DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION ENGINEERING

UNIVERSITY OF MORATUWA

EN2160 – Electronic Design Realization

Final Project Report

Mini UPS

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Abstract

The goal of the project was to manufacture a marketable product using electronics, with new features to meet an existing need. It was decided to manufacture a new Mini UPS which comes with quick charging USB port, short circuit protection, power switching system as well as a battery voltage level indicator in addition to the 12V,9V /2A rated outputs. A marketing plan also was carried out parallel to the designing and production procedure and a marketing survey was conducted in order to get the ideas of the customers. Quick charging port is a result of that survey. As it was also needed to market the newly manufactured product, several marketing strategies were planned to be put into action in order to market the product. The product was planned to be introduced to the market under a new company name created by myself. All the aspects such as getting necessary components, designing PCBs, manufacturing enclosures and packaging, which are connected to mass scale manufacture were taken into consider and ways of achieving them were well planned.

1.Introduction

1.1. Problem Description and Overview

In today's digital age, the internet has become an integral part of our daily lives, and a stable internet connection is crucial for both work and leisure activities. However, network disruptions caused by power outages or sudden power fluctuations can be frustrating and disruptive. Wi-Fi routers, being an essential component of home and office networks, are particularly susceptible to such issues. To address this problem, a Mini Uninterruptible Power Supply (UPS) for Wi-Fi routers is proposed. The Mini UPS for WiFi routers is designed to provide temporary power backup during unexpected power outages or voltage fluctuations. Its primary objective is to maintain a continuous and stable internet connection, ensuring uninterrupted network connectivity for connected devices.

Key Features and Functionality:

Compact and Portable Design: The Mini UPS is compact and lightweight, making it easy to place alongside the Wi-Fi router without occupying much space.

Battery Backup: Equipped with a rechargeable internal battery, the Mini UPS can provide a limited amount of power backup, typically ranging from a few minutes to an hour, depending on the power consumption of the connected Wi-Fi router.

Automatic Power Switching: The UPS features an automatic power sensing mechanism that detects power outages or fluctuations and swiftly switches the power supply from the main electrical source to the battery backup.

Intelligent Charging: The Mini UPS intelligently manages battery charging, preventing overcharging and extending the battery's lifespan.

Overall, the Mini UPS for Wi-Fi routers is an essential device for individuals and businesses seeking to maintain a stable internet connection during power interruptions. Whether for remote work, online learning, or staying connected to the digital world, this Mini UPS offers a reliable solution to keep the Wi-Fi router operational, ensuring uninterrupted internet access even in adverse power scenarios. While the research and the questionnaire were going on there were three main problems found. They are,

1. High cost
2. Not enough backup time

1.2. Product Validation

It is essential to validate the product to ensure it meets the desired functionality, safety standards, and user requirements. Start by researching existing Mini UPS products in the market. I understood their features, specifications, and user feedback. This gave insights into common design approaches and

potential improvements for DIY projects. As explained in the above section people are hoping to deploy mini-UPS but the initial cost to purchase them from the market is not affordable most of the time. This was a huge motivation. According to the questionnaire results, It is assured a need of new product with features and specifications up to the mark

1.3. Solution

The solution is to innovate existing products in different aspects, reduce the cost as much as possible and increase the backup time as much as possible. In order to meet those pointed features, Innovative product design is chosen.

2.Product Goals

2.1. Functionality

Once the device is connected to the power supply, it is ready to use by the power supply. In addition to that, even if there is no power supplement and if batteries are charged, the device is ready to give outputs the connected device demand. If the user only needs to charge the batteries, there is a switch backside of the Mini UPS for that. If not switch must be flipped the other side, then battery charge can be used to get output. However, is has also auto charging system as well.so that user doesn't need to flip switch manually.

2.2. Market Goals

Initial plan is to manufacture 100 units and identify the demand then go for mas manufacturing. Since this product is made by using the design driven innovation approach, the main target in the scope of the market is to maximize the profits while fulfilling the need of users. Since this product is made by using the design driven innovation approach, the main target in the scope of the market is to maximize the profits while fulfilling the need of users. Costs per unit and marketing prices can be illustrated as follows.

Approximate Cost per Unit – Rs. 9463.05.00

Market Price – Rs. 10,599.00

3. Features and Specifications:

- **Automatic Power Switching**: the UPS features an automatic power sensing mechanism that detects power outages or fluctuations and swiftly switches the power supply from the main electrical source to the battery backup. (If user needs only charging the batteries, a switch is provided with clear signs and user can act accordingly.)
  (Refer appendix C for signs)
- **Intelligent Charging**: The Mini UPS intelligently manages battery charging, preventing overcharging and extending the battery's lifespan. Prevent the draining the batteries below the level which causes the battery health issues.
- **Safety and Protection**: Implement safety features to prevent overcharging, short circuits, and other potential hazards by means of a BMS module. Ensure that the UPS does not cause any harm to the Wi-Fi router or connected devices.
  (Refer appendix C for BMS module visual aids)
- **LED seven segment Indicators**: The UPS is equipped with LED seven segment indicators to display the battery status (Voltage). can switch of that manually in order to reduce power consumption.
  (Refer appendix C for visual aids)
- **Battery Backup**: up to 7 to 7.5 hours
- **Compact and Portable Design**: The Mini UPS is compact and lightweight, making it easy to place alongside the Wi-Fi router without occupying much space.
  - Weight: 0.378 Kg
  - Size: 10 cm x 12 cm x 4 cm
- **Input**: 12V DC (up to 12.5V) / 2A DC (or below)
- **Battery Status:**
  - 3s2P configuration
  - 6 li-ion battery (18650 1800mAh)

- **Output**:
  - 12V DC (~11.7V - 12.2V) / up to 2A DC
  - 9V DC /up to 2A DC
  - 5V DC (USB): **Quick Charging USB port** (5V/2A)

4.Implementation

4.1. Component Selection

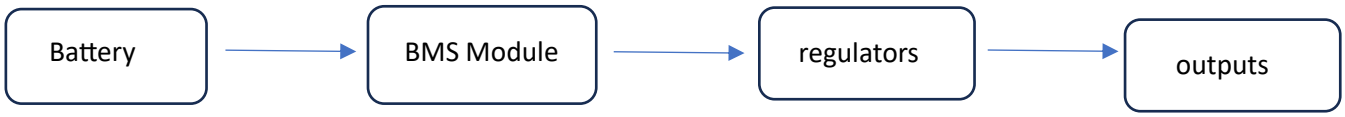
The following are how selected the critical components of our device.

- **Battery Management System** module: battery pack is designed in 3S2P configuration with six battery (Li-ion 18650 1800mAh). considering the capability of preventing short circuits and providing battery safe charging and discharging ,3s 20A BMS module is chosen.
- **IRF 9540/9540**: In order to power switching, this MOSFET is chosen compared to other MOSFET specifications current rating as well as voltage.
- **LM317:** selected in order to regulate voltage of the USB port accurately.
- **Li-ion Battery:** rechargeability, cost effectiveness, availability ease of handling etc.
- **Mini voltmeter** is selected to indicate the voltage of the battery pack within accuracy up to 1 decimal point. (Can be manually switch off if needed)

4.2. Circuit Design and Initial Testing

The device should be powered by a 12V DC /2A (or below) power supply.

