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IOT Based Home Power Monitoring System With Auto Billing

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Abstract: The goal of the Power Monitoring project is to increase energy efficiency and improve home safety. This clever setup tracks how much power is used at home using Arduino, voltage and current sensors. By delivering charges to each customer and the grid simultaneously, the device streamlines the billing procedure. The system also has features to identify fire, overvoltage, and overcurrent risks. When any of these dangers arise, the gadget turns off the electricity and uses GSM SMS to notify the householder and the fire brigade. By preventing electrical risks in household surroundings, this initiative helps to manage energy more efficiently.

Keywords: Energy Efficiency, Power Monitoring, Electrical Hazards, GSM Notification

I. INTRODUCTION

Effective power administration than electrical safety have grown to be major problems as households rely more and more on electrical appliances. In order to address these issues, the home Power Monitoring system project offers a complete solution for tracking power consumption, automating billing procedures, and averting electrical risks. The system makes use of Arduino, voltage, current, and current sensors as well as GSM modules to guarantee effective energy consumption and prompt reaction to any electrical hazards. As households increasingly depend on a wide range of electrical appliances, the need for effective power management and enhanced electrical safety has become more critical than ever. To tackle these challenges, the Home Power Monitoring System project provides an all-encompassing solution designed to monitor real-time power usage, streamline billing processes, and prevent potential electrical hazards. This system integrates advanced components such as Arduino, voltage sensors, current sensors, and GSM modules, ensuring not only efficient energy consumption but also immediate detection and response to any electrical abnormalities. By offering detailed insights into power usage patterns and automating crucial functions, this system empowers homeowners to maintain both safety and efficiency in their energy management, thereby reducing the risk of accidents and promoting more sustainable electricity usage. In addition to its core functionalities, the Home Power Monitoring System offers an array of benefits that extend beyond mere energy management. One of its standout features is the ability to generate detailed analytics on power consumption, enabling homeowners to identify trends and optimize their energy use over time. The system's integration with GSM modules allows for remote monitoring and alerts, providing peace of mind even when homeowners are away. Moreover, by automating billing and monitoring processes, the system reduces the likelihood of human error, ensuring accurate and timely payments. This not only simplifies the management of household energy expenses but also contributes to a broader effort towards energy conservation by promoting awareness and encouraging responsible energy consumption. Ultimately, the Home Power Monitoring System represents a significant step towards smarter, safer, and more efficient household energy management.

II. RELATED WORKS

An energy-efficient home automation system is one IoT application that has drawn a lot of interest from researchers. This state of the art technology improves accessibility and user-friendliness by utilizing web-based and Android-based platforms. Users will be able to control and access household appliances remotely from any location in the world with the proposed system.

The Online-connected primary power unit, integrated with a module that guarantees uninterrupted Internet connectivity, forms the system's core. A fixed IP address is used to facilitate wireless communication. This home automation system's multimodal application, which users may use using voice recognition, is at its core and offers a practical and easy way for homeowners to control their living space [1].

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Chano Wang et al. [2], noticed recent years have seen a sharp increase in energy use, and the quick development from sources of clean energy like solar and wind power has created serious problems for the natural world and energy security. Energy networks are evolving toward more intelligence as a result of these developments. The smart meter is a vital part of these smart energy networks. Although smart meters are capable of measuring energy flow, they frequently aren't able to interact directly with customers or utility providers regarding system condition and energy usage. Nevertheless, depending on user preferences and directions, these sophisticated meters may also monitor and control a variety of devices, including home appliances.

Gitanjali Mehta [3] noted that the energy sector is encountering significant challenges due to increased energy consumption and advancements in renewable energy technologies. To address these issues, there is a push towards developing smart energy networks that promise to define the future of energy management. Central to these next-generation grids are smart electricity meters, which not only track energy usage but also facilitate communication between utilities and consumers. These meters play a crucial role by using consumer data to manage and control household appliances and devices, making them a fundamental component of the evolving smart grid.

The advancement of smart grids in power systems depends on energy efficieny. Energy consumption monitoring and control is one of the primary objectives of smart grids. However, the lack of full-duplex communication capabilities with existing energy meter technology is a major barrier. They suggest utilizing a smart energy meter with Internet of Things (IOT) capabilities to solve this problem. The ESP8266 12E Wi-Fi module is used by this smart meter to track and manage energy use. Following collection, the data is transferred to the cloud so that manufacturers and customers can readily access and review it.[4]

M.S. Ballal [5] have developed single-phase energy meters with an accuracy class of 1.0, specifically designed for railway traction applications. In India, however, regulations set by the Central Electrical Regulatory Commission (CERC) and the Central Electricity Authority (CEA) require that metering systems for all Extra High Voltage (EHV) consumers meet a higher accuracy class of 0.2S. For measuring energy in multi-feeder circuits, summation meters are employed. However, the use of summation current transformers (CTs) introduces certain limitations that affect the accuracy of these summation meters.

