Preliminary Datasheet SGP30

Important Note:

- All specifications are preliminary and are subject to change without prior notice.
- Characterization and qualification of this product is ongoing.

SGP30
Sensirion Gas Platform *Preliminary Datasheet*

- MEMS metal-oxide gas sensor for measuring volatile organic compounds (VOCs)
- Outstanding long-term stability
- I²C interface with TVOC and CO_2eq output signals
- Very small 6-pin DFN package: 2.45 x 2.45 x 0.9 mm³
- Low power consumption: 48 mA at 1.8V
- Tape and reel packaged, reflow solderable

Product Summary

The SGP30 is a digital multipixel gas sensor designed for easy integration into air purifier, demand-controlled ventilation, and IoT applications. Sensirion's CMOSens® technology offers a complete sensor system on a single chip featuring a digital I²C interface, a temperature controlled micro hotplate, and two preprocessed indoor air quality signals. As the first metal-oxide gas sensor featuring multiple sensing elements on one chip, the SGP30 provides more detailed information about the air quality.

The sensing element features an unmatched robustness against contaminating gases present in real-world applications enabling a unique long-term stability and low drift. The very small 2.45 x 2.45 x 0.9 mm³ DFN package enables applications in limited spaces. Sensirion's state-of-the-art production process guarantees high reproducibility and reliability. Tape and reel packaging, together with suitability for standard SMD assembly processes make the SGP30 predestined for high-volume applications.

Block Diagram

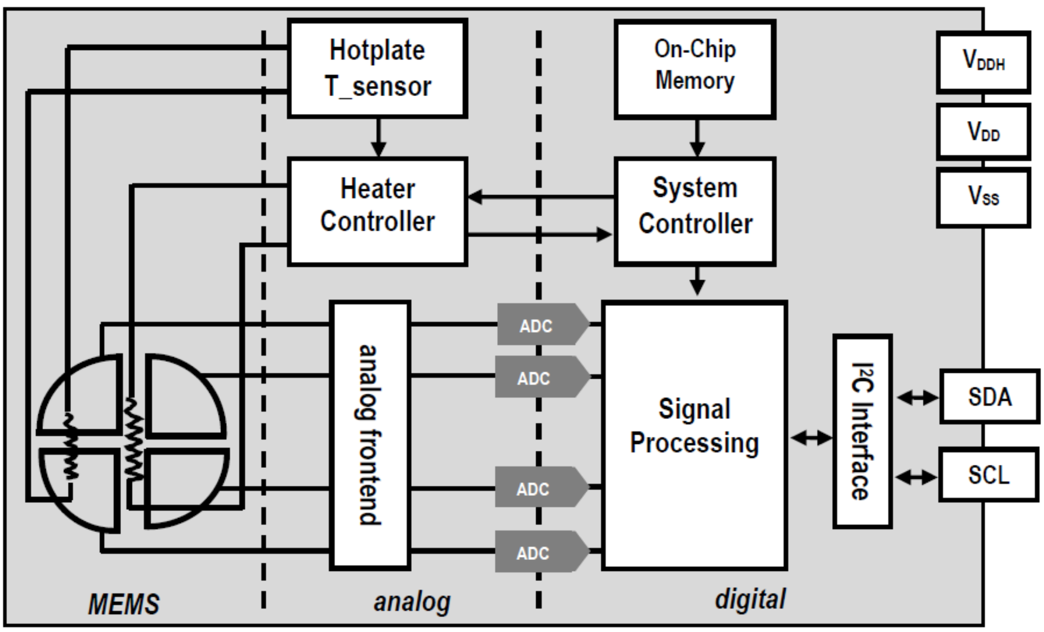

Figure 1 Functional block diagram of the SGP30.

1 Sensor Performance

1.1 Gas Sensing Performance

Parameter		minimum	typical	maximum	Comments
Measurement range	Ethanol signal	0 ppm to 1000 ppm			
	H_2 signal	0 ppm to 1000 ppm			
Specified range	Ethanol signal	0.3 ppm to 30 ppm			The specifications below are defined for this measurement range[1].
	H_2 signal	0.5 ppm to 10 ppm			
Accuracy	Ethanol signal	see **Figure 2** typ.: 15% of meas. value			Accuracy of the concentration *c* determined by $\ln\left({}^{c}/_{c_{ref}}\right) = \frac{(s_{ref}-s_{out})}{a}$ *a* = 512 s_{out}: EthOH/H_2 signal output at concentration *c* s_{ref}: EthOH/H_2 signal output at 0.5 ppm H_2 c_{ref} = 0.3 ppm
	H_2 signal	see **Figure 3** typ.: 10% of meas. value			c_{ref} = 0.5 ppm
Long-term drift[2]	Ethanol signal	see **Figure 4** typ.: 1.3% of meas. value			Change of accuracy over time: Siloxane accelerated lifetime test[3]
	H_2 signal	see **Figure 5** typ.: 1.3% of meas. value			

Table 1 Gas sensing performance. Specifications are at 25°C, 50% RH and typical VDD. The sensors have been operated for at least 24h before all characterizations.

