Electronic Replacement for Building Monitors @ UIUC

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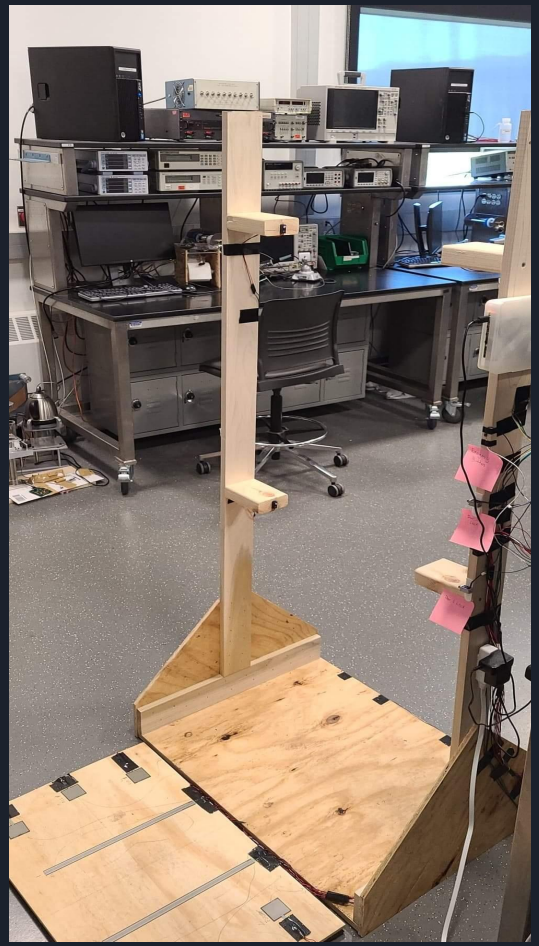
Team #13

What is our Project?

- Even with 6ft social distancing and masks, research shows that it is only about 99.5% effective at preventing the spread of the disease.
- We designed an automated solution to COVID testing check done at the entrance to every building on campus.
- Would limit human interaction to prevent further spread of the virus
- Allows for access to buildings to return to schedules similar to that of pre-COVID times



Objectives

Overall objective is to automate the entry process into buildings around campus using a physical two factor authentication style system, while taking advantage of the airlock style entryways that a majority of campus buildings use.

- Fast and easy to use
- Low error rate in our sensing techniques
- Efficient and safe data processing, to prevent ethical concerns

System Overview

Power Module

- Micro-B 5V 2A AC/DC Converter
- Micro-B Breakout Board

Control Unit Module

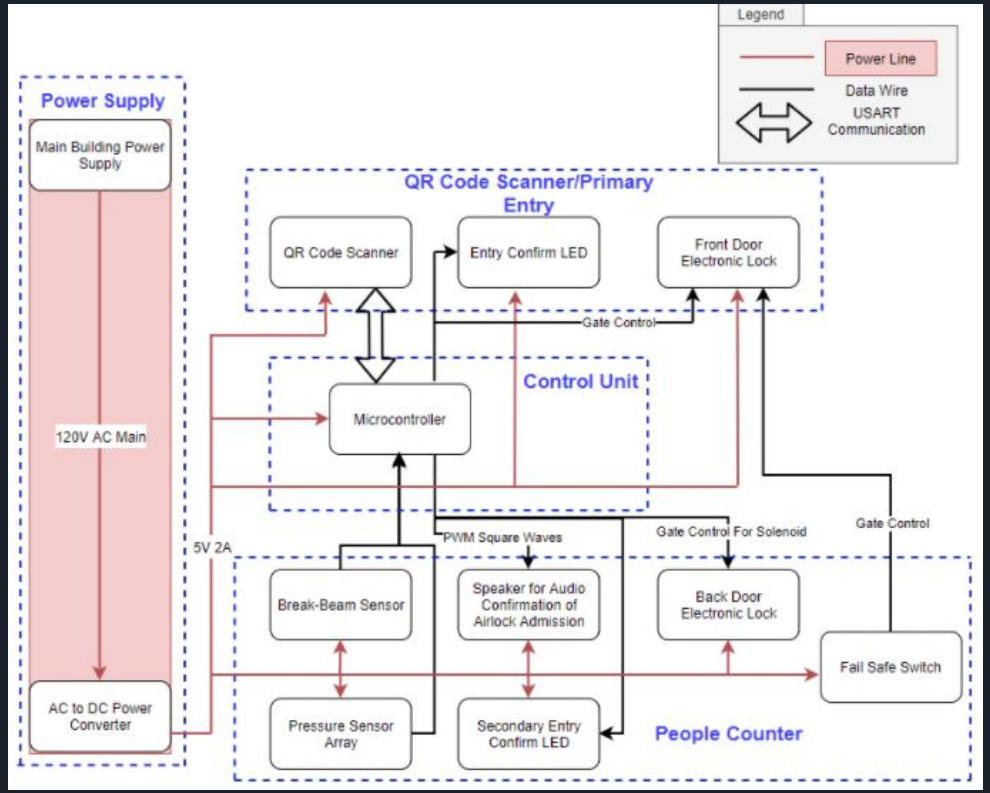
- ATMEGA32-16PU

Input Module (People Counter + QR)

- Raspberry Pi + Camera Module
- Emergency Release Button
- 2x Break-Beam Sensor Pair
- FSR Array Pressure Pad

