EN2160 Electronic Design Realization

Design Stages

Module:	EN2160
Group:	Battery Profiler
Index Numbers:	210027C, 210236P, 210253N, 210272V
Date:	2024.06.23

Contents

1 Introduction

This report covers the design process with regard to the battery profiler designed in fulfillment of the Electronic Design Realization module. This documentation covers the design process, stakeholder identification, user observation, requirement analysis, review and conceptual designs.

2 Brief Product Summary

The selected project is that of a battery profiler. This device is capable of charging and discharging a battery and plotting the charge curves and discharge curves which would be extremely useful in assessing the functionality and suitability of the battery. This device would be used in industries in order to obtain the suitability of a battery. Obtaining the characteristic performance of a battery is not just important for battery manufacturing companies but also for companies manufacturing any product with a battery. The battery is a crucial part of any product and hence, gauging its performance is vital. The device is designed to have the following capabilities:

- Constant voltage test
- Constant current test
- Constant resistance test
- Constant power test
- Plotting charging curves
- Plotting discharge curves

3 Review Progress

As the first step in the project the progress had to be reviewed and next steps had to be planned. In order to do the, the following questions were answered:

- What have we got?
  In this, we considered the currently available resources. The main resource available can be considered as the theoretical knowledge of the team. As students we have a good theoretical knowledge in electronics and this would immensely contribute to the project's success.
  Another resource is the existing practical knowledge as well. Since we were part of a few other projects in previous semesters, the practical knowledge gained such as schematic and PCB design, enclosure design and microcontroller programming can be considered as practical knowledge and experience. Additionally, since testing is an important part of the process since we have tested products as part of previous projects, this too would contribute towards the successes of the project.

- What are we missing?
  Here, we considered the resources that are required for the project's success but are currently unavailable. One such resource is the extensive knowledge in batteries, their

discharging curves and safety precautions that need to be maintained while using batteries. This is extremely important as it is vital for the safety of the users.
We also lacked expressed opinions from potential buyers. Opinions could include whether they would be willing to purchase the product, the price they are willing to pay and the expected needs

- What resources are available?
  The main resource available is the human resource. As a team of 4 passionate, knowledgable and hard-working individuals, the human resources we possess would be extremely important and handy.
  Another resource is the financial resource. Since the cost of the project would be split between four members, financially the project is feasible
  The available lab facilities are also a major resource. Since the university has modern lab facilities with professional equipment, these facilities would be extremely useful in testing the product and troubleshooting it.

- What are the deadlines?
  The main deadline is the submission date of the project as decided by our professor. We are confident that this deadline could be met, especially since we are given two week's vacation during the semester.
  Other deadlines would include finishing the project, obtaining certification and marketing it before other competitors do in order to gain a first mover advantage. These deadlines cannot be decided accurately and we are certain that meeting the first deadline would be sufficient.

- What are the risks?
  The main risk we face is the possible lack of expertise. Since we have not designed such a device before, there is a chance that the device might not function as expected. As part of this risk, the safety of the product also needs to be considered.
  Another risk is the potential lack of user acceptance and sales. Since the target market of the product is industries, there is a possibility that the product would not be purchased as they would likely rely on existing suppliers with well-established brand names.
  The availability of required components, the possibility of importing them to the country and the higher costs of purchasing such components is also a risk we face.

- What should we do next?
  The main step we would need to take next is to identify stakeholders. We would need to prioritize them based on their role as stated in section 4. Next, observation of users is crucial. Observing them is crucial in order to get an unbiased and accurate view of them as explained in section 5. We would also need to develop concepts, finalize the design and review the progress made and adjust the goals based on the review. After finalizing the design, the PCB and enclosure would need to be manufactured, components would need to be purchased and the design tested and implemented.

4 Identification of stakeholders

The project we are undertaking involves a multifaceted ecosystem of stakeholders, each playing a crucial role in the success and sustainability of the endeavor. At the forefront of our stakeholders are the executives and officials representing companies that manufacture products integrated with battery technology. Their involvement is pivotal as they provide insights into market demands, technological advancements, and consumer preferences shaping the trajectory of our product.

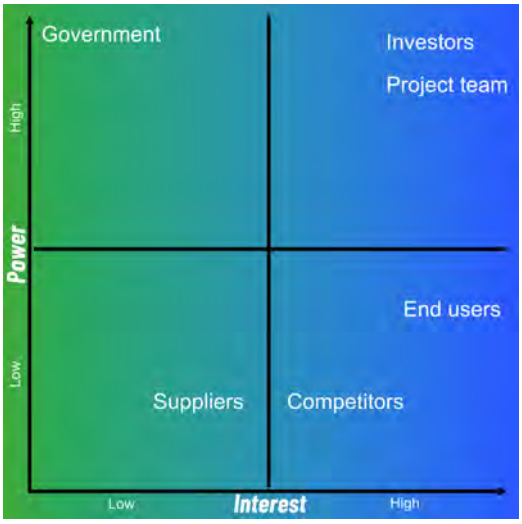
Furthermore, battery manufacturers stand as key stakeholders due to their integral role in the testing and development phases of our product. Their expertise and feedback are indispensable in ensuring the efficiency, safety, and reliability of the battery components integrated into our offering.

Beyond industry players, government agencies emerge as significant stakeholders, tasked with regulating and overseeing the safety, environmental impact, and compliance standards associated with products utilizing battery technology. Their involvement not only ensures adherence to legal frameworks but also fosters a conducive environment for innovation and market growth.

In addition to industry and regulatory bodies, competitors form a vital part of our stakeholder landscape. Their presence sparks healthy competition, driving continuous improvement and innovation within the market. Recognizing their concerns and responses to our product is essential in strategizing and positioning our offering effectively.

Moreover, our project necessitates collaboration with a diverse array of suppliers providing various components and raw materials essential for product manufacturing. These suppliers are stakeholders whose timely delivery, quality assurance, and cost-effectiveness directly impact our product's success and competitiveness in the market.

Stakeholders with high power and high interest are the key players involved in this project. Those with high power and low interest are the ones that need to be kept satisfied. Those with low power and high interest would need to be kept informed and those with low power and low interest would require minimal effort.



5 Observe Users

Observation of users is vital as interviewing them would not be as effective since most users usually have poor awareness of their own habits and may not be perfectly honest during an interview. Therefore, in order to observe users, we found the following videos online.
The following video is about how such battery profilers are currently being used in the Electric Vehicle industry in order to test batteries.
▶Lithium Battery Testing Plugin India Electric Vehicles

There are already existing products similar to ours being currently used in industry. One such product is the **Keysight E36731A**. This product is being used in various industries to test batteries before selling them to the eternal market. This was used to get an idea about the current users and the functionality of the existing solution in order to obtain a baseline for our design and what user requirements it should satisfy. The following video shows the functionality of the Keysight E36731A:
▶Introducing Keysight's E36731A Battery Emulator and Profiler

6 Need List

After careful reviews, identification of stakeholders and observation of users, the following list was compiled as needs that need to be satisfied by our product. The need list is mainly divided into two as user requirements and functional requirements.
The user requirements are the requirements that users expect the product would satisfy. The following requirements were identified as user requirements:

- Reliability: The product should produce results that are reliable and dependable
- Preventative maintenance: The product should be able to predict the lifetime of batteries and the number of charge cycles left
- Safety of the users while using the device: Since batteries are being tested, appropriate safety measures such as reverse current protection should be present.
- Accuracy of the results: There should be reasonable accuracy as industries would sell batteries to companies and hence the companies would ned to maintain customer satisfaction.
- Being relatively easy to obtain the results: Since it is a measurement device, obtaining results should be able to be done by mose people.
- Portability: Portability is an added benefit as batteries may be produced and tested in different places by the same manufacturer.

The functional requirements of the product are as follows. These are the tests that the device should be able to perform.

