

Model LF6000

Microfluidic Flow Meters

User Manual vA.0



Microfluidic Flow Meters with thermal time-of-flight technology

LF6000 Series

User 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 defection.
- * Do not use this product for corrosive media or in a 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 care

- * Be cautious for the electrical safety, even it operates at a low voltage, any electrical shock might lead to some unexpected damages.
- * The liquid to be measured should be clean and free of particles, as even light particles may be accumulated inside the tiny flow channel resulting in inaccuracy in metrology, clogging or other irrecoverable damage.
- * Do not apply for any unknown or non-specified liquids that may damage the product.
- * Be cautious for the bubbles inside the fluid, visible or invisible, that may lead to inaccuracy or erroneous output.

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1. Overview

This manual provides the essential information for operation of the LF6000 serial flow meters and sensors for microfluidic metering applications. The product performance, maintenance, and trouble-shooting as well as the information for product order, technical support and repair are also included.

The LF6000 microfluidic flow meters and sensors are manufactured with the company's proprietary MEMS (micro electro mechanical systems) thermal time-of-flight technology that offers a very high precision at a large dynamic ranges starting from 50 μ L/min up to 400 mL/min, water equivalent. The technology particularly merits for its temperature performance. The flow channel is readily connected with the standard 1/4"-28 pipes and the wetted materials for the channel are tailored by Polyetheretherketone (PEEK), Polyphenylsulfone and silicon nitride only, which allows excellent chemical and bio-compatibility.

The thermal time-of-flight sensing is achieved by modulating a thermal transmitter and acquiring the modulated signals that received by the receiver at a precise distance downstream via the micro-machined process. The pre-defined precise distance together with the measured time that the thermal signals travel between the transmitter and receiver allow the accurate measurement of the flow rate for the interested fluid moving inside the confined flow channel.

The products are packaged with either stainless steel (meters) house or aluminum alloy (sensors) in a miniaturized footprint for durability and easy installation that is good for instrumentation or manifold applications. The MEMS sensor chip is molded inside the channel that eliminates the dead volume and allows a pressure rating to 0.8MPa for a wider pressure rated applications.

While the current packages are best for instrumentation, equipment, OEM and/or laboratory applications, the manufacturer also offers alternative customized packages, including those for disposable formality as some medical or cross-contamination sensitive applications would have the disposable approach as the only practical path. For any other forms of packages that is not described in this manual, please contact the manufacturer.

The default data interfaces include I²C and analog with Bluetooth LE 4.2 enabled. Other options include RS485 Modbus, IO-Link, NB-IoT, and LoRa. These variety of communication options cover most of the current and near future application requirements, and each or multiple can be requested upon order from the manufacturer.

For the wireless/Bluetooth applications, please download the APP from Apple Store for iOS devices or Google Play Store for Andriod devices, looking for the APP name: "Siargo McWay".

2. Receipt/unpack of the product

Check the packing box prior to the dismantlement of the packing materials. Ensure no damages during shipping. If any abnormal 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 (either the meter or the sensor formality per the actual order), together with the power and data cable as shown below.



