SHTxx and STSxx Design Guide

How to design-in a humidity and temperature sensor.

Preface

The SHTxx are humidity and temperature sensors of high quality. The digital interface and factory calibration allows a fast and easy implementation as well as full interchangeability. In order to take full advantage of their outstanding performance and features a number of housing and PCB design rules need to be considered. This document lists this design rules and provides help during design-in phase. Please note that unbeneficial housing and/or PCB designs may cause significant temperature and humidity deviations as well as highly increased response times.

Overview: The Most Important Design-In Recommendations

1) Sensor has good access to environment

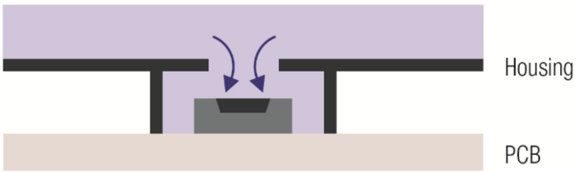


Figure 1: A large opening in the housing provides good access to environment and allows for air exchange.

2) Sensor is sealed from air entrapped in housing

Figure 2: Sealing of the sensor compartment towards the remaining housing minimizes the influence of entrapped air on the sensor.

3) Dead volume enclosed around sensor is small

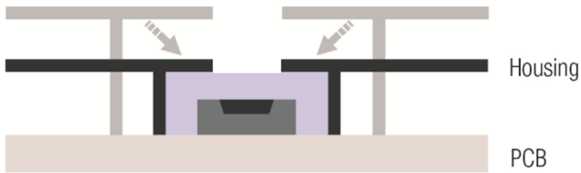


Figure 3: A small dead volume allows for rapid adaption to changes in the environment.

4) Sensor is decoupled from heat sources

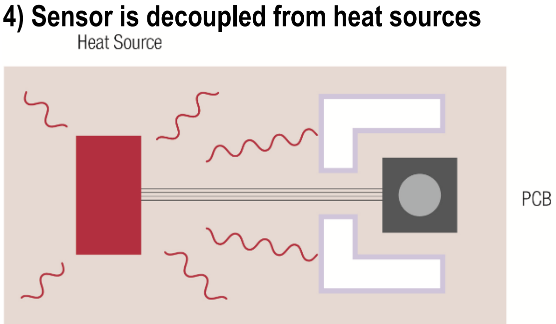


Figure 4: Decoupling of the sensor from heat sources in the PCB minimizes the influence of internal heating on the sensor.

Introduction

The accuracy of a measurement does not just depend on the sensor accuracy itself but also on the set up of the sensing system. The SHTxx sensors sample relative humidity and temperature of their direct environment. It is thus important that the local conditions at the sensor correspond to the conditions under test. *Figure 1* to *Figure 4* show the most important design-in recommendations to ensure good sensor performance: access to environment, sealing from entrapped air in the housing, small dead volume and decoupling from heat sources. The subsequent pages contain more in-depth descriptions of the design-in recommendations together with many practical examples.

For proper measurements using SHTxx sensors, temperature and relative humidity (RH) deviations between the sensor and the environment must be avoided.

A usual root cause for temperature deviations are heat sources, while RH deviations are mostly caused by temperature deviations as well as slow response times. Please note that every temperature deviation will cause RH deviations due to the temperature dependence of the relative humidity, i.e. a deviation of 1°C at 90%RH will result in a 5%RH deviation. For further details please check the application note "Introduction to Relative Humidity"[1].

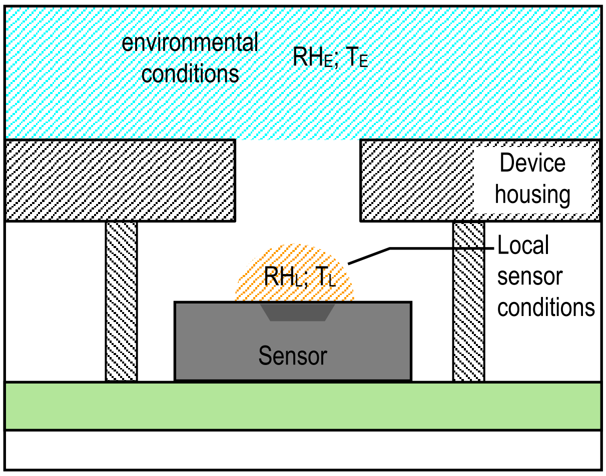


Figure 5: The sensor measures the local conditions at the sensing element (RH_L; T_L). In order to achieve good measurements this local conditions need to correspond to the conditions of the environment under test (i.e. RH_E; T_E).

