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SENSIRION
THE SENSOR COMPANY

Operating Guidelines for Liquid Flow Meter Kits

For SF06 based Liquid Flow Meters
Version 1

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1 Introduction

The Sensirion liquid flow meters allow (ultra-)low liquid mass flows to be measured at low power consumption and with a very fast response. The inert and biocompatible flow meters feature outstanding sensitivity and a unique dynamic range. Moreover, they are fully calibrated, temperature compensated, and provide a digital output signal. This can be accessed via Sensirion's smart SCC1-USB Sensor Cable (included in all kits) with serial communication. The liquid flow meter can be controlled from your PC with the supplied Windows Sensirion Viewer Software.

2 Getting Started

Sensirion`s **Liquid Flow Meter Kits** contain the following components:

Evaluation Kit for **SLF3x Series**:

- SLF3S-1300F liquid flow sensor
- SLF3x mounting clamp to enable mechanical fixation of the sensor
- SCC1-USB Sensor Cable with USB connector for plug-and-play to a PC
- Adapter cable from 6-pin connector to 4-pin M8, 15 cm
- Ribbon cable from 6-pin connector to pigtail, 30 cm
- A set of fluidic connectors
- Quick Start Guide



Evaluation Kit for the **LD20 Series**:

- **LD20-xxxx** liquid flow sensors
- Prototype connector block with 4-pin M8 connector for electrical connection
- SCC1-USB Sensor Cable with USB connector for plug-and-play to a PC
- Quick Start Guide

The kits offer an easy-to-use environment to implement high-end sensing technology in your laboratory setup with data visualization and data collection that can be set up within a couple of minutes.
For detailed technical specifications of your liquid flow meter please see its specific datasheet.

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2.1 PC Requirements

- Windows 7, 8, or 10. Older Windows versions may not be compatible and are not recommended.
- One available USB port for communication

2.2 Software Installation

To install the Sensirion Viewer Software, please download the latest version from our website (www.sensirion.com/file/usb-viewer).
After opening the installer file, select Run to begin the Installation Wizard and follow the instructions to allow the viewer to install software on your PC

Please note: This software is copyrighted and intended exclusively for laboratory and demonstration purposes. It may not be used or multiplied commercially. SENSIRION does not offer any warranty on Windows software features.

2.3 Connecting the Liquid Flow Meter to the PC

- Connect the SCC1-USB Sensor Cable to a USB port of the PC
- When plugging in the USB cable, the necessary Virtual Com-Port (VCP) driver should be installed automatically. After the driver has been successfully installed, the device appears in the windows device manager as USB Serial Port. If this does not happen, please install the necessary VCP driver manually from the original driver manufacturer: www.ftdichip.com/Drivers/VCP.htm
- Connect the SCC1-USB Sensor Cable to the sensor. Depending on the sensor type you may have to use the adapter cable.

Your liquid flow meter is now connected with your PC and ready to use.

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2.4 Connecting the Fluidic System to the Liquid Flow Meter

Depending on the selected liquid flow meter type, a basic set of fluidic connectors may be included in your Liquid Flow Meter Kit. If other connectors are needed, we recommend purchasing them through fluidic connector manufacturers such as Idex (www.idex-hs.com), Vici (www.vici.com), or Nordson Value plastics (www.valueplastics.com). For details, consult the Application Note Sensor Ports and Tubing Connections at www.sensirion.com/download-center.

Use caution to avoid overtightening of the fluidic fittings that could create a leak path. Finger tight is generally acceptable if not otherwise specified in the sensor's datasheet. Follow the recommendations of the fluidic connector manufacturer for the given fittings you work with.

We highly recommend using inlet tubing equal to or larger than sensor's flow channel inner diameter (ID), otherwise turbulences may affect the sensor performance at higher flow rates (the sensor datasheet contains flow channel ID information for your reference).

The sensor should be installed in a fixed horizontal position for best performance. However, if the sensor is mounted vertically it will also perform very well but may present an offset (for details see the mounting orientation sensitivity specification in the sensor's datasheet). Keep fluid temperatures within 3 degrees of the sensor temperature for best performance and preferably use dispense durations of at least 500 ms for best accuracy.

Finally, please note that many pumps deliver pulsatile flow where peak values may significantly exceed average flow values. Your flow meter may crop data prematurely if the peak flow rate is too high and saturates the sensor. Verify peak flows against maximum rated flow of the sensor. You can also try dampening the flow to reduce peak rates. Sometimes an additional length of flexible tubing along with a restriction will suffice.

