MEMS type Temperature and Humidity Sensor

(Model: WHT20)

Manual

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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

WHT20 MEMS type Temperature and Humidity Sensor

Overview

WHT20 is embedded in a dual-row flat no-lead SMD package, which is suitable for reflow soldering, with 3.0x3.0mm bottom surface and 1.0mm height. The temperature and humidity signals can be read on different pins. The sensor outputs calibrated digital signals in standard IIC format.

WHT 20 is equipped with an ASIC chip, a MEMS capacitive humidity sensor and a temperature sensor. WHT 20 temperature and humidity sensors have been calibrated and tested on factory, and have excellent reliability and long-term stability.

Features

Fully calibrated
±2.0% RH and ±0.3℃ Accuracy
Wide power supply voltage range, from 2.0V to 5.5V
SMD package suitable for reflow soldering
Temperature and humidity parallel measurement on different pins
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 etcs;
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

Parameter	Condition	Min	Typical	Max	Unit
Resolution	Typical		0.01		%RH
Accuracy error[1]	Typical		±2.0		%RH
	Max	See figure 2			%RH
Repeatable			±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

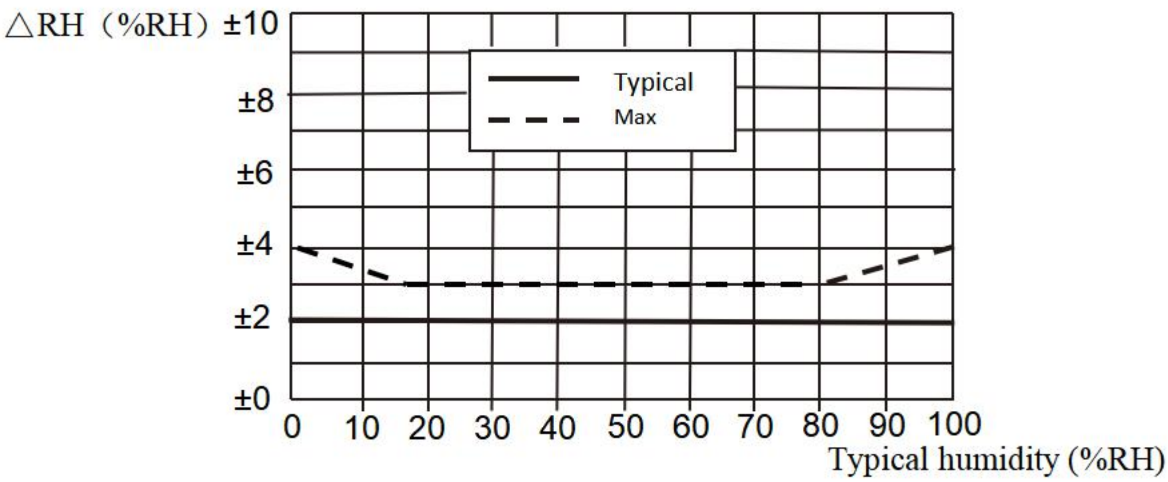


Figure 1 Maximum error of relative humidity at 25°C

Technical parameters of temperature

Parameter	Condition	Min	Typical	Max	Unit
Resolution	Typical		0.01		°C
Accuracy error[1]	Typical		±0.3		°C
	Max	See figure 2			°C
Repeatable			±0.1		°C
Hysteresis			±0.1		°C
Response time[6]	$t_{63\%}$	5		30	s
Scope of work	extended[3]	-40		80	°C
Prolonged Drift[4]			<0.04		°C/yr

