Shanghai Fudan Microelectronics Group Company Limited

复旦微电子

FM11NT021

NFC Forum Type2 Tag compliant IC with 144 bytes user memory

Datasheet

Jul. 2020

Trademarks

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1 Product Overview

1.1 Introduction

FM11NT021 is primarily designed for NFC Forum Type 2 Tag applications. Please consult Fudan Microelectronics Company for more documents.

1.2 Features

1.2.1 RF Interface

- ISO/IEC 14443A
- Contactless transmission of data and supply energy (no battery needed)
- Operating distance: up to 100 mm (depending on various parameters as e.g. field strength and antenna geometry)
- Operating frequency: 13.56 MHz
- Fast data transfer: 106 Kbit/s
- High data integrity: 16-bit CRC, parity, bit coding, bit counting
- 7 byte UID (cascade level 2 according to ISO/IEC 14443-3)
- Fast read command
- Read times counter function

1.2.2 EEPROM

- user memory: 144 bytes (36 pages)
- 4 bytes initialized capability container with one time programmable access bits
- Field programmable read-only locking function per page for the first 16 pages
- Field programmable read-only locking function above the first 16 pages per double page
- Data retention of 10 years
- Write endurance 500,000 cycles

1.2.3 NFC Forum Tag 2 Type compliance

FM11NT021 provides full compliance to the NFC Forum Type 2 Tag technical specification and enables NDEF data structure configuration.

1.2.4 Security

- Manufacturer programmed 7-byte UID for each chip
- Anti-tearing support for capability container (CC) and lock bits
- Field programmable read-only locking function

