ASSEMBLY PROTOCOL

Part 1: ENVIRONMENT

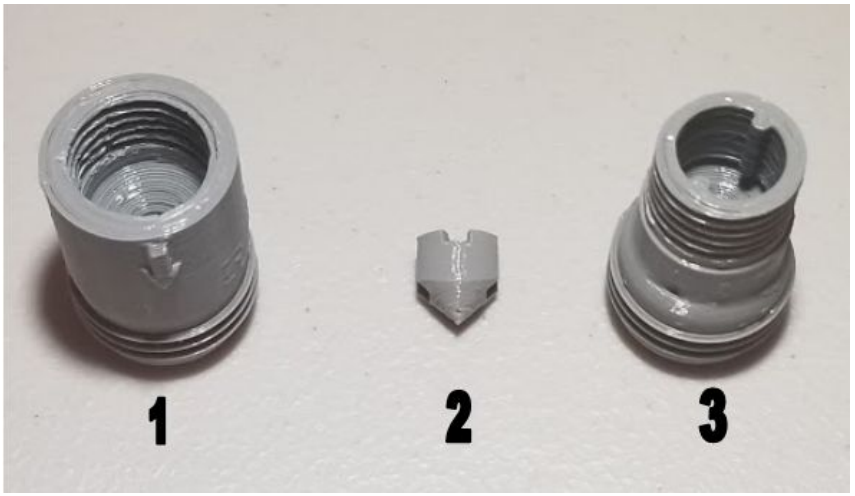
One should assemble all parts in a safe working environment which must have the following attributes:

- A smooth and clean surface
    - clean surface with 70% isopropyl alcohol
- Access to an UV light for disinfecting surfaces
- Well ventilated
    - uses a HEPA filter
- Access to appropriate PPEs:
    - nitrile gloves
    - face masks
    - safety goggles

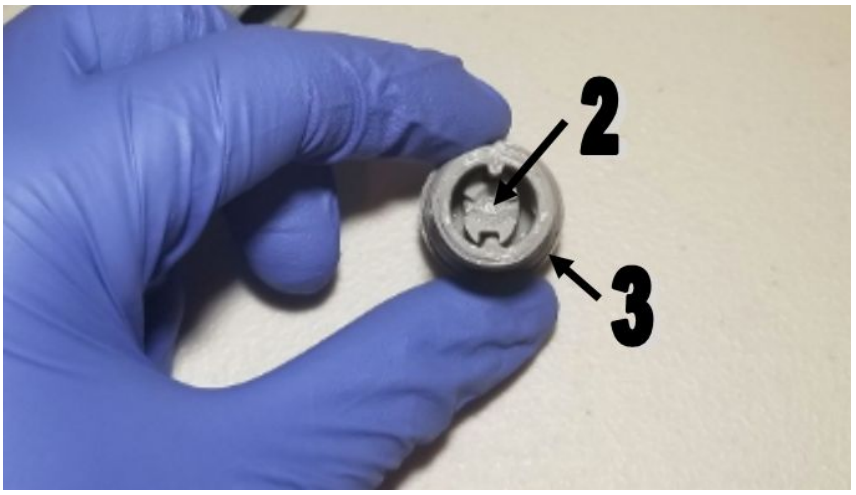
Part 2: MECHANICAL ASSEMBLY

Part 2-A: CHECK VALVES

1. There should be three components to each check valve.



2. Place **3** on a flat surface with the skinner end of the tube facing upwards. Place **2** inside **3** with the pointy end pointing down.

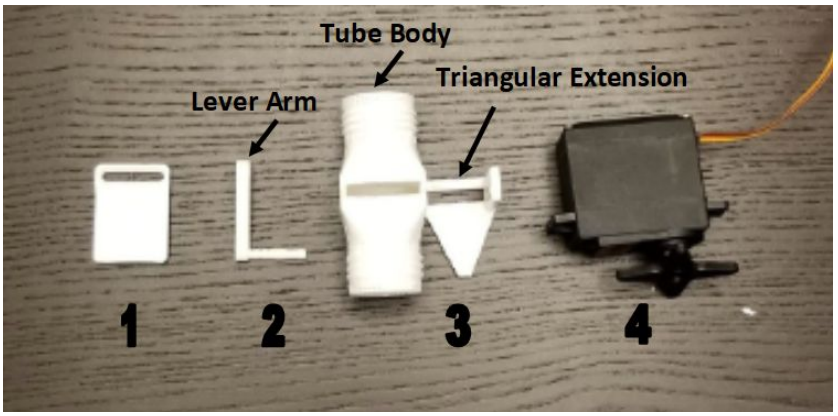


3. Screw **1** onto the skinny end of **3.** The arrow on **1** should be pointing upwards.

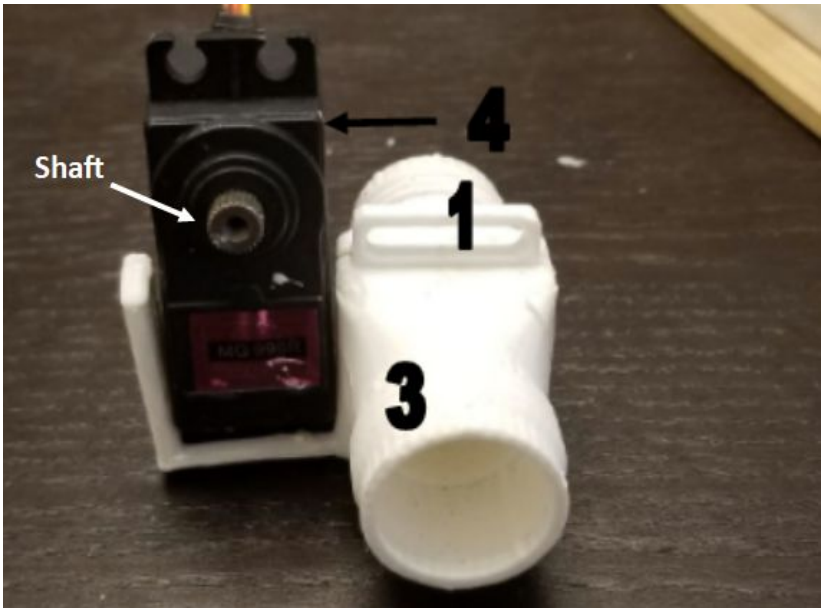
4. Apply steps 1-3 for all 3 check valves.

Part 2-B: GATE VALVES

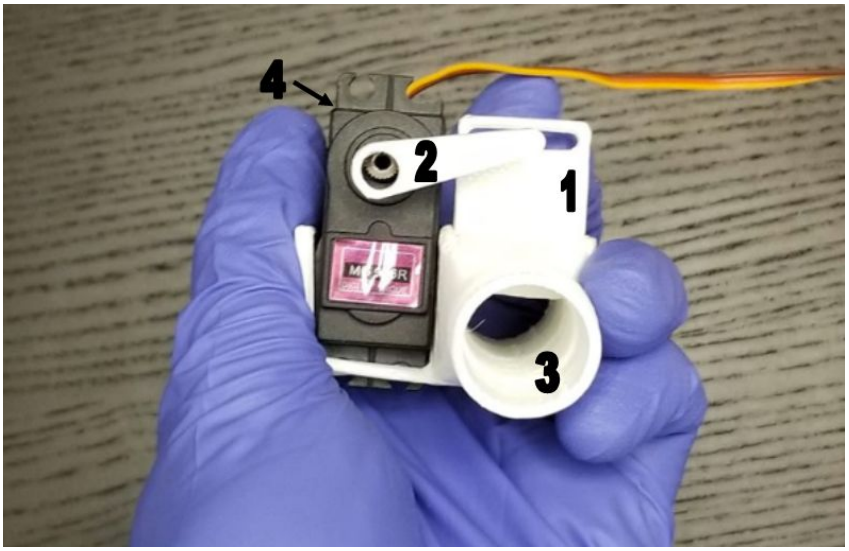
1. The gate valve consists of four components.



2. Position **3** such that the Triangular Extension is on the left side of the Tube Body. Insert **4** into the Triangular Extension such that the shaft of the motor is pointing in the opposite direction of the triangle on the Triangular Extension. insert **1** into the slit found on the top of **4**.



