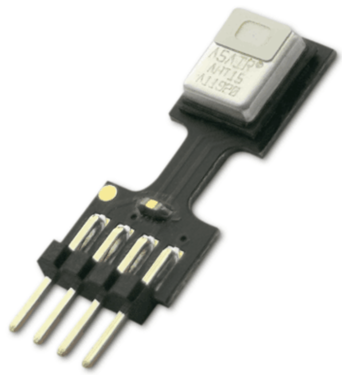
AHT15 Technical Manual

Temperature and Humidity Sensor

- •Full calibration
- •Digital output, I²C interface
- •Excellent long-term stability
- •Quick response and strong anti-jamming capability



Product Overview

AHT15 temperature and humidity sensors use standard pitch plug connectors for easy replacement in applications. In terms of protective performance, AHT15 uses PTFE film with waterproof and dust-proof performance without affecting RH signal response time.Therefore, it allows the sensor to be used in severe environmental conditions to ensure the best accuracy performance, making AHT15 the best choice in the most demanding application conditions. Each sensor is rigorously calibrated and tested. Because of improved sensors and miniaturization, it is more cost-effective.

Application Scope

HVAC system, dehumidifier, test and inspection equipment, consumer goods, automobiles, automatic control, data recorder, weather station, household appliances, humidity regulation, medical and other related temperature and humidity detection and control.

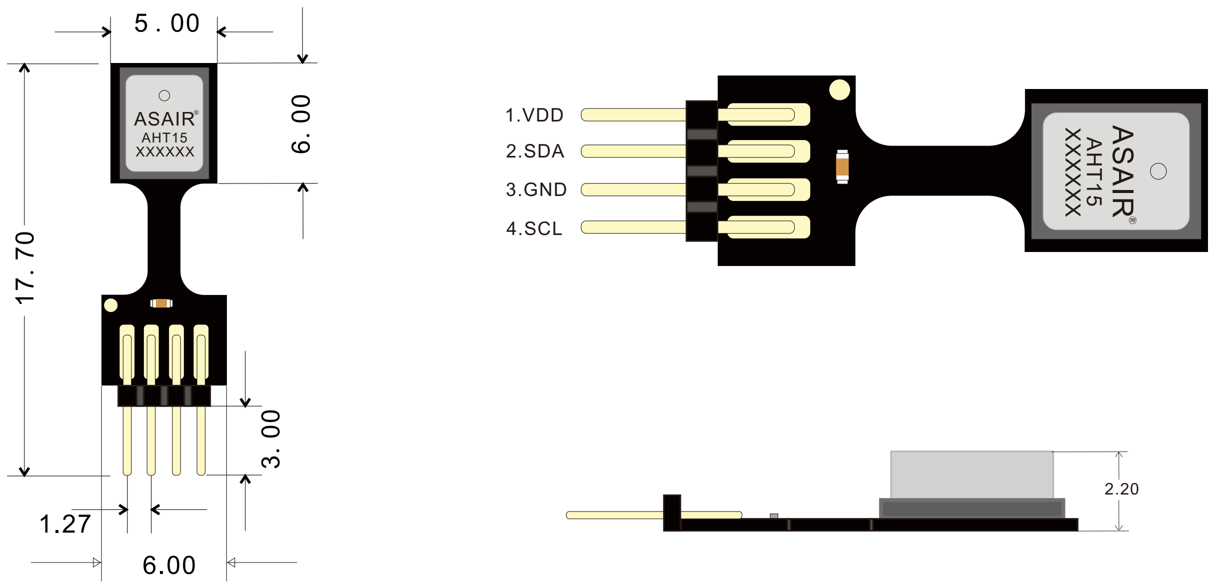


Figure 1: AHT15 Sensor Package Diagram (Unit: mm Tolerance: 0.1 mm)

Sensor Performance

Relative Humidity

Parameter	Condition	Min	Typical	Max	Unit
Resolution ratio	Typical		0.024		%RH
Accuracy error[1]	Typical		±2		%RH
	Max	See Figure 2			%RH
Repeatability			±0.1		%RH
Hysteresis			±1		%RH
Nonlinear			<0.1		%RH
Response time[2]	t 63%		8		S
Scope of work	extended[3]	0		100	%RH
Long time drift[4]	Normal		<0.5		%RH/yr

