

Humidity Sensor Application Note

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1. Overview

Humidity is one of the typical parameters in the environment. Describe basic knowledge and calculation formulas, notes on design method and use. This document applies to the humidity sensor HSHC series.

2. Basic knowledge on humidity

2.1. About Humidity

Types of humidity include relative humidity and absolute humidity (volume absolute humidity, volume absolute humidity). In the case of humidity in daily life, it mainly shows relative humidity. Our company's humidity sensor is a relative humidity sensor.

2.2. Relative Humidity

Relative humidity is defined as the ratio of water vapor pressure (water vapor pressure of the environment) to saturated water vapor pressure. It is 100% RH when the maximum water vapor pressure that the atmosphere can contain, and it is 0% RH when it does not contain moisture.

$$RH [\% RH] = \frac{P}{P_{\max}} \times 100$$

Here, RH represents relative humidity, P [Pa] represents water vapor pressure, and Pmax [Pa] represents saturated water vapor pressure.

2.3. Absolute Humidity

2.3.1 Volumetric humidity

Volumetric humidity is the amount of water vapor contained in the unit volume of the atmosphere in weight. Volume absolute humidity is calculated from relative humidity and temperature .

$$VH [g / m^3] = \frac{M_w}{V_a}$$

Here, VH represents volume absolute humidity, Va [m³] represents volume, and Mw [g] represents the weight of steam .

2.3.2 Weight absolute humidity

Weight absolute humidity is the ratio when the weight of water vapor contained in humid air is [kg] with respect to the weight [kg] of dry air. Weight absolute humidity is calculated from relative humidity and temperature and atmospheric pressure.

$$SH [kg / kg (DA)] = \frac{M_w}{M_{DA}}$$

Here, SH represents weight absolute humidity, MDA [kg] represents weight of dry air, and Mw [g] represents weight of steam.

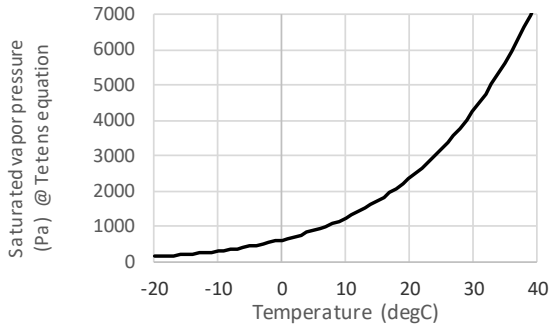
2.4. Saturated vapor pressure

The saturated water vapor pressure is the maximum water vapor pressure (the number of water vapor) that can exist in the atmosphere. Therefore, water vapor with saturated water vapor pressure or less can exist in the atmosphere. The saturated water vapor pressure varies with temperature, the higher the temperature, the larger the saturated water vapor pressure, and the lower the temperature the saturated water vapor pressure becomes smaller.

There are a lot of Tetens' equation, Wagner 's equation, Sonntag' s expression, etc. for calculating the saturated water vapor pressure. As an example, simplified Tetens' equation is shown below.

$$P_{\max} [Pa] = 611 \times 10^{\frac{7.5 \times t}{t+237.3}}$$

Here, Pmax [Pa] is saturated water vapor pressure, and t [° C.] is temperature (environmental temperature).



In the above figure, saturated water vapor pressure does not become zero even at 0 ° C or lower. Water vapor can exist in the air even at 0 ° C. or lower, and humidity also exists.

3. Design guideline

3.1. Product contents

Our company's humidity sensor is analog output type / digital output type and packaged product / module product..

	Output	form	Temp.
Analog package	Voltage	Package	none
Analog module	Voltage	Module	O(*1)
Digital package	I2C	package *	O
Digital module	I2C	Module	O

(*1) Analog module products are equipped with thermistors, use temperature conversion from thermistor resistance.

