



PPS2 Peristaltic Perfusion System Manual



Imprint

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Multi Channel Systems MCS GmbH

Aspenhastrasse 21

72770 Reutlingen

Germany

Phone +49-7121-909 25- 0

Fax +49-7121-909 25-11

sales@multichannelsystems.com

www.multichannelsystems.com

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1 Important Information and Instructions

1.1 Operator's Obligations

The operator is obliged to allow only persons to work on the device, who

- are familiar with the safety at work and accident prevention regulations and have been instructed how to use the device;
- are professionally qualified or have specialist knowledge and training and have received instruction in the use of the device;
- have read and understood the chapter on safety and the warning instructions in this manual and confirmed this with their signature.

It must be monitored at regular intervals that the operating personnel are working safely.

Personnel still undergoing training may only work on the device under the supervision of an experienced person.

1.2 Guarantee and Liability

The general conditions of sale and delivery of Multi Channel System MCS GmbH always apply. The operator will receive these no later than on conclusion of the contract.

Guarantee and liability claims in the event of injury or material damage are excluded when they are the result of one of the following.

- Improper use of the device.
- Improper installation, commissioning, operation, or maintenance of the device.
- Operating the device when the safety and protective devices are defective and / or inoperable.
- Non-observance of the instructions in the manual with regard to transport, storage, installation, commissioning, operation, or maintenance of the device.
- Unauthorized structural alterations to the device.
- Unauthorized modifications to the system settings.
- Inadequate monitoring of device components subject to wear.
- Improperly executed and unauthorized repairs.
- Unauthorized opening of the device or its components.
- Catastrophic events due to the effect of foreign bodies or Acts of God.

1.3 Important Safety Advice



Warning: Make sure to read the following advice prior to install or to use the device and the software. If you do not fulfill all requirements stated below, this may lead to malfunctions or breakage of connected hardware, or even fatal injuries.



Warning: Obey always the rules of local regulations and laws. Only qualified personnel should be allowed to perform laboratory work. Work according to good laboratory practice to obtain best results and to minimize risks.



Warning: Be very careful with the rotating parts of the pump! Do not clamp something in between neither long hair nor a cravat, for example.

The product has been built to the state of the art and in accordance with recognized safety engineering rules. The device may only

- be used for its intended purpose;
- be used when in a perfect condition.
- Improper use could lead to serious, even fatal injuries to the user or third parties and damage to the device itself or other material damage.



Warning: The device and the software are **not** intended for medical uses and **must not** be used on humans. MCS assumes no responsibility in any case of contravention.

Malfunctions which could impair safety should be rectified immediately.

Requirements for the installation and operation

- Do not use the PPS2 peristaltic pump for perfusion with flammable or aggressive (corrosive) liquids.
- Do not store flammable materials nearby during operation.
- Check in regular intervals that the PPS2 pump does not overheat.

2 Installation and Operation

2.1 Welcome to the PPS2 Peristaltic Perfusion System



The **peristaltic pump PPS2** with **software control** is developed for the perfusion of biological samples. The pumps are driven by stepper motors providing a very long lifetime without maintenance. The durable brushless motors are extremely reliable, show very constant rotation speed, are vibration free and have low electromagnetic emission. These characteristics make the PPS2-System an ideal choice for electrophysiological experiments.

The device consists of two independent peristaltic pumps, one perfusion (inlet) pump for delivering perfusion solution to the sample, and one waste (outlet) pump to remove dispensable solution. The droplet isolator chambers avoid pulsation artifacts and allow optical fluid control.

If you need more than two channels you can connect several PPS2-Systems in serial. Each pump can still be controlled separately.

The flow rate of the pumps vary between 0 to 30 ml / minute. Other flow rates are available on demand, please contact MCS.

The PPS2 is a highly flexible system which can be controlled in different ways:

- The pump velocity and the flow rate can be controlled from a connected computer via USB connection and the included software PPS2.
- In future versions it will be possible to control the PPS2 with the LTP-Director software from Multi Channel Systems MCS GmbH. Please see chapter "Software Control".
- Additional analog and digital inputs allow to operate the PPS2 pump via external inputs, for example from a stimulus generator STG.
- It is also possible to operate the pump without software control, via touch screen on top of the device.

2.2 Setting Up and Connecting the PPS2 Pump



Warning: Do not start the perfusion until you have double-checked that the perfusion lines are set up properly and that the inflow and outflow rate are matching. Spilled liquid may irreversibly damage electronic instruments.

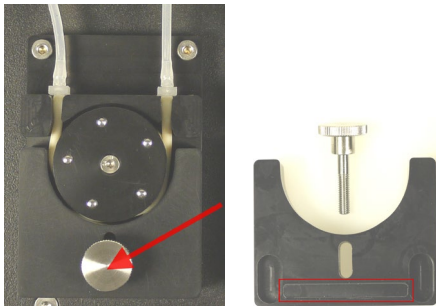
The PPS2 consists of two independent peristaltic pumps, which both are rotating counter-clockwise. The left one is intended for perfusion inlet, the right one for perfusion outlet. It is of course also possible to use both pumps as independent perfusion inlet pumps, and to use for example a vacuum pump for suction. This manual will focus on the intended function as inlet and outlet pumps. Each pump cycle contains a droplet isolator. The outlet pump is additionally equipped with a bubble detector.

Connecting the Tube Set

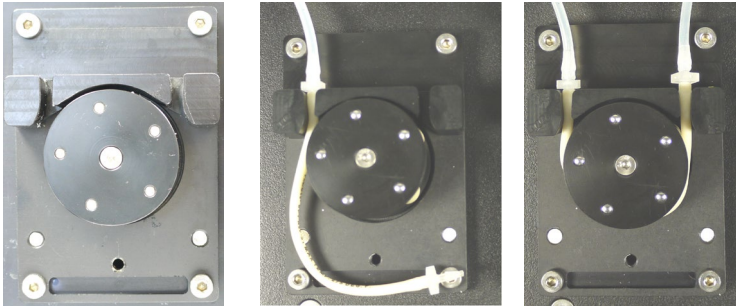
The following tubes are used:

- Identical Pharmed ® BPT (Saint-Gobain) tubes with an inner diameter of 1.65 mm and an outer diameter of 3.35 mm around the pump revolver and for the connection between outlet droplet isolator chamber and outlet pump, where the sensor of the bubble detector is located.
- A PVC tube with larger inner diameter is used for the tube to the waste bottle.
- Silicon tubing is used for all other connections.

