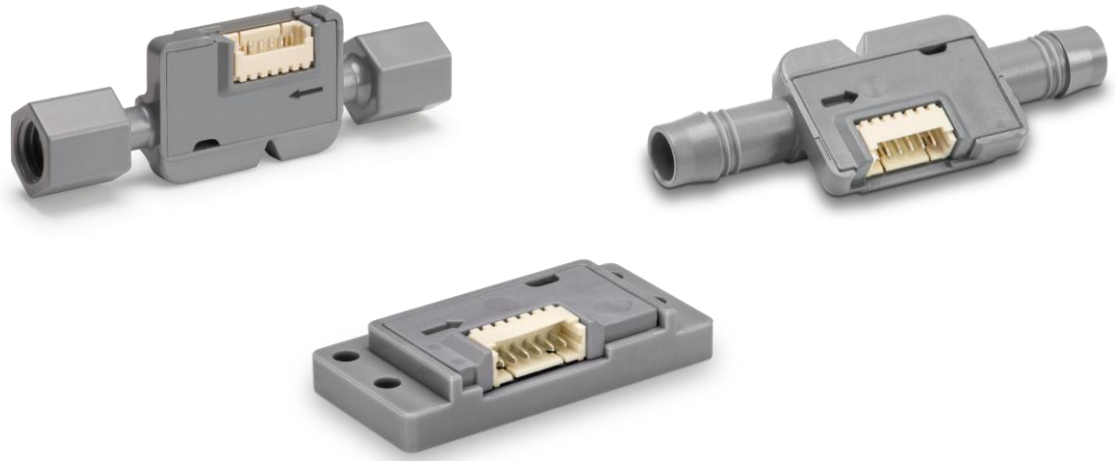
Engineering Guide - SLF3x Series

Liquid Flow Sensors and Evaluation Kits



This Engineering Guide provides comprehensive technical information to support the evaluation, integration, and optimal use of Sensirion's SLF3x sensor family. It is intended for engineers and developers involved in system design, offering detailed insights into evaluation tools, communication interfaces, design-in guidelines, and measurement principles. The guide aims to facilitate efficient product development by consolidating all relevant knowledge required to successfully implement SLF3x sensors in a wide range of applications.

Product Line Overview

Product	Details
SLF3S-0600F	±2 ml/min, flat-bottom ports
SLF3S-1300F	±40 ml/min, flat-bottom ports
SLF3S-4000B	±600 ml/min, barb ports
SLF3S-0600D	±2 ml/min, downmount
SLF3S-1300D	±40 ml/min, downmount

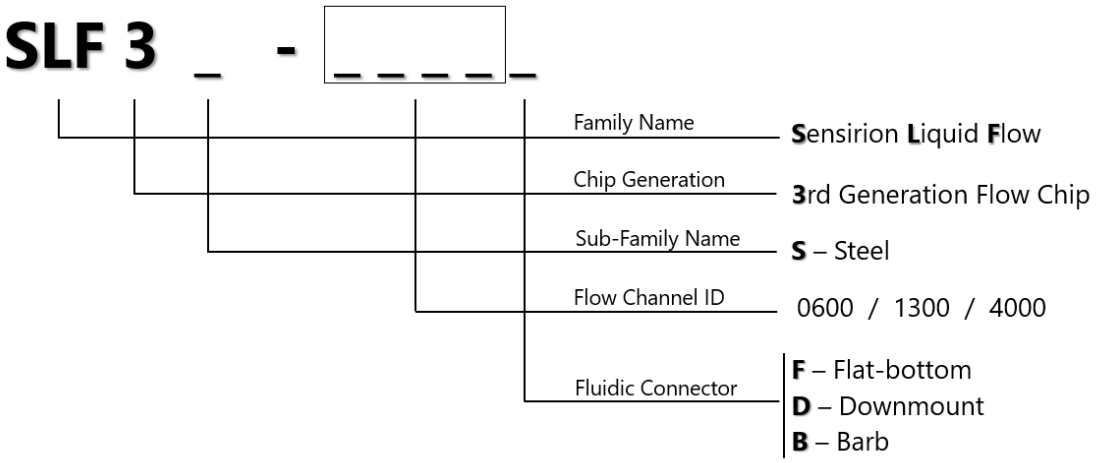
Contents

1 Introduction to the SLF3x Series 3
1.1 Evaluation Kits 3
1.2 First Steps with the Eval Kit 4
2 Evaluation Software 5
2.1 Sensirion's Viewer Software Installation 5
2.2 Connecting the Sensor 5
2.3 Performing a measurement 6
2.4 Product Settings 7
2.5 Data Logging 8
2.6 Measurement Graph 8
3 Digital I^2C Communication Interface 10
3.1 I^2C Address and Sequences 10
3.2 I^2C Basic Commands 11
3.3 Measurement Data and Product Identifier Format 11
3.4 Checksum Calculation 13
3.5 Conversion to Physical Values 13
4 Software Integration Resources 14
4.1 Drivers for Python, Arduino, Embedded and Raspberry-Pi 14
4.2 Analog Communication 15
4.3 RS485 Communication 15
5 Design-in Guidelines for the SLF3x Series 16
5.1 Electronic Design-In Guidelines 16
5.2 Fluidic Design-In Guidelines 17
5.3 Mechanical Design-In Guidelines 19
5.4 Cleaning, Preventive Maintenance, and Storage Instructions 20
6 Understand your measurement 21
6.1 Liquid Flow Meter Operating Principle 21
6.2 Recalibration and Monitoring Different Fluids 21
6.3 Air-in-line Detection 23
6.4 Pulsation and Flow Dampening 24
6.5 Thermal Conductivity Measurement 25
6.6 Auto Heater Management 25
7 Application Notes and Useful Links 26

1 Introduction to the SLF3x Series

Sensirion's SLF3x series is a next-generation family of microthermal liquid flow sensors designed for precise measurement of ultra-low to low liquid flow rates. Building on Sensirion's extensive experience in flow sensing, these sensors combine high sensitivity, fast response time and a wide dynamic range with an optimized mechanical design for improved performance and cost efficiency. The SLF3x sensors are fully calibrated, temperature compensated, and provide digital output, enabling straightforward integration into a wide range of applications. This guide provides an overview of the evaluation options and key considerations for successfully working with the SLF3x series. Detailed specifications can be found in the corresponding datasheets.

The SLF3x series includes multiple sensor variants that differ primarily in their measurable flow rate ranges and fluidic interface options. These differences are encoded in the product naming suffix. For example, the numerical value (e.g., "-0600") refers to the sensor's internal flow channel diameter in micrometers, which directly determines the applicable flow rate range, while the letter (e.g., "F") indicates the type of fluidic connector, such as flat-bottom ports. This naming convention allows users to easily identify the most suitable variant for their specific application.



1.1 Evaluation Kits

Each SLF3x sensor variant is supported by a dedicated evaluation kit designed to enable quick and straightforward testing. These kits provide an easy-to-use environment for implementing high-end sensing technology in a laboratory setup, including data visualization and data logging capabilities that can be set up within minutes.

The SLF3s Evaluation Kits are composed of:

- 1x SLF3x-xxxx sensor
- 1x SCC1 USB sensor cable
- 1x SLF3x mounting clamp (straight variants) or 1x SLF3x mounting manifold (downmount variants)
- 1x Adapter cable with 6-pin connector to 4-pin M8
- 1x Ribbon cable from 6-pin connector to pigtail
- Fluidic connectors
- Quick start guide



Figure 1. Evaluation kits for the SLF3S-xxxxF (left) and SLF3S-xxxxD (right) sensors.

All the SLF3x sensors and their corresponding Evaluation Kits are available via Sensirion's worldwide distribution network. Please find an overview for your region under: https://sensirion.com/products/channel-partners.

Sensor	Article Number
SLF3S-0600F	3.000.391
SLF3S-1300F	3.000.091
SLF3S-4000B	3.000.632
SLF3S-0600D	3.001.156
SLF3S-1300D	3.001.155

Evaluation Kit	Article Number
EK-SLF3S-0600F	3.000.392
EK-SLF3S-1300F	3.000.120
EK-SLF3S-4000B	3.000.633
EK-SLF3S-0600D	3.001.236
EK-SLF3S-1300D	3.001.235

Table 1. Overview of all article numbers for the SLF3x family.

1.2 First Steps with the Eval Kit

When assembling the Evaluation Kit setup, avoid overtightening the fittings, as this may create leak paths. Finger-tight connections are generally sufficient unless otherwise specified in the sensor datasheet. For optimal performance, use inlet tubing with an inner diameter equal to or larger than the sensor flow channel to minimize flow disturbances, especially at higher flow rates. A basic set of fluidic connectors is included in the evaluation kit. Additional connectors can be sourced from standard suppliers such as IDEX, Vici, or Nordson Value Plastics. For further details, see section 5.2.1 Tubing and Fluidic Ports.