1.3 Block Diagram

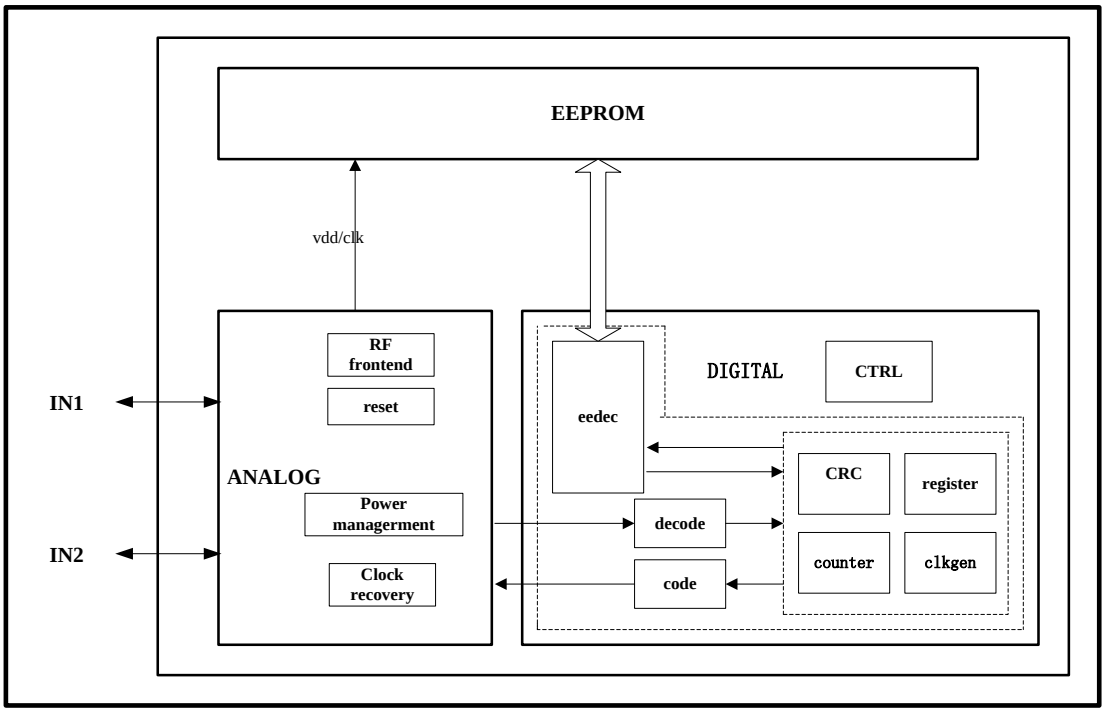


Figure 1-1 FM11NT021 Block diagram

1.4 Pin Description

1.4.1 Bumping Pin Description

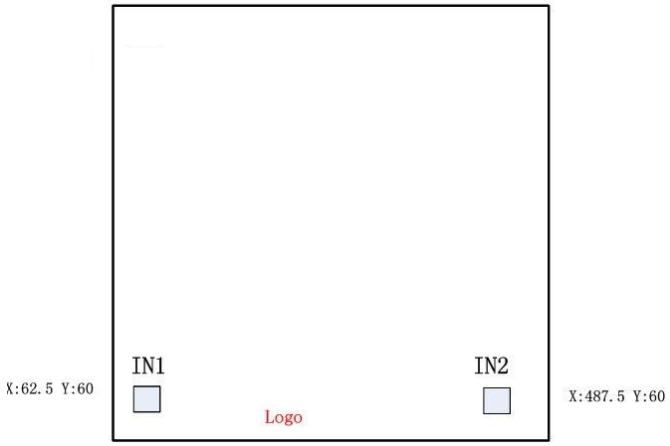


Figure 1-2 Bumping Pin Description

Number	Pin name	Description
1	IN1	Antenna Connection
2	IN2	Antenna Connection

1.4.2 TDFN4

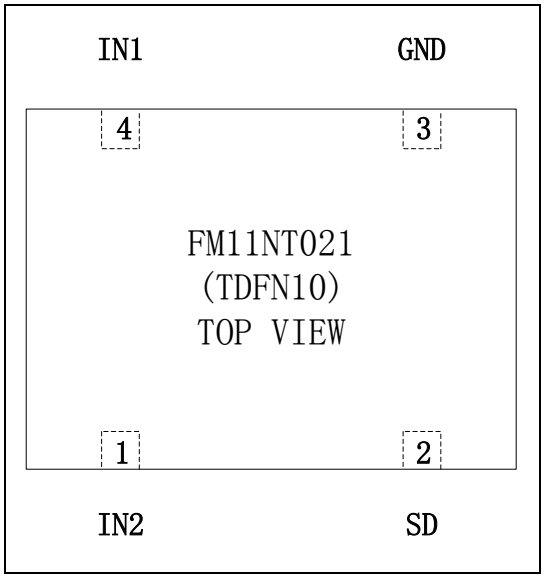


Figure 1-3 **TDFN4** Pin Description

Number	Bumping pin name	Description
1	IN2	Antenna Connection
2	SD	Selected detection signal output, open drain
3	GND	Ground pin
4	IN1	Antenna Connection

1.4.3 SD function

FM11NT021 has chip selected detection function. SD pin is open drain and a pull up resistor is needed. When the chip is selected by the reader, the SD pin will change from high to low. This signal can be used to wake up an off-chip MCU.

2 Functional Description

2.1 General Description

FM11NT021 chip has an 180bytes EEPROM memory embedded. FM11NT021 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 FM11NT021.

2.2 Memory Organization

- EEPROM: 180 bytes, organized in 45 pages of 4 byte per page.
  – 26 bytes reserved for manufacturer and configuration data
  – 34 bits used for the read-only locking mechanism
  – 4 bytes available as capability container
  – 144 bytes user programmable read/write memory

Table 2-1 FM11NT021 Memory organization

Page No		Byte Number inside a page			
DEC	HEX	0	1	2	3
0	0h	Serial Number			
1	1h	Serial Number			
2	2h	Serial Number	Internal	Lock Byte	Lock Byte
3	3h	Capability Container (CC)			
4	4h	TLV			
5	5h				
...	...	Static Data Area (Page4-15)			
15	Fh				
16	10h	Dynamic Data Area (Page 16-39, total 24blocks)			
...	...				
40	28h	Dynamic Lock Bytes			
41	29h	RFU	RFU	RFU	AUTH0
42	2Ah	ACCESS	REGU_CFG	RFU	
43	2Bh	PWD			
44	2Ch	PACK		RFU	
45	2Dh	24bit Counter			RFU

2.2.1 UID

The unique 7 byte serial number (UID) and its two Block Check Character Bytes (BCC) are programmed into the first 9 bytes of the memory. It covers page 00h, page 01h and the first byte of page 02h. The second byte of page 02h is reserved for internal data. Due to security and system requirements these bytes are write-protected after the programming during the IC production.

