MEMS MASS FLOW METER

User Manual

Rev 2.5

TMF-5000 Gas Mass Flow Meter

Model TMF5000

Gas Mass Flow Meter

with MEMS calorimetric sensing technology TMF5000 Series

Quick User Manual

⚠ 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 defects.

- 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 are allowed to perform product service.

⚠ Use with caution!

- Electrical safety: Any electrical surge or anomaly may lead to damage.

- The gas to be measured should be clean and free of particulate. Filter to 100 Microns. Do not use this meter with any liquid medium.

- Do not use meter with any unknown or unspecified gases that may cause damage.

Table of Contents

1. Overview,

All contact information can be found at the end of this manual.

This manual provides essential information for the operation of the TMF5000 series gas mass flow meters for general-purpose gas metrology applications. The product performance, maintenance, and trouble-shooting as well as the information for product order, technical support, and repair are also included.

TMF5000 mass flow meters are designed for general purpose precise industrial gas measurement, monitoring, or control. The meter series cover a wide dynamic flow range with a working pressure rating of up to 216 PSIG/1.5MPa, and a temperature range of -20 to 60°C.

The meters function with our proprietary MEMS calorimetric mass flow sensors integrated with smart control electronics. The sensor surface is passivated with silicon nitride ceramic materials with a water/oil proof nano-coating for performance and reliability. The meter body is fabricated using 304 stainless steel that is compatible with most gases.

2. Receipt / unpack of the products

Upon receipt of the products, please check the packing box before the disposal of the packing materials. Ensure no damage occured during shipping. If any abnormality is observed, please contact and notify the carrier who shipped the product and inform the distributors or sales representatives. For any further actions, please refer to the return and repair section in this manual.

You will find the flow meter and data cable as shown below:

| Flow meter | data cable |
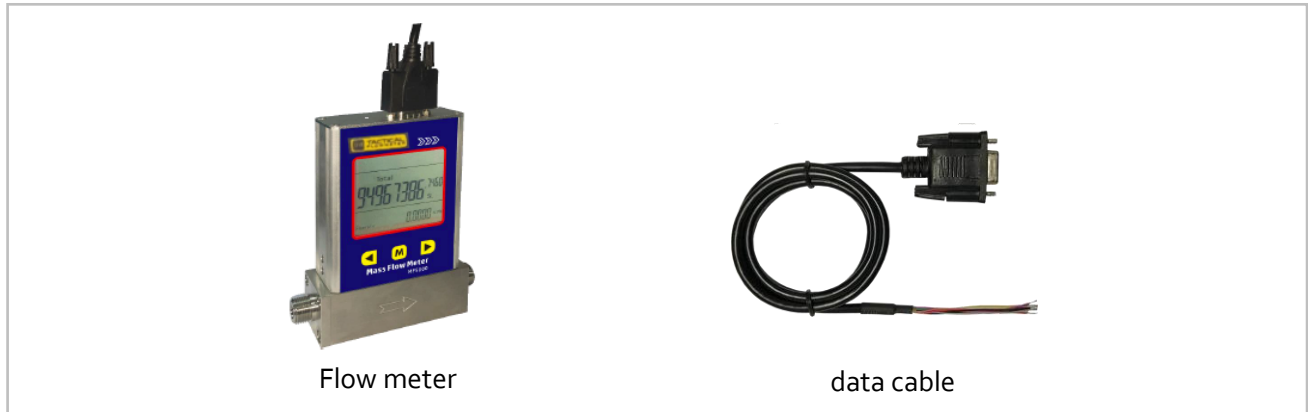
Once installed, check that the flow meter is opperating properly. If any abnormal operation is observed, please notify the distributor/sales representative or manufacturer for assistance

Pleas note that the data cable uses a standard a DB9 connector.

3.Product Introduction

3.1. Product description

Electrical interface, DB9

LCD display

MENU keys

NPT or other connectors

Meter body

Flow direction
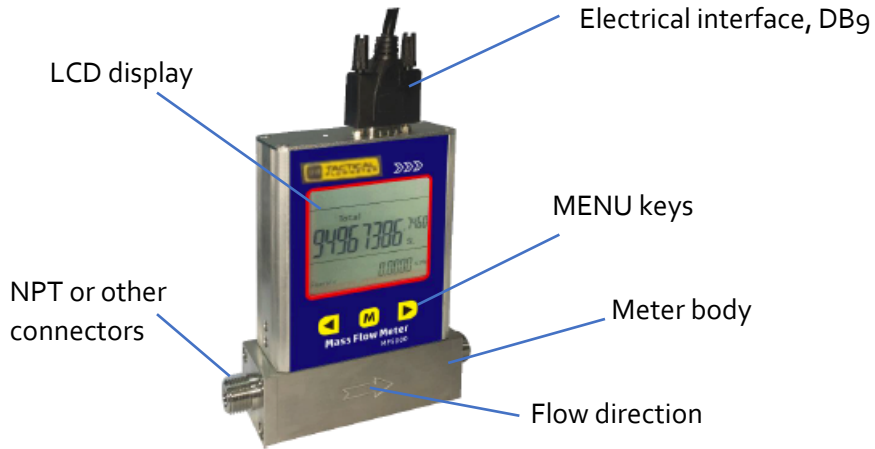
3.2. LCD description
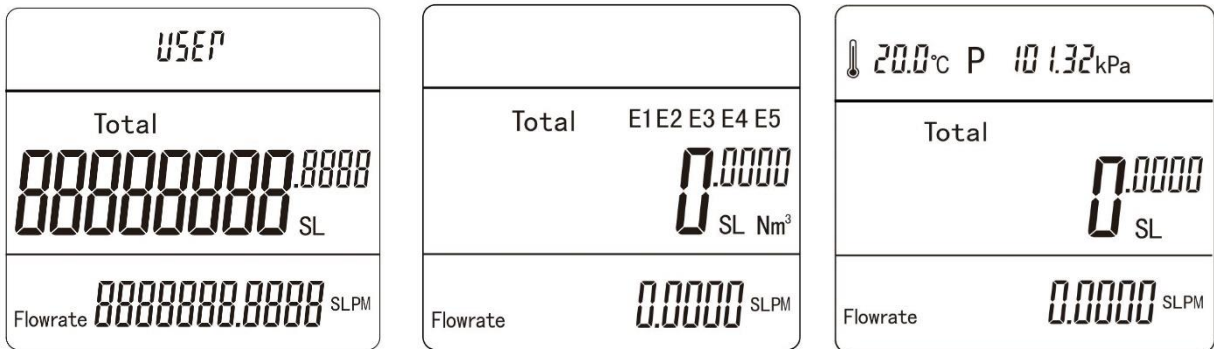
The LCD provides all information that the meter measures. Some symbols are reserved for custom options, and will not be lighted during the operation. The following table details the meaning of each of the symbols.

