ELP305| Design and Systems Laboratory

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Week 3 Report

Tribe C: Cadmus

Id	v4.0
Tribe	Tribe C
Submitted to	Prof. Subrat Kar, Course Coordinator |ELP305: Design and Systems Laboratory
Date of Submission	28/02/2023

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2. Document Statistics

Table 1. Document Statistics

2.1. Readability Indices

Table 2. Readability Indices Values And Ideal Ranges

Index	Value	Range
Readibility	60	0-100
Gunning Fog Index	8.6	0-20
Flesch Reading Ease	39.4	0-100
Coleman-Liau Index	13.24	0 - (17+)
Automated Readability Index	11	5-22

3. List of Abbreviations

S.No.	Abbreviation	Stands for
1	Cdd	Bypass Capacitor
2	Cin	Input Capacitor 1
3	Cin2	Input Capacitor 2
4	Cout	Output Capacitor
5	D2	Schottky Barrier Diode 1
6	D3	Schottky Barrier Diode 3
7	Dac	Diode Bridge Rectifier
8	Dsnub	Snubber Diode
9	Dz1	Transient Voltage Suppressor
10	L1	Input Inductance
11	Rbld	Pre-Load Resistance
12	Rcs	Current Sense Resistor
13	Rcbc	Cable Compensation Resistance
14	Rdd	Bypass Resistor
15	Rfbb	Voltage Divider Lower Resistance
16	Rfbt	Voltage Divider Upper Resistance
17	Rl	Inner Resistance
18	Rlc	Line Compensation Resistor
19	T1	Transformer

S.No.	Abbreviation	Stands for
20	U1	Flyback Controller
21	U2	Wakeup Monitor
22	M1	Mosfet

4. Requirements

Here are the requirements we have compiled for the following:

4.1. Input/Output

1. Input Voltage: 100-240V AC, 50-60 Hz
2. Output Voltage: 5V and 9V with maximum output current of 2.4A and 1.67A respectively

4.2. Plug

1. The plug should fit well in the socket to prevent it from being accidentally pulled out.
2. The plug needs to be sturdy enough to endure being inserted and removed from the socket several times.
3. There should be no sharp edges or other metal protrusions on the plug that might cause an electrical shock.
4. The plug needs to be safe by the standards of the market it's destined for, such as BIS in India.

4.3. Safety Features

1. Over-voltage, over-current, and short-circuit protection.
2. FCC, CE, RoHS, and UL certification for safety and quality assurance.
3. Energy efficiency compliance with Bureau of Energy Efficiency (BEE) standards.
4. High resistance in a circuit may cause other parts to overheat and fail. To be safe, we should aim for a temperature of 45°C or less while operating at full capacity.
5. There should be good insulation from interference, voltage surges and electrical noise. PP/PE insulation is the standard norm.

4.4. Cable

1. A cable length of 90 cm would be suitable, as it allows for more flexibility in positioning the charger and the phone while charging.
2. The length of the cable can affect the safety and the thermodynamics of wire heating. Longer cables generally have more resistance than shorter cables, which can lead to an increase in the amount of heat generated during charging. This can be a safety concern, as excessive heat can damage the charger, the cable, and the device being charged.

3. The potential of a short circuit or other electrical hazards increases with cable length, which is already more vulnerable to physical damage and wear and tear.
4. Use only cables and chargers that have been certified as safe by the appropriate authorities and only for their intended use to reduce the potential for harm. That means not just ensuring the cable isn't frayed or broken, but also utilising the suitable cable for the device.
5. Thermodynamic considerations for wire heating should be made while designing both the cable and the charger to ensure maximum charging efficiency and to reduce the amount of heat created by the cable and the charger.

4.5. Connector

1. Type-C USB connector for charging newer models of mobile phones after Dec 31, 2024, as it will become the standard in India.
2. Connector should have fast charging capability.
3. The connector should conform to current specifications for charging mobile devices.

4.6. Exterior Body

1. We should keep the size of the charger to be 10 cm in length and 4 cm in width for easy portability as well as light in weight.
2. The charger should also be able to withstand sudden impacts, such as falling on the ground, without damage to the inner circuit.

5. Specifications

5.1. Charger Cable

5.1.1. Requirements of a USB type C Cable

A USB Type-C charging cable must meet certain requirements in order to be compliant with the USB Type-C specifications. These requirements include:

1. Connector Type: The cable must have a Type-C connector on one end and a USB Type-C connector on the other end.
2. Pin Assignments: The cable must be wired according to the USB Type-C pin assignments, which include power and ground pins, data pins, and configuration pins.
3. Cable Length: We will use cable of length 1 m.
4. Voltage and Current Rating: The cable must be rated for a voltage of 20 V and a current of 5 A.
5. Cable Impedance: The cable impedance should be 90 Ohm.
6. Connector Dimensions: The Type-C connector should be 8.4 mm wide and 2.6 mm thick.
7. Contact Resistance: The contact resistance of the Type-C connector should be equal to 20 mOhm.

8. Insertion/Retention Force: The insertion force for a Type-C connector is 10 N maximum, and the retention force is 7 N minimum.
9. Data transfer: The cable should support data transfer up to 10 Gbps.
10. Power Delivery: The cable should support power delivery up to 100 W.
11. Audio/Video: The cable should not support audio/video signal transmission.
12. EMI/RFI Shielding: The cable should be shielded to protect against electromagnetic interference (EMI) and radio frequency interference (RFI).
13. Cable jacket: The cable jacket should be made of durable and flexible materials that can withstand repeated bending and twisting.
14. Compliance: The cable must comply with the USB Type-C specifications and be certified by the USB-IF (USB Implementers Forum).
15. Cable gauge: The copper wire diameter used in the cable affects the charging speed and power delivery capability, typically 26 or 28 gauge copper wire is used in Type-C cables. The diameter of the copper wire used in a Type-C mobile charging cable will be 0.75 mm. The diameter and thickness of the insulating PVC used to cover the wires of a Type-C charging cable can vary between different cables. The PVC diameter usually will be 6 mm, while the thickness will be around 1 mm .In general, the PVC should provide adequate insulation to protect the wires while also allowing the cable to be flexible and durable.

5.1.2. Manufacturing process

The manufacturing process of a Type-C USB cable involves several steps:

1. Raw materials procurement: The first step is to acquire the raw materials required for the cable, such as copper wire, PVC insulation, and the Type-C connector.
2. Stranding: The copper wire is then stranded together to form the conductors of the cable. The number of wires used and the way they are stranded together will depend on the desired specifications of the cable, such as its thickness and flexibility.
3. Insulation: The stranded wires are then coated with PVC insulation to protect them and prevent electrical interference.
4. Connector assembly: The Type-C connector is then assembled, which involves inserting the conductors into the connector and soldering them in place.
5. Cable assembly: The insulated conductors are then inserted into the PVC jacket and the connector is attached to one end of the cable.
6. Testing: The cable is then tested to ensure that it meets the required specifications and standards. This includes testing for continuity, insulation resistance, and electrical safety.
7. Packaging: The final step is to package the cable for shipment to customers.

5.1.3. Standards & Compliances for a USB type-C Cable

The detailed standards and regulations for a Type-C USB cable include:

1. USB 3.1 specification: This specification defines the physical and electrical characteristics of the

Type-C connector and cable. It covers the pin assignments, connector dimensions, and cable assembly requirements for the Type-C connector.

2. USB Type-C Cable and Connector Specification: This specification defines the requirements for Type-C cables, including the maximum cable length, voltage and current rating, and cable impedance. It also defines the requirements for the Type-C connector, including the connector dimensions, contact resistance, and insertion/retention force.
3. USB Power Delivery Specification: This specification defines the requirements for power delivery over a USB Type-C cable, including the maximum power level of 100W and the various power profiles that a cable should support.
4. USB-IF Compliance Testing Program: This program is run by the USB Implementers Forum (USB-IF) and includes a series of tests that a Type-C cable must pass in order to be compliant with the USB-IF standards.
5. Safety Standards: The cable must comply with safety standards such as UL, CE, FCC, and RoHS. These standards ensure that the cable is safe to use and does not pose any hazards to the user.
6. EMC Standards: The cable must comply with the Electromagnetic Compatibility (EMC) standards for cables, which ensure that the cable does not cause interference with other electronic devices.
7. Environmental Regulations: The cable must comply with environmental regulations such as REACH, WEEE, and RoHS. These regulations ensure that the cable is made of materials that are safe for the environment and that it can be recycled or disposed of safely. Country-specific regulations: Depending on the country where the cable is sold, it might be required to comply with additional regulations and standards.

5.1.4. Materials Required

The materials required in the manufacturing process of a USB Type-C cable include:

1. Copper wire: The cable core is made of copper wire, which is responsible for the electrical conductivity of the cable. The copper wire is typically stranded and coated with a layer of insulation to prevent short-circuiting.
2. Insulation materials: The insulation materials are used to coat the copper wire to prevent short-circuiting and to protect the wire from physical damage. The insulation materials can be made of PVC, TPE, rubber, or other materials.
3. Shielding materials: Shielding materials are used to protect the cable from electromagnetic interference (EMI) and radio frequency interference (RFI). The shielding materials can be made of aluminum foil, braided wire, or other materials.
4. Connectors: The connectors are the parts of the cable that connect to the devices. The connectors can be made of plastic or metal and typically have metal contacts for electrical connectivity. Cable jacket: The cable jacket is the outer layer of the cable that protects the other components from physical damage. The cable jacket can be made of PVC, TPE, rubber, or other materials.
5. Adhesive materials: Adhesive materials are used to hold the various components of the cable together and to ensure that the cable is durable.
6. Labels, Markings and Packaging: The cable is often labeled with the manufacturer’s

information, certifications, and other information, and is packaged for distribution.

5.1.5. Pricing

1. Copper wire: The price of copper wire can range from $2 to $5 per pound (360 - 900 Rs/kg). This will roughly cost us 10 - 11 Rs (considering 1 m length wire and 4 copper wires with diameter 1 mm).
2. Insulation materials and cable jackets: The price of insulation materials and cable jackets, such as PVC or TPE, can range from $0.5 to $1 per pound (90 - 180 Rs/kg). This will cost us roughly 5 - 6 Rs (considering 1 m length and inner radius of 2.5 mm and thickness 1 mm).
3. Shielding materials: The price of shielding materials, such as aluminum foil or braided wire, can range from $1 to $2 per pound (180 - 360 Rs/kg). This will cost us roughly 5 - 6 Rs.
4. Connectors: The price of connectors can range from $0.1 to $0.5 per piece, depending on the type and quality of the connector (18 - 90 Rs/kg).
5. Adhesive materials: The price of adhesive materials can range from $0.05 to $0.1 per pound (9 - 18 Rs/kg).
6. Labels, Markings, and Packaging: The cost of labels, markings, and packaging can vary widely depending on the materials and methods used.
7. Overall cost ~ around 25 - 30 Rs (including additional costs of label, adhesive materials etc).

