GXHTC3 Temperature and Humidity Sensor IC

Features

- Ultra-low power consumption
- Wide supply voltage range (1.60 ~ 5.5 V)
- Small DFN package: 2 × 2 × 0.75 mm³
- Typical accuracy: ±3 %RH and ±0.3 °C
- Factory calibrated and reflow solderable

Description

The GXHTC3 is a temperature and humidity sensor designed for consumer electronics applications. It fulfills requirements of the consumer electronics field in terms of package size, power consumption, supply voltage range and cost performance. The GXHTC3 implements a complete temperature and humidity sensor system on a single chip, including capacitive humidity sensing unit, PN junction temperature measurement unit, 16-bit ADC, digital signal processing circuit, calibration data storage unit and I²C digital communication interface circuit.

The GXHTC3 adopts a miniaturized DFN6 package with a size of 2 × 2 × 0.75mm³, which enables applications in the most limited of spaces. The GXHTC3 covers a humidity measurement range of 0 ~ 100%RH and a temperature measurement range of -45°C ~ 135°C. The supply voltage range is 1.60 ~ 5.5V and the energy consumption of 2μJ make the GXHTC3 suitable for mobile or wireless communication devices powered by batteries. Each GXHTC3 is fully calibrated before leaving the factory to ensure the consistency and accuracy of the chip. Tape and reel packaging together with suitability for standard SMD production process requirements.

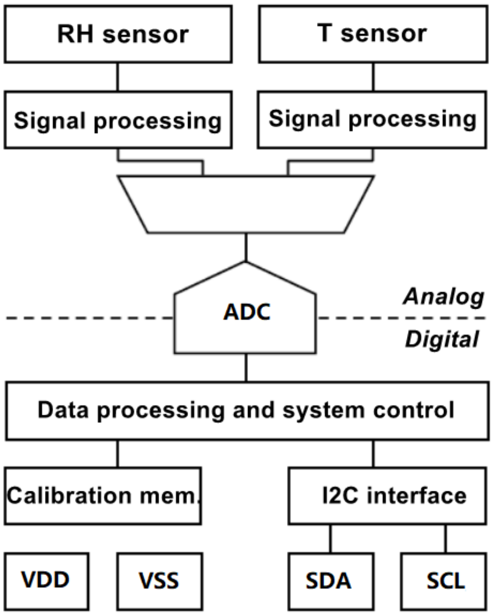


Figure 1. Functional block diagram of the GXHTC3.

Table of Contents

1 Sensor Performance

Each sensor is individually calibrated, and the calibrated instrument has passed the metrological calibration of ISO/IEC17025 accredited laboratory.

Relative Humidity

PARAMETER	CONDITION	VALUE	UNIT
Accuracy	Typ.	±3.0	%RH
	Max.	See Figure 2	%RH
Resolution	-	0.01	%RH
Hysteresis		±1.0	%RH
Specified range		0~100	%RH
Response time	τ 63%	8	s
Long-term drift	Typ.	<0.5	%RH/y

Table 1. Humidity sensor specifications.

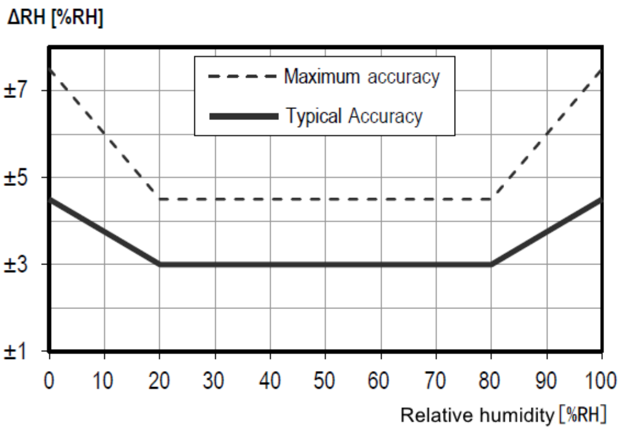


Figure 2. Typical and maximal tolerance for relative humidity at 25°C.

Temperature

PARAMETER	CONDITION	VALUE	UNIT
Accuracy	Typ.	±0.3	°C
	Max.	See Figure 3	°C
Resolution	-	0.01	°C
Hysteresis		±1.0	°C
Specified range		-45-130	°C
Response time	τ 63%	<5-30	s
Long-term drift	Typ.	<0.02	°C /y

Table 2. Temperature sensor specifications.

