Department Of Electronic and Telecommunication Engineering-University of Moratuwa

EN2160-Electronic Design Realization
Design Methodology Document-Exercise Mate

Discussion Group O

Group 39

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Contents

1 User Requirements

The exercise counting device is designed to be a reliable companion for individuals looking to track their workout progress with precision and ease. With a primary focus on accuracy, users can trust that each repetition of their chosen exercises will be counted accurately, providing valuable data for monitoring their fitness journey. This accuracy is coupled with an intuitive interface, ensuring that users can operate the device effortlessly, whether they're starting a new session, or choosing the exercise mode. By prioritizing ease of use, the device becomes an accessible tool for users of all fitness levels, eliminating unnecessary complexity and allowing them to focus on their workouts.

Versatility is a key aspect of the exercise counting device, catering to a wide range of exercises commonly incorporated into fitness routines. From classic moves to dynamic exercises, the device adapts to the user's workout preferences, providing accurate counts for each repetition. Its compact and portable design further enhances its utility, allowing users to take their tracking capabilities wherever their fitness journey may lead. Whether at home, in the gym, or outdoors, users can rely on the device to support their exercise regimen with consistency and convenience.

Beyond its core functionality, the exercise counting device prioritizes durability, ensuring it can withstand the rigors of regular use without compromising performance. With a sturdy construction and resilient materials, users can engage in their workouts with confidence, knowing that their tracking device will remain reliable over time, especially with the option for replaceable batteries. This feature adds to the longevity of the device, allowing users to easily swap out batteries when needed, ensuring uninterrupted tracking of their exercise repetitions. Additionally, features such as a clear and easily readable display, long-lasting battery life, and optional data transfer capabilities enhance the user experience, providing a comprehensive solution for monitoring and improving fitness goals. Ultimately, the exercise counting device empowers users to take control of their workouts, offering a valuable tool for achieving their desired levels of fitness and performance.

1.1 Review Existing Solutions

As we observed users and looked through some production and marketing videos from companies and some research papers, the thing is that these days most people use smart watches as their exercise monitoring devices. but as we have seen in many videos and research papers, the value readings are not very accurate. And also, when it comes to smart watches, their monitoring capacity is limited. Most of the smart watches measure the steps and the burned calaries; there is no other reading there. And we can get the heart rate as well. As we have seen in most of the experiments, the heart rate we get from the smart watches is very inaccurate.

But using these is very easy and does not require any technical knowledge. because these are very light weight, and because of their multi-functionality, people have begun to use them. but these are not the best devices to track your exercises. Most of the fitness trackers available on the market are very expensive, and most people can't afford to buy them.

Figure 1: Existing Products

1.2 Identification of Stake Holders

The creation of an exercise monitoring gadget is a complex project with a range of stakeholders, each with their own specialties, contributions, and areas of interest. The purpose of this stakeholder map is to provide a visual depiction of the important people and organisations associated with the project, emphasising their functions and connections within the ecosystem. We can work together successfully, meet their needs, and negotiate the challenges of introducing the exercise monitoring gadget to the market if we have a thorough awareness of the various viewpoints and driving forces of these stakeholders.

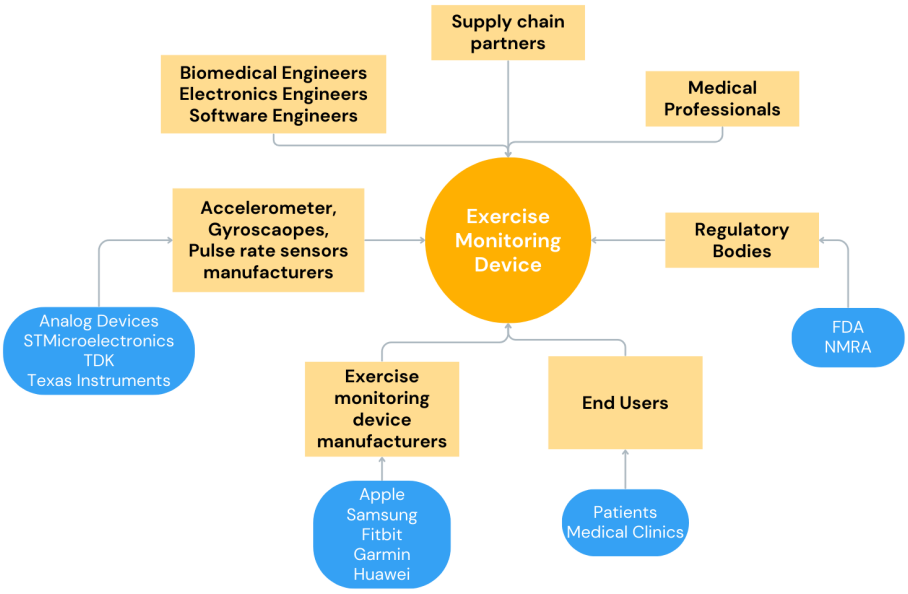


Figure 2: Stakeholder Map

1.3 Observe Users

- Medical clinics
- Professionals from the medical industry
- Gymnasiums
- Sports industry
- Corporate wellness programs

1.4 Need List

- Accurate counting of different exercises.
- Simple user interface to select exercise type and start/stop counting.
- Lightweight, portable design that doesn't interfere with workouts.
- Long battery life with less weight to last through extended workout sessions.
- Sweat/water resistance for use during intense training.
- Affordability for mass market appeal.

