Operating Manual
for
Micropump mp6/mp6-pp
and Controller

Content

1   General

This operating manual contains all necessary instructions for the installation, commissioning, operation and maintenance of the mp6 and mp6-pp micropump and of the controller mp-x, mp6-OEM and mp6-EVA with the mp6/mp6-AIR/mp6-pp. The manual is intended to help you achieving optimal results with the micropumps and the controllers in a short time and shall also assist avoiding possible sources of errors.

The products have been designed with state-of-the-art technology and in accordance with all relevant safety regulations. However, a risk of damage to the units, other property, the operator and/or other persons cannot be fully excluded.

Always ensure that specialized and trained personnel will comply with the following general instructions:

- Before working with a pump, you must be fully familiar with its operation and functions.
- Prior to operating the pump, read this operating manual and adhere to all instructions.
- Refrain from any operations that might endanger the safety of the product.
- Do not leave the products in operation unattended or without proper safety measures.

Therefore, please keep this manual and hand out copies as required.

Bartels Mikrotechnik GmbH rejects any responsibility for damages to persons or property resulting from non-compliance with the instructions in this manual. In this case all warranties shall be void.

1.1   Declaration of conformity

Bartels Mikrotechnik GmbH is certified according to DIN EN ISO 9001:2000 and declares that the products are compliant to the RoHS directive and the controller comply with the requirements of EMC 89/336/EEC and CE markings have been affixed to the devices.

1.2   Description of functions

The micropumps have been developed for the transport of gases or liquids. The mp-x controller, the mp6-a controller, mp6-OEM and mp6-EVA controller have been developed for operating one mp6, one mp6-AIR or one mp6-pp. Bartels Mikrotechnik can assume no liability for damages resulting from the pump media. This applies especially for hazardous fluids.

The pumps must be operated with Bartels Mikrotechnik electronics. Bartels Mikrotechnik GmbH cannot guarantee the proper work of the units with customer specific electronics. If other controllers than the ones from Bartels Mikrotechnik are used, Bartels Mikrotechnik disclaims any warranty.

Bartels mikrotechnik

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Please make sure that only skilled personnel works with the pump control and micropump. The micropump shall be under constant supervision at running conditions. **Moreover, please note that components of the controller and pump are operating with high-voltage.** Therefore, persons wearing pacemakers are recommended to avoid the operating system.

Bartels Mikrotechnik assumes no liability for abnormal handling, improper or negligent use of the micropump and the controller that is not conform to the specified purpose of the system. This applies especially for micropump controllers, components and systems of other manufacturers, which have not been certified by Bartels Mikrotechnik.

We guarantee that the micropumps comply with the actual state of scientific and technical knowledge and due to this, the operational risks are limited to a minimum.

Do not open the housing of the micropump and the controllers. In those cases, Bartels Mikrotechnik cannot issue a guaranty anymore. Please keep this manual safe and give a copy to all users.

2 Proper use

2.1 Intended purpose

The micropump is intended for pumping liquids or gases with varying flow rates controlled by the electronics. The mp-x, the mp6-a, mp6-OEM and mp6-EVA controllers are intended for operating one mp6 or one mp6-pp. Any other use of the micropump or controller unit is deemed improper.

Do not make any modifications or extensions to the pump or controller without the prior written consent of the manufacturer. Such modifications may impair the safety of the unit and are prohibited! Bartels Mikrotechnik GmbH rejects any responsibility for damage to the unit caused by unauthorized modifications to the pump and risk and liability are automatically transferred to the operator.

2.2 Misuse

The use of liquids, which may alone or in combination create explosive or otherwise health-endangering conditions (including vapors) is not permitted.

2.3 Staff selection and qualification

All work in connection with the installation, assembly, commissioning/decommissioning, disassembly, operation, servicing, cleaning and repairing of the pump and the controller must be carried out by qualified, suitably trained and instructed personnel. Work on electrical components and assemblies must be carried out by personnel with the necessary qualifications and skills.

2.4 About this operating manual

Warnings and important notes are clearly identified as such in the text. The relevant text sections feature a specific sign. However, this icon cannot replace the safety instructions. Therefore, carefully read all safety instructions in this manual. Warnings and important notes in this text are highlighted as shown below, according to the severity of the damage that might result from non-compliance.

⚠ DANGER
DANGER INDICATES A HAZARD WITH A HIGH LEVEL OF RISK THAT, IF NOT AVOIDED, WILL RESULT IN DEATH OR SERIOUS INJURY.

3   Technical specifications

3.1   Technical specifications mp6 [1]

mp6	Order code: mp6
Pump type	piezoelectric diaphragm pump
Number of actuators	2
Dimensions without connectors	30 x 15 x 3.8 mm³ 1.1811 x 0.5906 x 0.1498 in.
Weight	2 g
Fluidic connectors	barbed tube clip (outer diameter 1.9 mm, length 3.5 mm) [2]
Electric connector	flex connector 1.25 mm pitch
Power consumption	< 200 mW
Self-priming	yes [3]
Pumping media	liquids, gases and mixtures
Operating temperature	0 – 70°C
Life time	5000 h [4]
IP code	IP33 [5]
Materials in contact with media	polyphenylene sulphone (PPSU) [6]
Suitable evaluation controller	mp-x, mp6-EVA and mp6-OEM

Typical values of flow and back pressure for selected media (values defined with mp-x: 250 V, SRS):	
Liquids – water	
max. volume flow	7 ml/min +/- 15% (5.95 ml/min – 8.05 ml/min) [4]
max. back pressure	600 mbar +/- 15% (510 - 690 mbar) [4]

[1] Typical values. Values can vary under application conditions. Content is subject to changes without notice.
[2] Recommended tubing: 1.3 mm inner diameter.
[3] Conditions: Suction pressure < 10 mbar, DI water, settings mp-x: 100 Hz, 250 V, SRS, the max. volume flow will be reached after a few minutes of operation time.
[4] Conditions: DI water, room temperature, settings mp-x: 100 Hz, 250 V, SRS
[5] Can be changed to IP44.
[6] The mp6 is not stable against concentrated alcoholic solutions as MeOH or EtOH.

3.2   Technical specifications mp6–AIR [1]

The mp6-AIR is a regular mp6 that was specifically measured for gas flow.

mp6–AIR	Order code: mp6–AIR
Pump type	piezoelectric diaphragm pump
Number of actuators	2
Dimensions without connectors	30 x 15 x 3.8 mm³ 1.1811 x 0.5906 x 0.1498 in.
Weight	2 g
Fluidic connectors	barbed tube clip (outer diameter 1.9 mm, length 3.5 mm) 2
Electric connector	flex connector 1.25 mm pitch
Power consumption	< 200 mW
Self-priming	yes [3]
Pumping media	gases
Operating temperature	0 – 70°C
Life time	t.b.d.
IP code	IP33 [5]
Materials in contact with media	polyphenylene sulphone (PPSU) [6]
Suitable evaluation controller	mp-x, mp6-EVA and mp6-OEM
Typical values of flow and back pressure for selected media **(values defined with mp-x: 250 V, SRS):**	
Gases	
typ. max. volume flow	18 ml/min (300 Hz) [6]
typ. max. back pressure	100 mbar (300 Hz) [6]

[1] Typical values. Values can vary under application conditions. Content is subject to changes without notice.
[2] Recommended tubing: 1.3 mm inner diameter.
[3] Conditions: Gases, room temperature, settings mp-x: 300 Hz, 250 V, SRS, the max. volume flow will be reached after a few minutes of operation time.
[4] Can be changed to IP44.
[5] The mp6 is not stable against concentrated alcoholic solutions as MeOH or EtOH.
[6] Conditions: Gases, room temperature, mp-x: 300 Hz, 250 V, SRS

3.3 Technical specifications mp6-pp [1]

mp6-pp	Order code: mp6-pp
Pump type	piezoelectric diaphragm pump
Number of actuators	2
Dimensions without connectors	30 x 15 x 3.8 mm³ 1.1811 x 0.5906 x 0.1498 in.
Weight	2 g
Fluidic connectors	barbed tube clip, (outer diameter 1.9 mm, length 3.5 mm) [2]
Electric connector	flex connector 1.25 mm pitch
Power consumption	< 200 mW
Self-priming	yes [3]
Pumping media	liquids, gases and mixtures
Operating temperature	t.b.d.
Life time	t.b.d.
IP code	IP 33 [4]
Materials in contact with media	polypropylene (PP) [6]
Suitable evaluation controller	mp-x, mp6-EVA and mp6-OEM

Typical values of flow and back pressure for selected media (values defined with mp-x: 250 V, SRS):	
Gases	
max. volume flow	14 ml/min +/- 15% (11.9 – 16.1 ml/min) [5]
max. back pressure	150 mbar +/- 15% (127.5 – 172.5 mbar) [5]
Liquids – water	
max. volume flow	5 ml/min +/- 15% (4.25 – 5.75 ml/min) [6]
max. back pressure	650 mbar +/- 15% (552.5 mbar – 747.5 mbar) [6]
Liquids - MeOH	
max. volume flow	6.8 ml/min [7]
max. back pressure	550 mbar [7]

