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FM13HS01

HF SECURE RFID IC based on ISO/IEC 15693

Datasheet

Feb. 2022

Trademarks

Contents

1 Product Overview

1.1 Introduction

FM13HS01 is a smart label IC which based on ISO/IEC 15693 and ISO/IEC 18000-3 for the vicinity applications. It has excellent compatibility with all kinds of readers, enhanced RF performance and higher reliability of EEPROM. There is an algorithm embedded in the chip which can be used to verify the tag by the reader. This can be used in some counterfeiting applications. Please contact Fudan Micro Electronics Company for more documents.

1.2 Features

1.2.1 RF Interface

- ISO/IEC 15693
- Contactless transmission of data and supply energy (no battery needed)
- Operating distance: up to 1.5 m (depending on various parameters such as field strength and antenna geometry)
- Operating frequency: 13.56 MHz
- Fast data transfer: up to 53 kbit/s
- High data integrity: 16-bit CRC, framing
- True anti-collision
- Password protected Electronic Article Surveillance (EAS)
- Password protected Application Family Identifier (AFI)
- Data Storage Format Identifier (DSFID)
- Password protected Kill functionality
- Additional fast anti-collision read functionality
- Write 2 Block is supported
- Persistent quiet mode to enable faster inventory speed

1.2.2 EEPROM

- 1k bits of total memory, divided in 32 blocks (4 bytes each)
- 32 Blocks configurable data areas that can be divided into secure and common data areas as needed
- the secure data area is protected by password, you need to check the password before you can access it
- 50 years data retention

- Write endurance of 100,000 cycles

1.2.3 Security

- Unique identifier for each device, UID is unchangeable.
- Lock mechanism for each user memory block (write protection)
- Lock mechanism for DSFID, AFI, EAS
- Password (32-bit) protected EAS and AFI functionality
- Password(32-bit) protected Kill functionality
- Password(32-bit) protected memory access protection
- Authentication of the tag by the reader based on the algorithm
- The KEY and the password cannot be read directly
- Privacy mode is supported
- Customized communication protocol function
- 28bits counter function increased when the chip powers on and addressed automatically
- Tamper detection

1.2.4 Other characteristics

- Open-drain output which can be used to light a LED and make it flicker with the NFC field energy or give an IRQ to the MCU

1.3 Block diagram

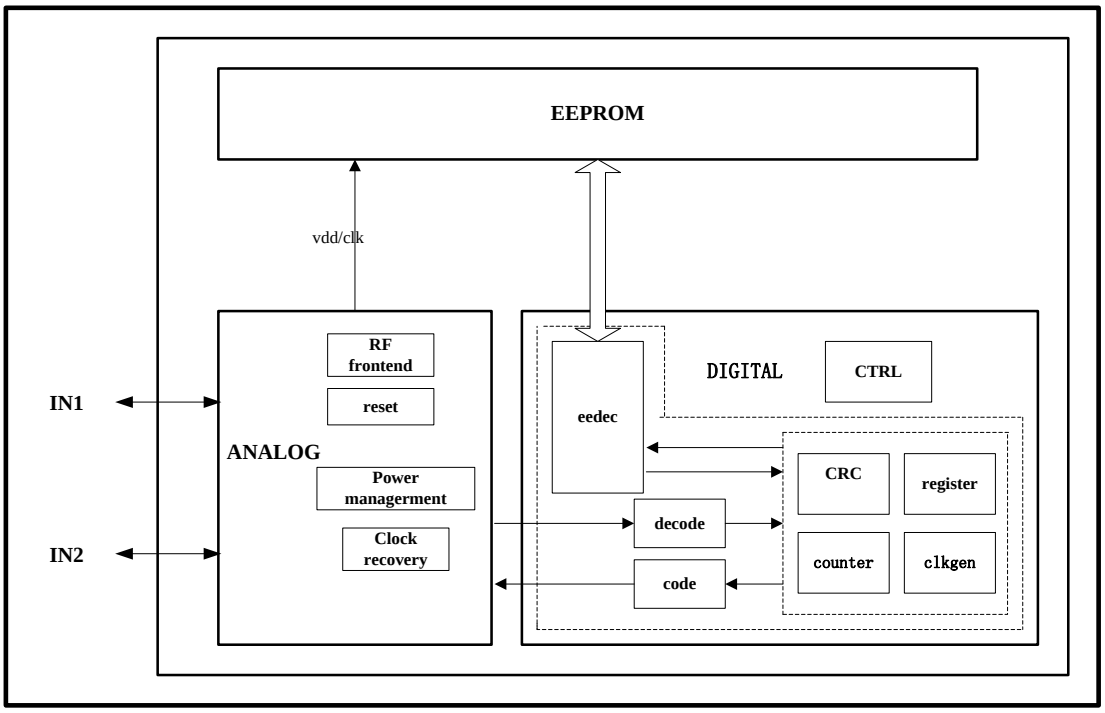


Figure 1-1 FM13HS01 Block diagram

1.4 Wafer layout

Please consult Fudan Micro Electronics Company for the wafer datasheet.

1.5 Pinning information

1.5.1 Bump Wafer: WTB2-4BG

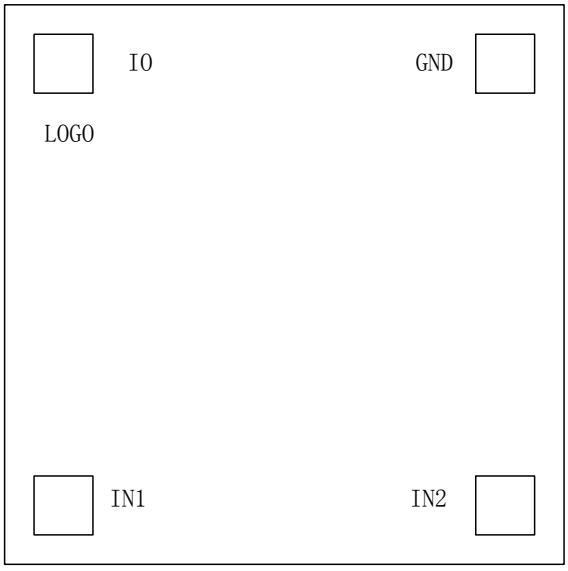


Figure 1-2 FM13HS01-WTB2-4BG Bonding pad

Table 1-1 FM13HS01-WTB2-4BG Bonding pad description

Number	PIN name	PIN Description
1	IN1	antenna RF input
2	IN2	antenna RF input
3	GND	Ground
4	IO	Open-drain output or analog in which can be used in tamper detection

