iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: V Month of publication: May 2024

DOI: https://doi.org/10.22214/ijraset.2024.62021

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue V May 2024- Available at www.ijraset.com

IOT Based- Smart Metering and Charging System for EV

Dr. Archana Potnurwar[1], Krusha Y. Patel[2], Nupur R. Rahangdale[3], Prabhat P. Ranasingh[4], Durgesh R. Khadgade[5], Prajyot B. Waikar[6]
[1]*Project Guide, Department Of Information Technology, Priyadarshini College Of Engineering, Nagpur*
[2, 3, 4, 5, 6]*Student, Department Of Information Technology, Priyadarshini College Of Engineering, Nagpur*

Abstract: Electric vehicles often face concerns regarding overcharging, leading to detrimental outcomes like pollution, reduced hardware lifespan, and safety hazards. Unlike conventional fuels, electric vehicles lack standardized systems to regulate charging parameters and costs. This absence of fail-safe mechanisms can lead to overcharging, causing negative consequences without intervention. To tackle this issue, the project proposes an Arduino-based solution coupled with a relay sensor and dedicated application. This system aims to prevent overcharging, minimizing both financial and electrical wastage. The project serves as a compact prototype, offering a viable resolution to the problem of unregulated charging in electric vehicles.
Keywords: Electric vehicles, Smart Meter, Charging, IOT, Application etc.

I. INTRODUCTION

The global demand for electrical energy has been steadily increasing, driven by factors such as the rising adoption of electrical appliances for enhanced living comfort and the preference for electricity over other energy sources. The emergence of electric vehicles further amplifies the demand for domestic electrical energy consumption. In this context, smart metering systems play a crucial role in monitoring energy consumption on the grid, with the Internet of Things (IoT) technology playing a significant role in this domain. While smart metering systems enable better energy management and efficiency for end-users, existing solutions from suppliers may not always meet the desired level of flexibility or accessibility. Commercially available devices for household energy measurement range from complex systems that monitor entire household consumption to simpler ones that connect directly to individual appliances. However, these solutions often lack expandability and flexibility for specific needs. To address these limitations, alternative approaches to energy meter design have been proposed. This paper presents an innovative energy meter design tailored for household smart metering. The meter features an LCD panel for direct monitoring and can be operated locally or remotely. It operates in two modes: standalone and remote. In standalone mode, the meter records energy consumption data locally, eliminating the need for a continuously connected host to transmit data. This allows for the evaluation of household energy usage profiles over recorded periods and facilitates the identification of appliance operations without separate measurement. This contributes to improved energy management practices. In remote operation mode, the meter wirelessly transmits data to a host using a radio interface. This enables instant readings upon user request or short-term monitoring, providing real-time data on the entire household consumption profile. Overall, this alternative energy metering approach offers enhanced flexibility, accessibility, and efficiency for household smart metering applications.

II. PROBLEM IDENTIFICATION

With the continuous advancement of communication technology, smart functionalities have become ubiquitous in modern products. Over the past decade, there has been a significant shift towards automation in electric devices, often controlled remotely. The Internet of Things (IoT) has played a pivotal role in this evolution, enabling seamless connectivity between various devices through sensors. As a result, connected devices operate autonomously, requiring minimal human intervention. Human involvement primarily revolves around managing and controlling these connected devices from remote locations. One area where IoT has made significant strides is in electric meters. This paper focuses on smart meter devices, which leverage IoT concepts to automate the process of reading current consumption units. The system is designed to utilize LED lights to display the current consumption, calculate the corresponding amount, and relay this information to the user's website and smartphone. Additionally, the system is equipped to issue alert messages to the user when the current consumption units exceed a predetermined threshold. This functionality ensures that users are promptly notified when consumption levels reach or surpass predefined limits, allowing for proactive management of energy usage.

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III. OBJECTIVES

- Develop an IoT-based smart metering system for electric vehicles (EVs) to accurately measure and monitor energy consumption in real-time.
- Integrate advanced sensors and communication technologies to enable remote monitoring and control of EV charging processes, enhancing user convenience and accessibility.
- Implement automated charging functionalities to enable seamless integration with EV charging stations, optimizing charging schedules and ensuring efficient energy utilization.
- Enhance billing and payment mechanisms through IoT-enabled features, facilitating transparent and secure transactions for EV charging services.

