Aosong Electronic Temperature and Humidity Sensor Design Guide

——Use temperature and humidity sensors correctly

Preface

Aosong electronic temperature and humidity sensor (hereinafter referred to as the sensor) is a temperature and humidity composite sensor with calibrated digital/analog signal output, and applies dedicated digital module acquisition technology and temperature and humidity sensor technology to ensure that the product has extremely high reliability and excellent long-term stability. In order to make full use of its excellent performance and features, this document makes provisions for the design of some housings, PCBs, software, etc. and provides assistance in the design stage.

Please note that unreasonable design of housing, PCB, etc. may cause significant temperature and humidity deviation and increase in response time, so please design strictly in accordance with the requirements of this document.

The most important design advice on accuracy

The accuracy of measurement depends not only on the accuracy of the sensor itself, but also on the design of the sensing system. The sensor collects the temperature and humidity from its direct environment, so the relativity between the local condition of the sensor and the measured condition is very important. Figures 1 to 4 illustrate the most important design recommendations to ensure good sensor performance: contact environment, air-tightness to the air inside the housing, small dead space volume, and isolation from heat sources. The following pages contain a more in-depth introduction.

1. The sensor is in good contact with the environment

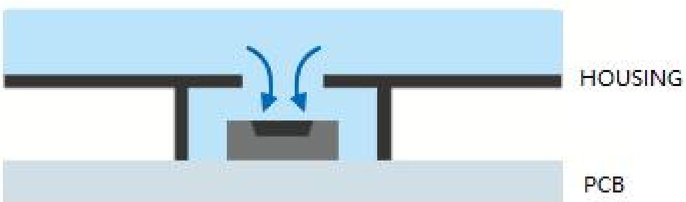


Figure 1: The opening of the shell should have a good channel in contact with the environment, so that the sensor can exchange well with the outside air.

2. The sensor is completely isolated from the dead space inside the housing

Figure 2: The sensor is completely isolated from the dead zone air inside the housing, which minimizes the influence of the airtight air inside the housing on the sensor

2. The closed dead zone around the sensor is small in size

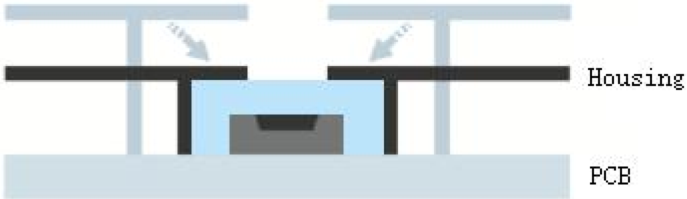


Figure 3: The small dead volume enables the sensor to quickly adapt to changes in the environment.

3. The sensor is isolated from the heat source

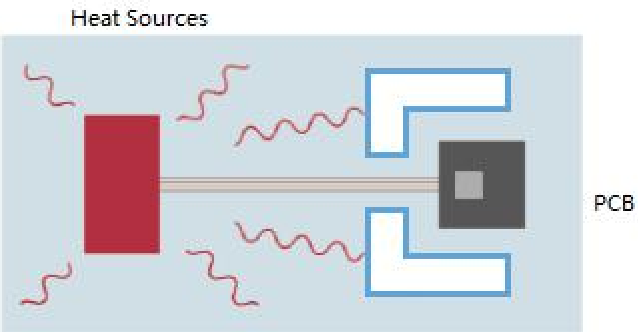


Figure 4: The isolation of the sensor from the heat source in the PCB reduces the influence of internal heating on the sensor.

Precision introduction

When using the Aosong electronic sensor for measurement, the temperature and relative humidity deviation between the sensor and the environment must be avoided. Usually the root cause of temperature deviation is the heat source, while humidity deviation is mainly caused by temperature deviation and slow response time. Please note that due to the dependence of humidity on temperature, every temperature deviation will cause a humidity deviation-relative humidity, a deviation of 1°C at 90%RH will result in a humidity deviation of 5%RH.