USER	The top row, only displayed when communication or other user-defined function is in process.
Total	The middle row displays the totalizer or accumulated flow rate in SL (standard liters) or Nm^3 (Normalized cubic meters). The standard (normalized) conditions refer to 20°C, 101.325kPa.

Flowrate	The bottom row displays the instant flow rate in SLPM (Standard Liters per minute) or the current units.
E1	Error 1 – Sensor error
E2	Error 2 – ADC error
E3	Error 3 – RTC error
E4	Error 4 – EEPROM error
E5	Error 5 – Oscillator (crystal) error
🌡	Temperature, Optional, for models with temperature option
P	Pressure, Optional for models with pressure option

*Note: The pressure and temperature sensors can be optionally provided

3.3. Power and data cable description
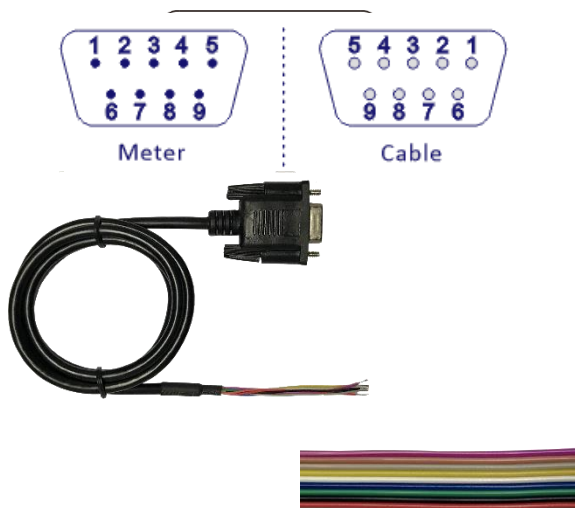
Table 3.3: MF5000 wire assignments.

Wire	Color	Definition
1	Purple	4~20 mA, output
2	Brown	RS485B
3	Gray	4~20mA, ground
4	Yellow	Pulse, output
5	White	Pulse, ground
6	Blue	N.C.
7	Green	RS485A
8	Black	Ground, common
9	Red	Power supply, 12 ~ 24Vdc

NOTE: This is NOT a Loop Powered device. Do NOT put 24 VDC into the 4-20 mA signal leads.

3.4. Mechanical dimensions
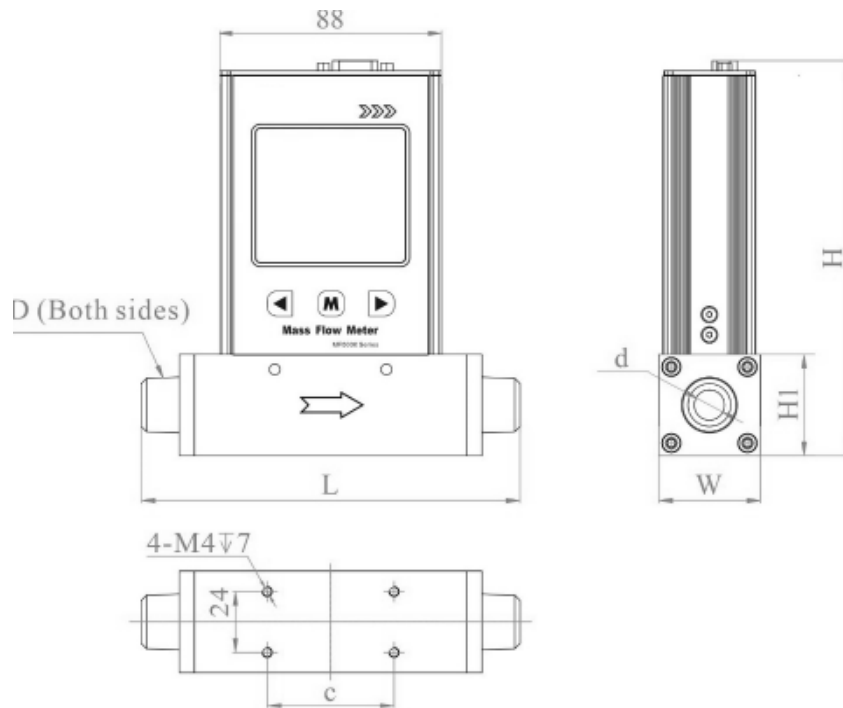
Figure 3.4.1. TMF5000 meter dimensions in mm

Model	DN (mm)	D (NPT)	L	H	H1	W	d	C
TMF5003	3.00	1/8"	118.0	144.0	28.0	38.0	Φ3.0	36.0
TMF5006	6.00	1/4"	124.0	144.0	28.0	38.0	Φ6.0	36.0
TMF5008	8.00	3/8"	124.0	151.0	35.0	38.0	Φ8.0	50.0
TMF5012	12.00	1/2"	150.0	156.0	40.0	40.0	Φ12.0	50.0
TMF5019	19.00	3/4"	182.5	156.0	40.0	40.0	Φ19.0	70.0

4. Installation

Do not open or alter any part of the product that could lead to malfunction and irrecoverable damage. Opening the meter will forfeit the terms of the warranty.

The product at the time of shipment is fully inspected for 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, DC voltage precautions. Other tasks such as calibration, part replacement, repair, and maintenance must only be performed by factory trained personnel.