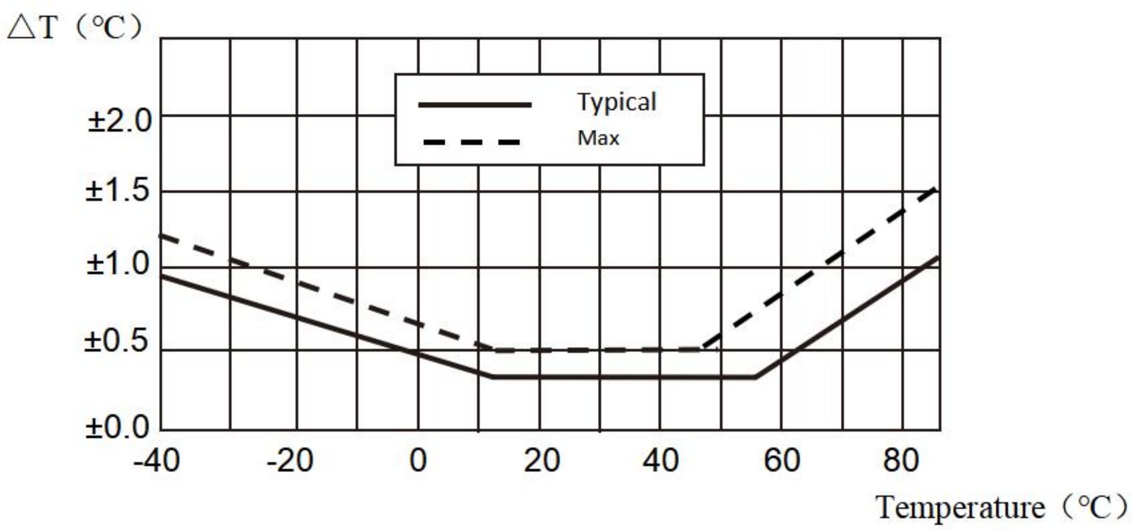


Figure 2 Temperature typical error and maximum error

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.

