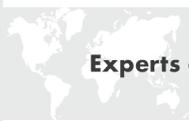


PFLOW5001

MEMS Mass flow sensors for manifold installation



MEMS Mass Flow Sensors

PFLOW5001 Series

Specification & 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.



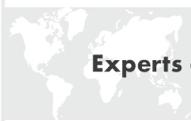
Use with caution !

- Be cautious for 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.



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1. Overview

This manual provides essential information for the operation of the PFLOW5001 series of gas mass flow sensors for general-purpose gas flow monitor and control applications with the full-scale mass flow rate from 0.2 to 20 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.

PFLOW5001 provides the manifold configuration for the mechanical connections. Optionally it can also be offered with a manifold body with the 4mm one-touch flexible piping. It can be applied to medical equipment and instrumentation applications. The series covers a wide dynamic flow range with a working pressure rating of up to 1.0 MPa (10 bar or 150 PSI), and a compensated temperature ranging from -5 to 50°C.

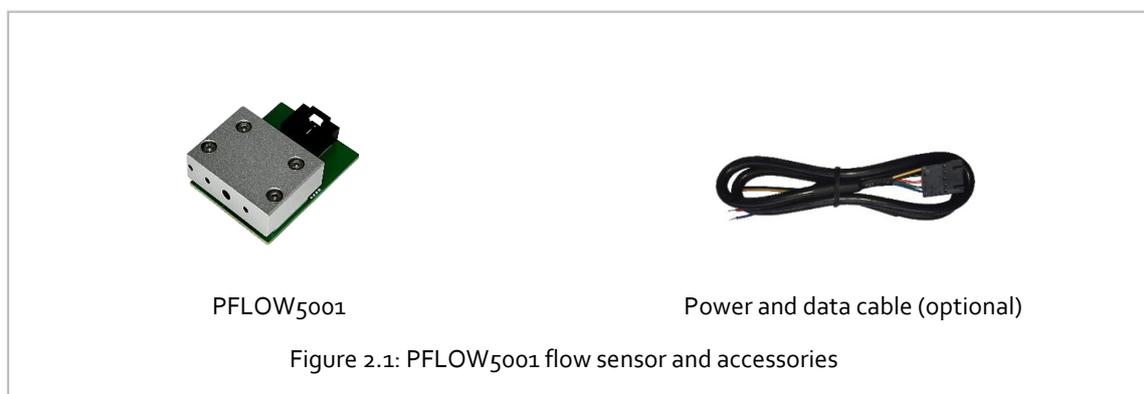
The sensing elements are manufactured with MEMS (micro-electro-mechanical systems) thermal mass flow sensing technologies that measures the calorimetry and diffusivity of the flow medium. The sensor surface is passivated with silicon nitride ceramic materials together with water/oilproof nano-coating 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 a 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.



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. For any further actions, please refer to the return and repair section in this manual.

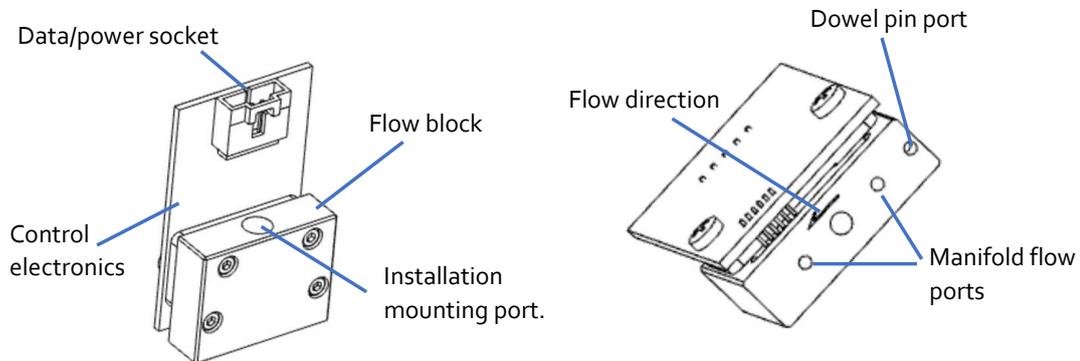
If the packing box is intact, proceed to open the packing box, and you shall find the product (either the sensor formality per the actual order), together with the power and data cable if the order is included as shown below.



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.

