

Interface Description Sensirion SCD30 Sensor Module

CO₂, humidity, and temperature sensor

- NDIR CO₂ 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 CO₂ sensor: $\pm (30 \text{ ppm} + 3\%)$
- Fully calibrated with digital interface UART or I²C



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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

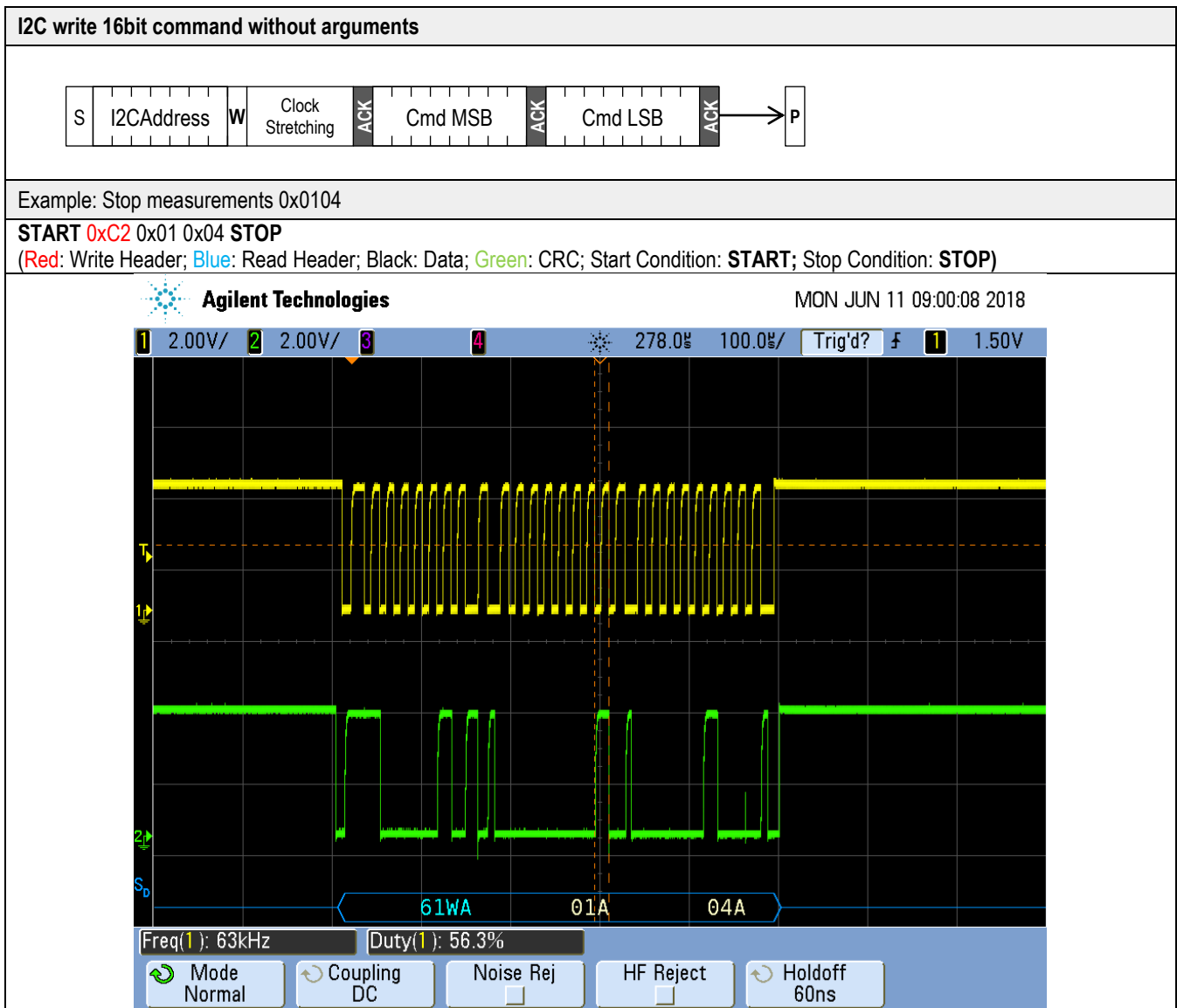
Maximal I2C speed is 100 kHz and the **master has to support clock stretching**. Sensirion recommends to operate the SCD30 at a baud rate of 50 kHz or smaller. Clock stretching period in write- and read-frames is 30 ms, however, due to internal calibration processes a maximal clock stretching of 150 ms may occur once per day. For detailed information to the I2C protocol, refer to NXP I2C-bus specification¹. 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.

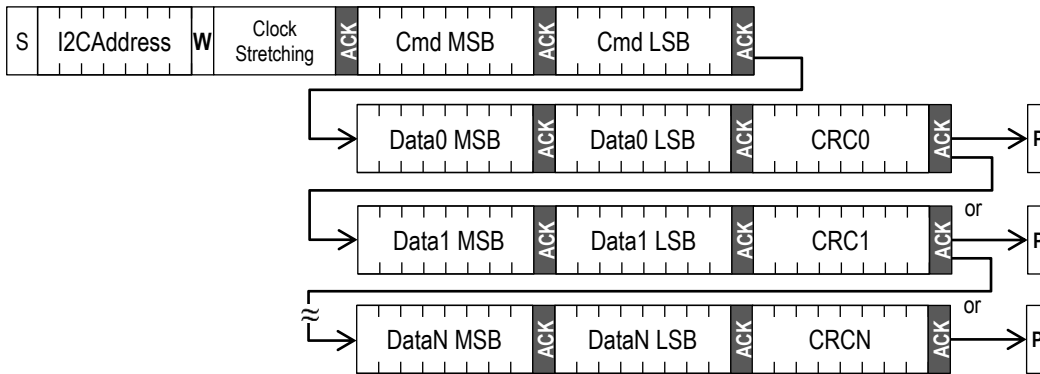
1.1.2 I2C Sequence

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.



