



IoT-Based Smart Electricity Monitoring System with Real-Time Alerts and Remote Control

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ABSTRACT: The increasing demand for electricity and lack of real-time monitoring systems lead to energy wastage and higher electricity costs. Traditional energy meters only provide total consumption data and do not offer real-time insights. To overcome these limitations, this paper presents an IoT-based Smart Electricity Monitoring System. The system uses voltage and current sensors along with an ESP32 microcontroller to monitor electricity usage in real time. The collected data is processed and transmitted to a mobile application through Wi-Fi, enabling remote monitoring and control. The system also includes a relay module for load control and an alert mechanism for abnormal power consumption. The proposed system is cost-effective, reliable, and suitable for domestic and small-scale applications.

The proposed system focuses on providing accurate and continuous monitoring of electricity consumption using IoT technology. By integrating voltage and current sensors with the ESP32 microcontroller, the system ensures precise data acquisition and processing. The use of wireless communication enables seamless data transmission to cloud or mobile platforms, allowing users to access information anytime and anywhere.

Another key aspect of the system is its ability to enhance user awareness and promote efficient energy usage. The real-time data visualization helps users identify high power-consuming appliances and take necessary actions to reduce energy wastage. The inclusion of alert mechanisms ensures timely notifications in case of abnormal consumption, improving safety and reliability.

Furthermore, the system is designed to be scalable and adaptable for various applications. It can be extended to smart homes, commercial buildings, and industrial environments. The low-cost design and easy installation make it accessible to a wide range of users. Overall, the solution contributes to sustainable energy management and supports the growing demand for smart and efficient monitoring systems.

KEYWORDS: IoT, Smart Electricity Monitoring, ESP32, Energy Efficiency, Sensors, Wireless Communication.

I. INTRODUCTION

In recent years, the rapid growth of smart technologies and increasing energy demands have created a need for intelligent monitoring systems. Traditional methods of energy management are no longer sufficient to handle modern requirements, as they lack automation and real-time feedback. Smart systems based on IoT provide an efficient solution by enabling continuous monitoring, data analysis, and remote access, making energy management more effective and convenient.

The proposed system aims to bridge the gap between conventional electricity monitoring and advanced smart solutions. By providing real-time insights and control features, it helps users make informed decisions regarding their energy usage. This not only reduces electricity costs but also contributes to environmental sustainability by minimizing unnecessary power consumption. The system highlights the importance of adopting smart technologies for efficient and responsible energy management. Electricity plays a vital role in modern life, but its improper usage leads to wastage and increased costs. Most traditional electricity meters provide only cumulative readings, making it difficult for users to analyze real-time consumption. This lack of awareness results in inefficient energy usage.



With the advancement of Internet of Things (IoT) technology, smart monitoring systems have become more popular. IoT enables devices to communicate and share data over the internet, providing real-time monitoring and control capabilities. Smart electricity monitoring systems can help users track their energy usage and reduce wastage.

This paper proposes an IoT-based Smart Electricity Monitoring System that allows users to monitor electricity consumption in real time using sensors and a microcontroller. The system provides accurate data, remote access, and control features, making it suitable for modern energy management.

II. LITERATURE REVIEW

Recent studies have also focused on integrating cloud computing and mobile applications with IoT-based energy monitoring systems. These systems allow users to visualize energy consumption data through user-friendly dashboards and receive real-time alerts. Some approaches have incorporated machine learning techniques to predict energy usage patterns and optimize consumption. Despite these advancements, challenges such as data accuracy, system complexity, and high implementation cost still exist. Therefore, there is a need for a simple, cost-effective, and reliable solution, which is addressed in the proposed system.

Various research works have been carried out in the field of smart energy monitoring systems. Earlier systems mainly focused on manual meter reading, which was time-consuming and inefficient. Later, digital energy meters were introduced, but they still lacked real-time monitoring capabilities.

Recent advancements in IoT have enabled the development of smart electricity monitoring systems. Many researchers have used microcontrollers like Arduino and ESP-based modules to monitor power consumption. These systems provide real-time data and remote access through mobile applications.

However, some existing systems are expensive and complex to implement. There is a need for a cost-effective and simple solution that provides accurate monitoring and easy accessibility. The proposed system addresses these limitations by integrating low-cost components and efficient communication technology.

III. RESEARCH METHODOLOGY

Recent studies have also focused on integrating cloud computing and mobile applications with IoT-based energy monitoring systems. These systems allow users to visualize energy consumption data through user-friendly dashboards and receive real-time alerts. Some approaches have incorporated machine learning techniques to predict energy usage patterns and optimize consumption.

Despite these advancements, challenges such as data accuracy, system complexity, and high implementation cost still exist. Therefore, there is a need for a simple, cost-effective, and reliable solution, which is addressed in the proposed system.

The proposed system is designed using a combination of hardware and software components. The hardware setup includes voltage and current sensors, an ESP32 microcontroller, a relay module, and an LCD display. The sensors measure electrical parameters and send data to the microcontroller.

The ESP32 processes the sensor data and calculates power consumption. The processed data is displayed on the LCD and transmitted to a mobile application through Wi-Fi. The relay module is used to control the connected load based on user input or system conditions.

The system is tested under different conditions to evaluate its performance. Parameters such as accuracy, response time, and reliability are analyzed to ensure effective operation.

IV. RESULTS AND DISCUSSION

The developed system was tested using a load such as a bulb. The sensors accurately measured voltage and current, and the ESP32 successfully calculated power consumption. The results were displayed on the LCD and transmitted to the mobile application in real time.