- Constant voltage test
- Constant current test
- Constant resistance test
- Constant power test
- Plotting charging curves
- Plotting discharge curves

7 Stimulation of Ideas

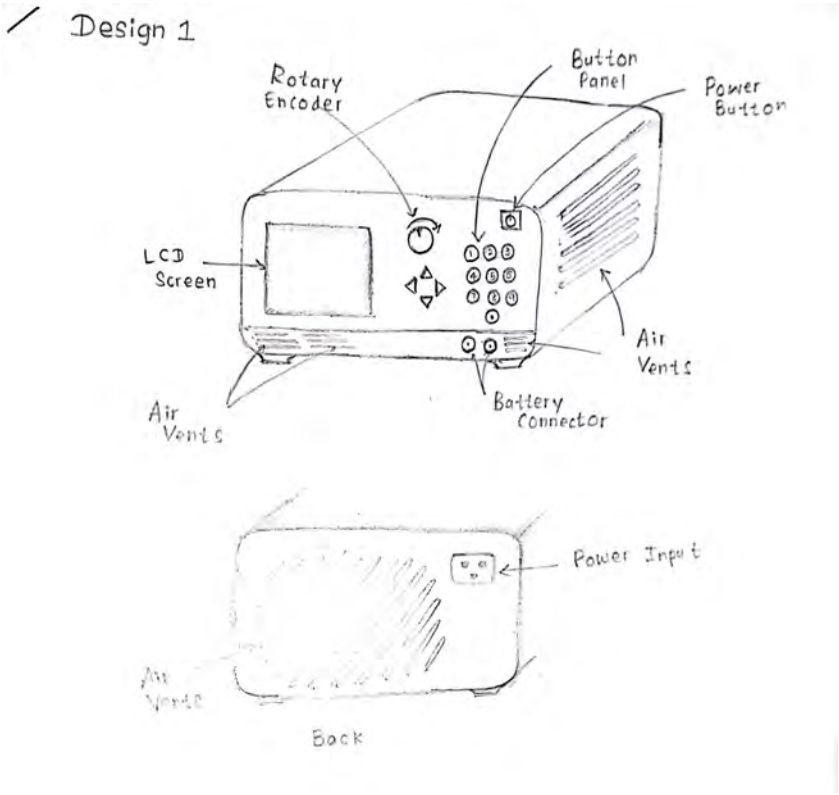
In this section, we consider the thought-provoking ideas we came up with as a group.

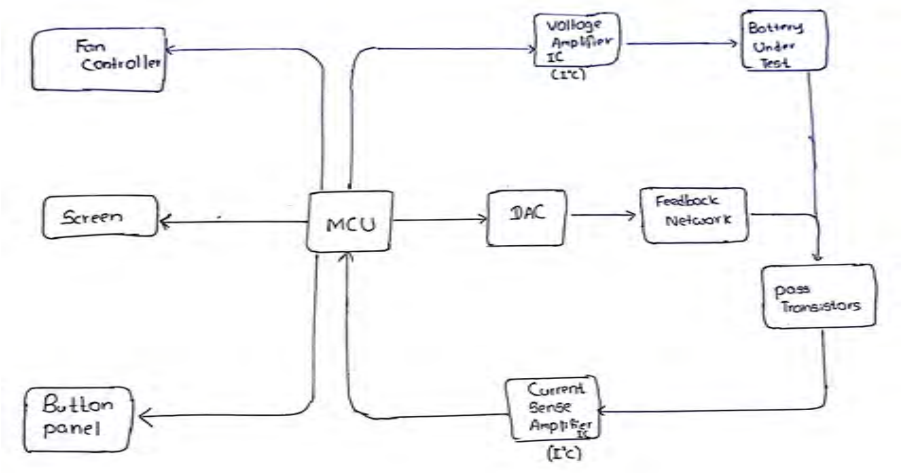
- Advanced data analytics: Although the product is a measurement device, it is possible to integrate machine learning in order to obtain advanced data analytics capabilities. This could be used for predictive analysis.
- IoT integration: Developing IoT integration would enable users to be able to view results on their mobile phones and computers remotely. Additionally, required setting for measurement also could be set up remotely.
- Intuitive interface: The interface is the only way users would interact with the product. This should be as user-friendly as possible. Additionally it should be informative and users should be able to easily obtain all required information through the interface with ease.
- Enhanced safety features: Safety of users should be a priority of the device and hence integrating enhanced safety features into the device is essential.
- Battery comparison tool: Integrating a tool that would be able to compare the performance characteristics of batteries would be an added feature as users would be able to decide on the appropriate battery with these results.
- Inclusion of user guides: It would be an added benefit if user guides on how the product needs to be used and features present are explained in videos and documented.

8 Conceptual Designs

8.1 Conceptual Design 1 and Block Diagram

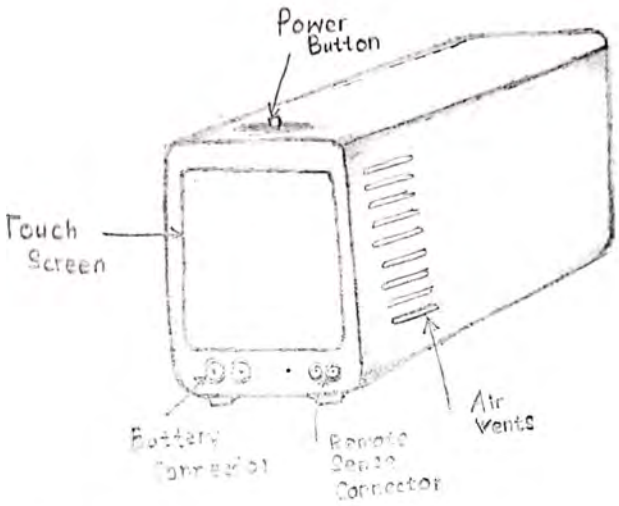
The first design consists of a cuboid-shaped enclosure. This device is small enough to be portable. The required modes can be selected using buttons and sliders on the front. The device has a display to show the curves required. This design is fully portable and requires no external components to be connected to it.

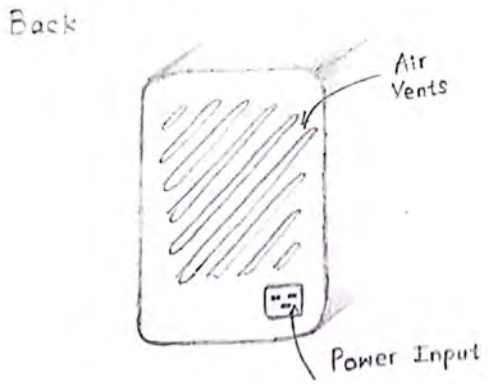


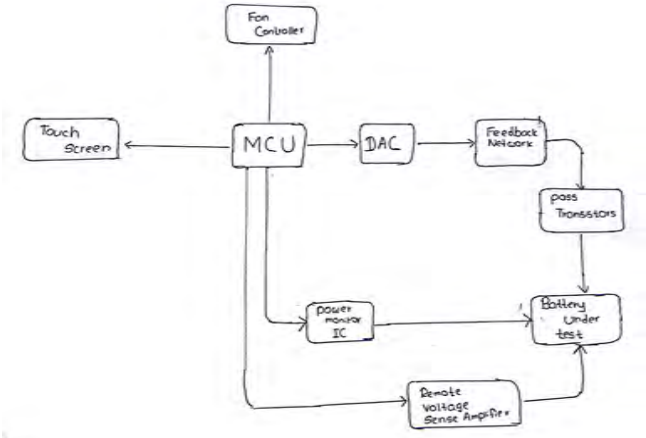


8.2 Conceptual Design 2 and Block Diagram

This design uses a touch screen instead of buttons and knobs. The touch screen would make it possible for users to easily interact with the device. However, it deosn't provide physical feedback as buttons and knobs do.

