Smart Electricity Billing System With Automated Load Control

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***Abstract*—In today's world of smart technology and rising energy demands, efficient energy management is essential for both homes and industries. This project introduces a smart energy management system that combines IoT (Internet of Things) technology with real-time energy monitoring, automated load control, and convenient billing. The Internet of Things (IoT) refers to the network of interconnected devices that communicate and exchange data over the internet. By leveraging IoT technology, our system provides real-time energy monitoring and control. This system utilizes a microcontroller with Wi-Fi capabilities and an optocoupler-based analog circuit to measure and track energy usage. Through the Blynk mobile app, users can monitor their energy use and view up-to-date billing information on an LCD screen, as well as remotely via the app from anywhere, making it highly convenient. Another feature of the system is its automated load management. When energy consumption is higher than a set threshold, the system will automatically turn off low-priority devices. It can control two different loads via the Blynk app, making it easier to manage and reduce energy usage effectively through IoT. In addition, current consumption of individual load is displayed on LCD. This integration of energy metering with IoT technology enhances efficiency and provides real-time control over energy consumption. This not only helps in managing energy usage more effectively but also contributes to cost savings and supports more sustainable energy practices.**

***Index Terms*—Lcd Display,Current Sensoracs712,Energy Meter,Dual Channel Relay,Esp32 Weoom Board,Opto Coupler**

I. INTRODUCTION

In the modern era of digitalization and smart technology, efficient energy management has become an essential requirement for both residential and industrial sectors. Traditional electricity billing systems often suffer from drawbacks such as human error, delayed billing, and the inability to monitor energy consumption in real time. These limitations can lead to energy wastage and inefficient usage of electrical power.

To overcome these issues, the concept of a Smart Electricity Billing System integrated with IoT (Internet of Things) technology has been introduced. This system enables real-time monitoring of energy usage, automated billing, and remote control of electrical loads through a cloud-based platform. By using IoT-enabled devices, users can monitor their energy consumption and billing details instantly on their mobile phones using applications like Blynk.

Additionally, this project includes an automated load control feature that helps in reducing energy consumption. When the power usage exceeds a predefined limit, the system automatically disconnects low-priority loads to prevent overconsumption. The integration of sensors such as ACS712 current sensor and microcontrollers like NodeMCU (ESP8266) ensures accurate data collection and efficient system performance.

This smart approach not only improves the accuracy and transparency of billing but also encourages users to adopt energy-saving habits. Hence, the Smart Electricity Billing System with Automated Load Control provides a sustainable and efficient solution for modern power management.

II. LITERATURE REVIEW

A. Maintaining the Integrity of the Specifications

"A Smart Home Energy Management System Utilizing Neurocomputing-Based Time-Series Load Modeling and Forecasting Facilitated by Energy Decomposition for Smart Home Automation" by Yu-Hsiu Lin, Huei-Sheng Tang, Ting-Yu Shen, and Chih-Hsien Hsia proposes an AIbased home energy system that overcomes the high cost and complexity of traditional sensor-based automation through non-intrusive load monitoring and neural forecasting.

"Time Synchronized Power Meters for Advanced Smart
Distribution of Energy in Smart Grids" by Rosario Morello, Gaetano Fulco, Subhas Mukhopadhyay, Laura Fabbiano, and Claudio De Capua resolves time synchronization issues in distributed smart meters by introducing the Precision Time Protocol (PTP) for accurate, low-cost, and reliable grid monitoring.

"A Secure and Resilient Smart Energy Meter" by Hussam A. Hseiki, Ahmad M. El-Hajj, Youssef O. Ajra, Fathelalem A. Hija, and Ali M. Haidar addresses past cybersecurity weaknesses in smart grids by designing a LoRaWAN-based smart meter with multi-layer protection against data theft and cyberattacks.

"Smart Meters for Smart Energy: A Review of
Business Intelligence Applications" by Muhammad Haseeb
Raza, Yousaf Murtaza Rind, Isma Javed, Muhammad Zubair, Muhammad Qasim Mehmood, and Yehia Massoud reviews how smart meters have evolved to support Business Intelligence and AI for data-driven energy optimization, solving earlier issues of inefficient monitoring and lack of analytics.

