LabSmith Microfluidic Application Note

Pressure Driven Flow with the uProcess™ Devices and Software

By Christine Cummings and Kirsten Pace
LabSmith, Inc., Livermore, CA 94550

This application note describes how to set up a microfluidic pressure-driven flow controller using uProcess syringe pumps, valves, and pressure sensors.

Introduction

The uProcess SPS01 is a positive displacement syringe pump that utilizes a stepper motor to deliver the displacement. This inexpensive and compact pump provides precise flow delivery; however, the resulting flow will be pulsatile, which is not suitable for many applications. Pressure-driven flow is often used for applications that require highly stable and pulseless flow. This application note describes how to assemble a pressure-driven flow controller using uProcess devices and software.

Experimental Setup

Figure 1 shows the setup used to make the flow controller. Two SPS01 syringe pumps and an AV202 (4-port) valve are used to achieve continuous flow. These components could be replaced with a single SPS01 syringe pump and AV201 (3-port) valve, but the steady flow would be interrupted when the syringe refills.

Downstream of the AV202 valve is the pressure vessel consisting of a BBRES-1ML reservoir with a uPS01 pressure sensor. The reservoir is partially filled with the reagent, leaving an air gap, and is sealed with an O-ring cap. The air gap at the top of the reservoir dampens the pulsations to achieve pulse-free flow. A uPS01 pressure sensor is threaded into the port on the reservoir cap. The ports at the base of the reservoir are used for the capillary tubing inlet and outlet.

An AV201 (3-port) valve downstream of the reservoir is used to stop the flow during initial pressurization. A 1m section of capillary tubing can be used to simulate a backpressure of a microfluidic chip or other device.

A flow sensor (Sensirion LG16-0430D) was used in the application to demonstrate the desired flow rates were achieved, but it is not necessary for the application.

Table 1 lists the products used in this setup.

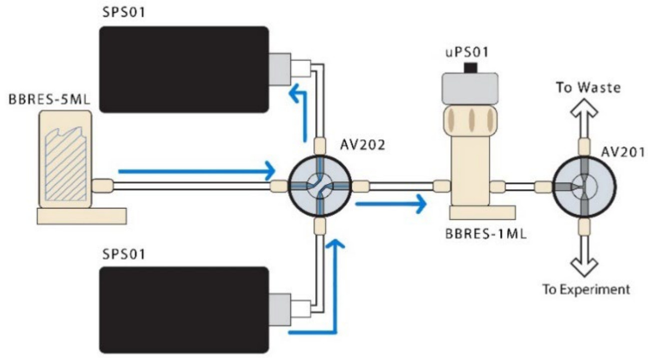

Figure 1. uProcess flow controller setup.

Determining the Correct Pressure

Once the experimental hardware is set up, the pressure required to achieve the desired flow rate can be calculated or easily determined experimentally, as shown in this application.

The two syringe pumps are programmed to alternatively flow at the desired flow rate (one is flowing while the other is filling) until a steady pressure is achieved. This can take up to 30 minutes depending on experimental conditions. Download a sample uProcess script here.

Figure 2 shows the resulting downstream flow rate and reservoir pressure for a set flow rate of 20 ul/min. The pressure and flow rate asymptotically increase until a steady pressure is reached, in this case 42 kPa. Data from the flow-rate sensor verifies that the steady flow rate corresponds to a set flow rate of 20 ul/min.

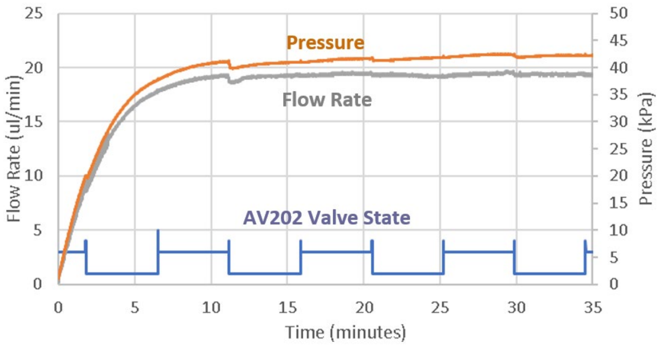

Figure 2. Pressure in the reservoir compared to the output flow. The desired flow rate in this application is 20 µl/min.

Note: experimental changes such as reagent, capillary length, and temperature will change the pressure/flow rate relationship.

Programming Pressure Driven Flow

Once the desired pressure is determined, the hysteresis function in uProcess can be used to create a pressure-driven flow controller with a constant flow rate. The hysteresis function maintains pressure within a set range. If the pressure is below the regulation range, uProcess will regulate up to the higher pressure (pmax) and let the pressure drift down to the lower pressure (pmin). See Figure 3 for a visual explanation.

