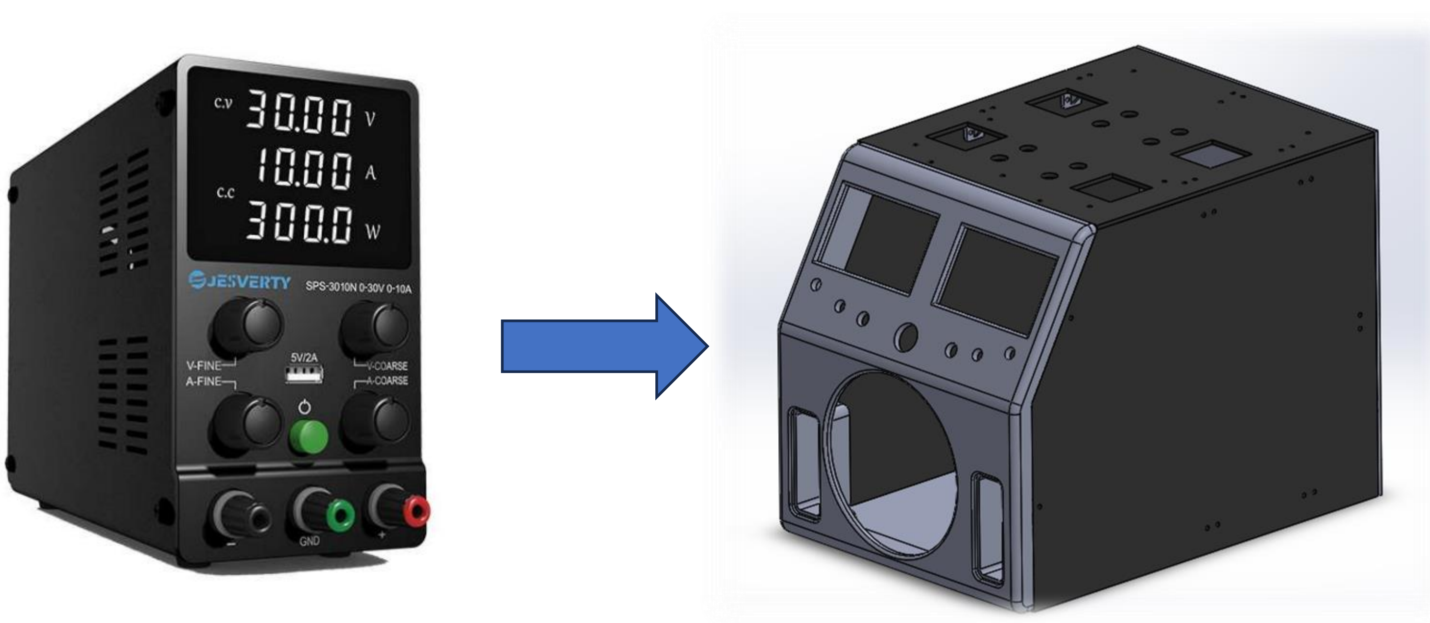
❖ Since this project is still ongoing, this report includes only the abstract, methodology, and testing results.

Multifunctional Smart Power Supply



Nimesh Kavinda Fernandopulle

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1) Abstract

This comprehensive power supply report details the development of an innovative multifunctional smart power supply system aimed at optimizing the provision of regulated DC output voltages (ranging from 1V to 30V) and accommodating currents of up to 10A, while effectively converting the 230V AC input. This project addresses the foundational requirement of laboratory power supplies while introducing a host of advanced features and smart capabilities, enhancing user experience and adaptability across a myriad of applications.

The power supply system offers a dual-channel output, allowing for versatile utilization and experimentation within laboratory settings. In addition to this, it incorporates an array of smart functionalities that transcend conventional power supplies. High-precision voltage and current measurements are an integral part of this design, ensuring utmost accuracy in research and experimentation.

Furthermore, the inclusion of current limiting features empowers users to safeguard their circuits from potential overloads, adding an invaluable layer of protection. To optimize user control, the system integrates intelligent switching mechanisms, enabling seamless transitions between different configurations and modes of operation.

Recognizing the growing interconnectedness of devices through the Internet of Things (IoT), this power supply is equipped with four 230V AC socket outlets that can be effortlessly toggled via touch switches. These outlets can be remotely controlled through Wi-Fi connectivity with IoT capabilities. This innovative feature grants users unparalleled flexibility, allowing them to manage connected equipment remotely and with ease.

Moreover, a robust cooling system has been incorporated into the design to maintain efficient operation and prevent overheating, ensuring long-term reliability and performance.

The multifunctional smart power supply system presented in this report redefines the capabilities of traditional laboratory power supplies. Its fusion of advanced features, precision measurements, current protection, intelligent switching, and IoT connectivity enhances functionality, fosters a superior user experience, and greatly simplifies a wide spectrum of tasks and experiments in various research and industrial contexts.

2) Specification of the Power Supply.

- Input Power.
  - 230V (50-60)Hz AC Voltage .
  - Maximum current - 6 A .
  - Maximum power - 1350 W .

- DC Output.
  - Dual Channel Output.
  - Adjustable Voltage Range - 1.2V to 30V (Both channels).
  - Current Flowing Range - (20V - 30V) up to 5A. (Single channel).
    (15V - 20V) up to 8A. (Single channel).
    (Below 15V) up to 10A. (Single channel).
  - Maximum DC Power - 250 W (from both channels).

- AC Output.
  - Four 230V AC Socket Outlets
  - Maximum Current Flowing - 4 A (By all four)
  - Maximum AC Power - 900 W (By all four)

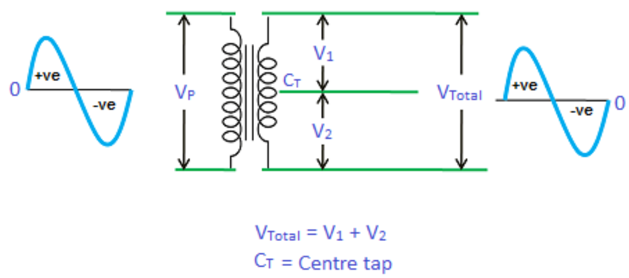
- Additional features.
  - There are two separate 3.5-inch LCD displays to show the voltage, current flow, and power consumption for each output channel.
  - Voltage resolution is 30mV and current resolution is 1mA (below 1A) & 10mA (below 10A).
  - Each channel can be controlled using separate touch switches.
  - An overcurrent feature is available, which is adjustable and has a sensitivity of 10mA (if the current flow exceeds 10mA compared to the adjusted value, the channel switches off automatically).
  - The AC socket outputs are also controlled by touch switches, and in addition, they have Wi-Fi capabilities. This allows us to control them using Wi-Fi without the need to physically touch the power supply.
  - It features a dual-fan super cooling system that helps maintain smooth performance even when drawing high power from the outputs for an extended period, preventing the power supply from overheating.
  - It has attractive indicator lights.

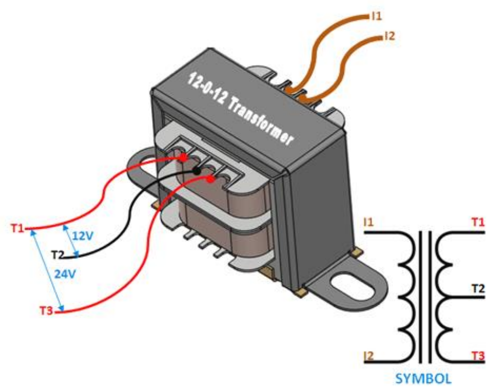
3) Methodology.

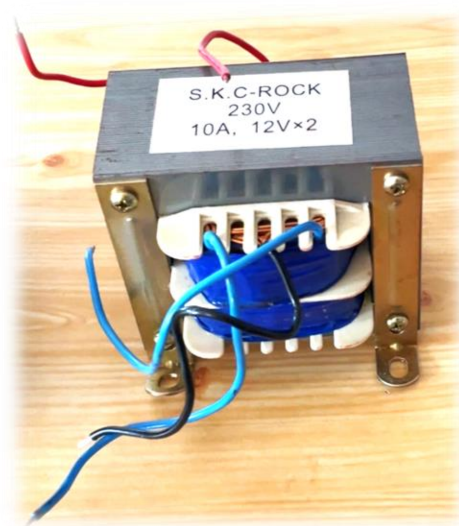
- **DC Output.**

  - **Step down transformer.**

    In this project, a 230:24 step-down transformer is used to achieve the desired voltage level that can be tolerated by the electronic components in the next stage. When connected to the household power supply, the transformer will provide a 24V RMS input voltage to the rectifier, which has a peak voltage value of √2 * 24 = 33.94V. To accommodate high currents, a 10A transformer is employed.