The specified tubing must be used for the pump revolvers to ensure that the volumes set in the software are correct. Other tubing can be used for all other connections as well. Sets of ten tubes for replacement are available from Multi Channel Systems (For example: PPRT1.65-10 tubes: Pharmed ® BPT, ID: 1.65 mm, OD: 3.35 mm). Additionally, you can order a replacement set for all fluidic components PPS2-Set-F. Please see section "Ordering Information" in the Appendix.



For connecting or changing the tubes, please open the screw and remove the bracket of the pump revolver. Insert the provided tube and fix it with the luer tube connectors in the denoted way. To remount the bracket, take care to insert the bar of the bracket into the corresponding socket on the pump housing. Fix the screw firmly.



If you do not need the droplet isolator, please use the circllet and connect the heads of the tube with a luer adapter.



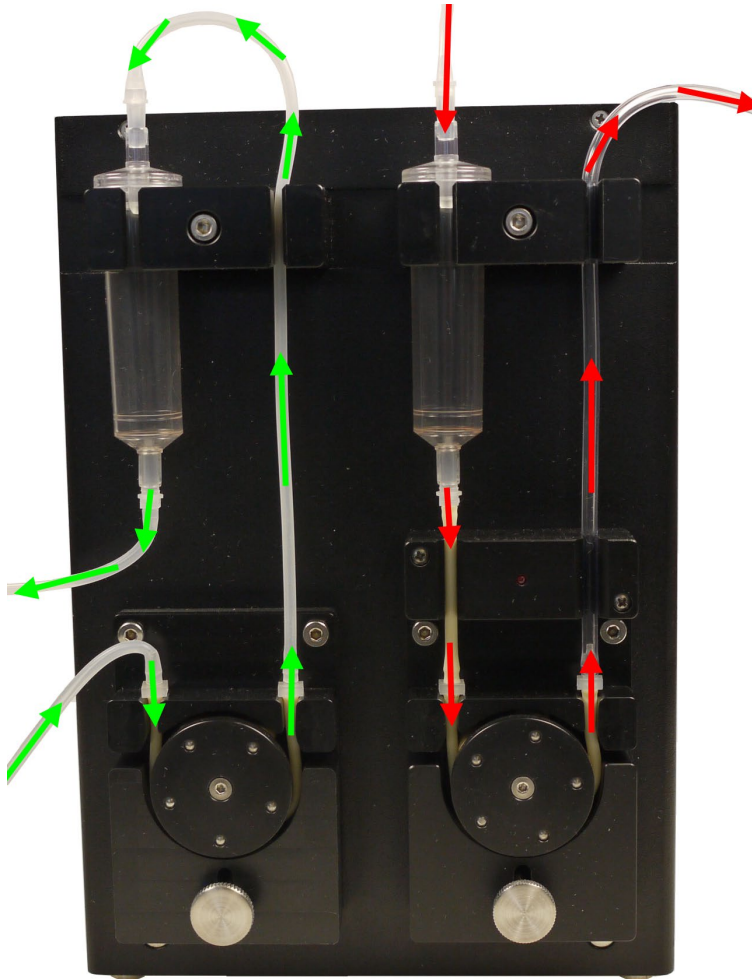
2.2.1 Use of Droplet Isolators

The droplet isolators can be used to disrupt the direct liquid column from the pump to the sample. This can help to remove low frequency noise originating from the pulsation of the pump head. On the other hand, the droplet isolators make the flow speed inaccurate, and cause a continued flow even after the pump is stopped. If the flow rate is high (approximate $> 6 - 8 \text{ ml / min}$) the droplet isolators will fill up over time and might even overflow.

The suggested procedure is to start working without the droplet isolators and use them only in case unacceptable fluctuations caused by the pump occur in the recordings which cannot be removed otherwise, for example by using a 10 Hz high pass filter.

Complete Setup

The left pump of the PPS2 is intended for perfusion inlet, the right one for perfusion outlet. Please connect all tubing and droplet isolators as indicated on the following image. Take care to use the short Pharmed ® BPT tube between outlet pump and droplet isolator.

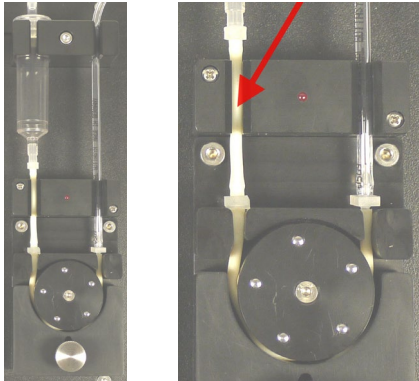


Warning: The droplet isolators remove pulsation artifacts, but also cause a continuing flow even some time after the pumps are stopped. To avoid flooding, please use hose clamps to stop the flow. Do not forget to open the clamps when you restart the pump.

