AHT40 Datasheet

Temperature and Humidity Sensor

- Fully calibrated
- Digital output, I2C interface
- Excellent long-term stability
- Fast response and strong anti-interference capability
- Wide voltage support: 2.0-5.5 VDC

Product Summary

AHT40 is a new temperature and humidity sensor offering the distinct advantages of low power consumption and high accuracy. Housed in a reflow-resistant dual-inline flat leadless SMD package, its rugged housing and compact size make it easily integrated into challenging designs. This sensor utilizes a newly optimized ASIC, an improved MEMS semiconductor capacitive humidity sensor, and a standard on-chip temperature sensor, significantly enhancing performance and maintaining stable performance even in harsh environments.

AHT40 temperature and humidity sensor reduces power consumption in applications and offers a high cost-performance ratio, making it particularly suitable for mass production by companies with stringent cost controls and a focus on quality.

Applications

The AHT40 temperature and humidity sensor has a wide range of applications, encompassing smart home (such as HVAC, dehumidifiers, and refrigerators in home appliances), consumer electronics, digital healthcare, automotive, industrial, and meteorological applications. It can also be used in temperature and humidity measurement and control products such as test and inspection equipment, facilitating precise measurement and control across various industries.

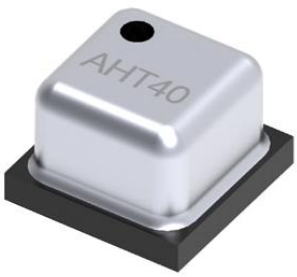


Figure 1. AHT40 temperature and humidity sensor

1. Sensor Performance

1.1 Relative Humidity

Table 1. Relative humidity characteristics

Parameters	Status	MIN	TYPICAL	MAX	Unit
Resolution	Typical	-	0.024	-	%RH
Accuracy[1]	Typical	See Figure 2			%RH
	MAX	See Figure 2			%RH
Repeatability	-	-	±0.1	-	%RH
Hysteresis	-	-1	±0.5	1	%RH
Non linear	-	-	<0.1	-	%RH
Response time[2]	τ63%	10	-	25	s
Measure range	extended[3]	0	-	100	%RH
Long time drift[4]	Normal	-	<1	-	%RH/yr

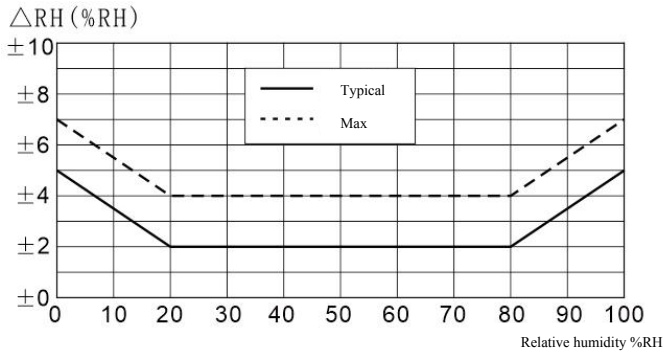


Figure 2. The typical error and Max error of Relative humidity at 25℃

1.1 Electric Specification

Table 2. Electric Specification

Parameter	Status	MINI	TYPICAL	MAX	Unit
Power supply	Typical	2.0	3.3	5.5	V
Supply current IDD[5]	Dormant	-	0.1	-	μA
	Measure	-	420	460	μA
Power consumption	Dormant	-	0.3	0.4	μW
	Measure	-	1.4	1.5	mW
Communication	Two wire digital interface, I²C protocol				

[1] This accuracy is the test accuracy under clean air condition of 25°C during factory inspection, excluding hysteresis and nonlinearity。

[2] The time required to reach 63% of the first order response at 25°C and 1m/s airflow.

[3] Beyond the 8~85% RH range, please refer to User Guide 1.1 for sensor reading deviation.

[4] The test data is in clean air. If there are volatile solvents, tapes, adhesives and packaging materials with pungent odors around the sensor, this parameter may be too large. For details, refer to the "User's Guide".

[5] The minimum and maximum values of the supply current and power consumption are based on tests at 25°C and VDD = 3.3 V. The average value is based on one measurement every 1 second.

