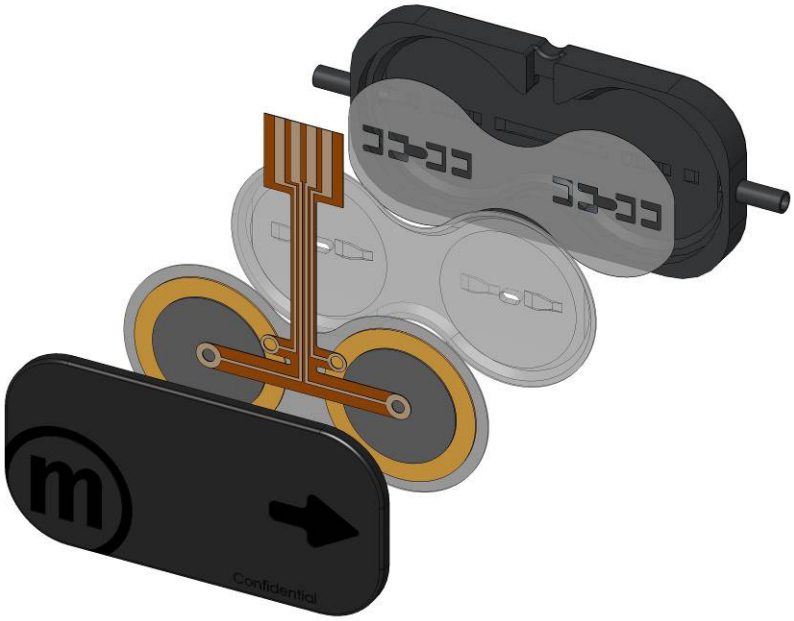
microComponents

Operating Manual

Micropump mp6/mp6-pp

and Controller



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Bartels mikrotechnik

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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 and mp6-pp.

The unit has 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 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 unit.

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 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.

Please make sure that only skilled personnel works with the pump control and micropump. The micropump shall be under constant supervision at running conditions. And 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 can not issue a guaranty anymore. Please keep this manual safe and give a copy to all users.

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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 WHICH, IF NOT AVOIDED, WILL RESULT IN DEATH OR SERIOUS INJURY.

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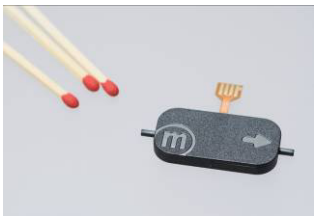
3. Technical specifications

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
Weight			2 g
Fluidic connectors			barbed tube clip (outer diameter 1.9 mm, length 3.5 mm) [2]
Electric connector			flex connector / Molex FCC 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):			
Gases		Max. flow	18 ml/min (300 Hz)
		Max. back pressure	100 mbar (300 Hz)
Liquids	Water	Max. flow	7 ml/min +/- 15% (100 Hz)
		Max. back pressure	600 mbar +/- 15% (100 Hz)

[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. flow rate 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.

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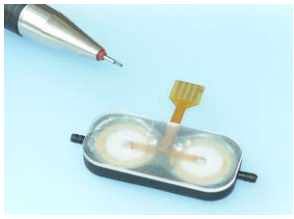
3.2 Technical specifications mp6-pp [1]



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
Weight			2 g
Fluidic connectors			tube clip (outer diameter 1.8 mm, length 3.5 mm) [2]
Electric connector			flex connector / Molex FCC 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			IP33 [4]
Materials in contact with media			poly propylene (PP)
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. flow	14 ml/min +/- 15% (300 Hz)
		Max. back pressure	150 mbar +/- 15% (300 Hz)
Liquids	Water	Max. flow	5 ml/min +/- 15% (100 Hz)
		Max. back pressure	650 mbar +/- 15% (100 Hz)
	MeOH	Typ. max. flow	6.8 ml/min (100 Hz)
		Typ. max. back pressure	550 mbar (100Hz)

[1] Typical values. Values can vary under application conditions. Content is subject to changes without notice.

[2] recommended tubing: 1 mm inner diameter.

[3] Conditions: suction pressure < 10 mbar, DI water, settings mp-x: 100 Hz, 250 V, SRS, the max. flow rate will be reached after a few minutes of operation time.

[4] Can be changed to IP44.

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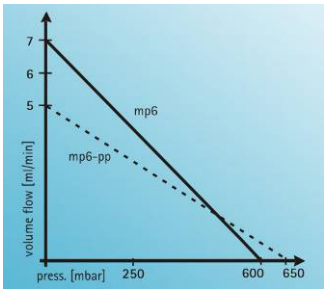
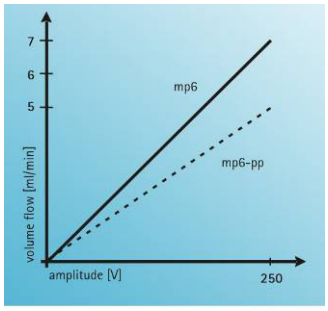
3.3 Typical flow characteristics mp6 and mp6-pp

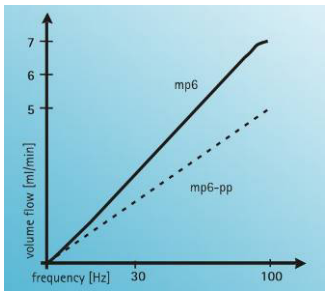


The flow rate of the pumps shows a linear dependency on the back pressure.

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.

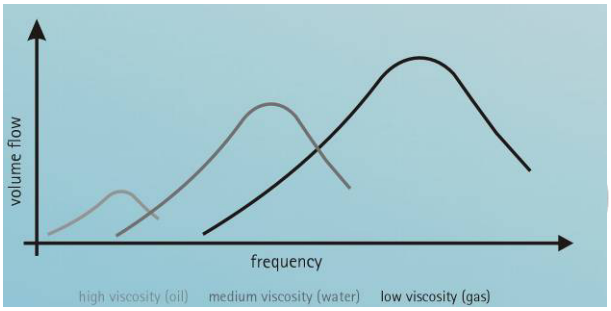
Increase in amplitude linearly increases the flow rate to the maximum.
The amplitude defines the stroke of the actuator and therefore the displacement of the pumping media per pump cycles.