3.2. Package product design

3.2.1 Shape for vent

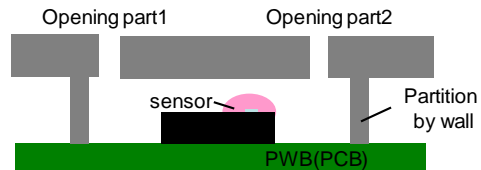
It is important that the environment near the humidity sensor is as close as possible to the external environment .

Recommended design:

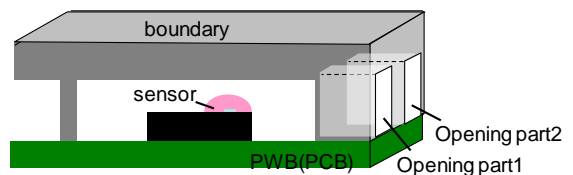
- The opening is made large and plural are formed
- The moisture entrance of the humidity sensor is not provided directly under the opening.
- Separate the area around sensor and the area with heat source.

Opening a large ventilation hole is effective for taking in outside air. It is also preferable to provide a plurality of ventilation holes for circulating the air around the sensor.

Type1



Type2

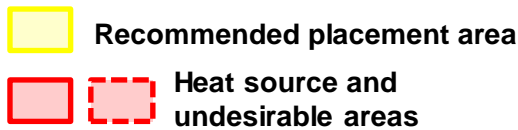
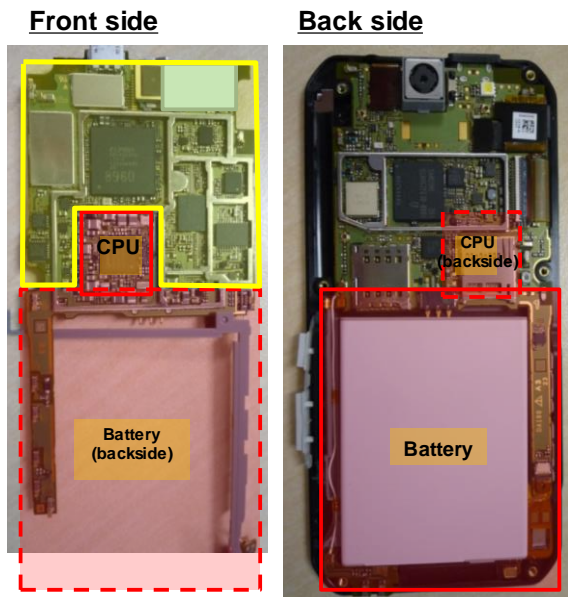


3.2.2 Isolation from heating element

It is important to avoid temperature rise due to the heat source. With temperature rise, the relative humidity decreases.

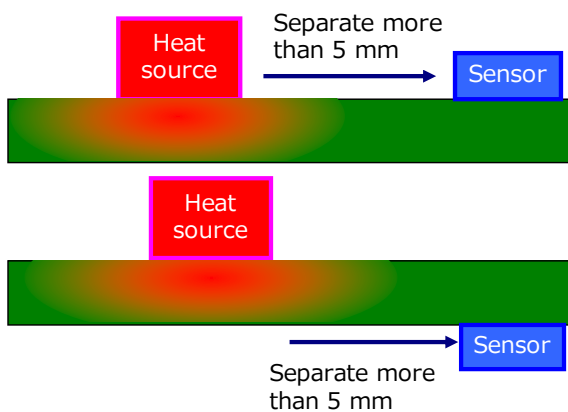
Recommended design:

- Separate the sensor from the heat source as much as possible.
- Keep distance more than 5 mm.