5.2. Charger Adapter

5.2.1. Shape and Size

1. Rectangular body (Box shape) with rounded corners.
2. The body will have a length of 7.5 cm, a width of 4.5 cm, and a height of 2 cm.

5.2.2. Materials

The main body of a mobile phone charger is typically made of plastic or metal.

Plastic is a popular choice because it is lightweight, inexpensive, and can be easily molded into various shapes and sizes. ABS (Acrylonitrile Butadiene Styrene) is a commonly used plastic material for the main body of a mobile phone charger, as it is durable and has good heat resistance. Hence, we will use ABS for making our chargers due to the above factors.

5.2.3. Colour

1. Typically, we have chargers in black and white colors.
2. We can make chargers in different colors too, like red, yellow, etc.

5.2.4. Standards & Compliances

The battery charger should be designed according to IEEE-1547, SAE-J2894, and similar standards such that the amount of harmonic and DC current injected into the utility grid must be controlled within the preset limit.

There are several standards that mobile phone chargers must adhere to in order to ensure safe and efficient charging of devices. Some of the most important standards include:

1. USB Charging: The USB (Universal Serial Bus) standard is widely used for charging mobile phones and other devices. USB chargers typically provide 5 V of power and can deliver up to 2.5 watts (500 mA) of current.
2. USB Power Delivery (USB-PD): USB-PD is a newer standard that allows for higher power charging up to 100 watts. This standard allows for faster charging and also supports charging of laptops and other devices.

These are the most common standards in the market, but there are others such as the European Union’s Energy-related Products (ErP) Directive, which limits the standby power consumption of devices, and the safety standards like UL, CE and FCC.

Our charger body should be compatible with these standards and should be safe to use at these specifications.

5.2.5. Pricing

The material we are using for charging is ABS (Acrylonitrile Butadiene Styrene), and the approximate weight of one charger body will be around 20 g. As of Jan’22 - Dec’22 the price of ABS is around 95 - 125 Rs/kg. So, considering the mass production of the charger body we can assume that we can make 30 - 35 charger bodies per kg of ABS material. Hence, it will cost around 4 Rs per charger body.

5.3. Electric Plug Pin

5.3.1. Material Options

1. Copper
2. Aluminium

5.3.2. Plating/Coating

Stainless Steel, and any finish as per customer requirements.

5.3.3. Features

1. Provide Quick and Easy Installation
2. Provide Space Saving Connection and Installation
3. Corrosion and Rust Resistant
4. Provide High Electrical Conductivity
5. Available with Safety Standards and Compliance
6. Custom Specific Range also available

5.3.4. Type-C

The Type-C plug or Euro plug is ungrounded with two round pins that converge slightly towards their free ends.

5.3.5. Other Specifications

Index	**Value**
Socket standard	CEE 7/17
Power rating	16 A/250 V
Grounded	No
Polarized	No
Fused	No
Insulated pins	No

6. Abstract

This report includes the requirements and specifications for the mobile charger designed by tribe CADMUS. We first compiled a list of requirements any commoner would expect from a mobile charger. Upon researching about the same, we trimmed our requirements to specifications we could actually incorporate. Major focus was to make our device accessible and future ready, keeping in mind the legalities involved. We ensured that our mobile charger was compatible with each standard and was safe to use at these specifications. We also kept in mind the prices of various raw materials used in the charger for our aim of catering to the masses.

7. Motivation

Exploring the device that we use everyday was actually the fun part. Observing the intricacies and realising the simplicity of the charger was motivating. It was thrilling to implement the electrical circuits knowledge we gained in high school and first year. The mechanical team realised size limitation most companies are facing and balanced the tradeoff in compactness and efficiency. We have also added the scope of improvement that was result of extensive brainstorming among our enthusiastic members.

8. Working

A mobile charger is a device that converts AC (alternating current) power from a wall outlet into DC (direct current) power that can be used to charge the battery of a mobile phone. The following steps will explain how our mobile charger works:

1. The charger is plugged into an AC power outlet, which supplies the charger with the required voltage (220V AC, it can vary from 100-240V) and current to operate.
2. The AC input is then passed through a bridge rectifier which converts it to DC voltage. This

rectifier has 4 HD06-T diodes with 2 terminals for the input and output signal.

3. The DC voltage then passed through a ripple remover which minimizes the AC ripples in the rectifier's output for a smoother output.
4. This DC voltage produced is passed to a flyback controller (UCC28730) which converts DC back to high frequency AC. The UCC28730 is an isolated-flyback power supply controller that uses primary-side winding sensing to offer precise voltage and constant current regulation, doing away with the need for opto-coupler feedback circuits. It's main components are the following:
    1. *VS (Voltage Sense)* - The VS pin is used to sense input voltage, output voltage, event timing, and Wait-state wake-up signaling. It is connected to a resistor-divider that runs from the auxiliary winding to ground. This pin also monitors the VS current produced through RS1 by the reflected bulk capacitor voltage during the MOSFET on-time in order to provide the AC-input Run and Stop thresholds and to adjust the current-sense threshold across the AC-input range.
    2. *CS (Current Sense)* - The current-sense pin is connected to the current-sense resistor by a series resistor (RLC, RCS). The maximum current-sense threshold (VCST(max)) for IPP(max) is roughly 0.74 V, and the minimum current-sense threshold (VCST(min)) for IPP is roughly 0.25 V (min).
    3. *DRV (Gate Drive)* - The DRV pin is connected to the MOSFET gate pin via a series resistor. A gate-drive signal with a 14 V maximum is provided by the gate driver.
5. After getting a high frequency voltage from the flyback controller the voltage is stepped down using a RF Pulse Transformer. They are intended to match impedances, isolate DC currents between circuits, and step down voltage. It has 3 windings - Primary, Secondary and Auxiliary.
6. Following the acquisition of the AC voltage, a half wave rectifier is used to convert the AC voltage to DC voltage. A 560 uF capacitor filters the DC voltage of the AC ripples before being sent to the phone via a USB output.

Our input AC voltage was rectified to DC voltage, and this DC was then converted back to AC at a higher frequency. After that, the AC was stepped down and rectified to produce the final DC output. One may wonder why we can't convert the AC input directly to the final DC output.
The size of the transformer is to blame. You would require a large transformer to step down to a lower voltage for the 220 V supply at a frequency of 50-60 Hz, which is an extremely low range, and this is not possible. Consequently, a high-frequency AC voltage is created with the aid of the flyback controller, which is then stepped down to a lower value by a transformer of an appropriate size.

Usage of Wake-Up monitor (UCC24650)
The wake-up function operates in conjunction with the flyback controller (UCC28730). This feature permits light-load and no-load switching rates to approach 32 Hz to reduce losses but rouses the UCC28730 from its wait state (sleep mode) in the case of a major load step between power cycles. It is not necessary to have a large output capacitance despite the low frequencies in order to retain a good transient response. The UCC28730 monitors the VS input while it is in wait mode in case a wake-up signal arrives. When it does, it reacts instantly by executing a few high-frequency power cycles before resuming its operations in accordance with the control law to recover from the load-step transient and restore output voltage regulation.

8.1. Working Flowchart

```
+--------------+
| Input Signal |
| (220V, 50Hz) |
+--------------+
        |
        v
+--------------+
|     Bridge   |
|   Rectifier  |
+--------------+
        |
        V
+--------------+
|    Ripple    |
|    Remover   |
+--------------+
        |
        v
+--------------+
|    Flyback   |         Wake Up Signal
|   Controller | <-----------------+
+--------------+                   |
        |                  +--------------+
        v                  |    Wake Up   |
+--------------+           |    Monitor   |
|  Transformer |           +--------------+
+--------------+                   ^
        |                          |
        +--------------------------+
        |
        v
+--------------+
|   Halfwave   |
|  Rectifier + |
|  Capacitor   |
+--------------+
        |
        v
+--------------+
|  USB Output  |
|   5V DC      |
+--------------+
```

9. Design Cycle

9.1. Circuit Design

9.1.1. First Iteration

The most fundamental part of designing a charger is its underlying circuit design. The Electrical Team of CADMUS attempted to design a circuit and tested it under various conditions to assess its feasibility. The circuit diagram for our attempt is shown below:

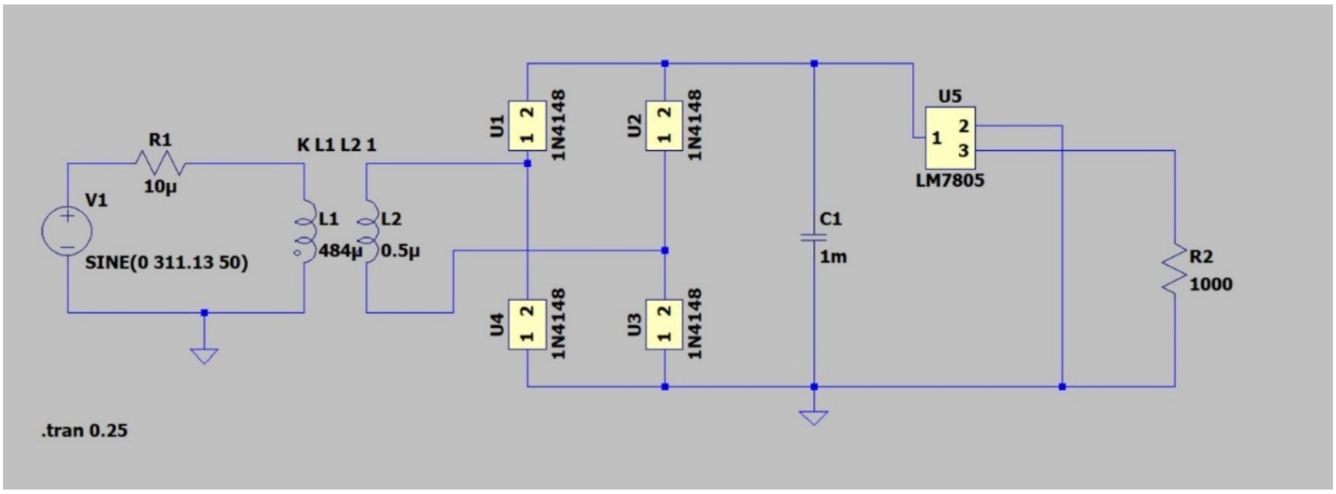


Figure 1. Circuit diagram

The following is the output-voltage vs time curve for the circuit:

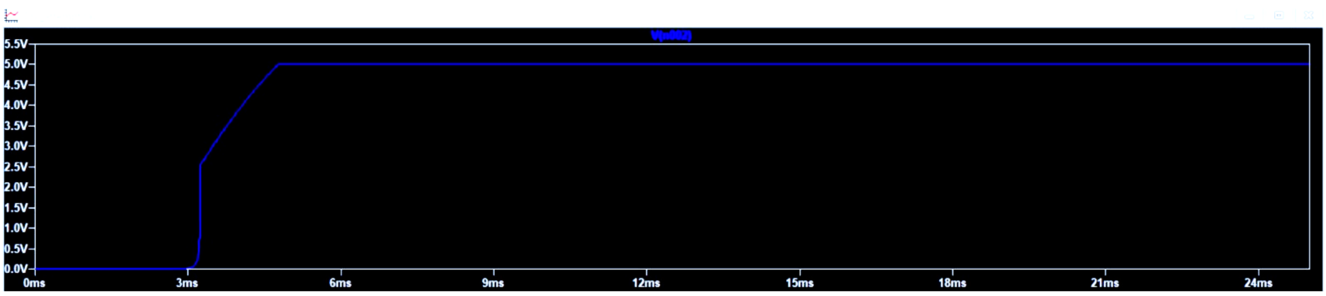


Figure 2. Simulation results on KiCAD

As clearly visible, the circuit worked well, and it converged to the desirable output voltage of 5V quite quickly. However, it had a few drawbacks, so, we had to discard it.