3. Insert the shaft of the motor into the hole found on the lever arm of **2**. Insert the shaft of **2** into the slit of **1**.



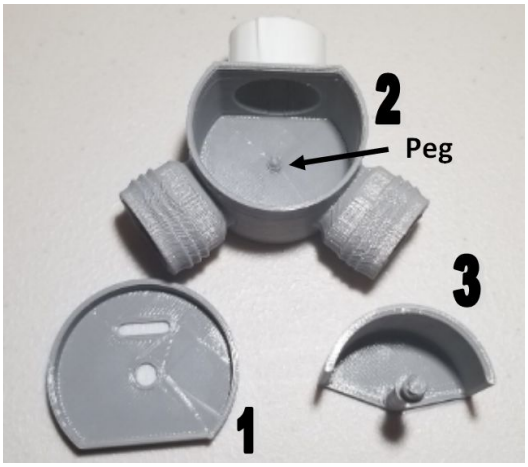
4. Repeat steps 1-3 for the second gate valve

Part 2-C: BURST DISK

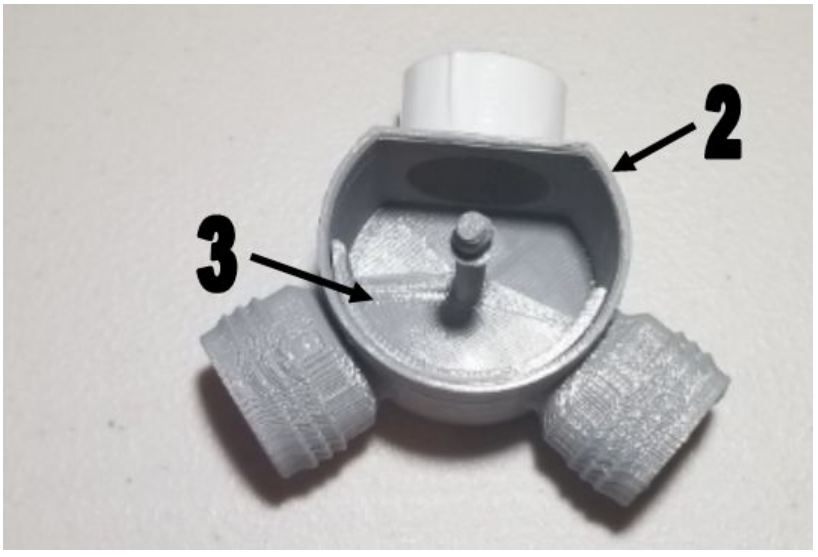
1. Cover the wide opening of the overpressure outlet with the burst disk until a *click* has been made.

Part 2-D: REGULATOR

1. The regulator should encompass 3 parts.



2. Insert **3** in **2** by placing the peg of **2** into the hole of **3**.



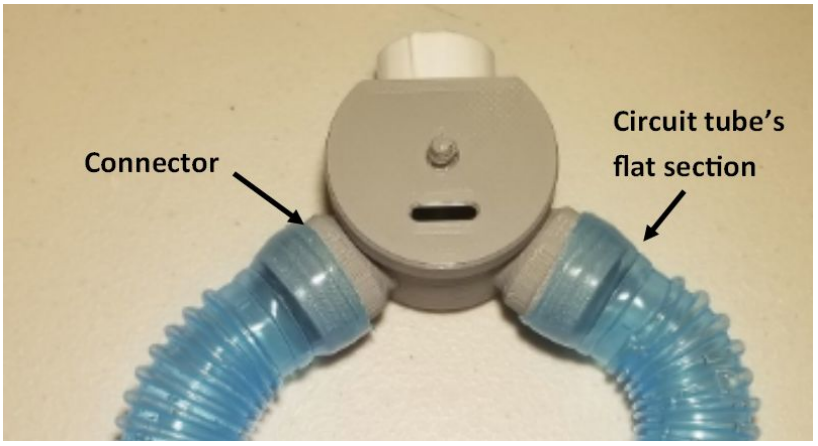
3. Cover **2** with **1**.

Part 2-E: TUBING

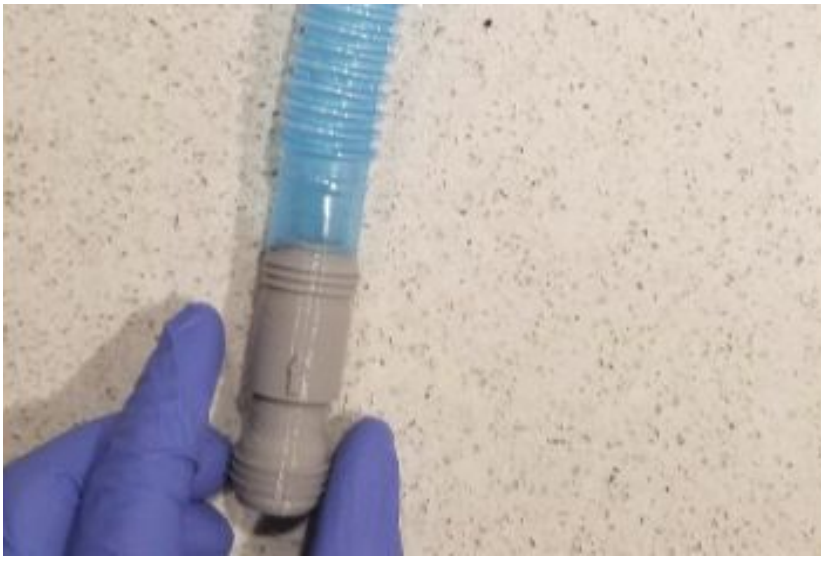
1. With a sharp blade, cut the ventilator circuit at each of the circuit tube's flat sections (junctions).There should be 12 sections and each section should be 15cm in length.

Part 7: OVERALL ASSEMBLY

1. Attach the ventilator circuit with the regulator by attaching the circuit tube's flat section at each connector of the regulator.

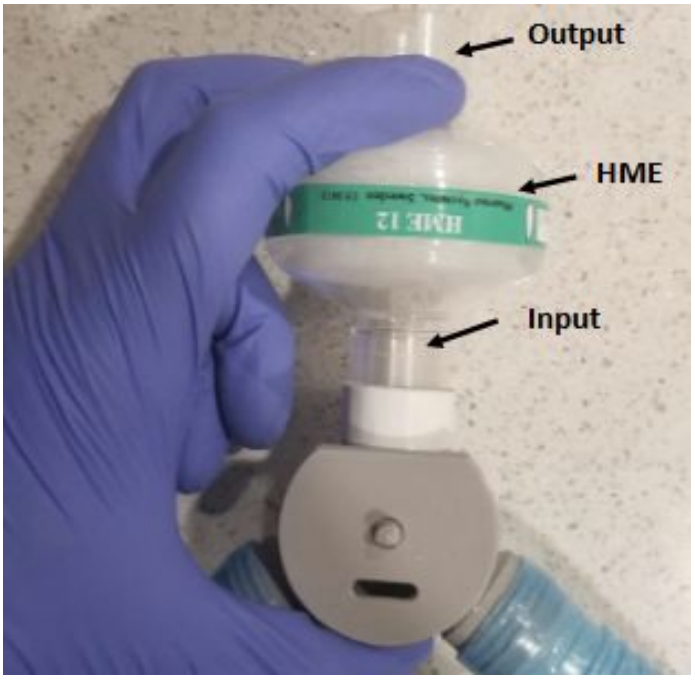


2. Attach an assembled check valve to the other free end of the ventilator circuit. Do this for both circuit tubes at each connector.