Accuracy Ethanol signal

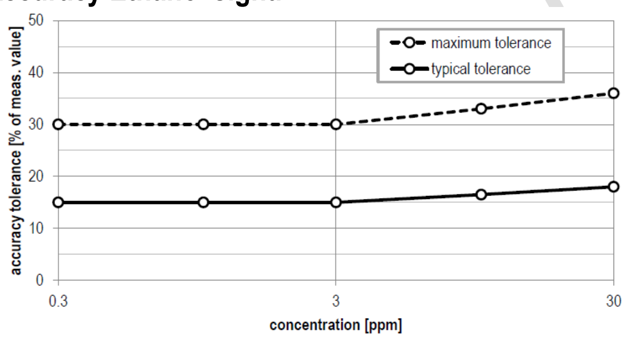

Figure 2 Typical and maximum accuracy tolerance in % of measured value at 25°C, 50% RH and typical VDD. The sensors have been operated for at least 24h before all characterizations.

Accuracy H_2 signal

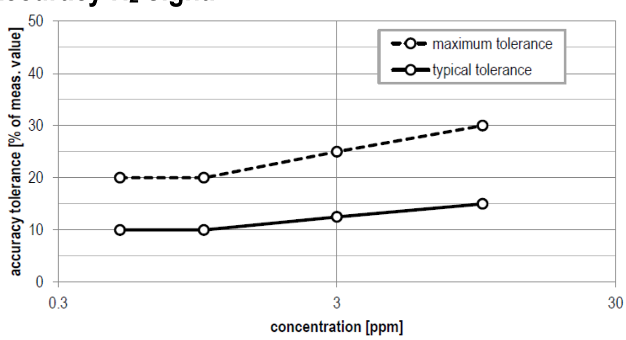

Figure 3 Typical and maximum accuracy tolerance in % of measured value at 25°C, 50% RH and typical VDD. The sensors have been operated for at least 24h before all characterizations.

1 ppm: parts per million. 1 ppm = 1000 ppb (parts per billion)
2 The long-term drift is stated as change of accuracy per year of operation.
3 Test conditions: operation in 250 ppm Decamethylcyclopentasiloxane (D5) for 200h simulating 10 years of operation in a typical indoor environment.

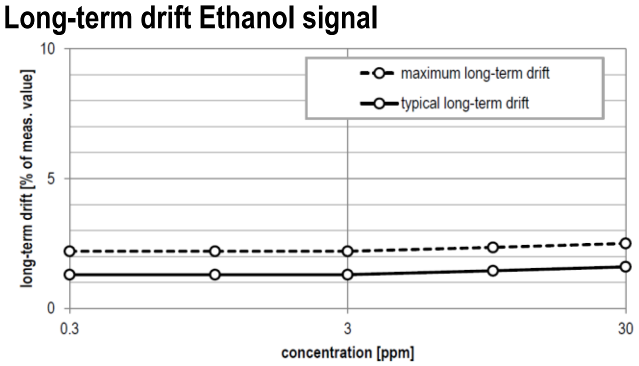

Figure 4 Typical and maximum long-term drift in % of measured value at 25°C, 50% RH and typical VDD. The sensors have been operated for at least 24h before all characterizations.

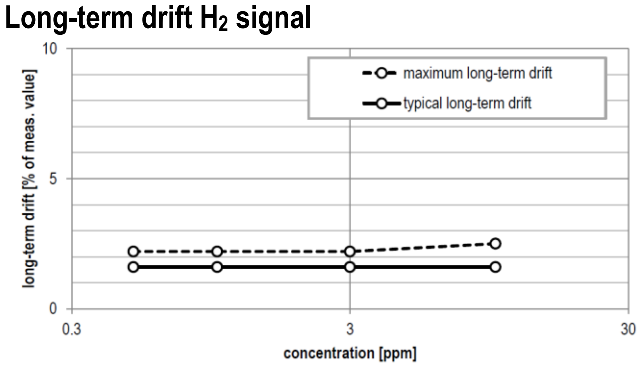

Figure 5 Typical and maximum long-term drift in % of measured value at 25°C, 50% RH and typical VDD. The sensors have been operated for at least 24h before all characterizations.

