**Department of Electronic and Telecommunication Engineering**
**University of Moratuwa**

# EN2160 - Electronic Design Realization


# Final Report

**~Portenta Playmate Expansion Board~**

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## Abstract

The "Portenta Playmate Expansion Board" is a custom-designed breakout board aimed at augmenting the functionality and versatility of the Arduino Portenta H7. The expansion board features expanded IO pins and an analog multiplexer to increase the number of analog inputs, enabling seamless integration of diverse sensors. Additionally, it incorporates protection circuitry to safeguard the Portenta H7 from over-current, over-voltage, and potential hazards, ensuring enhanced resilience when connected to various power sources and peripherals. Furthermore, the board includes level shifters, facilitating seamless communication with external components operating at different voltage levels. The Portenta Playmate Expansion Board empowers the Arduino Portenta H7 with increased GPIO, analog inputs, and protection features, making it more accessible and user-friendly for prototyping and beginner-level robotics projects. This abstract outline the design, implementation, and testing processes undertaken to achieve these enhancements, emphasizing its potential for further improvements and applications in the field of embedded systems and robotics.

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# 1. Introduction

## 1.1 Overview and Objectives

Portenta H7 ($) is an advanced development board from Arduino which caters powerful processing capabilities, making it ideal for complex applications in robotics, IoT, and automation. However, to cater to the demands of a wider range of prototyping and robotics projects, there is a need for additional GPIO pins and analog inputs, as well as protection circuitry to ensure the safety of the board and connected peripherals. Moreover, seamless interfacing with devices operating at different voltage levels is essential for a comprehensive and user-friendly experience. The "Portenta Playmate Expansion Board" addresses these requirements, providing expanded IO pins with added analog inputs through an integrated analog multiplexer. The inclusion of protection circuitry offers reliable safeguards against over-current, over-voltage, and other potential hazards. Furthermore, level shifters are incorporated to enable efficient communication with external devices operating at varying voltage levels. This report presents a detailed account of the design, implementation, testing, and integration processes undertaken to develop the "Portenta Playmate Expansion Board." Through the expansion board's enhanced capabilities and improved safety features, it aims to empower users, ranging from beginners to advanced makers, with a powerful and user-friendly platform for prototyping and robotics endeavors.

## 1.2 Motivation

The motivation behind the "Portenta Playmate Expansion Board" project stemmed from a vision to democratize and simplify the process of prototyping and experimentation in the fields of embedded systems and robotics. While the Arduino Portenta H7 is a remarkable development board with exceptional capabilities, we recognized the need to enhance its functionalities to cater to a broader range of users, including beginners and intermediate makers. The idea was to create a versatile and accessible platform that would empower enthusiasts, students, and professionals alike, enabling them to explore, experiment, and innovate with greater ease and flexibility. By augmenting the Portenta H7 with additional GPIO pins, analog inputs, and protection circuitry, we aimed to create a comprehensive and user-friendly solution that reduces the barriers to entry for individuals seeking to delve into the exciting world of prototyping and robotics. Through the "Portenta Playmate Expansion Board," our mission was to bridge the gap between novices and experienced developers, encouraging creativity, fostering a spirit of exploration, and ultimately inspiring the next generation of inventors and innovators.

# 2.Design & Architecture

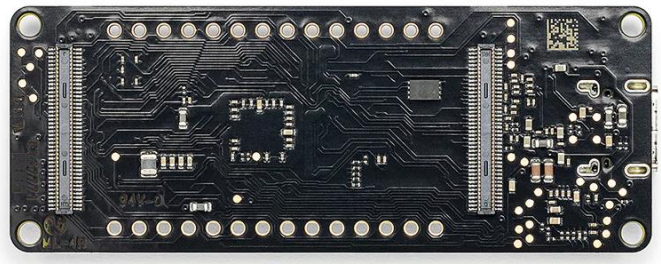
When designing the expansion board following areas were considered,

- Expanding the outputs available from high density connectors.
- Power supply
- Analog Multiplexers
- Protection circuitry
- Level shifter circuitry

## 2.1 Expanding IO

As mentioned above although Arduino portenta board offers high level of processing capability it doesn't give flexibility with the number of IO pins that a user can connect to.

But there are close to 140 IO connections available from the board's high-density connectors.



When designing the expansion board all connections offered by the high-density connectors are wired to female headers located around the expansion board

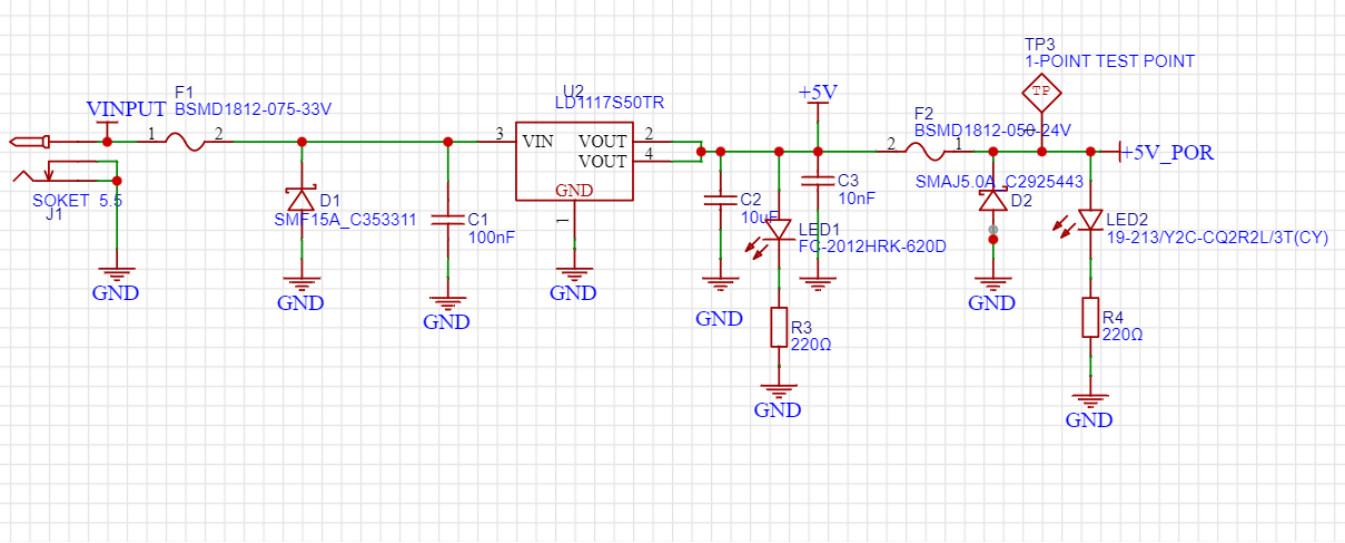
2.2 Power Supply

Anyone with knowledge of development boards are familiar with Arduino uno and mega boards among other good things offered by those boards one of the advantages that is highlighted is being able to power those boards from number of different power supply methods. (ie uno and mega boards has a broad input voltage range compared to other micro controllers) When designing the expansion board a voltage regulator was included to regulate broader spectrum of input voltages.