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: PFLOW5001 parts description

3.2 Power and data pinout description

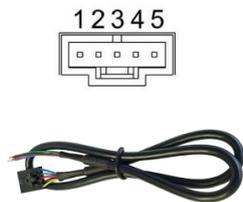


Figure 3.2: PFLOW5001 pinout
2.54mm centers; 0.635mm square

Table 3.1: PFLOW5001 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) |

! **!** **DO NOT connect or disconnect the sensor cable when the power is on!! It will damage the electronic chipsets inside the sensor module! The standard cable has an AMPMODU MTE (5 positions) compatible connector with a length of 0.5 meters.**

Note:

1. Power supply: The PFLOW5001 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.

3.3 Mechanical dimensions

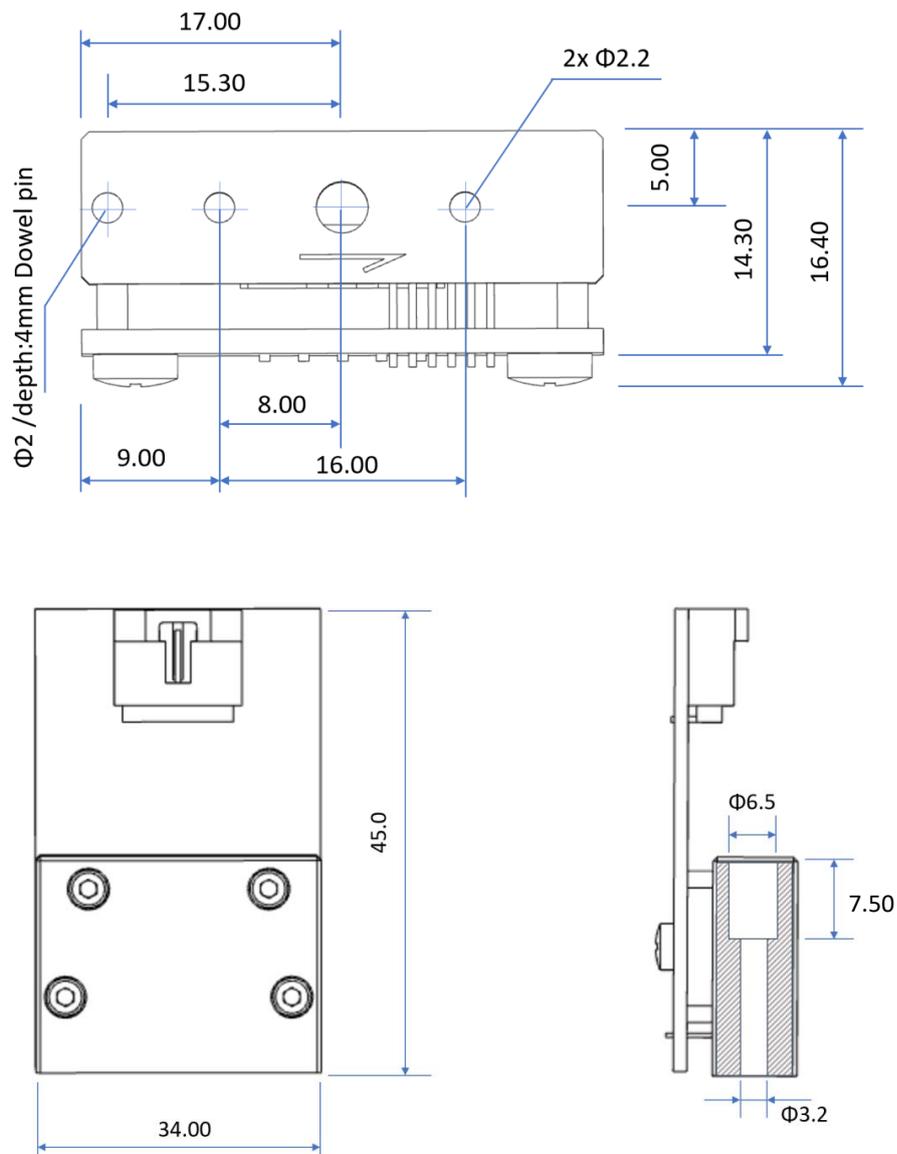


Figure 3.3.1. PFLOW5001 manifold mechanical dimensions.

4. Installation

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

For the installation, make sure the leakage proof of the connections and all electrical precautions are applied. Please make sure the electrical cable is 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 flow stability and related flow noises.

