MEMS type Temperature and Humidity Sensor

(Model: WHT20B)

Manual

Version: V1.1

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Zhengzhou Winsen Electronics Technology Co., Ltd

Statement

Thanks for purchasing our product. In order to let customers use it better and reduce the faults caused by misuse, please read the manual carefully and operate it correctly in accordance with the instructions. If users disobey the terms or remove, disassemble, change the components inside of the sensor, we shall not be responsible for the loss.

The specific such as color, appearance, sizes &etc, please in kind prevail.

We are devoting ourselves to products development and technical innovation, so we reserve the right to improve the products without notice. Please confirm it is the valid version before using this manual. At the same time, users' comments on optimized using way are welcome.

Please keep the manual properly, in order to get help if you have questions during the usage in the future.

Zhengzhou Winsen Electronics Technology CO., LTD

WHT20B MEMS type Temperature and Humidity Sensor

Overview

The WHT20B T/H sensor is embedded in a reflow friendly dual row flat pinless SMD package, where temperature and humidity signals can be read on different pins, with a base of 3.0 x 3.0 mm and a height of 1.0 mm. Sensor output calibrated digital signal, standard I2C format.

WHT20B temperature and humidity sensor, including a new design of ASIC dedicated chip built-in transistor Vbe temperature characteristics, to achieve high precision temperature detection; At the same time, a capacitive humidity chip is included, in which the change of dielectric constant of the hygroscopic material realizes the environmental humidity detection. And combined with the latest integrated circuit signal processing technology to form a dual chip solution. It has the advantages of small size, low power consumption, high reliability and good compatibility.

Features

High accuracy ±3.0% RH and ±0.5℃

Wide power supply voltage range, from 2.0V to 5.5V

SMD package suitable for reflow soldering

Quick response and strong anti-interference ability

Excellent long-term stability under high humidity condition

Application

Home appliance fields: home appliance, humidity control, HVAC, dehumidifiers, smart thermostats, and room monitors etc ;

Industrial fields: automobiles, testing equipment, and automatic control devices;

Other fields: data loggers, weather stations, medical and other related temperature and humidity detection devices.

Technical parameters of relative humidity Stable1. humidity characteristic

Parameter	Condition	Min	Typical	Max	Unit
Resolution	Typical		0.01		%RH
Accuracy error[1]	Typical		±3.0		%RH
	Max	See figure 1			%RH
Repeatability			±0.1		%RH
Hysteresis			±1.0		%RH
Non-linear			<0.1		%RH
Response time[2]	$t_{63\%}$		<8		s
Scope of work	extended[3]	0		100	%RH
Prolonged Drift[4]	Normal		<0.5		%RH/yr

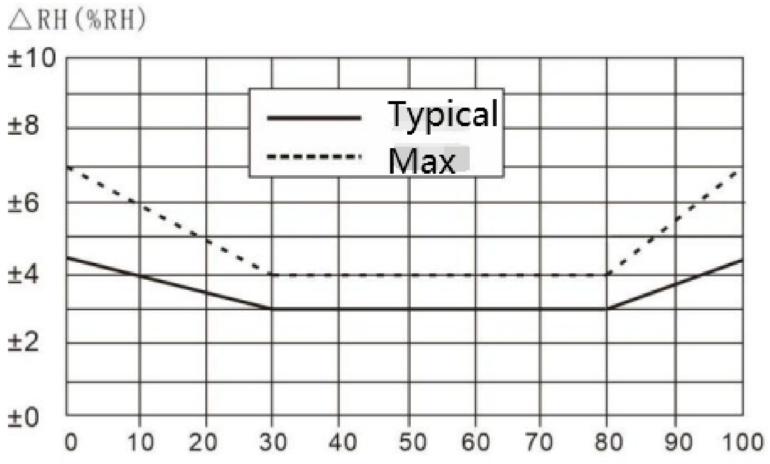


Figure 1 Maximum error of relative humidity at 25°C

Technical parameters of temperature Stable2. Temperature characteristic

Parameter	Condition	Min	Typical	Max	Unit
Resolution	Typical		0.01		°C
Accuracy error	Typical		±0.5		°C
	Max	See figure 2			°C
Repeatability			±0.1		°C
Hysteresis			±0.1		°C
Response time[5]	$t_{63\%}$	5		30	s
Scope of work	Extended[3]	-40		85	°C
Prolonged Drift			<0.04		°C/yr

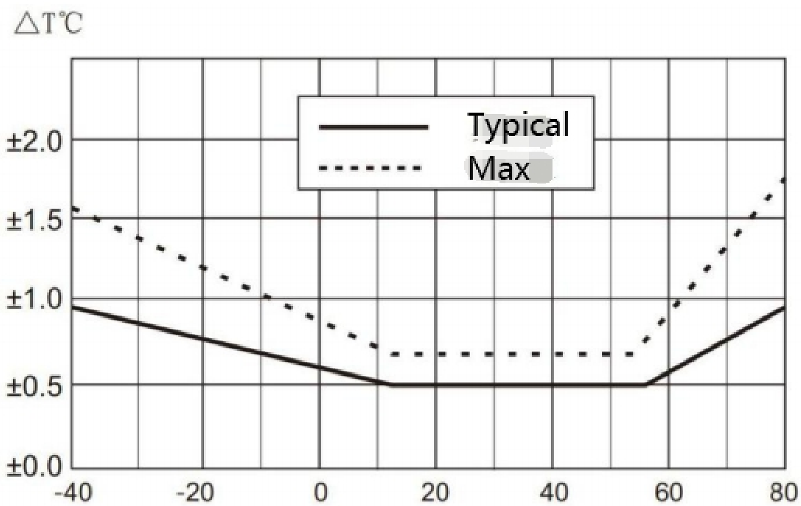


Figure 2 Temperature typical error and maximum error

Suggested working environment

The recommended temperature and humidity range of this sensor is 5~60℃ and 20~80% RH, as shown in Figure 3.

