# Commodore Open-source Ventilator (COV) version 3.1

*Control Electronics Box Fabrication and Assembly Guide*

# Disclaimer

- This device has not been tested on a live human and does not currently have FDA approval.

- This device is currently only intended for patients who are sedated, intubated, and chemically paralyzed, and should only be operated under the care of an experienced physician.

- No material on this site is intended to provide medical advice. All designs are intended for investigational use only.

- This site does not represent any official policies or procedures of Vanderbilt University.

- The material on this site is provided with no warranties explicit or implied.
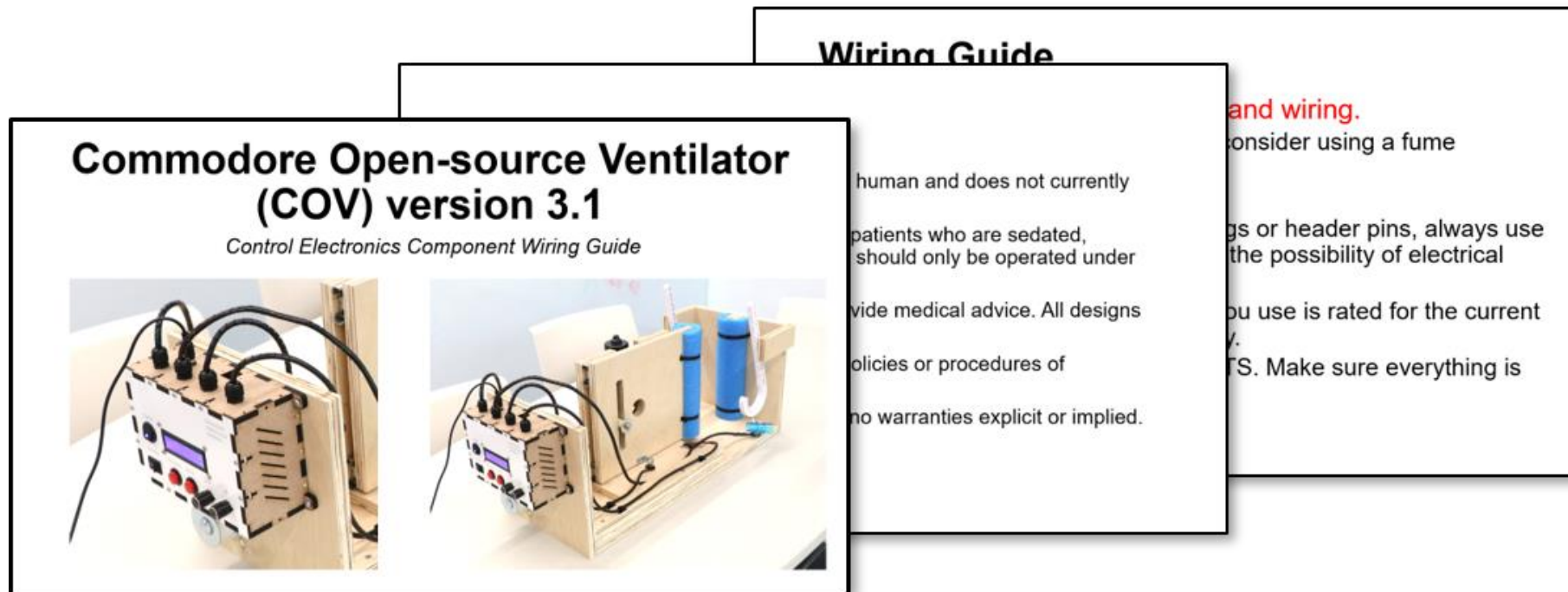
# Wiring Guide

- <span style="color:red">Use best practices for soldering and wiring.</span>
  - Ensure adequate ventilation and consider using a fume extractor
  - Use lead-free solder if available
  - When soldering onto terminals, lugs or header pins, always use insulating heat-shrink to minimize the possibility of electrical shorts.
  - Ensure that whatever wire gage you use is rated for the current capacity that it is expected to carry.
  - NEVER WORK ON LIVE CIRCUITS. Make sure everything is unplugged before working.

# Table of Contents

# Before you begin…

- If you have not yet gone through the component wiring guide, please do that first. Click the following picture to go to the vandyvents.com download page to download the component wiring instructions.



**Commodore Open-source Ventilator (COV) version 3.1**

*Control Electronics Component Wiring Guide*

**Wiring Guide**

...and wiring.

...human and does not currently

...consider using a fume

...patients who are sedated,
...should only be operated under

...gs or header pins, always use
...the possibility of electrical

...vide medical advice. All designs

...ou use is rated for the current
...y.

...olicies or procedures of

...TS. Make sure everything is

...no warranties explicit or implied.

# 1. Fabricate Enclosure Panels

- Using the .dxf files [here](#) and a CNC router or CO2 laser, fabricate the panel pieces using 1/8" MDF for the front piece (dark brown), and ¼"MDF for the side and back pieces (light brown).
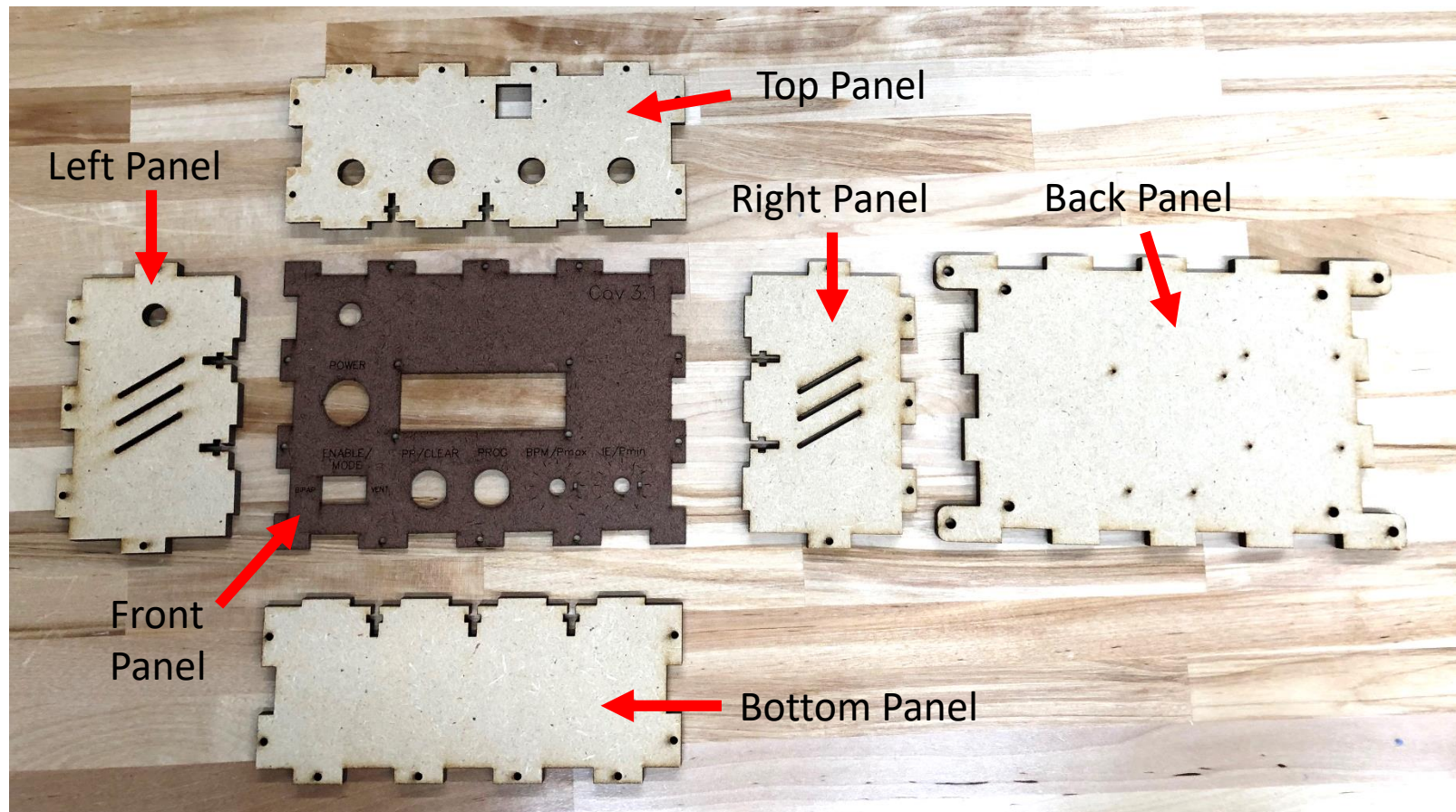
# 2. Mount Arduino and Motor Driver

- Collect the following components:
  1. Back panel
  2. Arduino Uno
  3. Motor Driver
  4. (4x) No.2, ¼" long brass wood screw (McMaster: 98685A220)
  5. (4x) No. 4, 1-1/4" long slotted flat head screw (McMaster: 90006A117)
  6. (4x) Nylon unthreaded spacer, 3/16" OD, 0.115" ID, 1" long (McMaster: 90176A125)
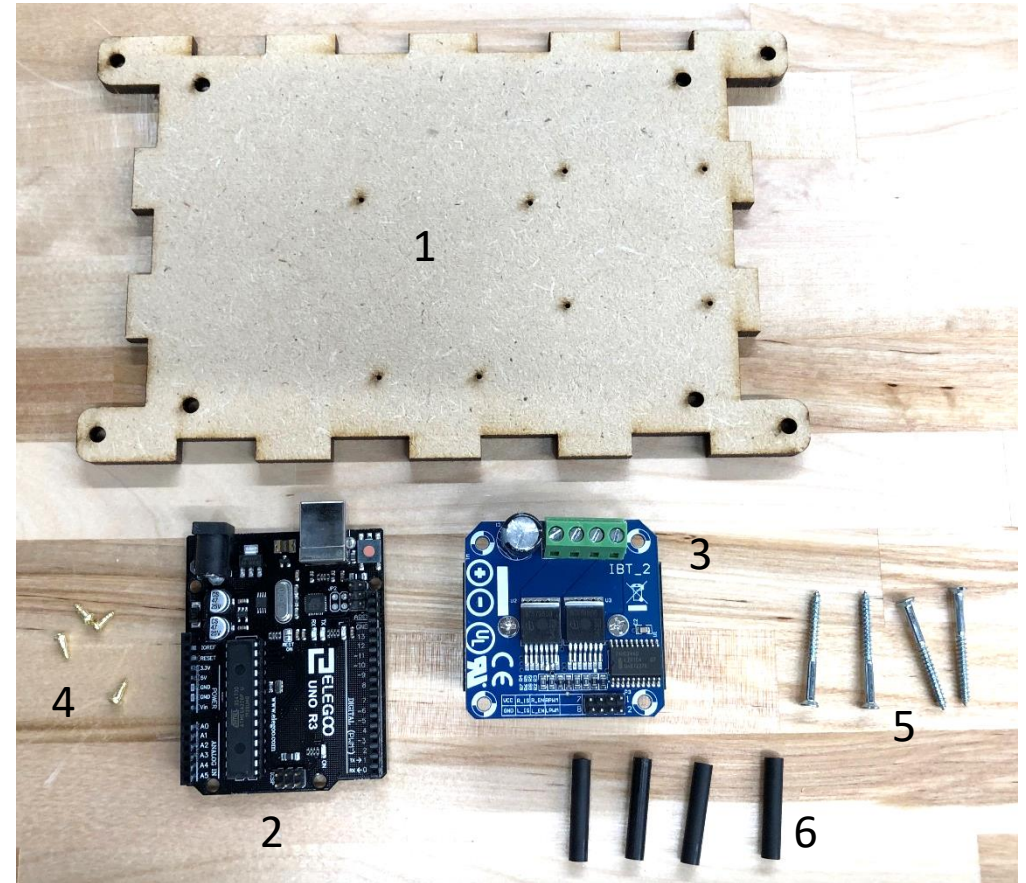
# 2.1 Mount Arduino and Motor Driver

- Align the Arduino (2) through holes with the pilot holes in the center of the back panel (1), and fasten using the No. 2 wood screw (4).
  - Lightly tighten all screws first so you can still wiggle the Arduino to help align, and then tighten them all down.



