908devices

MAVEN

Glucose/Lactate On-line Analysis System

User Manual

Version:
SW 7.6.14
Trace_Mon 5.1.30

For the latest version of this user guide, please visit my.908devices.com

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1. Introduction

MAVEN™ by 908 Devices is a highly versatile on-line (sample-free) monitor of glucose & lactate in bioreactors and fermenters with optional automated feed control. The device's compact housing contains all the necessary mechanical, fluidic, and modular electronics. MAVEN may be operated using a diffusion probe or diffusion module, both of which allow for sterile and safe measurement from the bioreactor/fermenter. Transport buffer, control solution, and waste can be suspended in bags and attached to the supplied stand hook to save space.

Analyses are performed in a biosensor module that uses a combination of enzymatic conversion and electrochemical detection. A two-channel electrode, coated with immobilized oxidase enzymes, serves as the biosensor. System control is performed via an external computer with an easy-to-use software interface.

In addition to measuring glucose and lactate concentrations, MAVEN also offers accurate control of substrate feeding for improved product titer, quality, and process robustness.

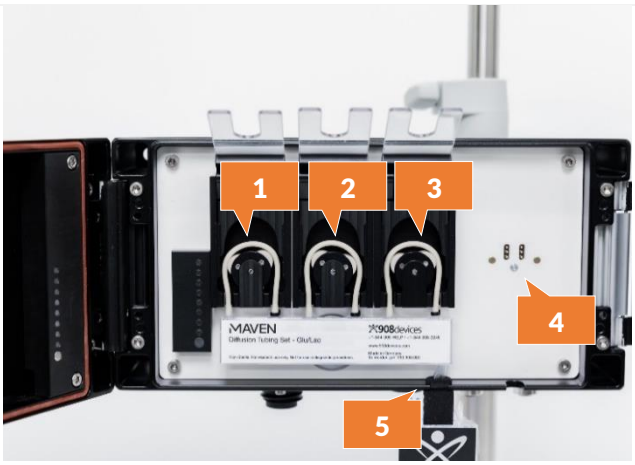
2. Components

2.1 Main body

1. Hook for control solution

Pump and sensor interface

1. Pump 1 transports buffer to probe and then to sensor
2. Pump 2 transports buffer to sensor
3. Pump 3 transports calibration standard to sensor
4. Biosensor connection (magnetic)
5. Fluidics box mounting point

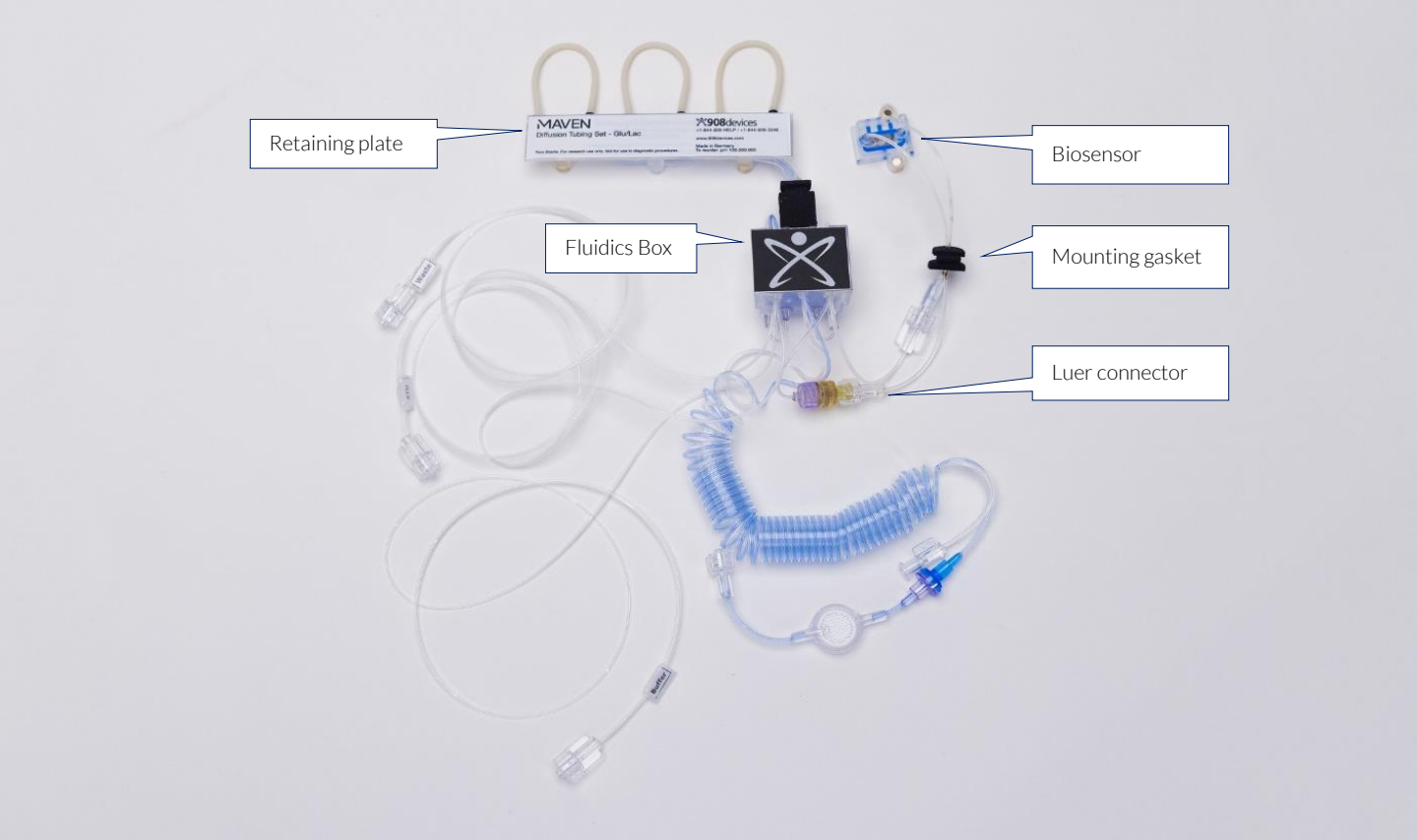


Bottom of device

1. Analog output connection socket
2. Serial interface connection socket
3. Ethernet connection socket
4. Power supply
5. Power switch

MAVEN can be switched on or off via the power switch. The electrochemical signal from the biosensor is automatically converted to a concentration value and sent to the analysis software on the associated PC via the ethernet port. MAVEN also features several additional options for signal output. Analyte concentrations may be output as analog voltage (0–10 V) or current (0–20 mA of 4–20 mA) or sent via RS232 serial interface.

2.2 Tubing Set



The MAVEN **tubing set** consists of all the components required for analysis:

- a **retaining plate** with peristaltic pump tubing loops ensures continuous flow of solutions
- a **fluidics box** organizes the connection lines for buffer, control solution, waste, and sampling
- a **biosensor** contains enzyme-coated electrodes for detecting glucose and lactate and attaches to the device panel with magnets.

3. Operational Checklist

Item	Action	Page & Section Reference	☑
0	Initial Setup		
	Set the IP address of your MAVEN	7, Network Setup	
1	Assemble diffusion probe		
	Install diffusion membrane	8, Diffusion Probe Assembly	
	Install probe in reactor	8, Connect Diffusion Probe to Bioreactor	
	Sterilize if necessary	9, Sterilization	
2	Prepare transport buffer and waste container		
	Dilute transport buffer concentrate	11, Prepare Buffer Solution	
	Provide waste container with disinfectant, if needed	14, Preventing Contamination	
3	Mount tubing set	10, Mount Tubing Set	
4	Connect supply and discharge lines	10, Connect Supply and Discharge Lines to Diffusion Probe	
	Connect transport buffer, control solution, and waste container	11, Connect Buffer, Control Solution, and Waste Container	
5	Switch on the device	15, Startup	
6	Launch PC software	15, Startup	
7	Set operating parameters		
	Enter project information	15, 1. Project Information	
	Set measurement parameters	16, 2. Measurement Parameters	
	Set controller settings (if using)	17, 3. Controller Parameters	
	Initialize tubing set	18, 4. Initialization	
8	Start measurements	18, Main Screen	
9	Check biosensor for air bubbles	10, Connect Supply and Discharge Lines to Diffusion Probe	
10	Perform reference measurement/calibration	20, Calibration	
11	Optional: connect analog outputs to process control system	Feed Pump Connectivity (25: Analog/Serial outputs and 26: OPC UA) Feed Pump Control (17: Controller Parameters)	

4. Network Setup

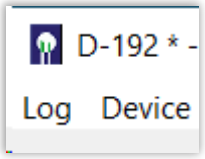
4.1 Connecting to a company network

Before you start, decide whether you will:

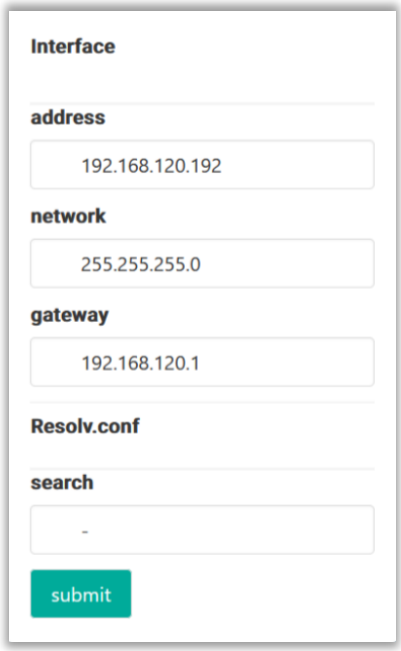
A. Connect MAVEN to your company network (preferred), or…
B. Connect MAVEN to a gateway PC via an ethernet cable

Option A: Connect MAVEN to network

1. Contact your IT department to assign a new IP address to MAVEN. The factory IP address may not be compatible with your corporate network.
2. Connect MAVEN to the network using an ethernet cable.
3. Open a web browser and type in the factory IP address `192.168.120.234` to configure the network settings on MAVEN.
4. Choose "Network settings" in the menu.
5. Enter the new IP address assigned by your IT department in the Address field and click Submit.
6. Reboot MAVEN.



Note: After changing the network address, the device is only accessible via this new IP address. If using the Trace_mon app (see appendix), the last 3 digits of the IP address (here 192) will be displayed in the upper left corner. The asterisk indicates successful connection.



Option B: Connect MAVEN to Gateway PC

1. MAVEN will not function as a DHCP client. Contact your IT department to configure the MAVEN PC from an automatic DHCP server to a static IP address.
2. Connect MAVEN directly to the PC via a cross-over Ethernet cable. In this case, the device will work with the factory IP address (`192.168.120.234`).
3. Edit ethernet adapter properties to direct connect to the MAVEN with default IP `192.168.120.234`.

4.2 Network Troubleshooting

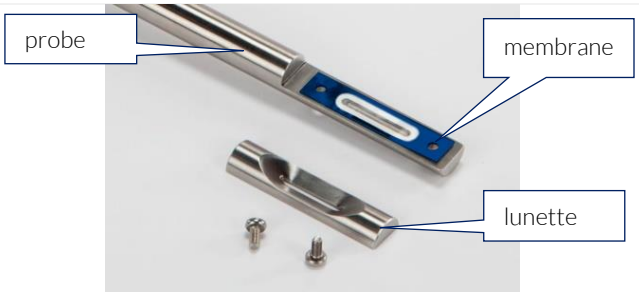
If you have entered an incorrect IP address on the device's website during installation, no connection will be established. Follow these steps to remedy:

1. First, try to connect to MAVEN's internal website (default IP address `192.168.120.234`) using a direct PC connection and a cross-over Ethernet cable.
2. If this is not possible, you may reboot MAVEN into a preconfigured network safe mode with the IP_set boot file. First, switch off MAVEN. Copy the IP_set boot file (available from the 908 Devices Customer Support Portal at my.908devices.com) to a USB drive, plug the drive into the front USB port, and switch on the device. After the boot process, MAVEN will have the IP address 192.168.120.232. Open a web browser and type in IP address 192.168.120.232. After establishing a connection to MAVEN, you can reset the network address via your web browser as described above. Remove the USB drive and restart MAVEN as normal.

5. Diffusion Probe Assembly

The diffusion probe consists of a probe body, a disposable membrane, and a lunette that holds the membrane in place. Follow these steps for proper assembly of the probe before use.

1. Place the diffusion membrane onto the bottom of the probe, with the colored/silver side facing the lunette.



2. Hold the lunette against the membrane and tighten the screws to secure the lunette onto the probe.

Important:

- *The membrane must sit flush against the sides of the probe. Inserting the membrane at an angle can result in leaks at the diffusion probe head and jeopardize sterility.*
- *The* white *side of the membrane must face the diffusion probe.*
- *The* colored/silver *side of the membrane must face the lunette.*

3. Before installation and sterilization, slide the white compression washer onto the probe body as shown; note that the flat side should contact the bottom of the probe threads. Slide the o-ring onto the probe body and up against the compression washer, as shown.

6. Connect Diffusion Probe to Bioreactor

The minimum immersion depth for the diffusion probe is 53 mm (or 25mm with low immersion depth membrane).

