



Siargo Ltd.

Model FS7001P (V3)

SIARGO MEMS FLOW SENSOR PRODUCTS

MEMS Mass Flow Sensors

MEMS Mass Flow Sensor

Model FS7001P

Features

- ✎ Mass flow sensing from 0 ~ 1 m/s
- ✎ Customizable and friendly user interface
- ✎ Customizable connection
- ✎ Pressure drop less than 15 Pa
- ✎ Miniature design for easy installation
- ✎ High sensitivity

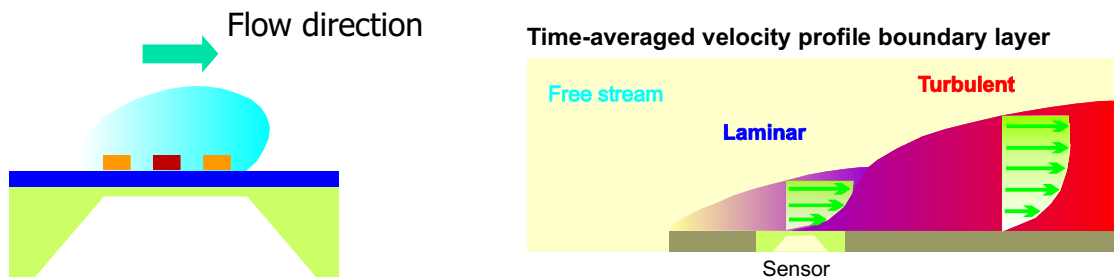


Introduction

This mass flow sensor can be used for medical applications, instrumentation or general purpose mass flow measurements, using Siargo's proprietary MEMS flow sensor configuration that ensures reliability, performance and low cost.

Working Principle and Configuration

The MEMS calorimetric sensor is installed at the flow channel wall forming a plate that serves as the additional flow condition from the boundary layer configuration resulting in a laminar flow. The mass flow measurement is established as the fluid carries heat away from the heater causing the redistribution of the temperature field. Accurate flow rate is obtained by calibration with the standard fluid at the preset conditions.



Specifications

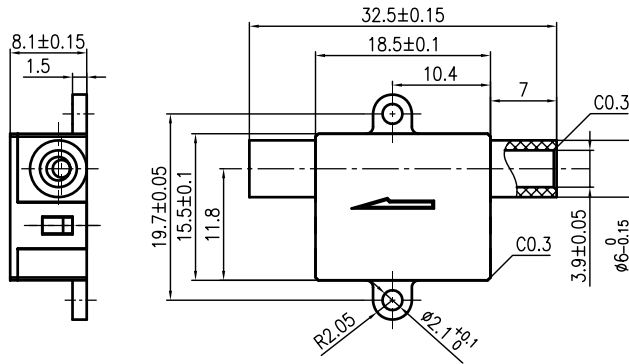
All data unless otherwise noted apply for calibration conditions: N₂, 20 °C, 101.325 kPa absolute pressure, horizontal mounting.

Spec	Value			Unit
Flow range ¹	0~1			m/sec
Repeatability ²	± 3%			FS
Supply voltage ³	3.3 ± 5%			Vdc
Output ⁴	Non-linear analog voltage			
	<i>Min.</i>	<i>Typ.</i>	<i>Max.</i>	
Output voltage@0.8m/sec (20°C)	2.5	2.75	3.0	Vdc
(0°C)	2.65	2.92	3.18	Vdc
(55°C)	2.23	2.46	2.68	Vdc
Null voltage (20°C)	0.4	0.6	0.8	Vdc
(0°C)	0.43	0.64	0.85	Vdc
(55°C)	0.35	0.53	0.71	Vdc
Power consumption ⁵ (@ Full scale)	8.5	9.2	10	mA
Working Pressure	70		140	kPa
Pressure drop (@ Full scale)		10	15	Pa
Humidity	0		95	%RH (no icing or condensation)
Temperature	0		55	°C
Temperature coeff.	0	0.25	0.3	%/°C
Offset/FS stability ^{6,7}		0.2		%FS/year
Noise level/SNR (signal to noise)		100 : 1		
Life time ⁷		10		years
Storage pressure	50		1000	kPa
Storage temperature	-20		60	°C
Storage humidity	0		90	%RH (no icing or condensation)
Connector	SM03B-SRSS-TB (JST)			

