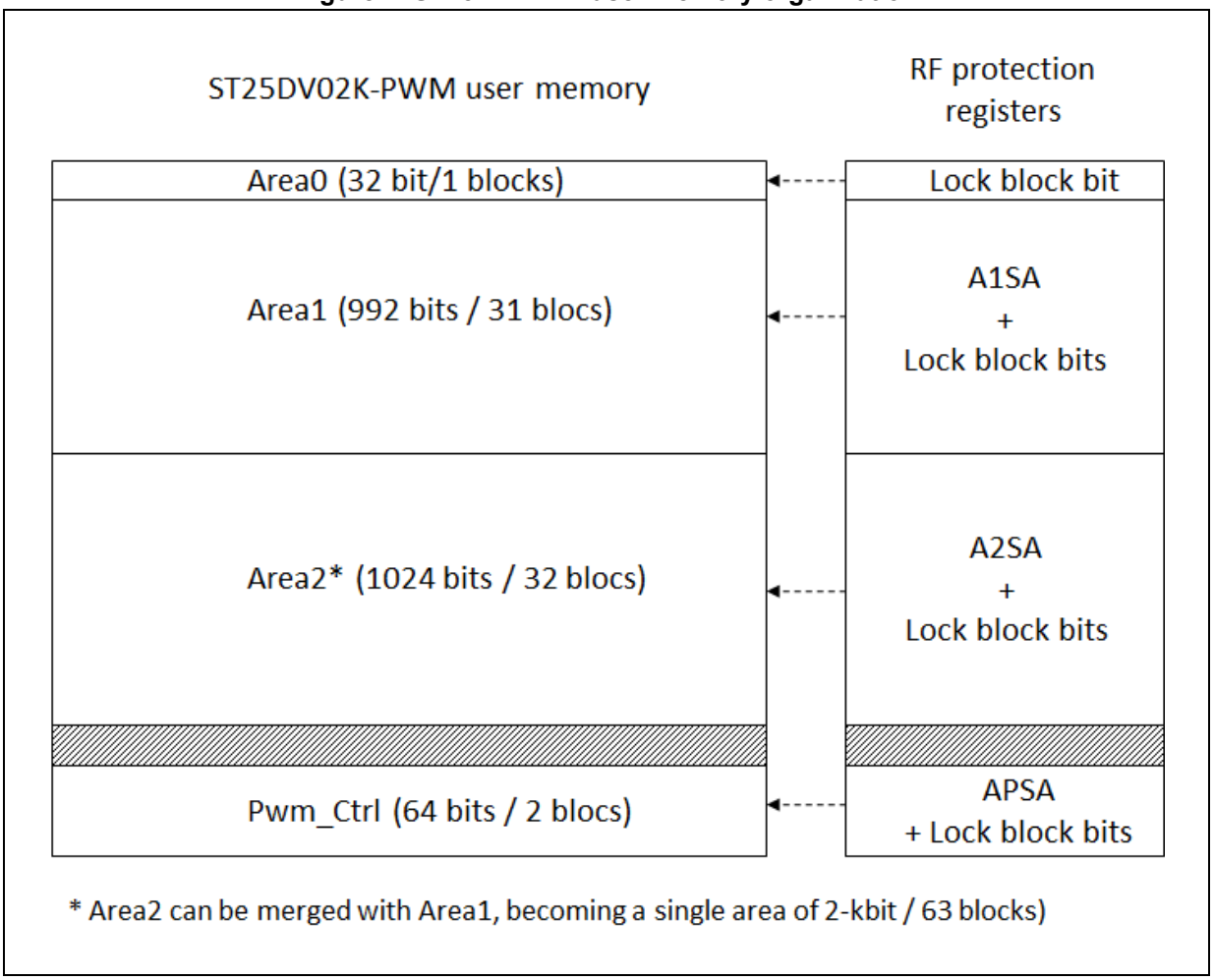
Area1 always starts at the second block of the memory. It is 31 blocks long. Its access is controlled by the A1SA register, allowing the user to set Read and Write access through an independent 32-bit password. In addition, all its blocks can also be permanently locked in Write individually, by issuing a Lock block command.

