ECE 445, SPRING 2021

Self-Cleaning Locker

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Introduction

- Gym lockers are the main storage units used to hold someone's belongings while at the gym

- No one knows who has used a particular locker before them, nor if the previous person was in contact with other people who had COVID-19

- Research shows that COVID-19 can last up to two days on fabric, and even up to nine days on certain surfaces

Objectives

- Allow gym users to be worry-free about where they place their belongings in the shared gym locker room
- Allow gym users to visually see whether or not a particular locker is clean
- Allow gym owners to monitor how much disinfectant supply their lockers have left

Proposal

- Build a gym locker that disinfects its interior space when not in use, to ensure that it is clean for the next user
- Include LCD display that allows users to see if locker is clean, in the process of cleaning, and if disinfectant supply is low
- Develop Android Application that allows gym owners to monitor how much disinfectant supply is left for a particular locker

High Level Requirements

1. Weight sensors correctly detect when items weighing at least 250 grams are on top of them with an error range of roughly 5%.

2. Spray correctly cleans the inside of the locker when it is empty and closed, covering at around 90% +/- 5% of the interior surface area.

3. Locker correctly detects different disinfectant supply levels with an error range of around 5% at each level.

Original Design Sketch

Figure 1: Sketch of locker front exterior

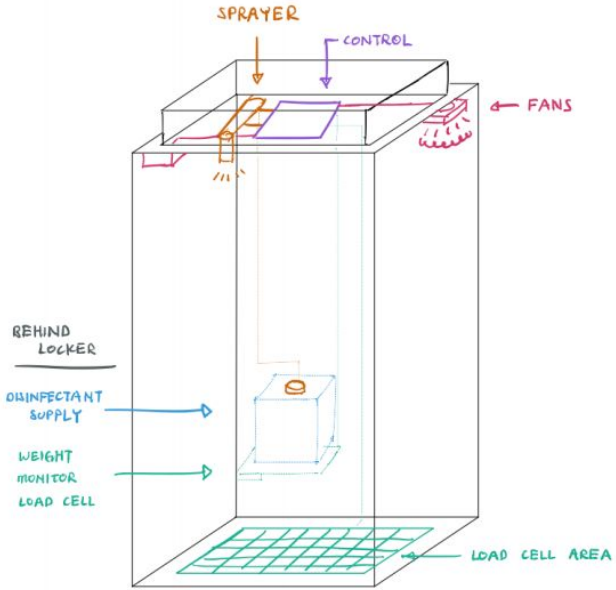
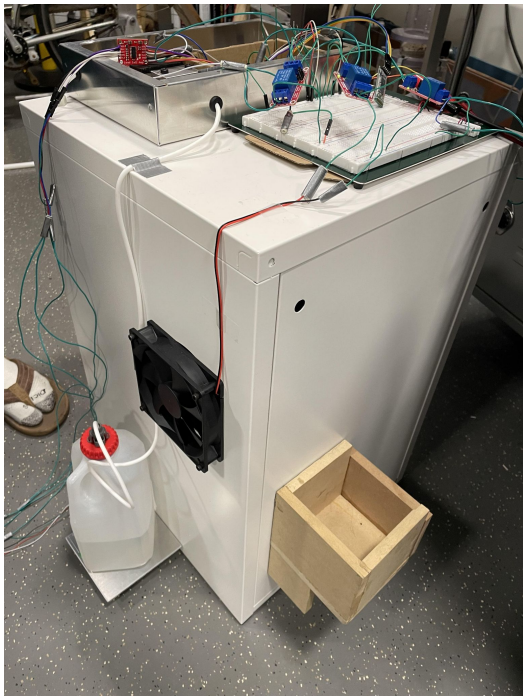