The meter is calibrated and designed to be installed horizontally. Flow direction should be aligned with the arrow mark on the meter body. If the flowing fluid has particles or debris, a 100 Micron filter is strongly recommended to be installed upstream of the meter.
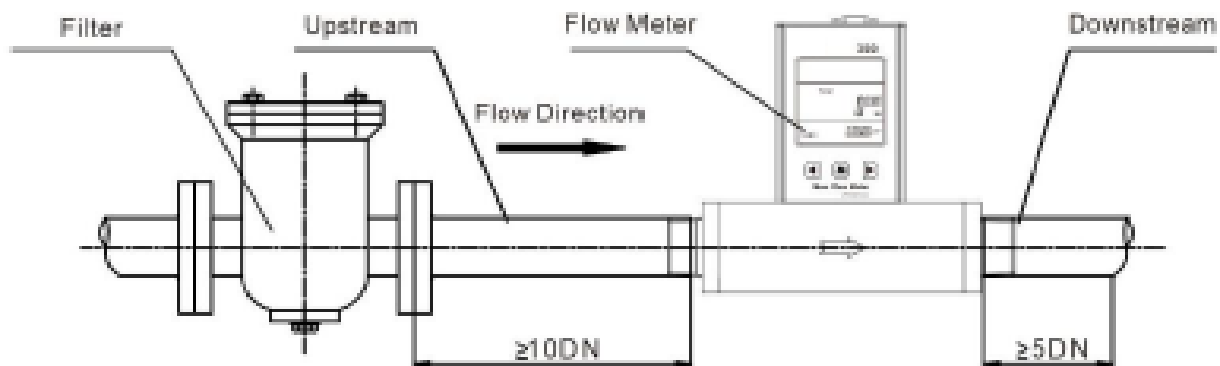
Please follow the following steps to complete the installation:

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 particulates, or any other foreign materials are removed or filtered.

c) Cautions during installation:

    i)   It is preferable to first install/connect the meter inlet and then the outlet end of the meter; To ensure the measurement accuracy, an upstream straight pipe of length no less than 10 diameters (DN) upstream and a downstream straight pipe of length no less than 5 diameters (DN) downstream should be used. Please refer to the following recommended installation configuration.
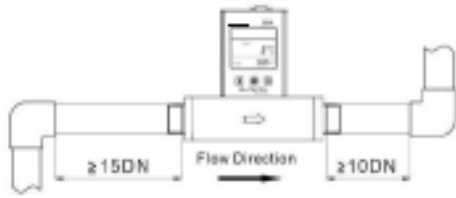
(a) 90-degree elbow or T-joint   (b) 2x90-degree elbow
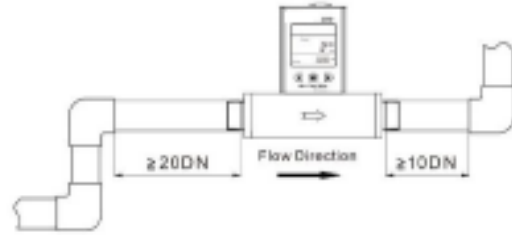
(ii) If the upstream or downstream pipe size is different from that of the product, the size of the installation line pipe diameter(s) should be larger than the flow channel (pipe) size of the meters to be installed. This prevents "jetting" into the meter For typical situations, please follow the installation recommendation detailed in the following sketches.
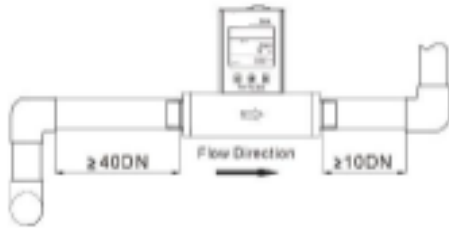
(c) 2x90-degree elbow, 3 D   (d) Pipe size-reduction
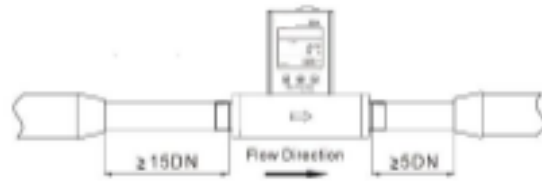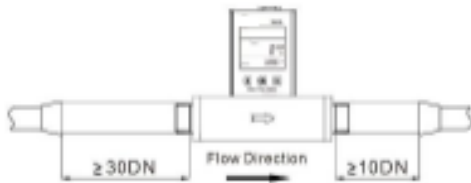
(e) Pipe size expansion   (f) Control valve at upstream or downstream
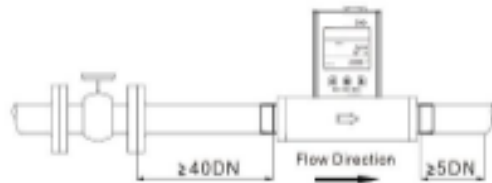
(iii) During installation, ensure no foreign materials (such as water, oil, dirt, particles,etc.) enter the installation pipeline.

d) Connect electrical wires per the wire definition in Table 3.3. Please ensure that the power supply range is (i.e., 12 ~ 24 VDC) and note power supply polarization. If an adapter other than the one optionally supplied by the manufacturer, is used make sure the adapter meets industrial standards and has all necessary safety certifications. Note: AutomationDirect.com is a good source for 24 VDC Power Supplies.

e) For data communication wire connections, please follow the description in Table 3.3 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.

f) Once the external power is successfully connected, the LCD should light up indicating the meter functions properly.

g) Slowly open the valve(s) if any, upstream or downstream or both of the pipeline, and the meter will then start to measure the flow in the pipeline.

Note: Because the meter has a large dynamic measurement range, it is common that you may you see the small instant flow rate before you open the valve as there could be some leakage in the valve. However, make sure the meter reads zero when there is no flow present in the pipeline, creating the zero flow condition may be impossible on some systems. It is OK if there is a small leak, the meter will show that low flow rate.

⚠ **Cautions**

a) Don't alter or open any parts of the product as this will void the warranty.

b) Ensure the electrical connection is properly configured per the instructions.

c) Make sure no mechanical stresses exist in the plumbing or electrical connections.

d) Strong electromagnetic interference sources close by or mechanical shock/vibration at the pipeline may create product malfunction or irregular readings.

e) Slowly open/close valves to prevent abrupt pulse flow to the meter to ensure the sensor does not experience sonic shock waves that can damage the sensor.
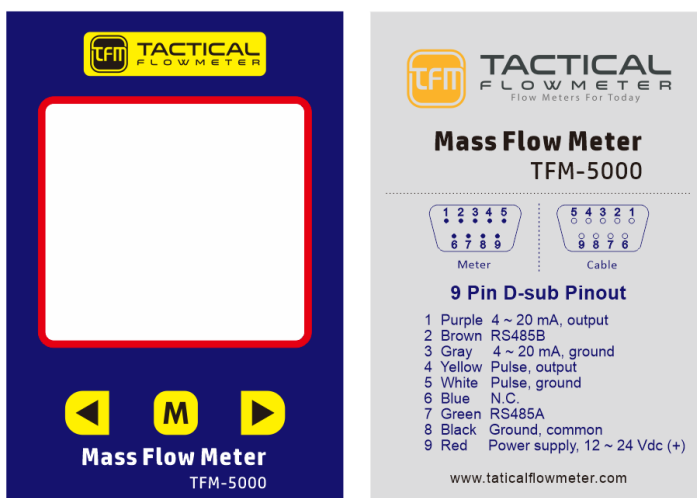
5. Operation and MENU description

5.1. Check product specifications

Before using this meter, check the meter specifications found in this manual or the basic information located on the back panel of the meter.