- Mount the motor driver (3) into the square pilot hole pattern to the right of the Arduino, using the 1-1/4" long flat head screw (5) and Nylon spacer (6) to offset the driver from the base as shown in the inset. Make sure the green screw terminal faces away from you.
  - As before, only lightly tighten all the screws until you have all 4 aligned.
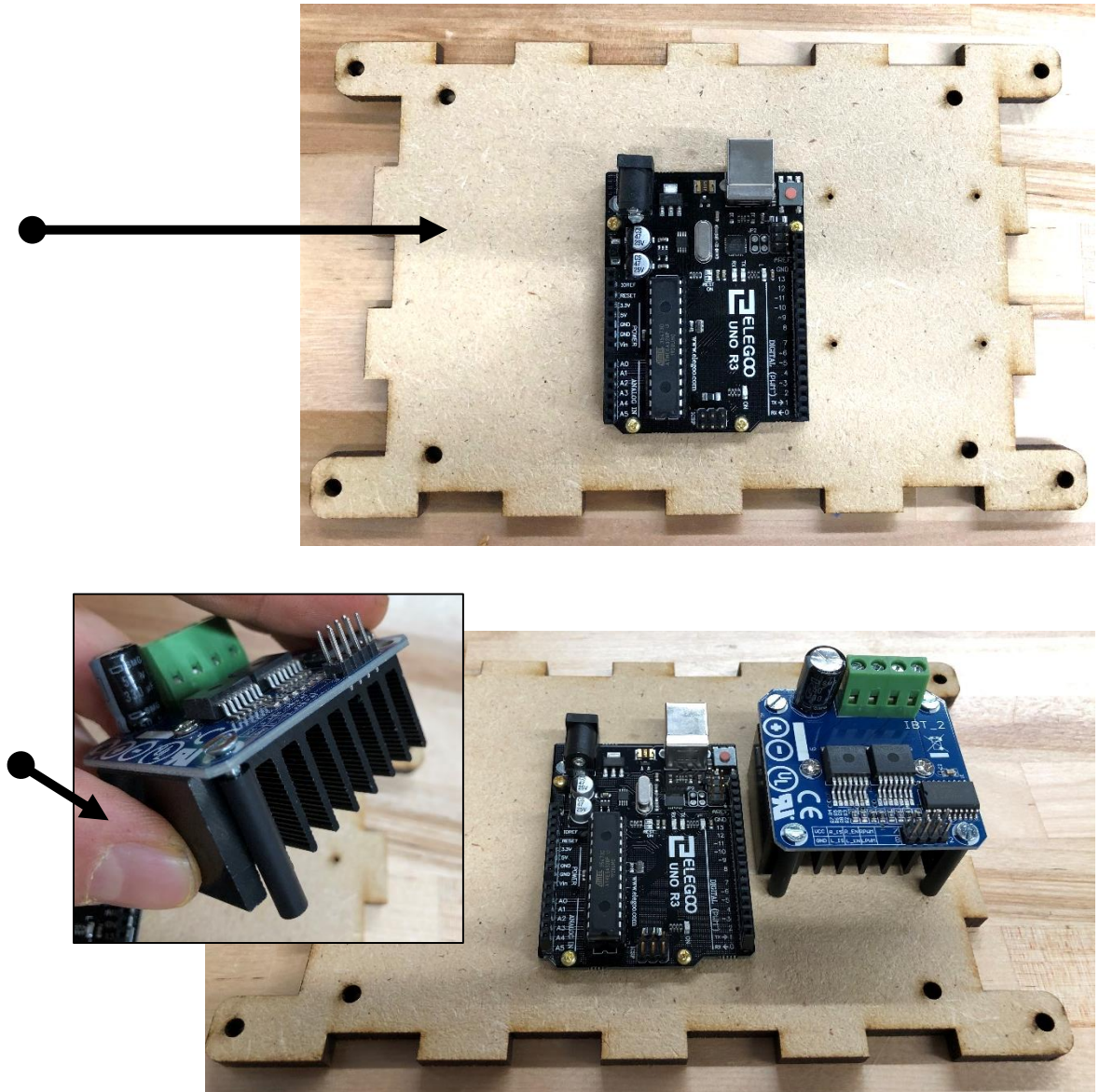
# 3. Mount Components to Front Panel

- Collect the following components:
    1. Front Panel
    2. LCD screen
    3. (4x) 4-40, ½" long machine screws (McMaster: 90272A110)
    4. (4x) 4-40 square nut (McMaster: 94855A281)
    5. Power Switch Assembly
    6. Rocker Switch
    7. (2x) Potentiometers
    8. Alarm LED
    9. (2x) Pushbuttons
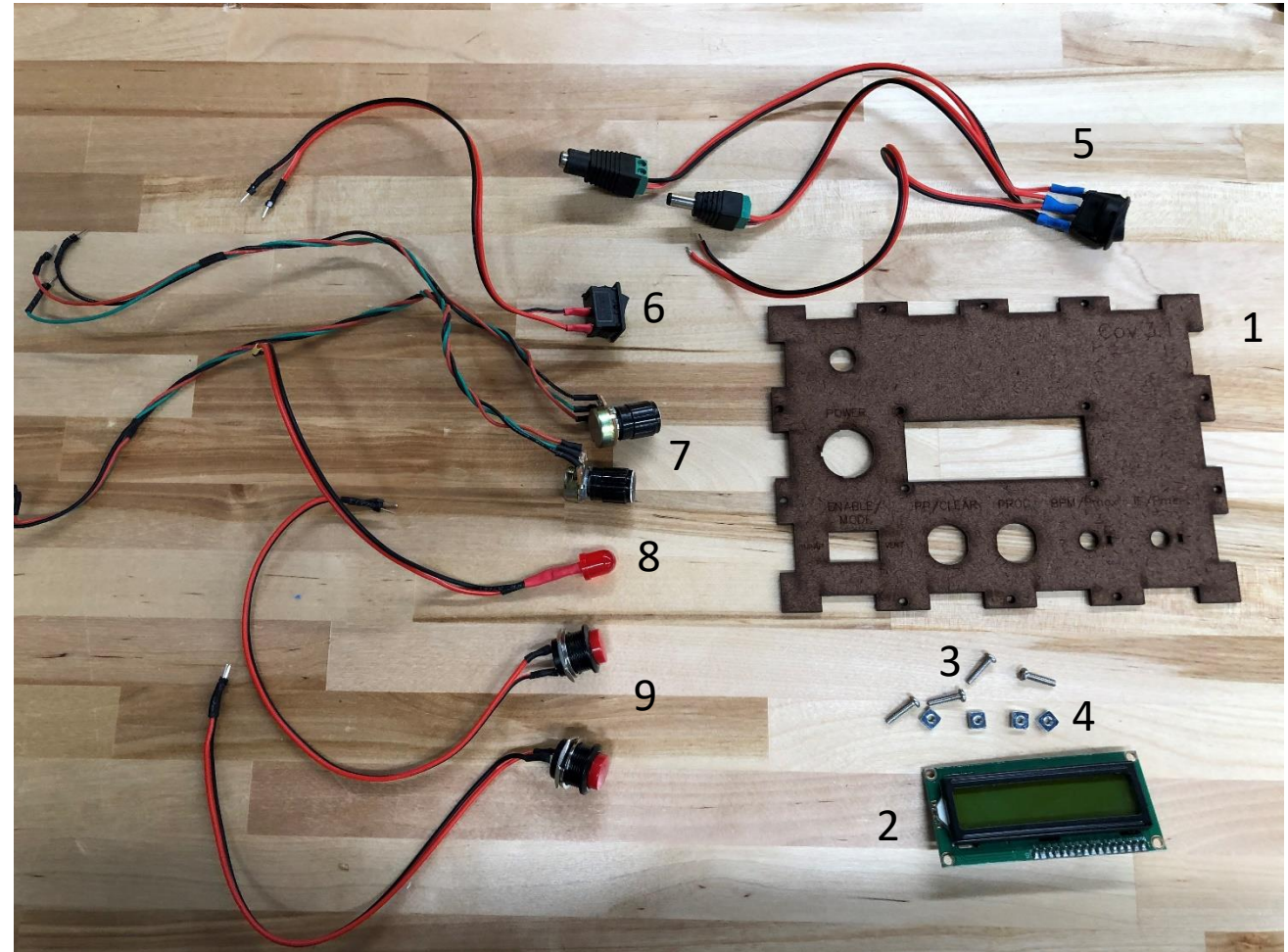
# 3.1 Mount LCD Screen

- Turn the LCD (2) over and make sure there is a jumper connecting these two pins. If not, use a blob of solder to short them.

- Use the 4-40 machine screws (3) and the square nuts (4) to fasten the LCD to the front panel (1). If the holes are not lining up, just rotate the LCD 180 degrees so the I2C pins are facing the power switch cutout, as shown.
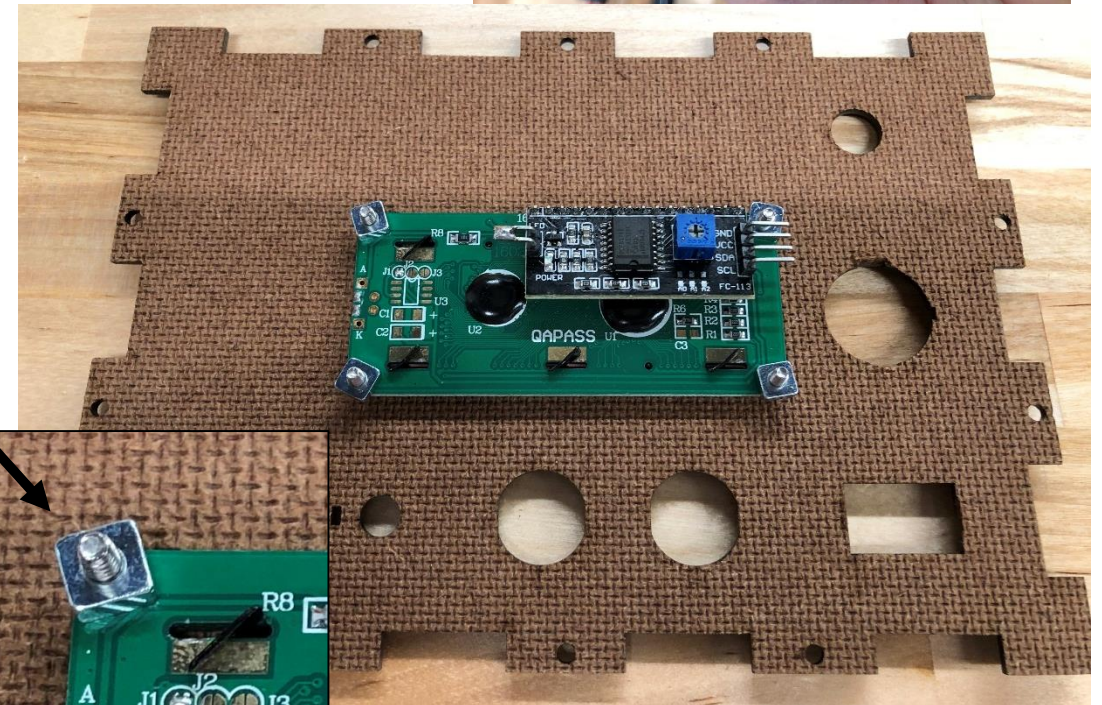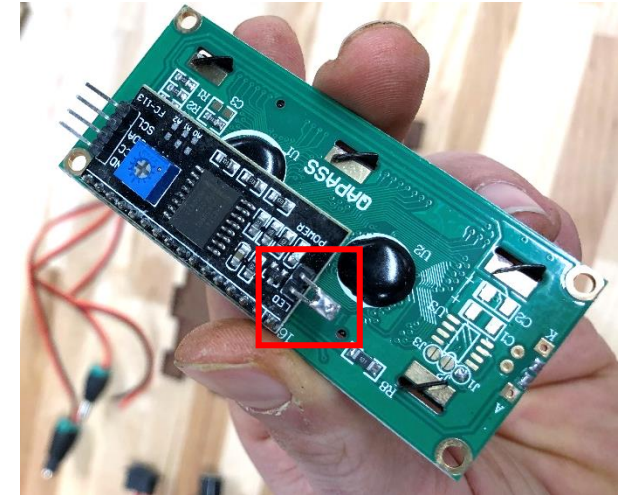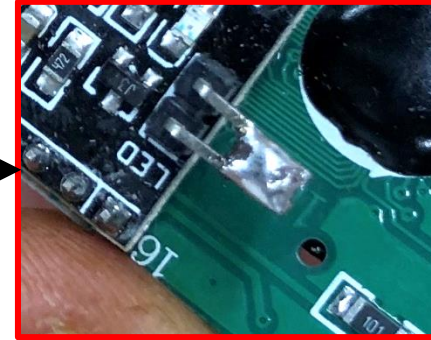
# 3.2 Mount Power Switch Assembly

- Turn the front panel (1) over and feed the two barrel adapters and the other wire of the power switch assembly (5) through the power switch hole. Line up the switch so that the tab (inset) lines up with the slot on the left side of the hole.