An Ensemble Detection Model Using Multinomial Classification of Stochastic Gas Smart Meter Data to Improve Wellbeing Monitoring in Smart Cities" by William Hurst et al. (2020) proposed a machine learning model using gas smart meter data to detect energy usage patterns and address fuel poverty problems, improving wellbeing monitoring in smart cities.

"Design, Deployment and Performance Evaluation of an IoT-Based Smart Energy Management System for Demand Side Management in Smart Grid" by M. Usman Saleem et al. (2022) focused on an IoT-based energy management system to optimize power usage. It solved issues of inefficiency and lack of automation in traditional grids by enabling real-time monitoring and control.

"LoRa IoT-Based Architecture for Advanced Metering Infrastructure in Residential Smart Grid" by Jose Luis´ Gallardo et al. (2021) presented a LoRa-based communication model for smart grids, overcoming earlier limitations of high cost and short communication range, achieving efficient and reliable data transfer.

"A Concealed-Based Approach for Secure Transmission in Advanced Metering Infrastructure" by Otisitswe Kebotogetse et al. (2022) developed a lightweight concealedbased security method to reduce energy consumption and computational load while enhancing data security during smart meter communication.

"A Unified Metering System Deployed for Water and Energy Monitoring in Smart City" by N. Sushma, H. N. Suresh, J. Mohana Lakshmi, Parvathaneni Naga Srinivasu, Akash Kumar Bhoi, and Paolo Barsocchi (2023) in proposed an integrated wireless metering system using LoRa technology to overcome issues of manual data collection and provide realtime energy and water monitoring.

"Detection for Non-Technical Loss by Smart Energy Theft With Intermediate Monitor Meter in Smart Grid" by Jin Young Kim, Yu Min Hwang, Young Ghyu Sun, Isaac Sim, Dong In Kim, and Xianbin Wang (2019) addressed the problem of energy theft and proposed an intermediate monitoring meter model achieving 95

"Design, Implementation, and Deployment of an IoTBased Smart Energy Management System" by M. Usman Saleem, M. Rehan Usman, and Mustafa Shakir (2021) developed an IoT-based energy management solution to handle excessive energy consumption and enable two-way communication between user and utility.

"Remote Malfunctional Smart Meter Detection in Edge Computing Environment" by Fangxing Liu, Chengbin Liang, and Qing He (2020) designed a data-driven model using decision tree and recursive algorithms to remotely detect faulty smart meters efficiently.

III. OBJECTIVE OF WORK

In the modern era of digitalization and smart technology, efficient energy management has become an essential requirement for both residential and industrial sectors. Traditional electricity billing systems often suffer from drawbacks such as human error, delayed billing, and the inability to monitor energy consumption in real time. These limitations can lead to energy wastage and inefficient usage of electrical power.

To overcome these issues, the concept of a Smart Electricity Billing System integrated with IoT (Internet of Things) technology has been introduced.

