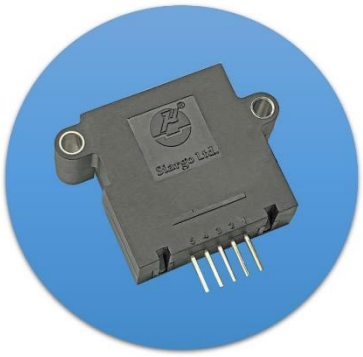
Siargo Ltd.

# FS5001L User Manual VC.0.01

MEMS Mass flow sensors for manifold installation



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# MEMS Mass Flow Sensors

**with thermal sensing technology for manifold configuration**

FS5001L Series

# User Manual

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Revision: VC.0.01

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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 FS5001L series of mass flow sensors for process control and instrumentation including gas chromatography applications. The product performance, maintenance, and troubleshooting, as well as the information for product order, technical support, and repair, are also included.

The FS5001L sensors are manufactured with the company's proprietary MEMS (micro-electro-mechanical systems) sensing and package technology, providing temperature and pressure independent mass flow sensing for a full-scale range from 200 to 15000 sccm with a maximum pressure rating of 10 bar or 150 psi.

The product provides the manifold configuration for the mechanical connections. Optionally it also opts for a stainless steel mechanical converter that offers the 4mm one-touch flexible piping.

## 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 the sensor formality per the actual order), together with the power and data cable if the order is included as shown below.

FS5001L

Power and data cable (optional)

Figure 2.1: FS5001L flow sensor and accessories

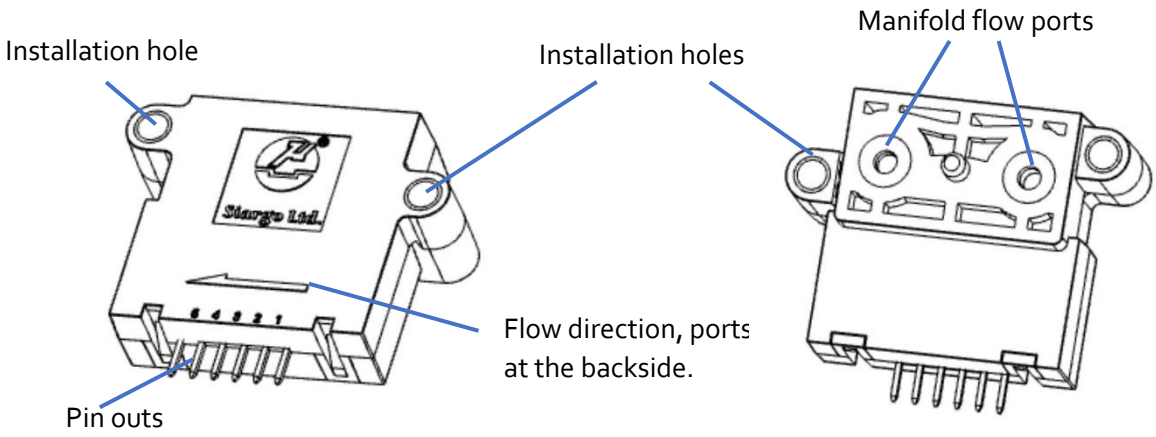
Please check immediately for the integrity of the product and the power and data cable; if any abnormality is identified, please notify the distributor/sales representative or manufacturer as soon as you can. If any defects are confirmed, an exchange shall be arranged immediately via the original sales 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.

For the purpose of preventing the sensor from over-force-related damage or malfunctions during installation, the product comes with a stainless steel installation plate, 2 screws (M3x20), and 2 O-rings (2.5x1.8).

Please note that the sensor has a pinout that is designed to be directly placed onto a printed circuitry board. Therefore, the power and data cable is an option that will not come with the order automatically. The product also is opted for a stainless steel accessory that allows the conversion of the manifold connection into 4mm one-touch connections for flexible piping.

