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Research on IoT Based Smart Wireless EV System with Real Time Monitoring

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Abstract - The rapid advancement of electric vehicles (EVs) has brought significant changes to the transportation sector. As electric vehicles (EVs) continue to gain popularity, the need for innovative, efficient, and user-friendly charging solutions has become increasingly important. 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).

This project presents the development of an IoT-based Smart Wireless EV Charging System with Real-Time Monitoring, designed to provide an innovative, secure, and user-friendly solution for charging electric vehicles. By leveraging sensorbased automation, real-time data tracking, and mobile connectivity, the system offers a modern and convenient alternative to traditional plug-in charging methods. The use of dual microcontrollers enables efficient separation of control and communication tasks, ensuring reliable and smooth operation. Advanced features such as automatic gate operation, live charging status accessible via QR code, and battery overcharge protection enhance safety, transparency, and user experience. Overall, the system promotes a smarter, more efficient, and secure EV charging environment aligned with the growing adoption of electric mobility.

KEYWORDS- Embedded Technology, Wireless EV Charging, Electric Vehicle (EV).

I. INTRODUCTION

Traditional plug-in charging stations often require human intervention, physical connectors, and longer charging durations, which can be inconvenient and inefficient for users. The lack of real-time monitoring and automation in these systems limits their ability to adapt to evolving technological needs. These limitations not only reduce user comfort but also make traditional charging solutions less reliable and less secure. Moreover, constant plugging and unplugging of cables lead to wear and tear, increasing maintenance requirements and reducing the overall lifespan of the charging infrastructure. Such drawbacks highlight the urgent need for improved systems that can meet the rising demands of electric vehicle adoption and ensure greater reliability, efficiency, and user satisfaction. In response to these challenges, modern engineering solutions are focusing on wireless charging and IoT integration to enhance the overall EV charging experience. A system that can autonomously detect a vehicle, initiate charging wirelessly, and provide live feedback to users via mobile platforms addresses many of the current limitations. By leveraging microcontrollers, smart sensors, and cloud-based applications, such systems not only simplify charging operations but also ensure safety through features like overcharge protection and parameter monitoring. This approach ensures safety, energy management, and user convenience, paving the way for advanced, sustainable, and intelligent EV charging infrastructures that align with the future of smart transportation.

II. LITERATURE REVIEW

[1] Vijayashanthi, R. S., et. al, In this paper, the author suggests software and hardware systems of charging stations aids to a massive growth in the number of electric vehicles on the road. Here, the dissertation takes three distinct scenarios into account in order to put the system through its paces. With a quick-reference (QR) code, you may see the current balance, choose the charging port, and set the charging time. The suggested scheme is tested by cross-validation with the traditional model known as Solar Powered EV Charging (SPEVC), which is based on Internet of Things (IoT) technology; the system is referred to as IoTSEVC. At DC fast charging stations, customers of electric vehicles may also take advantage of an ideal energy trading solution that takes into account all linked criteria. The electric vehicle metering architecture collects data in real-time at each charging station, allowing for up-to-the-minute insights on the operations and habits of the energy distribution network.

[2] Iqbal, Sheeraz, et al. This research focuses on an innovative wireless power transfer (WPT) system specifically designed for use in office parking areas. This system incorporates renewable energy resources (RERs) and uses the transformative power of the Internet of Things (IoT). It employs a mix of solar energy systems and battery storage solutions to facilitate a sustainable and efficient energy supply to EVs. The integration of IoT technology allows for the automatic initiation of charging as soon as an EV is parked. Additionally, the implementation of the Blynk application offers users real-time access to information regarding the operational status of the photovoltaic system and the battery levels of their EVs. The system is further enhanced with IoT

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and RFID technologies to provide dynamic updates on the availability of charging slots and to implement strict security protocols for user authentication and protection.

[3] Pathik, Bishwajit Banik, et. al, This research presented the challenges and opportunities for the electric vehicle charging station business. The analysis encompasses infrastructure development, technological barriers, charging station models, public awareness, and payment systems. A mobile application payment system has been developed for electric vehicle charging stations that meets the needs of both merchants and users. For merchants, the application facilitates transactions by ensuring a secure and efficient payment process. The main goal of the research is to introduce EV users to new technology in mobile application payment systems.

