



UNIVERSITY OF  
**ILLINOIS**  
URBANA-CHAMPAIGN

# A Cheaper Alternative to Temperature Controlled Sleep

ECE 445 Group 12

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2024*

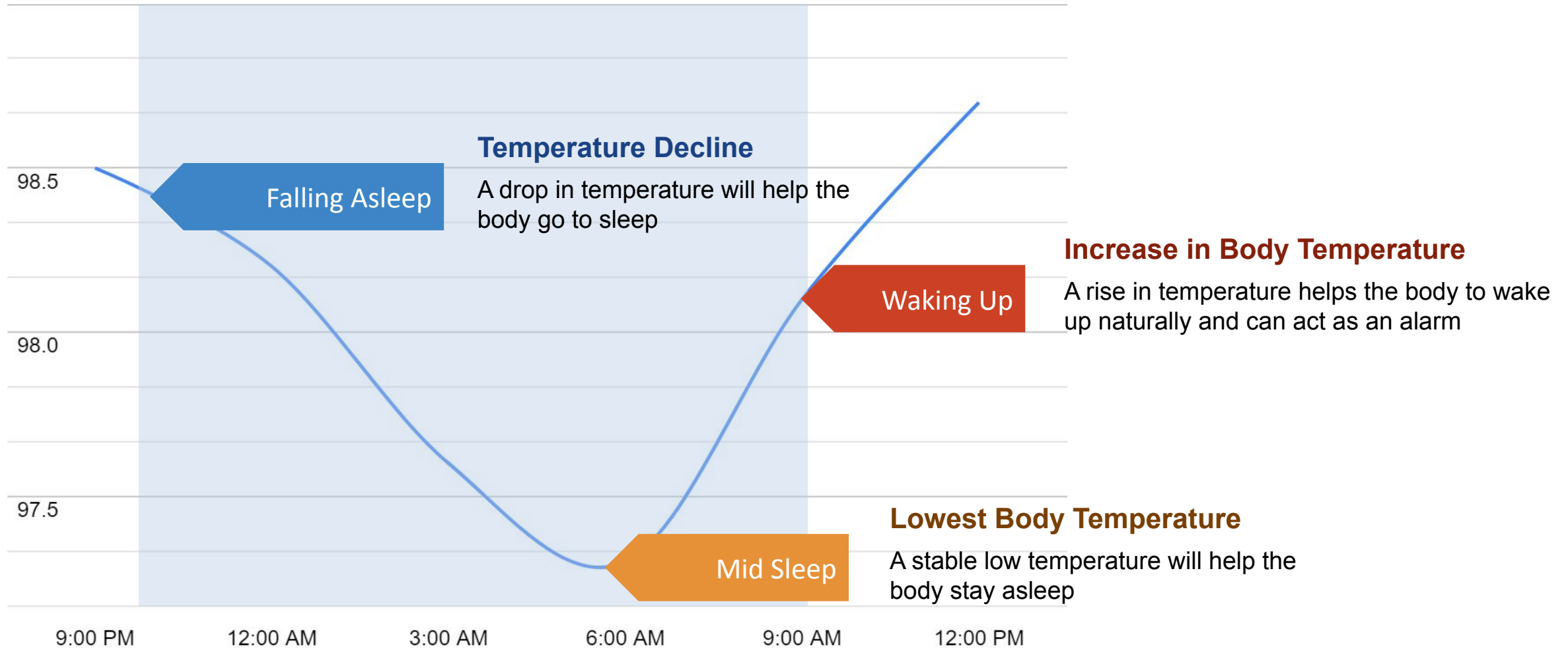


# Temperature and Sleep

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Body temperature drastically impacts sleep length and quality

# Body Temperature during the Night



## What's out there right now?

Bedjet **\$969**



[BedJet 3 Dual Zone Climate Comfort Sleep System](#) © BedJet.com,  
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SmartDuvet **\$815**



[Smartduvet Version 2](#) © SmartDuvet.com,  
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EightSleep Pod Cover **\$2245**



[EightSleep Pod Cover](#) © EightSleep.com,  
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## User Input

Choose and schedule temperatures

## Movement Detection

Detect blanket movements for insights on sleep quality

## Modularity

Distinct heating/sensing zones

[Stock Smartphone in Hand](#) © VectorPortal.com,  
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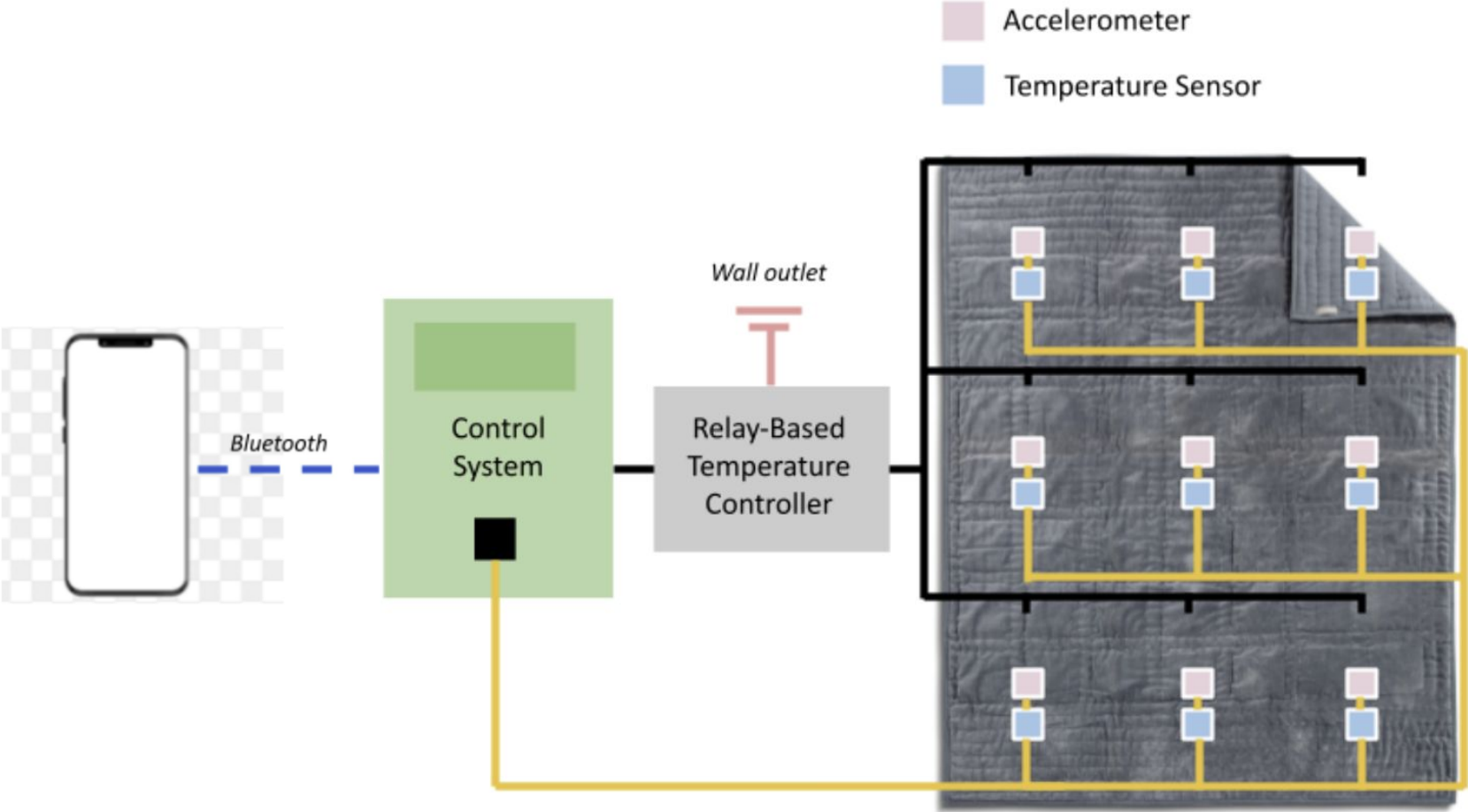
[Man Sleeping in Bed](#) ©  
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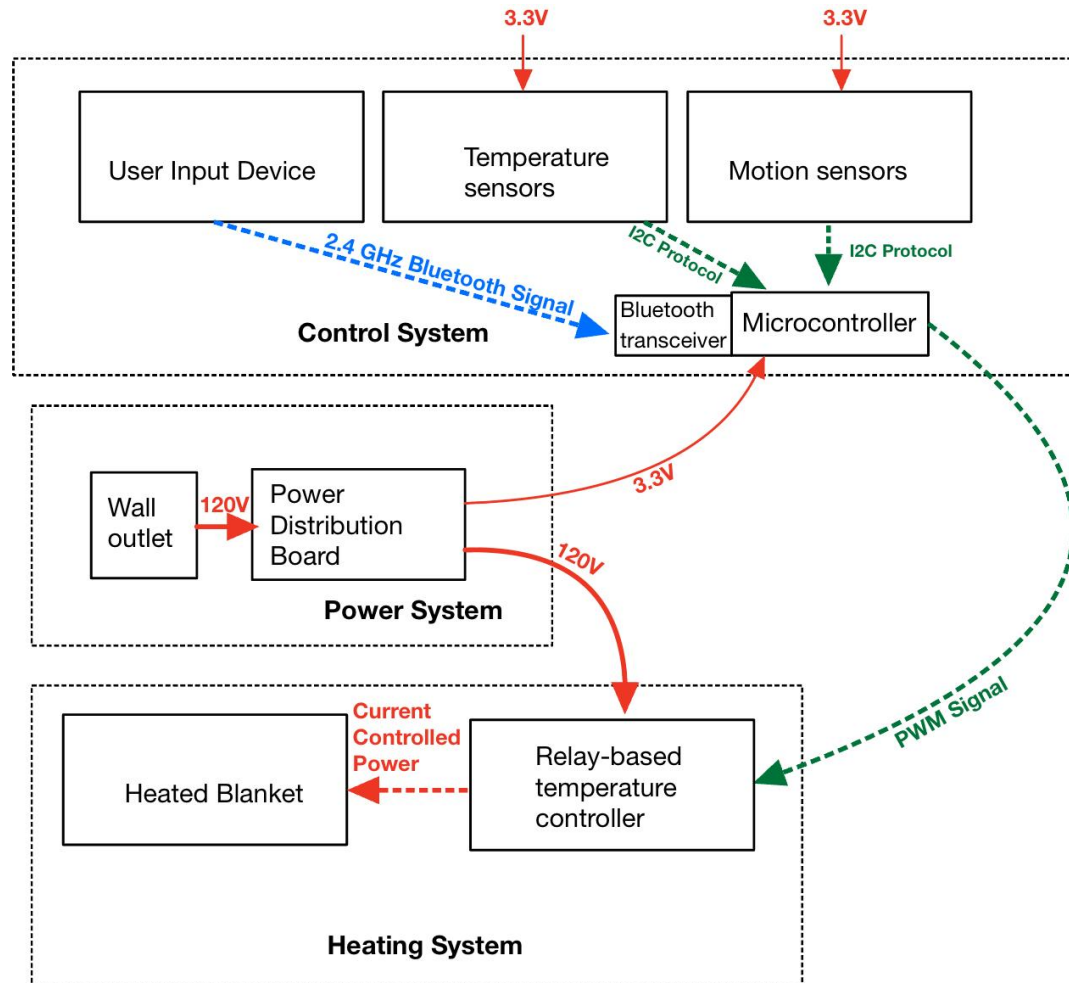