1.5.2 Bump Wafer: WTB2

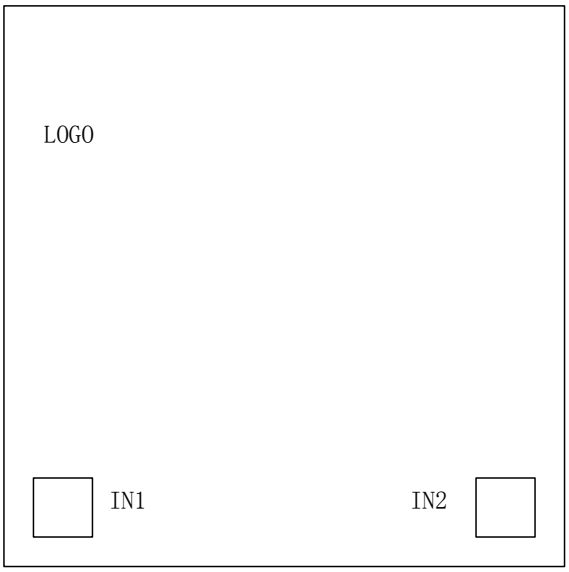


Figure 1-3 FM13HS01-WTB2 Bonding pad

Table 1-2 FM13HS01-WTB2 Bonding pad description

Number	PIN name	PIN Description
1	IN1	antenna RF input
2	IN2	antenna RF input

1.5.3 Package: TDFN4

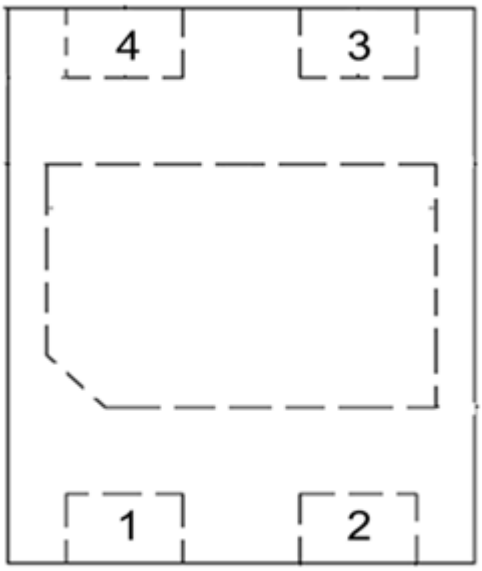


Figure 1-4 FM13HS01-TDFN4

Table 1-3 FM13HS01-TDFN4 PIN description

Number	PIN name	PIN Description
4	IN1	antenna RF input
1	IN2	antenna RF input
2	GND	ground
3	IO	Open Drain output

2 Functional Description

2.1 General description

The FM13HS01 chip consists of the 1.5k bits of the total EEPROM memory organized in 48 blocks each 4 bytes. FM13HS01 contains the RF-Interface and the Digital Control Unit. Energy and data are transferred via an antenna, which consists of a coil with a few turns directly connected to the IN1 and IN2 of the FM13HS01. No extra external components are necessary.

2.2 Memory organization

The 192 bytes of the total EEPROM memory are organized in 48 blocks each 4 bytes. 128bytes (32 blocks) are available for the user defined data.

Memory organization：

- User memory：block 00 to 31
- Password memory：configuration area
- UID: configuration area
- KEY: configuration area

Table 2-1 FM13HS01 Memory organization

Page Num		EE ADDR	Byte Num				
DEX	*HEX*		0	1	2	3	
0	*0h*	0x00~0x03					Common data area
…	…	…					
…	…	…					
…	…	…					Secure data area
…	…	…					
31	*1Fh*	0x7C~0x7F					
							Configuration area 【1】

【1】 *This area cannot be addressed directly.*

There are 32 blocks of the user data area. They are divided into common data area and secure data area by auth_start_block.

For example, if auth_start_block is set to Block17, Block0 to block16 will be common data area and block17 to block 31 will be secure data area.

Auth_start_block configuration word can be set by the custom commands which are Cust Write Auth Start Addr and Cust Read Auth Start Addr.

The data in the common data area can be written and read without limit.

The access to the data in the secure data area is controlled by the password. They can be written or read only after password verification passed.

Auth_start_block can only be set in the Fast Initial Mode. After the configuration completed and

the chip powers on, this will not be changed again. The size of the common data area and the secure data area will be fixed.

2.2.1 UID

The 64-bit unique identifier (UID) is programmed during the wafer test process according to ISO/IEC 15693-3 and cannot be changed afterwards.

The 64 bits are numbered according to ISO/IEC 15693-3 starting with LSB 1 and ending with MSB 64.

Table 2-2 UID

MSB							LSB
64：57	56:49	48：1					
E0	1D	IC Manufacture Serial Number					
UID 7	UID 6	UID 5	UID 4	UID 3	UID 2	UID 1	UID 0

2.2.2 Configuration of delivered ICs

FM13HS01 is delivered with the following configuration by Fudan Micro:

- Unique identifier is unique and read only
- Status of EAS mode is not defined
- AFI is supported and not defined
- All EAS/AFI password bytes are 00h
- EAS and AFI password protection is disabled
- DSFID is supported and not defined
- User data memory is not defined

Remark: Because the EAS mode is undefined at delivery, the EAS mode shall be set (enabled or disabled) according to your application requirements during the test or initialization phase.

Remark: If EAS and/or AFI password protection is not required in the targeted application, it is recommended a random EAS/AFI password is written during the label initialization.

2.3 Communication principle

For detailed description of the protocol and timing please refer to ISO/IEC 15693-2 (modulation, bit-coding, framing, Ref. 2) and ISO/IEC 15693-3 (anti-collision, timing, protocol, Ref. 3).

2.4 Command set

The FM13HS01 comprises the command set as described in following chapters.

