

EN - 2160
Electronic Design Realization

Design of the prototype



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Introduction

Introducing the Expandable Battery Management System, a cutting-edge solution designed to streamline the management of lithium polymer (LiPo) batteries. With the capacity to connect a high number of batteries in a single system, this innovative technology offers unparalleled scalability and versatility.

User Requirements

1. Simple Installation:

- This BMS is designed for easy installation, requiring minimal technical expertise or specialized tools.
- Clear instructions guide users through the installation process, ensuring a smooth setup experience.

2. Intuitive Operation:

- This BMS features a user-friendly interface with intuitive controls, making it easy to operate.
- Users can access vital battery information such as voltage levels and temperature through a centralized monitoring system.

3. Comprehensive Visibility:

- This BMS provides users with comprehensive visibility into battery status and performance.
- This enables informed decision-making regarding battery management and maintenance.

4. Minimal Maintenance Requirements:

- Routine maintenance tasks such as firmware updates and system diagnostics are straightforward and can be performed with ease.
- This BMS is equipped with self-diagnostic capabilities, allowing it to identify and address potential issues proactively.

5. Efficient System Management:

- This BMS streamlines system management processes, ensuring optimal performance and longevity of the battery system.
- Its advanced functionalities facilitate efficient battery charging and discharging, contributing to extended battery life.

6. Proactive Issue Resolution:

- This BMS is capable of identifying and addressing potential issues proactively, minimizing downtime and maximizing operational efficiency.
- This proactive approach to issue resolution enhances system reliability and safety.

Conceptual Designs

Conceptual Designs

The primary objective of the conceptual design stage is to generate and prototype various ideas for a specific product. This involves exploring different circuits, enclosures, and functional components, and presenting diverse concepts to create a comprehensive solution. During this phase, the underlying ideas are organized and communicated through freehand sketches to arrive at an optimal solution.

Design 1

- Two distinct units are envisioned:
 - One housing the main controller.
 - Another accommodating five slave modules, specifically Cell Monitoring PCBs.

This modular approach ensures efficient organization and optimal functionality for the overall product design.

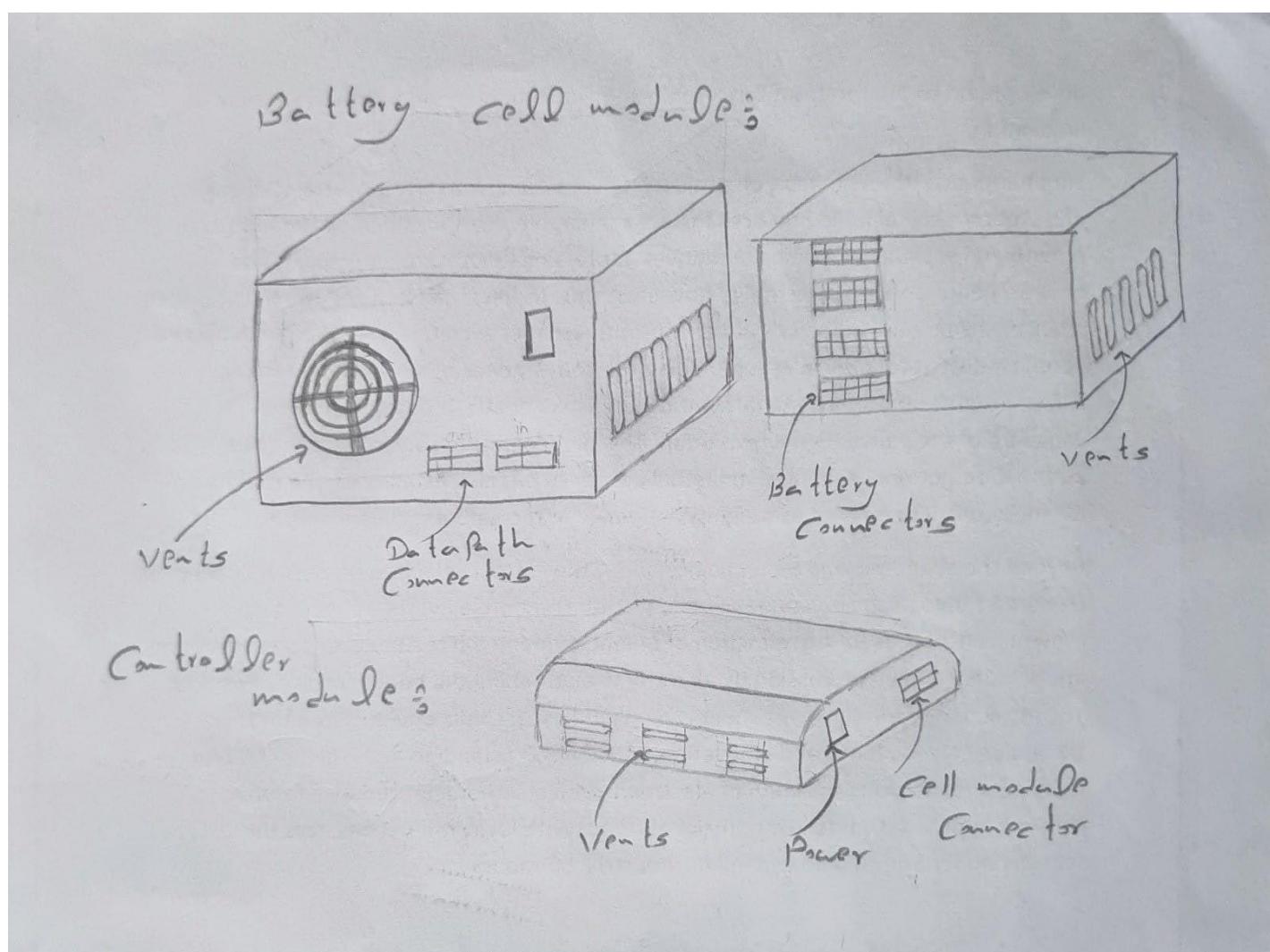
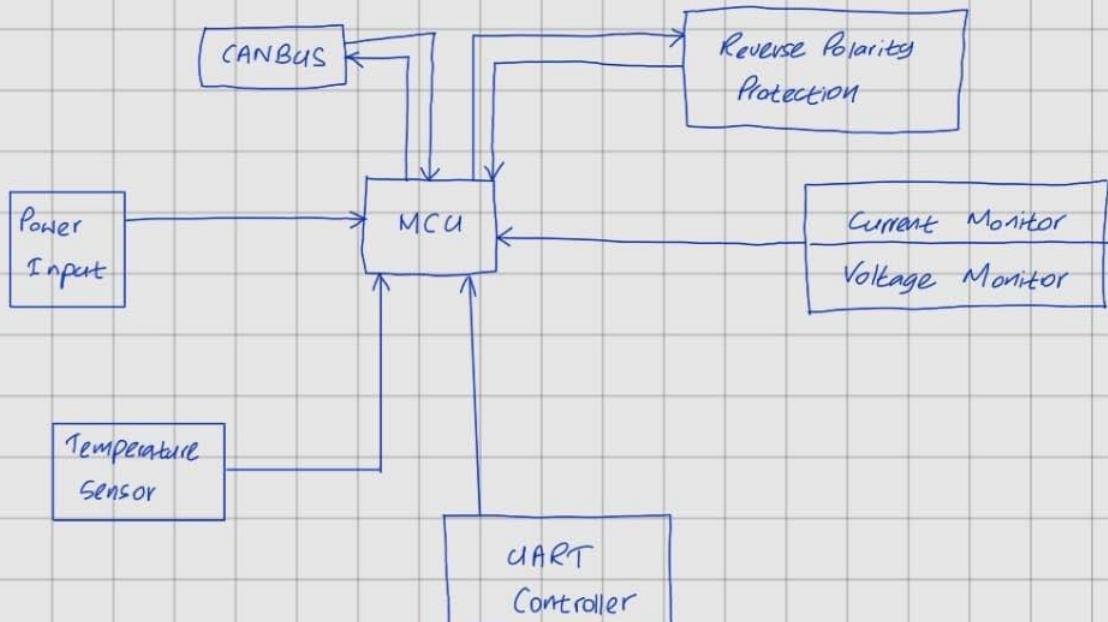


Figure 1: 3D Sketch of the design 1

Design 1

Master Circuit



Slave Circuit

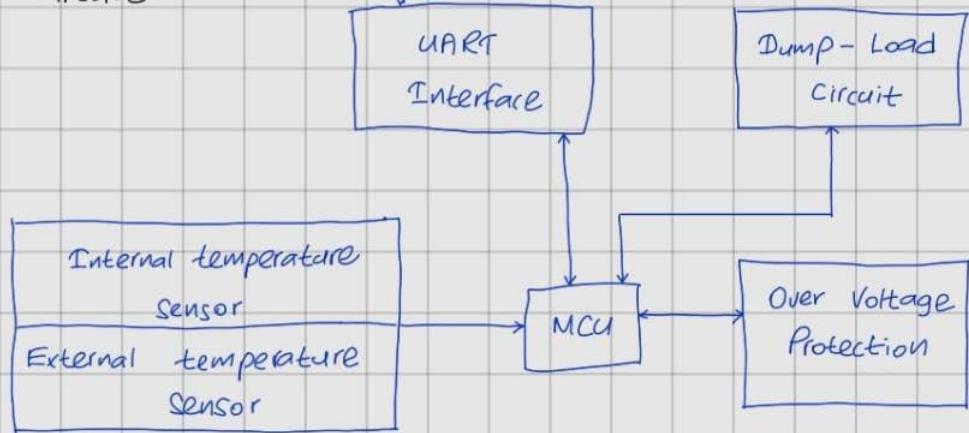


Figure 2: Block diagram of the design

Design 2

A singular unit integrates the main controller and five slave modules, namely Cell Monitoring PCBs. This consolidated approach enhances cohesion, fostering seamless communication and efficient functionality, ensuring a cohesive and optimized solution for the product design.



Figure 3: 3D Sketch of the design 2

Design 2

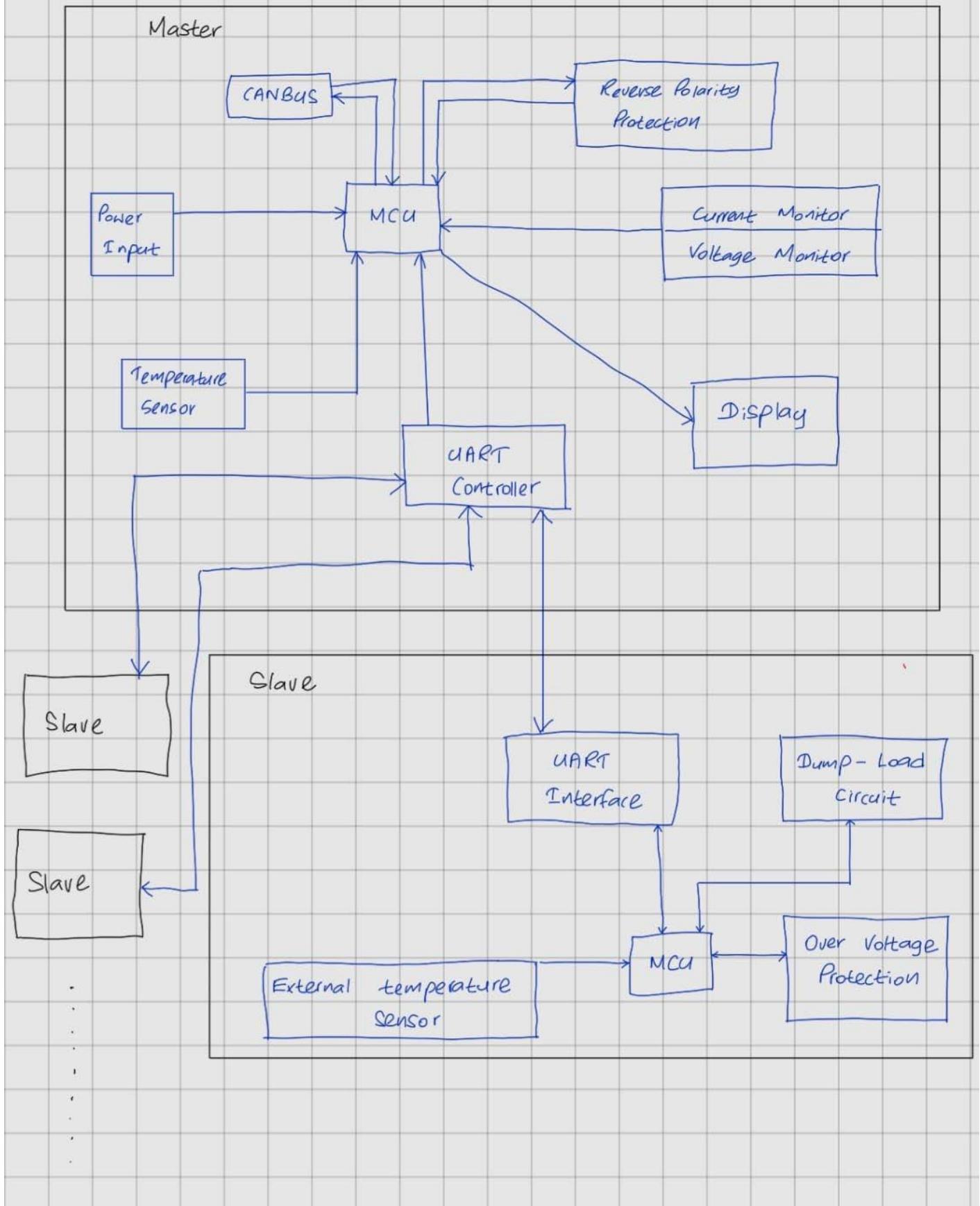


Figure 4: Block diagram of the design 2

Design 3

In a decentralized design, a central unit hosts the main controller, while separate enclosures house individual slave PCBs. This modular setup efficiently manages batteries located remotely, ensuring scalability, flexibility, and streamlined maintenance across diverse locations.

