

IN 1901 - Microcontroller Based Application Development Project



GATE SENTINEL

Group 46 – The Spark Squad

An advanced smart gate lock system with bell to ensure the
home security

Our Team



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Overview



1. Introduction
2. Problem Identification
3. Proposed Solution
4. Aims and Objectives
5. 3D Design & Real Design
6. System Diagrams
7. Components used
8. Technologies used
9. Work Distribution
10. Cost Estimation

Introduction

- The Advanced Smart Doorbell System is a modern home security solution that combines hardware with user-friendly software for seamless monitoring and control. It includes an outdoor panel with a PIR sensor for motion detection, an ESP32 cam for live video feed, a biometric fingerprint sensor for user authentication, an OLED display to display messages to the user for user convenience, and a microphone and a speaker for communication. GateSentinel also comes with an indoor panel with a 7-inch touch screen display, a microphone and a speaker to communicate with the visitor outside.
- With mobile and web app integration, users can control the lock remotely, giving users the ultimate convenience of the system. The lock mechanism is integrated with a limit switch for an auto-lock mechanism. The communication is done through wifi connectivity and the entire system is backed up with battery power for seamless



Problem Identification

- Home security is a growing concern in densely populated urban areas due to increased risks of theft and unauthorized access.
- Traditional security measures, such as conventional locks, often fail to provide adequate protection and convenience.
- The Advanced Smart Doorbell System addresses these challenges with:
 - Biometric fingerprint authentication for secure, keyless access.
 - Motion detection for precise monitoring.
 - Real-time monitoring via a mobile app for remote control and alerts.
- Enhances safety, convenience, and communication for urban homeowners.
- Combines innovative hardware and intuitive software to redefine home security.
- Provides a user-friendly and robust solution tailored to the needs of densely populated areas.

Proposed Solution

Advanced Smart Doorbell System for enhanced home security in urban areas.

Key Features:

- **Biometric Fingerprint Scanner:** Secure, keyless access for authorized individuals.
- **Camera:** 24/7 video surveillance.
- **PIR Motion Detection:** Alerts for real-time movement near the entrance.
- **Interactive Display & Indoor Panel:** Household status display and in-home management.
- **Backup Battery Support:** Uninterrupted operation during power outages.
- **Mobile App Integration:** Notifications, live feed, two-way audio, and remote gate control.

Benefits: Combines video surveillance, biometric access, and smart locks for robust, convenient, and reliable security

Aims and Objectives

Aim:

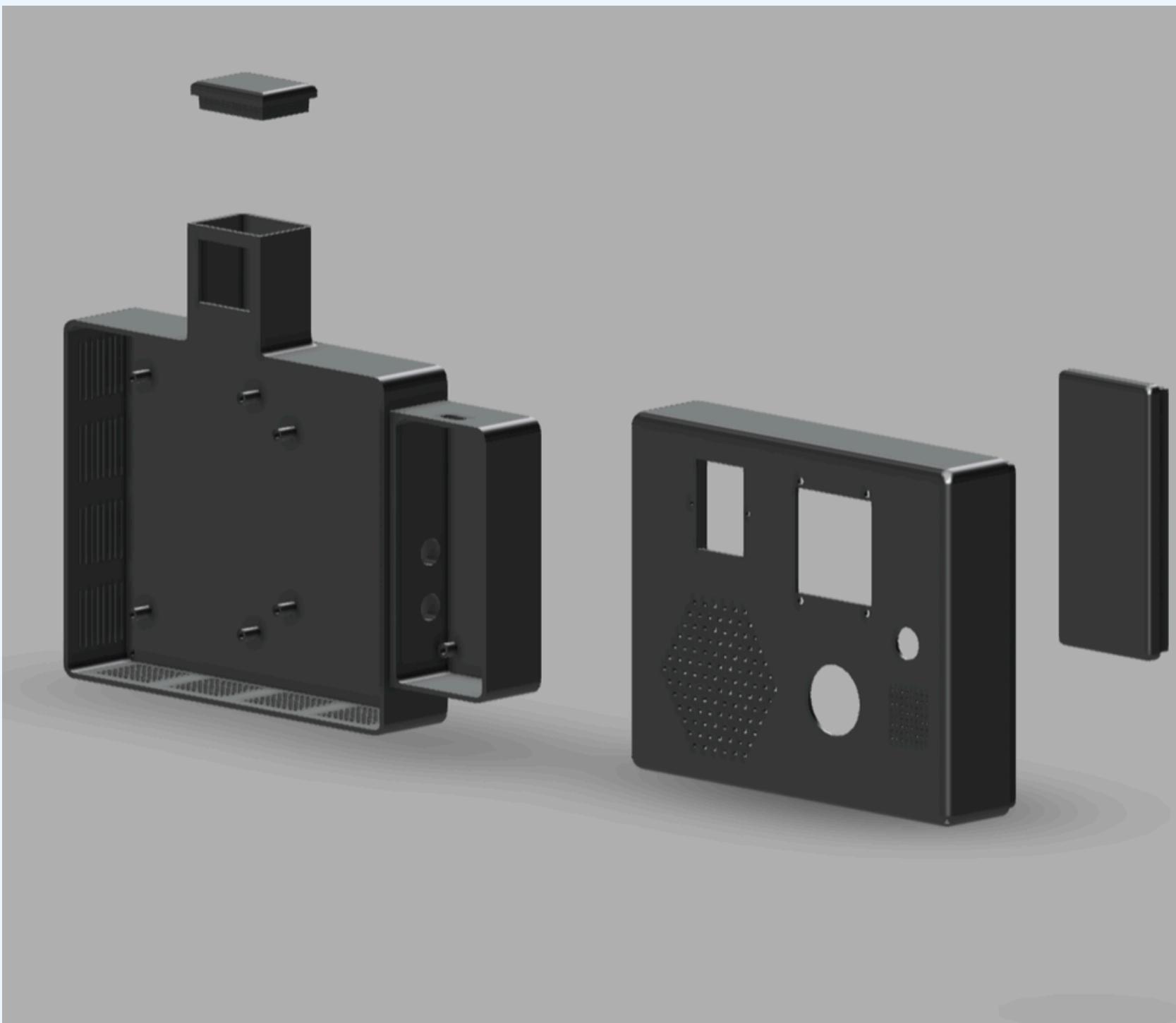
Develop a next-generation smart door lock system that goes beyond traditional key-based mechanisms that integrates advanced hardware and software.

Objectives:

- **Enhance Home Security:** Implement a smart doorbell system with biometric authentication to prevent unauthorized access.
- **Enable Real-Time Monitoring:** Provide live video and audio communication between the outdoor and indoor panels, and use a PIR sensor for motion detection.
- **Ensure User Convenience:** Allow remote control of the lock via mobile and web applications.

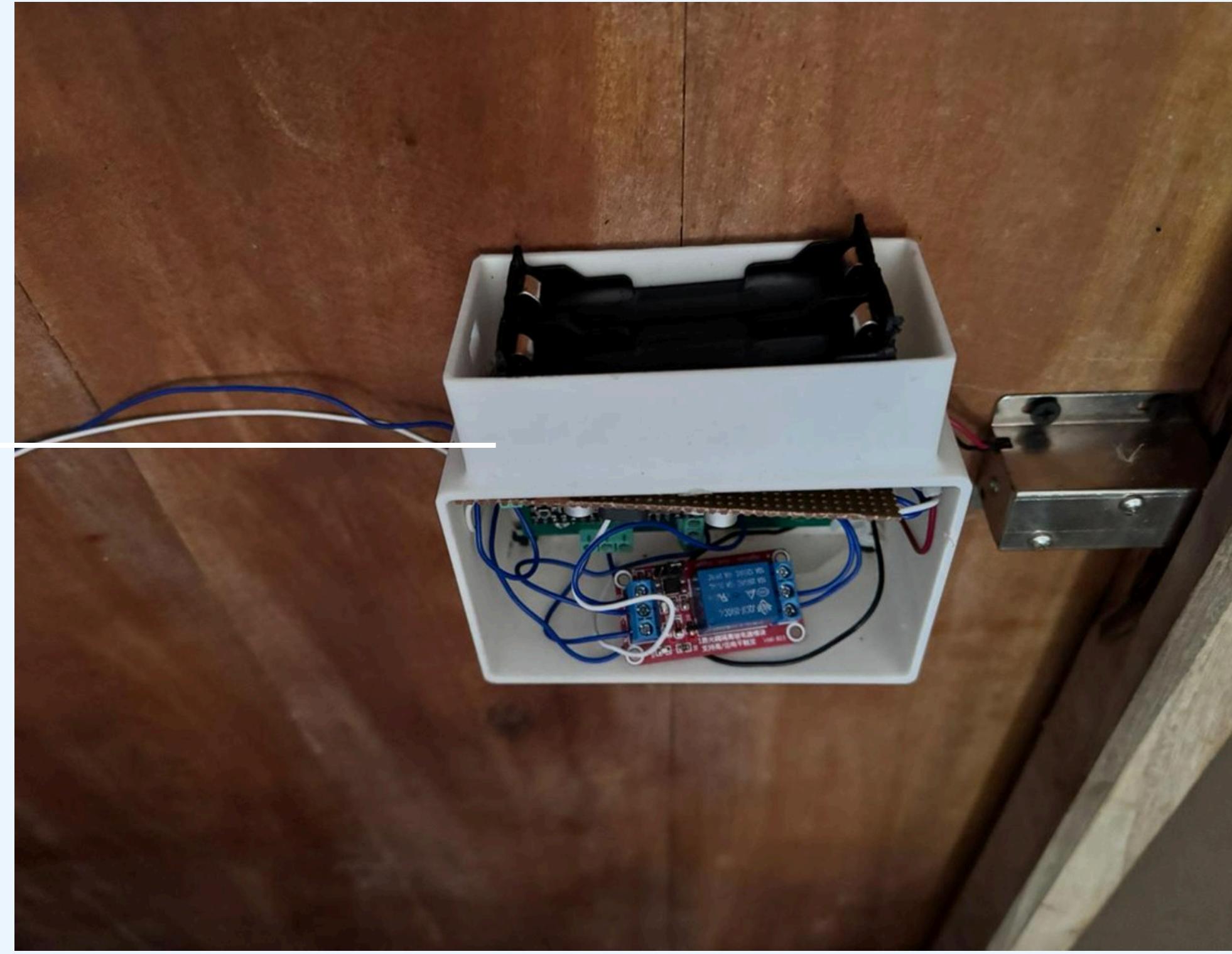
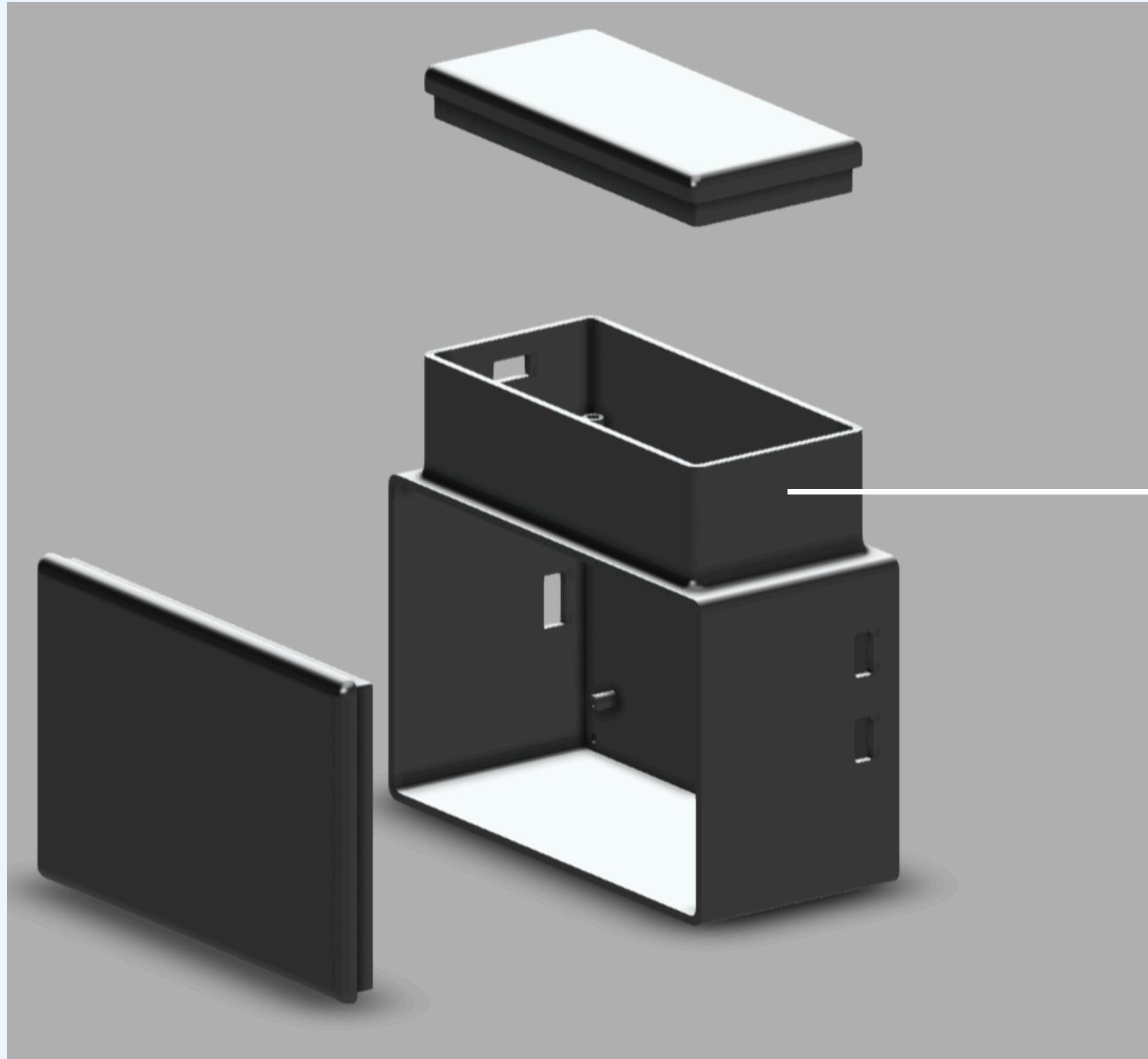
1.

