Shanghai Fudan Microelectronics Group Company Limited

复旦微电子

FM13DT160

Dual Frequency Three Interfaces Temperature Sensor and Logger IC

Brief Datasheet

Oct. 2019

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Contents

1 Product Overview

1.1 Introduction

FM13DT160 (DT160 for short) is a sensor IC optimized for temperature measurement and logging which has three interfaces. The contact interface follows I2C communication protocol. The contactless interface provides a HF (NFC) port operating in 13.56MHz and an UHF port operating around 900MHz. Benefited from the NFC port, users can read the sensor data log by a NFC smart phone which has Android system or IOS system. Through the UHF port, the sensor data can be gotten by an UHF reader which provides a long distance and dense reading ability.

DT160 can work in a semi-active mode powered by a battery or a passive mode powered by the RF field of the reader. When used as a temperature sensor data logger, it should be powered by a button battery, or a thin-film battery which turns the sensor into a thin stick-on RFID tag. In the passive mode, DT160 can accept the measurement command from the HF or UHF reader and fulfills a temperature measuring operation powered by the RF field.

In the semi-active mode, an embedded RTC (Real-time Clock) can be used to fulfill regular measurement and logging which could be used in cold chain application. The time step can be configured flexibly. The RTC can work with a current lower than 1uA. A continuous temperature logging which starts every 5 minutes can work for one year powered by an 18mAh battery. In this mode, DT160 can also start a single time measurement by receiving a command from the UHF reader. Thanks for the battery assistant, it provides an ultra high sensitivity which means a longer measurement distance and a more reliable communication.

The chip has a high-capacity EEPROM which provides a long time logging ability whose potential is 20,000 temperature points. It can be used to record the temperature data for a period up to 2 months with a 5 minutes measurement interval.

DT160 can be controlled by an off chip MCU communicating by the I2C port. In this application, the EEPROM can also be used to store the temperature data which can be read by the HF and UHF interfaces.

DT160 has HF and UHF energy harvesting ability. The energy can be used to light an off-chip LED which can provide visible information to indicate the current measuring state or provide a warning message.

A light sensor is embedded in the chip. It provides a rough light threshold which can be used to generate a warning data written to the memory together with the temperature data. This feature can be used in some light sensitive pharmaceuticals application.

DT160 has a multi-functional IO pin which can be connected with an off chip humidity sensor. A piezoresistor can also be connected to this IO pin to fulfill a pressure measurement.

1.2 Features

1.2.1 Interface

- **Contactless-UHF**
  - EPC Global C1G2 V1.2.0 & ISO/IEC 18000-63
  - Operating Frequency：840~960MHz

- Communication baud rate（reader to tag）：40~160k bits/s
- Communication baud rate（tag to reader）：5k~640k bits/s
- Temperature measurement sensitivity (battery assistant mode)：-25dBm

- **Contactless-HF (NFC)**
- ISO/IEC 15693 & NFC FORUM TypeV (T5T) or ISO/IEC14443 & NFC FORUM Type2(T2T)
- Operating Frequency：13.56MHz
- Resonant capacitance：23.5pF
- Temperature measurement distance：5cm（up to the reader and the tag antenna）
- Communication baud rate：26k bits/s for ISO15693; 106k bits/s for ISO14443

- **Contact**
- I2C
- Power supply：2.7V~3.6V
- Communication baud rate：100k bits/s

1.2.2 EEPROM

- Total memory：164kbits
- Two configurable sensor data storage area, the maximum size is 160kbits
- User area size is configurable：0~8kbits
- Potential temperature logging points: 20000 (8 bits dense data mode)
- Potential temperature logging points: 16000 (10 bits dense data mode)
- Potential temperature logging points: 4864 (10 bits sparse data mode, full information)

1.2.3 Temperature Measurement and Logging

- Battery Supply Voltage：1.1V~1.65V
- Precise Temperature Measurement Range：-35℃~50℃
- Temperature Sensor Absolute Accuracy：±0.5℃
- RTC Measurement Interval: 1s ~ 65535s
- Configurable Delay time for starting RTC logging: 1m~65535m
- Configurable stop time for the measurement and logging
- Multi-mode for logging: normal mode and limit mode
- RTC accuracy：±2%@-20℃~50℃

1.2.4 Security

- HF UID is unchangeable
- UHF TID is unchangeable
- Access to user area is controlled by password
- Lock mechanism for user memory block (write protection)
- Temperature data area is read-only by the contactless interface

1.2.5 Special feature

- RF field energy harvesting：Output voltage ≤ 5V
- LED lighted function in passive mode and semi-active mode
- Battery low voltage warning function
- Light strength warning function

1.3 Applications

- Cold chain evaluation for medical, fresh food, special chemicals
- Long distance temperature measurement and monitor
- NFC sensor for body or environment temperature measurement
- Pressure measurement