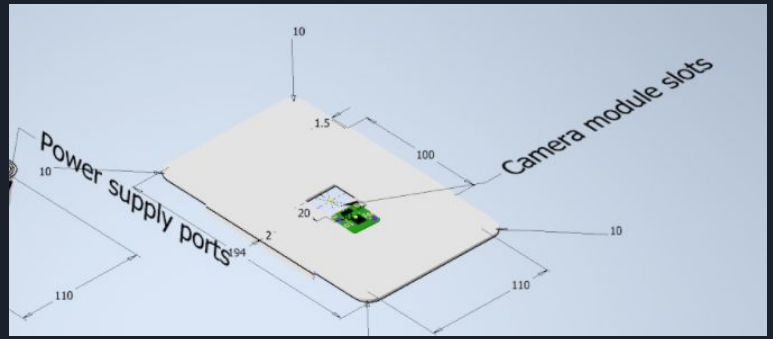
Output Module

- 2x Solenoid Actuators
- LED Indicator
- Audio Amplification + Output



QR Code Entry System

- QR code generator
  - Deployed on the remote server
- QR code scanner
  - Raspberry Pi and Pi Camera module
- QR code decoder
  - Microcontroller



QR Code Entry System - Generator

For first time user:

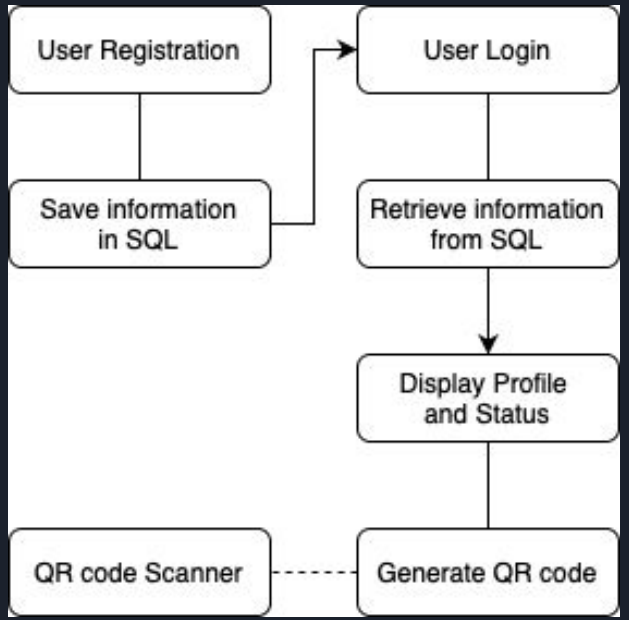
1. Get input new username, password
2. Encrypt the password and store the tuple into the database
   - `password_hash()`
3. Login in. Select the test result and store it
   - MySql


```
+----------+--------------+------+-----+---------+-------+
| Field    | Type         | Null | Key | Default | Extra |
+----------+--------------+------+-----+---------+-------+
| username | varchar(255) | NO   | PRI | NULL    |       |
| password | varchar(255) | NO   |     | NULL    |       |
| status   | tinyint(1)   | NO   |     | 0       |       |
+----------+--------------+------+-----+---------+-------+
```

QR Code Entry System - Generator

After logging in:

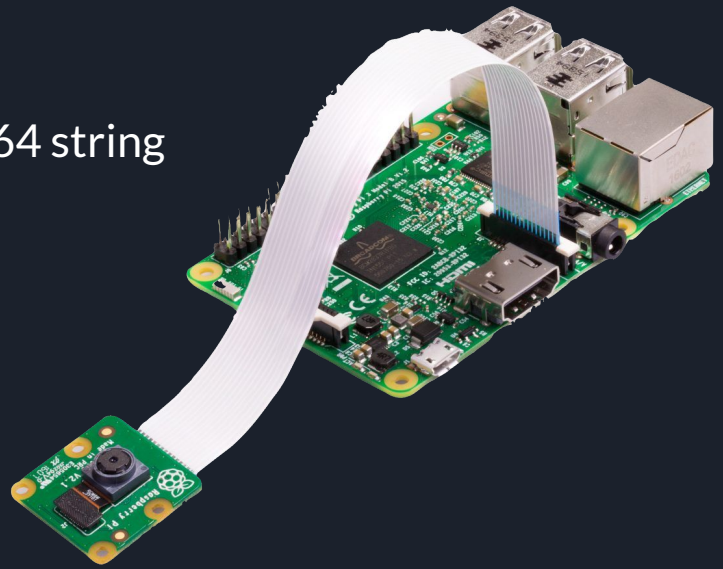
1. Retrieving user's information from database
2. Pack them into json file
    - e.g. {name:"abc",status:"negative"}
3. Encode the file using base64
    - To avoid escape characters
4. Generating the code using phpqrcode library



QR Code Entry System - Generator

After Pi Camera captures the QR code:

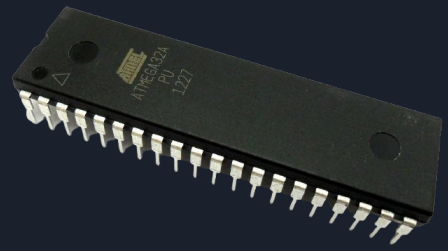
1. Raspberry Pi will transfer it back to base64 string
    - Using openCV library
2. Send it to Microcontroller
    - Using UART serial communication



QR Code Entry System - Decoder

After the microcontroller receives the base64 string:

1. Decode the string back to json file
2. Retrieve the key-value pair
3. Determine whether to open the door



QR Code Entry System - Requirements

- High accuracy (> 95%) to detect the QR code
- Workable under sunlight
- Rapidly send decoded QR code to the microcontroller

QR Code Entry System - Verification

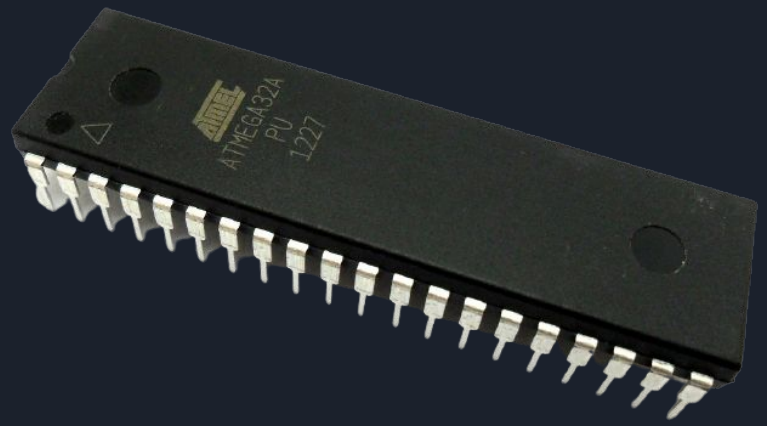
1. Connect the scanner to a monitor, and make sure the QR code scanner can output the expected string..

2. Use different models of phones to display the QR code, and test the scanner under sunlight.

3. Connect the QR code scanner to an Arduino using UART. Check the serial monitor can display the transmitted information correctly.

Microcontroller - Overview

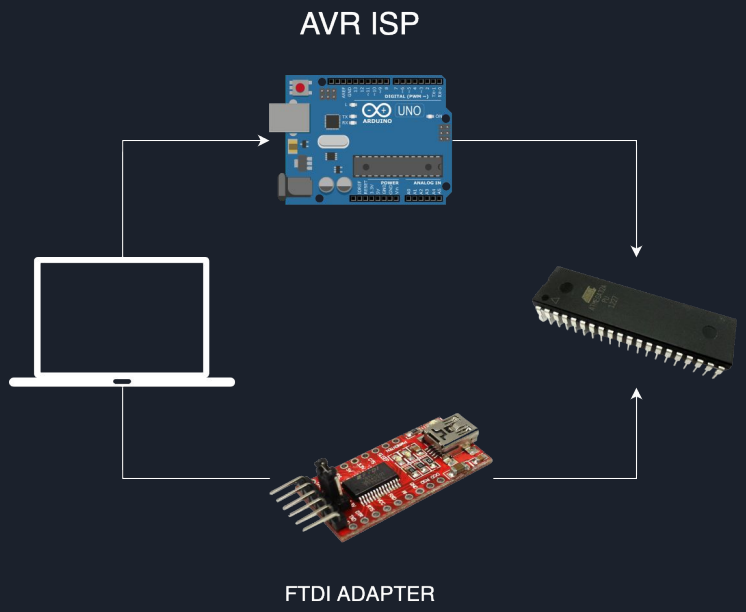
- ATMEGA32
- UART Communication
- QR Code Verification
- LED/Solenoid Control
- Sensors Data Processing
- ...