Recommended distance from heat source

Heat source	Recommended distance
CPU	5mm or more
Battery	5mm or more
Power IC	5mm or more



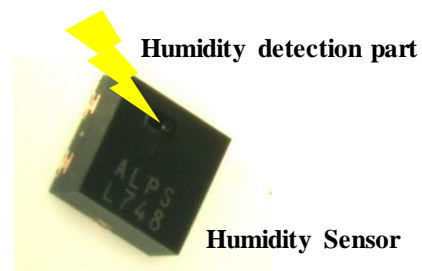
3.2.3 Attention of contamination

Our company's humidity sensor is electrostatic capacity detection type. When contamination adheres to the humidity detection part, the electrostatic capacity changes and characteristics may change in some cases. In particular, it is likely to occur in the case of organic matter contamination such as human skin. Care must be taken not to touch the humidity sensor detection part directly.

To protect the humidity sensor, protective cases and porous films are recommended.

3.2.4 Attention of ESD(ElectroStaticDischarge)

The humidity sensor terminal (PAD) section is resistant to 2 kV @ HBM or more. However, the electrostatic capacitive element of the humidity detection part is exposed to the outside. As a result, if an ESD voltage of 400 V @ HBM or more is applied to the humidity detector, the electrostatic capacitive element may be destroyed and output abnormality sometimes occurs. Care must be taken not to touch the humidity sensor detection part directly.

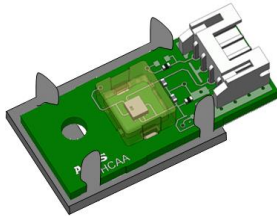


3.3. Module product design

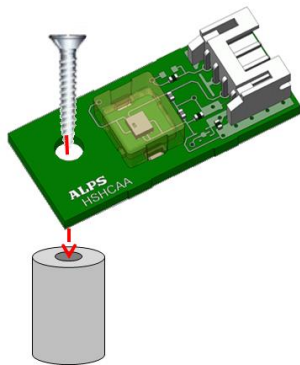
3.3.1 Attachment

Module products have types with and without mounting holes. As a mounting method, both types can be fixed from the side. Also, the type with mounting holes can be screwed.

Method 1: Side fixing



Method 2: Screw fixing



rises and the relative humidity becomes lower than the external environment.

The relative humidity when the sensor temperature changes when the external environment temperature is 25 ° C is shown below.

$$\text{Relative humidity [\% RH]} = \text{Vapor pressure} / \text{Saturated vapor pressure} \times 100$$

Sensor Environment		Temp								
		20oC	22oC	24oC	25oC	26oC	28oC	30oC	30oC	
External Environment	Saturated vapor pressure	2339 Pa	2645 Pa	2986 Pa	3170 Pa	3364 Pa	3783 Pa	4247 Pa	4247 Pa	
	Vapor pressure									
25oC	10%	317 Pa	13.6	12.0	10.6	10	9.4	8.4	7.5	7.5
25oC	20%	634 Pa	27.1	24.0	21.2	20	18.8	16.8	14.9	14.9
25oC	30%	951 Pa	40.7	35.9	31.9	30	28.3	25.1	22.4	22.4
25oC	40%	1268 Pa	54.2	47.9	42.5	40	37.7	33.5	29.9	29.9
25oC	50%	1585 Pa	67.8	59.9	53.1	50	47.1	41.9	37.3	37.3
25oC	60%	1902 Pa	81.3	71.9	63.7	60	56.5	50.3	44.8	44.8
25oC	70%	2219 Pa	94.9	83.9	74.3	70	66.0	58.7	52.2	52.2
25oC	80%	2536 Pa	100.0	95.9	84.9	80	75.4	67.0	59.7	59.7
25oC	90%	2853 Pa	100.0	100.0	95.6	90	84.8	75.4	67.2	67.2

4. Humidity measurement

4.1. Ventilation of measurement environment

In the humidity sensor, response time changes due to air permeability. Poor breathability results in slow response, and quicker breathability results in faster response. Generally, it suffices if sufficient ventilation ports are provided, and there is no need to intentionally circulate air. On the other hand, if the circulation of air is too fast, the probability of contamination adhesion increases.