2 Stimulate Ideas

2.1 Conceptual Designs and Functional Block Diagrams

2.1.1 Conceptual Design 01- Hand wearable with on-device display

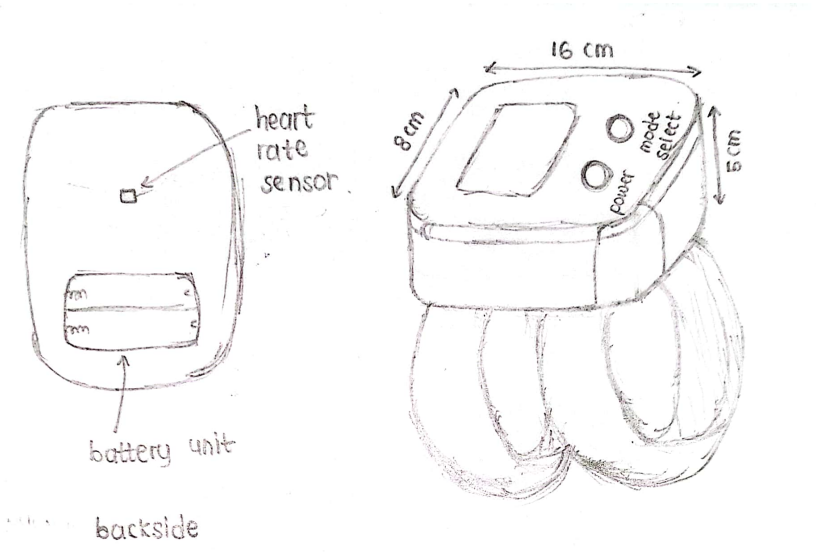


Figure 3: Design 1 - Enclosure

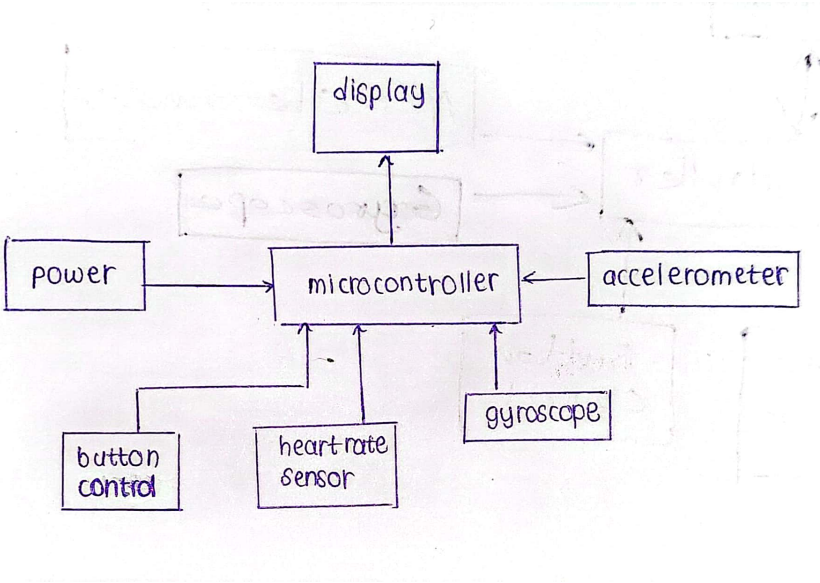


Figure 4: Design 1 - Function Block Diagram

2.1.2 Conceptual Design 02- Computer vision based exercise monitoring

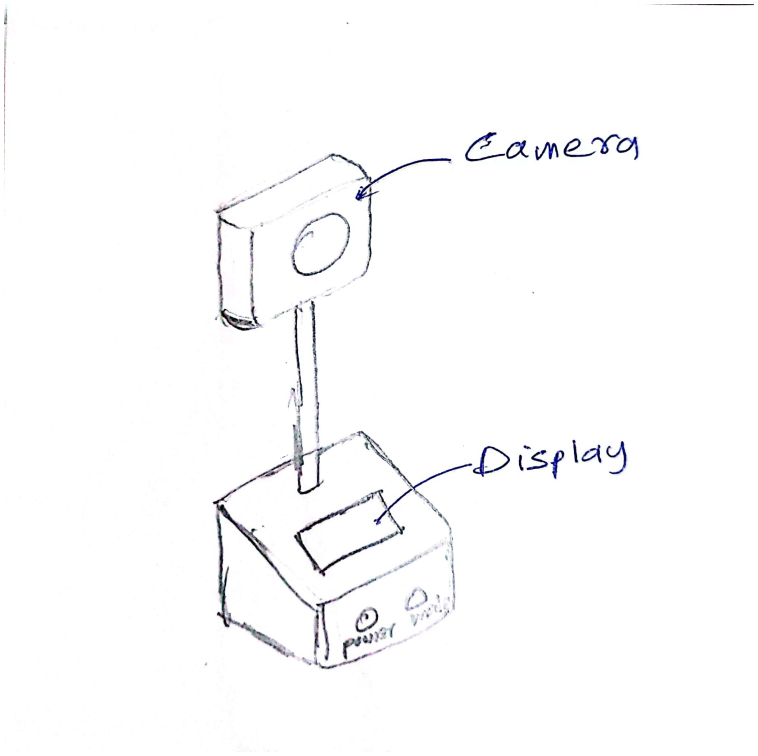


Figure 5: Design 2 - Enclosure

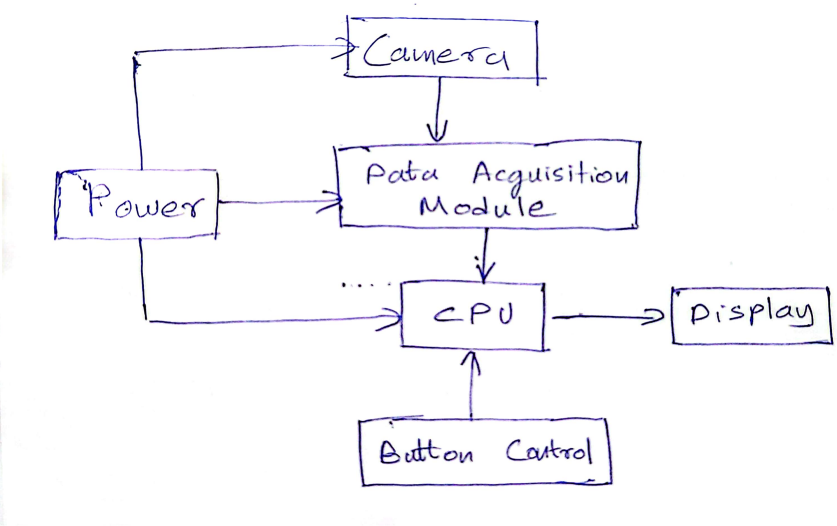


Figure 6: Design 2 - Function Block Diagram

2.1.3 Conceptual Design 03- Analysing EMG signals

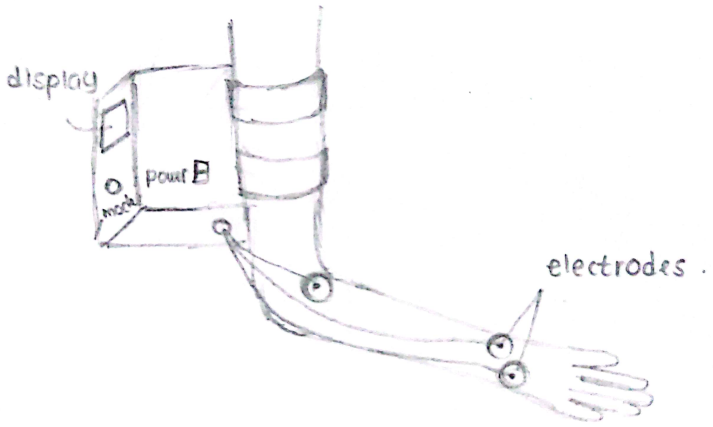


Figure 7: Design 3 - Enclosure

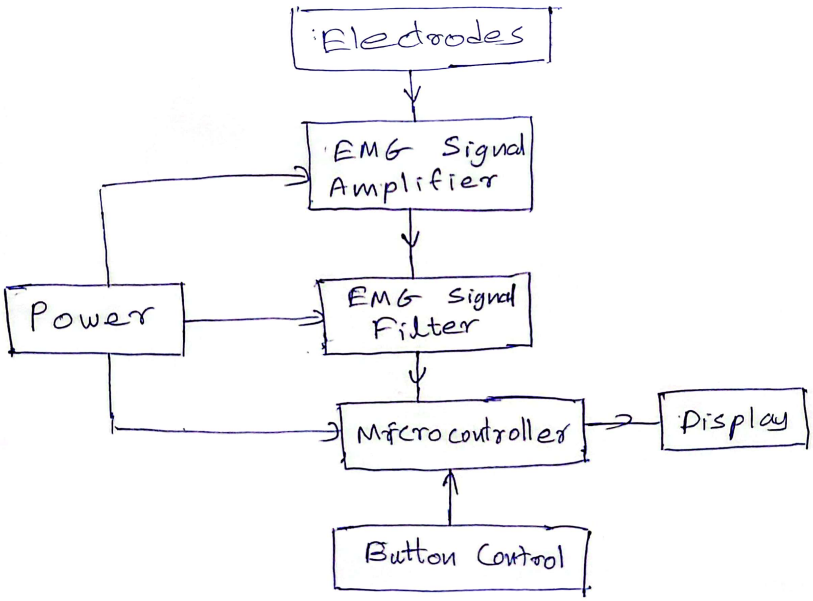


Figure 8: Design 3 - Function Block Diagram

2.1.4 Conceptual Design 04 - Wearable devices with separate display

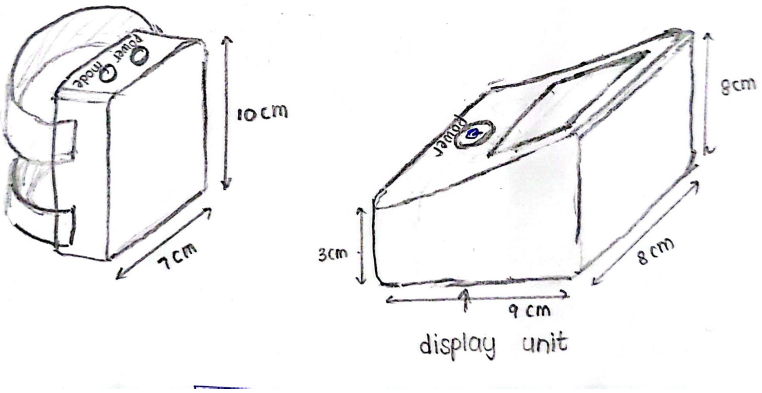


Figure 9: Design 4 - Enclosure

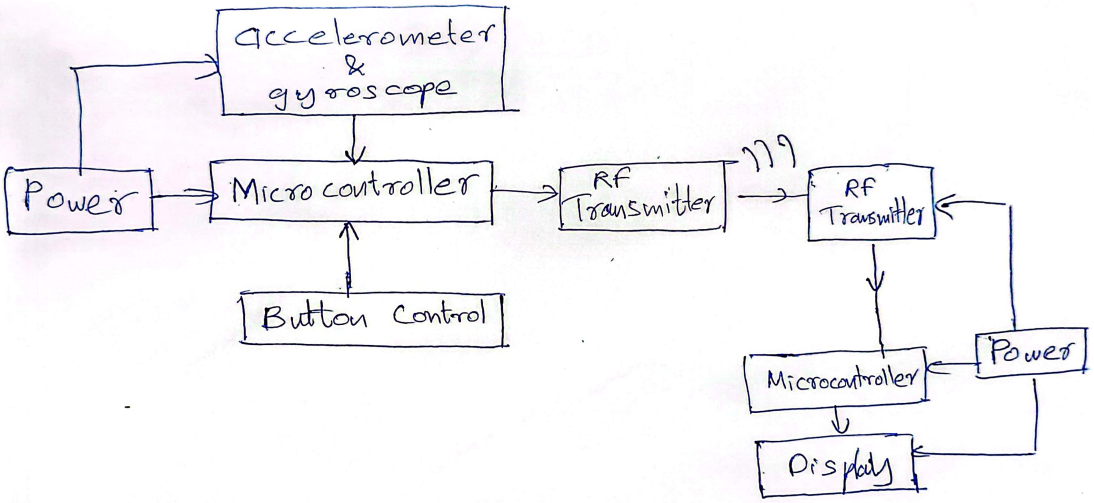


Figure 10: Design 4 - Function Block Diagram

2.2 Evaluation of the Design

2.2.1 Enclosure Design Criteria:

1. Functionality: Assessment of the design's ability to adequately support essential functions.
2. Aesthetics: Evaluation of the visual appeal and attractiveness of the design to users.
3. Heat Dissipation: Examination of heat generation levels and the effectiveness of heat management measures.
4. Assembly and Serviceability: Analysis of the ease with which assembly and disassembly processes can be carried out.
5. Ergonomics: Assessment of how well the design accommodates user interaction and fits comfortably in the user's hand.
6. Durability: Evaluation of the design's resilience against impacts and various environmental conditions.
7. Simplicity: Assessment of the design's simplicity in terms of structure and operation.

2.2.2 Functional Block Diagram Criteria:

1. Functionality: Evaluation of how effectively the circuit design meets functional requirements.
2. User Experience: Assessment of the intuitiveness and user-friendliness of the interaction with the circuit.
3. Manufacturing Feasibility: Analysis of the practicality and feasibility of manufacturing the design.
4. Cost: Evaluation of the overall cost-effectiveness of the design in relation to its provided functionality.
5. Performance: Assessment of signal quality, resolution, and bandwidth range.
6. Future Proofing: Evaluation of the extent to which the design facilitates easy replacement or upgrade of individual components.
