

SEN6x – Datasheet

3rd Generation Environmental Sensor Node for Air Quality Applications



Highlights

- PM, RH&T, VOC, NO_x, CO₂/HCHO sensing platform
- Fast & easy integration
- 10 years dust resistant – Patented Sheath Flow technology
- Fully calibrated digital output
- One node for up to 9 data signals
- Integrated compensation algorithms
- Ready for California Title 24¹, RESET^{®2} and WELL Building Standard^{™3}

The SEN6x sensor module family is an air quality platform that combines critical parameters such as particulate matter, relative humidity, temperature, VOC, NO_x and either CO₂ or formaldehyde, all in one compact package. The modules are a result of Sensirion’s extensive experience in environmental sensing and offer the best possible performance for each parameter, a superior lifetime and an unrivaled form factor. The combination of all measurement parameters, together with all relevant algorithms in one device simplifies the integration, streamlines the supply chain, and allows for a fast time to market with the best performance.

Product Overview

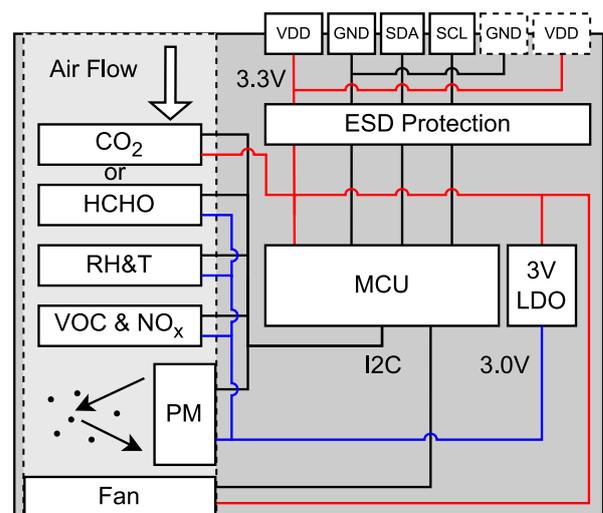
| Product Variant | Sensor Signals |
|-----------------|--|
| SEN60 | PM |
| SEN63C | PM, RH & T, CO ₂ |
| SEN65 | PM, RH & T, VOC, NO _x |
| SEN66 | PM, RH & T, VOC, NO _x , CO ₂ |
| SEN68 | PM, RH & T, VOC, NO _x , HCHO |

See full product list on page 57



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Functional Block Diagram



¹ 2022 California Building Energy Efficiency Standards for Residential and Nonresidential Buildings

² RESET Air Standard v2.0

³ WELL v2

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This is a preliminary datasheet; all specifications are to be understood as target specifications and can change without notice.

1 Environmental Sensor Node Specifications

For section 1.1 to 1.6, default conditions of continuous measurement-mode, 25 °C, 50 %RH (relative humidity), 1013 mbar, and 3.3 V supply voltage apply, unless stated otherwise.

Different products within the SEN6x family offer different sensing capabilities. Specifications in the following only apply if the parameter is present in the selected product.

1.1 Sensor Module Specifications

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

| Parameter | Conditions | Value | Units |
|--|---------------------------------|-----------|--------------|
| Sampling interval | - | 1 ± 0.03 | s |
| Sensor startup time (Time after power-on until I2C communication can be started) | - | 100 | ms |
| Lifetime ^{4,5} | 24 h/day operation ⁶ | > 10 | years |
| Acoustic emission level | 0.2 m | < 24 | dB(A) |
| Long term acoustic emission level drift | 0.2 m | +0.5 | dB(A) / year |
| Weight | - | 20 ± 10 % | g |

Table 1. Sensor Module Specifications

⁴ Lifetime is based on mean-time-to-failure (MTTF) calculation. Lifetime might vary depending on different operating conditions. For more details refer to "Sensor Specification Statement – Rev.2" [7]

⁵ Excluding formaldehyde specifications, formaldehyde lifetime limited to > 6 years

⁶ For an indoor air quality mission profile

1.2 Particulate Matter Specifications

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

| Parameter | Conditions | | Value | Units |
|---|---|------|---|--------------------------|
| Mass concentration specified range | - | | 0 to 1'000 | µg/m ³ |
| Mass concentration size range | PM1.0 | | 0.3 to 1.0 | µm |
| | PM2.5 | | 0.3 to 2.5 | |
| | PM4 | | 0.3 to 4.0 | |
| | PM10 | | 0.3 to 10.0 | |
| Mass concentration precision ^{7,10} for PM1 and PM2.5 ⁸ | 0 to 100 µg/m ³ | | ±5 µg/m ³ AND 5 % m.v. | |
| | 100 to 1000 µg/m ³ | | ±10 | % m.v. |
| Mass concentration precision ^{7,10} for PM4, PM10 ⁹ | 0 to 100 µg/m ³ | | ±25 | µg/m ³ |
| | 100 to 1000 µg/m ³ | | ±25 | % m.v. |
| Maximum long-term mass concentration precision limit drift ¹⁰ | 0 to 100 µg/m ³ | | ±2 | µg/m ³ / year |
| | 100 to 1000 µg/m ³ | | ±2 | % m.v. / year |
| Typical start-up time ¹¹ | - | | 30 | s |
| Sensor output characteristics | PM2.5 mass concentration | | Calibrated to TSI DustTrak™ DRX 8533 Ambient Mode | |
| Additional T-dependent mass precision limit drift ¹⁰ | temperature difference to 25°C | typ. | ±0.5 | % m.v. / °C |
| Laser wavelength (IEC 60825-1:2014 and DIN EN 60825-1:2022 Class 1) |  | typ. | 850 | nm |

Table 2. Particulate matter sensor specifications. ‘% m.v.’ means ‘% of measured value’.

1.2.1 Laser Safety

| | |
|---|--|
|  | This product is classified as a Class 1 laser product according to IEC 60825-1:2014 and DIN EN 60825-1:2022 standards. It is safe to operate without additional precautions. Do not open for servicing. Do not operate when damaged. Failure to follow this warning may result in direct exposure to the invisible Class 3R laser source and permanent eye damage. |
|---|--|

⁷ Also referred to as “between-parts variation” or “device-to-device variation”.

⁸ Verification Aerosol for PM2.5 is a 3% atomized KCl solution. Deviation to reference instrument is verified in end-tests for every sensor after calibration.

⁹ PM4 and PM10 output values are calculated based on distribution profile of all measured particles.

¹⁰ For more details refer to “Sensirion Environmental Node Sensor Specification Statement – Rev.2” [7]

¹¹ Time after starting continuous measurement-mode, until a stable measurement is obtained.

1.3 Temperature and Humidity Specifications

Applies to: SEN63C, SEN65, SEN66, SEN68

| Parameter | Conditions | Value ¹² | | | Units |
|---|--------------------------------|---------------------|-------|------|-------|
| | | Min | Typ. | Max | |
| Compensated outputs ¹³ | - | Temperature | | | °C |
| | | Relative Humidity | | | %RH |
| Accuracy temperature | @ 15-30 °C, 50 %RH | | ±0.45 | ±0.7 | °C |
| Repeatability temperature | @ 25 °C, 50 %RH | | 0.1 | | |
| Response time temperature ¹⁴ | @ 25 °C, 50 %RH, $\tau_{63\%}$ | | <60 | | s |
| Accuracy relative humidity | @ 25 °C, 30-70 %RH | | ±4.5 | ±6 | %RH |
| Repeatability relative humidity | @ 25 °C, 50 %RH | | ±1 | | |
| Response time relative humidity ¹⁵ | @ 25 °C, 50 %RH, $\tau_{63\%}$ | | <20 | | s |

Table 3. Temperature and humidity specifications

¹² For the definition of the typical and max. accuracy tolerance, please refer to the document “Sensirion Humidity Sensor Specification Statement” [8].

¹³ Self-heating of the module is compensated according to the application note “Temperature Acceleration and Compensation Instructions for SEN6x” [3].

¹⁴ For a step from 15°C to 25°C, for a bare module with default acceleration and offset parameters

¹⁵ For a step from 75%RH to 25%RH, for a bare module with default acceleration and offset parameters.

1.4 VOC and NO_x Specifications

Applies to: SEN65, SEN66, SEN68

| Parameter | Description | Values | | | Units |
|----------------------------|--|-----------------------|--------------------|--------|--|
| | | Min. | Typ. ¹⁶ | Max. | |
| Output signals | VOC Index | 1 | – | 500 | VOC Index points |
| | NO _x Index | 1 | – | 500 | NO _x Index points |
| | SRAW_VOC | 0 | - | 65'535 | ticks ¹⁷ |
| | SRAW_NO _x | 0 | - | 65'535 | |
| | TVOC output in ppb or µg/m ³ can be obtained by implementing application note: Compliance of Sensirion's VOC Sensors with Building Standards [1]. | | | | ppb or µg/m ³ |
| Device-to-device variation | VOC Index ¹⁸ | – | <±15 <±15 | – | VOC Index points or % VOC Index m.v. (the larger) |
| | NO _x Index ¹⁸ | – | <±50 <±50 | – | NO _x Index points or % NO _x Index m.v. (the larger) |
| Repeatability | VOC Index ¹⁸ | – | <±5 <±5 | – | VOC Index points or % VOC Index m.v. (the larger) |
| | NO _x Index ¹⁸ | – | <±10 <±10 | – | NO _x Index points or % NO _x Index m.v. (the larger) |
| Switch-on behavior | Time until reliably detecting events ¹⁹ | – | <60 | – | s |
| | Time until specifications in this table are met | VOC Index | <1 | – | h |
| | | NO _x Index | <6 | – | |

Table 4. VOC and NO_x sensing specifications in zero air (considered as clean air for indoor air quality applications). All concentrations refer to ethanol as test gas.

¹⁶ 95% of the sensors will be within the typical tolerance corresponding to 2σ assuming a normal distribution for ≥100 sensors.

¹⁷ Ticks is proportional to the logarithm of the resistance of the sensing layer.

¹⁸ Evaluated using the calibration and test sequence according to the application note "SGP40 – Quick Testing Guide" [9].

¹⁹ Signal change during 60s event of 5'000 to 10'000 ppb of ethanol or of 100 to 300 ppb of NO₂ is three times larger than raw signals (SRAW_VOC, SRAW_NO_x) drift, without this event during the same duration.

1.5 CO₂ Specifications

Default conditions as in section 1 apply to values in the table below, unless otherwise stated. Continuous operation with automatic self-calibration (ASC) enabled and exposure to fresh air (i.e. CO₂ concentration at 400 ppm) at least once per week is required to achieve the following specifications.

1.5.1 CO₂ Specifications – SEN66

Applies to: SEN66

Accuracy is defined as deviation to a high-precision reference with gas mixtures having a ±2% tolerance and is achieved after either forced CO₂ recalibration (FRC) or initial operation for 2 days including exposure to fresh air.

| Parameter | Conditions | Value | Units |
|---|---|--------------------|-------|
| CO ₂ output range ²⁰ | - | 0 to 40'000 | ppm |
| CO ₂ measurement accuracy | 400 ppm to 1'000 ppm | ±(50 + 2.5 % m.v.) | |
| | 1'001 ppm to 2'000 ppm | ±(50 + 3 % m.v.) | |
| | 2'001 ppm to 5'000 ppm | ±(40 + 5 % m.v.) | |
| Additional accuracy drift per year, starting after five years ²¹ | 400 to 5000 ppm, typ. | ±(5 + 0.5 % m.v.) | |
| Repeatability | typ. | ±10 | |
| Response time | τ _{63%} , typical, step change 400 – 2'000 ppm | 60 | s |

Table 5. CO₂ specifications, '% m.v.' means '% of measured value'.

1.5.2 CO₂ Specifications – SEN63C

Applies to: SEN63C

Accuracy is achieved after initial operation for 12 hours, followed by exposure to fresh air.

| Parameters | Conditions | Value | Units |
|--|--|--------------------|-------|
| CO ₂ output range ²⁰ | - | 0 to 32'000 | ppm |
| CO ₂ measurement accuracy | 400 ppm to 5'000 ppm | ±(100 + 10 % m.v.) | |
| Response time | τ _{63%} , typ., step change 2'000 – 400 ppm | 60 | s |

Table 6. CO₂ specifications in ambient air (defined as consisting of 78% N₂, 21% O₂, 0.93% Ar, plus a variable content of CO₂ and H₂O depending on the relative humidity), '% m.v.' means '% of measured value'.

²⁰ Exposure to CO₂ concentrations smaller than 400 ppm can affect the accuracy of the sensor with ASC enabled.

²¹ Deviation is additional to standard accuracy specifications Maximum additional accuracy drift per year starting after five years estimated from stress tests is ± (5 ppm + 2% m.v.). Stronger drift may occur if the sensor is not handled according to its handling instructions.

1.6 Formaldehyde Specifications

Applies to: SEN68

| Parameter | Conditions | Value | Units |
|--|---|--|-------|
| Formaldehyde concentration measurement range | - | 0 to 1000 | ppb |
| Typical Accuracy | 0 to 200 ppb HCHO in clean air | ±20 ppb or ±20 % m.v. (the larger) | - |
| Maximum long-term accuracy drift | Standard conditions as defined in section 1 | ±5 ppb / year or ±5 % m.v. / year (the larger) | - |
| Accuracy in VOC background | 100 ppb HCHO in background of 5 ppm of ethanol | +35 to -20 | ppb |
| Cross-sensitivity to ethanol | Tested in 5 ppm ethanol | ≤0.3 | % |
| Resolution | - | 0.1 | ppb |
| Start-up time | Time until sensor output is within specifications | ≤10 | min |
| Lifetime | Standard conditions as defined in section 1 | ≥6 | years |

Table 7. Formaldehyde specifications), '% m.v.' means '% of measured value'.