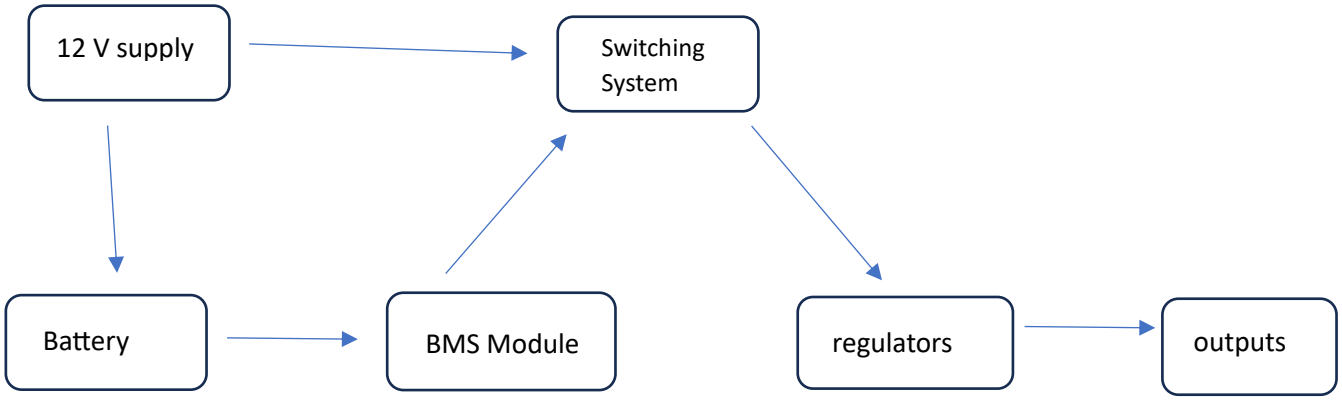
Initially circuit was designed to power the router or CCTV only by the Battery pack.



After ensuring that the battery pack gives the needed requirements for the relevant devices to be functional, the power supply voltages and currents were given in addition to the battery supplement. Using shottkey Diodes and IRF 9530/9540 Power is switched. (i.e., when the DC power is applied MOSFET cuts off the battery supply and as soon as the main DC supply is out,

MOSFET goes to Switch on mode then the power is supplied by the battery pack). Also, there should be a battery charging system as well. For that whenever the 12V power supply is applied there is a path through a shottkey diode to the BMS module.12V and 9 V are achieve by using buck converters (XL4015) and USB 5V is achieved using the LM 317T. Whether devices are connected or not batteries are charged automatically.

Block diagram of the described circuit is given below.



The initial implemented, described diagram is given below.

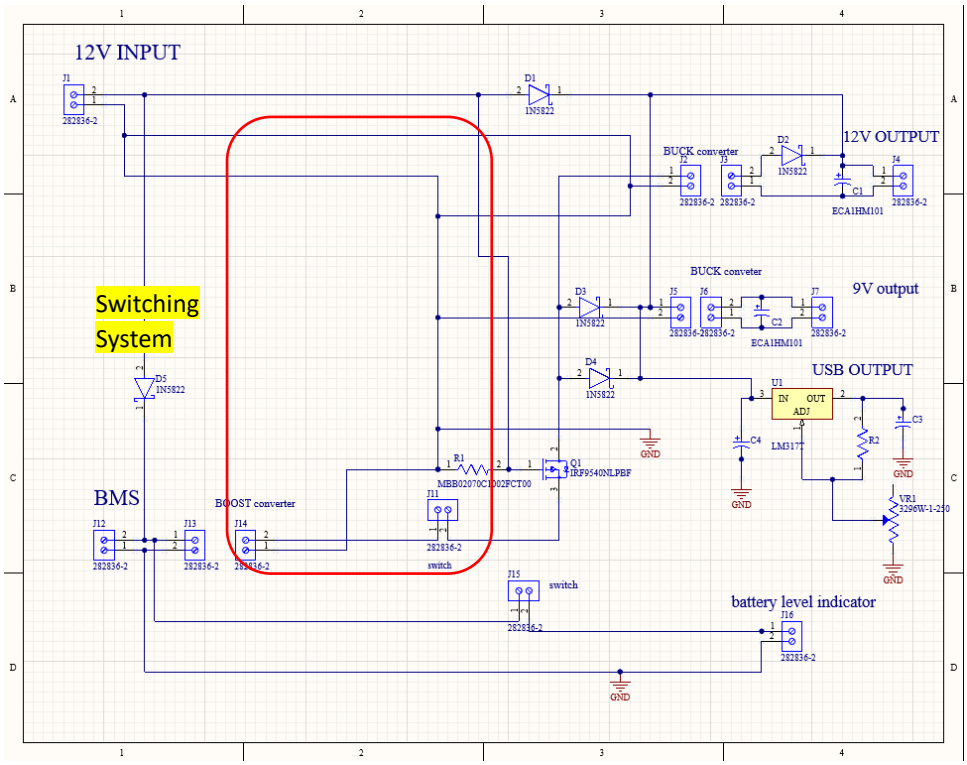


Figure 1: Initial Circuit Design

In the initial circuit itself worked as expected when it was implemented using wires and then the PCB design was done.

4.3. Printed Circuit Board Design

Printed circuit board was designed with Altium Designer 23.3.1. It was a two-layer design.

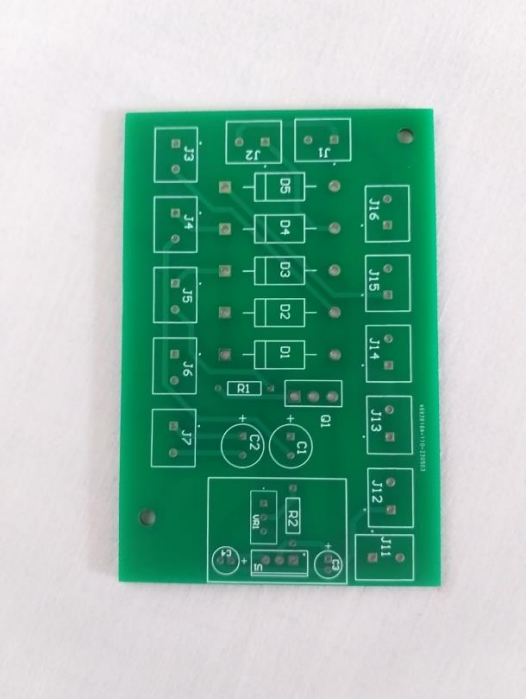


Figure 3: PCB Design top

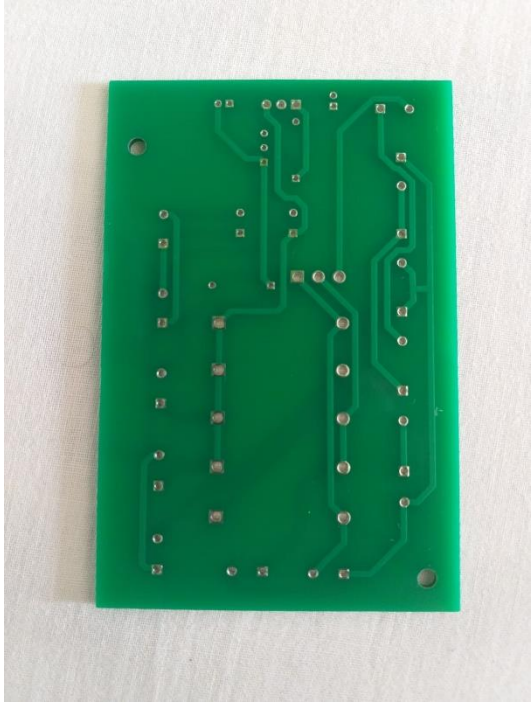


Figure 2: PCB Design bottom

Manufacturing was done at JLCPCB in China. Therefore, online available JLCPCB design rules were imported to Altium Designer.

