

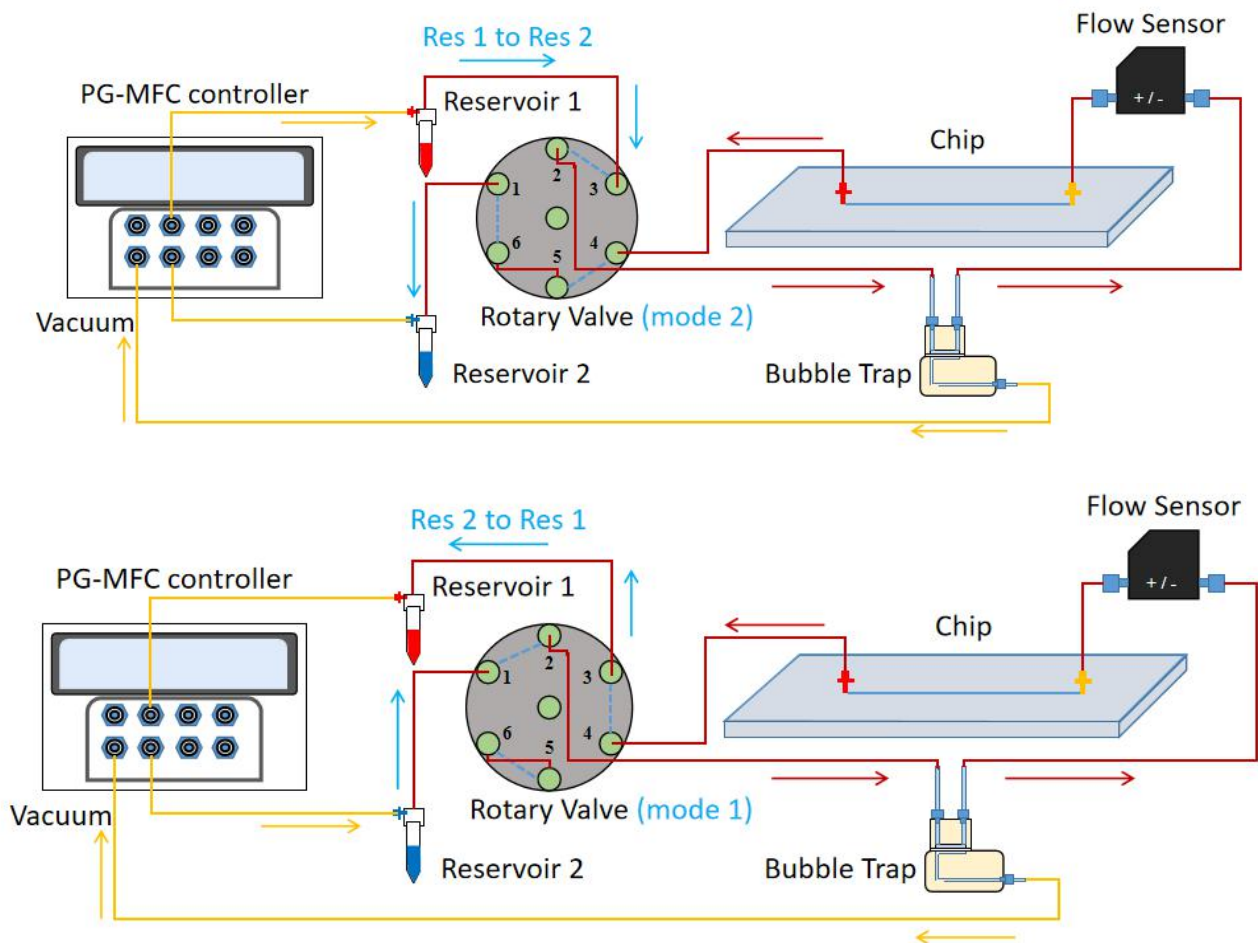
## Recirculation System Setup and Operation

### I. Introduction:

This document will detail how to assemble and operate a microfluidic recirculation system, which may be used to cycle fluid in a controlled, continuous, and unidirectional manner. It will cover:

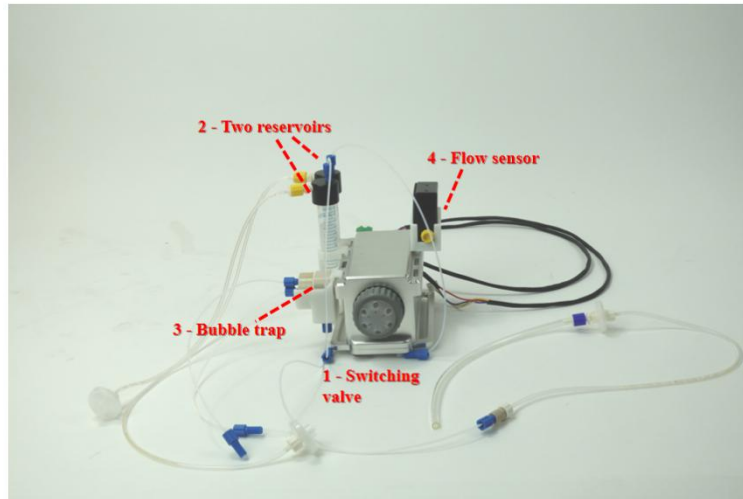
1. How to connect the required components.
2. How to check for successful connection.
3. How to perform scripting to automate the system.

