EN: This Datasheet/Document is presented by the manufacturer.

Please visit our website for pricing and availability at www.hestore.hu.

SEN6x – Datasheet

3rd Generation Environmental Sensor Node for Air Quality Applications



Highlights

- PM, RH&T, VOC, NO_x, CO_2/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 24[1], 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 CO_2 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.

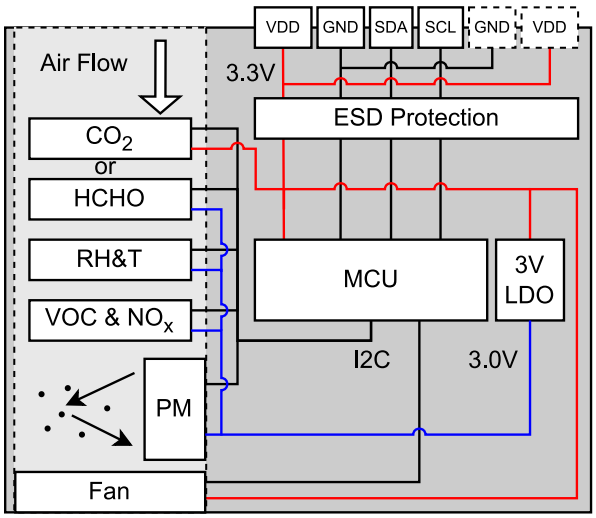
Product Overview

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

Scan me to provide feedback

Functional Block Diagram



[1] 2022 California Building Energy Efficiency Standards for Residential and Nonresidential Buildings
[2] RESET Air Standard v2.0
[3] WELL v2

Engineering Sample

Contents

1 Environmental Sensor Node Specifications 5
1.1 Sensor Module Specifications 5
1.2 Particulate Matter Specifications 6
1.2.1 Laser Safety 6
1.3 Temperature and Humidity Specifications 7
1.4 VOC and NO_x Specifications 8
1.5 CO_2 Specifications 9
1.5.1 CO_2 Specifications – SEN66 9
1.5.2 CO_2 Specifications – SEN63C 9
1.6 Formaldehyde Specifications 10
1.7 Recommended and Absolute Maximum and Minimum Operating and Storage Conditions 11
1.7.1 SEN60 11
1.7.2 SEN63C, SEN65 and SEN66 12
1.7.3 SEN68 13
2 Electrical Specifications 14
2.1 Electrical Characteristics 14
2.2 Absolute Maximum Ratings 15
2.3 ESD / EMC Ratings 15
2.3.1 Immunity 15
2.3.2 Emission 15
3 Hardware Interface Description 16
3.1 I^2C Interface Circuit 16
4 Digital Interface Description 17
4.1 Operation Modes 17
4.2 Temperature Compensation with STAR Engine 17
4.3 Device Status Register 18
4.3.1 SEN6x 18
4.3.2 SEN60 18
4.3.3 SPEED – Fan Speed Warning 18
4.3.4 CO_2-1 – CO_2 Sensor Error 19
4.3.5 PM – Particulate Matter Sensor Error 19
4.3.6 HCHO – Formaldehyde Sensor Error 20
4.3.7 CO_2-2 – CO_2 Sensor Error 20
4.3.8 GAS – Gas Sensor Error (VOC and NO_x) 21
4.3.9 RH&T – Relative Humidity and Temperature Sensor Error 21
4.3.10 FAN – Fan Error 22
4.4 I^2C Interface Settings 23
4.5 Power-Up and Communication Start 23
4.6 Data Type & Length 23
4.7 Command Sequence Types 24

Engineering Sample

4.8 I²C Commands 25
4.8.1 Start Continuous Measurement SEN6x 26
4.8.2 Start Continuous Measurement SEN60 26
4.8.3 Stop Measurement SEN6x 26
4.8.4 Stop Measurement SEN60 27
4.8.5 Get Data Ready SEN6x 27
4.8.6 Get Data Ready SEN60 28
4.8.7 Read Measured Values SEN60 29
4.8.8 Read Measured Values SEN63C 30
4.8.9 Read Measured Values SEN65 31
4.8.10 Read Measured Values SEN66 32
4.8.11 Read Measured Values SEN68 33
4.8.12 Read Measured Raw Values SEN63C 34
4.8.13 Read Measured Raw Values SEN65, SEN68 35
4.8.14 Read Measured Raw Values SEN66 36
4.8.15 Read Number Concentration Values SEN6x 37
4.8.16 Set Temperature Offset Parameters 38
4.8.17 Set Temperature Acceleration Parameters 39
4.8.18 Get Product Name 40
4.8.19 Get Serial Number SEN6x 40
4.8.20 Get Serial Number SEN60 41
4.8.21 Read Device Status SEN6x 41
4.8.22 Read Device Status SEN60 42
4.8.23 Read And Clear Device Status SEN6x 42
4.8.24 Device Reset SEN6x 43
4.8.25 Device Reset SEN60 43
4.8.26 Start Fan Cleaning SEN6x 43
4.8.27 Start Fan Cleaning SEN60 44
4.8.28 Activate SHT Heater 44
4.8.29 Get VOC Algorithm Tuning Parameters 45
4.8.30 Set VOC Algorithm Tuning Parameters 46
4.8.31 Get VOC Algorithm State 47
4.8.32 Set VOC Algorithm State 48
4.8.33 Get NO_x Algorithm Tuning Parameters 49
4.8.34 Set NO_x Algorithm Tuning Parameters 50
4.8.35 Perform Forced CO_2 Recalibration 51
4.8.36 Get CO_2 Sensor Automatic Self Calibration 51
4.8.37 Set CO_2 Sensor Automatic Self Calibration 52
4.8.38 Get Ambient Pressure 52
4.8.39 Set Ambient Pressure 53
4.8.40 Get Sensor Altitude 53
4.8.41 Set Sensor Altitude 54
4.9 Checksum Calculation (CRC) 54

Engineering Sample

5 Technical Drawing 55
5.1 Package Outline 55
5.2 Product Label 56
6 Ordering Information 57
7 Bibliography 58
8 Revision History 58

Engineering Sample

This is a preliminary datasheet; all specifications are to be understood as target specifications and can change without notice. The SEN66-SIN-T provided here are production equivalent engineering samples.

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

Engineering Sample

[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/m³
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[8,11] for PM1 and PM2.5[9]	0 to 100 µg/m³		±5 µg/m³ AND 5 % m.v.	
	100 to 1000 µg/m³		±10	% m.v.
Mass concentration precision[8,11] for PM4, PM10[10]	0 to 100 µg/m³		±25	µg/m³
	100 to 1000 µg/m³		±25	% m.v.
Maximum long-term mass concentration precision limit drift[11]	0 to 100 µg/m³		±2	µg/m³ / year
	100 to 1000 µg/m³		±2	% m.v. / year
Typical start-up time[12]	-		30	s
Sensor output characteristics	PM2.5 mass concentration		Calibrated to TSI DustTrak™ DRX 8533 Ambient Mode	
Additional T-dependent mass precision limit drift[11]	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.