1.3 Temperature

Table 3. Temperature Parameters

Parameters	Status	MINI	TYPICAL	MAX	Unit
Resolution	Typical	-	0.01	-	℃
Accuracy	Typical	see Figure 3			℃
	MAX	see Figure 3			℃
Repeatability	-	-	±0.1	-	℃
Hysteresis	-	-	±0.1	-	℃
Response time[6]	τ63%	4	-	10	s
Measure range	-	-40	-	120	℃
Long time drift	-	-	<0.1	-	℃/yr

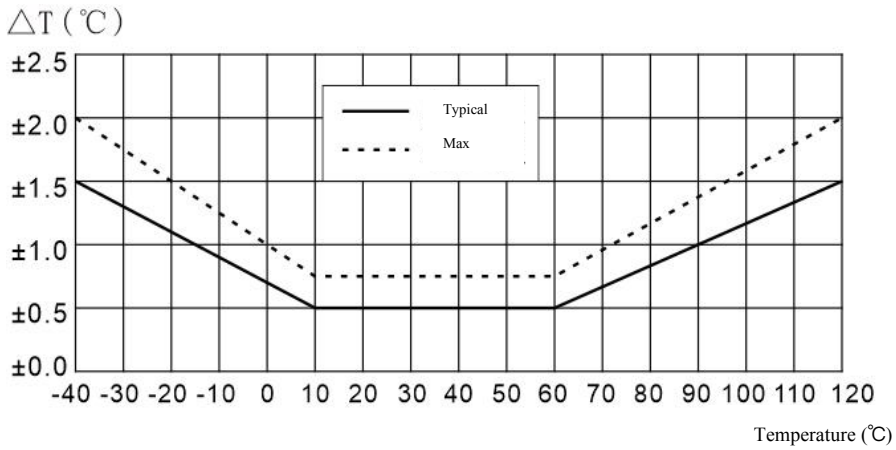


Figure 3. The typical error and Max error of Temperature

[6] Response time is affected by PCB layout and installation

2 AHT40 User Guide

2.1 Extended Performance

2.2.1 Operating Conditions

When operating within the recommended "normal range" environment (see Figure 4), the sensor's performance is relatively stable. Prolonged exposure outside the "normal range" and operating within the "maximum range," especially when exposed to high temperature and high humidity (e.g 85℃/85% RH for more than 12 hours), may result in temporary drift error. The relative humidity error is within ± 8% RH (see Figure 5). Upon returning to the "normal range," the sensor will slowly return to the relative error conditions listed in Table 1. Prolonged use outside the "maximum range" will shorten the product life and affect performance.

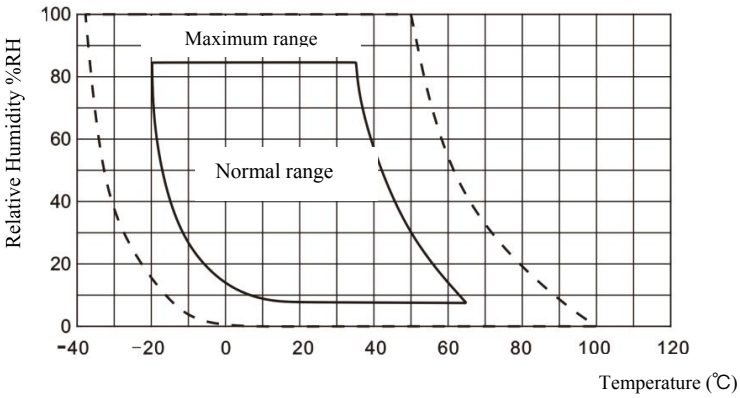


Figure 4. Work conditions

2.1.2 Relative Humidity Error at Different Temperatures

Figure 2 shows the relative humidity error at 25℃, while Figure 5 provides typical relative humidity errors at other temperature ranges.

