International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(REVIEW ARTICLE)

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Smart Plug: Intelligent energy management solution

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International Journal of Science and Research Archive, 2025, 15(01), 233-238

Publication history: Received on 17 February 2025; revised on 31 March 2025; accepted on 02 April 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.15.1.0848

Abstract

A SmartPlug is an intelligent energy management solution that functions as a power-point adapter, placed between your power socket and the appliance you wish to control. At its core, it acts as a simple switch to turn devices on and off. However, its true potential lies in its integration with smart home platforms, offering advanced features. With the SmartPlug, you can remotely control your appliances via a smartphone app from anywhere. It supports smart scheduling, allowing you to automate when devices turn on or off at specific times and days. Additionally, it offers detailed insights into energy consumption costs, customized to your location, helping you monitor and manage usage efficiently. You can also set customizable alerts. ensuring you're notified about specific appliance activities or unusual usage patterns. This comprehensive suite of features makes the SmartPlug an essential tool for intelligent energy management and a smarter home.

Keywords: Nodemcueps32; Acs712 Cs; Zmpt101b Vc; Buck Rectifier; Relay; Gemini AI; Firebase; Flutter

1. Introduction

Apart from replacing traditional outlets, smart plugs were linked to some of the most basic lat gadgets, which have a great market potential. The latest smart plug gadgets have a futuristic vision with several capabilities such as Wi-Fi connectivity, which allows you to operate items plugged into smart plugs remotely with your smartphone. Control choices like Alesa, Sin, or Google Assistant, which are becoming increasingly popular, allow you to control devices hooked into the smart plug unit (some models of smart plug might require a bridge or dongle for this capability). The plug not only meets the fundamental criteria of switching, but it also must do so at predetermined periods in order to maximise efficiency. As a result, set timer clocks were employed. The next significant feature to be included is the ability to track real-time information about energy usage and cost of use for a device that uses the plug. We're addressing several significant issues with this project, and we're hoping to discover a solution. Electrical power usage and electrical power networks are at the root of these difficulties. One of the issues we'd want to address is the rising trend in energy use. This might be the most pressing issue that the entire globe awaits a solution to.

People are dramatically increasing their electrical power usage nowadays. Second, we hoped to address the absence of electrical power usage awareness technology with this research. There are now several initiatives aimed at lowering electrical power usage and encouraging individuals to do so, however, many efforts lack the necessary technology to inform the public about their power use, as words alone are insufficient. The third issue we're addressing is the rise in environmental concerns associated with growing power consumption, and the fourth issue we're addressing is the demand for power consumption patterns by various power providers throughout the world.

Power providers would like to get a comprehensive understanding of how individuals use electricity. To date, several gadgets have been created to solve these issues. However, the numerous flaws they revealed increased the urgency of

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developing a sophisticated smart plug system. Outlet with Smart Plug MZ701 is a device that is associated with power measuring technology. M2701/702 smart plug outlet is an AC power outlet with relay control and over current protection device that can be controlled using a 2.4GHz bent wireless remote. The power circuit is a free design with the added benefit of being able to be controlled remotely via a proprietary network interface. MZ701/702 is used to accept RF commands from a remote controller or to do advanced remote administration through PC software. MZ701/702 saves energy thanks to its idle current sensing, which interrupts AC output when a plugged-in electrical equipment is not in use [1]. The Plug-In Power and Energy Monitor is yet another related project that has been released on the market. This gadget can measure the power of the loads connected to it. The voltage, current, and power of the load connected to it may all be measured. As a result, we can claim that this gadget is rather advanced in terms of measurement, yet it is unable to communicate the data that it collects elsewhere. In other words, it just measures and monitors the power measurements and does not provide any control functions.

1.1. Problem statement

The current SmartPlug model includes basic functionalities such as remote control for managing appliances from a smartphone, scheduling to automate device operations, and energy monitoring to track power usage. These features provide users with a convenient and efficient way to control their appliances.

1.2. Proposed system

The proposed SmartPlug model enhances the existing functionality by introducing advanced features. It offers energy insights and AI-driven suggestions to optimize energy usage, smart scheduling for adaptive and context-aware control, and customizable alerts to notify users of specific appliance activities or unusual patterns. These innovations aim to provide a smarter, more personalized energy management solution.