For each temperature or humidity change of the environment, the sensor requires a certain amount of time to equilibrate with the new environmental conditions. During this time the sensor readings may lag behind the actual values. This is called response time. To get precise data it is recommended to decrease the response time of the sensor system as good as possible. If the system must react on fast changes a sufficient fast response time is crucial.

How to effectuate a housing and PCB design to get accurate measurements with fast response times is descried in the following sections.

- Heating
- Humidity Response Time
- Temperature Response Time
- Design for harsh Environments
- Examples

Heating

External heat sources close to the sensor will cause increased temperature (and thus decreased RH) readings. To avoid heating of the sensor please consider the following:

- Heat conduction: The sensor should be thermally decoupled from all heat sources.
- Heat convection / radiation: Shield the sensor from heated air and heat radiation.

Heat conduction

The most common root cause for local heating of the sensor is due to thermal conduction from a nearby heat source (power electronics, microprocessors, displays, etc.). As thermal conduction mostly occurs through the metal on the PCB, thin metal lines and sufficient distances between the sensor and potential heat sources are recommended. Further, heat conduction can be decreased by milling slits in - and removing (etching) all unnecessary metal from the PCB around the sensor (see Figure 6). Another possibility to decrease heat conduction to the sensor is the use of a flex print to connect the sensor to the PCB (see *Figure 10*).

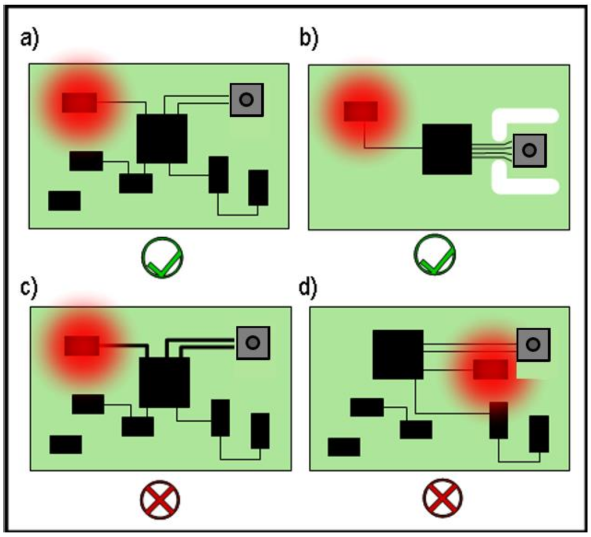


Figure 6: a) Thin metal connections and sufficient distance to the heat source helps to avoid heat conduction. Please note to remove unnecessary metal on the PCB around the sensor. b) The milled slits (white lines) around the sensor decrease the thermal conduction through the PCB. c) Unnecessary metal, such as thick metal connections will increase heat transfer from the heat source to the sensor. d) Heat sources in close proximity will heat the sensor

Heat convection / radiation

Inside of electronic devices the air might be heated up by electronic components. Contact of heated air and the sensor shall be avoided by shielding the sensor

[1] https://www.sensirion.com/de/download-center/

physically from all heat sources (see Figure 7). Additionally, there should be a sufficient heat transfer out of the devices to avoid the heating of the complete housing.

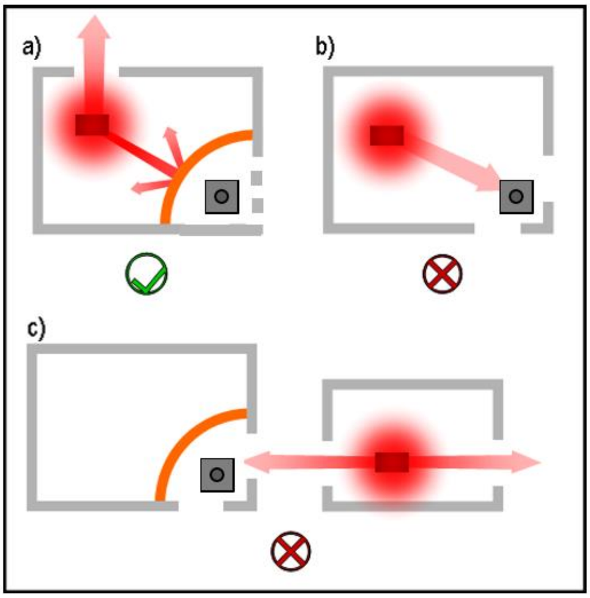


Figure 7: a) A wall (orange) shields the sensor from the heated air. The opening on the top avoids the heating of the complete housing. b) The heated air gets in direct contact with the sensor which will cause increased temperature readings. c) Even heated air from nearby devices may influence the sensor readings.