7. Power Efficiency: Analysis of how effectively the device manages power consumption.

2.2.3 Concept evaluation table

		Conceptual design 1	Conceptual design 2	Conceptual design 3	Conceptual design 4
Newly added features		Accerlerometer Gyroscope Microcontroller unit	Camera Video data analysis Central processing unit	Electrodes EMG signal amplifying EMG signal filtering	Accerlerometer(4) Gyroscope(4) Central processing unit
Envisioned design		Hand wearable device with on-device display	Computer vision based exercise monitoring	EMG signals based execise tracker	Wearable devices with separate display
Enclosure design criteria comparison	Functionality	6	7	5	9
	Serviceability	6	7	5	8
	Assembly	8	7	5	7
	Ergonomics	8	7	5	7
	Simplicity	8	6	5	7
	Durability	7	8	5	9
Functional block design criteria comparison	Functionality	6	8	7	9
	User experience	7	7	6	8
	Manufacturing feasibility	8	7	6	8
	Cost	9	6	6	7
	Performance	6	8	8	9
	Power	7	7	7	7
Total		86	85	70	95

Figure 11: Design 4 - Concept evaluation table

2.3 Selected Design

We selected Conceptual Design 4 as our final design because it received the highest score during the evaluation process. Utilizing wearable devices is user-friendly for motion tracking systems as well [1].

Our selected design features a hand-worn device that tracks motion using accelerometers and a gyroscope sensor. First, the user selects the exercise type from the available options using the control button. As the exercise is performed, data from the accelerometer and gyroscope is processed by the microcontroller to identify the motion. This allows for accurate tracking of the exercise count for the selected exercise type. The real-time count is transmitted to a central device via an RF antenna. The stationary central device receives the data and displays the count of the selected exercise type in real-time. This approach ensures that exercises can be effectively tracked in our chosen design.

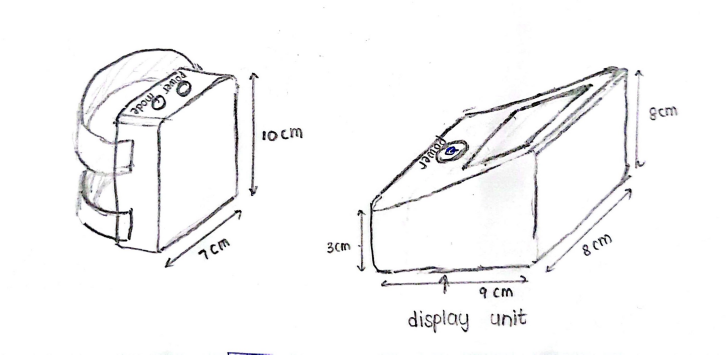


Figure 12: Selected Design

3 Schematic and PCB Design

3.1 Schematic Design

The schematic design for our electronic device project was created using Altium Designer software. The design focuses on surface-mounted components (SMD) to ensure the final product is compact and efficient. Throughout the design process, we adhered to the industry standards outlined in guidelines for drawing schematics [2]. These standards guided us in component selection, circuit layout, and ensuring the overall reliability and functionality of the device.

