Winsen
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Temperature and Humidity Sensor Module

(Model: ZS13)

Manual

Version: V1.0

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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

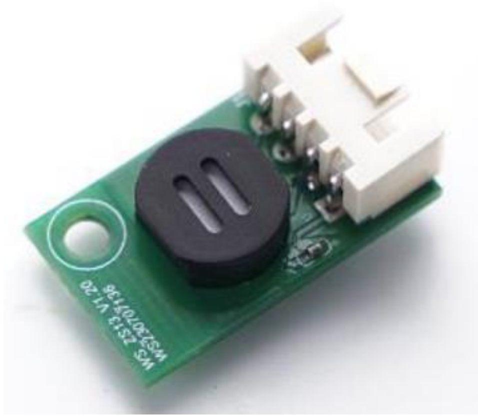
ZS13 Temperature and Humidity Sensor Module

1. Overview

ZS13 is a brand new product, which is equipped with special ASIC sensor chip, high-performance semiconductor silicon-based capacitive humidity sensor and a standard on-chip temperature sensor, it uses standard I^2C output signal format. ZS13 products have stable performance in high temperature and high humidity environment; At the same time, the product has great advantages in accuracy, response time and measurement range. Each sensor is strictly calibrated and tested before leaving the factory to ensure and meet the large-scale application of customers.

Features

- Fully calibrated
- Wide power supply voltage range, from 2.2V to 5.5V
- Digital output, standard I^2C signal
- Quick response and strong anti-interference ability
- Excellent long-term stability under high humidity condition



Application

Home appliance fields: 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.

2. Technical parameters of relative humidity

2.1 Relative humidity

Parameter	Condition	Min	Typical	Max	Unit
Resolution	Typical	-	0.024	-	%RH
Accuracy error[1]	Typical	-	±2	Refer to Figure 1	%RH
Repeatability	-	-	±0.1	-	%RH
Hysteresis	-	-	±1.0	-	%RH
Non-linearity	-	-	<0.1	-	%RH
Response time[2]	τ63 %	-	<8	-	s
Working Range[3]	-	0	-	100	%RH
Prolonged Drift[4]	Normal	-	< 1	-	%RH/yr

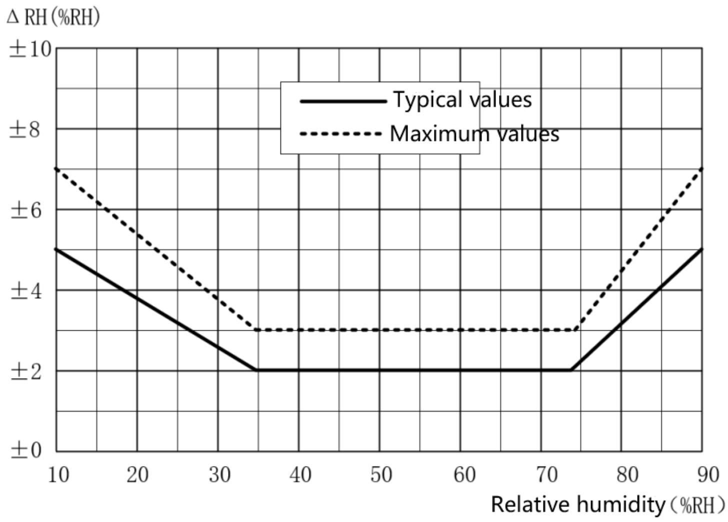


Fig 1 Typical and maximum errors of relative humidity at 25°C

2.2 Technical parameters of temperature

Parameter	Condition	Min	Typical	Max	Unit
Resolution	Typical	-	0.01	-	°C
Accuracy error[5]	Typical	-	±0.3	-	°C
	Max	See figure 2			-
Repeatability	-	-	±0.1	-	°C
Hysteresis	-	-	±0.1	-	°C
Response time[6]	τ63%	5	-	30	s
Working Range	-	-40	-	85	°C
Prolonged Drift	-	-	<0.04	-	°C/yr