Do not expose the sensor to direct heat radiation (e.g. direct sunlight) to avoid heating. If the radiation is strong the complete housing should be shielded from the radiation (see Figure 8).

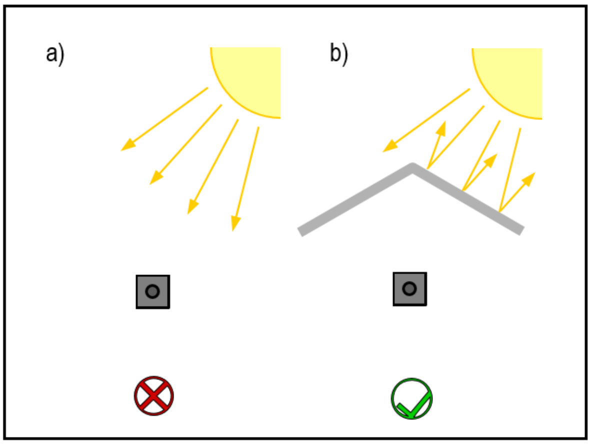


Figure 8: Direct sunlight or other heat radiation may cause increased temperature readings.

Humidity Response Time

For proper humidity measurements it is important that the humidity at the sensor matches the one of the environment while acquiring data. Therefore, the sensor should be connected as well as possible to environmental air. Housing designs with a large dead volume and/or small aperture may act as a separation of the sensor and environment (see Figure 5) which may result in highly increased response times. In order to achieve fast response times please consider the following:

- Place the sensor as close to the environment as possible.
- A design which allows an airflow over the sensor is preferred to a design with a single aperture.
- The dead volume should be as small as possible
- The aperture(s) should be as large as possible
- Filter membranes will slow down humidity response. Never use more than one membrane per aperture.
- Make sure that the dead volume is sealed airtight, otherwise humidity will diffuse.
- There should be no material which can absorb humidity inside of the dead volume.
- There should be no material which can absorb humidity used as a casing. Especially any **polyamide** should be avoided.

Design with a possible Airflow

If there is an airflow over the sensor (see Figure 9 a), the air inside of the dead volume is exchanged constantly. Such a design is favourable in terms of response times. Even if there is no defined flow (e.g. in a living room) a design with multiple openings and a possible flow is preferred. If there is no possibility to realize a design with airflow over the sensor, the following points become more important.

Dead Volume

The larger the dead volume the more air needs to be exchanged until the environmental and sensor conditions match each other. Large dead volumes will drastically increase the humidity response time. It is recommended to keep the dead volume as small as possible.

Aperture Size

The aperture is the connection between environment and sensor. A bigger aperture allows a faster air exchange and therefore better humidity response times.

Filter Membranes

Filter membranes may help to protect the sensor from harsh environments. But as they decrease the air exchange the response time may be slower. If a filter membrane is required, the size of the dead volume and the aperture become more critical.

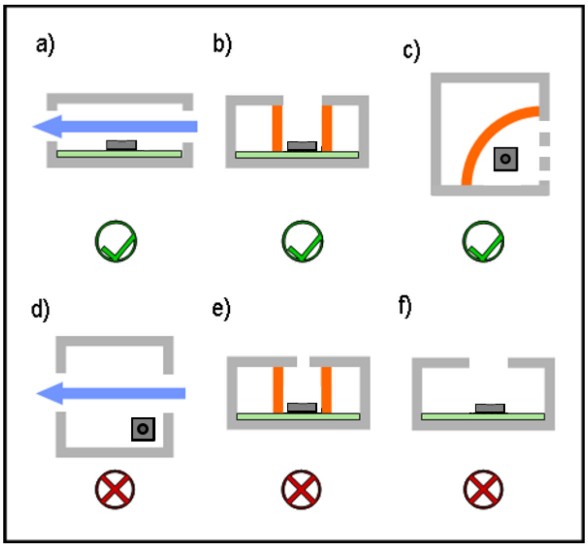


Figure 9: Schematic view of different design-ins. a) The defined airflow goes directly over the sensor and therefore the local conditions at the sensor equilibrate quickly with the environmental conditions. If there is no defined flow this design is not recommended as the dead volume is too big. b) The walls (orange) reduce the dead volume which will lead in combination with the large aperture to fairly good response times. c) The small dead volume, and multiple openings enable a good air exchange. d-f) These designs will have slow humidity response times due to the following reasons: d) The airflow misses the sensor and the dead volume is large. e) The aperture size is too small in respect to the dead volume. f) The dead volume is large.

