Smart Home Control Unit for Energy Optimization

- Group: SDDEC25-08
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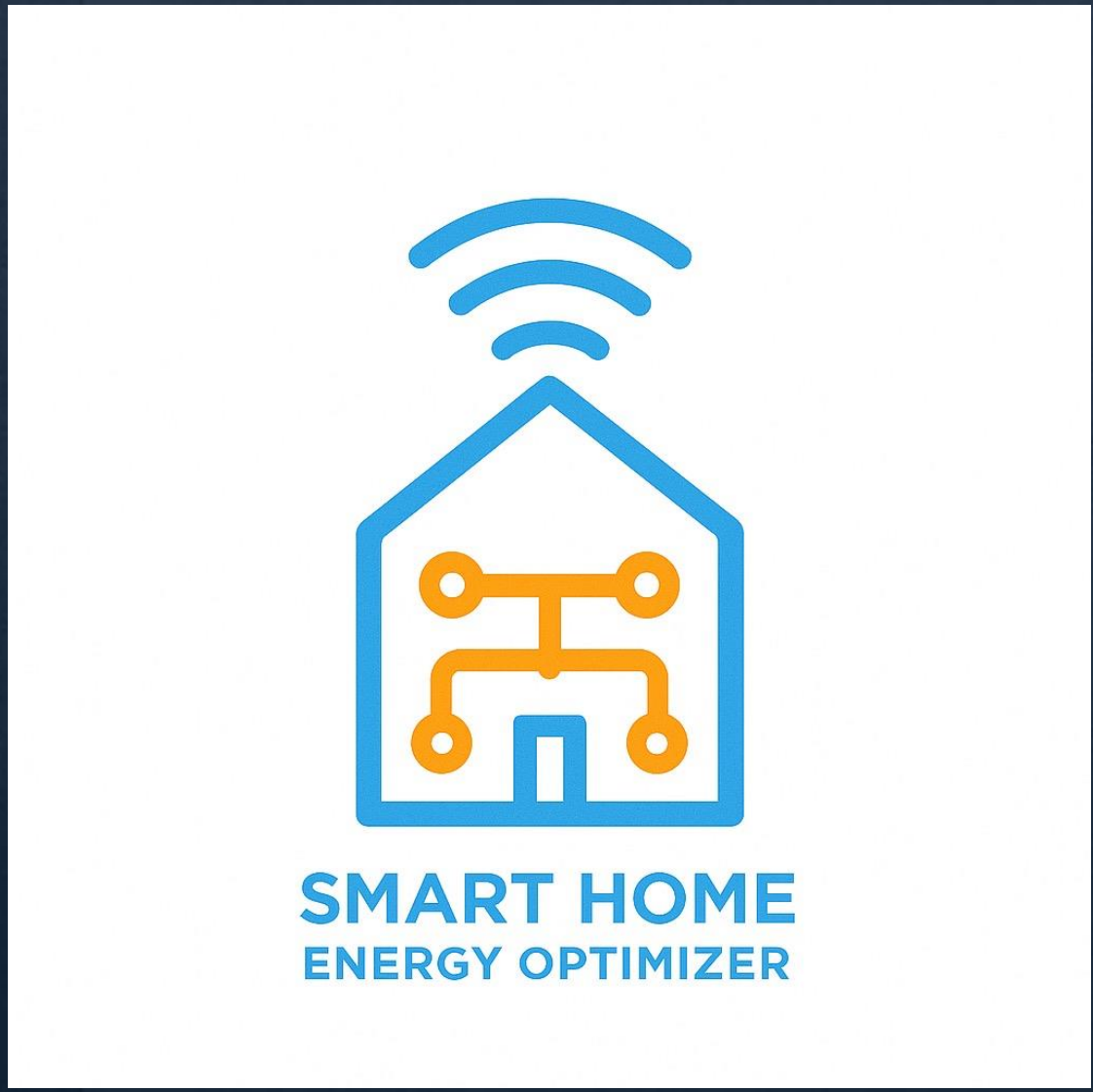


Market Survey

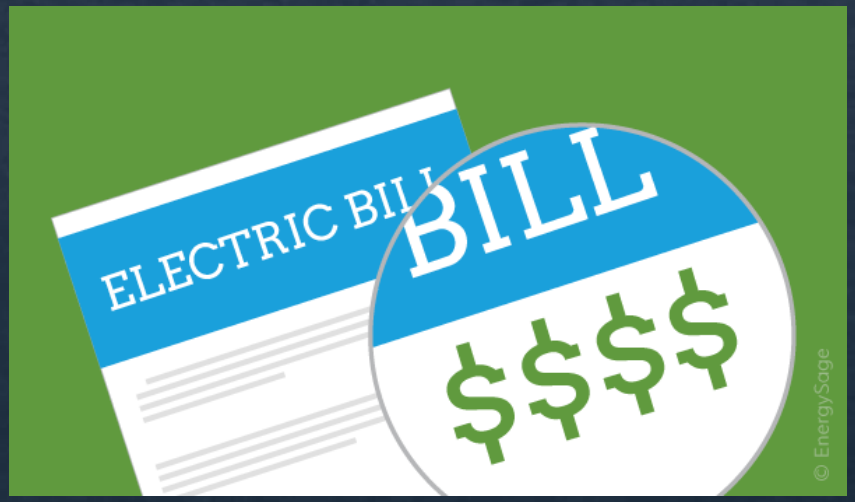
- Existing smart home systems (Nest, Ecobee) cost $200–$500 and often require professional installation.
- These solutions are not affordable for low-income households.
- Our design focuses on affordability (<$100), DIY setup, and modular expansion.

Project Overview

- Project focused on smart home automation
- Goal: Improve energy efficiency and reduce utility costs
- System uses sensors and automation to control lighting and HVAC
- Includes a central control hub and web interface
- Designed for ease of use and affordability

Problem Statement

- High energy bills strain household budgets
- Existing systems are costly and require professional installation
- Low-income families often lack access to smart home solutions
- Energy waste contributes to environmental impact



Intended Users

Homeowners – Want simple, cost-saving comfort.

Property Managers – Need energy tracking for long-term savings.

Business Owners – Reduce energy costs, boost efficiency.

Tech Enthusiasts – Value customization and integration.

Environmentalists – Monitor and minimize energy use.

Multi-Room Homeowners – Want balanced comfort with efficient zone control.

Contractors – Add smart features without increasing build costs.