Area2 starts at the 33rd block of the memory. It is 32 blocks long. Its access is controlled by the A2SA register, allowing the user to set Read and Write access through an independent 32-bit password. In addition, all its blocks can also be permanently locked in Write individually, by issuing a Lock block command.

Note that Area1 and Area2 can be merged in a single 63-block long area. In this case, the Lock block command still applies to permanently lock in Write each block individually, and the password protection is controlled through the A1SA protection register. The Area access is granted with 64bits password (merge of 32-bit passwords of Area1and Area2).

Pwm_Ctrl area always starts at block F8h. It is two-block long. Its access is controlled by the APSA register, allowing the user to set Read and Write access through an independent 32-bit password. In addition, all its blocks can also be permanently locked in Write individually, by issuing a Lock block command.

Figure 2. ST25DV-PWM user memory organization



All sector protection capabilities of the M24LR device are available for ST25DV-PWM areas, except for Area0 which is always readable in ST25DV-PWM devices.

6.3 Security sessions

M24LR and ST25DV-PWM products provide protection of user memory and of some configuration registers. The RF user, as well as the I^2C host only in the case of M24LR, can access those protected places by opening security sessions with the help of passwords. Access is more restricted when security sessions are closed and less restricted when security sessions are opened.

Security session features are described in *Table 21*.

Table 21. Security session features

Security sessions	M24LR		ST25DV-PWM	
	Opened with	Delivered access when the session is opened	Opened with	Delivered access when the session is opened
RF user	RF password 1, 2 or 3(1)	RF user access to user memory(2)	PWD_A1, PWD_A2 or PWD_PWM	User memory access(2)
		RF user write access to RF password(3)		User area password(3) write access
RF configuration	NA	NA	PWD_CFG	Configuration registers write access
				Configuration password(3) write access
I^2C	I^2C password	I^2C host write access to sectors security registers	NA	NA
		I^2C host write access to I^2C password		

1. The password number must be the same as the one selected for protection.
2. Depending on access rights in opened security session set for the corresponding memory block
3. Only applies to the successfully presented RF password

Passwords are all 32-bit (4-byte) long. In the case of ST25DV-PWM, PWD_A1 and PWD_A2 can be used as a 'merged' 64-bit password to protect the enlarged Area1 (merge of Area1 and Area2).

By default, every password is initialized with all bits set to 0.

Table 22. Password lengths

Password	M24LR	ST25DV-PWM
RF passwords 1, 2 and 3	32 bits	-
I^2C password	32 bits	-
PWD_A1, A2 or PWM	-	32 bits
PWD_CFG	-	32 bits

Possible actions for security sessions are described hereunder.

1. Open RF user security session:
   - **M24LR**: Present Sector Password command with password number (1, 2 or 3) and a valid corresponding password.
   - **ST25DV-PWM:** Present Password command with password number (0, 1or 2: 0 for PWD_PWM, 1 for PWD_AREA1, 2 for PWD_AREA2) and a valid corresponding password.
2. Write RF password:
   - **M24LR**: Present Sector Password command with chosen password number (1, 2 or 3) and a valid corresponding password. Then Write Sector Password command with the same chosen password number (1, 2 or 3).
   - **ST25DV-PWM:** Present Password command with password number (0, 1, 2 or 3) and a valid corresponding password. Then Write Password command with the same password number (0, 1, 2 or 3).
3. Close RF user security session:
   - **M24LR and ST25DV-PWM:** Present Password command with a different password number or wrong password, or remove the tag from the RF field.
4. Open RF configuration security session:
   - **M24LR**: no RF configuration security session.
   - **ST25DV-PWM:** Present Password command with password number 3 and a valid corresponding password.
5. Close RF configuration security session:
   - **M24LR**: no RF configuration security session.
   - **ST25DV-PWM:** Present Password command with a different password number, or password number 3, with a wrong password 3, or remove the tag from the RF field.
6. Open I^2C security session:
   - **M24LR**: I^2C Present Password command with a valid password.
7. Write the I^2C password:
   - **M24LR**: I^2C Present Password command with a valid password. Then I^2C Write Password command.
8. Close I^2C security session:
   - **M24LR**: I^2C Present Password command with a wrong password. Or remove the tag power supply.

