Project Hike Buddy
Evaluation Report

Designed by Voltrix

Team Voltrix

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Module: EN1190 Electronic Design Project

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1 | Problem Analysis

1.1 | Problem Identification

Navigating the challenges of outdoor expeditions, particularly during multi-day hikes, presents a unique set of problems, especially when dealing with limited resources.
One significant issue encountered by our team during personal hiking experiences was the difficulty in managing essential tools, such as torches, compasses, and water purity assessors, without compromising on weight or battery life. The inconvenience of carrying multiple devices, each with limited battery life, led to instances where critical tools became unavailable when needed the most.
This challenge is not unique to our team; in discussions with other outdoor enthusiasts, we found that many individuals faced similar difficulties, often resulting in compromised safety and efficiency during their hikes.
This personal and widespread problem underscored the necessity for an integrated solution that could provide reliable functionality while maintaining ease of use and durability in challenging outdoor environments.

1.2 | Problem Validation

In developing the Hike Buddy, our team identified and validated the challenges faced by outdoor enthusiasts, particularly those engaged in frequent hiking activities. Below is a detailed overview of our findings:

Source of Validation	Key Insights
Personal Experiences	Team members encountered challenges during various hiking expeditions, highlighting the need for reliable and multi-functional outdoor tools.
Survey Demographics	■ Diverse group of hiking enthusiasts. ■ Focused on individuals based in Sri Lanka. ■ Included participants from the international community.

Table 1.1: Validation Sources and Insights

Based on the survey results, we identified the following key problems:

- **Battery Life Concerns**
  - Hikers emphasized the importance of a torch with extended battery life.
  - Unpredictability of natural environments often requires prolonged usage of essential devices.
- **Need for Multi-functionality**
  - Respondents showed strong approval for a device integrating multiple tools (e.g., compass, water purity assessor).
  - Multi-functionality reduces the need to carry several items, lightening the load in challenging terrains.
- **Navigation and Psychological Assurance**
  - Hikers desire a device that aids in orientation, providing reassurance through reliable and consistent performance.
  - Emphasis on the importance of robustness and user-friendliness.

The iterative refinement of our design, driven by real-world feedback, has enabled us to tailor the Hike Buddy to meet the specific needs of modern hikers. This validation process has reinforced our commitment to delivering a product that is innovative, reliable, and aligned with the practical needs of its users.

2 | Technical Specifications

2.1 | Performance Specifications

- **Torch Battery Life:** Up to 5 days of continuous use (torch always on).
- **Compass Accuracy:** ±3° (suggestive).
- **Water Purity Assessor:** Measures TDS (Total Dissolved Solids) with ±10 ppm accuracy.
- **Torch Brightness:** 100 lumen (1 W Extra Luminous LED).
- **Operating Temperature Range:** -20°C to 60°C (current restriction due to manufacturing materials).

2.2 | Power Consumption

- **Battery Type:** Lithium-ion 18650 6500 mAh rechargeable battery.
- **Number of Removable Batteries:** 4.
- **Battery Life (Overall Device):** At least 12 days of standard usage (torch, compass, and water assessor).
- **Battery Life (Standby):** Over 20 days.

2.3 | Product Dimensions and Weight

- **Dimensions (LxWxH):** 21.7 x 6 cm x 6 cm.
- **Weight without Batteries:** 320 g.
- **Weight with Batteries:** 730 g.