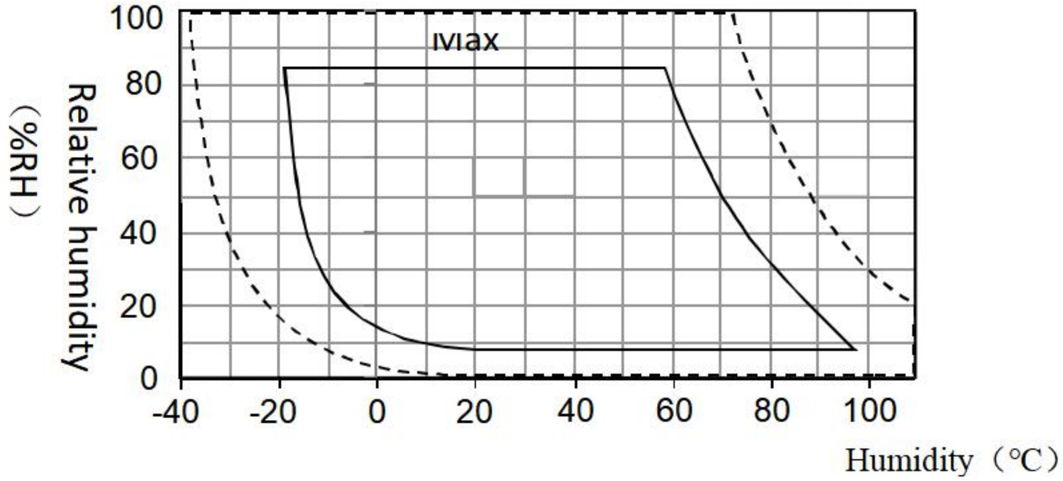


Figure 3 Working scope

RH accuracy at different temperatures

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

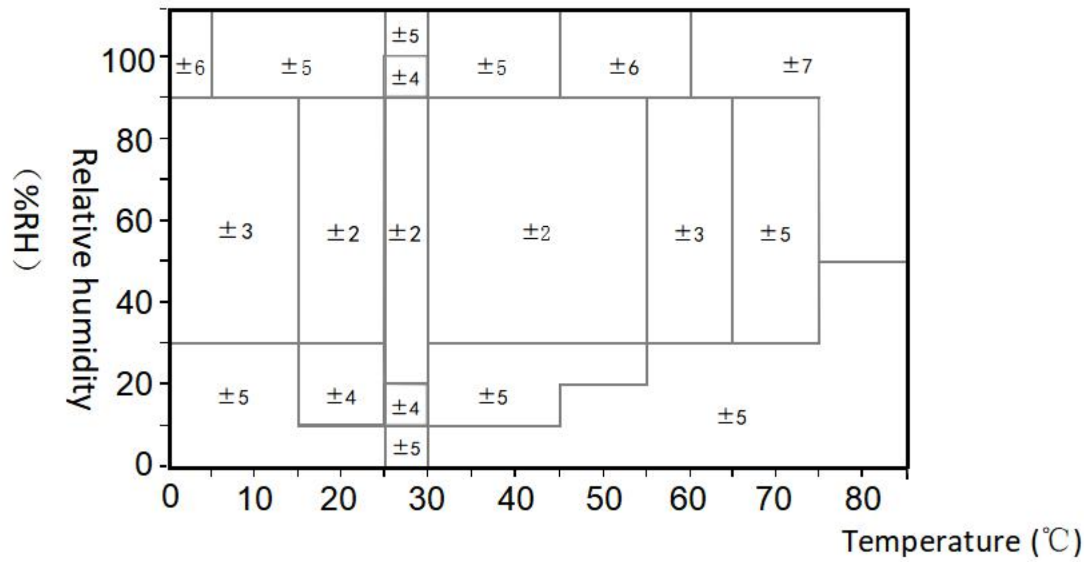


Figure 4 The maximum error of the corresponding humidity in the range of 0-80℃

Electrical specifications (Table 3)

Parameter	Condition	Min	Typical	Max	Unit
Voltage	Typical	2.0	3.3	5.5	V
Current, IDD[5]	Dormant	-		240	nA
	Measure		340		μA
Power consumption[5]	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.

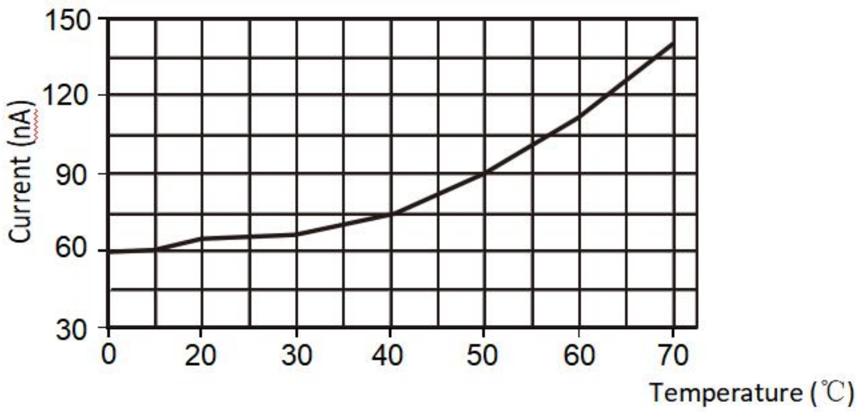


Fig. 5 Typical supply current vs. temperature curve (sleep mode) when VDD=3.3V. There is a deviation of approximately ±25% between these data and the displayed value.

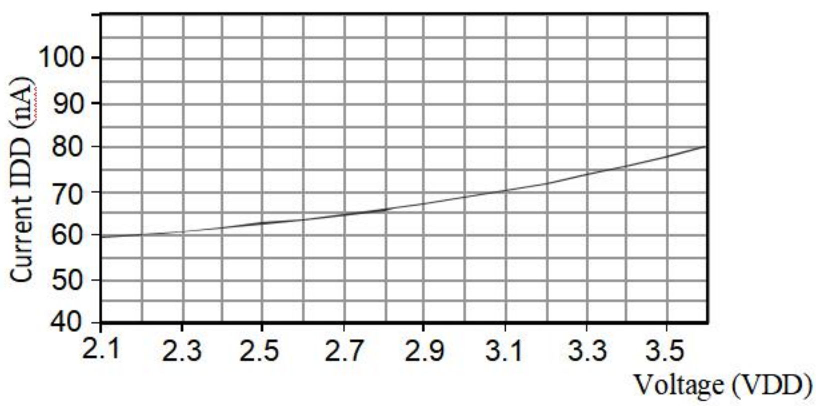


Figure 6 Typical supply current vs. supply voltage curve (sleep mode) at a temperature of 25 ℃.

