

ECE 445 Project Proposal: COVID-Safe Fitting Room

Team 22

Ege Guler, Bill Heniades, Arin Manav

TA: William Zhang

September 16, 2021

ECE 445

1 Introduction

1.1 Goals:

Due to Covid, most stores closed their fitting rooms to customers as a safety measure. This has made buying new clothes an unpleasant experience as people can't use the fitting rooms to make sure they are buying the right size of the clothing. This is also costing money to clothing stores because of decreased customer satisfaction. The stores that have reopened their fitting rooms during the pandemic have to go through disinfection procedures in order to ensure the safety of their customers. This includes spraying down all the high concentration surfaces inside the fitting rooms and still wearing masks to prevent infection from airborne particles.

1.2 Functions:

We are proposing a Covid-safe fitting room that can detect when a customer enters the fitting room and leaves it in order to start a disinfection process that involves using an air filter and sanitizer spray. A sound detector inside the room and two ultrasonic sensors installed next to each other horizontally at the entrance of the fitting room determines whether a customer is entering or leaving depending on which one of the two sensors is triggered first. When a customer enters the fitting room the wait state starts, and the Covid-Safe fitting room waits for the customer to leave. When the sensors detect the customer has left, the indicator light changes, and the sanitizer and air filters are then turned on to sanitize the air and surfaces in the fitting room. In addition to sensors at the entrance, a motion sensor can be used in the fitting room to make the customer detection more accurate. Also, a panic button inside prevents the customers from being stuck inside when the disinfection process starts. Instead of doing a full-scale model, a locker can be used to represent a room and a scaled down implementation can be done. Additionally, disinfection products are already being used in many commercial spaces, therefore in the long term, using the disinfection products wouldn't cause harm to furniture or the products in the fitting room. Another feature of the room is the indicator light which changes color according to the state of the room. For example if someone is in the room it lights up yellow, when the disinfection is taking place it lights up red, and when the room is empty and disinfected it lights up green.

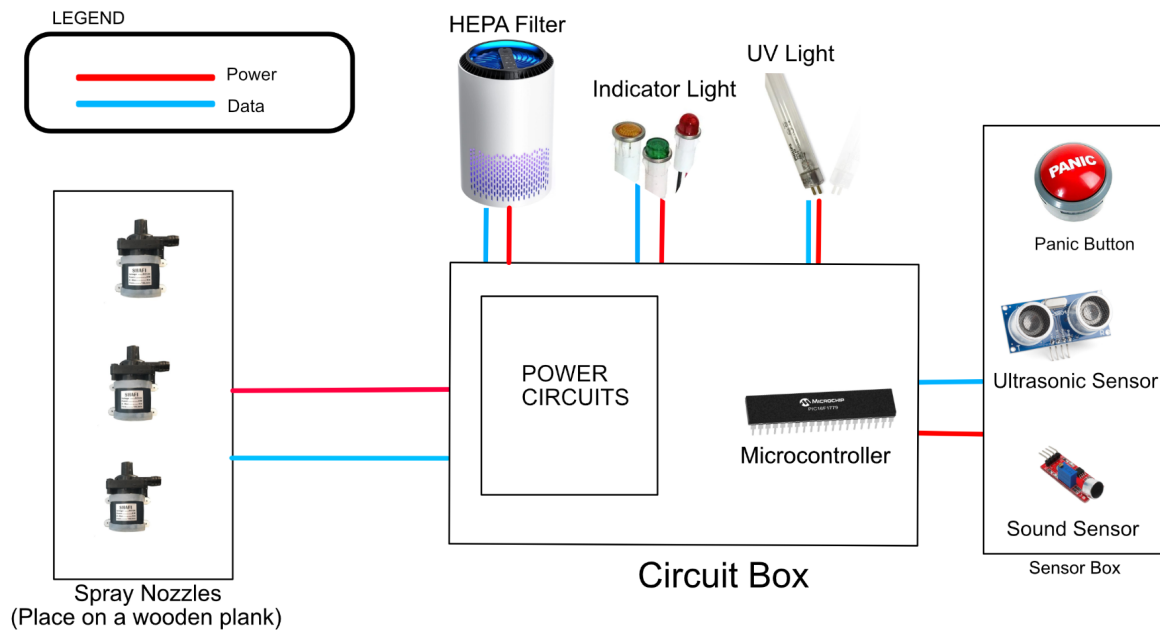
1.3 Benefits:

This product would allow users to feel safe going into cleaned and sanitized rooms all the time as well as providing stores a more efficient process to cleaning. This way, the store employees wouldn't always have to be monitoring and cleaning the fitting rooms whenever a customer wants to use them. It also ensures that the rooms are always clean and customers are happy.

