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A Review on IoT Based Power Meter Billing and Load Control Using GSM

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***Abstract:** The rapid growth in electricity consumption has created a strong need for efficient monitoring and management of energy usage. Conventional electricity meters depend on manual readings and do not provide real-time information about power consumption, which can lead to billing delays and inefficient energy management. To overcome these limitations, this research proposes an Internet of Things (IoT) based smart power meter that enables automated billing and remote load control through GSM communication technology. The proposed system incorporates voltage and current sensors to continuously monitor electrical parameters from the supply line. A microcontroller processes the sensed data to calculate energy consumption and manage system operations. The calculated energy usage is transmitted to the user through a GSM module in the form of SMS notifications, enabling remote monitoring of electricity consumption. In addition, the system includes a relay-based load control mechanism that automatically disconnects the electrical load when the power consumption exceeds a predefined threshold.*

The developed system improves transparency in electricity usage, reduces the need for manual meter reading, and enhances energy management efficiency. The implementation results demonstrate that the proposed system provides reliable monitoring and communication capabilities, making it suitable for modern smart energy management applications and future smart grid infrastructures.

***Keywords:** Internet of Things (IoT), Smart Energy Meter, GSM Communication, Energy Monitoring, Load Control, Automated Billing.*

I. INTRODUCTION

Efficient energy management has become increasingly important due to the rapid rise in electricity demand across residential, commercial, and industrial sectors. Traditional electricity metering systems rely on manual data collection, where utility personnel record readings on-site. This method is time-consuming, prone to human error, and often results in delays in billing and inefficient monitoring of energy usage.

With advancements in communication technologies, smart metering systems have emerged to automate energy monitoring and billing. The integration of IoT enables devices and sensors to communicate over networks, allowing real-time tracking of electricity consumption. This improves transparency and helps both consumers and utility providers manage energy usage more effectively.

GSM technology plays a key role in remote monitoring by providing reliable wireless communication over long distances. By integrating GSM modules with smart meters, electricity data can be transmitted automatically without physical inspection. Additionally, incorporating load control using relay systems allows electrical loads to be managed remotely, helping prevent excessive consumption and improving power distribution efficiency.

The proposed system focuses on an IoT-enabled power meter with automated billing and remote load control using GSM. It continuously monitors electrical parameters, calculates energy usage, and transmits data through GSM networks. This approach reduces human intervention and contributes to the development of smart energy systems with improved efficiency and reliability.

II. OBJECTIVES

The primary objectives of the proposed system are:

1) To design a smart electricity monitoring system capable of measuring real-time power consumption.
2) To implement automated meter reading using GSM communication technology.
3) To reduce the need for manual electricity meter inspection and improve billing efficiency.
4) To develop a remote load control mechanism that can manage electrical loads during excessive consumption.
5) To enable consumers to track their electricity usage through periodic notifications.

III. LITERATURE SURVEY

In recent years, the development of intelligent energy monitoring systems has received significant attention due to the increasing demand for efficient electricity management. Researchers have proposed various smart metering techniques that utilize wireless communication technologies and embedded systems to automate the process of energy monitoring and billing.

Kabalci (2016) presented a comprehensive overview of smart grid technologies and highlighted the importance of advanced metering infrastructure in improving energy distribution and monitoring systems. The study emphasized that smart meters enable two-way communication between the utility provider and consumers, which allows better energy management and demand response.

Depuru, Wang, and Devabhaktuni (2011) discussed the evolution of smart meters and advanced metering infrastructure (AMI). Their research explained how automated meter reading systems help reduce operational costs, improve billing accuracy, and provide real-time energy consumption data. The authors also highlighted the role of communication technologies in enabling remote monitoring and data transmission.

Another study conducted by Mahapatra et al. (2012) proposed a wireless energy meter system using GSM communication. The system was designed to transmit energy consumption data to the utility provider through SMS notifications. The research demonstrated that GSM-based communication provides a reliable solution for remote meter reading, especially in areas where internet connectivity is limited.

Jiang et al. (2014) explored the use of IoT-based smart energy management systems for monitoring household electricity usage. Their work focused on integrating sensors and communication networks to enable real-time energy monitoring through cloud-based platforms. The research highlighted that IoT technology can significantly improve transparency and efficiency in electricity management systems.

Therefore, the proposed IoT based power meter billing and load control system using GSM aims to combine automated meter reading, wireless communication, and load control features in a single integrated system. This approach can improve energy monitoring, reduce manual intervention, and enhance the overall efficiency of electricity distribution networks.

