Temperature Acceleration and Compensation Instructions for SEN5x

Preface

Integrating sensor components into systems, e.g., air quality monitors, air purifiers, etc. is a time-consuming task. It typically takes several design and test iterations until a working design is found.

SEN5x is designed to make this process faster and more straightforward.

This application note explains in detail what to expect in thermal behaviour comparing a bare SEN5x and a designed-in SEN5x. It will explain how a change in the measurement environment can affect the temperature reading and lastly give guidance on how to obtain temperature compensation and acceleration parameters of the STAR engine for your use case.

Standalone sensor versus built-in sensor

Comparing a temperature sensor on a flex PCB and a temperature sensor built into a device with other components, e.g., display, microprocessor, etc., the two sensors will behave very differently regarding ambient temperature readings or changes in temperature.

A sensor on a flex PCB without any enclosure has negligible thermal mass and is coupled perfectly to ambient air. It is able to accurately measure ambient temperature and will be able to react fast to changes in temperature. A built-in sensor is usually coupled weakly to ambient air, has a larger thermal mass, and shows additional self-heating due to other heat sources close by. To minimize those effects one can optimize the mechanical design-in, as well as apply complicated temperature compensation algorithms.

SEN5x solves most of these issues by design. An optimized flow path together with active ventilation from the built-in fan significantly improves coupling to ambient air and improves reaction times.
The included algorithm is optimized for compensating the module's self-heating and, in addition, it allows for improvement of the response time by customizing the STAR (Sensirion Temperature Acceleration Routine) engine's acceleration parameters to the built-in conditions.

Measurement environment for default compensation

The default parameters for the temperature compensation algorithm are obtained using a very specific and controlled measurement environment. Even small changes to the environment can add measurement variance and might lead to deviations to a reference. Most noticeable are effects due to change in ventilation (e.g., temperature-controlled chamber with fan versus water in chamber walls) or changes in heat coupling (e.g., sensors lying on wood versus metal).

The sensor's default compensation is optimized for the sensors lying on a wooden table with enough distance to other sensors or heat sources/sinks to prevent any additional heating/cooling. Any significant air flow over the sensors should be avoided to prevent additional heat dissipation due to convection. The reference temperature probe should not be placed too close to the sensors to avoid any heat transfer.
For the above stated conditions, the sensor will be within the specified limits for relative humidity and temperature.

Temperature settings for a given design-in

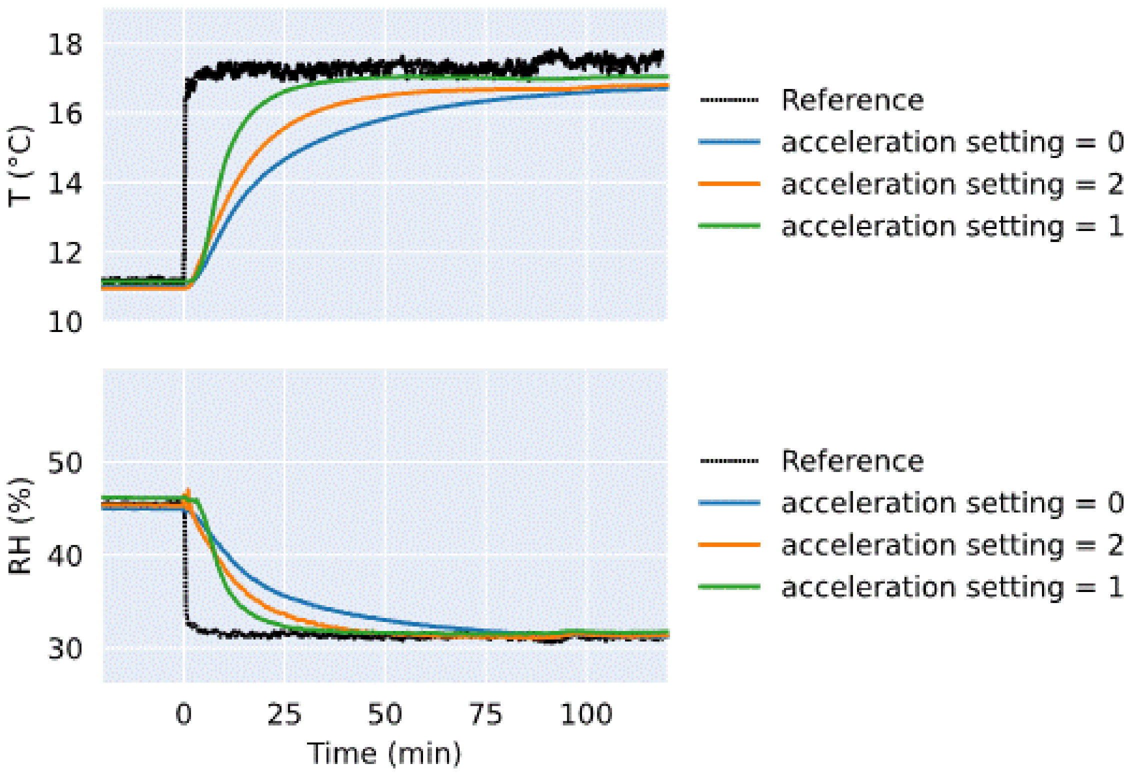
If SEN5x is integrated (e.g., into an air quality monitor), the default compensation might need to be adapted for mechanical design-in, e.g., due to a change in thermal coupling, additional thermal mass, or self-heating of other device components. To make mechanical design-in simpler, we provide mechanical design-in examples including more detailed instructions and CAD files found at www.sensirion.com.