# Design

Visual Aid and Block Diagrams





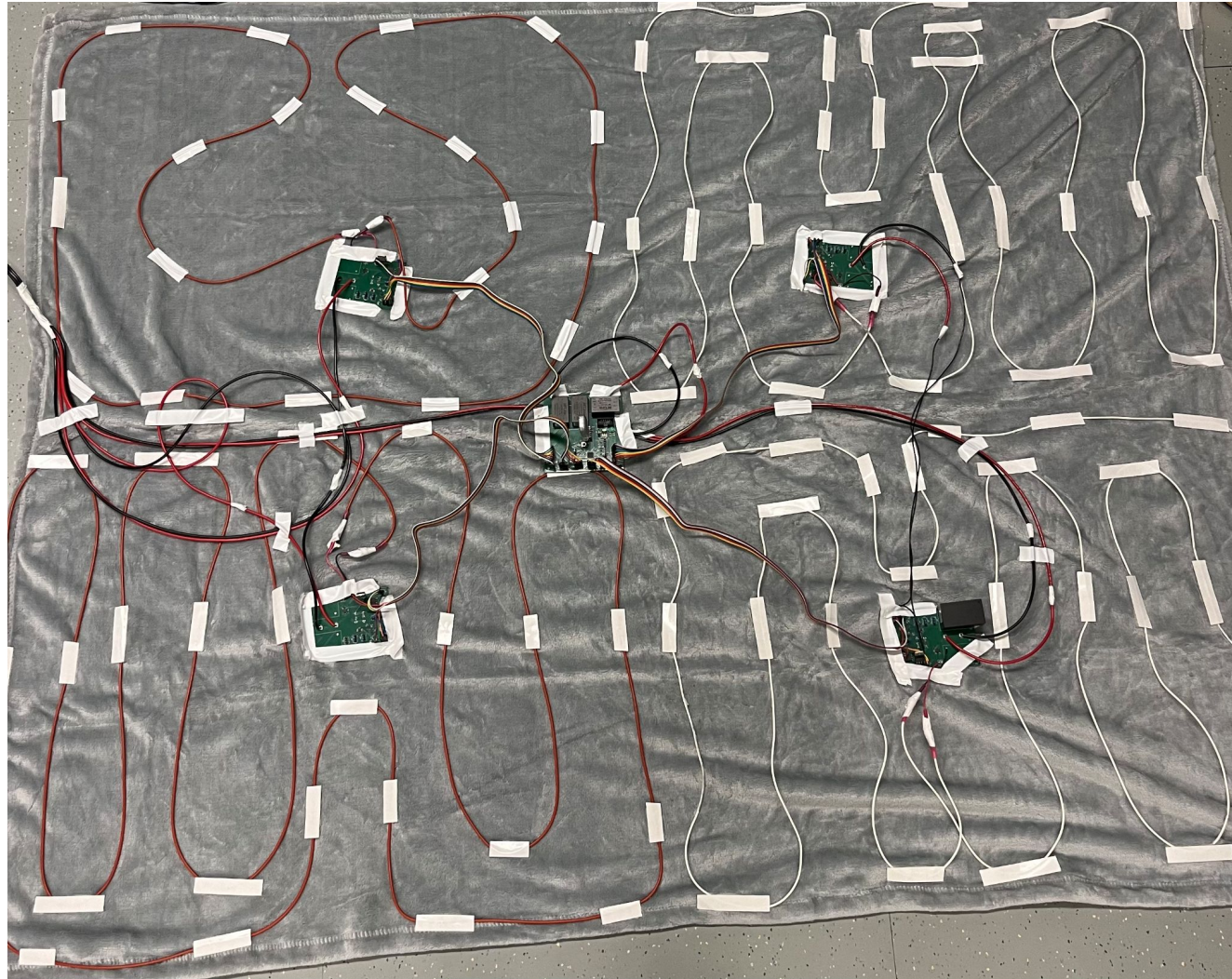


## 3 Main Subsystems:

**Control**

**Power**

**Heating**



## Subsystems Included

### Power Distribution

120VAC to heating coils

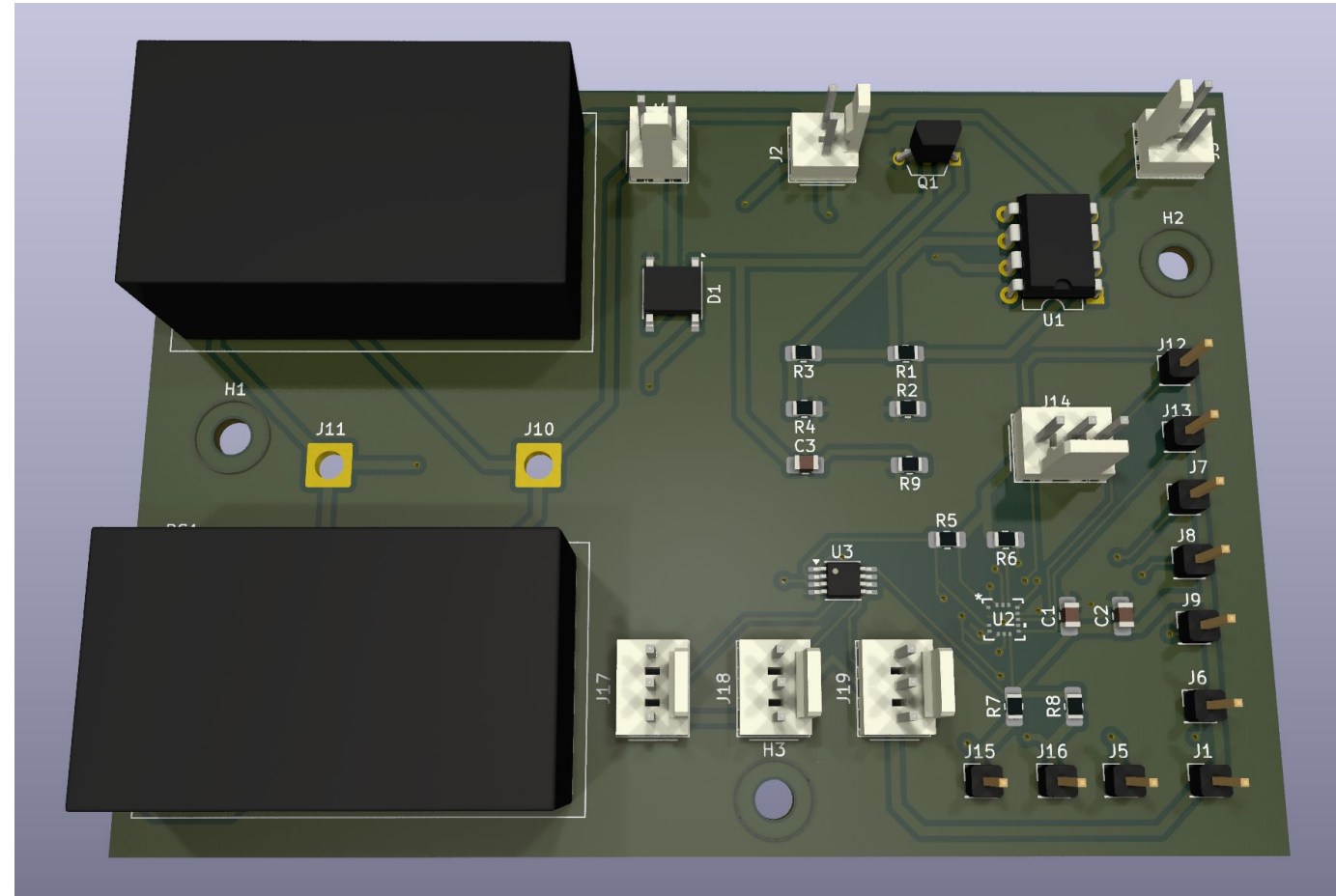
Parallel Circuit

Different voltages on same board

