Labm8 Web Control

Software Manual

Version 1.10

DISCLAIMER

The material in this data sheet is for informational purposes only. The products it describes are subject to change without prior notice, due to the manufacturer's continuous development program. This means that there may be changes in form, equipment and technology. Claims can therefore not be made on the basis of information, illustration or descriptions in these projects. The description for the products in this manual does not constitute an integral part of the contract.

The general terms and conditions of Labm8 shall apply. Alternative agreements must be in written form.

Labm8,
info@labm8.io

Feature request and bug s

Labm8 Web Control is continuously improving the software interface to expand its functionality. If you find that general features are missing, working incorrectly, or want some customized algorithms to be incorporated, please contact us at info@labm8.io

Software license

Labm8 Web Control is a modified version of Duet Web Control and is therefore licensed under the terms of the GNU Public License v3. Copies of Labm8 Web control are therefore available on request.

1 Overview and indexes

1.1 Table of contents

1.2 Change History

V1.02 - Increased Excel upload functionalities for big excel files, more algorithms for online kinetic experiments.

V1.03 - UI color change for improved visibility, addition of + sign in flowrates for syringe filling mode.

V1.04 - Addition of download / upload button for syringe configurations.

V1.05 - Addition syringe volume updater and automated segmentation of long duration experiments.

V1.06 - Automatic segmentation update using while.g

V1.07 - Addition of red color notifier in free for all

V1.08 - Addition of syringe library manager

V1.09 - Addition of interactive control feature

V.1.10 - addition of system design tab and fraction collector visualization / experiment generation.

2 Introduction

2.1 Foreword

Thank you for your interest in Labm8. With this user manual we would like to support you as well as possible when handeling the device. If you have any questions or suggestions, please do not hestitate to contact us.

info@labm8.io

2.2 Symbols and keywords used

HINT. *Describes practical tips*

IMPORTANT. *Signifies important hints and other useful information that may not result int potentially dangerous or harmful situations.*

ATTENTION. *Indicates a potentially harmfull situation. If it is not avoided the product or something in its environment may be damaged.*

CAUTION**.** Indicates a potentially dangerous situation. If it is not avoided, slight or minor injuries and property damage may result.

IMPORTANT. *Please read this manual as well as the corresponding hardware manual carefully and completly before putting your system into operation. Additionally please read the Labm8 system manual carefully and completly before putting your system into operation.*

3 Installation

3.1 Installing the software

Labm8 Web Control runs in your browser. We recommend using Google Chrome, as the software was developed and optimized for this browser. Therefore, installation begins with installing Google Chrome if it is not already installed.

Start up your Labm8 control unit and get connected to it by opening your network settings and connecting to Labm8's wifi network using the credentials found on the bottom of you Labm8 control unit.

Next, open the webbrowser and go to the corresponding IP adress, listed on the name plate of the Labm8 Control Unit.

You will now be promped with the login screen, were you will need to add the password: LABM8 (case sensitve).

The software and hardware is now ready to be used.

3.2 System requirements

Labm8 can be controlled via any device (Computer, Laptop, phone or tablet) but we highly recommend to only use a computer, since the interface is currently only optimized for usage with a computer.

Your computer should be able to run Google chrome and we advice you to have the following programs installed on your computed:

- Notepad application
- spreadsheet application able to export to .xlsx

Finally, we advice to disable sleep mode / standby mode on your pc and disable your computer to connect automatically to other networks. (If connection to the Labm8-control unit is lost, it may reconnect to an other network without you noticing). This may impair logging of experiments. We therefore recommend to use a second wifi dongle that only connects to Labm8's control unit.

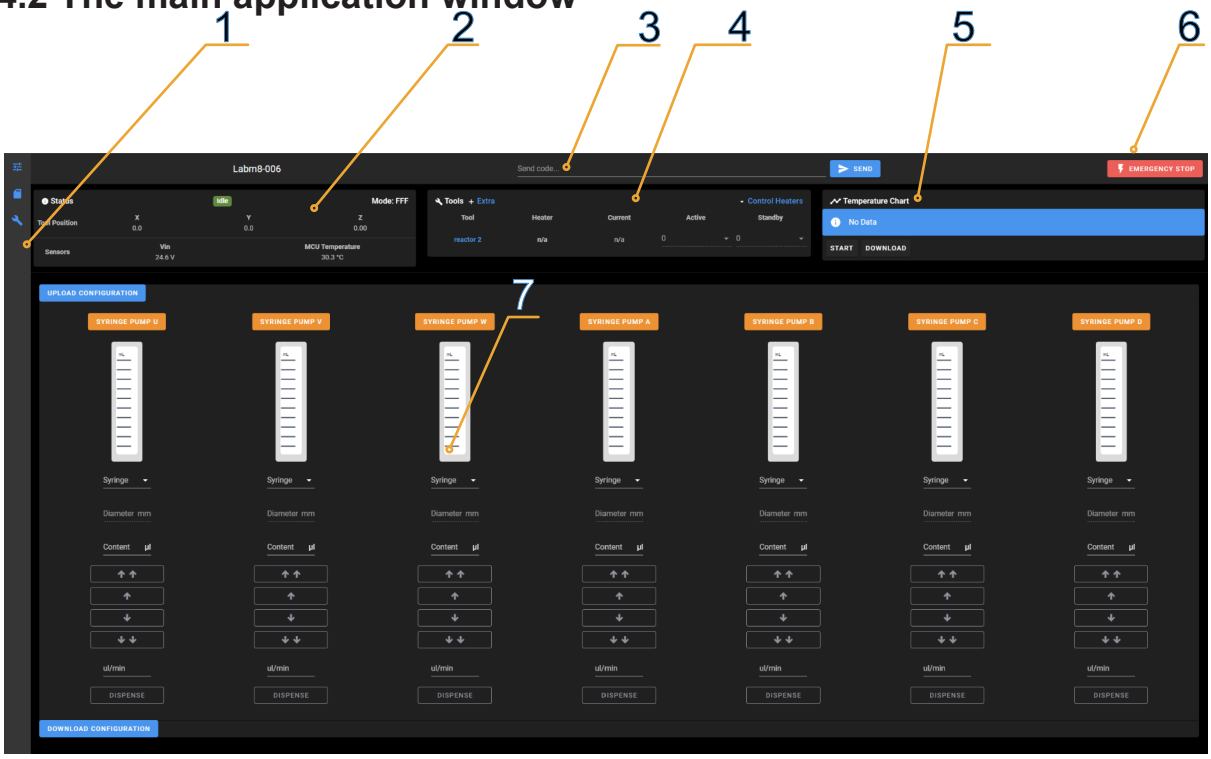
4 Introduction to Labm8 Web control

4.1 A note about Gcodes

All movements and commands send from the control software, to the device are in the form of Gcode. A full list of available gcodes and their detailed description in relation to the duet board used are availble on https://docs.duet3d.com/User_manual/Reference/Gcodes and discussing them all is beyond the scope of this manual and is clearly written out there.

The information in this link is complementairy to information provided in their user manual which can be referenced to develop deeper insights into the system and increase it's functionallity outside of the feature set that Labm8 currently offers. This, however, will void any warranty from Labm8's side. https://docs.duet3d.com/en/User_manual

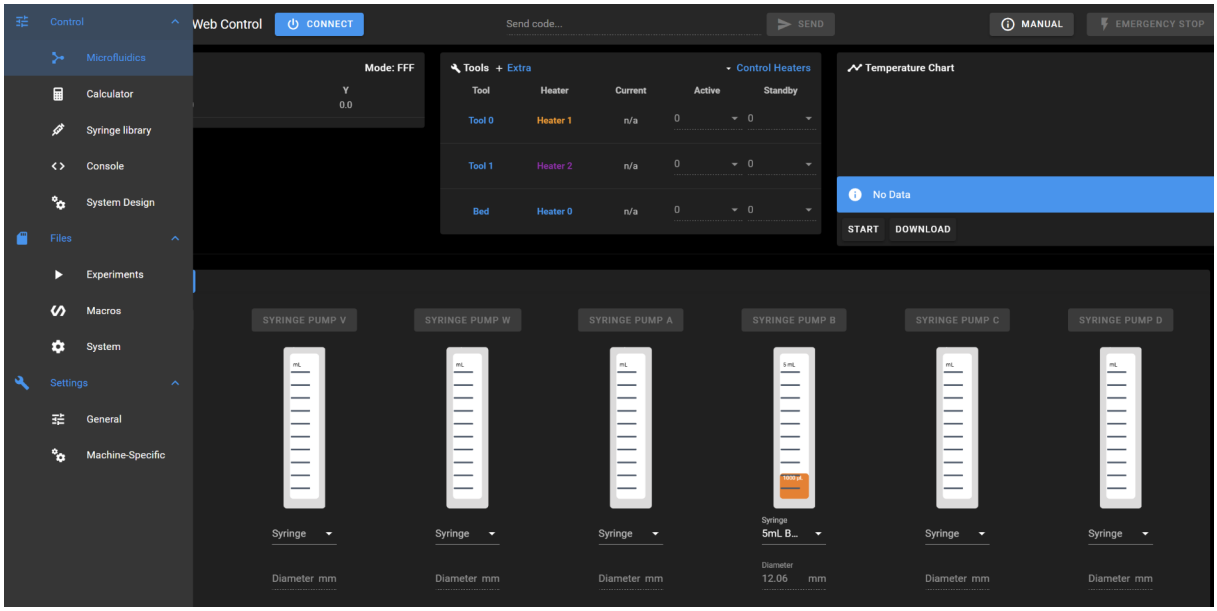
4.2 The main application window



1	Side panel menu that opens when you hoover over it.
2	Status panel, provides general information about the status
3	Gcode input bar with send option, simple Gcode comands can be send from here.
4	Tools panel, used to set temperatures for heaters if installed.
5	Temperature chart will provide a real time graph of the temperatures of the installed tools.
6	**Emergency stop**, pressing this stops all procceses and restarts the system.
7	Syringe pump configuration panel