According to ISO/IEC 14443-3, BCC0 is defined as CT SN0 SN1 SN2. An ABBREVIATION CT stays for Cascade Tag byte (88h) and BCC1 is defined as SN3 SN4 SN5 SN6. SN0 holds the Manufacturer ID for Fudan Microelectronics (1Dh) according to ISO/IEC 14443-3 and ISO/IEC 7816-6 AMD.1.

2.2.2 Lock bytes

Lock bytes enable the user to lock parts of the complete memory area for writing. A Read from user memory area cannot be restricted via lock bytes functionality. The lock bytes functionality is enabled with a WRITE command, where 2 out of 4 bytes transmitted are used for setting the lock bytes.

2.2.2.1 Static Lock

The bits of byte 2 and byte 3 of page 02h represent the field programmable read-only locking mechanism. Each page from 03h (CC) to 0Fh can be individually locked by setting the corresponding locking bit Lx to logic 1 to prevent further write access. After locked, the corresponding page becomes read-only memory.

The three least significant bits of lock byte 0 are the block-locking bits. Bit 2 deals with pages 0Ah to 0Fh, bit 1 deals with pages 04h to 09h and bit 0 deals with page 03h (CC). Once the block-locking bits are set, the locking configuration for the corresponding memory area is frozen.

Table 2-2 Lock0（Block 02，Byte2）

BIT	7 （MSB）	6	5	4	3	2	1	0 （LSB）
Locked Block Number （Decimal）	7	6	5	4	CC	BL 15~10	BL 9~4	BL CC

Table 2-3 Lock1（Block 02，Byte3）

BIT	7 （MSB）	6	5	4	3	2	1	0 （LSB）
Locked Block Number （Decimal）	15	14	13	12	11	10	9	8

For example if BL15-10 is set to logic 1, then bits L15 to L10 (lock byte 1, bit [7:2]) can no longer be changed. The so called static locking and block-locking bits are set by a WRITE command to page 02h. Bytes 2 and 3 of the WRITE command and the contents of the lock bytes are bit-wise

OR'ed and the result then becomes the new content of the lock bytes. This process is irreversible. If a bit is set to logic 1, it cannot be changed back to logic 0. The contents of bytes 0 and 1 of page 02h are unaffected by the corresponding data bytes of the WRITE command. The default value of the static lock bytes is 0000h. Any write operation to the static lock bytes is tearing-proof.

2.2.2.2 Dynamic Lock

The dynamic lock bytes are used to lock the pages starting at page address 10h.
The lock bytes are located at page 28h. The three lock bytes cover the memory area of 96 data bytes for FM11NT021. The granularity is 2 pages.

The default value of the dynamic lock bytes is 00 00 00h. The value of Byte 3 is always BDh when read. Any write operation to the dynamic lock bytes is tearing-proof.

2.2.3 CC bytes

The Capability Container CC (page 3) is programmed according to the NFC Forum Type 2 Tag specification Ref. 8. You can change these bytes by a WRITE command.

The content that needs to be written in will be OR'ed with the current contents of the CC bytes. The result will replace the old contents in CC area. This process is irreversible. If a bit is set to "1", it cannot be changed back to "0" again.

2.2.4 Initial memory configuration

The page 03h, 04h and 05h of FM11NT021 are initialized according to the NFC Forum Type 2 Tag specification.

Table 2-4 Initial memory organization of FM11NT021

Page Address	Byte0	Byte1	Byte2	Byte3
03h	E1h	10h	12h	00h
04h	01h	03h	A0h	0Ch
05h	34h	03h	00h	FEh

2.2.5 Configuration block

2.2.5.1 Overview

FM11NT021's 29h~2Ch store the configuration information：

Table 2-5 Configuration area

Page address	Byte0	Byte1	Byte2	Byte3
29h	RFU	RFU	RFU	AUTH0
2Ah	ACCESS	RFU	RFU	RFU
2Bh	PWD			