Table 1 Humidity Characteristic

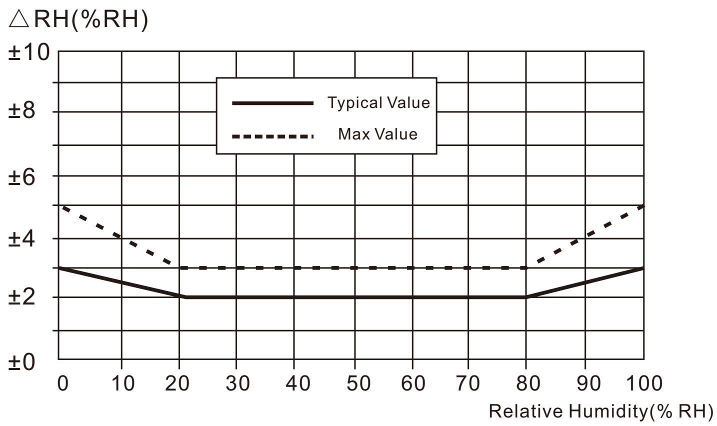


Figure 2 The maximum error of relative humidity at 25°C

Temperature

Parameter	Condition	Min	Typical	Max	Unit
Resolution ratio	Typical		0.01		℃
Accuracy error[1]	Typical		±0.3		℃
	Max	See Figure 3			℃
Repeatability			±0.1		℃
Hysteresis			±0.1		℃
Response time[6]	t 63%	5		30	S
Scope of work	extended[3]	-40		80	℃
Long time drift			<0.04		℃/yr

Table 3 Temperature Characteristic

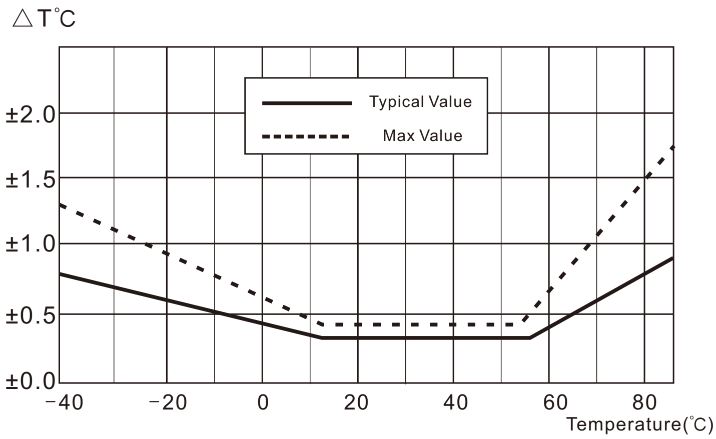


Figure 3 Typical error and maximum error of temperature

Electric Specification

Parameter	Condition	Min	Typical	Max	Unit
Voltage	Typical	1.8	3.3	3.6	V
Current, IDD[5]	Dormant	-		0.25	μA
	Measure		23		μA
Power consumption[5]	Dormant	-		0.9	μW
	Measure		0.07		mW
	Average	-	3.3	-	μW
Communication	Two-line digital interface, standard I^2C protocol				

Table 2 Electric Specification

Package Information

Sensor Model	Package	Quantity
AHT15	Tape package	2000PCS/Roll

Table 4 Package

[1] This precision is the test precision of the sensor with 3.3V voltage at 25℃ excluding hysteresis and nonlinearity, and only suitable for non-condensation conditions.

[2] The time required to reach 63% of the first-order response under the conditions of 25℃ and 1 m/s air flow.

[3] Normal working scope: 0 - 80% RH. Sensor reading will be deviated if beyond this range, (drift < 3% RH after 200 hours at 90% RH humidity). The working scope is further limited to - 40– 80℃.

[4] If the sensor is surrounded by volatile solvents, irritating tapes, adhesives and packaging materials, the reading may be higher. For more information, please refer to the relevant documents.

[5] The minimum and maximum of supply current and power consumption are based on the conditions of VDD = 3.3 V and T < 60 ℃. The average value is value measured every two seconds.

[6] The response time depends on the thermal conductivity of the sensor substrate.