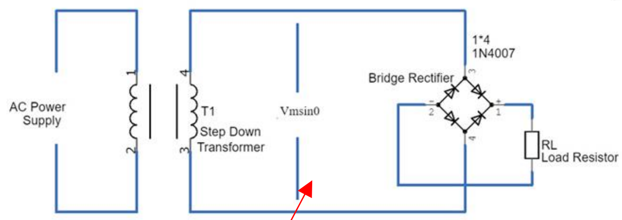


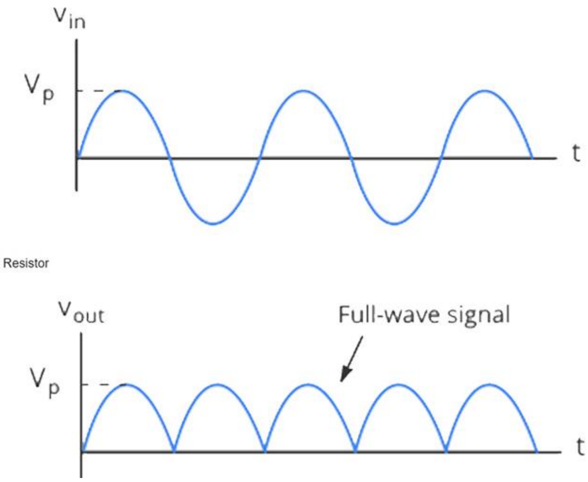


The transformer used in this project.

  - **Full wave rectification.**

    After stepping down the voltage level to a desirable level, the next step is to rectify the AC voltage using an appropriate method. AC voltage consists of a positive half cycle and a negative half cycle. In this stage, it is converted into an AC voltage with a single polarity. There are many methods to achieve this result, but in this project, a Wheatstone bridge rectifier is used because it is the most common and simplest method to rectify sinusoidal AC voltage. The Wheatstone bridge rectifier allows the output current to flow in a single direction regardless of the polarity of the input voltage applied.





Diode Bridge Rectifier Module

(KBPC3510 - 35A 1000V)

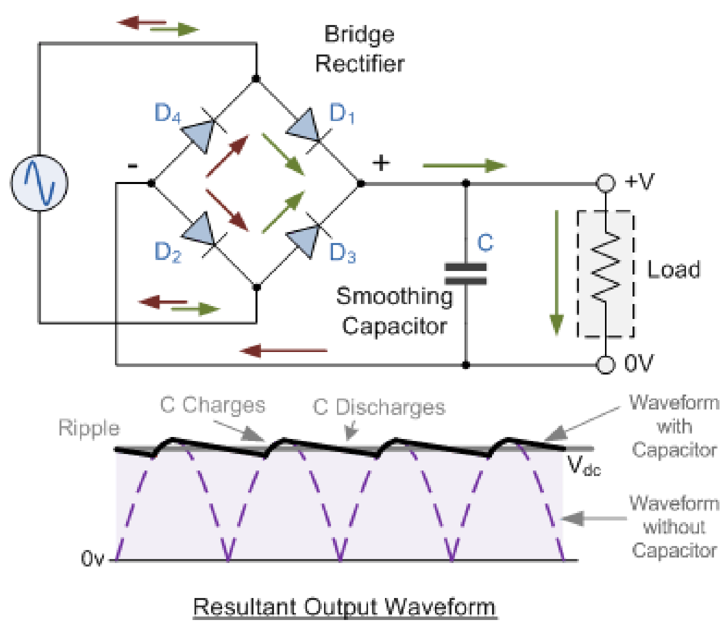
- **Smoothing stage.**

  After the rectification process, the output consists of a single-polarity voltage with significant voltage fluctuations. To convert it into a stable DC voltage, a smoothing process is employed. Capacitors are utilized to mitigate the voltage variations in the rectified output, resulting in a smoother signal with minimal ripple voltage close to the desired DC output.

  To achieve better smoothing, it's ideal to have a capacitor with a slower discharging rate. This can be accomplished by increasing the RC time constant. However, we typically cannot control the resistance (R) directly. Therefore, the approach is to increase the capacitance of the capacitor.

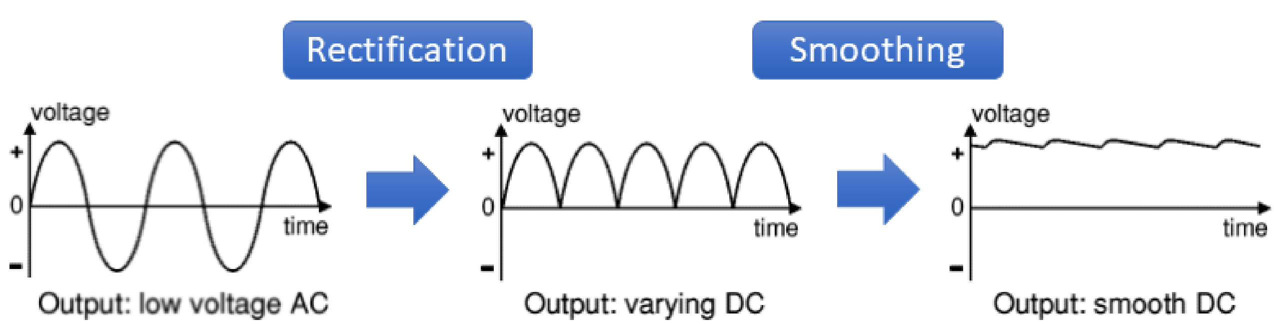
  Nevertheless, as capacitance increases, the initial surge current required to charge the capacitor during the first voltage cycle also becomes larger. This surge current could potentially harm the diodes within the rectifier bridge. Consequently, the selection of the smoothing capacitor must be carefully considered to ensure that the surge current remains within a manageable limit while still achieving an adequate level of smoothing.

In this project , a 40mF capacitor (four 10mF capacitors connected in parallel) is used for the smoothing process, but a small ripple remains. In the next step, voltage regulation will be employed to eliminate this remaining ripple.

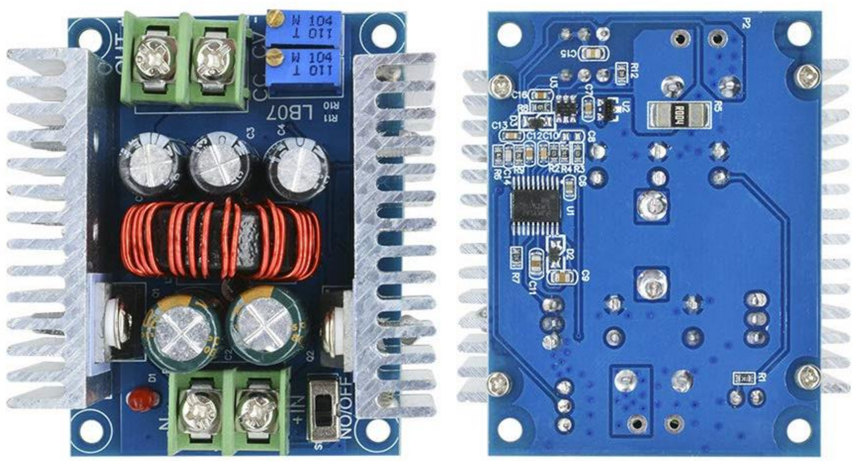


- **Regulating stage.**

So far, we have completed the steps described up to the following picture.



Adjustable voltage regulation is achieved using a buck converter. A buck converter is a type of DC-DC converter used for voltage regulation. It steps down a higher voltage to a lower voltage level while efficiently regulating the output. It typically consists of a switching element (usually a transistor or MOSFET), a diode, an inductor, and a control circuit. By controlling the switching of the transistor, it can efficiently convert a higher input voltage into a lower, regulated output voltage. Buck converters are commonly used in various electronic applications to provide stable DC voltage levels.