Table 2-3 Command Set Summary

NAME	CODE	IC MRG CODE	TYPE
Inventory	0x01	-	*Mandatory*
Stay Quiet	0x02	-	*Mandatory*

NAME	CODE	IC MRG CODE	TYPE
Read Single Block	0x20	-	*Optional*
Write Single Block	0x21	-	*Optional*
Lock Block	0x22	-	*Optional*
Read Multiple Blocks	0x23	-	*Optional*
Select	0x25	-	*Optional*
Reset To Ready	0x26	-	*Optional*
Write AFI	0x27	-	*Optional*
Lock AFI	0x28	-	*Optional*
Write DSFID	0x29	-	*Optional*
Lock DSFID	0x2A	-	*Optional*
Get System Information	0x2B	-	*Optional*
Get Multiple Block Security Status	0x2C	-	*Optional*
Inventory Read	0xA0	0x1D	*Custom*
Fast Inventory Read	0xA1	0x1D	*Custom*
Set EAS	0xA2	0x1D	*Custom*
Reset EAS	0xA3	0x1D	*Custom*
Lock EAS	0xA4	0x1D	*Custom*
EAS Alarm	0xA5	0x1D	*Custom*
Password Protect EAS/AFI	0xA6	0x1D	*Custom*
Get Random Number	0xB2	0x1D	*Custom*
Set Password	0xB3	0x1D	*Custom*
Write Password	0xB4	0x1D	*Custom*
Lock Password	0xB5	0x1D	*Custom*
Kill	0xB9	0x1D	*Custom*
Write 2 Blocks	0xD5	0x1D	*Custom*
Stay Quiet Persistent	0xBC	0x1D	Custom
Pad IO On Off	0xC5	0x1D	Custom
Cust Read Auth Start Addr	0xC3	0x1D	Custom
Cust Write Auth Start Addr	0xC2	0x1D	Custom
Cust Write Algo Key	0xC2	0x1D	Custom
Cust Read Algo Key	0xC3	0x1D	Custom
Cust Lock Algo Key	0xC4	0x1D	Custom
Act Auth	0xC7	0x1D	Custom
Cust Read INC CNT	0xC3	0x1D	Custom

2.4.1 Mandatory commands

2.4.1.1 Inventory

As defined in ISO/IEC 15693-3.

2.4.1.2 Stay Quiet

As defined in ISO/IEC 15693-3.

2.4.2 Optional commands

2.4.2.1 Read Single Block

As defined in ISO/IEC 15693-3.
Option 0 (Option flag not set) is supported.
Option 1 (Option flag set) is supported.

2.4.2.2 Write Single Block

As defined in ISO/IEC 15693-3.
Option 0 (Option flag not set) is supported.
Option 1 (Option flag set) is supported.

2.4.2.3 Lock Block

As defined in ISO/IEC 15693-3.
Option 0 (Option flag not set) is supported.
Option 1 (Option flag set) is supported.

2.4.2.4 Read Multiple Blocks

As defined in ISO/IEC 15693-3.
Option 0 (Option flag not set) is supported.
Option 1 (Option flag set) is supported.

Remark: If the sum of the first block number and the number of blocks exceeds the total available number of user blocks, the number of transmitted blocks is less than the requested number of blocks, which means that the last returned block is the highest available user block, followed by the 16-bit CRC and the EOF.

2.4.2.5 Select

As defined in ISO/IEC 15693-3.

2.4.2.6 Reset To Ready

As defined in ISO/IEC 15693-3.

2.4.2.7 Write AFI

As defined in ISO/IEC 15693-3.
Option 0 (Option flag not set) is supported.
Option 1 (Option flag set) is supported.

Remark: This command maybe password protected

2.4.2.8 Lock AFI

As defined in ISO/IEC 15693-3.
Option 0 (Option flag not set) is supported.
Option 1 (Option flag set) is supported.

Remark: This command maybe password protected

2.4.2.9 Write DSFID

As defined in ISO/IEC 15693-3.
Option 0 (Option flag not set) is supported.
Option 1 (Option flag set) is supported.

2.4.2.10 Lock DSFID

As defined in ISO/IEC 15693-3.
Option 0 (Option flag not set) is supported.
Option 1 (Option flag set) is supported.

2.4.2.11 Get System Information

As defined in ISO/IEC 15693-3.
The IC Reference in TAG response of FM13HS01 is “12h”.

2.4.2.12 Get Multiple Block Security Status

As defined in ISO/IEC 15693-3.

Remark: If the sum of the first block number and the number of blocks exceeds the total available number of user blocks the number of transmitted security status bytes is less than the requested number, which means that the last returned status byte is the one corresponding to the highest available user block, followed by the 16-bit CRC and the EOF.

2.4.3 Custom Commands

The IC Mfg Code in the custom command should be“1Dh”.
For the structure of custom commands please refer to ISO/IEC 15693-3.
If not explicitly specified differently all address modes are supported.

2.4.3.1 INVENTORY READ(0xA0)

Command code = A0h

When receiving the INVENTORY READ request, FM13HS01 performs the same as the anti-collision sequence, with the difference that instead of the UID and the DSFID, the requested memory content is re-transmitted from FM13HS01.

If an error is detected, the FM13HS01 remains silent.

If the Option flag is set to logic 0, n blocks of data are re-transmitted. If the Option flag is set to 1, n blocks of data and the part of the UID which is not part of the mask are re-transmitted.

The request contains:

- Flags
- INVENTORY READ command code
- IC manufacturer code
- AFI (if AFI flag set)
- Mask length
- Mask value (if mask length > 0)
- First block number to be read
- Number of blocks to be read
- CRC 16

Table 2-3 Request format

SOF	Flags	INVENTORY PASSWORD	IC Mfg Code	AFI	Mask Length	Mask Value	First block number	Number of blocks	CRC16	EOF
-	8 bits	8 bits	8 bits	8bits optional	8 bits	0 to 64 bits	8 bits	8 bits	16 bits	-

The Inventory_flag must be set to logic 1.

The meaning of flags 5 to 8 is in accordance with table 5 in ISO/IEC 15693-3.

The number of blocks in the request is one less than the number of blocks that the FM13HS01 returns in its response.

If the Option flag in the request is set to logic 0 the response contains:

Table 2-4 Response format: Option flag logic 0

SOF	Flags	Data	CRC16	EOF
-	8 bits	Block length	16 bits	-
		Repeated as needed		

The FM13HS01 reads the requested block(s) and sends back their value in the response. The mechanism and timing of the INVENTORY READ command performs the same as the INVENTORY command which is described in clause 8 of ISO/IEC 15693-3.

If the Option flag in the request is set to logic 1, the response contains:

Table 2-7 Response format: Option flag logic 1

SOF	Flags	Rest of UID which is not part of the mask and slot number	Data	CRC16	EOF
-	8 bits	0~64 bits	Block length	16 bits	-
		Multiple of 8 bits	Repeated as needed		

The FM13HS01 reads the requested block(s) and sends back their value in the response. Additionally the bytes of the UID, which are not parts of the mask and the slot number in case of 16 slots, are returned. Instead of padding with zeros up to the next byte boundary, the corresponding bits of the UID are returned. The mechanism and timing of the INVENTORY READ command perform the same as the INVENTORY command which is described in clause 8 of ISO/IEC 15693-3.