The detailed product technical specifications can be found in Section 7. For a specific application, the pressure rating must not be higher than the stated system pressure, and the flow range should also be within the specified range. 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 when ordered. 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 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. Again, utilize a 100 micron, or better, filter.

5.2. Check and ensure zero leaks

Check gas leakage before any measurement. Pressurized nitrogen or air can be used for the leak check.

5.3. Power the meter and digital data connection

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

The manufacturer-supplied data cable has the standard DB-9 screw locking feature. Lock the cable and make sure it is properly engaging and will not be accidentally get unplugged.

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

5.4. Meter MENU description

Left   MENU   Right
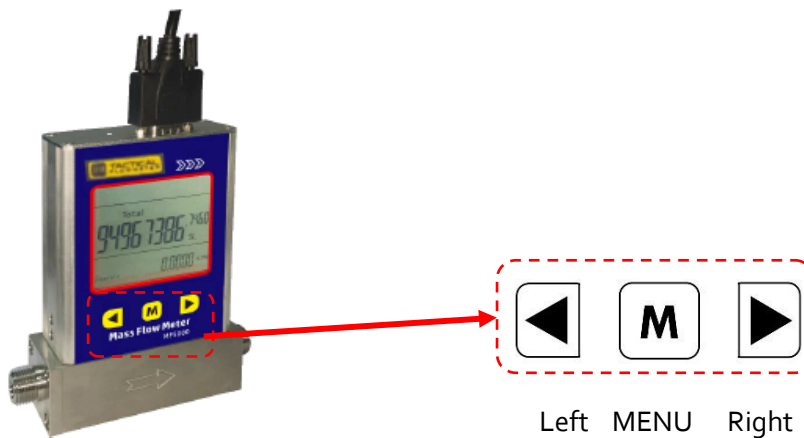
The meter has a front 3-key board for the user to set the desired functions, access data, and check for the status. The Menu key (M) is at the center position that allows the user to select a function and confirmation or other related actions that will be detailed below. Two keys ("Left" and "Right") to select the menu and sub-menu.

5.4.1. Starting the measurement
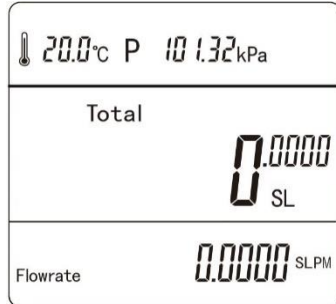
Once the power is supplied and no issues are observed, the meter is ready to perform the measurements. The default display is for the mass flow measurement having two numerical lines on the LCD. The middle line is the totalizer or accumulated flow rate, and the lower line is the instant flow rate.   The upper line will light up when the pressure or temperature option is selected.

5.4.2. MENU entry with a verified password
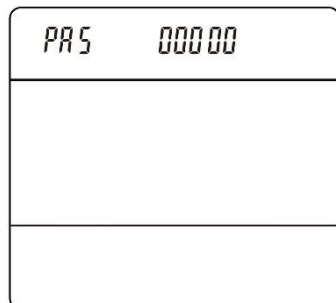
At the flow measurement (main) display, press the center "M" MENU key, it will enter into the password setting and verification MENU. The default password is "11111". If the password is incorrect, the display will return to the main display.

To enter a new password, press the "Left" or "Right" key to change the digit that flashes, and press the "M" key to confirm. Repeat this process for all 5 digits and the meter will enter into the menu setting interfaces/screen.

The MENU allows the user to set accumulated (totalized) flow rate unit, instant flow unit, response time, the gas conversion factor (GCF), communication protocol, device address, password, offset, and reset the accumulation register. Table 5.4 lists the on-screen characters and the corresponding functions.

Table 5.4 On-screen characters and their corresponding functions

On-screen character	Symbol	Functions
Un ITACC	UnITACC	Accumulated (totalized) flow rate unit
Un ITTYPE	UnITTyPE	Instant flow rate unit
In TErVAL	InTErVAL	Interval: response time
SET GCF	SET GCF	Gas conversion factor
PrOTOCOL	PrOTOCOL	Communication protocol
SET Addr	SET Addr	Communication address
SET PAS	SET PAS	Password
OFFSET	OFFSET	Reset offset CAUTION.. ONLY INVOKE AT ZERO FLOW
CLEArACC	CLEAr ACC	Reset accumulated flow rate register
qUIT	qUIT	Exit the MENU

Note: During this process, the meter will continue to measure the flow without being interrupted.

5.4.3. Set the unit for accumulated (total) flow rate units

After the password is verified (Default is 11111) and access is given to the MENU settings, press the "Left" or "Right" key until the screen shows the "UnITACC"

There are two units to select: "—n3—" or "—SL—", corresponding to the Nm^3 (normal cubic meter) or SL (standard liter). Note: both units referred to the calibration standard conditions of 20° C and 101.325kPa. Press the "M" key to enter into the change address screen. Press the "Left" or "Right" key to change, and then press the "M" key to confirm. After the selection, press the "M" key to exit the MENU and return to the Main Display screen.

5.4.4. Set the unit for instant flow rate

Following the above-mentioned steps, at the MENU setting screen, press the "Left" or "Right" key until the screen shows the "UnITTyPE"

There are two units to select: "—n3—" or "—SL—", corresponding to the Nm^3/hr (normalized cubic meter per hour) or SLPM (standard liter per minute). Note: both units referred to the calibration standard conditions of 20°C and 101.325kPa. Press the "M" key to enter into the change address screen. Press the "Left" or "Right" key to change, and then press the "M" key to confirm. After the selection, press the "M" key to exit the MENU and return to the Main Display screen.

5.4.5. Set the response time

Following the above-mentioned steps, at the MENU setting screen, press the "Left" or "Right" key until the screen shows the "InTErVAL"

The factory default response time is 0.125 sec. Press the "M" key to enter into the change response time screen. The following response time options are available: 0.250 sec, 0.500 sec, 1 sec, 2 sec, and 4 sec. Press the "Left" or "Right" key to change, and then press the "M" key to confirm. After the selection, press the "M" key to exit the MENU and return to the Main Display screen. This variable is a "FILTER" to remove "noise" if the flow is noisy.

