

Preliminary Datasheet SFC5400 / SFM5400 mass flow controller / meter for gases
Product Information October 2014 – V10

- Ultra-fast settling time (typ. value - 50 ms)
- Excellent accuracy/repeatability (0.8% s.p. / 0.1% s.p. respectively)
- Wide control range (1000:1)
- Vast choice of digital (RS485, DeviceNet, IO-Link) and analog (V/I) interfaces
- Optional multigas/multirange and gas recognition
- NIST traceable calibration



Unsurpassed CMOSens® Technology

The heart of the SFC5400 / SFM5400 mass flow controller/meter products is powered by Sensirion's unsurpassed CMOSens® sensor technology. It combines a high precision sensor element with ADC converter and complete signal processing for linearization and temperature compensation on a single silicon chip and is manufactured using CMOS processes (see Fig.1). Thanks to this sensor technology, the SFC5400 achieves unmatched ratings for speed, accuracy, repeatability and long-term stability at very attractive system cost.

The SFC5400 advances the technology of the well-proven SFC4000 series and offers an even faster settling time, improved control range, higher calibrated flow ranges, higher flexibility regarding mechanical connector options and new analog/digital communication interfaces. Digital versions also provide optional smart features like multigas/multirange, gas recognition and self-test capability.

The SFM5400 is a flow meter based on the SFC5400 series mass flow controller. It features the same

performance advantages and configurations as the MFC counterpart without providing the controller functionality (SFC5400 without valve).

The brilliant performance of the SFC5400 / SFM5400 products makes them the best choice for a wide range of applications, such as analytical instrumentation, coating/etching equipment, medical equipment and general process automation to name but a few.

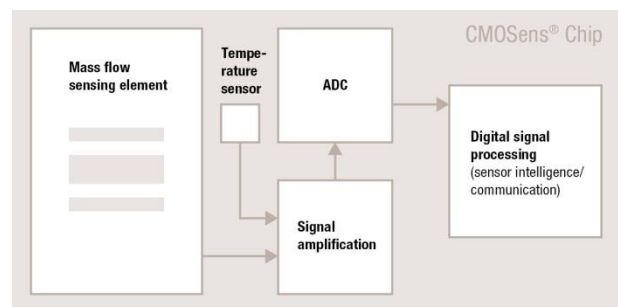


Figure 1: CMOSens® flow sensor diagram

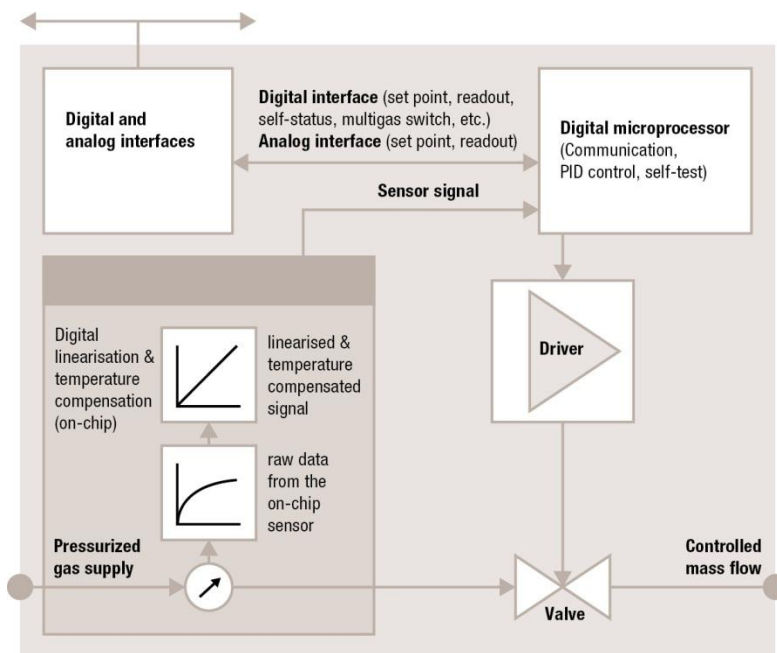


Figure 2: Block Diagram CMOSens[®] SFC5400 mass flow controller.

