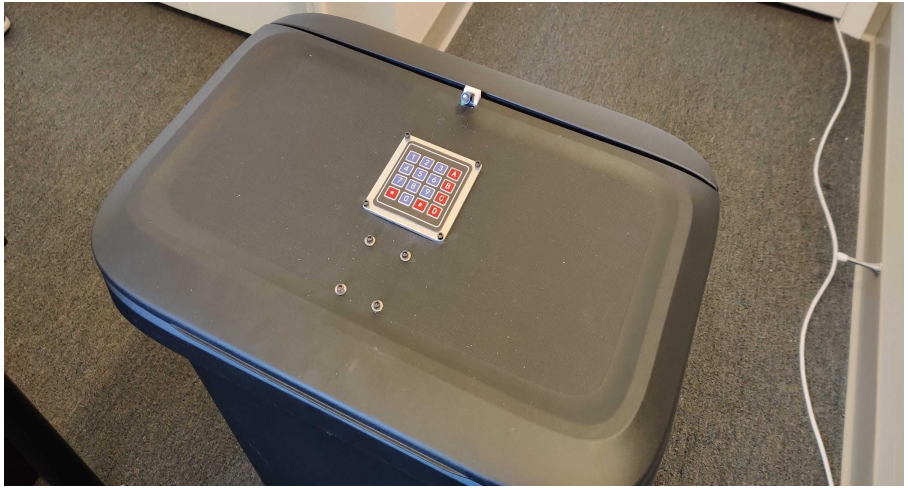
Secure Smart Locker For Doorstep Delivery

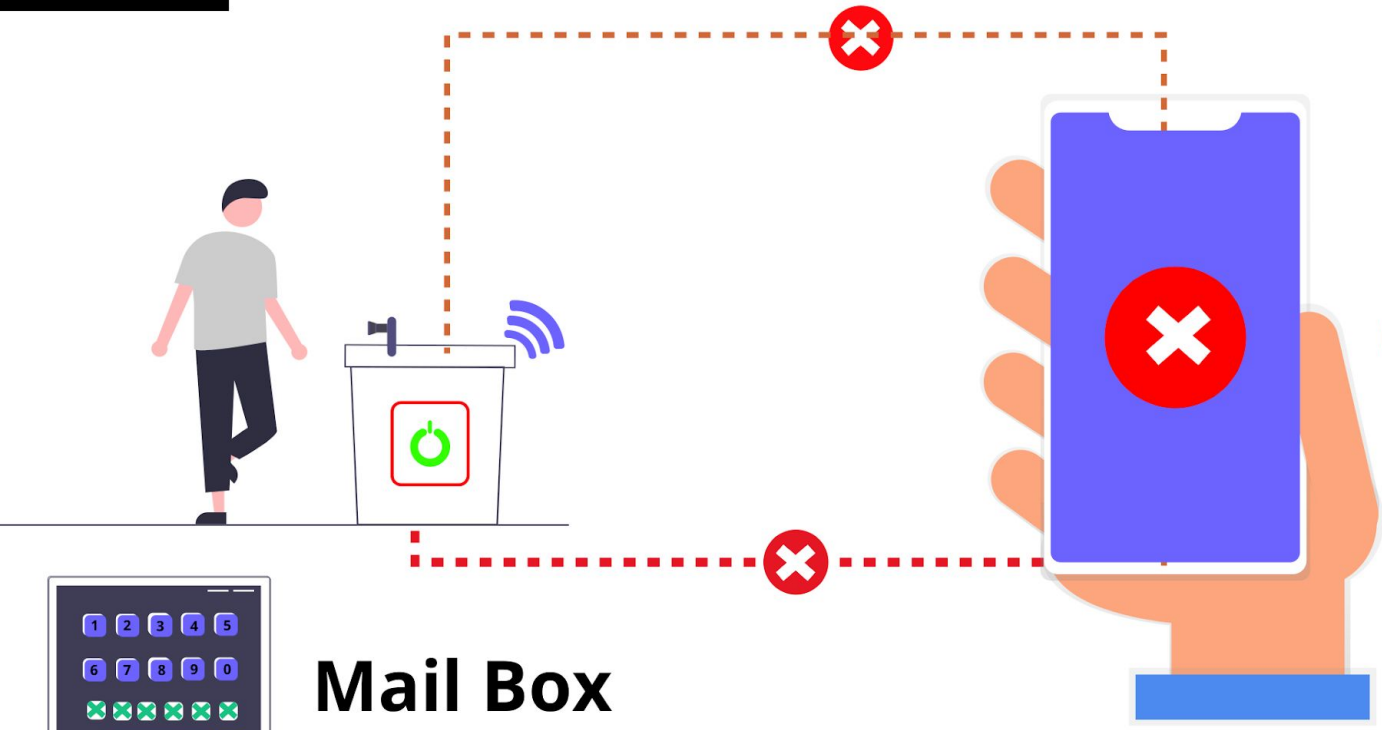
ECE 445 Fall 2020 Team #8
Team: Ernesto Marquez, Max Armbruster, Samarth Jain
TA: Yichi Zhang

What is the Project?

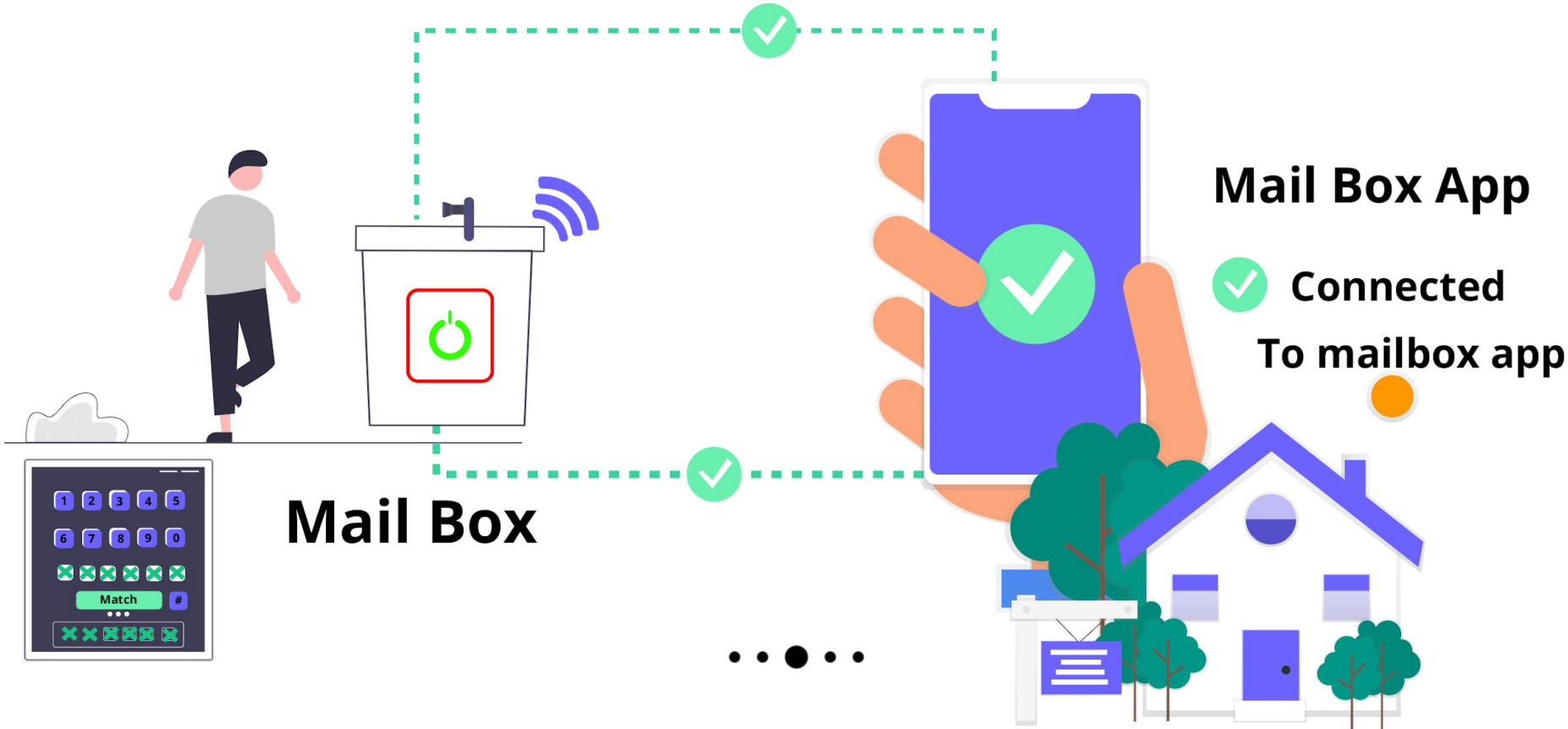


- IoT-ready Smart Locker Device for doorstep home deliveries
- An innovative way to personalize your delivery system and security.

