MEMS Mass Flow Sensors

Model FS4001

Features

- Low mass flow range from 0 ~ 30 sccm up to 0 ~ 1000 sccm
- Outstanding accuracy of ±1.5 %
- Fast response (4 ms selectable)
- Pressure rating up to 5 bar (73 psi)
- Analog and/or digital user interface
- Easy installation

Description

The FS4001 mass flow sensors are manufactured using Siargo's proprietary MEMS flow sensor and package technology. The sensors are specially designed for low flow rate range applications from 0 ~ 30 sccm up to 0 ~ 1000 sccm.   The maximum flow rate for each model is manufactured via specially designed package as well as smart electronics so that the optimal sensitivity would be achieved.

The packaging enclosure is made of the chemically inert and thermally stable polycarbonate material. The maximum over pressure rating is 5 bar (73 psi) that is benefitted from Siargo's unique MEMS sensor chip structure, special packaging technology and the rugged sensor housing.

The FS4001 can be used in a wide range of applications including instrumentation (e.g. GC mass spectrometry), leak detection, process control, gas flow metrology as well as medical applications. The FS4001 requires a power supply of 8 ~ 18 Vdc and provides an analog and/or digital user interface. The analog output is linearized from 0.5 to 4.5 Vdc corresponding with flow rate from 0 to full scale. The digital output is via RS232. The communication protocol of the RS232 can be found in this manual.

The calibration is generally performed with nitrogen at 20 °C and 101.325 kPa pressure rating. It can nonetheless be calibrated with other gases and conditions upon requests.

Working Principle

The MEMS sensor chip utilizes the calorimetric principle. It is packaged on a plate installed inside the flow channel, which provides additional flow conditioning from the boundary layer configuration resulting in a laminar flow. The mass flow measurement is established as the gas carries heat away from the heater leading to the redistribution of the temperature field. Accurate flow rate is obtained by calibration with standard gas at preset conditions.

Flow direction

Time-averaged velocity profile boundary layer

Free stream

Laminar

Turbulent
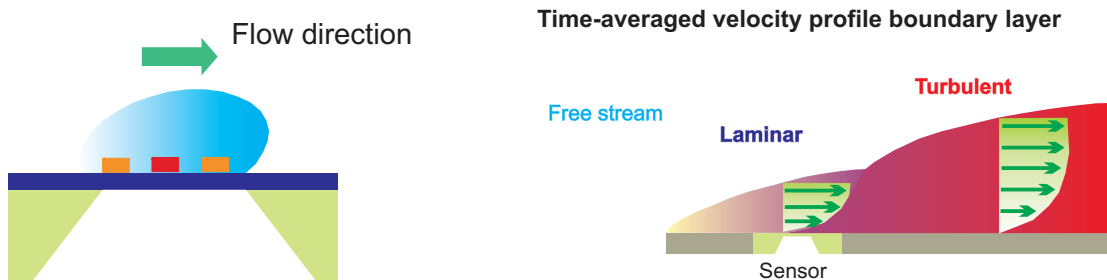
Sensor

Block Diagram

The functional block diagram is shown in the following figure. The MEMS sensor chip is powered by the sensor driving circuitry and sends flow rate related voltage to ADC. The micro-controller processes (amplifying, filtering, etc) the voltage then converts into flow rate. The flow rate signal is sent out through analog or both analog and digital formats (RS232).
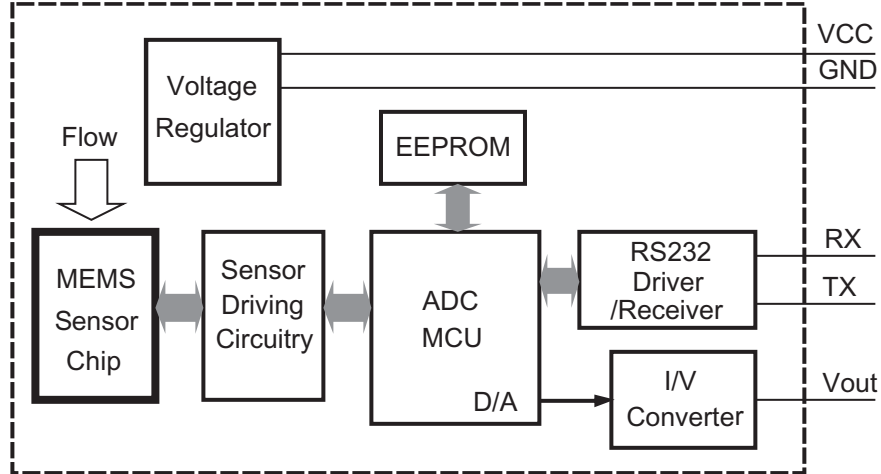
Functional block diagram of the FS4001.