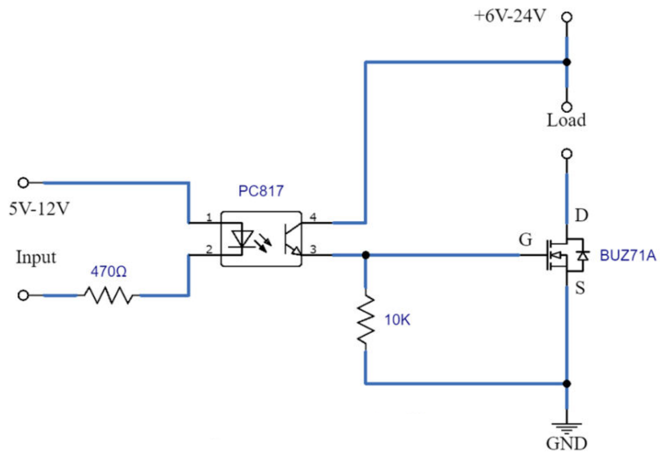
The buck converter using in the project (300W 20A)

Testing the circuit that has been built up to this point, a demonstration of high current is shown in the following video.
https://youtu.be/hfKjkCVAcGg

- **DC solid state relay.**

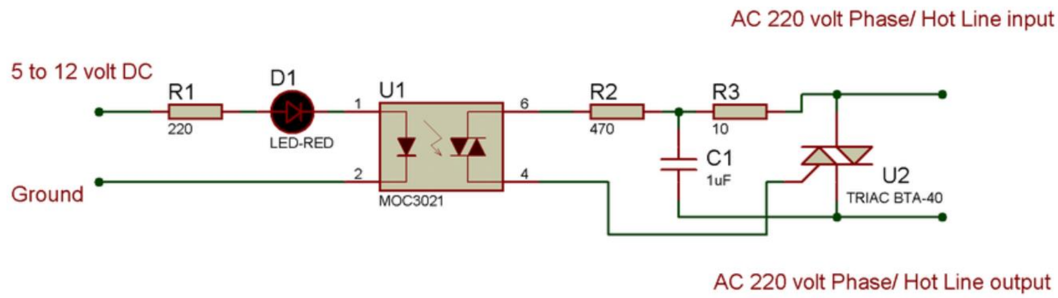
A DC solid-state relay (DC SSR) employing a MOSFET is an electronic switching device that enables the control of DC circuits without the need for mechanical contacts. It operates by responding to a low-voltage control signal, typically generated by a microcontroller or control circuit, to activate or deactivate the MOSFET, which serves as the switching element. This MOSFET-based relay offers several advantages, including electrical isolation between the control and load sides, enhanced reliability due to its absence of moving parts, rapid switching capabilities, and often includes overcurrent protection for load safety. DC SSRs with MOSFETs find widespread use in industries such as industrial automation, robotics, and renewable energy applications, offering a reliable and efficient means of controlling DC loads while minimizing wear and tear associated with traditional mechanical relays.

In this project , it is used for manual control of the output and for the overcurrent protection circuit to automatically cut off the output voltage from the load.



- **AC Output.**

  - **AC solid state relay.**
    An AC solid-state relay (AC SSR) employing a triac is an electronic switching device designed for controlling AC electrical circuits without the use of mechanical components. It relies on a triac, a semiconductor device, as the switching element. This type of SSR is well-suited for AC applications and is triggered by a low-voltage control signal. AC SSRs with triacs offer advantages such as silent operation, fast switching, and extended service life due to the absence of mechanical wear and tear. They are commonly used in industrial automation, heating and lighting control systems, and various AC-powered devices where precise and reliable switching of AC loads is required, making them a preferred choice in such applications.



In our project, we are using AC solid-state relays to control the AC socket outputs.

➢ **Additional features.**

- **Precision voltmeter and ammeter.**
- **Current limiting feature.**
- **Touch switches.**
- **Wi-fi capabilities.**

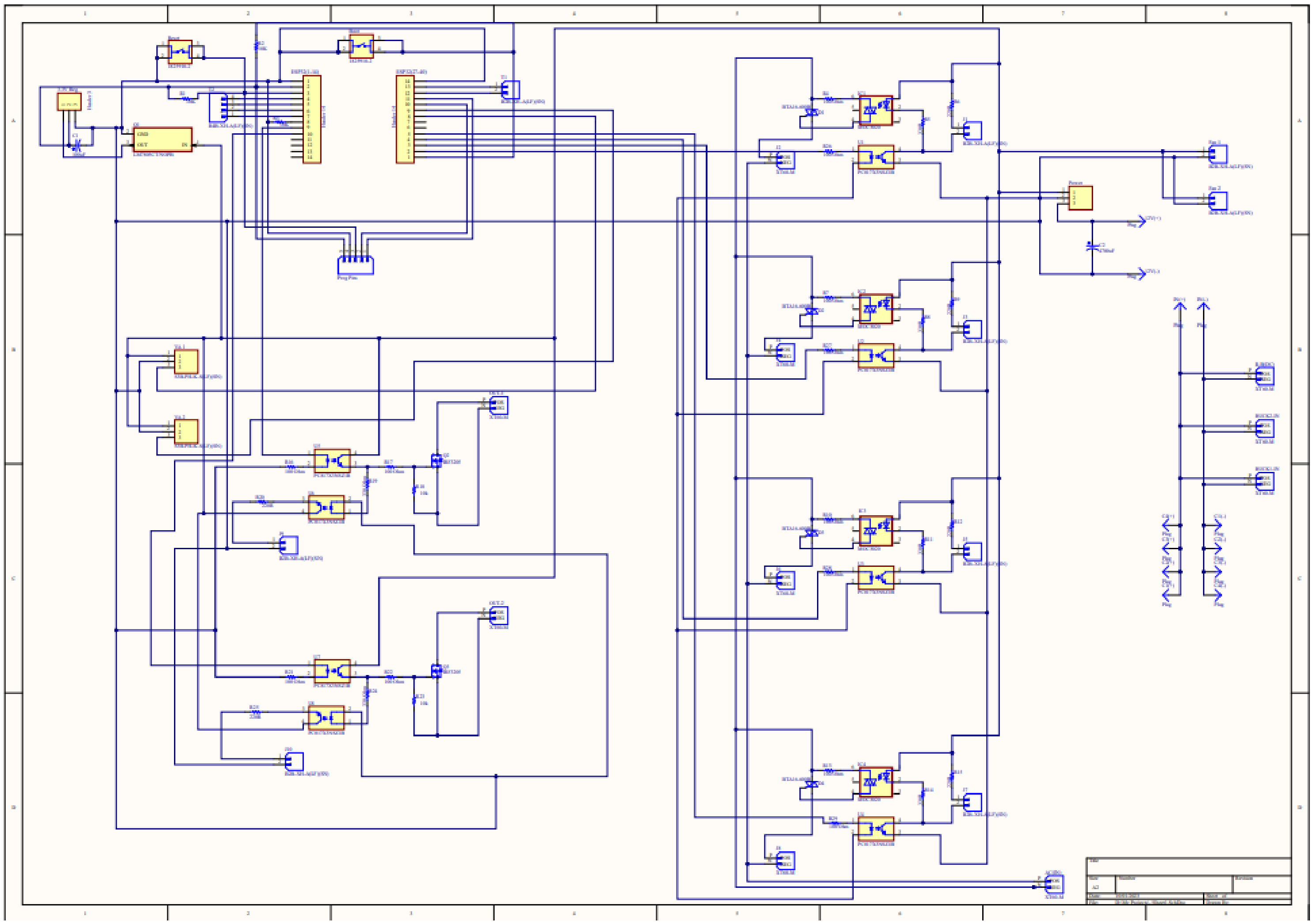
➢ **Super cooling system.**

- **Dual-fan cooling system.**

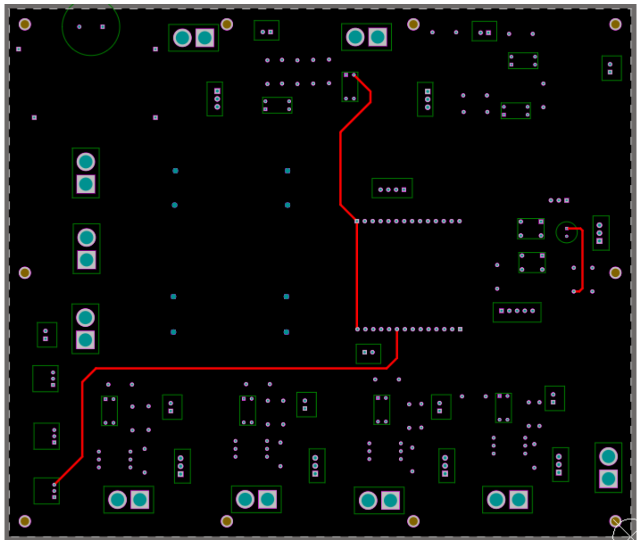
4) PCB Design.