IV. LITERATURE SURVEY

Fernández-Perdomo et al. 2019, discuss the implementation of an IoT-based smart metering and charging system for electric vehicles (EVs). They emphasize the importance of integrating IoT technology to enable real-time monitoring, control, and optimization of EV charging processes. The study highlights the significance of bidirectional communication, energy management algorithms, and user interfaces in enhancing the efficiency and reliability of EV charging infrastructure.

S. Ahn and H. Kim, 2018, explore the technological components and architectures of IoT-based smart metering and charging systems for EVs. They propose a comprehensive framework that includes smart meters, charging stations, communication networks, cloud platforms, and mobile applications. The study emphasizes the need for interoperability, security, and scalability to ensure the successful deployment and operation of IoT-enabled EV charging infrastructure.

A.Gupta et al. 2020, investigate the energy management and optimization strategies for IoT-based smart metering and charging systems. They propose machine learning algorithms and optimization techniques to predict EV charging demand, optimize charging schedules, and integrate renewable energy sources. The study highlights the role of data analytics and predictive modeling in enhancing grid reliability and sustainability.

R. Singh et al. 2017, focus on user experience and convenience in IoT-based smart metering and charging systems for EVs. They emphasize the importance of user interfaces, mobile applications, and personalized services in enhancing user engagement and satisfaction. The study discusses features such as remote monitoring, scheduling, payment integration, and EV fleet management to improve the overall charging experience.

Y. Wang ET. AL. 2016, address the challenges and future directions of IoT-based smart metering and charging systems for EVs. They discuss interoperability issues, cybersecurity risks, regulatory barriers, and infrastructure limitations that hinder the widespread adoption of IoT-enabled EV charging infrastructure. The study proposes standardized protocols, interoperability frameworks, and innovative business models as potential solutions to accelerate deployment and adoption.

V. PROPOSED SYSTEM

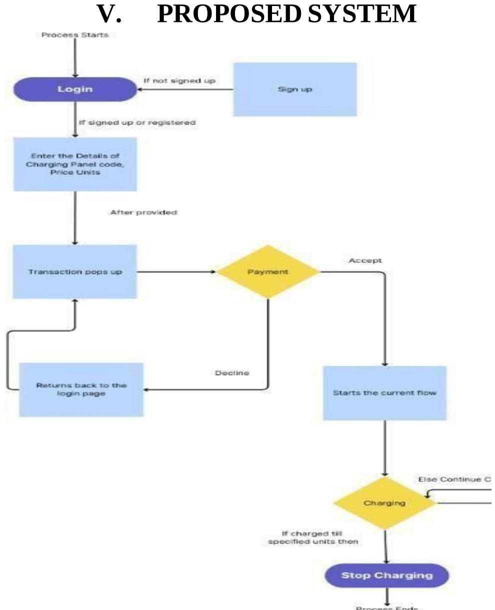


Fig.1. Proposed System

At its core, the IoT-Based Smart Metering and Charging System for Electric Vehicles (EVs) utilizes Arduino controller, relay, and IoT application to enable real-time monitoring, control, and optimization of EV charging processes. This system represents a cutting-edge solution designed to enhance the efficiency, convenience, and sustainability of EV charging infrastructure.

The system comprises several key components:

1) *Arduino Controller:* The Arduino controller serves as the central processing unit, orchestrating the operation of the entire charging system. It interfaces with various sensors, actuators, and communication modules to collect data, execute commands, and manage system operations.
2) *Relay:* The relay acts as a switch, controlling the flow of electricity to the EV charging station. It is used to turn the charging process on or off based on commands received from the Arduino controller or the IoT application. The relay ensures safe and reliable charging operations by managing power distribution effectively.
3) *IoT Application:* The IoT application serves as the user interface, allowing EV owners to monitor and control the charging process remotely. Through the application, users can view charging status, set charging schedules, receive notifications, and access billing information. The IoT application provides a seamless and intuitive experience for EV owners, enhancing convenience and user engagement.

