SENSIRION

SFM3505-300, SFM3505-300-X datasheet

High performance digital mass flow meter

Highlights

- High accuracy
- Low noise
- Low pressure drop
- Reduced dependency to inlet conditions
- Compact dimensions

The SFM3505 series are compact digital gas flow sensors that successfully combine ultra low noise, high accuracy and low pressure drop, all in a compact form factor. Succeeding the proven SFM3119 and SFM3100, the SFM3505 feature a completely re-engineered architecture to deliver best-in-class performance at a minimal pressure drop. The sensor is offered in two performance tiers, SFM3505-300 with standard and SFM3505-300-X with high accuracy.
Built on Sensirion's latest 5th-generation CMOSens® Technology, the SFM3505 integrates the sensor element and advanced signal processing on a single microchip. This enables fast, stable, and fully calibrated digital output via a standard I^2C interface. Designed to be integrated in long-lived devices, the sensor does not need any additional calibration in production nor recalibration in the field due to the excellent long-term stability of CMOSens® chips.
It is calibrated for air and oxygen and incorporates on-chip temperature compensation, ensuring precise measurements under varying conditions. This is the ideal sensor for inspiratory flow measurements in applications such as mechanical ventilation, anesthesia, and gas mixing systems.

Applications

- Ventilation
- Anesthesia
- High accuracy and high flows applications

Device Overview

Product	Details
SFM3505-300	Inspiratory gas flow sensor
SFM3505-300-X	High accuracy gas flow sensor

See full product references on page 15.

Contents

1 Specifications

1.1 Flow specifications for SFM3505-300 [1]

Parameter	Condition	Value		Unit
Flow range	air, O_2	-150 to 300		slm [2]
Sensor output		1: air flow, 2: O_2 flow		
		Typical	Maximal	
Accuracy [3,4]	Span	±2.3	±3	% m.v. [5]
	Offset	±0.04	±0.05	slm
Noise [6,7]	Span	0.5	1	% m.v.
	Offset	0.002	0.01	slm
Accuracy derating with temperature [8]	-20 to +85°C	±(0.03 slm or 0.5%)		… per 10°C from 25°C
Pressure dependence [9]	525 hPa (abs.)	-1.5	-	%
	750 hPa (abs.)	-0.5	-	%
	1400 hPa (abs.)	+0.7	-	%
	1650 hPa (abs.)	+1.0	-	%
Pressure drop [10]	60 slm	57	85	Pa
	100 slm	140	200	Pa
	200 slm	540	750	Pa
Flow step response time (τ_{63}) [11]	Default filter settings (adjustable)	3		ms
Resolution (24 bit)		0.00004		slm

[1] Unless otherwise noted, all sensor specifications are valid in calibration conditions: dry air, at T=25 °C, absolute pressure = 966 hPa, horizontal flow direction and V_{DD} = 3.3V.
[2] slm: mass flow measured in liters per minute at standard conditions (T = 20 °C, p = 1013.25 hPa)
[3] Total accuracy is a sum of offset and span accuracy levels. For "Typical" a CpK of 0.67 is targeted (95% of sensors within the typical limit). For "Maximal" no sensor measured outside these limits will be shipped and a CpK of 1.33 is targeted.
[4] Measurements in 100% oxygen showed an additional accuracy deviation of up to 0.5%m.v.
[5] % m.v. = % measured value = % of reading
[6] Noise Level is defined as standard deviation of individual sensor readings, measured at default settings. Default settings are: flow signal filter set to a response time of 3ms (see section 2.2), fixed N averaging set to N=2 (see section 2.3).
[7] Total noise is the sum of the offset and span noise levels. "Typical": average value. For "Maximal", a CpK of 1.33 is targeted.
[8] Accuracy derating with temperature defined as additional uncertainty to the calibration accuracy when the temperature deviates from 25 °C.
[9] Pressure dependence given as the average shift in sensor's output measured in the flow range 100 to 200 slm. The absolute pressure is the pressure inside the sensor.
[10] Pressure drop measured in air in calibration conditions. "Typical": average value. For "Maximal", a CpK of 1.33 is targeted.
[11] With default filter settings. The response time can be tuned by adjusting the chip low pass filter, see section 2.2.

