IOT Based Smart Energy Meter with Anti-Theft Detection System

Samruddhi V. Alone
Diploma
Dept. Of Electronics &Telecommunication Engineering
Dr. PDGP, Amravati

Shriya G. Rakhonde
Diploma
Dept. Of Electronics &Telecommunication Engineering
Dr. PDGP, Amravati

Unnati S. Mohale
Diploma
Dept. Electronics &Telecommunication Engineering
Dr. PDGP, Amravati

Sanchita G. Deshmukh
Diploma
Dept. Of Electronics &Telecommunication Engineering
Dr. PDGP, Amravati

Anjali P. Patil
H.O.D
Dept. Of Electronics &Telecommunication Engineering
Dr. PDGP, Amravati

---***---

Abstract - Electricity theft and inefficient energy monitoring are major challenges faced by power distribution companies worldwide. Conventional energy meters lack real-time monitoring capability and are unable to detect unauthorized power usage effectively. This paper presents the design and implementation of an IoT based Smart Energy Meter with an Anti-Theft Detection System using ESP32. The proposed system measures electrical parameters such as voltage, current, power, and energy consumption using appropriate sensing modules. The collected data is processed by the ESP32 microcontroller and transmitted to a cloud based platform via Wi-Fi for real-time monitoring and analysis. The anti-theft mechanism is implemented by comparing the input current from the main supply with the output current delivered to the load. If a significant mismatch beyond a predefined threshold is detected, the system identifies it as a theft condition and sends an alert notification to the utility provider. By integrating Internet of Things technology with intelligent monitoring and control, the proposed solution enhances transparency, improves billing accuracy, and reduces non-technical losses. The system is scalable, and suitable for residential as well as commercial applications. The proposed system provides an accurate, cost-effective, and reliable solution for smart energy management and electricity theft prevention. Therefore, the IoT-based smart energy meter provides. Therefore, the IoT-based smart energy meter provides a smart, efficient, and cost-effective solution for monitoring electricity usage and detecting unauthorized power consumption in modern smart grid environments.

Keywords :- Internet of Things (IoT), Smart Energy Meter, Electricity Theft Detection, ESP32 Microcontroller, Real-Time Monitoring, Energy Management, Cloud-Based Monitoring

1. INTRODUCTION

Electrical energy plays a vital role in residential, commercial, and industrial sectors, serving as the backbone of modern infrastructure and economic development. With the continuous growth in population, urbanization, and industrial activities, the demand for electricity has increased significantly. As a result, efficient monitoring and management of power consumption have become essential for maintaining grid stability and ensuring reliable power distribution. However, electricity theft and inaccurate billing remain major challenges for power distribution companies, leading to substantial revenue losses system ineffiencies.

Conventional energy meters require manual reading and periodic inspection, which are time-consuming and prone to human error. Moreover, these traditional meters lack real-time monitoring capabilities, making it difficult to detect unauthorized power usage or abnormal consumption patterns. Such limitations contribute to increased non-technical losses and reduce the overall efficiency of power management systems. The absence of automated monitoring also limits consumer awareness regarding energy usage.

The advancement of Internet of Things (IoT) technology has enabled the development of smart metering systems capable of real-time data monitoring, remote access, and automated reporting. IoT-based energy meters facilitate the transmission of consumption data to cloud platforms through wireless communication technologies, improving transparency, billing accuracy, and operational efficiency. Consumers and utility providers can access energy usage information instantly, supporting better decision-making and demand management.

2. RELATED WORK

The proposed system is an IoT-based smart energy meter integrated with anti-theft detection features. The system uses an ESP32 Wi-Fi module for wireless communication. Energy consumption data is transmitted to the Blynk mobile application for real-time monitoring. The study demonstrates improved transparency, accurate billing, and enhanced control over energy usage.[1]

An IoT-based smart energy meter system designed for real-time monitoring and remote data access. The system utilizes embedded controllers and wireless communication modules to transmit energy consumption data to a cloud server. A web-based dashboard is used for visualization and analysis of consumption patterns. The study emphasizes automated billing and improved transparency between consumers and utility providers. However, the theft detection mechanism is direct current comparison techniques.[2]

The proposed system is a smart energy metering system integrated with theft detection using current sensors and wireless communication technology. The system compares supply-side and load-side current values to identify discrepancies that may indicate unauthorized tapping. Upon detecting a mismatch beyond a predefined threshold, the system generates an alert notification to the concerned authority. The proposed model improves reliability and reduces non-technical losses but requires further enhancement in scalability and data security features.[3]

It proposed an IoT-based energy meter billing and monitoring system that enables real-time tracking of electricity consumption. The system integrates cloud-based monitoring and automated billing, reducing manual meter reading errors. This work laid the foundation for remote energy monitoring systems.[4]

The proposed system is an IoT-based smart energy meter system using the Arduino UNO and ESP8266 Wi Fi module for real-time energy monitoring and theft detection . The system reduces human involvement in meter reading by transmitting consumption data to the Blynk cloud platform, allowing consumers to access their usage information remotely. The system compares supply-side and load-side current measurements. If the absolute difference exceeds a predefined threshold value, the system identifies it as unauthorized power usage and generates an alert notification. The system compares supply-side and load-side current measurements. If the absolute difference exceeds a predefined threshold value, the system identifies it as unauthorized power usage and generates an alert notification. However, the system primarily focuses on basic current comparison and cloud monitoring. [5]

3. PROPOSED FRAMEWORK

The proposed framework presents an Internet of Things (IoT) based smart energy meter designed to monitor electricity consumption and detect possible electricity theft efficiently. The system is developed to improve the traditional energy metering process by enabling real-time monitoring, remote data access, and intelligent detection of abnormal energy usage. The central component of the system is the ESP32 microcontroller, which is responsible for processing the sensor data and transmitting it to the IoT platform using its built-in Wi-Fi capability.

