Design-in Guide SCD4x CO_2 Sensor

Sensirion's miniaturized CO_2 sensor combines smallest package with highest performance. In order to take full advantage of the SCD4x performance and the integrated features a number of housing and PCB design rules need to be considered. This guide describes an easy-to-implement and affordable design-in of the sensor. Please note that unbeneficial housing and/or PCB designs may cause significant CO_2 and temperature deviations, increased noise levels as well as highly increased response times.

Overview: The most important Design-in Recommendations

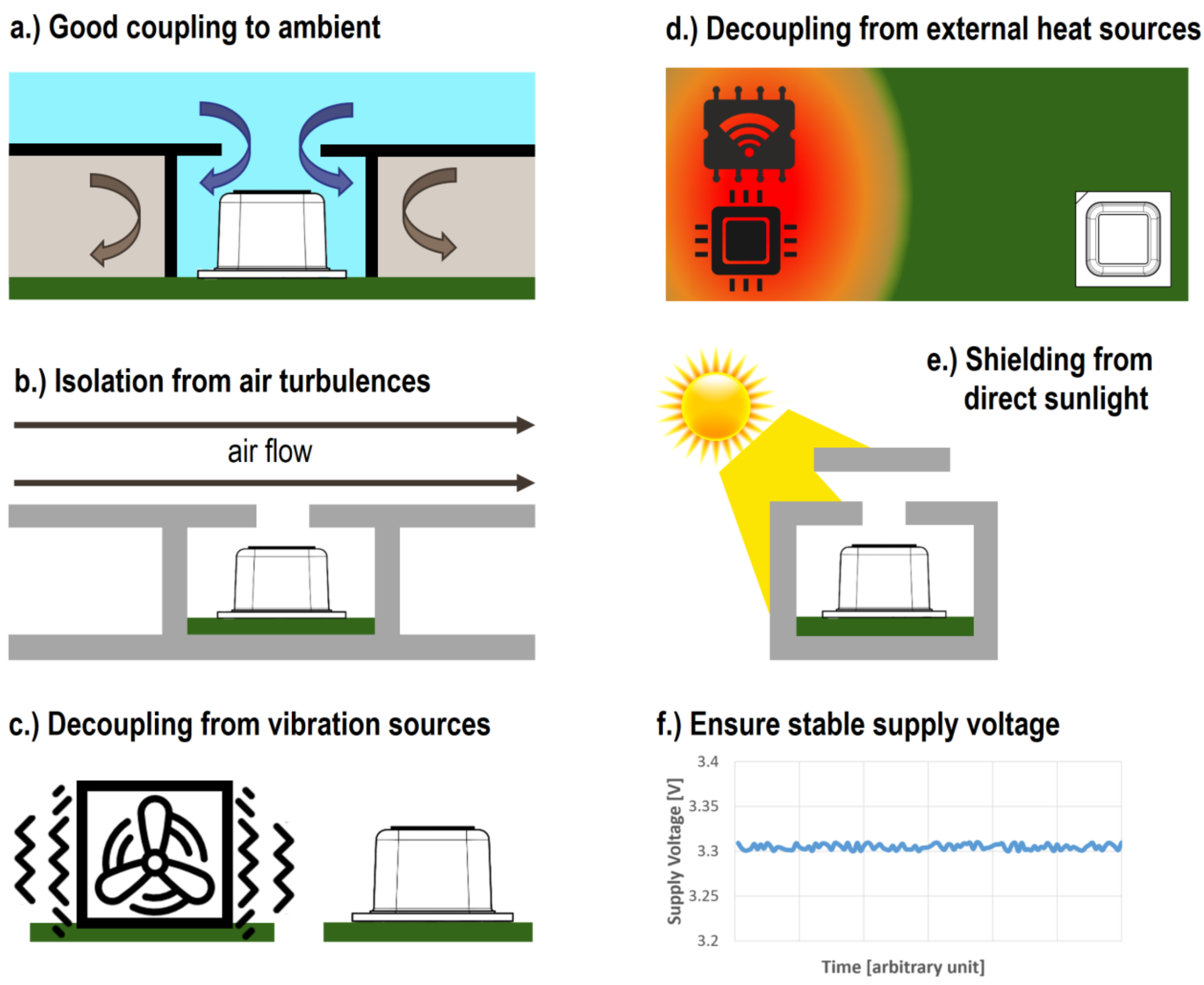

Figure 1: Most important design-in recommendation for the SCD4x CO_2, RH and T sensor. **(a)** Good coupling to ambient thanks to large opening of the device housing in proximity to the sensor and thanks to a small dead volume. **(b)** Good isolation from air turbulences is realized by placing the SCD4x in a separate compartment that is not exposed to the direct air flow. **(c)** Good decoupling from vibration source is realized thanks to a mechanical decoupling of the support structure. **(d)** Good decoupling from external heat sources such as MCU or Wifi module. Heat sources with varying intensity are especially problematic for the accuracy of the temperature output of the SCD4x since it only features a constant temperature offset compensation. Since hot air has the tendency to rise it is recommended to place the sensor in the lowest part of the device. **(e)** Shielding from direct sunlight thanks to the addition of a light-shade in the device housing. **(f)** Ensure stable supply voltage: Voltage Ripple Peak to Peak < 30 mV.

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1 Placement of sensor

1.1 Coupling to ambient