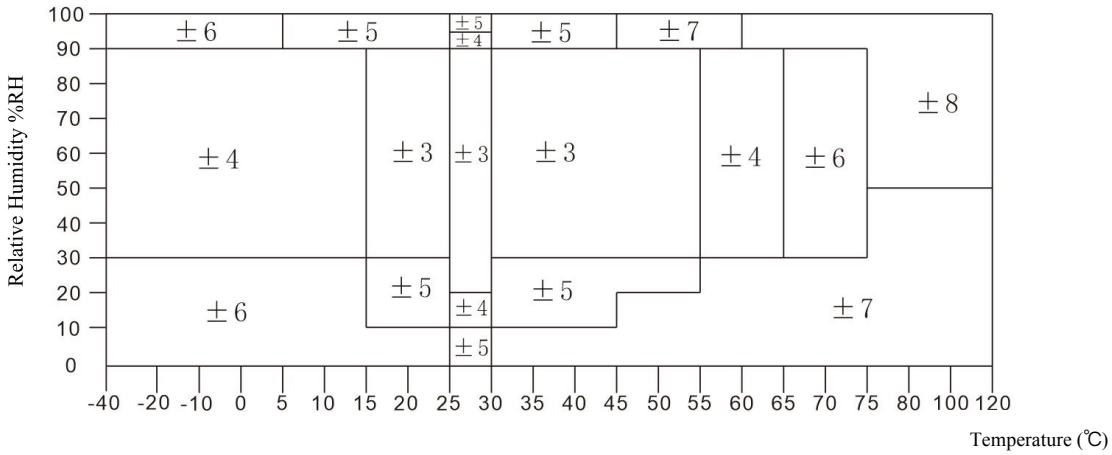


Figure 5. Typical relative humidity error Δ%RH in the range of -40°C to 100°C

Note: The above errors are typical errors (excluding hysteresis) when using a chilled mirror precision dew point meter for relative humidity standard testing.

2.2 Application Information

2.2.1 Soldering Instructions

The dashed lines in Figure 6 indicate the external dimensions of the SMD package.

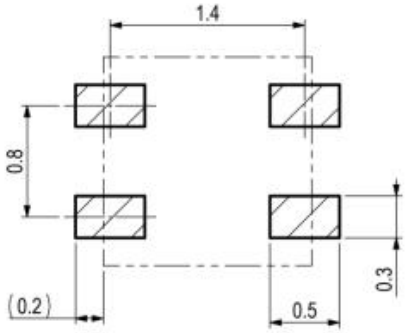


Figure 6. Recommended sensor PCB design dimensions (unit: mm)

For solder printing, a stencil thickness of 0.125mm is recommended. The stencil for the pad area must be 0.1mm wider than the PCB pad. For exposed pads, the stencil should cover 70%-90% of the pad area. Due to the low placement height of SMDs, it is recommended to use no-clean Type 3 solder and use nitrogen purge during reflow.

See Figure 7 for JEDEC standards: TP < 260 ˚ C, tP < 30 seconds for lead-free soldering. TL < 180 ˚ C, tL < 150 seconds. The temperature rise and fall rates during soldering should be < 5 ˚ C/second.

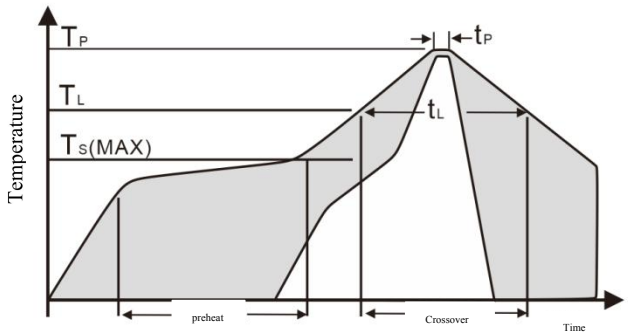


Figure 7. JEDEC-standard soldering process

Please use a standard reflow oven to solder the sensor. The sensor complies with IPC/JEDEC J-STD-020D soldering standards. The recommended reflow soldering temperature is below 230 ˚ C, with a low temperature of 180 ˚ C optimal. The maximum soldering temperature is 260 ˚ C. Note that at the maximum TP temperature, the contact time should be less than 30 seconds (see Figure 7).

Note: The sensor may temporarily display a low reading after soldering.

2.2.2 Storage Conditions and Operating Instructions

Temperature and humidity sensors are not ordinary electronic components. Users must provide due care and proper protection. Prolonged exposure to high concentrations of chemical vapors will cause reading drift. Therefore, it is recommended that the sensor be placed in an anti-static bag and stored in an environment with a temperature range of 10-50 ° C and a humidity range of 20-60% RH. For sensors that have been removed from their original packaging, we recommend storing them in an anti-static bag made of metal-lined PET/AL/CPE.

