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

1 INTRODUCTION

LEE Ventus has worked with Sensirion to combine the SLF3x liquid flow sensor series with the Disc Pump to create a development microfluidics driver. This application note details how exceptional liquid flow control 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.

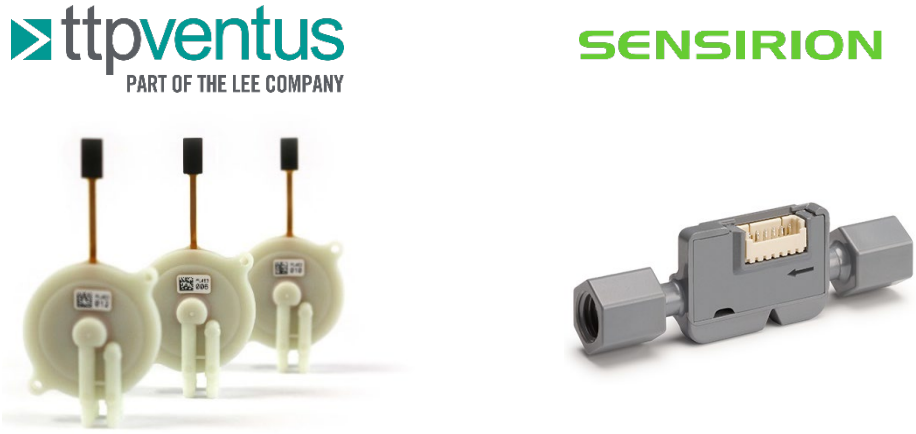

Figure 1: LEEVentus Disc Pump and Sensirion SLF3x series liquid flow sensor

1.1 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

2 DISCLAIMER

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3 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.

4 MICROFLUIDIC DRIVE SYSTEM

4.1 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.

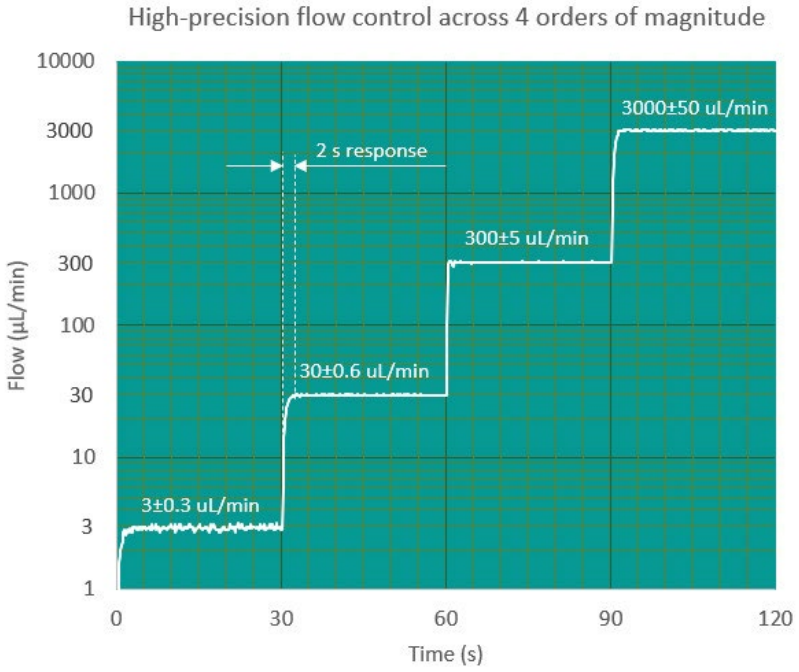

Figure 2: LEE Ventus Disc Pump and Sensirion SLF3x series liquid flow sensor

4.2 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. LEE 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.

4.3 System Components

- **LEE Ventus Disc Pump Evaluation Kit**, fitted, in this example with a XP-S2-007 pump[1].
- **Sensirion SLF3S-0600F flow sensor**, offering a 0 to ±2000 µL/min measurement range[2].
- **Liquid reservoir**—we used a Fluigent P-CAP Microfluidic Reservoir for a 15 mL Falcon Tube, but other reservoirs will work equally well.
- **Molex 151340602 cable assembly** to connect flow sensor to the Disc Pump Evaluation Kit[3].
- **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.