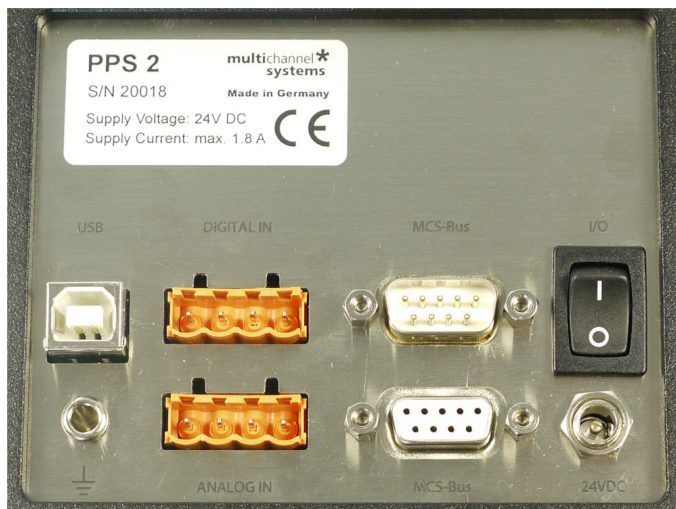
Bubble Detector

The bubble detector connected to the outlet detects the amount of bubbles in the outlet tube. A low number of bubbles can indicate that the perfusion outlet cycle is not working properly, so the bubble detector can be used as an alarm system to prevent flooding of the recording equipment.

The sensor of the bubble detector is on the left side of the LED, the short Pharmed ® BPT tube has to be guided through the bubble detector as shown on the picture. The LED indicates the fluid flow: The LED is constantly on without tube, when the fluid flow is not correct it flashes fast, with correct flow the LED flashes slow. Please pay attention to the LED. See also chapter "Software".



Rear Panel



1. Connect the PPS2 pump with the provided power supply cable to the power supply.
2. Connect the PPS2 pump with an USB cable (type A – B) to an USB 2.0 port.
3. If necessary, connect the ground connector to the ground of your recording system.
4. Use the "I/O" switch to switch the PPS2 on and off.

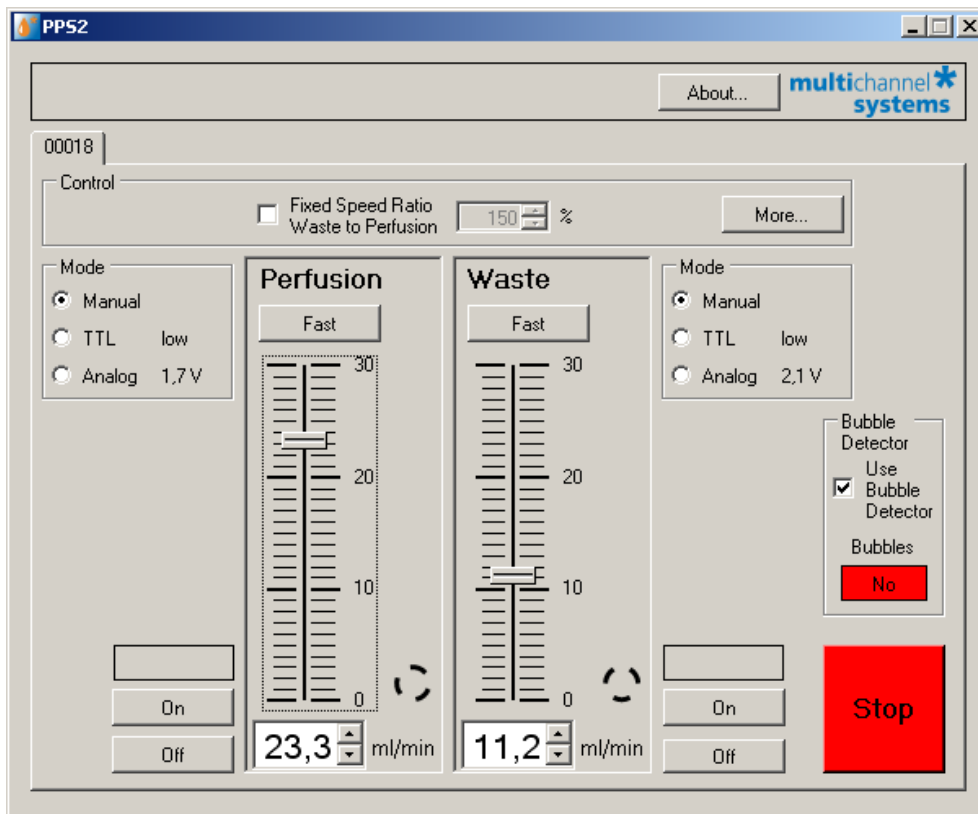
As additional means to control the PPS2, inputs for analog or digital (TTL) signals are provided. These inputs can be used to start / stop the pump and control the pump speed by external signals.

It is possible to connect several PPS2 devices via USB hub to one computer to be controlled by the same software. In future versions the MCS Bus interface can be used to connect several PPS2 devices in series, also controlled by the same software application.

2.3 Control Options

The PPS2 perfusion system can be controlled via USB connection by the provided software PPS2. In future versions it will be possible to control the PPS2 also with the LTP-Director software from Multi Channel Systems MCS GmbH. The device can also be controlled independently from a computer connection via touch screen.

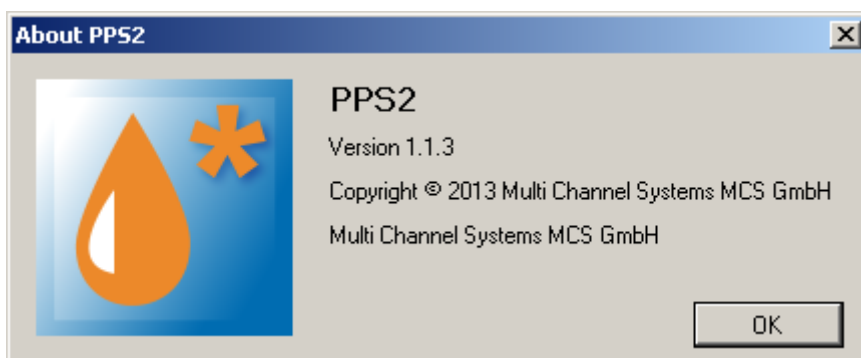
2.3.1 Operation of the Perfusion Peristaltic Pump with PPS2 Software



PPS2 software is running on Microsoft Windows® systems Windows XP or higher.