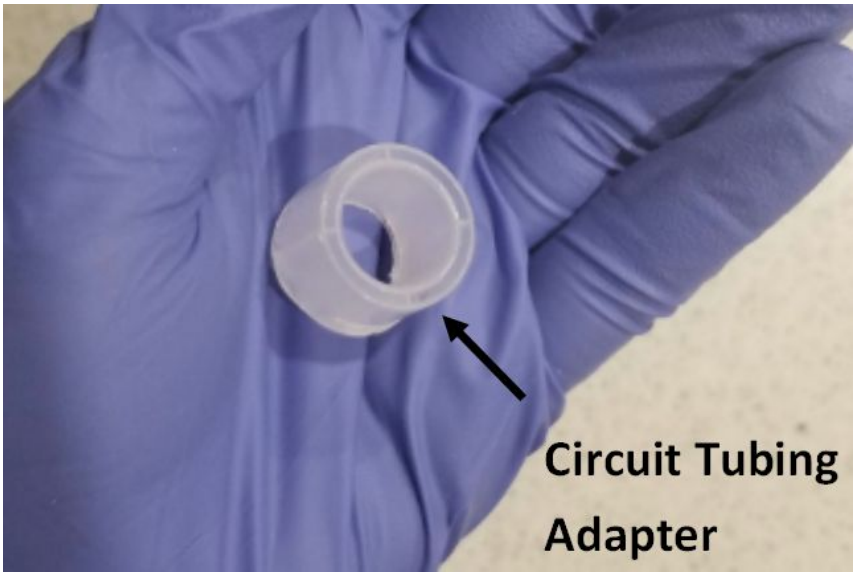


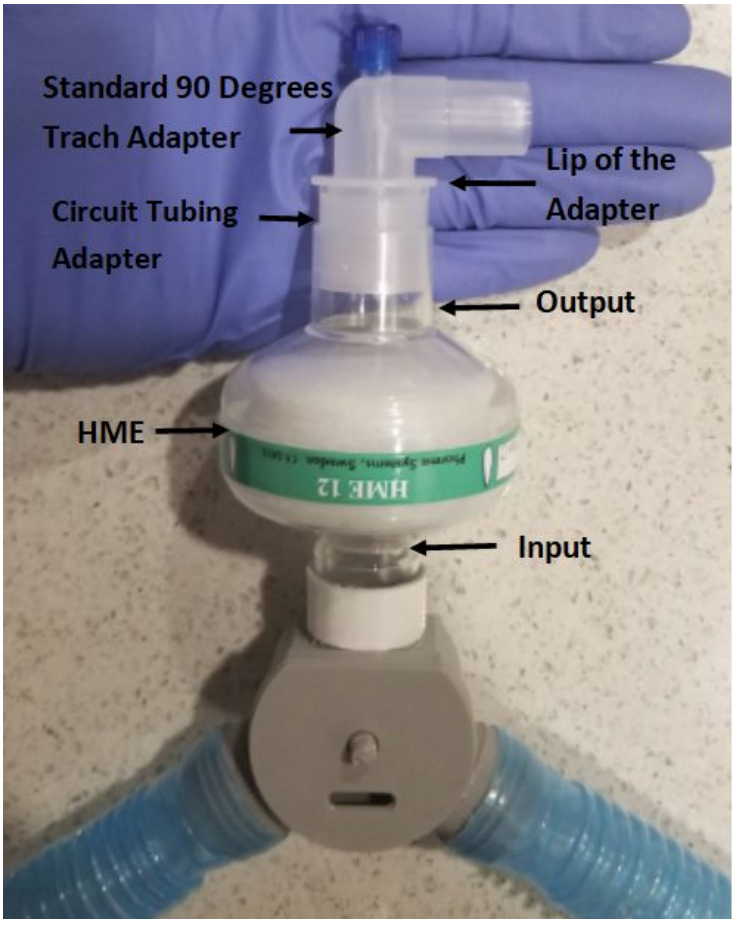
3. Connect the free end of the assembled check valve to the rest of the circuit tubing for each circuit tube.

4. Attach the input opening of a heat and moisture exchanger (HME) filter onto the white opening of the regulator.



5. Insert a circuit tubing adapter in the output opening of the HME with the lip of the adapter facing away from the output opening. Insert a

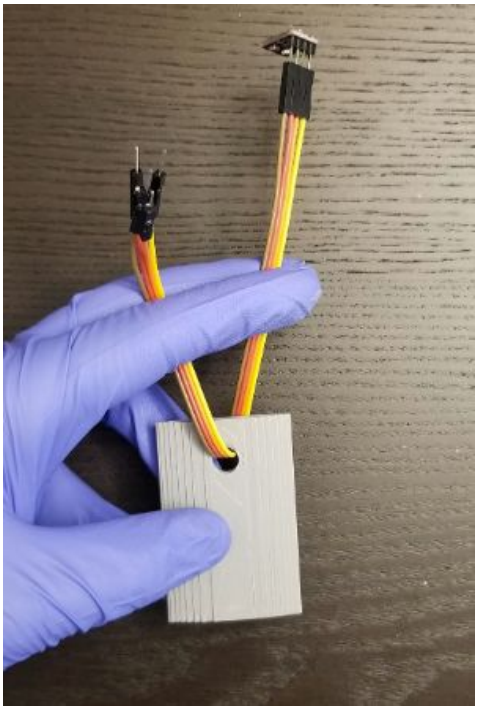




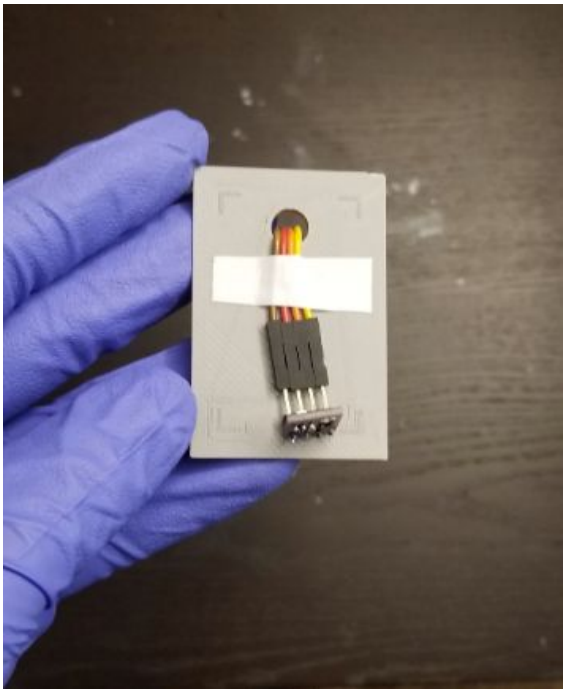
6. Place another circuit tubing adapter to the free end of the Standard 90 Degrees Trach Adapter.

Part 2-F: PRESSURE CHAMBER

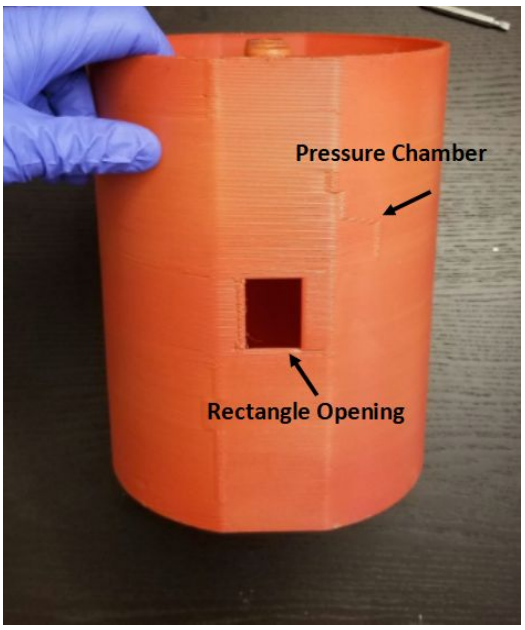
1. Loop the pressure and oxygen sensor through the hole of the pressure chamber plate.