Functional Requirements

WIRELESS COMMUNICATION

CONTROL LINE VOLTAGES FOR HVAC + LIGHTING

SECURE FROM HACKERS

ACCURATE SENSOR READINGS

Non-Functional Requirements

AFFORDABLE PRICING

ECO-FRIENDLY MATERIALS

VISUALLY PLEASING DESIGN

EASY-TO-USE INTERFACE

Constraints

Cost Efficient

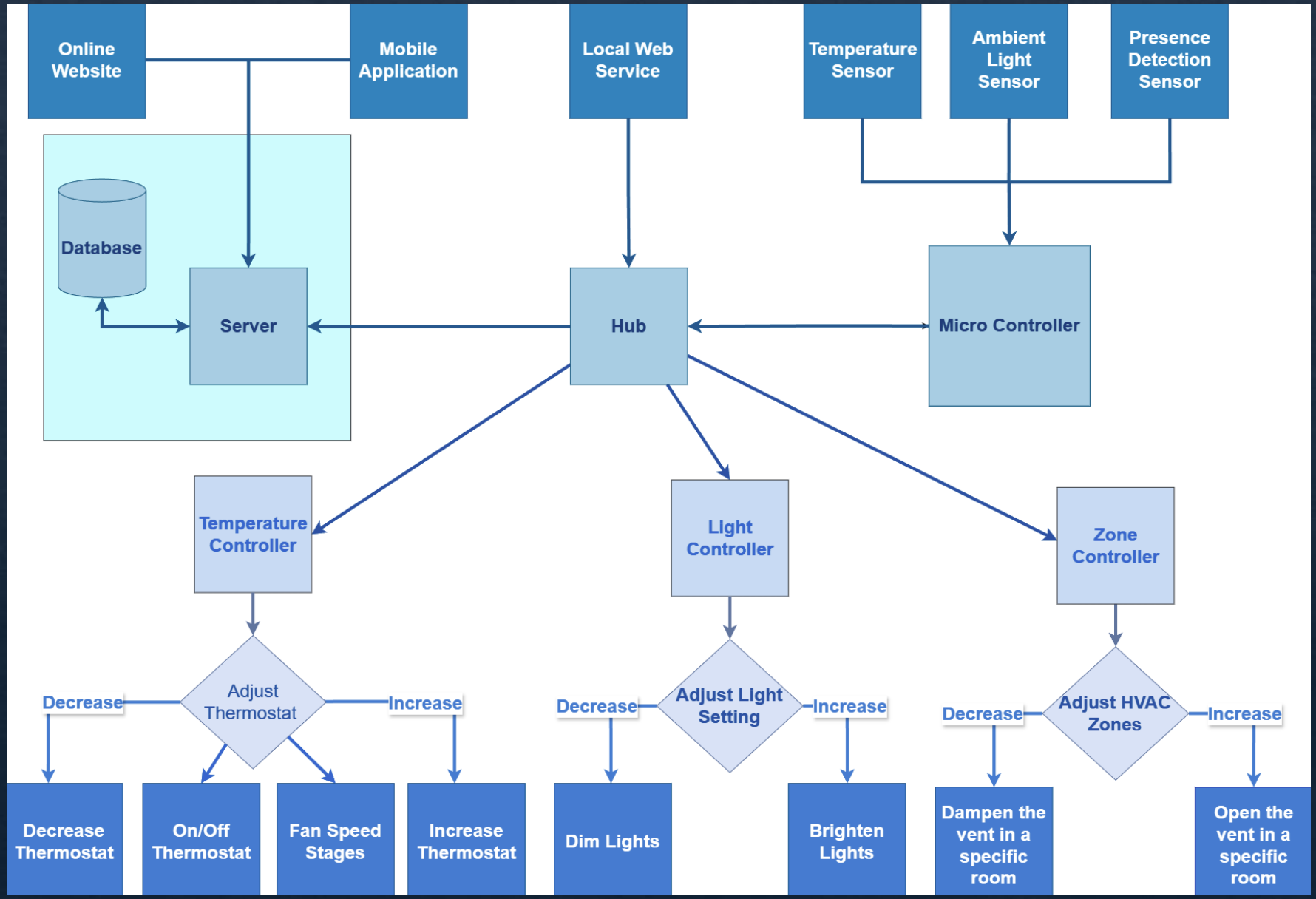
The product must be affordable for the user.

The hardware components we use must be low cost.

Time

The project must be completed within the year (timeframe of the course).

Design Diagram



Hardware Design

IEEE 802.11 - WiFi

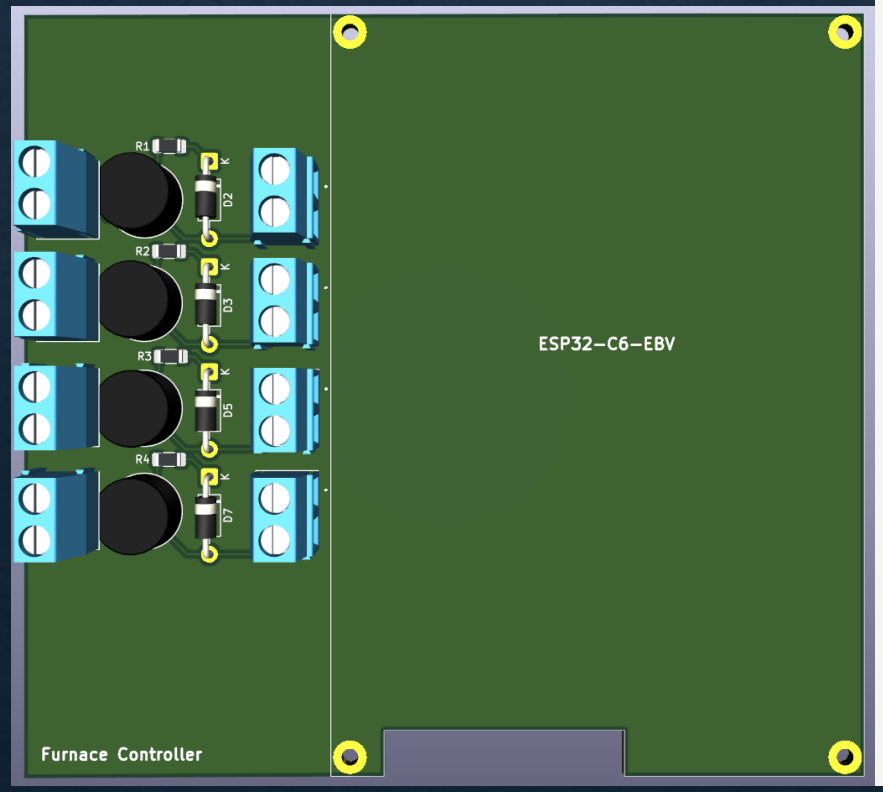
IEEE 802.15.4 - Zigbee

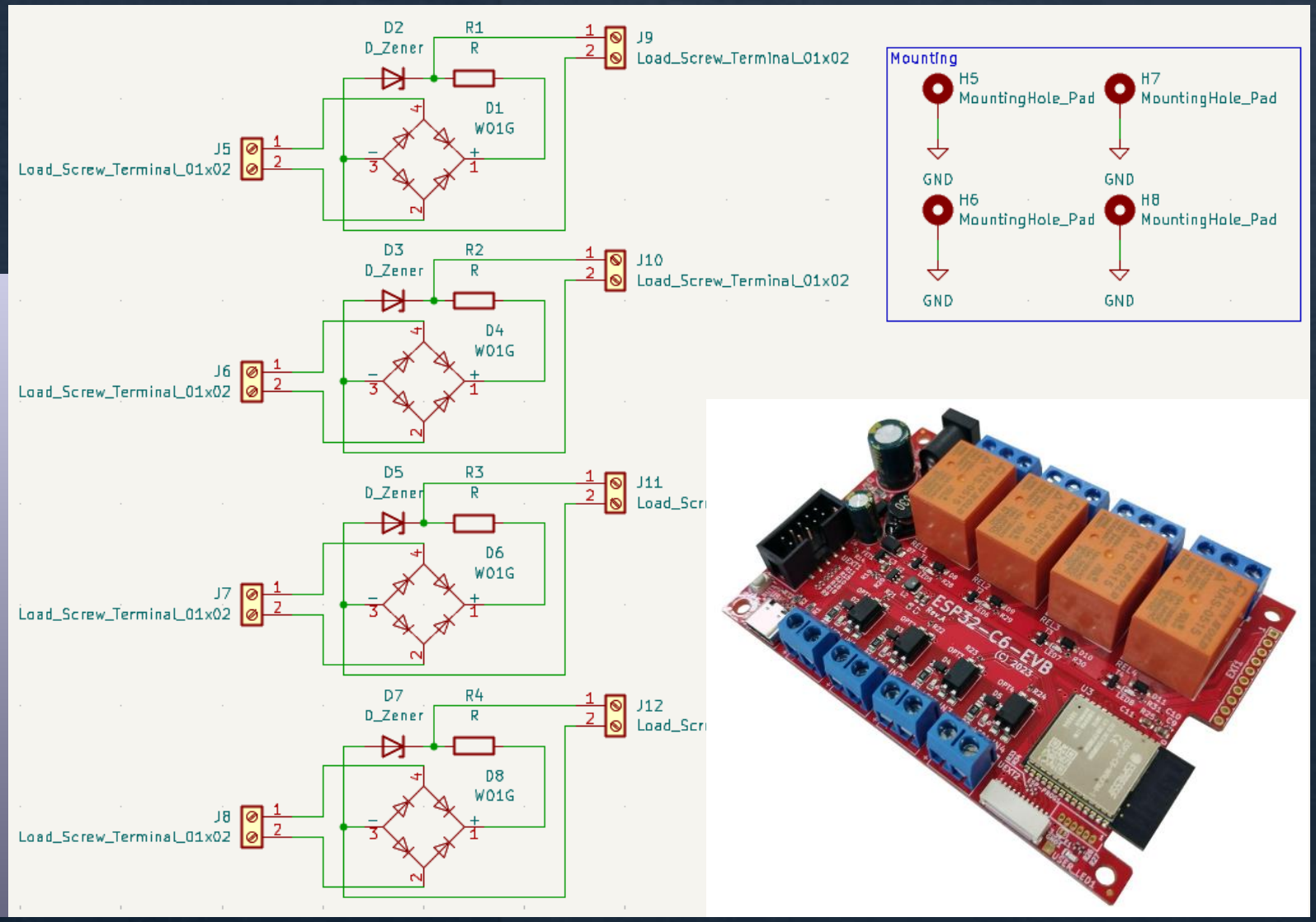
ISO Standards for Information Security Management