MBox.


Mail Box App
Not Connected
To mailbox app
Mail Box
1 2 3 4 5
6 7 8 9 0
Match
#

MBox.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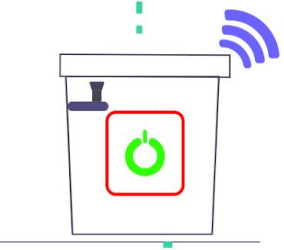
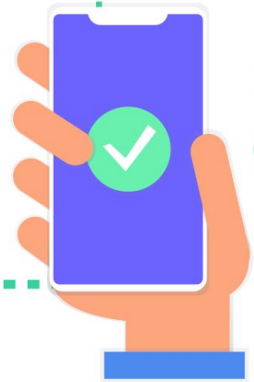


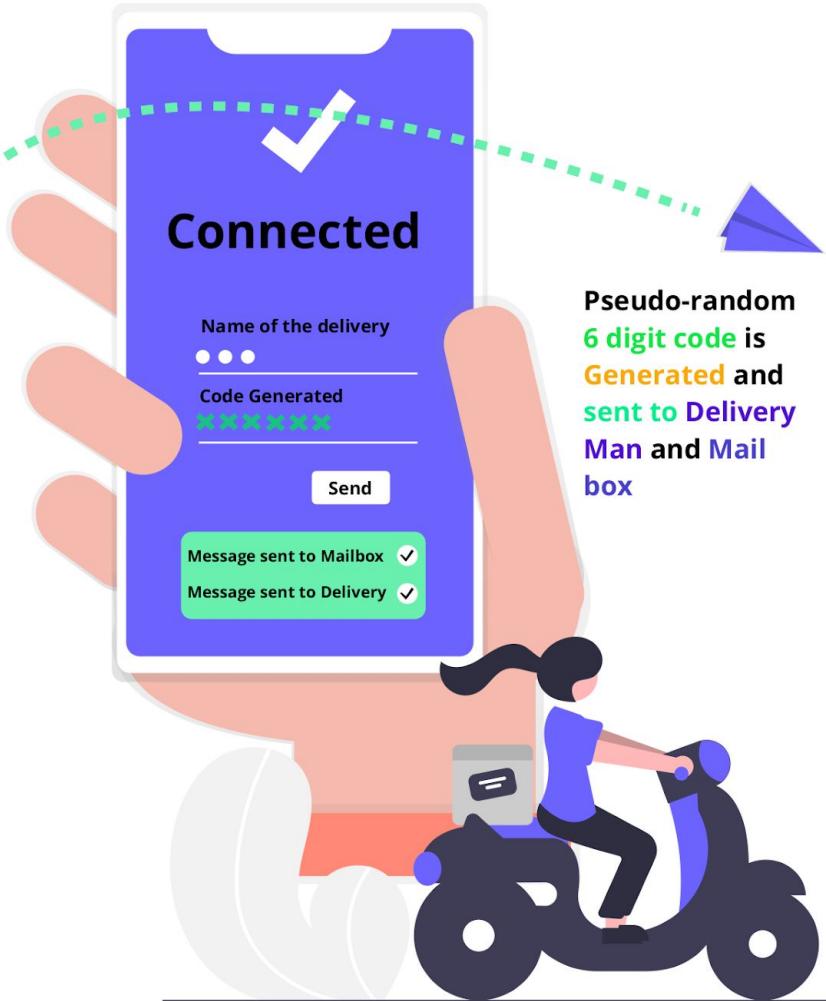
Mail Box



Mail Box App

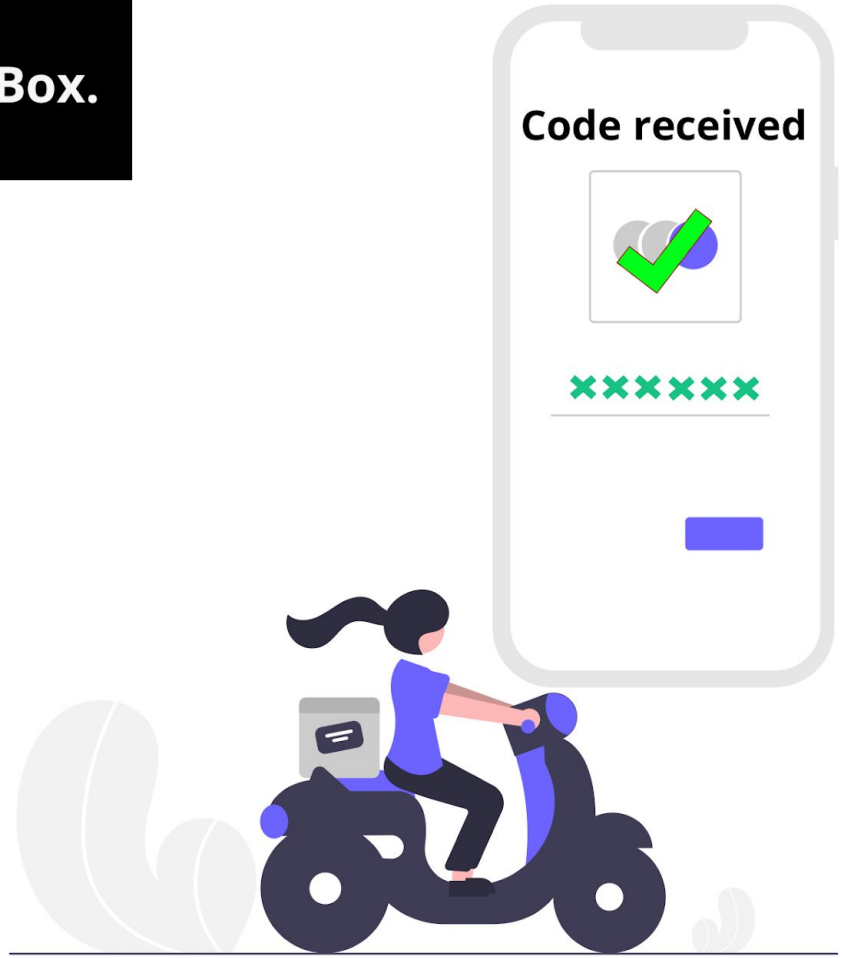
Connected

To mailbox app



Pseudo-random 6 digit code is Generated and sent to Delivery Man and Mail box

MBox.

