GXHTV3 Temperature and Humidity Sensor IC

1 Features

- Ultra-low power consumption
- I²C protocol compatibility
- Wide supply voltage range（1.6V-5.5V）
- Small DFN6 package (2×2×0.75mm³)
- Typical accuracy: ±3 %RH and ±0.3 °C
- Factory calibrated and reflow solderable

2 Applications

- Consumer electronics
- Cold chain transportation
- Smart home
- Smart agriculture
- Communication equipment
- Photovoltaic energy storage

Figure 1. Chip Rendering

3 Description

The GXHTV3 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 GXHTV3 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 GXHTV3 adopts a miniaturized DFN6 package with a size of 2×2×0.75mm³, which enables applications in the most limited of spaces. The GXHTV3 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 GXHTV3 suitable for mobile or wireless communication devices powered by batteries. Each GXHTV3 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.

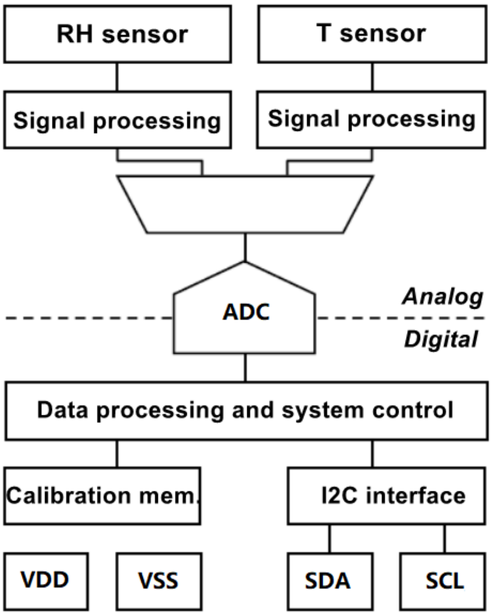

Figure 2. Functional block diagram of the GXHTV3.

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4 Sensor Performance

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

Table 1. Humidity Sensor Specifications.

PARAMETER	CONDITION	VALUE	UNIT
Accuracy	Typ.	±3.0	%RH
	Max.	See Figure 3	%RH
Resolution	-	0.01	%RH
Hysteresis	-	±1.0	%RH
Specified range	-	0-100	%RH
Response time	τ63%	8	s
Long-term drift	Typ.	<0.5	%RH/y

Table 2. Temperature Sensor Specifications.

PARAMETER	CONDITION	VALUE	UNIT
Accuracy	Typ.	±0.3	℃
	Max.	See Figure 5	-
Resolution	-	0.01	℃
Hysteresis	-	±1.0	℃
Specified range	-	-45 to +130	℃
Response time	τ63%	< 5-30	s
Long-term drift	Typ.	<0.02	°C /y