Flow meter



Flow sensor

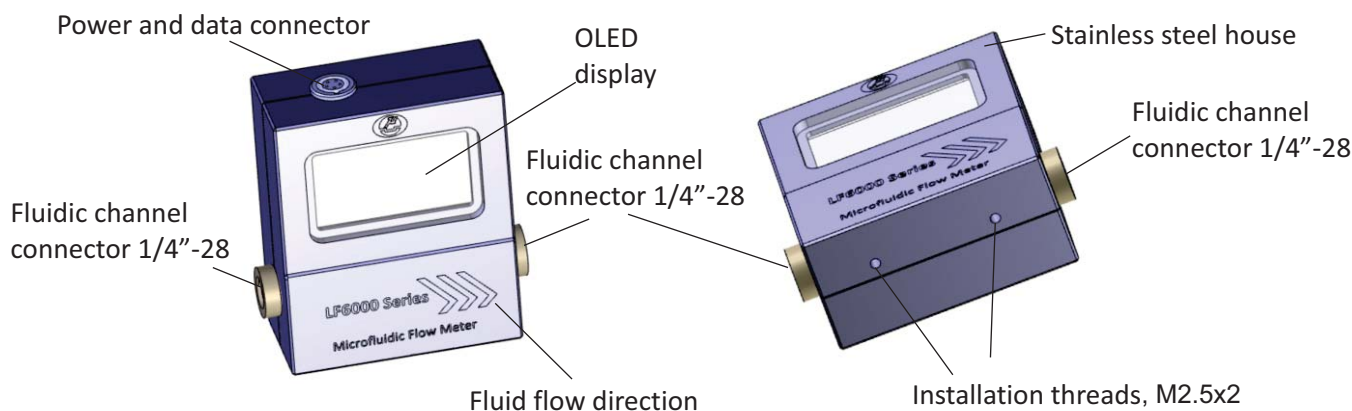


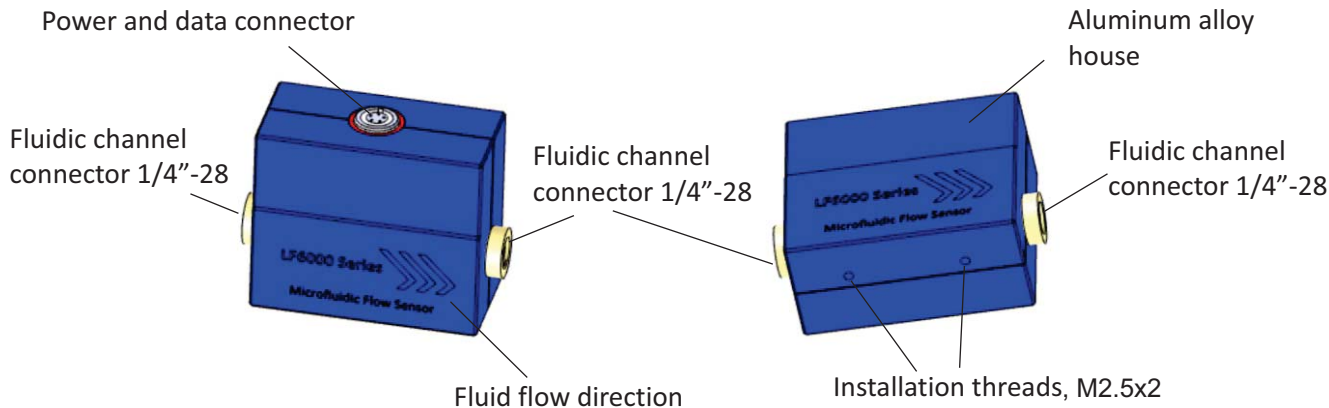
Power and data cable

Please check immediately for the integrity of the product as well as the power and data cable, if any abnormal 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. (Note: the OLED screen shall not be lighted until the power cable is plugged in). This user manual shall also either be included in the packing box or via online request for an electronic version. In most cases, this manual shall be made available to the customer before the actual order.

3. Knowing the product

3.1 Part description

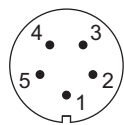




Note: For full scale flow rate over 50mL/min, the fluidic channel connector can be fully customized, default will be NPT.

3.2 Power and data cable description

Table 3.2: LF6000 pin assignment.



Pin	Color	Definition
1	Yellow	SCL, I ² C clock
2	Black	GND, Ground
3	Red	VCC, Power supply (3.6 ~ 6.0 Vdc)
4	Green	Vout, Analog output
5	Blue	SDA, I ² C data



3.3 Mechanical dimensions

Note: For full scale flow rate over 50mL/min, the fluidic channel connector can be fully customized, default will be NPT.

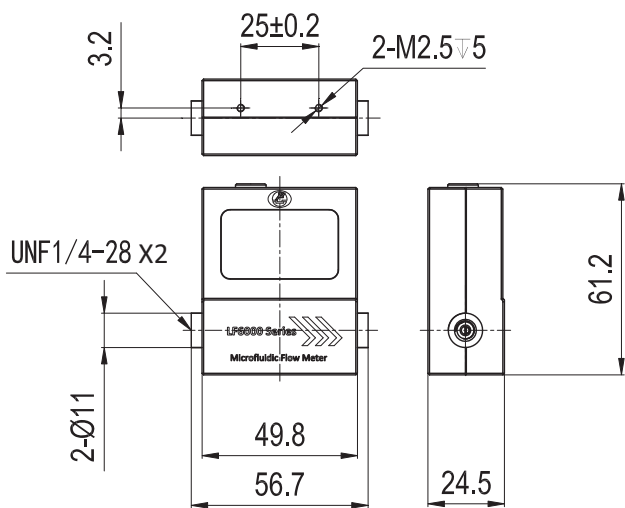


Figure 3.3.1 LF6000 meter dimensions

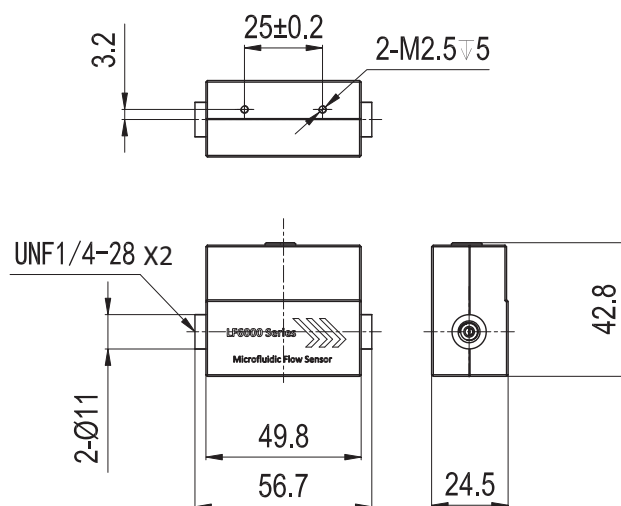


Figure 3.3.2 LF6000 sensor dimensions

4. Installation

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

To ensure the best performance of the products, it is suggested that the products should be installed at a base that eliminates environmental vibration as much as possible. There are two pre-threaded M2.5 ports at the bottom of the product as described in Section 3.1. A flat metal plate is suggested to be used as the holder before being fixed onto a solid base.