### II. System Schematic:

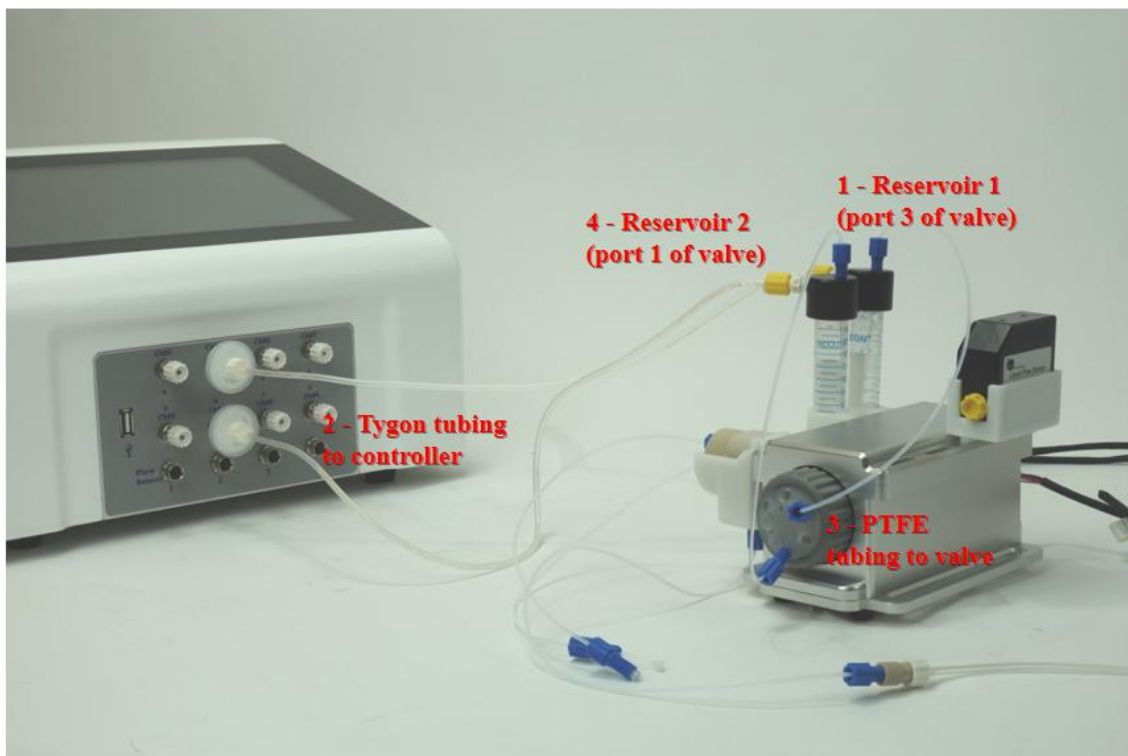


### III. General Procedure:

#### i. System Setup:



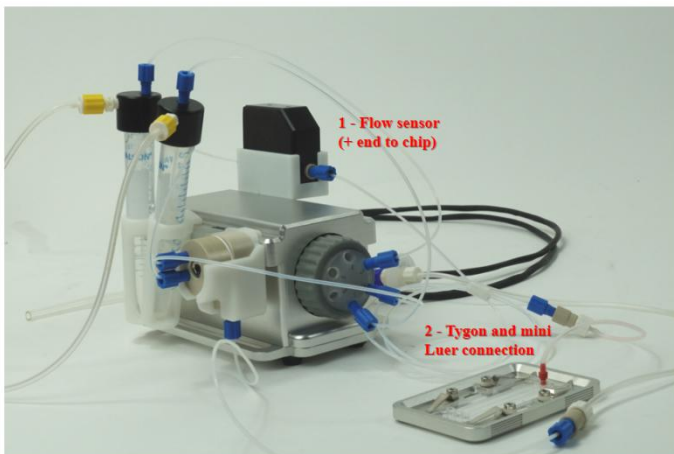
1. Mount the rotary switching valve<sup>1</sup> with two 15 ml reservoir kits<sup>2</sup>, a bubble trap<sup>3</sup>, and a flow sensor<sup>4</sup>.
2. Connect one reservoir<sup>1</sup> to the pressure controller at CH#3 and to the switching valve at port 3.
  - a) Tubing to the pressure controller should be Tygon<sup>2</sup> (gas).
  - b) Tubing to the valve should be PTFE<sup>3</sup> (liquid).
  - c) *From now on, this reservoir will be referred to as “reservoir 1”.*
3. Connect the other reservoir<sup>4</sup> to the pressure controller at CH#4 and to the switching valve at port 1.
  - a) Follow the same rules for tubing as step 2.
  - b) *From now on, this reservoir will be referred to as “reservoir 2”.*

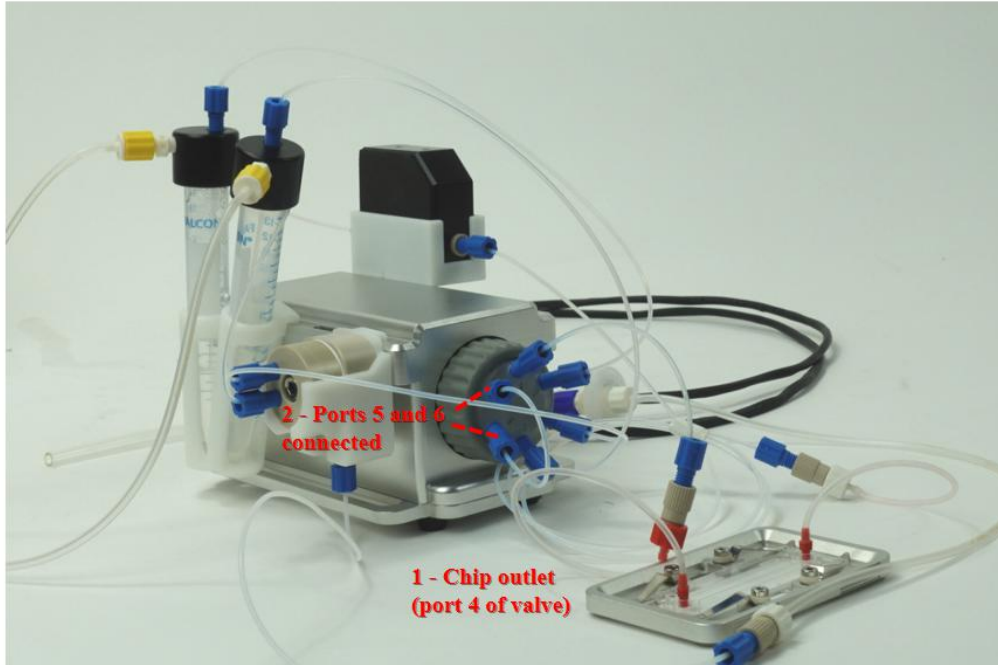


4. Using PTFE tubing, connect port 2 of the switching valve with one gas opening of the bubble trap<sup>1</sup>. Connect the other gas opening of the bubble trap to the (-) end of the flow sensor, also with PTFE tubing.