3D Printing Designs and Real Design

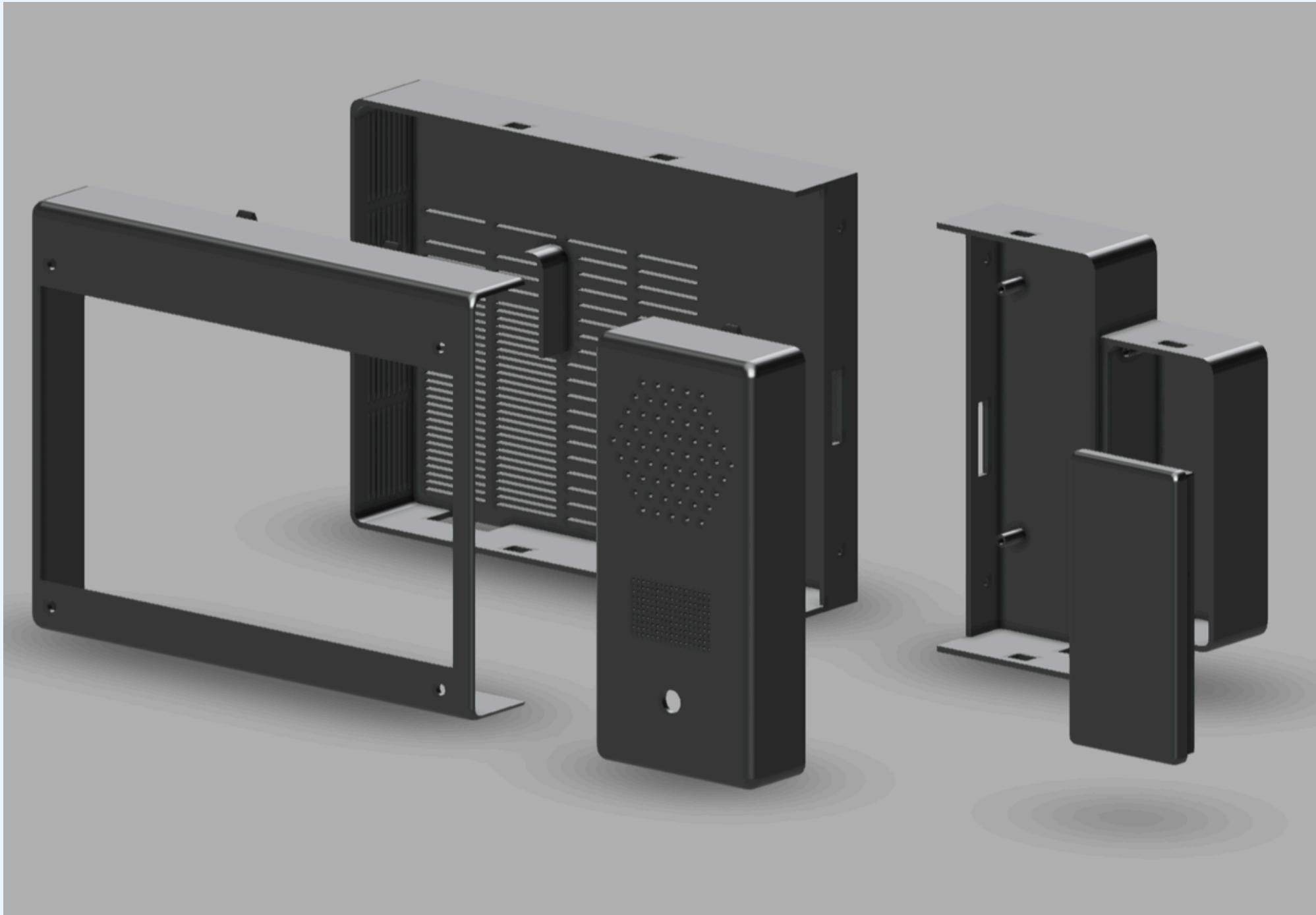


OutDoor Panel

Lock System



Indoor Panel



Real Design

Indoor Panel



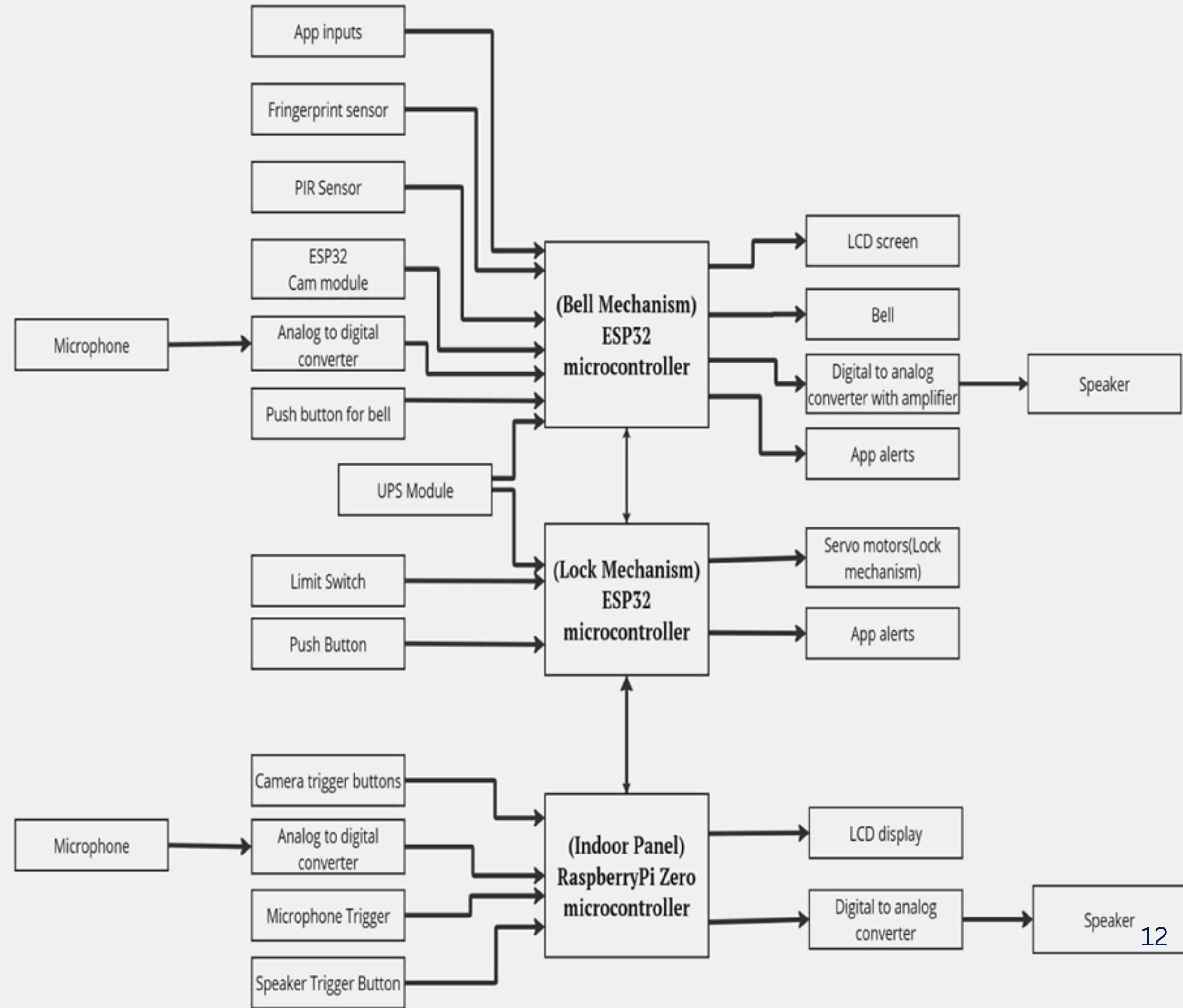
OutDoor Panel

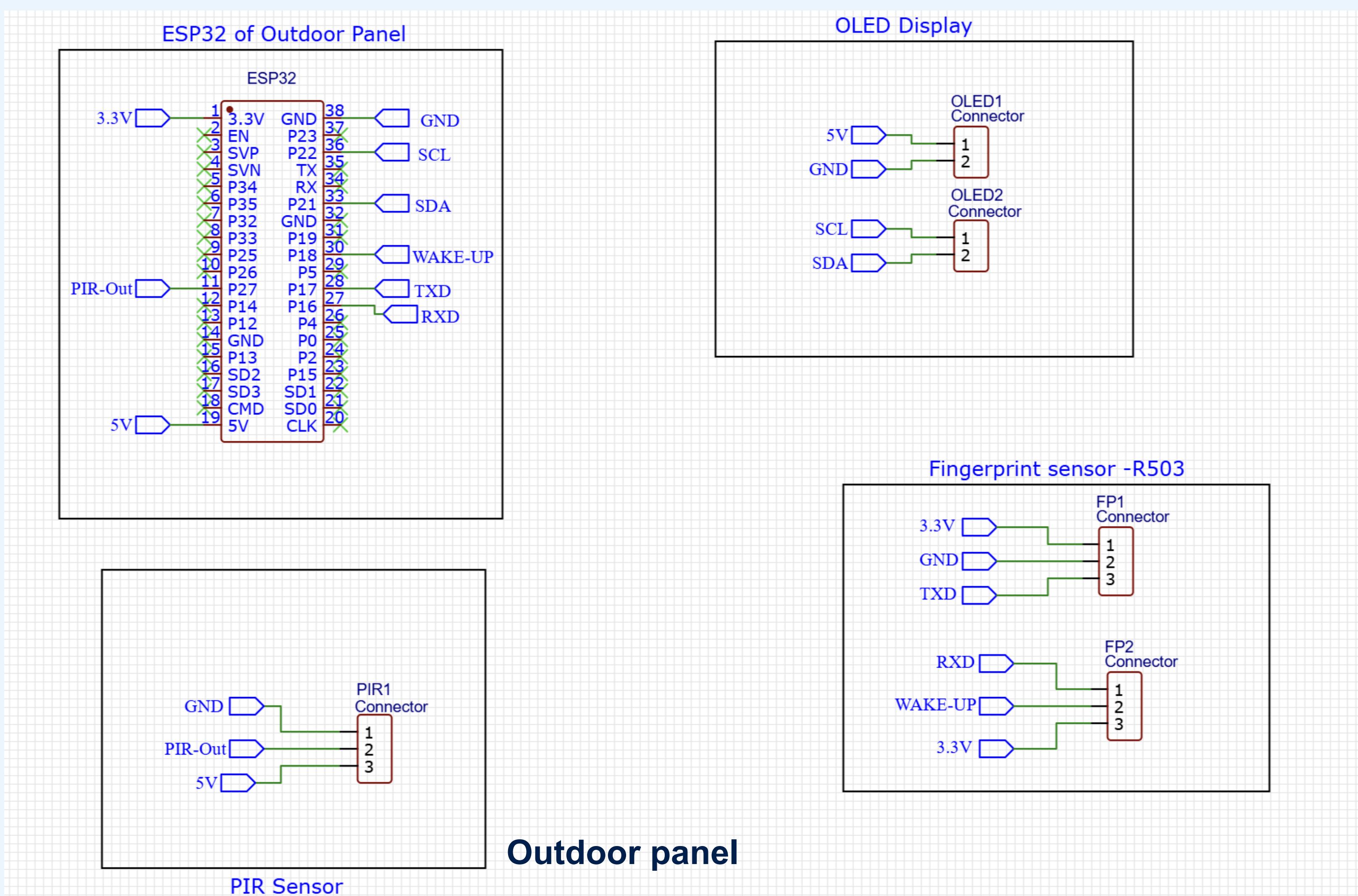


Lock System

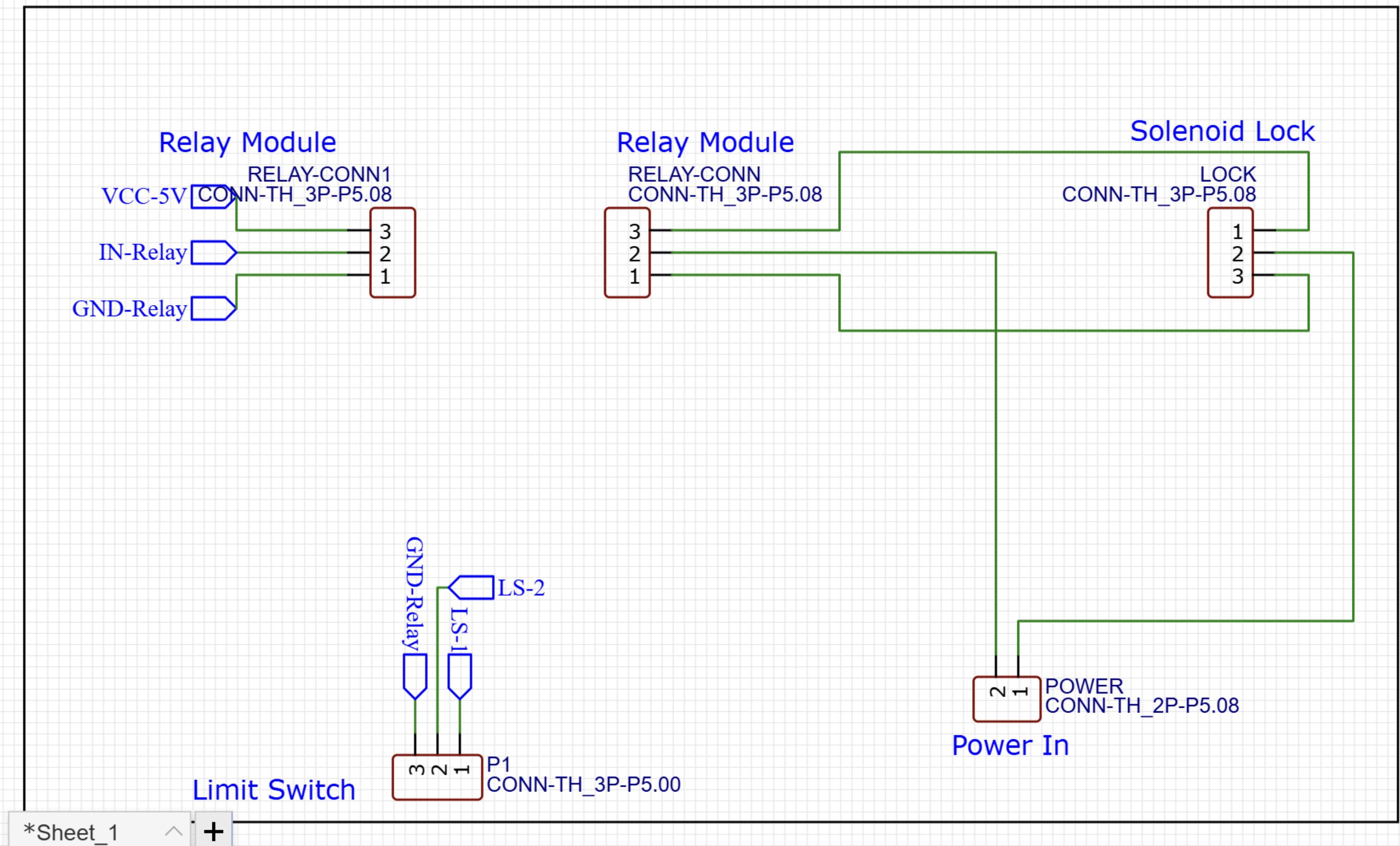


Block Diagram

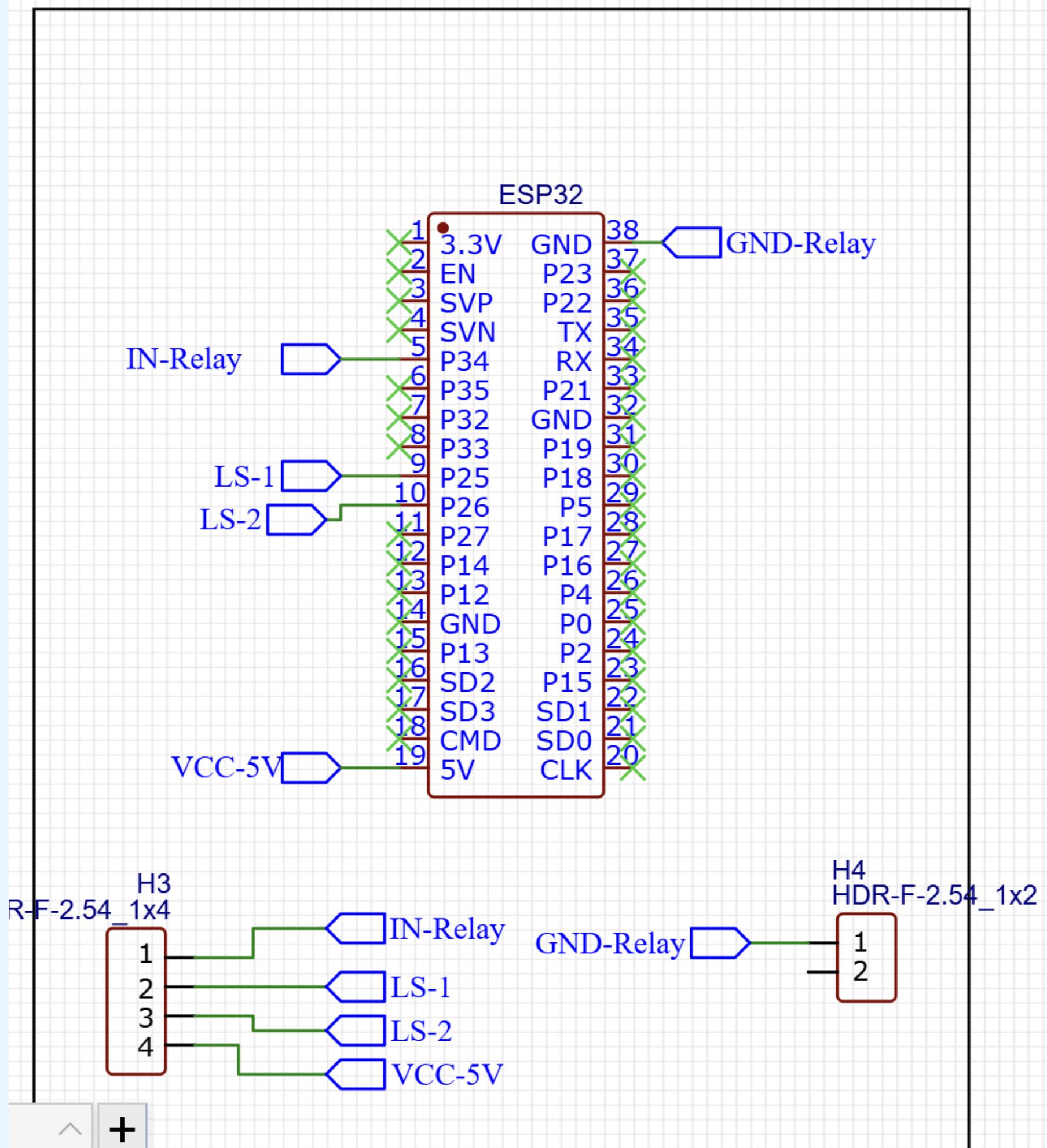




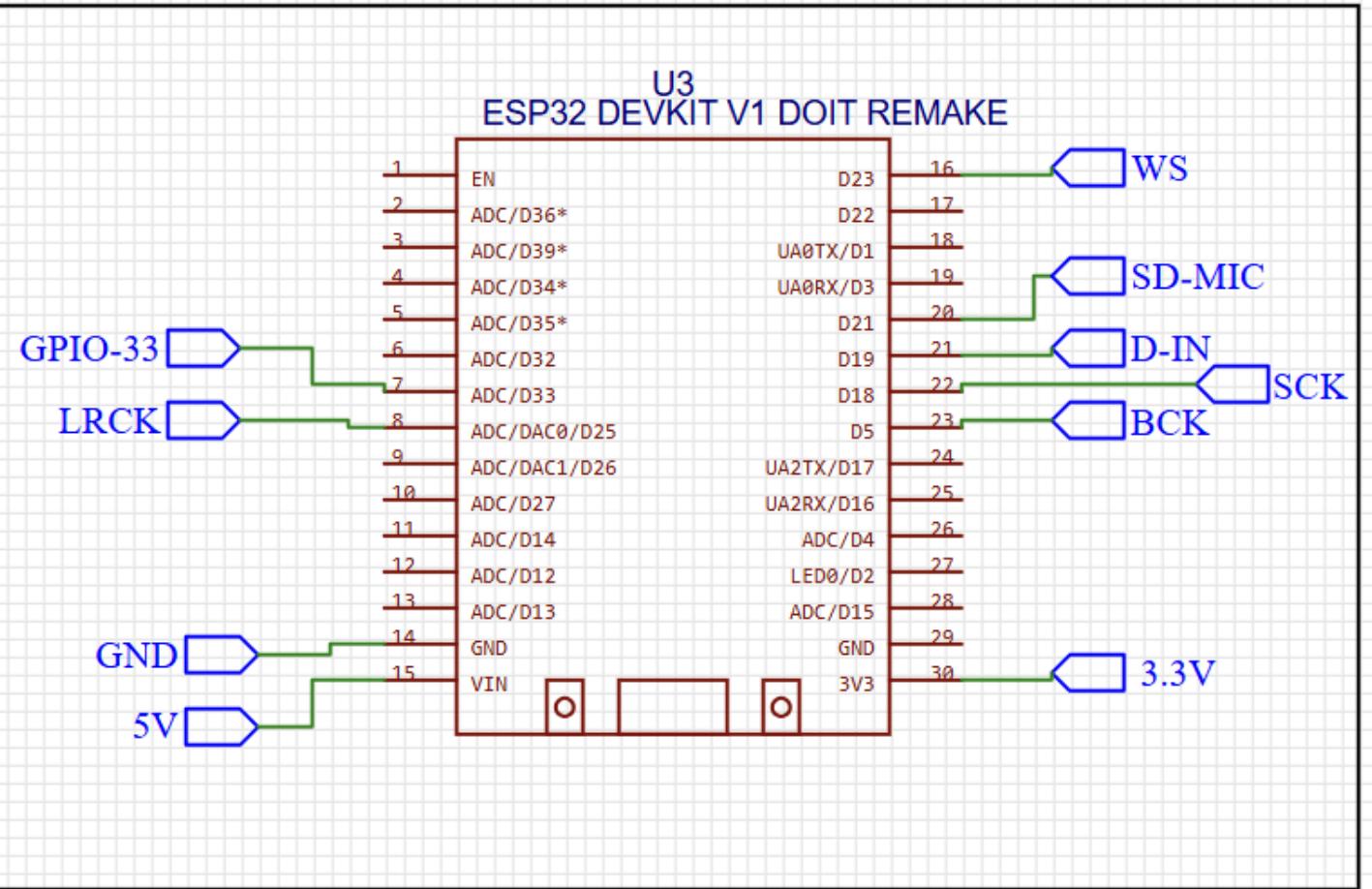
Lock-Unlock mechanism



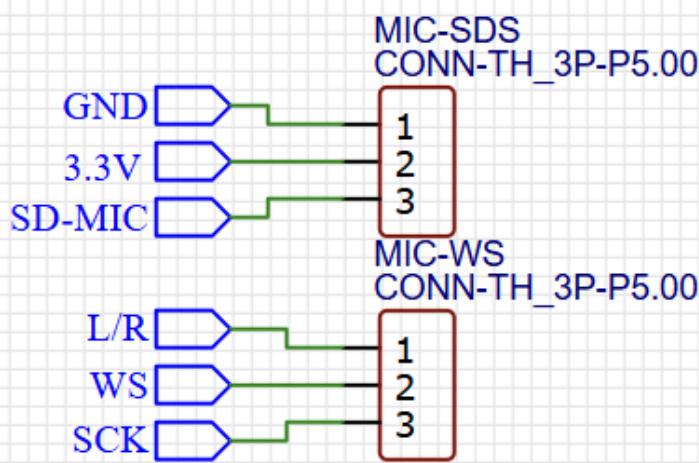
ESP32 of LOCK Mechanism



ESP32 of Walkie Talkie

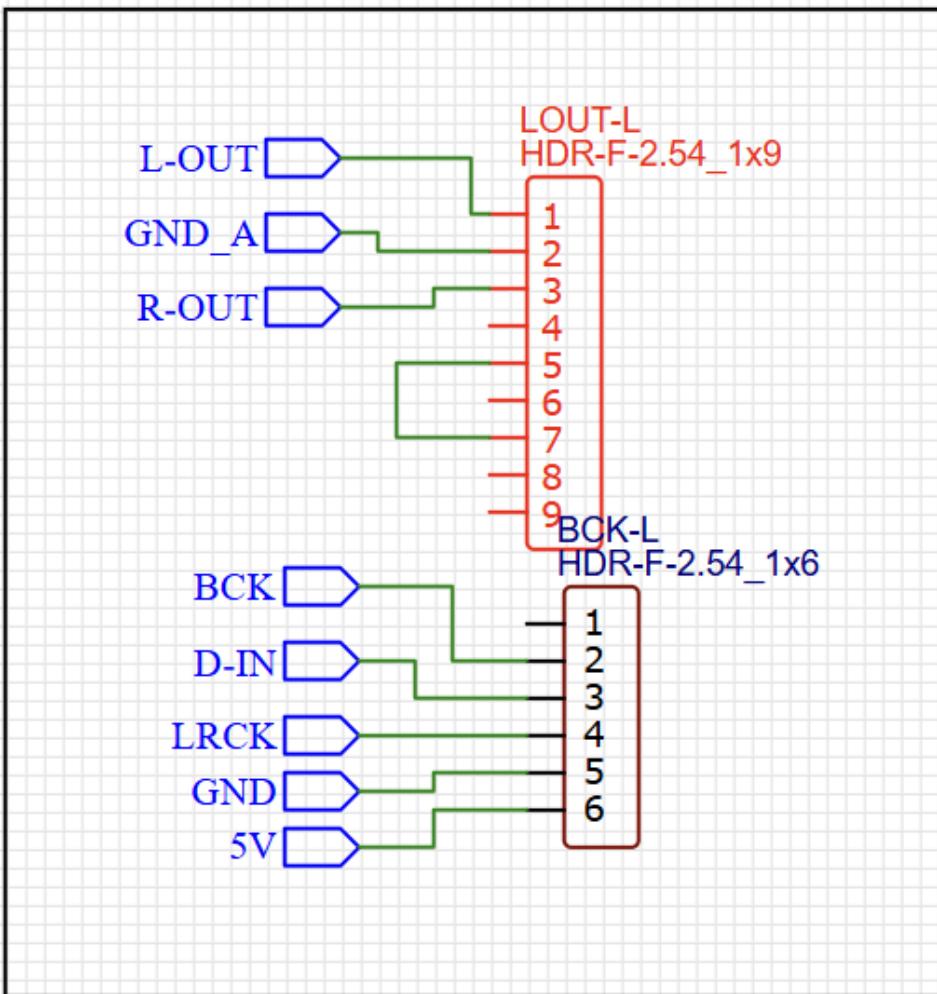


MIC



Push button

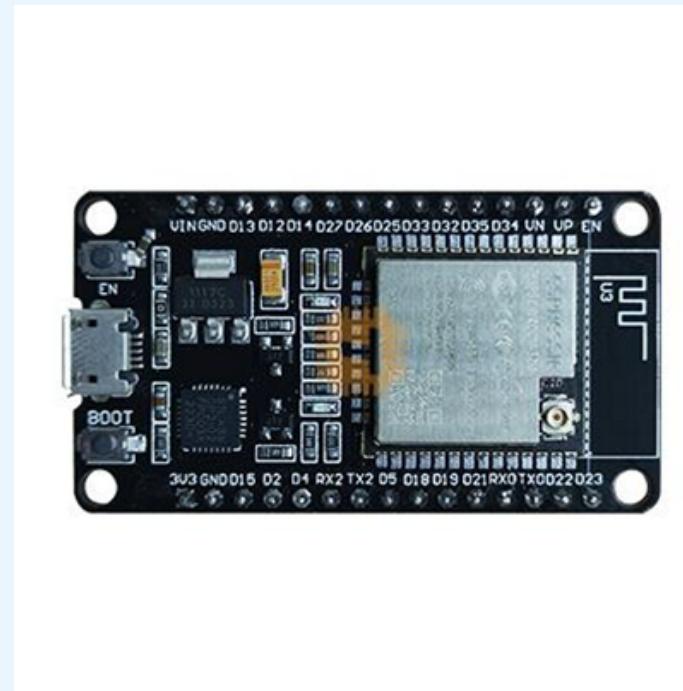
Communication Mechanism



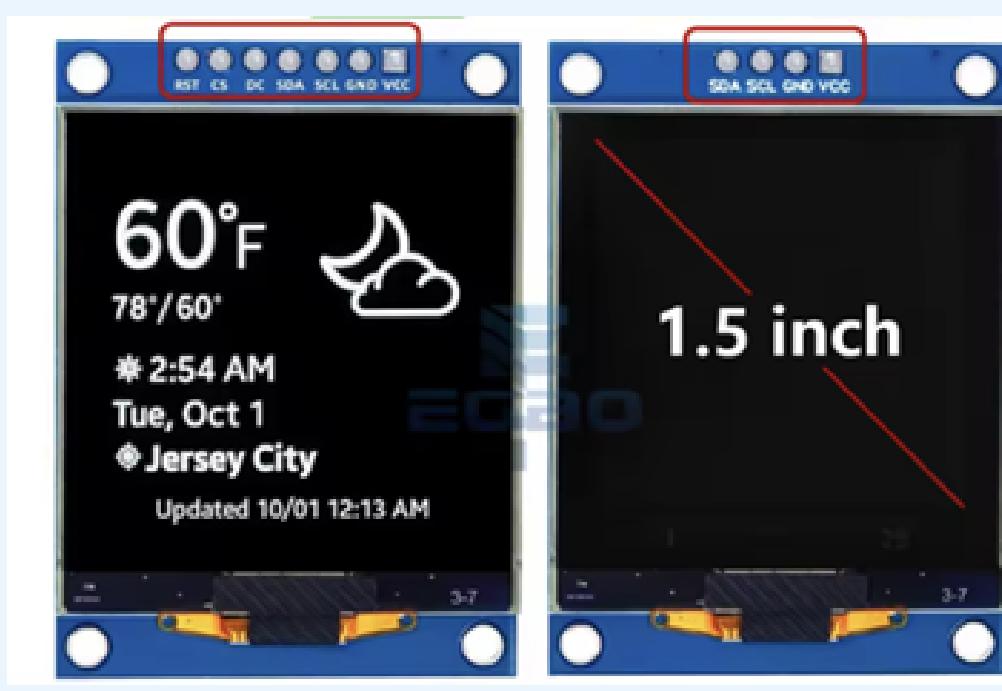
Amplifier

Components Used

NodeMCU ESP32-WROOM-32U



1.5 inch 128*128 OLED Display Module



HC-SR501 PIR Sensor Module



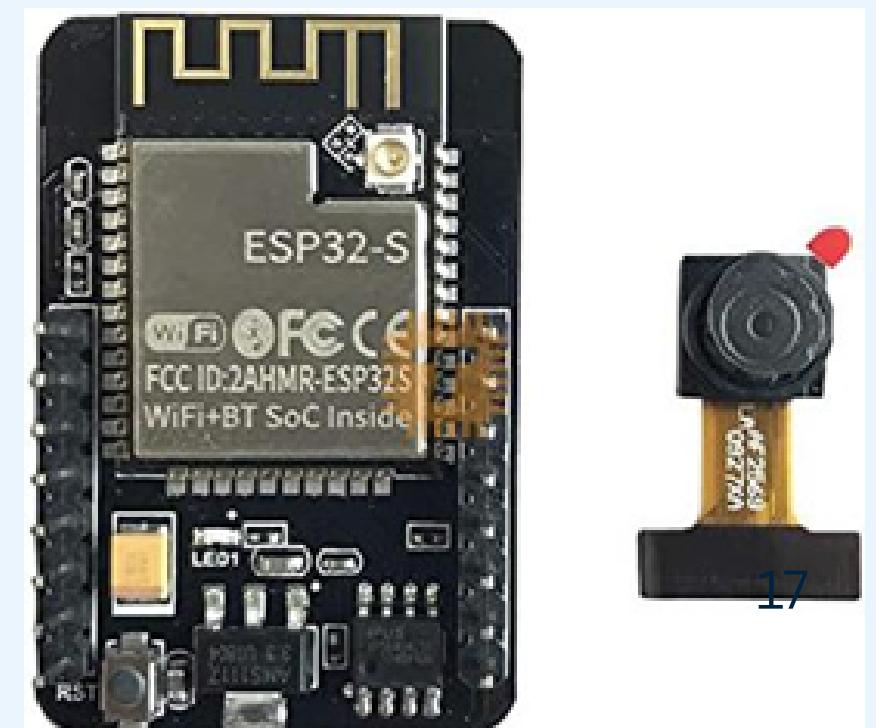
TZT Type-C 15W 3A Fast Charge ups



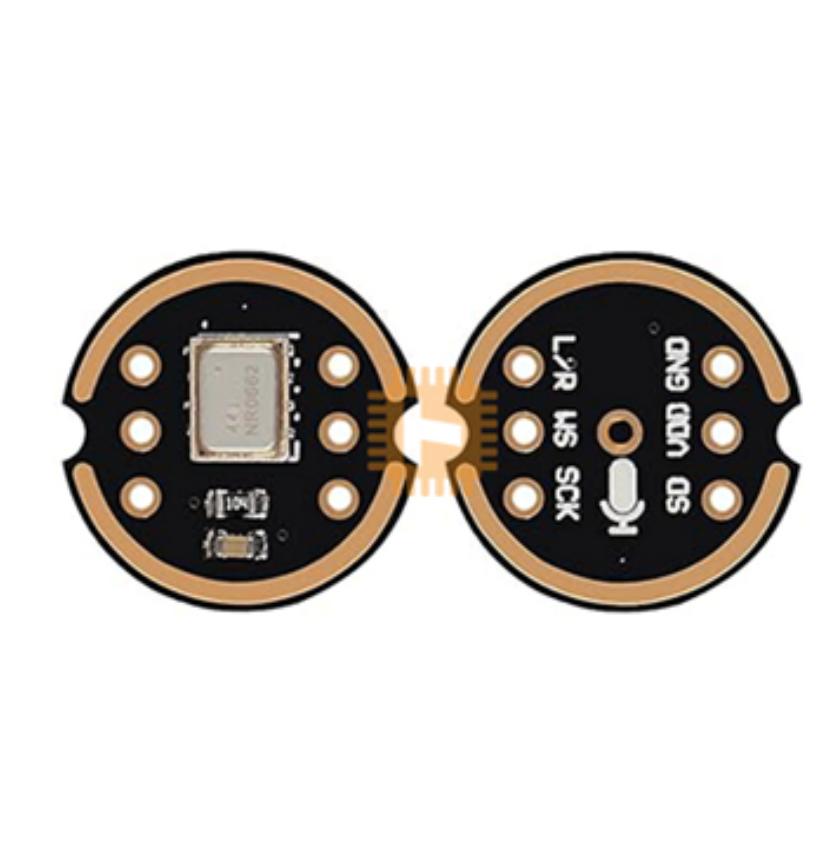
R503 Fingerprint Identification
