Automated Power Backup

EN-15 Group Members

1. 200395P H.E.Nilasi Methsarani
2. 200396U C.M.C.Clenson Miranda
3. 200397A M.K.D.M.Mirihagalla
4. 200398D K.Mithushan

Detail Design Project Proposal

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Problem Description

- **Starting point for our design idea**

Government-imposed power cuts that have been occurring in Sri Lanka since January are the worst power outages in over 25 years. The current crisis in our country forced companies and students to continue with the work-from-home policy to reduce the cost of traveling and for the continuity of work. That means our home's Wi-Fi networks are more dependent than ever.

- **Why does it need a solution?**

With ongoing power cuts, online teaching and learning are now severely affected. Parents and teachers said the power crisis, coming on top of the pandemic, has affected students physically and mentally. Anyone with a Wi-Fi connection knows their Wi-Fi will turn off whenever power cuts happen. It annoys us when there is an interruption due to power cuts while we are in an online lecture, webinar, or meeting. Therefore, a large and diverse group of wi-fi users need a solution for carrying out their day-to-day work without any interruptions. One of the best and easiest solutions for that is the use of automated power backup.

- **Who benefits from this solution?**

Backup power isn't just for one person. It can be used by a large number of users who need a reliable wi-fi connection. Students who are following online education and workers who are following the work-from-home policy are the main set of people who will get benefited from the Wi-Fi power backup.

Product Idea Validation

We also did a survey to get some idea about the difficulties and expectations of people who face wi-fi interruptions. The results of that survey are shown below. (Sample size = 308)

- What exactly is the problem?

According to the current situation in our country, long power outages occur daily.

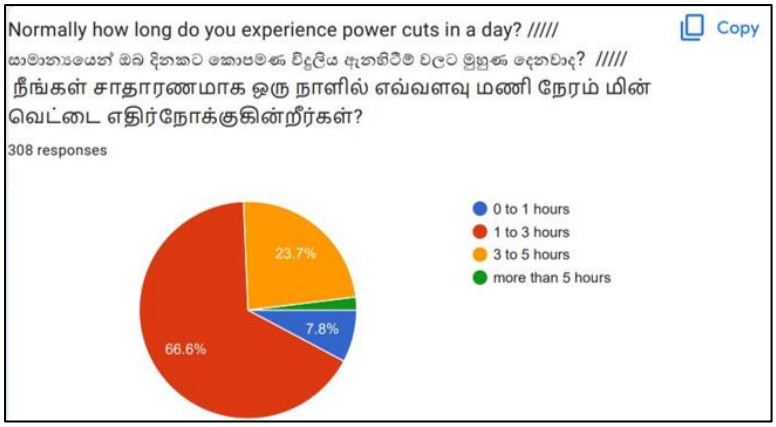


Fig 1: Survey Results 01

Survey Result: Most of the people (66.6%) are experiencing a power cut for 1 to 3 hours in a day. As a result, various difficulties arise in connecting to the Internet through Wi-Fi.

- How does it affect the end users?

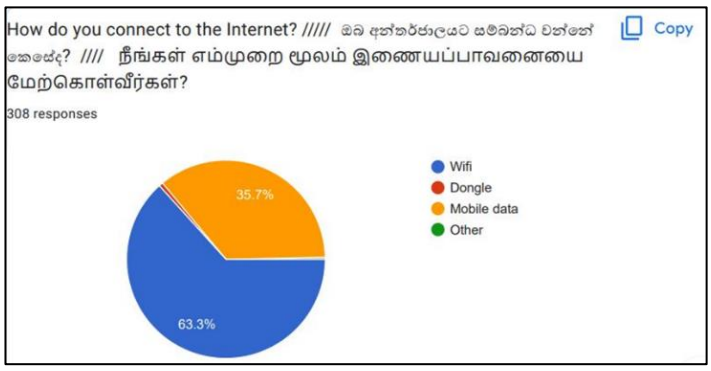


Fig 2: Survey Results 02

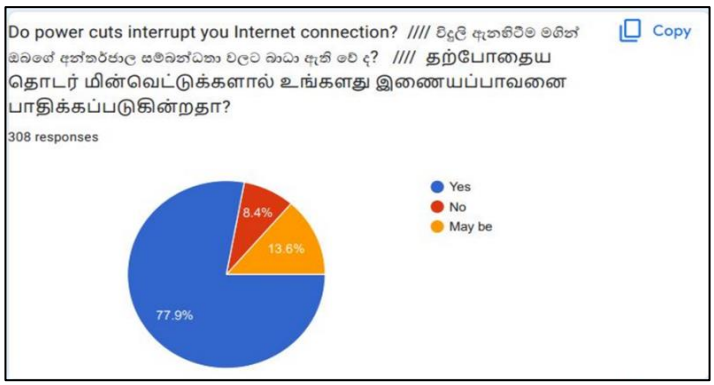


Fig 3: Survey Results 03

Survey Results: Most of the people (63.3%) are connecting to the internet through wi-fi. And majority of the people (77.9%) are facing difficulties due to the power interruptions while connecting through wi-fi to the internet.