Page address	Byte0	Byte1	Byte2	Byte3
2Ch	PACK		RFU	RFU
2Dh	24bits Counter			RFU

2.2.5.2 ACCESS

Table 2-6 Access byte

Name：ACCESS			
Field	**Description**	**Reset**	**Access**
7	PROT Definition of what will be protected by the password ✧ 0：Write operation need password check firstly ✧ 1：Write and read operation all need password check firstly	0	RW
6	CFGLOCK The lock bits of the configuration area（only lock the lowest 2 pages） ✧ 0：The configuration area can be changed ✧ 1：The configuration area cannot be changed permanently	0	RW
5	RFU		
4	NFC_CNT_EN ✧ 0：Counter function is disabled ✧ 1：Counter function is enabled	0	RW
3	NFC_CNT_PWD_PROT ✧ 0：Counter function is not protected by the password ✧ 1：Counter function is under the protection of the password	0	RW
2:0	AUTHLIM The up limit of the password check error times ✧ 000：no limit ✧ 001-111：the maximum times of the check error	3’b000	RW

2.2.5.3 AUTH0

Table 2-7 AUTH0

Name：AUTH0			
Field	**Description**	**Reset**	**Access**
7:0	AUTH0 Definition of the start page address which need to be protected by the password	8’hFF	RW

2.2.5.4 PWD

Table 2-8 PWD

Name：PWD			
Field	**Description**	**Reset**	**Access**
31:0	PWD 32bits password, unreadable in the user mode It is recommended to set the PWD under the protection of AUTH0	32'hFFFFFFFF	RW

2.2.5.5 PACK

Table 2-9 PACK Byte

Name：PACK			
Field	**Description**	**Reset**	**Access**
15:0	PACK The response of password verification PACK will be sent back when the password in PWD_AUTH command is the same to the stored password. Otherwise, NAK will be sent back. It is recommended to set the PACK under the protection of AUTH0.	16'h0000	RW

2.3 Special Function

2.3.1 Read times counter

FM11NT021 has a read times counter function. Once the tag is read by the READ command or FAST-READ command, the 24bits counter's value will be added automatically.
This function can be enabled or disabled with the NFC_CNT_EN bit. The actual counter value can be read by READ_CNT command.
The reading of the Counter can also be protected with the password authentication. The Counter password protection is enabled or disabled with the NFC_CNT_PWD_PROT bit.

2.3.2 Password protection

The read and write authority to the specific address of the memory can be controlled by the password which stored in the EEPROM (4bytes). The response which is 2 bytes is also stored in the EEPROM. User can change them all by themselves.
AUTHLIM is used to define the up limit of the failed password check times. If the error times is out of the limit value, the chip will not response to the check request anymore.
AUTH0's default value is FFh that main the password protection function has been shutdown. User can turn it on after the confiuration. The memory of EEPROM will be protected by the password whose address is startting from the AUTH0.

2.4 Command set

FM11NT021's command is following ISO/IEC14443-A.

Table 2-10 Command overviews

Command	Command code (hexadecimal)
Request	26h (7 bit)
Wake-up	52h (7 bit)
Anticollision CL1	93h 20h
Select CL1	93h 70h
Anticollision CL2	95h 20h
Select CL2	95h 70h
Halt	50h 00h
READ	30h
FAST_READ	3Ah
WRITE	A2h
READ_CNT	39h
PWD_AUTH	1Bh

2.4.1 READ

The READ command is used to read 16bytes data from the memory of FM11NT021 at a time. The data is the 4 pages that start from the address in the command's parameter.

Table 2-11 READ command

Name	Code	Description	Length
Cmd	30h	read four pages	1 byte
Addr	-	start page address	1 byte
CRC	-	CRC according to ISO/IEC14443	2 bytes
Data	-	Data content of the addressed pages	16 bytes
NAK	see Table 2-21	see Section 2.4.6	4-bit

The timing is according to ISO/IEC 14443-3 frame specification.

Table 2-12 READ timing

	$T_{ACK/NAK}$ min	$T_{ACK/NAK}$ max	$T_{TimeOut}$
READ	n=9	$T_{TimeOut}$	5 ms

2.4.2 FAST_READ

The FAST_READ command is used to read more than 16bytes data quickly. The data is all of the pages between the start address and the end address.