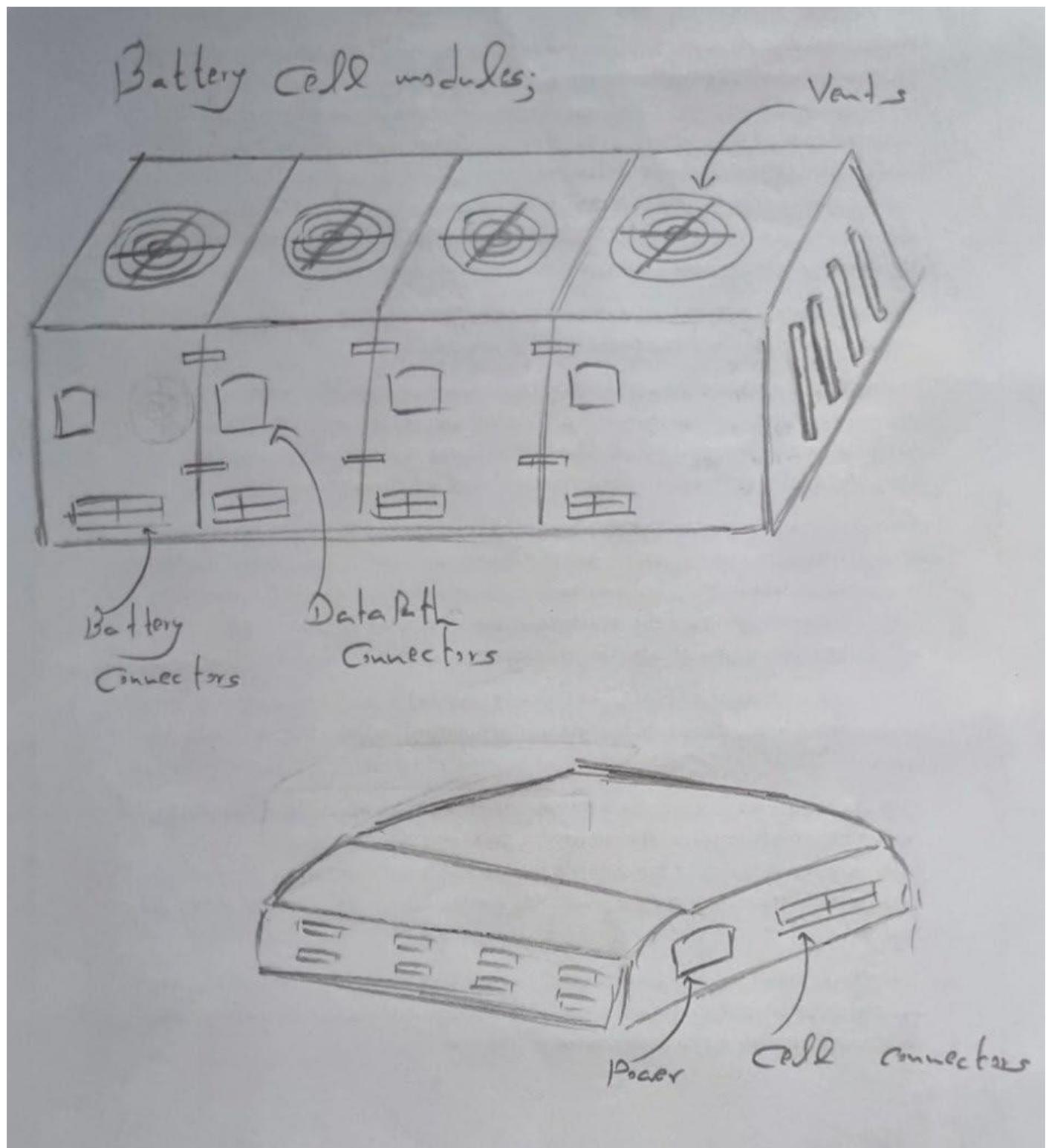


Figure 5: 3D design of design 3

Design 3

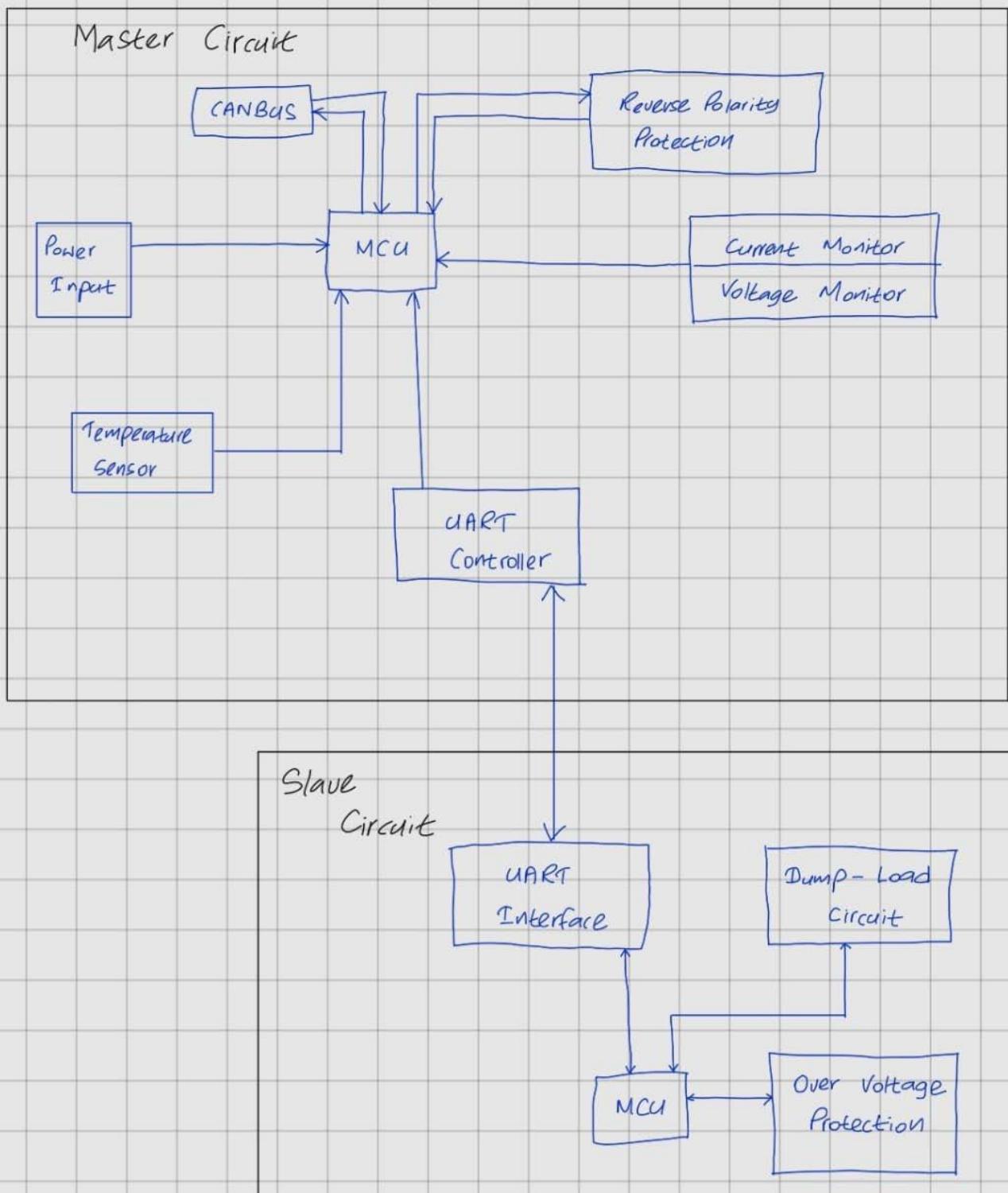


Figure 6: Block diagram

Design 4

The modular controller operates centrally, with individual BMS (Battery Management System) modules functioning as slaves within a master-slave configuration. This setup ensures that each BMS module is connected to the controller as a slave device, with dedicated parts allocated for managing the communication and control of each BMS module.

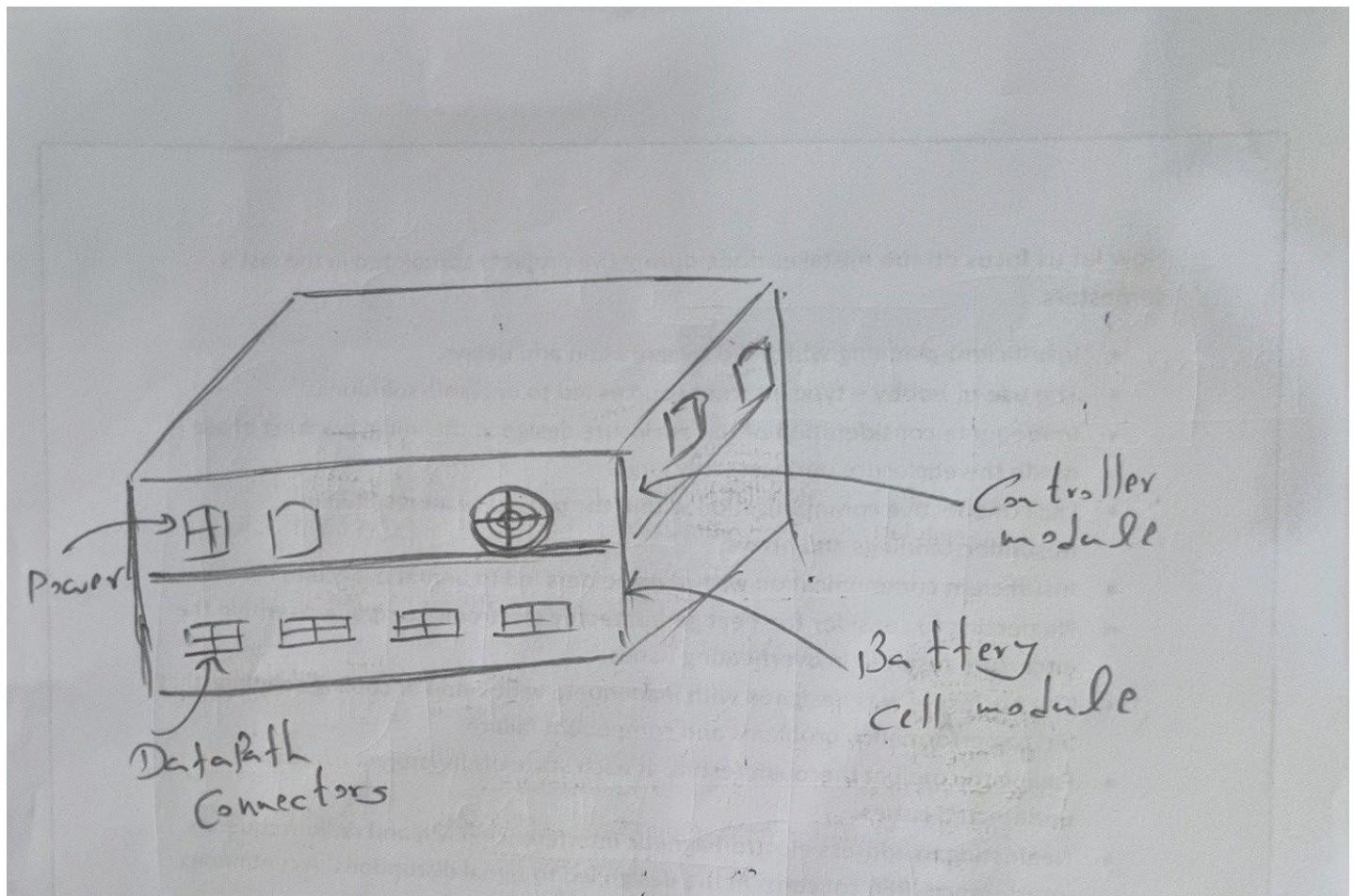


Figure 7: 3D design of a design 4

Design 4

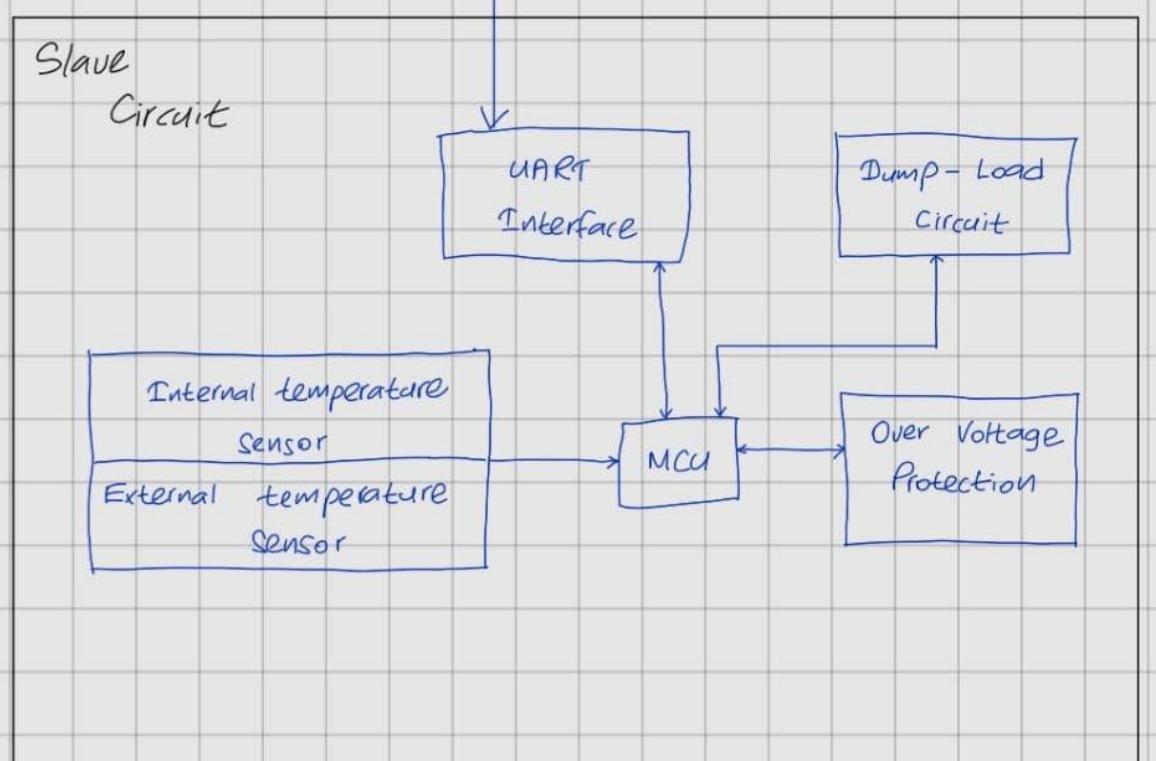
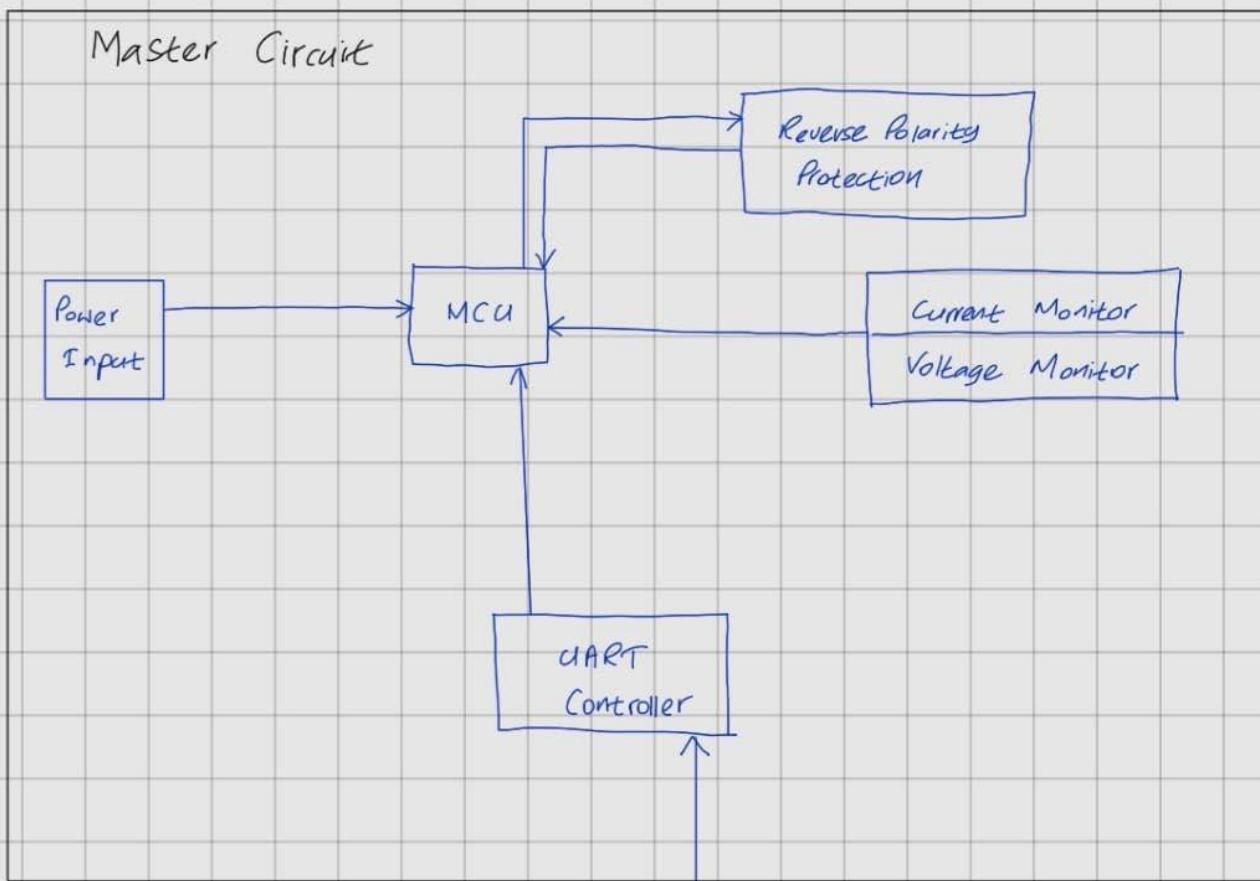


Figure 8: Block diagram,

	Conceptual Design 1	Conceptual Design 2	Conceptual Design 3	Conceptual Design 4
New Added Features	Ability to connect more cells	Single Unit with the ability to connect a limited number of batteries	Ability to connect more slave circuits	Rack mountable.
Removed Features		No separate units	Reduced the size of the BMS	Separated units
Enclosure Design Comparison	Functionality	8	6	7
	Aesthetics	7	6	8
	Heat Dissipation	8	6	7
	Assembly and Serviceability	9	7	6
	Ergonomics	8	7	6
	Durability	8	6	5
	Simplicity	8	9	6
Functional Block Diagram Comparison	Functionality	8	7	7
	User Experience	9	7	6
	Manufacturing Feasibility	8	6	8
	Cost	7	6	8
	Performance	8	8	8
	Future Proofing	7	6	7
	Power Efficiency	8	6	7
Total Score (out of 140)	112	93	96	104

By considering the scores of the evaluation of the design, the final selected design is **Design 1**

Final schematic and PCB design

Our BMS consists of two parts.