Introductory Description

The CMOSens[®] based SFC5400 / SFM5400 measure the gas mass flow using the calorimetric principle of measuring heat transfer. A heating element on a thermally insulated membrane is kept above ambient temperature. In the presence of gas flow, the temperature distribution up- and downstream is disturbed. This asymmetry is then measured. The whole arrangement is realized on a silicon chip using CMOS standard processes.

MEMS based CMOSens[®] technology enables a large cross section of the gas channel (about 1.5x1 mm²), which is substantially larger than bypass capillary diameter in conventional mass flow controllers (0.1 to 0.5 mm). This channel design makes the technology more robust against e.g. particles or humidified gases. Due to the compact single-chip design and mounting between metal parts (body and package plate), CMOSens[®] based sensors are very resistant to electromagnetic disturbances (EMC).

The minimal thermal mass of the membrane results in an ultra-fast sensor response time of 3-4 ms. Since the whole design of the amplification, A/D conversion, digital linearization and temperature compensation is matched to that sensor speed, a fully compensated flow measurement value can be delivered every millisecond.

Combined with advanced control algorithm running on an on-board microprocessor, the SFC5400 offers extremely short settling time compared to conventional mass flow controllers.

Furthermore, a special arrangement of the two temperature sensors, the on-chip temperature compensation and the minimizing of noise sources lead to the unbeatable performance with regard to repeatability and accuracy over a very wide dynamic range. Thanks to its flawless design, the SFC5400 / SFM5400 Series mass flow controllers/meters show zero-drift performance, control/measure true mass flow independently of the ambient temperature and pressure changes.

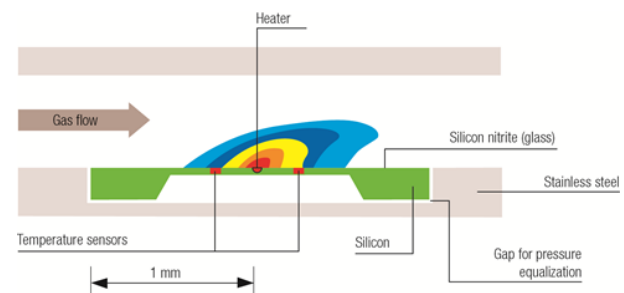


Figure 3: Cross-sectional view of gas channel.

CMOSens® SFC5400 / SFM5400 mass flow controller/meter performance

Table 1: Overview of CMOSens® SFC5400 / SFM5400 Mass Flow Controller/Meter Specifications¹

All data, unless otherwise noted, apply for calibration conditions and refer to the set point: 20°C, Nitrogen (N₂), 2.0 bar overpressure (inlet: 3.0 bar absolute) against atmosphere (outlet: 1.0 bar absolute), horizontal mounting position (connector on top), straight VCR inlet fitting (length min. 5x∅) or down-mount.

Specification	Value		Unit
Full scale flow (N ₂ equivalent)	0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10	20, 50, 100, 200	l/min or slm
Accuracy ^{2,3} whichever is greater	0.8	1	% s.p. ⁴
	0.08	0.1	% FS
Repeatability ³ whichever is greater	0.1	0.2	% s.p.
	0.01	0.02	% FS
Typical settling time ^{5,6,7}	50	100	ms
Measurement frequency	1000		Hz
Control range ⁶	Better than 1'000:1		
Standard calibration gases	Air/N ₂ , H ₂ , O ₂ , He, Ar, CO ₂		
Calibration using gas conversion ⁸	SF ₆ , CF ₄ , C ₄ F ₈ , NH ₃ , SiH ₄ , N ₂ O, O ₃ , CO, CH ₄ , CH ₃ F, Xe, Ne, Kr + other gases and mixtures on request (not compatible with aggressive gases, see wetted material list or contact Sensirion)		
Operating temperature (ambient and gas)	0 – 50 / 32 – 122		°C / °F
Temp. coeff. zero	0.005		% FS / °C
Temp. coeff. span	0.06		% s.p. / °C
Position sensitivity correction ⁹	on request		% FS
Pressure coefficient	< -0.15 / 1 bar		% s.p.
Pressure drop at full flow ¹⁰ SFC5400 SFM5400	<2.0 / 29 <0.1 / 1.5	<3.0 / 43 <0.2 / 3	bar / psig
Maximum input pressure ¹¹	10 / 145		bar / psig
Maximum differential pressure ^{6,12}	5 / 73	4 / 58	bar / psig
Leak integrity MFC external	9 x 10 ⁻⁹		mbar l/s He
Leak integrity through closed valve ⁶	1 x 10 ⁻⁶		mbar l/s He
Warming up time ¹³	1		sec