Temperature and Humidity sensor performance diagram

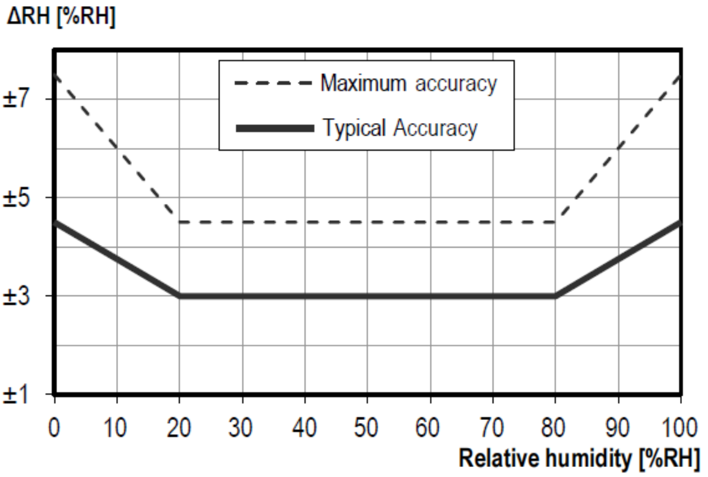


Figure 3. Tolerance of RH at 25°C for GXHTV3

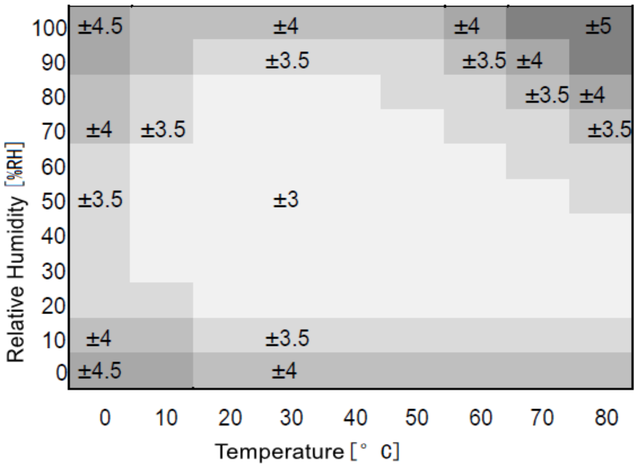


Figure 4. Typical accuracy of relative humidity measurements for different temperatures.

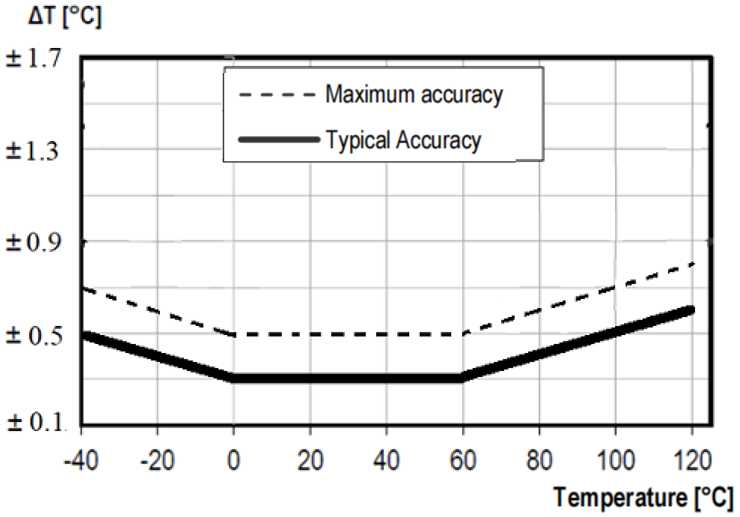


Figure 5. Temperature accuracy of GXHTV3

Recommended Operating Condition

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 at high humidity, may temporarily shift the relative humidity signal. After returning to normal temperature and humidity ranges, the sensor will slowly return to calibration state by itself.

5 Specifications

5.1 Electrical Characteristic Parameters

Table 3. Electrical characteristic parameters（@25℃, 3.3V）

PARAMETER	SYMBOL	CONDITIONS		MIN.	TYP.	MAX.	UNIT	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	μA	After power-up the sensor remains in idle state unless a sleep or measurement command is sent
		Sleep mode			0.2	0.3	μA	When in sleep mode, the sensor requires a wake-up command to enable other commands
		Measurement	Normal	-	500	860	μA	Average current consumption while the sensor is measuring
			Low power		320	620	μA	
		Average	Normal		3		μA	Average current consumption (continuous operation with one measurement per second)
			Low power	-	1	-	μA	
Low level input voltage	V_{IL}	-		-	-	$0.4V_{DD}$	V	
High level input voltage	V_{IH}	-		-	$0.7V_{DD}$	-	V	
Low level output voltage	V_{OL}	3mA sink current		-	-	$0.2V_{DD}$	V	

5.2 Absolute Maximum Ratings

Table 4. Absolute Maximum Ratings.

PARAMETER	RATING	UNIT
Supply voltage	-0.3 to +6	V
Operating temperature range	-45 to 130	℃
Storage temperature range	-45 to 130	℃
ESD HBM (human body mode)	-4 to +4	kV
ESD CDM (charge device mode)	-500 to +500	V
Latch up，JESD78 Class Ⅱ，125°C	-100 to +100	mA

NOTE: 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.