[1] Typical values. Values can vary under application conditions. Content is subject to changes without notice.
[2] Recommended tubing: 1.02 mm inner diameter.
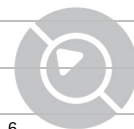[3] Conditions: Suction pressure < 10 mbar, DI water, settings mp-x: 100 Hz, 250 V, SRS, the max. volume flow will be reached after a few minutes of operation time.
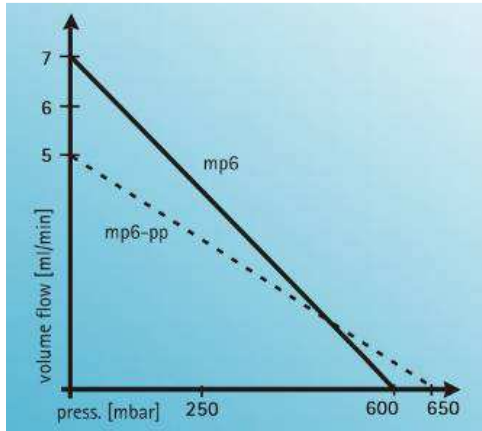[4] Can be changed to IP44.
[5] Conditions: Gases, room temperature, mp-x: 300 Hz, 250 V, SRS
[6] Conditions: DI water, room temperature, settings mp-x: 100 Hz, 250 V, SRS
[7] Conditions: DI water, room temperature, settings mp-x: 100 Hz, 250 V, SRS

3.4   Typical flow characteristics mp6 and mp6-pp

The flow rate of the pumps shows a linear dependency on the back pressure.

At 0 mbar back pressure the maximum pump rate can be achieved and at the maximum back pressure the flow rate is decreased to 0 ml/min.
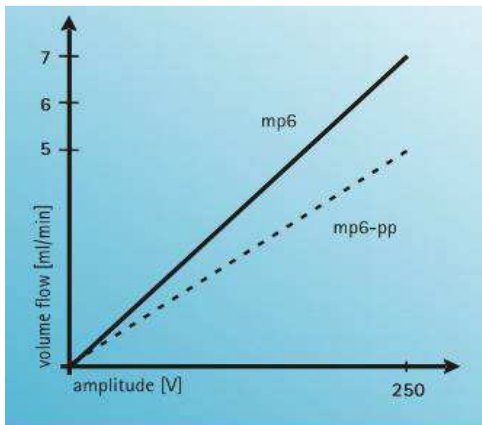
The amplitude defines the stroke of the actuator and therefore the displacement of the pumping media per pump cycles.

Increase in amplitude linearly increases the flow rate to the maximum.
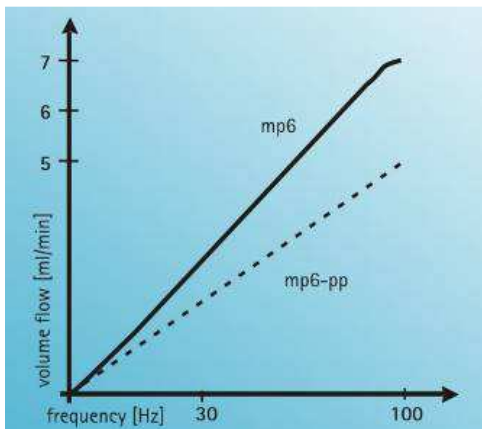
The frequency determines the number of pump strokes over time. Volume flow increases linear with frequency for a certain frequency range.
The diagram presents the maximum of volume flow at the micropumps resonant frequency.

At frequencies above the resonant point the flow rate decreases again.

Hochviskose Medien (Öl) Mittelviskose Medien (Wasser) Niedrigviskose Medien (Gas)

The resonance frequency and the maximum flow rate strongly depend on the viscosity of the media.
The lower the viscosity, the higher the maximum flow rate and the resonance frequency.

3.5 Final inspection

After production, the micropumps have to pass a final inspection. **They are tested concerning the maximum flow and back pressure.**

Measurement conditions:

Pumping media: distilled water

Temperature: room temperature
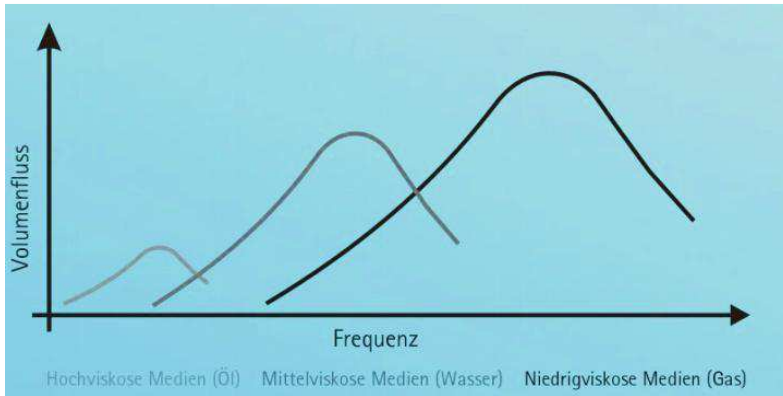
Controller: extended box mp-x

Electrical Input: amplitude of 250 Vpp and SRS-Signal with 100 Hz

Measurements with sensors:	
volume flow	range: 0 - 10 ml/min accuracy: +/- 1% FS (=0.1 ml/min)
pressure	range: 0 – 1 bar accuracy: +/- 0.35% (= 3.5 mbar)

Specifications mp6:

Flowrate [ml/min]:   min. 5.95   typ. 7.0   max. 8.05

Backpressure [mbar]:   min. 510   typ. 600   max. 690

Specifications mp6-AIR (mp-x; 250 Vpp; SRS-Signal; 300 Hz):

measured to have a typ. max. volume flow of 18.0 ml/min

measured to have a typ. max. back pressure of 100 mbar

Volume flow and back pressure may be higher.

Specifications mp6-pp:

Flowrate [ml/min]:   min. 4.25   typ. 5.0   max. 5.75

Backpressure [mbar]:   min. 552.5   typ. 650   max. 747.5

Other application specific outgoing inspections can be offered for all pumps upon customer demand.

In order to guarantee proper function of the delivered goods and exclude transportation damages please check the incoming devices according to specifications after receipt.

Based on these results a replacement can be carried out within 14 days after delivery free of costs.

4 Operating the micropump

In this chapter, operation of the micropump during the evaluation is described. This chapter provides information on the proper connection of the pump with tubing and electrical cables and typical driving parameters to start the evaluation.

4.1   Connecting the micropump
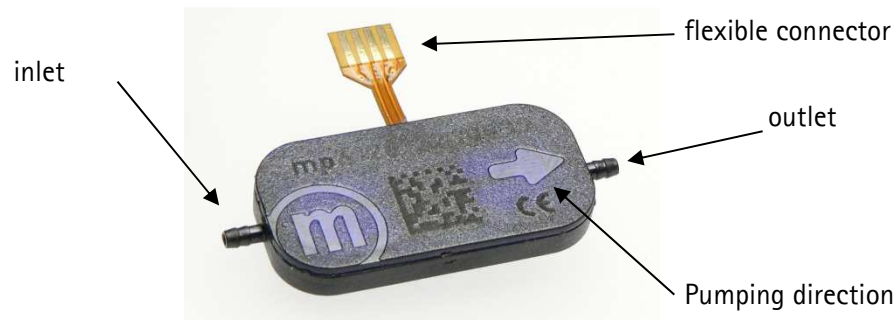
Please connect suitable tubes to the inlet and outlet. The tubing should have an inner diameter of ~1.3 mm for the mp6/mp6-AIR and ~1 mm for the mp6-pp. The micropump has to be connected to a suitable controller as described in the next sections.

Tygon; ID = 1.30 mm; OD = 3 mm

Tygon; ID = 1.02 mm; OD = 2.72 mm

The electrical connection of the micropumps flexible connector is described in chapter 4.1.1. The flexible connector will be attached to the desired controller.

On both the mp6 and mp6-pp type pumps, traces of surface corrosion may appear on the electrical connector. This corrosion only causes a visual influence, negative effects on the pump performance could not be detected based on performance tests carried out by Bartels Mikrotechnik. Because of the mechanical fixation inside the electrical connector and due to the use of elevated driving voltages it is ensured that the pump performance is not affected by the surface corrosion. In a long term, we will work on improving the production process. Until then, referring to the unrestricted pump performance we ask our customers to excuse visible defects on the electrical connector.

In general, the micropump can be driven with positive alternating voltages with maximum amplitude of 250 V at a frequency between 0 and 300 Hz. A rectangular signal results in best fluidic performance

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while a sine wave minimizes the audible noise. The actuators must be driven with a 180° phase shift in the signal.

If a pump will be damaged while using a customer's controller, we do not provide any warranty. We recommend using our dedicated controllers.

> ⚠️ **DANGER**
>
> THE MP6-SERIES MICROPUMPS ARE OPERATED AT HIGH VOLTAGES. BEFORE OPERATION, MAKE SURE THAT ALL SPECIFIC REGULATIONS FOR ELECTICAL SAFETY ARE FULLFILLED.

4.1.1   Connecting the mp6/mp6-AIR/mp6-pp to the cable

The mp6/mp6-AIR/mp6-pp pump can be connected via a FCC connector. The layout of the connector and pin assignment of the mp6/mp6-pp is as shown below. Each piezo (P1 / P2) has a single lead for the negative (-P1/-P2) and the positive (+P1/+P2) supply voltage.

