FS8000 User Manual VC.0.01

MEMS mass flow sensors
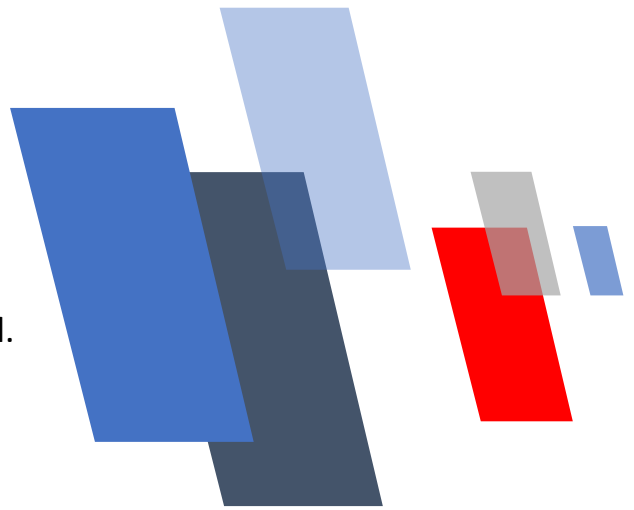
MEMS Mass Flow Sensors

with thermal calorimetric sensing technology
FS8000 Series

User Manual

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⚠ Attention !

- Please carefully read this manual prior to operating this product.

- Do not open or modify any hardware which may lead to irrecoverable damage.

- Do not use this product if you suspect any malfunctions or defection.

- Do not use this product for corrosive media or in a strong vibration environment.

- Use this product according to the specified parameters.

- Only the trained or qualified personnel shall be allowed to perform product services.

⚠ Use with caution !

- Be cautious for electrical safety, and even it operates at a low voltage, any electrical shock might lead to some unexpected damages.

- The gas to be measured should be clean and free of particles, as even light particles may be accumulated inside the tiny pressure port that may result in inaccuracy in metrology, clogging, or other irrecoverable damage.

- Do not apply for any unknown or non-specified gases that may damage the product.

Table of Contents

1. Overview

All contact information can be found at the end of this manual.

This manual provides essential information for the FS8000 series of mass flow sensors. The products are designed for applications in automation, testing, leakage detection, instrumentation, and medical applications. The FS8001 has a pure analog version with a fast response time of 1 msec which is particularly applicable for semiconductor equipment, such as die attachment and wire binder. The product performance, maintenance, and troubleshooting, as well as the information for product order, technical support, and repair, are also included.

The FS8000 sensors are manufactured with the company's proprietary MEMS (micro-electro-mechanical systems) sensing and package technology that offers primarily the mass flow rate measurements of a full scale from 30 to 500 sccm with a dynamic range of 100:1 for FS8001 and up to 6 SLPM for FS8003P. Both have a maximum pressure rating of 5 bar (75 psi).

2. Receipt / unpack of the products

Upon receipt of the products, please check the packing box before the dismantlement of the packing materials. Ensure no damages during shipping. If any abnormality is observed, please contact and notify the carrier who shipped the product and inform the distributors or sales representatives if the order is not placed directly with the manufacturer; otherwise, the manufacturer should be informed. For any further actions, please refer to the return and repair section in this manual.

If the packing box is intact, proceed to open the packing box, and you shall find the product (either FS8001 or FS8003 per the actual order), together with the power and data cable if the order is included as shown below.

FS8001 / FS8001N   FS8003P   Power and data cable
                                       SHR5-200 (FS8001 / FS8003P)
                                       SHR3-200 (FS8001N)

