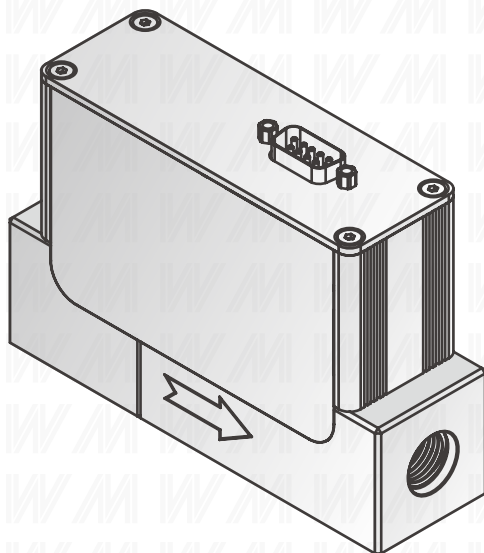


MFCA

Digital Flow Controllers

User Manual E1.2



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Warranty

All products manufactured by Mindman are under warranty regarding defective materials for a period of one year, starting from the date of delivery to the original purchaser.

Disclaimer

Mindman assumes no liability for damages resulting from the use of this product. Mindman reserves the right to change this manual at any time without notice. The information published by Mindman is believed to be accurate and reliable. However, no responsibility is assumed by Mindman for its use, not for any infringements of patents or other rights of third parties resulting from its use.

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Contact us

If there has any question, please contact Mindman right away. Thanks.

1. Overview

This manual provides essential information for the operation of the MFCA series of gas mass flow controllers for non-corrosive gas flow control applications with the full-scale mass flow rate (0~50 Ln/min, 0~100 Ln/min, 0~200 Ln/min) and both analog set point or RS485 Modbus interface for the mass flow control. The product performance, maintenance, and troubleshooting as well as the information for product orders, technical support, and repair are also included. Other standard communication options such as DeviceNet, ProfiNet, EtherNet, EtherCat, IO-Link, etc. are available by contacting the manufacturer and will become standard offers in due course. These interfaces can also be further customized upon request.

MFCA mass flow controller can be applied for process control with a 100:1 dynamic range and it controls in a pressure range of 0.1 to 1MPa (15 to 150 PSI), and a compensated temperature ranging from 0 to 50°C.

The products are designed with an easy change of mechanical connectors. The standard connectors are Rc 3/8" to 1/2"-female and other customized ones are available upon request.

The products are operated with calorimetric sensing technology together with smart control electronics. Compared to the conventional calorimetric flow sensing technology on the market, this unique mass flow sensing technology removes gas sensitivity for some gases with similar diffusivity and allows gas identification once programmed. The sensor surface is passivated with silicon nitride ceramic materials together with water/oilproof nano-coating for performance and reliability. This technology also offers better linearity and improves temperature performance. 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 allows high precision for gas process control 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 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.

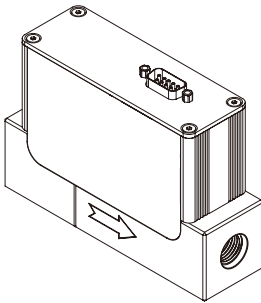


Fig 2.1 MFCA model

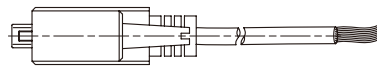


Fig 2.2 Power and data cable DB9-2-100

Please check immediately for the integrity of the product as well, 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