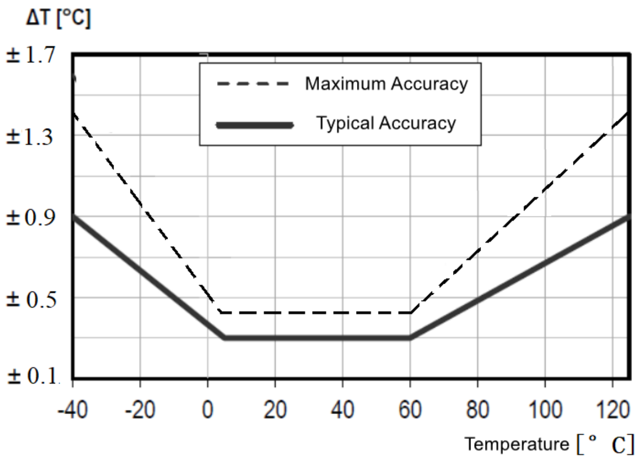


Figure 3. Typical and maximal tolerance for temperature sensor.

1.1 RH Accuracy at Different Temperatures

Typical RH accuracy at 25°C is defined in Figure 2. For other temperatures, typical accuracy has been shown in Figure 4.

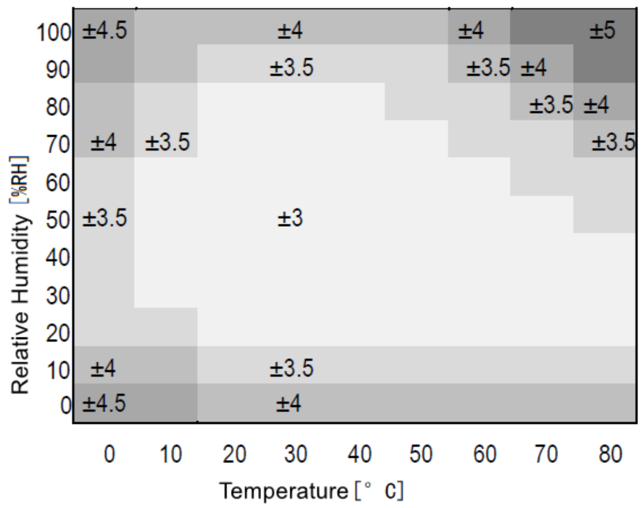


Figure 4. Typical accuracy of relative humidity measurements for different temperatures.

1.2 Recommended Operating Conditions

The sensor shows optimum performance when operating within the recommended normal temperature and humidity ranges (5°C ~ 60°C and 20%RH ~ 80%RH, respectively). Long-term exposure to conditions outside the normal range, especially in high humidity conditions, may cause temporary offset in RH signal (eg, 4%RH error after 60 hours at >80% RH). After returning to normal temperature and humidity ranges, the sensor will slowly revert to its factory calibration state. Long-term exposure to extreme conditions may accelerate aging. To ensure stable operation of the humidity sensor, the conditions described in the document "GXHT-xx Assembly of SMD Packages", section "Storage and Handling Instructions" regarding exposure to volatile organic compounds must be met. Note that this applies not only to transportation and manufacturing, but also to the operation of the GXHTC3.

2 Electrical Specifications

2.1 Electrical Characteristics

PARAMETER	SYMBOL	CONDITIONS		MIN.	TYP.	MAX.	UNITS	COMMENTS
Supply voltage	V_{DD}			1.6	3.3	5.5	V	-
Power-up level	V_{POR}	Static power supply		1.3	1.4	1.5	V	-
Supply current	I_{DD}	Idle state			45	80	uA	After power-up the sensor remains in idle state unless a sleep or measurement command is sent
		Sleep mode			0.2	0.3	uA	When in sleep mode, the sensor requires a wake-up command to enable other commands
		Measurement	Normal		500	860	uA	Average current consumption while the sensor is measuring
			Low power		320	620	uA	
		Average	Normal		3		uA	Average current consumption (continuous operation with one measurement per second)
			Low power		1		uA	
Low level input voltage	V_{IL}	-		-	-	0.4 V_{DD}	V	
High level input voltage	V_{IH}	-		-	0.7 V_{DD}	-	V	
Low level output voltage	V_{OL}	3mA sink current		-	-	0.2 VDD	V	

Table 3. Electrical specifications.

2.2 Absolute Maximum Ratings

The extreme conditions mentioned in Table 4 may cause permanent damage to the sensor, and the performance of the sensor under these extreme conditions cannot be guaranteed.

PARAMETER	RATING
Supply voltage	-0.3 to +6V
Operating temperature range	-45°C to 130°C
Storage temperature range	-45°C to 130°C
ESD (HBM model)	-4 to +4kV
ESD (MM model)	-500 to +500V
Latchup，JESD78 Class Ⅱ，125° C	-100 to +100mA

Table 4. Absolute maximum ratings.