Notes:

- *A special membrane is available for small bioreactors (<200 mL), featuring a diffusion probe immersion depth of only 2.5 cm.*
- *Different port adapters may decrease the minimum immersion depth. Please make sure to use a probe long enough to maintain total submersion of the diffusion membrane (49–53mm).*

7. Sterilization

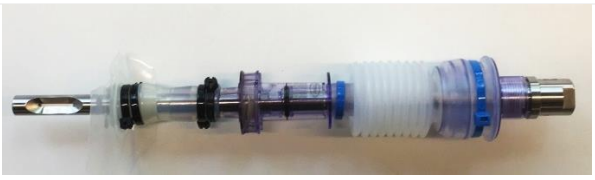
1. Connect the diffusion probe to a disposable Luer syringe, as shown.
2. Fill the diffusion probe with enough deionized water until fluid exits the discharge port.
3. Check that no water is leaking from around the membrane at the probe tip.

4. Close the diffusion probe with the sealing caps.

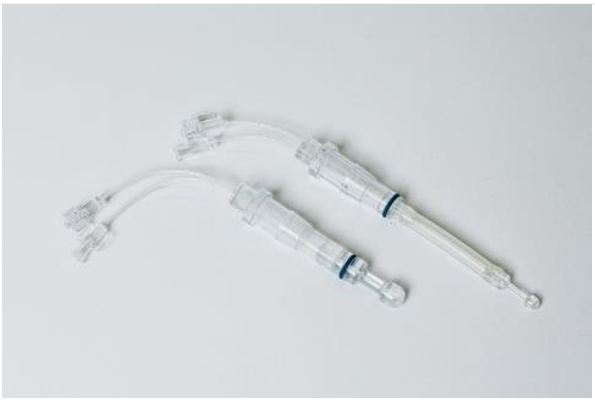
5. Utilize steam sterilization at 1 bar, 121°C.

Important: During sterilization, the diffusion probe must be filled with deionized water and closed with the included caps to prevent damage to the membrane.

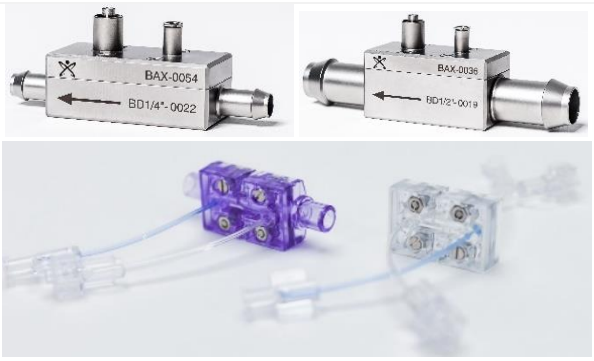
7.1 Also available



For single-use applications, the diffusion probe (length 300 mm) can be installed using a Kleenpak™ adapter, available from Thermo Scientific™—Bioreactor Probe Assembly, Order No. SH3B12122.01.



Single-use plastic probes can be integrated into reactor bags via common ½" ports. Separate designs are available for stirred and wave reactors.



Reusable or single-use diffusion modules are available for instances when a probe geometry is not suitable. The reusable modules are made entirely of stainless steel or PEEK to ensure high sterility assurance. A diffusion module may be installed in any line accessing the medium and the reusable versions may be sterilized *in situ* with the bioreactor.

8. Mount Tubing Set

1. The latch on the right of the MAVEN unit opens the front door.
2. Lift the three flaps to reveal the peristaltic pump rollers.

3. Hold the tubing set by the retaining plate and loop the tubes over the peristaltic rollers.
4. Carefully fold the flaps back down to press the rollers against the tubing.

5. Use the supplied Luer connectors to hook up the biosensor module.
6. The biosensor attaches to the sensor contact panel via a pair of magnets. Make sure the electrical contacts on the panel are aligned with the contacts on the biosensor.
7. Firmly insert both mounting gaskets into the corresponding notches in the case to maintain integrity of tubing when the door is closed.

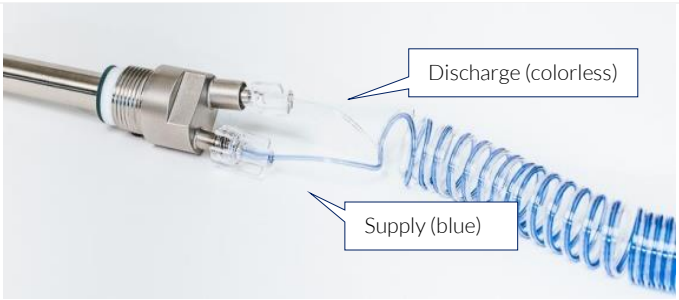
8. Close and latch the door.

Note: MAVEN is intended to be calibrated and run with the door closed.

9. Connect Supply and Discharge Lines to Diffusion Probe

After sterilization, connect the probe to the tubing set, making sure to introduce as little air as possible. Air bubbles from the tubing set that become trapped in the biosensor can result in fluctuating glucose/lactate measurements.

1. Remove sealing caps and set aside for later use.
2. Connect the supply line (blue tubing) and discharge line (colorless tubing) to the corresponding Luer connections on the probe.



10. Prepare Buffer Solution

Mix the transport buffer according to package instructions and sterile filter into the provided hanging bag labeled “Buffer.”

- The included hook stand provides convenient storage for buffer solution during your bioprocess.
- If bottles are required by your lab, make sure the tubing is fully inserted into the bottle and that the bottle is covered (Parafilm M or a similar product is ideal) to prevent foreign matter from entering the solution.

Tip: Proper dilution can be verified by measuring the conductivity of an aliquot. Correctly diluted buffer has a conductivity of 5–15 mS/cm.

Tip: The hanging stand is a convenient place to keep hardware for later use, such as the screwdriver, sealing caps, and spare membranes for the diffusion probe.

11. Connect Buffer, Control Solution, and Waste Container

1. Connect the control solution, transport buffer, and waste lines to the fluidics box.

Note: Lines are pre-assembled and come in labeled foil bags. To maintain sterility, we recommend these packets remain sealed until the tubing set has been mounted on the instrument.

- *“BUFFER”: to transport buffer*
- *“WASTE”: to waste container*
- *“STD”: to calibration solution*

2. After inserting tube into control solution, you may hang the bag on the convenient hook on the side of the main device housing.
3. Connect waste tubing to the provided hanging bag labeled “Waste”. See the section on Preventing Contamination in this guide to maintain the sterility of your bioprocess.

Hardware setup is complete.

12. Consumables Information

The **transport buffer** consists of a salt mixture (for cell cultures) or a concentrate (for microbial cultures) that must be dissolved/diluted with water (deionized or distilled) according to the instructions. Proper dilution can be verified by measuring the conductivity of an aliquot. Correctly diluted buffer has a conductivity of 5–15 mS/cm.

The consumption of transport buffer depends on the measuring interval and the number of measuring points in operation. For typical measurement, the following consumption can be expected:

Measurement Interval	**Buffer consumption**			**5 L will last…**	
minutes	mL/min	mL/h	mL/d	Hours	Days
2*	0.850	51.0	1224.0	98.0	4.1
5*	0.850	51.0	1224.0	98.0	4.1
10	0.769	46.1	1107.0	108.4	4.5
20	0.531	31.9	764.6	156.9	6.5
30	0.447	26.8	643.2	186.6	7.8
60	0.350	21.0	503.8	238.2	9.9
120	0.287	17.2	412.8	290.7	12.1
180	0.260	15.6	374.8	320.2	13.3
360	0.231	13.8	332.2	361.2	15.1

**Note: when measurement interval is set to two minutes, the system does not have sufficient time to conduct a flushing cycle, so it uses the same amount of buffer as the five-minute measurement interval.*

12.1 In Case of Emergency

Malfunction may result in injury or property damage. If there is immediate danger of personal injury or equipment damage, take the device out of operation immediately:

- Unplug the power cord from the device.
- Have any malfunctions repaired immediately by 908 Devices Customer Service or your authorized distributor.

The solutions (buffer concentration, cleaning, and calibration solution) used for the operation of the devices are not strongly corrosive, poisonous, or seriously harmful to skin. If skin contact occurs, rinsing with water for several minutes is sufficient. You can find more information on this in the safety data sheet for each solution.

13. Cleaning & Maintenance

13.1 General Notes

- Each sensor and tubing set is good for 30 days or 5,000 measurements.
- Clogged or damaged tubing sets must be replaced to prevent measurement errors.
- If measurements are interrupted for a short time (maximum two days), you may continue to use the system without replacing the tubing set. However, during the interruption, the system must be kept in "Standby" mode, with all tubing remaining in contact with liquid.

13.2 Cleaning the System

If the system will be idle for longer than two days, follow the instructions below to ensure that all tubing remains clean and free of buildup:

1. Fill a clean flask with 250 mL of Cleaning Solution
2. Immerse the ends of all tubing lines from the tubing set (Buffer, Control) into the Cleaning Solution.
3. If possible, the diffusion probe should remain connected during cleaning. If this is not possible, e.g., due to sterilization of the reactor, the Luer fittings on the tubes that connect to the diffusion probe should be connected to each other.
4. In the Maven Remote web app, click the **Clean** button, or in trace_mon.exe software, navigate to **Device > Clean** to begin the cleaning cycle.
5. Allow the unit to run until the Cleaning Solution is depleted.
6. Repeat steps 1–5 with one (1) liter of deionized water.

13.3 Cleaning the Diffusion Probe After Use

1. Remove the Luer connections between the tubing set and the probe.
2. After appropriate clean-in-place (CIP) procedures and/or sterilization, remove the diffusion probe from the bioreactor.
3. Clean the probe surface and caps with a soft brush and water.
4. Check the sealing rings of the diffusion probe for cleanliness and correct seating.
5. Remove the two TORX screws on the diffusion probe to remove the lunette and membrane.
6. Discard the membrane and clean the diffusion probe and lunette with a soft brush and water.
7. Flush cleaning solution followed by deionized water through the probe with the supplied syringe.
8. Dry the probe by flushing air with the supplied syringe.

13.4 Preventing Contamination

In longer, multi-week cultivation processes, it is possible for biofilm to develop in the tubing set, which can lead to clogged lines and inconsistent results. Below are some recommendations to keep both the instrument and your bioprocess running trouble-free.

Common Problems and Contamination Sources	Recommendation
Transport buffer is diluted in a contaminated vessel or stored in a frequently refilled bottle	Always use clean containers/bottles for the transport buffer. Do not refill an empty buffer container but replace it with a clean one. Ideally, the buffer should be sterile filtered (this is typical for cell culture and GMP facilities).
Waste line is immersed in the waste liquid, allowing contaminants to spread into the tubing set	Replace waste containers regularly and do not allow the waste line to be immersed in the waste mixture.
Tubing set (reused) insufficiently cleaned/disinfected	Clean the tubing set according to the Cleaning & Maintenance section in this manual.
No disinfectant in the waste container	Add a disinfectant, such as KOH or NaOH pellets or chemical disinfectant to the waste container.
Waste container left open to air	For best results, use the provided hanging bags to hold buffer solution and waste. If bottles are required by your lab, make sure the tubing is fully inserted into the bottle and that the bottle is covered (Parafilm M or similar product is ideal) to prevent foreign matter from entering the solution.
Insufficient sterilization of probe or subsequent contamination when rinsing with the syringe	Check whether contamination has occurred after sterilization. A typical error is the use of a non-sterile liquid to rinse the probe after sterilization.
Probe does not show a signal while the calibration is unaffected	This is a typical sign of contamination inside the probe. Disassemble probe, discard membrane and tubing set, and re-sterilize system according to the Cleaning & Maintenance section in this manual.

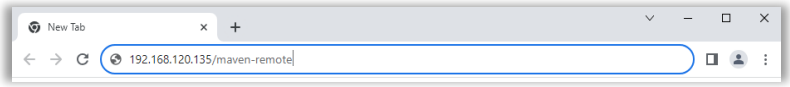
14. Software: MAVEN Remote

The MAVEN Remote web interface allows you to control MAVEN from any computer on the same network. Follow these steps to set up your device.

14.1 Startup

Activate the power switch at the bottom of the device.

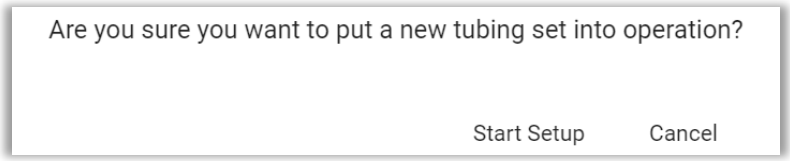
Open a web browser and type in the IP address obtained in the network setup step (see page 7) followed by "`/maven-remote`"



- To initialize a new tubing set, click on ***Set Up Device***.

To use previous settings and go to the home screen, click on ***Continue Measurement*** (skip to "
14.2 Main Screen", page 18).

When the pop-up appears, click ***Start Setup***. This will overwrite previously saved calibration factors and other settings.