1.7 Recommended and Absolute Maximum and Minimum Operating and Storage Conditions

The SEN6x family contains different sensing components with different operating and storage ranges. Make sure to select the appropriate table for the selected product.

1.7.1 SEN60

Table 8. and Figure 1 show the recommended operating and storage conditions in which all the sensing components of the SEN60 show the best performance, as well as absolute maximum/minimum conditions which must not be exceeded.

Exposure to conditions outside the recommended range may temporarily reduce sensor performance (PM precision). Exposure to conditions outside the absolute maximum/minimum range may lead to permanent damage to the device.

The sensor must not be exposed to condensing conditions at any time.

| Condition | Parameter | Recommended | | Short-Term Maximum/Minimum ²² | | Unit |
|----------------------|-------------------|-------------|------|--|---------------------|------|
| | | Min. | Max. | Min. | Max. | |
| Operating conditions | Temperature | 10 | 40 | -10 | 60 | °C |
| | Relative humidity | 20 | 80 | 0 | 95 (non-condensing) | % RH |
| Storage conditions | Temperature | 10 | 40 | -40 | 70 | °C |
| | Relative Humidity | 20 | 60 | 0 | 95 (non-condensing) | % RH |

Table 8. Recommended and absolute maximum/minimum operating and storage conditions for the SEN60

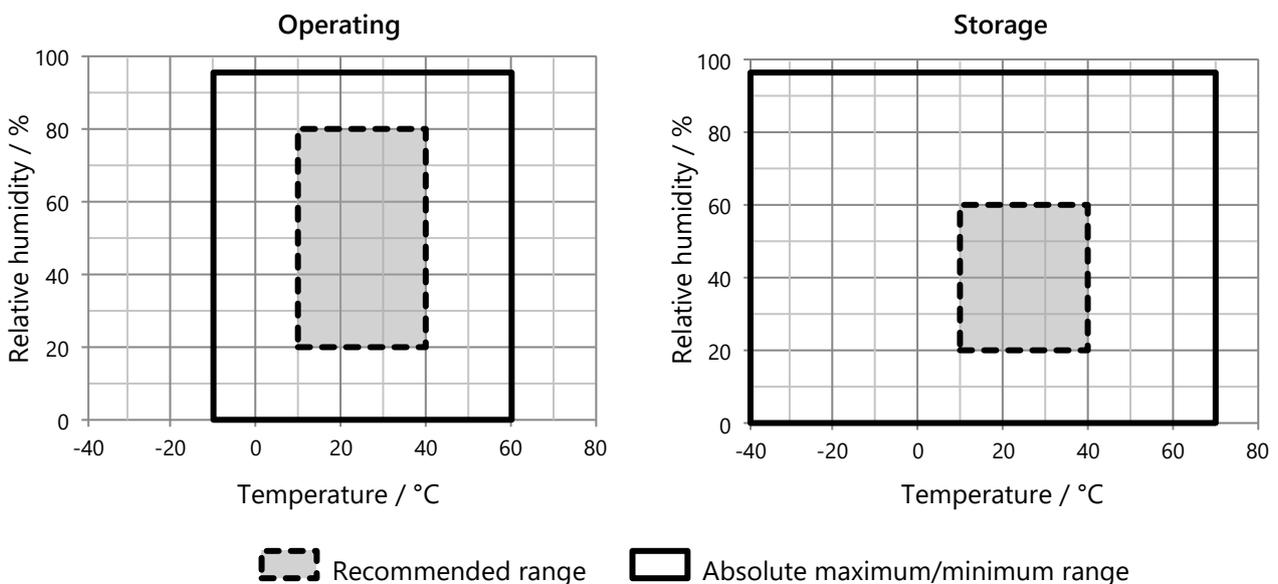


Figure 1. Recommended and absolute maximum/minimum operating and storage conditions for the SEN60

²² Short-term storage refers to temporary conditions, e.g., transport.

1.7.2 SEN63C, SEN65 and SEN66

Table 9. and **Figure 2** show the recommended operating and storage conditions in which all the sensing components of the SEN63C, SEN65 and SEN66 show the best performance, as well as absolute maximum/minimum conditions which must not be exceeded. Gas sensing specifications are guaranteed only when the SEN63C, SEN65 and SEN66 are operated and stored under the recommended conditions given in **Table 9.** and **Figure 2.**

Exposure to conditions outside the recommended range may temporarily reduce sensor performance (reversible RH drift, reduced RH, T, VOC, NO_x, CO₂, PM precision). Exposure to conditions outside the absolute maximum/minimum range may lead to permanently reduced sensor performance (VOC and NO_x sensitivity drift) or cause permanent damage to the device.

The sensor must not be exposed to condensing conditions at any time.

| Condition | Parameter | Recommended | | Short Term- Maximum/Minimum ²³ | | Unit |
|----------------------|-------------------|-------------|------|---|---------------------|------|
| | | Min. | Max. | Min. | Max. | |
| Operating conditions | Temperature | 10 | 40 | -10 | 50 | °C |
| | Relative humidity | 20 | 80 | 0 | 90 (non-condensing) | % RH |
| Storage conditions | Temperature | 10 | 30 | -40 | 70 | °C |
| | Relative Humidity | 20 | 60 | 0 | 80 (non-condensing) | % RH |

Table 9. Recommended and absolute maximum/minimum operating and storage conditions for the SEN63C, SEN65 and SEN66

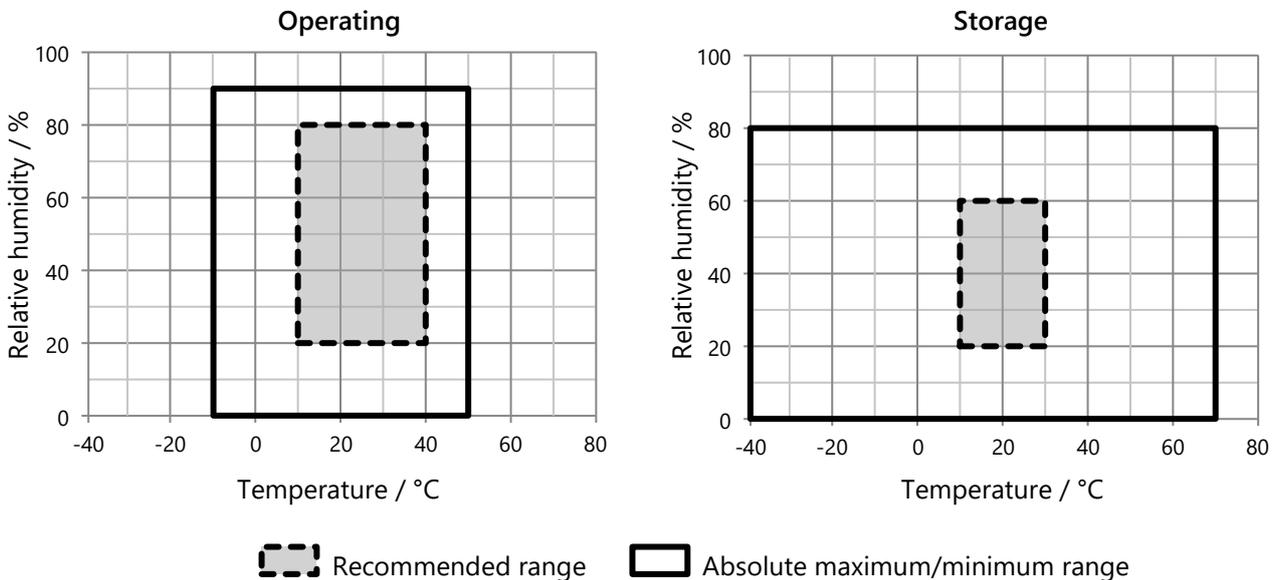


Figure 2. Recommended and absolute maximum/minimum operating and storage conditions for the SEN63, SEN65 and SEN66

²³ Short-term storage refers to temporary conditions, e.g., transport.

1.7.3 SEN68

Table 10. and **Figure 3** show the recommended operating and storage conditions in which all the sensing components of the SEN68 show the best performance, as well as absolute maximum/minimum conditions which must not be exceeded. Gas sensing specifications are guaranteed only when the SEN68 is operated and stored under the recommended conditions given in **Table 10.** and **Figure 3.**

Exposure to conditions outside the recommended range may temporarily reduce sensor performance (reversible RH drift, reduced RH, T, VOC, NO_x, HCHO, PM precision). Exposure to conditions outside the absolute maximum/minimum range may lead to permanently reduced sensor performance (VOC, NO_x and HCHO sensitivity drift) or cause permanent damage to the device.

The sensor must not be exposed to condensing conditions at any time.

| Condition | Parameter | Recommended | | Short-Term Maximum/Minimum ²⁴ | | Unit |
|----------------------|-------------------|-------------|------|--|---------------------|------|
| | | Min. | Max. | Min. | Max. | |
| Operating conditions | Temperature | 10 | 40 | 0 | 50 | °C |
| | Relative humidity | 20 | 80 | 15 | 90 (non-condensing) | % RH |
| Storage conditions | Temperature | 10 | 30 | -20 | 60 | °C |
| | Relative Humidity | 30 | 60 | 10 | 80 (non-condensing) | % RH |

Table 10. Recommended and absolute maximum/minimum operating and storage conditions for the SEN68

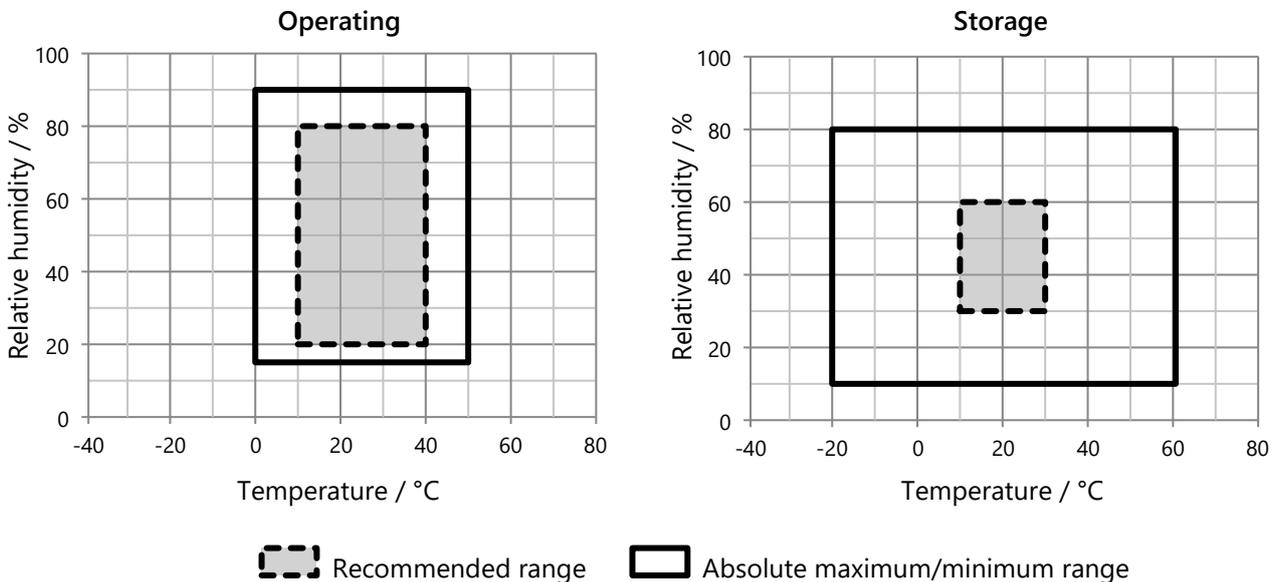


Figure 3. Recommended and absolute maximum/minimum operating and storage conditions for the SEN68

²⁴ Short-term storage refers to temporary conditions, e.g., transport.

2 Electrical Specifications

2.1 Electrical Characteristics

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

| Parameter | Conditions | | Min | Typ. | Max | Unit |
|--|---|--------|--------------------|------|--------------------|------|
| Supply voltage (V_{DD}) | - | | 3.15 ²⁵ | 3.3 | 3.45 | V |
| Supply voltage peak to peak ripple ($V_{DD,pp}$) | ≥ 100 Hz | SEN6x | - | - | 100 | mV |
| | < 100 Hz | SEN66 | - | - | 30 | |
| | | SEN6x | - | - | 100 | |
| Average supply current ²⁶ | Idle Mode (first 10 seconds) | SEN60 | | 3.3 | | mA |
| | | SEN63C | | 3.3 | | |
| | | SEN65 | | 4.6 | | |
| | | SEN66 | | 4.6 | | |
| | | SEN68 | | 4.6 | | |
| | Idle Mode (after first 10 seconds) | SEN60 | - | 3.3 | - | |
| | | SEN63C | - | 3.3 | - | |
| | | SEN65 | - | 3.3 | - | |
| | | SEN66 | - | 3.3 | - | |
| | | SEN68 | - | 3.3 | - | |
| | Measurement-Mode (after first 60 seconds) | SEN60 | - | 75 | 90 | |
| | | SEN63C | - | 80 | 100 | |
| | | SEN65 | - | 80 | 100 | |
| | | SEN66 | - | 90 | 110 | |
| | | SEN68 | - | 75 | 100 | |
| Peak supply current | Measurement mode (pulse width of 2 ms) | SEN60 | - | 130 | 190 | |
| | | SEN63C | - | 140 | 200 | |
| | | SEN65 | - | 140 | 200 | |
| | | SEN66 | - | 300 | 350 | |
| | | SEN68 | - | 140 | 200 | |
| SDA/SCL pin input high voltage (V_{IH}) | - | | $0.7 \cdot V_{DD}$ | - | - | V |
| SDA/SCL pin input low voltage (V_{IL}) | - | | - | - | $0.3 \cdot V_{DD}$ | |
| SDA pin output low voltage (V_{OL}) | - | | - | - | 0.45 | |

Table 11. Electrical Specifications at 25°C

²⁵ Minimum voltage including ripples.