Remark: The number of bits of the re-transmitted UID can be calculated as follows:

- 16 slots: 60 bits (bit 64 to bit 4) - mask length rounded up to the next byte boundary
- 1 slot: 64 bits - mask length rounded up to the next byte boundary

Remark: If the sum of first block number and number of blocks exceeds the total available number of user blocks, the number of transmitted blocks is less than the requested number of blocks, which means that the last returned block is the highest available user block, followed by the 16-bit CRC and the EOF.

Example: mask length = 30 bits

Returned: bit 64 to bit 4 (30 bits) = 30 gives 4 bytes

Table 2-8 Example: mask length = 30

Byte0 Byte1 Byte2 Byte3	Byte4 Byte5 Byte6 Byte7	UID
mask value including padding with zeros	-	transmitted by

		interrogator
-	returned value	transmitted by FM13HS01

2.4.3.2 FAST INVENTORY READ(0xA1)

Command code = A1h

When receiving the FAST INVENTORY READ command the FM13HS01 behaves the same as the INVENTORY READ command with the following exceptions:

The data rate in the direction FM13HS01 to the interrogator is twice that defined in ISO/IEC 15693-3 depending on the Datarate_flag 53 kbit (high data rate) or 13 kbit (low data rate).

The data rate from the interrogator to the FM13HS01 and the time between the rising edge of the EOF from the interrogator to the FM13HS01 remain unchanged (stay the same as defined in ISO/IEC 15693-3).

In the FM13HS01 to the interrogator direction, only the single subcarrier mode is supported.

2.4.3.3 SET EAS(0xA2)

Command code = A2h

The SET EAS command enables the EAS mode if the EAS mode is not locked. If the EAS mode is password protected the EAS password has to be first transmitted with the SET PASSWORD command.

The timing of the command is write alike.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Table 2-9 Request format

SOF	Flags	SET EAS	IC Mfg Code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

Table 2-10 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-11 Response format when Error_flag not set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

2.4.3.4 RESET EAS(0xA3)

Command code = A3h

The RESET EAS command disables the EAS mode if the EAS mode is not locked. If the EAS mode is password protected the EAS password has to be first transmitted with the SET PASSWORD command.

The timing of the command is write alike.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Table 2-12 Request format

SOF	Flags	RESET EAS	IC Mfg Code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

Table 2-13 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-14 Response format when Error_flag not set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

2.4.3.5 LOCK EAS(0xA4)

Command code = A4h

The LOCK EAS command locks the current state of the EAS mode and the EAS ID. If the EAS mode is password protected the EAS password has to be first transmitted with the SET PASSWORD command.

The timing of the command is write alike.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Table 2-15 Request format

SOF	Flags	LOCK EAS	IC Mfg Code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

Table 2-16 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-17 Response format when Error_flag not set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

2.4.3.6 EAS ALARM(0xA5)

Command code = A5h

If the EAS mode is enabled, the EAS sequence is returned from the FM13HS01.

Table 2-18 Request format

SOF	Flags	EAS ALARM	IC Mfg Code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

If an error is detected the FM13HS01 remains silent.

Table 2-19 Response format

SOF	Flags	EAS Sequence	CRC16	EOF
-	8 bits	256 bits	16 bits	-

EAS sequence (starting with the LSB, which is transmitted first; read from left to right):

11110100	11001101	01000110	00001110	10101011	11100101	00001001	11111110
00010111	10001101	00000001	00011100	01001011	10000001	10010010	01101110
01000001	01011011	01011001	01100001	11110110	11110101	11010001	00001101
10001111	00111001	10001011	01001000	10100101	01001110	11101100	11110111

If the EAS mode is disabled, FM13HS01 remains silent.

2.4.3.7 PASSWORD PROTECT EAS/AFI(0xA6)

Command code = A6h

The PASSWORD PROTECT EAS/AFI command enables the password protection for EAS and/or AFI if the EAS/AFI password is first transmitted with the SET PASSWORD command.

Option flag set to logic 0: EAS will be password protected.

Option flag set to logic 1: AFI will be password protected.

Both password protections (AFI and EAS) can be enabled separately.

Remark: Independent of the Option flag, this write-alike command will be executed like a write command with Option flag 0 (Option flag not set).

Once the EAS/AFI password protection is enabled, it is not possible to change back to unprotected EAS and/or AFI.

The timing of the command is write alike (as write command with Option flag 0).

Table 2-20 Request format

SOF	Flags	PASSWORD PROTECT EAS/AFI	IC Mfg Code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

Table 2-21 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-22 Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

2.4.3.8 GET RANDOM NUMBER(0xB2)

Command code = B2h

The GET RANDOM NUMBER command is required to receive a random number from the label IC. The passwords that will be transmitted with the SET PASSWORD command have to be calculated with the password and the random number.

The different passwords are addressed with the password identifier.

Table 2-25 Request format

SOF	Flags	GET RANDOM NUMBER	IC Mfg Code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

Table 2-26 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-27 Response format when Error_flag NOT set

SOF	Flags	Random number	CRC16	EOF
-	8 bits	16 bits	16 bits	-

2.4.3.9 SET PASSWORD(0xB3)

Command code = B3h

The SET PASSWORD command enables the EAS/AFI password to be transmitted to the label to access EAS and/or AFI (if the EAS and/or AFI password is enabled). The SET PASSWORD command has to be executed just once for the related password if the label is powered.

Remark: The SET PASSWORD command can only be executed in Addressed or Selected mode.

The XOR password has to be calculated with the password and two times the received random number from the last GET RANDOM NUMBER command:

XOR_Password[31:0]= Password[31:0] XOR {Random_Number[15:0], Random_Number[15:0]}

The EAS/AFI password is addressed with the password identifier.

Table 2-28 Request format

SOF	Flags	SET	IC	UID	Password	XOR	CRC16	EOF

		PASSWORD	Mfg Code		identifier	password		
-	8 bits	8 bits	8 bits	64 bits optional	8 bits	32 bits	16 bits	-

Table 2-29 Password Identifier

Password Identifier	Password
10h	EAS/AFI
0Fh	Read/Write/KILL

Table 2-210 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-211 Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

Remark:

If the IC receives an invalid password, it will not execute any following command until a Power-On Reset (POR) (RF reset) is executed.

2.4.3.10 WRITE PASSWORD(0xB4)

Command code = B4h

The WRITE PASSWORD command enables a new password to be written into the related memory if the related old password has already been transmitted with a SET PASSWORD command and the addressed password is not locked

Remark: The WRITE PASSWORD command can only be executed in addressed or selected mode. The new password takes effect immediately which means that the new password has to be transmitted with the SET PASSWORD command to access protected blocks.