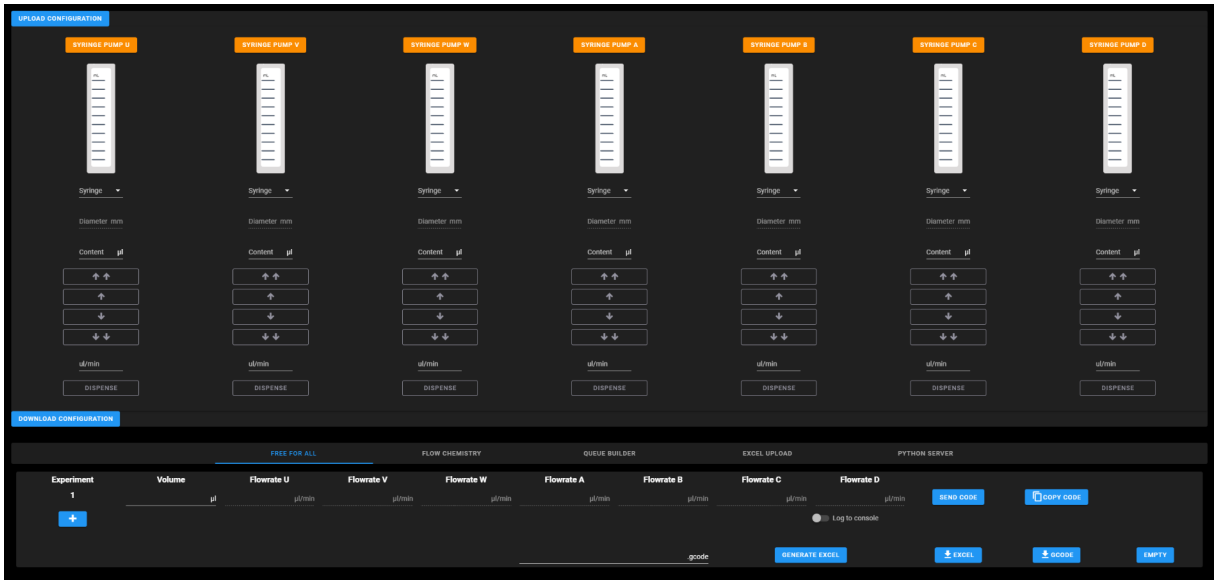
IMPORTANT. When pressing the emergency button the system restart and therefore the WIFI conection is lost. In some cases, your computer device may connect to a different network and you mannually have to reconnect to your Labm8 control unit.

4.3 Side bar navigation



Control	Microfluidics	Used to control and build simple microfluidic experiments
	Calculator	Used to calculate molarities of solutions and reactor volumes
	Syringe library	Management system for syringes
	Console	Used to get insight in what the system executed at what time.
	System design	Configuring the flow system setup
Files	Experiments	Experiment management system where experiment files can be stored, uploaded, started and edited.
	Macros	Macro management system, where macro files can be stored, uploaded, started and edited. Macro's are small scripts of gcode that encode repetitive tasks and can be called by an experiment file.
	System	System related management system where configuration files are stored.
Settings	General	General preferences of the user interface / machine
	Machine-Specific	General settings of the machine

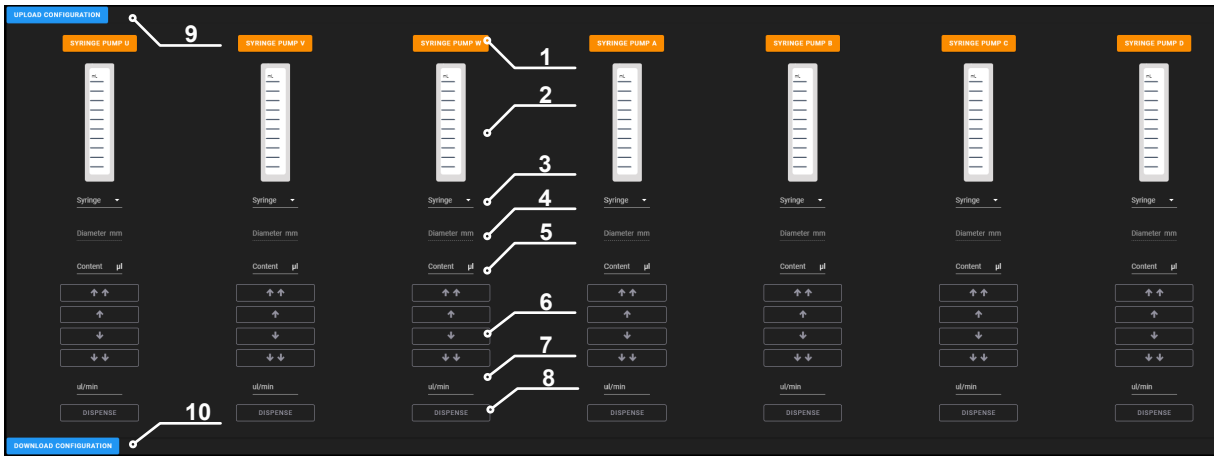
4.4 Tab menu - microfluidic page



Free For All	¶ 4.6	Used to create a simple script containing only pumping movements. Run can be directly send via the send button.
Interactive control	¶ 4.18	Used to control the syringe pumps in an interactive fashion, no time or volume is specified and flowrates can be updated without emergency stopping the system.
Flow chemistry	¶ 4.13	Used to create a advanced scripts using our built in algorithms. Currently only online kinetic experiments are build in.
Que Builder	¶ 4.11	Used to build scripts containing various actions with the abbility to have a live que that auto runs the specified jobs.
Exel upload	¶ 4.12	Used to upload Excel files containing only syringe pump movements

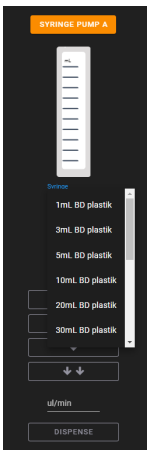
IMPORTANT. All the scripts generators / send buttons use the information provided in the syringe pump settings to calculate the required speed and steps the axis should move. If left empty, the software will not be able to create a correct script. Always double check the created Gcode lines to confirm the correct generation see ¶ 4.9 for understanding the script.

4.5 Syringe configuration window

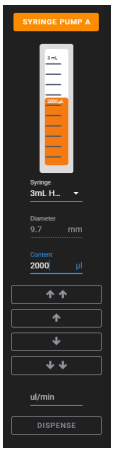


1	Syringe pump name and homing button, similar to sending G28 W, and calls for the file: *files/system/homeW.g* ¶ 4.15 The button will turn blue upon succesfull homing.
2	Syringe pump visualization, indicates if it's active and correctly configured and current volume in the syringes for experiments send through the free for all or que builder tab. This is only indicative and runs like a timer on the software side only and is not based on the actual position.
3	Dropdown menu with syringes configured in the syringe library manager
4	Displays the inner diameter of the selected syringe, configured in the **syringe library**
5	This input field requires you to tell how much volume is in the syringe, for the syringes that fill up, the and start empty, 0 should be put in for it to update correctly.
6	Jog buttons, moves the axis either 2.5 or 0.5 mm up is down arrows are dispensing direction.
7	Current flowrate of the syringe pump
8	Dispense button to complete dispense the volume in the syringe at flowrate specified in **7**
9	Upload button to upload a previously configured syringe pump configuration
10	Download button to download the current syringe pump configurations

4.6 Configuring the syringe pump(s)



1. Select the syringe brand and size from the dropdown menu, the listed syringes originate from the syringe library manager.