- Press the switch in firmly until it snaps into place. The LED should be on the bottom, as shown.
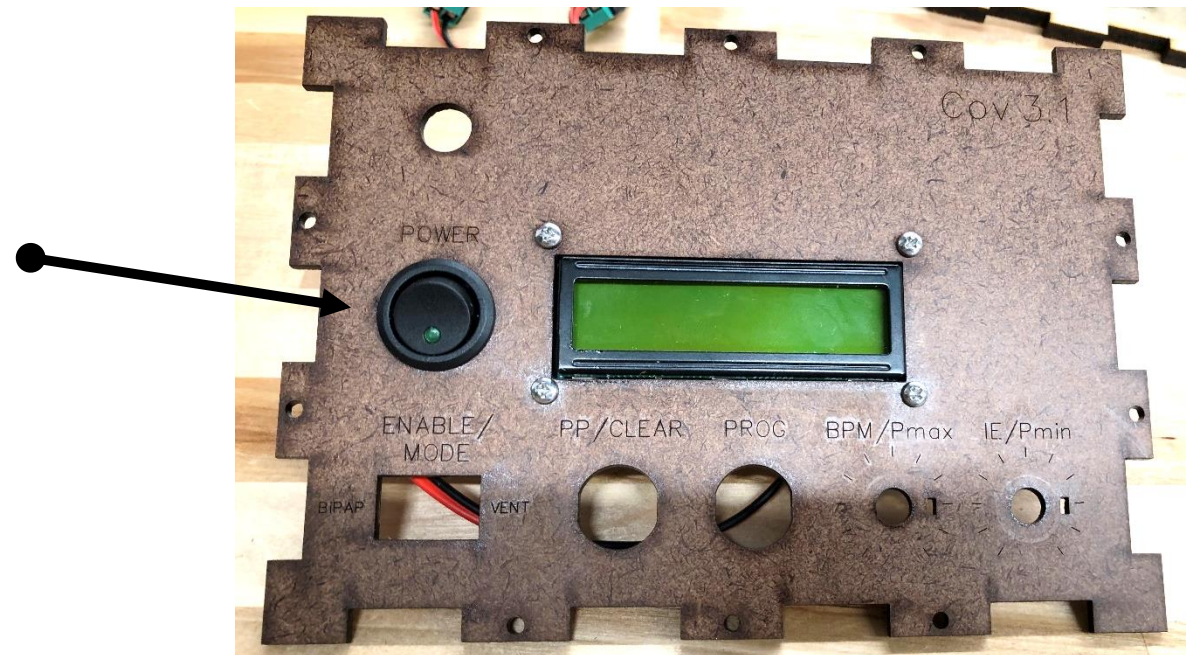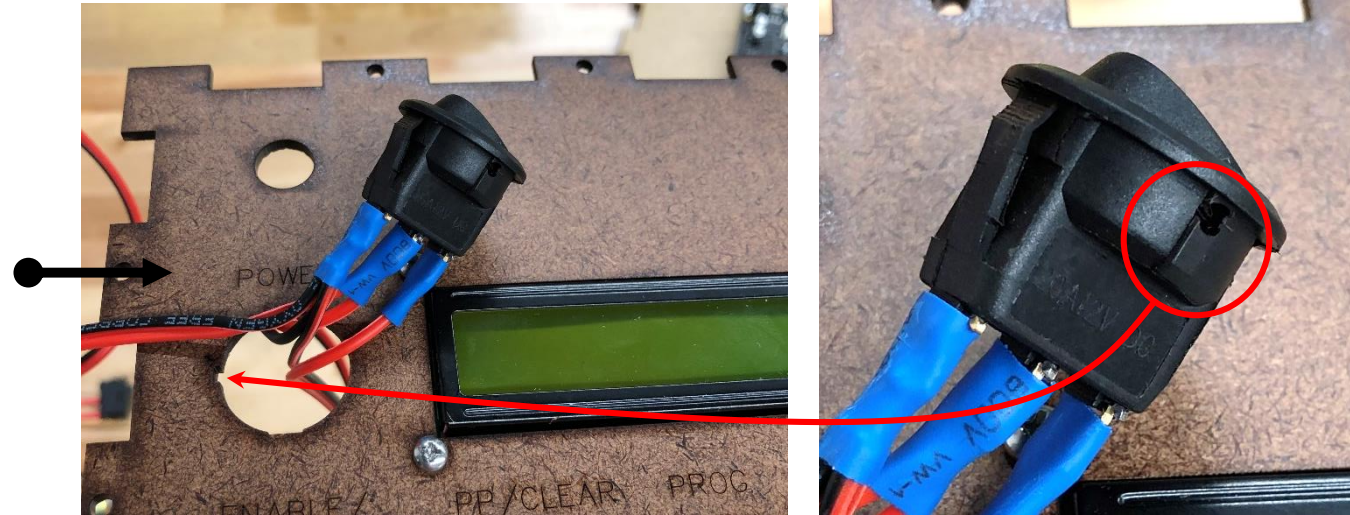
# 3.3 Mount the Rocker Switch

- Feed the wires from the rocker switch assembly (6) through the rocker switch cutout (ENABLE/MODE).

- Ensure that the circle faces towards the right, where the 'VENT' text is. Press in firmly until it snaps into place.
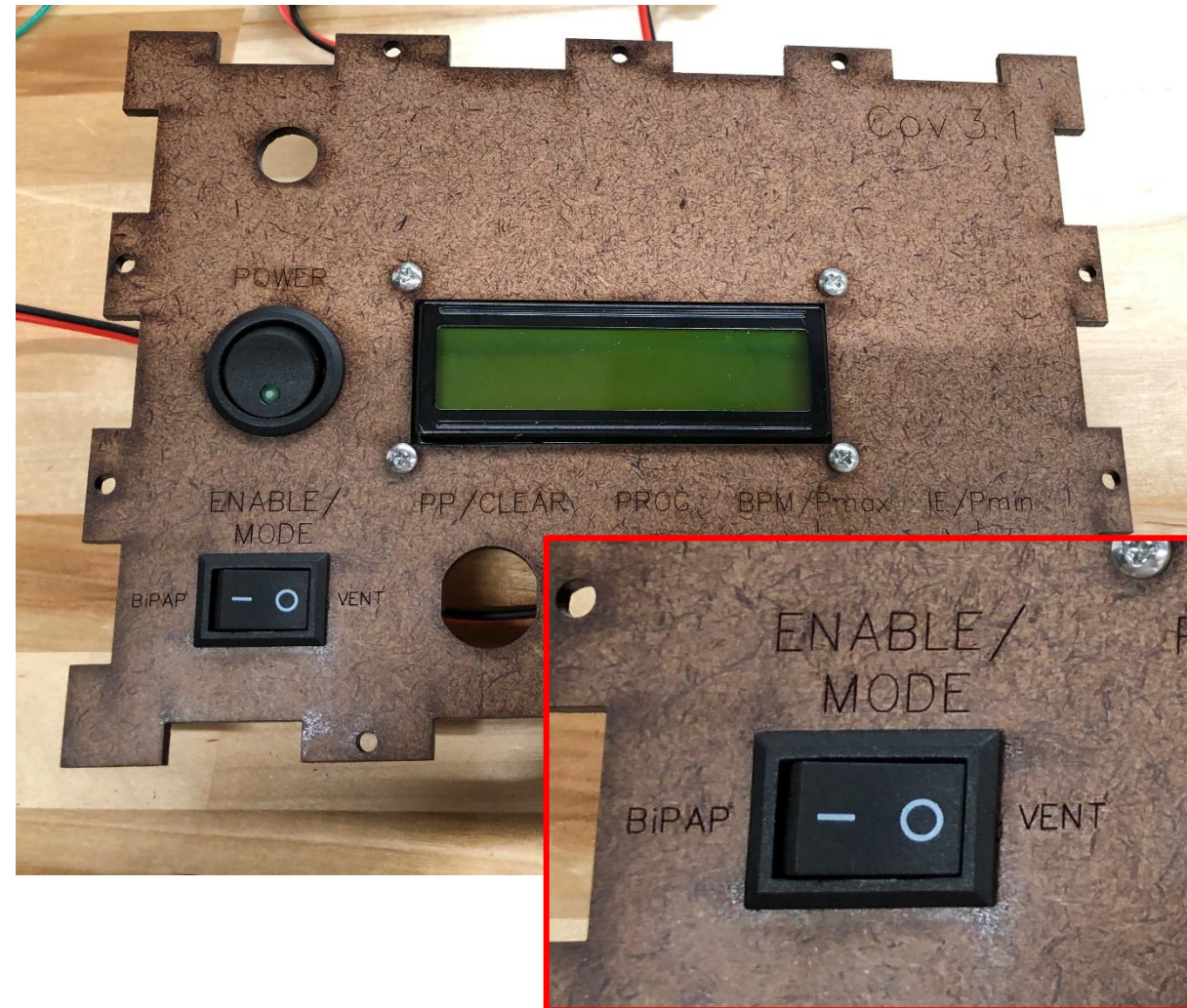
# 3.4 Mount the Pushbuttons



- Feed the wires from the two pushbuttons (9) into the pushbutton cutouts to the right of the rocker switch.

- Push the pushbuttons into place, ensuring that the flats on the threads align with the flats in the panel cutout.

- Flip the panel over, and fasten the pushbuttons with the split washer and the jamnut, as shown.
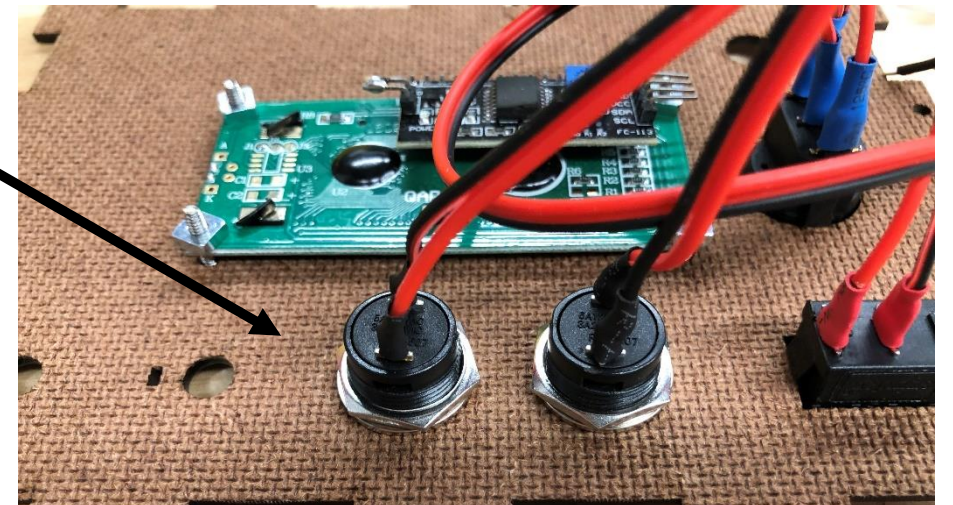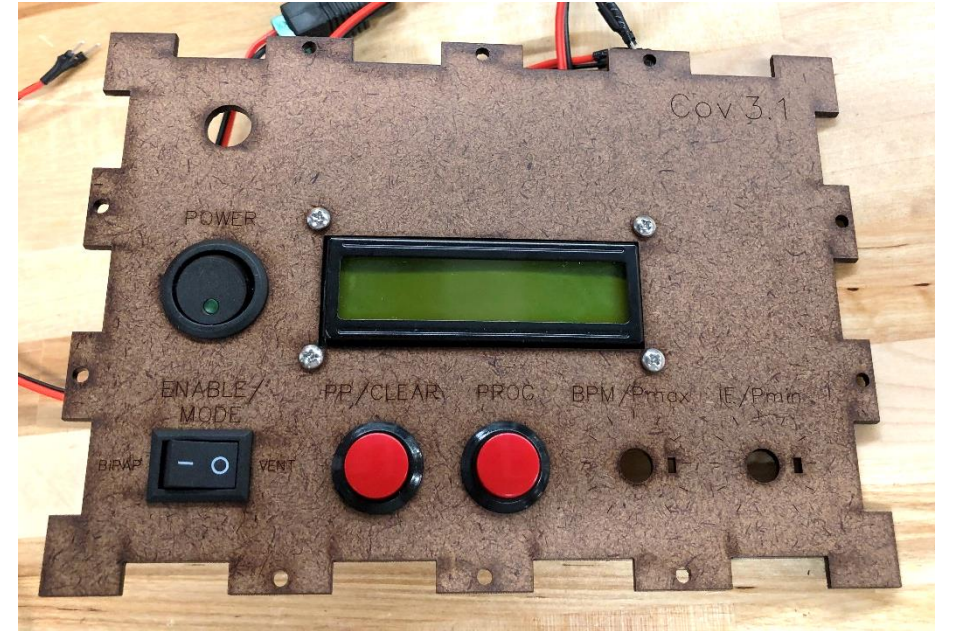
# 3.5 Mount the Potentiometers

- Fasten the two potentiometers (7) in place, aligning the small tab on the potentiometer with the small rectangular cutout in the panel.

