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Wireless EV Charging Vehicles Station with QR Code for Live Charging Status: A Review

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Abstract: ***This project presents the development of a Wireless EV Charging Station with QR Code for Live Charging Status, designed to provide an innovative, secure, and user-friendly charging solution for electric vehicles (EVs). The system leverages Arduino Nano for controlling core components, including an RFID module for vehicle authentication, IR sensors for vehicle detection, and a servo motor (SG90) for automated gate control. Wireless power transfer is facilitated through a charging coil, enabling efficient charging of a 4V in-vehicle battery. Real-time monitoring of charging parameters, such as voltage and current, ensures safe and optimized energy delivery. The ESP32 microcontroller enables seamless wireless communication with a mobile app, allowing users to remotely monitor the charging status. The integration of a 0.96-inch OLED display generates a dynamic QR code, providing users with easy access to advanced features on the app. Power regulation is managed via a single-channel relay module, while a 5V DC adaptor ensures continuous operation. This project addresses critical needs in the growing EV ecosystem, offering a sustainable, efficient, and contactless charging experience for users.***
Keywords: Embedded Technology, Wireless EV Charging, Electric Vehicle (EV), RFID Authentication etc.

I. INTRODUCTION

The rapid advancement of electric vehicles (EVs) has brought significant changes to the transportation sector, with growing concerns about environmental sustainability, energy efficiency, and the reduction of carbon emissions. As more individuals transition to electric vehicles, the demand for efficient, accessible, and user-friendly charging solutions has increased. One of the most significant challenges facing the EV industry today is the development of an effective, secure, and reliable charging infrastructure that can meet the needs of a growing number of electric vehicles on the road. Traditional charging stations often involve cumbersome physical connections, complex billing systems, and limited real-time monitoring capabilities. These limitations make the need for innovation in EV charging systems even more pressing. In this context, the development of a Wireless EV Charging Station with QR Code for Live Charging Status offers a cutting-edge solution that addresses many of these challenges while providing users with an efficient, convenient, and secure charging experience.

This project focuses on the integration of wireless technology and Internet of Things (IoT) to create an advanced EV charging station that allows users to charge their electric vehicles without the need for physical connectors. Wireless charging technology offers numerous advantages, including enhanced convenience, reduced wear and tear on physical connectors, and a more streamlined charging experience. By utilizing Arduino Nano, ESP32, and other key components such as RFID modules, IR sensors, and servo motors, the system enables automated charging processes, vehicle authentication, and seamless communication with users via a mobile app. These features ensure a secure, automated, and contactless charging process, making it easier and more efficient for EV owners to charge their vehicles.

A major innovation in this project is the incorporation of real-time monitoring of key charging parameters, such as voltage, current, and charging status, which are displayed on a 0.96-inch OLED display. The display generates a QR code, providing users with direct access to a mobile app that shows detailed information about their charging session. This enables users to track charging progress, receive notifications about charging status, and monitor energy consumption, all in real-time. Additionally, the system is equipped with an RFID authentication mechanism to ensure that only authorized vehicles can charge, further enhancing security.

Traditional EV charging stations often require users to wait in line, manually connect their vehicle to the charger, and rely on fixed payment systems that may not be as convenient or flexible. The QR code-based live charging status feature allows users to access the charging station remotely via their mobile devices, avoiding the need to physically interact with the station. This reduces the overall time spent at the station and provides a more efficient, hands-off charging experience. The system also eliminates the need for physical interaction with the station's gate or charging connectors, as the servo motor automatically controls the gate opening, making the process fully automated.

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In terms of power delivery, the wireless charging coil enables efficient and reliable power transfer to the vehicle's battery without the need for traditional cables or plugs. This significantly reduces the risk of wear and tear on charging connectors, making the system more durable and long-lasting. The integration of the single-channel relay module ensures that power delivery is regulated and controlled, preventing overcharging or undercharging of the vehicle's battery and optimizing energy consumption during each charging session.

Moreover, this project aims to enhance the sustainability of transportation by offering an energy-efficient charging solution that supports the growing adoption of electric vehicles. By reducing the reliance on fossil fuels and encouraging the use of renewable energy sources, the system contributes to a cleaner environment and aligns with global goals for reducing carbon emissions. In addition, by providing an automated, secure, and contactless charging experience, the system addresses user convenience and safety concerns while also improving the overall efficiency of the charging process.