2. Specify the volume you will put into your syringe and press the activate button

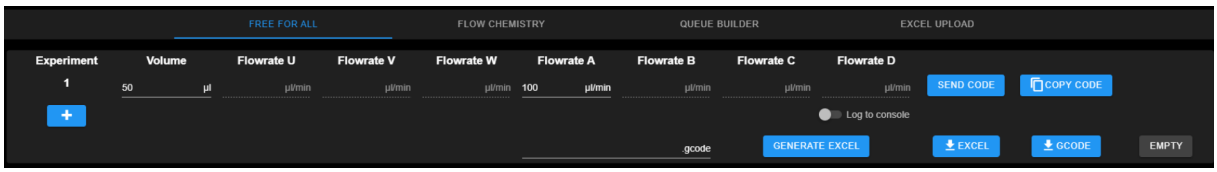
3. The orange bar will appear indicating that the syringe pump is active and succesfully configured

IMPORTANT. Always configure one syringe pump at a time from top to bottom. When you refresh the page all information on the page will be lost and the syringe pumps needs to be reconfigured. Restarting the system will not erase this data. Unless the page is reloaded. Always double check the diameters of your syringes.

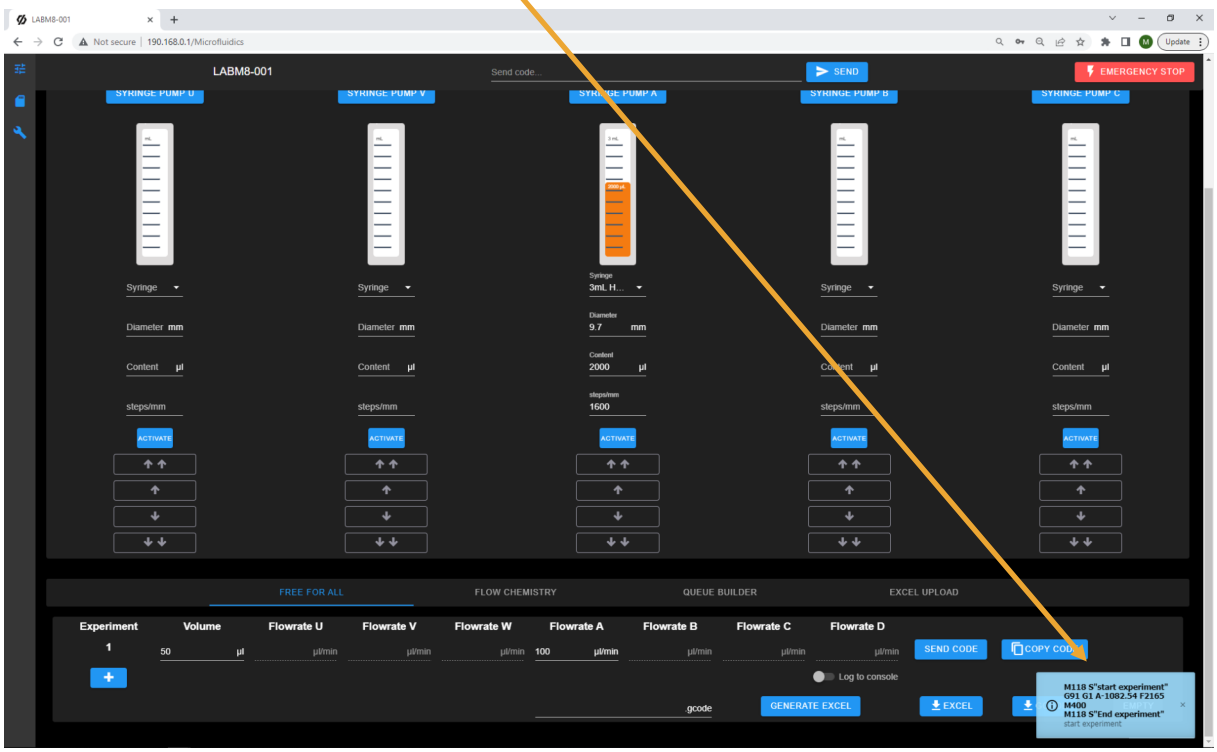
CAUTION. Pinch hazard, Keep any body parts away from the syringe pump during homing or movement sequences, to avoid any potantial pinch hazards.

4.7 Free For All tab - creating and executing a single run

After succesfully configuring a syringe pump, you can add a line in the free for all tab by pressing the + button. Flowrates for syringe pumps that are not fully configured are disabled and only the correctly configured syringe pumps can be filled in. The input field for Volume can be changed to Time by clicking on Volume. The unit of flowrate can be changed to µl/h by clicking on the flowrate [Letter]. Adding a + sign will move to pump in the opposite directions (filling mode).

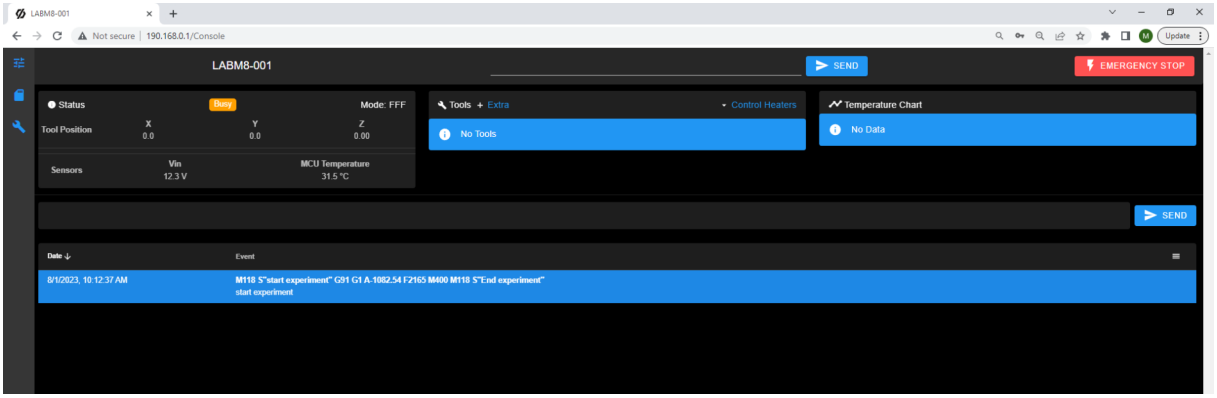


The configured single run can be executed by pressing the send button at the end of the run information. A blue pop up dialog should pop up indicating that the run was send succesfully. The orange bar in the syringe overview will start moving at the pace of the flowrate. The input field will turn red if it detects an experiment with insufficient volume in the syringe.

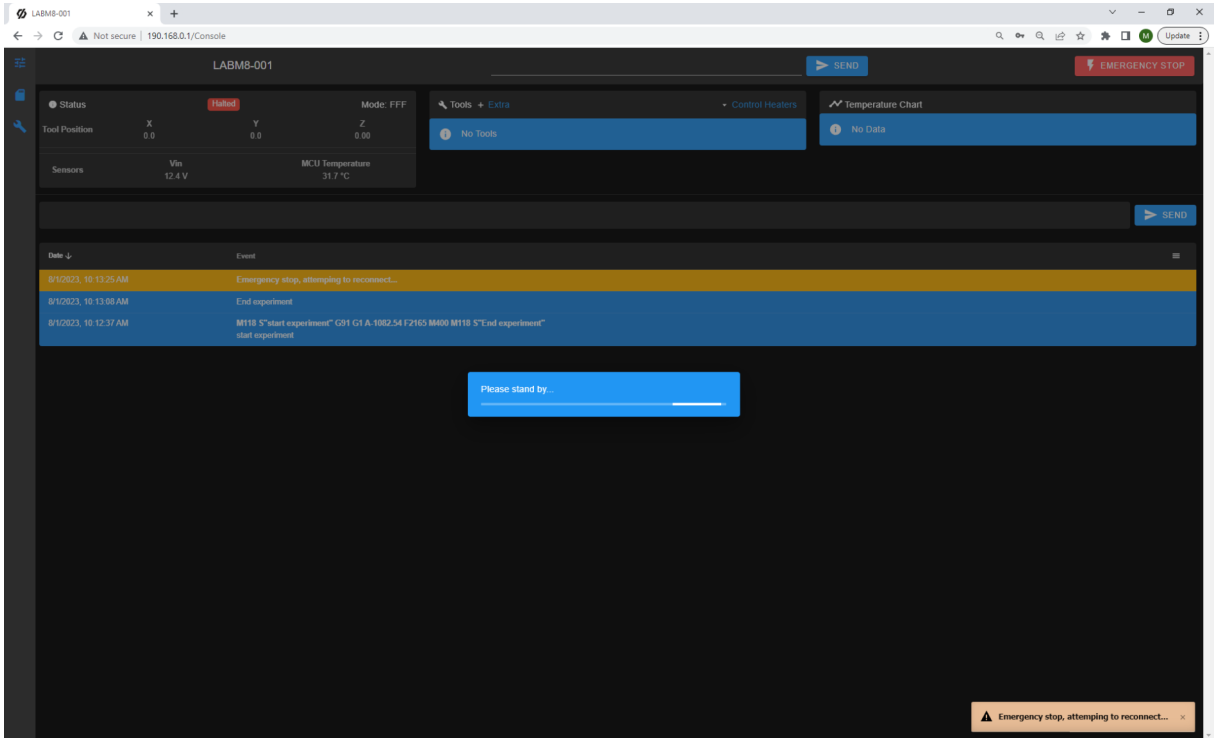


IMPORTANT. Always use dots as decimal seperators instead of comma's. Gcodes executes scripts line by line. A line can not be paused and can only be stopped by pressing the emercency stop button. Experiments exceeding more than 30 minutes are automatically segmented and ran via the macro "while.g", make sure this file is present and unedited in the files/macros page. The maximum duration of a single line is 256 hours.