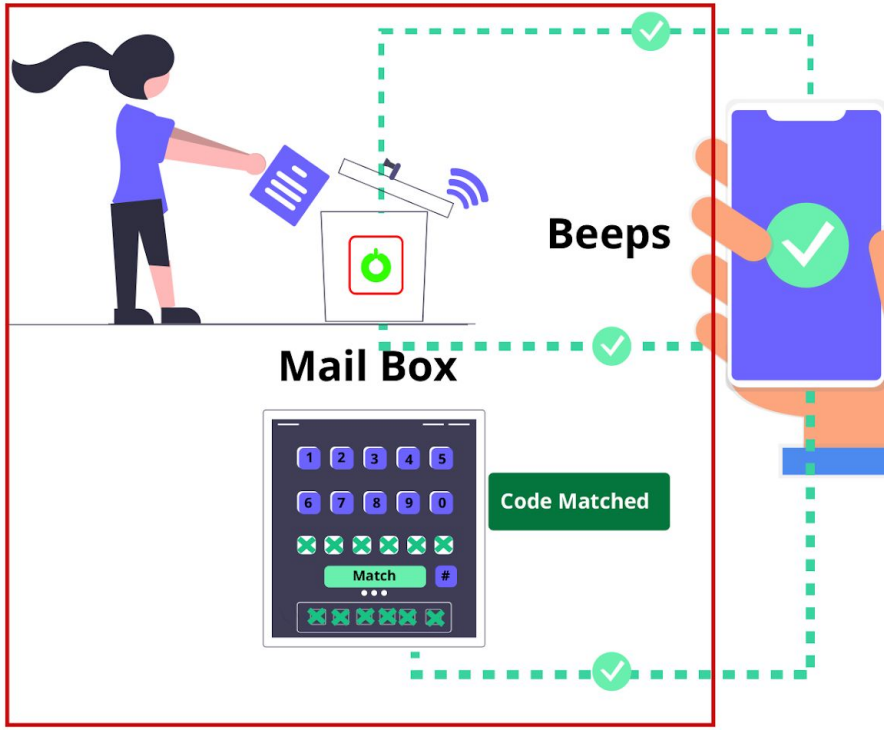


Input the Code

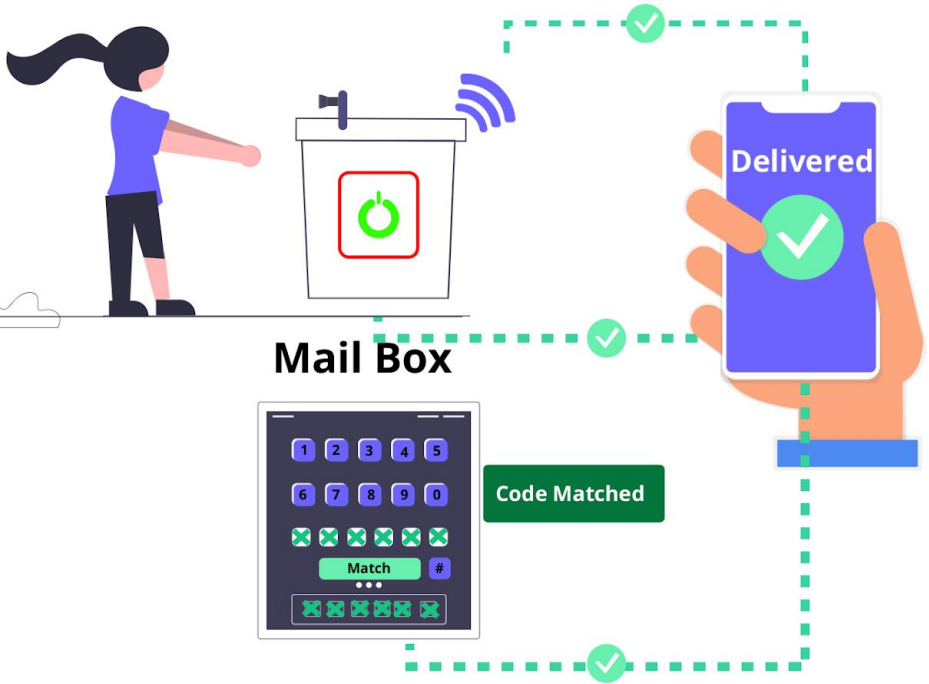
Unlocked : Mail Box

Face Captured

Code Matched



MBox.



1. Unlocked the Mail Box **Code Matched**

2. Face Captured

3. The Unique code is deleted

4. locks it by hitting **#**

5. Completion of the delivery.

MBox.

Mail Box

Mail Box App

Connected

Press Unlock

in mailbox app

Objective and Features: What Problem Does This Solve?

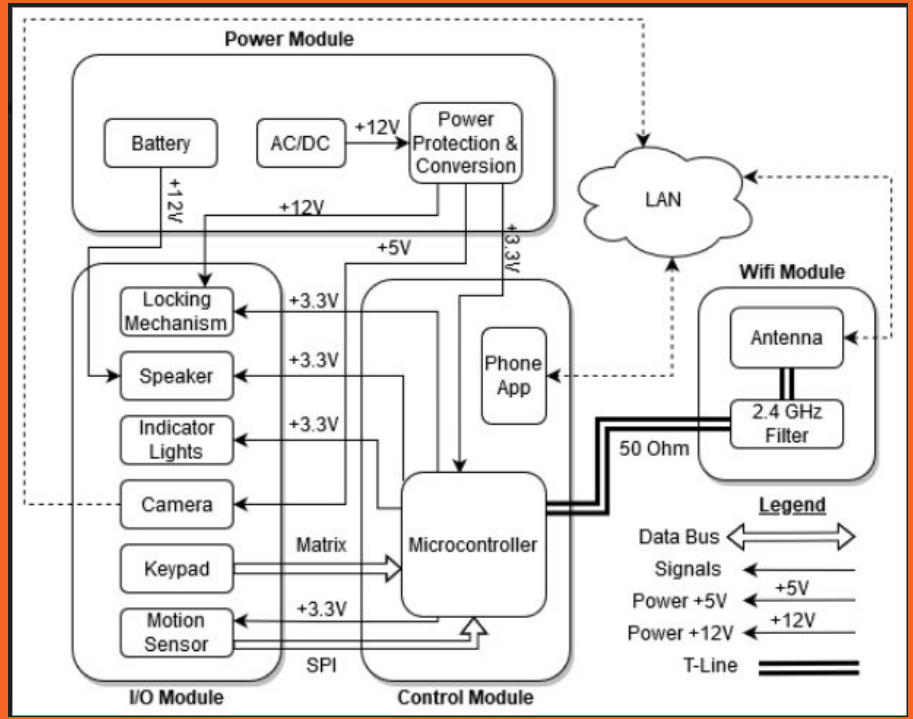
- Designed for an ideal use during the pandemic
  - During these hard times it creates a way to minimize theft
- Ability to
  - Connect via Wifi WLAN connection
  - Start new delivery orders, generate a random 6 digit code that can be given to the delivery service
  - Have indication lights and a speaker to show the status of the Secure Mailbox
  - Provide security in a scenario when wall power is unplugged