During production and transportation, sensors should avoid contact with high concentrations of chemical solvents and prolonged exposure to the elements. They should also avoid contact with volatile glue, tape, stickers, or volatile packaging materials such as bubble foil and foam. The production area should be well ventilated.

2.2.3 Temperature Influence

The sensor's relative humidity is calculated based on the dew point, so it is significantly affected by ambient temperature and humidity. Therefore, when measuring relative humidity, it is important to ensure that all sensors measuring the same relative humidity operate in the same temperature environment. This is crucial for comparing sensor readings to be meaningful.

If the sensor is located on the same printed circuit board as heat-sensitive electronic components, thermal insulation measures should be implemented during circuit design to minimize the effects of heat transfer. For example, ensure good ventilation in the enclosure, minimize the copper plating between the sensor and the rest of the printed circuit board, or create a 1.5mm gap between the sensor and the rest of the printed circuit board (see Figure 8).

Note: The milled slit design in Figure 8 can minimize heat transfer.

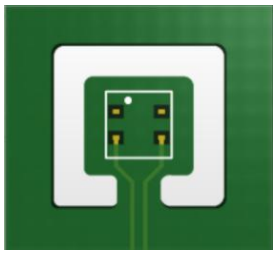


Figure 8. Top view of the sensor's printed circuit board.

In addition, if the sensor data acquisition frequency is too high, the sensor's internal temperature will rise, affecting measurement accuracy. To ensure the internal temperature rise is below 0.1℃, it is recommended that the I^2C sampling frequency during measurement be between 10kHz and 400kHz, not too high.

2.2.4 Product Application Scenario Design

In terms of product design, the sensor has the following features:

- The sensor is in full contact with ambient

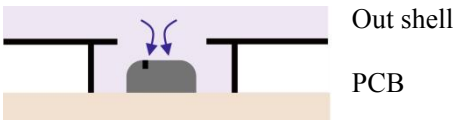


Figure 9. Appropriate windows in the housing provide good access to environmental measurements and allow for more adequate air exchange.

- The sensor is completely isolated from the air inside the housing

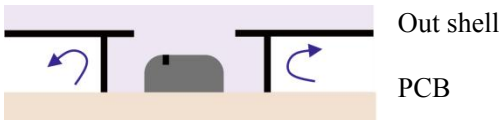


Figure 10. The sensor is isolated from the air inside the housing, minimizing the impact of the enclosed air inside the housing on the sensor.

- Small measurement blind area around the sensor

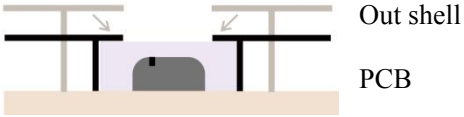


Figure 11. A small measurement blind zone allows the sensor to quickly and comprehensively detect environmental changes.

- The sensor is isolated from the heat source

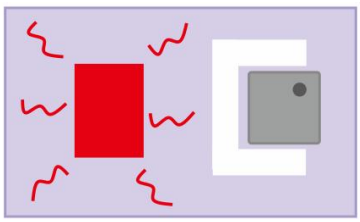


Figure 12. Isolating the sensor from internal heat sources minimizes the effects of internal heat on sensor measurements.

- Sensor power supply is controllable

To avoid signal conflicts and improve system stability, the microprocessor (MCU) can only drive SDA and SCL at a low level. An external pull-up resistor (for example, 2 to 10 kΩ) is required to pull the signals high. The circuit in Figure 13 is provided for reference.

