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TechNote

How to combine multiple pumps to increase flow or pressure performance

The flow and pressure performance of the micropump mp6 is limited to the performance of the controller that powers the pump. With the mp-x controller (250 Vpp, SRS signal) these values are possible:

Gases with mp6-AIR:	20 ml/min (300 Hz) and 100 mbar (300 Hz)
Water with mp6:	7 ml/min (100 Hz) and 600 mbar (100 Hz)

Applications requiring higher performance parameters can in general be accessed by combining multiple pumps together. The achievable effects are similar to how resistors behave in circuitry when connected in series or parallel. So summing it up in short, depending on the fluidic connection the flow or pressure performance is adding up. Here the example for liquid:

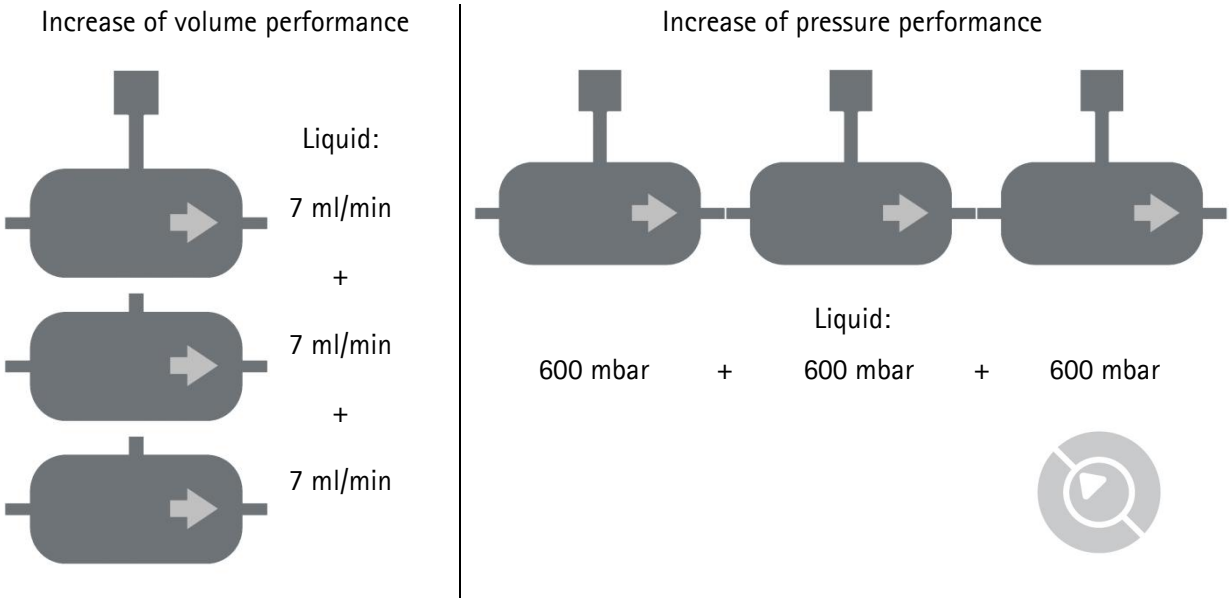

Figure 1 Combination methods of pumps.

For aqueous applications this means, by combining pumps in parallel connection the flow rate can be increased by approximately 7 ml/min for each pump added. With this method the flow rate will increase and the pressure remains unchanged.

When combining pumps in a serial connection the flow rate is not changed, but the pressures add up. This effect lowers for additional pumps. Combinations with more than 3 pumps are not advised. Pressure conditions of the application, i.e. external input or backpressure, has to be taken into account. The

reasonable maximal pressure the last pump in such a series can work is around ~1.5 bar. This means that once one pump (or one actuator inside a pump) is under ~1.5 bar it cannot add any more pressure.

Examples:

1) Pumps should generate liquid pressure out of an open reservoir. The input pressure will be environmental pressure, i.e. ~1 bar. Now with three pumps in serial connection it is possible to generate ~1.5 bar of liquid pressure.

2) Pumps should fill a closed reservoir that stands under a pressure of 0.5 bar. With three pumps in a serial connection the reservoir pressure can be raised to ~1.5 bar. The initial backpressure can be seen as a pressure load the pumps have to overcome before more pressure is brought into the reservoir.

3) Pumps should get liquid out of a closed reservoir that is connected to an underpressure of 0.5 bar. Again this pressure, a negative input pressure, is a load to the pumps. The pumps have to overcome this before generating pressure – in this case an underpressure at the inlet of the first pump. Mathematically, with three pumps this would be ~1.5 bar – 0.5 bar = ~1 bar underpressure, but this would be complete vacuum and is not possible to achieve in this way.

   With underpressure applications, the suction pressures of the pumps don't add up as nicely as in forward pressure. Therefore in these cases the pumps add only a fraction of their pressure. It has to be tested with the flow rate to maintain what final pressure can be achieved.

The combination methods are the same when pumping gases with the mp6-AIR. If gases should be pumped it is better to use higher frequencies, see the "ApplicationNote – Air" for more detailed information. Due to the power limitations of the controllers we specify the mp6-AIR with 300 Hz and amplitude of 250 Vpp on the mp-x. However, it is also possible to drive the mp6-AIR with the mp6-OEM controller. The controllers of the mp6-Quad series are especially designed to control the mp6-AIR as frequencies up to 800 Hz are possible and up to four pumps can be powered.