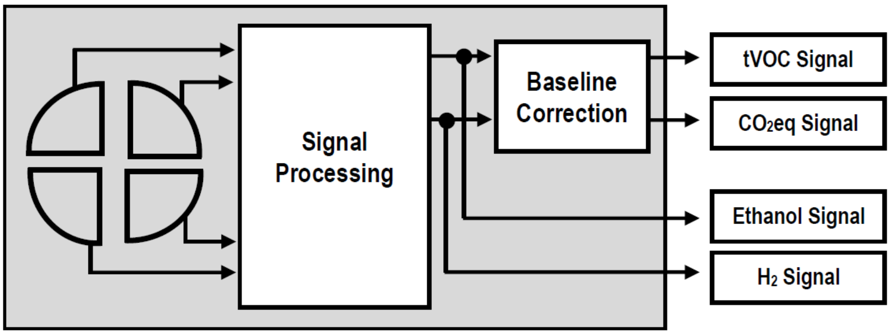

Figure 6 Simplified version of the functional block diagram (compare **Figure 1** Functional block diagram of the SGP30.) showing the signal paths of the SGP30.

1.2 Recommended Operating Conditions

The sensor shows best performance when operated within recommended normal temperature and humidity range of 5 – 55 °C and 25 –75 %RH, respectively. Long-term exposure to conditions outside normal range, especially at high humidity, may temporarily affect the sensor performance. Prolonged exposure to extreme conditions may accelerate aging. To ensure stable operation of the gas sensor, the conditions described in the document *SGP Handling and Assembly Instructions* regarding exposure to exceptionally high concentrations of some organic or inorganic compounds have to be met, particularly during operation. Please also refer to the *Design-in Guide* for optimal integration of the SGP30.

2 Electrical Specifications

Parameter	Min.	Typ.	Max.	Unit	Comments
Supply voltage V_{DD}	1.62	1.8	1.98	V	Minimal voltage must be guaranteed also for the maximum supply current specified in this table.
Hotplate supply voltage V_{DDH}	1.62	1.8	1.98	V	
Supply current during measurements		48.2		mA	A 20% higher current is drawn during 5ms on V_{DDH}, after issuing the "Measure" command (see 6.2).
Sleep current		2	10	µA	
LOW-level input voltage	-0.5		0.3*VDD	V	
HIGH-level input voltage	0.7*VDD		VDD+0.5	V	
Vhys hysteresis of Schmitt trigger inputs			0.05*VDD	V	
LOW-level output voltage			0.2*VDD	V	(open-drain) at 2mA sink current
Communication	Digital 2-wire interface, I2C fast mode.				

Table 2 Electrical specifications. Specifications are at 25°C and typical VDD.

3 Interface Specifications

The SGP30 comes in a 6-pin DFN package, see **Table 3**.

Pin	Name	Comments
1	V_{DD}	Supply voltage
2	V_{SS}	Ground
3	SDA	Serial data, bidirectional
4	R	Connect to ground (no electrical function)
5	V_{DDH}	Supply voltage, hotplate
6	SCL	Serial clock, bidirectional

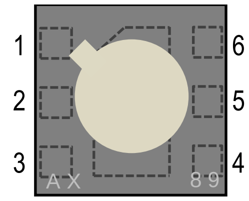

Table 3 Pin assignment (transparent top view). Dashed lines are only visible from the bottom.

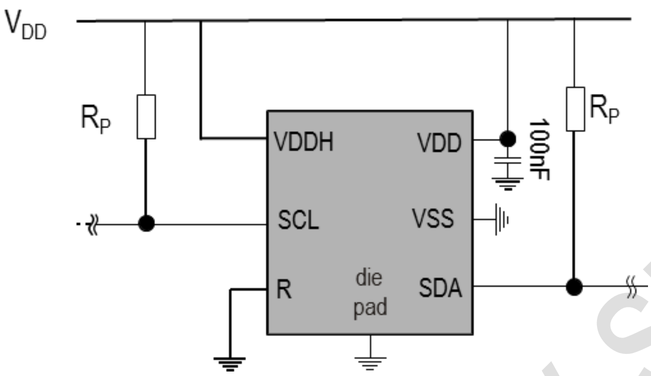

Figure 7 Typical application circuit (for better clarity in the image, the positioning of the pins does not reflect the positions on the real sensor).

The electrical specifications of the SGP30 are shown in **Table 2**. The power supply pins must be decoupled with a 100 nF capacitor that shall be placed as close as possible to pin VDD – see **Figure 7**. The required decoupling depends on the power supply network connected to the sensor. We also recommend VDD and VDDH pins to be shorted.

SCL is used to synchronize the communication between the microcontroller and the sensor. The SDA pin is used to transfer data to and from the sensor. For safe communication, the timing specifications defined in the I²C manual[4] must be met. Both SCL and SDA lines are open-drain I/Os with diodes to VDD and VSS. They should be connected to external pull-up resistors. To avoid signal contention, the microcontroller must only drive SDA and SCL low. The external pull-up resistors (e.g. R_p = 10 kΩ) are required to pull the signal high. For dimensioning resistor sizes please take bus capacity and communication frequency into account (see for example Section 7.1 of NXPs I²C Manual for more details[4]). It should be noted that pull-up resistors may be included in I/O circuits of microcontrollers.