Install the sensor in a fixed horizontal orientation for best accuracy. Vertical mounting is also possible but may introduce a small offset, see section 5.3 for more details. Many pumps generate pulsatile flow, where peak flow rates can significantly exceed the average flow rate. If these peaks exceed the specified sensor range, measurements may saturate. Verify peak flow conditions and, if necessary, reduce pulsation by adding damping elements such as flexible tubing followed by a flow restriction upstream of the sensor.

2 Evaluation Software

2.1 Sensirion's Viewer Software Installation

To install the Sensirion Viewer Software[1], please download the latest version from our website. 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.

Find the Sensirion Viewer Software in the section 2 of the Sensor Evaluation Kits for Liquid Flow page (link) under the name Viewer software USB/RS485 (V. 2.91).

When plugging in the SCC1-USB Sensor Cable to a USB port of the PC, 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

To use the SCC1-USB Sensor Cable with SLF3x sensors, it is necessary to use the adapter cable (M8 to 6-pin). This cable is included in the SEK-SLF3S evaluation kit as well as the SCC1-CONNECTIVITY kit. Your liquid flow meter is now connected with your PC and ready to use.

2.2 Connecting the Sensor

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)".

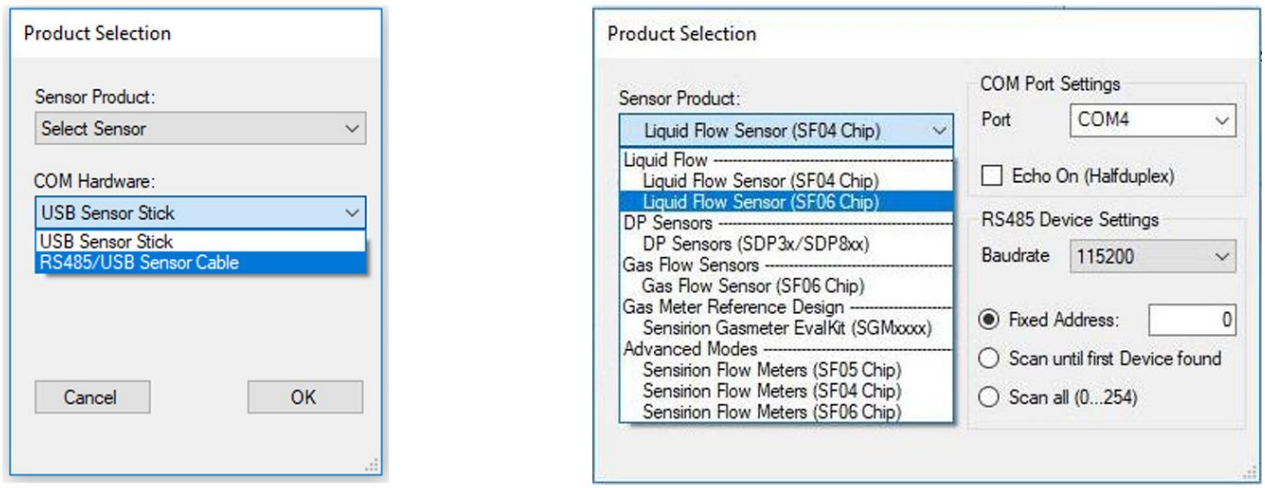


Figure 2. Sensirion Viewer Software product selection window

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.

[1] 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.

Once the appropriate settings are selected, click “OK” and the main window will appear:

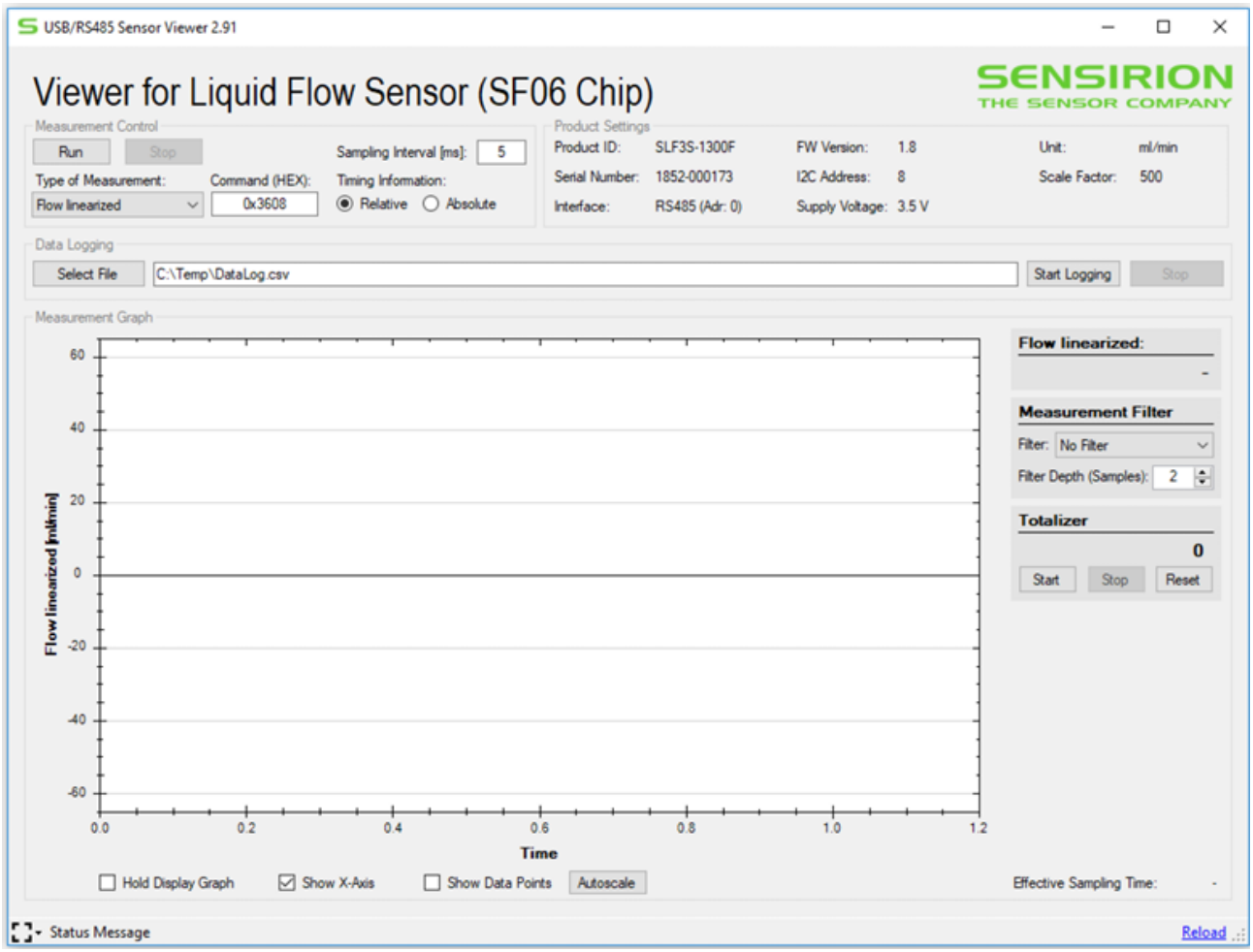


Figure 3. Sensirion Viewer Software main window

2.3 Performing a measurement

Run: Starts the measurement. By default, the sensor response is shown graphically as a running green line that rises and falls with the flow rate.

Stop: Stops the measurement. Many main-screen functions require the current measurement to be stopped before changes can be made. 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]: Provides access to the temperature reading from the sensor chip. This is not a direct measurement of the fluid or ambient temperature, but a combined reading influenced by both, as well as the on-chip electronics, near the flow measurement location.

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 simultaneously. However, when logging a measurement of the SLF3S, the flow, temperature and signaling flags are all 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.

2.4 Product Settings

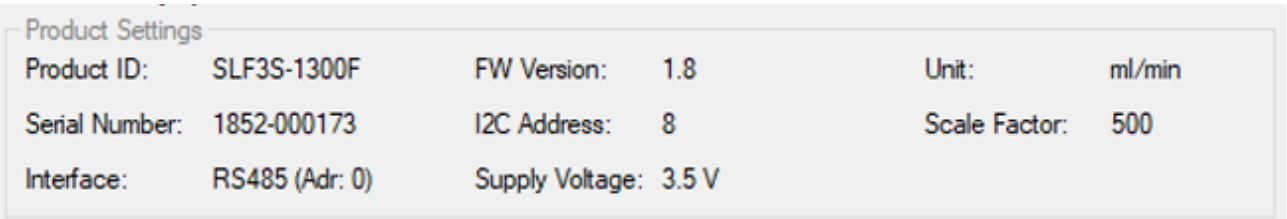


Figure 4. Sensirion Viewer product settings display

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 product

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

Command (HEX): Sensirion liquid flow sensors provide multiple calibration fields for different liquids, such as water or IPA, and support different measurement modes. This field lets users enter specific I²C commands defined in the sensor datasheet. The default command, 0x3608, starts continuous measurement mode for water.