The SCD4x interacts with the environment to sense the ambient CO_2 concentration, relative humidity and temperature. Therefore, coupling SCD4x to ambient via a suitable device design is from uttermost importance. Bad coupling to ambient environment can result in significantly increased response times and increased temperature offset. General design-in recommendations are illustrated in **Figure 2**.

Sensor is connected well to ambient air
Ideally, the sensor is placed as close as possible to the device's outer shell with a large opening allowing the sensor to be exposed to ambient. The larger and closer the opening, the better the air exchange between the sensor's direct surrounding and the ambient.

Dead volume enclosed around sensor is small
Ideally, the sensor is sealed from air entrapped in housing to minimize the dead volume (i.e. volume of air that surrounds sensor inside device housing). Large dead volumes can increase response time of the sensor significantly.

1.2 Decoupling from external heat sources

External heat sources in direct proximity to the SCD4x can have a significant effect on the measured temperature. Therefore, the SCD4x should be decoupled from heat sources as depicted in **Figure 3**. As the RH (relative humidity) and T (temperature) signals are required for on-chip signal compensation of the CO_2 output, decoupling the sensor from heat sources is also relevant for customers that do not leverage the RH and T output for their application. Typically, the largest heat sources in an electronic device are the CPU, the display, the Wifi module, voltage regulators and batteries.
While heat sources with constant heating can be compensated with the built-in temperature offset, compensation of non-constant heat sources is complex.
To minimize the effect of external heat sources, the sensor should be placed in the device's coldest part. Typically, lowest self-heating can be realized by placing the SCD4x in the lowest part of a device and having maximal distance to self-heating components.