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

I2C write 16bit command with arguments



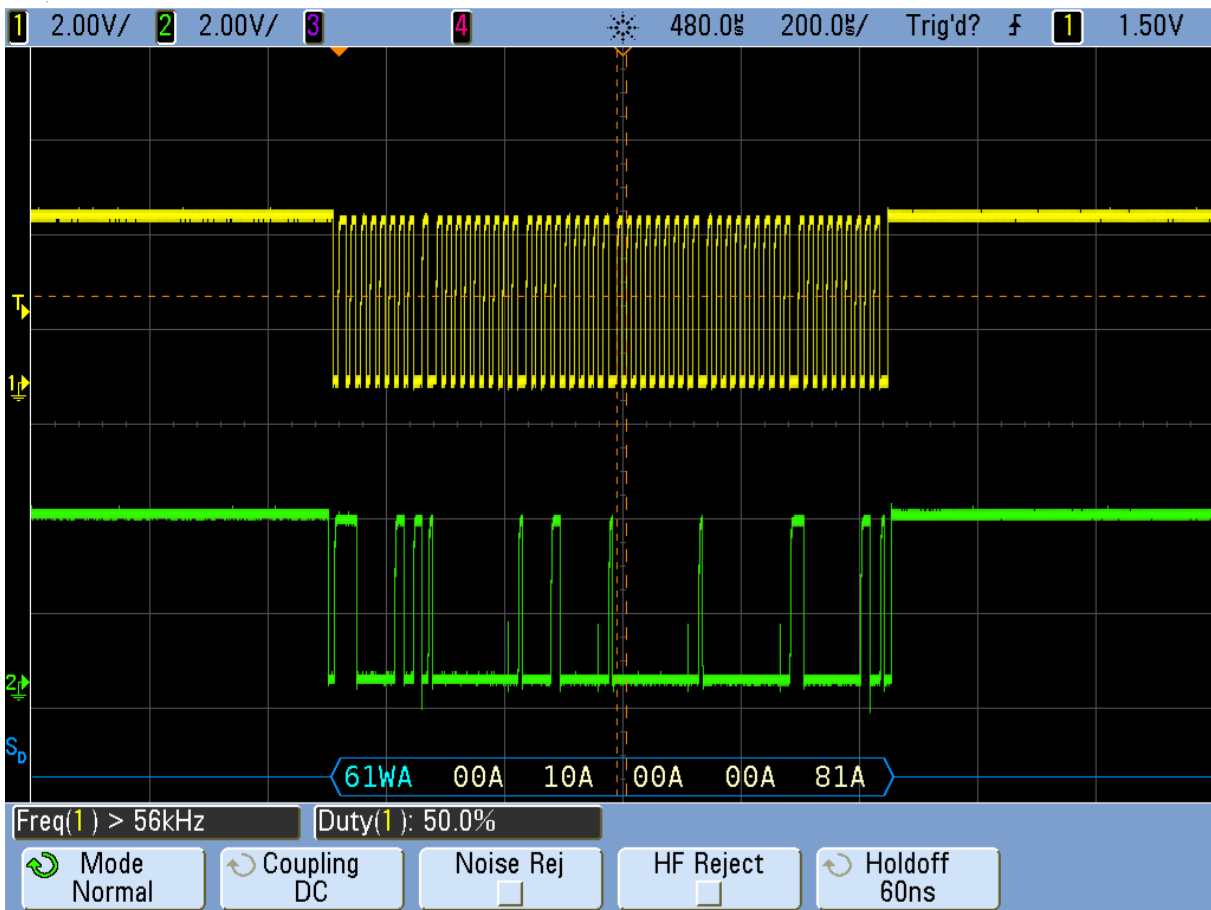
Example: Trigger continuous measurement (Pressure = 0mBar)

START 0xC2 0x00 0x10 0x00 0x00 0x81 **STOP**

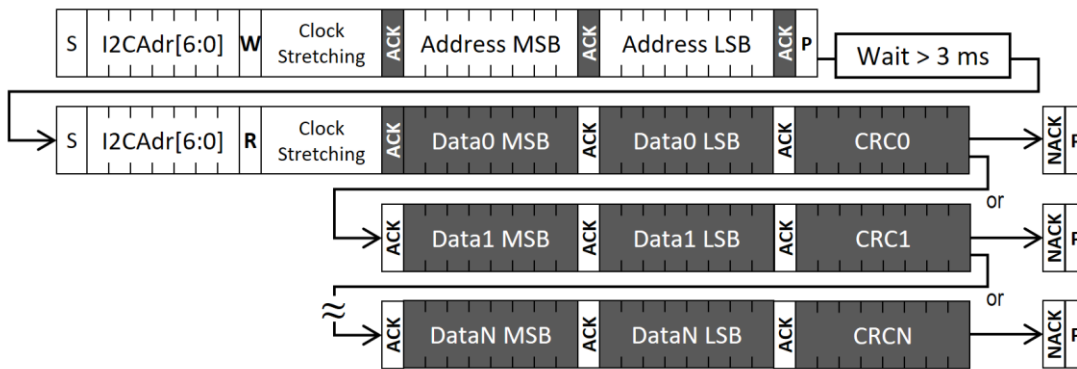
(Red: Write Header; Blue: Read Header; Black: Data; Green: CRC; Start Condition: **START**; Stop Condition: **STOP**)