1.4 Features:

The value behind this product lies in the efficiency and user interface of the system. Customers find the value in the easy to understand indication lights for knowing when a room has been thoroughly cleaned for them to use. Stores will want to incorporate this product into their own fitting rooms in order to increase the customer satisfaction as well as provide a more efficient system where their employees don't have to worry about always monitoring and cleaning the rooms but can direct their attention to more important matters around the store.

1.5 Visual Aid:

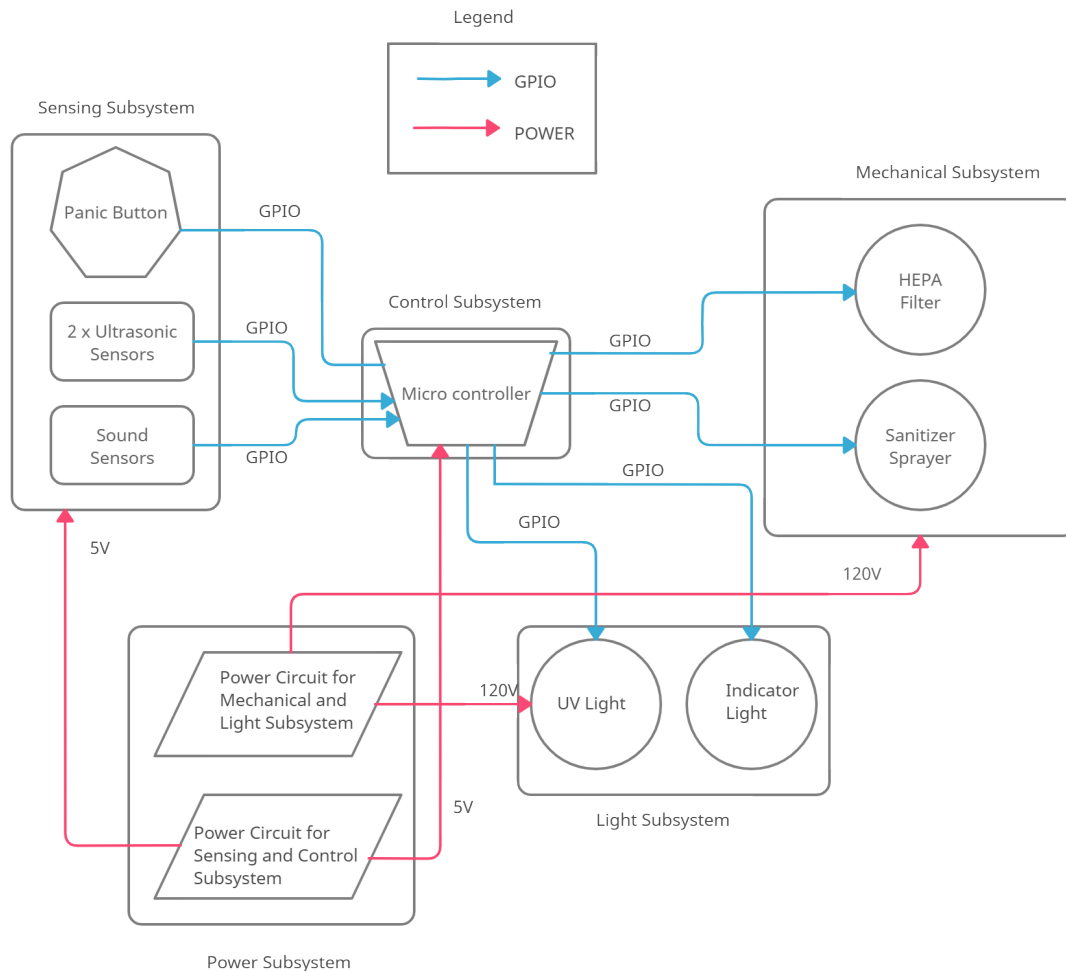


1.6 High-level requirements list:

- Nessbase HEPA Air Purifier can make air circulate 5 times in 30 minutes in an indoor environment of 20 cubic meters according to its documentation. An average fitting room is 10 cubic meters [6]. Therefore, the HEPA air filter must run for 3 minutes to circulate the volume of air in the room once through the filter.
- The fitting room must go through the entire disinfection process within 3 minutes of detecting the occupant leaving and change the indicator light (tolerance of 30 seconds). Disinfection process - spray all high contact zones, filter the air until calculated time has elapsed.
- The detection system of an occupant in the fitting room must have a 95% confidence interval with a 5% margin of error. The panic button must work 100% of the time when activated by an occupant during a false negative when detecting occupancy.

2 Design

2.1 Block Diagram:



2.2 Block Descriptions:

2.2.1 Sensing Subsystem: This subsystem has the sensors used for the advance detection scheme. The two ultrasonic sensors detect the entrance and exit of the customer depending on which sensor is triggered first. These sensors will be placed at the entrance and they will provide input to the microcontroller. Depending on this input the microcontroller will switch between OPEN, OCCUPIED and SANITIZE states. The sensor will interact with the microcontroller through GPIO connection. It will be powered by the power subsystem delivering 5V to it.

To make it more accurate a sound sensor will be placed in the room. These sensors will interact with the microcontroller through GPIO connections. The inputs from the sensor will determine the state of the room and the microcontroller will produce outputs accordingly. It will be powered by the 5V input coming from the power subsystem.

The panic button is also included in this subsystem. The panic button will reset the state of the microcontroller to OCCUPIED, in which the indicator light will be yellow and the mechanical subsystem as well as the UV light will remain powered off. It will be powered by the 5V input coming from the power subsystem.