This system enables real-time monitoring of energy usage, automated billing, and remote control of electrical loads through a cloud-based platform. By using IoT-enabled devices, users can monitor their energy consumption and billing details instantly on their mobile phones using applications like Blynk.
Additionally, this project includes an automated load control feature that helps in reducing energy consumption. When the power usage exceeds a predefined limit, the system automatically disconnects low-priority loads to prevent overconsumption. The integration of sensors such as ACS712 current sensor and microcontrollers like NodeMCU (ESP8266) ensures accurate data collection and efficient system performance.
This smart approach not only improves the accuracy and transparency of billing but also encourages users to adopt energy-saving habits. Hence, the Smart Electricity Billing System with Automated Load Control provides a sustainable and efficient solution for modern power management. The primary objective of this project is to design and develop a Smart Electricity Billing System with Automated Load Control that ensures accurate energy monitoring, efficient load management, and transparent billing using IoT technology. The system is intended to overcome the limitations of traditional manual billing methods, which are often time-consuming, inaccurate, and lack real-time monitoring capabilities.
This project aims to create an intelligent energy monitoring platform that continuously measures the amount of electrical energy consumed and instantly displays the billing details on an LCD screen as well as on a mobile application through cloud connectivity. By utilizing a NodeMCU (ESP8266) microcontroller integrated with current sensors and Wi-Fi, the system provides real-time data communication between the energy meter and the user interface.
Another key objective is to implement automated load control, which automatically disconnects low-priority electrical devices when the total consumption exceeds a predefined threshold value. This function helps in reducing excessive energy usage and prevents circuit overload, ensuring optimal power utilization.
The system also aims to provide users with the convenience of remote monitoring and control through the Blynk IoT app, enabling them to access consumption details and control household or industrial appliances from anywhere using an internet connection.
Furthermore, the project seeks to minimize human intervention in electricity billing, thereby reducing human errors and operational delays. By offering accurate, automated, and easily accessible data, this system encourages users to adopt energysaving practices and promotes sustainable energy management.
Ultimately, the objective of this work is to contribute toward the development of a smart, reliable, and user-friendly energy management system that supports both economic and environmental efficiency.

IV. METHODOLOGY

The system aims to achieve efficient energy management for homes and industries by combining IoT technology with real-time energy monitoring, automated load control, and convenient billing. By leveraging IoT, the system provides real-time energy monitoring and control. Specifically, a microcontroller with Wi-Fi capabilities and an optocoupler-based analog circuit are utilized to measure and track energy usage. Users can monitor their energy use and view up-to-date billing information on an LCD screen as well as remotely via the Blynk mobile app from anywhere, making it highly convenient. The system features automated load management, which works by automatically turning off low-priority devices when energy consumption rises above a set threshold. It can also control two different loads via the Blynk app, simplifying energy management and reduction. Furthermore, the current consumption of each individual load is displayed on the LCD. This holistic approach enhances efficiency, helps manage energy usage more effectively, contributes to cost savings, and supports more sustainable energy practices.

A. Circuit Diagram

The Smart Electricity Billing System with Automated Load Control circuit operates by using a 230V AC main power supply connected to an energy meter that measures the total energy consumption, and this energy meter is interfaced with an optocoupler circuit that safely isolates the high-voltage section from the control section while converting the energy pulses into digital signals readable by the microcontroller; simultaneously, ACS712 current sensors are employed to detect the realtime current flowing through each connected load, and all these signals are processed by a Wi-Fi-enabled microcontroller such as NodeMCU or ESP8266, which calculates parameters like voltage, current, power, and total energy consumed, displays these values on an LCD screen for local monitoring, and transmits the same data to a cloud server via the Internet for remote access through the Blynk mobile application, enabling users to view their energy usage, billing information, and control their electrical appliances from anywhere, while the system's relays connected to two separate loads allow for automated load management, where the microcontroller intelligently turns off low-priority devices whenever the total power consumption exceeds a predefined threshold, thereby promoting efficient energy usage, reducing wastage, ensuring user convenience, and supporting the development of smart and sustainable energy management systems.