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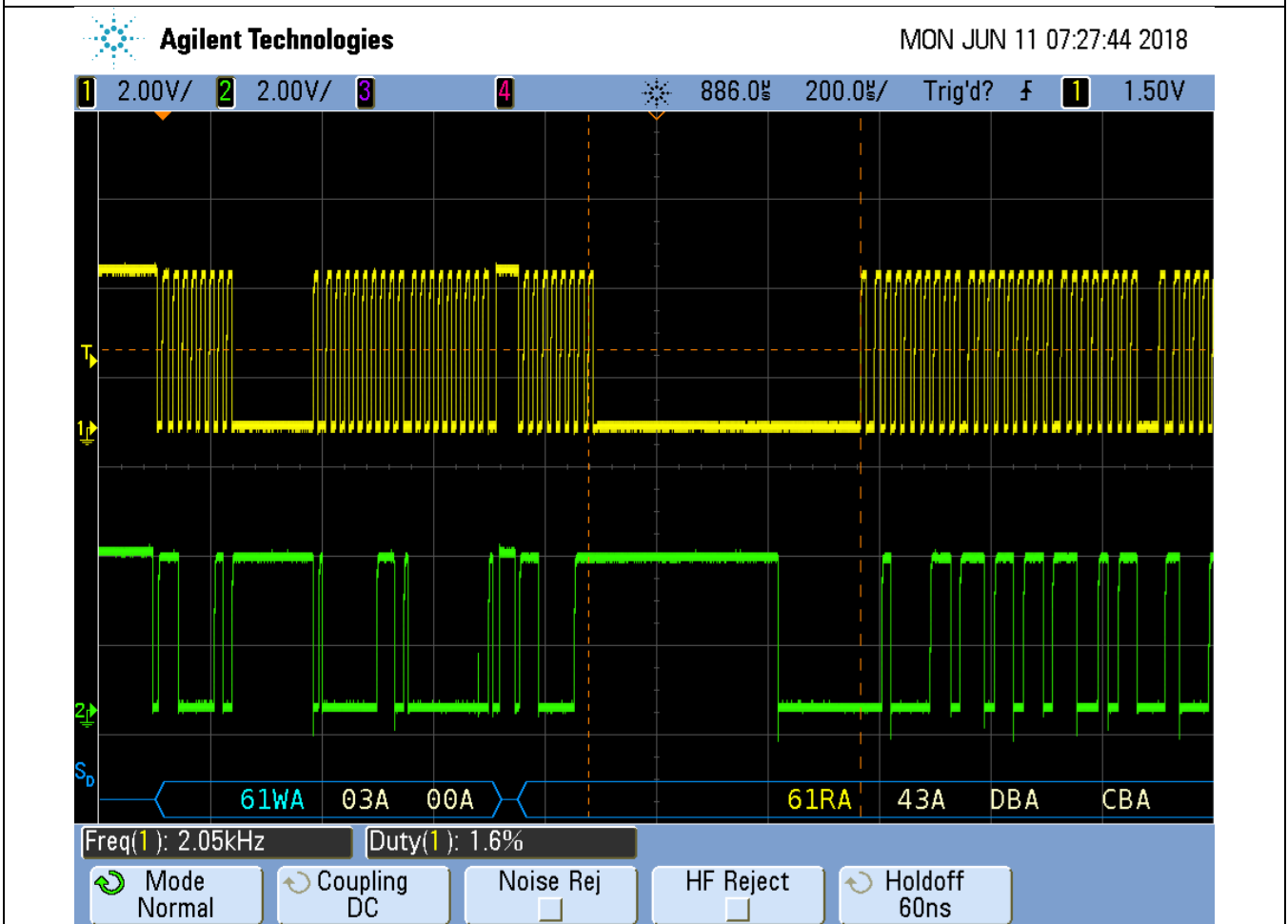
I2C read multiple 16bit words



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; Black: Data; Green: CRC; Start Condition: **START**; Stop Condition: **STOP**)