After the run is send, you can go to the *control/console* page where the event is logged. Here you can see the time stamp at which the experiment was started and finished. The time between start and end should not differ from the expected time, always double check this.

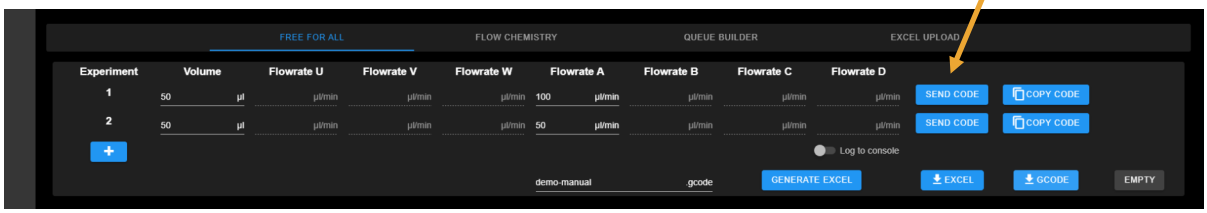


In case you need to stop the experiment by pressing the emergency stop button, this will also appear in the console view. Make sure it reconnects properly to the wifi.



4.8 Free For All tab - creating a script with multiple runs

Multiple runs can be configured by pressing the + button and filling in the required information. These runs can be send seperatly by pressing the send button, this button is deactivated after the code is send until the device is idle again. Or the sequence can be downloaded as a script by pressing the download Gcode button.



Various options are avaiable such as log to console, this will send the start and finish information to the console when the script is run. This, however stops the syringe pumps from moving inbetween experiments for a small amount of time. (less than 1 second).

The experiment can also be downloaded to excel. But first needs to generated using the generate excel button. This file can then be download using the download to excel button. This excel sheet can be opened in excel and will show an error when opening, this error can be ignored. The created excel sheet can also serve as a template for creating experiments that you can upload to the excel upload page.

After pressing the download button a dialog will apear asking you where to save the filename.gcode file. After saving, the file can be opened using any notepad application. Make sure that when you save it, you save it as a .gcode file and not as a .txt file.

The potentially modified Gcode script can be uploaded to the experiment management window. This is further explained in section **¶4.10.**

4.9 Understanding the Gcode script of multiple runs

Explanation of the generated Gcode from download / send / qued or copied function in the software

; :GCode comments begin at a semicolon, and end at the end of the line.

M564 H0 S0; move the syringes even if no homing operation is performed, also ignore the set axis limits.

G91 : Set relative positioning, all moves are now relative to the last position
G1 : linear move
A-1082.54 : Amount of steps the pump A needs to move. 1600 steps equals a linear travel of 1 mm. Having a syringe diameter with a diameter of **9.7** mm equals to an area of **73.9** mm^2 therefore, 1 mm of linear travel will dispens **~74** µl. In the example above, 1082.54 steps / 1600 steps/mm = 0.67 mm
6.76 mm x 74 µl/mm = 50 µl which is equal to our set amount.
F2165 : Speed at which the pumps move in (mm/min).
1082.54 steps / 2165 steps/min = 0.50 min as set in our experiment (50 ul / 100 ul/min = 0.5 min).
For experiments that utilize multiple pumps, the F parameter is calculated using the Pythagorean theorem by (shown for A and B):
F = √(stepsA2 + stepsB2)/experiment time

For experiments that last longer than 30 minutes, automatic segmentation takes place and the code looks slightly different:

An experiment for 35 minutes will look like:

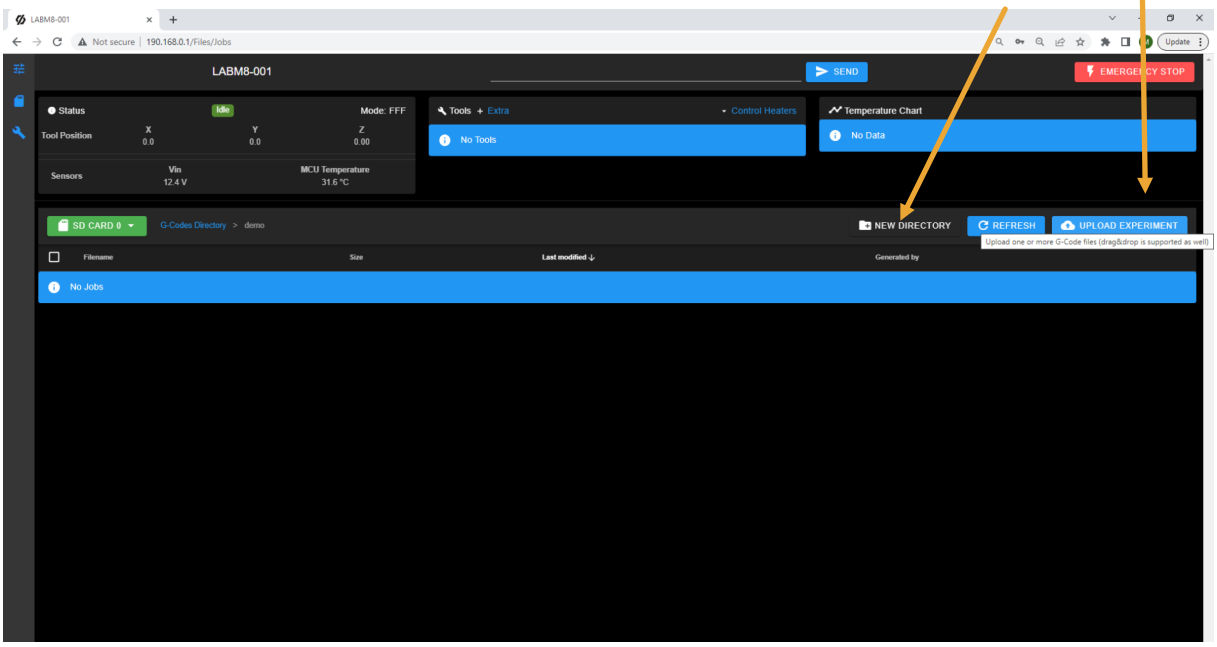
M98 P"0:/macros/while.g" A-155988.86 B-0 C-0 D-0 U-0 V-0 W-0 F8913.65 S2

M98 calls for a macro file that is located at location P, the S parameter (S2) is amount of segments.
The amount of steps for A is equal to total steps A / by S, the F parameter remains the same.

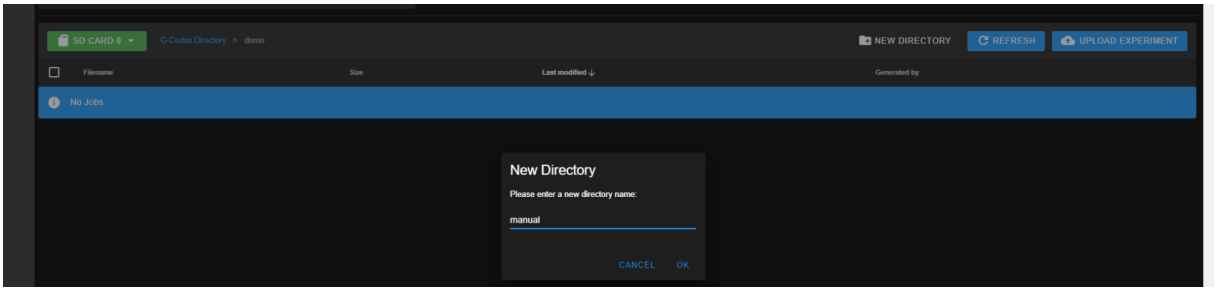
155988.86 steps / 8913.65 steps/minutes = 17.5 minutes
17.5 minutes x 2 (S) = 35 minutes as required.

4.10 Uploading a Gcode script

The Gcode script can be uploaded to the system by going via the side panel navigation to the *files/experiments* page using the upload experiment button. On this page you will find your previous experiments, which can be managed in folder structures. A new directory can be created using the new directory button.