Temperature Response Time

Due to the thermal mass of a device it temperature reacts slow on changes of environmental temperature. In order to achieve fast temperature response times the following points should be considered.

- Thermal coupling of the sensor to the environment under test should be as strong as possible.
- Thermal coupling of the sensor to the thermal mass of the housing (PCB) should be as weak as possible.

Thermal coupling of the Sensor to the Environment

To achieve a good thermal coupling between the sensor and the environment the sensor should be placed as close to the environment as possible – best at a corner or at least at the edge of the device. An airstream of ambient air will additionally increase the coupling.

Thermal coupling of the sensor to the thermal mass of the housing and the main PCB

In order to get a good decoupling of the sensor and the housing / PCB the heat conduction needs to be reduced as described in the heating section above (see *Figure 10*).

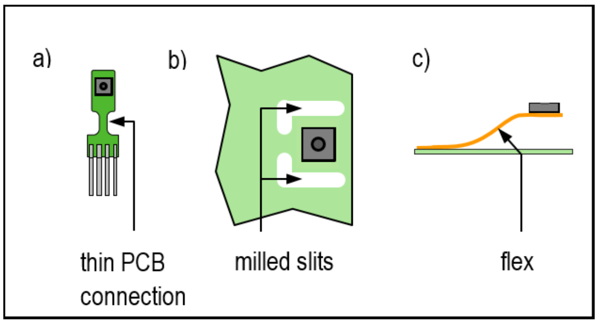


Figure 10: The sensor may be thermally decoupled from the PCB by small PCB connections or with a flex.

Designs for harsh Environments

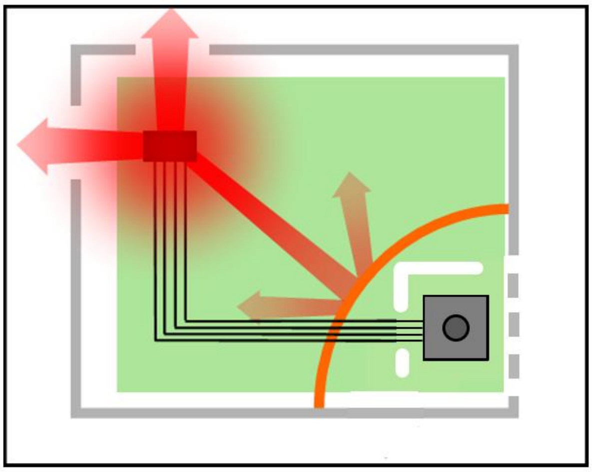
For selected versions of the SHT3x there is a filter membrane available which protects the sensor opening form water and dust according to IP67. Due to the minimal package volume and the membrane's high vapour permeability, the response time is identical to the sensor without membrane. Please note that for applications in harsh environments it may be necessary to apply conformal coating to avoid corrosion of the solder pads.

For more information on the SHT3x with filter membrane: Datasheet Filter Membrane

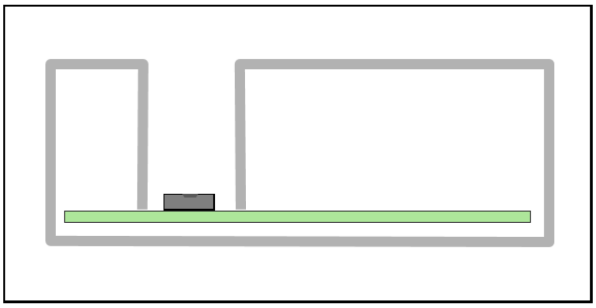
Alternatively, the SF2 filter cap can be used to achieve water and dust tight housings with good response times (see Example). In order to achieve fast humidity response time the SF2 filter cap is designed with a minimal dead volume. Detailed information about the SF2 filter cap may be found on: www.sensirion.com/sf2

Examples

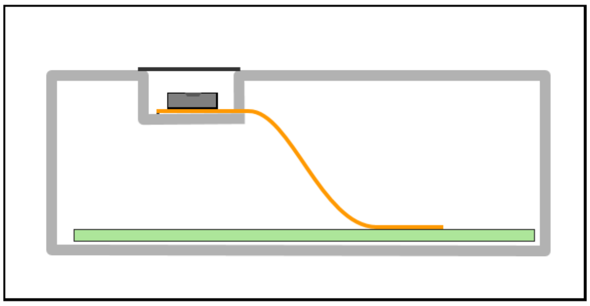
This chapter shows some different designs for different applications.