3.2 PCB Design

For the printed circuit board (PCB) design, we also utilized Altium Designer software. The decision to use surface-mounted components (SMD) was made to keep the PCB compact and suitable for modern electronic applications. The PCB is a four-layer board, which helps in managing the complexity of the circuit while maintaining a small footprint. The dimensions and layer overview of the PCB are detailed below.

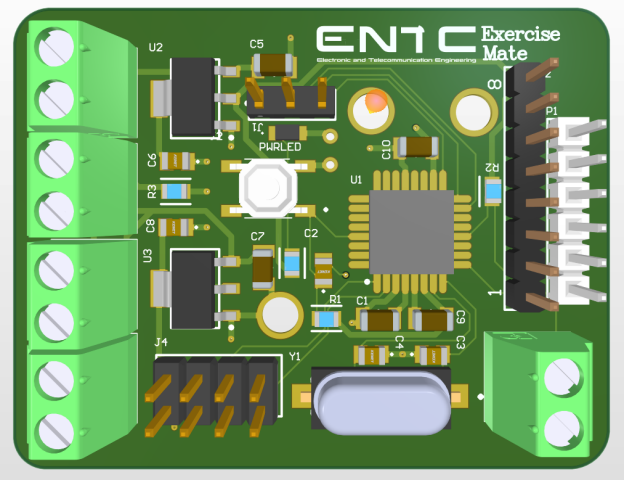
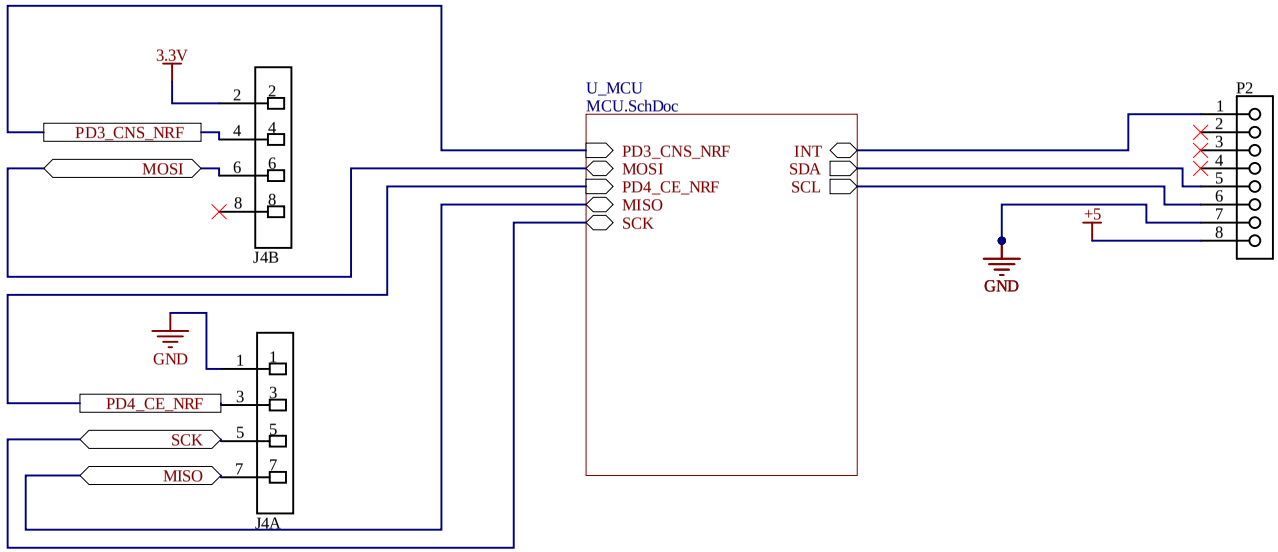
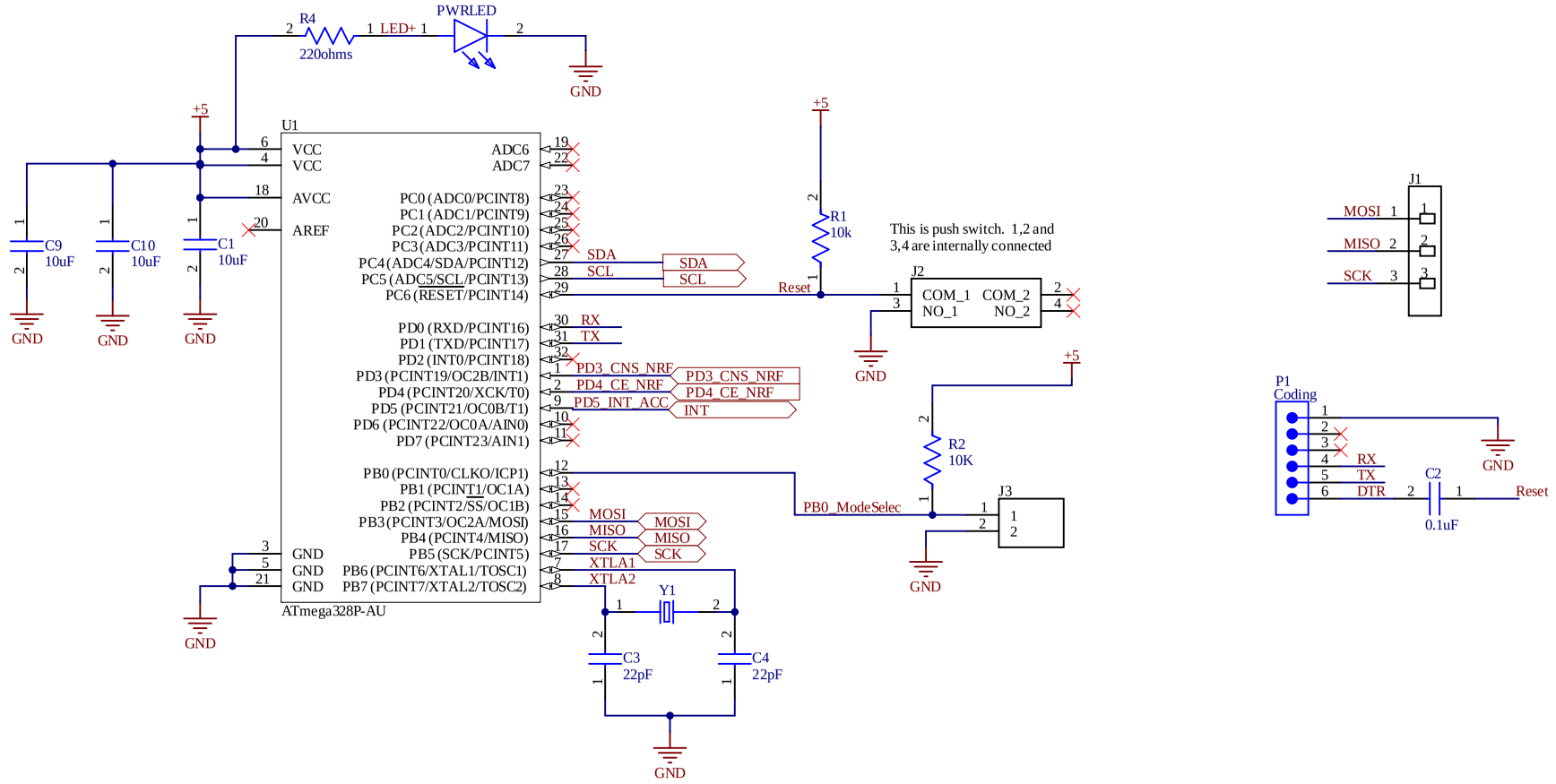


Figure 13: 3D view of the PCB



Designator
Power Reg.SchDoc

Title	Top-level circuit		
Size A4	Number 1		Revision 2
Date:	6/23/2024	Sheet 1 of 3	
File:	D:\Altium PCB\..\top-level.SchDoc	Drawn By:	Rajapaksha N.N.