Ultimately, this project aims to revolutionize the way EV charging stations operate, offering a modern and efficient alternative to traditional charging systems. By combining wireless charging, real-time monitoring, user-friendly mobile integration, and advanced security features, this system presents a comprehensive solution that can pave the way for future innovations in the field of electric vehicle infrastructure.

II. PROBLEM IDENTIFICATION

1) Reliance on Wired Connections: Most current EV charging systems rely on physical cables, which are prone to wear and tear, leading to potential issues such as cable damage, poor connections, and user inconvenience. These wired systems can also limit the ease of access and speed of charging.
2) User Inconvenience: Traditional EV charging stations require users to manually connect and disconnect their vehicles, which can be time-consuming and cumbersome, especially in outdoor or public environments where users may face challenges such as poor weather conditions or busy stations.
3) Security Risks: Many existing systems lack robust security measures, such as vehicle authentication, which can lead to unauthorized access or misuse of the charging station. This can lead to improper billing, theft, or fraudulent use of the charging infrastructure.
4) Lack of Real-Time Monitoring: Existing EV charging stations often do not offer real-time monitoring or feedback on the charging process. Users are unable to track the charging status, voltage, current, or energy consumption, which can lead to uncertainty, inefficiency, or potential damage to the vehicle's battery.
5) Limited Automation: Traditional charging stations often lack automation features such as automated gate control, resulting in a less seamless and user-friendly experience. The lack of such features makes the charging process more complex and less efficient.

III. NEED FOR THE SYSTEM

1) Elimination of Wired Connections: The need for a wireless charging system to eliminate the reliance on cables, reducing the risk of wear and tear, damage, and user inconvenience associated with physical connections.
2) Enhanced User Convenience: Users require a more convenient and automated charging experience, reducing the need for manual intervention. The system should provide an effortless, contactless charging process.
3) Improved Security: There is a need for secure vehicle authentication through RFID technology to prevent unauthorized access and ensure only authorized vehicles can use the charging station.
4) Real-Time Monitoring: Users need real-time updates on charging parameters such as voltage, current, and energy consumption to track progress and ensure efficient operation.
5) Automation of Charging Process: The system needs automated features like gate control and power regulation, which will optimize the charging experience and make it more efficient, user-friendly, and error-free.

IV. OBJECTIVES

1) To provide a secure and automated EV charging system using wireless technology.
2) To enhance user convenience with contactless charging and real-time monitoring.
3) To ensure energy efficiency and safety through continuous parameter monitoring.
4) To support sustainable transportation with advanced, user-friendly charging solutions.

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V. LITERATURE REVIEW

1) N. Shankar, K. Ramesh, and A. Kumar (2020)

This study provides an in-depth review of wireless charging technologies, focusing on inductive power transfer (IPT) systems for electric vehicles. It discusses the challenges of efficiency, alignment, and safety in wireless charging methods compared to traditional wired systems. The authors emphasize the growing importance of wireless charging infrastructure to reduce user inconvenience and maintenance costs. They also explore the benefits of eliminating physical connectors, which can improve durability and reduce wear and tear. The study concludes that further advancements in charging efficiency, power control, and standardization are needed for the widespread adoption of wireless EV charging.

2) Smith and L. Johnson (2019)

This paper focuses on the security aspects of EV charging stations, particularly emphasizing the need for robust authentication mechanisms to prevent unauthorized usage. The authors analyze various RFID-based authentication systems and discuss their role in enhancing the security and reliability of charging infrastructure. The study concludes that RFID technology can provide secure access control and user verification, significantly reducing the risk of fraudulent usage. The paper also explores other security measures, including encryption and user authentication via mobile apps, to provide a comprehensive solution to enhance EV charging station security.

