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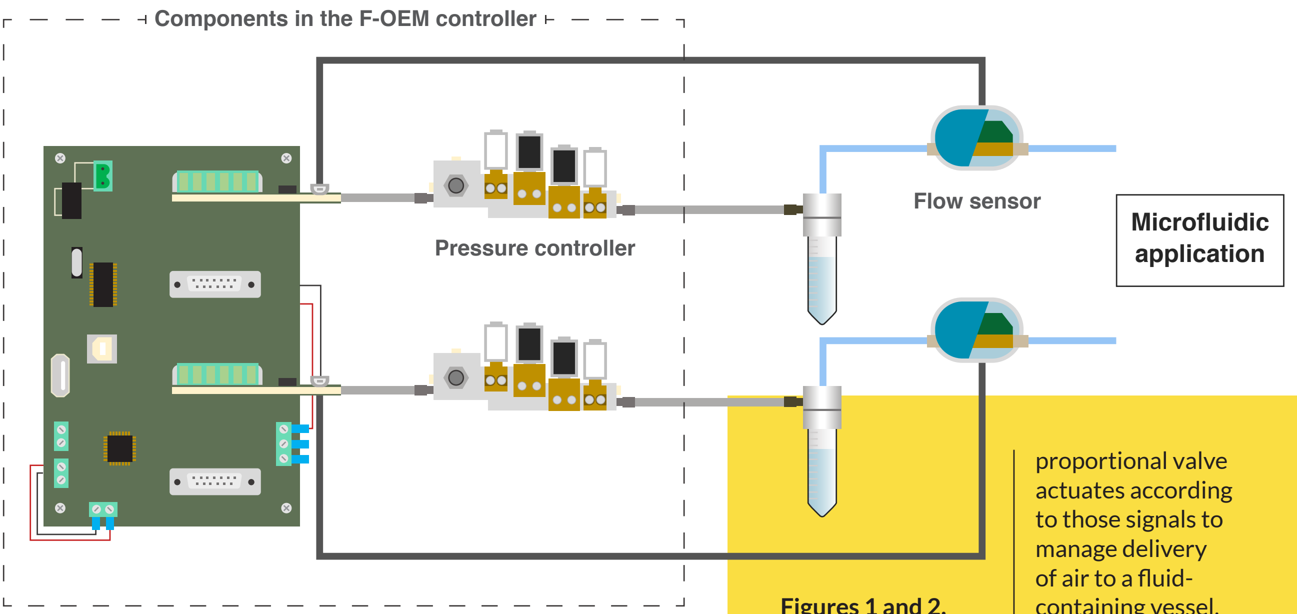
FLUIGENT MICROFLUIDIC PRESSURE-BASED FLOW CONTROLLER INCORPORATES EMERSON CUSTOM ENGINEERED VALVE MANIFOLD

Thanks to microfluidic technology, researchers and industrials from medical, biochemical and pharmaceutical domains are able to replicate, automate and miniaturize a growing number of complex laboratory, organ and/ cellular functions with amazing accuracy.



Microfluidics is the science of handling and controlling fluids in the microliter (10^{-6}) to picoliter (10^{-12}) range. It is a very attractive technology because, compared to traditional industrial methods, it enables everything from small-scale experiments to industrial-scale production to proceed using exceptionally small sample/reaction volumes. Thus, it dramatically decreases the consumption and cost of samples and reagents, shortens experiment times, and reduces the overall cost of experiments and applications. Further, the use of microfluidic technology typically improves experimental accuracy, lowers the limits of detection, and enables multiple analyses and experiments to proceed simultaneously.

One common application of microfluidics is to recreate intracellular processes within sub-millimeter fluid channels on specially designed chips. The success of such "lab on a chip" or "organ on a chip" technology relies not only on replicating the direction and path of fluid flows within the micro-channels on a chip, but also on the ability to deliver extremely small volumes of fluid (such as sub-milliliter-range droplets) through those channels at very precise flow rates.

To date, there have been several ways to deliver these micro-sized fluid flows, including mechanically driven peristaltic and syringe pumps. Peristaltic pumps move fluids

Figures 1 and 2. Within Fluigent's F-OEM microfluidic flow and pressure controller, an algorithm delivers control signals to a pneumatic control manifold engineered by Emerson. An ASCO 202 Preciflow proportional valve actuates according to those signals to manage delivery of air to a fluid-containing vessel, resulting in a precise microflow to the application. Flow sensors detect and measure the microflow, providing feedback to the control. Images courtesy of Emerson and Fluigent.