Title	Microcontroller Unit		
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Date: 6/23/2024		Sheet 2 of 3	
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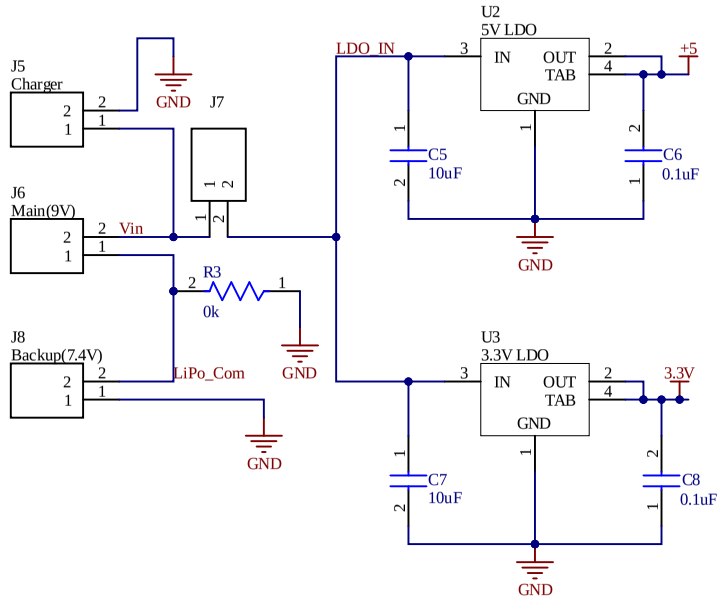

Title	Power regulator		
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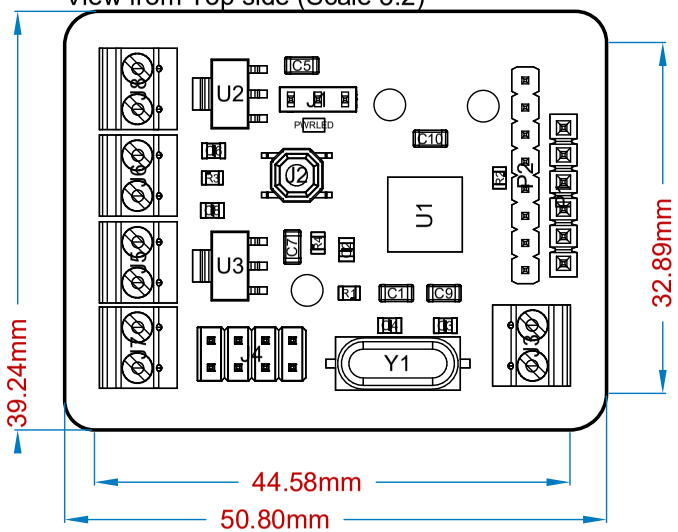
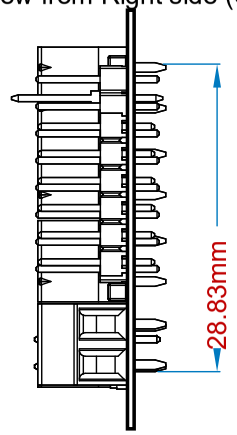
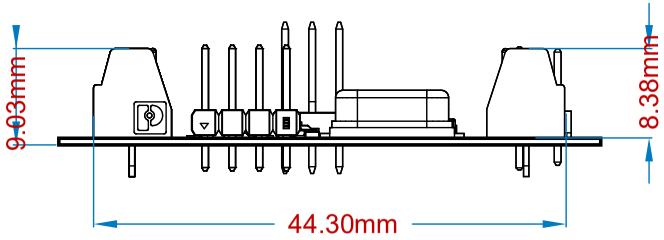
View from Top side (Scale 3:2)



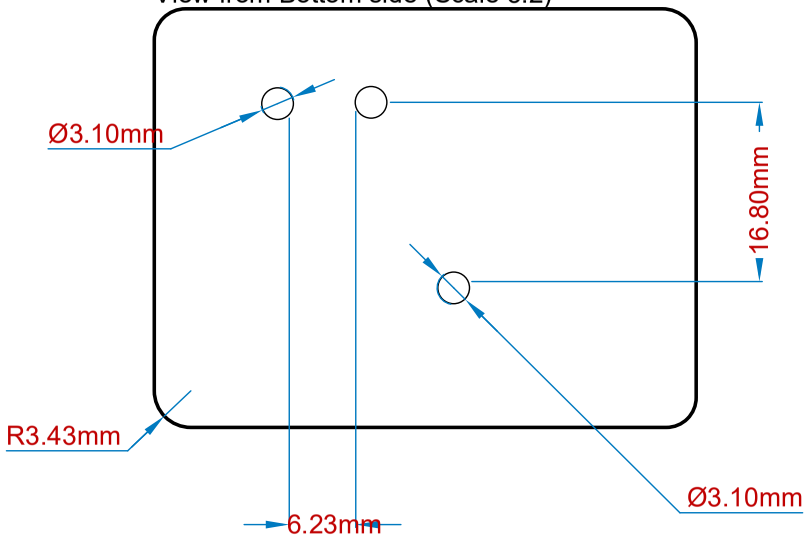
View from Right side (Scale 3:2)



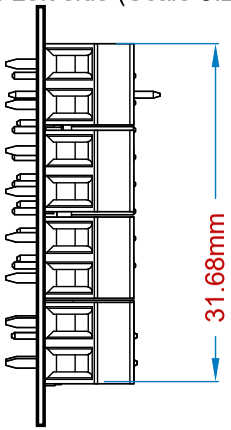
View from Front side (Scale 3:2)



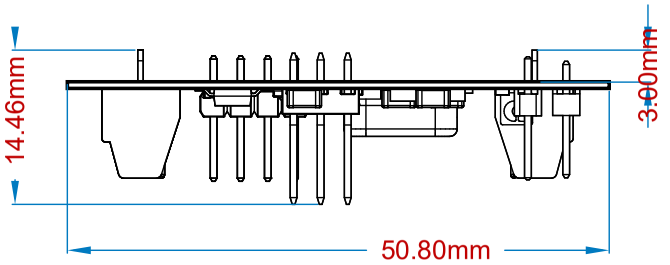
View from Bottom side (Scale 3:2)



View from Left side (Scale 3:2)



View from Back side (Scale 3:2)