IV. PROPOSED SYSTEM

The proposed system presents a smart electricity monitoring and control solution by integrating IoT technology with GSM communication. It replaces traditional meters with an intelligent device capable of continuously monitoring energy usage and automatically transmitting data to users and utility providers. The system architecture includes sensing units, an embedded controller, a communication module, and a load control mechanism, all working together to ensure accurate monitoring and efficient energy management.

Voltage and current sensors at the input stage measure electrical parameters and send the data to the embedded controller, such as a microcontroller. The controller processes this data to calculate power and total energy consumption, and temporarily stores the readings. A GSM module is used for communication, enabling wireless transmission of electricity usage details through mobile networks. This allows automated meter reading without the need for physical inspection.

In addition to monitoring and billing, the system includes a relay-based load control unit that can regulate power supply. When consumption exceeds a set limit or a command is received, the controller can disconnect the load to prevent excessive usage. The system is also suitable for remote areas due to GSM availability. Overall, it provides a cost-effective and reliable solution for real-time monitoring, automated billing, and improved energy management.

V. SYSTEM ARCHITECTURE

The architecture of the proposed smart power monitoring system is designed to provide continuous measurement of electrical parameters, wireless data communication, and intelligent load regulation. The system integrates sensing devices, a control unit, a communication interface, and a switching mechanism to form a complete smart metering infrastructure. The architecture is divided into four major functional layers, namely the data sensing layer, processing layer, communication layer, and control layer. Each layer performs a specific task in the overall operation of the system.

A. Data Sensing Layer

The sensing layer is responsible for collecting electrical parameters from the power supply. In this system, current sensors and voltage sensors are connected to the electrical line to measure the energy consumed by connected appliances. These sensors continuously monitor the electrical signals and convert them into measurable values. The output from these sensors is forwarded to the processing unit for further analysis.

B. Processing Layer

The processing layer consists of an embedded microcontroller unit that acts as the brain of the system. The controller receives electrical data from the sensing layer and performs calculations to determine parameters such as power consumption and total energy usage. The controller also manages system operations including communication, data storage, and load control decisions.

The microcontroller periodically analyzes the energy consumption data and determines whether the usage exceeds predefined limits. If abnormal power usage is detected, the controller activates the load control mechanism.

C. Communication Layer

The communication layer is implemented using a GSM communication module. This module enables wireless communication between the smart energy meter and the user or electricity distribution authority. The module transmits electricity consumption data through SMS messages or mobile network communication.

This communication feature allows consumers to receive periodic updates about their electricity usage and enables utility providers to obtain accurate billing data remotely.

D. Load Control Layer

The load control layer includes a **relay-**based switching system that regulates the electrical load connected to the meter. The relay acts as an electronically controlled switch that can disconnect or reconnect the power supply depending on system conditions.

When the energy consumption exceeds the specified threshold or when the utility provider sends a control command, the relay can temporarily cut off the power supply to prevent overload conditions.

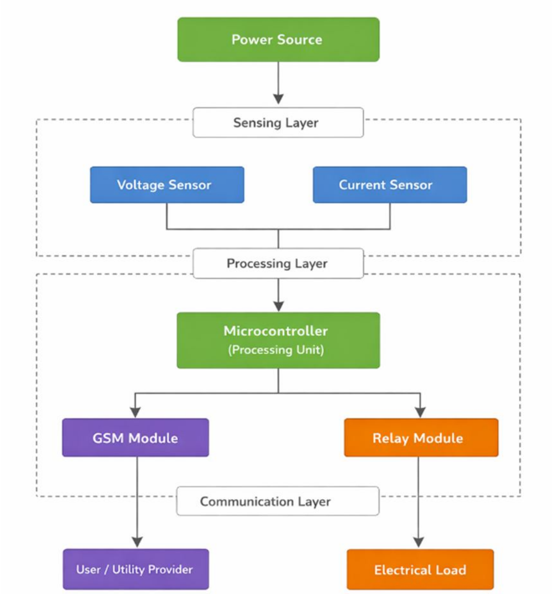

Fig. 1 Flowchart of IoT Based Power Meter Billing and Load Control System

VI. METHODOLOGY

The methodology of the proposed system focuses on implementing an intelligent energy monitoring and control mechanism that can measure electricity consumption, communicate the data to users through GSM networks, and regulate electrical loads when required. The workflow of the system is organized into several operational stages to ensure accurate monitoring and efficient power management.