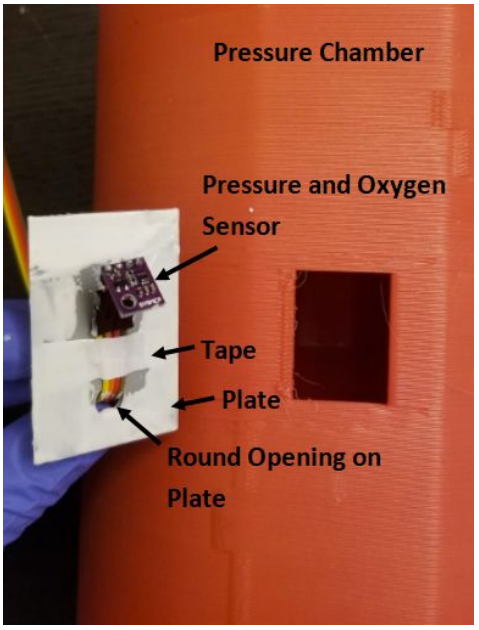



2. Securly tape the pressure and oxygen sensor to the inside of the plate.

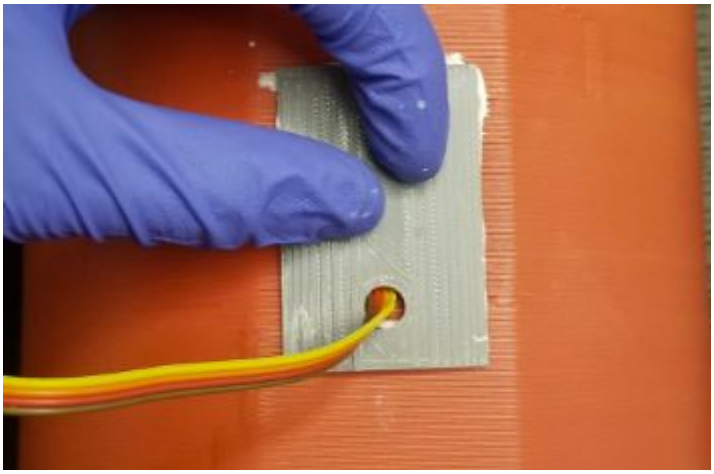


3. With the round hole facing down, cover the rectangle opening on the pressure chamber with the plate such that the pressure and oxygen sensor is in the chamber and the round hole on the plate is not overlapping the rectangle opening.



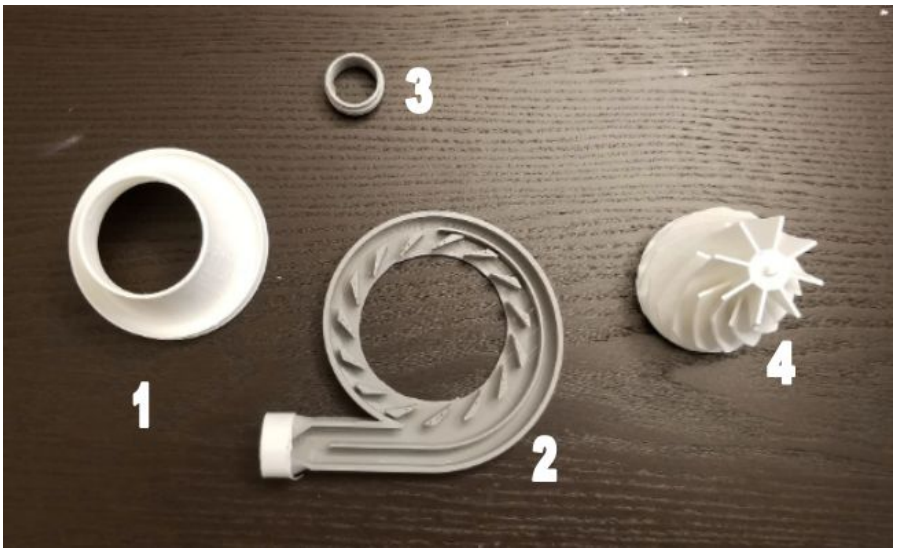


4. Apply a waterproof proxy around the perimeter of the plate to secure in place. Follow the instructions on the proxy to ensure optimal adhesivity.



Part 2-G: COMPRESSOR

1. The compressor consists of four components.

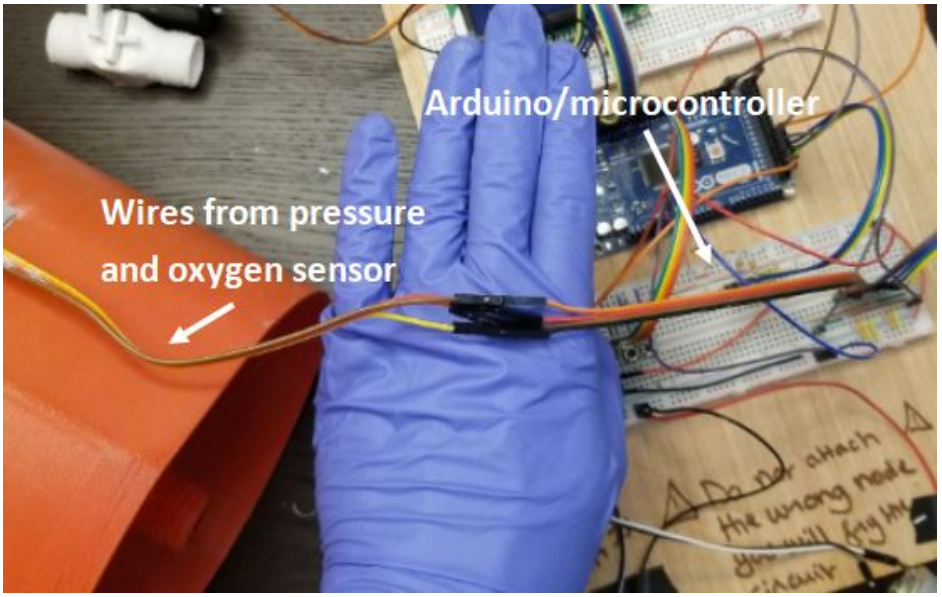


2. Place **2** such that the flat side is facing up. Place **4** into the hole of **2**.

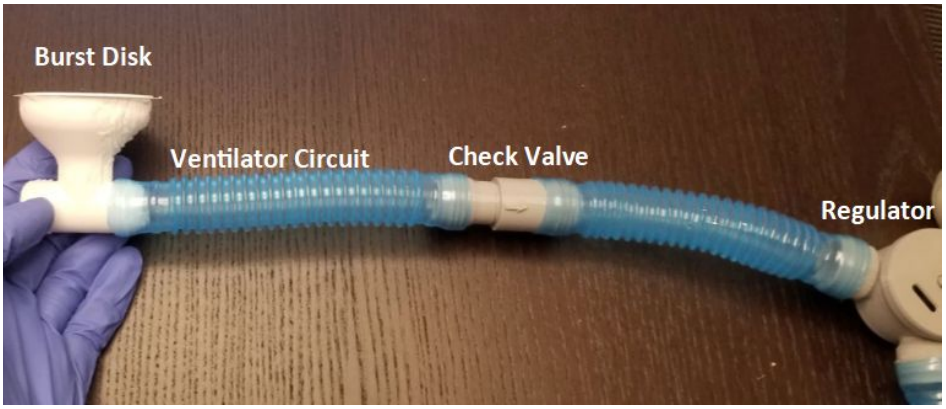
3. Cover **4** with **1**.

Part 2-H: TOTAL ASSEMBLY

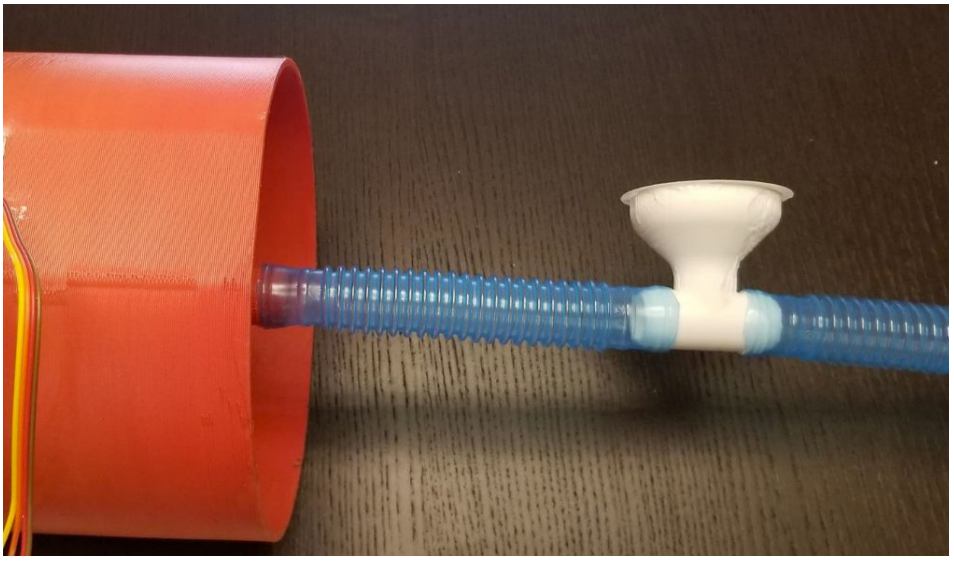
1. Connect the pressure and oxygen sensor from the pressure chamber to the arduino/microcontroller.