Requirement 1: The ultrasonic sensors are going to be placed a certain distance apart, which will be able to tell whether a person is entering or leaving a room depending on the order of triggering of the sensors.

Requirement 2: The sound sensor should disregard the noises below 40 decibel. In order to prevent accidentally picking up other background noises.

2.2.2 Control Subsystem: The control subsystem consists of a microcontroller that handles the input and outputs. The inputs to the microcontroller consist of sensor data and the outputs determine whether to run the mechanical parts and the lights. The duration of the SANITIZE state in which the HEPA filter runs is determined by the amount of time it takes the HEPA filter to filter the volume of air in the room. In this state sanitizer is also sprayed to certain areas in the room that are touched the most. In the OCCUPIED state, the indicator light changes to a color that indicates the room is occupied. In the OPEN state, the HEPA filter stops running, the sanitizer stops being sprayed and the UV light turns off.

Requirement 1: The microcontroller should switch between the states in the following order: OPEN, OCCUPIED, SANITIZE.

Requirement 2: The microcontroller must be able to communicate with a speed greater than 4mB/s.

2.2.3 Power Subsystem: Provides power to different subsystems with different voltage requirements. The voltage requirements of the microcontroller and sensors are different from the voltage requirements of the mechanical parts and lights. The power circuit for mechanical and light subsystems will be connected to the HEPA filter,

Requirement 1: Power circuit for control and sensor subsystems must be able to supply 5V with a tolerance of 0.2V to the microcontroller, ultrasonic sensors, and sound sensor.

Requirement 2: Power circuits for mechanical and light subsystems should provide 120V with a tolerance of 5V.

2.2.4 Light Subsystem: Light subsystem consists of two different types of light. The UV light is used for the SANITIZE state and only turns on during the sanitization process. The indicator

light remains on during every state but changes color depending on the state. The different colors of light indicate whether the room is in OCCUPIED, SANITIZE, or OPEN state.

Requirement 1: Lights must indicate the occupancy and state of the room within 30 seconds of changing states with 95% confidence interval and 5% margin of error.

Requirement 2: UV light should turn off within 10 seconds after the sanitization process is done with 99% percent confidence interval and 1% margin of error.

2.2.5 Mechanical Subsystem: Mechanical subsystem consists of the HEPA filter and the sanitizer sprayer. They interact with the microcontroller and depending on the state of the room the HEPA filter and sanitizer spray turn on. The HEPA filter helps filter Covid sized particles around 4-10 microns [1] [4].