[8] Also referred to as "between-parts variation" or "device-to-device variation".
[9] 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.
[10] PM4 and PM10 output values are calculated based on distribution profile of all measured particles.
[11] For more details refer to "Sensirion Environmental Node Sensor Specification Statement – Rev.2" [7]
[12] Time after starting continuous measurement-mode, until a stable measurement is obtained.

Engineering Sample

1.3 Temperature and Humidity Specifications

Applies to: SEN63C, SEN65, SEN66, SEN68

Parameter	Conditions	Value[13]			Units
		Min	Typ.	Max	
Compensated outputs[14]	-	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[15]	@ 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[16]	@ 25 °C, 50 %RH, $\tau_{63\%}$		<20		s

Table 3. Temperature and humidity specifications

Engineering Sample

[13] For the definition of the typical and max. accuracy tolerance, please refer to the document "Sensirion Humidity Sensor Specification Statement" [8].
[14] Self-heating of the module is compensated according to the application note "Temperature Acceleration and Compensation Instructions for SEN6x" [3].
[15] For a step from 15°C to 25°C, for a bare module with default acceleration and offset parameters
[16] 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.[17]	Max.	
Output signals	VOC Index	1	–	500	VOC Index points
	NOx Index	1	–	500	NOx Index points
	SRAW_VOC	0	-	65'535	ticks[18]
	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[19]	–	<±15 <±15	–	VOC Index points or % VOC Index m.v. (the larger)
	NOx Index[19]	–	<±50 <±50	–	NOx Index points or % NOx Index m.v. (the larger)
Repeatability	VOC Index[19]	–	<±5 <±5	–	VOC Index points or % VOC Index m.v. (the larger)
	NOx Index[19]	–	<±10 <±10	–	NOx Index points or % NOx Index m.v. (the larger)
Switch-on behavior	Time until reliably detecting events[20]	–	<60	–	s
	Time until specifications in this table are met	VOC Index	<1	–	h
		NOx 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.

Engineering Sample

[17] 95% of the sensors will be within the typical tolerance corresponding to 2σ assuming a normal distribution for ≥100 sensors.
[18] Ticks is proportional to the logarithm of the resistance of the sensing layer.
[19] Evaluated using the calibration and test sequence according to the application note "SGP40 – Quick Testing Guide" [9].
[20] Signal change during 60s event of 5'000 to 10'000 ppb of ethanol or of 100 to 300 ppb of NO_2 is three times larger than raw signals (SRAW_VOC, SRAW_NO_x) drift, without this event during the same duration.

1.5 CO_2 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. CO_2 concentration at 400 ppm) at least once per week is required to achieve the following specifications.

1.5.1 CO_2 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 CO_2 recalibration (FRC) or initial operation for 2 days including exposure to fresh air.

Parameter	Conditions	Value	Units
CO_2 output range[21]	-	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[23]	400 to 5000 ppm, typ.	±(5 + 0.5 % m.v.)	
Repeatability	typ.	±10	
Response time	$\tau_{63\%}$, typical, step change 400 – 2’000 ppm	60	s

Table 5. CO_2 specifications, ‘% m.v.’ means ‘% of measured value’.

1.5.2 CO_2 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[21]	-	0 to 32’000	ppm
CO_2 measurement accuracy	400 ppm to 5’000 ppm	±(100 + 10 % m.v.)	
Response time	$\tau_{63\%}$, typ., step change 2’000 – 400 ppm	60	s

Table 6. CO_2 specifications in ambient air (defined as consisting of 78% N_2, 21% O_2, 0.93% Ar, plus a variable content of CO_2 and H_2O depending on the relative humidity), ‘% m.v.’ means ‘% of measured value’.

[21] Exposure to CO2 concentrations smaller than 400 ppm can affect the accuracy of the sensor with ASC enabled.
[23] 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.

Engineering Sample

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'.

Engineering Sample

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[26]		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

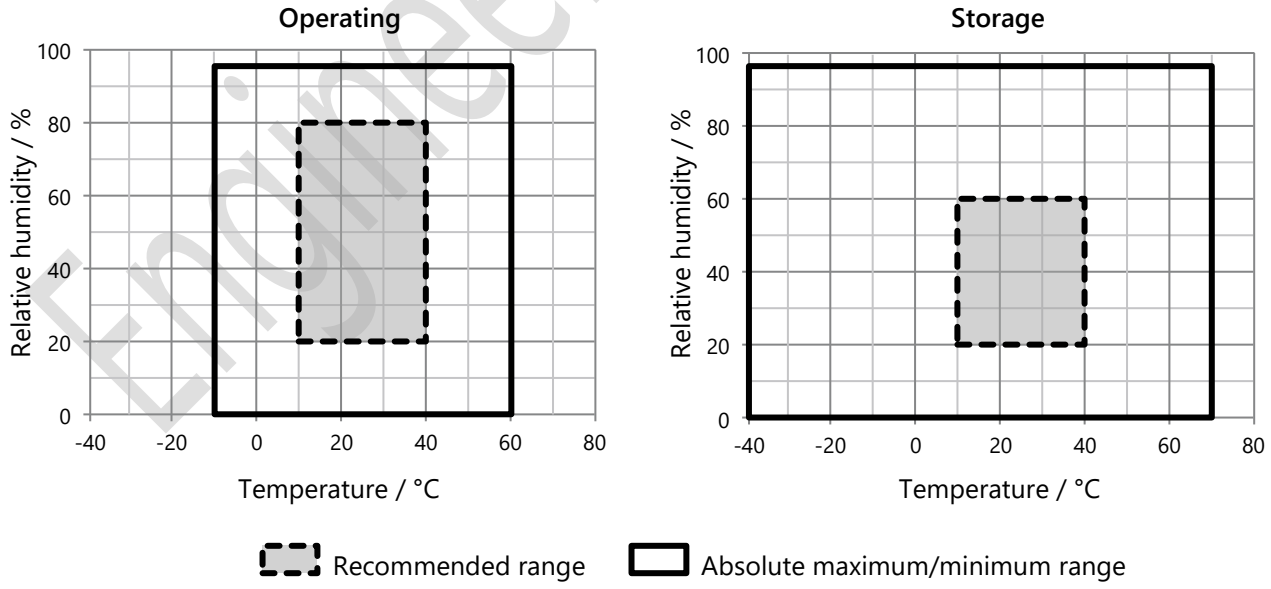


Figure 1. Recommended and absolute maximum/minimum operating and storage conditions for the SEN60

[26] Short-term storage refers to temporary conditions, e.g., transport.