The use of electricity is essential to our everyday existence. India was the third-largest global electricity consumer in 2016 with 5.5% of the global total. India has an average per-person energy consumption of about 0.7 kW. India's portion of the world's energy demand is predicted to increase to 9% by 2035. Despite being a relatively new industry, the IT and electronics industries have already seen substantial changes as a result of IoT-based products. The purpose of this project is to raise public awareness of energy usage and encourage energy-saving use of household equipment. The fact that the existing power billing system is manual-based is one of its main weaknesses. [6].

Dr. Ashwathy S. U [7] point out that various factors are driving the rapid rise in household power consumption. Many consumers lack awareness of their energy usage, leading to unnecessary power waste and inflated electricity bills. This financial burden can sometimes lead individuals to engage in power theft. To address these issues, the adoption of smart electric meters is crucial for accurately monitoring and recording energy use in households. The Internet of Things (IoT) can enhance this process by efficiently collecting, transmitting, and analyzing energy consumption data, thereby simplifying and accelerating energy management for both consumers and utility providers.

Innovation of e-metering (Electronic Metering) has experienced fast mechanical progressions and there is expanded interest in a solid and effective Automatic Meter Reading (AMR) framework. GSM Based shrewd vitality meter perusing framework replaces conventional meter perusing techniques. It empowers remote access to the existing vitality meter by the vitality provider. A GSM-based remote correspondence module is incorporated with the electronic vitality meter of every element to have remote access to the utilization of power. A PC with a GSM recipient at the opposite end, which contains the data base goes about as the charging point. Live meter perusing from the GSM-empowered vitality meter is sent back to this charging point intermittently and these subtle elements are refreshed in a focal database.[8]

With rising electricity costs and increasing demand, many companies are developing advanced methods for monitoring, controlling, and conserving energy. An effective energy management system (EMS) aims to reduce costs and meet energy demands efficiently. By incorporating modern technologies such as big data and the Internet of Things (IoT), energy usage can be more effectively managed across commercial, industrial, and residential sectors. This study presents an EMS designed specifically for smart homes, featuring an IoT-enabled device paired with a data collection module. This setup creates an extensive network of interconnected devices within the grid.

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An integrated System on Chip (SoC) module collects energy usage data from each smart home device and transmits it to a central administrative server for processing and analysis [9].

Smarajit Ghosh[10] recognize the diverse applications of the Internet of Things , including industrial automation and smart energy management. In a smart grid , sensors are deployed across various stages to monitor and control network data, ensuring safe and efficient power distribution. To achieve optimal performance, it is crucial to address the integration challenges between IOT and smart grids. This research proposes an IOT-based smart power grid monitoring system that utilizes neuro-fuzzy techniques to enhance its functionality.

The literature survey explores various approaches and techniques for optimizing home power monitoring and auto-billing systems.The rise in household power consumption has sparked significant interest in energy-efficient home automation systems, driven by the need for better control and management of energy usage. These systems utilize web-based and Android platforms, enabling users to remotely control household appliances from anywhere. The core of such systems often includes an online-connected power unit with continuous internet connectivity, using a fixed IP address for wireless communication. However, the rapid growth in energy use and advancements in renewable energy sources have introduced challenges to energy security and environmental impact, making smart meters an essential component of modern energy networks. Smart meters not only measure energy flow but also facilitate communication between utilities and consumers, helping manage and control household devices.

Despite their advantages, existing energy meters often lack full duplex communication capabilities, which limits their effectiveness. To address this, IOT based smart energy meters using the ESP8266 12E Wi-Fi module can track and manage energy use, with data transferred to the cloud for easy access and analysis by manufacturers and consumers. In India, accurate energy measurement is crucial, with regulations requiring a higher accuracy class for EHV consumers and addressing limitations in summation meters used for multi-feeder circuits. As the country's energy consumption rises, there is a need for advanced technologies to enhance energy management, including the use of IoT and big data. Electronic Metering (e-metering) innovations, such as GSM-based systems, allow for remote reading and billing, improving efficiency over traditional methods. Furthermore, the integration of IOT in smart grids, supported by techniques like neuro-fuzzy systems, can enhance power distribution and management, addressing the challenges of modern energy networks.

III. PROPOSED METHODOLOGY

The proposed Power Monitoring System effectively overcomes limitations related to unit usage tracking and electrical hazard detection, offering homeowners a comprehensive solution for monitoring and safety. With detailed real-time monitoring and reporting, consumers can track the electricity usage of specific devices, enabling them to manage and optimize their energy consumption efficiently.