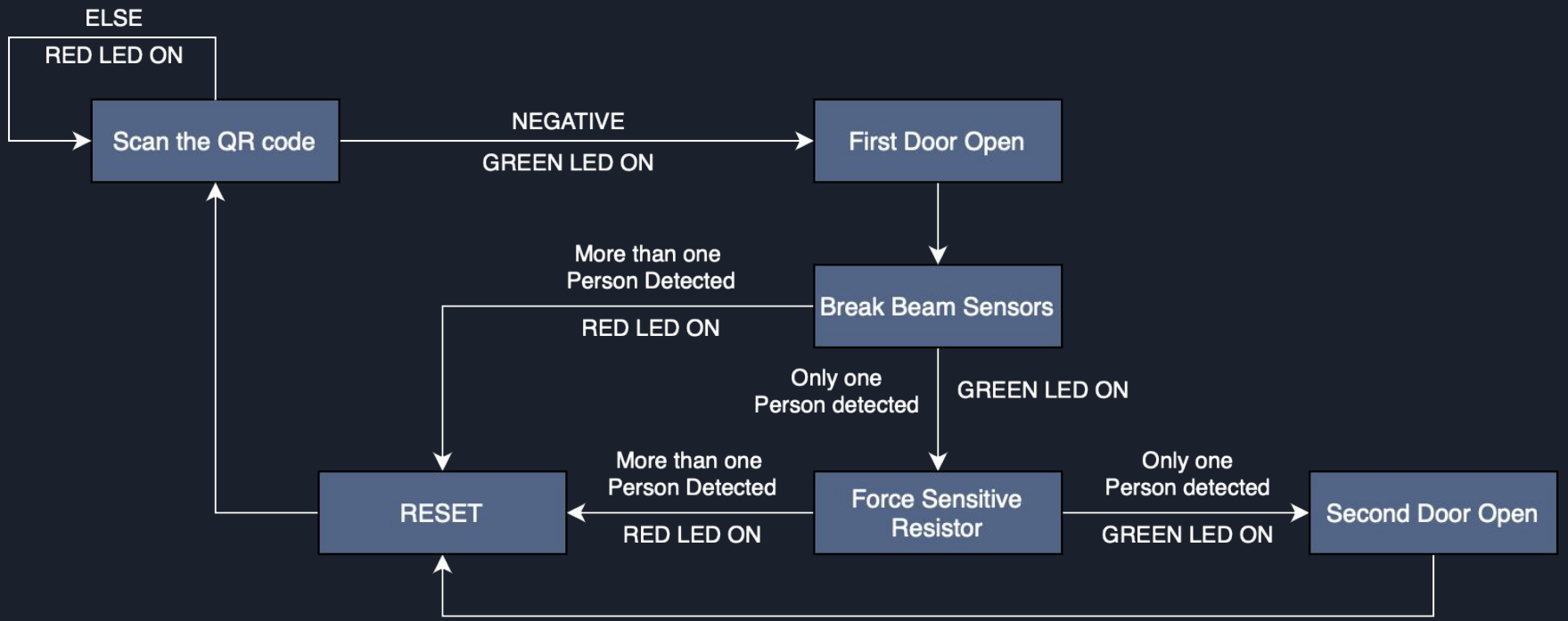
Microcontroller - Programmer

1. Use Arduino as AVR ISP to burn the bootloader into the microcontroller

2. Use FTDI based USB to Serial Adapter to program the microcontroller through UART communication



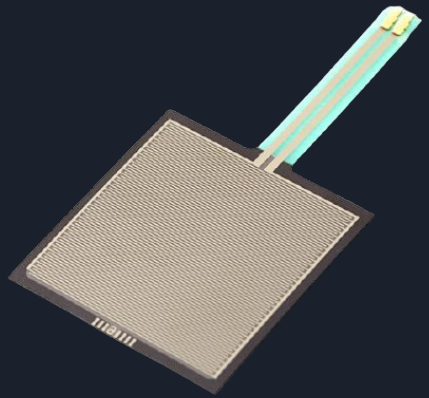
Microcontroller - Workflow



People Counting System - Design

- Break Beam Sensor
  - Active Low
  - Set 2 pairs at different heights

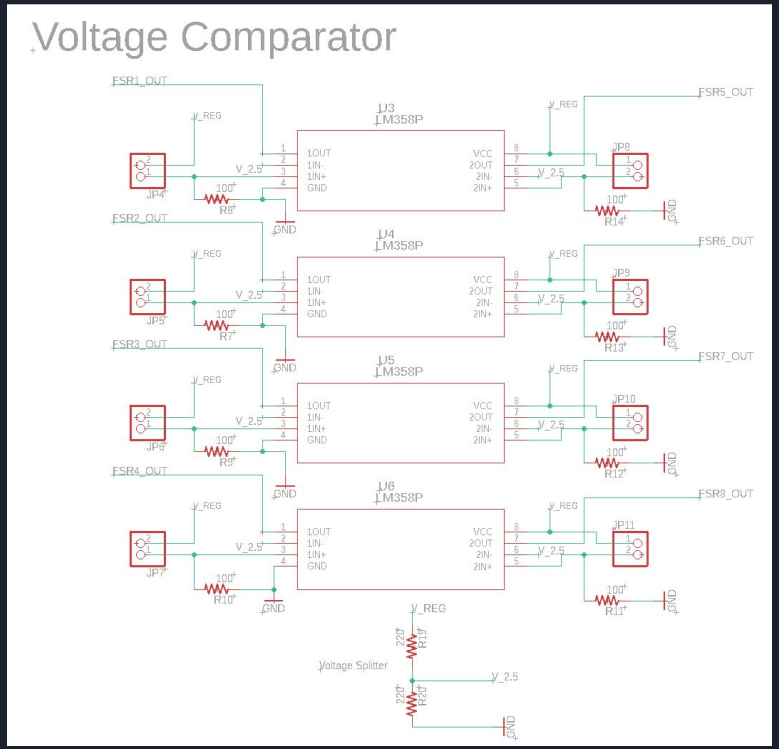
- Force Sensitive Resistor
  - Active HIGH
  - Standing on the middle 2 FSRs for 3 seconds to open the door
  - Set 6 trap FSRs to detect the second person in the area



People Counting System - Design (cont.)

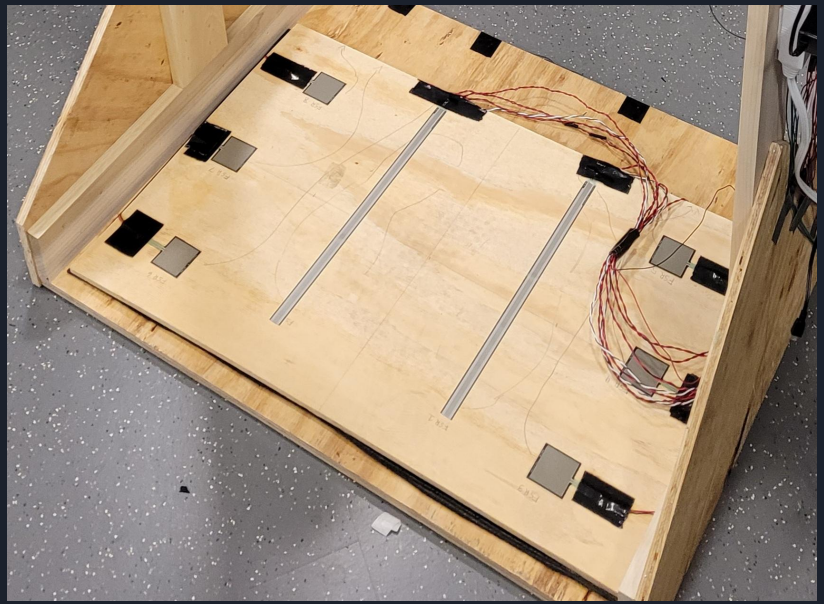
- Break-Beam sensors were very simple, only requiring power and a place for the input to go on the microcontroller with a corresponding pull up resistor