The following tables summarize password commands applying to M24LR and ST25DV-PWM devices:

- To update/write a password:
  - M24LR: Write Sector Password
  - ST25DV-PWM: Write Password

Both commands have the same format, as described in *Table 23*.

Table 23. Write Password command

SOF	Request_flags	Write Sector Password	IC Mfg code	UID (optional)	Password number	Password	CRC16	EOF
-	1 byte	B1h	02h	8 bytes	1 byte	4 bytes	2 bytes	-

- To present a password:
  - M24LR: Present Sector Password
  - ST25DV-PWM: Present Password

Each command has a different format, as described in *Table 24* and *Table 25*.

Table 24. Present Sector Password command (M24LR)

SOF	Request_flags	Present Sector Password	IC Mfg code	UID (optional)	Password number	Password	CRC16	EOF
-	1 byte	B3h	02h	8 bytes	1 byte	4 bytes	2 bytes	-

Table 25. Present Password command (ST25DV-PWM)

SOF	Request_flags	Present Password	IC Mfg code	UID (optional)	Password number	Password	CRC16	EOF
-	1 byte	B3h	02h	8 bytes	1 byte	4 or 8 bytes(1)	2 bytes	-

1. Password length depends on the presented password. It is 4 bytes in every case, except when Area1 and Area2 are merged in a single area. The protection password is 64bit (8-byte) long only in this case.

6.4 User memory protection

6.4.1 RF user memory protection: M24LR registers

To manage sector protection from RF access, M24LR has one SSS (Sector Security Status) register per sector and three RF passwords (RF_PWD1-3).

Table 26. M24LR registers related to RF user memory protection

RF			Registers	I^2C		
Command	Address	Type		Device select	Address	Type
Lock Sector	00h to 1Fh	W0(1)	SSS0	E2 = 1	0000h	R/W(2)
	20h to 3Fh	W0(1)	SSS1	E2 = 1	0001h	R/W(2)
	..	..	..	..	..	..
	@Last block-31 to @last block	W0(1)	SSSn	E2 = 1	000nh	R/W(2)
No access	-		I2C_PWD	E2 = 1	0900h	R(3)/W(4)
Present Sector PWD Write Sector PWD	00h	W(5)	RF_PWD1	-	No access	
	01h	W(5)	RF_PWD2			
	02h	W(5)	RF_PWD3			

1. Write access only if the sector is not already locked.
2. Write access only if the I^2C security session is open.
3. Read access only if the I^2C security session is open.
4. Write with I^2C Write Password command only if the I^2C security session is open.
5. Write access only if the corresponding RF security session is open.

Table 27. M24LR SSSn register description

SSSn			
Bit	**Name**	**Function**	**Factory value**
b0	Sector Lock	0: sector n not locked 1: sector n locked	0b
b2-b1	Read/Write protection	00: sector n RF user security session can’t be opened by password 01: sector n RF user security session opened by RF_PWD_1 10: sector n RF user security session opened by RF_PWD_2 11: sector n RF user security session opened by RF_PWD_3	00b
b4-b3	Password control	00: sector n RF access: Read always allowed- Write if RF user security session opened 01: sector n RF access: Read always allowed - Write always allowed 10: sector n RF access: Read if RF security user session opened - Write if RF user security session opened 11: sector n RF access: Read if RF user security session opened - Write always forbidden	00b
b7-b5	RFU	-	000b

6.4.2 User memory protection: ST25DV-PWM registers

To manage area protection, each area of the ST25DV-PWM has its own password (PWD_A1, PWD_A2 or PWD_PWM), plus one associated security attribute register (A1SA, A2SA, APSA).