The die pad or center pad is electrically connected to GND. Hence, electrical considerations do not impose constraints on the wiring of the die pad. However, for mechanical stability it is recommended to solder the center pad to the PCB.

4 Absolute Minimum and Maximum Ratings

Stress levels beyond those listed in **Table 4** may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions cannot be guaranteed. Exposure to the absolute maximum rating conditions for extended periods may affect the reliability of the device.

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

Parameter	Rating
Supply voltage V_{DD}	-0.3 V to +2.16 V
Supply voltage V_{DDH}	-0.3 V to +2.16 V
Storage temperature range	-40 to +125°C
Operating temperature range	-40 to +85°C
Humidity Range	10% - 95% (non-condensing)
ESD HBM	2 kV
ESD CDM	500 V
Latch up, JESD78 Class II, 125˚C	100 mA

Table 4 Absolute minimum and maximum ratings.

Please contact Sensirion for storage, handling and assembly instructions.

5 Timing Specifications

5.1 Sensor System Timings

Default conditions of 25°C and 1.8V supply voltage apply to values in the table below, unless otherwise stated. The timings refer to the power up and reset of the ASIC part and do not reflect the usefulness of the readings.

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Comments
Power-up time	t_{PU}	After hard reset, $V_{DD} \geq V_{POR}$	-	0.4	0.6	ms	-
Soft reset time	t_{SR}	After soft reset	-	0.4	0.6	ms	-

Table 5 System timing specifications. Specifications are at 25°C and typical VDD.

5.2 Communication Timings

Default conditions of 25 °C and 1.8 V supply voltage apply to values in the table below, unless otherwise stated.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units	Comments
SCL clock frequency	f_{SCL}	-	0	-	400	kHz	-
Hold time (repeated) START condition	$t_{HD;STA}$	After this period, the first clock pulse is generated	0.6	-	-	μs	-
LOW period of the SCL clock	t_{LOW}	-	1.3	-	-	μs	-
HIGH period of the SCL clock	t_{HIGH}	-	0.6	-	-	μs	-
Set-up time for a repeated START condition	$t_{SU;STA}$	-	0.6	-	-	μs	-
SDA hold time	$t_{HD;DAT}$	-	0	-	-	ns	-
SDA set-up time	$t_{SU;DAT}$	-	100	-	-	ns	-
SCL/SDA rise time	t_R	-	-	-	300	ns	-
SCL/SDA fall time	t_F	-	-	-	300	ns	-
SDA valid time	$t_{VD;DAT}$	-	-	-	0.9	μs	-
Set-up time for STOP condition	$t_{SU;STO}$	-	0.6	-	-	μs	-
Capacitive load on bus line	C_B	-			400	pF	-

Table 6 Communication timing specifications. Specifications are at 25°C and typical VDD.

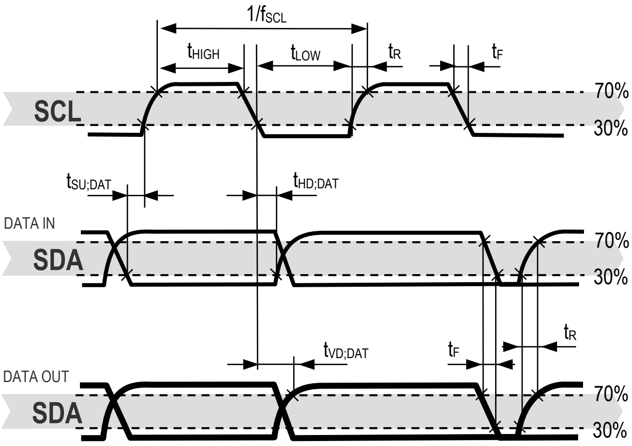

Figure 8 Timing diagram for digital input/output pads. SDA directions are seen from the sensor. Bold SDA lines are controlled by the sensor; plain SDA lines are controlled by the micro-controller. Note that SDA valid read time is triggered by falling edge of preceding toggle.

6 Operation and Communication

The SGP30 supports I²C fast mode. For detailed information on the I²C protocol, refer to NXP I²C-bus specification[4]. All SGP30 commands and data are mapped to a 16-bit address space. Additionally, data and commands are protected with a CRC checksum to increase the communication reliability. The 16-bit commands that are sent to the sensor already include a 3-bit CRC checksum. Data sent from and received by the sensor is always succeeded by an 8-bit CRC.
In write direction it is mandatory to transmit the checksum, since the SGP30 only accepts data if it is followed by the correct checksum. In read direction it is up to the master to decide if it wants to read and process the checksum.

SGP30	Hex. Code
I²C address	0x58

Table 7 I²C device address.