- Pressure plate designed using a voltage comparator
  - Cuts off any unwanted noise from possible disturbances
  - Allows the plate to act as a switch
  - The amount of pressure isn't important, only that there IS pressure



People Counting System - Design (cont.)

- The layout of the FSR array was chosen to maximize space with a limited number of FSRs.
- As the outer edge FSRs are considered “traps”, they needed to be an adequate distance away from the center set, to prevent false alarms and other errors in the system.
- Ideally, this setup would work well while enclosed within a rubber mat as well, for longevity and protection from the elements.

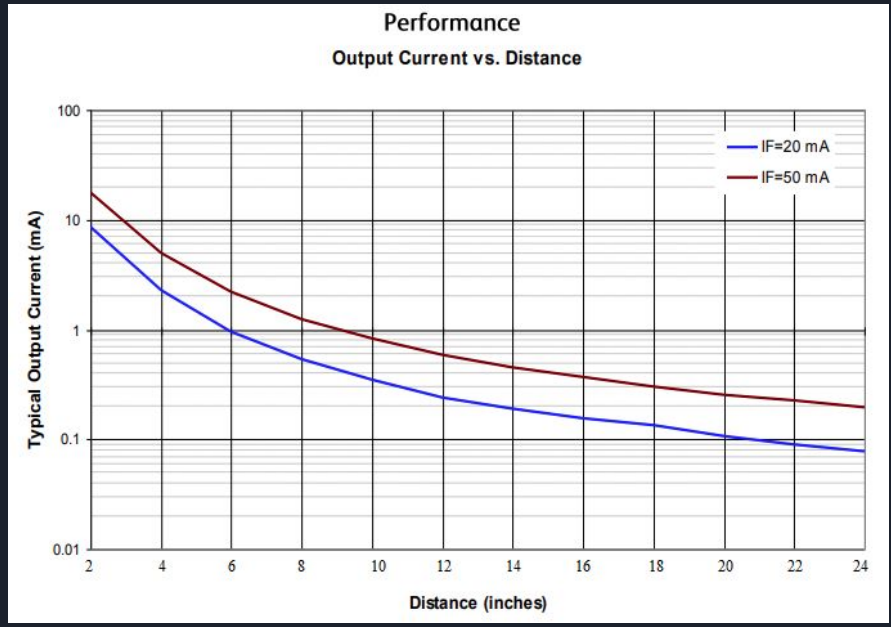


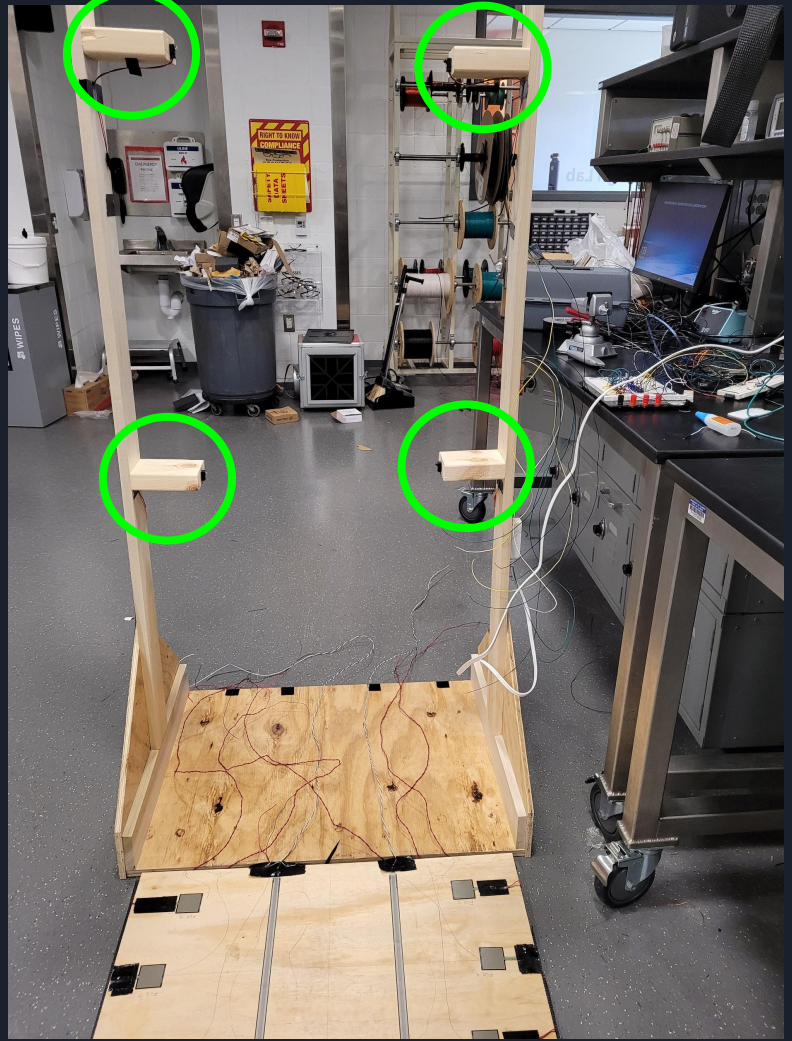
People Counting System - Requirements

- Break-Beam Sensor must be able to span the door frame without hindering the signal
- Pressure pad must be able to recognize multiple pressure profiles to better analyze the number of people entering the space
- Both sensors must work together to provide the best outcome