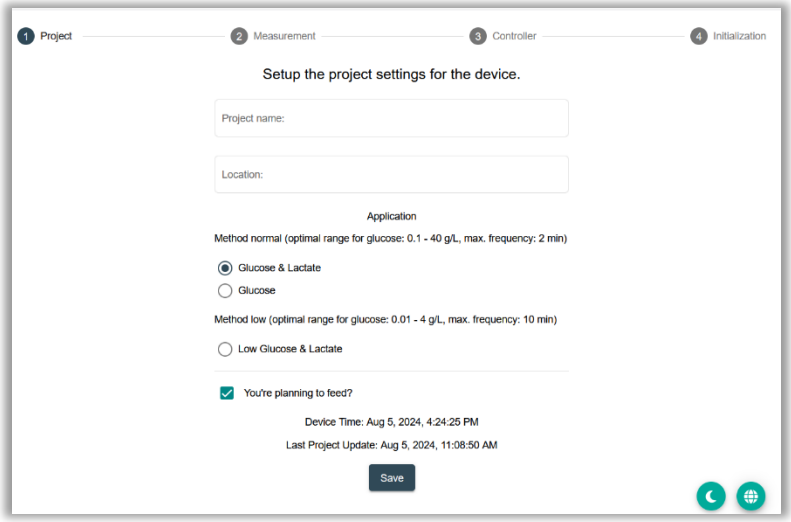


14.1.1. Project Information

- Enter a ***Project Name*** and ***Location*** for easy file identification later.
- Select an ***Application*** based on glucose/lactate concentration.
- Activate "***You're going to feed?***" if you are planning to use MAVEN to control a feed pump.

These settings can be changed later if needed.

Click ***Save*** and then click ***Next*** to continue.

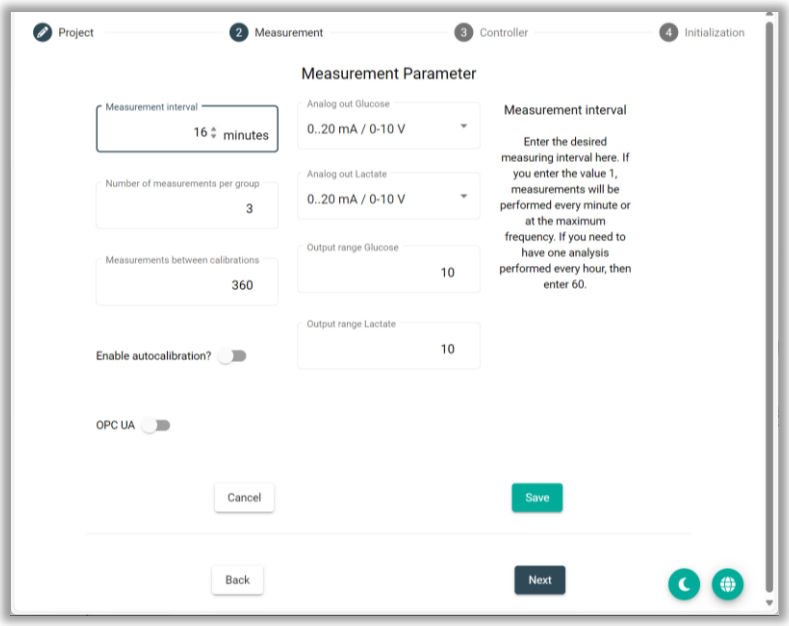


14.1.2. Measurement Parameters

These can be changed later as needed. Hints appear at the right side of the screen to help you determine the right settings.

- **Measurement Interval:** in minutes
- **Number of measurements per group**
- **Measurements between calibrations**
- **Enable autocalibration?** (on/off)
- **OPC UA** (on/off)
- **Analog out Glucose:** (Select the output of the signals for the analog port.)
- **Analog out Lactose**: (see above)
- **Output range Glucose** (For a required measurement range of 0–10 g/L of analyte, for example, set the value to 10 (upper limit). The lower limit is preset to 0. For a voltage range of 0–10 V, 10 volts equals 10 g/L of analyte)

Click ***Save*** and then click ***Next.***

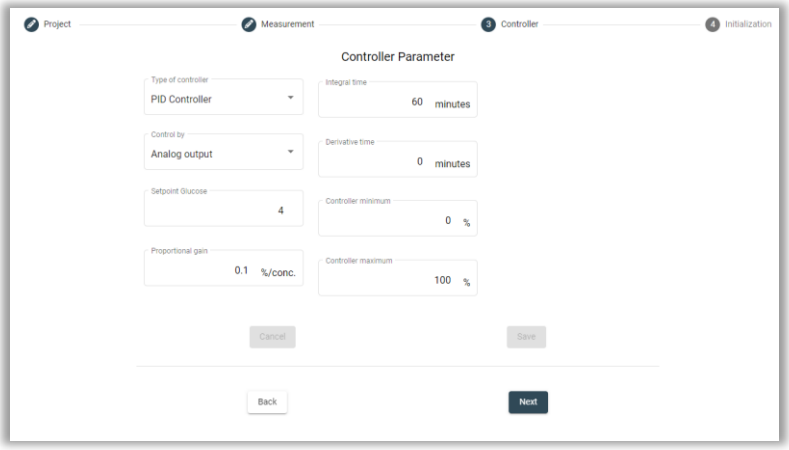


14.1.3. Controller Parameters

This screen appears when "***You're planning to feed?***" is activated in the Project screen. Under ***Type of Controller***, you may choose between PID or Min-Max two-point control; each controller type offers different options.

For ***PID control***, click on the individual options to set the ideal glucose levels, proportional gain, integral time, and derivative time.

Under "***Control by***" you can select whether the control acts on an external pump via the serial interface or the analog output 3.

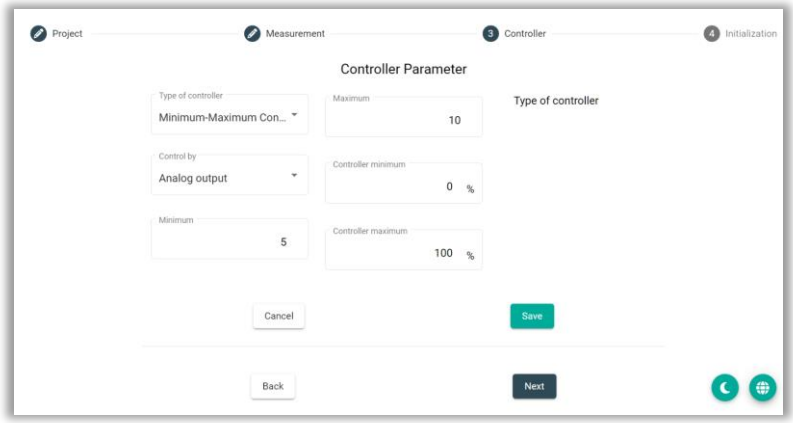


Microbial Culture Recommended PID Settings	**Cell Culture Recommended PID Settings**
P: 0.1–0.5	P: 0.01–0.1
I: 45 min (reset time)	I: 60 min (reset time)
D: 2 min (lead time)	D: 1 min (lead time)

Notes

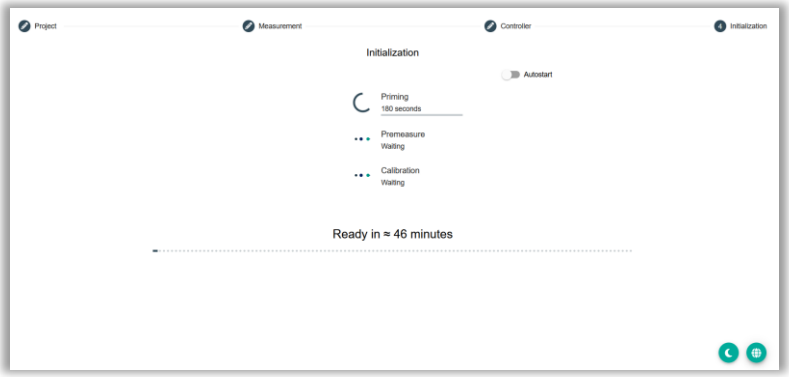
- *The P setting depends on the feed concentration, maximum delivery rate of the pump, pump tube diameter, reactor volume, etc.*
- *In most cases, adjustment of the P setting is sufficient and the I and D values can be maintained at the recommended value. If the feeding rate is too high, reduce the P setting. If the feeding rate is too low, increase the P setting.*
- *To avoid a too high integral gain (I-component) of the PID controller at the beginning, the I-component of the controller can be reset to the default I-component at any time with the "Reset controller" command.*
- *It is recommended to always reset the controller after filling the feeding line or in case of unknown history to avoid overdosing.*

The ***Min-Max*** controller switches the feeding pump to the minimum delivery rate or maximum delivery rate when the limit values are exceeded or not reached, respectively. "Minimum control value" and "maximum control value" set the minimum and maximum delivery rates of the pump. The default settings here are 0% and 100%.



14.1.4. Initialization

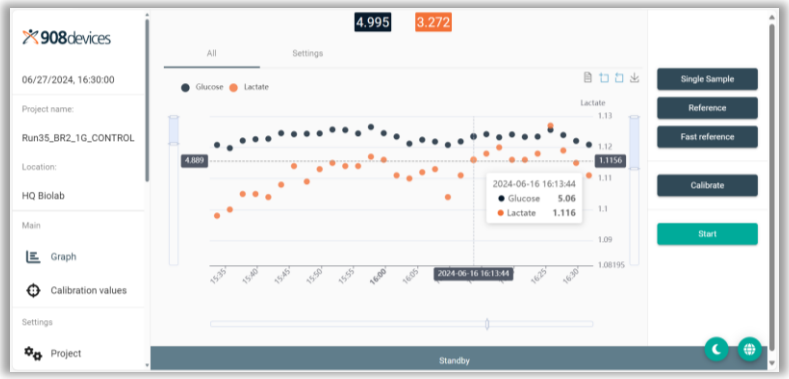
- **Start initialization**
  It takes about 45 minutes to perform the Priming, Premeasure, and Calibration.
- **Autostart:** If activated, the MAVEN will start measurement automatically. The browser window must remain open (minimized is fine) and computer must remain awake in order to send this command.



14.2 Main Screen

The graph updates in real-time as measurements occur, delivering insights into your bioprocess as they happen.

- Hovering over an individual data point shows the numerical values.
- The numbers in the top middle always show the latest measured values.
- The x-axes and y-axis may be adjusted by the sliders or within the Settings tab above the graph.
- The legend in the upper left can be used to show/hide data points for individual measurements (e.g., hide all the lactate data points)
- The colors assigned to the graph points may be changed in Settings tab above the graph.

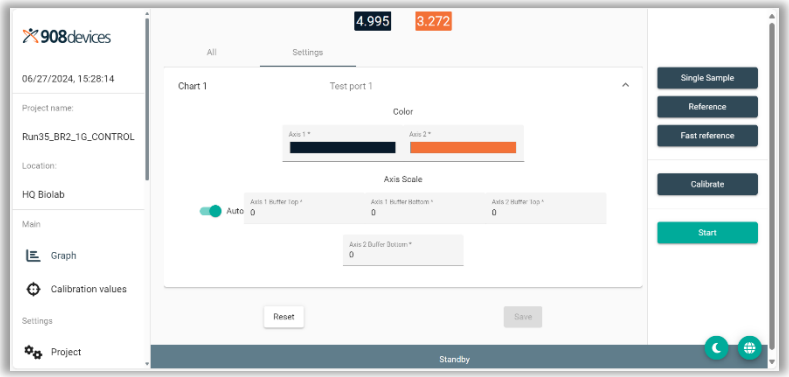


Current status of your MAVEN appears under the graph.

The buttons in the upper-right corner allow for further manipulation of the graph.

	Data view: displays measurements in a table format. Return to the graph by pressing the Close button.
	Zoom: specify an area of the graph to take a closer look
	Zoom Reset to zoom out to maximum
	Save as image: current state of the graph as a PNG

The settings tab lets you change the colors used in the graph and adjust the axes.



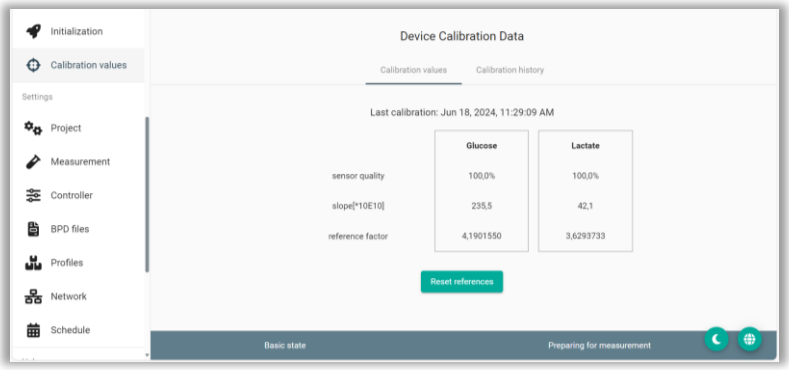
Basic commands for your MAVEN are located the right of the graph.

Single Sample	Takes a single measurement regardless of schedule.
Reference	(See Calibration section, below)
Fast reference	(See Calibration section, below)
Calibrate	(See Calibration section, below)
Start	Begins measurement according to Measurement Parameters.