2.5 Data Logging

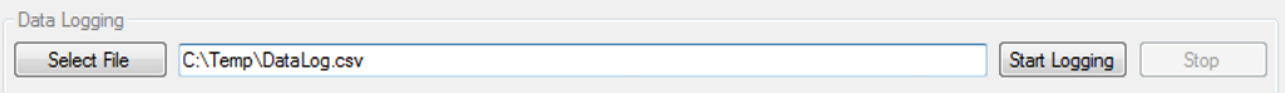


Figure 5. Viewer Software data Logging menu

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: Saves data to your computer. After starting logging, click **Run** to begin measurements; otherwise, the data file will remain empty. You can pause and resume logging to the same file or stop logging as described below.

Stop: Stops data logging. You can resume logging by saving to a new file or overwriting the existing file.

2.6 Measurement Graph

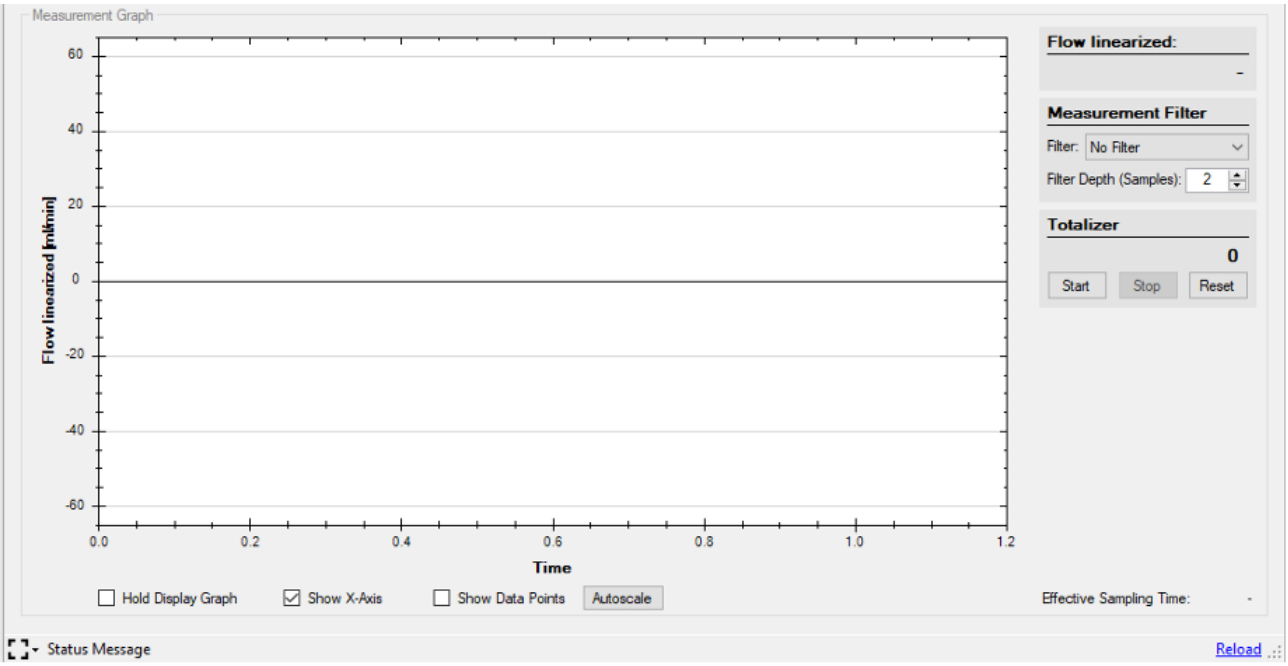


Figure 6. Viewer Software measurement graph

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.

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.

3 Digital I²C Communication Interface

The SLF3x sensors feature a digital interface compatible with the I²C protocol. This section provides an overview of the addressing scheme and communication structure used to interact with the sensor.

For detailed information on the I²C protocol, refer to the *NXP I²C-bus specification and user manual UM10204* (link).

The physical interface consists of two lines: a serial data line (SDA) and a serial clock line (SCL), both of which must be connected to the system supply via appropriate pull-up resistors. See section 5.1 for electronic design-in guidelines.

3.1 I²C Address and Sequences

By default, the sensor uses the I²C address 0x08. Each transmission begins with an address header consisting of the I²C address followed by a read or write bit.

The I²C address can be modified by connecting the IRQn pin to a microcontroller and following the procedure described in the application note *Changing the I²C Address and Activating New Data Interrupt* (link). Note that any address change must be repeated after each hard or soft reset of the sensor.

Communication with the sensor is based on 16-bit commands. Data is transferred in 16-bit words, each followed by an 8-bit checksum to ensure communication integrity. I²C sequences can be terminated at any time by issuing a NACK followed by a STOP condition.

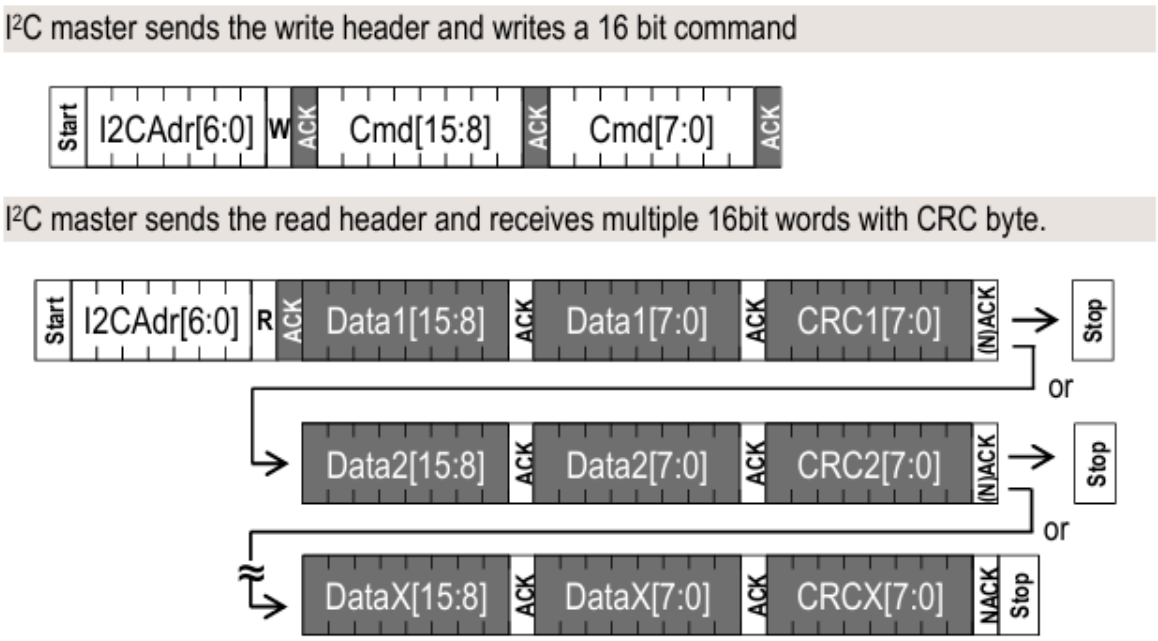


Figure 7. Diagram of I²C communication with the SLF3x sensor. Dark areas with white text indicate that the sensor controls the SDA (Data) line.

3.2 I²C Basic Commands

The following list contains the basic command set for all SLF3x variants.

Command	Command Code (Hex)	Description
Start Continuous Measurement (Water)	0x3608	Starts continuous measurement mode for H_2O.
Start Continuous Measurement (IPA)	0x3615	Starts continuous measurement mode for IPA.
Stop Continuous Measurement	0x3FF9	Stops the continuous measurement and puts the sensor in idle mode.
General Call Reset	0x0006 (I2C address + W bit + command code)	Performs a soft reset of the sensor. Note that the I2C address is 0x00, which is the general call address, and that the command is 8 bit, i.e., the soft reset command must not be preceded by an I2C write header.
Read product identifier	0x367C 0xE102	This sequence of commands returns the product number and serial number

Table 2. SLF3x command set.

3.3 Measurement Data and Product Identifier Format

After the Start Continuous Measurement command has been sent, the chip continuously measures and updates the measurement results. The first measurement result is available after 12ms, and the sensor will respond with a NACK to the I²C read header if no data is available yet.