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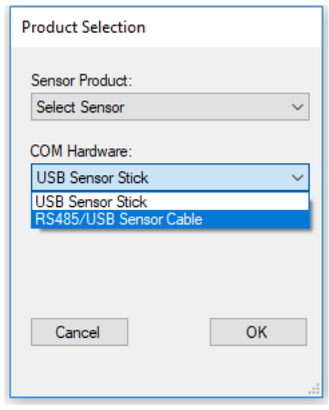
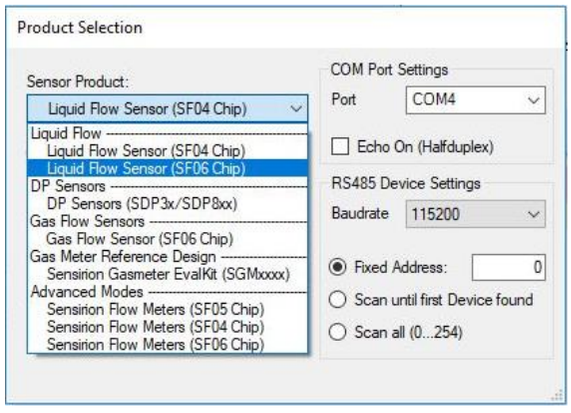
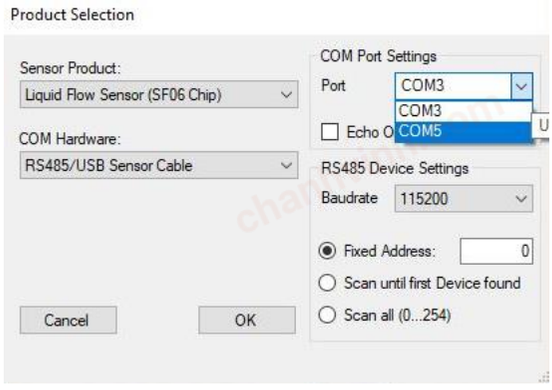
3 Sensirion Viewer Software

To start the USB/RS485 Sensor Viewer, double click its icon. When the “Product Selection” pop-up window appears, first select “RS485 Sensor Cable” under “COM Hardware” followed by the “Sensor Product” with the selection “Liquid Flow Sensor (SF06 Chip)”.





Default “COM Port Settings” and “RS485 Device Settings” are generally recommended for liquid flow meters. If you cannot communicate with the sensor, try selecting a different COM port so that “USB Serial Port” appears next to your COM port setting as shown in the screenshot to the right.



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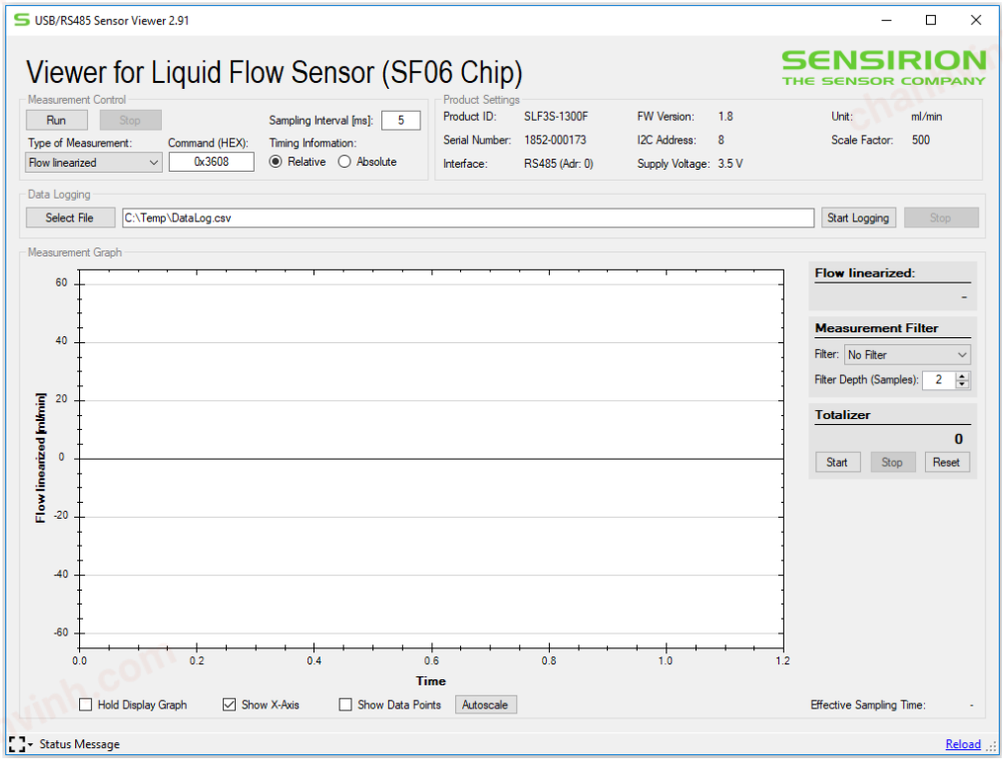
Once the connection has been set up, the USB/RS485 Sensor Viewer main window will appear:



From the main window a wide variety of functions can be accessed. The main window functions are described below:



1) Measurement Control:

Run: Starts the measurement. In the default setting you will see the sensor's response graphically displayed as a running green line that rises and falls with the flow rate.