ISO Standards for Energy management

Furnace Controller

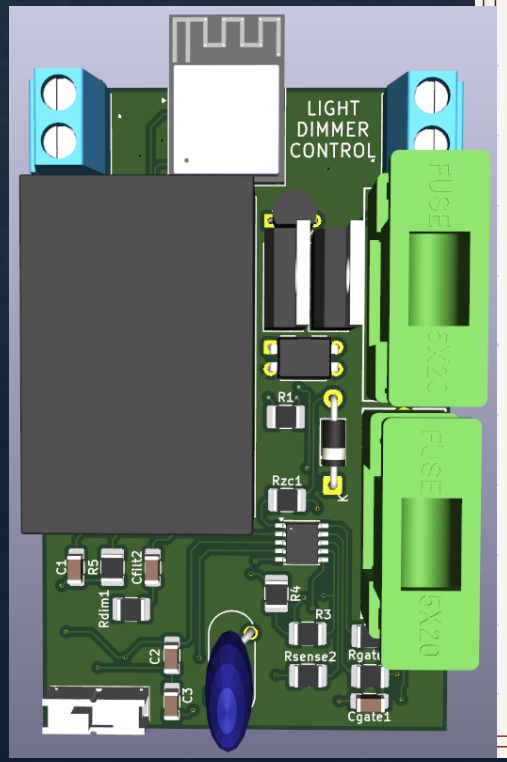
- ESP32-C6-EVB
  - ZigBee
  - 4 Inputs
  - 4 Relay outputs

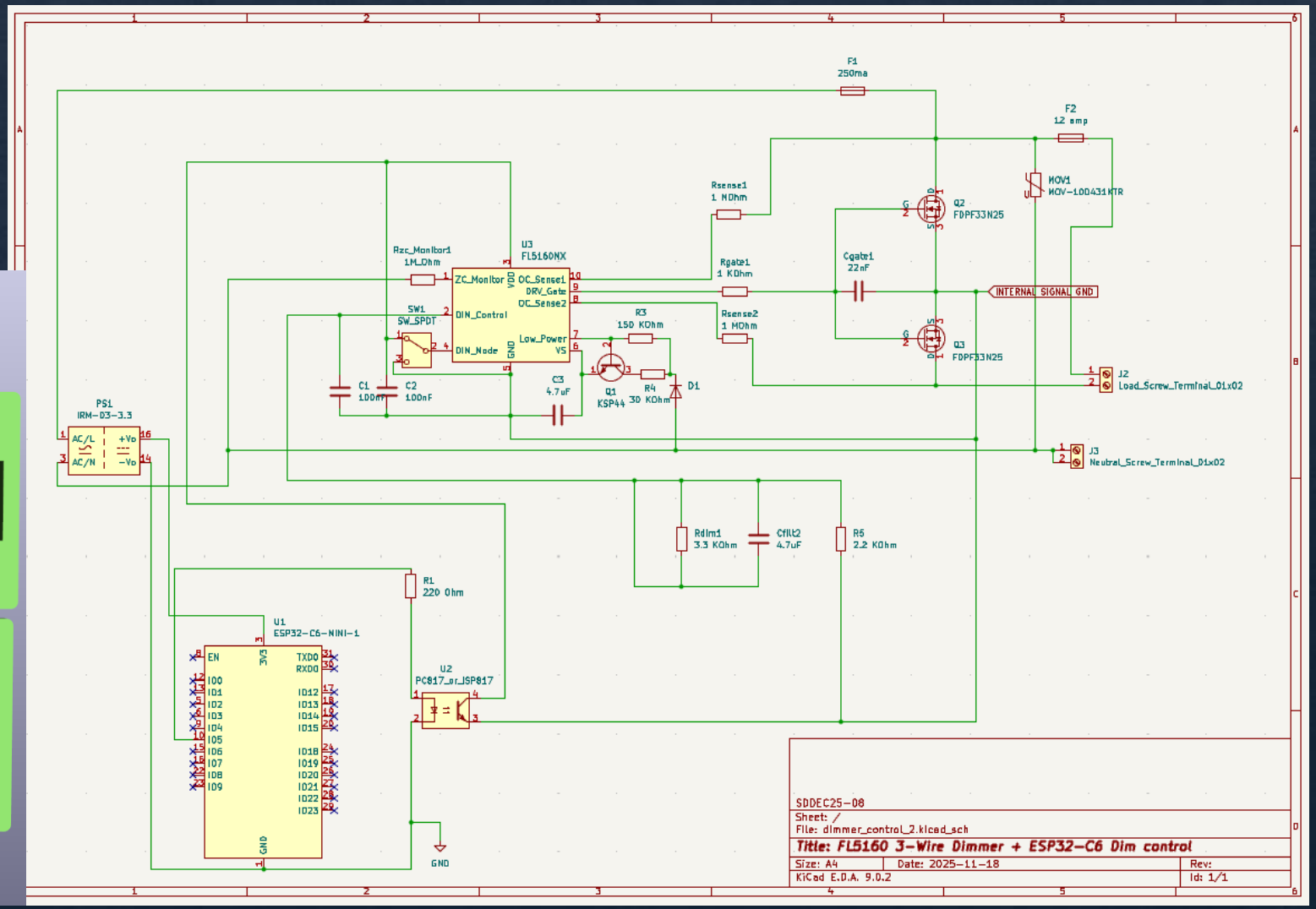




Automatic Light Dimmer

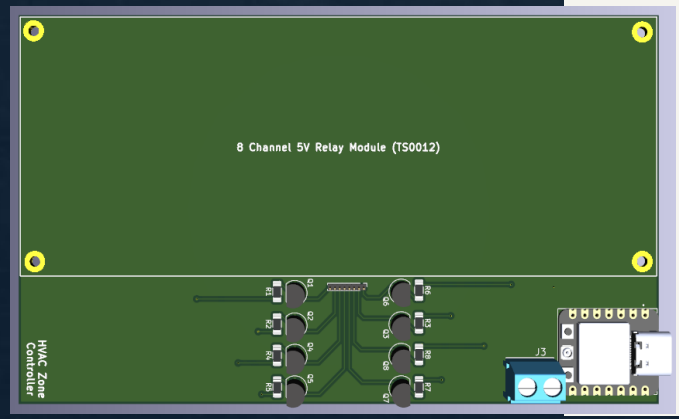
- 120 Volt
- ESP32-C6
- FL5160MX AC Dimmer Controller Chip
- 0 to 100% dimming range