### Heating Subsystem

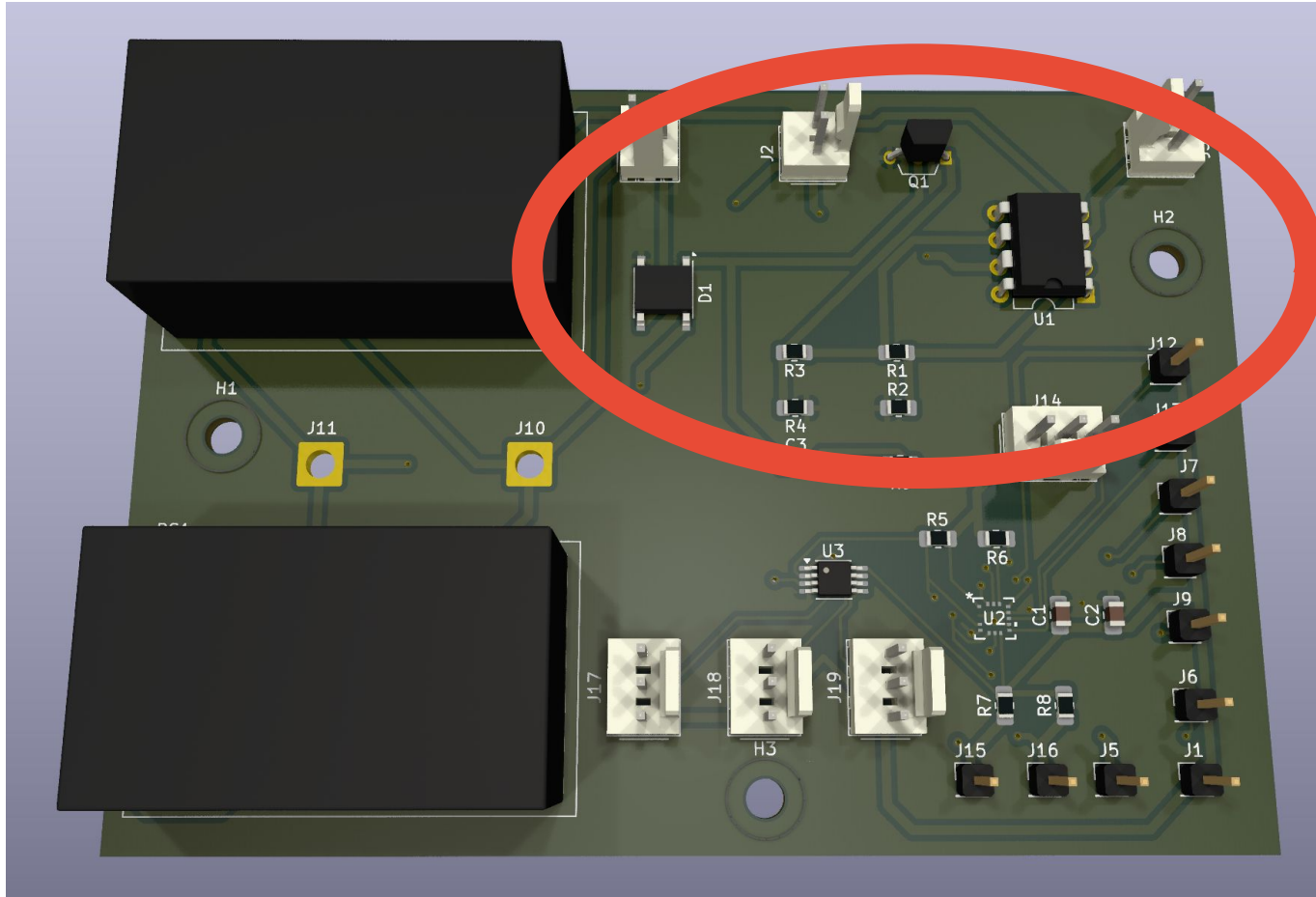
Modulate AC Voltage

Supply power independently

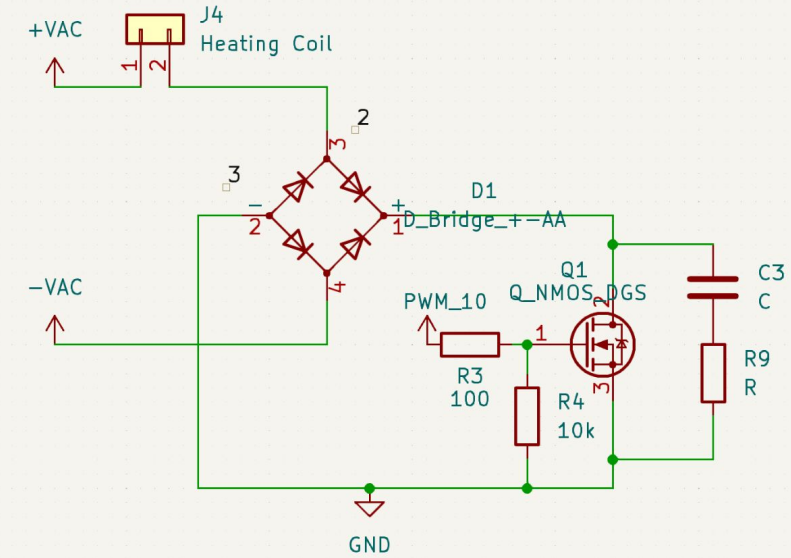




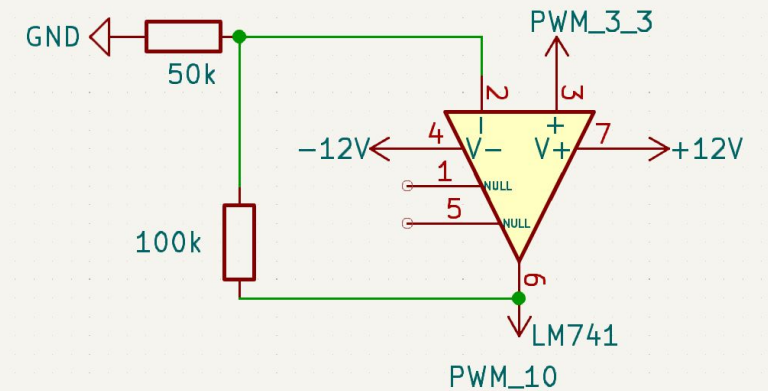
# Heating System - Heating Coil Modules



PWM Modulation

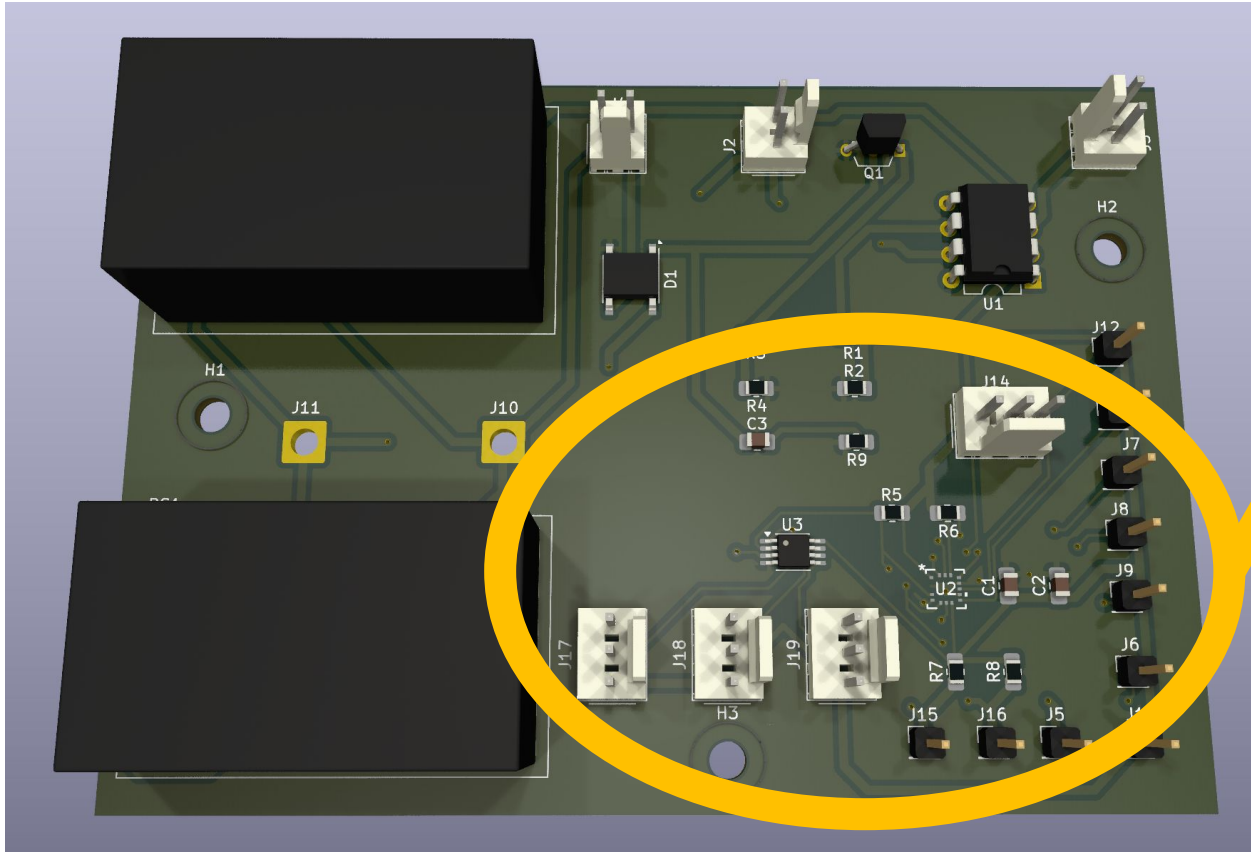