Table 2

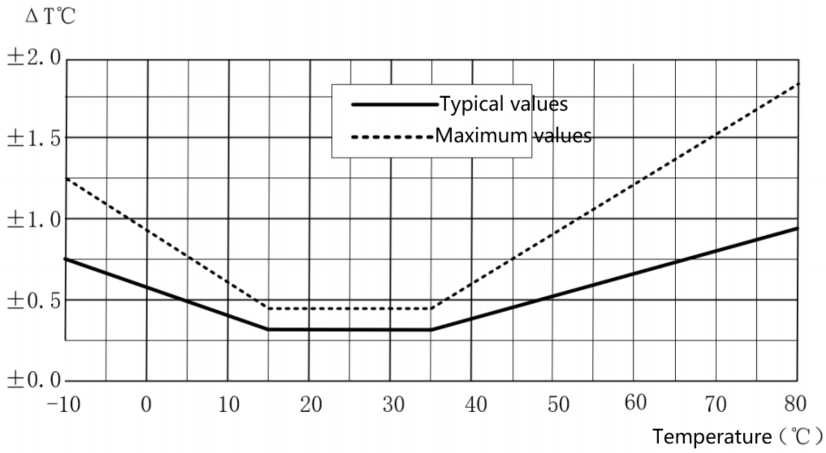


Fig 2 Temperature typical error and maximum error

2.3 Electrical characteristics

Parameter	Condition	Min	Typical	Max	Unit
Power Supply	Typical	2.2	3.3	5.5	V
Power Supply, IDD[7]	Sleep	-	250	-	nA
	Measure	-	980	-	µA
Consumption[8]	Sleep	-	-	0.8	µW
	Measure	-	3.2	-	mW
Communication Format	I^2C				

Table 3

1. This accuracy is the testing accuracy of the sensor under the condition of 25 ℃, power & supply voltage of 3.3V during delivery inspection. This value excludes hysteresis and nonlinearity and applies only to non-condensing conditions.
2. The time required to reach 63% of the first-order response at 25 ℃ and 1m/s air flow.
3. Normal working range: 0-80% RH. Beyond this range, the sensor reading will deviate (after 200 hours under 90% RH humidity, it will temporarily drift < 3% RH). The working range is further limited to - 40 - 85 ℃.
4. If there are volatile solvents, pungent tapes, adhesives and packaging materials around the sensor, the reading may be offset.
5. The accuracy of the sensor is 25℃ under the factory power supply condition. This value excludes hysteresis and nonlinearity and applies only to non condensing conditions.
6. The response time depends on the thermal conductivity of the sensor substrate.
7. The minimum and maximum supply current are based on VDD = 3.3V and T < 60 ℃.
8. The minimum and maximum power consumption are based on VDD = 3.3V and T < 60 ℃.

3. Interface definition

No.	PIN	Name	Definition
1	V	VDD	Power 2.2-5.5V
2	D	SDA	Serial data, bidirectional
3	G	GND	Power -Ground
4	C	SCL	Serial data, bidirectional

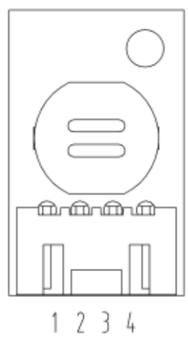


Table 4 ZS13 Pin distribution

4. Sensor Communication

ZS13 uses standard I2C protocol for communication.

4.1 Start sensor

The first step is to power on the sensor at the selected VDD power supply voltage (range between 2.2V and 5.5V). After power on, the sensor needs a stabilization time of no less than 100ms (at this time, SCL is high level) to reach the idle state to be ready for receiving the command sent by the host (MCU).

4.2 Start/Stop Sequence

Each transmission sequence starts with the Start state and ends with the Stop state, as shown in Fig 9 and Fig 10.

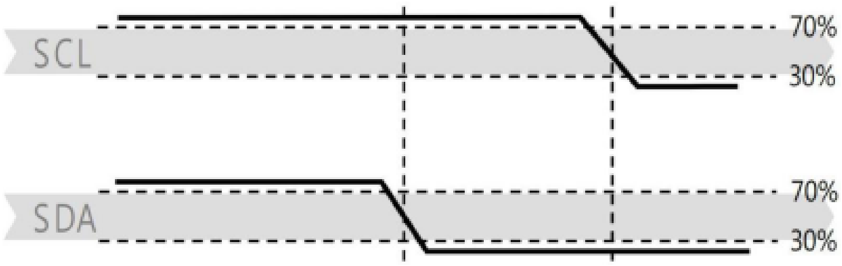


Figure 3 Start transmission state (S)

Note: When SCL is high, SDA is converted 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 is generally considered to be in a busy state)

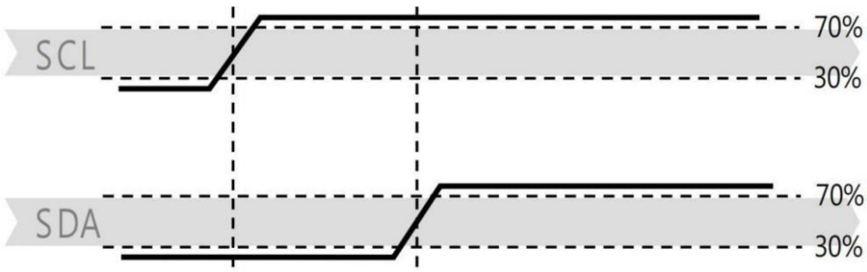
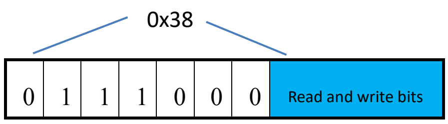


Figure4 Stop transmission state (P)

Note: When SCL is high, the SDA line changes from low to high. The stop state is a special bus state controlled by the master, indicating the end of the slave transmission (after Stop, the BUS is generally considered to be in an idle state).

