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JL Olfactometer Practical Guide

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Background

The larger model olfactometer was the only olfactometer used in the Restrepo lab until 2019. As the lab grew space for machines became limited, and there was a need to have a portable olfactometer that could be wheeled in and out of microscope rooms. Two lab members (Justin Losacco, PhD and Nicole Arevalo, MA) redesigned the machine dimensions to reduce the size while retaining the functionality of the original model.

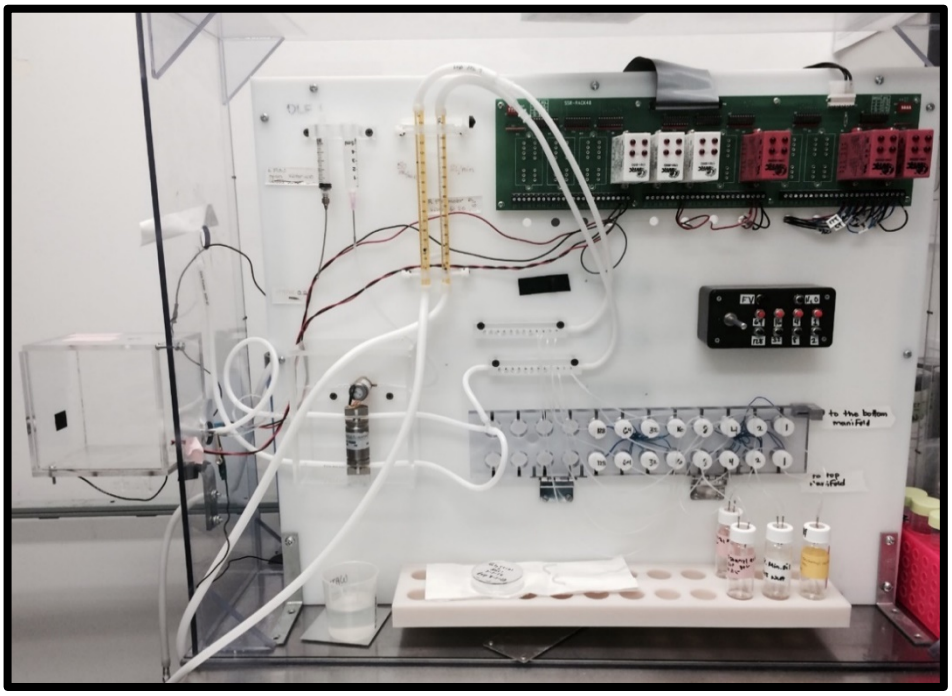

Figure 1. Large olfactometer. The interface board (SSR Rack48), control box, air/water system, manifolds, solenoid valves are mounted on the front and the odorant chamber is mounted on a polycarbonate shell. The PVC board allows the user the flexibility to change the components around and manipulate the design.

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A portable “mini” olfactometer was designed. The machine dimensions were reduced by 50% and a custom-made sliding mechanism was made for both the operant animal chamber and holders for the diverter/water solenoid valves allowing the user to adjust the position of the parts.

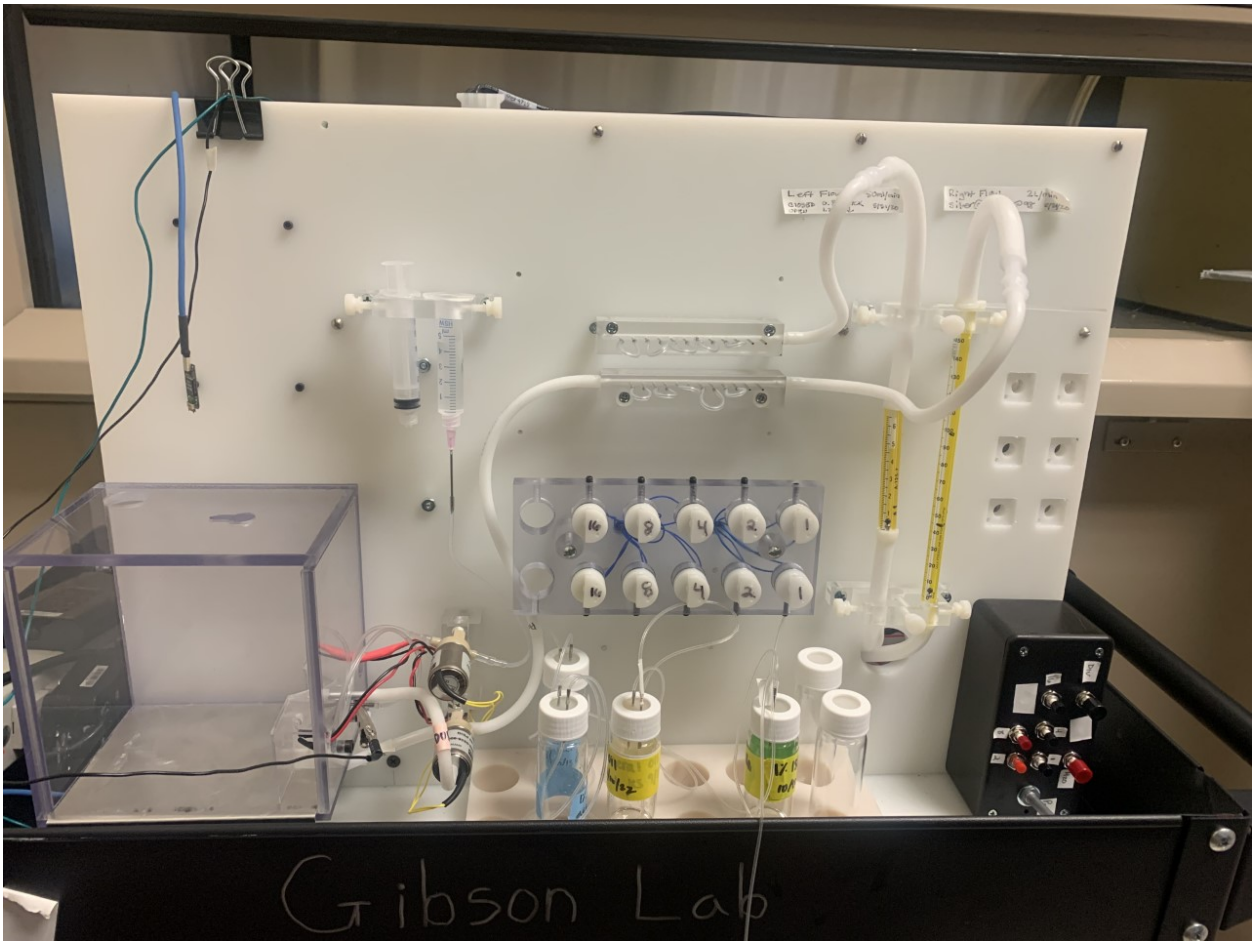

Figure 2. Portable mini olfactometer(front). The dimensions of the white board are 22”W, 16”H and 8.5”D.

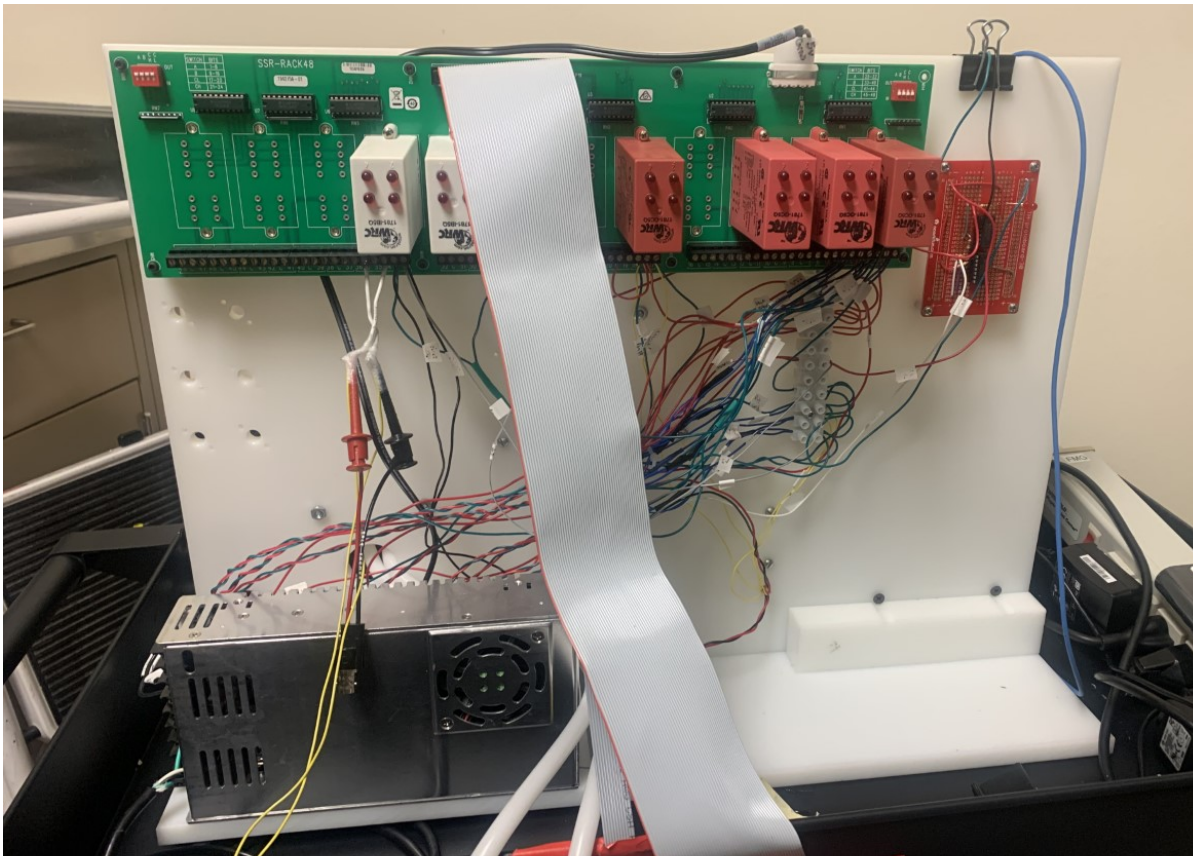

Figure 3. Portable mini olfactometer(back).

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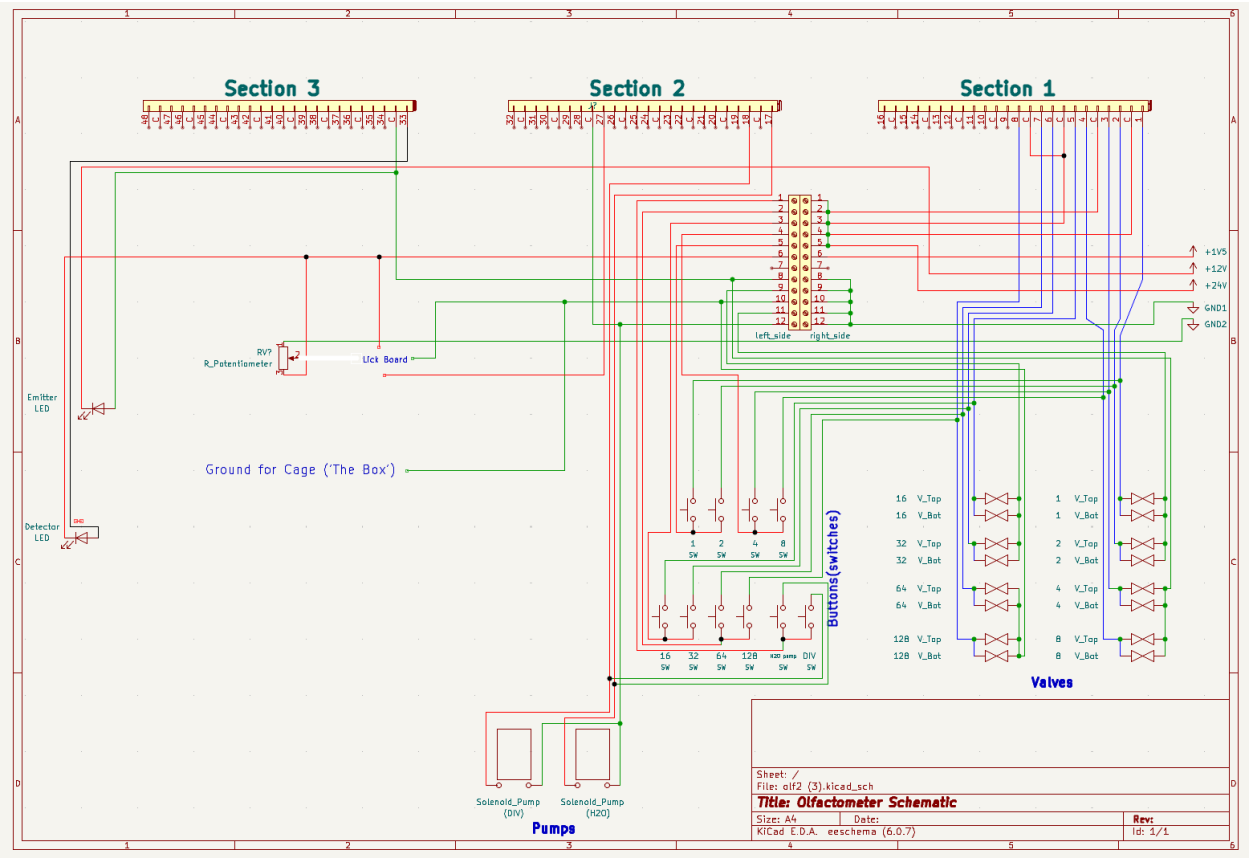
Schematics and Images

Large and Mini (~50% smaller) JL Olfactometer

The schematics (wiring) can be found in the section (github/restrepd/JL_olfactometer), an example of what this looks like:



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Construction

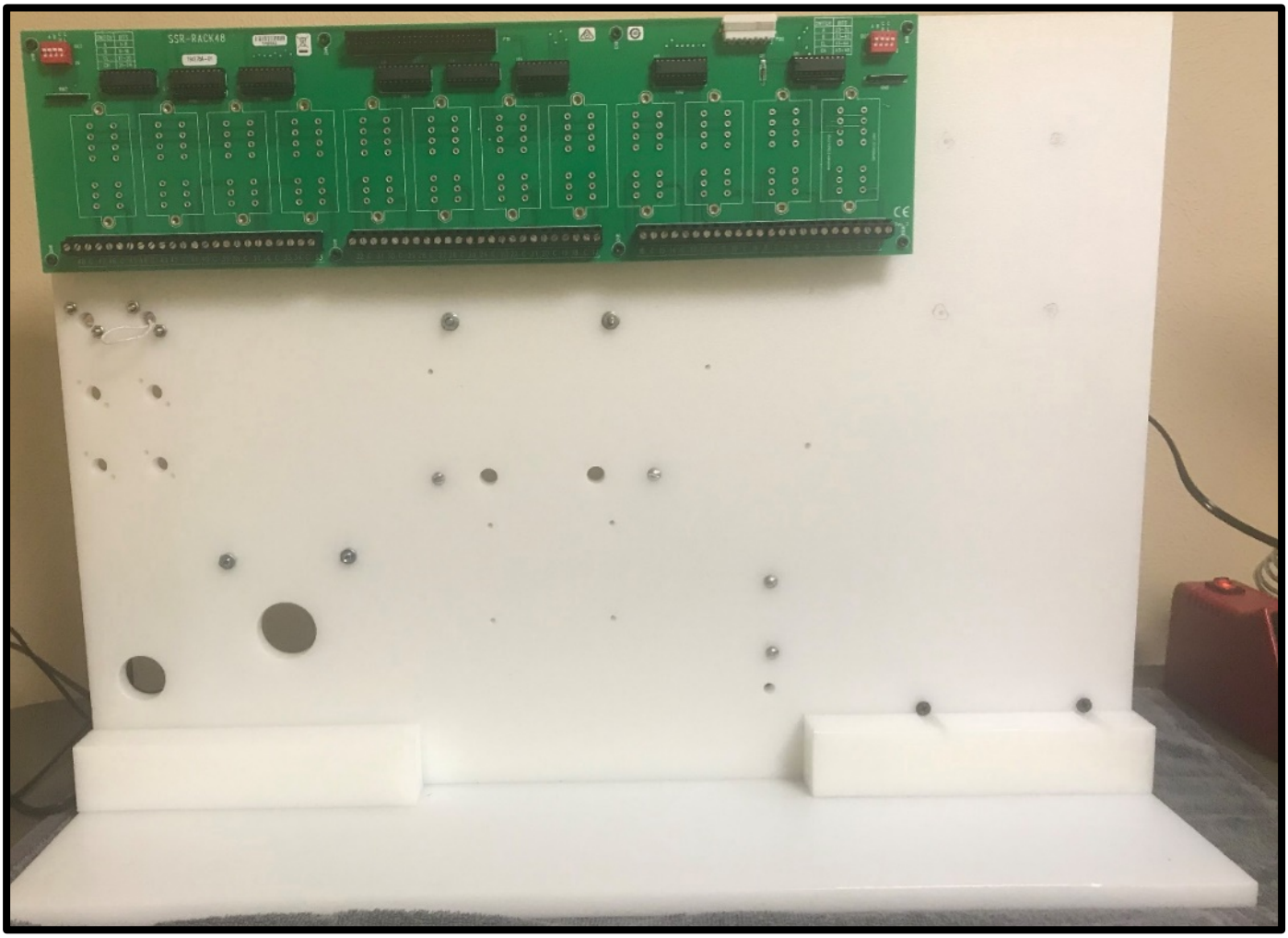

Figure 4. Back of the mini olfactometer without a power supply. The picture displays the back of the mini with the SSR Rack48 interface board installed. The SSR Rack48 provides positions for 12 quad relays and has screw terminals or "pins" for each module. The screw terminals allow the user to connect signals via 12-22 AWG wire. Quad relays have shared common connections between each pair of the two SSR circuits.

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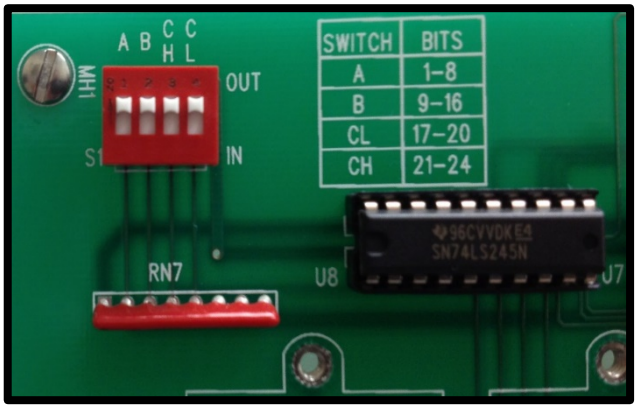

Figure 5. On the left side the SSR Rack48 has built-in switches so that the user can choose to convert input TTL (Transistor-Transistor Logic) voltage to the SSR to digital bits (IN) or send output commands to switch valves by SSR relay modules (OUT). The switch on the left side is the output switch and all the levers should be in the up position ("OUT"). The switch on the left is the Port-Directional Control for screw terminal 1-24 (on the right, odor valves, diverter, and water valves).

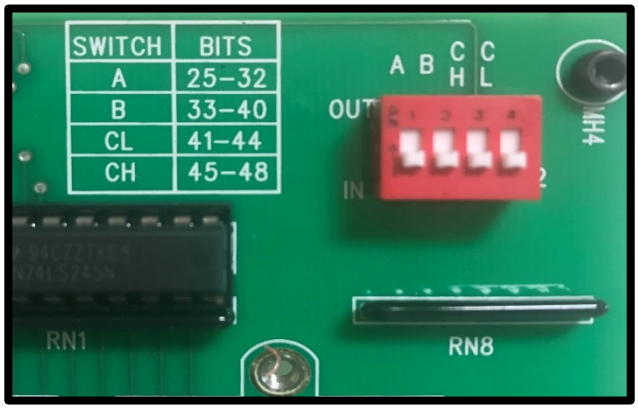

Figure 6. The right side of the SSR Rack48 has a switch that is the input switch, and the levers should all be in the down position ("IN"). The switch is the Port Directional Control for screw terminal 25-48 (lick sensor board and LEDs). ***Note that the switches on the right control the relays on the left and vice versa****.*

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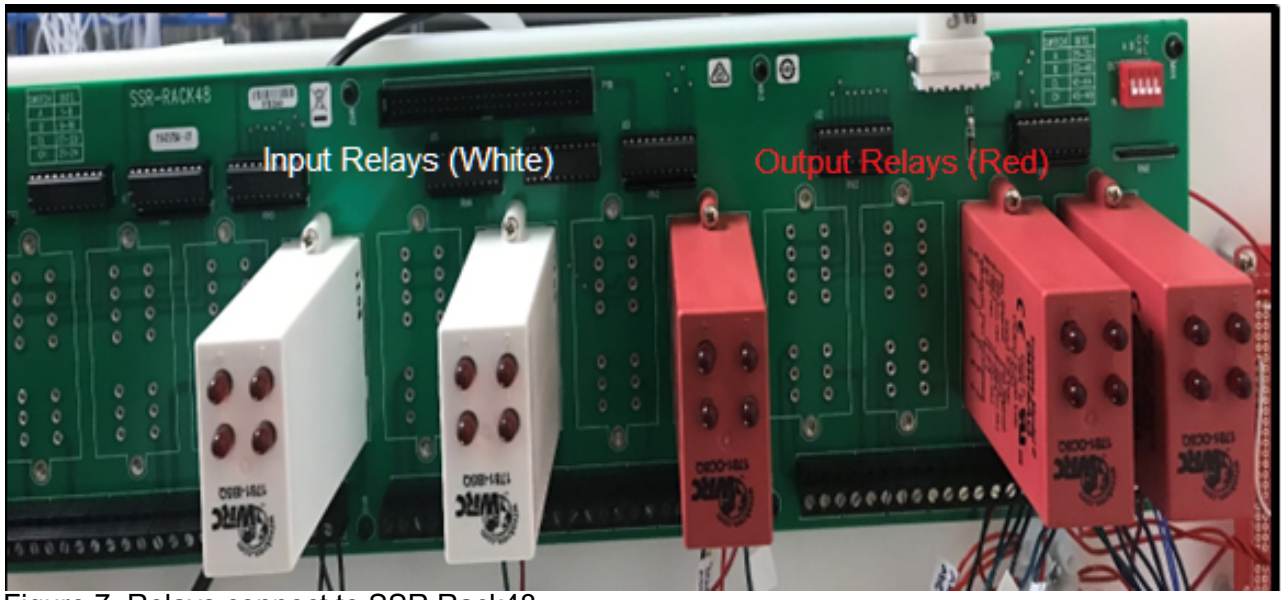

Figure 7. Relays connect to SSR Rack48.

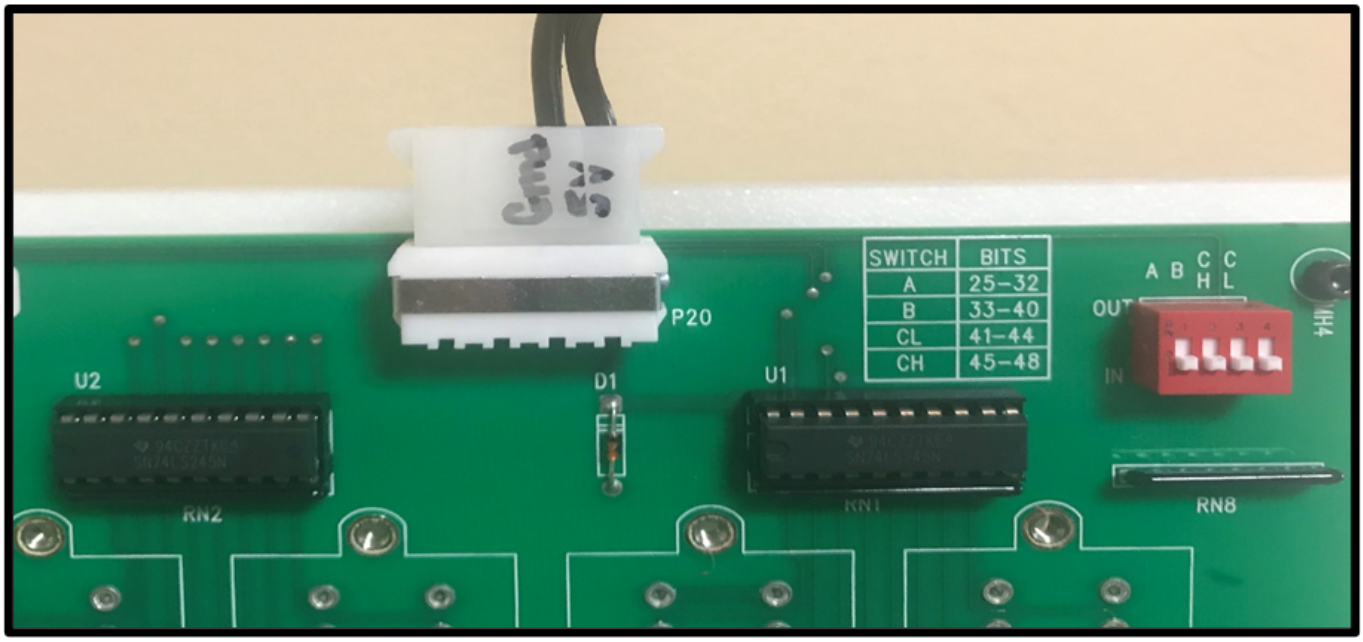

Figure 8. The picture displays the connection for the PC Power cable. The far-right cable should be connected to the 5V (directly) to the external power supply and the left connection should go to ground on the external power supply. The cable comes with the SSR Rack48.

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Figure 9. Solid State Relay Module, Quad, VDC Output, 5 to 200 VDC, 3.5 A. P/N SSR-4-ODC05A.

Figure 10. Solid State Relay Module, Quad, VDC Input, 3 to 32 VDC.

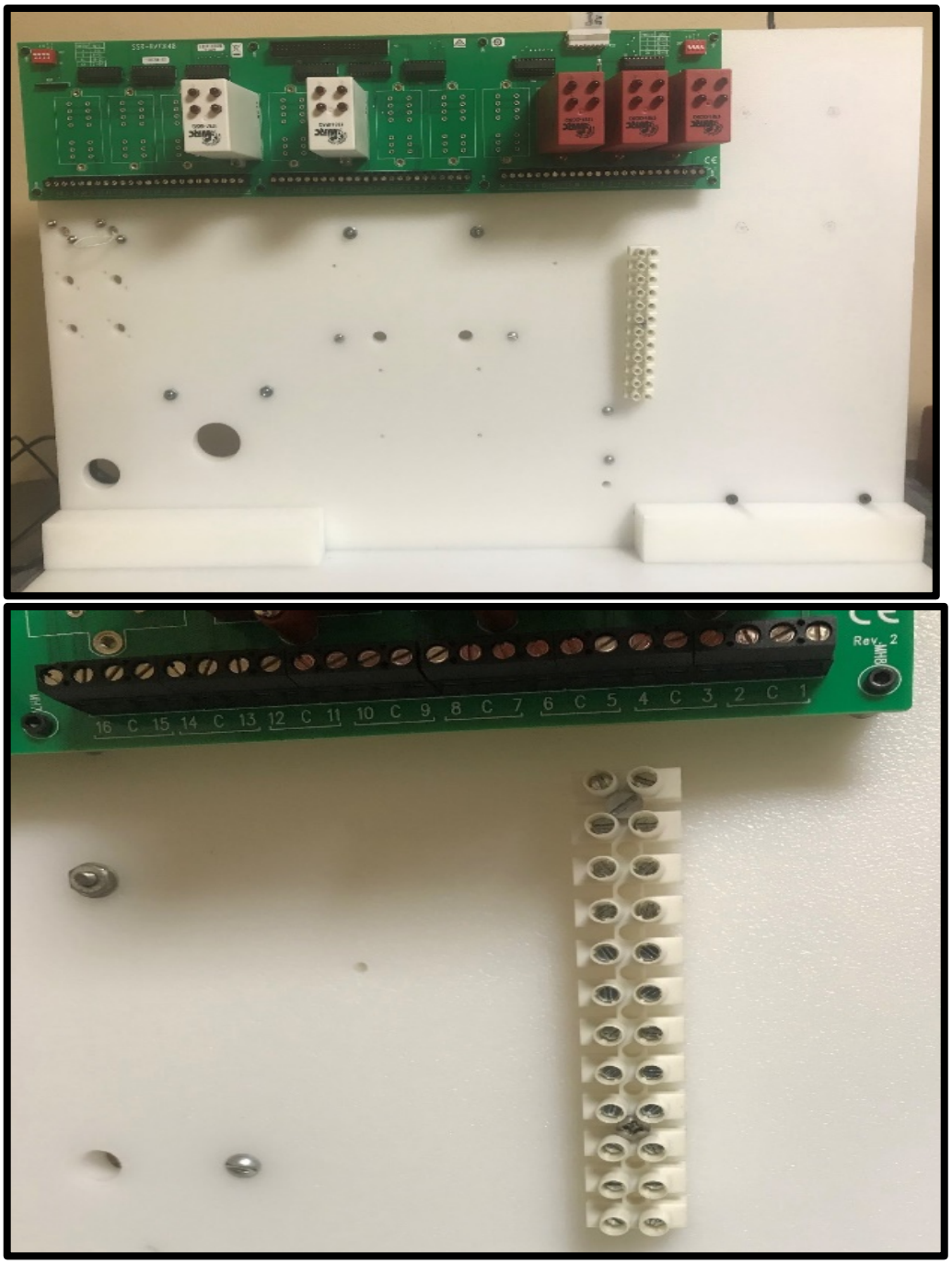

Figure 11. Both images are showing the dual row barrier strip that is used for many of the connections on the SSR Rack48 (5V, 24V and Ground).

