Step-by-Step Build Setup Guide # 5

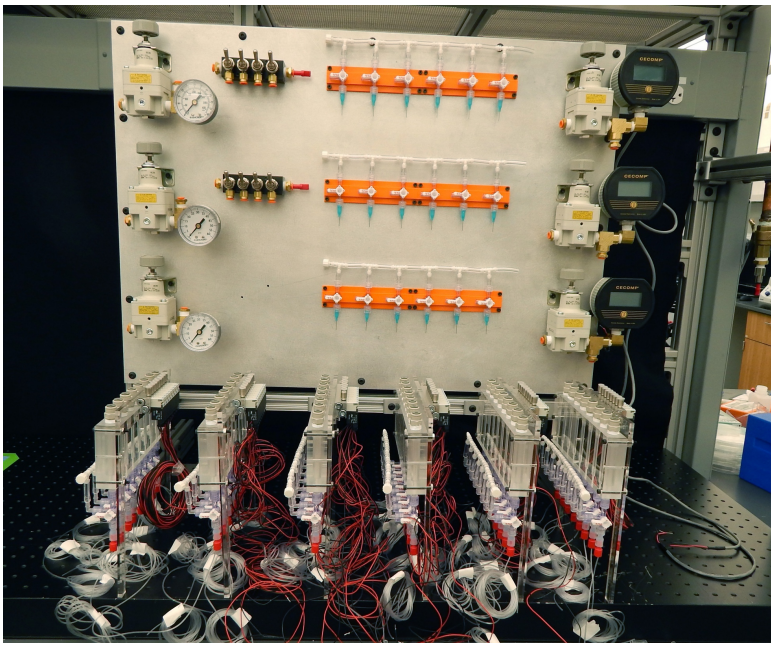
Pneumatic Control System Module 5: WAGO Digital Control

Part 1: Solenoid Valve Indexing

1. Gently unravel the red and black wires connected to the solenoid valve arrays (**Part h**) from the completed Control Line Manifolds from **Module 3**.

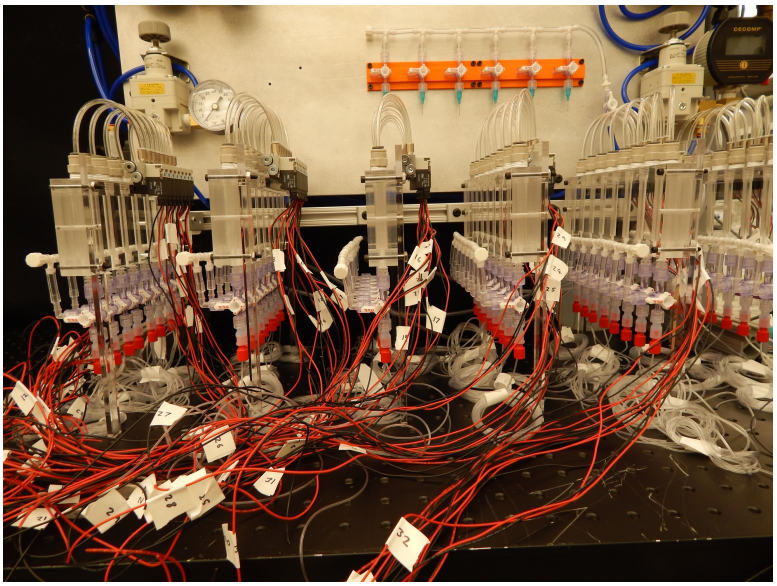
Note: Here we show unindexed control line coils, but you should have previously completed control line indexing in **Module 3**. It is arbitrary whether valves or control lines are indexed and labelled first as long as the indexing is consistent.

(!) Tip: In this Module, the individual solenoid connections will be established to a Modbus controller that essentially acts as a programmable logic circuit (PLC) for fast, remote control of the valve states. It is therefore important to keep track of the individual solenoid electrical connections by clearly indexing them by valve number. We label at the **bottom** (near the end of the lines) and **top** (near the solenoid valve array) of each wire set.