# 3. Knowing the products

## 3.1 Product description




**Note:** The manifold base port size should not be smaller than those of the flow ports on the product.

Figure 3.1: FS5001L parts description

## 3.2 Power and data pinout description

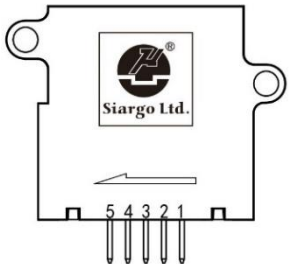



Figure 3.2: FS5001L pinout
2.54mm centers; 0.635mm square

Table 3.1: FS5001L pin assignment.

| PIN | DEFINITION |
|---|---|
| 1 | SDA, I²C data |
| 2 | Analog output, 0.5 ~ 4.5 Vdc |
| 3 | VCC, power supply, 8 ~ 24 Vdc |
| 4 | GND, ground |
| 5 | SCL, I²C clock |

**DO NOT connect or disconnect the sensor cable when power is on!! It will damage the electronic chipsets inside the sensor module!**

**Note:** 1. Power supply: The FS5001L requires a power supply of 8 ~ 24 Vdc. No particular requirements for the external power supply, but standard industrial power cautions should be applied.

2. The analog outputs 0.5 ~ 4.5 Vdc are corresponding to the specified full-scale flow range at the time of order. If the analog option is not selected, this pin output could be NULL.

3. SDA and SCL are the I²C serial data line and serial clock line, please refer to the information in the subsequent section.

## 3.3 Mechanical dimensions

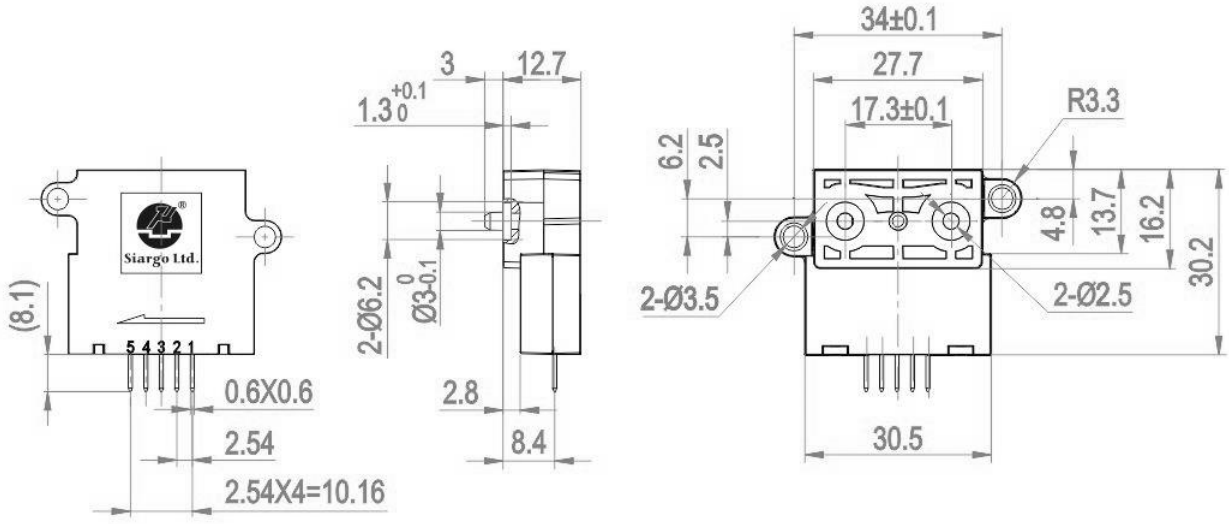



Figure 3.3: FS5001L: 0...6 SLPM model mechanical dimensions.