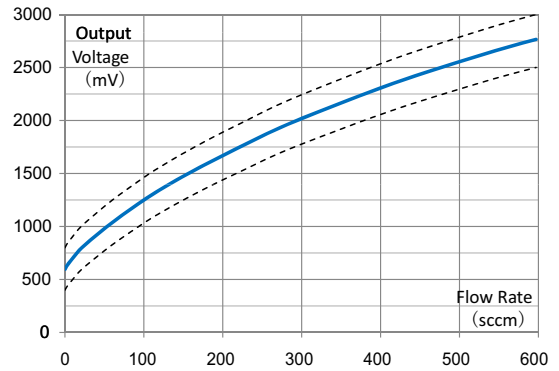
Notes:

1. The absolute maximum flow rate is 4 m/sec;
2. Repeatability is same for different temperature, whether it is 0 degC, 20 degC or 55degC;
3. The maximum power supply voltage is 5.5Vdc, but without 3.3±5% Vdc, the accuracy will be worse;
4. The maximum output load is 30mA. Void add a power supply to the output pin. If add a 3.3Vdc power supply to the output pin, the analog output component will be damaged;
5. The power consumption range include the temperature effect;
6. Offset and full scale stability means the average value shift. This value includes temperature effect of conditions that includes specification of storage and operation condition.
7. if customer use or storage the sensors out of spec, the offset and full scale stability will be higher, and the life time will be shorted.

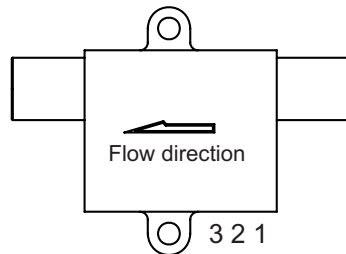
Dimensions



Output



Electrical connection



Pin definition and 3 wire cable color

- 1 VCC (Red)
- 2 Vout (Green)
- 3 GND (Black)

Connector

3 Pin, S3B-ZR-SM2-TF

Application Notes :

1. The operational output curves are from the measurement of the sensor for air flow at 20°C, 101.325kPa with straighteners. For applications deviated from these conditions, the performance may vary depending on the specific environments.
2. Place of the sensor in an environment where particle size is larger than 1.5mm may have chances to block the sensing channel thus resulting in undesired output. Presence of excessive grease or grease-like materials may also result in sensor malfunction.
3. Pressure variation would usually not result in the change of the performance of the sensor.
4. Humidity variation but without condensation would not lead to deteriorate in performance of the sensor.
5. The sensor can be cleaned by blow the dry air through the sensing channel in case some excessive foreign materials block the channel. Alternatively, the sensor can be washed with alcohol and dried with dry air or even dried in natural conditions after wash.
6. Avoid using any sharp or metal or hard solid tool to clean the channel that may result in unrecoverable damage to the sensors.
7. Avoid using any heavy tool to hit or press the sensor that may break the PC package and result in unrecoverable damage.
8. The sensors can also be configured into a linear output with additional cost. For such requirements, please contact manufacture for further information.

Appendix Calibration Procedure

1. Introduction

This procedure is specially prepared for Panasonic for the customized Siargo proprietary MEMS mass flow sensing products FS7001P. With this procedure, customer shall be able to perform calibrations/linearization.