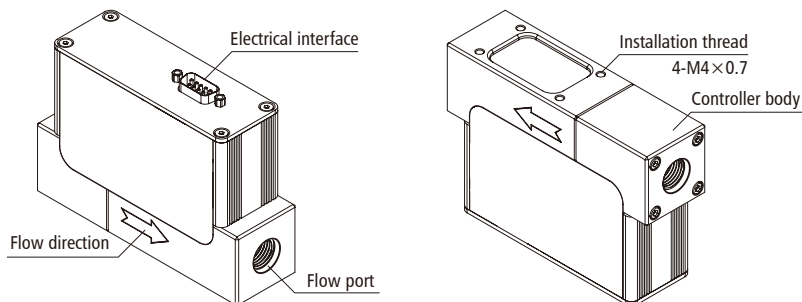


Fig 3.1 MFC product with DB9 interface

3.2 Power and data cable description

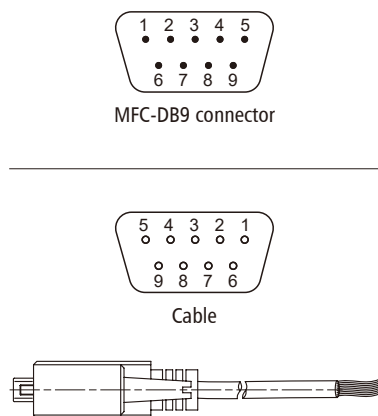


Fig 3.2 Connection and cable

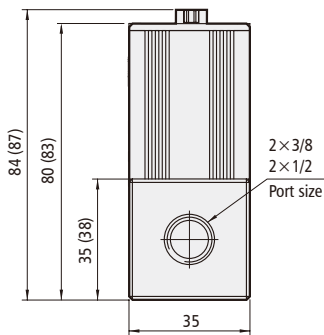
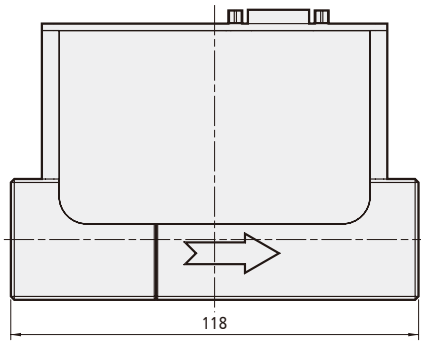
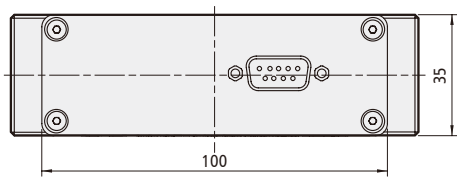
Table 3.1 Pin/wire assignments

Pin no.	Color	Definition
1	Purple	N/A
2	Red	N/A
3	White	RS485B (-)
4	Yellow	Setpoint, analog 0 ~ 5 Vdc or 4 ~ 20 mA
5	Black	RS485A (+)
6	Gray	Flow rate output, 0 ~ 5 Vdc or 4 ~ 20 mA
7	Brown	Power supply, 24 Vdc, 1A
8	Blue	Common
9	Green	Common

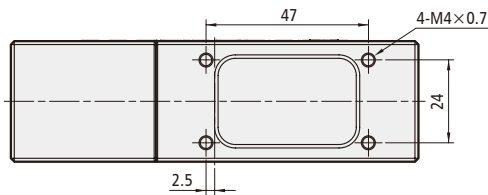
Note :

The standard cable (part number: DB9-2-100) has a DB9 connector with a length of 1.0 meters. The other end for customer connection is open wires.

3.3 Mechanical dimensions



* () value for MFCA-200.



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. Check the application requirements and verify whether they are matching to the product specifications, in particular the gas compatibility and pressure/temperature ratings for safety reasons.

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 EDS (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. However, since the products are calibrated at the horizontal installation, vertical placement of the product may incur some minor offset if the products are calibration with a large dynamic range. When this happened, please apply the reset offset function described in this manual (Section 5) to ensure the offset is properly zeroed. 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.

The products have four mounting holes (threaded) located at the bottom of the products, refer to Section 3.3.

The connection pipes or tubes should be clean and free of foreign materials. Gas compatibility must be observed for the proper performance of the products. To ensure there is no gas instability, the pipe or tube diameter should be matching with that of the product. Avoid installing pipes or tubes with a smaller diameter than that of the products, otherwise, it may create a strong flow instability in particular at the laminar flow range, and result in significant inaccuracy of the measurements.

If another valve or pressure regulator must be installed closer to the products, please keep them at a distance of at least 15 times the pipe diameter from the products.

