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Design and Implementation of a Smart Energy Metering, Monitoring and Control System

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Abstract—The growing dependence on electrical appliances in modern settings has amplified concerns regarding energy efficiency, safety, and convenience. Conventional methods for monitoring and controlling appliances frequently rely on manual intervention, which can be susceptible to human error and inefficiency. Additionally, the absence of real-time insights into appliance usage patterns hinders the identification of areas for energy efficiency improvement and proactive maintenance interventions. To address these limitations, this work proposes an IoT-based monitoring and control system for electrical appliances. This system utilizes a network of sensors and relays to collect real-time data on appliance usage and control their operation remotely. This data is then transmitted to a cloud platform for comprehensive analysis and visualization. The system empowers users to monitor their appliance usage in real-time, identify areas for energy savings, and schedule appliance operations remotely, fostering a more efficient, sustainable, and convenient environment.

I. INTRODUCTION

Energy management and consumption on a worldwide scale are at a turning point. The need for energy resources is increasing as the world's population continues to rise and industrialization and urbanization progress. This increased demand causes serious problems for the economy, the environment, and the energy infrastructure that is currently in place. Energy is the most well-known and most significant asset furthermore; the requirement for it use it in a controlled way is vital where the assets for it are scant[1]. Effective energy management hinges on the theory that real-time energy consumption monitoring is important for optimizing energy utilization. Electrical devices that are equipped to detect and display energy consumed in the form of readings are termed as electric meters or electricity meters [2].

The limitations of conventional energy metering systems, which have long served as the foundation of energy monitoring, are now becoming clear. These traditional meters frequently require human reading, are electromechanical or digital in nature, and record energy use at predetermined intervals. The 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 [3].

The urgent need for a more complex, sensitive, and long-term strategy to energy management has resulted in the growth of Internet of Things (IoT) technologies [4]. This groundbreaking technology not only enables real-time data collection but also facilitates remote monitoring, predictive analytics, and the integration of renewable energy sources into household energy management systems.

In response to these significant challenges, this project aims to create a robust energy metering and monitoring system utilizing Internet of Things (IoT) technology. This envisioned system is engineered to provide real-time data access, remote functionality, and advanced analytical capabilities. The goal of this project, is to equip users, energy providers, and policymakers with the tools necessary to optimize energy consumption, reduce operational costs, mitigate environmental impacts, and promote a transition towards a smart, sustainable energy landscape.

The major contribution of this work are

i. To design an energy metering, monitoring and control system that can monitor and control the energy consumption in electrical appliances in homes using a microcontroller, current sensors and energy relays.

ii. To construct an energy metering, monitoring and control system.

iii. To evaluate the performance of the energy metering, monitoring and control system.

The rest of the paper is as follows

II discusses about literature review, similar works, and the improvement. III discusses the method used in the designing the system. IV entails detailed results from the system while conclusion and recommendations were presented in V.

II. LITERATURE REVIEW

The historical evolution of energy monitoring has transitioned from manual, periodic readings to automated,

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