This level of insight allows users to identify high-consumption devices and make informed decisions to reduce electricity bills. Beyond monitoring, the system significantly enhances safety by incorporating advanced detection mechanisms for overvoltage, overcurrent, and potential fire hazards. If any of these dangerous conditions are detected, the system automatically cuts off the electricity supply to prevent appliance damage, reduce the risk of electrical fires, and ensure household safety.

Additionally, the device is equipped with a GSM module that sends immediate notifications to the homeowner and the fire department via SMS in case of any detected hazards. This prompt alert system ensures that necessary actions can be taken swiftly, potentially saving lives and property by mitigating the effects of electrical emergencies. The system also includes an easy-to-use mobile app and web interface, allowing users to view their electricity usage patterns, receive alerts, and manage their electrical devices remotely. This feature enhances convenience and control, enabling homeowners to adjust their energy consumption even when they are away from home. \

Furthermore, the Power Monitoring and Electrical Hazard Prevention Device supports integration with smart home ecosystems, facilitating seamless communication with other smart devices and systems. This integration enables automated responses to electrical hazards, such as triggering home alarms, notifying emergency services, and powering down other devices in case of an emergency. Overall, this system not only provides detailed monitoring and reporting of electricity usage but also offers robust safety features that protect both the household and its occupants.

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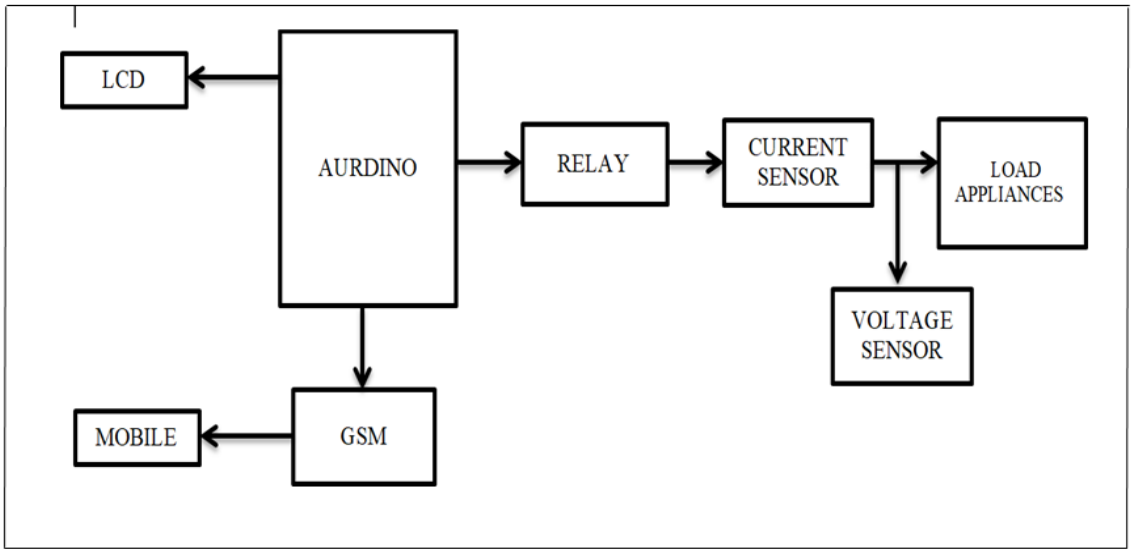

Figure 1: Block Diagram

The proposed system the following methodology:

Arduino Boards:
The central control units responsible for processing data from sensors, implementing safety measures, and controlling communication with GSM modules.

Version: AVR micro controller
The AVR microcontroller-based Arduino boards are a popular choice for IoT projects due to their versatility, ease of use, and robust performance. hich offer a balanced combination of processing power, memory, and input/output capabilities.

The AVR architecture is known for its efficiency and reliability, making it ideal for a wide range of embedded applications.the low power consumption of AVR microcontrollers makes Arduino boards suitable for battery-powered IoT devices, ensuring longevity and efficiency in real-world applications.

Current Sensors:
These sensors measure the current flowing through electrical circuits, providing real-time data on power usage.

Version: SCT-100A sensor
The SCT-100A current sensor is widely used in IoT projects for its ability to measure alternating current (AC) with high accuracy. The SCT-100A is a non-invasive, clamp-style sensor that easily attaches around a conductor without the need for direct electrical contact, ensuring safety and ease of installation. the SCT-100A is known for its durability and reliability, providing consistent performance in a wide range of environmental conditions.

Voltage Sensors:
Voltage sensors monitor the voltage levels in the electrical system, allowing the detection of overvoltage conditions.