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 20	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 be high.
5. 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.
6. The response time depends on the thermal conductivity of the sensor substrate.

1. Application:

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. it is recommended to store the sensor in the original packaging including a sealed ESD bag, and meet the following conditions: temperature range 10℃-50℃ (within a limited time 0-85℃); humidity 20-60%RH (without ESD package sensor). 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

As mentioned above, 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

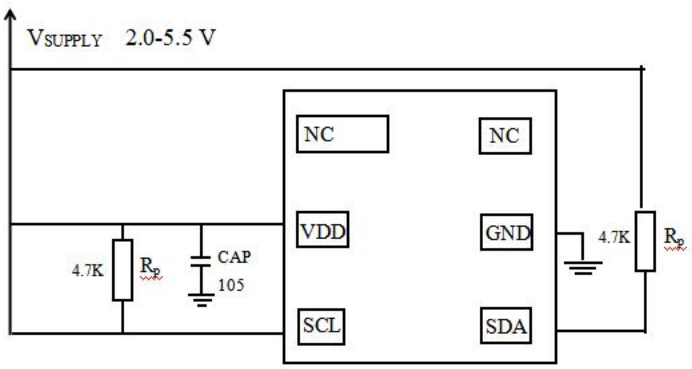
The relative humidity of gases depends largely on temperature. Therefore, when measuring humidity, all sensors measuring the same humidity should work at the same temperature as possible. When testing, it is necessary to ensure that the same temperature, and then compare the humidity readings.

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 WHT 20 should not exceed 10% of the measurement time. It is recommended to measure the data every 2 seconds.

1.4 Product application scenario design

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 WHT20 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

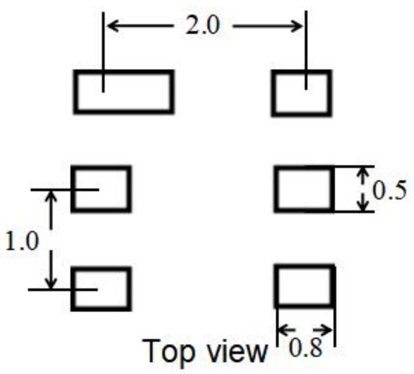
WHT20 has two operating modes: sleep mode and measurement mode. After power-on, WHT20 enters sleep mode. In this mode, WHT20 waits for the I2C input configuration conversion time, reads the battery status, triggers the measurement, and reads the measured value. After completing the measurement, WHT20 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.



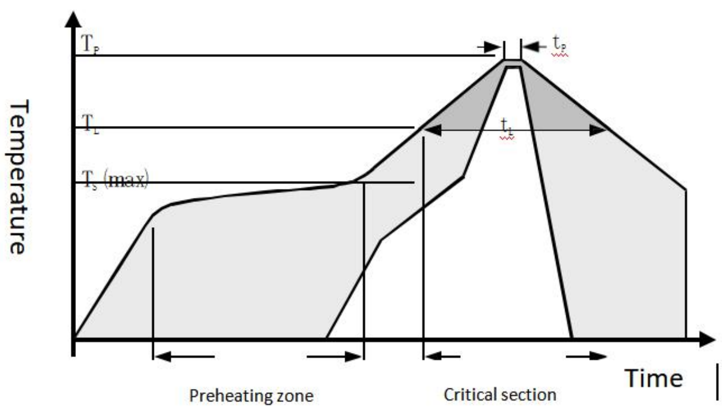


Figure 8: Recommend WHT 20 PCB design size (unit: mm), the outer dotted line part is the external size of the SMD package.

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.

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/JEDEC J-STD-020D welding standard. 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.

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 lead pad and PCB need to be sealed (such as: use conformal coating) to avoid poor contact or short circuit.