AHT15 User Guide

1 Expansion of performance

1.1 Working Conditions

The sensor performance is stable in the suggested working scope, as shown in Figure 4. Long-term exposure to abnormal scope, especially when humidity > 80%, may lead to temporary signal drift (drift + 3% RH after 60 hours). When the sensor is restored to normal working conditions, it will slowly restore itself to the correct state. Refer to Recovery Processing in Section 2.3 to speed up the recovery process. Long-term use under abnormal conditions will accelerate the aging of products.

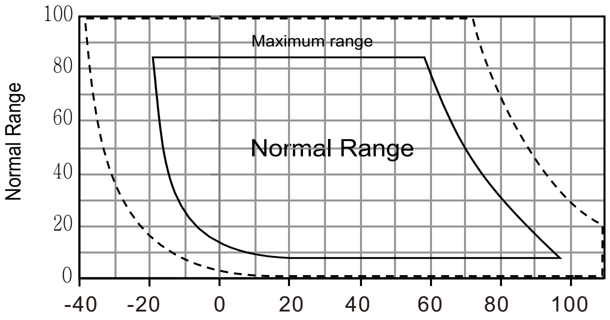


Figure 4 Working Conditions Temperature (°C)

1.2 RH Accuracy at Different Temperatures

The RH accuracy at 25°C is defined in Fig. 2, and the maximum humidity error at other temperatures is shown in Fig. 5.

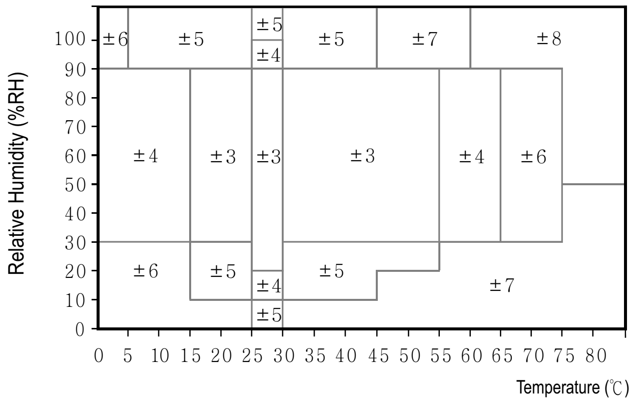


Figure 5 Maximum humidity error between 0~80 °C, unit: (% RH)

Note: Above errors are the tested maximum errors (excluding hysteresis) with the high precision dew-point instrument as reference instrument. The typical error is± 2 % RH with the range of maximum error. In other scopes, the typical value is 1/2 of the maximum error.

1. 3 Electric Specification

The power consumption given in Table 1 is related to temperature and supply voltage VDD. Estimated power consumption, see Figures 6 and 7. Note that the curves in Figures 6 and 7 are typical natural characteristics andmay have deviations

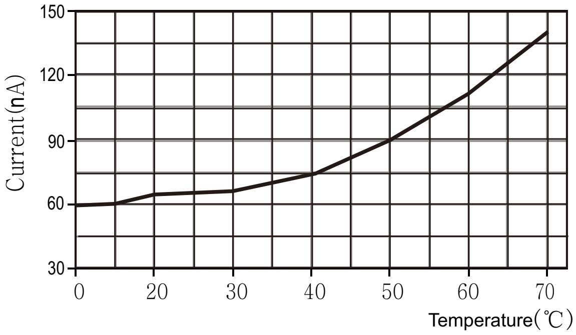


Figure 6 When VDD = 3.3V, the typical relationship between supply current and temperature (dormancy mode). Please note that there is a deviation of about ± 25% with the display value.

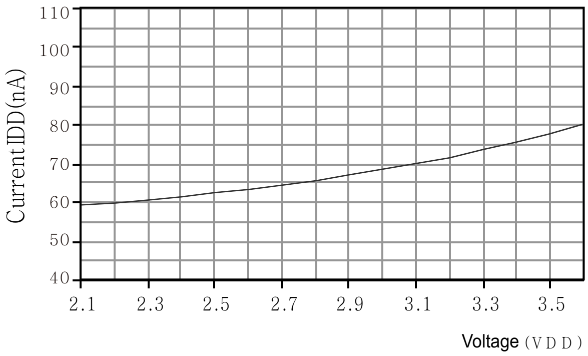


Figure 7 shows the typical relationship between supply current and voltage (dormancy mode) at 25 ℃. Please be noted that the deviation between these data and the display value may reach ± 50 % of the display value. At 60 ℃, the coefficient is about 15. (Compared with Table 2).