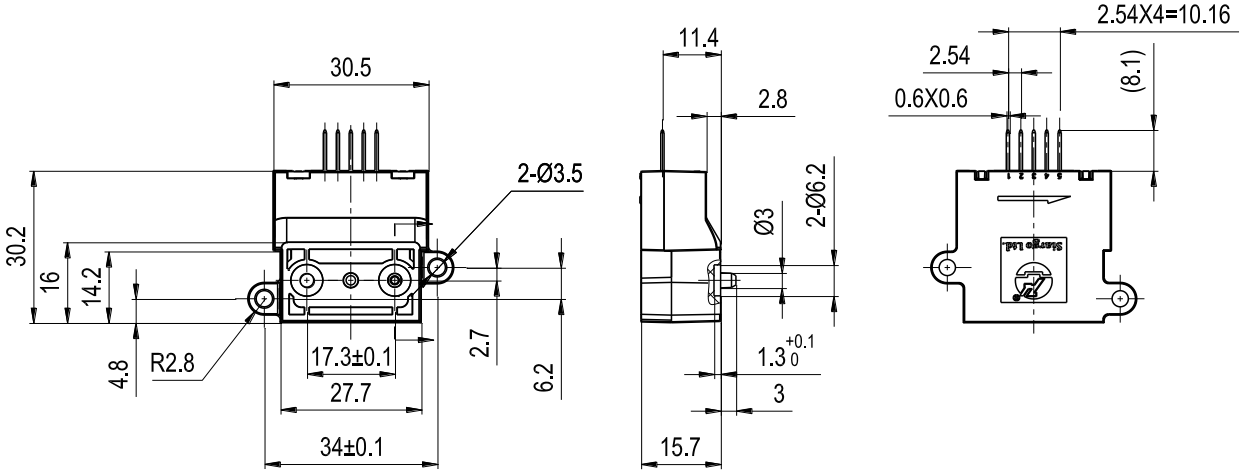



Figure 3.4: FS5001L: 0...15SLPM model mechanical dimensions.

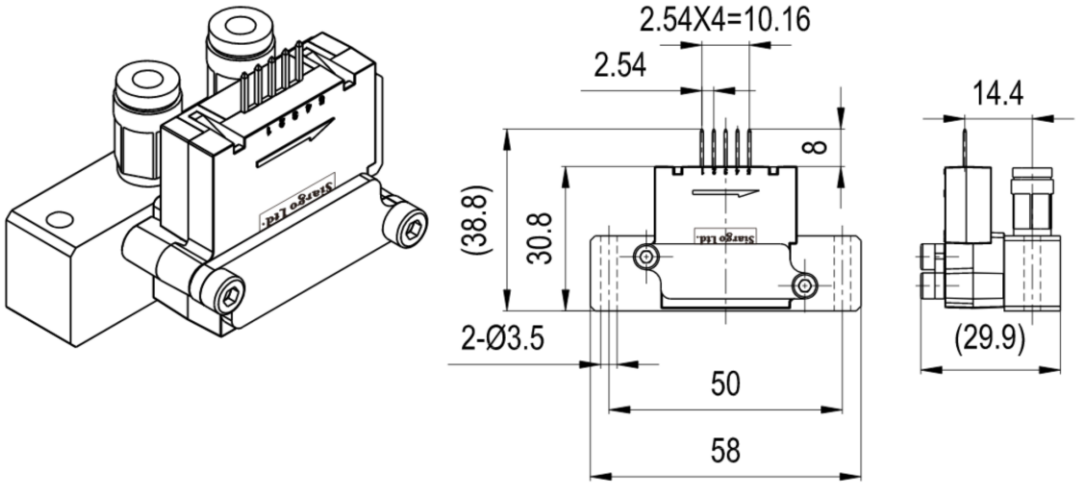



Figure 3.5: The mechanical dimensions for FS5001L with optional Φ4 mm one-touch connection block.

# 4. Installation

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

For the installation, make sure the 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.

In order to prevent over-forced installation, the product comes with a stainless steel installation plate, 2 screws (M3x20), and 2 O-rings (2.5x1.8). The mounding torque applied should be within 0.35±0.03 N·m. Please follow the following graph for the installation with the stainless steel plate.

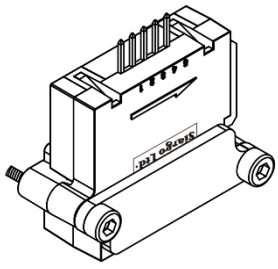
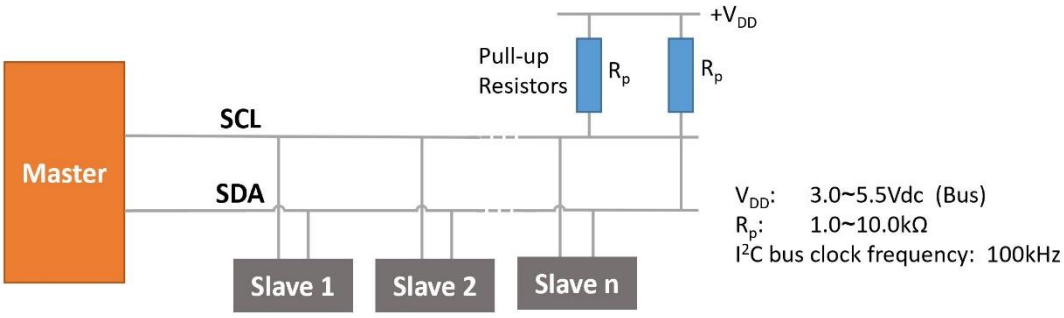


Figure 4.1: Illustration of the installation with the supplied metal plate.