1) System Initialization: All components such as the microcontroller, sensors, GSM module, and relay are powered and checked for proper operation and network availability.
2) Measurement of Electrical Parameters: Voltage and current sensors continuously monitor the electrical supply and send data to the microcontroller.
3) Energy Calculation: The microcontroller processes the sensor data to calculate power and total energy consumption.
4) Data Transmission: The calculated energy data is sent to users or utility providers via the GSM module through SMS.

5) Threshold Monitoring: The system compares energy usage with predefined limits to detect excessive consumption.
6) Load Control: If the limit is exceeded, the relay is activated to disconnect the load and prevent overuse.
7) Continuous Monitoring: The system repeats the process continuously to ensure real-time monitoring and efficient energy management.

VII. ADVANTAGES AND LIMITATIONS

several benefits in terms of automation, monitoring efficiency, and improved power management. However, certain practical challenges and limitations must also be considered while deploying such systems in real-world environments.

A. Advantages

1) Automated Monitoring: Tracks electricity usage continuously without manual effort.
2) Remote Access: Sends consumption data via GSM for easy remote monitoring.
3) Power Management: Controls load to prevent excessive energy usage.
4) Error Reduction: Minimizes human errors in meter reading and billing.
5) Consumer Awareness: Provides regular updates to encourage energy saving.
6) Scalability: Can be integrated into smart grid systems.
7) Faster Billing: Enables quick and efficient bill generation.

B. Limitations

1) Network Dependence: GSM performance relies on signal strength.
2) Higher Initial Cost: Sensors and modules increase installation expenses.
3) Maintenance Needs: Components may require periodic upkeep or replacement.

VIII. RESULTS AND DISCUSSION

The proposed IoT-based power monitoring and load control system was implemented and tested to evaluate its performance in energy measurement, communication efficiency, and load management. The system was experimented on different electrical loads, such as household appliances, to observe variations in consumption. Voltage and current sensors accurately measured electrical parameters, while the microcontroller processed the data to calculate power usage and transmitted the readings through the GSM module to the user. This confirmed the system’s capability for automated and remote energy monitoring without physical meter inspection.

The load control feature was tested by setting predefined energy consumption thresholds. When usage exceeded the limit, the microcontroller activated the relay to disconnect the load, demonstrating effective prevention of excessive consumption and efficient energy management. Additionally, the system showed fast response times, processing sensor data and transmitting updates nearly in real time. Continuous operation tests confirmed the stability and reliability of the hardware components.

Overall, the experimental results indicate that the system provides an effective solution for automated energy monitoring and billing. IoT integration with GSM communication ensures continuous data collection and transmission, enabling consumers and utility providers to monitor and manage energy usage more efficiently. While performance may slightly depend on network coverage and sensor calibration, the system offers improved transparency, reduced manual intervention, and practical potential for smart energy management applications.

IX. FUTURE SCOPE

Although the proposed system effectively demonstrates automated energy monitoring and remote load control, several enhancements can improve its efficiency, scalability, and functionality. Integrating cloud-based data storage and analytics would allow long-term tracking of electricity usage, enabling consumers and utility providers to analyze patterns and optimize energy management. Replacing the GSM module with advanced wireless technologies like NB-IoT, LoRaWAN, or 5G could improve transmission efficiency and network reliability. Additionally, developing mobile or web applications would provide users with real-time monitoring, alerts for excessive usage, and remote appliance control. Future developments may also include integration with renewable energy sources, allowing users to track both consumption and generation for better energy management. Machine learning algorithms could enable predictive analysis to forecast demand and suggest optimal usage strategies. Security and tamper detection measures, along with encrypted communication, would enhance system reliability and protection.

Finally, the system could be incorporated into smart city infrastructure, enabling multiple meters to communicate with centralized control systems for optimized power distribution. These improvements could transform the proposed IoT-based smart meter into a comprehensive intelligent energy management platform for modern smart grids.

X. CONCLUSION

The need for efficient power management has driven the development of intelligent energy monitoring systems. Traditional electricity meters rely on manual data collection, which can result in delays, inaccurate readings, and inefficient monitoring. To overcome these issues, the proposed system introduces an IoT-enabled smart power meter that integrates automated monitoring, GSM-based wireless communication, and relay-based load control. Voltage and current sensors measure electrical parameters, while a microcontroller processes the data to calculate energy consumption. The GSM module transmits usage information directly to consumers or utility providers, eliminating manual meter reading and improving billing accuracy and transparency.