Subject to change without further notice
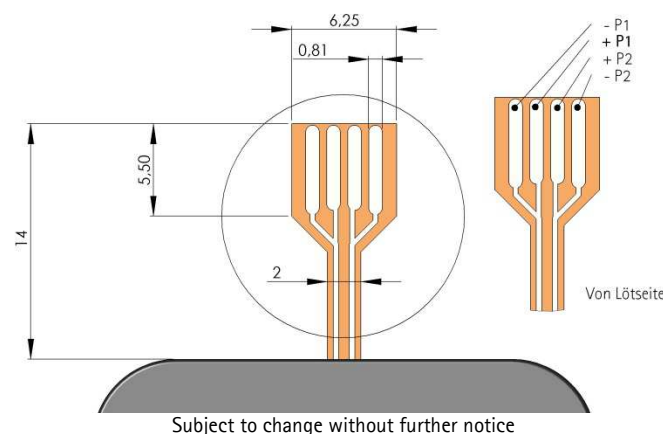
The recommended connector is a 4-pin 1.25 mm pitch FCC connector manufactured by Molex. The straight version part number 39 53 2045. An alternative is the angulated version with the part number 39 53 2044.

The connector is available in different versions to fit various applications. Reference drawings and further specifications are available under www.molex.com .

The recommended maximum wire length between controller and the pump is 1 m. The customer has to assure that the assembly of pump, controller and electrical connection complies with the EMC regulations and electrical safety in the specific field of application.

To connect the mp6/mp6-AIR/mp6-pp and Molex, refer to following three figures. Orientate both components as indicated on the first picture, the mp6/mp6-pp facing downwards with its serial number marking (!) and the Molex connector with the four small openings visible from above. Then insert the mp6/mp6-pp flex into the Molex connector (Step1). Close the Molex connector to complete the interconnection between both components (Step 2).

| Step 1 | Step 2 | Step 3 |
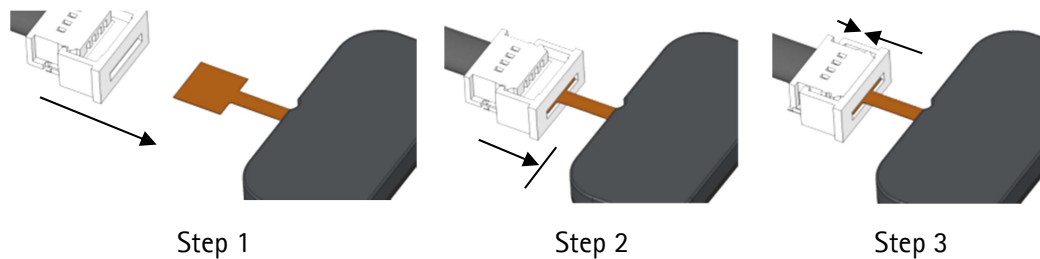
If the pump should be removed again, the Molex connector needs to be opened before removal!

In order to prevent damage to the flexible cable, the following points should be considered for the final pump assembly:

- the flexible connector must not be bent around sharp edges or kinked
- the flexible connector must not be bend on top or bottom of the pump
- the Molex connector is not water tight, additional sealing with e.g. silicone will be necessary
- fixation of the Molex connector in the final assembly is recommended
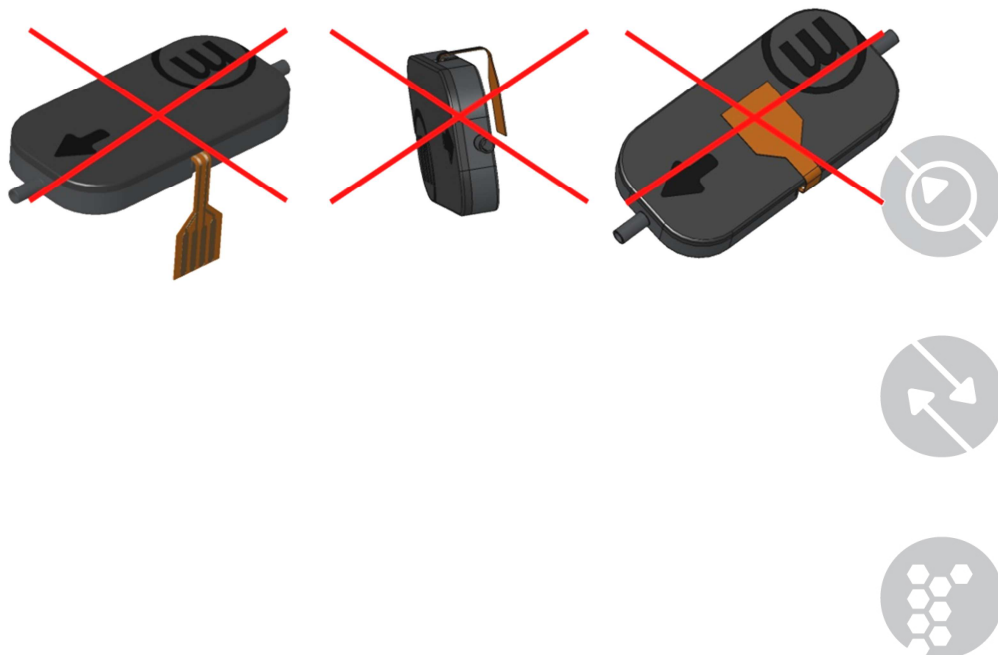
4.2 Cleaning the system

The pump can be washed with water, alcohol (isopropanol) or if necessary with weak acid by pumping or by flushing with the help of a syringe. **Flushing is only possible in pump direction!**

4.3 Typical operation parameters

4.3.1 mp6

The following applies to the media water. If gases are pumped, please refer to the chapter 4.3.2. Note that the regular mp6 can pump gases too, but is not specifically measured for it.

To achieve individual flow rates and optimal flow conditions, the driving parameters need to be tested, optimized and confirmed by testing under full application conditions. As an example, typical driving parameters are listed below to give a general orientation for testing. **The parameters have been obtained using the mp-x controller with the SRS signal preset.** Please refer to chapter 5 for operation of the mp-x controller.

target volume flow	amplitude	frequency
7 ml/min	250 V	100–110 Hz
6 ml/min	250 V	80–90 Hz
5 ml/min	250 V	55–65 Hz
4 ml/min	250 V	40–50 Hz
3 ml/min	250 V	30–35 Hz
2 ml/min	220–240 V	20 Hz
1 ml/min	125–135 V	20 Hz
0,5 ml/min	90–100 V	15 Hz
0,25 ml/min	85–95 V	8 Hz
0,1 ml/min	80–90 V	3 Hz

As a general guideline, the amplitude should be kept as high as possible while varying the frequency.

The flow curves present typical flow data, results may differ under varying operation conditions.

Flow vs. frequency of mp6 — DI water, 250 V, SRS

Flow vs. pressure of mp6 — DI water, 250 V, SRS
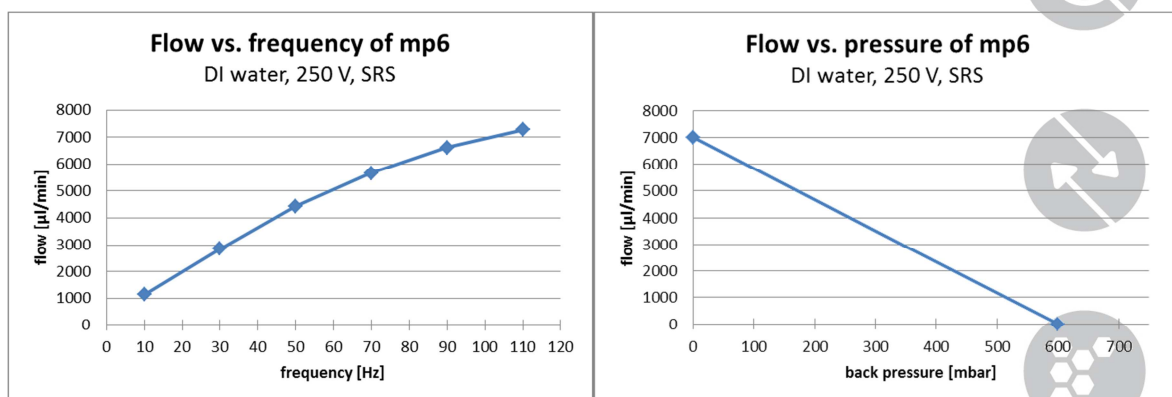
4.3.2   mp6–AIR

Driving the micropump with the controller mp-x at 300 Hz with 250 V, flow rates of typ. max. 18 ml/min and backpressures of typ. max. 100 mbar can be achieved.

In general, for driving the pump with air the following points should be taken into account:

- Higher frequencies should be used (compared to pumping water).
- Large amplitudes respectively driving voltages should be used.

With low frequencies and amplitudes, the volume flow and pressure generation is rather weak due to the passive character of the valves inside the micropump. These valves are more effective with fast and high pressure changes induced by the actuator.

If the desired flow rates should be small, the application of a restrictor is recommended. Please contact us about the right choice of the restrictor!

Please note the different frequency ranges of mp6–OEM and mp–x.

To minimize audible noise, using the sine signal is recommended.

The signal has influence on volume flow and back pressure, thereby applies rectangular > SRS > sine.