PWM Amplifier

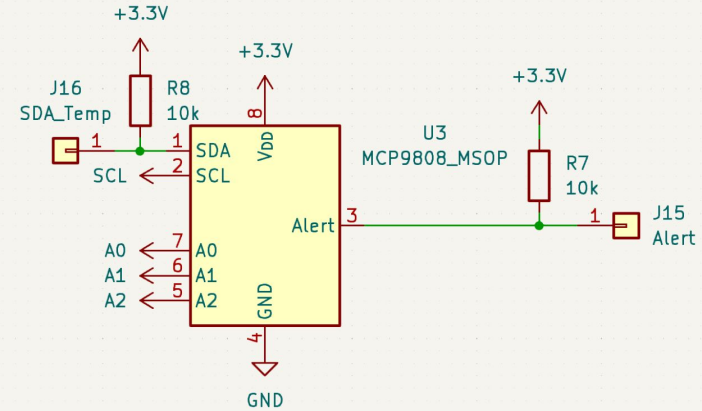




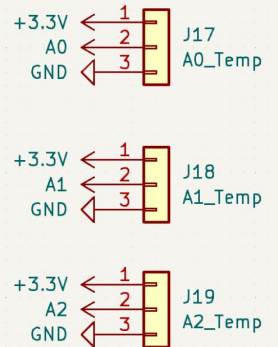
# Heating System - Sensor Modules



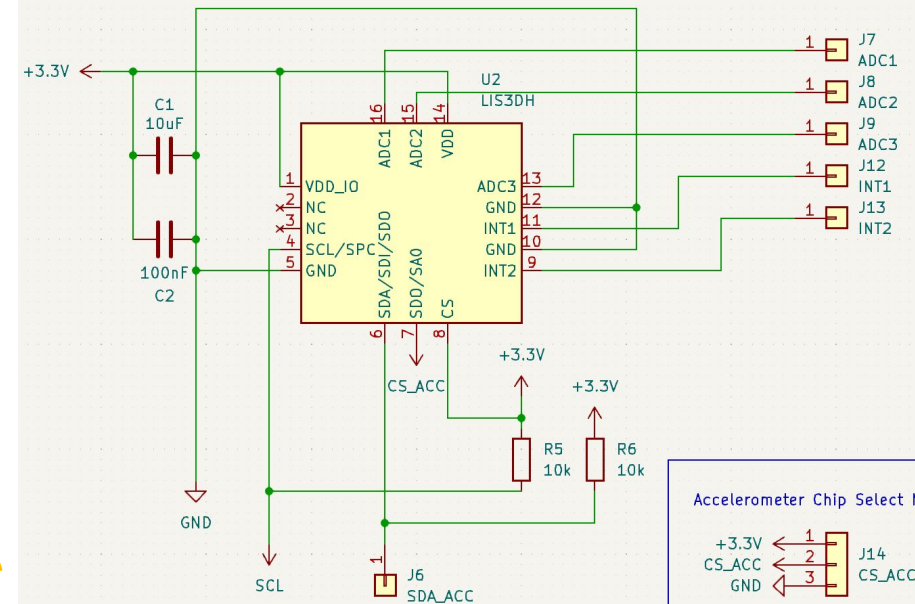
Temperature Sensor



Temperature Sensor Address Pin Mux



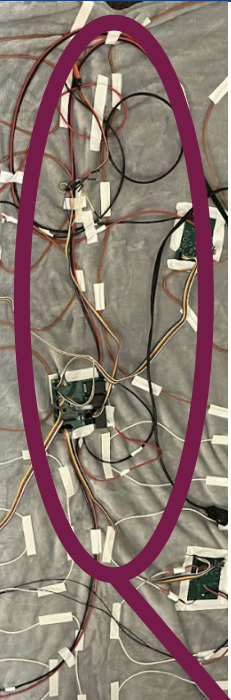
Accelerometer (I2C)



