Datasheet SFC5400 / SFM5400 mass flow controller / meter for gases

Product Information October 2016 – V12

- Ultra-fast settling time (down to 50 ms)
- Excellent accuracy/repeatability (0.8% / 0.1% of setpoint respectively)
- Wide control range (1000:1)
- Broad choice of interfaces: RS485, DeviceNet, IO-Link and analog voltage / current
- Broad choice of connectors: Downmount, Swagelok, VCR, VCO, Legris, C-Seal, W-Seal
- Multiple gases and gas recognition
- NIST traceable calibration
- MTBF 169 years



SFM5400

SFC5400

Unsurpassed CMOSens® Technology

The SFC5400 / SFM5400 series continues the Sensirion pioneering work in MEMS-based mass flow controllers and meters: The heart of this product is the unsurpassed Sensirion CMOSens® technology. It combines a high precision sensor element with state of the art signal processing on a single chip and thereby providing an accurately calibrated and temperature compensated signal (see Figure 1). Thanks to this sensor technology, the SFC5400 achieves unmatched ratings for speed, accuracy and repeatability at very attractive system cost. In addition, no recalibration is needed due to the inherent longterm stability of the CMOSens® technology.

The SFC5400 offers fastest settling time, high control range as well as high flexibility regarding mechanical connectors and communication interfaces. Digital versions also provide optional smart features like multiple gases and ranges, gas recognition and self-test capability.

The SFM5400 is the valve-free flow meter based on the SFC5400 mass flow controller. It features the same performance advantages and configurations as the MFC counterpart without providing the controller functionality.

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 a few.

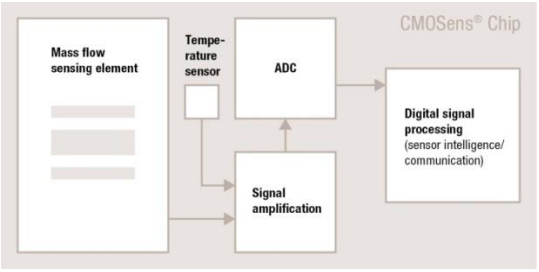


Figure 1: CMOSens® flow sensor diagram.

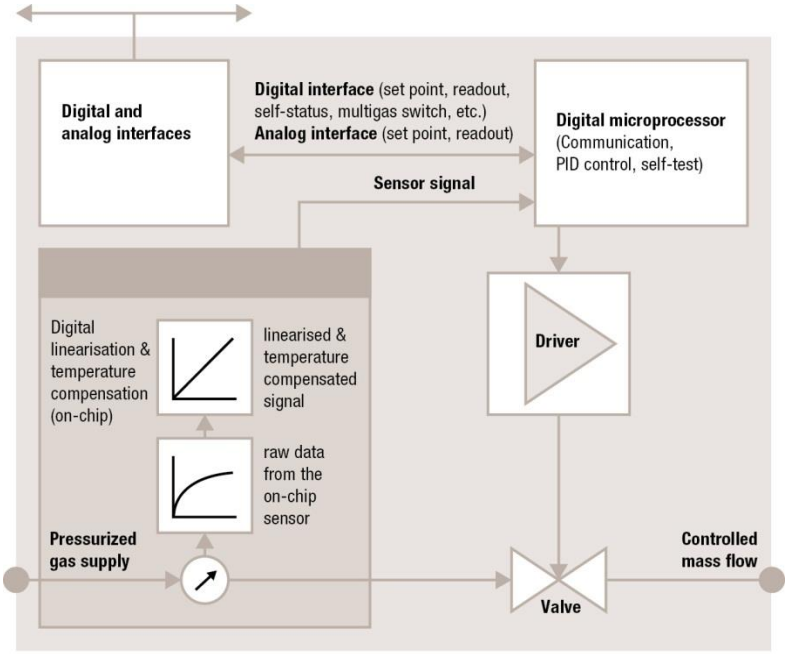


Figure 2: Block diagram CMOSens® SFC5400 mass flow controller.

Introductory Description

The CMOSens® based SFC5400 / SFM5400 measure the gas mass flow by the calorimetric principle based on 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 (see Figure 3).