1. Battery Module

Each battery has its own cell module. In our PCB design, we have integrated five modules in a single PCB since we are monitoring 20 LiPo batteries, using four PCBs.

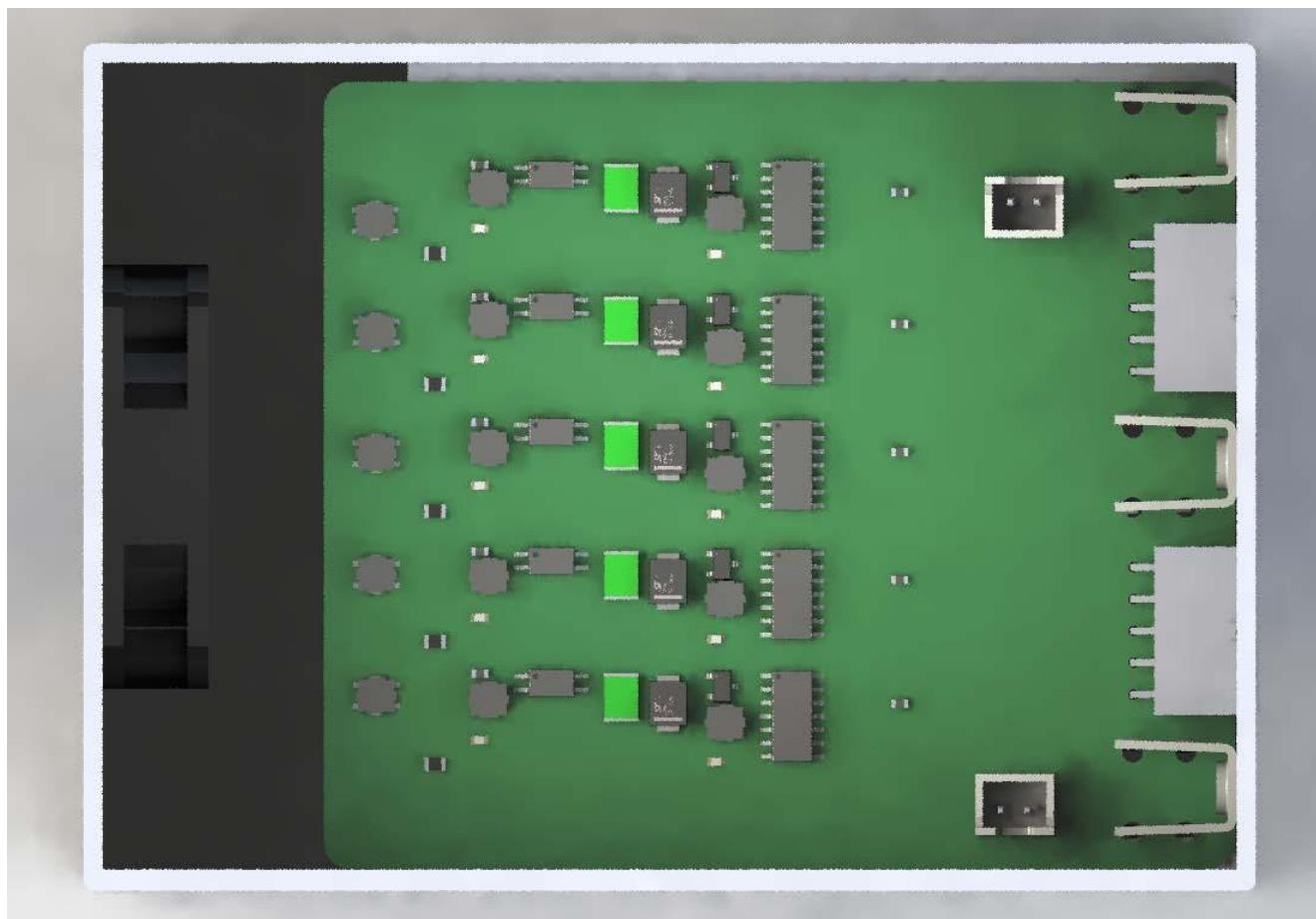
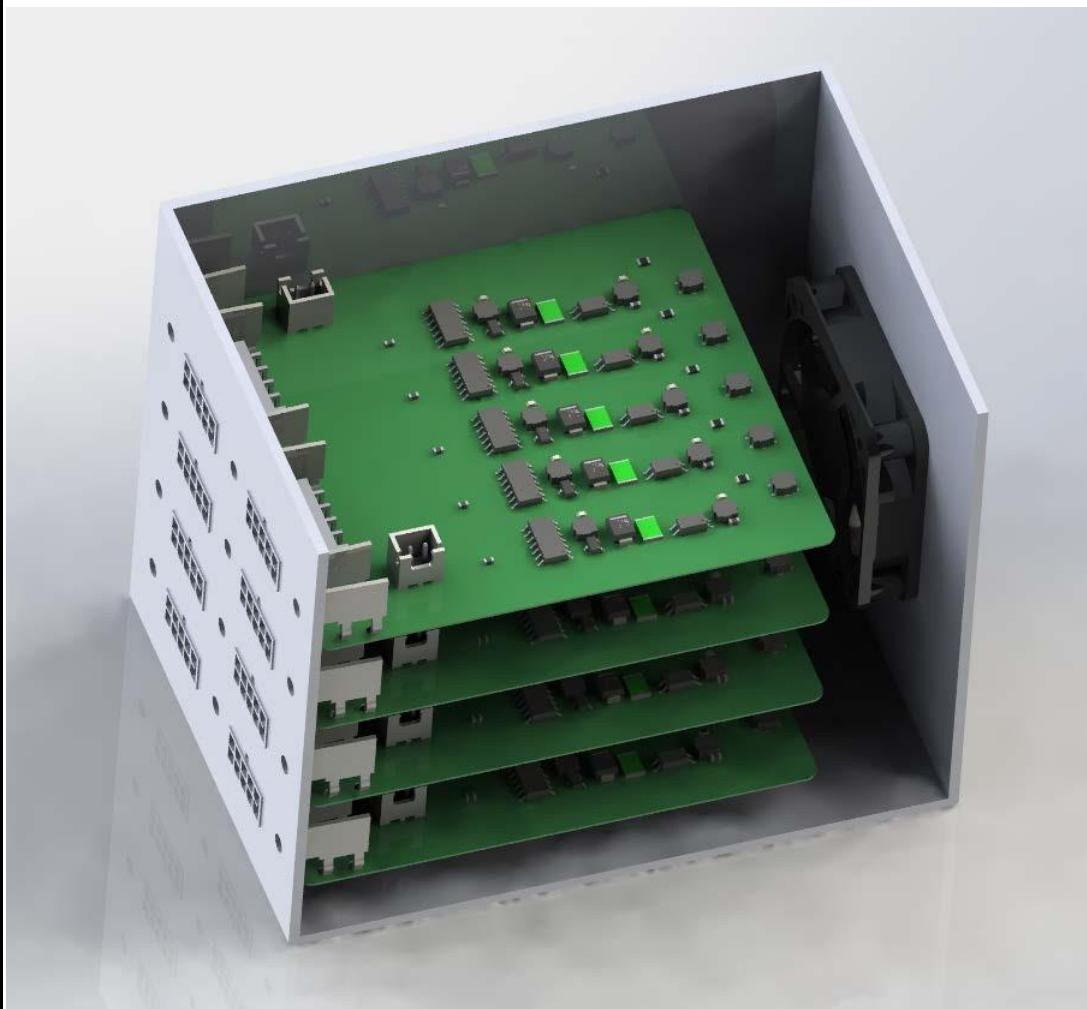
2. Controller Circuit

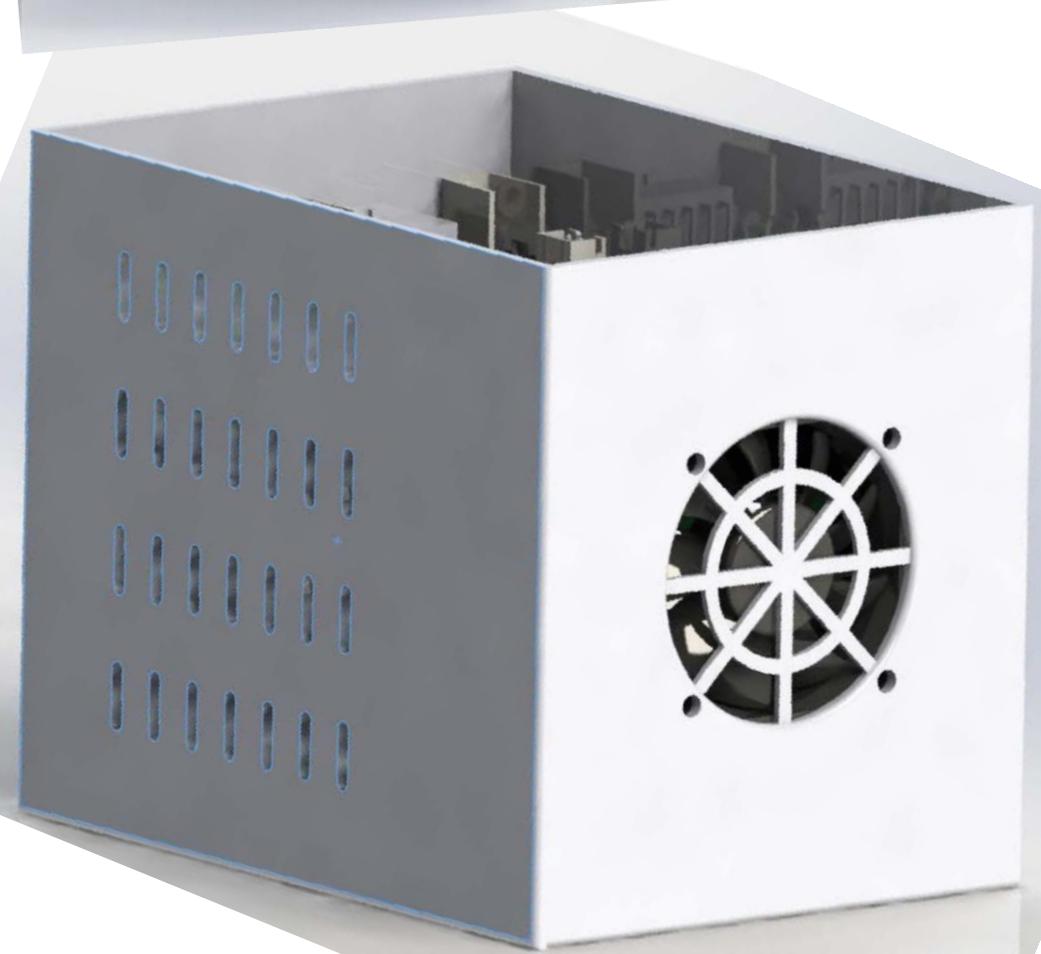
The controller circuit acts as the brain of the system. All the battery modules are connected to the controller circuit. We have chosen ESP32 - 12E as our microcontroller.