1. Sensor Performance

1.1 Performance Specifications

All data unless otherwise noted apply for calibration conditions: N_2, 20°C, 101.325kPa absolute pressure, horizontal mounting.

Model	FS4001	
Flow Range	0 ~ 30, 100, 200, 500, 1000, or customer specified	sccm
Turn-down Ratio	>100:1	
Accuracy[1]	±(1.5 + 0.5 FS)	%
Repeatability	± 0.25	%Reading
Null Shift	± 30	mV
Output Shift	± 0.2	%/°C
Response Time[2]	65 (Default, 4, 8, 16, 33, 131 selectable)	ms
Output	Linear: RS232, Analog 0.5 ~ 4.5 Vdc	
Pressure Drop[3]	< 350	Pa
Pressure Range	-0.08 ~ +0.5	MPa
Power Supply[4]	8 ~ 18 Vdc, 50 mA	
Operating Current	20 typical when RS232 not connected	mA
	25 typical when RS232 communicates with a PC	
Power Consumption	<200	mW
Working Temperature	-5 ~ +55	°C

1　Denotes ±(1.5 %Reading + 0.5 %Full Scale). To obtain accurate flow measurement, let the sensor warm up 1 minute at power up.

2　The response time is determined by ADC sampling rate and data process algorithm. The default response time is 65 ms. It can be programmed via RS232 communication.

3　The maximum pressure drop is measured at flow rate 1000 sccm. For lower range flow sensors, the pressure drop will be smaller.

4　One DC power supply is necessary. The required minimum output current is 50 mA. The sensor actually consumes less than that in operation.

1.2 Additional Specifications

Pins Out	5 Pin, 2.54 mm centers, 0.635 mm square	
Calibration Options[1]	Air, CO_2, He, H_2, N_2, O_2, Ar @ 20 °C, 101.325 kPa	
Packaging material	Polycarbonate	
Dimensions	62 x 54 x 12.8	mm^3
Weight	15	g
Srorage Temperature	-20 ~ +65	°C
Humidity	<95 %RH (No icing or condensation)	

1　Calibrations at other gases and conditions available upon request.

Compliance Statement: All components of this product are RoHS compliant. The product fully complies with CE norm EN61000-6-1 through 61000-6-4, EN50081-2 through 50082-2 and EMC directive 89/336/EEC.

1.3 Flow Characteristics

1.3.1 Analog Output Characteristics

The FS4001 provides an analog output of 0.5 ~ 4.5 Vdc corresponding with 0 ~ full scale flow rate. Using 100 sccm as an example, the typical analog output *v.s.* flow rate is illustrated in Table 1.1 and Figure 1.1.

Table 1.1: Typical output voltage *v.s.* flow rate.

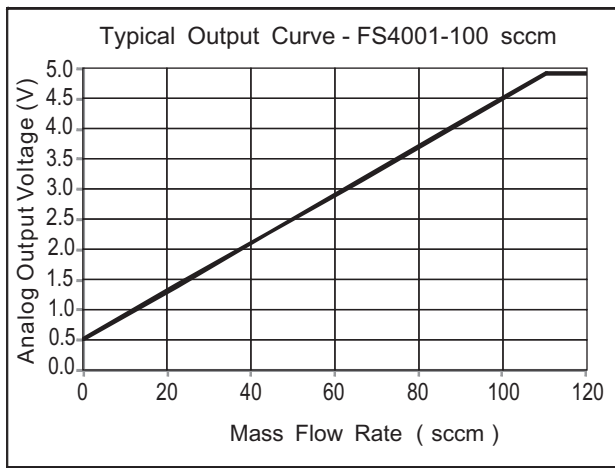| Flow Rate (sccm)	Typical Voltage (Vdc)
0	0. 5
20	1. 3
40	2. 1
60	2. 9
80	3. 7
100	4. 5
110	4. 9
120	4. 9

Figure 1.1: A typical analog output curve.