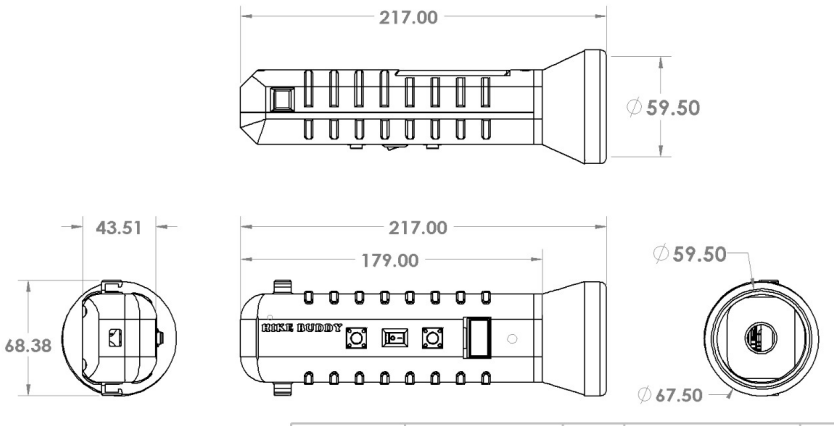

Figure 2.1: Dimensions of the Product

2.4 | Main Product Features

- **5-Day Battery Life for Torch:** Ensures consistent illumination during extended hikes.
- **Inbuilt Compass:** Provides reliable navigation assistance.
- **Water Purity Assessor:** Assesses the quality of natural water sources for safe drinking.
- **Ergonomic Design:** Compact and easy to carry, with an intuitive user interface.

2.5 | Secondary Product Features

- **OLED Indicators:** Optimized for viewing under harsh conditions.
- **SOS Mode:** Activates flashing torchlight with a dedicated button for emergencies.
- **Water- and Dust-resistant** Designed to withstand harsh outdoor environments.

2.6 | Expected Lifetime of the Product

- **Warranty Terms:** Two-year warranty for manufacturing defects and faulty components.
- **Replaceability:** Batteries are replaceable to extend the product's life cycle.
- **Durability:** Shock-resistant design to withstand rugged outdoor conditions.
- **Expected Lifetime:** At least 4 years with proper care and maintenance.

3 | Proposed Design Concepts

3.1 | Design Overview

The proposed designs for the Hike Buddy integrate both functionality and user-centric principles. These designs focus on delivering a durable, easy-to-use device that seamlessly integrates multiple essential tools for hiking enthusiasts.

3.1.1 | Design Concept 1: Main Device Structure

- **Ergonomic Shape:** The design features an ergonomic, handheld structure that fits comfortably in the user's hand, ensuring ease of use during prolonged hikes.
- **Button Placement:** The buttons are strategically placed on the top surface of the device, allowing for quick access and operation. This includes the power button, mode selectors, and an SOS button for emergencies.
- **OLED Screen:** A small OLED screen is integrated on the top surface, providing clear visibility of critical information such as modes, compass direction, and water purity readings.
- **Torch and Battery Compartment:** The device houses a powerful torch at the front end, with the battery compartment located underneath, designed to hold 4 removable lithium-ion batteries. This compartment is easily accessible for quick battery replacement.

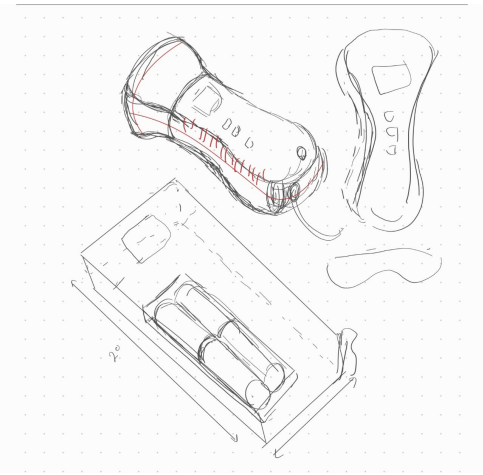

Figure 3.1: Sketch of the Main Device Structure Concept

3.1.2 | Design Concept 2: TDS Probe and Strap

- **TDS Probe:** The device includes a built-in TDS (Total Dissolved Solids) probe, housed at the rear side. The probe is designed to be extendable, allowing users to accurately measure water quality in natural sources.
- **Integrated Strap:** A strap is integrated into the design for enhanced portability. The strap is positioned on the lower side of the device, providing a secure grip when the device is not in active use.
- **Waterproof and Shock-resistant:** The device casing is engineered to be both waterproof and shock-resistant, ensuring reliable performance in harsh outdoor conditions.