About

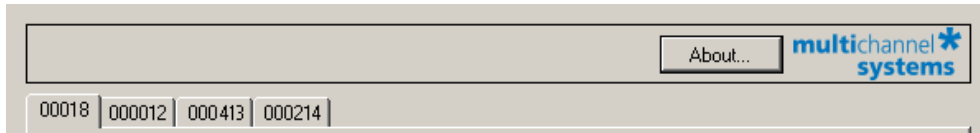
Click the "About" button to see the software version. Free software updates will be available on the MCS web site. Please check <http://www.multichannelsystems.com/downloads/software>.



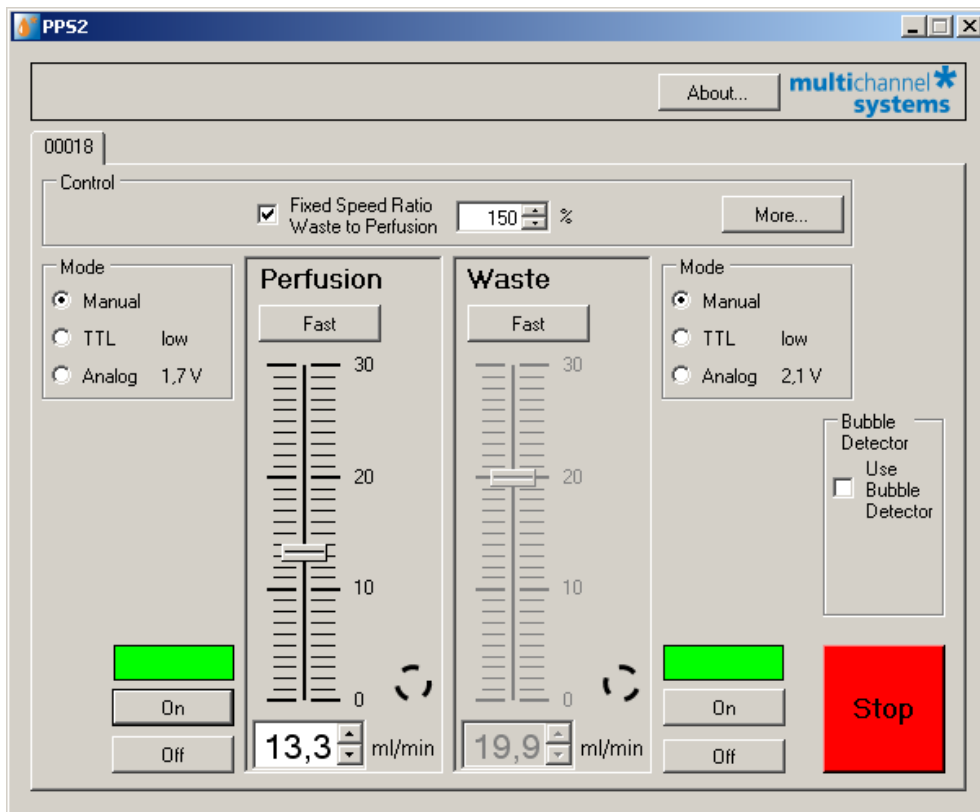
Main Window of PPS2 Software

Manual Control Mode

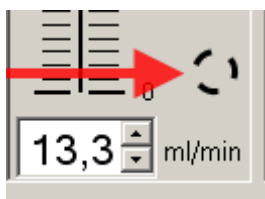
When using more than one PPS2-System, connected via USB cable, one main window tab page will be available for each PPS2 connected. The tab slider will show the serial number of the devices. The pumps can be operated independently from each other. Only the **"Stop"** button will affect all connected pumps, all other control functions are independent.



The intended use for the PPS2-System is the perfusion of a biological sample on a MEA and the aspiration of the waste solution. To avoid flooding of the amplifier, the flow rate of the outlet must always be higher than the flow rate of the inlet. Select the check box **"Fixed Speed Ratio Waste to Perfusion"** in %. Via slider or up-down box you can choose the relation between the velocity of the waste and the perfusion pump. If the "Fixed Speed Ratio" function is active, both pump speeds will remain at the same relative relation, and only the control slider for the perfusion pump is active.



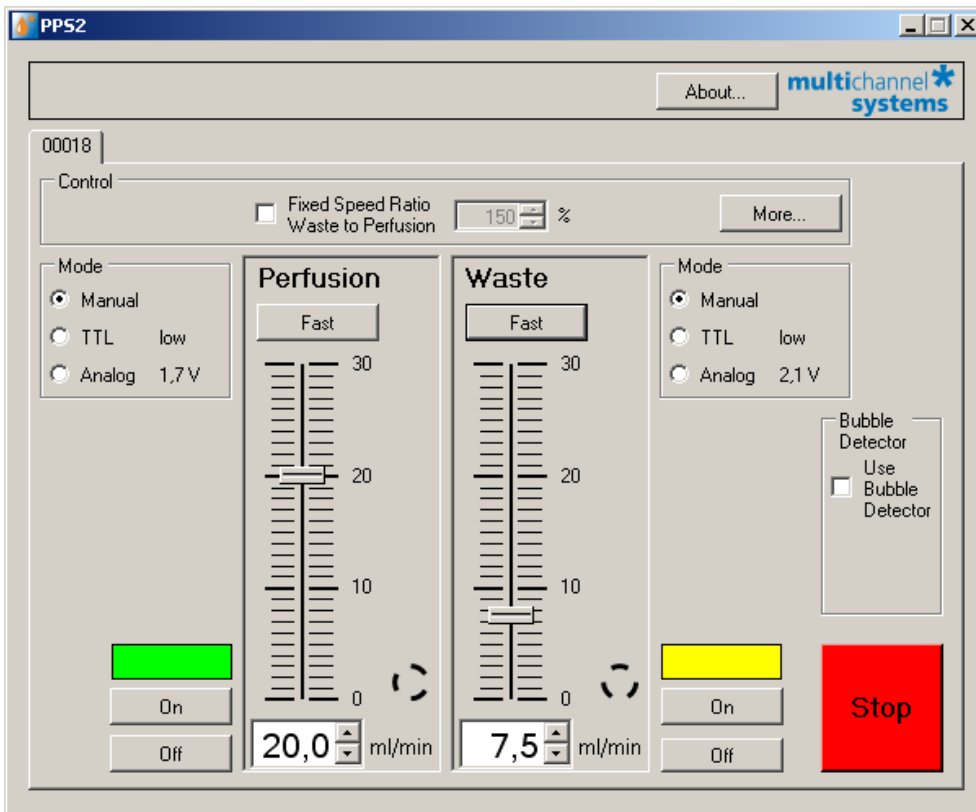
The green color of the buttons above the "On" and "Off" buttons indicate that the respective pump is running. Additionally, the speed symbol is rotating.