# 5. Basic operation

## 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;<br>Bit 7 ~ Bit 1 are available. |
| 0AH | 1 | Write the gas conversion factor | Write | Int 16, the default value is 1000 for air |
| 0BH | 1 | Filter depth | Write | Int 8, 0 ~ 254 |
| 1CH | 1 | Flowrate offset reset | Write | 1 byte, ensure no-flow conditions |
| 9DH | 4 | Write protection | Write | 4 bytes, 0x53, 0x49, 0x41, 0x52.<br>One-time effective. |
| 82H | 12 | Serial number | Read | ASCII |
| 83H | 5 | Flow rate | Read | Int32(/1000 SLPM)+CRC<br>CRC=(Byte1)xOR(Byte2)x(OR(Byte3)XOR(byte4) |
| 85H | 1 | I²C address | Read | Bit 7 ~ Bit 1 |
| 8AH | 1 | Read the gas conversion factor | Read | Int16, the default value is 1000 for air |
| 8BH | 1 | Filter depth | Read | Int 8, 0 ~ 254 |

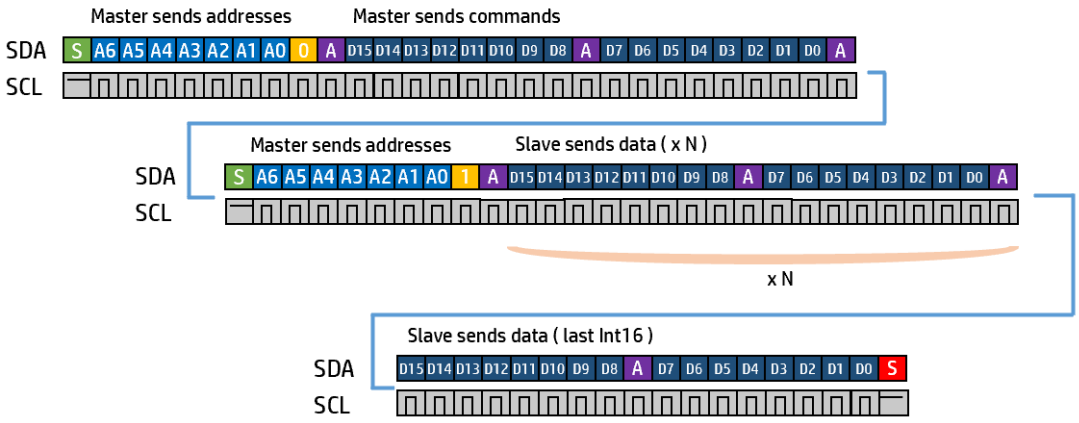
**Note:** 1. Before writing to the register, please ensure the write protection is disabled.

2. 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).

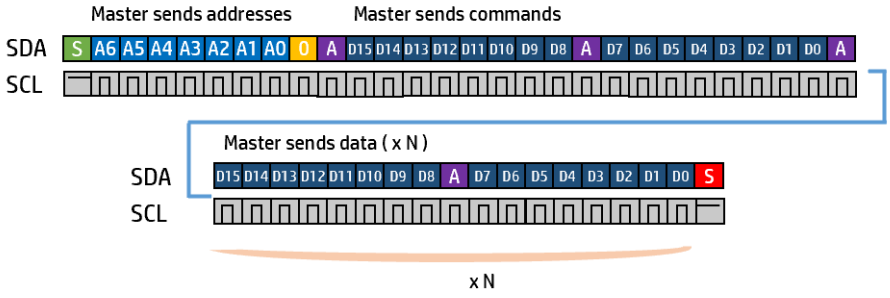
3. The write protection is a one-time effective function.

