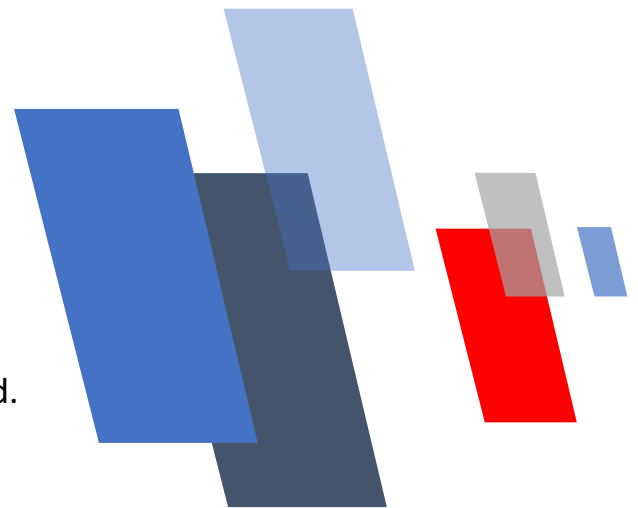




FS4100 User Manual

VA.1.01

MEMS mass flow sensors



Gas Mass Flow Sensor

With proprietary thermal-D[®] sensing technology

FS4100 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 deflection.
- 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 the electrical safety, 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. Do not apply this meter for liquid medium.
- Do not apply for any unknown or non-specified gases that may damage the product.
- For remote data, please be sure the meter is properly configured.

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1. Overview

This manual provides essential information for the operation of the FS4100 series of gas mass flow sensors for general-purpose gas flow monitor and control applications with the full-scale mass flow rate from 2 to 50 SLPM, and both analog and digital outputs. The product performance, maintenance, and troubleshooting as well as the information for product order, technical support, and repair are also included.

FS4100 mass flow sensors are an upgraded version of the third generation of FS4000 sensors that were first released in 2008. It can be applied for a number of medical equipment such as anesthesia applications, endoscopes, and cancer treatment; industrial applications including welding machines, laser equipment, gas mixture; and many more. The series covers a wide dynamic flow range with a working pressure rating of up to 0.5 MPa (5 bar or 73 PSI), and a compensated temperature ranging from -10 to 55°C.

The products are designed with an easy change of mechanical connectors. The standard connectors are BSPT 1/4" or one-touch connectors, and other customized ones are available upon request.

The sensing elements are manufactured with Siargo's proprietary MEMS (micro-electro-mechanical systems) thermal mass flow sensing technologies (Thermal-D®) that measures the calorimetry and diffusivity of the flow medium. The sensor surface is passivated with silicon nitride ceramic materials together with a water/oil proof nano-coating for performance and reliability. Compared to the conventional calorimetric flow sensing technology, this unique sensing approach offers better linearity, removes gas sensitivity for gases with similar thermal diffusivities, and improves temperature performance. It can also auto-recognize pre-programmed gases with significant differences in thermal diffusivity. It is the first of the kind in the industry that senses the mass flow with multiple gases without a manual gas conversion factor. As such, it ensures high precision for gas measurements with air calibration.

The current product also has a much smaller form factor compared to the previous versions.

Thermal-D® is a trademark of Siargo's thermal sensing technology.

2. Receipt / unpack of the products

Upon receipt of the products, please check the packing box before dismantling 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 as well. 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. The power and data cable (part number: SN5-50) as shown below may also be found according to the same packing materials.



Figure 2.1: FS4100 flow sensor



Figure 2.2: power and data cable SN5-50

Please check immediately for the integrity of the product as well as 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 either be included in the packing box or via an online request for an electronic version. In most cases, this manual shall be made available to the customer before the actual order.

The standard cable (part number: SN5-50) has an AMPMODU MTE (5 positions) compatible connector with a length of 0.5 meters.

3. Knowing the products

3.1. Product description

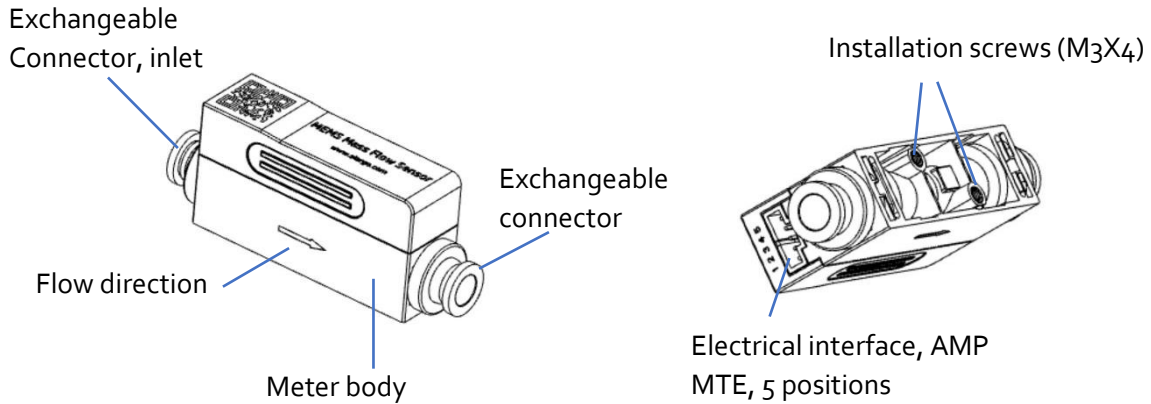


Figure 3.1: FS4100 parts description

3.2. Power and data cable description

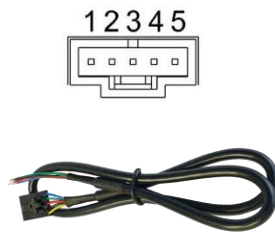


Figure 3.2: FS4100 connection and cable

Table 3.1: FS4100 pin/wire assignments.

| Wire | Color | Definition |
|------|--------|------------------------------------|
| 1 | Blue | RS485 B(+) / SDA(I ² C) |
| 2 | Green | Analog output, 0.5 ~ 4.5 Vdc |
| 3 | Red | Power supply, 8 ~ 24 Vdc |
| 4 | Black | Ground |
| 5 | Yellow | RS485 A(-) / SCL(I ² C) |

- Note:**
1. The standard cable (part number: SN5-50) has an AMPMODU MTE (5 positions) compatible connector with a length of 0.5 meters.
 2. The RS485 Modbus is asynchronous, half-duplex communication. When the data are transmitted or received from the product, the other pin is serving as the ground.