The system showed stable performance and provided continuous monitoring without interruption. The relay module successfully controlled the load based on predefined conditions. The alert system notified users in case of abnormal power consumption.

The results indicate that the system is reliable and efficient for real-time electricity monitoring. It helps users understand their energy usage and take necessary actions to reduce wastage.

The system was further evaluated under different load conditions to observe its performance and consistency. It was found that the readings remained stable and accurate for varying power levels. The response time of the system was quick, and data updates were reflected in real time without noticeable delay. This confirms that the system is capable of handling continuous monitoring effectively.

Additionally, the user interface provided clear and understandable information about electricity usage, making it easy for users to interpret the data. The alert mechanism functioned properly by notifying users during abnormal consumption levels. Overall, the system demonstrated good efficiency, reliability, and usability, proving its effectiveness as a smart electricity monitoring solution.

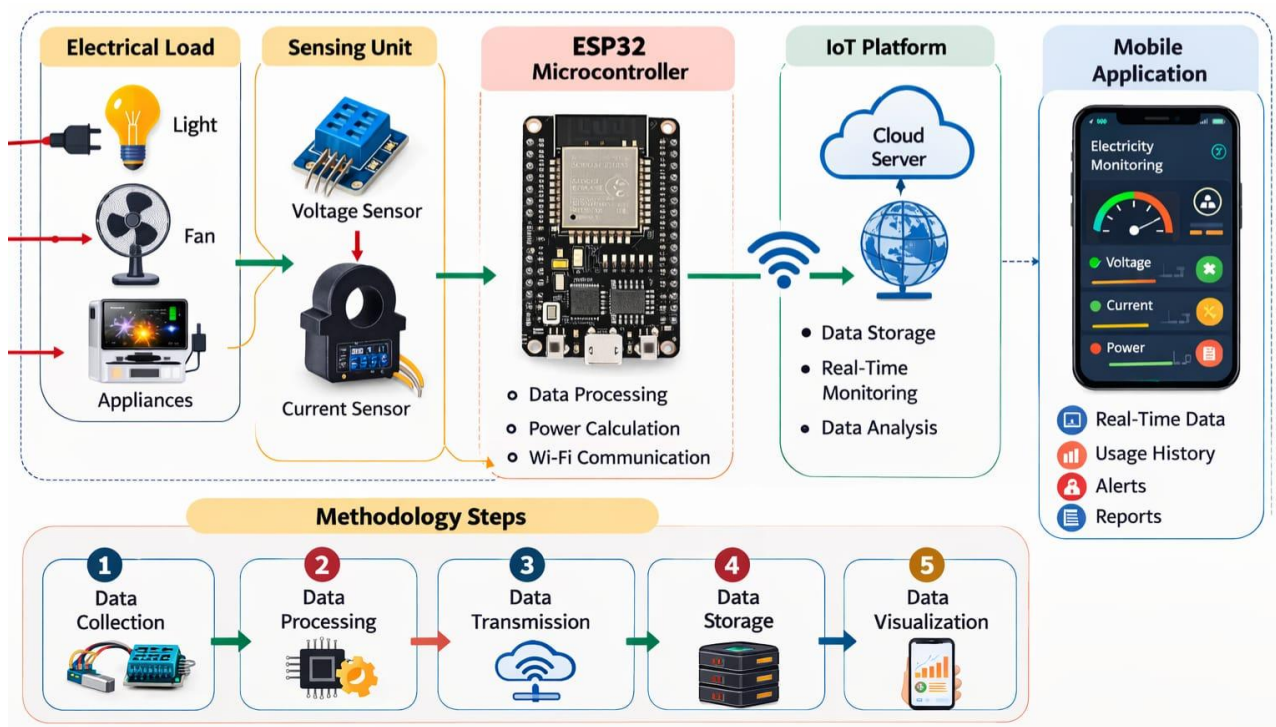


FIG: 1

V. CONCLUSION

The IoT-based Smart Electricity Monitoring System provides an effective solution for real-time monitoring and management of electricity consumption. By integrating sensors, microcontroller, and wireless communication, the system enables users to track and control energy usage efficiently.

The system is cost-effective, easy to implement, and suitable for both residential and small-scale applications. It helps in reducing electricity wastage and promotes energy efficiency. Overall, the proposed system contributes to smarter energy management and sustainable development.

The system demonstrates the effective use of IoT technology in addressing real-world energy management challenges. By providing real-time monitoring and control features, it empowers users to make informed decisions about their



electricity usage. The integration of sensing, processing, and communication modules ensures smooth operation and accurate data reporting.

Moreover, the project highlights the importance of adopting smart solutions for sustainable development. By reducing unnecessary power consumption, the system contributes to energy conservation and environmental protection. With further enhancements and scalability, the proposed system has the potential to be widely implemented in smart homes, industries, and smart city applications.

VI. FUTURE WORK

1. Integration with cloud platforms for advanced data storage and analysis.
2. Development of a dedicated mobile application with enhanced user interface.
3. Implementation of AI/ML algorithms for predicting energy consumption patterns.
4. Addition of multiple load monitoring for appliance-level analysis.
5. Integration with smart home automation systems.
6. Enhancement of system security to protect data from cyber threats.
7. Use of renewable energy sources like solar integration.
8. Expansion of the system for industrial and large-scale applications.
9. Implementation of voice control and automation features.
10. Improvement in sensor accuracy and system efficiency.

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