Drawbacks:

- The frequencies at which this circuit would be operating would be around 50-60 Hz, which is relatively low. In our design, we require the use of a Step Down Transformer which would work at the said frequency. Such available transformers are usually quite large and bulky in size, and have low efficiency, that is, they generate a significant amount of heat. This would lead to thermal issues with the charger.
- The circuit is very unstable with respect to sudden variations/surges in current/voltage. It needs to be protected from the same using fuse resistors. This can lead to unexpected heating of the circuit which can damage the components and dissipate unnecessary heat in order to maintain constant output voltage.

Due to these reasons we started looking at SMPS circuits, which are not only much more energy efficient compared to linear regulators, but also allow for usage of smaller components. They are also capable of operating at a wide range of inputs.

9.1.2. Second Iteration

After exploring on the web, we found a lot of SMPS circuits whose components would only allow a maximum current of 1 A, which is when we came across WEBENCH Power Designer by Texas Instruments. This gave us a circuit based on our requirements. We later verified if whether the components provided by the tool were fit for use or not, which was followed by PCB Design and Simulation.

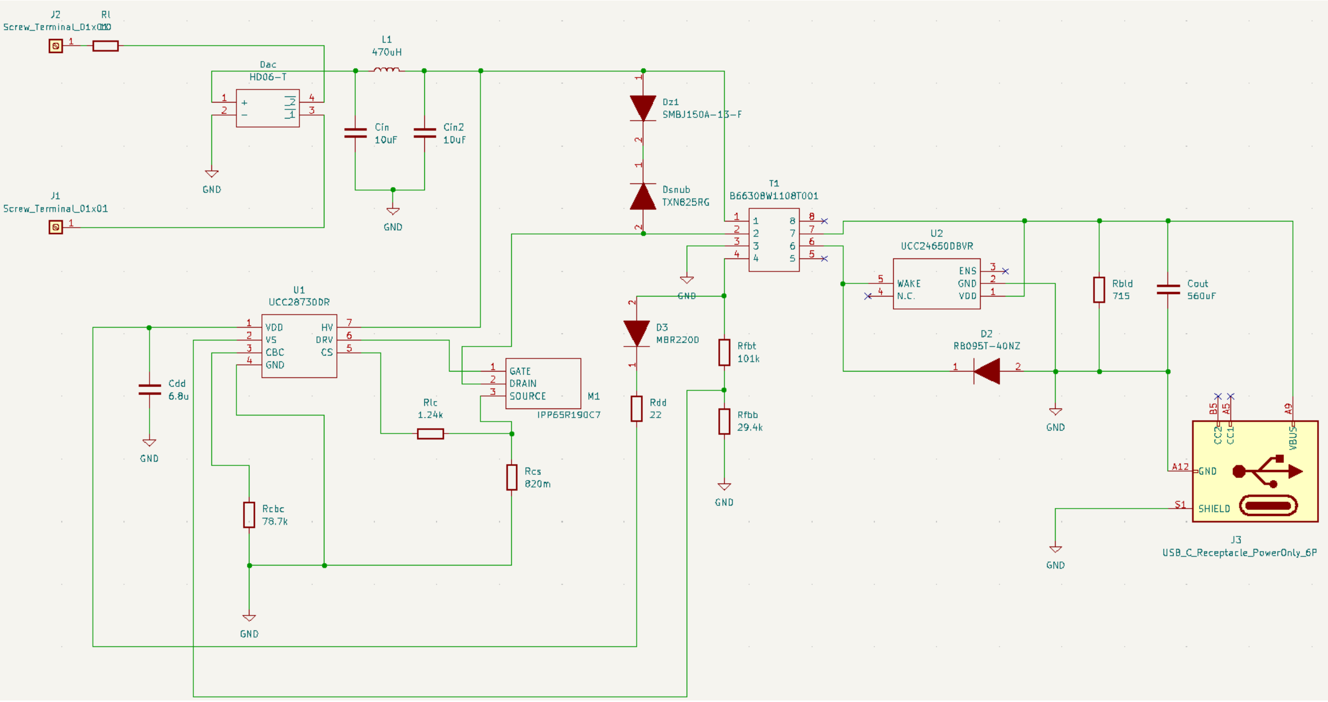


Figure 3. Circuit Diagram for our Charger

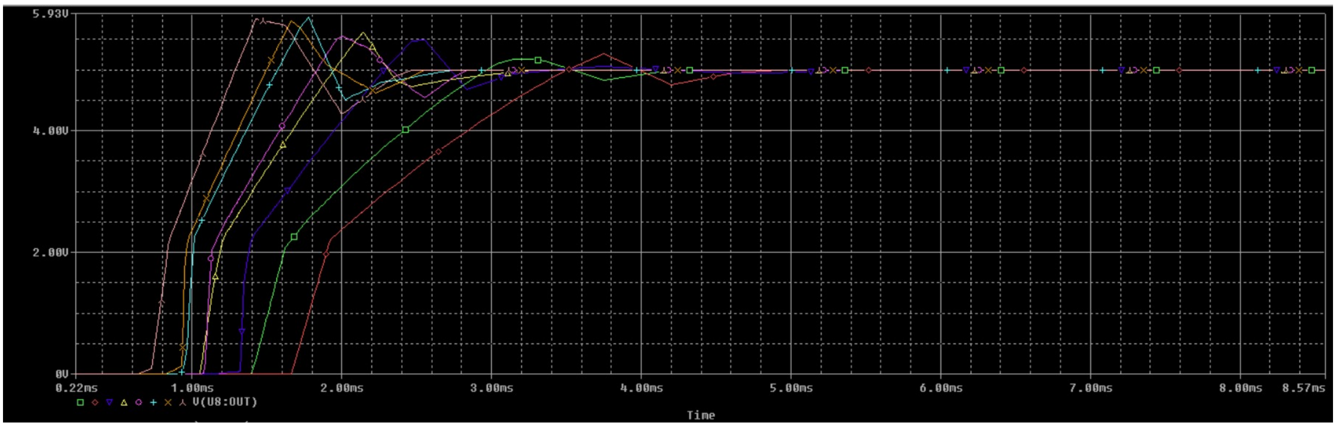


Figure 4. Simulation results

We tested the circuit on PSPICE 16.6. Above circuit diagram shows 8 waveforms which represent output voltages at 8 inputs:

Color	ValueAmplitude Voltage (Volt)	Frequency (Hertz)
Pink	312	60
Orange	312	50
Light Blue	250	60
Magenta	250	50
Yellow	200	60
Blue	200	50
Green	140	60
Red	140	50

As we can see, for various ranges of inputs, we obtain a constant 5V DC output, with the time taken to reach steady state being less than 5ms in each case. We observe that this time increases with decrease in amplitude voltage and decrease in input frequency. However the differences of these times is quite minute.

9.2. Body Design

The charger design involves two critical aspects, including CAD model design and 3D printing. To improve our models, we took apart a pre-existing mobile charger to gain insights. Our improvements included adding a backside lid and attaching it with an adhesive, leaving space for metal prongs on the front side, and filleting sharp edges to avoid potential hazards. Additionally, we incorporated a Type C port on the back lid to allow for future connectivity and engraved our tribe's logo (CADMUS) on the top side to prevent copying. The use of a backside lid for analysis and the incorporation of a Type C port align with the increasing use of this technology in the future.

The size is sightly bugger than normal chargers as bigger PCB size which has almost no relation with the CAD model but is still a potential drawback for the model.

10. System Diagram

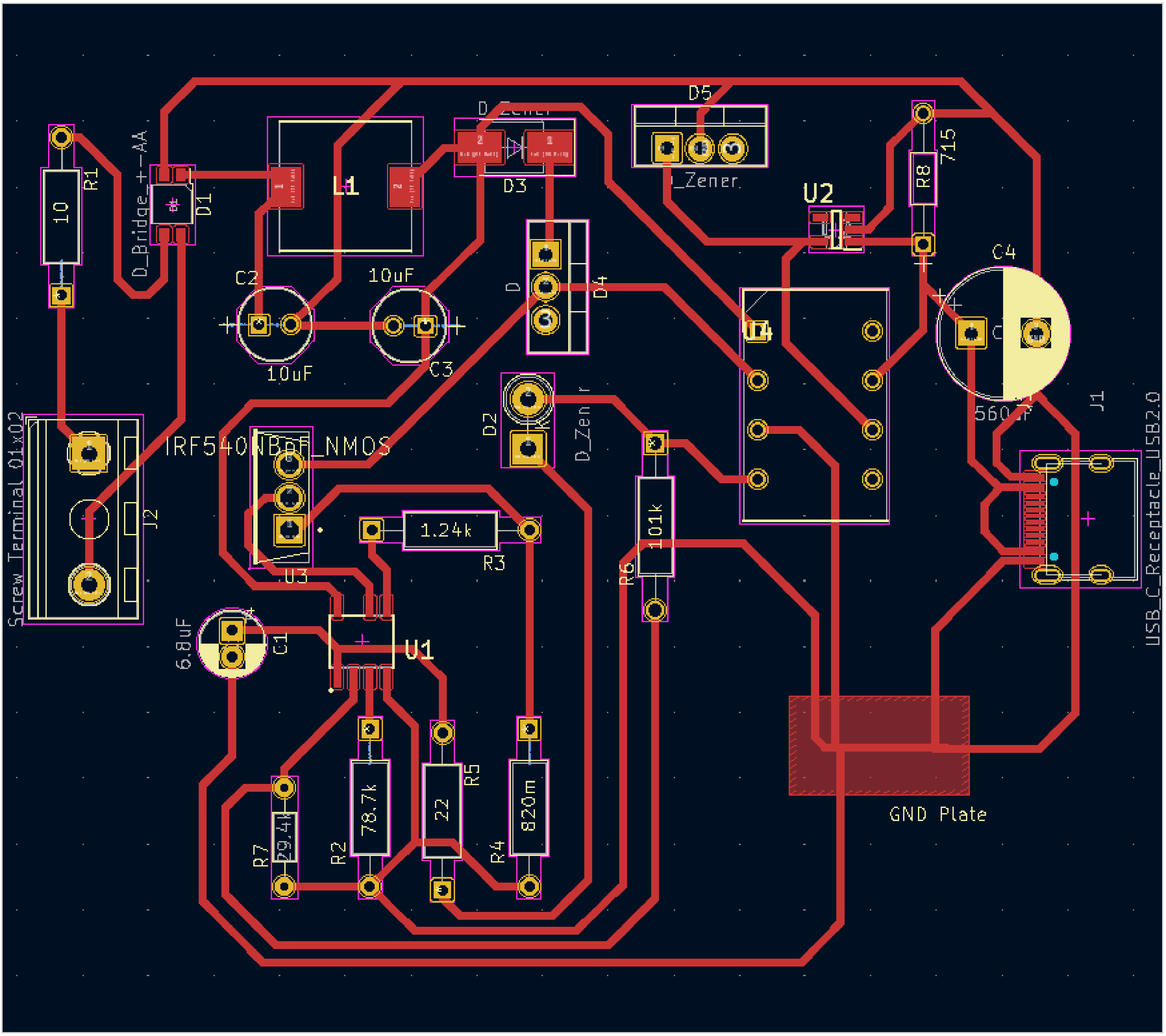


Figure 5.