Figure 2: Sketch of locker interior with subsystems

Final Project



Block Diagram

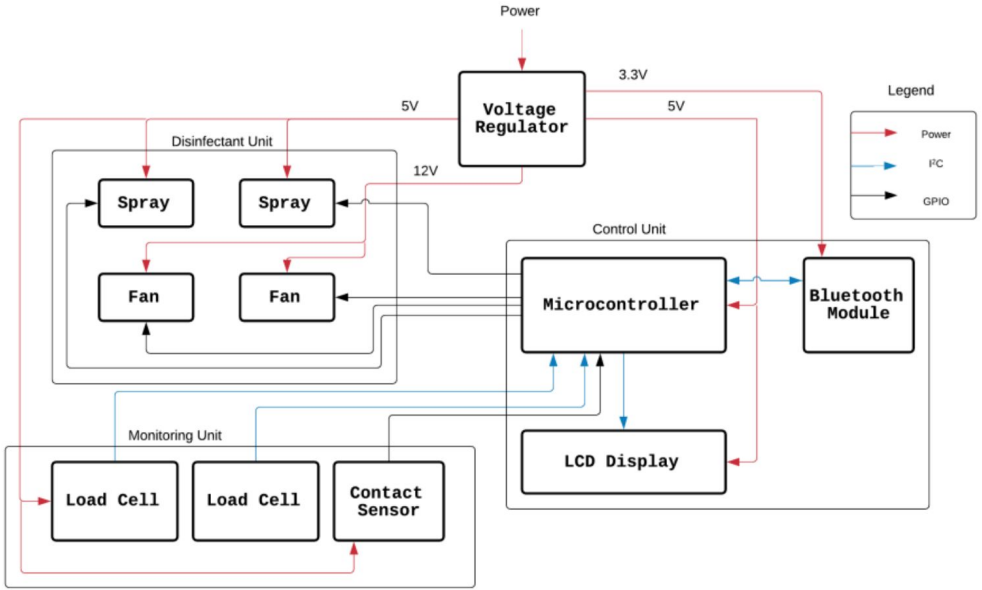


Figure 3: Block Diagram

Circuit & PCB Design

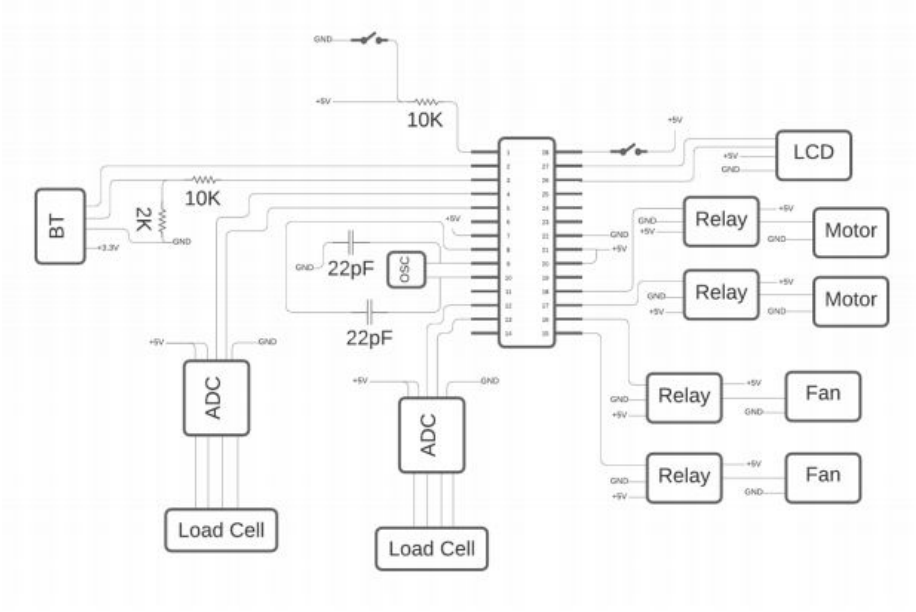


Figure 4: Circuit Schematic

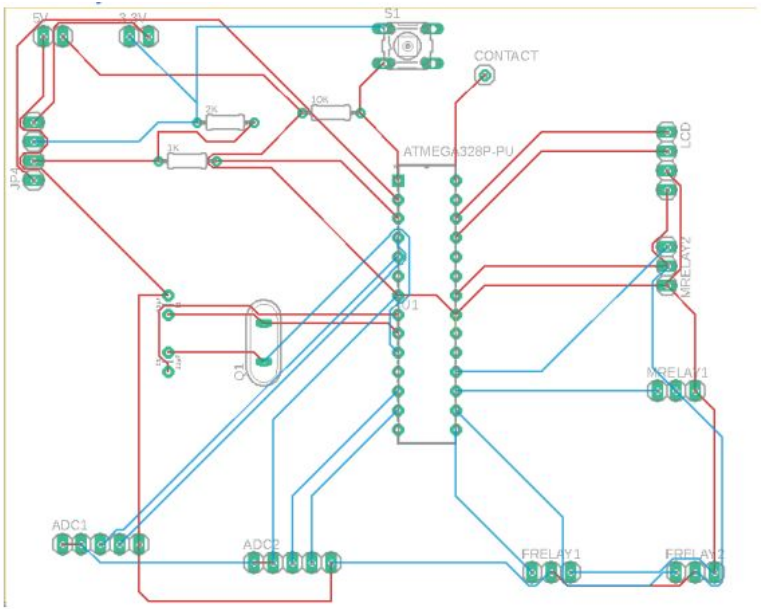
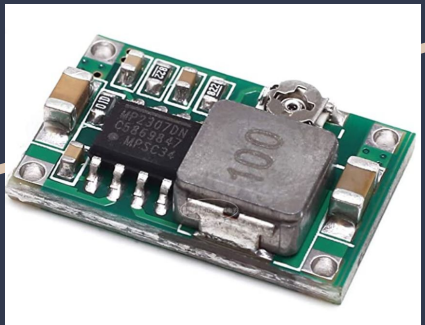


Figure 5: Board Layout

Components & Design

Power Supply



Components:

- 12V DC Wall Power Supply
  - Supplies voltage to sprayer and fans