- Fasten the potentiometers down with the washer and the jam nut.

- Press-fit the knob onto the potentiometer. Ensure that the line on the knob points 'upwards' when the pots are at the center of travel.

# 3.6 Mount the Alarm LED

- Press the LED (8) through the LED cutout just over the power switch from the back side of the front panel, until the flange of the LED is flush with the back surface of the panel.



- Use epoxy or hot glue to glue the LED into place. Make sure that the flange remains flush while the glue is setting.
  - Hopefully you do a better job than I did here!
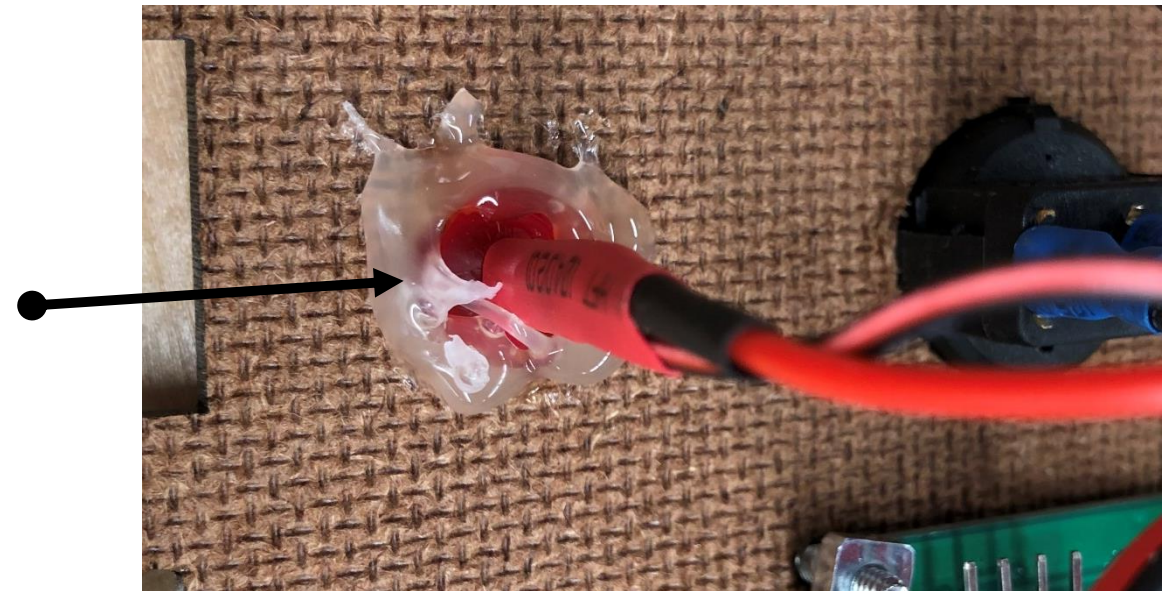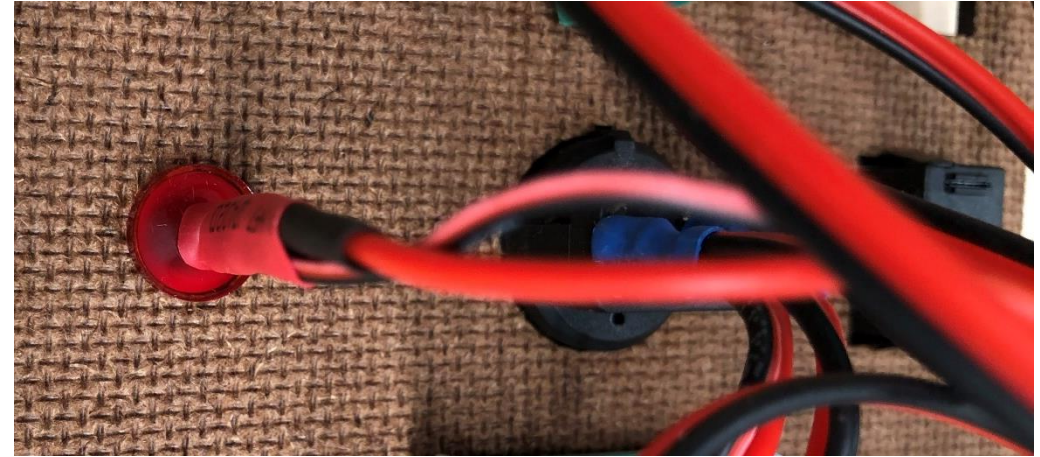
# 4. Front to Bottom Panel Connections

- Seat the CoV Shield into the Arduino Uno and press into place, ensuring that all male header pins align with their female counterparts.

- Position the populated front panel over the populated bottom panel, as shown here
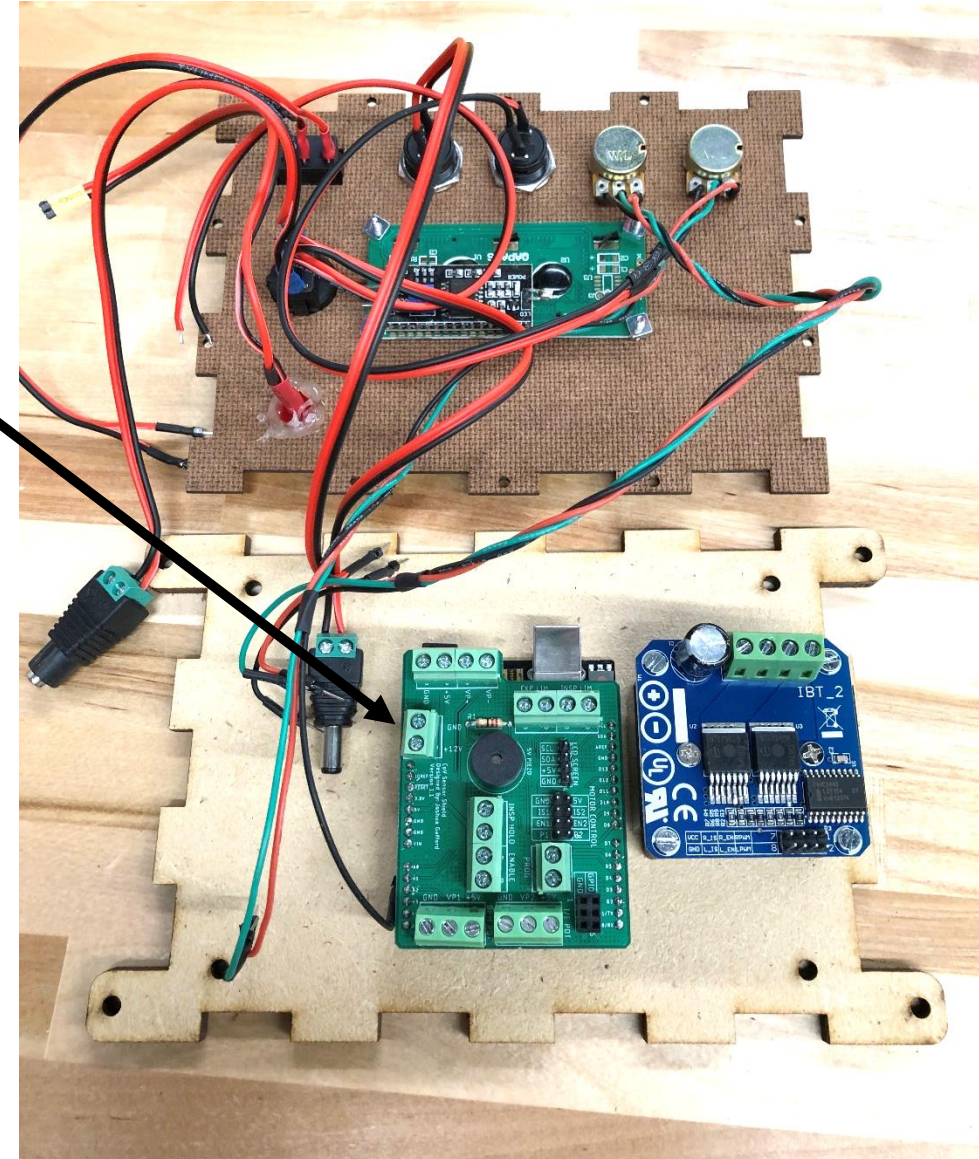
# 4.1 Connect Pots

- Connect the potentiometer pin headers to their respective screw terminals on the bottom side of the CoV shield, as shown here.

- The right-most potentiometer goes to the right (IE Pot) terminal, and the left potentiometer goes to the left (BPM Pot) terminal.

- The **red**/**yellow** pin goes to the 5V terminal, the **green**/white pin goes to the VP1/VP2 terminal, and the **black**/**blue** pin goes to the GND terminal.
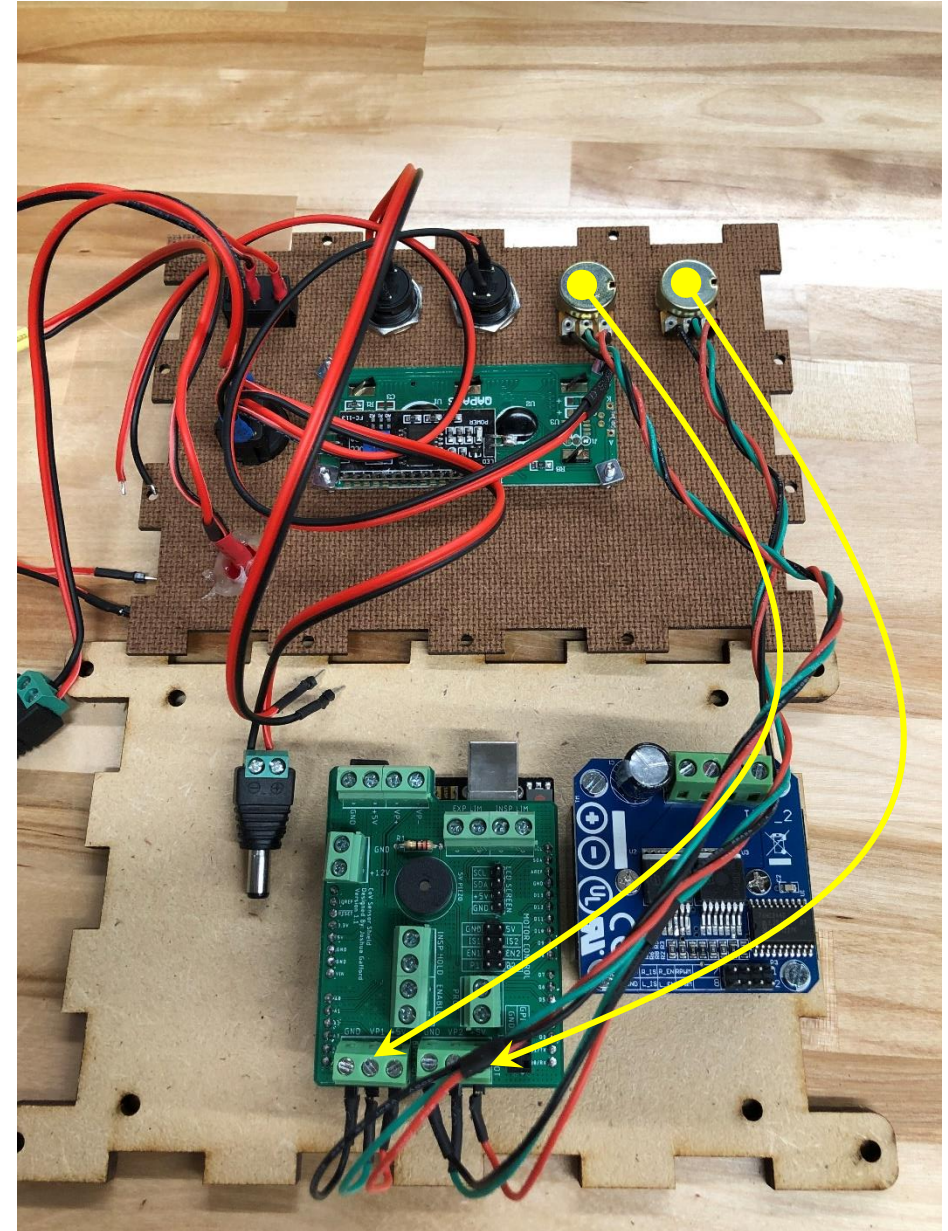
# 4.2 Connect PROG Button

- Connect the headers from the PROG pushbutton (the button nearest the potentiometers) to the PROG screw terminal on the CoV shield.

