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IoT Control System for Switch and Socket

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Abstract

This project aims to develop a Smart IoT Control System for Switches and Sockets, driven by the growing demand for intelligent and automated control in residential and commercial settings. Utilizing IoT technology, the system enables remote operation and monitoring through a user-friendly interface. The initiative involves a literature analysis, hardware selection, circuit design, and software development. Rigorous testing ensures system dependability, functionality, and adherence to objectives, while addressing ethical concerns. The goal is to create an efficient, user-friendly interface for remote control and monitoring, leading to improved energy efficiency and enhanced user experience.

1. Introduction

The rapid evolution of technology has given rise to the Internet of Things (IoT), fundamentally transforming how we engage with the world. In the realm of home automation, IoT has catalyzed the development of smart control systems, exemplifying heightened convenience, efficiency, and control [1]. This project endeavors to propel this industry forward by crafting a Smart IoT Control System for Switches and Sockets. The escalating popularity of such systems stems from their manifold advantages, offering users the flexibility of remote operation for switches and sockets, promoting energy conservation, and facilitating cost-effective, environmentally conscious power management. Automation capabilities, driven by planned operations and sensor-triggered activations, further elevate comfort and safety. Traditional control methods exhibit shortcomings, necessitating proximity for manual access and lacking real-time consumption data. This project aims to address these issues by creating a user-friendly, customizable IoT control system, aiming to surpass existing solutions by mitigating drawbacks such as limited customization, complex interfaces, and compatibility issues [1].

1.1 Problem Statement

The initiative aims to address major issues with conventional electrical control systems. It begins by addressing the issue of limited accessibility by suggesting an intelligent Internet of Things control system that improves ease by allowing switches and outlets to be operated remotely via smartphones. Second, it addresses wasteful energy use by integrating energy monitoring, offering real-time data for optimal power utilization, encouraging energy economy, and cutting expenses. Finally, the project improves general comfort and safety in the house by adding features like scheduling and sensor-triggered actions, which address the absence of advanced automation in the current systems.

1.2 Objective

The project aims to achieve several objectives including to design a user-friendly and efficient solution for managing sockets and switches in residential settings; secondly, to develop a comprehensive system that facilitates real-time control of switches and sockets, incorporates monitoring features for voltage and current values, and integrates IoT functionalities to enable remote access; and thirdly, to integrate the aforementioned features into a cohesive and user-centric solution for enhanced control and monitoring of electrical appliances in residential environments.

1.3 Scope of Project

This project focuses on designing and implementing a smart home control system capable of managing the electrical system from anywhere and at any time. The project's scopes include conducting a thorough literature review on switch and socket control systems and system monitoring using IoT. The home appliances involved in this project are standard lighting fixtures, including pendant lamps and compact fluorescent lamps. The IoT platform relies on the Blynk application for system control and data monitoring. To measure current, a Split Core Current Transformer (SCT-103) is employed, while a Voltage Sensor (ZMPT101B) is used for voltage measurement. The system requires the installation of software on the user's smartphone, which will then connect to the NodeMCU ESP32 microcontroller programmed for this project.

2. Methodology

The project employs an ESP32 microcontroller connected to the Blynk IoT platform for remote control and monitoring of switches for lamps and sockets. The Blynk app acts as the user interface, facilitating communication with the ESP32 over Wi-Fi. The code integrates the Blynk library for bidirectional communication and includes sections for handling switch functionality, allowing virtual switches in the app to control physical switches. Current monitoring is achieved using the SCT-013 current transformer and ZMPT101B voltage sensor. However, the system is dependent on continuous Wi-Fi connectivity, posing a challenge if the connection is lost. Future recommendations include implementing an offline mode and enhancing local processing capabilities for improved system resilience.

2.1 Flowchart of the system

Figure 1 depicts the smart control for switch and socket system flowchart. This flowchart represents the flow of the smart control system for switches and sockets. It starts with powering on the NodeMCU ESP32 and connecting it to Wi-Fi. It then establishes a connection with the Blynk app for Internet access. The system reads current and voltage measurements from the sensors (SCT-103 and ZMPT101B). It receives commands from the Blynk app and analyzes the data to determine the action required. The system controls the relay (acting as the main switch) based on the command signal received. The Blynk app is updated with the latest status and readings. The system continually checks for user input and processes it accordingly. The loop repeats until the system is powered off.

