Smart Power Monitoring Plug

Internet Of Things

Project Proposal

Submitted By

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Introduction

The Smart Power Monitoring Plug is an IoT-based device designed to transform traditional electrical outlets into intelligent, connected power points. It can be directly plugged into a standard wall socket, enabling users to connect household or office appliances through it. By integrating Wi-Fi connectivity with a powerful ESP32 microcontroller, the device allows appliances to be monitored and controlled remotely via a dedicated web application.

One of the key features of the Smart Power Monitoring Plug is its ability to measure real-time power consumption, including voltage, current, and wattage of the connected load. This data is transmitted securely to the database, giving users clear insights into their energy usage patterns. Furthermore, the device is equipped with a high-load alert mechanism**,** which notifies the user when the connected appliance exceeds a safe power threshold, thereby reducing the risks of electrical hazards and improving energy efficiency.

By combining remote control, live energy monitoring, and safety alerts in one compact form factor, the Smart Power Monitoring Plug provides a convenient, safe, and eco-friendly solution for smart homes and workplaces. It empowers users to not only manage their devices more effectively but also to save energy and enhance electrical safety in their daily lives.

Problem Statement

In modern households and workplaces, the increasing use of electrical appliances has led to higher energy consumption and a greater risk of electrical hazards such as overloads and short circuits. Traditional wall outlets provide no visibility into power usage and offer no means of controlling devices remotely. As a result, users are often unable to monitor their electricity consumption effectively, leading to unnecessary energy wastage and increased utility costs. Additionally, the absence of early warning systems for high power loads exposes appliances and users to potential electrical accidents.

Objectives

1. **Remote Device Control**

   Allow users to switch connected appliances ON or OFF remotely via a web application.

2. **Real-Time Power Monitoring**

   Continuously measure and display voltage, current, power consumption, and energy usage of connected devices.

3. **High-Load Detection & Alerts**

   Implement a safety mechanism to detect overloads and notify the user immediately to prevent electrical hazards.

4. **Data Logging & Insights**

   Record energy usage data over time to help users understand their consumption patterns and reduce electricity costs.

5. **User-Friendly Web Application**

   Develop a cross-platform web app that provides seamless control, monitoring, and alert notifications.

6. **Energy Efficiency & Safety**

   Promote responsible energy usage by enabling users to track, manage, and optimize their electricity consumption while ensuring safe operation.

Budget

ITEM	PRICE
• Hi-Link HLK-PM01	800.00
• ESP32 (NodeMCU)	1340.00
• PZEM-004 Meter	2600.00
• Solid State Relay (OMRON G3MB- 202P)	680.00
• LED Bulb	590.00
• Filament Bulb	190.00
• Wires	730.00
• USB Cable	430.00
Total	7360.00/=

Gantt Chart

Task	Week				
Month	September	September	September	September	September
Date	02-04	05-07	08-17	18-20	21-24
Planning					
Requirement Analysis					
Designing					
Testing					
Deployment & follow up					

Task	Start Date	End Date	Days to Complete
1. Planning	Sep02	Sep04	3
2. Requirement Analysis	Sep05	Sep07	3
3. Designing	Sep08	Sep17	10
4. Testing	Sep18	Sep20	3
5. Deployment & follow up	Sep21	Sep24	4

System Architecture

1. Hardware Layer (Device Side)

- **ESP32 Microcontroller** – acts as the brain of the device, handling data collection, decision-making, and communication.
- **Relay Module** – switches the connected appliance ON or OFF as commanded.
- **AC-DC Power Supply (Hi-Link Module)** – converts 230V AC mains supply to 5V DC to power the circuit.
- **Plug and Socket Interface** – allows household appliances to be connected.
- **Safety Components** – fuse, MOV surge protector, and earthing for safe operation.

2. Communication Layer

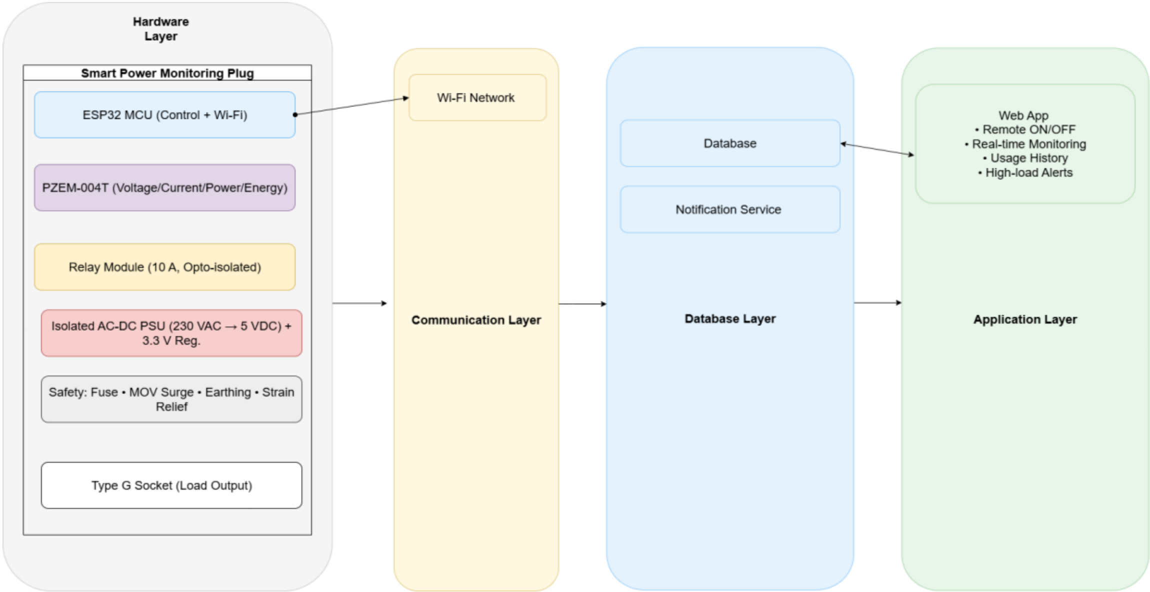
- **Wi-Fi Module (ESP32 built-in)** – provides wireless connectivity to the internet.