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Solenoid Valves

Figure 13. DIVERTER SOLENOID VALVE (P/N 003-0258-900, www.ph.parker.com)

Series 3: 3-Way Cross Section, Barb Wetted Material and Dimensions

Moderate PEEK, EPDM Diaphragm, 3-way valve, without bleach, 0.078" orifice size, 24 DC voltage, 1/8" connection barbs

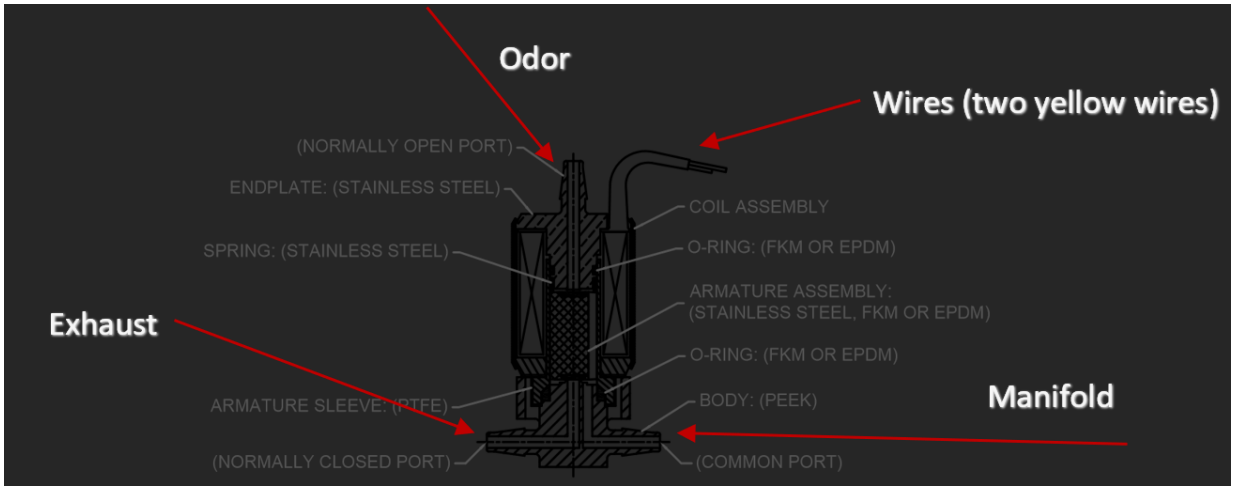
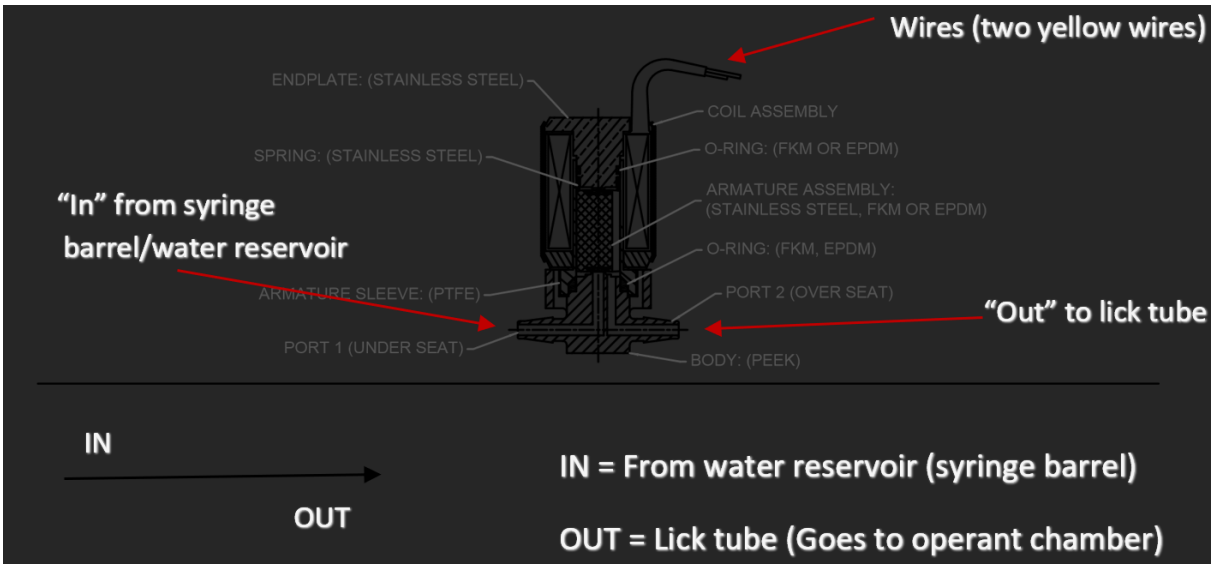


Figure 14, WATER SOLENOID VALVE (P/N 003-0257-900, www.ph.parker.com)

Series 3: 2-Way Cross Section, Barb Wetted Material and Dimensions

2 way normally closed valve, 1/8" barb connection.



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Solenoid Valves

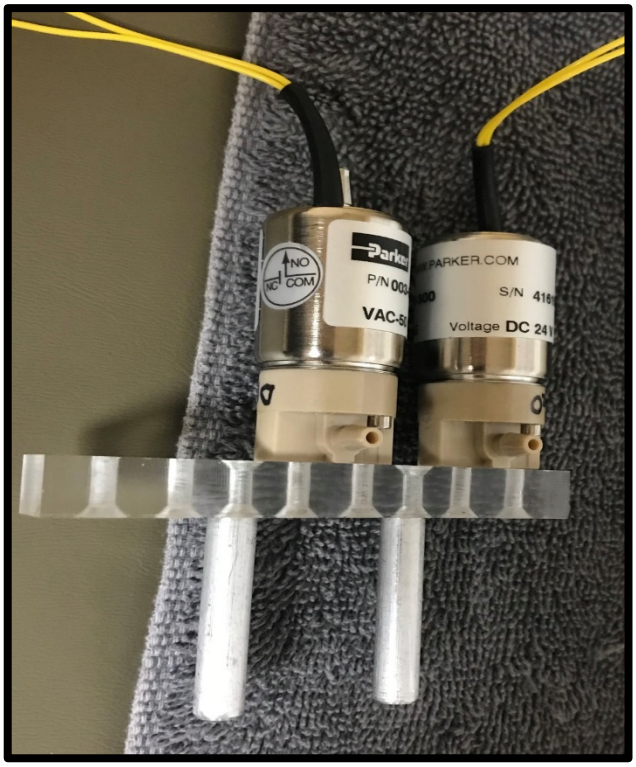

Figure 15. The image shows the removable holder we had built for both the diverter and water valves. Each valve has two wires (shown in yellow). One of the wires goes to Ground on the barrier/terminal strip on the back of the "Mini." The other wire goes to the correct screw terminal pin position on the SSR Rack48. For the water valve, the pin position is #17. For the Diverter valve, the pin position is #18.

Figure 16. The picture shows how the holder for the Diverter/Water valves attach to the base. The builder can place the solenoid valves in any position, but we would recommend placing the diverter valve closest to the odor port (the stainless-steel tube where the odor comes into the operant animal chamber pictured as a larger diameter silver tube in the background. The smaller tube is the lick port where water is dispensed).

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Odor Valves

Figure 17. The odor valves were purchased through www.nresearch.com.
P/N 161P012 (Normally closed solenoid pinch valve, 24 vdc, 0.030 x 0.065). Tubing that fits these valves can also be purchased from the same company, P/N TBGM107.

Wire – The odor valves have two blue wires. One wire goes to "Ground" on the dual row barrier strip on the barrier. The other wire goes to the correct screw terminal ("pin") on the SSR Rack 48. The odor valves are pins 1-6 (or 1-8 is using all 8 odor valves). Each odor has a pair of valves, so that will be two wires going to GRND and two wires to the pin. For ease, you can solder these together (shown in wiring diagram).

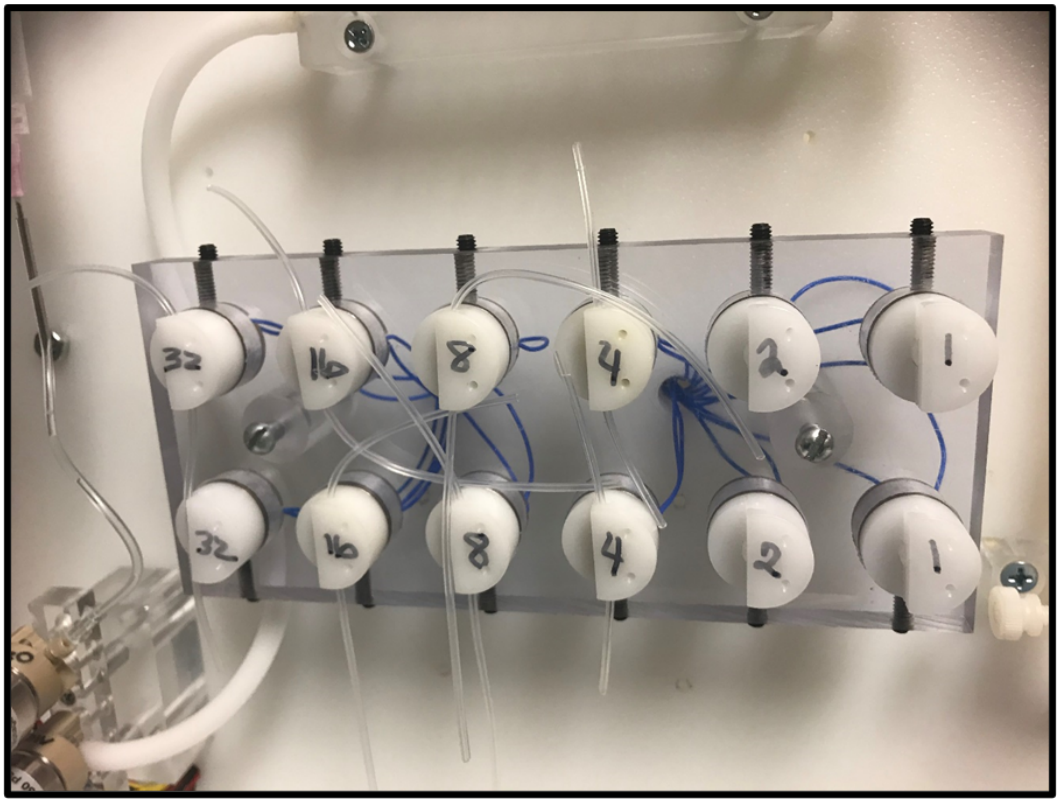

Figure 18. The picture (above) shows the front side of the "Mini" olfactometer that houses the custom-made holder for the odor valves. Since the system has two different flowmeters (2L/minute and 50 mL/minute), you will also need two odor valves (pair per odor) and two manifolds (directs the air flow into either a particular odorant tube or

constant air flow). The numbers can be assigned to what you put into the operating code.