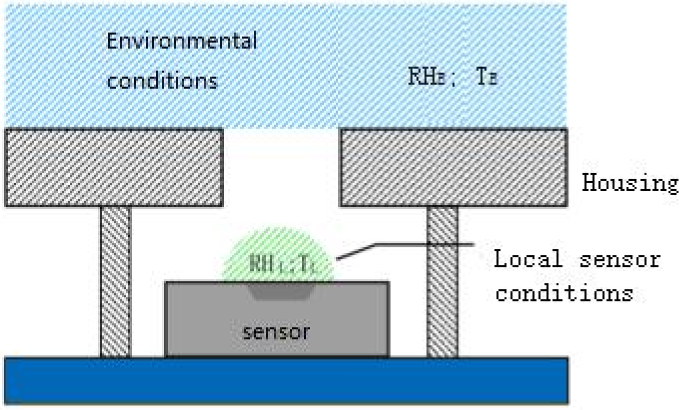


Figure 5: The sensor measures the sensing element (RHL; TL).

In order to achieve accurate measurement, this local sensor condition (RHL; TL) must correspond to the measured environmental condition (RHE; TE). For every temperature or humidity change in the environment, the sensor needs a certain amount of time to balance with the new environmental conditions. During this period, the sensor's reading may lag behind the actual value. This is called the response time. In order to obtain accurate data, it is recommended to reduce the response time of the sensor system as much as possible. If the system must respond to rapid changes, then a sufficiently fast response time is critical.

How to implement a housing and PCB design to obtain accurate measurement and fast response time will be described in the following sections:

- Heated.
- Humidity response time.
- Temperature response time.
- Harsh environment design, examples.

1. Heat

An external heat source close to the sensor will cause the temperature to rise, thereby reducing the RH reading. To avoid sensor be heated, please consider the following points:

- Thermal conduction: the sensor should be thermally isolated from all heat sources.
- Convection/radiation: protect the sensor from hot wind and heat radiation.

1) Heat conduction

The most common root cause of local heating of sensors is heat conduction from nearby heat sources (power electronics, microprocessors, displays, etc.). Since heat conduction occurs mainly through the metal on the PCB, it is recommended that the sensor and the potential heat source be connected with a thinner metal wire while keeping a sufficient distance. In addition, heat conduction can be reduced by grooving and removing (etching) all unnecessary metal on the PCB around the sensor (see Figure 6). Another possible method to reduce heat conduction is to use flexible printing technology to connect the sensor to a flexible printed circuit board (see Figure 10).

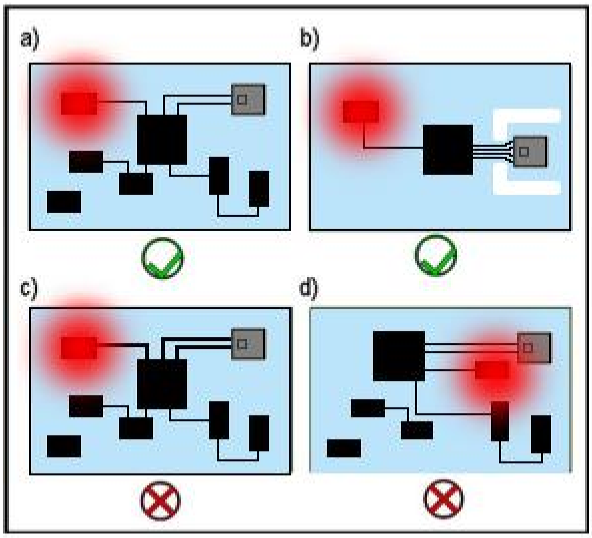


Figure 6: Sensor measuring sensing element (RHL; TL)

a) The thin metal wire is connected to keep a sufficient distance from the heat source to avoid heat conduction. Please be careful to remove unnecessary metal on the PCB around the sensor. b) The hollow (white line) around the sensor reduces the heat conduction of the PCB. c) Unnecessary metal, such as thick metal wire connection, will increase the heat transfer from the heat source to the sensor. d) A nearby heat source will heat the sensor

2）Heat convection/heat radiation

Inside the electronic device, the air may be heated by the electronic components. Avoid contact of hot air with the sensor by isolating the sensor. In addition, there should be enough heat to be transferred out of the equipment to avoid heating of the entire enclosure.