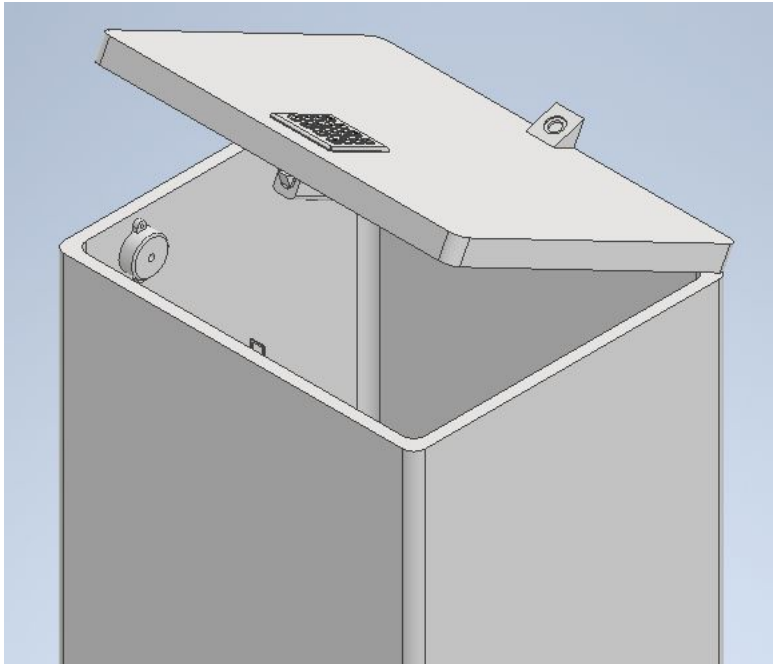
System Overview

- Power Module
  - Protection and Conversion
  - Battery
- IO Module
  - Lock
  - Speaker
  - 3 Indicator Lights (Green/Blue/Yellow)
    - (Unlocked, Status, Locked)
  - Keypad having 8 outputs
  - IMU, Camera
- Control Module
  - MCU CC3200
- Wifi Module
  - TCP with Server and Client via a WLAN
- Mobile App Module

Block Diagram and Microcontroller

- CC3200 Microcontroller from Texas Instrument
- Tested and used CC3200-LaunchXL Launchpad





Requirements and Verifications

Power Protection & Conversion, Battery

Supplies stable power to our subsystems

Features:

- +12V DC for lock, speaker
- Conversion to +3.3V
- Overvoltage, reverse voltage, and overcurrent protection

Requirement:

1. Provide alarm power to speaker
2. Provide stable +12V input (<300mV fluctuation
3. Isolate PCB if dangerous input is detected

Power Protection & Conversion, Battery

Battery pack lifetime calculation:

$$8[batteries] * \frac{2500[mAh]}{[battery]} = 20{,}000[mAh]$$

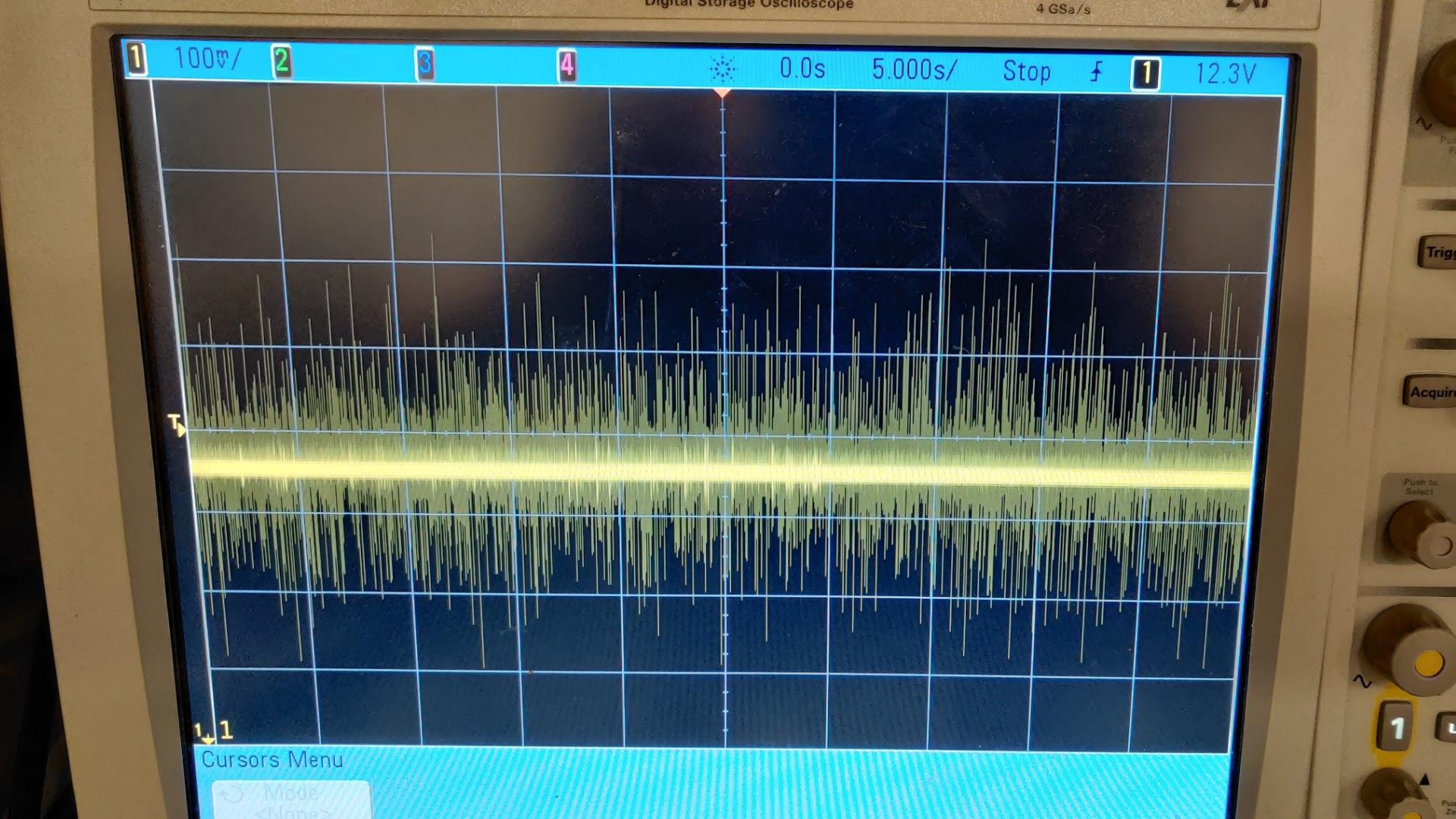
$$20000[mA*h] / 10[mA] = 2{,}000[hours]$$

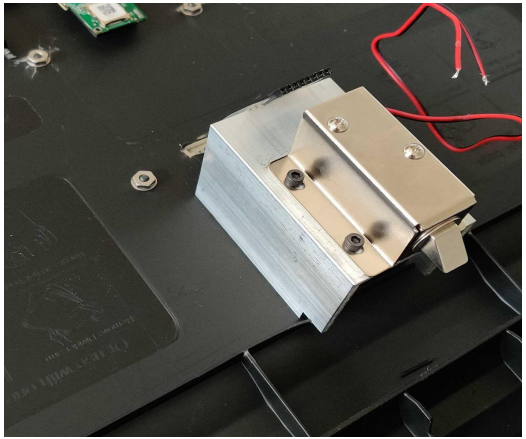
Verification:

1. Disconnect power supply to test alarm
2. Probe power supply output
3. Supply dangerous inputs to test protection circuit

Results:

- Alarm relay works and switches in <1s
- Scope reading on next slide
- Couldn't secure lab time with completed protection circuit


Digital Storage Oscilloscope
4 GSa/s
1 100mV/ 2 3 4 0.0s 5.000s/ Stop 1 12.3V
1 1
Cursors Menu
Mode
<None>
Trig
Acquir
Push to Select
1



Lock

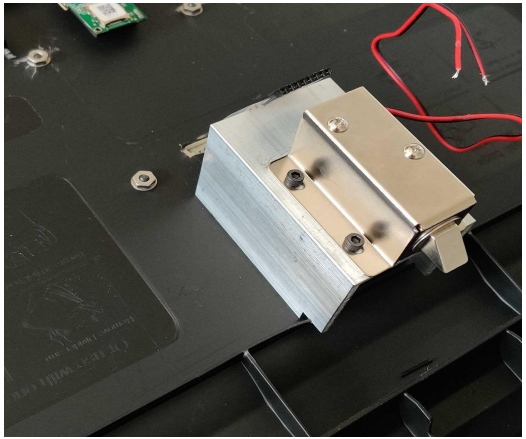
Needed for Security

Features:

- Mounting Lock
- Pull Type
- Closed Frame
- +12V triggered

Requirement:

1. Controlled via MCU signal gating the +12V power
2. Fail Secure (locked when powered off)



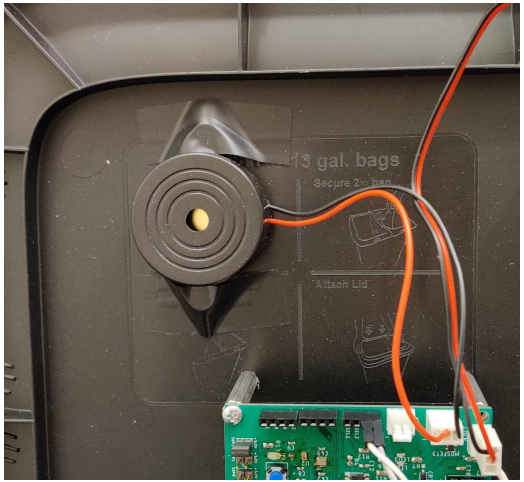
Lock

Verification:

1. Toggle MCU control signal and observe correct lock behavior

Results:

- Couldn’t send signal from MCU
- Jumpered +3.3V to FET gate instead
- Works as intended



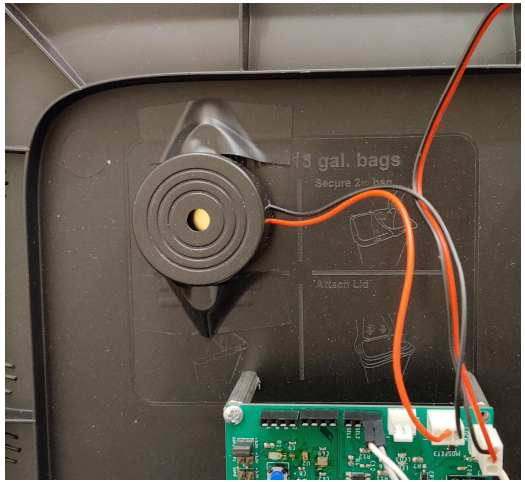
Speaker

Needed for alerts
Features:

- Small, Compact
- +12V rating w/ 105dB

Requirement:

1. Makes soft indicator sound when controlled by MCU
2. The speaker correctly produces a much louder sound when the box is disconnected from the wall outlet.



Speaker

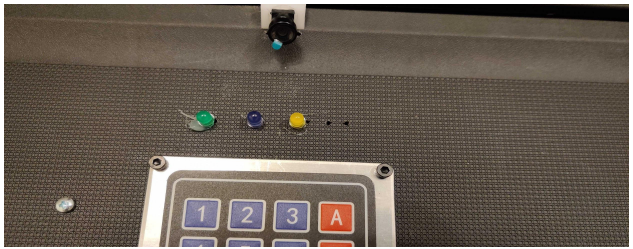
Verification:

1. Code is typed and when code is correct makes small sound.
2. The power connection to the wall is taken out, loud sound is made.

Results:

- Speaker very loud with +12V
- Too loud for “soft” indicator @ 3.3V
- Set up voltage divider to cut the indicator voltage in half
- Result was reasonable volume

$$3.3V * \frac{100\Omega}{100\Omega + 100\Omega} = 1.65V$$



Indicator Lights

Needed for alerts

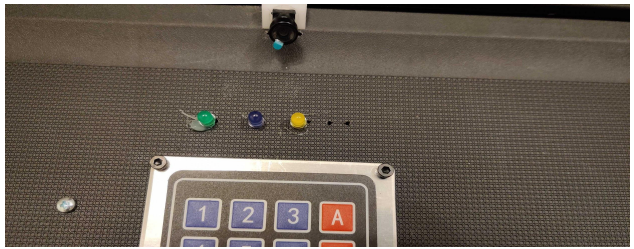
Features:

- Lights for indication
- Wrap along the box

(Green Unlocked/Blue Status/Yellow Locked)

Requirement:

The lights turn on and off according to state of the Finite State Machine of the MCU



Indicator Lights

Verification:

The LEDs behave in the following manner:

- Green LED: flashes green when the box is unlocked
- Yellow LED: indicates that the MCU is in a reset state
- Blue LED: indicates when the MCU is connected to the internet

Results: The indicator lights functioned the way they were supposed to

KeyPad

Needed for taking code input

Features:

- 8 jumper wires
- 16 buttons

Requirement:

The numpad accepts the code typed in, and sends the data to the MCU to process.

KeyPad

Verification: Run simple code to test a single character. Connect GPIO from MCU to keypad, connections create the correct 6 digit code in the MCU.

Results: Running a simple code to test a single char, successful.

Implemented all the rest of the characters.

Camera

Needed for capturing faces

Features:

- Connects to app using Wifi
- Uses Real Time Streaming Protocol

Requirement:

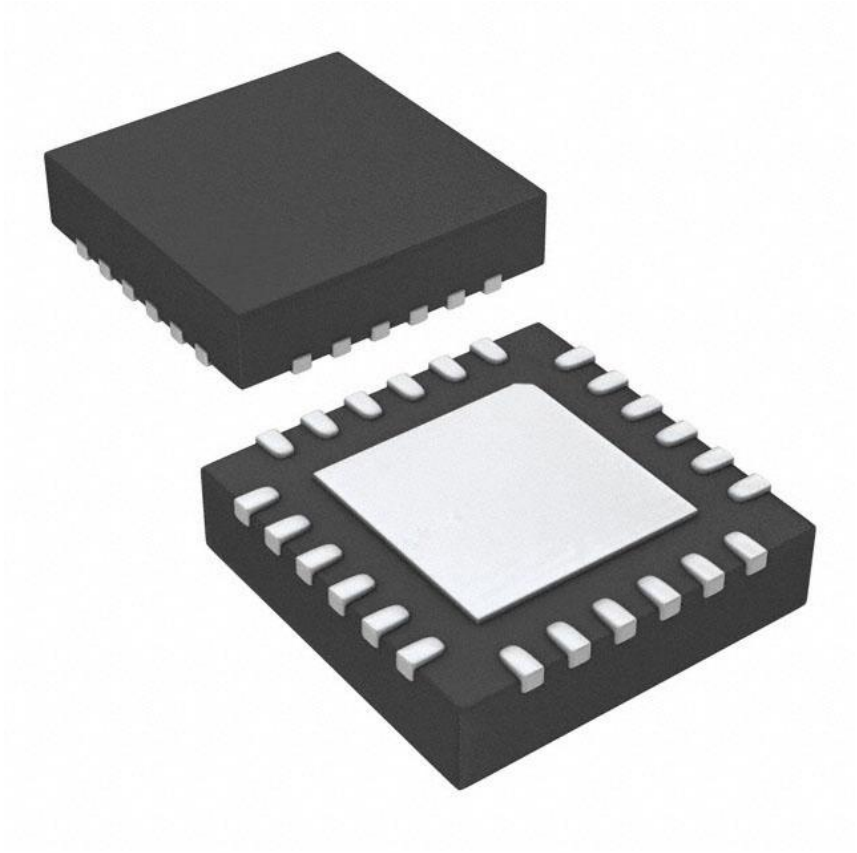
1. Needs an antenna that can reach high frequency (2.4Ghz or 5Ghz) for internet connection
2. It will need to be powered from the Microcontroller with +3.3V

Camera

Verification:

1. Connects to Local Wifi
2. Use the multimeter and the oscilloscope to measure whether the voltage and the current going to the camera are appropriate