In order to prevent over-forced installation, The mounding torque applied should be within 0.35 ± 0.03 N·m. Sealing O-ring is recommended to be the ones that comply with ISO 3601/1; the mounting screw is specified for M3x20mm by ISO 14583; the dowel pin should be $\Phi 2m6 \times 6$ mm.

Please align the products with your gas manifold block properly, and no excessive force should be applied during installation, and subsequent leakage tests would be required for safety and performance.



5. Basic operation

5.1 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 the cable connection.

5.1.1 Hardware connection

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

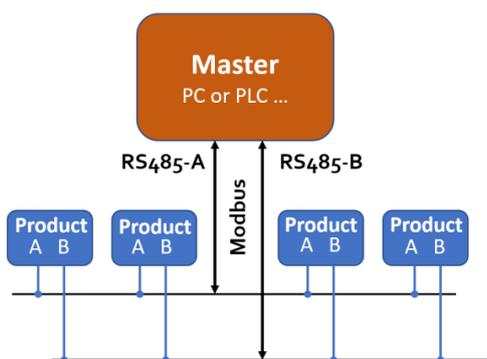


Figure 5.1: RS485 hardware

5.1.2 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 |

5.1.3 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 |
|-------------|---------|----------------|------------------|--------|-------------|
| T1-T2-T3-T4 | 8 bit | 8 bit | N 8 bit (20≥n≥0) | 16 bit | T1-T2-T3-T4 |

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.

5.1.4 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 |

5.1.5 Registers

The product 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 the 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. | | |

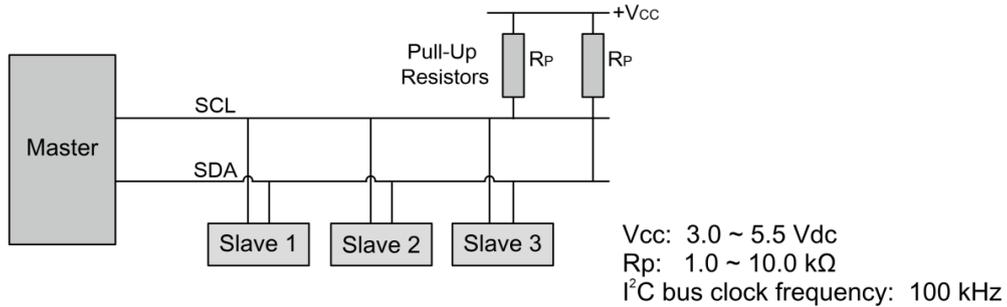
| | | | |
|----------------------|--|--------------|---|
| Response time | 0x008C | Write | Y |
| | | Read | Y |
| Description | Digital filter depth setting | | |
| Value type | UINT 16 | | |
| Notes | 0 ~ 9 programmable, corresponding to 2 ⁰ ~ 2 ⁹ data sampling in the software filter. The default value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