❖ **Main PCB.**

- Schematic



- Top layer



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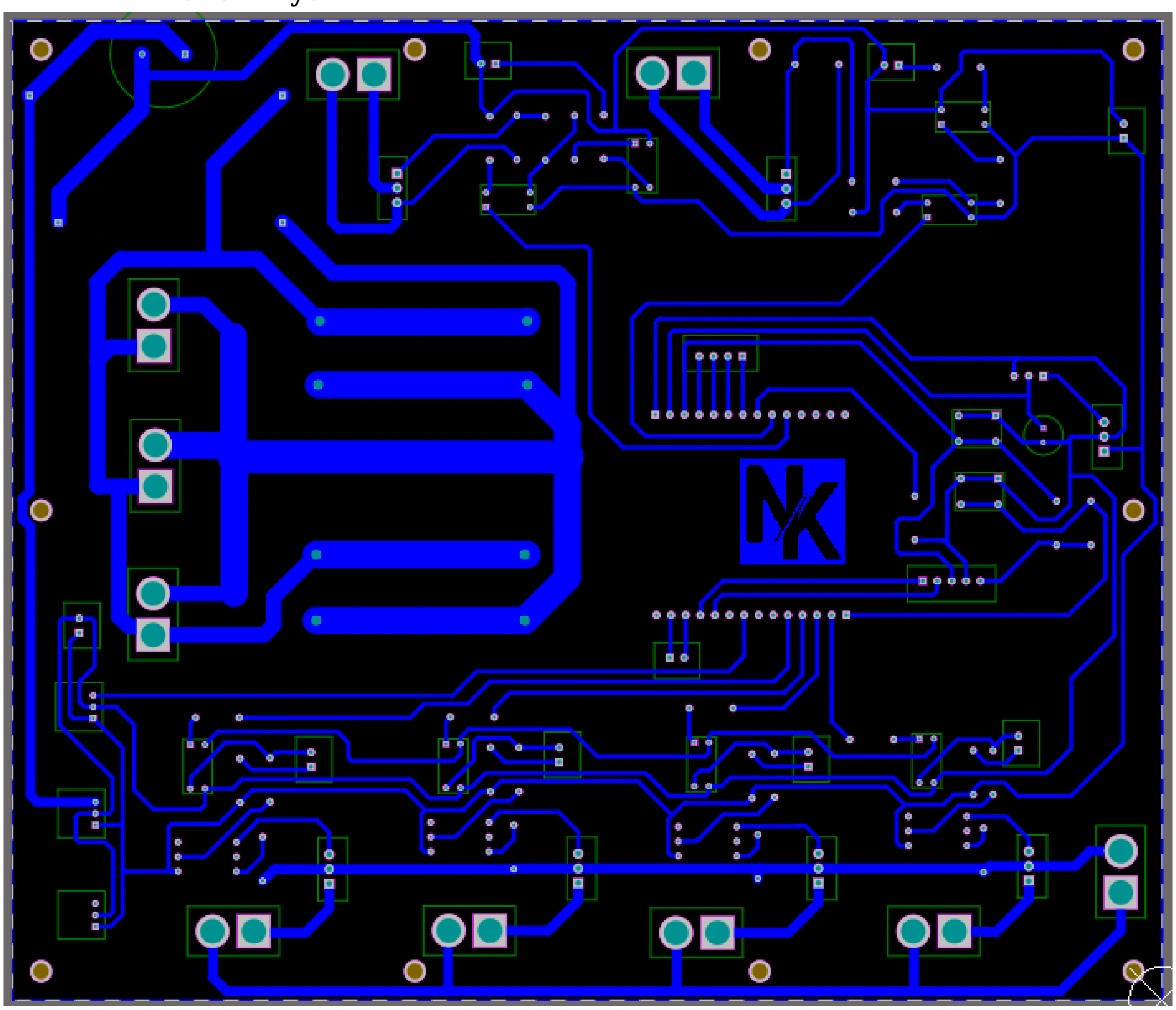
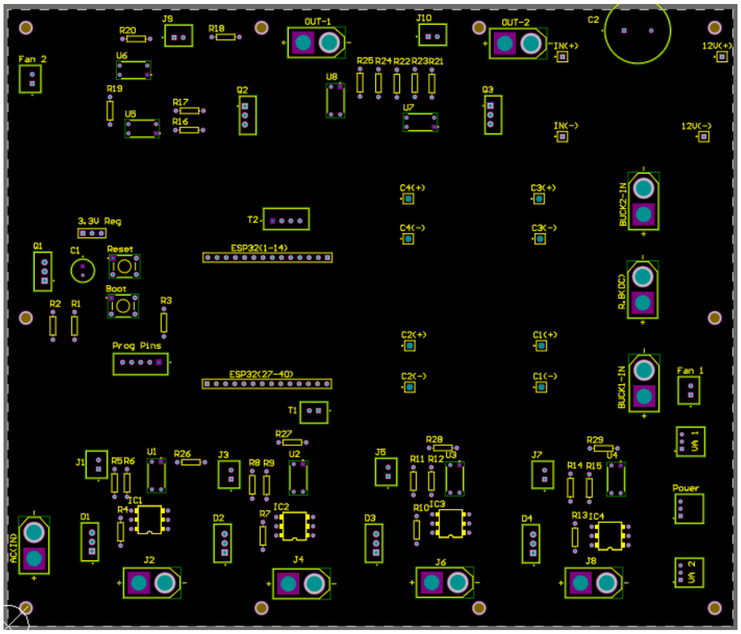
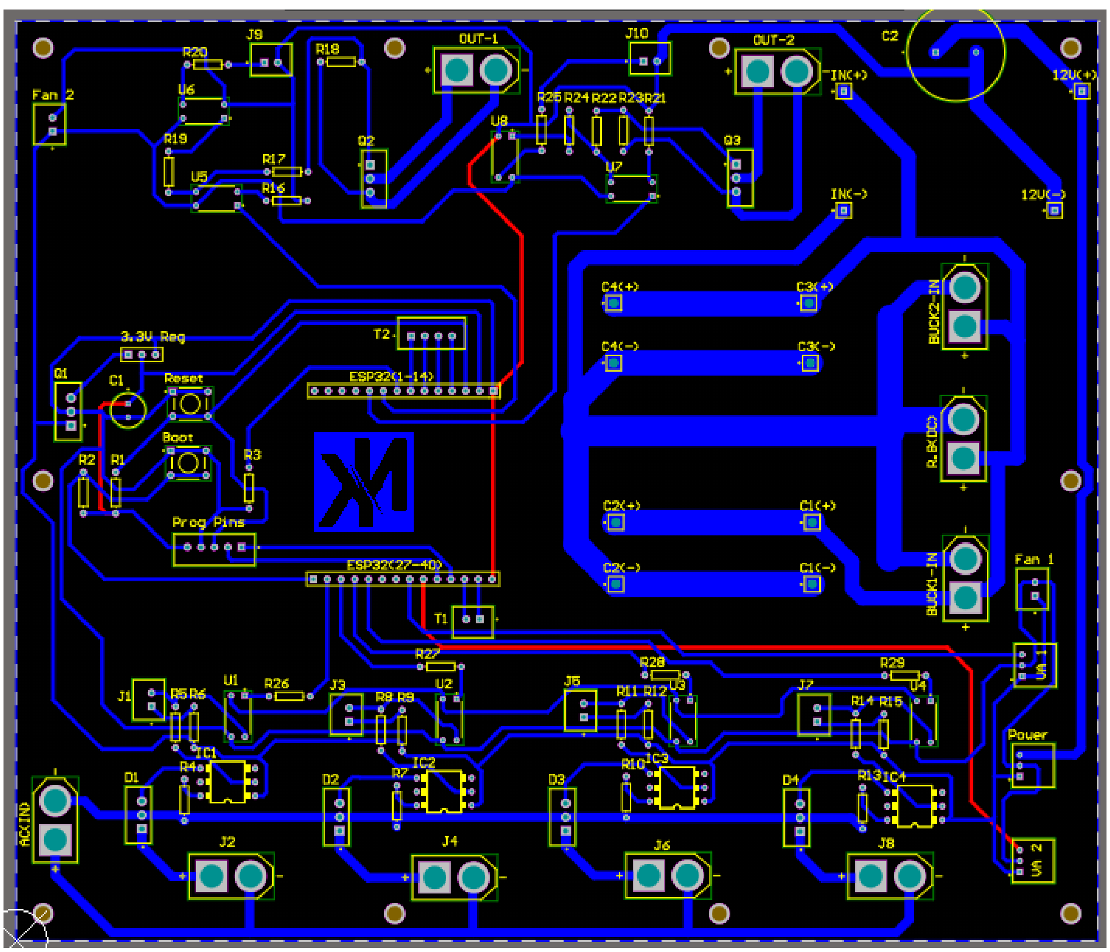
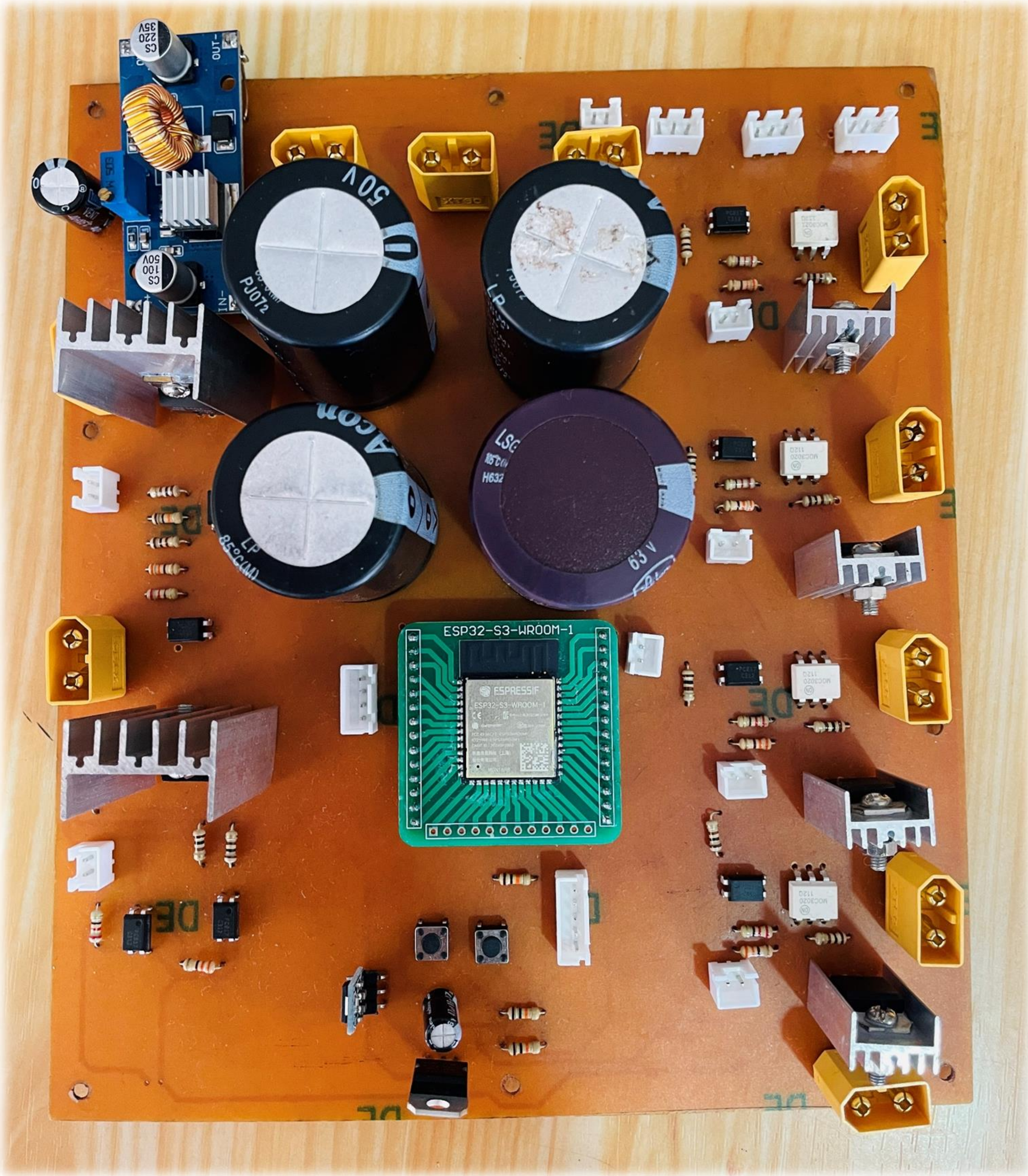