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) The installation environment should avoid strong magnetic field interference and strong vibration.
- c) Before installation of the product, please ensure that the pipe debris or particles or any other foreign materials are completely removed.
- d) Close the upstream valve, if any, completely.
- e) During installation, please make sure no foreign materials (such as water, oil, dirt, particles, etc.) enter the installation pipeline.

- f) Make sure the power source is at the off status before connecting electrical wires per the wire definition in Table 3.1. Please be sure of the power supply range (i.e., 24 Vdc, 1 A) and power supply polarization. If an adapter is used, make sure the adapter meets industrial standards and has all safety certifications.
- g) 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.
- h) Before starting to flow control process, make sure no leakage is present after the installation.
- i) This will conclude the installation.

 Caution

- 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.
-

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.

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. The gas medium to be for the controller 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 applied must be clean and free of particles or other foreign materials.

5.2 Check the leakage

Check gas leakage in the pipe system before the operation. 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, 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 EDS (electrostatic discharge) and DC voltage are observed. Excessive electrostatic discharge may damage the product.

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

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 3.1 for the cable connection.

5.4.1 Hardware connection

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

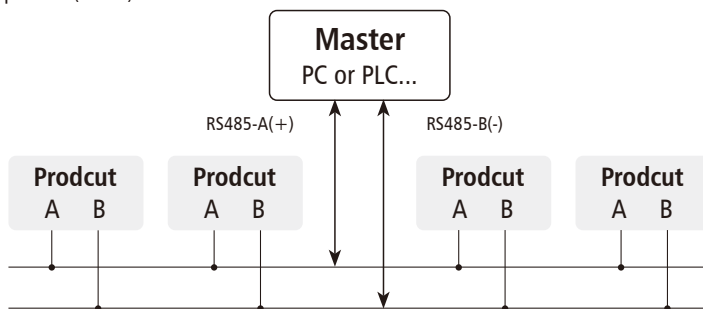


Fig 5.1 RS485 hardware

5.4.2 Communication parameters

Table 5.1 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
T1-T2-T3-T4	8 bit	8 bit	N 8 bit ($20 \geq n \geq 0$)	16 bit	T1-T2-T3-T4

Start_bits	4 periods of a 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.
Stop_bits	4 periods of a 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 (MFCA) 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 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 ~ 0x0035	40049 (0x0030)
Flow rate	Current gas instantaneous flow rate (R)	0x003A ~ 0x003B	40059 (0x003A)
Baud rate	Communication baud rate (R/W)	0x0082	40131 (0x0082)
Setpoint source	Set the setpoint source (R/W)	0x00BA	40187 (0x00BA)
Setpoint	Set the flow rate in percentage of the full-scale flow (R/W)	0x00BB	40188 (0x00BB)
Setpoint flow	Read the current flow rate set by the user. (R)	0x00BC ~ 0x00BD	40189 (0x00BC)
P Gain	PID proportional control of the valve/flow rate. (R/W)	0x00BE	40191 (0x00BE)
D Gain	PID differential control of the valve/flow rate. (R/W)	0x00BF	40192 (0x00BF)
Offset calibration	Offset reset or calibration (W)	0x00F0	40241 (0x00F0)
Write protection	Write protection of selected parameters (W)	0x00FF	40256 (0x00FF)

* R – Read-only, W – Write only, R/W – Read and write.

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 disabled, and the default address is 1.		

SN, Serial number	0x0030 ~ 0x0035	Write	N
		Read	Y
Description	Series Number of the product, SN		
Value type	ASCII		
Notes	0x0030~0x0035 provides 12 bytes in ASCII, representing the product serial number. For example, if the values obtained through Modbus are 0x2A4D, 0x4332, 0x5442, 0x3830, 0x3231, and 0x342A, then the product serial number (SN) is *MC2TB80214*.		

Flow rate	0x003A ~ 0x003B	Write	N
		Read	Y
Description	Current gas instantaneous flow rate		
Value type	UINT 32		
Notes	Flow rate = [Value (0x003A) * 65536 + value (0x003B)] / 1000 e.g., When the user reads "0" from register 0x003A and "20340" from register 0x003B, the current flow rate = (0 * 65536 + 20340) / 1000 = 20.340 Ln/min		

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

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; 4: baud rate=57600; 5: baud rate=115200. The default value is 3. e.g., When the user reads "3" from register 0x0082, the baud rate is 38400.		

