Department of Electronic and Telecommunication Engineering,
University of Moratuwa
Sri Lanka

# EN1190 - Engineering Design Project
# Smart Plug Base

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|---|---|
| 220071M | BASITH M.N.A. |
| 220343B | KUMARAGE R.V. |
| 220514C | RANSIKA L.G.C. |
| 220562U | SAMUDITHA H.K.P. |

**Abstarct**

This report documents the development of the AmpAware Smart Plug Base, designed to address everyday challenges related to energy management and control over electrical appliances. Based on identified user needs, the device provides remote and manual control, real-time power monitoring, and safety features, all integrated into a compact and user-friendly design. Market analysis and marketing strategy are also presented, emphasizing the product's potential for broad user adoption and its contribution to smart home ecosystems. Rigorous testing ensures performance and safety, positioning the AmpAware Smart Plug Base as an innovative and accessible solution for sustainable energy consumption and smart home automation.

# Contents

# 1 INTRODUCTION

## 1.1 Arriving at a problem

The initial phase involved identifying the everyday challenges encountered by members of our group. These problems were systematically categorized into distinct sections:

- By Area of Life: This categorization focuses on concerns related to daily activities that impact a broad demographic, ensuring relevance to a wide population.

- By Urgency: Problems were evaluated based on their immediacy, prioritizing those that required urgent attention.

- By Complexity: We assessed the feasibility of implementing solutions within a three-month timeframe, considering the technical complexity of the problem. By Frequency: The frequency of occurrence of each problem was analyzed to determine its commonality and impact.

- By Resource Requirements: We evaluated the resources necessary to address each problem, including time, money, and human capital.

- By Type of Solution Required: Solutions were categorized based on the nature of the required fix, such as technical solutions for problems involving technology or equipment.

## 1.2 Arriving at a solution

- Following the categorization of identified problems, we applied a systematic evaluation to determine which solutions were most applicable to the identified criteria. We then re-categorized the potential solutions and selected those that satisfied the majority of the identified cases:

- By Approach: Mitigative Solutions were prioritized for their ability to reduce the severity or impact of the problem.

- By Scope: Incremental Solutions were selected for their gradual implementation over time, allowing for manageable and sustainable progress (e.g., step-by-step debt repayment plans).

- By Resource Requirements: We focused on Moderate Resource Solutions that necessitate a reasonable investment of time, money, or effort, making them feasible within available resources.

- By Complexity: Simple Solutions were favored due to their ease of implementation and comprehension.

- By Innovation: Hybrid Solutions were chosen for their ability to combine conventional and innovative elements, offering a balanced and adaptable approach.

## 1.3 Motivation

Many households face challenges related to energy usage, including the risk of forgotten appliances consuming unnecessary energy, difficulty in controlling energy consumption due to lack of detailed data, and the resulting environmental and financial implications

## 1.4 Justification for selection

When it comes to existing solutions smart homes are increasingly popular with new technology and the ability to connect existing products to the internet and control them with common handheld devices.

But unlike a fully smart home, our smart plug base offers laser-focused control. Users can target specific appliances for automation, like lamps for security or coffee makers for energy efficiency, without needing to upgrade their entire home. Smart homes can be a significant financial investment. our smart plug base allows users to automate key areas for a fraction of the cost, making smart home technology more accessible. Users can choose which appliances they want to automate with our smart plug base. This provides more flexibility and customization compared to a pre-defined smart home system.

# 2 PRODUCT ARCHITECTURE

The architecture of a smart plug base is designed to enable remote control, monitoring, and automation of connected devices. Here's a breakdown of the key components and how they interact:

## 2.1 Power Supply and Relay Control

- AC Input: The smart plug base receives power from a standard AC outlet (230V). Relay Switch: A relay controls the flow of electricity to the connected device. The relay is electronically controlled, allowing the smart plug to turn the device on or off remotely.

- Surge Protection: Built-in protection mechanisms (FUSE) prevent damage from electrical surges, ensuring the safety of both the smart plug and the connected device.

## 2.2 Microcontroller Unit (MCU)

- Central Processing Unit: The microcontroller (ESP32) acts as the brain of the smart plug. It processes commands from the user, controls the relay, and manages communication with external devices.