[4] Pakhare, Shalom Richard, et. al, The author's project presented a system designed to facilitate the existing power grid infrastructure. The system employs the Raspberry Pi as our primary controller board and hosts the User Interface on the LCD Display mounted on the Charger Housing. The Pi Board interfaces with our custom Pilot PCB to communicate with the Electric Vehicle Battery Management Systems to negotiate the charging speed, capacity of the car battery and perform safety checks. The user can choose AC level 1, 2 or DC level 3 charging. The system uses a 30A relay circuit to isolate the battery from the power supply until all the necessary checks and payment processes are completed.

[5] Shahin, Ahmed, et. al, This paper comprehensively analyzes EV charging methods with a particular focus on both grid-based direct charging and the utilization of renewable energy sources. However, the most practical approach for EV charging is through large-scale grid-based renewable energy stations. This study outlines the significant challenges facing the application of EV chargers. Overcoming these challenges is vital for the widespread adoption of new technologies such as Wireless power transfer charging systems in the EV sector.

[6] Cheng, Wen-Yu, Wen-Chung Cheng, et al. In this paper, we propose to develop a low-cost wireless charging system based on the on-board vision/camera sensor. This design is capable of autonomous docking for the robot chassis without further external supervision. Specifically, we use the QR codes to label the charging station and establish the robot's camera vision system to recognize the dock. The robot will drive to the station automatically. The low-cost charging station is also designed for wireless charging of the robot.

[7] Pathik, Bishwajit Banik, et. al, This paper proposes a prepaid system for solar PV-based EV charging stations. The planning and design of an RFID-based solar-powered charging for electric vehicles will enable seamless and efficient payment transactions between users and charging station operators. EV customers can get charging services by coming to the station and making real-time payments through an RFID card or mobile application. Here a solar photovoltaic (PV) EV charging station has been designed to reduce the demand on the grid system.

[8] Balamurugan, et. al, In this paper, The main aim of the project is to charge multiple brand Electric Vehicle (EV) in single station with real time monitoring, fast charging facility and some smart features which are not available in current market. This increasing market makes an opportunity to build Universal Electrical Vehicle Charging Station (UEVCS) and make the user satisfied to use EV. The station has charging and smart features for all types of EV.

[9] Vujasinović, Jovan, et. al, Realization of hardware and software of such a terminal has been described in this paper. The net result of development and commercialization of terminals would encourage an increase in the use of electric vehicles powered by energy from renewable sources, which would cause a decrease in the level of air pollution and all negative effects it causes in the future. Different categories of this device are considered. Moreover, although it is a device with embedded software, a very advanced method was used, that is, a modeldriven development method, which enables fast and more efficient development and maintenance of the device.

[10] Nethravathi, S. et. al, The proposed pricing model aims to maximise user satisfaction by keeping the charging bills low, as well as maximise the utilisation of renewable energy to lower the dependency on the grid. The blueprint also includes a comprehensive business plan to discuss its feasibility. Furthermore, the blueprint also involves building a suitable interface for EV users through a mobile application to efficiently book slots and charge their EVs and an admin dashboard supervises all the operations and helps keep an eye on the operational constraints.

III. METHODOLOGY

The proposed system introduces the "EV Charging Station Enabled with QR Code Live Status Access" project which integrates two microcontrollers: Arduino Nano and ESP32 NodeMCU. The Arduino Nano is responsible for controlling the wireless charging coil and handling battery charging operations, while the ESP32 manages real-time monitoring and data communication with the Android application.

When a vehicle approaches the charging station, an IR sensor module detects its presence. Based on this detection, the servo motor (SG90) automatically lifts the gate, granting access to the charging spot. Once the car is properly positioned, the Arduino Nano activates the wireless charging coil, which begins charging the 3.7V battery installed in the vehicle. To ensure safe charging, voltage and current sensors continuously monitor the charging parameters. An overcharge protection mechanism is implemented: when the battery reaches 100% charge, the relay module instantly

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disconnects the charging supply to avoid overheating or damage.

Meanwhile, the ESP32 NodeMCU collects real-time data from the sensors and displays a QR code on the 0.96-inch OLED display. By scanning this QR code, the user can directly access an Android application to view live charging information such as voltage, current, and battery status via Wi-Fi.