4.3.3   mp6–pp

Again the following applies to the media water. Note that the mp6-pp can pump gases too, but is not specifically measured for it.

To achieve individual flow rates and optimal flow conditions, the driving parameters need to be tested, optimized and confirmed by testing under full application conditions. As an example, typical driving parameters are listed below to give a general orientation for testing. **The parameters have been obtained using the mp-x controller with the SRS signal preset.** Please refer to chapter 5 for operation of the mp-x controller.

target volume flow	amplitude	frequency
6 ml/min	250 V	120–130 Hz
5 ml/min	250 V	90–100 Hz
4 ml/min	250 V	60–80 Hz
3 ml/min	250 V	40–50 Hz
2 ml/min	250 V	30 Hz
1 ml/min	180–190 V	20 Hz
0,5 ml/min	130–140 V	15 Hz
0,25 ml/min	120–130 V	8 Hz
0,1 ml/min	95–105 V	4 Hz
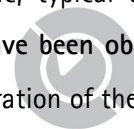
As a general guideline, the amplitude should be kept as high as possible while varying the frequency.

The flow curves present typical flow data, results may differ under varying operation conditions.

Flow vs. frequency of mp6-pp
DI water, 250 V, SRS

Flow vs. pressure of mp6-pp
DI water, 250 V, SRS
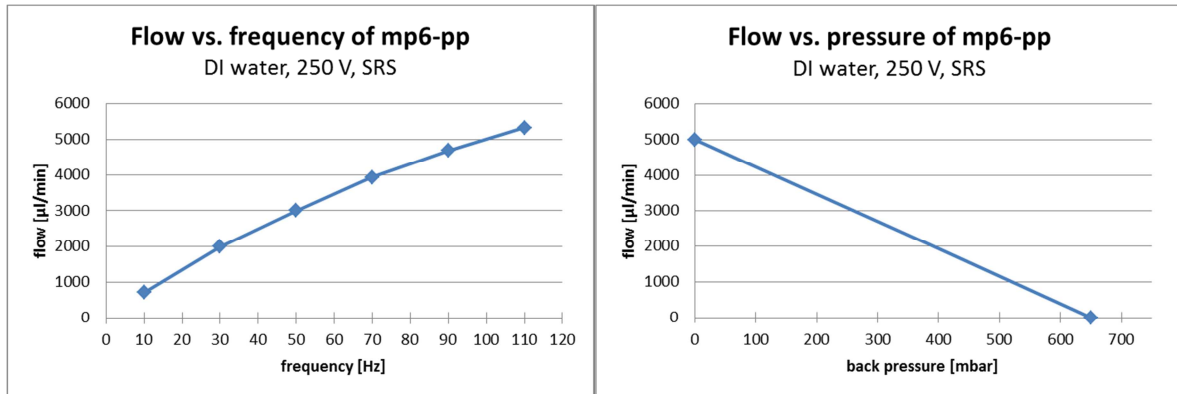
4.4 Combination of micropumps

The micropumps (mp6, mp6-AIR or mp6-pp) can be combined to achieve higher flow rates or pressure than the single unit can generate.

With **series connection,** the pressures add up.

With **parallel connection,** the volume flows add up.
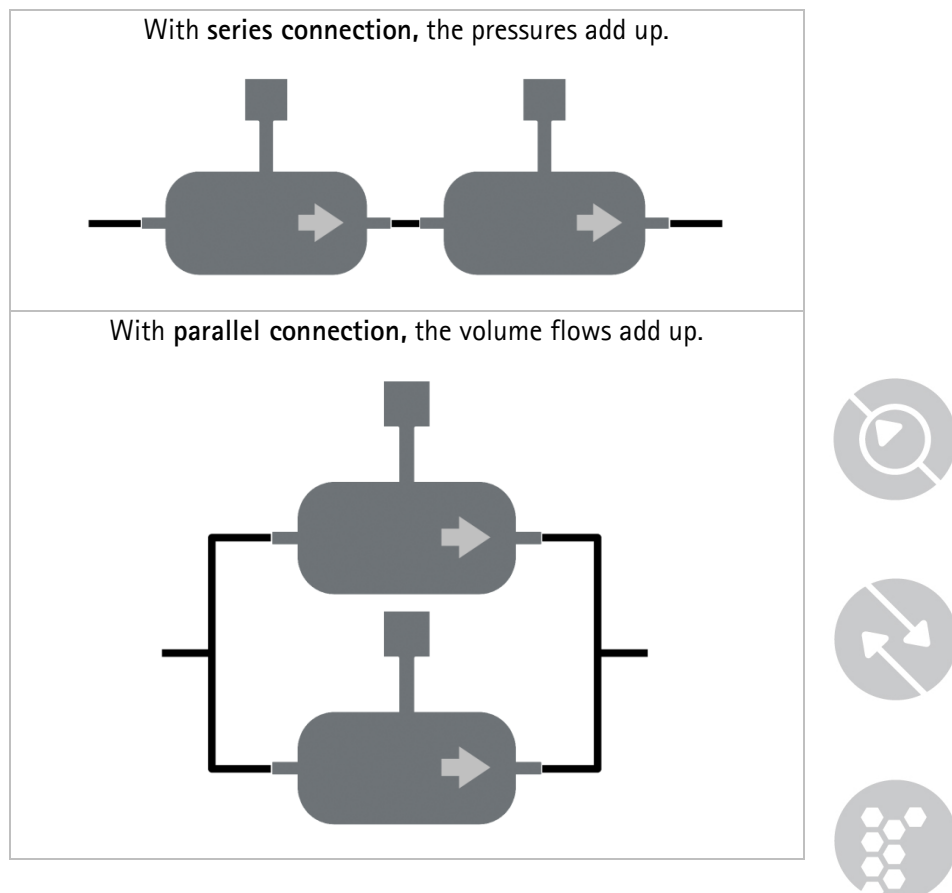
5 The mp-x controller

5.1 Technical specifications mp-x controller

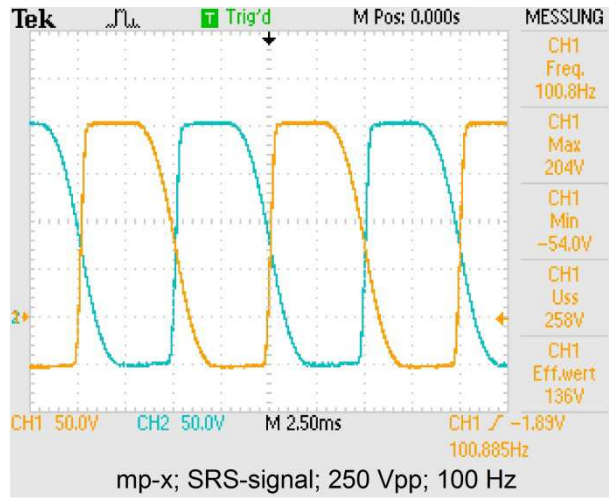| mp-x controller	Order code: mp-x
Access to the full range of driving parameters. A system for the professional evaluation of the micropumps. (excl. mp6-connection cable, please order when required)	
Dimensions	7.5 x 16 x 20 cm³ 2.983 x 6.299 x 7.874 in.
Weight	ca. 800 g
Pumping media	liquids, gases
Max. volume flow	mp6: 7 ml/min (SRS, 250 V, 100 Hz), DI-water mp6-AIR: 18 ml/min (SRS, 250 V, 300 Hz), air mp6-pp: 5 ml/min (SRS, 250 V, 100 Hz), DI-water mp5: 5 ml/min (SRS, 250 V, 100 Hz), DI-water
Adjustable parameters	amplitude, frequency, signal form
Amplitude range	0 – 250 V
Frequency range	0 - 300 Hz
Signal form	SRS, rectangular, sine
Power supply	mains adaptor
Current consumption	750 mA bei 7.5 V
USB-Port inkl. Treiber	one; a CD with driver software is included
connectable micropumps	mp5: 1x-2x or mp6, mp6-AIR and respectively mp6-pp: 1x