A register to lock the configuration (LOCK_CFG) and a password to open configuration security session (PWD_CFG) are also involved in area protection.

Finally, each block of the whole user memory can be individually and permanently locked with the LOCK_BLOCK registers.

Table 28. ST25DV-PWM registers related to user memory protection

Command	Registers	Address	Type
Read Configuration Write Configuration	A1SA	00h	RW(1)
	A2SA	01h	
	APSA	02h	
Present password Write password	PWD_PWM	NA(2)	WO(3)
	PWD_A1		
	PWD_A2		
	PWD_CFG		
Get Multiple Block Security Status Lock Block	LOCK_BLOCK	NA	R(4)W(5)
Read configuration Write configuration	LOCK_CFG	04h	RW(1)

1. Write access is granted if the RF configuration security session is open and the configuration is not locked (LOCK_CFG register equals 0).
2. Passwords are identified thanks to a password number given as an argument to Present/Write password command.
3. Write access only if the corresponding RF security session is open.
4. LOCK_BLOCK content is only readable through reading the Block Security Status of blocks.
5. Write access only if the blocks are not already locked (The corresponding security session is open and the block is not already locked by a previous LOCK_BLOCK command).

Table 29. ST25DV-PWM Area Security Attribute description_1

A1SA			
Bit	**Name**	**Function**	**Factory value**
b1-b0	RW_PROTECTION_A1	AREA1 access rights: 00: Read always is allowed / Write always allowed 01: Read always is allowed / Write allowed only if AREA1 user security session is opened (the proper AREA1 password has been presented) 10: Read and Write is allowed only if AREA1 user security session is opened (the proper AREA1 password has been presented) 11: Read is only allowed if AREA1 user security session is opened (the proper AREA1 password has been presented) / Write always forbidden	00b
b2	MEM_ORG	User memory split: 0: user memory is split into four areas (AREA0/1/2 & PWM_CTRL) 1: user memory is split into three areas (AREA0/1 & PWM_CTRL): AREA1 & AREA2 are merged in a single AREA1. In the case of merged areas, RW_PROTECTION_A1 register applies as access rights.	1b
b7-b3	RFU	-	00000b

Table 30. ST25DV-PWM Area Security Attribute description_2

A2SA			
Bit	**Name**	**Function**	**Factory value**
b1-b0	RW_PROTECTION_A2	AREA2 access rights: 00: Read is always allowed / Write always allowed 01: Read always is allowed. Write is only allowed if AREA2 user security session is opened (= the proper AREA2 password has been presented) 10: Read and Write is only allowed if AREA2 user security session is opened (the proper AREA2 password has been presented) 11: Read is only allowed if AREA2 user security session is opened (the proper AREA2 password has been presented), Write is always forbidden. In case of merged AREA1 + AREA2 in a single AREA1, the RW_PROTECTION_A2 bits are not used.	00b
b7-b2	RFU	-	000000b

Table 31. ST25DV-PWM Area Security Attribute description_3

APSA			
Bit	**Name**	**Function**	**Factory value**
b1-b0	RW_PROTECTION_AP	Area PWM_CTRL access rights: 00: Read and Write are always allowed. 01: Read is always allowed. Write is only allowed if Area PWM_CTRL user security session is opened (= the proper Area PWM_CTRL password has been presented) 10: Read and Write are only allowed if Area PWM_CTRL user security session is opened (the proper area PWM_CTRL password has been presented) 11: Read is only allowed if Area PWM_CTRL user security session is opened (the proper area PWM_CTRL password has been presented). Write is always forbidden.	00b
b7-b2	RFU	-	000000b

6.4.3 M24LR and ST25DV-PWM user-memory protection equivalence

The equivalence of Read/Write protection bits (in the SSSn and AxSA registers) is summarized in *Table 32*.