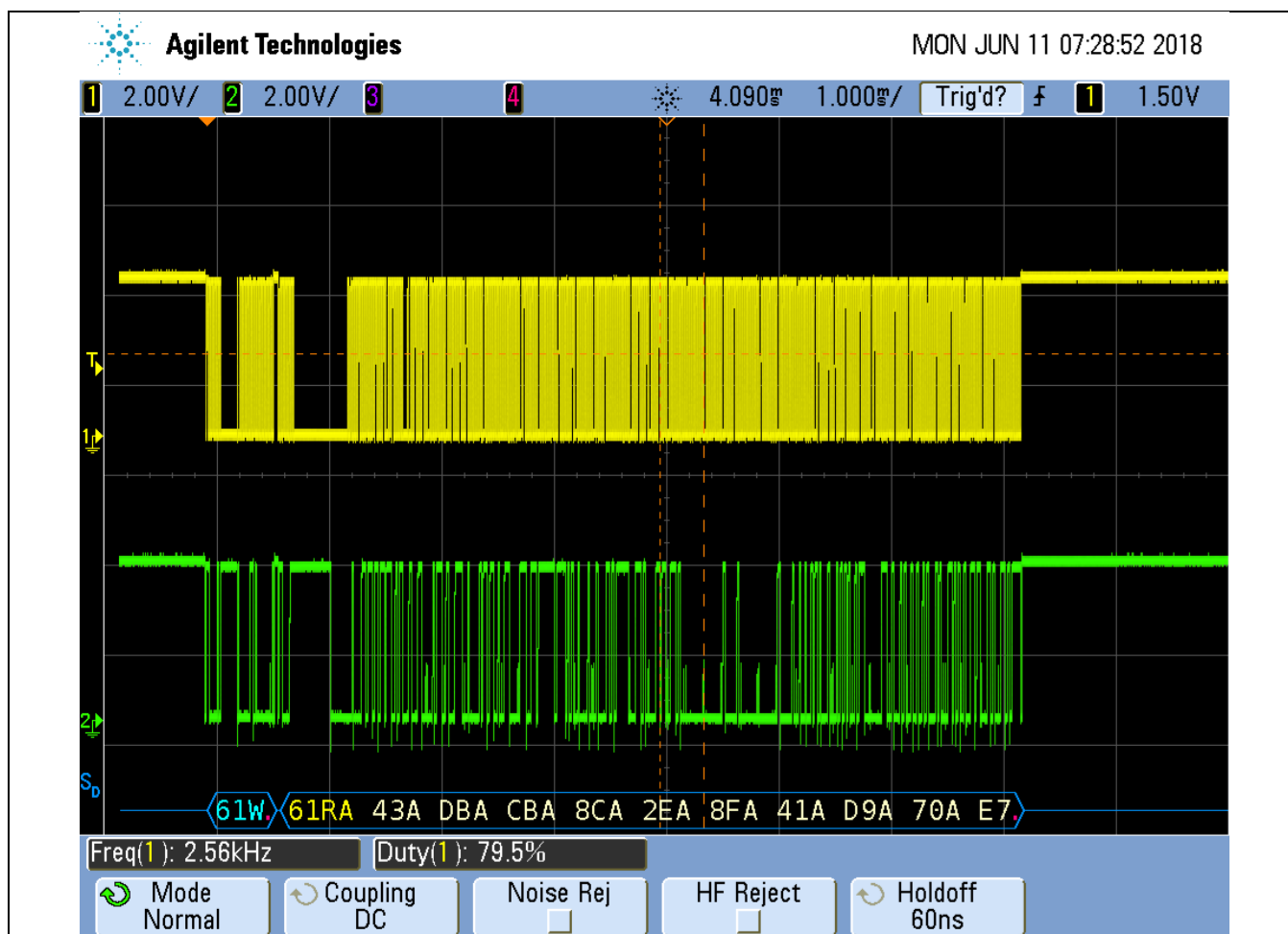


Table 1 I2C write and read communication frames. SDA is controlled by the I2C master in clear blocks and by the sensor in dark blocks.

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 CO₂ 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.

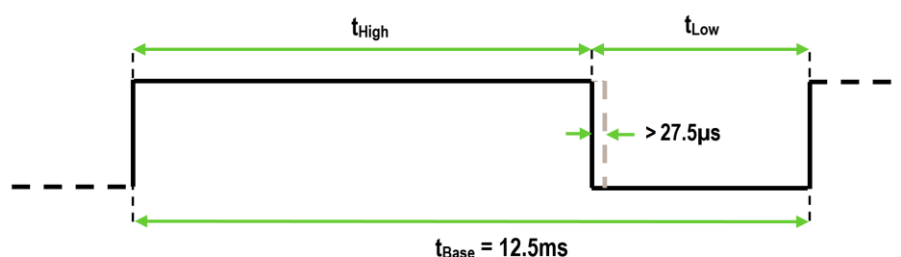
1.3.1 Sensor configuration and measurement start

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.

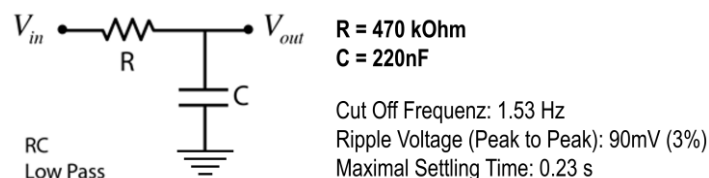
Base Frequency	80 Hz
DutyCycle	linear from 0 to 100% (0 ppm to 5000 ppm)
Minimal Stepsize of DutyCycle	11 ppm
Output	3.0V Push/Pull Driver
Signal Conversion	$\text{CO}_2 \text{ concentration [ppm]} = \frac{t_{high}}{t_{base}} * 5'000$



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: $CO_2 \text{ concentration [ppm]} = \frac{V_{\text{measure}}}{3} * 5'000$.

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:



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 CO₂ 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 CO₂ 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 <i>argument</i>			Format: uint16 Available range: 0 & [700 ... 1400]. Pressure in mBar.	Triggers continuous measurement. Ambient pressure is compensated by setting <i>argument</i> . <i>argument</i> = 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	Start	Write Header	Cmd MSB	CMS LSB	Pressure MSB	Pressure LSB	CRC	Stop	
	Start	0xC2	0x00	0x10	0x00	0x00	0x81	Stop	
Modbus	Request:								Start continuous measurement without ambient pressure compensation
	Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB	
	0x61	0x06	0x00	0x36	0x00	0x00	0x60	0x64	
	Response:								
	Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB	
	0x61	0x06	0x00	0x36	0x00	0x00	0x60	0x64	

1.4.2 Stop continuous measurement

Stops the continuous measurement of the SCD30.

Protocol	Command (hex)			Description
I2C	0x0104, no argument			Stops continuous measurement.
Modbus	6	0x0037	0x0001	

Full sequence examples:

Protocol	Data to write								Description
I2C	Start	Write Header	Cmd MSB	Cmd LSB	Stop				
	Start	0xC2	0x01	0x04	Stop				
Modbus	Request:								
	Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB	
	0x61	0x06	0x00	0x37	0x00	0x01	0xF0	0x64	
	Response:								
Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB		
0x61	0x06	0x00	0x37	0x00	0x01	0xF0	0x64		

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 <i>argument</i>			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.
Modbus	6	0x0025	<i>argument</i>		

Full sequence examples:

Protocol	Data to write								Description
I2C	Set measurement interval								Set measurement interval to 2s
	Start	Write Header	Cmd MSB	Cmd LSB	Interval MSB	Interval LSB	CRC	Stop	
	Start	0xC2	0x46	0x00	0x00	0x02	0xE3	Stop	
	Get measurement interval								
	Write:								
	Start	Write Header	Cmd MSB	Cmd LSB	Stop				
Start	0xC2	0x46	0x00	Stop					
Read:									
Start	Read Header	Interval MSB	Interval LSB	CRC	Stop				
Start	0xC3	0x00	0x02	0xE3	Stop				