Rising frequencies result in a maximum flow rate at resonance frequency. At frequencies above the resonant point the flow rate decreases again.

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.



3.4 Final inspection

After production the micropumps have to pass a final inspection. They are tested concerning the maximum flow and back pressure and the self-priming characteristic (conditions: suction pressure < 10 mbar; DI water; settings mp-x: 100 Hz, 250 V, SRS, the max. flow rate will be reached after a few minutes of operation time).

Measurement conditions
Pump media: DI-Water

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Temperature: room temperature
Controller: extended box mp-x
Electrical Input: amplitude of 250Vpp and SRS-Signal with 100 Hz
Sensors used:

Flow sensor
- Range: 0 - 10 ml/min
- Accuracy: +/- 1%FS (=0,1 ml/min)

Pressure Sensor
- 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; 250Vpp, SRS-Signal, 300 Hz)

Flowrate [ml/min]:	min. 15.3	typ. 18.0	max. 20.7
Backpressure [mbar]:	min. 85	typ. 100	max. 115

Specifications mp6-pp

Flowrate [ml/min]:	min. 5.1	typ. 5.0	max. 6.9
Backpressure [mbar]:	min. 467.5	typ. 650	max. 632.5

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. On the basis of these results a replacement can be carried out within 14 days after delivery free of costs.

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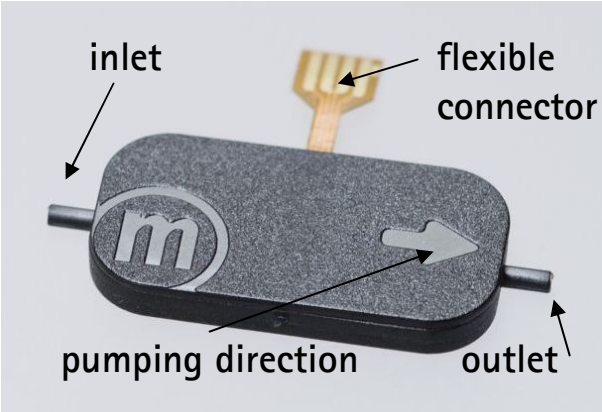
4. Operating the micropump

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 and ~1 mm for the mp6-pp. The micropump has to be connected to a suitable controller as described in the next sections.

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 a maximum amplitude of 250 V at a frequency between 0 and 300 Hz. A rectangular signal results in best fluidic performance while a sine wave minimizes the audible noise. The actuators must be driven with a 180° phase shift in the signal.

If a pump gets 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.

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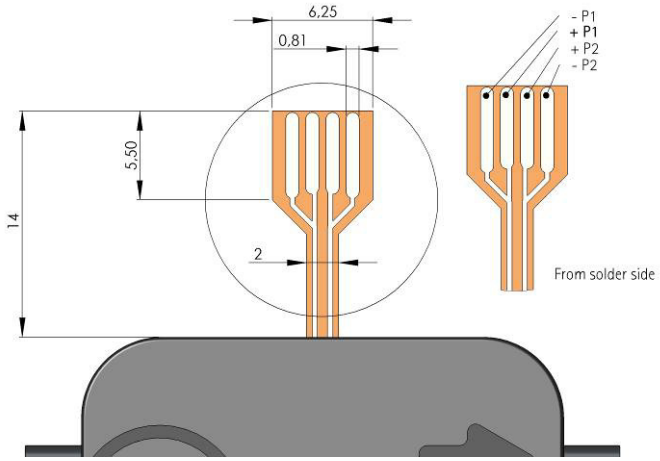
4.1.1 Connecting the mp6/mp6-pp to the cable

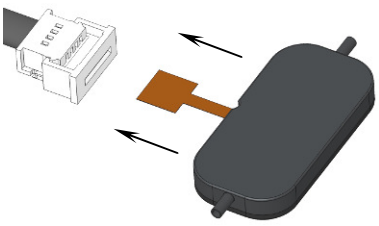
The mp6/mp6-pp pump can be connected via a standard electrical connector manufactured by Molex. The layout of the connector and pin assignment of the mp6/mp6-pp is as shown below. Each piezo (P1 / P2) has a single lead for the negative (-P1/-P2) and the positive (+P1/+P2) supply voltage.



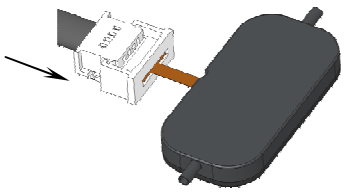
Subject to change without further notice

The recommended connector is a 4 pin 1.25 mm pitch FCC connector manufactured by Molex, part number 39 53 2045. 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.

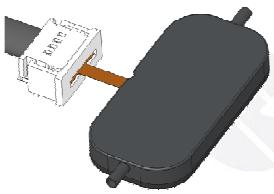
To connect the mp6/mp6-pp and Molex, refer to following three figures. Orientate both components as indicated on the first picture, the mp6/mp6-pp facing downwards with its serial number marking (!) and the molex connector with the four small openings visible from above. Then insert the mp6/mp6-pp flex 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 of both pump and connector with e.g. silicone might 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 (iso-propanol) or if necessary with weak acid by pumping or by flushing with the help of a syringe.

!! Only use the syringe pulling from the outlet in pumping direction!!