3 Timing Specifications

3.1 Sensor System Timings

Operating conditions in the table default to 25°C and 3.3V supply voltage.

PARAMETER	SYMBOL	CONDITIONS		MIN.	TYP.	MAX.	UNITS	COMMENTS
Power-up time	t_{PU}	After hard reset, V_{DD} > V_{POR}		-	180	500	us	Time from power-up to the voltage reaches V_{POR}
Soft reset time	t_{SR}	After soft reset.		-	180	500	us	Time between ACK of soft reset command and sensor entering the idle state
Measurement duration	t_{MEAS}	Average	Normal	-	10	11	ms	Duration for a humidity and temperature measurement
			Low power	-	1.5	2	ms	

Table 5. Sensor system timing specifications

3.2 Communication Timings

Operating conditions in the table default to 25°C and 3.3V supply voltage.

PARAMETER	SYMBOL	CONDITIONS	NORMAL		LOW POWER		UNITS
			MIN.	MAX.	MIN.	MAX.	
SCL clock frequency	f_{SCL}	-	0	100	0	1000	KHz
Hold time START condition	$t_{HD;STA}$	After this period, the first SCL pulse is generated	4.0	-	0.6	-	us
Low period of the SCL clock	t_{LOW}	-	4.5	-	0.5	-	us

High period of the SCL clock	t_{HIGH}	-	4.0	-	0.26	-	us
Set-up time for a repeated START condition	$t_{SU;STA}$	-	4.7	-	0.5	-	us
SDA hold time	$t_{HD;DAT}$	-	0	-	0	-	us
SDA set-up time	$t_{SU;DAT}$	-	250	-	50	-	ns
SCL/SDA rise time	t_R	-	-	1000	-	120	ns
SCL/SDA fall time	t_F	-	-	300	-	120	ns
SDA valid time	$t_{VD:DAT}$	-	-	3.5	-	0.5	us
Set-up time for STOP condition	$t_{SU:STO}$	-	4	-	0.26	-	us
Capacitive load on bus line	C_B	-	-	500	-	400	pF

Table 6. Communication timing specifications

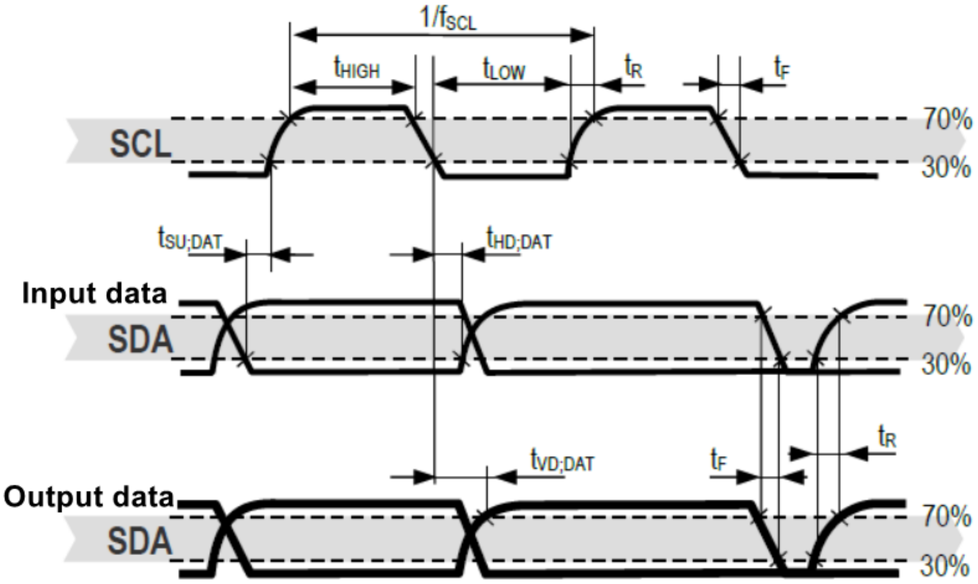


Figure 5. Timing diagram for digital input/output pads. SDA direction refers from the sensor. Bold SDA lines are controlled by the sensor, and the plain SDA lines are controlled by the microprocessor. Note that the valid time of SDA is calculated from the falling edge of SCL.

4 Interface Specifications

The GXH3C3 supports I²C Normal, Fast Mode and Fast Mode Plus (SCL clock frequency up to 1MHz) with clock stretching. Users can choose the mode according to actual needs. For detailed information on the I²C protocol, refer to NXP I²C bus specification and user manual UM10204, Rev. 6, April 4th, 2014.