Below you will find the air pressure date of combined pumps for these different controllers.

For performance improvement through multiple pumps, please keep in mind the diameter of the tubing suitable for the desired flow, otherwise the advantages gained through multiple pumps are lost to the flow friction of the tubes. Additionally the tubing connectors for stacking pumps in series should be as short as possible to reduce performance loss. And furthermore the tubings have to be very tight on the tubing connectors to prevent pressure loss, we recommend using a ferrule on the tubing to ensure a tight fit to the tubing connector of the pump.

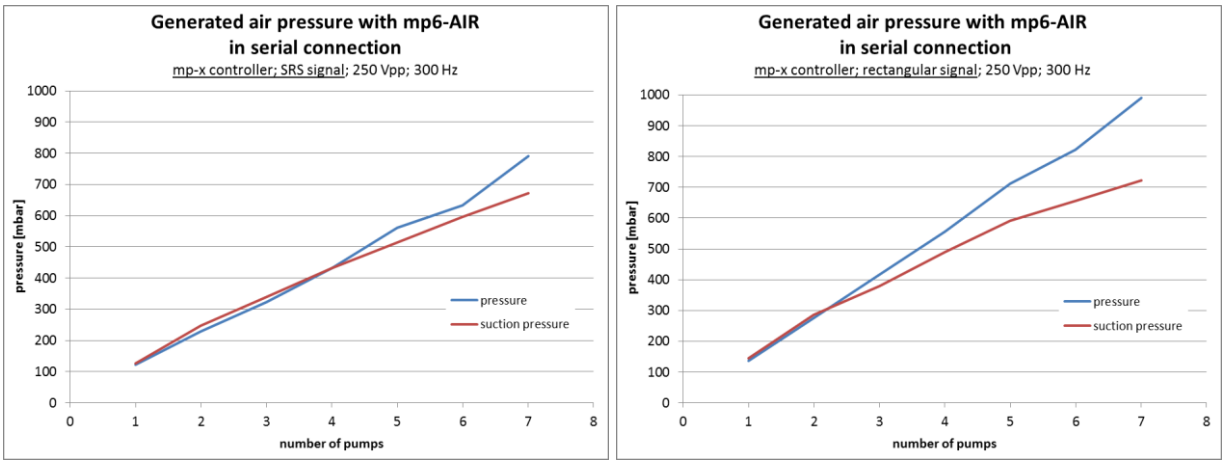

Figure 2 Generated forward and suction air pressure of mp6-AIR with the mp-x controller.

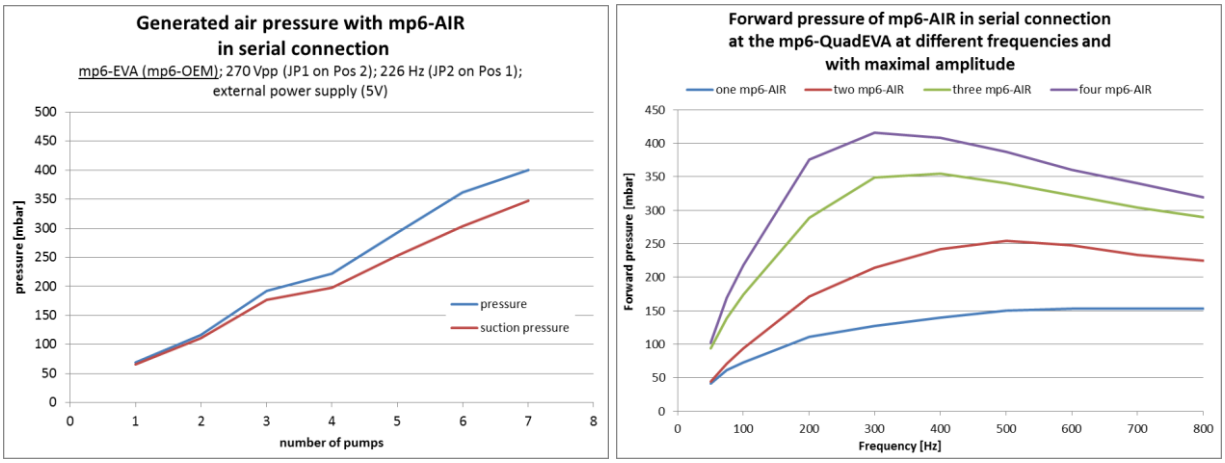

Figure 3 Left side: Generated for forward and suction air pressure of mp6-AIR with the mp6-EVA (mp6-OEM) controller.
Right side: Generated forward air pressure of up to four mp6-AIR pumps with the mp6-QuadEVA controller.

For applications requiring even higher flow or pressure performance the piezo micropump can also be customized. Due to the simple design, pumps can be scaled in terms of flow rate and pressure performance. The flow rate scales approximately by the power of two with the piezo diameter. Higher pressures require stronger actuators. If flow rate is allowed to be smaller than the regular pump, a smaller actuator will also grant more pressure due to its stiffness. Improvement of the compression rate can be achieved by redesign of the overall fluidic design and the pump chamber. Due to required development time and costs this approach is advisable for quantities above 10k pieces per year.

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