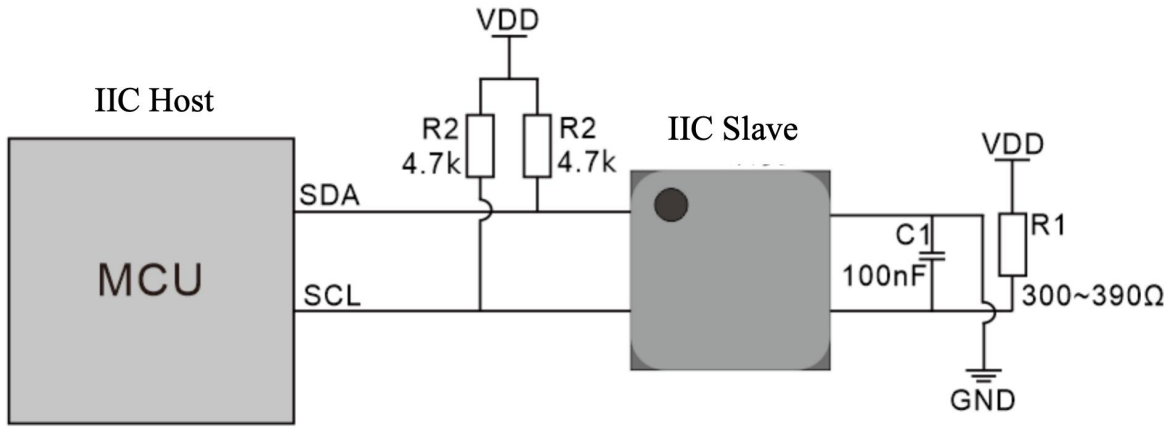


Figure 13. Typical Application Circuit

Note: 1. The power supply voltage VDD for both the host MCU and the sensor ranges from 2.0V to 5.5V.

2.When the sensor is first powered on, the MCU prioritizes supplying power to VDD. SCL and SDA can only be set to high level after 5ms.

3.An RC filter circuit, as shown by R1 and C1 in the diagram, is required for the sensor's VDD.

- Sensor Routing Rules and Signal Integrity on PCB

If the SCL and SDA signal lines are parallel and very close to each other, it can cause signal crosstalk and communication failure. Solutions include placing VDD or GND between the two signal lines to separate them, and using shielded cables. Additionally, reducing the SCL frequency may improve signal transmission integrity.

To improve sensor reliability, avoid routing or copper-clad designs on the bottom of the sensor during PCB routing.

2.2.5 Materials Used for Sealing and Encapsulation

In some application scenarios, certain materials may absorb and slowly release moisture, thus weakening the response characteristics of the AHT40. Therefore, the materials surrounding the AHT40 should be carefully selected. Recommended materials include: metals, LCP, POM (Delrin), PTFE (Teflon), PE, PEEK, PP, PB, PPS, PSU, PVDF, and PVF.

For AHT40 applications requiring adhesive sealing or bonding processes, epoxy encapsulants, silicone greases, polyurethane sealants, and UV-curable encapsulants are recommended. Note that the gases released by these materials may contaminate the sensor (see 2.2.5). Therefore, in the assembly processes involving the AHT40, good ventilation or drying at 60 ° C should be ensured to release residual odors.

2.2.6 Precautions

Do not use the sensor in corrosive gases or where condensation occurs.

3 Pin definition

Table 5. Pin of AHT40

Pin	Name	Description
1	SDA	Serial data
2	SCL	Serial clock
3	VDD	Power supply voltage
4	GND	power ground

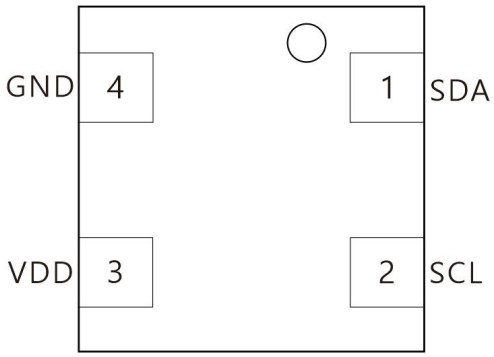


Figure 14. bottom view

3.1 Serial Clock (SCL)

SCL is used for communication synchronization between the microprocessor and the AHT40. Since the interface contains completely static logic, there is no minimum SCL frequency.

3.2 Serial Data (SDA)

The SDA pin is used for data input and output to the sensor. When a command is sent to the sensor, SDA is valid on the rising edge of the serial clock (SCL), and must remain stable while SCL is high. The SDA value can be changed after the falling edge of SCL. To ensure communication security, the valid duration of SDA should be extended to T_{SU}[5] and T_{H0}[6] before the rising edge and after the falling edge of SCL, respectively, as shown in Figure 16. When reading data from the sensor, SDA generates a valid signal after SCL goes low and remains valid until the next falling edge of SCL.