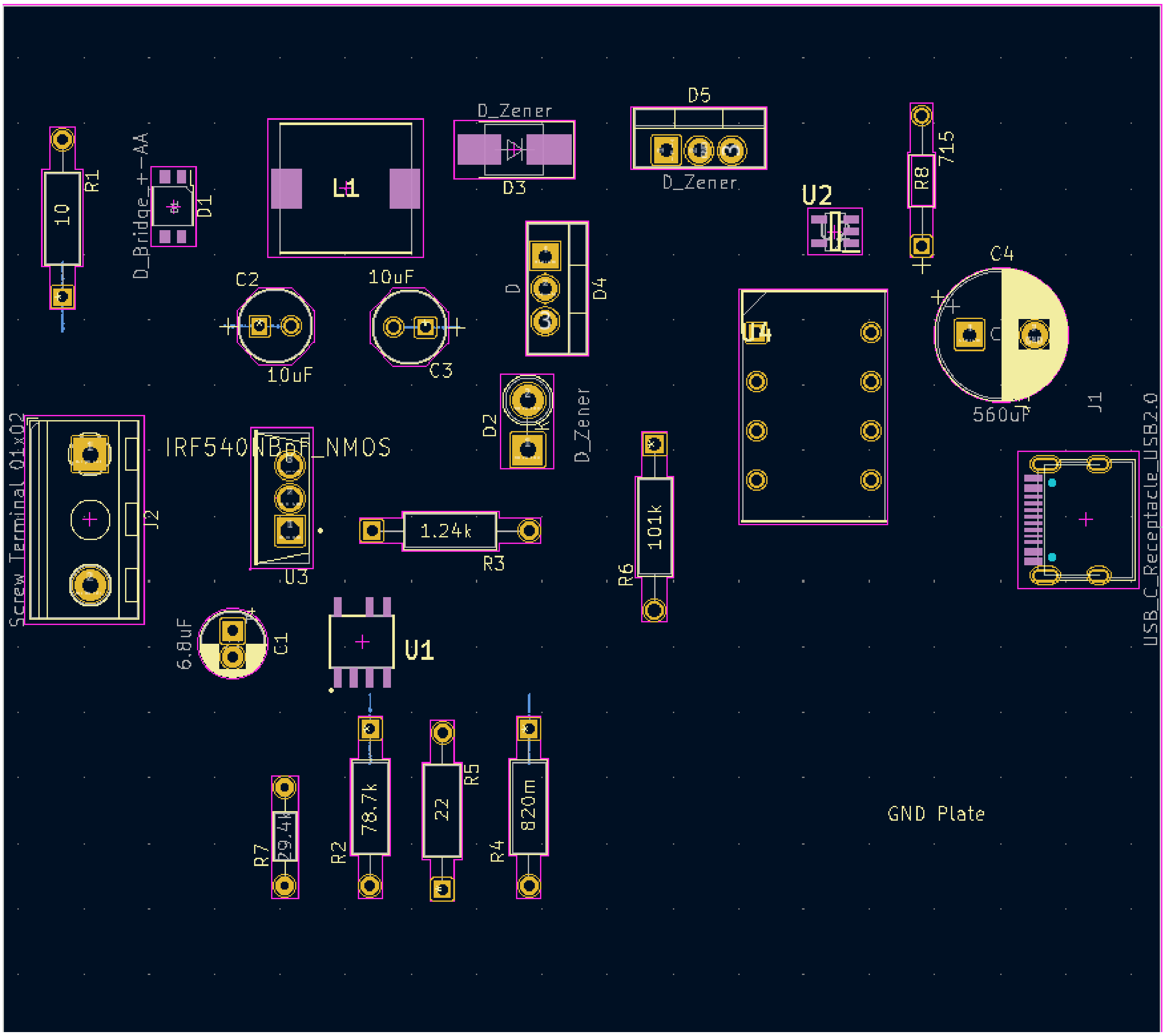
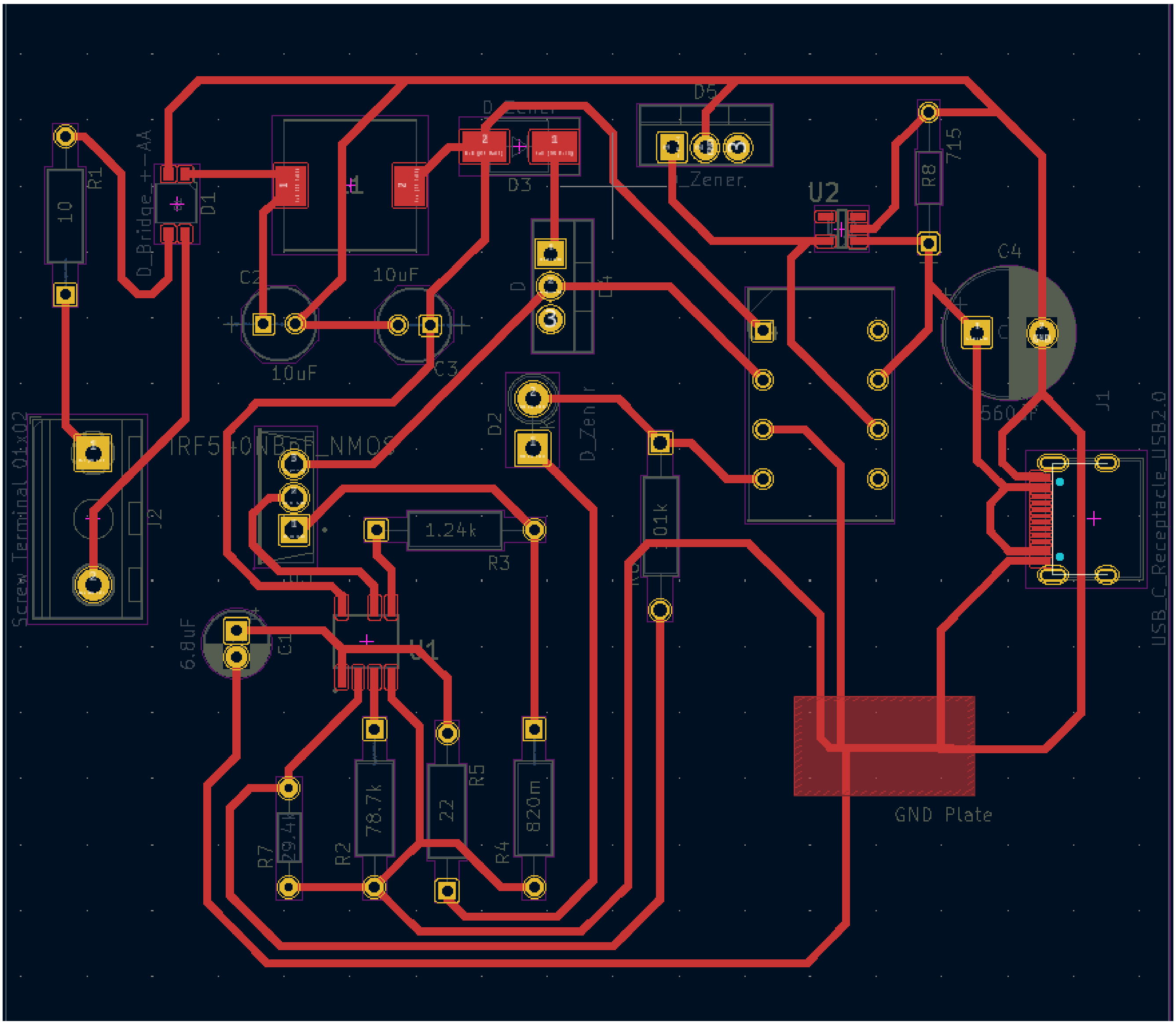
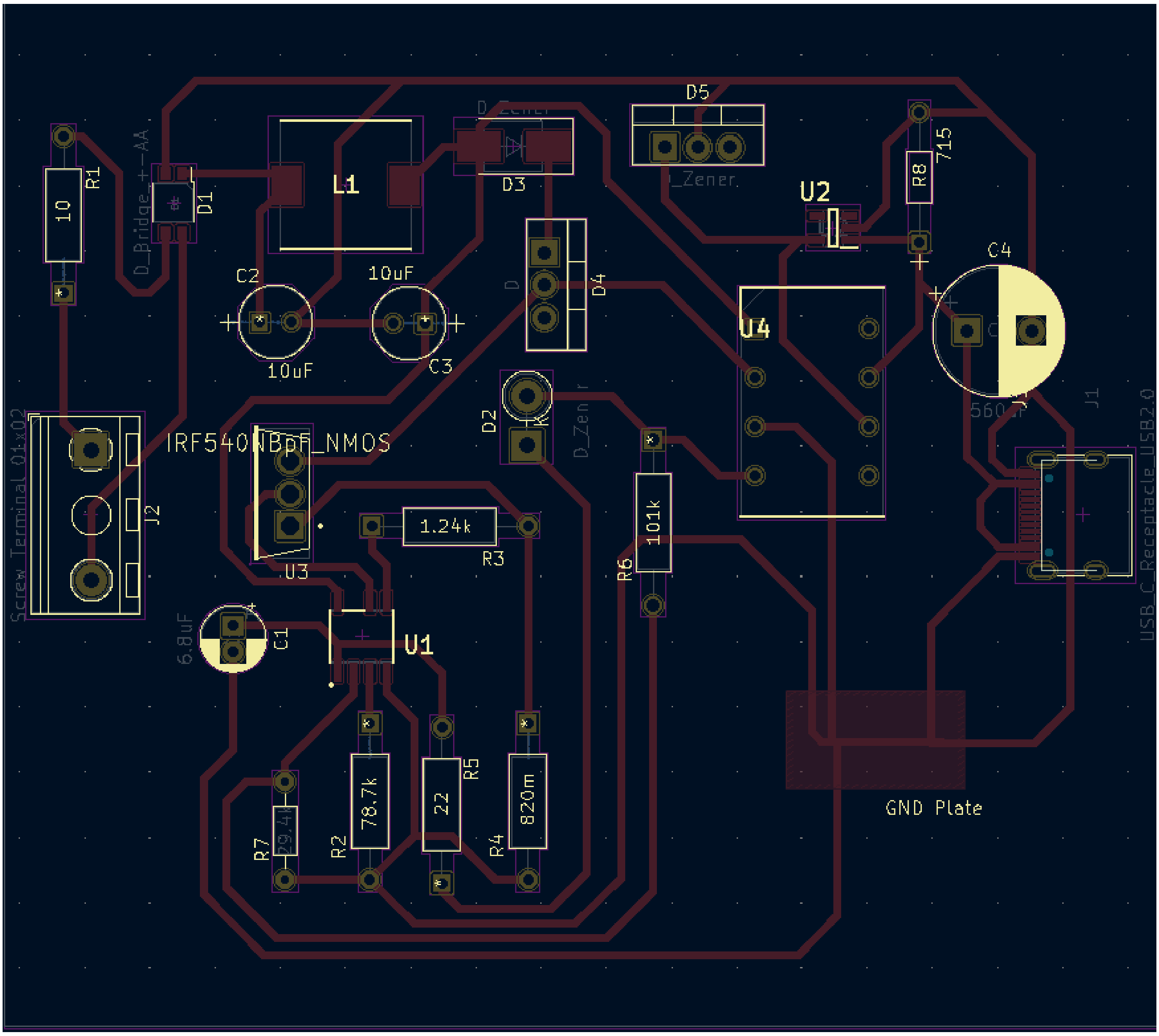