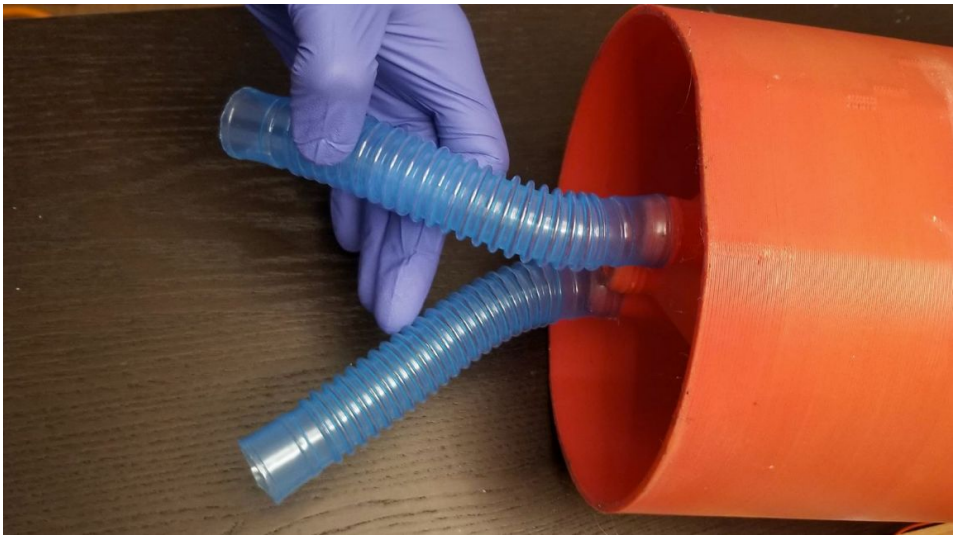
2. Connect the assembled burst disk to the free end of the ventilator circuit left of the regulator



3. Take another Ventilator section and attach the free end of the burst disk to the pressure chamber at the end with only **one** nozzle.



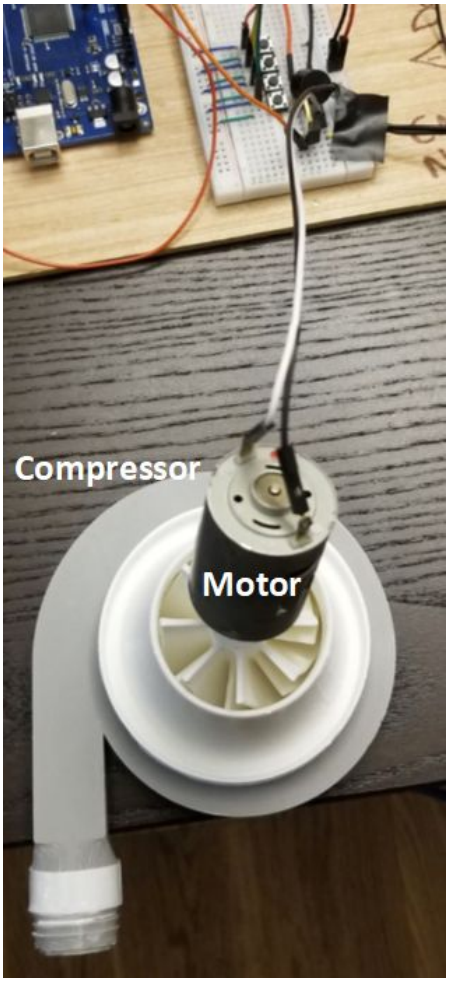
4. The opposite side of the pressure chamber should consist of **three** nozzles. Attach a section of the ventilator tubing the 2 outer nozzles.



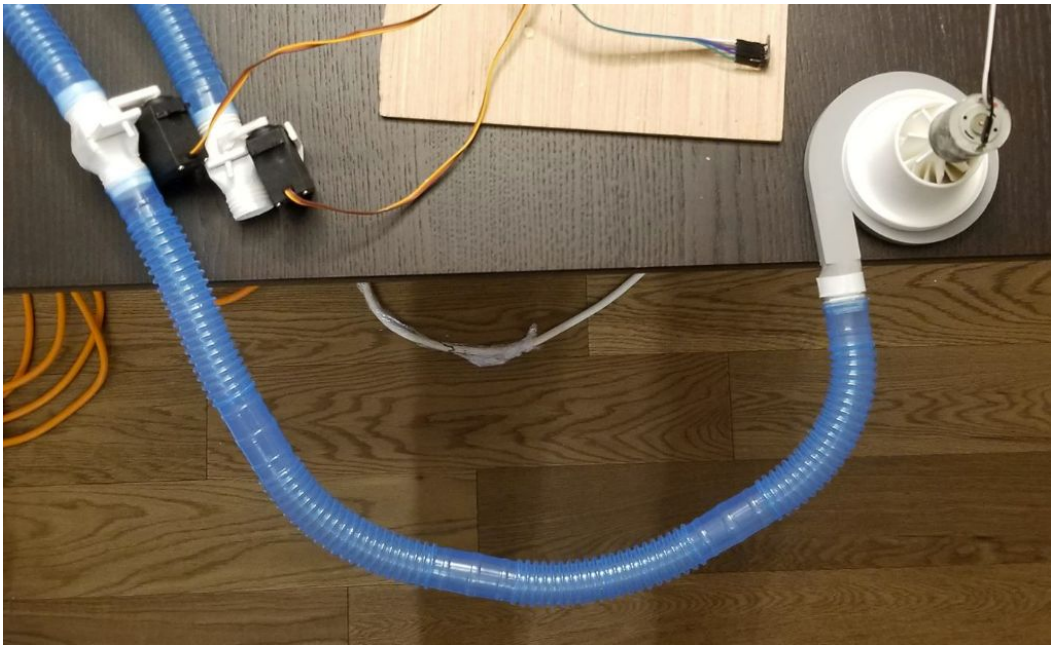
5. Attach 2 check valves to each of the free ends of the ventilator circuits such that the arrows of the check valves are pointing towards the pressure chamber. Attach another section of the ventilator circuit to the free end of each check valve.


6. Connect the 2 assembled gate valves to the free ends of the ventilator circuits connecting to the pressure chamber. Connect the motors of the gate valve to the arduino/microcontroller.

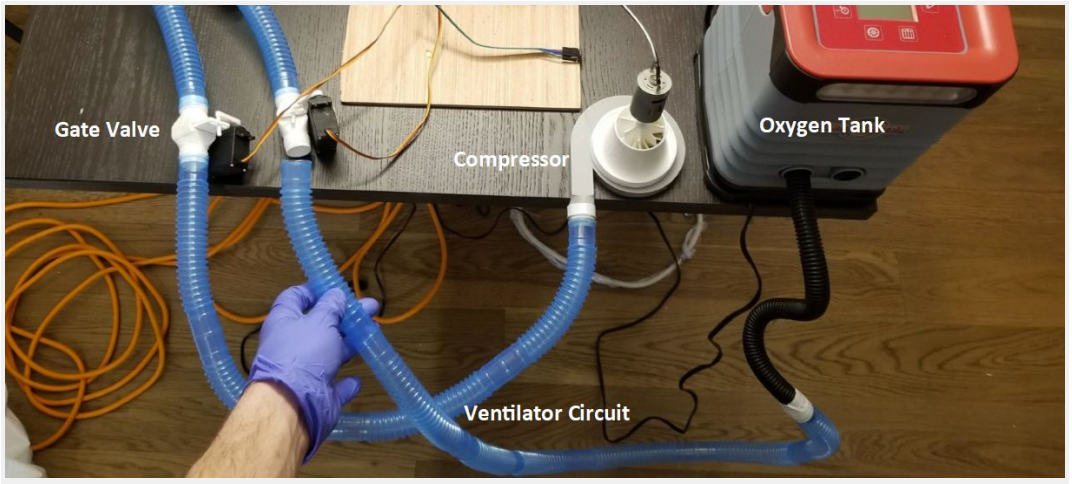
7. Place the shaft of a motor into the whole located on the top of the compressor and attach the other end to the arduino/microcontroller.



