IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

VOLUME : 9 ISSUE : 12 Print / Issue Publication Date: 29-May-2025

ISSN : 2455-2143

DOI : 10.33564/IJEAST.2025.v09i12.007

Indexed In

WWW.IJEAST.COM

editor@ijeast.com

International Journal of Engineering Applied Sciences and Technology, 2025
Vol. 9, Issue 12, ISSN No. 2455-2143, Pages 67-70
Published Online April 2025 in IJEAST (http://www.ijeast.com)

IOT BASED SMART ENERGY PREPAID METER

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Abstract— **The Smart Prepaid Energy Meter with individual load measurement is designed to automate the energy billing process and provide real-time analysis of energy consumption. The system allows users to prepay for electricity and monitors the usage of individual appliances through load measurement. The integration of IoT technology ensures continuous monitoring and provides consumers with the ability to analyze their consumption patterns. This project helps in reducing human errors in meter reading, enhances energy conservation, and prevents electricity theft.**

Keyword sot: **Internet of Things, GSM: Global System for Mobile Communications, ESP32: A microcontroller with integrated Wi-Fi and Bluetooth, LCD: Liquid Crystal Display, kWh: Kilowatt-hour, BMS: Billing Management System, API: Application Programming Interface, AC: Alternating Current DC: Direct Current**

I. INTRODUCTION

The rapid advancement of technology has significantly transformed various sectors, and the energy sector is no exception. With the increasing demand for energy and the need for efficient management of resources, traditional metering systems are becoming inadequate. The integration of the Internet of Things (IoT) into energy metering has emerged as a promising solution to address these challenges. IoT-based smart energy prepaid meters represent a revolutionary approach to energy consumption monitoring, billing, and management. Smart energy prepaid meters leverage IoT technology to provide real-time data on energy usage, enabling consumers to monitor their consumption patterns and manage their energy budgets effectively. Unlike conventional meters, which often require manual readings and can lead to billing discrepancies, smart meters automate the metering process, ensuring accuracy and transparency. This automation not only enhances user experience but also reduces operational costs for utility providers. Moreover, the prepaid model empowers consumers by allowing them to pay for energy in advance, thereby promoting responsible energy usage and reducing the risk of unpaid bills. This system is particularly beneficial in regions with high rates of energy theft, as it incorporates advanced security features that can detect irregularities in consumption patterns and alert providers to potential fraud. The implementation of IoT-based smart energy prepaid meters also facilitates the integration of renewable energy sources into the grid, supporting the transition towards sustainable energy systems. By providing real-time data analytics, these smart meters enable better demand forecasting and grid management, ultimately contributing to a more resilient and efficient energy infrastructure. This research paper aims to explore the design, implementation, and impact of IoT-based smart energy prepaid meters. It will examine the technological components, benefits, challenges, and future prospects of this innovative solution, highlighting its potential to revolutionize energy management and consumption in the modern world. Through a comprehensive analysis, this study seeks to contribute to the growing body of knowledge in the field of smart energy systems and provide insights for stakeholders involved in energy distribution and management

II. LITERATURE VIEW

Literature on IoT-based smart energy prepaid meters identifies numerous designs and implementations focused on improving energy management and billing effectiveness. Major studies concentrate on real-time monitoring, user experience, and the integration of smart card systems to allow prepaid tracking of energy consumption. Key Studies and Innovations:

Smart Card-Based Systems: Studies show that smart card technology can make the prepaid energy meter process more efficient. Customers top up their smart cards, which are then utilized to retrieve energy consumption information. This process reduces errors in billing and increases user control over energy consumption.

Automated Metering Solutions: Recent research suggests multifunctional smart energy meters that automate the billing

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and metering process. These systems use IoT connectivity to offer real-time information to consumers, minimizing the need for manual readings and enhancing accuracy.

Mobile Application Integration: Various studies highlight the significance of mobile applications for prepaid energy meters. The apps enable users to track their energy usage, low balance notifications, and effortless account recharging.

Challenges Addressed: Common challenges in conventional energy billing systems, including electricity theft, complex billing procedures, and high manpower requirements, are highlighted by literature. IoT-based prepaid meters seek to overcome these challenges with a more efficient and convenient solution.