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5.2 Electrical signal form

SRS

mp-x; SRS-signal; 250 Vpp; 100 Hz

Rectangular

mp-x; rectangle signal; 250 Vpp; 100 Hz

Sine

mp-x; sine signal; 250 Vpp; 100 Hz
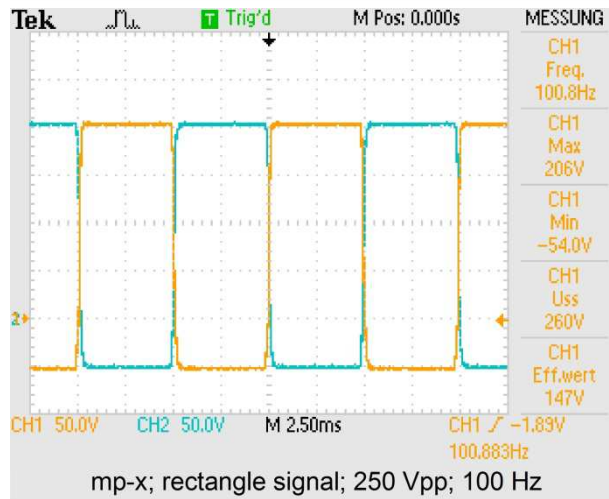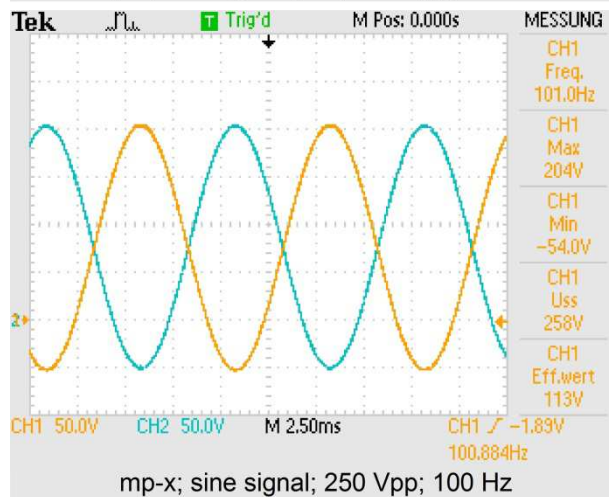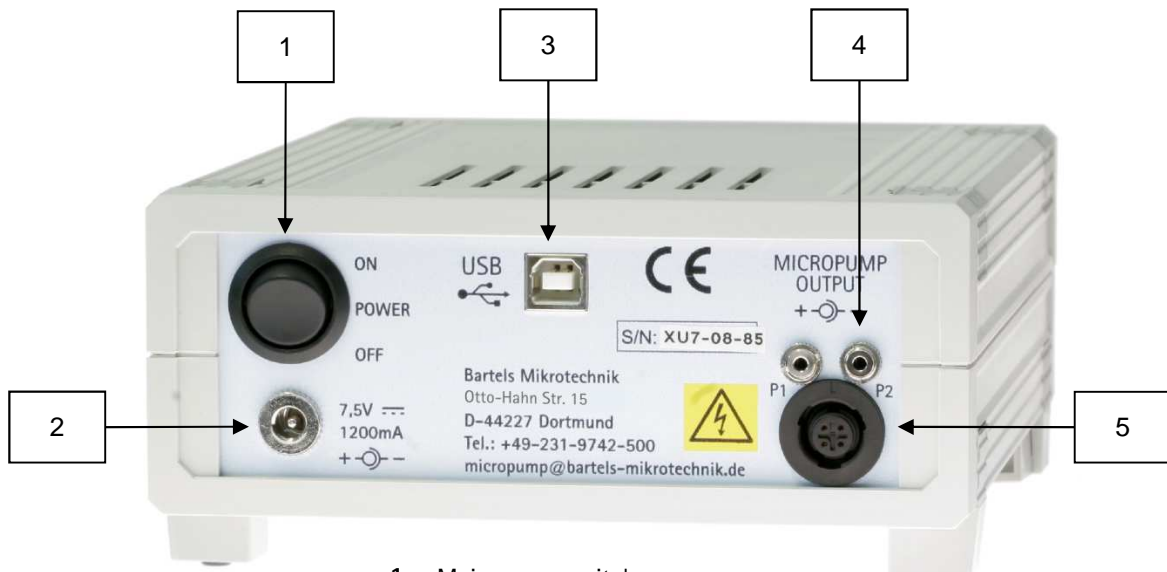
5.3   Connecting the pump to the mp-x

1   Main power switch
2   Power supply connector
3   USB interface for computer connection
4   Connections port for one or two mp5
5   Connection port for mp6

Please note that it is only possible to connect either one mp6/mp6-pp or a maximum of two mp5 to the mp-x otherwise a maximum voltage drop is possible!

Step 1:   Plug the micropump control cable into the corresponding micropump connector.
Step 2:   Check the mains adaptor plug polarity. It is pictured next to the power supply connector at the back of the controller. If the plug polarity is wrong, the controller cannot work.
Please make sure that the setting on the included connector is attuned to 7.5 V.
Step 3:   Connect the mains adaptor with the power supply connection.
Step 4:   Plug the mains adaptor into a mains socket.
Step 5:   Now you can start the control unit with the main power switch.

⚠ **DANGER**

THE "MICROPUMP OUT" CONNECTOR CAN CARRY HIGH VOLTAGE!
PLUG IN THE MICROPUMP CONTROL CABLE ONLY WHEN THE MP-X CONTROLLER IS SWITCHED OFF!

5.4   Operation of the mp-x

The mp-x provides three parameters to be selected independently of each other to control the micropumps:

-   Frequency
-   Amplitude
-   Signal form

It is possible to change the settings while the pump is operating. However, to extend the lifetime it is advisable to turn off the micropump first before changing the settings.
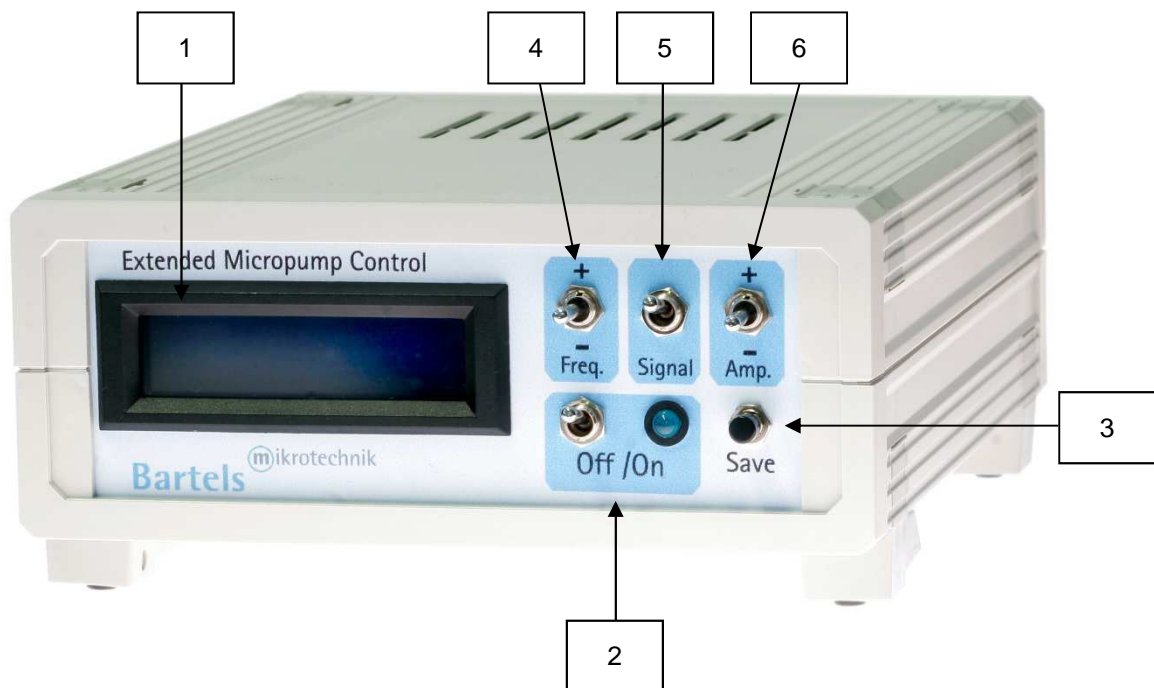
1   **LCD Display**
2   **On/Off-switch**: Push the on/off switch to turn the pump and control diode on or off.
3   **Save**:   Push the save switch to save the present settings.
4   **Freq.**:   Push the switch up to raise and down to reduce the frequency.
5   **Signal**:   Push the switch once to changes between SRS, rectangular or sine.
6   **Amp.**:   Push the switch up to raise and down to reduce the amplitude.

To operate the micropump, prepare the controller as described in point 5.3 and follow the steps below:

Step 1:   Choose a frequency by pushing the frequency switch up and down.

Step 2:   Choose one of the signal forms by pushing the signal switch.

Step 3:   Set the amplitude by pushing the amplitude switch up and down.

Step 4:   Push the on/off switch to turn on the micropump and the control diode.

Step 5:   Push the on/off switch again and the micropump will stop while the control diode turns off.

The Save-switch will store the current settings.

For shutdown of the controller please switch off the mp-x first and then the main power-switch on the backside of the controller. Then disconnect the power plug. Do not unplug the micropump before switching off the controller.

5.5   Installation of the drivers "USB Micropump Control" and "USB Serial Port"

In order to control the mp-x with a computer, a driver needs to be installed. The installation is done in two steps. First, the USB driver is installed. Second, the driver for the mp-x itself is installed which can be used as a serial interface from different software packages.

5.5.1   For "Windows XP" and former Windows versions

Step 1:   Connect the control unit with the USB port and turn it on. A message appears that new hardware was found and the hardware assistant starts automatically. Please click "Next" to continue.

Step 2:   Choose "Find a suitable driver for the device" and click "Next" to continue.

Step 3:   Place the CD into the disc drive.

Step 4:   Choose "Search for the best driver in these locations" and tag "Include this location in the search". Then browse and select the CD.

Step 5:   When the software has found the driver named "USB Micropump Control" select "Next"
The installation will start now. If the message appears that the Windows Logo Test was not successful, please select "Continue Anyway" as this has no relevance in this case. Click "Finish" to complete the installation.

Step 6:   After that installation, the hardware assistant pops up again for the serial port. Repeat the steps 1-5.

5.5.2   For "Windows 7"

Dependent on the individual system settings, different steps for installation might be necessary. The procedure applies in general also for Windows Vista.