- Mechanical layers & Top overlay



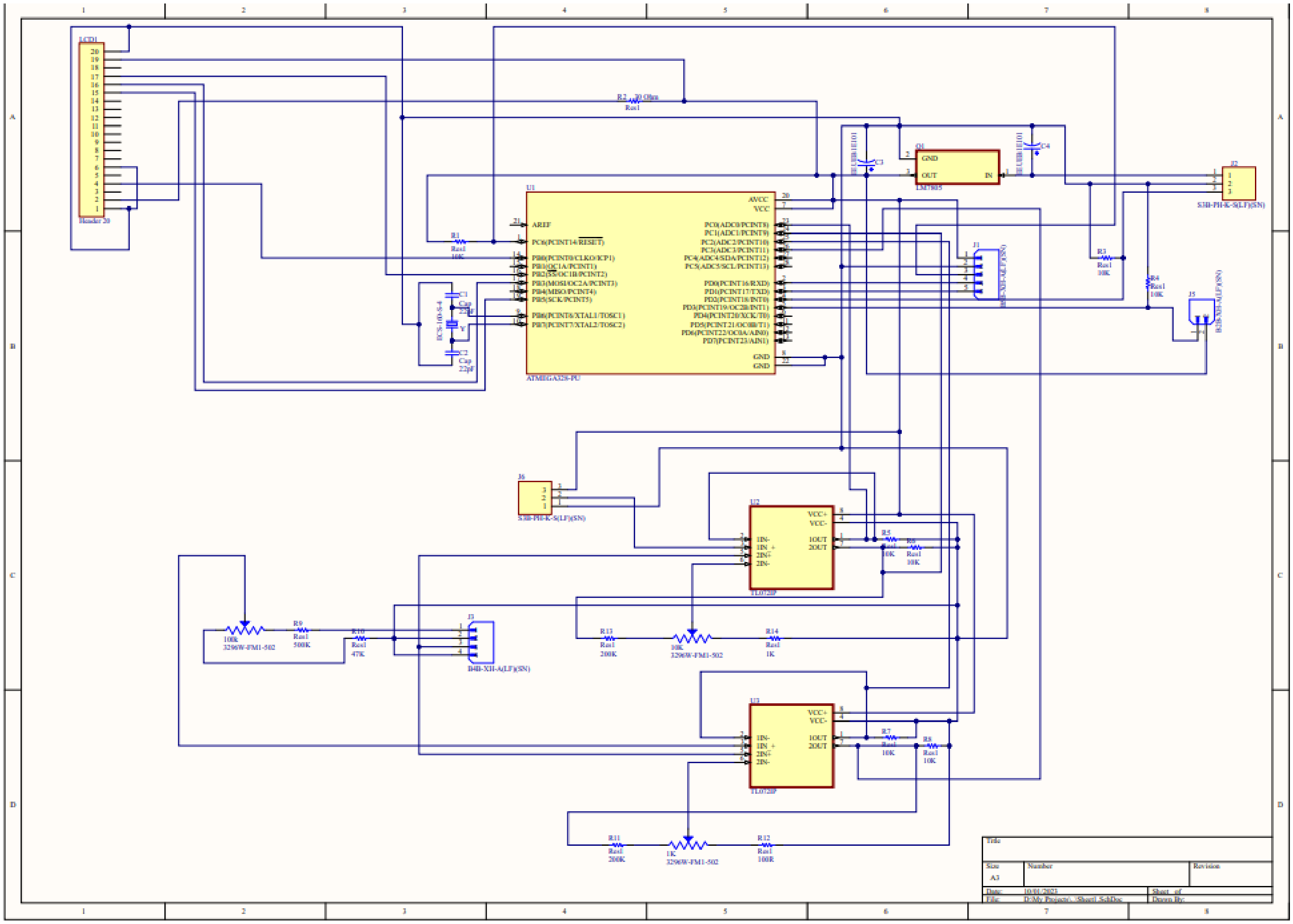
- Completed PCB



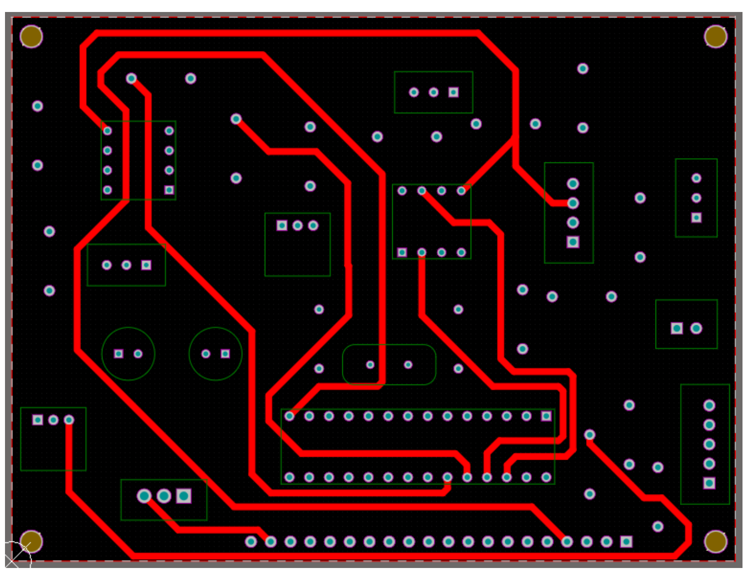

ESP32-S3-WROOM-1
ESPRESSIF
ESP32-S3-WROOM-1
50 V
63 V
PJ072
LSG
H632
CS 220 35V
CS 100 50V
OUT-
IN-

❖ Display PCB.