Accelerometer Chip Select Mux



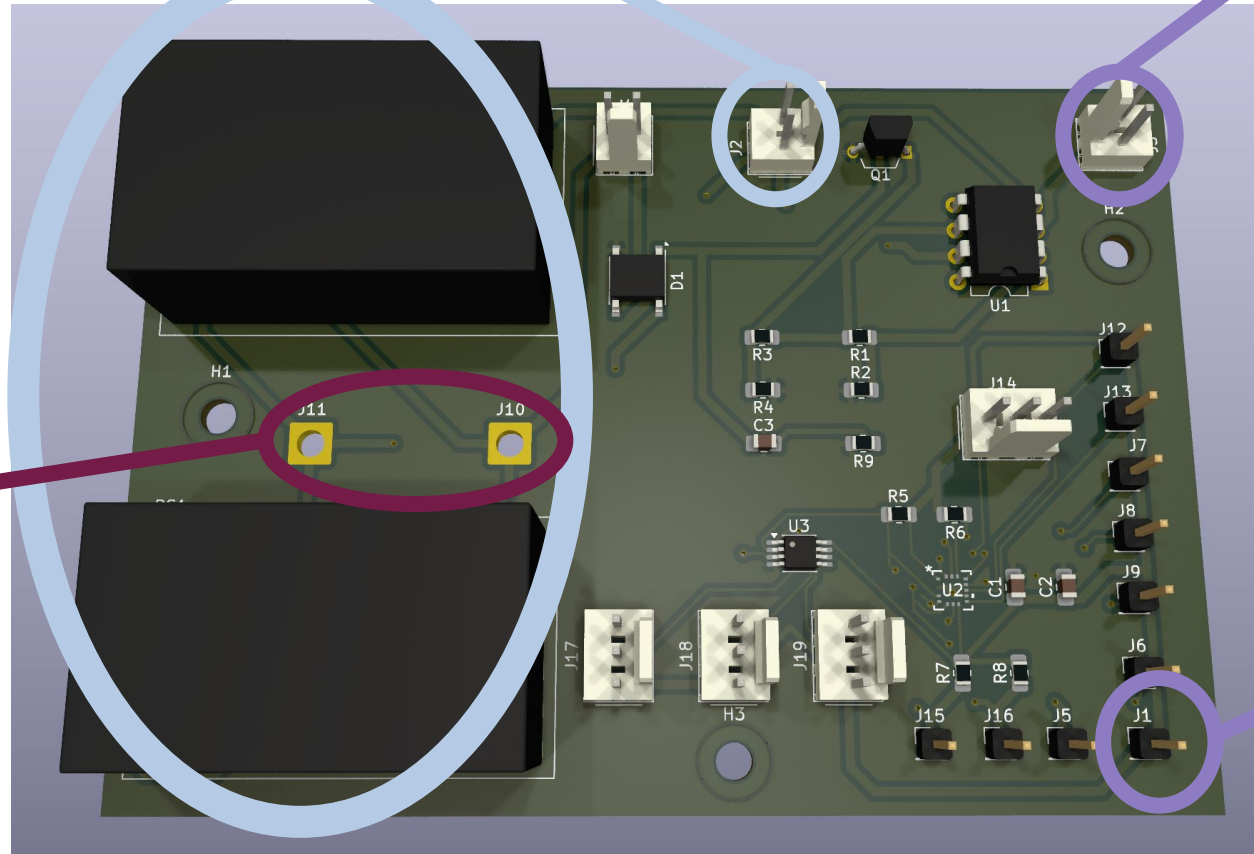
# Heating System - Power Modules



**Outlet  
(120V AC)**

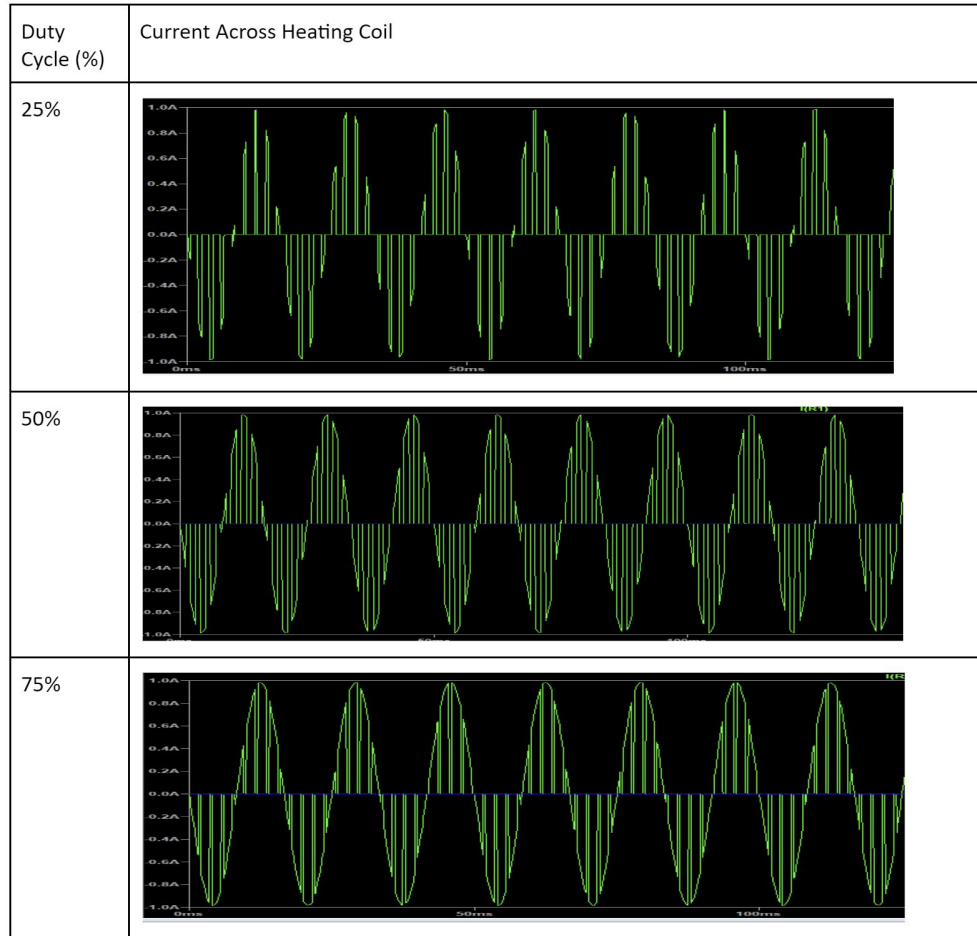
**12V DC**

**PWM  
(0-3.3 V DC)**

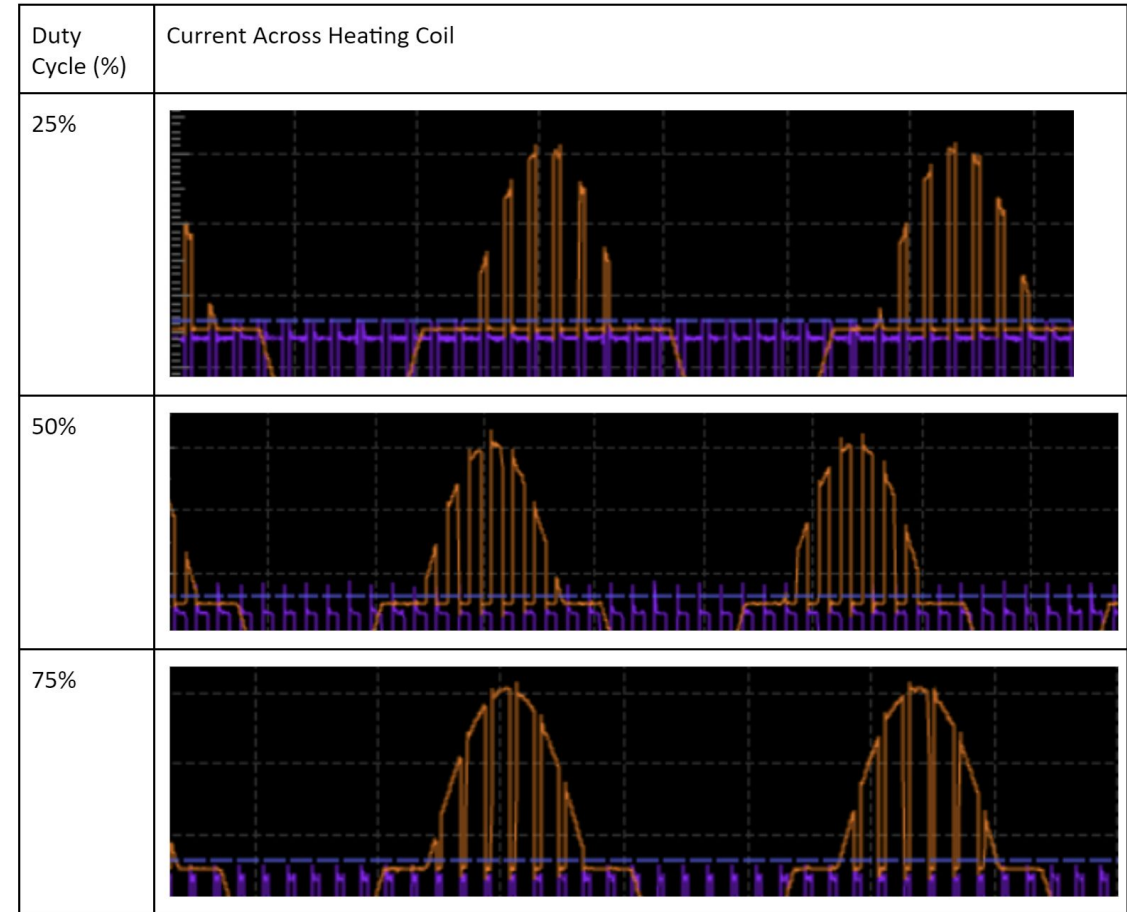


**Sensor  
(3.3 V DC)**

## Theoretical Output (LTSpice)



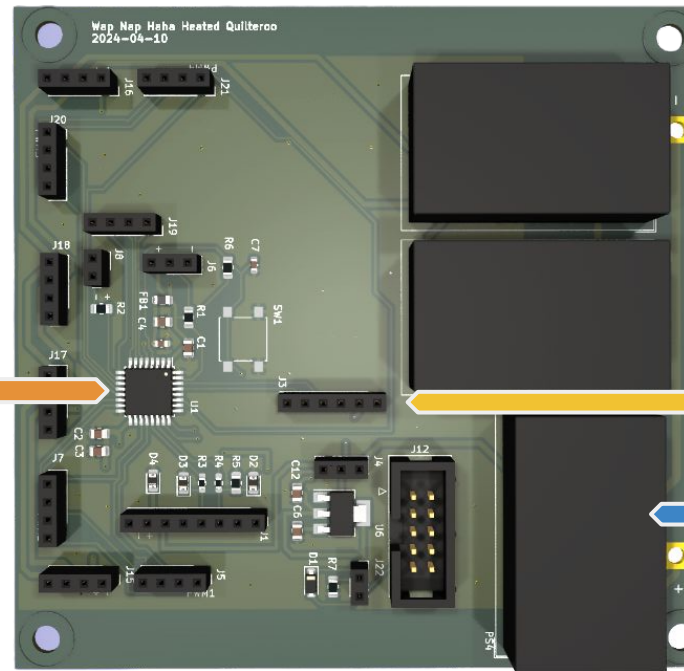
## Empirical Output (Oscilloscope)