3) B. Lee, C. Park, and M. Cho (2021)

This research highlights the importance of real-time monitoring in EV charging stations, emphasizing how continuous tracking of charging parameters such as voltage, current, and energy consumption can optimize performance and user experience. The authors propose an IoT-based monitoring system that provides real-time feedback to users via mobile apps, helping them monitor the status of their EVs remotely. They argue that data analytics can play a crucial role in predicting charging behavior and optimizing power delivery. The study suggests integrating machine learning algorithms to improve the efficiency and management of EV charging infrastructure.

4) M. Patel, R. Kumar, and S. Gupta (2020)

This paper explores the advancements in wireless power transfer (WPT) for electric vehicle charging, particularly the challenges in efficiency and power transfer distances. The authors discuss the types of WPT technologies, including inductive and resonant systems, and how they compare to traditional plug-in charging methods. The paper emphasizes the importance of electromagnetic compatibility and safety standards in WPT systems. The authors also highlight the role of intelligent control algorithms that can optimize power delivery, reduce losses, and ensure the efficiency of wireless charging systems for EVs. The paper concludes with a discussion on the future potential of automated wireless charging stations that can provide users with seamless charging experiences.

5) D. Wang, Z. Li, and Y. Xu (2021)

This paper investigates the integration of IoT in the development of smart EV charging stations, focusing on the benefits of real-time data monitoring. The authors present an IoT-based system that continuously tracks the charging status, power consumption, and health of the EV battery, providing users with insights into the charging process through mobile applications. They emphasize the role of cloud computing in storing and analyzing the large datasets generated by charging stations, which can be used for performance optimization and predictive maintenance. The study shows that real-time monitoring via IoT not only improves efficiency but also enhances the user experience by providing full visibility of the charging process.

6) H. Zhang, L. Zhao, and F. He (2021)

This study addresses the security and privacy issues in electric vehicle (EV) charging systems, particularly in the context of user authentication and payment systems. The authors examine potential vulnerabilities such as data breaches and unauthorized access, proposing solutions like end-to-end encryption, multi-factor authentication, and blockchain technology for secure transactions. The paper discusses how incorporating these technologies can enhance both the security and privacy of users, thus promoting trust in EV charging infrastructure. The authors also highlight the importance of secure communication protocols to ensure data integrity and prevent unauthorized manipulation of charging station operations.

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7) K. Tanaka, M. Shimizu, and S. Sato (2020)
This review paper focuses on the optimization techniques for electric vehicle charging stations, particularly in terms of energy management and charging scheduling. The authors explore how smart grids and demand-response systems can be integrated into charging stations to improve energy efficiency and reduce peak load demands. They discuss various scheduling algorithms, such as genetic algorithms and linear programming, that can optimize the charging process by balancing user demand with grid constraints. The paper highlights the role of predictive analytics in forecasting charging needs and optimizing the allocation of energy resources, making the charging process more efficient and sustainable.

8) Rai, S. Bhat, and R. Chouhan (2019)
This paper explores the role of Internet of Things (IoT) in enhancing electric vehicle charging networks. The authors focus on how IoT technology can enable smart charging stations that automatically adjust charging parameters based on the battery status of the EV and grid conditions. The study presents a case where IoT-enabled sensors and cloud-based analytics optimize energy use, provide real-time updates to users, and enable remote monitoring and control of charging stations. The authors emphasize how IoT improves the efficiency, reliability, and cost-effectiveness of charging infrastructure, making it a key enabler of the future of EV networks.

9) S. Kumar, A. Verma, and P. Mehta (2020)
This paper investigates the integration of wireless power transfer (WPT) and Internet of Things (IoT) technologies in EV charging stations. The authors focus on how wireless charging can simplify the charging process by eliminating physical connectors, while IoT integration can enable real-time monitoring of charging parameters and station status. They discuss the benefits of combining WPT with IoT, such as energy efficiency, user convenience, and remote management of charging stations. The paper concludes that combining these technologies will improve the overall user experience by providing seamless, automated charging with enhanced monitoring capabilities.

10) L. Lin, M. Zhang, and H. Liu (2020)
This paper examines the use of cloud computing to create a smart charging system for electric vehicles (EVs). The authors propose an architecture that combines cloud storage with real-time data analytics to optimize charging schedules and enhance system performance. By utilizing cloud-based platforms, users can access detailed reports on their EV charging, while the system itself adapts to fluctuations in electricity demand and supply. The paper demonstrates that this cloud-integrated solution enhances efficiency, allows for predictive maintenance, and provides users with greater control over their charging activities.