3.3. Mechanical dimensions

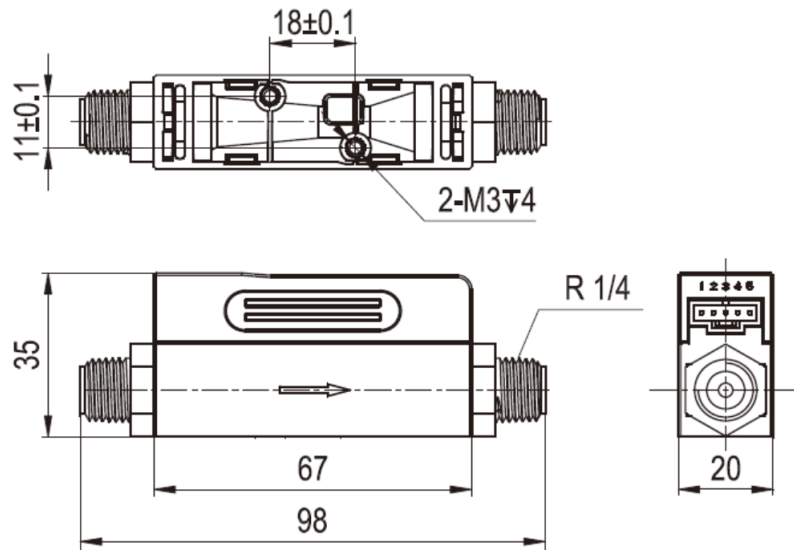


Figure 3.3: FS4100 dimensions with BSPT 1/4" (R 1/4") connectors

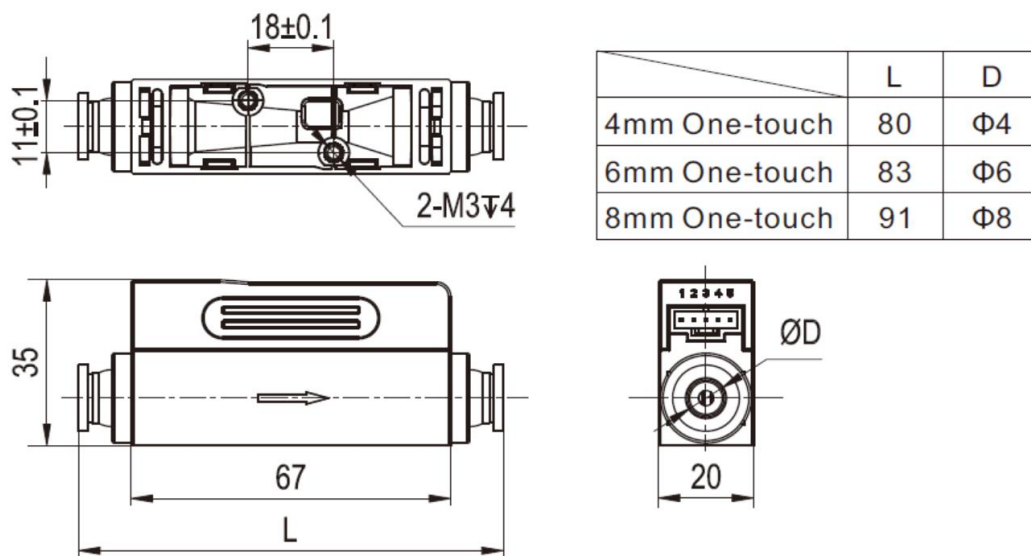


Figure 3.4: FS4100 dimensions with one-touch connectors

Note: * Other threads or compressive types can be customized.

** The mounting screw length is <4mm; and the suggested mounting torque is <0.25 N·m.

4. Installation

Do not open or alter any part of the product which would lead to malfunction and irrecoverable damage. It will also forfeit the terms of the warranty and cause liability.

The product at the time of shipment is fully inspected for its quality and meets all safety requirements. Additional safety measures during the installation should be applied. This includes, but is not limited to the leakage verification procedures, standard ESD (electrostatic discharge) precautions, and DC voltage precautions. Other tasks such as calibration, part replacement, repair, and maintenance must only be performed by trained personnel. Upon request, the manufacturer will provide necessary technical support and/or training for the personnel.

There are no preferred space directions for the installation. The flow direction should be aligned with the arrow mark on the meter body. If the flowing fluid may have particles or debris, a filter is strongly recommended to be installed upstream of the meter.

Please follow the following steps to complete the installation:

- a) Upon opening the package, the product's physical integrity should be inspected to ensure no visual damage.
- b) Before installation of the product, please ensure that the pipe debris or particles or any other foreign materials are completely removed.
- c) Close the upstream valve, if any, completely.
- d) During installation, please make sure no foreign materials (such as water, oil, dirt, particles, etc.) enter the installation pipeline.
- e) Connect electrical wires per the wire definition in Table 3.1. Please be sure of the power supply range (i.e., 8 ~ 24 VDC) and power supply polarization. If an adapter is used, make sure the adapter meets industrial standards and has all safety certifications. Alternatively, this product can also be powered by a 9Vdc battery.
- f) For the data communication wire connection, please follow the description in Table 3.1 and make sure that the wires are correctly connected to the proper ports on your data device/equipment. Please make sure the data cable meets industrial standards with proper shielding.
- g) Slowly open the valve(s) of the gas supply if any, upstream or downstream, or both of the pipelines. the product should then start to measure the flow in the pipeline.