## Main Control System and Peripherals

**STM32 Microcontroller**  
Low energy

**Connectors to Sensors  
and PWM**

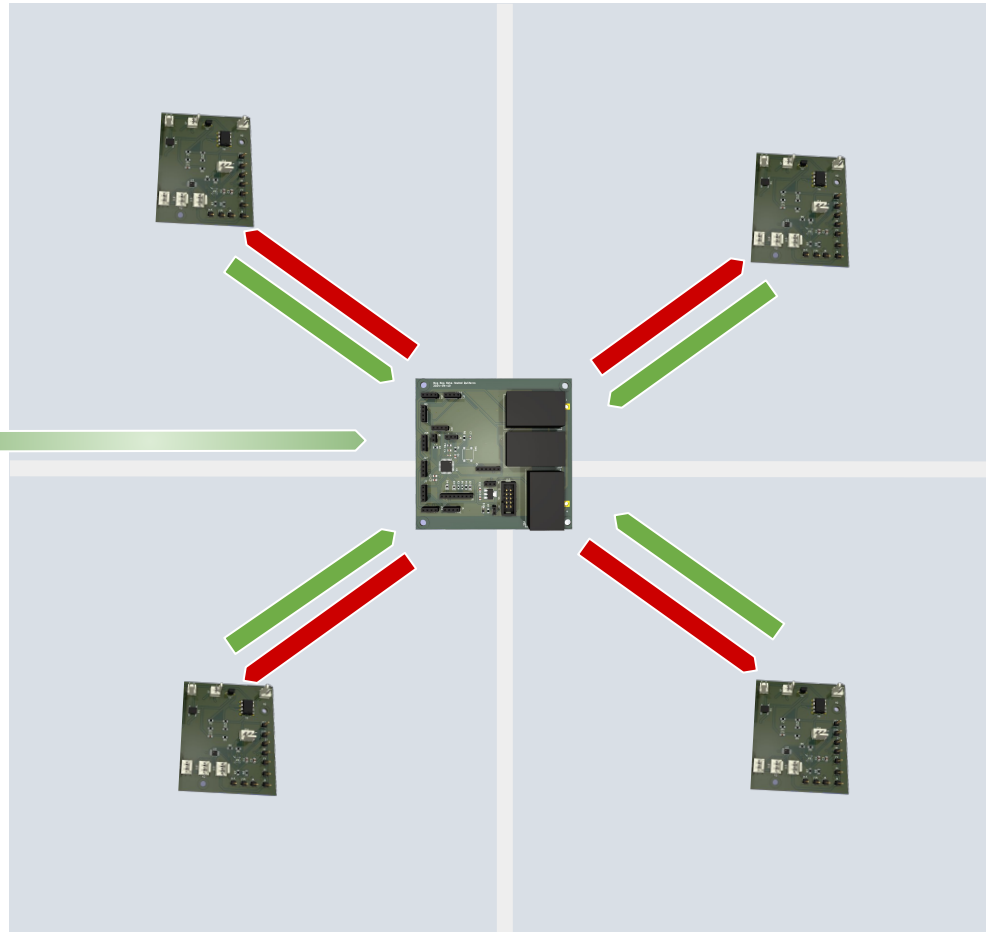


**Connector for Bluetooth  
Module  
HM11**

**Power System**  
120V AC → Buck → 5V DC →  
Linear Regulator → 3.3V DC



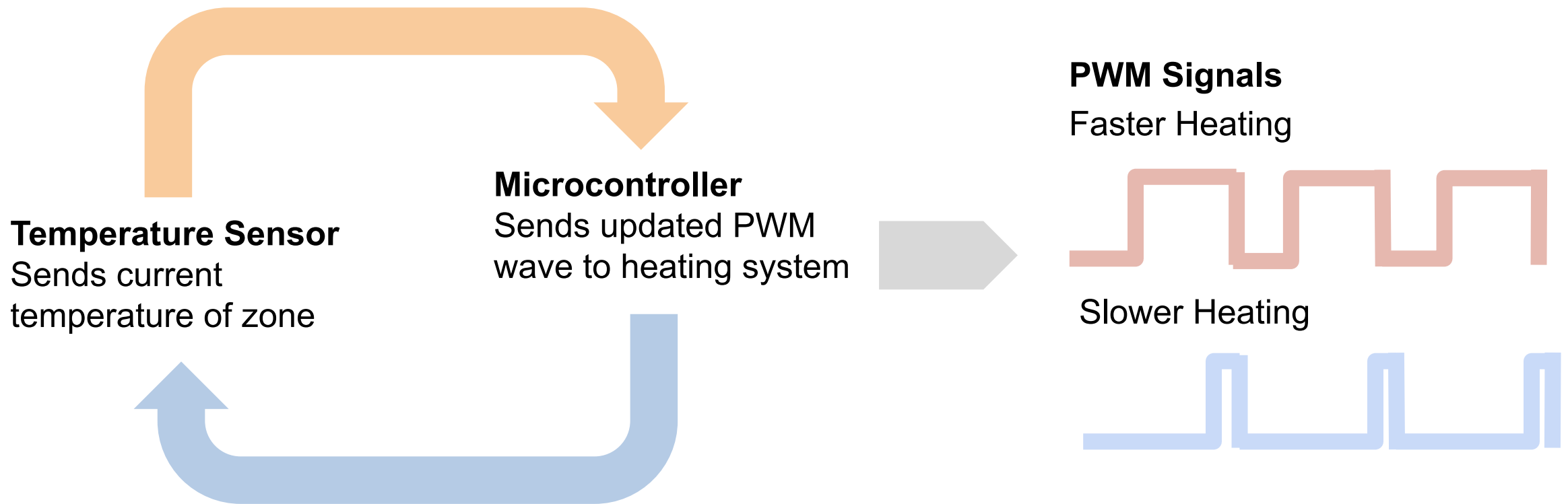
**Bluetooth Signal**  
Inputs temperature for  
each zone



**Temperature Sensors (x4)**  
Sends I2C signal to Microcontroller

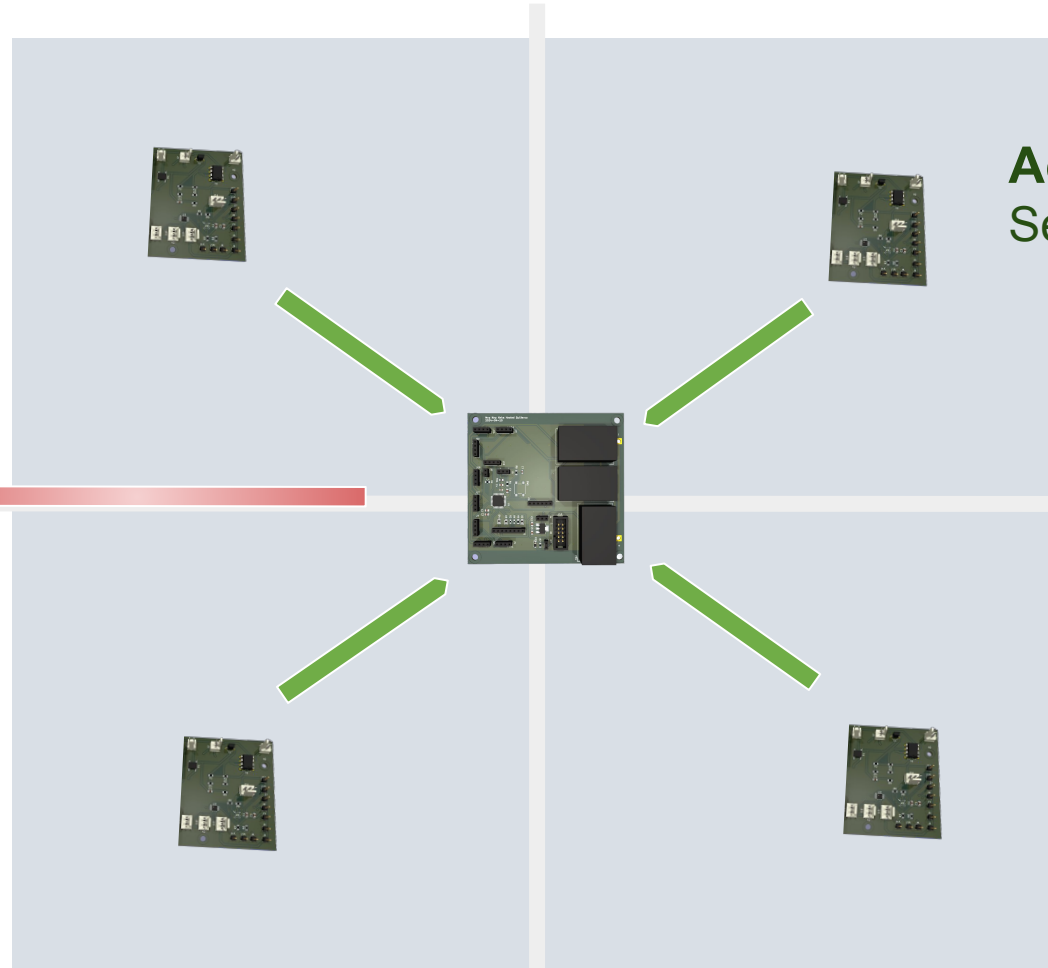
**Heating Wire Input (x4)**  
Microcontroller sends PWM to wire