2. **Interface Definition**

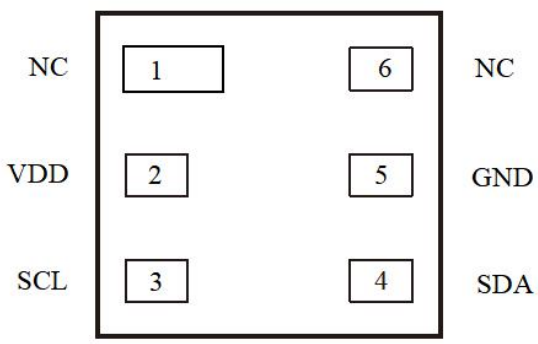


Table 4 WHT20 pin-out (top view)

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, SDA, 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 TSU and THD before and after the rising edge of SCL (refer to Figure 10).

3. Electrical Characteristics

3.1 Absolute Maximum Ratings

The absolute maximum ratings of WHT20 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.

3.2 Input /Output Characteristics 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 LOV	VOL	VDD = 3.3 V Reverse current 3mA	0	-	0.4	V
High output voltage VOH	VOH		0.7VDD	-	VDD	V
Output sink current IOL	IOL		-	-	-4	mA
Low output voltage VIH	VIL		0	-	0.3VDD	V
High output voltage VIH	VIH		0.7VDD	-	VDD	V
Input current		VDD = 5.5 V,VIN = 0 V to 5.5 V	-	-	±1	uA

3.3 I2C interface timing

Table 7 Timing characteristics of I2C fast mode digital input/output terminals

Parameter		I^2C Standard		I^2C Fast		Unit
		MIN	MAX	MIN	MAX	
I^2C clock frequency	f_{SCL}	0	100	0	400	KHz
Start signal time	t_{HDSTA}	0.1				µs
SCL clock high level (width)	t_{HIGH}	4.7		1.3		µs
SCL clock low level (width)	t_{LOW}	4.0		0.6		µs
Data storage time (relative to SCL, SDA edge)	t_{HDDAT}	0.09	3.45	0.02	0.9	µs
Data setting time (relative to SCL, SDA edge)	t_{SUDAT}	250		100		µs

The idle time of the BUS bus before stopping and starting	t_{BUS}			1		μs

Note: (1) The two pins are measured from 0.2 VDD and 0.8 VDD. (2) The above I2C timing is determined by the following internal delays: the internal SDI input pin is delayed relative to the SCK pin, typically The value is 100 ns; the internal SDI output pin is delayed relative to the falling edge of SCK, and the typical value is 200 ns.

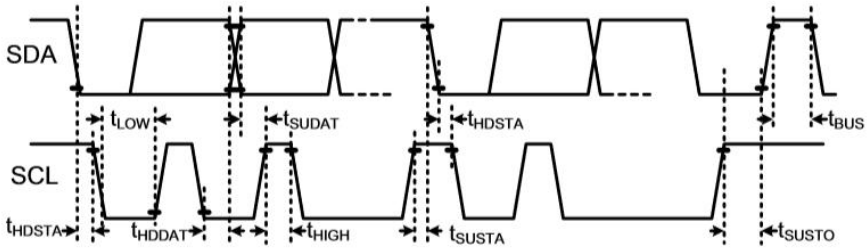


Figure 10 The timing diagram and abbreviations of the digital input/output terminals are explained in Table 7. The thicker SDA line is controlled by the sensor, and the ordinary SDA line is controlled by the microcontroller. Please note that the SDA valid read time is triggered by the falling edge of the previous conversion.

4. Sensor communication

WHT 20 communicates as a slave of the I2C bus interface. It takes up to 20 ms for the sensor to reach the sleep mode after power-on (SCL is high at this time). When the host sends a command, the temperature and humidity measurement can be started.

4.1 Start/stop sequence

Each transmission sequence starts with the Start state and ends with the Stop state, as shown in (1) and (2) in Figure 11.