## 2.3 Protection Circuitry

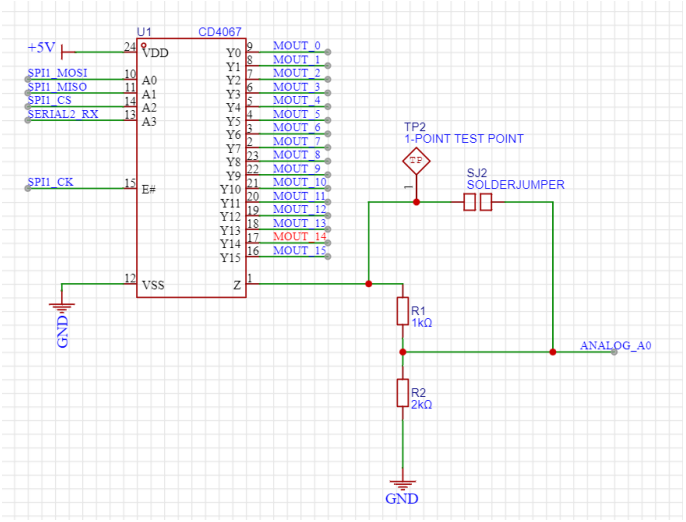
Portenta h7 board is a expensive board compared to other microcontrollers and it's prone to be damaged if it is used as a development board. So protections circuits are included for

- Over voltage hazards
- Reverse voltage hazards
- Over current hazards
- Transient voltage hazards




## 2.4 Analog Multiplexer

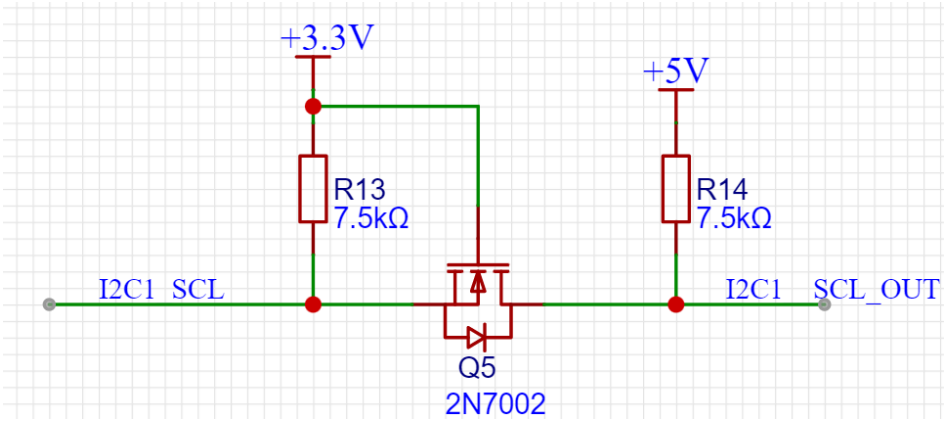
From high density connectors Arduino Portenta h7 provides 8 analog inputs but that is not enough in some situations (when many sensors are needed to be connected). The expansion board includes an analog




multiplexer which multiplexes one analog input into 16 inputs.

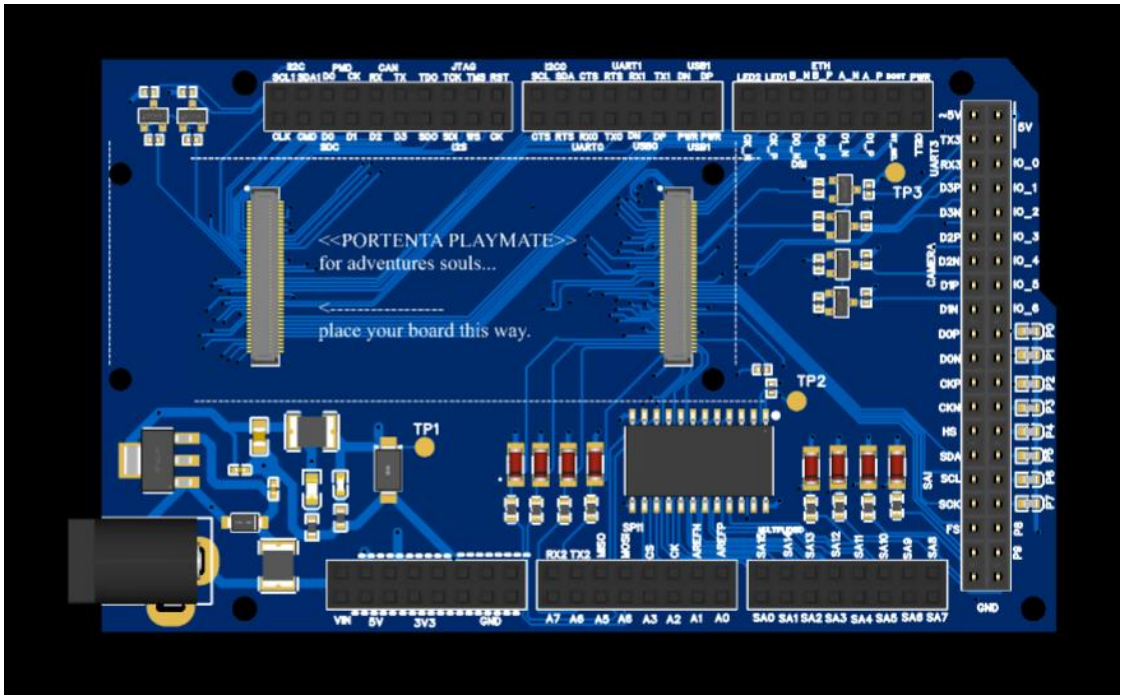
2.5 Level Shifter Circuit

Arduino portenta works in 3V3 logic levels but there are many sensors and actuators that work with 5V logic levels. The Expansion  board offers 3V3 – 5V translation for some selected pins.