Refer Appendix A for schematic diagram and layout respectively.

4.4. Enclosure Design

Enclosure design was designed with SOLIDWORKS 2020.enclosure consist of Lid and the Body. Plastic is used in the enclosure. This was designed to contain the main PCB and battery pack as well as the boost converters and buck converters. All of them can be mounted on the body by means of 3mmx 5mm screws.

Refer Appendix B for enclosure design.

Figure 4: Enclosure Design

5. Instructions for Assembly

5.1. Components required

- 3.7V Li Ion battery (18650 1800mAh (6 batteries))
- DC-DC step-up (boost) converter module
- DC-DC step-Down (Buck) converter Module (2 modules)
- IRF 9540/9530
- LM317T regulator
- 1N5822 diodes
- 10K resistor
- Lug connectors
- Power output connector(s) (DC jack, USB ports, etc.)
- Wires, soldering iron, solder, and basic tools.
- Power input connector (DC jack or similar)
- 3mm screws (10mm length)

5.2. Assembly Steps:

NOTE: connections are made according to the diagrams and pictures given in the appendix D

5.2.1. Prepare the Battery:

- Battery pack should be connected accordingly to the BMS module. (Voltage outlets should be connected correctly)
- Ensure the battery is fully charged (if not, battery pack can be directly charged through DC 12V/2A rated power supply).
- Double-check the voltage and capacity of the battery to ensure it meets the requirements.

5.2.2. Setup the DC-DC Step-Up (Boost) Converter:

The DC-DC step-up converter is used to boost the battery voltage to the desired output voltage 12V.Connect the input of the DC-DC converter to the positive and negative terminals to the terminals in PCB.

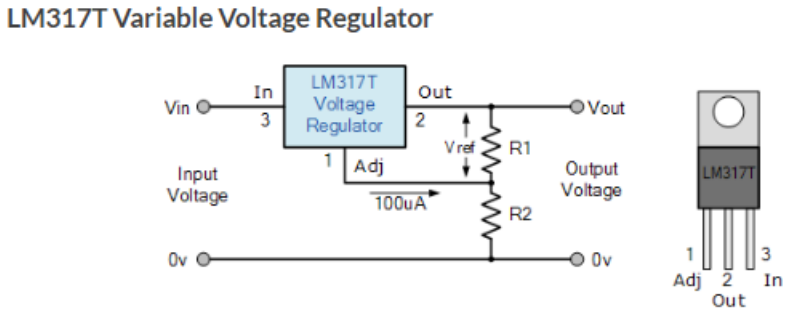
5.2.3. Setup the DC-DC Step-Down (Buck) Converter:

- The DC-DC step-Down converter is used to down the battery voltage to the desired output voltage 12V and the other module for 9V. Connect the input of the DC-DC converter to the positive and negative terminals to the terminals in PCB.

5.2.4. Ensure Proper Wiring:

- Double-check all the connections to ensure they are secure and well-insulated to prevent any short circuits or accidents.

5.2.5. Setup the LM317T regulator



R2 Value	Resistor R1 Value								
	150	180	220	240	270	330	370	390	470
100	2.08	1.94	1.82	1.77	1.71	1.63	1.59	1.57	1.52
120	2.25	2.08	1.93	1.88	1.81	1.70	1.66	1.63	1.57
150	2.50	2.29	2.10	2.03	1.94	1.82	1.76	1.73	1.65
180	2.75	2.50	2.27	2.19	2.08	1.93	1.86	1.83	1.73
220	3.08	2.78	2.50	2.40	2.27	2.08	1.99	1.96	1.84
240	3.25	2.92	2.61	2.50	2.36	2.16	2.06	2.02	1.89
270	3.50	3.13	2.78	2.66	2.50	2.27	2.16	2.12	1.97
330	4.00	3.54	3.13	2.97	2.78	2.50	2.36	2.31	2.13
370	4.33	3.82	3.35	3.18	2.96	2.65	2.50	2.44	2.23
390	4.50	3.96	3.47	3.28	3.06	2.73	2.57	2.50	2.29
470	5.17	4.51	3.92	3.70	3.43	3.03	2.84	2.76	2.50
560	5.92	5.14	4.43	4.17	3.84	3.37	3.14	3.04	2.74
680	6.92	5.97	5.11	4.79	4.40	3.83	3.55	3.43	3.06
820	8.08	6.94	5.91	5.52	5.05	4.36	4.02	3.88	3.43
1000	9.58	8.19	6.93	6.46	5.88	5.04	4.63	4.46	3.91
1200	11.25	9.58	8.07	7.50	6.81	5.80	5.30	5.10	4.44
1500	13.75	11.67	9.77	9.06	8.19	6.93	6.32	6.06	5.24

This table can be used to obtain the r1 and r2 values respectively.

5.2.6. Testing:

- Before using the mini-UPS with the devices, test it with a multimeter or a suitable load (e.g., a small LED) to verify that the output voltage is correct and stable.
- If everything looks good, then connect the devices to the power output connector(s) of the mini-UPS.

Important Safety Tips:

- Always exercise caution when working with batteries and electronics. Be mindful of polarity and avoid short circuits.
- Make sure the battery and components you use are appropriate for the load you plan to connect to the mini-UPS.
- Keep the battery and UPS away from heat sources and flammable materials.
- If you're not sure about any step or the functionality of the components, consult the datasheets or seek assistance from an experienced individual.

6. Testing the Product Functionality

Testing a MINI UPS (Uninterruptible Power Supply) is essential to ensure its proper functioning and to verify its ability to provide backup power during a power outage or voltage fluctuation. Here's a step-by-step guide to testing a MINI UPS:

6.1. Initial Inspection:

- Examine the UPS and its components for any visible damage or loose connections. If you notice any issues, before proceeding testing make sure damaged components are dealt with accordingly.

6.2. outputs testing

- First make sure the power switch is switched towards the charging sign and the power switch is on.
- Then plug in the device to a wall outlet and connect a 12V/2A rated Wi-Fi router to see whether it gets powered on,9V/2A rated CCTV to see whether it gets powered on or 5V/2A demanded mobile phone to see whether it gets charged. If it works as expected switch the power switch towards the discharging sign.
- And then switch off the wall outlet. Even then the devices connected to the UPS are not interrupted that means UPS outputs are properly achieved.in other words, Connect a small electronic device to the UPS, such as mobile phone, Wi-Fi router, or CCTV cam. Make sure the device's power consumption is within the UPS's rated capacity.

- Turn on the device and let it run on battery power for a short duration (e.g., 5-10 minutes).
- Then if the power switch is switched towards the charging sign, then the outputs should not be given.

6.3. Recharge the UPS:

- After the simulated power outage, plug the UPS back into the wall outlet and let it recharge for the recommended time.

6.4. Repeat the Test:

- Perform the testing process multiple times to ensure consistent performance.