The product is preferably to be installed horizontally. If the vertical installation is a must, the fluid in the tubing must be required to be fully filled in particular at the measurement position.

After the product being placed, and making sure the product is properly fixed to a vibration free base, then the flow channel can be connected with the standard UNF 1/4"-28 connectors together with the 1/16" OD microfluidic tubing. Before connection, the tubing should be carefully checked for its integrity and cleanness. There must be no particles, dirt, greases, or other foreign materials inside the tubing. The connectors should also be free of any physical damages and should also be in a clean condition without any visible contamination. After the connection, the tubing should not be twisted, and is preferably to be kept straight or with less turns. If any turns must be present, each of the turns should be smooth without sharp bending.

For models with flow rate higher than 50mL/min, the default will be NPT threaded ports, or the other connections with full customization can be requested at the time of order. Make sure the flow direction on the meter/sensor is observed. A bi-directional version of the product is possible upon request with the manufacturer.

It is important to make sure there is no bubbles inside the fluid for the best performance of the product. It is highly recommended a de-bubbler should be installed prior to the flow meter/sensor.

The proposed installation schematics is shown in Figure 4.

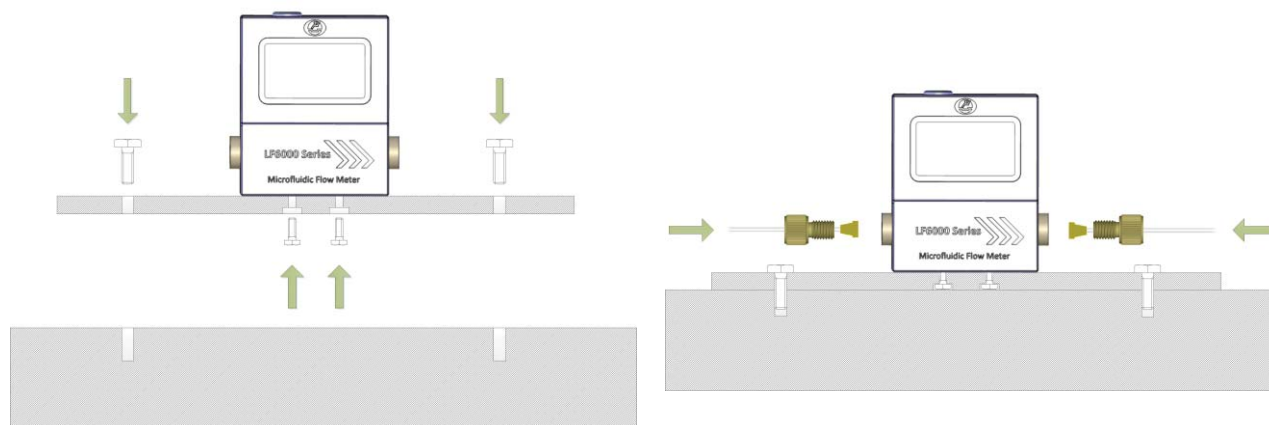
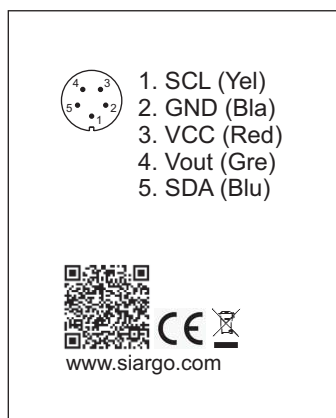


Figure 4 Suggested installation.

5. Basic operation

5.1. Check the product specifications

Before starting to use this product, check the product specifications that can be found in this manual or the basic information located on the back panel of the product.



One can find the product information from this manual according to the model as defined in Section 6. Or use any optical scanner such as those with a smart mobile device to read the 2D code on the label for the basic product specifications. In particular, the pressure rating must not be higher than the system pressure of the fluid to be measured, and the flow range should also be within the specified ones. In most cases, use of a high full scale ranged meter for the low flow rate measurement often results in erroneous data. The fluid to be measured must also be consistent with that specified by the product. Be particularly cautious for 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.