Preceding Command	Consecutive read	Description
Start Continuous Measurement	Byte1: Flow 8msb Byte2: Flow 8lsb Byte3: CRC Byte4: Temp 8msb Byte5: Temp 8lsb Byte6: CRC Byte7: Signaling flags 8msb Byte8: Signaling flags 8lsb Byte9: CRC	After a start continuous measurement command, the measurement results can be read out. The temperature and the consecutive bytes don't need to be read out (every time). The read sequence can be aborted by a NACK and a STOP condition. The signaling flags are active high. Bit 0 and bit 1 of the signaling flags are used to detect air-in-line and high flow events. Bit 5 of the signaling flags indicates whether the sensor uses exponential smoothing for flow data averaging. Bit 2 … 4 and 6 … 15 are reserved for future use.

Table 3. Consecutive reads after I²C command to start continuous measurement.

To read the product identifier and serial number, the I²C master sends two consecutive write headers and writes 16 bits for each command. Then the I2C master sends the read header and receives 6 words of 16 bit with a CRC byte after each word. The command and response sequence are detailed in the diagram below. Dark areas with white text indicate that the sensor controls the SDA (Data) line.

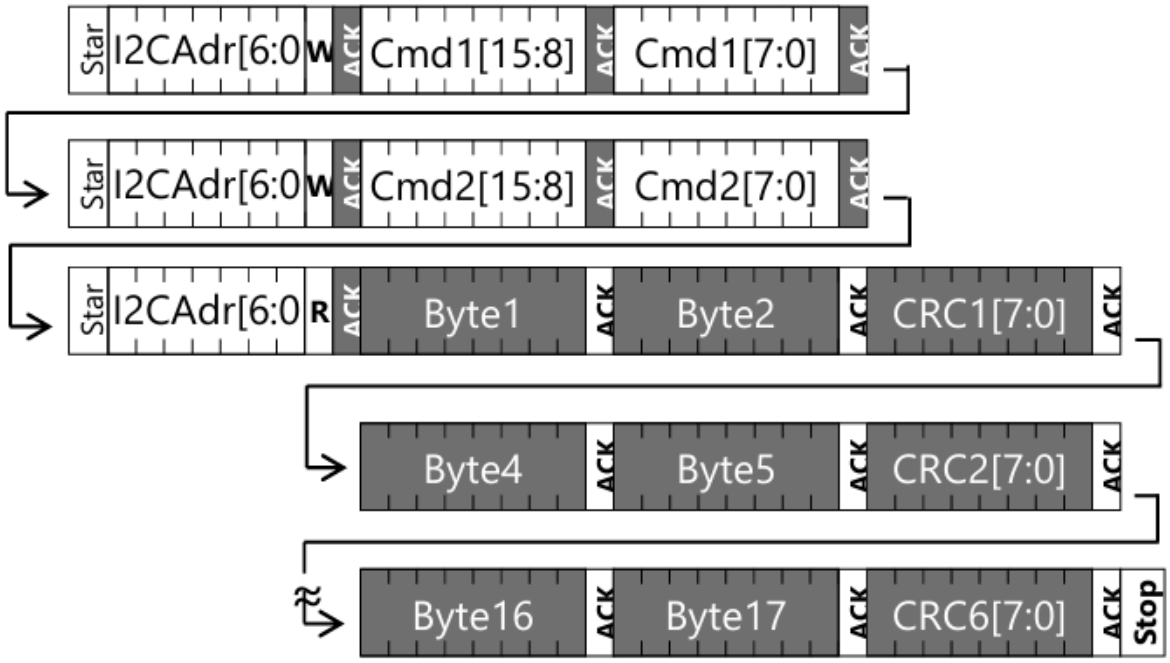


Figure 8. Schematics of product identifier command sequence

Command	Command code	Consecutive read	Description
Read product identifier	0x367C 0xE102	Byte1: Product number [31:24] Byte2: Product number [23:16] Byte3: CRC Byte4: Product number [15:8] Byte5: Product number [7:0] Byte6: CRC Byte7: Serial number [63:56] Byte8: Serial number [55:48] Byte9: CRC Byte10: Serial number [47:40] Byte11: Serial number [39:32] Byte12: CRC Byte13: Serial number [31:24] Byte14: Serial number [23:16] Byte15: CRC Byte16: Serial number [15:8] Byte17: Serial number [7:0] Byte18: CRC	Note that both commands need to be preceded with an I2C write header (I2C address + W). The second command returns: - 32 bit product and revision number. The number is listed in the table below. - 64 bit unique serial number

Table 4. Read product Identifier

Product	Product Number
SLF3S-0600F	0x07030302
SLF3S-1300F	0x07030202
SLF3S-4000B	0x07030501
SLF3S-0600D	0x07030901
EK-SLF3S-1300D	0x07030801

Table 5. Product numbers for SLF3S Series

3.4 Checksum Calculation

The 8-bit CRC checksum is transmitted after each data word, and its properties are displayed in Table 6. The CRC covers the contents of the two previously transmitted data bytes. To calculate the checksum only these two previously transmitted data bytes are used.

Property	Product Number
Name	CRC-8
Protected data	Read data
Width	8 bit
Polynomial	0x31 (x8 + x5 + x4 + 1)
Initialization	0xFF
Reflect input	False
Reflect output	False
Final XOR	0x00

Table 6. Checksum definition.

3.5 Conversion to Physical Values

Conversion of the liquid flow rate and temperature sensor signals to a physical value is done with the scale factor. The liquid flow rate and temperature are each a 16 bit signed integer number. The integer value can be converted to the physical value by dividing it by the scale factor.

Sensor(s)	Liquid Flow Scale Rate	Temperature Scale Rate
SLF3S-0600x	10 $(\mu l/min)^{-1}$	200 $°C^{-1}$
SLF3S-1300x	500 $(ml/min)^{-1}$	200 $°C^{-1}$
SLF3S-4000B	32 $(ml/min)^{-1}$	200 $°C^{-1}$

Table 7. Scale Factors.

4 Software Integration Resources

4.1 Drivers for Python, Arduino, Embedded and Raspberry-Pi

Sensirion provides software resources for the following platforms on its Github page.

Python Driver: The Python driver enables communication between a PC and an SLF3x sensor. It requires an SEK-Sensorbridge and an SEK-SLF3X evaluation kit to establish the hardware connection.

The repository is named "python-i2c-slf3x", and it can be found on Sensirion's Github page (link).

Arduino Driver: The arduino driver enables the user to communicate with an SLF3x sensor with an I^2C capable Arduino.

The repository is named "arduino-i2c-slf3x", and it can be found on Sensirion's Github page (link).

Embedded Driver: The embedded driver provides a framework for the user to communicate with an SLF3x sensor with any embedded platform. Sample implementations are included for Atmel SAMD2 series, GPIO bit banging, Nordic nRF5 series, Raspberry Pi Pico, STM32F1 series, esp32, Linux user space, mbed and zephyr user space.

The repository is named "embedded-i2c-slf3x", and it can be found on Sensirion's Github page (link).

Raspberry Pi Driver: The raspberry pi driver enables the user to communicate with an SLF3x sensor with a PC. The sensor connects directly to the GPIO pins of the Pi, and a wiring diagram is provided on the Github page.

The repository is named "raspberry-pi-i2c-slf3x", and it can be found on Sensirion's Github page (link).

Arduino Code Snippets: The Arduino code snippets are streamlined Arduino code examples that, unlike the Arduino driver, are not dependent on Sensirion's libraries.

The repository is named "arduino-liquid-flow-snippets", and it can be found on Sensirion's Github page (link).

4.2 Analog Communication

The SCC1 analog cable from Sensirion is not compatible with the SLF3S sensors family.

To convert the digital I2C output to an analog signal, we recommend integrating the sensor with a microcontroller and a DAC as outlined in the image below.

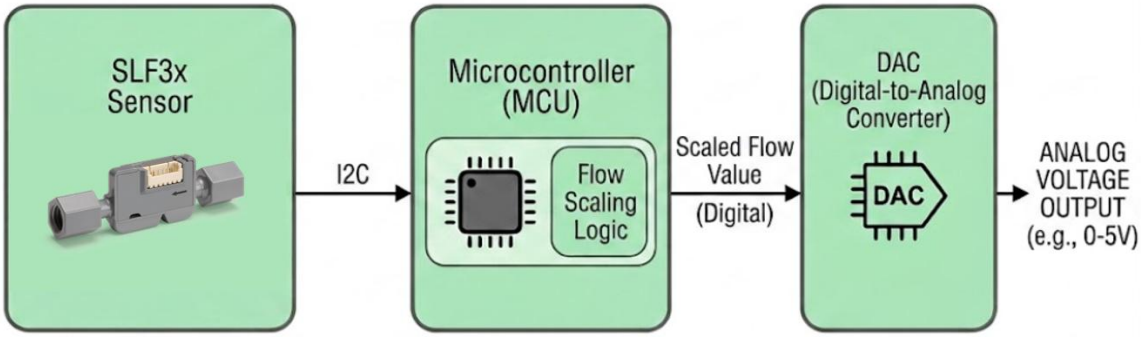


Figure 9. Block diagram of and SLF3S DAC integration

4.3 RS485 Communication

The SCC1-RS485 cable from Sensirion can be used with the SLF3x sensor family to enable RS485 output. This will require an adapter to convert the M8 connector on the SCC1 cable to the connector on the SLF3x. The adapter is included in the SCC1-Connectivity kit.