Future Directions

Extension to Other Utilities: Future studies propose that the concepts of IoT-based prepaid meters can be extended to other utilities like water and gas for better management of resources overall.

Increased User Control: Features may be included to enable users to remotely control their electrical appliances via mobile apps, increasing flexibility and energy saving.

Cost Savings: Continuous innovation in these systems focuses on lowering service providers' operating costs while presenting consumers with an easier means of managing their energy bills.

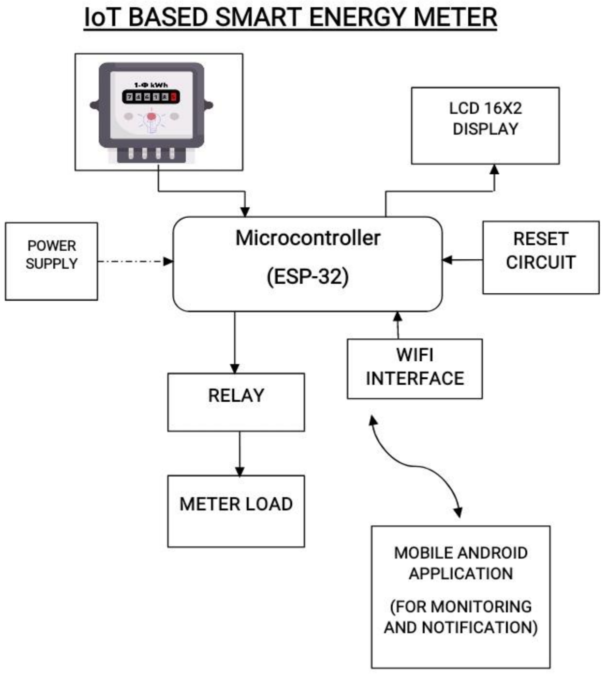
This literature review highlights the revolutionary role that IoT-based prepaid energy meters can play in contemporary energy management systems

III. PROPOSED WORK

The proposed work involves developing an IoT-based smart energy prepaid meter using the ESP32 microcontroller. This system will enable real-time monitoring of energy consumption, facilitate prepaid transactions, and provide users with access to their energy usage data via a mobile application, enhancing user experience and energy management.

Key Features:

- To Monitor All Meter Reading Online (No Need to Take Meter Reading Physically)
- To Disconnect Electricity Automatically if Bill is Unpaid or Balance Over
- To Recharge Meter Online
- Daily Consumption based Payment Deduction
- WIFI Based Connectivity
- BLYNK Server Based Mobile Application
- Embedded C Based Hardware Programming
- Eagle PCB Designing Software for PCB And Schematic Design



The diagram illustrates an IoT-based smart energy meter system. It consists of several components working together to measure, monitor, and manage energy consumption:

Power Supply: Provides the necessary power to operate the system.
Energy Meter: Measures the energy consumption (in kWh).
Microcontroller (ESP-32): The central processing unit that controls the entire system. It receives data from the energy meter, processes it, and communicates with other components.
LCD 16x2 Display: Shows real-time energy consumption data.
Reset Circuit: Allows for resetting the microcontroller if needed.
Relay: Acts as a switch to control the power supply to the load based on the microcontroller's instructions.
Wi-Fi Interface: Enables wireless communication with a network, allowing data transmission to a remote server or mobile application.
Mobile Android Application: Used for monitoring energy consumption and receiving notifications.

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i)EMBEDDED C

Embedded C is a distinct form of the C programming language intended for developing embedded systems applications. These devices are generally microcontroller-based systems found in appliances, automotive, medical and IoT devices including the ESP32 that have limited resources and perform dedicated functions.

Fundamental Principles of Embedded C Programming

Microcontroller Architecture: It is important to know the architecture of the microcontroller you want to program including its registers, memory map, and other peripherals associated with it.

Hardware Control: With Embedded C, one can communicate directly with the computer hardware through memory mapped peripheral. You are able to read from and write to specific addresses that represent hardware registers.