Fingerprint Module



ESP32-S Camera



INMP441 Omnidirectional Microphone



5VDC 1 Way 1 Channel Relay Module



7 inch 1024x600 HDMI IPS LCD Touch Screen for Raspberry



Solenoid Door Lock 12VDC
27x15x17mm



BU0031-Micro Limit Switch
with 10mm Roller Lever 15A 250VAC



3.7V 3200mA 18650
Rechargeable Battery



8 Ohm 5W speaker 2.5 inch
for portable amplifiers



TPA001 Digital Stereo Power
Amplifier Module



Raspberry Pi 5 8GB)



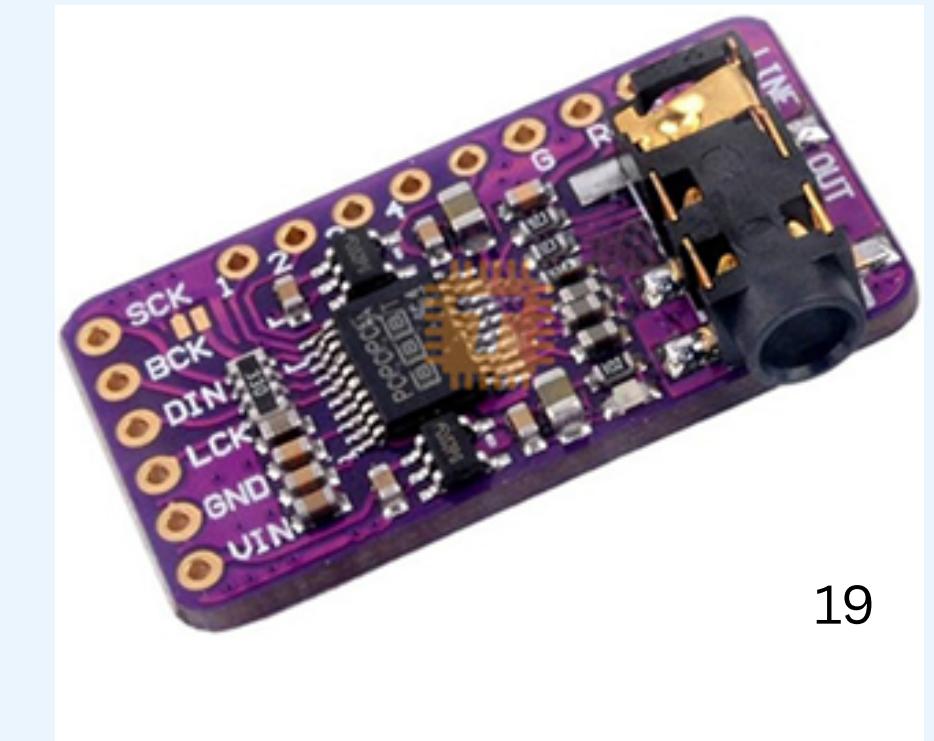
12V 5A SMPS Power Supply
Metal Casing (PS0052)



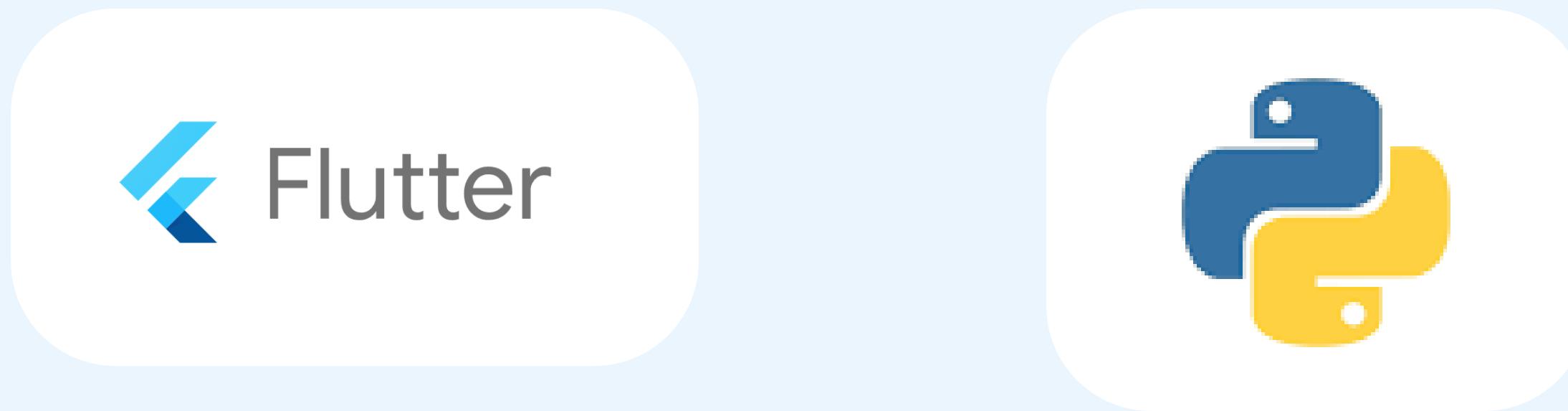
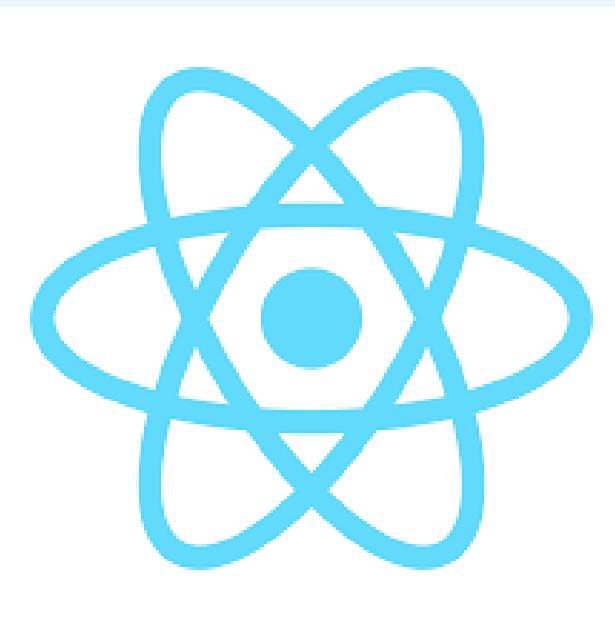
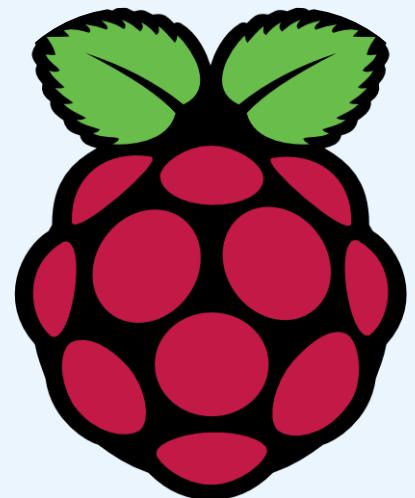
. LM2596S 3-40V to 1.5-35V 4A DC to DC
Adjustable Step-Down Buck Module (MD0042)



PCM5102 DAC Decoder
I2S Player Module



Technologies Used



Work Distribution

GitHub Links:

https://github.com/Vineth-R/GateSentinal_Arduino.git



Responsibilities

- Integrating the camera.
- Set up Raspberry Pi and touch screen.
- Develop the web.