Figure 2.1: FS8000 flow sensor and accessories
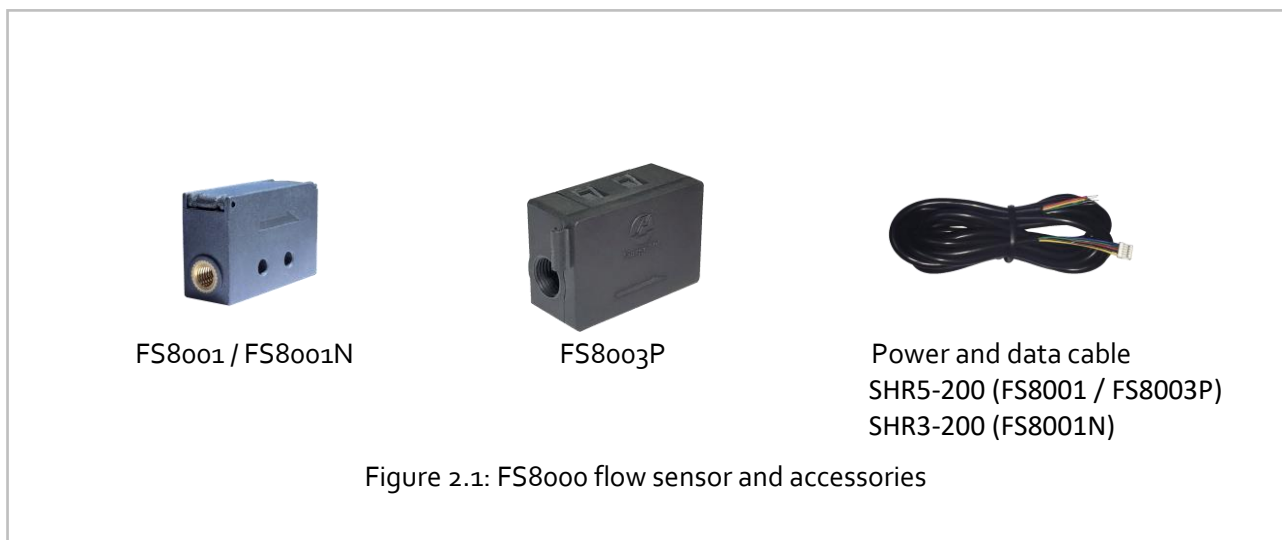
Please check immediately for the integrity of the product and the power and data cable; if any abnormality is identified, please notify the distributor/sales representative or manufacturer as soon as you can. If any defects are confirmed, an exchange shall be arranged immediately via the original sales channel. This user manual shall also be included in the packing box or via an online link for an electronic version which should be sent by your sales agent. In most cases, this manual shall be made available to the customer before the actual order.

3. Knowing the products

3.1 Product description

Direction for flow measurement.

Power and data connector.

Threaded outlet, inlet at the opposite

Installation hole
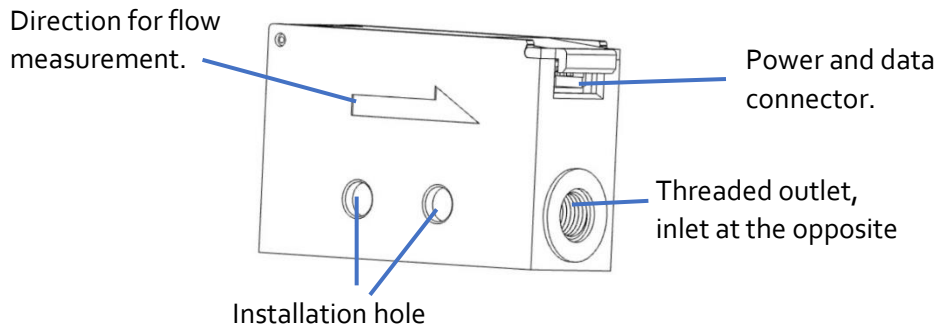
Figure 3.1: FS8001 / FS8001N description

Power and data connector.

Flow direction

Threaded inlet

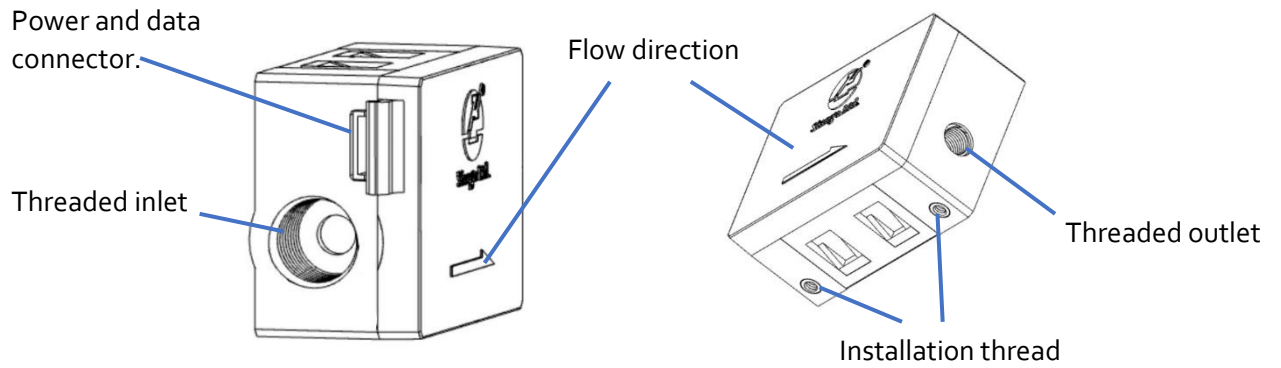Threaded outlet

Installation thread

Figure 3.2: FS8003P description

3.2 Power and data pinout description

FS8001 has two models: linearized and non-linear output. The non-linear output models only offer analog output with a response time of 1.0 msec for fast automation such as die-attachment equipment. FS8003 only offers linearized models.