Engineering Sample

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, CO_2, 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[27]		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

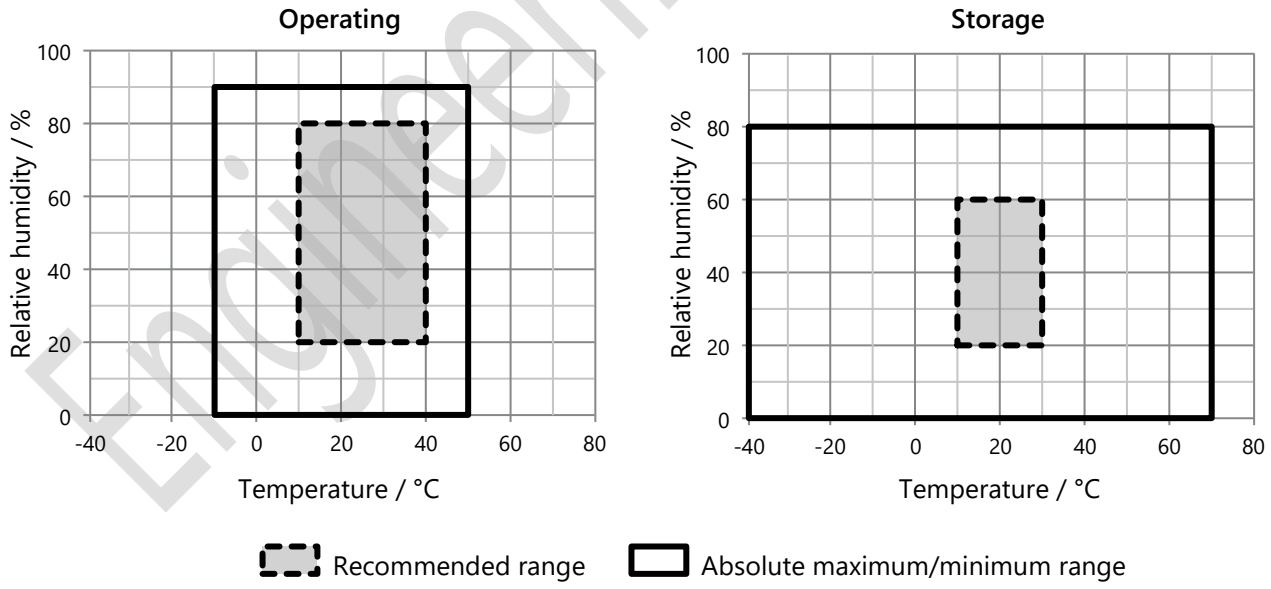


Figure 2. Recommended and absolute maximum/minimum operating and storage conditions for the SEN63, SEN65 and SEN66

[27] Short-term storage refers to temporary conditions, e.g., transport.

Engineering Sample

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[28]		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

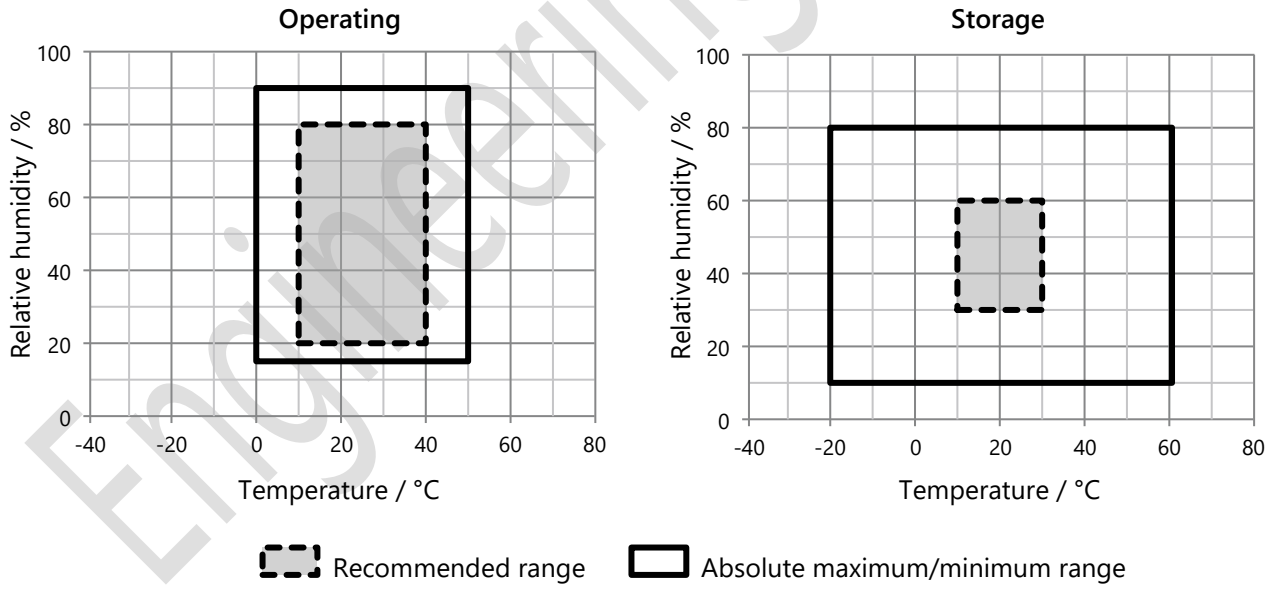


Figure 3. Recommended and absolute maximum/minimum operating and storage conditions for the SEN68

[28] Short-term storage refers to temporary conditions, e.g., transport.

Engineering sample

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[29]	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[30]	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*V_{DD}	-	-	V
SDA/SCL pin input low voltage (V_{IL})			-	-	0.3*V_{DD}	
SDA pin output low voltage (V_{OL})	-		-	-	0.45	

Table 11. Electrical Specifications at 25°C

[29] Minimum voltage including ripples.
[30] Averaged over 5 seconds

Engineering Sample

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

Engineering Sample

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

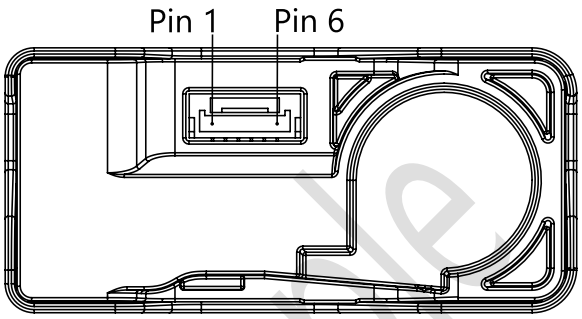


Figure 4. Pin layout. The communication interface connector (ACES 51468-0064N-001) is located at the side of the sensor adjacent to the air outlet.