Version: ZMPT101-400KV sensor
This sensor is specifically designed to measure high AC voltages up to 400kV with excellent accuracy and stability, making it ideal for applications in both industrial and residential settings

The ZMPT101-400KV utilizes a high-precision voltage transformer and operational amplifier to convert the high voltage into a low, readable analog signal that can be easily processed by microcontrollers.

GSM Modules:
Enable communication by sending bills and alert messages to predefined contacts, including the home owner and the fire department.

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Version:800L-GSM

The 800L GSM module is a popular choice in IOT projects for enabling cellular communication and connectivity. This compact and cost-effective module supports GSM and SMS functionalities, making it versatile for various applications such as remote monitoring and SMS-based alert systems. The 800L GSM module operates on the quad-band frequencies, ensuring compatibility with global GSM networks.

IV. RESULT AND DISCUSSION

The system provides real-time monitoring and detailed reporting of electricity usage, enabling homeowners to make informed decisions that can lead to lower electricity bills, as illustrated in Figure 2. It incorporates advanced detection features for overvoltage, overcurrent, and potential fire hazards, adding a crucial safety layer by automatically cutting off power to prevent damage and reduce the risk of electrical fires, as shown in Figure 3. The GSM module included in the system ensures that homeowners and emergency services receive immediate notifications of any hazards, allowing for quick response to protect lives and property, as depicted in Figure 4. The user-friendly mobile notifications and web interface make it easy for users to manage their electrical devices and monitor energy consumption remotely. Integration with smart home ecosystems further enhances the system's functionality by enabling automated responses to emergencies and seamless communication with other smart devices. This comprehensive approach not only boosts safety and energy efficiency but also provides homeowners with peace of mind through effective electrical monitoring and hazard prevention. The system's capability to prevent electrical emergencies while optimizing energy usage highlights its effectiveness in addressing the key concerns of modern households. Overall, it offers a reliable and robust solution that significantly improves both safety and energy management in any home.

Figure 2: Generating bill

Figure 3: Volatge and current reading

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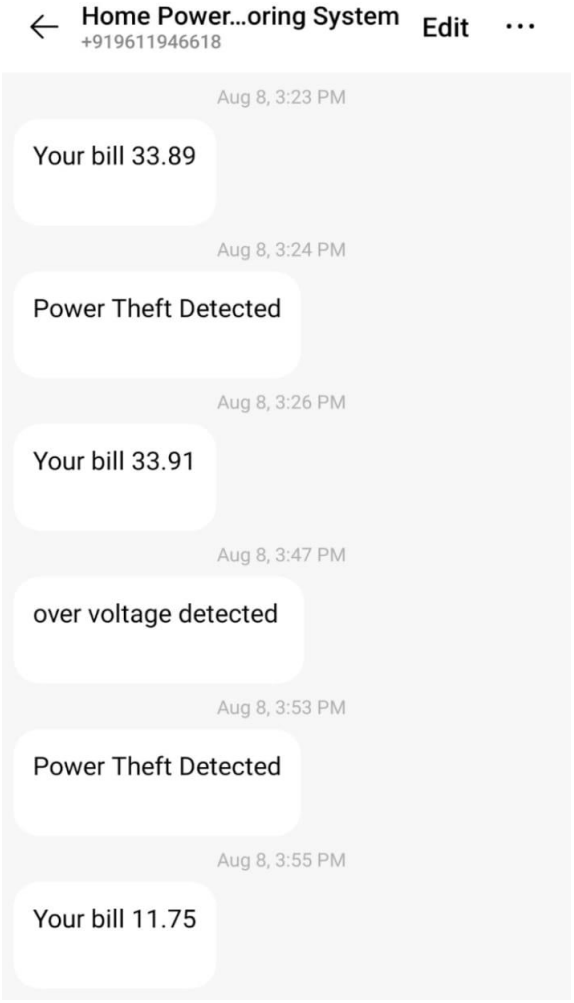

Figure 4: SMS Notification

V. CONCLUSION

The Power Monitoring and Electrical Hazard Prevention Device marks a significant advancement in residential power management and safety. By integrating Arduino technology with current and voltage sensors, the system offers real-time monitoring of power consumption, automatic billing, and proactive protection against electrical hazards. This innovative approach addresses the limitations of traditional power management systems by providing a comprehensive solution that adapts to the evolving demands of safety and energy management.

The device enhances electrical safety and home automation through active hazard prevention, automated billing, and real-time monitoring. It also allows users to set custom alerts for unusual power consumption or when specific thresholds are reached. To support a growing number of users and devices, the cloud infrastructure will be optimized for greater scalability. The system will include accessibility features for users with disabilities, ensuring a more inclusive experience. It will also support multiple payment methods, including digital wallets and installment plans for high energy bills. Additionally, the platform will offer tips and recommendations to help users improve energy efficiency in their homes.

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