Based on the current situation in our country, the learning and teaching process started mostly through the online method. As a result, students are not able to carry out their studies and people who do various jobs through the internet are not able to carry out their jobs in a proper manner due to power outages.

- Are you building the right product?

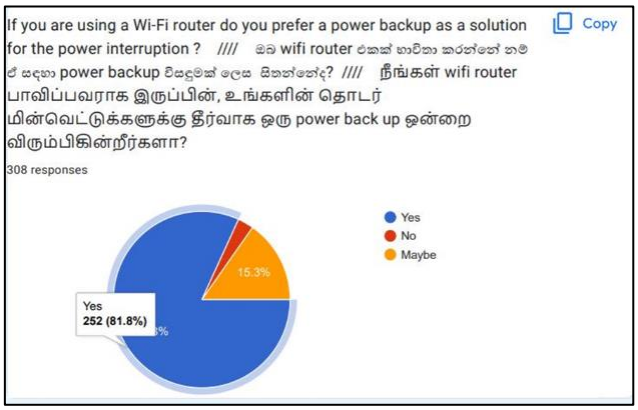


Fig 4: Survey Results 04

Survey Result: Most of them (81.8%) are thinking that the wi-fi power backup is a solution for the power interruptions to the routers.

One of the things that was implied to us through the above survey is that lot of people are facing difficulties in connecting to the internet through Wi-Fi technology due to sudden power outages. Therefore, we intended to create a Wi-Fi power backup as the cheapest and most durable solution for that.

- What do users expect from a power backup?

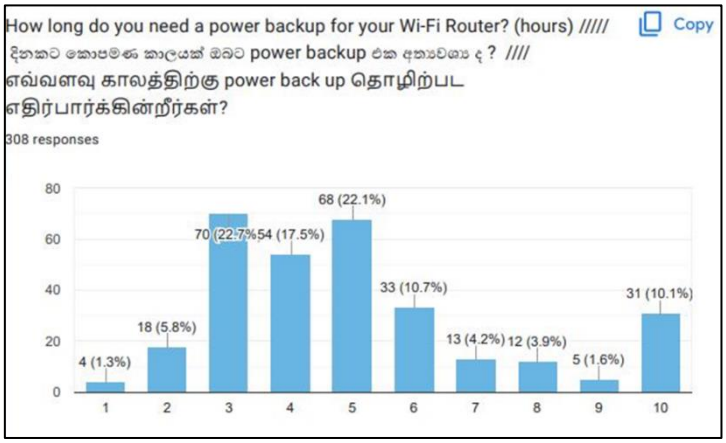


Fig 5: Survey Results 05

Survey Result: Most people are expecting to have a power backup for 3 to 5 hours.

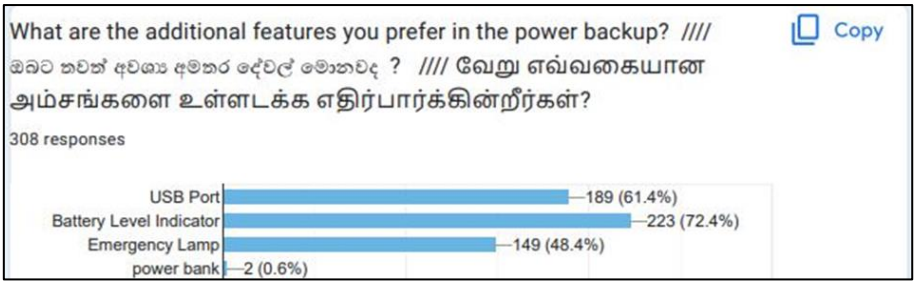


Fig 6: Survey Results 06

Survey Result: Most of the people are preferring a USB port (61.4%), battery level indicator (72.4%), and emergency lamp (48.4%) as additional features of the power backup.

People are expecting a power backup to avoid the difficulties of a sudden power outage and to be able to continue using wi-fi connection for a significant period of time even in the event of a prolonged power outage.

Overall summary of the survey

Almost every person in our country is facing power failure situations. Most people are experiencing power cuts between one to three hours. Majority of the people are using Wi-Fi technology to connect to the Internet. A significant number of people are accessing the Internet using mobile data. Due to the ongoing power cuts many people are facing various obstacles in connecting to the Internet. Most of them are thinking that power backup is the solution to power interruption and continuous internet connectivity. According to the data in the survey, people are expecting a Wi-Fi power backup for 3 to 5 hours a day. As additional features, many people have expressed their preference for the USB port, battery level indicator, and emergency lamp.