Stop: Stops the measurement. For many functions on the main screen you will need to stop the current measurement before making changes. Also stop the measurement before disconnecting the sensor or the SCC1-USB Sensor Cable.

Type of Measurement: Choose from:

Flow [Linearized]: This is the most common setting. It accesses the active calibration field stored on the sensor chip to provide a linear response to changes in flow.

Temperature [Linearized °C]: You may access the temperature reading on board of the sensor chip. This is neither a direct measurement of the fluid nor a measurement of ambient conditions. It is a combination of the two (and on-chip electronics) that provides a coarse temperature reading near the flow measurement location.

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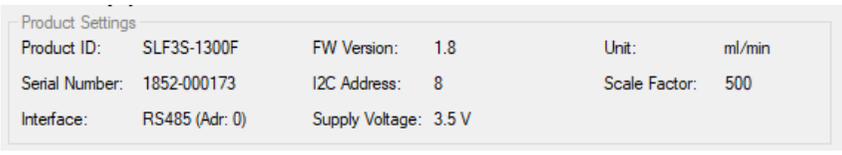
Signaling Flags: There are two signaling flags for failure mode detection which can be displayed using the USB/RS485 Sensor Viewer. The Air-in-Line and the High Flow flag, report if an air-in-line or high flow event occurred at least once since the last readout took place. An air-in-line condition is displayed as a "1" and a high flow condition is displayed as a "2". If both conditions occur simultaneously this is hence displayed as "3". Whereas steady flow is displayed as "0". For more detailed information please refer to the respective sensor datasheet.

Note that it is not possible to view the data of multiple measurement types in the graph at the same time. However, for sensors based on the SF06 chip, when logging the measurement to a file, the flow measurement, the temperature measurement and all available signaling flags are saved to the file.

Sampling Interval [ms]: The sampling interval setting determines how often the viewer will read the data from the sensor**.** When it is set to 0 the data is captured at the fastest speed possible (2 kHz). This can exceed the capability of the PC and cause gaps in the captured data which will be visible as interruptions in the graph. Typically, 5 ms is a good starting point for tests. The measurement is internally averaged by the sensor until read out. For details, refer to the datasheet of the specific sensor.

Timing Information: Default setting of "Relative" is generally preferred. This means data files saved will show initial reading taking place at time zero and every reading thereafter incrementally increasing by sampling time (or averaging time determined by bit resolution, whatever is larger). When "Absolute" is selected the actual time at measurement (according to the PC clock) is inserted instead. Either setting has no effect on real time graphical representation of the flow rate in the Viewer main window.

2) Product Setting Options:



Product ID: Displays the Sensirion sensor model name. Not user adjustable.

Serial Number: Displays Sensirion serial number which is unique to each flow meter. Not user adjustable.

Interface: Displays existing communication link (typically RS485 for liquid flow meters).

FW Version: Displays current RS485 cable firmware version for reference.

I2C Address: Displays flow meter I²C address for reference. Not user adjustable. When integrating flow sensors in custom software, customer will set RS485 cable addresses not the flow sensor I²C address.

Supply Voltage: Displays the flow sensor's supply voltage. Not user adjustable.

Unit: Displays the flow sensor's physical unit of measurement. Not user adjustable.

Scale Factor: The scale factor is a number used by the viewer software to convert linearized flow data into units of flow (such as mL/min or mL/h). Flow in physical units is equal to linearized flow data (2 byte integers) divided by the scale factor. The scale factor is accessed from flow meter memory and is generally the same within a sensor model for a given fluid. However, Sensirion may modify this value in production to meet

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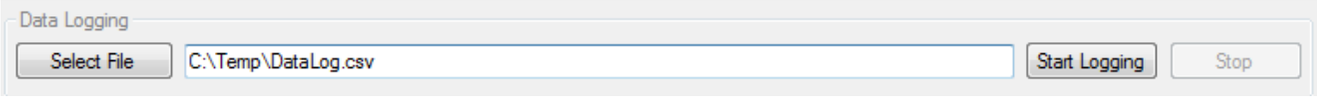
product specifications. The viewer software automatically displays the physical flow units if “Flow [linearized]” is chosen as measurement mode. The scale factor is not user adjustable.

Command (HEX): Sensirion’s liquid flow sensors contain multiple calibration fields for different types of liquid (such as water or IPA on the SLF3x Series) or allow for different measurement modes to be executed. This field allows to enter specific I²C commands as specified in the sensor’s datasheet. The standard setting 0x3608 will start the continuous measurement mode for water.