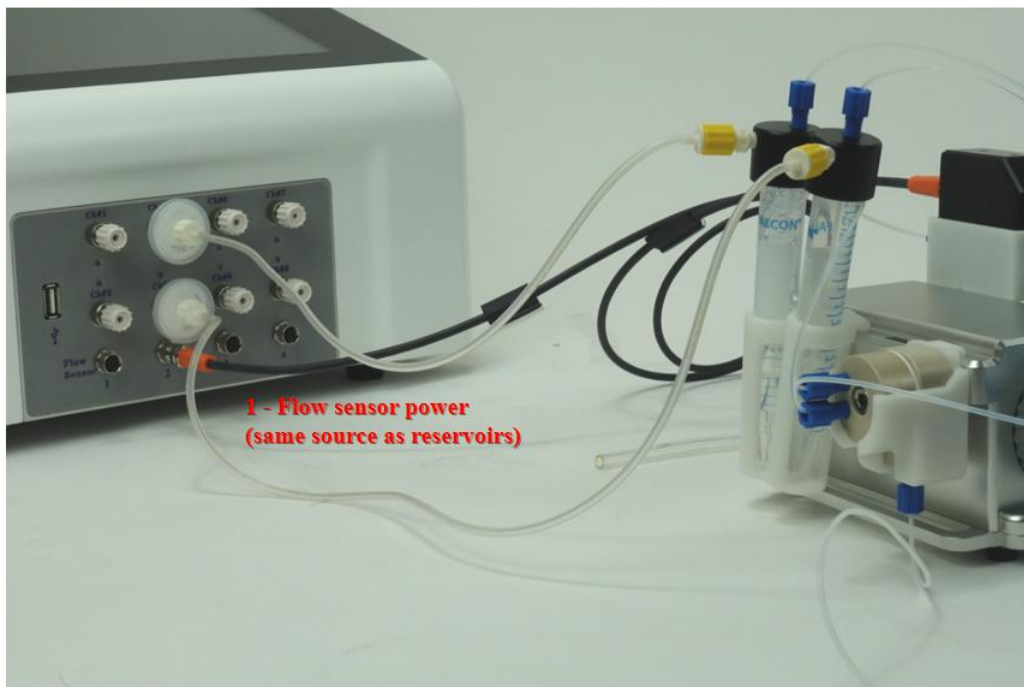


5. Mount the reaction chamber chip. Connect its inlet to the (+) end of the flow sensor<sup>1</sup>.
  - a) Connection type varies with chip; this guide will assume a mini-Luer chip.
  - b) Using a male mini-Luer connector, attach a short length of Tygon tubing to the chip<sup>2</sup>.
  - c) Connect the free end of the Tygon tubing to a male Luer lock. Then connect this tubing to the PTFE tubing of the flow sensor with a female Luer-to-flat bottom adapter<sup>3</sup>

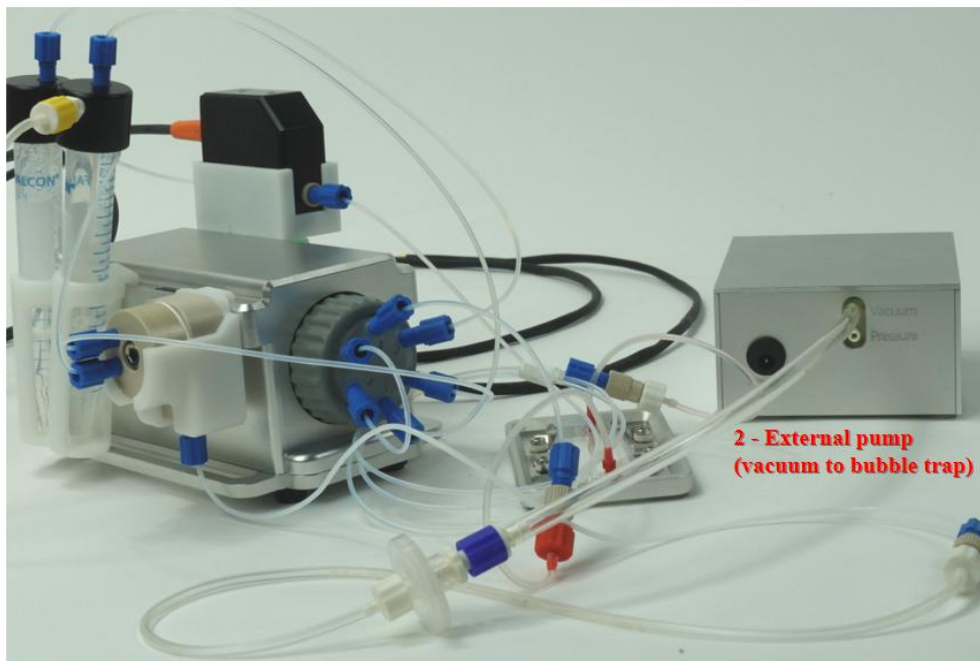
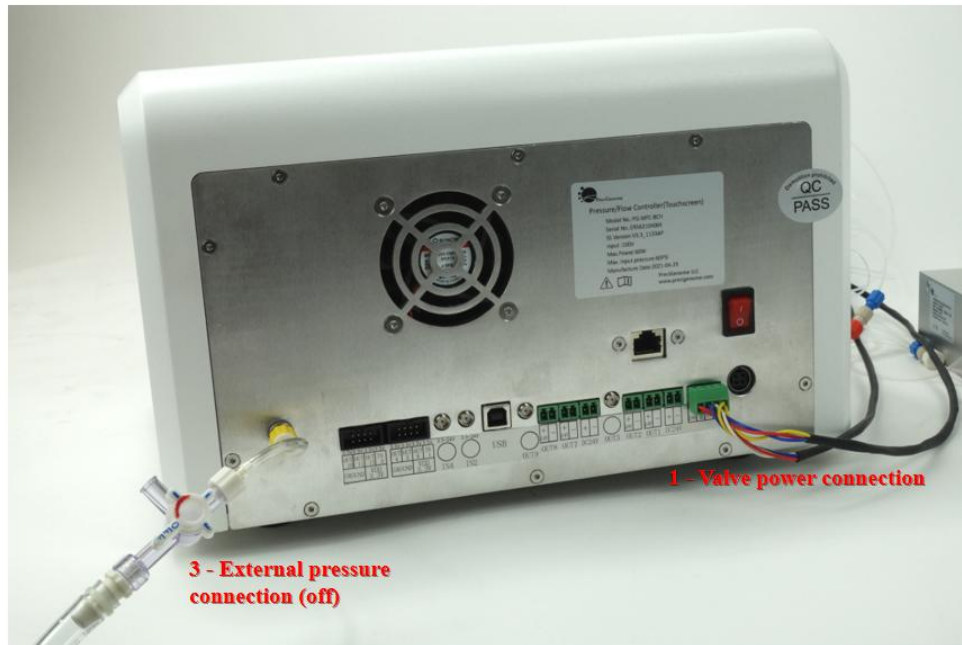