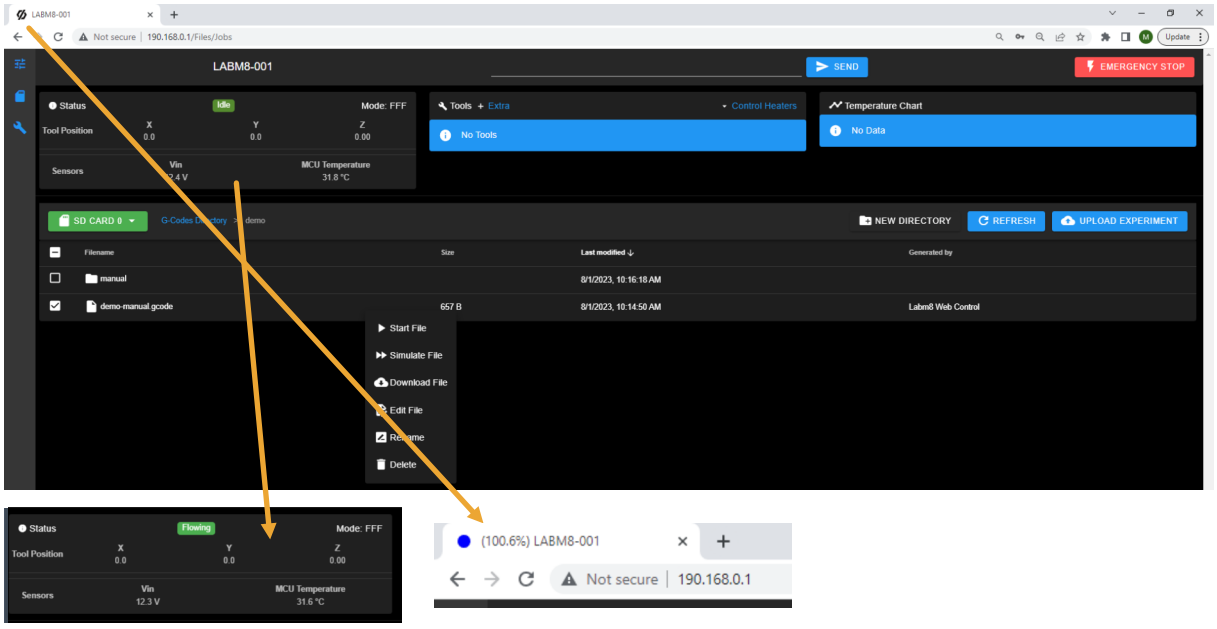


Clicking the new directory button will open a pop up dialog where you can name your new directory



The created script can be uploaded to the new folder by pressing the upload experiment button. This wil open a dialog in which you can select the experiment.

Right click on the name of the experiment will show various options. The experiment can be started by clicking start file option in the dropdown menu. The status of the machine should now change from Idle to Flowing.

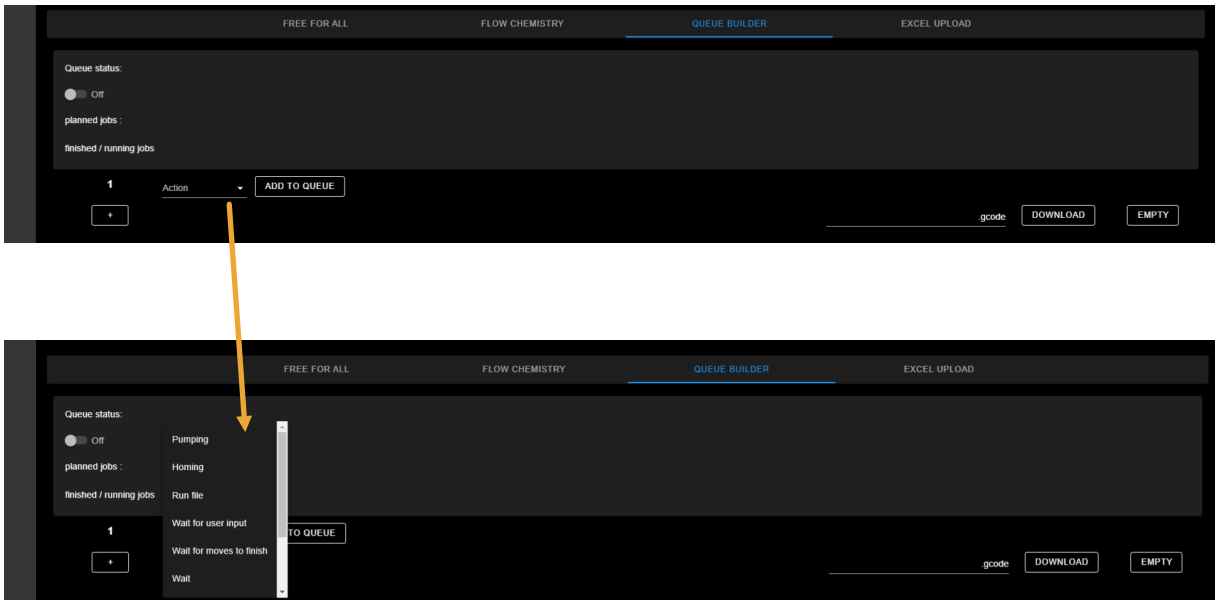


IMPORTANT. *Gcodes executes scripts line by line. When a experiment is started, a percentage of completion will be shown nex to the 'browser tab name. This percentage is based on the amount of lines in the script, not the total duration of the experiment in time.*

IMPORTANT. *Uploaded experiments are saved and read from the onboard micro SD card. If an experiment is started via the start file, the lines are run from the SD card, and if, the connection between the computer and control unit fails,the control unit remains active, as in the computer goes into sleep mode, or you change the wifi connection on your pc, the system will continu to run the experiment. Logging to the console, however, is impaired.*

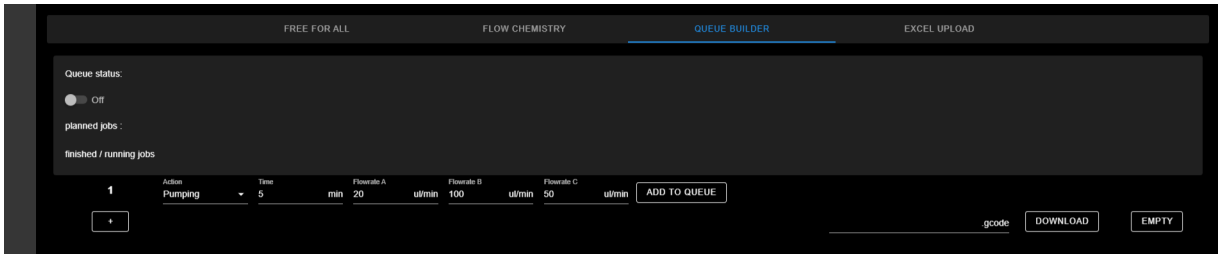
4.11 Queue builder

The queue builder can be used to build a que of actions that your device needs to perform. For pumping actions, it works similar to the free for al page and syringe pumps must be configured. Start by pressing the + button to create a new action. After pressing the + button, a new dropdown menu appears. From this dropdown menu, one action per row can be selected.



Pumping	Is used for moving liquid, similar as the free for all tab
Homing	Brings the gantry of the axis towards the end of the axis this by using the **G28** command for example G28 A “homes” axis A this is done by running the script found in *files/system/omeA.g*
Run file	Is used to start a Gcode script / file located in *files/experiments/ filename.g*
Movements	Used for linear travels, unrelated to liquid flow.
Wait	Pause the device for a specific amount of time
Logging	Log a message to the console
Macro	Run a a macro file from *files/macros/filename.g* Macro’s contain small Gcode script for that program a repetitive task.
Custom Gcode block	Write any Gcode yourself, following the Gcode format described here: https://docs.duet3d.com/User_manual/Reference/Gcodes

IMPORTANT. *When using the que builder, your laptop or computer needs to stay active (not in sleep mode) and connected to the device in order to send and recieve new Gcodes. If you are planning to take away your computer, you should create a script and upload this as an experiment as described in chapter 4.10.*



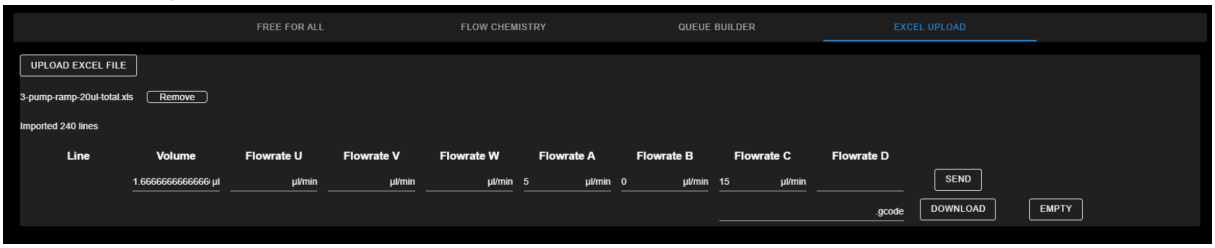
After filling in the required information the job can be added to the queue by pressing add to que.The queue status is off by default and can be turned on by pressing the switch. This will immediately start running. The planned job will be put to finished / running jobs after it is excecuted. Each execution will show a blue pop up message. The order of the planned jobs can be changed by clicking the up and down button.