4.3 Transmission of command

The first byte of I²C that is subsequently transmitted includes the 7-bit I²C device address 0x38 and a 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. After sending measure command 0xAC, MCU should wait until the measurement is completed.



Bit	Meaning	Description

Bit[7]	Busy indication	1 -- busy, in measurement status 0 -- idle, sleep status
Bit[6:5]	Retain	Retain
Bit[4]	Retain	Retain
Bit[3]	CAL Enable	1 --calibrated 0 --uncalibrated
Bit[2:0]	Retain	Retain

Table 5 Status bit description

4.4 Sensor reading process

1. 40ms waiting time is required after power-on. Before reading the temperature and humidity value, check whether the calibration enable bit (Bit[3]) is 1 or not (you can get a status byte by sending 0x71). If it's not 1, send the 0xBE command (initialization), this command has two bytes, the first byte is 0x08, and the second byte is 0x00.
2. Send the 0xAC command (measurement trigger) directly. This command 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 indicator is 0, and then six bytes can be read (read 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, which is not required during the normal reading process.

To trigger measurement

<table>
<tr><td>Start</td><td colspan="8">I²C address + write</td><td>ACK</td><td colspan="8">Measurement trigger 0xAC</td><td>ACK</td><td colspan="8">DATA0</td><td>ACK</td><td colspan="8">DATA1</td><td>ACK</td><td>Stop</td></tr>
<tr><td>S</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td></td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td><td></td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td><td>P</td></tr>
</table>

To read humidity and temperature data

<table>
<tr><td>Start</td><td colspan="8">I²C address + read</td><td>ACK</td><td colspan="8">Status</td><td>ACK</td><td colspan="8">Humidity data</td><td>ACK</td><td colspan="8">Humidity data</td><td>ACK</td></tr>
<tr><td>S</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td></td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td></td></tr>
</table>

<table>
<tr><td colspan="4">Humidity data</td><td colspan="4">Temperature data</td><td>ACK</td><td colspan="8">Temperature data</td><td>ACK</td><td colspan="8">Humidity data</td><td>ACK</td><td colspan="8">CRC data</td><td>NAK</td><td>Stop</td></tr>
<tr><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td></td><td>P</td></tr>
</table>

	Slave to master
ACK	Slave response ACK
ACK	Master response ACK
NAK	Master response NAK
S	Start
P	Stop

Table 6 Description of sensor program commands

4.5 Serial Data SDA

SDA pin is used for data input and output of sensor. When sending a command to the sensor, SDA is valid on the rising edge of the serial clock (SCL), and when SCL is high, SDA must remain stable. After the falling edge of SCL, the SDA value can be changed. In order to ensure communication security, the effective time of SDA should be extended to TSU and tho before the rising edge and after the falling edge of SCL respectively. When reading data from the sensor, SDA is effective (TV) after SCL becomes low and maintained to the falling edge of the next SCL.

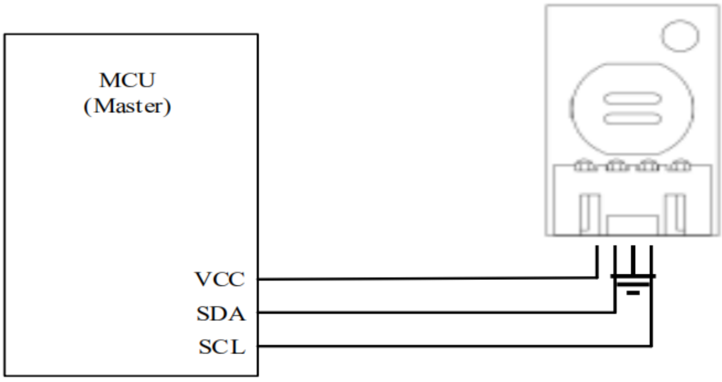


Figure 5 Typical application circuit

In order to avoid signal conflict, the microprocessor (MCU) must only drive SDA and SCL at low level. An external pull-up resistor (e.g. 4.7K Ω) is required to pull the signal to high level. The pull-up resistor has been included in the I / O circuit of the microprocessor of ZS13. Detailed information on the input / output characteristics of the sensor can be obtained by referring to tables 6 and 7.