1.4 Package

1.4.1 DFN10

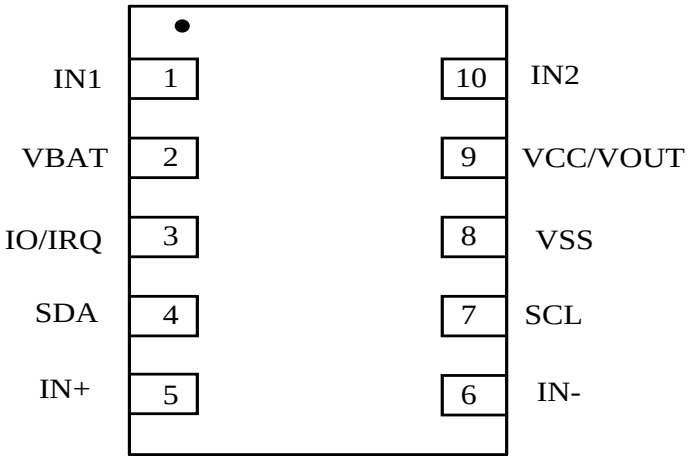


Figure 1-1 DFN10 Package

Table 1-1 DFN10 Pin Description

Number	PIN name	PIN Type	Description
1	IN1	Analog input	HF antenna pin
2	VBAT	Power	Anode of the battery
3	IO/IRQ	Digital in/out Analog in/out	(1) As an analog input, connected with a humidity sensor; (2) As an analog output, connected with a piezoresistor; (3) Output a digital IRQ signal with an off-chip pull-up resistor (10kΩ); (4) Control the LED's lighting;
4	SDA	Digital input/OD output	I2C data pin
5	IN+	Analog input	UHF antenna pin
6	IN-	Analog input	UHF antenna pin
7	SCL	Digital input	I2C clock pin
8	VSS	Power ground	Ground pin, Cathode of the battery
9	VCC/VOUT	Power input / Power output	Power supply of the I2C interface / Energy harvesting output
10	IN2	Analog input	HF antenna pin

1.4.2 Bare die with Gold bumps

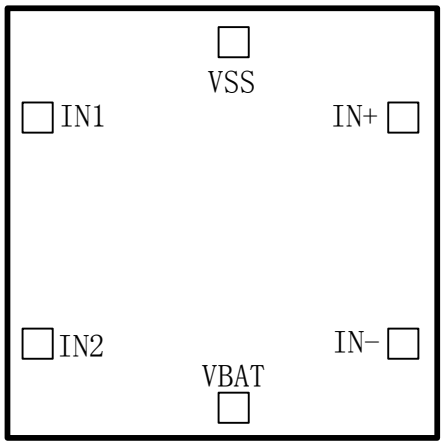


Figure 1-2 Bumps Pin

Table 1-2 Bump Pin Description

Number	PIN name	PIN Type	Description
1	IN1	Analog input	HF antenna pin
2	IN2	Analog input	HF antenna pin
3	VBAT	Power	Anode of the battery
4	IN-	Analog input	UHF antenna pin
5	IN+	Analog input	UHF antenna pin
6	VSS	Power ground	Cathode of the battery

2 Functional Description

2.1 General Description

The FM13DT160 chip consists of the following blocks:

- RF analog blocks: signal's modulator and demodulator of the HF interface and the UHF interface.
- Power management: Manage the power from four sources: Battery, VCC of contact interface, rectified power from the HF field, rectified power from the UHF field.
- Temperature sensor: Including a semiconductor temperature sensor and an ADC which converts the analog data to digital code.
- RTC: Including a low power RC oscillator which outputs a high accuracy frequency clock, low power digital counter and timer. These blocks which work in the standby mode are powered by the battery.
- Digital control logic: handling the communication protocol of HF, UHF, and I2C, managing the measurement process and the data logging process.
- EEPROM: storage of the communication protocol information, user data, temperature data etc.