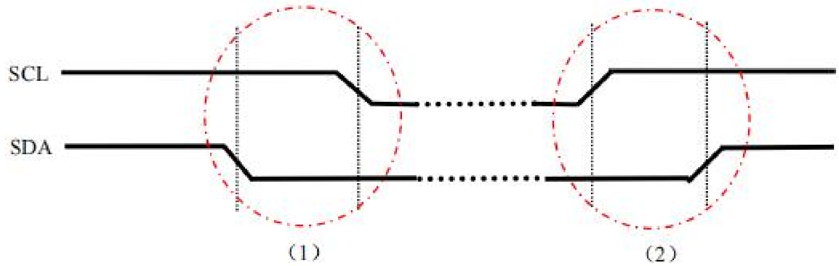
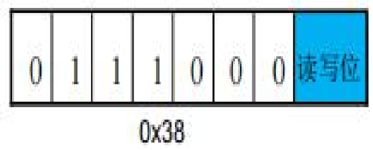


Figure 11 Start transmission (S) and stop state (P)

Note: (1) When SCL is high, SDA changes from high to low. The start state is a special bus state controlled by the master, indicating the start of the slave transfer (after Start, the BUS bus is generally considered to be in a busy state) (2) When SCL is high, the SDA line changes from low to low High level. The stop state is a special bus state controlled by the master, which indicates the end of the transfer from the slave (after Stop, the BUS bus is generally considered to be in an idle state).

4.2 Transmission of commands

The first byte of the transmitted I2C includes the 7-bit I2C device address 0x38 and an SDA direction bit x (read R: ‘1’, write W: ‘0’). After the 8th falling edge of the SCL clock, pull down the SDA pin (ACK bit) to indicate that the sensor data is received normally.



Code	Command	meaning
1011'1110 (0xBE)	Initialization command	Keep the host
1010'1100 (0xAC)	Trigger measurement	Keep the host

Table8 Basic command

As shown in the basic commands in Table 8, after sending the ‘1011’1110’ command, the representative will initialize, and after sending the ‘1010’1100’ command, the representative will perform temperature and humidity measurement, and the MCU must wait until the measurement is completed.

4.3 Status word

Table 9 shows the status bit description returned by the slave. Different bits represent different meanings, and the meanings are not all the same

Bit	Meaning	Description
Bit[7]	Busy indication	1-The device is busy and in the measurement state 0-The device is idle and in the dormant state
Bit[6:5]	Current working mode	00 is currently in NOR mode 01 is currently in CYC mode 1x is currently in CMD mode
Bit[4]	Memory data integrity indicator	1 - Indicates that the integrity test failed 0 - Indicates that the memory data integrity test passed
Bit[3]	CAL Enable	1-The calibration calculation function is enabled, and the output data is the calibrated data 0-The calibration calculation function is disabled, and the output data is the raw data output by the ADC
Bit[2:0]	Reserve	Reserve

4.4 Sensor reading process

1. Wait for 40 ms after power-on. Before reading the temperature and humidity value, first check whether the calibration enable bit Bit[3] of the status word is 1 (you can get a byte of status word by sending 0x71), if not It is 1, to send the 0xBE command (initialization), this command parameter has two bytes, the first byte is 0x08, and the second byte is 0x00. 2. Send the 0xAC command (trigger measurement) directly. This command parameter has two bytes, the first byte is 0x33, and the second byte is 0x00. 3. Wait for 75 ms for the measurement to be completed, and Bit[7] of the busy state is 0, and then six bytes can be read (you can read by sending 0X71). 4. Calculate the temperature and humidity value.

Note: The calibration status check in the first step only needs to be checked when the power is turned on, and no operation is required during the normal acquisition process.

Trigger measurement data

Start	I²C address + write	ACK	Trigger measurement 0xAC	ACK	DATA0	ACK	DATA1	ACK	Stop
S	0 1 1 1 0 0 0 0		1 0 1 0 1 1 0 0		0 0 1 1 0 0 1 1		0 0 0 0 0 0 0 0		P

Read temperature and humidity data

Start	I²C address + read	ACK	State	ACK	Humidity data	ACK	Humidity data	ACK
S	0 1 1 1 0 0 0 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	

Humidity data and temperature data	ACK	Temperature data	ACK	Humidity data	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		x x x x x x x x		P