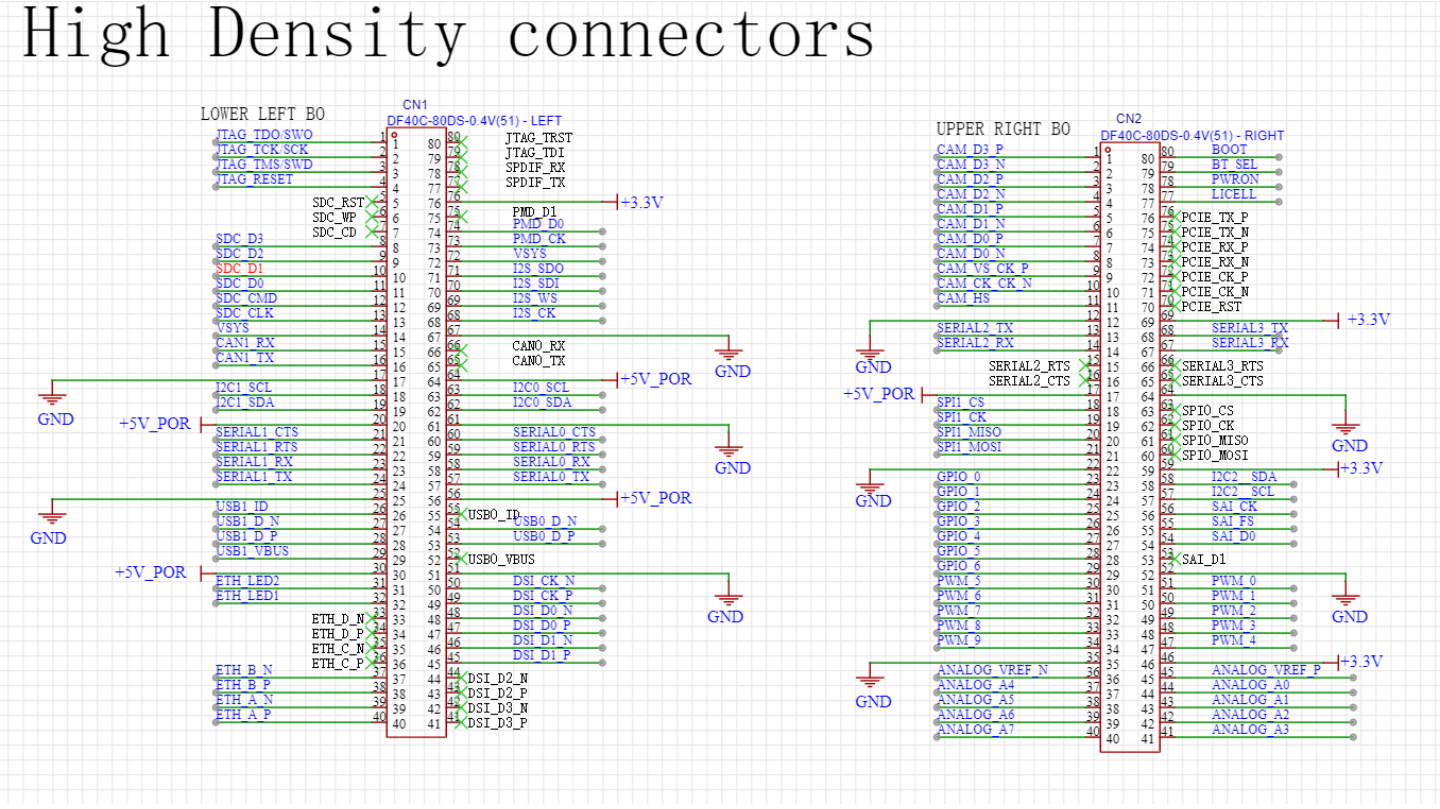

2.6 Dimensions of the expansion board

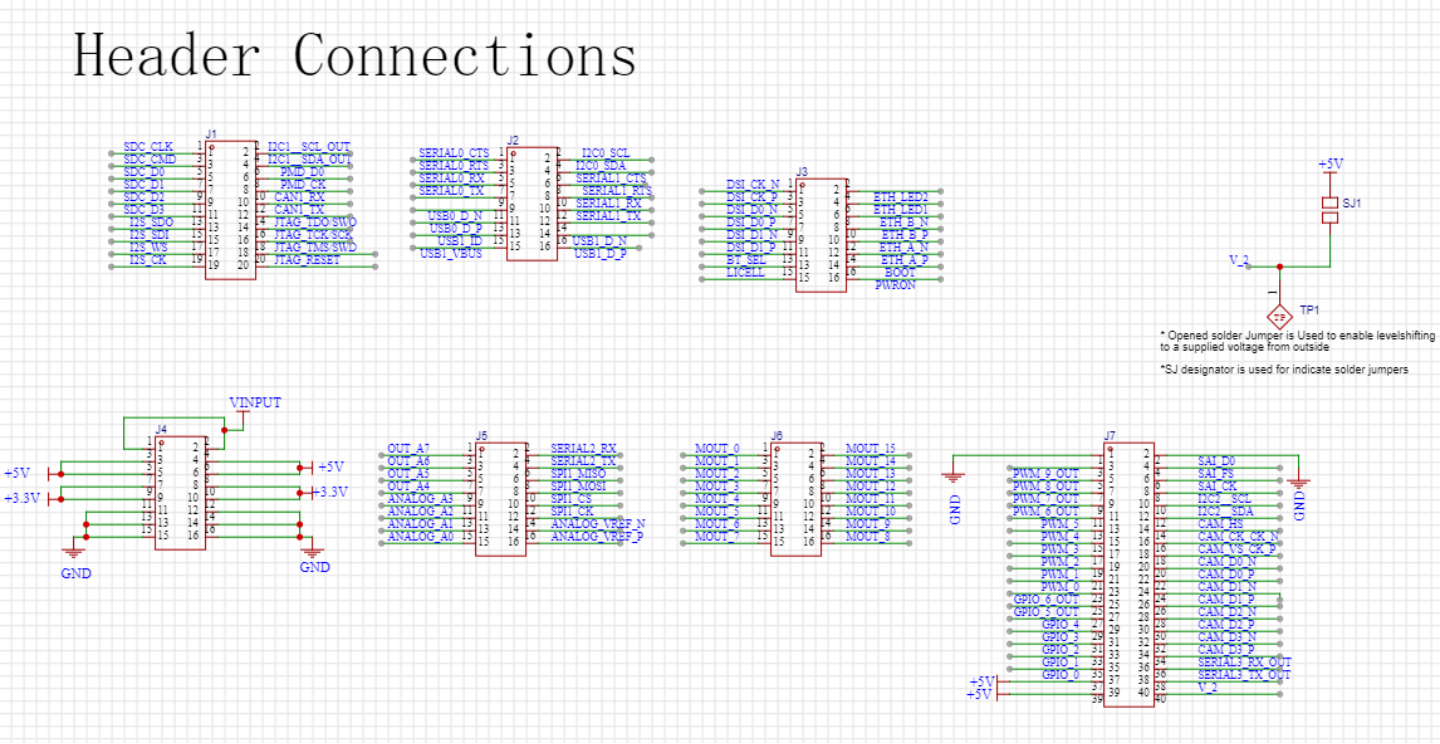
The size and shape of the expansion board were designed the same as the Arduino mega board.