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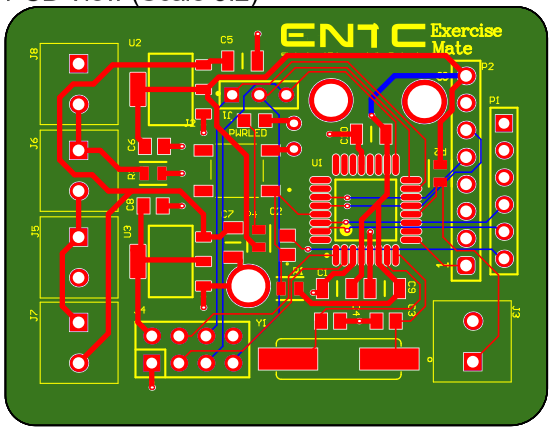
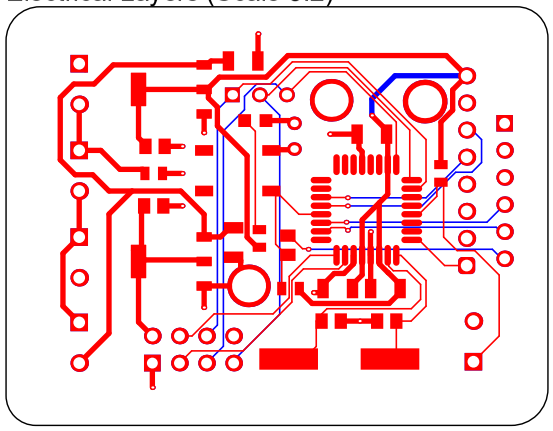
File	D:\Altium PCB\exercise_mate\	Drawn by	Rajapaksha N.N.

PCB View (Scale 3:2)



Electrical Layers (Scale 3:2)



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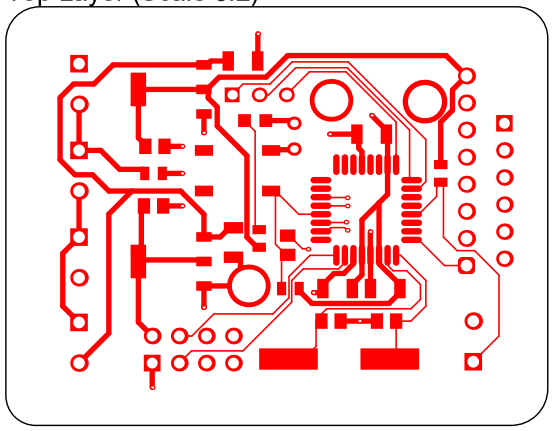

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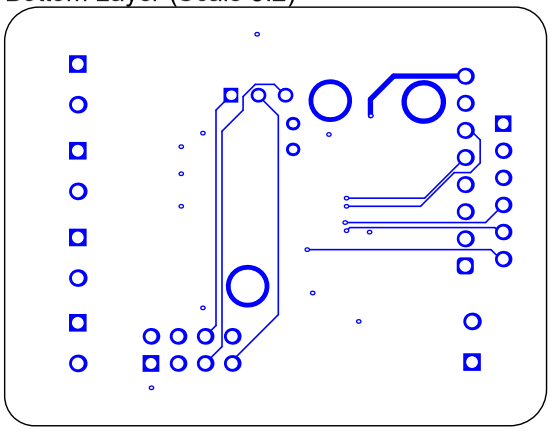
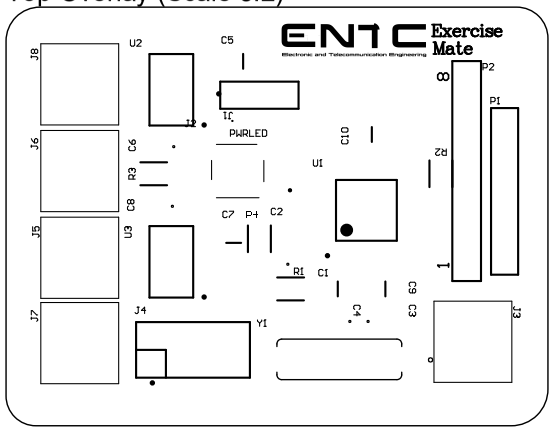
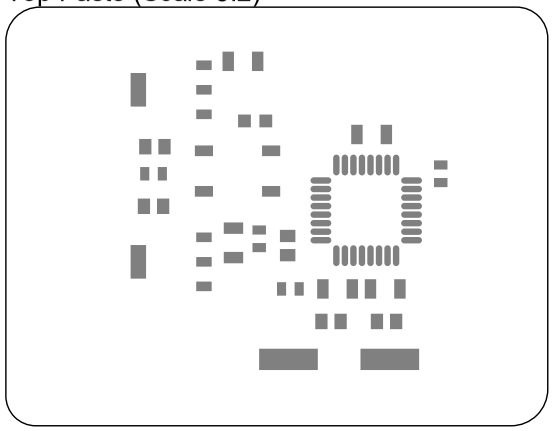


Top Overlay (Scale 3:2)



Top Paste (Scale 3:2)



Title	PCB layer overview		
Size	A4	Number 2	Revision 2
Date	22/06/2024	Sheet 2 of 2	
File	D:\Altium PCB\exercise_mate\	Drawn by	Rajapaksha N.N.