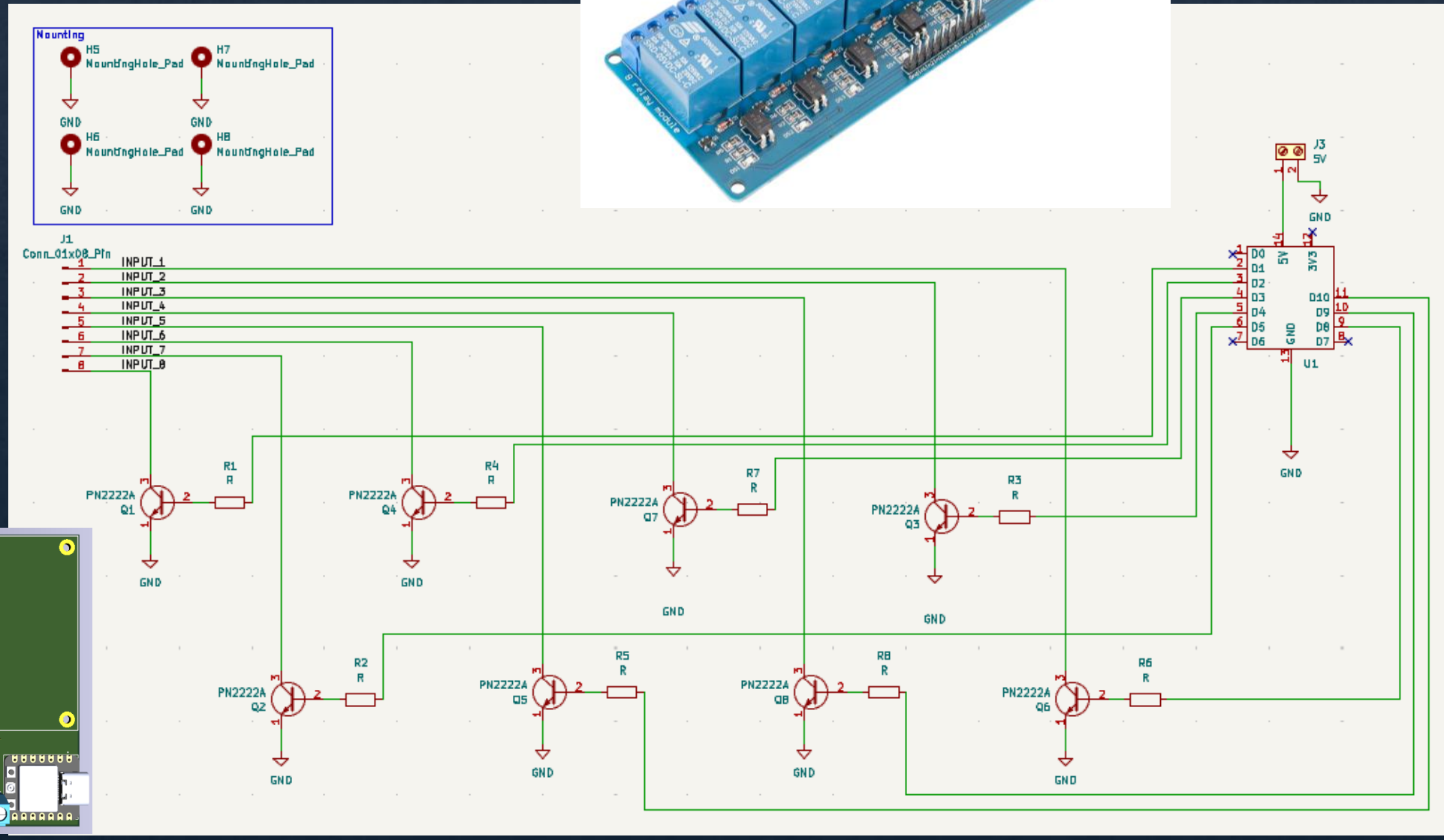




HVAC Zone Controller

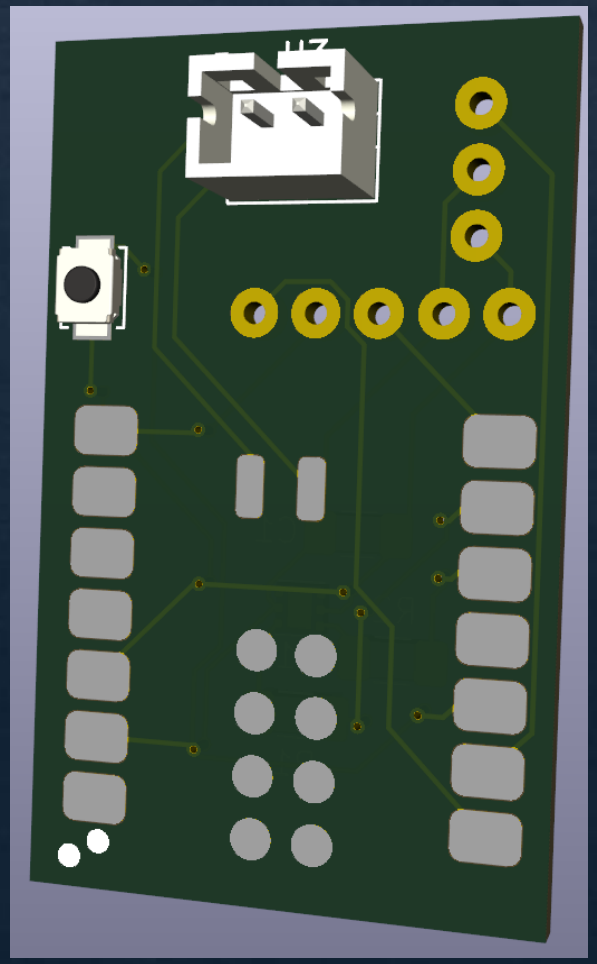
- Control Individual Room(s)
- Easy Installation
- 24 Volt AC
- Zigbee
- Eight Zones
- 8 Channel 5V Relay Module TS0012