4.2. Temperature influence of measurement environment

Relative humidity is a physical quantity that changes with temperature. When temperature difference occurs between the external environment (measurement target) and the sensor, it outputs relative humidity according to the sensor temperature. For example, when there is a heat source in the vicinity of the sensor, the temperature of the sensor

For example, when the external environment is 25 ° C. and 50% RH, if the sensor temperature rises by 1 ° C. due to the heat source, the temperature and humidity of the sensor section will be 26 ° C. 47.1% RH and the relative humidity will be about 3% RH lower.

As a countermeasure, it is preferable to keep the distance between the heat source and the sensor away so that it is not affected by heat generation. However, when it is inevitable to avoid the influence of the heat source, the temperature rise due to heat generation is verified beforehand, and the user can numerically correct the temperature rise

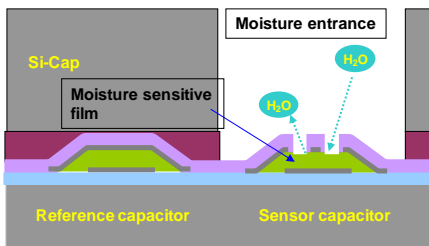
5. Rehydration and offset change

5.1. Humidity sensor structure and principle

Our humidity sensor is capacitance type. There is a physical property in which the moisture absorption of the humidity sensitive film is proportional to the relative humidity. And, the

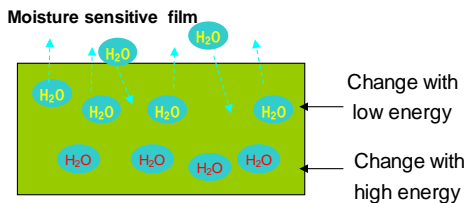
moisture absorption amount is proportional to the electrostatic capacity. And, it is converted into a voltage by the electrostatic capacity-voltage conversion circuit. As a result, the relative humidity is output as a voltage.

Sensor structure



5.2. Moisture absorption of humidity sensor

The output of the humidity sensor varies with the moisture absorption amount. This water absorption is considered to have two states.



One is a state of entering and leaving the interior of the moisture sensitive film depending on the relative humidity even at a low temperature, and it changes with low energy. This is conceptually considered to be the behavior of H₂O molecules near the surface of the moisture sensitive film.

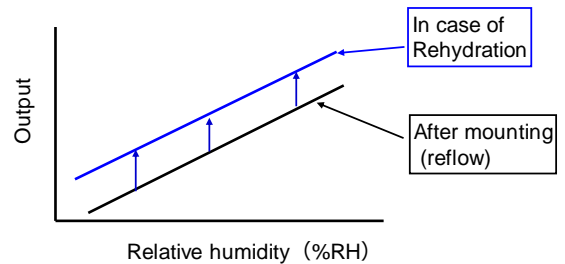
The other is a state of entering and leaving the interior of the humidity sensitive film only in a high temperature environment, and it changes with high energy. Conceptually, this is considered to be the behavior of H₂O molecules in the deep portion in the thickness direction of the humidity sensitive film.

H₂O entering and leaving with low energy is an element that outputs relative humidity, and H₂O

which enters and exits with high energy is considered to be an element of rehydration / offset change described later.

5.3. Rehydration

For packaged products, it is necessary to select and treat whether or not the user will rehydrate.



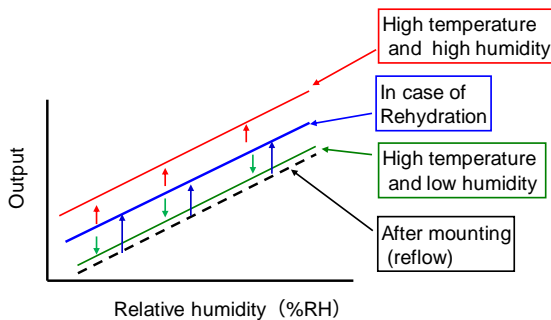
Without rehydration: For packaged products, the user always performs mounting (reflow) for use. Since it is exposed to a high-temperature environment in mounting (reflow), H₂O molecules are released to the outside. For use in this state, use conversion formula without rehydration (for details see the datasheet).