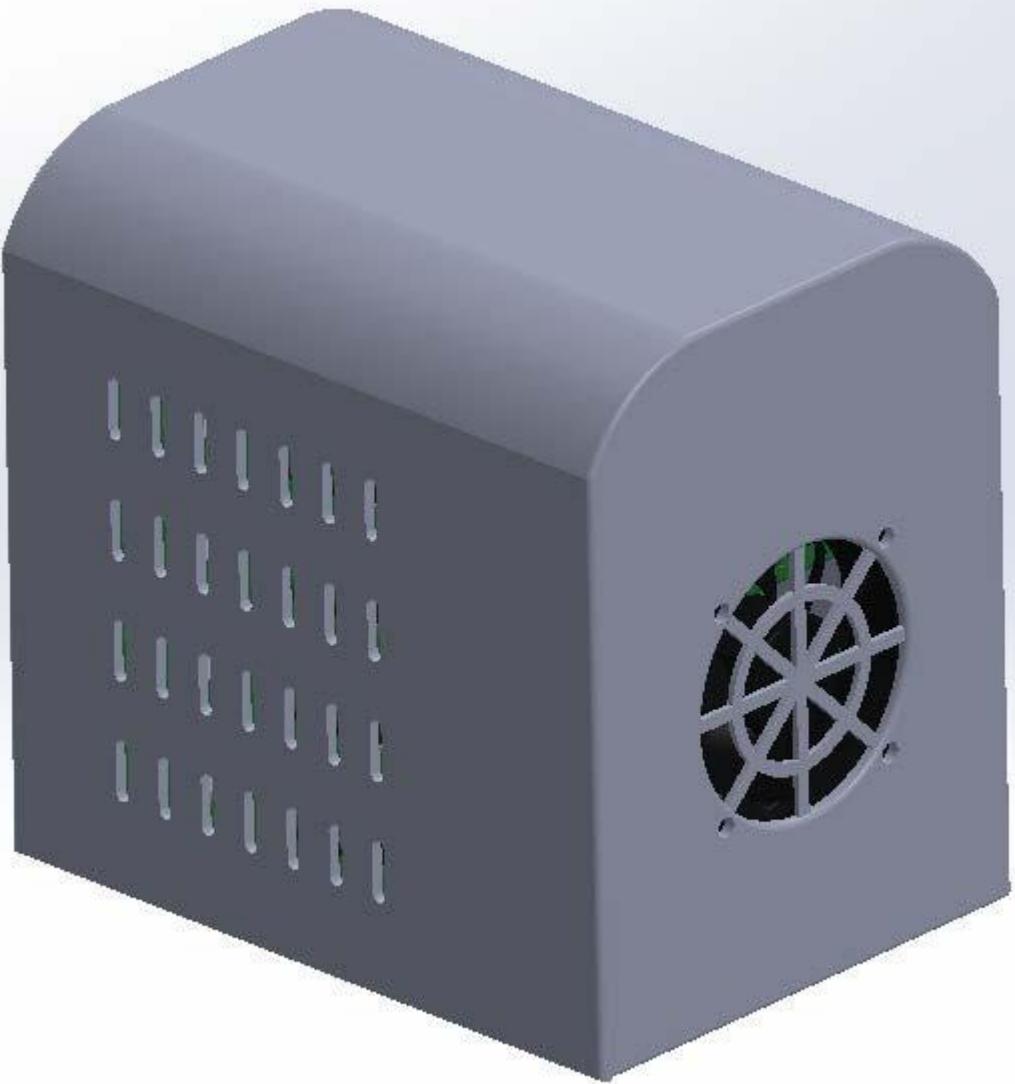
SolidWorks

Design

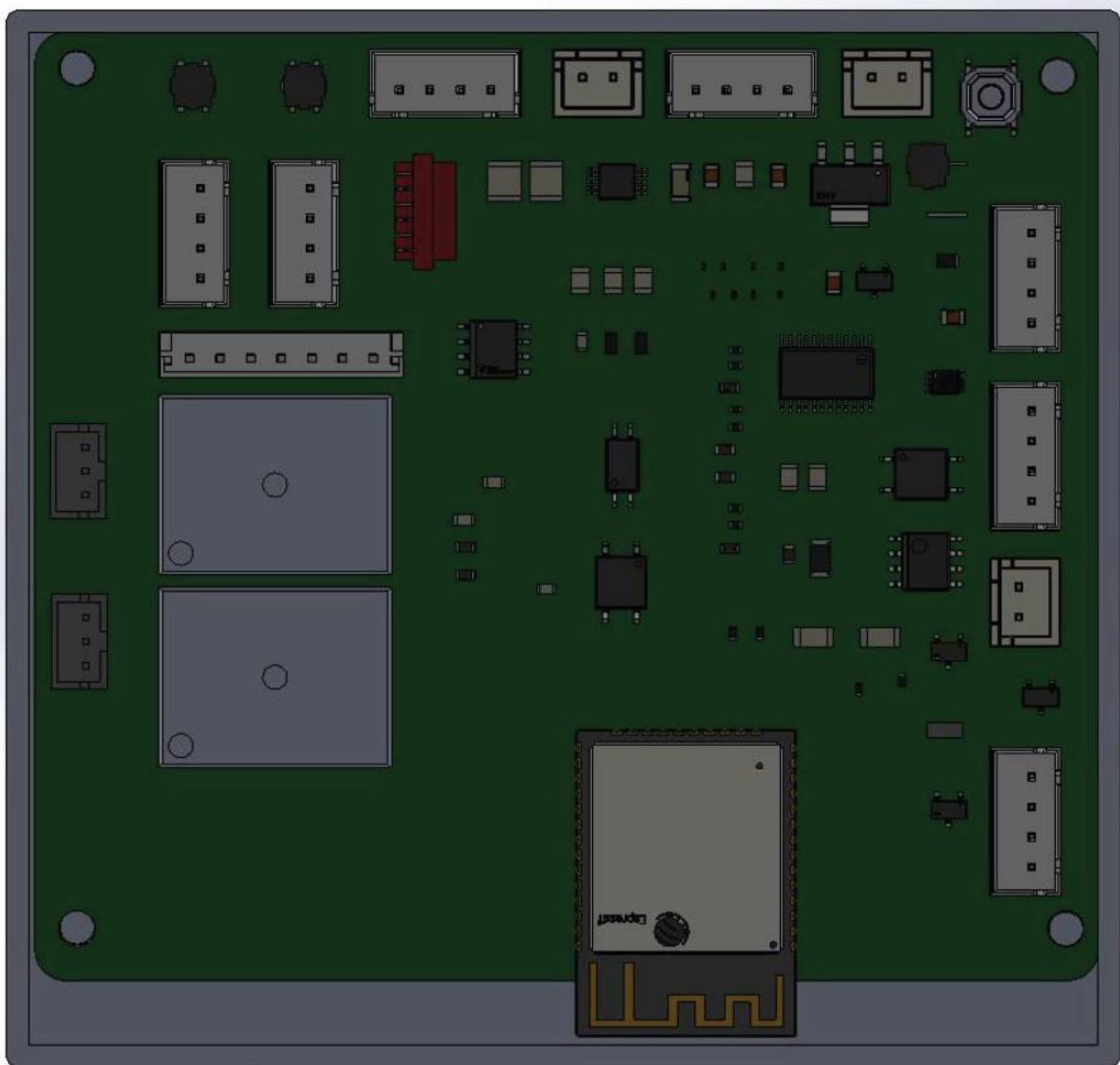
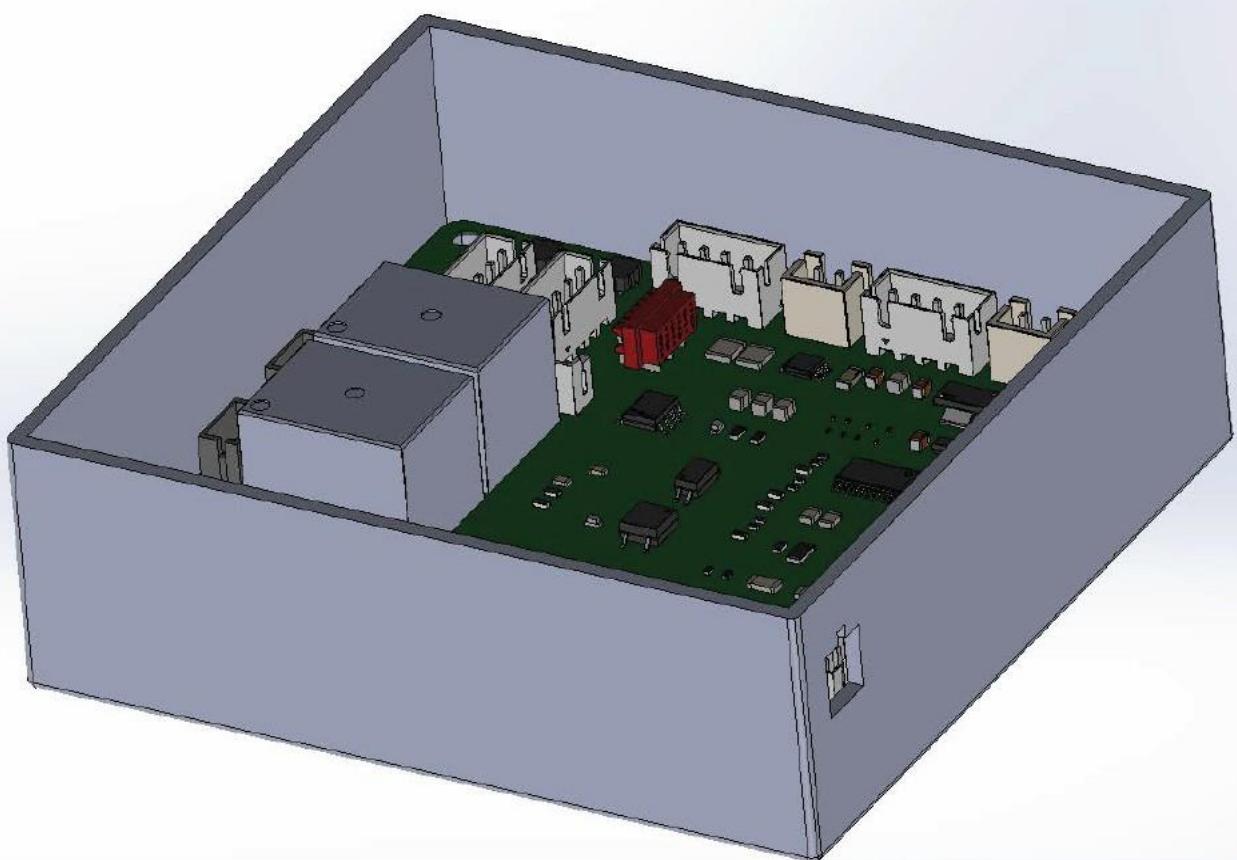
Battery Module