¹ Valid for Air/N₂ calibration (specifications for other gases may deviate)

² Including offset, non-linearity, hysteresis. Measured against NIST traceable reference

³ Accuracy specification for 0.05 l/min version is 0.8% s.p. and 0.16% FS whichever is greater

⁴ in % of set point (s.p.) = measured value (m.v.) = of rate = of reading

⁵ Step answer within 10% and 100% of full scale to within ±5% of set point. 3.0bar input pressure, 1.0bar ambient/outlet pressure, gas type: N₂.

⁶ Specification is valid for mass flow controller only

⁷ MFCs with analog interface have longer settling time due to the analog circuitry delays (typically by factor 2)

⁸ Gas conversion is generated from the real gas calibration data using the combination of standard gases. Typical accuracy is 2% m.v. / 0.2% FS (whichever is greater). Please contact Sensirion if better accuracy specification is required for your OEM project.

⁹ For any other position than horizontal (electrical connector on top), accuracy may deviate depending on gas type due to buoyance of the media

¹⁰ 1 bar = 100 000 Pa = 0.9869 atm = 401.9 inch H₂O = 14.5 psi. For lower pressure drop option, contact Sensirion AG

¹¹ Pressure between flow inlet and ambient

¹² Pressure between flow inlet and flow outlet. For availability of higher differential pressure option, contact Sensirion AG

¹³ to within ±2 % of set point

1.1 Accuracy

Figure 4 compares the set point accuracy of a conventional mass flow controller/meter with a CMOSens® SFC5400 / SFM5400. Typically, an accuracy of 1% FS (full scale) is stated for mass flow controllers using conventional sensor technology. The graph shows this in relation to the accuracy of the SFC5400 mass flow controller. It can be seen that especially at low flow rates the CMOSens® technology reaches superior performance.

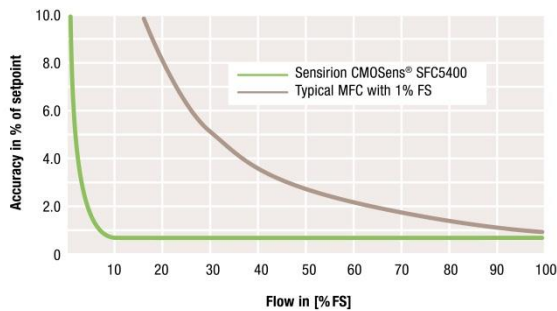


Figure 4: Accuracy comparison of the CMOSens® SFC5400 / SFM5400 device compared to a typical thermal mass flow controller/meter.

1.2 Repeatability

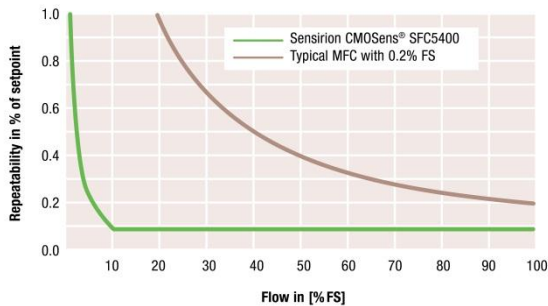


Figure 5: Repeatability comparison of the CMOSens® SFC5400 / SFM5400 device compared to a typical thermal mass flow controller/meter.

1.3 Settling time

The CMOSens® SFC5400 mass flow controller has an ultra-fast settling time of about 50 ms only. Figure 6 shows the typical response time of the SFC5400 in comparison to a mass flow controller using conventional sensor technology.

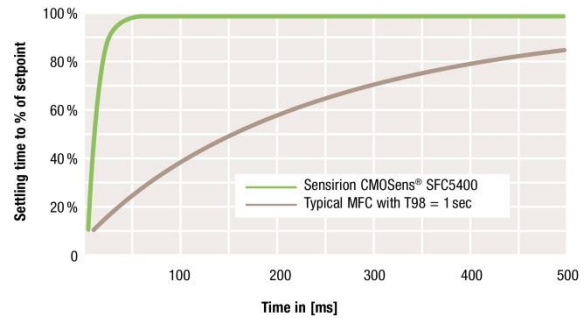


Figure 6: Settling time of the SFC5400 vs. typical thermal mass flow controller.