11) R. Gupta, S. Rao, and S. Mehta (2021)
This study explores the use of blockchain technology to secure electric vehicle charging stations against unauthorized access and fraud. The authors suggest that traditional security mechanisms like RFID and password authentication can be vulnerable to breaches. They propose integrating blockchain for secure transaction validation and user authentication, ensuring that only authorized users can access the charging station. The study highlights the potential for blockchain to create transparent, tamper-proof logs of all interactions with the charging station, improving overall system security and trust among users.

12) M. Patil, T. Sharma, and P. Agrawal (2020)
This paper discusses how artificial intelligence (AI) and data analytics can be applied to optimize EV charging stations. The authors explore the use of machine learning algorithms to predict charging demands, manage energy distribution efficiently, and optimize charging schedules based on user habits and grid conditions. They emphasize the role of data analytics in identifying trends and making predictive decisions to ensure that the charging infrastructure operates efficiently and can accommodate high traffic during peak hours. The study advocates for AI's role in enhancing the scalability and adaptability of future EV charging networks.

13) V. Joshi, K. Sharma, and R. Bhaskar (2021)
In this paper, the authors propose an IoT and blockchain-based framework to address the challenges of security and efficiency in EV charging systems. They discuss how IoT sensors can collect data on charging status, battery health, and energy consumption, while blockchain ensures secure data exchange and transactions.

The authors argue that combining these technologies can result in a more reliable, transparent, and secure charging infrastructure. They also explore the potential for using this integrated approach to reduce operational costs and improve the overall user experience in EV charging stations.

14) J. Wang, S. Lee, and X. Zhang (2021)
This review article delves into the development and potential of wireless charging systems for electric vehicles. The authors provide an overview of the technology, focusing on the various techniques for inductive and resonant wireless power transfer. The paper explores the challenges and benefits of wireless charging, such as the elimination of physical connectors, and its integration into existing EV infrastructure. The study also addresses issues like efficiency, alignment, and safety, recommending further research to enhance the reliability and cost-effectiveness of wireless charging solutions in the EV sector.

15) A. Bansal, R. Tiwari, and K. Desai (2020)
This paper discusses the integration of smart technologies in EV charging stations that allow for real-time monitoring and automated control. The authors explore the use of sensors and IoT devices to monitor key charging parameters, including voltage, current, and energy consumption. The paper proposes a centralized system that can automatically adjust the charging parameters based on real-time data and user preferences. Additionally, the study emphasizes the benefits of automating the charging process to minimize human intervention and enhance efficiency while ensuring safety.

Research Gap :
Despite significant advancements in electric vehicle (EV) charging systems, several critical gaps remain unaddressed. Most existing systems are heavily reliant on wired infrastructure, which introduces limitations in user convenience, maintenance, and durability. While some studies have explored wireless power transfer, few have successfully integrated it with secure authentication methods like RFID and real-time data access through IoT platforms. Additionally, the lack of QR code-based smart interfaces for seamless mobile interaction and live monitoring restricts user engagement and system transparency. There is also limited focus on compact, low-voltage wireless chargers for small-scale EV applications. Therefore, a need exists for a fully integrated, secure, wireless, and user-friendly EV charging solution combining automation, IoT, and real-time access features.

VI. METHODOLOGY

The Wireless EV Charging Vehicle Station introduces a smart and contactless approach to powering electric vehicles, effectively overcoming the drawbacks of traditional wired systems. At the core of its security feature is an RFID module, which verifies and authorizes each vehicle before access is granted. Once authorization is successful, IR sensors detect the vehicle's presence, prompting a servo motor (SG90) to automatically open the entry gate to the charging bay. When the EV is properly positioned, the system initiates wireless charging via a coil that transmits energy directly to a 4V in-vehicle battery—eliminating the need for cables. An Arduino Nano serves as the central controller, managing all sensor and actuator functions, while ESP32 handles Wi-Fi-based communication with a dedicated mobile app. Through this app, users can monitor the charging process and access system functions remotely, improving usability and flexibility. A 0.96-inch OLED display provides a QR code that connects users to the Android app for real-time status and controls. Integrated voltage and current sensors track power flow to ensure safety and efficiency, with a relay module regulating energy delivery to the wireless coil. Altogether, the system seamlessly blends IoT, automation, and live monitoring to deliver a secure and futuristic EV charging solution.

