Engineering Guideline for the Design-In of the SLF3x Series

Application Note for SLF3x Liquid Flow Sensors

Preface

Sensirion's next generation liquid flow sensor, the SLF3x series, represents a breakthrough for microthermal liquid flow sensors. By combining Sensirion's excellent 20-year track record in low and lowest flow rate sensing with a radically optimized mechanical design, the SLF3x takes the well-established functionality to the next level in price-performance ratio.

This application note provides engineers integrating Sensirion's SLF3x liquid flow sensor into their product with an overview of the recommended design-in guidelines with respect to a proper mechanical, electrical and fluidic integration of all SLF3x sensor variants. The sensor's datasheet should be consulted in addition as an important source of comprehensive specifications and detailed dimensions.

Contents

1 Made To Measure – an Introduction to the SLF3x Series

The SLF3x series comprises four variants as of today:

- the SLF3S-1300F for flow rates up to ±40 ml/min,
- the SLF3S-0600F for flow rates up to ±2000 µl/min, and
- the SLF3C-1300F for flow rates up to ±40 ml/min and with addition thermal conductivity feature
- the SLF3S-4000B for flow rates up to 1l/min

Onboard calibrations for water- and hydrocarbon-based fluids are available on both sensor variants. Furthermore, both variants have the same outer dimensions, fluidic ports and use the same electrical connector type. The design-in of sensors of the SLF3x series is, apart from flow range dependent characteristics (see section 3.2), identical.

2 Electronic Design-In Guidelines

2.1 Pin Assignment

The SLF3x sensor uses a 6-pin connector (Molex part number: 53261-0671; 1.25 mm pitch PicoBlade header, 6 circuits) as its electrical connection, see Table 1 below for the pin assignment.

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

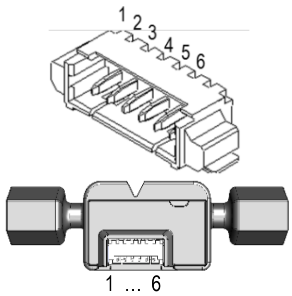

Table 1: Pin assignment

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.

2.2 Digital I^2C Communication Interface

Digital communication between a master and the SLF3x sensor (= slave) runs via the standard I^2C-interface. The physical interface consists of two bus lines, a data line (SDA) and a clock line (SCL), which need to be connected via pull-up resistors to the bus voltage of the system.

Note: For the detailed specifications of the I^2C communication, please refer to the respective SLF3x datasheet (www.sensirion.com/slf3x).While the measurement commands are the same for all variants, please note that the product number and flow rate scale factor differ per sensor variant. The required specification is noted in the sensors' datasheet. However, the sensors' I^2C address is the same for all sensors and all variants. Different sensors can be identified through their unique serial number. The I^2C-Address can be changed by connecting the IRQn-pin of the sensor to a microcontroller and following the steps explained in the application note "Changing the I2C-Address and activating new data interrupt". Please note that procedure needs to be repeated after every hard or soft reset of the sensor.

To simplify testing and design-in of the SLF3x series, several helpful code snippets from first simple measurements to the usage of an I^2C multiplexer to communicate with up to eight SLF3x sensors on the same bus can be found on Github. The SLF3x sensor series uses Sensirion's latest flow chip generation, the SF06. Thus only code samples applicable for this flow chip should be used as a design in reference for the SLF3x series.

2.3 Electronic Wiring Diagram

Please find below a schematic electronic circuitry that allows for a stable I²C communication, ESD protection, and stabilization of the supply voltage (see Figure 1). The resistors R3 and R4 are necessary pull-up resistors for the I²C interface. They need to be added to the customer's PCB design (recommended resistance is between 2.2 kΩ and 10 kΩ depending on setup and communication speed).