[5] T_{SU} refers to the minimum time that data needs to be stable before the clock signal edge arrives, i.e., the trigger setup time.

[6] T_{H0} refers to the minimum time that data needs to be held after the clock signal edge arrives, i.e., the flip-flop hold time.

4 Dimension

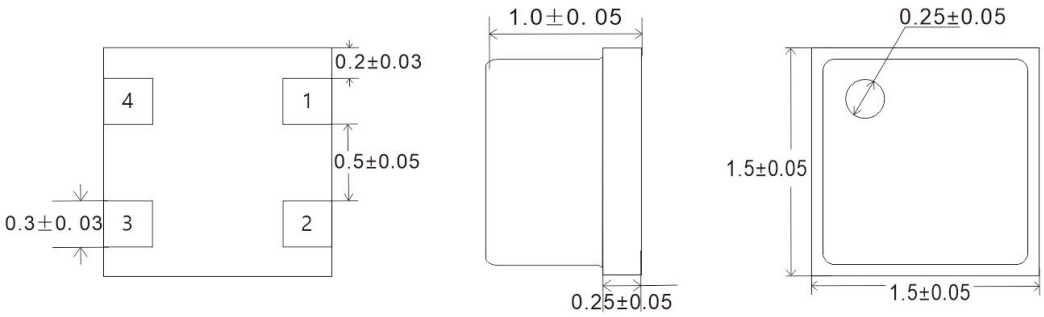


Figure 15. AHT40 sensor package diagram (unit: mm)

5 Electrical Characteristics

5.1 Absolute Maximum Ratings

The electrical characteristics of the sensor are defined in Table 2. The absolute maximum ratings given in Table 6 are only stress ratings and provide further information. Functional operation under these conditions is not advisable. Prolonged exposure to absolute maximum ratings may affect the reliability of the sensor.

Table 6. Absolute Maximum Electrical Ratings

Parameter	MINIMUM	MAX	UNIT
VDD to GND	-0.3	5.5	V
Digital I/O pins to GND	-0.3	VDD+0.3	V
Pin input current	-10	10	mA

The electrostatic discharge complies with JEDEC JESD22-A114 standard (human body mode ±4kV) and JEDEC JESD22-A115 standard (machine mode ±200V). If the test conditions exceed the nominal limits, the sensor requires additional protection circuitry.

5.2 Input/Output Characteristics

Electrical characteristics, such as power consumption, high and low level voltages of the input and output, depend on the power supply voltage. Thicker SDA lines are controlled by the sensor, while standard SDA lines are controlled by the micro controller. To ensure smooth sensor communication, note that the effective SDA readout time is triggered by the falling edge of the previous transition. Ensure that the signal design is strictly limited to the ranges given in Tables 7 and 8 and Figure 16.

Note: Unless otherwise stated, VDD = 2.2V to 5.5V, T = -40℃ to 120℃.

Table 7. DC Characteristics of Digital Input/Output Pads

Parameter	Condition	MINI	TYPICAL	MAX	UNIT
Output low voltage V_{OL}	VDD=3.3V	0	-	0.4	V
Output high voltageV_{OH}	-	70%VDD	-	VDD	V
Input low voltage V_{IL}	-	0	-	30%VDD	V
Input high voltage V_{IH}	-	70%VDD	-	VDD	V
Output low current I_{OL}	-	-4	-	0	mA