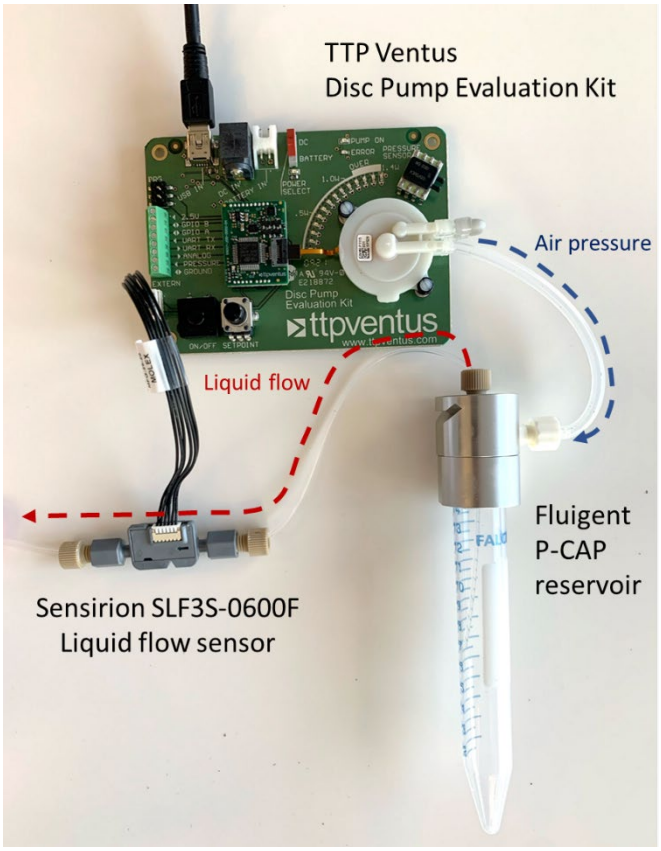

Figure 3: System components

4.4 Ordering Parts

LEE Ventus only supplies the Disc Pump Evaluation Kit shown in Figure 3. Please order the other components separately from their respective suppliers.

The SLF3x liquid flow sensors and flow sensor evaluation kits are available through Sensirion's worldwide distribution network https://www.sensirion.com/en/distributor-search/.

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[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—https://www.ttpventus.com/micropump-products —and contact us for selection guidance.

[2] The Disc Pump Evaluation Kit also supports the SLF3S-1300F and LD20 Series flow sensors from Sensirion. For further guidance on sensor selection, please contact Sensirion.

[3] We recommend that the Molex 151340602 cable assembly is purchased *even when* the liquid flow sensor is procured as part of a Sensirion evaluation kit; the cables provided in the Sensirion evaluation kit are not compatible with the Disc Pump Evaluation Kit without custom termination.

4.5 System Schematic

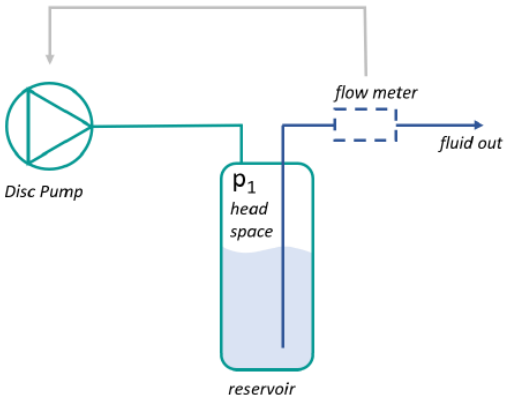

Figure 4: System schematic

4.6 System Operation

LEE 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 LEE 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.