D_Zener
D5
D_Zener
D3
L1
R1
10
D_Bridge_+-AA
D1
U2
R8
715
C4
C2
10uF
10uF
C3
D
D4
U4
560uF
J1
D2
D_Zener
Screw_Terminal_01x02
IRF540NBpF_NMOS
J2
U3
1.24k
R3
101k
R6
USB_C_Receptacle_USB2.0
6.8uF
C1
U1
R7
29.4k
R2
78.7k
22
R5
R4
820m
GND Plate

Figure 6.



R1
10
D_Bridge_+-AA
D1
C2
10uF
10uF
C3
D3
D5
Zener
U2
R8
715
C4
560uF
J1
USB_C_Receptacle_USB2.0
Screw_Terminal_01x02
J2
IRF540NBPF_NMOS
D2
1.24k
R3
6.8uF
U1
R7
R2
78.7k
22
R5
R4
820m
GND Plate

Figure 7.



D5
U2
R8
715
R1
10
D_Bridge_+-AA
D1
L1
D3
C2
10uF
10uF
C3
D4
C4
U4
560uF
J1
USB_C_Receptacle_USB2.0
Screw_Terminal_01x02
J2
IRF540NBpF_NMOS
D2
D_Zener
101k
R6
1.24k
R3
U3
6.8uF
C1
U1
78.7k
R2
22
R5
820m
R4
R7
GND Plate

Figure 8.

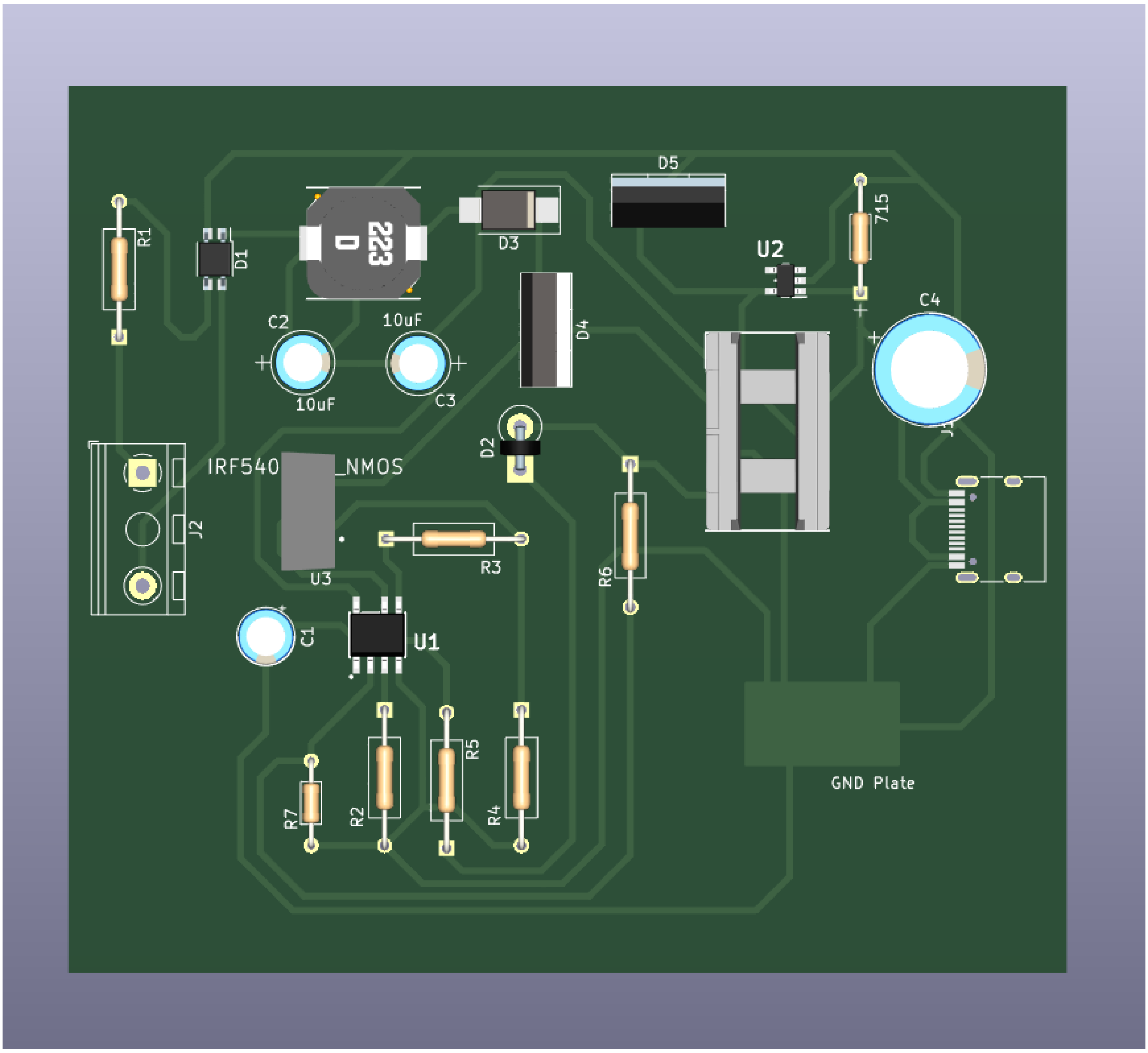

R1
D1
223
D3
D5
715
U2
C2
10uF
10uF
C3
D4
C4
D2
J2
IRF540_NMOS
U3
R3
R6
C1
U1
R7
R2
R5
R4
GND Plate

Figure 9.

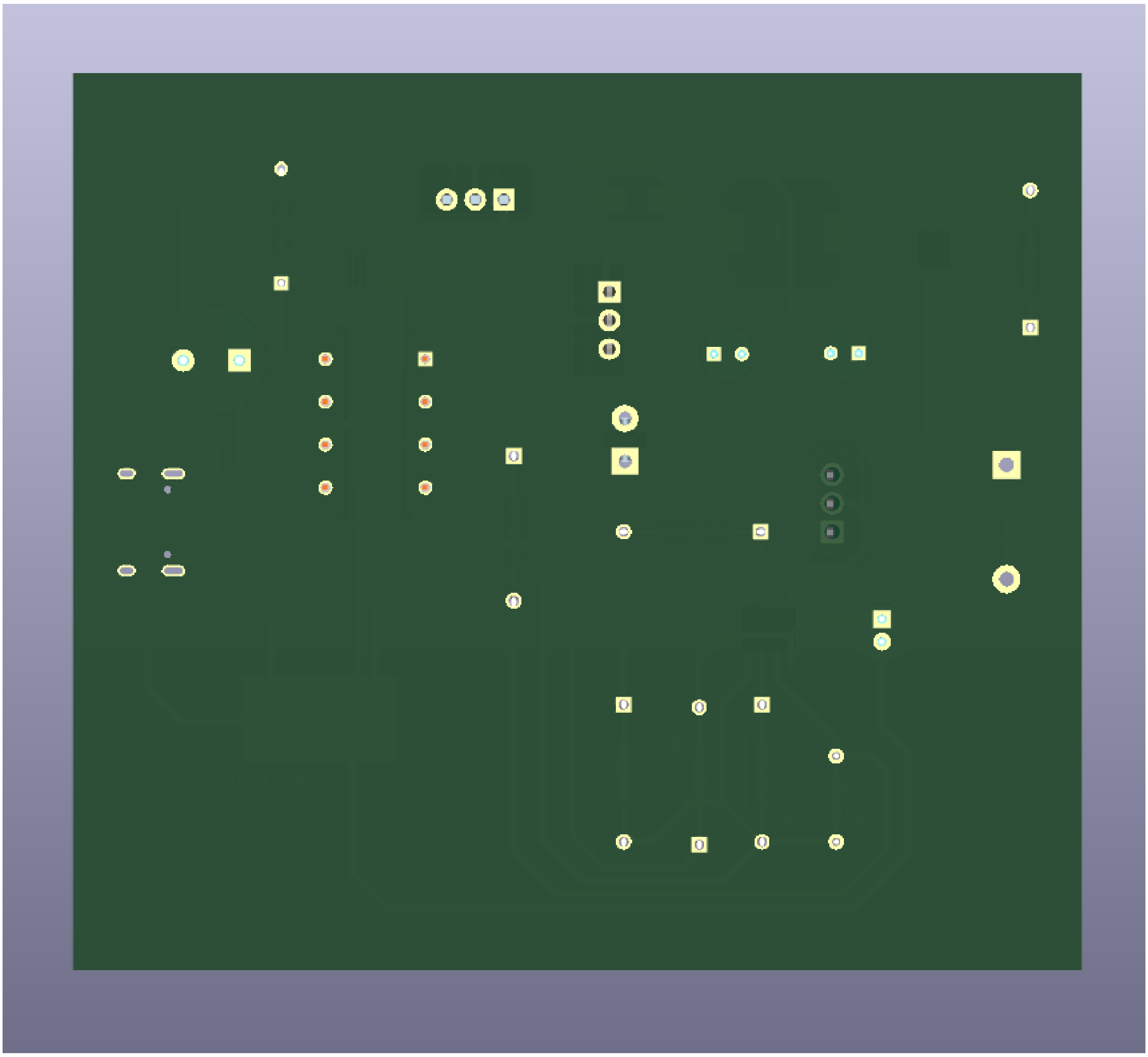


Figure 10.