Further details about the cable can be found in the SCC1-RS485 datasheet (link).

The RS485 interface uses Sensirion's custom SHDLC communication protocol. For Microsoft Windows®, Sensirion provides a driver DLL with simple C functions that can be called from any programming language capable of opening DLLs. Implementation instructions are included with the DLL, and the full SHDLC command set is available upon request.

A list with the DLL Commands for the communication between the SLF3x sensor series via the SCC1-RS485 and SCC1-USB cables can be found here (link). The DLL driver can be downloaded directly from the product page of the SCC1-RS485 (link).

5 Design-in Guidelines for the SLF3x Series

5.1 Electronic Design-In Guidelines

The SLF3x sensors communicate with a host controller via the standard I²C interface. For detailed I²C specifications, please refer to chapter 0.

The interface uses two bus lines: the serial data line, SDA, and the serial clock line, SCL. Both lines must be connected to the system bus voltage through appropriate pull-up resistors. When designing the electronics interface, ensure that the host system provides a stable sensor supply, correctly sized I²C pull-up resistors, and suitable ESD protection at the connector. The following subsections summarize the required pin assignment and a recommended reference circuit for integrating the sensor into a customer PCB.

5.1.1 Pin Assignment

The SLF3x sensors use a 6-pin Molex PicoBlade header as their electrical connector. The sensor-side connector is Molex part number 53261-0671, with 1.25 mm pitch and 6 circuits.

Pad	Description	Comments
1	IRQn	Connect IRQn to the microcontroller if an I²C address change or data interrupt functionality is required. Otherwise, connect IRQn to GND or leave it floating.
2	SDA (data)	Serial data, bidirectional
3	VDD	Supply voltage
4	GND	Ground
5	SCL (clock)	Serial clock, bidirectional
6	n.c.	Nonfunctional, leave floating

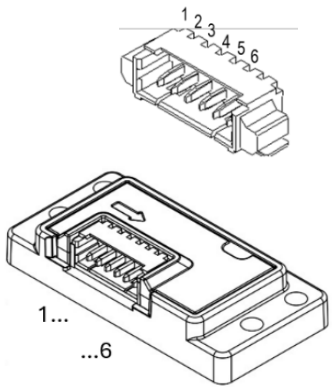


Table 8. Pin assignment for SLF3x sensors.

The sensor is compatible with the mating standard connector (Molex part number 51021-0600) and the PicoBlade Standard Cable Assembly series 15134-06xx (PicoBlade-to-PicoBlade cable assembly, available in different lengths). These parts can be ordered from major online electronics distributors.

5.1.2 Electronic Wiring Diagram

Figure 10 shows a recommended electronic circuit that supports stable I²C communication, ESD protection, and supply-voltage stabilization. Resistors R3 and R4 are required pull-up resistors for the I²C interface and must be included in the customer PCB design. The recommended resistance range is 2.2 kΩ to 10 kΩ, depending on the setup and communication speed.

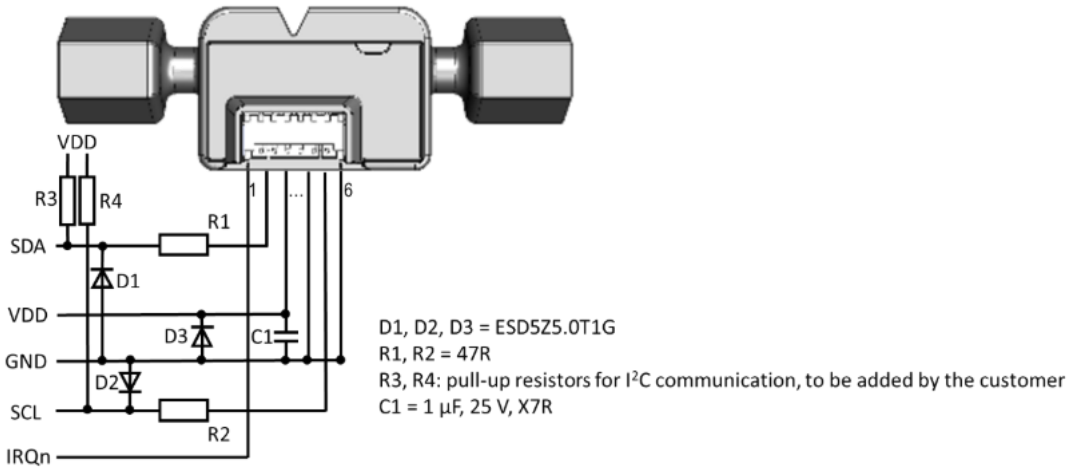


Figure 10. Recommended electronic circuitry for stable I²C communication with the SLF3x sensor series.

ESD Warning: The sensor is susceptible to ESD damage, especially when the connector pins are touched. Suitable ESD precautions must be taken during handling and testing

The electrical isolation between the sensor chip and the flow channel is insufficient to protect against ESD. To minimize this risk, significant voltage differences between the sensor and the medium should be prevented through proper system grounding and electrical design.

One method of proper system grounding is to electrically bond a metal fluidic fitting that contacts the liquid path to the instrument chassis ground.

5.2 Fluidic Design-In Guidelines

5.2.1 Tubing and Fluidic Ports

The SLF3x sensor family is available with different fluidic interface options. The last letter of the product name indicates the interface type: **F** for ¼"-28 flat-bottom ports, **D** for downmount variants, and **B** for barb ports. Table 9 provides an overview of the available variants, their flow rate ranges, and the corresponding fluidic interface. Detailed mechanical dimensions, recommended tubing dimensions, tightening torques, O-ring specifications, and pressure limits are provided in the datasheet of each sensor variant.

Product	Flow rate range	Fluidic interface
SLF3S-0600F	±2 ml/min	¼"-28 flat-bottom
SLF3S-1300F	±40 ml/min	¼"-28 flat-bottom
SLF3S-4000B	±600 ml/min	Barb ports
SLF3S-0600D	±2 ml/min	Downmount
SLF3S-1300D	±40 ml/min	Downmount

Table 9. Summary of SLF3x sensor variants and their fluidic interface.

- **¼"-28 Flat-bottom ports (F variants):** The fluidic seal is achieved by pressing a ferrule against the flat bottom of the port while compressing the connecting tube. The appropriate ferrule and fitting must be selected according to the outer diameter of the tubing. Avoid overtightening the fittings, as

excessive force may damage the interface or create leak paths. Use the tightening torque and tubing dimensions specified in the corresponding sensor datasheet.

- **Downmount interface (D variants):** This interface is designed for direct integration into a manifold rather than for tubing connection. The sensor is mounted against the manifold, and sealing is typically achieved using an O-ring placed at the fluidic interface.
- **Barb ports (B variant):** The tubing material, elasticity, and inner diameter must be selected to ensure a secure connection over the intended pressure and flow range. If required by the application, additional clamping or strain relief should be considered.

For optimal measurement performance, the tubing and fluidic connection accessories should introduce as little disturbance as possible at the sensor inlet. In general, the tubing inner diameter should be equal to or larger than the sensor flow channel or the recommended value specified in the datasheet. This helps avoid jetting effects and non-laminar flow conditions near the microthermal sensing area, especially at higher flow rates.

Additional recommendations for compatible fluidic fittings and tubing connections are provided in Sensirion's Application Note *Sensor Fluidic Ports and Tubing Connections* (link).

