



UNIVERSITY OF
ILLINOIS
URBANA-CHAMPAIGN

ECE 445: Senior Design Covid-Safe Fitting Room

Team 22

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Meet the Team



Bill Heniades

Senior in Electrical Engineering



Ege Guler

Senior in Electrical Engineering



Arin Manav

Senior in Electrical Engineering

Fitting Room Confusion: Why Some Are Still Closed As Stores And Restaurants Begin To Reopen

By Marie Saavedra April 30, 2021 at 10:35 pm Filed Under: COVID-19, Dressing Rooms

Consumer's View

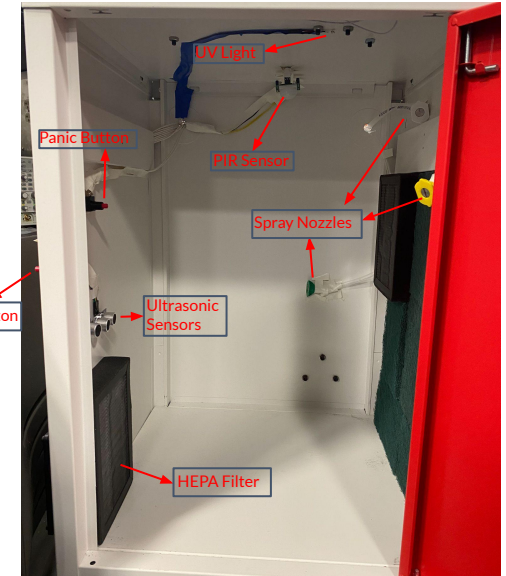
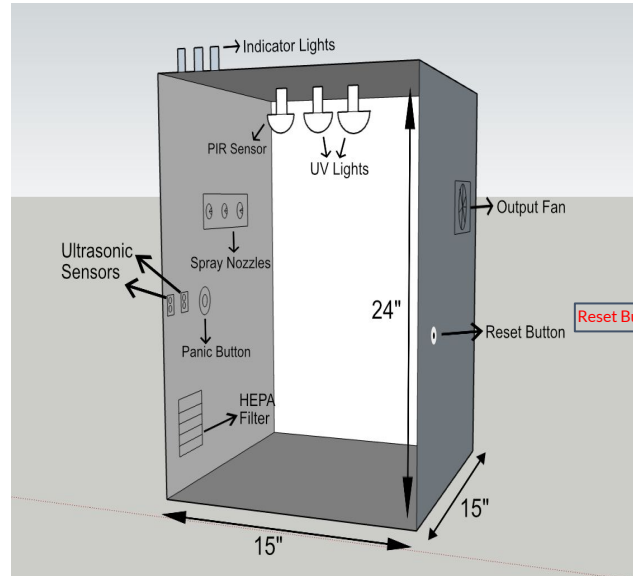
- Decreases customer satisfaction
- Overall unpleasant shopping experience
- Have to buy multiple sizes

Retailer's View

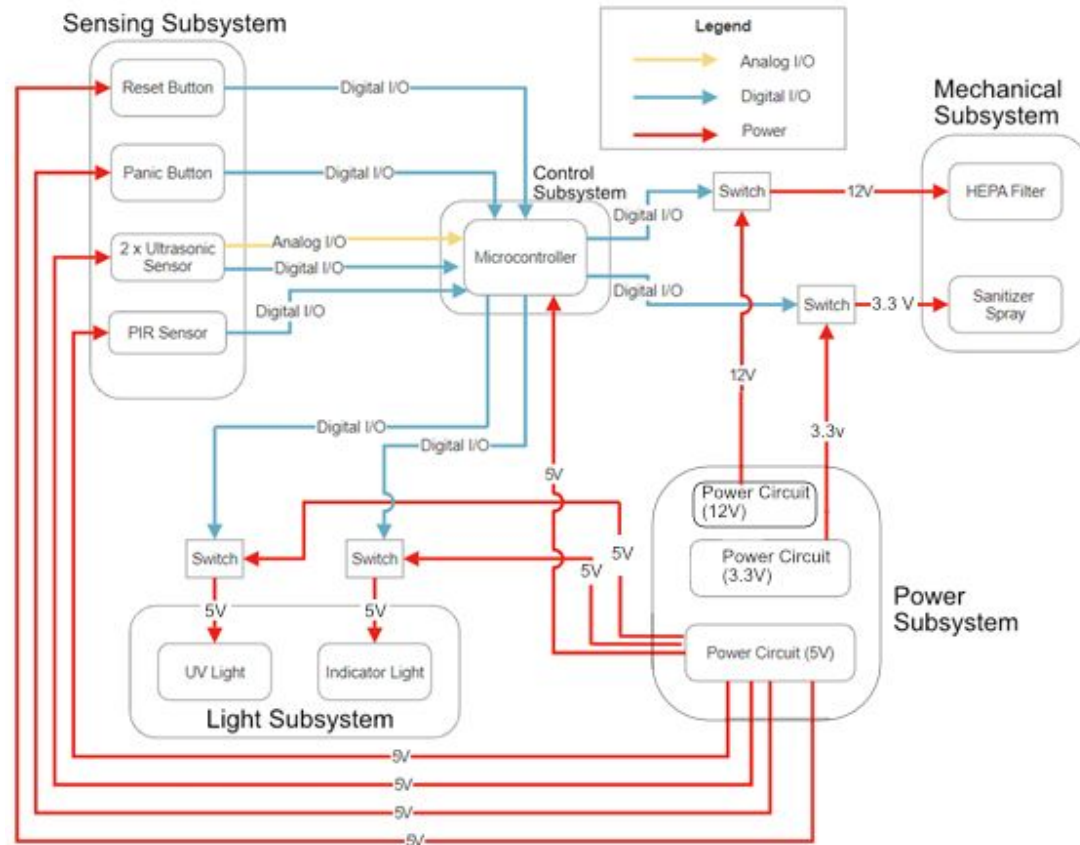
- Higher return rates
- Losing sales to online shopping
- Staff members need to continuously clean