Setpoint source	0x00BA	Write	Y
		Read	Y
Description	Set the setpoint source		
Value type	UINT 16		
Notes	Available valve modes: 0 and 1. 0 – analog control; 1 – digital control.		

Setpoint (PID control)	0x00BB	Write	Y
		Read	Y
Description	Set the flow rate in percentage of the full-scale flow, where 0 is zero flow or 0% and 64000 corresponds to the full scale of 100%. The default value is 0, or zero flow		
Value type	UINT 16		
Notes	0 ~ 64000 corresponding to 0% ~ 100%. 0 - 0%; 64000 - 100%.		

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

Setpoint flow	0x00BC ~ 0x00BD	Write	N
		Read	Y
Description	Read the current flow rate that is set by the user.		
Value type	UINT 32		
Notes	Flow rate $F = [\text{value}(0x00BC) * 65536 + \text{value}(0x00BD)] / 1000$; Example: When the user reads "0" from register 0x00BC and "50000" from register 0x00BD, the flow rate F is calculated as $50000 / 1000 = 50$ Ln/min.		

P Gain	0x00BE	Write	Y
		Read	Y
Description	PID proportional control of the valve/flow rate		
Value type	UINT 16		
Notes	Available valve parameters: 0 ~ 9999. The default value is 150.		

D Gain	0x00BF	Write	Y
		Read	Y
Description	PID differential control of the valve/flow rate		
Value type	UINT 16		
Notes	Available valve parameters: 0 ~ 9999. The default value is 250.		

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

Offset calibration	0x00F0	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 0x00F0. Note: When executing this function, ensure 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 Analog voltage (0 ~ 5 Vdc) output

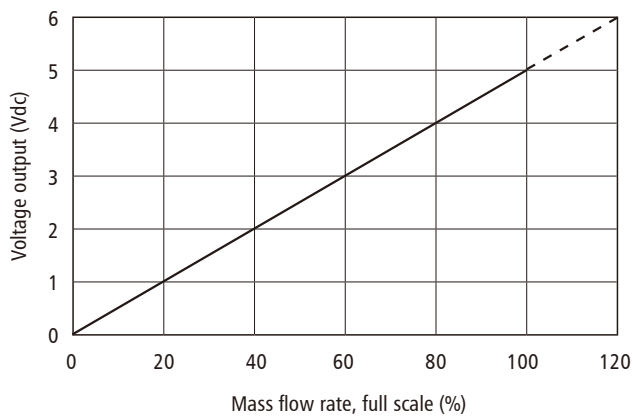


Fig 5.2 Analog output

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.

MFCA – 100 – 10A – A2 0 A – □

①
②
③
④
⑤
⑥

① FLOW RATE RANGE

050: 0 ~ 50 Ln/min
100: 0 ~ 100 Ln/min
200: 0 ~ 200 Ln/min

② PORT SIZE

10A: 3/8
15A: 1/2

③ I/O SIGNAL

A2: 0~5V + RS485
B2: 4~20mA + RS485
 (Switchable between analog and digital signals)

④ DEFAULT SETTING

0: Analog signal
1: Digital signal

⑤ FLUID

A: Air, N₂, O₂, Ar
 (For other gases, please contact our sales)

⑥ PORT THREAD

Blank: Rc thread
NPT: NPT thread
 (For G thread, please contact our sales)

7. Technical specifications

All specifications listed in the following table unless otherwise noted apply for calibration conditions at 0 °C and 101.325 kPa absolute pressure with air. The product is horizontally mounted at the time of calibration.