1.4 Wide control range

Ultra-wide control range of the SFC5400 brings a decisive benefit in applications with a wide dynamic range of gas flows. Instead of two devices used for high flow and low flow ranges, a single SFC5400 device can efficiently cover a flow range of three orders of magnitude.

1.5 Multigas & Gas recognition

For large OEM projects, the new SFC5400 / SFM5400 can be equipped with Multigas feature, which allows switching between a set of gas calibrations saved in the device memory.

Another interesting OEM feature is gas recognition. It allows performing a check whether activated gas calibration is matching the media in the gas line. This is a safety feature which prevents wrong operation due to mistake of user etc.

2 Construction details

2.1 Packaging principle and sealing

To guarantee a vacuum proof housing of the sensor and the flow path, several patented technologies are used. The CMOSens® chip itself is placed vacuum tight in a stainless steel package that is connected via O-ring sealing to the aluminum body. The packaging allows the SFC5400 / SFM5400 mass flow controller/meter to operate under high input pressure conditions (up to 10 bar/145 psi standard).

The electrical connection from the chip to the main controller board is realized using vacuum tight glass feed through pins. This chosen packaging method ensures high reliability and tightness for all kinds of gases (see Figure 7 below).

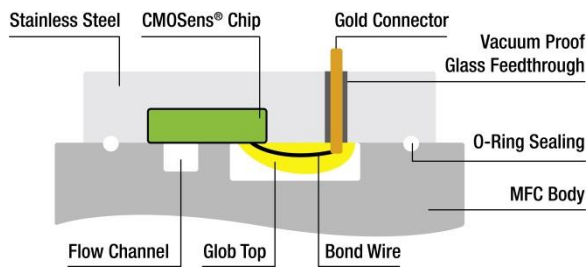


Figure 7: Vacuum tight glass feed through (longitudinal view)

2.2 Wetted materials & compatibility

The packaging method ensures that a minimum number of inert materials are wetted by the media. Table 2 gives an overview of the materials wetted by the gas.

For high volume OEM applications different specialized materials for body, valve and sealing can be used.

Table 2: Overview of Wetted Materials. Standard configuration materials are shown in bold text. Optional materials are provided for large projects only.

Part	Wetted Material
Body	Aluminum or Stainless steel
Sensor element	Silicon (Si) Silicon oxide (SiOx) Silicon nitride (Si₃N₄) Stainless steel Glass Glob top
Sealing	FKM or on request: EPDM / FFKM
Valve	Brass, FKM or on request: Stainless steel, EPDM / FFKM

2.3 Safety instructions

2.3.1 Toxic gases

The whole gas assembly must be checked for leakage before applying toxic gas to the device.

2.3.2 Aggressive or corrosive gases

Please make sure that the gases you use are compatible with the wetted materials listed in this chapter. In case of doubt please contact Sensirion for further advice.

2.3.3 Explosive gases

The maximum heating energy of the sensor is limited to 12 mW in every circumstance (even in the case of a failure). The CMOSens® sensor element is tested according to EN 50020 chapter 6.2.4 b). Sensirion guarantees the safe use of gases of the classes T1 or T2 (ignition temperature < 300 °C). This includes also mixtures of air or oxygen with hydrogen or hydrocarbons. However, the SFC5400 / SFM5400 are not designed for the use in hazardous areas (EN 6079-10) where explosive gases can occur outside of the device.

3 Electrical and communication specifications

3.1 Connector and pin layout (digital, analog + Aux RS485, analog)

SFC5400 / SFM5400 feature following analog and digital communication interfaces:

- Analog: 0-5 V, 0-10 V, 4-20 mA
- Digital: RS485, DeviceNet, IO-Link

Detailed specification of the digital communication protocols can be found on Sensirion’s website.