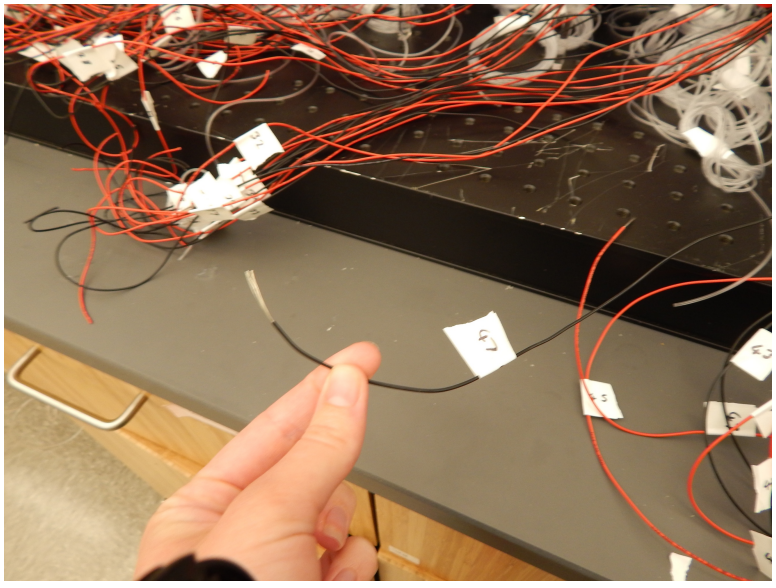
1. Each red and black wire set controls the positive voltage and ground connections, respectively, for each solenoid. Starting with the leftmost manifolds, label the top and bottom of the red and black wires associated with each solenoid valve with the valve number, starting at 0 (***e.g.*** Manifold 1 = Valves 0-7, indexed per each red and black wire). Place the bottom label ~7" from the end of the wire (to make room for stripping

and cutting later). These valve and manifold numbers should be consistent with those made in **Module 3**. Our labels are shown below.



(!) **Tip:** It is important to label ***both*** the top and bottom wires with the valve number as we later will place black hosing around all the wires from one manifold to organize and secure them. Without the top labels, it becomes difficult to isolate individual valves connections if there arises a problem or if the setup must be dissembled (for moving around, for instance). Use a label maker or solvent resistant markers on lab tape when labelling the solenoids.

2. With a wire cutter, cut ~4" from the end of each red and black wire set and strip the wire back ~1/2". The exposed wire will be used to connect +V (red) and ground (black) for each valve into the WAGO Fieldbus Controller to enable digital valve control.

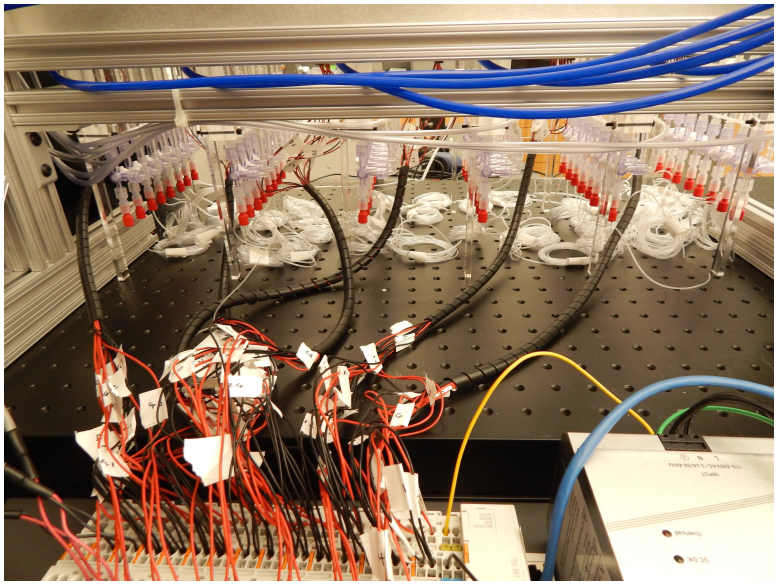


3. Cut ~14" pieces of **Tubing T5**. Collect all the solenoid wires from one manifold and gently snake the **T5 Tubing** up the collection of wires to organize and secure them This step tidies up the wires so that wiring the WAGO Modbus controller is easy and less messy.

(!) **Tip:** Start from the bottom of the collection of wires, wrap the first end around the whole group, and thread the tubing upward by coiling to the right. Stop coiling when the tubing reaches the labels near the solenoid array. **Be sure to keep labels at both the top and bottom of each wire visible**. **T5** should terminate tubing ~2" from valve solenoid arrays, as shown above.