The sensor is calibrated 10% above the full scale flow rate to ensure the accuracy within the defined range during interpolation. For example, full scale of 100 sccm is calibrated till 110 sccm. Hence at flow rate beyond the full scale, there is still analog output but the accuracy is not guaranteed.

1.3.2 Digital Output Characteristics

The digital output is delivered through RS232. Figure 1.2 shows the mass flow rate *v.s.* the digital output of the 1000 sccm. Same as analog output, when flow rate is beyond the defined full scale, the output accuracy is not guaranteed.
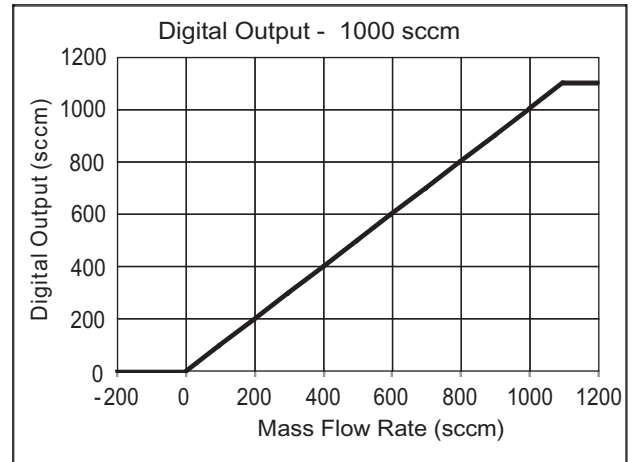

Figure 1.2: Typical digital transfer characteristics.

2. Pins and Interface
2.1 Pin Definition
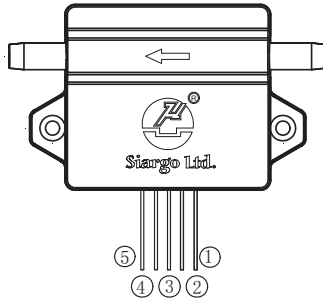The FS4001 provides 5 pin interface. The pin layout and definition are as Figure 2.1 and Table 2.1.

Figure 2.1: FS4001 pin configuration.

Table 2.1: FS4001 pin definition.

Pin Num.	Definition
1	RX (RS232)
2	GND, Ground
3	VCC, Power supply
4	Vout, Analog output
5	TX (RS232)

2.2 Pin Description

VCC and **GND**: The FS4001 requires a power supply of 8 ~ 18 Vdc. The voltage is internally regulated to power the circuitry. Therefore, there is no stringent requirements on the accuracy, stability as well as ripple of the external supply.

Vout: The analog output pin provides 0.5 ~ 4.5 Vdc corresponding with the specified flow range 0 ~ full scale. Beyond this range, there is still voltage reading, but the accuracy is not guaranteed.

TX and **RX**: The digital communication is bi-directional. TX is the transmit pin for RS232 and it sends out signal from the sensor. RX is the receive pin and it receives signal. Using these two pins together with GND pin, the sensor's working mode can be selected, and the voltage as well as flow rate data can be obtained.

2.3 RS232 Communication Protocol

The following settings is preferred:

Baud rate (Bits per second):	38400
Date bits:	8
Stop bits:	1
Parity:	None
Flow control:	None

The FS4001 works in several modes to help customers obtain data in different ways. The modes are described as the following.

Operation Mode:

a). Send 0x9d to the sensor and receive 0x9d from the sensor;

b). Send 0x54 to the sensor and receive 0x54 from the sensor;

The time interval between two bytes sent to the sensor must be longer than 5 ms. The sensor will send follow data:

　　IN OPERATION MODE ......\n\r

Then the sensor will be at the Operation Mode in which the data from the sensor will be sent via RS232 in an interval of 200 ms.