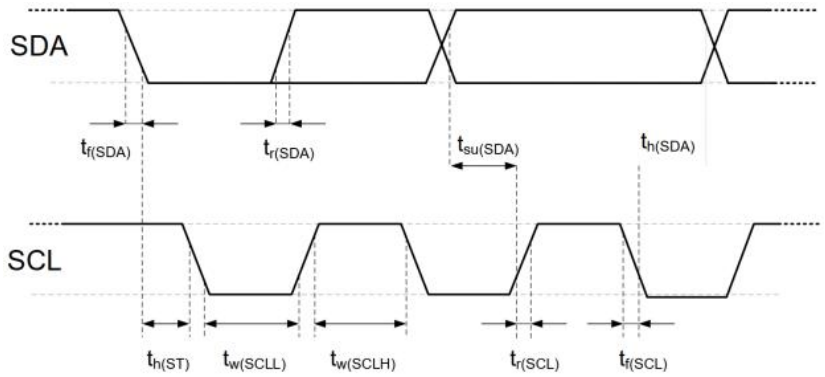


Figure 16. Timing Diagram of Digital Input/Output Terminals

Table 8. Timing Characteristics of I^2C Fast Mode Digital Input/Output Terminals. The specific meanings are shown in Figure 16.

Mark	Parameter	I^2C standard model		I^2C high speed model		Unit
		MINI	MAX	MINI	MAX	
tf(SCL)	SCL clock frequency	0	100	0	400	kHz
tw(SCLL)	SCL low level time	4.7	\	1.3	\	μm
tw(SCLH)	SCL High level time	4.0	\	0.6	\	μm
tsu(SDA)	SDA Startup time	250	\	100	\	ns
t_h(SDA)	SDA Data retention time	0.09	3.45	0.02	0.9	μm

6 Sensor Communication

The AHT40 uses the standard I²C communication protocol. Device address: 0x44.

6.1 Sensor I²C Protocol Timing and Command Format

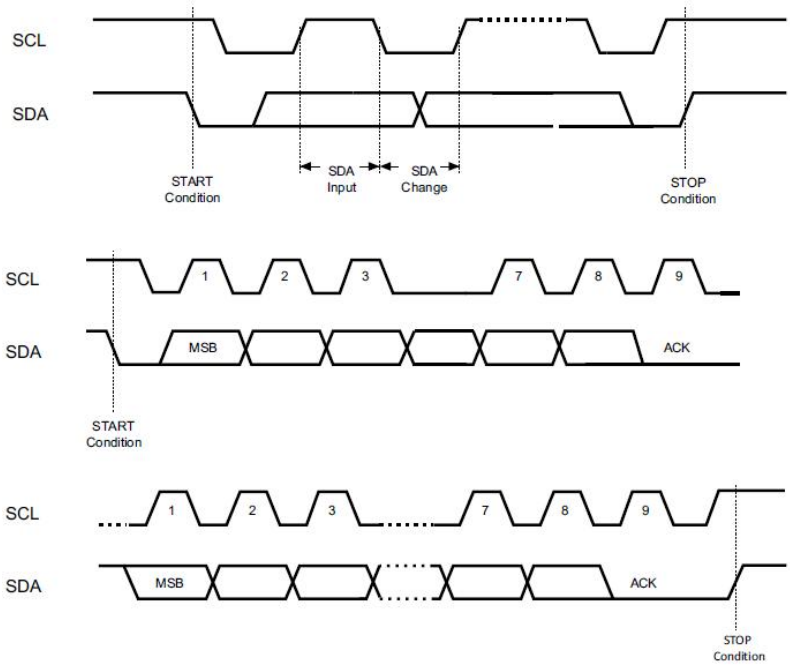


Figure 17. I²C bus timing diagram

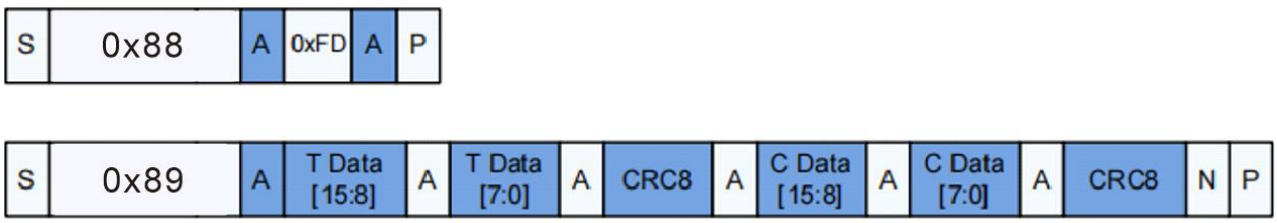


Figure 18. Command to read temperature and humidity calibration values

6.2 Sensor Measurement Procedure

1) Send Measurement Command: After the sensor's VDD is powered on, wait 5ms, then send the 0x88 write measurement command (0xFD), and wait 80ms for the measurement to complete;