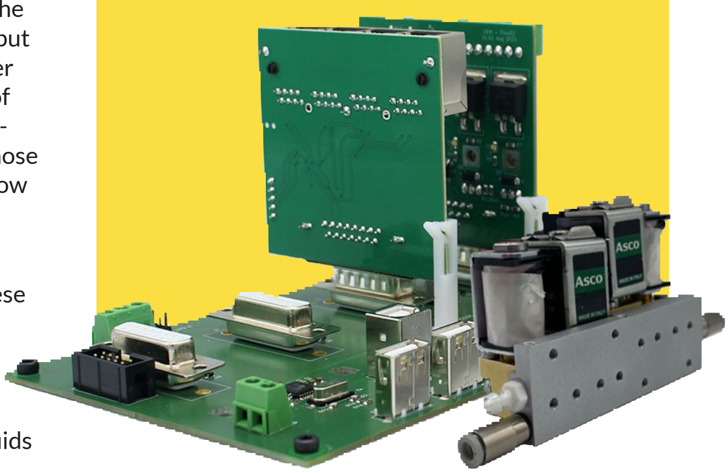


Chart: Pressure-based Microfluidic Flow Controllers

Benefits	Limitations
Pulse free flow control — zero oscillation	Higher initial cost
Combines pressure and flow-rate control	Microfluidic pressures are limited to ≤8 bars
High flow stability: 0.005%	
Enables exact pressure determination within the microfluidic component	

by using a rotor that gently compresses a tube containing the fluid, producing a regular "pulse" of fluid flow that varies based on the internal volume of the tubing, the number of rollers on the rotor, and the rotor's rotational speed. Syringe pumps use a motorized screw mechanism to move a syringe piston that provides precise fluid flows, much like a syringe used for injecting medications.

A newer, third microfluidic pumping technology is the pressure-based microfluidic flow controller. Instead of driving fluid mechanically with a rotor or piston, pressure-based flow controllers regulate flow by varying the pneumatic pressure (or vacuum) exerted within a reservoir containing a fluid. Extremely small variances in air pressure within the vessel move precise amounts of fluid within the microfluidic system.

Fluigent, a leading developer of pressure-based microfluidics, delivers this technology in its patented F-OEM modular pressure and flow-control platform, which is capable of dispensing micro fluid volumes or continuous microflow rates with exceptional accuracy. The brains of the platform are found in a proprietary Fluigent algorithm that calculates how tiny adjustments in pneumatic air pressure or vacuum in a fluid vessel translate into precise microflows of a liquid to or from a system.

Fluigent's F-OEM platform has been adopted readily into devices dedicated to liquid chromatography, digital polymerase chain reaction (dPCR), single cell analysis, and many other applications. This pressure and flow-control platform relies in part on a pneumatic valve manifold, rapidly engineered by Emerson (see Figure 1). The valve manifold encloses an ASCO 202 Preciflow™ proportional valve with an orifice size of just 200µm (0.2 mm) to manage airflow and pressure into the fluid reservoir (see Figure 2).

Designed to provide high reliability with low hysteresis, this valve offers extremely fine control of actuation. Driven by the proprietary control algorithm in the Fluigent F-OEM platform, the valve can regulate air pressure within a fluid-containing vessel with exceptional precision — and without the risk of contamination. This is because the liquid itself never actually touches the interior of the valve or control.

Instead, the ASCO manifold and valve manage a stream of air, regulated by the Fluigent algorithm, that exerts pneumatic force on the liquid in the vessel. Minute changes in the pressure or vacuum of the air stream translate into minute changes in fluid flow into or from the vessel. Actual flow rates will vary based on the characteristics of the flow path and the fluid being used.

Each fluid or reagent used in a microfluidic system requires its own microfluidic pump. In operation, low-pressure air is supplied to the inlet of the F-OEM pressure/flow controller. Inside the controller, the air flows through an ASCO-designed manifold including the ASCO 202 Preciflow proportional valve. The valve is actuated using 0-24V signals on closed-loop control circuit. To support the precision of the Fluigent control algorithm, voltage resolution used for valve actuation is based on a very fine degree of valve actuation control (equivalent of 0.00037 V per step).

Microflow pumps like the F-OEM can operate on a range of input air pressures, ranging from -0.8bar to 7 bar, depending on application requirements. Variances in input air pressure affect the flow rate through the Preciflow valve and, ultimately the rate of fluid flow in the microfluidic system. For example, when supplied with air at 1 bar of pressure, the valve flow rate is 0.8L/minute, with accuracy of 12 µl/minute. A well-tuned, pressure-based Fluigent microflow pump, utilizing the F-OEM pressure and flow controller equipped with the ASCO 202 valve, can deliver liquid flow rates as low as approximately 1 nanoliter (one billionth of a liter), per minute.

Compared to peristaltic pumps, pressure-based flow-control devices like the Fluigent F-OEM platform can offer more precise, continuous and stable microflows, without the pulses or oscillations in flow rate that might damage or disrupt fragile cells. Like syringe pumps, pressure-based microfluidic pumps can also deliver precise fluid volumes with exceptional accuracy. But unlike syringe pumps, they can also operate continuously and thus can handle the greater, continuous fluid volumes typical of larger experiments or production operations.

For research and industrial applications that require microfluidic flows with high stability, high response time and excellent pressure control, pressure-based microfluidic pumps represent a new step forward. Their remarkable precision and consistency are already opening the way to new discoveries and therapeutic advances in medicine, biochemistry, and pharmaceutical development.

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Figure 3. An ASCO 202 Preciflow proportional valve, equipped with an orifice size of just 200µm (0.2 mm), offers the precise actuation required to manage minute changes in airflow and pressure essential to accurate microfluidic delivery. The valve is part of a larger manifold engineered by Emerson. Photo courtesy of Emerson.