5.3 Sensor System Timings

Table 5. Sensor SystemTiming Specifications（@ 25℃ ， 3.3V）

PARAMETER	SYMBOL	CONDITIONS		MIN.	TYP.	MAX.	UNIT	COMMENTS
Power-up time	t_{PU}	After hard reset $V_{DD} > V_{POR}$		-	180	500	μs	Time from power-up to the voltage reaches V_{POR}
Soft reset time	t_{SR}	After soft reset.		-	180	500	μs	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	

5.4 Communication Timings

Table 6. Communication Timing Specifications（@ 25℃ ， 3.3V）

PARAMETER	SYMBOL	CONDITIONS	NORMAL		LOW POWER		UNIT
			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

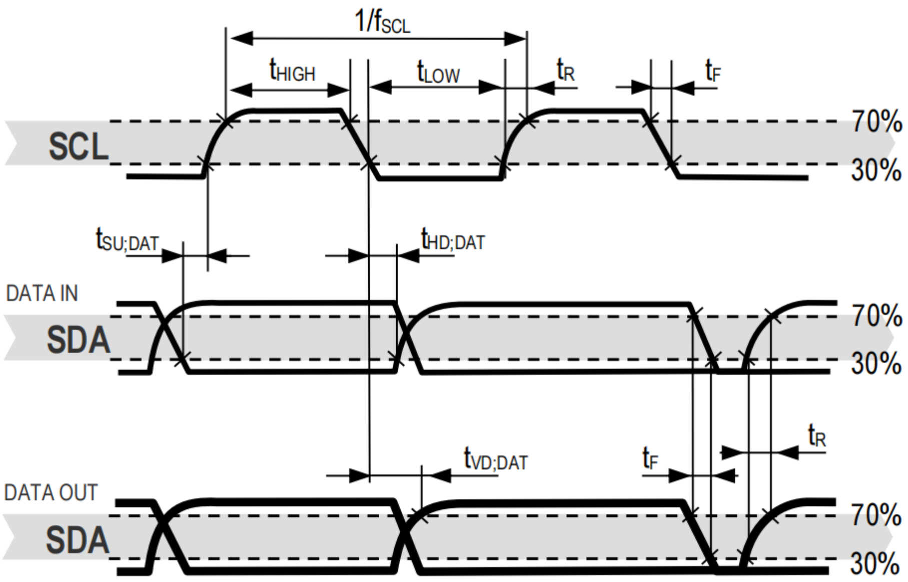


Figure 6. Timing diagram for digital input/output pads.

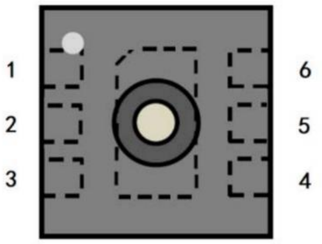
NOTE: SDA direction refers from the sensor. Bold SDA lines are controlled by the sensor, and the plain SDA lines are controlled by the microprocessor. Note that the valid time of SDA is calculated from the falling edge of SCL.。

6 Pin Assignment

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 GXHTV3 comes in DFN6 package, see Table 7 for detailed description.

Table 7. Pin Assignment (the center pad is grounded).

PIN	NAME	DESCRIPTION	
1	V_{DD}	Supply voltage	
3	SCL	Serial clock	
4	SDA	Serial data	
6	GND	Ground	
2，5	NO USE		

VDD and GND must be decoupled with a 100nF capacitor that should be placed as close t the sensor as possible, see Figure 7.

SCL is used to synchronize the communication between the microcontroller and the sensor. The microcontroller must keep the SCL clock frequency below 1MHz. The GXHTV3 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 that some microcontroller I/O circuits may include pull-up resistors.