Technical Specifications

- **Accuracy of Measurements**
  - Automatic Switching is done by a relay so the tripping time of the router can be neglected. So that the router will remain turned on at the very moment of power interruption.
  - Battery Level is measured by a module. Therefore, the accuracy of indication is also high.
  - Voltage regulation of 12V and 5V is handled by the regulator ICs (7812 and7805). So, we can ensure that the output voltage is exactly 12V and 5V.

- **Power Consumption**
  - Depending on the router user plugs, power consumption may vary. And if a user plugs more devices to the USB, batteries will be drained quickly. Here, user is recommended to plug limited appliances to this product.

- **Product Dimensions and weight**
  - We have planned to design the project according to the following dimensions.

    10cm x 15 cm x 5cm (width x length x height)
  - Weight of the product is approximately 1kg.

    (Note that we can't ensure the Exact measurements yet.)

- **Lifetime of the product**
  - Depending on the appliances the user is going to plug, the lifetime of the batteries will be decided. If only the router is plugged, it is approximated that user can use the router around 3 hours. If it seems like the batteries are drained quickly, user is advised to reinsert the batteries with the help of the manufacturer.

Technical Feasibility

- **12V DC power input for our product**

Users who have the Wi-Fi routers will also have the 12V adapter which convert the 220V AC supply into 12V DC supply with them. This will be our first requirement to get the 12V DC input for our product. And we can achieve this through the adapter of the user itself.

- **Automatic switching between grid power supply and backup power supply**

We use lithium-ion (18650) batteries as a power source in our product to give power to the router when there is any power interruption from the main supply. We have planned when power is available from the main supply. We can directly use that for giving power to the router and charging the batteries at the same time. When power interruptions occur, it will automatically get the power from batteries as a power source for the router.

For switching action, we decided to use a transistor and a relay. By giving the output voltages of the main supply to the transistor, Transistor will swap between the active and cut-off regions of the transistor depending on the availability of power. The relay will be energized due to the current flown through it. Then it will do the switching action. Through this, we can achieve our goal.

- **12V DC to 15V DC conversion to charge the batteries**

For the proper functioning of the router, we must maintain the input voltage of the router to be 12V DC. Manufacturers of the routers have already given the 12V adapter for their products. But for the power backup, we are going to use 4-Lithium-ion batteries 3.7V each. So, the total input from these batteries will be higher than 12V. If we directly connect the inputs from the main supply and from batteries, both will work at the same time to give power to the router even when the power is available. This is not an efficient way, and it may reduce the lifetime of the batteries as well. To overcome this issue, we decided to step up the power output of the adapter from 12V to 15V DC. Then we add a mechanism to charge the batteries (when power is available) and do the switching of the supplies automatically. For this purpose, a step-up module (Ex: MT3608) is used rather than the conventional step-up transformers to design the product with a light weighted, portable and efficient.

- **12V regulation**

But a new problem arises regarding the feeding input voltages to the block. Because after being switched, any of the outputs are not in the required 12V. So, then we need to add a regulating circuit which should give an output of 12V whatever the input is. We decided to use the Regulator ICs for this purpose.

- **Battery level indication**

But there are some areas we must focus on to give a user-friendly product. There is confusion that may arise from the customers regarding the battery level of the batteries. So, we decided to add the battery level indicator block to our product. We plan to give indications of four levels. The number of blocks which are glowing is proportional to the voltage given by the batteries. But if the indicators continuously glow during the working time, batteries may get drained fast as well. So, to overcome this issue, we decided to add a switch which connects the battery level indicator block with the system. If we push the switch the indicator will show the battery level remaining and if not, it remains off.

- **Additional features**

Furthermore, we decided to include some additional features in our product. We thought of including a LED strip and a USB charging port in the design. Because these facilities are also required in the power cut times. So, we decided to modify the earlier regulation block in such a way as to give two regulated DC voltages (12V and 5V). 12V can be used to power up the router. 5V can be used for the LED strip and USB.

- **Enclosure design**

We decided to design the enclosure of the product using Solidworks Software and for PCB designing we tend to use the Altium software and run the simulation whether the circuit is correct or not. After that, we can use the real components and design the circuit manually.

Product Architecture

Our design mainly contains the following blocks. This has aimed at mainly 3 things. Automated switching between the main power supply and backup power supply, regulating voltages to get the outputs 5V & 12V, and stepping up the voltages to get the required voltages to feed into the particular stages. Overall block diagram will be as follows.