²⁶ Averaged over 5 seconds

2.2 Absolute Maximum Ratings

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

Stress levels beyond those listed in **Table 12** may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions cannot be guaranteed. Exposure to the absolute maximum rating conditions for extended periods may affect the reliability of the device.

| Parameter | Min | Max | Unit |
|-----------------------------|------|-----|------|
| Supply voltage VDD | 0 | 3.6 | V |
| I/O pins (SDA, SCL) | -0.3 | 5.5 | |
| Max. current on any I/O pin | -20 | 20 | mA |

Table 12. Absolute minimum and maximum ratings

2.3 ESD / EMC Ratings

2.3.1 Immunity

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

| Description | Standard | Rating |
|---------------------------------------|---------------|---|
| Electrostatic Discharge | IEC 61000-4-2 | ±4 kV contact, ±4 kV air |
| Power-Frequency Magnetic Field | IEC 61000-4-8 | 30 A/m, 50 Hz and 60 Hz |
| Radio-Frequency EM-Field AM-modulated | IEC 61000-4-3 | 80 MHz – 1000 MHz, 3 V/m, 80% AM @1 kHz |
| Radio-Frequency EM-Field AM-modulated | IEC 61000-4-3 | 1.4 GHz – 6 GHz, 3 V/m, 80% AM @1 kHz |

Table 13. ESD and EMC immunity

2.3.2 Emission

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

| Description | Standard | Rating |
|---------------------------------------|--------------|--------------------|
| Emission in SAC for 30MHz to 230MHz | IEC/CISPR 16 | 40 dB(µV/m) QP @3m |
| Emission in SAC for 230MHz to 1000MHz | IEC/CISPR 16 | 47 dB(µV/m) QP @3m |

Table 14. EMC emission

3 Hardware Interface Description

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

The sensor is equipped with a serial communication interface. In Table 16, a description of the pin layout is given.

| Part | Description |
|--------------------------|--|
| Connector sensor side | ACES 51468-0064N-001 |
| Connector cable side | ACES 51452-006H0H0-001 or compatible (e.g., JST GHR-06V-S) |
| Cable cross section area | ≥AWG26 (≥0.128 mm ²) |
| Cable length | ≤50 cm |

Table 15. SEN6x physical interface

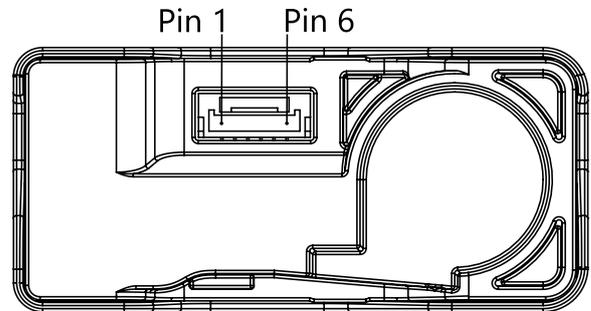


Figure 4. Pin layout. The communication interface connector (ACES 51468-0064N-001) is located at the side of the sensor adjacent to the air outlet.

| Pin | Name | Description | Comments |
|-----|------|--------------------------|---------------------------------------|
| 1 | VDD | Supply voltage | - |
| 2 | GND | Ground | - |
| 3 | SDA | Serial data input/output | TTL 5V compatible |
| 4 | SCL | Serial clock input | TTL 5V compatible |
| 5 | GND | Ground or NC | Pins 2 and 5 are connected internally |
| 6 | VDD | Supply voltage or NC | Pins 1 and 6 are connected internally |

Table 16. SEN6x pin assignment

3.1 I²C Interface Circuit

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

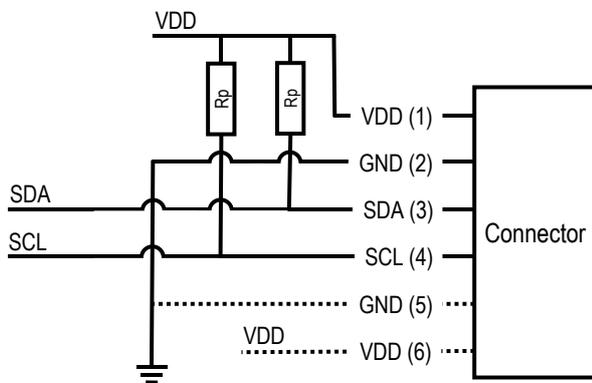


Figure 5. I²C application circuit

Both SCL and SDA lines are open drain I/Os. They must be connected to external pull-up resistors (e.g. Rp = 10 kΩ).

SEN6x uses an I²C interface, which was originally designed to connect two chips on a PCB at relatively close distance. Hence, when the sensor is connected to the main PCB via a cable, particular attention must be paid to electromagnetic interference and crosstalk. Use as short as possible (< 10 cm) and/or well shielded connection cables.

For detailed information on the I²C protocol, refer to NXP I²C-bus specification [2].

4 Digital Interface Description

4.1 Operation Modes

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

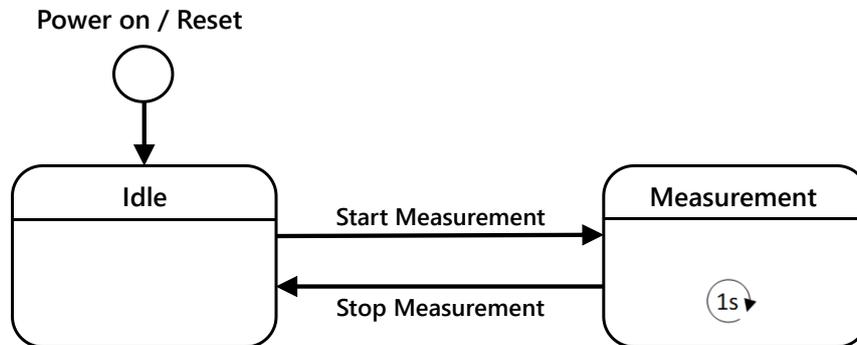


Figure 6. SEN6x operating modes

Idle:

- The module is in Idle Mode after power on or reset.
- Most of the internal electronics switched off / reduced power consumption.
- Fan and laser are switched off.
- The module is ready to receive and process any command.

Measurement:

- All electronics switched on / max. power consumption.
- The measurement is running, and the module is continuously processing measurement data.
- New readings are available every second.

4.2 Temperature Compensation with STAR Engine

Applies to: SEN63C, SEN65, SEN66, SEN68

By default, the temperature and humidity outputs from the sensor are compensated for the module’s self-heating. If the module is designed into a device, the temperature compensation might need to be adapted to incorporate the change in thermal coupling and self-heating of other device components. A guide to achieve optimal performance, including references to mechanical design-in examples can be found in the app note “Temperature Acceleration and Compensation Instructions for SEN6x” [3].

4.3 Device Status Register

The device status register contains information about the internal state of the module.

4.3.1 SEN6x

Applies to: SEN63C, SEN65, SEN66, SEN68

| | | | | | | | | | | | | | | | |
|------|------|------|--------------------|-------|-------|--------------------|------|-------|-------|---------|-------|------|------|------|------|
| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| | | | | | | | | | | Warning | | | | | |
| res. | res. | res. | res. | res. | res. | res. | res. | res. | res. | SPEED | res. | res. | res. | res. | res. |
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| | | | Error | Error | Error | Error | | Error | Error | | Error | | | | |
| res. | res. | res. | CO ₂ -1 | PM | HCHO | CO ₂ -2 | res. | GAS | RH&T | res. | FAN | res. | res. | res. | res. |

Figure 7. SEN6x device status register description

4.3.2 SEN60

Applies to: SEN60

| | | | | | | | | | | | | | | | |
|------|------|------|------|------|------|------|------|------|------|------|-------|------|------|---------|------|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| | | | | | | | | | | | Error | | | Warning | |
| res. | FAN | res. | res. | SPEED | res. |

Figure 8. SEN60 device status register description

4.3.3 SPEED – Fan Speed Warning

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

| Fan Speed Warning | |
|-------------------|--|
| Bit | SEN6x |
| | 21 (see Figure 7) |
| State | 0 Fan speed is ok |
| | 1 Fan speed is too high or too low |
| Sticky | No |
| Description | Fan is switched on, but its speed is more than 10% off the target speed for multiple consecutive measurement intervals. During the first 10 seconds after starting the measurement, the fan speed is not checked (settling time). Very low or very high ambient temperature could trigger this warning during startup. If this flag is set constantly, it might indicate a problem with the power supply or with the fan, and the measured PM values might be wrong. This flag is automatically cleared as soon as the measured speed is within 10% of the target speed or when leaving the measure mode. Can occur only in measurement mode. |

Table 17. Fan speed warning bit description

4.3.4 CO₂-1 – CO₂ Sensor Error

Applies to: SEN63C

| CO2-1 Sensor Error | |
|--------------------|--|
| Bit | 12 (see Figure 7) |
| State | 0 CO ₂ sensor is running normally |
| | 1 CO ₂ sensor error |
| Sticky | Yes – Even if the error disappears or when leaving the measure mode, the flag remains set. This flag will only be reset by Read And Clear Device Status SEN6x or through a reset, either by calling Device Reset SEN6x or through a power cycle. |
| Description | Error related to the CO ₂ sensor. The CO ₂ values might be unknown or wrong if this flag is set, relative humidity and temperature values might be out of specs due to compensation algorithms depending on CO ₂ sensor state. Can occur only in measurement mode. |

Table 18. CO₂-1 sensor error bit description

4.3.5 PM – Particulate Matter Sensor Error

Applies to: SEN63C, SEN65, SEN66, SEN68

| PM Sensor Error | |
|-----------------|---|
| Bit | 11 (see Figure 7) |
| State | 0 PM sensor is running normally |
| | 1 PM sensor error |
| Sticky | Yes – Even if the error disappears or when leaving the measure mode, the flag remains set. This flag will only be reset by Read And Clear Device Status SEN6x or through a reset, either by calling Device Reset SEN6x or through a power cycle. |
| Description | Error related to the PM sensor. The particulate matter values might be unknown or wrong if this flag is set, relative humidity and temperature values might be out of specs due to compensation algorithms depending on PM sensor state. Can occur only in measurement mode. |

Table 19. PM sensor error bit description

4.3.6 HCHO – Formaldehyde Sensor Error

Applies to: SEN68

| Formaldehyde Sensor Error | | |
|---------------------------|---|---|
| Bit | 10 (see Figure 7) | |
| State | 0 | Formaldehyde sensor is running normally |
| | 1 | Formaldehyde sensor error |
| Sticky | Yes – Even if the error disappears or when leaving the measure mode, the flag remains set. This flag will only be reset by Read And Clear Device Status SEN6x or through a reset, either by calling Device Reset SEN6x or through a power cycle. | |
| Description | Error related to the formaldehyde sensor. The formaldehyde values might be unknown or wrong if this flag is set, relative humidity and temperature values might be out of specs due to compensation algorithms depending on formaldehyde sensor state. Can occur only in measurement mode. | |

Table 20. Formaldehyde sensor error bit description

4.3.7 CO₂-2 – CO₂ Sensor Error

Applies to: SEN66

| CO ₂ -2 Sensor Error | | |
|---------------------------------|--|--|
| Bit | 9 (see Figure 7) | |
| State | 0 | CO ₂ sensor is running normally |
| | 1 | CO ₂ sensor error |
| Sticky | Yes – Even if the error disappears or when leaving the measure mode, the flag remains set. This flag will only be reset by Read And Clear Device Status SEN6x or through a reset, either by calling Device Reset SEN6x or through a power cycle. | |
| Description | Error related to the CO ₂ sensor. The CO ₂ values might be unknown or wrong if this flag is set, relative humidity and temperature values might be out of specs due to compensation algorithms depending on CO ₂ sensor state. Can occur only in measurement mode. | |

Table 21. CO₂-2 sensor error bit description

4.3.8 GAS – Gas Sensor Error (VOC and NO_x)

Applies to: SEN65, SEN66, SEN68

| Gas Sensor Error | |
|------------------|---|
| Bit | 7 (see Figure 7) |
| State | 0 Gas sensor is running normally |
| | 1 Gas sensor error |
| Sticky | Yes – Even if the error disappears or when leaving the measure mode, the flag remains set. This flag will only be reset by Read And Clear Device Status SEN6x or through a reset, either by calling Device Reset SEN6x or through a power cycle. |
| Description | Error related to the gas sensor. The VOC index and NO _x index might be unknown or wrong if this flag is set, relative humidity and temperature values might be out of specs due to compensation algorithms depending on gas sensor state. Can occur only in measurement mode. |

Table 22. Gas sensor error bit description

4.3.9 RH&T – Relative Humidity and Temperature Sensor Error

Applies to: SEN63C, SEN65, SEN66, SEN68

| RH&T Sensor Error | |
|-------------------|---|
| Bit | 6 (see Figure 7) |
| State | 0 RH&T sensor is running normally |
| | 1 RH&T sensor error |
| Sticky | Yes – Even if the error disappears or when leaving the measure mode, the flag remains set. This flag will only be reset by Read And Clear Device Status SEN6x or through a reset, either by calling Device Reset SEN6x or through a power cycle. |
| Description | Error related to the RH&T sensor. The temperature and humidity values might be unknown or wrong if this flag is set, and other measured values might be out of specs due to compensation algorithms depending on RH&T sensor values. Can occur only in measurement mode. |

Table 23. RH&T sensor error bit description

4.3.10 FAN – Fan Error

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

| Fan Error | | | |
|-------------|---|----------------------|---|
| Bit | SEN6x | | SEN60 |
| | 4 (see Figure 7) | | 4 (see Figure 8) |
| State | 0 | Fan running normally | |
| | 1 | Fan error | |
| Sticky | SEN6x | | SEN60 |
| | Yes – Even if the error disappears or when leaving the measure mode, the flag remains set. This flag will only be reset by Read And Clear Device Status SEN6x or through a reset, either by calling Device Reset SEN6x or through a power cycle. | | Yes – if the error disappears or when leaving the measure mode, the flag remains set. This flag will only be reset through a reset, either by calling Device Reset SEN60 or through a power cycle. |
| Description | <p>Fan is switched on, but 0 RPM is measured for multiple consecutive measurement intervals. This can occur if the fan is mechanically blocked or broken. Note that the measured values are most likely wrong if this error is reported.</p> <p>Can occur only in measurement mode.</p> | | |

Table 24. Fan error bit description

4.4 I²C Interface Settings

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

| Property | SEN60 | SEN6x |
|--------------------------|--|--------------|
| I ² C Address | 0x6C (7-bit) | 0x6B (7-bit) |
| Max. Speed | 100kbit/s (standard mode) | |
| Clock stretching | Not used, the sensor NACKs when busy with processing | |

Table 25. I²C interface settings

4.5 Power-Up and Communication Start

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

The sensor starts powering-up after reaching the power-up threshold voltage $V_{DD,min}$ and will take up to the maximum of the sensor startup time, specified in **Table 1**, to enter the idle state. Once the idle state has been reached, it is ready to receive commands from the controller. Any incoming command will be acknowledged (address header and all data bytes). After the stop condition, the sensor validates and processes the received data. During this time, the sensor does not acknowledge any I²C requests (address header will be NACK'd). As soon as the command is fully processed, the I²C interface becomes ready again. The controller can then either read the result with a read operation or send the next command with a write operation.