People Counting System - Results

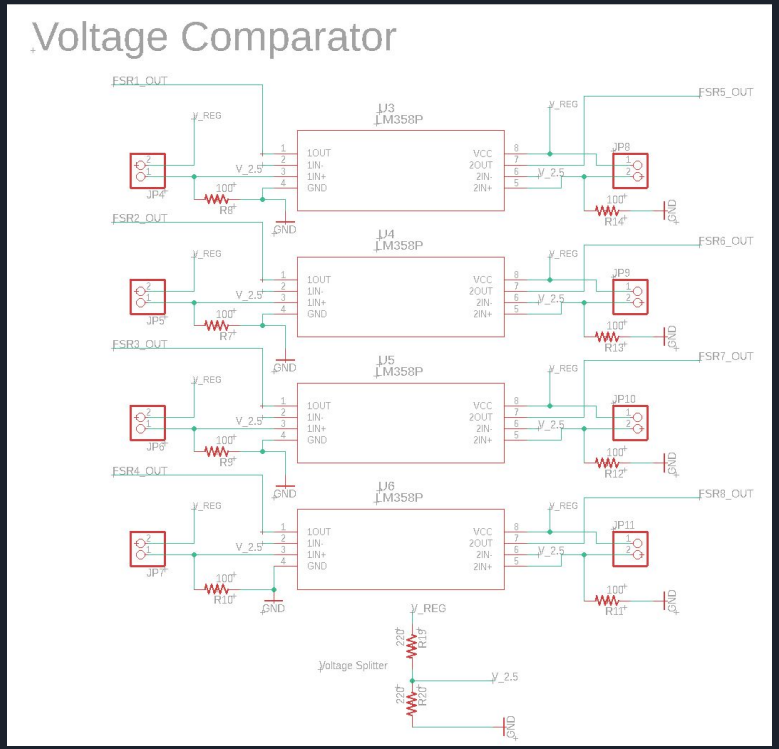
- Set of tests run on BB sensor to determine the maximum range of use
- Tests run due to inconsistent data from datasheet
- 32in. Max range in datasheet, did not work in our case, so had to test.
- Was able to produce an adequate signal up to 28in.
- Had to close gap in our model to account for range issues




RIGHT TO KNOW
COMPLIANCE
WIPES

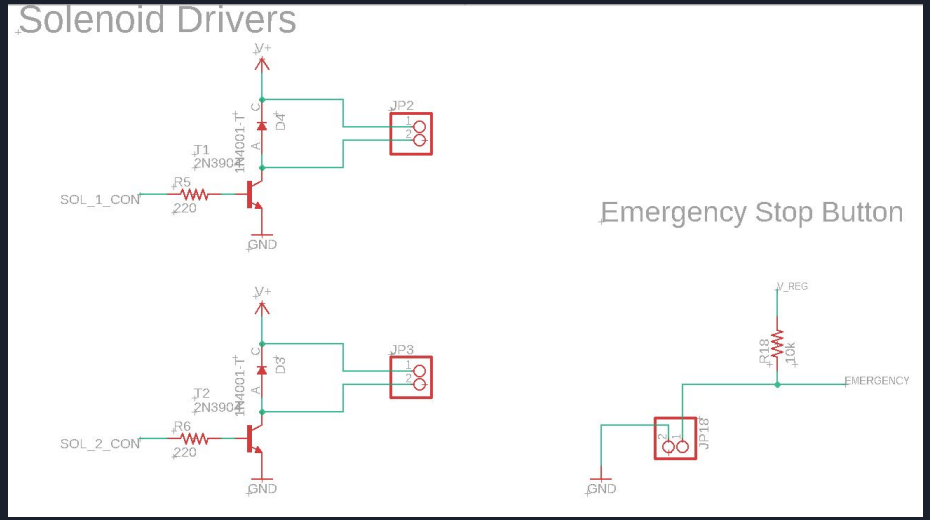
People Counting System - Results (cont.)

- Testing on the FSR Array was more Qualitative
- Does the switching signal saturate HIGH when pressure is applied
- Didn't account for losses in the Op-Amp
- Planned to do more detailed pressure testing but ran out of time