5.2.2 Wetted Materials

The wetted materials of the SLF3x series are specified in the respective sensor datasheets and include the following:

- Polyphenylene sulfide (PPS): sensor's main body
- Stainless steel type 316L: membrane between the flow channel and the sensor chip
- Epoxy-based adhesive: connection between PPS body and steel membrane

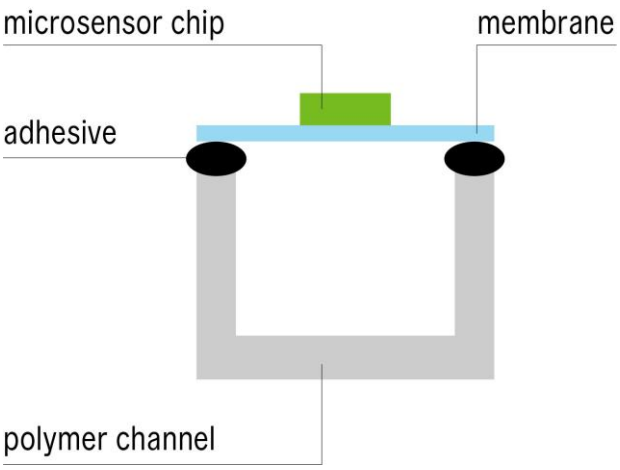


Figure 11. Schematic cross-section of the flow channel and wetted materials.

It is the customer's responsibility to ensure that these materials are compatible with the fluids used in the application.

Further details can be found in Sensirion's Application Note *Chemical Resistance* (link).

5.2.3 Handling of Air Bubbles inside the Fluidic System

Air bubbles already present in the fluid, or generated over time through outgassing, may affect sensor performance. When air bubbles pass the sensor's sensitive area, they temporarily cause a rapid change in the sensor output signal. The SLF3x sensor usually indicates a passing air bubble with an air-in-line flag for easy identification (see section 6.3). Air bubbles may also stick to certain areas of the fluidic system and accumulate, especially at large step changes or dead volumes in the fluidic path. These trapped bubbles can negatively affect the flow profile near the sensing element and lead to measurement errors and other random effects.

A stuck air bubble inside the flow sensor can sometimes be identified by gently tapping the sensor housing and observing both the outlet tube, if transparent, and the sensor output signal. If air bubbles are present in the system, it can be helpful to mount the sensor vertically with the outlet pointing upward, as this reduces the risk of air bubbles remaining trapped inside the sensor. If the application allows it, regular high-flow purging cycles can also be used to flush bubbles out of the system.

When the SLF3x sensor is mounted vertically, an additional error applies due to convection. See the sensor datasheet for the exact specification of this mounting-orientation sensitivity. This additional error is nearly independent of flow rate in absolute terms and can therefore be compensated in the final application by simple subtraction. In relative terms, the effect becomes more significant at lower flow rates.

5.3 Mechanical Design-In Guidelines

The following guidelines summarize key mechanical design considerations for integrating SLF3x sensors into a fluidic system:

- The SLF3x sensor has been calibrated horizontally mounted. To achieve the best performance, the same mounting orientation should be implemented when installing the sensor.
- Avoid connecting the sensor to vibrating parts of the system or to loose tubing whenever possible. Vibrations can move the liquid column inside the sensor and appear in the sensor output signal because of the sensor's high sensitivity and fast measuring speed.
- Avoid applying torsion onto the sensor housing while installing the fluidic fittings. Use strain relief methods to ensure no force is applied onto the connector interface.

For secure and compact mechanical mounting, Sensirion provides a dedicated SLF3x mounting clamp. Firmly fastening the clamp to the system structure helps the sensor achieve its full performance, and it is recommended for laboratory tests and device integration. The SLF3x mounting clamp is made from POM (polyoxymethylene) and is available from Sensirion and Sensirion's distribution network. For detailed dimensions and further information, refer to the corresponding sensor datasheet.



Figure 12. Pictures of the SLF3x mounting clamps with and without sensor installed.

When designing a custom mounting support, it is recommended to use only the middle section of the sensor's plastic body to hold and align the sensor in the customized interface (see the colored surfaces in Figure 5). These surfaces have the same outer dimensions across all SLF3x variants, allowing different versions to be exchanged while using the same mechanical interface.

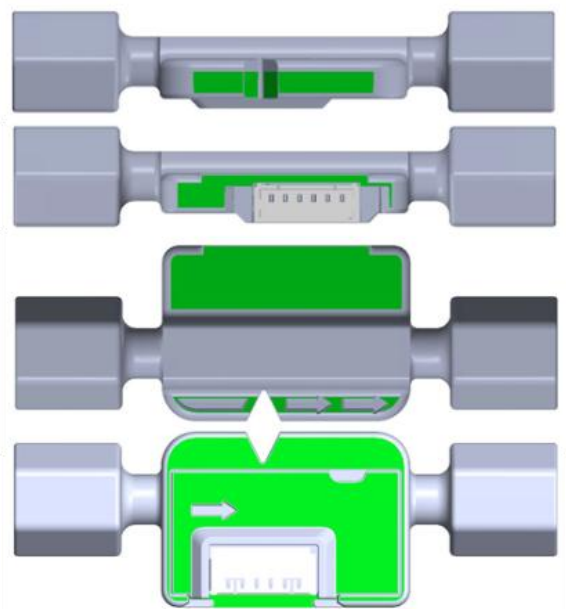


Figure 13. Surfaces (in green) to be used to align and secure the SLF3x sensor.

For SLF3x sensor variants with a downmount interface, refer to the corresponding datasheet for detailed manifold-integration guidelines.

5.4 Cleaning, Preventive Maintenance, and Storage Instructions

The SLF3x sensors are designed for robust operation in its intended application; however, it is also a sensitive instrument that must be properly handled to maintain high performance. Follow these basic handling rules:

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

Since the sensor relies on a thermal measurement principle through the wall of the capillary tube, precautions should be taken to avoid build-up or deposits that could alter the thermal properties of the capillary and influence the sensor reading. Flow meters do not require periodic cleaning unless the medium tends to leave deposits or the sensor has been disconnected from the fluidic path without being properly flushed. Residues left by drying fluids can alter sensor performance or even plug the capillary. In such cases, cleaning by flushing with acetone and IPA may be attempted. Never attempt to mechanically clean the sensor's flow channel.

Detailed information is provided in Sensirion's Application Note *Formation, Prevention and Removal of Biofilms* (link).

Before storing the sensor, always drain the fluid and flush it with a suitable cleaning agent. In most cases, flushing with distilled water, then acetone, and finally IPA is sufficient. Then blow the sensor dry with pressurized air and install sensor plugs for storage. The cleaning agent, such as a detergent or solvent, should be selected based on its effectiveness in removing the liquid medium and its compatibility with the wetted materials.

Further guidelines regarding cleaning procedures and general handling of Sensirion's liquid flow products can be found in Sensirion's Application Note *Cleaning and Clean Handling* (link).

6 Understand your measurement

6.1 Liquid Flow Meter Operating Principle

Sensirion's CMOSens® technology integrates the sensing element, signal conditioning electronics, calibration memory, and digital interface on a single CMOS chip. The sensor chip is mounted externally to the flow channel, enabling a media-isolated measurement principle with no direct contact between the electronics and the fluid. Flow measurements are performed through the channel wall, providing excellent chemical compatibility and long-term reliability.

The SLF3x series operates according to a microthermal flow sensing principle. A small heater introduces a controlled amount of thermal energy into the fluid stream, while temperature sensors located upstream and downstream of the heater measure the resulting temperature distribution. When flow is present, heat is transported in the flow direction, creating a temperature difference that is proportional to the flow rate. This temperature difference is continuously measured and converted into a calibrated flow value.

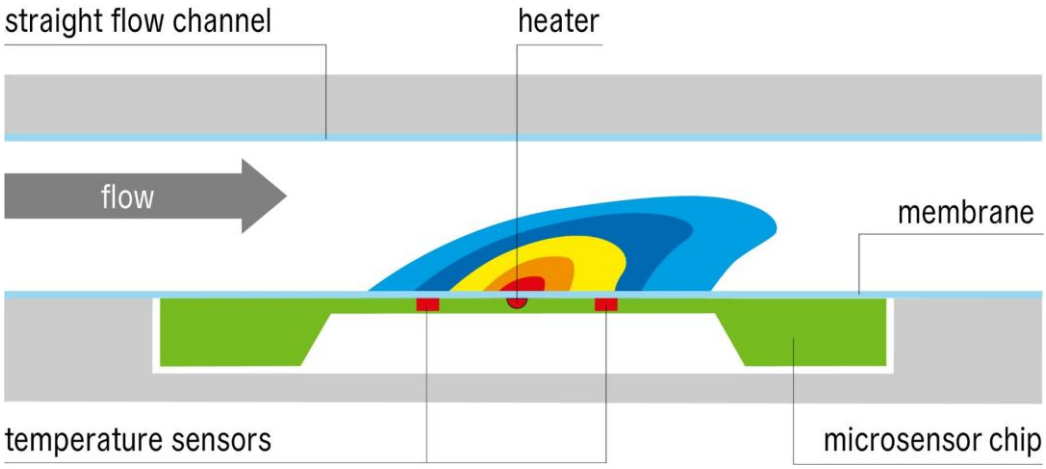


Figure 14. Illustration of the temperature profile within the sensor's channel during liquid flowing conditions.