14.3 Calibration

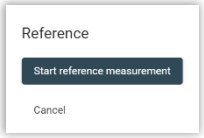
MAVEN is calibrated by a two-step process.

1. The **sensor** is calibrated using the MAVEN Calibration Standard Solution. Click the Calibrate button to begin. It is recommended to calibrate MAVEN once per day.



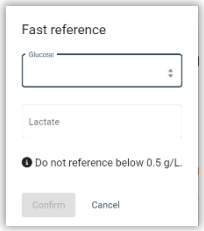
The **Calibration Values** screen displays current and historical values.

2. The **probe membrane** diffusion factor must be calibrated to account for the environmental conditions inside the bioreactor. This process is accomplished through the "**Reference**" or "**Fast Reference**" buttons.

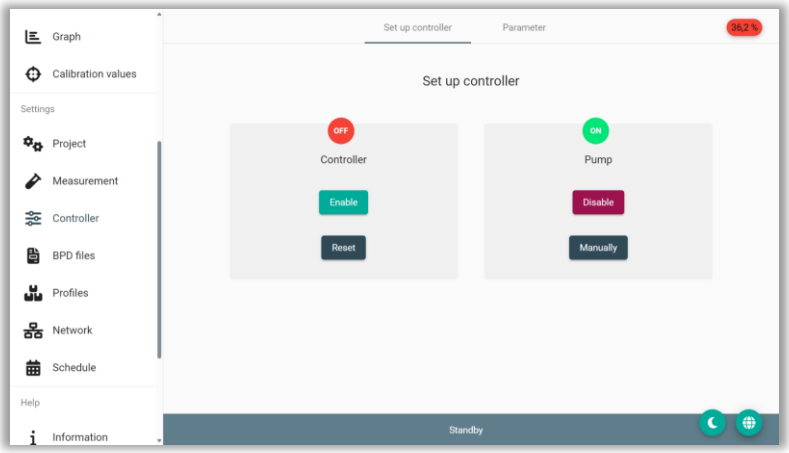
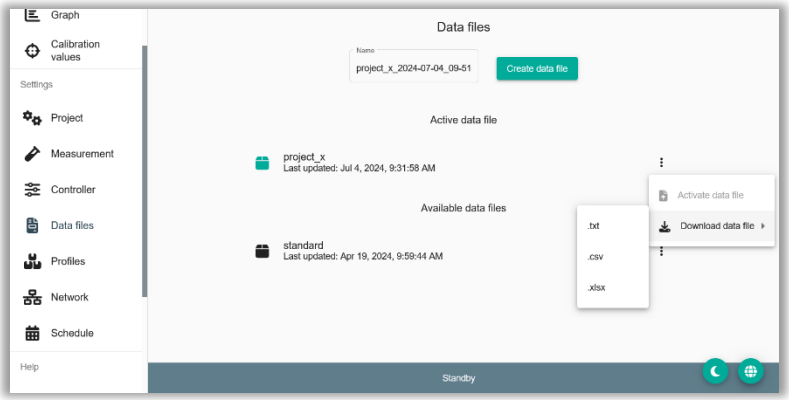


Reference should be used when you plan to take samples to confirm measurements from MAVEN with off-line analysis. After clicking the Reference button, a dialog box pops up, displaying current measurements. After you enter confirmed measurements from off-line analysis and click "Apply," MAVEN will calculate a new reference factor based on the two values.

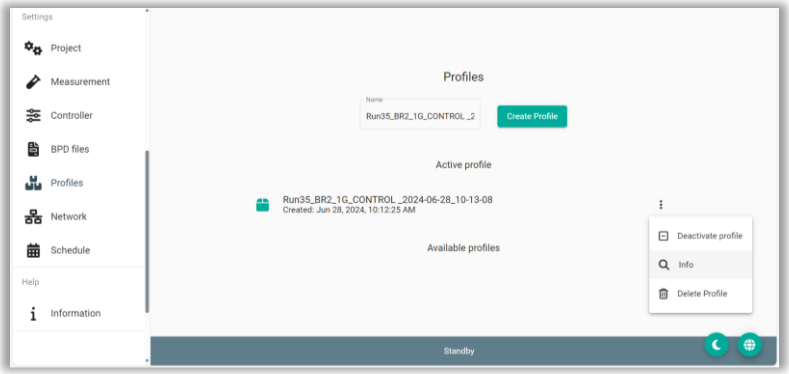
Fast Reference: allows you to enter known concentration values of the medium before the reference measurement is made.



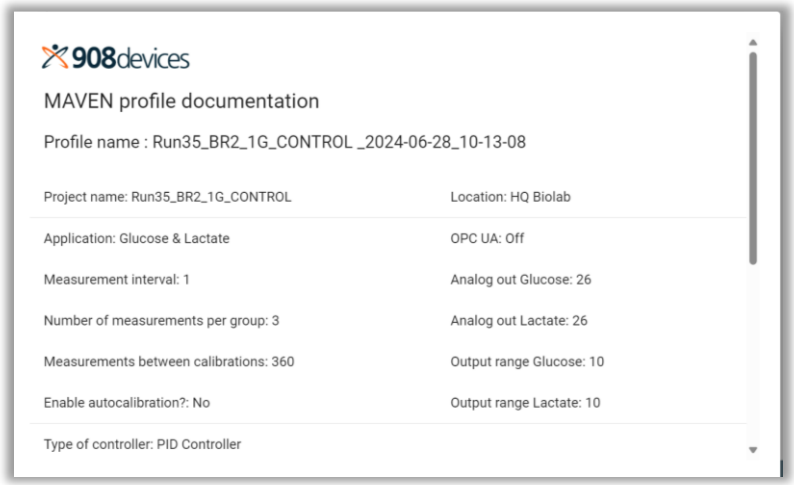
14.4 Settings

Project	See “14.1.1. Project Information” page 15
Measurement	See “14.1.2. Measurement Parameters” page 16
Controller You may use MAVEN to control your external feed pump via serial interface or analog output on the bottom of the device. When the controller function is enabled, a green field appears in upper right corner indicating the current delivery rate (0–100%) of the feed pump. If the controller is disabled, the background turns red.	 • While the controller function is enabled, the feed pump cannot be switched off or operated manually. • When the controller is disabled, the pump will continue to run at the last rate set by the controller until it is disabled. • The controller reset button can be used to bring the integral gain back to the default value for the PID controller. • The pump rate can also be manually set. Please also see “14.1.3. Controller Parameters” page 17.
BPD files	 The data recorded by MAVEN may be downloaded as *.txt, *.csv, or *.xlsx file. If downloaded as *.xlsx, the file comes an automatically generated chart that can be altered in Excel. The currently active save file appears in green at the top of the list. Use the three-dots menu (:) for additional file functions.

Profiles



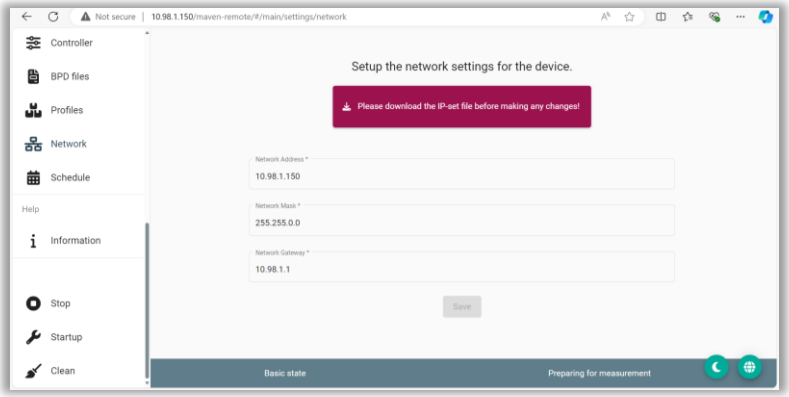
Profile includes measurement parameters and other settings for a project type. For example, you may find it convenient to save profiles for different cell types or media, and then download the file to recreate the setup over multiple MAVEN devices.



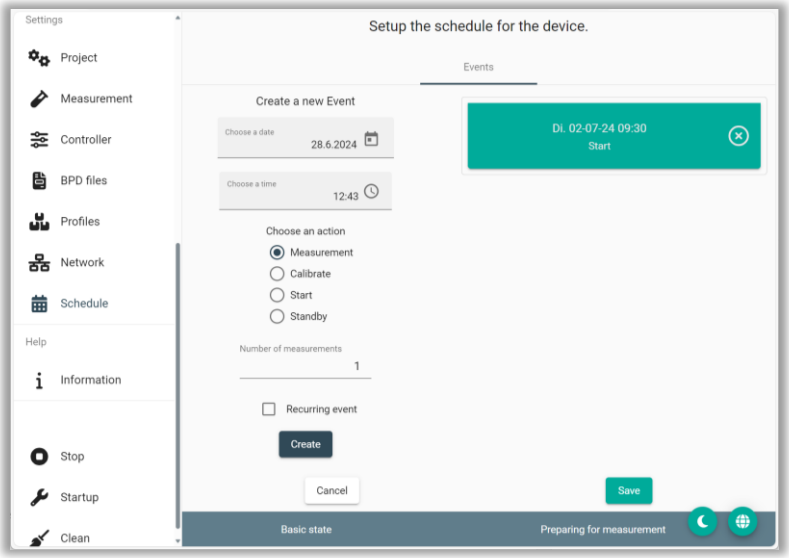
See the ***Info*** screen under the three-dots (⋮) menu to view the parameters that are saved to the profile.

Network

Network settings should only be changed under supervision from your organization's IT department.



Use the "Please download…" button at the top to export the backup IP settings to a USB drive before making changes. The USB drive can then be used to re-establish IP parameters in case any network changes cause MAVEN to become inaccessible. See "4. Network Setup" for more information on booting with the IP_set file.

Schedule	 Use the dropdowns to set a date and time for your event. You may also make your events recurring daily or weekly. After creating an event, click ***Save*** to add it to the schedule.
Information	 The **Information** screen displays version numbers of MAVEN Remote and the internal device software, along with serial number of your device.
Stop	Halts all measurements, pauses both the workflow and scheduled event; MAVEN is placed on standby until further commands are issued.
Startup	Begins the initialization process with previous settings.
Clean	Begins a cleaning cycle. See section 13. Cleaning & Maintenance, page 13

The **Schedule** function allows you to program calendar-based events (e.g., “run a sensor calibration next Monday at 8:30am; standby every Friday at 1:00pm”).

You may still use the Measurement parameters (see page 16) control the normal workflow for your MAVEN (e.g., “take three measurements every 60 minutes”).

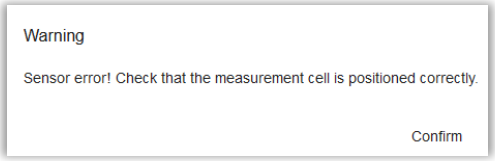
14.5 Error Messages

Spectator Mode

If you are already connected to your MAVEN as primary user on a different computer, other connection attempts will appear in Spectator Mode to prevent competing commands. Close the MAVEN Remote on all other computers before trying to connect again.

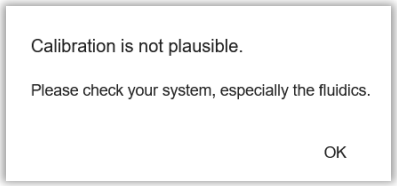
Sensor Error

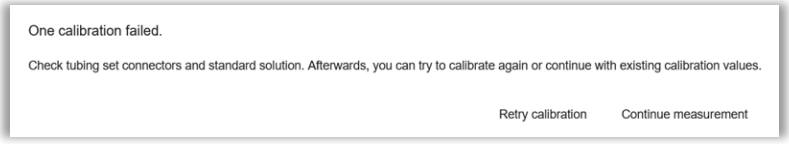
Ensure that the biosensor is correctly mounted. See page 10, Mount Tubing Set.



Calibration Error

There are two calibration errors. In either case, check the device and ensure that all fluidic connections are tight and that there is enough calibration standard solution in the bag.



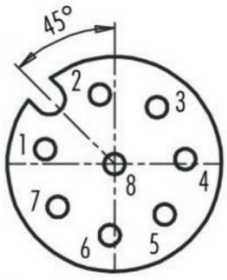
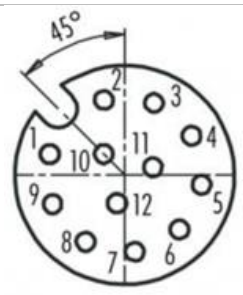


15. Feed Pump Connectivity

15.1 Analog and Serial Outputs

You can use MAVEN to control your feed pump. The signal at the analog output is changed each time a new measurement is acquired and remains unchanged until the device is rebooted or a new tubing set is activated.

Under Parameters (Settings > Parameters), the output format can be switched between 0–10 V and 2–10 V or 0–20 mA and 4–20 mA, respectively.