3) Data Logging:

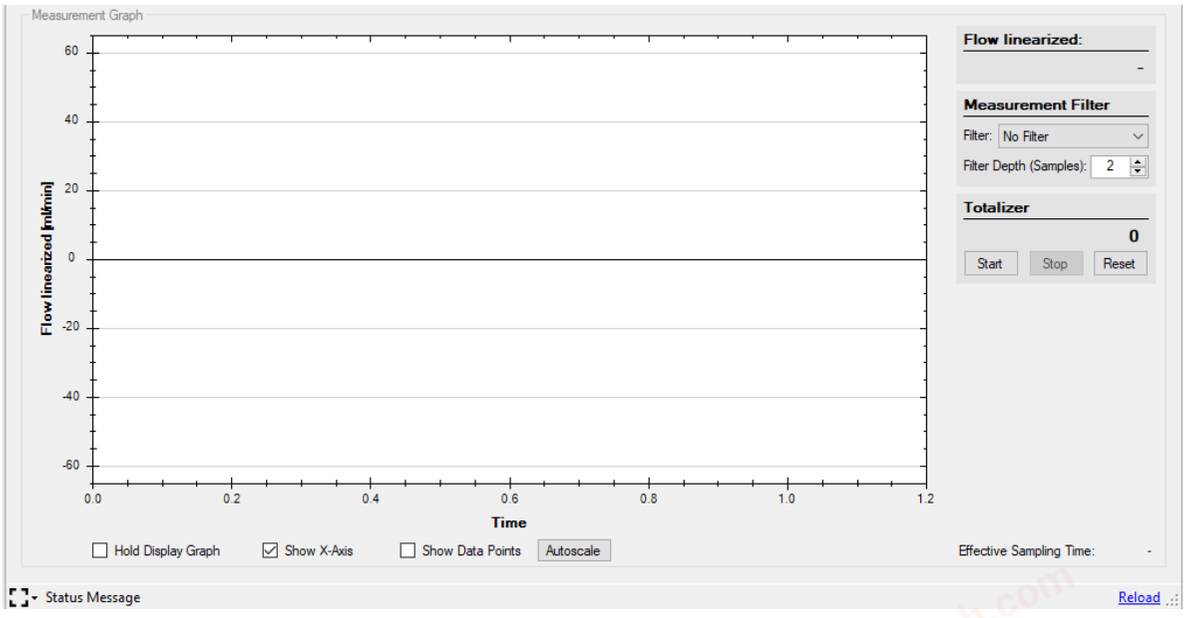


Select File: By default, the Viewer Software will save to a “DataLog.csv” file in your Temp folder. This button allows you to select a different folder location or edit the file name. You may also type this information directly into the field next to the “Select File” button.

Start Logging: Select this button to save data on your computer. Once you have started logging, you must also press “Run” to start measurements otherwise the data file will be empty. You have the option to pause data collection and resume saving to the same data file. Or you can stop logging as described below.

Stop: Stops logging of data on to data file. You may resume data collection by either writing to a new file or overwriting the existing file.

4) Measurement Graph:



Flow Rate: The display shows the real time flow rate measurement of the flow meter, averaged over and updated every 500 ms.

Measurement Filter: Select the filter type (‘No Filter’ or ‘Average’) as well as the number of samples to be used for the filter. The ‘Average’ filter is a simple moving average over the number of samples selected. The averaged flow signal is displayed as a blue line in the graph.

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Totalizer: Use this tool for a simple volume measurement by integrating the flow rate over time.
'Start' starts the volume integration, 'Stop' stops the volume integration and 'Reset' resets the volume to zero.

Hold Display Graph: Selecting this checkbox turns off the real time display of flow events on the graph window.

Show X-Axis: Selecting this shows values for time on the X-Axis of the graph. If timing was previously set to "Relative", scale will start at zero with first data measurement. If set to "Absolute", scale will show real time in the format [hh:mm:ss:ms].

Show Data Points: Selecting this check box displays the individual data points.

Autoscale: Automatically scales the display graph to current measurement values.

Effective Sampling Time: Shows sampling rate currently used by flow meter.

Flow Graph and Zoom Level: Place your pointer over the graph and use your mouse scroll wheel to zoom in or out. You can also click and hold a region of interest to zoom into when you release. Right-click of the mouse will allow you to reset the zoom level.

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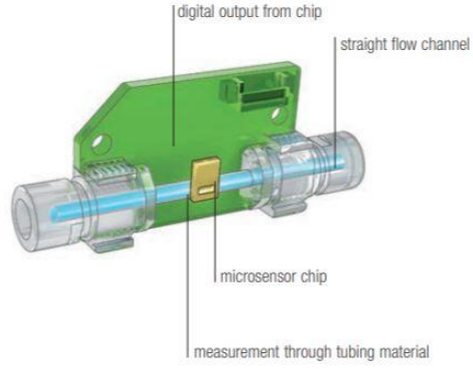
4 Understand your Measurement