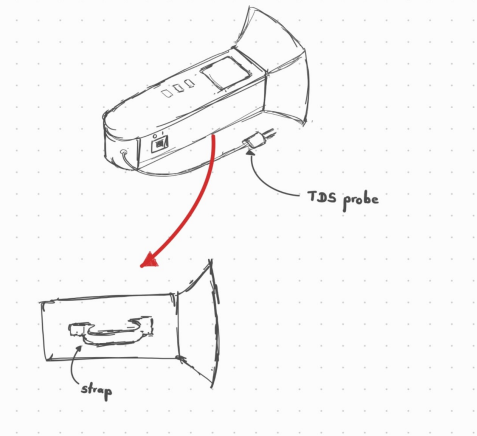

Figure 3.2: Sketch of the TDS Probe and Strap Concept

3.2 | Final Design Selection

The final design of the Hike Buddy is a blend of the two proposed concepts, combining the best elements of each to create a highly functional and user-friendly device. The ergonomic curves of the device are specifically designed to fit comfortably in the user's hand, making it easier to hold and operate for extended periods. This ergonomic focus ensures that users can rely on the Hike Buddy during long hikes without experiencing discomfort or fatigue.

3.2.1 | Design Considerations

- **Portability:** The overall size and weight of the device have been optimized to ensure it is compact enough for easy carrying yet robust enough to withstand outdoor use.
- **Material Selection:** Durable, lightweight materials are proposed for construction, maintaining a balance between strength and portability.
- **Aesthetics:** The design maintains a rugged yet modern aesthetic, appealing to both casual hikers and serious outdoor enthusiasts.

3.2.2 | Conclusion

The final design of the Hike Buddy effectively merges the strengths of the initial concepts with a focus on ergonomic comfort and manufacturing efficiency. The use of 3D printing not only allows for the precise creation of the device's curves but also ensures that each unit is produced with consistent quality and durability. As a result, the Hike Buddy is poised to be an essential tool for hikers, providing the functionality and reliability needed in challenging outdoor environments.

4 | Final Enclosure Design

4.1 | Design Overview

The final enclosure design of the Hike Buddy encapsulates the essence of portability, durability, and user-friendly interface. The design is tailored to meet the rigorous demands of outdoor enthusiasts, ensuring that it remains functional, reliable, and aesthetically appealing even in challenging environments.

4.2 | 3D Model and Primary Features

The final design features a robust and ergonomic structure, making it comfortable to hold and operate during long hikes. Key aspects of the design include:

- **Ergonomic Grip:** The enclosure is shaped to fit naturally in the user's hand, reducing fatigue during prolonged use.
- **Button Layout:** Buttons are strategically positioned for easy access, allowing users to operate the device seamlessly.
- **Integrated TDS Probe:** The extendable TDS probe is integrated into the design for water purity assessment, enhancing the device's functionality.
- **Durable Materials:** The enclosure is constructed from high-grade materials that offer waterproof and shock-resistant properties.

(All of the 3D Designs were done using SolidWorks through the University License)