Note: because the meter has a large dynamical measurement range, it could be normal if you see the small instant flow rate even if there is “no flow” in the pipeline. If the value is consistently present, double-check the pipe leakage and then reset the offset if you are sure there is no leakage or flow.

- h) This will conclude the installation.



Cautions

- a) Don't alter any parts of the product.
- b) Ensure the electrical connection is properly done per the instructions.
- c) Make sure no mechanical stresses in the connections.
- d) The strong electromagnetic interference sources close by or any mechanical shocks at the pipeline may also create malfunctioning of the product.
- e) Slowly open/close valves at the gas supply piping to prevent abrupt pulse flow impact.

5. Operation

5.1 Check the product specifications

Before starting to use this product, check the product specifications that can be found in this manual or the basic information from the datasheet at the company's website www.Siargo.com.

The detailed product technical specifications can be found in Section 7. For a specific application, the pressure rating must not be higher than the system pressure to be measured, and the flow range should also be within the specified ones. In most cases, the use of a high full-scale ranged meter for the very low flow rate measurement often results in erroneous data. The gas to be measured must also be consistent with that specified by the product. Be particularly cautious about the supplied voltage indicated in the specification. A higher voltage may lead to irrecoverable damage, and a lower voltage will not power the product for any desired functions.

For the best performance of the product, it is advised that the gas to be measured must be clean and free of particles or other foreign materials.

5.2 Check the leakage

Check gas leakage before any measurement. If it is needed, pressurized nitrogen or air can be used for the leakage check.

5.3 Power the product and digital data connection

Although this product complies with the CE-required EMC regulations, it also requires the product to be used according to the standard electrical device practice. Before connecting the product with external DC power or an AC-DC adapter, make sure the supply voltage is within the range of the specified ones in Section 7. Be cautious that standard electrical device precautions such as ESD (electrostatic discharge) and DC voltage are observed. Excessive electrostatic discharge may damage the product.

The manufacturer-supplied power and data cable have a locking fixture. Lock the cable and make sure it is properly engaging and will not be accidentally got unplugged.

Half-duplex RS485 Modbus is used for digital data communication. Make sure the wires are properly connected to the receiver side.

5.4 RS485 Modbus communication protocol

The digital communication protocol is based on standard Modbus RTU Half-plex mode. A master (PC or PLC) can communicate with multiple slaves (the current product) for data exchange and communication parameter configuration. Refer to Table 3.2 for cable connection.

5.4.1 Hardware connection

The RS485 hardware layer is TIA/EIA-485-A, as illustrated below. In this configuration, the product (FS4100) is a slave.

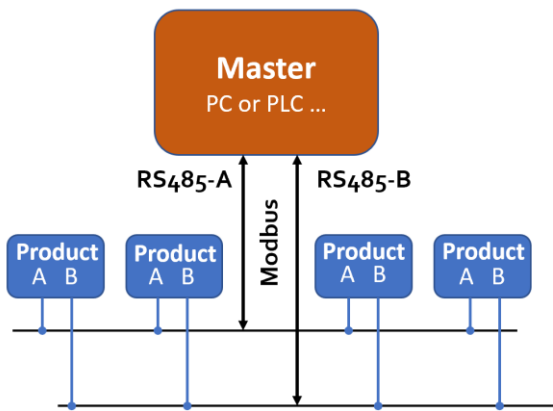


Figure 5.1: RS485 hardware

5.4.2 Communication parameters

The PC UART communication parameters are listed in table 5.1.

Table 5.1: PC UART communication parameters

| Parameters | Protocol |
|-----------------------------|-----------------|
| | RTU |
| Baud rate (Bits per second) | 38400 bps |
| Start bits | 1 |
| Data bits | 8 |
| Stop bits | 1 |
| Even/Odd parity | None |
| Bits period | 104.2 μ sec |
| Bytes period | 1.1458 msec |
| Maximum data length | 20 |
| Maximum nodes | 247 |

5.4.3 Frame

The frame function is based on the standard Modbus RTU framing:

Table 5.2: frame function

| Start_bits | Address | Function codes | Data | CRC | Stop_bits |
|--|---------|----------------|------------------|--------|--|
| T ₁ -T ₂ -T ₃ -T ₄ | 8 bit | 8 bit | N 8 bit (20≥n≥0) | 16 bit | T ₁ -T ₂ -T ₃ -T ₄ |

Start_bits: 4 periods bit time, for a new frame.

Address: The address can be set from 1 to 247 except for 157 (0x9d). 0 is the broadcast address.

Function codes: Define the product's functions/actions (slaves), either execution or response.

Data: The address of the register, length of data, and the data themselves.

CRC: CRC verification code. The low byte is followed by the high byte. For example, a 16-bit CRC is divided into BYTE_H and BYTE_L. In the framing, the BYTE_L will come first, then followed by the BYTE_H. The last one is the STOP signal.

Stop_bits: 4 periods bit time, for ending the current frame.

5.4.4 Function codes

The Modbus function codes applied for the product are the sub-class of the standard Modbus function codes. These codes are used to set or read the registers of the product:

Table 5.3: function codes

| Code | Name | Functions |
|------|------------------------|----------------------------------|
| 0x03 | Read register | Read register(s) |
| 0x06 | Set single register | Write one single 16-bit register |
| 0x10 | Set multiple registers | Write multiple registers |

5.4.5 Registers

The product (FS4100) has multiple registers available for the assignment of the various functions. With these functions, the user can obtain the data from the products, such as *product address* and *flow rates* from the registers, or set the product functions by writing the corresponding parameters.

The currently available registers are listed in the following table, and the registers may be customized upon contacting the manufacturer. Where R: read; W: write-only; W/R: read and write.

Note: At the time of shipping, the write protection function is enabled except for address and baud rate. Once the user completes the register value change, the write protection will be automatically enabled once again to prevent incidental data loss.