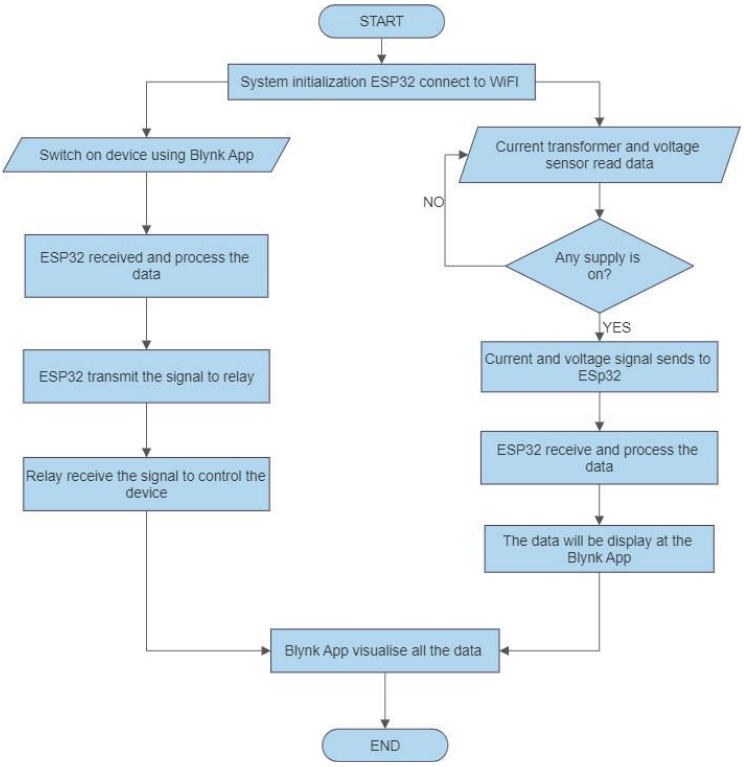

Fig. 1 *Flowchart of the system*

2.2 Block diagram

Figure 2 shows the block diagram of the project, delineates the system's architecture into four key sections: input, microcontroller as the central processing unit, output, and the IoT platform. The selected microcontroller, NodeMCU ESP8266, serves as the "brain" of the system, equipped with a Wi-Fi module for seamless communication with IoT applications like Blynk. Tasked with data analysis, the microcontroller processes inputs from the current transformer (SCT-013) sensor and the AC voltage sensor module (ZMPT101B) in the input section. These sensors, powered by a 9V adapter, transmit signals to the NodeMCU ESP32 upon detecting current flow from the Miniature Circuit Breaker (MCB). The output section utilizes displays to present voltage, current, and power usage. Simultaneously, the NodeMCU ESP32 communicates with the Blynk application, serving as the IoT platform, and transmits data over Wi-Fi. This arrangement enables remote control of the system through the Blynk application on a smartphone or via a website. The system employs a relay as the controller to manage switches and sockets, receiving signals from the NodeMCU ESP32 and facilitating remote control functionality through the IoT platform.

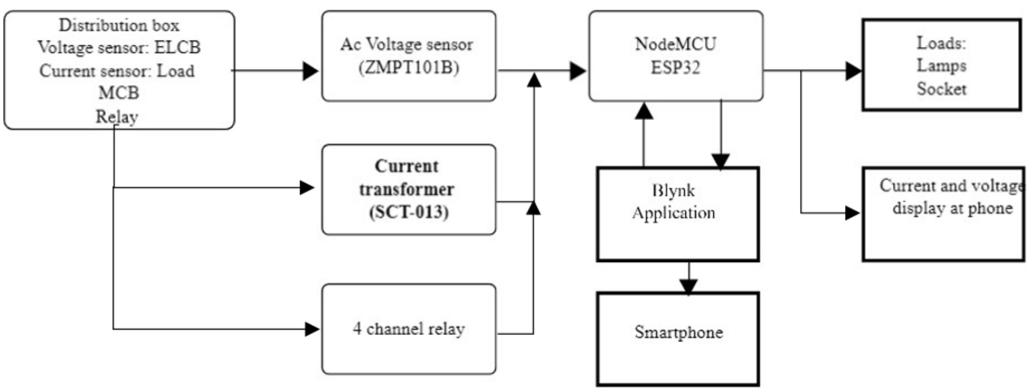

Fig. 2 *Block diagram of project*

2.3 Hardware design and circuit diagram

2.3.1 Circuit diagram of system

The finalized circuit diagram for this project incorporates essential components such as the ESP32, 4-channel relay, voltage sensor, distribution box, current sensor (SCT-013), and various loads. A crucial aspect of the project involves the extensive utilization of the Blynk software, a platform offering versatile tools for developers. This software not only facilitates real-time information on energy consumption but also allows seamless control of switches and sockets directly from smartphones. The circuit integrates the SCT-013 current transformer and the AC voltage sensor module ZMPT101B for data visualization. Notably, users can access labeled data widgets to view specific information, providing a detailed analysis of energy consumption. Additionally, the system enables users to monitor all active switches and sockets in real-time, enhancing overall control and awareness. Figure 3 shows the circuit diagram of the system