With rehydration: For long-term use in high-temperature high-humidity environment, rehydration treatment is recommended. Rehydration is a process of absorbing an adequate amount of moisture in the humidity sensor after mounting, and for use in this state, a conversion formula with rehydration is specified (for details, see data sheet). The recommended condition for rehydration is 85 °C 85% RH 6 Hrs.

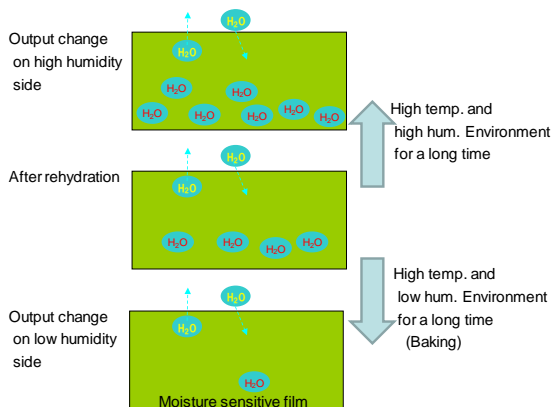
For module products, it becomes a product to be rehydrated. Alpsalpine ship it after carry out with rehydration..

5.4. Offset change

In the capacitance type humidity sensor, moisture absorption / moisture release phenomenon of the moisture sensitive film occurs in a high temperature environment, so that an offset change occurs.



Assuming a change from after rehydration, the output shifts to plus when the high temperature and humidity condition continues, and the output shifts minus when the high temperature and low humidity condition continues.

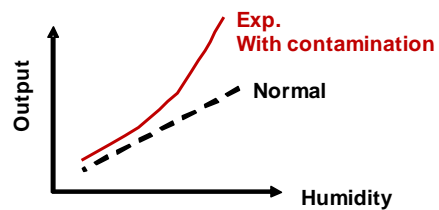
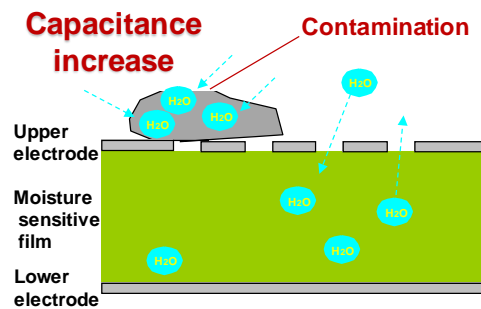


When the high temperature and high humidity environment continues, a large amount of H₂O is held in the moisture sensitive film and the output changes to the high humidity side. On the contrary, when the environment of high temperature and low humidity continues, the H₂O held in the moisture-sensitive film is released, and the output

changes to the low humidity side.

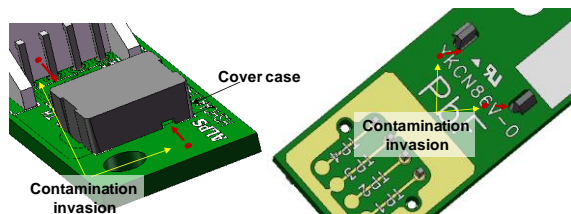
6. Contamination

When contamination adheres to the humidity sensing part (near the moisture sensitive film), the electrostatic capacity increases and there is a case that the output increases. In particular, in the case of organic contamination, since it absorbs moisture in the surroundings, it is greatly affected and the characteristic change becomes large. In the case of organic matter contamination adhesion, the behavior becomes higher as the humidity increases.



As a countermeasure, for packaged products, as described in 3.2.3, a case or a porous film is recommended.