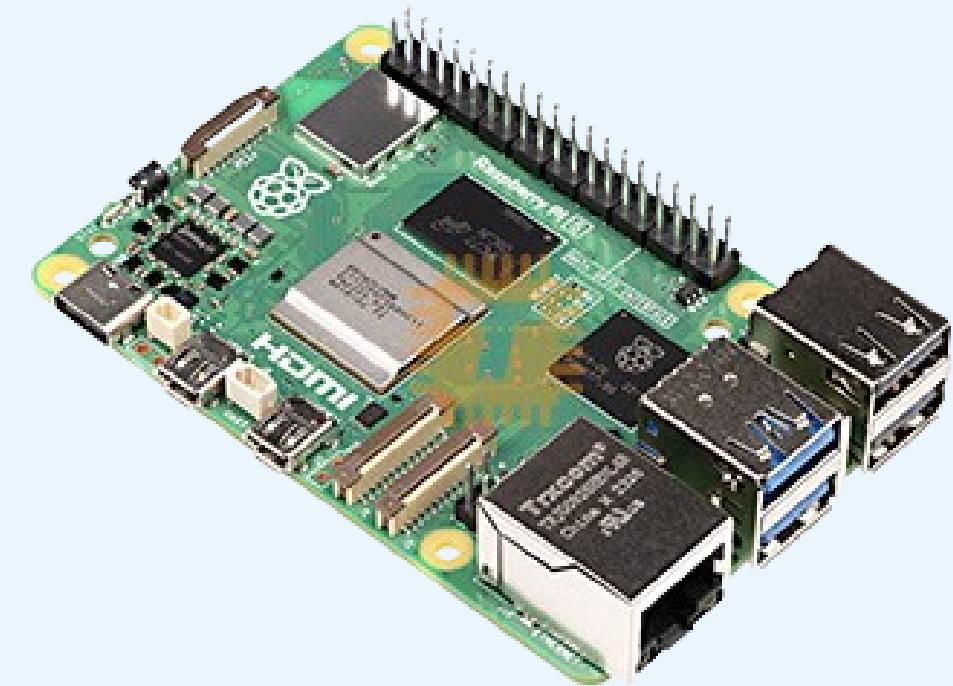
Integrating the camera

- used camera module : ESP32 CAM OV2640 2Megapixel Camera Development Module
- Low power 32-bit CPU
- Wireless Module: ESP32-S WiFi 802.11 b/g/n + Bluetooth 4.2 LE module with PCB antenna, u.FL connector, 32Mbit SPI flash, 4MBit PSRAM.
- micro SD card slot up to 4GB.
- Image Format: JPEG
- Power Supply: 5V via pin header.
- Power Consumption : 180mA , 5V.(Flash LED off)
- Dimensions (ESP32): 40 x 27 x 12 (L x W x H) mm.
- Temperature Range: Operating: -20 °C ~ 85 °C; storage: -40 °C ~ 90 °C @ < 90>



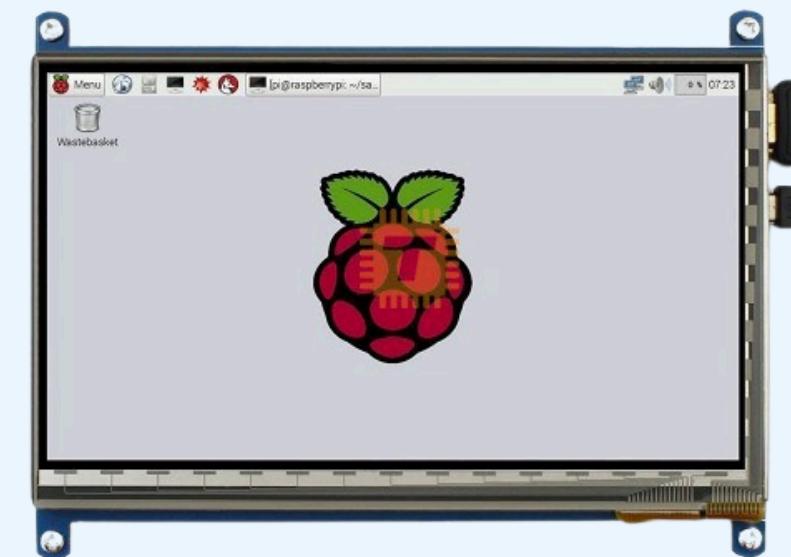
setting up the raspberry pi and touch screen

- Raspberry pi 5 8GB RAM
- Broadcom BCM2712 2.4GHz quad-core 64-bit Arm Cortex-A76 CPU, with cryptography extensions, 512KB per-core L2 caches and a 2MB shared L3 cache.
- VideoCore VII GPU, supporting OpenGL ES 3.1, Vulkan 1.2
- Dual 4Kp60 HDMI® display output with HDR support
- 4Kp60 HEVC decoder
- 5V/5A DC power via USB-C.



Waveshare 7 inch 1024x600 HDMI IPS LCD Touch Screen

- Size: 7.0 inch
- Physical Resolution: 1024x600
- Capacitive touch screen



web app

Home

About Us

Contact

Welcome to GateSentinel

Your advanced smart doorbell system

Control Panel

VIDEO

UNLOCK

Home Page

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Home

About Us

Contact

Video Management

Live View

Recordings



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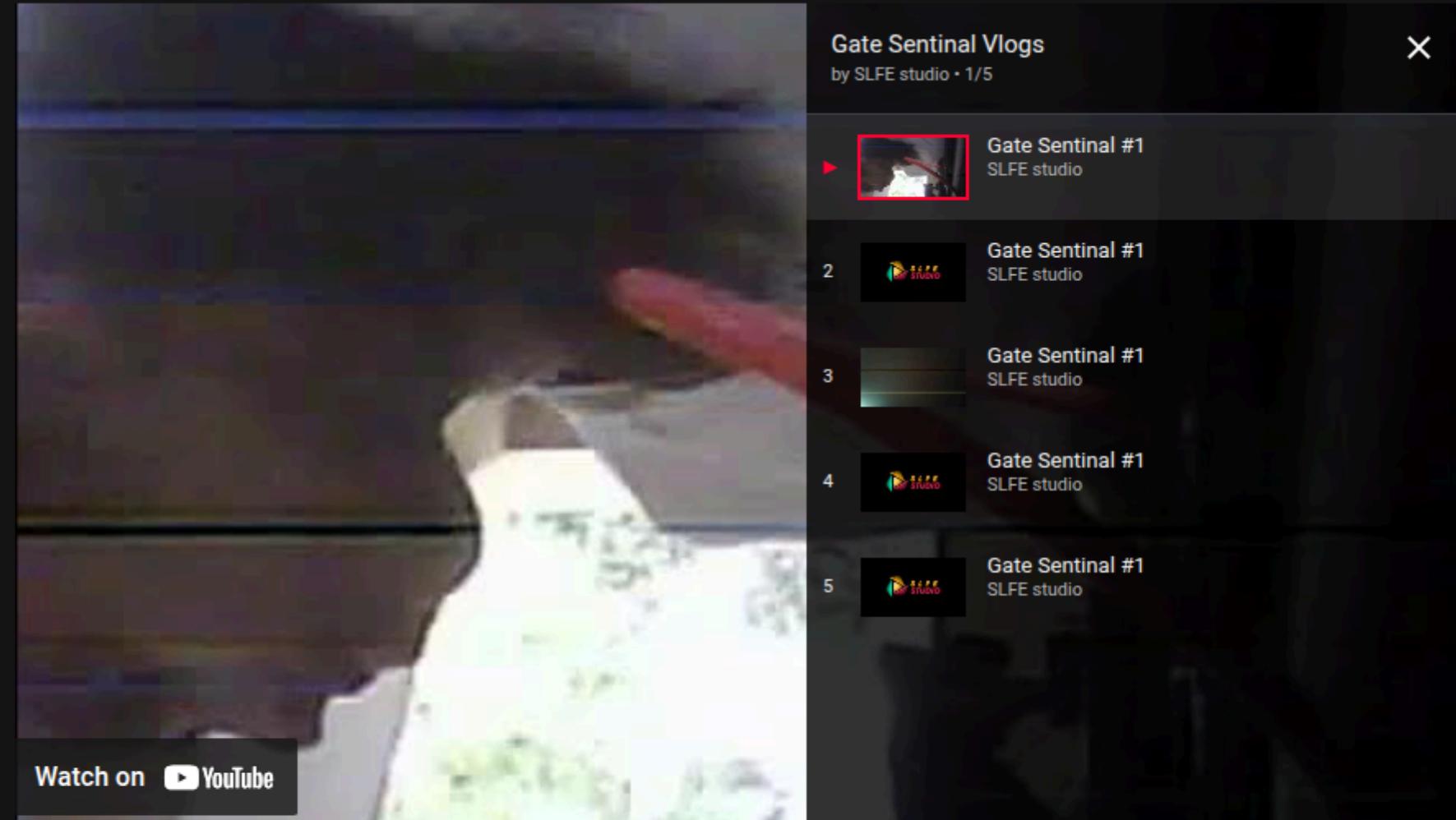
Video Management

Live View

Recordings

Recorded Streams

Watch past streams from your YouTube playlist



Video Recordings



Responsibilities

- **Fingerprint Sensor Integration:** Configured and programmed the R503 fingerprint sensor, ensuring reliable enrollment, storage, and authentication functions for secure system operation.
- **Camera Module Setup:** Installed and calibrated the camera module, optimizing image orientation and stream quality to guarantee smooth and accurate functionality.
- **OLED Display Configuration:** Connected and programmed the OLED display, implementing text and graphic outputs for real-time system feedback and user interaction.
- **PCB Layout Design:** Designed the printed circuit board (PCB) layout, organizing component placement, power routing, and signal traces to achieve a compact, efficient, and reliable hardware design.

Fingerprint Sensor_(R503 Sensor Module)



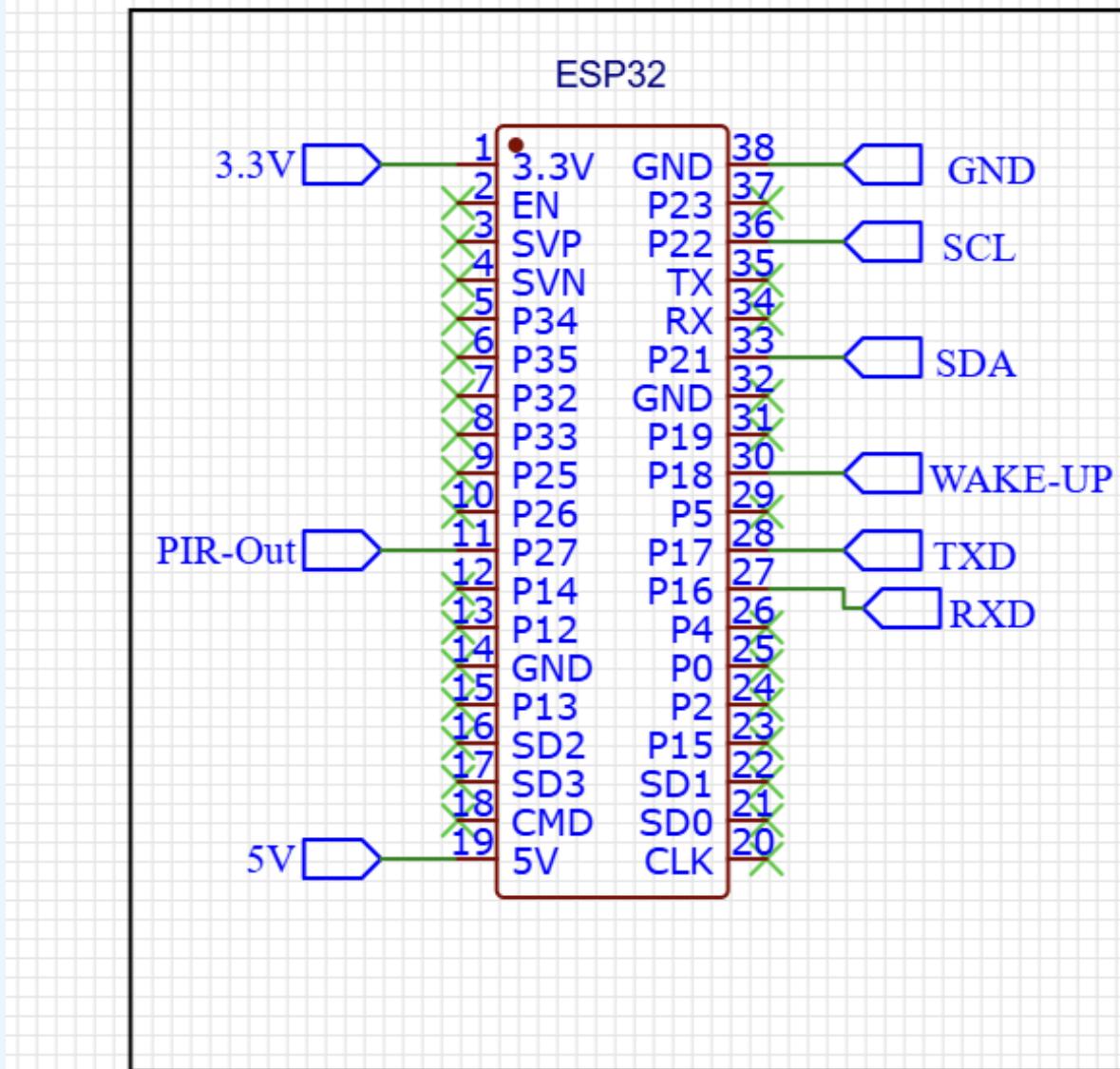
- **Module name - R503 Circular Capacitive Fingerprint Identification Sensor**
- **192 x 192 pixel sensor**
- **Can save upto 200 fingerprints.**
- **Can adapt to many types of fingers. (dry fingers, wet fingers, light-textured fingerprints, and old fingers.)**
- **Voltage: 3.3V DC**
- **Working current: 20mA**

Fingerprint Sensor_(R503 Sensor Module)

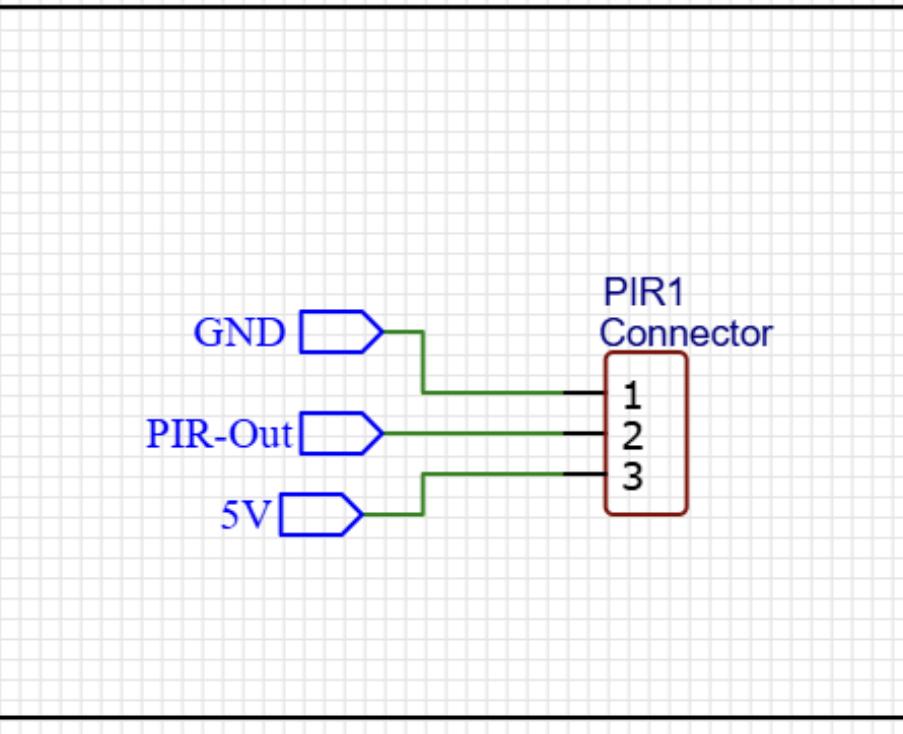
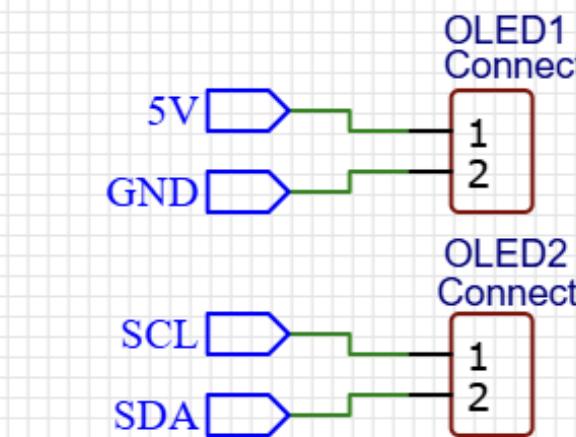
```
// Fingerprint sensor
HardwareSerial mySerial(1); // UART1 port for fingerprint sensor
Adafruit_Fingerprint finger(&mySerial);
```

```
// 3. If a finger is detected, perform fingerprint recognition
if (digitalRead(WAKEUP_PIN) == LOW) {
    finger.LEDcontrol(FINGERPRINT_LED_ON, 0, FINGERPRINT_LED_BLUE, 0);
    recognizeFingerprint();
    finger.LEDcontrol(FINGERPRINT_LED_ON, 0, FINGERPRINT_LED_PURPLE, 0);
} else {
    finger.LEDcontrol(FINGERPRINT_LED_ON, 0, FINGERPRINT_LED_PURPLE, 0);
    delay(1000); // Wait a second before next check
}
```

