# Interface Description Sensirion SCD30 Sensor Module

$CO_2$, 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
- Accuracy $CO_2$ sensor: ± (30 ppm + 3%)
- Fully calibrated with digital interface UART or $I^2C$

Contents

# 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 during power-up of the SCD30 sensor module. It is not possible to switch the communication protocol during operation. Please refer to datasheet.

## 1.1 I2C Protocol

Maximal I2C speed is 100 kHz and the **master has to support clock stretching**. Sensirion recommends to operate the SCD30 at a baud rate of 50 kHz or smaller. Clock stretching period in write- and read-frames is 30 ms, however, due to internal calibration processes a maximal clock stretching of 150 ms 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. 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.

### 1.1.1 I2C Address

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

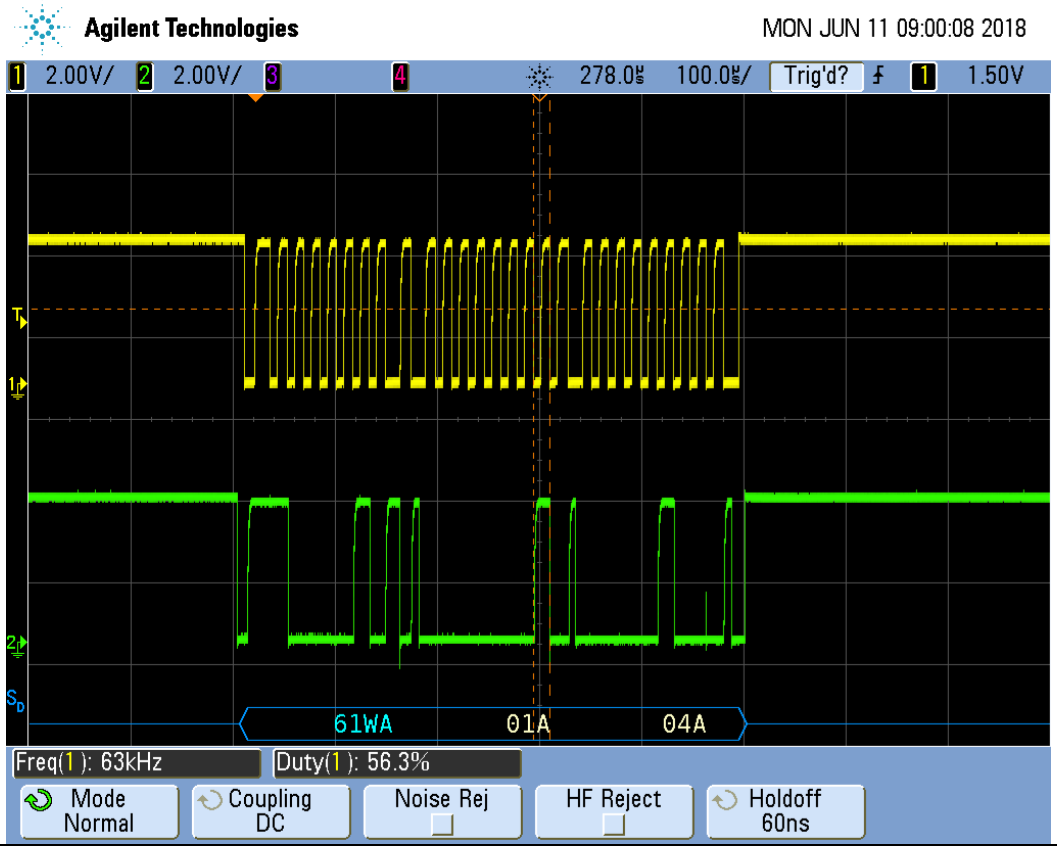
### 1.1.2 I2C Sequence

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. Examples are shown below.

**I2C write 16bit command without arguments**

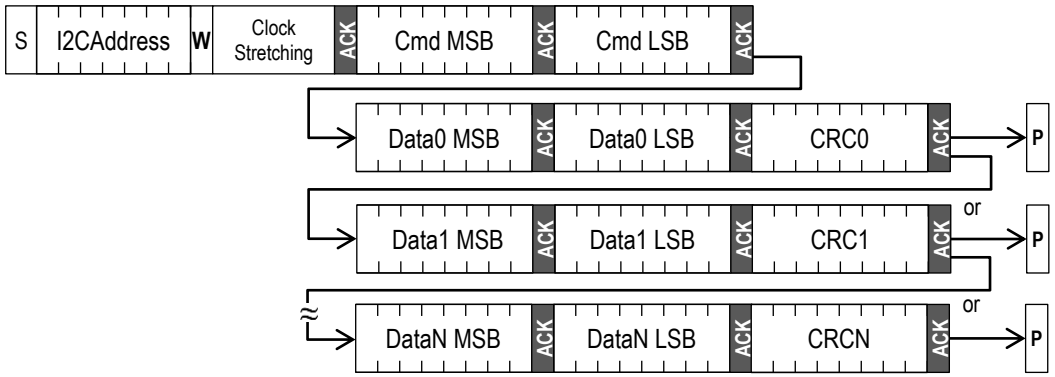

Example: Stop measurements 0x0104

**START** 0xC2 0x01 0x04 **STOP**
(Red: Write Header; Blue: Read Header; Black: Data; Green: CRC; Start Condition: **START;** Stop Condition: **STOP)**