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 I^{2}C Interface Circuit

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

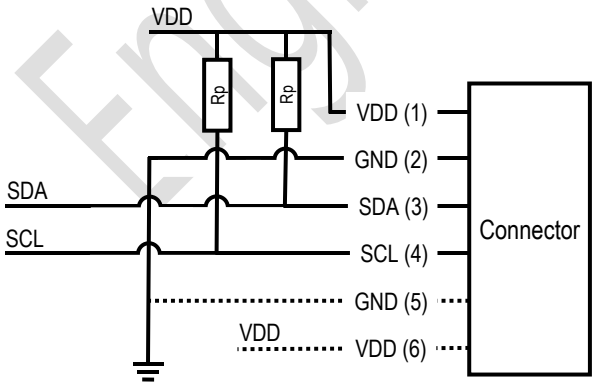


Figure 5. I^{2}C application circuit

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 I^{2}C 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 I^{2}C protocol, refer to NXP I^{2}C-bus specification [2].

Engineering Sample

4 Digital Interface Description

4.1 Operation Modes

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

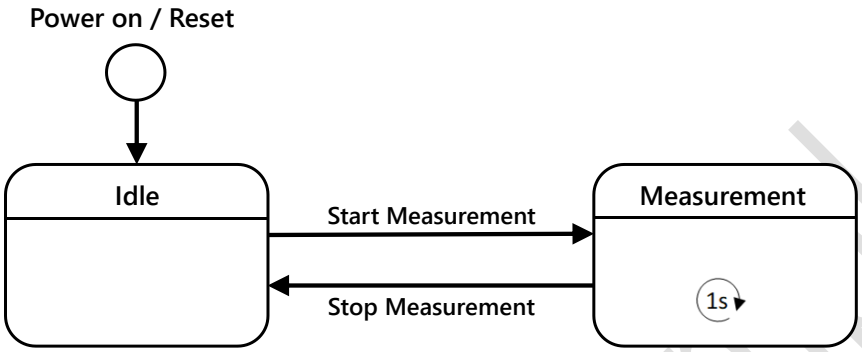


Figure 6. SEN6x operating modes

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].

Engineering Sample

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.	res.	res.	res.	res.	res.	res.	res.	res.	res.	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	SEN60
	21 (see **Figure 7**)	1 (see **Figure 8**)
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

Engineering sample

4.3.4 CO_2-1 – CO_2 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. CO_2-1 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

Engineering Sample

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 CO_2-2 – CO_2 Sensor Error

Applies to: SEN66

CO2-2 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

Engineering Sample

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 NOx 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 compensation algorithms depending on RH&T sensor values. Can occur only in measurement mode.	

Table 23. RH&T sensor error bit description

Engineering Sample

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 – 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	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. Can occur only in measurement mode.		

Table 24. Fan error bit description

Engineering Sample

4.4 I²C Interface Settings

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

Property	SEN60	SEN6x
I²C 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.

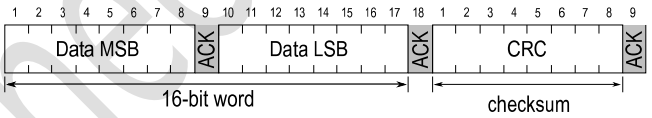


Figure 9. Data type structure with 16-bit word and 8-bit CRC

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.**.

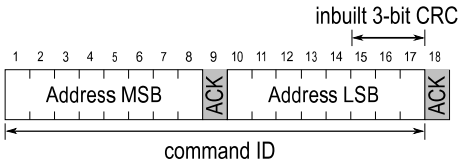


Figure 10. Command ID with inbuilt 3-bit CRC

Engineering Sample

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].

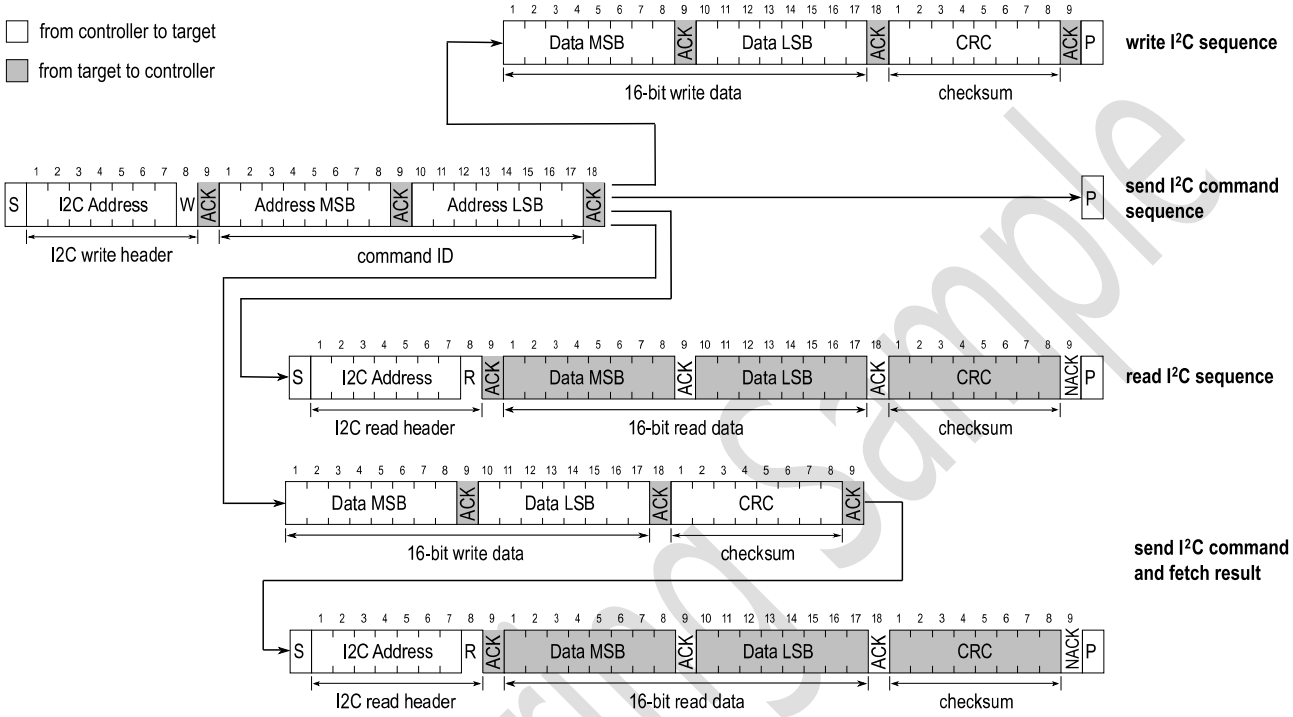


Figure 11. Command sequence types: write sequence, send command sequence, read sequence and send command and fetch result sequence.

After issuing read sequence commands and sending the ACK Bit, the sensor needs the *execution time* (see **Table 26. Command** overview. The column ('During measurement') indicates whether the command can be executed in the measurement mode.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.

Engineering Sample

4.8 I²C Commands

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

Command ID	Command	I²C 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.

Engineering Sample

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 I^2C 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 I^2C 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 I^2C command description

Engineering Sample

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: `bool8` 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

Engineering Sample

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 Data Ready: `bool11` (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.
	1		
	2	CRC	CRC for the previous two bytes.