Table 3.1: FS8001 linearized model pin assignment.
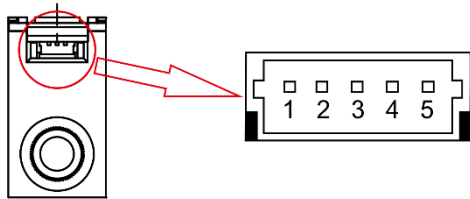
PIN	DEFINITION
1	SCL, I²C clock
2	GND, ground
3	VCC, power supply, 8~24Vdc
4	Analog output, 0.5~4.5 Vdc
5	SDA, I²C data

Table 3.2: FS8001 non-linear model (FS8001N) pin assignment.
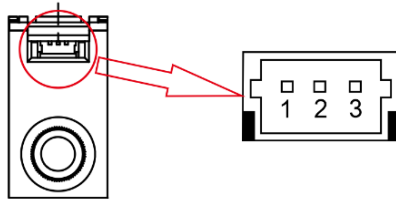
PIN	DEFINITION
1	VCC, power supply, 8~24Vdc
2	GND, ground
3	Analog output, 1~5 Vdc

Table 3.3: FS8003P pin assignment.
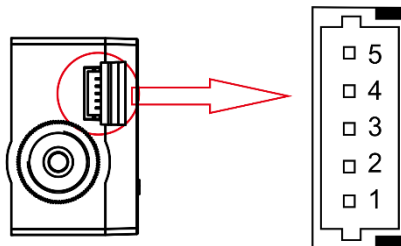
PIN	DEFINITION
1	SCL, I²C clock
2	GND, ground
3	VCC, power supply, 8~24Vdc
4	Analog output, 0.5~4.5 Vdc
5	SDA, I²C data

Note: The connector on the sensor is an SM05B-SRSS-TB manufactured by JST; the cable match is SHR-05V-S (no protrusions), also made by JST. The contact is either SH-003GA-P0.2 or SSH-003-P0.2H.

3.3 Mechanical dimensions
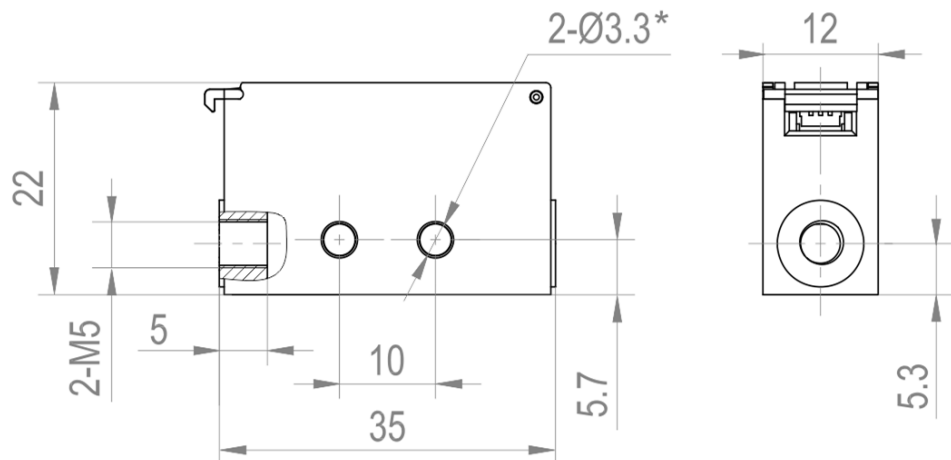
Figure 3.3: FS8001 / FS8001N mechanical dimensions.
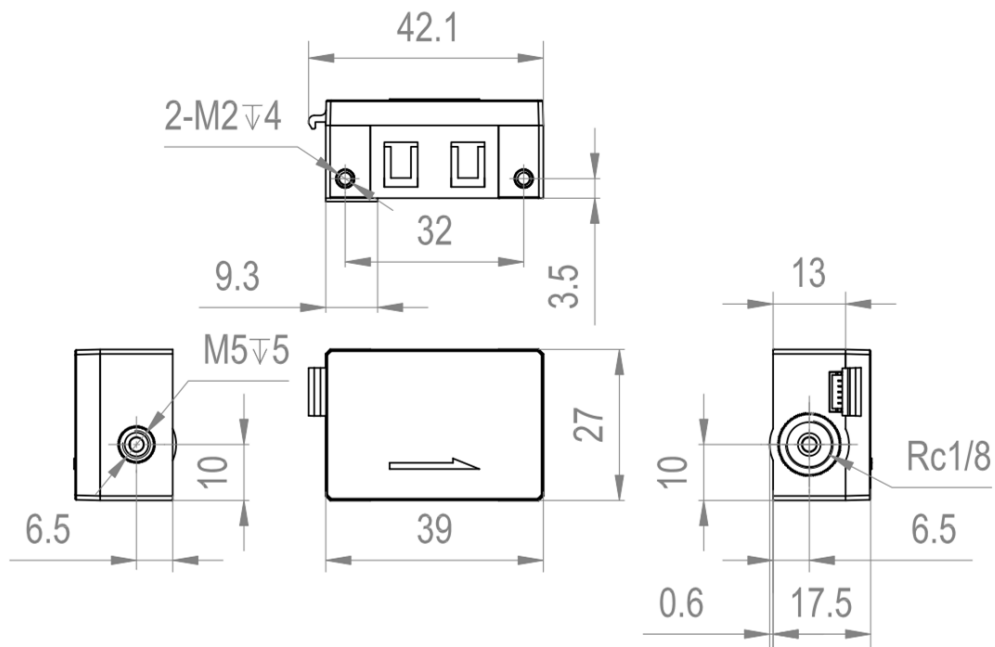
Figure 3.4: FS8003P mechanical dimensions.