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.
Modbus	3	

Full sequence examples:

Protocol	Data to write/Read	Description								
I2C	Write:	Reading Data Ready status (returning 1)								
	Start		Write Header	Cmd MSB	Cmd LSB	Stop				
	Start		0xC2	0x02	0x02	Stop				
	Read:		Start	Read Header	Data Ready MSB	Data Ready LSB	CRC	Stop		
Start	0xC3		0x00	0x01	0xB0	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	0x27	0x00	0x01	0x3D	0xA1	
	Response:		Slave Address	Function Code	No. of Bytes	Content MSB	Content LSB	CRC LSB	CRC MSB	
	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.
Modbus	3	0x0028 - 0x002D	

Full sequence examples:

Protocol	Data to write/read								Description																
I2C	Write:								Example with sensor returning: CO ₂ Concentration = 439 PPM Humidity = 48.8 % Temperature = 27.2 °C																
	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																		
<table border="1"> <thead> <tr> <th>T MMSB</th> <th>T MLSB</th> <th>CRC</th> <th>T LMSB</th> <th>T LLSB</th> <th>CRC</th> <th colspan="2"></th> </tr> </thead> <tbody> <tr> <td>0x41</td> <td>0xD9</td> <td>0x70</td> <td>0xE7</td> <td>0xFF</td> <td>0xF5</td> <td colspan="2"></td> </tr> </tbody> </table>								T MMSB		T MLSB	CRC	T LMSB	T LLSB	CRC			0x41	0xD9	0x70	0xE7	0xFF	0xF5			
T MMSB	T MLSB	CRC	T LMSB	T LLSB	CRC																				
0x41	0xD9	0x70	0xE7	0xFF	0xF5																				
<table border="1"> <thead> <tr> <th>RH MMSB</th> <th>RH MLSB</th> <th>CRC</th> <th>RH LMSB</th> <th>RH LLSB</th> <th>CRC</th> <th>Stop</th> <th></th> </tr> </thead> <tbody> <tr> <td>0x42</td> <td>0x43</td> <td>0xBF</td> <td>0x3A</td> <td>0x1B</td> <td>0x74</td> <td>Stop</td> <td></td> </tr> </tbody> </table>								RH MMSB		RH MLSB	CRC	RH LMSB	RH LLSB	CRC	Stop		0x42	0x43	0xBF	0x3A	0x1B	0x74	Stop		
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																		
<table border="1"> <thead> <tr> <th>T MMSB</th> <th>T MLSB</th> <th>T LMSB</th> <th>T LLSB</th> <th>RH MMSB</th> <th>RH MLSB</th> <th>RH LMSB</th> <th>RH LLSB</th> </tr> </thead> <tbody> <tr> <td>0x41</td> <td>0xD9</td> <td>0xE7</td> <td>0xFF</td> <td>0x42</td> <td>0x43</td> <td>0x3A</td> <td>0x1B</td> </tr> </tbody> </table>								T MMSB	T MLSB	T LMSB	T LLSB	RH MMSB	RH MLSB	RH LMSB	RH LLSB	0x41	0xD9	0xE7	0xFF	0x42	0x43	0x3A	0x1B		
T MMSB	T MLSB	T LMSB	T LLSB	RH MMSB	RH MLSB	RH LMSB	RH LLSB																		
0x41	0xD9	0xE7	0xFF	0x42	0x43	0x3A	0x1B																		
<table border="1"> <thead> <tr> <th>CRC LSB</th> <th>CRC MSB</th> </tr> </thead> <tbody> <tr> <td>0x50</td> <td>0x07</td> </tr> </tbody> </table>								CRC LSB	CRC MSB	0x50	0x07														
CRC LSB	CRC MSB																								
0x50	0x07																								

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 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 CO₂ 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 Word1: CO ₂ LSW Word2: Temperature MSW Word3: Temperature LSW Word4: Humidity MSW 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 CO₂ 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			Format: uint16 "1": Activate continuous ASC "0": Deactivate continuous ASC	See notes above, feature is switched off by default.
Modbus	6	0x003A	Argument		

Full sequence examples:

Protocol	Data to write	Description																
I2C	Deactivate Automatic Self-Calibration <table border="1"> <thead> <tr> <th>Start</th> <th>Write Header</th> <th>Cmd MSB</th> <th>Cmd LSB</th> <th>ASC MSB</th> <th>ASC LSB</th> <th>CRC</th> <th>Stop</th> </tr> </thead> <tbody> <tr> <td>Start</td> <td>0xC2</td> <td>0x53</td> <td>0x06</td> <td>0x00</td> <td>0x00</td> <td>0x81</td> <td>Stop</td> </tr> </tbody> </table>	Start	Write Header	Cmd MSB	Cmd LSB	ASC MSB	ASC LSB	CRC	Stop	Start	0xC2	0x53	0x06	0x00	0x00	0x81	Stop	
	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: <table border="1"> <thead> <tr> <th>Start</th> <th>Write Header</th> <th>Cmd MSB</th> <th>Cmd LSB</th> <th>Stop</th> </tr> </thead> <tbody> <tr> <td>Start</td> <td>0xC2</td> <td>0x53</td> <td>0x06</td> <td>Stop</td> </tr> </tbody> </table>	Start	Write Header	Cmd MSB	Cmd LSB	Stop	Start	0xC2	0x53	0x06	Stop							
Start	Write Header	Cmd MSB	Cmd LSB	Stop														
Start	0xC2	0x53	0x06	Stop														
Read: <table border="1"> <thead> <tr> <th>Start</th> <th>Read Header</th> <th>ASC MSB</th> <th>ASC LSB</th> <th>CRC</th> <th>Stop</th> </tr> </thead> <tbody> <tr> <td>Start</td> <td>0xC3</td> <td>0x00</td> <td>0x00</td> <td>0x81</td> <td>Stop</td> </tr> </tbody> </table>	Start	Read Header	ASC MSB	ASC LSB	CRC	Stop	Start	0xC3	0x00	0x00	0x81	Stop						
Start	Read Header	ASC MSB	ASC LSB	CRC	Stop													
Start	0xC3	0x00	0x00	0x81	Stop													
Modbus	Deactivate Automatic Self-Calibration Request: <table border="1"> <thead> <tr> <th>Slave Address</th> <th>Function Code</th> <th>Address MSB</th> <th>Address LSB</th> <th>Content MSB</th> <th>Content LSB</th> <th>CRC LSB</th> <th>CRC MSB</th> </tr> </thead> <tbody> <tr> <td>0x61</td> <td>0x06</td> <td>0x00</td> <td>0x3A</td> <td>0x00</td> <td>0x00</td> <td>0xA0</td> <td>0x67</td> </tr> </tbody> </table>	Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB	0x61	0x06	0x00	0x3A	0x00	0x00	0xA0	0x67	Example: deactivate ASC
	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: <table border="1"> <thead> <tr> <th>Slave Address</th> <th>Function Code</th> <th>Address MSB</th> <th>Address LSB</th> <th>Content MSB</th> <th>Content LSB</th> <th>CRC LSB</th> <th>CRC MSB</th> </tr> </thead> <tbody> <tr> <td>0x61</td> <td>0x06</td> <td>0x00</td> <td>0x3A</td> <td>0x00</td> <td>0x00</td> <td>0xA0</td> <td>0x67</td> </tr> </tbody> </table>	Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB	0x61	0x06	0x00	0x3A	0x00	0x00	0xA0	0x67	
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 <table border="1"> <thead> <tr> <th>Slave Address</th> <th>Function Code</th> <th>Address MSB</th> <th>Address LSB</th> <th>No. of registers MSB</th> <th>No. of registers LSB</th> <th>CRC LSB</th> <th>CRC MSB</th> </tr> </thead> <tbody> <tr> <td>0x61</td> <td>0x03</td> <td>0x00</td> <td>0x3A</td> <td>0x00</td> <td>0x01</td> <td>0xAD</td> <td>0xA7</td> </tr> </tbody> </table>	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		
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: <table border="1"> <thead> <tr> <th>Slave Address</th> <th>Function Code</th> <th>No. of Bytes</th> <th>Content MSB</th> <th>Content LSB</th> <th>CRC LSB</th> <th>CRC MSB</th> </tr> </thead> <tbody> <tr> <td>0x61</td> <td>0x03</td> <td>0x02</td> <td>0x00</td> <td>0x00</td> <td>0x38</td> <td>0x4C</td> </tr> </tbody> </table>	Slave Address	Function Code	No. of Bytes	Content MSB	Content LSB	CRC LSB	CRC MSB	0x61	0x03	0x02	0x00	0x00	0x38	0x4C				
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 CO₂ 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 CO₂ concentration by the method described here will always supersede corrections from the ASC (see chapter 1.4.6) and vice-versa. The reference CO₂ concentration has to be within the range $400 \text{ ppm} \leq c_{\text{ref}}(\text{CO}_2) \leq 2000 \text{ ppm}$.

The FRC method imposes a permanent update of the CO₂ 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			Format: uint16 CO ₂ concentration in ppm	See notes above.
Modbus	6	0x0039	Argument		

Full sequence examples:

Protocol	Data to write	Description																
I2C	Set Forced Recalibration value <table border="1"> <tr> <td>Start</td> <td>Write Header</td> <td>Cmd MSB</td> <td>Cmd LSB</td> <td>FRC MSB</td> <td>FRC LSB</td> <td>CRC</td> <td>Stop</td> </tr> <tr> <td>Start</td> <td>0xC2</td> <td>0x52</td> <td>0x04</td> <td>0x01</td> <td>0xC2</td> <td>0x50</td> <td>Stop</td> </tr> </table>	Start	Write Header	Cmd MSB	Cmd LSB	FRC MSB	FRC LSB	CRC	Stop	Start	0xC2	0x52	0x04	0x01	0xC2	0x50	Stop	
	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: <table border="1"> <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>0x52</td> <td>0x04</td> <td>Stop</td> </tr> </table>	Start	Write Header	Cmd MSB	Cmd LSB	Stop	Start	0xC2	0x52	0x04	Stop							
Start	Write Header	Cmd MSB	Cmd LSB	Stop														
Start	0xC2	0x52	0x04	Stop														
Read: <table border="1"> <tr> <td>Start</td> <td>Read Header</td> <td>FRC MSB</td> <td>FRC LSB</td> <td>CRC</td> <td>Stop</td> </tr> <tr> <td>Start</td> <td>0xC3</td> <td>0x01</td> <td>0xC2</td> <td>0x50</td> <td>Stop</td> </tr> </table>	Start	Read Header	FRC MSB	FRC LSB	CRC	Stop	Start	0xC3	0x01	0xC2	0x50	Stop						
Start	Read Header	FRC MSB	FRC LSB	CRC	Stop													
Start	0xC3	0x01	0xC2	0x50	Stop													
Modbus	Set Forced Recalibration value Request: <table border="1"> <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>0x39</td> <td>0x01</td> <td>0xC2</td> <td>0xD0</td> <td>0x66</td> </tr> </table>	Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB	0x61	0x06	0x00	0x39	0x01	0xC2	0xD0	0x66	Example: Set FRC with argument 450 ppm
	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: <table border="1"> <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>0x39</td> <td>0x01</td> <td>0xC2</td> <td>0xD0</td> <td>0x66</td> </tr> </table>	Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB	0x61	0x06	0x00	0x39	0x01	0xC2	0xD0	0x66	
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: <table border="1"> <tr> <td>Slave Address</td> <td>Function Code</td> <td>Address MSB</td> <td>Address LSB</td> <td>No. of registers MSB</td> <td>No. of registers LSB</td> <td>CRC LSB</td> <td>CRC MSB</td> </tr> <tr> <td>0x61</td> <td>0x03</td> <td>0x00</td> <td>0x39</td> <td>0x00</td> <td>0x01</td> <td>0x5D</td> <td>0xA7</td> </tr> </table>	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		
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: <table border="1"> <tr> <td>Slave Address</td> <td>Function Code</td> <td>No. of Bytes</td> <td>Content MSB</td> <td>Content LSB</td> <td>CRC LSB</td> <td>CRC MSB</td> </tr> <tr> <td>0x61</td> <td>0x03</td> <td>0x02</td> <td>0x01</td> <td>0xC2</td> <td>0xB8</td> <td>0x4D</td> </tr> </table>	Slave Address	Function Code	No. of Bytes	Content MSB	Content LSB	CRC LSB	CRC MSB	0x61	0x03	0x02	0x01	0xC2	0xB8	0x4D				
Slave Address	Function Code	No. of Bytes	Content MSB	Content LSB	CRC LSB	CRC MSB												
0x61	0x03	0x02	0x01	0xC2	0xB8	0x4D												