Output	View mating side	Occupancy		
Analog		1	A1 => 0/4–20 mA	White
		2	A1/A2 => Ground	Brown
		3	A2 => 0/4–20 mA	Green
		4	A3/A4 => Ground	Yellow
		5	A1 => 0–10 V	Gray
		6	A2 => 0–10 V	Pink
		7	A4 => 0–10 V	Blue
		8	A3 => 0–10 V	Red
Serial		1	+5V	Brown
		2	GND	Blue
		3	+12V	White
		4	RX5	Green
		5	RX4	Pink
		6	TX5	Yellow
		7	TX4	Black
		8	+24V	Grey
		9–12	not in use	n/a

Measured values are available as analog signals at pins A1 (analyte 1—glucose) and A2 (analyte 2—lactate). Output A3 is intended for connecting an analog-controlled external feeding pump and can be configured via the Parameter settings.

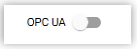
The serial output of MAVEN can be used to output measured values or to control a digital feeding pump. For connection to the analog and digital outputs, ready-made cables are available as accessories.

15.2 Open Platform Communications Unified Architecture (OPC UA)—Data transfer via TCP/IP

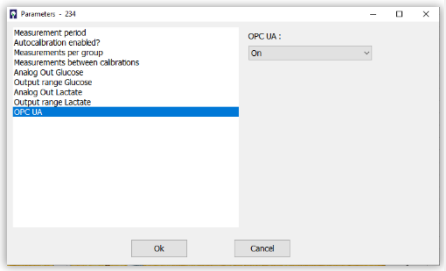
OPC UA is an open standard communication protocol for industrial automation developed by the OPC Foundation. It is manufacturer-independent and can be used for different kinds of data exchange.

MAVEN can act as an OPC UA server to send data to external clients, such as a process control system or a feed pump. This function is switched off at the factory but can be activated in the MAVEN Remote web app under the Measurement Parameters (see page 16) or in Trace_mon application under the **Settings > Parameters** menu.

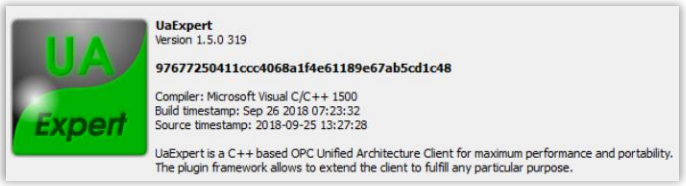
MAVEN Remote:



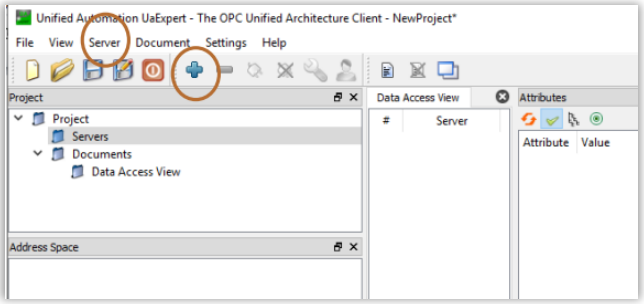
Trace_mon:



You will need an OPC-UA Client on your PC.
The following instructions are illustrated with UaExpert Client, but any appropriate client can be used. Regardless of client, the data structure will be the same because the structure is created by the OPC-UA Server.

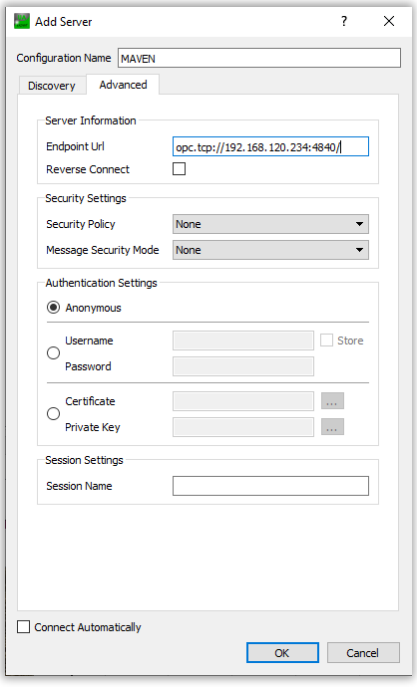


To add MAVEN as an OPC-Server, navigate to **Server > Add** in the menu or choose the "**+**" icon on the toolbar.



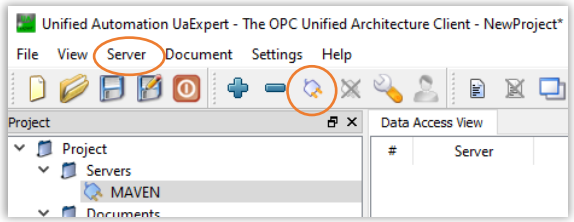
Complete the following fields:

- **Configuration Name**: (device number of your MAVEN, last three digits of the IP address)
- **Endpoint URL** consists of these components (no spaces):
  - Begin with `opc.tcp://`
  - IP address of your device
  - end with `:4840/`
- **Authentication:** select "Anonymous"
- Click **OK** to save.



MAVEN should now appear as a selectable option. Highlight your device under the **Project list**.

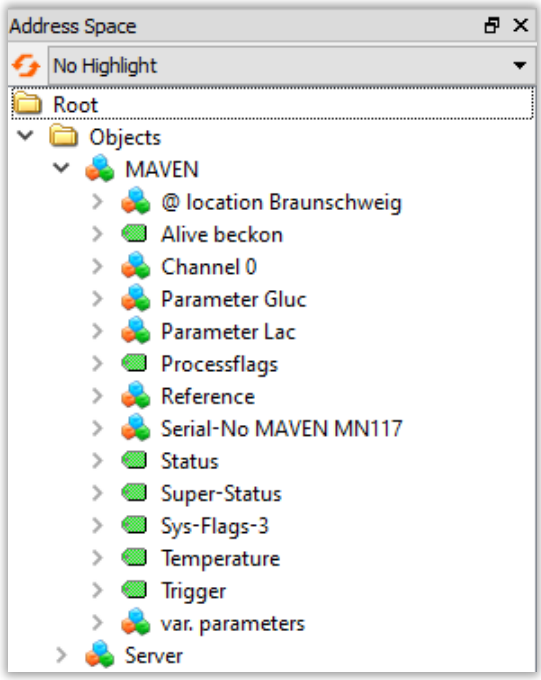
To open a connection, navigate to **Server > Connect** in the menu or press the **connect icon** in the toolbar.



After connecting, the structure of the device will be shown in the **Address Space** field. The data structure transmitted by MAVEN as an OPC-UA Server will be displayed here.

Inside the device folder are seven subfolders: “Temperature”, “Trigger”, “Status”, “Super-Stat”, “Sys-Flags-3”, “Processflags”, and “Alive beckon”.

Below are the explanations and possible values for each variable.



Trigger (Node Id 2004, Int32) can be used to operate the device.

1.	Measurement	4301
2.	Stand-by	4321
3.	Filling of new tube set	4322
4.	Calibration	4323
5.	Reference Measurement	4324
6.	New tube set	4335
7.	Cleaning	4341
8.	Reset reference values	8226
9.	Stop	8240

Status (Node Id 1121, Int32) shows internal information from the device.

1.	Stand-by	0
2.	Loading time	2
3.	Unloading time	4
4.	Filling	256 / 512
5.	Cleaning	513
6.	Flushing probe	16416
7.	Changing Media	16512
8.	Changing Media (double)	17408

Super-Stat (Node Id 1120, Int32) shows information from the device and is also displayed in MAVEN Remote the Trace_mon program.

1.	Initial state	0
2.	Filling	1
3.	Pre-Measurement	4098
4.	Calibration	4100
5.	Stand-by	4104
6.	Measurement	4112
7.	Cleaning	8193

Sys-Flags-3 (Node Id 1123, Int32) returns a “1” when the MAVEN probe is active. The other values are used for Trace C2/M4 only.

1.	Probe 1 active	1
2.	Probe 2 active	2
3.	Probe 3 active	4
4.	Probe 4 active	8

Temperature (Node Id 1013, Float) transmits temperature data from the sensor.

Alive beckon (NS2; NodeID 13; Int32) shows values between 0 and 7. A new value is set every second. This variable can be used to check the connection between server and client.

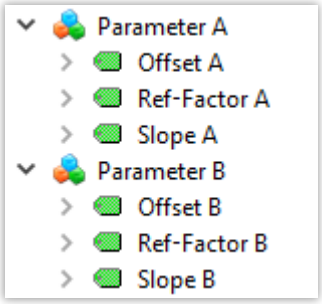
Processflags (Node Id 1122, Int32) sends a variety of information. Flagbits [hex] are accumulated and are shown in OPC-UA as processflags in decimal. A decimal-hexadecimal conversion is necessary to understand which flags are set.

1. Measurement requested 0000 0001 [hex]
2. Measurement in progress 0000 0002 [hex]
3. Last measurement OK 0000 0004 [hex]
4. Last measurement not OK 0000 0008 [hex]
5. Measurement evaluation 0000 0010 [hex]
6. Retard 0000 0020 [hex]
7. Time of evaluation 0000 0040 [hex]
8. Calibration allowed 0000 0080 [hex]
9. Calibration in progress 0000 0100 [hex]
10. Calibration done and OK 0000 0200 [hex]
11. Calibration not OK 0000 0400 [hex]
12. Change of media allowed 0000 0800 [hex]
13. Calibration requested 0000 1000 [hex]
14. Automatic generic 0000 2000 [hex]
15. Automatic calibration 0000 4000 [hex]
16. Automatic measurement 0000 8000 [hex]
17. Sensor error (no contact) 1000 0000 [hex]

Measurement Parameters

The folders Parameters A (glucose/methanol/ethanol) and B (lactate) contain common variables for measurement that can only be changed during calibration and reference measurements:

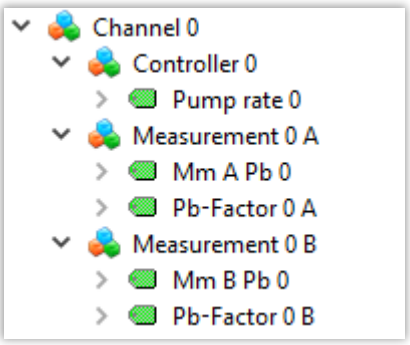
- **Offset** (Node Id 3014/3024): calibration curve
- **Slope** (Node Id 3013/3023): calibration curve
- **Ref-Factor**: reference factor



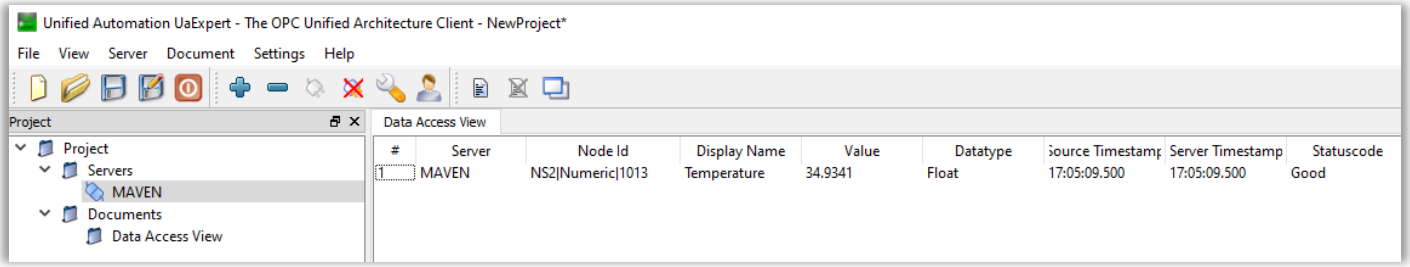
Measurement Channels

Channel 0 contains data from the MAVEN probe in your bioreactor. There are three sub folders.

- Within the Measurements folders are the floating-point variables “MW A Pb 0” and “MW B Pb 0”, which contain measurement values for each analyte from the probe.
  - A = Glucose (or Ethanol/Methanol)
  - B = Lactate
- Controller 0 contains the floating-point variable Pump Rate 0, which describes the pump rate of the feeding pump if the controller is activated.



Click and drag on a variable from the **Address Space** to “Data Access View”; the variable with all information will be displayed here.



Each variable has its own Node ID. Typically, the Temperature (Node Id 1013) and all Measurement values will be transferred to the OPC-UA Client.

