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SMART ENERGY METER FOR REAL TIME MONITORING

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Abstract : In recent years, every energy management has an essential requirement due to the increasing of electricity consumption. Traditional energy meter did not provide separate detailed level of usage information. This paper provides an IOT-based smart energy meter system for analysing total and each device usage level and shows in mobile application. The proposed system allows users set a limit for alerting while reached the limit the mobile get alert message and the bill amount also set the limit reached the mobile got an notification message with bill amount. By combined the IOT technology and mobile based monitoring, The proposed system provide tracking of energy consumption, reduce the wastage and manage amount of the bill efficiently .

Keywords : Internet Of Things(IOT) , Real time monitoring , Energy management .

1. INTRODUCTION

Using of Electricity is increased significantly for an residential and commercial environments. Conventional energy meter displayed only total amount of used current do not provide any individual device consumption and detailed information. Because of that the users didn't know the bill amount until the monthly bill generation. To solve this issues Internet of Things technology involved or played an important role by real-time data collection and monitoring at remote location. IOT-based smart energy meter provides continuous energy usage data and displayed in users mobile application. This paper proposes an IOT-based smart energy meter that monitors total and individual consumption of energy, send alert message for mobile when the usage limit and setup bill amount are exceeded .

2. RELATED WORKS

Several studies have addressed energy management and security in smart home and smart grid systems. Hseiki et al. presented a secure smart energy meter architecture focusing on protecting data and communication from cyberattacks using multi-layer security mechanisms. Although the system improves resilience, it increases hardware complexity. Ahmad et al. proposed a dynamic pricing and clustering-based home energy management system for microgrids, aiming to reduce energy cost and peak demand by scheduling household loads and renewable resources efficiently. However, the approach relies on accurate forecasting and user behavior data. Lin et al. developed a non-intrusive smart home energy management system using neurocomputing-based load forecasting, eliminating the need for individual appliance sensors. Despite its effectiveness, the model requires large datasets and high computational resources. Bhardwaj and Joshi introduced an adaptive energy management framework for MATTER-enabled smart homes using machine learning and reinforcement learning techniques. While the framework improves adaptability and security, it is computationally intensive and lacks extensive real-world validation.

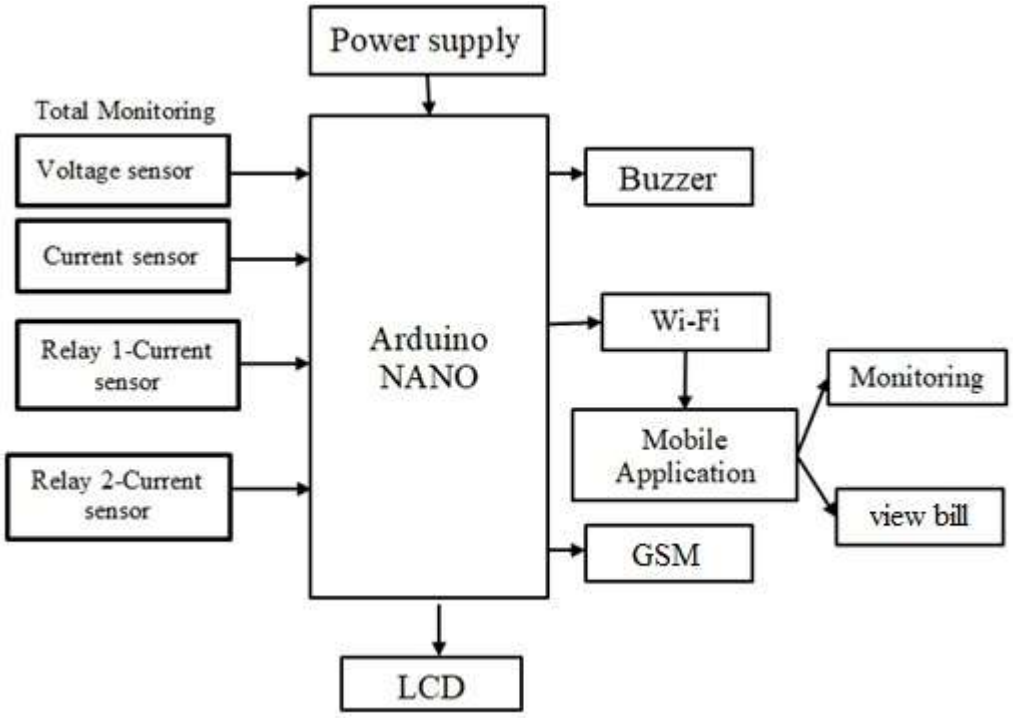
Author(s)& Year	Technique Used	Results/ Outcomes	Limitations
Navodit Bhardwaj & Pallavi Joshi, 2025	Machine learning and reinforcement learning for adaptive energy management in MATTER-enabled smart homes	Improved energy efficiency, adaptability, and interoperability in smart home environments	High computational complexity and limited real-world validation
Ubaid ur Rehman, 2025	Proximal Policy Optimization (PPO)-based real-time energy management	Achieved optimized energy usage with storage and renewable integration	Requires high computational power and complex model training
Nabila Ahmad et al., 2025	Dynamic pricing and load clustering in microgrid-based HEMS	Reduced electricity cost and peak demand through efficient scheduling	Depends on accurate forecasting and user behavior data
Moslem Dehghani & Seyyed Mohammad Bornapour, 2025	Multi-objective appliance scheduling with renewable energy and storage	Improved energy cost efficiency and optimized appliance usage	High computational complexity and difficulty in real-time implementation
Vikas Deep Juyal & Sandeep Kakran, 2024	Smart home energy management with active power loss analysis	Reduced power losses and improved energy efficiency in residential communities	Focus limited to power loss; lacks real-time user interaction features
Piotr Powroźnik & Paweł Szcześniak, 2024	Smart response-based energy management aligned with energy generation profile	Enhanced energy utilization efficiency based on generation patterns	Requires accurate generation prediction; limited flexibility in dynamic conditions
Naman Raj et al., 2024	AI-powered IoT-based energy optimization for smart homes	Improved energy efficiency and automation using IoT and AI techniques	Security concerns and dependency on continuous connectivity
Zohreh Rostmnezhad & Louis Dessaint, 2023	Reinforcement learning-based power management in smart buildings	Achieved efficient power distribution and adaptive energy control	Training complexity and scalability challenges in large systems