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 <i>argument</i>			Format: uint16 Temperature offset, unit [°C x 100], i.e. one tick corresponds to 0.01°C	See notes above.
Modbus	6	0x003B	<i>argument</i>		

Full sequence examples:

Protocol	Data to write								Description
I2C	Set Temperature Offset								Example: Set temperature offset to 5 K
	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								Example: Set temperature offset to 5 K
	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			

1.4.8 Altitude Compensation

Measurements of CO₂ 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 <i>argument</i>	Format: uint16 Height over sea level in [m] above 0.	See notes above.		
Protocol	Function Code			Address	Data to write
Modbus	6			0x0038	<i>argument</i>

Full sequence examples:

Protocol	Data to write	Description																
I2C	Set altitude: <table border="1"> <thead> <tr> <th>Start</th> <th>Write Header</th> <th>Cmd MSB</th> <th>Cmd LSB</th> <th>Altitude MSB</th> <th>Altitude LSB</th> <th>CRC</th> <th>Stop</th> </tr> </thead> <tbody> <tr> <td>Start</td> <td>0xC2</td> <td>0x51</td> <td>0x02</td> <td>0x03</td> <td>0xE8</td> <td>0xD4</td> <td>Stop</td> </tr> </tbody> </table>	Start	Write Header	Cmd MSB	Cmd LSB	Altitude MSB	Altitude LSB	CRC	Stop	Start	0xC2	0x51	0x02	0x03	0xE8	0xD4	Stop	
	Start	Write Header	Cmd MSB	Cmd LSB	Altitude MSB	Altitude LSB	CRC	Stop										
	Start	0xC2	0x51	0x02	0x03	0xE8	0xD4	Stop										
	Get altitude: Write: <table border="1"> <thead> <tr> <th>Start</th> <th>Write Header</th> <th>Cmd MSB</th> <th>Cmd LSB</th> <th>Stop</th> </tr> </thead> <tbody> <tr> <td>Start</td> <td>0xC2</td> <td>0x51</td> <td>0x02</td> <td>Stop</td> </tr> </tbody> </table>	Start	Write Header	Cmd MSB	Cmd LSB	Stop	Start	0xC2	0x51	0x02	Stop							
Start	Write Header	Cmd MSB	Cmd LSB	Stop														
Start	0xC2	0x51	0x02	Stop														
Read: <table border="1"> <thead> <tr> <th>Start</th> <th>Read Header</th> <th>Altitude MSB</th> <th>Altitude LSB</th> <th>CRC</th> <th>Stop</th> </tr> </thead> <tbody> <tr> <td>Start</td> <td>0xC3</td> <td>0x03</td> <td>0xE8</td> <td>0xD4</td> <td>Stop</td> </tr> </tbody> </table>	Start	Read Header	Altitude MSB	Altitude LSB	CRC	Stop	Start	0xC3	0x03	0xE8	0xD4	Stop						
Start	Read Header	Altitude MSB	Altitude LSB	CRC	Stop													
Start	0xC3	0x03	0xE8	0xD4	Stop													
Modbus	Set altitude: Request: <table border="1"> <thead> <tr> <th>Slave Address</th> <th>Function Code</th> <th>Address MSB</th> <th>Address LSB</th> <th>Content MSB</th> <th>Content LSB</th> <th>CRC LSB</th> <th>CRC MSB</th> </tr> </thead> <tbody> <tr> <td>0x61</td> <td>0x06</td> <td>0x00</td> <td>0x38</td> <td>0x03</td> <td>0xE8</td> <td>0x01</td> <td>0x19</td> </tr> </tbody> </table>	Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB	0x61	0x06	0x00	0x38	0x03	0xE8	0x01	0x19	Set altitude to 1000m above sea level
	Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB										
	0x61	0x06	0x00	0x38	0x03	0xE8	0x01	0x19										
	Response: <table border="1"> <thead> <tr> <th>Slave Address</th> <th>Function Code</th> <th>Address MSB</th> <th>Address LSB</th> <th>Content MSB</th> <th>Content LSB</th> <th>CRC LSB</th> <th>CRC MSB</th> </tr> </thead> <tbody> <tr> <td>0x61</td> <td>0x06</td> <td>0x00</td> <td>0x38</td> <td>0x03</td> <td>0xE8</td> <td>0x01</td> <td>0x19</td> </tr> </tbody> </table>	Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB	0x61	0x06	0x00	0x38	0x03	0xE8	0x01	0x19	
Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB											
0x61	0x06	0x00	0x38	0x03	0xE8	0x01	0x19											
Get altitude: Request: <table border="1"> <thead> <tr> <th>Slave Address</th> <th>Function Code</th> <th>Address MSB</th> <th>Address LSB</th> <th>No. of registers MSB</th> <th>No. of registers LSB</th> <th>CRC LSB</th> <th>CRC MSB</th> </tr> </thead> <tbody> <tr> <td>0x61</td> <td>0x03</td> <td>0x00</td> <td>0x38</td> <td>0x00</td> <td>0x01</td> <td>0x0C</td> <td>0x67</td> </tr> </tbody> </table>	Slave Address	Function Code	Address MSB	Address LSB	No. of registers MSB	No. of registers LSB	CRC LSB	CRC MSB	0x61	0x03	0x00	0x38	0x00	0x01	0x0C	0x67		