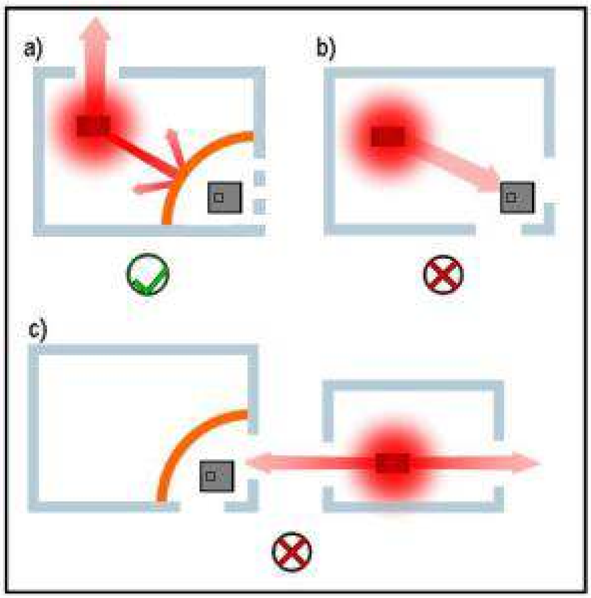


Figure 7: Schematic diagram of heat conduction

a)A wall (orange) protects the sensor from hot air. The opening at the top avoids heating of the entire shell. b) The heated air is in direct contact with the sensor, which will cause the temperature reading to increase. c) Even hot air from nearby equipment may affect sensor readings.

Do not expose the sensor to direct heat radiation (such as direct sunlight) to avoid heat. If the radiation is strong, should be shielded by the complete enclosure (see Figure 8).

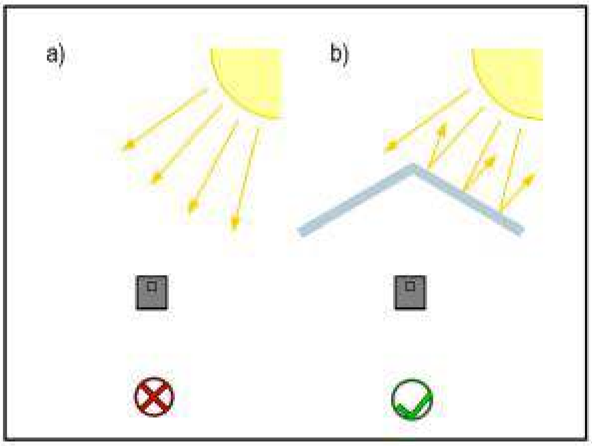


Figure 8: Direct sunlight or other heat radiation may cause temperature readings to increase.

2. Humidity response time

In order to perform accurate humidity measurement, it is important that the humidity of the sensor matches the humidity of the environment when acquiring data. Therefore, the sensor should be in contact with the ambient air as much as possible. A housing design with a large dead volume and/or small aperture may separate the sensor from the environment (see Figure 5), which may greatly increase the response time. In order to achieve fast response time, please consider the following points:

- Place the sensor as close as possible to the environment.
- A design that allows airflow through the sensor is better than a single-aperture design.
- The volume of the dead zone is as small as possible, and the aperture is as large as possible.
- The filter membrane will slow down the humidity response, so do not use more than one layer of membrane per hole.
- Please make sure the dead zone is airtight, otherwise the humidity will spread.
- There must be no material that can absorb humidity in the dead zone.
- Materials that can absorb humidity should not be used as the housing, especially any polyamide should be avoided.