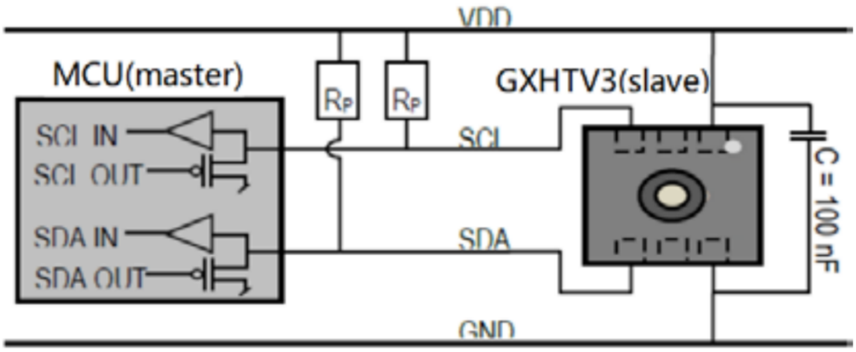


Figure 7. Typical application circuit for GXHTV3(including pull-up resistors and decoupling capacitors)

NOTE:For mechanical stress considerations, the center pad must be soldered to ground

7 Communication and Operation

All commands and memory locations of the GXHTV3 are mapped to a 16-bit address space which can be accessed via the I²C protocol.

7.1 I²C Address

Table 8. GHXTV3 I²C device address.

GXHTV3	HEX	BINARY
I²C address	0x70	111’0000

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

7.2 Power-Up, Sleep, Wake up

When the power supply voltage V_{DD} reaches the power-up voltage level V_{POR}, the GXHTV3 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:

Table 9. Sleep command of the sensor.

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

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

Table 10. Wake-up command of the sensor.

COMMAND	HEX	BINARY
Wake up	0x3517	0011’0101’0001’0111

7.3 Measurement Commands

The GXHTV3 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.

Table 11. Measurement commands.

Mode	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

7.4 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 8:

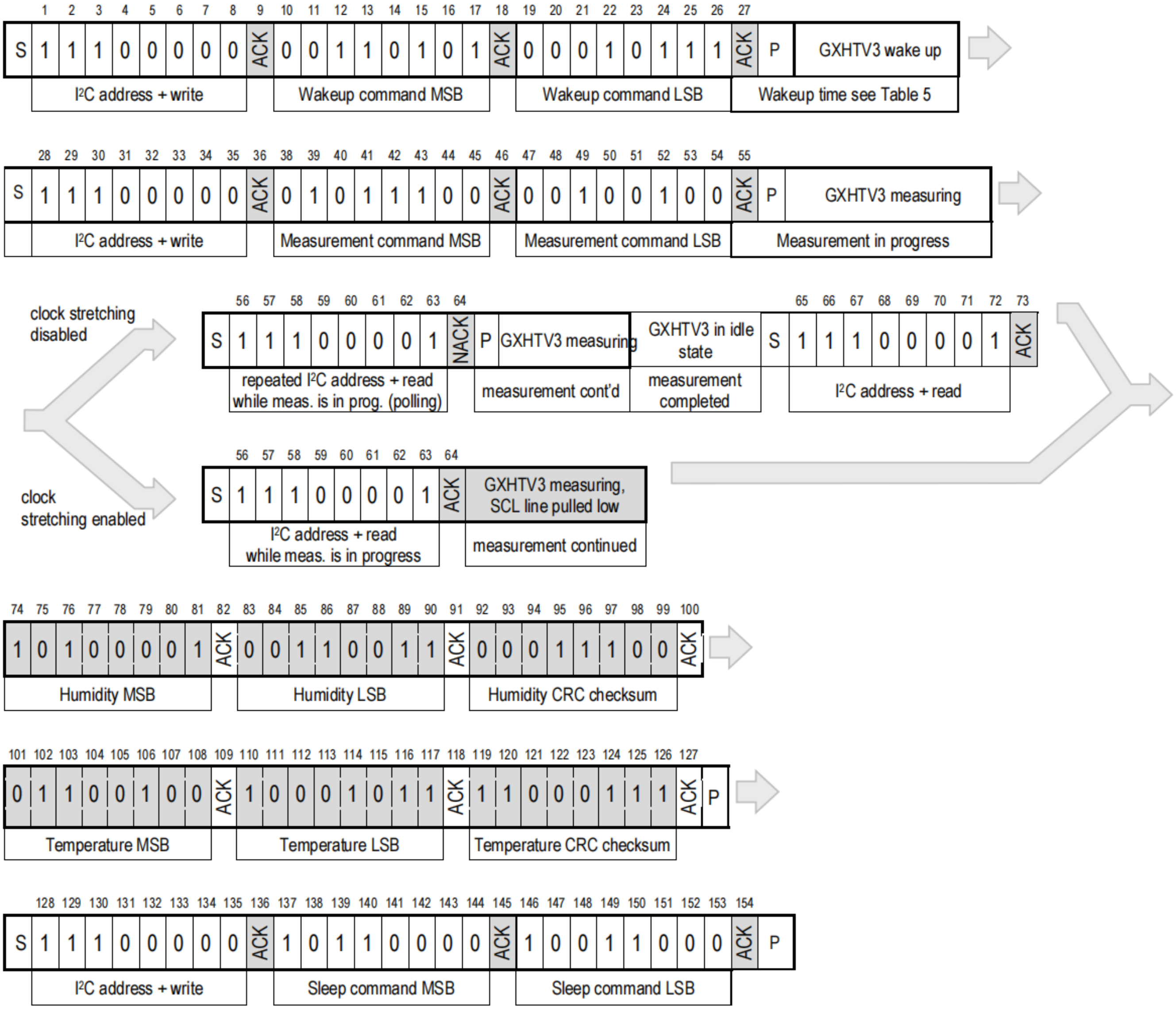


Figure 8. Wake-up, start temperature and humidity measurement, temperature and humidity conversion and sleep command execution sequence diagram.

NOTE: 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.

7.5 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.

7.6 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.

7.7 Soft Reset

The GXHTV3 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:

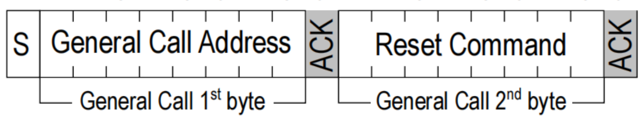
Table 12. Soft reset command.

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

7.8 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 GXHTV3, 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:

Table 13. General call reset command.

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

7.9 Readout of ID Register

The GXHTV3 has an ID register for storing the product code of GXHTV3. 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:

Table 14. Readout command of ID register.

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

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.

7.10 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.

Table 15. CRC check algorithm.

PROPERTY	VALUE
Name	CRC-8
Width	8 位
Polynomial	0x31($x^8+x^5+x^4+1$)
Initialization	0xFF
Reflect input	false
Reflect output	false
Example	CRC (0xBEEF) = 0x92

7.11 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):

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

Temperature Conversion Formula (°C):

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

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.

8 Quality Control

8.1 Environmental Stability

The qualification of the GXHTV3 is based on the JEDEC JESD47 qualification test method.

8.2 Material Contents

The GXHTV3 is fully RoHS, REACH and Halogen compliant, free of Pb, Cd and Hg.

9 Packaging Information

The GXHTV3 is packaged in a miniaturized DFN6 package with an outline size of 2×2×0.75 mm^3 and a pin pitch of 0.5mm. DFN stands for 2-sided no-lead form. The device is made of silicon wafers and fastened to the lead frame. The lead frame consists of copper and Ni/Pd/Au. The device and lead frame are molded by epoxy resin compound.

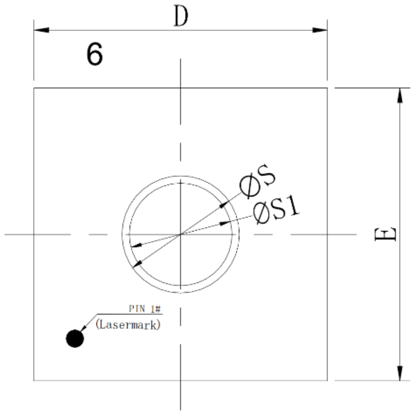
The device complies with the Small Outline Plastic Leadless Specification as described in 4.22 of JEDEC95 and in Small Outline (QFN/SON) Specification D.01.2009. The GXHTV3 complies with IPC/JEDEC J-STD-020 moisture sensitive Class 1 standards.