Note: 1. When the product is used in the circuit, the power supply voltage of the host MCU must be consistent with the sensor.

2. In order to further improve the reliability of the system, the sensor power supply can be controlled.

3. When the system is just powered on, give priority to supplying power to the sensor VDD, and set the SCL and SDA high level after 5ms.

4.6 Relative humidity conversion

The relative humidity RH can be calculated according to the relative humidity signal S_{RH} output by SDA through the following formula (the result is expressed in% RH).

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

4.7 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 ℃).

$$T[℃]=\left(\frac{S_T}{2^{20}}\right)\times 200-50$$

5 Product Dimension

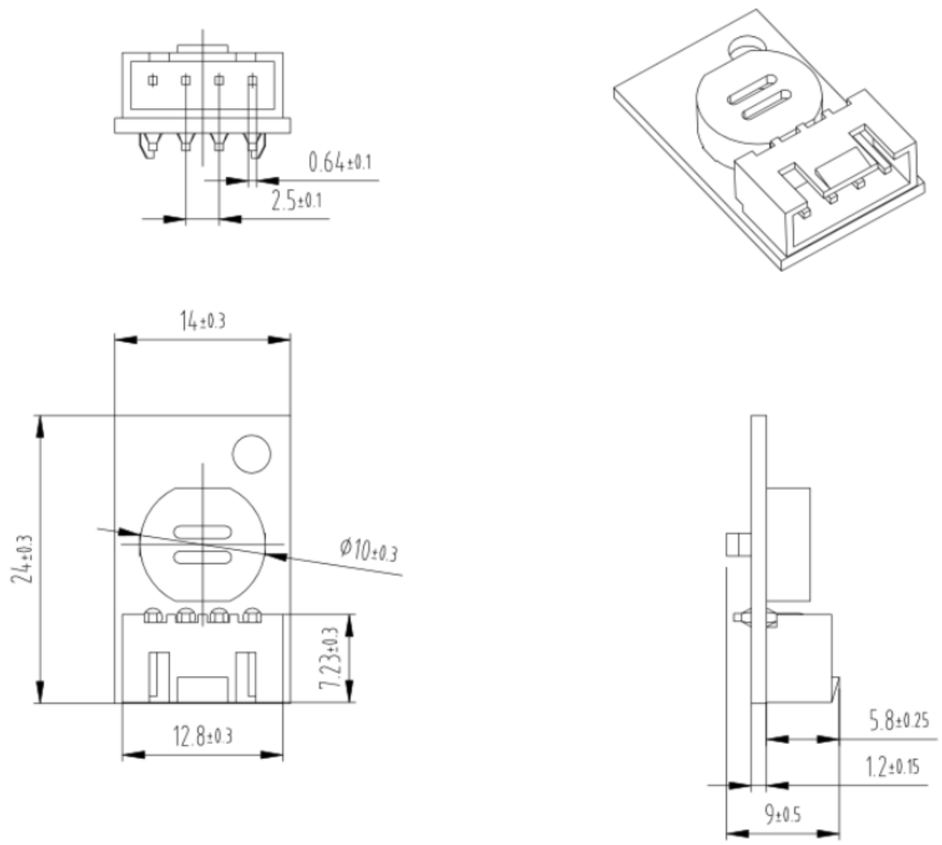


Figure 6 Product structure diagram (unit: mm)

6 Performance Supplement

6.1 Suggested working environment

The sensor has stable performance within the recommended working range, as shown in Figure 7. 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.

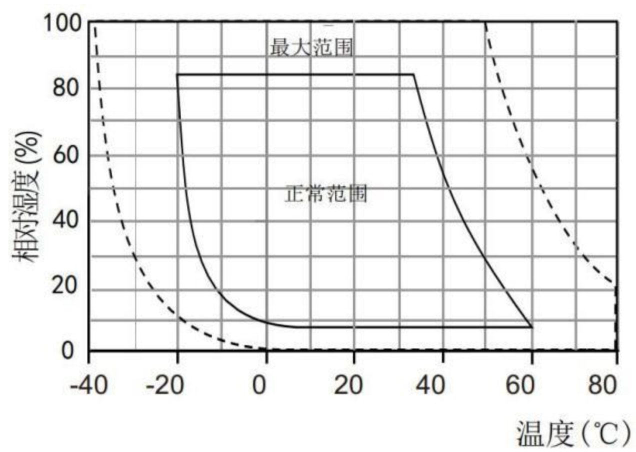


Figure 7 Working scope

6.2 RH accuracy at different temperatures

Figure 8 shows the maximum humidity error for other temperature ranges.