- The polarity does not matter.
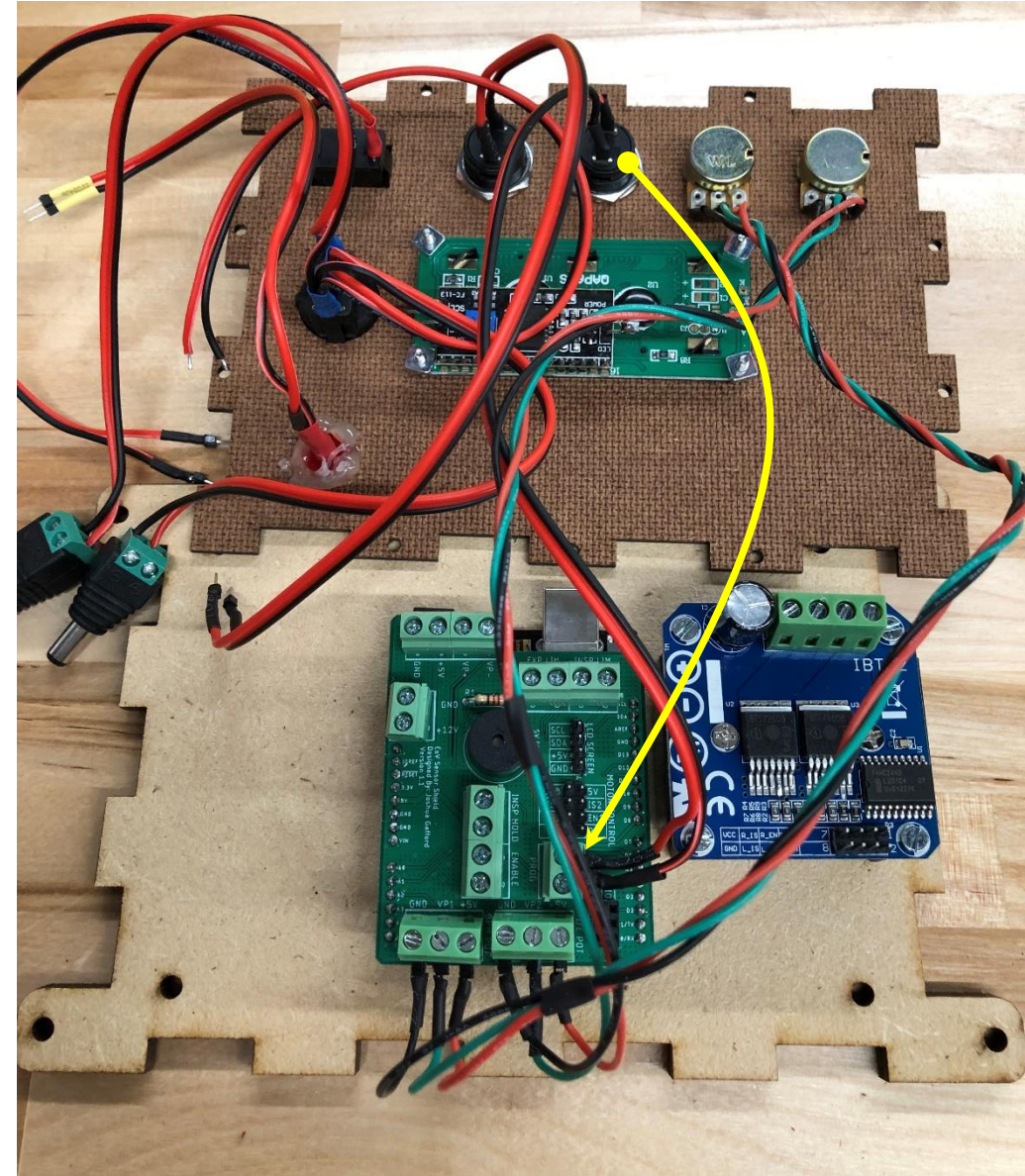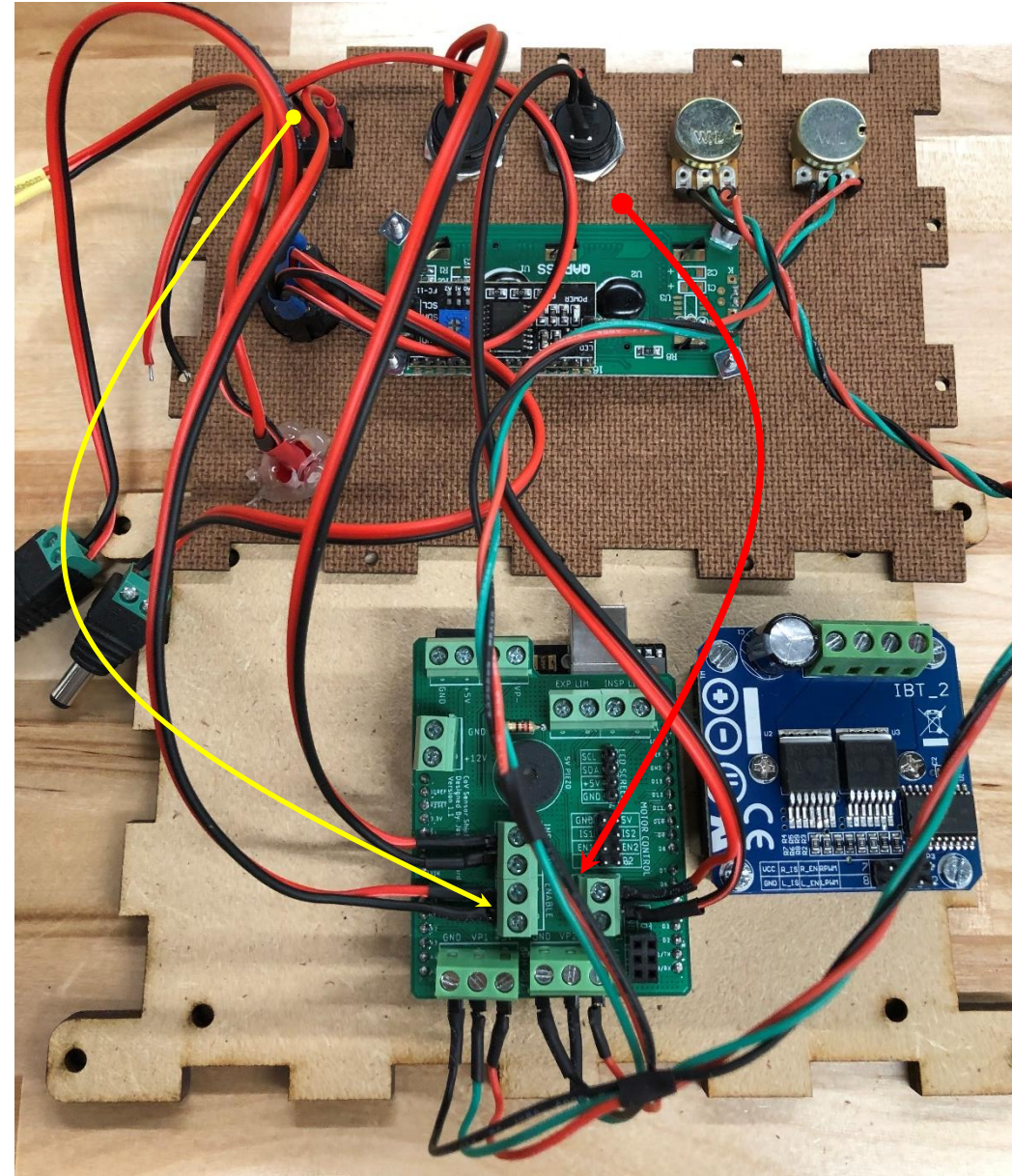
# 4.3 Connect PP/CLEAR Button

- Connect the headers from the PP/CLEAR pushbutton (the button next to the one you just connected) to the INSP HOLD screw terminal on the CoV shield.

- The polarity does not matter.
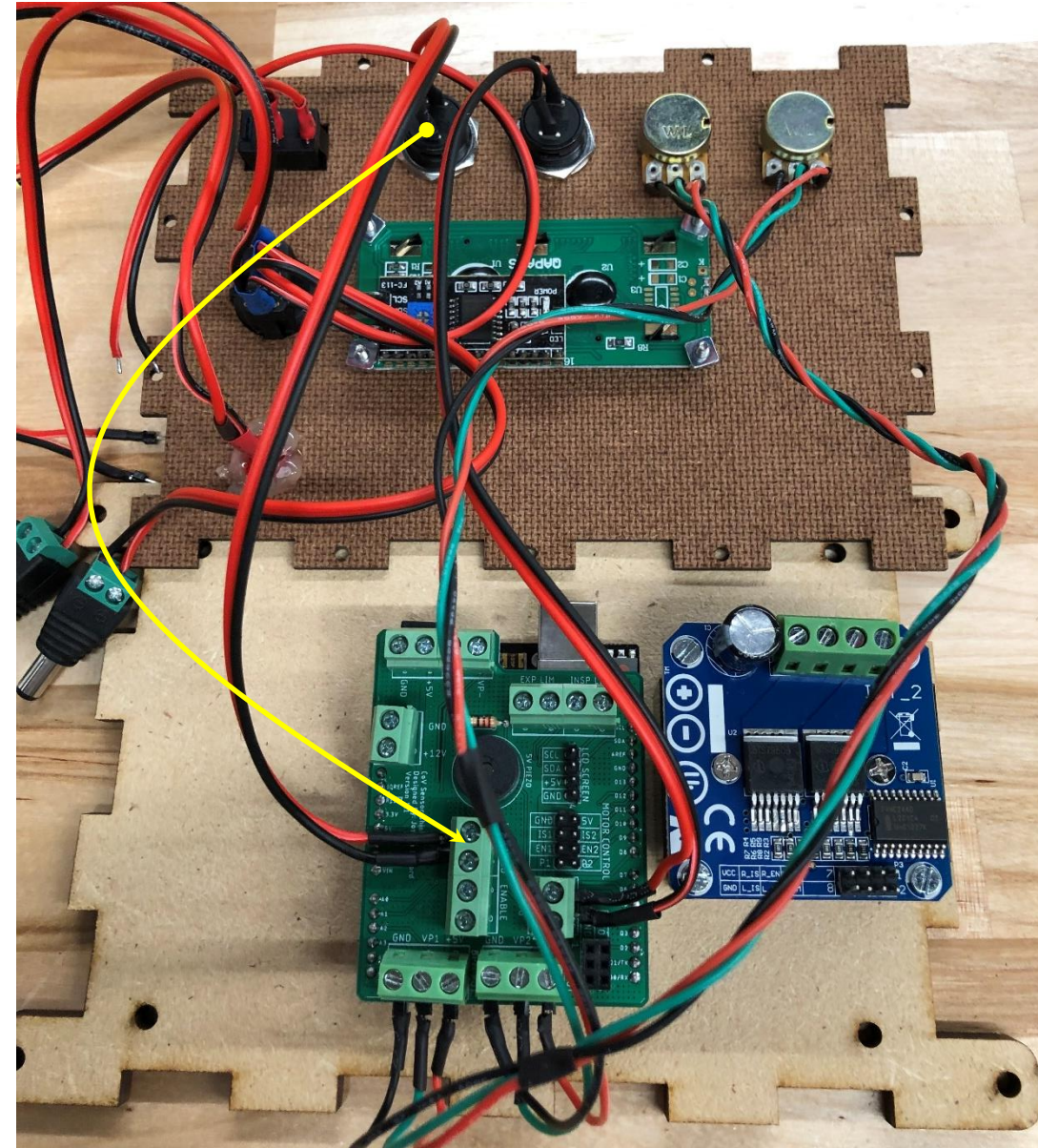
# 4.4 Connect ENABLE/MODE Switch

- Connect the headers from the ENABLE/MODE rocker switch to the ENABLE screw terminal on the CoV shield.

- The polarity does not matter.

# 4.5 Connect the Alarm LED

- Connect the headers from the Alarm LED and connect them to the first row of the GPIO header, as shown here.