Table 32. RF user memory protection equivalence

M24LR		Sector/Area access when user security session opened		Sector/Area access when user security session closed		ST25DV-PWM
Sector Lock	**R/W protection bits**					**R/W protection bits**
0	xx	Read	Write	Read	Write	00
1	00	Read	Write	Read	No Write	01
1	01	Read	Write	Read	Write	00
1	10	Read	Write	No Read	No Write	10
1	11	Read	No Write	No Read	No Write	11

The Sector lock bit is not present in ST25DV-PWM devices. In M24LR devices, the Sector Lock bit prevents sector protection modification by an RF user. The same behavior can be achieved on ST25DV-PWM devices in two different ways:

- Using the configuration password (PWD_CFG) protection to prevent RF from modifying AxSA registers without presenting the correct password.
- Using the LOCK_CFG register, issuing a Write Configuration (@04h), to permanently prevent RF from modifying AxSA registers (this also locks all configuration registers.

6.4.4 M24LR RF user memory protection configuration

Configuration by RF user

- **If the sector is already locked**, the RF user cannot change the sector protection (this can be done through the I^2C).
- **If the sector is not already locked**, the RF user can lock the sector by issuing a Lock Sector command (@Block, SSSn). The Lock Sector command must point to any block inside the target sector, and provide the desired SSS value.

Configuration by I^2C host

- The I^2C host must open the I^2C security session by issuing an I^2C Present Password command.
- The I^2C host can then write any SSSn register using the I^2C Write Byte command (even if the block is locked).
- Optionally, the I^2C host can close the I^2C security session by issuing an I^2C Present Password command with the wrong I^2C password.

6.4.5 ST25DV-PWM user memory protection configuration

Configuration by an RF user

- **If the RF configuration is locked (LOCK_CFG register = 1)**, it is not possible to change the area protection.
- **If the RF configuration is not locked**:
  - The user must first open the configuration security session by issuing a Present Password (03h, PWD_CFG) command with a valid PWD_CFG password.
  - The user sets area protection by issuing a Write Configuration (@AxSA, RW_PROTECTION_An) command to write into any AxSA register.
  - Optionally, the user can close the configuration security session by issuing a Present Password command with a wrong password (or different password number, or remove the tag from the field).

6.4.6 Retrieve security status of a block

In M24LR devices, an RF user can read the block security status by issuing a Get Multiple Blocks SS(@Block, NbBlocks) command, or (Fast) Read Single Block(@Block) and (Fast) Read Multiple Blocks(@Block, NbBlocks) commands with the option flag set to 1. The Block security status returned by M24LR devices is shown in *Table 33*.

Table 33. M24LR RF block security status response

b7	b6	b5	b4	b3	b2	b1	b0
0	0	0	Password control bits		Read/Write protection bits		Sector lock: 0: the sector is not locked 1: the sector is locked(1)

1. In M24LR devices, Get Multiple Blocks SS rolls over address 0 if the end of memory is reached. In ST25DV-PWM devices Get Multiple Blocks SS returns an error if the end of memory is reached.

In ST25DV-PWM devices, a user can read the block security status by issuing a Get Multiple Blocks SS (@Block, NbBlocks) command, or Read Single Block(@Block), Read Multiple Blocks (@Block, NbBlocks) commands with the option flag set to 1. The Block security status returned by ST25DV-PWM devices is shown in *Table 34*.