The GXHTC3 comes in DFN6 package, see Table 7 for detailed description.

PIN	NAME	DESCRIPTION
1	VDD	Supply voltage
3	SCL	Serial clock
4	SDA	Serial data
6	GND	Ground
2，5	No used	

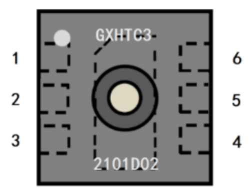


Table 7. Pin assignment, the center pad is grounded.

VDD and GND must be decoupled with a 100nF capacitor that should be placed as close t the sensor as possible, see Figure 6.

SCL is used to synchronize the communication between the microcontroller and the sensor. The microcontroller must keep the SCL clock frequency below 1MHz. The GXHTC3 may pull down the SCL clock line in clock stretching mode.

SDA is used for the data input and output of the sensor. For reliable communication, its timing must meet the requirements in the I²C specification.

To avoid signal contention, the microcontroller can only pull down the SDA and SCL buses, and the high level of the bus is realized by the pull-up resistor. The selection of the pull-up resistor needs to be determined according to the bus capacity requirements. Note thatsome microcontroller I/O circuits may include pull-up resistors.

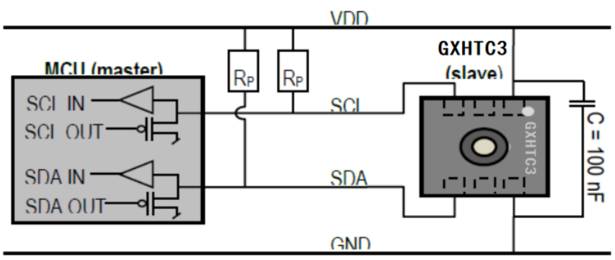


Figure 6. Typical application circuit for GXHTC3, including pull-up resistors and decoupling capacitors. For mechanical stress considerations, the center pad must be soldered to ground.

5 Communication and Operation

All commands and memory locations of the GXHTC3 are mapped to a 16-bit address space which can be accessed via the I²C protocol.

5.1 I²C Address

The I²C device address of the GXHTC3 is given in Table 8.

GXHTC3	HEX	BINARY
I²C address	0x70	111 ’0000

Table 8. GHXTC3 I²C device address.

According to the I²C protocol, each communication starts with a START signal and ends with a STOP signal.

5.2 Power-Up, Sleep, Wakeup

When the power supply voltage V_{DD} reaches the power-up voltage level V_{POR}, the GXHTC3 enters the idle state. Then the sensor should be set to sleep mode to reduce the power consumption. The format of the sleep command is shown in Table 9:

COMMAND	HEX	BINARY
Sleep	0xB098	1011’0000’1001’1000

Table 9. Sleep command of the sensor.

When the sensor is in sleep mode, it requires the following wake-up command before other operations, see Table 10.

COMMAND	HEX	BINARY
Wakeup	0x3517	0011’0101’0001’0111

Table 10. Wake-up command of the sensor.

5.3 Measurement Commands

The GXHTC3 provides clock stretching option and the order of temperature and humidity data. These parameters can be implemented with the different commands in Table 11. Each command triggers a temperature and humidity conversion.

	Clock stretching on		Clock stretching off	
	T first	RH first	T first	RH first
Normal	0x7CA2	0x5C24	0x7866	0x58E0
Low power	0x6458	0x44DE	0x609C	0x401A

Table 11. Measurement commands.

5.4 Measuring and Reading the Signals

Each measurement consists four commands, starting with a STRAT signal and ending with a STOP signal. The specific execution sequence is as follows:

1. Wake-up command
2. Measurement command
3. Read command
4. Sleep command

The specific typical command sequence is shown in Figure 7:

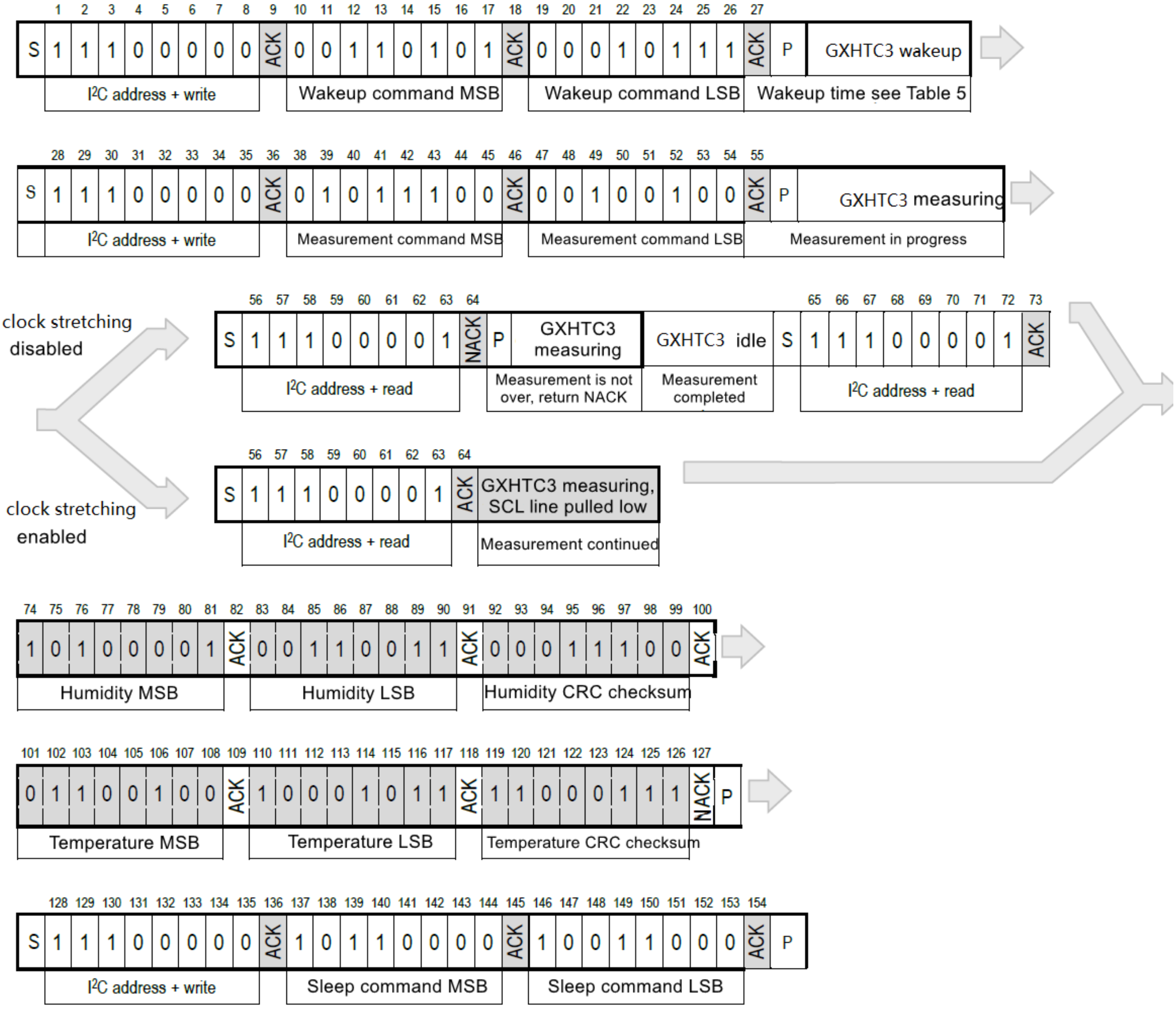


Figure 7. Wake-up, start temperature and humidity measurement, temperature and humidity conversion and sleep command execution sequence diagram.

This example shows that the humidity data is sent first. The actual humidity data is 63% and the temperature is 23.7°C. The white box is controlled by the microcontroller and the gray box is controlled by the sensor.

5.5 Measurement Process

In general, the sensor will not respond to any I²C communication request during the temperature and humidity measurement process. For example, the microcontroller will receive a NACK signal when sending read and write commands. However, when the clock stretching mode is enabled, the sensor responds to the read command of the microcontroller with an ACK signal and pulls down the SCL line until the measurement is complete. At this time, the sensor starts sending the measurement results.

The power consumption during measurement is shown in Table 3. In order to ensure the repeatability of the temperature and humidity measurement, it is recommended to avoid any I²C communication during the measurement.

5.6 Readout of Measurement Results

After the microcontroller sends the temperature and humidity measurement command, the sensor starts to perform temperature and humidity conversion, and the conversion time is shown in Table 5. After the conversion is completed, the microcontroller can read the measurement results by sending the START signal and the I²C read header. The sensor will acknowledge the reception of the I²C read header, and send 2 bytes of temperature/humidity data and 1 byte of CRC checksum. Then continue to send two bytes of humidity/temperature data and 1 byte of CRC check data. The microcontroller must generate an ACK response signal for each received byte. If the sensor does not receive the ACK signal sent by the microcontroller, it will not continue to transmit subsequent data.

If the I²C master is not concerned about the subsequent data, it can abort the data transmission with a NACK signal.