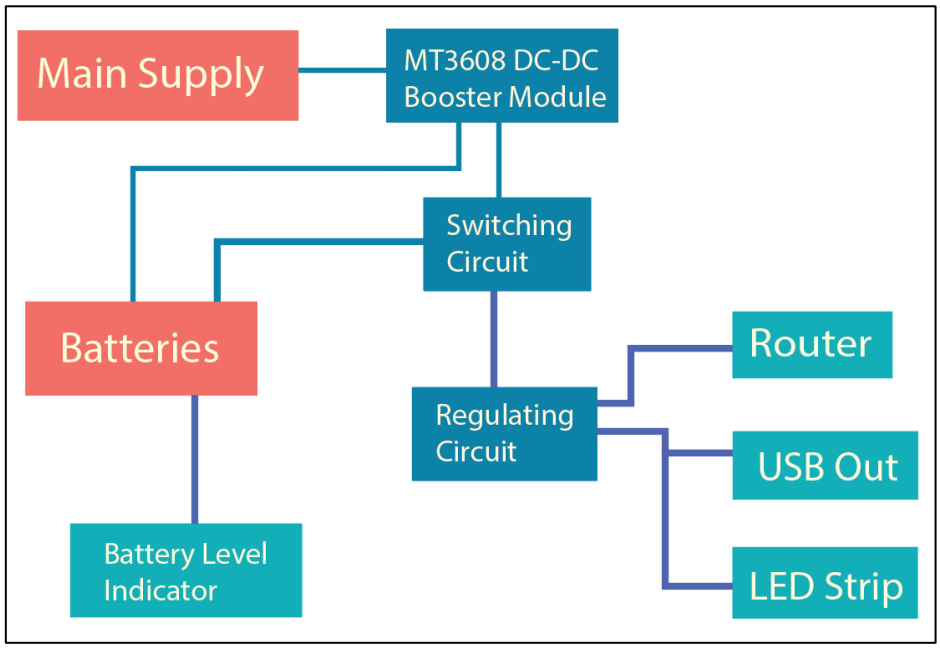


Fig 7: Block Diagram

Functions of Each Blocks

- Block 1: Booster Module
  - MT3608 DC-DC Step Up Boost Power Supply Module is used to get a properly stable output.
  - Input range of the module: 3V to 32V
  - Output range: 5V to 30V

Here we are expecting to set the output to 15V for the requirements of the other blocks.

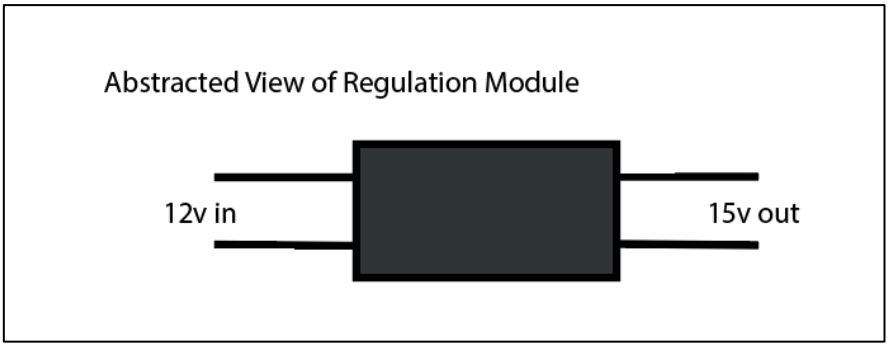


Fig 8: Abstracted View of Regulator module

- Block 2: Voltage Regulator
    - In this block, whatever the input is given to the block, the output of this block is going to be either 5V or 12V. Then the 12V out will be directed to power up the routers, 5v is taken out for the USB out and for the LED strip. To Ensure the Exact 12V and 5V, we are going to use regulated ICs.
      (Ex: 7805 and 7812)