1） Design an airflow as much as possible

If there is air flow through the sensor (see Figure 9a), the air in the dead zone space is continuously exchanged. Such a design can greatly shorten the response time. If there is no clear flow direction (e.g. in the living room), a design with multiple openings and possible flow is preferred. If it is impossible to achieve the design of air flow through the sensor, then the following points become more important.

2）Dead zone volume

The larger the dead zone volume, the more air needs to be exchanged until the environment and sensor conditions match each other. A large dead zone volume will greatly increase the humidity response time. It is recommended to keep the dead zone volume as small as possible.

3）Aperture size

The ventilation hole is the connection between the environment and the sensor. The larger the hole diameter, the faster the air exchange, so the response time of humidity is faster.

4) Filter membrane

The filter membrane can help protect the sensor from harsh environments. However, as the air exchange decreases, the reaction time may become slower. If a filter membrane is required, the dead volume and pore size become more critical.

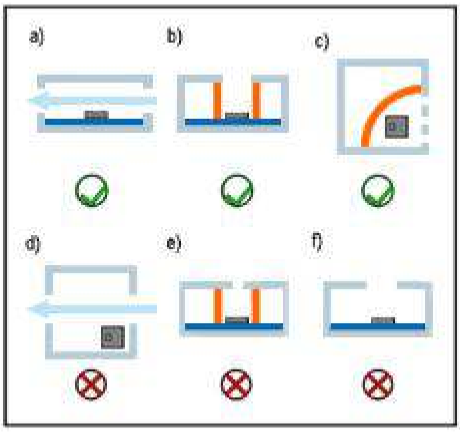


Figure 9: Schematic diagram of different design options
a) The defined airflow passes directly through the sensor, so the local conditions and environmental conditions at the sensor are quickly balanced. If the flow direction is not defined, this design is not recommended because the dead zone volume is too large. b) The wall (orange) reduces the volume of the dead zone, and combined with the large aperture, there will be a faster response time. c) The volume of the dead zone is small, and multiple openings are conducive to good air exchange. d-f) These designs have slower humidity response time due to the following reasons: d) The air flow staggers the sensor and the dead zone volume is too large. e) The aperture is too small relative to the volume of the dead zone. f) Large volume of dead zone.

3.Temperature response time

Due to the heat of the equipment itself, its temperature reacts slowly to changes in the ambient temperature. In order to achieve a fast temperature response time, the following points should be considered.

- The thermal coupling between the sensor and the measured environment (thermal coupling refers to the heat transfer connection between the two) should be as strong as possible.
- The thermal coupling between the sensor and the housing heat (PCB) should be as weak as possible.

1) Thermal coupling between sensor and environment

In order to achieve a good thermal coupling between the sensor and the environment, the sensor should be as close to the environment as possible-preferably in the corner or at least at the edge of the device. The airflow of the ambient air will add additional coupling.

2) Thermal coupling of the sensor to the housing and the main PCB

In order to reduce the thermal coupling between the sensor and the housing/PCB, heat conduction needs to be reduced, as described in the heated section above (see Figure 10).

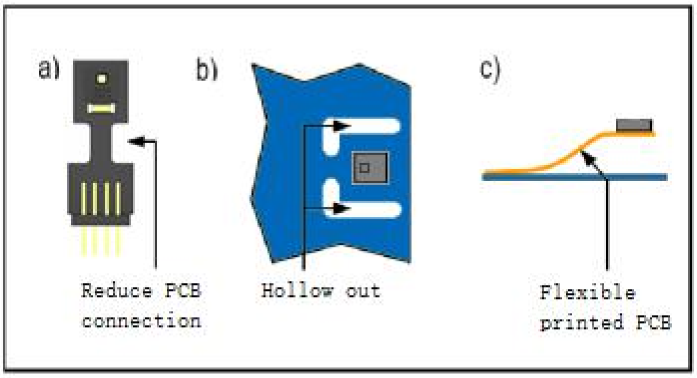


Figure 10: The sensor can be separated from the PCB with heat by reducing the PCB connection, hollowing out the place where there is no wire connection, or using a flexible printed PCB.