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

Table 10 Description of sensor program commands

5 Signal

5.1 Phase opposite Humidity conversion

Relative humidity RH Metropolitan SDA Imported Relative humidity signal SRH Relatively calculated formula (% RH display after result).

$$RH[\%]=\left(\frac{S_{RH}}{2^{20}}\right)\times 100\%$$

5.2 Temperature conversion

Temperature T Metropolitan temperature export signal ST Substitution reached Bottom formula calculation reached (resulting temperature °C shown).

$$T[°C]=(\frac{S_T}{2^{20}})\times 200-50$$

6 Environmental qualification

This sensor is installed or used in a machine, and it is used as a reference sensor. It is left at the same temperature and humidity. Insufficient measurement time to prevent the completion of the test. Insufficient error.

7 packaging

WHT20 Double-sided non-pulled leg flat seal for 采. 传sensor core piece Yuba Ni / Au-like copper line sill system. Weight of the sensor is about 19 mg, and 12 specific dimensions of the sensor are shown.

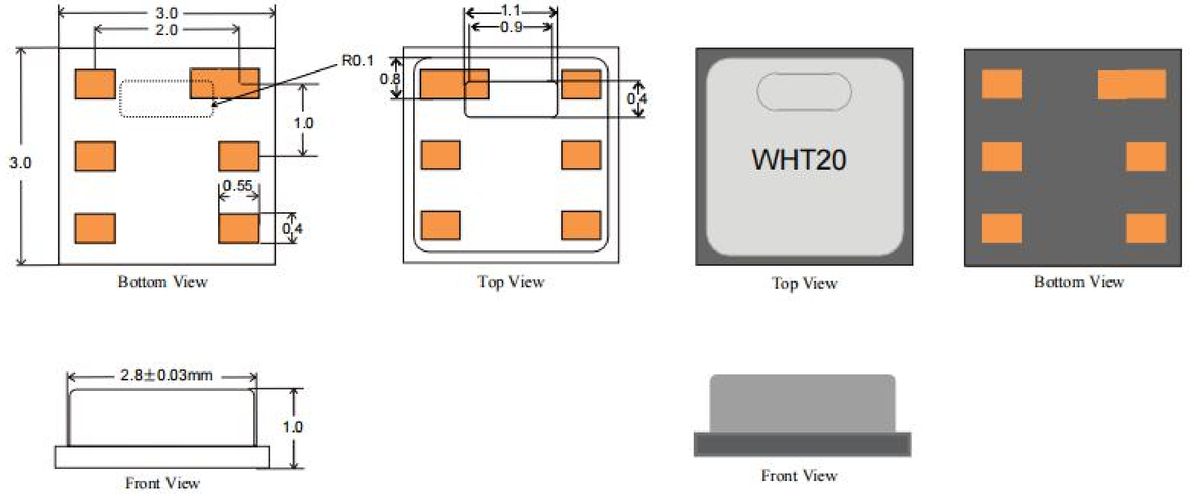
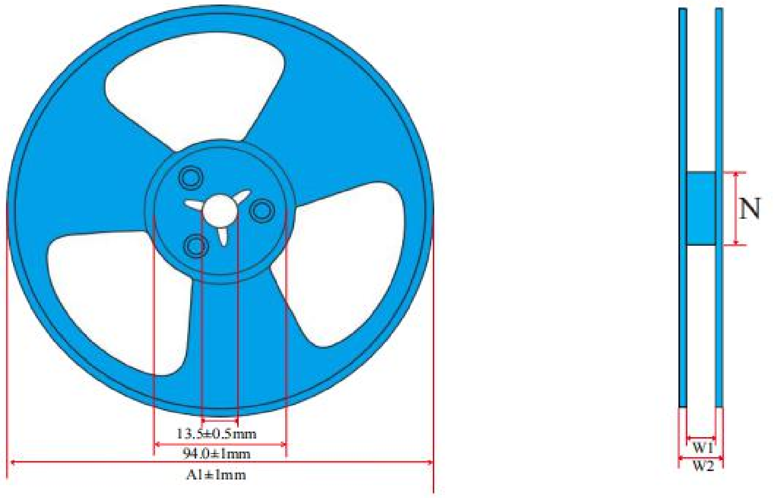
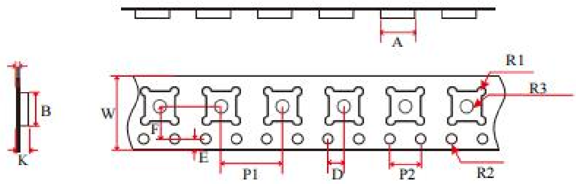