- Firmware: The firmware embedded in the MCU handles the logic for device control, Wi-Fi connectivity, and communication with the mobile app

## 2.3 Communication Module

Wi-Fi Module ( ESP32): Enables the smart plug to connect to a local Wi-Fi network, allowing remote control through a smartphone app.

## 2.4 Sensors and Monitoring

Current and Voltage Sensors: Monitor the power usage of the connected device. These sensors provide real-time data on energy consumption, allowing for usage tracking and alerting users to abnormal conditions.

- ACS712 Sensor - Can measure up to 20A current.

- 230VAC ZMPT101B 2mA - This module can measure AC voltage within 250V.

## 2.5 Power Management

- Energy Efficiency: The smart plug is designed to consume minimal power when in standby mode, ensuring energy efficiency even when not actively controlling a device.

- Power Regulation: Integrated circuits regulate the voltage and current supplied to the microcontroller and sensors, ensuring stable operation.

## 2.6 User Interface

- Mobile App Integration: Users interact with the smart plug through a mobile app. The app allows for on/off control, monitoring energy usage, and setting automation rules.

- Manual Control Button: A physical button on the smart plug base provides manual control over the relay, allowing users to turn the device on or off without the app.

Figure 1: MobileApp

## 2.7   Printed Circuit Board

Our PCB design was carefully optimized to create a compact and efficient layout, accommodating all essential components while adhering to the spacing requirements of a 13A standard socket plug. To achieve a smaller footprint, we utilized several components in Surface-Mount Device (SMD) form.

Key features of the PCB include a microcontroller (ESP32 WROOM-32), resistors, capacitors, and a voltage regulator, all strategically placed to enhance functionality and minimize space. The layout is designed to streamline assembly and testing processes, with well-defined electrical pathways ensuring clear and reliable signal flow throughout the board.
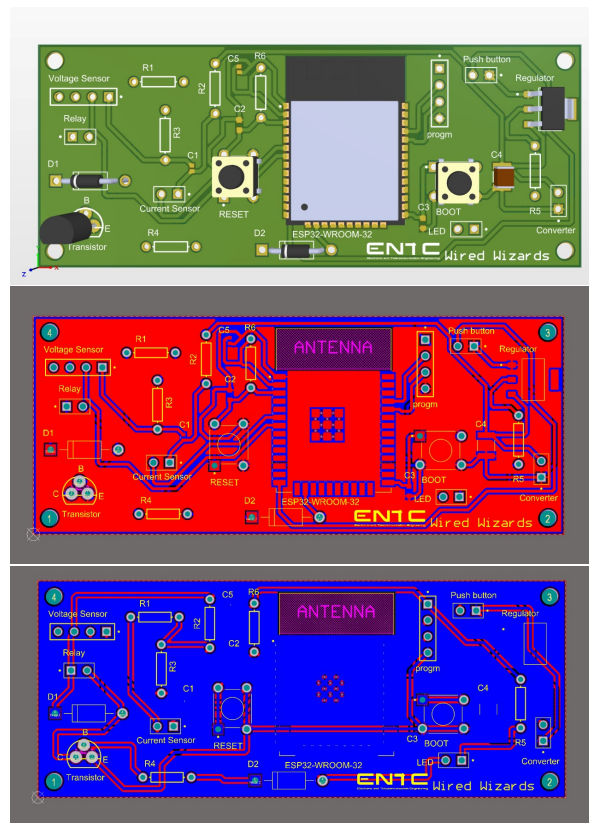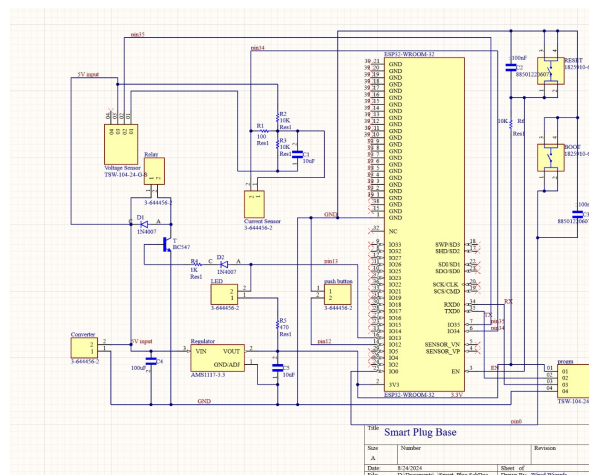
Figure 2: PCB



Figure 3: Schematics

## 2.8 Enclosure Design

When designing the enclosure our main focus was to design it in a such way that it is very easy to install and easily replaceable. So we designed our enclosure such that it closely resembles the standard 13A plug socket. In the enclosure we designed separate mounting areas for the circuit components and the PCB making it modularised and easily replaceable when a repair has to be done.