6. Connect the chip outlet to port 4 of the switching valve<sup>1</sup>.
  - a) Use the same adapter setup as step 5.
7. Using PTFE tubing, connect ports 5 and 6 of the switching valve<sup>2</sup>.

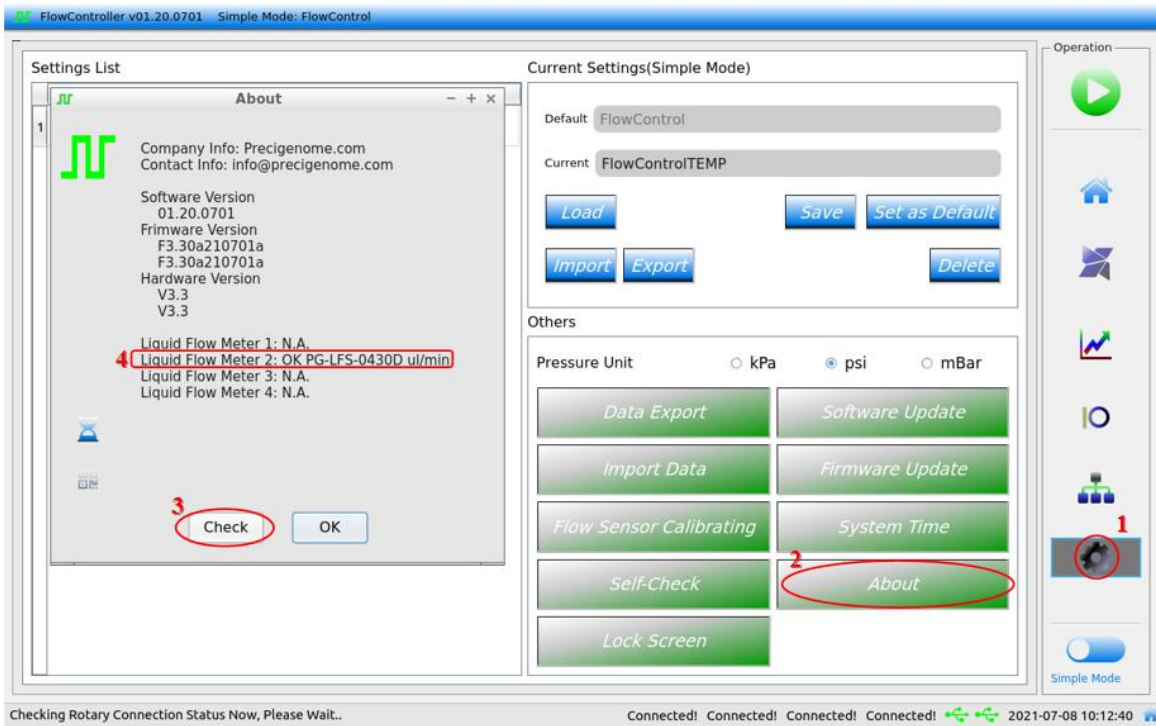



8. Connect the power cable of the flow sensor to the outlet on the pressure controller under CH#4. This ensures it is connected to the same source (2) as the reservoir channels<sup>1</sup>.
9. If plugging the reservoirs into a different channel, ensure the power cable is still connected to the same source.