Although the module products are protected with a cover case, there are 2 ventilation holes on the front side and 2 vents on the back side, and there is a possibility of contamination entering. If there are a lot of dust and dirt around it, it is recommended to protect with a filter.



7. Chemically resistant

Be careful not to expose to volatile organic solvent, alcohol etc. Exposure to organic solvents such as toluene, xylene, formalin, acetone, methanol and ethanol for a long time causes increase (fluctuation) in output.

8. Condensation environment

Our humidity sensor is in the operating range 0 to 100% RH (excluding some) and it displays up to 100% RH, but condensation is not supported. And, there is no waterproofness. If there is adhesion of corrosive substances etc. due to dew condensation, there is a possibility of failure. Avoid condensation and use it.

9. Analog product output

9.1. Ratiometric

For ratiometric specifications of analog products (described in the datasheet), output voltage proportional to the power supply voltage. This is aimed at canceling power supply voltage fluctuation for A / D having the reference voltage function. The output voltage is as follows.

$$Vo' [mV] = \frac{VDD}{VDD_{typ}} \times Vo$$

Here, VDD is the supply voltage, VDD_{typ} is the supply voltage TYP of the data sheet, Vo is the output voltage when VDD_{typ} is applied, and Vo 'is the output voltage when VDD is applied.

As an example, the following calculation is

performed.

$$Vo' [mV] = \frac{3.3V}{3.0V} \times 1500 mV = 1650 mV$$

On the other hand, output of the regulator specification (no ratiometric description in the data sheet) is not changed by the power supply voltage. This is to regulate the voltage with the regulator. Even if the power supply voltage changes, it shows the specified output voltage.

9.2. Output impedance

The output voltage of analog products may drop due to the pull-down resistance. Although it is desirable that the pull-down resistor not be connected, if it is necessary to connect, it is recommended to be 10 MΩ or more. The output voltage is as follows.

$$Vo' [mV] = \frac{Rp}{Rp + Rout} \times Vo$$

Here, Rout is the output resistance, Rp is the pull-down resistance, Vo is the output voltage without Rp (Open), and Vo 'is the output voltage when Rp is connected.

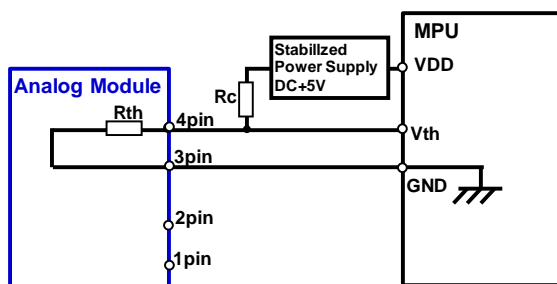
As an example, the following calculation is performed.

$$Vo' = \frac{10M\Omega}{10M\Omega + 28k\Omega} \times 1500 = 1496 mV$$

10. How to use the thermistor

10.1. Thermistor configuration

The analog humidity module has a thermistor for temperature measurement. A simple circuit example for detecting the temperature from the thermistor is shown.



10.2. Thermistor temperature calculation

Calculation formula for calculating temperature from thermistor resistance is shown.

Thermistor resistance R_{th} [Ω]

$$R_{th} [\Omega] = \frac{V_{th} \times R_c}{V_{DD} - V_{th}}$$

Thermistor temperature T [$^{\circ}$ C.]

$$T = \frac{1}{\left(\frac{\ln\left(\frac{R_{th}}{R_{25}}\right)}{B} + \frac{1}{(25 + 273.15)} \right)} - 273.15$$

Here, V_{th} is a thermistor voltage, R_c is an external resistor, R_{25} is a thermistor resistance at 25° C, and B is a thermistor B constant. See R_{25} , B for data sheet.

As R_c , for example, about 33 k Ω is assumed. The larger the resistance value, the smaller the influence of heat generation becomes.

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