MEMS based CMOSens® technology enables a larger cross section (about 1.5x1 mm^2) of the gas channel than bypass capillary diameter in conventional mass flow controllers (0.1 to 0.5 mm). This channel design makes the device more robust against particles, clogging and humidified gases. Due to the compact single-chip design and its mounting between metal parts, 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 algorithms running on an on-board microprocessor, the SFC5400 offers greatly reduced settling times compared to conventional mass flow controllers (see Figure 2).

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 large dynamic range. Thanks to its flawless design, the SFC5400 / SFM5400 mass flow controllers/meters show zero-drift performance and control/measure true mass flow independently of the ambient temperature and pressure changes.

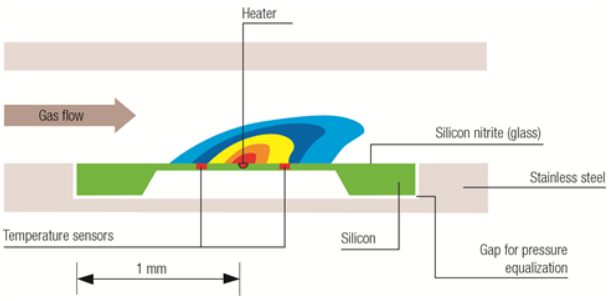


Figure 3: Cross-sectional view of gas channel.

1 CMOSens® SFC5400 / SFM5400 mass flow controller / meter performance

Table 1: Overview of CMOSens® SFC5400 / SFM5400 Mass Flow Controller / Meter Specifications
All data, unless otherwise noted, apply for the following calibration conditions: Temperature 20°C, Nitrogen (N2), 3.0 bar overpressure (inlet: 4.0 bar absolute) against atmosphere (outlet: 1.0 bar absolute), horizontal mounting position (el. connector on top), downmount connection

Specification	Value		Unit
Full scale flow	0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10	20, 50, 100, (200[1])	l_n/min or slm
Accuracy [2]	0.8	1	% s.p.[3]
whichever is greater	0.08	0.1	% FS
Repeatability whichever is greater	0.1	0.2	% s.p.
	0.01	0.02	% FS
Typical settling time [4]	100 (50 for optimized OEM versions [5])		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 [7]	Standard: SF_6, C_4F_8 OEM versions [5]: CF_4, NH_3, SiH_4, N_2O, O_3, CO, CH_4, CH_3F, 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
Pressure drop at full flow SFC5400 SFM5400	 < 2.0 / 29 < 0.1 / 1.5	 < 3.0 / 43 < 0.2 / 3	bar / psig
Maximum input pressure [8]	10 / 145		bar / psig
Maximum differential pressure [9]	5 / 73	4 / 58	bar / psig
Leak integrity MFC external	9×10^{-9}		mbar l/s He
Leak integrity through closed valve	1×10^{-6}		mbar l/s He
Warming up time [10]	1		sec

[1] Reduced performance
[2] Including offset, non-linearity and hysteresis. Measured against NIST traceable reference
[3] in % of set point (s.p.) = measured value (m.v.) = rate = reading
[4] Step answer from 10% to 100% of full scale within ±5% of set point. MFCs with analog interfaces have longer settling time due to the analog circuitry delays (typically by factor 2).
[5] Minimal order quantity of 50 units per year
[6] Specification is valid for mass flow controller only. Performance of devices with analog interface depends on wiring quality and is usually not better than 500:1
[7] 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.
[8] Pressure between flow inlet and ambient
[9] Pressure between flow inlet and flow outlet. For availability of higher differential pressure option, contact Sensirion
[10] 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.

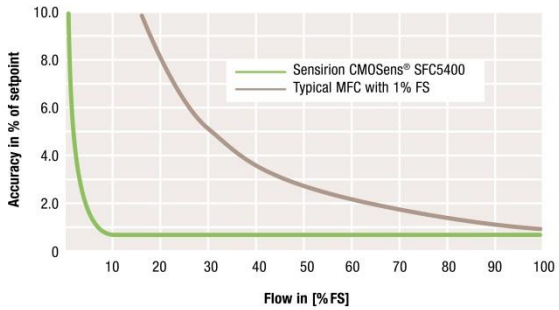


Figure 4: Accuracy comparison of the CMOSens® SFC5400 / SFM5400 device compared to a typical thermal mass flow controller / meter.