The EAS/AFI password is addressed with the password identifier.

The timing of the command is write alike.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Table 2-12 Request format

SOF	Flags	WRITE PASSWORD	IC Mfg Code	UID	Password identifier	Password	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits	8 bits	32 bits	16 bits	-

				optional				

Table 2-13 Password identifier

Password Identifier	Password
10h	EAS/AFI
0Fh	Read/Write/KILL

Table 2-14 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-33 Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

2.4.3.11 LOCK PASSWORD(0xB5)

Command Code = B5h

The LOCK PASSWORD command enables the addressed password to be locked if the related password has already been transmitted with a SET PASSWORD command. A locked password cannot be changed.

The EAS/AFI password is addressed with the password identifier.

The timing of the command is write alike.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Table 2-15 Request format

SOF	Flags	LOCK PASSWORD	IC Mfg Code	UID	Password identifier	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	8 bits	16 bits	-

Table 2-16 Password identifier

Password Identifier	Password
10h	EAS/AFI
0Fh	Read/Write/KILL

Table 2-17 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-18 Response format when Error_flag not set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

2.4.3.12 Kill(0xB9)

Command code = B9h

The Kill command enables the FM13HS01 Label IC to be destroyed if the Kill password is correct. This command is irreversible and the FM13HS01 will never respond to any command again after the KILL command is executed.

Table 2-19 Request format

SOF	Flags	Kill	IC Mfg Code	UID	XOR Password	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	32 bits	16 bits	-

Table 2-20 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-40 Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

2.4.3.13 WRITE 2 BLOCKS(0xD5)

Command code = D5h

User data will be fast initialized with this command. 64bits data are written into the two adjacent blocks by one time communication.

The timing is about the same to Write Single Block command except the time that the chip spends on running the write operation is about the twice of it.

Table 2-41 Request format

SOF	Flags	WRITE 2 Blocks	IC Mfg Code	UID	Start Block	Data	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	8 bits	64 bits	16 bits	-

UID is optional. It is only effective in Addressed mode.

Start Block is the start block address.

The low 32 bits Data will be write into the Start Block. The high 32 bits Data will be written into the next of the start block(Start Block+1).

Write Data[63:0]	
Bit 63 ~ Bit 32	Bit 31 ~ Bit 0
Start Block + 1	Start Block

In the Addressed mode or Selected mode, if the Start Block is out of range and the command is effective, error code “0F” will be returned. Because two block are written successively, the Start Block’s effective range is Block0~Block61. Block61 is the highest block which can be addressed. The number of Start Block can be even or odd.

The data written will be unsuccessful if one of the Block has been locked. In the Addressed mode and the Selected mode, Error code “0F” will be returned.

The Error code is “0F” when there is a response error. Otherwise, when response error not occurred, if Option_flag is set, FM13HS01 start to backscatter after the EOF is received from the reader. If Option_flag is not set, FM13HS01 will start to backscatter after the time that specified in the ISO/IEC 15693-3.

Table 2-42 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-43 Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

2.4.3.14 Stay Quiet Persistent（0xBC）

Command code = BCh

Remark:

The Stay Quiet Persistent command can only be executed in Addressed or Selected mode.

When receiving the STAY QUIET PERSISTENT command, the label IC enters the persistent quiet state and will not send back a response.

The Stay Quiet Persistent command does not support Option_flag =1.

The chip that correctly executed the Stay Quiet Persistent command will jump to the Quiet state. the chip in the Quiet state does not respond to Inventory instructions and only executes instructions sent in Addressed mode.

The Stay Quiet Persistent command provides the same behavior as the mandatory STAY QUIET command with the only difference at a reset (power off). The label IC will turn to the

ready state, if the power off time is exceeding the persistent time whose typical value is about 2s.

Table 2-44 Request format

SOF	Flags	Stay Quiet Persistent	IC Mfg Code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

2.4.3.15 PAD IO On-Off（0xC5）

Command code =C5h

PAD IO On-Off instruction is used to control the IO pin to output the open-drain signal at a certain frequency. This signal can be used to light a LED.

Table 2-45 Request format

SOF	Flags	PAD IO On Off	IC Mfg Code	UID	LED CFG1	LED CFG2	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	8 bits	64 bits	16 bits	-

Command's parameter description:

(1) UID is optional which is effective only in addressed mode

(2) LED CFG1 is used to set the IO signal:

Led Cfg1[1:0]	signal type
8'h00	High level (realized by the off-chip pull up resistor)
8'h01	Low level
8'h02	A pin signal is switched between high level and low level at a certain frequency, and the switching frequency is determined by the Led CFG2.
Other	Invalid

LED CFG2 is used to set the switching frequency of the IO when LED cfg1=8'h02. That means the LED's flicker frequency.

Led Cfg2[1:0]	signal period
2'b00	77ms
2'b01	38ms
2'b10	154ms
2'b11	308ms

(3) The T1 time of this command is the same to Read Single Block which is 320.9us.

Table 2-46 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-47 Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

2.4.3.16 Cust Read Auth Start Addr（0xC3）

Command code=C3H
Remark:
This instruction is used to confirm the configuration after setting the secure address boundary in fast initialization mode.

Block Address=0x0F

This instruction is valid only if the chip is in fast initialization mode

Table 2-48 Request format

SOF	Flags	Cust Read Auth Start Addr	IC Mfg Code	UID	Block Address	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	8 bits	16 bits	-

Table 2-49 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-50 Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

2.4.3.17 Cust Write Auth Start Addr（0xC2）

Command code=C2H
Remark:

Block Address=0x0F

This command is used to set Auth Start Block. It is valid only if the chip is in fast initialization mode

Table 2-51 Request format

SOF	Flags	Cust Write Auth Start Addr	IC Mfg Code	UID	Block Address	Data	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	8 bits	32bits	16 bits	-

In the command, Data's length is 32 bits whose first 16 bits [31:16] is meaningless data which cannot be written into the EEPROM. The last 16 bits [15:0] is valid. Data[15:8] is the security boundary and Data[7：0] is its inverse code.

Table 2-52 Response format when Error_flag set

SOF	Flags	Error Code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 2-53 Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

2.4.3.18 Cust Write Algo Key（0xC2）

Command code=C2H
Remark:

Block Address=0x10 or 0x11 or 0x12

IC Mfg Code=0x1D

SOF	Flags	Cust Write Algo Key	IC Mfg Code	Optional UID	Block Address	Data	CRC16	EOF
	8 bits	8 bits	8 bits	64 bits	8 bits	32 bits	16 bits	

Description:

(1) UID is optional, it is available only in the addressed mode.