Figure 4.1: 3D Model of the Final Enclosure Design

4.3 | Side, Front, and Top Views

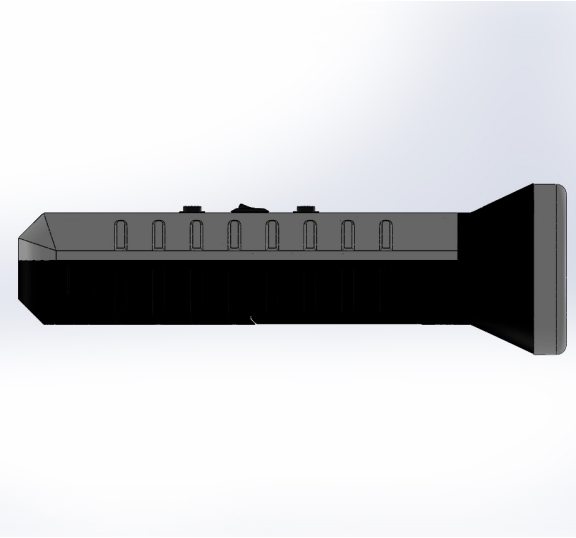

Figure 4.2: Side View of the Final Enclosure

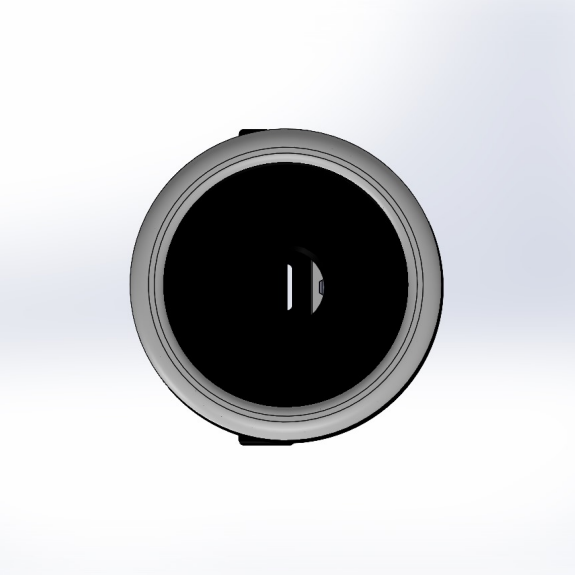

Figure 4.3: Front View of the Final Enclosure

4.4 | Design Considerations

Several factors were carefully considered during the design process to ensure that the Hike Buddy meets the needs of its users:

- **User-Centric Design:** Emphasis was placed on creating an intuitive layout, ensuring that even first-time users can operate the device with ease.
- **Rugged Aesthetics:** The design embodies a rugged, yet modern look, appealing to outdoor enthusiasts who value both form and function.
- **Manufacturing Efficiency:** The enclosure is designed for efficient manufacturing, with a focus on 3D printing techniques that allow for precision and consistency in production.

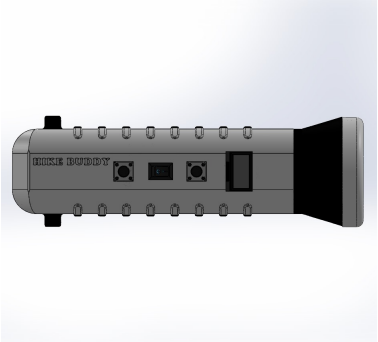

Figure 4.4: Top View of the Final Enclosure

4.5 | 3D Printing Process

The final enclosure design was optimized for 3D printing to ensure both durability and manufacturability. The model was broken down into five parts: the top body, bottom body, head, head ring, and battery lid. This breakdown allows for more efficient printing, easier assembly, and enhanced durability.

- **Material Selection:** The parts were printed using PLA Plus, which offers greater toughness and durability compared to standard PLA, making it suitable for outdoor use.
- **Assembly Considerations:** The breakdown of the model into parts ensures that each component can be printed with high precision, and the assembly process is straightforward.
- **Design for Durability:** The use of PLA Plus and the careful design of each component contribute to the overall durability of the device, ensuring it can withstand the rigors of outdoor environments.