4.6 Data Type & Length

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

Data sent to and received from the sensor consists of a sequence of 16-bit words, most significant byte (MSB) transmitted first. Each word is succeeded by an 8-bit CRC. See **Figure 9** for more detail. In write direction it is mandatory to transmit the checksum. In read direction it is up to the controller to decide whether to process the checksum.

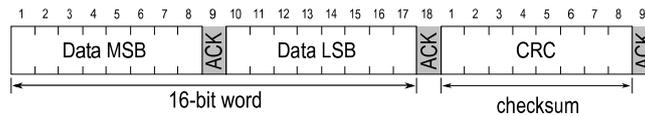


Figure 9. Data type structure with 16-bit word and 8-bit CRC

Please note that the CRC is used only for the 16-bit data packets. The 16-bit command ID itself already contains a 3-bit CRC and therefore no CRC must be appended to it as seen in **Figure 10**. Each command ID is represented by a 4-digit Hex. Code as seen in **Table 26**.

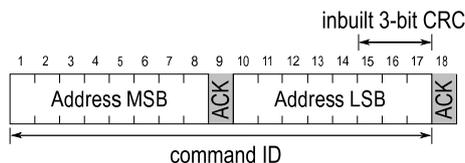


Figure 10. Command ID with inbuilt 3-bit CRC

4.7 Command Sequence Types

The SEN6x features four different I²C command sequence types: write I²C sequences, send I²C command sequence, read I²C sequences and send & fetch I²C sequence. **Figure 11** illustrates how the I²C communication for the different sequence types is built up. For detailed information on the I²C protocol, refer to NXP I²C-bus specification [2].

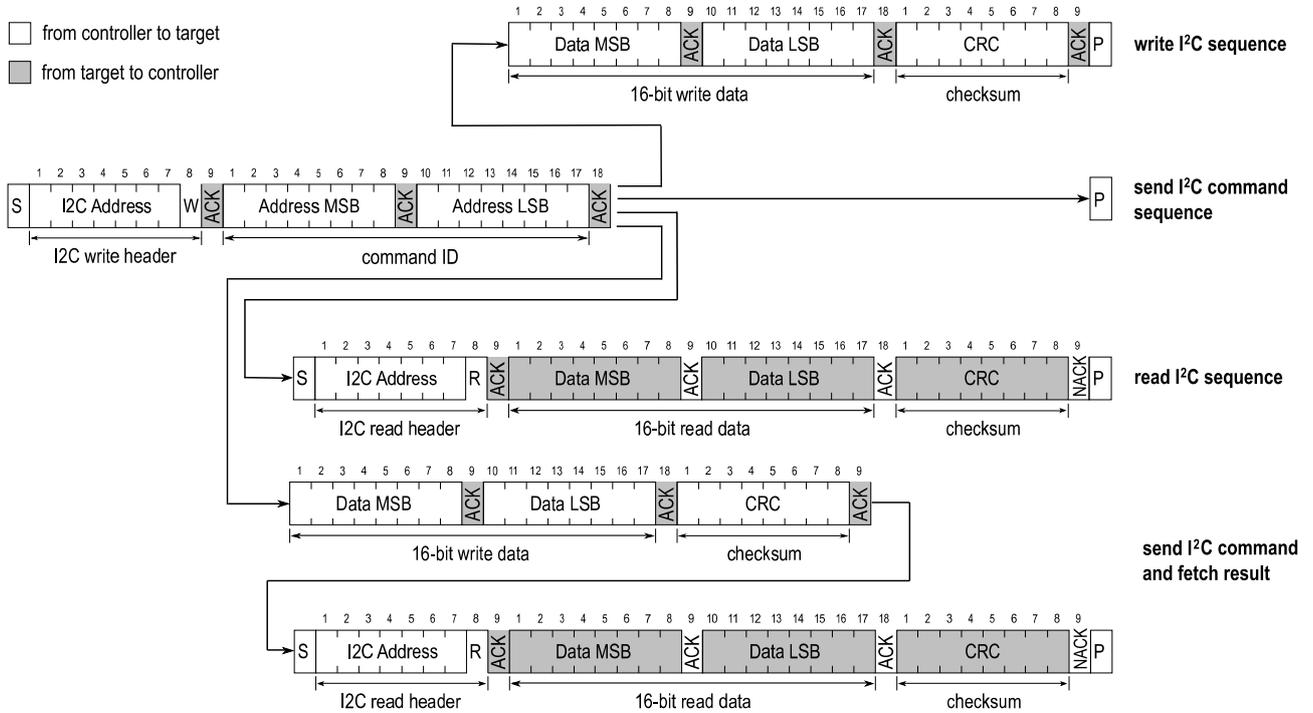


Figure 11. Command sequence types: write sequence, send command sequence, read sequence and send command and fetch result sequence.

After issuing read sequence commands and sending the ACK Bit, the sensor needs the *execution time* (see **Table 26**) to respond to the I²C read header with an ACK bit. Hence, it is required to wait the command execution time before issuing the read header. Commands must not be sent while a previous command is being processed.

4.8 I²C Commands

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

| Command ID | Command | I ² C Sequence Type (see Section 4.7) | Execution | | Applicable to | | | | |
|------------|---|--|-----------|----------------|---------------|--------|-------|-------|-------|
| | | | Time [ms] | During Measur. | SEN60 | SEN63C | SEN65 | SEN66 | SEN68 |
| 0x0021 | Start Continuous Measurement SEN6x | send | 50 | no | - | ✓ | ✓ | ✓ | ✓ |
| 0x2152 | Start Continuous Measurement SEN60 | send | 1 | no | ✓ | - | - | - | - |
| 0x0104 | Stop Measurement SEN6x | send | 1000 | yes | - | ✓ | ✓ | ✓ | ✓ |
| 0x3F86 | Stop Measurement SEN60 | send | 1000 | yes | ✓ | - | - | - | - |
| 0x0202 | Get Data Ready SEN6x | read | 20 | yes | - | ✓ | ✓ | ✓ | ✓ |
| 0xE4B8 | Get Data Ready SEN60 | read | 1 | yes | ✓ | - | - | - | - |
| 0xEC05 | Read Measured Values SEN60 | read | 1 | yes | ✓ | - | - | - | - |
| 0x0471 | Read Measured Values SEN63C | read | 20 | yes | - | ✓ | - | - | - |
| 0x0446 | Read Measured Values SEN65 | read | 20 | yes | - | - | ✓ | - | - |
| 0x0300 | Read Measured Values SEN66 | read | 20 | yes | - | - | - | ✓ | - |
| 0x0467 | Read Measured Values SEN68 | read | 20 | yes | - | - | - | - | ✓ |
| 0x0492 | Read Measured Raw Values SEN63C | read | 20 | yes | - | ✓ | - | - | - |
| 0x0455 | Read Measured Raw Values SEN65, SEN68 | read | 20 | yes | - | - | ✓ | - | ✓ |
| 0x0405 | Read Measured Raw Values SEN66 | read | 20 | yes | - | - | - | ✓ | - |
| 0x0316 | Read Number Concentration Values SEN6x | read | 20 | yes | - | ✓ | ✓ | ✓ | ✓ |
| 0x60B2 | Set Temperature Offset Parameters | write | 20 | yes | - | ✓ | ✓ | ✓ | ✓ |
| 0x6100 | Set Temperature Acceleration Parameters | write | 20 | no | - | ✓ | ✓ | ✓ | ✓ |
| 0xD014 | Get Product Name | read | 20 | yes | - | ✓ | ✓ | ✓ | ✓ |
| 0xD033 | Get Serial Number SEN6x | read | 20 | yes | - | ✓ | ✓ | ✓ | ✓ |
| 0x3682 | Get Serial Number SEN60 | read | 1 | yes | ✓ | - | - | - | - |
| 0xD206 | Read Device Status SEN6x | read | 20 | yes | - | ✓ | ✓ | ✓ | ✓ |
| 0xE00B | Read Device Status SEN60 | read | 1 | yes | ✓ | - | - | - | - |
| 0xD210 | Read And Clear Device Status SEN6x | read | 20 | yes | - | ✓ | ✓ | ✓ | ✓ |
| 0xD304 | Device Reset SEN6x | send | 20 | no | - | ✓ | ✓ | ✓ | ✓ |
| 0x3F8D | Device Reset SEN60 | send | 1 | yes | ✓ | - | - | - | - |
| 0x5607 | Start Fan Cleaning SEN6x | send | 20 | no | - | ✓ | ✓ | ✓ | ✓ |
| 0x3730 | Start Fan Cleaning SEN60 | send | 1 | no | ✓ | - | - | - | - |
| 0x6765 | Activate SHT Heater | send | 1300 | no | - | ✓ | ✓ | ✓ | ✓ |
| 0x60D0 | Get VOC Algorithm Tuning Parameters | read | 20 | no | - | - | ✓ | ✓ | ✓ |
| 0x60D0 | Set VOC Algorithm Tuning Parameters | write | 20 | no | - | - | ✓ | ✓ | ✓ |
| 0x6181 | Get VOC Algorithm State | read | 20 | yes | - | - | ✓ | ✓ | ✓ |
| 0x6181 | Set VOC Algorithm State | write | 20 | no | - | - | ✓ | ✓ | ✓ |
| 0x60E1 | Get NOx Algorithm Tuning Parameters | read | 20 | no | - | - | ✓ | ✓ | ✓ |
| 0x60E1 | Set NOx Algorithm Tuning Parameters | write | 20 | no | - | - | ✓ | ✓ | ✓ |
| 0x6707 | Perform Forced CO2 Recalibration | send and fetch | 500 | no | - | ✓ | - | ✓ | - |
| 0x6711 | Get CO2 Sensor Automatic Self Calibration | read | 20 | no | - | ✓ | - | ✓ | - |
| 0x6711 | Set CO2 Sensor Automatic Self Calibration | write | 20 | no | - | ✓ | - | ✓ | - |
| 0x6720 | Get Ambient Pressure | read | 20 | yes | - | ✓ | - | ✓ | - |
| 0x6720 | Set Ambient Pressure | write | 20 | yes | - | ✓ | - | ✓ | - |
| 0x6736 | Get Sensor Altitude | read | 20 | no | - | ✓ | - | ✓ | - |
| 0x6736 | Set Sensor Altitude | write | 20 | no | - | ✓ | - | ✓ | - |

Table 26. Command overview. The column ('During measurement') indicates whether the command can be executed in the measurement mode.