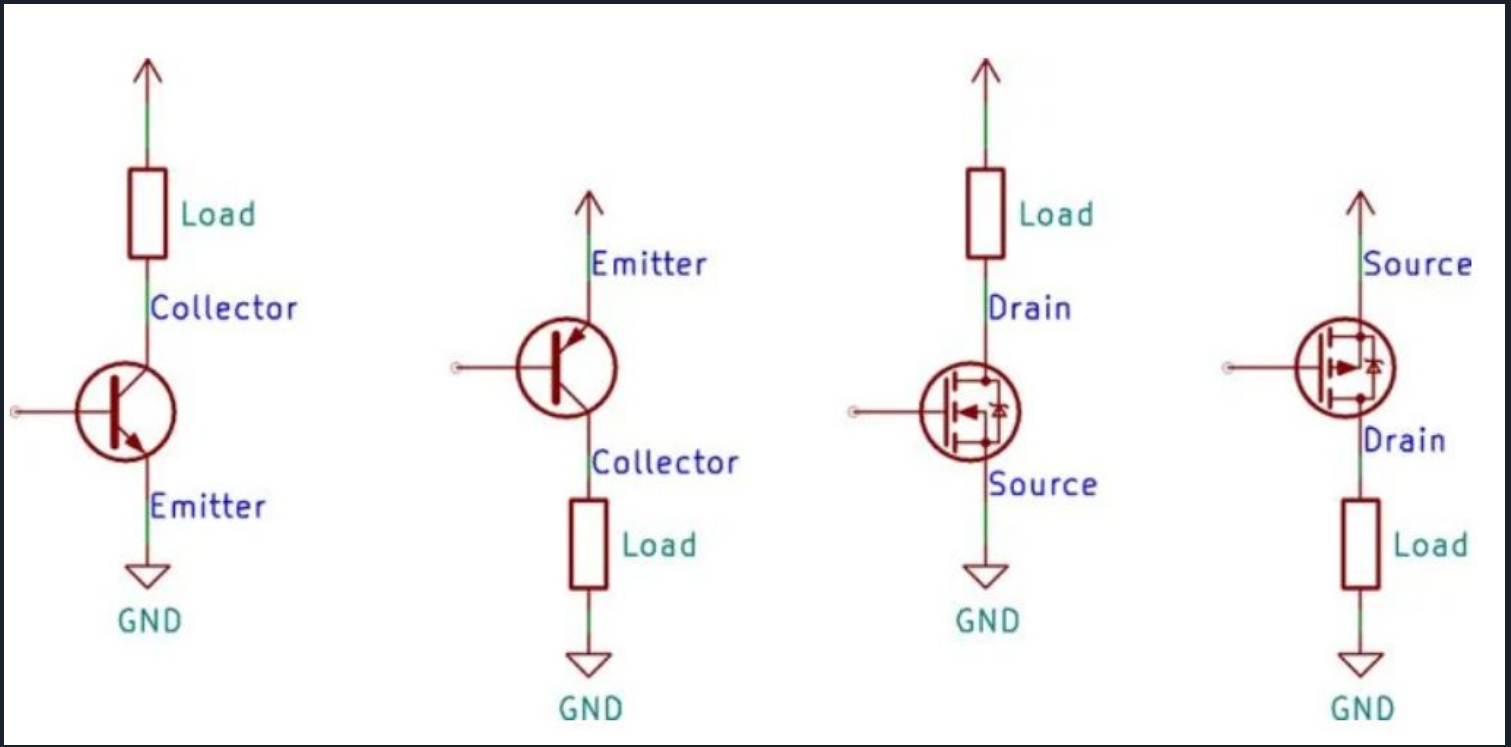


Locking Mechanism - Design

- Output of our system.
- Build with two Solenoid valve circuits
- 5V 2A Solenoids as listed in the System Overview.
- Emergency release button in case of accidental reset of the system
- Many challenges came in the design of the valve.

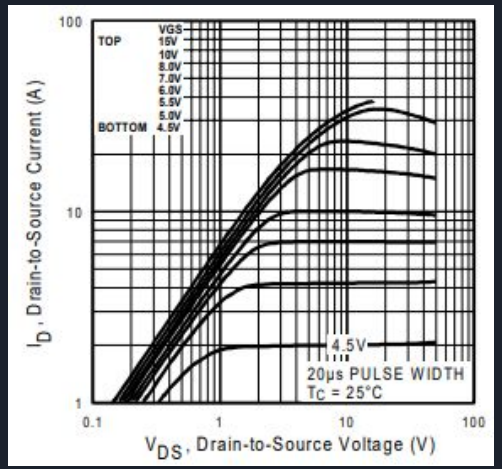


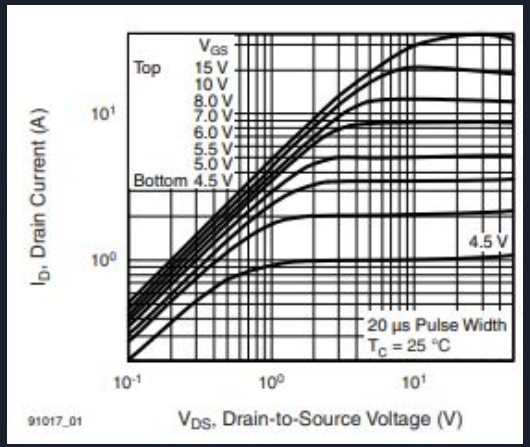
Locking Mechanism Design (cont.)



Locking Mechanism Design (cont.)