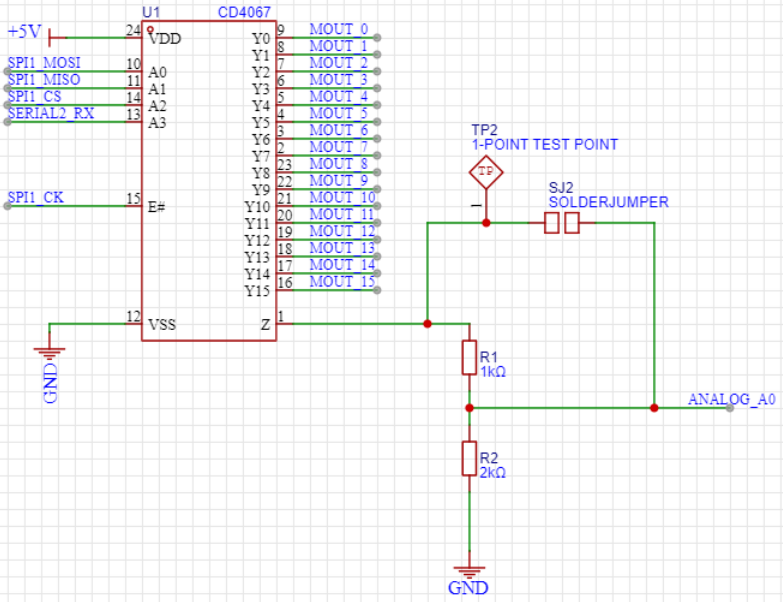
# 3.Implementation

## 3.1 Schematic Implementation

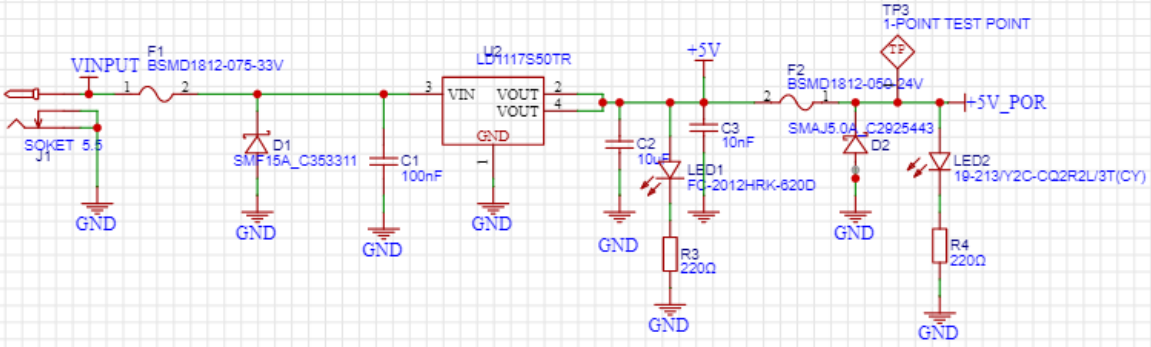


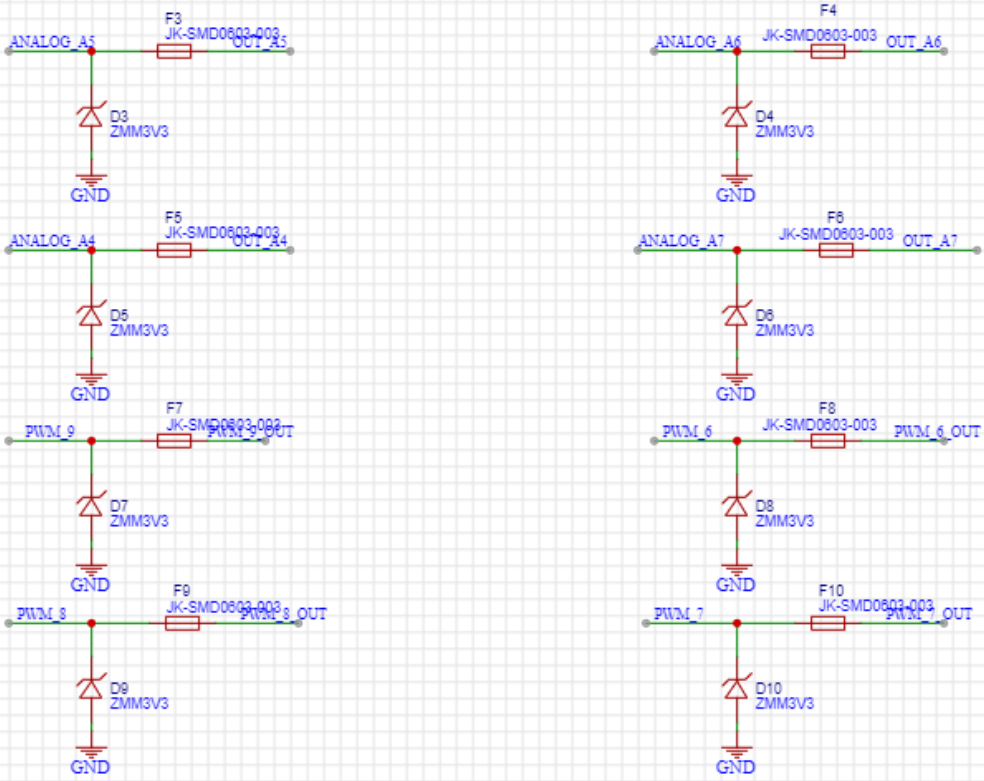
# Analog Multiplexer



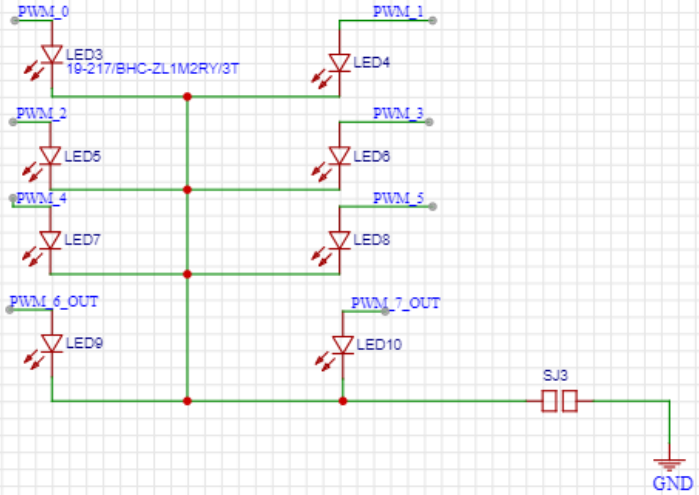

# Power Circuit



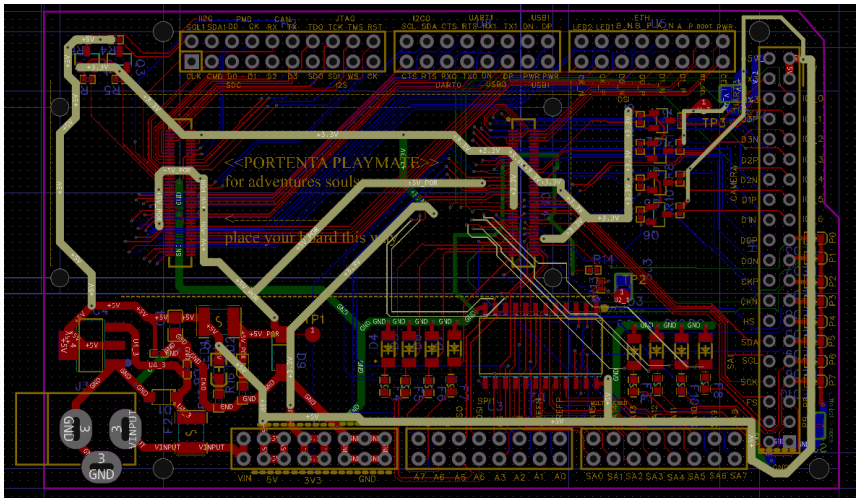
# Current limited/ Short circuit/ Over voltage protected pins