(2) Block Address can be one of the three values which shown below, corresponding to the different part of the Key data:

- 0x10: write Key[31:0]
- 0x11: write Key[63:32]
- 0x12: write Key[79:64]

(3) This command is effective only when the Key has not been locked

(4) Data area is the data to be written whose length is 32bits

The response of this command is shown below:

If the write command has not been executed successfully, the response is below whose Flags is 0x01 and Error Code is 0x0F.

SOF	Flags	Error Code	CRC16	EOF
	8 bits	8 bits	16 bits	

If the write command has been executed successfully, the response is below whose Flags is 0x00.

SOF	Flags	CRC16	EOF
	8 bits	16 bits	

2.4.3.19 Cust Read Algo Key（0xC3）

Command code=C3H
Remark:

Block Address=0x10 or 0x11 or 0x12

IC Mfg Code=0x1D

SOF	Flags	Cust Read Algo Key	IC Mfg Code	Optional UID	Block Address	CRC16	EOF
	8 bits	8 bits	8 bits	64 bits	8 bits	16 bits	

Description:

(1) UID is optional, it is available only in the addressed mode.

(2) Block Address can be one of the three values which shown below, corresponding to the different part of the Key data:

- 0x10: read Key[31:0]
- 0x11: read Key[63:32]
- 0x12: read Key[79:64]

(3) This command is effective only when the Key has not been locked.

(4) This command is used to verify if the KEY has been written correctly.

The response of this command is shown below:

If the Read command has not been executed successfully, the response is below whose Flags is 0x01 and Error Code is 0x0F.

SOF	Flags	Error Code	CRC16	EOF
	8 bits	8 bits	16 bits	

If the write command has been executed successfully, the response is below whose Flags is 0x00. Block Security Status is optional which will be 0x00 when Option_flag is 1. There will not be Block Security Status in the response data when Option_flag is 0.

SOF	Flags	Block Security Status	Data	CRC16	EOF

	8 bits	8 bits	32 bits	16 bits	

2.4.3.20 Cust Lock Algo Key（0xC4）

Command code=C4H
Remark:

Block Address=0x10

IC Mfg Code=0x1D

SOF	Flags	Cust Lock Algo Key	IC Mfg Code	Optional UID	Block Address	CRC16	EOF
	8 bits	8 bits	8 bits	64 bits	8 bits	16 bits	

Description:

(1) UID is optional, it is available only in the addressed mode.

(2) This command is used to lock the KEY. If the key is locked to read-only state, it will not be changed back to writeable.

The response of this command is shown below:

If the Lock command has not been executed successfully, the response is below whose Flags is 0x01 and Error Code is 0x0F.

SOF	Flags	Error Code	CRC16	EOF
	8 bits	8 bits	16 bits	

If the write command has been executed successfully, the response is below whose Flags is 0x00.

SOF	Flags	CRC16	EOF
	8 bits	16 bits	

2.4.3.21 Act Auth（0xC7）

Command code=C7H
Remark:

Block Address=0x10

IC Mfg Code=0x1D

SOF	Flags	Act Auth	IC Mfg Code	UID	RR	CRC16	EOF
	8 bits	8 bits	8 bits	64 bits	32 bits	16 bits	

Description:

(1) UID is optional, it is available only in the addressed mode.

(2) This command is used to verify the tag by the reader. RR is the 32bits random number that created by the reader. The tag will also create 16bits random number which named RT. Then RT || RR will be encrypted to Token= Enc(RT || RR, KEY) whose length is 48bits, and be send

back to the reader afterward. The reader will decrypted Token, then verify if the random number RR is the same to judge if the tag can pass the verification.

(3) Act Auth command only support Addressed mode and Selected mode.

If the this command has not been executed successfully, the response is below whose Flags is 0x01 and Error Code is 0x0F.

SOF	Flags	Error Code	CRC16	EOF
	8 bits	8 bits	16 bits	

If the this command has been executed successfully, the response is below whose Flags is 0x00. Token will be the encrypted data whose length is 48bits.

SOF	Flags	Token	CRC16	EOF
	8 bits	48bits	16 bits	

2.4.3.22 Cust Read INC CNT（0xC3）

Command code=C3H
Remark:

Block Address=0x15

IC Mfg Code=0x1D

SOF	Flags	Cust Read INC CNT	IC Mfg Code	Optional UID	Block Address	CRC16	EOF
	8 bits	8 bits	8 bits	64 bits	8 bits	16 bits	

Description:

(1) UID is optional, it is available only in the addressed mode.

(2) This command is used to read the counter value by the reader. This counter will increased automatically when the tag enters the NFC field.

If the this command has not been executed successfully, the response is below whose Flags is 0x01 and Error Code is 0x0F.

SOF	Flags	Error Code	CRC16	EOF
	8 bits	8 bits	16 bits	

If the this command has been executed successfully, the response is below whose Flags is 0x00. Block Security Status is optional which will be 0x00 when Option_flag is 1. There will not be Block Security Status in the response data when Option_flag is 0.

SOF	Flags	Block Security Status	Data	CRC16	EOF
	8 bits	8bits	32 bits	16 bits	

2.4.4 Error handling

2.4.4.1 Transmission errors

According to ISO/IEC 15693 the label IC will not respond if a transmission error (CRC, bit coding, bit count, wrong framing) is detected and will silently wait for the next correct received command.

2.4.4.2 Not supported commands or options

If the received command or option is not supported, the behavior of the label IC depends on the addressing mechanism.

2.4.4.2.1 Non Addressed Mode

The label IC remains silent.

2.4.4.2.2 Addressed or Selected Mode

The addressed or selected label IC responds with the error code “0Fh” (error with no information given or error code is not supported).

If the Inventory flag or the Protocol Extension flag is set, the label IC will not respond if the command or option is not supported.

2.4.4.3 Parameter out of range

2.4.4.3.1 Read commands

If the sum of the first block number and the number of blocks exceeds the total available number of user blocks, the number of transmitted blocks is less than the requested number of blocks, which means that the last returned block is the highest available user block, followed by the 16-bit CRC and the EOF.

2.4.4.3.2 Write and lock commands

If the address of a block to be written does not exist or a block to be written is locked, the behavior of the label IC depends on the addressing mechanism.

- Non Addressed Mode
  The label IC remains silent and aborts the command without writing anything.
- Addressed or Selected Mode
  The addressed or selected label IC responds with the error code “0Fh”(error with no information given or error code is not supported).