4. The completed manifolds should appear as following:

5. After **Module 5**, the valve wiring collections wired into the WAGO will appear like this image.



Part 2: WAGO Modbus Setup

(!) **Tip:** The following steps are the **coolest** but also most complicated of the whole setup build. In these steps, you will wire the connections from each individual solenoid valve (in the order of the valve numbers) to a MODBUS controller, the WAGO. This will allow for fast programmable control of each individual solenoid valve corresponding to each individual control line as set up in **Module 3**. We will assemble the WAGO **Parts W1-W4** according to the manufacturer's instructions. You can follow along here or skip to the solenoid wiring if you chose to use the manufacturer's tutorial.

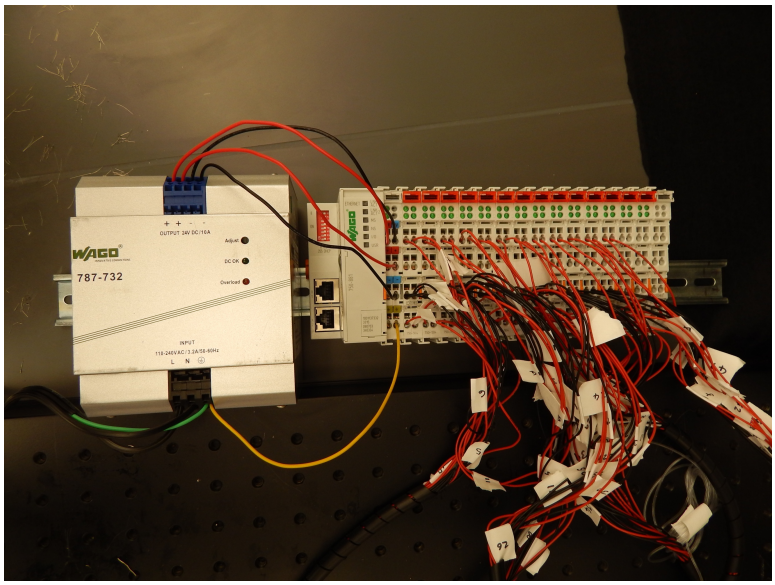
6. Wire the Power Supply Module of the WAGO controller (**Part W2**). First, cut 3 sets of ~6" of 18G red and black wire (**Part o**). Strip each wire approximately ½" on the top and bottom. Insert the wires to the 24V DC output lanes at the top of the brick (red: +, black: -). These wires are used for powering the rest of the WAGO. Similarly, wire the input lanes at the bottom of the brick by stripping wires within the 24V power supply (**Part n**) and inserting them into the L, N and ground lanes as shown. These connections are used to externally power the Power module brick. Add an additional wire (shown in yellow here, but black **Part o** wire is just fine) to the final lane of the input lanes. The completed wiring should look like this:

7. Mount the wired Power Supply Module **Part W2** to the DIN rail, **Part W5**. This will help stabilize later components.

8. Assemble **Parts W1, W3,** and **W4** by first mounting the I/O controller (**Part W1**) onto the DIN rail and then clicking in subsequent digital output (DO) modules (**Part W3**) using the orange tabs on the end of each module, ending with the end module (**Part W4**). You will need the following number of digital output (DO) modules (**Part W3**) for your build since each DO Module controls 4 valve states and (separately) powers up to 2 regulators.