Click the button "**More**" to display further information. At the moment, the default "Analog Range" of the analog input and the internal "Supply Voltage" is noted.



For using both pumps independently, deactivate the check box "Fixed Speed Ratio".



With the two sliders, the speed of the left **Perfusion** (inlet tube) pump, and the right **Waste** (outlet tube) pump can be controlled. The unit is milliliter per minute, the maximum is 30 ml / min for the inlet and 30 ml / min for the drain, if no relation between both parameters is selected. Alternatively, type the desired value into the text box below the slider or click the up-down box. The resolution is 100 µl / min. Click the button "**On**" to start the pump of your choice and the button above will turn to green. Click "**Off**" to stop the pump and the button above turns to grey. It is possible to change the velocity via slider or by writing into the window while the pump is running. Clicking the button "**Fast**" sets the pump speed to maximum as long as the button is pressed. The yellow color indicates the "**Fast**" mode. This feature can be used for rinsing the tubes, for example.

The Peristaltic Perfusion PPS2-System has three different operation modes via software and the additional possibility to control the device without computer connection via touch screen. Please see chapter "Operation of the Perfusion Peristaltic Pump via PPS2 Touch Screen".

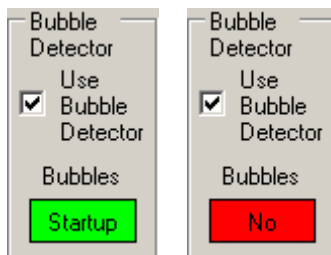
Stop



The "On" and "Off" buttons will affect one pump of the PPS2. The "Stop" button will always stop both pumps. If several pumps are connected with a serial cable, all connected pumps will be stopped.

Bubble Detector

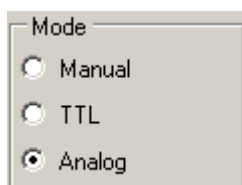
The bubble detector can be used as an alarm system to prevent flooding of the recording equipment. A light barrier detects the changes of fluid to air in the outlet tube and measures whether this event takes place at least once every ten seconds or not. More than one bubble per 10 seconds is considered okay, less is considered as an indicator that the fluid flow in the outlet is too low. The LED is constantly on without tube, when the fluid flow is not correct it flashes fast, with correct flow the LED flashes slowly.



Select the check box "Use Bubble Detector" to use the function of the bubble detector. The detector is only active while the pump is running and the "Bubbles" button turns to green "Startup".

When fluid flow in the outlet tube is too low or too high, the bubble detector stops the inlet perfusion pump automatically. The waste pump runs continuously to prevent overflow. The button turns to red "No".

External Control: Digital (TTL) and Analog Mode



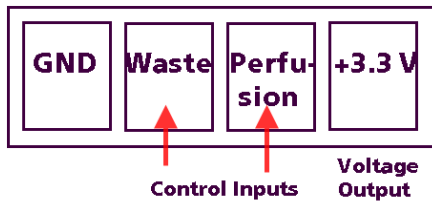
External control via analog input or digital TTL input allows the same functions as the manual mode or the controlling via touch screen without software. You can use different modes for each pump.

The pump speed is still selected in PPS2 software, and the pump status has to be "On", as the state of the external input and the pump state are in a logical **AND** relation:

Digital Mode: The digital input must be "high" **AND** the pump must be "On" to start the pump.

Analog Mode: The analog input must be > 0.0 V **AND** the pump must be "On" to start the pump.

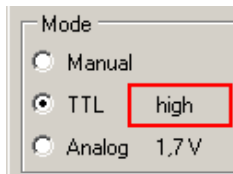
When looking directly to the rear panel of the PPS2 the pin layout of the digital and analog inputs are as shown on the picture.



Connect either a TTL or an analog output device to the respective inputs and select the desired control mode in the PPS2 software. In sum (digital and analog input), the maximum load current for the voltage output (+3.3 V) is 100 mA.

Digital Control

Connect, for example a stimulation generator STG4000, to the "Ground" and "Control Input(s)" of the digital input on the rear panel. The "Voltage Output" is not needed. The status of the TTL inputs are displayed in the "Mode" window. If nothing is connected to the TTL inputs the status is low.



TTL input low ($\leq +0.4$ V) \rightarrow pump off.

TTL input high ($\geq +1.5$ V) \rightarrow pump on.

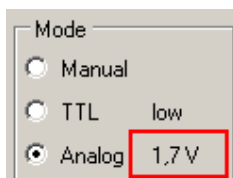
As long as the status of the TTL input is high, the respective pump will run at the speed selected in PPS2 software. The maximum voltage for the TTL input is +5.5 V.

Analog Control

With the analog control, it is possible not only to start and stop the pump by an external device, but also the pump speed. Connect an adjustable voltage source, for example a potentiometer to the "Ground" and "Control Input(s)" of the analog input on the rear panel. The pin layout of the analog input is the same as for the digital input when looking directly to the rear panel of the PPS2. If nothing is connected to the analog inputs the status is 0.0 V.

The maximum voltage for the analog input is +10.3 V.

The current voltage level on the analog inputs is displayed in the "Mode" window. The analog range is by default +5.0 V, as stated in the dialog "More".