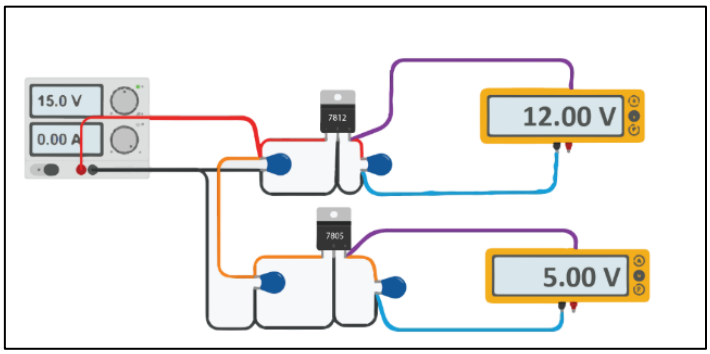


Fig 9: Voltage Regulator Model

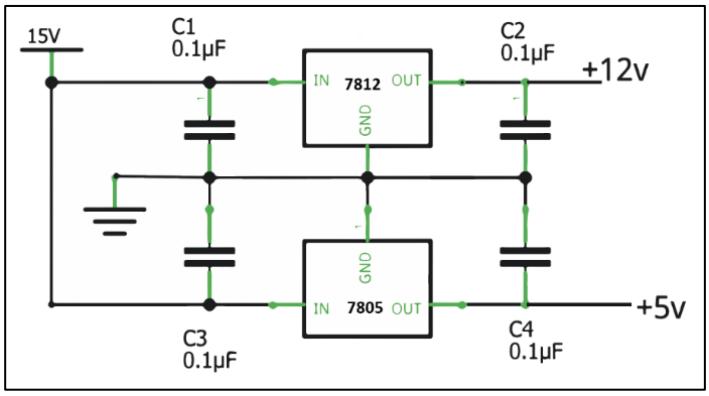


Fig 10: Circuit Diagram of Voltage Regulation

- Block 3: Switching Mechanism
    - When power is available

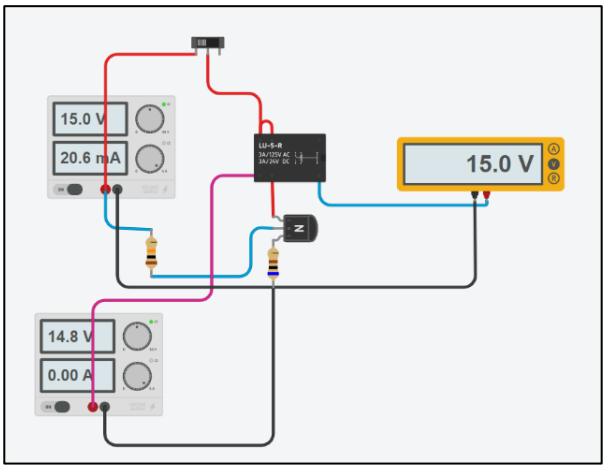


Fig 11: Switching Mechanism (When power is available)

- The transistor is at its saturation state.
- Then the relay is ON.
- Then the output voltage is given by the main supply (15V).

- When power is not available

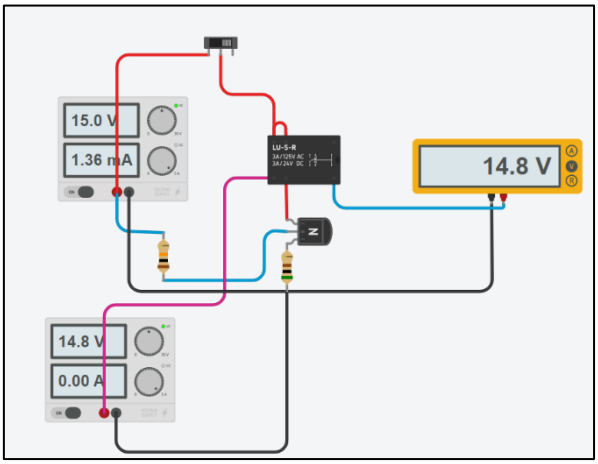


Fig 12: Switching Mechanism (when power is not available)

- The transistor is at the cutoff region.
- Relay is at its Normal close state(N/C)
- The rechargeable batteries will give the output voltage (14.8V).

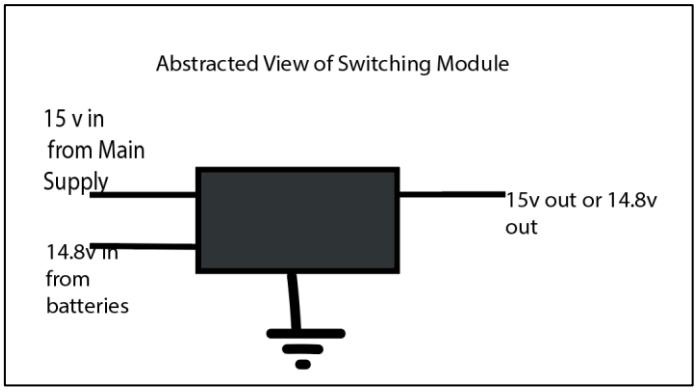


Fig 13: Abstract view of Switching Mechanism

- Block 4: Level Indicator

This Battery Level indicator module will be directly connected to the batteries via the PCB. Then the battery level will be indicated depending on the voltages of the batteries currently it has. A push button will be attached as a cascade to check the remaining Level whenever the User wants to know. This will also save the power of the batteries rather than indicate all the time.

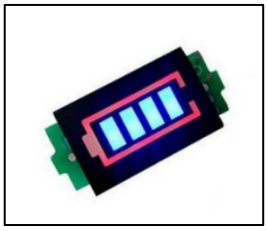


Fig 14: Battery Level Indicator Module

Enclosure Design

Our design is to give an uninterrupted power supply to Wi-Fi routers by automatically changing the AC power to the DC power. Our plan is to make a design which is so simple and handy to use.

- **User Interface (UI)**

User interface of our design is so simple to interact with and we didn't plan any complex controls for our product. The simple description of our product usage is consumers just need to plug in the DC male power jack from the adapter (AC power grid) to the back of our design and then they need to get the input for the router from the front side of our design via a DC male power jack as well.