9.1 Product Traceability

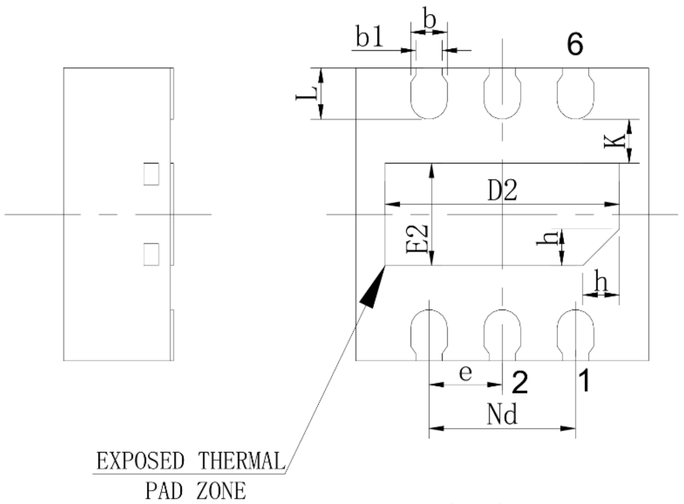
All GXHTV3 front faces are laser marked for identification and traceability. As shown in Figure 8, the upper left corner of the front of the sensor is the pin 1 mark and the sensor model mark. The bottom mark contains 7 characters. The first four ABCD characters represent the production date, AB represent year, CD present month. The latter X represents chip version. Batch mark decoding is 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 9. GXHTV3 front laser marking

