Application Note 007:
Microfluidics Driver – Prototyping with the Disc Pump Evaluation Kit and Sensirion SLF3x Series Flow Sensor

1 REVISION HISTORY

Date	Version	Change
30 July 2020	r200730	Initial release.
25 September 2020	r200925	Corrections and clarifications.

2 INTRODUCTION

TTP Ventus has teamed up with Sensirion to combine their SLF3x liquid flow sensor series with our Disc Pump Evaluation Kit to create a prototype microfluidics driver, highlighting the exceptional liquid flow control that can be achieved by combining our technologies. This approach suits a wide range of microfluidics applications, from IVD diagnostic instrumentation (including miniaturised systems for Point of Care) to droplet microfluidics.

The key features of the system:

- High-precision, stable flow-rate control.
- Large dynamic flow range (four orders of magnitude).
- Smooth liquid flow – no pulsation or oscillation.
- Rapid response to setpoint changes.
- Highly compact implementation possible.
- Pressure-driven flow approach supports reusable/disposable model where cross-contamination needs to be avoided.

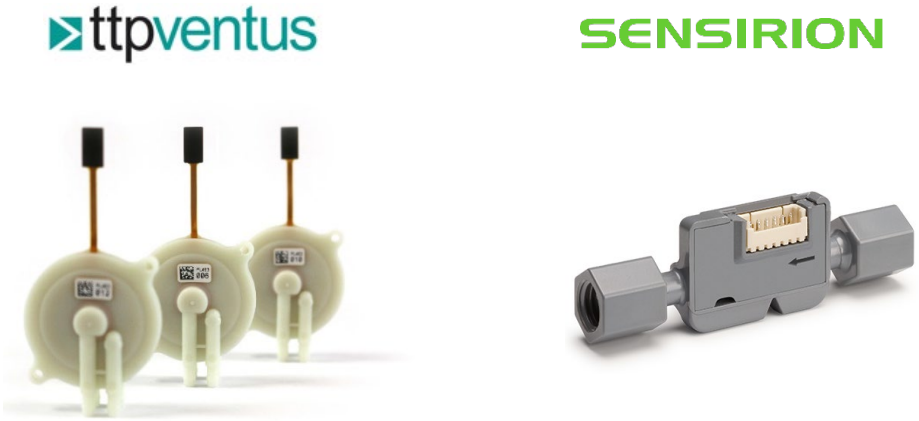

Figure 1: TTP Ventus Disc Pump and Sensirion SLF3x series liquid flow sensor

2.1 About this Application Note

This application note explains the how to set up the same system for your own experiments. In particular, it outlines:

1. The performance that can be achieved with the system.
2. System components, set up and operation.
3. Ordering information
4. Resources to support the next stage of product development and integration

3 DISCLAIMER

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4 HEALTH AND SAFETY

WARNING
The Disc Pump Driver PCB is capable of producing DC voltages up to 60V, and output AC voltages up to 120V peak- to- peak, at frequencies between 19 and 23 kHz. It is the user's responsibility to ensure that the Disc Pump Driver PCB is used and/or integrated within any product in a safe manner. Read the user manual prior to first operation and take note of all safety notices.

WARNING
Take care during use of the Disc Pump Drive PCB not to create short circuits between exposed conductive parts of the board. Short circuits may lead to malfunctioning and heating.

WARNING
The liquid flow sensor is susceptible to ESD damage, especially when touching the connector pins. During handling and testing, suitable ESD precautions must be taken.

Please note, that 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.

5 MICROFLUIDIC DRIVE SYSTEM

5.1 Performance

Figure 2 shows a logarithmic step-function in flow rate over four orders of magnitude: 3, 30, 300 and 3000 µL/min. At each step, flow is held for 30 seconds to demonstrate the flow control precision and stability. The time required to transition between steps is less than 2 seconds.