If the user needs temperature and humidity data and is unwilling to process CRC data, it is recommended to read the first two bytes of data with the CRC byte after reading the second two data bytes with a NACK to abort data transmission.

5.7 Soft Reset

The GXHTC3 provides a soft reset mechanism to force the system into an idle state without power loss. It acts the same as power-on reset.

The send command for soft reset is shown in Table 12:

COMMAND	HEX	BINARY
Soft reset	0x805D	1000’0000’0101’1101

Table 12. Soft reset command.

5.8 General Call Reset

Sensors can also be reset using General Call in the I²C specification, which acts as an on-power reset. It is important to note that this reset is not for GXHTC3, it resets slave devices on all I²C buses, but it requires that the slave devices be able to respond to this command. The specific reset commands are shown in Table 13:

Command	Code
Address byte	0x00
Second byte	0x06
Reset command using the general call address	0x0006

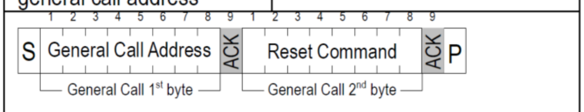


Table 13. General call reset command.

5.9 Readout of ID Register

The GXHTC3 has an ID register for storing the product code of GXHTC3. The readout of the ID register can be used to verify the communication between the sensor and the microcontroller. The commands for reading the ID register are shown in Table 14:

COMMAND	HEX	BINARY
Read ID	0xEFC8	1110'1111'1100'1000

Table 14. Readout command of ID register.

This command needs to be followed by I²C write header, then the microcontroller can send the I²C read header to read the 16-bit ID and one byte CRC check data.

5.10 CRC Checksum

The CRC check algorithm for data transfer is shown in Table 15. The CRC check object is the two bytes of data transferred before it.

PROPERTY	VALUE
Name	CRC-8
Width	8 bits
Polynomial	0x31(x8+x5+x4+1)
Initialization	0xFF
Reflect input	false
Reflect output	false
Example	CRC(0xBEEF)=0x92

Table 15. CRC check algorithm.

5.11 Conversion of Sensor Output

The output temperature and humidity data are transferred as 16-bit unsigned binary values. These values are linearized and temperature compensated inside the sensor. The following formulas are needed to convert these original data into true temperature and humidity data:

Relative Humidity Conversion (%RH):

$$\mathrm{RH} = 100 \cdot \frac{S_{RH}}{2^{16}}$$

Temperature Conversion Formula (°C)

$$\mathrm{T} = -45 + 175 \cdot \frac{S_{T}}{2^{16}}$$

S_{RH} and S_T denote the raw sensor output for humidity and temperature output, respectively. It is important to note that the raw output is converted to decimal in formula calculation.

6 Quality Control

6.1 Environmental Stability

The qualification of the GXHTC3 is based on the JEDEC JESD47 qualification test method.

6.2 Material Contents

The GXHTC3 is fully RoHS, REACH and Halogen compliant, free of Pb, Cd and Hg.

7 Packaging and Traceability

The GXHTC3 adopts miniaturized DFN6 package, and the overall dimension is 2 × 2 × 0.75mm³, and the pin spacing is 0.5mm. DFN represents dual flat no leads. The chip is made of silicon chip and is mounted to a lead frame. The lead frame is made of Cu plated with Ni/Pd/Au. The chip and lead frame are molded by epoxy-based mold compound.

The chip conforms to the specification of small size plastic encapsulated no pin as described in 4.20 of JEDEC95, and also conforms to the specification of small size (QFN/SON) D.01.2009. GXHTC3 conforms to IPC/JEDEC J-STD-020 humidity sensitivity class 1 standard.

All GXHTC3 front faces are laser marked for identification and traceability. As shown in Figure 8, the upper left corner of the front of the sensor is the pin 1 mark and the sensor model mark. The bottom mark contains 5 characters.

The first four ABCD represent the production date, AB represent year, CD represent month.The latter X represents chip version.