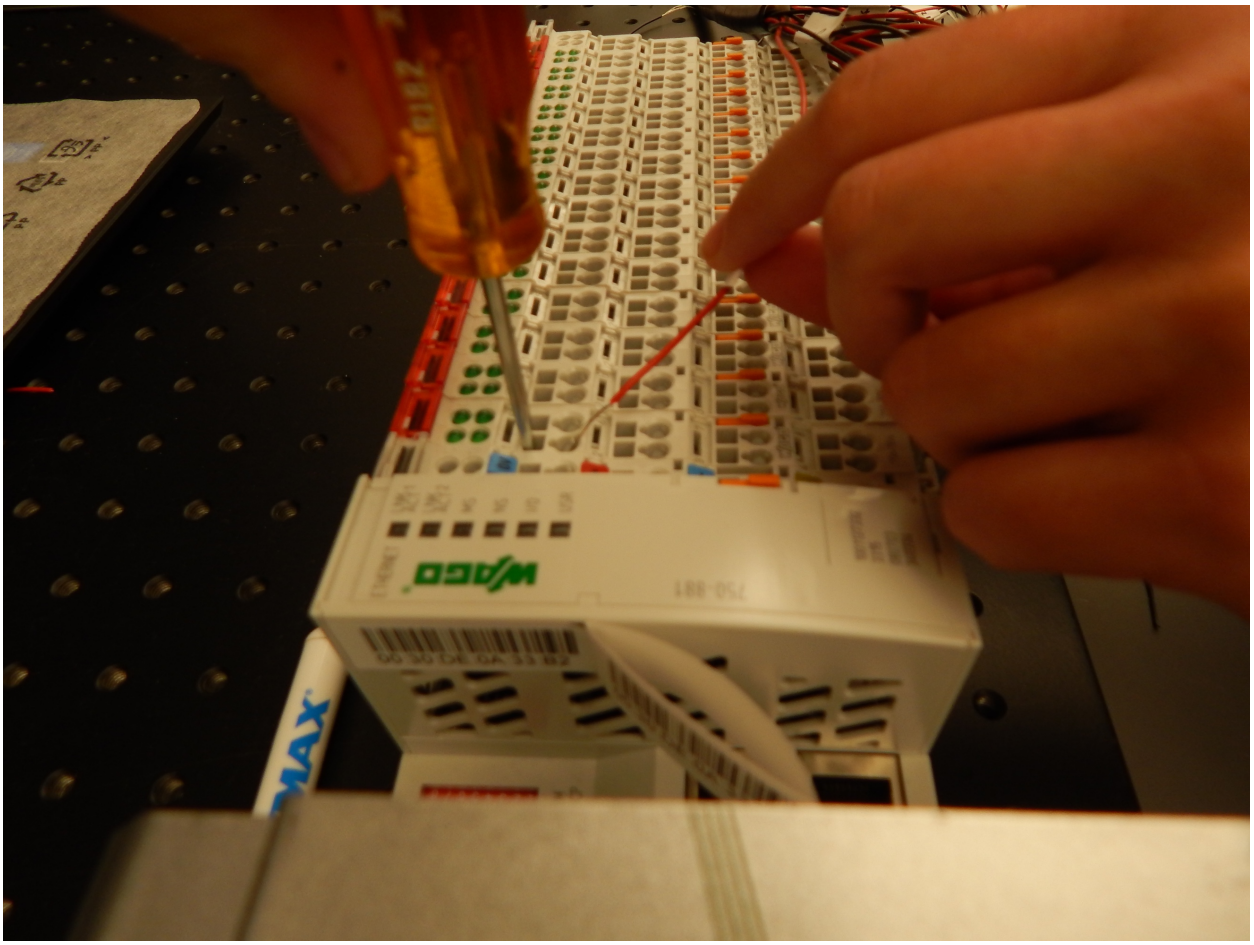
$$\#\ of\ needed\ DO\ modules = \frac{\#\ of\ Control\ Lines}{4} + \frac{\#\ of\ Digital\ Flow\ Regulators}{2}$$

The WAGO assembly should now look like this (minus all the wires):