Table 34. ST25DV-PWM RF block security status response

b7	b6	b5	b4	b3	b2	b1	b0
0	0	0	0	0	0	0	Lock_flag: 0: block is not locked 1: block is locked(1)(2)

1. Lock_flag may be different if a security session is opened or closed.
2. In M24LR devices, if the SSSx register value is xxxxx011 (Sector lock bit=1, R/W protection bits=01b), the meaning of the Sector Lock bit returned is ‘write access to the SSSx register is locked, but read/write access to the sector is not locked’. This state cannot be reflected in the Sector Lock bit returned by ST25DV-PWM.

In order to obtain the same information as block security status of an M24LR device, the ST25DV-PWM’s user must read the AxSA registers of the corresponding area by issuing a Read Configuration(@AxSA) command. Note that it only concerns the 'Read/Write protection bits'. There are no 'Password control bits' in ST25DV-PWM, due to a fixed allocation of passwords to their corresponding areas.

Table 35. ST25DV-PWM AxSA register content

b7	b6	b5	b4	b3	b2	b1	b0
0	0	0	0	0	x	Read/Write protection bits	

With the M24LR device, the RF sector and area security status information can be retrieved by reading the SSSn and RFAnSS registers through the I^2C interface.

7 Tag identification

There are two ways to identify STMicroelectronics ISO/IEC 15693 products:

- With the product code field of the UID
- With the IC reference.

Memory size can also be used to differentiate products.

7.1 Product codes

The product code field for M24LR and ST25DV-PWM devices is defined as shown in *Table 36*.

Table 36. M24LR and ST25DV-PWM product codes

Product	M24LR			ST25DV-PWM	
	04E-R	16E-R	64E-R	02K-W1	02K-W2
Product code	58h to 5Bh	4Ch to 4Fh	5Ch to 5Fh	38h	39h

RF users can read the Product code by issuing an Inventory command and analyzing the product code field of the UID.

The UID of the STMicroelectronics ISO/IEC 15693 products is defined in *Table 37*.

Table 37. STMicroelectronics ISO/IEC 15693 products UID

UID	byte 7	byte 6	byte 5	byte 4 to 0
Value	E0h	02h(1)	Product code	IC manufacturer code

1. Manufacturer code 0x02 for STMicroelectronics

7.2 IC Ref and memory size

The IC Ref definition for M24LR and ST25DV-PWM products is shown in *Table 38*.

Table 38. M24LR and ST25DV-PWM IC Ref values

Product	M24LR			ST25DV-PWM	
	04E-R	16E-R	64E-R	02K-W1	02K-W2
IC Ref	5Ah	4Eh	5Eh	38h	39h

RF users can read the IC Ref by issuing the Get System Information command in all versions of M24LR and ST25DV-PWM products.

RF users can also read the Memory size by issuing the Get System Information command. Note that the Protocol_extension_flag must be set to 1, to retrieve memory size on M24LR16E-R and M24LR64E-R devices.

This is summarized in *Table 39*, *Table 40* and *Table 41*.

Table 39. M24LR04E-R and ST25DV-PWM response to Get System Information command

SOF	Response_flags	Info_flags	UID	DSFID	AFI	Memory size	IC Ref	CRC16	EOF
-	00h	0Fh	8 bytes	1 byte	1 byte	037Fh 033Fh	5Ah 38h/39h	2 bytes	-

Table 40. M24LR16E-R and M24LR64E-R response to Get System Information command with Protocol_extension_flag=0

SOF	Response_flags	Info_flags	UID	DSFID	AFI	IC Ref	CRC16	EOF
-	00h	0Bh	8 bytes	1 byte	1 byte	4Eh 5Eh	2 bytes	-

Table 41. M24LR16E-R and M24LR64E-R response to Get System Information command with Protocol_extension_flag=1

SOF	Response_flags	Info_flags	UID	DSFID	AFI	Memory size	IC Ref	CRC16	EOF
-	00h	0Fh	8 bytes	1 byte	1 byte	0301FFh 0307FFh	4Eh 5Eh	2 bytes	-

8 ISO/IEC 15693 states

Changing the ISO/IEC 15693 state is done in the same way for M24LR and ST25DV-PWM products, using Inventory, Select, Reset To Ready and Stay Quiet commands. Refer to the ISO/IEC 15693-3 specification *[7]* for more details.