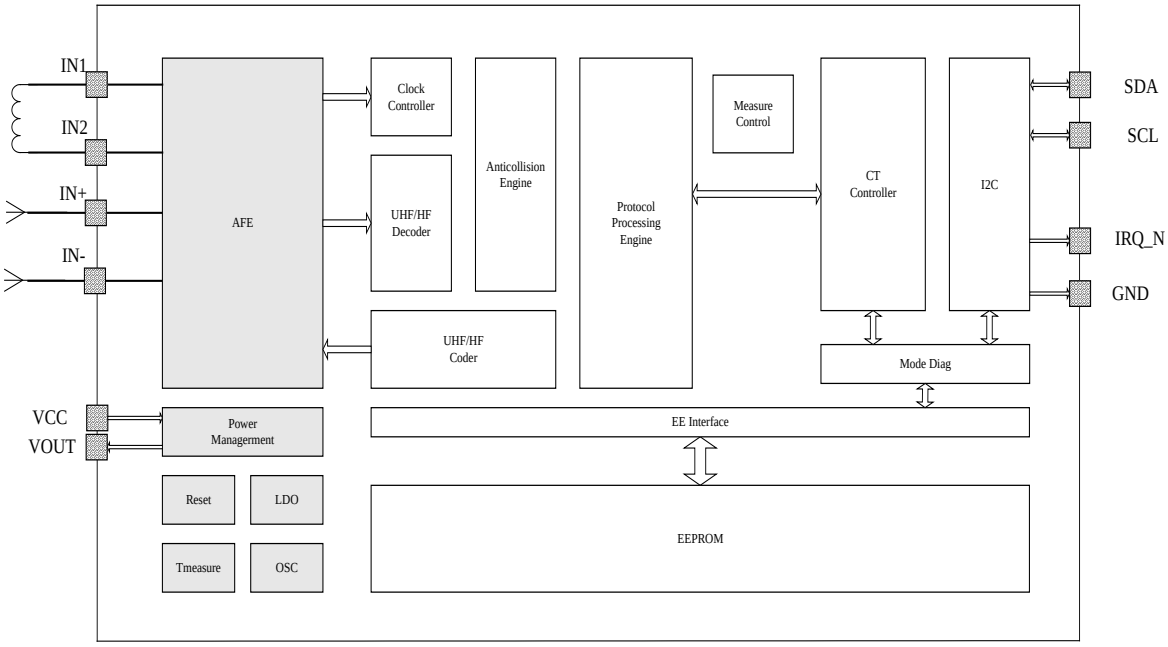


Figure 2-1: FM13DT160 Block Diagram

2.2 Memory organization

The memory of FM13DT160 is a physical EEPROM. The 164kbits of the total memory are organized in blocks each 4 bytes which can be accessed by the three interfaces: HF, UHF and I2C. It is divided into three areas which are configuration area, user area and sensor data area.

The configuration area is used to store the UHF protocol information including TID data, EPC data, and reserved passwords, UID of the HF interface, chip configuration information, etc.

The user area serves as the storage of the three interface's information such as the user data of HF and UHF interface. Commands such as Read or Write from UHF, HF, and I2C interface can access this area separately. The arbitration mechanism is first come first served. The size of the user area can be configured from 0kbits to 8kbits.

Sensor data area is divided into two areas whose size can be configured flexibly. These two areas are used to store the temperature logging data. If the user area is not needed, its size can be configured to 0kbits. Then the total sensor data area will be 160kbits.