Table 5.4: Registers

| Functions | Description | Register | Modbus |
|----------------------|---|-----------------|----------------|
| Address | Product address (R/W) | 0x0081 | 40130 (0x0081) |
| Serial number | Serial number of the product (R) | 0x0030 | 40049 (0x0030) |
| Flow rate | Current flow rate (R) | 0x003A ~ 0x003B | 40059 (0x003A) |
| Baud rate | Communication baud rate (R/W) | 0x0082 | 40131 (0x0082) |
| GCF | Gas conversion factor (R/W) | 0x008B | 40140 (0x008B) |
| Digital filter depth | Response time or sampling time (R/W) | 0x008C | 40141 (0x008C) |
| Offset calibration | Offset reset or calibration (W) | 0x00Fo | 40241 (0x00Fo) |
| Write protection | Write protection of selected parameters (W) | 0x00FF | 40256 (0x00FF) |

The detailed information of each register is described below: Y: enabled; N: disabled

| | | | |
|--------------------|--|--------------|---|
| Address | 0x0081 | Write | Y |
| | | Read | Y |
| Description | Address of the product | | |
| Value type | UINT 16 | | |
| Notes | Values from 1 to 247 except for 157 (0x9d). The broadcast address is not enabled, and the default address is 1. | | |

| | | | |
|--------------------------|--|--------------|---|
| SN, Serial number | 0x0030 | Write | N |
| | | Read | Y |
| Description | Series Number of the product, SN | | |
| Value type | UINT 8 (12 bits) | | |
| Notes | SN= value(0x0030), value(0x0031),...,value (0x0035); Receiving 12 bits as: 2A 41 31 42 32 33 34 35 36 2A , the corresponding Serial Number is **A1B23456**. | | |

| | | | |
|--------------------|---|--------------|---|
| Flow rate | 0x003A ~ 0x003B | Write | N |
| | | Read | Y |
| Description | Current flow rate | | |
| Value type | UINT 16 | | |
| Notes | Flow rate = [Value (0x003A) * 65536 + value (0x003B)] / 1000 e.g.: When the user reads "0" from register 0x003A and "20340" from register 0x003B, current flow rate = (0 * 65536 + 20340) / 1000 = 20.340 SLPM | | |

| | | | |
|--------------------|---|--------------|---|
| Baud rate | 0x0082 | Write | Y |
| | | Read | Y |
| Description | Communication baud rate | | |
| Value type | UINT 16 | | |
| Notes | 0: baud rate=4800; 1: baud rate=9600; 2: baud rate=19200; 3: baud rate=38400. The default value is 3. e.g.: When the user reads "3" from register 0x0082, the baud rate is 38400. | | |

| | | | |
|-------------|---|-------|---|
| GCF | 0x008B | Write | Y |
| | | Read | Y |
| Description | The gas conversion factor for applicable gas is different from calibration gas | | |
| Value type | UINT 16 | | |
| Notes | The GCF of air is 1000 (default), normally read from register 0x008B. Note: The product will disable this function with write protection once the metering gas is confirmed with the proper GCF. For a specific GCF value, please contact the manufacturer. | | |

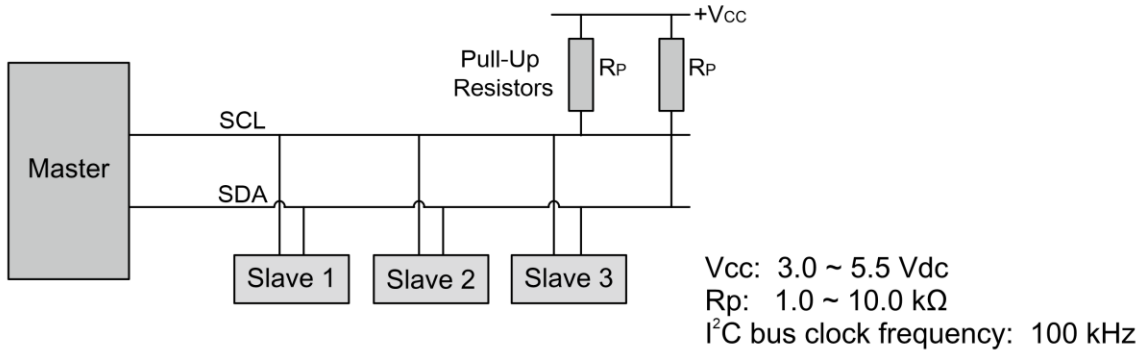
| | | | |
|---------------|--|-------|---|
| Response time | 0x008C | Write | Y |
| | | Read | Y |
| Description | Digital filter depth setting | | |
| Value type | UINT 16 | | |
| Notes | 0 ~ 9 programmable, corresponding to $2^0 \sim 2^9$ data sampling in the software filter. The default value is 3, corresponding to $2^3 = 8$ data sampling. | | |

| | | | |
|--------------------|--|-------|---|
| Offset calibration | 0x00Fo | Write | Y |
| | | Read | N |
| Description | Reset or calibrate the offset | | |
| Value type | UINT 16, Fixed value 0xAA55 | | |
| Notes | To reset or calibrate the offset, write 0xAA55 to register 0x00Fo. Note: When you execute this function, make sure there is NO flow in the flow channel. | | |