3. Database Layer

- **Database** – stores historical data for analysis and visualization.
- **Notification Service** – pushes alerts to users when high-load conditions are detected.

4. Application Layer (User Side)

- **Web Application**
  - Control connected device remotely (ON/OFF).
  - View real-time and historical power consumption data.
  - Receive high-load alerts instantly via push notifications.
  - Display analytics for energy-saving decisions.



Technology Stack

Category	Technology	Purpose
1. Power Supply	• Hi-Link HLK-PM01	• Converts 220V AC to 5V DC for device
2. Microcontroller	• ESP32 (NodeMCU)	• Processing unit,Wi-Fi communication
3. Sensor	• PZEM-004 Meter	• Measures voltage, current, wattage, energy
4. Control Unit	• Solid State Relay (OMRON G3MB-202P)	• ON/OFF switching of appliances
5. Programming Language	• C++ (Arduino IDE)	• ESP32 firmware development
6. Backend	• PHP	• Handles user requests and server logic
7. Database	• SQL Server	• Stores usage data and logs
8. User Interface	• Web Application	• Provides remote control and monitoring

Component Description

1. Hardware Components

Component	Description	Use in Project
1. Hi-Link HLK-PM01	• Step-down power supply (220V → 5V DC)	• Powers ESP32 and Relay safely
2. ESP32 (NodeMCU)	• WiFi + Bluetooth microcontroller board	• Controls system, connects to server, processes sensor data
3. PZEM-004 Meter	• AC power monitoring sensor (Voltage, Current, Watt, Energy)	• Measures real-time power usage and sends data to ESP32
4. Solid State Relay (OMRON G3MB-202P)	• Electronic switch (5V control → 220V load)	• Turns appliances ON/OFF under ESP32 control

2. Software Components

Component	Description	Use in Project
1. C++	• Programming language for ESP32	• Implements firmware logic (WiFi, sensor, relay)
2. PHP	• Server-side scripting language	• Provides web interface & APIs for remote control
3. SQL Server	• Relational database System	• Stores power data and device logs for monitoring

Feasibility Analysis

A thorough feasibility analysis was conducted in order to determine the viability and likelihood of success of the proposed Smart Power Monitoring Plug system. The analysis considers technical, functional, and economic factors in making the project feasible using available resources.

1. Technical Feasibility

There exists high technical feasibility of the project since there is existing hardware and software that can be used with the selected components. The ESP32 microcontroller incorporates built-in Wi-Fi features, reducing the consumption of individual modules and enabling effortless communication with the server. The PZEM-004 power meter sensor is very reliable and provides real-time reading functionality for electrical parameters. Moreover, the Hi-Link power supply module provides voltage conversion from 220V AC to 5V DC in a secure manner, protecting sensitive electronic devices. On the software side, C++ with Arduino IDE offers flexible firmware development, while PHP and SQL Server are a robust, open-source backend platform. Together, these technologies make the system stable and scalable.

2. Operational Feasibility

On the operational front, the system is user-friendly and efficient. The device can be accessed by users easily via a web interface without requiring much technical knowledge. The system's integration of remote monitoring and appliance control means greater convenience in everyday usage. The electrical safety of the device is enhanced by the high-load alert function that prevents hazardous overloads. The system is easily implemented in smart homes, offices, and even industry with little modification, thereby demonstrating its adaptability to real-life applications.

3. Economic Feasibility

The economic Feasibility of the project is very high. Hardware elements like ESP32, relay, and sensors are cost-effective and readily available in the market. Since the software stack (C++, PHP, SQL Server) is open-source, licensing cost is zero, which adds negligible amounts to overall costs. In comparison to commercially produced smart plugs, the proposed system provides similar or greater functionality at a very low price. Furthermore, by offering users a facility to monitor and control their energy consumption, the system facilitates long-term cost saving on utility bills.

4. Overall Feasibility

According to technical dependability, ease of use, and cost, the proposed Smart Power Monitoring Plug is convenient and feasible for use. Not only does it answer user needs for convenience and energy saving but also environmental sustainability through encouraging conservation of energy. The project offers short-term benefits in terms of ease of use and long-term benefits in terms of safety and cost-saving, which makes it useful and feasible IoT implementation.