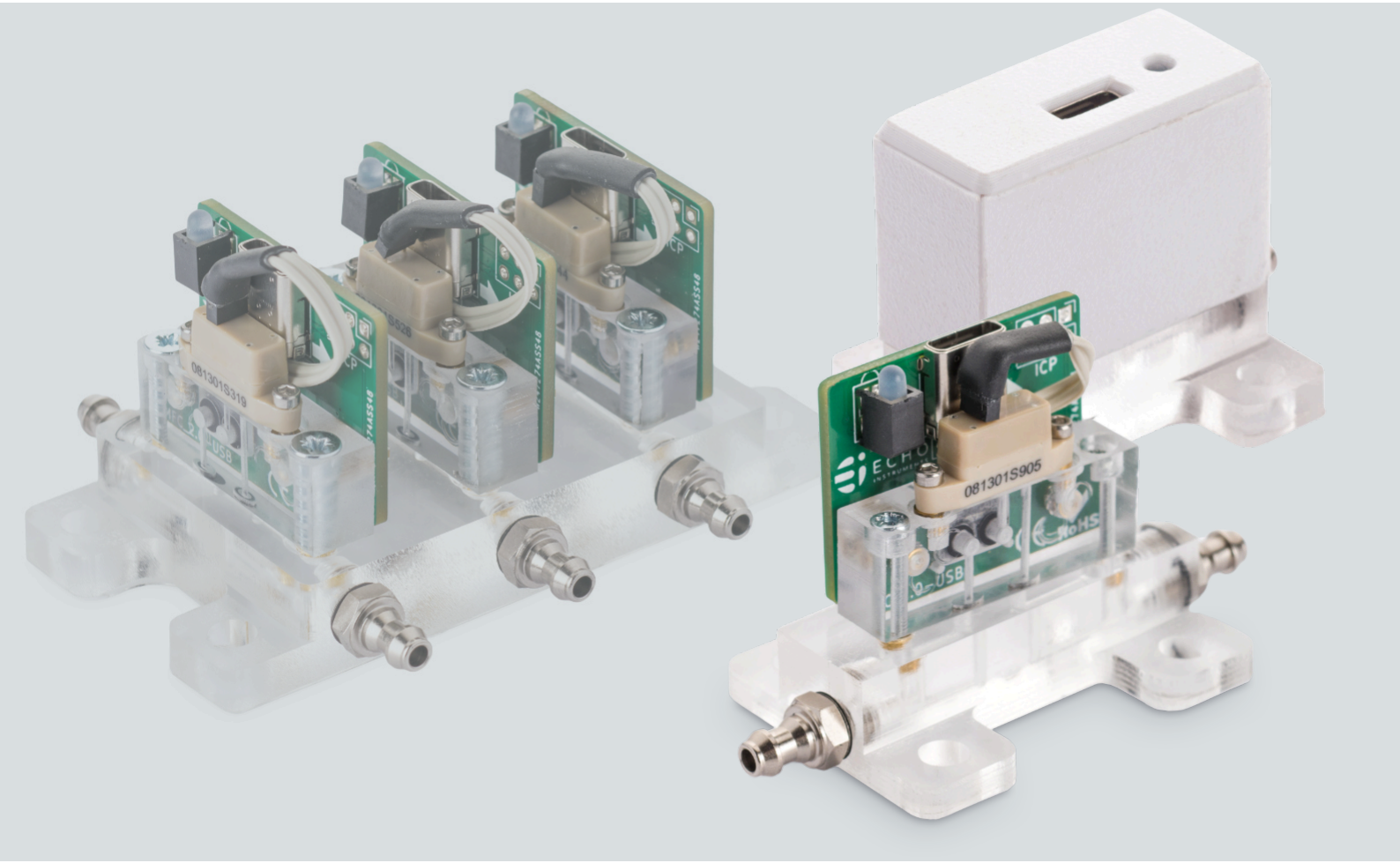
Gas Analysis

memetis Valve Use Case

Smallest Mass Flow Controller for Precise Gas Quantification



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ECHO INSTRUMENTS

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Introduction

This memetis Valve Use Case describes design of the Mass Flow Controller (MFC) EMF 100 built by ECHO Instruments. The purpose of creating the MFC was to enable multiple plastic biodegradability measurements in a compact space with flow ranges up to 100 sml/min. Having done this, ECHO Instruments can build respirometers with smaller control units, while reducing production costs and becoming independent from external mass flow control device suppliers.