4. Designed for harsh environments

1）Influence of dust

If used in a dusty environment, dust may enter the sensor, adhere to the surface of the sensor's moisture-sensitive layer, block the vents on the moisture-sensitive layer, and affect the entry of water molecules, thereby affecting the humidity accuracy. Therefore, it is necessary to pay attention to the dust-proof of the sensor, and use a filter film that can reach the dust-proof level to protect the sensor.

2）Influence of water droplets

In the outdoor environment, if it is rainy, water droplets may enter the sensor, which may cause a short circuit of the sensor. In addition, the humidity is saturated at this time, and the water inside the sensor is difficult to evaporate, which may cause the humidity to be saturated for a long time until the water evaporate completely. Therefore, pay attention to the waterproof of the sensor, and use a filter membrane that can reach the waterproof level to protect the sensor.

For various temperature and humidity sensors of Aosong Electronics. There is an IP67 filter membrane to protect the sensor, so that outside water and dust cannot directly enter the sensor. Due to the extremely small package volume and the high air permeability of the membrane, the response time is the same as that of the same sensor without the membrane. Please note that in harsh environments, it may be necessary to apply a protective coating, such as conformal coating, to avoid corrosion of the pad, but it must be ensured that the coating does not touch the wet-felling part of the sensor, otherwise the humidity will be inaccurate.

In addition, for the application environment that needs to use the filter membrane, Aosong has designed an AF02 filter cap, which has the smallest dead space volume and can quickly obtain the response time. See example 5 for specific applications.

3）High temperature effect

After reflow soldered or high-temperature soldered, the sensor will have low humidity when heated. This phenomenon is normal and can be ignored. It will gradually return to normal accuracy after using it in a normal environment. The recovery speed depends on the humidity of the environment, the higher the humidity, the faster the recovery. If there is an urgent need to quickly restore the humidity accuracy, please refer to the recovery process in the product specification for details.

For reflow soldering or manual soldering, please strictly follow the requirements of the specification. The temperature should not be too high and the soldering time should not be too long, otherwise the sensor may be damaged or the humidity may be permanently shifted. When using a soldering iron or using a hot air gun, care should be taken to prevent the flux, rosin and other substances from splashing into the sensor, otherwise it will cause poor humidity.

4）High humidity effect

If the sensor is used in a high humidity environment greater than 90% RH for a long time, it may temporarily shift upward when the humidity drops, that means humidity value is higher. This phenomenon is normal and can be ignored, and the accuracy will slowly return to normal after use in a normal environment. If there is an urgent need to quickly restore the humidity accuracy, please refer to the recovery process in the product specification for details.

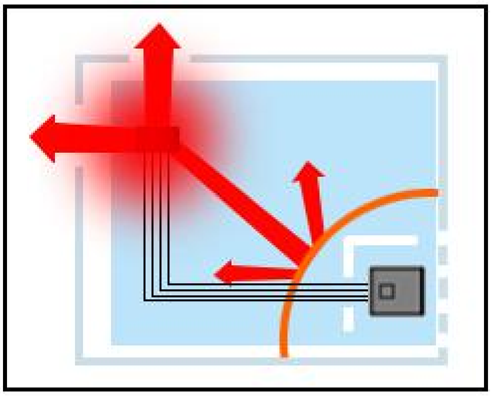
5）Impacts of extreme environmental containing corrosive chemical substances

If the sensor is used in an environment containing corrosive chemical substances, it may be exposed to substances or components such as acetone, ammonia, hydrochloric acid, nitric acid, chlorine, etc., which may cause the sensor to shift irreversibly. Therefore, it is forbidden to be used in such environments.