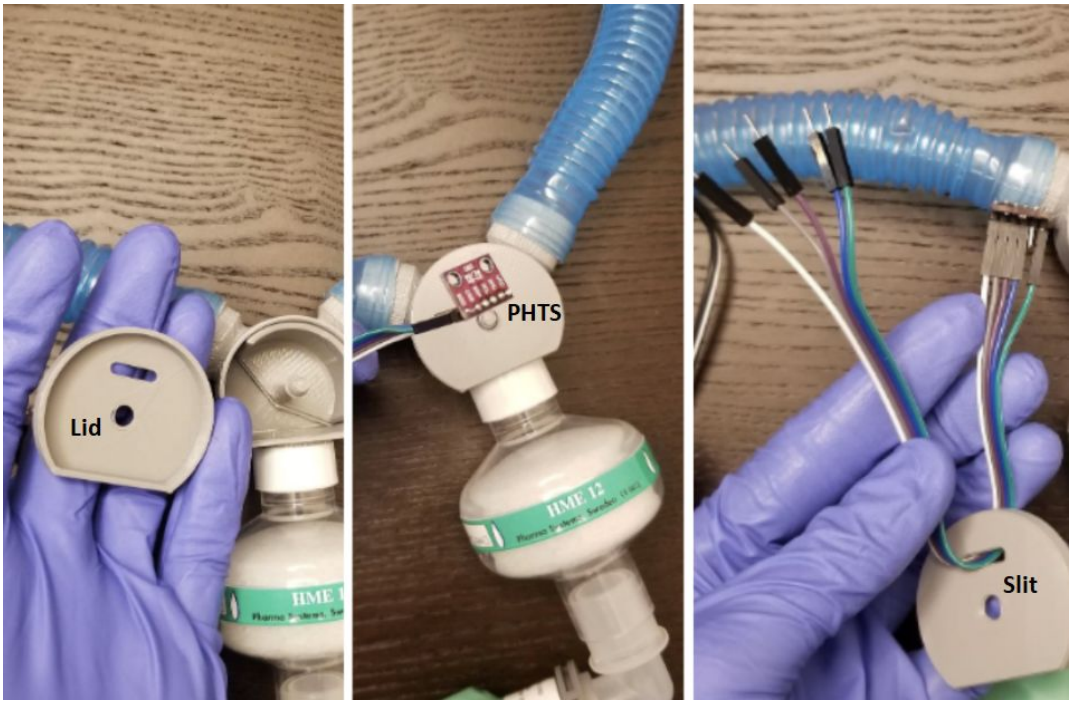
8. Using a long and uncut section of the ventilator circuit, attach the open nozzle on the compressor to one of the assembled gate valves attached to the pressure chamber.



9. Using another long and uncut section of the ventilator, connect the other gate valve to an oxygen tank.

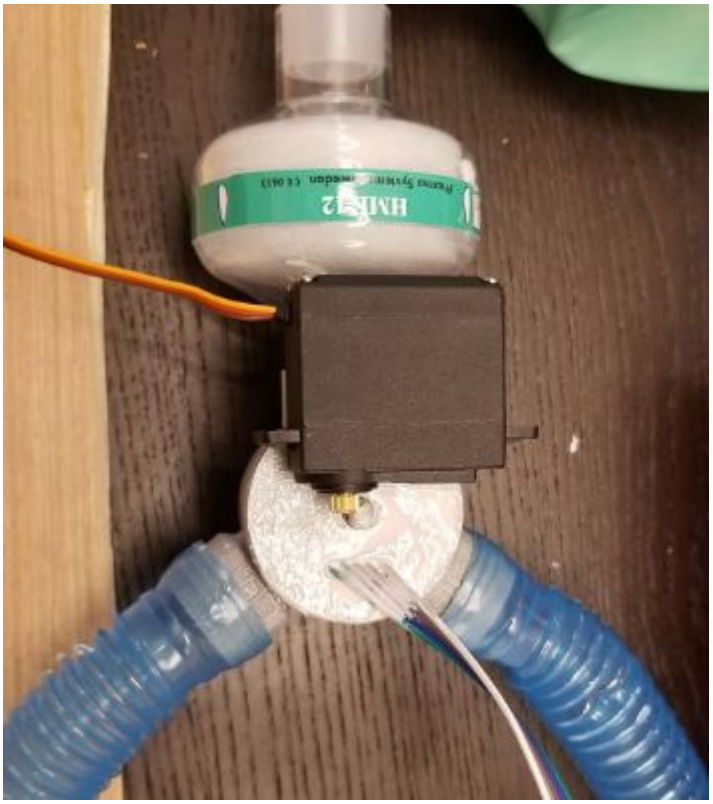


10. Open the lid of the regulator and with a Pressure Humidity Temperature Sensor (PHTS), loop the wires of the PHTS through the slit of the lid such that the PHTS is on the inside of the lid



11. Place the lid back onto the regulator such that the PHTS is inside the regulator. Apply a generous coating of waterproof epoxy on the exterior of the lid such that the slit is sealed.

12. Place the servo motor so that the gears on the shaft are aligned with the gears on the top of the regulator.



Part 3: ELECTRONICS

For the electronic part, you will have to choose from two options first:

- The Arduino Assembly (Part 8-A-1)
- The PCB Assembly (Part 8-A-2)

Afterwards, proceed to Part 8-B

Part 3-A-1: ARDUINO

Build the following circuit with Bill of Materials described in Annex A:

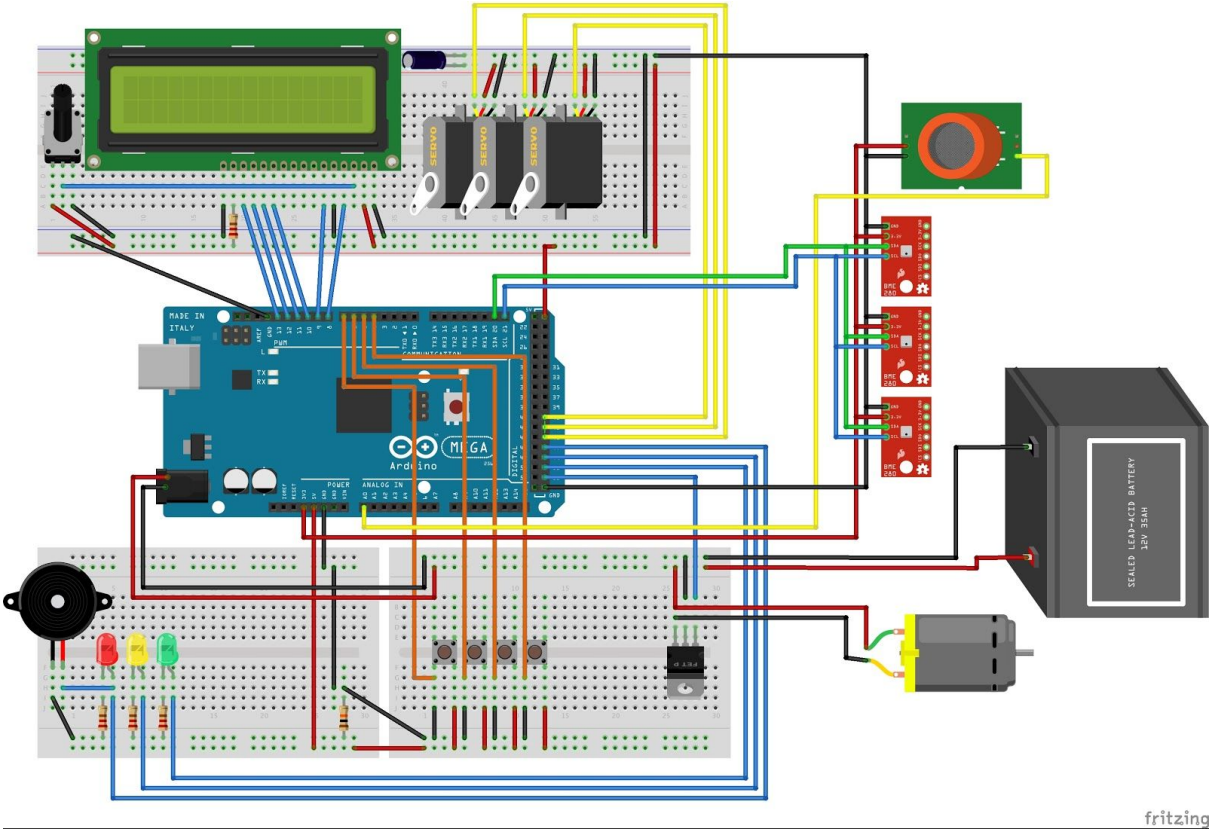


Figure 1: Arduino breadboard schematic

NOTE 1: The orange part at the top-right of the schematic is the Grove O2 sensor. The Grove O2 sensor has 3 ports (VCC 3.3V, GND and an analog port).
NOTE 2: This schematic is considering that the 3 BME280 or equivalent sensors have different I2C ports. If this is not the case, use SPI connectivity and change the Arduino code accordingly.

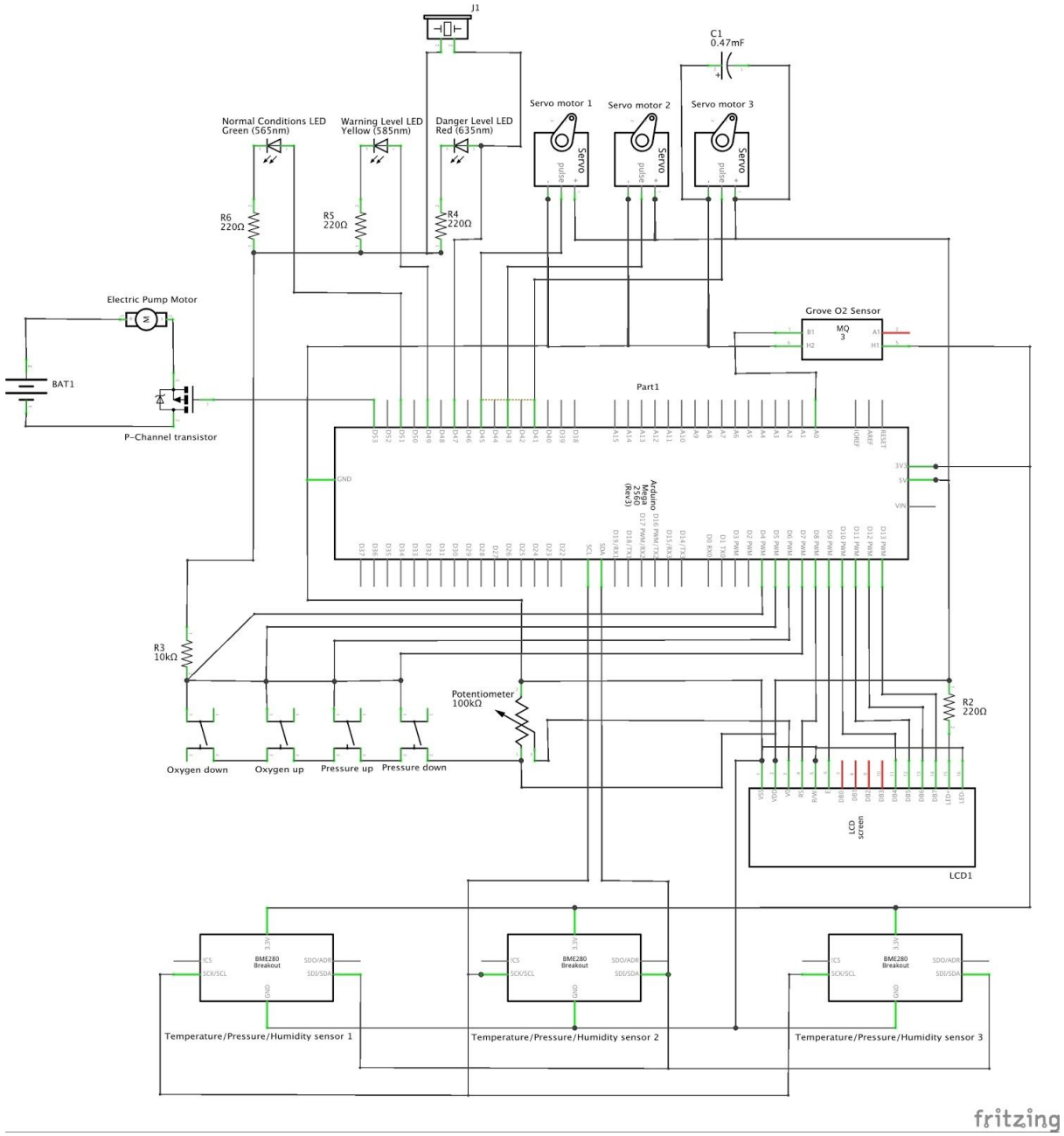


Figure 2: Arduino electrical schematic

Part 3-A-2: PCB

Plug the different sensors/parts into the PCB.

- The red LED goes at the P19 port
- The yellow LED goes at the P18 port
- The green LED goes at the P13 port
- The pressure tank BME280 sensor is connected at the I2C 1 port
- The pressure tank O2 sensor is connected at the Analog port
- The expiration BME280 sensor is connected at the I2C 2 port
- The dc motor is connected to its port

- The air compressor valve servo is connected to the servo 1 port
- The O2 valve is connected to the servo 2 port
- The regulator servo is connected to the servo 3 port
- A button is connected to each BTN port

Note that the PCB is using a multiplexer, so the temperature/humidity/pressure sensors can have the same I2C address.