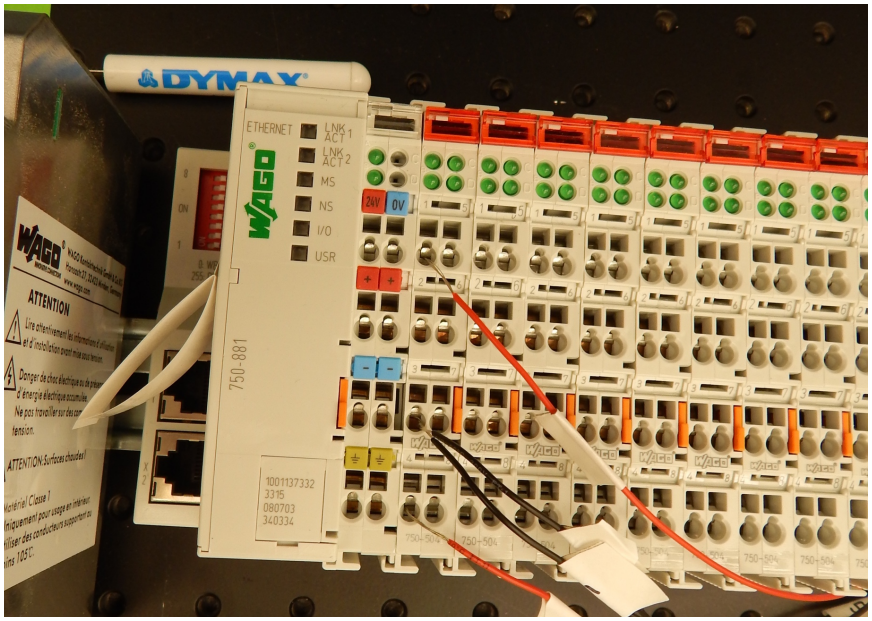
(*) Modifier: Assemble only the amount of digital output (DO) modules (**Part W3**) that are needed for your build. Alternative modules, such as combined digital input (DI) and digital output (DO) modules are available from WAGO Inc. for more specialized purposes, such as addition of other PLC-controllable instrumentation (for instance, we also control UV curing lamps with our WAGO) to customize your build. The WAGO system is highly modular; components can easily be exchanged or added ***after*** the build if later functionality is desired.

9. Begin wiring connections from the digital output (DO) modules to the individual solenoids. You will wire in the order of the valve numbers. Each DO module contains 4 outputs to control 4 solenoids. The 4 green lights at the top of each module from top left to bottom right register the valve state. Each column of a single DO module controls 2 outputs so they must be wired together. To wire, use a small flat head screw driver to pull back the metal tongue in the rectangle above the circular breakout connector and insert the wires into the circular breakout as shown below. Practice once before proceeding.

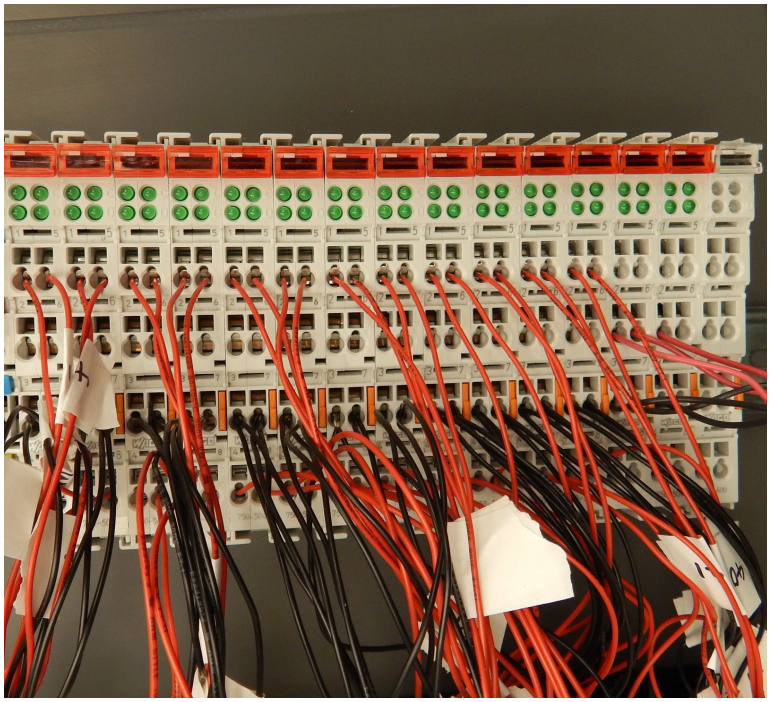


10. Starting with the first DO module (**Part W3**) closest to the I/O controller module (**Part W1**), put the red wire for Valve 0 in the left breakout of the 1st row (labeled position 1 on the Module). Put the red wire for Valve 1 on the left breakout of the 4th row (labeled postion 4 on the Module). Put the two black wires for both Valve 0 and Valve 1 in the left breakout of the 3rd row (position 3 on the Module).

(!) **Tip:** Here you are attaching the red leads to the 24V pulse outputs and the black leads to the Module ground, which interfaces with the global ground. If you are interested in further information about the WAGO wiring, check out the WAGO guide for this module 750-504. There are some excellent diagrams on the manufacturer's site that explain the internal WAGO wiring in greater detail.