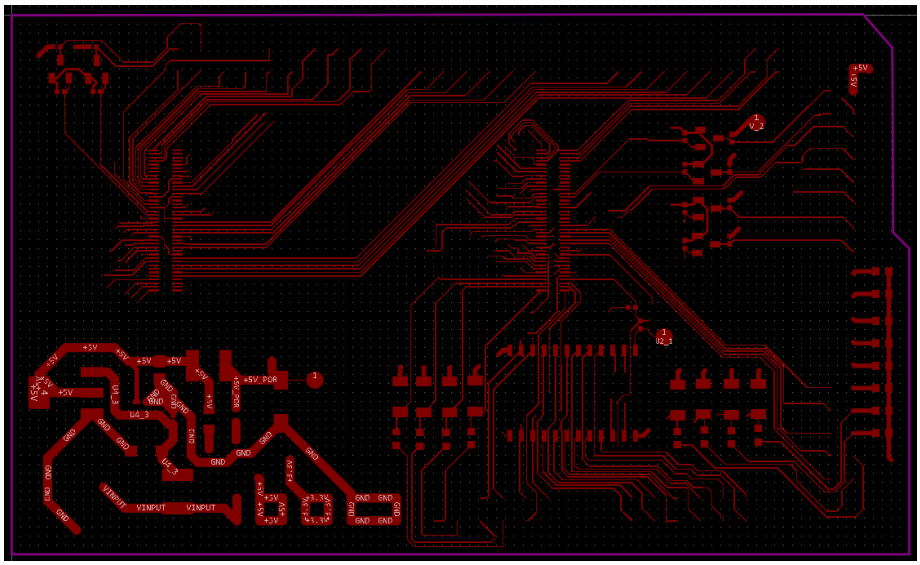

# LED Indicators

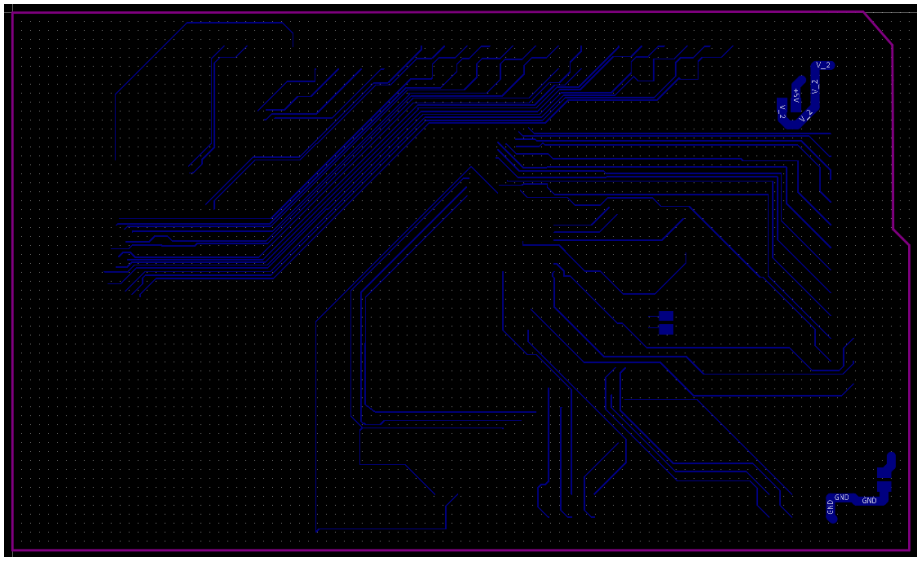


3.2 PCB implementation



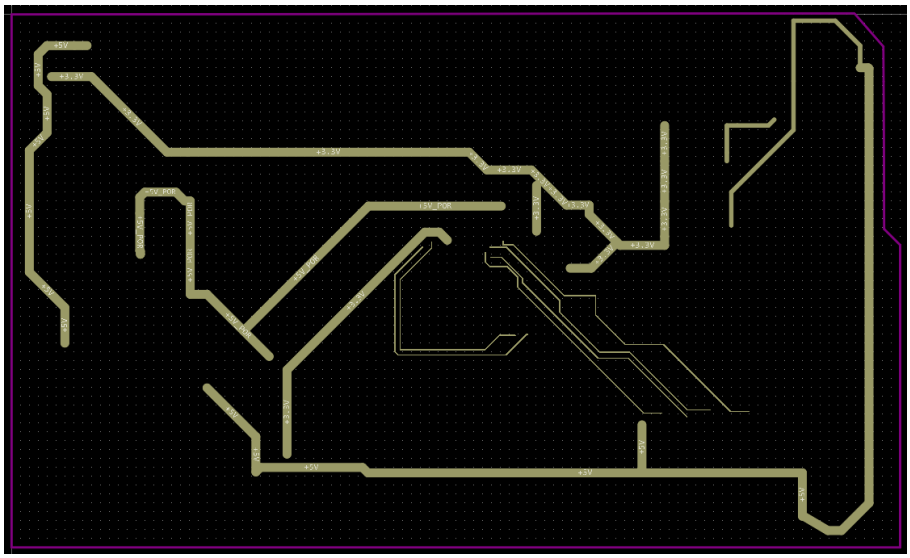

## Top Layer & Bottom Layer



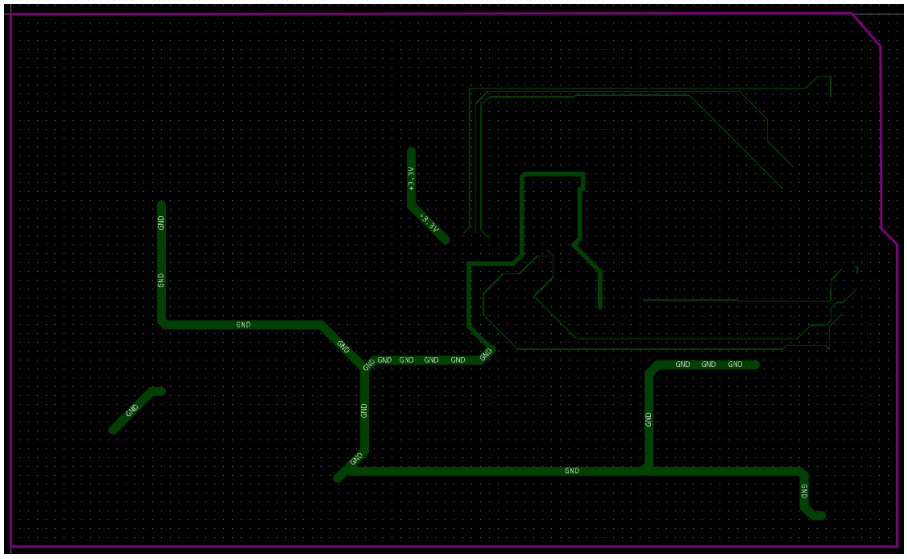


## Mid Layers

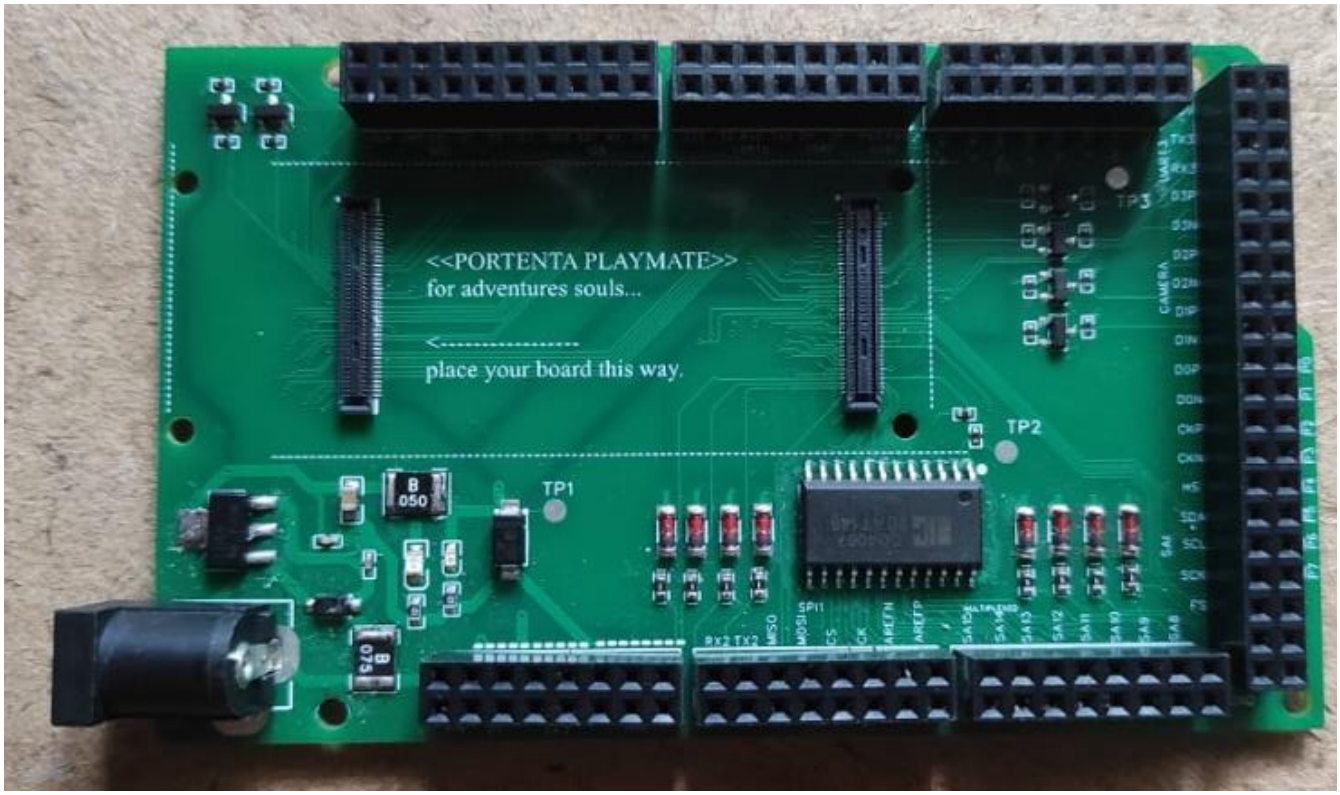