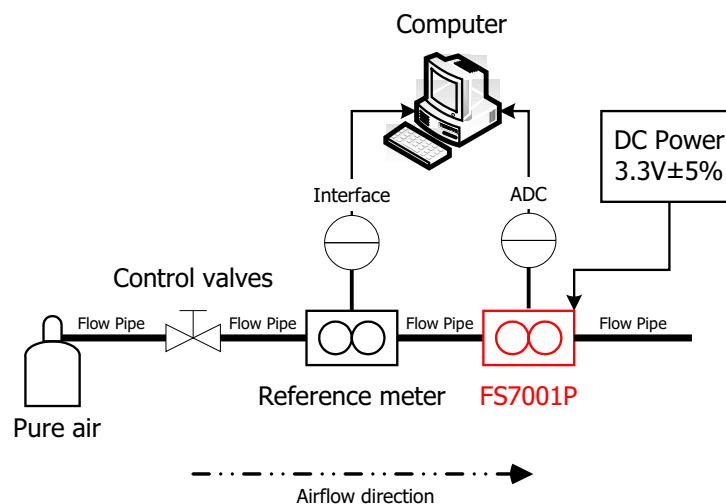
2. Calibration equipment

The calibration requires proprietary calibration software by Siargo and the following specified equipment:

- Cable with SM03B-SRSS-TB connector. For the pin definition, please refer to the user manual.
- A standard meter that shall have an accuracy at least 1/2 of the sensor specified accuracy, and preferably 1/3 of that for the specified sensor. The maximum flow shall be at least 20% higher than the specified maximum flow of the sensor.
- Clean and dry gas sources with stable pressure.
- 3.3V±5% power supply, sensor current $\leq 10\text{mA}$.
- The linearization algorithm dynamic link library by Siargo.

3. Calibration procedure

3.1. Preparation



Connect the sensor to be calibrated as shown in the above figure. Connect the sensor with the cable and connect the power supply and computer as described in the user manual. Wait for the sensor to warm up in about 2 minutes.

Safety and Maintenance

Wetted Materials and Compatibility

The sensor body is made of aluminum. Sensors comprise of silicon, silicon nitride and silicon dioxide and the sensor 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 $\text{HOCH}_3(\text{SiO})_n\text{CH}_3\text{H}$.

Safety Precautions

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 manufacturer or visit www.Siargo.com. Use for other gases such as extreme corrosive and toxic may cause the product malfunctioning or even severe damages. The product sealing is ensured to work under working pressure of 20 psi and is leakage proof before the shipment. But cautions and further leakage test are important at installation as well since any leakage could cause severe safety issue. The power supply for this product requires a voltage supply of $3.3 \pm 5\%$ VDC, all precautions and measures for electrical voltage handling must apply.

Attention: Any alternation and/or improper use of the product without the permission of the manufacturer can cause unpredicted damages and even injuries or other severe situations. Siargo Ltd. or any of its employees subsidiaries shall not be hold and indemnified against such consequences due to such circumstances via improper use of the product.

All maintenance of the sensor should be done by trained and certified personnel by Siargo Ltd. products.

For further information, please contact the manufacturer:

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3.2. Dynamic link library

FS7001P outputs 0 ~ 3.3Vdc. In most cases, this voltage needs to be converted into digital numerical via ADC (or ADCCode). The numerical can be further computed into mass flow rate. As the FS7001P sensor outputs are nonlinear, the outputs needs to be further linearized using an algorithm. Siargo has provided such a special algorithm for the customized FS7001P which has been compiled into a dynamic link library SiargoFitting.dll that user can readily apply. In addition, file cal_v3_release.dll which SiargoFitting.dll needs to use also are provided.

The followings are the library description:

[Pascal version]

Type

```
TDoubleArray = array of Double;  
TIntegerArray = array of Integer;
```

```
function DataFitting( pTstADCCodeBuf: TDoubleArray;  
                    pStdFlowrateBuf: TDoubleArray;  
                    nSizeOfInBuf: Integer;  
                    var pOutFlowrateBuf: TDoubleArray  
                    ): Integer; stdcall; external 'SiargoFitting.dll';
```

[C++ version]

```
typedef int(*TDataFitting)(double pTstADCCodeBuf[],  
                          double pStdFlowrateBuf[],  
                          int nSizeOfInBuf,  
                          double* pOutFlowrateBuf[]  
                          );
```

Parameters :

pTstADCCodeBuf
input parameter, ADCCode buffer for FS7001P output voltage.

pStdFlowrateBuf
input parameter, reference flowrate buffer.

nSizeOfInBuf
input parameter, the length of pTstADCCodeBuf/pStdFlowrateBuf.

pOutFlowrateBuf
output parameter, output flowrate buffer, the enough storage space must be allocated for the parameters by calling program.