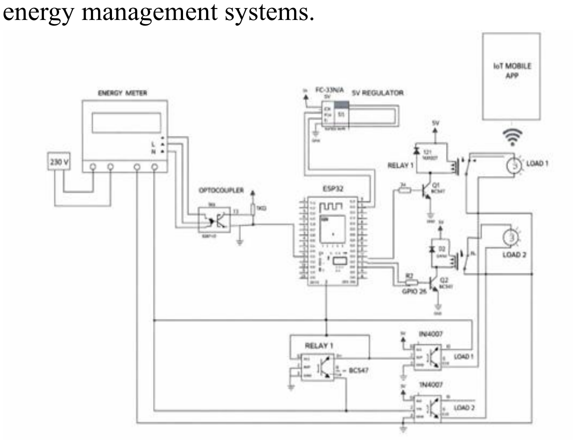

Fig. 1. Cicuit Diagram

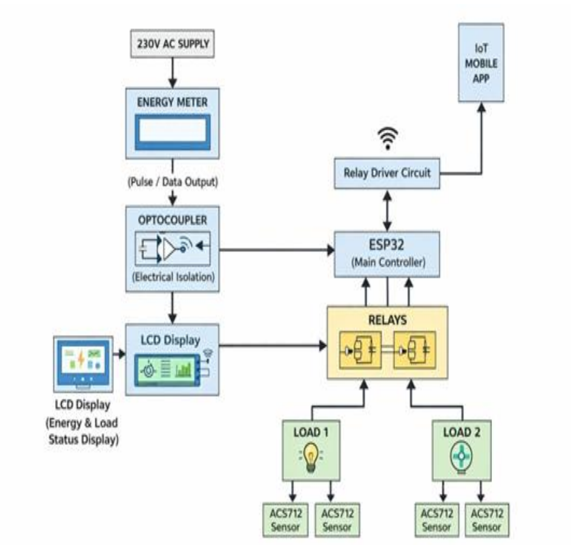

Fig. 2. Block Diagram

B. Control Part

The system's automated load management is a key control feature. When the energy consumption is higher than a set threshold, the system will automatically turn off low-priority devices. The core of the control is the Microcontroller with Wi-Fi, which sends control signals to Relay 1 and Relay 2 to manage Load 1 and Load 2. Users can also control these two loads via the Blynk mobile app, which makes it easier to manage and reduce energy usage effectively through IoT.

C. Power Circuit Part

The control parts of the Smart Electricity Billing System include the microcontroller (NodeMCU/ESP8266), which acts as the central control unit that receives input signals from the optocoupler circuit and ACS712 current sensors, processes this data to calculate energy usage, and decides when to activate or deactivate connected loads through the relay modules; the optocoupler circuit serves as a control interface that safely transmits pulses from the energy meter to the microcontroller by providing electrical isolation; the ACS712 current sensors continuously monitor the load current and send analog signals to the controller for accurate measurement; the relay drivers act as electronic switches controlled by the microcontroller to turn electrical appliances ON or OFF automatically based on load conditions or commands from the user via the Blynk app; and finally, the Wi-Fi module within the microcontroller ensures communication with the cloud server, allowing remote monitoring and control of the entire system, making these components collectively responsible for the automation, decisionmaking, and IoT-based control functions of the project.

V. ACKNOWLEDGMENT

We would like to express our sincere gratitude to our project guide, SK Rajesh. Associate Professor, Department of Electrical and Electronics Engineering, for his valuable guidance, advice, and constant encouragement throughout the course of this work. His support and insightful suggestions have been instrumental in the successful completion of this project. We are also grateful to all the faculty members of the Department of Electrical and Electronics Engineering for their continuous support and cooperation. We extend our heartfelt thanks to our friends and classmates for their help, motivation, and encouragement during the development of this project. We also wish to express our gratitude to Dr. Mary P. Vargh- ese, Head of the Department of Electrical and Electronics Engineering, and to our Principal, Dr. Sunitha C., for their support and encouragement. Finally, we express our deepest gratitude to God Almighty for His abundant blessings, guidance, and strength, without which this work would not have been possible.

VI. CONCLUSION

The Smart Electricity Billing System with Automated Load Control successfully integrates IoT technology to deliver an efficient and user-friendly solution for modern energy management. By leveraging a microcontroller with Wi-Fi capabilities and an optocoupler-based analog circuit, the system provides real-time energy monitoring and control. A key achievement of this project is the seamless user experience offered through the Blynk mobile app. Users can monitor their energy consumption and view up-to-date billing information both on an LCD screen and remotely via the app, making energy tracking highly convenient. The integration of energy metering with IoT technology significantly enhances efficiency and allows for real-time control over energy consumption. Furthermore, the system features automated load management, which is crucial for reducing waste and achieving energy efficiency. When the energy consumption exceeds a pre-set threshold, the system automatically shuts off low-priority devices. Users can also manage and reduce energy usage effectively by controlling the two different loads via the Blynk app, with the current consumption of individual loads displayed on the LCD.

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