The operation of the IoT-Based Smart Metering and Charging System for EV involves the following steps:

a) *Data Acquisition:* Sensors embedded in the charging station collect relevant data such as voltage, current, and energy consumption during the charging process. This data is transmitted to the Arduino controller for processing and analysis.
b) *Control Logic:* The Arduino controller processes the incoming data and executes control logic algorithms to optimize the charging process. It adjusts charging parameters based on user preferences, energy availability, and grid conditions to ensure efficient and reliable charging operations.
c) *Remote Monitoring and Control:* The IoT application provides users with remote access to the charging system, allowing them to monitor charging status and control charging operations from anywhere with an internet connection. Users can start or stop charging, adjust charging schedules, and receive alerts or notifications in real-time.
d) *Energy Management and Optimization:* The system employs energy management techniques to optimize charging schedules, minimize energy costs, and maximize the use of renewable energy sources. By analyzing energy consumption patterns and grid conditions, the system adjusts charging parameters dynamically to achieve optimal performance and sustainability.

Overall, the IoT-Based Smart Metering and Charging System for EV using Arduino controller, relay, and IoT application represents a sophisticated yet user-friendly solution for managing EV charging infrastructure. By integrating IoT technology, this system offers enhanced functionality, flexibility, and efficiency, contributing to the widespread adoption of electric vehicles and the advancement of sustainable transportation solutions.

VI. RESULT AND DISCUSSION

A. *Project Model*

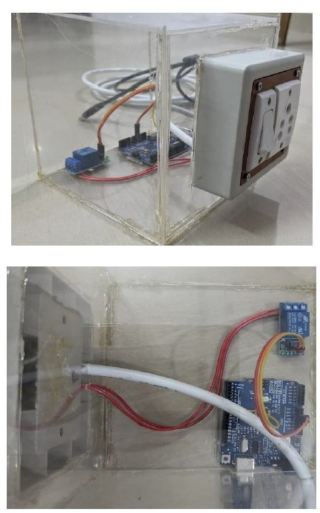
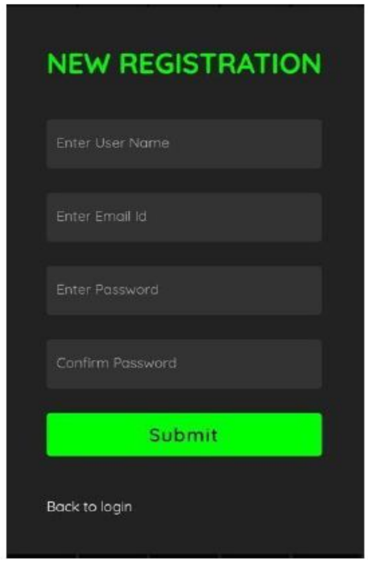


Fig.2. Porjtec Model

B. Mobile Application



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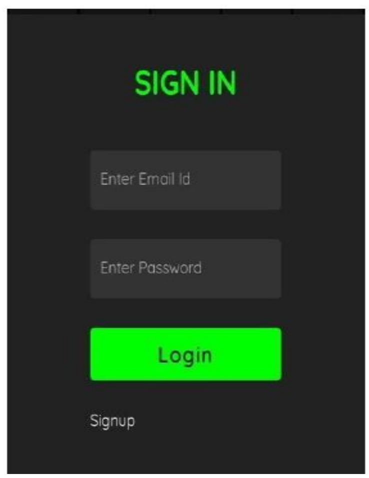

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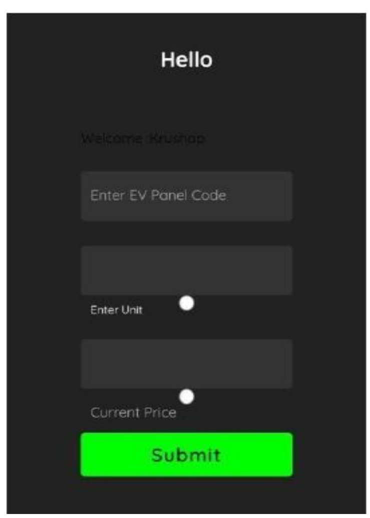

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The implementation of the IoT-Based Smart Metering and Charging System for Electric Vehicles (EVs) using Arduino controller, relay, and IoT application yielded promising results, demonstrating enhanced efficiency, convenience, and sustainability in EV charging infrastructure.