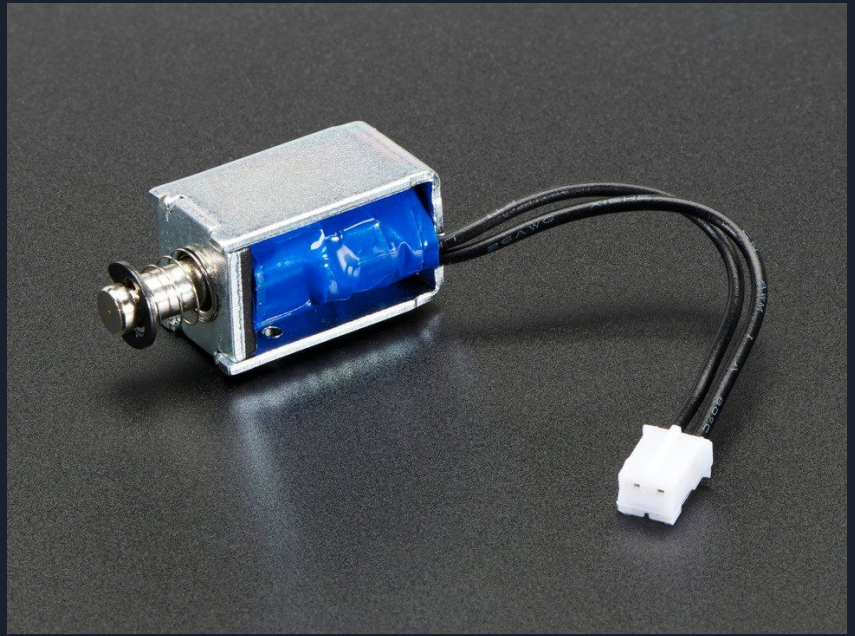
- Realized a lot of our issues were caused due to us choosing the wrong MOSFET
- Remember to check the transfer characteristics of your device!





Locking Mechanism - Requirements

- Actuator must remain open while a control signal is being received, and only retract when that control signal is removed.
- Minimal power fluctuations to the system due to the inductive nature of the device



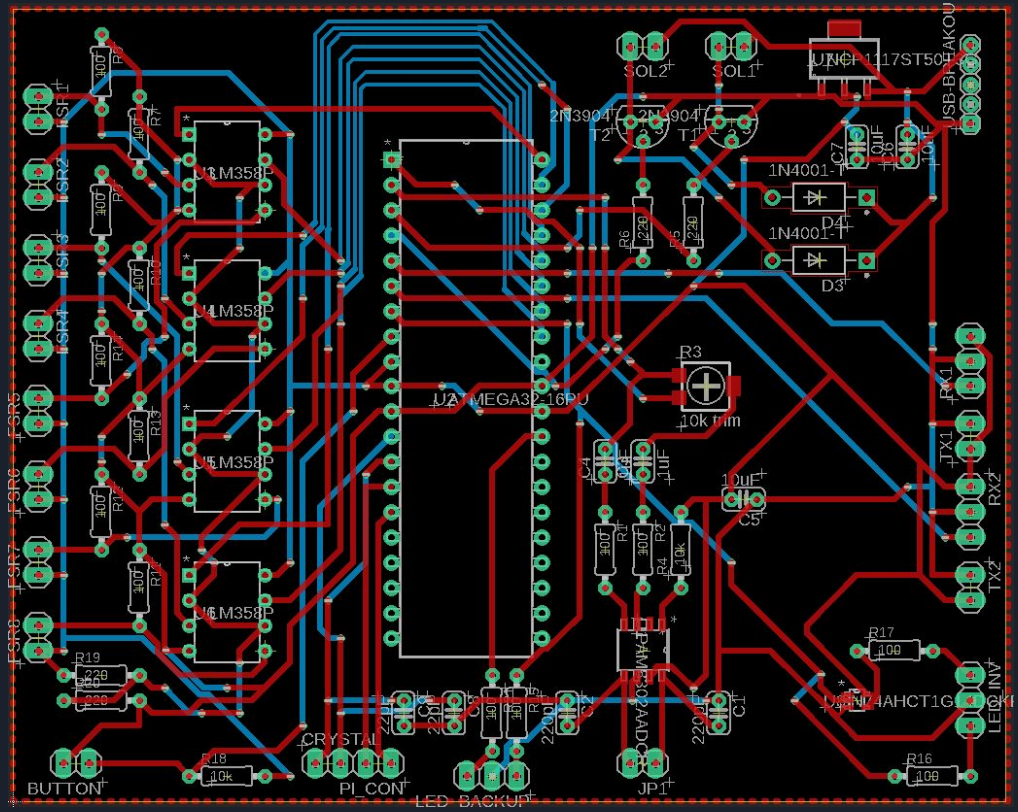
Locking Mechanism - Results

- System was resetting every time solenoid valve was triggered
- Issue determined to be caused by the inductive nature of the device causing transient noise in the system
- 125 mF capacitor bank put in parallel with the power source to alleviate issue

Capacitance	Voltage at MCU When Solenoid Triggered
25uF	4.5V
50uF	4.56V
75uF	4.63V
100uF	4.8V
125uF	4.91V

PCB Layout

- Multiple contingencies due to known PCB delays
- Audio Amp integration was not successful due to time constraints
- LED Inverter Circuit was scrapped in place of direct drivers from the MCU due to easier functionality and visibility to the user.
- Poor trace efficiency due to multiple reworks that probably should have been done from scratch.



Future Work

- Modular design for easy integration into buildings
- Higher resolution pressure detection method, to reduce potential errors
- Integration with Safer Illinois or expand upon backend database for more reliable authentication of the user.
- Functionality improvements on the feedback system. (Working audio, multiple LEDs at different locations).
- Battery operated solution for areas with no easy access to outlets. Allows for easier integration.
- Redesign of housing due to environmental concerns, as half of the device would be sitting outside 24/7.

Thank you for listening!

Any Questions?