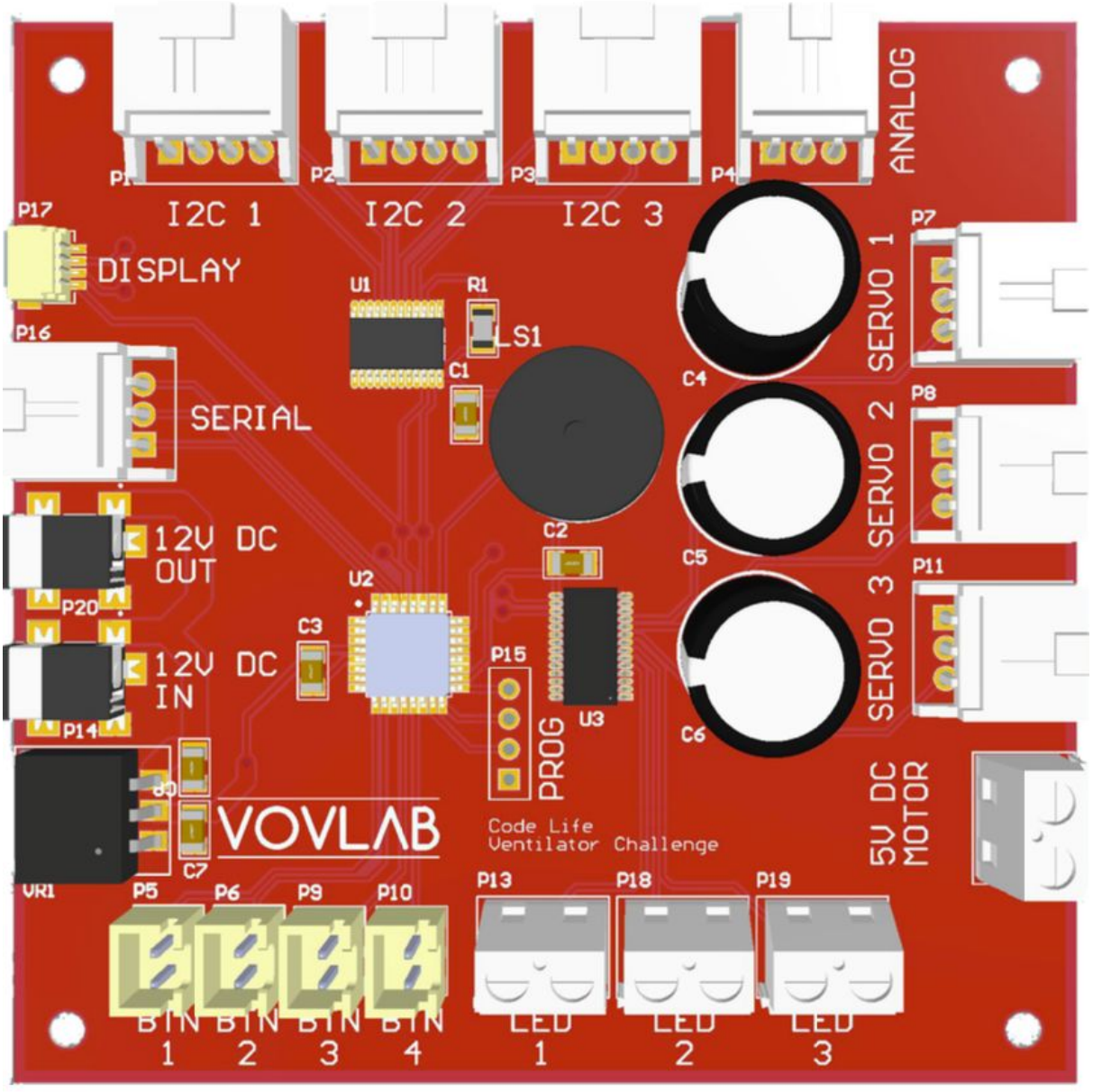


Figure 3: PCB

Part 3-B: UPS

Connect the UPS to the battery as the UPS documentation specifies it.

Part 3-C: UPLOADING THE CODE ON THE ARDUINO/PCB

Download the arduino code. If you do not have the Arduino IDE on your computer, please download it at the following address: https://www.arduino.cc/en/Main/Software. Open the Arduino code in the Arduino IDE. Plug a USB cable from your computer to the Arduino mega/PCB and upload the code to it from Arduino IDE. Note that if you are using the PCB the Arduino code may need some tweaks (changing ports). The arduino code can be found on the following Github repository in the folder arduino:
https://github.com/ilangleben19/SFVentilator.git

Part 3-D: RASPBERRY PI GUI

Connect the USB cable from the raspberry pi to the Arduino/PCB. Connect the screen to the raspberry pi. If you feel like you need these, connect a mouse/keyboard to the Raspberry Pi. Set up the Raspberry Pi with Rasbian in your preferred way.

Open a terminal. Update the system as follows:

```
$ sudo apt update
$ sudo apt -y upgrade
$ sudo apt -y dist-upgrade
$ sudo apt -y full-upgrade
```

Install packages needed to build Node.js packages:

```
$ sudo apt -y install git gcc g++ make
```

Install Node.js (which comes with NPM) and Yarn package manager:

```
$ curl -sL https://deb.nodesource.com/setup_12.x | sudo bash -
$ sudo apt -y install nodejs
$ curl -sS https://dl.yarnpkg.com/debian/pubkey.gpg | sudo apt-key add -
$ sudo apt update; sudo apt -y install yarn
```

Clone the Git repository and enter it:

```
$ cd ~
$ git clone https://github.com/ilangleben19/SFVentilator.git
$ cd SFVentilator
```

Install frontend and backend pages and create a production build:

```
$ cd react-ui; yarn install; yarn build
$ cd ../backend; npm i
```

Register the web-app to open on startup:

```
$ sudo echo “@lxterminal -e node /home/pi/SFVentilator/backend/index.js” >>
/etc/xdg/lxsession/LXDE-pi/autostart
```

And reboot the RPi. Everything should now work.

Annex A: Bill of Materials (Electronic)

Assembly List

Label	Part Type	Properties
BAT1	12 battery	package battery ; variant YTH2448-mini
C1	Electrolytic Capacitor	voltage 6.3V; capacitance 0.47mF; package 1010 [SMD, electrolytic]
Danger Level LED	Red (635nm) LED	color Red (635nm); package 5 mm [THT]; leg yes
Electric Pump Motor	DC Motor	RS380 motor or equivalent
Grove O2 Sensor	GAS_SENSOR	Grove Gas O2 Sensor
J1	Piezo Speaker	
LCD1	LCD screen	type Character; pins 16
Normal Conditions LED	Green (565nm) LED	color Green (565nm); package 5 mm [THT]; leg yes
Oxygen down	Pushbutton	package [THT]
Oxygen up	Pushbutton	package [THT]
P-Channel transistor	Basic FET P-Channel	type p-channel; package DPak [SMD]
Part1	Arduino Mega 2560 (Rev3)	type Arduino MEGA 2560 (Rev3)
Potentiometer	Rotary Potentiometer (Small)	type Rotary Shaft Potentiometer; size Rotary - 9mm; track Linear; maximum resistance 100kΩ; package THT
Pressure down	Pushbutton	package [THT]
Pressure up	Pushbutton	package [THT]

R2	220Ω Resistor	tolerance ±5%; bands 4; pin spacing 400 mil; resistance 220Ω; package THT
R3	10kΩ Resistor	tolerance ±5%; bands 4; pin spacing 400 mil; resistance 10kΩ; package THT
R4	220Ω Resistor	tolerance ±5%; bands 4; pin spacing 400 mil; resistance 220Ω; package THT
R5	220Ω Resistor	tolerance ±5%; bands 4; pin spacing 400 mil; resistance 220Ω; package THT
R6	220Ω Resistor	tolerance ±5%; bands 4; pin spacing 400 mil; resistance 220Ω; package THT
Servo motor 1	Basic Servo	Any servo that has more than 2 kg mm of torque and has a higher rotational speed than 40 RPM and has a rotation angle of 180°.
Servo motor 2	Basic Servo	Any servo that has more than 2 kg mm of torque and has a higher rotational speed than 40 RPM and has a rotation angle of 180°.
Servo motor 3	Basic Servo	Any servo that has more than 2 kg mm of torque and has a higher rotational speed than 40 RPM and has a rotation angle of 180°.
Temperature/Pressure/Humidity sensor 1	BME280 Breakout	power 3.3V; variant BME280
Temperature/Pressure/Humidity sensor 2	BME280 Breakout	power 3.3V; variant BME280
Temperature/Pressure/Humidity sensor 3	BME280 Breakout	power 3.3V; variant BME280
Warning Level LED	Yellow (585nm) LED	color Yellow (585nm); package 5 mm [THT]; leg yes

Shopping List

Amount	Part Type	Properties
1	12 battery	package battery ; variant YTH2448-mini
1	Electrolytic Capacitor	voltage 6.3V; capacitance 0.47mF; package 1010 [SMD, electrolytic]
1	Red (635nm) LED	color Red (635nm); package 5 mm [THT]; leg yes
1	DC Motor	
1	GAS_SENSOR	package mq-3
1	Piezo Speaker	
1	LCD screen	type Character; pins 16
1	Green (565nm) LED	color Green (565nm); package 5 mm [THT]; leg yes
4	Pushbutton	package [THT]
1	Basic FET P-Channel	type p-channel; package DPak [SMD]
1	Arduino Mega 2560 (Rev3)	type Arduino MEGA 2560 (Rev3)
1	Rotary Potentiometer (Small)	type Rotary Shaft Potentiometer; size Rotary - 9mm; track Linear; maximum resistance 100kΩ; package THT
4	220Ω Resistor	tolerance ±5%; bands 4; pin spacing 400 mil; resistance 220Ω; package THT
1	10kΩ Resistor	tolerance ±5%; bands 4; pin spacing 400 mil; resistance 10kΩ; package THT
3	Basic Servo	
3	BME280 Breakout	power 3.3V; variant BME280

1	Yellow (585nm) LED	color Yellow (585nm); package 5 mm [THT]; leg yes