## 5.3 I²C interface read/write sequences

**I²C reads:**




**I²C writes:**

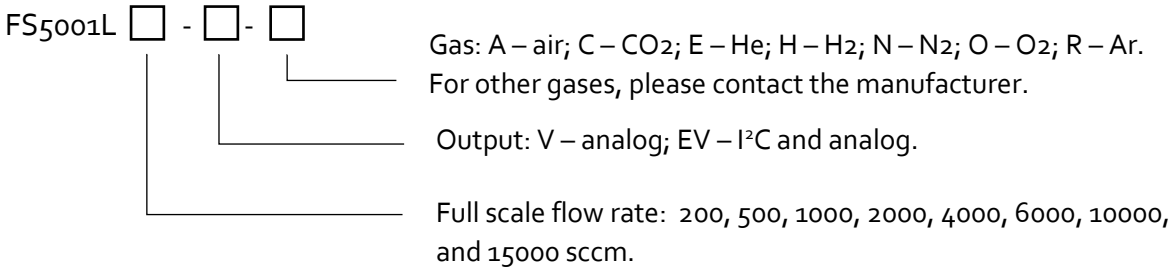



**Note:**

| 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.



# 7. Product performance

## 7.1 Technical specifications

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

| | Value | Unit |
|---|---|---|
| Flow range | 0 ~ 200, 500, 1000, 2000, 4000, 6000, 10000, 15000 | sccm |
| Accuracy | ±(2.0+0.5FS) | % |
| Repeatability | 0.5 | % |
| Turn-down ratio | 100:1 | |
| Response time* | 10 | msec |
| Temperature range | -10 ~ 55 | °C |
| Temperature coefficient | ±0.12 | %/°C |
| Pressure range | -0.08 ~ 0.5 | MPa |
| Maximum pressure | 1.0 (150) | MPa (psi) |
| Humidity | <95, no condensation | %RH |
| Analog null shift | ±30 | mV |
| Power supply | 8 ~ 24 | Vdc |
| Working current | 50 | mA |
| Output | Linear, analog 0.5 ~ 4.5 Vdc / I²C | |
| Analog load | Sourcing: 25 / Sinking: 15 | mA |
| Maximum overflow | 3000 (3SLPM) (200, 500, 1000 models);<br>18000 (18 SLPM) (2000, 4000, 6000 models)<br>45000(45SLPM) (10000, 15000 models) | sccm (SLPM) |
| Maximum flow change | 500 (200, 500, 1000 models);<br>3000 (2000, 4000, 6000 models)<br>7500(10000, 15000 models) | sccm/sec |
| Calibration | Air @ 20°C, 101.325 kPa | |
| Storage temperature | -20 ~ +70 | °C |
| Compliance | RoHS; REACH | |
| CE | IEC 61000-4-2; 4-8 | |