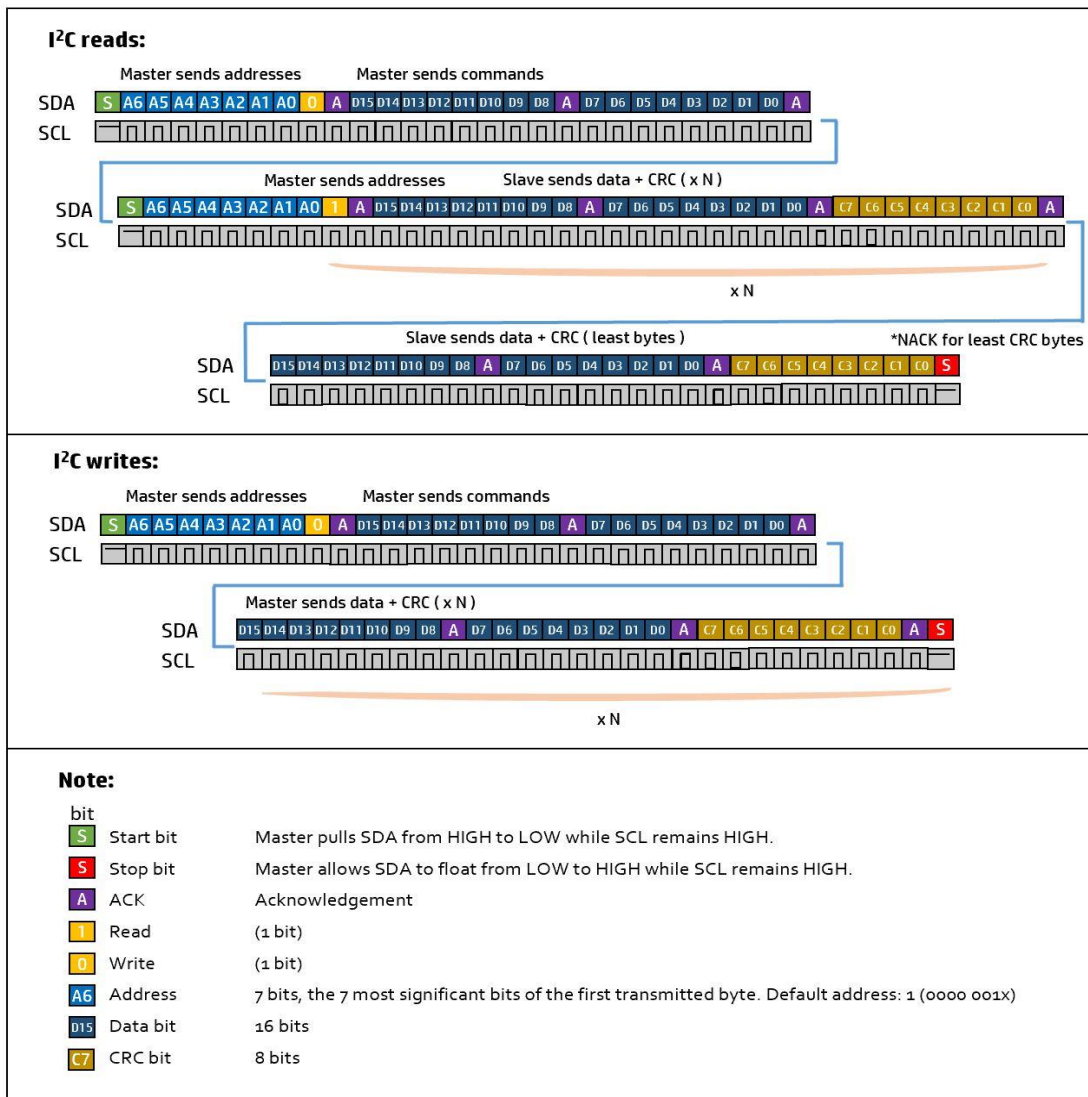
| | | | |
|------------------|---|-------|---|
| Write protection | 0x00FF | Write | Y |
| | | Read | N |
| Description | Write protection disabler for a set value to a specific register. | | |
| Value type | UINT 16, Fixed value 0xAA55 | | |
| Notes | This function is enabled at the time of product shipment. To enable the write function of a specific parameter, such as GCF, or offset, the user needs to send 0xAA55 to the register 0x00FF, and then the write function will be enabled (write protection is disabled). After the write execution is completed, the firmware will automatically re-enable the write protection. | | |

5.5 I²C communication protocol

5.5.1 I²C interface connection diagram



5.5.2 I²C interface read/write sequences



5.5.3 I²C interface command description

Please note the addition of the CRC in the protocol. If you are using an older version, you may need to update your firmware for the current products.

| Command Byte | Length (int 16) | Command Name | Read/Write | Notes |
|--------------|-----------------|---|------------|--|
| 0x00A4 | 1 | I ² C address | Read/Write | Int 16. bit 0 is the R/W flag bit; bit 1 ~ bit 7 are available; bit 8 ~ bit 15 = 0. The default I ² C address is 1. Hex: 0x0002 (write) /0x0003 (read), Bin: 0000 0000 0000 0010 (write) 0000 0000 0000 0011 (read). |
| 0x0030 | 6 | Sensor serial number | Read | ASCII |
| 0x003A | 2 | Flow rate | Read | Int 32/1000 SLPM |
| 0x008B | 1 | Gas correction factor (GCF) | Read/Write | The gas conversion factor for applicable gas is different from calibration gas. |
| 0x008C | 1 | Filter depth | Read/Write | Int 16, 0 ~ 9, corresponding to 2 ⁰ ~ 2 ⁹ data in the software filter. The default value is 3, corresponding to 2 ³ = 8 data in the software filter |
| 0x00Fo | 1 | Reset the offset of differential pressure | Write | Fixed value, 0xAA55 |

Note:

1. The I²C address is set to bit7 ~ 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).
2. GCF table

| Gas type | Correction factor |
|-----------------------------------|-------------------|
| Air | 1000 |
| Oxygen (O ₂) | 1000 |
| Nitrogen (N ₂) | 1000 |
| Argon (Ar) | 1000 |
| Carbon dioxide (CO ₂) | 545 |

5.5.4 CRC checksum calculation

The 8-bit CRC checksum transmitted after each two data bytes (int 16) is generated by a CRC algorithm. Its properties are listed in the table below. To calculate the checksum, only these two previously transmitted data bytes are used.

| Property | Value |
|----------------|--|
| Name | CRC-8 |
| Protected data | I ² C read and write |
| Width | 8 bits |
| Polynomial | 0x07 (x ⁸ + x ² + x + 1) |
| Initialization | 0x00 |
| Reflect input | False |
| Reflect output | False |
| Final XOR | 0x00 |
| Example | CRC(0x4E20) = 0x6D |

5.6 Analog output (0.5 ~ 4.5 Vdc)

The product offers a voltage analog output of the instant flow rate. Refer to Table 5.5 for the wire connection for this output. The meter is calibrated to 110% of the specified full-scale flow rate. The typical analog output is indicated below. This over range applies to both analog and digital output.