1.2 Repeatability

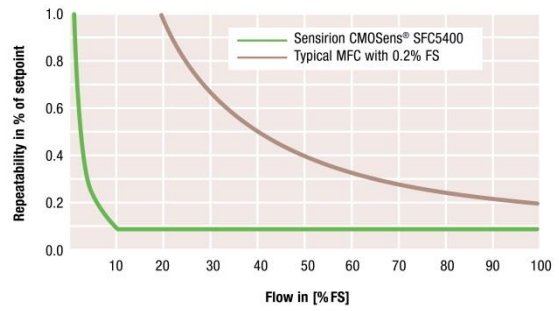


Figure 5: Repeatability comparison of the CMOSens® SFC5400 / SFM5400 device compared to a typical thermal mass flow controller / meter.

1.3 Settling time

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

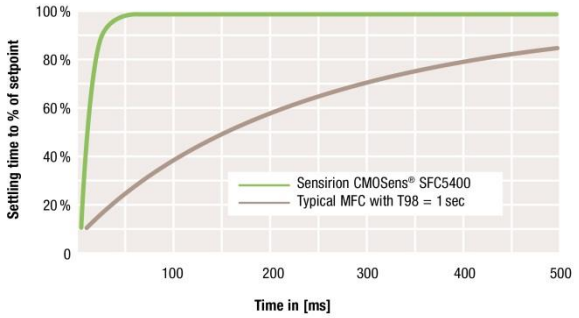


Figure 6: Settling time of the SFC5400 vs. typical thermal mass flow controller.

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 Multiple gases, ranges & gas recognition

For large OEM projects, the new SFC5400 / SFM5400 can be equipped with multigas feature allowing switching between a set of gas calibrations saved in the device memory. Similarly, different ranges for the same gas can be stored. Another interesting OEM feature is gas recognition. It allows performing a check whether the activated gas calibration matches 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).

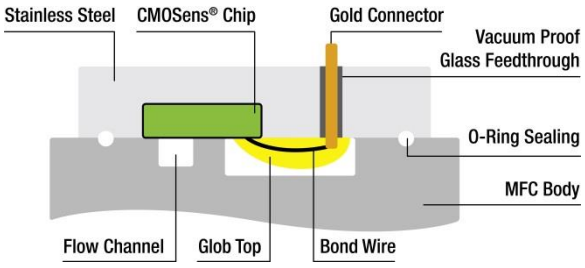


Figure 7: Vacuum tight glass feed through (longitudinal view)

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** Stainless steel or plastic on request
Sensor element	**Silicon (Si)** **Silicon oxide (SiOx)** **Silicon nitride (Si_3N_4)** **Stainless steel** **Glass** **Glob top**
Sealing	**FKM** EPDM / FFKM on request
Valve	**Brass, FKM** Stainless steel, EPDM / FFKM on request

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 60079-10) 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 the following analog and digital communication interfaces:

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

Detailed specification of the digital communication protocols can be found on the Sensirion 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:

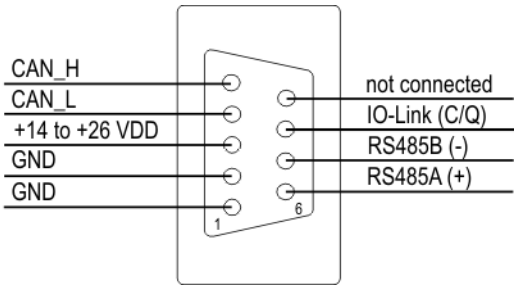


Figure 8: Digital interface version (RS485, DeviceNet and IO-Link). This version has the order code “L” (see Sec. 6).

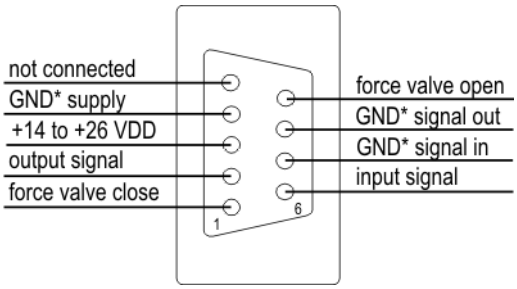


Figure 9: Standard analog only interface versions (0-5VDC, 0-10VDC, 4-20mA). These versions have order codes “U”, “W”, and “C” respectively (see Sec. 6).
*GND pins are interconnected on the PCB of the device.