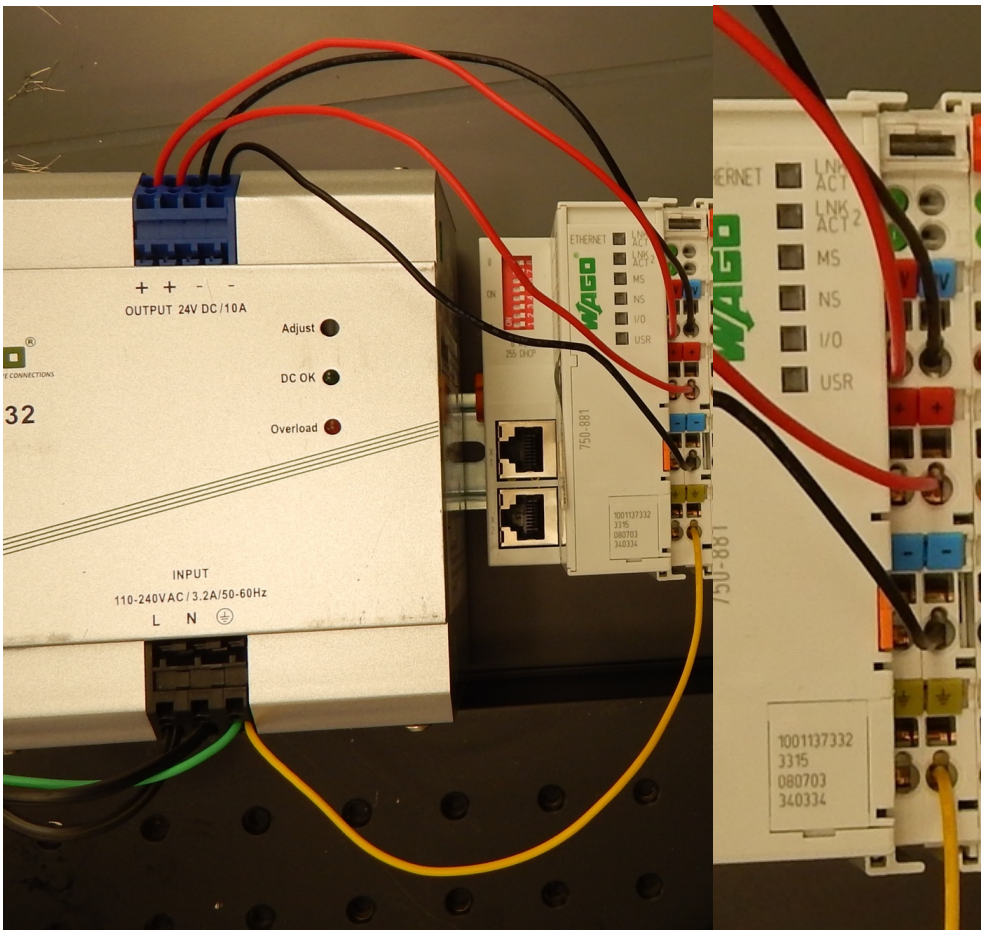
11. Repeat for Valves 2, 3 using the right breakouts for the first module then continue wiring all the rest of the valves. Your WAGO build should now look like this.



12. Wire the global ground wire (yellow wire from the ending input lane) to the first module of the I/O controller base (**Part W1**) as shown below. Insert the striped wire in the bottom right input of the module. This connects the input ground to the shared module

ground. Next wire the power supply to the positive and negative leads from the output of the Power Supply Module (**Part W2**) as shown.

