# Datasheet SCD40 $CO_2$, RH and T Sensor

- Photoacoustic $CO_2$ sensor technology
- Integrated temperature and humidity sensor
- Best performance-to-price ratio
- Smallest form factor: 10.1 mm x 10.1 mm x 6.5 mm
- Measurement range: 0 ppm – 40'000 ppm
- Accuracy: ±(30 ppm + 3%)
- Fully calibrated and linearized output
- Digital interface $I^2C$
- SMD for cost- and space-saving integration




**Product Summary**

The SCD40 is Sensirion's next generation miniature $CO_2$, RH and T sensor. This sensor builds on the photoacoustic sensing principle and Sensirion's patented PAsens® and CMOSens® technology to offer highest accuracy at an unmatched price and smallest form factor. SMD assembly allows cost- and space-effective integration of the sensor combined with maximal freedom of design. Finally, ambient humidity and temperature can be measured by Sensirion's algorithm expertise through modelling and compensating of external heat sources without the need for any additional components.

$CO_2$ is a key indicator for indoor air quality as high levels compromise human health and productivity. Thus, the SCD40 enables smart ventilating systems in the commercial and the residential sector to regulate ventilation in the most energy-efficient and human-friendly way. Furthermore, $CO_2$ sensors play an essential role for indoor air quality monitoring and are therefore integrated in IAQ monitors, air purifiers, smart thermostats and similar devices.

Functional block diagram of the SCD40 - Confidential

# 1 Sensor Performance[1]

## 1.1 $CO_2$ Sensing Performance

| Parameter | Conditions | Value |
|---|---|---|
| $CO_2$ measurement range | - | 0 – 40'000 ppm |
| Accuracy[2] | 0 ppm – 5'000 ppm | ± (30 ppm + 3%MV) |
| Repeatability[3] | 0 ppm – 5'000 ppm | ± 10 ppm |
| Response time[4] | $T_{63\%}$ | 60 s |
| Accuracy drift over lifetime[5] | 400 ppm – 5'000 ppm<br>ASC field-calibration algorithm activated and SCD40 in environment allowing for ASC, or FRC field-calibration algorithm applied. | ± 50 ppm |

**Table 1:** SCD40 $CO_2$ sensor specifications

## 1.2 Humidity Sensing Performance[6]

| Parameter | Conditions | Value |
|---|---|---|
| Humidity measurement range | - | 0 %RH – 95 %RH |
| Accuracy[7] | 25°C, 0 – 95 %RH | ± 5 %RH |
| Repeatability[3] | - | ± 0.1 %RH |
| Response time[4] | $T_{63\%}$ | > 90 s |
| Accuracy drift | - | < 0.25 %RH / year |

**Table 2:** SCD40 humidity sensor specifications

## 1.3 Temperature Sensing Performance[6]

| Parameter | Conditions | Value |
|---|---|---|
| Temperature measurement range[8] | - | - 20°C – 60°C |
| Accuracy[7] | 0 – 50°C | ± (0.5°C + 0.023 × \|(T [°C] – 25°C)\|) |
| Repeatability[3] | - | ± 0.1°C |
| Response time[4] | $T_{63\%}$ | > 90 s |
| Accuracy drift | - | < 0.03 °C / year |

**Table 3:** SCD40 temperature sensor specifications



[1] Default conditions of T = 25°C, humidity = 50 %RH, p = 1013 mbar.
[2] Deviation to a high-precision reference. Accuracy is fulfilled by > 90% of the sensors after calibration. Rough handling, shipping and soldering reduces the accuracy of the sensor. Full accuracy is restored with FRC or ASC recalibration features. Accuracy is based on tests with gas mixtures having a tolerance of ± 1.5%.
[3] RMS error of consecutive measurements at constant conditions. Repeatability is fulfilled by > 90% of the sensors.
[4] Time for achieving 63% of a respective step function. Response time depends on the operating mode, design-in and environment of the sensor in the final application. The specified response time represents ideal design-in situation and high performance mode operation.
[5] $CO_2$ concentrations < 400 ppm may result in sensor drifts when ASC is activated. For proper function of ASC field-calibration algorithm SCD40 has to be exposed to air with $CO_2$ concentration 400 ppm regularly.
[6] Design-in of the SCD40 in final application and the environment impacts the accuracy of the RH/T sensor. Heat sources have to be considered for optimal performance. Please use integrated on-board RH/T compensation algorithm to account for the actual design-in.
[7] Deviation to a high-precision reference. Accuracy is fulfilled by > 90% of the sensors after calibration.
[8] RH/T sensor component is capable of measuring up to T = 120°C. However, measuring at T > 70°C might result in permanent damage of the sensor module.