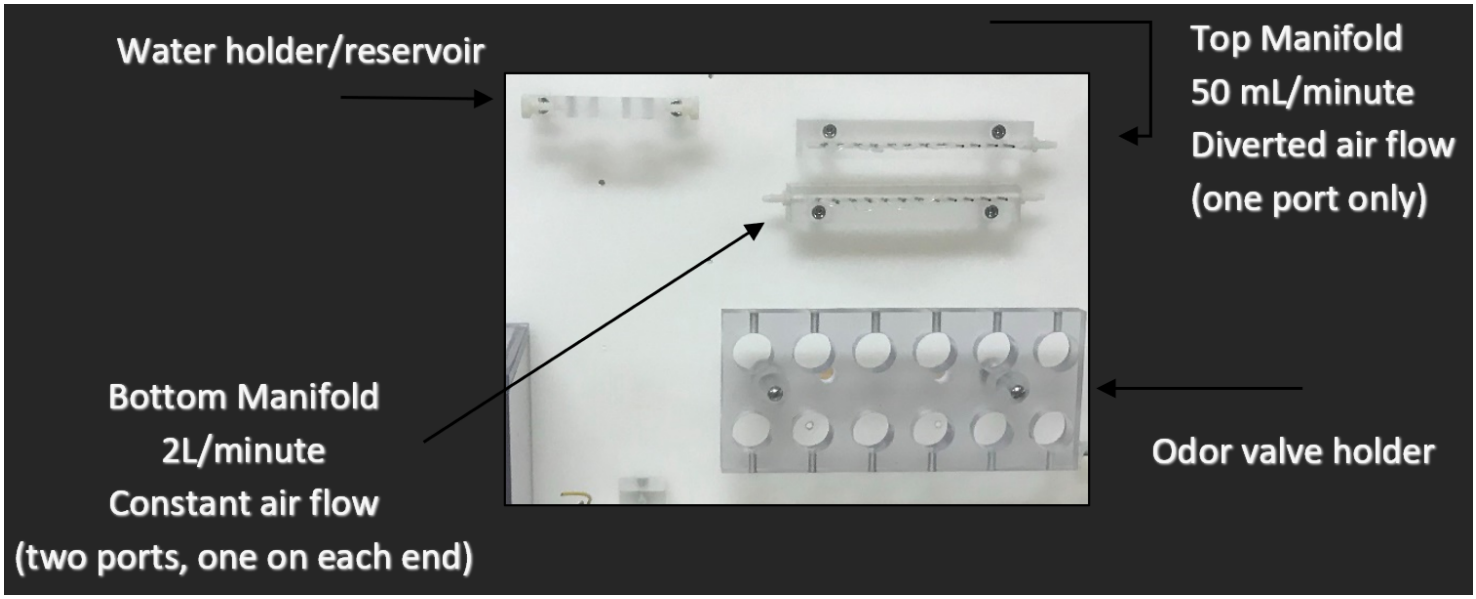

Figure 19. The reservoir has two different flow rates. The top manifold is measured at 50mL/minute while the bottom runs at 2L/minute. The top air flow is taking in odorant (gas/air) from the odorant bottle. The bottom air flow is directing air into the odorant bottle bottom with the tube extending into the liquid forming bubbles which creates air for the top manifold to send to the mouse.

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Air System

These are all the parts for the air system.

Parts for the Air System:

Pump

- Aquarium pump like the Rena Air 400 5L/min (Rena is hard to find, so you can use Air Pump 7.8 by ActiveAQUA on amazon.com, AAPA7.8L, 125 GPH, 2 outlets 3W 7.8 L/min)
-
    - Also JW Pet Company Fusion Air Pump 200 aquarium pump works well, amazon.com)

Housing (filter)

- Cole Parmer double open end cold water housing with blue sump (ColeParmer, EW-01508-25) $33.30
- Carbon impregnated paper cartridge 10” (ColeParmer, EW-01509-25) $10.80
    - You can also purchase via Filtersfast, Pentek NCP-10 carbon impregnated polyester filter (P/N NCP-10, $9.00)
    -
- Pentek 151120 filter o-ring that replaces W34-OR (Filters Fast, P/N 151120) $3.00

Tubing/adapters

- Pipe Adapters that fit on the water housing pump (Cole Parmer/VWR, EW-06365-42 [ensure this fits the thread size for the housing independently!])
    - These are replacement o-rings for inside the blue housing.
- Cflex tubing, white 1/4” ID x 3/8” OD 25 ft (ColeParmer/VWR, EW-06424-71) $51.75
- Cflex tubing, white 1/8” ID x 1/4” OD 25 ft (ColeParmer/VWR, EW-06424-67) $31.50
- Pipe adapter 3/4” x 1/4” 5 pack (ColeParmer/VWR, EW-40610-48) $8.78

- Fitting reducer 1/4” x 1/8” 10 pack (ColeParmer/VWR, EW-30622-27) $17.32

- Valve Ball PVC 1/4” barb buna (ColeParmer/VWR, EW-01378-87) $13.28 each

- Barbed Tee connector polyethylene 1/4” 10 pack (ColeParmer/VWR, EW-30623-71) $14.85

- Barbed Tee connector polyethylene 3/16” 10 pack (ColeParmer/VWR, EW-30623-67) $14.85

Flowmeters

- Bel-Art Riteflow unmounted flowmeters plain ends 150mm (FisherSci, Cat# 1116370E) $147.00 each
    - For smaller flowmeters that work great for the 50 ml/min try A-125-7 porter instruments (FisherSci or ColeParmer/VWR?)

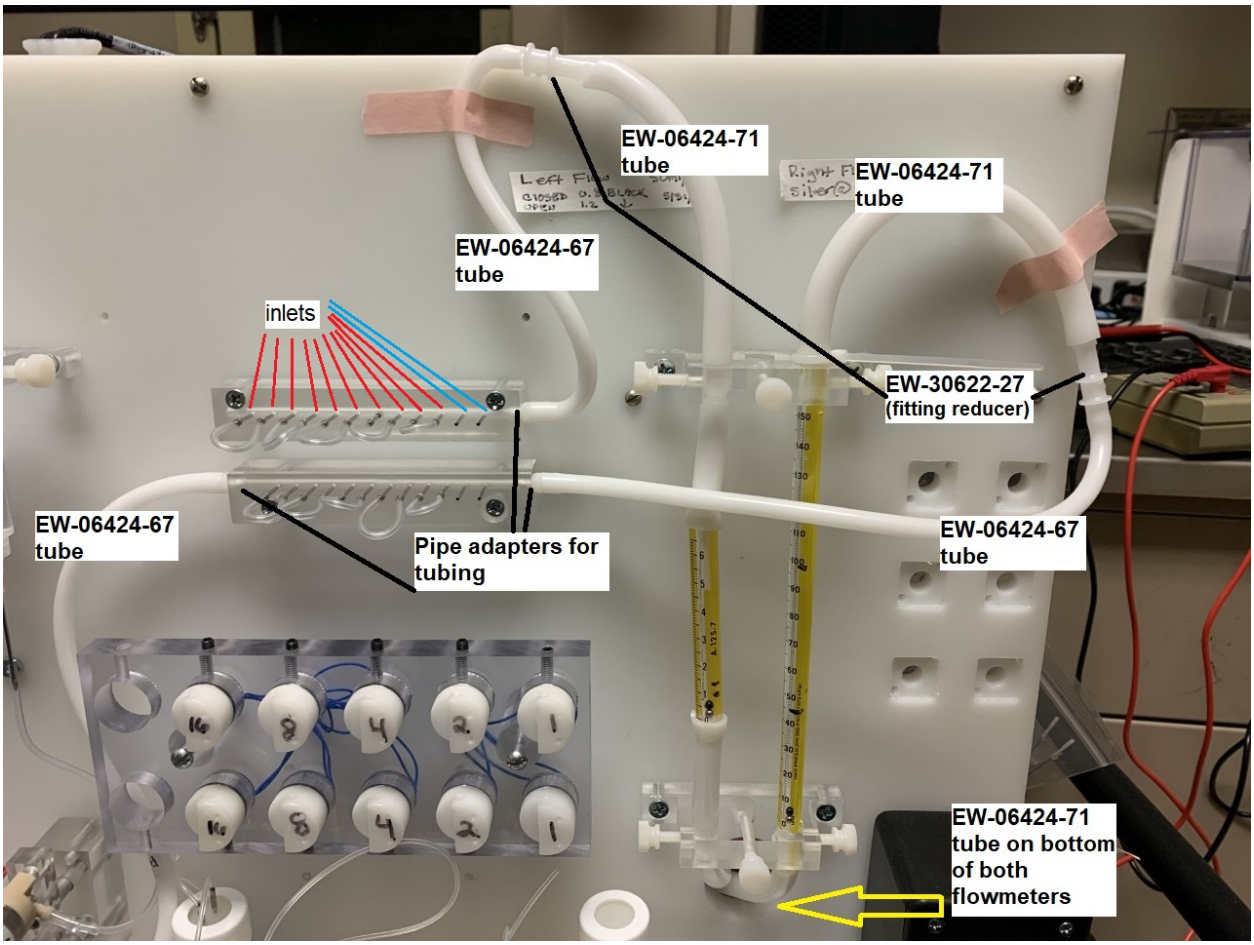

Figure 20. Partial picture of air flow system in relation to Top and Bottom Manifold. The Top manifold is connected to the top of the left flow system while the Bottom Manifold is connected to the right flow system. The bottom manifold tube on the far most left leads out to the diverter solenoid which then has an exhaust as seen in figure 22. Tubing leading from top and bottom manifolds (right side) are connected to the flowmeters (right side of each manifold). On the manifold, each inlet for odors is blocked off with tubing as seen with the tubes (pointed to in red) connecting each inlet when not in use. When in use, the odorant bottles are connected to the top and bottom manifold as to figure 23.

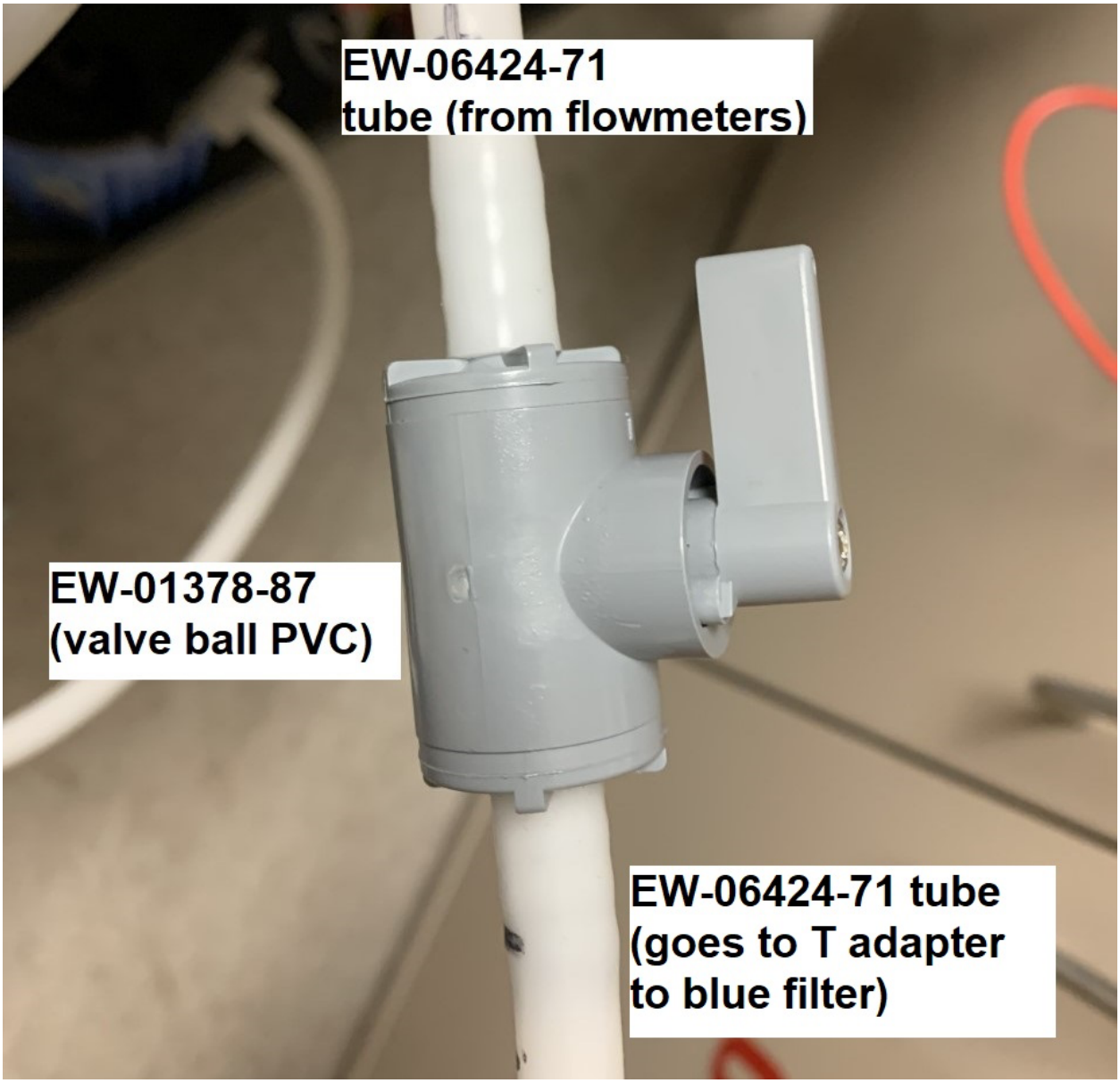

Figure 21. Each flowmeter has an independent line which leads to the back of the JL olfactometer to an independent valve ball PVC used to control the inward flow to the flowmeters (to adjust to correct output flow). This valve adapter is for calibrating the flow rate on each line. When adjusting the flow rate between the tubes, ensure to keep one valve closed to get an accurate reading on the flowmeter being tested.