Table 5.5: FS4100 analog output

| Flow rate | Analog output (Vdc) |
|------------|---------------------|
| 0 | 0.50 |
| 10 % F.S. | 0.90 |
| 20 % F.S. | 1.30 |
| 40 % F.S. | 2.10 |
| 50 % F.S. | 2.50 |
| 70 % F.S. | 3.30 |
| 90 % F.S. | 4.10 |
| 100 % F.S. | 4.50 |
| 110 % F.S. | 4.90 |
| 120 % F.S. | 4.90 |

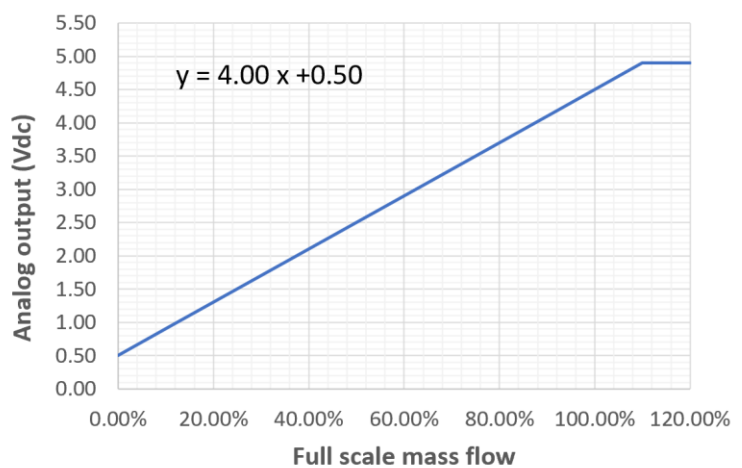


Figure 5.2: FS4100 analog output

5.7 Pressure loss

The product is designed for low-pressure loss. The major drop in the pressure is at the manual valve structure. The following graph illustrated the pressure losses of the selected models.

Table 5.6: FS4103 pressure loss

| Flow rate (SLPM) | Pressure loss (Pa / PSI) |
|------------------|--------------------------|
| 0.0 | 0 / 0 |
| 1.0 | 6 / 0.001 |
| 2.0 | 15 / 0.002 |
| 3.0 | 30 / 0.004 |
| 4.0 | 55 / 0.008 |
| 5.0 | 95 / 0.014 |

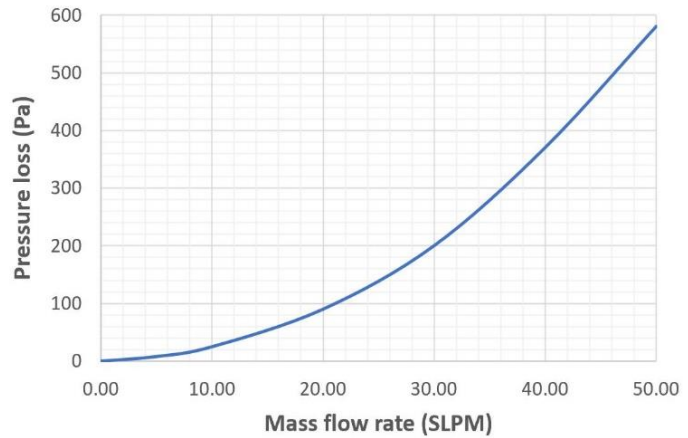


Figure 5.3: FS4103 pressure loss

Table 5.7: FS4108 pressure loss

| Flow rate (SLPM) | Pressure loss (Pa / PSI) |
|------------------|--------------------------|
| 0.0 | 0 / 0 |
| 5.0 | 8 / 0.001 |
| 10.0 | 25 / 0.004 |
| 20.0 | 90 / 0.013 |
| 30.0 | 200 / 0.029 |
| 40.0 | 370 / 0.054 |
| 50.0 | 580 / 0.084 |