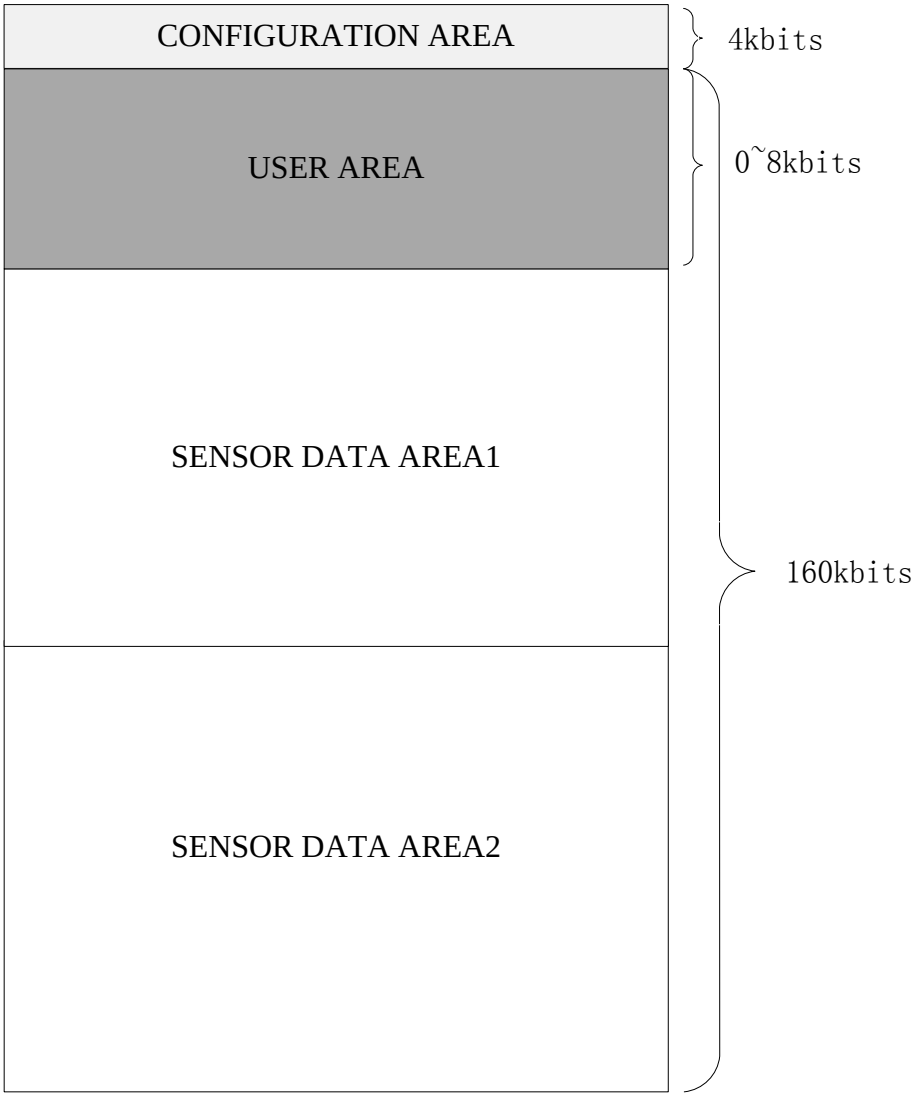


Figure 2-2: FM13DT160 Memory organization

2.2.1 UHF Configuration memory

Following the EPC Global protocol, the three configuration areas of UHF are showed below.

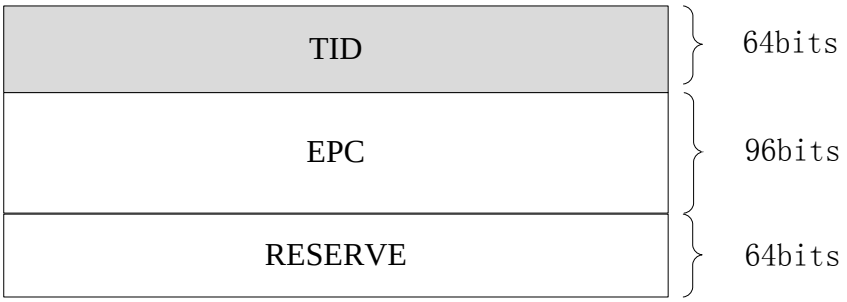


Figure 2-3: UHF Configuration Memory

2.2.2 UID of HF

FM13DT160 has two type of product whose HF interface can be chosen to be ISO15693 or ISO14443.

For the ISO15693 version, The 64-bit unique identifier (UID) in the configuration area is programmed during the production process 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. The Fudan Micro Electronics' manufacturer code is"1Dh".

UID7	UID6	UID5	UID4	UID3	UID2	UID1	UID0
E0	1D	Serial Number					

For the ISO14443 version, the unique 7 byte serial number (UID) and its two Block Check Character Bytes (BCC) are programmed during the wafer test procedure. According to ISO/IEC 14443-3 BCC0 is defined as CT SN0 SN1 SN2. Abbreviations CT stays for Cascade Tag byte (88h) and BCC1 is defined as SN3 SN4 SN5 SN6. SN0 holds the Manufacturer ID for Fudan (1Dh) according to ISO/IEC 14443-3 and ISO/IEC 7816-6 AMD.1.

Block Address	Byte Number inside a page			
	0	1	2	3
0	UID0	UID1	UID2	BCC0
1	UID3	UID4	UID5	UID6
2	BCC1	Internal	Lock Byte	Lock Byte

2.2.3 TID of UHF

The 96bits Tag identifier(TID) in the sector5 of the configuration area is programmed during the production process and will be read-only in the user mode.

The 96bits TID are numbered according to EPC Global C1G2 and ISO/IEC 18000-6C. The Fudan Micro Electronics' manufacturer code is "827h". XTID is fixed to "2000h".

TID0	TID1	TID2	TID3	TID4	TID5	TID6	TID7	TID8	TID9	TID10	TID11
Class ID	Msg code			XTID		SN5	SN4	SN3	SN2	SN1	SN0
E2	827	0	01	2000		Serial Number					

2.2.4 ID Uniformity

Since the chip's contactless interface conforms to three protocols, there are 2 UID of the HF interface and 1 TID of the UHF interface. For the convenience of chip identification, they share the same seriel number (SN5~SN0) as shown in below 3 tables.

ISO14443 UID：

UID6	UID5	UID4	UID3	UID2	UID1	UID0
SN5 (fixed)	SN4	SN3	SN2	SN1	SN0	Msg Code
70	40bits series number					1D

ISO15693 UID：UID is sent from tag to reader in sequence of UID0 to UID7 by bytes.

UID7	UID6	UID5	UID4	UID3	UID2	UID1	UID0
Class ID	Msg Code	SN5 (fixed)	SN4	SN3	SN2	SN1	SN0
E0	1D	70	40bits series number				

ISO18000-6C TID：TID is sent from tag to reader in sequence of TID0 to TID11 by words.