5.2. Check the microfluidic system

For the best performance of the product, it is advised that the fluid to be measured must be clean and free of particles or other foreign materials. An upstream filter of 2 μ m pore size would be an example for safe usage of the product from particle contamination. Before releasing the fluid to pass through the product, check the tubing again to avoid any twist or sharp bending, tighten the tubing fittings, and verify the measurement fluid flow direction,

For measurement of fluid flow rate less than 50mL/min, the standard UNF 1/4"-28 would only allow 1/16" OD tubing for leakage free connection. Alternatively the same sized UNF barbed male fittings can be used with 3/32" - ID tubing. A new ferrule must be used for each connection to prevent leakage.

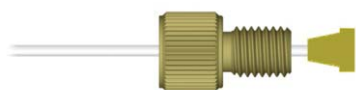


Figure 5.2.1. 1/4"-28 with 1/16" OD tubing



Figure 5.2.2. Barbed 1/4"-28 with 3/32" ID tubing

5.3. Check the leakage

Check leakage before any measurement. If it is needed, the pressurized nitrogen or air can be used for the leakage check, in particular if the fluid is non-conventional.

5.4. Connect the power supply

Although this product is in compliance with the CE required EMC regulations, it also requires the product be used according to the standard electrical device practice. Before connecting the product with the external power, make sure the standard electrical device precautions such as EDS (electrostatic discharge) and DC voltage shall be observed. Excessive electrostatic discharge may damage the product. Use only the power and data cable shipped together with the product. The cable comes with the a high quality connector at one end to be plugged into the product and the other end is with wires for connections with options. Other manufacturer shipped cable may lead to malfunctions if not being properly made.

Pin	Color	Definition
1	Yellow	SCL, I ² C clock
2	Black	GND, Ground
3	Red	VCC, Power supply (3.6 ~ 6.0 Vdc)
4	Green	Vout, Analog output
5	Blue	SDA, I ² C data

Plug the manufacturer supplied cable into the meter or sensor connector with the red dot aligned, as shown in Figure 5.4. Do not force the plug or it may create damage to the product.

The other end of the cable has 5 pre-soldered wire terminals with different colors, refer to the above table for the connection information (the same as Table 3.2).

Take special care and connect **ONLY** the power to the **RED** power cord/wire, and make sure the power supply is within the specified 3.6~6.0Vdc before switching the power on. In addition, the power supply should be properly grounded, connecting the **BLACK** wire terminal to the ground on the power supply or other safe system ground.

The product's power terminal has the incoming voltage internally filtered and regulated to power the product circuitry. The product operates at a maximum current less than 25mA, which normally is surely available for most of the power supply.

The terminal Vout (Green in color) is for analog data output from 0.25 to 2.75 Vdc, corresponding to the specified flow range from zero to full scale flow rate.

SDA (Blue in color) and SCL (Yellow in color) terminals are used for I²C serial data line and serial clock line, which provides the digital data communication and the remote control of the product.

Upon switching on the power supply, the meter OLED screen will be lighted up, and for sensor product, the status can be checked with the analog or digital interface.

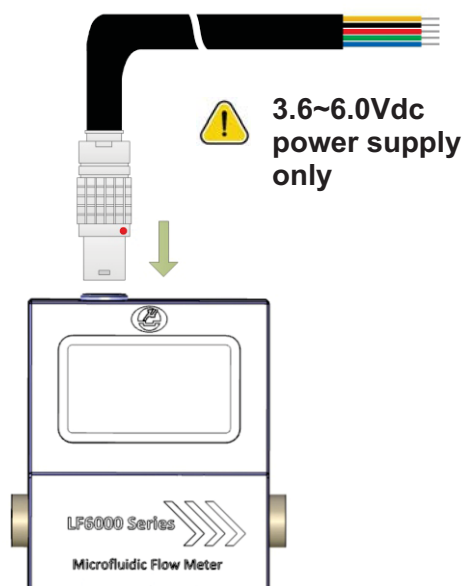


Figure 5.4. Connect the power /data cable

5.5. Analog interface/measurement

After switching on the power supply, the OLED display screen will show two rows of data. The upper row is the instant flow rate in ccm (mL/min) and the lower row is the totalized or accumulated flow volume. The data are referred back to the calibration condition at 20°C and 101.325 kPa, although the temperature effects are not measurable within the specified working conditions and the fluid is normally non-compressible.