## Layer 1

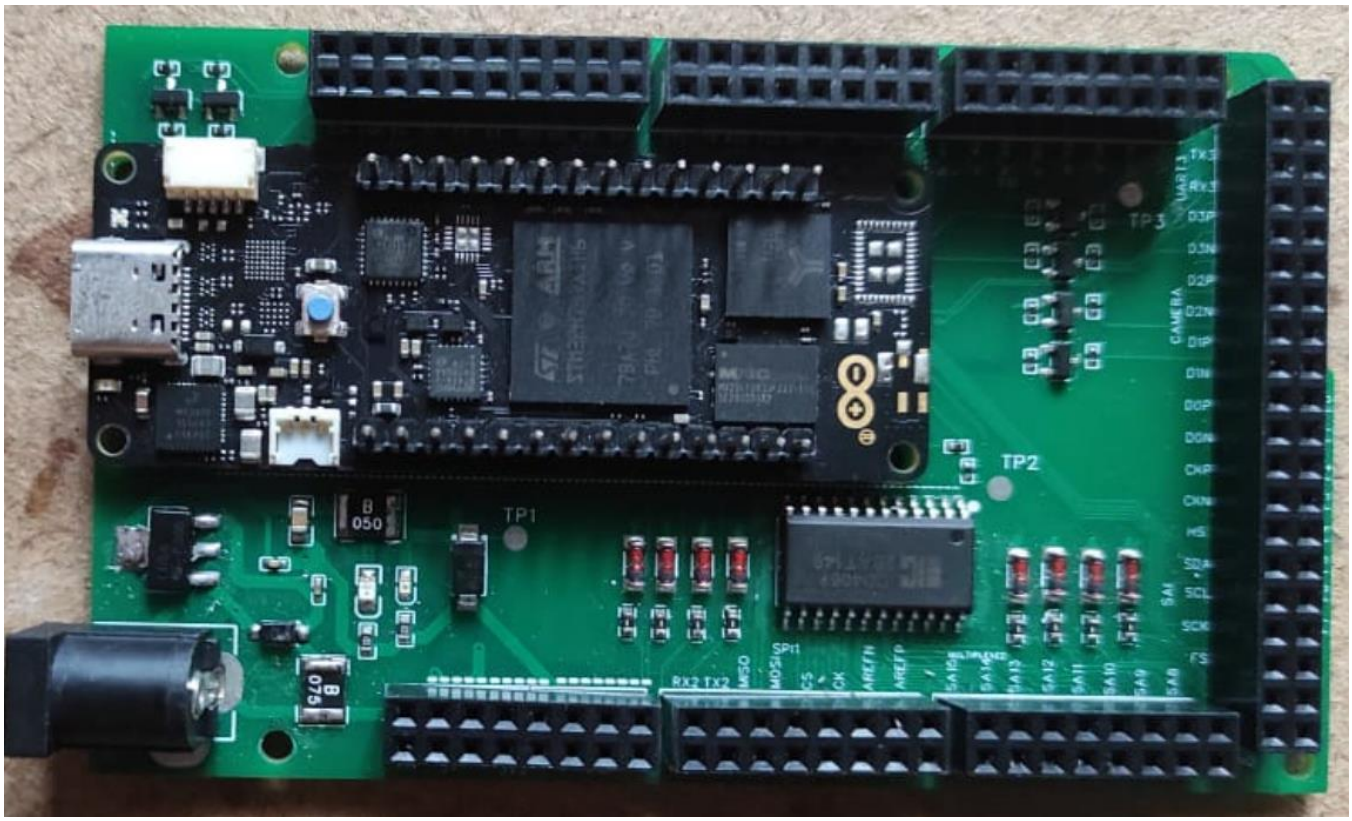


## Layer 2



## 3.3 Physical PCB implementation



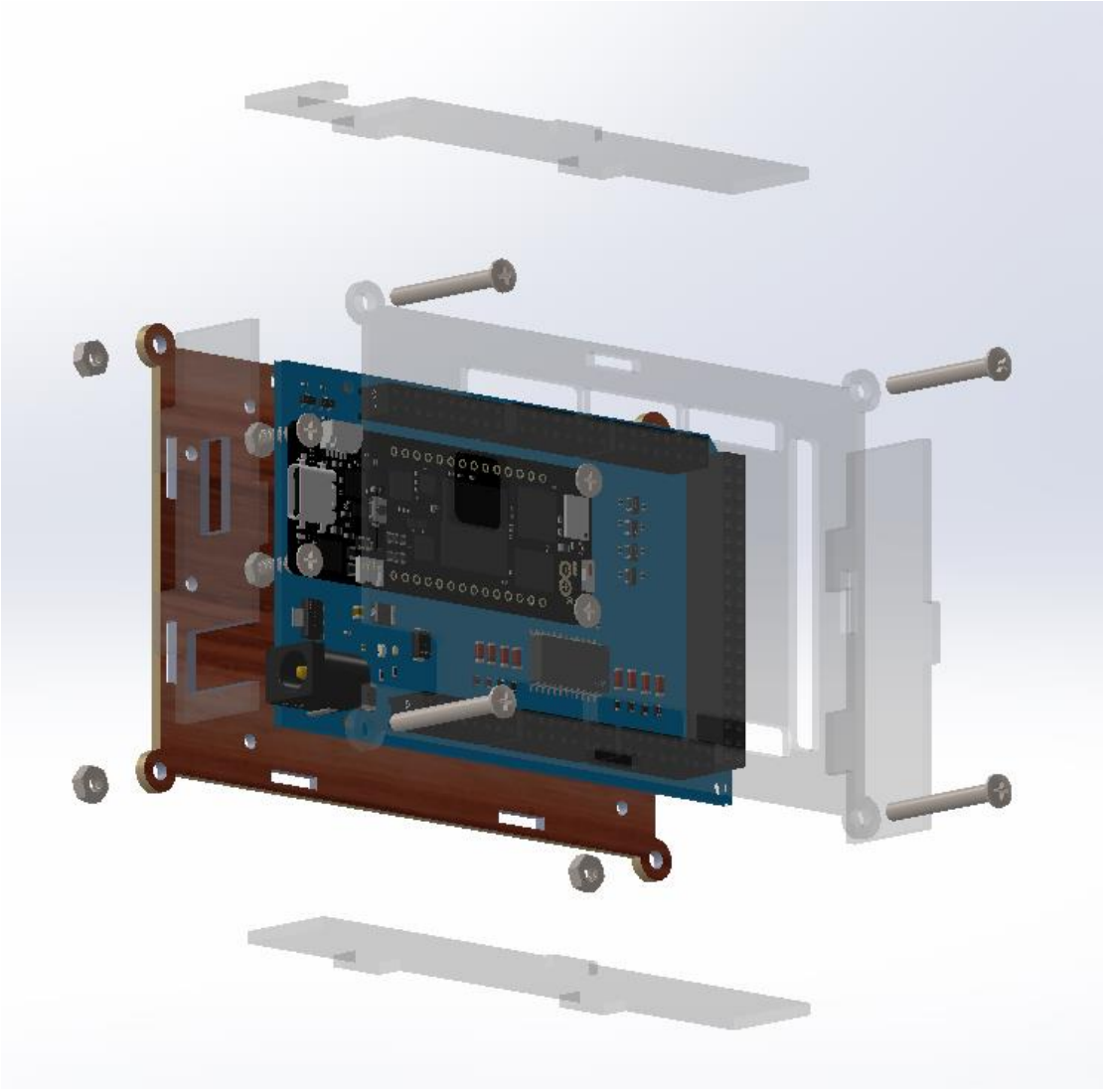



## 3.4 Enclosure Implementation

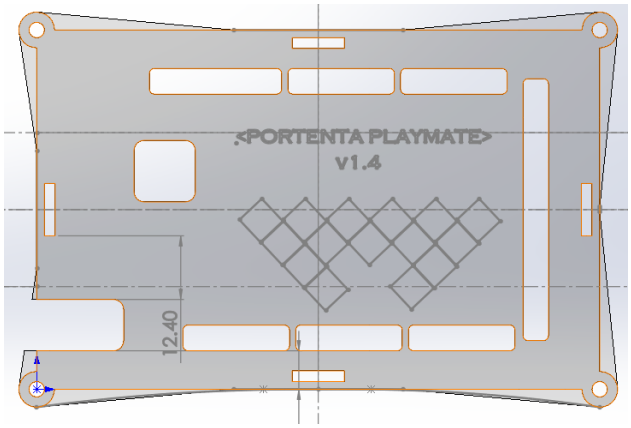
Enclosure is made with laser cut plywood and transparent acrylic sheet.