The electrical connector of the SFC5400 / SFM5400 is a standard HD Sub-D 9pin. This enables an easy and reliable universal connection. See the pin layouts for different interface versions below:

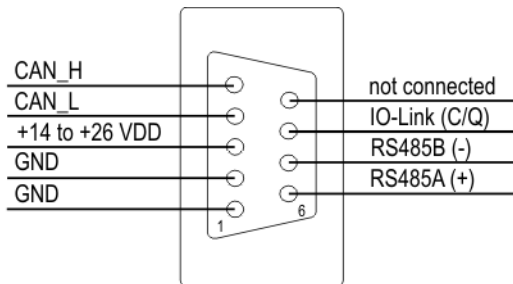


Figure 8: Digital interface version (RS485, DeviceNet and IO-Link). This version has an order code “L”

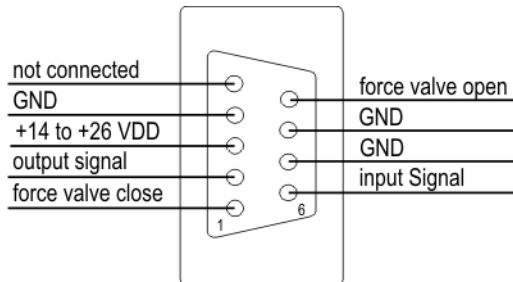


Figure 9: Standard analog only interface versions (0-5VDC, 0-10VDC, 4-20mA). These versions have order codes “U”, “W”, and “C” respectively.

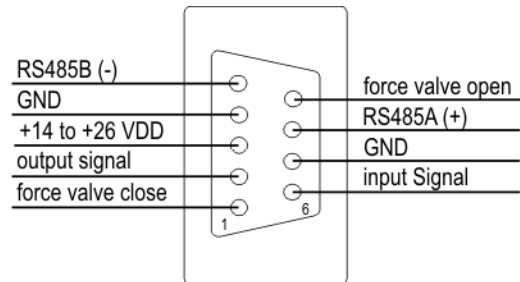


Figure 10: Analog interface versions (0-5VDC, 0-10VDC, 4-20mA) with auxiliary RS485 interface for extended functionality. RS485 interface is for service purposes only, e.g. it is not possible to set the set point using RS485. These versions have order codes “Q”, “R”, and “S” respectively. Note, that pin layout of this version is not compatible to our analog only devices and deviates from the standard industrial pin layout.

3.2 Power supply

The SFC5400 / SFM5400 mass flow controller/meter requires a standard voltage supply of +14.0 to + 26.0 VDC.

Since this voltage is internally regulated, there are no stringent requirements as far as ripple and stability are concerned.

3.3 Valve override inputs (analog versions)

The valve of the SFC5400 mass flow controller is a “normally closed” type. For security reasons the SFC5400 mass flow controller is equipped with two valve override functions:

Purge Mode: Setting 5Vdc to pin 9 will fully open the control valve ignoring any set point.

Shut Mode: Setting 5Vdc to pin 1 will fully close the control valve ignoring any set point.

3.4 Electrical specifications

Table 3: Electrical characteristics (analog versions)

Parameter	Value	Units
Analog Input Set Point	0 – 5V / 0 – 10V / 4...20mA	V / mA
Analog Output	0 – 5V / 0 – 10V / 4...20mA	V / mA
Valve force input active	5.0	VDC
Valve force input inactive	0...1	VDC
Supply Voltage Range (VDD)	14.0 –26.0	VDC
Electrical Connector	Sub-D 9pin (female on device)	

4 Physical dimensions and mounting information for SFC5400 / SFM5400

Physical dimensions and mounting information for the down mount and 1/4" VCR/VCO versions are provided below. All drawings are generated from SFC5400

models. SFM5400 has completely identical dimensions with the only difference of absent control valve.