The system is powered by a 5V DC supply and uses two separate 3.7V batteries—one placed in the EV for charging and another to power the wireless transmission coil. This design ensures stable operation and uninterrupted monitoring.

❖ BLOCK DIAGRAM

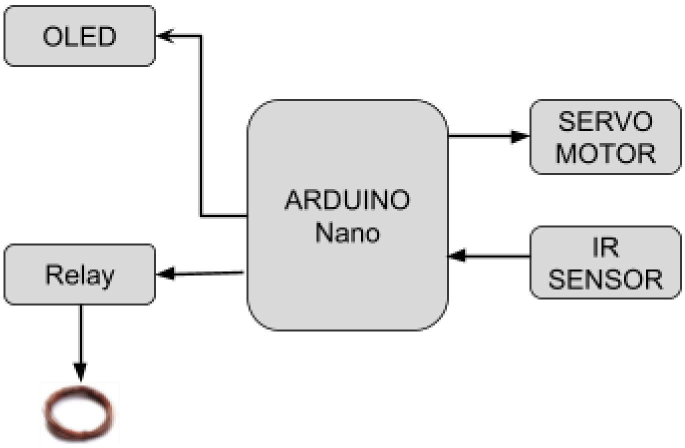

Fig. 1 (A)

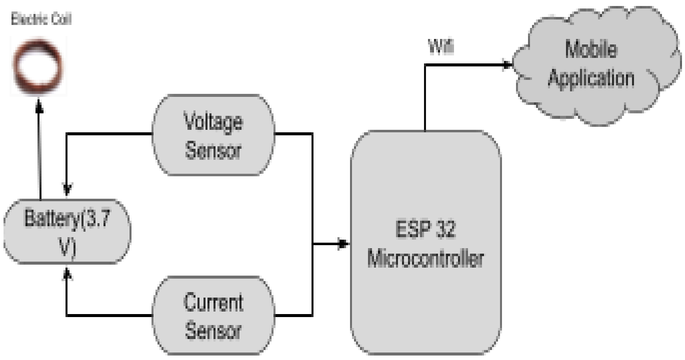

Fig. 1 (B)

Fig. 1 (A) & 1 (B) Shows the Block Diagram of Proposed System

DESCRIPTION

Block Diagram 1: Control System Using Arduino Nano

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

i. Input Components:

- **IR Sensors:** One IR sensor is 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.

ii. 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.

Block Diagram 2: 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.
- **3.7V Battery:** Serves as the energy storage unit in the dummy car, receiving power from the wireless charging coil.
- **Wireless Charging Coil:** Connected to the 3.7V battery, this coil enables efficient, contactless energy transfer to the vehicle.

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

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❖ FLOW CHART

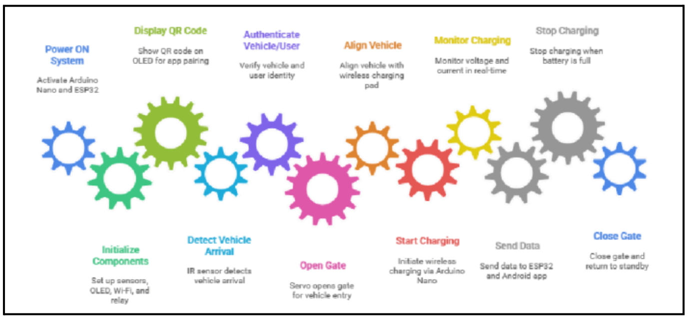

Fig. 2 Shows the Flowchart of the Proposed System

WORKING

The IoT-based Smart Wireless EV Charging System operates through coordinated interaction between the Arduino Nano and the ESP32 NodeMCU to provide automated and safe vehicle charging with real-time monitoring. When the system is powered on, the IR sensor continuously detects the presence of a vehicle at the charging station. Upon detection, the Arduino Nano activates the SG90 servo motor to automatically open the gate, allowing the vehicle to enter and position itself over the wireless charging coil. Once properly aligned, the Arduino Nano initiates wireless power transfer to charge the 3.7V battery installed in the vehicle. During the charging process, voltage and current sensors continuously monitor battery parameters to ensure safe operation. If the battery reaches full charge, the relay module immediately disconnects the power supply to prevent overcharging and overheating. Meanwhile, the ESP32 NodeMCU gathers real-time charging data and displays a QR code on the 0.96inch OLED screen, enabling users to scan and access an Android application via Wi-Fi to view live battery status, voltage, and charging progress. The system is powered by a 5V DC supply and uses separate 3.7V batteries for the EV and wireless transmission coil to ensure stable performance. After charging is complete and the vehicle leaves, the gate closes automatically, and the system returns to standby mode for the next user.