6.5. Battery Replacement (if necessary):

- If UPS fails to provide sufficient backup power or shows signs of battery degradation during testing, must go for a battery replacement option.

6.6. Safety Testing:

- Safety tests should be conducted to ensure the UPS complies with relevant safety standards and regulations, such as electrical safety, insulation resistance, grounding, and protection against electric shock.

6.7. Overload and Short Circuit Protection Testing:

- The UPS is subjected to overload conditions to verify its protective mechanisms can handle excess power demands without damage. That can be performed by connecting a device and measuring whether the currents and voltages are given accordingly. Short circuit tests should be performed to ensure that the UPS can safely handle such situations without risking harm to itself or the connected devices. Short circuit protection can be tested by short circuiting the output and checking whether the power is still flowing or not.

6.8. Efficiency and Power Output Testing:

- The UPS's efficiency is measured to assess how much power it consumes from the mains supply compared to the power it delivers to the connected devices. Output voltage stability and

waveform quality should be tested to ensure a consistent and clean power supply to connected devices.

6.9. Environmental Testing:

- The UPS should be tested under various environmental conditions, such as different temperatures and humidity levels, to ensure it operates reliably in different settings.

6.10. Charge the Battery:

- The switch at the back side (refer appendix c) should be switch towards charging sign and plug in the MINI UPS to a wall outlet and allow it to charge for the recommended time. Switching in front of the UPS is recommended while charging when the battery level indicates 11.4V it says that battery pack is fully charged.

7.Bill of Materials

Item	supplier	amount	Price per unit $/LKR	Total amount LKR	
IRF 9540/9530	mouser	1	3.00$	957.00	https://www.mouser.com/ProductDetail/Vishay-Siliconix/IRF9540?qs=zorda86t5M9lAcHgw5xC5w%3D%3D
LM317T	mouser	1	2.50$	797.5	https://www.mouser.com/ProductDetail/STMicroelectronics/LM317T?qs=swDD%252BF%252Bps7c8uLyY%252B3mJJw%3D%3D
1N5822	mouser	5	0.45$	143.55	https://www.mouser.com/ProductDetail/STMicroelectronics/1N5822?qs=JV7lzlMm3yJ50hlrGV6%252BnQ%3D%3D
10K resistors	Tronic.lk	1	2.00 LKR	2.00	https://tronic.lk/product/10k-14w-resistor-pack-carbon-film-tht-5-approx-40pcs
12V DC jack	Tronic.lk	4	10.00 LKR	40.00	https://tronic.lk/product/dc-base-barrel-female-socket-panel-mount-dc-022-3-pin
Lug connectors	Tronic.lk	22	2.50 LKR	55.00	https://tronic.lk/
XL6009	Tronic.lk	1	450.00 LKR	450.00	https://tronic.lk/product/xl6009-3-32v-to-5-35v-4a-dc-to-dc-adjustable-step-up-bo
12V dc male connector and cables	Tronic.lk	4	30 LKR	120.00	https://tronic.lk/
XL4015	Tronic.lk	2	460 LKR	920.00	https://tronic.lk/product/xl4015-8-36vdc-to-1-25-32vdc-5a-dc-to-dc-step-down-buck
PCB	JLCPCB	1	480 LKR	480.00	https://jlcpcb.com/
Enclosure	Xydder Labs		5500LKR	5500.00	