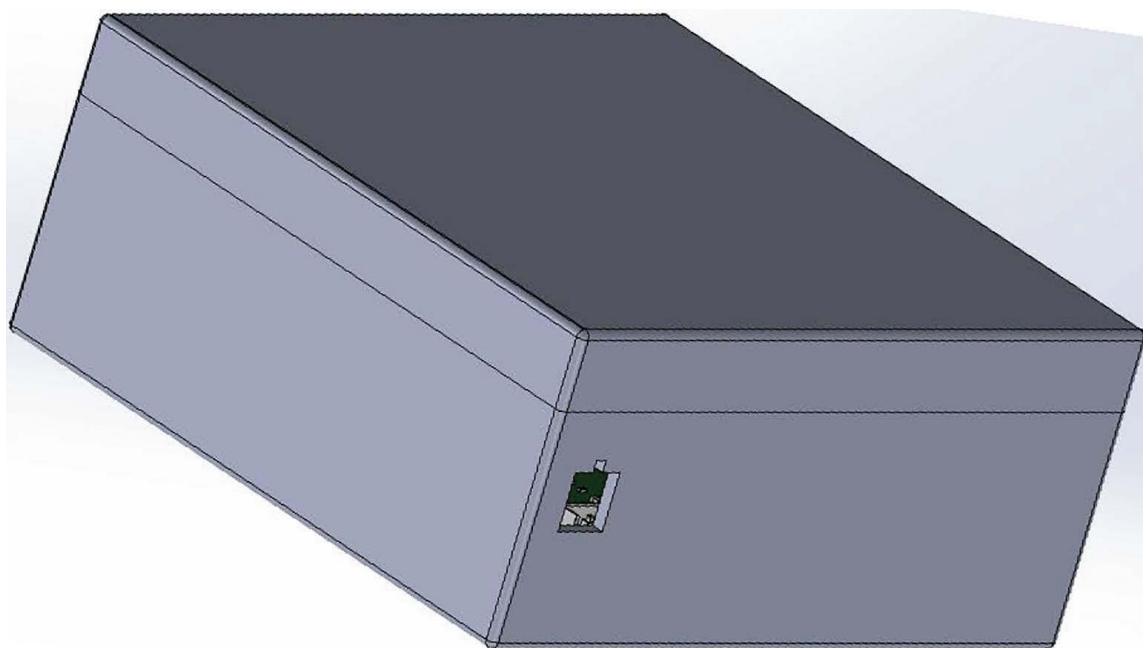






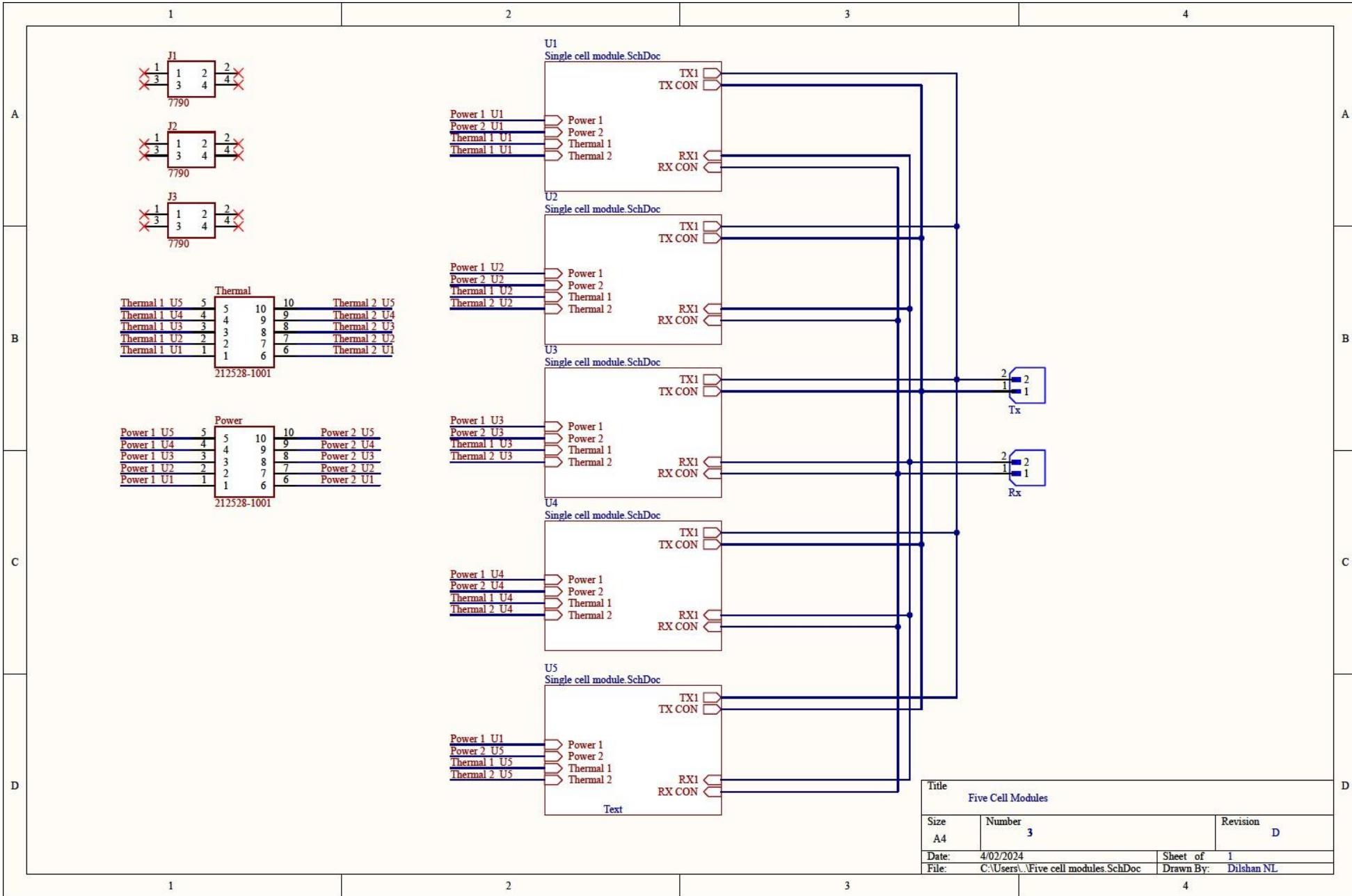
Controller Circuit

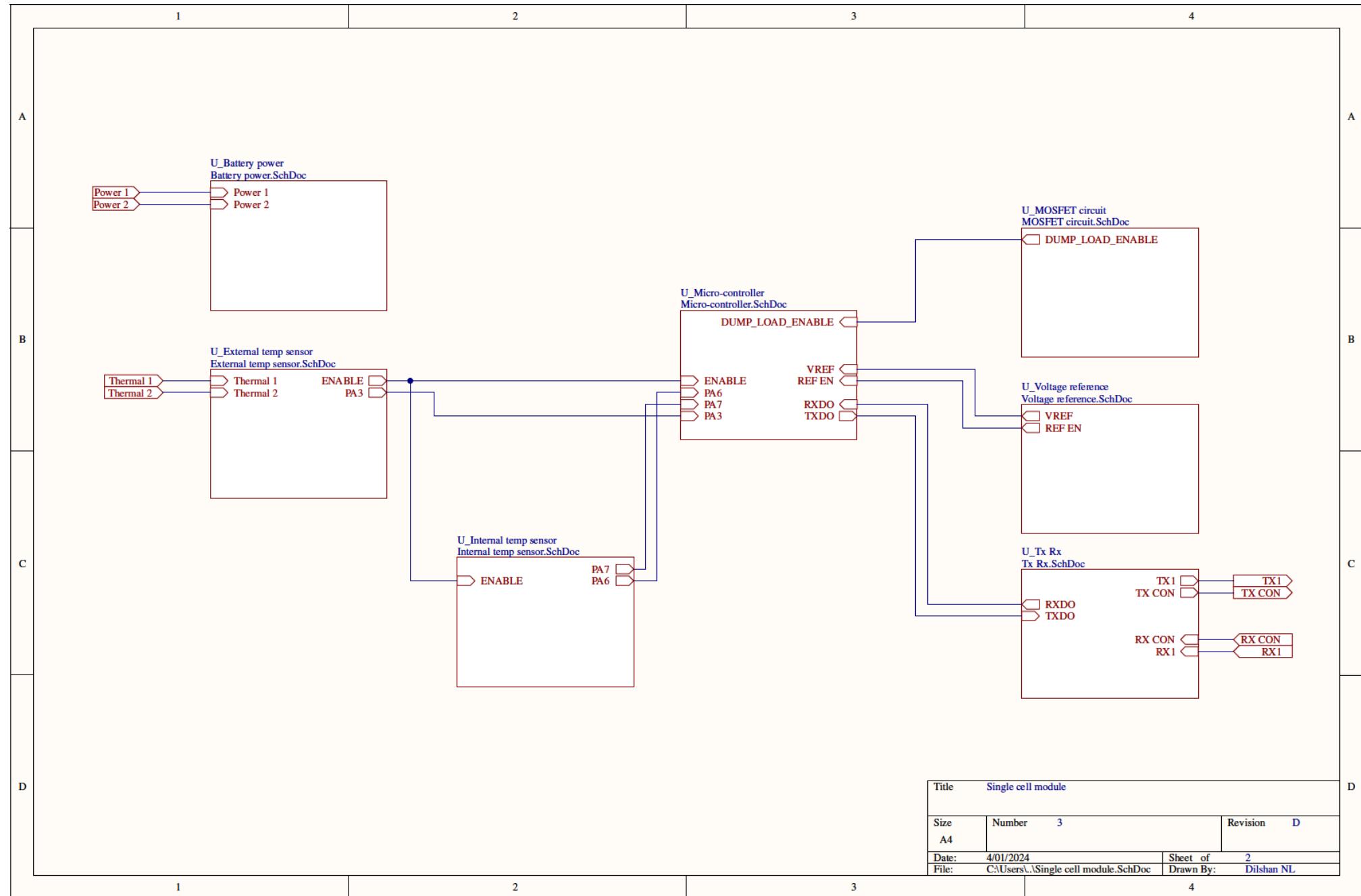




Final Schematics

1. Battery Module



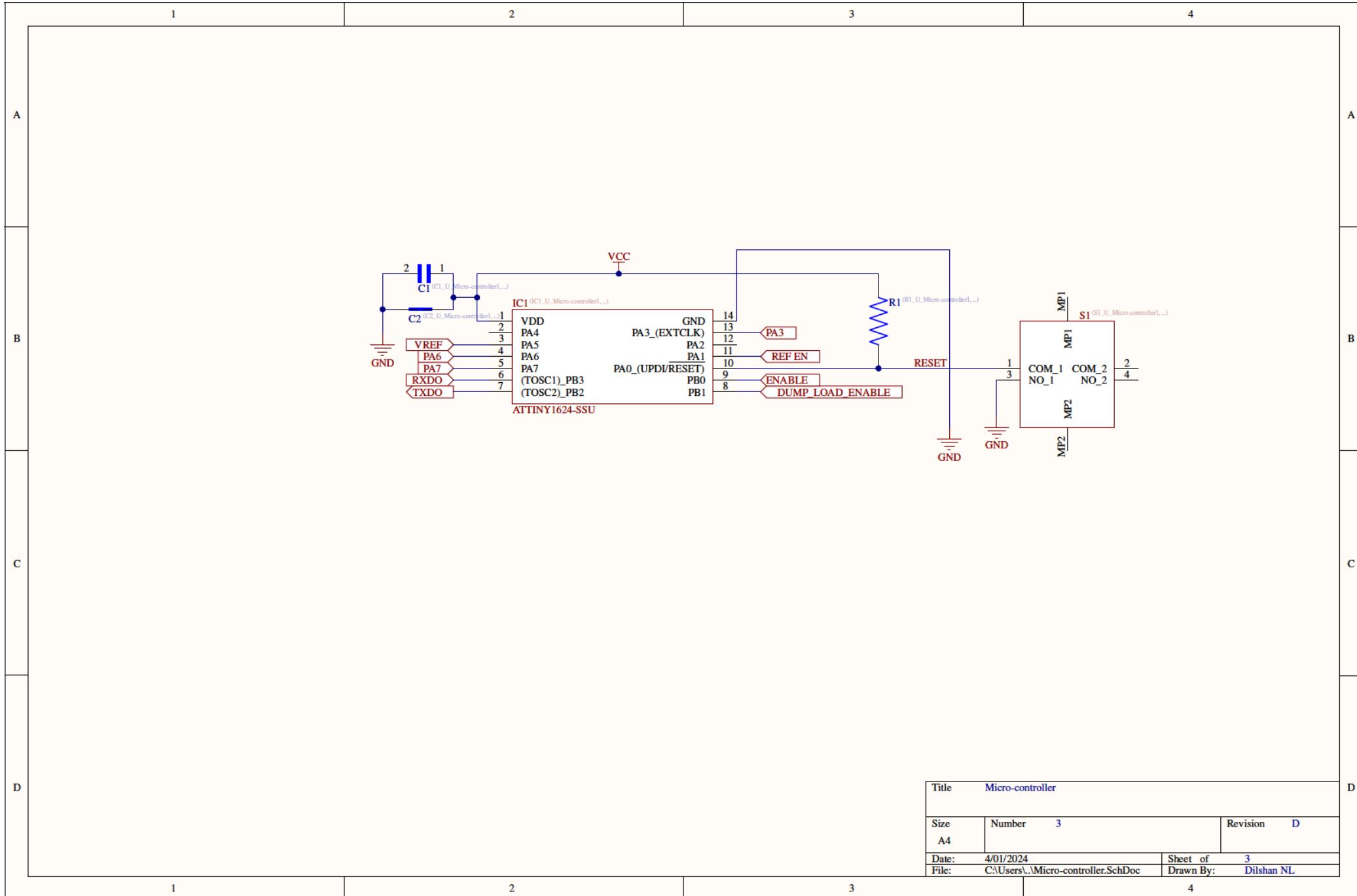


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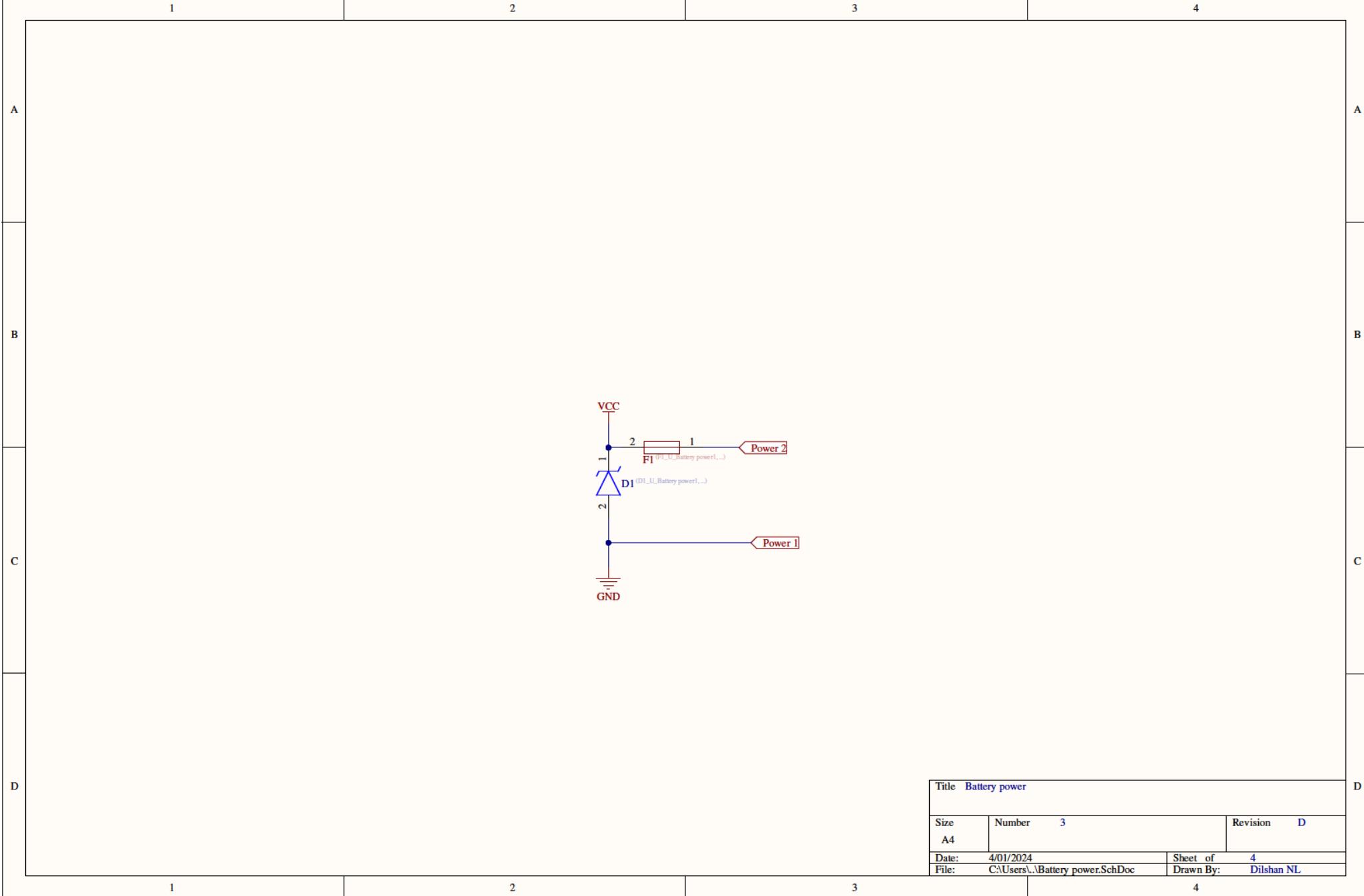
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A

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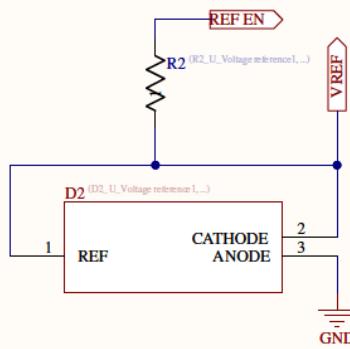
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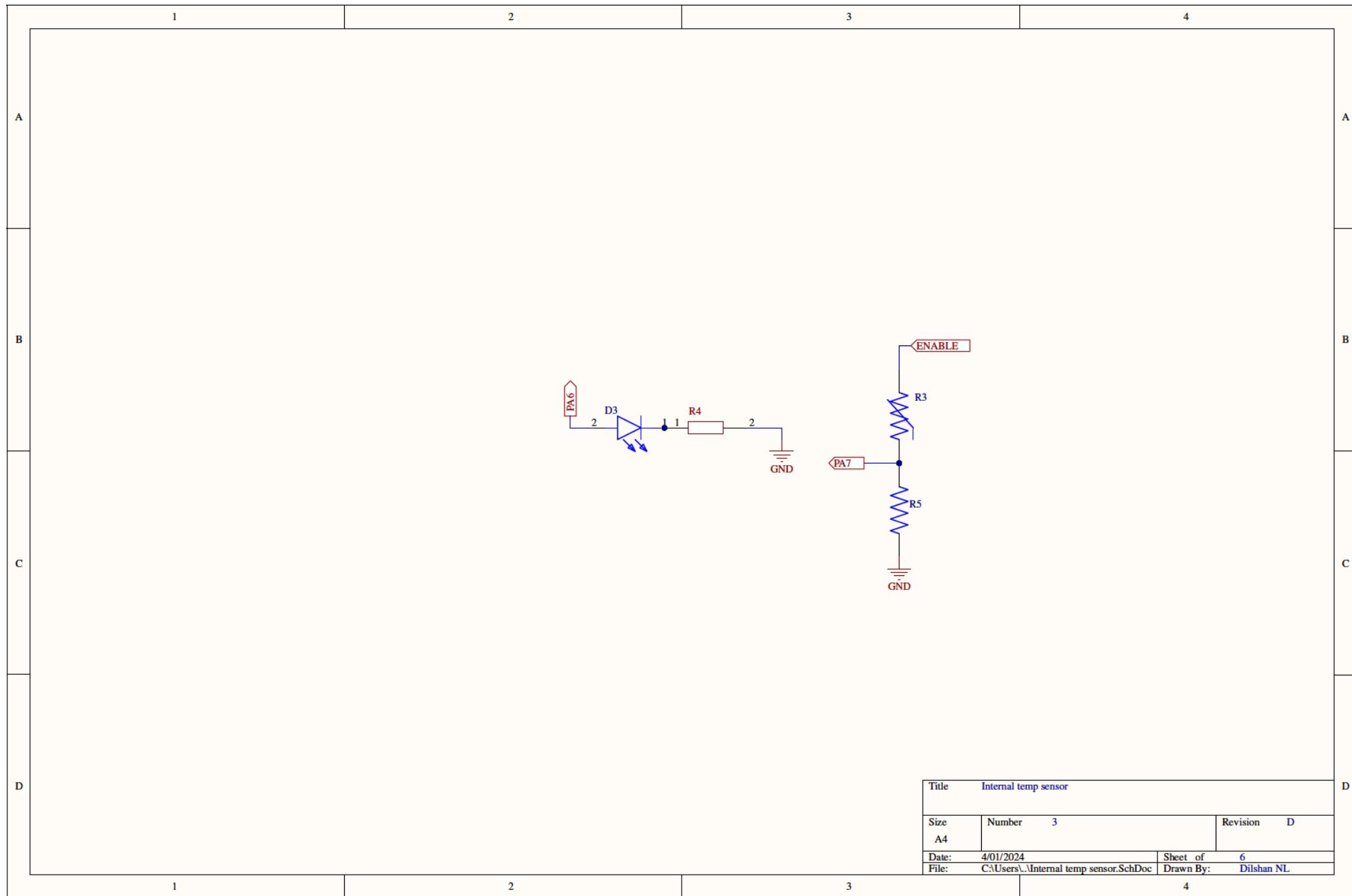
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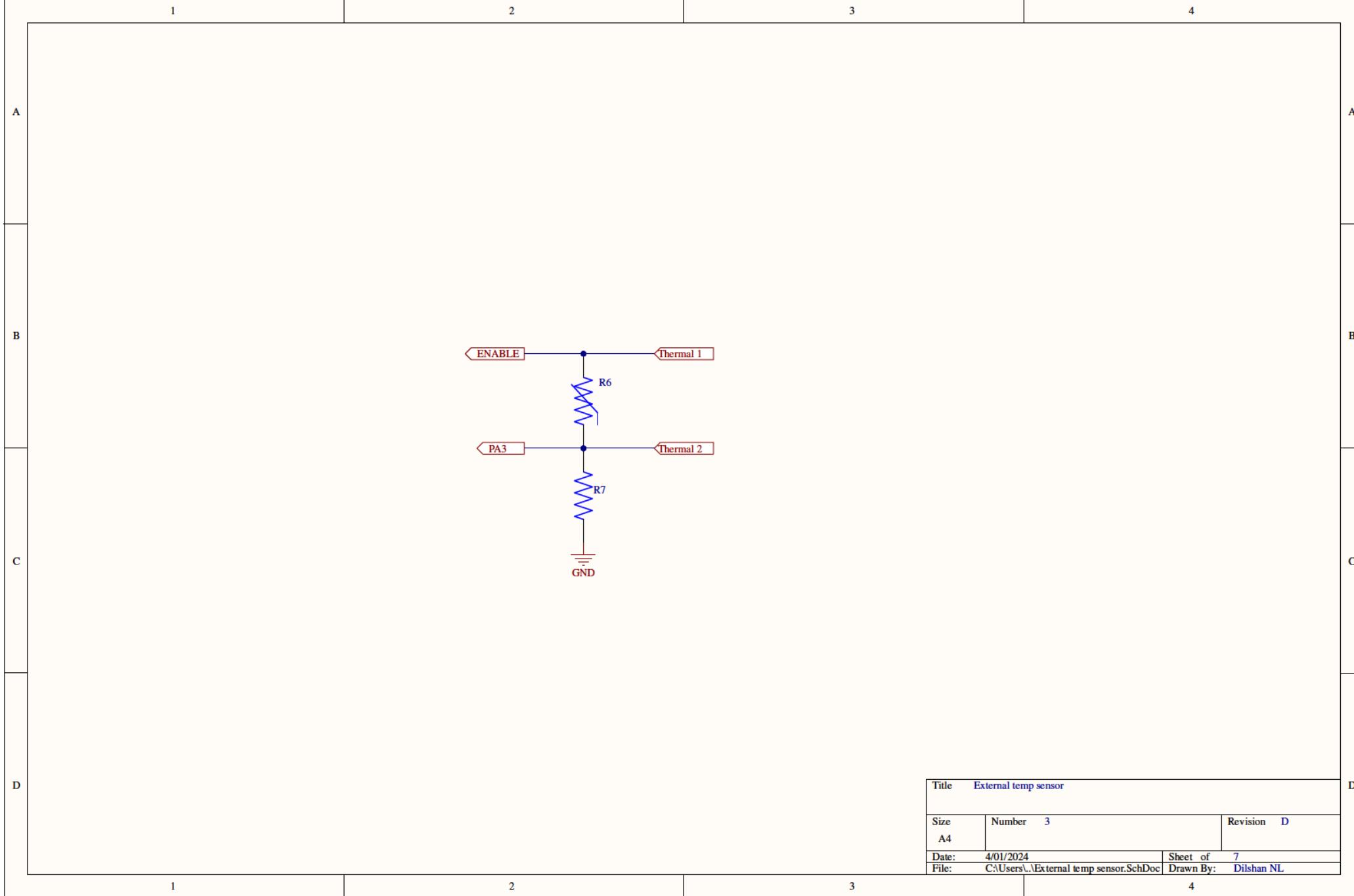