**Note:** 1. Allow the product to warm up for 60 seconds for the best performance.

2. Response time shown is the default. It can be programmed to the fastest <2 msec.

## 7.2 Typical (analog) output

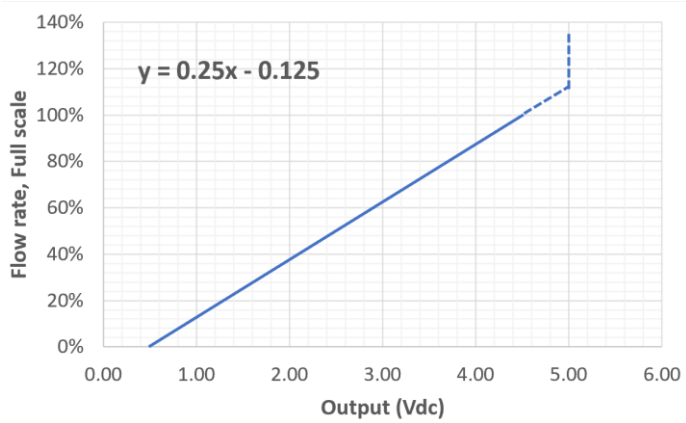



Figure 7.1: Typical analog output

## 7.3 Pressure loss

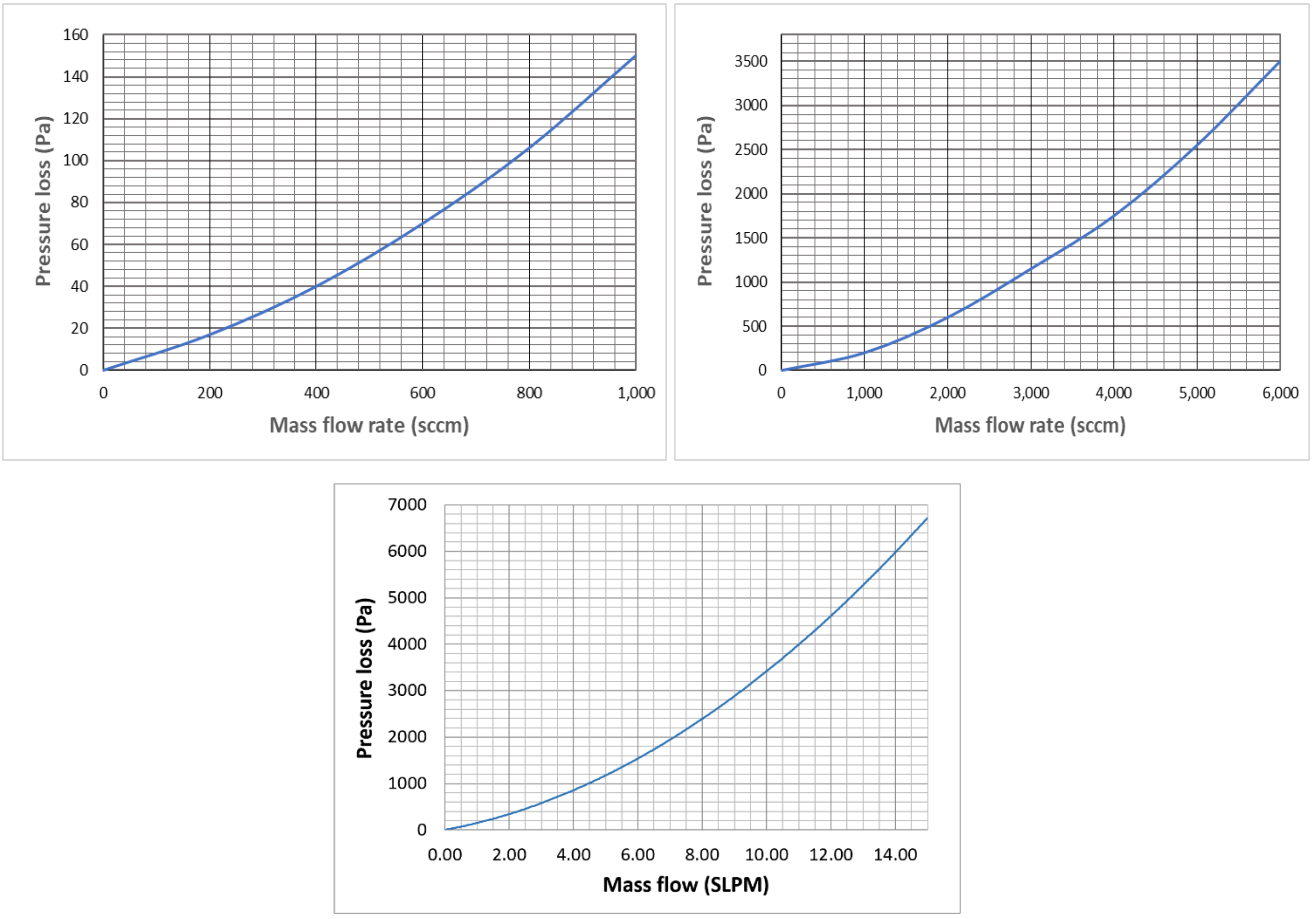



Figure 7.2: Upper row: from left to right, for models of full scale up to 1000 sccm; and of full scale from 2000 to 6000 sccm. Lower row: models of full scale from 10000 to 15000 sccm (10 to 15SLPM).

# 8. Technical notes for the product performance

## 8.1 Measurement principles

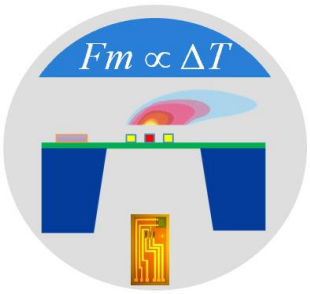



Figure 8.1: Measurement approach illustration.