TID0	TID1	TID2	TID3	TID4	TID5	TID6	TID7	TID8	TID9	TID10	TID11
Class ID	Msg code			XTID		SN5 (fixed)	SN4	SN3	SN2	SN1	SN0
E2	827	0	01	2000		70	40bits series number				

3 Characteristics

3.1 Limiting values

Symbol	Parameter	Conditions	Min	Max	Unit
T_{stg}	storage temperature		-55	+125	°C
I_{I_HF}	HF interface input current （IN1 to IN2）	IN1 to IN2; RMS	-	30	mA
P_{i_UHF}	Maximum input power	IN+ to IN-		20	dBm
V_{ESD}	ESD （HBM）		【2】	±2	KV

Table 3-1 FM13DT160 Limiting values【1】【2】

【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 = 1.5kΩ

3.2 Electrical characteristics

3.2.1 Pin characteristics

Symbol	Parameter	Conditions	Min	TYP	Max	Unit
f_{i_HF}	HF input frequency	【1】	13.553	13.56	13.567	MHz
C_{i_HF}	HF input capacitance	Between IN1 and IN2 【2】	22.3	23.5	24.7	pF
f_{i_UHF}	input frequency of UHF		840		960	MHz
Ri	UHF input resistance	Between IN+ and IN-, 25℃，920MHz		10-j*72		Ω
Digital Input						
V_{IL}	Input low voltage		0		0.3Vcc	V
V_{IH}	Input high voltage		0.7Vcc		Vcc	V
I_{leak}	Input leakage current				1	uA
Open Drain output						
VOL	OD output	Vcc=3.3V，I_O=4mA	0		0.3 Vcc	

Table 3-2 Pin characteristics

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

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

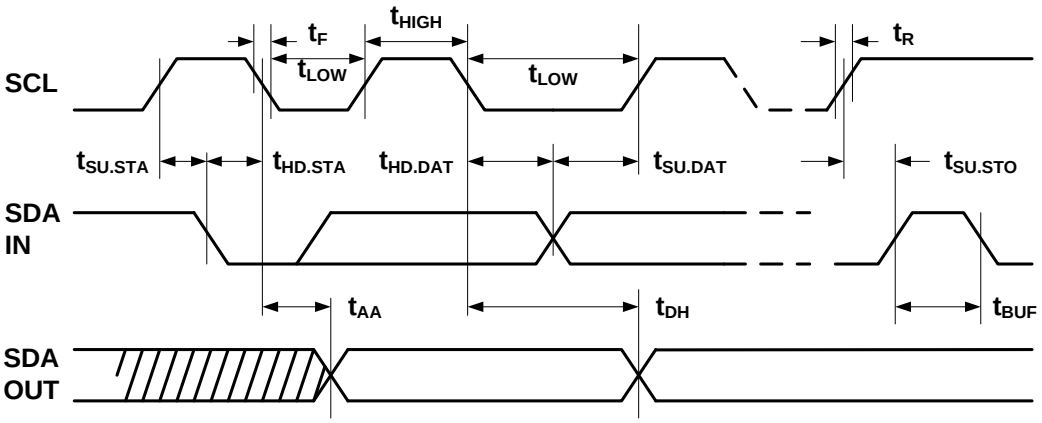
3.2.2 Electrical characteristics

Symbol	Parameter	Conditions	Min	TYP	Max	Unit
V_{cc}[1]	Contact interface supply voltage		2.7	3.3	3.6	V
Vbat	Battery supply voltage		1.1	1.5	1.65	V
I_{BAT-PD}	Supply current in power down mode	25℃, Vbat=1.5v		0.06	0.1	uA
$I_{BAT-STD}$	Supply current in standby mode, RTC is working	25℃, VBat=1.5v		0.6	1	uA
I_{BAT-OP}	Battery current in measurement	25℃		440		uA
I_{EE_WR}	Contact interface supply current when Writing the EEPROM	25℃, Vcc=3.3V，I2C data rate: 400KHz		640		uA
V_{out}	Harvesting energy output voltage	25℃			5	V
T_{SR}	Temperature measurement range		-35		50	℃
T_{ACC}	Temperature accuracy	-35~50℃	-0.5		0.5	℃
T_{RTC-I}	Logging step	configurable	1		65535	s
T_{delay}	Logging start delay time	configurable	0		65535	m
T_{meas}	The duration time of single step temperature measurement in the logging process			180		ms
t_{RTC}	RTC accuracy	-20~50℃, Vbat=1.1~1.65	-2%		2%	

Table 3-3 Electrical characteristics

【1】 When testing the input voltage Vcc of the chip, it is necessary to add a reverse diode from Vcc to the external power supply to prevent the internal voltage output from affecting the test results of the external input voltage.