1.2 Flow specifications for SFM3505-300-X [12]

<table>
<tr><th>Parameter</th><th>Condition</th><th colspan="2">Value</th><th>Unit</th></tr>
<tr><td>Flow range</td><td>air, O_2</td><td colspan="2">-150 to 300</td><td>slm</td></tr>
<tr><td>Sensor output</td><td></td><td colspan="2">1: air flow, 2: O_2 flow</td><td></td></tr>
<tr><td></td><td></td><td>Typical</td><td>Maximal</td><td></td></tr>
<tr><td rowspan="2">Accuracy [13,14]</td><td>Span</td><td>±1.5</td><td>±2</td><td>% m.v.</td></tr>
<tr><td>Offset</td><td>±0.04</td><td>±0.05</td><td>slm</td></tr>
<tr><td>Noise</td><td colspan="4" rowspan="6">see 1.1</td></tr>
<tr><td>Accuracy derating with temperature</td></tr>
<tr><td>Pressure dependence</td></tr>
<tr><td>Pressure drop</td></tr>
<tr><td>Flow step response time (τ_{63})</td></tr>
<tr><td>Resolution (24 bit)</td></tr>
</table>

[12] Unless otherwise noted, all sensor specifications are valid in calibration conditions: dry air, at T=25 °C, absolute pressure = 966hPa, horizontal flow direction and V_{DD} = 3.3V.

[13] For "Typical" a CpK of 0.67 is targeted (95% of sensors within the typical limit) and total accuracy is the sum of offset and span accuracy levels. For "Maximal" no sensor measured outside of these limits will be shipped, a CpK of 1.33 is targeted and total accuracy is the offset or span accuracy level, whichever is greater.

[14] Measurements in 100% oxygen showed an additional accuracy deviation of up to 0.5%m.v.

1.3 Electrical specifications

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply Voltage	VDD	working voltage	3.2	3.3	3.4	V
		absolute min and max ratings	-0.3		5.5	V
Power-up level	VPOR_H				2.5	V
Power-down level	VPOR_L		1.5			V
Max Voltage on pins (SDA, SCL, DRDY)		absolute min and max ratings	-0.3		VDD+0.3	V
Supply current	IDD	measuring		3.8	10	mA
		idle state		0.05	0.6	mA
SCL and SDA sink current capability			3			mA
DRDY driving strength					0.05	mA
DRDY internal resistance				4		kΩ

1.4 Timing specifications

Parameter	Symbol	Comment	Min.	Typ.	Max.	Unit
Power-up time	t_{PU}	Time to sensor ready			2	ms
Soft reset time	t_{SR}	Time between soft reset command and sensor ready			2	ms
Time for first flow output available	t_{1st}	Time between measurement command and first flow measurement available			4 [15]	ms
Warm-up time	t_w	Time to reach accuracy spec after measurement command			50	ms
I^2C SCL frequency	f_{I2C}			400	1000 [16]	kHz
Internal flow sampling rate	f_S		3880	4000	4120	Hz
Output rate of the flow value		Adjustable, see section 2.3		$f_S/2$	f_S	Hz

[15] Valid for the default settings. This time depends on the configured number of samples to be averaged (N), see section 2.3.
[16] The choice of pull-up resistors and designed bus capacitance need to allow for fast enough signal transition. As an example, for 1000 kHz SCL frequency pull-up resistors of 1.5 kOhm combined with a bus capacitance of less than 90 pF achieve the transition time and respect the product's capability on SCL and SDA sink current.

1.5 Conditions of use

Parameter	Comment	Min.	Max.	Unit
Operating overpressure	at 25°C Pressure dependence: see 1.1		650	hPa gauge
Allowed overpressure	Tested for 1000 min at 40°C		650	hPa gauge
Burst overpressure[17]	Tested for 5 min at 40°C		1250	hPa gauge
Operating temperature [18]	Accuracy derating: see 1.1	-20	85	°C
Storage temperature	Tested for 48h	-20	85	°C
Operating humidity [18]		non-condensing		
ESD HBM	Human body model tested on IC chip level		2	kV