The typical communication sequence between the I²C master (e.g., a microcontroller in a host device) and the sensor is described as follows:

1. The sensor is powered up, communication is initialized
2. The I²C master periodically requests measurement and reads data, in the following sequence:
    a. I²C master sends a measurement command
    b. I²C master waits until the measurement is finished, either by waiting for the maximum execution time or by waiting for the expected duration and then poll data until the read header is acknowledged by the sensor (expected durations are listed in **Table 8**)
    c. I²C master reads out the measurement result

6.1 Power-Up and Communication Start

The sensor starts powering-up after reaching the power-up threshold voltage V_{POR} specified in **Table 5**. After reaching this threshold voltage, the sensor needs the time t_{PU} to enter idle state. Once the idle state is entered it is ready to receive commands from the master.
Each transmission sequence begins with a START condition (S) and ends with a STOP condition (P) as described in the I²C-bus specification.

6.2 Measurement Communication Sequence

A measurement communication sequence consists of a START condition, the I²C write header (7-bit I²C device address plus 0 as the write bit) and a 16-bit measurement command. The proper reception of each byte is indicated by the sensor. It pulls the SDA pin low (ACK bit) after the falling edge of the 8th SCL clock to indicate the reception. With the acknowledgement of the measurement command, the SGP30 starts measuring.

When the measurement is in progress, no communication with the sensor is possible and the sensor aborts the communication with a NACK condition.
After the sensor has completed the measurement, the master can read the measurement results by sending a START condition followed by an I2C read header. The sensor will acknowledge the reception of the read header and responds with data. The response data length is listed in **Table 8** and is structured in data words, where one word consists of two bytes of data followed by one byte CRC checksum. Each byte must be acknowledged by the microcontroller with an ACK condition for the sensor to continue sending data. If the sensor does not receive an ACK from the master after any byte of data, it will not continue sending data.
After receiving the checksum for the last word of data, an NACK and STOP condition have to be sent (see **Figure 9**).
The I2C master can abort the read transfer with a NACK followed by a STOP condition after any data byte if it is not interested in subsequent data, e.g. the CRC byte or following data bytes, in order to save time. Note that the data cannot be read more than once, and access to data beyond the specified amount will return a pattern of 1s.

6.3 Measurement Commands

The available measurement commands of the SGP30 are listed in **Table 8**.

Feature Set

The SGP30 features a versioning system for the available set of measurement commands and on-chip algorithms. This so called feature set version number can be read out by sending a “Get_feature_set_version” command. The sensor responds with 2 data bytes (MSB first) and 1 CRC byte. This feature set version number is used to refer to a corresponding set of available measurement commands as listed in **Table 8**.

Air Quality Signals

The SGP30 uses a dynamic baseline correction algorithm and on-chip calibration parameters to provide two complementary air quality signals. Based on the sensor signals a total VOC signal (TVOC) and a CO_2 equivalent signal (CO_2eq) are calculated. Sending an “Init_air_quality” command starts the air quality measurement. After the “Init_air_quality” command, a “Measure_air_quality” command has to be sent in regular intervals of 1s. The sensor responds with 2 data bytes (MSB first) and 1 CRC byte for each of the two preprocessed air quality signals in the order CO_2eq (ppm) and TVOC (ppb).
The SGP30 also provides the possibility to read and write the baseline values of the baseline correction algorithm. This feature is used to save the baseline in regular intervals on an external non-volatile memory and restore it after a new power-up or soft reset of the sensor. The command “Get_baseline” returns the baseline values for the two air quality signals. The sensor responds with 2 data bytes (MSB first) and 1 CRC byte for each of the two values in the order CO_2eq and TVOC. These two values should be stored on an external memory. After a power-up or soft reset, the baseline of the baseline correction algorithm can be restored by using the “Set_baseline” command with the two baseline values as parameters in the order as (TVOC, CO_2eq). An example implementation of a generic driver for the baseline algorithm can be found in the document *SGP30_driver_integration_guide*.
A new “Init_air_quality” command has to be sent after every power-up or soft reset.

Sensor Signals

The command “Measure_signals” is intended for part verification and testing purposes. It returns the sensor signals which are used as inputs for the on-chip calibration and baseline correction algorithms as shown in **Figure 6**. The command performs a measurement to which the sensor responds with 2 data bytes (MSB first) and 1 CRC byte (see **Figure 9**) for 2 sensor signals in the order H2_signal (s_{out_H2}) and Ethanol_signal (s_{out_EthOH}) Both signals can be used to calculate gas concentrations c relative to a reference concentration c_{ref} by

$$\ln\left(c/c_{ref}\right) = \frac{s_{ref} - s_{out}}{a}$$

with a = 512 (9-bit shift), s_{ref} the H2_signal or Ethanol_signal output at the reference concentration, and $s_{out} = s_{out\_H2}$ or $s_{out} = s_{out\_EthOH}$.

Measure Test

The command “Measure_test” which is included for integration and production line testing runs an on-chip self-test. In case of a successful self-test the sensor returns the fixed data pattern 0xD400 (with correct CRC).