4.12 Excel upload

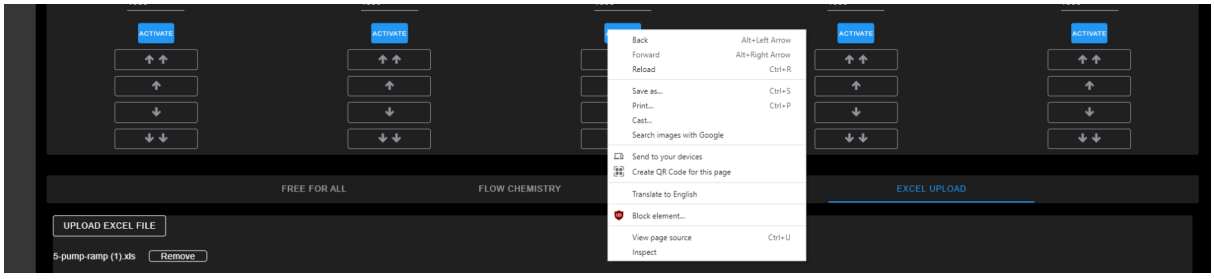
For dynamic flow experiments, in which flowrates change frequently (interval smaller than 30 minutes, the excel upload tab can be used to process a large amount of flowrates. The data must have the same format as an excel sheet downloaded from the Free For All page and should look like:

A	B	C	D	E	F	G	H	I	J
Line	Time	Volume	FlowrateU	FlowrateV	FlowrateW	FlowrateA	FlowrateB	FlowrateC	FlowrateD
		5				100			
		2				25			

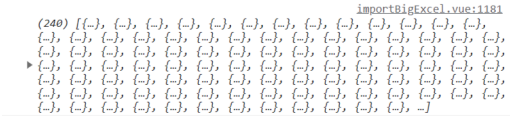
The volume can be put in as µl or min, since this can be changed in the interface later. The flowrates can be in either µl/min or µl/h as this can also be changed in the interface after uploading. When using a function in excel, copy and paste the complete table in a new excel spreadsheat as value only else the importer can't read the data.To upload the file, press the upload excel button, this opens a dialog that ask's you for the excel file. Units of flowrates and Volume can be changed by clicking on the corresponding column name.



For large files, the import function may take some time and showing more than 1000 lines makes the web interface slow. Therefore we only show the first line in the excel file. The interface does list how many lines it has imported. To see the rest, right click somewhere in the webpage and select inspect and go to the console tab.



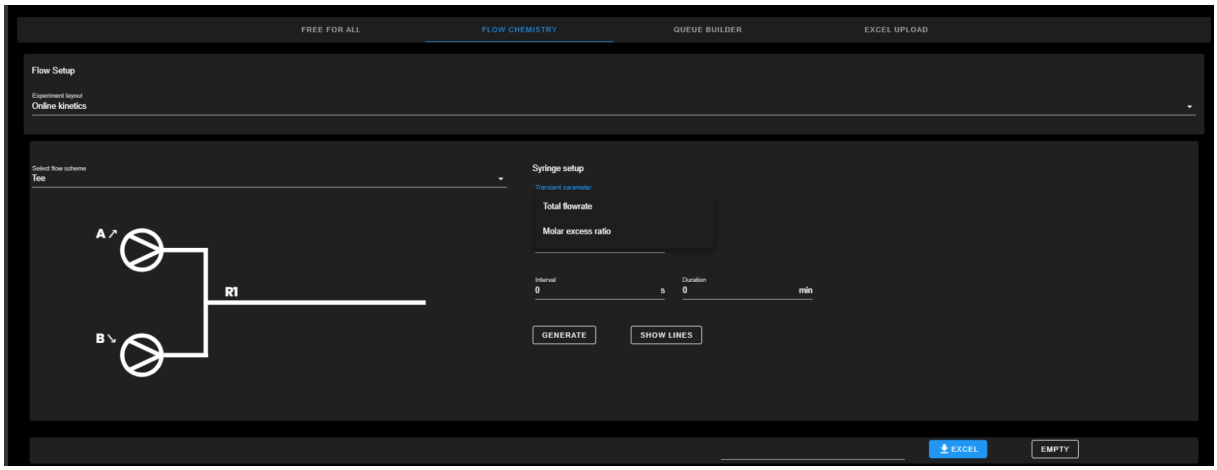
In the console panel of the inspector Tool you will see the following data, which can be expandend, to show the parsed data.



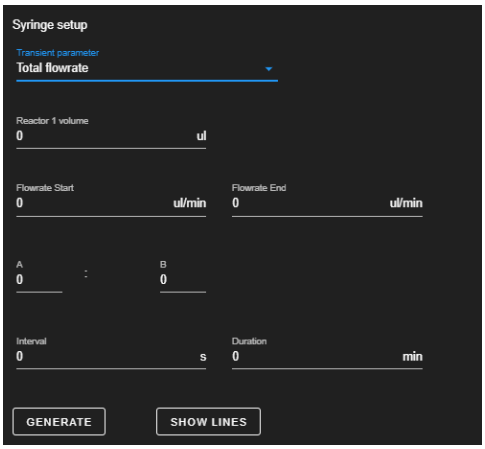
IMPORTANT. Before you download your uploaded excel data to a Gcode file all syringe pumps that will be used should be configured in the syringe configuration panel. If the information for one or more syringe pumps is missing, the excel file will display NaN in the Gcode commands. Single lines uploaded via the excel tab have a maximum duration of 30 minutes.

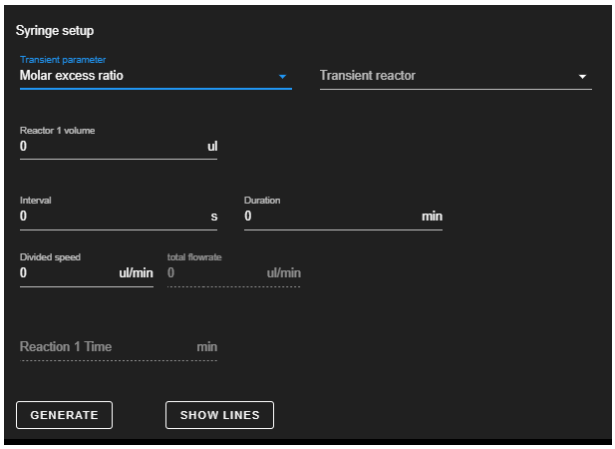
4.13 Flowchemistry Tab

The Flow chemistry tab contains advanced algorithms to create flow profiles. Currently there are only algorithms available for Online kinetic experiments.



After selecting the setup corresponding to your setup you can select out of two transient parameters. Transient parameters, or, dynamic parameters change over-time in an automated fashion. Currently, there are two transient parameters availble, these are the total flowrate and molar excess ratio. The total flowrate increases or decreases the total flowrate while maintaing a constant ratio between the pumps, while the molar excess ratio keeps a total flowrate but varies the ratio between the pumps. Selecting either one of these creates a corresponding form with the listing the required information needed to create the flow profile.

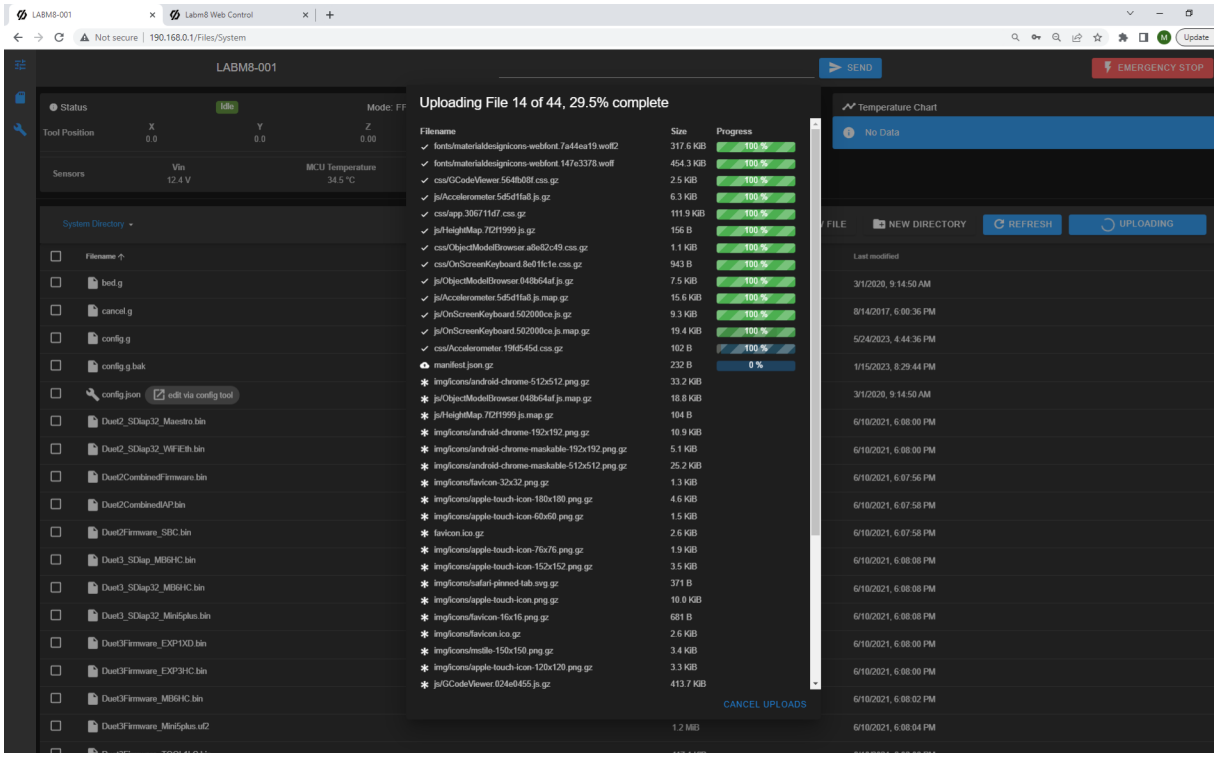




In these forms, the input field interval determines at what intervals a new code is generated. Usual values are 10 seconds. It than splits up the script in 10 second fragments. For the duration, set in the duration input field. For the total flowrate the input field A : B define the ratio between these pumps in flowrate. For the molar excess ratio, the divided speed is the flowrate that will be varied between. For example setting 20 ul/min, one pump will go from 0 to 20 ul/min while the other pump will go from 20 to 0 ul/min. Arrows in the flow setup diagram show which pumps will go up or down. These flow profiles are also easily generated in excel or using pyton.