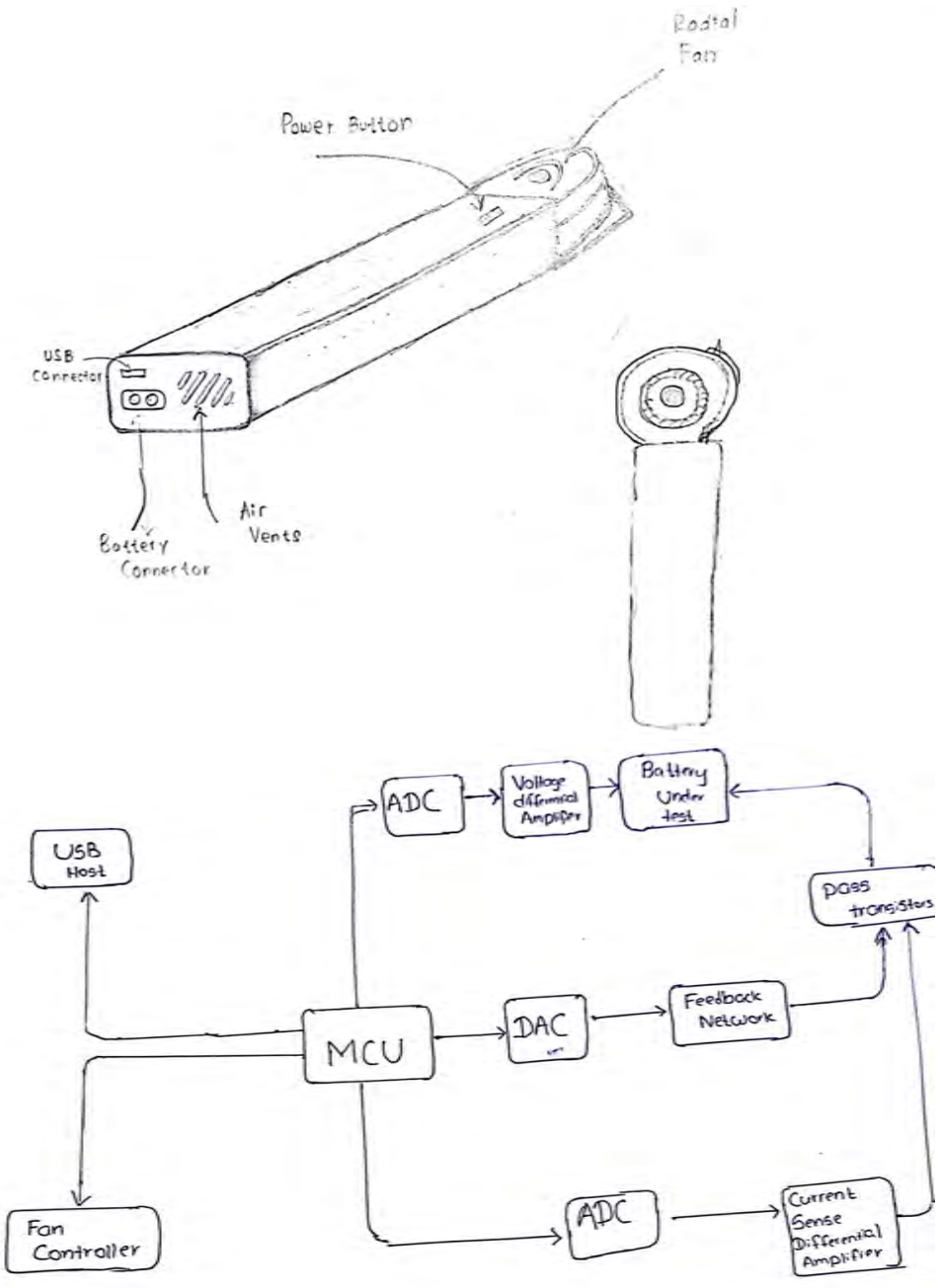






8.3 Conceptual Design 3 and Block Diagram

The third design offers the same functionality as the other two designs but doesn't incorporate a screen. Due to this, the device is smaller than previous designs. The required reading and graphs can be obtained by connecting an external display to it.



9 Evaluation Criteria

9.1 Enclosure Design Criteria

1. Functionality: How well the design supports the main functionalities?
2. Aesthetics: How much eye-catching and overall appeal of the user?
3. Heat dissipation: How much heat is generated and how well it has been managed?
4. Durability: How well does the design withstand impacts and environmental conditions?
5. Simplicity: Simplicity of manufacturing and assembling the enclosure

9.2 Functional Block Diagram Criteria

1. Functionality: How well the circuit design meets functional requirements?
2. User experience: How intuitive and user-friendly is the interaction?
3. Manufacturing feasibility: Evaluate the feasibility of manufacturing the design
4. Cost: Evaluate the overall cost-effectiveness for the provided functionality
5. Performance: Evaluate the accuracy of the results by comparing them with real results

10 Comparison

		Design 1	Design 2	Design 3
Desirable Features		Fully portable High power dissipation Easy interface	Fully portable Light Touchscreen	Fully portable Light
Removed Features		Larger than design 3	Larger than design 3	No display Slightly lower maximum power dissipation
Enclosure Design Comparison	Functionality	9	9	7
	Aesthetics	8	9	4
	Heat Dissipation	9	9	7
	Durability	9	8	9
	Simplicity	9	8	9
Functional Block Design Criteria Comparison	Functionality	9	9	7
	User Experience	9	8	6
	Manufacturing Feasibility	8	8	9
	Cost	8	7	9
	Performance	9	9	9
Total		**87**	**84**	**76**

Table 1: Comparison of Conceptual Designs

11 Design selection

After careful consideration and thorough discussion sessions, we thought of proceeding with the first design. Based on the comparison, it scores the highest and it would satisfy user requirements easily. It is also more easy to use when compared to the other 2 designs.

12 Schematic

The following is the schematic of the product. It incorporates circuits for charging and discharging the battery. The schematic was designed after a thorough analysis of existing designs. A hierarchical design has been used.