The thermodynamic properties of the fluid, such as thermal conductivity and heat capacity, directly influence the sensor response. For this reason, the sensor is calibrated for specific fluids: water (H_2O) and isopropyl alcohol (IPA). When measuring other liquids, additional considerations may be required (see section 6.2).

Accurate measurements also depend on maintaining laminar flow within the sensor channel. The specified flow ranges of the SLF3x sensors are selected accordingly. To minimize flow disturbances, the inner diameter of the inlet tubing should be equal to or larger than the sensor channel diameter. While higher-viscosity fluids generally suppress turbulence, care should be taken not to exceed the maximum operating pressure specified in the sensor datasheet.

6.2 Recalibration and Monitoring Different Fluids

The SLF3x sensors can be used to monitor fluids that are not calibrated at the factory, provided that the sensor response is verified for the intended operating range. Start with the calibration field that best matches the fluid properties, such as the water calibration for saline solutions or the IPA calibration for fluids with similar thermal behavior.

6.2.1 Verify Sensor Performance

When measuring a fluid that differs from the factory calibration fluid, it is recommended to verify that the selected sensor and calibration provide accurate volume measurements over the intended operating range. The following procedure can be used to determine whether a given flow rate range is suitable for the application.

1. Select a fixed dispense duration (between 3 to 10 seconds is recommended).
2. Set the pump to a target flow rate representative of the intended application.
3. Perform a dispense and record both:
    - the volume given by the SLF3x sensor output, and
    - the actual dispensed volume, determined by an independent reference method such as gravimetric measurement.
4. Repeat the measurement at two additional flow rates, for example 50% below and 50% above the nominal flow rate.
5. Plot the actual dispensed volume against the sensor's output for all test points.

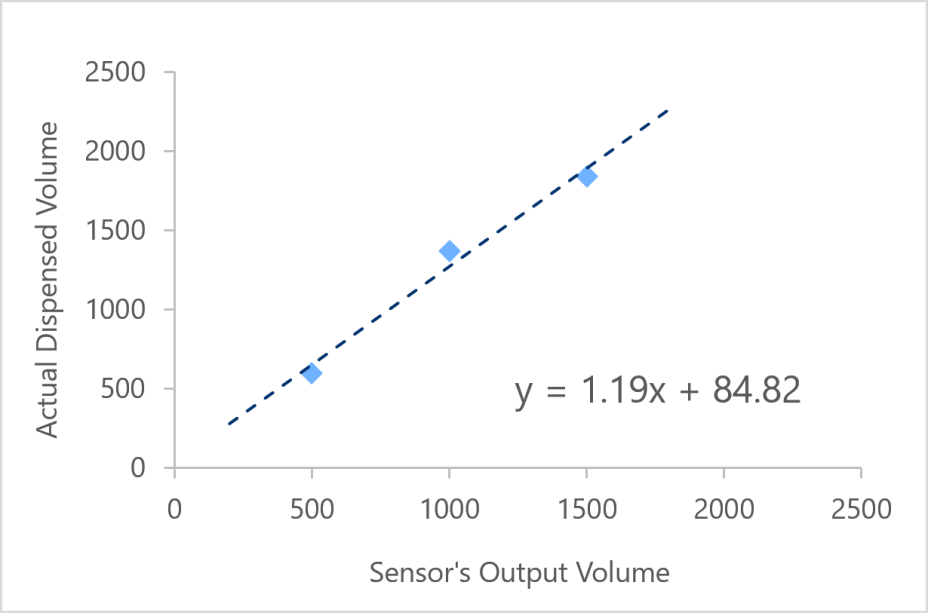


Figure 15. Example of a suitable results with a linear correlation. The test points follow a linear correlation y = *a*·x + *b*, where the correction factors a and b are displayed in the graph.

If the selected flow range is compatible with the sensor and calibration, the measured and actual dispensed volumes will show a linear relationship as in Figure 15. Significant deviations from linearity, especially at higher flow rates, may indicate that the sensor is operating outside its effective range for the fluid under test.

6.2.2 Flow Rate and Dispensed Volume Correction

When SLF3x liquid flow sensors are used with liquids other than the factory calibration media, the sensor output may remain stable and repeatable while deviating from the actual flow rate or delivered volume. For this reason, the sensor response should be verified under the relevant operating conditions before the output is used as an absolute measurement.

Two correction approaches are available depending on the application.

- **Flow rate correction:** in applications where the instantaneous or continuous flow value is relevant, the measured flow rate can be corrected externally in the user software. For the case where a linear or polynomial correction is not suitable enough, a look-up-table can be created to accurately correct the flow rate output across the whole range of interest

- **Dispensed volume:** in dispense applications, where the total delivered amount is the key parameter, the dispensed volume calculated from the sensor signal can be corrected instead by properly characterizing the dispensing process in operation conditions

Both methods rely on comparing the sensor output with an independent reference measurement over the intended operating range and applying the resulting correction in the user's system. The appropriate option depends on whether the application requires a corrected flow rate signal or a corrected dispensed volume. Detailed implementation guidance is provided in the corresponding sections of this application note.

Detailed recalibration and output corrections guidance is provided in Sensirion's Application Note *Flow Rate and Volume Correction* (link). This document includes examples on how to create a look-up-table as well as how to apply quadratic corrections to dispensed volume measurements.

For many applications, the sensor can be used as a highly repeatable relative flow monitor, even when the displayed absolute flow value is not fully corrected for the liquid under test. In this case, record the sensor response at the acceptable minimum and maximum process flow rates and use these values as lower and upper guard bands. The sensor can then monitor whether the process remains within the verified limits.

6.3 Air-in-line Detection

Air bubbles cause the measured flow rate to drop close to zero when they pass through the sensor. Due to the microthermal measurement principle of Sensirion's liquid flow sensors, the sensor can distinguish whether the flow channel is filled with liquid or air. As the measurement is taken at a defined position along the flow channel, the sensor should ideally be mounted so that the sensor chip is located at the top of the channel, where air bubbles are most likely to travel and be detected.

The SLF3x sensor family provides a signaling flag that indicates when air is passing through the sensor. When air is detected, bit 0 of the signaling flag output is set high (= 1) and remains high until the signaling flags are read out. Because an air bubble disturbs the flow velocity profile inside the sensor channel, the High Flow flag may also be set briefly at the beginning or end of the bubble event.

Figure 16 shows the response of the flow rate measurement and the two signaling flags when an air bubble passes through the sensor. In the Sensirion Viewer Software measurement graph, an air-in-line event is displayed as "1", a high-flow event as "2", and simultaneous air-in-line and high-flow events as "3". Steady flow within the sensor's measurement range is displayed as "0". These values correspond to the decimal representation of the binary signaling flag states b001, b010, b011, and b000. For further details on signaling flags, refer to the sensor datasheet.