Table 2-13 FAST_READ command

Name	Code	Description	Length
Cmd	3Ah	read multiple pages	1 byte
StartAddr	-	start page address	1 byte
EndAddr	-	end page address	1 byte
CRC	-	CRC according to ISO/IEC14443	2 bytes
Data	-	data content of the addressed pages	n*4 bytes
NAK	see Table 2-21	see Section 2.4.6	4-bit

The timing is according to ISO/IEC 14443-3 frame specification.

Table 2-14 FAST_READ timing

	$T_{ACK/NAK}$ min	$T_{ACK/NAK}$ max	$T_{TimeOut}$
FAST_READ	n=9	$T_{TimeOut}$	5 ms

2.4.3 WRITE

The WRITE command is used to writes 4 bytes of data into the addressed FM11NT021's page.

Table 2-15 WRITE command

Name	Code	Description	Length
Cmd	A2h	write one page	1 byte
Addr	-	page address	1 byte
CRC	-	CRC according to ISO/IEC14443	2 bytes
Data	-	data	4 bytes
NAK	see Table 2-21	see Section 2.4.6	4-bit

The timing is according to ISO/IEC 14443-3 frame specification.

Table 2-16 WRITE timing

	$T_{ACK/NAK}$ min	$T_{ACK/NAK}$ max	$T_{TimeOut}$

FAST_READ	n=9	$T_{TimeOut}$	5 ms

2.4.4 READ_CNT

The READ_CNT command is used to read out the current value of the 24 bits counter.

Table 2-17 READ_CNT command

Name	Code	Description	Length
Cmd	39h	read counter	1 byte
Addr	02h	page address	1 byte
CRC	-	CRC according to ISO/IEC14443	2 bytes
Data	-	counter value	3 bytes
NAK	see Table 2-21	see Section 2.4.6	4-bit

The timing is according to ISO/IEC 14443-3 frame specification.

Table 2-18 READ_CNT timing

	$T_{ACK/NAK}$ min	$T_{ACK/NAK}$ max	$T_{TimeOut}$
READ_CNT	n=9	$T_{TimeOut}$	5 ms

2.4.5 PWD_AUTH

PWD_AUTH is used to check the password which protects the area defined by AUTH0.

Table 2-19 PWD_AUTH command

Name	Code	Description	Length
Cmd	1Bh	password authentication	1 byte
Addr	-	password	4 bytes
CRC	-	CRC according to ISO/IEC14443	2 bytes
Data	-	password authentication acknowledge	2 bytes
NAK	see Table 2-21	see Section 2.4.6	4-bit

The timing is according to ISO/IEC 14443-3 frame specification.

Table 2-20 PWD_AUTH timing

	$T_{ACK/NAK}$ min	$T_{ACK/NAK}$ max	$T_{TimeOut}$
READ_CNT	n=9	$T_{TimeOut}$	5 ms

2.4.6 ACK and NAK

FM11NT021 uses a 4 bit ACK / NAK:

Table 2-21 ACK and NAK values

Code (4-bit)	ACK/NAK
Ah	Acknowledge (ACK)
0h	NAK for invalid argument (i.e. invalid page address)
1h	NAK for parity or CRC error
4h	NAK for invalid authentication counter overflow
5h	NAK for EEPROM write error

FM11NT021 replies to a Select CL2 command with 44h which is transmitted with the least significant byte first.

3 Characteristics

3.1 Limiting values

Parameter	Min	Max	Unit
storage temperature	-55	+125	°C
input current（IN1 to IN2）	-	±30	mA
ESD (HBM)） 【2】	-	±4	KV

Table 3-1 FM11NT021 Limiting values【1】

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

【2】Human body model: C = 100 pF, R = 1.5 k

3.2 Working Condition

Symbol	Parameter	Min	Typ	Max	Unit
T_A	Temperature	-40	+25	+85	°C
H_A	Field strength	1.5		7.5	A/M

Table 3-2 FM11NT021 Working Condition

3.3 Electrical characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_i	input frequency		13.553	13.56	13.567	MHz
C_i	input capacitance【1】	Between IN1 and IN2		50		pF

Table 3-3 Electrical characteristics

【1】Measured with Agilent E5061B, the frequency is 13.56MHz, RMS voltage is 0.707V.