Long-term exposure in the non-recommended range, such as high humidity, may cause temporary signal drift (for example, >80%RH, drift +3% RH after 60 hours). After returning to the recommended range environment, the sensor will gradually return to the calibration state. Long-term exposure to the non-recommended range may accelerate the aging of the product.

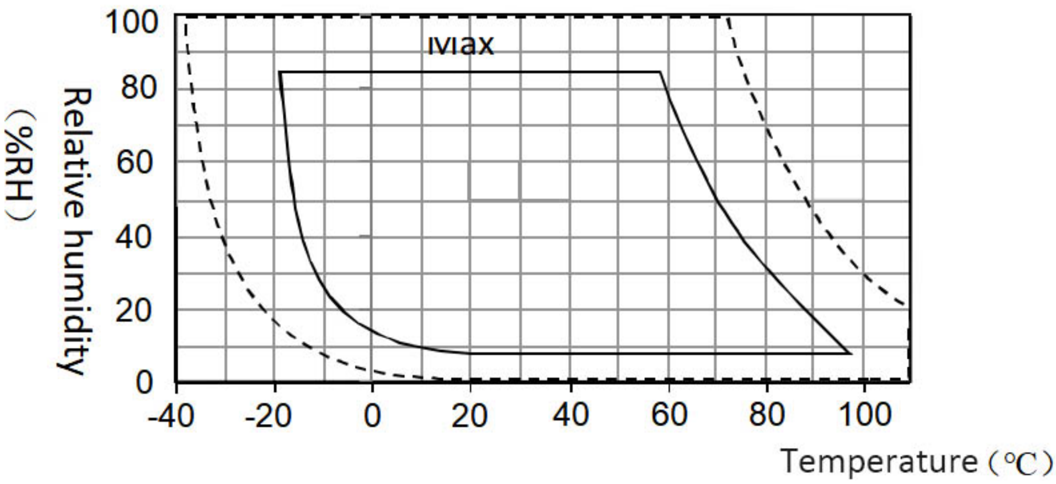


Figure 3 Working scope

RH accuracy at different temperatures

Figure 4 shows the maximum humidity error for other temperature ranges.

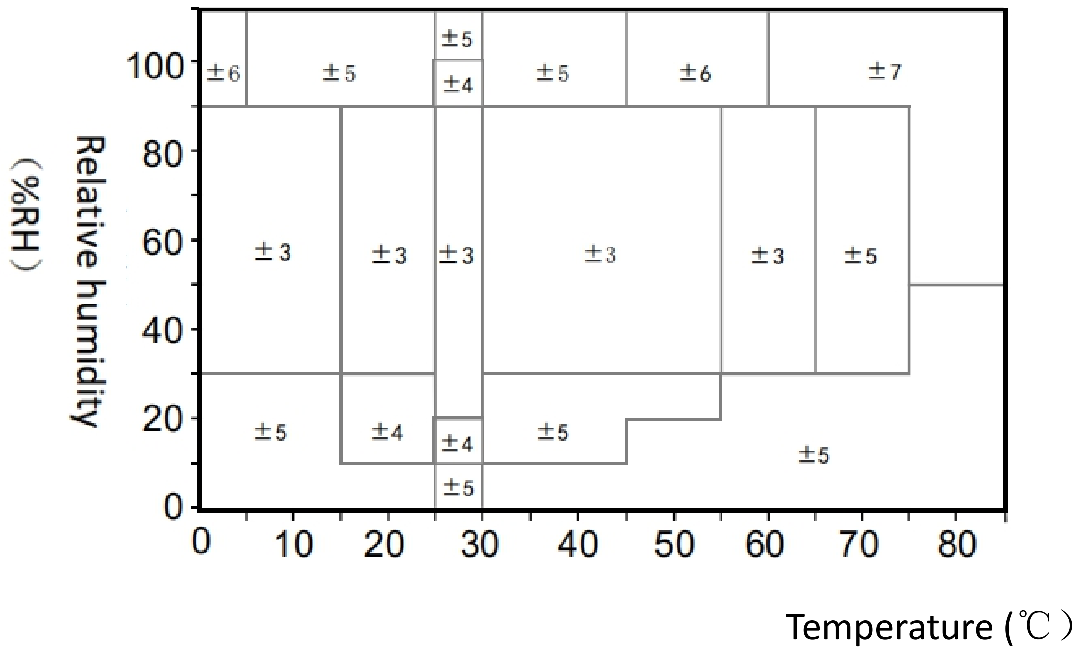


Figure 4 The maximum error of the corresponding humidity in the range of 0-80℃

Electrical specifications (Table 3)

Parameter	Condition	Min	Typical	Max	Unit
Voltage	Typical	2.0	3.3	5.5	V
Current, IDD[6]	Dormant	-		240	nA
	Measure		340		µA
Power consumption[6]	Dormant	-		0.8	µW
	Measure		0.07		mW
	Average	-	3.3	-	µW
Communication	Dual-line digital interface, standard I^2C protocol				

The power consumption given in Table 3 is related to temperature and supply voltage VDD. See Figures 5 and 6 for power consumption estimates. Please note that the curves in Figures 5 and 6 are typical natural characteristics, and there may be deviations.