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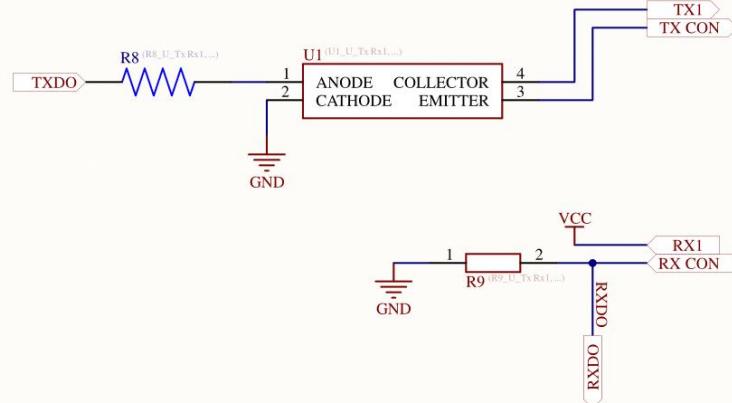
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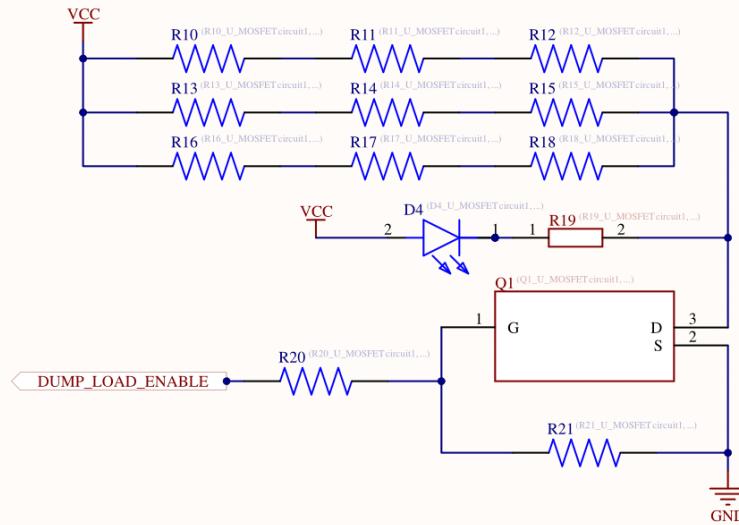
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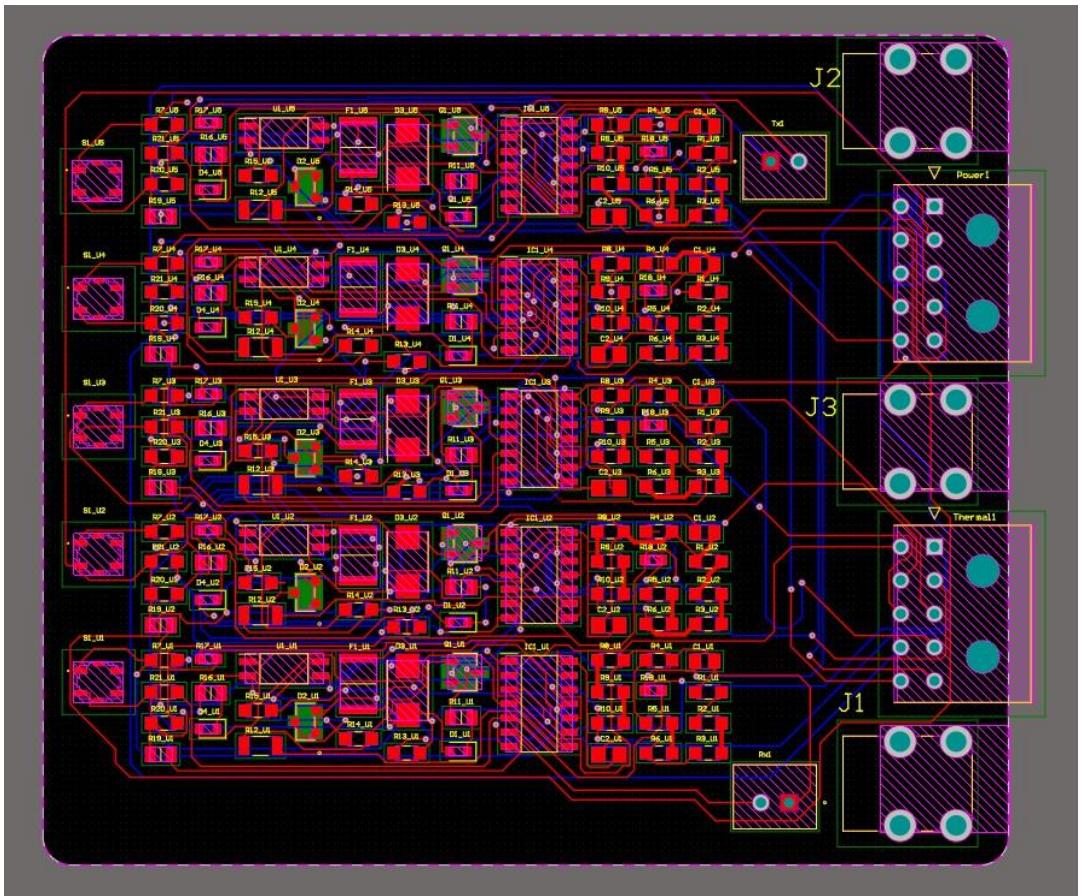
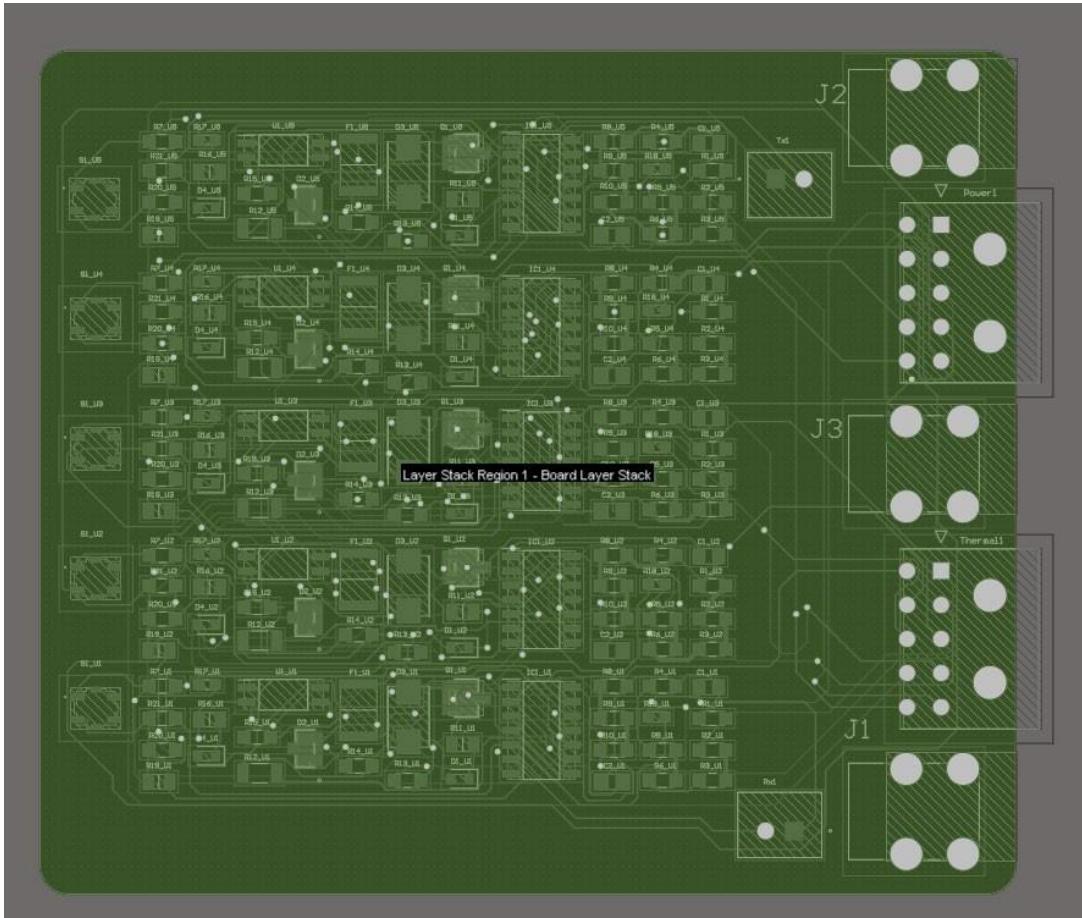
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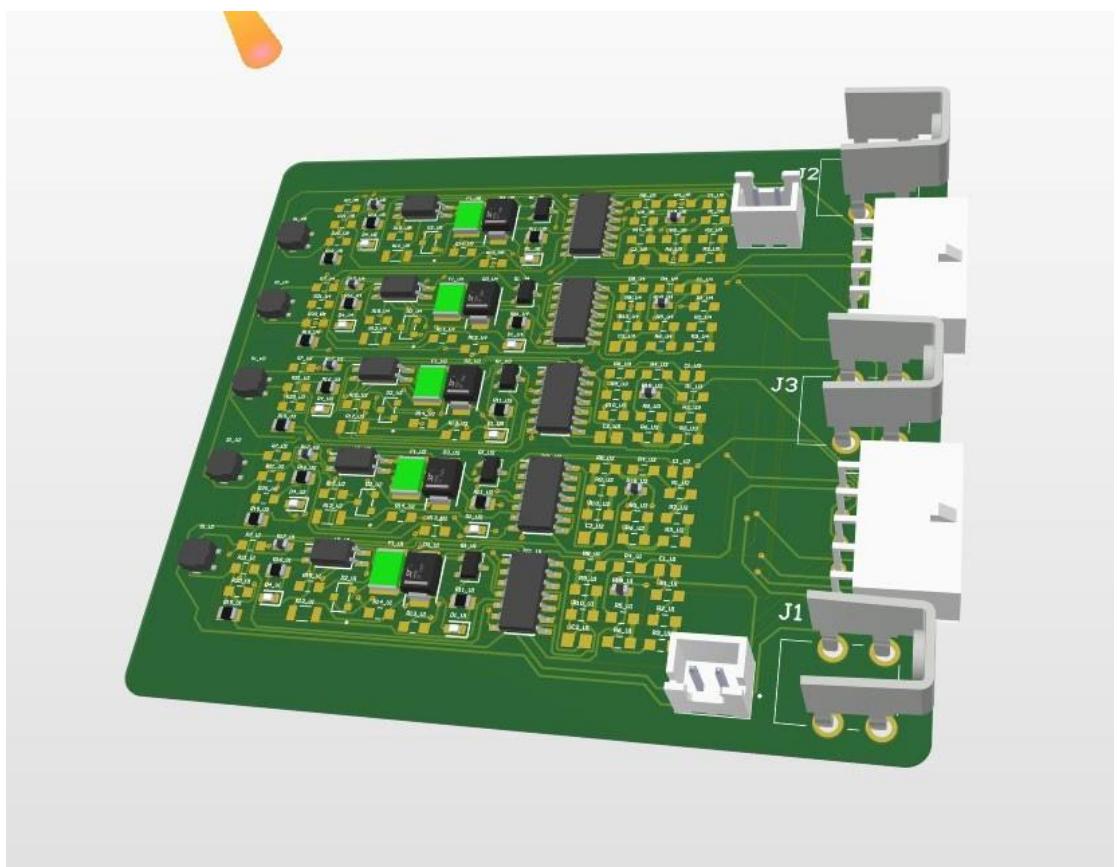
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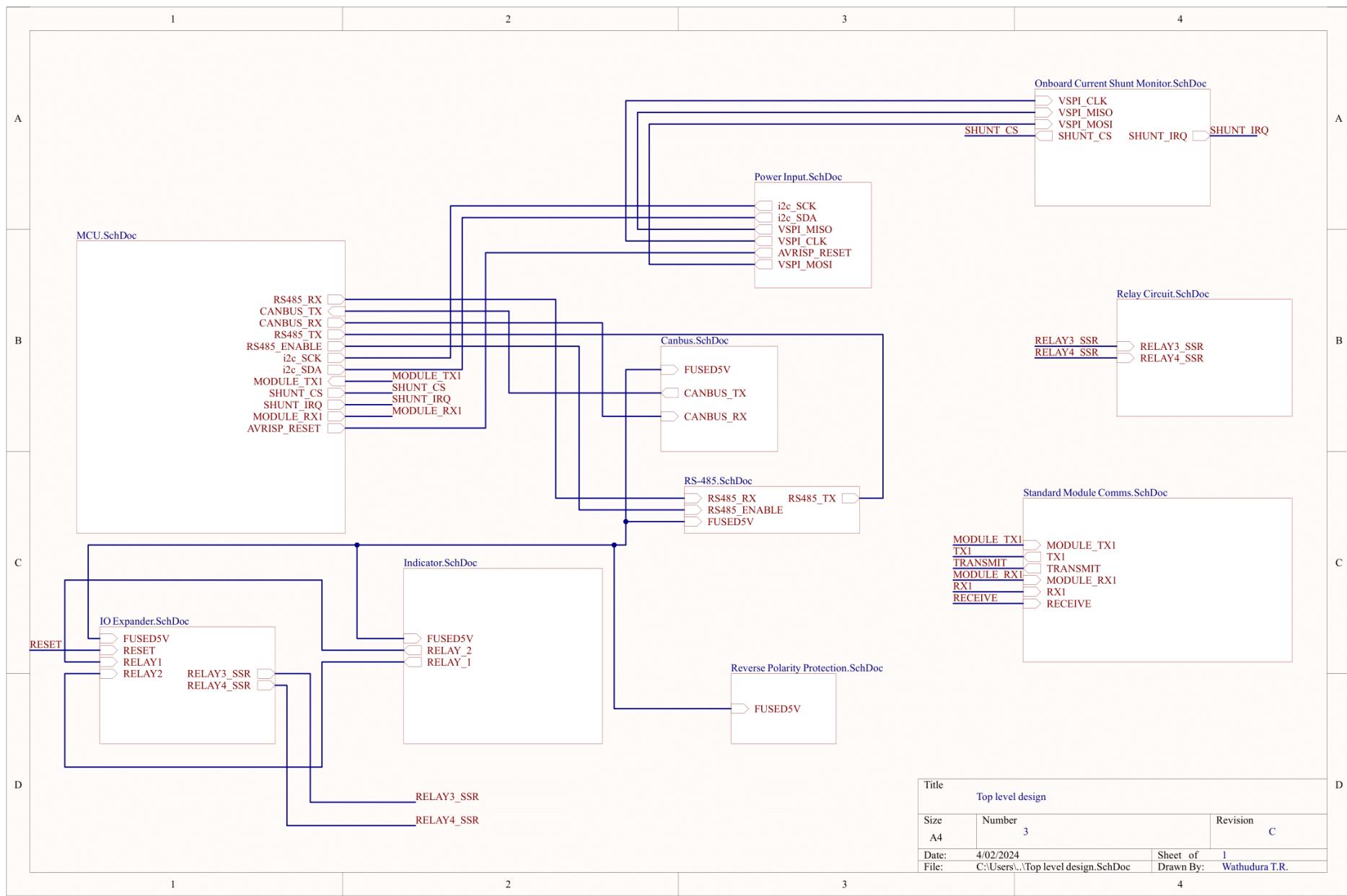
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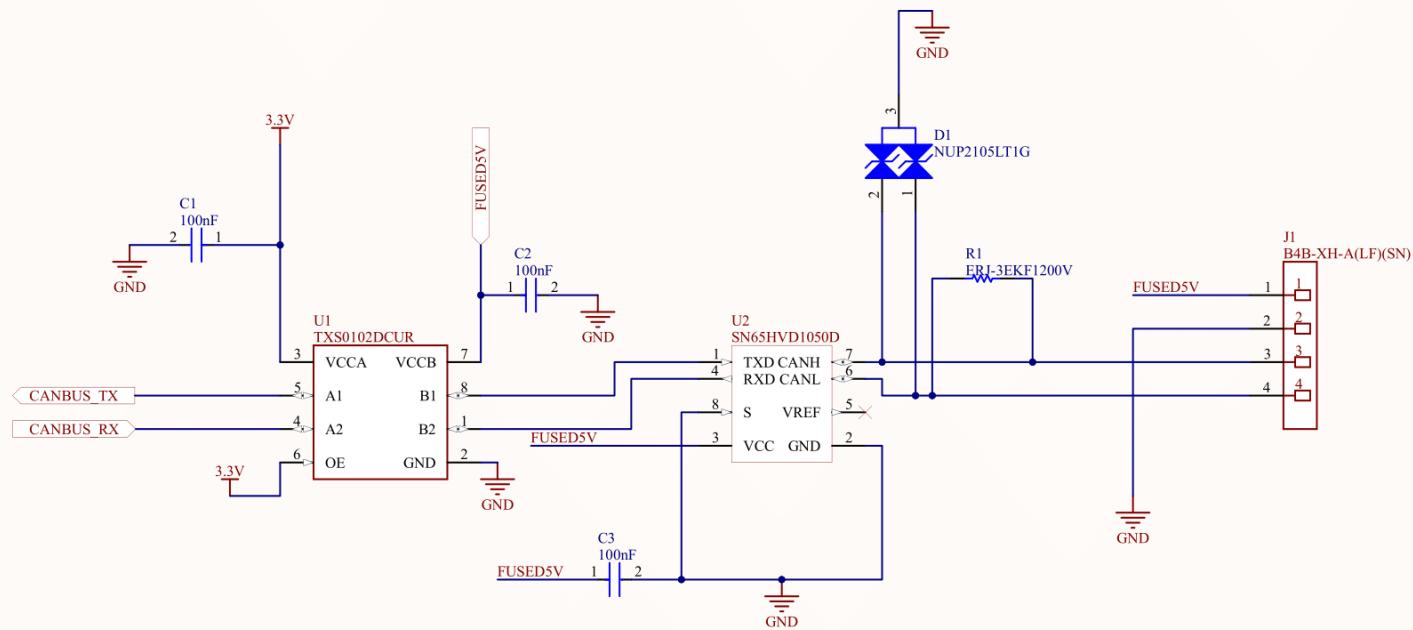
PCB Design