Glucose or alcohol values example: “MW A So 0”

- “MW” = Measurement value
- “A” = Glucose/Alcohol
- “So” = Probe
- “0” = fermenter 1

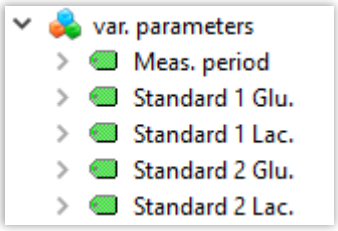
Lactate values example: “MW B So 0”

- “MW” = Measurement value
- “B” = Lactate
- “So” = Probe
- “0” = fermenter 1

Variable name	NodeID-Namespace	NodeID-Identifier	Datatype	Access Level	Remarks
Alive beckon	2	13	Int32	read	Alive bit
Mm A Pb 0	2	1001	Float	read	Glucose or Alcohol conc.
Mm B Pb 0	2	1002	Float	read	Lactate conc.
Mm A Pb 1	2	1011	Float	read	Glucose or Alcohol conc. (Reactor 2; ONLY: MultiTRACE/M4)
Mm B Pb 1	2	1012	Float	read	Lactate conc. (Reactor 2; ONLY: MultiTRACE/M4)
Mm A Pb 2	2	1021	Float	read	Glucose or Alcohol conc. (Reactor 3; ONLY: MultiTRACE/M4)
Mm B Pb 2	2	1022	Float	read	Lactate conc. (Reactor 3; ONLY: MultiTRACE/M4)
Mm A Pb 3	2	1031	Float	read	Glucose or Alcohol conc. (Reactor 4; ONLY: MultiTRACE/M4)
Mm B Pb 3	2	1032	Float	read	Lactate conc. (Reactor 4; ONLY: MultiTRACE/M4)
Pb-Factor 0 A	2	3111	Float	read	probe factor Glucose
Pb-Factor 0 B	2	3121	Float	read	probe factor Lactate
Pump rate 0	2	1015	Float	read	feed pump rate (if internal controller is used)
Temperature	2	1013	Float	read	temperature at sensor
Slope A	2	3013	Float	read	calibration slope Glucose or Alcohol
Slope B	2	3023	Float	read	calibration slope Lactate
Offset A	2	3014	Float	read	calibration offset Glucose or Alcohol
Offset B	2	3024	Float	read	calibration offset Lactate
Ref-Factor A	2	3012	Float	read	reference factor
Ref-Factor B	2	3022	Float	read	reference factor
Super-Status	2	1120	Int32	read	status value
Status	2	1121	Int32	read	status value
Processflags	2	1122	Int32	read	status value
Sys-Flags-3	2	1123	Int32	read	status value
Trigger	2	2004	Int32	read / write	trigger
extern T 0	2	10001	Float	read / write	bioreactor temperature
Ref.meas. A-1	2	11001	Float	read / write	Glucose or Alcohol conc. for reference
Ref.meas. B-1	2	11002	Float	read / write	Lactate conc. for reference
Reference-Trg.	2	2006	Int32	read / write	trigger for reference measurement
Meas. Period	3	101301	Float	read / write	measurment period
Standard 1 Glu.	3	105000	Float	read / write	Conc. of Standard 1 Glucose
Standard 1 Lac.	3	105100	Float	read / write	Conc. of Standard 1 Lactate
Standard 2 Glu.	3	105001	Float	read / write	Conc. of Standard 2 Glucose
Standard 2 Lac.	3	105101	Float	read / write	Conc. of Standard 2 Lactate

Other Parameters

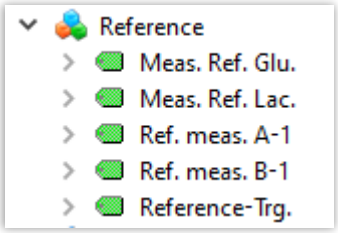
The “var. parameters” folder contains the “meas. period” variable, which allows you to set the measurement interval through your OPC UA client. (Equivalent to Measurement Parameters in MAVEN Remote; see section 14.1.2. Measurement Parameters).



Reference

The “Reference” folder allows you to perform a fast reference (see page 20) measurement via OPC-UA. There five variables involved in the process. Follow these steps:

- Enter the values for glucose and lactate in "Ref.meas. A-1" for glucose and in "Ref.meas. B-1" for lactate. This corresponds to the previous entry into the window.
- Set the trigger "Reference-Trg.”:
  - Set to "48" for glucose and lactate.
  - Set to "16" for glucose (only the glucose value is referenced if lactate is e.g. zero)
  - Set to "32" for lactate (only the lactate value is referenced).
- After the reference measurement is finished, the "Reference-Trg." is reset to "0".



16. Technical Information

16.1 System Specifications

Measuring principle	Selective flow-diffusion with enzyme-based amperometric biosensor
Measuring range (glucose)	0.01–40 g/L
Measuring range (lactate)	0.05–10 g/L
Measuring frequency	Up to 30 per hour (every 2 minutes). User configurable.
Measurement precision (glucose)	≤ 1.5 % at 2.0 g/L
Measurement precision (lactate)	≤ 1.5 % at 1.0 g/L
pH range of bioreactor medium	4.8–9.2
Biosensor service Life	30 days or 5,000 analyses
Ambient operating temperature	15–35 °C (59–95 °F)
Ambient operating humidity	10–90% RH (non-condensing)
Interfaces	RS 232, Ethernet, OPC UA, Modbus TCP
Software requirements	PC operating system Windows XP, 7, 8, 10, Windows Server 2012 R2
Analog output options	0–10 V; 0–20 mA; 4–20 mA
Power requirements	100–120, 220–240 VAC ; 50–60 Hz
Device battery	Lithium (0.09 g, UN test 38.3) Type CR2430 (3V, 270 mAh)
Dimensions in mm (W x H x D)	280 x 140 x 140
Weight	3 kg
Device ingress protection rating	IP54

16.2 Front Panel LED Status

The front LED panel of MAVEN shows the device's operating status, separate from the operating software on your PC. The unmarked LED on top changes color based on the current state of the device.

Status	Action	LED Color	LED Status
Startup & Shutdown			
Boot process		⊗ n/a	Off
Stop		● cyan	On
Filling		● cyan	Flashing
Premeasurement		●● green + cyan	Flashing, alternating
Clean		●● magenta + cyan	Flashing, alternating
Pauses			
Measuring mode	loaded	● green	On
Measuring mode	unload	● green	Flashing
Standby	Readiness	● yellow	On
Interval	Rest	● yellow	Flashing
Rinsing Operations			
Media change		● magenta	On
Rinse probe		● magenta	Flashing
Calibrations			
Sensor control / Reference	loaded	● blue	On
Sensor control / Reference	unload	● blue	Flashing
Interface			
No network connection		● red	On

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- Software updates
- Spreadsheet import macro

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Appendix: Trace_mon Application

APPENDIX: Trace_mon Application

If MAVEN RemoteUI is unsuitable for your lab environment, you may download and install Trace_mon, which provides the same functionality but in a local executable program.

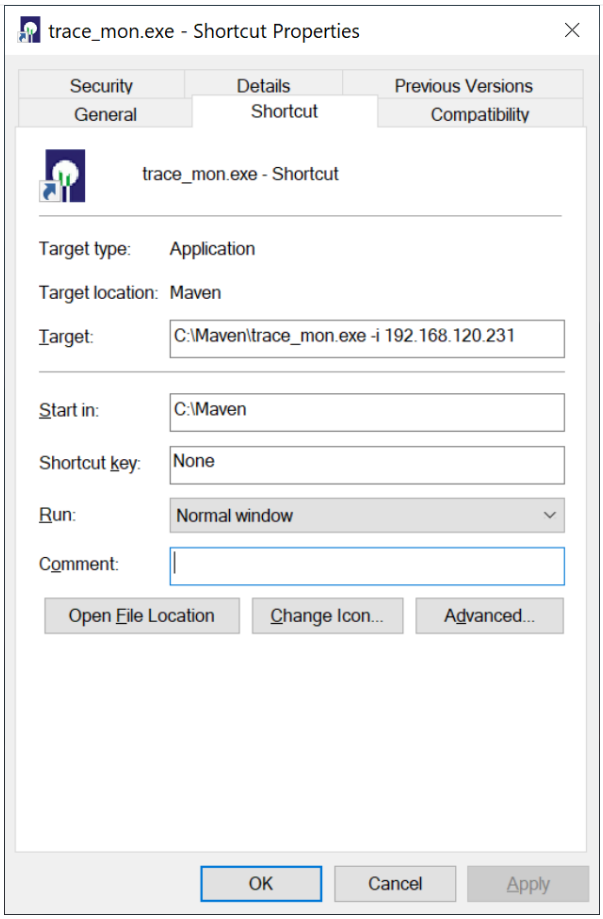
Operational Checklist for Trace_mon

Item	Action	Page & Section Reference	Page	☑
0	Initial Setup			
	Download and Install MAVEN control software onto PC	Trace_mon—Installing the Operating Software	33	
	Ensure PC is set to “always on” and automatic sleep mode disabled	Trace_mon—Installing the Operating Software	33	
1–4	Hardware setup	see main Operational Checklist	6	
5	Switch on the device	Trace_mon—Start Up	36	
6	Launch PC software	Trace_mon—Start Up	36	
	Connect device	Trace_mon—Start Up	36	
	Initialize new tubing set	Trace_mon—Start Up	36	
7	Set operating parameters	Trace_mon—Setting Measurement Parameters	40	
	Review basic settings	Trace_mon—Start Up	36	
	Select measurement method and parameters	Trace_mon—Setting Measurement Parameters	40	
	Create log file to save measured values	Trace_mon—Start Up		
8	Start measurements	Trace_mon—Home Screen Commands	38	
	Click “Fill" button and wait for sensor control to initiate	Trace_mon—Start Up	36	
	Alternative: Activate the "automatic start" option	Trace_mon—Start Up	36	
9	Check biosensor for air bubbles	9. Connect Supply and Discharge Lines to Diffusion Probe	10	
10	Perform reference measurement/calibration	Trace_mon—Calibration	37	
	Reference with external sample or known measured value	Trace_mon—Calibration	37	
11	Optional: connect analog outputs to process control system	Feed Pump Connectivity • 15.1 Analog and Serial Outputs • 15.2 Open Platform Communications Unified Architecture (OPC UA)—Data transfer via TCP/IP	 25 26	
		Trace_mon—Feed Pump Control • Proportional Integral Derivative (PID) Control • Min-Max Two-point Controller	 42 42	
		Trace_mon—Scheduling Actions • Events • Workflow	 43 44	

Trace_mon—Installing the Operating Software

Prior to installing the operating software, please make sure MAVEN is connected to your network via either option A (Direct Connect) or B (Gateway PC) as described above in “Network Setup.” Navigate to 908 Devices Customer Support Portal (my.908devices.com) to download the installation and setup files. To install the operating software on your computer, run "**setup_tracemon.exe.**"

You will be prompted to enter a new IP address, overwriting the factory preset IP address (Option A). If you have not changed the IP address (Option B), confirm with "Next". If you change the IP address, follow these steps to update the start settings in the program shortcut to ensure that the device connects automatically:



1. Go to your desktop.
2. Right-click the trace_mon.exe shortcut icon.
3. Select “Properties”.
4. In the Target field, after the “.exe” type “ -i ” (with spaces before and after), followed by your new IP address.
5. Confirm the change with “Apply.”
6. Click “OK.”

The software will start the device at the specified IP address and connect to the device automatically.

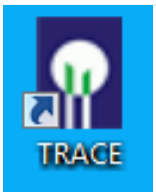
During installation, you will also be prompted to specify data storage locations.

Make sure that the PC remains permanently active and does not switch to energy-saving/stand-by mode, which may result in incorrect measurements or lost data.

Trace_mon—Start Up

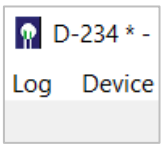
1. Activate the power switch at the bottom of the device.

2. Double-click the Trace_mon icon on your desktop to start the application.



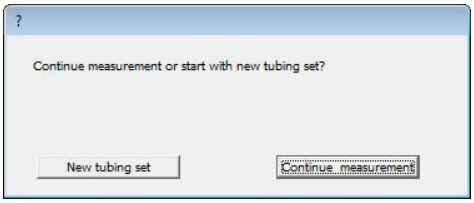
3. Wait for automatic connection between PC and MAVEN

Note: Once connected, the device number of MAVEN appears in the title bar (234 here). The asterisk indicates that the computer is connected to the device. If there is no connection, navigate to* Device > Connect *in the menu and refer to instructions in the section on Network Setup in this document.*



4. A dialog box will pop up.
   - *Choose "*New tubing set*" if you have changed the tubing set or if a longer interruption has occurred. In this case it is recommended to perform a sensor check before continuing with further measurements. (See section in this guide on Calibration)*
   - *Choose "*Continue Measuring*" to use the same calibration values as before. No flushing processes or sensor checks will be performed.*

Tip: If MAVEN is taken out of service for less than two days, it may be left standing, filled with buffer. If the system is not used for a longer period, the tubing set must be changed before restarting.



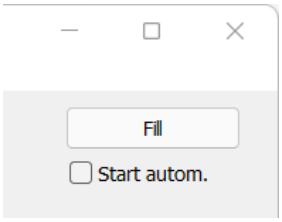
5. Navigate the menu to **Log > New** to create a new *.bpd file to store your data. MAVEN will not store your data unless a file is created first.

6. Navigate the menu to **Settings > Basic Settings** and check the box for "Adjust time" to ensure that MAVEN system clock matches the PC clock.
7. Click OK.

8. Click the "**Fill**" button and wait for sensor calibration to initiate.

Note: this process will flush buffer through the tubing and run pre-measurements to ensure that the sensor system is in a stable state. This initial process takes 40–60 minutes. Review the section on Calibration in this guide for more information. After priming, the instrument enters the standby state, ready to take measurements.

You may also activate the "Start autom." checkbox to automatically begin measurement immediately after the priming process, however, this will skip the calibration/referencing step. If you choose to automatically start the system, make sure all tubing is properly connected to the bioreactor.



