Microfluidic pressure-driven flow control

What is microfluidic pressure-driven flow control?

Recently, researchers switched to microfluidic pressure-driven flow control systems because of their unique performances for microfluidic experiments. However, for historical reasons syringe pump were the most used system in microfluidics.

In this application note, you should learn:

- **How pressure-driven flow control works**
- **The advantages / disadvantages of the different technologies**

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Applications

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Starter Pack
Droplet generation Pack

NANOPARTICLES PACKS
Lipid nanoparticle synthesis
Alginate beads generation

BIOLOGY PACKS
Perfusion Pack
Organ-on-a-chip Pack

REVIEWS
General microfluidics
Flow control
Microfluidics for cell biology
Droplet & digital microfluidics
Microfabrication
Organs-on-chip & 3D models

APPLICATION NOTES
Flow control
Droplets & digital microfluidics
Cell culture

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How to perform ultra-precise & responsive pressure-driven flow control?

List of components

OB1 MK3+ flow controller
Sample Falcon reservoirs
Microfluidic flow sensor

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Setup diagram: pressure-driven flow controlled microfluidic system

A pressure driven flow controller is a smart alternative to syringe pump. It allows pulseless flow within subsec response time. It consists in using a gas input pressure within a hermetic liquid tank in order to flow liquid from the tank to your microfluidic device.

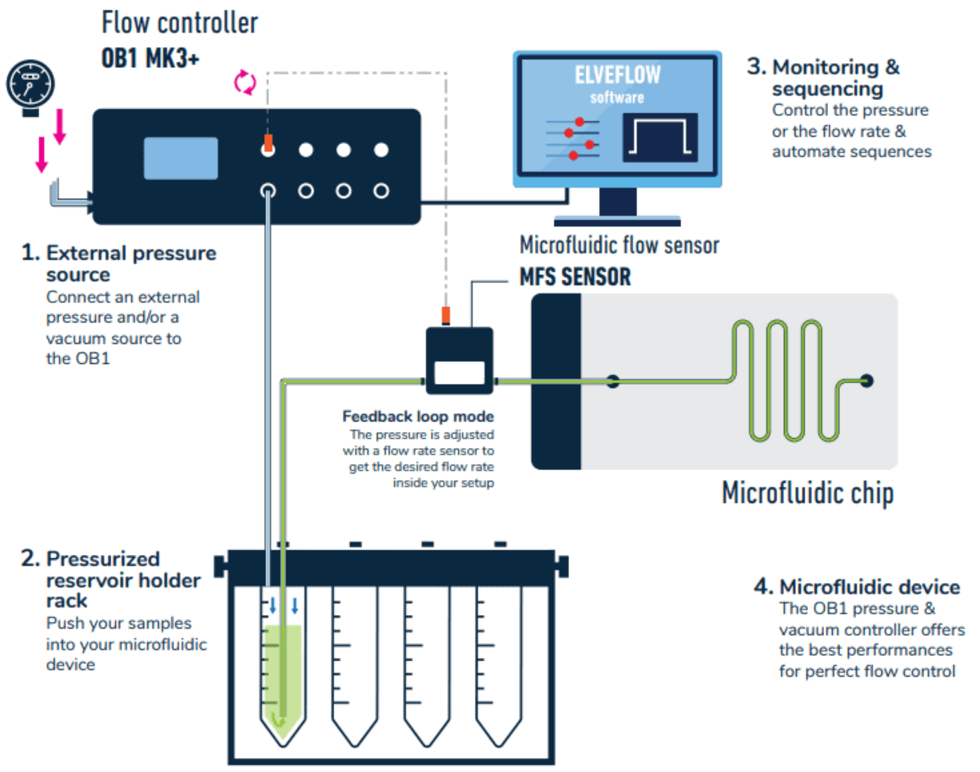

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Figure 3: pressurized reservoir

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Advantages / Weaknesses

Syringe Pump

ADVANTAGES

- Fast setup for fluidic experiments.
- The amount of dispensed liquid can be known for long term experiment.
- Maximum pressure generated by a syringe pump can be of several hundred bars.

WEAKNESSES

- Response time (1.)
- Knowledge of the real time flow rate (2.)
- Limited volume dispensed (3.)
- Pulses (4.)
- Device destruction (5.)
- No pressure measurement (6.)
- Dead-end channels (7.)

Pressure Control

ADVANTAGES

- Fast response time (down to 40ms)
- High stability and pulseless flow
- Possibility to handle fluid volumes of several liters
- Possibility to control fluids in dead-end channels
- Enable both flow and pressure control when used with a flow meter

WEAKNESSES

- 8 bar maximum
- Possible backflows (8.)

Technical comments:

1. Response time can vary from seconds to hours depending on the fluidic resistance and compliance.
2. Without flow meters, users cannot know the real flow rate during the transient period (seconds to hours).
3. The amount of fluid dispensed by the syringe pump is limited in volume.
4. Even pulseless syringe pumps require to carefully choose the syringe size depending on your experimental conditions to avoid periodic pulsations on the flow rate due to the step-by-step motor of the syringe pump.
5. If channels are clogging (due to dust for example) the pressure increases without limit and can lead to device destruction.
6. Knowing the pressure inside the fluidic system requires a pressure sensor.
7. Flow control of fluids in dead-end channels (like integrated valves) is impossible using syringe pumps.
8. When pressure is unbalanced, it is possible to have backflows, when doing flow switches with multiple inputs (association with valves is required to solve that problem).

Performance: response time & stability

The main advantage of syringe pumps is that they are easy to use, and but they present slow response time when setting a new flow rate and flow oscillations due to motor steps.

Flow changes inside chips can take seconds to hours (see the tutorial on syringe pump responsiveness in microfluidics). This lack of reactivity is one of the main limitations of syringe pumps for numerous applications notably for droplet-based microfluidics as described in this short video:

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