2. Controller Circuit





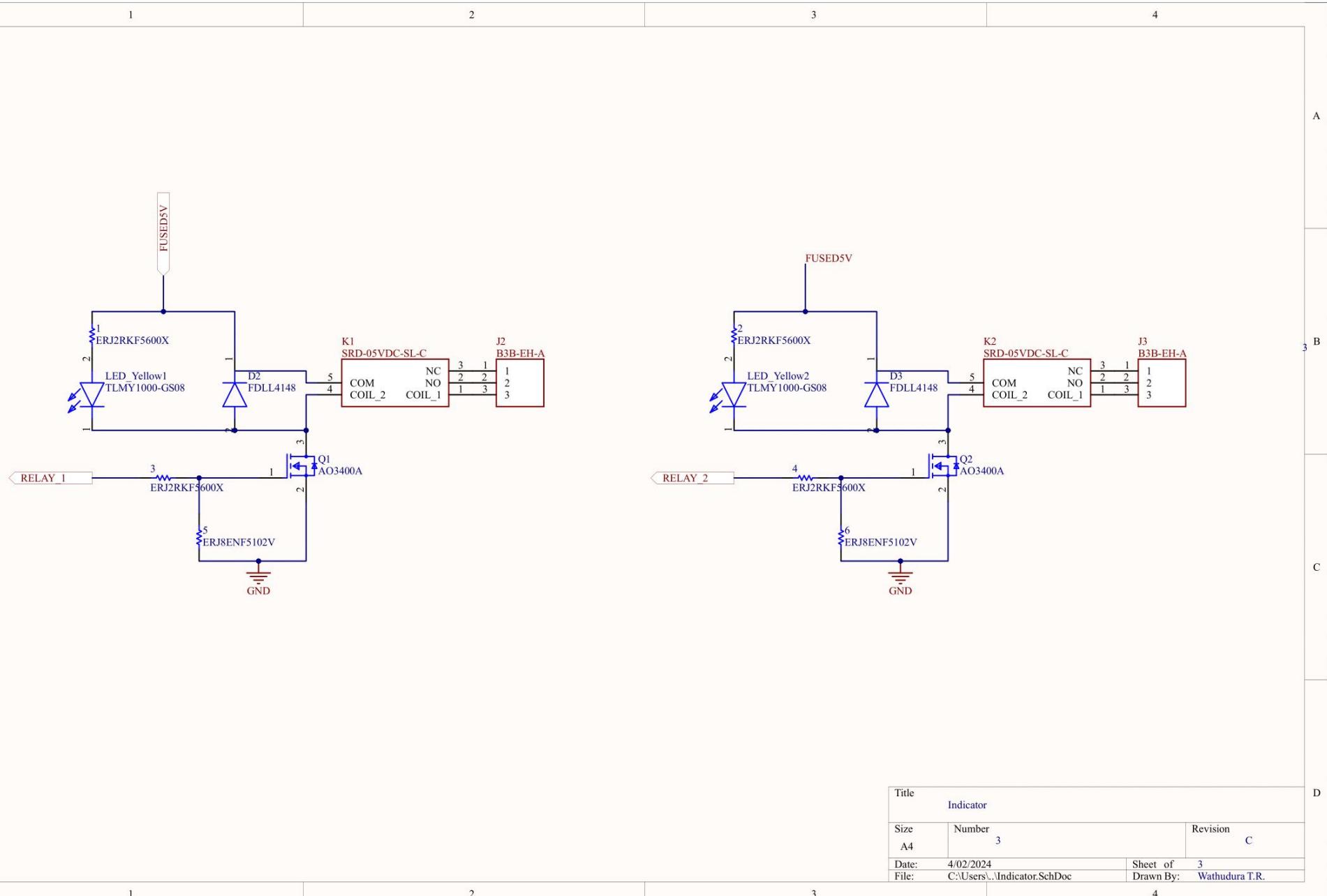
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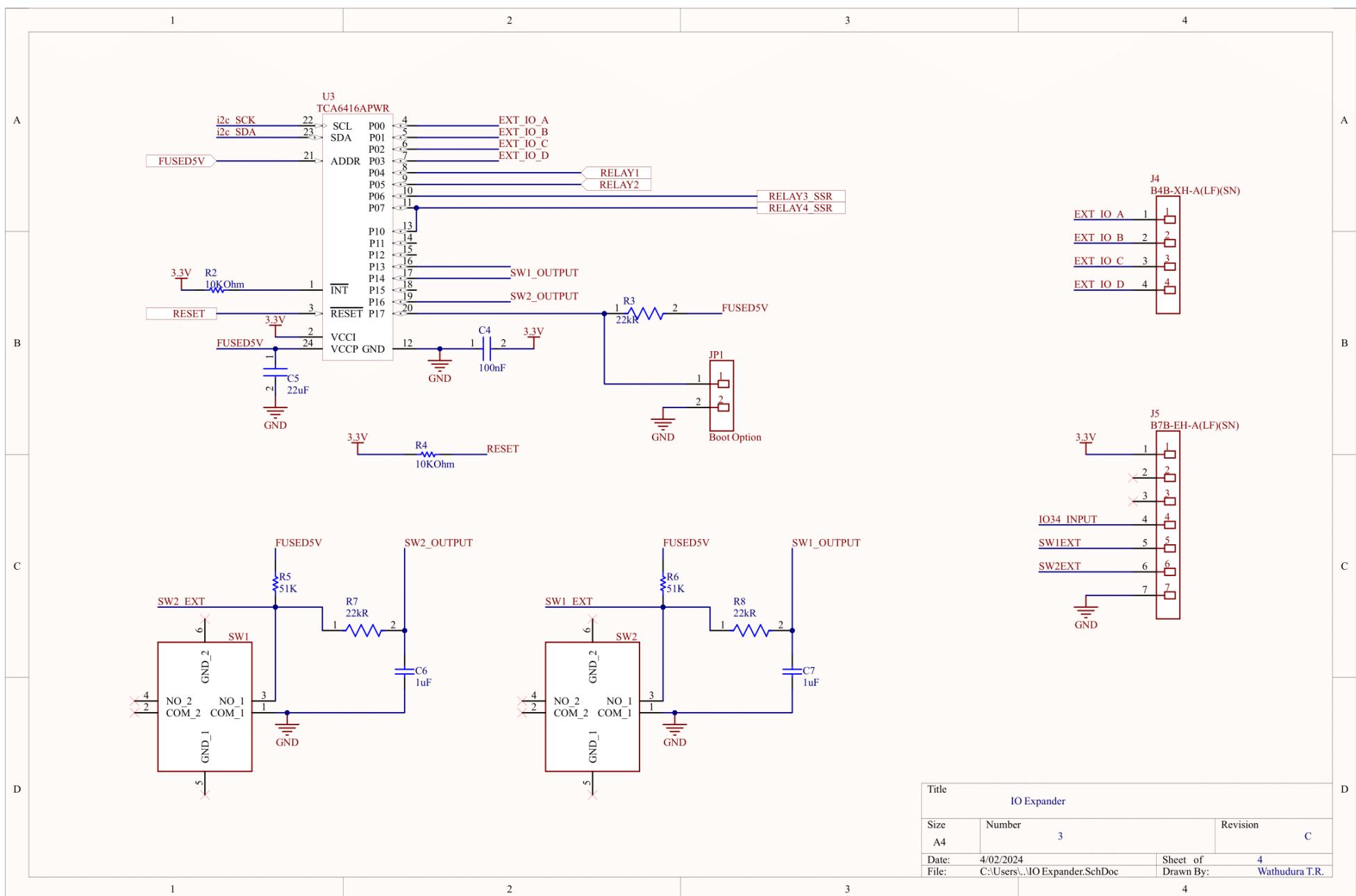
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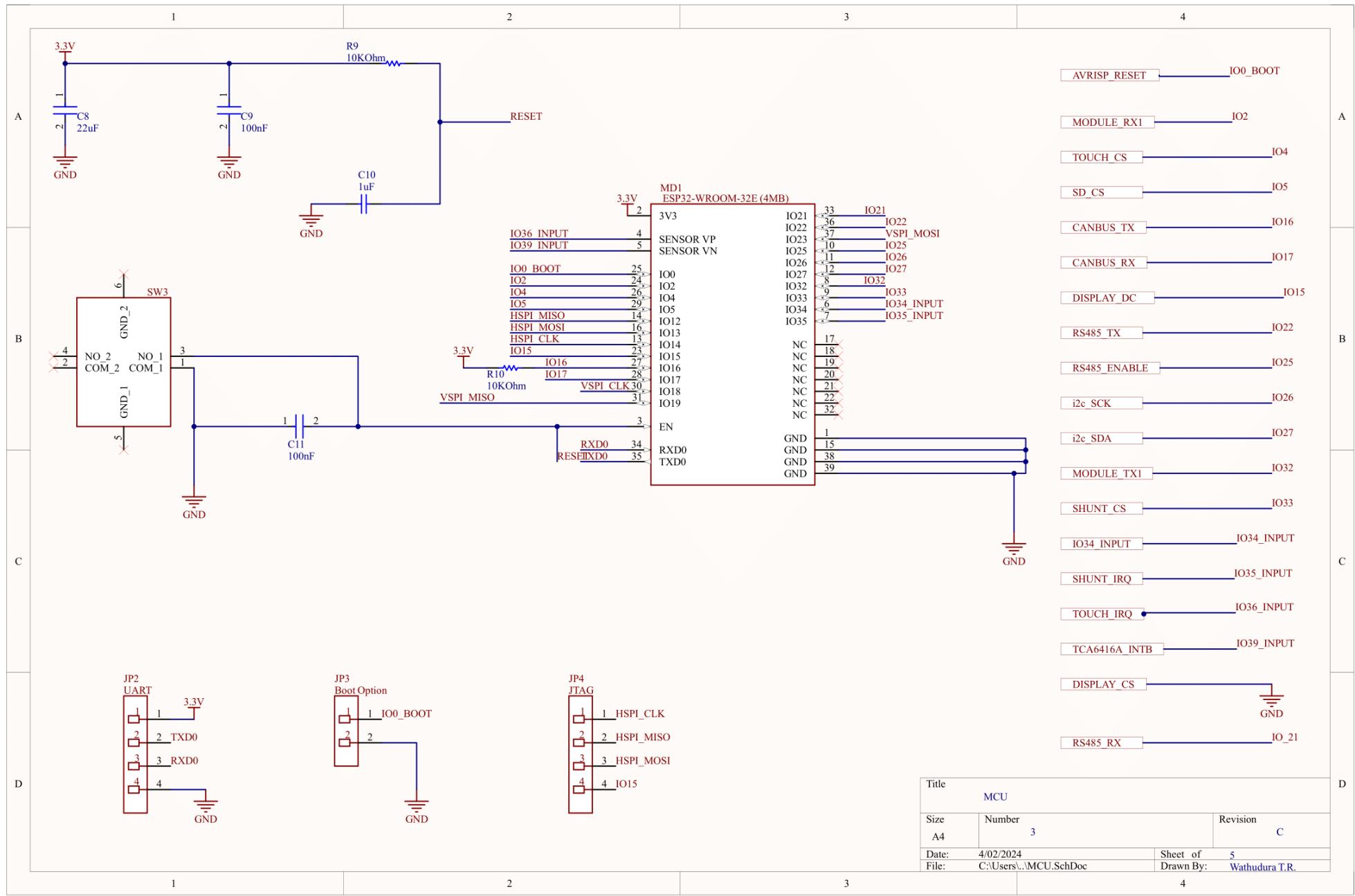
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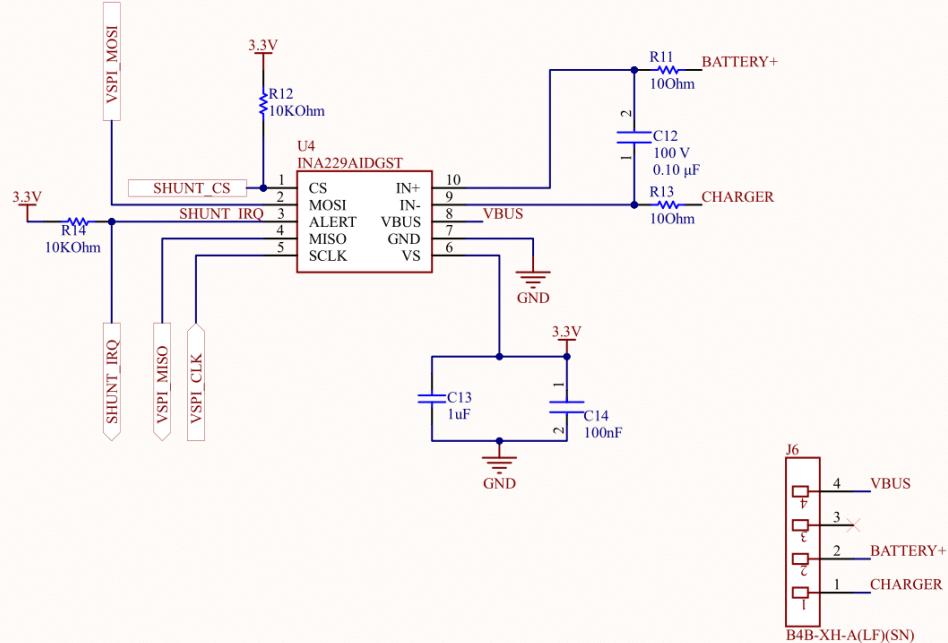
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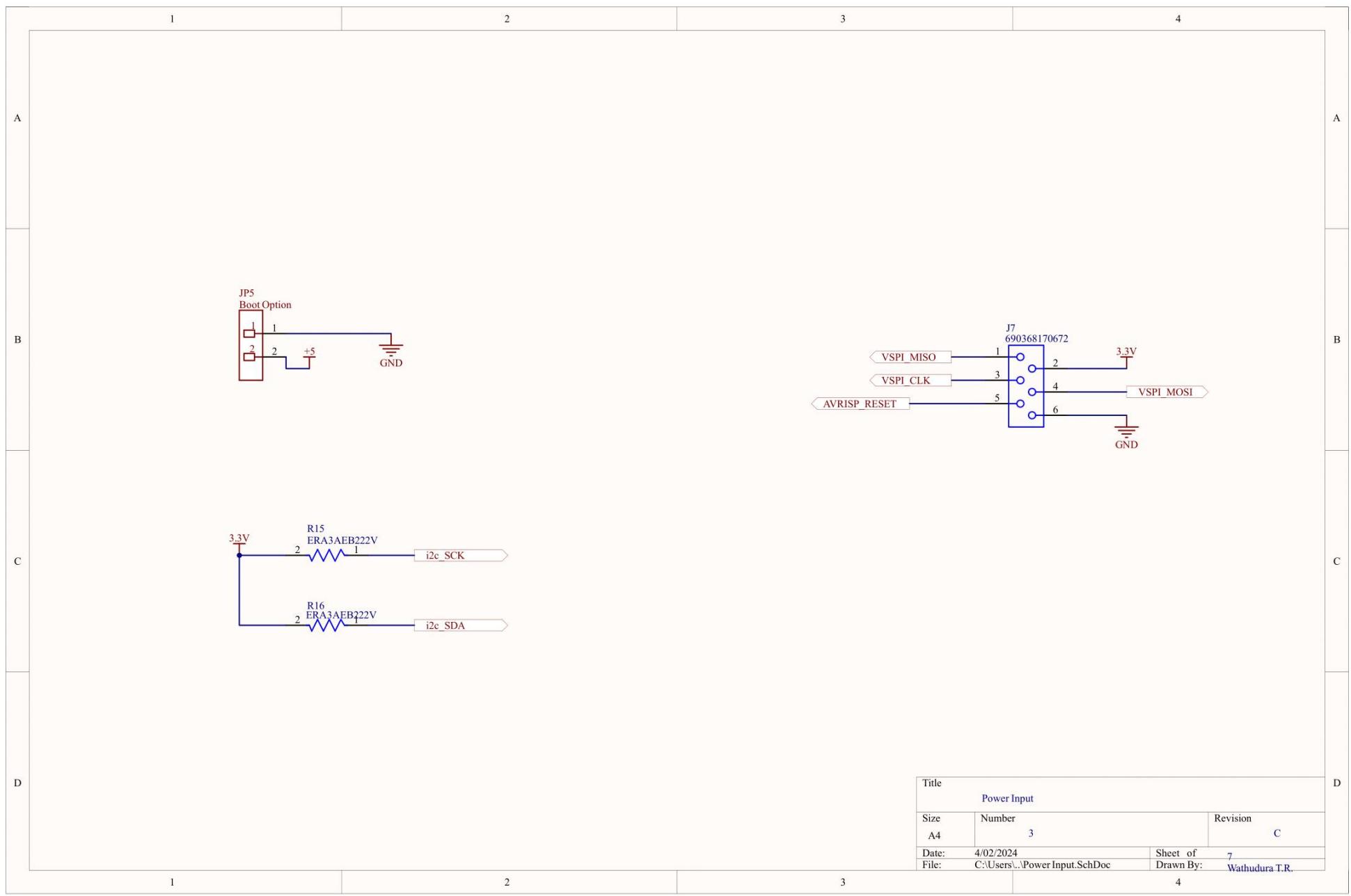
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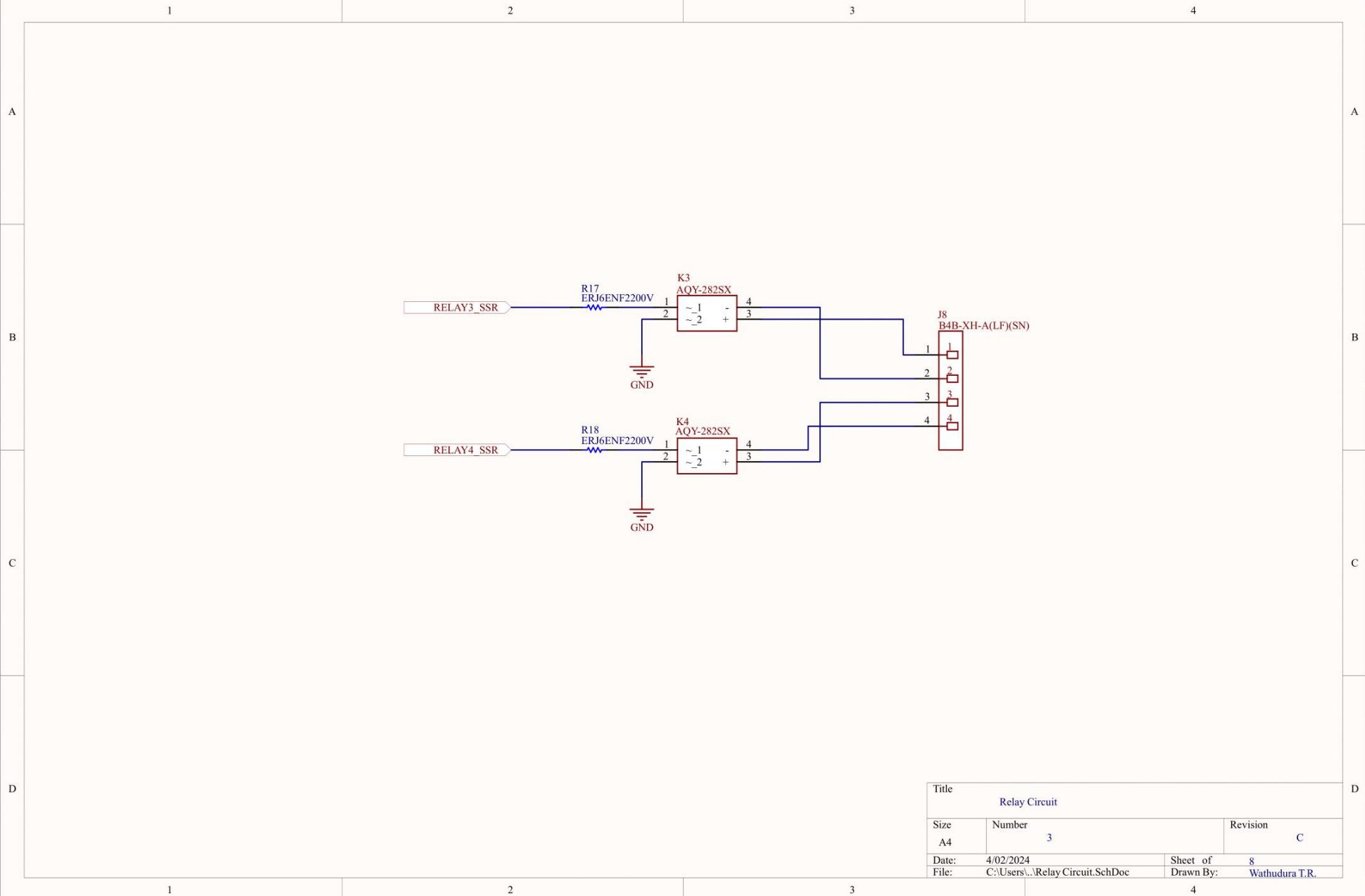