4. Installation

Do not open or alter any part of the product, which would lead to malfunction and irrecoverable damage.

For the installation, the FS8001 has an installation hole fixture that can be fitted with M3 screws. Proper torque should be applied to avoid damage. The recommended torque for the M3 screw is 0.25±0.03 N m. The sensor comes with a standard data and power cable of 0.5m, users can extend the cable with a shielded counterpart. Make sure to the mechanical leakage proof of the connections and all electrical precautions are applied. Please make sure the electrical pins are properly engaged. It should be noted that the sensor is designed for medium to low pressure per the applications, therefore, the system design would be important for the flow stability and related flow noises.

5. I²C digital communication descriptions

5.1 I²C interface connection diagram
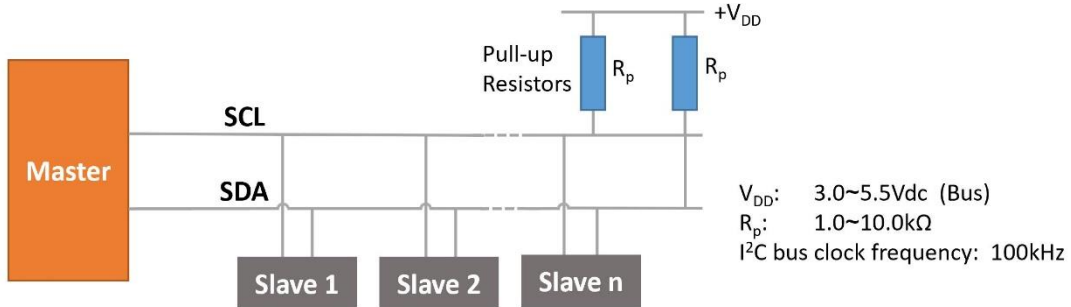
5.2 I²C interface command description

Command Byte (Hex)	Length (int 16)	Command Name	Read/Write	Notes
05H	1	I²C address	Write	Bit 0 is the R/W flag bit; Bit 1~ Bit 7 are available.
0BH	1	Filter depth	Write	Int 8, 0~254
1CH	1	Flowrate offset reset	Write	1 byte, ensure no-flow conditions
82H	12	Serial number	Read	ASCII
83H	4	Flow rate	Read	Int32(/1000 SLPM)+CRC CRC=(Byte1)xOR(Byte2)x(OR(Byte3)XOR(byte4)
85H	1	I²C address	Read	Bit 7 ~ Bit 1
8BH	1	Filter depth	Read	Int 8, 0~254

Note: The I²C address is set to Bit 7~Bit 1., e.g., if the I²C address is 1 (0000 001x), the write address will be 0x02 (0000 0010) and the read address will be 0x03 (0000 0011).