Build a Self-Sanitizing Room

- Sanitization System:
 - UV Light
 - HEPA Filter
 - Sanitizer Solution
- Detection System
 - Ultrasonic Sensors
 - PIR Sensor
- Additional Features
 - Panic Button
 - Maintenance Button



Block Diagram

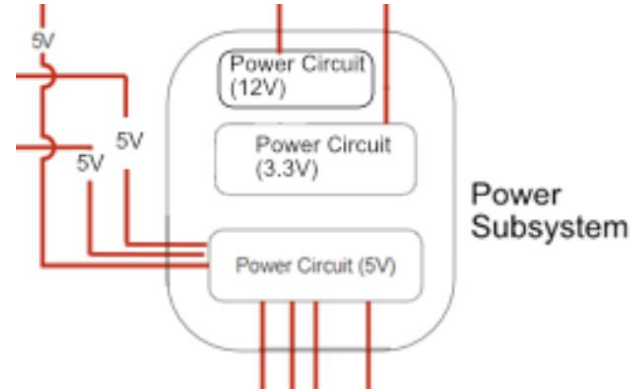


- 95% of the air in the fitting room $\pm 5\%$ must be filtered during the disinfection process
- The fitting room must go through the entire disinfection process within 3 minutes ± 10 seconds of detecting the occupant leaving with the disinfectant covering 95% $\pm 5\%$ of the bench, hangar, and doorknob surfaces
- The detection system of an occupant in the fitting room must be accurate 95% of the time $\pm 5\%$

Power Subsystem

DC/DC Converters:

- Power circuits for control and sensor subsystems must be able to supply 5V +/- 0.2V and 40mA
- Power circuits for mechanical and light subsystems should provide 12V/**3.3V**, 200/**150mA**, and 5V/80mA respectively



AC/DC Converter:

- 12V/1A wall adapter should provide 12V/500mA to the board from a 120V wall plug

Sensor Subsystem

Buttons:

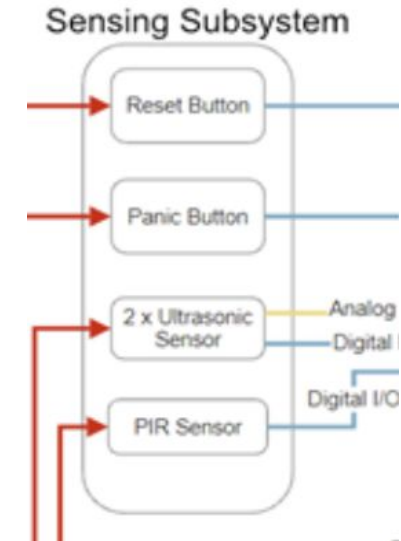
- Panic button should always reset the microcontroller to the OCCUPIED state
- Maintenance button should always set the microcontroller to a HOLD state until pressed again

PIR Sensor:

- PIR Sensor have 95% +/- 5% accuracy
- Check the output duration of the sensor with the oscilloscope

Ultrasonic Sensor:

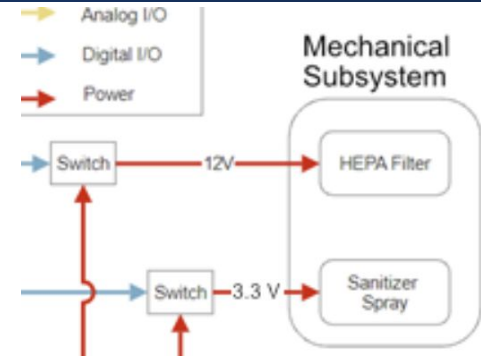
- 95% +/- 5% accuracy with an average speed of 1m/s to 4m/s
- Using **wave generator for trigger signal**, measure the output with the oscilloscope



Mechanical Subsystem

Water Pump:

- The doorknob, hangar, and bench must receive sanitizer spray for 10 seconds +/- 5 seconds, 5 seconds +/- 2 seconds, and 5 seconds +/- 2 seconds respectively
- Check if the sprayers turn on in the SANITIZE state and turn off in the OPEN and OCCUPIED state



HEPA Filter:

- HEPA filter should circulate 95% +/- 5% of the air in the fitting room
- Check if the HEPA filter turns on in the SANITIZE state and turns off in the OPEN and OCCUPIED state

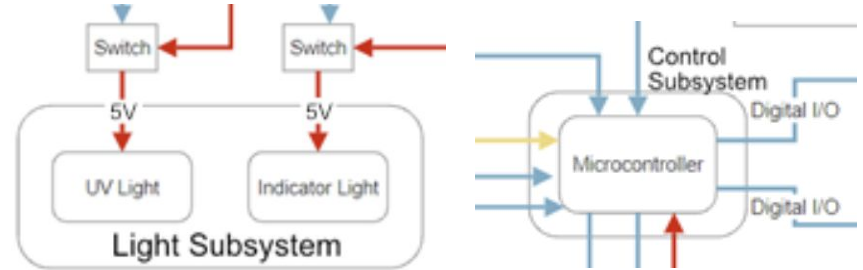
Light and Control Subsystems

UV Lights:

- UV light should always turn on within 10 seconds after the sanitization process starts

Indicator Lights:

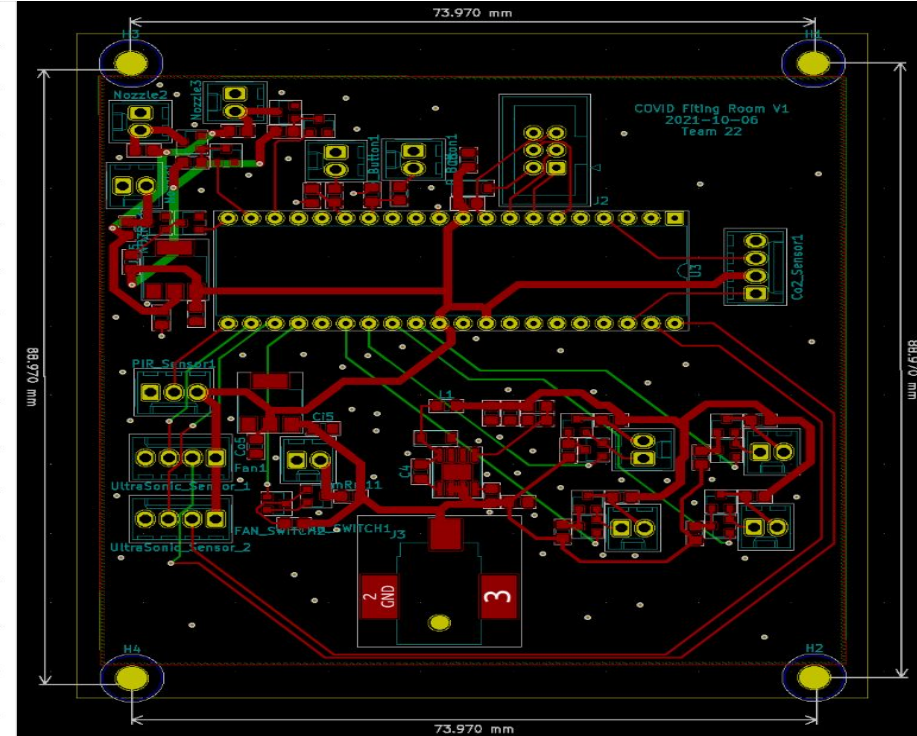
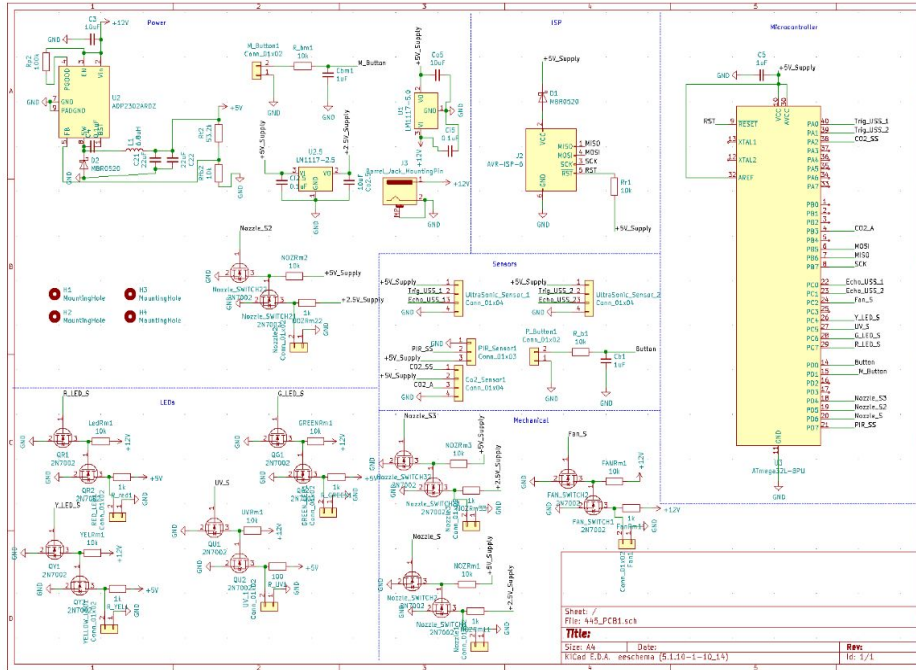
- Lights must indicate the occupancy and state of the room within 10 seconds of changing states