4.8.1 Start Continuous Measurement SEN6x

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: Starts a continuous measurement. After starting the measurement, it takes some time (~1.1s) until the first measurement results are available. You could poll with the command **Get Data Ready SEN6x** to check when the results are ready to be read.

| Start Continuous Measurement SEN6x | |
|------------------------------------|-----------|
| Command ID | 0x0021 |
| Available in | Idle mode |
| Execution Time | 50 ms |
| Max. RX Data With CRC | 0 Bytes |
| TX Data | None |
| RX Data | None |

Table 27. Start continuous measurement SEN6x I²C command description

4.8.2 Start Continuous Measurement SEN60

Applies to: SEN60

Description: Starts a continuous measurement. After starting the measurement, it takes some time (~1.1s) until the first measurement results are available. You could poll with the command **Get Data Ready SEN60** to check when the results are ready to be read.

| Start Continuous Measurement SEN60 | |
|------------------------------------|-----------|
| Command ID | 0x2152 |
| Available in | Idle mode |
| Execution Time | 1 ms |
| Max. RX Data With CRC | 0 Bytes |
| TX Data | None |
| RX Data | None |

Table 28. Start continuous measurement SEN60 I²C command description

4.8.3 Stop Measurement SEN6x

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: Stops the measurement and returns to idle mode. After sending this command, wait at least 1000 ms before starting a new measurement.

| Stop Measurement SEN6x | |
|------------------------|------------------|
| Command ID | 0x0104 |
| Available in | Measurement mode |
| Execution Time | 1000 ms |
| Max. RX Data With CRC | 0 Bytes |
| TX Data | None |
| RX Data | None |

Table 29. Stop measurement SEN6x I²C command description

4.8.4 Stop Measurement SEN60

Applies to: SEN60

Description: Stops the measurement and returns to idle mode. After sending this command, wait at least 1000 ms before starting a new measurement.

| Stop Measurement SEN60 | |
|------------------------|------------------|
| Command ID | 0x3F86 |
| Available in | Measurement mode |
| Execution Time | 1000 ms |
| Max. RX Data With CRC | 0 Bytes |
| TX Data | None |
| RX Data | None |

Table 30. Stop measurement SEN60 I²C command description

4.8.5 Get Data Ready SEN6x

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: This command can be used to check if new measurement results are ready to read. The data ready flag is automatically reset after reading the measurement values.

| Get Data Ready SEN6x | | |
|-----------------------|------------------|--|
| Command ID | 0x0202 | |
| Available in | Measurement mode | |
| Execution Time | 20 ms | |
| Max. RX Data With CRC | 3 Bytes | |
| TX Data | None | |
| RX Data | Byte # | Description |
| | 0 | Padding: uint8 Padding byte, always 0x00. |
| | 1 | Data Ready: bool True (0x01) if data is ready, False (0x00) if not. When no measurement is running, False will be returned. |
| | 2 | CRC CRC for the previous two bytes. |

Table 31. Get data ready SEN6x I²C command description

4.8.6 Get Data Ready SEN60

Applies to: SEN60

Description: This command can be used to check if new measurement results are ready to read. The data ready flag is automatically reset after reading the measurement values.

| Get Data Ready SEN60 | | |
|-----------------------|------------------|--|
| Command ID | 0xE4B8 | |
| Available in | Measurement mode | |
| Execution Time | 1 ms | |
| Max. RX Data With CRC | 3 Bytes | |
| TX Data | None | |
| RX Data | Byte # | Description |
| | 0 | Reserved: Bit 15 to 11 |
| | 1 | Data Ready: boo111 (Bit 10 to 0) True (return value is unequal 0) if data is ready, False (return value is 0) if not. When no measurement is running, False will be returned. |
| 2 | CRC | CRC for the previous two bytes. |

Table 32. Get data ready SEN60 I²C command description

4.8.7 Read Measured Values SEN60

Applies to: SEN60

Description: Returns the measured values. The command **Get Data Ready SEN60** can be used to check if new data is available since the last read operation. The measurement data can only be read out once per signal update interval, as the buffer is emptied upon read-out. If no data is available in the buffer, the sensor returns a NACK. To avoid a NACK response, the **Get Data Ready SEN60** can be issued to check data status. The I2C controller can abort the read transfer with a NACK followed by a STOP condition after any data byte if the user is not interested in the subsequent data

| Read Measured Values SEN60 | | | |
|----------------------------|------------------|-----|---|
| Command ID | 0xEC05 | | |
| Available in | Measurement mode | | |
| Execution Time | 1 ms | | |
| Max. RX Data With CRC | 27 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | |
| | Description | | |
| | 0 | MSB | Mass Concentration PM1.0: uint16 Value is scaled with factor 10: PM1.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 1 | LSB | |
| | 2 | CRC | |
| | 3 | MSB | Mass Concentration PM2.5: uint16 Value is scaled with factor 10: PM2.5 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 4 | LSB | |
| | 5 | CRC | |
| | 6 | MSB | Mass Concentration PM4.0: uint16 Value is scaled with factor 10: PM4.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 7 | LSB | |
| | 8 | CRC | |
| | 9 | MSB | Mass Concentration PM10.0: uint16 Value is scaled with factor 10: PM10.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 10 | LSB | |
| | 11 | CRC | |
| | 12 | MSB | Number Concentration PM0.5: uint16 Value is scaled with factor 10: PM0.5 [particles/cm ³] = value / 10 |
| | 13 | LSB | |
| | 14 | CRC | |
| | 15 | MSB | Number Concentration PM1.0: uint16 Value is scaled with factor 10: PM1.0 [particles/cm ³] = value / 10 |
| | 16 | LSB | |
| | 17 | CRC | |
| | 18 | MSB | Number Concentration PM2.5: uint16 Value is scaled with factor 10: PM2.5 [particles/cm ³] = value / 10 |
| | 19 | LSB | |
| | 20 | CRC | |
| | 21 | MSB | Number Concentration PM4.0: uint16 Value is scaled with factor 10: PM4.0 [particles/cm ³] = value / 10 |
| | 22 | LSB | |
| | 23 | CRC | |
| | 24 | MSB | Number Concentration PM10.0: uint16 Value is scaled with factor 10: PM10.0 [particles/cm ³] = value / 10 |
| 25 | LSB | | |
| 26 | CRC | | |

Table 33. Read measured values SEN60 I²C command description

4.8.8 Read Measured Values SEN63C

Applies to: SEN63C

Description: Returns the measured values. The command **Get Data Ready SEN6x** can be used to check if new data is available since the last read operation. If no new data is available, the previous values will be returned. If no data is available at all (e.g. measurement not running for at least one second), all values will be at their upper limit (0xFFFF for uint16, 0x7FFF for int16).

| Read Measured Values SEN63C | | | |
|-----------------------------|------------------|--|--|
| Command ID | 0x0471 | | |
| Available in | Measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 21 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | Description | |
| | 0 | MSB | |
| | 1 | LSB | Mass Concentration PM1.0: uint16 |
| | 2 | CRC | Value is scaled with factor 10: PM1.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 3 | MSB | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 4 | LSB | Mass Concentration PM2.5: uint16 |
| | 5 | CRC | Value is scaled with factor 10: PM2.5 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 6 | MSB | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 7 | LSB | Mass Concentration PM4.0: uint16 |
| | 8 | CRC | Value is scaled with factor 10: PM4.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 9 | MSB | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 10 | LSB | Mass Concentration PM10.0: uint16 |
| | 11 | CRC | Value is scaled with factor 10: PM10.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 12 | MSB | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 13 | LSB | Ambient Humidity: int16 |
| | 14 | CRC | Value is scaled with factor 100: RH [%] = value / 100 |
| | 15 | MSB | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 16 | LSB | Ambient Temperature: int16 |
| | 17 | CRC | Value is scaled with factor 200: T [$^{\circ}\text{C}$] = value / 200 |
| | 18 | MSB | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 19 | LSB | CO2: uint16 |
| 20 | CRC | CO2 concentration [ppm] | |
| | | <i>Note: If this value is unknown, 0xFFFF is returned.</i> | |

Table 34. Read measured values SEN63C I²C command description

4.8.9 Read Measured Values SEN65

Applies to: SEN65

Description: Returns the measured values. The command **Get Data Ready SEN6x** can be used to check if new data is available since the last read operation. If no new data is available, the previous values will be returned. If no data is available at all (e.g. measurement not running for at least one second), all values will be at their upper limit (0xFFFF for uint16, 0x7FFF for int16).

| Read Measured Values SEN65 | | |
|----------------------------|------------------|-------------|
| Command ID | 0x0446 | |
| Available in | Measurement mode | |
| Execution Time | 20 ms | |
| Max. RX Data With CRC | 24 Bytes | |
| TX Data | None | |
| RX Data | Byte # | Description |
| | 0 | MSB |
| | 1 | LSB |
| | 2 | CRC |
| | 3 | MSB |
| | 4 | LSB |
| | 5 | CRC |
| | 6 | MSB |
| | 7 | LSB |
| | 8 | CRC |
| | 9 | MSB |
| | 10 | LSB |
| | 11 | CRC |
| | 12 | MSB |
| | 13 | LSB |
| | 14 | CRC |
| | 15 | MSB |
| | 16 | LSB |
| | 17 | CRC |
| | 18 | MSB |
| | 19 | LSB |
| | 20 | CRC |
| | 21 | MSB |
| | 22 | LSB |
| 23 | CRC | |

Table 35. Read measured values SEN65 I²C command description

4.8.10 Read Measured Values SEN66

Applies to: SEN66

Description: Returns the measured values. The command **Get Data Ready SEN6x** can be used to check if new data is available since the last read operation. If no new data is available, the previous values will be returned. If no data is available at all (e.g. measurement not running for at least one second), all values will be at their upper limit (0xFFFF for uint16, 0x7FFF for int16).

| Read Measured Values SEN66 | | |
|----------------------------|--|---|
| Command ID | 0x0300 | |
| Available in | Measurement mode | |
| Execution Time | 20 ms | |
| Max. RX Data With CRC | 27 Bytes | |
| TX Data | None | |
| RX Data | Byte # | Description |
| | 0 MSB | Mass Concentration PM1.0: uint16 |
| | 1 LSB | Value is scaled with factor 10: PM1.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 2 CRC | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 3 MSB | Mass Concentration PM2.5: uint16 |
| | 4 LSB | Value is scaled with factor 10: PM2.5 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 5 CRC | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 6 MSB | Mass Concentration PM4.0: uint16 |
| | 7 LSB | Value is scaled with factor 10: PM4.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 8 CRC | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 9 MSB | Mass Concentration PM10.0: uint16 |
| | 10 LSB | Value is scaled with factor 10: PM10.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 11 CRC | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 12 MSB | Ambient Humidity: int16 |
| | 13 LSB | Value is scaled with factor 100: RH [%] = value / 100 |
| | 14 CRC | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 15 MSB | Ambient Temperature: int16 |
| | 16 LSB | Value is scaled with factor 200: T [$^{\circ}\text{C}$] = value / 200 |
| | 17 CRC | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 18 MSB | VOC Index: int16 |
| | 19 LSB | Value is scaled with factor 10: VOC Index = value / 10 |
| | 20 CRC | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 21 MSB | NOx Index: int16 |
| | 22 LSB | Value is scaled with factor 10: NOx Index = value / 10 |
| | 23 CRC | <i>Note: If this value is unknown, 0x7FFF is returned. During the first 10..11 seconds after power-on or device reset, this value will be 0x7FFF as well.</i> |
| | 24 MSB | CO2: uint16 |
| | 25 LSB | CO2 concentration [ppm] |
| 26 CRC | <i>Note: If this value is unknown, 0xFFFF is returned. During the first 5..6 seconds after measurement start, this value will be 0xFFFF as well.</i> | |

Table 36. Read measured values SEN66 I²C command description

4.8.11 Read Measured Values SEN68

Applies to: SEN68

Description: Returns the measured values. The command **Get Data Ready SEN6x** can be used to check if new data is available since the last read operation. If no new data is available, the previous values will be returned. If no data is available at all (e.g. measurement not running for at least one second), all values will be at their upper limit (0xFFFF for uint16, 0x7FFF for int16).

| Read Measured Values SEN68 | | | |
|----------------------------|------------------|---|---|
| Command ID | 0x0467 | | |
| Available in | Measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 27 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | Description | |
| | 0 | MSB | |
| | 1 | LSB | Mass Concentration PM1.0: uint16 |
| | 2 | CRC | Value is scaled with factor 10: PM1.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 3 | MSB | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 4 | LSB | Mass Concentration PM2.5: uint16 |
| | 5 | CRC | Value is scaled with factor 10: PM2.5 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 6 | MSB | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 7 | LSB | Mass Concentration PM4.0: uint16 |
| | 8 | CRC | Value is scaled with factor 10: PM4.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 9 | MSB | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 10 | LSB | Mass Concentration PM10.0: uint16 |
| | 11 | CRC | Value is scaled with factor 10: PM10.0 [$\mu\text{g}/\text{m}^3$] = value / 10 |
| | 12 | MSB | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 13 | LSB | Ambient Humidity: int16 |
| | 14 | CRC | Value is scaled with factor 100: RH [%] = value / 100 |
| | 15 | MSB | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 16 | LSB | Ambient Temperature: int16 |
| | 17 | CRC | Value is scaled with factor 200: T [$^{\circ}\text{C}$] = value / 200 |
| | 18 | MSB | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 19 | LSB | VOC Index: int16 |
| | 20 | CRC | Value is scaled with factor 10: VOC Index = value / 10 |
| | 21 | MSB | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 22 | LSB | NOx Index: int16 |
| | 23 | CRC | Value is scaled with factor 10: NOx Index = value / 10 |
| | 24 | MSB | <i>Note: If this value is unknown, 0x7FFF is returned. During the first 10..11 seconds after power-on or device reset, this value will be 0x7FFF as well.</i> |
| | 25 | LSB | Formaldehyde: uint16 |
| 26 | CRC | Value is scaled with factor 10: HCHO [ppb] = value / 10 | |
| | | <i>Note: If this value is unknown, 0xFFFF is returned. During the first 60 seconds after the first measurement start after power-on or device reset, this value will be 0xFFFF as well.</i> | |

Table 37. Read measured values SEN68 I²C command description

4.8.12 Read Measured Raw Values SEN63C

Applies to: SEN63C

Description: Returns the measured raw values. The command **Get Data Ready SEN6x** can be used to check if new data is available since the last read operation. If no new data is available, the previous values will be returned. If no data is available at all (e.g. measurement not running for at least one second), all values will be at their upper limit (0x7FFF for int16).

| Read Measured Raw Values SEN63C | | | |
|---------------------------------|------------------|--|--|
| Command ID | 0x0492 | | |
| Available in | Measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 6 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | MSB | Raw Humidity: int16 |
| | 1 | LSB | Value is scaled with factor 100: RH [%] = value / 100 |
| | 2 | CRC | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 3 | MSB | Raw Temperature: int16 |
| | 4 | LSB | Value is scaled with factor 200: T [°C] = value / 200 |
| 5 | CRC | <i>Note: If this value is unknown, 0x7FFF is returned.</i> | |