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 Contamination and sterilization

It is critical to have the measurements performed in a contamination-free environment for data accuracy. Excessive contaminants such as vapors will lead to data deviation or even product malfunctions in severe cases.

For medical applications, it may be desired to have the product to be sterilized from time to time. A standard EtO sterilization process is recommended. For the detailed procedure please consult your local experts or contact the manufacturer.

### 8.2.2 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.

### 8.2.3 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.

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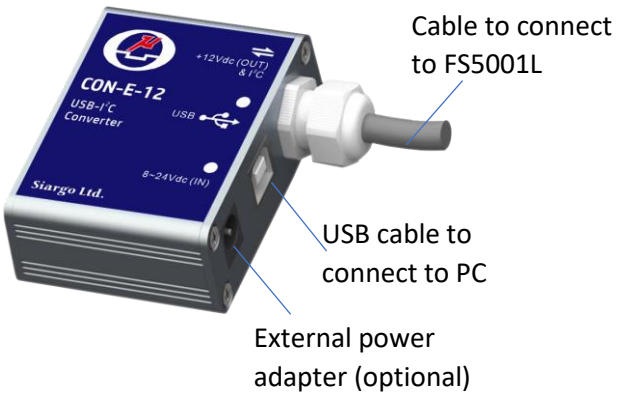
Phone: +01(408)969-0368
Email: info@Siargo.com

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

# Appendix I: Sensor evaluation kit

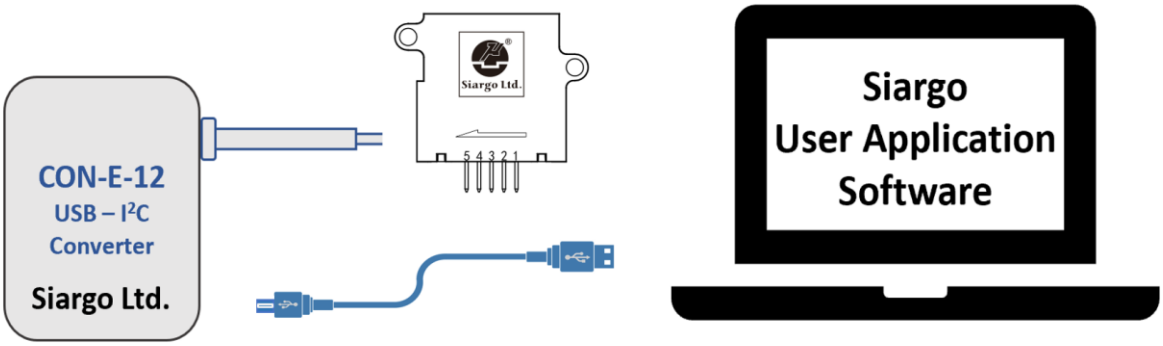
Siargo offers a sensor evaluation kit, including a digital data converter, USB data cable, and User Application software, that allows the user to evaluate the product performance on a Microsoft Windows-based computer. The user can read and visualize the flow rate of the product, obtain the totalized values, and save the data for further analysis. It can read from up to 128 sensors with the I²C interface in serial.

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




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 ~ 24 Vdc will be required.



## Appendix II: Document history

**Revision C.0.01 (July 2022):**

- Update service and sales contact.

**Revision C.0 (May 2022):**

- Addition of 15L/min model, and minor changes.

**Revision B.0 (July 2021):**

- The new format, with additions.

**Revision A.8 (June 2021):**

- Update maximum pressure, and revise the $I^2C$ voltage symbol.

**Revision A.7 (October 2020):**

- Revised ISO 45001.

**Revision A.6 (June 2018):**

- Revised the $I^2C$ commands.

**Revision A.5 (December 2018):**

- Revised the pressure drop;
- Revised the $I^2C$ command description.

**Revision A.4 (June 2018):**

- Corrected the features.

**Revision A.3 (April 2018):**

- Added the mounting information.

**Revision A.2 (March 2018):**

- Updated the photo;
- Revised the packaging material to PBT;
- Corrected the mechanical dimensions to 40.6 x 36.3 x 15.7 $mm^3$;
- Revised the $I^2C$ command description;
- Revised the wetted materials.

**Revision A.1 (December 2017):**

- Added the $I^2C$ commands of response time.