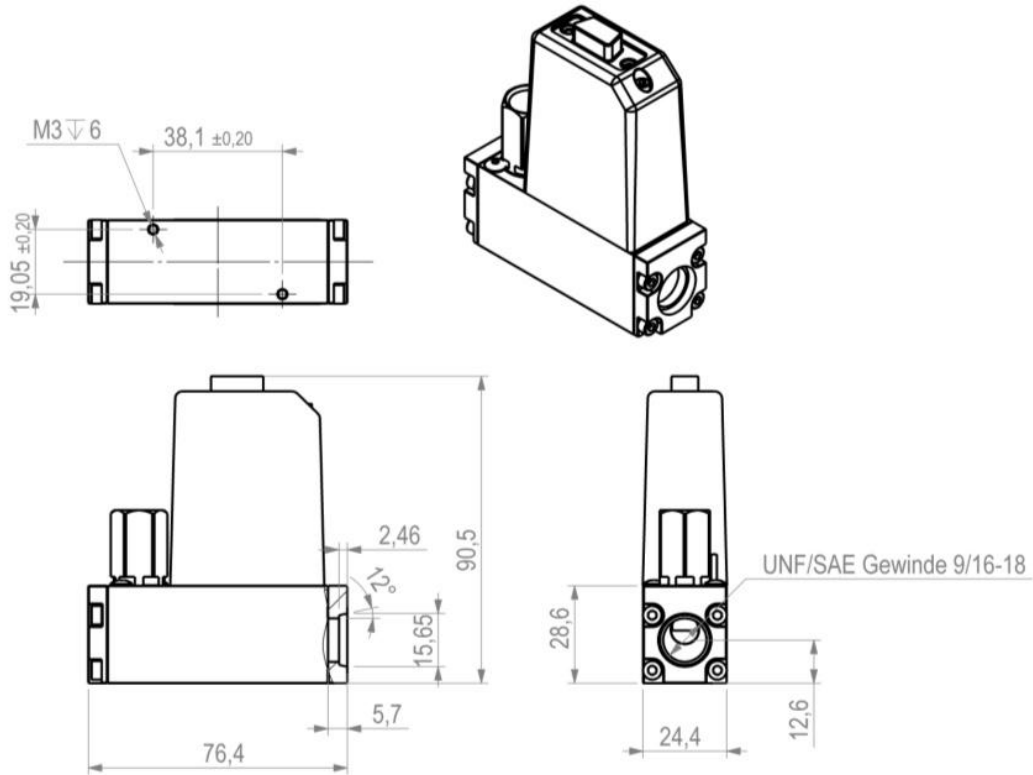


Figure 11: Physical dimensions and mounting information for the fitting versions.

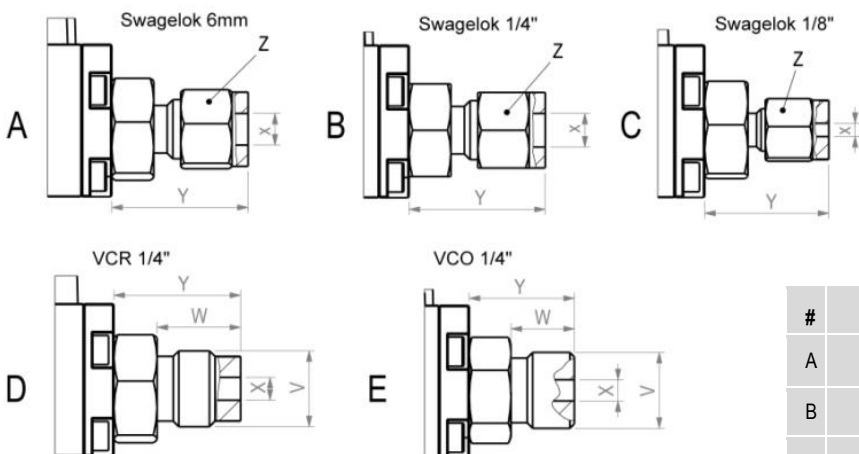


Figure 12: Physical dimensions of Swagelok, VCR and VCO fitting options. All units are in [mm]

#	V	X	Y	Z
A		6.0mm	24.7mm	14.0mm
B		1/4"	25.7mm	9/16"
C		1/8"	23.4mm	7/16"
D	1/4"	15.8mm	4.6mm	23.9mm
E	1/4" Male VCO	12.0mm	4.6mm	19.8mm