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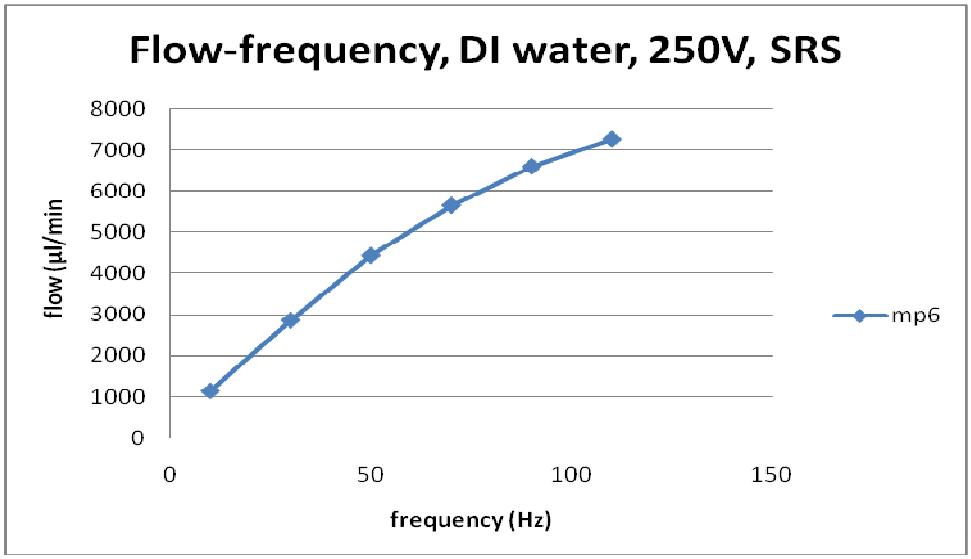
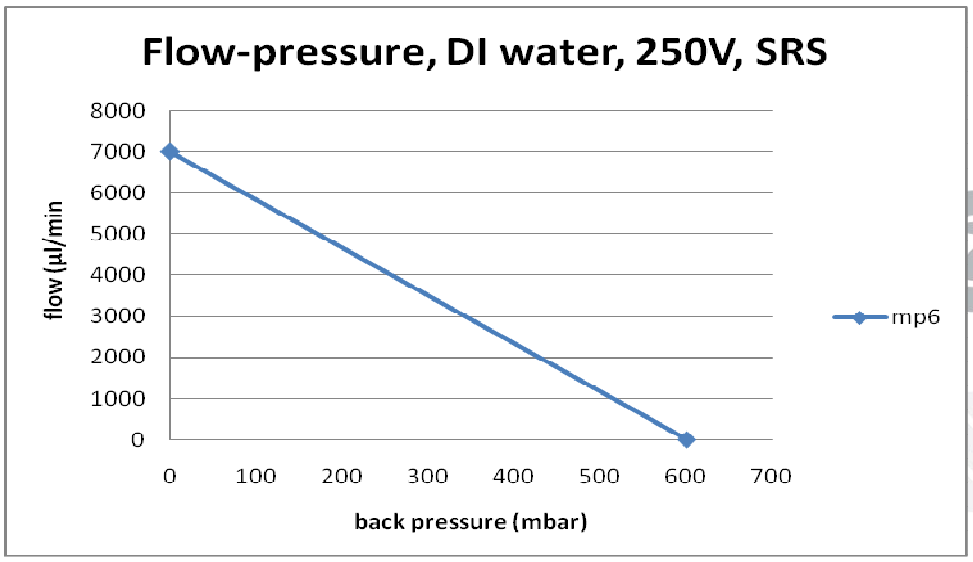
4.3 Typical operation parameters

4.3.1 mp6

4.3.1.1 Medium: DI water

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





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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 flow rate	Amplitude	Frequency		Target flow rate	Amplitude	Frequency
7 ml/min	250 V	100-110 Hz		2 ml/min	220-240 V	20 Hz
6 ml/min	250 V	80-9 0Hz		1 ml/min	125-135 V	20 Hz
5 ml/min	250 V	55-65 Hz		0,5 ml/min	90-100 V	15 Hz
4 ml/min	250 V	40-50 Hz		0,25 ml/min	85-95 V	8 Hz
3 ml/min	250 V	30-35 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.

4.3.1.2 Medium: air

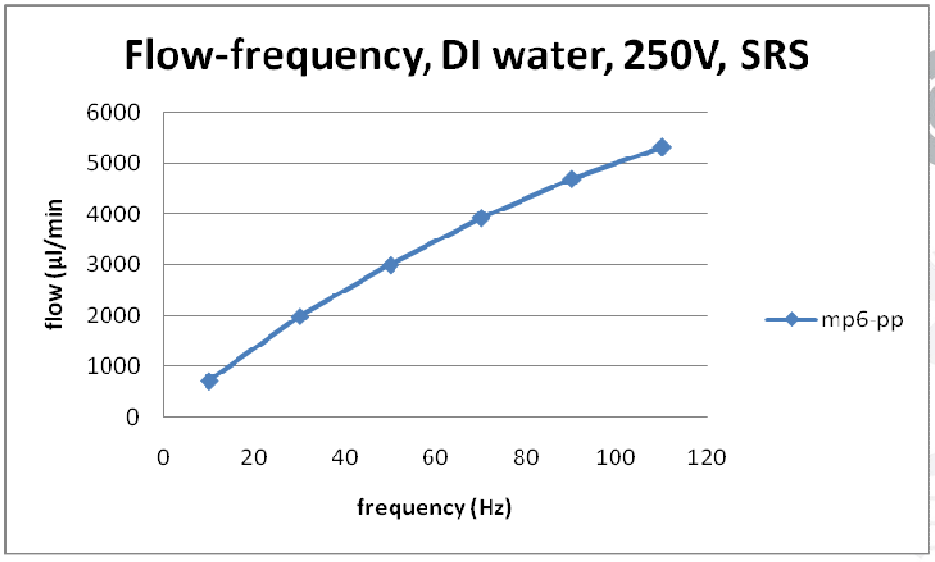
Driving the micropump with the controller mp-x at 300 Hz with 250 V, flow rates of 18 ml/min and backpressures of up to 100 mbar have been achieved.

In general, for driving the pump with air, higher frequencies should be used than for water. To minimize audible noise, using the sine signal is recommended. As this is preliminary data, please contact us for more information when you intend to use the pump with air.