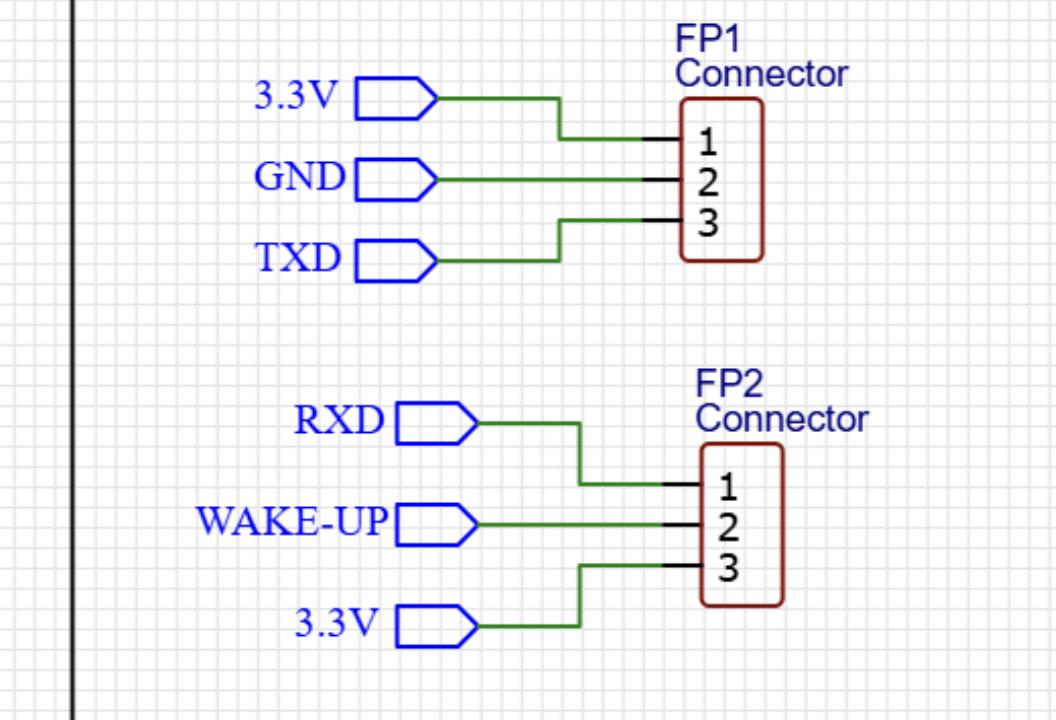
ESP32 of Outdoor Panel



OLED Display



Fingerprint sensor -R503

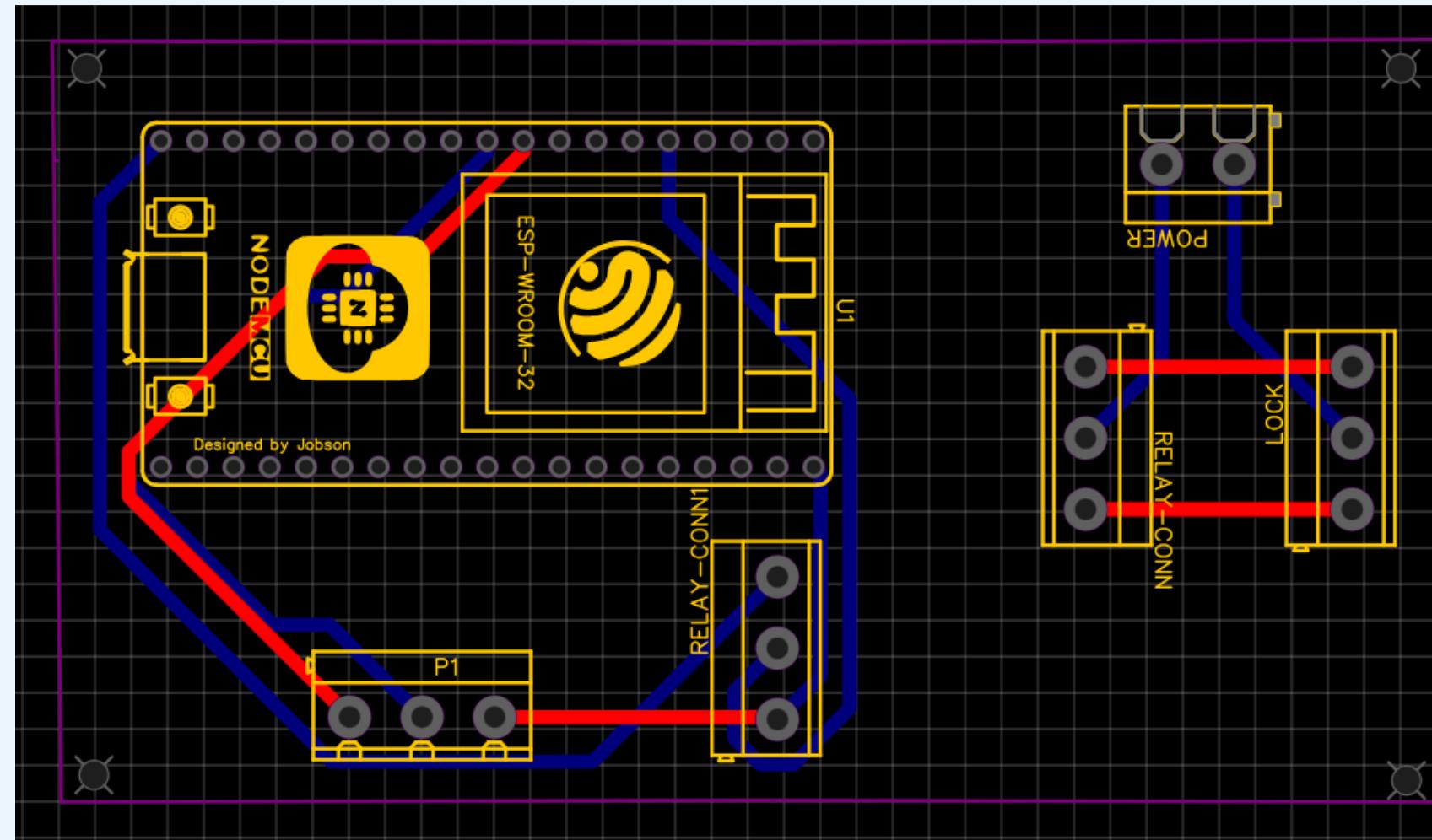


OLED Display

- **1.5 Inch OLED LCD Module White Display 128*128 Dots Driver Chip SH1107 COG I²C IIC 4PIN 3V-5V**
- **Resolution: 128 × 128 dots**
- **Driver IC: SH1107 (similar to SSD1306 but supports 128×128 resolution)**
- **Interface: I²C (IIC, 4-pin)**
- **Voltage: 3.3V – 5V compatible (with onboard regulator/level shifting)**

PCB Layout Design

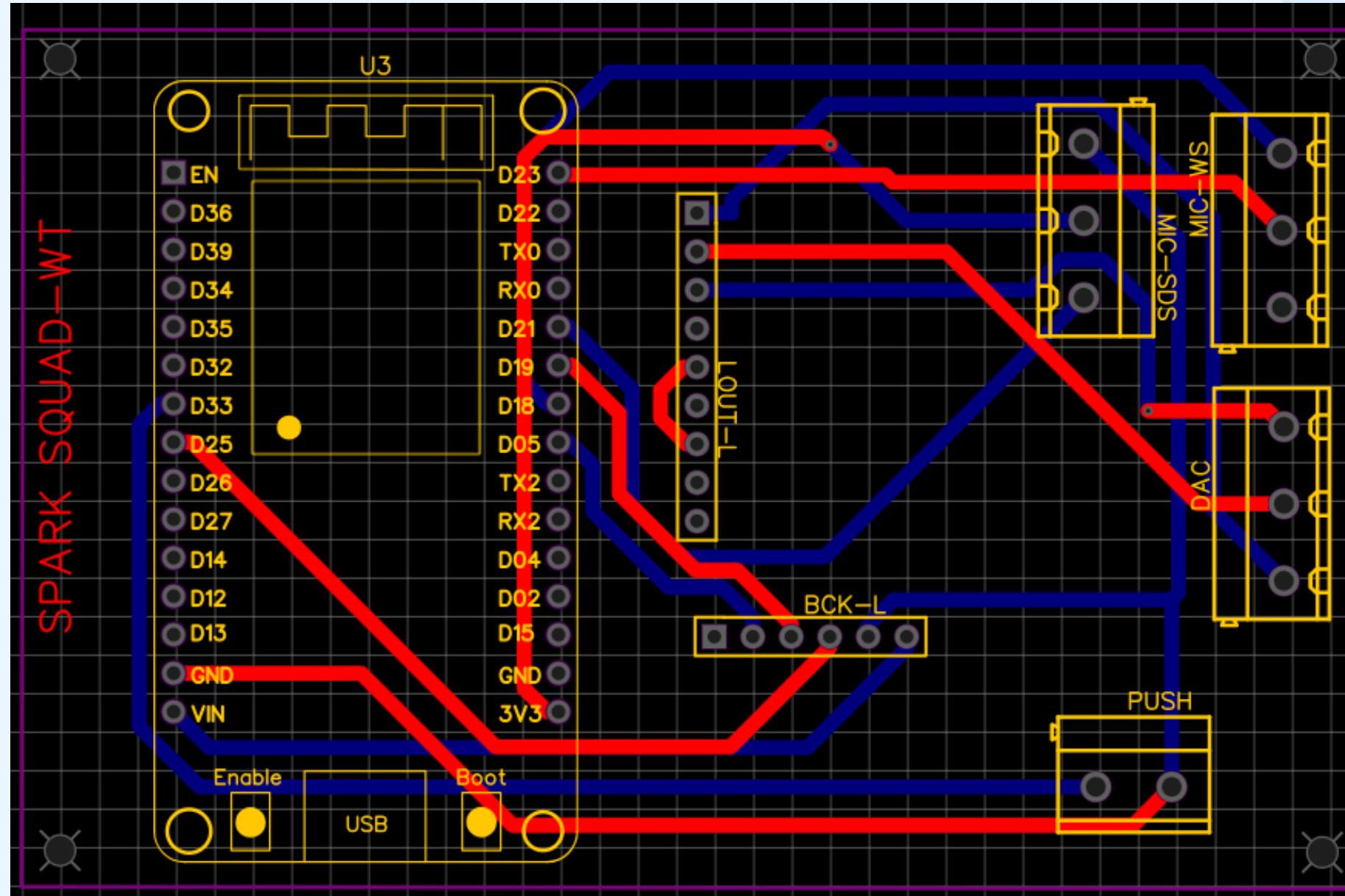
- Designed 3 PCBs for the system



Lock Mechanism

- Dimensions :
 - Length : 97mm
 - Width: 54 mm
- Number of layers : 2
- Track width : 1mm

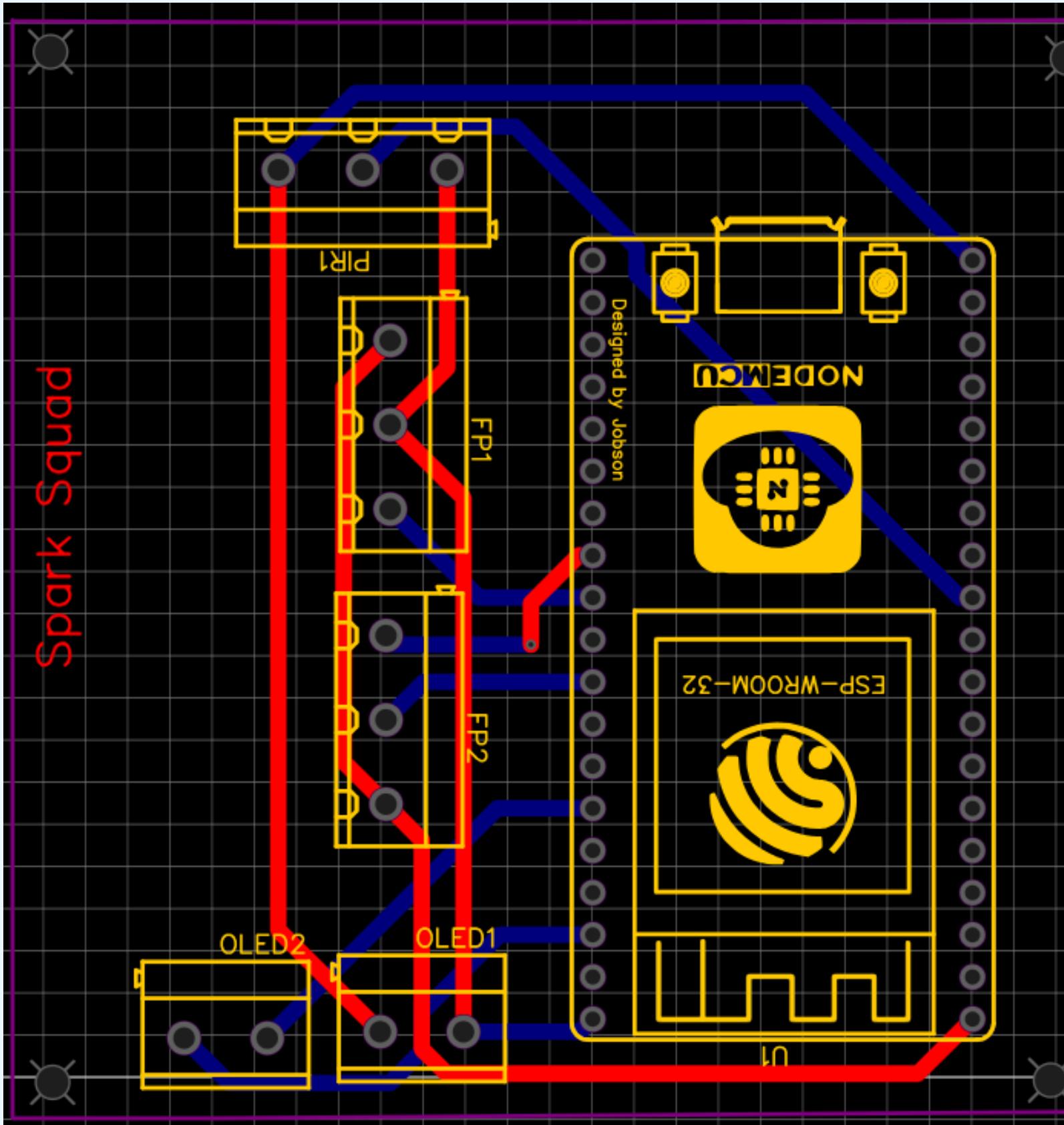
PCB Layout Design



Communication Device

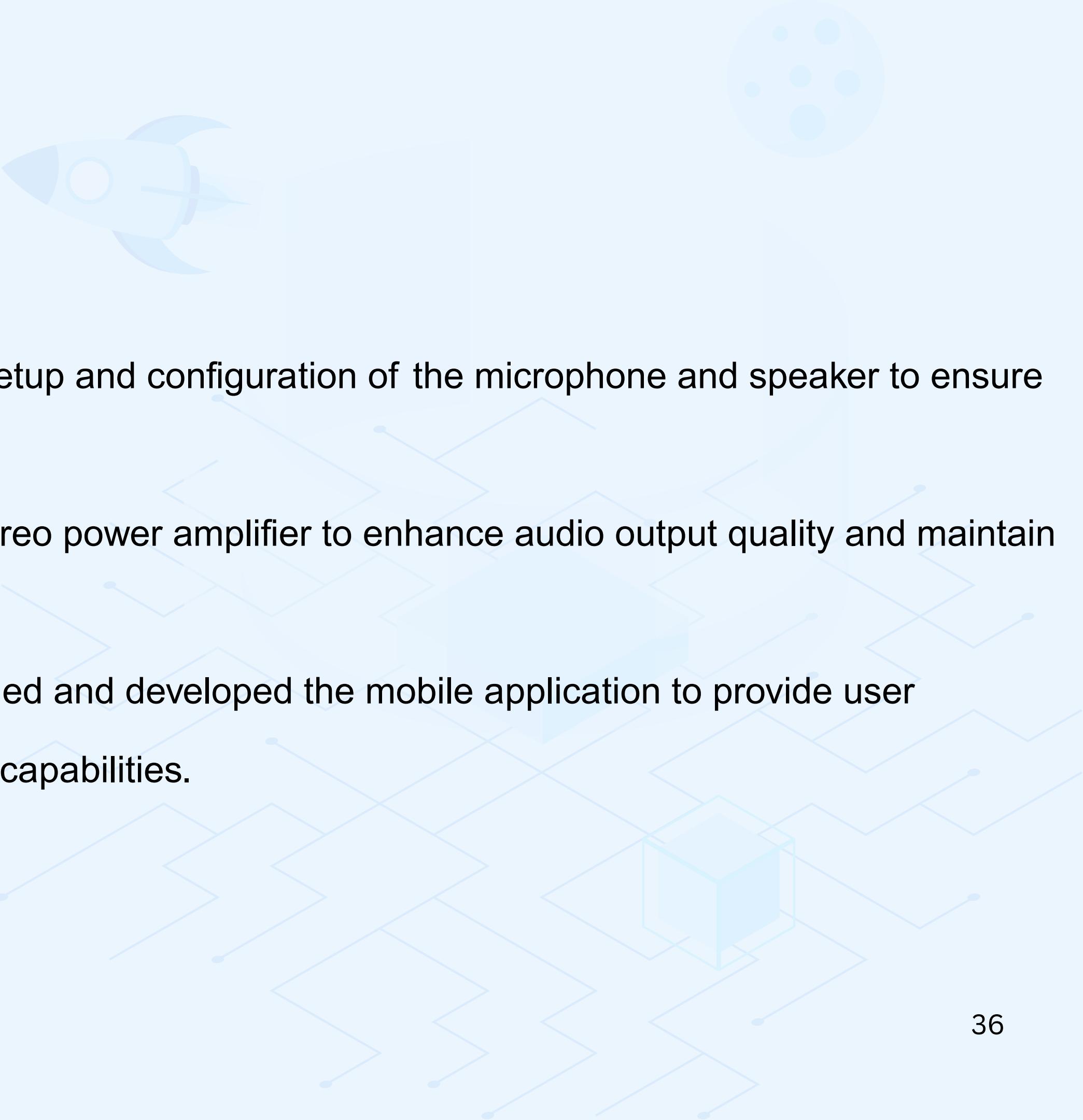
- Dimensions :
 - Length : 88mm
 - Width: 57 mm
- Number of layers : 2
- Track width : 1mm

PCB Layout Design



Outdoor Panel

- Dimensions :
 - Length : 66mm
 - Width: 65 mm
- Number of layers : 2
- Track width : 1mm



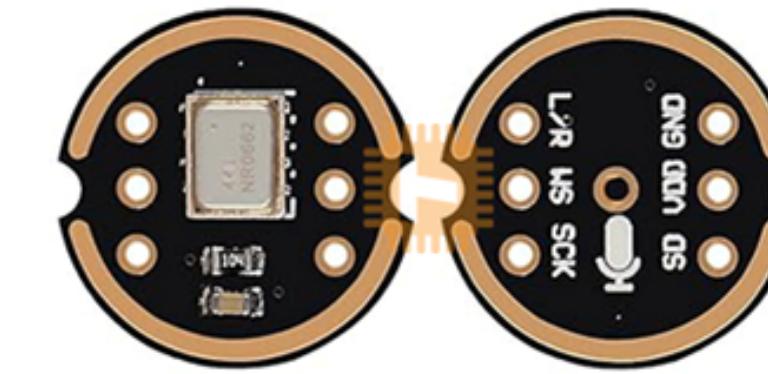
Responsibilities

- **Audio System Integration:** Handled the setup and configuration of the microphone and speaker to ensure clear input and output for the system.
- **Amplifier Setup:** Configured the digital stereo power amplifier to enhance audio output quality and maintain reliable performance.
- **Mobile Application Development:** Designed and developed the mobile application to provide user interaction, system control, and monitoring capabilities.

Walkie-Talkie System: Premium Audio Capture & Processing

INMP441 MEMS

- High-Performance, Omnidirectional MEMS Sensor
- Digital **I²S Output** (24-bit data)
- Eliminates analog noise pickup and ground loops.
- Direct digital interface to the ESP32.
- SNR: 61 dBA (Superior voice clarity over analog mics)
- Current Consumption: Only 1.4 mA (@ 1.8V) - Ultra low power

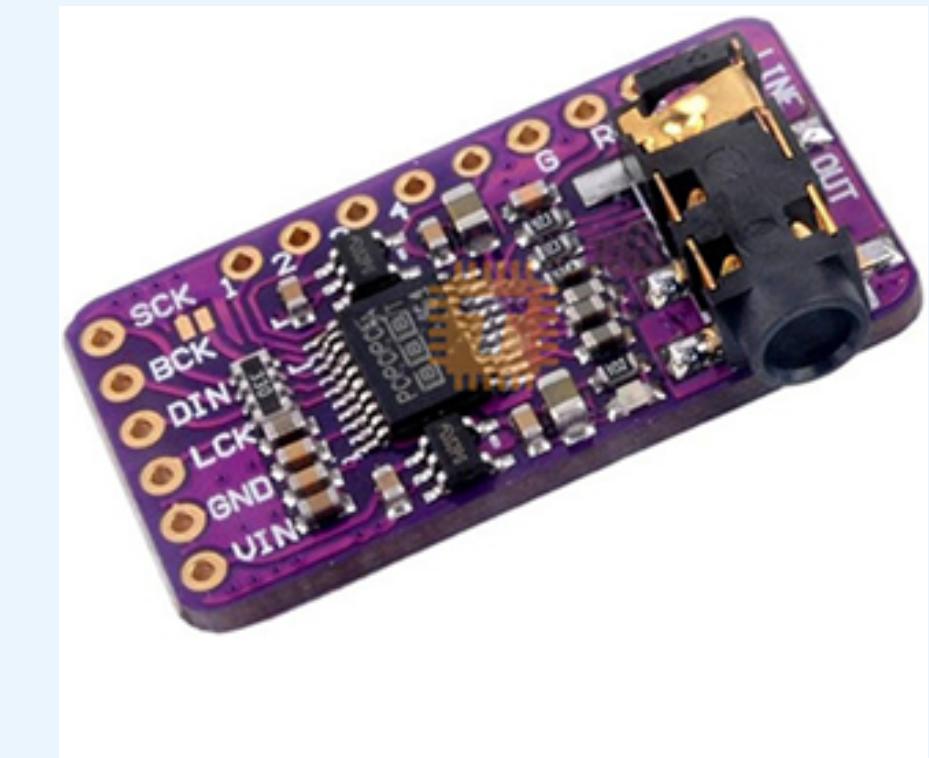


ESP32 Microcontroller

- Processes the I²S digital audio stream directly.
- Implements the ESP-NOW protocol for low-latency, peer-to-peer communication.
- Manages the push-to-talk (PTT) logic and system state.
- All-Digital Signal Path: From the mic to transmission, preserving signal integrity.