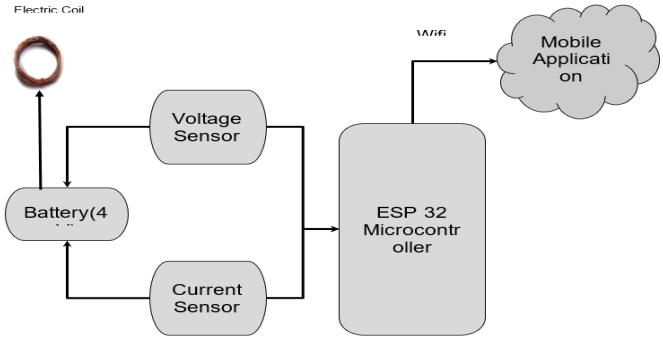


Fig.1. Section 1 Wireless Charging System Using ESP32

- ESP32 Microcontroller: Acts as the central processing unit, managing communication and monitoring in the wireless charging system.
- Voltage and Current Sensors: These sensors are connected to the ESP32, continuously measuring the charging parameters such as voltage and current to ensure safe power transfer.
- 4V Battery: Serves as the energy storage unit in the dummy car, receiving power from the wireless charging coil.
- Wireless Charging Coil: Connected to the 4V battery, this coil enables efficient, contactless energy transfer to the vehicle.

The ESP32 communicates with a mobile application via Wi-Fi, allowing real-time monitoring and control of the charging process. It ensures safety, efficiency, and seamless operation of the wireless charging mechanism.

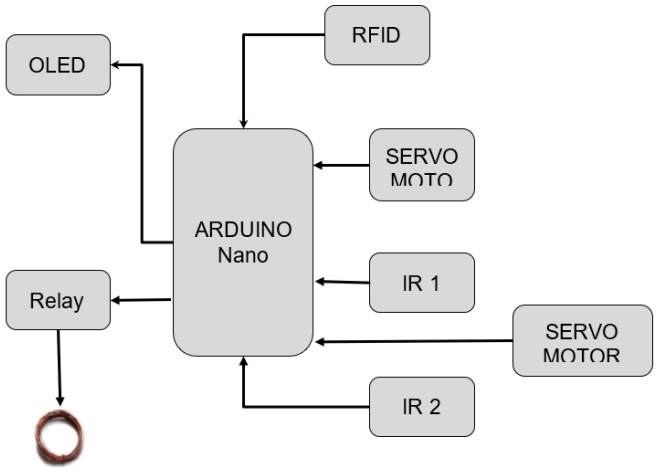


Fig 2. Section 2: Control System Using Arduino Nano

Arduino Nano: Functions as the primary microcontroller for managing inputs and outputs related to access and authentication.

1) Input Components:

- IR Sensors: Two IR sensors are connected to the Arduino Nano to detect vehicle entry and exit.
- SG90 Servo Motor: Controlled by the Arduino Nano, it operates physical access mechanisms, such as opening and closing gates.
- RFID Module: Ensures vehicle authentication by verifying RFID tags against pre-stored data.

2) Output Components:

- OLED Display: Displays relevant information, including a QR code for quick access to advanced functionalities.
- Relay Module: Regulates power flow for operating external devices or mechanisms.

This part of the system automates vehicle detection, access control, and real-time status display, enhancing user convenience and security.

Together, these two block diagrams represent the integration of wireless charging and automated control, showcasing a complete, innovative solution for EV charging infrastructure.