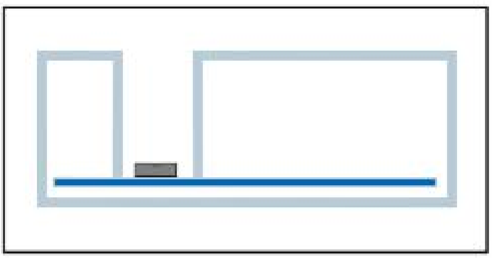
6）Other extreme environments

If the sensor inevitably needs to be applied to the extreme environment that may cause offset, it is recommended to design the sensor as a convenient replacement type, such as a pluggable terminal type. To ensure accuracy, the sensor can be replaced regularly.

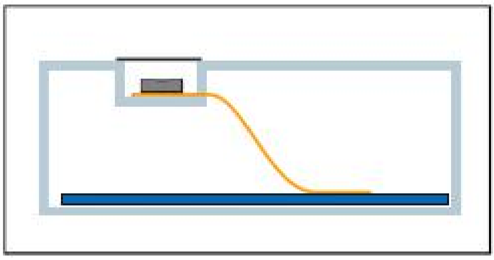
Here are some application examples:



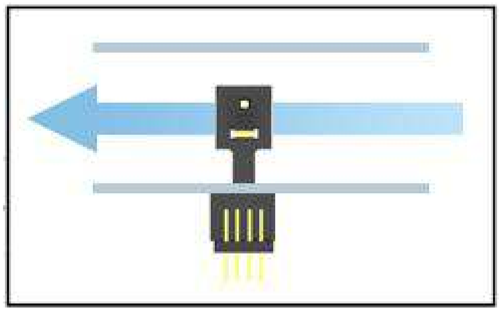
Example 1: If no filter membrane is required, this is the most recommended design. It combines the above rules very well. The wall (orange) helps protect the sensor from the hot air and also reduces the dead space volume. The large opening allows good air exchange and the hollowed groove reduces heat conduction through the PCB. Therefore, this design provides fast response time and low-impact heating components.



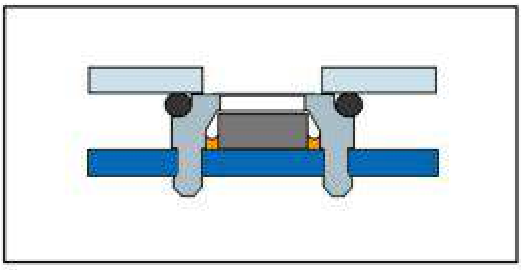
Example 2: This is a simpler variant of Example 1. Because there is no air flow, the humidity response time is slow (depending on the distance from the sensor to the opening). If necessary, add an extra slot on the PCB to shield the external heating on sensor.



Example 3: This is a more complicated version of Example 2, using flexible pcb for thermal isolation (but please note that violent bending or pulling is prohibited when using flexible pcb, so as not to pull the sensor pad), the module can be connected through the way of lead , There is also a filter membrane to protect the sensor. The short distance between the sensor and the environment under test improves response time.



Example 4: This design shows an AHT25 in a tube with airflow. The thin PCB connection can separate the AHT25 from the tube well, and provide a very fast thermal response time, and reduce the impact of the temperature deviation between the tube and the airflow.



Example 5: AF2 filter cap may help to design a compact housing. The filter membrane protects the sensor and housing from dust and water. Due to the small volume between the sensor and the environment, a fast humidity response time can be achieved.

Please note that all the rules and recommendations described above are simplified examples and may not apply to specific customer products. Therefore, careful design evaluation is inevitable for each individual project. Please read the operating instructions carefully during the design phase and before product release.

The most important design suggestions for temperature and humidity system design

Aosong electronic temperature and humidity sensors are widely used in consumer electronics, medical, automotive, industry, agriculture, meteorology and other fields, such as: HVAC, dehumidifiers and refrigerators and other home appliances, testing and inspecting equipment and other related temperature and humidity detection and control products . Most of the temperature and humidity sensors are used as core or important devices in the application, so the reliability of the temperature and humidity system design is very important. Especially when using the sensor in high frequency, high noise, magnetic field and other scenes that may cause interference, it is recommended to add a power control design to avoid communication failure when the sensor is severely interfered, thereby affecting the operation of the host.