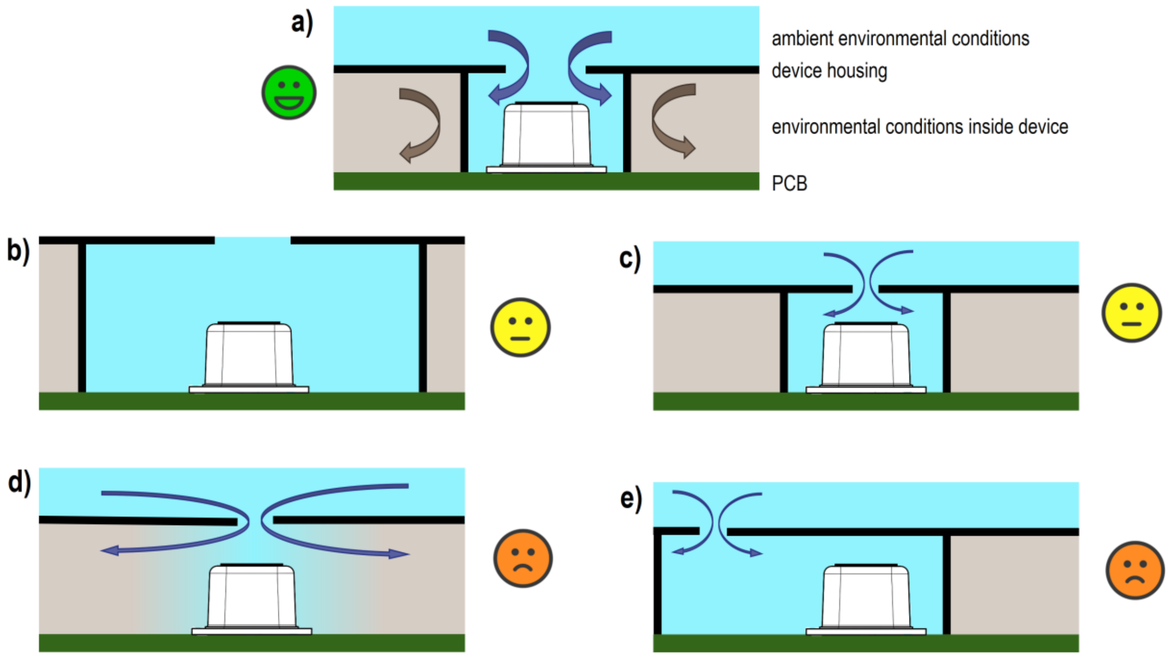

Figure 2: Sensor coupling to ambient environment. **(a)** Good coupling to the ambient air thanks to large opening in proximity to sensor and thanks to a small dead volume. **(b)** Moderate coupling to the ambient air due to large dead volume and **(c)** small opening in the device housing. **(d)** Poor coupling because of missing sealing from air entrapped in housing and **(e)** due to small opening that is far away from the sensor.

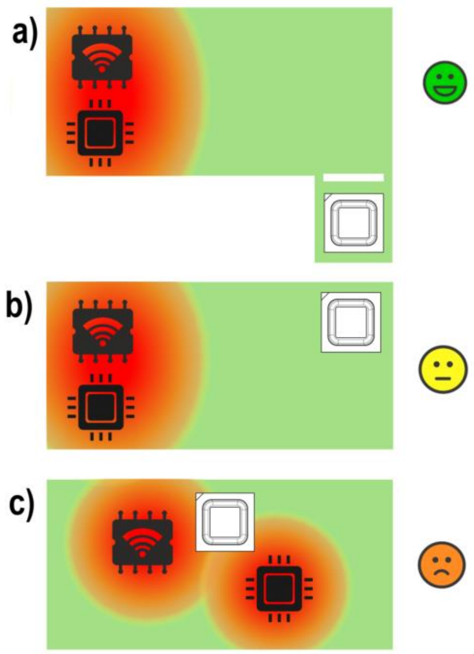

Figure 3: Sensor coupling to external heat sources (top view). The green color represents the customer PCB; the red circles indicate heat that dissipates from self-heating components. **(a)** Superb decoupling from external heat sources enabled by a slit in customer PCB. **(c)** Bad decoupling from external heat sources due to immediate proximity to self-heating components.

1.3 Isolation from air turbulences

Air flow as present in e.g. ducts can generate pressure drops, back pressure and dynamic fluctuations leading to increased sensor noise and reduced accuracy. Therefore, it is recommended to isolate SCD4x from air flow and air turbulences. This can be achieved by placing the sensor in a volume separated from the main air flow (**Figure 4**).

1.4 Decoupling from vibration sources

Vibration waves with high amplitudes can affect the noise level of the SCD4x. Lower frequency vibrations tend to be most critical.
To avoid compromised noise levels, the sensor should be decoupled from vibrations sources. This is best realized if there is no stiff material (such as a PCB or a metal bar) that bridges the vibration source and the sensor (see **Figure 5**). If this cannot be realized, damping elements such as rubber supports can be introduced to avoid increased noise levels.
Potential sources of low frequency vibration depend on the customer application.