5.4.6. Set Gas conversion factor (GCF) for different gas measurement

For the general purpose of the application, a gas conversion factor (GCF) can be applied to meter the gas different from the default one or that used for calibration. The GCF is determined by the thermal calorimetric sensing principle as well as the meter fluid dynamics properties and the control circuitry.

Following the above-mentioned steps, at the MENU setting screen, press the "Left" or "Right" key until the screen shows the "SET GCF"

The manufacturer's GCF for air is 1000. **Note: If the meter during purchase is ordered for a special real gas calibration, contact the manufacturer before proceeding further.** Press the "M" key to enter the change option, and press the "Left" or "Right" key to change, and then press the "M" key to confirm. After the selection, press the "M" key to exit the MENU and return to the Main Display screen.

This GCF factor can also be used equivalent to the "K" factor to adjust the meter due to the system deviations. Take 3 to 5 data points using your preferred reference meter, and perform a least square fit to identify the K factor, and input here to make the meter agree with your system.

5.4.7. Set the communication protocol

Following the above-mentioned steps, at the MENU setting screen, press the "Left" or "Right" key until the screen shows the "PrOTOCOL"

The meter communication can be operated as a single meter or multiple meters via RS485 ModBUS communication:

P0-000 – is a communication mode for a single meter.

P1-xxx (xxx from 001 to 255) – is the RS485 ModBUS communication for multiple meters.

Press "M" key to enter the change option, and press the "Left" or "Right" key to change, and then press the "M" key to confirm. After the selection, press the "M" key to exit the MENU and return to the Main Display screen.

5.4.8. Set flow meter address

This function allows the user to set the meter address for multiple meter operations with RS485 ModBUS. Following the above-mentioned steps, at the MENU setting screen, press the "Left" or "Right" key until the screen shows the "SET Addr"

Currently, the default address is 255. Press the "M" key to enter into the change address screen. The address available is from 001 to 255. Press the "Left" or "Right" key to change, and then press the "M" key to confirm. After the selection, press the "M" key to exit the MENU and return to the Main Display screen.

5.4.9. Change default password

For data safety, it is recommended that the default password of 11111 should be changed and recorded in a safe place.

Following the above-mentioned steps, at the MENU setting screen, use the "Left" or "Right" key to enter the password change screen, and it will show the default password of 11111. Press "M" key to enter the change option. Use the "Left" or "Right" and the "M" confirming key to enter the desired one, and press the "M" key again to complete the task and exit.

Please keep the changed password in a safe yet accessible place. In case it is unrecoverable, please use the special password of 85139 to access the meter MENU and reset the password to your new value.

5.4.10. Reset offset

This function allows the user to reset the offset of the meter. Following the above-mentioned steps, at the MENU setting screen, use the "Left" or "Right" key to enter the "OFFSET" option. Press the "M" key to confirm and use the "Left" or "Right" to select "Yes" or "No" to change or keep the current offset value, and then press the "M" key to confirm and then exit.

5.4.11. Reset totalizer or accumulated flow rate

Note the maximum value of the totalizer or accumulated flow rate is 99,999,999 the totalizer register will stop accumulating once this value is reached. This could take 100 years… At this time, it is necessary to reset this register. Following the above-mentioned steps, at the MENU setting screen, use the "Left" or "Right" key to select "CLEAr ACC". Press "M" key to enter the change option, and use the "Left" or "Right" to select "Yes" or "No" to change or keep the current offset value, and then press the "M" key to confirm and then exit.

5.4.12. Exit MENU

At the MENU settings, use the "Left" or "Right" key to select the qUIT option and press the "M" confirming key to exit the MENU settings and return to the Main Display screen.

Mass Flow Meter
TFM-5000

Meter   Cable

9 Pin D-sub Pinout

1 Purple 4 ~ 20 mA, output
2 Brown RS485B
3 Gray   4 ~ 20 mA, ground
4 Yellow Pulse, output
5 White   Pulse, ground
6 Blue   N.C.
7 Green   RS485A
8 Black   Ground, common
9 Red   Power supply, 12 ~ 24 Vdc (+)