# 2 Electrical Specifications

| Parameter | Conditions | Value |
|---|---|---|
| Average current[9] | High performance mode, VDD=3.3 V<br>Low power mode, VDD=3.3 V<br>Ultra low power mode, VDD=3.3 V | < 60 mA<br>< 12 mA<br>< 1.5 mA |
| Max. current[10] | During measurement, VDD=3.3 V<br>During measurement, VDD= 5 V | 170 mA<br>115 mA |
| DC supply voltage ($Vdd_{min}$ - $Vdd_{max}$)[11] | Min. and max. criteria to operate SCD40 | 2.4 – 5.5 V |
| Interface | - | $I^2C$ |
| Input high level voltage ($V_{IH}$) | Min. and max. criteria to operate SCD40 | 0.7 x VDD – 1 x VDD |
| Input low level voltage ($V_{IL}$) | Min. and max. criteria to operate SCD40 | -0.5 x VDD – 0.3 x VDD |
| Output low level voltage ($V_{OL}$) | 3 mA sink current | 0.66 V |

**Table 4** SCD40 electrical specifications

## 2.1 Operation Conditions, Lifetime and Maximum Ratings

| Parameter | Conditions | Value |
|---|---|---|
| Temperature operating conditions | | 0 – 50°C |
| Humidity operating conditions | Non-condensing. | 0 – 95 %RH |
| DC supply voltage | Exceeding specified range will result in damage of the sensor. | - 0.3 V – 6.0V |
| Max voltage on pins SDA, SCL, GND | Exceeding specified range will result in damage of the sensor. | -0.3 to VDD+0.3 |
| Input current on pins SDA, SCL, GND | Exceeding specified range will result in damage of the sensor. | +- 100 mA |
| Storage temperature conditions | Exceeding specified range will result in damage of the sensor. | - 40°C – 70°C |
| ESD HBM | | 2 kV |
| ESD CDM | | 500 V |
| Maintenance Interval | Maintenance free when ASC field-calibration algorithm[12] is used. | None |
| Sensor lifetime | - | 10 years |

**Table 5:** SCD40 operation conditions, lifetime and maximum ratings



[9] Average current including idle state and processing. Other update rates for small power budgets can be selected via the digital interface.
[10] Power supply should be designed with respect to maximum current.
[11] FRC must be applied to engineering samples that are not operated at 3.3 V to realize full accuracy.
[12] $CO_2$ concentrations < 400 ppm may result in sensor drifts. For proper function of ASC field-calibration algorithm SCD40 has to be exposed to air with 400 ppm regularly.

# 3 Interface Specifications

The SCD40 comes in an LGA package, see **Table 6**.

| Name | Comments |
|---|---|
| VDD | Supply voltage |
| VDDH | Supply voltage, hotplate |
| GND | Ground contact |
| SDA | Serial data, bidirectional |
| SCL | Serial clock |
| DNC | Do not connect, pads must be soldered to a floating pad on the customer PCB |