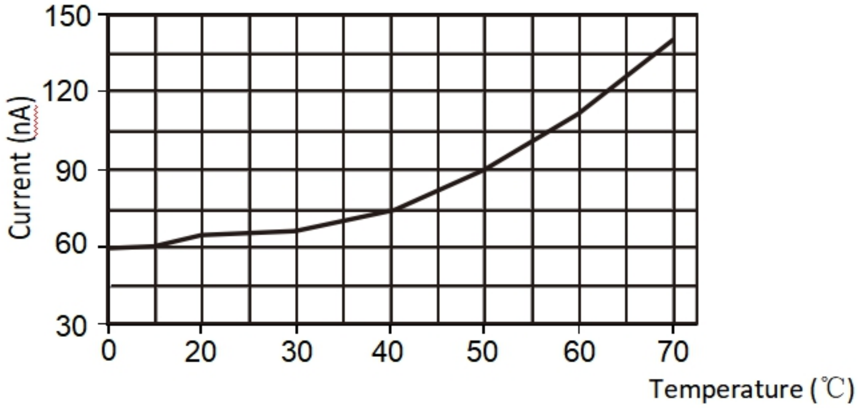
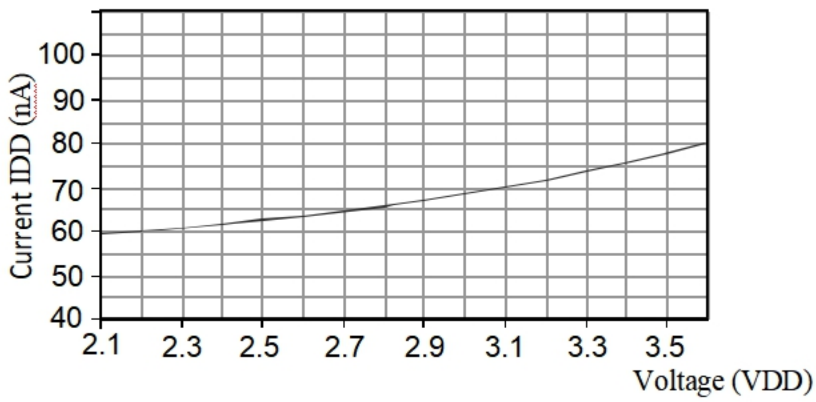


Fig. 5 Typical supply current vs. temperature curve (sleep mode) when VDD=3.3V. There is a deviation of approximately ±25% between these data and the displayed value.



Figures 6 Typical supply current vs. supply voltage curve (sleep mode) at a temperature of 25 ℃. Note: The deviation between these data and the displayed value may reach ±50% of the displayed value. At 60 ℃, the coefficient is approximately 15 (compared to Table 3).

Package information

Part no.	Package	Quantity
WHT 20B	Tape package	5000PCS/Roll (MAX)

Note: 1. This accuracy is the test accuracy of the sensor at 25℃ and the supply voltage is 3.3V during the factory inspection.

2. The time required to reach 63% response under the conditions of 25°C and 1m/s airflow.

3. Normal working range: 0-80%RH, beyond this range, the sensor reading will be biased (after 200 hours under 90%RH humidity, drift <3%RH). The working range is limited to -40-80℃.

4. If there are volatile solvents, tapes with pungent odors, adhesives and packaging materials around the sensor, the readings may get higher and speed up the drifting.

5. The response time depends on the thermal conductivity of the sensor substrate.

6. The minimum and maximum values of supply current and power consumption are based on the conditions of VDD = 3.3 V and T <60°C.

Application Guide

1.1 Storage Conditions

The temperature and humidity sensor should not be exposed to volatile chemicals, such as organic solvents or other inorganic compounds, otherwise it will cause irreversible drift in humidity output readings. Therefore, it is recommended that sensors sealed in ESD pockets be stored under the following conditions: temperature range 10-50℃(0-85℃ in limited time); The humidity is 20-60%RH(without ESD encapsulated sensors). For those sensors that have been removed from the original packaging, we recommend storing them in an anti-static bag made of PET/AL/CPE containing metal.

1.2 Recovery Processing

The readings can drift if the sensor is exposed to extreme operating conditions or chemical vapors. It can be restored to the calibration state by the following processing. (1) Drying: Keep it at 80-85 ℃ and <5% RH humidity for 10 hours; (2) Re-hydration: Keep it at 20-30 ℃ and >75% RH humidity for 24 hours.

1.3 Temperature Effect

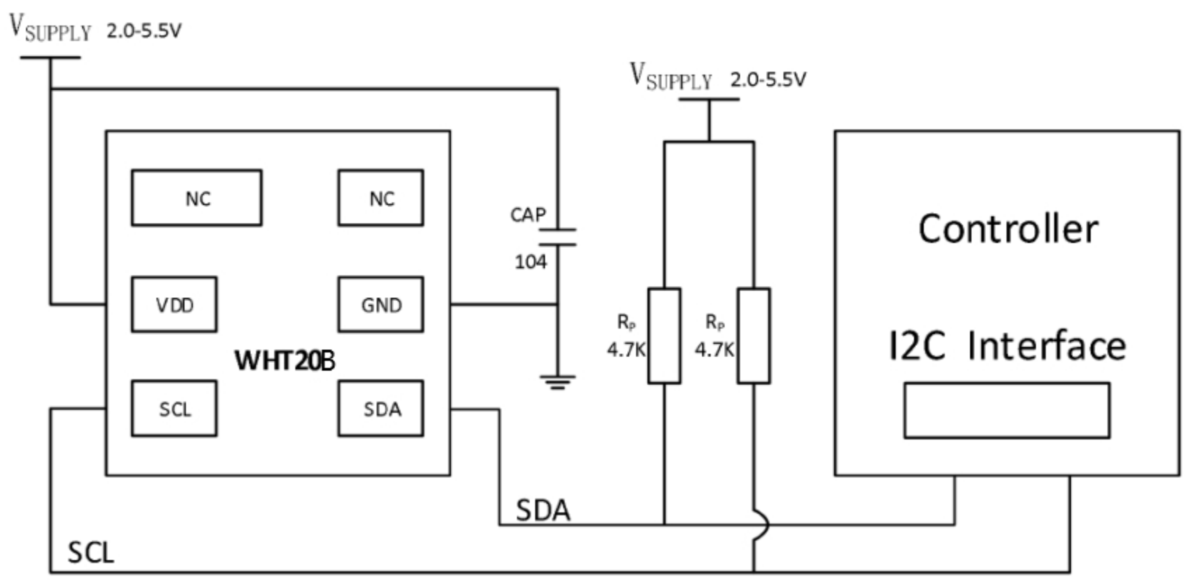
Temperature affects the relative humidity of the environment. Therefore, in the process of measuring humidity, the temperature of all sensors should be consistent. Secondly, during the test, the temperature of the tested sensor should be consistent with the temperature of the reference sensor.