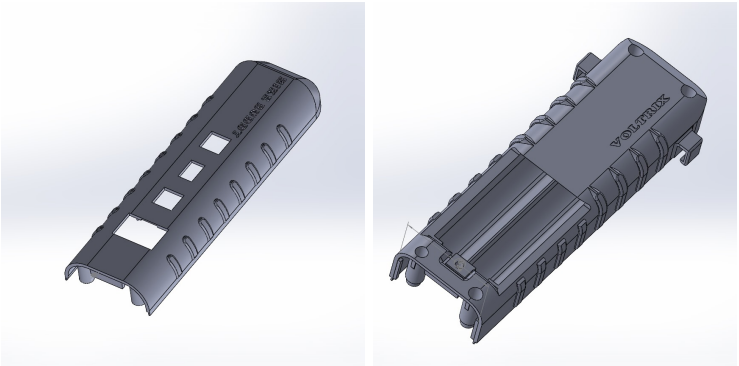

Figure 4.5: Top Body and Bottom Body Parts of the Enclosure

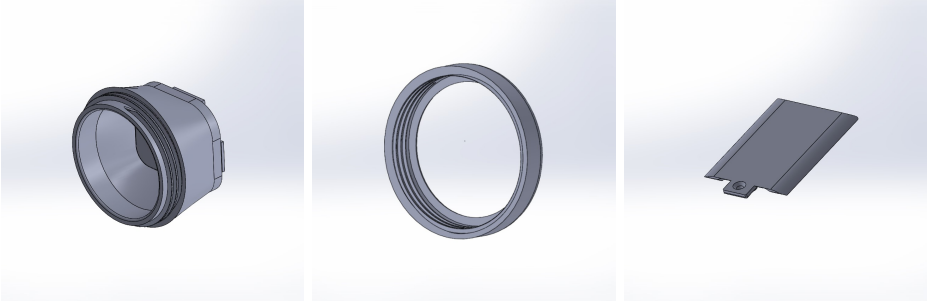

Figure 4.6: Head, Head Ring, and Battery Lid Components

5 | Components

5.1 | TDS Sensor

The TDS sensor was chosen as the most reliable way to assess water purity. It accurately measures the total dissolved solids in the water, providing crucial data for determining water safety. The TDS sensor has proven to be effective in various environmental conditions, ensuring consistent performance during outdoor activities.

5.2 | QMC5883L Electronic Compass

For the electronic compass, the QMC5883L model was selected due to its adequate price/performance ratio, making it a perfect fit for our product. This component provides precise directional information, essential for navigation purposes, and integrates seamlessly with the other modules.

5.3 | OLED Display

The OLED display is capable of clear visibility under various lighting conditions, making it ideal for outdoor use. It efficiently displays the necessary information while consuming moderate power, ensuring prolonged battery life for the device.

5.4 | AMS1117 Voltage Regulator

To ensure the microcontroller operates within its required voltage range, the AMS1117 voltage regulator is used to step down the supplied voltage to 3.3V. This regulator was chosen for its reliability and efficiency, crucial for maintaining stable power delivery to the microcontroller.

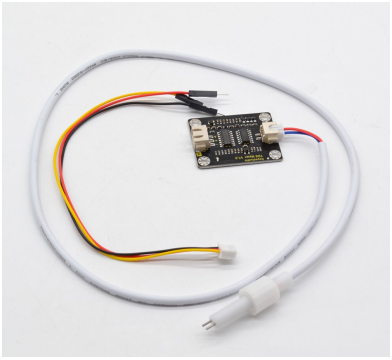

Figure 5.1: TDS Sensor Module

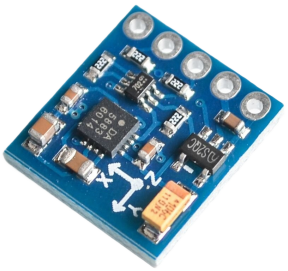

Figure 5.2: QMC5883L Compass Module

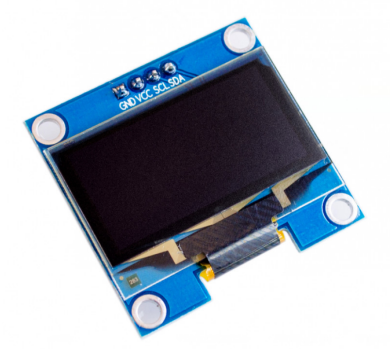

Figure 5.3: OLED Display Module

Figure 5.4: AMS1117 Voltage Regulator

6 | PCB Design

6.1 | Abstract Architecture

The PCB design for the Hike Buddy reflects a modular architecture, allowing for efficient integration of components while maintaining a compact form factor. Designed using Altium Designer under a university license, the PCB layout was tailored to fit the physical constraints of the enclosure, balancing advanced functionality with practical design considerations.