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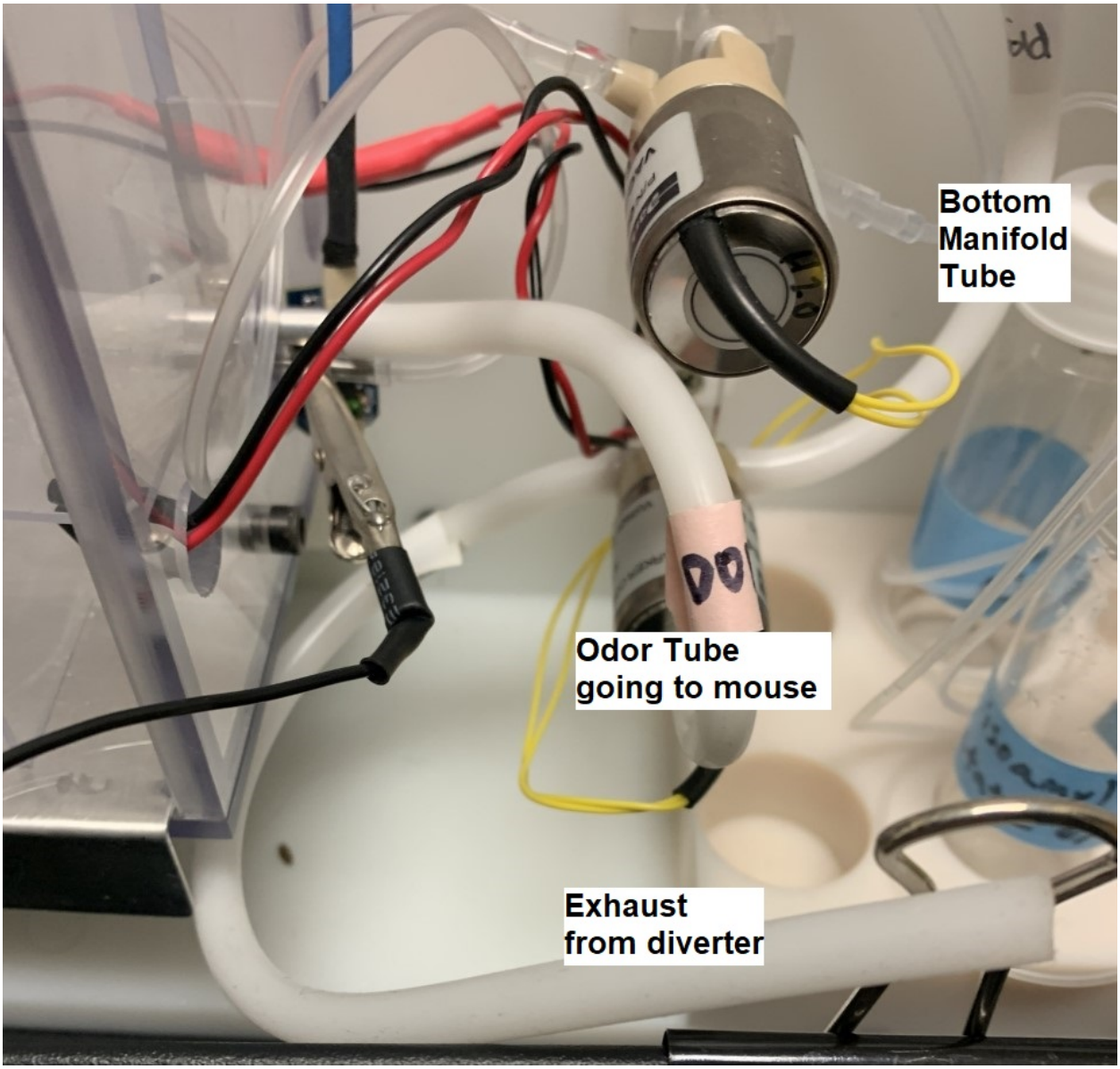

Figure 22. A closer picture of the diverter solenoid pump with EW-06424067(white) tubing.

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Figure 23. The image shows the odorant bottle. With the top manifold odor valve (50mL/minute) sent through to the left port which has no tube inside the odorant bottle. While the right is sent through to the bottom manifold valve (2L/minute). Needle tips were cut blunt to punch through membrane of odorant bottle.

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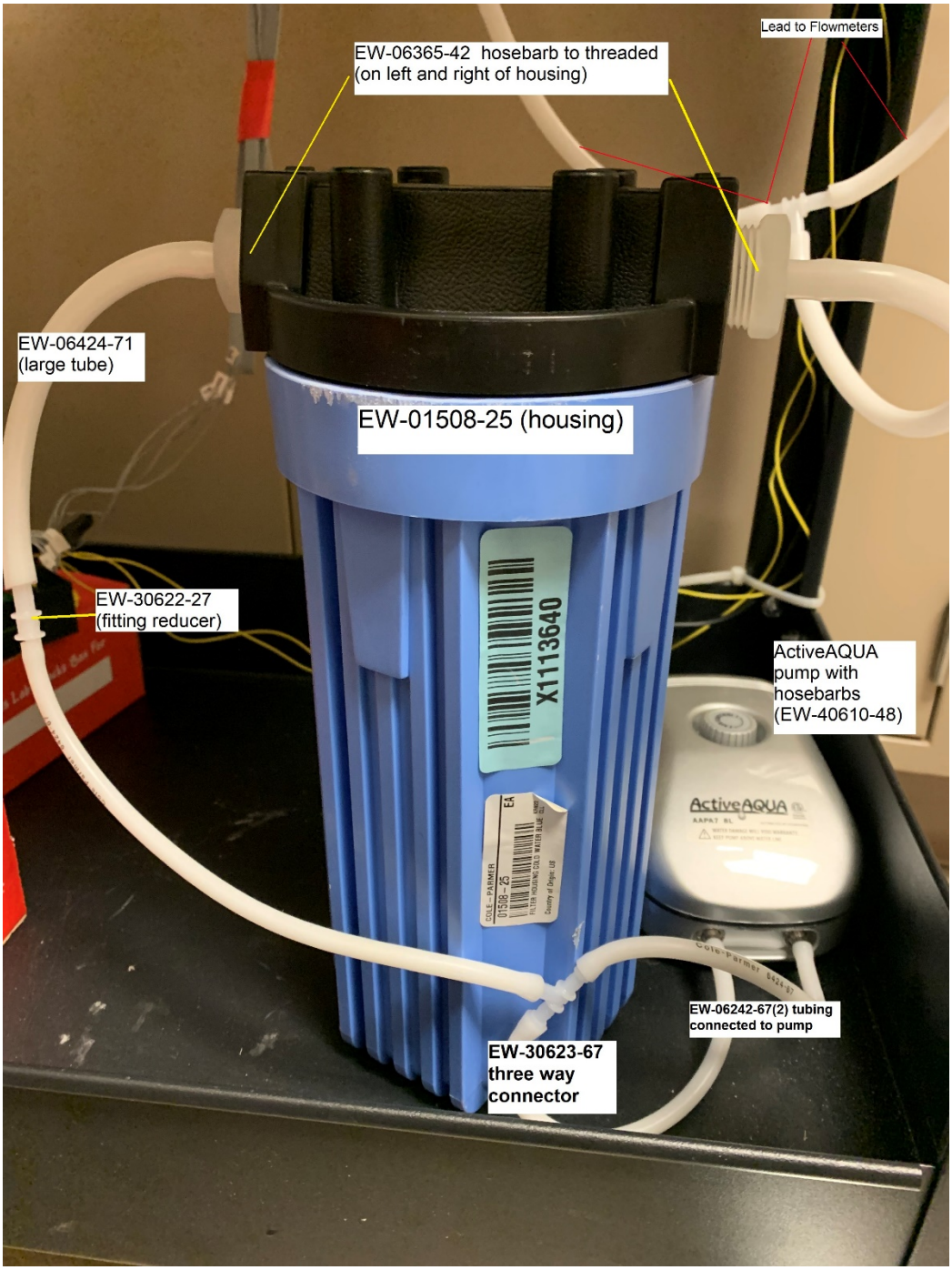

Figure 24 Here, the ActiveAQUA pump is controlling the input airflow. The blue housing holds the filter for air, and on the output, a three way connector using EW-06424-71 tubes (pointed to with red line)

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CONTROL BOX

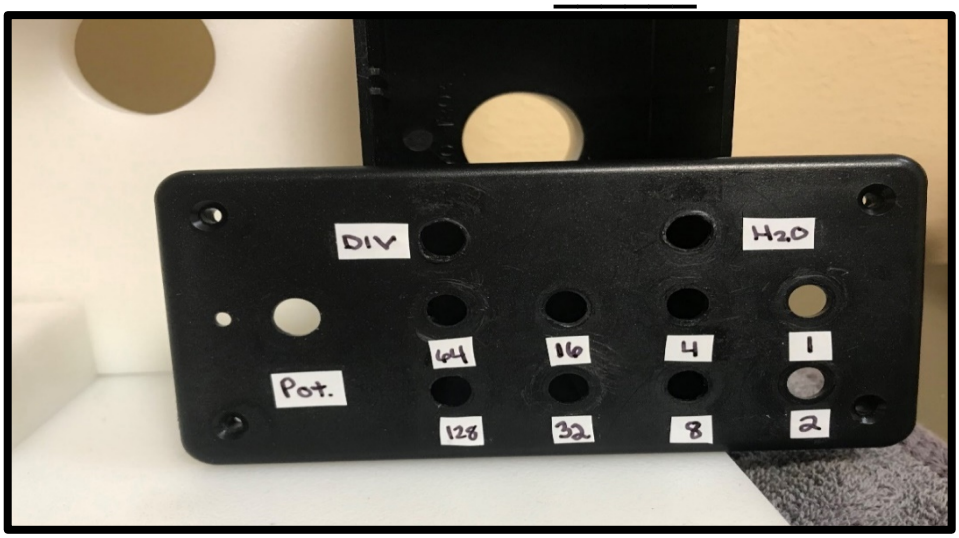

Figure 25. Picture of the project enclosure box ("Control Box") that we use for the push button manual switches and potentiometer. The box is machined to house a hole for all solenoid valves that include the diverter, water, odor (anywhere from 2-8) and potentiometer. The box can be purchased at RadioShack, P/N 2701803 and the dimensions are: 5 x 2.5 x 2."

Figure 26. A picture of the control box completed

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Figure 27. Pictured are the SPST Momentary Push Button Switch, 125 VAC, 1.5A. This part can be purchased through Radioshack, P/N 2751556. The part comes in a 2/PK, one red and one black switch. We usually assign the water valve as “Red” and the Diverter valve as “Black.” All the switches mount in a ¼” hole.

Figure 28. Pictured are the Mini Momentary Push Button Switch, 250 VAC, 1.5A, 2P SPST Off - (ON). This part can be purchased through Radioshack, P/N 2751547. The part comes in a

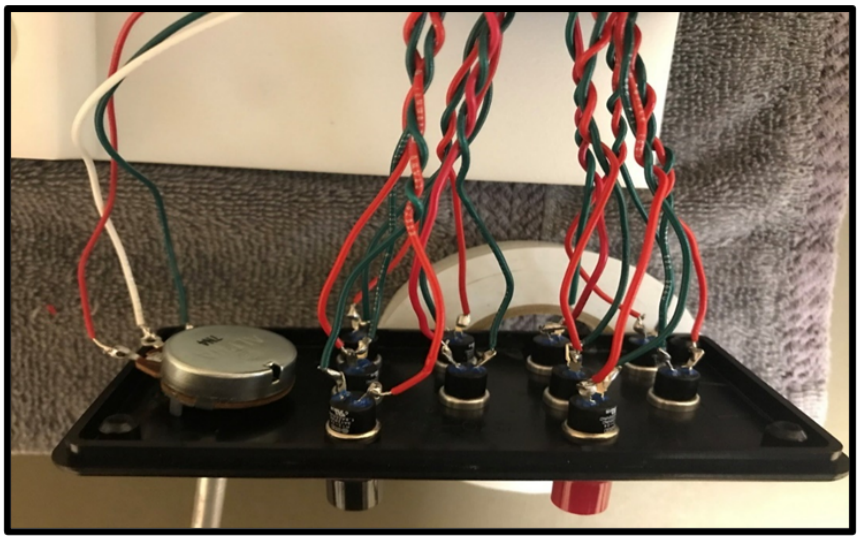

Figure 29. The image shows what the front panel looks like after the switches are installed and wired. Each switch has a green and red wire. The red wire goes to 24V on the dual row barrier strip and the green wire goes to the correct screw terminal ("pin") on the SSR Rack48. The screw terminal pictures will be later in the presentation. The picture also shows the potentiometer installed as well. The Potentiometer has three wires: "Red" = 5V connected to the power supply directly, "Green" = Ground connected to the power supply directly, and "White" = connected to the lick sensor board (B20).

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Figure 30. The potentiometer can be purchased from Radioshack or other suppliers (P/N 2711716).

Audio-Taper Potentiometer 50K Ohm, 500 VDC, 0.5W

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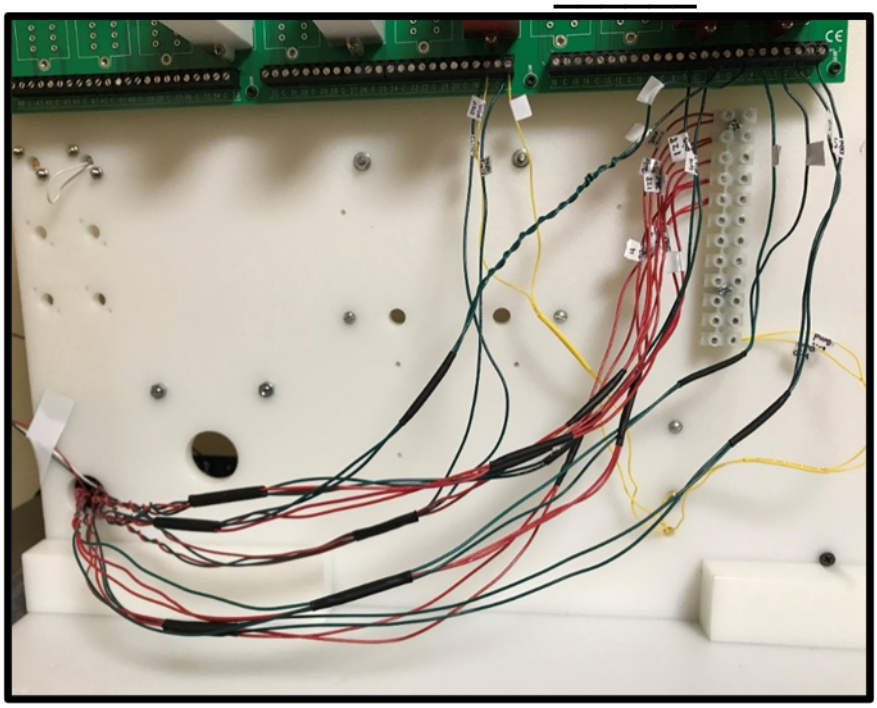
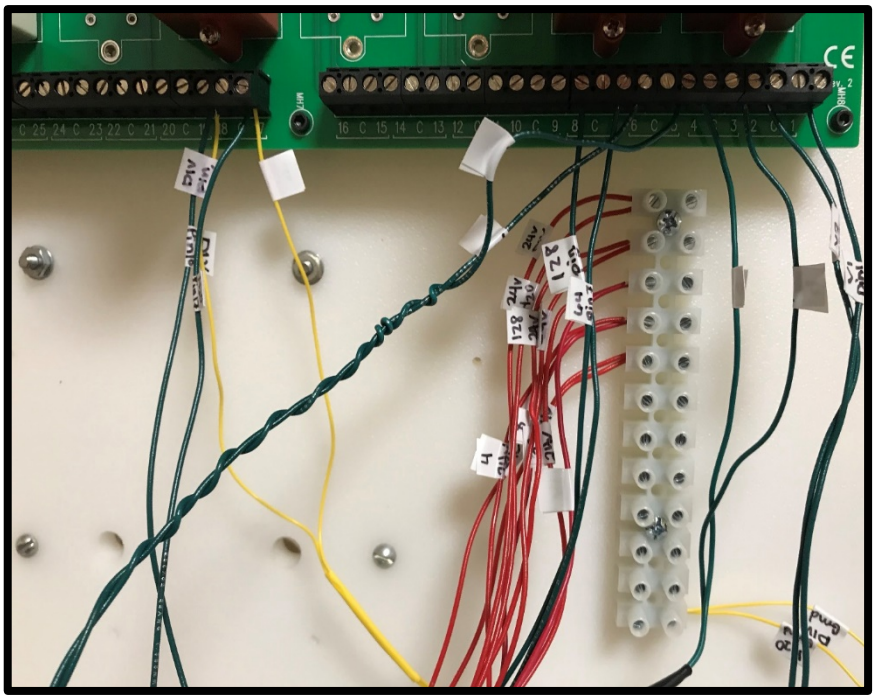
SSR Rack48 Wiring





Figures 31/32.

