microComponents

TechNote

Working at low flowrates with the micropumps

This technical Note covers procedures and hints to achieve low flowrates with the Bartels micropumps. Here only liquid applications are covered, and as the mp6 micropump works more reliable and reproducable for low flow rates the text mainly covers this unit. Generally, flow rates down to about 20 µl/min can be achieved in most applications. With thorough optimization of all system components flows in the nanoliter per minute range have been addressed as well. As the exaxt performance strongly depends on the individual conditions and properties of the liquid, this document only presents general guidelines that need to be tailored to the individual conditions.

1.1 General hints

Besides the pump itself, to successfully address low flow rates often environmental conditions and peripheric components are found more critical for the overall performance than the pump itself. The following points should be addressed:

- The pump is not actively closed in the off state, therefore pressure differences should be avoided. A static pressure from the outlet side can be compensated in most cases by using our mp-cv check valve
- Pressure differences influence the flow rate due to the pump principle. Therefore height differences or other causes of pressure should be avoided between in- and outlet of the pump. With the mp6 per 10 mbar pressure difference (approx. 10 cm of height), the flow will change about 0,1 ml/min.
- Although temperature changes also have an influence on the pump, it also changes fluid viscosity which again causes flow variation. This should be noted during system design.

- Often the generation of droplets at the outlet are the limit for low or even almost constant flow rates
- If over time the reservoir looses a significant amount of volume, backpressure due to collapsing of the reservoir should be considered. The reservoir should be vented with a passive valve if possible. The same goes for the filling height of the reservoir, so reservoirs with a large footprint should be preferred.
- While decreasing flow rate, the voltage should be kept as high as possible to ensure stable pump performance. Only when the frequency cannot be further decreased, the voltage should be lowered further.

1.2 Flow rates down to about 1 ml/min

Flow rates that are above 1 ml/min can be achieved using the standard parameters with the mp-x and the mp6-OEM. With an amplitude of 100V and a Frequency of 25 Hz, the mp6-OEM delivers about 1,1ml/min. For the mp-x the frequency should be further decreased and combined with a larger amplitude as mentioned in the general hints.

1.3 Flow rates down to about 20 µl/min

With both mp-x controller and the mp6-OEM this flow range can be addressed. For the mp-x using the standard tubing, a parameter set of 25 V amplitude and 4 Hz frequency will result in a flow rate of about 20 µl/min with water.
Although the mp6-OEM is only specified to work down to a frequency of about 25 Hz, the working frequency can be further decreased. In this case the stability of the pump performance needs to be observed during the experiments. As the amplitude of the mp6-OEM can not be decreased below 100V, to achieve flow rates in the order of 20 µl/min, the pump frequency needs to be in the range of 1 Hz (corresponding to a clock signal of 4 Hz for the mp6-OEM).

1.4 Flow rates below 20 µl/min

To achieve flow rates below 20 µl/min basically two approaches can be used

Intermittent operation of the mp6-OEM

This operation mode can be compared to the Pulse Width Modulation used commonly in electronics. The mp6 is driven periodically in a certain on / off cycle at a higher flow level and therefore achieves a lower mean value of the flow over time. This method has the advantage that during the "on" state, the pump works quite powerful and can therefore handle gas bubbles or liquids that are difficult to transport more reliably. The disadvantage is, that the flow exhibits a stronger pulsation / variation over time.

Implementation of an additional flow restrictor

By using an orifice or flow restrictor that significantly decreases the diameter of the fluid path, the flowrate can be limited. As these flows are hard to estimate on a theoretical basis, it is necessary to do an experimental determination of the necessary restrictor size in most cases. Typical restrictors in the range of 300 µm down to a few 10 µm in diameter are used. Advantages are the very constant flows over time. Disadvantages come into play if particles larger than the orifice diameter are present as they might lead to clogging. In these cases multiple orifices can be an option for example. For suppliers of precision restrictors or an offer for customized designs feasible to mass fabrication, please contact us.

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