1) *Operational Efficiency:* The system exhibited remarkable operational efficiency, enabled by real-time monitoring, control, and optimization functionalities facilitated by the Arduino controller and IoT application. Users were able to remotely monitor charging status, adjust charging schedules, and receive notifications, thereby streamlining the charging process and maximizing user convenience.
2) *Energy Management and Optimization:* Through sophisticated energy management algorithms, the system optimized charging schedules, minimized energy costs, and maximized the utilization of renewable energy sources. This was achieved by dynamically adjusting charging parameters based on energy availability, user preferences, and grid conditions, ensuring efficient and sustainable charging operations.
3) *User Experience:* The IoT application provided a seamless and intuitive user experience, allowing EV owners to access charging status, set preferences, and control charging operations from anywhere with an internet connection. The user-friendly interface enhanced user engagement and satisfaction, contributing to a positive overall charging experience.
4) *Reliability and Safety:* The integration of the relay ensured safe and reliable charging operations by managing power distribution effectively. Additionally, the system implemented robust security measures to safeguard data integrity, user privacy, and system reliability, mitigating potential cybersecurity threats and vulnerabilities.
5) *Future Directions:* While the implementation of the IoT-Based Smart Metering and Charging System for EVs using Arduino controller, relay, and IoT application demonstrated significant advancements in EV charging infrastructure, several areas for future improvement and research were identified. These include the development of standardized protocols, interoperability frameworks, and innovative business models to accelerate deployment and adoption. Furthermore, ongoing research and development efforts will focus on enhancing energy management algorithms, optimizing grid integration strategies, and advancing user-centric design principles to further enhance the efficiency, reliability, and sustainability of EV charging infrastructure.

The IoT-Based Smart Metering and Charging System for EVs using Arduino controller, relay, and IoT application represents a transformative solution that addresses key challenges in EV charging infrastructure. By leveraging IoT technology, this system offers enhanced operational efficiency, energy management, user experience, and safety, paving the way for widespread adoption of electric vehicles and the advancement of sustainable transportation solutions.

VII. ADVANTAGES

Advantages of IoT-Based Smart Metering and Charging System for EV:

1) *Enhanced Efficiency:* The integration of IoT technology enables real-time monitoring, control, and optimization of EV charging processes, leading to improved operational efficiency and energy utilization.
2) *Convenience:* Users can remotely monitor charging status, adjust charging schedules, and receive notifications through the IoT application, enhancing convenience and flexibility in managing EV charging.
3) *Sustainability:* By optimizing charging schedules and maximizing the use of renewable energy sources, the system promotes sustainability and reduces carbon emissions associated with EV charging operations.
4) *Cost Savings:* Energy management algorithms help minimize energy costs by leveraging off-peak electricity rates and optimizing grid integration, resulting in cost savings for EV owners.
5) *User Experience:* The user-friendly interface of the IoT application enhances the overall charging experience, providing intuitive access to charging information and control functionalities.
6) *Reliability and Safety:* The system ensures safe and reliable charging operations through the integration of safety features such as relay control and robust security measures to protect user data and system integrity.
7) *Grid Integration:* By dynamically adjusting charging parameters based on grid conditions, the system facilitates seamless integration with the existing electrical grid infrastructure, minimizing grid congestion and optimizing energy distribution.
8) *Scalability:* The modular design of the system allows for scalability and expansion to accommodate growing EV adoption and evolving charging needs, making it adaptable to future requirements.
9) *Environmental Benefits:* By promoting the use of electric vehicles and renewable energy sources, the system contributes to environmental conservation efforts and reduces dependence on fossil fuels.

10) *Innovation and Technological Advancement:* The implementation of IoT technology in EV charging infrastructure represents a cutting-edge solution that drives innovation and technological advancement in the transportation sector, paving the way for smart, sustainable mobility solutions.

VIII. CONCLUSION

The core objective of this project was to develop a charging station tailored for small electric vehicles (EVs) to facilitate on-campus usage. Specifically, the capstone project aimed to construct a modest EV charging facility suitable for campus settings. This report provides a comprehensive overview of electric vehicles and EV charging, integrating state-of-the-art research findings. It delves into system design considerations and theoretical calculations essential for the project's implementation. Moreover, it underscores the importance of theoretical computations and meticulous system design in achieving project objectives. Significant attention was dedicated to the study and design of a DC-DC converter with isolation and a DC-AC inverter tailored to accommodate solar energy input and meet the charging requirements of the selected EV models. The report presents an up-to-date analysis of electric vehicle technology and charging infrastructure, shedding light on the latest advancements in the field.