Fig 15: Isometric View of enclosure (Solidworks)

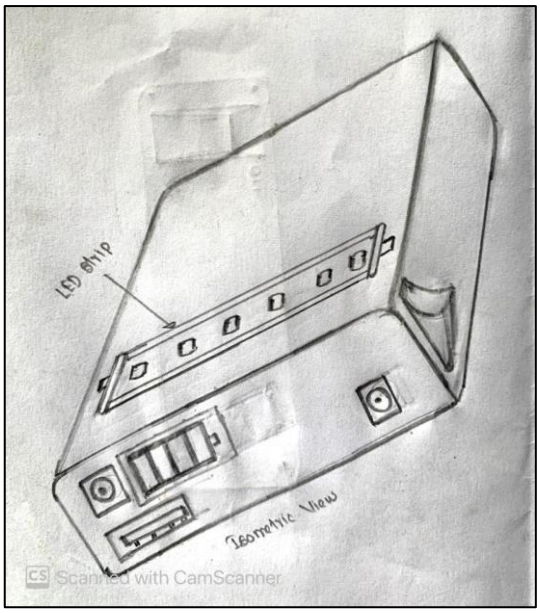


Fig 16: Isometric View of enclosure (Hand-sketched)

Firstly, when we consider about the front side of the design, it'll have 2 ports on it. One is USB A port and the next is DC male power jack socket. Front side of our design is totally dedicated to the output from our deign. As mentioned above, USB A port can be used to charge mobile phones and other electronic devices which requires the input voltage of 5V. And 12V DC male power jack socket will be used to give power to the Wi-Fi router. And a DC male to male extension cord will be given along with our product to the consumers to connect the Wi-Fi router and our power backup.

Other than that, there will be a battery level indicator with a button switch on the front side of our design. The button switch has been dedicated to control the battery level indicator. Initially, we've planned to have the battery level indicator for whole time. But later we realized that it would consume more energy and it'll affect the working hours of our design. So, to avoid that, our design will have a button switch on front. By pushing the switch one can turn on the

battery level indicator and he can get the power remaining during the period when the router is working with the power stored in our design. If the router is working with the grid power, the batteries in our design will get recharged automatically and if one press the button switch, he can get the info about the current recharged level of the batteries.

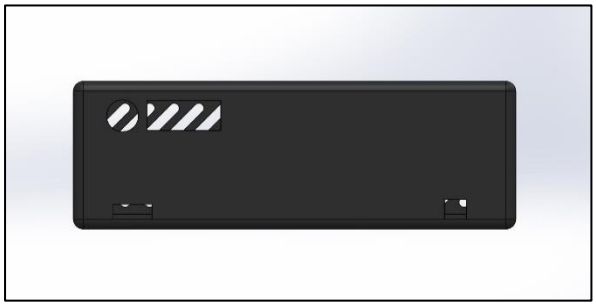


Fig 17: Front View of enclosure (Solidworks)

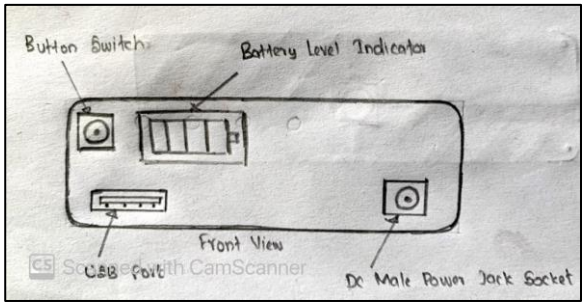


Fig 18: Front View of enclosure (Hand-sketched)

In order to achieve what we have planned; we are using a 'Battery level indicator' module along with a display. The interface of the display will be mentioned as below.

Number of blocks illuminated	During the period of Wi-Fi router working with the battery power	During the period of Wi-Fi router working with grid power
4 blocks	100% power is available (Can work up to 3 working hours)	Batteries are fully charged
3 blocks	Nearly 75% power is remaining	Batteries are 75% charged
2 blocks	Nearly 50% power is remaining	Batteries are 50% charged
1 block	Nearly 25% power is available	Batteries are 25% charged
0	No power remaining (Should charge the batteries)	Batteries are started to recharge

Table 1: Battery Level Indications

Now in the back side of our design there will be a DC male power jack socket dedicated to get the power from AC grid. Other than that, back side of the design will have the air vents to maintain a proper air flow in order to decrease the heating issues.