Table 38. Read measured raw values SEN63C I²C command description

4.8.13 Read Measured Raw Values SEN65, SEN68

Applies to: SEN65, SEN68

Description: Returns the measured raw values. The command **Get Data Ready SEN6x** can be used to check if new data is available since the last read operation. If no new data is available, the previous values will be returned. If no data is available at all (e.g. measurement not running for at least one second), all values will be at their upper limit (0xFFFF for uint16, 0x7FFF for int16).

| Read Measured Raw Values SEN65, SEN68 | | | |
|---------------------------------------|------------------|---|--|
| Command ID | 0x0455 | | |
| Available in | Measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 12 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | MSB | Raw Humidity: int16 |
| | 1 | LSB | Value is scaled with factor 100: RH [%] = value / 100 |
| | 2 | CRC | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 3 | MSB | Raw Temperature: int16 |
| | 4 | LSB | Value is scaled with factor 200: T [°C] = value / 200 |
| | 5 | CRC | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 6 | MSB | Raw VOC: uint16 |
| | 7 | LSB | Raw measured VOC ticks without scale factor. |
| | 8 | CRC | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 9 | MSB | Raw NOx: uint16 |
| | 10 | LSB | Raw measured NOx ticks without scale factor. |
| 11 | CRC | <i>Note: If this value is unknown, 0xFFFF is returned. During the first 10..11 seconds after power-on or device reset, this value will be 0xFFFF as well.</i> | |

Table 39. Read measured raw values SEN65, SEN68 I²C command description

4.8.14 Read Measured Raw Values SEN66

Applies to: SEN66

Description: Returns the measured raw values. The command **Get Data Ready SEN6x** can be used to check if new data is available since the last read operation. If no new data is available, the previous values will be returned. If no data is available at all (e.g. measurement not running for at least one second), all values will be at their upper limit (0xFFFF for uint16, 0x7FFF for int16).

| Read Measured Raw Values SEN66 | | | |
|--------------------------------|------------------|--|---|
| Command ID | 0x0405 | | |
| Available in | Measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 15 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | MSB | Raw Humidity: int16 |
| | 1 | LSB | Value is scaled with factor 100: RH [%] = value / 100 |
| | 2 | CRC | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 3 | MSB | Raw Temperature: int16 |
| | 4 | LSB | Value is scaled with factor 200: T [°C] = value / 200 |
| | 5 | CRC | <i>Note: If this value is unknown, 0x7FFF is returned.</i> |
| | 6 | MSB | Raw VOC: uint16 |
| | 7 | LSB | Raw measured VOC ticks without scale factor. |
| | 8 | CRC | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 9 | MSB | Raw NOx: uint16 |
| | 10 | LSB | Raw measured NOx ticks without scale factor. |
| | 11 | CRC | <i>Note: If this value is unknown, 0xFFFF is returned. During the first 10..11 seconds after power-on or device reset, this value will be 0xFFFF as well.</i> |
| | 12 | MSB | Raw CO2: uint16 |
| | 13 | LSB | Not interpolated CO2 concentration [ppm] updated every five seconds. |
| 14 | CRC | <i>Note: If this value is unknown, 0xFFFF is returned. During the first 5..6 seconds after measurement start, this value will be 0xFFFF as well.</i> | |

Table 40. Read measured raw values SEN66 I²C command description

4.8.15 Read Number Concentration Values SEN6x

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: Returns the measured number concentration values. The command **Get Data Ready SEN6x** can be used to check if new data is available since the last read operation. If no new data is available, the previous values will be returned. If no data is available at all (e.g. measurement not running for at least one second), all values will be at their upper limit (0xFFFF for uint16).

Note: Number concentration values for SEN60 are included in the output of **Read Measured Values SEN60**.

| Read Number Concentration Values SEN6x | | | |
|--|------------------|--|--|
| Command ID | 0x0316 | | |
| Available in | Measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 15 Bytes | | |
| TX Data | | | |
| RX Data | Byte # | | Description |
| | 0 | MSB | Number Concentration PM0.5: uint16 |
| | 1 | LSB | Value is scaled with factor 10: PM0.5 [particles/cm ³] = value / 10 |
| | 2 | CRC | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 3 | MSB | Number Concentration PM1.0: uint16 |
| | 4 | LSB | Value is scaled with factor 10: PM1.0 [particles/cm ³] = value / 10 |
| | 5 | CRC | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 6 | MSB | Number Concentration PM2.5: uint16 |
| | 7 | LSB | Value is scaled with factor 10: PM2.5 [particles/cm ³] = value / 10 |
| | 8 | CRC | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 9 | MSB | Number Concentration PM4.0: uint16 |
| | 10 | LSB | Value is scaled with factor 10: PM4.0 [particles/cm ³] = value / 10 |
| | 11 | CRC | <i>Note: If this value is unknown, 0xFFFF is returned.</i> |
| | 12 | MSB | Number Concentration PM10.0: uint16 |
| | 13 | LSB | Value is scaled with factor 10: PM10.0 [particles/cm ³] = value / 10 |
| 14 | CRC | <i>Note: If this value is unknown, 0xFFFF is returned.</i> | |

Table 41. Read number concentration values SEN6x I²C command description

4.8.16 Set Temperature Offset Parameters

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: This command allows to compensate temperature effects of the design-in at customer side by applying custom temperature offsets to the ambient temperature. The compensated ambient temperature is calculated as follows:

$$T_Ambient_Compensated = T_Ambient + (slope * T_Ambient) + offset$$

Where slope and offset are the values set with this command, smoothed with the specified time constant. All temperatures (T_Ambient_Compensated, T_Ambient and offset) are represented in °C. There are 5 temperature offset slots available that all contribute additively to T_Ambient_Compensated. The default values for the temperature offset parameters are all zero, meaning that T_Ambient_Compensated is equal to T_Ambient by default. For more details on how to compensate the temperature on the SEN6x platform, refer to "Temperature Acceleration and Compensation Instructions for SEN6x" [3].

Note: This configuration is volatile, i.e. the parameters will be reverted to their default value of zero after a device reset.

| Set Temperature Offset Parameters | | | |
|-----------------------------------|---------------------------|-----|--|
| Command ID | 0x60B2 | | |
| Available in | Idle and measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 0 Bytes | | |
| TX Data | Byte # | | |
| | 0 | MSB | Offset: int16 Constant temperature offset scaled with factor 200 (T [°C] = value / 200). |
| | 1 | LSB | |
| | 2 | CRC | |
| | 3 | MSB | Slope: int16 Normalized temperature offset slope scaled with factor 10000 (applied factor = value / 10000). |
| | 4 | LSB | |
| | 5 | CRC | |
| | 6 | MSB | Time Constant: uint16 The time constant determines how fast the new slope and offset will be applied. After the specified value in seconds, 63% of the new slope and offset are applied. A time constant of zero means the new values will be applied immediately (within the next measure interval of 1 second). |
| | 7 | LSB | |
| | 8 | CRC | |
| | 9 | MSB | Slot: uint16 The temperature offset slot to be modified. Valid values are 0 .. 4. If the value is outside this range, the parameters will not be applied. |
| 10 | LSB | | |
| 11 | CRC | | |
| RX Data | None | | |

Table 42. Set temperature offset parameters I²C command description

4.8.17 Set Temperature Acceleration Parameters

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: This command allows to set custom temperature acceleration parameters of the RH/T engine. It overwrites the default temperature acceleration parameters of the RH/T engine with custom values. This configuration is volatile, *i.e.* the parameters will be reverted to their default values after a device reset.

For more details on how to compensate the temperature on the SEN6x platform, refer to “Temperature Acceleration and Compensation Instructions for SEN6x” [3].

| Set Temperature Acceleration Parameters | | |
|---|-----------|-----|
| Command ID | 0x6100 | |
| Available in | Idle mode | |
| Execution Time | 20 ms | |
| Max. RX Data With CRC | 0 Bytes | |
| TX Data | Byte # | |
| | 0 | MSB |
| | 1 | LSB |
| | 2 | CRC |
| | 3 | MSB |
| | 4 | LSB |
| | 5 | CRC |
| | 6 | MSB |
| | 7 | LSB |
| | 8 | CRC |
| | 9 | MSB |
| | 10 | LSB |
| 11 | CRC | |
| RX Data | None | |

Table 43. Set temperature acceleration parameters I²C command description

4.8.18 Get Product Name

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: Gets the product name from the device.

| Get Product Name | | | |
|-----------------------|---------------------------|---------|-------------|
| Command ID | 0xD014 | | |
| Available in | Idle and measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 48 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | Char 0 | |
| | 1 | Char 1 | |
| | 2 | CRC | |
| | ... | ... | |
| | 45 | Char 30 | |
| | 46 | Char 31 | |
| 47 | CRC | | |

Table 44. Get product name I²C command description

4.8.19 Get Serial Number SEN6x

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: Gets the serial number from the device.

| Get Serial Number SEN6x | | | |
|-------------------------|---------------------------|---------|-------------|
| Command ID | 0xD033 | | |
| Available in | Idle and measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 48 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | Char 0 | |
| | 1 | Char 1 | |
| | 2 | CRC | |
| | ... | ... | |
| | 45 | Char 30 | |
| | 46 | Char 31 | |
| 47 | CRC | | |

Table 45.Get serial number SEN6x I²C command description

4.8.20 Get Serial Number SEN60

Applies to: SEN60

Description: Gets the serial number from the device.

| Get Serial Number SEN60 | | | |
|-------------------------|-----------|-----|-------------|
| Command ID | 0x3682 | | |
| Available in | Idle mode | | |
| Execution Time | 1 ms | | |
| Max. RX Data With CRC | 9 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | MSB | |
| | 1 | - | |
| | 2 | CRC | |
| | 3 | - | |
| | 4 | - | |
| | 5 | CRC | |
| | 6 | - | |
| | 7 | LSB | |
| 8 | CRC | | |

Table 46. Get serial number SEN60 I²C command description

4.8.21 Read Device Status SEN6x

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: Reads the current device status.

Use this command to get detailed information about the device status. The device status is encoded in flags. Each device status flag represents a single bit in a 32-bit integer value. If more than one error is present, the device status register value is the sum of the corresponding flag values. For details about the available flags, refer to the **Device Status Register** documentation.

Note: The status flags of type "Error" are sticky, i.e. they are not cleared automatically even if the error condition no longer exists. So, they can only be cleared manually with **Read And Clear Device Status SEN6x** or through a reset, either by calling **Device Reset SEN6x** or through a power cycle. All other flags are not sticky, i.e. they are cleared automatically if the trigger condition disappears.

| Read Device Status | | | |
|-----------------------|---------------------------|-----|-------------|
| Command ID | 0xD206 | | |
| Available in | Idle and measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 6 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | MSB | |
| | 1 | - | |
| | 2 | CRC | |
| | 3 | - | |
| | 4 | LSB | |
| 5 | CRC | | |

Table 47. Read device status SEN6x I²C command description

4.8.22 Read Device Status SEN60

Applies to: SEN60

Description: Reads the current device status.

Use this command to get detailed information about the device status. The device status is encoded in flags. Each device status flag represents a single bit in a 16-bit integer value. If more than one error is present, the device status register value is the sum of the corresponding flag values. For details about the available flags, refer to the **Device Status Register** documentation.

Note: The status flags of type "Error" are sticky, i.e. they are not cleared automatically even if the error condition no longer exists. So, they can only be cleared manually through a reset, either by calling **Device Reset SEN60** or through a power cycle. All other flags are not sticky, i.e. they are cleared automatically if the trigger condition disappears.

| Read Device Status | | | |
|-----------------------|---------------------------|-----|--|
| Command ID | 0xE00B | | |
| Available in | Idle and measurement mode | | |
| Execution Time | 1 ms | | |
| Max. RX Data With CRC | 3 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | MSB | Device Status: uint16 Device status (16 flags as an integer value). For details, please refer to the Device Status Register documentation. |
| | 1 | LSB | |
| | 2 | CRC | |
| | | | |

Table 48. Read device status SEN60 I²C command description

4.8.23 Read And Clear Device Status SEN6x

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: Reads the current device status (like command **Read Device Status SEN6x**) and afterwards clears all flags.

| Read And Clear Device Status | | | |
|------------------------------|---------------------------|-----|---|
| Command ID | 0xD210 | | |
| Available in | Idle and measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 6 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | MSB | Device Status: uint32 Device status (32 flags as an integer value) before clearing it. For details, please refer to the Device Status Register documentation. |
| | 1 | - | |
| | 2 | CRC | |
| | 3 | - | |
| | 4 | LSB | |
| | 5 | CRC | |
| | | | |

Table 49. Read and clear device status SEN6x I²C command description

4.8.24 Device Reset SEN6x

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: Executes a reset on the device. This has the same effect as a power cycle.

| Device Reset SEN6x | |
|-----------------------|-----------|
| Command ID | 0xD304 |
| Available in | Idle mode |
| Execution Time | 1200 ms |
| Max. RX Data With CRC | 0 Bytes |
| TX Data | None |
| RX Data | None |

Table 50. Device reset SEN6x I²C command description

4.8.25 Device Reset SEN60

Applies to: SEN60

Description: Executes a reset on the device. This has the same effect as a power cycle.

| Device Reset SEN60 | |
|-----------------------|---------------------------|
| Command ID | 0x3F8D |
| Available in | Idle and measurement mode |
| Execution Time | 1 ms |
| Max. RX Data With CRC | 0 Bytes |
| TX Data | None |
| RX Data | None |

Table 51. Device reset SEN60 I²C command description

4.8.26 Start Fan Cleaning SEN6x

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: This command triggers fan cleaning. The fan is set to the maximum speed for 10 seconds and then automatically stopped. Wait at least 10s after this command before starting a measurement.

| Start Fan Cleaning SEN6x | |
|--------------------------|-----------|
| Command ID | 0x5607 |
| Available in | Idle mode |
| Execution Time | 20 ms |
| Max. RX Data With CRC | 0 Bytes |
| TX Data | None |
| RX Data | None |

Table 52. Start fan cleaning SEN6x I²C command description

4.8.27 Start Fan Cleaning SEN60

Applies to: SEN60

Description: This command triggers fan cleaning. The fan is set to the maximum speed for 10 seconds and then automatically stopped. Wait at least 10s after this command before starting a measurement.

| Start Fan Cleaning SEN60 | |
|--------------------------|-----------|
| Command ID | 0x3730 |
| Available in | Idle mode |
| Execution Time | 1 ms |
| Max. RX Data With CRC | 0 Bytes |
| TX Data | None |
| RX Data | None |

Table 53. Start fan cleaning SEN60 I²C command description

4.8.28 Activate SHT Heater

Applies to: SEN63C, SEN65, SEN66, SEN68

Description: This command allows you to use the inbuilt heater in SHT sensor to reverse creep at high humidity. This command activates the SHT sensor heater with 200mW for 1s. The heater is then automatically deactivated again.