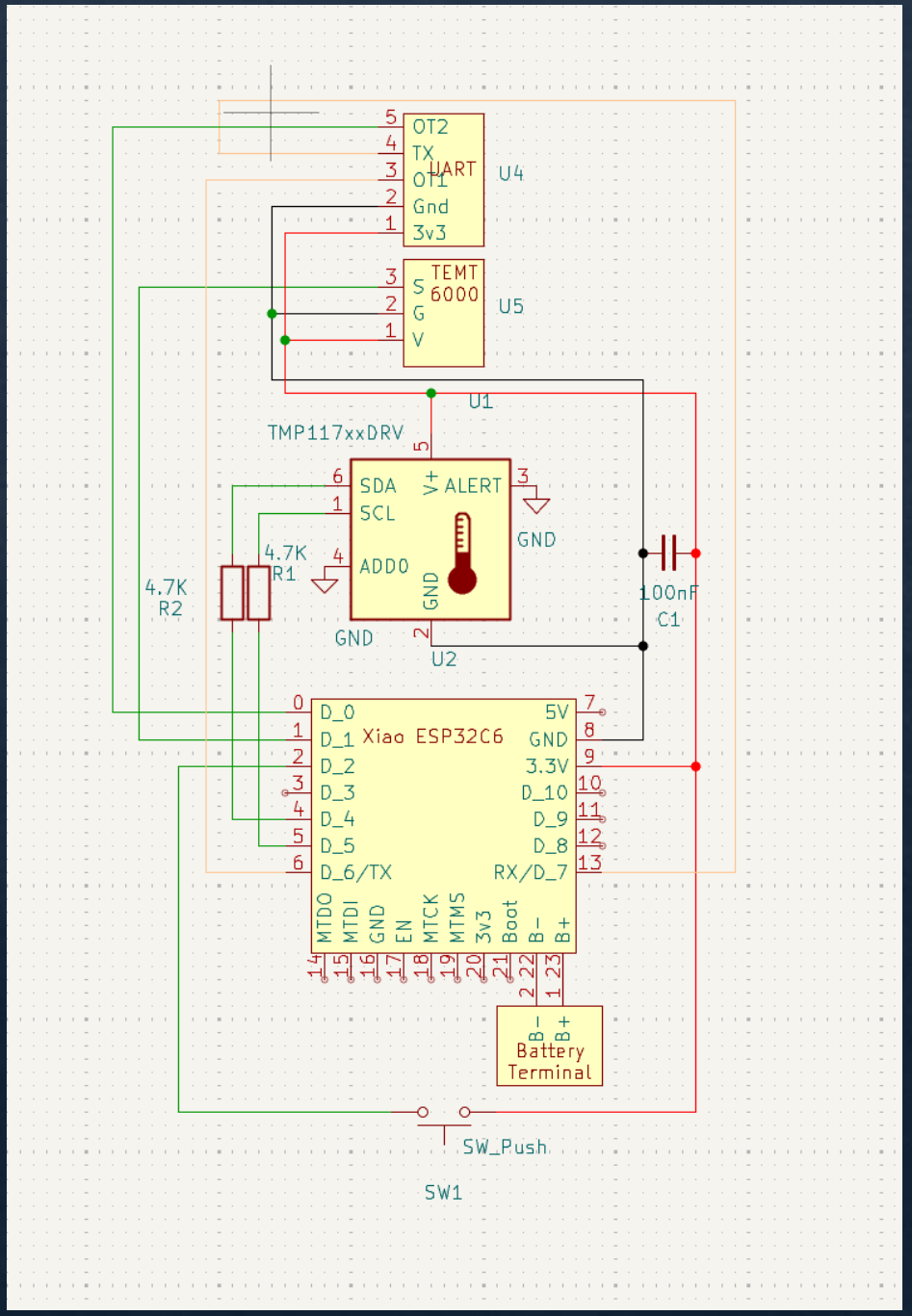


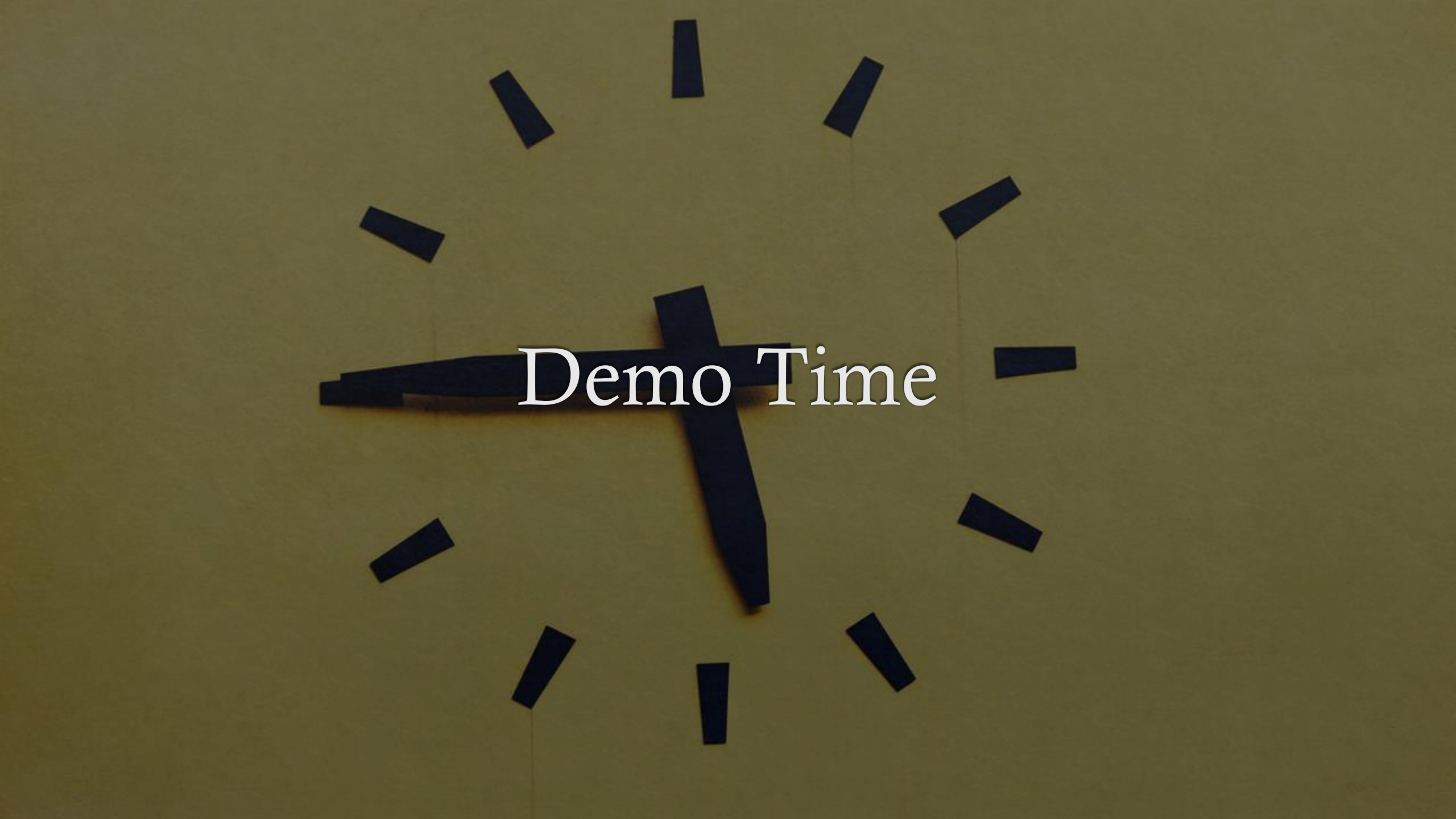


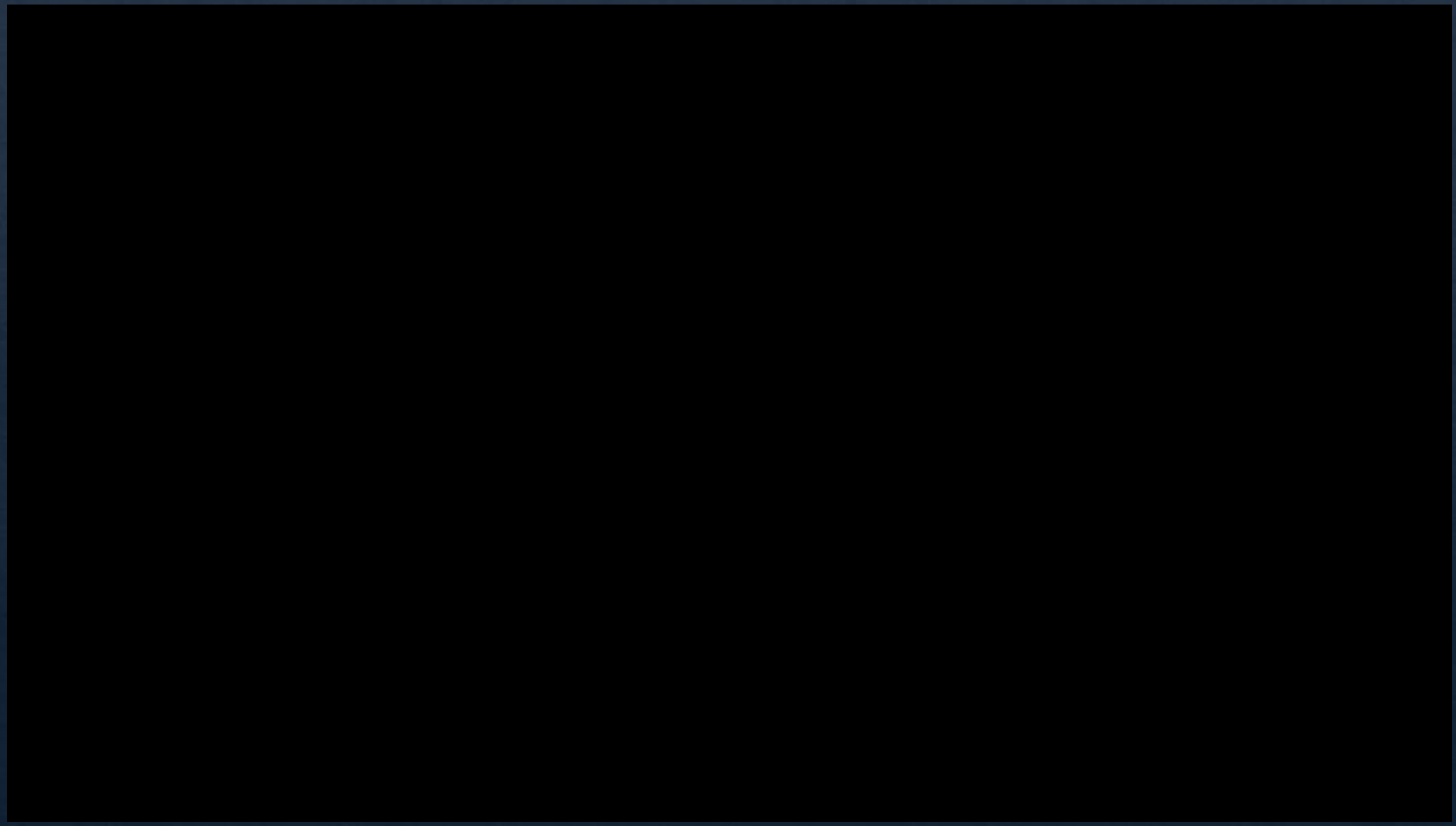
Multi-Sensor

- SOC: ESP32-C6
  - Protocols:
    - Zigbee
    - I2C
    - UART
- Sensors:
  - Temperature: TMP 117
  - Illuminance: VEML 7700
  - Occupancy: HLK 2420