Return Values :

If the function succeeds, the return value is equal to or greater than 0, and represents the number of output data. If the function fails, the return value is less than 0. Below are possible values :

- 0 : The Max(pTstADCCodeBuf) is more than 65535.
So the ADC resolution should be less than or equal to 16 bits.

- 1 : The number of input data(ie. nSizeOfInBuf) is less than 5.
- 2 : The number of input data(ie. nSizeOfInBuf) is more than 1000.
- 3 : The length of pOutFlowrateBuf is too small to store all the output data.
- 4 : Memory allocation failure.
- 5 : The file “cal_v3_release.dll” not found or invalid.

In most cases, the data in the buffer of `pTstADCodeBuf` are floaters, but `ADCode` are expressed with integers. (e.g. for 12 bit ADC, the range of `ADCode` is 0 ~ 4095). In order to make it easier for user application, all the data in 0~`Max (pTstADCodeBuf)` will be processed and the results will be stored in `OutFlowrateBuf`. And the number of data shall be returned as a value of function to the program. Therefore, before the user utilizes the program, the user must reserve a space for `pOutFlowrateBuf`. Such a space must have a minimal of $(\text{Max}(\text{pTstADCodeBuf}) + 1) * \text{sizeof}(\text{Double})$ bytes so that the data can be received correctly.

After calibration, ADC can be used to obtain real-time `ADCode` as the subscribe of buffer `pOutFlowrateBuf` to visit the flow rate after linearization, e.g. `pOutFlowrateBuf[ADCode]`. An example is shown as follows (regardless of the program language, either static or dynamic link can be used) :

[Pascal version, Static link approach]

```

procedure TForm1.Button1Click(Sender: TObject);
var
  i: Integer;
  nSizeOfInBuf: Integer;           // The length of input buffer
  nSizeOfOutBuf: Integer;          // The length of output buffer
  pTstADCodeBuf: TDoubleArray;      // The ADCode buffer for FS7001P output voltage
  pStdFlowrateBuf: TDoubleArray;     // The reference flowrate buffer
  pOutFlowrateBuf: TDoubleArray;     // The output flowrate buffer
begin
  // Allocate memory space for input buffer
  nSizeOfInBuf := 10;
  SetLength(pTstADCodeBuf, nSizeOfInBuf);
  SetLength(pStdFlowrateBuf, nSizeOfInBuf);

  // Initialize input data buffer
  for i := 0 to nSizeOfInBuf - 1 do
  begin
    pTstADCodeBuf[i] := i * 2;
    pStdFlowrateBuf[i] := i * 37.23;
  end;

  // Allocate memory space for output buffer
  nSizeOfOutBuf := Trunc(pTstADCodeBuf[nSizeOfInBuf - 1]) + 1;
  SetLength(pOutFlowrateBuf, nSizeOfOutBuf);

  // Call the function DataFitting in the dynamical link library
  nSizeOfOutBuf := DataFitting(pTstADCodeBuf, pStdFlowrateBuf, nSizeOfInBuf, pOutFlowrateBuf);

  // Display the Result
  Edit1.Text := IntToStr(nSizeOfOutBuf);
  Memo1.Clear;

```

```

    for i := 0 to Trunc(pTstADCodeBuf [nSizeOfInBuf-1]) do
        Memo1.Lines.Add(FloatToStr(pOutFlowrateBuf[i]));
    end;