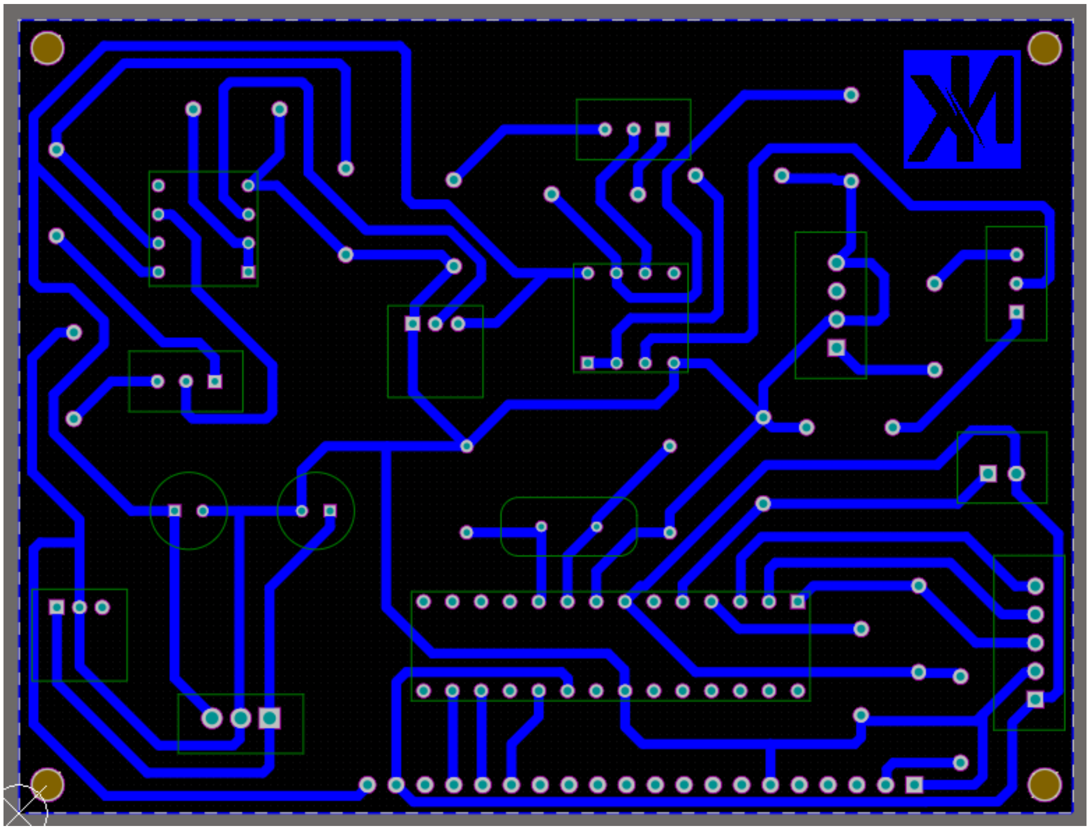
- Schematic



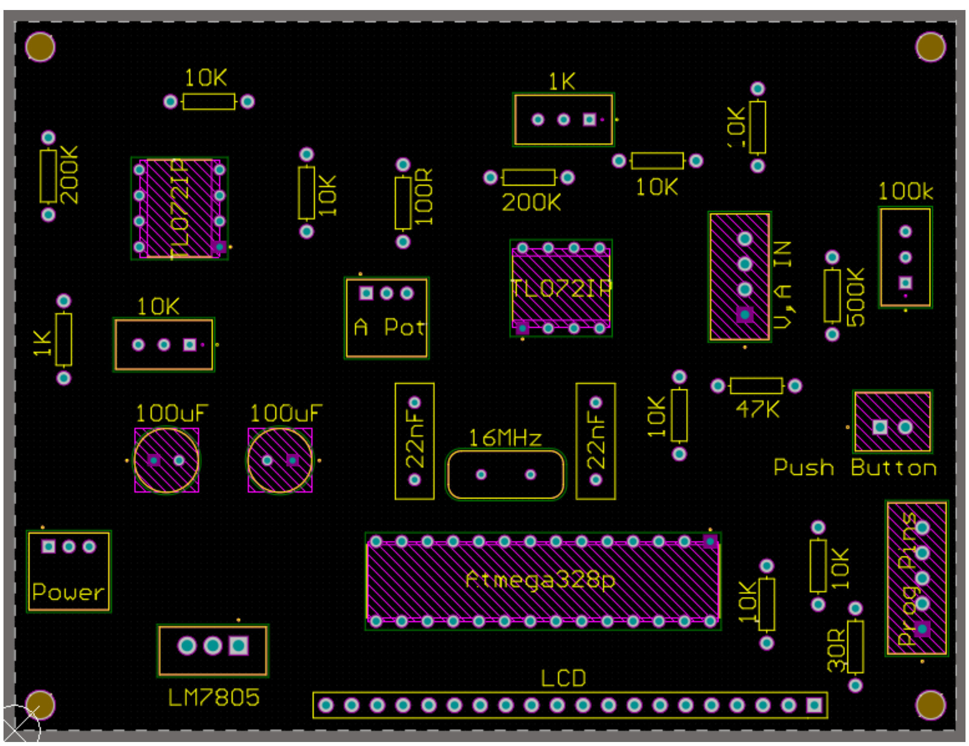
- Top layer



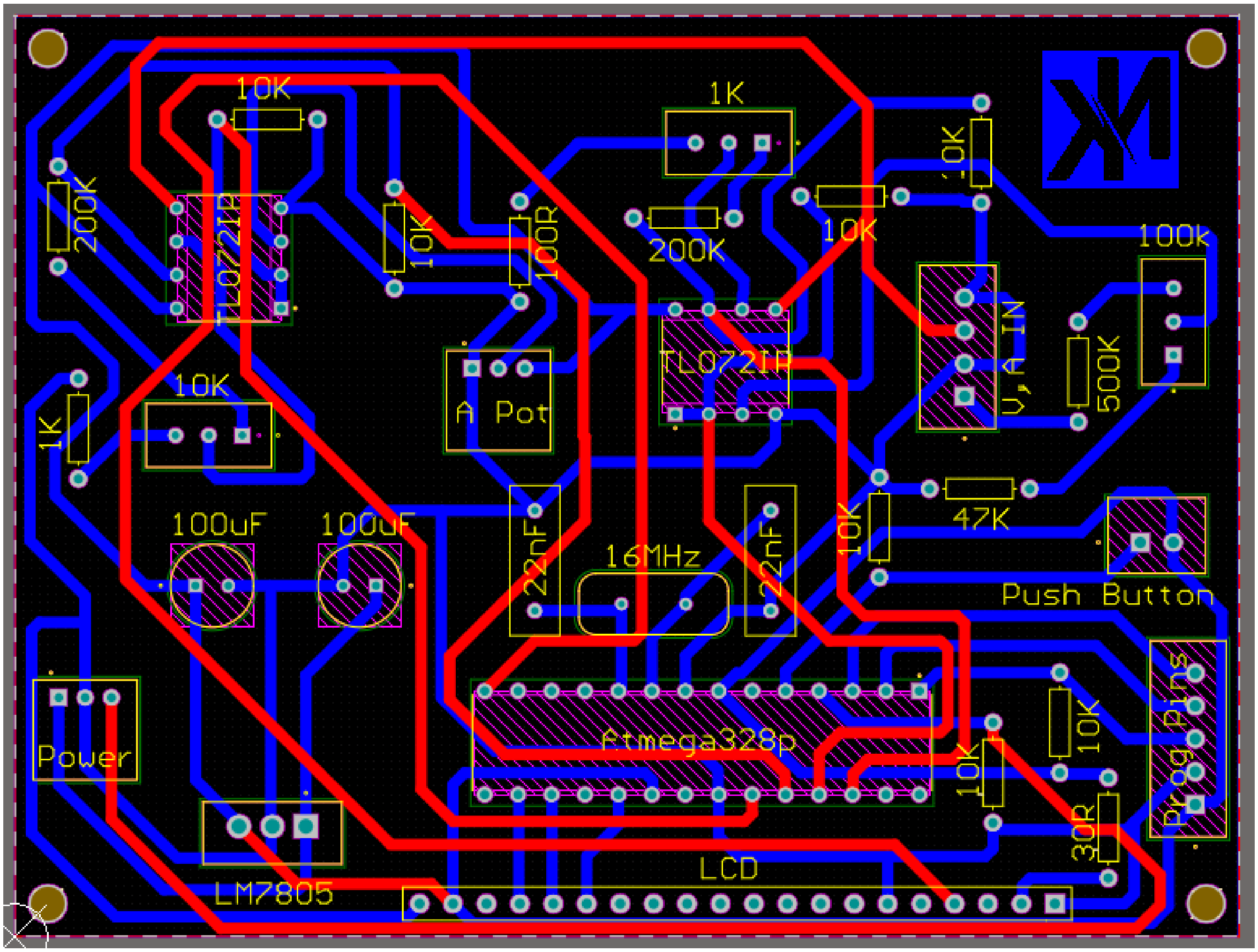
- Bottom layer

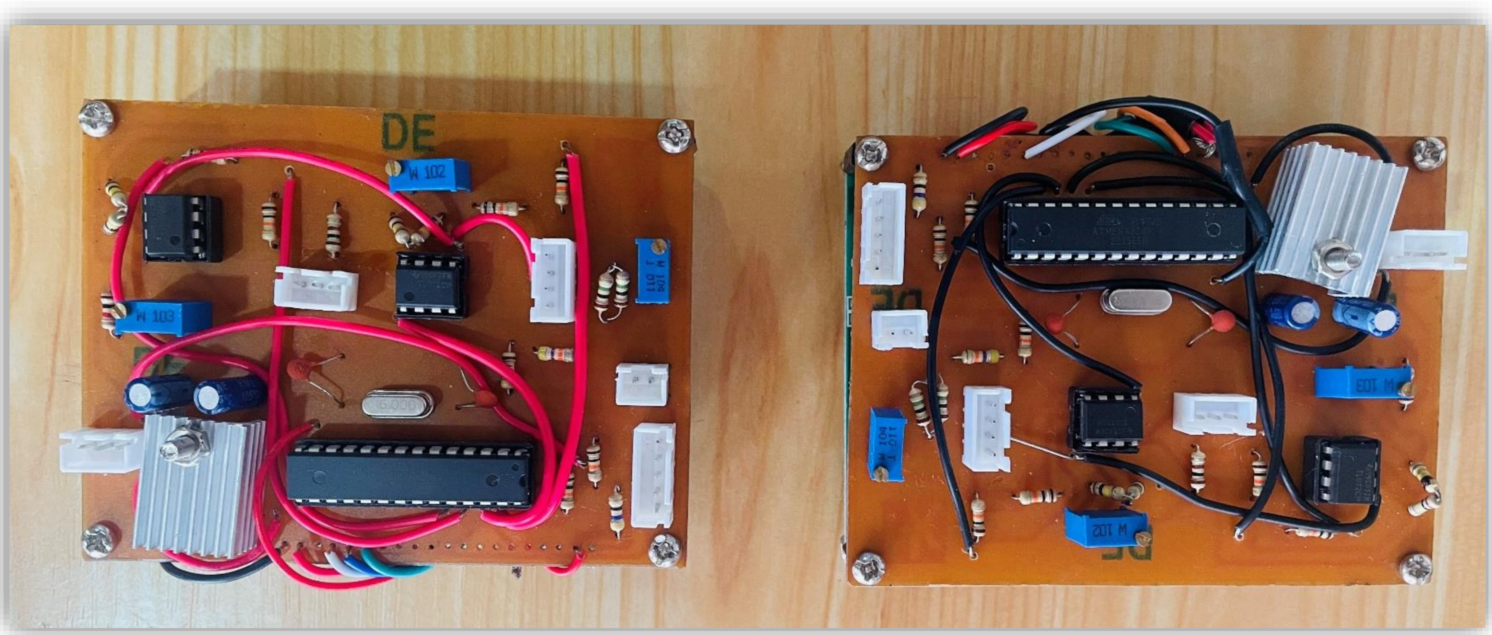


- Mechanical layer & Top overlay

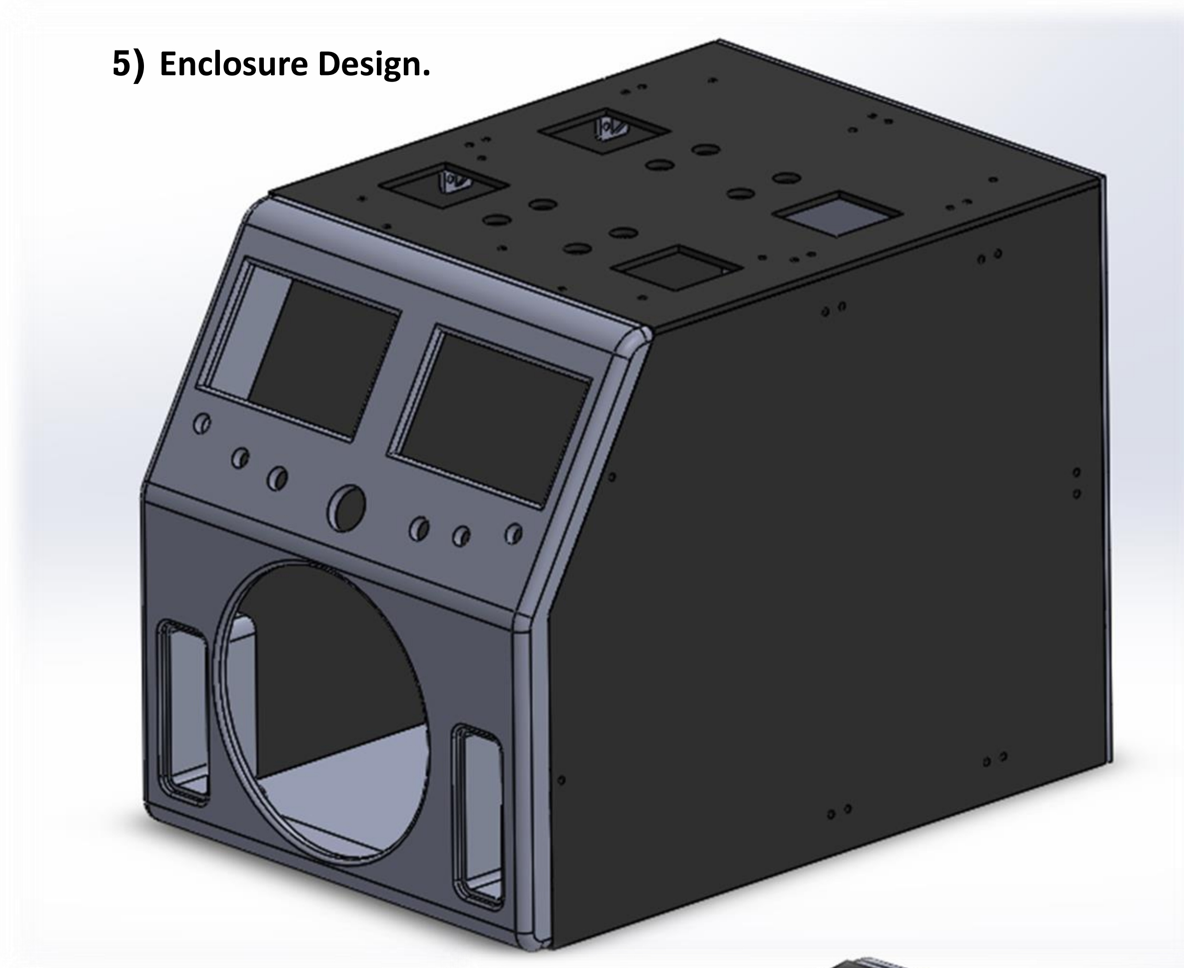


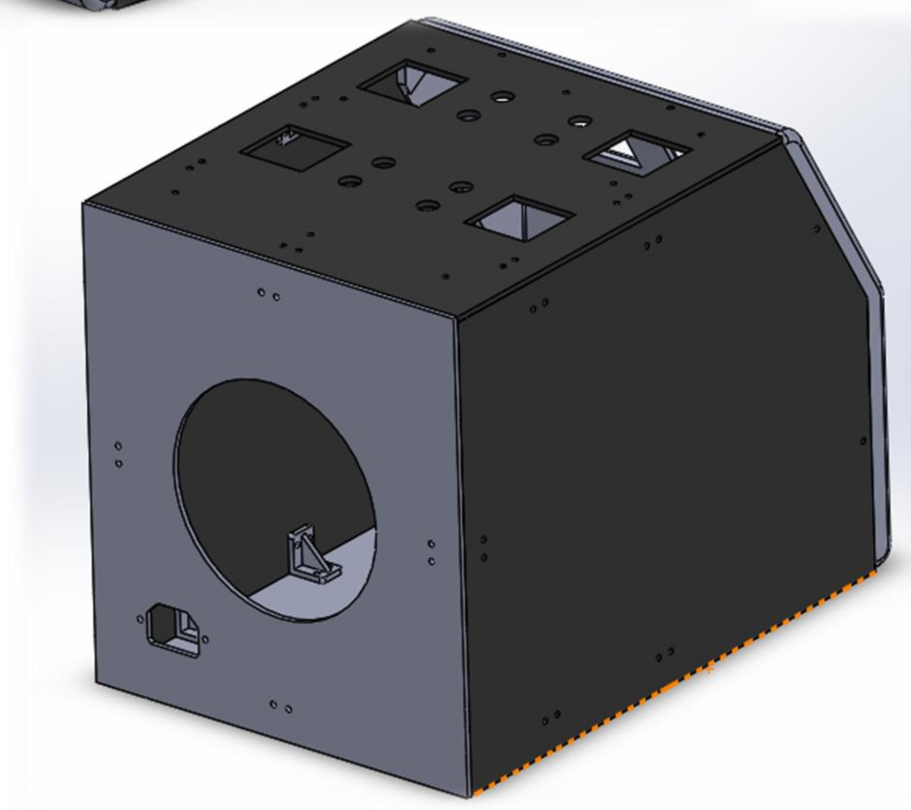
- Completed PCB