Step 1: Log in with administrator rights.

Step 2: Connect the control unit with the USB port and turn it on. A message appears that new hardware was found.

Step 3: Open the device manager and double click the item "USB Micropump control" filed under "additional hardware" (or similar). In the pop up window click on "update driver" and select the directory including the driver files (e.g. the cd rom drive). It needs to be confirmed that the driver should really be installed as it has no digital signature.

Step 4: Repeat the steps 2 and 3 for the serial port. Starting with step 2 again, a device named "USB serial port" will be listed. The drivers need to be installed as described above.

Step 5: The device manager will show the number of the serial port (e.g. COM 4). Note this for further use of the device with application programs.

5.5.3 For "Windows 8"

Step 1: Log in with administrator rights.

Step 2: From the Metro Start Screen, open Settings (move your mouse to the bottom-right-corner of the screen and wait for the pop-out bar to appear, then click the Gear icon).

Step 3: Click "More PC Settings".

Step 4: Click "General".

Step 5: Scroll down, and click 'Restart now' under "Advanced startup".

Step 6: Click "Troubleshoot".

Step 7: Click "Advanced Options".

Step 8: Click "Windows Startup Settings".

Step 9: Click "Restart".

Step 10: On the Startup Settings screen, tap the F7 or 7 key on your keyboard to select the "Disable driver signature enforcement" option.
Wait until the system has restarted.

Step 11: Go to the mp-x driver folder "XU7 USB Driver 2.08.30" and click on "ftdibus Bami.inf", then click "Install".
Wait until installation is finished.

Step 12: Go again to the mp-x driver folder "XU7 USB Driver 2.08.30".
Click now "ftdiport Bami.inf", then "Install".
Wait until installation is finished.

Step 13: Now you can connect the mp-x with any USB-port. If the mp-x was already connected, disconnect it and connect it again.

5.6 Operation via USB port (after installation of the drivers)

The driving parameters can be set via your PC. For this purpose you can use software (or programming language) of your choice that is capable of sending commands to serial COM-Ports. In the example below the Windows software Hyperterminal is used. As the Hyperterminal is not available in Windows 7 anymore, we recommend freeware terminal software like PuTTY (http://www.putty.org).

Please note that the mp-x requires a time of approx. 100 ms to process a command. Therefore real-time flow control is not possible. Regardless of the time for processing a command, every change (amplitude, frequency or signal form) results in a jump in flow.

Hyperterminal example:

Step 1:   Connect the control unit to your computer and turn it on.
Step 2:   Start Windows Hyperterminal. Every new session has to be titled.
Step 3:   Choose the COM-port specified in the device manager.
Step 4:   The connection-settings have to be:
            Bits per second: 9600; Data bits: 8; Parity: none; Stop bits: 1; Flow control: none

Possible commands (followed by the enter key):

bon	turns the micropump on
boff	turns the micropump off
F(1–300) F100	sets the required frequency between 1 and 300 Hz here as an example 100 Hz.
A(1–250) A100	sets the required frequency between 1 and 250 Vpp here as an example 100 Vpp
MS	sets signal form modus (S)ine
MR	sets signal form modus (R)ectangular
MC	sets signal form modus SRS
(enter key)	displays present settings of the control unit

The control unit can also be used via LabView, Matlab or other programs. Using LabView, please ensure that the "NI-Serial" package is installed. This will be installed in regular cases together with LabView, but sometimes this option is skipped during install.

It can be downloaded on the National Instruments website as the "NI-Serial" package:

http://joule.ni.com/nidu/cds/view/p/id/2316/lang/en

Afterwards it is possible to select the right COM-port for your mp-x in the VISA resource name.

On request, we can send a package of LabView-Routines as an example of implementation.

We also offer to develop customer specific software for the application of the controller units!

6 The mp6–OEM controller

The mp6-OEM is a small, easy to use driving circuit developed for the mp6, mp6–AIR or mp6–pp micropump. It generates up to 270 Vpp voltage from a 3-5 V supply.

Its low power consumption makes it ideal for battery powered handheld devices or even solar powered devices.

The module can be integrated into a PCB design like a 14 pin DIL package.

The build-in interface allows the user to adapt frequency and/or amplitude to its application by the use of a few additional components or a microcontroller.

In order to locate Pin 1, please refer to the following figure. The pin is marked with a white spot.

6.1   Technical specifications mp6–OEM

mp6–OEM controller	Order code: mp6–OEM
The OEM-controller drives the micropump at adjustable performance in a package similar to an integrated circuit. It enables integration into system electronics or on a PCB.	
Dimensions	10.5 x 20.5 x 6 mm 0.4134 x 0.8070 x 0.2362 in.
Pumping media	liquids, gases
Max. volume flow (DI-water)	4.9 ml/min @ 3 VDC supply; 100 Hz 7 ml/min @ 5 VDC supply; 100 Hz
Adjustable parameters	amplitude, frequency
Amplitude range	85 – 270 Vpp [1]
Frequency range	25 - 226 Hz (Frequencies up to 1000 Hz are possible; please note that the amplitude will decrease in that case. Frequencies down to 1 Hz are possible with an external clock generator.)
Signal form	similar to rectangular
Power supply	2.5 – 5.5 VDC (5 V recommended for optimized performance)
Pumping media	ca. 30 mA at 5 V
Pin arrangement	DIL 14; horizontal ~2.54 mm, vertical ~7.62 mm

[1] Before May 2014: mp6-OEM have an amplitude range of 85 – 235 Vpp

6.2 Electrical Characteristics

Applies to a connected micropump and the internal defined frequency and slew rate.

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Supply voltage	VDD		2.5		5.5	V
Average current consumption	IDD	VDD = 5 V (1)		30		mA
Setting range AMPLITUDE			0.35		1.3	VDC
min. voltage at pump	Vpump	AMPLITUDE = 0.5 VDC	80	85	90	Vpp
max. voltage at pump (2)	Vpump	AMPLITUDE = 1.3 VDC	260	270	280	Vpp
PWM-range AMPLITUDE			0,2		1	MHz
Frequency output	F	VDD = 5 V (1)	90	100	110	Hz
Digital Low-Signal				0		V
Digital High-Signal			2		VDD	V
Capacitance CLOCK			1.0	2.2	10	nF
Input current AMPLITUDE			1		3	µA
Operating current during Shutdown Mode				1.6		µA

(1)   The signal output is determined by internal components.

(2)   Before May 2014: mp6-OEM have an amplitude range of 85 – 235 Vpp, typ.

6.3 Pin layout

VDD   Supply voltage

GND   Ground

SHUTDOWN   If the micropump should be switched off, the mp6-OEM has to be set to the Shutdown Mode. Then AMPLITUDE **and** SHUTDOWN have to be set to 0 V.

CLOCK   Predefined clock signal. Frequency will be set to the nominal 100 Hz, when this pin is connected to CLOCK_INT (see image "Schematic 1" in chapter 6.6.1).

(The internal capacitor is 2.2 nF.)

A capacitor of 1 to 10 nF can be placed between CLOCK and GND to define other frequencies (see image "Schematic 2" in chapter 6.6.2). It is also possible to connect an external clock signal with a **quadruplicated** frequency of the micropumps frequency.

CLOCK_INT   When connected to CLOCK the frequency is set to 100 Hz.

AMPLITUDE   The amplitude can be set either with an analogue voltage between 0.35 V to 1.3 V, or with an equivalent pulse-width modulation (PWM) at a voltage level of 5 V and a pulse

frequency of 0.2 to 1 MHz.

SLEWRATE	Setting of the slew rate. This pin will be connected to SLEW_INT.
SLEW_INT	Internal resistor against GND for set the slew rate.
	(The internal resistor is 360 kΩ.)
GND2, GND3	Connected internally with ground (GND). No need to connect.
+P1	Piezo actuator 1, positive electrode (see chapter 6.6)
–P1	Piezo actuator 1, negative electrode (see chapter 6.6)
+P2	Piezo actuator 2, positive electrode (see chapter 6.6)
–P2	Piezo actuator 2, negative electrode (see chapter 6.6)

6.4   Typical flow behavior
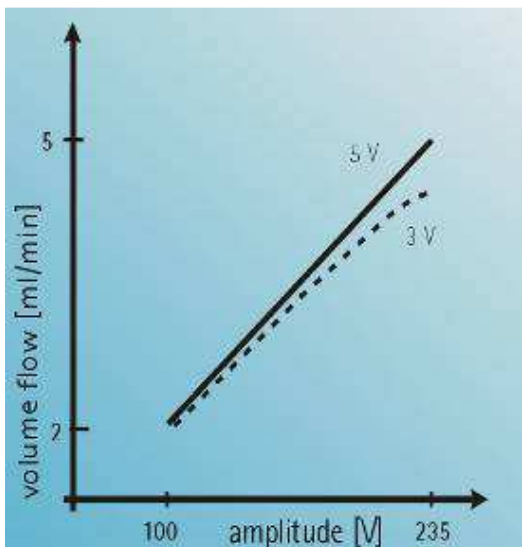
6.5   Connecting the micropump with the mp6–OEM

The micropumps mp6/mp6-pp can be connected with the mp6–OEM via a FCC connector. More information concerning this connector and the pin layout of the micropump can be found in chapter 4.1.