PCM5102 DAC

- Resolution: 32-bit, 384 kHz capable DAC.
- Dynamic Range: 112 dB (Exceeds CD quality)
- Voltage: 3.3V operation
- Current: ~25 mA typical total consumption during active playback.
save mode.

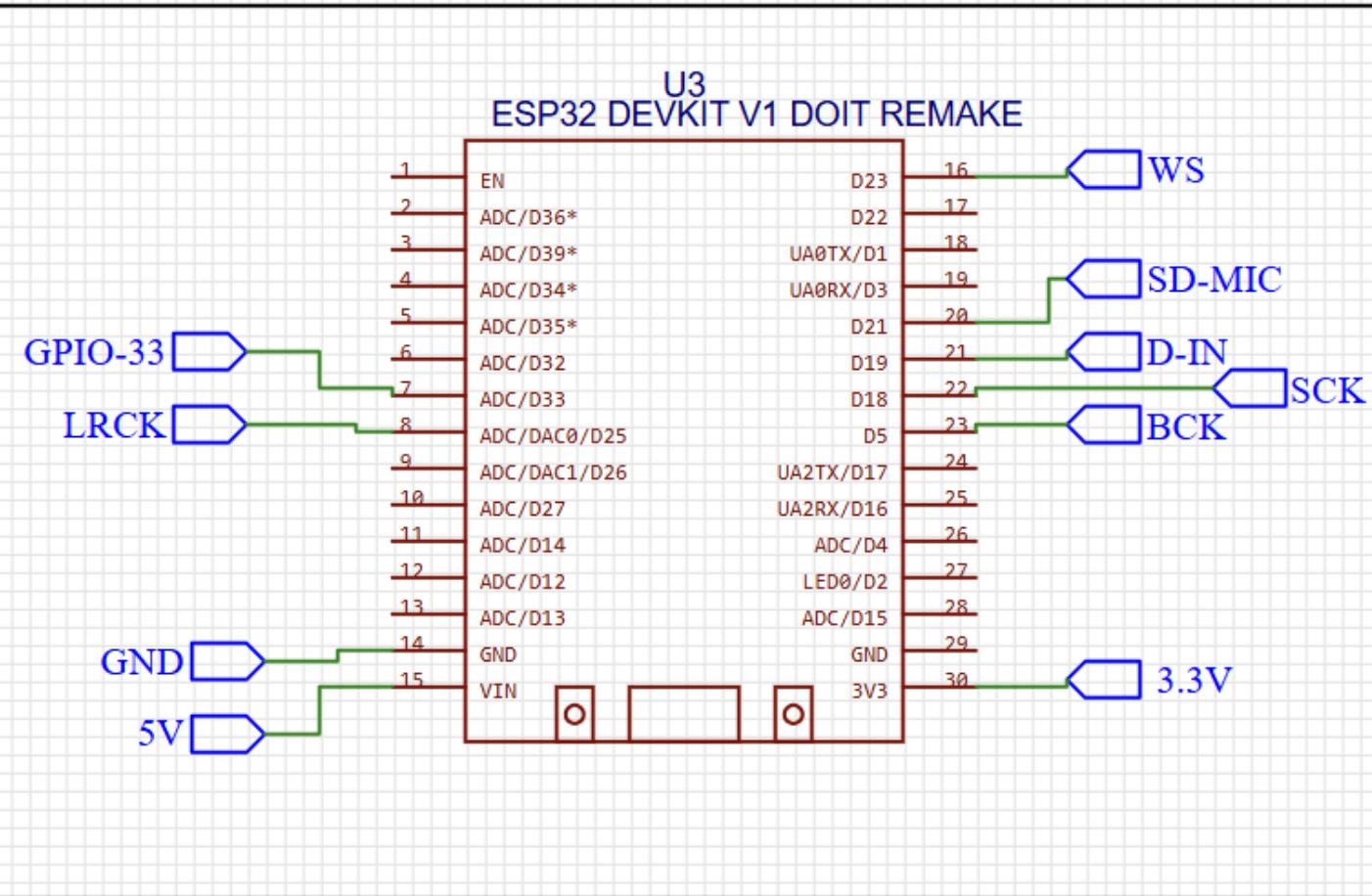


TPA31101 Amplifier

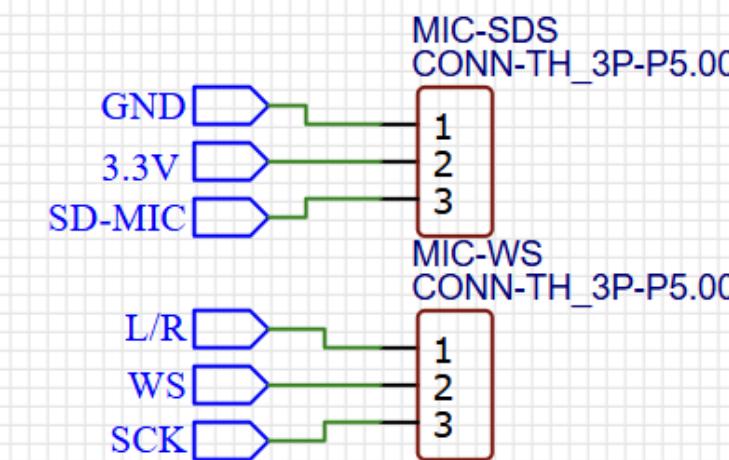
- Efficiency:** >90% (Minimal heat, extends battery life)
- Output Power: Up to 15W per channel into 8Ω (from a 16V supply).
- Wide Voltage Range: Operates from 8V to 26V, offering great flexibility for different power supplies.
- Filter-Free Operation: Simplifies board design and reduces component count and cost.



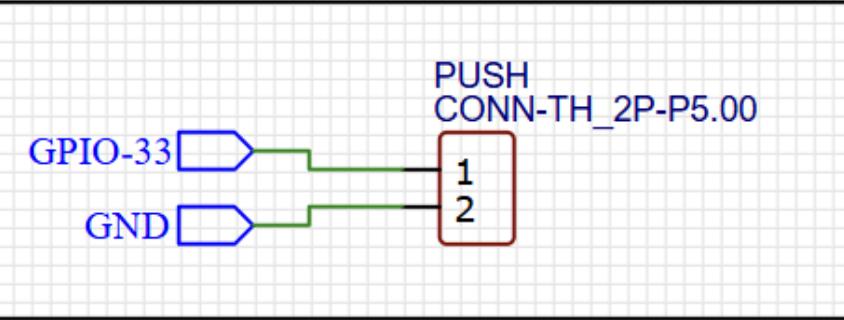
ESP32 of Walkie Talkie



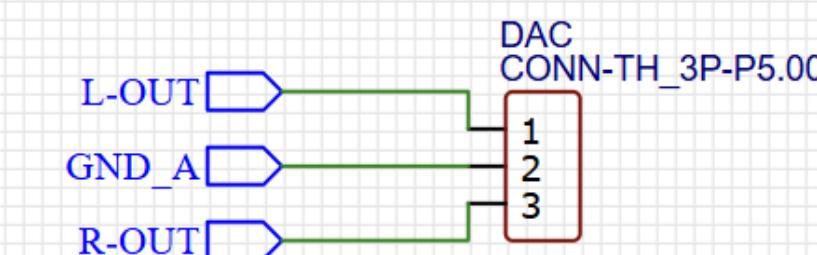
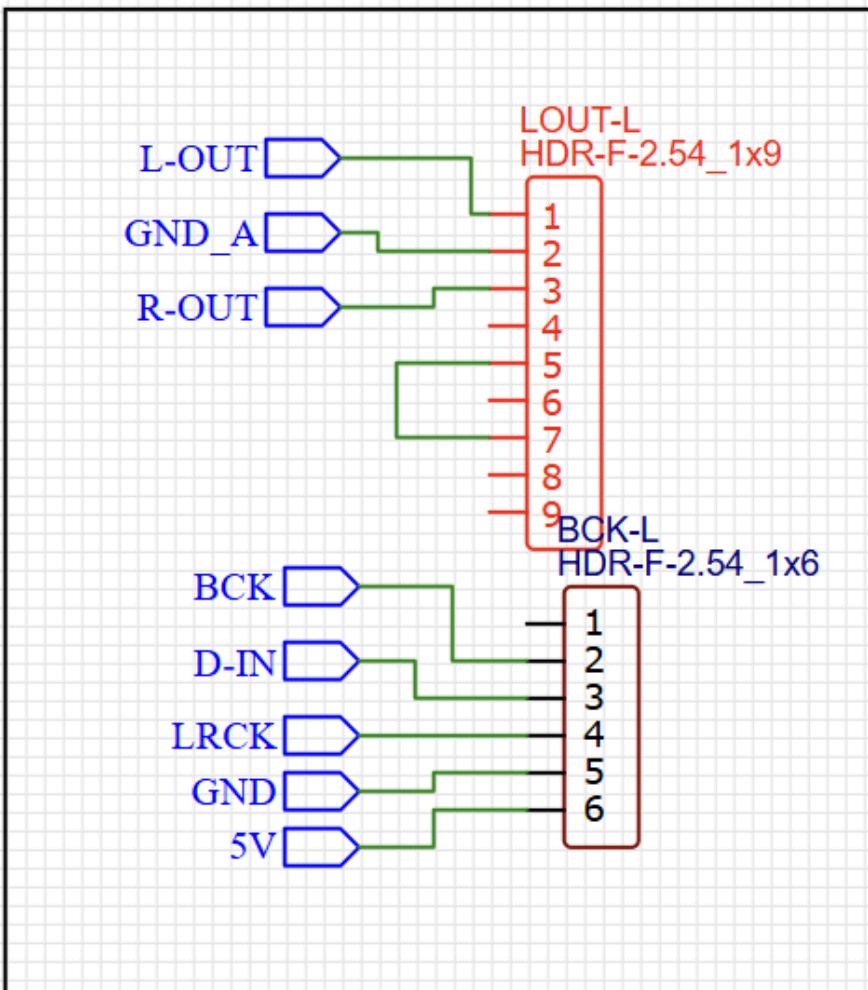
MIC



Push button



Amplifier



Mobile Application

Core Development Framework:

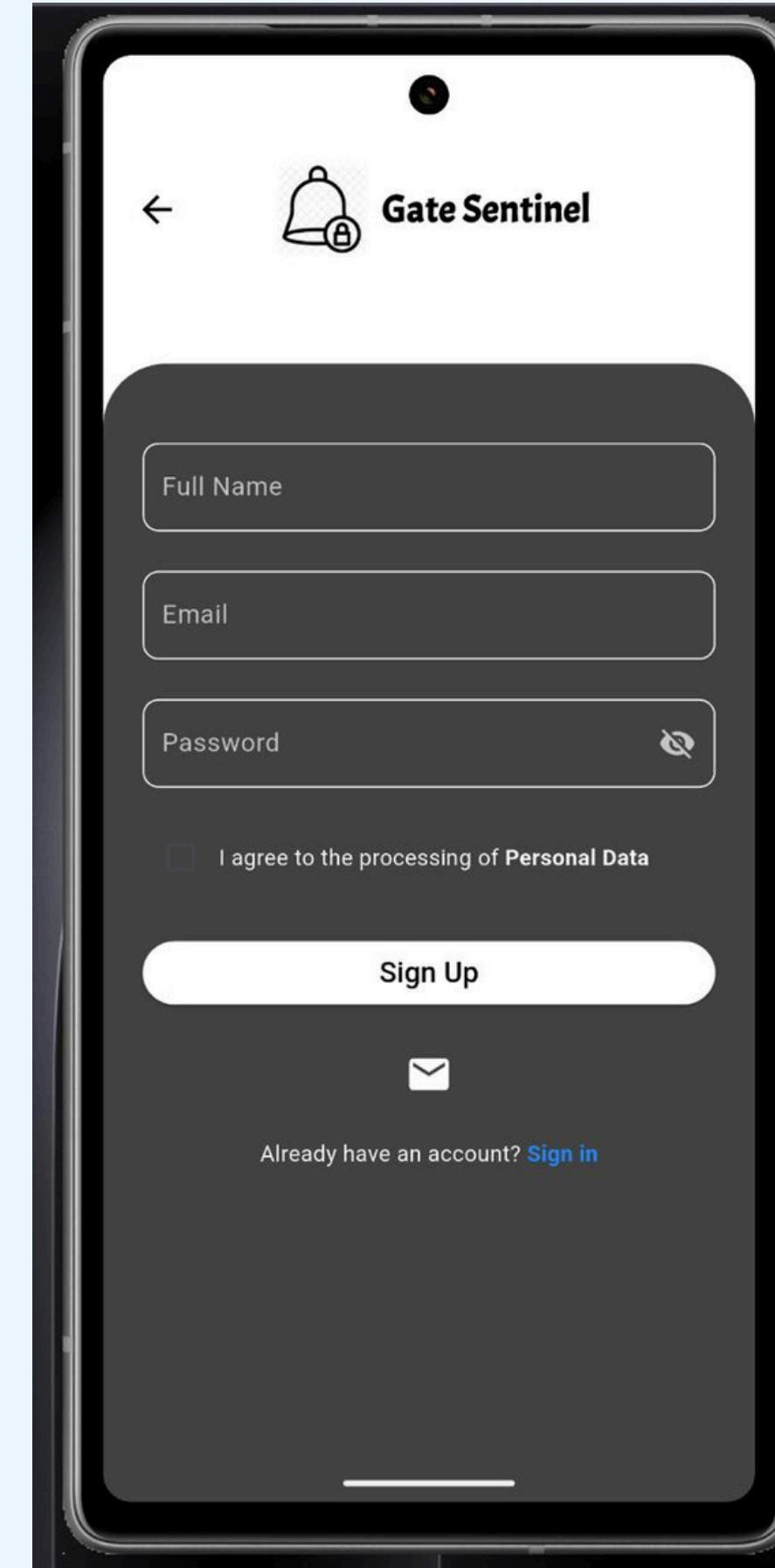
- Flutter & Dart: For a single codebase producing high-performance Android applications.

Key Application Features:

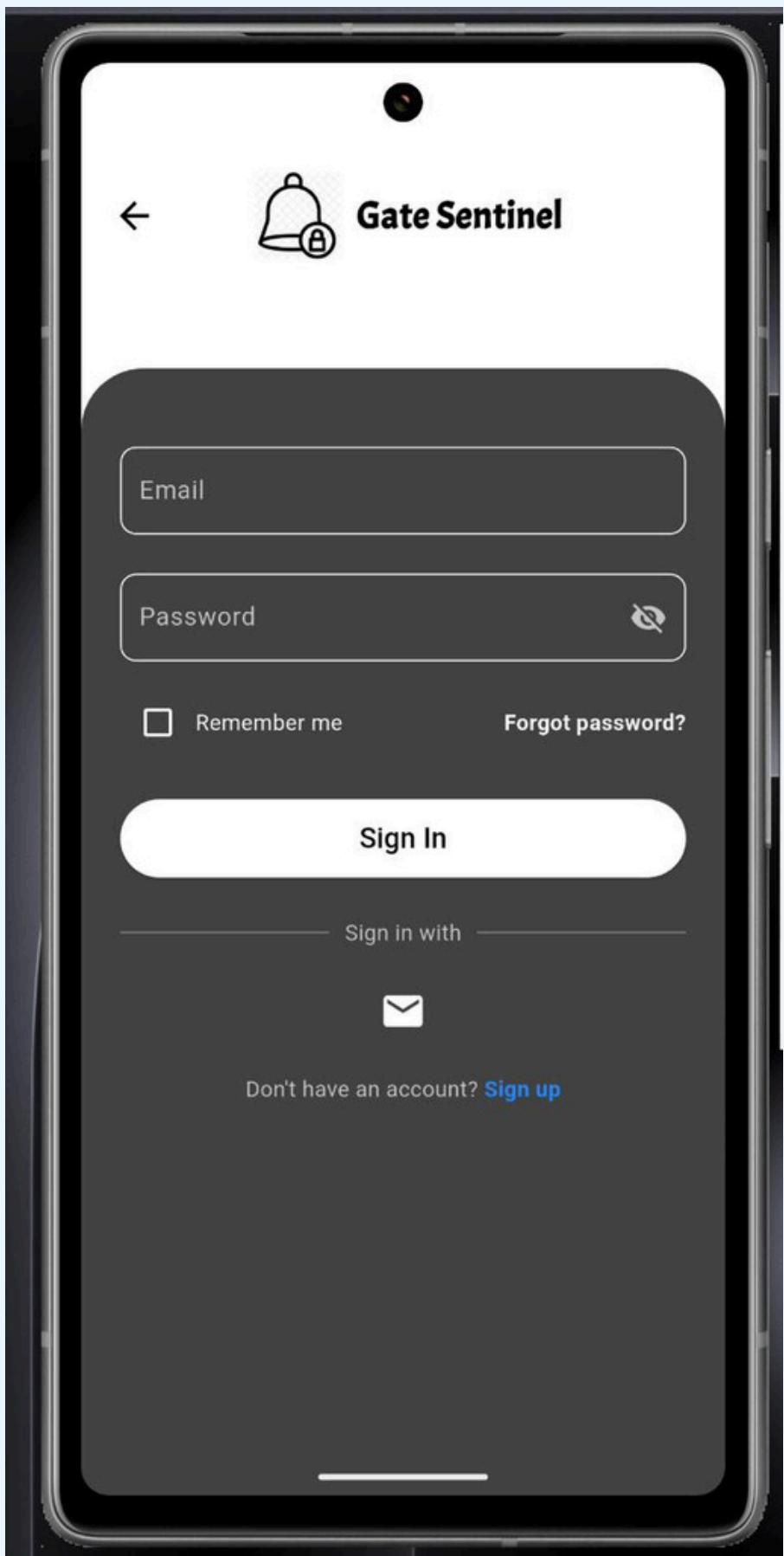
- Secure User Authentication: Managed by Firebase Auth.
- Biometric Enrollment: Users can register fingerprints via the app for secure, biometric-based access control.
- Real-Time Video Surveillance: Integrated ESP32-CAM module streams a live, low-latency video feed directly to the application.
- Secure Cloud Data Storage: All data (user info, fingerprints) is securely stored and managed using Realtime database.
- Audit & Review: Securely access a history of previous live video recordings for security reviews.