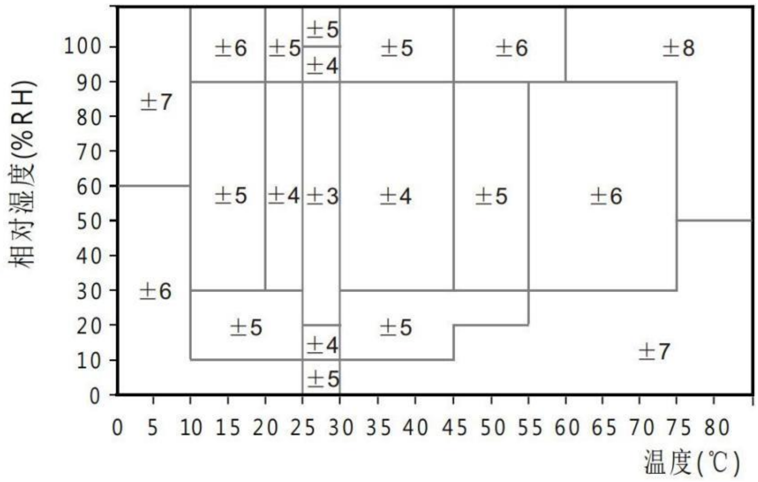


Figure 8 The maximum error of the corresponding humidity in the range of 0-80℃

Please note that the above errors are typical errors for testing with high-precision dew point meters as reference instruments(excluding hysteresis).

7. Application guide:

- **7.1 environment instructions**

Reflow soldering or wave soldering is prohibited for products. For manual welding, the contact time must be less than 5 seconds under the temperature of up to 300 ℃.

Note: after welding, the sensor shall be stored in the environment of > 75% RH for at least 12 hours to ensure the rehydration of the polymer. Otherwise, the sensor reading will drift. The sensor can also be placed in a natural environment (> 40% RH) for more than 2 days to rehydrate it. The use of low-temperature solder (such as 180 ℃) can reduce the hydration time.
Do not use the sensor in corrosive gases or in environments with condensate.

7.2 Storage Conditions and Operating instructions

Humidity sensitivity level (MSL) is 1, according to IPC/JEDECJ-STD-020 standard. Therefore, it is recommended to use it within one year after shipment.

Temperature and humidity sensors are not ordinary electronic components and need careful protection, which users must pay attention to. Long term exposure to high concentration of chemical vapor will cause the reading of the sensor to drift. Therefore, it is recommended to store the sensor in the original package, including the sealed ESD pocket, and meet the following conditions: the temperature range is 10 ℃ - 50 ℃ (0-85 ℃ in a limited time); Humidity is 20-60% RH (sensor without ESD package). For those sensors that have been removed from their original packaging, we recommend storing them in antistatic bags made of metal containing PET/AL /CPE materials.

In the process of production and transportation, the sensor should avoid contact with high concentration of chemical solvents and long-term exposure. Avoid contact with volatile glue, tape, stickers or volatile packaging materials, such as foam foil, foam materials, etc. The production area should be well ventilated.

7.3 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.

7.4 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.

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 ZS13 should not exceed 10% of the measurement time. It is recommended to measure the data every 2 seconds.

7.5 Materials for sealing and encapsulation

Many materials absorb moisture and will act as a buffer, which increases response time and hysteresis. Therefore, the material of the surrounding sensor should be selected carefully. Recommended materials are: metal materials, LCP, POM (Delrin), PTFE (Teflon), PE, peek, PP, Pb, PPS, PSU, PVDF, PVF.

Materials for sealing and bonding (conservative recommendation): it is recommended to use the method filled with epoxy resin for the packaging of electronic components, or silicone resin. Gases released from these materials may also contaminate ZS13 (see 2.2). Therefore, the sensor should be finally assembled and placed in a well ventilated place, or dried in an environment of > 50 ℃ for 24 hours, so that it can release the polluting gas before packaging.

7.6 Wiring rules and signal integrity

If the SCL and SDA signal lines are parallel and very close to each other, it may lead to signal crosstalk and communication failure. The solution is to place VDD or GND between two signal lines, separate the signal lines, and use shielded cables. In addition, reducing the SCL frequency may also improve the integrity of signal transmission.

8. Important notice

8.1 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.

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

8.2 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.

8.3 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 product should be within the warranty period.

The company is only responsible for products that are defective when used in applications that meet the technical conditions of the product. 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 about the reliability of its products when applied to products or circuits.

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