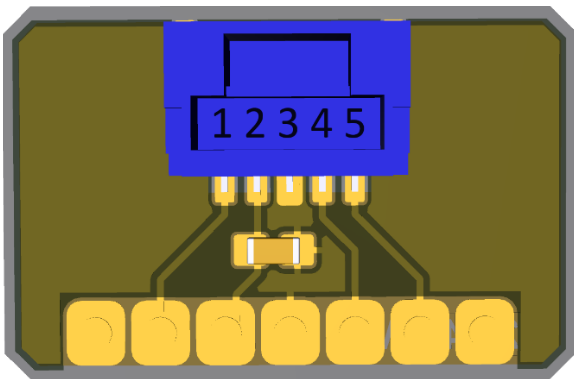
1.6 Media compatibility

Parameter	Value
Compatible gases	Air, N_2, O_2, other non-aggressive gases (non-condensing)
Wetted materials	PPE+PS blend, Si, glass (Si3N4, SiOx), epoxy, FKM typically non wetted: gold, FR4, lead-free solder
RoHS, REACH	RoHS and REACH compliant

1.7 Pin assignment

The pin assignment of SFM3505 can be found in the table below. The connector on the sensor is a 5-pin, 1mm pitch JST socket (part number: BM05B-NSHSS-TBT(LF)(SN)) which fits to the corresponding JST connector plug (part number: NSHR-05V-S).

Connector Pin	Name	Description
1	SDA	Bidirectional Serial Data (I^2C Interface)
2	VDD	V_{DD} Supply
3	GND	Connect to ground
4	SCL	Serial Clock (I^2C Interface)
5	DRDY	Data ready signal



[17] No burst means that the PCB remains in the sensor housing and leakage rate is below 5sccm at 300hPa overpressure.
[18] Long term exposure to high temperature and high humidity or high concentrations of O_2 can reduce the product lifetime.

2 Measurement Mode

After the sensor receives a “start continuous measurement” command (for more details see section 3.3.1) it enters the measurement mode and continuously provides measurement readings with the update rate of the flow output (see section 2.3). A single reading consists of two flow values: a 24-bit flow value for gas air and a 24-bit flow value for gas oxygen.

2.1 Data Ready Signal (DRDY)

The DRDY signal indicates whether new measurement results are available. The polarity is active low, meaning that when the signal is low there is new measurement data available and if the signal is high there is no new measurement data available. The DRDY will automatically clear to high when a measurement value is read out. The DRDY pin will also be set to low after initial power up, or after any hard- or soft-reset, until a measurement command, read device identifier command or fixed-N averaging configuration command is sent.

If the DRDY signal is not used, the pin should stay unconnected.

2.2 Flow Signal Filter

The response time and the noise level of the flow signal are both affected by the internal signal processing of SFM3505. A central element in this signal processing is a third order low pass filter with a default setting to achieve a τ_{63} step response time of 3 ms.

However, for some applications it might be preferred to have either a faster signal response (at the cost of higher noise level), or oppositely a lower noise level (at the cost of slower signal response).

With SFM3505 it is possible to reconfigure the low pass filter setting by sending a “start continuous measurement” command with an additional command argument (see section 3.3.1). The custom low pass filter setting then stays active for as long as the continuous measurement mode stays active.

The command argument a_{filter} (unsigned 16-bit integer value) defines the low pass filter setting by:

Response Time: τ_{63}	Command argument: a_{filter}
1 ms	33601
3 ms	50961 (default)
5 ms	56105
10 ms	60527

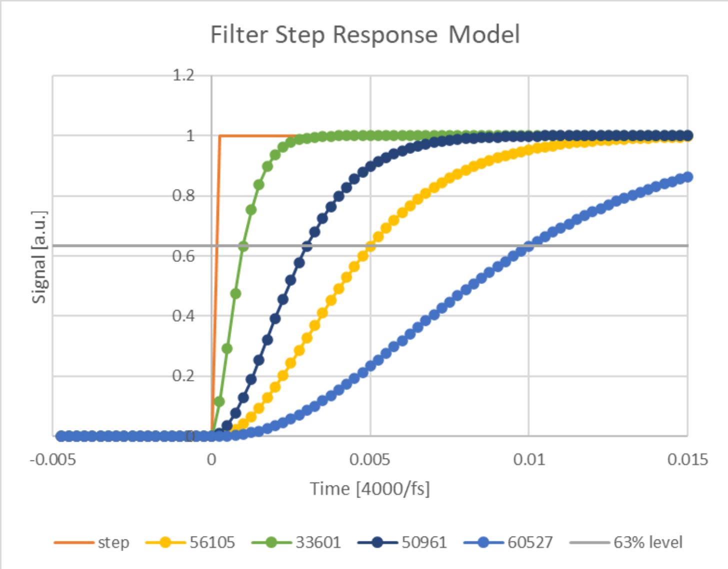


Figure 1: Model of the flow signal output for a step change of flow with different settings of the low pass filter. Remark: the time unit 4000/fs approximately corresponds to seconds.