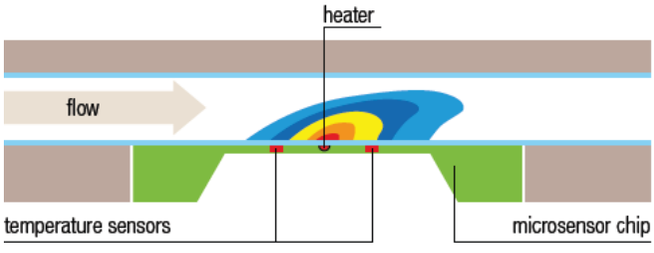
4.1 Liquid Flow Meter Operating Principle

Sensirion's highly advanced CMOSens® technology combines all associated electronics from signal conditioning circuitry to calibration memory and MEMS micro heater structure on a single integrated CMOS chip. The extremely compact chip creates a small thermal mass for very fast responses and consumes very little power. The chip is bonded to the outside of the flow channel and due to its media isolated sensing principle, there is no direct contact between the digital microchip and the fluid. Measurements are taken through the flow channel wall.



Schematic layout of a liquid flow meter

Your Sensirion liquid flow meter operates on a microthermal sensing principle. A negligible amount of heat is introduced to the fluid and monitored to correlate temperature differentials to actual flow. Temperature sensors before and after the heater detect temperature changes as flow transfers heat from one side to another. The illustration below highlights the temperature profile during flow:



Fluid thermodynamic properties (i.e., heat capacity, thermal conductivity) will directly affect sensor response. The standard sensor calibrations for H_2O and IPA cover most commonly used fluids.

It is important to maintain laminar flow within the capillary during measurements. The flow meter maximum flow ranges have been specified having this in mind. Use inlet tubing with the same inner diameter or larger than the sensor's capillary inner diameter. More viscous fluids reduce turbulence although one must use caution to avoid exceeding the recommended pressure limits of the flow meter (see the datasheet for specifications of recommended maximum operating pressure and burst pressure).

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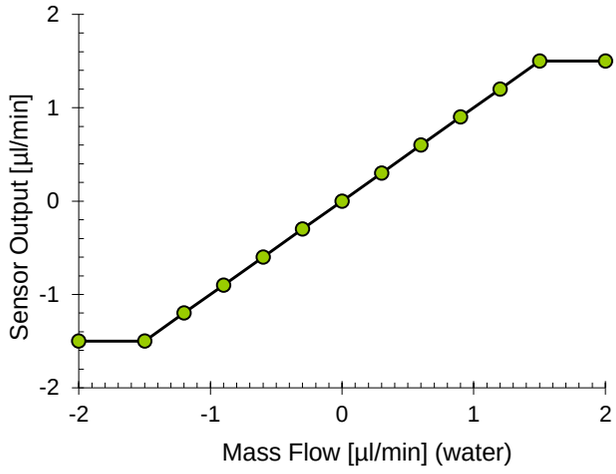
4.2 Sensor Linearization

Sensirion liquid flow meters are 100% factory calibrated for at least one standard fluid (typically H_2O or IPA). Most sensors are also bidirectional allowing for flow measurements in both directions of flow.



Exceeding the flow range will not damage the sensor or stress components that will affect calibration. Flow meters typically respond linearly up to about 10% beyond the specified maximum flow range before saturating. Reference your specific sensor datasheet for more information.

4.3 Monitoring Different Fluids

Your Sensirion flow meter can be used to monitor fluids not originally calibrated at the factory. Select a standard calibration field that most closely matches your fluid. For example, water calibration for saline solution or hydrocarbon calibration for lubricant oil (a matching calibration field increases the possibility of a linear response from the sensor).
Regardless of the fluid, your flow meter is capable of very high repeatability. Typical error range is 0.8% to 1.5% for all media. This allows you to use the sensor as a very precise relative gauge when flow is required to stay within an acceptable range. In such a case, sensor response can be recorded at maximum and minimum flow rates and used as upper and lower guard bands for reference. The flow meter can then monitor process repeatability within verified acceptable limits. Since absolute values may vary from sensor to sensor, this guard band must be set for each individual flow meter.

4.4 Dispense Volume Measurement Correction

Some applications require not only great repeatability but also high accuracy that tightly correlates sensor readings to actual flows. This is particularly true for dispense applications. The following procedure can significantly improve accuracy when monitoring liquids which have not been originally calibrated at the factory.

Please note the volume correction steps below require *fixed flow rates* during the dispense event. If the dispense flow rate is changed then the process below should be repeated with the new dispense flow rate to ensure accuracy. The intention below is to compare actual vs. dispensed volumes calculated from sensor readings and to apply a simple correction factor to adjust for accuracy.

- Program your pump to the flow rate you intend to use during your actual dispense process. In the example below, 1000 µL/s was the fixed flow rate chosen.