On the same printed circuit board, to minimize the influence of heat transfer, the sensor should be isolated from electronic components that are prone to heat as much as possible.

High measurement frequency will also affect the measurement accuracy, because the temperature of the sensor itself will increase as the measurement frequency increases. To ensure that its own temperature rise is below 0.1°C, the activation time of WHT20B should not exceed 10% of the measurement time. It is recommended to measure the data every 2 seconds.

1.4 Typical application circuit

In order to improve the stability of the system, the following power supply controllable scheme is provided:



1.5 Materials for Sealing and Encapsulation

To avoid the response time and hysteresis increase caused by the moisture absorption of the surrounding materials, the following materials are recommended: metal materials, LCP, POM (Delrin), PEEK, PVDF, PTFE (Teflon), PP, PB, PPS, PSU , PE, PVF.

It is recommended to use epoxy resin to encapsulate electronic components, or silicone resin. However, the gas released by the packaging material may also contaminate WHT20B sensor. Therefore, the final assembly of the sensor should be done in a well-ventilated place, and the contaminated gas can also be released before packaging.

1.6 Wiring rules

To avoid signal crosstalk and communication failure caused by wiring, do not place SCL and SDA signal lines in parallel or very close to each other. The solution is to place VDD and/or GND between the SCL and SDA signal lines, or use shielded cables.

1.7 Signal integrity

Reducing SCL frequency may also improve the integrity of signal transmission. A 100nF decoupling capacitor should be added between the power supply pins (VDD, GND) for filtering.

1.8 Device function mode

WHT20B has two operating modes: sleep mode and measurement mode. After power-on, WHT20B enters dormancy mode. In this mode, WHT20B waits for the I2C input configuration conversion time, reads the battery status, triggers the measurement, and reads the measured value. After completing the measurement, WHT20B returns to sleep mode.

1.9 Welding instructions

SMD I/O pads are made of copper lead frame plane substrates, except these pads are exposed and are used for mechanical and circuit connections. For use, both I/O pads and bare pads need to be soldered to the PCB. To prevent oxidation and optimize welding, the solder joints at the bottom of the sensor are coated with Ni/Au.

On the PCB, the length of the I/O contact surface should be 0.2-0.3mm larger than the sensor's I/O sealing pad, and the width should be 0.1-0.2mm larger than the sealing pad. The part near the inner side should match the shape of the I/O pad, and the ratio of the pin width to the SMD sealing pad width should be 1:1, as shown in Figure 8.

For mesh and solder layer designs, it is recommended to use copper foil defined pads (SMD) with openings in the solder layer larger than the metal pads. For SMD pads, if the gap between the copper foil pads and the solder resistance layer is 60μm-75μm, the size of the solder resistance layer opening should be greater than the size of the pad 120μm-150μm. The square portion of the sealing pad shall match the corresponding square solder mask opening to ensure that there is sufficient solder mask area (especially at the corners) to prevent solder intersecting. Each pad shall have its own solder layer opening to form a network of solder layers around adjacent pads.

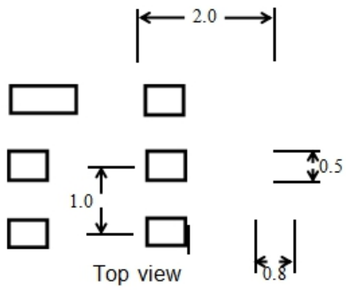


Figure 8: Recommend WHT20B PCB design size (unit: mm)

For solder printing, laser cutting stainless steel mesh with electronic polishing trapezoidal wall is recommended, with recommended thickness of 0.125 mm. The steel mesh size of the pad should be 0.1 mm longer than PCB pad and placed 0.1 mm away from the packaging center. Steel mesh with bare pads must cover 70% - 90% of the pad area - that is, the central position of the heat dissipation area reaches 1.4 mm x 2.3 mm.

Due to the low SMD mounting, it is recommended to use no-cleaning type3 solders tin and to purify it with nitrogen during reflux.

Sensor can be welded through standard reflow furnace. The sensor fully meets the IPC/JEDECJ-STD-020D welding standard. The best temperature for reflow soldering is lower than 200 ℃,the ultimate welding temperature that the sensor can withstand is 260℃, and the contact time should be less than 30 seconds at the highest 260℃ (see Fig. 9). It is recommended to use low temperature 180℃ when reflow soldering.