Table 32. Get data ready SEN60 I^2C command description

Engineering Sample

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 [μg/m^3] = value / 10
	1	LSB	
	2	CRC	
	3	MSB	Mass Concentration PM2.5: `uint16` Value is scaled with factor 10: PM2.5 [μg/m^3] = value / 10
	4	LSB	
	5	CRC	
	6	MSB	Mass Concentration PM4.0: `uint16` Value is scaled with factor 10: PM4.0 [μg/m^3] = value / 10
	7	LSB	
	8	CRC	
	9	MSB	Mass Concentration PM10.0: `uint16` Value is scaled with factor 10: PM10.0 [μg/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 I^{2}C command description

Engineering Sample

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	Mass Concentration PM1.0: `uint16`
	1	LSB	Value is scaled with factor 10: PM1.0 [$\mu g/m^3$] = value / 10
	2	CRC	*Note: If this value is unknown, 0xFFFF is returned.*
	3	MSB	Mass Concentration PM2.5: `uint16`
	4	LSB	Value is scaled with factor 10: PM2.5 [$\mu g/m^3$] = value / 10
	5	CRC	*Note: If this value is unknown, 0xFFFF is returned.*
	6	MSB	Mass Concentration PM4.0: `uint16`
	7	LSB	Value is scaled with factor 10: PM4.0 [$\mu g/m^3$] = value / 10
	8	CRC	*Note: If this value is unknown, 0xFFFF is returned.*
	9	MSB	Mass Concentration PM10.0: `uint16`
	10	LSB	Value is scaled with factor 10: PM10.0 [$\mu g/m^3$] = value / 10
	11	CRC	*Note: If this value is unknown, 0xFFFF is returned.*
	12	MSB	Ambient Humidity: `int16`
	13	LSB	Value is scaled with factor 100: RH [%] = value / 100
	14	CRC	*Note: If this value is unknown, 0x7FFF is returned.*
	15	MSB	Ambient Temperature: `int16`
	16	LSB	Value is scaled with factor 200: T [°C] = value / 200
	17	CRC	*Note: If this value is unknown, 0x7FFF is returned.*
	18	MSB	CO2: `uint16`
	19	LSB	CO2 concentration [ppm]
	20	CRC	*Note: If this value is unknown, 0xFFFF is returned.*

Table 34. Read measured values SEN63C I^2C command description

Engineering Sample

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	Mass Concentration PM1.0: `uint16` Value is scaled with factor 10: PM1.0 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	1	LSB	
	2	CRC	
	3	MSB	Mass Concentration PM2.5: `uint16` Value is scaled with factor 10: PM2.5 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	4	LSB	
	5	CRC	
	6	MSB	Mass Concentration PM4.0: `uint16` Value is scaled with factor 10: PM4.0 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	7	LSB	
	8	CRC	
	9	MSB	Mass Concentration PM10.0: `uint16` Value is scaled with factor 10: PM10.0 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	10	LSB	
	11	CRC	
	12	MSB	Ambient Humidity: `int16` Value is scaled with factor 100: RH [%] = value / 100 *Note: If this value is unknown, 0x7FFF is returned.*
	13	LSB	
	14	CRC	
	15	MSB	Ambient Temperature: `int16` Value is scaled with factor 200: T [°C] = value / 200 *Note: If this value is unknown, 0x7FFF is returned.*
	16	LSB	
	17	CRC	
	18	MSB	VOC Index: `int16` Value is scaled with factor 10: VOC Index = value / 10 *Note: If this value is unknown, 0x7FFF is returned.*
	19	LSB	
	20	CRC	
	21	MSB	NOx Index: `int16` Value is scaled with factor 10: NOx Index = value / 10 *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.*
	22	LSB	
	23	CRC	

Table 35. Read measured values SEN65 I^2C command description

Engineering Sample

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` Value is scaled with factor 10: PM1.0 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	1	LSB	
	2	CRC	
	3	MSB	Mass Concentration PM2.5: `uint16` Value is scaled with factor 10: PM2.5 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	4	LSB	
	5	CRC	
	6	MSB	Mass Concentration PM4.0: `uint16` Value is scaled with factor 10: PM4.0 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	7	LSB	
	8	CRC	
	9	MSB	Mass Concentration PM10.0: `uint16` Value is scaled with factor 10: PM10.0 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	10	LSB	
	11	CRC	
	12	MSB	Ambient Humidity: `int16` Value is scaled with factor 100: RH [%] = value / 100 *Note: If this value is unknown, 0x7FFF is returned.*
	13	LSB	
	14	CRC	
	15	MSB	Ambient Temperature: `int16` Value is scaled with factor 200: T [°C] = value / 200 *Note: If this value is unknown, 0x7FFF is returned.*
	16	LSB	
	17	CRC	
	18	MSB	VOC Index: `int16` Value is scaled with factor 10: VOC Index = value / 10 *Note: If this value is unknown, 0x7FFF is returned.*
	19	LSB	
	20	CRC	
	21	MSB	NOx Index: `int16` Value is scaled with factor 10: NOx Index = value / 10 *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.*
	22	LSB	
	23	CRC	
	24	MSB	CO2: `uint16` CO2 concentration [ppm] *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.*
	25	LSB	
	26	CRC	

Table 36. Read measured values SEN66 I²C command description

Engineering Sample

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	Mass Concentration PM1.0: `uint16` Value is scaled with factor 10: PM1.0 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	1	LSB	
	2	CRC	
	3	MSB	Mass Concentration PM2.5: `uint16` Value is scaled with factor 10: PM2.5 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	4	LSB	
	5	CRC	
	6	MSB	Mass Concentration PM4.0: `uint16` Value is scaled with factor 10: PM4.0 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	7	LSB	
	8	CRC	
	9	MSB	Mass Concentration PM10.0: `uint16` Value is scaled with factor 10: PM10.0 [$\mu g/m^3$] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	10	LSB	
	11	CRC	
	12	MSB	Ambient Humidity: `int16` Value is scaled with factor 100: RH [%] = value / 100 *Note: If this value is unknown, 0x7FFF is returned.*
	13	LSB	
	14	CRC	
	15	MSB	Ambient Temperature: `int16` Value is scaled with factor 200: T [°C] = value / 200 *Note: If this value is unknown, 0x7FFF is returned.*
	16	LSB	
	17	CRC	
	18	MSB	VOC Index: `int16` Value is scaled with factor 10: VOC Index = value / 10 *Note: If this value is unknown, 0x7FFF is returned.*
	19	LSB	
	20	CRC	
	21	MSB	NOx Index: `int16` Value is scaled with factor 10: NOx Index = value / 10 *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.*
	22	LSB	
	23	CRC	
	24	MSB	Formaldehyde: `uint16` Value is scaled with factor 10: HCHO [ppb] = value / 10 *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.*
	25	LSB	
	26	CRC	