2 Application Information

2. 1 Welding Specification

Reflow or wave soldering is prohibited. Manual welding at the highest temperature of 350 ℃ under the condition of contact must be less than 5 seconds.

Note: After welding, the sensor should be stored in the environment of > 75% RH for at least 12 hours to ensure the re-hydration of the polymer. Otherwise, it will cause sensor reading drift. The sensor can also be placed in a natural environment (> 40% RH) for more than five days to re-hydrate.Hydration time can be reduced by using low temperature reflow welding (e.g.180℃).
If the sensor is applied to corrosive gases, condensate water may be produced (e.g. in high humidity environment), both pin pads and PCB need to be sealed (e.g. using conformal coating) to avoid poor contact or short circuit.

2.2 Storage conditions and instructions

The humidity sensitivity level (MSL) is 1, according to IPC/JEDEC J-STD-020 standard. Therefore, it is recommended to use it within one year after delivery.

Humidity sensor is not an ordinary electronic component, and it needs careful protection, which users must pay attention to. Long-term exposure to high concentration of chemical vapor will cause the sensor reading to drift.
Therefore, it is recommended that the sensor be stored in the original package including sealed ESD bag, and meet the following conditions: temperature range 10℃ - 50℃ (0 - 85℃ in a limited time), humidity 20 - 60% RH (no ESD packaged sensor). For sensors that have been removed from the original package, we recommend that they be stored in antistatic bags made of metal PET / AL / CPE.

During production and transportation,sensors should avoid exposure to high concentration of chemical solvents and prolonged exposure. Avoid exposure to volatile glue, adhesive tape, stickers or volatile packaging materials, such as foamed foil, foam material, etc. The production area should be well ventilated.

2.3 Recovery processing

As mentioned above, if the sensor is exposed to extreme working conditions or chemical vapor, the reading will drift. It can be restored to the calibration state by processing as follows.
Drying: Keep for 10 hours at 80 - 85℃ and < 5% RH humidity.
Rehydration: Keep for 12 hours[7] at 20 - 30℃ with the humidity of more than 75 % RH.

[7] 75 % RHIt can be easily generated from saturated Na Cl.

2.4 Temperature Influence

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 tested sensors and reference sensors are at the same temperature, and then compare the humidity readings.

If the sensor and the heating-prone electronic components are placed on the same printing circuit board, measures should be taken to minimize the effect of heat transfer as far as possible in the design of the circuit.For example, to maintain good ventilation of the shell, the copper coating of AHT15 and other parts of the printed circuit board should be as smallest as possible, or leave a gap between them. (See Fig. 10)

2.5 Material used for sealing and encapsulation

Many materials absorb moisture and act as buffer, which will increase response time and hysteresis. Therefore, the material around the sensor should be carefully selected. Recommended materials are: metal materials, LCP, POM (Delrin), PTFE (Teflon), PE, PEEK, PP, PB, PPS, PSU, PVDF, and PVF. Material for sealing and bonding (conservative recommendation): It is recommended to use method of filling epoxy resin or silicone resin for packaging electronic components. Gases released from these materials may also contaminate AHT15 (see 2.2). Therefore, the sensor should be finally assembled and placed in a well-ventilated place, or dried for 24 hours in an environment of > 50℃, in order to release the contaminated gas before packaging.

2.6Wiring rules and signal integrity

If SCL and SDA signal lines are parallel and very close to each other, they may cause signal crosstalk and communication failure. The solution is to place VDD and/or GND between the two signal lines, separate the signal lines and use shielded cables. In addition, reducing SCL frequency may also improve the integrity of signal transmission. A 100nF decoupling capacitor must be added between the power supply pin (VDD, GND) for smoothing.This capacitor should be as close to the sensor as possible. See the next chapter.

3 Interface Definition

Pin	Name	Definition
1	VDD	Power supply(1.8-3.6V)
2	SDA	Serial data, bidirectional
3	GND	Power ground
4	SCL	Serial clock

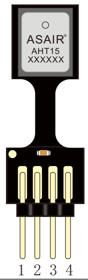


Table 5 AHT15 Distribution of pins（Top View）

3.1 Power Pins (VDD,GND)

The power supply range of AHT15 is 1.8-3.6V, and the recommended voltage is 3.3V. A 100nF decoupling capacitor should be connected between the power supply (VDD) and the ground (GND) and the capacitor should be located as close as possible to the sensor - Reference to Figure. 8

3.2 Serial clock SCL

SCL is used to synchronize the communication between microprocessor and AHT15. Because the interface contains complete static logic, there is no minimum SCL frequency.