## Temperature Feedback Control



## Sensing Sleep

**Bluetooth Signal**  
Microcontroller sends movement data to app



**Accelerometer Sensors (x4)**  
Sends I2C signal to Microcontroller

## Challenges within the control system

### Sensor Communication Protocol

Long wires

Multiple sensors on one wire

### Bluetooth

Using ESP32 for built in bluetooth



## High-Level Overview

**Built for iOS devices**

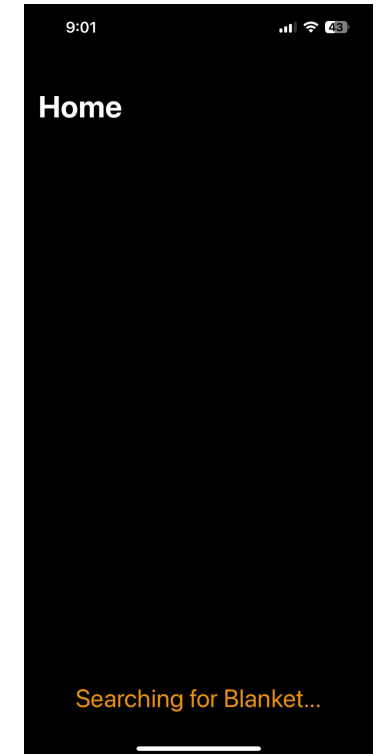
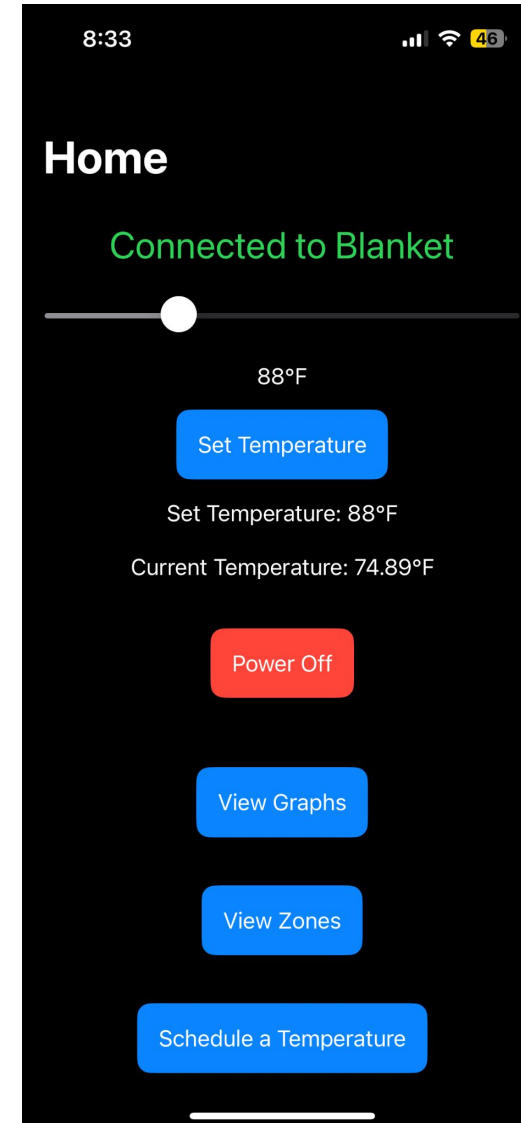
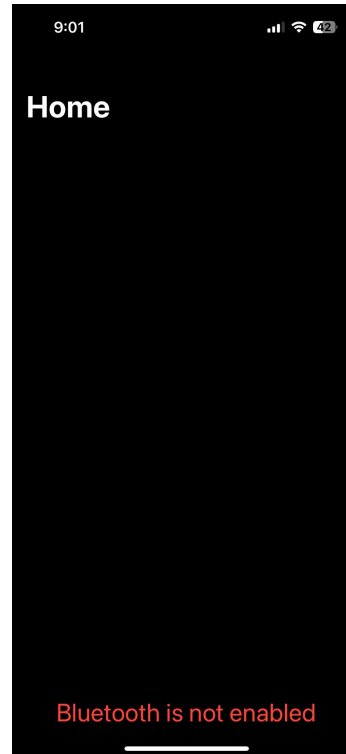
**Programmed in Xcode with Swift**