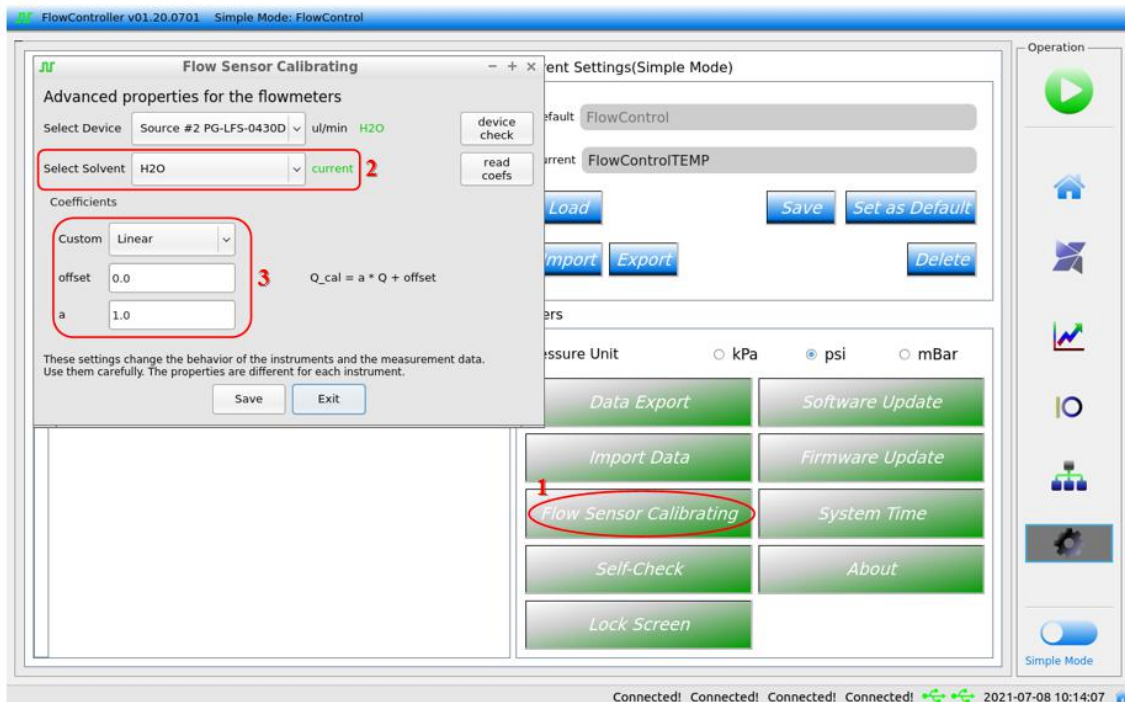


10. Connect the switching valve to the rear of the pressure controller with its 4-pin cable<sup>1</sup>.
  11. To enable active operation of the bubble trap, connect it to any channel of the pressure controller in source 1 or 3.
    - a) **Make sure to add a filter before connection to prevent liquid entering the controller.**
  12. If using an external pump, connect the bubble trap to the vacuum port of the pump<sup>2</sup>. Pressure control may still be left to the same controller however.
  13. If using an external pressure source, connect its tubing to the rear of the pressure controller<sup>3</sup>.
    - a) Turn its valve's "off" section in the direction of the pressure source to keep it off, and perpendicular to this direction to turn it on.
- ii. System Connection Check:

1. Verify the flow sensor was recognized by the pressure controller.




a) On the pressure controller, go to  System Settings<sup>1</sup> > About<sup>2</sup> > Check<sup>3</sup>. Ensure that the flow sensor model is updated in the window<sup>4</sup>.



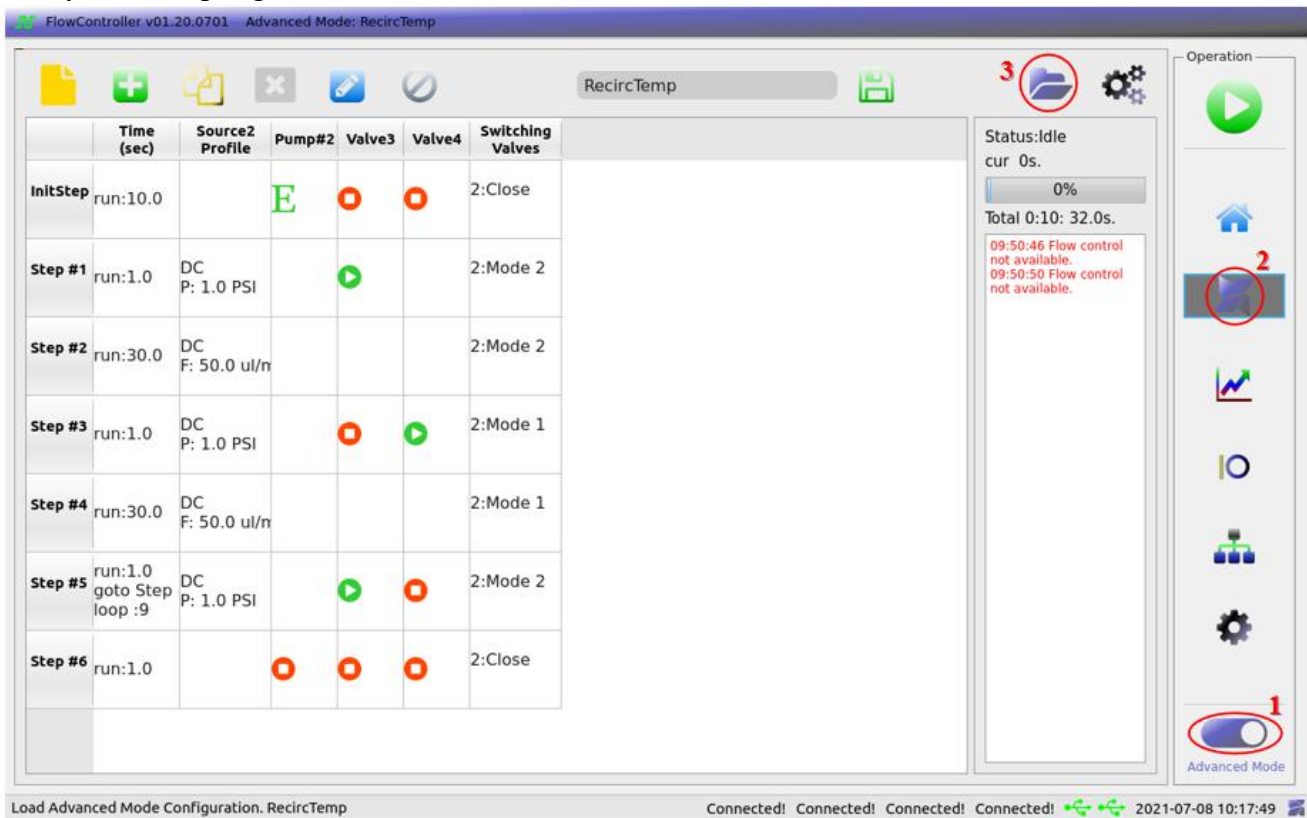
b) While still in System Settings, go to Flow Sensor Calibrating<sup>1</sup> > Select Solvent > H<sub>2</sub>O<sup>2</sup>. Set the coefficients to Linear with offset = 0 and a (slope) = 1<sup>3</sup>.

2. Now verify the switching valve was recognized by the pressure controller.







- a) On the pressure controller, go to  Rotary Valve Settings<sup>1</sup> > Check Rotary Valve<sup>2</sup>. If successful, the options under Switching Valves<sup>3</sup> will now be colored instead of gray.