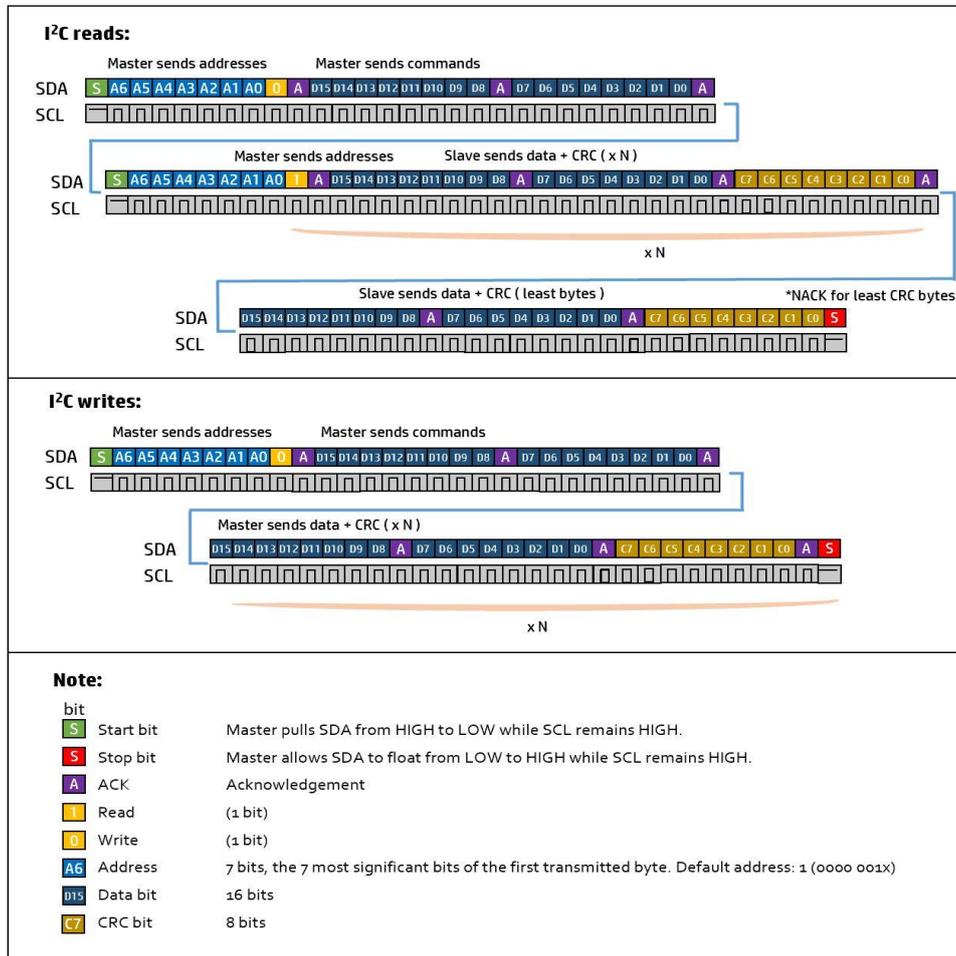
| | | | |
|-------------------------|---|--------------|---|
| Write protection | 0x00FF | Write | Y |
| | | Read | N |
| Description | Write protection disabler for a set value to a specific register. | | |
| Value type | UINT 16, Fixed value 0xAA55 | | |
| Notes | This function is enabled at the time 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. | | |

5.2 I²C communication protocol

5.2.1 I²C interface connection diagram



5.2.2 I²C interface read/write sequences



5.2.3 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 |
| 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 |
| 0x00F0 | 1 | Reset the offset of differential pressure | Write | Fixed value, 0xAA55 |

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

5.2.4 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 |

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.

PFLOW5001 - -

Gas: A – air; N₂; O₂; Ar; C – CO₂; E – He; H – H₂. For other gases, please contact the manufacturer.

Output: V – analog; B – RS485 Modbus half plex; E – I²C;

Also available with BV, and EV.

Full scale flow rate: 200, 500, 1000, 2000, 4000, 6000, 10000, 15000, and 20000 sccm. For higher flow rate options, please contact the manufacturer.

Note: For CO₂, the full-scale flow is 60% of the specified ones.

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 ~ 100...20000; or 0~±100 ...±20000 | sccm |
| Accuracy | ±(1.5+0.5FS) | % |
| Repeatability | 0.5 | % |
| Turn-down ratio | 100:1 | |
| Response time* | 10 | msec |
| Temperature range | -5 ~ 50 | °C |
| 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 / Rs485 Modbus / I ² C | |
| Analog load | Sourcing: 25 / Sinking: 15 | mA |
| Maximum overflow | 3000 (3SLPM) (200, 500, 1000 models); 18000 (18 SLPM) (2000, 4000, 6000 models) 45000(45SLPM) (10000, 15000 models) | sccm (SLPM) |
| Maximum flow change | 500 (200, 500, 1000 models); 3000 (2000, 4000, 6000 models) 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 | |
| Wetted materials | Aluminum alloy; silicon nitride; Ablestik 84-3J; FR4 | |