VII.FLOW DIAGRAM

The Wireless EV Charging Station with QR Code for Live Charging Status operates through a seamless sequence of automated steps. When a vehicle enters the station, an IR sensor detects its presence and signals the Arduino Nano to initiate the authentication process using the RFID module, granting access only to authorized vehicles. Upon successful authentication, the SG90 servo motor manages gate access and positions the wireless charging coil beneath the vehicle. The system then triggers the relay module to activate the wireless charging coil, efficiently transferring power to the in-car battery while voltage and current sensors monitor the process in real-time to ensure safety and efficiency. Concurrently, the 0.96-inch OLED display generates a QR code, enabling users to scan and monitor live charging metrics, including voltage, current, and progress, via an Android app. Once charging is complete or the exit IR sensor detects the vehicle leaving, the system deactivates the charging coil, resets the servo motor, and readies itself for the next session, delivering a secure and user-friendly charging experience.

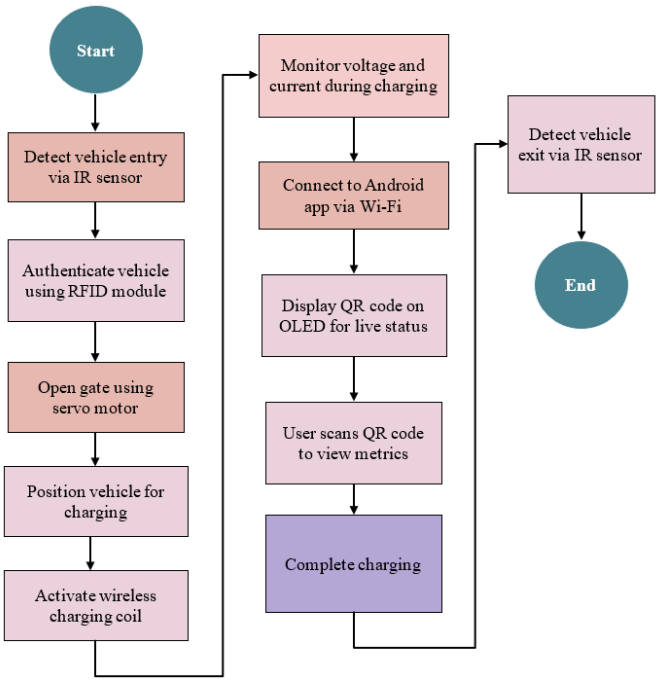


Fig. 3. Flow Diagram

VIII. ADVANTAGES

1) Contactless Charging: The wireless system eliminates the need for physical cables, offering a hassle-free and user-friendly EV charging experience.
2) Enhanced Security: The use of an RFID module ensures that only authenticated vehicles can access the charging station, preventing unauthorized usage.
3) Real-Time Monitoring: Integration with a mobile app allows users to monitor charging parameters such as voltage and current in real-time, improving transparency and control.
4) Reduced Wear and Tear: Unlike wired systems, wireless charging reduces mechanical damage to cables and connectors, leading to lower maintenance costs.
5) Eco-Friendly Solution: Supports the transition to sustainable transportation by offering a smart and efficient charging alternative with low energy loss.

IX. APPLICATIONS

1) Public EV Charging Stations: Perfect for cities aiming to offer secure, automated charging options in public spaces.
2) Residential EV Charging Systems: Offers homeowners an efficient and compact solution for daily vehicle charging.
3) Corporate EV Parking Facilities: Enables companies to support employee EV usage with smart, secure, and automated charging setups.
4) Smart Highways and Rest Areas: Can be integrated into highway infrastructure to provide quick, unattended charging for long-distance travelers.