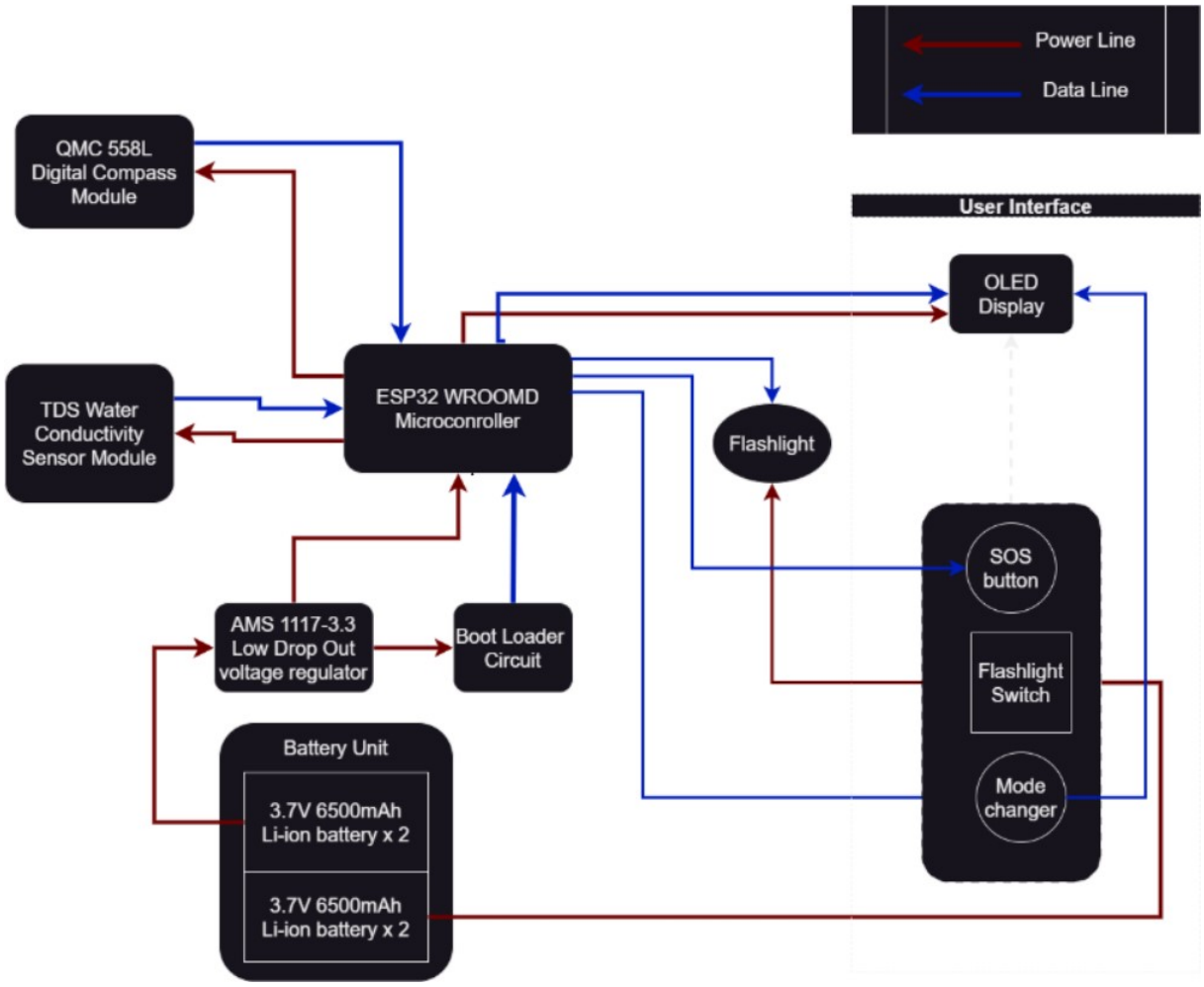

Figure 6.1: Abstract Architecture of the Hike Buddy PCB

6.2 | Design Tools and Constraints

The PCB was designed with Altium Designer, considering both the spatial limitations of the enclosure and the need for reliable, cost-effective components. A combination of SMD components, such as the ESP32 WROOM-D microcontroller and AMS voltage regulator, alongside through-hole components, was selected to optimize accessibility and cost.

- **Component Selection:** SMD components were chosen for their compact size and efficiency, while through-hole components were included for easier assembly and maintenance.
- **Thermal Management:** The PCB was designed to dissipate heat effectively, directing excess heat through the casing to prevent overheating.