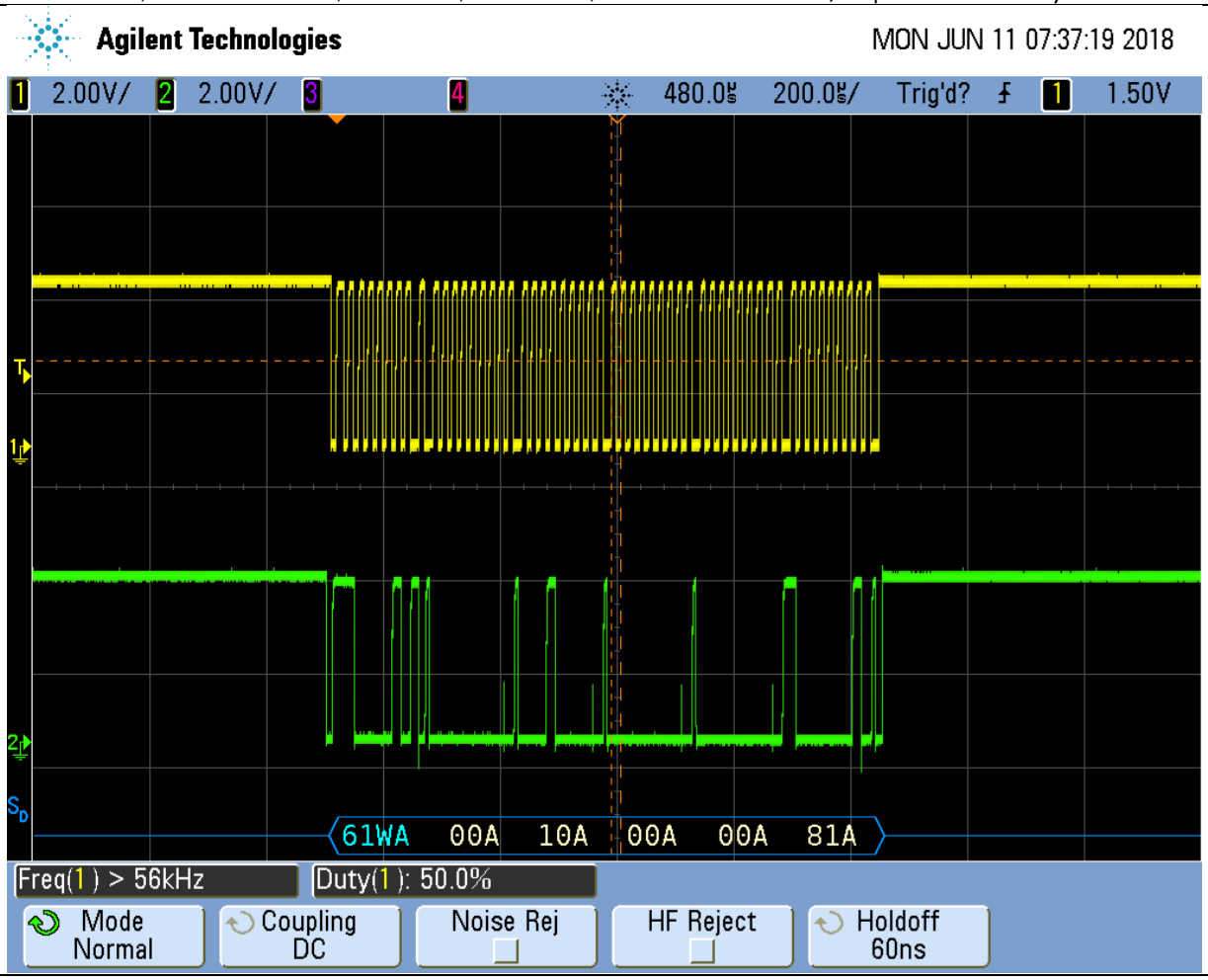



[1] http://www.nxp.com/documents/user_manual/UM10204.pdf

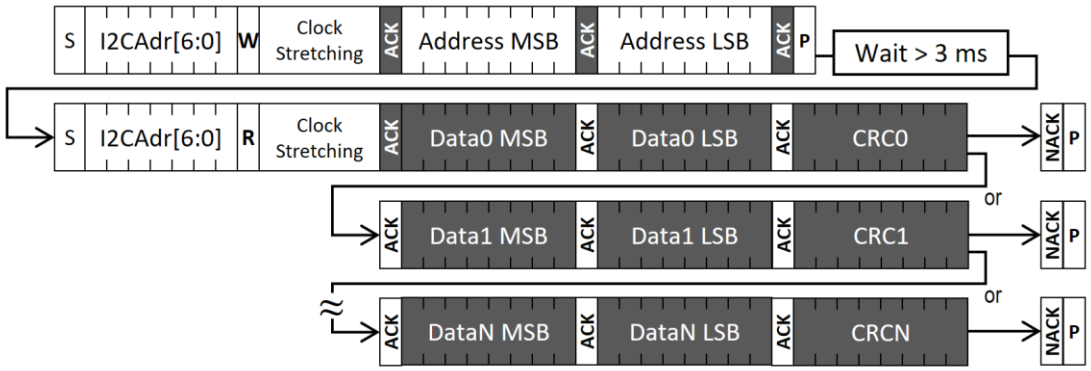
**I2C write 16bit command with arguments**