2.4.5 Data integrity

Following mechanisms are implemented in the contactless communication link between interrogators and label to ensure very reliable data transmission:

- 16-bit CRC per block
- Bit count checking
- Bit coding to distinguish between logic 1, logic 0, and no information
- Channel monitoring (protocol sequence and bit stream analysis)

2.5 Fast Init Mode

Fast Init Mode is the default mode when the chip leaves the factory.

In Fast Init Mode, the data area can be accessed using mandatory and optional instructions.

Fast Init Mode is a special mode that exists only once throughout the whole life cycle of the label. After the initialization of the tag data completed, the starting address of the security data area Auth Start Block must be set. This step causes the chip to exit the Fast Init Mode. After the chip is powered on again, it will exit the Fast Init Mode, and Auth Start Block will no longer be rewritten.

Note: in Fast Init Mode, Block data can be rewritten even if the Block is locked to read-only. After exiting fast init mode, read-only settings will take effect.

2.5.1 Identification of Fast Init Mode

The value of Auth Start Block in the configuration information area 0x0F in Fast Init Mode is 8' hA5 whose inverse code is 8' h5A. The Cust Read Auth Start Addr (0xC3) command can be used to read out the safe configuration area (Block address 0 x0F) data to judge whether the label is in fast initialization mode.

Page No		Byte Number inside a page			
DEC	HEX	0	1	2	3
15	0Fh			Auth Start Block 0xA5	Invt Auth Start Block 0x5A

2.5.2 Exit of Fast Init Mode

Fast Init Mode is used to fulfill the initialization of the label's data quickly. In this mode, data can be written into the chip's user area without any permission restriction. The label should exit the fast initialization mode so that the sensitive data can be protected properly.

FM13HS01 support users to divide data areas into common data areas and secure data areas. Among them, the security data area needs to pass the password check to get the permission to access. User can set the starting address of the secure data area by configuring the Auth Start Block value. User should complete the setting of the security configuration area at the last step of the initialization of the label data, setting the starting address of the security data area to the desired value. Auth Start Block settings are checked using inverse code. They must be set correctly.

Depending on the Auth Start Block value, the configurable data area can be divided into:

Auth Start Block value	**Common data Block**	**Secure data Block**
0x00	No exit	0x00 ~ 0x1F
0x00 < Auth Start Block <= 0x1F	0x00 ~ Auth Start Block - 1	Auth Start Block ~ 0x1F
>0x1F	0x00 ~ 0x1F	No exit

2.6 Authentication

FM13HS01 has an algorithm embedded in the chip which can be used for the reader to authenticate the tag.

The key of the algorithm which is stored in the tag's EEPROM should be identical among the different tags. It can be dispersed based on a root key and another algorithm in the tag initialization phase. The key can be written into the chip by Cust Write Algo Key command and can be read by Cust Read Algo Key command to verify if it is written correctly. After that, Cust Lock Algo Key command can be used to lock the key to be read-only.

Authentication flow is shown below:

1. The reader creates a 32bits random number RR, then send it to the tag by Act Auth command.

2. After RR is received by the tag, it will also create 16bits random number which named RT. Then RT || RR will be encrypted to Token= Enc(RT || RR, KEY) whose length is 48bits, and be send back to the reader afterward.

3. The reader will decrypted Token, then verify if the random number RR is the same to judge if the tag can pass the verification.

2.7 Password Verification

FM13HS01 has password protection function which can be used in the accessing to the secure data area or in Kill command executed or in EAS function.

Password verification flow:

1. The reader gets the 16bits random number from the tag by Get Random Number command;

2. The random number will be XOR with the corresponding password, and then the result will be sent to the tag by Set Password command.

XOR Password = Password[31:0] **XOR** {Random[15:0],Random[15:0]}

3. When the tag receives the XOR Password, it will compare it with the corresponding password which Password ID in the command refers to, if it passed, the authority will be gotten.

3 Characteristics

3.1 Limiting values

Table 3-1 FM13HS01 Limiting values【1】【2】

Symbol	Parameter	Conditions	Min	Max	Unit
T_{stg}	storage temperature		-55	+125	°C
I_I	input current（IN1 to IN2）	IN1 to IN2; RMS	-	30	mA
V_{ESD}	ESD （HBM）		【3】	±2	KV
VIO	IO pin maximum withstand voltage			1.65	V

【1】： Stresses above one or more of the limiting values may cause permanent damage to the device.

【2】： This product includes circuitry specifically designed for the protection of its internal devices from the damaging effects of excessive static charge. Nevertheless, it is suggested that conventional precautions be taken to avoid applying greater than the rated maxima.

【3】： Human body model: C = 100 pF, R = 1.5 k. For ESD measurement, the IC was mounted in a CDIP8 package.

3.2 Normal Working Condition

Table 3-2 FM13HS01 normal working condition

Symbol	Parameter	Min	Typ	Max	Unit
T_A	Temperature	-40	+25	+85	°C
HA	Antenna field strength	0.15		8	A/M

3.3 Electrical characteristics

Table 3-3 Electrical characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_i	Input frequency	【1】	13.553	13.56	13.567	MHz
C_i	Input capacitance	Between IN1 and IN2【2】	22.3	23.5	24.7	pF
Tp	Silence persistent time	25℃ 【3】		2		s

【1】 Bandwidth limitation (±7 kHz) according to ISM band regulations.

【2】 Measured with Agilent E5061B at 13.56 MHz and 0.707V RMS.

【3】 The maximum persistent time strongly depends on the ambient temperature.