The images show the back of the “Mini” olfactometer. The dual row barrier strip has the following connections:

24V = Control box, main power supply and the “C” (common) between the odor valves and Water/Diverter valves.

Ground = Water/Div/Odor valves and the “C” (common) between the lick sensor board and the LED.

5V = lick sensor board, LED and main power supply.

Note – Please label all connections.

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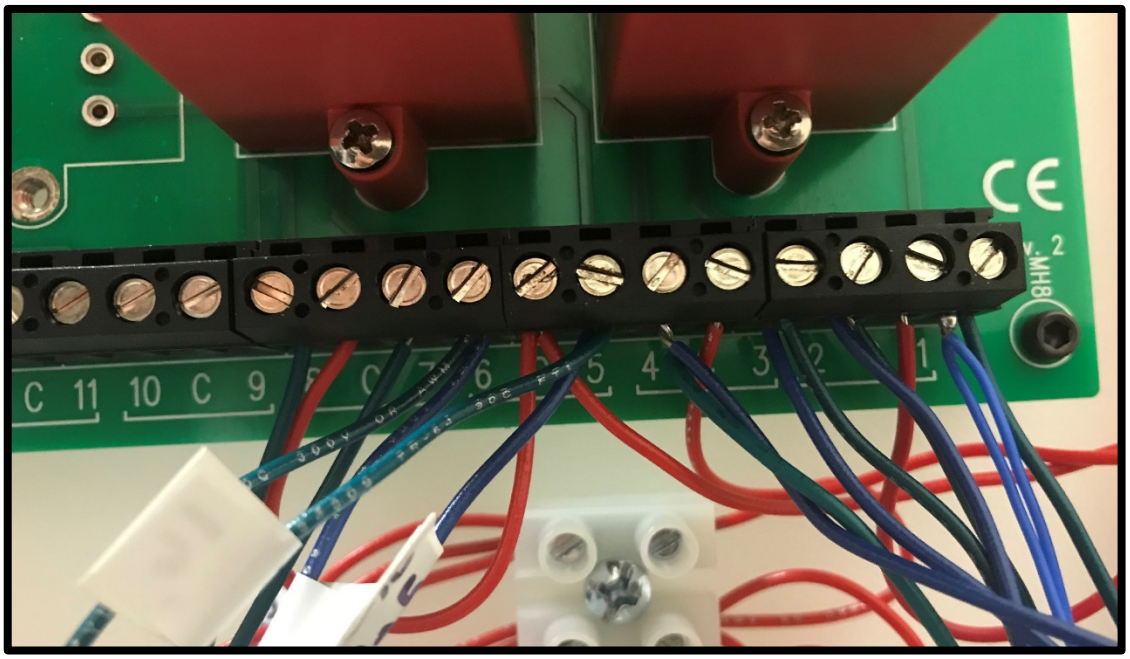

Figure 33. The image shows the SSR Rack48 wire connections for the screw terminals 1-8 (Odor valves). Pin 1 connects the odor valve #1 and the control box switch for valve #1. The "C" between pin 1 and 2 connects to 24V. All other screw terminal connections follow the same pattern. Note that pin 1 has two soldered blue wires and this is because odor valve #1 consists of a wire from the top positioned valve and one from the bottom positioned valve (in the holder).

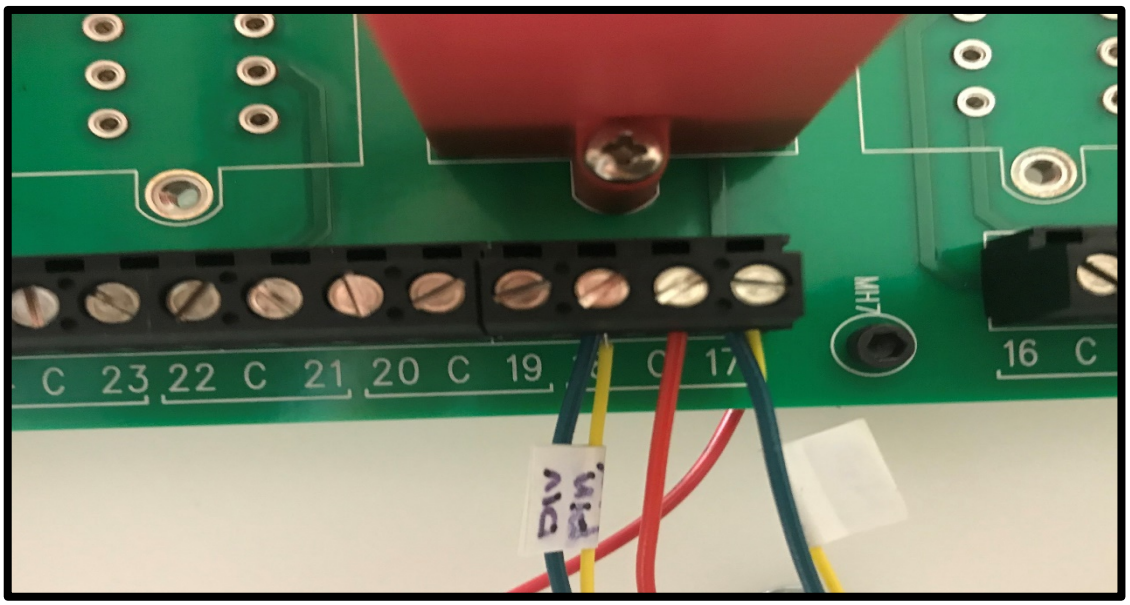

Figure 34. The picture shows the SSR Rack48 wire connections for the water and diverter valves. Screw terminal, pin17, is the water connection. Pin 17 has a "yellow" wire (water valve) and a "green" (from the control box switch). Screw terminal, pin18, is the diverter connection. Pin18 has a "yellow" wire (diverter valve) and a "green" (from the control box switch). The "C" between the pins is a "Red" wire going to 24V on the dual row barrier strip. If you add an extra water or diverter valve (pin19 or 20), make sure you power the common ("C") between these screw terminal positions.

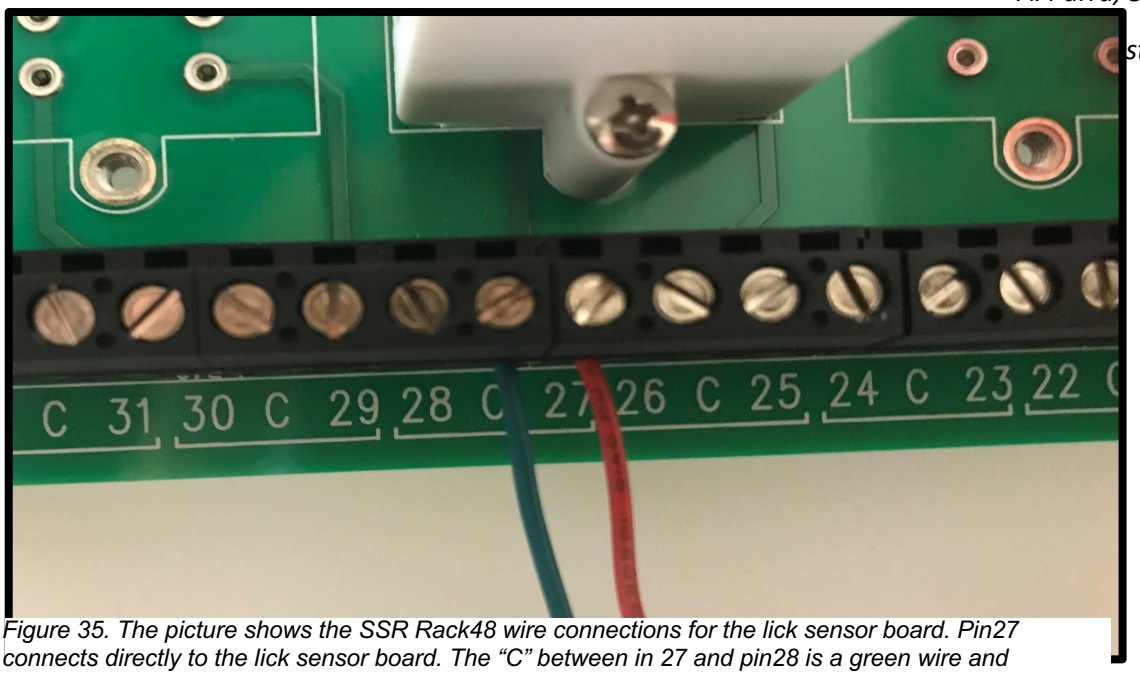

Figure 35. The picture shows the SSR Rack48 wire connections for the lick sensor board. Pin27 connects directly to the lick sensor board. The "C" between in 27 and pin28 is a green wire and connects to ground on the dual row barrier strip.

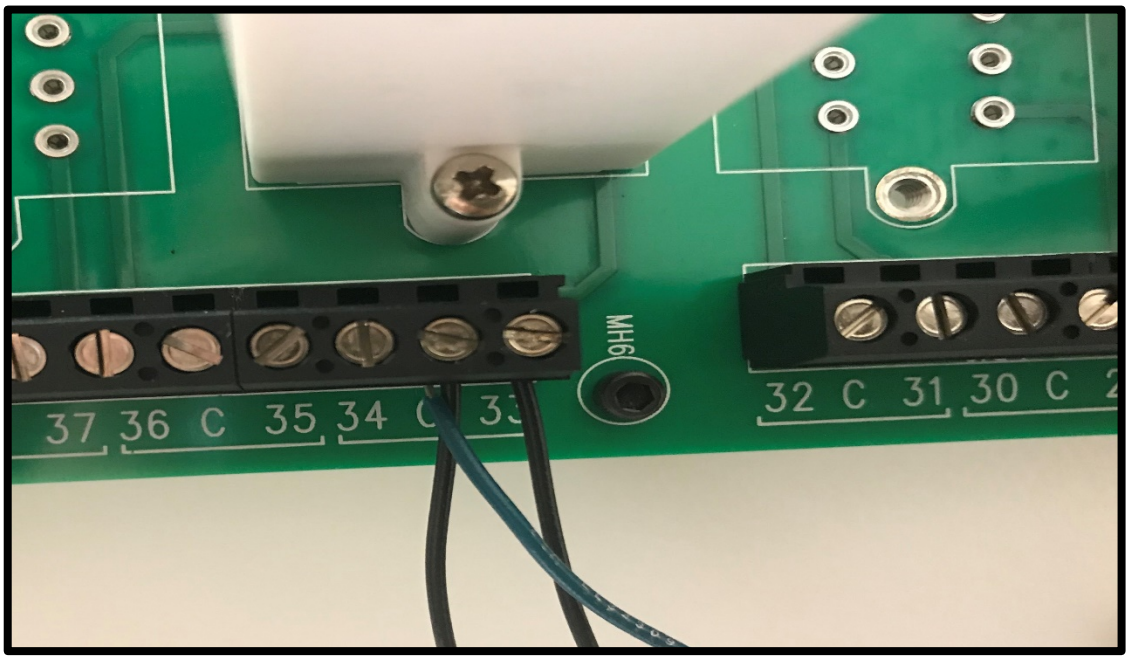

Figure 36. The picture shows the Infrared LED Detector (pin33) wire connections and the Infrared LED Emitter ("C") wire connections. The "C" between pin33 and pin34 should also have a green wire connection that goes to Ground on the dual row barrier strip.

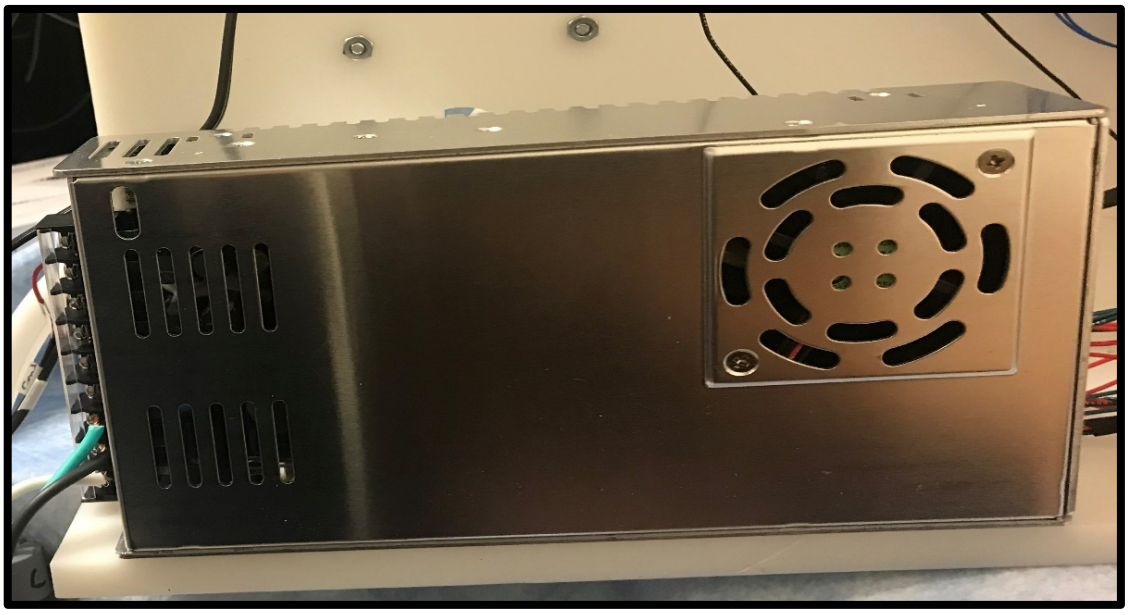

Figure 37. An image of the main power supply that the lab uses to power all the olfactometers.