3.3 Serial data SDA

SDA pins are used for data input and output of sensors. When sending commands to sensors, SDA is valid at the rising edge of serial clock (SCL), and SDA must remain stable when SCL is high level. After the descending edge of SCL, the SDA value can be changed. To ensure communication safety, the effective time of SDA should be extended to TSU and THO respectively before SCL rising edge and after SCL falling edge - refer to Figure. 9. When the data is read from the sensor, SDA is valid (TV) after the SCL decreases and maintains the descent edge of the next SCL.

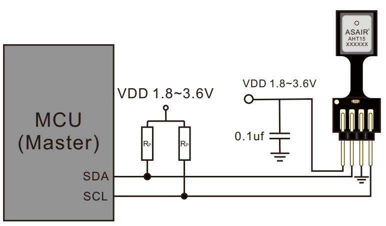


Figure 8.Typical application circuits including pull-up resistance RP and decoupling capacitance between VDD and GND.

Note:
1. The supply voltage of MCU of main engine must be the same as that of the sensor when the product is used in the circuit.
2. If the reliability of the system needs to be further improved, the power supply of the sensor can be controlled.
3. I^2C bus can only connect a single AHT15, and cannot connect other I^2C devices.

To avoid signal collision, MCU must only drive SDA and SCL at low levels.An external pull-up resistor (e.g.10kΩ) is needed to lift the signal to a high level. The pull-up resistance may have been included in the MCU's I/O circuit. Detailed information about sensor input/output characteristics can be obtained by referring to tables 7 and 8.

4 Electric Specification

4. 1 Absolute Maximum Rating

The electric specifications of AHT15 are defined in Table 2. The absolute maximum ratings given in Table 6 are only stress ratings and to provide more information. Under such conditions, it is not advisable for the device to perform functional operation. Exposure to absolute maximum rating for a long time may affect the reliability of the sensor.

Parameters	Min	Max	Unit
VDD to GND	-0.3	3.6	V
Digital I/O pin (SDA, SCL) to GND	-0.3	VDD + 0.3	V
Input current for each pin	-10	10	mA

Table 6 Absolute maximum electric rating

ESD electrostatic discharge conforms to JEDEC JESD22-A114 standard (human body mode ±4kV) and JEDEC JESD22-A115 (machine mode±200V). If the test condition exceeds the nominal limit, the sensor needs additional protection circuit.

4.2 Input/output characteristics

Electric specifications include power consumption, high and low voltage of input and output, voltage of power supply. In order to make the sensor communication smooth, it is important to ensure that the signal design is strictly limited to the range given in Tables 7, 8 and Figure 9.

Parameter	Condition	Min	Typical	Max	Unit
Output low voltage VOL	VDD = 3.3 V, -4 mA < IOL < 0mA	0	-	0.4	V
Output high voltage VOH		70% VDD	-	VDD	V
Output sink current IOL		-	-	-4	mA
Input low voltage VIL		0	-	30% VDD	V
Input high voltage VIH		70% VDD	-	VDD	V
Input current	VDD = 3.6 V, VIN = 0 V to 3.6 V	-	-	±1	uA

Table 7.Direct current characteristics of DIO pads, if without special declaration, VDD = 1.8V to 3.6V, T = -40 °C to 80 °C.

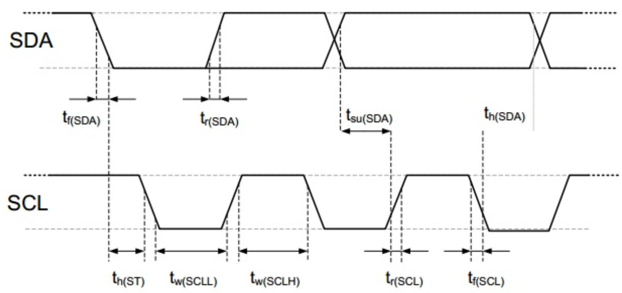


Figure 9.The sequence diagrams and abbreviations of digital input/output are explained in Table 8. Thicker SDA lines are controlled by sensors, and ordinary SDA lines are controlled by single chip computer. Please be noted that the effective read time of SDA is triggered by the drop edge of the previous conversion