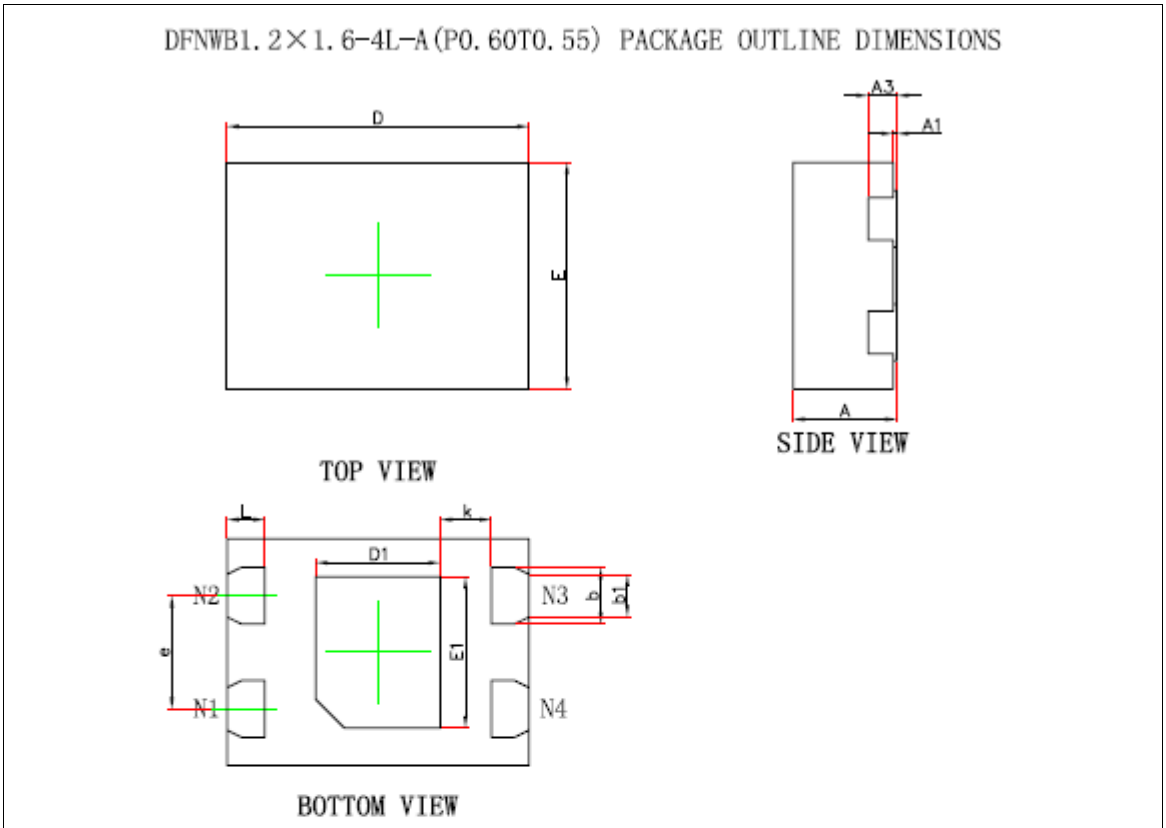
3.4 EEPROM characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_{ret}	retention time	T_{amb} = 55℃	10			year
$N_{endu(W)}$	write endurance	T_{amb} = 25℃	500000			cycle