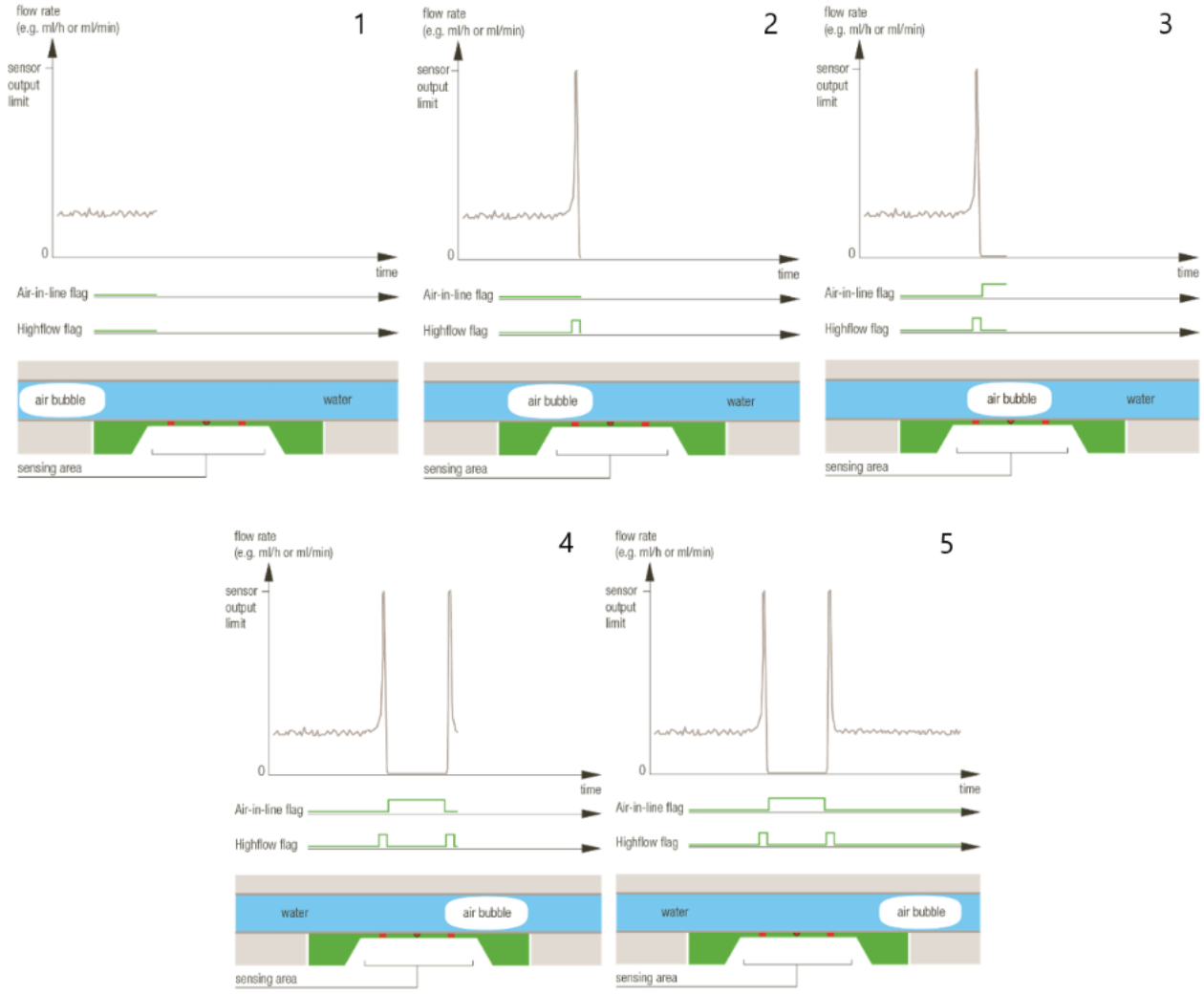


Figure 16. Representation of the signaling flags output as well as the typical flow rate signal while an air bubble travels through the sensor's flow channel from left to right.

6.4 Pulsation and Flow Dampening

Pumps and valves can generate pulsating flow that is influenced by the resistance and capacity of the fluidic system. Sensirion liquid flow sensors, although calibrated for steady-state flow, can capture rapidly changing flows due to their fast response and high sampling rate. However, measurement accuracy can be affected if peak flow exceeds the sensor's output limit or if flow changes occur too rapidly, causing signal distortion. If this occurs, the effect can be mitigated with appropriate fluidic design and/or flow dampening components.

More information about pulsatile flow, and how to dampen it, can be found in Sensirion's application note *Pulsation Dampening* (link). This document includes an example of a pulsation dampening system.

6.5 Thermal Conductivity Measurement

Some variants of the SLF3x sensors can be operated in a special mode to measure the thermal conductivity of the liquid inside the sensor. This measurement needs to be executed at zero flow, when the thermal conductivity of the medium determines the heat transport away from the sensor's microheater. A higher thermal conductivity leads to a stronger cooling and hence to a lower heater temperature. This is illustrated in Figure 17.

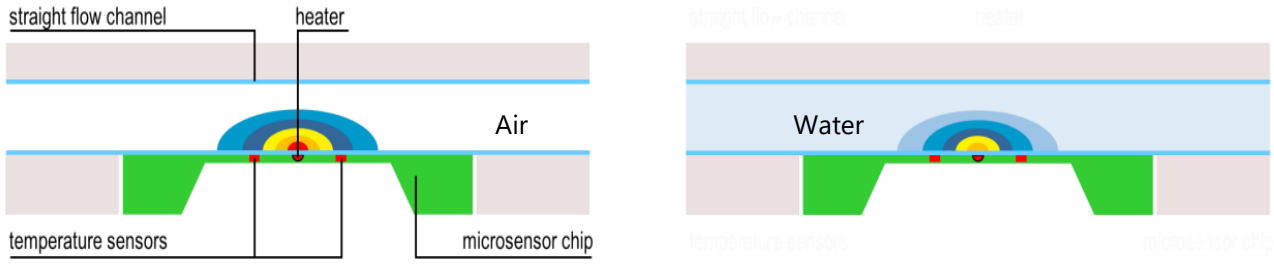


Figure 17. Thermal conductivity measurement at zero flow. Air has low thermal conductivity, leading to a higher heater temperature (left), while water higher thermal conductivity leads to a lower heater temperature (right).

The SLF3x sensor provides the result of the thermal conductivity measurement in arbitrary units, which are scaled such that, when measuring at room temperature, the output for air is 100 and the output for water is 10 000. These arbitrary units can be used as an approximate measure for the thermal conductivity of the liquid. The thermal conductivity measurements of the SLF can be used for multiple applications such as media recognition or concentration measurements.

More information about the thermal conductivity measurements and use case examples can be found in Sensirion's Application Note *Thermal Conductivity Measurement* (link).

The thermal conductivity feature is available by default in the following SLF3x sensors:

Sensor variant	Thermal Conductivity Measurement
SLF3S-0600F	Yes, from SN 2639-xxxxxx onwards
SLF3S-1300F	Yes, from SN 2639-xxxxxx onwards
SLF3S-4000B	No
SLF3S-0600D	Yes
SLF3S-1300D	Yes

Table 9. Overview of thermal conductivity measurement feature availability per SLF3x sensor variant.

6.6 Auto Heater Management

In liquid dispensing applications, the thermal flow measurement principle can introduce inaccuracies in the flow reading by emitting too much heat during the stagnant flow condition between the dispenses. This excess heat can lead to an overshoot of the flow rate during the first milliseconds of the next dispense. To reduce this overshoot, the SLF3x family offers a functionality to automatically manage the heating power of the sensor.

All the details regarding this functionality are described in Sensirion's Application Note *Using the Auto Heater Management in Dispensing Applications* (link).

The excel sheet required to generate the HEX-command for running such functionality is here (link).

7 Application Notes and Useful Links

Sensirion Application Notes

- *Flow Rate and Volume Correction*
- *Thermal Conductivity Measurement*
- *Chemical Resistance*
- *Sensor Fluidic Ports and Tubing Connections*
- *Cleaning and Clean Handling*
- *Formation, Prevention and Removal of Biofilms*
- *Changing the I^2C Address and Activating New Data Interrupt*
- *Using the Auto Heater Management in Dispensing Applications*
- *Pulsation Damping*

Other Sensirion Links

- *Sensirion Viewer Software installer*
- *SCC1-RS485/USB Sensor Cable Datasheet*
- *SCC1-RS485/USB Sensor Cable Driver DLL Documentation*

Github Repositories

- *Arduino driver — arduino-i2c-slf3x*
- *Python driver — python-i2c-slf3x*
- *Embedded driver — embedded-i2c-slf3x*
- *Raspberry Pi driver — raspberry-pi-i2c-slf3x*
- *Arduino code snippets — arduino-liquid-flow-snippets*

Important Notices

Warning, Personal Injury

Do not use this product as safety or emergency stop devices or in any other application where failure of the product could result in personal injury (including death). Do not use this product for applications other than its intended and authorized use. Before installing, handling, using or servicing this product, please consult the data sheet and application notes. Failure to comply with these instructions could result in death or serious injury.

If the Buyer purchases or uses SENSIRION products for any unintended or unauthorized application, Buyer shall defend, indemnify and hold harmless SENSIRION and its officers, employees, subsidiaries, affiliates and distributors against all claims, costs, damages and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if SENSIRION is allegedly negligent with respect to the design or the manufacture of the product.

ESD Precautions

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take customary and statutory ESD precautions when handling this product. See application note "ESD, Latchup and EMC" for more information.

Warranty

SENSIRION solely warrants to the original purchaser of this product for a period of 12 months (one year) from the date of delivery that this product is of the quality, material and workmanship defined in SENSIRION's published specifications of the product. Within such period, if proven to be defective, SENSIRION shall as sole and exclusive remedy, in SENSIRION's discretion, repair this product or send a replacement product, free of charge to the Buyer, provided that:

- notice in writing describing the defects shall be given to SENSIRION within fourteen (14) days after their appearance;
- such defects shall be found, to SENSIRION's reasonable satisfaction, to have arisen from SENSIRION's faulty material or workmanship;
- the defective product shall be returned to SENSIRION's factory at the Buyer's expense; and
- the warranty period for any repaired or replaced product shall be limited to the unexpired portion of the original period.

The Buyer shall at its own expense arrange for any dismantling and reassembly that is necessary to repair or replace the defective product.
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