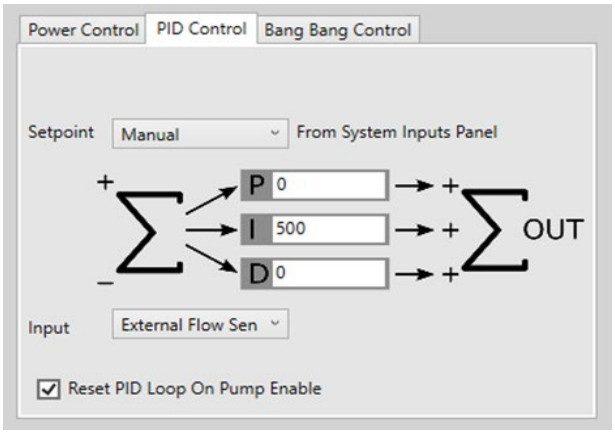

Figure 5: PID Control tab of the LEE Ventus Pump Control App

- 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.

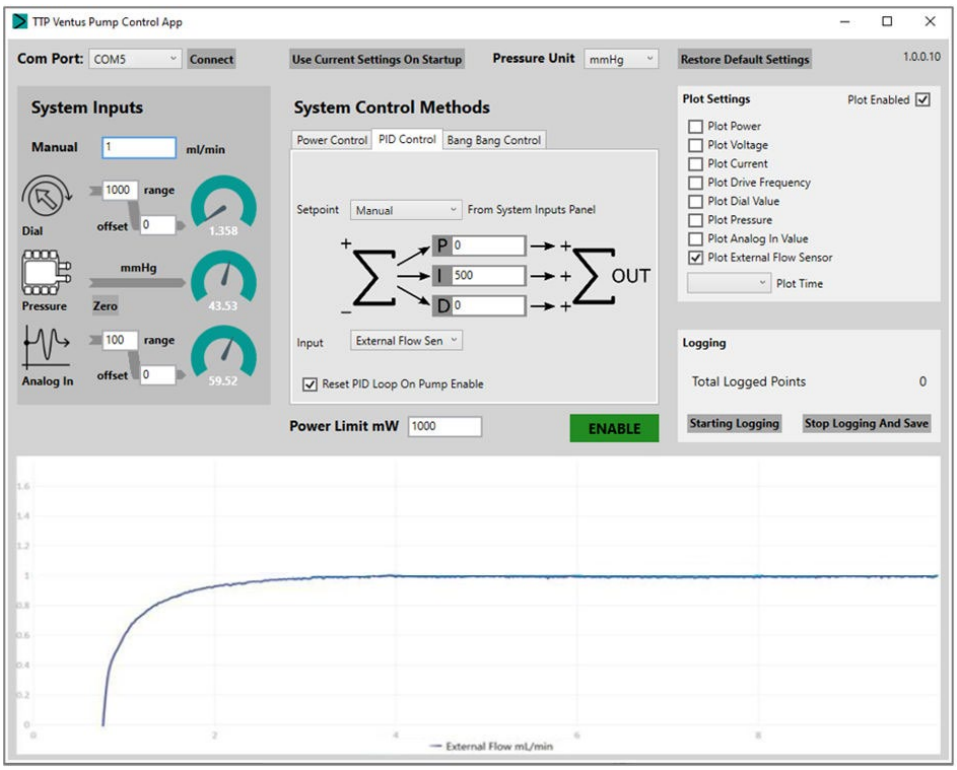

Figure 6: LEE Ventus Pump Control App

5 SUPPORT

5.1 Code snippet library

The LEE Ventus code snippet library, hosted on GitHub (https://github.com/TTP-Ventus/), provides serial communication and control examples in Python for common functions, including turning the pump on and off, setting drive power, closed loop control of pressure and reading back and plotting data. The code snippet library implements the aspects of the communication protocol set out in application note AN0003 and is intended to support customers after their initial evaluation of our pump technology, as they move on to developing prototypes and products.

5.2 Additional Support

The support section of LEE Ventus website (https://www.ttpventus.com/support) provides advice on:

- Getting Started
- Applications
- Development Process
- Downloads (including datasheets, application notes, case studies and 3D models)
- Frequently Asked Questions

LEE Ventus is happy to discuss next steps beyond prototyping, including system design. If you would like to discuss this with us, or for any other additional support, please contact us at support@ttpventus.com

6 REVISION HISTORY

Date	Version	Change
14 May 2021	R210514	Update support, Figure 3 components and Sensirion models covered
25 September 2020	r200925	Corrections and clarifications.
30 July 2020	r200730	Initial release.