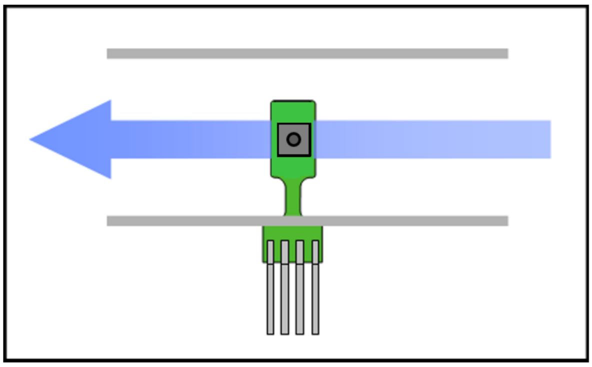
Example 1: This is the most recommended design if no filter membrane is required. It well combines the rules above. The wall (orange) helps to shield the sensor from the heated air as well as it decreases the dead volume. The large opening allows for a good air exchange and the milled slits reduce thermal conduction through the PCB. Therefore this design provides fast response times as well as low influences from heating parts.



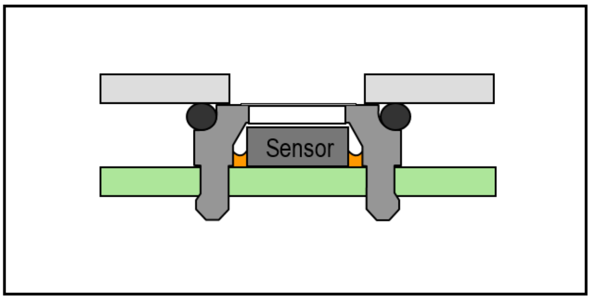
Example 2: This is a more simple variation of Example 1. As there is no airflow the humidity response time is slower (depends on the distance of the sensor to the opening). With additional slits in the PCB the sensor could be shielded from external heating if required.



Example 3: This is a more sophisticated version of Example 2 using a flex pcb for thermal decoupling. Additionally there is a filter membrane to protect the sensor. The short distance between the sensor and the environment under test improves response times.



Example 4: This design shows an SHT85 inside of a tube with an airflow. The thin PCB connection decouples the SHT85 very well from the tube and grants a very fast thermal response time as well as reduced influence from temperature deviations between the tube and the airflow.



Example 5: The SF2 filter cap may help to design tight housings. The filter membrane protects the sensor and the housing from dust and water. Due to the very small volume between the sensor and the environment fast humidity response times can be achieved.

Final remark

Please note that all rules and suggestions of this application note are term of simplified examples and may be not applicable for specific customer products. Therefore, it is inevitable to carefully evaluate the design-in separately for each individual project. Please also read carefully the handling instructions during design-in phase and before production release.

Revision History

Date	Revision	Changes
24 June 2010	1.0	Initial release
27. May 2019	1.1	Updated front page and figures

Important Notices

Warning, Personal Injury

Do not use this product as safety or emergency stop devices or in any other application where failure of the product could result in personal injury. Do not use this product for applications other than its intended and authorized use. Before installing, handling, using or servicing this product, please consult the data sheet and application notes. Failure to comply with these instructions could result in death or serious injury.

If the Buyer shall purchase or use SENSIRION products for any unintended or unauthorized application, Buyer shall defend, indemnify and hold harmless SENSIRION and its officers, employees, subsidiaries, affiliates and distributors against all claims, costs, damages and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if SENSIRION shall be allegedly negligent with respect to the design or the manufacture of the product.

ESD Precautions

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take customary and statutory ESD precautions when handling this product.
See application note "ESD, Latchup and EMC" for more information.

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SENSIRION warrants solely to the original purchaser of this product for a period of 12 months (one year) from the date of delivery that this product shall be of the quality, material and workmanship defined in SENSIRION's published specifications of the product. Within such period, if proven to be defective, SENSIRION shall repair and/or replace this product, in SENSIRION's discretion, free of charge to the Buyer, provided that:

- notice in writing describing the defects shall be given to SENSIRION within fourteen (14) days after their appearance;
- such defects shall be found, to SENSIRION's reasonable satisfaction, to have arisen from SENSIRION's faulty design, material, or workmanship;
- the defective product shall be returned to SENSIRION's factory at the Buyer's expense; and
- the warranty period for any repaired or replaced product shall be limited to the unexpired portion of the original period.

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