4.14 Updating to a new version of Labm8 Web Control

New Labm8 Web Control updates will be distributed by us in the form of a zip file. This file can be uploaded via *files/system* upload experiment button. This wil open a dialog in which the procces of the upload can be tracked.

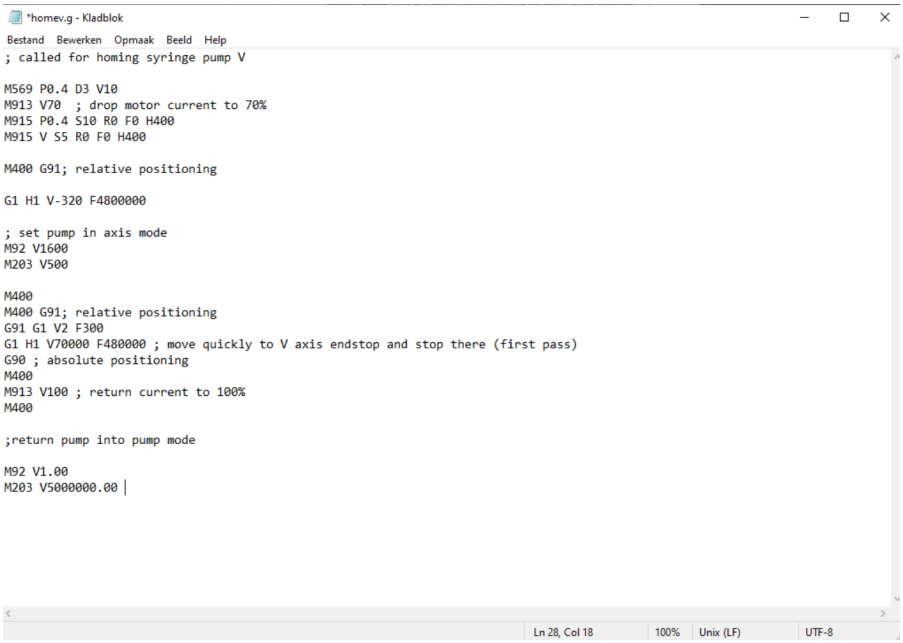


4.15 Labm8 configuration files

In general, Labm8 is ready to use straight out of the box and all settings are pre-configured. We do not advice to change settings in the config files, unless you are completly sure of what you are changing. We can not guarantee that the changes you make will work in the way that you intend to.

4.16 Understanding the homing procedure

The system uses so called sensorless homing to home the syringe pumps into their loading position without using end stop switches but using stall detection, a feature of the stepper drives used. The syringe pumps come correctly tuned for this stall detection when shipped. If overtime your pump is detecting stalling without an apperent mechanical limit, you may need to clean and regrease your pump, or reduce the stall detection sensitivity.

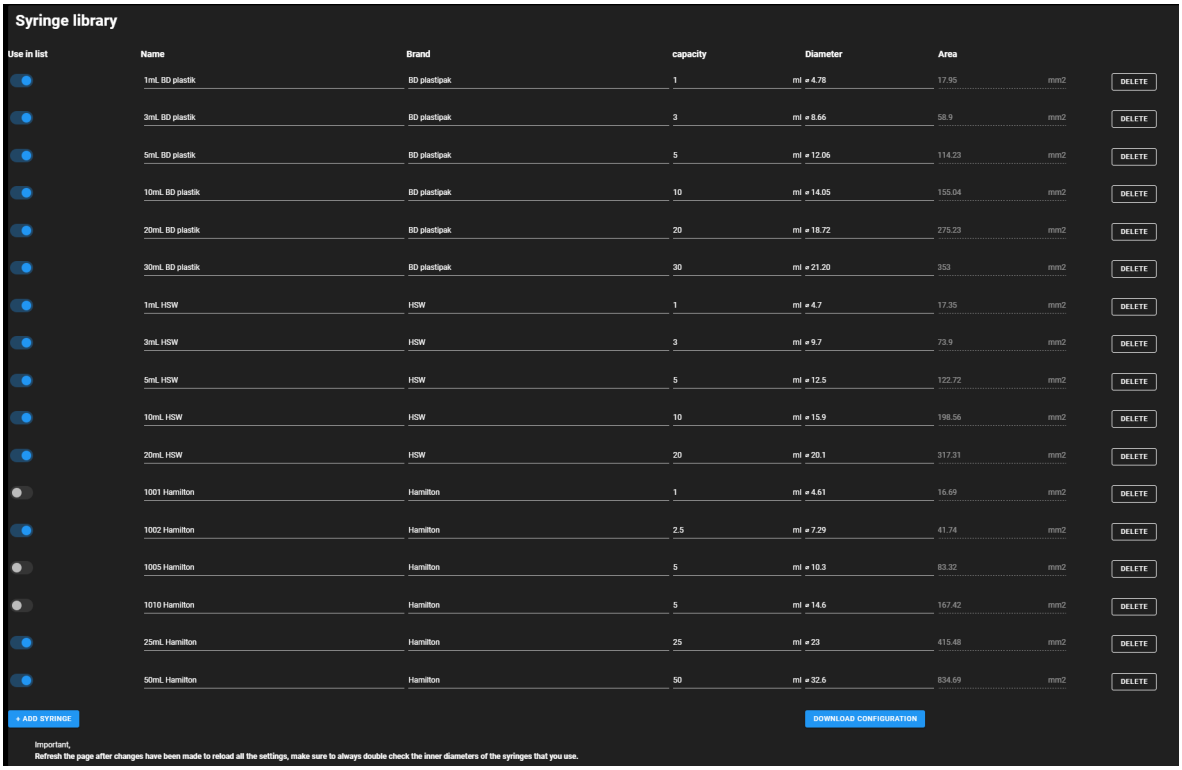


Explanation of the Gcode

M569 : Set driver in stealth chop mode, needed for detecting stalls.
M913 : reduce motor current
M915 : configure motor stall detection, The S parameter, is the stall detection threshold, with a range from -64 to 64. Lower values make it more senstive.
G1 H1: perform a small move in stealth chop mode to tune the driver
M92 : change axis setting, from 1 step / mm to 1600 steps/mm. The axis are configured with 1 step/mm to obtain lower speeds and more intuitive calculations for flowrates. We switch back here to allow for high enough speed for performing stall detection.
M203: change maximum speed accordingly, relativly high speeds are needed for stall detection.

After this we run the **G1 H1** command to move the pump until it detects a stall, we return the original power to the motor using the **M913** command and reconfigure the pump into pump mode by the **M92 / M203** command.

4.17 Syringe library manager

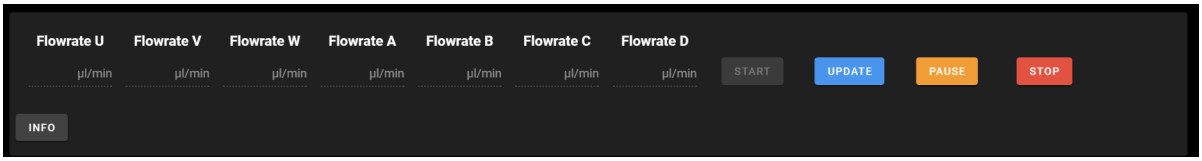


Syringes displayed in the syringe list of the syringe pump configuration module are configured on this page. The blue switch either adds or removes the syringe from the list. Most common syringes are preconfigured, but always double check the diameter of your syringes yourself. Either by datasheets or by a calibration procedure, which we strongly advice doing if highly quantitative results are needed.

A syringe can be added to the list by the add syringe button and can be deleted by the delete button. Clicking on the delete button will show a pop up asking for conformiation, this action cannot be undone. Installing updates will not change the syringe information, but we advice to make back up's time to time by using the download configuration button.