Requirement 1: The HEPA filter should run for 3 minutes in order to circulate all the air fitting room through the filter.

Requirement 2: The spray zones must cover the targeted zones with the appropriate amount of sanitizer. The highest concentration zone of the doorknob must receive sanitizer spray for 30 seconds with a tolerance of 5 seconds. The two lower concentration zones of the bench and hangar must receive sanitizer spray for 15 seconds each with a tolerance of 5 seconds.

2.3 Risk Analysis: Identify an aspect of your design that poses a risk to successful completion of the project. Demonstrate the feasibility of this component through mathematical analysis or simulation.

We need to test our pcb design and individual components before putting them together. The pcb design will be reviewed with a professor or TA in the pcb. The components will be individually tested on a breadboard to ensure they are working properly. Also, a bulk order will be placed for small and fragile components.

3 Ethics and Safety

One ethical issue pertaining to the project is the similarity to the Covid Convenience Locker which was done in the past. In order to prevent any plagiarism or copying from the previous project, we will make sure our solution is unique and have applications that are solely for fitting rooms rather than the locker which was done in the past. We will also make sure that all the work is evenly distributed amongst the group to treat everyone fairly and ensure it's a group project. We will abide by the IEEE Code of Ethics and make sure all research conducted is correctly cited and referenced [5].

As with all other projects, our project also utilizes high current systems where we would have to physically test. This could create a dangerous environment if not controlled during the development and testing stage. We would also need to test these circuits on the PCB board, which due to its size can cause some accidents in addition to the potential risk while soldering the components onto the PCB.

Long exposure to UV light can also present harmful effects. Direct exposure to skin and eyes from UVC radiation could cause painful eye injury or rashes on the skin [7]. Therefore, the margin of error for the UV light is set very low at 1%. Also, it has been set to turn off within 10 minutes after the end of the SANITIZE state. The design also has a panic button that a user can press so if the detection system fails and an occupant is still inside during the disinfection stage, they can press the button to cancel the disinfection process. Similarly, we will have the sanitization zones and hepa filter turn on first rather than the UV light in case this situation occurs.

While testing spray nozzles, we will use water instead of an alcohol based sanitizer since alcohol is both flammable and corrosive. Therefore, it would be dangerous to test it with real sanitizer in a lab setting. The nozzles will also be placed on a wooden plank separating them from the electrical components.

References

- [1]B. Lee, "Minimum Sizes of Respiratory Particles Carrying SARS-CoV-2 and the Possibility of Aerosol Generation", *National Center for Biotechnology Information*, 2021. [Online]. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7579175/>. [Accessed: 16- Sep- 2021].
- [2]C. Barber, "Protecting against COVID's Aerosol Threat", *Scientific American*, 2021. [Online]. Available: <https://www.scientificamerican.com/article/protecting-against-covids-aerosol-threat/>. [Accessed: 16- Sep- 2021].
- [3]NCIRD, "Community, Work, and School", *Centers for Disease Control and Prevention*, 2021. [Online]. Available: <https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html>. [Accessed: 16- Sep- 2021].
- [4]"Fine Particles (PM 2.5) Questions and Answers", *Health.ny.gov*, 2021. [Online]. Available: https://www.health.ny.gov/environmental/indoors/air/pm2_5.htm#:~:text=National%20

Ambient%20Air%20Standards%20are, is%2012%20%C2%B5g%2Fm3. [Accessed: 16-Sep- 2021].

[5]"IEEE Code of Ethics", Ieee.org, 2021. [Online]. Available: <https://www.ieee.org/about/corporate/governance/p7-8.html>. [Accessed: 16- Sep- 2021].

[6]"Nessbase HEPA Air Filter Purifier", Amazon.com, 2021. [Online]. Available: <https://www.amazon.com/Nessbase-Purifier-Cleaner-Pretreatment-Eliminate/dp/B09BQMPDS5>. [Accessed: 16- Sep- 2021].

[7]"UV Lights and Lamps: Ultraviolet-C Radiation, Disinfection, and Corona", U.S. Food and Drug Administration, 2021. [Online]. Available: <https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/uv-lights-and-lamps-ultraviolet-c-radiation-disinfection-and-coronavirus>. [Accessed: 16- Sep- 2021].