Interface Description Sensirion SCD30 Sensor Module

Ambient CO_2, humidity, and temperature sensor

- NDIR CO_2 sensor technology
- Integrated temperature and humidity sensor
- Best performance-to-price ratio
- Dual-channel detection for superior stability
- Small form factor: 35 mm x 23 mm x 7 mm
- Measurement range: 400 ppm – 10.000 ppm
- Accuracy: ±(30 ppm + 3%)
- Energy consumption: 120 mJ @ 1 measurement
- Fully calibrated with digital interface UART or I^2C

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Important Note

All information and specifications in this document are preliminary and subject to change without prior notice.

1 Digital interface description

The SCD30 digital interface is compatible with the I2C protocol and the Modbus protocol. For selecting Modbus protocol, the SEL pin needs to be pulled to VDD Voltage. Please refer to datasheet.

1.1 I2C Protocol

Maximal I2C speed is 100 kHz and the master has to support clock stretching. Clock stretching period in write- and read-frames is 12 ms, however, due to internal calibration processes a maximal clock stretching of 150ms may occur once per day. For detailed information to the I2C protocol, refer to NXP I2C-bus specification[1]. SCD30 does not support repeated start condition.

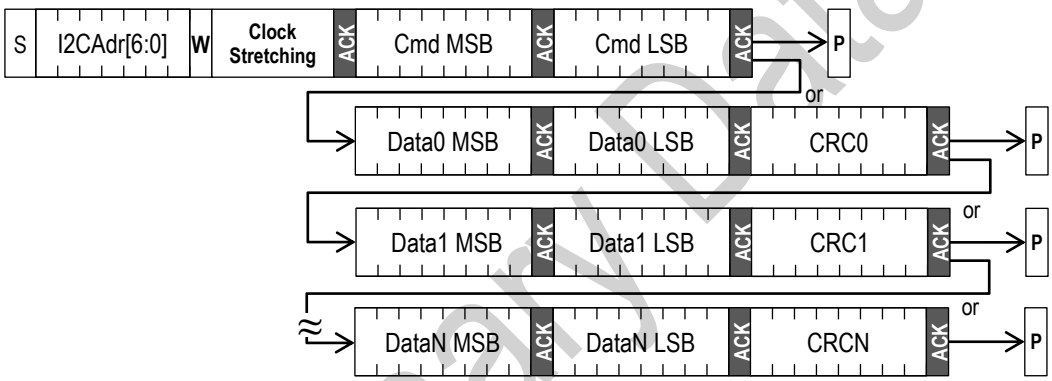
1.1.1 I2C Address

After power-up of the sensor, the I2C address of the prototype module is set to the address 0x61.

1.1.2 I2C Sequence

The commands issued by the I2C master are 16 bit with an optional parameter. Data sent to the master is protected by a CRC. This also applies to data arguments sent to the sensor, please see chapter 1.1.3 for CRC checksum calculation. 2 byte data sent from or received by the sensor is always succeeded with an 8 bit CRC.

I2C write 16bit command



I2C read multiple 16bit words

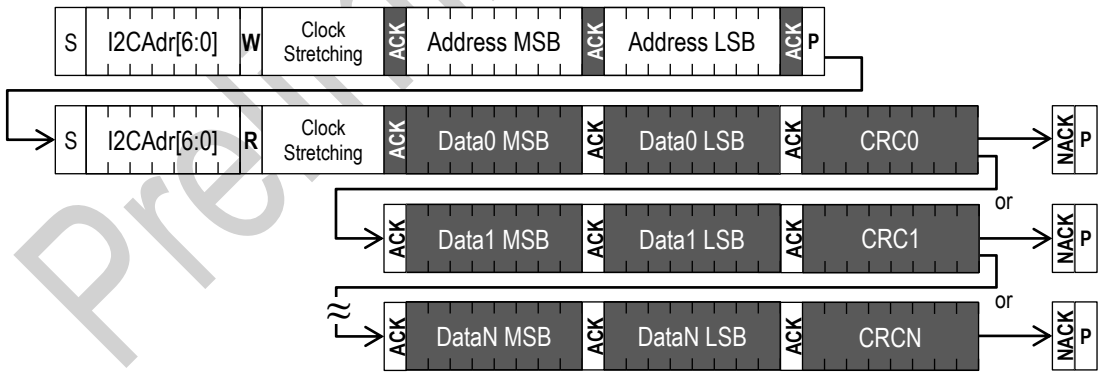


Table 1 I2C write and read communication frames. SDA is controlled by the I2C master in clear blocks and by the sensor in dark blocks.