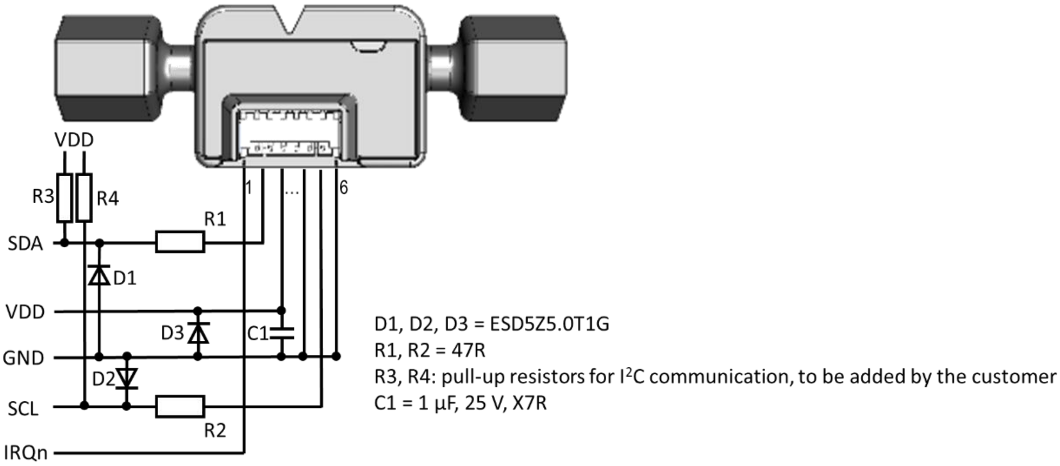

Figure 1: Recommended electronic circuitry for stable I2C communication with the SLF3x sensor series

ESD Warning: The sensor is susceptible to ESD damages, especially when touching the connector pins. During handling and testing, suitable ESD precautions must be taken.

Note: The sensor chip is not electrically isolated from the flow channel and the medium passing through it. Therefore, a voltage difference between sensor and medium should be avoided at all times through proper system grounding and design.

3 Fluidic Design-In Guidelines

3.1 Fluidic Ports

The SLF3x series (except the SF3S-4000B) has flat bottom ports at the sensor's inlet and outlet. Here, a fluidic seal is achieved by a ferrule being pressed against the flat bottom of the port and by compressing the connecting tube. Depending on the outer diameter of the connecting tube, different ferrules need to be used. This port is commonly used in low and moderate pressure applications and in combination with larger tubing.

In order to achieve a reliable and durable seal it is recommended to tighten the nuts on the flat bottom ports of the SLF3x sensors with a torque of 0.5 Nm ± 10 %.

The SLF3S-4000B uses barbed fittings for tubes with an inner diameter of 5-6mm.

3.2 Tubing

The UNF ¼"-28 flat bottom fitting chosen for the SLF3x series can only accommodate tubing with an outer diameter (OD) of up to 1/8" (3.2 mm). See sections 3.4 and 3.5 of the application note "Sensor Fluidic Ports and Tubing Connections" for a list of recommended fluidic fittings for the SLF3x series. Please read section 3.7 of the same application note if you need to connect tubing with an OD >1/8".

In general, the maximum flow range of a Sensirion liquid flow sensor is specified in a way that achieves laminar flow at the position of the micro thermal measurement chip during normal usage. To avoid jetting effects that may create non-

laminar flow conditions at the sensor's sensitive area, tubing and fluidic connection accessories with an inner diameter on par with or larger than that of the sensor shall be used.
Due to the different full scale flow rates of the available SLF3x sensor variants, the recommended inner diameter (ID) of the connecting tubes differ for the SLF3S-1300F and the SLF3S-0600F. To avoid adverse fluidic effects as described above, Sensirion recommends to use tubing with an ID of ≥4 mm for the SLF3S-4000B, ≥2 mm for the SLF3S-1300F, and of ≥1 mm for the SLF3S-0600F.

3.3 Wetted Materials

The wetted materials of the SLF3x series are specified in the respective datasheets. These are:

- Polyphenylene sulfide (PPS) as body housing
- Stainless steel, type 316L, as separation layer between the flow channel and the sensor chip
- Epoxy-based adhesive

It is in the responsibility of the customer to ensure that these materials comply with the fluids to be used.
By design, only the bottom face of the fluidic port, the ferrule and the tube are in contact with the fluid and consequentially need to be checked for compliance with the fluid, too. See application note "Chemical Resistance" for further details.

4 Mechanical Design-In Guidelines

A few general instructions:

- The SLF3x sensor has been calibrated horizontally mounted. To achieve the best performance, the same mounting orientation should be implemented when installing the sensor inside a device.
- Avoid connecting the sensor to vibrating parts of the system or loose tubing, where possible. Vibrations will induce movements of the liquid column inside the sensor and will be visible in the sensor's output signal due to its high sensitivity and measurement 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 a secure and compact mechanical mounting of the SLF3x sensors, Sensirion provides a mounting clamp. Using the SLF3x mounting clamp and screwing the clamp firmly to the device structure ensures that the sensor can unfold its full performance. It is thus highly recommended to use it for mounting of the sensor during lab tests and also in the final application. The SLF3x mounting clamp is made from POM (Polyoxymethylene). It is available from Sensirion and Sensirion's distribution network. Please read the SLF3x datasheet for further information and detailed dimensions of the SLF3x mounting clamp.