Real Time Operating System (RTOS): Some Embedded systems are managed using traditional task and resource level RTOS. Free RTOS is one of the RTOS you can use with Embedded C, and is very popular with microcontrollers.

Interrupts: Embedded systems need to respond fast to external stimuli. With Interrupts, the CPU can temporarily halt its current execution in favor of a different special purpose function (ISR) when some specific event takes place.

Low Level Programming: On the whole, Embedded C programming is low level bit manipulation, direct memory addressing and speed and memory optimization programming.

ii) EAGL

Eagle, which stands for Easily Applicable Graphical Layout Editor, is a widely-used software for designing printed circuit boards (PCBs) that was created by CadSoft and is now part of Autodesk. Eagle empowers electronic engineers and enthusiasts to craft schematics as well as PCB layouts for a variety of electronic devices and circuits with relative ease.

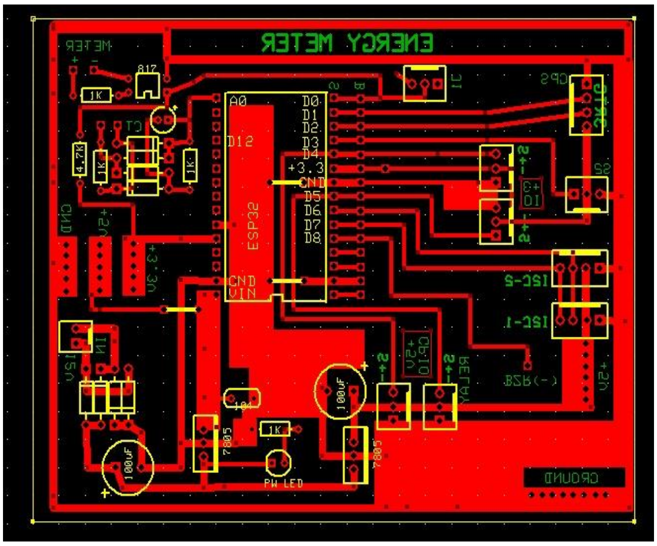
Some of the features that Eagle offers are:

- A schematic capture editor for circuit schematic diagrams
- A PCB layout editor for PCBs
- An auto-router for automated routing of PCB traces
- A wide collection of component libraries containing more than 7000 components
- Ability to open and save Gerber files
- Forwarding and reverting annotations of schematics to PCB and vice versa
- Multi-sheet schematics
- Real time DRC (Design Rule Checking)

With Eagle, transforming circuit concepts from a schematic diagram into a PCB ready for production is effortless. Eagle is ideal for students and hobbyists with little or no experience as well as practicing engineers due to its rich features and flexible interface. This detailed guide aims to provide crucial information on the usage of Eagle PCB software.

IV. CIRCUIT DIAGRAM:

PCB LAYOUT DESIGNING:



V. CONCLUSION:

In conclusion, the IoT-based smart energy prepaid meter using the ESP32 offers a highly efficient, scalable, and innovative solution to traditional energy metering systems. By integrating the ESP32 microcontroller with IoT technology, this system enables real-time energy monitoring, prepaid billing, and remote management, significantly enhancing there user experience and operational efficiency.

The use of wireless communication, such as Wi-Fi or Bluetooth, ensures that consumers can easily monitor their energy consumption and manage their prepaid balance through a mobile application or web interface. Additionally, utilities can track energy usage, identify faults, and improve billing accuracy through real-time data collection, reducing human error and operational costs

VI. FUTURE SCOPE:

The IoT-based smart energy prepaid meter utilizing the ESP32 microcontroller represents a significant advancement in energy management technology. This innovative system enables real-time monitoring of electricity consumption, allowing users to manage their energy usage efficiently through a user-friendly mobile application. With features such as prepaid billing, automatic notifications for low balances, and energy theft detection, the smart meter enhances user engagement and promotes energy conservation. The ESP32's robust connectivity options, including Wi-Fi and Bluetooth, facilitate seamless data transmission to the cloud for analytics and remote management. As the demand for sustainable energy solutions grows, this smart meter not only empowers consumers with greater control over their energy consumption but also supports the integration of renewable energy sources and smart home technologies, paving the way for a more efficient and sustainable energy future.

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