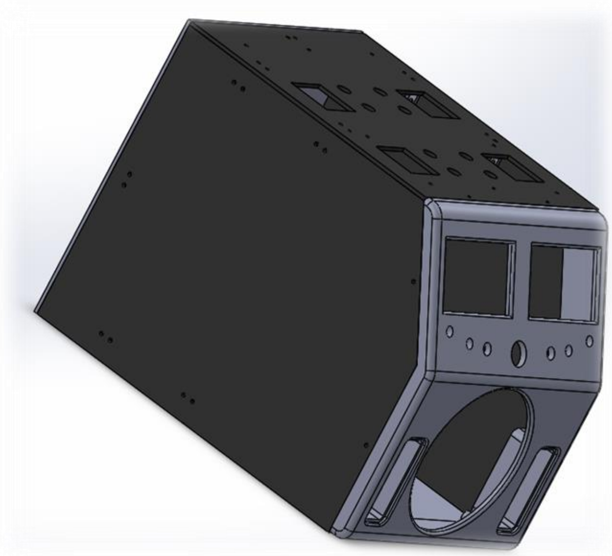


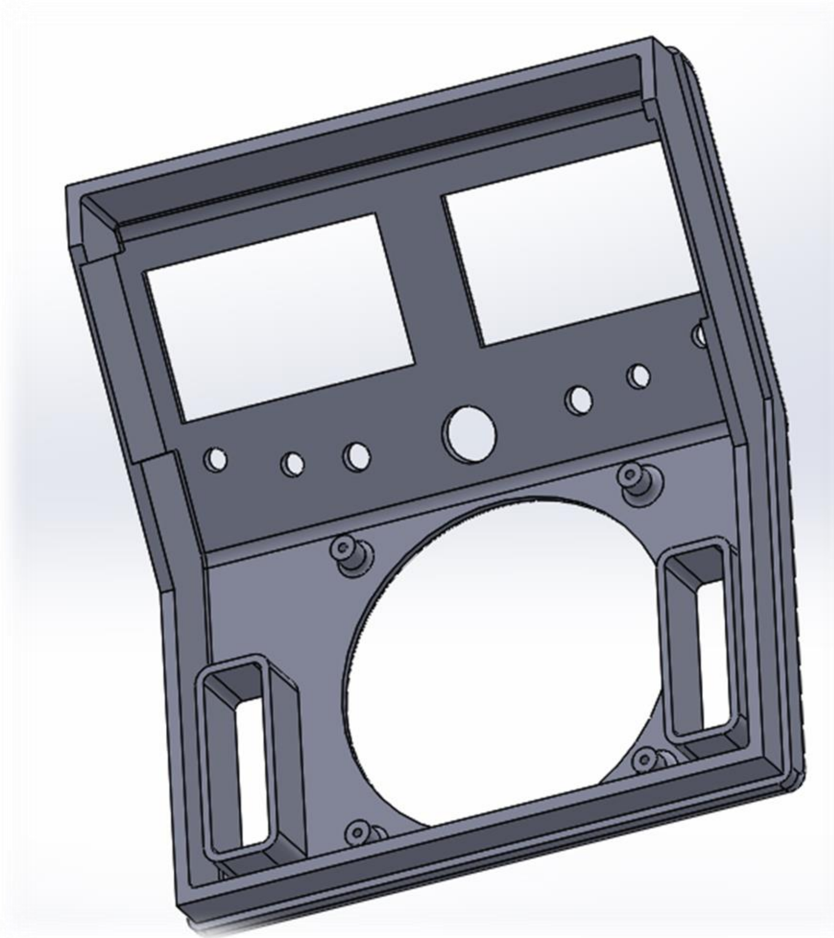


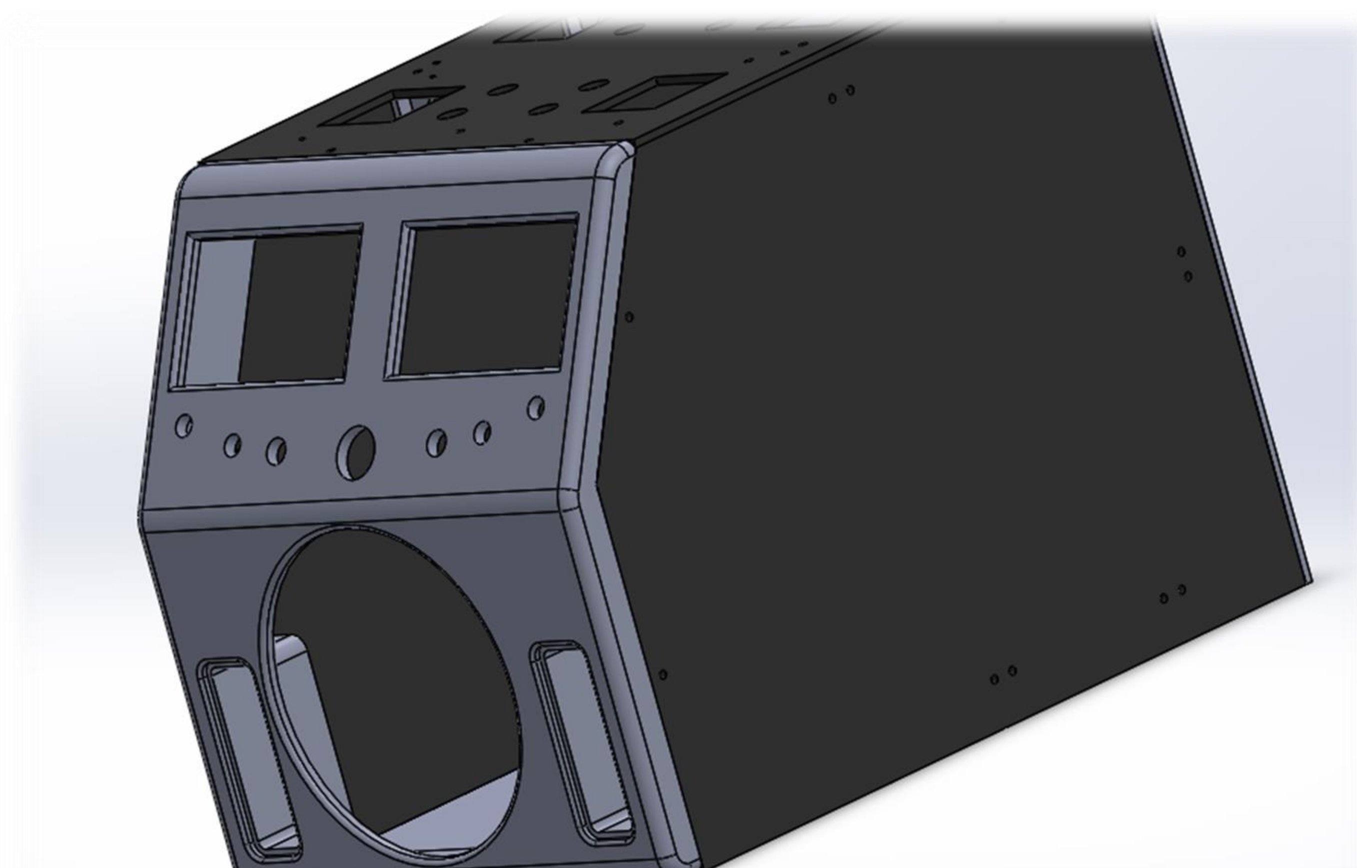
5) Enclosure Design.











6) Acknowledgement.

Our gratitude goes to the project supervisors and the advisory board who provided the necessary guidance and motivation to complete this project. We highly appreciate the Department of Electrical and Telecommunication Engineering laboratory staff for setting up and providing the essential testing equipment as well as facilitating us in working in the lab without any second thoughts. Finally, we thank our colleagues from the Department of Electrical and Telecommunication Engineering for giving us a helping hand during the past weeks without any hesitation.

7) References.