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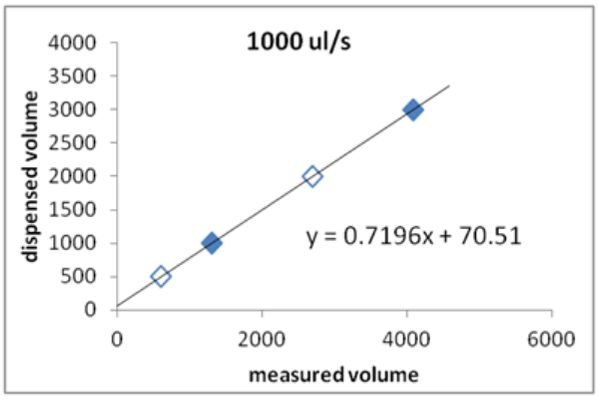
- Use the flow meter to measure several dispenses with varying dispense times. The range of dispense times should be limited to the expected dispense times in your application.
- For each dispense, also use a secondary measurement (such as measuring weight) to verify actual dispense volume.
- Plot the measured volume from sensor output vs. actual dispensed volume as in the example below:



solid symbols:

dispense time	1	3
dispensed volume	1000	3000
measured volume	1291.6	4070.8

open symbols:

dispense time	0.5	2
dispensed volume	500	2000
measured volume	598.6	2679.8

- The data points should fit a straight line through the measured points allowing you to determine the variables a and b from the formula below:

$$V_{dispensed} = a \cdot V_{measured} + b$$

- Implement the correction factors above in your software and repeat several dispense events using dispense times within the range you tested to confirm accuracy against a secondary measurement. If the readings match then you are ready to use the flow sensor.
- If the collected data points show a non-linear behavior, you will likely need to reduce the dispense flow rate. The next section will explain how to determine whether your preferred dispense flow rate is a good match for the flow sensor you are testing.

4.5 Verify Sensor Performance

The steps below will help you evaluate whether a specific dispense flow rate is a good match for your sensor when using a fluid not originally calibrated by the factory. Start by selecting a calibration (water vs. IPA for example) that most closely matches your fluid. If you are unsure, try both calibration fields (if available): the data will show you what is best.

The intent is to compare several calculated vs. actually dispensed volumes using *fixed dispense times* and varying flow rates.

- Set a fixed dispense time (in the example below, 1 second was chosen). We recommend a dispense time of at least one second for this exercise. Three seconds is usually a good choice. It is not necessary to use dispense times that match your expected application dispense times.
- Set your pump to the first of three dispense flow rates. We recommend starting with your expected dispense flow rate.
- Using the fixed dispense time from above, collect dispense data and calculate volume. Also verify actual dispensed volume through a secondary measurement such as weighing sample.
- Repeat dispense and data collection (calculated & actual volumes) two more times with different flow rates (try 50% higher flow and 50% lower flow).
- Plot measured volume vs. actual dispensed volumes of all three dispenses:

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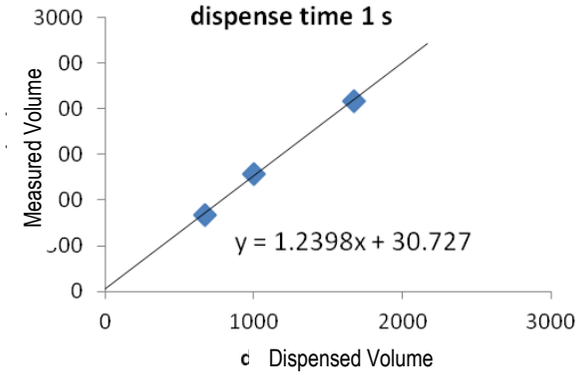
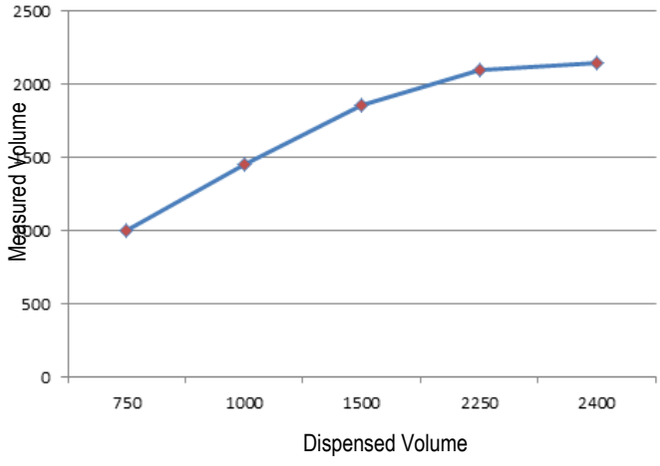


If all three flow rates are a good match for the sensor the dispense data will lie on a straight line as shown above.

Sometimes the higher flows will fall noticeably off the linear path. The maximum flow range of the sensor has likely been exceeded for the particular liquid being evaluated. Reduce maximum flow rates and collect data again. The maximum measurable flow for the unknown fluid being tested will correspond to the highest linear data point on your plot. For example, in the plot below the top two dispense volumes are not linear so their corresponding flow rates would not be recommended for the sensor tested.