Wait at least 20s after this command before starting a measurement to get coherent temperature values (heating consequence to disappear).

| Activate SHT Heater | |
|-----------------------|-----------|
| Command ID | 0x6765 |
| Available in | Idle mode |
| Execution Time | 1300 ms |
| Max. RX Data With CRC | 0 Bytes |
| TX Data | None |
| RX Data | None |

Table 54. Activate SHT heater I²C command description

4.8.29 Get VOC Algorithm Tuning Parameters

Applies to: SEN65, SEN66, SEN68

Description: Gets the parameters to customize the VOC algorithm. For more information on what the parameters below do, refer to Sensirion’s VOC Index for Indoor Air Applications [4].

| Get VOC Algorithm Tuning Parameters | | | |
|-------------------------------------|-----------|-----|--|
| Command ID | 0x60D0 | | |
| Available in | Idle mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 18 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | MSB | Index Offset: <code>int16</code> VOC index representing typical (average) conditions. |
| | 1 | LSB | |
| | 2 | CRC | |
| | 3 | MSB | Learning Time Offset Hours: <code>int16</code> Time constant to estimate the VOC algorithm offset from the history in hours. Past events will be forgotten after about twice the learning time. |
| | 4 | LSB | |
| | 5 | CRC | |
| | 6 | MSB | Learning Time Gain Hours: <code>int16</code> Time constant to estimate the VOC algorithm gain from the history in hours. Past events will be forgotten after about twice the learning time. |
| | 7 | LSB | |
| | 8 | CRC | |
| | 9 | MSB | Gating Max Duration Minutes: <code>int16</code> Maximum duration of gating in minutes (freeze of estimator during high VOC index signal). Zero disables the gating. |
| | 10 | LSB | |
| | 11 | CRC | |
| | 12 | MSB | Std Initial: <code>int16</code> Initial estimate for standard deviation. Lower value boosts events during initial learning period but may result in larger device-to-device variations. |
| | 13 | LSB | |
| | 14 | CRC | |
| | 15 | MSB | Gain Factor: <code>int16</code> Gain factor to amplify or to attenuate the VOC index output. |
| 16 | LSB | | |
| 17 | CRC | | |

Table 55. Get VOC algorithm tuning parameters I²C command description

4.8.30 Set VOC Algorithm Tuning Parameters

Applies to: SEN65, SEN66, SEN68

Description: Sets the parameters to customize the VOC algorithm. It has no effect if at least one parameter is outside the specified range. For more information on what the parameters below do, refer to Sensirion’s VOC Index for Indoor Air Applications [4].

This configuration is volatile, i.e. the parameters will be reverted to their default values after a device reset.

| Set VOC Algorithm Tuning Parameters | | | |
|-------------------------------------|-----------|--|--|
| Command ID | 0x60D0 | | |
| Available in | Idle mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 0 Bytes | | |
| TX Data | | Description | |
| | 0 | MSB | Index Offset: int16 Range: 1..250 |
| | 1 | LSB | VOC index representing typical (average) conditions. Allowed values are in range 1..250. The default value is 100. |
| | 2 | CRC | |
| | 3 | MSB | |
| | 4 | LSB | Learning Time Offset Hours: int16 Range: 1..1000 Time constant to estimate the VOC algorithm offset from the history in hours. Past events will be forgotten after about twice the learning time. Allowed values are in range 1..1000. The default value is 12 hours. |
| | 5 | CRC | |
| | 6 | MSB | |
| | 7 | LSB | Learning Time Gain Hours: int16 Range: 1..1000 Time constant to estimate the VOC algorithm gain from the history in hours. Past events will be forgotten after about twice the learning time. Allowed values are in range 1..1000. The default value is 12 hours. |
| | 8 | CRC | |
| | 9 | MSB | |
| | 10 | LSB | Gating Max Duration Minutes: int16 Range: 0..3000 Maximum duration of gating in minutes (freeze of estimator during high VOC index signal). Set to zero to disable the gating. Allowed values are in range 0..3000. The default value is 180 minutes. |
| | 11 | CRC | |
| | 12 | MSB | |
| | 13 | LSB | Std Initial: int16 Range: 10..5000 Initial estimate for standard deviation. Lower value boosts events during initial learning period but may result in larger device-to-device variations. Allowed values are in range 10..5000. The default value is 50. |
| | 14 | CRC | |
| | 15 | MSB | |
| 16 | LSB | Gain Factor: int16 Range: 1..1000 Gain factor to amplify or to attenuate the VOC index output. Allowed values are in range 1..1000. The default value is 230. | |
| 17 | CRC | | |
| RX Data | None | | |

Table 56. Set VOC algorithm tuning parameters I²C command description

4.8.31 Get VOC Algorithm State

Applies to: SEN65, SEN66, SEN68

Description: Allows backup of the VOC algorithm state to resume operation after a power cycle or device reset, skipping initial learning phase. By default, the VOC Engine is reset, and the algorithm state is retained if a measurement is stopped and started again. If the VOC algorithm state shall be reset, a device reset, or a power cycle can be executed.

Gets the current VOC algorithm state. This data can be used to restore the state with **Set VOC Algorithm State** command after a short power cycle or device reset.

This command can be used either in measure mode or in idle mode (which will then return the state at the time when the measurement was stopped). In measure mode, the state can be read each measure interval to always have the latest state available, even in case of a sudden power loss.

| Get VOC Algorithm State | | | |
|-------------------------|---------------------------|---|-------------|
| Command ID | 0x6181 | | |
| Available in | Idle and measurement mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 12 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | Byte 0 | |
| | 1 | Byte 1 | |
| | 2 | CRC | |
| | ... | ... | |
| | 9 | Byte 6 | |
| | 10 | Byte 7 | |
| 11 | CRC | State: bytearray<8> Current VOC algorithm state. | |

Table 57. Get VOC algorithm state I²C command description

4.8.32 Set VOC Algorithm State

Applies to: SEN65, SEN66, SEN68

Description: Allows restoration of the VOC algorithm state to resume operation after a power cycle or device reset, skipping initial learning phase. By default, the VOC Engine is reset, and the algorithm state is retained if a measurement is stopped and started again. If the VOC algorithm state shall be reset, a device reset, or a power cycle can be executed.

Sets the VOC algorithm state previously received with **Get VOC Algorithm State** command. This command is only available in idle mode and the state will be applied only once when starting the next measurement. In measure mode, this command has no effect.

| Set VOC Algorithm State | | |
|--|-----------|--------|
| Command ID | 0x6181 | |
| Available in | Idle mode | |
| Execution Time | 20 ms | |
| Max. RX Data With CRC | 0 Bytes | |
| TX Data | Byte # | |
| | 0 | Byte 0 |
| | 1 | Byte 1 |
| | 2 | CRC |
| | ... | ... |
| | 9 | Byte 6 |
| | 10 | Byte 7 |
| | 11 | CRC |
| Description | | |
| State: bytearray<8> VOC algorithm state to restore. | | |
| RX Data | None | |

Table 58. Set VOC algorithm state I²C command description

4.8.33 Get NO_x Algorithm Tuning Parameters

Applies to: SEN65, SEN66, SEN68

Description: Gets the parameters to customize the NO_x algorithm. For more information on what the parameters below do, refer to Sensirion’s NO_x Index for Indoor Air Applications [5].

| Get NO _x Algorithm Tuning Parameters | | |
|---|-----------|-------------|
| Command ID | 0x60E1 | |
| Available in | Idle mode | |
| Execution Time | 20 ms | |
| Max. RX Data With CRC | 18 Bytes | |
| TX Data | None | |
| RX Data | Byte # | Description |
| | 0 | MSB |
| | 1 | LSB |
| | 2 | CRC |
| | 3 | MSB |
| | 4 | LSB |
| | 5 | CRC |
| | 6 | MSB |
| | 7 | LSB |
| | 8 | CRC |
| | 9 | MSB |
| | 10 | LSB |
| | 11 | CRC |
| | 12 | MSB |
| | 13 | LSB |
| | 14 | CRC |
| | 15 | MSB |
| 16 | LSB | |
| 17 | CRC | |

Table 59. Get NO_x algorithm tuning parameters I²C command description

4.8.34 Set NO_x Algorithm Tuning Parameters

Applies to: SEN65, SEN66, SEN68

Description: Sets the parameters to customize the NO_x algorithm. It has no effect if at least one parameter is outside the specified range. For more information on what the parameters below do, refer to Sensirion’s NO_x Index for Indoor Air Applications [5].

This configuration is volatile, i.e. the parameters will be reverted to their default values after a device reset.

| Set NO _x Algorithm Tuning Parameters | | | |
|---|-----------|-----|---|
| Command ID | 0x60E1 | | |
| Available in | Idle mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 0 Bytes | | |
| TX Data | Byte # | | |
| | 0 | MSB | Index Offset: int16 Range: 1..250 NO _x index representing typical (average) conditions. Allowed values are in range 1..250. The default value is 1. |
| | 1 | LSB | |
| | 2 | CRC | |
| | 3 | MSB | Learning Time Offset Hours: int16 Range: 1..1000 Time constant to estimate the NO _x algorithm offset from the history in hours. Past events will be forgotten after about twice the learning time. Allowed values are in range 1..1000. The default value is 12 hours. |
| | 4 | LSB | |
| | 5 | CRC | |
| | 6 | MSB | Learning Time Gain Hours: int16 Range: 1..1000 The time constant to estimate the NO _x algorithm gain from the history has no impact for NO _x . This parameter is still in place for consistency reasons with the VOC tuning parameters command. This parameter must always be set to 12 hours. |
| | 7 | LSB | |
| | 8 | CRC | |
| | 9 | MSB | Gating Max Duration Minutes: int16 Range: 0..3000 Maximum duration of gating in minutes (freeze of estimator during high NO _x index signal). Set to zero to disable the gating. Allowed values are in range 0..3000. The default value is 720 minutes. |
| | 10 | LSB | |
| | 11 | CRC | |
| | 12 | MSB | Std Initial: int16 Range: 10..5000 The initial estimate for standard deviation parameter has no impact for NO _x . This parameter is still in place for consistency reasons with the VOC tuning parameters command. This parameter must always be set to 50. |
| | 13 | LSB | |
| | 14 | CRC | |
| | 15 | MSB | Gain Factor: int16 Range: 1..1000 Gain factor to amplify or to attenuate the NO _x index output. Allowed values are in range 1..1000. The default value is 230. |
| 16 | LSB | | |
| 17 | CRC | | |
| RX Data | None | | |

Table 60. Set NO_x algorithm tuning parameters I²C command description

4.8.35 Perform Forced CO₂ Recalibration

Applies to: SEN63C, SEN66

Description: Execute the forced recalibration (FRC) of the CO₂ signal. See the datasheet of the SCD4x sensor for details how the forced recalibration shall be used [6].

Note: After power-on wait at least 1000 ms and after stopping a measurement 600 ms before sending this command. The recalibration procedure will take about 500 ms to complete, during which time no other functions can be executed.

| Perform Forced CO ₂ Recalibration | | | |
|--|-----------|-----|---|
| Command ID | 0x6707 | | |
| Available in | Idle mode | | |
| Read Delay | 500 ms | | |
| Max. RX Data With CRC | 3 Bytes | | |
| TX Data | Byte # | | Description |
| | 0 | MSB | Target CO ₂ Concentration: uint16 Target CO ₂ concentration [ppm] of the test setup. |
| | 1 | LSB | |
| | 2 | CRC | |
| RX Data | Byte # | | Description |
| | 0 | MSB | Correction: uint16 |
| | 1 | LSB | Correction value as received from the SCD [ppm CO ₂]. FRC correction [ppm CO ₂] is return value - 0x8000, if the recalibration has failed this value is 0xFFFF. |
| | 2 | CRC | |

Table 61. Perform forced CO₂ recalibration I²C command description

4.8.36 Get CO₂ Sensor Automatic Self Calibration

Applies to: SEN63C, SEN66

Description: Gets the status of the CO₂ sensor automatic self-calibration (ASC). The CO₂ sensor supports automatic self-calibration (ASC) for long-term stability of the CO₂ output. This feature can be enabled or disabled. By default, it is enabled.

This configuration is volatile, i.e. the parameter will be reverted to its default value after a device reset.

| Get CO ₂ Sensor Automatic Self Calibration | | | |
|---|-----------|-----|--|
| Command ID | 0x6711 | | |
| Available in | Idle mode | | |
| Execution Time | 20 ms | | |
| Max. RX Data With CRC | 3 Bytes | | |
| TX Data | None | | |
| RX Data | Byte # | | Description |
| | 0 | | Padding: uint8 Padding byte, always 0x00. |
| | 1 | | Status: bool Is set true (0x01) if the automatic self-calibration is enabled or false (0x00) if the automatic self-calibration is disabled. |
| | 2 | CRC | CRC for the previous two bytes. |

Table 62. Get CO₂ sensor automatic self calibration I²C command description

4.8.37 Set CO₂ Sensor Automatic Self Calibration

Applies to: SEN63C, SEN66

Description: Sets the status of the CO₂ sensor automatic self-calibration (ASC). The CO₂ sensor supports automatic self-calibration (ASC) for long-term stability of the CO₂ output. This feature can be enabled or disabled. By default, it is enabled.