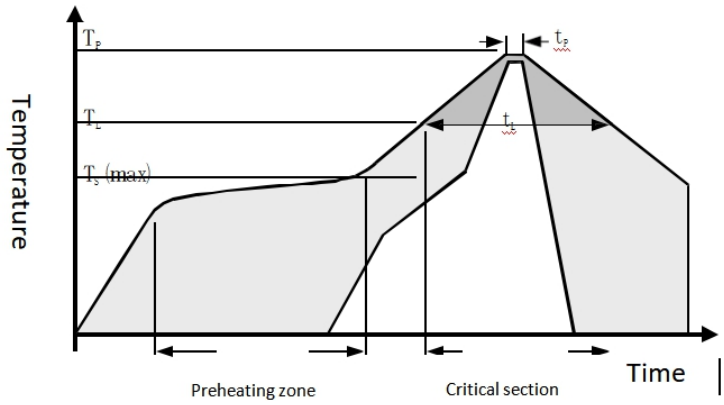


Figure 9: JEDEC standard welding process diagram, Tp<=260 ℃, tp<30 sec, lead-free soldering. TL<220 ℃, tl<150 sec, the temperature rise and fall speed during welding should be <5 ℃ /sec.

Note: After reflow soldering, the sensor should be stored in an environment of >75% RH for at least 24 hours to ensure the rehydration of the polymer. Otherwise, it will lead to sensor reading drift. The sensor can also be placed in a natural environment (>40% RH) for more than 5 days to rehydrate it. Using low temperature reflow soldering (for example: 180 ℃) can reduce the hydration time.

It is not allowed to rinse the circuit board after soldering. Therefore, it is recommended to use "no-clean" solder paste. If the sensor is used in corrosive gas or condensed water is generated (such as: high humidity environment), both the pin pad and PCB need to be sealed (such as: use form coating) to avoid poor contact or short circuit.

Interface Definition

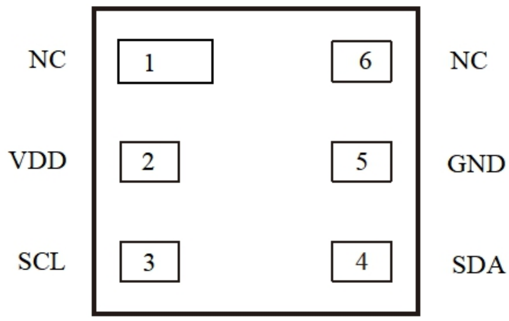


Table 4 WHT20B pin distribution

PIN	Name	Definition
NC	1	Remain suspended
VDD	2	Power supply voltage, 2.0~5.5V power supply, recommended voltage of 3.3V
SCL	3	I^2C serial clock, two-way, for Synchronous Communications between the microprocessor and sensor
SDA	4	I^2C serial data, two-way, for data input and output of the sensor
GND	5	Power ground
NC	6	Remain suspended

Note:

1. To prevent the current from being poured into the signal line (SCL/SDA) by the leakage current, which may lead the chip in a non-working state after power-on, VDD should be powered on prior to or synchronized with SDA and SCL.
2. To ensure communication safety, the effective time of SDA should be extended to T_{SU} and T_{HD} before and after the rising edge of SCL (refer to Figure 10).

Electrical Characteristics

Absolute Maximum Ratings

The absolute maximum ratings of WHT20B are shown in Table 5. In addition, Table 5 also provides information such as pin input current. If the test condition exceeds the nominal limit index, the sensor needs to add an additional protection circuit.

Table 5 Electrical absolute maximum ratings

Parameter	Min	Max	Unit
VDD to GND	-0.3	5.5	V
Digital I/O Pins (SDA,SCL) to GND	-0.3	VDD+0.3	V
Input current per pin	-10	10	mA

Note: Long-term exposure to absolute maximum ratings may affect the reliability of the sensor.

I2C interface voltage

Electrical characteristics, such as power consumption, high and low voltages of input and output, etc., depend on the power supply voltage.

Table 6 DC characteristics of digital input and output pads, if there is no special statement, VDD=2.0 V to 5.5 V, T =-40 ℃ to 85℃

Parameter		Condition	Min	Typ.	Max	Unit
Low output voltage	VOL	VDD = 3.3 V Reverse current 3mA	0	-	0.4	V
High output voltage	VOH		0.7VDD	-	VDD	V

Output sink current	IOL		-	-	-4	mA
Low input voltage	VIL		0	-	0.3VDD	V
High input voltage	VIH		0.7VDD	-	VDD	V
Input current		VDD = 5.5 V,VIN = 0 V to 5.5 V	-	-	±1	uA

I2C interface timing

Table 7 Timing characteristics of I^2C fast mode digital input/output terminals

Parameter		I^2C Standard Mode		I^2C Fast Mode		Unit
		MIN	MAX	MIN	MAX	
SCL frequency	f_{SCL}	0	100	0	400	KHz
SCL low level time	t_{Low}	4.7	-	1.3	-	µs
SCL high level time	t_{High}	4.0	-	0.6	-	µs
The persistent time of SCL high level after SDA pulls down when starting/restarting	$T_{HD;STA}$	4.0	-	0.6	-	µs
The interval time from SCL pull down to SDA data changing	$T_{HD;DAT}$	5.0	-	-	-	µs
The interval time from SDA data stabilizes to SCL pulls up	$T_{SU;DAT}$	250	-	100 (2)	-	µs
The persistent time of SCL high level before SDA pulls down when restarting	$T_{SU;STA}$	4.7	-	0.6	-	µs
The interval time from SCL pulls up to SCL pulls up when stopping	$T_{SU;STO}$	4.0	-	0.6	-	µs
The interval time from starting to stopping	T_{BUF}	4.7	-	1.3	-	µs
Time required for SCL/SDA to rising edge	tr	-	1000	$20+0.1C_b$ (3)		ns
Time required for SCL/SDA to falling edge	tr	2.5	300	$20+0.1C_b$ (3)		ns

Note:

1) All values are based on VIHmin and VILmax.

2) Fast device mode I^2C devices can operate in standard mode, but must meet tSU;DAT=250ns required.