3.2.3 I2C interface characteristics



Operating condition：T_{BAB}= -40°C ~ +85°C，V_{BCCB} = +3.0V ~ +3.6V，CL = 100 pF

Symbol	Parameter	Standard(100kHz)			Unit
		Min	Typ	Max	
f_{SCL}	Clock Frequency, SCL			400	kHz
t_{LOW}	Clock Pulse Width Low	1.3			μs
t_{HIGH}	Clock Pulse Width High	0.6			μs
t_{AA}	Clock Low to Data Out Valid	0.1		0.9	μs
t_{BUF}[1]	Time the bus must be free before a new transmission can Start	1.3			μs
$t_{HD.STA}$	Start Hold Time	0.6			μs
$t_{SU.STA}$	Start Setup Time	0.6			μs
$t_{HD.DAT}$	Data In Hold Time	0			μs
$t_{SU.DAT}$	Data In Setup Time	100			ns
t_R	Inputs Rise Time			0.3	μs
t_F	Inputs Fall Time			0.3	μs
$t_{SU.STO}$	Stop Setup Time	0.6			μs
t_{DH}	Data Out Hold Time	100			ns
t_{WR}	Write Cycle Time			8	ms

Table 3-4 I2C interface characteristics

【1】 These parameters are up to the sample test and not tested 100% on wafer.

【2】 Test condition：

RL (connect to VCC)：1.3 kΩ

Input pulse voltage：0.3 VCC ~ 0.7 VCC

Input rising time/falling time：≤ 50 ns

Reference voltage of input /output：0.5 VCC

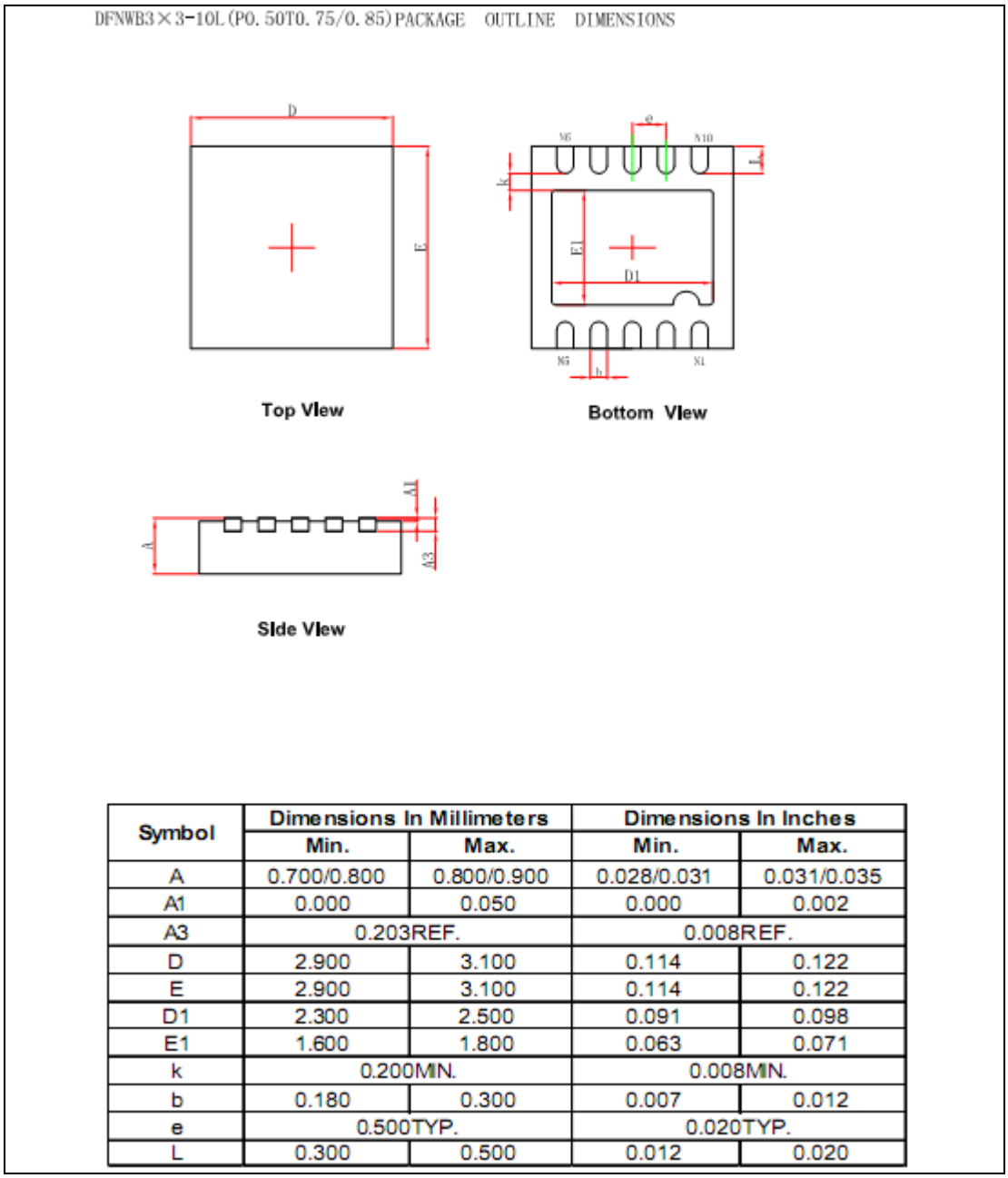
3.3 EEPROM characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_{ret}	retention time	T_{amb} = 55℃	10			year
$N_{endu(W)}$	write endurance	T_{amb} = 25℃	200000			cycle