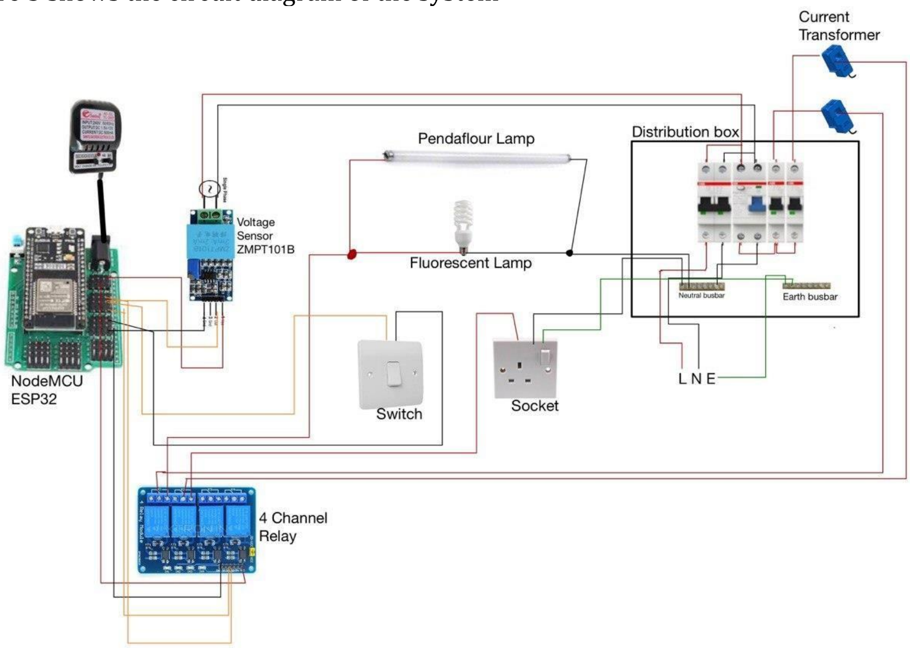

Fig. 3 *Circuit diagram of system*

2.3.2 Final design

Figure 4 illustrates the finalized hardware design, resembling typical house wiring with a distribution box (DB box). The system sources power from a standard 220V socket. A PVC box houses the entire ESP32 system wiring. Power for the ESP32 is supplied by a 5VDC adaptor, always ensuring a consistent and reliable power source for the ESP32.

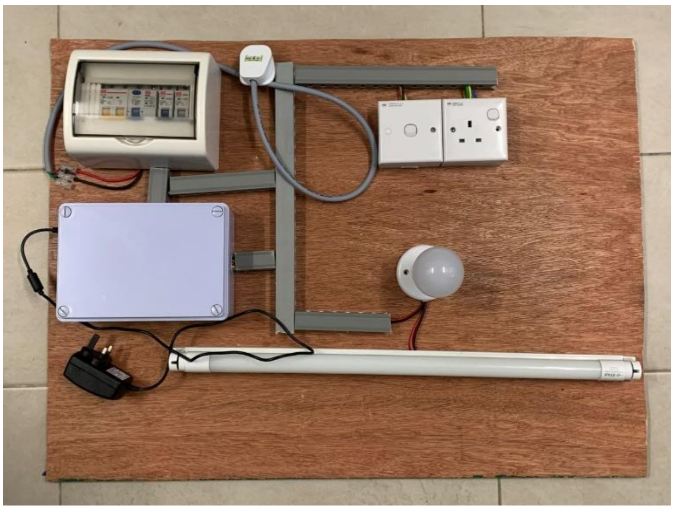

Fig. 4 *Final design of the hardware*

3. Results and discussion

The results were acquired following thorough testing of the system's functionality to ensure consistent measurements. In the realm of energy monitoring, the primary emphasis was on obtaining precise measurements of voltage and current, which subsequently allowed for the calculation of power values. The code was implemented to automate the calculation of total current and total power consumption. Prior to assessing the functionality of the control system for switches and sockets, a continuity test was conducted to verify the operational integrity of the system components.

3.1 Result for socket and lamp switch testing

Table 1 and table 2 show the results for socket and lamp switch testing. These tables summarize the state of the socket and lamp based on the combination of physical and virtual switch positions, considering the 'OR' gate logic that allows either switch to control the respective device.