Model	MFCA
Flow rate range	0~50, 0~100, 0~200 Ln/min
Fluid	Air, N ₂ , O ₂ , Ar
Accuracy	± 1.5% R.D. (20 ~ 100% of full scale) ± 0.3% F.S. (< 20% of full scale)
Repeatability	± 0.5% R.D. (20 ~ 100% of full scale) ± 0.1% F.S. (< 20% of full scale)
Turn-down ratio	100:1
Max. control range	120% F.S.
Rated pressure range	0.1~0.8 MPa
Max. operating differential pressure	0.4 MPa
Proof pressure	1.5 MPa
Settling time	100 ms
Max pressure loss	80 kPa (100L/min models)
Power supply	24V DC
Control valve	Normal closed (N.C.)
Electrical connector	DB9
Port size	3/8, 1/2
Analog	Input
	Output
	Voltage 0~5V or Current 4~20mA
Max null shift (analog)	± 30 mVdc
Digital (*)	Input
	Output
	RS485 Modbus
Environment	Protection
	IP40
	Working temperature
	0~55°C (No freezing)
	Humidity
	<95%RH (No condensation)
	Storage temperature
	-20~70°C (No freezing)
	Reference conditions
	Air (0°C, 101.325 kPa)
	Certification
	CE(EN61000-2;-3;-4), RoHS, REACH

* For the other digital interface, please contact the manufacturer.

8. Technical notes for the product performance

8.1 Measurement principle

The products utilize the Company's proprietary micro-machined (MEMS) thermal calorimetric sensing with time-domain data 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 amplitude, time, and temperature differences, calculating the thermal diffusivity and further correlating to the fluid mass flow rate via the calibration process.

This unique thermal sensing approach offers a large dynamic range with a better performance against environmental parameter alternations. It is the first of the kind in the industry that offers the gas property independent mass flow measurements for gases with similar thermal diffusivities. It significantly simplifies process control with high precision and easy maintenance.

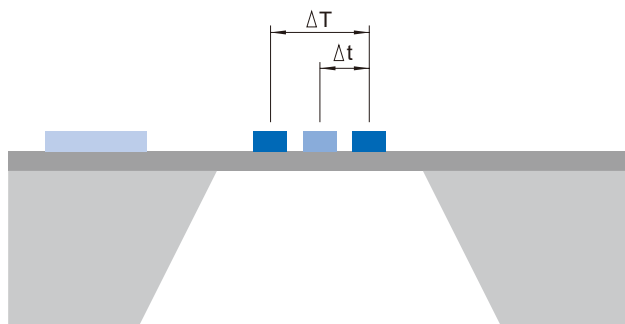


Fig 8.1 Measurement approach illustration

8.2 Precautions for the best performance of the product

8.2.1 Comparison with a third-party reference meter

It is a general practice 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 cleanliness

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 product can be applied to meter and control 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, N₂, O₂, Ar.

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. Please contact your sales or manufacturer for additional information.

Under normal operation conditions, the wetted materials are fully compatible with common gases, such as air, oxygen, nitrogen, argon, and carbon dioxide. If a special gas will be applied, please check back with the manufacturer for gas compatibility analysis. In some cases, some package materials may need to be changed for gas compatibility, or additional hazardous zone certification will be needed before the products can be used.

8.2.4 Re-calibration and maintenance

The re-calibration of the controller will be dependent on the usage and application requirements, and therefore it is more a decision by the applications.

Alternatively, please contact your sales or directly contact the manufacturer for assistance. We calibrates all products with NIST (National Institute of Standards and Technology, USA) traceable calibrators.

For maintenance, the services must be performed by trained or certified technicians by Mindman. Any arbitrary changes to the products will nullify the warranty of the products. It could lead to irrecoverable damages to the products and even could lead to unexpected injuries.

The products do not require regular maintenance if the specified application conditions are exactly observed. Only if any clear indications of contamination and or malfunctions, maintenance would be required. Once this happened, please contact your sales or directly contact customer support (information available on the Company's webpage).

9. Troubleshooting

Phenomena	Possible causes	Actions
No signal	The power is not connected	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
	Sensor failure	Return to factory
Large errors or unexpected flow rate	The type of gas is incorrect or the gas is unclean	Confirm gas type and cleanliness
Large fluctuations	Vibration, unstable flow	Check the surrounding environment and gas status
Valve not work	Wire connection, valve	Return to factory
Offset unstable	Circuit problems, sensor contamination	Return to factory
No digital interface	Wrong address, communication setting error	Check commands, communication settings