3. METHODOLOGY

The proposed system is designed as a smart energy meter capable of monitoring electrical parameters and providing user alerts through a mobile application. The energy meter continuously measures voltage and current from the electrical supply using appropriate sensing circuits. These measured values are processed by a microcontroller and stored locally, enabling the system to operate in offline mode without continuous internet connectivity. The real-time voltage and current values are transmitted to a mobile application via a local communication interface, allowing users to monitor energy parameters directly on their smartphones. In he second stage, the system allows users to set a maximum current usage limit through the mobile application. The microcontroller continuously compares the real-time current value with the predefined threshold. When the current consumption reaches or exceeds the set limit, the system immediately triggers an alert notification, which is sent to the user's mobile device to warn about excessive power usage. In the third stage, the energy meter calculates power consumption and estimates the electricity bill based on predefined tariff values. Users can configure a billing amount limit in the mobile application. When the calculated bill amount approaches or exceeds this limit, an alert message is generated and sent to the user's mobile phone. This enables proactive energy management and cost control. Overall, the proposed methodology integrates offline energy monitoring, user-defined current and billing limits, and real-time mobile alerts to provide an efficient, user-friendly smart energy management solution.

S. No	Hardware Component Name	Specification
1	Arduino Nano	ATmega328P microcontroller, 5V operating voltage, 16 MHz clock speed, compact size
2	Voltage Sensor Module	AC voltage measurement up to 250V, scaled analog output suitable for microcontroller
3	Current Sensor	AC current measurement up to 20–30A, analog output, high accuracy
4	Relay Module	5V relay module, supports load control up to 10A, electrically isolated
5	LCD Display	16×2 character LCD, operates at 5V, used for real-time data display
6	Wi-Fi Module	ESP8266 / equivalent, supports wireless data transmission to mobile application
7	GSM Module	SIM800 / equivalent, supports SMS alert functionality, quad-band operation
8	Buzzer	5V active buzzer, used for local alert indication
9	Power Supply Unit	Regulated 5V DC power supply for system operation
10	Connecting Wires & PCB	Jumper wires and PCB for secure electrical connections