2.3 Averaging of Flow Value

A fixed-N averaging mode for on-sensor averaging of the flow signal is implemented, in which every reading is the average of a fixed number (*N*) of measured flow values. Upon startup, a fixed averaging with *N* = 2 is set by default.

Averaging may be set to any fixed number 1≤*N*≤128 of measurements to be averaged (c.f. section 3.3.3). If fixed-N averaging is chosen, the update time for new readings is $N \times 1/f_S$ accordingly. Averaging has the benefit that users can reduce the sensor output rate to their own desired speed, without losing information and thus preventing aliasing. In this case, the averaged value $\bar{x}$ is the arithmetic mean of the individual measurements x_i:

$$\bar{x} = \sum_{i=1}^{N} \frac{x_i}{N}$$

If no averaging is desired, set *N* to 1.

2.4 Sensor Start-Up and Warm-Up Behavior

The typical time for system power-up (until the sensor responds to communication requests) is t_{PU}. The typical time from a soft reset until the sensor responds to communication requests is t_{SR} (see section 1.4).
After reset or start-up of the sensor, the sensor's internal heater is off and is automatically turned on by performing a *Start Continuous Measurement* command (see section 3.3.1). The very first measurement after *Start Continuous Measurement* is ready after t_{1st}.
Due to the thermal measurement principle, a total warm-up time under default settings of typically t_w is necessary for an accurate measurement. This includes t_{1st} needed for measurement initialization.

3 Digital Interface Description

The sensor's digital interface is compatible with the I^2C protocol. This chapter describes the available command set. For detailed information about the I^2C protocol, please consult the document "NXP I^2C-bus specification and user manual" (https://www.nxp.com/docs/en/user-guide/UM10204.pdf).
The physical interface consists of two bus lines: a data line (SDA) and a clock line (SCL) which need to be connected via pull-up resistors to the bus voltage of the system.

3.1 I²C Address

The I²C address for SFM3505 is:

Product Version	I2C address (hex)	I2C address (binary)
SFM3505	0x2E	0b010'1110

In the I²C protocol, a read or write bit follows the I²C address.

3.2 I²C Sequences

An I²C sequence typically consists of a command sent by the master to the slave (the sensor) and a subsequent readout of data by the master from the slave. It depends on the specific command if an argument to the command is needed and if data can be read out from the slave following the command. I²C read sequences can be aborted with a NACK and STOP condition. The following sections provide I²C sequences for the specific tasks. Dark areas with white text indicate that the sensor controls the SDA (Data) line:

3.2.1 Write Command without Argument

The commands have a length of 16 bits:

I²C master sends the write header and writes a 16-bit command:

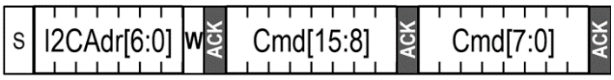


Figure 2: I²C sequences to send a command without an argument to the sensor.

3.2.2 Write Command with Argument

Commands have a length of 16 bits and are followed by a 16-bit argument plus an 8-bit checksum:

I²C master sends the write header and writes a 16-bit command, followed by a 16-bit argument plus a CRC byte:

Figure 3: I²C sequences to send a command with an argument to the sensor.

3.2.3 Read data from the Slave

After that, data is read from the sensor in multiples of 16-bit words, each followed by an 8-bit checksum to ensure communication reliability. I²C sequences can be aborted with a NACK and STOP condition as indicated below.

I²C master sends the read header and receives multiple 16-bit words followed by a CRC byte:

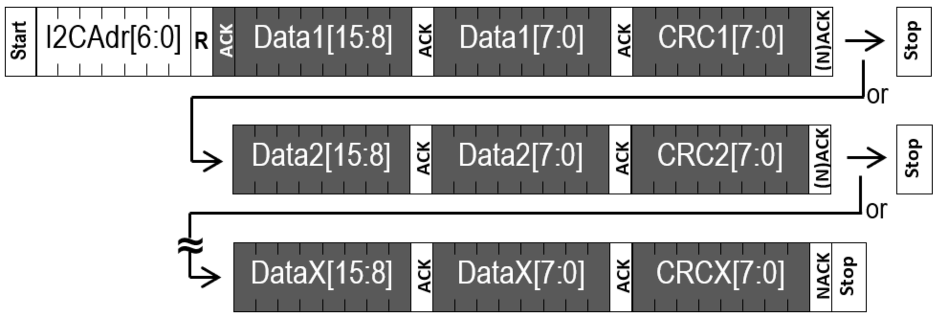


Figure 4: I²C sequences to read results from the sensor. Dark areas with white text indicate that the sensor controls the SDA (Data) line**.**