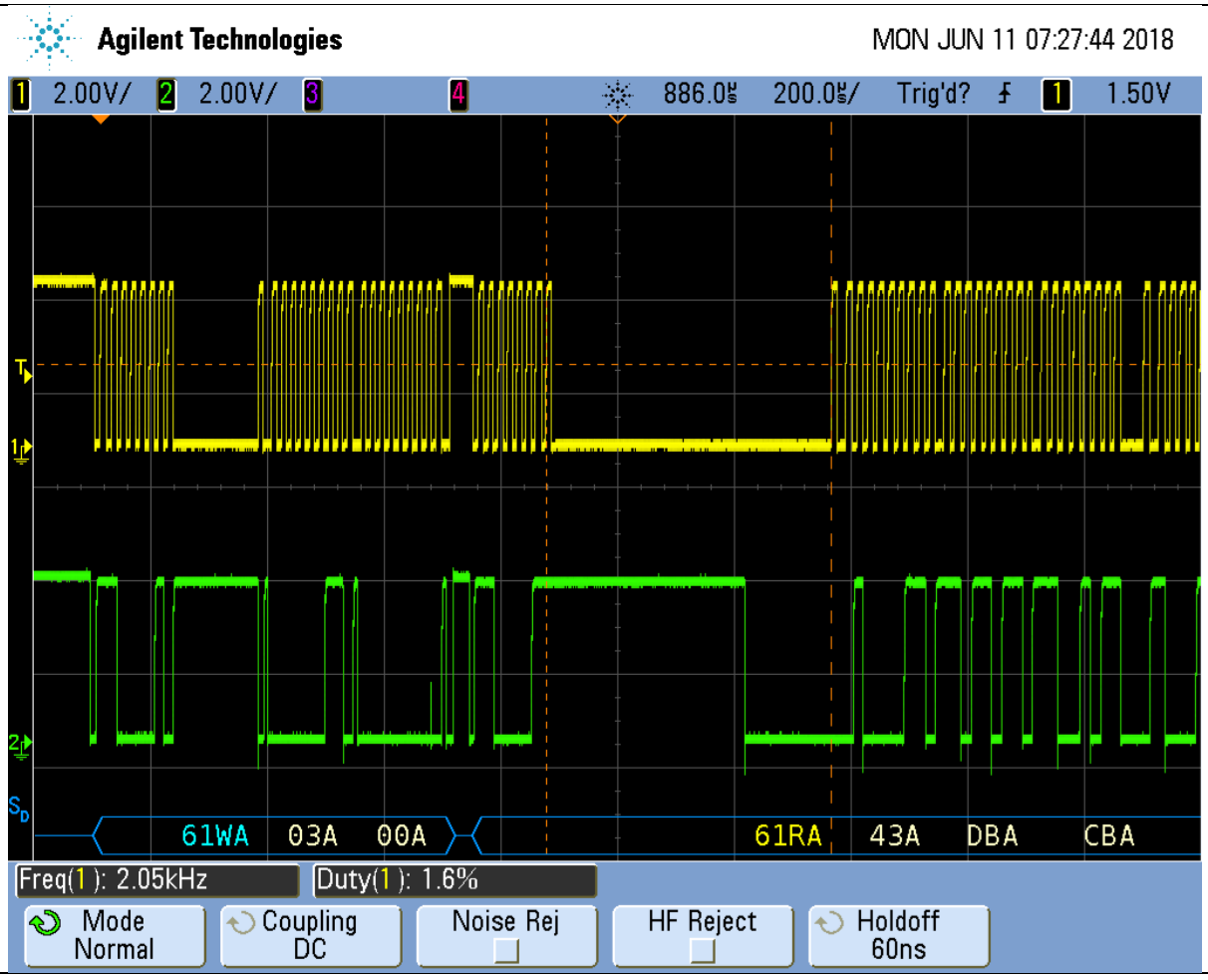

Example: Trigger continuous measurement (Pressure = 0mBar)
**START** 0xC2 0x00 0x10 0x00 0x00 0x81 **STOP**
(Red: Write Header; Blue: Read Header; Black: Data; Green: CRC; Start Condition: **START;** Stop Condition: **STOP)**



**I2C read multiple 16bit words**




Example: Read Measurement (example with 439 PPM, 48.8% RH, 27.2 °C)
**START** 0xC2 0x03 0x00 **STOP START** 0xC3 0x43 0xDB 0xCB 0x8C 0x2E 0x8F 0x41 0xD9 0x70 0xE7 0xFF 0xF5 0x42 0x43 0xBF 0x3A 0x1B 0x74 **STOP**
(Red: Write Header; Blue: Read Header; Black: Data; Green: CRC; Start Condition: **START;** Stop Condition: **STOP)**