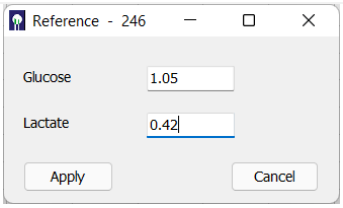
Trace_mon—Calibration

Calibration of MAVEN is a two-step process.

1. The **sensor** is calibrated using the MAVEN Calibration Standard Solution. It is recommended to calibrate MAVEN once per day. There are several ways to start this process:

- Click the "**Sensor control**" button on the home screen
- Auto sensor control, after a set number of measurements (see section on Setting Measurement Parameters in this guide)
- Automatically via the scheduler (see section on Scheduling Actions in this guide)
- Automatically via the workflow (see section on Scheduling Actions in this guide)

2. The **probe membrane** diffusion factor must be calibrated to account for the environmental conditions inside the bioreactor. This process is accomplished through the "**Reference**" or "**Fast Reference**" buttons on the home screen.



- **Reference** should be used when the user plans to take samples to confirm measurements from MAVEN with off-line analysis. After clicking the Reference button, a dialog box pops up, displaying current measurements. After you enter confirmed measurements from off-line analysis and click "Apply," MAVEN will calculate a new reference factor based on the two values.
- **Fast Reference**: allows the user to enter known concentration values of the medium before the reference measurement is made.

Tip: After starting your process, it is recommended run another sensor calibration and reference factor within the first 12 and 36 hours. Afterwards you can decrease the frequency of sensor calibration to once daily.

(0h): Calibration + Reference → Start
(12h): Calibration + Reference
(36h): Calibration + Reference
(After, daily): Calibration

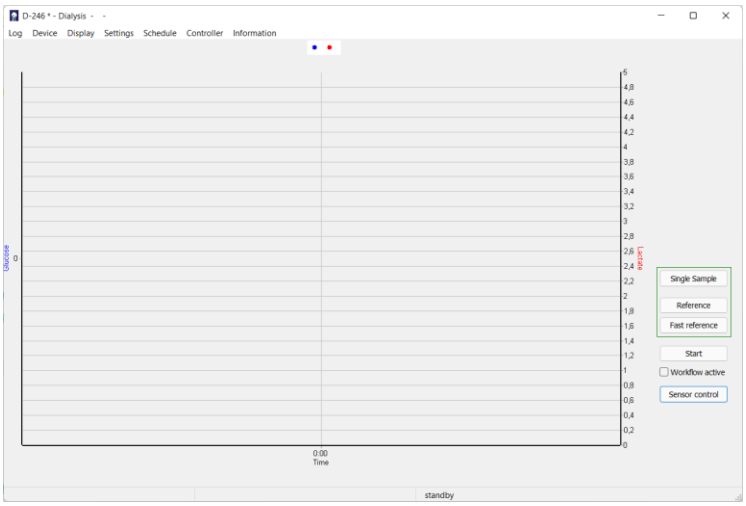
Tip: Do not overwrite low lactate reference measurements at the start of your culture.

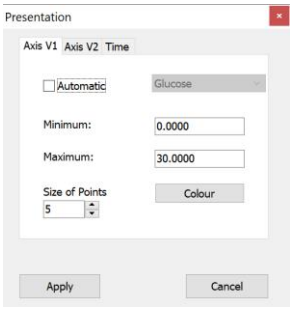
At the start of cultivation, the culture typically has abundant glucose and no lactate. When performing a reference, the device suggests a value after the reference measurement, which is usually overwritten by entering a known value. If the existing lactate concentration is still very low, do not overwrite this value at first (the reference factor for lactate then remains at 1.0). As cultivation continues, increase in lactate concentration can then be better observed and a normal referencing, in which both values are overwritten, can be carried out at the appropriate time.

Tip: Take a reference measurement with MAVEN before extracting a sample for off-line analysis, especially in a case where a change in concentration is expected.

Trace_mon—Home Screen Commands

After the priming process is complete, the Fill button will be hidden, "standby" will appear in the status bar at the bottom of the window, and commands will appear in the lower right of the window. You are ready to begin measuring with MAVEN.



Start	Begins measuring. This command can also be scheduled for a specific date and time using the Schedule menu.
Standby	Ends the current action of the device. This command can also be scheduled for a specific date and time using the Schedule menu.
Sensor Control	Begins a sensor calibration cycle. This command can also run automatically: • Auto sensor control (after a set number of measurements). See section on Setting Measurement Parameters in this guide. • Scheduler entry—see section on Scheduling Actions in this guide.
Single Sample	Begins a spontaneous, unscheduled single measurement. This function can be useful during long pauses between intervals. The current measurement program is not interrupted, and scheduled intervals are retained. This command can only be triggered if there is sufficient time to perform the measurement.
Reference	See section on Calibration in this guide.
Fast Reference	See section on Calibration in this guide.
Workflow Active	When checkbox is activated, the schedule list will run. If this box is unchecked, the measuring sequences from the default parameter list are processed instead. See section on Scheduling Actions in this guide.
Graph area  	Plot parameters can be adjusted at any time by right-clicking in the graph area, which opens a popup (pictured, left) allowing the user to change point sizes, colors, and axis scales. The left y-axis (1) corresponds to glucose and the right y-axis (2) corresponds to lactate. Units are g/L. By default, the values for glucose are displayed in blue and lactate in red. **Zoom in**: click-and-drag a box diagonally from left to right (↘). **Pan/move the graph**: Right-click and drag in direction desired. **Zoom out:** Click-and-drag in the plot area from right to left (↖).

Trace_mon—Menu Navigation

Log	**New >** *Creates a new *.bpd file, which records all measured values in a text format (also plotted on the on-screen graph). By default, this is stored in the "Data" subfolder. MAVEN will not store your data unless a file is created first.* **Load >** *Displays measurement data from an existing file*
Device	**Connect >** *Connects a new device. Any new device must have its IP address configured before further measurement can take place.* **Setting-up operation >** *Overrides previous sensor activity and reference data after changing the tubing set. Requires a new priming of the tubing system.* **Cleaning >** *Starts automatic cleaning cycle; recommended if the system will be idle for more than two days. Connect supply and buffer lines to the cleaning solution. Once cleaning solution container is empty, repeat the process with deionized water to ensure no salt residues remain.* **Stop >** *Suspends measurements and halts pump activity. You may close the software and switch off the device without affecting the biosensor or calibration data. When restarting, the system will check whether tubing sets were replaced. In case of longer interruptions, e.g., overnight, it is recommended to perform a sensor check before continuing with measurements.*
Display	**Print Diagram >** *Sends the graph currently shown on screen to your printer.* **Sensor activity >** *Opens a pop-up window showing the residual activity of the biosensor module relative to its activity at start-up; 1.00 corresponds to 100%. The slope and reference factor ("Reference fr") are also displayed. Clicking the "Reset references" option resets the reference factor to 1.0.* **Sensor History >** *Opens a pop-up window showing recent activity values. Right-click to save the biosensor module history as a *.txt file.* **Status >** *Shows/hides status bar at the bottom of the window. Field 1 shows the number of pending group measurements (or pre-measurements). Field 2 counts down the time until the end of the current action (in seconds). Field 3 shows the remaining time in the interval of the measurement period (in seconds).*
Settings	**Parameters >** *Allows user-specific setting of measurement frequency, frequency of sensor checks, data transmission, etc. See section on* Setting Measurement Parameters, *next page, for more details.* **Basic settings >** *Changes general information about the device and the project, which will later be used in the data output. This is where you can choose glucose and lactate or glucose-only modes, in addition to synchronizing system clocks between device and PC.* **Language >** *choose a different language for menu navigation. Current options include Chinese, English, French, German, Italian, and Spanish*
Schedule	*See page 43, Scheduling Actions.*
Controller	*See page 41, Feed Pump Control.*
Login	*Contains options to set up individual user logins and access levels*
Information	*Displays version numbers of the device firmware, trace_mon control software, and device serial number.*

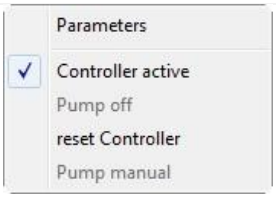
Trace_mon—Setting Measurement Parameters

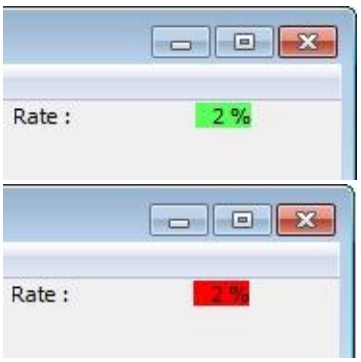
In the menu, navigate to ***Settings > Parameters***. All relevant parameters for the measuring operation can be set in this window.

Measuring period	Enter the desired measuring interval here. A value of 1 means measurement is performed every minute (this is also the maximum frequency). A value of 60 means once per hour. You can change of the frequency any time and it becomes effective immediately after clicking "OK."
Auto sensor control	Yes/No. If this option is activated, an automatic sensor calibration takes place every X measurements (see "Measurements between sensor controls" below).
Measurements per group	In the case of larger measurement intervals, it can be useful to run several measurements in quick succession at a desired time, for example, a group of 10 measurements every 6 hours. You can set the number of measured values in the group here. Each value is output directly after measurement, not an average. If the time necessary for processing the group is longer than the measuring period, then the next group starts with the new measuring interval.
Measurements between sensor controls	Set the number of measurements before an automatic sensor calibration occurs. Requires "Auto sensor control" to be enabled. For example, if measuring period is set to every 2 minutes and "measurements between sensor controls" is set to 30, then a sensor calibration will take place every 60 minutes. You can also trigger a sensor calibration at any time by pressing the "Sensor control" button. When changing the auto sensor control setting during operation, the changes will apply with the next control.
Output range glucose / Output range lactate	Set ranges of the analog outputs here. The procedure is as follows: The upper limit of the measuring range is always specified. The lower limit is preset to 0. With a desired measuring range of e.g. 0–10 g/L glucose, Glucose 10 (upper limit) is set for the output range. When selecting the voltage range 0–10 V, 10 volts then correspond to 10 g/L glucose.
TRACE SeMDaP— Data output via serial interface	The TRACE SeMDaP is a protocol to output data via an interface. Standard is the serial interface. The protocol contains telegrams of variable length and variable contents. This function is switched off at the factory and can be activated here. For more details about the protocol, please contact 908 Devices Customer Service.
OPC UA— Data transfer via TCP/IP	The device can act as an OPC UA server send data to external clients. This function is switched off at the factory and can be activated by the end-user. Please read the section on OPC UA in this guide for more information.

Trace_mon—Feed Pump Control

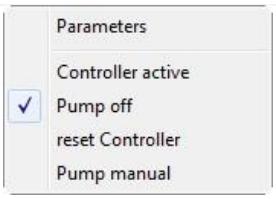
Under the **Controller** menu are options to help you set parameters for automating an external feed pump via the serial interface or analog output on the bottom of the device.



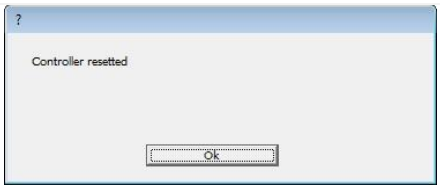


When "**Controller active**" is selected, the controller function is switched on and the feeding pump is activated.

- While the controller function is active, the pump cannot be switched off or operated manually.
- When the controller function is active, a green field appears in the main window indicating the current delivery rate (0–100%) of the feed pump. If the pump is turned off, the background turns red.
- Un-check "Controller active" to deactivate the controller. Although the controller is now inactive, the feeding pump will continue to run at the rate last set by the controller.

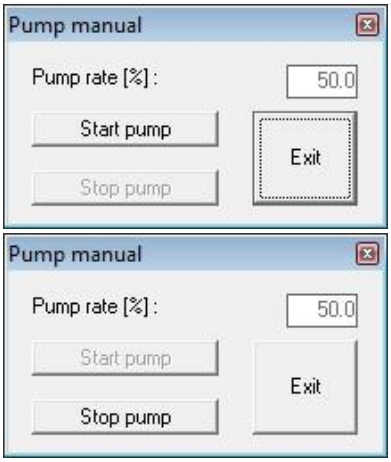


With "**Pump off**", the feeding pump is switched off manually. It can then only be switched on again by reactivating the controller.



In order to avoid a too high influence of the integral gain on the PID-controller at the beginning, the integral gain can be reset to the pre-set value by the "**Reset Controller**" command at any time. Click "OK" to save.

Note: this function has no effect on the Min-Max controller.



The "**Pump manual**" function can be used to fill the feeding tube. In this operating window, the pump rate can be set and the pump can be started or stopped.