A key feature of the system is the load control mechanism, which disconnects electrical loads when consumption exceeds predefined limits, preventing energy wastage and supporting efficient power management. Experimental results show that the system reliably monitors energy usage and transmits data in real time. By combining IoT technology with wireless communication, the system provides a practical solution for remote energy monitoring. Overall, it enhances efficiency, reduces human effort, and supports intelligent power distribution, with potential for further integration into future smart grid and smart city infrastructures.

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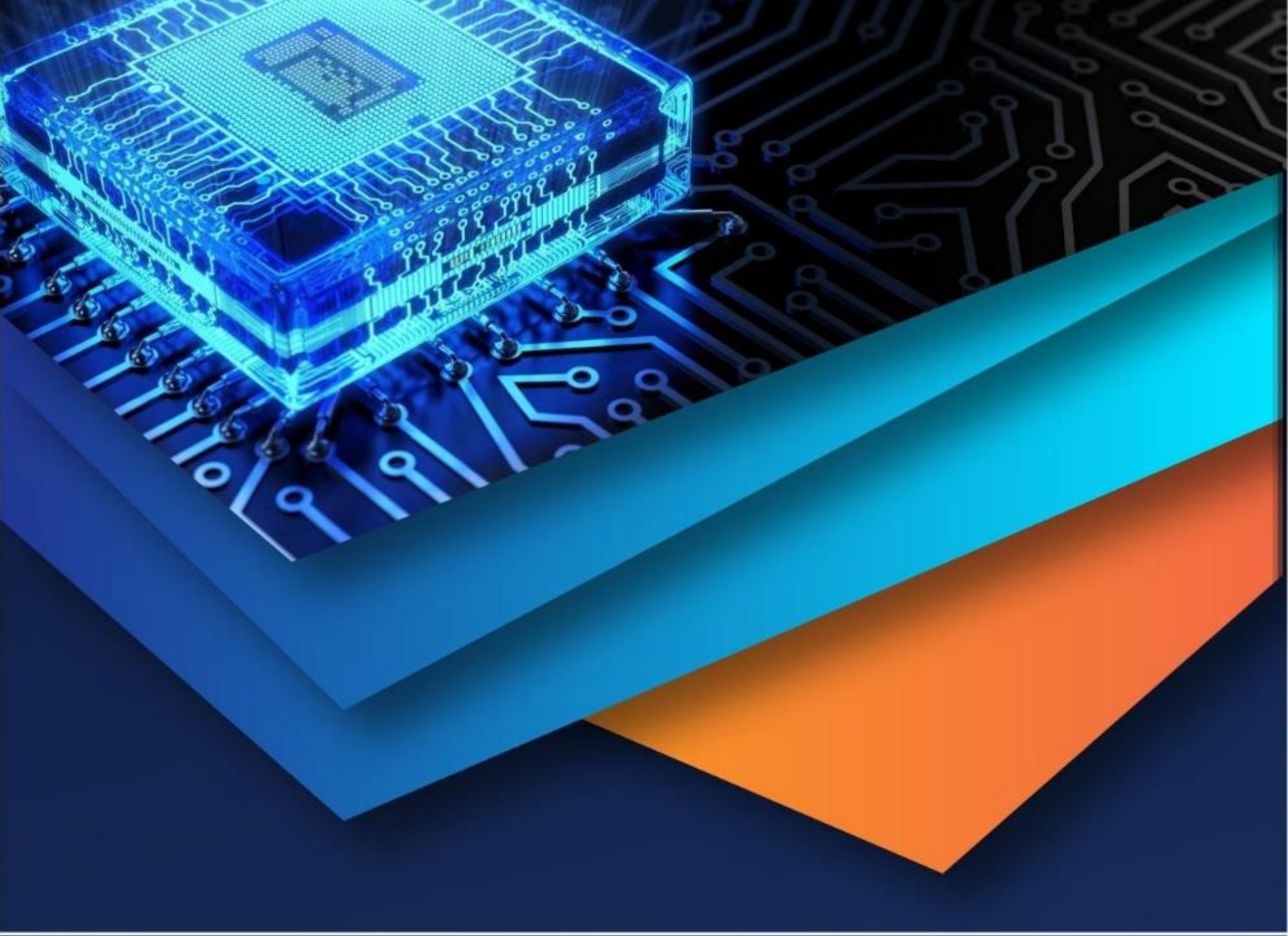

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