Microcontroller:

- Microcontroller should send correct output signals in each of the OPEN, SANITIZE, and OCCUPIED states with 99% accuracy

Final PCB Design and Schematic



Sensing Subsystem

Ultrasonic Sensor:

- Triggered with 40kHz, 10us pulse
- Duration of the ECHO signal matches the measured distance
- Powered with 5V/8mA



PIR Sensor:

- Gives HIGH output of 3.3V
- Picks up movement in ~5ft radius
- Duration adjusted to ~13s with the potentiometer



Buttons:

- Floating node connected to the MCU pin
- Shorts the node when the button is pressed, triggering a LOW input



Mechanical and Light Subsystems

Fans:

- Works with 12V
- Pulls 107mA



Water Pumps:

- Works within voltage range 2.5-5V
- Powered by 3.3V/50mA per pump



LEDs:

- Works with 5V supply
- All LEDs together drew 80mA



UV LEDs:

- Tested done with multimeter without viewing the UV LED itself due to safety hazards



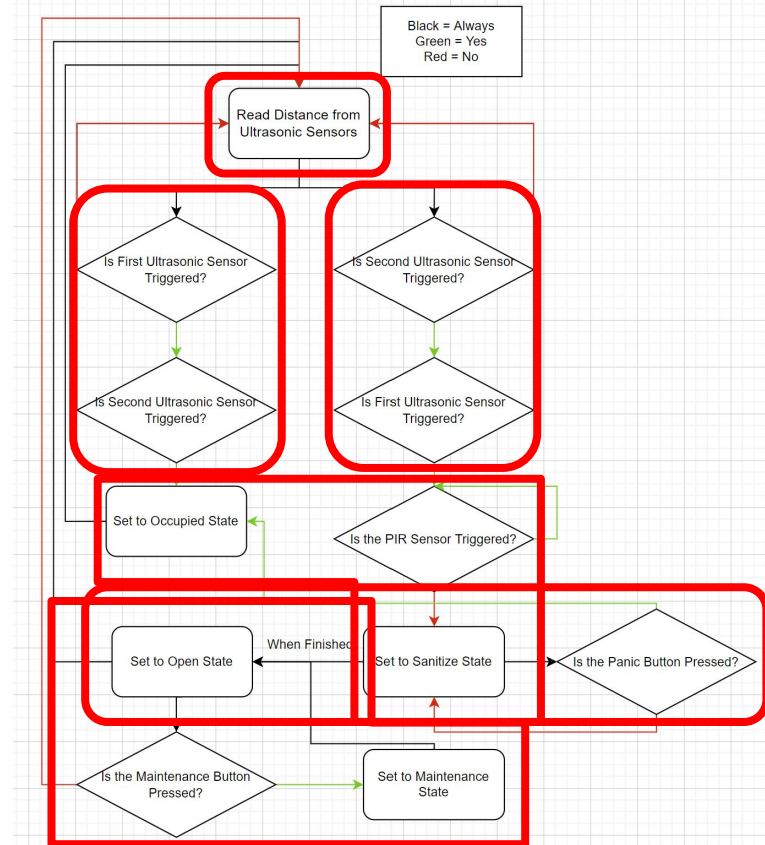
Power Subsystem

Power Component	3.3V Voltage Regulator	5V Voltage Regulator	Buck Converter	12V AC/DC Adapter
Supplies	Water Pumps	Ultrasonic Sensors, PIR Sensor, Microcontroller	LED Lights, 3.3V Voltage Regulator	Filter Fans, Buck Converter, 5V Voltage Regulator
Measured Voltage	3.302V	5.017V	4.617V	12.102V

Coding Algorithm

```
#define TRIG_1 A0
#define TRIG_2 A1
#define ECHO_1 PIN_PC0
#define ECHO_2 PIN_PC1
#define FAN_S PIN_PC2
#define NOZZLE1_S PIN_PD6
#define NOZZLE2_S PIN_PD5
#define NOZZLE3_S PIN_PD4
#define Y_LED_S PIN_PC4
#define UV_S PIN_PC5
#define G_LED_S PIN_PC6
#define R_LED_S PIN_PC7
#define BUTTON PIN_PD0
#define M_Button PIN_PD1
#define PIR_S PIN_PD7
```

```
void setup() {
  pinMode(TRIG_1, OUTPUT);
  pinMode(TRIG_2, OUTPUT);
  pinMode(ECHO_1, INPUT);
  pinMode(ECHO_2, INPUT);
  pinMode(FAN_S, OUTPUT);
  pinMode(NOZZLE1_S, OUTPUT);
  pinMode(NOZZLE2_S, OUTPUT);
  pinMode(NOZZLE3_S, OUTPUT);
  pinMode(Y_LED_S, OUTPUT);
  pinMode(UV_S, OUTPUT);
  pinMode(G_LED_S, OUTPUT);
  pinMode(R_LED_S, OUTPUT);
  pinMode(BUTTON, INPUT);
  pinMode(M_Button, INPUT);