The material we chose to print the enclosure is PLA plastic as it is a very good electrical insulator and somewhat good heat resistant as this is the prototype of our product. Although we thought of a way to find a very good heat resistive material, we were constrained by the project budget. But when manufacturing the enclosure commercially we can use far better materials as we can compensate the cost as the large scale manufacturing of the enclosures can be done using moulding. Also we added an indicator in the enclosure to show the user to indicate the status of the equipment. When connecting the main AC wires to the enclosure we added connectors so that the user can activate our product on his own without needing any help of a technician. The enclosure also includes a fuse to protect the main circuitry from overcurrent situations.
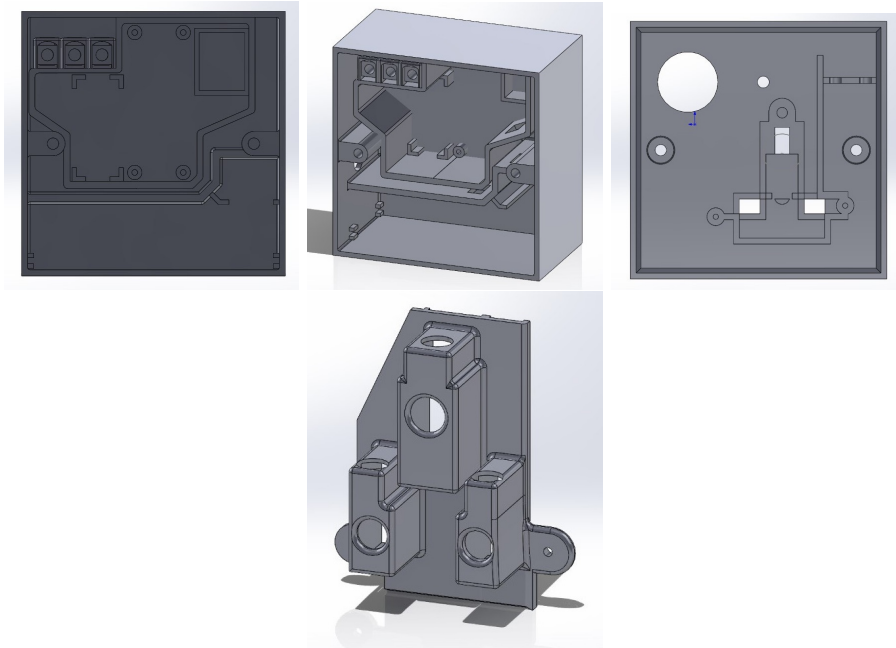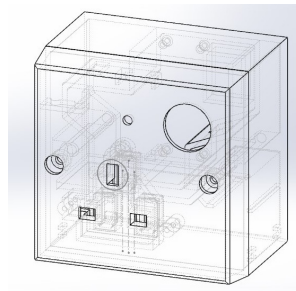


Figure 4: Parts of the enclosure



Figure 5: Final Model of the complete enclosure

# 3　FINAL PRODUCT

The "Final Product" section presents the AmpAware Smart Plug Base in its completed form, highlighting its features, design, engineering, and user experience. This section aims to give a comprehensive understanding of what the product is, its functionalities, and the innovations behind its development.

## 3.1　Product Overview

The AmpAware Smart Plug Base is an innovative smart home device designed to provide users with the convenience of manual and remote switching, along with real-time power monitoring. The product is aimed at tech-savvy consumers and households looking to optimise energy consumption while maintaining control over their electrical devices from anywhere via the Blynk IoT platform. AmpAware's intuitive design and seamless integration with the Blynk app make it an essential addition to any smart home ecosystem.