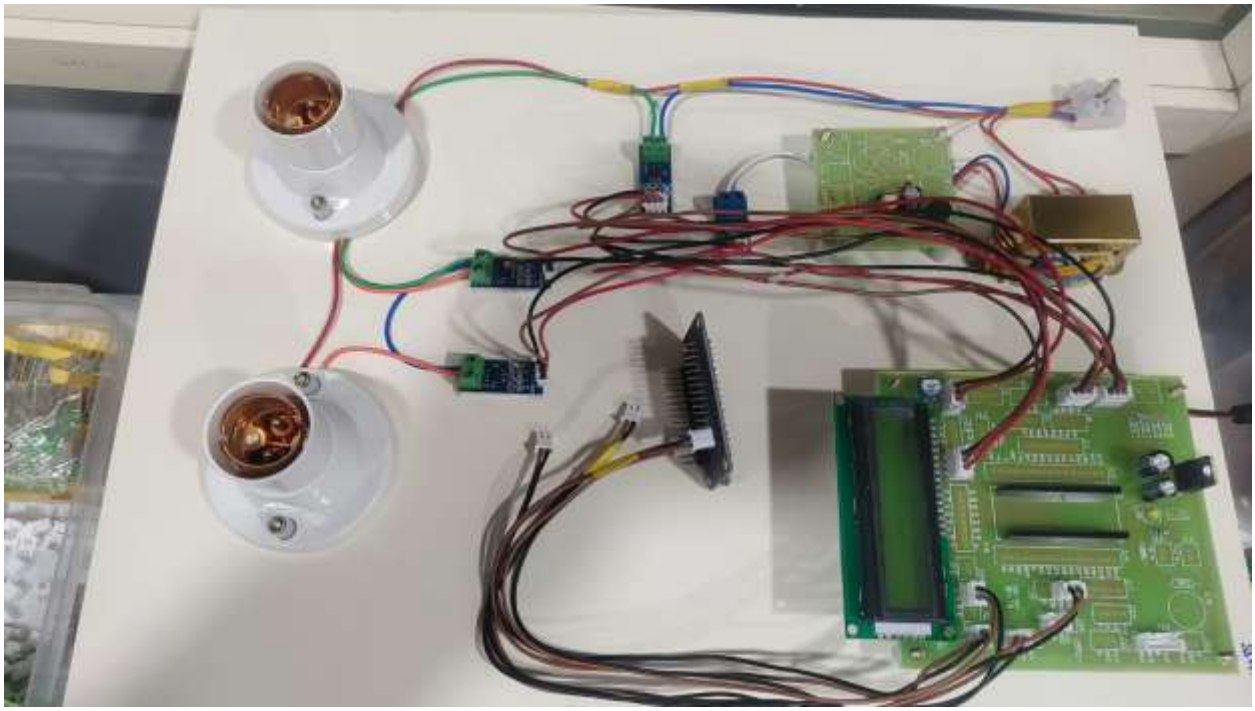
4. BLOCK DIAGRAM



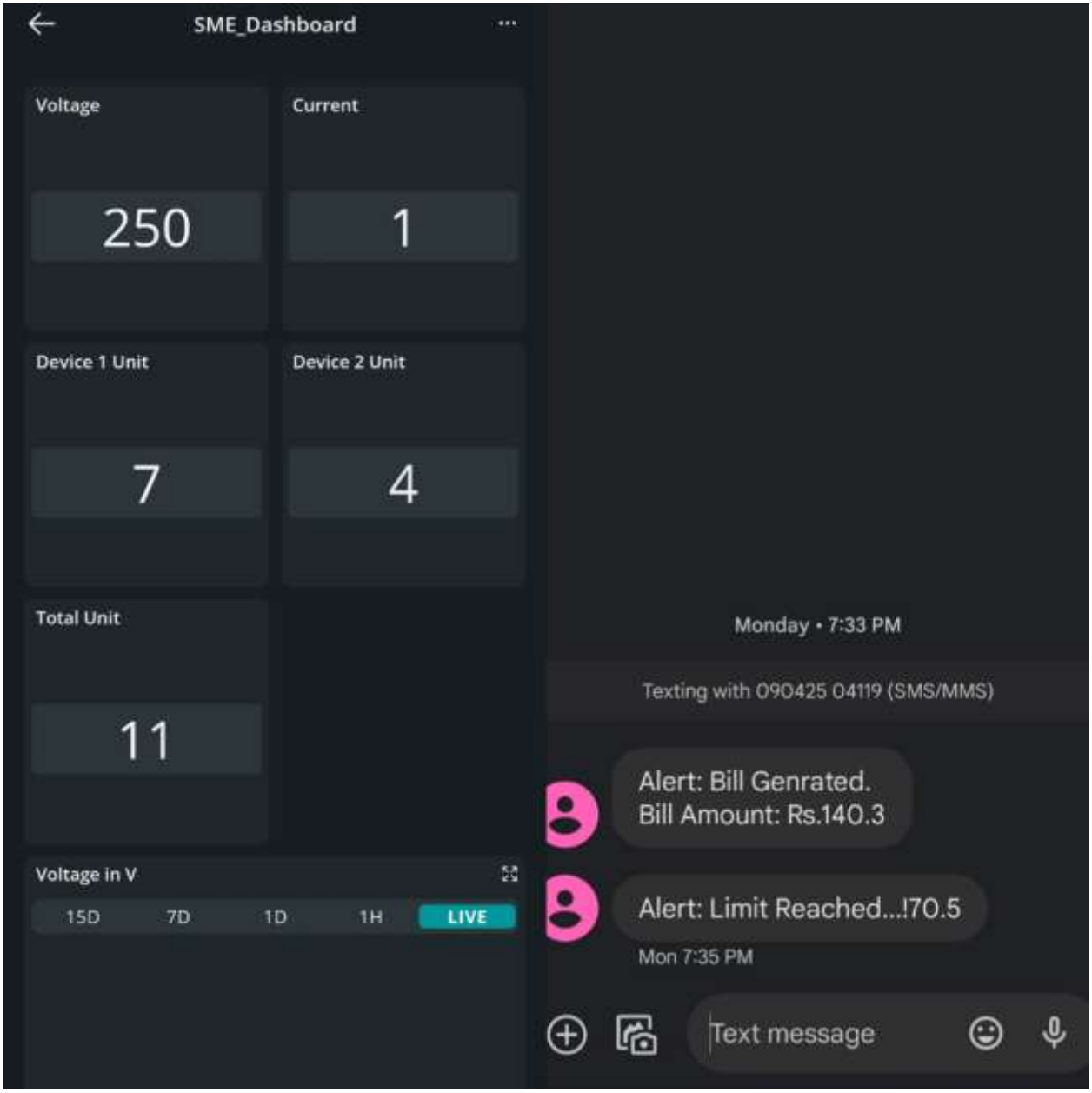
The proposed system is centered around an Arduino Nano, which acts as the main control unit. The power supply provides the required operating voltage to all components. Voltage and current sensors continuously monitor the electrical parameters and send real-time data to

the Arduino Nano for processing. Two relay-based current sensing units are used for load monitoring and control. The processed data is displayed locally on an LCD for immediate reference. For user alerts and communication, the system is integrated with Wi-Fi and GSM modules. The Wi-Fi module enables real-time monitoring and bill viewing through a mobile application, while the GSM module sends alert messages when predefined current or billing limits are exceeded. A buzzer is used for local alert indication during abnormal conditions. Overall, the block diagram represents an efficient smart energy meter system that supports offline monitoring, mobile-based visualization, and alert mechanisms. ..

5. EXPERIMENTAL SETUP AND RESULTS



The experimental setup consists of a smart energy meter prototype built using an Arduino Nano as the central controller. A regulated power supply is used to power the Arduino and associated modules. Voltage and current sensors are connected to the supply line to continuously monitor electrical parameters. Relay-based current sensing units are incorporated to manage load conditions. An LCD is interfaced with the Arduino to display real-time voltage, current, and power values locally. For communication, Wi-Fi and GSM modules are integrated with the controller. The Wi-Fi module connects the system to a mobile application for monitoring, while the GSM module is configured to send alert messages. A buzzer is included to provide local alerts during abnormal or threshold-exceeding conditions.



The experimental results demonstrate that the proposed system successfully monitors voltage and current in offline mode and displays the measured values on the mobile application in real time. Users are able to set current usage limits and billing amount thresholds through the mobile app. When the predefined current limit or bill amount is reached, alert messages are automatically sent to the user's mobile phone via GSM, and a buzzer is activated locally. The system effectively provides real-time monitoring, timely alerts, and improved awareness of energy consumption, validating its suitability for smart energy management applications.

6. CONCLUSION

This project presented the design and implementation of a smart energy meter capable of monitoring voltage and current in offline mode and displaying the data through a mobile application. The system allows users to set current usage and billing amount limits, and it provides timely alert notifications through GSM when the predefined thresholds are exceeded. The experimental results confirm that the proposed system effectively supports real-time monitoring, user awareness, and proactive energy management. By integrating local sensing, mobile-based visualization, and alert mechanisms, the system offers a reliable and user-friendly solution for efficient energy monitoring and cost control in residential and small-scale applications.

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