Feature Set	0x0009				
Command	**Hex. Code**	**Parameter length, including CRC [bytes]**	**Response length, including CRC [bytes]**	**Measurement duration [ms]**	
				Typ.	**Max.**
Init_air_quality	0x2003	-	-	1	10
Measure_air_quality	0x2008	-	6	40	50
Get_Baseline	0x2015	-	6	10	10
Set_Baseline	0x201e	6	-	10	10
Measure_test	0x2032	-	3	200	220
Get_feature_set_version	0x202f	-	3	1	2
Measure_signals	0x2050	-	6	180	200

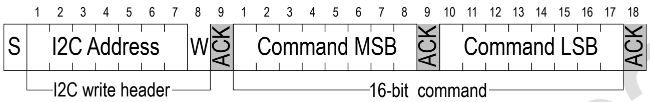

Table 8 Measurement commands.

6.4 Soft Reset

A sensor reset can be generated using the "General Call" mode according to I²C-bus specification. It is important to understand that a reset generated in this way is not device specific. All devices on the same I²C bus that support the General Call mode will perform a reset. The appropriate command consists of two bytes and is shown in **Table 9**.

Command	Hex. Code
Address byte	0x00
Second byte	0x06
Reset Command using the General Call address	0x0006

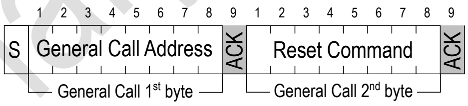

Table 9 Reset through the General Call address (Clear blocks are controlled by the microcontroller, grey blocks by the sensor.).

6.5 Get Serial ID

The readout of the serial ID register can be used to identify the chip and verify the presence of the sensor. The appropriate command structure is shown in **Table 10**. After issuing the measurement command and sending the ACK Bit the sensor needs the time t_{IDLE} = 0.5ms to respond to the I²C read header with an ACK Bit. Hence, it is recommended to wait t_{IDLE} =0.5ms before issuing the read header.

The get serial ID command returns 3 words, and every word is followed by an 8-bit CRC checksum. Together the 3 words constitute a unique serial ID with a length of 48 bits.

The ID returned with this command are represented in the big endian (or MSB first) format.

Command	Hex. Code
Get Serial ID	0x3682

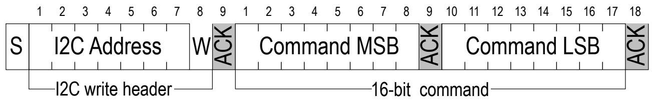

Table 10 Get serial ID command.

6.6 Checksum Calculation

The 8-bit CRC checksum transmitted after each data word is generated by a CRC algorithm. Its properties are displayed in **Table 11**. The CRC covers the contents of the two previously transmitted data bytes. To calculate the checksum only these two previously transmitted data bytes are used.

Property	Value
Name	CRC-8
Width	8 bit
Protected Data	read and/or write data
Polynomial	0x31 (x8 + x5 + x4 + 1)
Initialization	0xFF
Reflect input	False
Reflect output	False
Final XOR	0x00
Examples	CRC (0xBEEF) = 0x92

Table 11 I^{2}C CRC properties.

6.7 Communication Data Sequences

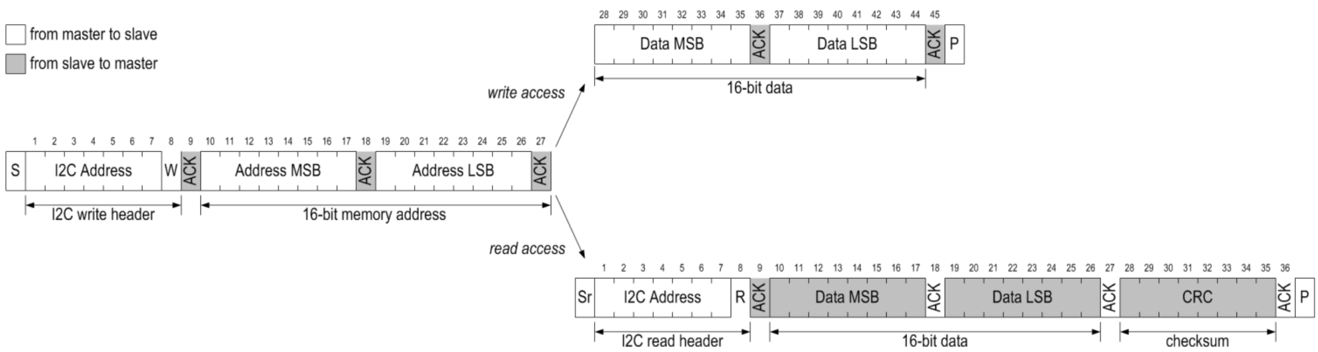

Figure 9 Communication sequence for starting a measurement and reading measurement results.