5.3 I²C interface read/write sequences

I²C reads:

Master sends addresses   Master sends commands

SDA S A6 A5 A4 A3 A2 A1 A0 0 A D15 D14 D13 D12 D11 D10 D9 D8 A D7 D6 D5 D4 D3 D2 D1 D0 A

SCL

Master sends addresses   Slave sends data (x N)

SDA S A6 A5 A4 A3 A2 A1 A0 1 A D15 D14 D13 D12 D11 D10 D9 D8 A D7 D6 D5 D4 D3 D2 D1 D0 A

SCL

x N

Slave sends data (last Int16)

SDA D15 D14 D13 D12 D11 D10 D9 D8 A D7 D6 D5 D4 D3 D2 D1 D0 S

SCL

I²C writes:

Master sends addresses   Master sends commands

SDA S A6 A5 A4 A3 A2 A1 A0 0 A D15 D14 D13 D12 D11 D10 D9 D8 A D7 D6 D5 D4 D3 D2 D1 D0 A

SCL

Master sends data (x N)

SDA D15 D14 D13 D12 D11 D10 D9 D8 A D7 D6 D5 D4 D3 D2 D1 D0 S

SCL

x N

Note:

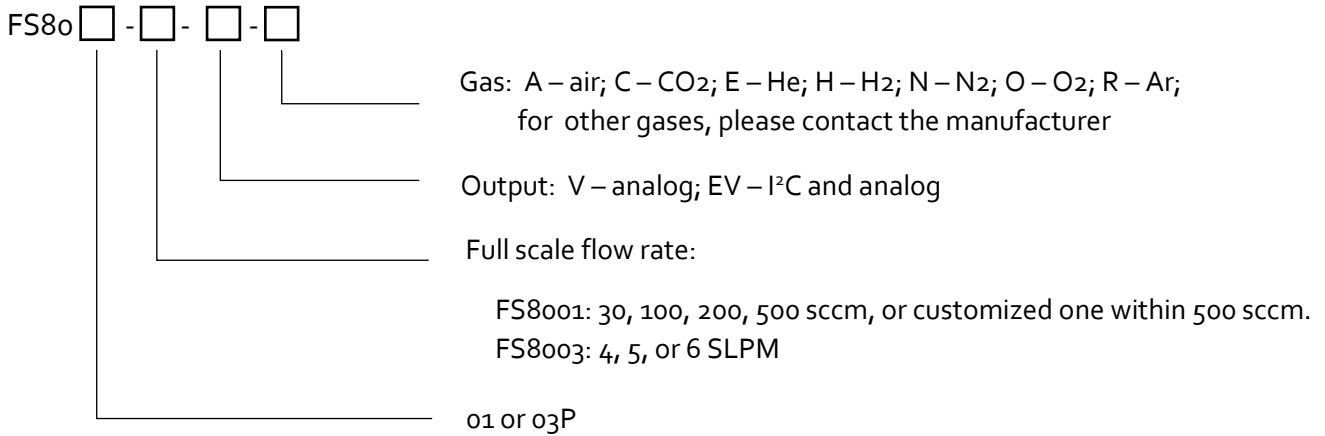| bit		
S	Start bit	Master pulls SDA from HIGH to LOW while SCL remains HIGH.
S	Stop bit	Master allows SDA to float from LOW to HIGH while SCL remains HIGH.
A	ACK	Acknowledgement
1	Read	(1 bit)
0	Write	(1 bit)
A6	Address	15 bits, bit15~bit8=0; bit7~bit1 are available. Default address: 1 (0000 0000 0000 001x)
D15	Data bit	16 bits

6. Product selection

The product part number is composed of the product model number and suffixes, indicating each of the selectable parameters. Refer to the following for details.

FS8001 linear models and FS8003P can be selected by following:

FS80☐ -☐- ☐-☐

Gas: A – air; C – CO_2; E – He; H – H_2; N – N_2; O – O_2; R – Ar;
for other gases, please contact the manufacturer

Output: V – analog; EV – I^2C and analog

Full scale flow rate:

FS8001: 30, 100, 200, 500 sccm, or customized one within 500 sccm.
FS8003: 4, 5, or 6 SLPM

01 or 03P

FS8001 nonlinear model does not have options, the model is named FS8001N.

Note: For CO_2, the maximum flow rate is 75% of the available full scale.

7. Product performance

7.1 Technical specifications

All specifications listed in the following table, unless otherwise noted, apply for standard conditions at 20°C and 101.325 kPa absolute pressure with air.