⚠ **DANGER**

THE "MICROPUMP OUT" CONNECTOR CAN CARRY HIGH VOLTAGE!
PLUG IN THE MICROPUMP CONTROL CABLE ONLY WHEN THE MP–X CONTROLLER IS SWITCHED OFF!

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6.6   Examples of circuiting the mp6–OEM

6.6.1   Operation with fixed settings

The mp6-OEM can operate the mp6/mp6-pp without further external components. In this case, frequency and amplitude to the micropump are predefined to **270 V and 100 Hz** by the internal circuit.
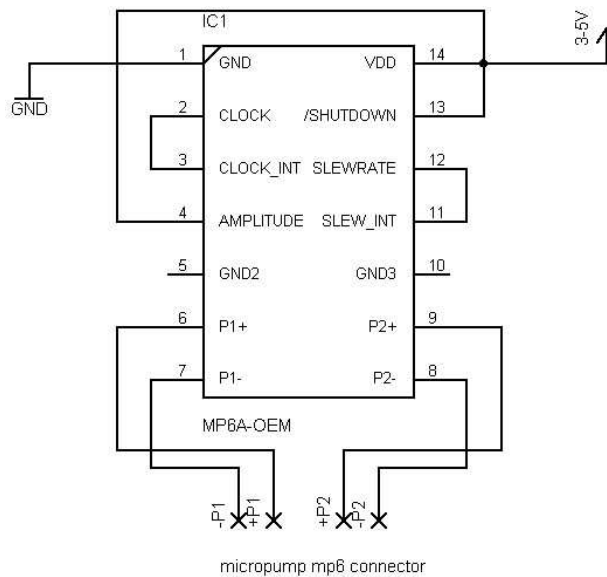
Schematic 1: Predefined amplitude of 270 V and frequency of 100 Hz by internal circuit.

### 6.6.2   Operation with variable settings via external components

In this example, frequency and amplitude to the micropump will be defined by external components. The amplitude can be varied in the range from 85 Vpp to 270 Vpp, the frequency from 25 Hz to 226 Hz. With frequencies above 226 Hz it is possible that the maximal amplitude will decrease. Frequencies below 25 Hz are possible too, however, the stability of the signal form has to be verified then!

Using a potential divider it is possible to change the amplitude, see image "Schematic 2" below. The voltage at the AMPLITUDE-Pin can be calculated with this formula:
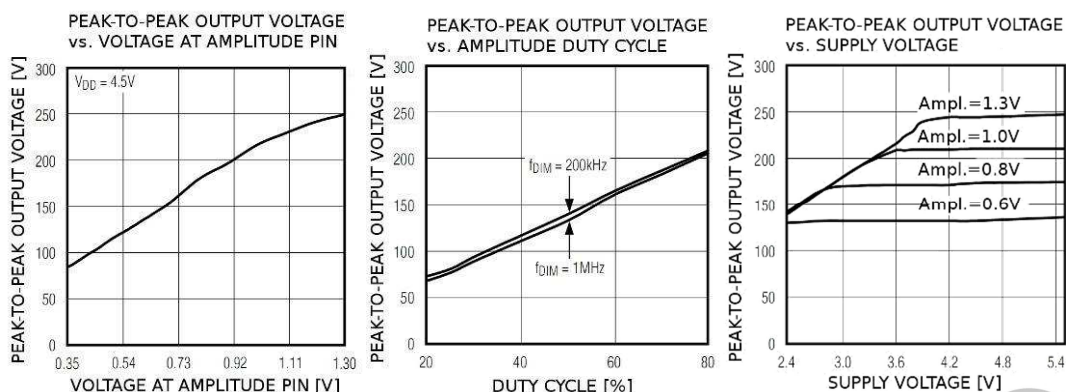
$$V_{AMPLITUDE} = V_{DD} \cdot \frac{R1}{R1 + R2}$$

As an alternative to the potential divider, an appropriate potentiometer (e.g. 10 kΩ) is possible too.

The relation of the voltage at the AMPLITUDE-Pin to the output voltage is shown in image "OEM-Behavior 1" below.
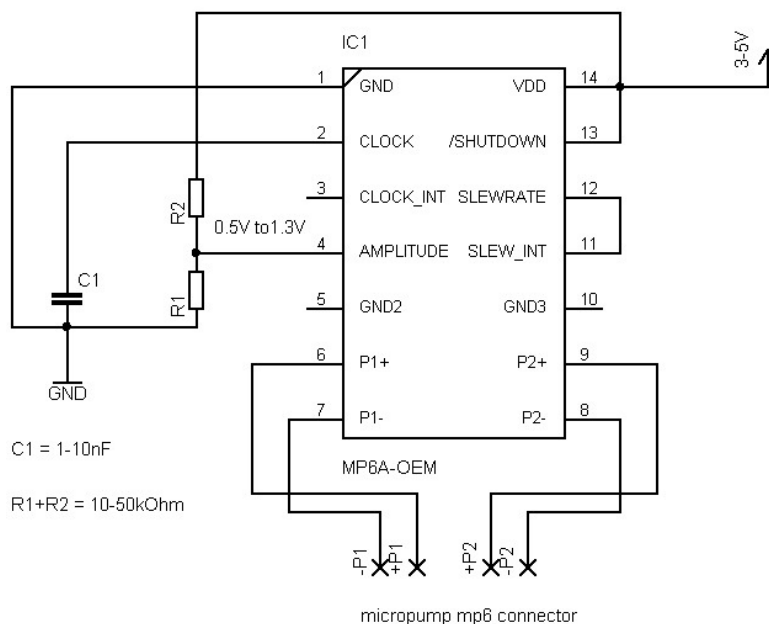
Schematic 2: Defining frequency and amplitude with external components.

OEM-Behavior 1: Output voltage changed with external components.

Variation of frequency is realized with a capacitor of 1 to 10 nF. Typical capacitances are shown in the image "OEM-Behavior 2" below.

For frequencies lower than 25 Hz an external frequency signal has to be uses, as explained in chapter 6.6.3!
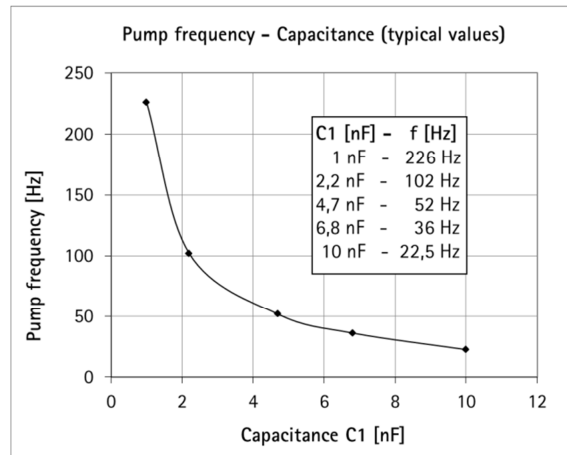
OEM-Behavior 2: Typical capacitances for different frequencies.

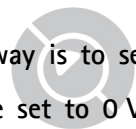### 6.6.3   Operation with variable settings via microcontroller

Using a microcontroller to operate the micropump, a quadruplicated frequency of the final micropumps frequency has to be connected to the CLOCK Pin. With this procedure, single-digit frequencies can be achieved.

Please take into account to set the pulse-width of the frequency duty cycle at a level of 95% when operating at frequencies lower than 25 Hz.
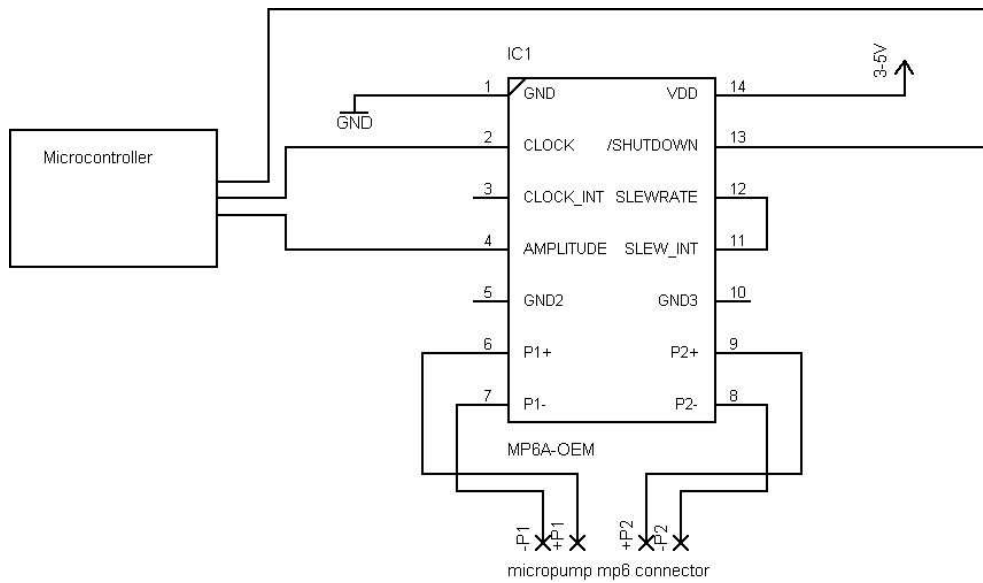
The amplitude can be set either with an analogue voltage between 0.35 V to 1.3 V, or with an equivalent pulse-width modulation (PWM) at a voltage level of 5 V and a pulse frequency of 0.2 to 1 MHz at the pin AMPLITUDE.