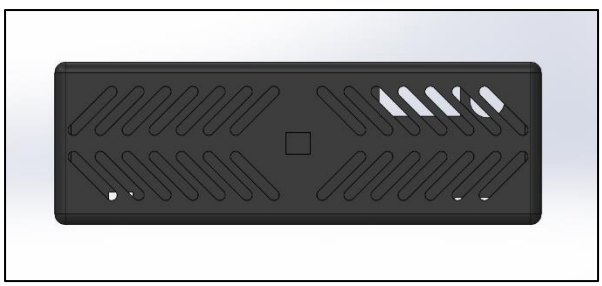


Fig 19: Back View of enclosure (Solidworks)

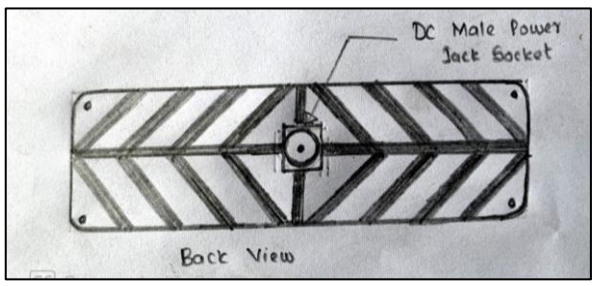


Fig 20: Back View of enclosure (Hand-Sketched)

Next, in the top of our design there will be a strip of LEDs. As mentioned earlier, this will act as an emergency lamp during the power cuts at nights. Controlling switch for this

emergency lamp will be in the side of our design. And we've planned to give a toggle switch for this operation. There will be indications for the ON position and OFF position to avoid unnecessary confusions. And as the controlling switch is on the side of the enclosure, it'll be easier for the users to handle and control during nights.

Fig 21: Top View of enclosure (Solidworks)

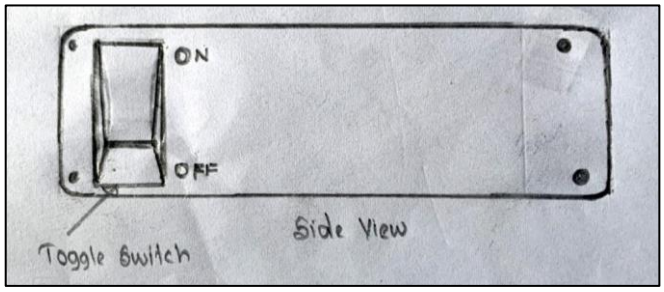


Fig 22: Side View of enclosure (Hand-sketched)

- **User Experience (UX)**

Under the concerns of user experience, as the User interface are so simple and the enclosure has a handy to use appearance, we are hoping that users will get best UX while interacting and using our product. As our product is a multipurpose product, users may experience different phases of our design in various situations, and we are believing that our product will fulfill and satisfy the user's needs efficiently.

- **Ergonomics**

When we consider about the ergonomics, as we mentioned earlier, the enclosure will be in a reasonable size. Therefore, users do not want to worry about the physical space required to place our product. And even, routers can be placed on top our design, so that it'll decrease the space consume even more. And our product can be used as a portable power bank and emergency lamp, our enclosure we've planned is to hold it in one hand and to control it in one hand too.

- **Look and Feel**

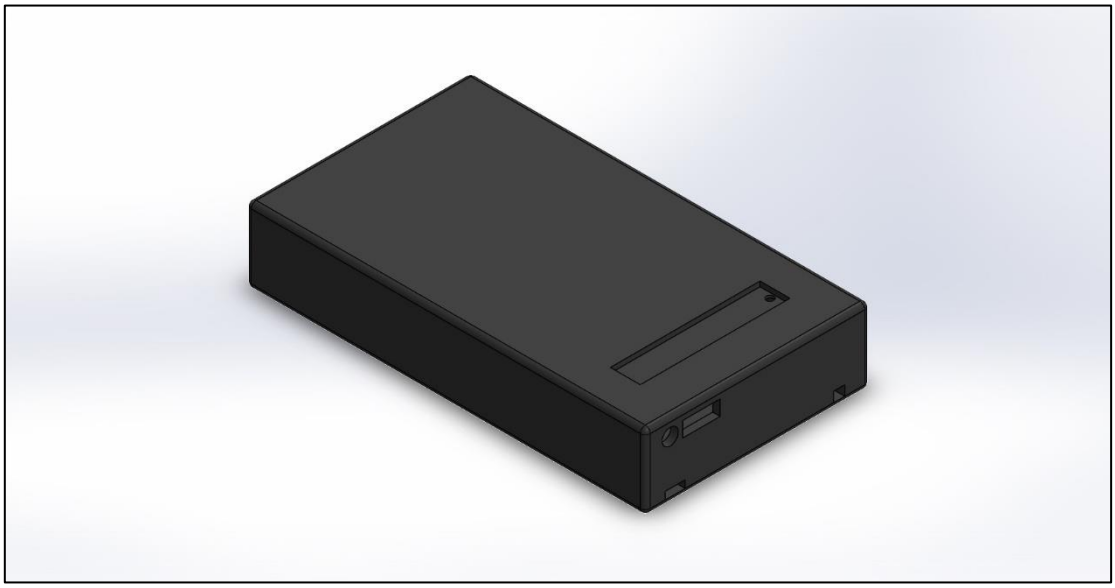
Our design will have curved edges instead of sharp edges. It's to avoid any accidents that may cause and to hold our product easily. And our design won't be shiny, and it will be grippy to hold them while using it as an emergency lamp. As the top and bottom of our product are flat it'll be easier for the users to place our design and even routers can be placed on top of our design to utilize the space.