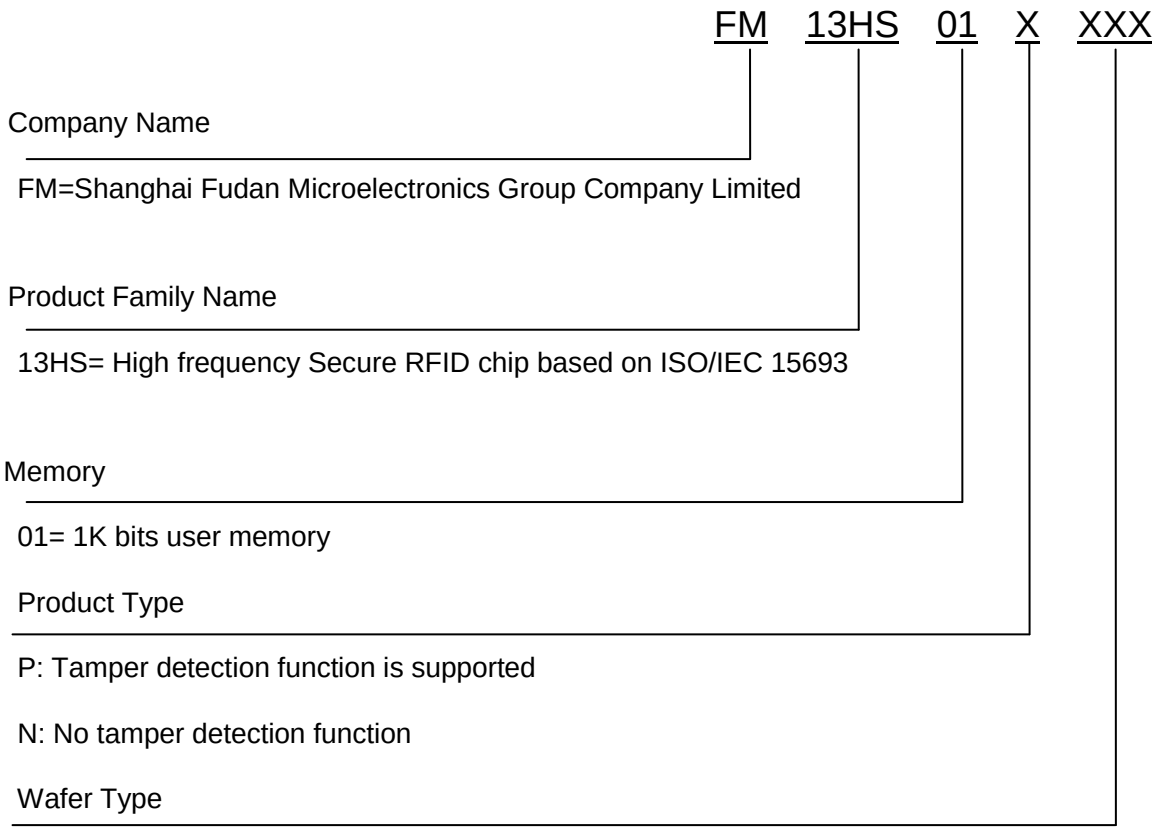
3.4 EEPROM characteristics

Table 3-4 EEPROM characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_{ret}	Retention time	T_{amb} = 55℃	50			year
$N_{endu(W)}$	Write endurance	T_{amb} = 25℃	100,000			cycle

4 Ordering information

Type Number	Wafer Type	Description
FM13HS01-N-WTB2	Bump Sawn Wafer	8 inch bump wafer (2 bumps; 120um thickness, on film frame carrier; electronic wafer mapping of the fail dies according to SECSII format including the test results in wafer test and bumping process; inkdots are applied for the extra fail dies in wafer sawing)
FM13HS01-P-WTB2-4BG	Bump Sawn Wafer	8 inch bump wafer (4 bumps; 120um thickness, on film frame carrier; electronic wafer mapping of the fail dies according to SECSII format including the test results in wafer test and bumping process; inkdots are applied for the extra fail dies in wafer sawing)
FM13HS01-X-WTS2	Sawn Wafer	8 inch sawn wafer (no bumps; 120um thickness, on film frame carrier; electronic wafer mapping of the fail dies according to SECSII format including the test results in wafer test process; inkdots are applied for the extra fail dies in wafer sawing)



Type Number	Package	Description
FM13HS01-X-DNB-T-G	Plastic Package	TDFN4(1.2*1.6*0.55mm)，Reel

FM 13HS 01 X -XXX –X -X

Company Name

FM=Shanghai Fudan Microelectronics Group Company Limited

Product Family Name

13HS= High frequency Secure RFID chip based on ISO/IEC 15693

Memory

01= 1K bits user memory

Product Type

P: Tamper detection function is supported

N: No tamper detection function

Package

DNB=TDFN4(1.2*1.6*0.55mm)

Wrap

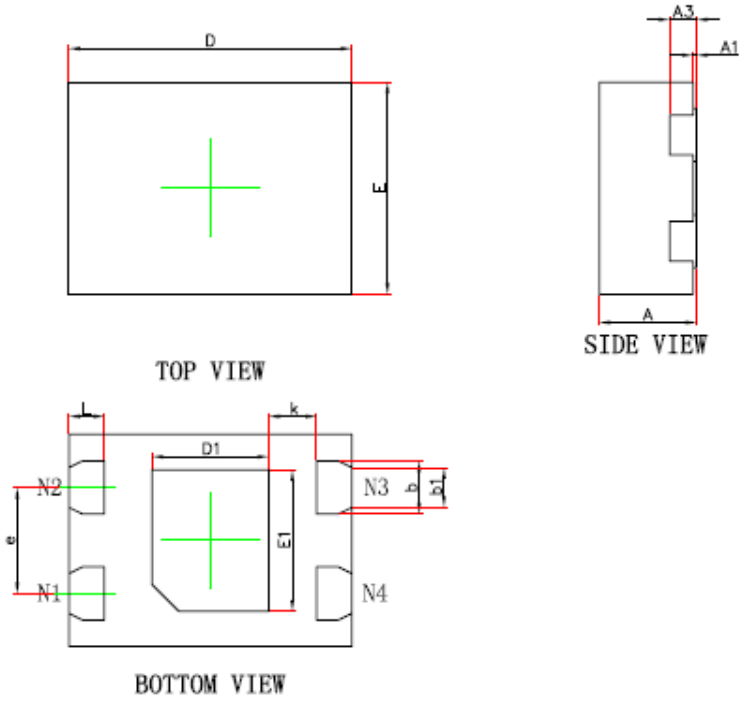
T= Reel

HSF code

G=ROHS Compliant, Halogen-free, Antimony-free

5 封装信息

DFNWB1.2×1.6-4L-A(P0.60T0.55) PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN.	MAX.	MIN.	MAX.
A	0.500	0.600	0.020	0.024
A1	0.000	0.050	0.000	0.002
A3	0.152REF.		0.006REF.	
D	1.500	1.700	0.059	0.067
E	1.100	1.300	0.043	0.051
D1	0.560	0.760	0.022	0.030
E1	0.700	0.900	0.028	0.035
b	0.250	0.350	0.010	0.014
b1	0.175	0.275	0.007	0.011
e	0.600TYP.		0.024TYP.	
L	0.150	0.250	0.006	0.010
k	0.200MIN.		0.008TYP.	

Revision history

Rev	Release date	Pages	Modifications
1.0	April 2020	37	Initial release
1.1	Feb.2022	38	Order information is updated

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