Once the sensor is integrated, we suggest the following order of steps to customize the settings:

- Choose STAR-engine acceleration setting
- Offset correction and slope
- Configure warm start behavior

Temperature acceleration for a given design-in

The SEN5x comes with 3 different presets for the Sensirion temperature acceleration routine (STAR). In the default case a minor acceleration is applied. This setting works well for a standalone module such as for application in air purifiers. In the application of air quality monitors or mobile devices we recommend choosing between settings 1 and 2 for high and medium acceleration of the temperature measurement. The figure shows the difference between the acceleration settings in a measurement for an exemplary IAQ device. The ambient condition of the devices is changed by 7°C in a step manner.



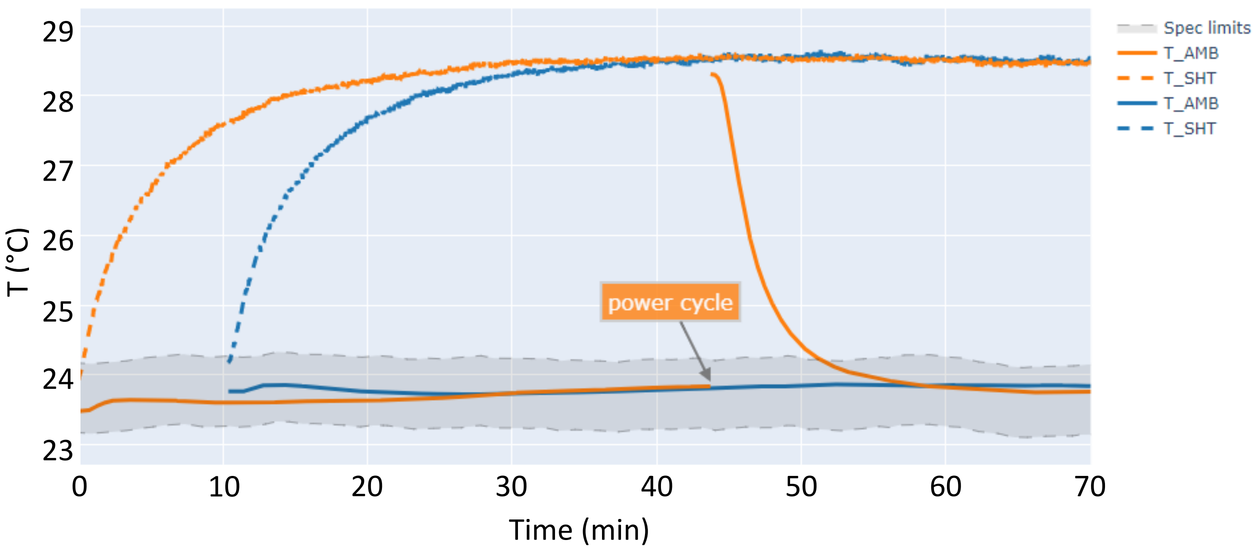
In order to configure the acceleration, place the device in an environment with a different temperature together with a reference. Exposing both the device and the reference to standard environment conditions quickly results in data similar to what is presented in the above figure. Repeating the same experiment for different acceleration settings the correct configuration is found for the setting where the device temperature is closest to the reference and almost no overshooting is observed. In the given example the fastest acceleration effectively reduces the time to reach 63% of the temperature difference (this is referred to τ_{63}) from 24 minutes to 10 minutes for the minor accelerated case.

Offset correction for a given design-in

Take an accurate external temperature sensor as reference and place it next to your device. Be sure to place the reference far enough away to avoid measuring heat dissipation from your device. Also be sure that there are no significant heat fluctuations over time. Wait until both devices are in steady state. Ideally both sensors already show the same temperature. If there is a temperature offset, calculate the difference in temperatures. Write this value (multiplied by the factor from the datasheet) as temperature offset parameter to the sensor. Now the sensor is compensated for your design-in.
Repeating the same procedure at a different temperature, but similar ventilation and environmental conditions, the slope parameter can be calculated to adjust the offset over a range of temperatures. The time constant can be used to compensate the warmup phase of the module during the startup of the sensor.

Power cycling / warm start behavior

The below figure shows the modules temperature raw signal and compensated output for an experiment with two SEN5x modules and a reference sensor (grey dashed region) on a wooden table. The modules are powered up consecutively with a delay of approximately 10 minutes. As the modules warm up due to self-heating (cold start), the temperature reading from the internal temperature sensor (SHT, dashed line) increases while the compensated output (solid line) shows an accurate reading of ambient temperature. After approximately 50 minutes, the module described by the orange line was turned off and on again, simulating a power cycle (warm start). Since the module was already warm, in the very first moments of operation the temperature reading will show values larger than ambient temperature until the built-in algorithm realizes the warm start and quickly compensates for the current conditions. After 7 minutes the sensor is within specifications. Using the warm start parameter this behavior can be optimized by cutting off the initial peak before compensation. The feature can be set between the default no cut off setting (parameter equals zero) and maximum cut-off (maximum value), the optimum value depends on the cooling that took place in the off time of the module.



Revision History

Date	Version	Changes
January 2022	1.0	Initial version

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.

Warranty

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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SENSIRION reserves the right, without further notice, (i) to change the product specifications and/or the information in this document and (ii) to improve reliability, functions and design of this product.

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