www.taticalflowmeter.com
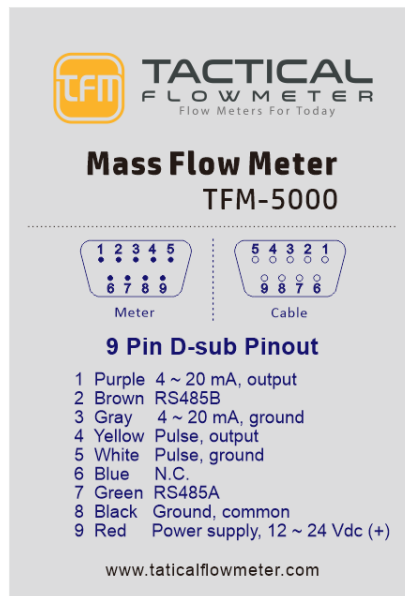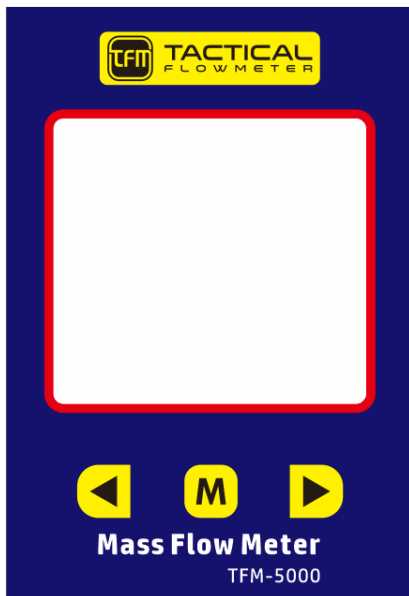
5.4.13. MENU key sequence for settings
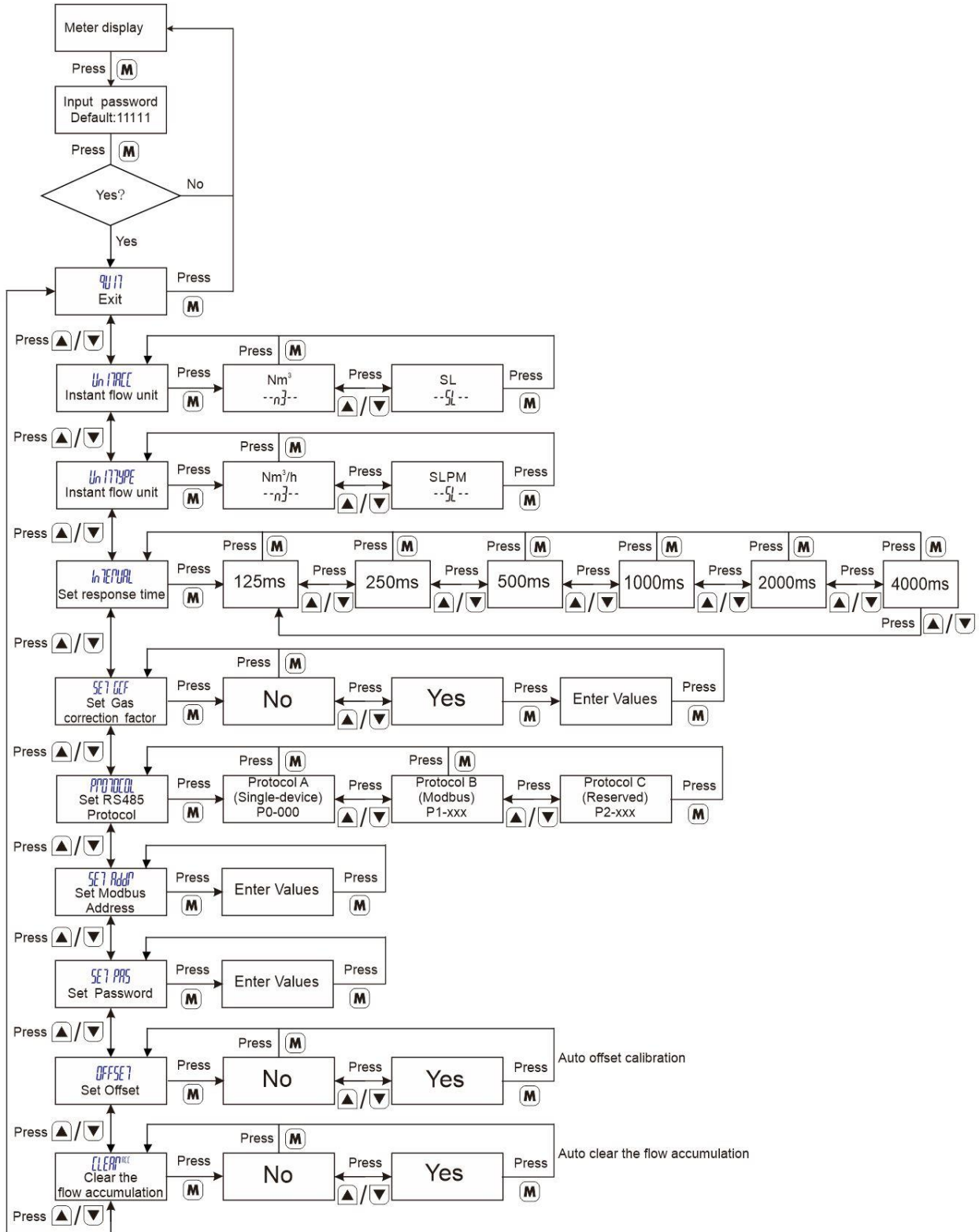
5.5. RS485 ModBUS communication protocol (Mode P1)

The digital communication protocol Mode P1 is based on standard ModBUS RTU Half-duplex mode. A master (PC or PLC) can communicate with multiple slaves (the current product) for data exchange and communication parameter configuration. Refer to Table 3.3 for cable connection.

5.5.1. Hardware connection

The hardware layer is TIA/EIA-485-A, as illustrated below. In this configuration, the product (TMF5000) is a slave.
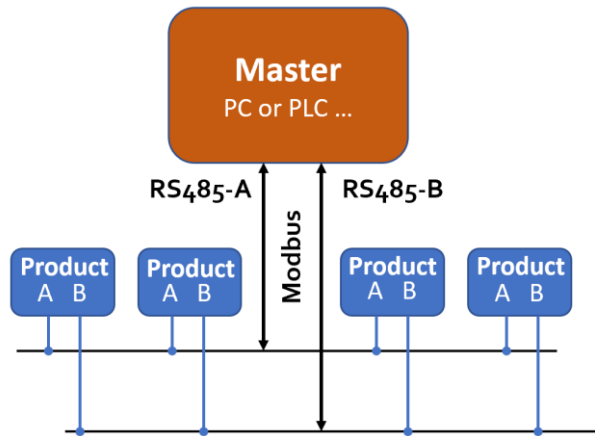
5.5.2. Communication parameters

The PC UART communication parameters are listed in the following table.

Parameters	Protocol
	RTU
Baud rate (Bits per second)	9600 bps
Start bits	1
Data bits	8
Stop bits	1
Even/Odd parity	None
Bits period	104.2 µsec
Bytes period	1.1458 msec
Maximum data length	20
Maximum nodes	247

5.5.3. ModBus frame Protocol

The frame function is based on the standard ModBUS RTU protocol:

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 255 except for 157 (0x9d). 0 is the broadcast address.

Function codes: Define the product (TMF5000)'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.

5.5.4. 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:

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

5.5.5. Registers

The product (TMF5000) 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.

Functions	Description	Register	ModBUS reference
Address	Product address (R/W)	0x0001	40001 (0x0001)
Flow rate	Current flow rate (R)	0x0002~0x0003	40002 (0x0002)
Totalizer	Totalizer or accumulated flow rate (R)	0x0004~0x0006	40004 (0x0004)
Communication mode	Gas correction factor (R/W)	0x0000	40000 (0x0000)

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

Address	0x0001	Write	Y
		Read	Y
Description	Address of the product		
Value type	UINT 16		
Notes	Values from 1 to 255 except for 157 (0x9d). 0 is the broadcast address.		