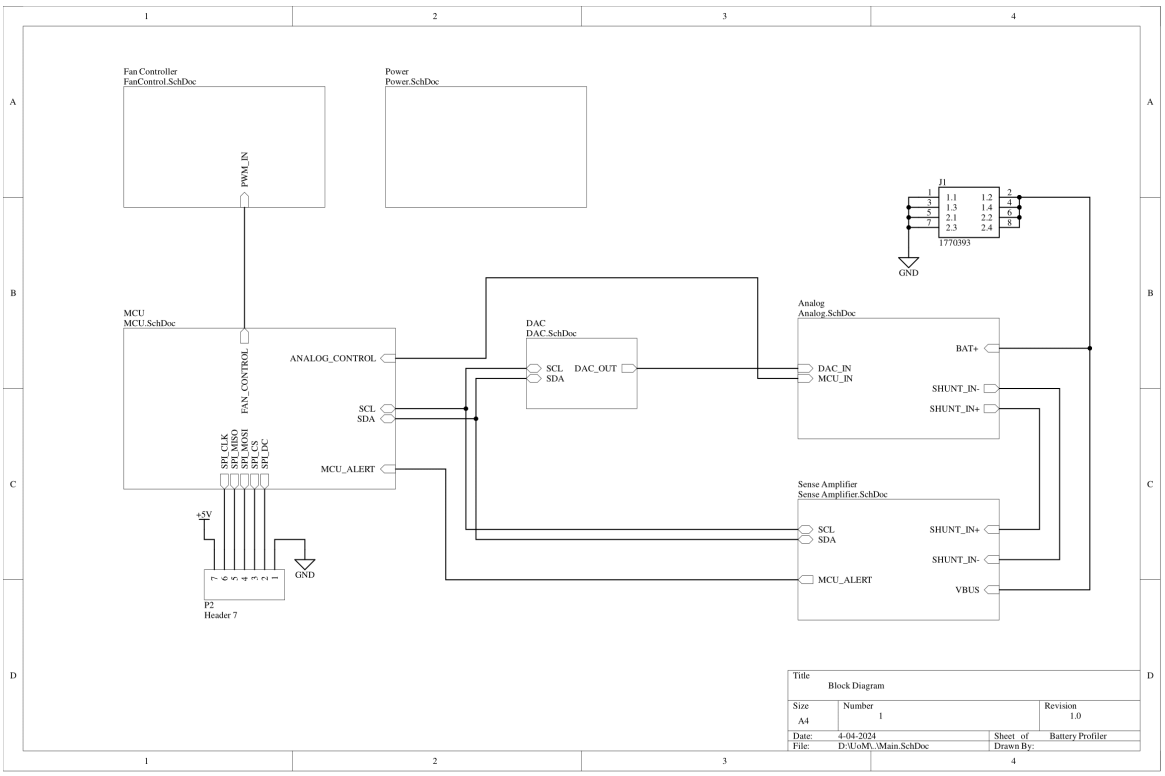


Figure 1: Block Diagram

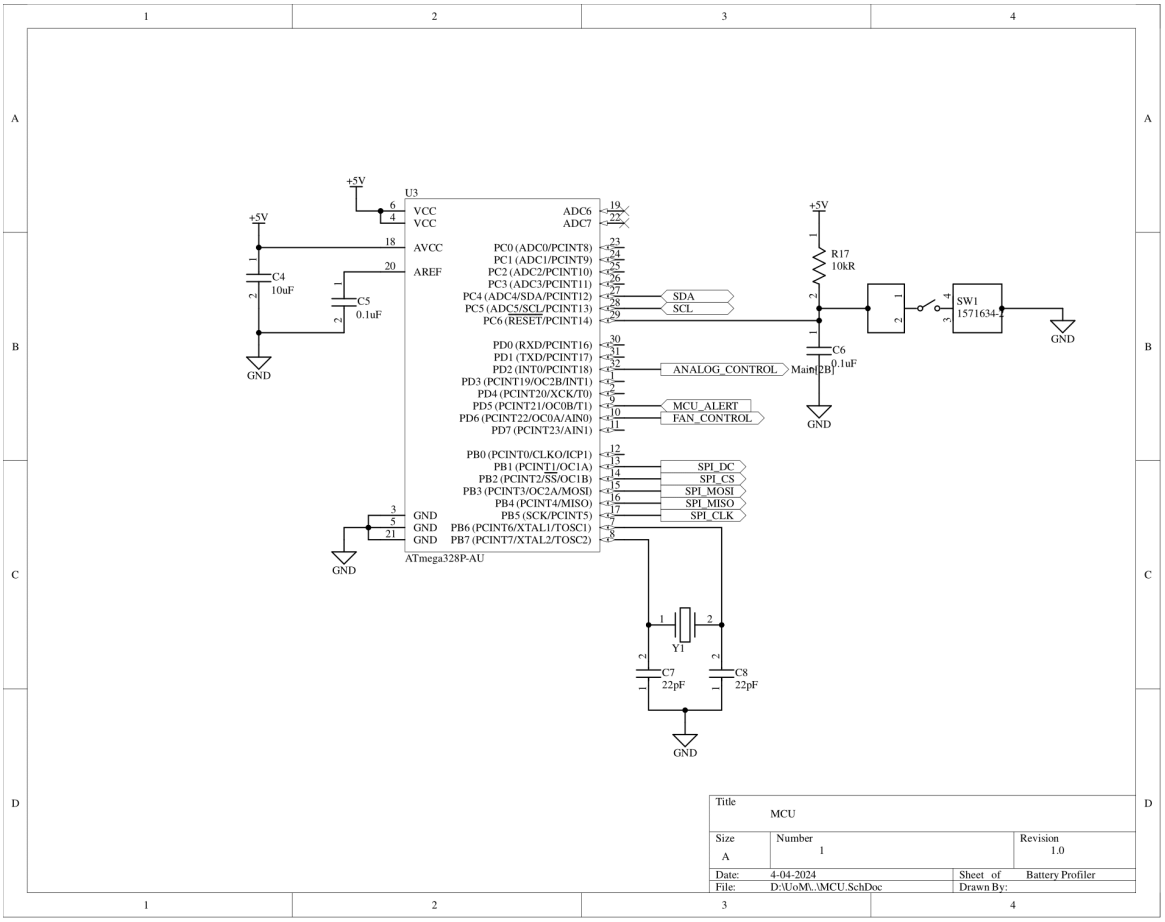


Figure 2: Microcontroller Unit

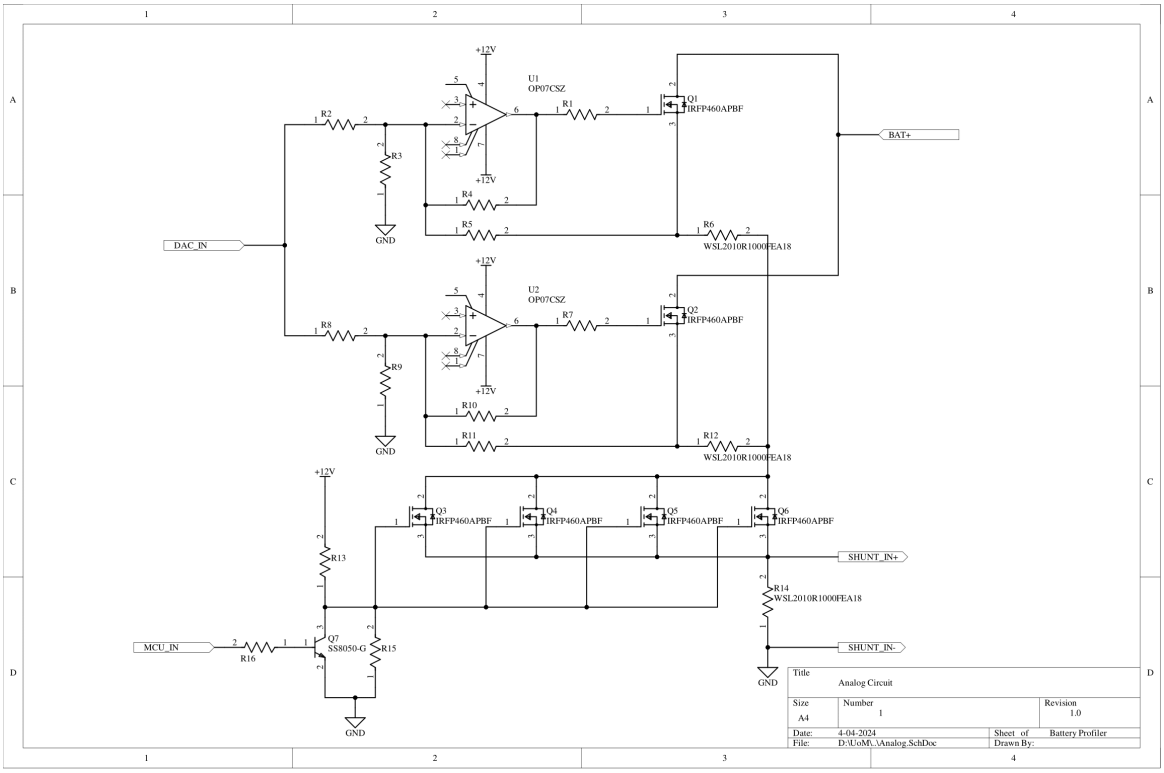


Figure 3: Analog Circuit

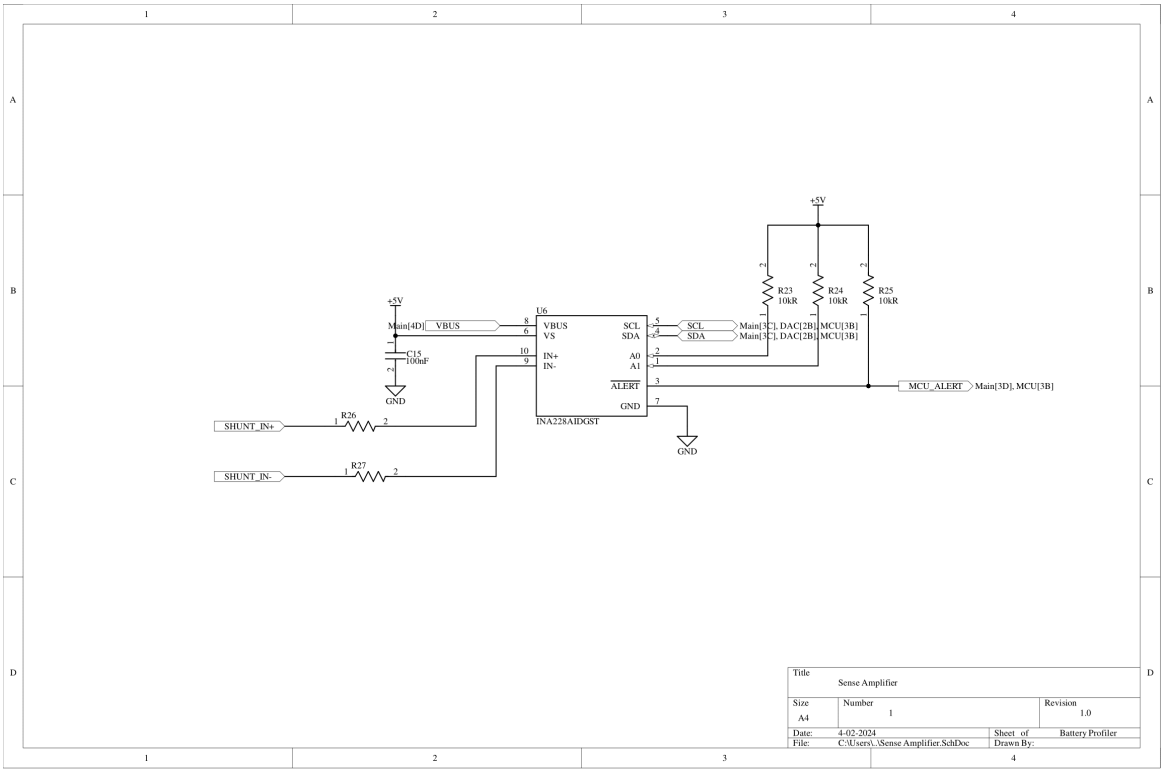