	Value	Unit
Flow range (FS8001)	0 … 30, 100, 200, 500	sccm
(FS8001N)	0 … 500	sccm
(FS8003P)	0 … 4, 5, 6	SLPM
Accuracy (total error band)	±(2.5+0.5FS)	%
Repeatability	0.1	%FS
Response time (FS8001 / FS8003P)	5.0	msec
(FS8001N)	1.0	msec
Working temperature	0~ 55	°C
Temperature coefficient	<±0.12	%/°C
Working pressure	0.5	MPa
Humidity	<95 (no condensation)	%RH
Power supply	8~24	Vdc
Working current	<20	mA
Output (FS8001 / FS8003P)	Linear, I²C; Analog: 0.5~4.5Vdc	
(FS8001N)	Nonlinear, Analog: 1.0 (±0.025) ~ 5.0 (±0.1) Vdc	
Mechanical connection (FS8001 / FS8001N)	M5	
(FS8003P)	BSPT 1/8" (inlet); M5 (outlet)	
Maximum overflow	10x of the full scale	
Maximum flow change per second	2.5x of the full scale	
Storage temperature	-20~70	°C
Calibration	Air @ 20°C, 101.325kPa	
Compliance	RoHS	
CE	IEC 61000-2;-4	

Note: 1. Calibration with real gas is optional. Please contact the manufacturer for further information.
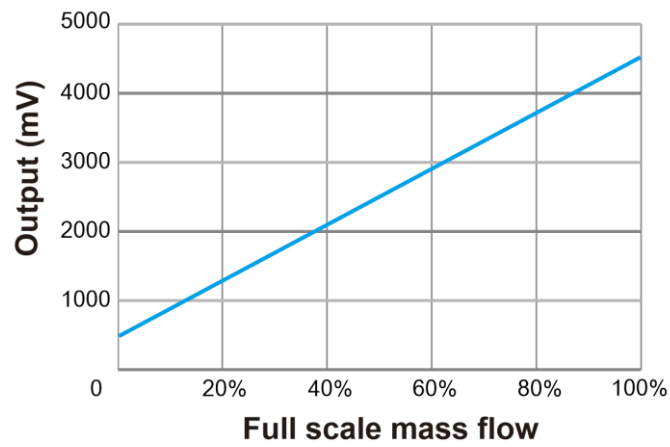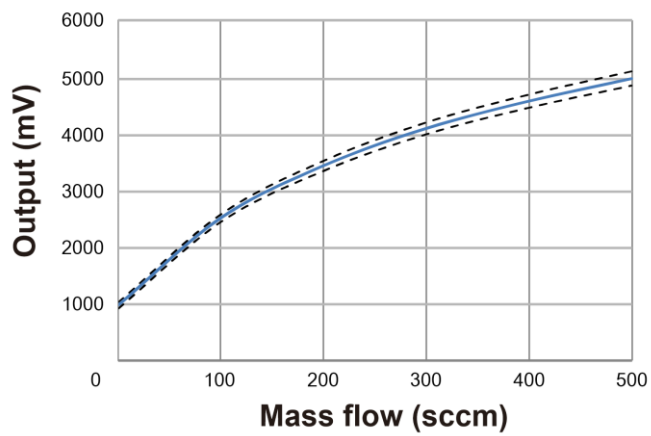
7.2 Analog output

Figure 7.1: The typical analog output of the linearized models: FS8001 and FS8003P.

Mass flow (sccm)	Typical analog output (mV)
0	1000
100	2540
200	3460
300	4060
400	4600
500	5000

Figure 7.2: The typical analog output of the non-linearized model: FS8001N.

8. Technical notes for the product performance

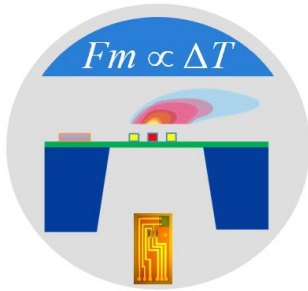## 8.1 Measurement principles

Figure 8.1: Measurement approach illustration.

The products utilize the Company's proprietary micro-machined (MEMS) calorimetric sensing and data process technology. A thermal signal generator with a pair of sensing elements up and downstream of the microheater is precisely manufactured and separated at predefined micrometer distances on a chip surface with excellent thermal isolation. When a fluid is flowing through the sensing chip, the fluid carries the thermal signal downstream. The sensing elements register the temperature differences, further correlated to the fluid mass flow rate via the calibration process.

The calorimetric sensing approach offers a large dynamic range with a better performance against the environmental parameter alternations. Please refer to the company's US patents and other publications made available to the public for additional information.

8.2 Precautions for the best performance of the product

8.2.1 Altitude changes

Unlike some other products on market, the design of the sensor has a built-in pressure balancer that prevents membrane deformation due to altitude changes. Therefore, the sensor is intrinsically insensitive to altitude change-induced errors. The specified altitude in Sec 7.1 has been fully tested.