- Step-Down Power Converter
  - Converts 12V to 5V
  - 5V used to power microcontroller, Bluetooth transceiver, & load cells/amplifiers

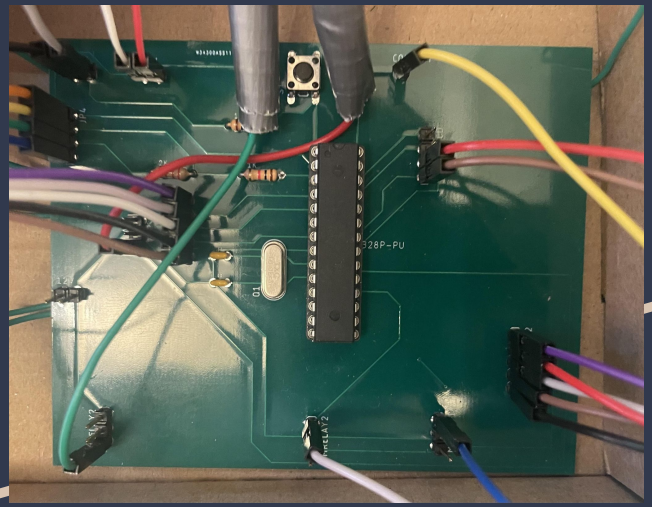
Input Voltage	Desired Voltage	Output Voltage
+12V	+5V	+4.994V

Control Unit

Components:

- ATMEGA328P-PU Microcontroller
- HC-05 Bluetooth Transceiver
- LCD Display

ATMEGA328P-PU Microcontroller

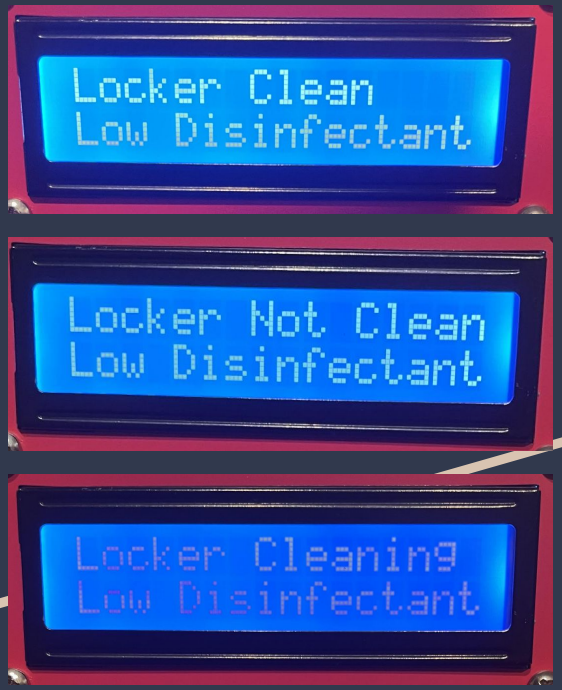


Programmed to allow locker functionality for sanitation process:

- If interior load cell & door is closed: initiate sprayer
- After sprayer finishes, start fans
- LCD display should show correct corresponding message (next slide)

Also programmed to communicate with exterior load cell to HC-05 Module to update Android Studio application image (more info later)

LCD Display



1. Locker finished sanitizing/drying & is empty:

   → **“Locker Clean”**

2. Locker has an object inside:

   → **“Locker Not Clean”**

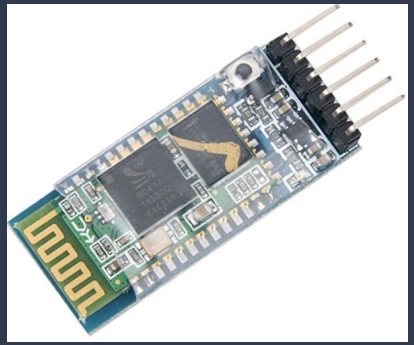
3. Sprayer/fan is in use:

   → **“Locker Cleaning”**

4. Disinfectant supply is ≤ 25% of total supply:

   → **“Low Disinfectant”**

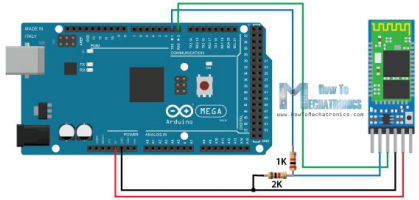
HC-05 Bluetooth Transceiver



Used to send disinfectant supply level to Android Application

Needed to implement voltage divider circuit:

- Transmit pin has 5V output
- Receive pin only supports 3.3V



$V_{out} = V_{in} * (R1 / (R1 + R2))$

$V_{out} = 5 * (2 / (2+1)) =$ **3.3V**

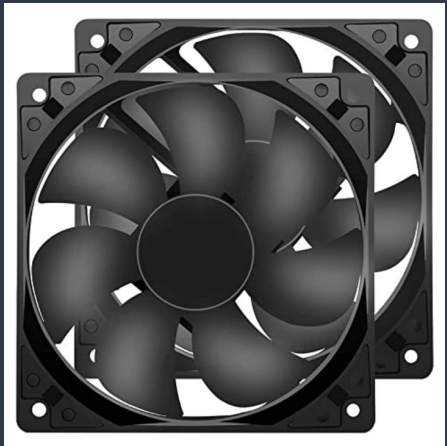
Input Voltage	Transmit Pin	Receive Pin
+5V	+4.99V	+3.35V

Disinfectant Unit

Components:

- Fans
- Sprayer

Fans

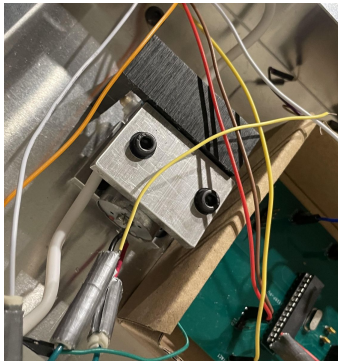


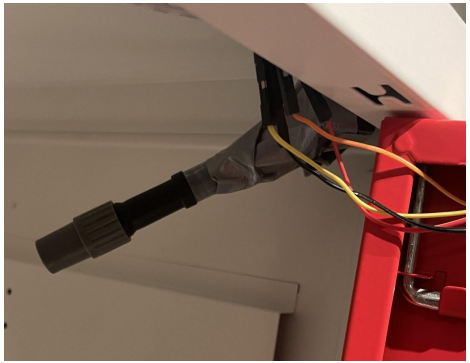
Used to dry interior of locker after sprayer finishes