We've planned to have our product in the color of black. Our enclosure will be made of plastic, the best color for it is black so that they show wear and tear. If the plastic is colored white, the white becomes yellowish over time and loses its appeal, and this is due to sunlight

and UV damage. Moreover, other colors also start wearing off while black stays the same for years. Black-colored objects also do not pick up fingerprints, keeping them consistent overall. A lot of heat is generated by electronics while in use, and the black shade is the best to help manage and diffuse it. As the black color absorbs heat, the product acts as a heat-sponge and soaks up all the internal heat. Hence, as black can absorb more heat than it can dissipate, there is a net loss in temperature, keeping the surroundings comparatively cooler.

- **Size and weight**

As it's a power backup for a router it cannot be bulky and heavy. Even though the power storage consumes more of the space of the enclosure, we have planned to utilize the inner space of the enclosure to the maximum. And, as it used as a portable power bank and emergency lamp it has to be small enough to carry it in one hand and also it can't be so heavy. So, the approximate dimension we've planned is 10cm x 15 cm x 5cm (width x length x height). (But we can't ensure the exact dimension of our design as we didn't know about the size of the PCB). In terms of weight our plan is to have it under 200g. (It may vary because of the weight of PCB and batteries). To make the weight more less, our enclosure we have planned is fully plastic.



Marketing and Sales

- **Product packaging**

Packaging can help to sell and market products because it allows us to provide detailed information to the consumer who may be looking to buy. So, we decided to design the packages in such a way to attract the consumers and provide the clear idea about our product. We decided to print the color pictures of the enclosure in different angles on the cover box of the product with the indication of the product. We will use the right color which attract the customers for the background of the package.

We planned to take further research and analysis based on the surveys done in the past to give our product to the market. First, we will find the correct target peoples who suit to our product. Then we will take the steps to introduce our products to them. In our case, main target circle are the workers and students who badly need the uninterrupted internet connection for their continuous activities. We planned to start our advertising and related things from that side. We may do some presentations regarding to our products in schools and other offices just like a launching done by big companies.

- **Maintenance**

Proper maintenance is important for efficient use of any product. In our product there are certain areas we must consider.

To expand the lifetime of the products there are some tips:

- Keep the product in correct temperature range
  - Since our product using the Lithium-ion batteries, it is recommended to maintain the temperature within 15C-35C
- Test the batteries regularly
  - The best battery test method is the impedance test. This can be done by applying an AC signal and then measuring the AC voltage loss across the length of the battery. If the battery shows a high value for the impedance, then it should be replaced.
- Store batteries in a cool, dry place
  - Humidity and water can affect the battery and other circuit components. They induce corrosion and lead to reduction of lifetime of the product.
- Airflow is also important when storing batteries. So, packing the device in a tight box also affects the lifetime of batteries.

Other than that, overcharging also affects the device's lifetime. If the battery level is full, then it is recommended to stop the charging. If the device is charging for a longer time, then batteries may explode.

- **Reuse/Recycle/Replace**

Since our device was designed in the vision of fulfilling multi purposes, we are also considering the reusability of the device. Our device can use as a flashlight or charging device (for Phone and other devices) along with the Wi-Fi backup facility. Even if any collapses in the battery block, we can use the other functions like USB charging and flashlight. Because these are independent from the battery block.

Since we are designing such that, the separate functions are allocated in separate blocks, we can replace the block or module easily if we notice a malfunction in the device. For example, we can replace the battery if the existing battery has any defect or if the regulating function does not work properly, we can replace the module with a new one.

If the circuit board of the product has any defects, we must design the new board, but we can simply use the existing components if they are working properly. We can also use the individual components for some other purposes as well.

- **Disposal**

Devices containing lithium-ion batteries should not go in household garbage or recycling bins. Lithium-ion batteries should be removed from the product. These batteries can be recycled in separate methods. Then we can dispose the remaining part in a way a plastic product must dispose.

Project Budget

No.	Component	Price (LKR)
1.	MT3608	300.00
2.	7805 IC	15.00
3.	7812 IC	50.00
4.	0.1 µF capacitors x 4	20.00
5.	SPST relay (9V or 6V)	100.00
6.	D400 transistor	40.00
7.	Resistor 1k x 2	10.00
8.	Battery level indicator	400.00
9.	3.7 V Batteries x 4	2400.00
10.	5V LED strip	300.00
11.	USB out	30.00
12.	Wires and Switches	135.00
	Sub-total	3800.00
	Manufacturing cost (PCB & Enclosure)	700.00
	Total	4500.00

Table 2: Bill of Quantities

Units to Manufacture = 100

Profit per unit = 10%

Selling Price per unit = 4500.00 + 10% of 4500.00

= 4950.00 (LKR)

-THANK YOU-