```

[C++ version, Dynamic link approach]

```

//-----
void __fastcall TForm1::Button1Click(TObject *Sender)
{
    HINSTANCE hDLL;           // The handle for dynamical link library
    TDataFitting DataFitting; // The pointer to fitting function
    int nSizeOfInBuf;         // The length of input buffer
    int nSizeOfOutBuf;        // The length of output buffer
    double* pTstADCodeBuf;    // The ADCode buffer for FS7001P output voltage
    double* pStdFlowrateBuf;  // The reference flowrate buffer
    double* pOutFlowrateBuf; // The output flowrate buffer

    // Allocate memory space for input buffer
    nSizeOfInBuf = 10;
    pTstADCodeBuf = (double *)GetMemory(sizeof(double) * nSizeOfInBuf);
    pStdFlowrateBuf = (double *)GetMemory(sizeof(double) * nSizeOfInBuf);

    // Initialize input data buffer
    for (int i = 0; i < nSizeOfInBuf; i++)
    {
        pTstADCodeBuf[i] = i*2;
        pStdFlowrateBuf[i] = i * 37.23;
    }

    // Allocate memory space for output buffer
    nSizeOfOutBuf = pTstADCodeBuf[nSizeOfInBuf - 1] + 1;
    pOutFlowrateBuf = (double*)GetMemory(sizeof(double) * nSizeOfOutBuf);

    // Call the function DataFitting in the dynamical link library
    hDLL = LoadLibrary("SiargoFitting.dll");
    try
    {
        DataFitting = (TDataFitting)GetProcAddress(hDLL, "DataFitting");
        nSizeOfOutBuf = DataFitting(pTstADCodeBuf, pStdFlowrateBuf, nSizeOfInBuf,
            &pOutFlowrateBuf);

        // Display the Result
        Edit1->Text = IntToStr(nSizeOfOutBuf);
        Memo1->Clear();
        for (int i = 0; i <= pTstADCodeBuf [nSizeOfInBuf-1]; i++)
        {
            Memo1->Lines->Add(FloatToStr(pOutFlowrateBuf[i]));
        }
    }
    finally
    {
        // Unload the dynamical link library
        FreeLibrary(hDLL);
        // Deallocating memory
        FreeMemory(pTstADCodeBuf);
    }
}

```

```

        FreeMemory(pStdFlowrateBuf);
        FreeMemory(pOutFlowrateBuf);
    }
}

```

3.3. Calibration procedure

- a. Close the control valve, record the flow rate from the standard meter and the ADCode from the FS7001P sensor, respectively.
- b. Adjust the control valve to the desired flow rate, wait for the flow to stabilize, and then record the flow rate from the standard meter and the ADCode from the FS7001P sensor, respectively.
- c. Repeat *Step b* until the desired calibration data points have been taken.
- d. Depending on the flow range, turn-down ratio and accuracy requirements, the calibration data points can be anywhere from 7 to 30. The maximum flow rate calibrated should be at least 10% over the full scale, e.g. the sensor full scale is 600sccm, the maximum flow rate calibrated shall be 660sccm.
- e. The data (flow rate) from the standard meter should be stored into the buffer of `pStdFlowrateBuf` while the data (ADCode value) from FS7001P should be stored into the buffer of `pTstADCodeBuf`. The number of the calibration data points should be stored into the variable of `nSizeOfInBuf`.
- f. The space in the buffer of `pOutFlowrateBuf` must be at least $(\text{Max}(\text{pTstADCodeBuf}) + 1) * \text{sizeof}(\text{Double})$ (unit is bytes).
- g. Load `SiargoFitting.dll`, and input the data from *Step e and f* into function of `DataFitting` and execute.
- h. The results should be stored into the buffer of `pOutFlowrateBuf`.

4. Verification

The accuracy or repeatability can be obtained via verification procedure.

Adjust the control valve, read the voltage output from FS7001P, convert the voltage into ADCode via the ADC. Input ADCode into the buffer of `pOutFlowrateBuf`, then the actual flow rate measured by FS7001P can be obtained. Compared the value to those from the standard meter, the verification can be performed accordingly.

For the authentication of the data and measurement validation, the followings must be observed:

- a. A stable power supply for FS7001P.
- b. A certified standard meter with a stable performance.
- c. The ADC and its reference voltage for FS7001P must be accurate and stable.