Results: We unfortunately broke the ribbon cable from the camera to the board



IMU

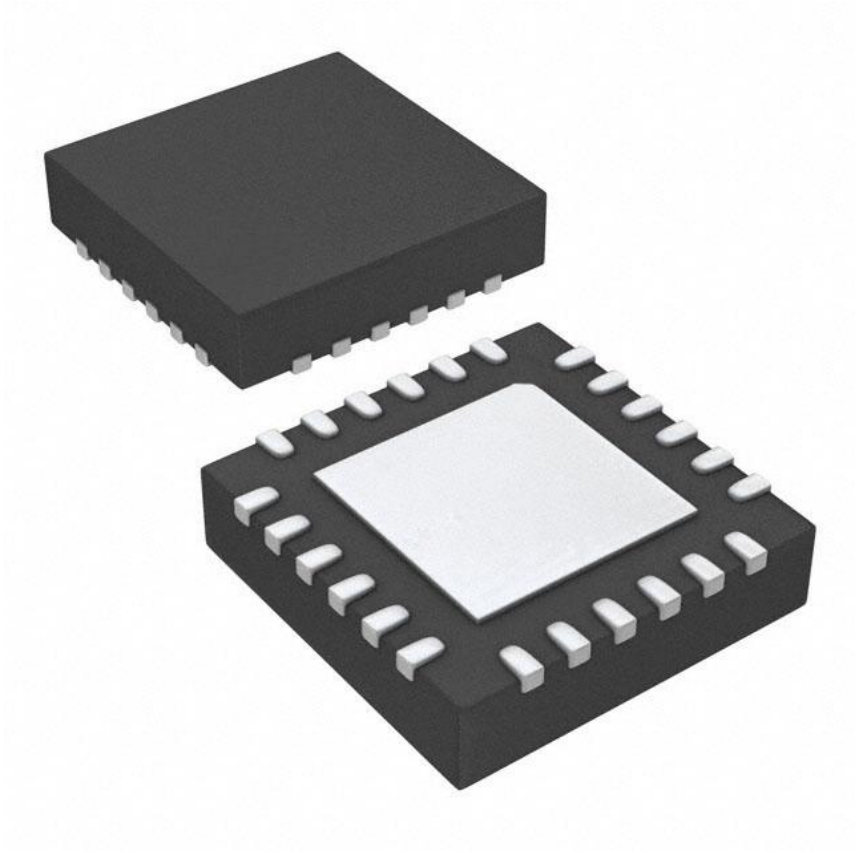
Needed for orientation and force within the system

Features:

- Built in accelerometer and gyroscope
- Programmable sensitivity levels

Requirement:

The accelerometer sends data to the MCU



IMU

Verification:

Use simple code to test by retrieving data from the IMU to the MCU. When *unnatural* motion by triggering an alarm and sending data to the mobile app.

Results: Unsuccessful. Soldering difficulty, and simple code no reading.

Control Unit: MCU, Mobile App

Needed for control of the two systems

Requirement:

1. Microcontroller Unit connected to the Wifi
2. Mobile App connected to the Wifi
3. Microcontroller connected to the mobile app using TCP

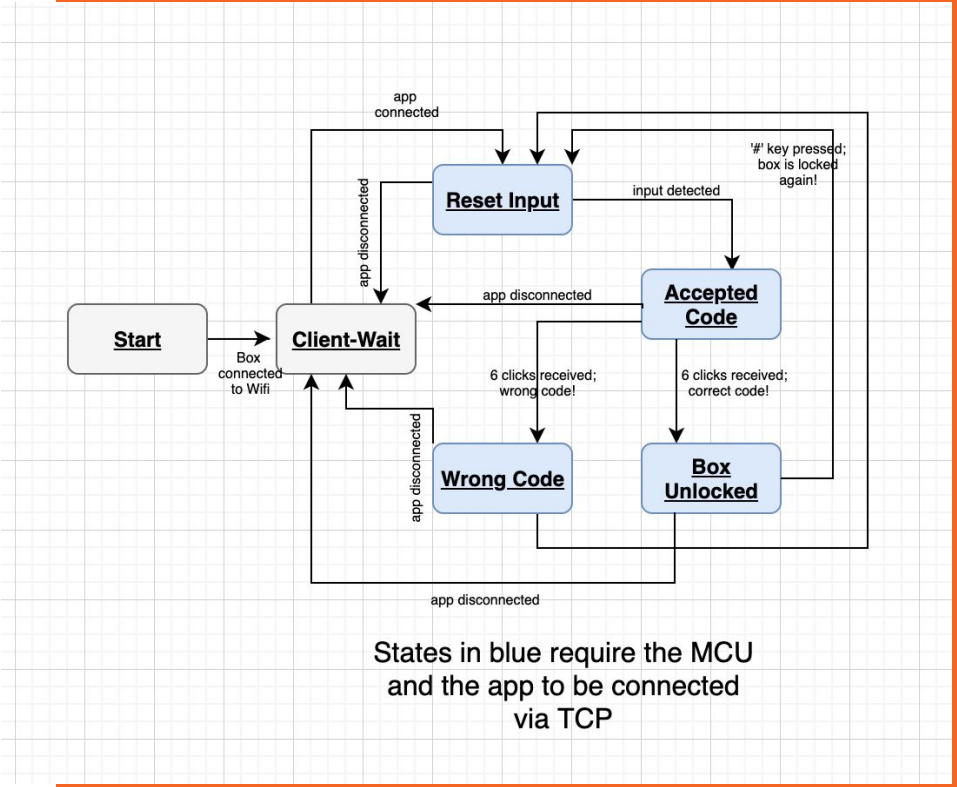
Control Unit: MCU, Mobile App

Verification:

1. Blue LED on the mailbox is on
2. Check the Wifi connection on the mobile
3. Hit “Connect” button on the app; the app displays “Successfully connected to the box” message

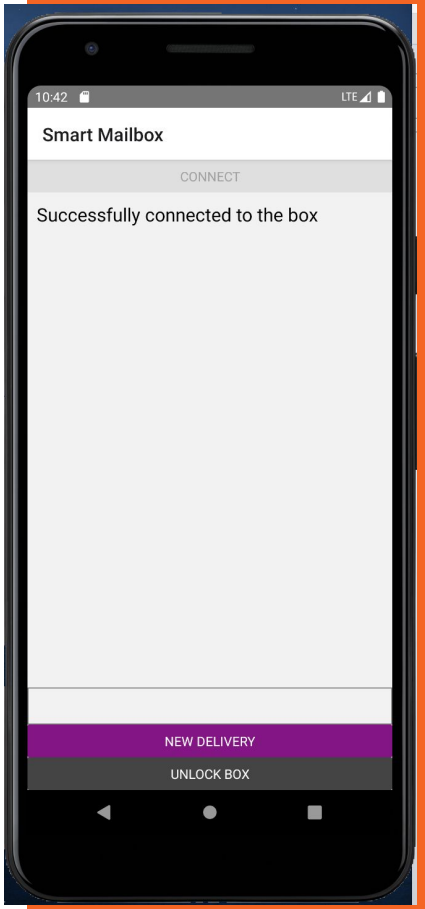
Results: The MCU’s code runs a modified FSM correctly. The app communicates with the MCU using TCP successfully (to be shown later)