Table 3-5 EEPROM characteristics

4 Package info

4.1 DFN10



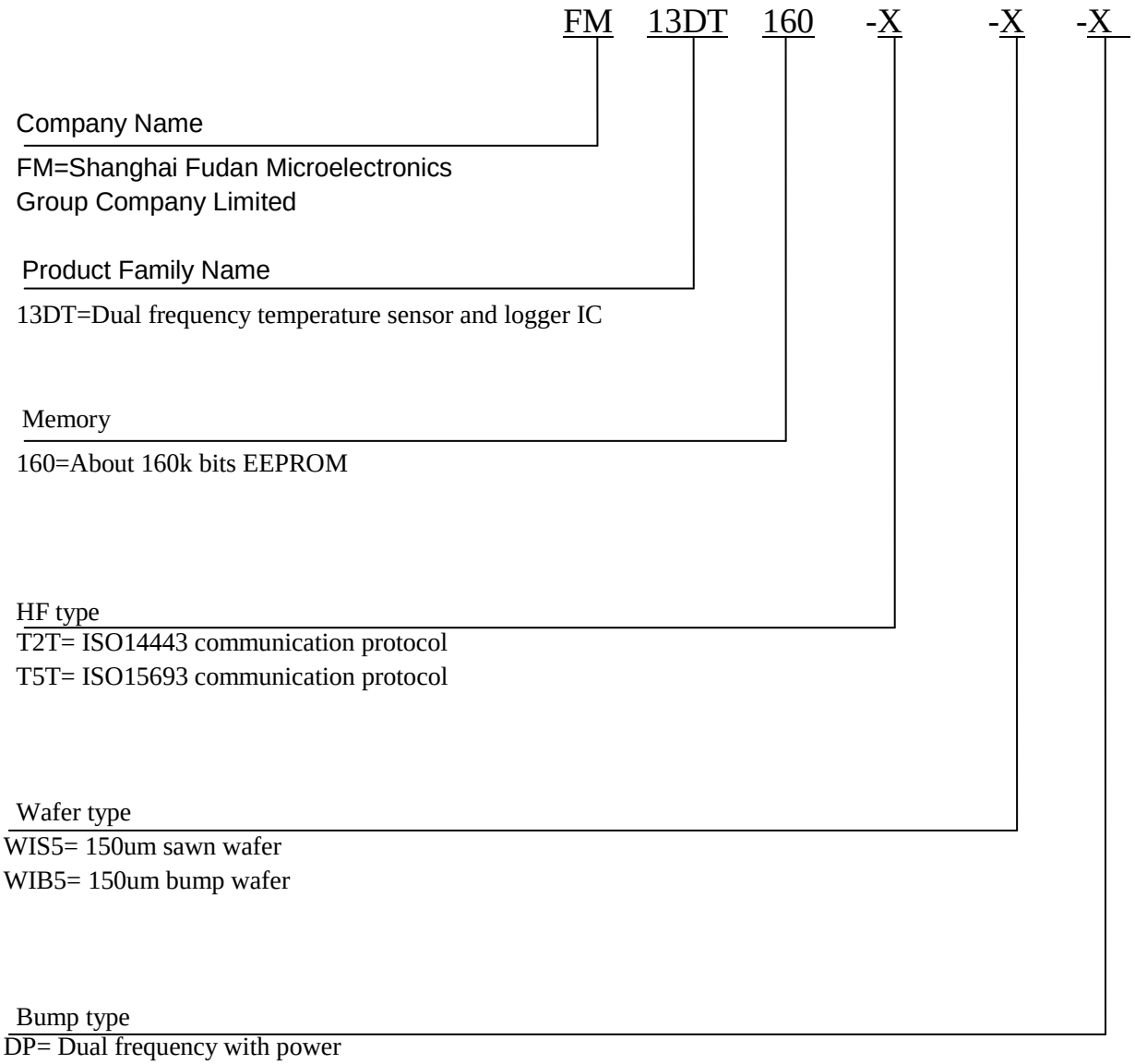
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700/0.800	0.800/0.900	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
D1	2.300	2.500	0.091	0.098
E1	1.600	1.800	0.063	0.071
k	0.200MIN.		0.008MIN.	
b	0.180	0.300	0.007	0.012
e	0.500TYP.		0.020TYP.	
L	0.300	0.500	0.012	0.020