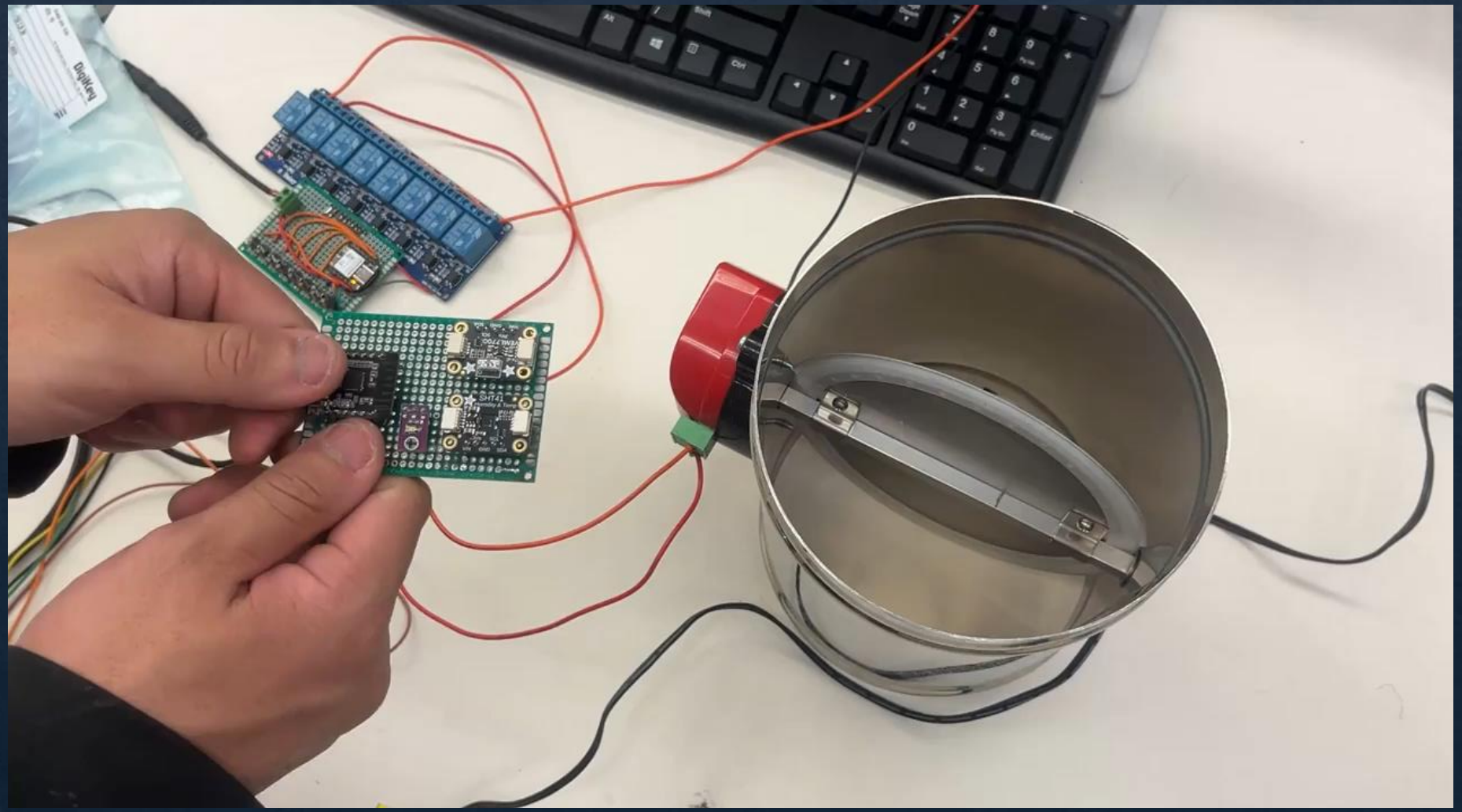




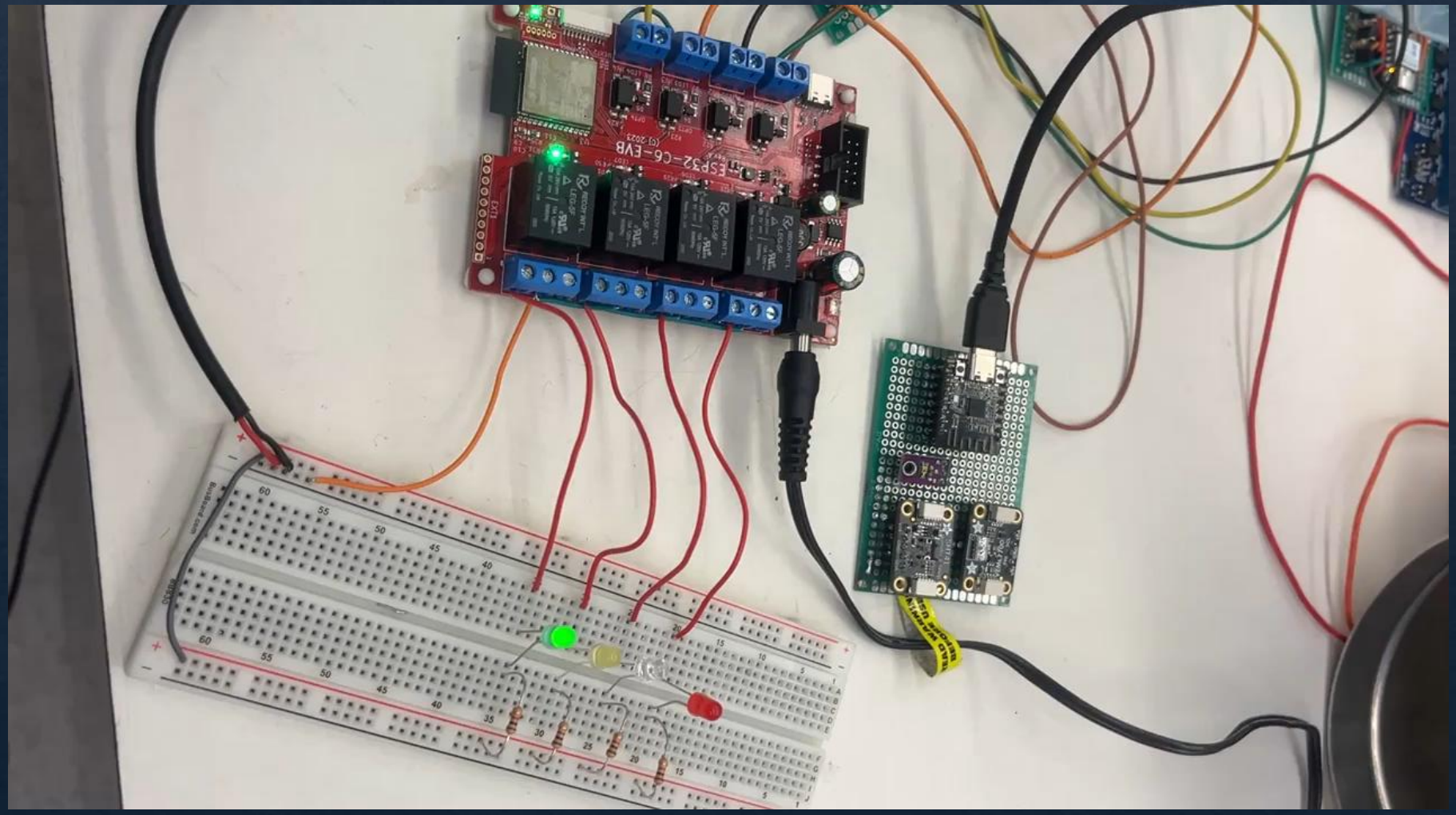

Demo Time



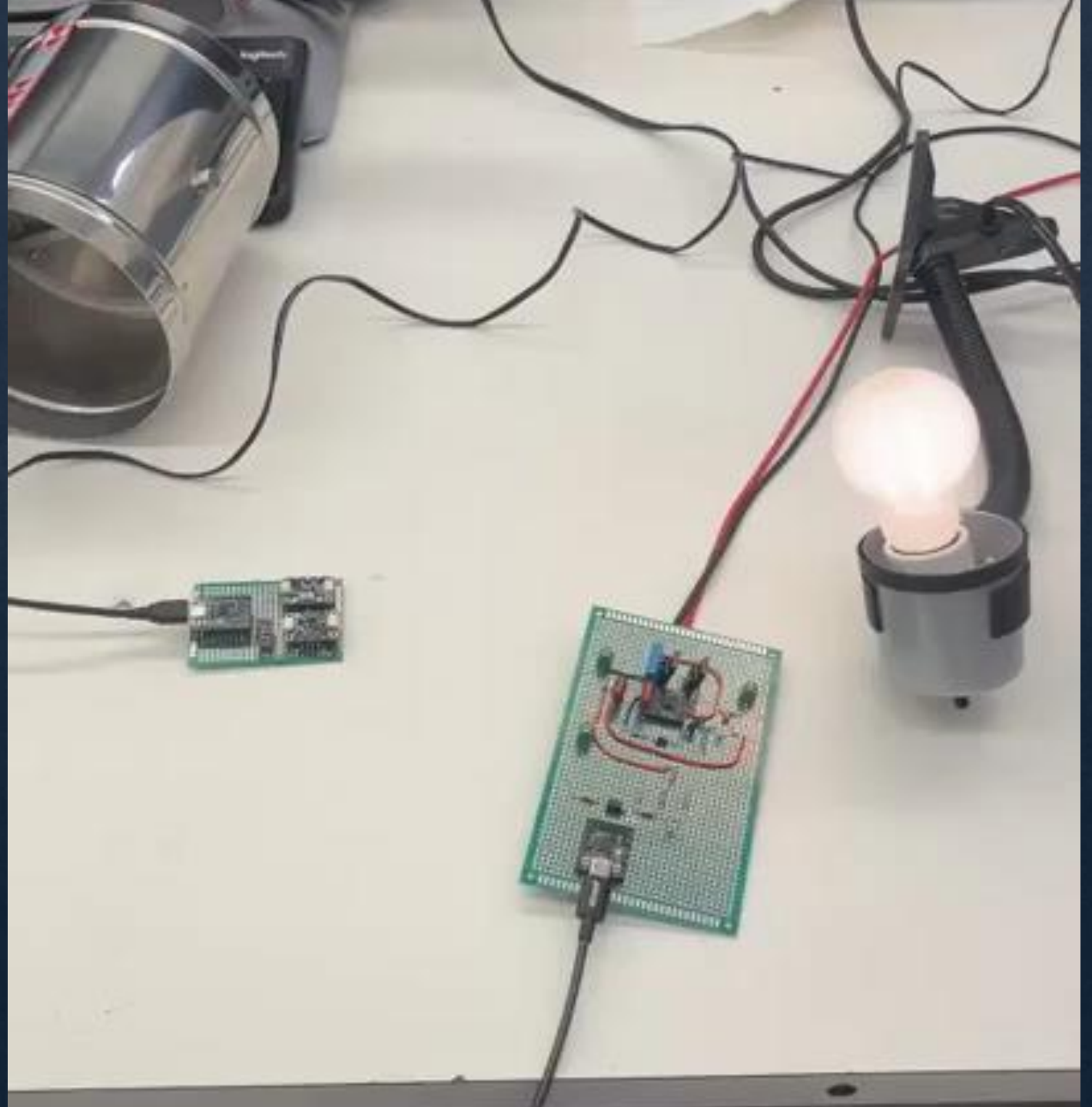
Zone Controller:



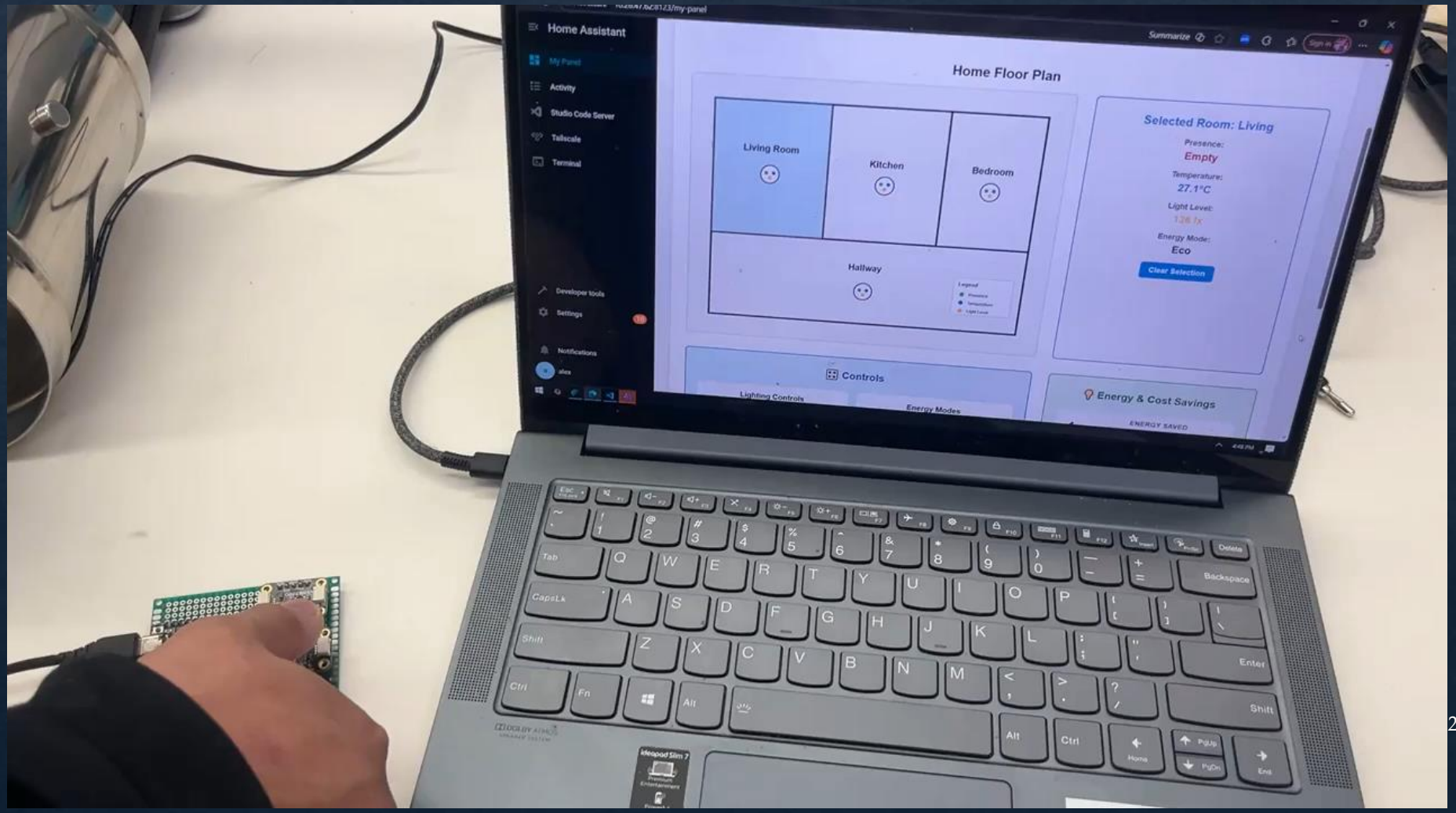
Furnace Control



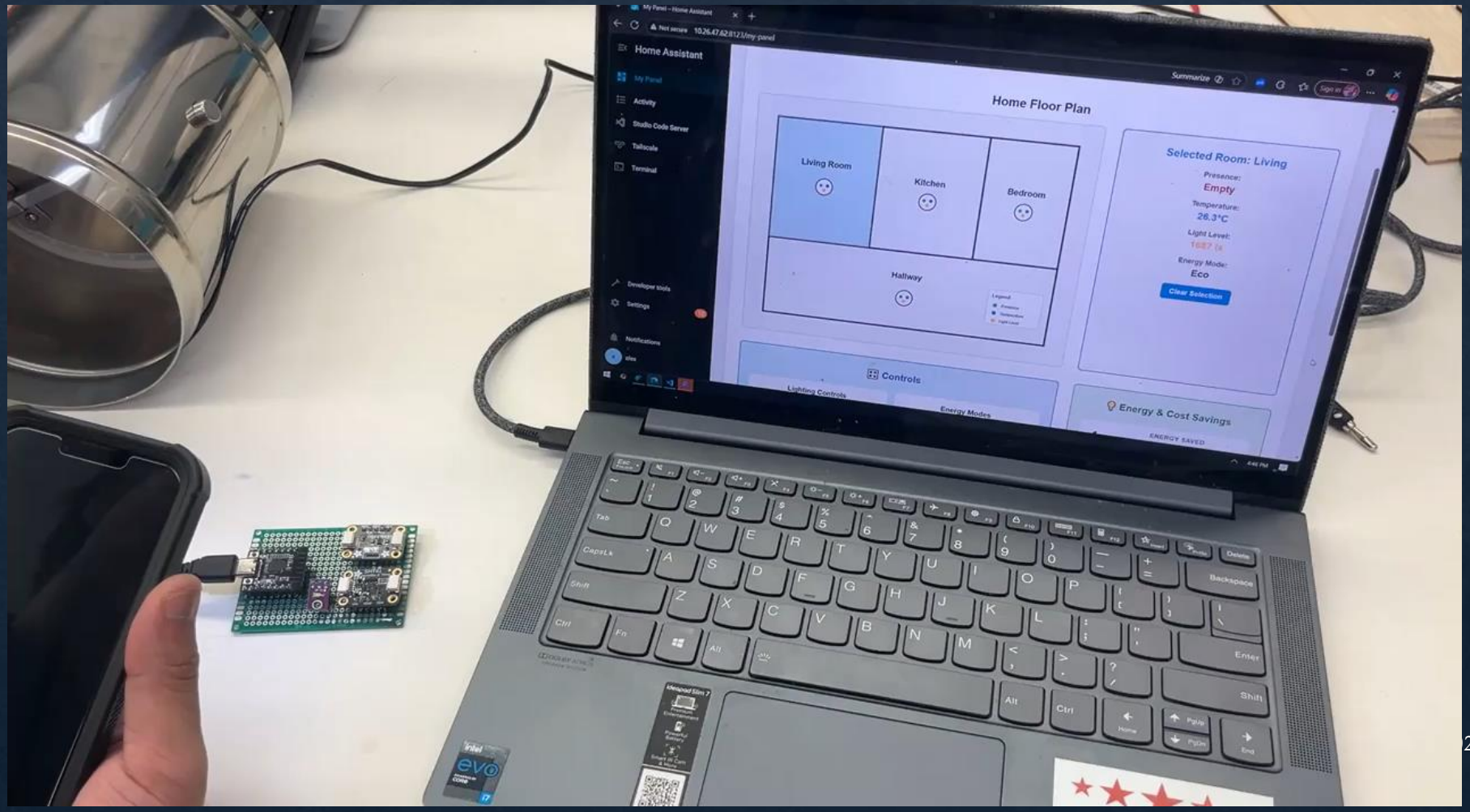
Light Dimmer



Temp Sensor + Display:



Light sensor + Display:



Software Design

IEEE 830 – Software requirements specification

IEEE 829 – Software Testing

React Standards

Home Assistant API

WCAG (Web Content Acessibility Guidelines)

Smart Home Energy Dashboard

Optimizing your home's energy with smart detection

Connected

Home Floor Plan

Selected Room: Living

Presence:
Empty

Temperature:
26.2°C

Light Level:
514 lx

Energy Mode:
Eco

Clear Selection

Energy Mode:
Eco

Clear Selection

Controls

Lighting Controls

- Toggle Living Room
- Toggle Kitchen
- Toggle Bedroom
- All Lights Off

Energy Modes

- Set Eco Mode
- Set Normal Mode
- Set Comfort Mode

Automations

- Trigger Occupied
- Enable Automation
- Disable Automation

Custom Events

- Send Test Event
- Send Energy Alert

Energy & Cost Savings

ENERGY SAVED
120.0 kWh
per month

COST SAVED
$18.00
per month

ACTIVE AUTOMATIONS
2
optimizing now

How we calculate savings:

- Eco mode: ~2.5 kWh/day saved
- Unoccupied detection: ~1.5 kWh/day saved
- Smart lighting: ~0.8 kWh/day saved
- Based on $0.15/kWh average rate

Connected to Home Assistant — Custom Smart Hardware Integration

Testing

Security Testing:

- WPA2 encryption implemented for Wi-Fi
  • Basic penetration testing – no major vulnerabilities found

Acceptance Testing:

- Meets ease-of-use and reliability requirements

Test Type	Metric	Result
Temp Sensor	±0.5°C	Passed
Light Dimmer	Response < 200 ms	Passed
Furnace Control	Relay switching stable	Passed
React Custom UI	Reads + writes data from HA	Passed

Risk Identification & Mitigation

Risks:

- Hardware failure → Mitigation: Redundant components
- Security breach → Mitigation: Encryption & authentication
- Cost overruns → Mitigation: Budget buffer

Design Tradeoffs & Innovativeness

Tradeoffs:

- Zigbee vs Bluetooth → Chose Zigbee for better range and mesh capability
- ESP32 vs Raspberry Pi → Chose ESP32 for lower cost and power consumption

Innovations:

- Modular design for easy expansion
- Local server compatibility for privacy

Future Work

- Add voice control integration
- Expand to solar energy management
- Improve AI-based energy optimization

Questions