8.2.2 Excessive humidity or condensation

The humidity change will not alter the performance of the sensor. However, if excessive humidity is present resulting in condensation, the measurement port or channel could be blocked or altered. This would result in a very unreliable data output. Please filter or other tools to prevent this situation to occur when using this product.

8.2.3   Metrology verification

Testing the products with local metrology tools will be performed in almost all cases. It should be noted that for this particular sensor, special care should be applied while performing such a task.

The gauge pressure tests are relatively simple, as long as the pressure is tested under a stable media condition, the metrology data should be well reproduced.

For the mass flowrate comparison, however, in addition to the flow system setup conditions recommended by OIML R137, a stable flow system must be ensured. This is because the current product is designed for a small pressure loss, therefore the sensor does not have a strong flow restrictor or conditioners to handle the flow instability that may exist in the system. Therefore to compare the metrology data, the user should ensure the system is stable, otherwise, the output could be noisy and metrology deviations would be inevitable.   If such cases are present, please contact the manufacturer for further solutions.

For temperature and humidity measurement, because of the small package space, the response of the humidity could be slower than specified. For additional information, please contact the manufacturer.

9. Warranty and Liability

(Effective January 2018)

Siargo warrants the products sold hereunder, properly used, and properly installed under normal circumstances and service. As described in this user manual, it shall be free from faulty materials or workmanship for 180 days for OEM products and 365 days for non-OEM products from the date of shipment. This warranty period is inclusive of any statutory warranty. Any repair or replacement serviced product shall bear the same terms in this warranty.

Siargo makes no warranty, representation, or guarantee and shall not assume any liability regarding the suitability of the products described in this manual for any purposes that are not specified in this manual. The users shall be held full responsibility for validating the performance and suitability of the products for their particular design and applications. For any misusage of the products out of the scope described herein, the user shall indemnify and hold Siargo and its officers, employees, subsidiaries, affiliates, and sales channels harmless against all claims, costs, damages, and expenses or reasonable attorney fees from direct or indirect sources.

Siargo makes no other warranty, express or implied, and assumes no liability for any special or incidental damage or charges, including but not limited to any damages or charges due to installation, dismantling, reinstallation, etc. other consequential or indirect damages of any kind. To the extent permitted by law, the exclusive remedy of the user or purchaser, and the limit of Siargo's liability for any and all losses, injuries, or damages concerning the products, including claims based on contract, negligence, tort, strict liability, or otherwise shall be the return of products to Siargo, and upon verification of Siargo to prove to be defective, at its sole option, to refund, repair or replacement of the products. Regardless of form, no action may be brought against Siargo more than 365 days after a cause of action has accrued. The products returned under warranty to Siargo shall be at the user or purchaser's risk of loss and will be returned, if at all, at Siargo's risk of loss. Purchasers or users are deemed to have accepted this limitation of warranty and liability, which contains the complete and exclusive limited warranty of Siargo. It shall not be amended, modified, or its terms waived except by Siargo's sole action.

This manual's product information is believed to be accurate and reliable at the time of release or made available to the users. However, Siargo shall assume no responsibility for any inaccuracies and/or errors and reserves the right to make changes without further notice for the relevant information herein.

This warranty is subject to the following exclusions:

(1) Products that have been altered, modified, or have been subject to unusual physical or electrical circumstances indicated but not limited to those stated in this document or any other actions which cannot be deemed as proper use of the products;

(2) Products that have been subject to chemical attacks, including exposure to corrosive substances or contaminants. In the case of battery usage, long-term discharge or leakage induced damages;

(3) Products that have been opened or dismantled for whatever reasons;

(4) Products that have been subject to working conditions beyond the technical specification as described by this manual or related datasheet published by the manufacturer;

(5) Any damages incurred by the incorrect usage of the products;

(6) Siargo does not provide any warranty on finished goods manufactured by others. Only the original manufacturer's warranty applies;

(7) Products that are re-sold by unauthorized dealers or any third parties.

10. Service/order contact and other information

Siargo Ltd. is making every effort to ensure the quality of the products. In case of questions and or product support, please contact your direct sales, or in case you need additional assistance, please contact customer service at the address listed below. We will respond to your request in a timely fashion and work with you toward your complete satisfaction.

For sales or product orders, please contact the local sales representatives or distributors that can be found on the company's webpage: www.Siargo.com.