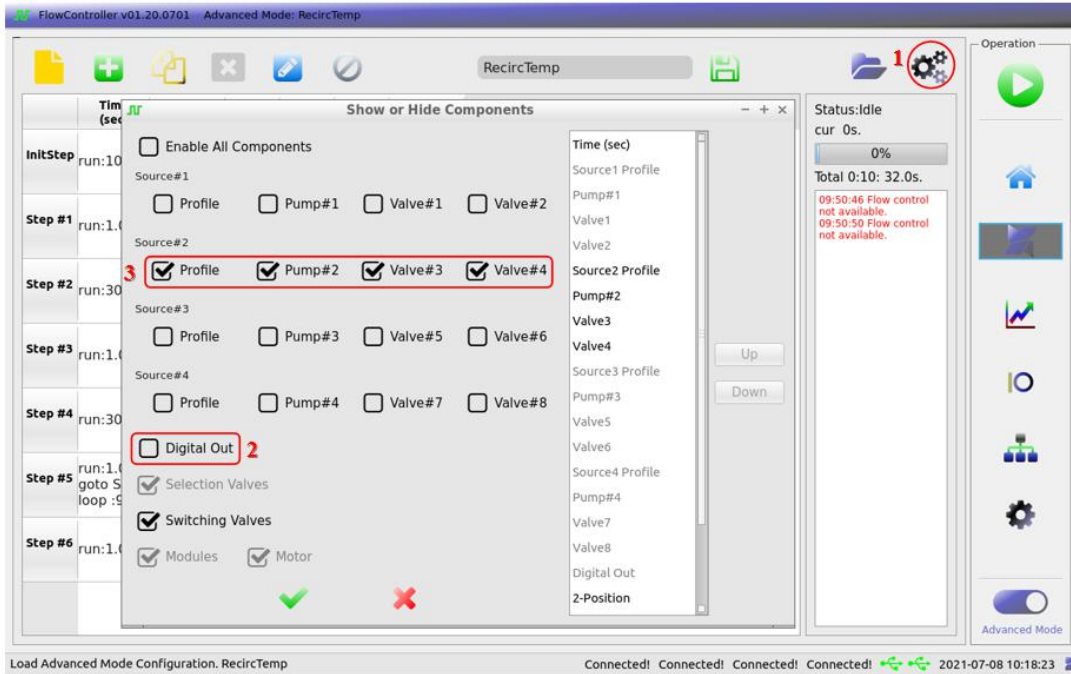
iii. System Scripting:




	Time (sec)	Source2 Profile	Pump#2	Valve3	Valve4	Switching Valves
InitStep	run:10.0		E	○	○	2:Close
Step #1	run:1.0	DC P: 1.0 PSI		●		2:Mode 2
Step #2	run:30.0	DC F: 50.0 ul/n				2:Mode 2
Step #3	run:1.0	DC P: 1.0 PSI		○	●	2:Mode 1
Step #4	run:30.0	DC F: 50.0 ul/n				2:Mode 1
Step #5	run:1.0 goto Step loop :9	DC P: 1.0 PSI		●	○	2:Mode 2
Step #6	run:1.0		○	○	○	2:Close

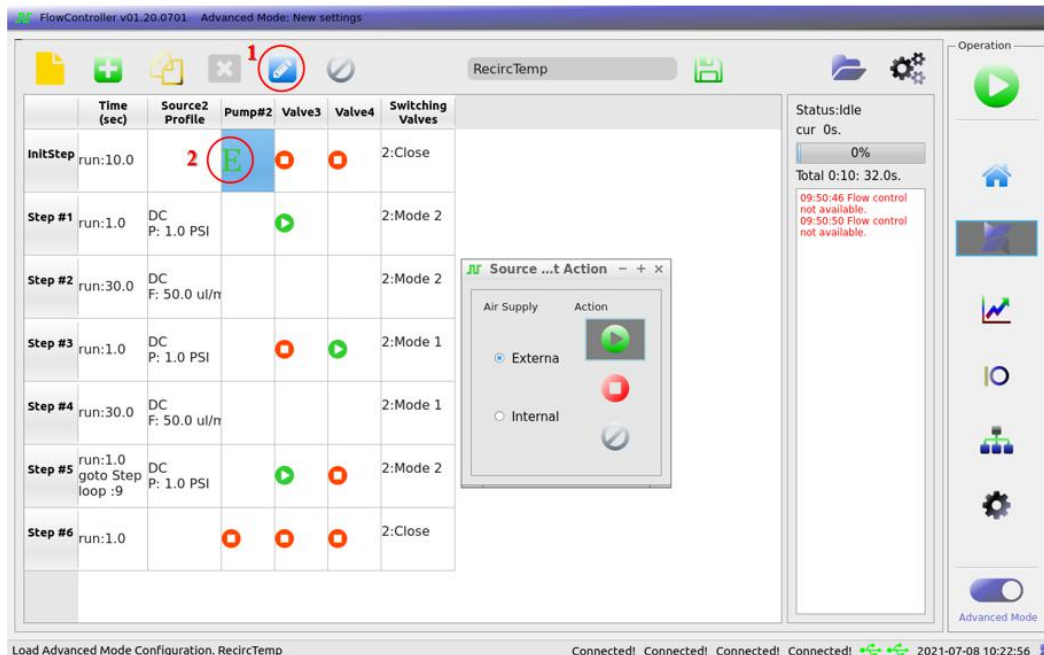
1. On the pressure controller, press  to toggle from Simple Mode to  Advanced Mode<sup>1</sup>.
2. Go to  Advanced Scripting<sup>2</sup>. If your desired script was already written, you may load it with  Load Script<sup>3</sup> > [script name]. Otherwise, follow the rest of this procedure.






3. Click  Script Settings<sup>1</sup> and uncheck all unused profiles, pumps, and valves. Also uncheck Digital Out<sup>2</sup>. This will reduce the displayed options to just what is being used.



a) For the previously described setup, only pump 2 and valves 3 and 4<sup>3</sup> should be turned on.