Table 3-4 EEPROM characteristics

4 Package information

4.1 TDFN4

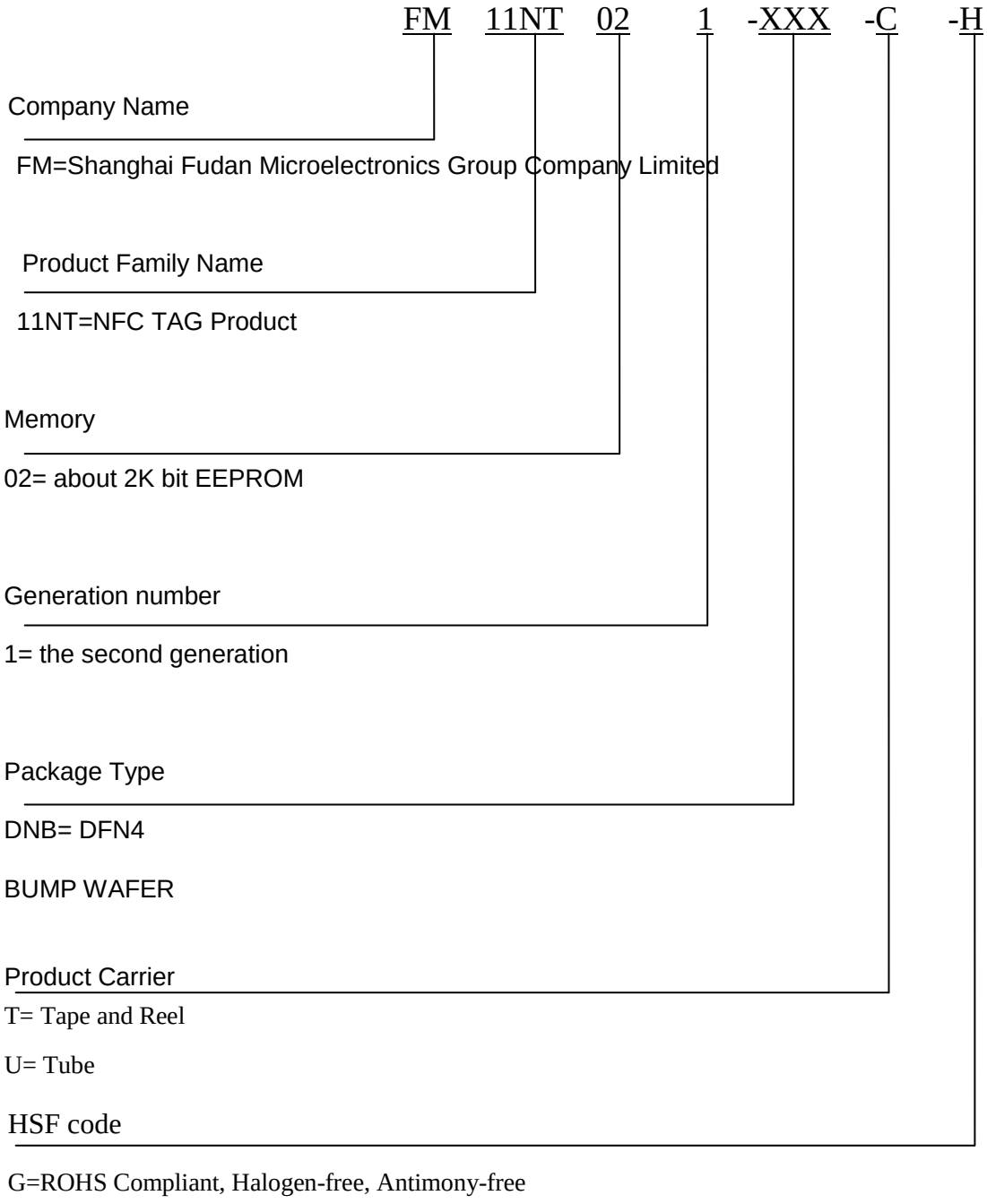


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN.	MAX.	MIN.	MAX.
A	0.500	0.600	0.020	0.024
A1	0.000	0.050	0.000	0.002
A3	0.152REF.		0.006REF.	
D	1.500	1.700	0.059	0.067
E	1.100	1.300	0.043	0.051
D1	0.560	0.760	0.022	0.030
E1	0.700	0.900	0.028	0.035
b	0.250	0.350	0.010	0.014
b1	0.175	0.275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

Figure 4-2 DFN4 package size

5 Ordering information

Type Number	Wafer Type	Description
FM11NT021-DNB-T-G	TDFN4	Reel package
FM11NT021-WIB2	Bump Sawn Wafer	8 inch bump wafer (120um thickness, without UV exposure, on film frame carrier; electronic fail die marking according to SECSII format)



Revision history

Version	Publication date	Pages	Paragraph or Illustration	Revise Description
1.0	Jul. 2020	23		New datasheet for the new chip version

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