2) Obtain Temperature and Humidity Calibration Data: After waiting 80ms for the measurement to complete, send the 0x89 read sensor command to obtain the temperature calibration data T DATA[15:0], humidity calibration data C DATA[15:0], and calibration word CRC8;

3) CRC Verification:

The measured temperature calibration data T DATA[15:0] and humidity calibration data C DATA[15:0] are subjected to CRC8 verification. The initial CRC value is 0xFF, and the CRC8 check polynomial is: $CRC[7:0]=1+x^4+x^5+x^8$, CRC calculation code is as follows:

```
//*************************************************************//
//CRC Validation type：CRC8
//Polynomial:X8+X5+X4+1
//Poly:0011 0001 0x31
unsigned char Calc_CRC8(unsigned char *message,unsigned char Num)
{
   unsigned char i;
   unsigned char byte;
   unsigned char crc =0xFF;
   for (byte = 0;byte<Num;byte++)
   {
    crc^=(message[byte]);
    for(i=8;i>0;--i)
     {
       if(crc&0x80)
          crc=(crc<<1)^0x31;
       else
          crc=(crc<<1);
     }
   }
Return crc;
}
//*************************************************************//
```

4) Calculate temperature and humidity values:

Relative humidity conversion formula:

$$\text{Cap}[\%] = -6 + \frac{C[15:0]}{65535} \cdot 125$$

Temperature conversion formula:

$$\text{Temperature}[℃] = -45℃ + \frac{T[15:0]}{65535} \cdot 175℃$$

Example: T[15:0]：0x2FFAConvert to decimal number 12282，T=(12282/65535)*175-45=-12.2℃

Note: The sensor needs time to collect data. After the host sends the measurement command (0x88, 0xFD), if there is no 80ms delay, the status word Bit7 may be 1. At this time, the temperature and humidity data read is the temperature and humidity data of the previous measurement command. After the sensor completes the measurement, it will enter a sleep state until it is woken up during the next communication.

7 Environmental Stability

If the sensor is used in equipment or machinery, ensure that the sensor used for measurement senses the same temperature and relative humidity conditions as the reference sensor. If the sensor is placed in equipment, the response time will be prolonged; therefore, sufficient measurement time must be allowed in the program design. The sensor is tested according to the Auson temperature and humidity sensor enterprise standard. We do not guarantee the sensor's performance under other test conditions, and this performance should not be considered part of the sensor's overall performance. In particular, no commitment is made regarding specific user requirements.

8 Packaging

Packaging is done in roll-type anti-static bags, 10,000 pieces per roll (Figure 18). The outer anti-static bag is labeled, as shown in Figure 19, and provides tracking information.

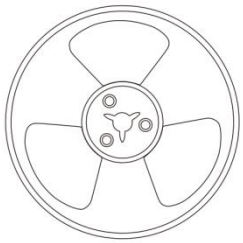


Figure 18. Reel



Figure 19. Label on the antistatic bag

Warnings and Personal Injury

Do not use this product with safety protection devices or emergency stop equipment, or in any other application where a malfunction of this product may result in personal injury, unless specifically intended or authorized. Refer to the product datasheet and instruction manual before installing, handling, using, or maintaining this product. Failure to follow these recommendations may result in death or serious personal injury. The company will not be liable for any personal injury or death arising therefrom, and will disclaim all claims against the company's management, employees, affiliated agents, distributors, etc., including all costs, claims fees, attorney fees, etc.

Quality Assurance

Guangzhou Aosong Electronic Co., Ltd. provides a quality guarantee (calculated from the date of shipment) to its direct purchasers of products as shown in the table below, based on the technical specifications stated in the Aosong Electronic product instruction manual. If the product is found to be defective during the warranty period, the company will provide free repair or replacement services.

Product	Warranty
AHT40 temperature and humidity sensor	12 months

This company is only responsible for products that exhibit defects when used in accordance with the product's technical specifications. This company makes no warranty regarding product application in non-recommended special scenarios. This company also makes no commitment regarding the reliability of the product when used in other non-company-supplied products or circuits.

This manual is subject to change without notice.

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