IMPORTANT. *The configured syringes are saved locally on the device. Upon initial commisioning of the device, make sure to double check each of the diameters with the syringes that you are using. Failure to do so, can lead to incorrect settings and flowrates. As the diameter is a critical parameter in the flowrate to steps/mm conversion calculation.*

4.18 Interactive control



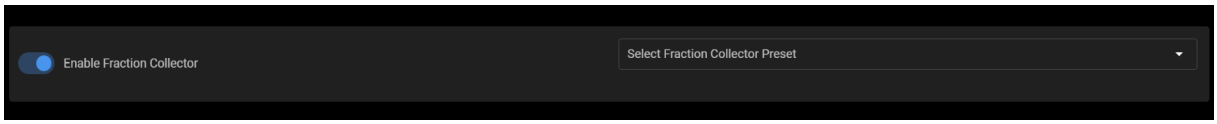
The Interactive control is a more dynamic way of controlling the syringe pumps. Normally, a gcode line contains a time period (the amount of steps to be performed/ movement speed) and pausing, stopping or updating the pumps will only be executed ones the line is finished. Therefore, in the previous gcode generators / controls the pumps could only be stopped by pressing the emergency stop since the single lines of gcode's sent would often be too lenghty.

The interactive control solves this by reducing the time each lines takes to a minimum, by normalizing the movements of the pumps to 1 step. (lowest movement speed is equal to 1) both the ratio's* between the pumps and the F parameter are not changed. This updated Gcode updates the global parameters and runs them in an infitine while loop. By directly updating these global parameters, the new speeds are set without stopping the while loop. Due to the operating mechanism it is not advised to have extremly high feedrates, at some point the gcode line would last such a shorr time that it can becomes faster than the computuing power, leading to incorrect flowrates it is therefore recommended to stay below F<15000.

Response times to updating the flowrates are gcode specific and can be calibrated by setting the flowrate and stopping it using the stop button. The times between the message: stop command and expeirment stoppped is the response times.

4.19 System design

The purpose for the system design page is to allow for easy configuration of various modules that can be connected to the control unit. For now only the fraction collector can be configured but many more modules are on the way.



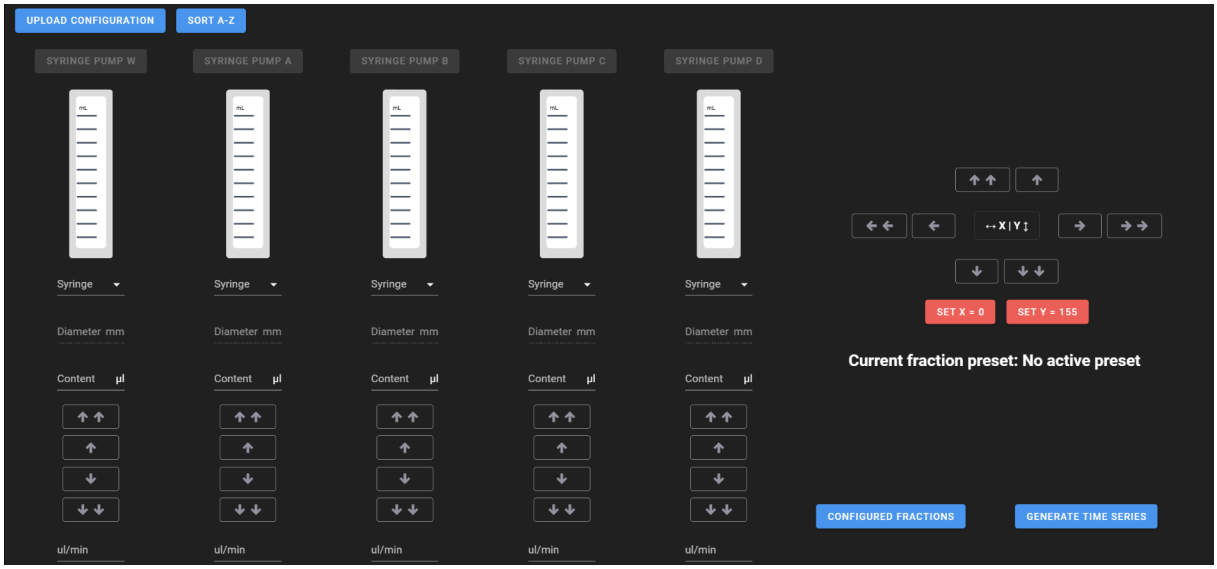
By enabling the fraction collector, the syringe pump modules for the axis U and V are removed from the microfluidic page and are substituted for the fraction collector visualization. Make sure that the changes in the driver mapping in the config file found in the files/system page have been commited. The ";" should be removed in front of the second **M584** and two last **M569** commands. Please make sure to undo this, if the axis are to be used as syringe pumps again.

```
M584 B0.1 A0.0  C0.2 D0.3 U0.4 V0.5 W0.6  S0
;M584 X0.4 Y0.5
```

```
;M569 P0.4 D2 V10           ; put in spread cycle  mode
;M569 P0.5 D2 V10           ; put in spread cycle mode
```

These lines can be found in the config file located at files/system/ config.g

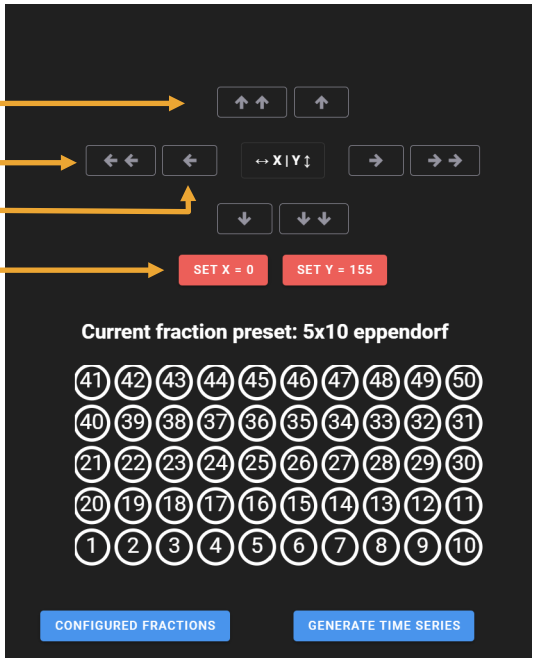
After both steps from above are completed, the microfludic page should now look as the image below, with the U and V axis removed.



As no preset /fraction layout is activated yet, the fraction collector visualization only shows the movement buttons for the X and Y axis along with their set coordinate buttons.

Back in the system design tab, after enabling the fraction collector, you can select a saved or create a new fraction tray preset. By activating this preset, the fraction collector module on the microfluidic page is updated.

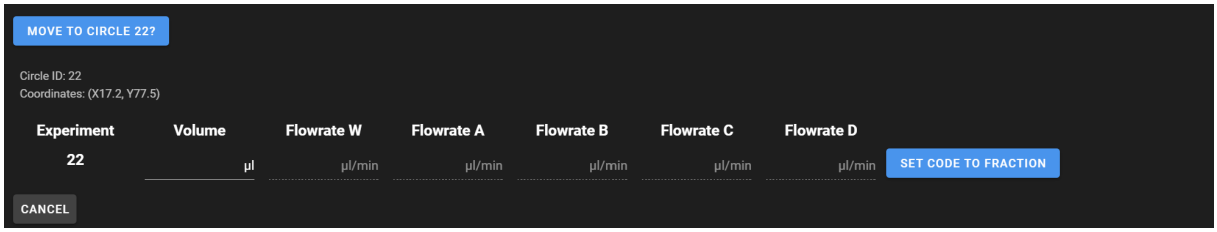
4.20 Fraction Collection



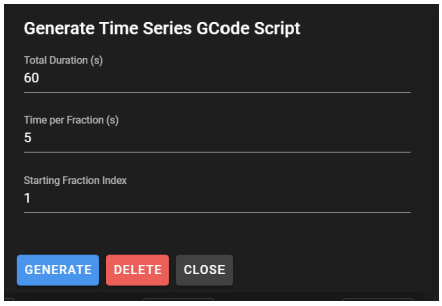
The fraction collector can be used in two ways, either as part of the complete microfluidic setup controlled by the Labm8 control unit, in which the syringe pump are the only pumps delivering liquid to the fraction collector, or it can be used as a standalone device and fractions in time can be collected.

Mode 1 Configured fractions

By hovering over the fractions, the mouse cursor will change to a pointer while the vial will change color from black to orange, by clicking on the fraction, a new dialog will open, shown below:



This dialog, works in the same way as how fractions are configured using the free for all window, with all the same functionalities. After the approiate settings are configured the conditions can be set to the selected fraction. A simple check will be performed if the experiment will not exceet the fraction value. Setting the code to the fraction wlil result in a fraction list that contains the information of that fraction. This list can be seen, sorted and downloaded as a script from the configured fraction dialog which opens by clicking on the configured fractions button. The downloaded script can than be uploaded to the files/experiments page where it can be executed.



Mode 2 Time Series fractions

In the second mode, the script is created by defining the total time of collection followed by the time per fraction in seconds and the location of the starting fraction. The fraction collector can not collect fractions after the last fraction (in this case 50), as it will not automatically go from fraction 50 back to to fraction 1. For example: if you want to collect 40 fractions, the starting fraction should at least be fraction 10.