Total cost **9463.05 LKR**

8. References

https://www.vishay.com/docs/91078/91078.pdf

https://www.mouser.com/datasheet/2/389/lm217-1849593.pdf

https://www.alldatasheet.com/datasheet-pdf/pdf/1132228/XLSEMI/XL6009.html

https://www.alldatasheet.com/datasheet-pdf/pdf/1134361/XLSEMI/XL4015.html

https://www.mouser.com/datasheet/2/389/1n5822-1848813.pdf

https://eteleshop.slt.lk/product/dcp-mini-ups-0

Appendix A

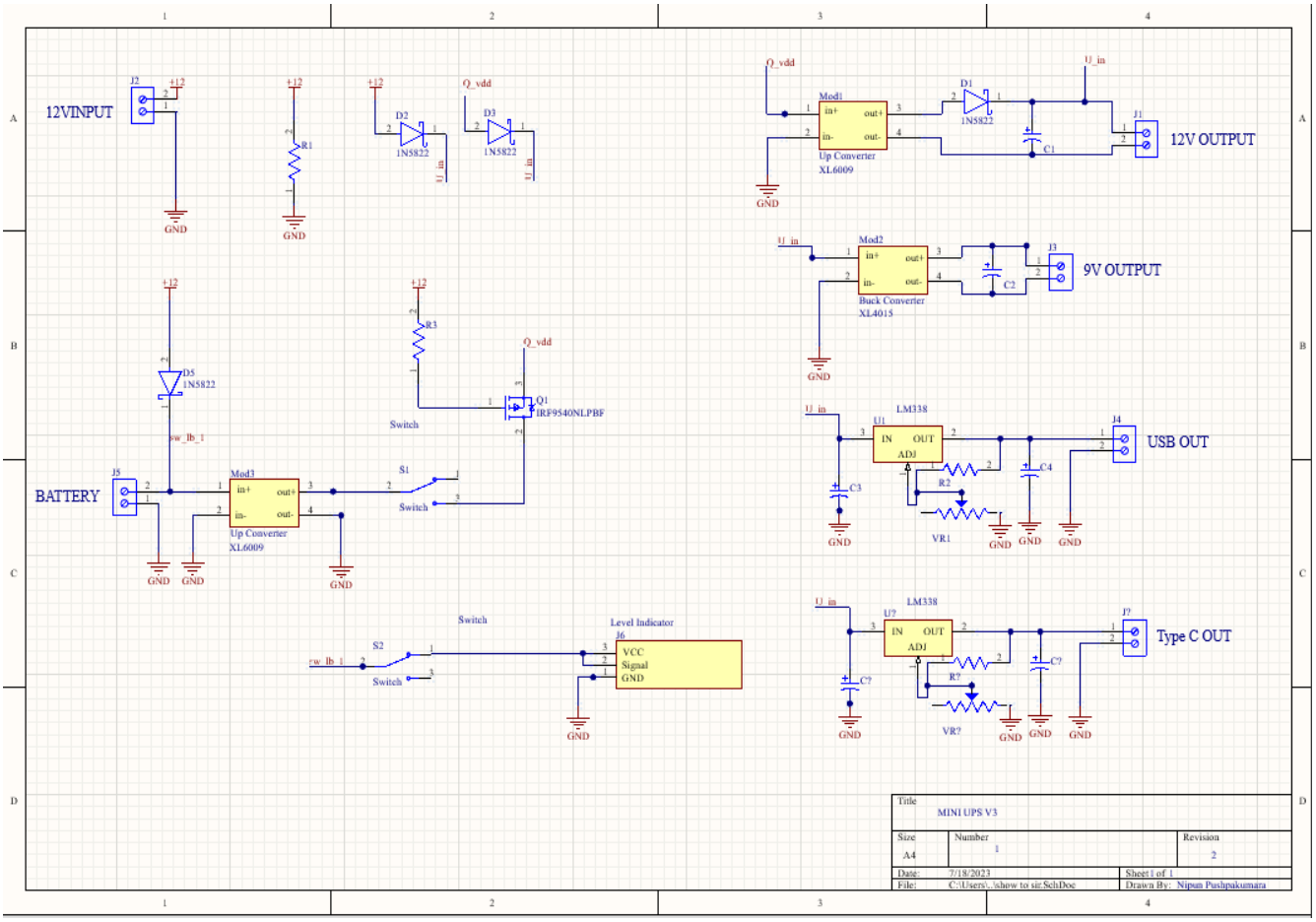


Figure 6: Altium Schematic

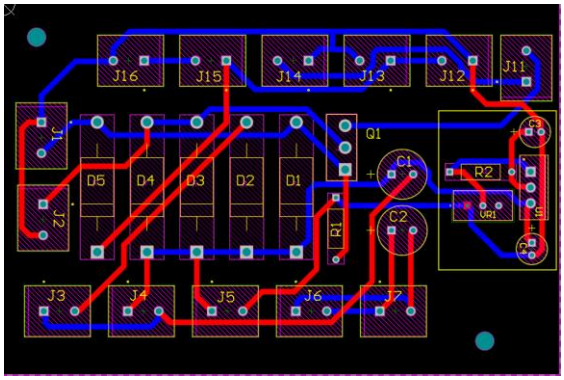


Figure 7: PCB Layout

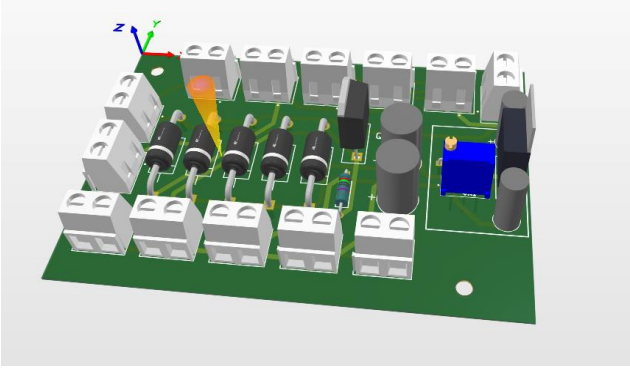


Figure 5: PCB 3D View

Appendix B

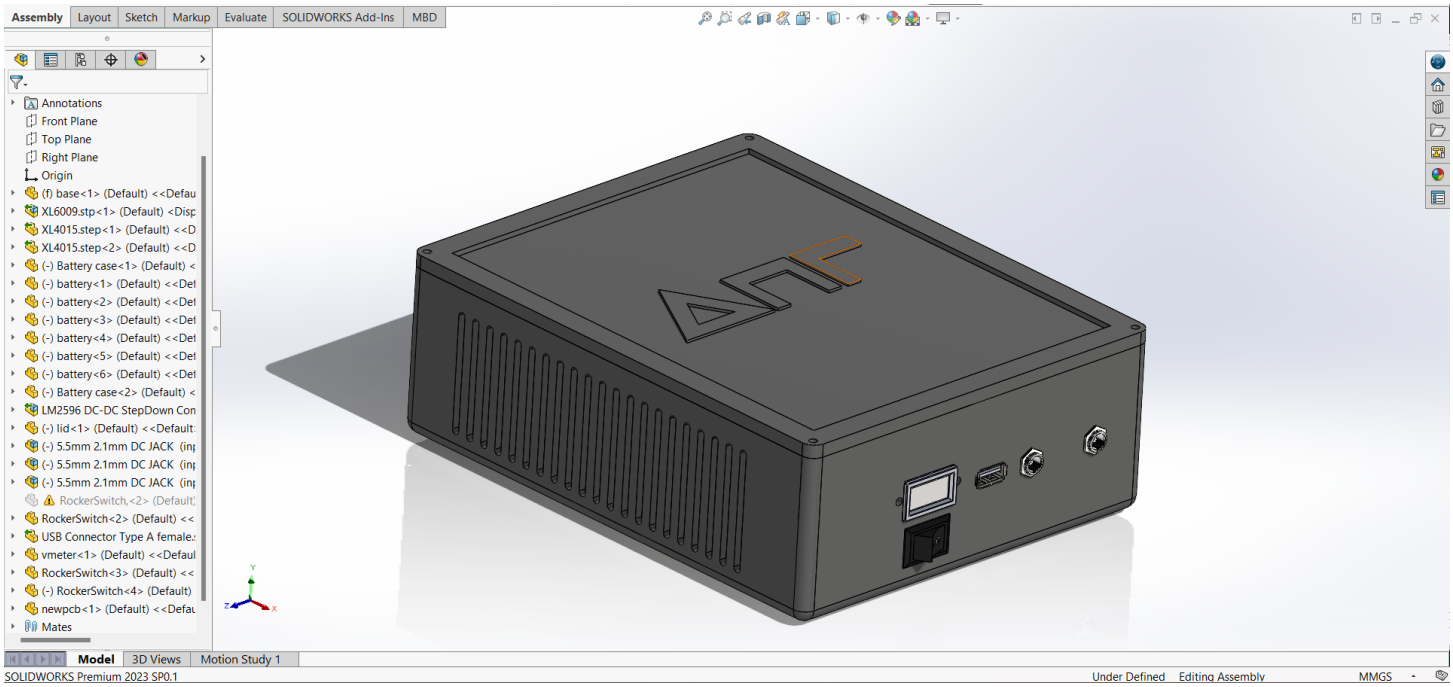


Figure 8:isometric view

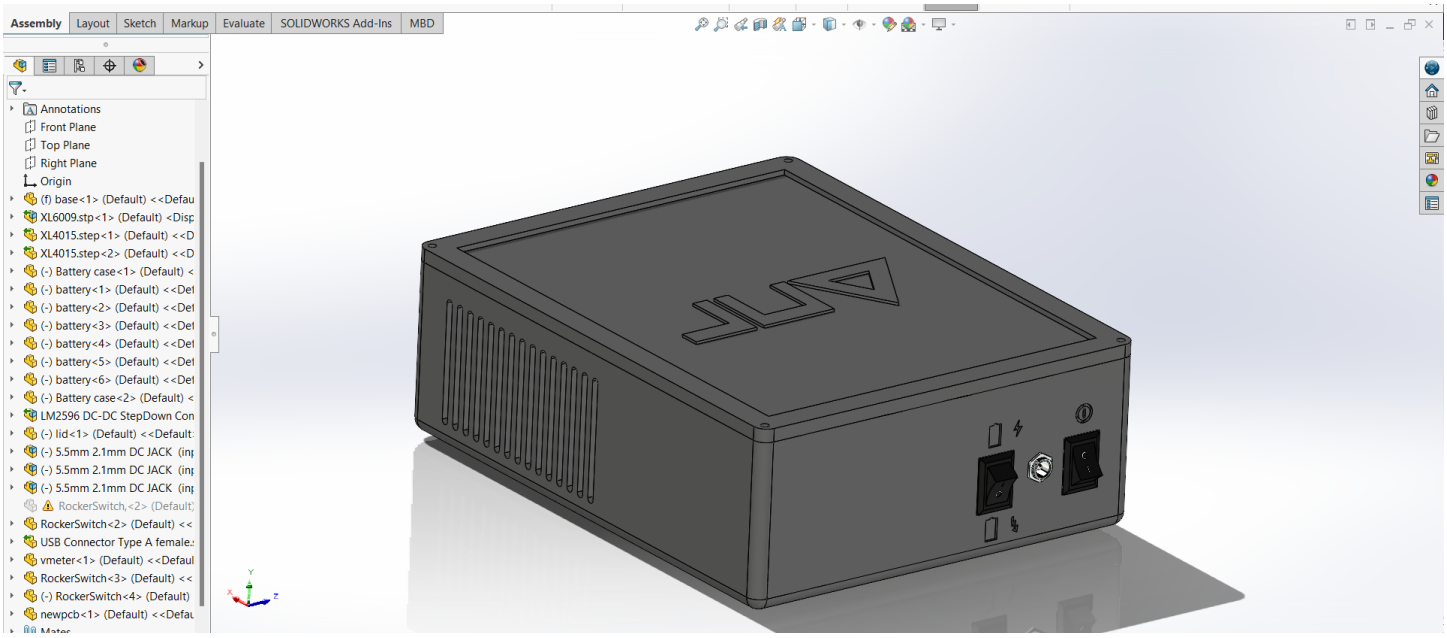
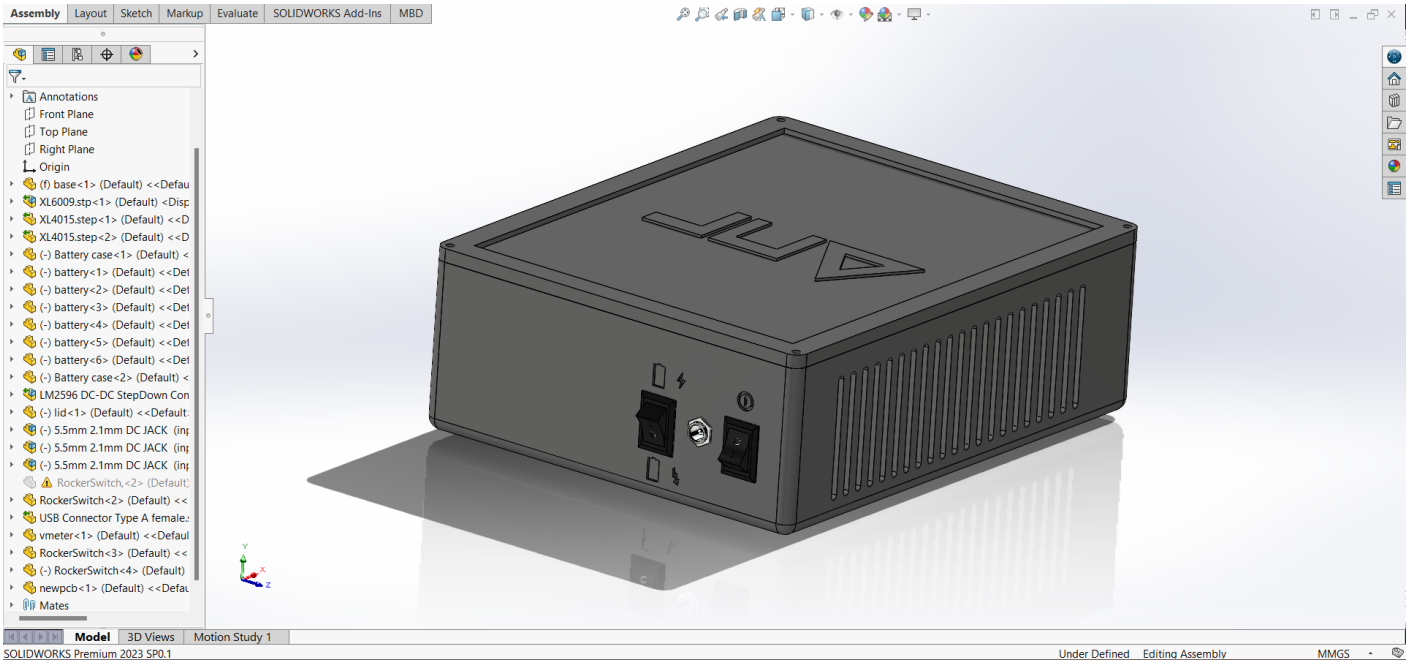