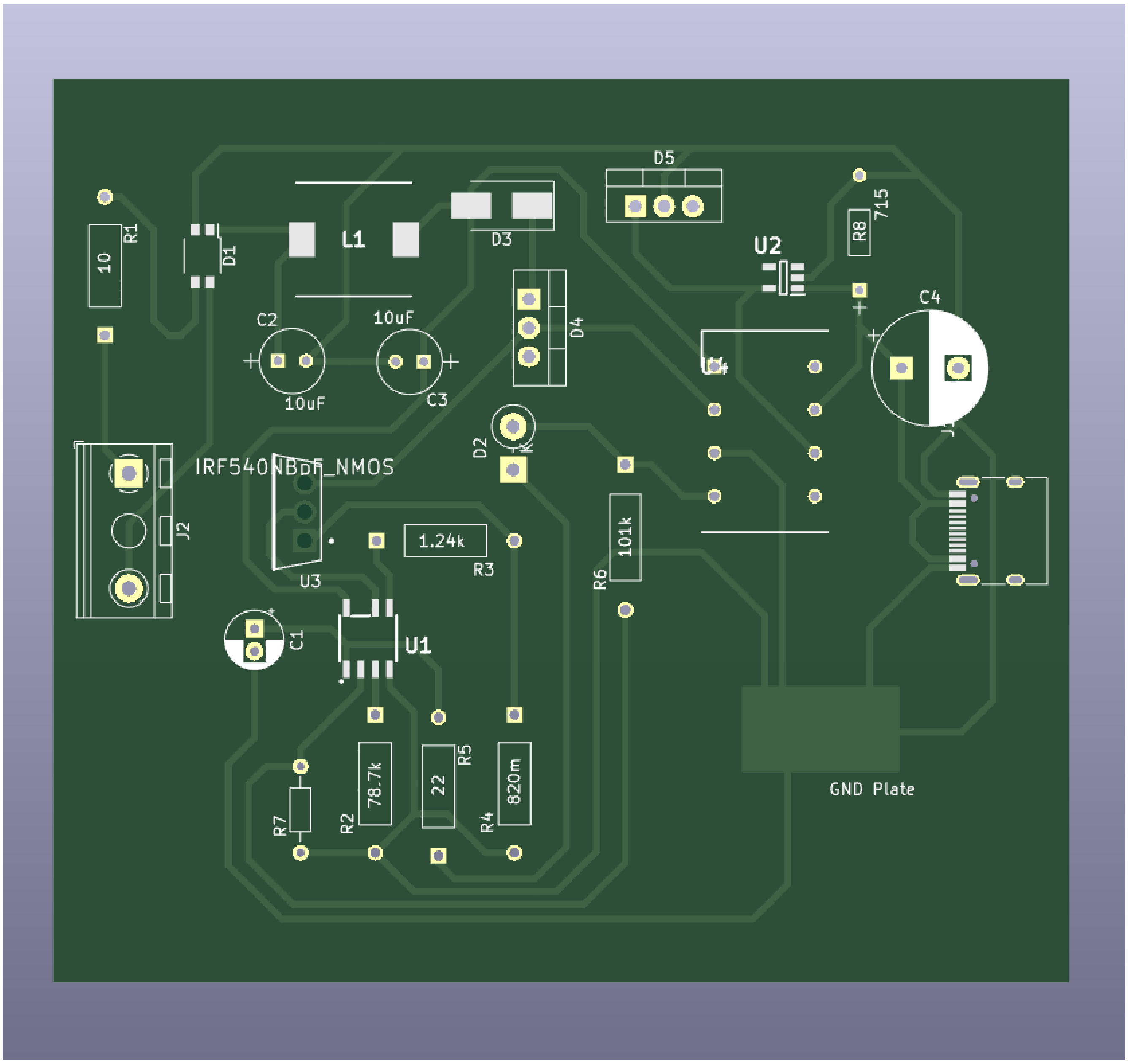

D5
R1
10
D1
L1
D3
U2
R8
715
C4
C2
10uF
10uF
C3
D4
D2
IRF540NBdF_NMOS
J2
U3
1.24k
R3
101k
R6
C1
U1
GND Plate
R7
R2
78.7k
22
R5
R4
820m

Figure 11.

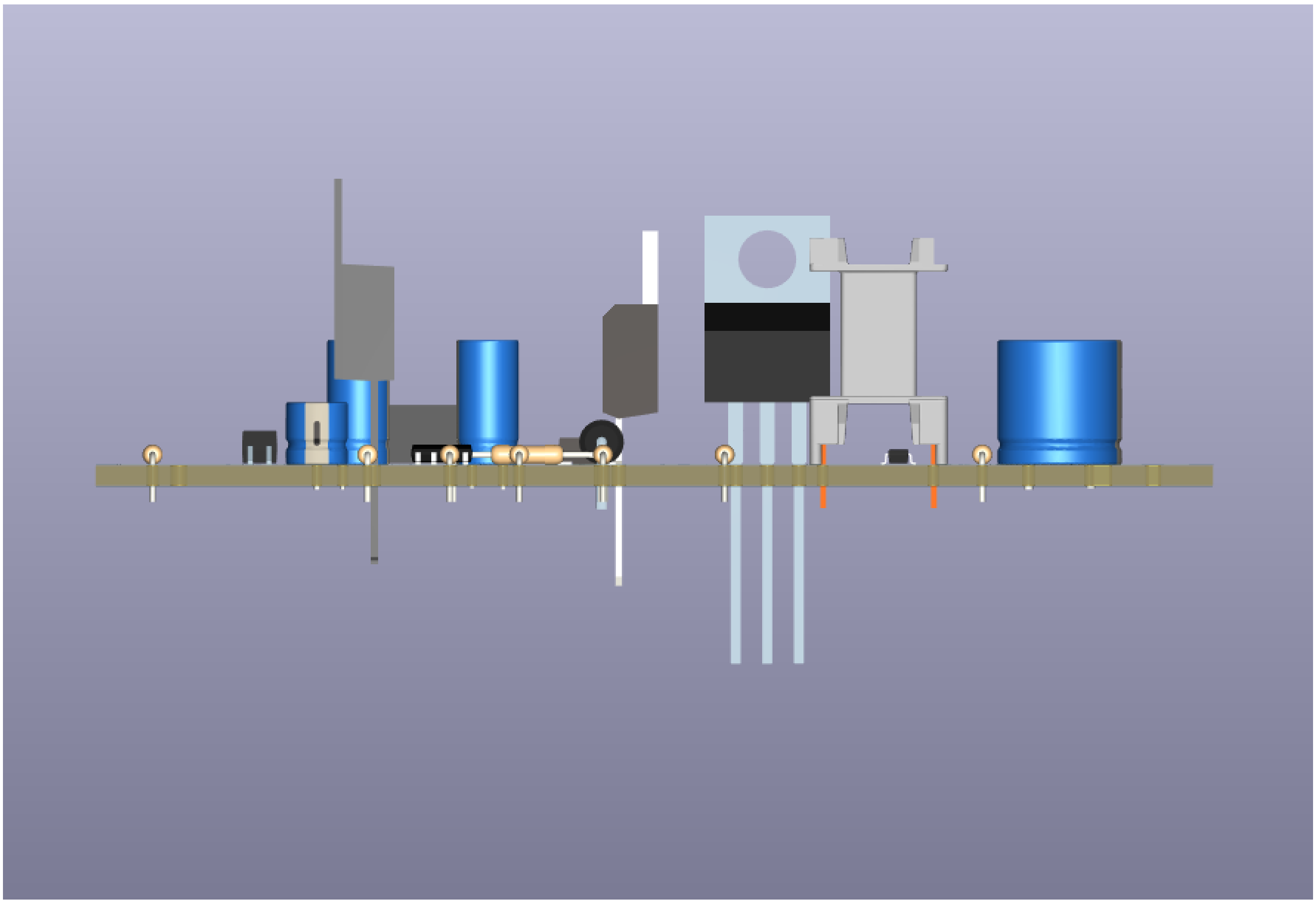


Figure 12.

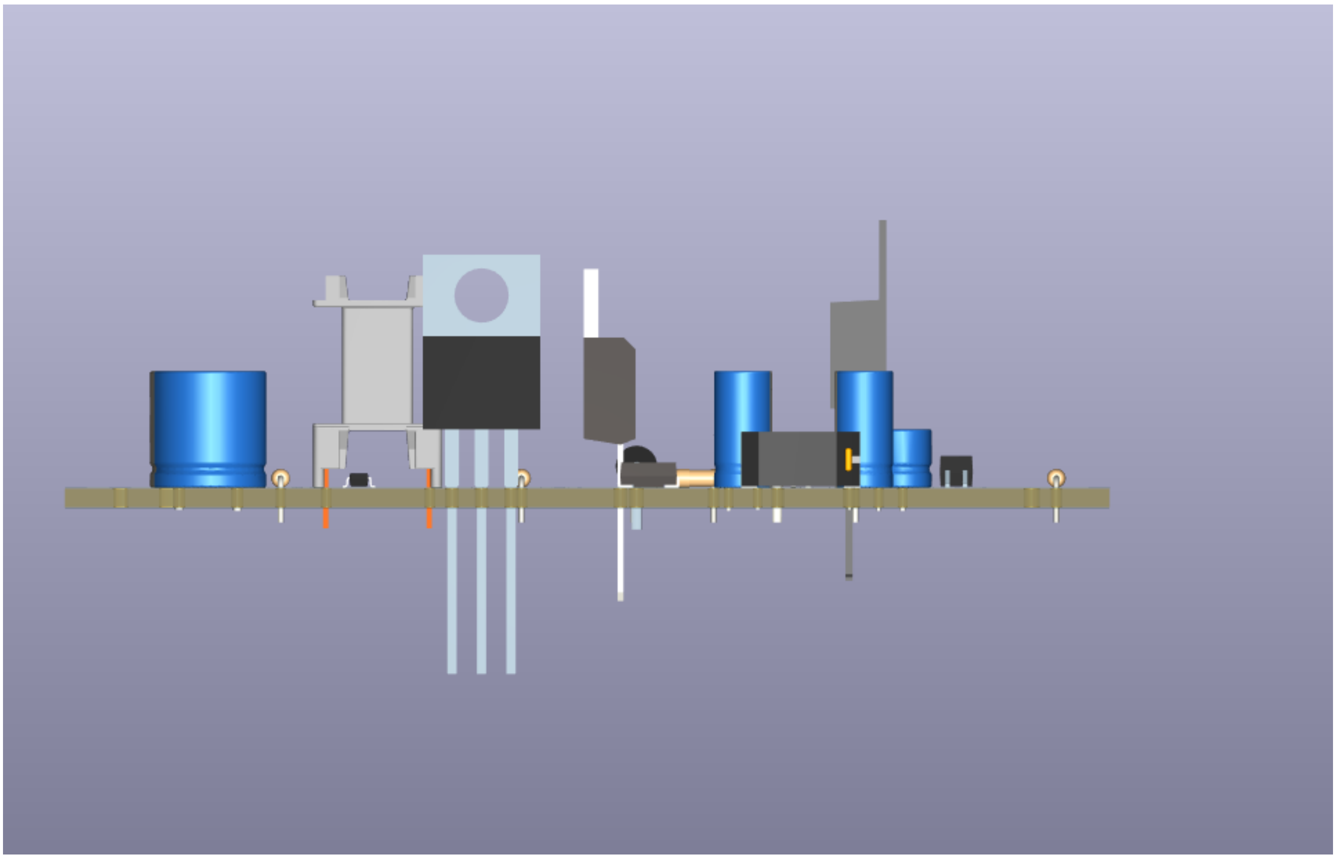


Figure 13.