Parameter	Mark	I²C Typical Mode		I²C High speed mode		Unit
		MIN	MAX	MIN	MAX	
I2Cclock frequency	fSCL	0	100	0	400	KHz
Initial signal time	tHDSTA					μs
SCL Clock High Level Width	tHIGH	4. 7		1. 3		μs
SCL Clock Low Level Width	tLOW	4. 0		0. 6		μs
Data save time relative to SCL SDA edge	tHDDAT	0. 09	3. 45	0. 02	0. 9	μs
Data Setting Time Relative to SCL SDA Edge	tSUDAT	250		100		μs

Note: Both pins are measured from 0.2 VDD and 0.8 VDD.
Note: The above I²C time serial is determined by the following internal delays:
(1)The internal SDI input pins are delayed relative to SCK pins with a typical value of 100ns.
(2)The internal SDI output pin is delayed relative to SCK failing edge with a typical value of 200 ns.

Table 8. I²C Sequence Characteristics of Digital Input/output in fast Mode. The specific meaning is shown in Figure 9. Unless otherwise indicated

5 Sensor Communication

AHT15 adopts standard I²C protocol to communicate. For information on the I²C protocol except the following chapters, please refer to the following website: www.aosong.com for sample reference.

5.1 Start Sensor

Step 1: Make the sensor power on with selected voltage of VDD power supply voltage (ranging from 1.8 V to 3.6 V). When the sensor is powered on, it takes 20 milliseconds at most (the SCL is high level) to enter idle state, that is, to be ready to receive commands sent by MCU.

5.2 Timing sequence of start/stop

Each transport sequence starts with the Start state and ends with the Stop state,as shown in Figures 10 and 11.

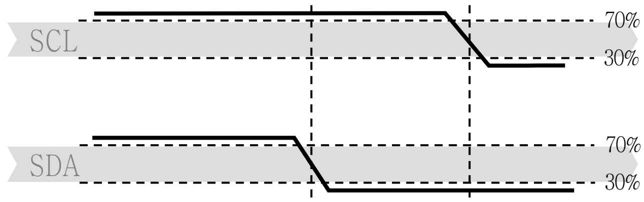


Figure 10.Start Transmit State (S) - When SCL is at high level, SDA is converted from high level to low level. The start state is a special bus state controlled by the main engine, indicating the start of slave machinetransit (after Start, BUS is generally considered to be in a busy state).

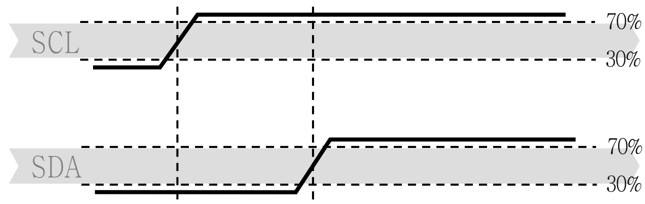


Figure 11.Stop Transmit State (P) - When the SCL is at high level, the SDA line is converted from low level to high level. Stop state is a special bus state controlled by the main engine, indicating the end of slave machine transmit (after Stop, BUS is generally considered to be in idle state).

5. 3 Send Command

After transmit is started,the I^2C first byte of the transmitted afterwards includes a 7-bit I^2C device address 0x38 and an SDA direction bit (read as R:'1' and written as W:'0').After the 8th SCL clock falling edge,it is indicated that the sensor data is received normally by lowering the SDA pin (ACK bit). After issuing the initialization command, ('1110'0001' refers to initialization, and '1010'1100' refers to temperature and humidity measurement),the MCU must wait for the measurement to be completed.The basic commands are summarized in Table 9 and the status bits returned from the machine is illustrated in Table 10.