Table 37. Read measured values SEN68 I²C command description

Engineering Sample

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	*Note: If this value is unknown, 0x7FFF is returned.*
	3	MSB	Raw Temperature: `int16`
	4	LSB	Value is scaled with factor 200: T [°C] = value / 200
	5	CRC	*Note: If this value is unknown, 0x7FFF is returned.*

Table 38. Read measured raw values SEN63C I^2C command description

Engineering Sample

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` Value is scaled with factor 100: RH [%] = value / 100 *Note: If this value is unknown, 0x7FFF is returned.*
	1	LSB	
	2	CRC	
	3	MSB	Raw Temperature: `int16` Value is scaled with factor 200: T [°C] = value / 200 *Note: If this value is unknown, 0x7FFF is returned.*
	4	LSB	
	5	CRC	
	6	MSB	Raw VOC: `uint16` Raw measured VOC ticks without scale factor. *Note: If this value is unknown, 0xFFFF is returned.*
	7	LSB	
	8	CRC	
	9	MSB	Raw NOx: `uint16` Raw measured NOx ticks without scale factor. *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.*
	10	LSB	
	11	CRC	

Table 39. Read measured raw values SEN65, SEN68 I^2C command description

Engineering Sample

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` Value is scaled with factor 100: RH [%] = value / 100 *Note: If this value is unknown, 0x7FFF is returned.*
	1	LSB	
	2	CRC	
	3	MSB	Raw Temperature: `int16` Value is scaled with factor 200: T [°C] = value / 200 *Note: If this value is unknown, 0x7FFF is returned.*
	4	LSB	
	5	CRC	
	6	MSB	Raw VOC: `uint16` Raw measured VOC ticks without scale factor. *Note: If this value is unknown, 0xFFFF is returned.*
	7	LSB	
	8	CRC	
	9	MSB	Raw NOx: `uint16` Raw measured NOx ticks without scale factor. *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.*
	10	LSB	
	11	CRC	
	12	MSB	Raw CO2: `uint16` Not interpolated CO2 concentration [ppm] updated every five seconds. *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.*
	13	LSB	
	14	CRC	

Table 40. Read measured raw values SEN66 I²C command description

Engineering Sample

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` Value is scaled with factor 10: PM0.5 [particles/cm^3] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	1	LSB	
	2	CRC	
	3	MSB	Number Concentration PM1.0: `uint16` Value is scaled with factor 10: PM1.0 [particles/cm^3] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	4	LSB	
	5	CRC	
	6	MSB	Number Concentration PM2.5: `uint16` Value is scaled with factor 10: PM2.5 [particles/cm^3] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	7	LSB	
	8	CRC	
	9	MSB	Number Concentration PM4.0: `uint16` Value is scaled with factor 10: PM4.0 [particles/cm^3] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	10	LSB	
	11	CRC	
	12	MSB	Number Concentration PM10.0: `uint16` Value is scaled with factor 10: PM10.0 [particles/cm^3] = value / 10 *Note: If this value is unknown, 0xFFFF is returned.*
	13	LSB	
	14	CRC	

Table 41. Read number concentration values SEN6x I^{2}C command description

Engineering Sample

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 #		Description
	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

Engineering Sample

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 #		Description
	0	MSB	K: `uint16` Filter constant K scaled with factor 10 (K = value / 10).
	1	LSB	
	2	CRC	
	3	MSB	P: `uint16` Filter constant P scaled with factor 10 (P = value / 10).
	4	LSB	
	5	CRC	
	6	MSB	T1: `uint16` Time constant T1 scaled with factor 10 (T1 [s] = value / 10).
	7	LSB	
	8	CRC	
	9	MSB	T2: `uint16` Time constant T2 scaled with factor 10 (T2 [s] = value / 10).
	10	LSB	
	11	CRC	
RX Data	None		

Table 43. Set temperature acceleration parameters I^2C command description

Engineering Sample

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	Product Name: `string<32>` Null-terminated ASCII string containing the product name. Up to 32 characters can be read from the device.
	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	Serial Number: `string<32>` Null-terminated ASCII string containing the serial number. Up to 32 characters can be read from the device.
	1	Char 1	
	2	CRC	
	...	...	
	45	Char 30	
	46	Char 31	
	47	CRC	

Table 45. Get serial number SEN6x I²C command description

Engineering Sample

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	Serial Number: `bytearray<6>` 12-digit hexadecimal serial number
	1	-	
	2	CRC	
	3	-	
	4	-	
	5	CRC	
	6	-	
	7	LSB	
	8	CRC	

Table 46. Get serial number SEN60 I^2C 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	Device Status: `uint32` Device status (32 flags as an integer value). For details, please refer to the **Device Status Register** documentation.
	1	-	
	2	CRC	
	3	-	
	4	LSB	
	5	CRC	

Table 47. Read device status SEN6x I^2C command description

Engineering Sample

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

Engineering Sample

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

Engineering Sample

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 I^2C 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 I^2C command description

Engineering Sample

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: `int16` VOC index representing typical (average) conditions.
	1	LSB	
	2	CRC	
	3	MSB	Learning Time Offset Hours: `int16` 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: `int16` 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: `int16` 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: `int16` 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: `int16` Gain factor to amplify or to attenuate the VOC index output.
	16	LSB	
	17	CRC	

Table 55. Get VOC algorithm tuning parameters I^2C command description

Engineering Sample

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	Byte #		Description
	0	MSB	Index Offset: `int16` Range: `1..250` VOC index representing typical (average) conditions. Allowed values are in range 1..250. The default value is 100.
	1	LSB	
	2	CRC	
	3	MSB	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.
	4	LSB	
	5	CRC	
	6	MSB	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.
	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 VOC index signal). Set to zero to disable the gating. Allowed values are in range 0..3000. The default value is 180 minutes.
	10	LSB	
	11	CRC	
	12	MSB	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.
	13	LSB	
	14	CRC	
	15	MSB	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.
	16	LSB	
	17	CRC	
RX Data	None		

Table 56. Set VOC algorithm tuning parameters I²C command description

Engineering Sample

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 the **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	State: `bytearray<8>` Current VOC algorithm state.
	1	Byte 1	
	2	CRC	
	…	…	
	9	Byte 6	
	10	Byte 7	
	11	CRC	

Table 57. Get VOC algorithm state I^2C command description

Engineering Sample

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 the **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.