Input Voltage	Output Voltage	Current
+12V	+12.33V	0.13 A

Sprayer

Used to sanitate interior of locker with disinfectant





Input Voltage	Output Voltage	Current
+12V	+12.22V	0.11 A

Monitoring Unit

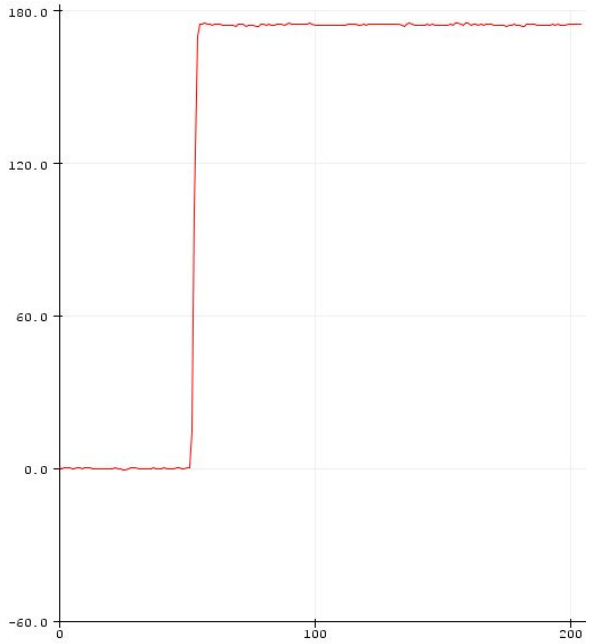
Components:

- HX711 Load Cell Amplifier
- Interior & Exterior Load Cells
- Contact Sensor
- Mobile Android Application

Interior Load Cell & Amplifier

iPhone 12 With Case	Median Load Cell Reading	Percent Difference
172 grams	174.66 grams	1.54%

Graph Readings: (Grams vs. Time (ms))

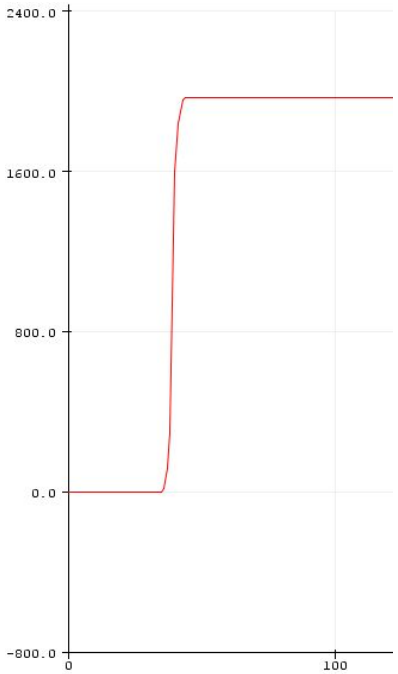



```
23:01:15.555 -> Reading: 0.3 g
23:01:15.622 -> Reading: 0.3 g
23:01:15.725 -> Reading: 0.4 g
23:01:15.825 -> Reading: 0.4 g
23:01:15.929 -> Reading: 0.1 g
23:01:16.031 -> Reading: 0.1 g
23:01:16.131 -> Reading: -0.5 g
23:01:16.198 -> Reading: -0.2 g
23:01:16.299 -> Reading: 0.1 g
23:01:16.400 -> Reading: -0.1 g
23:01:16.501 -> Reading: -0.3 g
23:01:16.604 -> Reading: -0.2 g
23:01:16.703 -> Reading: -0.3 g
23:01:16.772 -> Reading: 10.3 g
23:01:16.876 -> Reading: 87.2 g
23:01:16.978 -> Reading: 163.6 g
23:01:17.078 -> Reading: 174.6 g
23:01:17.180 -> Reading: 175.1 g
23:01:17.248 -> Reading: 174.6 g
23:01:17.351 -> Reading: 174.8 g
23:01:17.452 -> Reading: 175.2 g
23:01:17.553 -> Reading: 175.0 g
23:01:17.657 -> Reading: 174.8 g
23:01:17.725 -> Reading: 174.6 g
23:01:17.827 -> Reading: 174.4 g
23:01:17.930 -> Reading: 174.5 g
23:01:18.033 -> Reading: 174.5 g
23:01:18.136 -> Reading: 174.2 g
```

Exterior Load Cell & Amplifier

Full Disinfectant Supply	Median Load Cell Reading	Percent Difference
1890 grams	1970.43 grams	4.25%