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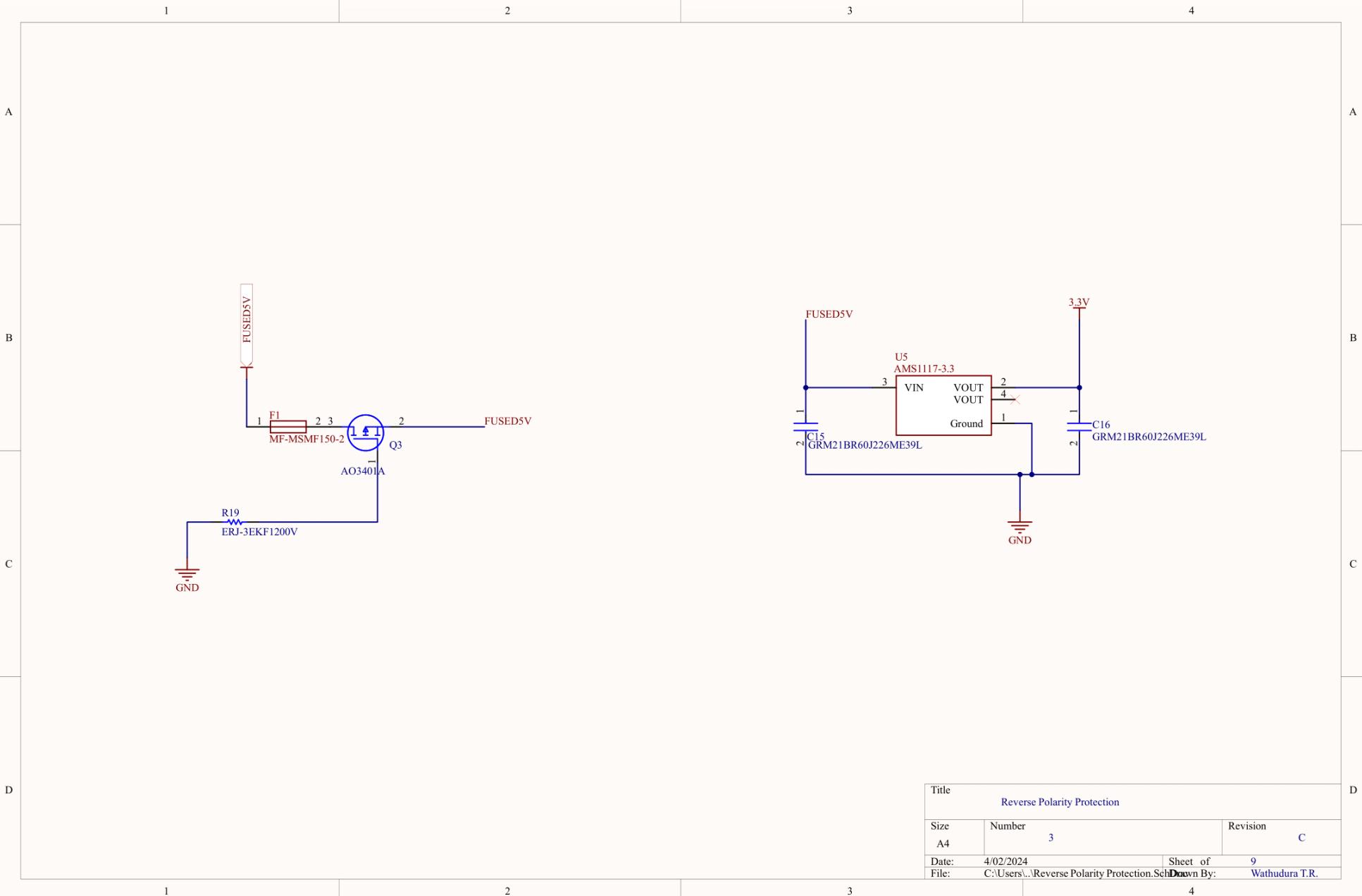
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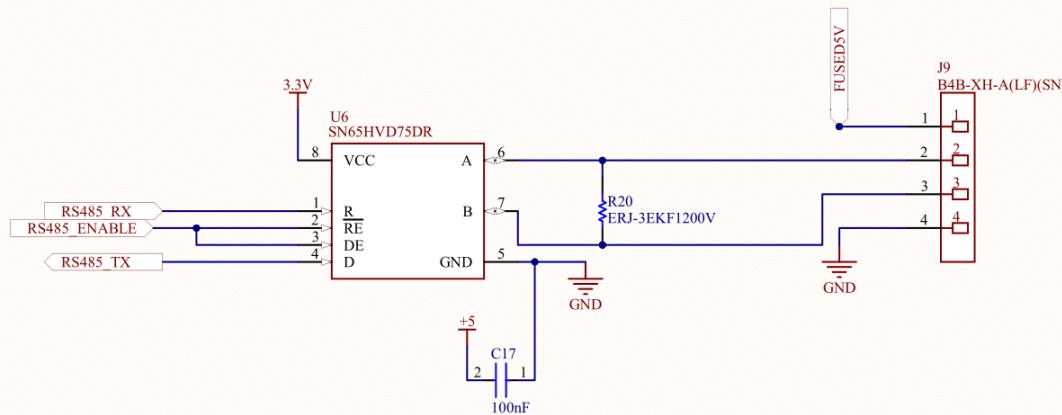
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