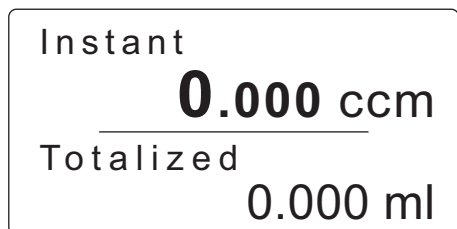


Figure 5.5.1. The OLED display

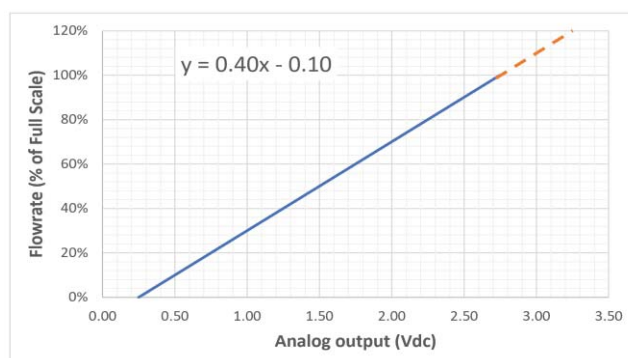


Figure 5.5. 2. Analog output

Unlike most of traditional thermal flow meters, the current product does not require a warm up time. But for the best performance, wait for few seconds for electronics to get stabled. The analog data can be acquired by connecting the analog terminal 4 (Green wire). Figure 5.5.2 shows the correlation of the analog reading with the flow rate. For example, if one orders a model of full scale flow rate of 50mL/min, then 0.25 Vdc corresponds to zero flow rate and 2.75Vdc corresponds to 50mL/min. For any given voltage output x (Vdc), the flow rate shall be $(0.40x-0.10)*50\text{mL/min}$. Beyond this specified range, voltage could also be read, but the accuracy is not guaranteed, as those are obtained by extrapolation (orange dashed line, maximum calibration to 120% full scale).

Other analog interface such as 4~20mA is also optional and can be requested by directly contacting the manufacturer.

5.6. Digital interface/measurement

The default digital interface for the current product is I²C. Other standard digital interface such as RS485 (Modbus) or IO-Link is also available by request.



IO-Link

For each of the specified digital interface, the corresponding protocol as well as a special cable for each shall be required as well. Please contact the manufacture for detailed information.

For the default I²C digital interface, the manufacturer also provides a Microsoft Windows based evaluation software for simple operation and measurement tasks. Please contact the manufacturer for detailed information.

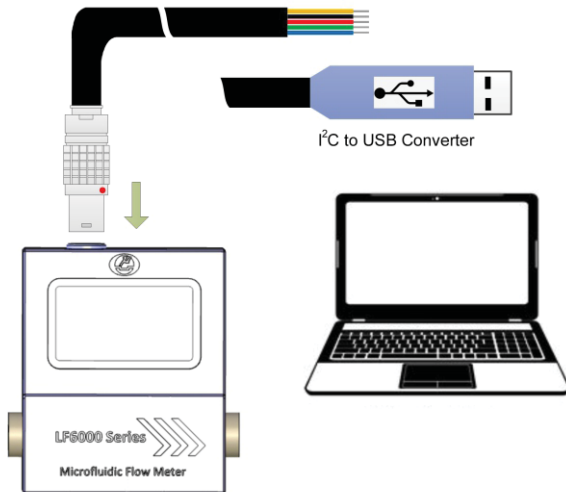


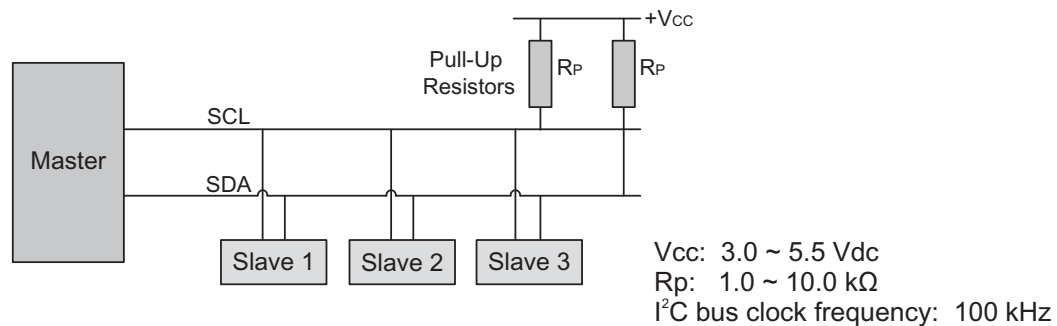
Figure 5.5.1. I²C interface connection

For the default I²C digital interface, one can connect the SCL (Yellow, clock) and SDA (Blue, data) terminals of the provided cable to the corresponding port of an I²C bus interface on user's electronics, and proceed with tasks of desire.