4.3.2 mp6-pp

4.3.2.1 Medium: DI water

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



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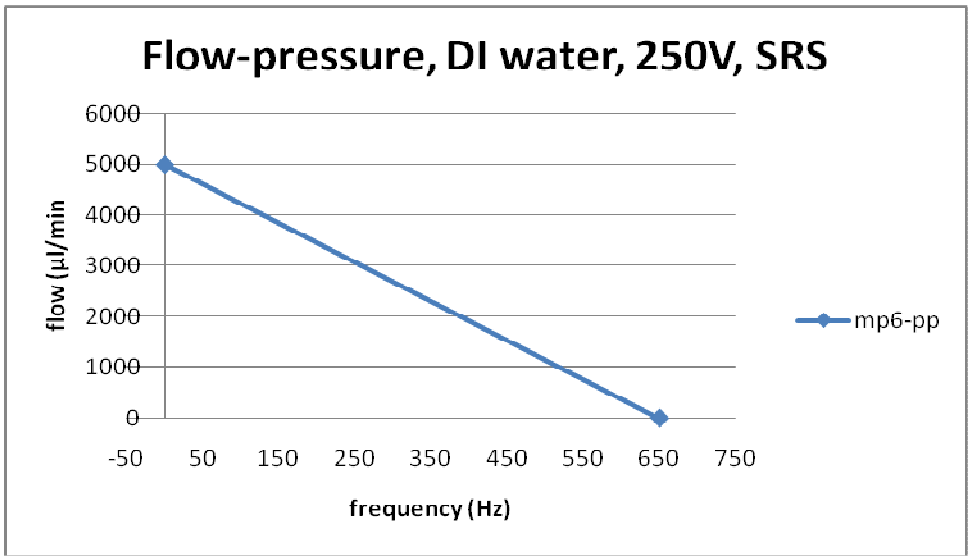

To achieve individual flow rates and optimal flow conditions, the driving parameters need to be tested, optimized and confirmed by testing under full application conditions. As an example, typical driving parameters are listed below to give a general orientation for testing. The parameters have been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

Target flow rate	Amplitude	Frequency		Target flow rate	Amplitude	Frequency
6 ml/min	250 V	120-130 Hz		1 ml/min	180-190 V	20 Hz
5 ml/min	250 V	90-100 Hz		0,5 ml/min	130-140 V	15 Hz
4 ml/min	250 V	60-80 Hz		0,25 ml/min	120-130 V	8 Hz
3 ml/min	250 V	40-50 Hz		0,1 ml/min	95-105 V	4 Hz
2 ml/min	250 V	30 Hz				

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

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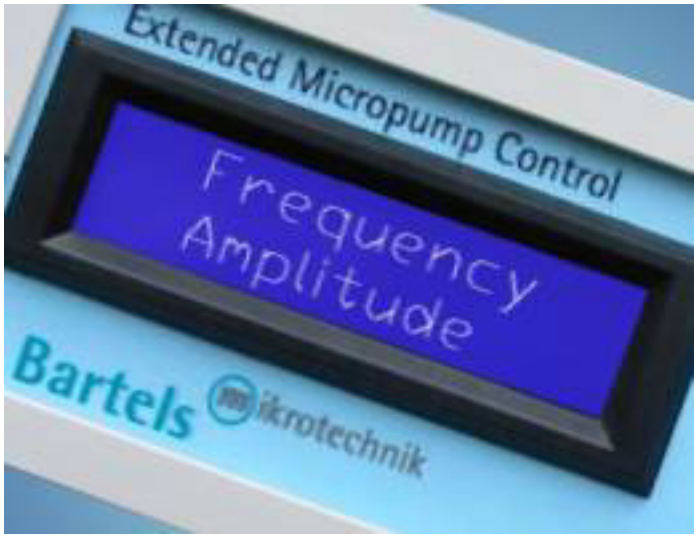
5. The mp-x controller

5.1 Technical specifications mp-x controller

Dimensions	7.5 x 16 x 20 cm³
Weight	approx. 800 g
Pumping media	liquids or gases
Max. flow water	mp6: 7 ml/min (SRS, 250V, 100 Hz) mp6-pp: 5 ml/min (SRS, 250V, 100 Hz)
Controlling 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 with 7.5 V
USB (port)	one, a CD with driver software is enclosed.



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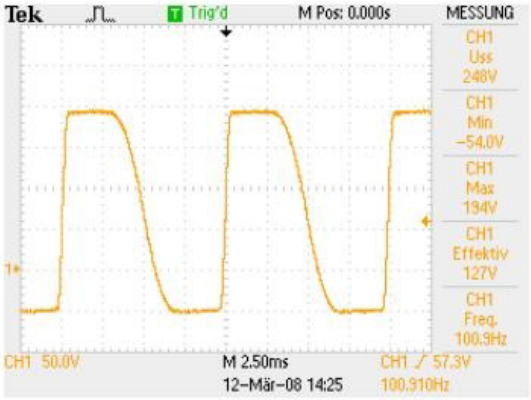
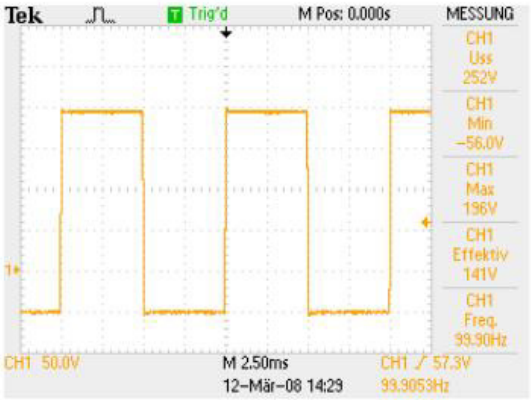
5.2 Electrical signal form

SRS:



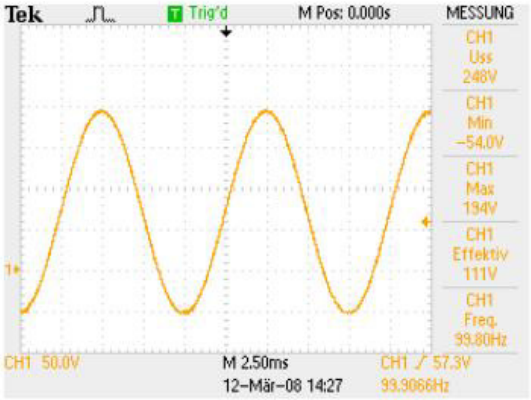
mpx, SRS-Signal, 250Vpp, 100Hz

Rectangular:



mpx, Rectangel-Signal, 250Vpp, 100Hz

Sine:



mpx, Sine-Signal, 250Vpp, 100Hz

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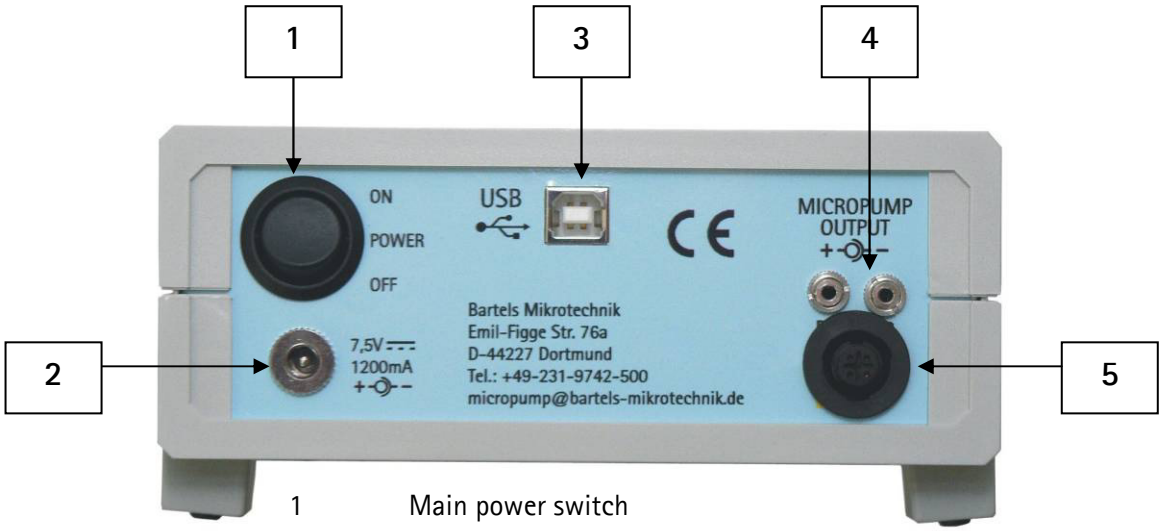
5.3 Connecting the pump to the mp-x



1	Main power switch
2	Power supply connector
3	USB interface for computer connection
4	Two connectors for the mp5
5	One connector for the 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 can't 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.

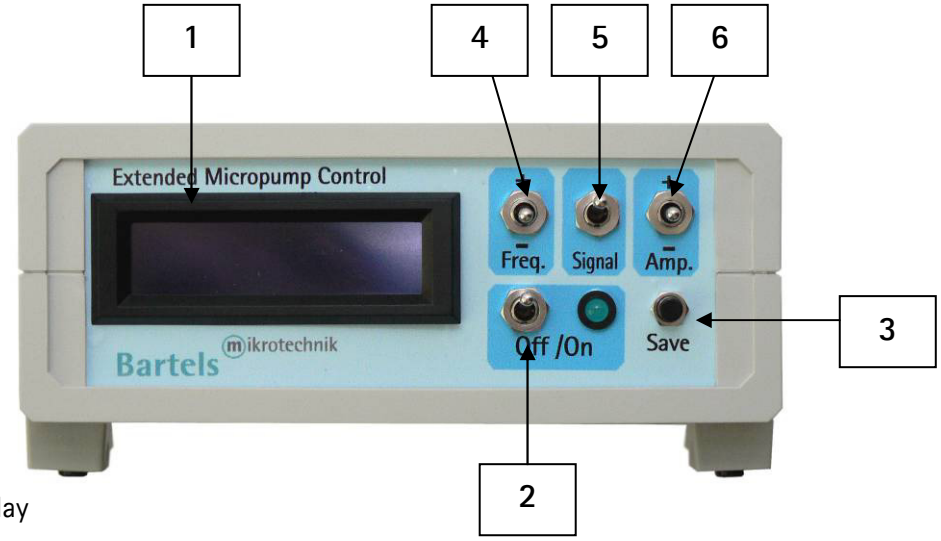
⚠ DANGER
THE "MICROPUMP OUT" CONNECTOR CAN CARRY HIGH VOLTAGE ! BE CAREFUL, WHEN YOU PLUG IN THE MICROPUMP CONTROL CABLE!

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 and signal wave form.

It is possible to change the settings while the pump is operating. But to extend the life time 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 Frequency (0 – 300 Hz): push the switch up to raise and down to reduce the frequency

5 Signal form modus: push the switch once to choose between SRS, rectangular or sine

6 Amplitude (0 – 250 V): 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.

Before the control unit is turned off, you can save the present settings by pushing the save switch. For shutdown of the pump please switch off the mp-x first and then disconnect the power plug. Do not unplug the micropump before switching off the controller.

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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 older operating systems including "Windows XP"

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: Activate the box "search for new driver" and insert the accompanying CD.

Step 4: After you have found the driver "USB Micropump Control", click "next" to start the installation. Maybe a message appears that the windows-logo-test has failed. This warning can be ignored. After installation click "complete" to finish the installation.

Step 5: After finishing the installation the assistant will start again to install the corresponding USB serial port by repeating the description.

5.5.2 For operating system 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. This dialog does NOT allow to install the software.

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: Second the serial port needs to be installed. Starting with step 2) again, a device named "USB serial port" will be listed. The drivers need to be installed as described above.

Step5: Finally in the device manager the number of the serial port (e.g. COM 4) is listed, for further use of the device with application programs, the port number should be noted.

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 any software (or programming language) capable of sending commands to a COM-Port, like the Hyperterminal as shown below.
As the Hyperterminal is not available in Windows 7 anymore, other free terminal programs are recommended like PuTTY for example http://www.putty.org/

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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 (9600, 8, n,1).

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 Hertz: ...for example 100 Hertz.
A(0-250) A100,5	sets the required amplitude between 5 and 250 Volt: ...for example 100,5 Volt. (in increments of 0.5 Volt)
MS	sets signal form modus (S)ine
MR	sets signal form modus (R)ectangle
MC	sets signal form modus SRS
(enter key)	displays present settings of the control unit

The unit can also be used via LabView, Matlab or other programs. Using the unit with LabView, please ensure that the "NI-Serial" package is installed. Normally the package is installed on yoursystem together with LabView, but sometimes this option is skipped during install.
It can be downloaded on the National Instruments website:
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 do however not offer a complete software environment for the use of the mp-x controller. Development of specific software routines can be offered on request.