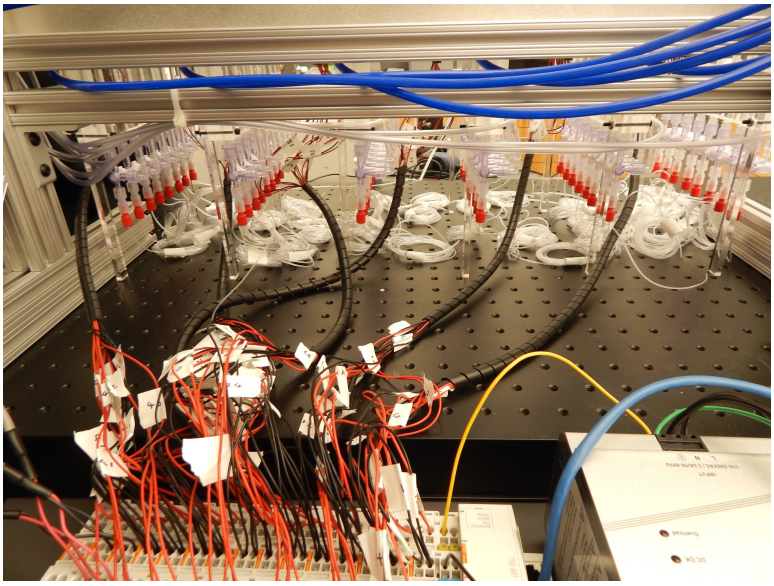
(!) Tip: The I/O module powers the rest of the DO module blocks and establishes block-wide ground ("global ground"). It can be identified by lack of an orange top.

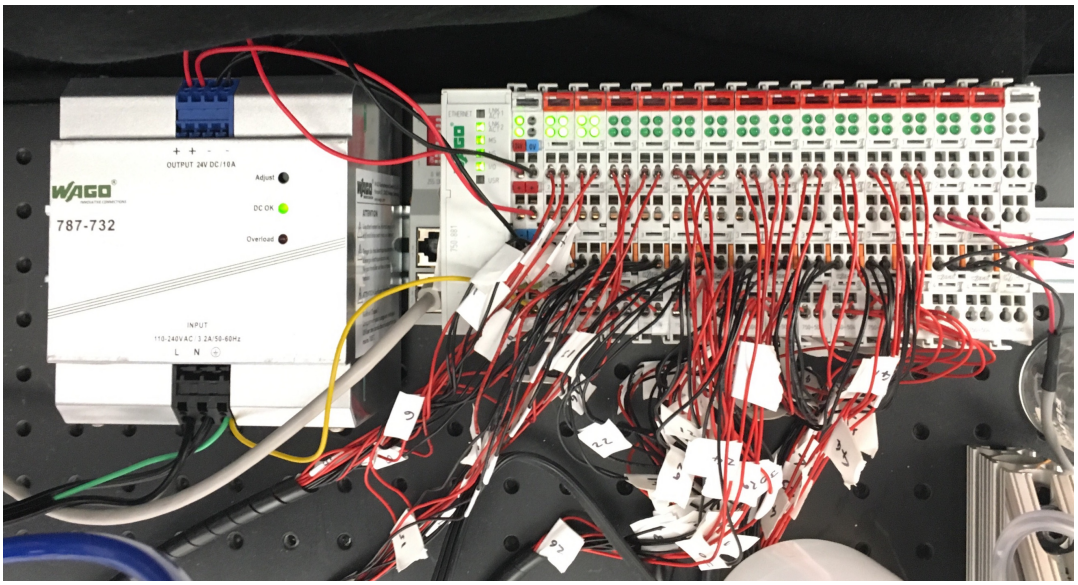


13. Next, connect the Ethernet cable, **Part m**, to the top Ethernet port (shown above) of the WAGO I/O (**Part W1**) and to your computer. Change the WAGO dipswitch (top red box on **Part W1**) to the desired WAGO Ethernet address. We use 192.168.1.3 but this address may depend on your institutional requirements. Use the manufacturer instructions to change the dipswitch as desired.

14. Plug in the WAGO power (**Part n**) to an outlet.

15. The WAGO assembly, with all the wiring connected, should now appear as the following images.





You should see the power lights and connectivity lights (**Parts W1, W2**) on in your setup upon powering the WAGO but valve state lights (top of **Parts W3**) may or may not be active yet depending on the initialization parameters.

16. In a browser, type in the WAGO Ethernet address you set in Step 13. You should see the following display.

If you do not, change your WAGO Ethernet settings under your Network Settings to have the following subnet. At startup, the Watchdog timer (under the Watchdog tab at the WAGO Ethernet website shown below) should be set to 0. If it is not, set it as such on this site.

17. Now proceed to set up your WAGO device interface using our control software according to the Geppetto Read Me as described in the main text of the article.

Congratulations!
You have finished all the Modules for the Build!

Proceed to Device Operation and Setup