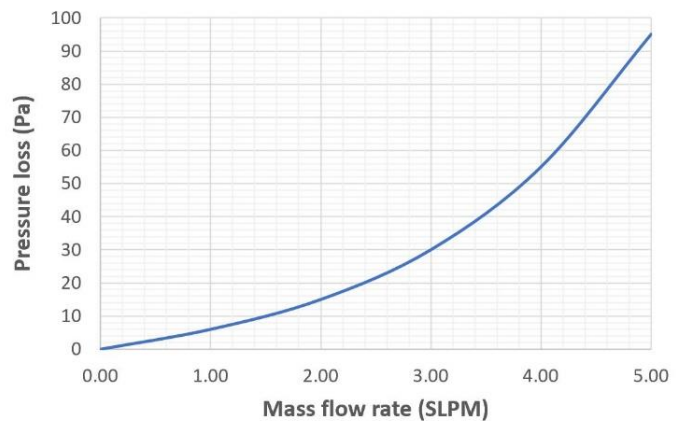
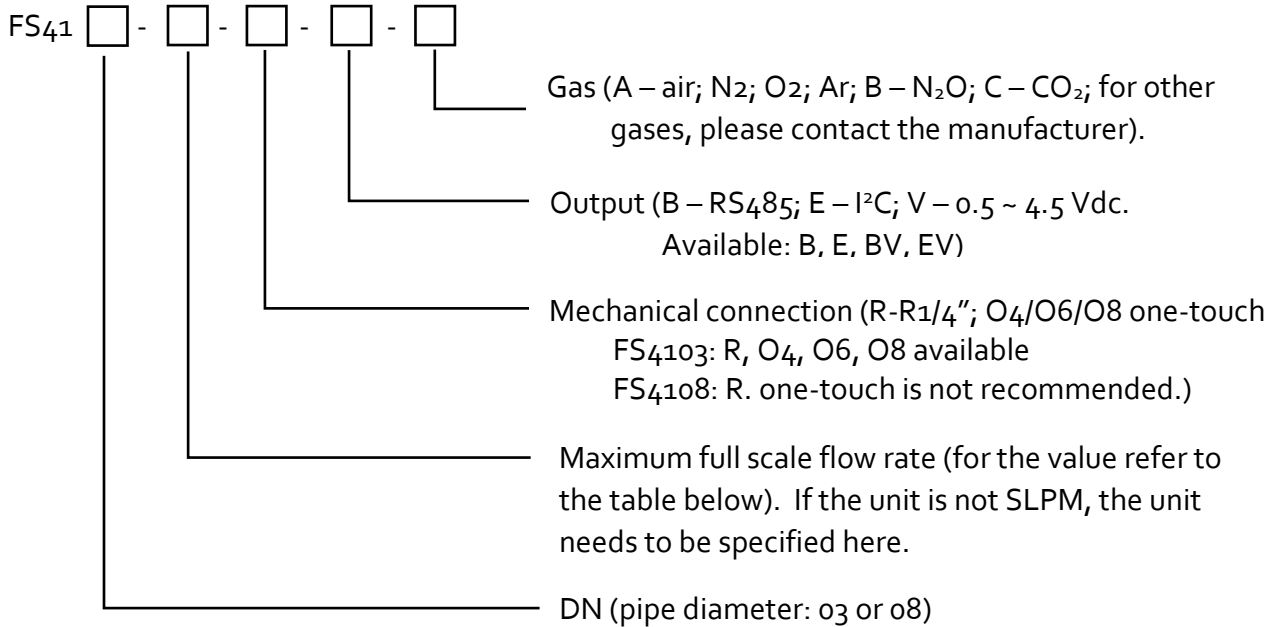


Figure 5.4: FS4108 pressure loss

6. Product selection

The product part number is composed of the product model number and suffixes indicating the full-scale flow rate, as well as the other parameters. Refer to the following for details.



7. 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. The product is horizontally mounted at the time of calibration.

| | Value | Unit |
|--------------------------|---|----------|
| Full-scale flow range | 2, 3, 4, 5 (FS4103) / 10, 20, 30, 40, 50 (FS4108) | SLPM |
| Accuracy | ± (1.5 + 0.2FS) | % |
| Repeatability | 0.25 | % |
| Turn-down ratio | 100:1 | |
| Working temperature | -10 ~ 55 | °C |
| Maximum pressure | 0.5 | MPa |
| Response time | 10 | msec |
| Digital filter depth | 3 (default, 0 ~ 9 programmable) | |
| Humidity | <95, no condensation | %RH |
| Power supply | 8 ~ 24 (50 mA) | Vdc |
| Analog output | 0.5 ~ 4.5 | Vdc |
| Max. null shift (analog) | ±30 | mVdc |
| Analog output load | Sourcing: 14; Sinking: 11 | mA |
| Digital output | RS485 (Modbus) / I ² C | |
| Max. overflow | 30 (FS4103) / 200 (FS4108) | SLPM |
| Max. flow change | 4 (FS4103) / 30 (FS4108) | SLPM/sec |
| Electrical connector | AMPMODU MTE 5 positions | |
| Mechanical connection | BSPT or 4mm/6mm/8mm One-touch | |
| Protection | IP40 | |
| Storage temperature | -20 ~ 70 | °C |
| Reference conditions | 20°C, 101.325 kPa, air | |
| Fluid compatibility | Non-corrosive | |
| CE | EN61000-2; -3; -4 | |
| RoHS/REACH | Certified | |

Note: Wetted materials include: polycarbonate (flow channel); brass with plated chromium (O-touch connector); stainless steel 304 (filter); FKM (O-ring); silicon, silicon nitride, and silicon dioxide.

8. Technical notes for the product performance

8.1 Measurement principle

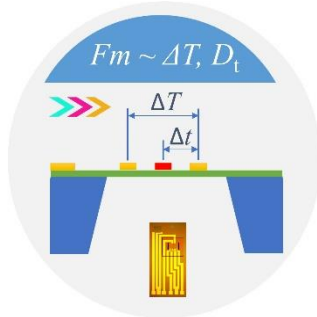


Figure 8.1: Illustration of the measurement principle.

The products utilize the Company's proprietary micro-machined (MEMS) calorimetric sensing with thermal diffusivity detection and data process technology. A thermal signal generator with a pair of sensing elements up and downstream of the micro heater 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 and measure the fluidic thermal diffusivity, further correlated to the fluid mass flow rate via the calibration process.

Compared to the calorimetric sensing products offered by other manufacturers on the market, the proprietary sensing approach offers a large dynamic range with a better performance against environmental parameter alternations. It removes some gas sensitivities for gases with the same diffusivity and much-improved the linearity when a gas conversion factor is used for the metering of the non-calibration gases. 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 Comparison with a third-party reference meter

It is very common that a user may compare the data from the product with a third-party reference meter, and in many cases, there could be some discrepancies.

When performing such a comparison, please note that the reference meter should have a better-specified accuracy (about 1/3 of the product), and pay special attention to the differences in the reading accuracy and full-scale accuracy.

A full scale accuracy = reading accuracy x (full scale flow rate/ set point (current) flow rate)

Another key point to comparing the different flow meters is that as long as the fluidic flow is a continuous flow without pulsation, then the fluidic dynamic will have the system following the Bernoulli equation:

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

where ρ is the fluid density; g is the acceleration due to gravity; P_1 is the pressure of the reference meter; P_2 is the pressure at the test meter; v_1 is the velocity of the reference meter, and v_2 is the velocity of the test meter. h_1 and h_2 are the corresponding height for the meters which in most cases is the same in the system. Therefore, it would be very critical to have the system not have a pressure variation. (This explains our recommendations for the installations in Section 4). Also, the meter measurement principle is often very important for the understanding of any discrepancies.