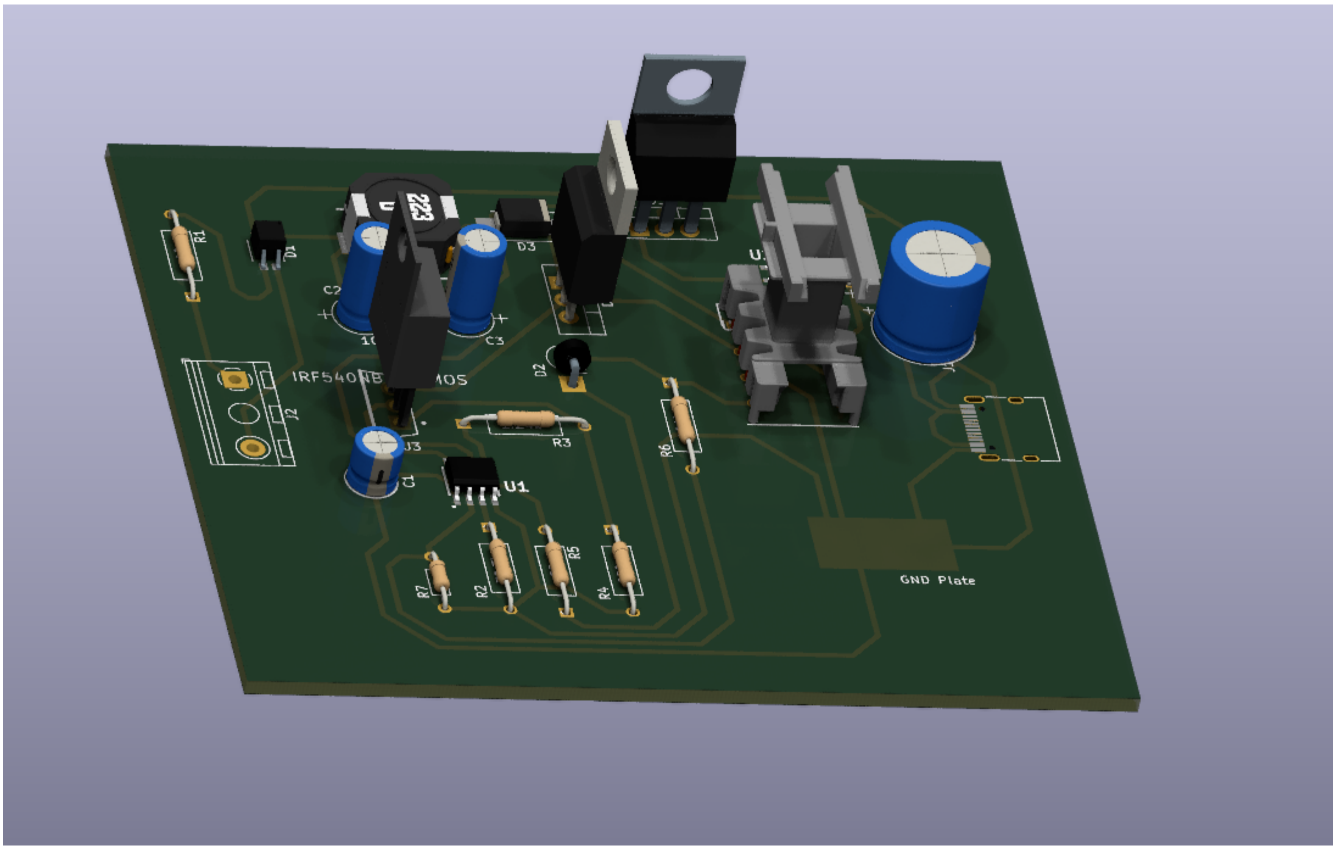


Figure 14.

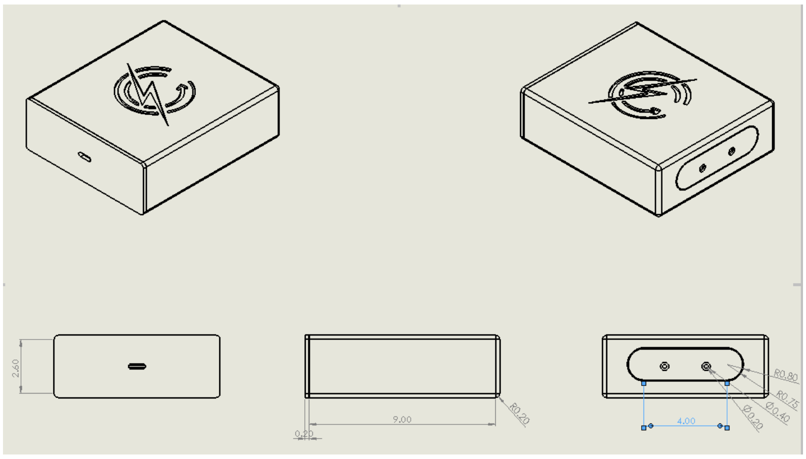


Figure 15.

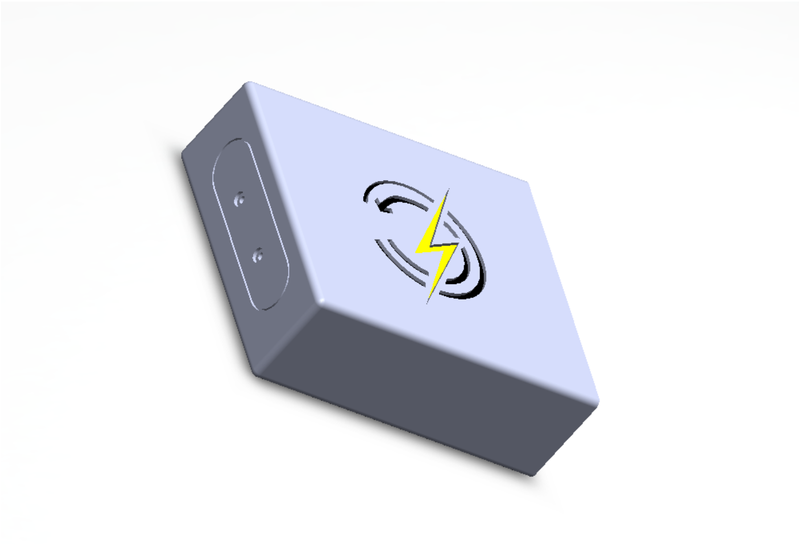


Figure 16.

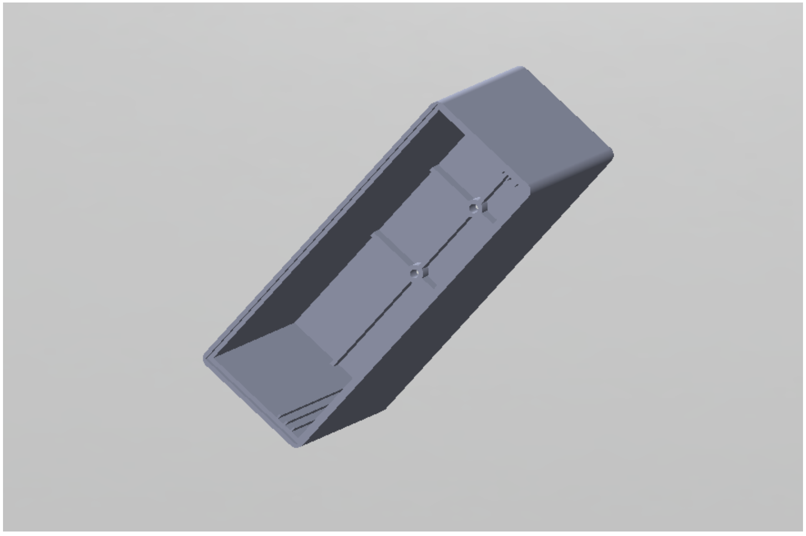


Figure 17.

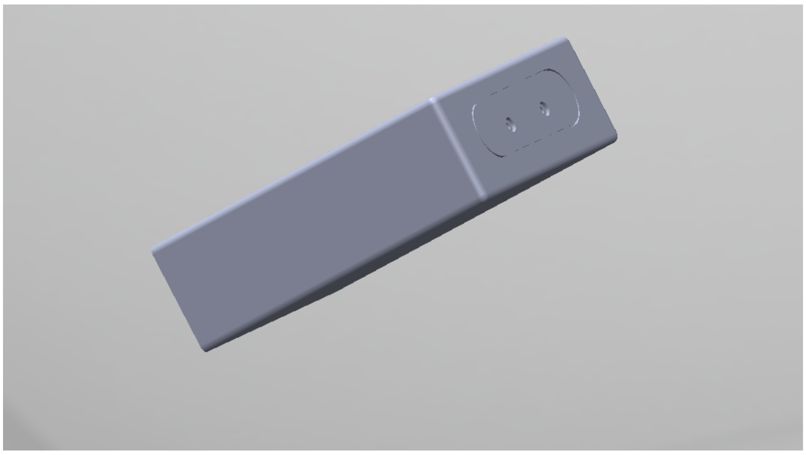


Figure 18.