The resulting fluid flow of the pumps can be calculated by the following equation:

$$\text{flow rate} = \text{selected flow rate} \times \frac{\text{analog input voltage}}{\text{analog range}}$$

Example:

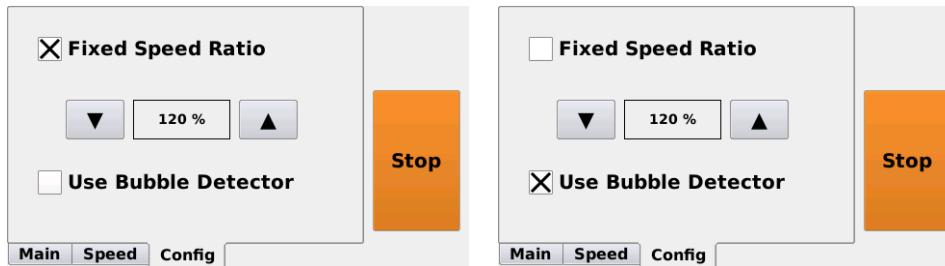
Selected flow rate 5ml / min x (analog input voltage 10 V / analog range 5 V) = 10 ml / min.

2.3.2 Operation of the Perfusion Peristaltic Pump via PPS2 Touch Screen

Alternatively it is possible to operate the peristaltic pump without software control, via touch screen on top of the device. The touch screen provides the same control functions of the PPS2 which are available via software. The pumps can be operated independently from each other or in a fixed ratio. The **"Stop"** button will always affect both pumps. The touch screen has three windows, **Configuration**, **Main** and **Speed**.

Configuration Window of PPS2 Touch Screen

Please open the **"Configuration"** window first because settings done here influence the settings in the **"Main Window"** and the **"Speed Window"**.



Select the check box **"Fixed Speed Ratio"**. Via up and down arrows you can choose the relation between the velocity of the waste and the perfusion pump. If the **"Fixed Speed Ratio"** function is active, both pump speeds will remain at the same relative relation. For example, 150 % to make sure that the waste pump runs faster than the perfusion pump. Define a ratio below 100 % and the perfusion pump will run faster than the waste pump.

Note: If the waste perfusion pump is used for the suction of "waste" do not use a ratio below 100 %, this will result in flooding of the connected device!

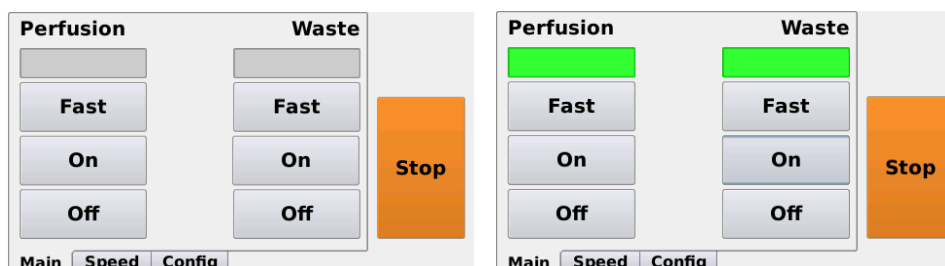
Bubble Detector

The bubble detector connected to the waste pump tube detects insufficient flow in the waste tube. This can be an indicator for a problem with the perfusion. A light barrier detects the changes of fluid to air in the outlet tube and measures whether this event takes place at least once every ten seconds or not. More than one bubble per 10 seconds is considered okay, less is considered as an indicator that the fluid flow in the outlet is too low. The LED is constantly on without tube, when the fluid flow is not correct it flashes fast, with correct flow the LED flashes slowly. When the bubble detector detects too low fluid flow in the outlet tube, the inlet perfusion pumps will be stopped automatically. The waste pump runs continuously to prevent overflow.

Select **"Use Bubble Detector"** to switch the bubble detector on. This option influences the **"Main Window"**. The indicator **"Bubbles"** is only visible in the main window when the check box is selected here.

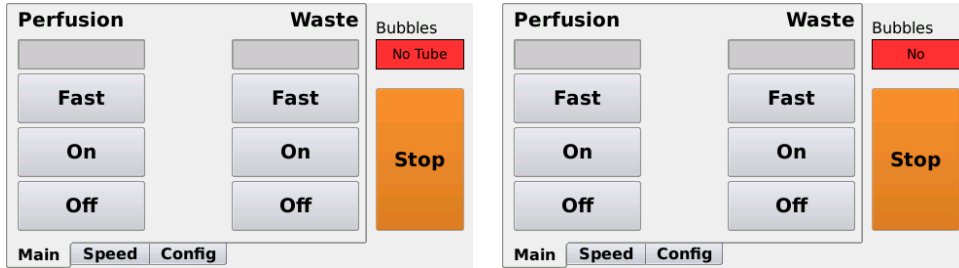
Main Window of PPS2 Touch Screen

In the **"Main Window"** you can start and stop the pumps separately. The **"Fast"** mode is, for example for rinsing the tubes, the pump runs fast as long as the **"Fast"** button is pressed. The color of the button above indicates whether a pump is running or not.

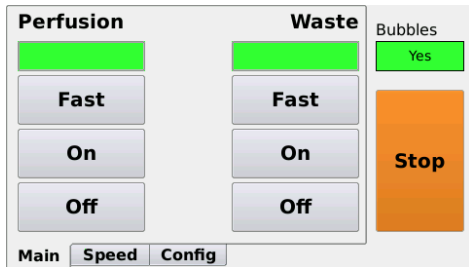


The pictures shows the “**Main Window**” of the touch screen. The “**On**” and “**Off**” buttons are connected for the operation of both pumps. The grey color of the upper buttons indicate that no pump is running at the moment, the green color indicates running pumps.

Select the check box “**Use Bubble Detector**” in “**Configuration**” to switch the bubble detector on and the “**Bubbles**” indicator will be visible in the “**Main window**”.