Please note for comparison with a rotameter, the reading could have large deviations due to the different measurement principles, in particular as a rotameter is sensitive to pressure and temperature variations.

8.2.2 Particle contamination and fluidic cleanness

Any contamination including particles and liquid vapors would be detrimental to the accuracy of the flow measurement and also to the meter functionality. It is important to ensure the applied flow medium will be clean and dry. If any contamination is suspected, please allow experienced technical personnel to have it checked and re-conditioned. Do not use a foreign cleanser or other fluids to clean the flow path which could bring irrecoverable damage.

8.2.3 Apply to a different gas medium

The product is calibrated with a high-precision NIST traceable metrological standard with clean and dry air. Thanks to the unique thermal sensing technology, the sensor can be applied to meter the other clean and dry gas with similar thermal diffusivities without losing accuracy. It effectively solves the nonlinearity issues of applying a gas conversion factor in calorimetric sensing, making the measurement highly accurate in a large dynamic range. Gases that can be applied include air, N_2 , O_2 , Ar, CO_2 , and N_2O .

This innovative product operates also follows the basic sensing principle described in the international standard for thermal mass flow meters (ISO 14511:2001 - Measurement of fluid flow in closed conduits — Thermal mass flowmeters). For gases with different diffusivities, a gas conversion factor could be applied. But due to the meter assembled procedure, the head loss value from the meter to the meter would not be 100% identical, and at the large dynamic measurement range, the thermal response would also have some deviations and nonlinearity from gas to gas. Therefore, measurement by the sensor for a gas medium with substantially different diffusivities compared to that of the calibration gas would bear larger measurement errors, particularly at the low Reynold number range where the laminar flow has a sensitive flow profile.

9. Troubleshooting

| Phenomena | Possible causes | Actions |
|--------------------------------------|--|------------------------------------|
| No signal | The power is not connected; the battery is empty | Connect the power, check the cable |
| | Cable connection incorrect | Check cable |
| | No flow or clogging | Check flow and contamination |
| | Power regulator failure | Return to factory |
| Large errors or unexpected flow rate | Sensor failure | Return to factory |
| | Particles, fluid type | Check system |
| Erroneous or large noise | Vibration, unstable flow | Check system |
| Offset unstable | Circuitry instability | Check the system, power off |
| No digital interface | Wrong address, software | Check commands, connection |

10. 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 misuse 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.

11. Service/order contact and other information

Siargo Ltd. is making every effort to ensure the quality of its 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

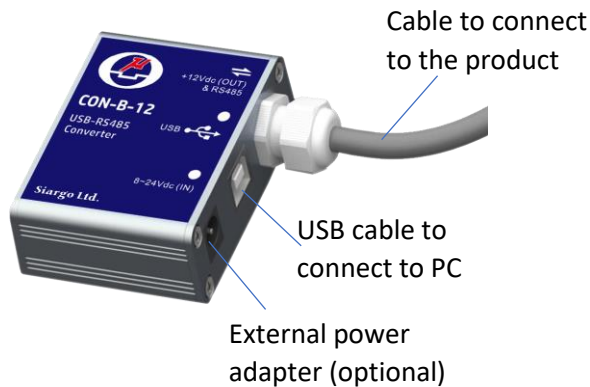
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For further information and updates, please visit www.Siargo.com.

Appendix I: Product evaluation kit

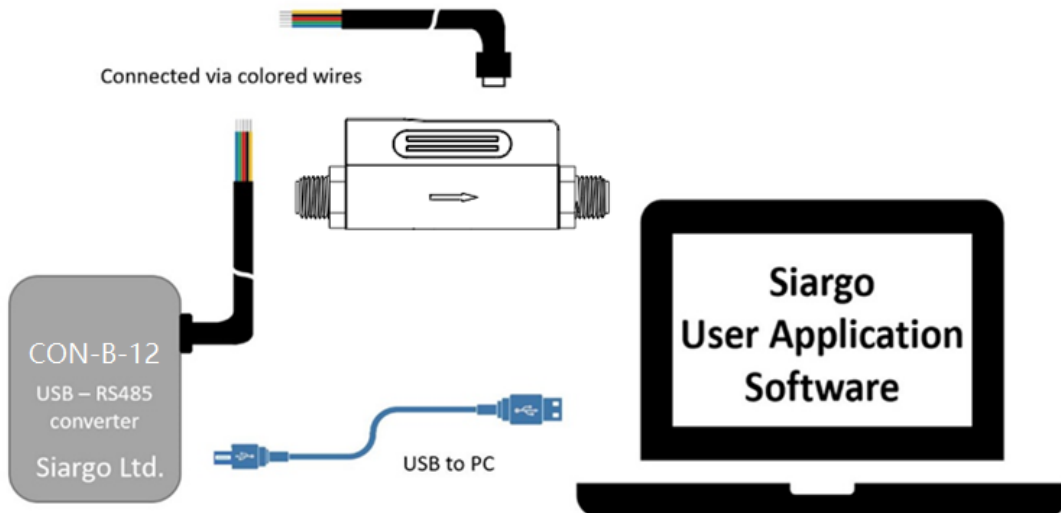
Siargo offers a product evaluation kit, including a digital data converter, USB data cable, and User Application software, that allows the user to evaluate the product performance on a Microsoft Windows-based computer. For some simple applications with digital data transfer, this kit could serve the purpose. The user can read and visualize the flow rate of the product, obtain the totalizer or accumulated flow rate values, and save the data for further analysis. It can read from up to 128 sensors with the RS485 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 A.1.01 (September 2022)

- Update I²C communication protocol.

Revision A.1 (August 2022)

- Update the overview and measurement principle.
- Correction: add Modbus digital filter, replacing the response time, p.15.
- Add I²C communication protocol.
- Update service and sales contact.

Revision A.o.01 (February 2022)

- Correction: Modbus serial number information, p. 14.

Revision A.o (August 2021)

- First release.