2. Working

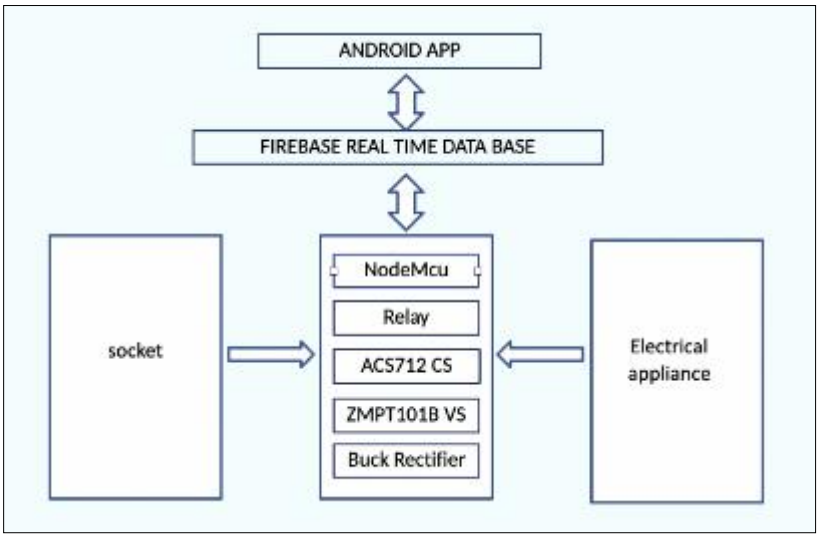

Figure 1 Block diagram

2.1. Mobile Application

The SmartPlug Mobile Application provides users with a seamless way to monitor and control their smart plugs remotely. Through its User Module, users gain access to a centralized system that enables efficient management of connected devices.

2.1.1. The mobile application allows users to

- Monitor real-time power consumption of connected appliances.
- Turn devices ON/OFF remotely to optimize energy usage and enhance convenience.
- Set automation rules and schedules to power devices at specific times.
- Receive alerts and notifications for unusual power consumption or faults.
- Track energy usage history with detailed insights to manage electricity consumption efficiently.

2.2. SmartPlug Device

2.2.1. Current/Voltage Consumption

The SmartPlug mobile application allows users to track real-time current and voltage consumption of connected devices. Users can view detailed reports and analytics to understand their energy usage patterns. The system provides power consumption alerts, helping users make informed decisions about energy efficiency.

2.2.2. Scheduling the Devices

Users can schedule their smart plugs to turn ON/OFF at specific times, ensuring better energy management and convenience. The scheduling feature helps automate daily tasks, such as turning off lights at night or switching on appliances before users arrive home.

2.2.3. Remote Control ON/OFF

The application provides remote access to control connected devices from anywhere. Users can instantly turn appliances ON/OFF using the app, ensuring safety and energy conservation. The system also includes a fail-safe mechanism to prevent overloading.

2.3. Smart Scheduling

The SmartPlug mobile application integrates Gemini AI to analyze past scheduling data and suggest optimized automation rules. By studying historical usage patterns, the AI identifies the most frequently used schedules and provides intelligent recommendations for automating device operations. This helps users efficiently manage their appliances while reducing unnecessary energy consumption. The system continuously learns from user behavior to refine scheduling suggestions, ensuring an adaptive and energy-efficient experience.

2.3.1. Customizable Alerts

Users receive custom alerts for unusual power consumption, device malfunctions, or high energy usage. These alerts help users take timely action to prevent energy wastage, reduce electricity bills, and maintain appliance health.

2.4. Firease

2.4.1. Real-Time Data Storage and Device Control

The SmartPlug mobile application leverages Firebase to store and manage real-time data related to current and voltage consumption, as well as device status (ON/OFF). The system continuously records power usage data from connected appliances and updates the Firebase Realtime Database, ensuring instant synchronization across user devices.

2.4.2. Data Processing and Automation

When a smart plug is turned ON or OFF, the status change is immediately reflected in Firebase, allowing seamless control and monitoring. Additionally, Gemini AI analyzes past power consumption patterns and suggests automated schedules, which are updated in Firebase. This enables efficient energy management by dynamically adjusting device operation times.