Figure 12 WHT 20 sensor package diagram (unit: mm tolerance: ±0.1 mm)

WHT20 is packaged in tape and reel, sealed in an antistatic ESD bag. The standard packaging size is 5000 pieces per roll. For WHT20 packaging, the rear 440 mm (55 sensors capacity) and the front 200 mm (30 sensors capacity) of each reel are empty packages.

The packaging diagram with sensor positioning is shown in Figure 13. The reel is placed in an anti-static bag.





Model	A1	E	W1	W2	N
reel	233/330	2	12	16	100

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

Model	A/B	K	W	R2/R3	R1
taping	$3.30^{+0.1}_{-0.0}$	$1.2^{+0.01}_{-0.0}$	12.5±0.3	$1.50^{+0.01}_{-0.0}$	$0.50^{+0.01}_{-0.0}$

Model	P1	P2	I	F	E	D
taping	8.25±0.1	4.25±0.1	0.4±0.05	5.5±0.1	1.8±0.1	2.0±0.1

Figure 13 Packaging tape and sensor positioning diagram

8 Tracking information

All WHT20 sensors have laser markings on the surface. Refer to Figure 14. There are labels on the reels, as shown in Figure 15, and other tracking information is provided.

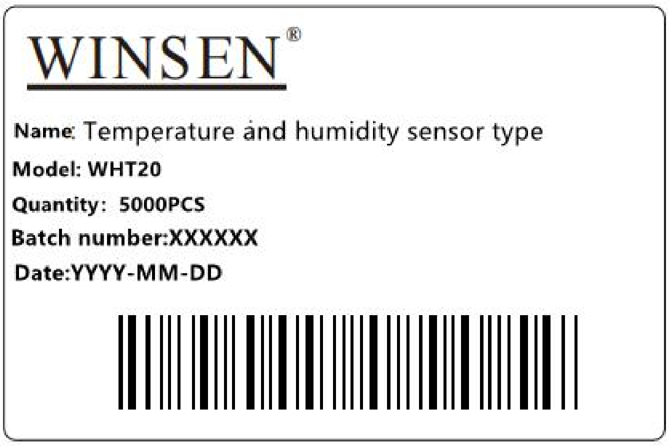


Figure 154 Sensor laser marking

Figure 15 The label on the reel

Precautions

Warning, personal injury

Do not use this product in safety protection devices or emergency stop equipment, and any other applications that may cause personal injury due to product 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.

If the buyer intends to purchase or use Weisheng's products without obtaining any application licenses and authorizations, the buyer will bear all compensation for personal injury and death arising therefrom, and exempt the managers and employees of Weisheng Company and its affiliated subsidiaries. , Agents, distributors, etc. may incur any claims, including: various costs, compensation fees, attorney fees, etc.

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 assurance (calculated from the date of shipment) to direct purchasers of its products, based on the technical specifications in the product data manual published by Weisheng. If the product is proved to be defective during the warranty period, the company will provide free repair or replacement. The user needs to meet the following conditions:

1. The product shall be notified to the company in writing within 14 days after the defect is discovered;
2. The product defect will help to find the company's design, material, and workmanship deficiencies;
3. The product should be purchased by the purchaser Pay and send it back to our company;

4. The product should be within the warranty period. The company is only responsible for those products that are used in the occasions that meet the technical conditions of the product and produce defects.
The company does not make any guarantees, guarantees or written statements about the application of its products in those special applications. At the same time, the company does not make any promises regarding the reliability of its products when applied to products or circuits.

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