Clock stretching is necessary to start the microcontroller and might occur before every ACK. I2C master clock stretching needs to be implemented according to the NXP specification. The boot-up time is < 2 s.

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

1.1.3 I²C Checksum calculation

The checksum byte for I²C communication is generated by a CRC algorithm with the following properties:

Preceding Command	Value
Name	CRC-8
Protected Data	read data
Width	8 bits
Polynomial	0x31 ($x^8 + x^5 + x^4 + 1$)
Initialization	0xFF
Reflect Input	false
Reflect Output	false
Final XOR	0x00
Example	CRC(0xBEEF) = 0x92

1.2 Modbus protocol

For selecting Modbus protocol, the SEL pin needs to be pulled to VDD Voltage. Please refer to datasheet.

The supported baudrate is 19200 Baud with 8 Databits, 1 Startbit and 1 Stopbit, no Parity bit.

1.2.1 Modbus address

Modbus address is 0x61.

1.2.2 Modbus function codes

Available function codes are

Function code	Description
3	Read holding registers
4	Read input registers
6	Write single holding register

1.3 Sensor commands

The command set of the SCD30 is defined as follows. All commands are available via Modbus and I2C.

- Trigger continuous measurement with optional ambient pressure compensation
- Stop continuous measurement
- Set measurement interval
- Get data ready status
- Read measurement
- (De-)Activate continuous calculation of reference value for automatic self-calibration (ASC)
- Set external reference value for forced recalibration (FRC)
- Set temperature offset for onboard RH/T sensor
- Altitude compensation

1.3.1 Trigger continuous measurement with optional ambient pressure compensation

Starts continuous measurement of the SCD30 to measure CO_2 concentration, humidity and temperature. Measurement data which is not read from the sensor will be overwritten. The measurement interval is adjustable via the command documented in chapter 1.3.3, initial measurement rate is 2s.

Continuous measurement status is saved in non-volatile memory. When the sensor is powered down while continuous measurement mode is active SCD30 will measure continuously after repowering without sending the measurement command.

The CO_2 measurement value can be compensated for ambient pressure by feeding the pressure value in mBar to the sensor. Setting the ambient pressure will overwrite previous and future settings of altitude compensation. Setting the argument to zero will deactivate the ambient pressure compensation. For setting a new ambient pressure when continuous measurement is running the whole command has to be written to SCD30.

Protocol	Command (hex)			Argument	Description
I2C	0x0010 *argument*			Format: uint16 Available range: 0 & [700 … 1200]. Pressure in mBar.	Triggers continuous measurement. Ambient pressure is compensated by setting *argument.* *argument* = 0 deactivates pressure compensation.
Protocol	Function Code	Address	Data to write		
Modbus	6	0x0036	0x0000 or pressure in mBar		

1.3.2 Stop continuous measurement

Stops the continuous measurement of the SCD30.

Protocol	Command (hex)			Description
I2C	0x0104			Stops continuous measurement.
Protocol	Function Code	Address	Data to write	
Modbus	6	0x0037	0x0001	

1.3.3 Set measurement interval

Sets the interval used by the SCD30 sensor to measure in continuous measurement mode (see chapter 1.3.1). Initial value is 2 s. The chosen measurement interval is saved in non-volatile memory and thus is not reset to its initial value after power up.

Protocol	Command (hex)			Argument	Description
I2C	0x4600 *argument*			Format: unit16 Interval in seconds. Available range: [2 … 1800] given in 2 byte in the order MSB, LSB.	Sets the interval for continuous measurement mode. Standard measurement interval is 2.
Protocol	Function Code	Address	Data to write		
Modbus	6	0x0025	*argument*		

Example: Writing [0xc2 0x46 0x00 0x00 0x78 0xC0] to I2C bus will set the measurement frequency to 120 s.