3.3 I²C Commands

The I²C command set consists of the following commands:

- Start Continuous Measurement
- Stop Continuous Measurement
- Configuration of Averaging
- Soft Reset
- Read Device Identifier

3.3.1 Start Continuous Measurement and Read Results

The command code for starting the continuous measurement is 0x3603. If sent without an argument (see Figure 2) the measurement starts in default mode and returns the flow value for air with the default filter response setting. For custom filter settings the command can be sent with an argument (see Figure 3), where the argument configures the flow signal filter as described in section 2.2.

Command code (Hex)	Command argument	Output values	Filter response time	Comment
0x3603	None	Output pair: Air & O_2	default, see 2.2	Call without argument
0x3603	a_{filter}	Output pair: Air & O_2	According to sec. 2.2	Customize signal filter setting

After the command has been sent, the chip continuously measures and updates the measurement results. New data can be read continuously with a single I²C read header for each measurement.

Further commands must not be sent until the stop measurement command has been sent. Consult section 3.3.2 for more details.

After the start measurement command is sent:

- the first measurement result will be available after t_{1st} (see timing specifications, section 1.4)
- accuracy deviations can occur during the first t_w (including t_{1st})

If an I^2C read header (I^2C address + read bit) is sent to the sensor when no measurement data is available, the sensor will respond with a NACK condition. Otherwise, the sensor will respond with the following output:

Preceding command	Consecutive read	Description
Continuous measurement 0x3603	Byte1: Flow Air [23:16] Byte2: Flow Air [15:8] Byte3: CRC Byte4: Flow Air [7:0] Byte5: Flow O2 [23:16] Byte6: CRC Byte7: Flow O2 [15:8] Byte8: Flow O2 [7:0] Byte9: CRC	After a start continuous measurement command, the measurement results can be read out. The read sequence can be aborted by a NACK and a STOP condition.

The flow values are 24bit unsigned integers. For conversion into physical units refer to section 3.5.

3.3.2 Stop Continuous Measurement

Command	Command code (Hex)	Description
Stop continuous measurement	0x3FF9	This command stops the continuous measurement and puts the sensor in idle mode. After it receives the stop command, the sensor needs up to 0.5 ms to power down the heater, enter idle mode and be receptive for a new command.

When the sensor is in continuous measurement mode, the sensor must be stopped before it can accept another command. The only exception is the soft reset command (see section 3.3.4). In idle mode the sensor will consume less power.

3.3.3 Configuration of Averaging

Command	Command code (Hex)	Command argument	Description
Configure averaging	0x364D	*N*	This command configures the sensor's averaging mode: 1≤*N*≤128 (default N=2): fixed-*N* averaging mode. *N* is the number of internal measurements that are averaged for one returned measurement value (i.e. the average over *N* flow samples, where *N* = CmdArgument, c.f. section 2.3). The configured averaging mode will be used for flow measurements until a reset or re-execution of this command is performed. After a reset, averaging is set to fixed-N averaging mode with N = 2. The highest averaging number allowed is 128. If a higher number is used in the command argument, it will be overruled by the maximal value of 128 samples to average. If no averaging is desired, set *N* to 1.

3.3.4 Soft Reset

Command	I^2C address + W bit + command code (Hex)	Consecutive read	Description
General call reset	0x0006	NA	This sequence resets the sensor with a separate reset block, which is as much as possible detached from the rest of the system on chip. Note that the I^2C address is 0x00, which is the general call address, and that the command is 8 bits long. The reset is implemented according to the I^2C specification.

After the reset command the sensor will maximally take t_{SR} to reset. During this time, the sensor will not acknowledge its address nor accept commands.

3.3.5 Hard Reset

In order to hard reset the sensor, all pins need to be pulled to 0V: Vdd but also the communication lines.

3.3.6 Read Device Identifier

The product identifier and the serial number can be read out by sending the command below. The command can only be issued in idle mode, i.e. when the sensor is not performing measurements. Please note that it takes maximally 60 us until the values can be read from the sensor (the sensor can be polled and the data availability is also indicated by the DRDY pin).