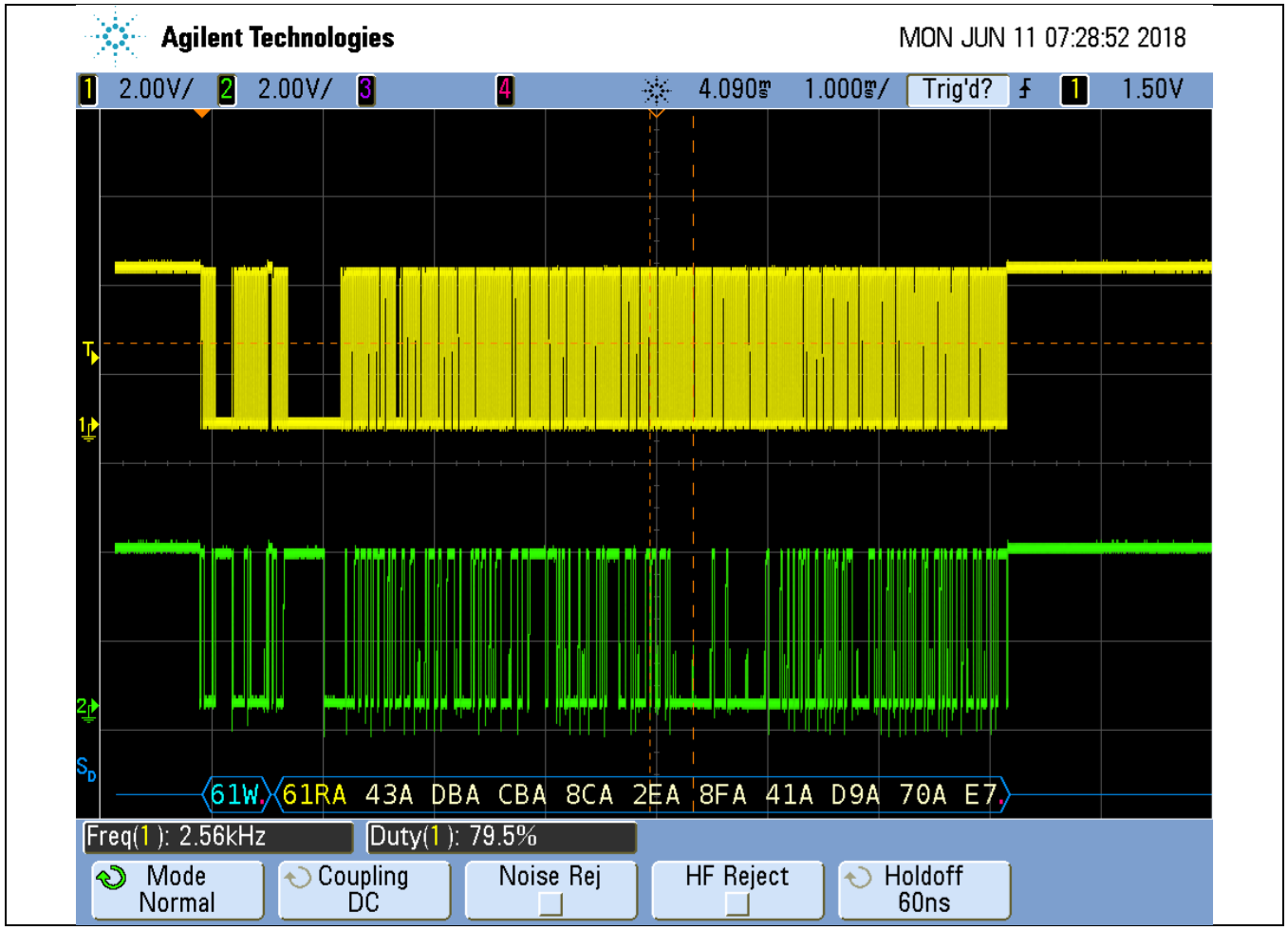



**Table 1** I2C write and read communication frames. SDA is controlled by the I2C master in clear blocks and by the sensor in dark blocks.

### 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 baud rate is 19200 Baud with 8 Data bits, 1 Start bit and 1 Stop bit, no Parity bit.

More details on the Modbus protocol can be found here:

| Description | Link |
|---|---|
| General introduction | http://www.modbus.org/docs/Modbus_over_serial_line_V1_02.pdf |
| Modbus frame generator | http://modbus.rapidscada.net/ |
| Modbus CRC generator | https://www.lammertbies.nl/comm/info/crc-calculation.html |

### 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 PWM output

The SCD30 features the possibility to read out the $CO_2$ concentration via the PWM protocol. During operation, the SCD30 must be connected via the VDD-pin (supply voltage), the GND-pin (ground) and the PWM-pin. Please refer to the data sheet for pin assignment.

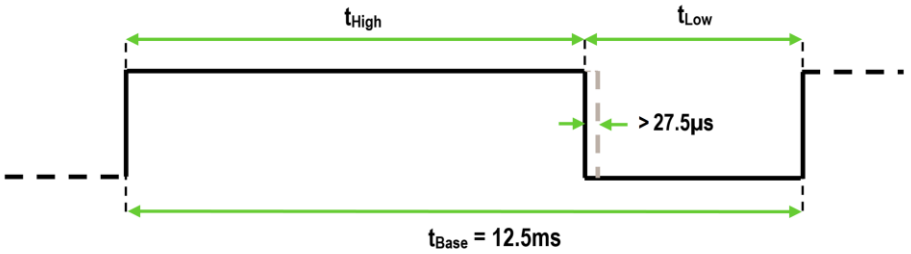
### 1.3.1 Sensor configuration and measurement start

The SCD30 must be configured via the I2C or the Modbus protocol according to this interface description. This can either be done by the host system or alternatively in the assembly line with temporary connector pins. Sensor output is only provided after sending the start measurement command to the SCD30.

### 1.3.2 Technical specification PWM output

Below, the technical specifications of the PWM protocol are provided. The output signal can be converted by either directly measuring the pulse-duration or alternatively by employing a low-pass filter and measuring the output voltage.

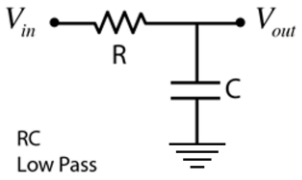
| | |
|---|---|
| Base Frequency | 80 Hz |
| DutyCycle | linear from 0 to 100% (0 ppm to 5000 ppm) |
| Minimal Stepsize of DutyCycle | 11 ppm |
| Output | 3.0V Push/Pull Driver |
| Signal Conversion | $CO_2$ concentration [ppm] = $^{t_{high}}/_{t_{base}} * 5'000$ |



### 1.3.3 Low pass filter parametrization

Typically, the PWM signal is converted to a voltage signal via a low pass filter. Upon conversion of the PWM signal to a voltage signal the CO2 concentration is defined as follows: $CO_2$ concentration [ppm] = $^{V_{measure}}/_{3} * 5'000$.

Since there's an inherent trade-off between settling time, the ripple and the current consumption, the ideal parameterization of the low pass filter differs depending on the application. Nevertheless, an example parameter set for a first order low-pass is provided below:




**R = 470 kOhm**
**C = 220nF**

Cut Off Frequenz: 1.53 Hz
Ripple Voltage (Peak to Peak): 90mV (3%)
Maximal Settling Time: 0.23 s

## 1.4 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
- Read firmware version
- Soft reset

### 1.4.1 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 1.4.3, 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 settings of altitude compensation. Setting the argument to zero will deactivate the ambient pressure compensation (default ambient pressure = 1013.25 mBar). 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:<br>0 & [700 … 1400]. 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 |