Figure 4: Sense Amplifier

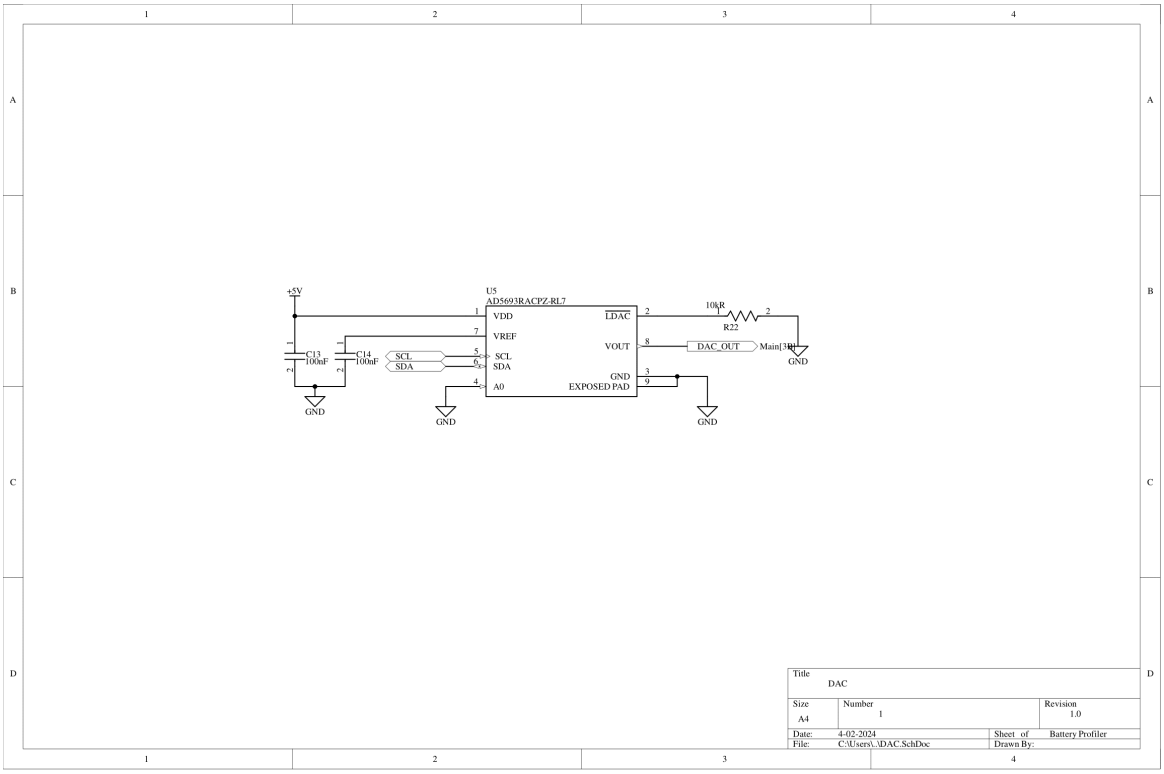


Figure 5: DAC circuit

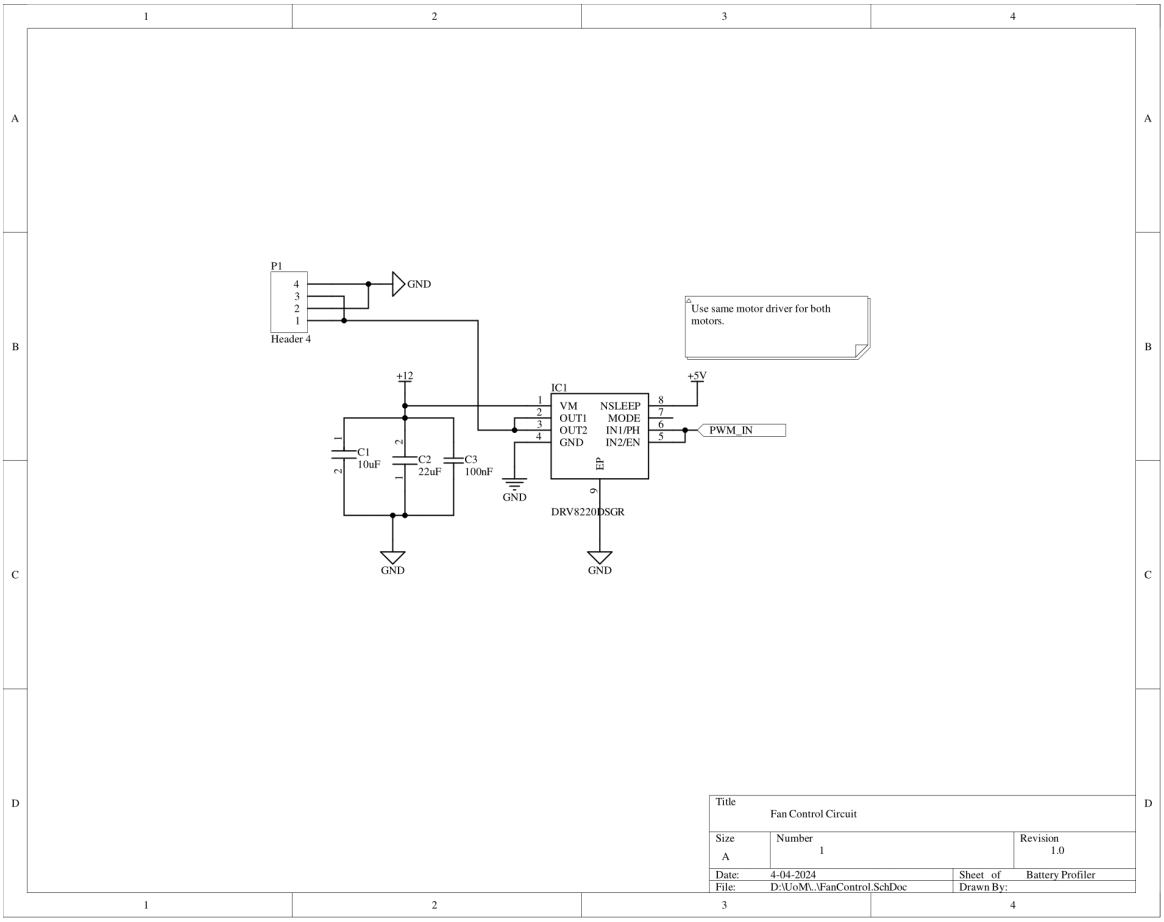


Figure 6: Fan Control Circuit

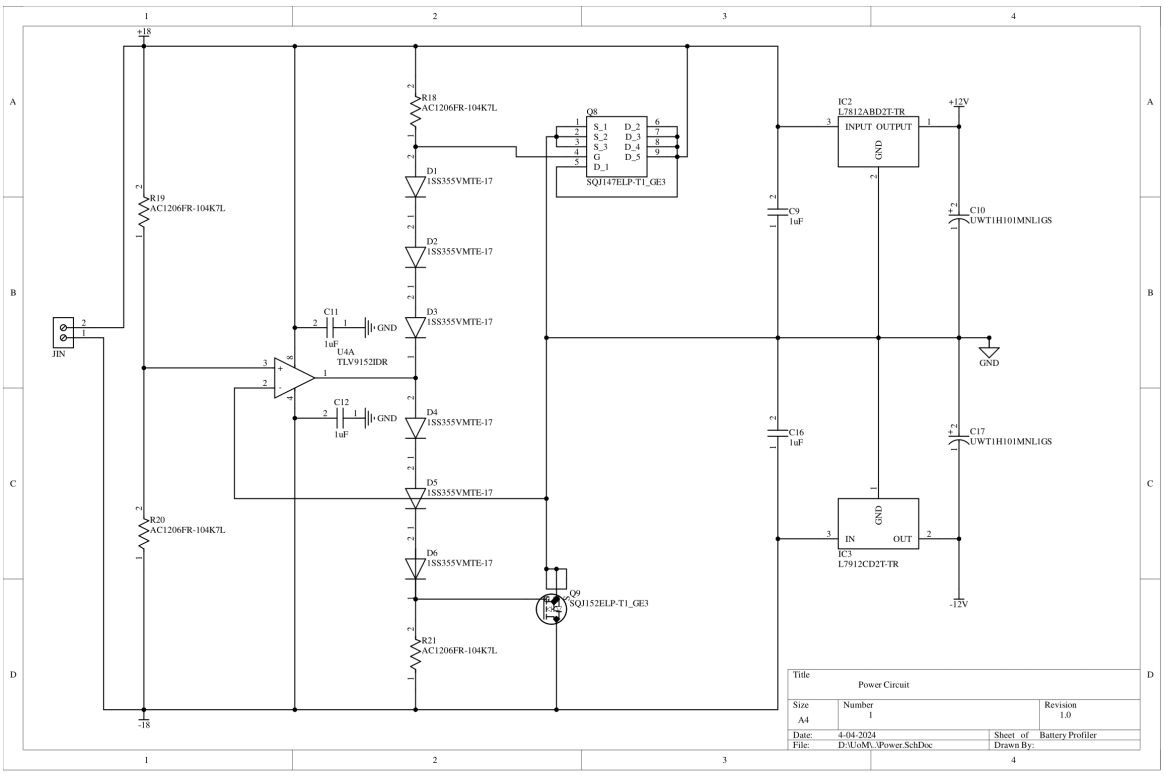


Figure 7: Power Circuit

13 Printed Circuit Board

The following is the printed circuit board of the product. It is of 4 copper layers. It is designed to be able to be manufactured by JLC PCB in China. Component placement and routing were done by us.