- **Polarity Matters!** The **Red** wire should go on the right (on the GPIO column), and the **Black** should go on the left (on the GND column), as shown.
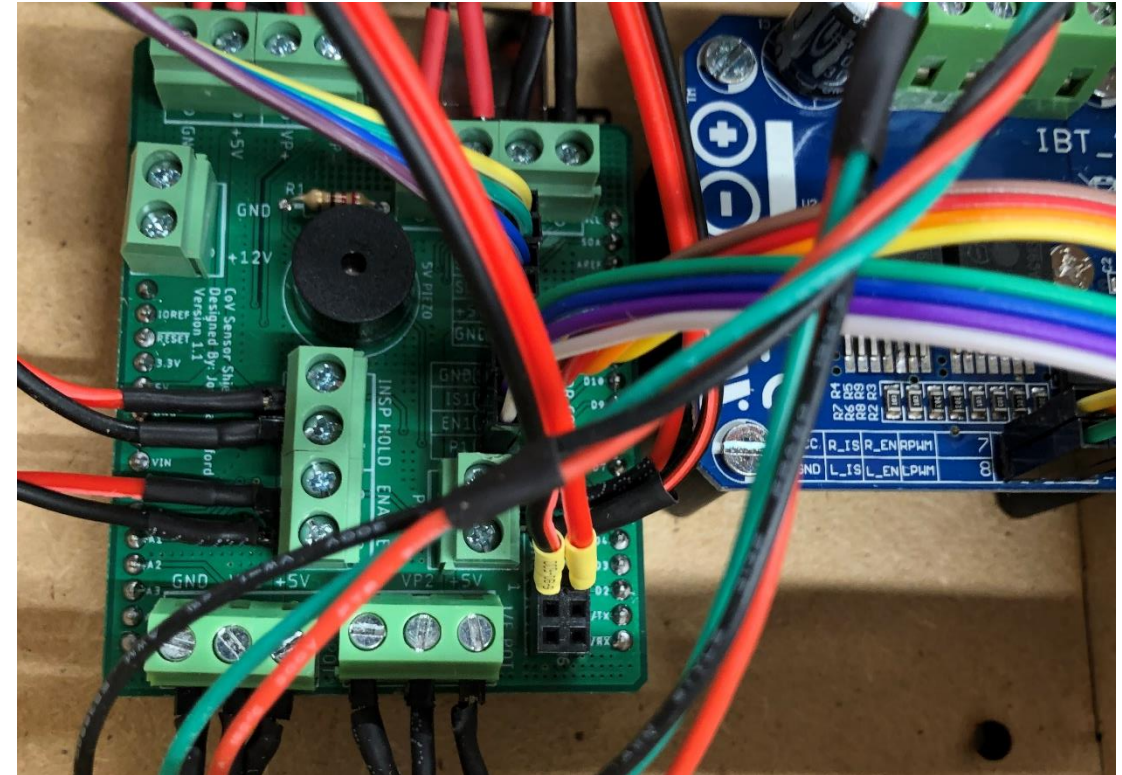
# 4.6 Connect the LCD and Driver

- Collect two 4-wire, 10cm, F-F ribbon cables, and one 4-wire, 20cm, F-F ribbon cable.



- Using the two 10cm cables, make the following connections from the CoV shield to the motor driver:
  - P1 -> LPWM
  - P2 -> RPWM
  - EN1 -> L_EN
  - EN2 -> R_EN
  - IS1 -> L_IS
  - IS2 -> R_IS
  - GND -> GND
  - 5V -> VCC

- Connect the third wire pair from the power switch assembly (the one without a barrel jack adapter on it) to the left two terminals on the driver, as shown here. **POLARITY MATTERS** - the red wire goes to the right position!
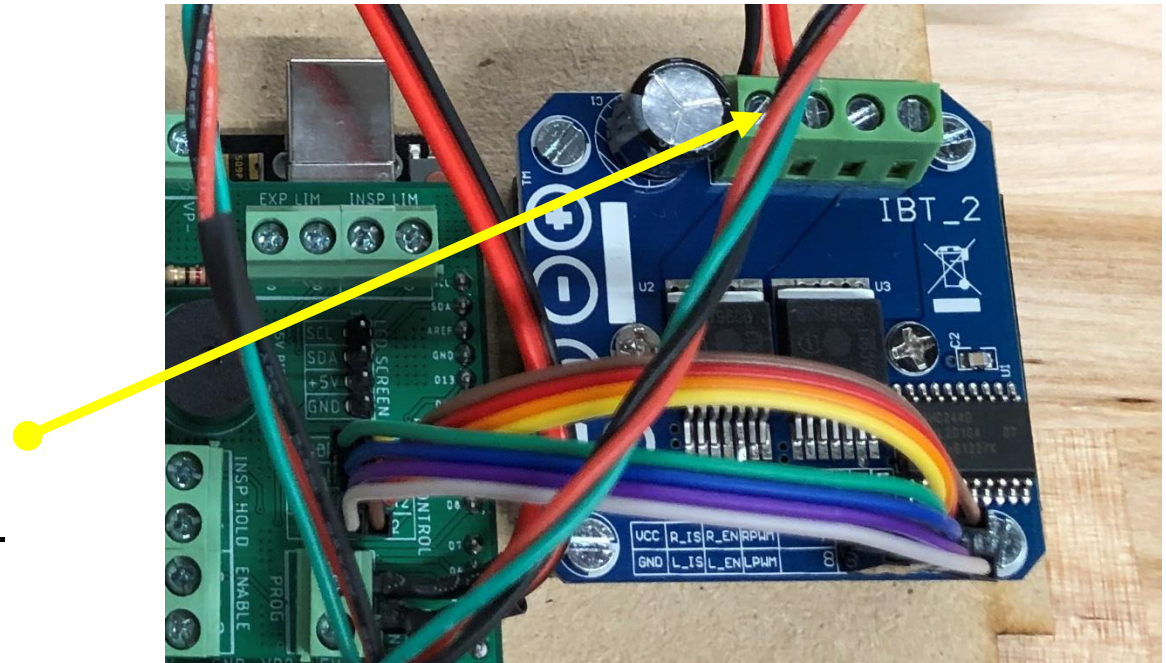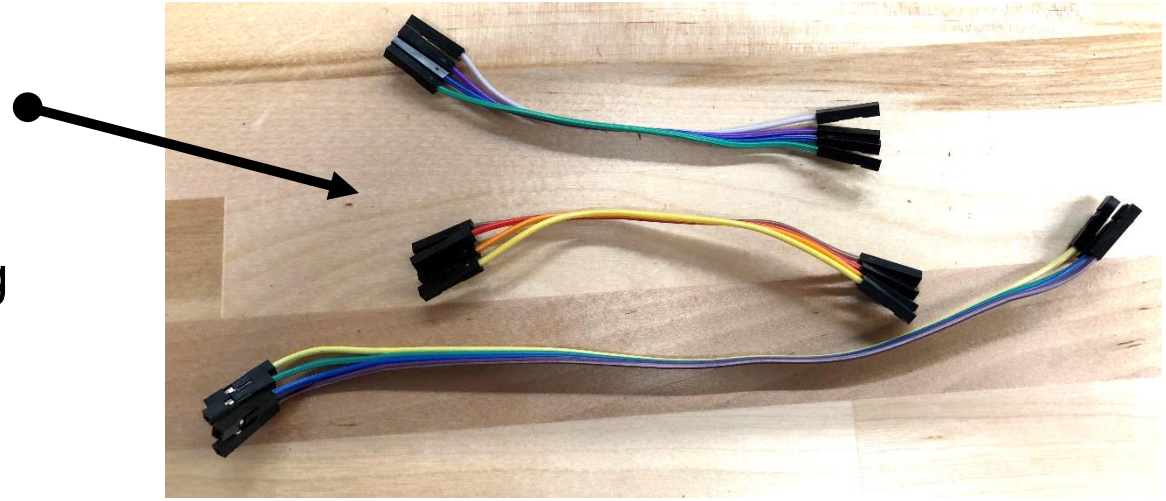
# 4.6 Connect the LCD and Driver

- Using the 20cm cables, make the following connections from the CoV shield to the motor driver:
  - SCL -> SCL
  - SDA -> SDA
  - +5V -> VCC
  - GND -> GND
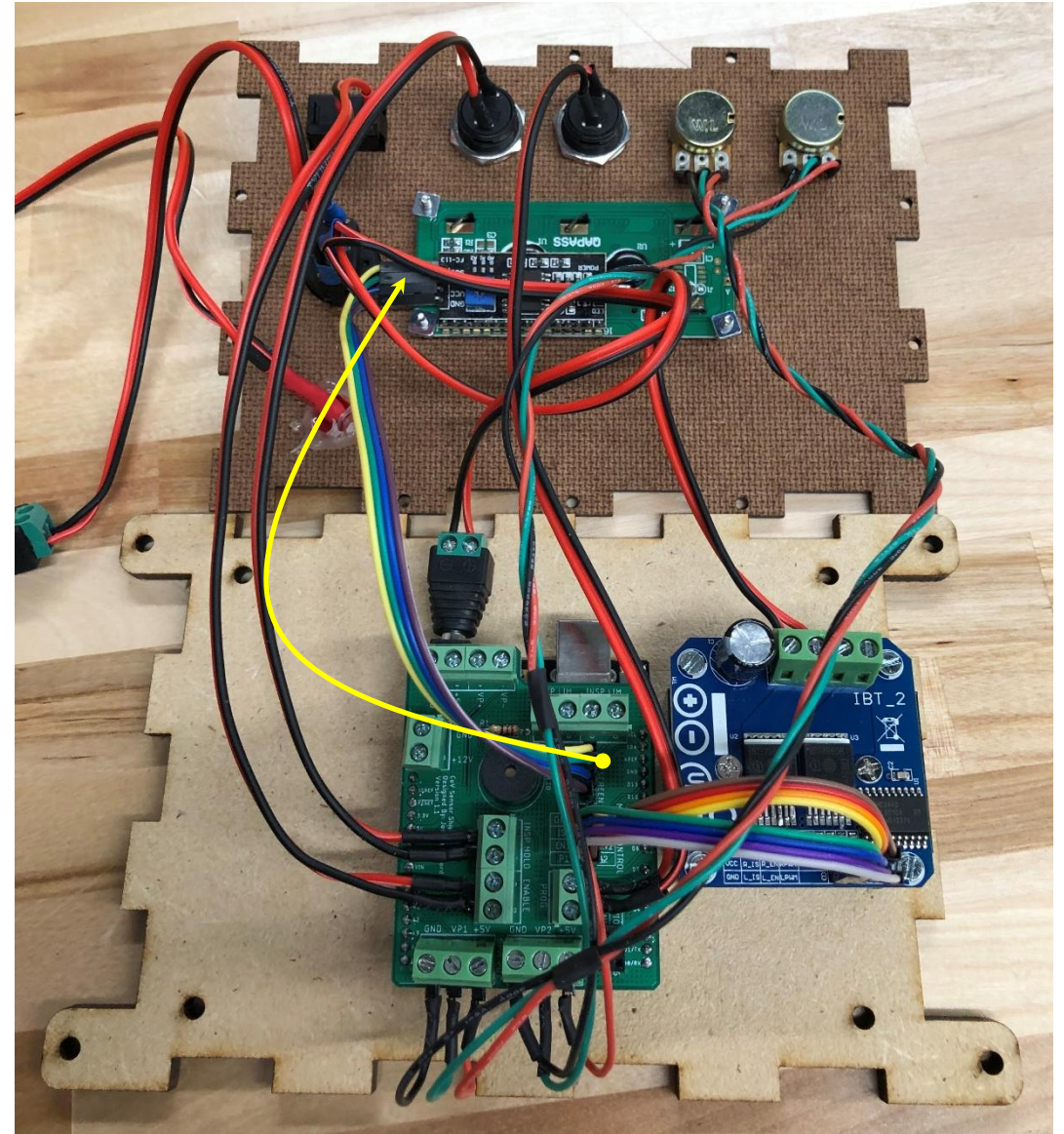
# 5 Left Panel Connections

- Grab the female barrel jack adapter and the left panel.

- Press the cylindrical part of the barrel jack through the hole, and **make sure the Phillips head on the screw terminal is pointed towards the cruciform cutouts**. This makes it so we can access the screw terminal simply by taking the fronte plat off when the box is assembled.

- Use epoxy or hot glue to glue the screw terminal to the panel.