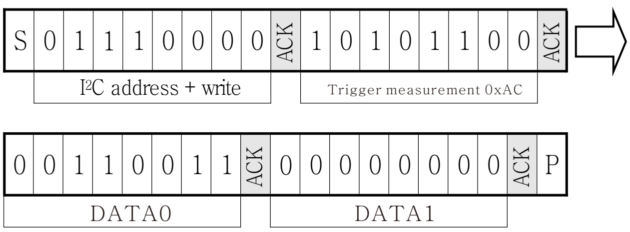
Command	Definition	Code
Initialization	Keep main engine	1110'0001
Trigger Measurement	Keep main engine	1010'1100
Soft reset		1011'1010

Table 9 Basic Commands

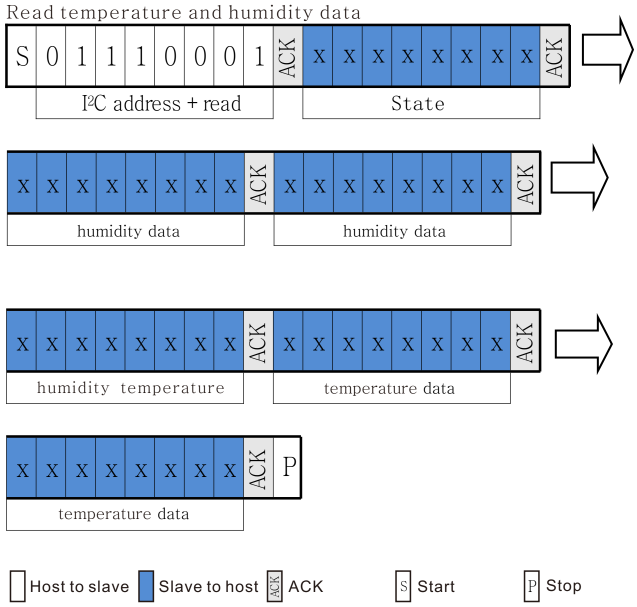
Bit	Definition	Description
Bit[7]	(Busyindication)	1 -- Busy in measurement 0 -- Free in dormant state
Bit[6:5]	(ModeStatus)	00 in NOR mode 01 in CYC mode 1x in CMD mode
Bit[4]	Remained	Remained
Bit[3]	CAL Enable	1--calibrated 0--uncalibrated
Bit [2: 0]	Remained	Remained

Table 10. State bit description.

Trigger measurement data



Read temperature and humidity data



Note: The sensor takes time to collect data. After the host sends out the measurement command (0 x AC), it delays more than 75 milliseconds to read the converted data and judge whether the returned status bits are normal. If the state bit [Bit 7] is 0, the data can be read normally, and 1 represents that the sensor is busy, the host needs to wait for data processing to complete.

5. 4 Soft Reset

This command (see Table 9) is used to restart the sensor system without having to turn off and turn on the power again. After receiving this command, the sensor system starts to reinitialize and restore the default settings. Soft reset takes no more than 20 milliseconds.

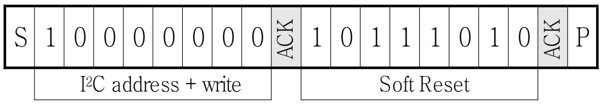


Figure 12. Soft Reset– The grey part is controlled by AHT15.

6 Signal Transformation

6. 1 Relative humidity transformation

Relative humidity RH can be calculated according to the relative humidity signal SRH output from SDA by the following equation.
(The result is expressed in% RH)

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

6. 2 Temperature transformation

Temperature T can be calculated by substituting the temperature output signal ST into the following formula.(The results are expressed as temperature°C):

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

7 Environmental stability

If the sensor is used in equipment or machinery, please make sure that it is the same temperature and humidity that the sensor used for measurement and the sensor used for reference that have sensed. If the sensor is placed in the equipment, the reaction time will be prolonged, so it is necessary to ensure that sufficient measurement time is reserved in the programming. The AHT15 sensor is tested according to the enterprise standard of Aosong temperature and humidity sensor. The performance of sensors under other test conditions is not guaranteed and cannot be regarded as a part of sensor performance. Especially for the specific occasions required by users, we do not make any commitments.

8 Package

8.1 Trace Information

All AHT15 sensors have laser labels on their surfaces. See Figure 13.

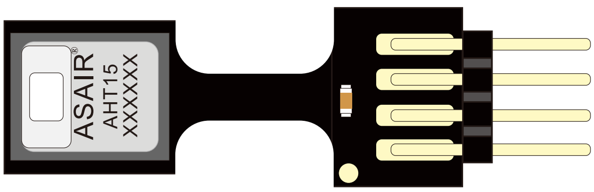


Figure 13 sensor laser label

A label is also attached to the tape, as shown in Figure 14, and other trace information is provided.