<table>
<tr><th colspan="4">Set VOC Algorithm State</th></tr>
<tr><td>Command ID</td><td colspan="3">0x6181</td></tr>
<tr><td>Available in</td><td colspan="3">Idle mode</td></tr>
<tr><td>Execution Time</td><td colspan="3">20 ms</td></tr>
<tr><td>Max. RX Data With CRC</td><td colspan="3">0 Bytes</td></tr>
<tr><td rowspan="9">TX Data</td><td colspan="2">Byte #</td><td>Description</td></tr>
<tr><td>0</td><td>Byte 0</td><td rowspan="8">State: <code>bytearray<8></code>
VOC algorithm state to restore.</td></tr>
<tr><td>1</td><td>Byte 1</td></tr>
<tr><td>2</td><td>CRC</td></tr>
<tr><td>…</td><td>…</td></tr>
<tr><td>9</td><td>Byte 6</td></tr>
<tr><td>10</td><td>Byte 7</td></tr>
<tr><td>11</td><td>CRC</td></tr>
<tr><td>RX Data</td><td colspan="3">None</td></tr>
</table>

Table 58. Set VOC algorithm state I^2C command description

Engineering Sample

4.8.33 Get NO_x Algorithm Tuning Parameters

Applies to: SEN65, SEN66, SEN68

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

Get NOx 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	Index Offset: `int16` NOx index representing typical (average) conditions.
	1	LSB	
	2	CRC	
	3	MSB	Learning Time Offset Hours: `int16` Time constant to estimate the NOx 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: `int16` The time constant to estimate the NOx algorithm gain from the history has no impact for NOx. This parameter is still in place for consistency reasons with the VOC tuning parameters command.
	7	LSB	
	8	CRC	
	9	MSB	Gating Max Duration Minutes: `int16` Maximum duration of gating in minutes (freeze of estimator during high NOx index signal). Zero disables the gating.
	10	LSB	
	11	CRC	
	12	MSB	Std Initial: `int16` The initial estimate for standard deviation has no impact for NOx. This parameter is still in place for consistency reasons with the VOC tuning parameters command.
	13	LSB	
	14	CRC	
	15	MSB	Gain Factor: `int16` Gain factor to amplify or to attenuate the NOx index output.
	16	LSB	
	17	CRC	

Table 59. Get NO_x algorithm tuning parameters I^2C command description

Engineering Sample

4.8.34 Set NO_x Algorithm Tuning Parameters

Applies to: SEN65, SEN66, SEN68

Description: Sets the parameters to customize the NOx 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 NOx 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 NOx Algorithm Tuning Parameters			
Command ID	0x60E1		
Available in	Idle mode		
Execution Time	20 ms		
Max. RX Data With CRC	0 Bytes		
TX Data	Byte #		Description
	0	MSB	Index Offset: `int16` Range: `1..250` NOx 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 NOx 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 NOx algorithm gain from the history has no impact for NOx. 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 NOx 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 NOx. 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 NOx 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 I^2C command description

Engineering sample

4.8.35

4.8.35 Perform Forced CO_2 Recalibration

Applies to: SEN63C, SEN66

Description: Execute the forced recalibration (FRC) of the CO_2 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` 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.
	1	LSB	
	2	CRC	

Table 61. Perform forced CO_2 recalibration I^2C command description

4.8.36 Get CO_2 Sensor Automatic Self Calibration

Applies to: SEN63C, SEN66

Description: Gets the status of the CO_2 sensor automatic self-calibration (ASC). The CO_2 sensor supports automatic self-calibration (ASC) for long-term stability of the CO_2 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 CO_2 sensor automatic self calibration I^2C command description

Engineering Sample

4.8.37 Set CO_2 Sensor Automatic Self Calibration

Applies to: SEN63C, SEN66

Description: Sets the status of the CO_2 sensor automatic self-calibration (ASC). The CO_2 sensor supports automatic self-calibration (ASC) for long-term stability of the CO_2 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 CO2 measurement self-calibration feature.
	2	CRC	CRC for the previous two bytes.
RX Data	None		

Table 63. Set CO_2 sensor automatic self-calibration I^2C 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 CO_2 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` Currently used ambient pressure [hPa] for pressure compensation.
	1	LSB	
	2	CRC	

Table 64. Get ambient pressure I^2C command description

Engineering Sample

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 CO_2 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 CO_2 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 #		Description
	0	MSB	Ambient Pressure: `uint16` Ambient pressure [hPa] to be used for pressure compensation.
	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 CO_2 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 #		Description
	0	MSB	Altitude: `uint16` Current sensor altitude [m].
	1	LSB	
	2	CRC	

Table 66. Get sensor altitude I²C command description

Engineering Sample

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 CO_2 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 #		Description
	0	MSB	Altitude: `uint16` Sensor altitude [m], valid input between 0 and 3000m.
	1	LSB	
	2	CRC	
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	`#define CRC8_POLYNOMIAL 0x31`
		`#define CRC8_INIT 0xFF`
		
		`uint8_t sensirion_generate_crc(const uint8_t* data, uint16_t count) {`
		`  uint16_t current_byte;`
		`  uint8_t crc = CRC8_INIT;`
		`  uint8_t crc_bit;`
		`  /* calculates 8-Bit checksum with given polynomial */`
		`  for (current_byte = 0; current_byte < count; ++current_byte) {`
		`  crc ^= (data[current_byte]);`
		`  for (crc_bit = 8; crc_bit > 0; --crc_bit) {`
		`  if (crc & 0x80)`
		`  crc = (crc << 1) ^ CRC8_POLYNOMIAL;`
		`  else`
		`  crc = (crc << 1);`
		`  }`
		`  }`
		`  return crc;`
		`}`

Width	8 bits	
Protected Data	read and/or write data	
Polynomial	0x31 ($x^8+x^5+x^4+1$)	
Initialization	0xFF	
Reflect input	No	
Reflect output	No	
Final XOR	0x00	
Examples	CRC (0xBEEF) = 0x92	