### 3.4.1 Enclosure manufacturing specifications

- Thickness – 2mm
- Tolerance – 0.1mm
- Screws –
    - 3 x 20 mm screws and Nuts
    - 2 x 10 mm screws and Nuts
    - 2 x 12 mm screws and Nuts

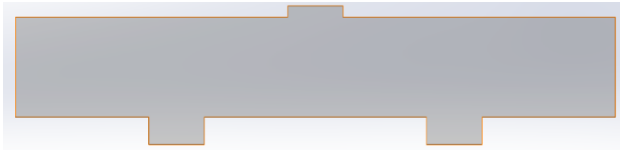


Top



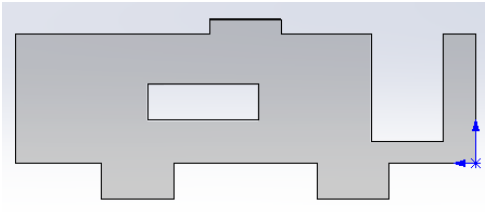

Bottom

Left



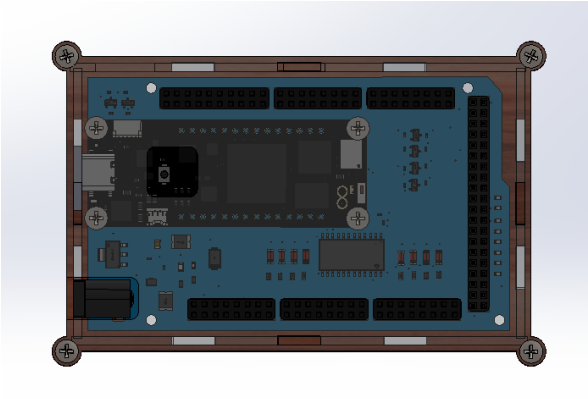
Right

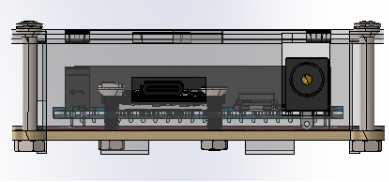
Front

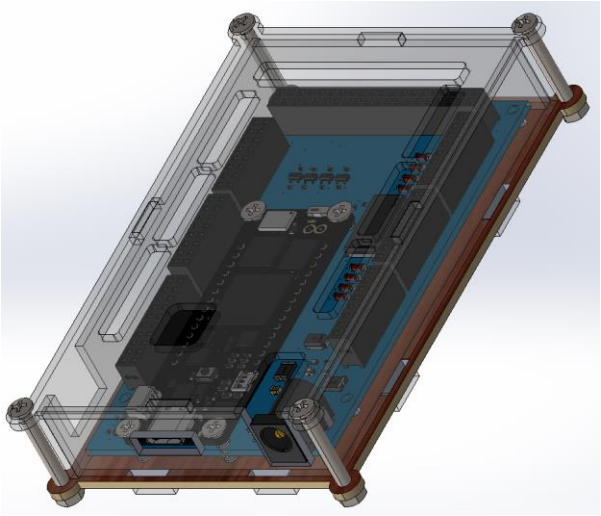


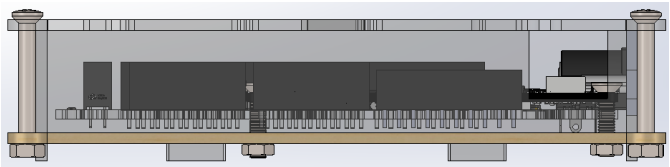
Back

## 3.4.2 After Assembly

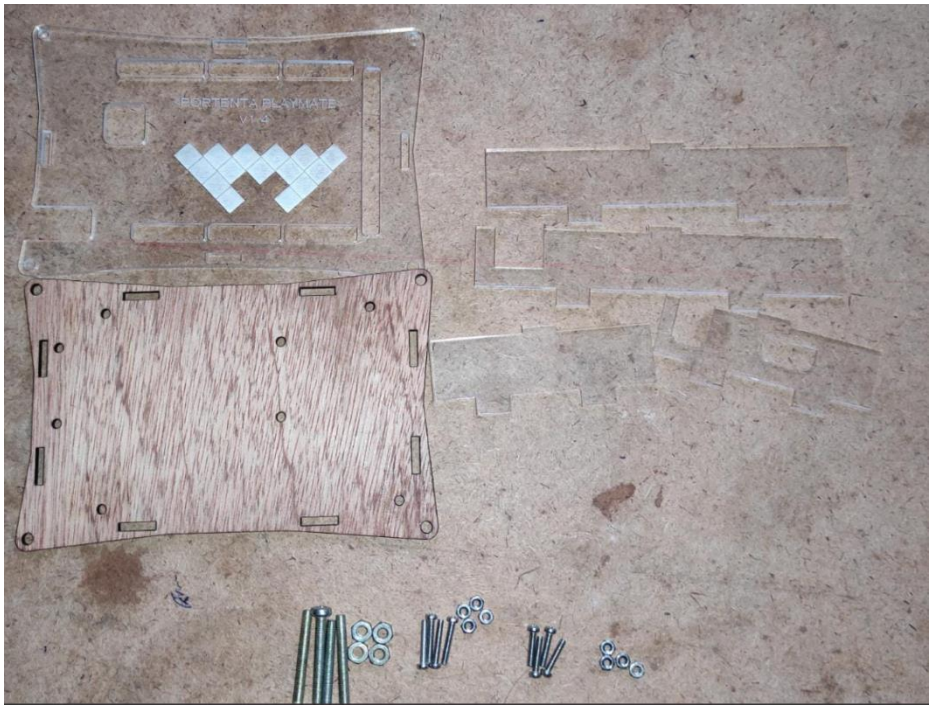


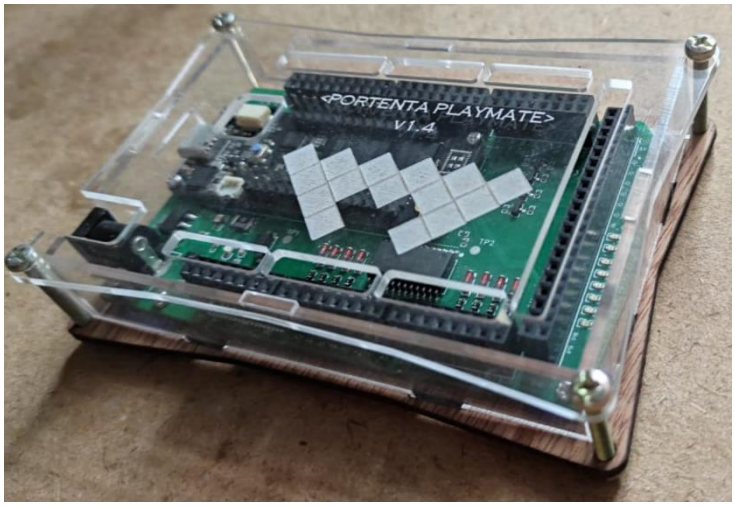


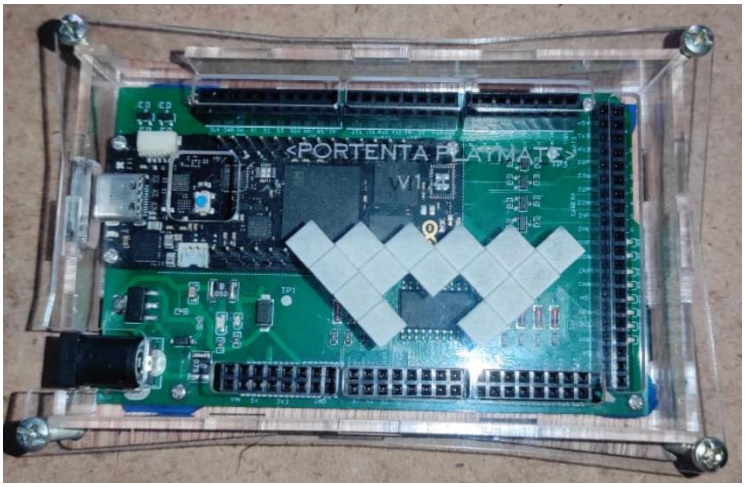




## 3.4.3 Physical Product Implementation





## 3.5 BOM

| Name | Quantity | Manufacturer | Supplier | Price (Rs.) |
|---|---|---|---|---|
| | | PCB | | |
| PCB | 1 | JLC PCB | JLC PCB | 948.40 |
| | | Components | | |
| SMAJ5.0A_C2925443 | 1 | Liown(里阳半导体) | LCSC | 13.2 |
| BSMD1812-050-24V | 1 | BHFUSE(佰宏) | LCSC | 14.52 |
| FC-2012HRK-620D | 1 | 国星光电 | LCSC | 3.63 |
| 19-213/Y2C-CQ2R2L/3T(CY) | 1 | EVERLIGHT(亿光) | LCSC | 7.26 |
| 19-217/BHC-ZL1M2RY/3T | 8 | EVERLIGHT(亿光) | LCSC | 5.94 |
| 220Ω | 2 | UNI-ROYAL(厚声) | LCSC | 0.33 |
| 10uF | 1 | SAMSUNG(三星) | LCSC | 3.63 |
| 100nF | 1 | SAMSUNG(三星) | LCSC | 2.31 |
| 10nF | 1 | SAMSUNG(三星) | LCSC | 0.33 |
| DF40C-80DS-0.4V(51) - RIGHT | 1 | HRS(广濑) | LCSC | 238.92 |
| DF40C-80DS-0.4V(51) - LEFT | 1 | HRS(广濑) | LCSC | 238.92 |
| SMF15A_C353311 | 1 | 晶导微电子 | LCSC | 6.6 |
| ZMM3V3 | 8 | ST(先科) | LCSC | 5.61 |
| JK-SMD0603-003 | 8 | JK(金科) | LCSC | 15.84 |
| BSMD1812-075-33V | 1 | BHFUSE(佰宏) | LCSC | 20.13 |
| FH-00083 | 1 | Liansheng(连盛) | LCSC | 98.34 |
| FH-00088 | 1 | Liansheng(连盛) | LCSC | 34.98 |
| SOKET 5.5 | 1 | Tensility International Corp | Digi-Key | 120.25 |
| 2N7002 | 6 | CJ(江苏长电/长晶) | LCSC | 4.95 |
| DW254R-22-16-85 | 5 | DEALON(德艺隆) | LCSC | 58.08 |
| CD4067 | 1 | I-CORE(中微爱芯) | LCSC | 95.37 |
| LD1117S50TR | 1 | ST(意法半导体) | LCSC | 96.03 |
| 7.5kΩ | 12 | UNI-ROYAL(厚声) | LCSC | 0.33 |
| 1kΩ | 1 | UNI-ROYAL(厚声) | LCSC | 0.33 |
| 2kΩ | 1 | UNI-ROYAL(厚声) | LCSC | 0.33 |
| | | Enclosure | | |
| Acrylic + Plywood & Laser cut | 1 | CM Lasers | | 700.00 |
| Screws & Nuts | 8 | | Local distributors | 245.00 |

# 5.Specifications

- INPUT Voltages
  - 6.5V – 15V to Vin input
  - 4.5V – 5.5V to 5V input
  - 3.3V to 3.3V input

- ratings

| | Min | Typical | Max |
|---|---|---|---|
| Current | 80mA | 200mA | 850mA |
| Output Voltage | 4.9 V | 5.0 V | 5.2 V |
| Input Voltage | 6.2 V | 6.6 V | 7.5 V |

- IO Pins
  - Digital – 80 pins
  - Analog – 23 pins

- Multiplexer Configuration

| SPI1_CK | SPI1_MOSI | SPI1_MISO | SPI1_CS | SERIAL2_RX | Active INPUT |
|---|---|---|---|---|---|
| 1 | X | X | X | X | _ |
| 0 | 0 | 0 | 0 | 0 | SA0 |
| 0 | 0 | 0 | 0 | 1 | SA1 |
| 0 | 0 | 0 | 1 | 0 | SA2 |
| 0 | 0 | 0 | 1 | 1 | SA3 |
| 0 | 0 | 1 | 0 | 0 | SA4 |
| 0 | 0 | 1 | 0 | 1 | SA5 |
| 0 | 0 | 1 | 1 | 0 | SA6 |
| 0 | 0 | 1 | 1 | 1 | SA7 |
| 0 | 1 | 0 | 0 | 0 | SA8 |
| 0 | 1 | 0 | 0 | 1 | SA9 |
| 0 | 1 | 0 | 1 | 0 | SA10 |
| 0 | 1 | 0 | 1 | 1 | SA11 |
| 0 | 1 | 1 | 0 | 0 | SA12 |
| 0 | 1 | 1 | 0 | 1 | SA13 |
| 0 | 1 | 1 | 1 | 0 | SA14 |
| 0 | 1 | 1 | 1 | 1 | SA15 |

- Physical dimensions – 100mm x 60mm
- The following pin outputs are translated to 3.3 Voltage level
  - UART 2 RX, TX
  - UART 3 RX, TX
  - I2C SCL, SDA

# 6 Testing

**Following testing procedure is given to the manufacturer to verify functionality of the product.**

1. Functional Testing: Ensure that all expanded GPIO pins and analog inputs are functioning correctly by performing various input/output operations. Test the board's ability to read input signals from sensors and control output signals to actuators.

2. Analog Multiplexer Testing: Verify the analog multiplexer's ability to switch between multiple analog inputs without signal interference or crosstalk. Test different combinations of connected sensors to ensure accurate and reliable analog signal transmission.