For any returns, please contact your direct sales to obtain an RMA. In case you need any further assistance, please contact info@siargo.com to obtain additional information or a Return Materials Authorization (RMA) before shipping the product back to the factory for factory services such as calibration. Please specify as clearly as possible in your email message about the product's status that you intend to ship back to the factory, and include your shipping address. Be sure to write the RMA on the returned package or include a letter with the RMA information.

Direct customer service request(s) should be addressed to

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Phone: +01(408)969-0368
Email: info@Siargo.com

For further information and updates, please visit www.Siargo.com.

Appendix I: Sensor evaluation kit

Siargo offers a sensor evaluation kit, including a digital data converter, USB data cable, and User Application software, that allows the user to evaluate the product performance on a Microsoft Windows-based computer.   The user can read and visualize the flow rate of the product, obtain the totalized values, and save the data for further analysis.   It can read from up to 128 sensors with the I^2C interface in serial.

For further information and purchase of the evaluation kit, please contact the manufacturer or the sales representative.

Cable to connect to the product

USB cable to connect to PC

External power adapter (optional)
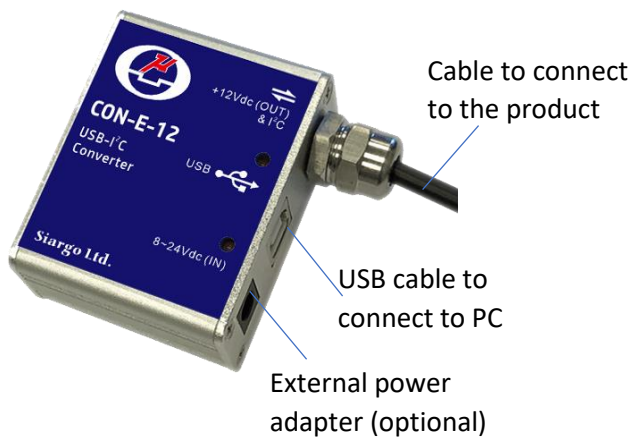
Each converter has a fixed cable that can be directly connected to the product. The USB cable connected to the PC is also included.

For most of the products, the power from the PC via the USB cable will be sufficient to power the sensor product, no external power will be required. However, for multiple sensors in serial, the power via the USB cable may not be enough, an external power adapter with 8~24Vdc will be required.
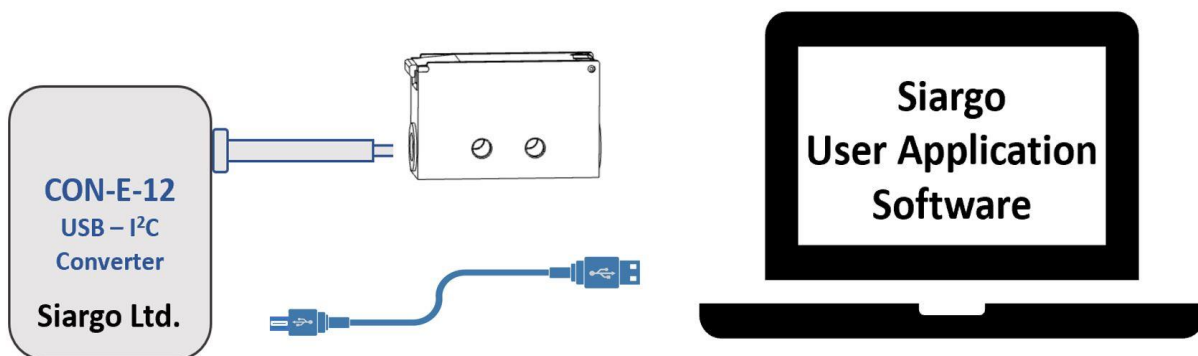
Appendix II: Document history

Revision C.0.01 (July 2022)
- Update service/sales and contact information

Revision C.0 (July 2021)
- The new format, and additions; combines FS8001, FS8001N, and FS8003 user manuals.

FS8001 Revision B.1 (October 2020):
- Revised ISO 45001.

FS8003 Revision B.0 (November 2018):
- Formulated standalone manual.
- Maximum pressure update.

FS8001 Revision B.0 (November 2018):
- Formulated standalone manual.

FS8000 Revision A.11 (August 2018):
- I^2C protocol descriptions; lifetime update.

FS8000 Revision A.10 (March 2018):
- Add maximum overflow rate and flow changes.

FS8001N Revision B.0 (November 2017):
- FS8001N user manual first release.

FS8000 Revision A.9 (April 2017):
- Added accuracy notes; cable connector information; installation screw torque; revision history.

FS8000 Revision A.8 (January 2017):
- Connector information added.