7 Quality

7.1 Environmental Stability

The qualification of the SGP30 will be performed based on the JEDEC JESD47 qualification test method.

7.2 Material Contents

The device is fully RoHS and WEEE compliant, e.g., free of Pb, Cd, and Hg.

8 Device Package

SGP30 sensors are provided in a DFN (dual flat no leads) package with an outline of 2.45 × 2.45 × 0.9 mm³ and a terminal pitch of 0.8 mm. The circular sensor opening of maximally 1.6 mm diameter is centered on the top side of the package. The sensor chip is assembled on a Ni/Pd/Au plated copper lead frame. Sensor chip and lead frame are over-molded by a black, epoxy-based mold compound. Please note that the side walls of the package are diced and therefore the lead frame sidewall surfaces are not plated. SGP30

8.1 Traceability

All SGP30 sensors are laser marked for simple identification and traceability. The marking on the sensor consists of a 4-digit, alphanumeric tracking code. This code is used by Sensirion for batch-level tracking throughout production, calibration, and testing. Detailed tracking data can be provided upon justified request. The pin-1 location is indicated by the keyhole pattern in the light-colored central area. See **Figure 10** for illustration.

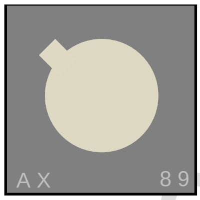

Figure 10 Laser marking on SGP30. The pin-1 location is indicated by the keyhole pattern in the light-colored central area. The bottom line contains a 4-digit alphanumeric tracking code

8.2 Package Outline

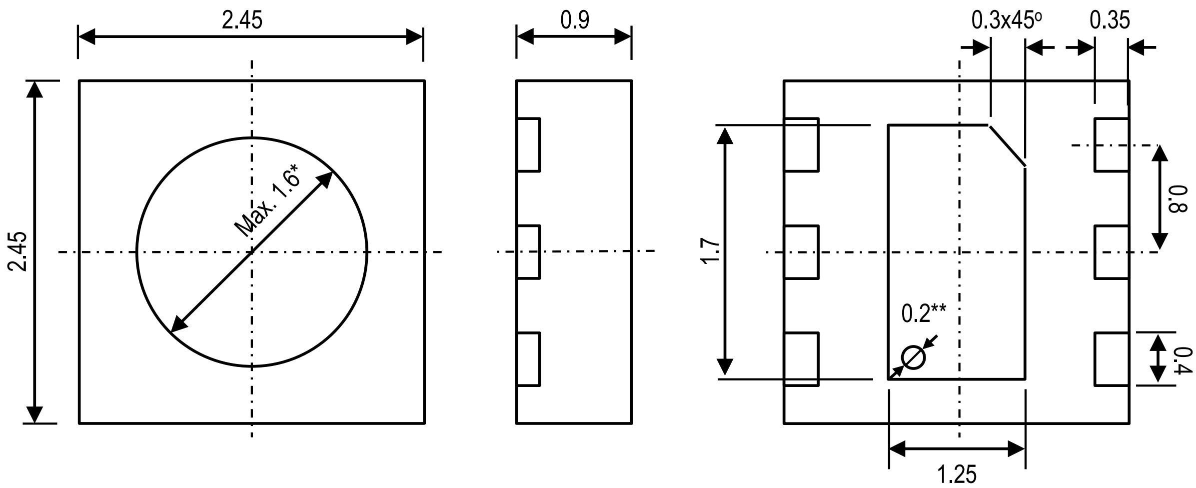

Figure 11 Package outlines drawing of the SGP30 with nominal values. Dimensions are given in millimeters. * Mold opening shows a smooth transition to package surface. ** The die pad shows a small recess in the bottom left part. *,** These dimensions are not well defined and given as a reference only.

8.3 Landing Pattern

Figure 12 shows the PCB landing pattern. The landing pattern is understood to be the metal layer on the PCB, onto which the DFN pads are soldered. The solder mask is understood to be the insulating layer on top of the PCB covering the copper traces. It is recommended to design the solder mask as a Non-Solder Mask Defined (NSMD) type. For solder paste printing it is recommended to use a laser-cut, stainless steel stencil with electro-polished trapezoidal walls and with 0.125 to 0.150 mm stencil thickness. The length of the stencil apertures for the I/O pads should be the same as the PCB pads. However, the

position of the stencil apertures should have an offset of 0.1 mm away from the package center, as indicated in **Figure 12**. The die pad aperture should cover 70 – 90 % of the die pad area, resulting in a size of about 1.05 mm x 1.5 mm.
For information on the soldering process and further recommendation on the assembly process please contact Sensirion.