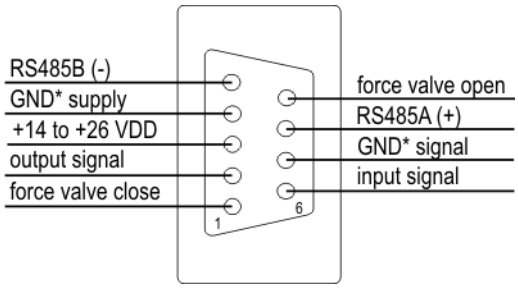


Figure 10: Analog interface versions (0-5VDC, 0-10VDC, 4-20mA) with auxiliary RS485 interface for extended functionality. RS485 interface is for service purposes only, e.g. it is not possible to set the set point using RS485. These versions have order codes “Q”, “R”, and “S” respectively (see Sec.0). Note that the pin layout of this version is not compatible to our analog only devices shown in Figure 9.
*GND pins are interconnected on the PCB of the device.

3.2 Power supply

The SFC5400 / SFM5400 mass flow controller / meter requires a standard voltage supply of +14.0 to + 26.0 VDC. There are no stringent requirements for voltage ripple and stability because of the internal voltage regulation.

3.3 Installation instructions for voltage or current controlled devices

It is important to use completely independent signal ground lines for each device. Interconnection of signal ground lines between each other or with supply ground will lead to wrong operation of MFC / MFM devices. Ground pins for signal and supply circuits are interconnected on the PCB of the device.

3.4 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 fully opens the control valve ignoring any set point.

Shut Mode: Setting 5VDC to pin 1 fully closes the control valve ignoring any set point.

3.5 Electrical specifications

Table 3: Electrical characteristics

Parameter	Conditions	Units
Analog and digital versions		
Supply Voltage Range (VDD)	Typ. 15.0 – 24.0 Max. 14.0 – 26.4	VDC
Electrical Connector	Sub-D 9pin (female on device)	
Analog version only		
Analog Input	0 – 5 VDC / 0 – 10 VDC / 4...20 mA	VDC / mA
Minimum Input Resistance	300	kΩ
Analog Output	0 – 5 VDC / 0 – 10 VDC / 4...20 mA	VDC / mA
Minimum Output Load Resistance	10	kΩ
Purge / Shut Mode active (fully open / closed)	Typ. 5.0, Range 4.5 – 30	VDC
Purge / Shut Mode inactive	0 … 1	VDC

Table 4: Current consumption

Parameter	Conditions	Typical value (within +/- 5%)	Units
Flow range equal and below 500 sccm N2			
Max. Supply Current	VDD = 15 / 24 VDC	120 / 75	mA
Standby current	VDD = 15 / 24 VDC	50 / 35	mA
Flow range higher than 500 sccm N2			
Max. Supply Current	VDD = 15 / 24 VDC	320 / 200	mA
Standby current	VDD = 15 / 24 VDC	50 / 35	mA
Mass flow meter SFM5400			
Typical	VDD = 15 / 24 VDC	50 / 35	mA

Table 5: Electromagnetic compatibility

Parameter	Hall mark	Notes	Applied values
Electromagnetic Compatibility / Immunity in Industrial Environment: (EN 61000-6-2)	EN 61000-4-2	Air discharge (ESD)	± 8 kV (air) ± 4 kV (contact)
	EN 61000-4-6	High frequency electromagnetic radiation (HF)	10 V_{eff}
	EN 61000-4-4	Fast transients (burst)	± 4 kV

4 Physical dimensions and mounting information for SFC5400 / SFM5400

Physical dimensions and mounting information for the downmount and ¼" VCR / VCO versions are provided below. All drawings are generated from SFC5400 models. SFM5400 has identical dimensions with the only difference of absent control valve.