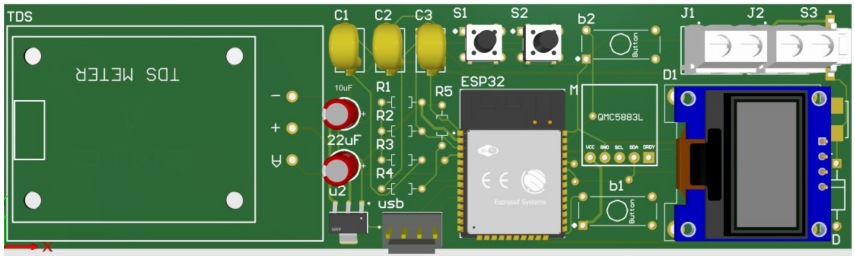

Figure 6.2: 3D View of the Final PCB Design

6.3 | Component Selection and Justification

The ESP32 WROOM-D microcontroller was selected over other options like the ATmega for its superior processing speed and power efficiency. Its dual-core processor and integrated Wi-Fi and Bluetooth capabilities make it ideal for potential upgrades that can be added to the current multifunctional needs of the Hike Buddy, ensuring reliable performance in all conditions.

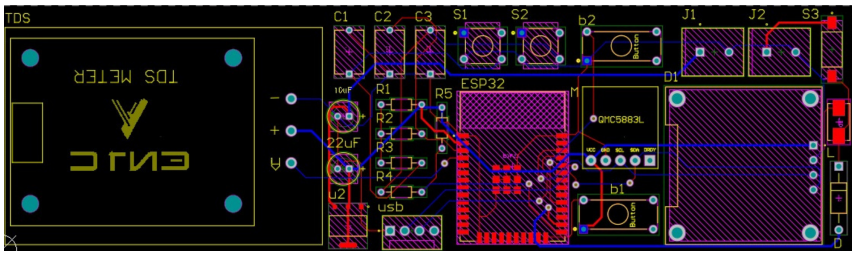

Figure 6.3: Wiring Diagram of the PCB

6.4 | PCB Layout and Versions

The PCB layout evolved through several iterations, each one refining the component placement, routing paths, and overall design. The current version addresses all design challenges, resulting in a highly optimized and efficient layout.

6.5 | Design Amendments

During development, an issue was encountered where the microcontroller struggled to handle floating values on the digital pins, particularly affecting the buttons' functionality. To address this, pull-down resistors were added, stabilizing the inputs and ensuring reliable operation. This amendment was crucial in refining the PCB to meet the project's stringent performance requirements.

7 | Code Implementation

7.1 | Overview

The firmware for the Hike Buddy was developed to manage the device's multifunctional features, including the OLED display, TDS sensor readings, and compass data processing. The code was structured for efficiency, responsiveness, and ease of future updates or modifications. Additionally, functionality has been included to allow users to add custom code, enabling them to personalize the device according to their needs. We have also provided accessible pins for easy firmware uploads and future updates.

7.2 | Libraries and Dependencies

To integrate and control the various components, several libraries were utilized within the firmware. These include:

- **Wire.h:** Used for I2C communication between the microcontroller and peripheral devices.
- **Adafruit_GFX.h:** A core graphics library for displays that provides functions to draw shapes, text, and images.
- **Adafruit_SSD1306.h:** Specifically designed for the SSD1306 OLED display, facilitating display initialization and control.
- **OneWire.h:** Enables communication with one-wire devices such as the TDS sensor.
- **QMC5883LCompass.h:** A library to interface with the QMC5883L compass module, allowing for accurate direction readings.

7.3 | User Customization and Firmware Updates

To ensure the Hike Buddy remains adaptable, we have incorporated the capability for users to add their own code. This feature allows for greater flexibility, enabling users to personalize the device's functions to suit their specific hiking needs. The device is equipped with easily accessible pins that facilitate firmware uploads, ensuring that users can update or modify the firmware as required.

7.4 | Code Structure

The code is organized to prioritize readability and maintainability. Key functionalities, such as handling button presses, switching between modes, and processing sensor data, are modularized to allow for straightforward debugging and enhancements.

7.5 | Future Extensions

Given the open nature of the firmware design, future updates can include additional features or integrations with other sensors. The architecture supports easy expansion, ensuring that the Hike Buddy can evolve to meet new challenges in outdoor environments.

Visit the Hike Buddy GitHub Repository for the Latest Code Updates

8 | Product Assembly

The Hike Buddy assembly process was carefully designed to ensure that the final product is robust, reliable, and easy to maintain. This section details the key considerations and steps involved in the assembly process.
To enhance the structural integrity of the Hike Buddy, M3 screws were used in conjunction with threaded inserts. This combination was chosen for its durability and ability to maintain rigidity over time.