## 3.2　Key Features and Specifications

1. The AmpAware Smart Plug Base offers several key features that distinguish it from other smart plugs on the market:

2. Remote Control: Allows users to switch devices on and off remotely through the Blynk IoT app, providing convenience and energy savings.

3. Power Monitoring: Real-time monitoring of power consumption helps users understand and manage their energy usage more effectively.

4. Safety Features: Equipped with overcurrent protection

5. User-Friendly Design: Simple setup process and easy-to-use interface.

6. Technical Specifications:

   - Input Voltage:100-240V AC
   - Maximum Load:13A
   - Wi-Fi Standard:2.4GHz-2.5GHz 802.11b/g/n
   - Operating Temperature:0°C to 40°C (32°F to 104°F)
   - Dimensions:84 x 84 x 62 mm

## 3.3　Design and Aesthetics

The AmpAware Smart Plug Base has been carefully designed to balance form and function. The enclosure is made from durable, fire-resistant materials that provide a sleek, modern appearance while ensuring safety. The compact design allows it to fit comfortably in any standard wall socket without obstructing adjacent outlets. The product's aesthetic design reflects a minimalist approach, with a clean white finish and subtle branding that blends seamlessly with any home décor.

## 3.4　Engineering and Manufacturing Insights:

During the development of the AmpAware Smart Plug Base, several engineering challenges were encountered, including minimising the size of the PCB while maintaining full functionality and ensuring robust Wi-Fi connectivity. These challenges were addressed through iterative prototyping and testing, resulting in a compact yet powerful device. The manufacturing process was designed to be efficient and scalable, utilising high-quality components and rigorous quality control measures to ensure each unit meets our strict standards for performance and safety.

## 3.5 User Experience and Functionality:

The AmpAware Smart Plug Base is designed with user convenience in mind. Users can easily set up the device by replacing a standard outlet and connecting it to their Wi-Fi network using the Blynk app. Once connected, users can control their devices from anywhere, monitor energy usage, and receive notifications about power consumption. The user interface of the Blynk app is intuitive, featuring a clean design with easy-to-navigate controls and real-time feedback.

## 3.6 Quality Assurance and Testing:

The final product has undergone extensive testing to ensure it meets all relevant safety and performance standards. This includes testing for electrical safety, Wi-Fi connectivity, and endurance under various operating conditions. The AmpAware Smart Plug Base has confirmed its adherence to international safety and quality standards.

# 4 Marketing, Sales, and After-Sale Service Considerations

The "Marketing, Sales, and After-Sale Service Considerations" section outlines the strategies and plans for launching, promoting, selling, and supporting the AmpAware Smart Plug Base. This section aims to provide a comprehensive overview of how the product will be brought to market, how it will reach its target audience, and the support mechanisms in place to ensure customer satisfaction.

## 4.1 Market Analysis:

The target market for the AmpAware Smart Plug Base consists of homeowners, renters, and tech enthusiasts who are interested in smart home automation and energy management. The product is particularly appealing to individuals who want to reduce their energy costs and increase the convenience of controlling their home devices. Market research indicates a growing trend in smart home devices, driven by the increasing availability of IoT technology and consumer demand for energy-efficient solutions. The competitive landscape includes several established brands, but AmpAware differentiates itself through its unique combination of features, ease of use, and integration with the Blynk IoT platform.

## 4.2 Positioning and Branding:

AmpAware is positioned as a premium smart plug base that offers both advanced functionality and ease of use. The brand message focuses on empowering users to take control of their energy consumption and contribute to a more sustainable future. The visual identity of AmpAware is clean, modern, and professional, reflecting the product's high quality and reliability. The branding strategy includes consistent messaging across all marketing channels, emphasising the product's innovative features and user benefits.

## 4.3 Pricing Strategy:

The pricing strategy for the AmpAware Smart Plug Base is designed to be competitive while reflecting the product's premium features and quality. The product will be priced slightly above mid-range competitors to position it as a high-value option within the smart home market. Additionally, promotional pricing will be offered during the initial launch phase to attract early adopters and build market share. Bundling options with other smart home devices will also be considered to increase the perceived value of the product.