The PWM signal must have an amplitude of at least 1.3 V and maximal the same as the supply voltage to ensure that the output voltage is only dependent on the duty cycle!

For minimizing the power consumption, the mp6-OEM can be switched off. One way is to set the mp6-OEM into the Shutdown Mode; then AMPLITUDE and SHUTDOWN have to be set to 0 V. The other way is to interject the power supply.

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Schematic 3: Microcontroller as an external component.

6.7 Noise reduction

If the noise generated by the pump is critical, a series resistor of 2-10 kΩ in the P1+ and the P2+ line between the mp6-OEM and the pump will help. There is no limit for the resistor value but it will decrease the maximum pump performance.

7 The mp6–EVA evaluation board

The evaluation board enables the simple use of the mp6 based on the mp6-OEM controller. Next to preset standard parameter (270 Vpp, 100 Hz) the mp6-EVA also allows to adjust the pump parameters, partly by external tuning. As the supply voltage of the module can be provided via USB (no data interface), just attach it to a USB power supply and start the evaluation. Alternatively, it can also be supplied by a 2.5 – 5 V voltage source.

7.1 Safety notice

The mp6–EVA generates voltages of up to 270 Vpp. All parts of the mp6-EVA evaluation board can carry voltages in this range. Therefore, the board should only be used by qualified personal. Although the output power of the module is very low, **proper insulation according to the application conditions needs to be considered by the customer.** This especially applies to the lower side of the PCB. Contact with water or other liquids needs to be prevented. The pump must not be changed while a driving voltage is applied to the board.

⚠ DANGER
THE EVALUATION BOARD CAN CARRY HIGH VOLTAGE ! BE CAREFUL, WHILE CONNECTING AND HANDLING THE BOARD!

7.2 Electrical specifications mp6–EVA evaluation board

As the evaluation board is based on the mp6–OEM module, all electrical characteristics and specifications of this product must be considered. Please see chapter 6.2 of this manual for more details.

7.3 Functional elements
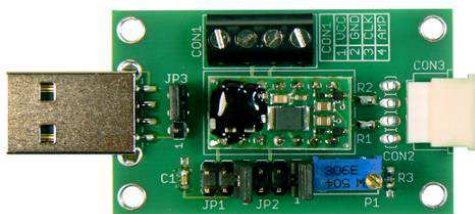
Elements are listed with their names according to the printed description on the PCB.

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|||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

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Connectors:

CON 1 – Screw terminal for external power supply and external clock / amplitude signal
CON 2 – Solder terminal for extension cable to connect one mp6 micropump
CON 3 – Molex connector to connect one mp6 micropump
USB connector for voltage supply via USB

Jumpers:

JP1 – Jumper for pump frequency setting
JP2 – Jumper for pump amplitude setting
JP3 – Jumper for power supply setting

Others:

P1 – Variable resistor for amplitude adjustment

7.4   Operation

To operate a pump with the evaluation board, the following steps are necessary:

Step 1:   Connect the mp6/mp6-pp pump to the board according to the description in chapter 4.1.1. Due to the orientation of the connector, the pump needs to be inserted with its metallic contacts upwards.
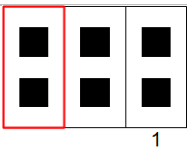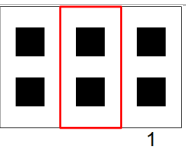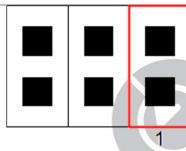
Step 2:   Choose the pump frequency setting with Jumper 1

Step 3:   Choose the pump amplitude setting with Jumper 2

Step 4:   Choose the power supply setting with Jumper 3 (CON 1- or USB-port).

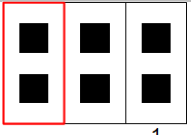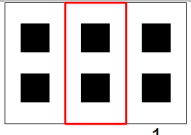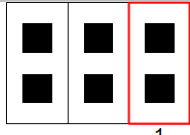**Step 5:**   Connect the board with the voltage source.

7.4.1   Pump frequency setting with jumper JP1

Frequency defined by clock signal at Pin 3 (CLK) at screw terminal CON1	Frequency defined by capacitor C1 (at delivery set to 226 Hz)*	Internal frequency of the mp6-OEM (100 Hz)

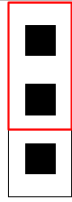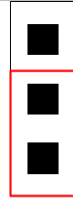*versions before July 2011 had a setting of 50 Hz

More information on the frequency setting with the CLK signal can be found in chapter 6. The capacitor C1 can as well be changed by re-soldering, see image "OEM-Behavior 2" in chapter 6.6.2.

7.4.2 Pump amplitude setting with jumper JP2

Amplitude defined by AMPLITUDE signal at Pin 4 (AMP) of screw terminal CON1	Amplitude defined by position of potentiometer P1	Maximal amplitude (270 Vpp)

More information on the amplitude setting with the AMP signal can be found in chapter 6.

7.4.3 Operation voltage setting with jumper JP3

Supply voltage via Pin 1 (Vcc) and Pin 2 (GND) of screw terminal CON1	Supply voltage via USB–port

7.5 Connecting the pump via CON2

If the mp6/mp6-pp micropump shall not be connected directly to the PCB with the Molex connector CON 3, an extension cable can be soldered to the connector CON 2.

The solder pads have the following pin assignment:

P2 – (negative voltage Piezo 2)
P2 + (positive voltage Piezo 2)
P1 + (positive voltage Piezo 1)
P1 – (negative voltage Piezo 1)

Please make sure that the cable can handle voltages up to 270 Vpp and ensure proper insulation of the cable!
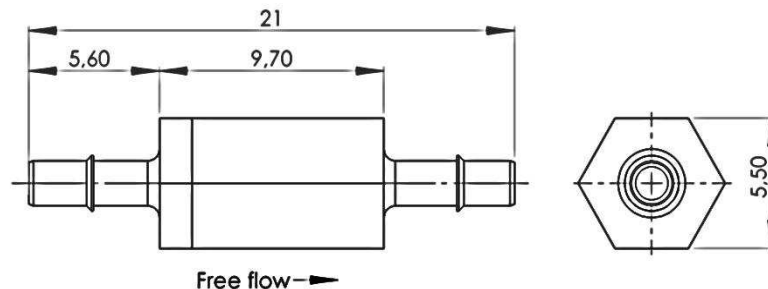
8   Passive check valve mp-cv

When the micropump is switched off, a back flow of the pumping medium, depending on a differential pressure between in- and outlet is possible!

In order to impede a back flow Bartels Mikrotechnik offers a passive check valve integrated in stainless steel.

The connection of the valves with the micropump can be done easily with suitable tubing. The valve should be placed between the micropump and the outlet reservoir.

Dimensions:

The valves are individually marked regarding the free flow direction.

Technical specifications:

mp-cv check valve	Order code: mp-cv
The passive check valve eliminates the back flow of the pumping medium, when the micropump is switched off. It can be connected via tubing.	
Dimensions	21 mm x 5.5 mm (length x wrench size) 0.82677 x 0.2165 in.
Materials in contact with the pumped media	silicone, stainless steel
Fluidic connectors	barbed tube clip, length : 5.6 mm for tubing with internal diameter: 1.3 mm
Cracking pressure	typical < 35 mbar
Max. back pressure	500 mbar
Typical leak rate	<20 µl/h for DI-water (at 500 mbar)

Please note that the volume flow of the micropump will be influenced by the check valve.

9   Trouble shooting

Observation	Trouble shooting
Maximum flow rate cannot be achieved	Gas bubbles within the system, the compressible gas volume in the pump can result in decrease of pump rate = system should be primed with a syringe. - Gas bubbles within the system The compressible gas volume in the pump can result in decrease of pump rate. Remedy: Manual priming should be carried out by flushing the pump with the help of syringe. Only pull the fluid from the outlet, i.e. in pumping direction. Extreme sucking pressures can damage the pump. - Tubing is too long: Shorten tubing - Tubing diameter is too small: Use appropriate tubing with an inner diameter of 1.3 mm for the mp6 and 1.02 mm for the mp6-pp. - Back pressure is too high: Reduce pressure or lower outlet reservoir. - Check signal form used to drive pump: Highest flow rate is achieved with SRS signal and at resonance frequency (100 Hz for water). The flow rate is viscosity dependent as described in chapter 3.4
Non-linear flow behavior	The linear range of the pump characteristic is described for selected media in chapter 3.4. Gas bubbles in the pump act as compressible volume. When they are digested through the pump, this can lead to non-linear flow behavior. To avoid this the system should be primed with a syringe as mentioned above.
Fluid is flowing through the system although pump is switched off	The valves inside the pump are opening and closing by differential pressure of in- and outlet. Lower in- or outlet reservoir to avoid hydrodynamic behavior or add check valve as described in chapter 8.
Pump is not working, no buzzing audible	- Please check if the mains adaptor is correctly connected - Please check if the connection between pump and the Molex connector is correct according to chapter 4.1.1. - Defect piezo actuator = contact Bartels Mikrotechnik for support.

For further notes on troubleshooting please refer to our online FAQ section on the micropump website www.micro-components.com

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