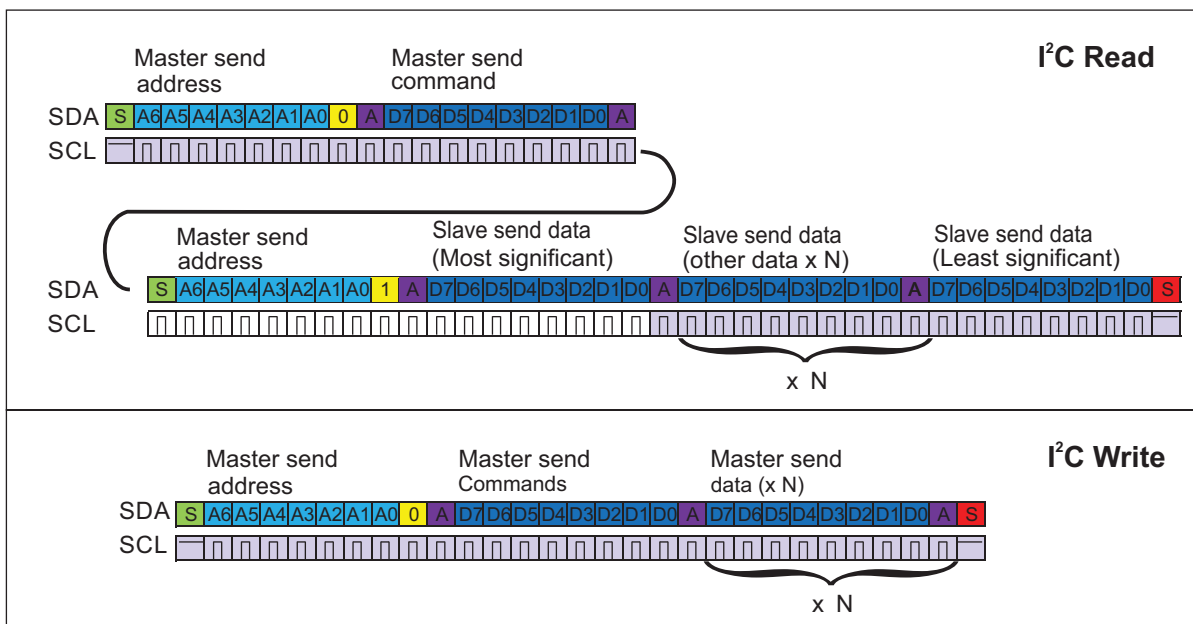
Alternatively, one can order the special cable by the manufacturer in which an I²C to USB port converter is integrated, and therefore it can be plugged into the computer for programming.

The detailed instruction of coding and/or commands of the I²C protocol is described and listed below for references.

5.6.1. I²C connection diagram



5.6.2. I²C read and write sequences



Notes

B	Name	Description
S	Start bit	Master pulls SDA from high to low while SCL remains high.
S	Stop bit	Master allows SDA to float from low to high while SCL remainshigh.
A	ACK	
1	Read(1Bit)	
0	Write(1Bit)	
A6	Address	7 bits, the 7 Most Significant bits of the first transmitted byte.*
D7	Data bit	8 bits

*Note: the default address is 0x01 (0000 001x).

5.6.3. I²C commands description

Command Byte (Hex)	Length	Command Name	Read / Write	Notes
05H	2	Write the filter depth	W	Int16, 0 ~ 10, default value is 10
08H	2	Write the I ² C address	W	Bit15~Bit1 can be set* (Bit15~Bit8=0)
81H	4	Read flow rate	R	Int32/1000mL/min
82H	4	Read forward flow rate	R	Int32/1000 mL/min
83H	4	Read reversed flow rate	R	Int32/1000 mL/min
85H	2	Read the filter depth	R	Int16, 0 ~ 10
86H	12	Read the sensor SN	R	ASCII
88H	2	Read the I ² C address	R	Bit15 ~ Bit1 (Bit15 ~ Bit8 = 0)

* The address is set with Bit7~Bit1. For instance, sensor I²C address 4, write address will be 0x08 (0000 1000) , while read address will be 0x09 (0000 1001).

5.7. Wireless interface

The product has built in Bluetooth LE 4.2 wireless data transmission capability.



An application APP named “Siargo McWay” can be downloaded from either Apple Store for smart devices based on the iOS system or from Google Play Store for smart devices based on Android system.

The APP provides the basic functions to access the meter/sensor data, plot instant flow rate chart, calculate totalized or accumulated flow volume at a specific time defined by the user. It allows the user to send the local data instantly to a remote destination when wired connection is not an option. Also, the interface provides the readout of the product information as well as technical support information.