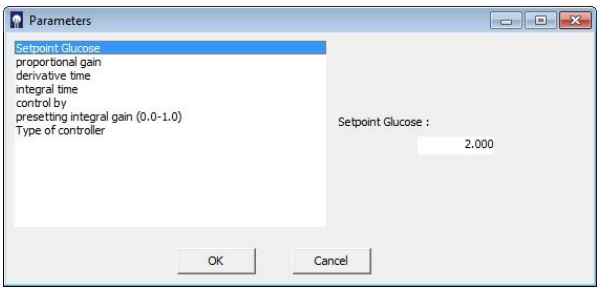
Note: after clicking "Exit" or closing the window, the pump is stopped automatically—do not close this window if you require the pump to continue operating.

To choose between PID control or Min-Max control, navigate to **Controller > Parameters** in the menu.

Proportional Integral Derivative (PID) Control

If you are using the PID control function, click on the individual options within the Parameters window to set the ideal glucose levels, proportional gain, integral time, and derivative time.

Under "Set via" option, you can select whether the control acts on an external pump via the serial interface or the analog output 3.



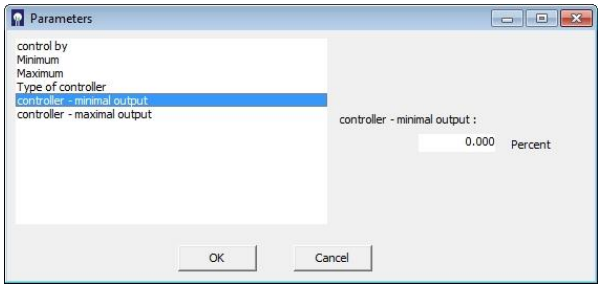
	Microbial Culture Recommended PID Settings		Cell Culture Recommended PID Settings
P	0.1–0.5 (depending on the concentration of the feed, maximum delivery rate of the pump, pump tubing diameter, reactor volume, etc.)	P	0.01–0.1 (depending on the concentration of the feed, maximum flow rate of the pump, pump tubing diameter, reactor volume, etc.)
I	45 min (reset time)	I	60 min (reset time)
D	2 min (lead time)	D	1 min (lead time)

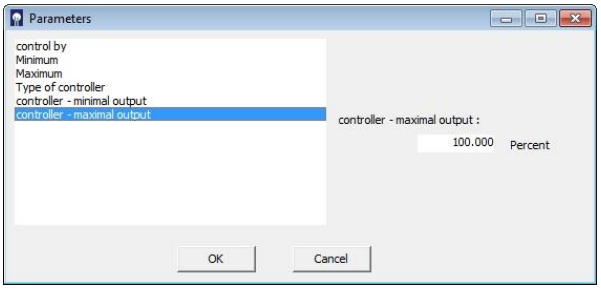
Notes

- *In most cases, adjustment of the P factor is sufficient and the I and D values can be maintained at the recommended value. If the feeding rate is too high, reduce the P-value. If the feeding rate is too low, increase the P-value.*
- *To avoid a too high integral gain (I-component) of the PID controller at the beginning, the I-component of the controller can be reset to the default I-component at any time with the "Reset controller" command.*
- *It is recommended to always reset the controller after filling the feeding line or in case of unknown history to avoid overdosing.*

Min-Max Two-point Controller

After selecting the Min-Max control, the minimum and maximum values for the control can be entered in the "Parameters." The min-max controller switches the feeding pump to the minimum delivery rate or maximum delivery rate when the limit values are exceeded or not reached, respectively. "Minimum control value" and "maximum control value" set the minimum and maximum delivery rates of the pump. The default settings here are 0% and 100%.



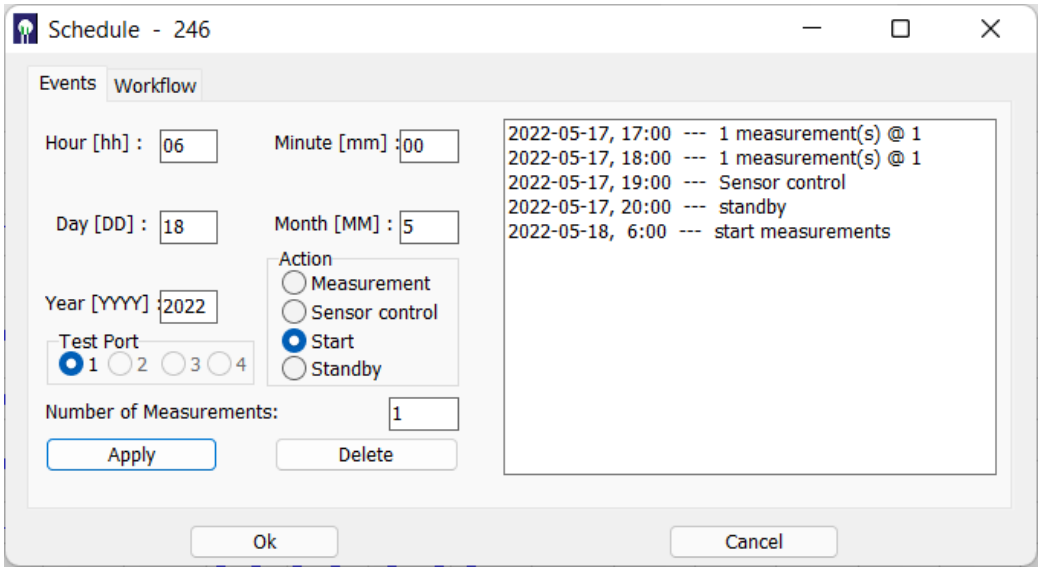


Trace_mon—Scheduling Actions

The **Schedule** menu allows you to set actions at specific times (**Events** tab) or regular intervals (**Workflow** tab).

Events

Events are actions set to fixed points in time, *e.g.*, "next Tuesday at 9:30".

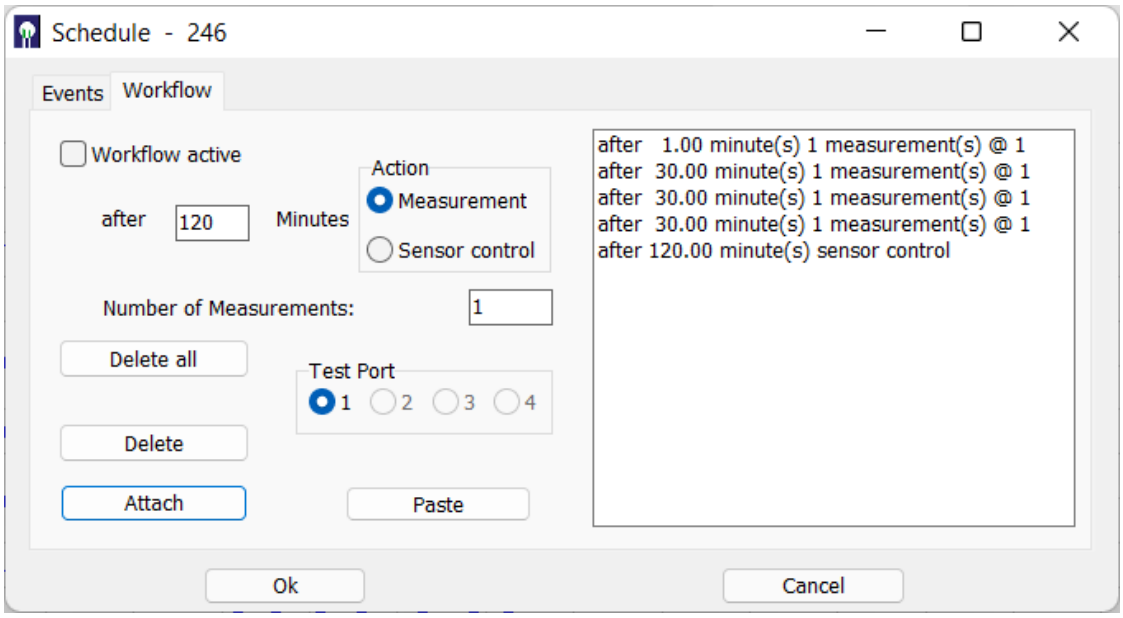


Hour [hh], Minute [mm] **Day [DD], Month [MM],** **Year [YYYY]**	Sets time and date of event. *Note that 24h format is used, so 1pm should be written as 13:00.*
Action	Choose between Measurement, Sensor control (calibration), Start, or Standby
Number of Measurements	This field corresponds to "Group" in the parameter list. Enter the number of measurements to take place at the specified time.
Apply	Transfer the current settings to the list box on the right. Actions are automatically sorted earliest to latest.
Delete	Removes the highlighted event from the list.
OK	Saves all entries.
Cancel	Discards changes.

Notes

- *Schedule Events are always treated with higher priority than others, e.g., actions from the Workflow tab or the main parameter list. If an action from another source needs to run during a scheduled event, the system waits until the scheduled action is finished. For example, you may schedule MAVEN to come online (start) and go back into standby at specific times. While online MAVEN will execute auto-calibrations and measurements according to the main parameter list.*
- *After a scheduled event has been carried out, the entry is removed from the list and does not reappear when the schedule is reopened later—only the events that are still pending are displayed.*
- *Duplicate entries are ignored.*
- *For simultaneous entries, only the command further up is processed.*

Workflow
Workflow creates a sequence of actions to happen at specific regular intervals.



Workflow active	When checkbox is activated, the schedule list will run. If this box is unchecked, the measuring sequences from the default parameter list are processed instead.
after ___ minutes	Enter the desired time interval between individual actions. *Note: If "1" is entered here, the next action takes place after a probe flush. By selecting larger intervals, the measuring frequency is reduced accordingly.*
Number of Measurements	Enter the number of measurements to take place at the specified interval. *This field corresponds to "Group" in the parameter list.*
Action	Choose between Measurement or Sensor control (calibration)
Attach	Appends the current settings to the workflow list box as the last entry.
Paste	Inserts the current settings above the selected line in the workflow list box.
Delete	Removes a selected line from the workflow list.
Delete All	Removes all entries from the list box.
OK	Saves all entries
Cancel	Discards changes

Notes

- *The time interval selected for the first action in line 1 only becomes active during the second run of the list. This ensures that processing of the list is started immediately after the start. During the second run, the selected interval then also applies to the action in line 1.*
- *The list repeats until stopped or device is placed in standby mode.*

Trace_mon—Data Transmission, Storage, and Visualization

MAVEN offers several output options for easy, flexible integration into your data recording system.

- MAVEN can act as an Open Platform Communications Unified Architecture (OPC UA) server to transfer data to another device (PC, process control system) on your local network.
- Standard analog output for signal ranges from 0 to 20mA, 0 to 10V, or 4 to 20mA.
- Ethernet connects the device to a PC via a network. If the network connection between the device and the PC is interrupted, data will be buffered within the device until a connection is restored. The missing data is then automatically transferred to the trace_mon software.
- The supplied software allows you to configure and control measurements as well as a feeding pump.
- Measurements are plotted directly on screen and stored as text in a user-defined log file. The user must start a new log file PRIOR to data acquisition in order to access the data. This file is saved as a *.bpd file in the default subdirectory "Data" and can be exported in a spreadsheet format.
- Data will include date and time of measurements, temperature*, glucose, and lactate levels. If the controller is active, the respective delivery rate (1 = 100%) is also recorded.

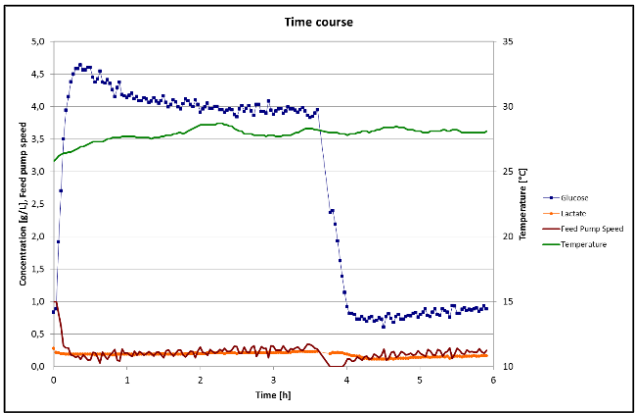
Data transfer to Excel via Macro

The easiest way to transfer data from the MAVEN is through a macro, which is available for download from the 908 Devices Customer Support Portal. The macro will help transfer the data into a table and plot the points on a graph.

To use the Macro:

- Open "Macro_bpd.xlsm"
- Start the transfer by pressing ctrl + M on your keyboard
- The macro will generate a table and graph in Excel, similar to the examples below:

Date	Time	Reactor No.	Temperature	Glucose	Lactate	Feed pump sp	Time of Exp.
23.04.2015	09:13:59	0	25,800	0,840	0,280	1,000	0,000
23.04.2015	09:15:59	0	26,000	0,890	0,220	1,000	0,033
23.04.2015	09:17:59	0	26,200	1,920	0,210	0,828	0,067
23.04.2015	09:19:59	0	26,300	2,700	0,200	0,633	0,100
23.04.2015	09:21:59	0	26,400	3,500	0,200	0,322	0,133
23.04.2015	09:23:59	0	26,400	3,940	0,190	0,288	0,167
23.04.2015	09:25:59	0	26,500	4,150	0,190	0,289	0,200
23.04.2015	09:27:59	0	26,500	4,380	0,190	0,185	0,233



**Temperature data comes from bioreactor controller if your equipment supports it. The MAVEN diffusion probe does not provide temperature data.*