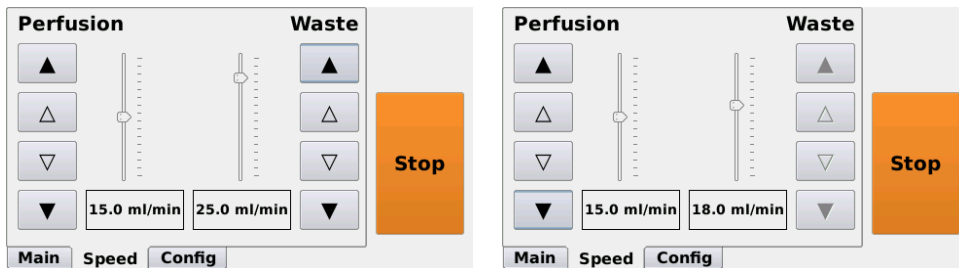
In the left picture of the “**Main Window**” no tube is connected to the bubble detector. In the right picture no pump is running and therefore no bubbles are detected by the bubble detector.



“**Main Window**” when both pumps are running and the bubble detector detects bubbles.

Speed Window of PPS2 Touch Screen

The up down arrows in the “**Speed Window**” are responsible for controlling the fluid flow.



In the “**Speed Window**” on the left picture, the speeds of the perfusion and waste peristaltic pump are independent adjustable with the up down arrows under “**Perfusion**” and “**Waste**”. When both pumps are coupled because a “**Fixed Speed Ratio**” is selected, you control the speeds of both pumps together via up down arrows under “**Perfusion**” as shown on the right picture.

2.4 Cleaning and Maintenance

To clean the peristaltic pump system after use, flush all tubes with distilled water for a few minutes and then quickly with 70 % Ethanol (EtOH). Suck the tubes dry. Disconnect all tube connectors and unscrew the caps of the compound or waste bottle. Empty the bottles and wash them out. Take care not to mistake the tubing when reconnecting.



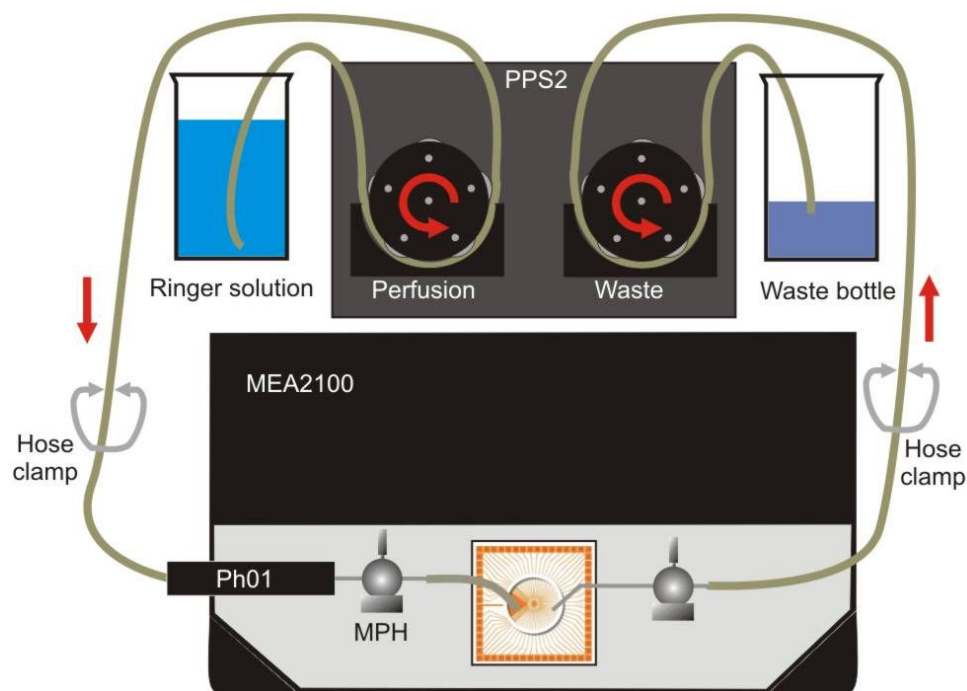
Warning: Make sure no liquid is sucked into the pump revolvers! This can lead to irreversible damage. Empty the bottle after each experiment. Avoid remaining liquid in the bottle and tubing, this can result in contamination.

3 Application Example: MEA2100-System

The peristaltic perfusion **PPS2-System** consists of two peristaltic pumps. In this application example, one is connected to a reservoir for ringer solution and pumps solution through a perfusion heating PH01 to a MEA recording chamber inside a MEA2100 headstage. The PH01 is connected to a temperature controller TC01/02 and heats the solution to a set value. A cannula is connected to the second pump, which removes the ringer from the MEA chamber and pumps it into a waste bottle. PH01 and cannula are positioned by magnetic perfusion holders MPH. The MPHs connect both perfusion in- and outlet to the ground of the recording system, via the metal plate in the front of the MEA2100 recording system.

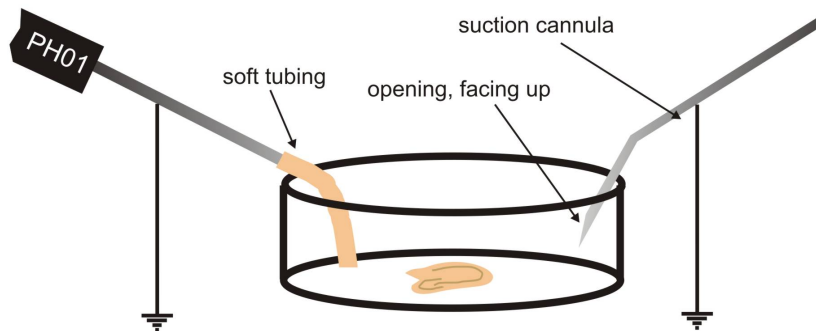
3.1 Setup

1. Provide a power supply in the immediate vicinity of the installation site.
2. Place all devices on a stable and dry surface, where the air can circulate freely and the devices are not exposed to direct sunlight. Take care not to position the PPS2 and fluid reservoirs directly above the recording system, to prevent damage by accidentally spilled liquid.
3. Set up the computer with installed PPS2 program and connect the PPS2 with an USB cable.
4. Set up the MEA2100 system as described in the respective manual.
5. Connect the PH01 via tube to the inlet (left) peristaltic pump of the PPS2 and the bottle with ringer solution.
6. Connect the outlet tube to the outlet (right) peristaltic pump and the waste bottle.
7. Add a hose clamp to the inlet and the outlet tube each.
8. Connect the ground of the PPS2 to the ground on the interface board of the MEA2100, if necessary.