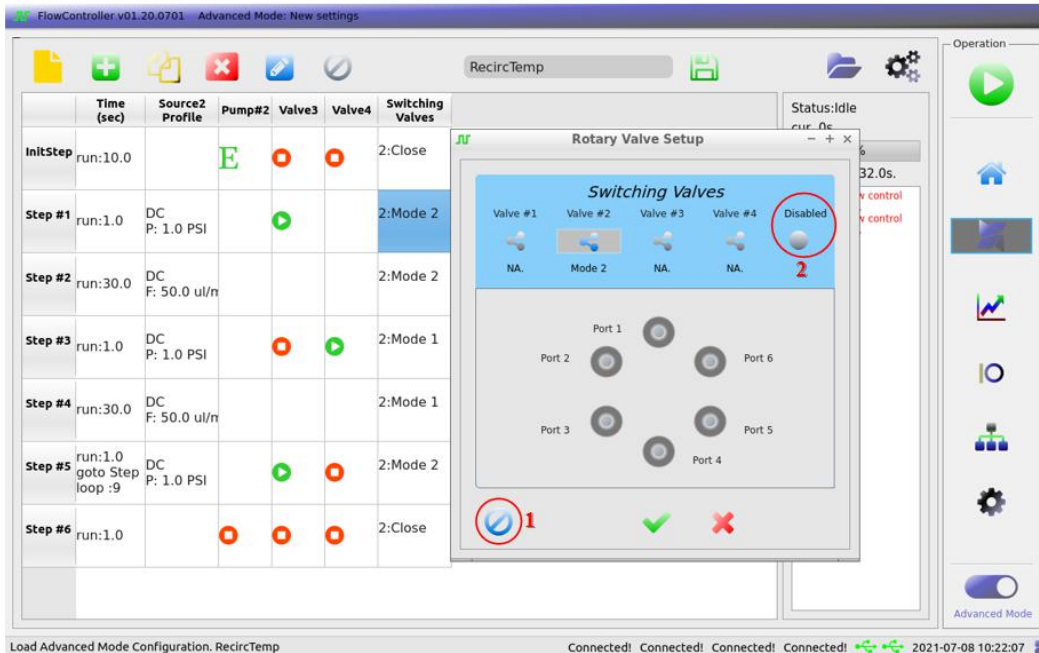



4. InitStep: Turn off all valves and turn on the pump corresponding to the source of your channels. Set runtime to 10 sec and switching valve mode to Close. Do not set Source Profile.

- Press the  symbol<sup>1</sup> to edit the selected step value.
- For the previously described setup, pump 2 should be turned on.


- c) Runtime should be kept this way to allow the switching valve to initialize.
- d) If using an external pump, make sure to check external when turning it on. This should display

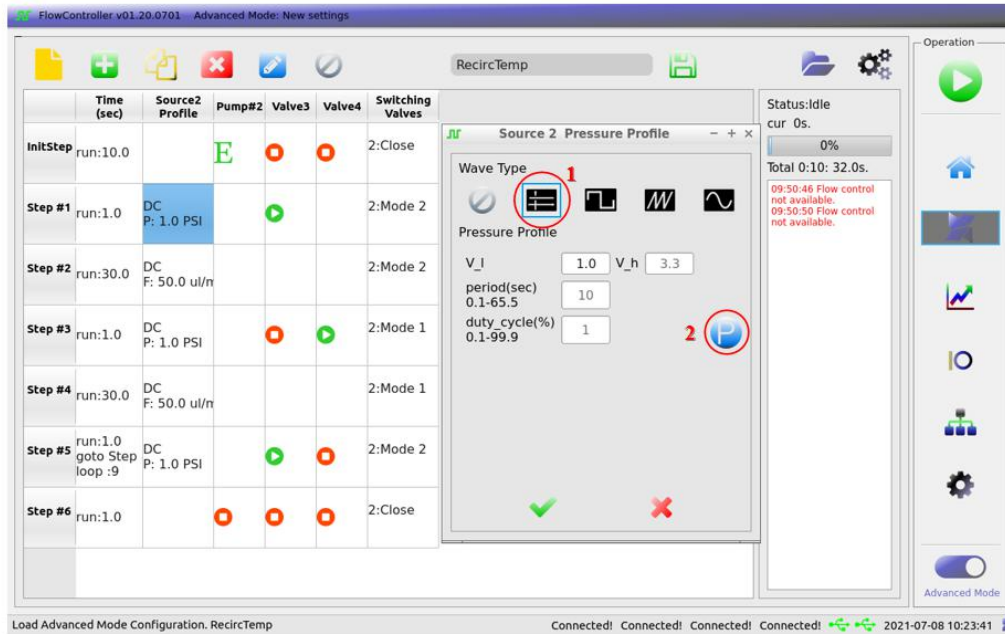
the symbol<sup>2</sup>  instead of 






- e) To edit the switching valve mode, press the  icon<sup>1</sup> so that it is colored. Toggle between active modes 1 and 2 by tapping the ports, or set to Close by toggling from Enabled to Disabled<sup>2</sup>.

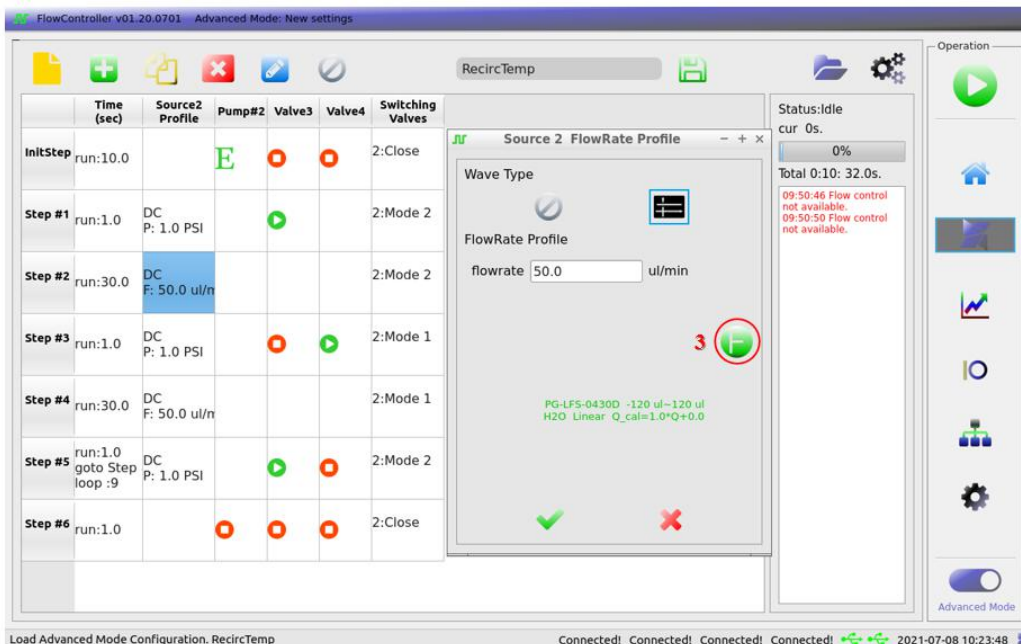
5. Step #1: Turn on valve 3 and set the source profile to 1 psi. Additionally, set runtime to 1 sec and switching valve to Mode 2.