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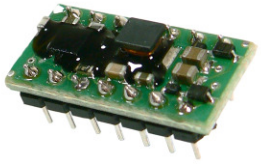
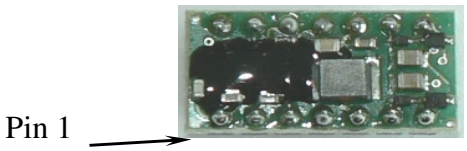
6. The mp6-OEM controller

The mp6-OEM is a small, easy to use low cost driving circuit developed for the mp6 or mp6-pp micropump. It generates up to 235 V peak to peak 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.
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. Looking onto the mp6-OEM from the top with the black encapsulation on the left side, Pin 1 is in the lower left. The pin is as well marked by a small white spot.

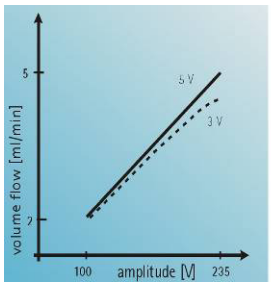




6.1 Technical specifications mp6-OEM

Dimensions	10,5 x 20,5 x 6 mm³
Pumping media	liquids or gases
Adjustable parameters	amplitude / frequency
Amplitude range	85 – 235 V
Frequency range	25 – 120 Hz (frequencies up to 1000 Hz possible, but output voltage will decrease, frequencies down to 1 Hz are possible using an external frequency source)
Signal form	trapezoid
Power supply	2.5 – 5.5 V DC (5V recommended for full performance)
Current consumption	approx. 30 mA at 5 V
Max. flow rate mp6 (typ.)	4.5 ml/min (water)
Pin layout	DIL 14, Horizontal spacing ~2,54 mm, vertical ~7,62 mm

6.2 Typical flow characteristics mp6



6.3 Connecting the mp6 to the mp6-OEM controller

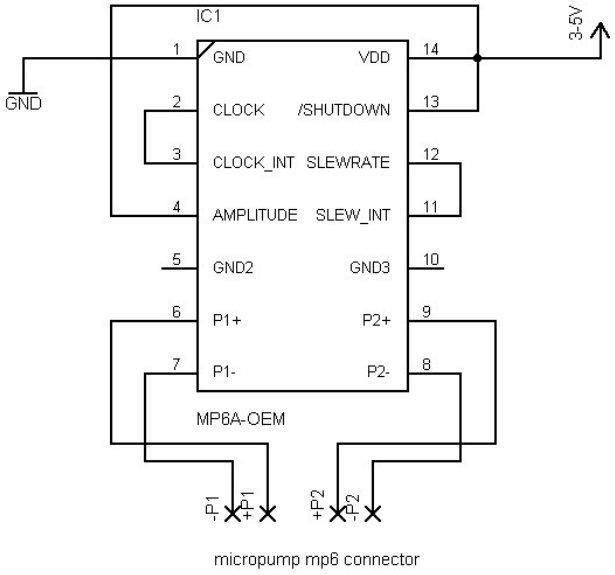
The mp6/mp6-pp pump can be connected to the mp6-OEM via a standard electrical connector manufactured by Molex, see chapter 4.1.1

DANGER
THE MP6-OEM MODULE CAN CARRY HIGH VOLTAGE ! BE CAREFUL, WHILE CONNECTING AND HANDLING THE MODULE!

6.4 Typical schematics

6.4.1 Fixed pump rate

The mp6-OEM can drive the mp6/mp6-pp without the need of external components. In this case the pumps frequency and amplitude is fixed determined by internal components to 235 V and 100 Hz.



Schematic 1: Fixed amplitude of 235 V and fixed frequency of 100 Hz ±10 % with internal components.

6.4.2 Pump rate set by external components

In this example the frequency and the amplitude is set by external components. The amplitude can be varied from approximately 85 V to 235 V peak to peak. The frequency can be changed from 25 Hz to 120 Hz. For higher frequencies the amplitude will decrease. Lower frequencies are also possible but stability of the output signal needs to be checked.

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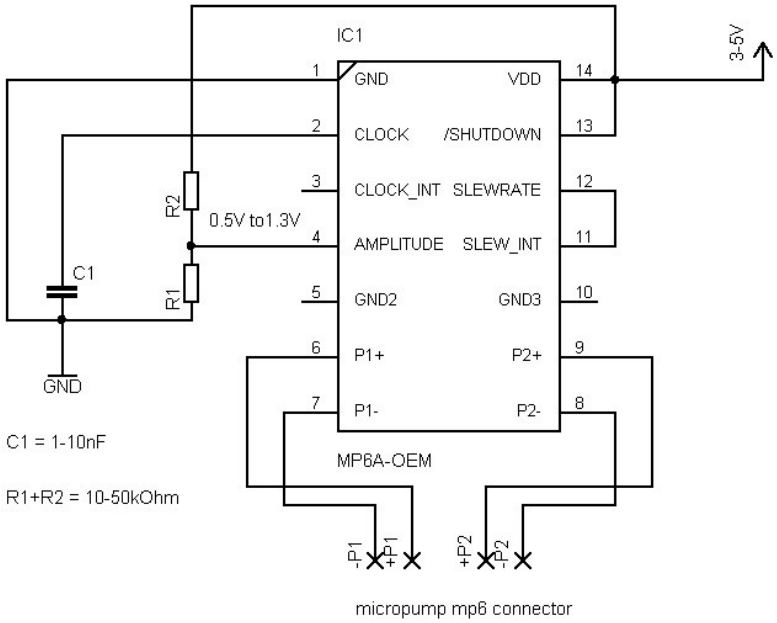
To set the amplitude, either a potentiometer with 10 kOhms, or a voltage divider of two resistors R1 and R2 as shown in the schematic 2 can be used. The voltage at the amplitude pin can be calculated with the following formula (voltage divider)

$$V_{AMPLITUDE} = V_{DD} \cdot \frac{R1}{R1 + R2}$$

The relation between the voltage at the amplitude pin and the output voltage is shown in table 7.1