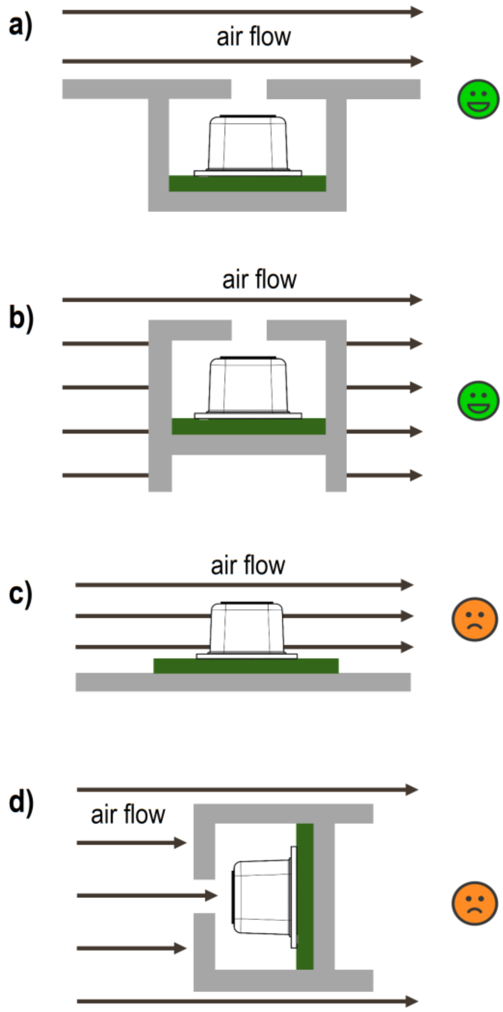

Figure 4: Isolation from air turbulences (side view). The grey structure represents the customer device housing. **(a-b)** Good isolation. **(c-d)** Bad isolation, as the SCD4X is exposed to wind turbulences directly.

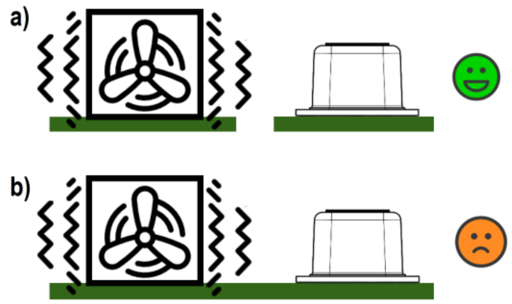

Figure 5: Decoupling from vibration source (side view). **(a)** Good decoupling is realized thanks to a gap of the support structure. **(b)** Bad decoupling since the PCB (green) serves as a bridge that transfers vibration to the sensor.

1.5 Shielded from sunlight

Exposing the SCD4x to direct sun light might introduce temperature offsets that affect the CO_2, RH and T output. Additionally, direct sunlight can accelerate the ageing of the sensor. Thus, it is recommended to protect the sensor from direct sunlight. This can be achieved by a suitable design-in or by using a light shade (see **Figure 6**).

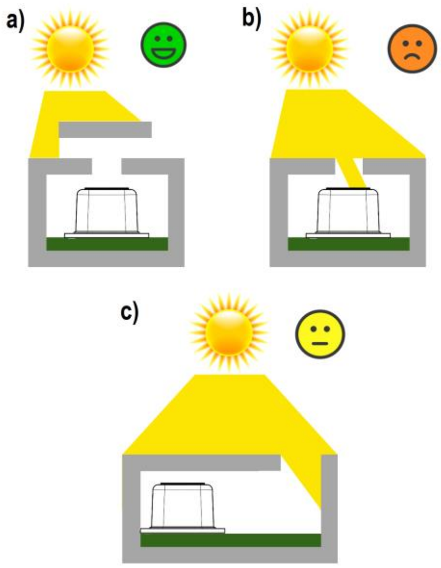

Figure 6: Sensor protection from sunlight (side view). **(a)** Good protection and **(b)** bad protection from incoming sunlight. **(c)** Good protection from sunlight, however, at the cost of bad coupling to ambient.