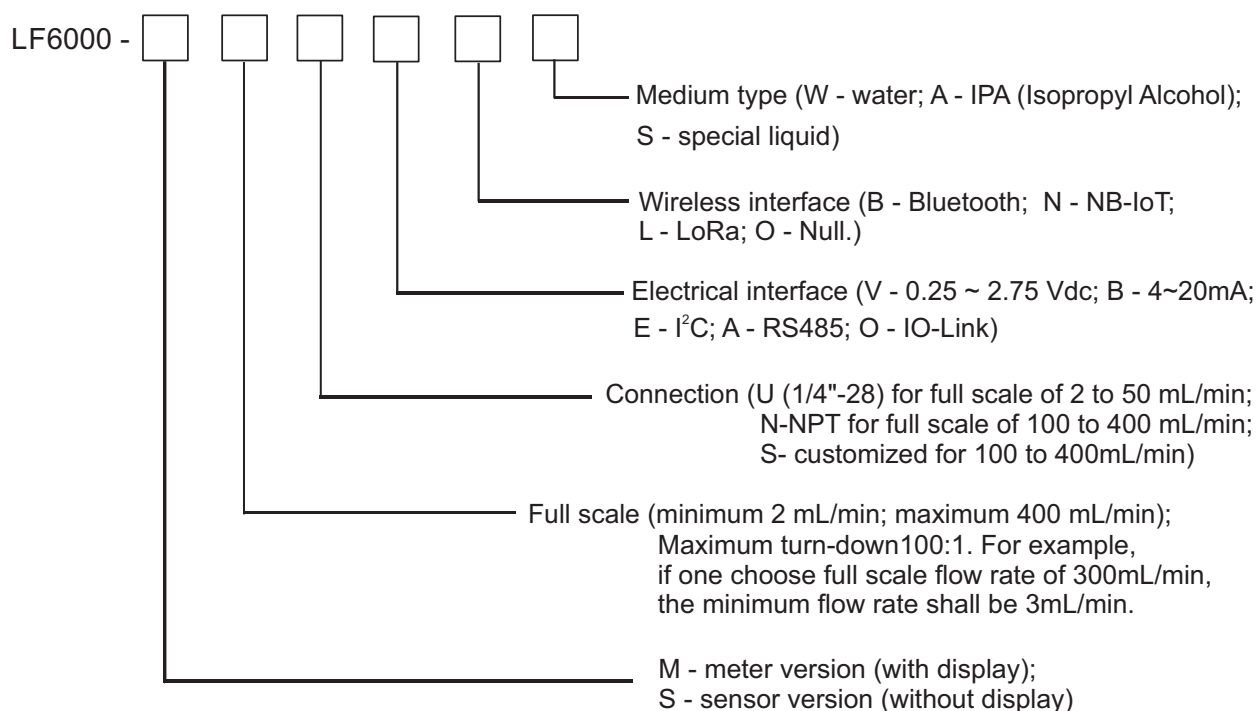
Alternatively, we can also offer NB-IoT and LoRa interface, if requested.

Figure 5.7. Wireless connection.

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 followings for details.



Note: for special liquids, please contact the manufacturer prior to order.

6.2. Order contact and customer support

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

Siargo is making every effort to ensure the quality of the products. In case of questions and/or product supports, please contact customer service listed at the end of the document.

7. Performance

All specifications listed in the following table unless otherwise noted apply for calibration conditions at 20°C and 101.325 kPa absolute pressure with de-ionized water. The product is horizontally mounted at calibration.

	Value	Unit
Full scale flow range	2 ... 50 / 100 ... 400	mL/min
Minimal flow rate*	50.0	μL/min
Turn-down ratio	100:1	
Accuracy	±(2.0+0.5FS)	%
Working temperature	5 ~ 50	°C
Temperature effects	< 0.02	%/°C
Pressure rating	0.8	MPa
Maximum pressure	1.0	MPa
Dead volume	< 7.0	μL
Power supply	3.6 ~ 6.0	Vdc
Electrical interface	I ² C/ 0.25~2.75 Vdc / IO-Link optional	
Wireless interface	Bluetooth 4.2 with APP and optional cloud data	
Response time	200	msec
Display (meter product)	OLED, Instant flow rate and totalized flow	
Mechanical connection	1/4" - 28 (0~50mL/min); NPT or customized (0~400mL/min)	
Wetted materials	Polyphenylsulfone, PEEK, SiNx, and stainless steel	
Reference conditions	20°C, 101.325 kPa; DI water	
Storage temperature	-10 ~ +70	°C
Weight	<230	gram
Protection	IP50	
RoHS	Compliant certified	
CE	EN61326-1; -2;-3	

*Note: for the low flow model, say 2mL/min full scale, the current model offers 40:1 dynamic range to the lowest flow rate of 50μL/min. The company is due to release the lower flow rate models, please contact the manufacturer for the release date and the corresponding information.

8. Technical notes for the product performance

8.1. Measurement principle

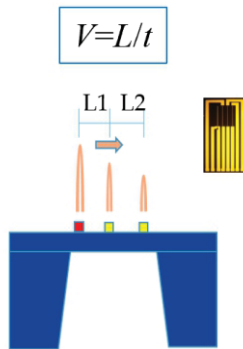


Figure 8.1.1. Measurement principle

The products utilize the Company's proprietary micro-machined (MEMS) thermal time-of-flight sensing technology. A thermal signal generator with a plural set of receivers are precisely manufactured and separated at predefined micrometer distances on a chip surface with thermal isolation. When a fluid is flowing through the sensing chip, the fluid carries the modulated thermal signal down stream and a precise time span of the fluid traveling from the generator to the receiver is recorded by the downstream receivers. The predefined distances together with the measured time span allow the sensor to register the precise flow speed of the fluid in the sensing regime, and by

calibrating out any mechanical alignment and other assembly related factors, the fluid flow rate can be determined.