In the proposed system, a current sensor is used to measure the current flowing through the electrical load. The sensor continuously monitors the current and sends the measured values to the ESP32 microcontroller. The microcontroller processes the received data and calculates the energy consumption. The collected information is then transmitted to a cloud-based or IoT monitoring platform, allowing users or electricity providers to access the energy consumption data remotely.

The system also incorporates an anti-theft detection mechanism based on a predefined threshold value of current. A specific threshold is set in the system to represent the normal operating current range. If the measured current exceeds this threshold in an abnormal condition, the system identifies it as a possible electricity theft scenario, such as bypassing the energy meter or unauthorized power usage. This abnormal condition can trigger alerts or notifications to the monitoring system.

By integrating IoT technology with smart energy monitoring, the proposed framework enhances transparency in electricity consumption, reduces manual meter reading, and provides an effective approach for detecting and preventing electricity theft in modern power distribution systems.
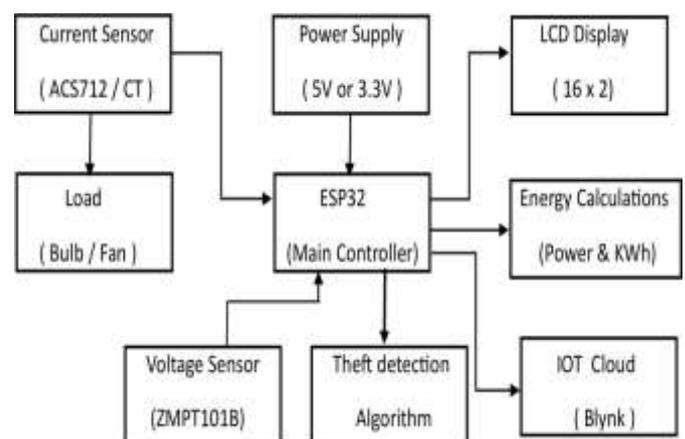

Figure 1: Block Diagram Of IoT Based Smart Energy Meter With Anti-Theft Detection System

4. FUTURE SCOPE

The proposed IoT-based Smart Energy Meter with Anti-Theft Detection system can be further enhanced by integrating advanced technologies such as Artificial Intelligence (AI) and Machine Learning (ML). In the current system, electricity theft detection is based on a predefined threshold value of current. In future implementations, ML algorithms can analyze historical energy consumption data to identify abnormal usage patterns more accurately. This will help in improving the efficiency of theft detection and reducing false alarms. AI-based predictive analysis can also be used to estimate future energy consumption trends and detect suspicious activities in advance.

Another possible enhancement is the integration of a prepaid billing system, where consumers can recharge their electricity balance through digital payment platforms. The system can automatically deduct the balance based on real-time energy consumption and provide alerts when the balance becomes low. Additionally, a mobile application can be developed to provide real-time monitoring, usage reports, and instant theft notifications, making the system more efficient and user-friendly.

5. CONCLUSION

This paper presented the design and implementation of an IoT-based Smart Energy Meter with an Anti Theft Detection System using the ESP32 microcontroller. The proposed system enables real-time monitoring of electrical parameters such as voltage, current, power, and energy consumption through a cloud-based platform. By integrating wireless communication technology, the system eliminates the need for manual meter reading and improves billing transparency. The theft detection mechanism is implemented using a dual current sensing approach, where the supply side and load-side currents are continuously compared. If the predefined threshold value exceeds, the system identifies it as unauthorized power usage and generates an alert notification. Additionally, a relay module can disconnect the power supply in case of confirmed theft or abnormal conditions. This enhances system reliability and reduces non-technical losses. The proposed solution is cost-effective, scalable, and suitable for residential as well as commercial applications. By combining IoT technology with intelligent monitoring and automated control, the system improves energy management efficiency and supports the development of smart grid infrastructure. Future enhancements may include advanced data analytics, improved cybersecurity mechanisms, and integration with renewable energy sources for smarter and more sustainable power management.

6. REFERENCES

[1] S. Nashte, V. Nalawade, J. Lavate, K. Dhekale, R. Vyavahare, S. Pawar, and A. Pandey, "IoT Based Smart Energy Meter with Anti-theft Detection," Journal of Emerging Technologies and Innovative Research (JETIR), vol. 12, no. 5, May 2025, ISSN: 2349-5162, Paper ID: JETIR2505125.

[2] Authors, "IoT-Based Smart Energy Meter for Real-Time Monitoring," International Journal of Research Publication and Reviews (IJRPR), Paper ID: IJRPR40910.

[3] Authors, "IoT Based Smart Energy Meter With Theft Detection," Journal Article.

[4] Authors, "Secure IoT Communication Framework for Smart Grid Applications," Cluster Computing, Springer, 2023. DOI: s13677-023-00525-4.

[5] Shinde, S., Yadav, Y., Zapake, P., and Sontakke, B., "IoT Based Smart Energy Meter Monitoring, Theft Detection. Literature Survey