1.3.4 Get data ready status

Data ready command is used to determine if a measurement can be read from the sensor's buffer. Whenever there is a measurement available from the internal buffer this command returns 1 and 0 otherwise. As soon as the measurement has been read by the return value changes to 0.

It is recommended to use data ready status byte before readout of the measurement values.

Protocol	Command (hex)		Description
I2C	0x0202		Data ready status. Status equals "1" when a measurement is available to be read from the sensor.
Protocol	Function Code	Address	
Modbus	4	0x0027	

1.3.5 Read measurement

When new measurement data is available it can be read out with the following command. Make sure that the measurement is completed by reading the data ready status bit before read out.

Protocol	Command (hex)		Description
I2C	0x0300		Reads a single measurement of CO_2 concentration.
Protocol	Function Code	Address	
Modbus	4	0x0028 - 0x0033	

Table 2 and Table 3 shows the data layout of the data read out from the sensor.

I2C:

Using I2C for read-out the sensor will stream out the data in the given order.

Preceding Command	Consecutive read	Description
Read measurement	Byte1: CO_2 concentration MMSB Byte2: CO_2 concentration MLSB Byte3: CRC Byte4: CO_2 concentration LMSB Byte5: CO_2 concentration LLSB Byte6: CRC Byte7: Temperature MMSB Byte8: Temperature MLSB Byte9: CRC Byte10: Temperature LMSB Byte11: Temperature LLSB Byte12: CRC Byte13: Humidity MMSB Byte14: Humidity MLSB Byte15: CRC Byte16: Humidity LMSB Byte17: Humidity LLSB Byte18: CRC	Data read-out table for I2C communication. Measurement of CO_2 concentration, humidity and temperature has to be finished before read-out.

Table 2: I2C data read-out table. Read-out of measurement data can be aborted by sending a NACK followed by a stop condition after any data byte.

Example: The CO_2 concentration 400 ppm corresponds to 0x43c80000 in Big-Endian notation.

Modbus:

Words for retrieving CO_2 concentration, humidity and temperature can be read out at the following addresses. The words can be read from the sensor in an arbitrary order.

Preceding Command	Consecutive read	Memory address	Description
Read measurement	Word0: CO_2 MSW Word1: CO_2 LSW Word2: Temperature MSW Word3: Temperature LSW Word4: Humidity MSW Word5: Humidity LSW	0x0028 0x0029 0x0030 0x0031 0x0032 0x0033	Data read-out table for modbus communication. Measurement of CO_2 concentration, humidity and temperature has to be finished before read-out.

Table 3: Modbus data read-out table.

1.3.6 (De-)Activate Automatic Self-Calibration (ASC)

Continuous automatic self-calibration can be (de-)activated with the following command. When activated for the first time a period of minimum 7 days is needed so that the algorithm can find its initial parameter set for ASC. The sensor has to be exposed to fresh air for at least 1 hour every day. Also during that period, the sensor may not be disconnected from the power supply, otherwise the procedure to find calibration parameters is aborted and has to be restarted from the beginning. The successfully calculated parameters are stored in non-volatile memory of the SCD30 having the effect that after a restart the previously found parameters for ASC are still present. Note that the most recently found self-calibration parameters will be actively used for self-calibration disregarding the status of this feature. Finding a new parameter set by the here described method will always overwrite the settings from external recalibration (see chapter 1.3.7) and vice-versa. The feature is switched off by default.

To work properly SCD30 has to see fresh air on a regular basis. Optimal working conditions are given when the sensor sees fresh air for one hour every day so that ASC can constantly re-calibrate. ASC only works in continuous measurement mode.

ASC status is saved in non-volatile memory. When the sensor is powered down while ASC is activated SCD30 will continue with automatic self-calibration after repowering without sending the command.