The thermal time-of-flight sensing technology is in particularly effective in metering the microfluidic flow where the tiny channel makes other flow measurement techniques difficult to register the data. For additional information, please refer to the company's US patents and other publications made available to the public.

8.2. Precautions for the best performance of the product

8.2.1. Particle contamination

It is critical to have the measure fluid free of particle contamination. Since the fluidic channel is small, any presence of the particle may create a deformed channel leading to a large measurement errors. The deposition of the particle may also clog the channel creating unstable flow and other instability resulting in a unpredictable measurement circumstances.

8.2.2. Presence of bubbles

As the measurement principle is via a thermal transportation, the presence of the bubbles shall significantly alter the thermal property of fluid. In most cases, the bubble inclusion inside the fluid would lead to a negative deviation of the measurement. Therefore, it is recommended to flush the flow channel before the measurement if presence of bubbles is suspected. On the other hand, if the accuracy of the measurement is in question, the channel could be first dried with a clean gas such as nitrogen and the flush the channel with degassed fluid before a new measurement.

8.2.3. Pressurized flow delivery

Although the product can be subject to rated pressure, it is recommended to ensure there is no abrupt changes in pressure inside the flow channel, the pressure shock may lead to impact to

the electronics and the control scheme resulting in a malfunction of the system.

8.2.4. Constant operation

It is recommended that the product be powered off when it is not in a measurement status. Constant power might risk an overheat for the tiny channel which may detrimentally create small bubbles or other instability. If such phenomena are observed, power off the product and dry the system with a clean gas before reuse.

8.2.5. Measurement of non-conventional fluid

The product by default is calibrated with de-ionized water, if other fluid is to be measured, there could result in a large errors. If the product is to measure the clean water, after foreign fluid had been passed or presented in the channel, purge the product with dry and clean gas such as nitrogen and then flush the channel with de-ionized water before a new measurement.

The wetted materials of the flow channel ensure it is inert to most of the conventional fluid, but precaution should be applied for any possible damages.

8.2.6. Product calibration

The product is calibrated with a high precision reference syringe that is traceable to NIST standard. Additional verification with a high precise balance of the system for calibration is also periodically performed. In normal operation, the product should maintain its status as that at the shipment. However, for heavy usage, it is recommended that the product shall be re-calibrated at least once a year.

9. Troubleshooting

Phenomena	Possible causes	Actions
No signal / display	Power not connected	Connect power, check cable
	Cable connection incorrect	Check cable
	No flow or clogging	Check flow and tubing
	Power regulator failure	Return to factory
	Sensor failure	Return to factory
Large errors or unexpected rate	Bubbles, clogging, wrong fluids	Check system, dry, and flush
Erroneous or large noise	Vibration, unstable flow	Check system
Offset unstable	Vibration, overheat	Check system, power off
No digital interface	Wrong address, software	Check commands, connection
No wireless, BT cannot pair	Wrong model, data jam	Check model, power off/on

10. Warranty and Liability

(Effective January 2018)

Siargo warrants the products sold hereunder, properly used and properly installed under normal circumstances and service as described in this user manual, shall be free from faulty materials or workmanship for 180 days for OEM products, and 365 days for non-OEM products from the date of shipment. This warranty period is inclusive of any statutory warranty. Any repair or replacement serviced product shall bear the same terms in this warranty.

Siargo makes no 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 for full responsibility for validating the performance and suitability of the products for their particular design and applications. For any of the misuse of the products out of the scope described herein, the user shall indemnify and hold Siargo and its officers, employees, subsidiaries, affiliates and sales channels harmless against all claims, costs, damages, and expense or reasonable attorney fee from direct or indirect sources.

Siargo makes no other warranty, express or implied and assumes no liability for any special or incidental damage or charges, including but not limited to any damages or charges due to installation, dismantling, reinstallation or any other consequential or indirect damages of any kind. To the extent permitted by law, the exclusive remedy of the user or purchaser, and the limit of Siargo's liability for any and all losses, injuries or damages concerning the products including claims based on contract, negligence, tort, strictly liability or otherwise shall be the return of products to Siargo, and upon verification of Siargo to prove to be defective, at its sole option, to refund, repair or replacement of the products. No action, regardless of form, may be brought against Siargo more than 365 days after a cause of action has accrued. The products returned under warranty to Siargo shall be at user or purchaser's risk of loss, and will be returned, if at all, at Siargo's risk of loss. Purchasers or users are deemed to have accepted this limitation of warranty and liability, which contains the complete and exclusive limited warranty of Siargo, and it shall not be amended, modified or its terms waived except by Siargo's sole action.

The product information provided in this manual is believed to be accurate and reliable at the time of release to or made available to the users. However, Siargo shall assume no responsibility for any inaccuracies and/or errors and reserves the rights 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) Siargo does not provide any warranty on finished goods manufactured by others. Only the original manufacturer's warranty applies;
- (3) Products re-sold to the third parties.