  pinMode(PIR_S, INPUT);
  // enable internal pullup
  digitalWrite(BUTTON, HIGH);
  digitalWrite(M_Button, HIGH);
  digitalWrite(FAN_S, LOW);
  digitalWrite(NOZZLE1_S, LOW);
  digitalWrite(NOZZLE2_S, LOW);
  digitalWrite(NOZZLE3_S, LOW);
  digitalWrite(Y_LED_S, LOW);
  digitalWrite(G_LED_S, LOW);
  digitalWrite(R_LED_S, LOW);
  digitalWrite(UV_S, LOW);
}
```





Ethical and Safety Concerns



- IEEE Code of Ethics
 - Made sure all work was done equally and fairly with all references cited
- Ensure Customer Privacy
 - Utilized a PIR sensor instead of a camera
- Exercise Caution in the Lab
- Water Pumps in the Lab
 - Used water instead of sanitizer when testing the pumps
- UV Light Safety Hazards
 - Long exposure to UV light can cause eye damage



Challenges:

- Preventing false triggers
- Not being able to use footage or visual cues for detection for privacy

Successes:

- Power subsystem delivers power at required voltages
- Switching circuit works correctly
- Microcontroller and the control system function in the right order
- Sanitizer pump, HEPA filters, and UV lights turn on for the desired duration
- Overall all subsystems work as desired under ideal circumstances

- Water pump not being powerful enough to push fluid through sharp corners in the tube
 - Low nozzle quality to stop flow instantly
- Some MOSFET connections in the second PCB design was missing resistors
 - Adding the resistors decreased the power going to the pumps
 - Did not work until we found the right resistor value
- Fan blade broke while testing the filter
- Microcontroller burned due to voltage regulator overheating

Looking Forward:

- Viral infections will continue to exist after COVID-19 pandemic
- Fitting rooms still need to be cleaned

Improvements:

- More powerful water pump and higher quality nozzles
- More sensors to decrease the amount of false detections
- Cheap and efficient way to monitor air quality can add value to the design



Questions?

Thank You!

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