Figure 38. AC to DC Power Supply Quad Output (5V, 12V, 24V).

Jameco P/N 213752

Manufacturer: Mean Well

Manufacturer No. QP-200D

V1 = 5V

V2 = 12V

V3 = 24V

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Lick Sensor Board

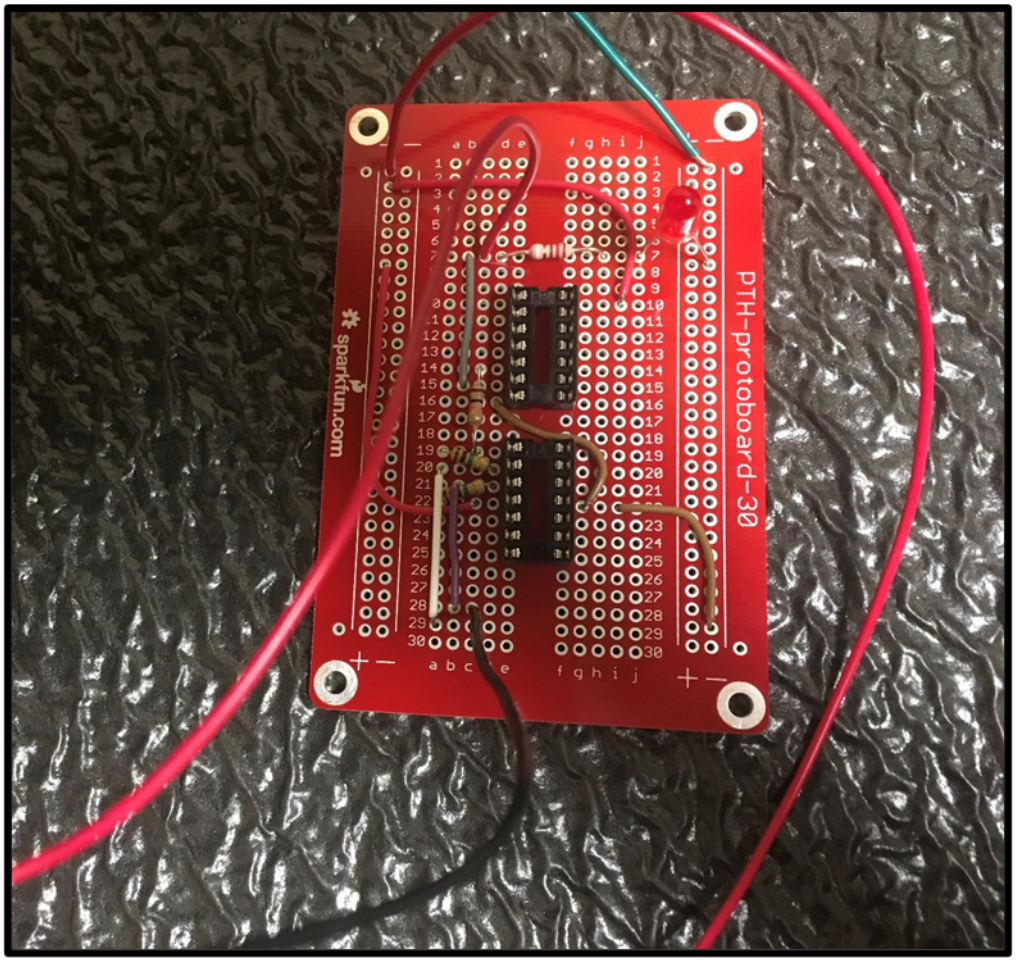

Figure 39. An image of the "Lick Sensor Board." (schematic on github)

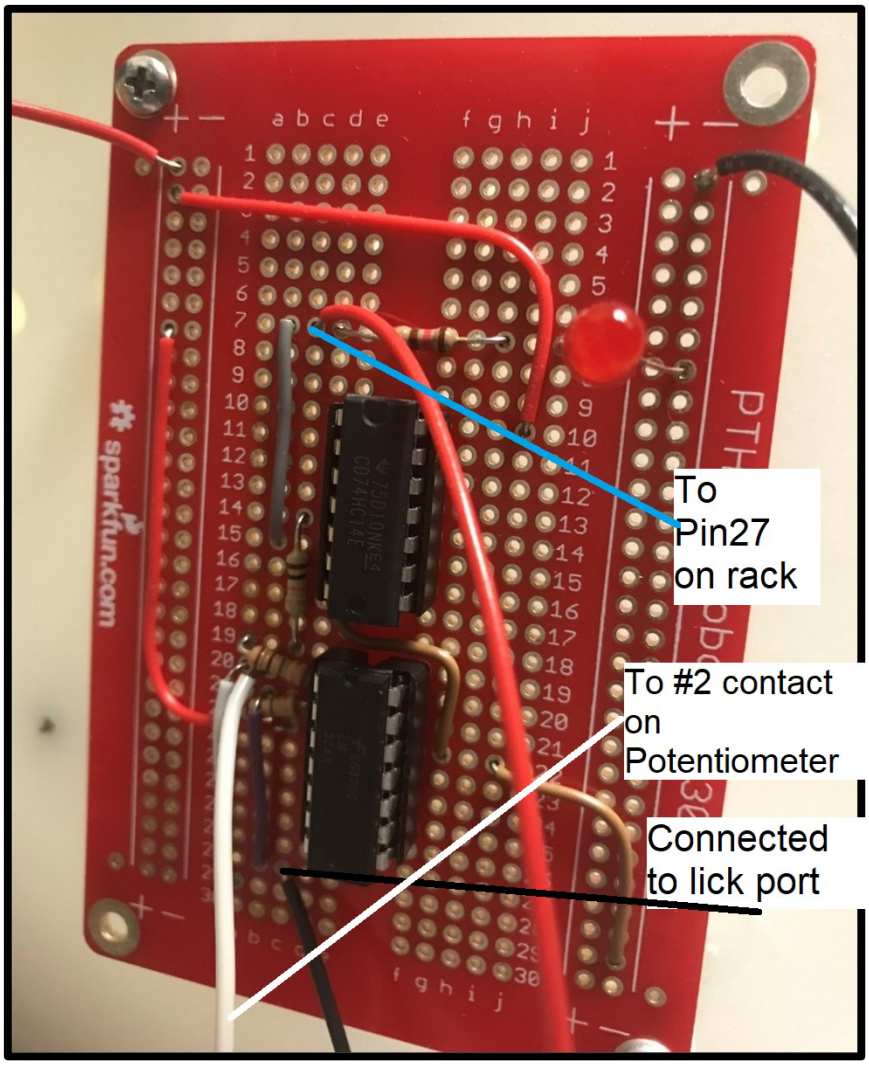

Figure 40. An image of the "Lick Sensor Board."

Figure 41. An alternative solution to the traditional “Lick Sensor Board,’ is to use a ***Capacitive touch sensor*.**

To look at the schematics and how to use/wire this touch sensor board, please look at the “Capacitive Touch Sensor Use” resource.

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Programs/Software

The JL olfactometers can be used in either C++ or Matlab programs. Dr. Restrepo has developed the code in both platforms.

- C++ (general purpose programming language)
- Matlab (a programming platform that is used by scientists to analyze, develop algorithms, and create models). The lab specifically uses Matlab 2015B 32bit (64bit unsupported).
- Measurement Computing software – InstaCal, newer version work fine (see image below)

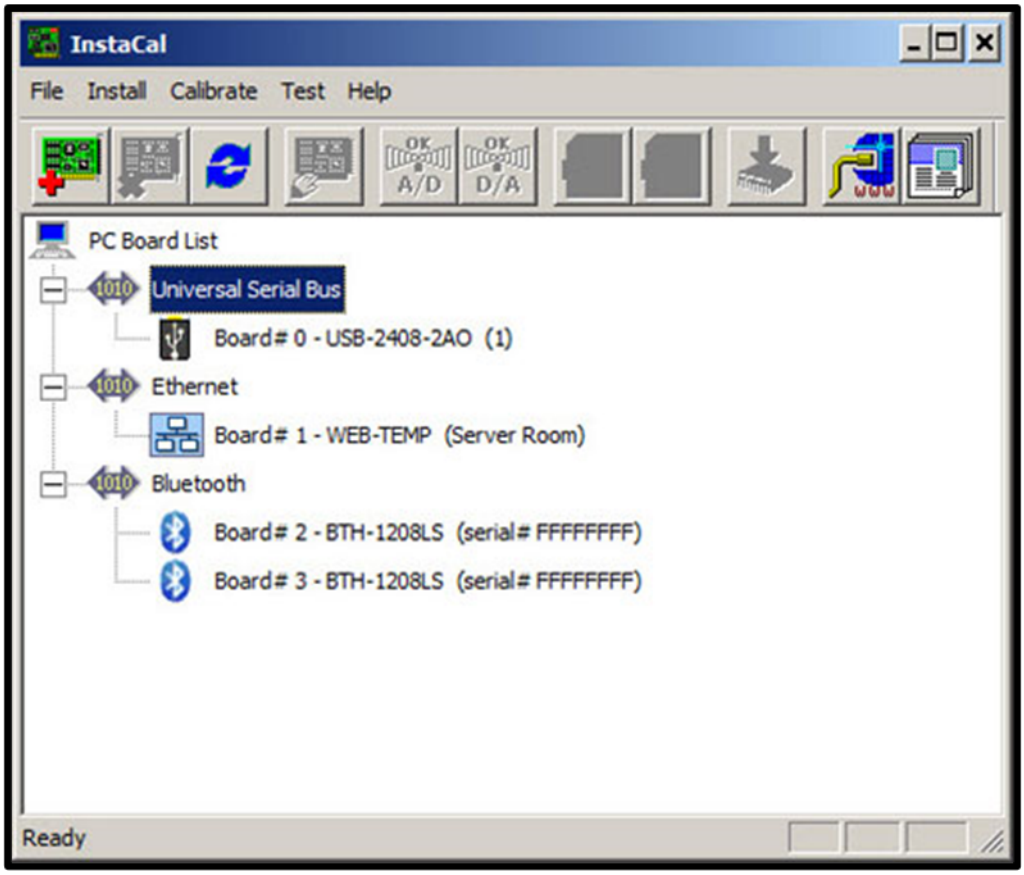

Figure 42. InstaCal is an installation, configuration, and test utility to use with SSR Rack48 from measurement computing. InstaCal can detect the measurement computing hardware, which controls the olfactometer and automatically tests it both internally and externally. When you open the program, make sure it recognizes the correct board under the "Universal Serial Bus." For more information, refer to the "InstaCal – Olfactometer" resource.

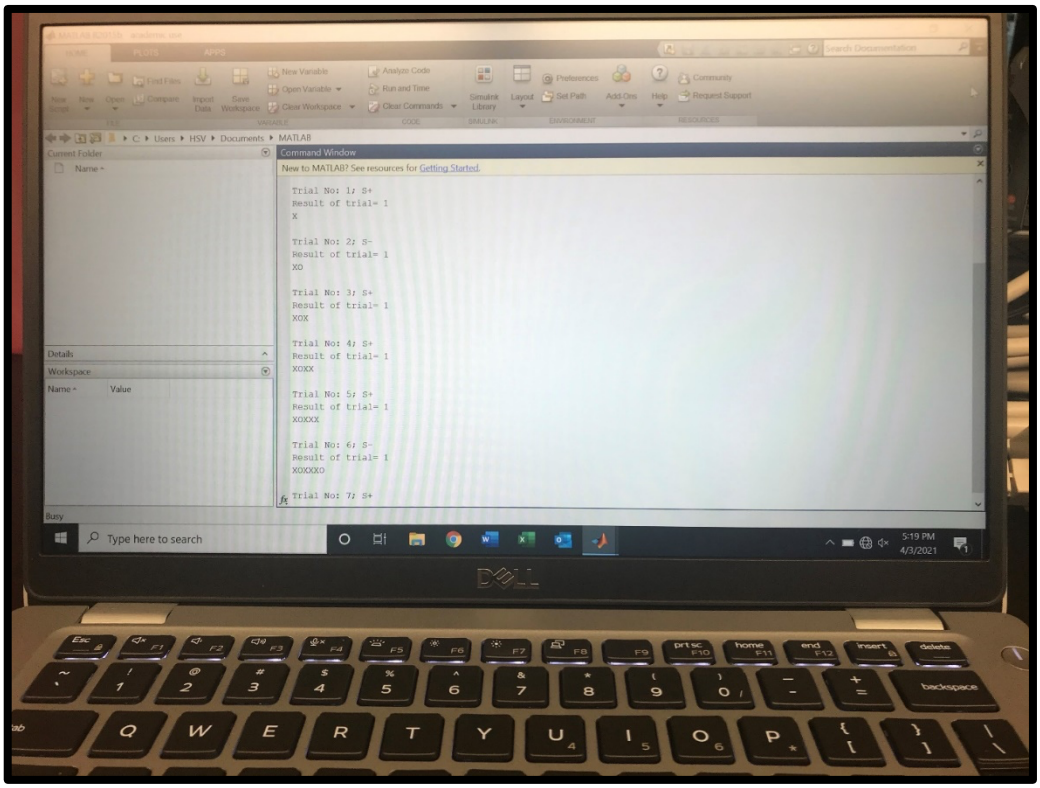

Figure 43. An image of the Matlab program.