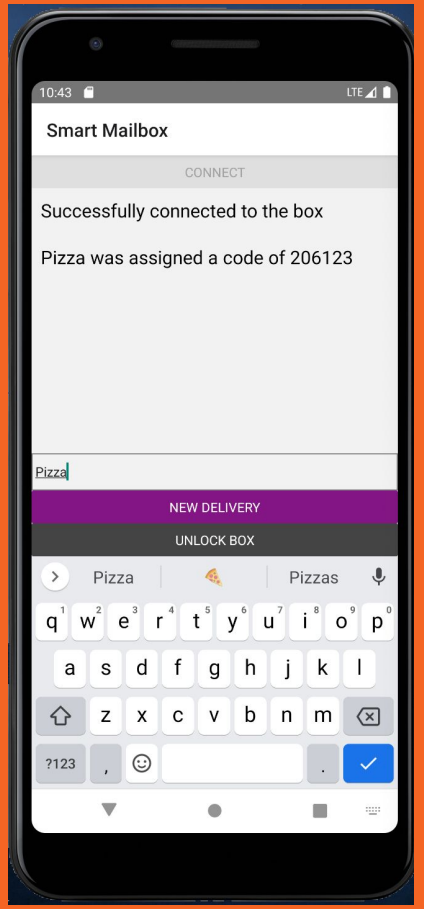
FSM Diagram of the MCU code



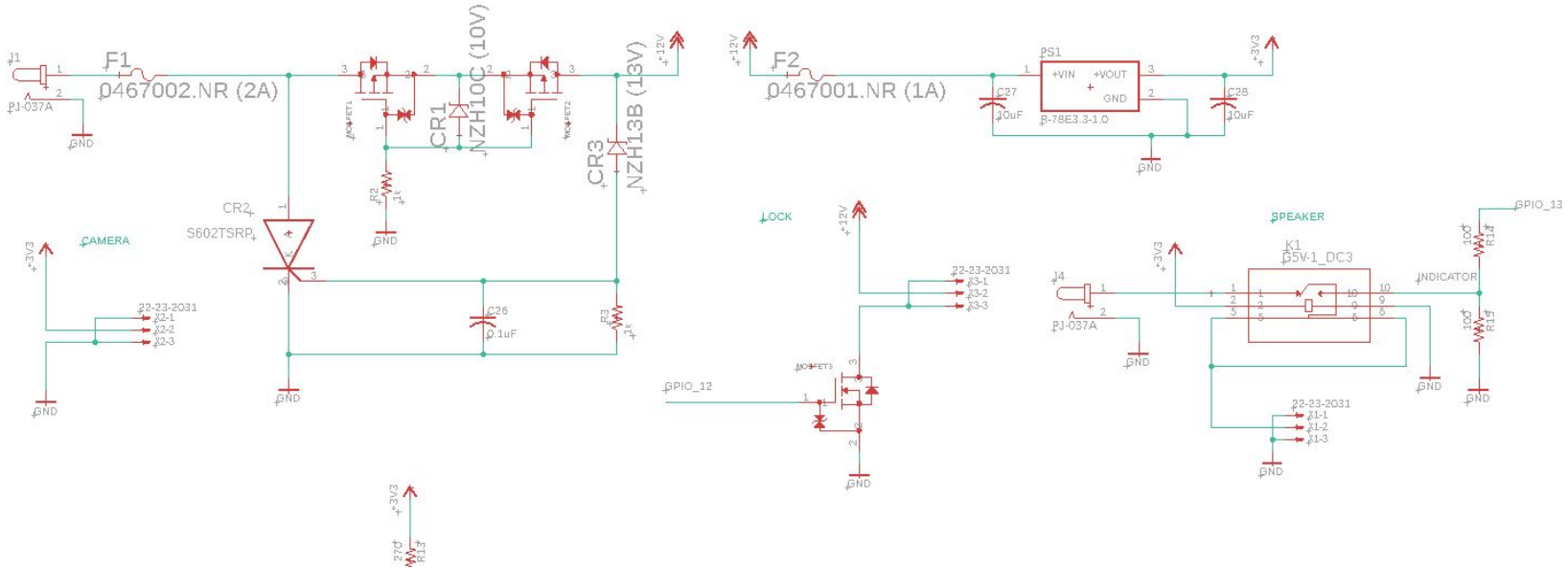
TCP Communication

App design

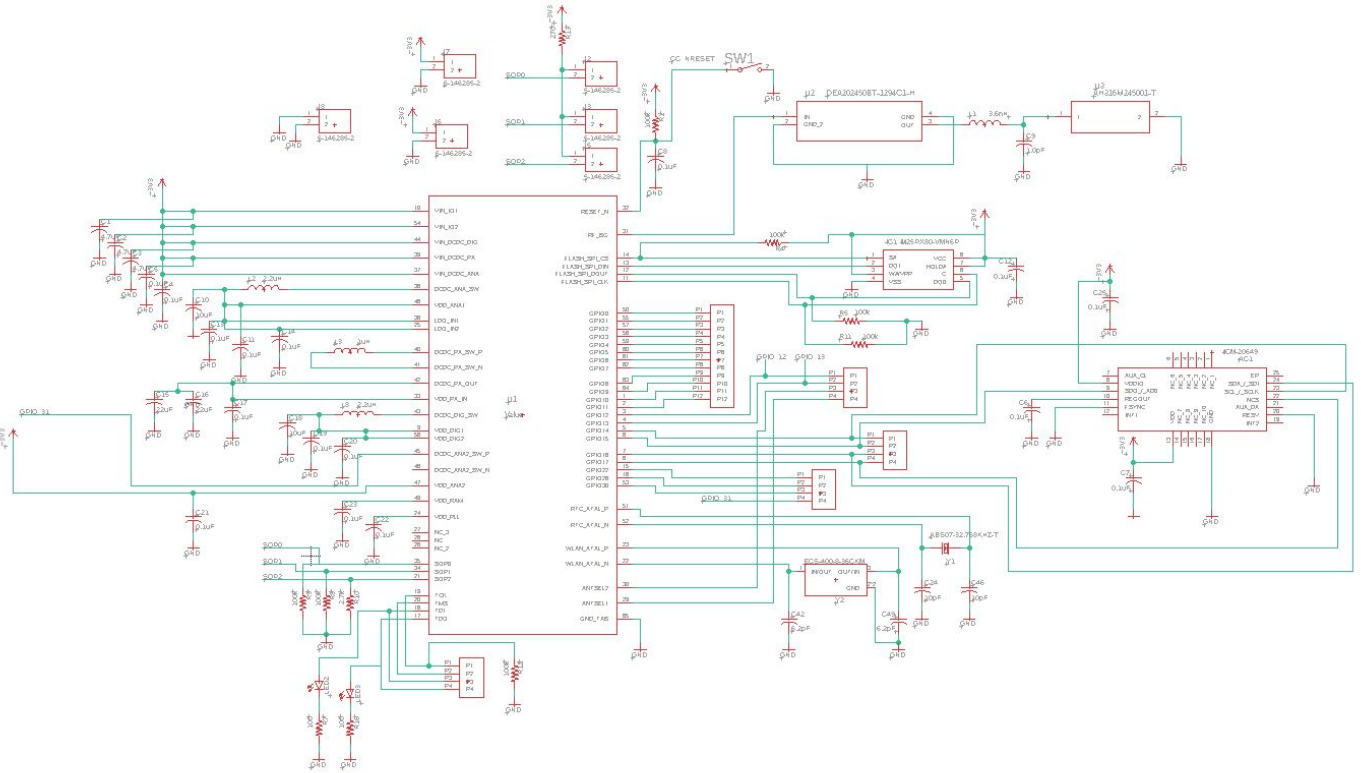

10:42
LTE
Smart Mailbox
CONNECT
Successfully connected to the box
NEW DELIVERY
UNLOCK BOX


10:43
LTE
Smart Mailbox
CONNECT
Successfully connected to the box
Pizza was assigned a code of 206123
Pizza
NEW DELIVERY
UNLOCK BOX
Pizza
Pizzas

PCB Schematic Design



PCB Schematic Design (cont.)