Graph Readings: (Grams vs. Time (ms))




```
01:04:36.404 -> Reading: -0.0 g
01:04:36.505 -> Reading: -0.2 g
01:04:36.573 -> Reading: -0.6 g
01:04:36.673 -> Reading: -0.4 g
01:04:36.774 -> Reading: 20.7 g
01:04:36.875 -> Reading: 211.4 g
01:04:36.977 -> Reading: 224.2 g
01:04:37.078 -> Reading: 624.2 g
01:04:37.145 -> Reading: 1186.6 g
01:04:37.246 -> Reading: 1612.1 g
01:04:37.350 -> Reading: 1854.6 g
01:04:37.452 -> Reading: 1941.7 g
01:04:37.556 -> Reading: 1966.4 g
01:04:37.625 -> Reading: 1978.2 g
01:04:37.724 -> Reading: 1977.0 g
01:04:37.826 -> Reading: 1973.9 g
01:04:37.927 -> Reading: 1971.0 g
01:04:38.028 -> Reading: 1970.6 g
01:04:38.129 -> Reading: 1970.4 g
01:04:38.230 -> Reading: 1970.3 g
01:04:38.296 -> Reading: 1970.4 g
01:04:38.398 -> Reading: 1970.6 g
01:04:38.499 -> Reading: 1970.1 g
01:04:38.599 -> Reading: 1969.8 g
01:04:38.700 -> Reading: 1970.4 g
01:04:38.768 -> Reading: 1970.5 g
01:04:38.871 -> Reading: 1970.8 g
01:04:38.972 -> Reading: 1970.8 g
01:04:39.075 -> Reading: 1970.6 g
```

Contact Sensor

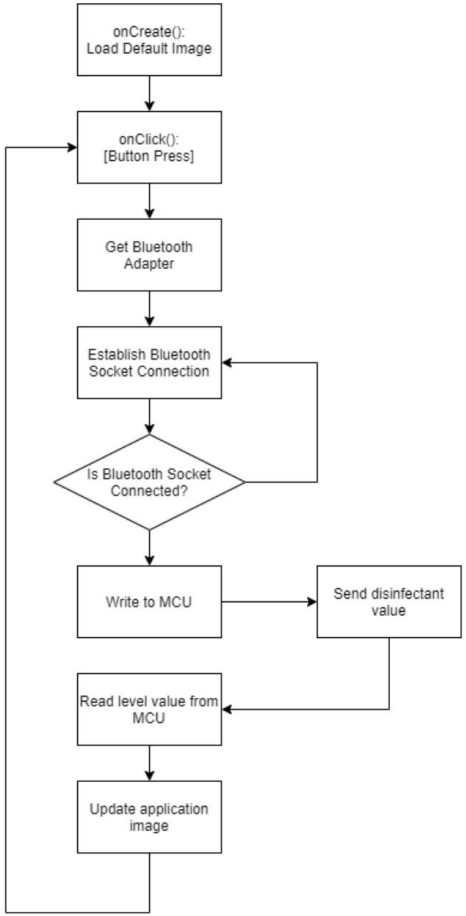
Used to check whether locker door is open or closed in order to tell when to initiate sanitation sequence

Input Voltage	Contact Status	Output Voltage
+5V	Together	+4.95V
+5V	Separate	+0V

Android Studio Application

Integrated HC-05 Bluetooth Transceiver with Android Studio application & MCU

Flow Chart:



Successes

1. Interior load cell was able to correctly detect items weighing significantly less than 250 grams (iPhone 12 With Case: 172 grams)

2. Locker functioned as intended (microcontroller programming worked perfectly)

3. Exterior load cell correctly detects different disinfectant supply levels and communicates changes with the Android Application, updating the image when hitting “Refresh” button

Challenges

1. Interior Coverage
    a. Sprayer did not hit 90% interior coverage that we wanted
    b. We wanted a mist over a light spray so locker is not soaking (which makes it easier for fans to dry as well)
2. Power Step Down Converters
    a. May have gotten low-quality step-down converters, as the 12V to 5V conversion did not hold during testing and burnt out one of our microcontrollers
    b. Had to use separate 5V power source to a different rail during demonstration in addition to our 12V wall outlet plug

Next Steps

Improvements:

a. Make it more presentable

b. Add more sprayers and fans

Additional Features:

a. Biometric Lock

b. Additional Hook Weight Sensor

c. Multiple HC-05 modules

Thank You for Your Time!

Any Questions?