- 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

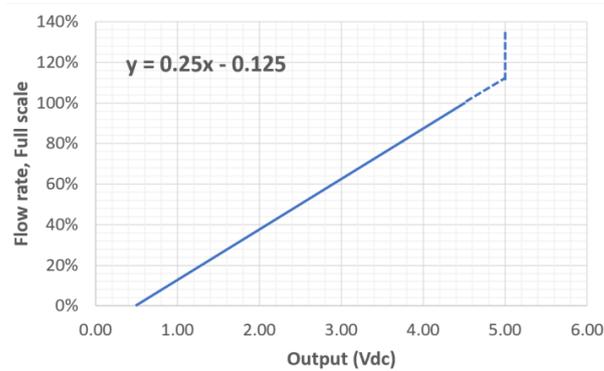


Figure 7.1: Typical analog output

7.3 Pressure loss

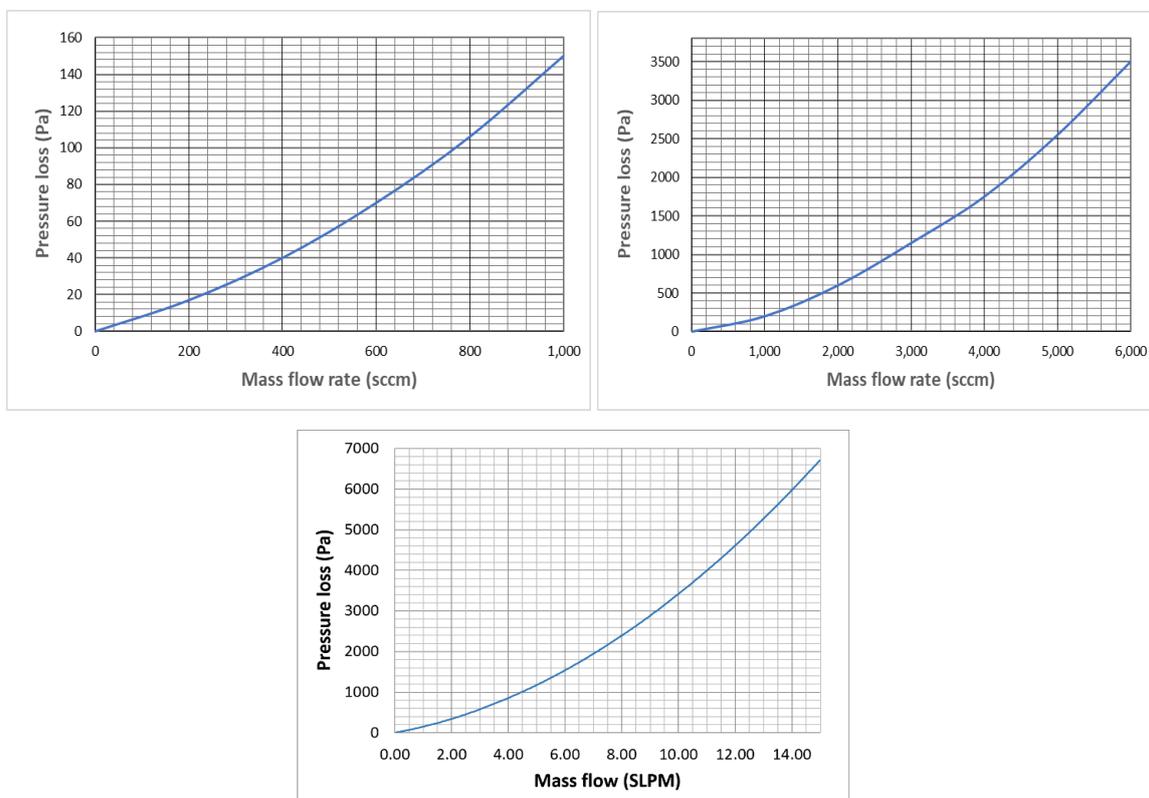


Figure 7.2: Upper row: from left to right, for models of full scale up to 1000 sccm; and of full scale from 2000 to 6000 sccm. Lower row: models of full scale from 10000 to 15000 sccm (10 to 15SLPM).

8. Technical notes for the product performance

8.1 Measurement principles

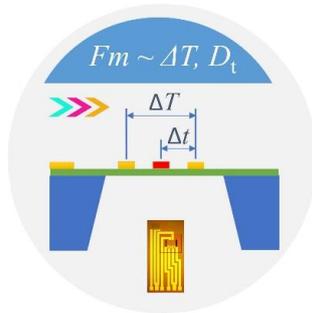


Figure 8.1: Illustration of the measurement principle.

The products utilize 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 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 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, this 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.

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)

APSP 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.

APSP 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 APSP 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.

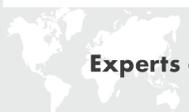
APSP makes no other warranty, express or implied, and assumes no liability for any special or incidental damage or charges, including but not limited to any damages or charges due to installation, dismantling, reinstallation, etc. other consequential or indirect damages of any kind. To the extent permitted by law, the exclusive remedy of the user or purchaser, and the limit of APSP'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 APSP, and upon verification of APSP 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 APSP more than 365 days after a cause of action has accrued. The products returned under warranty to APSP shall be at the user or purchaser's risk of loss and will be returned, if at all, at APSP'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 APSP. It shall not be amended, modified, or its terms waived except by APSP'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, APSP 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) APSP 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.



We are here for you. Addresses and Contacts.

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