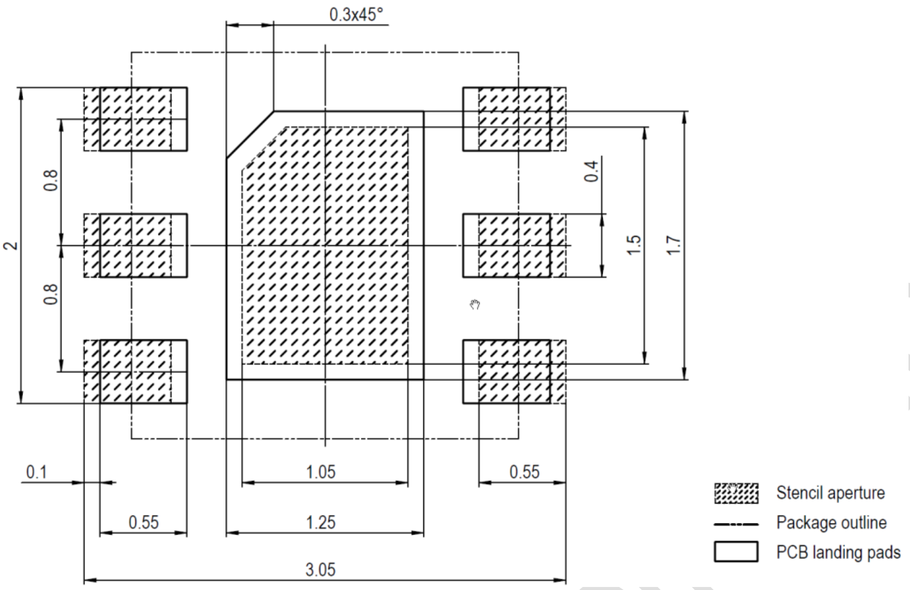

Figure 12 Recommended landing pattern.

9 Ordering Information

Samples are available upon request. Please contact Sensirion.

10 Tape & Reel Package

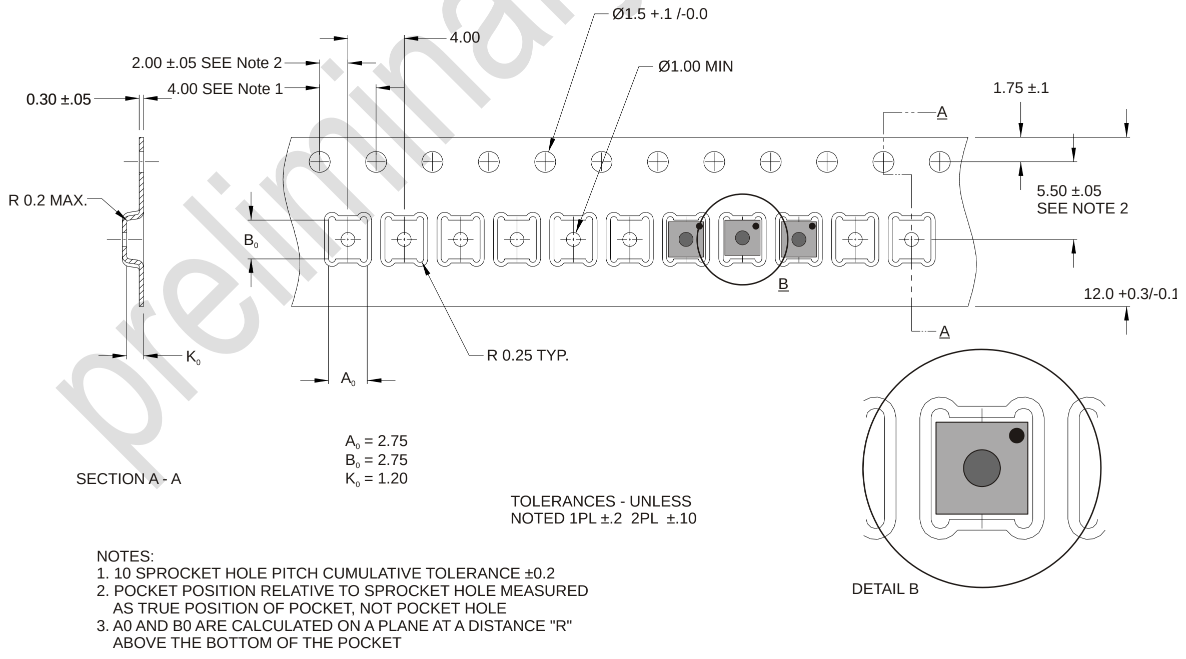

Figure 13 Technical drawing of the packaging tape with sensor orientation in tape. Header tape is to the right and trailer tape to the left on this drawing. Dimensions are given in millimeters.

Headquarters and Subsidiaries

SENSIRION AG
Laubisruetistr. 50
CH-8712 Staefa ZH
Switzerland

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

Sensirion Taiwan Co. Ltd.
phone: +41 44 306 40 00
info@sensirion.com

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

Sensirion Japan Co. Ltd.
phone: +81 3 3444 4940
info-jp@sensirion.com
www.sensirion.co.jp

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

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

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