Slave Address	Function Code	Address MSB	Address LSB	No. of registers MSB	No. of registers LSB	CRC LSB	CRC MSB											
0x61	0x03	0x00	0x38	0x00	0x01	0x0C	0x67											
Response: <table border="1"> <thead> <tr> <th>Slave Address</th> <th>Function Code</th> <th>No. of Bytes</th> <th>Content MSB</th> <th>Content LSB</th> <th>CRC LSB</th> <th>CRC MSB</th> </tr> </thead> <tbody> <tr> <td>0x61</td> <td>0x03</td> <td>0x02</td> <td>0x03</td> <td>0xE8</td> <td>0x38</td> <td>0xF2</td> </tr> </tbody> </table>	Slave Address	Function Code	No. of Bytes	Content MSB	Content LSB	CRC LSB	CRC MSB	0x61	0x03	0x02	0x03	0xE8	0x38	0xF2				
Slave Address	Function Code	No. of Bytes	Content MSB	Content LSB	CRC LSB	CRC MSB												
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:	Firmware version: Major.Minor															
	<table border="1"> <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>0xD1</td> <td>0x00</td> <td>Stop</td> </tr> </table>		Start	Write Header	Cmd MSB	Cmd LSB	Stop	Start	0xC2	0xD1	0x00	Stop					
	Start		Write Header	Cmd MSB	Cmd LSB	Stop											
	Start		0xC2	0xD1	0x00	Stop											
Read:																	
<table border="1"> <tr> <td>Start</td> <td>Read Header</td> <td>Firmware version major</td> <td>Firmware version minor</td> <td>CRC</td> <td>Stop</td> </tr> <tr> <td>Start</td> <td>0xC3</td> <td>0x03</td> <td>0x42</td> <td>0xF3</td> <td>Stop</td> </tr> </table>	Start		Read Header	Firmware version major	Firmware version minor	CRC	Stop	Start	0xC3	0x03	0x42	0xF3	Stop				
Start	Read Header		Firmware version major	Firmware version minor	CRC	Stop											
Start	0xC3		0x03	0x42	0xF3	Stop											
Modbus	Request																
	<table border="1"> <tr> <th>Slave Address</th> <th>Function Code</th> <th>Address MSB</th> <th>Address LSB</th> <th>No. of registers MSB</th> <th>No. of registers LSB</th> <th>CRC LSB</th> <th>CRC MSB</th> </tr> <tr> <td>0x61</td> <td>0x03</td> <td>0x00</td> <td>0x20</td> <td>0x00</td> <td>0x01</td> <td>0x8C</td> <td>0x60</td> </tr> </table>		Slave Address	Function Code	Address MSB	Address LSB	No. of registers MSB	No. of registers LSB	CRC LSB	CRC MSB	0x61	0x03	0x00	0x20	0x00	0x01	0x8C
	Slave Address	Function Code	Address MSB	Address LSB	No. of registers MSB	No. of registers LSB	CRC LSB	CRC MSB									
	0x61	0x03	0x00	0x20	0x00	0x01	0x8C	0x60									
Response:																	
<table border="1"> <tr> <th>Slave Address</th> <th>Function Code</th> <th>No. of Bytes</th> <th>Firmware version major</th> <th>Firmware version minor</th> <th>CRC LSB</th> <th>CRC MSB</th> </tr> <tr> <td>0x61</td> <td>0x03</td> <td>0x02</td> <td>0x03</td> <td>0x42</td> <td>0xB8</td> <td>0x8D</td> </tr> </table>	Slave Address	Function Code	No. of Bytes	Firmware version major	Firmware version minor	CRC LSB	CRC MSB	0x61	0x03	0x02	0x03	0x42	0xB8	0x8D			
Slave Address	Function Code	No. of Bytes	Firmware version major	Firmware version minor	CRC LSB	CRC MSB											
0x61	0x03	0x02	0x03	0x42	0xB8	0x8D											

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					Restarts the sensor
	Start	0xC2	0xD3	0x04	Stop					
Modbus	Request:									
	Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB		
	0x61	0x06	0x00	0x34	0x00	0x01	0x00	0x64		
	Response:									
Slave Address	Function Code	Address MSB	Address LSB	Content MSB	Content LSB	CRC LSB	CRC MSB			
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 format². Conversion of digital values S_x , ($x = c(\text{CO}_2)$, RH, T) to physical values and respective units are shown in the following table

Physical quantity	Conversion formula	Units	Range
CO ₂ concentration $c(\text{CO}_2)$	$c(\text{CO}_2) = S_{c(\text{CO}_2)}$	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.

Conversion of temperature to °F as well as relative humidity to absolute humidity and dew point temperature can be found in Sensirion's online support center³

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