- a) To edit source profile pressure, set wave type to  Constant<sup>1</sup> and enter desired value.
- b) PSI setting is kept low to prevent sudden spikes in pressure or flowrate when switching modes.



6. Step #2: Set source profile to desired flowrate and runtime to desired value. Keep switching valve at Mode 2.

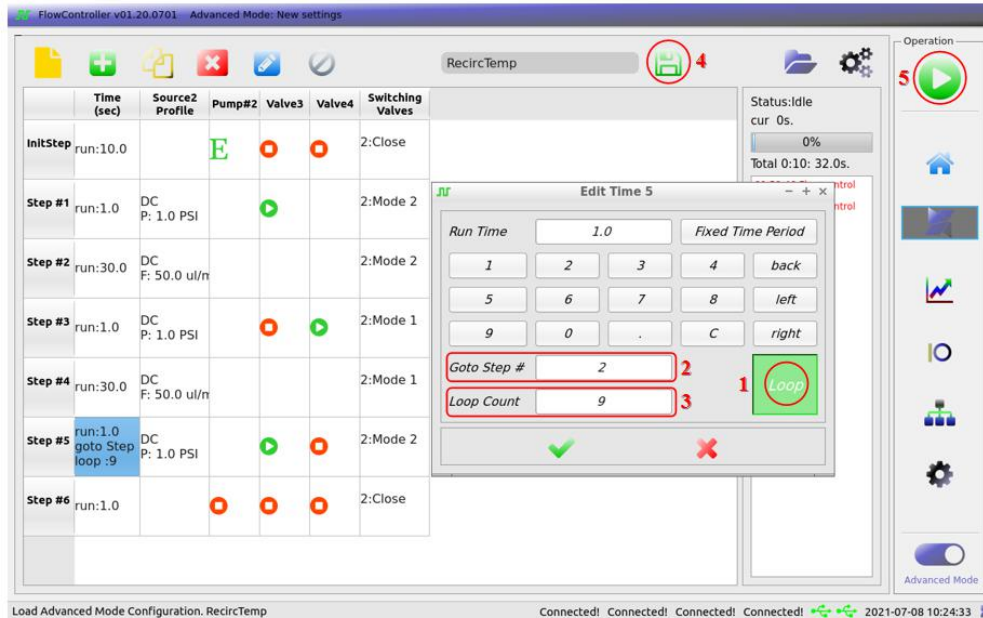
- a) To edit source flowrate, click the  symbol<sup>2</sup> to toggle from pressure to flowrate. The new symbol<sup>3</sup> should be  - now set wave type to  Constant and enter desired value.



7. Step #3: Turn off valve 3 and turn on valve 4. Set source profile to 1 psi, runtime to 1 sec, and switching valve to Mode 1.



8. Step #4: Set source profile to desired flowrate and runtime to desired value. Keep switching valve at Mode 1.

9. Step #5: Turn off valve 4 and turn on valve 3. Set source profile to 1 psi, runtime to 1 sec, and switching valve to Mode 2. Additionally, adjust loop settings to desired value.



- To implement a loop, edit the time setting for this step and toggle Loop<sup>1</sup>. Enter the step to return to in Goto Step #<sup>2</sup> and the desired Loop Count<sup>3</sup> below.
- In this example, the loop returns to step 2 since its own step restores the system settings to match step 1.
- Since the first iteration of the loop is not accounted for in this setting, make sure to set loop count to 1 less than your total number of desired cycles. In this example, it is set to 9 for a total of 10 cycles.

10. Step #6: Turn off the pump and all valves. Set runtime to 1 sec and switching valve mode to Close.

11. When you are finished editing your script, press the  symbol<sup>4</sup> to save and apply your changes. Press  Start<sup>5</sup> to run the script.

**IV. Components Used:**

Name	Catalog Number	Website Link
Microfluidics flow/pressure control system (8 channel)	PG-MFC-8CH	<a href="#">Link</a>
Microfluidic reservoir kit for 15 ml tube (2 ports; tube)	PG-MRK-2P15ML	<a href="#">Link</a>
Microfluidic flow rate sensor (5000 µl/min full scale)	PG-LFS-2000	<a href="#">Link</a>
Inline bubble trap (PEEK; 1/4"-28; 300 µl; EZMount version)	PG-BT-REC300UL	<a href="#">Link</a>
SwitchEZ™ electric rotary/selector valve (2-position, 3-way, 6-port)	PG-ROTV-6P-3W2P	<a href="#">Link</a>
Reaction chamber chip (4Device; Mini Luer; 50 µl volume; 350 µm depth)		<a href="#">Link</a>
Microfluidic fitting connectors kit (1/4"-28 to 1/16" OD * 3/32" ID; flangeless fittings; Luer barb; ferrule)	KIT-MRK-MUNF-BARB	<a href="#">Link</a>
PTFE tubing (1/16" OD * 0.012" ID) (Use 1/32 ID for high; above for low)	TUB1-16-ID300-L50I	<a href="#">Link</a>
Luer Lock Fittings Kit for Pressure Controller Connection	KIT-MFC-MLUR-MLUR	<a href="#">Link</a>
Tygon tubing (3/32" OD * 1/32" ID; Luer barb) - for chip		<a href="#">Link</a>
Microfluidic fitting connectors kit (male Mini Luer; 1 mm OD)		<a href="#">Link</a>
Microfluidic fitting connectors kit (female Luer to 1/4"-28 flat bottom adapter)	FIT-FUNF-FLUR-PK-Q5	<a href="#">Link</a>