The data is in the following format:

　　V=vvvvvvv\nF=ffffffff\nA=0\n; **\n**

with "V=vvvvvvv" as the voltage code, and "F=ffffffff" as flow rate. It equals to *fffff.fff* sccm

User Mode:

a). Send 0x9d to the sensor and receive 0x9d from the sensor;

b). Send 0x00 to the sensor and receive 0x00 from the sensor;

The time interval between two bytes sent to the sensor must be longer than 5 ms. The sensor will send follow data:

　　IN USER MODE......\n\r

The sensor will be at the User Mode in which no data will be sent via RS232 by the sensor.

Customer Mode:

a). Send 0x9d to the sensor and receive 0x9d from the sensor;

b). Send 0x56 to the sensor and receive 0x56 from the sensor;

The sensor will send follow data:

　　IN CUSTOMER MODE......\n\r

The sensor will be at the Customer Mode in which the data from the sensor will be sent via RS232 in an interval of 200 ms. The data format is:

　　F= ffffffff\n;\n

It represents an instant flow rate of *fffff.fff* sccm.

Lookup Instant Flow Rate:

a). Send 0x9d to the sensor and receive 0x9d from the sensor;

b). Send 0x55 to the sensor and receive 0x55 from the sensor;

The sensor will return an instant flow rate value via RS232, and then enter into the Communication Mode. The data format is:

　　ffffffff IN USER MODE......\n\r

It represents an instant flow rate of *fffff.fff* sccm. In which the data "IN USER MODE......\n\r" mean the sensor will enter into the User Mode.

3. Mechanical Dimensions and Mountings

The FS4001 has a dimension of 62 x 54 x 12.8 mm^3. The dimension is illustrated in Figure 3.1.

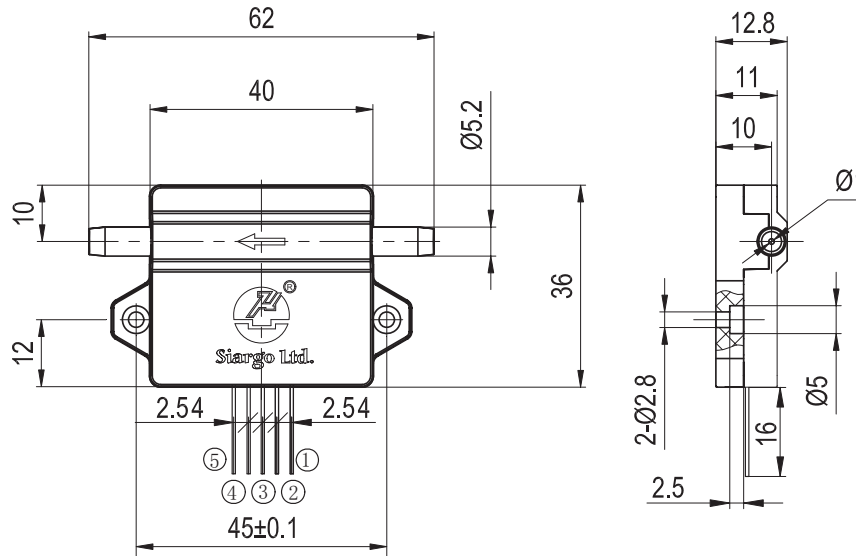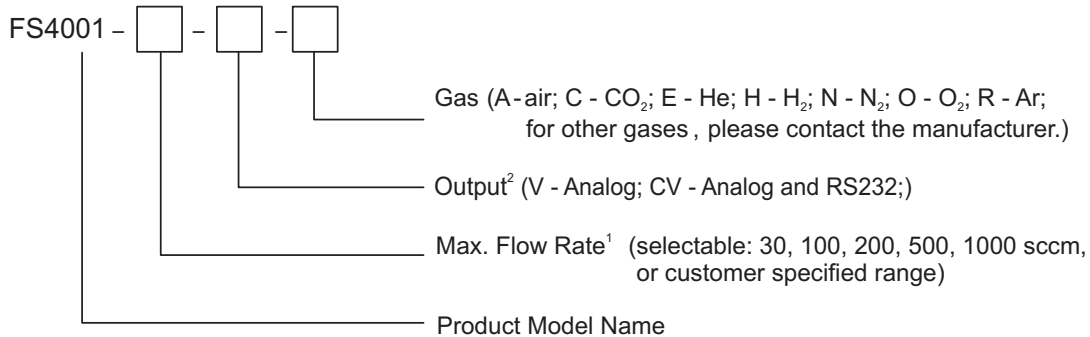
Figure 3.1: Mechanical dimensions of the FS4001.