Measuring Biodegradability

Assessment of biodegradability is a key part of certifying eco-friendly plastic polymers that can replace those plastic materials which cause harm to wildlife and human health due to very slow natural degradability.

When plastic disintegrates in the presence of air, the biochemical break-down process produces water, heat and CO_2. A reliable way to determine the speed of biodegradation is to measure CO_2 production in a closed aerobic system with a known initial amount of test material.

As the produced CO_2 is calculated from two variables - gas flow and gas concentration - both of these must be precisely measured to accurately quantify CO_2 production. A common approach is to make the gas flow rate constant during each gas concentration measurement. This can be done with the use of a mass flow control mechanism.

ECHO Instruments in Slovenia have been building respirometers, gas mixers and analyzers for 30 years, and recently have built their own mass flow controller to keep gas flow rate constant during their gas concentration measurements.

Mass Flow Controller Design

Working Principle

ECHO's MFCs are used to keep a steady gas flow supply to the part of the instrument that measures gas concentration. This means that the gas flow rate at the inlet of the MFC which comes from the air pump/supply is adjusted within the MFC device to match the desired gas flow rate at the outlet, even if the input flow rate fluctuates. The required flow rate set for the outlet of the MFC is called the setpoint value.

In the case of MFC EMF 100 by ECHO (see figure 1), once gas from a sample enters the MFC it first reaches the differential pressure flow sensor where the input flow is measured. Next, this flow value is compared to the setpoint value and control electronics determine the right amount of current that needs to be applied to a control valve that will adjust the input flow rate to the desired output flow rate. If the flow sensor detects that the input flow during the measurement is increasing, the current supply to the valve will be reduced and the valve will reduce flow to match the setpoint by closing slightly and reducing the cross section of the flow path inside the valve. If the opposite happens and input flow rate is decreasing, more current will be applied to the valve and it will again adjust the input flow to keep the needed output flow constant by, in this case, increasing the cross section of the flow path.

The flow sensor, the control electronics and control valve together form a closed feedback loop (orange arrows in Fig. 1) for executing the mass flow control function. The control loop is active and the valve is powered for as long as the gas concentration measurement takes place.

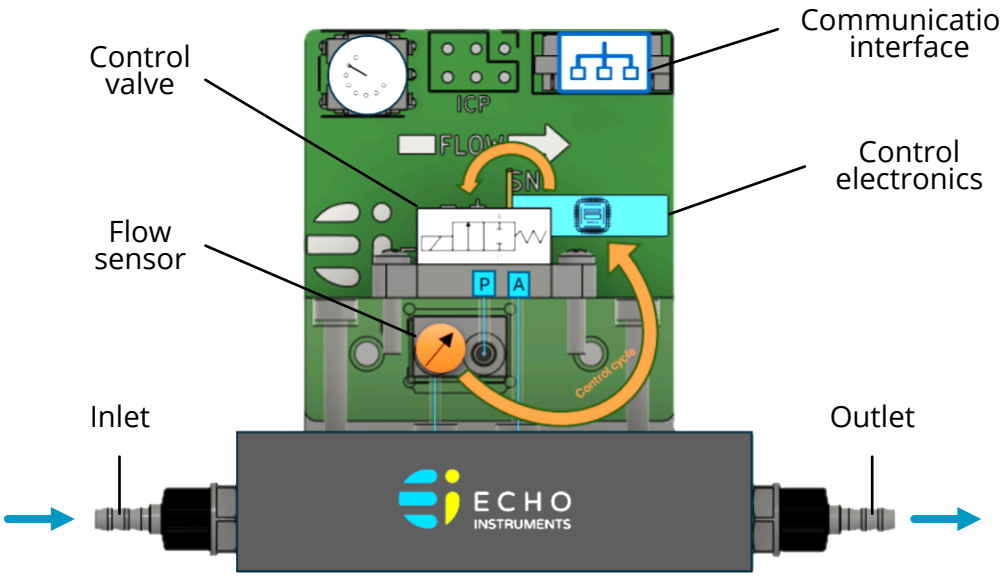

Fig. 1: Mass Flow Controller EMF 100_RS-485 working principle scheme: Blue arrows indicate the flow direction, while the orange arrows show the closed-loop control path. Communication interface consists of a modbus slave integration with RS-485 interface and a rotary "address" switch (top left corner).