The following points should be considered.

- Hardware: The IO port is used to control the power supply in the hardware circuit design, and the hardware can be reset if necessary.
- Software: There are multiple wrong judgments and restarts in the software acquisition logic.

1. Hardware

When designing the hardware circuit, it is recommended to use VDD or GND to connect to the IO port control method, as shown in Figure 11 and Figure 12, to illustrate the application of the digital IIC protocol sensor using the IO port to control the power supply.

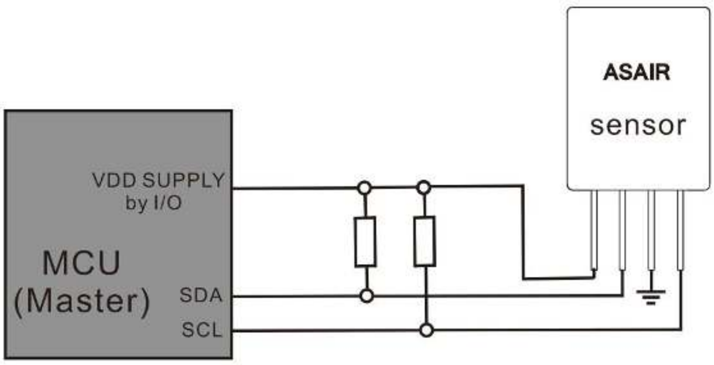


Figure 11: IO port control VDD scheme, please note that if an external pull-up resistor is required, the pull-up VDD of the pull-up resistor must be the same as the sensor power supply VDD.

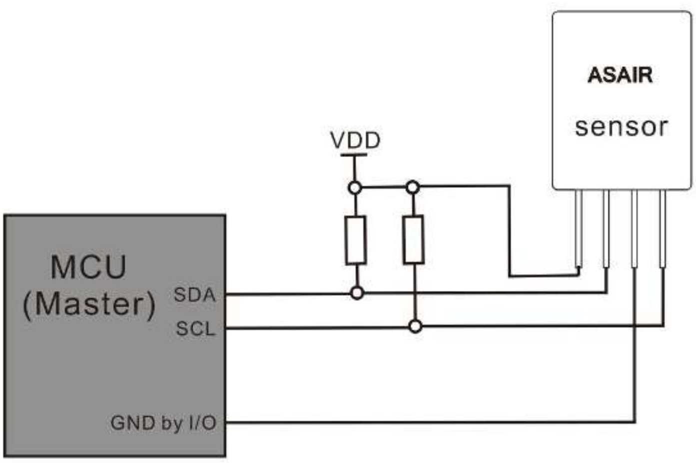


Figure 12: IO port control GND scheme.

2. Software

When designing the software, the acquisition frequency needs to follow the requirements of the sensor in the specification. For example, some require at least 2s to collect once, otherwise it may cause communication failure. If data errors or communication abnormalities occur during normal collection, the following points should be considered。

1) Multiple misjudgments.

When affected by external high frequency, high noise, electromagnetic interference, etc., the communication with the sensor may have a short signal error, resulting in abnormal data readings. Therefore, it is recommended to add multiple error filtering on the software to allow individual errors to occur, such as after continuous 10 times collecting, there is an error and then determine the sensor abnormality, and make the sensor abnormality treatment.

2) If necessary, restart the sensor through the IO of the control power supply (VDD/GND).

On the basis of the above (1), if the error is still reported, consider that the sensor enters an abnormal working mode under strong interference. At this time, you can pull down VCC or pull up GND to the sensor through the IO port of the control power supply (VDD/GND) to turn off the power, and then pull up VCC or pull down GND again to power on, and after the sensor is completely reset, go to collect data. It should be noted that if the VCC control method is used, the communication port needs to be set to low when the VCC is pulled down and the power is turned off, so as to prevent the voltage from backflow from the IO port, causing the sensor to work abnormally.