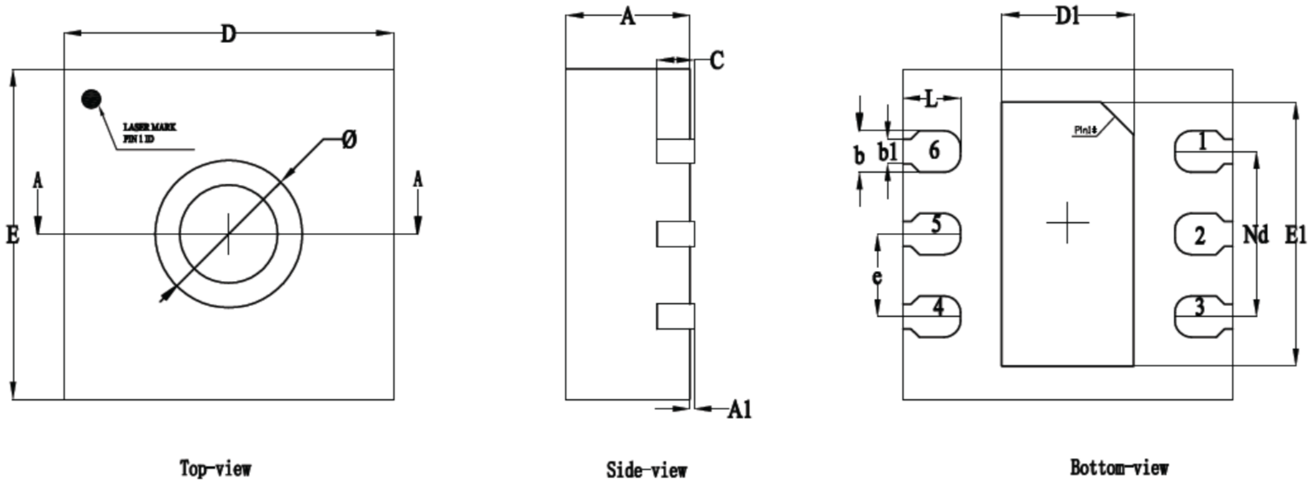
Batch mark decoding processed by GXCAS,which can track the production,calibration and test information of products.

If there is a reasonable request,you can apply to GXCAS for decoding the batch mark to trace the source of the product.

Figure 8. GXHTC3 front laser marking

8 Technical Drawings

8.1 Package Outline



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	—	0.02	0.05
b	0.20	0.25	0.30
b1	—	0.15	—
L	0.30	0.35	0.40
c	0.203 REF		
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D1	0.60	0.70	0.80
E1	1.50	1.60	1.70
Nd	1.0 BSC		
e	0.50 BSC		
Ø	0.70	0.80	0.90
h	—	0.29	—

Figure 9. Package outline drawing of the GXHTC3

8.2 Metal and Pattern

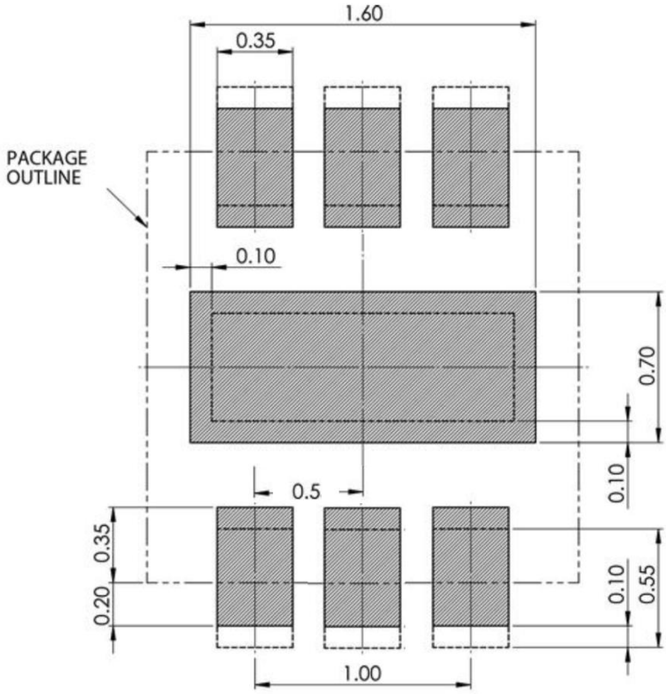


Figure 10. Metal and pattern

8.3 Tape and Reel Package

DATA	12.00 +0.30 -0.30	2.30 +0.10 -0.10	2.30 +0.10 -0.10	1.1 +0.10 -0.10	0.00 +0.10 -0.10	1.75 +0.10 -0.10	5.50 +0.10 -0.10	4.00 +0.10 -0.10	4.00 +0.10 -0.10	2.00 +0.10 -0.10	1.50 +0.10 -0.00	2.00 +0.10 -0.00	0.30 +0.05 -0.05
	W	A_0	B_0	K_0	K_1	E	F	P	P_0	P_2	D_0	D_1	T