Figure 10:isometric view



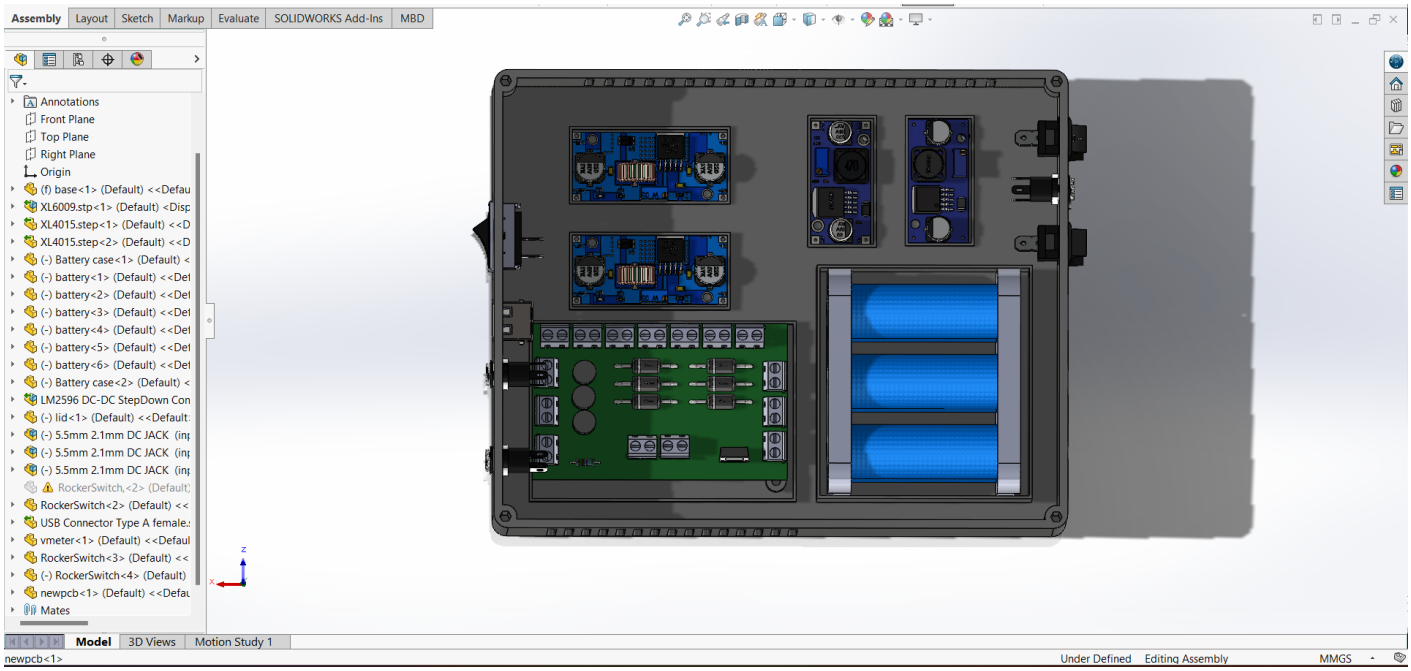


Figure 11:component placements

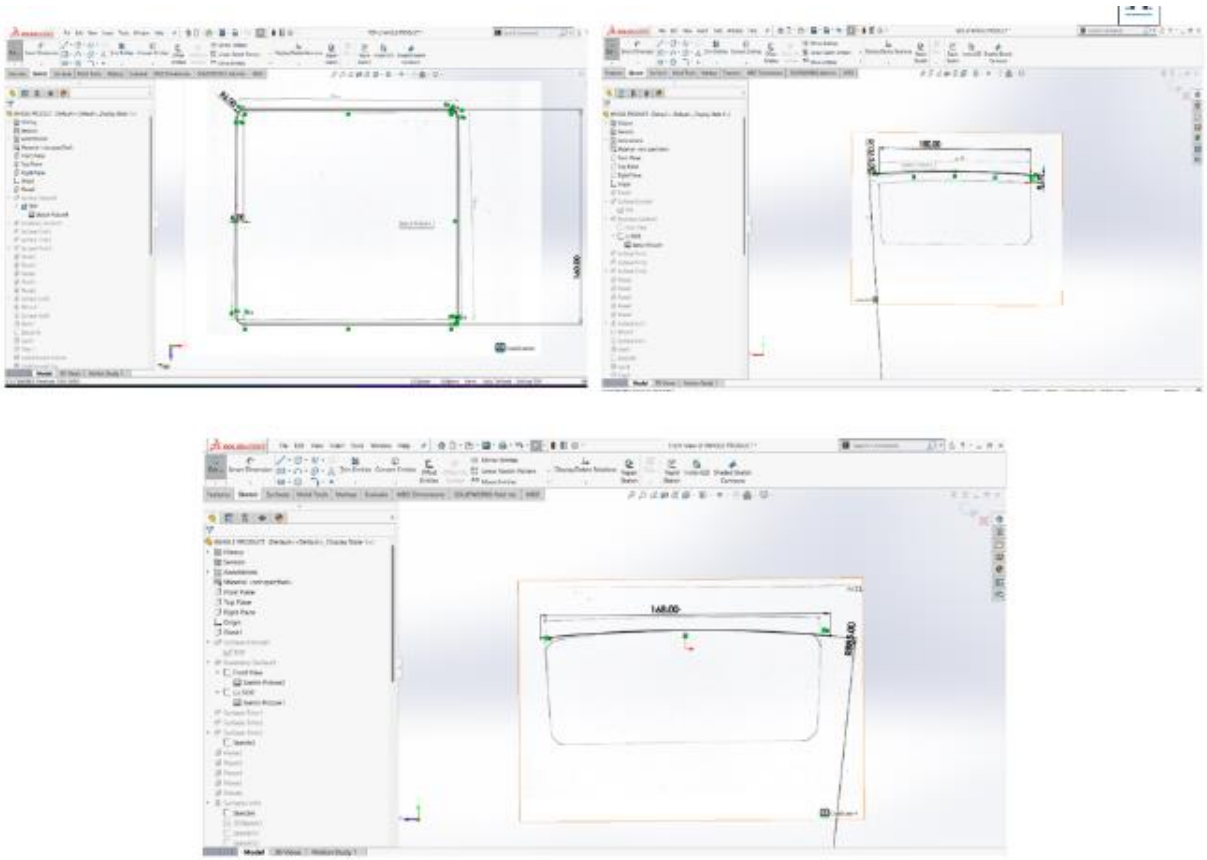


Figure 12: sketches for enclosure

Appendix C

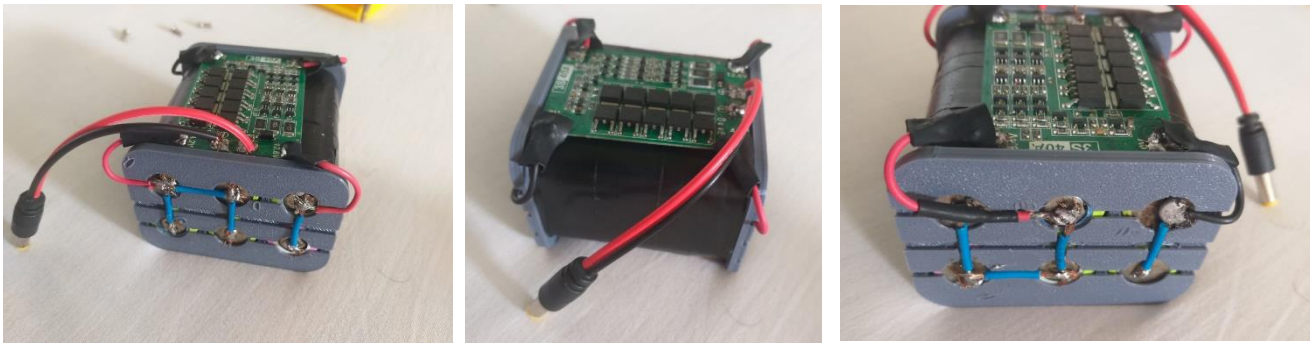


Figure 13: Battery Pack

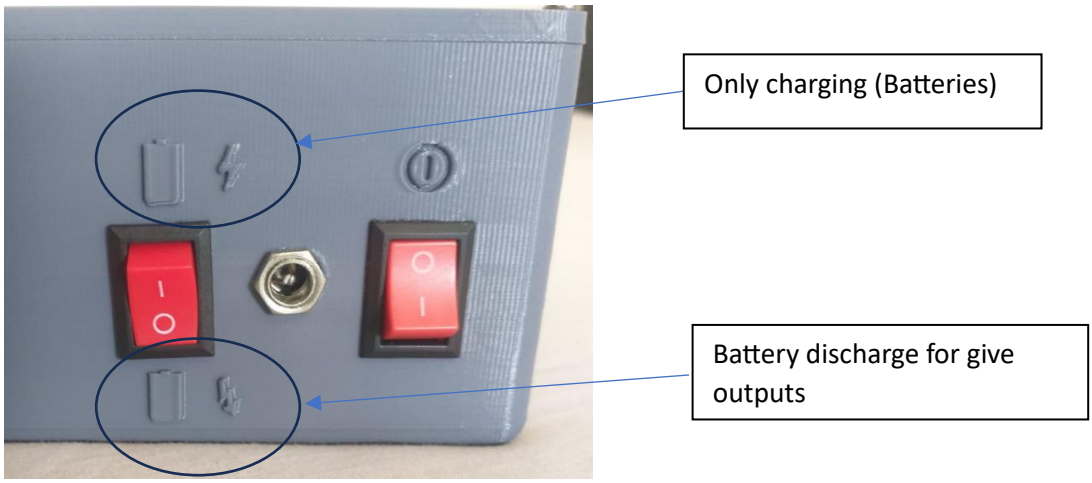


Figure 14: Power Switching Signs

Appendix D