Command	Command code (Hex)	Consecutive read	Description
Read device identifier	0x365B	Byte1: Product identifier [31:24] Byte2: Product identifier [23:16] Byte3: CRC Byte4: Product identifier [15:8] Byte5: Product identifier [7:0] Byte6: CRC Byte7: Serial number [63:56] Byte8: Serial number [55:48] Byte9: CRC Byte10: Serial number [47:40] Byte11: Serial number [39:32] Byte12: CRC Byte13: Serial number [31:24] Byte14: Serial number [23:16] Byte15: CRC Byte16: Serial number [15:8] Byte17: Serial number [7:0] Byte18: CRC	The command returns: - 32-bit unique product and revision identifier. The identifier is listed in section 3.3.7 below. *Note that the last 8 bits are the revision number and are subject to change during development.* - 64-bit unique serial number in the format of an unsigned long integer. The serial number can be converted from binary into decimal, whereby in decimal it has the following format: *yywwxxxxxx*, where: • *yy*: last 2 digits of year of manufacturing • *ww*: calendar week of manufacturing • *xxxxxx*: unique 6-digit number

3.3.7 Product Identifier Values

Material description	Product identifier	Comment
SFM3505-300	0x040602xx	meaning of the last byte: product revision
SFM3505-300-X	0x040601xx	

3.4 Checksum Calculation

The 8-bit CRC checksum transmitted after each data word is generated by a CRC algorithm. Its properties are listed in the table below. 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
Protected data	read data
Width	8 bit
Polynomial	0x31 (x8 + x5 + x4 + 1)
Initialization	0xFF
Reflect input	False
Reflect output	False
Final XOR	0x00
Example	CRC (0xBEEF) = 0x92

3.5 Number Format and Conversion to Flow Physical Value

The digital calibrated gas flow signals read from the sensor are 24-bit unsigned integer number. The integer values are converted to physical values by subtracting an offset and dividing by a scale factor:

$$\text{Gas flow in slm } Q = \frac{sensor\ output - offset}{scale\ factor}$$

The scale factor and offset for SFM3505 are given in the table below:

Signal	Scale Factor	Offset
Air / O_2 flow	25’600 LSB24 / slm 0x6400 LSB24 / slm	8'388'608 LSB24 0x80’0000 LSB24

The flow unit slm signifies standard liters per minute with reference temperature equal to 20°C and reference pressure equal to 1013.25 hPa.