Table 68. I²C CRC properties

Engineering Sample

5 Technical Drawing

5.1 Package Outline

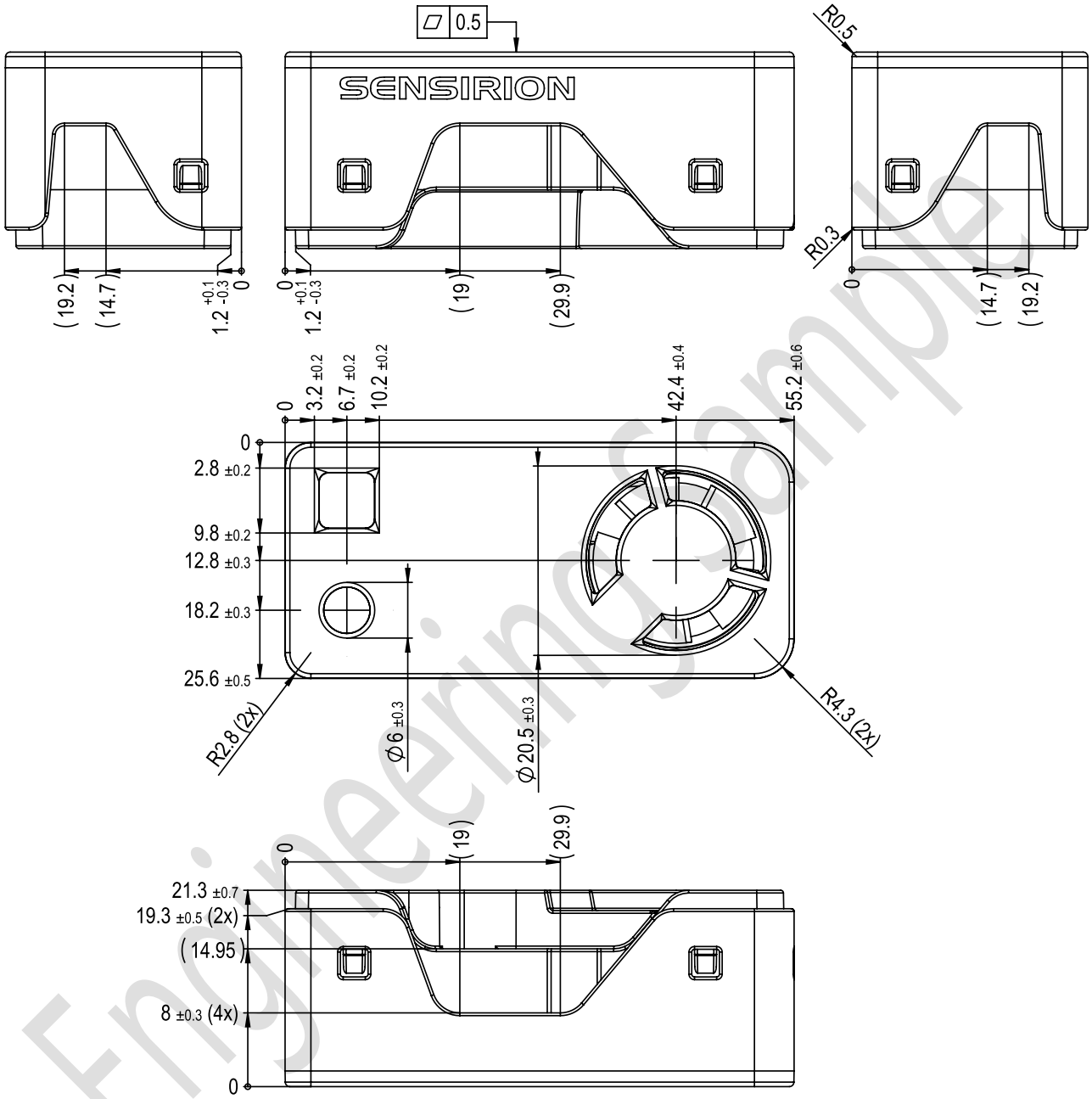


Figure 12. Technical Drawing of the SEN6x platform. All dimensions are in millimeters

Engineering Sample

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
SEN6xx – SIN – T EEEEEEEE FFFFFFFF	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
	FFFFFFFF	Last 8 digits of the 16-digit HEX code

Table 69. Label information

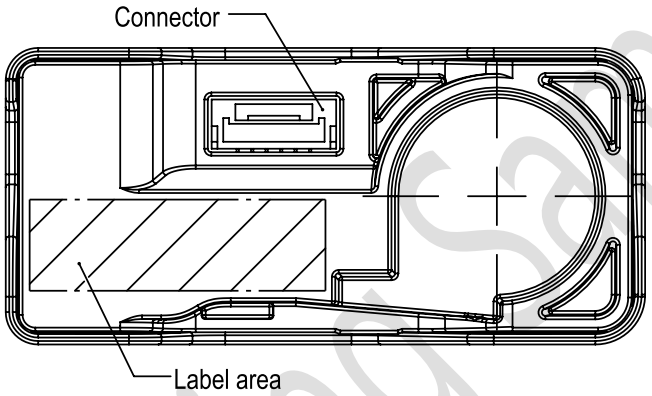


Figure 13. Label position on SEN6x

Engineering Sample

6 Ordering Information

Material Description	Material Number	Sensor Outputs	Quantity
SEN60-SIN-T	3.001.163	• Particulate Matter	420pcs per box, 7 trays, 60pcs per tray
SEN63C-SIN-T	3.001.197	• Particulate Matter • Relative Humidity • Temperature • CO_2	
SEN65-SIN-T	3.001.203	• Particulate Matter • Relative Humidity • Temperature • VOC Index • NOx Index	
SEN66-SIN-T	3.001.030	• Particulate Matter • Relative Humidity • Temperature • VOC Index • NOx Index • CO_2	
SEN68-SIN-T	3.001.198	• Particulate Matter • Relative Humidity • Temperature • VOC Index • NOx Index • Formaldehyde	

Table 70. Ordering information

Engineering Sample

7 Bibliography

[1] Sensirion, "Compliance of Sensirion's VOC Sensors with Building," March 2023. [Online]. Available: sensirion.com.

[2] NXP, "UM10204 I2C-bus specification and user manual Rev.7.0," 1 October 2021. [Online]. Available: https://www.nxp.com/docs/en/user-guide/UM10204.pdf. [Accessed 04 October 2024].

[3] Sensirion, "Temperature Acceleration and Compensation Instructions for SEN6x," October 2024. [Online]. Available: www.sensirion.com.

[4] Sensirion AG, "Sensirion's VOC Index for Indoor Air Applications," January 2022. [Online]. Available: www.sensirion.com.

[5] Sensirion AG, "Sensirion's NOx Index for Indoor Air Applications," January 2022. [Online]. Available: www.sensirion.com.

[6] Sensirion AG, "Datasheet SCD4x," September 2024. [Online]. Available: www.sensirion.com.

[7] Sensirion AG, "Sensirion Environmental Node Sensor Specification Statement – Rev.2," November 2024. [Online]. Available: www.sensirion.com.

[8] Sensirion, "Sensirion Humidity Sensor Specification Statement," 19 April 2021. [Online]. Available: www.sensirion.com. [Accessed 12 October 2024].

[9] Sensirion, "SGP40 - Quick Testing Guide," March 2021. [Online]. Available: www.sensirion.com. [Accessed 12 October 2024].

8 Revision History

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

Engineering Sample

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.

SENSIRION is only liable for defects of this product arising under the conditions of operation provided for in the data sheet and proper use of the goods. SENSIRION explicitly disclaims all warranties, express or implied, for any period during which the goods are operated or stored not in accordance with the technical specifications.

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.

Headquarters and Subsidiaries

Sensirion AG
Laubisruetistr. 50
CH-8712 Staefa ZH
Switzerland

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

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

Sensirion Japan Co. Ltd.
phone: +81 45 270 4506
info-jp@sensirion.com
www.sensirion.com/jp

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

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

Sensirion Taiwan Co. Ltd
phone: +886 2 2218-6779
info@sensirion.com
www.sensirion.com

To find your local representative, please visit
www.sensirion.com/distributors

Copyright © 2024, by SENSIRION. CMOSens® is a trademark of Sensirion. All rights reserved

Engineering Sample