There are nevertheless differences in the following conditions:

- Initial state: Quiet.
- Command received:
  - Reset To Ready
  - Request_flags: 001000xxb (option_flag =0, Address_flag=1, Select_flag=0, Inventory_flag=0)
  - UID: incorrect UID of the device included in the Reset To Ready command.

In the above conditions, the new state after the Reset-To-Ready command is:

- M24LR switches to the Ready state
- ST25DV-PWM stays in the Quiet state.

9 Behavior when erroneous RF commands are received

M24LR and ST25DV-PWM products may behave differently when receiving commands with the wrong number of bytes, unknown command codes or commands with the wrong Request_flags. This can lead to some modifications in error handling for the RF reader when migrating from M24LR to ST25DV-PWM products.

Depending on the issue in the received command, M24LR and ST25DV-PWM products can either respond with an error or stay quiet with no answer. *Table 42*, *Table 43* and *Table 44* show the differences between M24LR and ST25DV-PWM products in the cases of malformed commands, unknown command codes, and correct and incorrect flags in the Request_flags field.

Table 42. Behavior in case of malformed RF commands (CRC OK)

Command	Default command (High DR, Single SC)	Wrong command example	M24LR	ST25DV-PWM	Comments
Inventory	26 01 00	26 01 00 xy	No answer		Too many parameters
		26 01			Parameter missing
Stay Quiet	02 02 or 22 02 UID	22 02 UID xy	No answer		Too many parameters
		22 02 part-of-UID			Device not identified
Select	22 25 UID	22 25 UID xy	No answer	Error answered	Device identified, but too many parameters
		22 25 part-of-UID		No answer	Device not identified
Reset to Ready	02 26 or 22 26 UID	02 26 xy	No answer	Error answered	Too many parameters
		22 26 part-of-UID		No answer	Device not identified
Any other command	(Read) 02 20 00 or 22 20 00 UID	02 20 00 xy	No answer	Error answered	Too many parameters
		02 20			Parameter missing

Table 43. Behavior in case of unknown command code

Command	M24LR	ST25DV
Unknown command code(1)	No answer	Error answered

1. Command code must be on one byte. If less than one byte is sent, command code cannot be interpreted, and no devices reply, neither M24LR nor ST25DV-PWM.

Table 44. Behavior in case of good and wrong flags in the Request_flags field of the RF command (CRC OK)

Command[1] [2]	M24LR[3]	ST25DV-PWM[3]
Inventory	If Request_flags = xxxxx1xxb (inv) and the device is not in the Quiet state: answer Any other case: no answer	
Stay Quiet	No answer	
Select	**If Request_flags = xx1xxxxxb (addr) and good UID provided: answer** If Request_flags = xx1xx1xxb (addr+inv) and any UID provided: answer Any other case: no answer	**If Request_flags = xxxxxxxxb and good UID provided: answer** Any other case: no answer
Reset to Ready	**If Request_flags = xx00x0xxb (no addr+no sel+no inv): answer** **If Request_flags = xx1xxxxxb (addr) and good UID provided: answer** If Request_flags = xxx1xxxxb (sel) and good UID provided and the device is in the Select state: answer If Request_flags = xx1xx1xxb (addr+inv) and any UID provided: answer If Request_flags = xx00x1xxb (no addr+not sel+inv) and good UID provided and the device is not in the Quiet state: answer Any other case: no answer	**If Request_flags = xx00x0xxb (no addr+no sel+no inv) and the device is not in the Select state: answer** **If Request_flags = xx1xxxxxb (addr) and good UID provided: answer** If Request_flags = xxx1xxxxb (sel) and good UID provided and the device is in the Select state: answer Any other case: no answer
Any other command	**If Request_flags = xx00x0xxb (no addr+no sel+no inv) and the device is not in the Quiet state: answer** **If Request_flags = xx1xxxxxb (addr) and good UID provided: answer** If Request_flags = xxx1xxxxb (sel) and good UID provided and the device is in the Select state: answer If Request_flags = xx1xx1xxb (addr+inv) and any UID provided: answer If Request_flags = xx00x1xxb (no addr+not sel+inv) and good UID provided and the device is not in the Quiet state: answer Any other case: no answer	**If Request_flags = xx00x0xxb (no addr+no sel+no inv) and the device is not in the Quiet state: answer** **If Request_flags = xx1xxxxxb (addr) and good UID provided: answer** If Request_flags = xxx1xxxxb (sel) and good UID provided and the device is in the Select state: answer Any other case: no answer