Flow Control Execution to Keep the Dimensions Small

To keep the mass flow control system as small as possible, ECHO Instruments looked for control loop components that excel in compactness. Choosing the smallest proportional control valve on the market was the key to reducing the size of the device. Usually, the valve takes the biggest space inside the device and flow sensors are very small in comparison.

memetis shape memory alloy (SMA) valves are the smallest valves available with the proportional control capacity. This functionality is packed within 5 mm width, 12 mm height and 20 mm length (see fig. 2) and requires a closed loop system which is naturally the case in mass flow controllers.

Thanks to using the memetis SMA proportional control valve Classic variant, ECHO could design their MFC with less than 13 mm width, 40 mm height and 66 mm length (fig. 3). Furthermore, the dimensions can be reduced even more if needed!

Fig. 2: memetis proportional control 2/2-way seat valve normally-closed Classic variant.

The small device dimensions is a distinguishing factor for the MFC series by ECHO Instruments. In fact, the MFC EMF 100_USB is the smallest MFC device on the market at the time of writing this case study in August 2024.

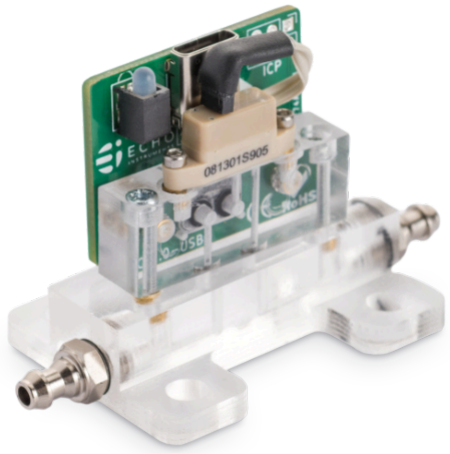

Fig. 3: Mass Flow Controller EMF 100_USB with USB-C interface.

MFC EMF 100 Specifications

- Flow range: 0 - 100 sml/min
- Flow sensor principle: differential pressure sensor
- Valve functionality: proportional control 2/2-way seat valve normally-closed (NC)
- Accuracy: < 0.75 % full-scale
- Repeatability: 0.2 % full-scale
- Response time: < 1 s
- Connectivity: RS-485 (single or array) or USB C (single-unit)
- Applicable gases: Air, O2, N2, CO2, Ar, etc. Other gases and mixtures on demand

ECHO Instruments have 30 years of experience building respirometers, gas mixers and analyzers for a wide range of applications. They make devices for both OEM and stand-alone use and serve industries ranging from medical and pharmaceutical to industrial and environmental.

memetis are experts in shape memory alloy actuation and supply miniature valves and integrated fluid control systems. The innovative technology ensures reduced device size, reduced power consumption and proportional control capability utilized in life science, fluid analysis and space applications where miniaturization is crucial.

Fig. 4: ECHO XC 6 Channel Respirometer with an XC Controller containing 7 units of MFC EMF 100 attached on the right side for analyzing CO_2 production in 2 samples simultaneously.

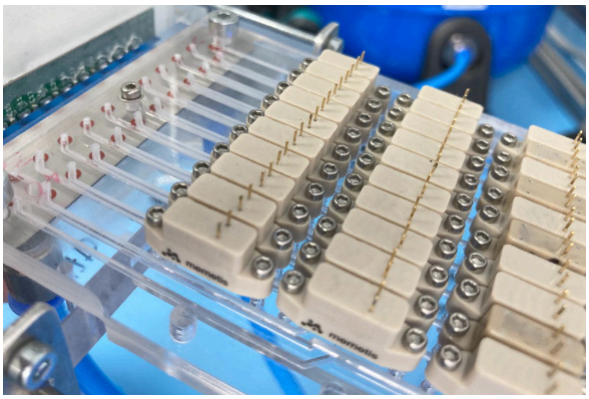

Fig. 5: memetis miniature valves integrated on a 30-valve manifold.

Further Information

For more details and further questions please feel free to get in touch!

Website	Website
MFC info sheet	Webshop
Contact email	Contact email