3.2 Perfusion and Noise

Low frequency fluctuations in electrophysiological measurements can be caused by the perfusion. Shortly switch off the pump to see whether the fluctuations disappear if the pump is off. 50 Hz noise can also be caused by the perfusion, but is independent of the pump running or not. Perfusion in and out should contain a piece of metal that can be connected to the amplifiers ground to remove 50 Hz noise. The easiest way is to use a bend cannula for suction. In the setup described above, both perfusion in- and outlet are already grounded via the MPHs. The opening of the cannula should be positioned in a way that it always sucks air and liquid at the same time, possibly resulting in a constant slurping noise. This prevents the fluid level from going up and down, which also causes noise. See a suggested perfusion setup below.



Warning: The droplet isolators remove pulsation artifacts, but also cause a continuing flow even some time after the pumps are stopped. To avoid flooding, please use hose clamps to stop the flow. Do not forget to open the clamps when you restart the pump.

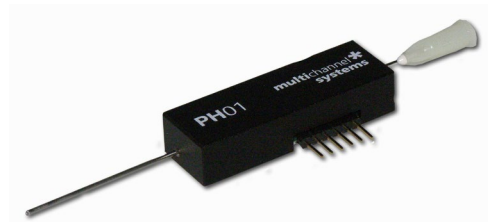
If you experience low frequency noise from the perfusion, try to optimize the suction as described above. Additionally, the droplet isolator chambers of the PPS2 interrupt the fluid flow between pump and recording chamber, and thereby minimize the influence of the pump head movement on the recordings.

50 Hz noise can be caused by the perfusion or by external noise sources. Remove perfusion in and out from the bath. If the noise persists, check for external noise sources, like microscope lamp, power supplies close by and so on. If the noise is caused by the perfusion, check the grounding of the perfusion in and out. If the magnetic perfusion holders (MPH) from MCS are used, make sure that there is an electrical contact between PH01, suction cannula, and the metal plate in front of the MEA2100.

Perfusion Cannula PH01 with Magnetic Perfusion Holder MPH

All MEA amplifiers can be equipped with a magnetic stainless steel plate on top to enable the use of magnets as perfusion holders. The magnetic perfusion holders MPH also connect any attached metal cannula directly to the ground of the MEA recording system. The metal ball holding the cannula allows an accurate positioning of the perfusion tips and a quick and easy detachment of the perfusion by removing the ball from the magnetic base, if necessary.

The perfusion cannula PH01 with heating element and sensor and a temperature controller TC01 or TC02 is able to heat the perfusion solution with an accuracy of 0.1 °C to any temperature from room temperature up to a maximum of 50 °C.



4 Appendix

4.1 Technical Specifications

General Information	
Operating temperature	10 °C to 40 °C
Storage temperature	10 °C to 50 °C
Dimensions (H x W x D)	235 x 160 x 110 mm
Weight	3.6 kg
Number of perfusion pump inlets	1
Number of perfusion pump outlets	1
Maximum perfusion rate inlet	30 ml per minute
Maximum perfusion rate outlet	30 ml per minute
Bubble detector	optical fluid flow control
Analog and Digital Input	
Maximal voltage of the digital input	+ 5.5 V
Maximal voltage of the analog input	+ 10.3 V
Maximal load current (+3.3 V output)	100 mA
Power Supply	
Type	SPU63-108
Voltage range @ frequency	100 to 240 VAC @ 47 to 63 Hz
Power consumption	10 W
Software Control	
Connection to the computer	USB 2.0 High Speed (cable type A – B)
Operating system	Microsoft Windows ® 10 or 8, English and German version

4.2 Ordering Information

4.2.1 Scope of Delivery

- 1 PPS2 main device
- 1 PPS2 CD (Software and Manual)
- 1 PPS2 power supply (SPU63-108)
- 1 power cord, country-specific
- 1 USB 2.0 cable (A – B)
- 1 PPRT1.65-10
- Fluidic: 3 hose clamps, 2 luer adaptors, 2 circlets
- Electrical accessories: 1 grounding cable, 1 alligator clip, 2 A/D input connectors
- Fluidic devices: 2 PPS2-Set-F

Optionally

- 1 MCS Bus cable

4.2.2 Replacement

Peristaltic Pump PPS2 Replacement Tube Set

PPRT1.65-10: Unit of 10 peristaltic pump tubes: Pharmed ® BPT (Saint-Gobain), (ID = 1.65 mm, OD = 3.35 mm, L = 90 mm)

Peristaltic Pump PPS2 Replacement Complete Fluidic

PPS2-Set-F: Set of complete fluidic device components for the PPS2

- 1 supply tube (Silicone L = 1000 mm)
- 1 interconnection tube (Silicone L = 210 mm)
- 1 detector tube (Pharmed ® BPT L = 45 mm)
- 1 waste tube (PVC L = 1000 mm)
- 2 sample tube (Silicone L = 1000 mm)
- 2 drip chamber bodies with cover

Peristaltic Pump PPS2 Replacement Fluidic Accessories

PPS2-Set-FA: Fluidic accessories

- 3 hose clamps
- 2 luer adapter
- 2 circlets

Peristaltic Pump PPS2 Replacement Electrical Accessories

PPS2-Set-EA: Electrical accessories

- 1 alligator clip
- 1 grounding cable
- 2 D / A input connectors

4.3 Contact Information

Local retailer

Please see the list of official MCS distributors on the [MCS web site](#).

Mailing list

If you have subscribed to the [Mailing List](#), you will be automatically informed about new software releases, upcoming events, and other news on the product line. You can subscribe to the list on the contact form of the MCS web site.

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