3) Cb= Total capacitance of the I^2C

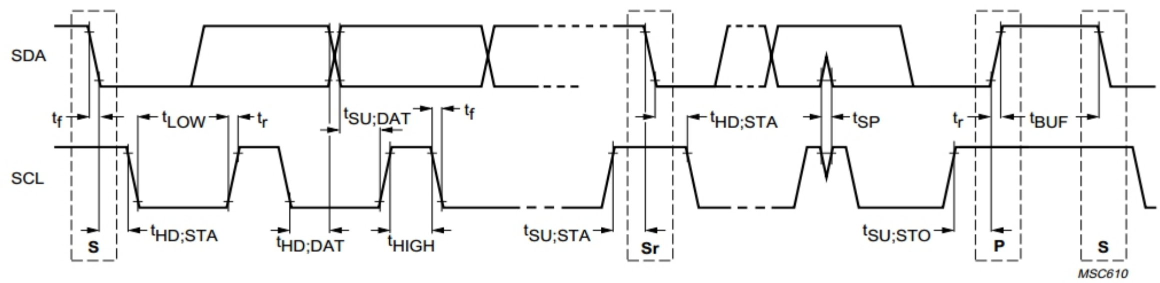


Figure 10 IIC Sequence parameters

Sensor Communication

The WHT20B supports I^2 C fast mode (up to 400 kHz). Clock stretching can be enabled and disabled by appropriate user commands.

Start/Stop Sequence

After the sensor is powered on, it takes 2ms for the sensor to enter the idle state. Once idle, commands can be received from the master device (microcontroller). Each transmission sequence begins with the START condition (S) and ends with the STOP condition (P), as described in the I^2 C bus specification. Whenever the sensor is energized, but no measurement or communication is performed, it automatically goes to idle to save energy. The idle state cannot be controlled by the user.

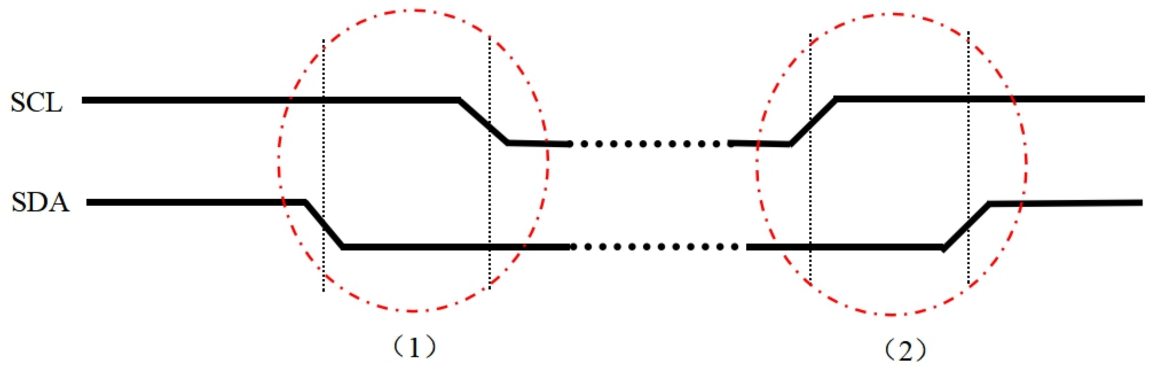


Figure 11 Start transmission state (S) and stop transmission state (P)

Start measuring

The measurement communication sequence consists of the START condition, I^2 C write head (7-bit I^2 C device address plus 0 as write bit) and 16-bit measurement command. The sensor reply indicates the correct reception of each byte. It pulls the SDA pin down (ACK bit) after the falling edge of the eighth SCL clock to indicate reception. By confirming the measurement command, the sensor begins to measure the temperature and humidity. In addition, the measurement repeatability and single/continuous measurement mode are set by the corresponding control bit of the configuration register.

Configuration register (address: 0x06) Table 8 Details of configuration registers

Reset value	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0X00	Reserved	Reserved	Clk_stretch	Mps2	Mps1	Mps0	Repeatbility1	Repeatbility0
Description	The value is reserved and cannot be changed.		IIC Interface clock Stretch enable: 0: Stretch is not allowed 1: Stretch allowed	Periodic measurement frequency configuration MPS (Note 1) 000: single time 001: 0.5 times/second 010: 1 time/second 011: 2 times/second 100: 4 times/second 101: 10 times/second			Repetitive setting: (Note 2) 00: Low repeatability 01: Medium repeatability 10: High repeatability	

Note 1: The default periodic measurement configuration is single measurement, and the measurement frequency can be configured as required. The fastest time for low repeatability is about 133 times/s, the fastest time for medium repeatability is about 111 times/s, and the fastest time for high repeatability is about 70 times/s.
Note 2: Repeatability and conversion time are directly tradeoffs. The higher the repeatability, the longer the conversion time; The lower the repeatability, the shorter the conversion time.

Sensor reading process

1. Wait 20 ms after power-off. Before measuring temperature and humidity, users can configure repeatability, cycle measurement frequency and clock stretch by setting configuration register command. Send 0x5206 (Set configuration register). This command has three bytes, the first byte is the value of the configuration register to be set, the second byte is 0xFF, and the third byte is the CRC check of the first two bytes;
2. Send 0x2C10 (trigger measurement). After this command is sent, the sensor starts to measure the temperature and humidity.
3. Wait 20ms to complete the measurement, and directly read 6 bytes of temperature and humidity data (send 0x8B to read).
4. Send 0xD208 (Read bytes with Low Humidity Intercept) to request reading the data with low humidity intercept. Then send 0x89 to read the data with low humidity intercept directly.
5. Send 0xD209 (Read the High bytes of Humidity Intercept) to request reading the data with high bytes of humidity intercept. Then send 0x89 to read the data with high bytes of humidity intercept directly.
6. Calculate the temperature and humidity value.