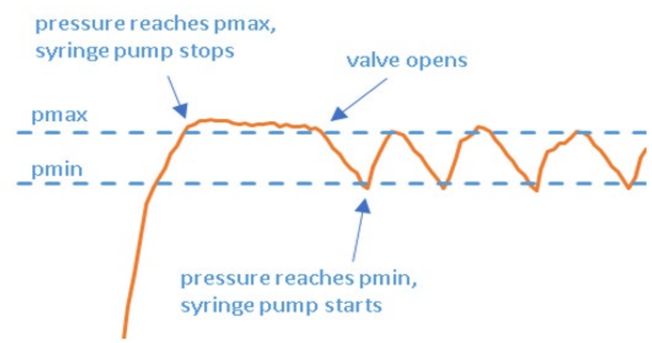

Figure 3. Hysteresis regulation between pmin and pmax

The code snippet shown below regulates between a pressure of 42 and 42.5.

```
pmin = 42
pmax = 42.5
P11111:         HysteresisReg(pmin kPa, pmax kPa,
DChA)
Syringe1:       SetFlowRate(100 ul/min)
Syringe1:       MoveWith(DChA)
```

The chart in Figure 4 shows a log of the pressure and the flow rate using pressure regulation. Download a full sample script here.

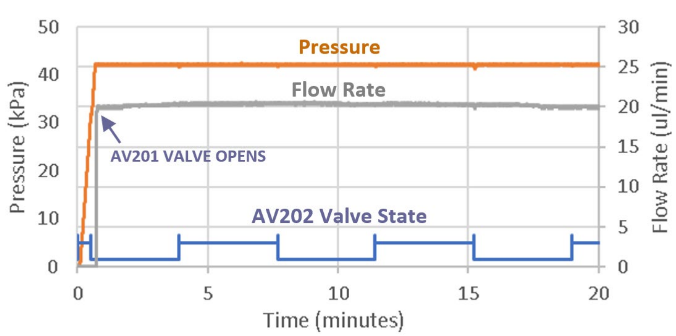

Figure 4. Pressure and flow rate during pressure driven flow

Figure 5 shows the resulting flow-rate profiles for direct SPS01 flow vs the pressure-driven flow in this application. The pulsations observed in the direct (positive displacement) approach are eliminated with the pressure-driven approach.

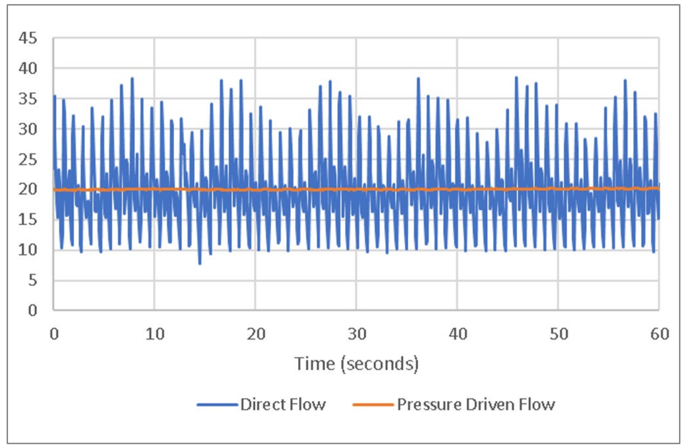

Figure 5. Pressure regulated flow is steadier than direct flow from the syringe pump

TABLE 1. Components used for flow controller

LabSmith P/N*	Description	Qty
uPB-5	uProcess Breadboard	1
EIB200	Electronic Interface Board	1
4VM02	Valve Manifold	1
AV202-C360	Three-position, 4-port automated valve	1
AV201-C360	Three-position, 3-port automated valve	1
4AM01	Pressure Sensor Manifold	1
uPS-800-360	Pressure sensor with 0-800 kPa abs range	1
SPS01-080	Syringe pump (100 µl volume)	2
BBRES-1ML-C360	Breadboard reservoir with cap and O-ring, 1.1 ml volume	1
BBRES-5ML-C360	Breadboard reservoir, 5 ml volume	1
C360-100	One-piece fitting, to connect capillary to syringe pumps, reservoirs, and chip ports	12
C360-101	One-piece plug to plug unused ports	4
BB-Tools	Breadboard hardware and installation tools	1
CAP-150P	PEEK tubing. 360 µm OD, 150 µm ID (1 m)	1-2

* All components listed are also available in 1/32" & 1/16" versions

For more information or pricing please call +1 (925) 292-5161 or email sales@labsmith.com.