Full sequence examples:

| Protocol | Data to write / read | Description |
|---|---|---|
| I2C | <table><tr><td>Start</td><td>Write Header</td><td>Cmd MSB</td><td>CMS LSB</td><td>Pressure MSB</td><td>Pressure LSB</td><td>CRC</td><td>Stop</td></tr><tr><td>Start</td><td>0xC2</td><td>0x00</td><td>0x10</td><td>0x00</td><td>0x00</td><td>0x81</td><td>Stop</td></tr></table> | Start continuous measurement without ambient pressure compensation |
| Modbus | Request:<br><table><tr><td>Slave Address</td><td>Function Code</td><td>Address MSB</td><td>Address LSB</td><td>Content MSB</td><td>Content LSB</td><td>CRC LSB</td><td>CRC MSB</td></tr><tr><td>0x61</td><td>0x06</td><td>0x00</td><td>0x36</td><td>0x00</td><td>0x00</td><td>0x60</td><td>0x64</td></tr></table> Response:<br><table><tr><td>Slave Address</td><td>Function Code</td><td>Address MSB</td><td>Address LSB</td><td>Content MSB</td><td>Content LSB</td><td>CRC LSB</td><td>CRC MSB</td></tr><tr><td>0x61</td><td>0x06</td><td>0x00</td><td>0x36</td><td>0x00</td><td>0x00</td><td>0x60</td><td>0x64</td></tr></table> | |

### 1.4.2 Stop continuous measurement

Stops the continuous measurement of the SCD30.

| Protocol | Command (hex) | Description |
|---|---|---|
| I2C | 0x0104, no argument | Stops continuous measurement. |

| Protocol | Function Code | Address | Data to write |
|---|---|---|---|
| Modbus | 6 | 0x0037 | 0x0001 |

Full sequence examples:

| Protocol | Data to write | Description |
|---|---|---|
| I2C | <table><tr><td>Start</td><td>Write Header</td><td>Cmd MSB</td><td>Cmd LSB</td><td>Stop</td></tr><tr><td>Start</td><td>0xC2</td><td>0x01</td><td>0x04</td><td>Stop</td></tr></table> | Stops continuous measurement. |
| Modbus | Request:<br><table><tr><td>Slave Address</td><td>Function Code</td><td>Address MSB</td><td>Address LSB</td><td>Content MSB</td><td>Content LSB</td><td>CRC LSB</td><td>CRC MSB</td></tr><tr><td>0x61</td><td>0x06</td><td>0x00</td><td>0x37</td><td>0x00</td><td>0x01</td><td>0xF0</td><td>0x64</td></tr></table><br>Response:<br><table><tr><td>Slave Address</td><td>Function Code</td><td>Address MSB</td><td>Address LSB</td><td>Content MSB</td><td>Content LSB</td><td>CRC LSB</td><td>CRC MSB</td></tr><tr><td>0x61</td><td>0x06</td><td>0x00</td><td>0x37</td><td>0x00</td><td>0x01</td><td>0xF0</td><td>0x64</td></tr></table> | |

### 1.4.3 Set measurement interval

Sets the interval used by the SCD30 sensor to measure in continuous measurement mode (see chapter 1.4.1). 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<br>Interval in seconds.<br>Available range:<br>[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* |

Full sequence examples:

| Protocol | Data to write | Description |
|---|---|---|
| I2C | Set measurement interval<br><table><tr><td>Start</td><td>Write Header</td><td>Cmd MSB</td><td>Cmd LSB</td><td>Interval MSB</td><td>Interval LSB</td><td>CRC</td><td>Stop</td></tr><tr><td>Start</td><td>0xC2</td><td>0x46</td><td>0x00</td><td>0x00</td><td>0x02</td><td>0xE3</td><td>Stop</td></tr></table><br>Get measurement interval<br>Write:<br><table><tr><td>Start</td><td>Write Header</td><td>Cmd MSB</td><td>Cmd LSB</td><td>Stop</td></tr><tr><td>Start</td><td>0xC2</td><td>0x46</td><td>0x00</td><td>Stop</td></tr></table><br>Read:<br><table><tr><td>Start</td><td>Read Header</td><td>Interval MSB</td><td>Interval LSB</td><td>CRC</td><td>Stop</td></tr><tr><td>Start</td><td>0xC3</td><td>0x00</td><td>0x02</td><td>0xE3</td><td>Stop</td></tr></table> | Set measurement interval to 2s |

Modbus

Set measurement interval
Request:

| Slave Address | Function Code | Address MSB | Address LSB | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x06 | 0x00 | 0x25 | 0x00 | 0x02 | 0x10 | 0x60 |

Response:

| Slave Address | Function Code | Address MSB | Address LSB | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x06 | 0x00 | 0x25 | 0x00 | 0x02 | 0x10 | 0x60 |

Get measurement interval
Request

| Slave Address | Function Code | Address MSB | Address LSB | No. of registers MSB | No. of registers LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x03 | 0x00 | 0x25 | 0x00 | 0x01 | 0x9C | 0x61 |

Response:

| Slave Address | Function Code | No. of Bytes | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|
| 0x61 | 0x03 | 0x02 | 0x00 | 0x02 | 0xB9 | 0x8D |

### 1.4.4 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. Note that the read header should be send with a delay of > 3ms following the write sequence.

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

| Protocol | Address (hex) | Description |
|---|---|---|
| I2C | 0x0202, no argument needed | Data ready status. Status equals "1" when a measurement is available to be read from the sensor. |

| Protocol | Function Code | Address |
|---|---|---|
| Modbus | 3 | 0x0027 |

Full sequence examples:

| Protocol | Data to write/Read | Description |
|---|---|---|
| I2C | Write:<br>Start \| Write Header \| Cmd MSB \| Cmd LSB \| Stop<br>Start \| 0xC2 \| 0x02 \| 0x02 \| Stop<br>Read:<br>Start \| Read Header \| Data Ready MSB \| Data Ready LSB \| CRC \| Stop<br>Start \| 0xC3 \| 0x00 \| 0x01 \| 0xB0 \| Stop | Reading Data Ready status (returning 1) |
| Modbus | Request<br>Slave Address \| Function Code \| Address MSB \| Address LSB \| No. of registers MSB \| No. of registers LSB \| CRC LSB \| CRC MSB<br>0x61 \| 0x03 \| 0x00 \| 0x27 \| 0x00 \| 0x01 \| 0x3D \| 0xA1<br>Response:<br>Slave Address \| Function Code \| No. of Bytes \| Content MSB \| Content LSB \| CRC LSB \| CRC MSB<br>0x61 \| 0x03 \| 0x02 \| 0x00 \| 0x01 \| 0xF9 \| 0x8C | |

I2C: SDA is controlled by the I2C master in clear blocks and by the sensor in dark blocks.