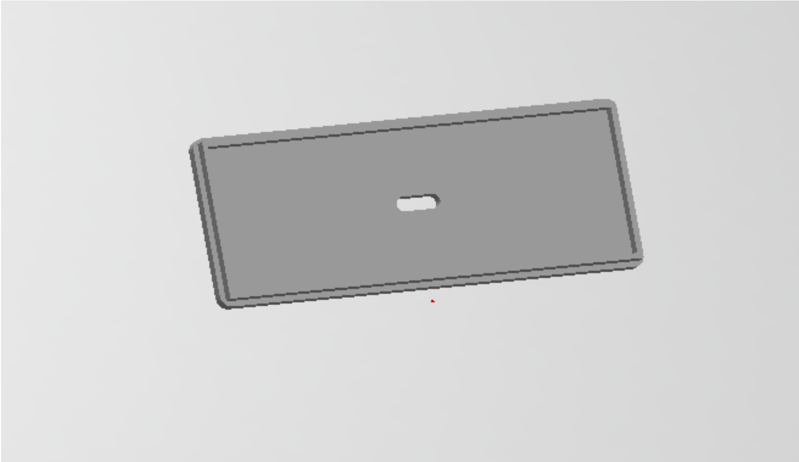


Figure 19.

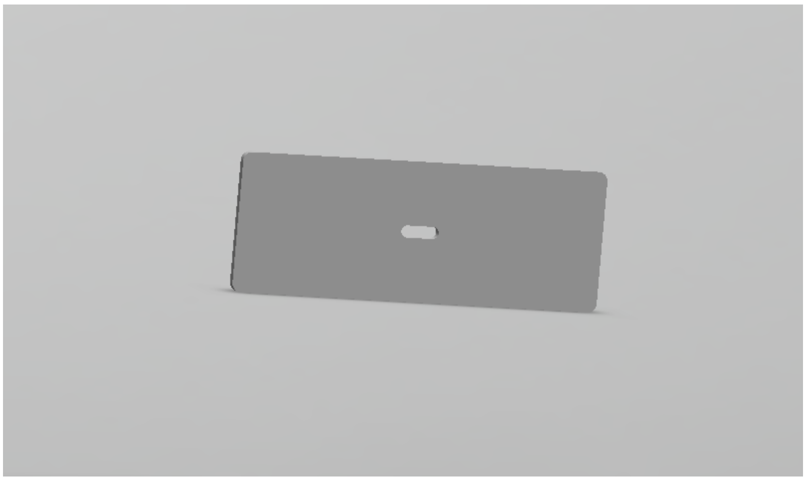


Figure 20.

11. Maintenance

The charger would come with clear instructions regarding its usage, including information on how to properly connect it to a device and how to troubleshoot common issues that users might face while using the product.

Some common issues related to chargers include:

- *Loose connections*: If the charger cable is not securely connected to the device or power source, the device may not charge properly or may disconnect frequently.
- *Damaged cables*: With extended usage, charging cables can become frayed, bent, or damaged, which can prevent the charger from functioning properly.
- *Incompatible charging ports*: If the charger is not compatible with the device's charging port, it may not charge the device at all or may charge it very slowly. Some factors that might affect this include power output and the type of cable used.
- *Check the voltage and current rating*: Make sure the voltage and current rating of your charger

matches the requirements of your device. Using a charger with a higher voltage or current rating than your device can handle can damage it.

- *Avoid overcharging*: Overcharging your device can damage the battery and reduce its lifespan. To avoid this, unplug your device once it reaches a full charge, or use a charger that automatically stops charging once the battery is full.
- *Insufficient power supply*: If the charger is not providing enough power, the device may not charge properly or may take a long time to charge. This may also negatively impact the battery life of the device as well as the battery of the mobile phone.
- *Avoid twisting or bending the cord*: Twisting or bending the cord repeatedly can cause it to wear out or break. Instead, unplug the charger by pulling on the plug itself, not the cord.

If a user is experiencing issues with their charger, they should try checking for loose connections or damage to the cable. The user may also want to try using a different charging cable or power source to verify if the issue is with the charger itself.

Replacements for the charging cable are neither viable nor practical since a fault with the cable can occur to various reasons not in the control of the manufacturer. Moreover, there is no ensured method to determine whether the fault was a manufacturing issue or not. In case the customer asks for a replacement for the adapter, while they are under warranty period, we proceed as follows:

- We can check for underlying causes for the faults experienced by the user, and attempt to troubleshoot the issues if possible. In a case where a replacement is inevitable, we can replace the charger and attempt to restore the damaged piece.
- If the problem is a mechanical one, such as the cable, then only that component will need to be replaced. On the other hand, if the problem is with the circuit, then we can salvage the parts that are still functional to ensure the system's continued operation.

12. Future Scope

There are several areas for potential future development and improvement for the mobile charger. In this section, we outline six potential areas of future scope for the charger:

1. **Holder for Mobile Devices**: One potential future development for the charger is to modify the adapter to include a holder for mobile devices. This would allow users to charge their phone while also using it, without the need for an additional holder. However, this would require an increase in the size of the casing and the charger material would need to be stronger to support the additional weight. Additionally, the pins would need to be tightly attached to the adapter to ensure they can support the weight of the phone.
2. **Fast Charging**: Another potential area for future development is to incorporate fast charging into the design. This would involve changes to the circuit design and CAD model to ensure that the charger can provide fast charging without compromising the safety of the mobile device. Fast charging can be achieved by optimizing the power output and charging algorithm to reduce the charging time while maintaining the safety of the device.
3. **Retractable Pins**: To increase the portability and ease of use of the charger, one potential future development is to include retractable pins in the design. This would make the charger more compact and easier to carry, as the pins could be retracted when not in use.

4. **Compatibility with Wide Range of Input Frequencies**: Another potential future development for the charger is to make it compatible with a wide range of input frequencies. This would involve changes to the circuit design and CAD model to ensure that the charger can accept different input frequencies without compromising its performance. This would increase the versatility of the charger, making it suitable for use in a wider range of geographic locations.
5. **Surface Mount Technology (SMT) for PCB Realization**: Another potential area for future development for the mobile charger is to use Surface Mount Technology (SMT) for PCB realization, instead of Through Hole Technology (THT). SMT enables more precise soldering, leading to a more compact PCB and thus a more compact charger overall. However, implementing SMT printing requires a higher level of expertise and is more expensive than THT, which we were unable to perform at this stage due to our limited expertise and budget constraints.
6. **Glow-in-the-dark Capability**: A glow-in-the-dark charger can be helpful in situations where it's difficult to locate your charger in the dark. It can also just be a cool accessory to boost product sales. This would involve sanding the charger's surface and applying glow-in-the-dark paint, which contains phosphors that absorb light and emit it when it is dark.

13. Bill of Materials and Vendors

S.No.	Name	Part Number	Amount in Bulk	Bulk price per piece (Rs)	Price per single piece (Rs)	Link
1	C_{dd}	80-ESC685M035AC3AA	10,000	0.059	0.29	https://octopart.com/search?q=80-ESC685M035AC3AA&currency=USD&specs=0
2	C_{in}	UVK2A100MDD	10,000	0.068	0.32	https://octopart.com/search?q=UVK2A100MDD&currency=USD&specs=0
3	C_{in2}	UVK2A100MDD	10,000	0.068	0.32	https://octopart.com/search?q=UVK2A100MDD&currency=USD&specs=0
4	C_{out}	860010375013	10,000	0.213	0.37	https://octopart.com/search?q=860010375013&currency=USD&specs=0
5	D_2	RB095T-40NZ	10,000	0.898	1.95	https://octopart.com/search?q=RB095T-40NZ&currency=USD&specs=0
6	D_3	MBR2200	10,000	0.153	0.186	https://octopart.com/search?q=MBR2200&currency=USD&specs=0

S.No.	Name	Part Number	Amount in Bulk	Bulk price per piece (Rs)	Price per single piece (Rs)	Link
7	D_{ac}	HD-06T	10,000	0.105	0.487	https://octopart.com/search?q=HD-06T&currency=USD&specs=0
8	D_{snub}	TXN825RG	10,000	0.947	2.22	https://octopart.com/search?q=TXN825RG&currency=USD&specs=0
9	D_{z1}	SMBJ150A-13-F	10,000	0.054	0.08	https://octopart.com/search?q=SMBJ150A-13-F&currency=USD&specs=0
10	L_1	MSS1048-474KLB	10,000	0.972	1.753	https://octopart.com/search?q=MSS1048-474KLB&currency=USD&specs=0
11	R_{bld}	RN50E7150BRE6	10,000`	0.936	NA	https://octopart.com/search?q=RN50E7150BRE6&currency=USD&specs=0
12	R_{cs}	MFR50SFBF52-0R82-ND	10,000	0.012	NA	https://mg.components-store.com/product/Yageo/MFR50SFBF52-0R82.html
13	R_{dd}	CFR0W2	10,000	0.06	NA	https://octopart.com/search?q=CFR0W2&currency=USD&specs=0
14	R_{fbb}	CMF5029K400FHEB	10,000	0.268	0.87	https://octopart.com/search?autosugg_idx=1&q=cmf5029k400fheb&currency=USD&specs=0
15	R_{fbt}	RN55C1013BR36	25,000	0.075	NA	https://mg.components-store.com/product/Dale-Vishay/RN55C1013BR36.html
16	R_l	RNF14FTD10R0	10,000	0.022	0.118	https://octopart.com/search?q=RNF14FTD10R0&currency=USD&specs=0
17	R_{lc}	RN55E1241FRE6	10,000	0.31	NA	https://www.digikey.in/en/products/detail/vishay-dale/RN55E1241FRE6/3329406
18	T_1	B66307G0000X187	10,000	0.239	0.522	https://octopart.com/b66307g0000x187-epcos-20737672

S.No.	Name	Part Number	Amount in Bulk	Bulk price per piece (Rs)	Price per single piece (Rs)	Link
19	T_1	B66308W1108T001	10,000	0.63	0.849	https://octopart.com/b66308w1108t001-epcos-22229300
20	U_1	UCC28730DR	10,000	0.367	0.539	https://octopart.com/ucc28730dr-texas+instruments-55597326
21	U_2	UCC24650DBVR	10,000	0.16	0.459	https://octopart.com/ucc24650dbvr-texas+instruments-48523579
22	M_1	IPP65R190C7	10,000	1.88	3.82	https://octopart.com/search?q=IPP65R190C7&currency=USD&specs=0

NOTE: All prices are exclusive of import TDS @1%

14. References

1. Patel Mech. Available at: https://patelmech.com/products/electrical-parts/electrical-plug-pins/ (Accessed: January 31, 2023).
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5. ABS plastic granules - abs plastic raw material latest price, Manufacturers & Suppliers IndiaMART. Available at: https://dir.indiamart.com/impcat/abs-plastic-granules.html (Accessed: January 31, 2023).
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7. USB Type-C® Cable and Connector Specification, USB-IF. https://www.usb.org/usb-type-cr-cable-and-connector-specification/ (Accessed: January 31, 2023).
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