X. CONCLUSION

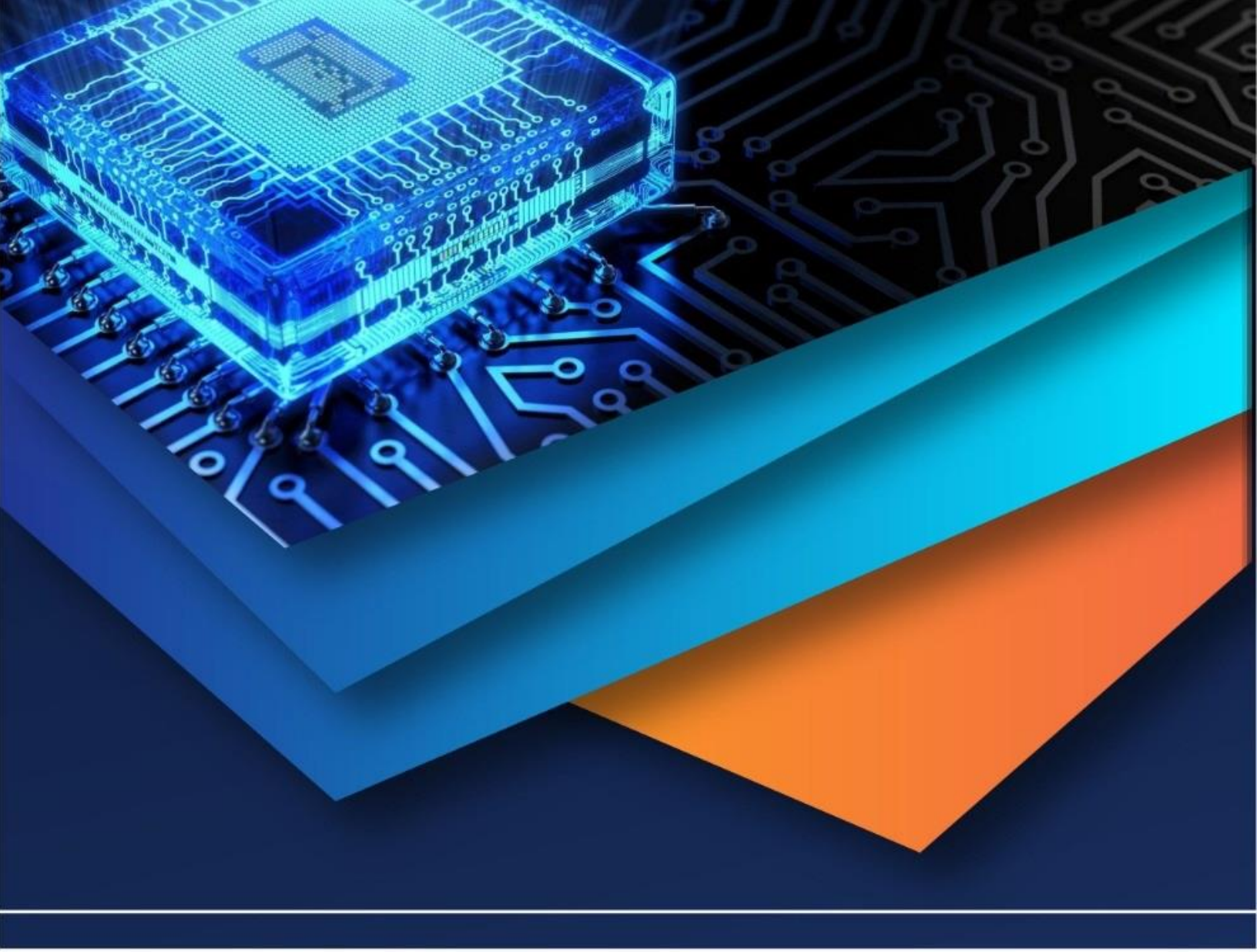
The "Wireless EV Charging Station with QR Code for Live Charging Status" presents an innovative and practical solution to the growing demands of electric vehicle (EV) infrastructure. By replacing conventional wired systems with a wireless charging mechanism, the project eliminates the inconvenience of handling charging cables and reduces maintenance due to wear and tear. The integration of RFID-based authentication ensures only authorized vehicles can access the system, enhancing security and control. IR sensors and a servo motor automate vehicle detection and gate operation, providing a seamless user experience. The Arduino Nano coordinates hardware functions, while the ESP32 microcontroller enables real-time data transmission via Wi-Fi to an Android app, allowing users to monitor charging status remotely.

The system further improves user accessibility with a 0.96-inch OLED display that generates a QR code linking to live charging details. Voltage and current sensors ensure efficient and safe power delivery, monitored continuously to prevent overcharging or faults. This comprehensive integration of wireless charging, IoT technology, and automated control positions the system as a forward-thinking approach to sustainable transportation. By addressing efficiency, safety, and user convenience, this project supports the transition toward smart cities and eco-friendly mobility solutions, offering a glimpse into the future of EV infrastructure.

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