Table 8.1: Advantages of M3 Screws with Inserts

Feature	Description
Enhanced Durability	Threaded inserts distribute the load across a wider area, preventing wear and tear over repeated assembly and disassembly.
Ease of Maintenance	The inserts allow for secure, repeatable fastening, ensuring that the device can be easily opened and reassembled without degrading the internal threads.
Increased Rigidity	The combination of M3 screws and inserts ensures that the enclosure remains tightly secured, preventing any unwanted movement of internal components.

8.1 | Assembly Process

The following table outlines the step-by-step assembly process for the Hike Buddy, emphasizing the precision and care taken at each stage.

Table 8.2: Step-by-Step Assembly Process

Step	Description
1	**Inserting Threaded Inserts**: Insert the threaded inserts into the pre-designed cavities within the 3D printed parts. This ensures strong, reusable threads for M3 screws.
2	**Aligning Components**: Carefully align the top and bottom parts of the enclosure to ensure all internal components fit perfectly without stress or misalignment.
3	**Securing with M3 Screws**: Secure the top and bottom parts of the enclosure using M3 screws, tightened to ensure a firm fit while avoiding over-tightening.
4	**Final Inspection**: Inspect the assembled product thoroughly to ensure all components are properly secured and the device functions as intended.

8.2 | Visual Representation of Assembly

The following images provide a visual overview of the Hike Buddy after assembly, highlighting the secure fit and final appearance.

Figure 8.1: Hike Buddy after Final Assembly

9 | Product Price Estimation

In the initial production run, we plan to manufacture 100 units of the Hike Buddy. This batch will primarily target crowdfunding campaigns and our initial partnerships with outdoor and adventure organizations. To optimize costs, we will source PCBs from an international manufacturing service provider and utilize 3D printing techniques for the enclosures, with a future plan to transition to injection molding for large-scale production.

Table 9.1: Cost Breakdown for 100 Units

Component	**Unit Cost (USD)**	**Total Cost for 100 Units (USD)**
TDS Sensor	2.50	250
HMC Magnetometer	0.70	70
ESP32 Wroom D MCU	2.50	250
AMS1117 Voltage Regulator	0.1	10
PCB Manufacturing & Assembly	8.00	800
Enclosure Manufacturing (PLA Plus)	7.00	700
Packaging	1.50	150
Total	**-**	**2230**

The total estimated cost for producing 100 units is $2230 USD. This brings the cost per unit to approximately $22.30 USD. Considering a profit margin of 15%, the Hike Buddy can be priced at $29.99 USD per unit. This pricing strategy positions the product competitively within the market, ensuring affordability while covering research, development, and production costs.

10 | About Team

The Hike Buddy project is the result of the collective creativity, technical acumen, and dedication of four undergraduates from the Department of Electronics and Telecommunications. As part of the EN1190 module for Engineering Project Design, our team came together with a shared vision: to develop a multifunctional hiking device that would enhance safety and convenience for outdoor enthusiasts.

From the outset, our team embraced a collaborative approach, leveraging the diverse strengths of each member to tackle the various challenges that arose during the project. The journey from concept to completion required not only technical skills but also effective communication, problem-solving, and a deep commitment to quality. By pooling our knowledge in electronics, programming, and design, we were able to seamlessly integrate multiple components into a single, cohesive device.

Throughout the project, we faced numerous obstacles that tested our ingenuity and resilience. However, by working closely together, we found innovative solutions that allowed us to overcome these challenges. Each member brought a unique perspective, contributing to a dynamic team environment where ideas were freely exchanged and the best solutions were identified through rigorous discussion and experimentation.

The success of the Hike Buddy project is a testament to our ability to collaborate effectively, combining our individual skills to create a product that meets the needs of its users. Our teamwork not only allowed us to meet our goals but also enriched our learning experience, as we each grew in our respective fields and gained valuable insights into the importance of interdisciplinary collaboration.

This project has been more than just an academic requirement; it has been an opportunity for us to push the boundaries of our knowledge and creativity, culminating in a device that we are proud to present. The Hike Buddy stands as a symbol of our hard work, innovation, and the power of teamwork. .