Table 1 *Result for socket switch testing*

Physical switch	Virtual Switch	Socket state
OFF	OFF	OFF
OFF	ON	ON
ON	OFF	ON
ON	ON	ON

Table 2 *Result for lamp switch testing*

Physical switch	Virtual Switch	Lamp state
OFF	OFF	OFF
OFF	ON	ON
ON	OFF	ON
ON	ON	ON

3.2 Energy monitoring result

Table 3 shows the energy consumption when both loads are activated. The recorded values for voltage, current, and power are sourced directly from the Blynk app display, ensuring accurate and real-time measurements. This data offers a detailed insight into the energy dynamics when both loads are concurrently activated, providing essential information for assessing and optimizing the system's performance and efficiency. Figure 5 also illustrates the correlation between Total Current (measured in Amperes) and Power Consumption (measured in Watts) in the project context. Each data point on the graph signifies distinct scenarios reflecting different states of the lamp and socket. The first data point (0.062 A, 15.14 W) suggests a relatively lower power draw, potentially indicating minimal electrical load. As the total current increases to 0.128 A (Data Point 2), the power consumption rises to 31.43 Watts, possibly due to additional electrical loads being activated. Further escalation is evident in Data Point 3 (0.187 A, 45.88 W), suggesting higher-powered devices or multiple appliances in operation. This visual representation facilitates an understanding of how alterations in total current correspond to fluctuations in power consumption, offering insights for optimizing energy usage and managing electrical appliances effectively.

Table 3 *Energy monitoring data*

Socket state	Lamp state	Voltage(V)	Total current(A)	Power(W)
ON	OFF	244.23	0.062	15.14
OFF	ON	245.51	0.128	31.43

ON	ON	245.33	0.187	45.88

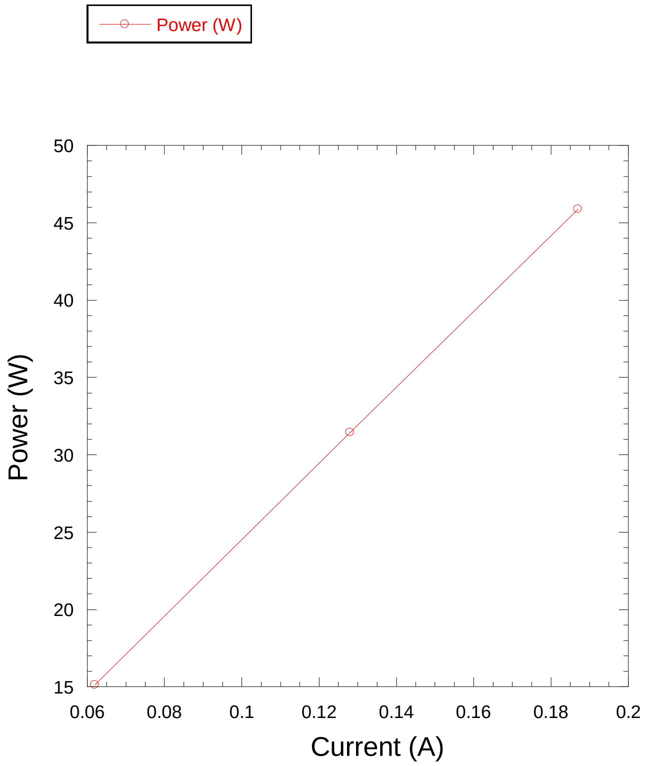

Fig. 5 *Graph current versus power*

4. Conclusion and recomendation

In conclusion, he PSM 1 report extensively outlines the design and execution of a home automation system employing Arduino ESP32, the Blynk app, and diverse sensors to deliver a user-friendly solution for the effective management of residential switches and sockets. The system facilitates remote control and real-time monitoring through IoT technology, providing insights into energy usage trends via sensors like SCT-013 and ZMPT101B. The integration of a 4-channel relay module enhances convenience, and safety measures, including an MCB, contribute to a secure environment. Despite notable successes, the system's dependence on continuous Wi-Fi connectivity poses a substantial challenge. Recommendations made for PSM 2 encompass implementing offline functionality, enhancing local processing capabilities, and integrating an automatic reconnection mechanism to ensure uninterrupted operation during Wi-Fi disruptions. The proposed inclusion of a user notification system within the Blynk app and an offline data logging mechanism on the ESP32 aims to enhance resilience and user-friendliness. Overall, the project aligns successfully with its objectives, delivering efficient and sustainable home management, with ongoing development already completed in PSM 2.

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6. Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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