Schematic 2: Frequency and amplitude set with external components

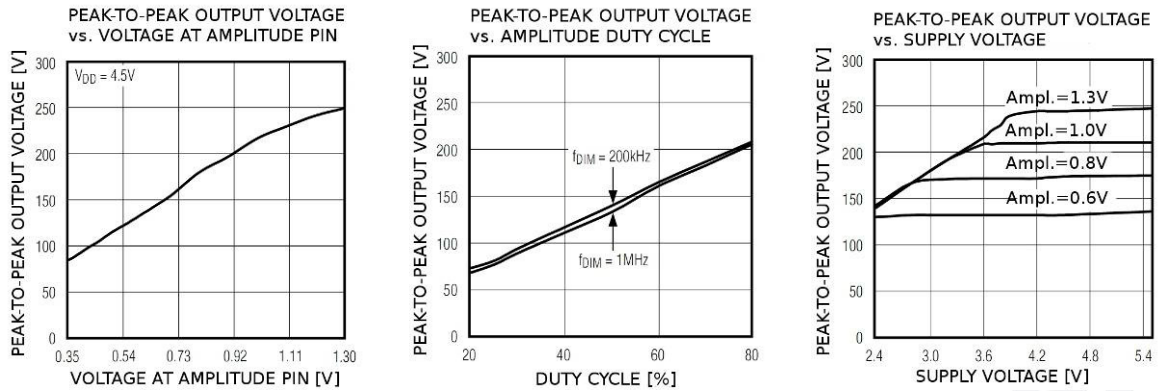


Table 6.1 : Behavior of output voltage according to external circuitry

To set the frequency, a capacitor C1 between in the nF range can be used as shown in the schematic 2 above. Typical capacitor values are shown in the following table 6.1.

For frequencies that are lower than 20 Hz, an external frequency signal needs to be applied as described in chapter 6.4.3.

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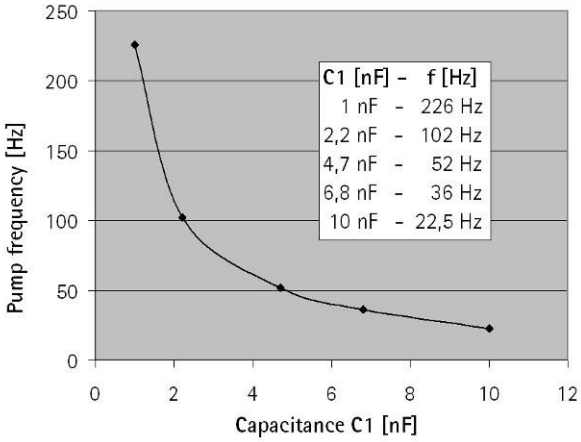


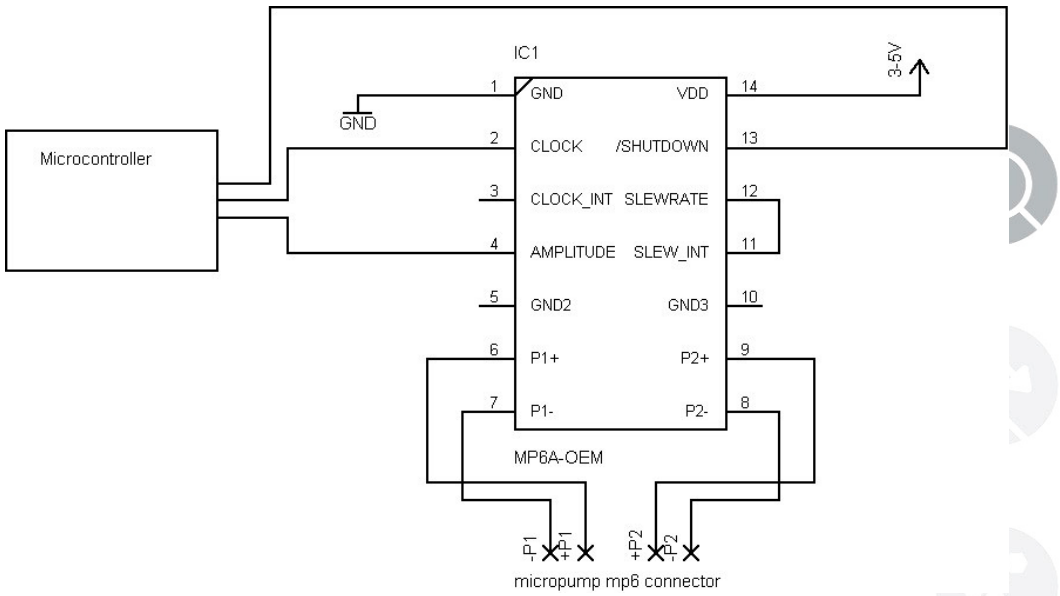
Table 6.2 : Typical capacitor values for different pump frequency values

6.4.3 Pump rate control via microcontroller

To control the mp6-OEM with a microcontroller, an external clock with four times the desired frequency connected to the CLOCK pin can directly set the output frequency. In this case the pump frequency can be decreased down to the single Hz range. Working at pump frequencies below 25 Hz, the duty cycle of the frequency signal needs to be high (95% on time) to result in an appropriate output signal.

The amplitude can either be adjusted by an analog voltage according to table 6.2, or by an equivalent PWM signal with a frequency between 0.2 and1 MHz connected to the AMPLITUDE pin (see table 6.2 for details). The PWM signal should be higher than 1.3 V to make the output solely dependent on the duty cycle of the PWM signal.

For a minimum of power consumption the electronics can be switched off by applying zero volts to the AMPLITUDE input and the SHUTDOWN port, but the most efficient way is to cut the power supply.