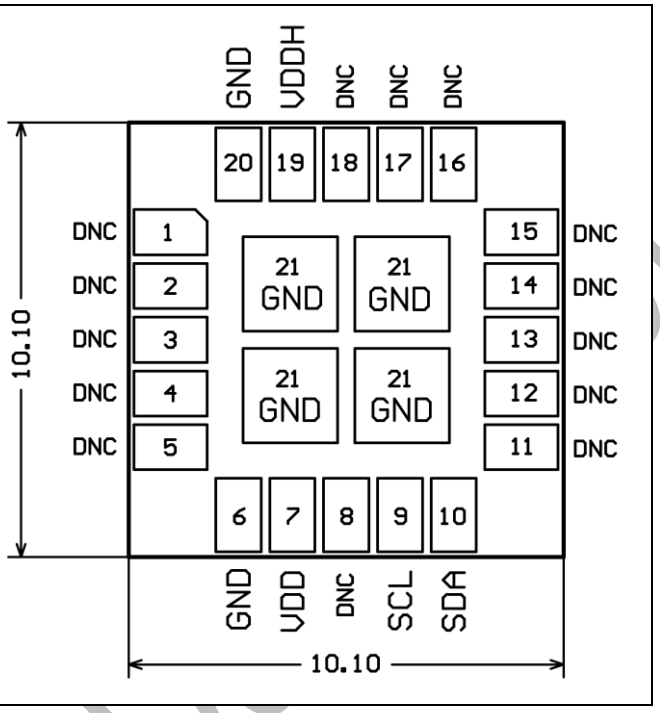


**Table 6** Pin assignment (top view).

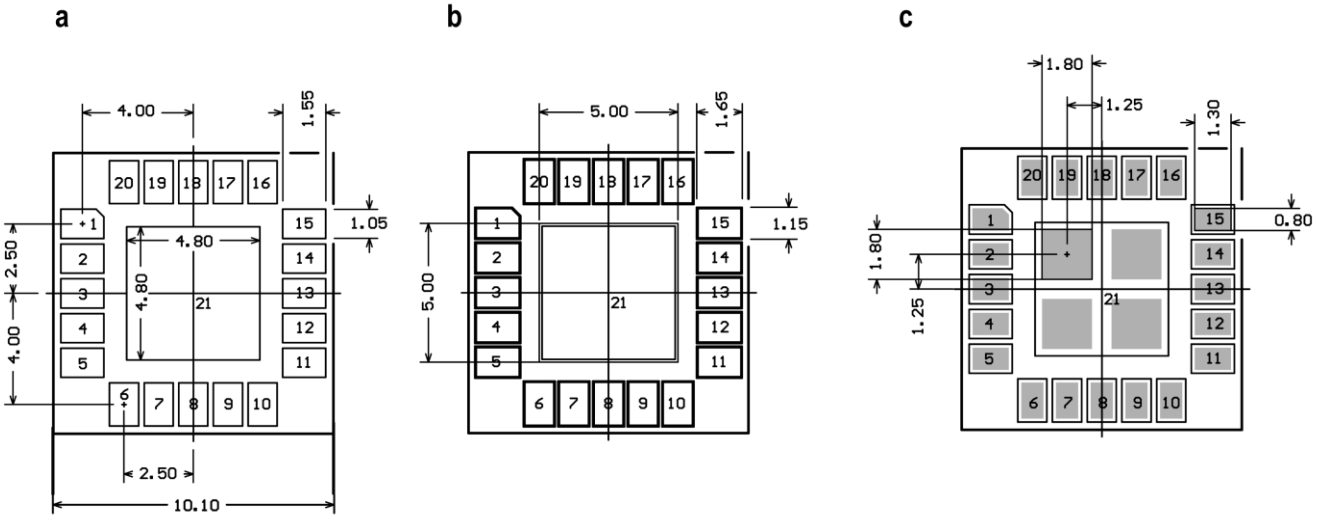


**Figure 1**: SCD40 Footprint (top view): landing pads (**a**), soldermask (**b**) and solderpaste (**c**).

SCL is used to synchronize the communication between the microcontroller and the sensor. The SDA pin is used to transfer data to and from the sensor. For safe communication, the timing specifications defined in the I²C manual[13] must be met. Both SCL and SDA lines should be connected to external pull-up resistors. To avoid signal contention, the microcontroller must only drive SDA and SCL low. The external pull-up resistors (e.g. $R_p$ = 10 kΩ) are required to pull the signal high. For dimensioning resistor sizes please take bus capacity and communication frequency into account (see for example Section 7.1 of NXPs I²C Manual for more details[13]). It should be noted that pull-up resistors may be included in I/O circuits of microcontrollers.

[13] http://www.nxp.com/documents/user_manual/UM10204.pdf

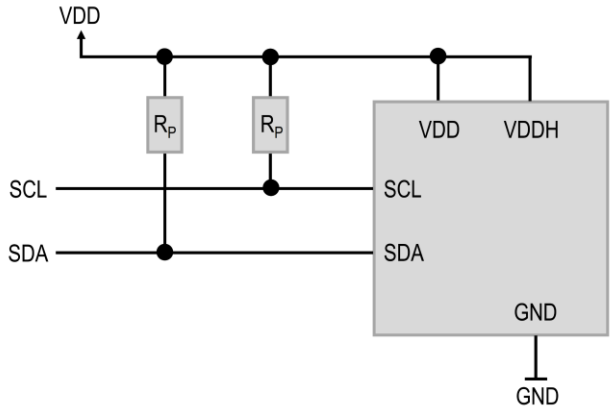


**Figure 2**: Typical application circuit (for better clarity in the image, the positioning of the pins does not reflect the positions on the real sensor). VDD and VDDH must be connected to each other close to the sensor on the customer PCB.

# 1 Important Notices

## a. 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.

## b. 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.

## c. 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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