Carrier belt direction ⟸

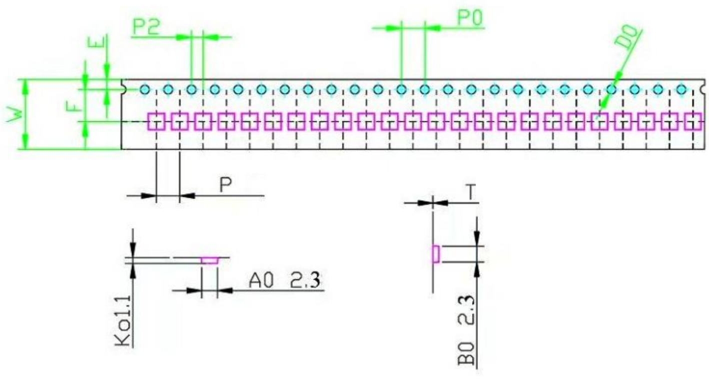


Figure 11. Tape-and-reel package size

9 Ordering Information

The GXHTC3 can order packaging in the form of tape. See the table below for ordering information of different types of sensors.

ORDER NUMBER	TYPE	PACKAGE	MINIMUM QUANTITY	COMMENTS
GXHTC3-T&R	GXHTC3	DFN6 2*2mm	2000	Tape packaging
GXHTC3C-T&R	GXHTC3C	DFN6 2*2mm	2000	The chip is provided with a dust-proof breathable film and wrapped with tape
GXHTC3CF-T&R	GXHTC3CF	DFN6 2*2mm	2000	The chip is provided with a film that can be sprayed with three proofing paint, and is packaged with tape

10 Important Notices

10.1 ESD Precautions

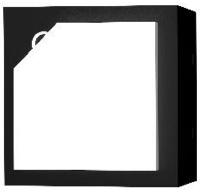
The inherent design of this component makes it very sensitive to electrostatic discharge (ESD). To prevent damage or degradation caused by electrostatic discharge, the sensor should be operated in an electrostatic protected area (EPA) and electrostatic protected measures should be taken (the operator should be grounded through wrist strap, and all non-insulated or conductive objects should be grounded).

10.2 Exposure to Chemicals

The temperature and humidity sensor of Galaxy-CAS is a highly sensitive environmental sensor, not an ordinary electronic component. The sensor used at the opening of the packaging bag is vulnerable to pollution when exposed to the environment. The sensor should not be exposed to volatile chemicals, such as chemical solvents or organic compounds, in close proximity, especially at high concentrations and for a long time. It has been proved that (ethyl) ketene, acetone, isopropanol, ethanol, toluene, etc. can cause the humidity reading shift, which is irreversible in most cases.

10.3 Dust Proof Breathable Film

The temperature and humidity sensor are different from the general sensor chip. The sensor is very sensitive, so its opening part is vulnerable to dust, impurities and other pollution. For outdoor applications, customers are recommended to order our products with a dust-proof breathable film. The film can prevent dust, protect the sensor, resist pollution, improve the sensor life and reliability, and must not be torn off.



10.4 Applications in Extreme Environments

In some applications, temperature and humidity sensors need to be exposed to harsh environments. In many cases, the suitability of the sensor is not considered, and some situations need special attention.

1) The sensor needs to return to the normal environment for a period of time after working under the conditions of super normal temperature and humidity (> 90).

2) In some application environments, the sensor may be exposed to high concentration volatile organic solvent environment for a long time, which may occur in both assembly and application links. The application of this class

requires attention.

3) In some application environments, the sensor may be exposed to acidic or alkaline environment, but only when a certain concentration is reached, the sensor will be damaged. For alkali, pH>9 will damage the sensor. Etching materials, such as H_2O_2 and NH_3, will also harm the sensor if the concentration is very high.

4) Corrosive gas may exist in some application environments. If the concentration is relatively low, it will not affect the sensor, but will affect the connection of solder joints. If the concentration is high, it will also cause damage to the sensor.

10.5 Spraying Three Proofing Paint

The three proofing paint itself pollutes the temperature and humidity sensor. Customers who must spray the three-proofing paint on the board need to order our products with the three proofing paint film. After spraying the three-proofing paint, the three proofing paint film can be torn off to test the temperature and humidity normally. When spraying the three-proofing paint, it is required to be at least 30 cm away from the sensor. Move the tank slowly to ensure uniform coating. The surface is dry for about 30 minutes, and the second spraying can be carried out. After the three proofing paint is fully dried, it will take about 24 hours, and then gently remove the three proofing paint film.

10.6 Packaging and Storage

Before use, it is strongly recommended to seal the sensor in the original packaging. The storage environment requirements are as follows: temperature 10 °C ~ 50 °C (0 °C ~ 125 °C for a limited time), 20% ~ 65% RH.

10.7 Assembly

The sensor can be stored for 1 year in the normal storage environment, and the moisture-proof level of the sensor is Level 1.