Flow rate	0x0002 ~ 0x0003	Write	N
		Read	Y
Description	Current flow rate		
Value type	UINT 16		
Notes	Flow rate = [Value (0x0002)*65536 + value (0x0003)]/1000 e.g.: for a flow rate of 123.456 SLPM, the user will read "1 (0x0001)" from register 0x0002 and "57920 (0xE240)" from register 0x0003, therefore Current flow rate = (1*65536+57920)/1000 = 123.456		

Totalizer	0x0004 ~ 0x0006	Write	Y
		Read	Y
Description	Totalizer or accumulated flow rate		
Value type	UINT 32 + UINT 16		
Notes	A1 = Value (0x0004) * 65536 + Value (0x0005) A2 = Value (0x0006) Totalizer or accumulated flow rate = (A1 * 1000 + A2)/1000 e.g.: for a totalizer or accumulated flow rate of 3452.245 m^3, the user will read "0 (0x0000)" from register 0x0004; "3452(0x0D7C)" from register 0x0005, and "245(0x00F5)" from register 0x0006. Then, the totalizer or accumulated flow rate = ((0 + 3452)*1000 + 245)/1000=3452.245.		

Communication mode	0x0000	Write	Y
		Read	Y
Description	Communication mode		
Value type	UINT 16		
Notes	Value=0, factory mode; Value=1 RS485 Modubus.		

5.6. Analog output

5.6.1. 4~20mA output

The loop resistor connection is illustrated below. The current output load depends on the power supply (the yellow area in the graph). The maximum load resistor, R_L, with a 24Vdc supply, will be 850 Ohm.
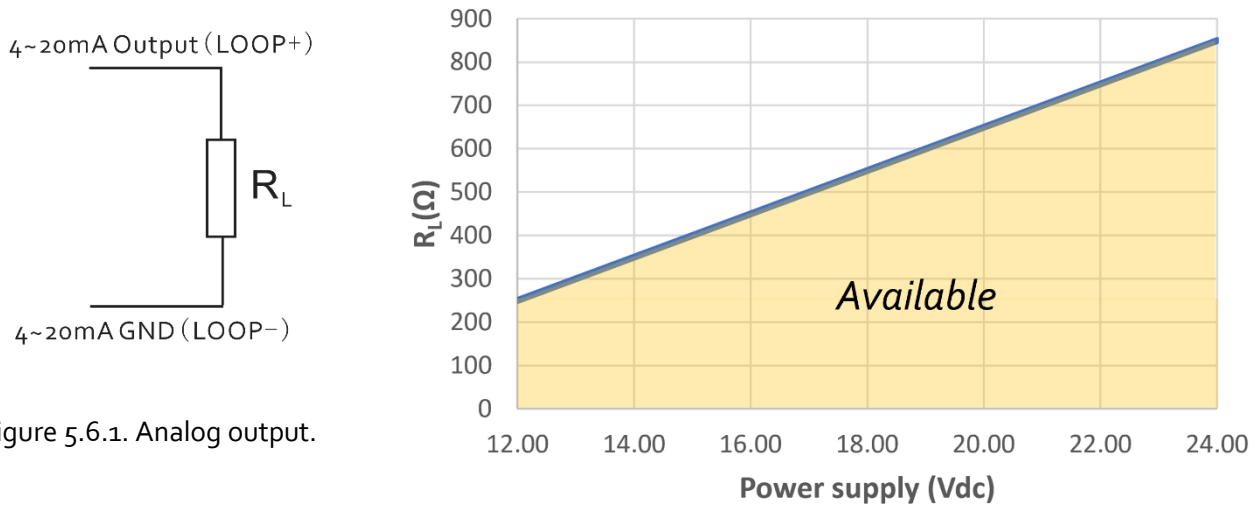

Figure 5.6.1. Analog output.

5.6.2. Pulse output

The pulse output for the accumulated flow rate is an even square wave having 3.3 Vdc high and 0 Vdc low. The pulse can be programmed to 0.01 SL, 0.1 SL, 1 SL or 10L/pulse. The default value is 1.00 SL/pulse.
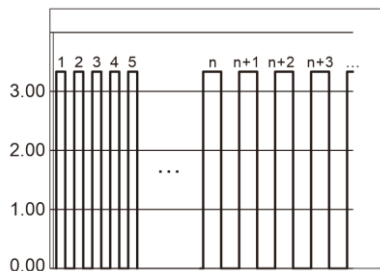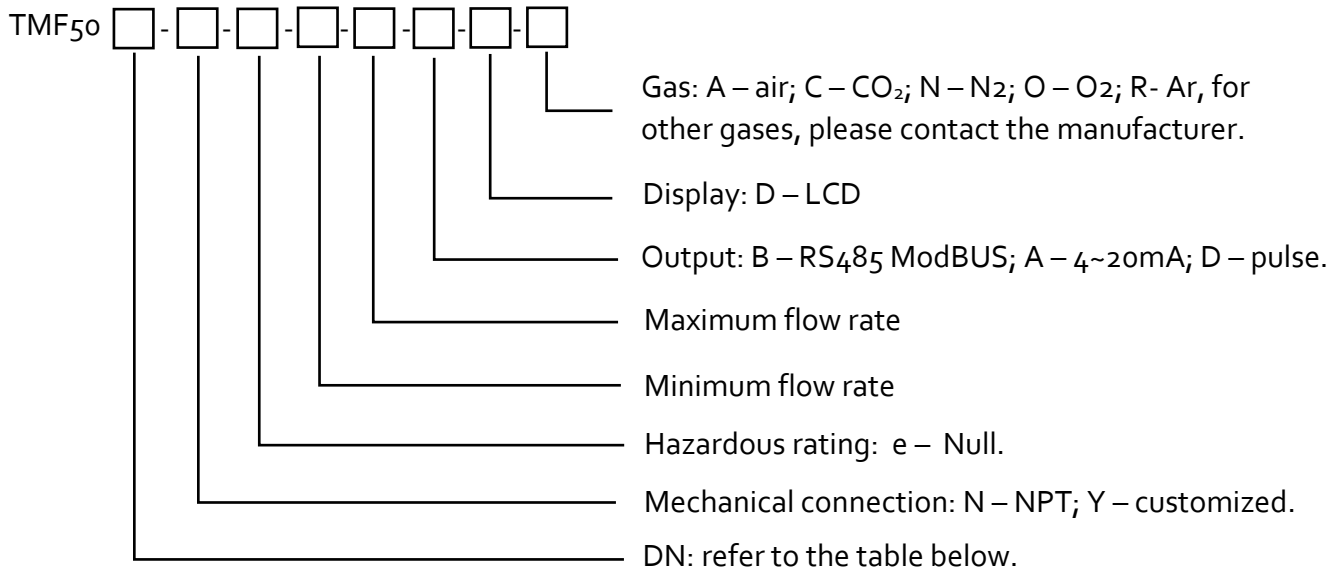

Figure 5.6.2. Pulse output for accumulated flow rate.