If your plot is strongly non-linear, try a different calibration field and repeat the experiment. In rare cases, a linear relationship is not possible and a higher-order interpolation must be used. Please contact Sensirion for additional support.

4.6 Air-in-line Detection

Bubbles cause the flow rate measurement to drop to near zero flow rates when they pass through the flow sensor. Since the measurement is made at a distinct location along the sensor's flow channel, ideally one should mount the sensor such that the sensor chip is positioned on top where a bubble is most likely to travel and most likely to be detected.

Sensors based on the SF06 chip, provide a signaling flag that indicates when air is passing though the sensor. This Air-in-Line flag can be viewed (alongside the High Flow flag) by choosing signaling flags as the Type of Measurement (see chapter 3). For further detailed information on signalling flags please refer to the datasheet.

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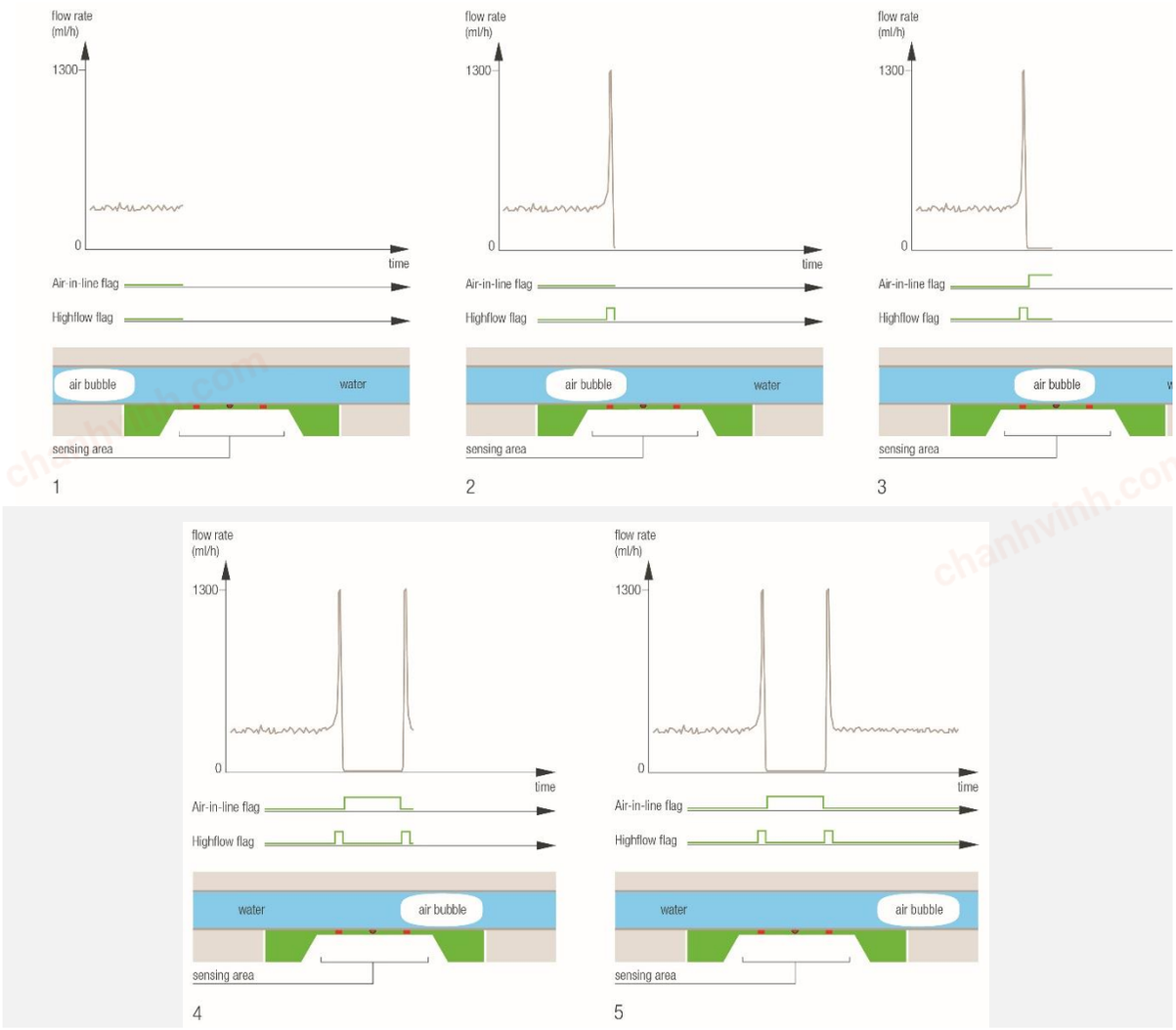
The figure below shows the response of the flow rate measurement and the two signaling flags to a bubble passing through the sensor. An air-in-line condition is displayed as a “1” and a high flow condition is displayed as a “2” in the Sensirion Viewer Software’s measurement graph. If both conditions occur simultaneously this is hence displayed as “3”. Whereas steady flow within the sensor’s measurement range is displayed as “0”. These are the decimal representations of the binary signalling flags: b001, b010, b011 and b000.