- Note:
  Register the daq in matlab so drivers in 2015b are able to control the DAQ controlled the relays with line :

  daqregister('mcc')

  - Please use the following Matlab programs for “Mini.”
    - dropcbegin
    - dropcspm
  - Please use the following C++ programs for the “Mini.”
    - Begin
    - S+S-

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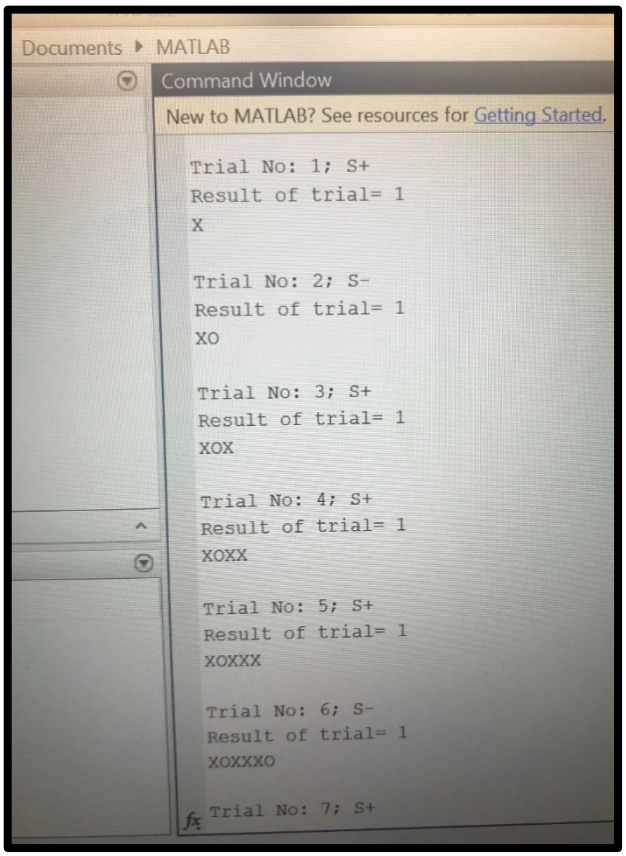

Figure 44. An image of the results output in Matlab.

Matlab program

Each trial results in either an “X” or an “O.” The “X” stands for a correct response and the “O” is an incorrect response.

Trial 1 S+

Result is 1. This means the 1 is a correct response. If the result were a 0, that would be incorrect.

Trial 2 S-

Result is a 1. This means a 1 is incorrect for S-. If the result were a 0, that would have been correct.

Trial 3 S+

Same as S+ above

Trial 4 S+

Same as S+ above

Trial 5 S+

Same as S+ above

Trial 6 S-

Result is a 1. This means a 1 is incorrect for S-. If the result were a 0, that would have been correct.

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Written Wiring Outline for SSR Rack 48/Mini Machine

Control Box

- The control box was machined in the dimensions of the switches. A large hole was needed to be machined in the back for the wires to exit.
- Each switch should be wired with two wires: Red (goes to 24V on the dual terminal/barrier strip) and Green (goes to the SSR Rack 48 screw terminal "pin").
    - Diverter Valve green wire goes to pin 18
    - Water Valve green wire goes to pin 17
    - Odor Valve #1 green wire goes to pin 1
    - Odor Valve #2 green wire goes to pin 2
    - Odor Valve #4 green wire goes to pin 3
    - Odor Valve #8 green wire goes to pin 4
    - Odor Valve #16 green wire goes to pin 5
    - Odor Valve #32 green wire goes to pin 6
    - Odor Valve #64 green wire goes to pin 7
    - Odor Valve #128 green wire goes to pin 8

Common "C" between screw terminal "pins"

- There are screw terminal connections labeled as "C" between pin 1-8.
- The 'C" in these areas all need to have a red wire that goes to 24V on the dual terminal strip.

Odor Valve Connections

- Each odor needs two solenoid odor valves because we have a two-directional air flow system (2 flowmeters: 2L/min and 50 mL/min).
- You can find a picture of the odor valve setup earlier in this document.
    - Each odor valve has two blue wires.
    - Take one wire from each pair and connect them to ground on the dual terminal strip.
    - Take the other wire from the pair and connect to whatever corresponding pin on the SSR Rack they represent (Odor valve 1,2,4,8,16,32,64,128 etc.)

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Diverter Valve

- You can find images of the diverter valve and connections earlier in this document.
- The diverter valve has two wires.
    - One wire connects to ground on the dual terminal strip.
    - The other wire connects to pin 18 on the SSR Rack 48.
- Purge valve (extra diverter valve)
    - If you want to connect another diverter valve for a “Purge” system, you will need to do the following:
        - Add another push button switch on the control box with the same wiring configuration, but the pin will be 19 or 20.
        - Add an additional 2L/min flowmeter.

Water Valve

- You can find images of the water valve and connections earlier in this document.
- The water valve has two wires.
    - One wire connects to ground on the dual terminal strip.
    - The other wire connects to pin 17 on the SSR Rack 48.
- Extra water valve
    - If you want to connect an additional water system, you will need to do the following:
        - Add another push button switch on the control box with the same wiring configuration, but the pin will be 19 or 20.
        - Add an extra syringe barrel, water tubing etc.

Common “C” connections between Diverter and Water

- Common “C” connections between Diverter and Water and any extras will be a red wire that goes to 24V on the dual position terminal strip.

Power Supply and Extension Cord (figures 45/46)

- The power supply P/N and images can be found earlier in the document.

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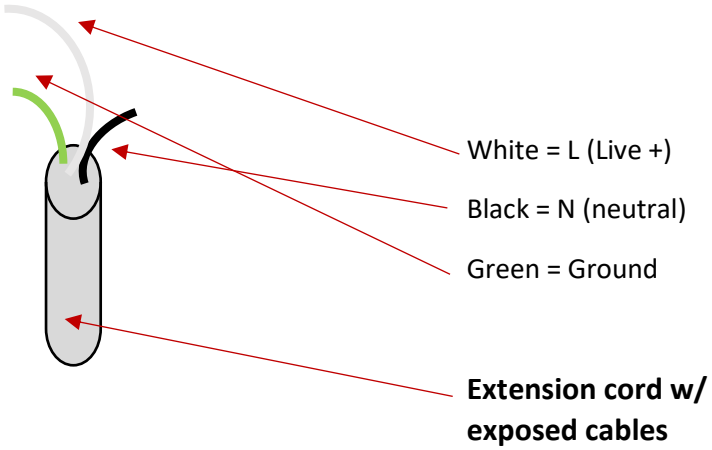
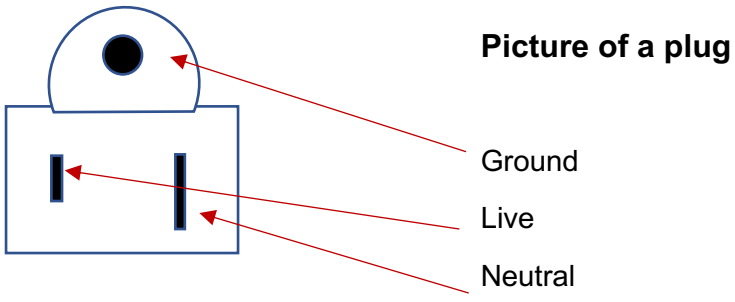
- We buy generic extension cords, cut off the part that has the outlets (keep plug) and expose the wires that will connect to the main power supply.
- We usually solder any frayed ends of these wires.
- Below is a diagram of the extension cord wire.
    - White = L (Live +)
    - Black = N (neutral)
    - Green = Ground
        - In 12+ years, the extension cords we have bought (usually from Staples) have always followed the above pattern.
        - But it is always a good idea to check with a multimeter.





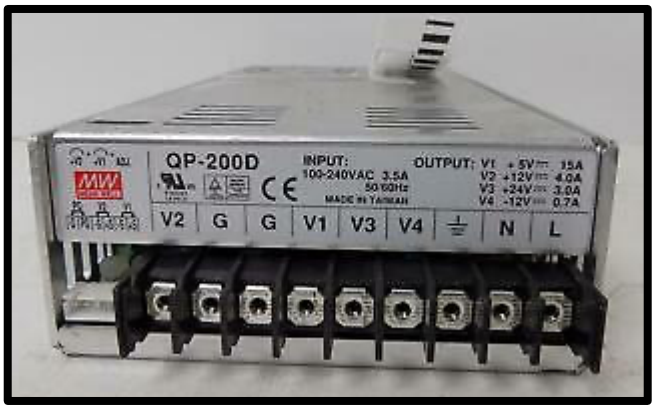


Figure 47. The white wire from the extension cord goes to “L.”

The green wire from the extension cord goes to the universal sign for ground (see below).

The black wire from the extension cord goes to “N.”

- V1 (5V) use a red wire to connect this to 5V on the dual terminal strip.
- V2 (12V) is the connection for one of the LEDs.
- V3 (24V) use a red wire to connect to 24V on the dual terminal strip.
- Ground, use a green wire to connect to the ground on the dual terminal strip.
- Also, the PC Power cable (earlier in document) that connects to the SSR Rack48 should also connect here on the power supply at 5V and Ground. This powers the SSR Rack 48.

Phototransistors/LEDs

- We have included some hand drawn diagrams of the Detector (usually clear is using RadioShack parts) and the Emitter, which are the Infrared LED system we use to detect “licks” when the animal begins a trial. You can purchase these parts on many places online and they may differ in clear vs blue tinted.
- Always test the polarity as companies often reverse them.
- To test the polarity of the phototransistors, do the following:
    - Clear (Detector)
        - Use a multimeter
        - Connect the clips to the ends of the detector
        - Use the K ohm setting
        - You should see some resistance
        - If you do not see resistance, the polarity is reversed and it is not the detector, but the emitter
        - If you do see resistance, shine light on the LED and the resistance should drop low (the LED is the detector)
    - Tinted blue (Emitter)
        - Use a multimeter

- The “+” end of the multimeter should connect to the anode (long end) and the “-“ end of the multimeter should connect to the cathode (short end)
- The multimeter should read zero ohm if the part is the emitter
- If the multimeter detects some resistance, then it is not the emitter, but the detector

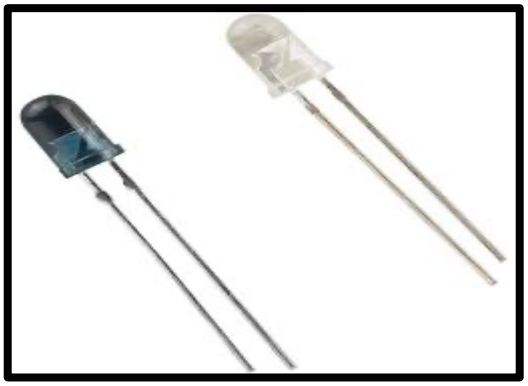


Figure 48.
RadioShack P/N
2760142

Infrared LED Emitter
and Detector pack

- The detector:
  - The cathode (short leg) of the detector should be a red wire that goes to 5V on the dual terminal strip.
  - The anode (long leg) of the detector should be a black wire and should connect to pin 33 on the SSR Rack 48.
- The emitter:
  - The cathode (short leg) of the emitter should have a black wire that connects to ground (either on the power supply or the ground on the dual terminal strip).
  - The anode (long leg) should first connect to a 1K ohm resistor, and the other end of the resistor should connect to 12V on the power supply (V2). Use a red wire because it connects to power.

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Common “C” connections between “Input” relays

- Common “C” connections between input relays (LEDs, Lick sensor board) need to go to ground.
- Wire a green wire from these “C” (C near pin27, which is the lick sensor and the C between pin 33 and 34, which is the LED). The wire can connect to the dual terminal strip.

Lick Sensor Board

- Separately a hard schematic should be located on the Github page for this olfactometer.
- The lick sensor has a built-in red LED, a ground wire (black, “-“), a red wire that goes to 5V on the dual terminal strip (“+”), a potentiometer, a red wire that goes to pin27 on the SSR Rack48 and a black wire attached to an alligator clip that connects to the lick tube.

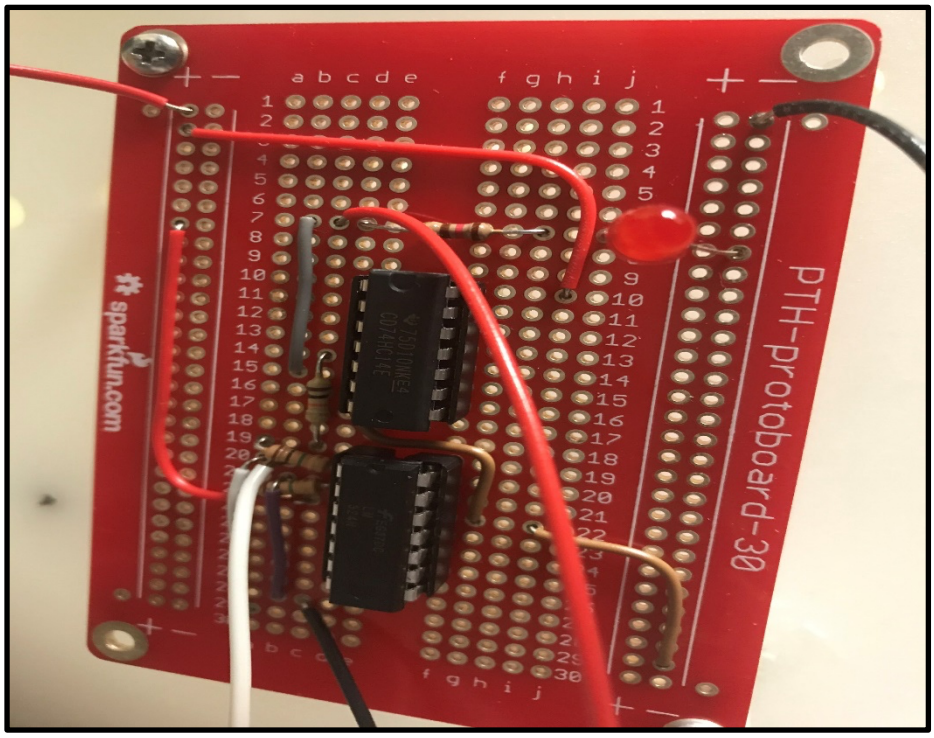

Figure 49. Example of the Lickboard wired up.