This configuration is volatile, i.e. the parameter will be reverted to its default value after a device reset.

| Set CO ₂ Sensor Automatic Self Calibration | | |
|---|-----------|---|
| Command ID | 0x6711 | |
| Available in | Idle mode | |
| Execution Time | 20 ms | |
| Max. RX Data With CRC | 0 Bytes | |
| TX Data | Byte # | Description |
| | 0 | Padding: uint8 Padding byte, always 0x00. |
| | 1 | Status: bool Set to true (0x01) to enable or false (0x00) to disable the automatic CO ₂ measurement self-calibration feature. |
| | 2 | CRC CRC for the previous two bytes. |
| RX Data | None | |

Table 63. Set CO₂ sensor automatic self-calibration I²C command description

4.8.38 Get Ambient Pressure

Applies to: SEN63C, SEN66

Description: Gets the ambient pressure value. The ambient pressure can be used for pressure compensation in the CO₂ sensor.

| Get Ambient Pressure | | |
|-----------------------|---------------------------|---|
| Command ID | 0x6720 | |
| Available in | Idle and measurement mode | |
| Execution Time | 20 ms | |
| Max. RX Data With CRC | 3 Bytes | |
| TX Data | None | |
| RX Data | Byte # | Description |
| | 0 | MSB Ambient Pressure: uint16 |
| | 1 | LSB Currently used ambient pressure [hPa] for pressure compensation. |
| | 2 | CRC |

Table 64. Get ambient pressure I²C command description

4.8.39 Set Ambient Pressure

Applies to: SEN63C, SEN66

Description: Sets the ambient pressure value. The ambient pressure can be used for pressure compensation in the CO₂ sensor. Setting an ambient pressure overrides any pressure compensation based on a previously set sensor altitude. Use of this command is recommended for applications experiencing significant ambient pressure changes to ensure CO₂ sensor accuracy. Valid input values are between 700 to 1'200 hPa. The default value is 1013 hPa.

This configuration is volatile, i.e. the parameter will be reverted to its default value after a device reset.

| Set Ambient Pressure | | |
|-----------------------|------------------------------|-----|
| Description | Sets ambient pressure value. | |
| Available in | Idle and measurement mode | |
| Command ID | 0x6720 | |
| Execution Time | 20 ms | |
| Max. RX Data With CRC | 0 Bytes | |
| TX Data | Byte # | |
| | 0 | MSB |
| | 1 | LSB |
| | 2 | CRC |
| RX Data | None | |

Table 65. Set ambient pressure I²C command description

4.8.40 Get Sensor Altitude

Applies to: SEN63C, SEN66

Description: Gets the current sensor altitude. The sensor altitude can be used for pressure compensation in the CO₂ sensor.

| Get Sensor Altitude | | |
|-----------------------|-----------|-----|
| Command ID | 0x6736 | |
| Available in | Idle mode | |
| Execution Time | 20 ms | |
| Max. RX Data With CRC | 3 Bytes | |
| TX Data | None | |
| RX Data | Byte # | |
| | 0 | MSB |
| | 1 | LSB |
| | 2 | CRC |

Table 66. Get sensor altitude I²C command description

4.8.41 Set Sensor Altitude

Applies to: SEN63C, SEN66

Description: Sets the current sensor altitude. The sensor altitude can be used for pressure compensation in the CO₂ sensor. The default sensor altitude value is set to 0 meters above sea level. Valid input values are between 0 and 3000m.

This configuration is volatile, i.e. the parameter will be reverted to its default value after a device reset.

| Set Sensor Altitude | | |
|-----------------------|---|-----|
| Command ID | 0x6736 | |
| Available in | Idle mode | |
| Execution Time | 20 ms | |
| Max. RX Data With CRC | 0 Bytes | |
| TX Data | Byte # | |
| | 0 | MSB |
| | 1 | LSB |
| | 2 | CRC |
| | Description | |
| | Altitude: uint16 | |
| | Sensor altitude [m], valid input between 0 and 3000m. | |
| RX Data | None | |

Table 67. Set sensor altitude I²C command description

4.9 Checksum Calculation (CRC)

Applies to: SEN60, SEN63C, SEN65, SEN66, SEN68

The 8-bit CRC checksum transmitted after each data word is generated by a CRC algorithm. Its properties are displayed in **Table 68**. The CRC covers the contents of the two previously transmitted data bytes. To calculate the checksum, only these two previously transmitted data bytes are used. Note that command words are not followed by CRC.

| Property | Value | Example code (C/C++) |
|----------------|--|--|
| Name | CRC-8-Dallas/Maxim | <code>#define CRC8_POLYNOMIAL 0x31</code> |
| Width | 8 bits | <code>#define CRC8_INIT 0xFF</code> |
| Protected Data | read and/or write data | <code>uint8_t sensirion_generate_crc(const uint8_t* data, uint16_t count) {</code> |
| Polynomial | 0x31 (x ⁸ +x ⁵ +x ⁴ +1) | <code>uint16_t current_byte;</code> |
| Initialization | 0xFF | <code>uint8_t crc = CRC8_INIT;</code> |
| Reflect input | No | <code>uint8_t crc_bit;</code> |
| Reflect output | No | <code>/* calculates 8-Bit checksum with given polynomial */</code> |
| Final XOR | 0x00 | <code>for (current_byte = 0; current_byte < count; ++current_byte) {</code> |
| Examples | CRC (0xBEEF) = 0x92 | <code> crc ^= (data[current_byte]);</code> |
| | | <code> for (crc_bit = 8; crc_bit > 0; --crc_bit) {</code> |
| | | <code> if (crc & 0x80)</code> |
| | | <code> crc = (crc << 1) ^ CRC8_POLYNOMIAL;</code> |
| | | <code> else</code> |
| | | <code> crc = (crc << 1);</code> |
| | | <code> }</code> |
| | | <code> }</code> |
| | | <code> return crc;</code> |
| | | <code>}</code> |

Table 68. I²C CRC properties

5 Technical Drawing

5.1 Package Outline

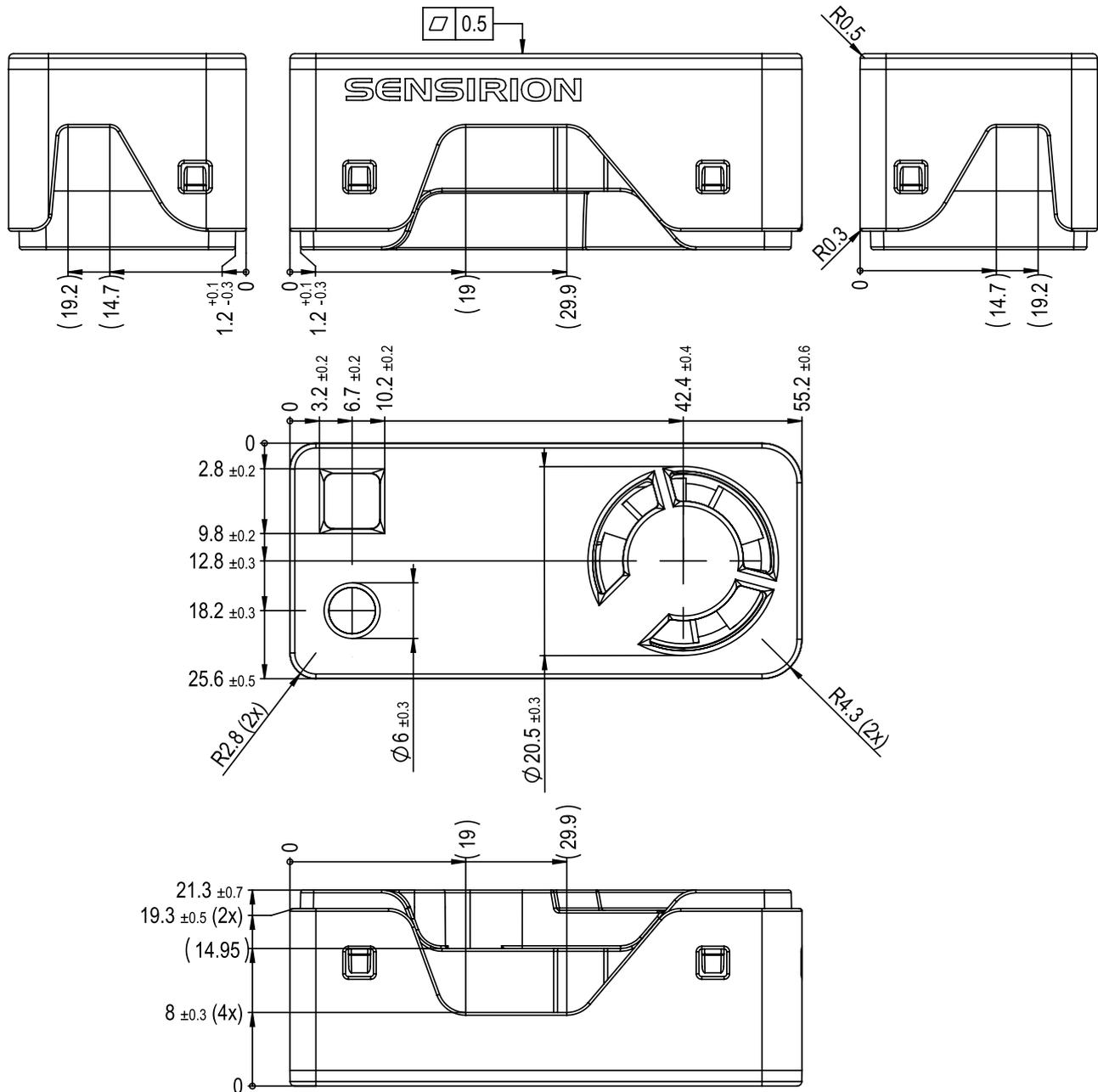


Figure 12. Technical Drawing of the SEN6x platform. All dimensions are in millimeters

5.2 Product Label

All SEN6x sensors include a 22mm x 8mm label as seen in **Figure 13**. For more information on the content, see **Table 69**.

| Label Design | Label Content | Description |
|---|---------------|---|
|  | QR Code | QR code containing the 16-digit HEX serial number |
| | SEN6xx-SIN-T | Material description as in Table 70 |
| | EEEEEEEE | First 8 digits of the 16-digit HEX code |
| | FFFFFF | Last 8 digits of the 16-digit HEX code |

Table 69. Label information

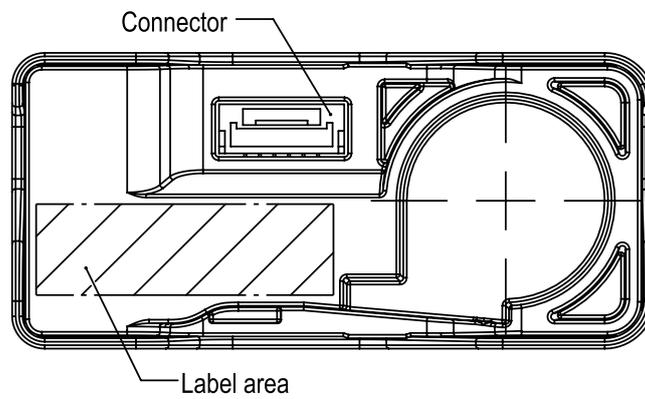


Figure 13. Label position on SEN6x

6 Ordering Information

| Material Description | Material Number | Sensor Outputs | Quantity |
|----------------------|-----------------|--|--|
| SEN60-SIN-T | 3.001.163 | <ul style="list-style-type: none"> • Particulate Matter | 420pcs per box, 7 trays, 60pcs per tray |
| SEN63C-SIN-T | 3.001.197 | <ul style="list-style-type: none"> • Particulate Matter • Relative Humidity • Temperature • CO₂ | |
| SEN65-SIN-T | 3.001.203 | <ul style="list-style-type: none"> • Particulate Matter • Relative Humidity • Temperature • VOC Index • NOx Index | |
| SEN66-SIN-T | 3.001.030 | <ul style="list-style-type: none"> • Particulate Matter • Relative Humidity • Temperature • VOC Index • NOx Index • CO₂ | |
| SEN68-SIN-T | 3.001.198 | <ul style="list-style-type: none"> • Particulate Matter • Relative Humidity • Temperature • VOC Index • NOx Index • Formaldehyde | |

Table 70. Ordering information

7 Bibliography

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8 Revision History

| Date | Version | Pages | Changes |
|---------------|---------|-------|------------------------|
| November 2024 | V0.9 | all | Initial public release |

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.

This warranty does not apply to any equipment which has not been installed and used within the specifications recommended by SENSIRION for the intended and proper use of the equipment. EXCEPT FOR THE WARRANTIES EXPRESSLY SET FORTH HEREIN, SENSIRION MAKES NO WARRANTIES, EITHER EXPRESS OR IMPLIED, WITH RESPECT TO THE PRODUCT. ANY AND ALL WARRANTIES, INCLUDING WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY EXCLUDED AND DECLINED.

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SENSIRION does not assume any liability arising out of any application or use of any product or circuit and specifically disclaims any and all liability, including without limitation consequential or incidental damages. All operating parameters, including without limitation recommended parameters, must be validated for each customer's applications by customer's technical experts. Recommended parameters can and do vary in different applications.

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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