### 1.4.5 Read measurement

When new measurement data is available it can be read out with the following command. Note that the read header should be send with a delay of > 3ms following the write sequence. Make sure that the measurement is completed by reading the data ready status bit before read out.

| Protocol | Address (hex) | Description |
|---|---|---|
| I2C | 0x0300, no argument needed | Reads a single measurement of $CO_2$ concentration. |

| Protocol | Function Code | Address |
|---|---|---|
| Modbus | 3 | 0x0028 - 0x002D |

Full sequence examples:

**I2C**

Write:

| Start | Write Header | Cmd MSB | Cmd LSB | Stop |
|---|---|---|---|---|
| Start | 0xC2 | 0x03 | 0x00 | Stop |

Read:

| Start | Read Header | CO2 MMSB | CO2 MLSB | CRC | CO2 LMSB | CO2 LLSB | CRC |
|---|---|---|---|---|---|---|---|
| Start | 0xC3 | 0x43 | 0xDB | 0xCB | 0x8C | 0x2E | 0x8F |

| T MMSB | T MLSB | CRC | T LMSB | T LLSB | CRC |
|---|---|---|---|---|---|
| 0x41 | 0xD9 | 0x70 | 0xE7 | 0xFF | 0xF5 |

| RH MMSB | RH MLSB | CRC | RH LMSB | RH LLSB | CRC | Stop |
|---|---|---|---|---|---|---|
| 0x42 | 0x43 | 0xBF | 0x3A | 0x1B | 0x74 | Stop |

**Modbus**

Request

| Slave Address | Function Code | Address MSB | Address LSB | No. of registers MSB | No. of registers LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x03 | 0x00 | 0x28 | 0x00 | 0x06 | 0x4C | 0x60 |

Response:

| Slave Address | Function Code | No. of Bytes | CO2 MMSB | CO2 MLSB | CO2 LMSB | CO2 LLSB |
|---|---|---|---|---|---|---|
| 0x61 | 0x03 | 0x0C | 0x43 | 0xDB | 0x8C | 0x2E |

| T MMSB | T MLSB | T LMSB | T LLSB | RH MMSB | RH MLSB | RH LMSB | RH LLSB |
|---|---|---|---|---|---|---|---|
| 0x41 | 0xD9 | 0xE7 | 0xFF | 0x42 | 0x43 | 0x3A | 0x1B |

| CRC LSB | CRC MSB |
|---|---|
| 0x50 | 0x07 |

Example with sensor returning:
$CO_2$ Concentration = 439 PPM
Humidity = 48.8 %
Temperature = 27.2 °C

SDA is controlled by the I2C master in clear blocks and by the sensor in dark blocks.

**I2C read-out stream:**

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

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<br>Byte2: $CO_2$ concentration MLSB<br>Byte3: CRC<br>Byte4: $CO_2$ concentration LMSB<br>Byte5: $CO_2$ concentration LLSB<br>Byte6: CRC<br>Byte7: Temperature MMSB<br>Byte8: Temperature MLSB<br>Byte9: CRC<br>Byte10: Temperature LMSB<br>Byte11: Temperature LLSB<br>Byte12: CRC<br>Byte13: Humidity MMSB<br>Byte14: Humidity MLSB<br>Byte15: CRC<br>Byte16: Humidity LMSB<br>Byte17: Humidity LLSB<br>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 read-out stream:**

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

Table 3: Modbus data read-out table.

| Preceding Command | Consecutive read | Description |
|---|---|---|
| Read measurement | Word0: $CO_2$ MSW<br>Word1: $CO_2$ LSW<br>Word2: Temperature MSW<br>Word3: Temperature LSW<br>Word4: Humidity MSW<br>Word5: Humidity LSW | Data read-out table for Modbus communication. Measurement of $CO_2$ concentration, humidity and temperature has to be finished before read-out. |

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

### 1.4.6 (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 0) 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<br>"1": Activate continuous ASC<br>"0": Deactivate continuous ASC | See notes above, feature is switched off by default. |

| Protocol | Function Code | Address | Data to write |
|---|---|---|---|
| Modbus | 6 | 0x003A | *Argument* |

Full sequence examples:

| Protocol | Data to write | Description |
|---|---|---|
| I2C | Deactivate Automatic Self-Calibration | Example: deactivate ASC |

| Start | Write Header | Cmd MSB | Cmd LSB | ASC MSB | ASC LSB | CRC | Stop |
|---|---|---|---|---|---|---|---|
| Start | 0xC2 | 0x53 | 0x06 | 0x00 | 0x00 | 0x81 | Stop |

Get Automatic Self-Calibration Status
Write:

| Start | Write Header | Cmd MSB | Cmd LSB | Stop |
|---|---|---|---|---|
| Start | 0xC2 | 0x53 | 0x06 | Stop |

Read:

| Start | Read Header | ASC MSB | ASC LSB | CRC | Stop |
|---|---|---|---|---|---|
| Start | 0xC3 | 0x00 | 0x00 | 0x81 | Stop |

Modbus

Deactivate Automatic Self-Calibration
Request:

| Slave Address | Function Code | Address MSB | Address LSB | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x06 | 0x00 | 0x3A | 0x00 | 0x00 | 0xA0 | 0x67 |

Response:

| Slave Address | Function Code | Address MSB | Address LSB | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x06 | 0x00 | 0x3A | 0x00 | 0x00 | 0xA0 | 0x67 |

Get Automatic Self-Calibration
Request

| Slave Address | Function Code | Address MSB | Address LSB | No. of registers MSB | No. of registers LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x03 | 0x00 | 0x3A | 0x00 | 0x01 | 0xAD | 0xA7 |

Response:

| Slave Address | Function Code | No. of Bytes | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|
| 0x61 | 0x03 | 0x02 | 0x00 | 0x00 | 0x38 | 0x4C |

**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 FRC command and sending the reference value. Setting a reference $CO_2$ concentration by the method described here will always supersede corrections from the ASC (see chapter 1.4.6) and vice-versa. The reference $CO_2$ concentration has to be within the range 400 ppm ≤ $c_{ref}(CO_2)$ ≤ 2000 ppm.