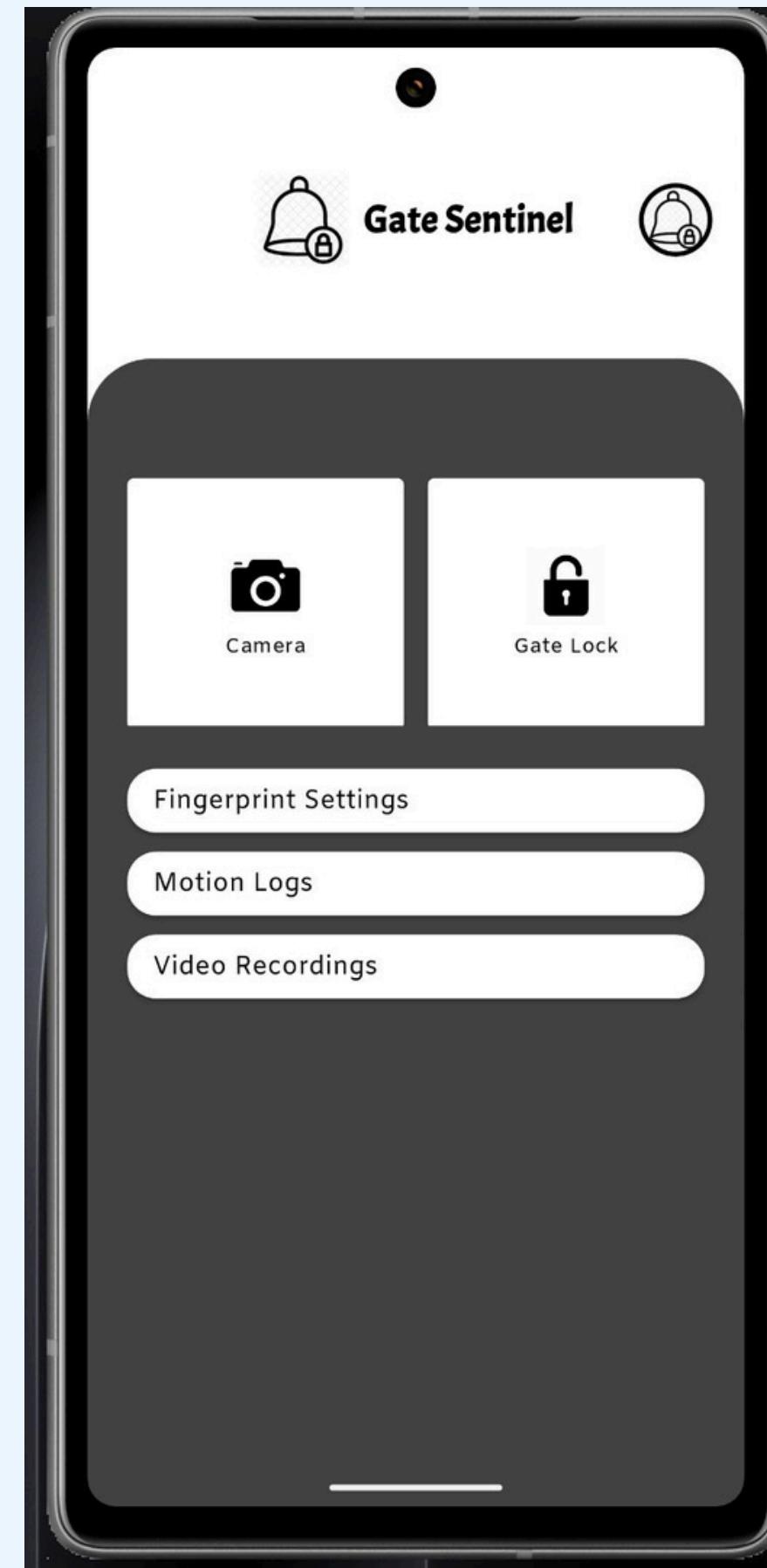
Started page



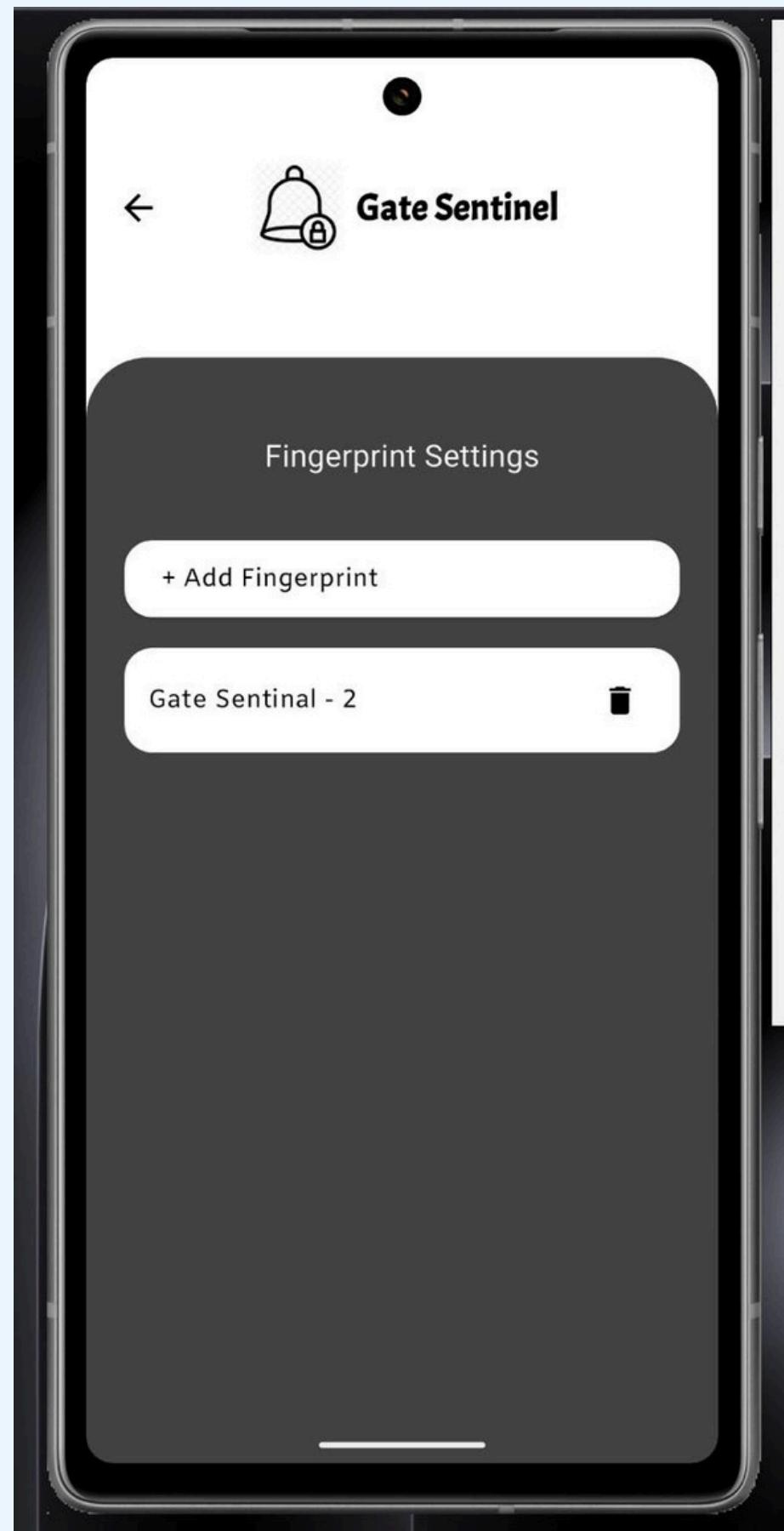
Sign up page



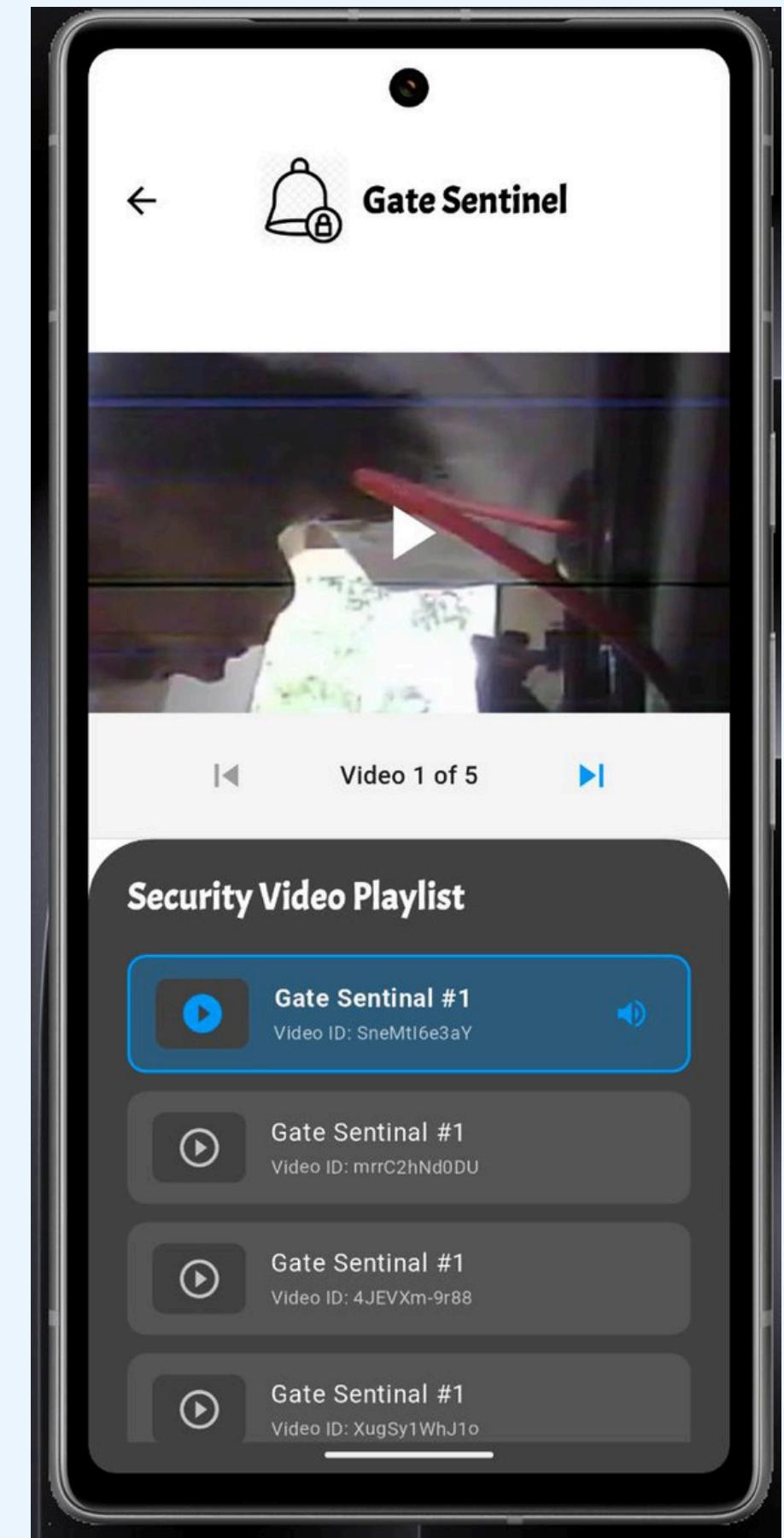
sign-In



Home Page



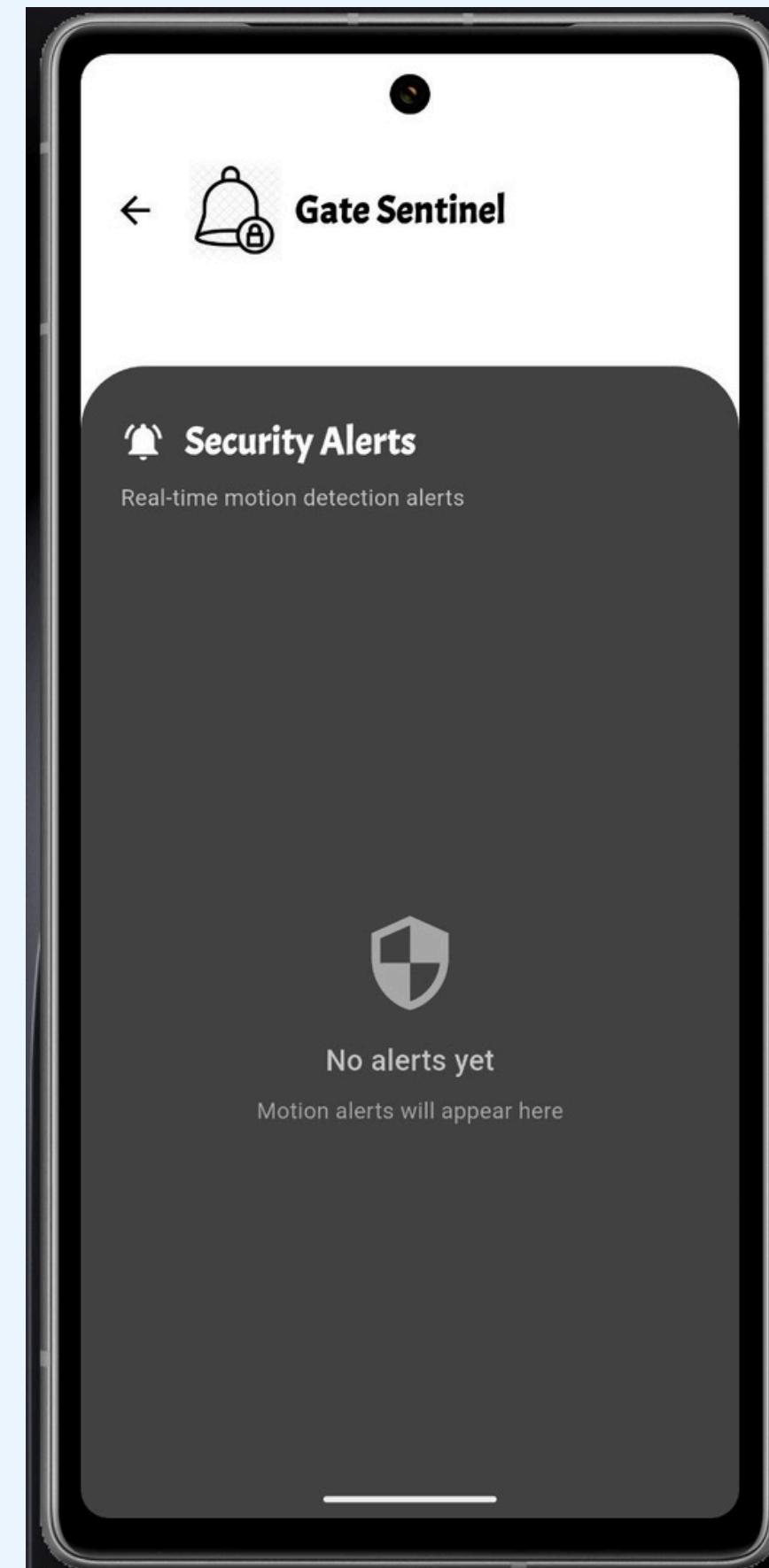
Finger print enroll page



video recording page



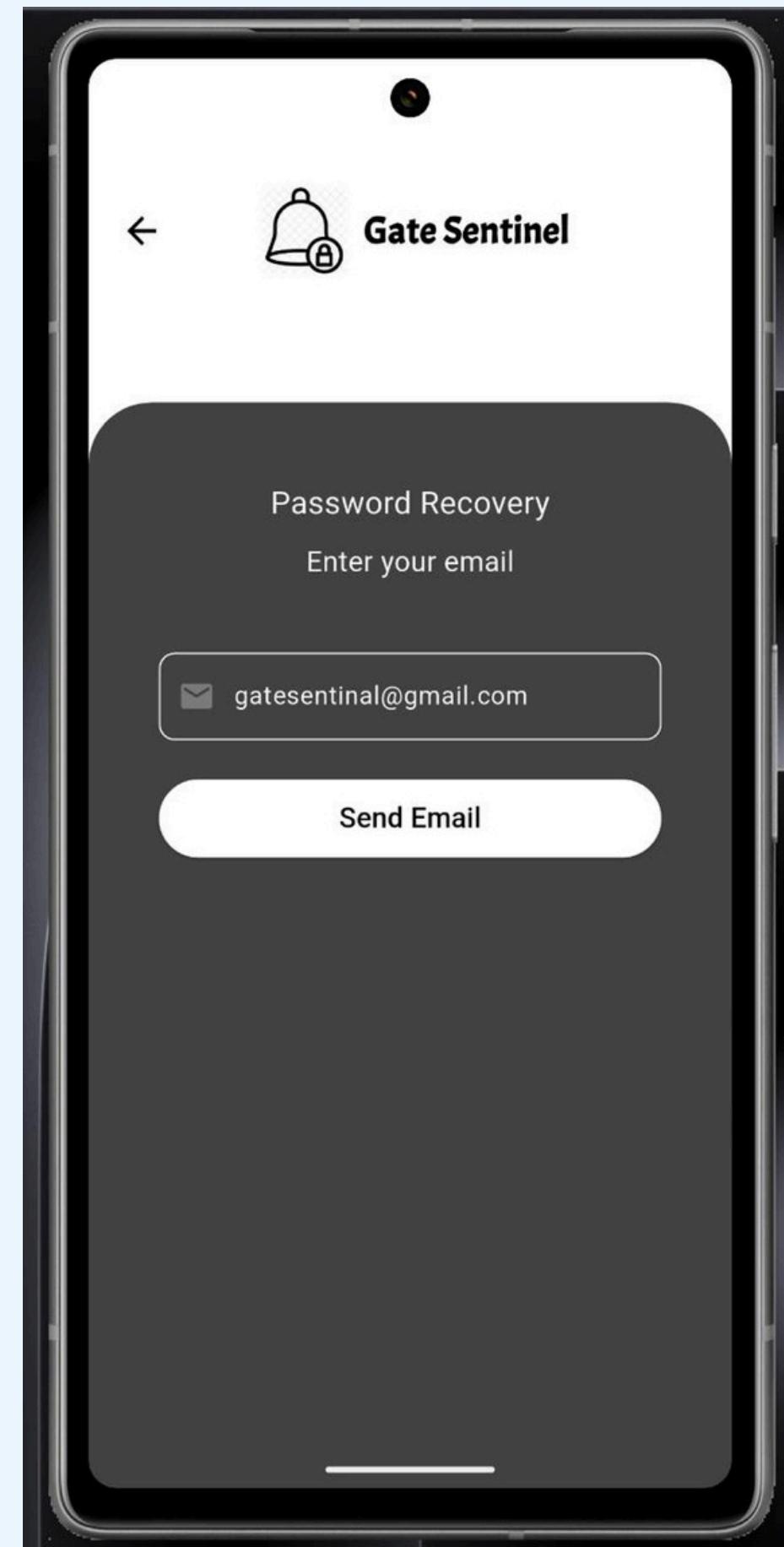
Live cam feed



Motion detection log page



Profile page



Password reset page



Responsibilities

- Focused on setting up the PIR sensor.
- Integrating the UPS power supply into the system.
- Use buck converters to reduce the UPS voltage.

PIR sensor



- Detects motion by sensing changes in infrared radiation from warm objects like humans.
- Positioned near the gate to trigger, send alerts, and prepare the system for user interaction.
- Operates at 5V with a 120° detection angle and up to 7 m range.
- Set to an 11-second reset time to prevent multiple triggers from the same movement.
- Ensures stable and efficient system operation

TZT Type-C 15W 3A Fast Charge UPS power supply



- Designed to charge 18650 lithium-ion batteries.
- Provides a regulated DC output using a DC-DC step-up converter.
- Commonly used in DIY power banks, mini-UPS systems, portable lights, and battery-powered devices.
- Combines fast charging, battery protection, and voltage boosting.
- Compact and efficient design.