6.Product selection and order information

6.1. 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.

TMF50 ☐-☐-☐-☐-☐-☐-☐-☐

Gas: A – air; C – CO_2; N – N2; O – O2; R- Ar, for other gases, please contact the manufacturer.

Display: D – LCD

Output: B – RS485 ModBUS; A – 4~20mA; D – pulse.

Maximum flow rate

Minimum flow rate

Hazardous rating: e – Null.

Mechanical connection: N – NPT; Y – customized.

DN: refer to the table below.

Note: For explosion proof rating of (Ex ia II C T4), no digital output is available.

Table 6.1.1. Maximum and minimum flow range of all models.

Model	DN (mm)	DN (")	Flow range		
			sccm	SLPM	SCFM
TMF5003	3.0	1/8"	15~15000	0.15~15.00	-
TMF5006	6.0	1/4"	-	0.50~50.00	0.02~2.00
TMF5008	8.0	3/8"	-	1.20~120.00	0.04~4.20
TMF5012	12.0	1/2"	-	3.00~300.00	0.10~10.00
TMF5019	19.0	3/4"	-	8.00~800.00	0.28~28.00

6.2. Order contact and customer support

Call 831-244-8080 for technical help or send an email to Dave@TacticalFLowMeter.com or refer to the website www.TacticalFlowMeter.com or the sales office.

TFM makes every effort to ensure the quality of the products.

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	See table 6.1.1	SLPM
Accuracy	±(1.5+0.20FS)	%
Repeatability	0.5	%
Turn-down ratio	100:1	
Working temperature	-20~60	°C
Maximum pressure	1.5	MPa
Humidity	<95, no condensation	%RH
Power supply	12~24 (50 mA)	Vdc
Digital output*	RS485 ModBUS half-duplex / 4~20 mA / Pulse	
MENU access	3 key – front face keyboard/digital	
Display	Instant flow rate, totalizer, or accumulated flow rate	
Mechanical connection	NPT or customized	
Enclosure Protection	IP40	
Storage temperature	-20 ~ 70	°C
Reference conditions	20°C, 101.325 kPa, air	
Fluid compatibility	Non-corrosive	
CE	EN61326-1; -2; -3	

	MF5003	MF5006	MF5008	MF5012	MF5019	
Maximum overflow	30	120	200	450	1200	SLPM
Maximum flow change	4	15	30	60	150	SLPM/sec

Note: 1. For other features or specifications not listed, please contact the manufacturer.

8. Technical notes for the product performance

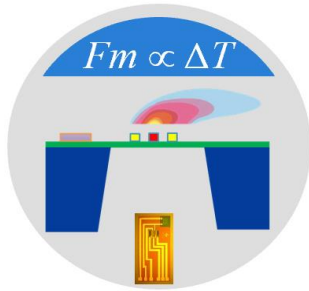## 8.1. Measurement principle

$$Fm \propto \Delta T$$

Figure 8.1. Measurement method illustration.

The TMF5000 Series Flow Meters utilize a proprietary micro-machined (MEMS) calorimetric sensor using the First Law of thermo: Q=ṁ cp $\triangle$T. Where a heater is placed in the center between a pair of temperature sensing elements at the upstream and downstream positions. The sensor is precisely manufactured and separated at predefined distance on a chip surface with excellent thermal isolation. The measuring channel is approx 500x500 microns and 1500 microns long. When the fluid flows past the sensing chip, the fluid carries the heat from the middle heater to the downstream sensor, giving us the $\triangle$T. The flow in the sensor is in parallel with a larger flow path (Or we create a boundary layer condition in some cases) to get the required high flows that are further correlated to the fluid mass flow rate via the calibration process. This method is quite similar to conventional Capillary thermal mass flow meters, only with much more reproducible and stable sensors.

This calorimetric sensing approach offers a large dynamic range with a better performance under environmental parameter changes.

8.2. Notes for the best performance of the product

8.2.1. Comparison with a third party reference meter

It is quite 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 compare the different flow meter is to ensure that the fluidic flow is a continuous flow without pulsation. Ensure the fluid dynamics behave according to 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 is critical to ensure that the system does not have a pressure difference. (This explains our recommendations for the installations in Section 4). Also, the meter measurement principle is very important for the understanding of any discrepancies.

8.2.2. Particulate contamination and fluid 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 is clean and dry. If any contamination is suspected, please allow experienced technical personnel to have it checked and re-conditioned. Do not use a caustic or corrosive or even a mild chemical cleanser or other fluids to clean the flow path which could result in irrecoverable damage.

8.2.3. Apply to a different gas medium

The meter is normally calibrated with NIST traceable meteorological standards using clean and dry air. In cases where the meter will be applied to meter another clean and dry gas, a correct gas conversion factor needs to be entered into the meter before the measurement. Or, the meter may be optionally calibrated with other gases.

The meter operates in accordance with the principle described in the international standard for thermal mass flow meters (ISO 14511:2001 - Measurement of fluid flow in closed conduit — Thermal mass flowmeters). There is a method to invoke a K-Factor, if the meter shows any deviations or nonlinearity from gas to gas. Therefore, measurement by the meter for a gas medium other than the calibration gas may indicate larger measurement errors, particularly at the low Reynold's number range where the laminar flow has a undeveloped flow profile.

9. Troubleshooting

Phenomena	Possible causes	Actions
No signal / display	Power 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	Particles, fluid type	Check system
Erroneous or large noise	Vibration, unstable flow	Check system for leaks
Offset unstable	Circuitry instability	Check system, power off
No digital interface	Wrong address, software	Check commands, connection

10. Service contact Info

TFM makes every effort to ensure the quality of the flow meters. For questions, and or product support, please contact customer service at the address listed below. We will respond to your request in a timely fashion and will work with you toward your complete satisfaction.

Customer service and all orders should be addressed to

Take 5, Inc., dba
TacticalFlowMeter.com
1335 Dayton Street, Unit A,
Salinas, California 93901, USA
Phone: 831-244-8080
Email: Dave@TacticalFlowMeter.com or Jorge@TacticalFlowMeter.com

For orders, please provide an accurate and full postal address. TFM will not ship to P.O. Boxes or via a third party.

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