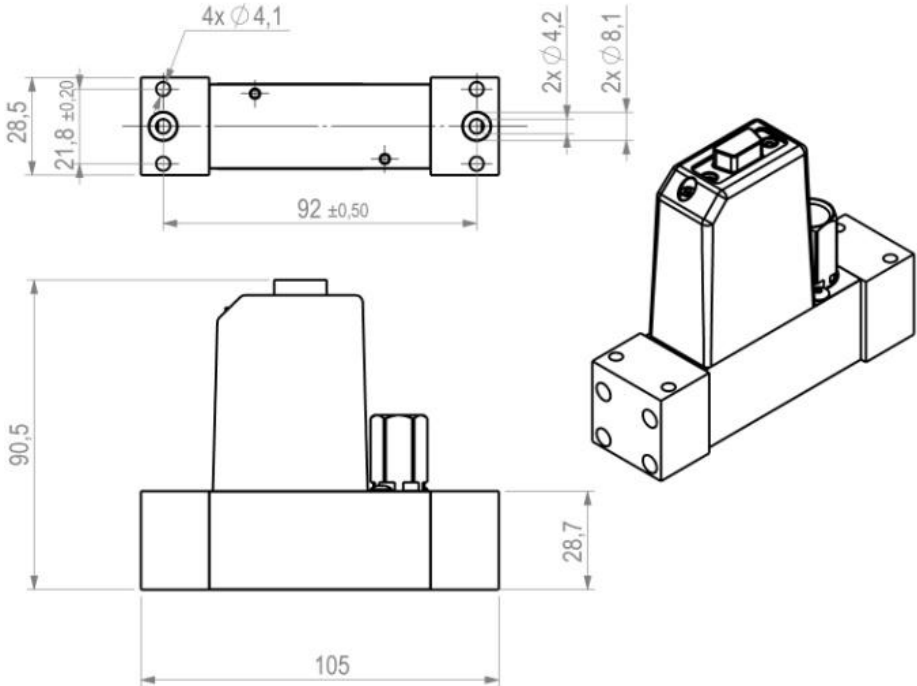


Figure 13: Physical dimensions and mounting information for the down mount version. All units are in [mm]

5 Supported flow units

Table 4: Units for gas flow rates

Typical flow unit	Reference condition	
	Gas Temperature	Gas Pressure
mln/min (norm milliliter per minute)	0 °C / 32° F	1013 mbar / 14.69 psi
ln/min (norm liter per minute)		
sccm (standard cubic centimeter per minute)	20 °C / 68° F	
slm (standard liter per minute)		

Example: Relationship for N₂ between:

ln/min (0°C, 1013 mbar)	and	slm (20°C / 68°F, 1013 mbar / 14.69)
1 ln/min	=	1.073 slm
10 ln/min	=	10.73 slm

6 Ordering information

Until unrestricted market release, the SFC5400 / SFM5400 products are offered for large OEM projects. Ordering information will be provided by Sensirion on request.

7 Revision history

Date	Version	Page(s)	Changes
October 2014	V10	11	

Important notices

Warning, personal injury

Do not use this product as safety or emergency stop device or in any other application where failure of the product could result in personal injury. Do not use this product for applications other than its intended and authorized use. Before installing, handling, using or servicing this product, please consult the data sheet and application notes. Failure to comply with these instructions could result in death or serious injury.

If the Buyer shall purchase or use SENSIRION products for any unintended or unauthorized application, Buyer shall defend, indemnify and hold harmless SENSIRION and its officers, employees, subsidiaries, affiliates and distributors against all claims, costs, damages and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if SENSIRION shall be allegedly negligent with respect to the design or the manufacture of the product.

ESD precautions

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take customary and statutory ESD precautions when handling this product.

Warranty

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

- notice in writing describing the defects shall be given to SENSIRION within fourteen (14) days after their appearance;

- such defects shall be found, to SENSIRION's reasonable satisfaction, to have arisen from SENSIRION's faulty design, material, or workmanship;
- the defective product shall be returned to SENSIRION's factory at the Buyer's expense; and
- the warranty period for any repaired or replaced product shall be limited to the unexpired portion of the original period.

This warranty does not apply to any equipment which has not been installed and used within the specifications recommended by SENSIRION for the intended and proper use of the equipment. 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 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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FCC and CE statement

The SFC5400 and SFM5400 products have been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules (FCC CFR 47). These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult a dealer or an experienced radio/TV technician for help.



The CMOSens® SFC5400 / SFM5400 devices fully comply with norm EN 61000-6-1 to EN 61000-6-4 (Immunity and Emission Test Series).



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 AG (Germany)
phone: +41 44 927 11 66
info@sensirion.com
www.sensirion.com

Sensirion Inc., USA
phone: +1 805 409 4900
info_us@sensirion.com
www.sensirion.com

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

Sensirion Korea Co. Ltd.
phone: +82 31 345 0031 3
info@sensirion.co.kr
www.sensirion.co.kr

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

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