The FRC method imposes a permanent update of the $CO_2$ calibration curve which persists after repowering the sensor. The most recently used reference value is retained in volatile memory and can be read out with the command sequence given below. After repowering the sensor, the command will return the standard reference value of 400 ppm.

| Protocol | Command (hex) | Argument | Description |
|---|---|---|---|
| I2C | 0x5204 *argument* | Format: uint16<br>$CO_2$ concentration in ppm | See notes above. |

| Protocol | Function Code | Address | Data to write |
|---|---|---|---|
| Modbus | 6 | 0x0039 | *Argument* |

Full sequence examples:

**I2C**

Set Forced Recalibration value

| Start | Write Header | Cmd MSB | Cmd LSB | FRC MSB | FRC LSB | CRC | Stop |
|---|---|---|---|---|---|---|---|
| Start | 0xC2 | 0x52 | 0x04 | 0x01 | 0xC2 | 0x50 | Stop |

Get Forced Recalibration value

Write:

| Start | Write Header | Cmd MSB | Cmd LSB | Stop |
|---|---|---|---|---|
| Start | 0xC2 | 0x52 | 0x04 | Stop |

Read:

| Start | Read Header | FRC MSB | FRC LSB | CRC | Stop |
|---|---|---|---|---|---|
| Start | 0xC3 | 0x01 | 0xC2 | 0x50 | Stop |

**Modbus**

Set Forced Recalibration value

Request:

| Slave Address | Function Code | Address MSB | Address LSB | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x06 | 0x00 | 0x39 | 0x01 | 0xC2 | 0xD0 | 0x66 |

Response:

| Slave Address | Function Code | Address MSB | Address LSB | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x06 | 0x00 | 0x39 | 0x01 | 0xC2 | 0xD0 | 0x66 |

Get Forced Recalibration value

Request:

| Slave Address | Function Code | Address MSB | Address LSB | No. of registers MSB | No. of registers LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x03 | 0x00 | 0x39 | 0x00 | 0x01 | 0x5D | 0xA7 |

Response:

| Slave Address | Function Code | No. of Bytes | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|
| 0x61 | 0x03 | 0x02 | 0x01 | 0xC2 | 0xB8 | 0x4D |

Example: Set FRC with argument 450 ppm

### 1.4.7 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 | 0x003B | *argument* |

Full sequence examples:

**I2C**

| Set Temperature Offset Start | Write Header | Cmd MSB | Cmd LSB | SHT Offset MSB | SHT Offset LSB | CRC | Stop |
|---|---|---|---|---|---|---|---|
| Start | 0xC2 | 0x54 | 0x03 | 0x01 | 0xF4 | 0x33 | Stop |

Get Temperature Offset
Write:

| Start | Write Header | Cmd MSB | Cmd LSB | Stop |
|---|---|---|---|---|
| Start | 0xC2 | 0x54 | 0x03 | Stop |

Read:

| Start | Read Header | SHT Offset MSB | SHT Offset LSB | CRC | Stop |
|---|---|---|---|---|---|
| Start | 0xC3 | 0x01 | 0xF4 | 0x33 | Stop |

**Modbus**

Set Temperature Offset
Request:

| Slave Address | Function Code | Address MSB | Address LSB | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x06 | 0x00 | 0x3B | 0x01 | 0xF4 | 0xF1 | 0xB0 |

Response:

| Slave Address | Function Code | Address MSB | Address LSB | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x06 | 0x00 | 0x3B | 0x01 | 0xF4 | 0xF1 | 0xB0 |

Get Temperature Offset
Request:

| Slave Address | Function Code | Address MSB | Address LSB | No. of registers MSB | No. of registers LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|---|
| 0x61 | 0x03 | 0x00 | 0x3B | 0x00 | 0x01 | 0xFC | 0x67 |

Response:

| Slave Address | Function Code | No. of Bytes | Content MSB | Content LSB | CRC LSB | CRC MSB |
|---|---|---|---|---|---|---|
| 0x61 | 0x03 | 0x02 | 0x01 | 0xF4 | 0x38 | 0x5B |

Example: Set temperature offset to 5 K

### 1.4.8 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 section 1.4.1.

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<br>Height over sea level in [m] above 0. | See notes above. |

| Protocol | Function Code | Address | Data to write |
|---|---|---|---|
| Modbus | 6 | 0x0038 | *argument* |