Protocol	Command (hex)			Argument	Description
I2C	0x5306 *argument*			Format: uint16 "1": Activate continuous ASC "0": Deactivate continuous ASC	See notes above, feature is switched off by default.
Protocol	Function Code	Address	Data to write		
Modbus	6	0x0040	*Argument*		

1.3.7 Set Forced Recalibration value (FRC)

Forced recalibration (FRC) is used to compensate for sensor drifts when a reference value of the CO_2 concentration in close proximity to the SCD30 is available. For best results the sensor has to be run in a stable environment in continuous mode at a measurement rate of 2s for at least two minutes before applying the calibration command and sending the reference value. Setting a reference CO_2 concentration by the here described method will always overwrite the settings from ASC (see chapter 1.3.6) and vice-versa. The reference CO_2 concentration has to be within the range 400 ppm ≤ $c_{ref}(CO_2)$ ≤ 2000 ppm.

FRC value is saved in non-volatile memory, the last set FRC value will be used for field-calibration after repowering.

Protocol	Command (hex)			Argument	Description
I2C	0x5204 *argument*			Format: uint16 CO_2 concentration in ppm	See notes above.
Protocol	Function Code	Address	Data to write		
Modbus	6	0x0039	*argument*		

1.3.8 Set Temperature Offset

The on-board RH/T sensor is influenced by thermal self-heating of SCD30 and other electrical components. Design-in alters the thermal properties of SCD30 such that temperature and humidity offsets may occur when operating the sensor in end-customer devices. Compensation of those effects is achievable by writing the temperature offset found in continuous operation of the device into the sensor.

Temperature offset value is saved in non-volatile memory. The last set value will be used for temperature offset compensation after repowering.

Protocol	Command (hex)			Argument	Description
I2C	0x5403 *argument*			Format: uint16 Temperature offset, unit [°C x 100], i.e. one tick corresponds to 0.01°C	See notes above.
Protocol	Function Code	Address	Data to write		
Modbus	6	0x0041	*argument*		

1.3.9 Altitude Compensation

Measurements of CO_2 concentration based on the NDIR principle are influenced by altitude. SCD30 offers to compensate deviations due to altitude by using the following command. Setting altitude is disregarded when an ambient pressure is given to the sensor, please see sections **Error! Reference source not found.** and 1.3.1.

Altitude value is saved in non-volatile memory. The last set value will be used for altitude compensation after repowering.

Protocol	Command (hex)			Argument	Description
I2C	0x5102 *argument*			Format: uint16 Height over sea level in [m] above 0.	See notes above.
Protocol	Function Code	Address	Data to write		
Modbus	6	0x0038	*argument*		

1.4 Signal conversion to physical values

All data read from the sensor are float numbers in big-endian format[2]. Conversion of digital values S_x, (x = c(CO2), RH, T) to physical values and respective units are shown in the following table

Physical quantity	Conversion formula	Units	Range
CO_2 concentration $c(CO_2)$	$c(CO_2) = S_{c(CO2)}$	ppm	0 – 10000
Temperature T	$T = S_T$	°C	-40 – 125°C
Relative humidity RH	$RH = S_{RH}$	%RH	0 – 100

Table 4: Signal conversion table.

Conversation of temperature to °F as well as relative humidity to absolute humidity and dew point temperature can be found in Sensirion's online support center[3]

[2] IEEE 754 applies.

[3] https://www.sensirion.com/fileadmin/user_upload/customers/sensirion/Dokumente/2_Humidity_Sensors/Sensirion_Humidity_Sensors_at_a_Glance_V1.pdf

Revision History

Date	Version	Page(s)	Changes
May 2018	0.8	all	

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.

Warranty

SENSIRION warrants solely to the original purchaser of this product for a period of 12 months (one year) from the date of delivery that this product shall be of the quality, material and workmanship defined in SENSIRION's published specifications of the product. Within such period, if proven to be defective, SENSIRION shall repair and/or replace this product, in Sensirion's discretion, free of charge to the Buyer, provided that:

- notice in writing describing the defects shall be given to SENSIRION within fourteen (14) days after their appearance;
- such defects shall be found, to SENSIRION's reasonable satisfaction, to have arisen from SENSIRION's faulty design, material, or workmanship;
- the defective product shall be returned to SENSIRION's factory at the Buyer's expense; and
- the warranty period for any repaired or replaced product shall be limited to the unexpired portion of the original period.

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

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