1.6 Avoid large voltage fluctuations

Large voltage fluctuations negatively affect the noise-levels of the CO_2 reading. Use of the SCD4x current supply for other components that have high current consumption with large transients should be avoided. Voltage Ripple Peak to Peak must be below 30 mV during sensor operation. Stable supply voltage is best realized with a low dropout (LDO) regulator.

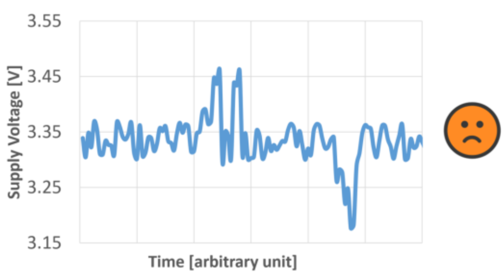

Figure 7: Non-constant supply voltage schematic.

2 Design-in sanity check

After having built a first prototype, a quick sanity check will give a hint on the quality of the design-in.
First, operate the device under normal / typical conditions in a typical environment for 15 minutes to allow complete thermal equilibration.
It the temperature and / or the relative humidity output is leveraged by the customer device, the output temperature should be compared with a temperature reference. We propose using a Sensirion SHTxx evaluation kit for RH and T reference. Note that the reference sensor should be isolated from heat sources. If the deviation of the temperature is higher than 0.5 °C, Sensirion recommends adapting the temperature offset accordingly via the digital interface (see SCD4x datasheet).
Next, the noise level of the CO_2 output should be investigated. A deviation larger than 20 ppm between subsequent CO_2 readings indicate a need for improvement of the SCD4x design-in.
Finally, the response time of the CO_2 output should be determined while running the SCD4x in the high-performance mode (**Figure 8**). To do so, an event should be triggered close to the customer device. Sensirion recommends using a CO_2 cartridge to realize a prompt increase of the CO_2 concentration. Alternatively, one can exhale few times in close proximity to the device under investigation. To have an effective test, CO_2 concentration should rise by at least 1000 ppm. After triggering the CO_2 event,
the reaction time should be compared with Table 1.

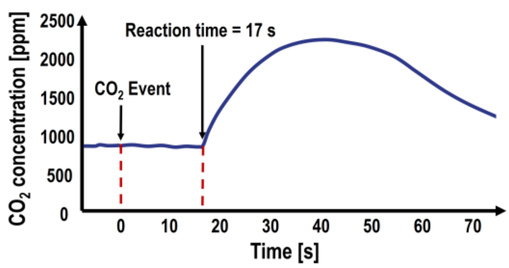

Figure 8: Schematic representation of the reaction time a CO_2 event at t = 0s.

Table 1: Quality of design in depending on reaction time of the CO_2 signal.

Reaction time	Design-in
Reaction time < 60 s	☺
Reaction time > 60 s	☹

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Disclaimer

This document is meant as a guideline and cannot be considered to be complete. It is subject to changes without prior notice.

Revision History

Date	Version	Page(s)	Changes
January 2021	1	all	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.

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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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- such defects shall be found, to SENSIRION's reasonable satisfaction, to have arisen from SENSIRION's faulty design, material, or workmanship;
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- the warranty period for any repaired or replaced product shall be limited to the unexpired portion of the original period.

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Headquarters and Subsidiaries

Sensirion AG
Laubisruetistr. 50
CH-8712 Staefa ZH
Switzerland

phone: +41 44 306 40 00
fax: +41 44 306 40 30
info@sensirion.com
www.sensirion.com

Sensirion Taiwan Co. Ltd
phone: +886 3 5506701
info@sensirion.com
www.sensirion.com

Sensirion Inc., USA
phone: +1 312 690 5858
info-us@sensirion.com
www.sensirion.com

Sensirion Japan Co. Ltd.
phone: +81 3 3444 4940
info-jp@sensirion.com
www.sensirion.com/jp

Sensirion Korea Co. Ltd.
phone: +82 31 337 7700~3
info-kr@sensirion.com
www.sensirion.com/kr

Sensirion China Co. Ltd.
phone: +86 755 8252 1501
info-cn@sensirion.com
www.sensirion.com/cn

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