Full sequence examples:

| Protocol | Data to write | Description |
|---|---|---|
| I2C | Set altitude:<br>Start \| Write Header \| Cmd MSB \| Cmd LSB \| Altitude MSB \| Altitude LSB \| CRC \| Stop<br>Start \| 0xC2 \| 0x51 \| 0x02 \| 0x03 \| 0xE8 \| 0xD4 \| Stop<br><br>Get altitude:<br>Write:<br>Start \| Write Header \| Cmd MSB \| Cmd LSB \| Stop<br>Start \| 0xC2 \| 0x51 \| 0x02 \| Stop<br><br>Read:<br>Start \| Read Header \| Altitude MSB \| Altitude LSB \| CRC \| Stop<br>Start \| 0xC3 \| 0x03 \| 0xE8 \| 0xD4 \| Stop | Set altitude to 1000m above sea level |
| Modbus | Set altitude:<br>Request:<br>Slave Address \| Function Code \| Address MSB \| Address LSB \| Content MSB \| Content LSB \| CRC LSB \| CRC MSB<br>0x61 \| 0x06 \| 0x00 \| 0x38 \| 0x03 \| 0xE8 \| 0x01 \| 0x19<br><br>Response:<br>Slave Address \| Function Code \| Address MSB \| Address LSB \| Content MSB \| Content LSB \| CRC LSB \| CRC MSB<br>0x61 \| 0x06 \| 0x00 \| 0x38 \| 0x03 \| 0xE8 \| 0x01 \| 0x19<br><br>Get altitude:<br>Request:<br>Slave Address \| Function Code \| Address MSB \| Address LSB \| No. of registers MSB \| No. of registers LSB \| CRC LSB \| CRC MSB<br>0x61 \| 0x03 \| 0x00 \| 0x38 \| 0x00 \| 0x01 \| 0x0C \| 0x67<br><br>Response:<br>Slave Address \| Function Code \| No. of Bytes \| Content MSB \| Content LSB \| CRC LSB \| CRC MSB<br>0x61 \| 0x03 \| 0x02 \| 0x03 \| 0xE8 \| 0x38 \| 0xF2 | |

### 1.4.9 Read firmware version

Following command can be used to read out the firmware version of SCD30 module

| Protocol | Address (hex) | Description |
|---|---|---|
| I2C | `0xD100`, no argument needed | Returns the firmware version |

| Protocol | Function Code | Address |
|---|---|---|
| Modbus | 3 | 0x0020 |

Full sequence examples:

| Protocol | Data to write/Read | Description |
|---|---|---|
| I2C | Write:<br>Start \| Write Header \| Cmd MSB \| Cmd LSB \| Stop<br>Start \| 0xC2 \| 0xD1 \| 0x00 \| Stop<br><br>Read:<br>Start \| Read Header \| Firmware version major \| Firmware version minor \| CRC \| Stop<br>Start \| 0xC3 \| 0x03 \| 0x42 \| 0xF3 \| Stop | |
| Modbus | Request<br>Slave Address \| Function Code \| Address MSB \| Address LSB \| No. of registers MSB \| No. of registers LSB \| CRC LSB \| CRC MSB<br>0x61 \| 0x03 \| 0x00 \| 0x20 \| 0x00 \| 0x01 \| 0x8C \| 0x60<br><br>Response:<br>Slave Address \| Function Code \| No. of Bytes \| Firmware version major \| Firmware version minor \| CRC LSB \| CRC MSB<br>0x61 \| 0x03 \| 0x02 \| 0x03 \| 0x42 \| 0xB8 \| 0x8D | Firmware version: Major.Minor |

I2C: SDA is controlled by the I2C master in clear blocks and by the sensor in dark blocks.

### 1.4.10 Soft reset

The SCD30 provides a soft reset mechanism that forces the sensor into the same state as after powering up without the need for removing the power-supply. It does so by restarting its system controller. After soft reset the sensor will reload all calibrated data. However, it is worth noting that the sensor reloads calibration data prior to every measurement by default. This includes previously set reference values from ASC or FRC as well as temperature offset values last setting.

The sensor is able to receive the command at any time, regardless of its internal state. In order to start the soft reset procedure the following command should be sent.

| Protocol | Command (hex) | Argument | Description |
|---|---|---|---|
| I2C | 0xD304 | | Restarts the sensor |

| Protocol | Function Code | Address | Data to write |
|---|---|---|---|
| Modbus | 6 | 0x0034 | *0x0001* |

Full sequence examples:

| Protocol | Data to write | Description |
|---|---|---|
| I2C | Start \| Write Header \| Cmd MSB \| Cmd LSB \| Stop<br>Start \| 0xC2 \| 0xD3 \| 0x04 \| Stop | Restarts the sensor |
| Modbus | Request:<br>Slave Address \| Function Code \| Address MSB \| Address LSB \| Content MSB \| Content LSB \| CRC LSB \| CRC MSB<br>0x61 \| 0x06 \| 0x00 \| 0x34 \| 0x00 \| 0x01 \| 0x00 \| 0x64<br>Response:<br>Slave Address \| Function Code \| Address MSB \| Address LSB \| Content MSB \| Content LSB \| CRC LSB \| CRC MSB<br>0x61 \| 0x06 \| 0x00 \| 0x34 \| 0x00 \| 0x01 \| 0x00 \| 0x64 | |

## 1.5 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]

Sample pseudo code for converting data read from the sensor to physical value can be found below.

```
// CO2 concentration
float co2Concentration;
unsigned int tempU32;

// read data is in a buffer. In case of I2C CRCs have been removed
// beforehand. Content of the buffer is the following
unsigned char buffer[4];

buffer[0] = 0x43; //  MMSB CO2
buffer[1] = 0xDB; //  MLSB CO2
buffer[2] = 0x8C; //  LMSB CO2
buffer[3] = 0x2E; //  LLSB CO2

// cast 4 bytes to one unsigned 32 bit integer
tempU32 = (unsigned int)((((unsigned int)buffer[0]) << 24) |
                         (((unsigned int)buffer[1]) << 16) |
                         (((unsigned int)buffer[2]) << 8)  |
                          ((unsigned int)buffer[3]));

// cast unsigned 32 bit integer to 32 bit float
co2Concentration = *(float*)&tempU32; // co2Concentration = 439.09f
```

[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 | Revision | Page (s) | Changes |
|---|---|---|---|
| May 2020 | 1.0 | All | General makeover, correction of typos |

# 2 Important Notices

## 2.1 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.

## 2.2 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.

## 2.3 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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