4 Mechanical specifications

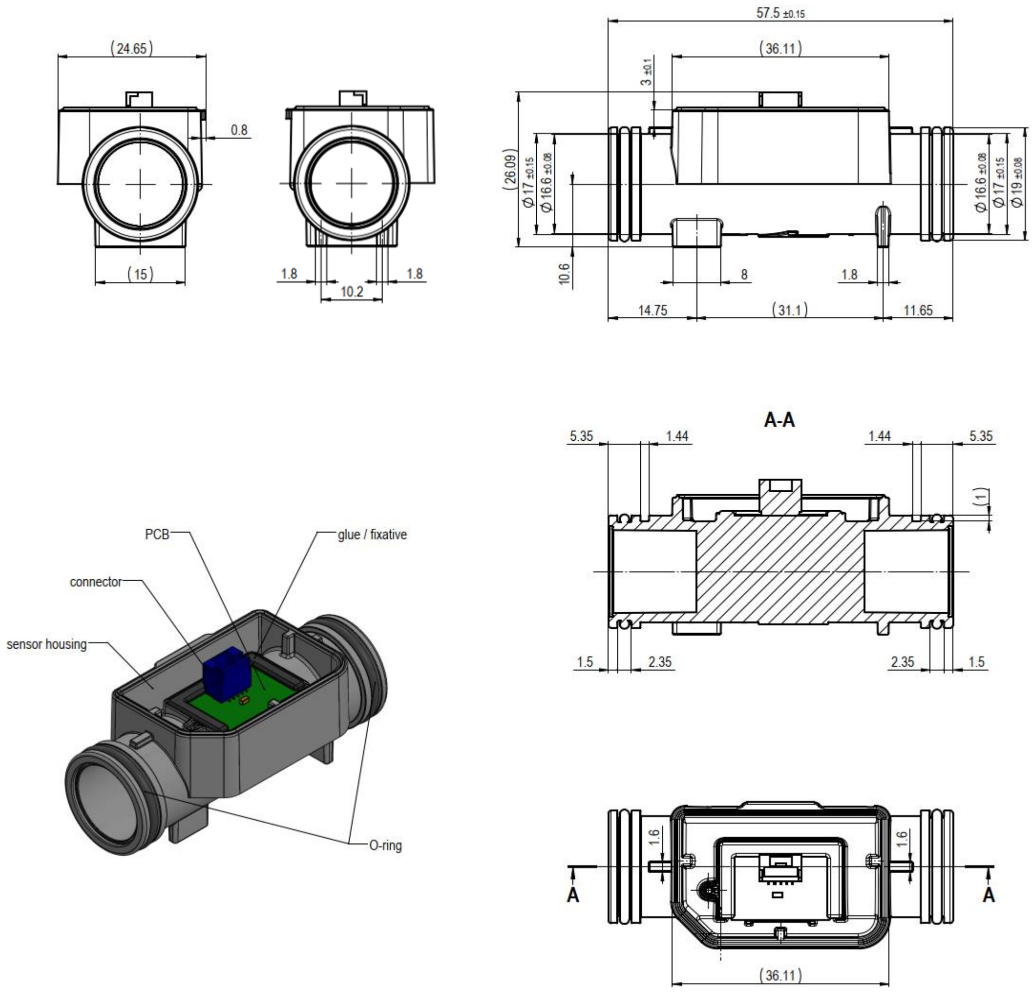


Figure 5: Drawing of SFM3505 with dimensions in mm. Extracted from drawing number 176937, revision 00.

4.1 O-rings

The white O-rings on the SFM3505 are produced according to ISO3601 class B and have the following dimensions:

Dimension	Inner diameter	Wire diameter	Unit
Value	16.1	1.6	mm

4.2 Flow path

The inner inlet diameter of the flow path is 14.0 mm. For optimal design-in, we recommend matching this inner diameter.

4.3 Label on sensor body

The sensor has a label on its body containing the following information in human readable text and in a GS1 data matrix:

Description	GS1 matrix application identifier	Comment
Material description	-	Only in human readable text, see section 5
Material number	240	See section 5
Serial number	21	See section 3.3.6. Preceded by the mention "SN" for the human readable text.

5 Ordering information

Use the material numbers shown in the following table when ordering the SFM3505. For the latest product information and local distributors, visit www.sensirion.com.

Material description	Details	Material number
SFM3505-300	Inspiratory gas flow meter	3.001.246
SFM3505-300-X	High accuracy inspiratory gas flow meter	3.001.273

Packaging unit = minimal order quantity = 120 sensors (4 trays).

6 Revision History

Date	Version	Pages	Changes
2025/10	1.0	all	first released version

Important Notices

Warning, Personal Injury

Do not use this product as safety or emergency stop devices or in any other application where failure of the product could result in personal injury (including death). 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 purchases or uses 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 is allegedly negligent with respect to the design or the manufacture of the product.

ESD Precautions

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take customary and statutory ESD precautions when handling this product. See application note "ESD, Latchup and EMC" for more information.

Warranty

SENSIRION solely warrants to the original purchaser of this product for a period of 12 months (one year) from the date of delivery that this product is 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 as sole and exclusive remedy, in SENSIRION's discretion, repair this product or send a replacement product, 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 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.

The Buyer shall at its own expense arrange for any dismantling and reassembly that is necessary to repair or replace the defective product. This warranty does not apply to any product which has not been installed or used within the specifications recommended by SENSIRION. EXCEPT FOR THE WARRANTIES EXPRESSLY SET FORTH HEREIN, SENSIRION MAKES NO WARRANTIES, EITHER EXPRESS OR IMPLIED, WITH RESPECT TO THE PRODUCT. ANY AND ALL WARRANTIES, INCLUDING WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY EXCLUDED AND DECLINED.

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SENSIRION does not assume any liability arising out of any application or use of any product or circuit and specifically disclaims any and all liability, including without limitation indirect, consequential, and incidental damages, and loss of profit. No obligation or liability shall arise or grow out of SENSIRION's rendering of technical advice, consulting, or implementation instructions or guidelines. All operating parameters, including without limitation recommended parameters, must be validated for each Buyer's applications by Buyer's technical experts. Recommended parameters can and do vary in different applications.

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

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