Schematic 3: External control via microcontroller

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6.5 Electrical characteristics

One mp6 connected, internally defined frequency and slew rate

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Power Supply Voltage	VDD		2.5		5.5	V
Power Supply Current, average	IDD	VDD = 5 V (1)			30	mA
Control voltage AMPLITUDE			0.35		1.3	V
Peak to Peak Output Voltage	Vpump	AMPLITUDE =1.3 V	230	235	245	V
Peak to Peak Output Voltage	Vpump	AMPLITUDE = 0.35 V	85	100	120	V
PWM frequency AMPLITUDE			0.2		1	MHz
Internal Pump Frequency	F	VDD = 5 V (1)	90	100	110	Hz
Digital Inputs Low				0		V
Digital Inputs High			2		VDD	V
Capacity at Clock Input			1.0	2.2	10	nF
Input Current AMPLITUDE			1		3	µA
Current in shutdown mode				1,6		µA

(1) Output signal set by internal components

6.6 Pin description

VDD	Power supply voltage
GND	Ground
SHUTDOWN	To shutdown the device, AMPLITUDE and SHUTDOWN needs to be tied to GND.
CLOCK	Output frequency control, the frequency can be set to nominal 100 Hz by connecting this pin to CLOCK_INT (Schematic 1) A capacitor of 1 to 10 nF can be connected between this pin and GND to set another frequency (Schematic 2) The output frequency can be set by a clock signal with **four times** the desired output frequency
CLOCK_INT	Output frequency control, the frequency can be set to nominal 100 Hz by connecting this pin to CLOCK
AMPLITUDE	Apply a DC Voltage (0-1.3 V) or a PWM signal (0.2-1 MHz) to this input to adjust the amplitude of the output from 100 V to 235 V
SLEWRATE	Slew rate control. This pin is connected to SLEW_INT
SLEW_INT	Internal slew rate resistance, connect this pin to SLEW
GND2, GND3	Internally connected to GND, can be left unconnected
+P1	Piezo 1 positive (see connection diagram for the mp6)
-P1	Piezo 1 negative (see connection diagram for the mp6)
+P2	Piezo 2 positive (see connection diagram for the mp6)
-P2	Piezo 2 negative (see connection diagram for the mp6)

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.

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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 (235 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

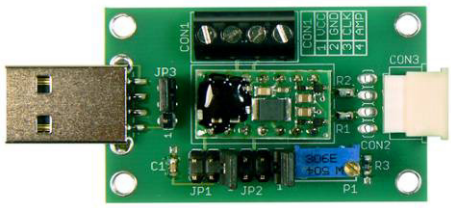
The mp6-OEM generates voltages of up to 250 V peak to peak. All parts of the mp6-EVA evaluation board can carry voltages in this range. Therefore the board should only be used by qualified personal. Although the output power of the module is very low, proper insulation according to the application conditions 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 of this manual for more details.

7.3 Functional elements



Elements are listed with their names according to the printed description on the PCB

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

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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

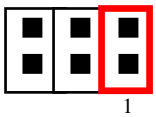
7.4 Operation

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

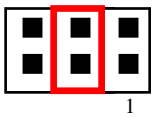
1) Connect the mp6/mp6-pp pump to the board according to the description in chapter 4.1.1. Due to the orientation of the connector, the pump needs to be inserted with its metallic contacts upwards.
2) Choose the pump frequency setting with Jumper 1
3) Choose the pump amplitude setting with Jumper 2
4) Choose the power supply setting with Jumper 3
5) Connect the board with the voltage source

7.4.1 Pump frequency setting with jumper J1

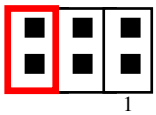
Setting of Jumper J1



Internal frequency of the mp6-OEM (100 Hz)



Frequency defined by capacitor C1 (predefined to 300 Hz)*
*50 Hz in versions delivered until July 2011

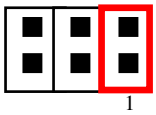


Frequency defined by CLK input on terminal CON1 – Pin 3

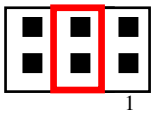
More information on the frequency setting with the CLK signal can be found in chapter 6.4.2. The capacitor C1 can as well be changed by resoldering, see table 6.2.

7.4.2 Pump amplitude setting with jumper J2

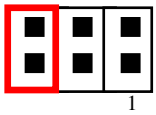
Setting of Jumper J2



Maximum voltage (235 V)



Amplitude defined by variable resistor P1



Amplitude defined by AMP input on terminal CON1 – Pin 4

More information on the amplitude setting with the AMP signal can be found in chapter 6.4.2.

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7.4.3 Operation voltage setting with jumper J3

Setting of Jumper J3

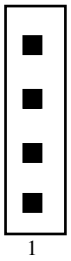
Driving voltage via screw terminal CON 1
Pin 1 (Vcc) and Pin2 (GND) of CON 1

Driving 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:



CON 2

P2 -	(negative voltage piezo 2)
P2 +	(positive voltage piezo 2)
P1 +	(positive voltage piezo 1)
P1 -	(negative voltage piezo 1)

For further details, please refer to chapter 4.1.1 of this manual. Please make sure that the cable can handle voltages up to 250 V peak-to-peak and ensure proper insulation of the cable.

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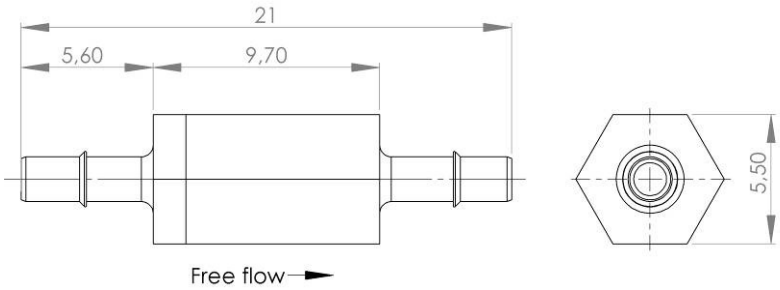
8. Passive check valve mp-cv

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:

Material	silicone, stainless steel
Fluidic connectors	barb inner diameter: 1.6 mm length: 5.6 mm
Cracking pressure	typically < 35 mbar
Max. back pressure	500 mbar
Leak rate	< 20 µl/h for liquids (500 mbar)

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

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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. Manual priming should be carried out by flushing the pump with the help of syringe. Only pull the fluid from the outlet in pumping direction. Do not exceed 1 bar of internal pressure. - 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 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 by SRS signal and at resonance frequency (100 Hz for water) - The flow rate is viscosity dependent as described in 3.2
Non-linear flow behavior	- The linear range of the pump characteristic is described for selected media in 3.2 - Gas bubbles in the pump act as compressible volume and when they are digested through the pump this can lead to non-linear flow behavior = 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 9.
No buzzing sound = pump is not working	- 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 also refer to our online Q&A section on the micropump website

http://www.micro-components.com/index.php/support/qaa

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