Top of screw terminal faces the crosses
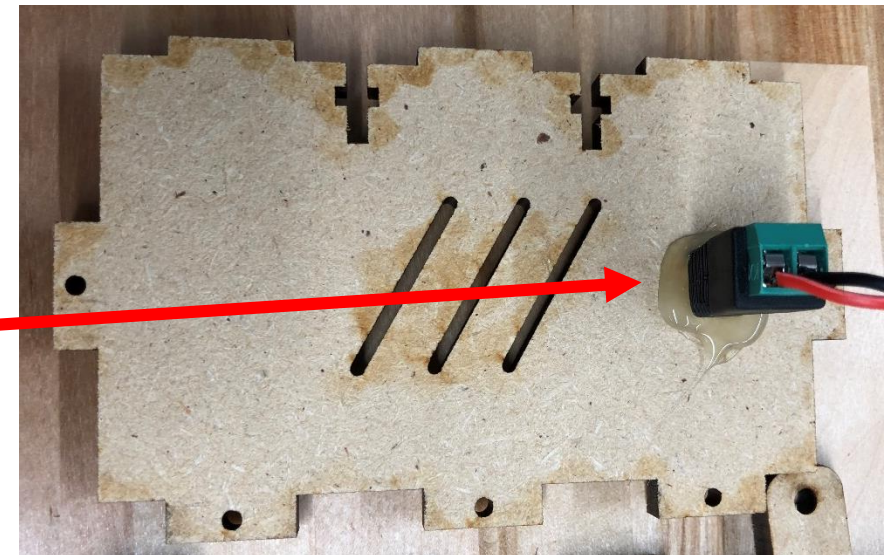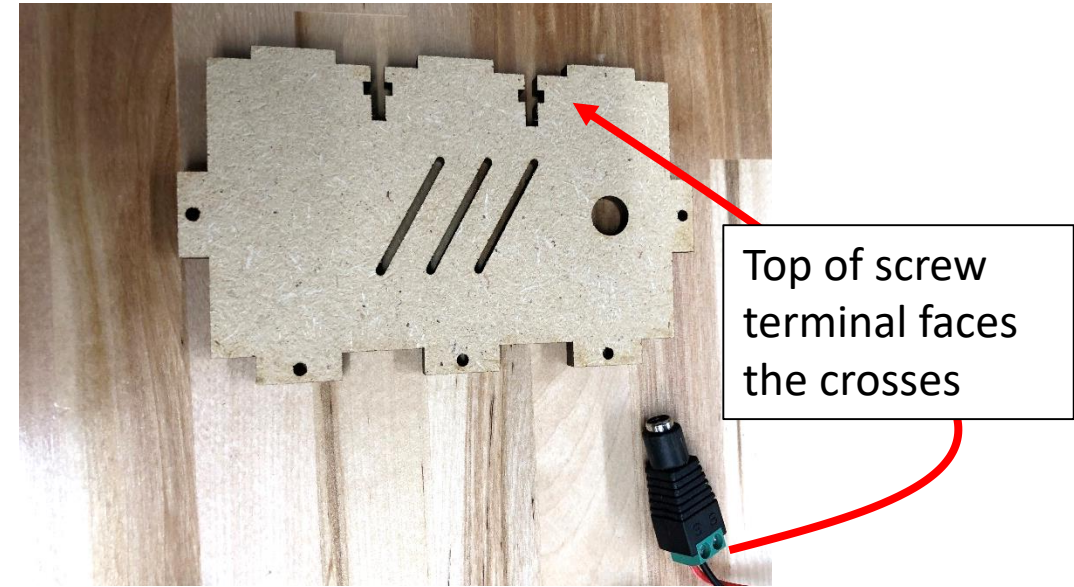
# 6 Top Panel Connections

- We've made all the connections for wires that are fully contained within the box. Now we need to make the connections for wires that enter the box from the outside (the two limit switches, pressure sensor, and motor wires).

- These wires enter the box through the top plate, and are strain relieved by plastic M12 cable glands (to keep them from getting yanked out)
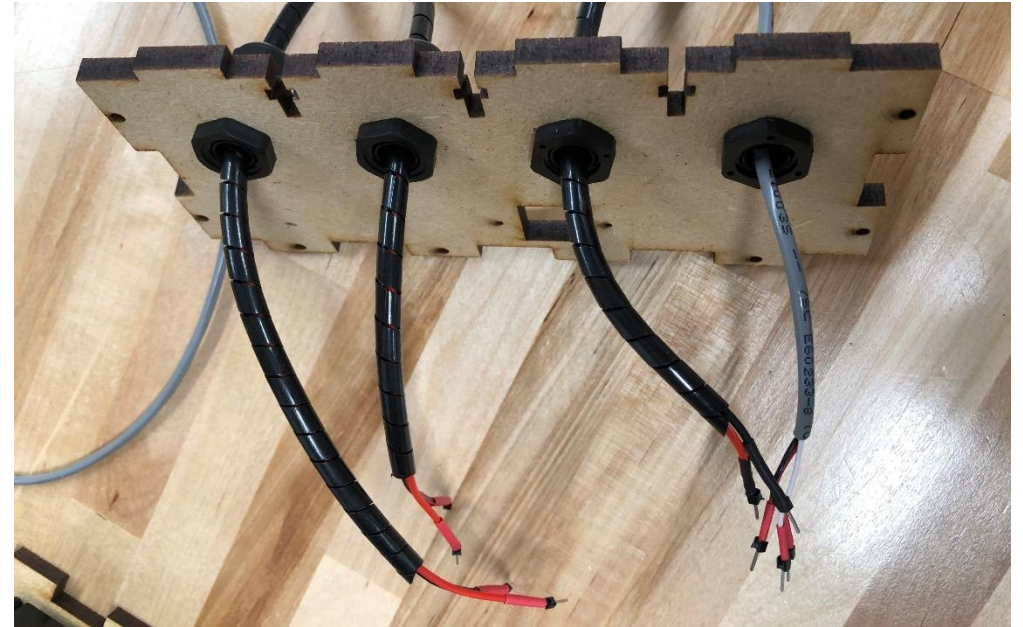
# 6.1 Put Cable Glands Onto Wires

- Grab the two limit switches, pressure sensor, and motor leads, as well as (4x) M12 cable glands. Each cable gland should have the gland part (2) and the jamnut (3).

- Feed the gland over the pin headers onto the wire, as shown, for the pressure sensor, limit switches, and motor leads.





Pressure Sensor



Limit Switches, Motor Leads
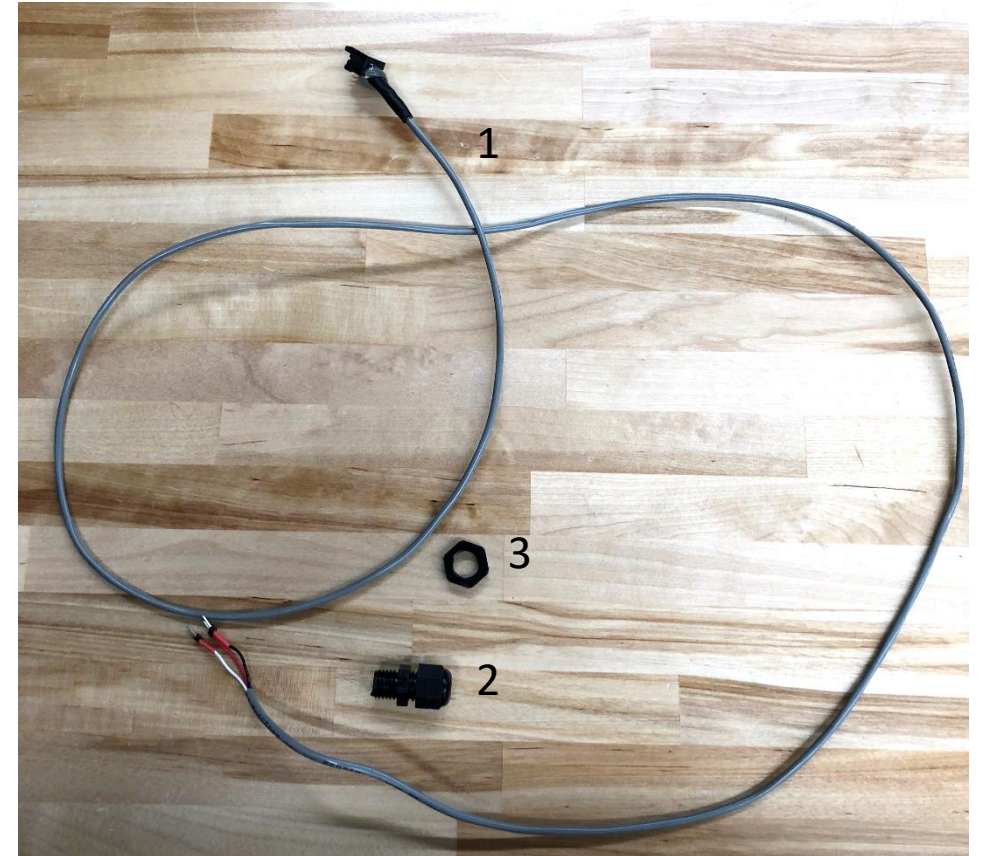
# 6.2 Fasten Wires to Top Plate

- Feed each of the wires through the four circular cutouts in the top plate. Feed the threaded portion of the cable gland through the hole, and use the jamnut to fasten the gland to the top plate, as shown.

- Repeat this for all 4 wires. Observe the orientation of the four wires here, and note the position of the square cutout. Make sure you match this image exactly.
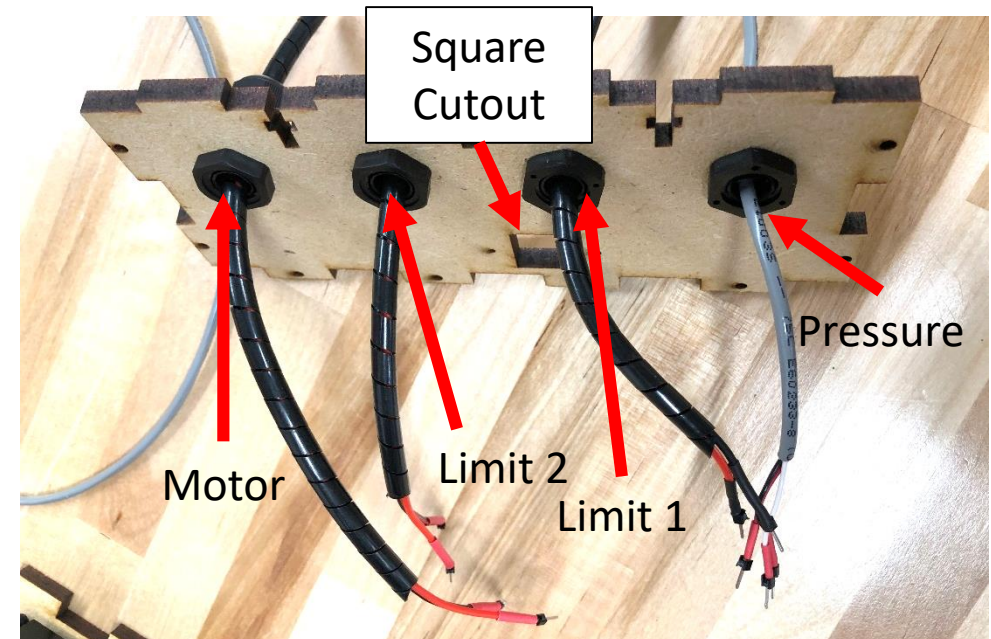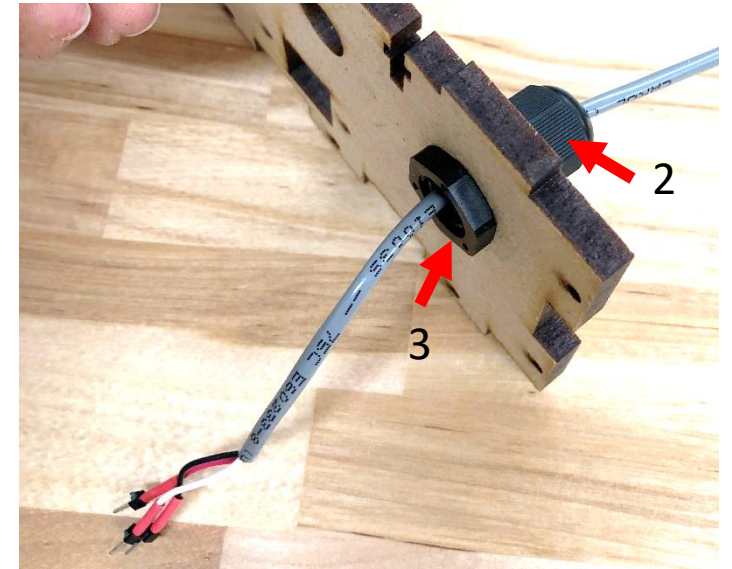
# 6.3 Fasten Wires to Top Plate

- Place the top plate between the front and bottom plate, as shown. Make sure the square cutout is directly above the Arduino USB port.