3. Protection Circuitry Testing: Simulate over-current and over-voltage conditions to trigger the protection circuitry. Ensure that the board responds appropriately by shutting down power to the affected components and preventing damage to the Portenta H7.

4. Level Shifter Compatibility Testing: Connect the expansion board to external devices operating at different voltage levels. Confirm that the level shifters are translating logic levels accurately and that communication between the board and external components is successful.

5. Temperature and Environmental Testing: Assess the expansion board's performance and reliability under different temperature and environmental conditions. Ensure that the board operates within specified temperature ranges and withstands typical environmental factors.

6. Electromagnetic Compatibility (EMC) Testing: Evaluate the board's susceptibility to electromagnetic interference and its emission of electromagnetic radiation. Ensure that the board complies with EMC regulations and does not interfere with other devices.

7. Power Consumption Testing: Measure the power consumption of the expansion board under different load conditions. Validate that the board operates efficiently and within acceptable power consumption limits.

8. Long-Term Reliability Testing: Conduct prolonged stress tests to assess the board's long-term reliability and durability under continuous operation.

9. Compatibility Testing with Portenta H7: Verify that the expansion board seamlessly integrates with the Arduino Portenta H7 and that all functionalities work as expected when connected to the base board.

10. Software Integration Testing: Test the compatibility of the expansion board with Arduino libraries and software tools. Verify that the board can be easily programmed and controlled using standard Arduino development environments.

By performing these tests, the manufacturer can ensure that the "Portenta Playmate Expansion Board" meets its specifications, is reliable, and operates as intended, providing users with a robust and functional platform for their prototyping and robotics projects.

# Conclusion

The successful development and testing of the "Portenta Playmate Expansion Board" have culminated in a versatile and user-friendly platform that significantly enhances the capabilities of the Arduino Portenta H7. By expanding the GPIO pins and providing an integrated analog multiplexer, the board offers a comprehensive solution for diverse sensor and actuator integration, catering to the needs of a wide range of prototyping and robotics applications. The inclusion of protection circuitry ensures the safety and resilience of the Portenta H7 when connected to different power sources and peripherals, fostering a reliable and secure environment for experimentation and project development. Additionally, the level shifters enable seamless interfacing with devices operating at different voltage levels, further extending the compatibility of the board with a variety of external components. The "Portenta Playmate Expansion Board" successfully bridges the gap between novices and experienced developers, providing an accessible platform that inspires creativity, experimentation, and innovation. Its robust performance, verified through rigorous testing, assures users of a dependable and seamless experience during their prototyping endeavors. As we look to the future, the "Portenta Playmate Expansion Board" holds promise for further advancements and opens doors to new possibilities in the realm of embedded systems and robotics. The project's realization embodies our commitment to democratizing technology and empowering the maker community, as we strive to accelerate the journey from concept to creation, sparking ingenuity, and driving the next generation of inventors and innovators.

## References:


- Portenta H7 — Arduino Official Store
- Portenta Breakout — Arduino Official Store
- Level shifter - Wikipedia
- https://store.arduino.cc/products/arduino-portenta-breakout