## 4.4 Distribution Channels:

The primary sales channels for the AmpAware Smart Plug Base will include online platforms such as the company's website, major e-commerce sites like Amazon, and select brick-and-mortar retail partners. This multi-channel approach ensures broad product availability and convenience for customers.

Partnerships with smart home solution providers and home improvement retailers will also be pursued to expand reach and visibility.

## 4.5   Marketing and Promotional Plan:

The marketing strategy for AmpAware will leverage a mix of digital and traditional channels to create awareness and drive sales. Digital marketing efforts will include social media advertising, influencer partnerships, content marketing, and search engine optimization (SEO). Traditional marketing methods such as print advertising in home automation magazines, participation in trade shows, and public relations efforts will complement digital strategies. A product launch event and targeted email campaigns will be used to generate buzz and engage potential customers.

- Making partnerships with plug base manufacturers

- Collaborate with electric repairing companies to introduce the product to the people

- Direct Sales from digital marketing

**Target Market**



Figure 6: 24-25yrs, Both Male and Female, Middle and high income, Professional, Urban and semiurban, Convenient oriented

## 4.6   After-Sale Service and Customer Support:

After-sale service is a critical component of the AmpAware customer experience. The company will offer a one-year warranty on the smart plug base, covering any defects in materials or workmanship. Customer support will be available through multiple channels, including phone, email, and live chat, with a commitment to timely and effective responses. A comprehensive online help centre will provide troubleshooting guides, FAQs, and instructional videos to assist customers in using and maintaining their devices.

## 4.7   Customer Retention and Feedback:

Retaining customers and fostering brand loyalty will be achieved through a combination of excellent customer service, regular product updates, and engagement initiatives. A customer feedback program will be implemented to gather insights on product performance and user experience, with feedback being used to drive continuous improvement. Additionally, loyalty programs and targeted offers will encourage repeat purchases and referrals.

# 5  TASK ALLOCATION

- Problem Research and Validation - Team

- Conceptual Design and Circuit Diagram Development, Marketing Strategy and Promotion - Praveen

- Software Development and Microprocessor Programming - Chamudi

- PCB Layout and Design - Rivindu

- Enclosure Design and Development - Basith

# 6  Total Budget

| COMPONENTS | QUANTITY | PRICE(Rs.) |
|---|---|---|
| ESP32 - WROOM - 32D | 1 | 1600 |
| acs712 30A Current sensor | 1 | 340 |
| 230VAC ZMPT101B 2mA voltage sensor | 1 | 400 |
| 5v Relay | 1 | 100 |
| 5V AC to DC buck convertor module | 1 | 350 |
| BC547 Transistor | 1 | 10 |
| Linear Voltage Regulator | 1 | 11 |
| LED (Red) | 1 | 2 |
| Resistors | 5 | 10 |
| Capacitors 10V 100uF x 2 6.3V 10uF x 1 | 3 | 84 |
| Push button | 1 | 80 |
| JST headers | 6 | 350 |
| Diodes | 2 | 6 |
| **OTHER** | | |
| PCB printing | 1 | 533 |
| Enclosure | 1 | 3500 |
| TOTAL | | 7376 |

Table 1: Budget.

Although the initial cost of designing and developing the "Smart Plug Base" is relatively high, the cost per unit can be significantly reduced through mass production.By leveraging economies of scale and optimizing the manufacturing process, the unit price can be lowered, allowing us to offer the product at an estimated retail price of around Rs.4500.00/=. This pricing strategy makes the device more accessible to a broader range of consumers, increasing its market potential.

# 7  FUTURE DEVELOPMENTS

- Integration with Smart Home Ecosystems: Expand compatibility with popular smart home ecosystems like Amazon Alexa, Google Assistant, and Apple HomeKit for seamless voice control and automation.

- Support for Zigbee/Z-Wave: Adding Zigbee or Z-Wave protocols could enhance connectivity and reduce reliance on Wi-Fi, improving network stability and range.

- AI-Powered Automation: Implement AI algorithms that learn from user behavior to suggest or automate schedules, such as turning devices on or off based on typical usage patterns or external factors like weather conditions.

- Different Plug Types: Expand the product line to include variants compatible with different plug types and power standards used globally.

- Integrated USB Ports: Add USB charging ports to the plug base to provide additional functionality without taking up extra socket space.