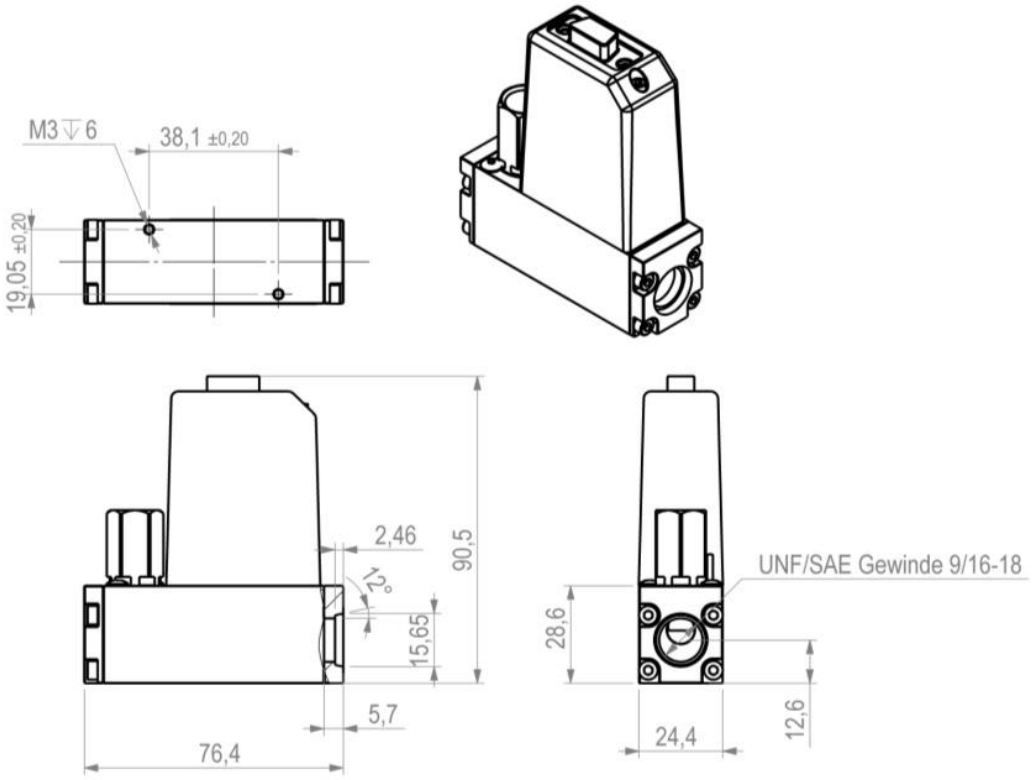


Figure 11: Physical dimensions and mounting information for the fitting versions. Specific dimensions for different types of fittings are shown in the next figure. All units are in [mm].

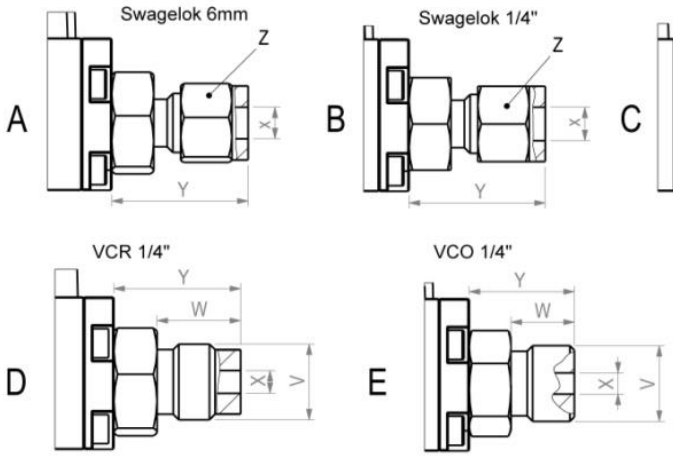


Figure 12: Physical dimensions of Swagelok, VCR and VCO fitting options.