IX. FUTURE SCOPE

In the future, we propose a solution to the current lack of charging stations by installing charging points on electric poles along roadsides. This innovative approach aims to alleviate the inconvenience faced by people when seeking charging stations. The solution not only addresses the issue but also emphasizes the importance of system design and theoretical calculations, particularly concerning solar energy input, the requirements of chosen electric vehicles, and the design of a DC-DC converter with isolation and a DC-AC inverter.

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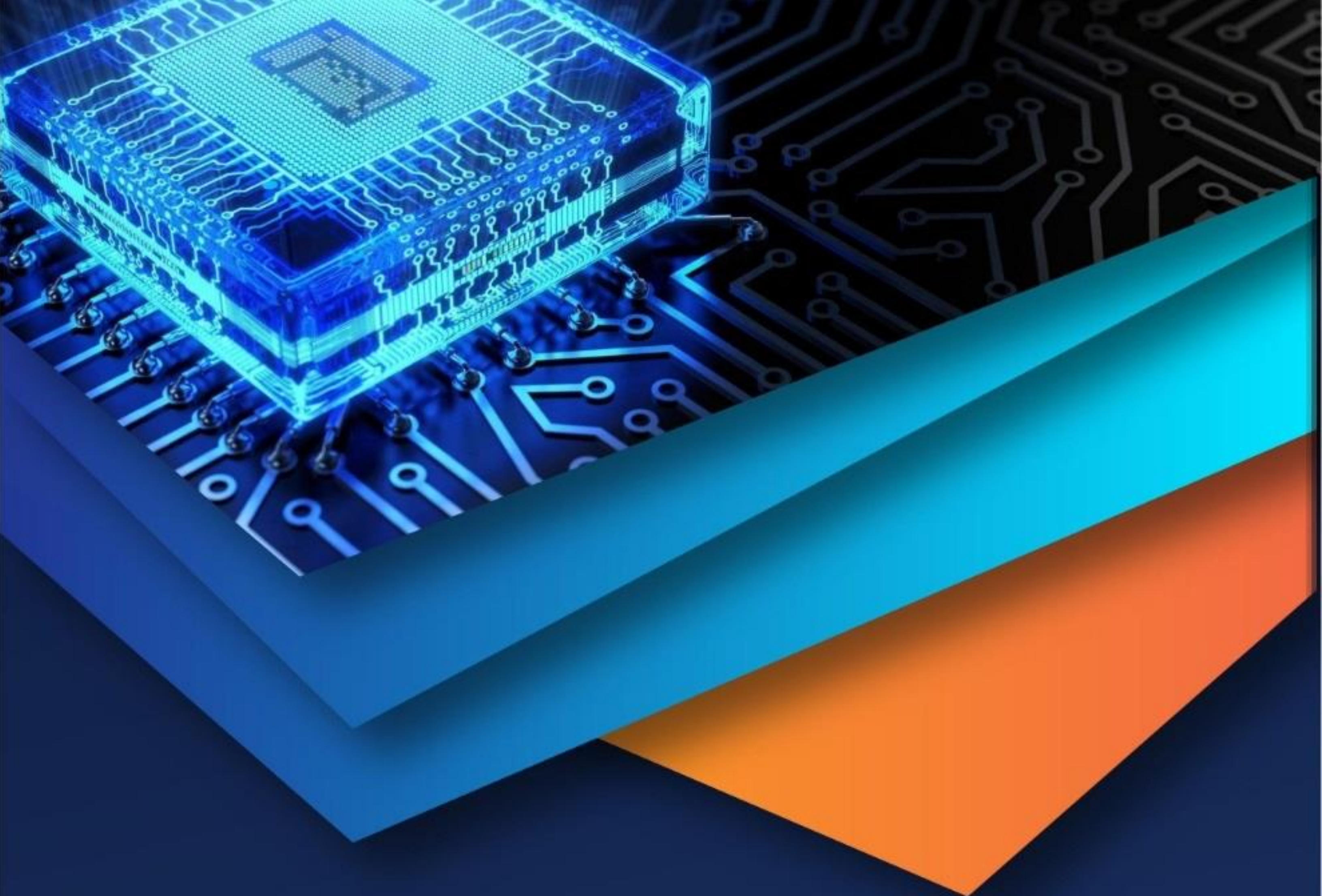

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