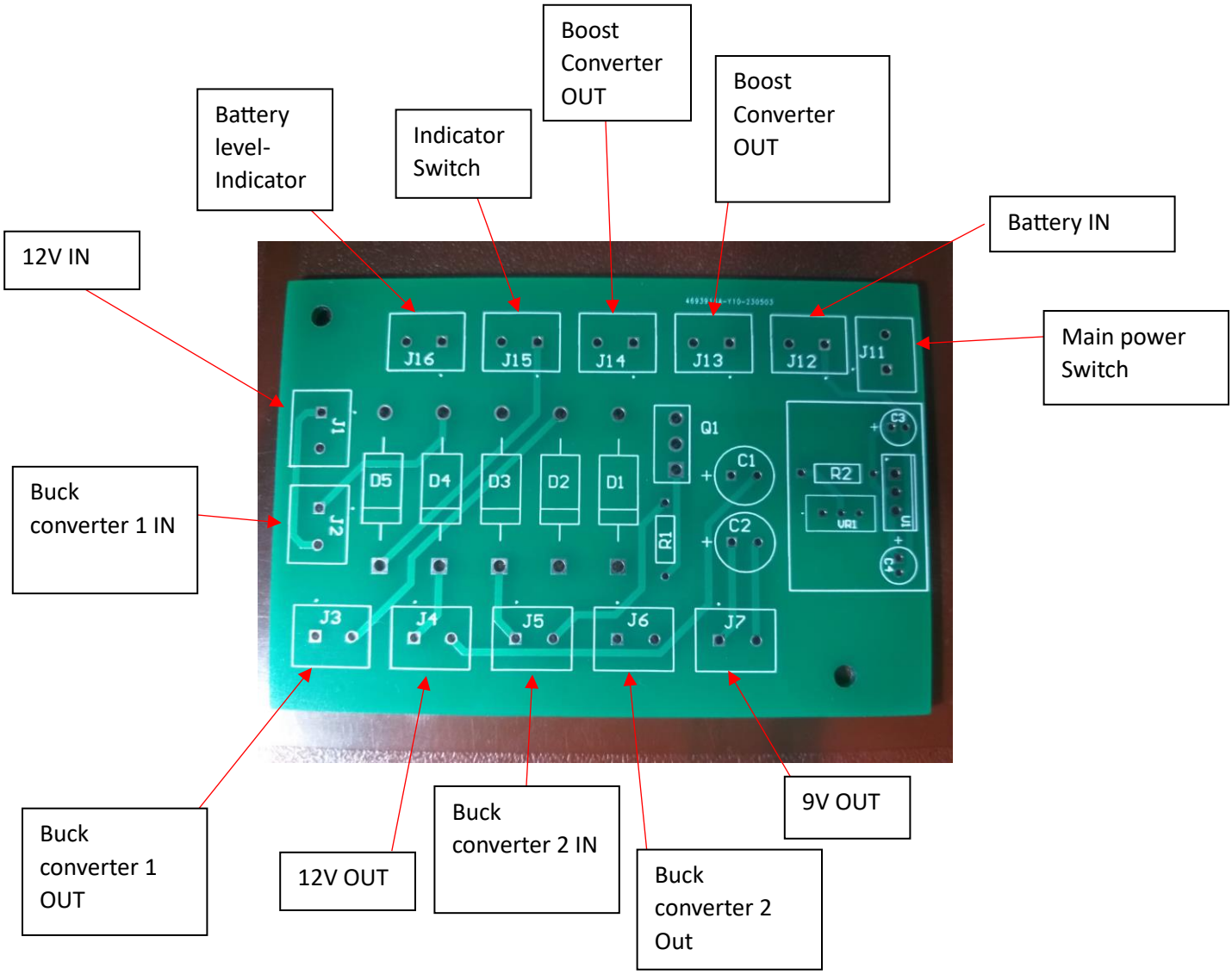


Figure 15: PCB Connections

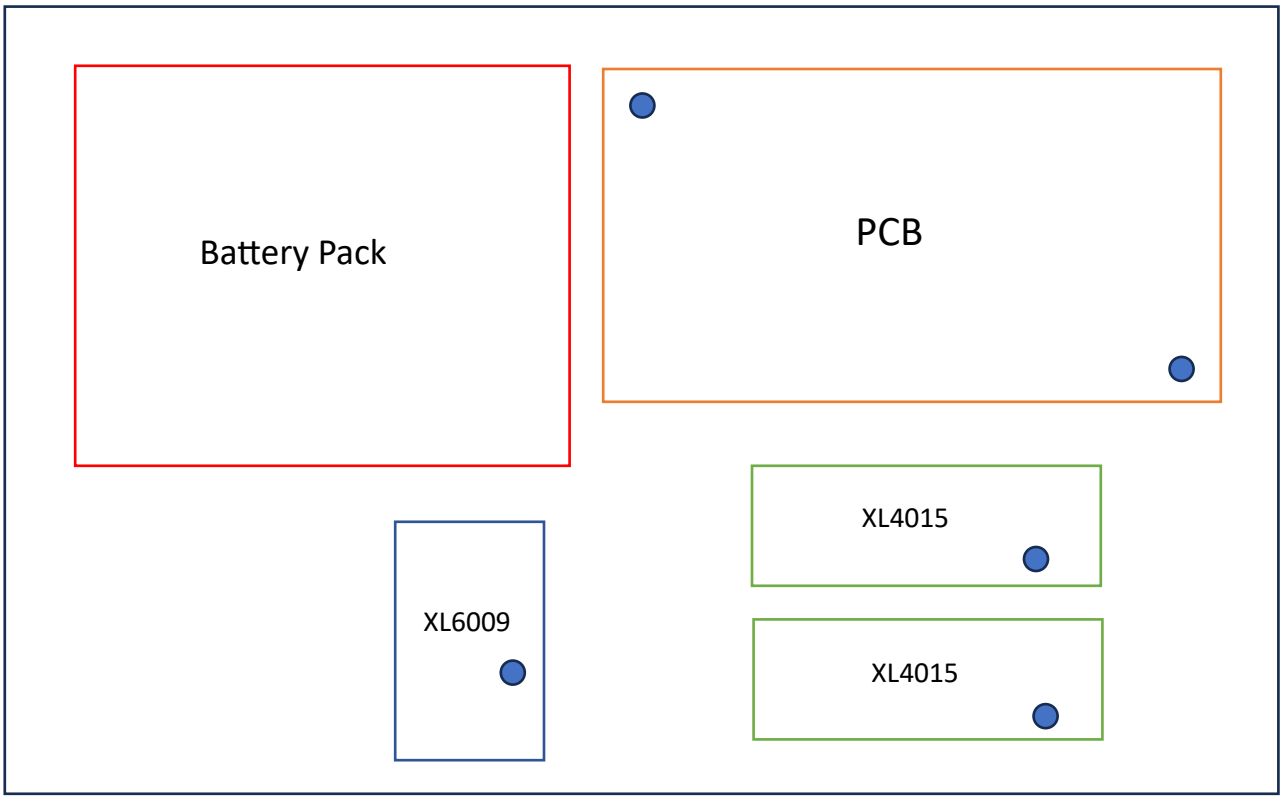


Figure 16: Component Placement

Figure 17: Input Side Placements

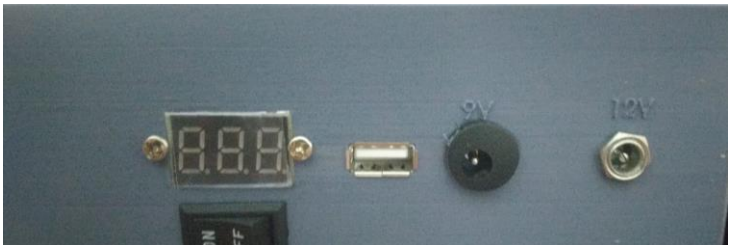


Figure 18: Output Side Placements

There are 4 screw bases as shown below. These should be connected by means of 3mm screws.

Figure 19: Enclosure Lid and body assembly