#	V	X	Y	Z/W
A		6.0mm	24.7mm	14.0mm
B		1/4"	25.7mm	9/6“
C		1/8”	23.4mm	7/16”
D	1/4" Male VCR	4.6mm	23.9mm	15.8mm
E	1/4" Male VCO	4.6mm	19.8mm	12.0mm

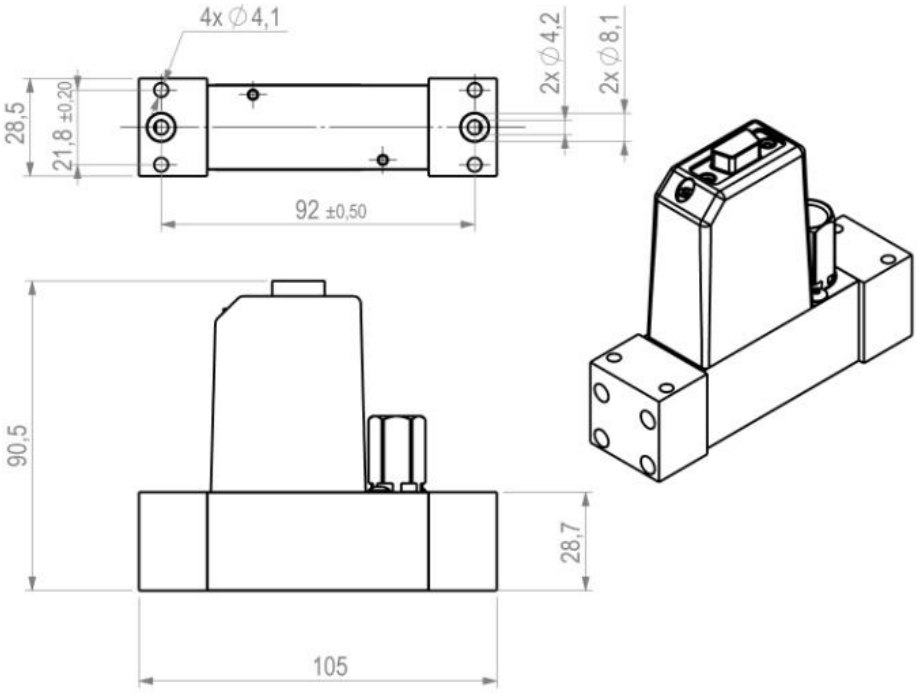


Figure 13: Physical dimensions and mounting information for the downmount version. All units are in [mm].

Table 6: Weight

Parameter	Value	Units
Mechanical		
Weight (without fittings)	215	g
Weight (down mount)	280	g
Weight (VCR / VCO)	280	g

5 Supported flow units

Table 7: 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 N_2 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 codes

SFC5400 / SFM54000 can be ordered by a product specific ordering code.

Example: SFC5400 LAG N2 500 mln/min
Code structure: Product XAZ Gas Range Unit (see Table 8 for explanation)

Table 8: Description and values for SFC5400 / SFM5400 ordering codes

Parameter	Value	Description	Where to look in this document
Product	SFC5400 SFM5400	Mass flow controller Mass flow meter	Page 1
X – Electrical Interface	U W C Q R S L	Analog voltage 0-5 VDC Analog voltage 0-10 VDC Analog current 4-20 mA Analog + service RS485 voltage 0-5 VDC Analog + service RS485 voltage 0-10 VDC Analog + service RS485 current 4-20 mA Digital RS485 & Devicenet & IO-Link	Section 3
A – Material Body	A	Aluminum (steel only on request for OEM volumes)	Table 2
Z – Fitting	5 6 7 A B D E W C F G H I	Swagelok 6mm Swagelok 1/4" Swagelok 1/8" Legris 6 mm Legris 8 mm Legris 10 mm Legris 12 mm W-seal C-seal SAE/MS; 9/16-18 UNF Thread Downmount, Manifold VCO 1/4" VCR 1/4"	Section 4
Gas	Air/N_2, H_2, O_2, He, Ar, CO_2, SF_6, C_4F_8		Table 1
Range	0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200		Table 1
Unit	mln/min ln/min sccm slm	Norm milliliter per minute Norm liter per minute Standard cubic centimeter per minute Standard liter per minute	Table 7

7 Revision history

Date	Version	Page(s)	Changes
October 2014	V10	11	
January 2016	V11	11	Fitting dimensions corrected, 200 slm FS removed, further minor corrections
September 2016	V12	All	Updated specs, introduced ordering codes

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 or 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.

CE

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

Zertifiziertes Managementsystem SQS ISO 9001

CERTIFIED IQNet MANAGEMENT SYSTEM

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