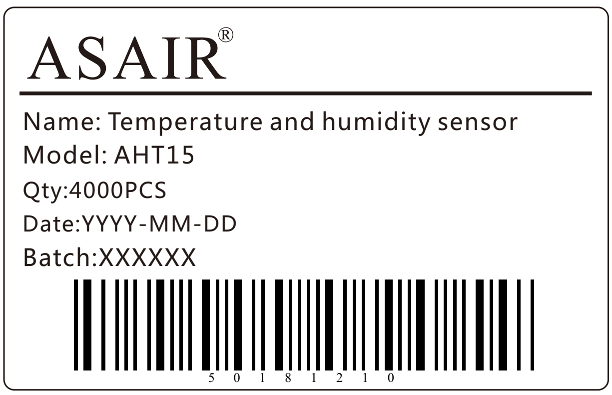


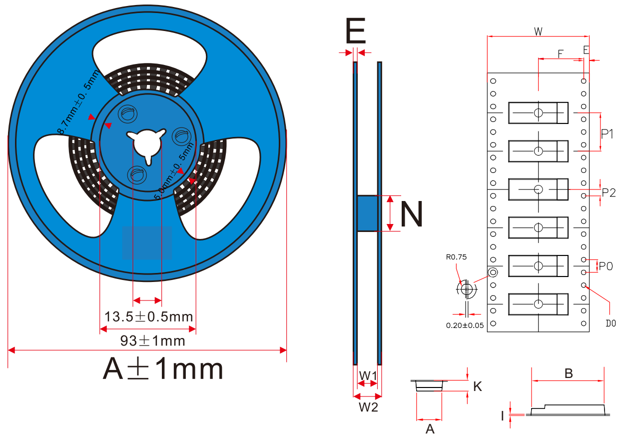
Figure 14 : Label on the tape

8.2 Transport Package

AHT15 is packed in coiled tape and sealed in antistatic ESD bags. The standard packing size is 2000 pieces per roll. For AHT15 packaging, the last 240 mm (20 sensor capacity) and first 240 mm (20 sensor capacity) of each roll are empty packaging.The weight of a single sensor is about 181mg, and the total weight of a plate is about 870g.

The package diagram with sensor positioning is shown in Figure 15. The reel is placed in the antistatic pocket.

Model	A	E	W1	W2	N	Unit	Tolerance	Quantity	Weight
AHT15	330	2	32	36	100	mm	±0.5	2000	about 870g



Model	A	B	ΦD0	K	W	P0	P1	P2	I	F	E
AHT15	6.3±0.1	18. 4±0.1	$1.5^{+0.1}_{-0}$	2.3±0.1	32.0±0.3	4.0±0.1	12.0±0.1	2.0±0.1	0. 3±0.05	14.2±0.1	1. 75±0.1

Figure 15 Package tape and sensor location diagram

Version

Date	Version	Page	Alteration
2018/11	V1.0	1-9	Initial Version

This manual is likely to change sometime without prior notice.

Attention

Warning of personal injury

Do not apply this product to safety protection devices or emergency stop equipment, as well as any other applications that may cause personal injury due to the failure of the product. This product cannot be used unless there is a special purpose or with an authorization to use it. Please refer to the product data sheet and Application guide before installing, processing, using or maintaining the product. Failure to comply with this recommendation may result in death and serious bodily injury.

If the Buyer intends to purchase or use the Aosong products without any application license and authorization, the buyer shall bear all compensation for personal injury and death resulting therefrom, and shall not claim for compensation including various costs, compensation fees, lawyers, etc. Expenses and so on with the managers and employees of Aosong Company, as well as subsidiaries, agents, distributors, etc.

ESD Protection

Due to the inherent component design, it is sensitive to static electricity. In order to prevent the damage and the reduction of the product's performance caused by static electricity, the necessary anti-static measures should be taken when applying this product.

Quality Assurance

Our company provides 12-month (1-year) quality assurance for buyers of its products (calculated from the date of delivery) based on the technical specifications in the data manual of the product published by Aosong. If the product is found to be defective under warranty, our company will provide free maintenance or replacement. Users need to satisfy the following conditions:

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

Our company is only responsible for the defective products which are used in the occasions that meet the technical requirements of the product. Our company makes no warranties or written representations regarding the use of its products in special application occasions.

At the same time, the company does not make any commitment to the reliability of the products applied to products or circuits.