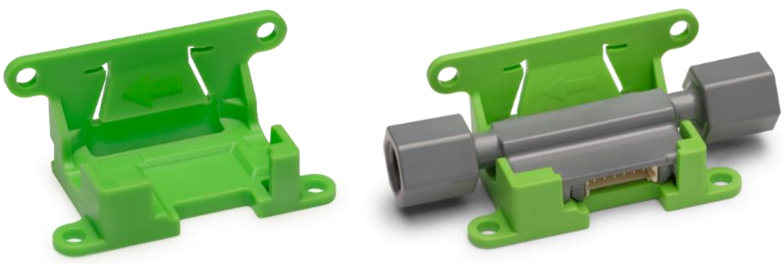

Figure 2: Pictures of the SLF3x mounting clamp with and without sensor installed

In case you decide to design your own mounting support, it is recommended to use only the middle section of the sensor's plastic body to hold and align the sensor in a customized interface (see colored surfaces in Figure 3). The outer dimensions of these surfaces are the same for all variants of the SLF3x series, enabling an easy exchange of the different SLF3x versions while using the same mechanical interface.

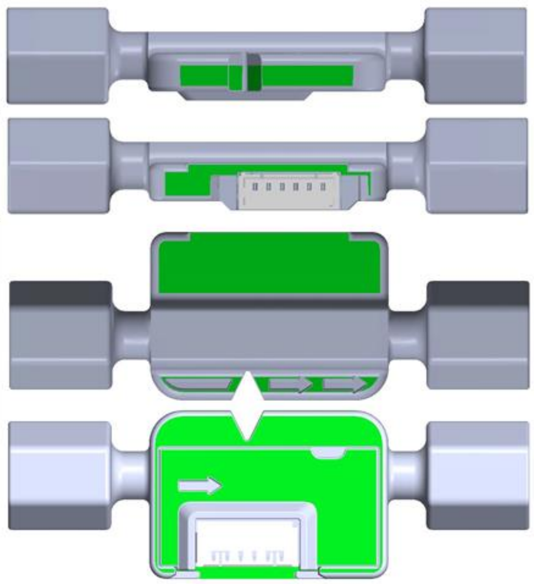

Figure 3: Surfaces (green) to be used to align and secure the SLF3x sensor

4.1 Handling of Air Bubbles inside the Fluidic System

Pre-existing air bubbles in the fluid, or air bubbles generated over time through outgassing of the fluid may impact the sensor performance.
Air bubbles passing the sensor's sensitive area will temporarily cause a rapid change in sensor's signal output. The passing-by of an air bubble will usually be signaled by the SLF3x sensor with an "air-in-line" flag for easy identification.
Air bubbles may also stick to certain areas of the fluidic system and accumulate. Especially large step changes and dead volumes in the fluidic path are likely to trap air bubbles present in the fluid. Such trapped air bubbles can negatively affect the flow profile in the vicinity of the sensing element and hence lead to measurement errors and many other random effects.
Whether or not an air bubble sticks to the internals of the flow sensor can sometimes easily be proven by snipping with your fingers against the flow sensor housing and observing the tube at the outlet (in case it is transparent) as well as the sensor's output signal.

If air bubbles are present in your system, it can be helpful to mount the sensor vertically with the outlet pointing upwards. This mounting orientation will lower the risk of air bubbles remaining stuck inside the sensor.
Further, if the application allows it, purging cycles at high flow rates can be introduced on a regular basis to flush the bubbles out of the system.
In case of vertical mounting of the SLF3x sensor, an additional error applies due to convection. See the sensor's datasheet for the exact specification of this *mounting orientation sensitivity*. However, this additional error is almost flow rate independent in terms of an absolute flow rate value and can thus be easily compensated for in the final application by a simple subtraction. Relatively seen, this effect weighs heavier the lower the set flow rate is.

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Internal Revision History

Revision	Date	Author	Changes Chapter	Description
1	Aug 2020	SJUN	All	First version
1.1	Dec 2021	PARE	1, 2.1, 2.2	I2C address change added