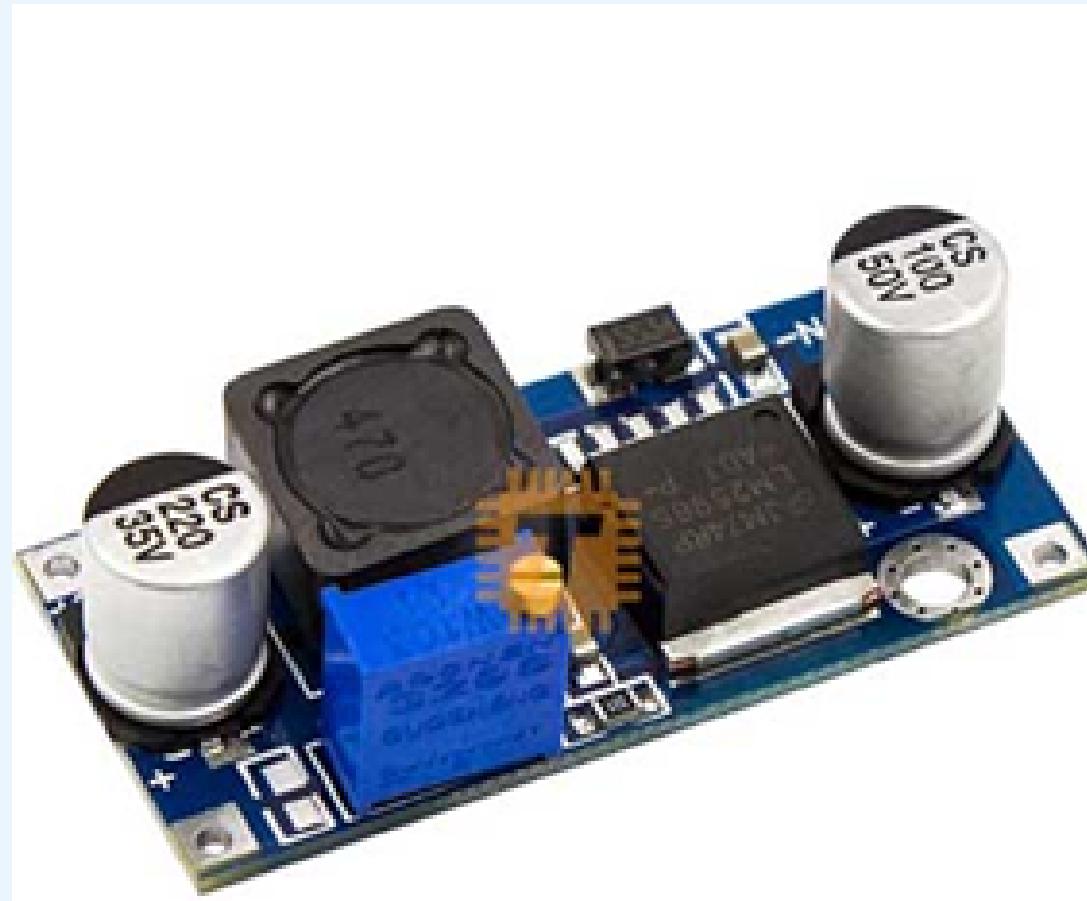


UPS Functionality: Supports uninterruptible power switching between USB input and battery power.

Type-C Fast Charging: 5V 3A input for rapid charging of lithium batteries.

Output Voltage: Regulated 5V output to power devices.

LM2596S 3-40V to 1.5-35V 4A DC to DC Adjustable Step-Down Buck Module (MD0042)



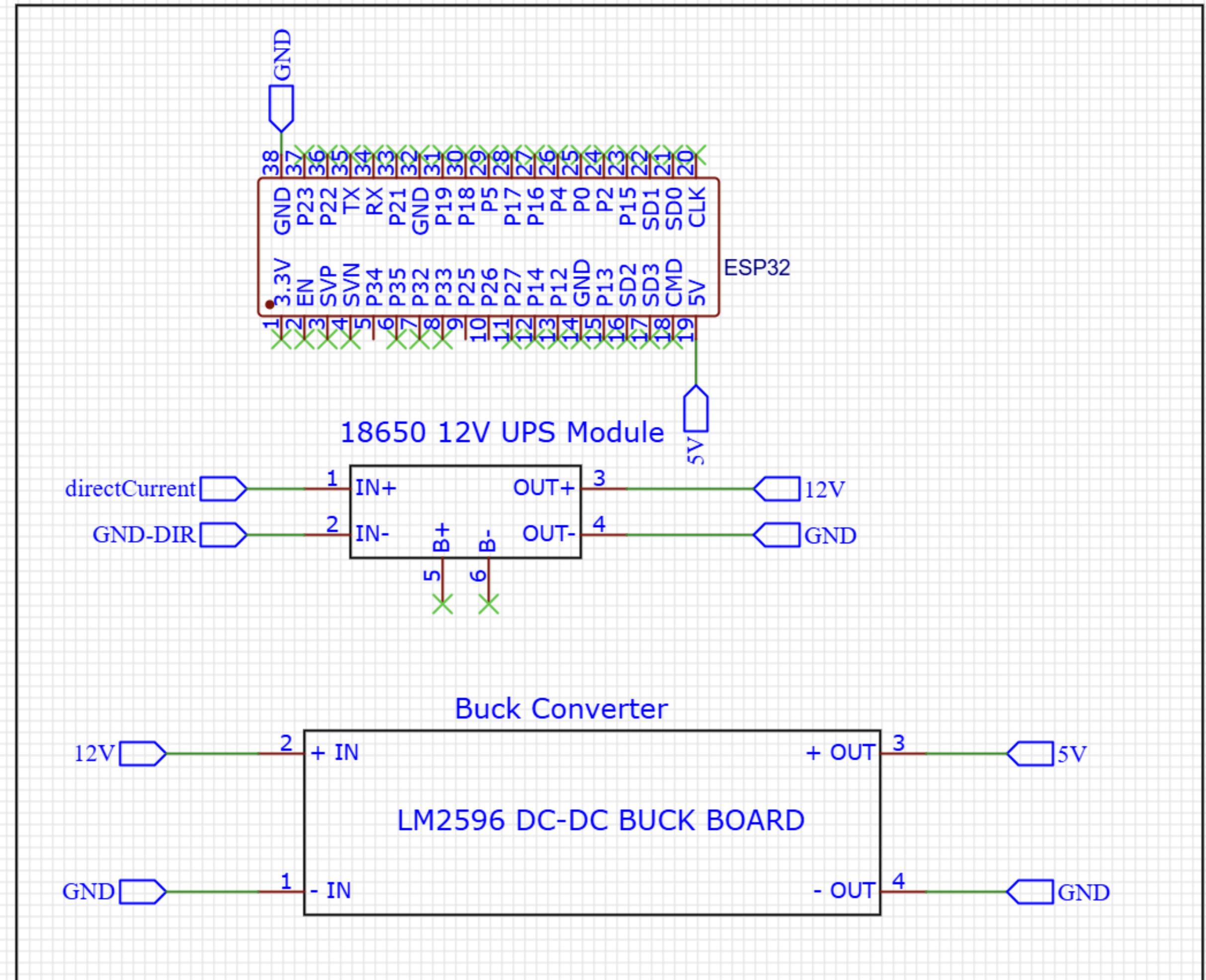
- Efficiently steps down higher input voltages to a stable, lower voltage.
- Provides the required voltage for various system components.
- Ensures safe and reliable operation.
- Prevents overheating or damage to sensitive electronics

Input voltage: (4-35V)range

Output Voltage: 1.5-35V (adjustable)

Output current: rated current 2A, maximum 3A (heat sink required)

ESP32 Powerup Circuit



Responsibilities

- **Gate Lock Integration:** Configured and tested the electronic gate lock system to ensure reliable locking and unlocking mechanisms.
- **Relay and Limit Switch Setup:** Installed and programmed the relay module and limit switch to control the gate's motor and detect its open/closed positions accurately.
- **Web Application Development:** Developed the web interface to provide remote monitoring and control of the gate lock system, enabling real-time interaction and status updates.

Solenoid Door Lock (12VDC, 27×15×17mm)



- Electromechanical device used for locking/unlocking doors.
- Operates on 12V DC power supply.
- Compact size: 27mm × 15mm × 17mm.
- Normally locked: stays locked when no power.
- Unlocks when 12V current energizes the solenoid.
- Commonly used in access control systems (keypads, RFID, biometrics).

5VDC 1-Channel Relay Module



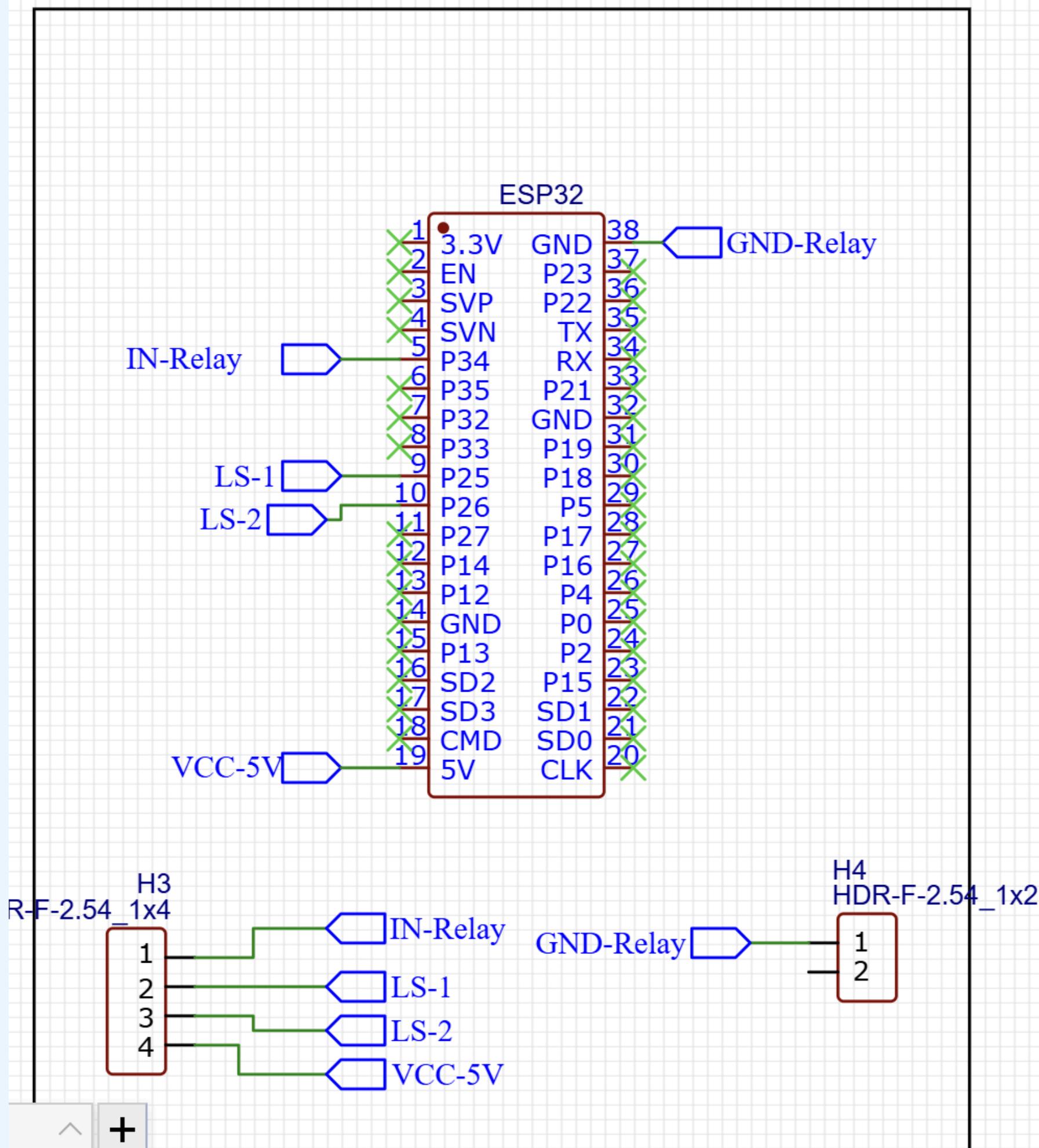
- Acts as an electrical switch controlled by microcontrollers (ESP32, Arduino, etc.).
- Input control voltage: 5V DC.
- Output side can switch high-voltage/high-current loads (e.g., 12V solenoid lock).
- Provides isolation between control circuit (low voltage) and load circuit (high voltage).
- Has three output terminals:
 - COM (Common)
 - NO (Normally Open)
 - NC (Normally Closed)

BU0031 Micro Limit Switch with Roller Lever (15A 250VAC)

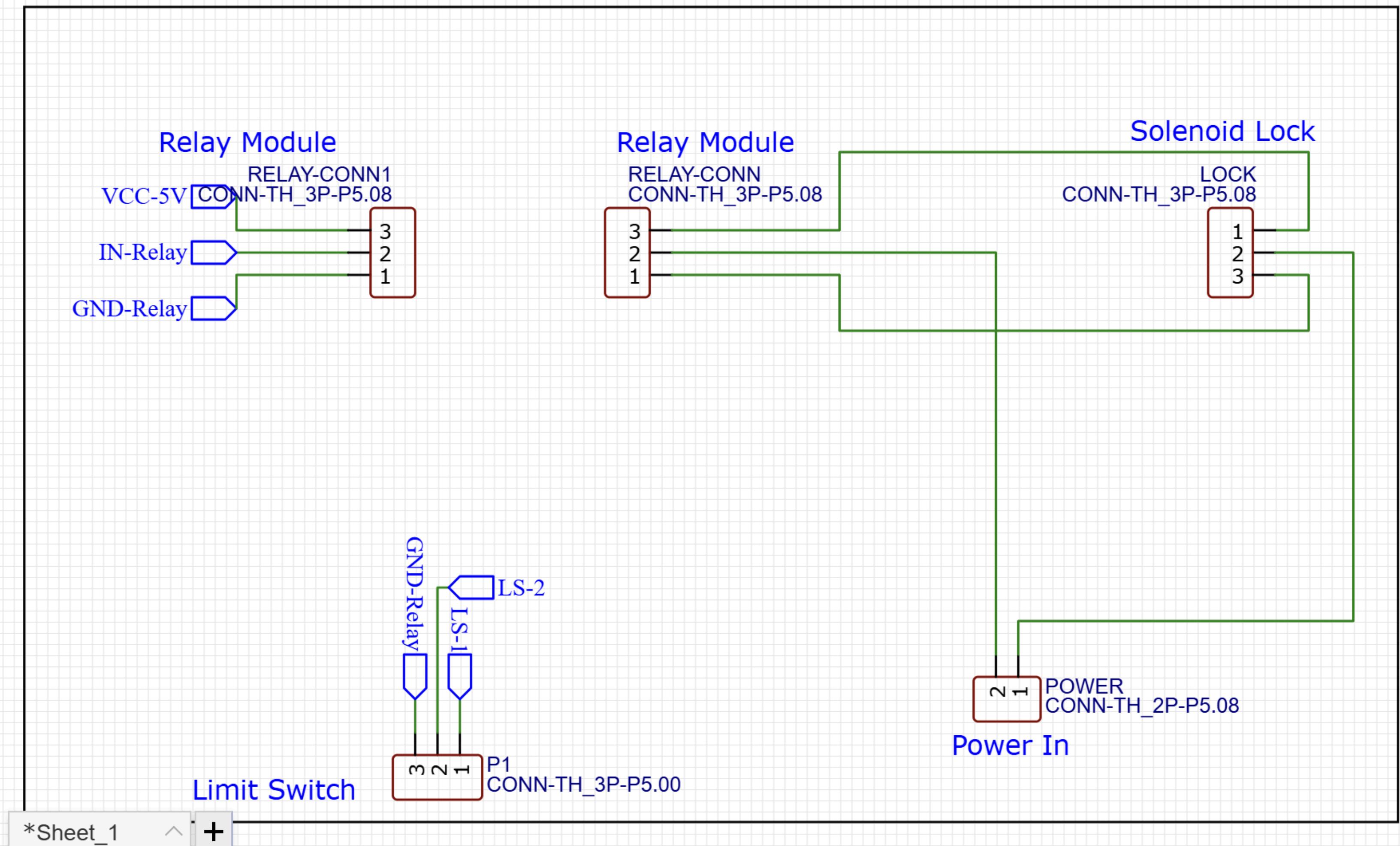


- Small mechanical switch that detects physical movement/position.
- Fitted with a 10mm roller lever for smooth actuation.
- Electrical rating: 15A at 250V AC (also works in low-voltage DC circuits).
- Provides digital output:
- Pressed = LOW (0V)
- Released = HIGH (Vcc)
- Commonly used as door detection switch, safety interlock, or position sensor.

ESP32 of LOCK Mechanism



Lock-Unlock mechanism



Cost Estimation

Component	Unit Price(LKR)	Units	Total Price(LKR)
NodeMCU ESP32-WROOM-32 Wi-Fi Bluetooth	1250.00	4	5000.00
1.5 inch 128*128 OLED Display Module	1528.00	1	1528.00
HC-SR501 PIR Sensor Module for Arduino	560.00	1	560.00
TZT Type-C 15W 3A Fast Charge ups power supply	929.90	3	2789.70
R503 Fingerprint Identification Circular Capacitive Fingerprint Module	6650.00	1	6650.00
ESP32-S Camera	2200.00	1	2200.00
INMP441 Omnidirectional Microphone Module I2S Interface MEMS	840.00	2	1680.00
MD0486-5VDC 1 Way Channel Relay Module (Transistor version)	130.00	1	130.00
BU0031-Micro Limit Switch with 10mm Roller Lever 15A 250VAC	100.00	1	100.00
RL0018-Solenoid Door Lock 12VDC 53*26*23mm	1270.00	1	1270.00
Adjustable Door Closer	1780.00	1	1780.00
12V/5A Power Supply	1250.00	1	1250.00
3.7V 3200mA 18650 Rechargeable Battery	530.00	6	3180.00
Micro HDMI to HDMI cable	800.00	1	800.00
Waveshare7 inch 1024x600 HDMI IPS LCD Touch Screen for Raspberry	15850.00	1	15850.00

8 Ohm 5W speaker 2.5 inch for portable amplifiers	180.00	2	360.00
Tactile button cap red colour 12*12*7.3mm	10.00	2	20.00
Tactile Push Button 12*12*7.3mm	20.00	2	40.00
LM2596S 3-40V to 1.5-35V 4A DC to DC Adjustable Step-Down Buck Module (MD0042)	180.00	2	360.00
NodeMCU ESP32 Wi-Fi Bluetooth Dual Mode IoT Dev Board	1100.00	2	2200.00
Solder Wire Lead Roll 60/40 0.8mm per meter (TA0159)	60.00	1	60.00
BA033T 3.3V Voltage Regulator THT (IC0008)	150.00	2	300.00
PCM5102 DAC Decoder I2S Player Module GY-PCM5102 (MD0831)	850.00	1	850.00
TPA3110 Digital Stereo Power Amplifier Module 2x15W HW-644 (MD0597)	390.00	2	780.00
5.08mm Pitch 2-Pin 2-way Screw Terminal Block PCB Mount (TB0009)	20.00	4	80.00
5.08mm Pitch 3-Pin 3-way Screw Terminal Block PCB Mount	30.00	3	90.00
MIC29302WU Low Drop-out Regulators (IC0058)	120.00	2	240.00
PCB			12500.00
3D Printing			21700.00
Total			84 347.70

References

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- <https://lastminuteengineers.com/oled-display-esp32-tutorial/> - OLED Display start
- <https://gammon.com.au/interrupts> - Article about Interrupts
- <https://randomnerdtutorials.com/esp32-cam-video-streaming-face-recognition-arduino-ide/> - esp32 cam
- **Data sheets :** <https://randomnerdtutorials.com/esp32-cam-video-streaming-face-recognition-arduino-ide/> - esp32 cam



THANK YOU!