Note: The operation of setting the configuration register in the first step only needs to be configured once after power-up, and there is no need to repeat the configuration during normal acquisition.

Set the configuration register

Start	IICaddress+write								ACK	Write register 0x52								ACK	Register address 0x06								ACK	Set value								ACK
S	1	0	0	0	1	0	1	0		0	1	0	1	0	0	1	0		0	0	0	0	0	1	1	0		x	x	x	x	x	x	x	x	

0xFF								ACK	CRC Data								ACK	Stop
1	1	1	1	1	1	1	1		x	x	x	x	x	x	x	x		P

Trigger measurement data

Start	IIC address+write								ACK	Trigger measurement 0x2C								ACK	Trigger measurement 0x10								ACK	Stop
S	1	0	0	0	1	0	1	0		0	0	1	0	1	1	0	0		0	0	0	1	0	0	0	0		P

Reading temperature and humidity data

Start	I2C address+read	ACK	Temperature low byte	ACK	Temperature high byte	ACK	CRC value	ACK
S	1 0 0 0 1 0 1 1		X X X X X X X X		X X X X X X X X		X X X X X X X X	

Temperature low byte	ACK	Temperature high byte	ACK	CRC data	NAK	Stop
X X X X X X X X		X X X X X X X X		X X X X X X X X		P

Read the humidity intercept data

Start	IIC address+write	ACK	Read register 0xD2	ACK	Register address 0x08	ACK	Start	IIC address+read	ACK
S	1 0 0 0 1 0 1 0		1 1 0 1 0 0 1 0		0 0 0 0 1 0 0 0		S	1 0 0 0 1 0 1 1	

Humidity intercept low byte BRH_L	ACK	0xFF	ACK	CRC Check	NAK	Stop
1 0 0 0 1 0 1 0		1 1 1 1 1 1 1 1		x x x x x x x x		P

Start	IIC address+write	ACK	Read register 0xD2	ACK	Register address 0x09	ACK	Start	IIC address+read	ACK
S	1 0 0 0 1 0 1 0		1 1 0 1 0 0 1 0		0 0 0 0 1 0 0 1		S	1 0 0 0 1 0 1 1	

Humidity intercept high byte BRH_H	ACK	0xFF	ACK	CRC Check	NAK	Stop
1 0 0 0 1 0 1 0		1 1 1 1 1 1 1 1		x x x x x x x x		P

Table 9 Sensor program command description

	Slave to host machine
ACK	ACK from slave
ACK	ACK from host
NAK	NAK from host
S	Start
P	Stop

Signal conversion

Relative humidity conversion

Relative humidity RH can be calculated according to the relative humidity signal S_{RH} and intercept signal B_{RH} output by SDA through the following formula (the result is expressed as % RH).

$$\mathbf{RH[\%]} = \frac{S_{RH}}{2^{16}-1} * \mathbf{100} + \frac{B_{RH}}{2^{16}-1} * \mathbf{100}$$

Temperature conversion

The temperature T can be calculated by substituting the temperature output signal ST into the following formula (the result is expressed in temperature ℃).

$$\mathbf{T}\left[{}^{o}C\right] = \mathbf{40} + \frac{S_T}{\mathbf{256}}$$

Environmental stability

When the sensor is used in equipment or machinery, the sensor must be placed at the same temperature and humidity as the sensor used for reference. In order to prevent the error caused by insufficient test time, the sensor should be programmed to ensure adequate measurement time when placed in equipment or machinery.

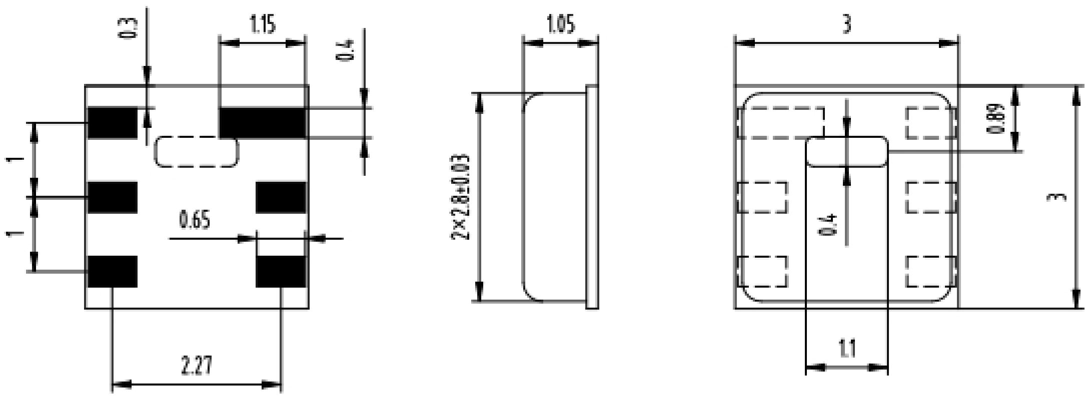


Fig 12 WHT20B Sensor package (Unit: mm Tolerance: ± 0.1mm)

The WHT20B is packaged with roll tape and sealed in an antistatic ESD bag. The standard package size is 5000 pieces per roll. For the WHT20B package, the rear 400 mm (50 sensor capacity) and the first 200 mm (25 sensor capacity) sections are empty packages per reel.

The package diagram with sensor positioning is shown in Figure 13. The reel is placed in an antistatic pocket.