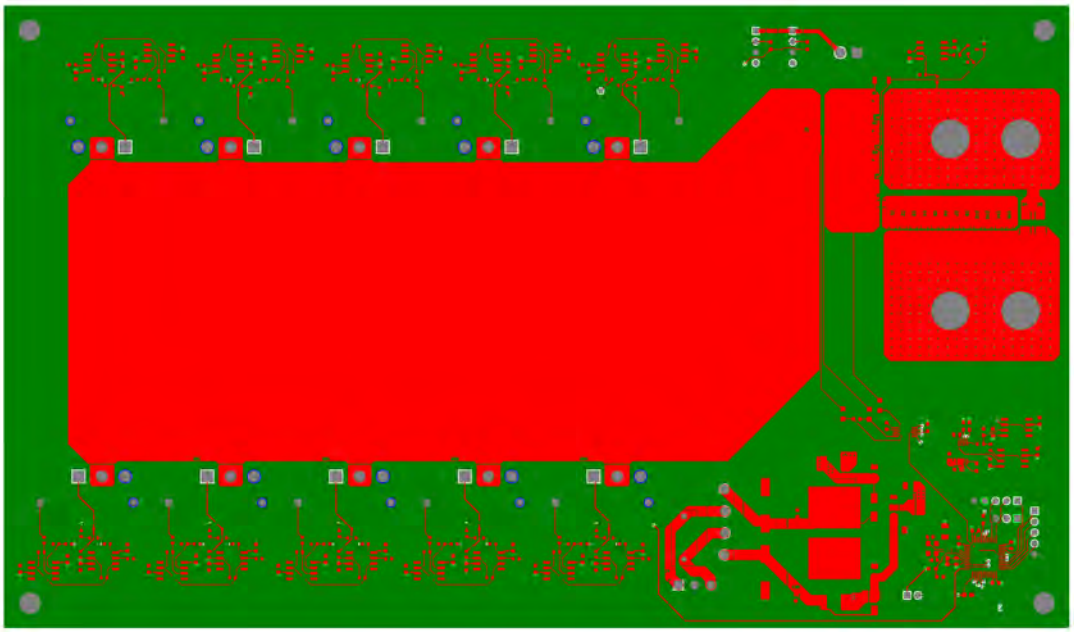


Figure 8: All Layers

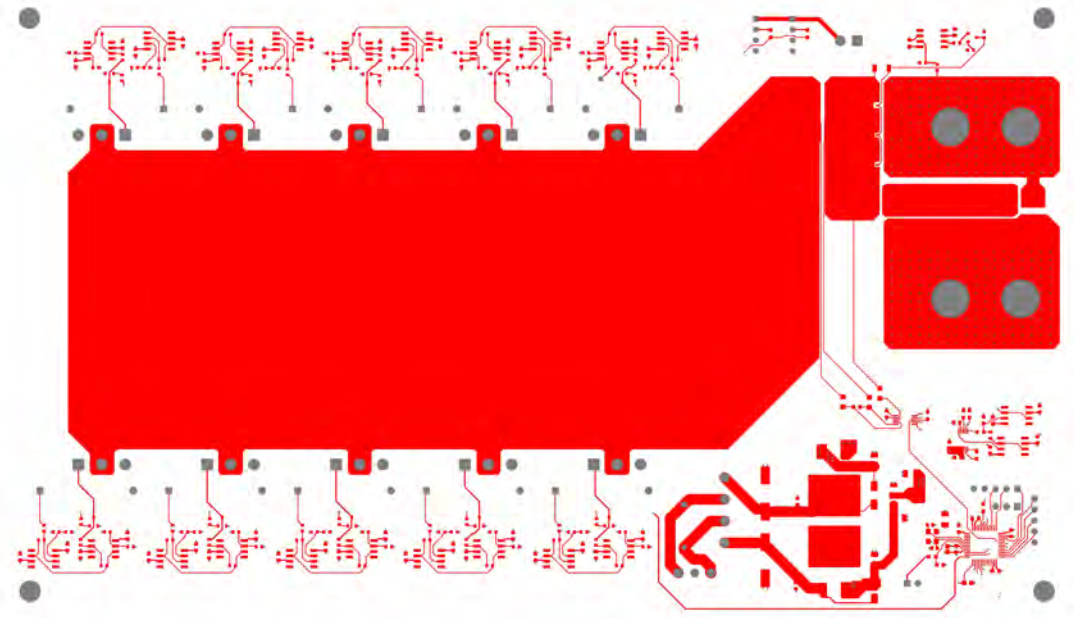


Figure 9: Top Layer

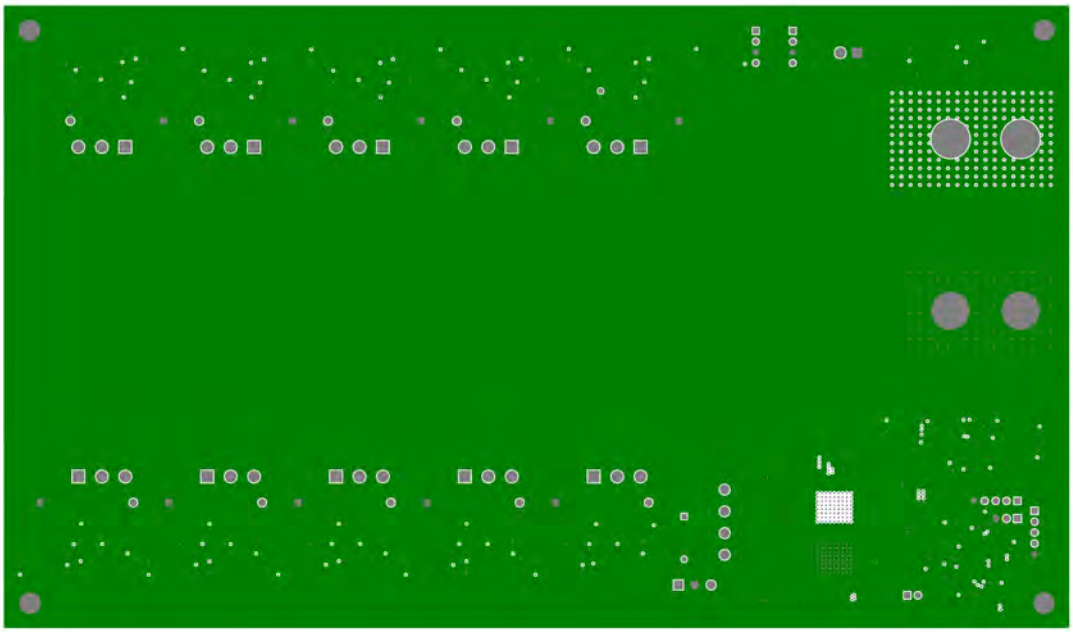


Figure 10: Ground Layer

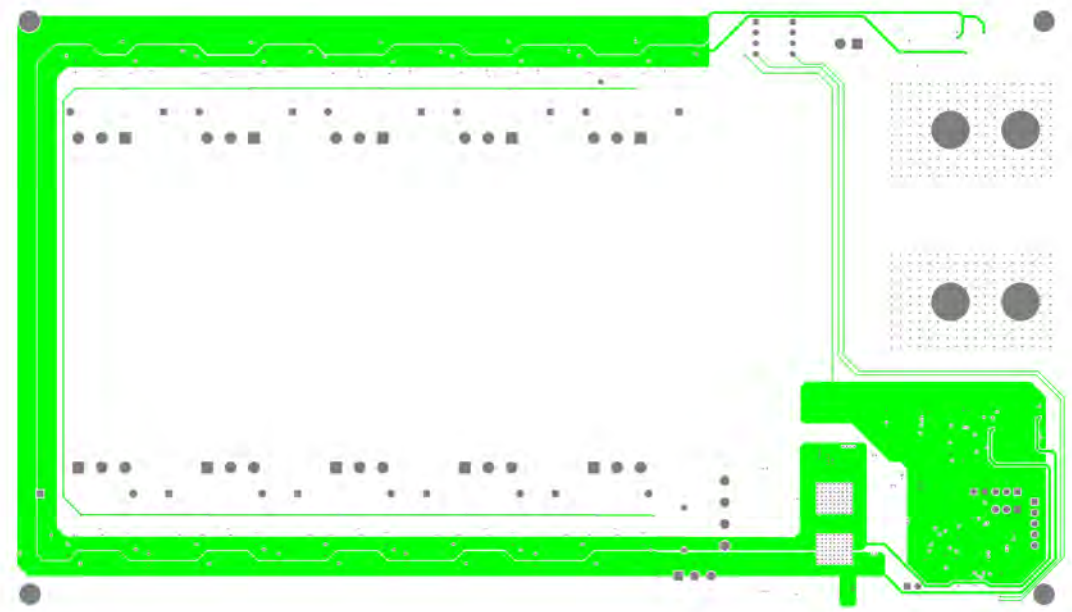


Figure 11: Power Plane

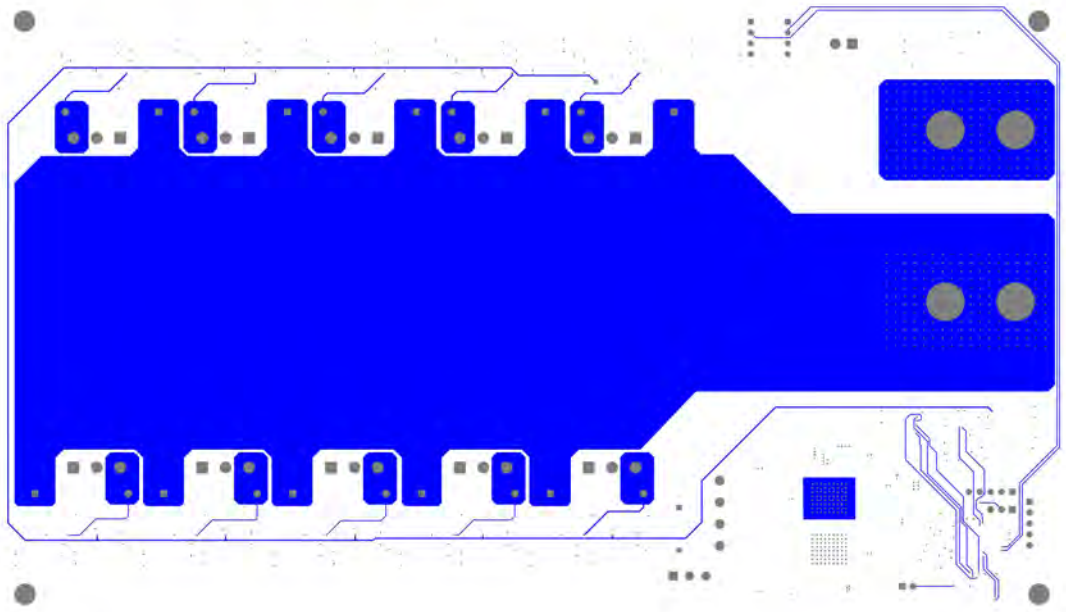


Figure 12: Bottom Layer

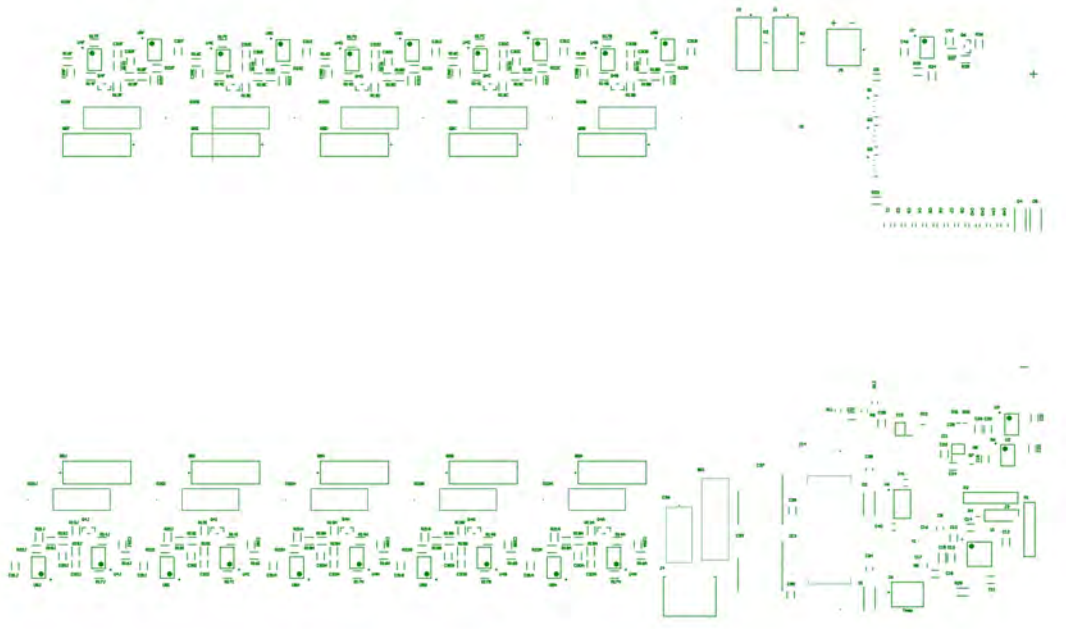


Figure 13: Top Overlay

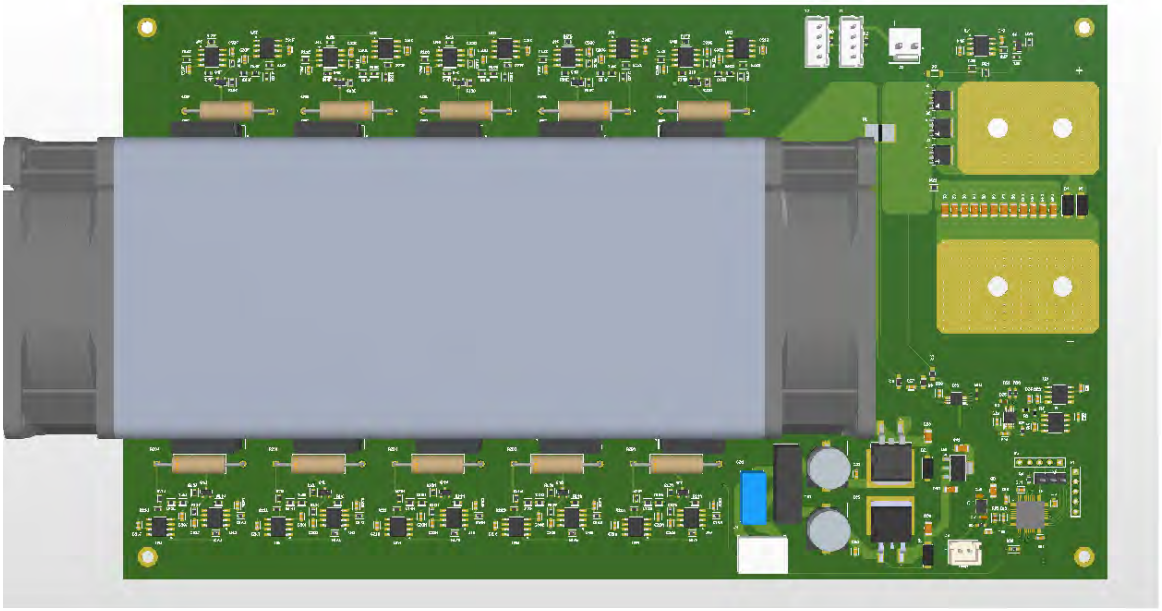


Figure 14: 3d model of PCB (top)

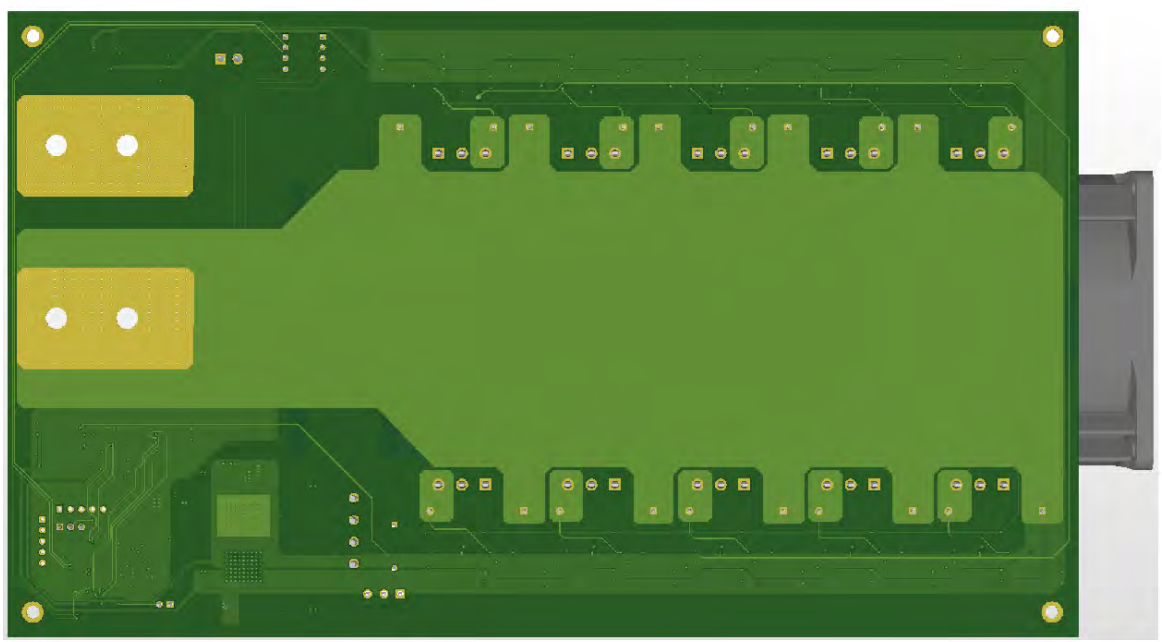


Figure 15: 3d model of PCB (bottom)

14 Enclosure

The following are designs of the enclosure of the product. It is made out of sheet metal and the front cover is of plastic which has been designed to be capable of being injection molded. The reason for using sheet metal is because the components inside are would get hot and sheet metal is a much better dissipator of heat than plastic. Additionally, air vents are present for cooling purposes.

Figure 16: Overall View of the product

Figure 17: Front View of the product

Figure 18: Rear View of the product

Figure 19: Right View of the product

Figure 20: Left View of the product

15 References

1. Lithium Battery Testing
2. Introducing Keysight's E36731A Battery Emulator and Profiler
3. M. I and V. Chayapathy, "Programmable DC Electronic Load for Testing on-Board Voltage Regulators," International Journal of Engineering Research & Technology (IJERT), vol. 6, no. 09, pp. 335-338, September 2017.