**Primary user interface with blanket**

Set temperature, see sensor data

**Communicates via Bluetooth**

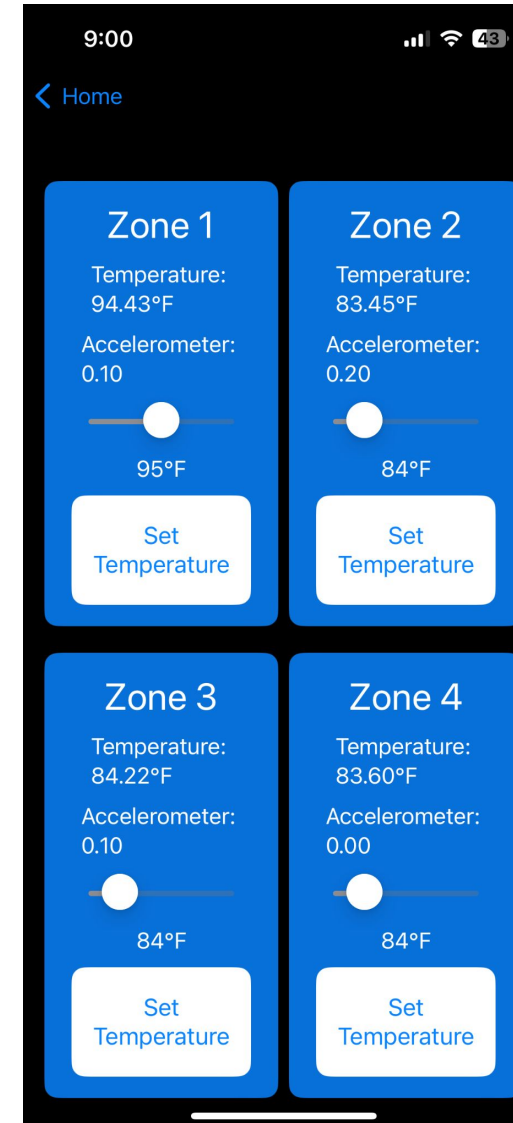
Custom packets: (zone, data1, data2, end)



## Zones Page

Set temperatures independently

View sensor data



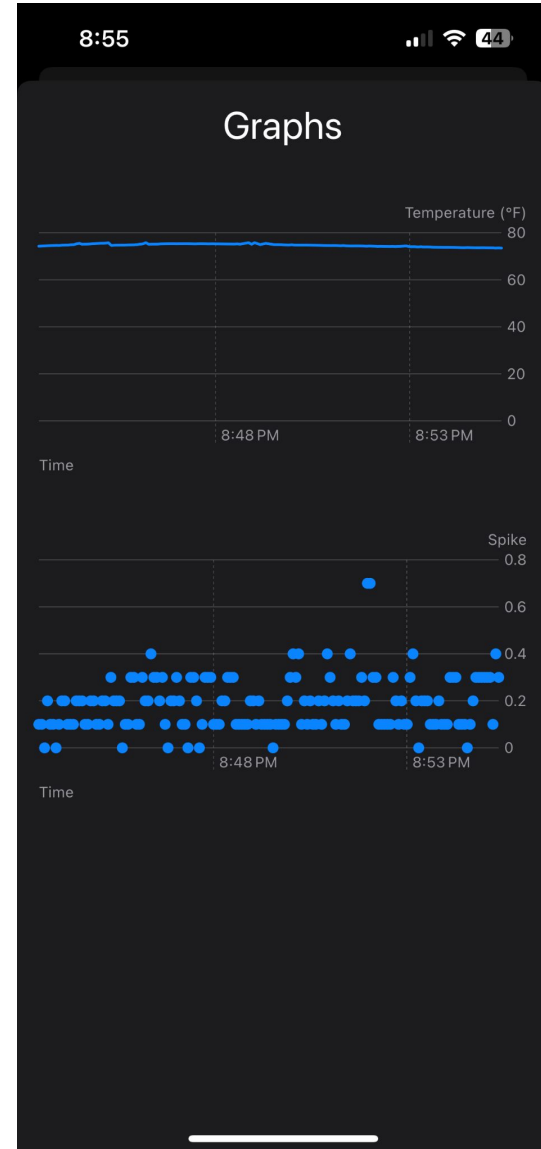
## Graphs Page/Data Storage

Average temperature over time

Accelerometer readings over time

Non-persistent data storage

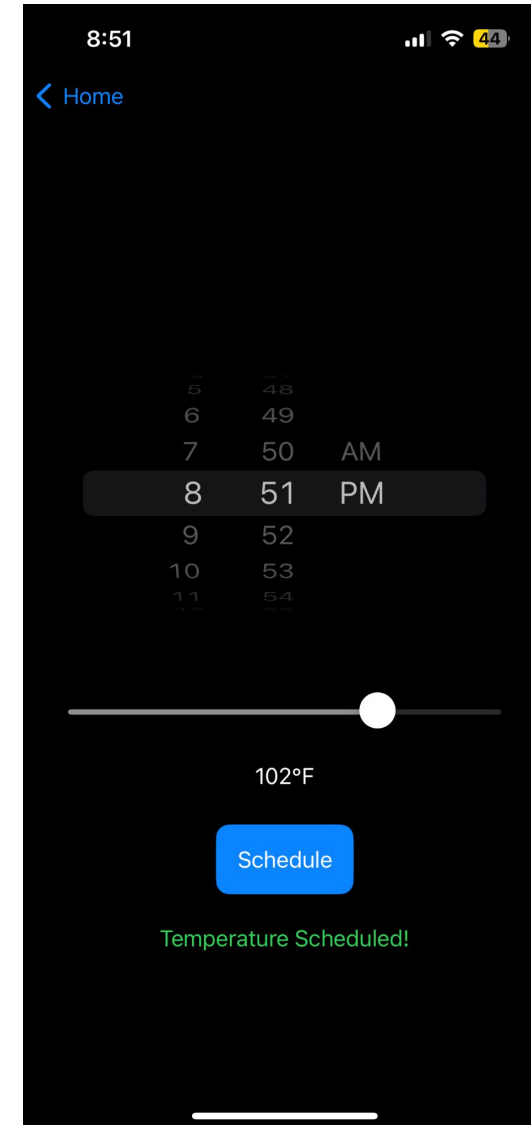
```
// Data Model
struct DataPoint: Codable, Identifiable {
    var id = UUID()
    var value: Double
    var timestamp: Date
}
```



# Schedule Temperature Page

Schedule a time and a temperature

Easily extendable







# Conclusions

Successes, Failures, and Future Goals

## What's working? (And what's not?) **Future Goals**

### **Distinct heating zones**

Materials  
Layout

### **MCU and App for control**

Reliability  
Communication protocols

### **Aesthetic and Comfort**

Machine washability

### **More Zones**

Faster cooling

### **Using data for more fun(ctions)**

Better graphs  
Medical research backed sleep suggestions  
LLM based data summarization  
Data storage and security



# Thank You!

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Questions? :)





# The Grainger College of Engineering

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