Figure 4-1 TDFN10 package size

5 Ordering information

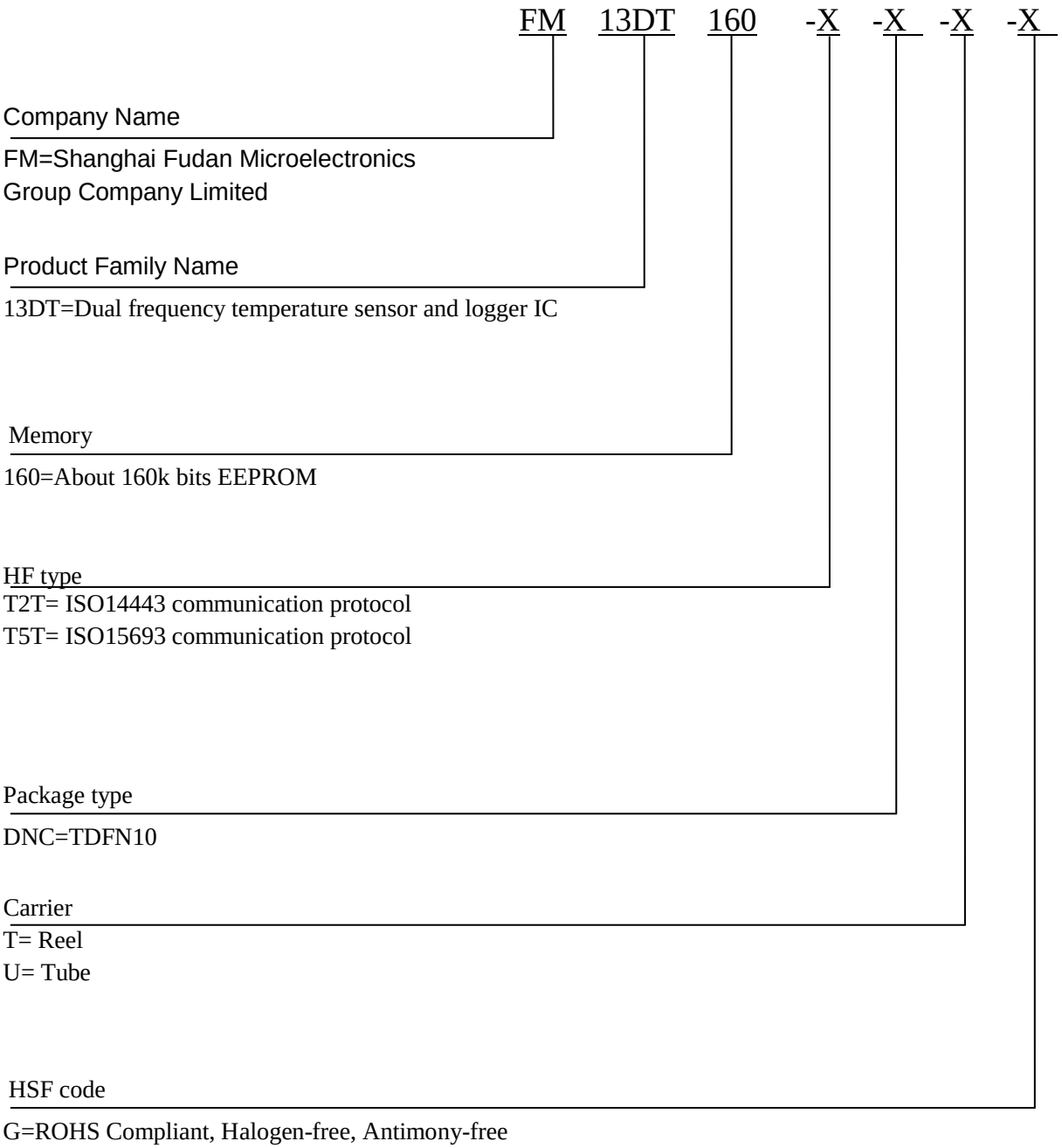
5.1 Bare die with Gold bump

Type name	wafer type	规格说明
FM13DT160-T2T-WIB5-DP	Bump wafer	8inch bump wafer(sawn,150um thickness)
FM13DT160-T2T-WIS5	Sawn wafer	8inch wafer(sawn,150um thickness)
FM13DT160-T5T-WIB5-DP	Bump wafer	8inch bump wafer(sawn,150um thickness)
FM13DT160-T5T-WIS5	Sawn wafer	8inch wafer(sawn,150um thickness)



5.2 TDFN10

Type name	Package type	Pack type
FM13DT160-T2T-DNC-T-G	TDFN10	Reel
FM13DT160-T5T-DNC-T-G	TDFN10	Reel



Revision history

Rev	Release date	Pages	Modifications
1.0	Aug. 2019	15	The first formal brief version.
1.1	Oct. 2019	15	Add ordering information

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