- Make the connections as shown.
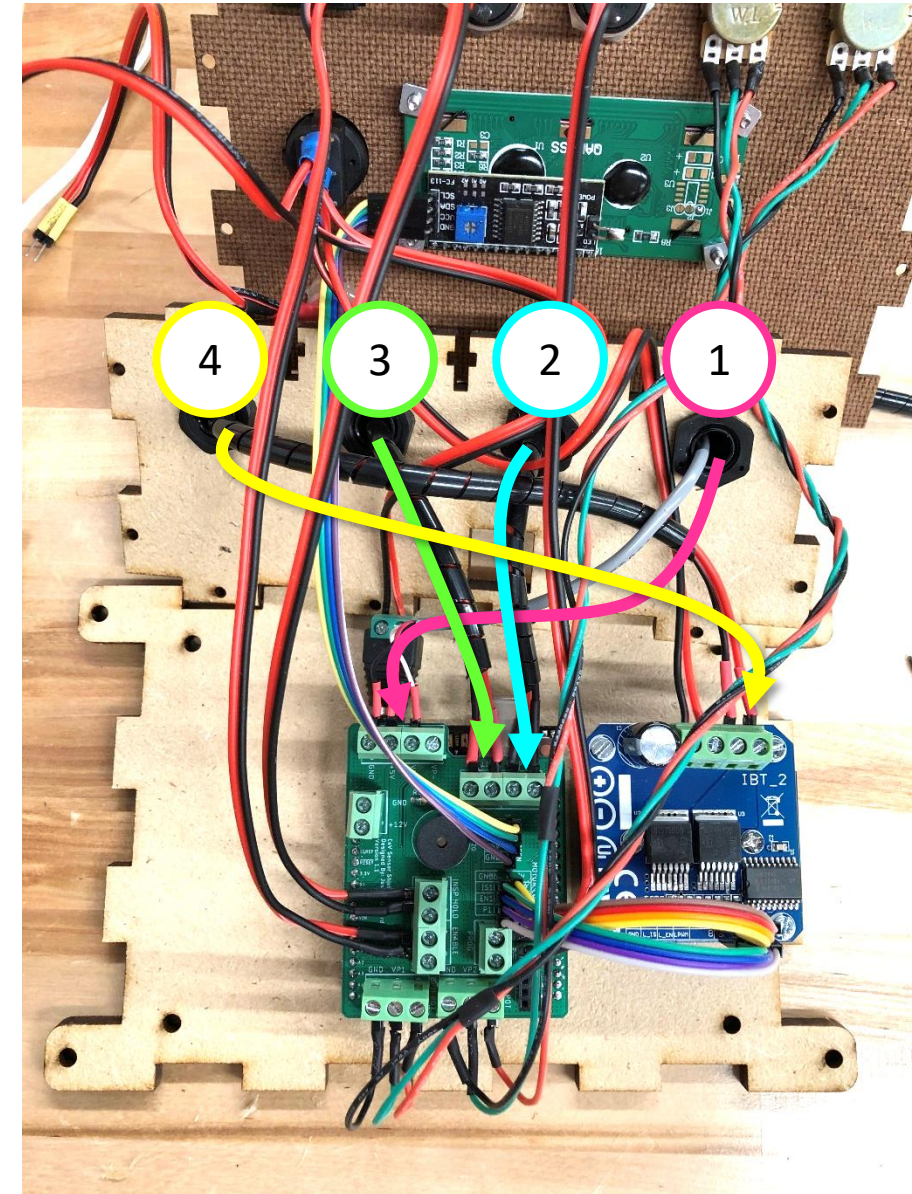
  - **1** Pressure sensor to pressure sensor header on CoV shield. **Red** -> 5V, **Black** -> GND, **White** -> VP+

  - **2** Limit Switch 1 to Insp Lim header on CoV shield. Polarity doesn't matter.

  - **3** Limit Switch 2 to Exp Lim header on CoV shield. Polarity doesn't matter.

  - **4** Motor leads to motor screw terminal on the driver. Put the red wire on the outside, as seen here.

# 6.4 Loosely Close Up the Box

- Good news – we're done making connections! Now we get to see if we did everything right.

- Grab the remaining right panel and bottom panel, and place orient all of the panels, as shown.

- Construct the box by placing the tabs from one panel into the mating slots of the other panel. Construct the top, bottom, right and left panels into the bottom panel first, and then put the front panel on top.

- The friction between the panels should loosely hold things together for now.
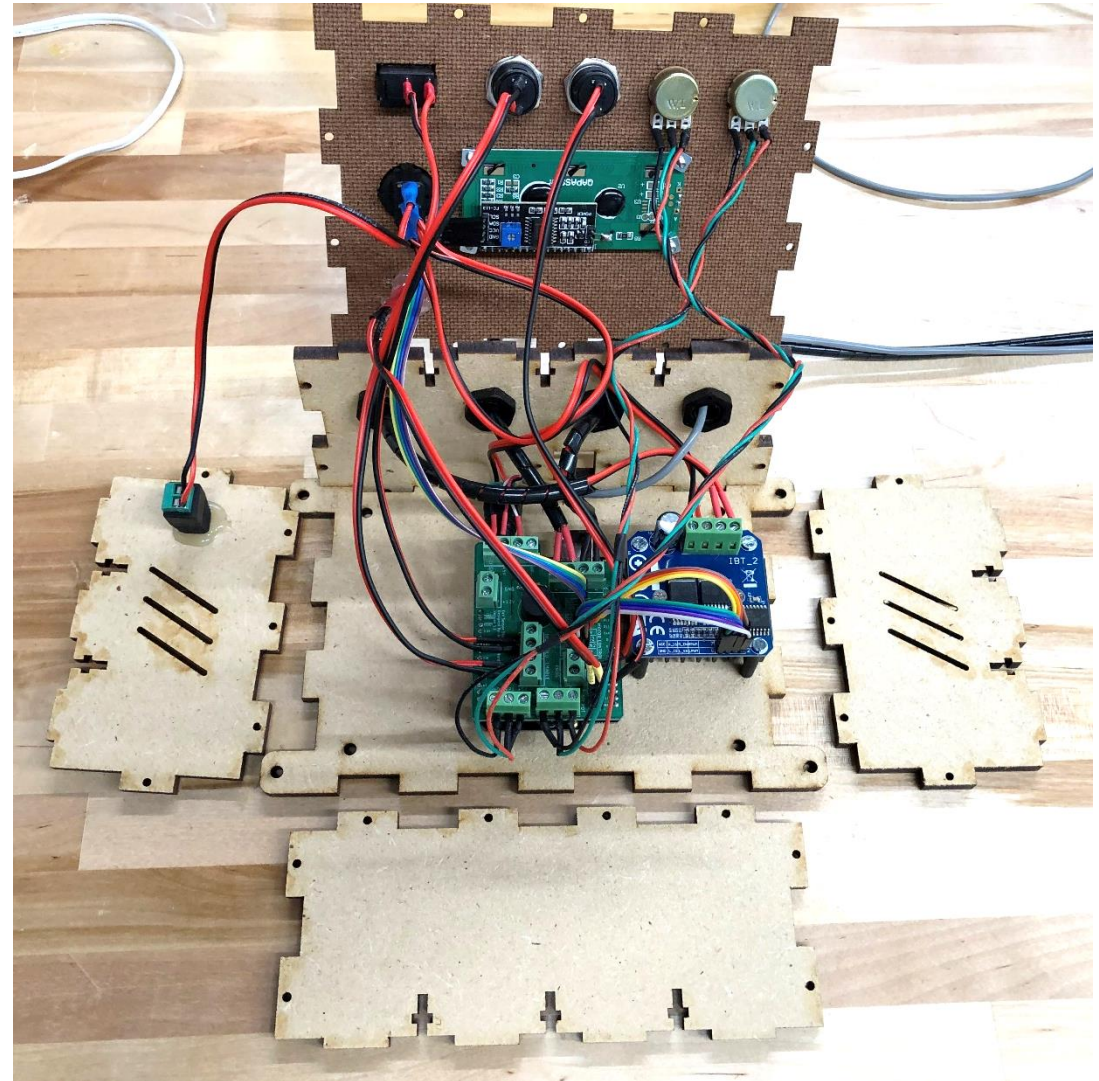
# 6.5 Loosely Close Up the Box

- If done correctly, the control box should look like this. The barrel jack should be sticking out of the left side.

- Before we close the box up, we will execute a script that will allow us to quickly confirm the proper functionality of all the connections we just made.

# 7. Wiring Test: Code Upload

- Go to the vandyvents.com download page and download Sensor_Test.ino
  - If you haven't already, first you need to download the Arduino IDE from here.
- Pass a serial cable through the cutout in the top plate and connect it to the Arduino's serial jack. The LCD screen should turn on when the jack is plugged in.
  - If the serial cutout does not align with the Arduino's serial port, you've put the top panel on backwards. Go back to 6.2 and put the glands through the opposite size, and repeat 6.3.
- Upload the code. Make sure you've selected the correct COM port and Arduino board (Uno)
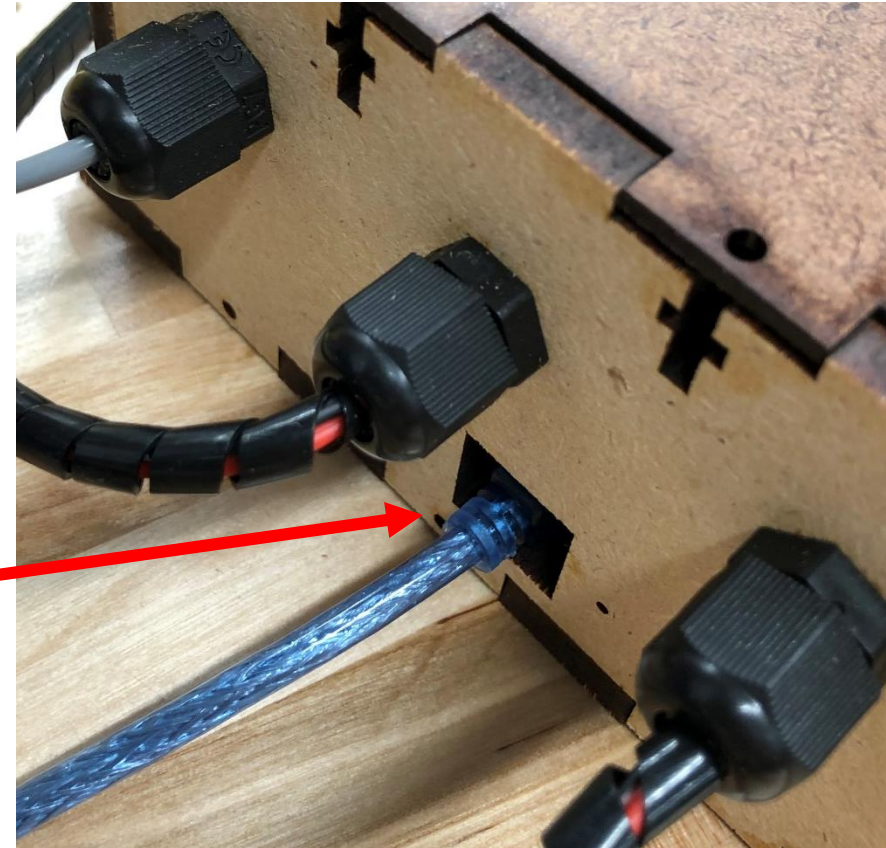
# 7. Wiring Test: Code Upload

- If done correctly, you should be met with a welcome prompt on the LCD, and then this should show up.

- **NOTE:** If the code uploaded successfully and you still can't see any text on the LCD, you might need to turn the brightness down. Take the front panel off, flip it over, and turn this potentiometer on the LCD backpack with a small Phillips head until the text shows up.

# 7.1 Wiring Test: ENABLE test

# 7.2 Wiring Test: PP/CLEAR test

# 7.3 Wiring Test: PROG test



If the motor is hooked up, and you've plugged the 12VDC adapter into the barrel jack, the motor should start spinning the other way as long as the button is pressed

# 7.4 Wiring Test: BPM/Pmax Pot test

This number should change as you turn the pot. It should go down as you turn clockwise, and up as you turn counter-clockwise

# 7.5 Wiring Test: IE/Pmin Pot test

This number should change as you turn the pot. It should go down as you turn clockwise, and up as you turn counter-clockwise

# 7.6 Wiring Test: Pressure Sensor Test



Blow into the pressure sensor and this number should increase

# 7.7 Wiring Test: Finish

- If any of those functions did not behave as described, open up the front panel and make sure all connections are made correctly. We don't want to close up the box until everything is working perfectly!

# 8 Closing the Box

- Collect the following
  - The constructed electronics box
  - (14x) Size 3, ½" long slotted wood screw (McMaster: 92407A096)
  - (10x) 4-40, ½" long machine screws (McMaster: 90272A110)
  - (10x) 4-40 square nut (McMaster: 94855A281)

# 8.1 Fastening to the Bottom Panel

- Go around the bottom panel, screwing the (14x) brass wood screws into the holes to fasten the top, bottom, left and right panels into the bottom panel.

- Using a drill to make a small (~1mm) pilot hole will help to prevent splitting and better guide the screw.

- Using a drill with a flat-head insert will help to speed up this process.

# 8.2 Screwing on the Front Panel

- Fasten the top plate by using the square nuts and the 4-40 machine screws.

- Use a needle-nose pliers to feed the square nuts into the captive nut cutouts, and screw the machine screw in from the top.

- Repeat this for all 10 holes on the top plate.

- Run the Wiring Test protocol once more to make sure everything is still working.

- If so, and your box looks like this, you're done!