1. Cases where address flag is set in Request_flags field and no UID is provided are considered as commands with too few bytes, and are treated in *Table 42: Behavior in case of malformed RF commands (CRC OK)*.
2. Cases where Address flag and Select flags are not set in Request_flags field and UID is provided are considered as commands with too many bytes, and are treated in *Table 42: Behavior in case of malformed RF commands (CRC OK)*.
3. Bold text indicates cases where flags are correctly set.

10 NFC file format

NFC file format is defined in the NFC Forum *Type 5 Tag Technical Specification [8]*.

ST25DV-PWM products are based on the NFC Type 5 Tag specification and thus support the NFC file format as described by the NFC Forum. For more details, refer to the application note *NDEF management with ST25DV02K-W1 and ST25DV02K-W2* (AN5151) *[9]*.

M24LR products were released prior to the NFC Forum Type 5 Tag specification, and some adaptation has to be made to support the CC File format in order to support high-density memory devices.

Low-density devices, M24LR04E-R and ST25DV-PWM share the same CC file standard format, whereas M24LR16E-R and M24LR64E-R higher density devices need to be formatted with a different CC file.

Refer to the application note *Using LRIxx, LRISxx, M24LRxx-R, and M24LRxxE-R products as NFC vicinity tags* (AN3408) *[5]* for details of the CC File format to be used with M24LR16E-R and M24LR64E-R devices.

11 Reference documents

Table 45. Reference documents

Reference	Owner	Revision	Title
[1]	STMicroelectronics	Latest version	M24LR04E-R datasheet *Dynamic NFC/RFID tag IC with 4-Kbit EEPROM, energy harvesting, I²C bus and ISO 15693 RF interface* (DS8648)
[2]			M24LR16E-R datasheet *Dynamic NFC/RFID tag IC with 16-Kbit EEPROM, energy harvesting, I²C bus and ISO 15693 RF interface* (DS7261)
[3]			M24LR64E-R datasheet *Dynamic NFC/RFID tag IC with 64-Kbit EEPROM, energy harvesting, I²C bus and ISO 15693 RF interface* (DS8854)
[4]			ST25DV02K-W1 ST25DV02-W2 datasheet *Dynamic NFC/RFID tag IC with up to two PWM outputs and 2-Kbit EEPROM* (DS12114)
[5]			Application note *Using LRIxx, LRISxx, M24LRxx-R and M24LRxxE-R products as NFC vicinity tags* (AN3408)
[6]			Application note *Comparison of RF addressing modes of low-density and high-density ISO/IEC 15693 devices* (AN4054)
[7]	ISO/IEC		International standard ISO/IEC*15693-3: Identification cards -- Contactless integrated circuit cards -- Vicinity cards*
[8]	NFC Forum		Type 5 Tag Technical Specification
[9]	STMicroelectronics		Application note *NDEF management with ST25DV02K-W1 and ST25DV02K-W2', STMicroelectronics* (AN5151)
[10]	NFC Forum		Digital Protocol Technical Specification

12 Revision history

Table 46. Document revision history

Date	Revision	Changes
31-Oct-2019	1	Initial release