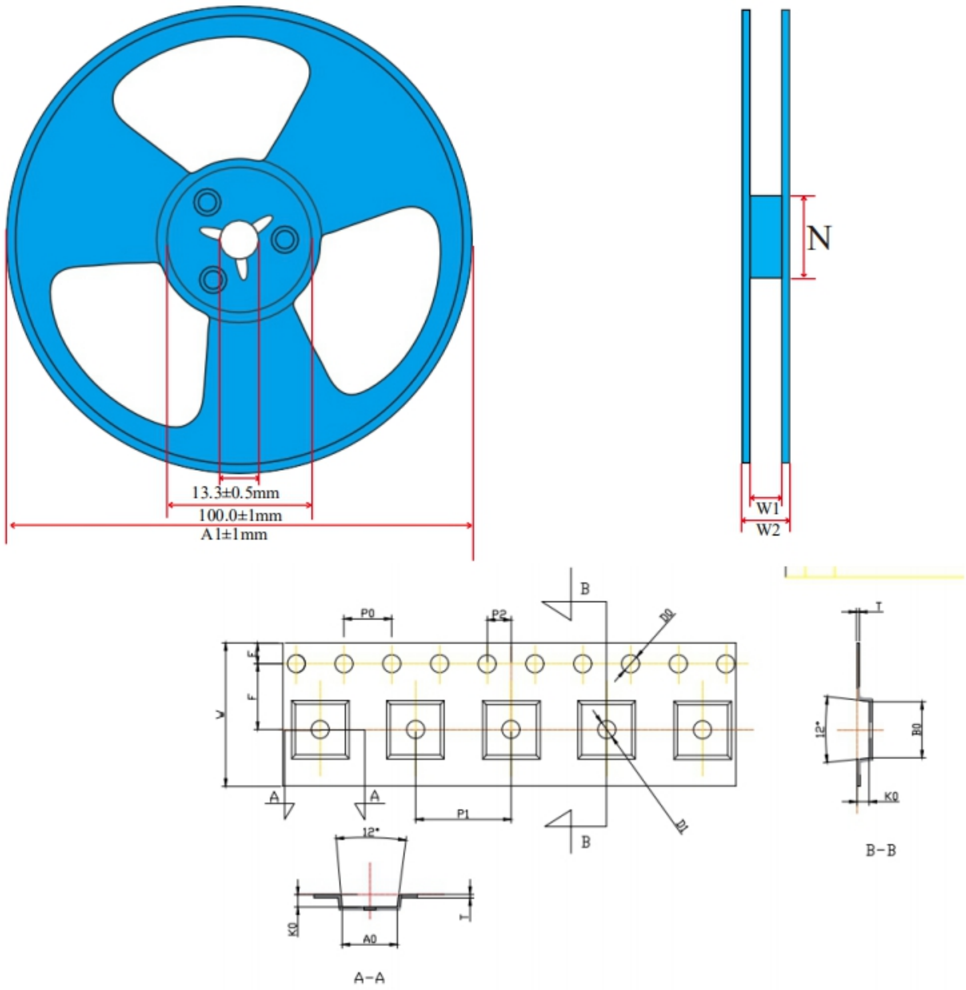


Figure 13 Packing tape and sensor location

Model	A1	E	W1	W2	N
Scroll	330	2	12.5	16.7	100

Model	Unit	Tolerance	Quantity	Weight
Scroll	mm	±0.5	5000(AMX)	500/g

Model	A0	B0	K0	P0	P1	P2
Tape	3.23±0.1	3.23±0.1	1.05±0.1	4±0.1	8±0.1	2±0.1

Model	W	T	F	E	D0	D1
Tape	12±0.3	0.2±0.05	5.5±0.1	1.75±0.1	Φ15±0.05	Φ15±0.05

Tracking information

All WHT20B sensors have laser markings on the surface. See Figure 14.

There are labels on the reels, as shown in Figure 15, and other tracking information is provided.

Figure 14 Sensor laser marking

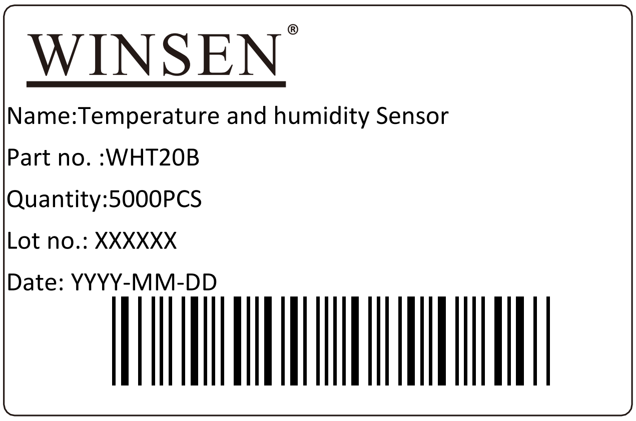


Figure 15 The label on the reel

Important notice

Warning, Personal Injury

Do not apply this product to safety protection devices or emergency stop equipment, and any other applications that may cause personal injury due to the product's failure. Do not use this product unless there is a special purpose or use authorization. Refer to the product data sheet and application guide before installing, handling, using or maintaining the product. Failure to follow this recommendation may result in death and serious personal injury.

ESD Protection

Due to the inherent design of the component, it is sensitive to static electricity. In order to prevent the damage caused by static electricity or reduce the performance of the product, please take necessary anti-static measures when using this product.

Quality Assurance

The company provides a 12-month (1 year) quality guarantee (calculated from the date of shipment) to direct purchasers of its products, based on the technical specifications in the product data manual published by Winsen. If the product is proved to be defective during the warranty period, the company will provide free repair or replacement. Users need to satisfy the following conditions:

1. Notify our company in writing within 14 days after the defect is found.
2. The defect of this product will help to find out the deficiency in design, material and technology of our product.
3. The product should be sent back to our company at the buyer’s expense.
4. The product should be within the warranty period.

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