2.5. Custom Alerts and Insights

Based on threshold values set by users, Firebase triggers custom alerts for excessive power consumption or unusual fluctuations. Users receive notifications about device status, power trends, and scheduling recommendations, helping them optimize energy usage while ensuring the safety of connected appliances.

2.6. Output

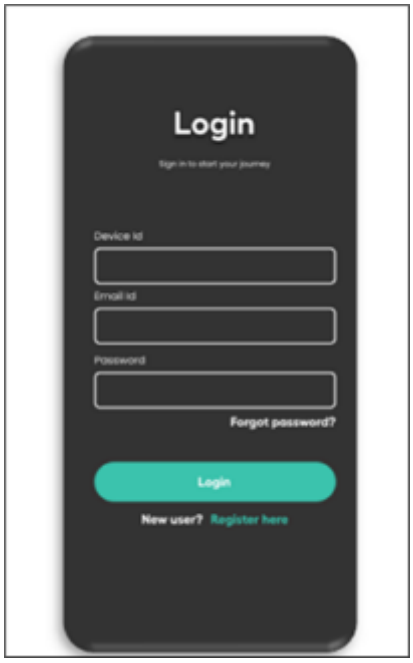

Figure 2 Login page

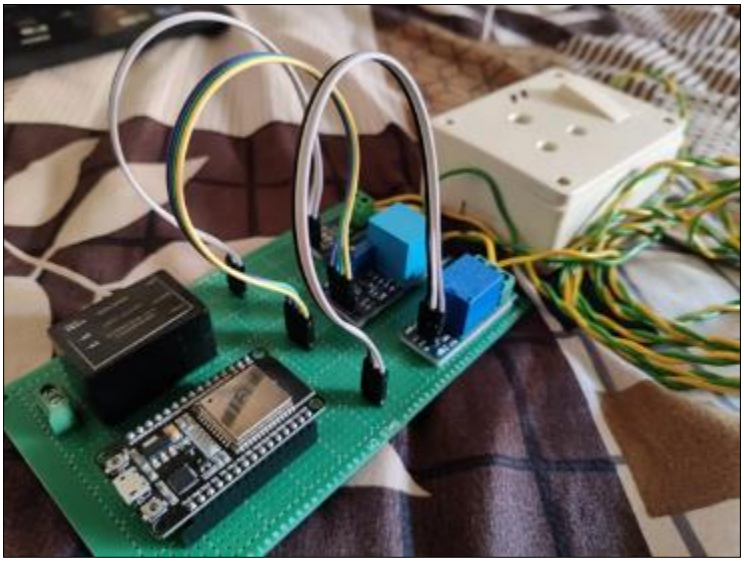

Figure 4 Home page

Figure 5 Signup page

3. Conclusion

This study examined the possibility of reducing electricity use in homes through users' voluntary education and use of loT-based smart plugs and switches to leap into smart cities and energy prosumers. Unlike previous studies that present the results of an energy data analysis at the urban level, or analyze the results of collective education for students or practitioners, actual members of households voluntarily installed smart plugs and switches, and monitored and quantitatively verified the trends in energy-reduction effects through training. Satisfaction with this program, which includes supplied devices and education, had the most significant impact on the power savings of each household; the number of applications designed for real-time power usage monitoring using applications, for which training was

provided, had a positive effect on power savings at a relatively high rate. It is therefore expected that these strategies can impact energy savings in efficient homes if the program is implemented in collective residential areas such as apartment complexes with relatively clear management entities.

Future enhancements

The future scope of this project study includes several advancements aimed at enhancing the efficiency and intelligence of the smart plug system. One key improvement is the introduction of a smart algorithm for billing, which will optimize energy consumption calculations and provide users with accurate, real-time billing information. Additionally, the integration of machine learning (ML) will enable the system to predict the type of device plugged in, allowing for better energy management and automation based on device-specific usage patterns. Furthermore, the project aims to expand the functionality of the smart plug to a smart socket system, which will provide greater flexibility and control over multiple devices simultaneously. These enhancements will contribute to a more intelligent, user-friendly, and efficient energy management solution.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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