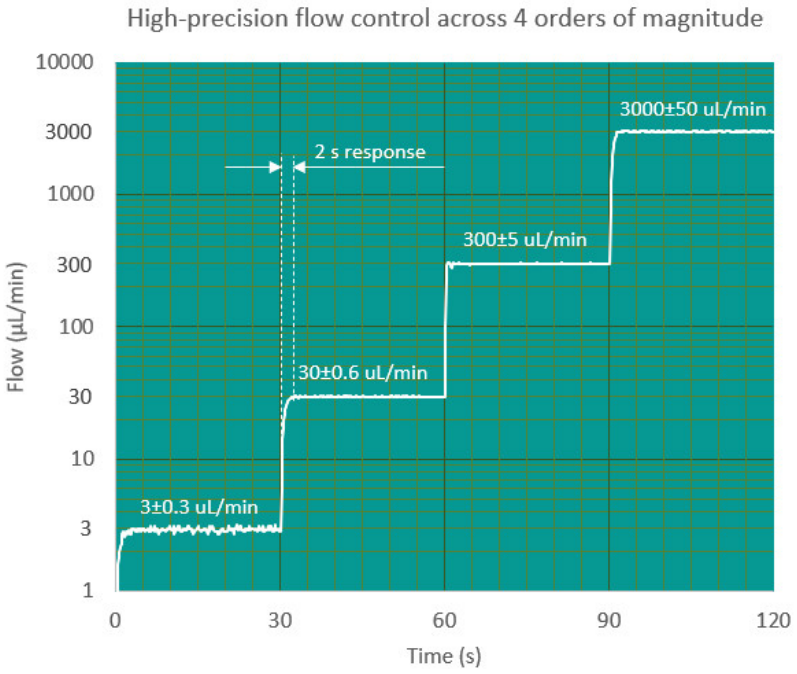

Figure 2: TTP Ventus Disc Pump and Sensirion SLF3x series liquid flow sensor

5.2 What limits performance?

The maximum flow rate that can be achieved is determined by the maximum pneumatic pressure the pump can deliver, and a range of other factors including the liquid flow resistance through the system (e.g. as determined by the channel geometry and surface properties), the viscosity and surface tension of the fluid. TTP Ventus offers a range of pumps to suit your pressure requirements.

The minimum flow rate, in principle, should be zero, as Disc Pump has no stall speed and therefore has a near-infinite turn-down ratio. The resolution of the pump output is also ‘continuous’. In practice, both the minimum flow rate and flow rate resolution are likely to be determined by the limits of the flow sensor and the pump drive electronics, rather than by the pump itself.

5.3 System Components

- **TTP Ventus Disc Pump Evalutuation Kit**, fitted in this example with a DP-S2-007 pump[1].
- **Sensirion SLF3S-0600F flow sensor**, offering a 0 to ±2000 µL/min measurement range[2].
- **Liquid reservoir**—we used an Elveflow Microfluidic Reservoir for 15 mL Falcon Tube - S (2 port) with the add-on fluidic fittings kit, but other reservoirs will work equally well.
- **Molex 151340602 cable assembly** to connect flow sensor to the Evaluation Kit.
- **Optional**: needle valve / bleed orifice between pump and reservoir (not shown in photo). This may be helpful for very low flow rate control and/or ability to stop liquid flow quickly, dependent on the specific system architecture.

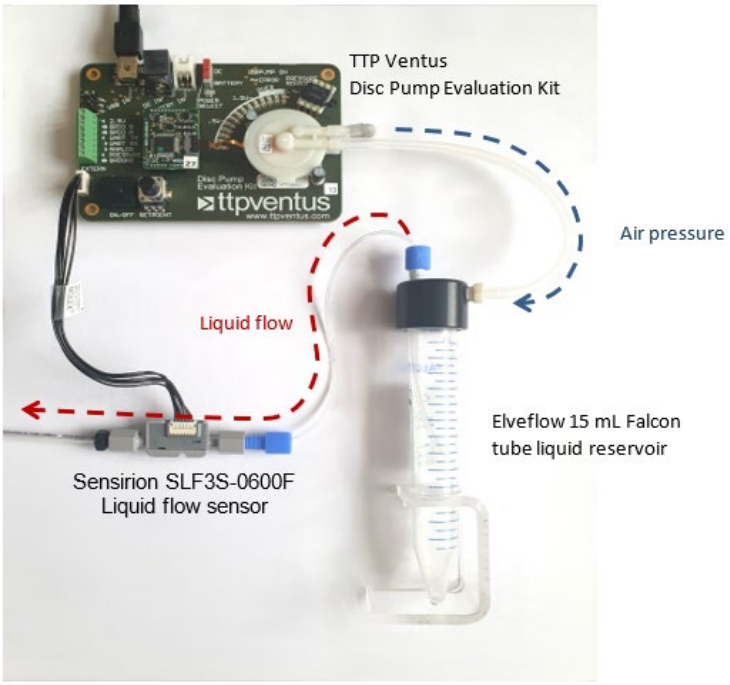

Figure 3: System components

[1] Other pump models are available to suit your requirements. Please refer to the products section of our website for more information on the available pump options—ttpventus.com/micropump-products—and contact us for selection guidance.