4. Ordering Guide

4.1 Sensor Selection

The sensor part number is composed of the model number and suffix indicating the full scale flow rate, output format as well as the calibration gas. Refer to the followings for details.

FS4001 – ☐ – ☐ – ☐

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[2] (V - Analog; CV - Analog and RS232;)

Max. Flow Rate[1] (selectable: 30, 100, 200, 500, 1000 sccm, or customer specified range)

Product Model Name

1 Max. flow rate number only, for example, 100 meaning maximum flow rate of 100 sccm.
2 The sensor shipped with analog output. Digital output is optional.

4.2 Order Contact and Customer Support

The sales offices are listed at the end of this document. For small quantities, the order can be placed either through Siargo website: www.siargo.com or the sales office. For large quantities, please contact the sales office or distributors or sales representatives.

Siargo is making every effort to ensure the quality of the products. In case of questions and/or product supports, please contact customer service listed at the end of the document. We will respond your request in a timely fashion and will work with you toward your complete satisfaction.

Important Notices

Wetted Materials and Compatibility

The sensor body is made of medical compatible plastics. The sensor chip comprises of silicon, silicon nitride and silicon dioxide and the sensor chip surfaces are passivated with silicon nitride and silicon dioxide. The electronic sealing is provided by RTV (room temperature vulcanizing) silicone sealant WR-704 composed of $HOCH_3(SiO)_nCH_3H$.

Cautions for Handling and Installations

The product at the time of shipment is fully inspected for product quality and meets all safety requirements. Additional safety measures during handling and installation should be applied. To prevent ESD (electrostatic discharge) damage and /or degradation, take customary and statutory ESD precautions when handling. Do power the product with the correct polarity, voltage and amperage. All precautions and measures for electrical voltage handling must apply. The product sealing is ensured to work under working pressure of 0.5MPa and is leakage proof before the shipment. But cautions and further leakage test are important at installation as well since any leakage may cause severe safety issues.

This product contains no user serviceable components. Do not attempt to disassemble, substitute parts or perform unauthorized modifications to the product. Doing so will forfeit the terms of the warranty and cause the liability to any damages thereafter. The product should only be serviced by authorized personnel. Upon requests, Siargo will provide necessary technical support and/or training of the personnel.

Cautions for Product Applications

The product is designed for use with general purpose gases such as air and nitrogen. It is advised that the products are best used for non-explosive clean gases. The sensors cannot be used for gas metrology of fluoride or fluoride-containing gases. For updates of the product certification information, please contact the manufacturer. Use for other gases such as extreme corrosive and toxic gases may cause the product malfunctioning or even severe damages.

Don't expose the product's outer surface to any liquids, the unit does not have a water tight electronics package.

Don't flow gas in conditions that can cause condensing water vapor to be trapped inside the unit as the accuracy could be significantly altered.

It is suggested to design your application so that nominal flow rate is approximately 70% of the full scale flow rate of the sensor. Don't use a sensor with an extreme flow rate , for instance, don't use a 1000sccm sensor for a 10 sccm application.

Warranty and Liability

(effective March 2009)

Siargo warrants the products sold hereunder, properly used and properly installed under normal circumstances and service as described in the user manual, 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 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 or any 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, strictly 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. No action, regardless of form, 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 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, and it shall not be amended, modified or its terms waived except by Siargo's sole action.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) Siargo does not provide any warranty on finished goods manufactured by others. Only the original manufacturer's warranty applies.