4.7 Cleaning, Preventive Maintenance, and Storage Instructions

Your flow meter has been robustly designed for its intended application, however, it is also a sensitive instrument that must be well cared for to maintain a high level of performance.

The basic rules are simple:

- avoid letting fluid dry in the liquid flow meter
- avoid strong mechanical shocks that could dislodge internal components or compromise the fluidic seals.

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Since the sensor relies on a thermal measurement principle through the wall of the capillary tube, one must take precautions to avoid any build-up or deposits that could alter the thermal properties of the capillary and thus influence the sensor's reading.

Before storing the sensor, always drain the fluid, flush with cleaning agent. In most cases flushing with distilled water, then acetone, and finally IPA will suffice. Then blow the senor dry with pressurized air. Sensor plugs should be installed for storage. The cleaning agent (detergent, solvent, etc) should be chosen for its effectiveness in removing the liquid media and compatibility with wetted materials.

Flow meters do not need periodic cleaning unless the medium has a tendency to leave deposits, or flow meters have been disconnected from the fluidic path and not properly flushed. The residue left by the drying fluids can alter sensor performance or even plug the capillary. You may try cleaning it by flushing with acetone and IPA.

Never attempt to mechanically clean the sensor's flow channel.

For details, consult the Application Note Cleaning and Clean Handling at www.sensirion.com/download-center.

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5 Frequently Asked Questions

Problem	Possible Cause	Possible Solution
No function at all, software cannot find sensor	1. COM port not available 2. Windows operating system too old 3. USB cable driver (Virtual COM port) not installed correctly	1. Check if USB driver is providing a virtual COM port and use its number. Make sure all other programs using COM ports are closed. Maybe it is necessary to reboot the computer. Stop all programs working with COM-ports. 2. Verify recent version of Windows software is installed on your PC. 3. Install virtual com port driver.
Flow signal of sensor is different compared to reference	1. Sensor is saturated high 2. Fluid does not match reference fluid of calibration; or wrong calibration field is chosen 3. Reference not accurate. 4. Flow is pulsating with high frequency 5. Little air bubble is caught in sensor or at inlet of sensor	1. Reduce flow rates 2. When using media other than the one the sensor is calibrated for, the sensor output may significantly change. Try a different calibration field. When using the SCC1-Analog sensor cable, set a different default calibration field (“Edit default”, page 9). 3. Please check if reference is working properly. 4. If the flow rate is pulsating (e.g. due to pumping mechanism) try to eliminate this, e.g. by fluidic damping. 5. Flush the sensor.
Sensor output is inaccurate compared to reference at higher flows	1. Turbulence caused by small inlet tubing relative to sensor capillary inner diameter (ID) 2. Flow deviations by strong tubing bends on inlet side	1. Use inlet tubing with inner diameter at least as big as the sensor’s capillary inner diameter. 2. Keep connection tubing on inlet side straight.
Sensor output appears to have drifted compared to readings taken in the past	Deposits in capillary inner diameter affecting performance.	Follow cleaning procedures provided in this document.
Flow signal out of range	Flow higher than calibrated flow range or different medium than the one the sensor is calibrated for. For selecting the right flow meter look at the *peak* flow rates in your application, not at the average flow rates.	Check if type of medium and calibration match. Try to work with smaller maximum flows.
Signal not 0 at zero flow in calibrated mode.	1. Offset changed or differs because type of medium used and calibration medium mismatch. 2. Depositions inside the sensor.	Offsets within the specifications are normal (see datasheet). For larger offsets please refer to

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	3. Mounting position not horizontal. See datasheet.	cleaning procedures in this document. Ensure zero-flow condition in your fluidic system. Contact Sensirion if the problem remains.
Flow signal shows unexpected behaviour (e.g. fluctuations, increasing/decreasing flow although pump is working steadily)	Note: Sensor is highly sensitive and fast. It may show effects which have not previously been observable.	Analyze the fluidic system in order to understand the effects monitored. In most cases the sensor is just representing the reality. Contact Sensirion for additional support. Please provide flow data, graphs, and description of fluidic system set-up.
Flow signal changes although static conditions apply.	There may be several causes, such as change of physical properties of the medium or strong temperature change, increasing blockage of fluidic path, fluid supply, e.g. pump, not properly working, system leaking.	Make sure environmental conditions and physical properties of the medium don't change. Check fluidic path and fluid supply for possible errors.
Strong signal noise	Vibrations in the fluidic system.	Make sure the fluidic system is not influenced by mechanical disturbances. Vibrations make the fluid in the system move which is obviously visible on the sensor signal.

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