4 Final Solidworks Design

4.1 Hand Wearable Device

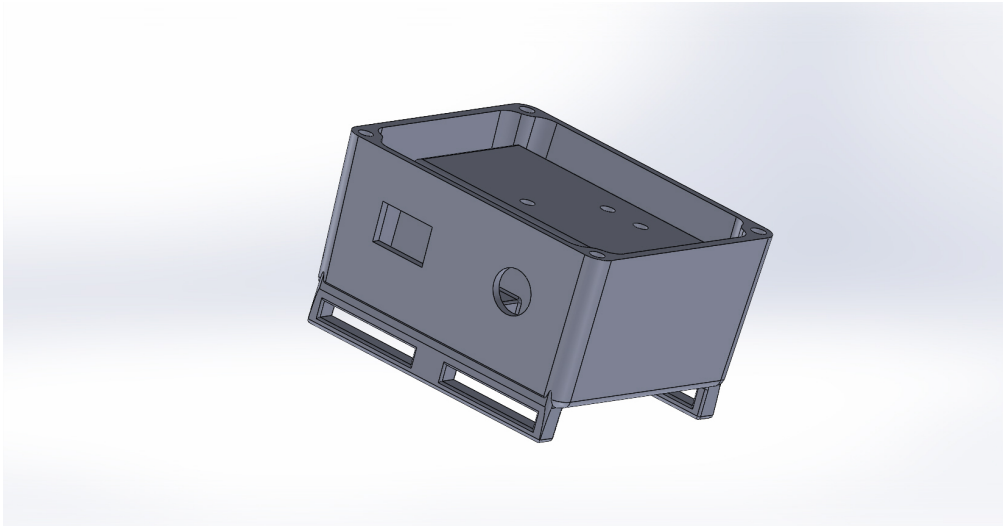


Figure 14: Bottom part of the design

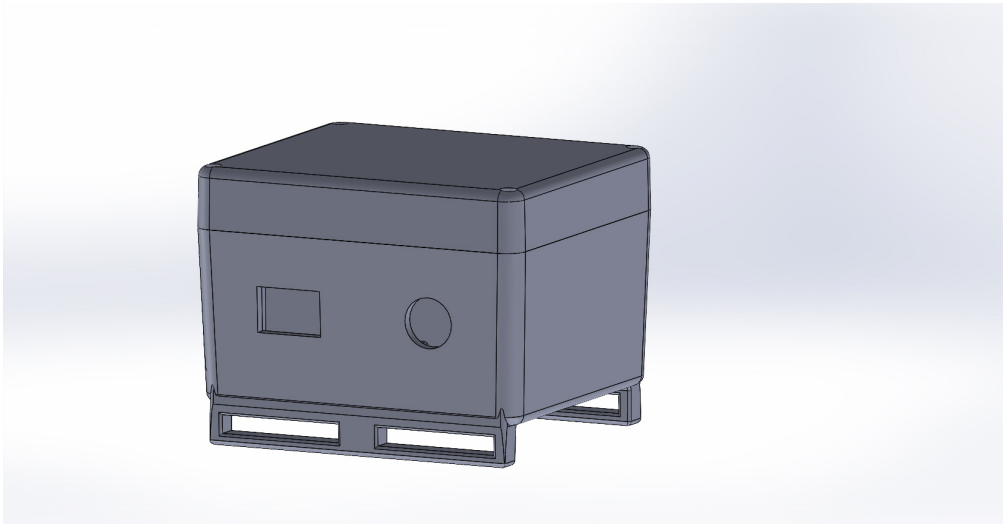


Figure 15: Full device design

4.1.1 Design Tree-Hand Wearable Device

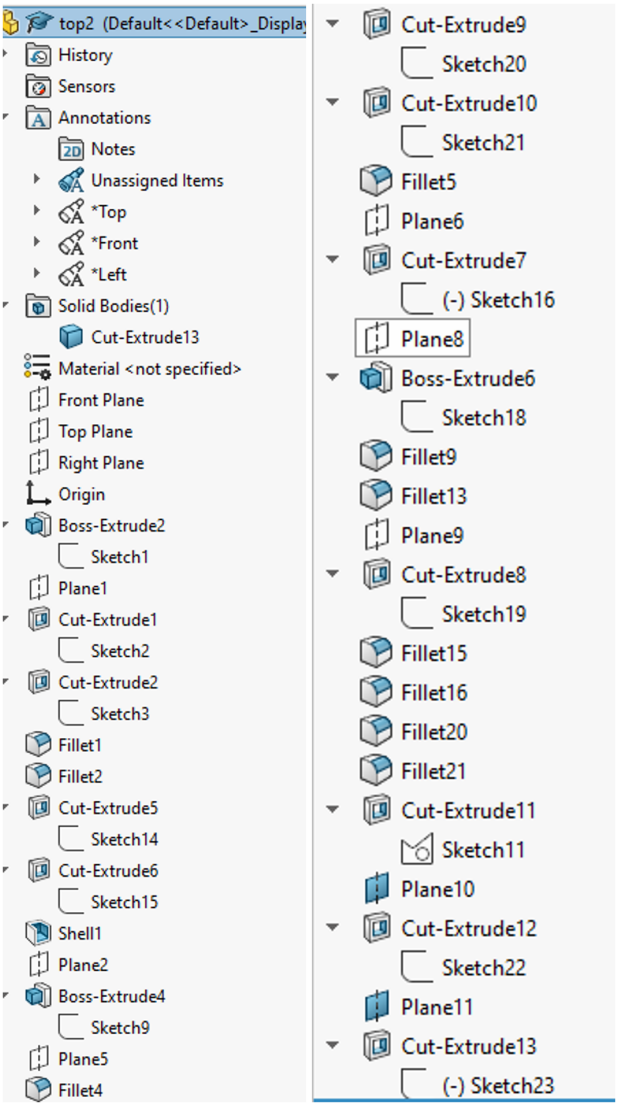


Figure 16: Bottom part of the design

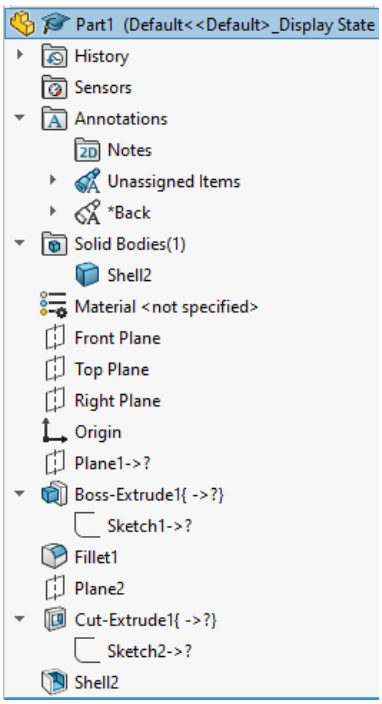


Figure 17: Lid of the design

4.2 Central Device

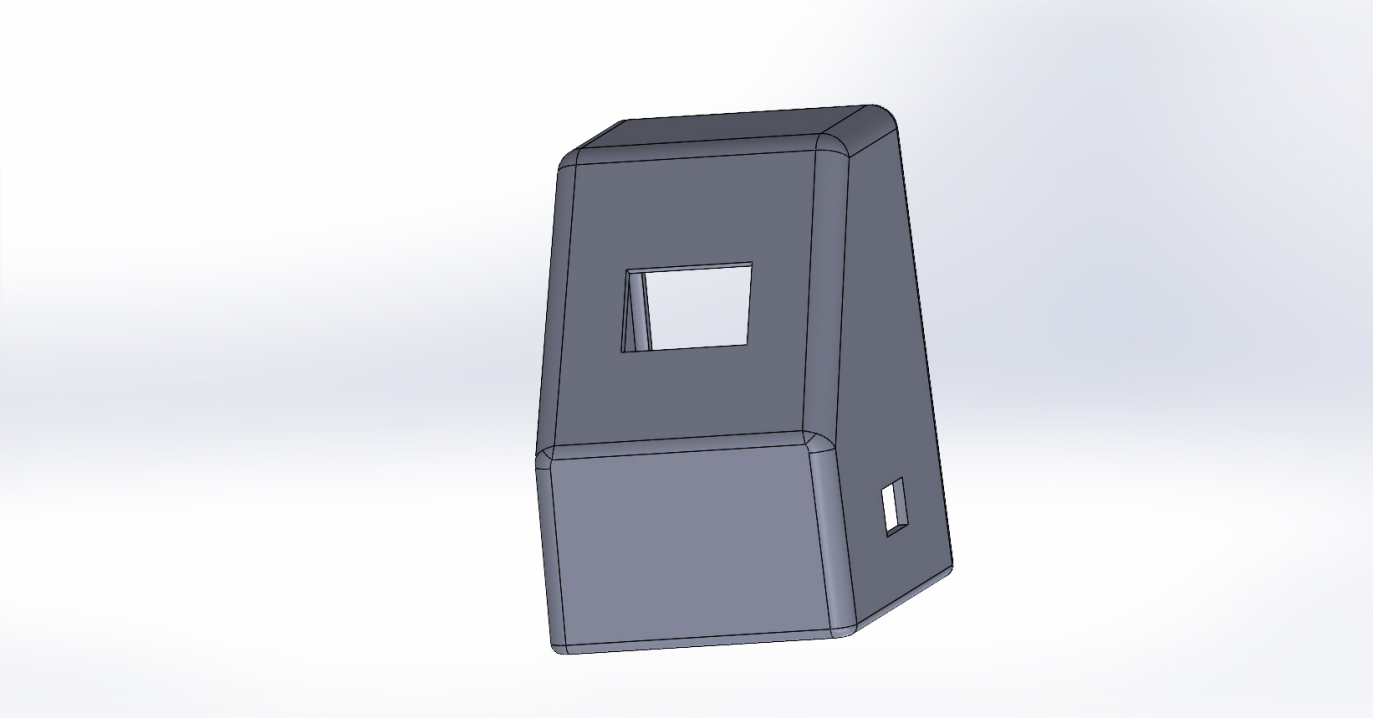


Figure 18: Design of the diplay unit

4.2.1 Design Tree-Central Device

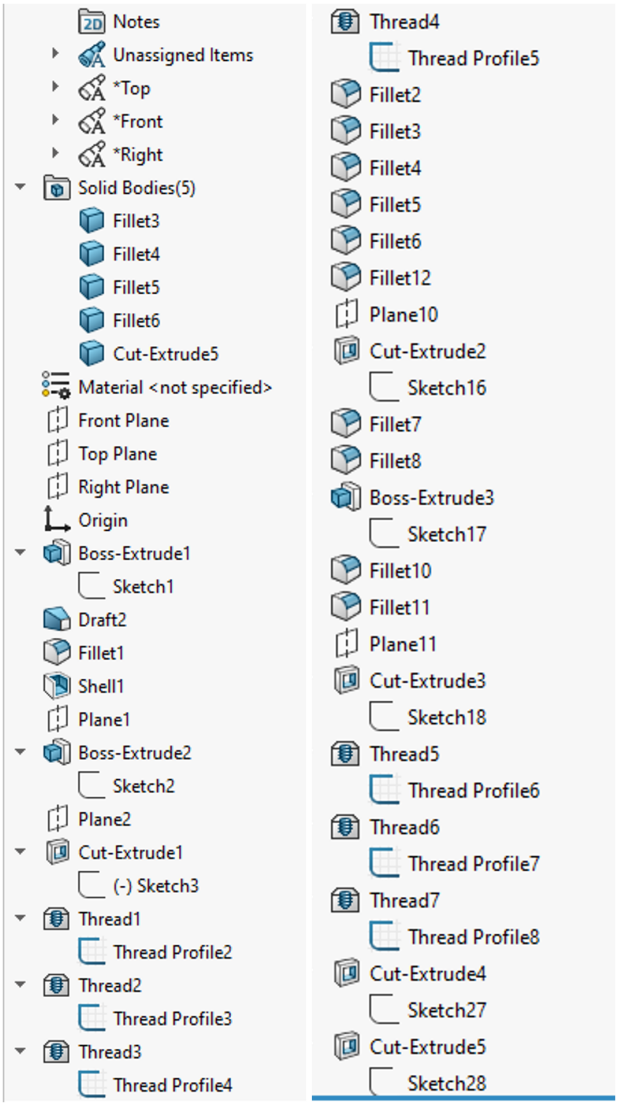


Figure 19: Bottom part of the design

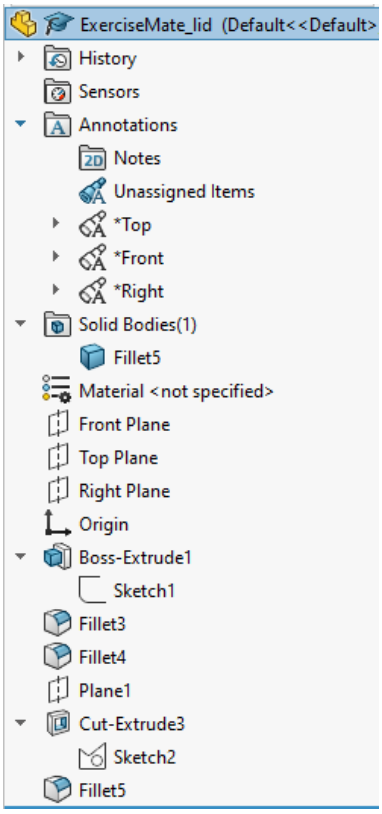


Figure 20: Lid of the design