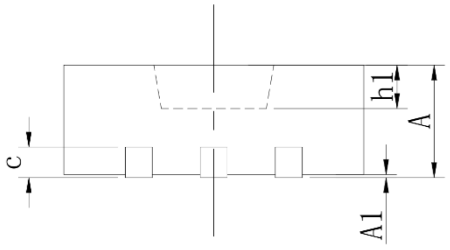
9.2 Technical Drawings



TOP VIEW



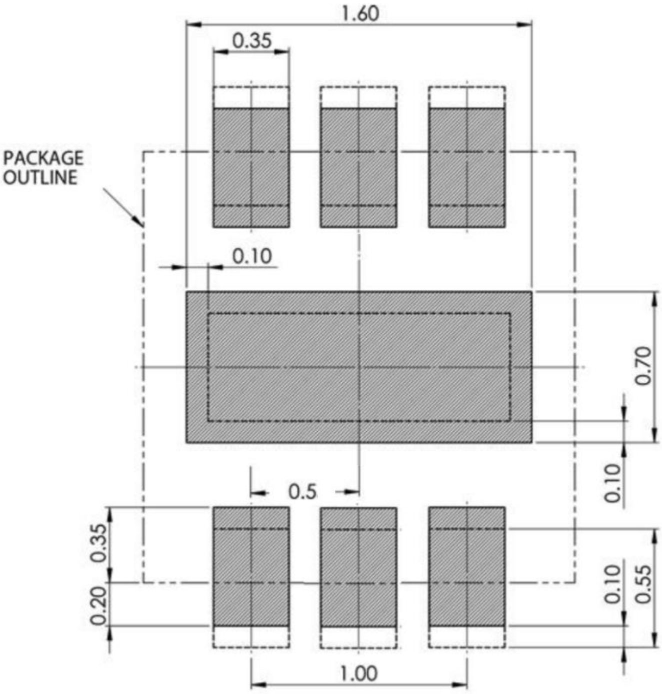
BOTTOM VIEW



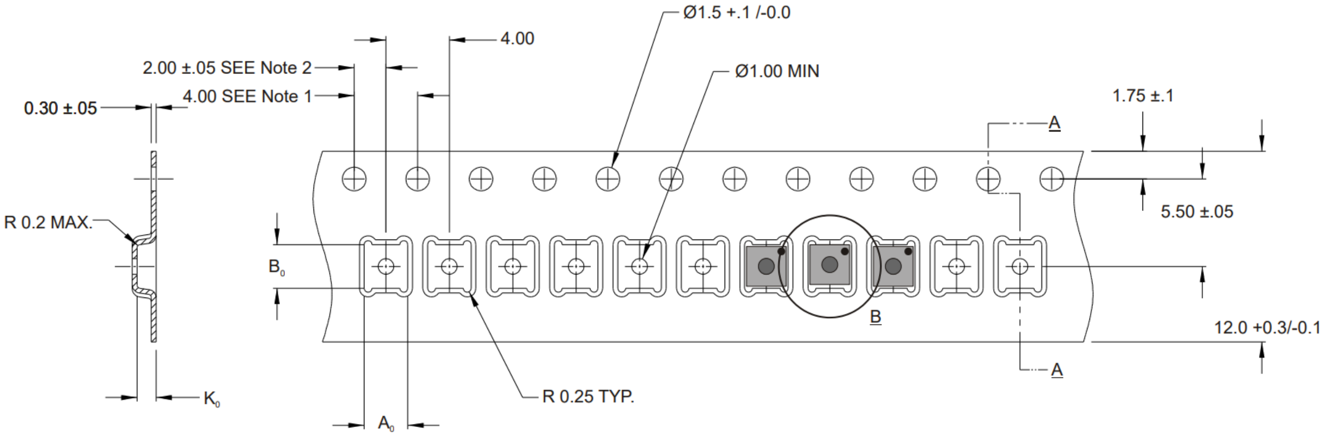
SIDE VIEW

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0. 70	0.75	0. 80
A1	0	0.02	0. 05
b	0. 20	0. 25	0. 30
b1	0.18REF		
c	0.203REF		
D	1. 90	2. 00	2. 10
D2	1. 50	1. 60	1. 70
Nd	1. 00BSC		
E	1. 90	2. 00	2. 10
E2	0. 60	0. 70	0. 80
e	0. 50BSC		
K	0. 30REF		
L	0. 30	0. 35	0. 40
h	0. 20	0. 25	0. 30
ØS	0. 80BSC		
ØS1	0. 70BSC		
h1	-	0. 29	-

9.3 Metal Land Pattern



9.4 Tape and Reel Package



A_0 = 2.75
B_0 = 2.75
K_0 = 1.20

10 Chip description and Ordering information

Order number description:

GXHTV3-T&R：GXHTV3 represents the product.number, T&R represents packaged form is tape and reel.

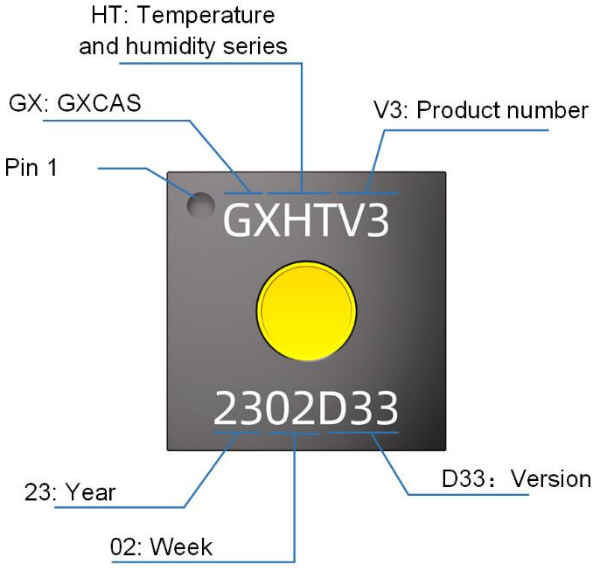
Model Coding：

（1）GXHTV3：GX represents the trademark of the company GXCAS, which can also be represented by G; HT represents temperature and humidity series products; V3: represents the chip number

（2）GXHTV3C：GX represents the trademark of the company GXCAS, which can also be represented by G; HT represents temperature and humidity series products; V3: represents the chip number; C: Indicates that the chip is covered with a dustproof and breathable film, which cannot be removed and provides protection for the chip.