[2] The Disc Pump Evaluation Kit also supports the SLF3S-1300F liquid flow sensor (full-scale flow rate range: ±40 ml/min). Future support will be provided for the LD20 single-use liquid flow sensor – please discuss with TTP Ventus. For further guidance on sensor selection, please contact Sensirion.

5.4 System Schematic

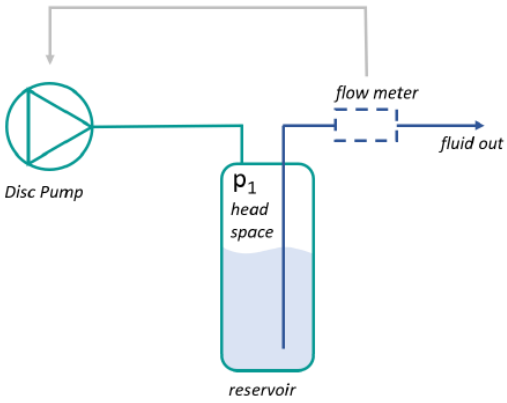

Figure 4: System schematic

5.5 System Operation

TTP Ventus has created firmware to communicate with and take measurements from the SLF3S-0600F liquid flow sensor, and to operate closed-loop control of the flow rate.

To operate the system:

- Connect the components together per the schematic (Figure 4) and system photograph (Figure 3).
- Connect the Disc Pump Evaluation Kit to a PC with the supplied USB cable.
- Open the TTP Ventus Pump Control App supplied with the kit
    - Select the appropriate COM port and connect to the board
    - Select the PID control tab
    - Select your preferred flow rate setpoint source – we recommend using Manual, initially. *Please see the Evaluation Kit User Manual for more information on setpoint sources.*
    - Select External Flow Sensor as the Input.

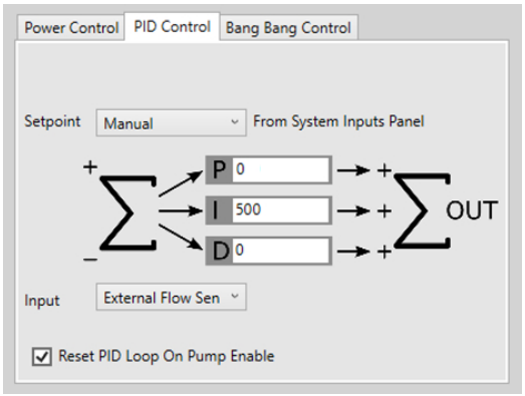

Figure 5: PID Control tab of the TTP Ventus Pump Control App

- Using the System Inputs panel, enter your desired flow rate into the Manual entry box, such as 1 ml/min as in the in Figure 6.

Figure 6: TTP Ventus Pump Control App

6 SUPPORT

6.1 Ordering Parts

- Please order components separately from their respective suppliers.
- When ordering the Disc Pump Evaluation Kit, please indicate to TTP Ventus that you would like the variant with Sensirion SLF3x support.
- The SLF3x liquid flow sensors are available through Sensirion's worldwide distribution network. Find your local distributor here: www.sensirion.com/distributor-search. Evaluation Kits are also available for these sensors (note: these are not the same as the TTP Ventus Disc Pump Evaluation Kit).
- TTP Ventus can provide support when selecting pump models – please ask us.

6.2 Further Support

Resources to support the next stage of product development and integration can be found at:

- www.ttpventus.com/support
- https://www.ttpventus.com/micropump-applications/life-sciences/microfluidics
- Example code for Arduino for Sensirion's Liquid Flow Sensors
- Building a standalone flow meter using Arduino and Sensirion's Liquid Flow Sensors

For specific questions, please contact support@ttpventus.com.