4.3 Battery area closing part

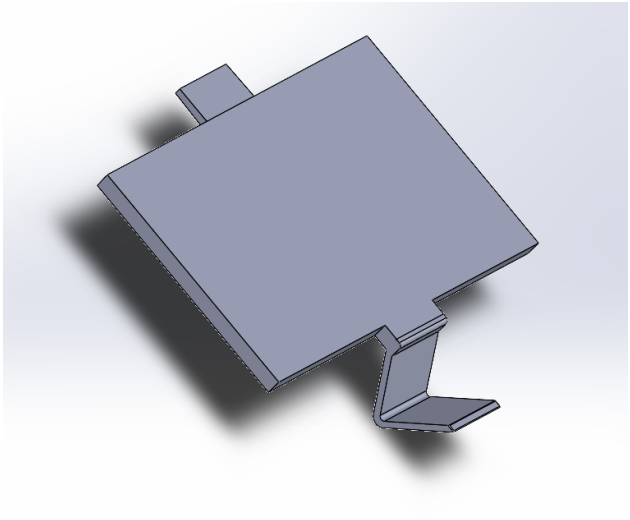


Figure 21: Battery area closing part

4.3.1 Design Tree-Battery area closing part

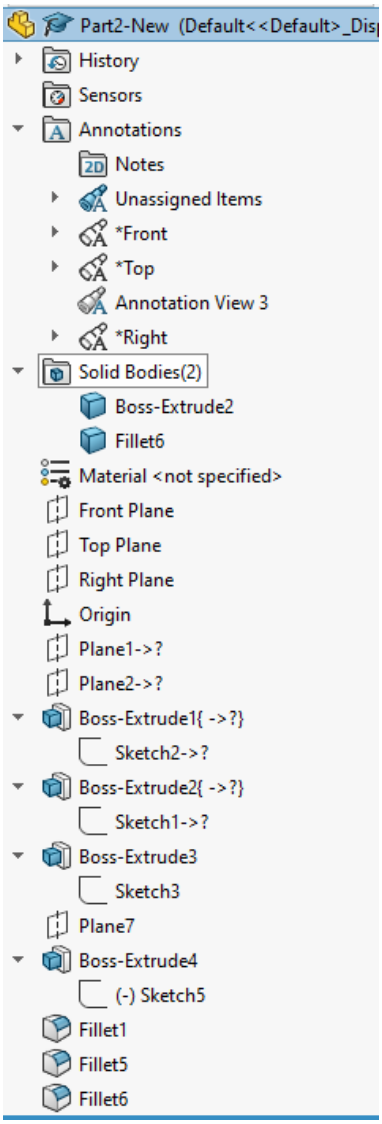


Figure 22: Lid of the Battery area closing part

References

[1] Ahmad Jalal, Majid Ali Khan Quaid, Sheikh Badar ud din Tahir, and Kibum Kim. A study of accelerometer and gyroscope measurements in physical life-log activities detection systems. *Sensors*, 20(22):6670, 2020.

[2] Tim J. Sobering. Guidelines for drawing schematics. Technical report, SDE Consulting, 2008. Accessed: 2024-06-22. URL: https://www.k-state.edu/edl/docs/pubs/technical-resources/Technote8.pdf.