Successes and Challenges

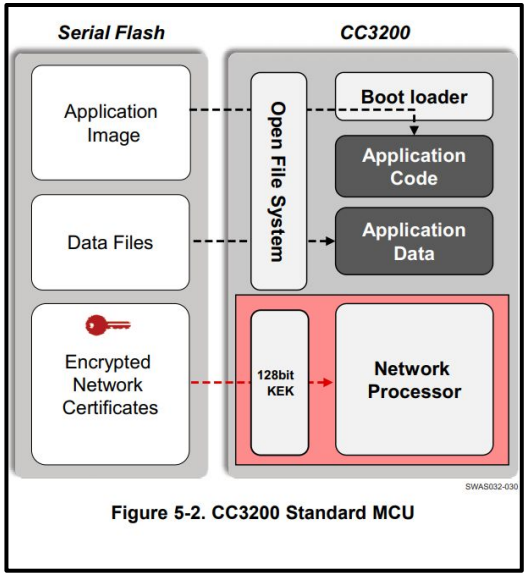
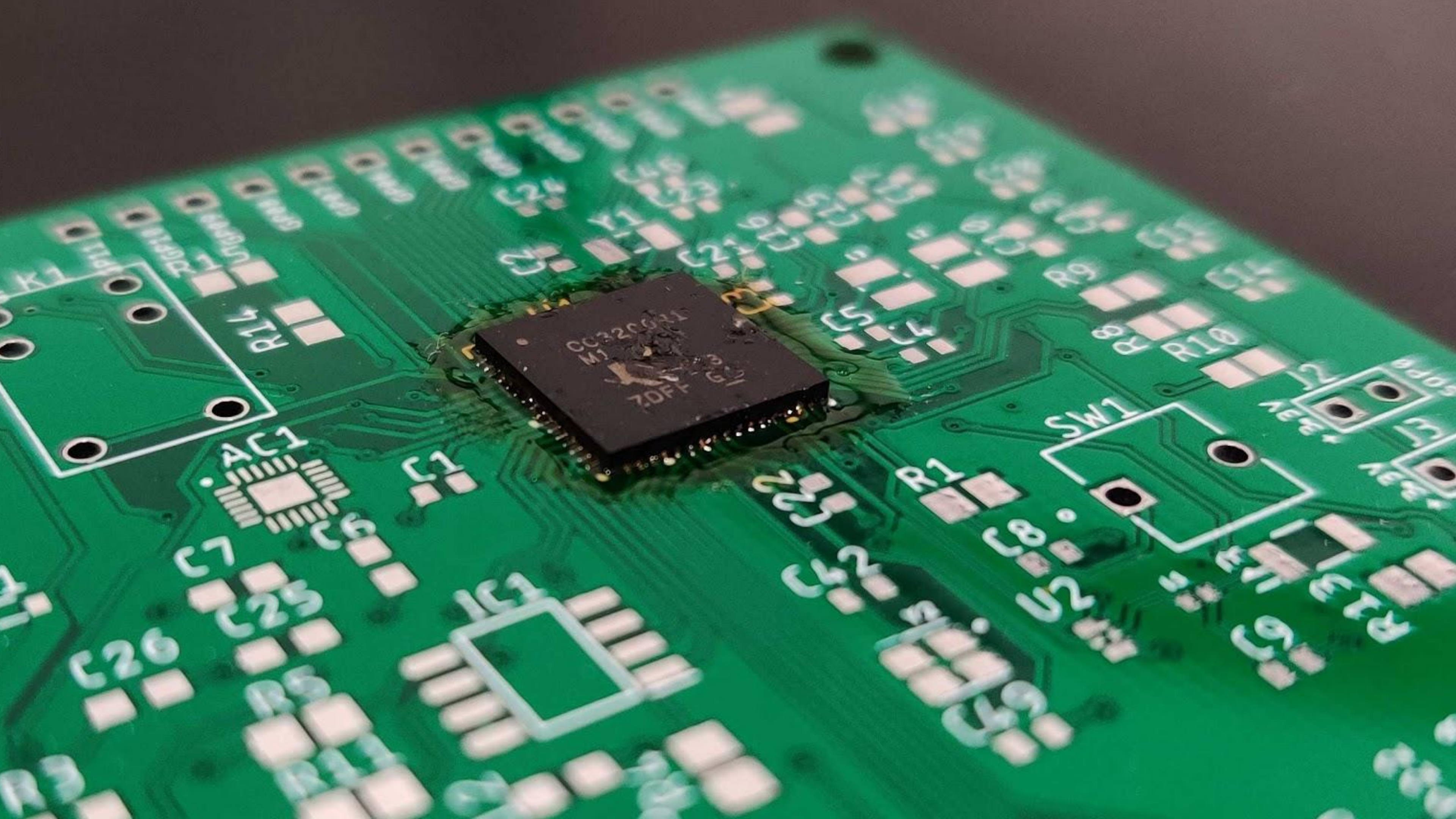


Figure 5-2. CC3200 Standard MCU

- Successes
  - Mounted all necessary components on box
  - Lock, Speaker, Indicator Lights, Keypad, are all functional which were integrated with the CC3200 Launchpad MCU
- Challenges
  - Multiple revisions to the PCB board
  - Difficulty with reflow soldering
  - Receiving no feedback from IMU or MCU
  - Camera ribbon very delicate and torn.



AC1
C1
C6
C7
C25
C26
IC1
R14
R1
SW1
C8
C42
U2
R9
R10
C5
C24
Y1

To Conclude

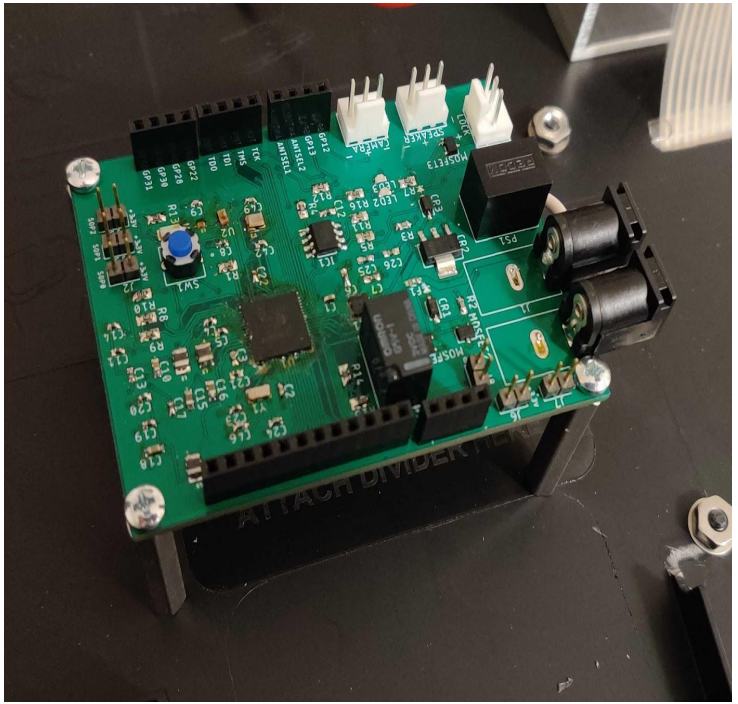
- Camera, IMU, MCU unfortunately did not function properly
- Thanks to the team's preparation, we had a contingency plan to use the CC3200 development board and pcb analog design to implement most of the subsystems.
- Lock, Speaker, Indicator Lights, Keypad, are all functional which were integrated with the CC3200 Launchpad MCU
- In the future, consider using a more beginner-friendly MCU (ATmega328 or similar)
- Manage time and communicate better to allow for troubleshooting in the lab

Future Work

- Broader WIFI connection rather than WLAN.
- Mobile application with more features (e.g. Video footages, Picture Storage etc.)
- Rechargeable Batteries trickle-charged via the power supply
- Connect multiple TCP clients, more than one device for the personalized secure box at home
- LED screen for additional interaction
- Climate control for food/grocery deliveries

Ethical Issues

- Uniqueness of the Project
- Using the Launchpad CC3200-LAUNCHXL
- Security issues with Wifi
- Batteries have limited lifetime



Thank you! Questions?