（3）GXHTV3CF：GX represents the trademark of the company GXCAS, which can also be represented by G; HT represents temperature and humidity series products; V3: represents the chip number; CF: Indicates that the chip is coated with a conformal coating film, which needs to be removed after Painting

GXHTV3 LOGO description：



Ordering Information：

Purchase Number	Device	Package	SPQ	Note
GXHTV3-T&R	GXHTV3	DFN6 2mm*2mm	2000	Tape and reel
GXHTV3C-T&R	GXHTV3C	DFN6 2mm*2mm	2000	Tape and reel; covered with a dustproof breathable film
GXHTV3CF-T&R	GXHTV3CF	DFN6 2mm*2mm	2000	Tape and reel; covered with a conformal coating film

11 Important Notices

（1）ESD Precautions

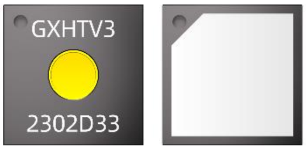
The inherent design of this part makes it very sensitive to electrostatic discharge (ESD). To prevent damage or degradation caused by electrostatic discharge, operate the sensor in an Electrostatic Protected Area (EPA) and take proper measures (operator should be grounded by wrist strap, and all non-insulated or conductive objects should be grounded).

（2）Exposure to Chemicals

The temperature and humidity sensors of Galaxy-CAS Technology are high-sensitivity environmental sensor, not ordinary electronic components. The sensors should not be in close contact with volatile chemicals, such as chemical solvents or organic compounds, especially high concentrations and prolonged exposure are more dangerous. (Ethyl)ketene, acetone, isopropanol, ethanol, toluene, etc., have been shown to cause a shift in humidity readings that is irreversible in most cases.

（3）Dustproof Breathable Film

The temperature and humidity sensors are different from the general sensor chips. The sensors are very sensitive, so their opening part are easily polluted by dust and impurities. For customers in outdoor applications, it is recommended to order our products with a dust-proof and breathable film, which can prevent dust. It can protect the sensor, resist pollution, improve the life and reliability of the sensor, and must not be torn off.



（4）Applications in Extreme Environments

Some applications require the temperature and humidity sensor to be exposed to harsh environments. In many cases, the suitability of the sensor is not considered. There are some situations that require special attention.

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

b) In some application environments, the sensor may be exposed to a high concentration of volatile organic solvents for a long time, which may occur in both the assembly process and the application process. Such applications require attention.

c) In some application environments, the sensor may be exposed to an acidic or alkaline environment, but only a certain concentration will cause harm to the sensor. For bases, pH > 9 will cause damage to the sensor. Etching materials, such as H2O2, NH3, etc., can also harm the sensor in high concentrations.

d) There may be corrosive gases in some application environments. If the concentration is relatively low, it will not affect the sensor, but it will affect the connection of the solder joints. Higher concentrations can also cause damage to the sensor.

（5）Spraying of Conformal Coating

The paint itself is contaminating to the temperature and humidity sensor. For customers who must spray the paint on the board, they need to order our products with a conformal coating film, after spraying the conformal coating, tear off the conformal coating film before normal testing of temperature and humidity. When spraying the conformal coating, keep at least thirty centimeters away from the sensor and move the can slowly to ensure an even coating, the surface will dry in about thirty minutes and the second spraying can be carried out. Allow the paint to dry fully, approximately 24 hours, then gently remove the film.

（6）Packaging and Storage

Before use, it is strongly recommended to store the sensor in its original packaging in the following environment: temperature 10 °C ~ 50 °C (0 °C - 125 °C for a limited time), 20% ~ 65% RH.

（7）Assemblage

The sensor can be stored for 1 year in normal storage environment, and the sensor has a moisture resistance level of 1.