Using a Configurable Digital Process Controller to Manage Multiple Pressure, Flow, and Process Parameters in Microfluidic Applications

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Introduction

New microfluidic instruments, "lab on a chip" systems for separation and detection, micro-reactors, micro-mixers, and analytical detection tools take many years and millions of dollars for companies to develop. This is partly due to the limited availability of prototype, development, and automation tools, as well as the costly and time-consuming requirements to build product support systems from the ground up.

Instrument developers can greatly reduce the method and target product development time for their products by partnering with vendors for integrated fluidic control components, such as analytically clean proportional valves, pressure controllers, sensors, fittings, tubing, and manifolds Using a fluidic solution that is already sourced, developed, and validated, allows engineers, chemists, and researchers to focus on their core strengths and move the final product to market faster.

This paper describes a recently patented, multi-channel Microfluidic Process Controller (MPC) that incorporates a newly invented pressure, flow, and process control device and effectively acts as a configurable host controller in a variety of analytical instrumentation. This invention integrates multiple channels of closed loop pressure or flow control with additional digital and analog inputs and outputs, allowing the user to ideally configure the unit for specific applications.

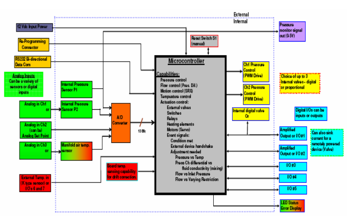
Conventional pressure or flow controllers exhibit a variety of drawbacks. One drawback is that these devices are generally "dumb," void of any decision-making capability. For example, a user can set a conventional device to a certain pressure or flow rate, but no other parameters can be specified and/or controlled. A second drawback is the requirement of one or more additional devices to monitor conditions and generate a control signal, triggering a function and/ or operation performed by another device. A final drawback with conventional controllers is their difficulty working with multiple sensors. Custom electronics are generally needed for each sensor to properly communicate with the controllers, and access is not guaranteed to all process parameters. Users can become frustrated with the inability to remotely view parameters over computers networks such as the internet.

The MPC overcomes the conventional pitfalls by providing users with decision-making capability and allowing them to develop and control the pressure- or flow-dependant process parameters of their application. This enables designers to create and protect the intellectual property around their invention, process, or application. The MPC can be configured as an autonomous independent host controller, taking over most or all control functions of a process or it can be configured as a slave to a master controller, such as a laptop computer or PDA using various commercially available control software.

This new approach to pressure or flow control can be broadly applied to any separation, detection, or process application.

MPC Architecture

In a compact analytically clean package, the MPC integrates a microcontroller, 3 pneumatic valves (proportional and/or digital), 2 pressure sensors, and 2 temperature sensors on a pneumatic manifold with bubble tight connections. Digital and proportional connectivity allows for external feedback and control of sensors, lasers, pumps, valves, ovens, actuators, detectors, etc. Base configuration programming includes pre-programmed 15 psig and 100 psig pressure channels.



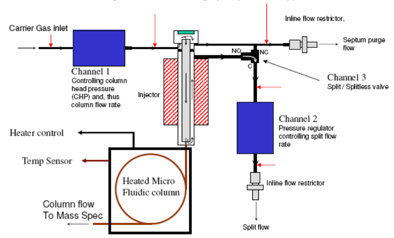
MPC Features

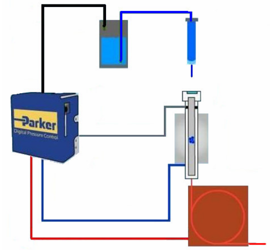
The MPC offers the highest level of system control for gas and liquid pressure and flow control applications available on the market. With pressure control up to 150 psig (10 Bar) and resolutions up to 0.0001 psig, this unique product combines the features of digital pressure or flow controllers with the decision-making capability of a Programmable Logic Controller (PLC). Its stand-alone ability to monitor key process parameters from either internal or external transducers and close-loop control multiple pressure channels allows it to function independent of a host controller. This permits the MPC to completely manage the electronic and fluidic sides of an application, enabling scientists to focus on their core detection competencies.

Application Example 1: Gas Chromatography

A portable GC manufacturer involved in chemical/biological warfare detection needed to automate its manual GC for ease of use by military personnel in field conditions. It had budgeted 4 people and 18 months for the feasibility, development, qualification and validation of an automated fluidic control system. After investigating the MPC and implementing the controller in its GC instruments, the manufacturer was able to **reduce its development time from 18 months to 12 weeks and decrease the Bill of Material content and its Supplier base to less than 20% of what was initially required.**

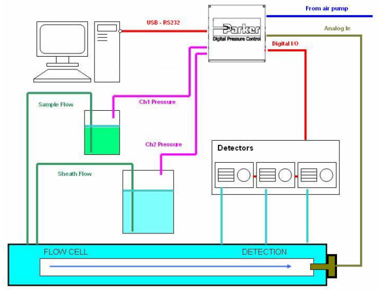
Functional diagram Gas Chromatograph Split mode application.





Application Example 2: Flow Cytometry

A typical Flow Cytometer uses two channels of gas pressure control to drive fluids through a flow cell. Pressure Channel 1 drives the sample flow, while Channel 2 drives the sheath flow at a slightly higher pressure. Extremely accurate and stable pressure control is required to achieve the desired flow rates for repeatable and predictable cell separation. Users can employ software controls to maintain fixed settings for each pressure channel or program a master-slave relationship to ensure a correct and consistent pressure differential. The MPC offers the ability to store unique pressure settings for different flow rates and sample/sheath fluid combinations, enabling the processing of different samples. External system requirements such as diode lasers, ultrasonic devices, pumps, level sensors and valves for filling or draining of reservoirs can also be actuated or monitored by the MPC.



Conclusion

Today's Life Sciences instrumentation developers must have expertise in fluidic systems, electronics (including controls circuit design through PC board layout), software, and mechanical engineering in addition to the core chemistry requirements. Developers trying to "do it all" in-house often find themselves over budget and delayed in their development cycle. When the instrumentation calls for pressure or flow control, developers have a new solution to meet their critical needs. The patented Microfluidic Process Controller, compact in size, ideal for miniature instruments, offers power and reliability unavailable in a controller until now. Using the MPC, companies can remain focused on their expertise and ensure product integration and fluidic control, while greatly reducing business risks and time to market.

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