IV. SYSTEM REQUIREMENT

HARDWARE REQUIREMENT

1. Arduino Nano
2. NodeMCU ESP32 Module
3. IR Sensor
4. Current Sensor
5. Voltage Sensor
6. 0.96 inch OLED Display
7. 3.7V Battery
8. Electric Coil
9. Relay Module (Single channel)
10. Servo Motor SG90
11. 5V DC Adapter

SOFTWARE REQUIREMENT

1. Arduino IDE
2. Proteus

V. EXPERIMENTAL SETUP & RESULT

Fig. 3 Shows the Experimental Setup of the Proposed System

RESULT

The project delivers a secure, efficient, and user-friendly charging experience. The system effectively integrates critical components, including an IR sensor for entry detection, a servo motor for automated gate control, a wireless charging coil for contactless energy transfer, and an OLED display for QR code generation. Each function, from vehicle detection and authentication to automated coil positioning and real-time charging status monitoring, operates seamlessly, ensuring safe, reliable, and optimal energy transfer to the in-car battery.

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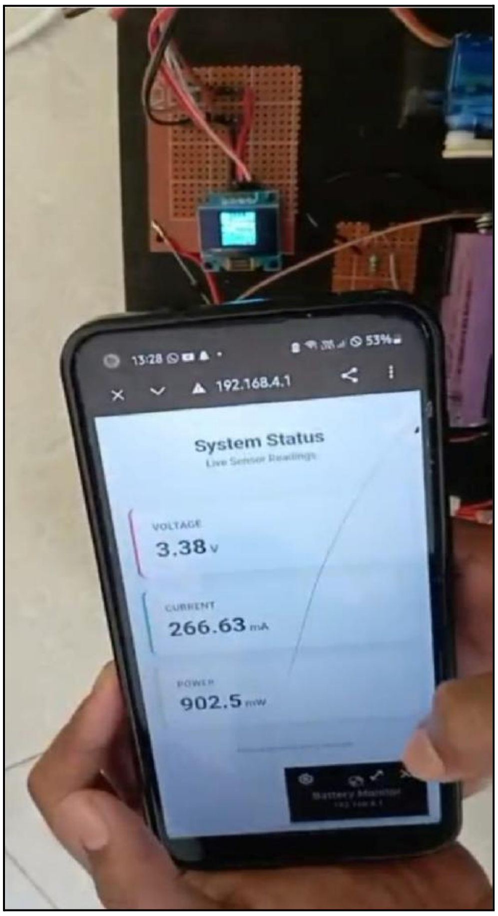

Fig. 4 Shows the Live System Status of the EV Charging Station Displayed on the Android Application, Showing Voltage (3.38 V), Current (266.63 mA), and Power (902.5 mW) Parameters

The user scans the QR code displayed on the charging station using a smartphone. After scanning the QR code, the Android application opens and displays the real-time charging parameters such as voltage, current, and power. This allows the user to monitor the live charging status of the EV wirelessly.

The Android application displays the live operational status of the EV charging station after scanning the QR code. The application shows real-time electrical parameters including voltage (3.38 V), current (266.63 mA), and power (902.5 mW) measured by the sensors connected to the ESP32 microcontroller. This feature allows the user to remotely monitor the charging performance and system condition through the mobile interface.

VI. CONCLUSION

This project successfully implements a smart, wireless EV charging station equipped with automated control, real-time monitoring, and enhanced safety features. By utilizing a dualmicrocontroller architecture—Arduino Nano for hardware-level control and ESP32 NodeMCU for wireless communication—the system ensures smooth coordination between all components. The use of an IR sensor combined with a servo motor enables seamless vehicle detection and gate operation, eliminating the need for manual access systems. Wireless charging technology, supported by real-time voltage and current sensing, ensures efficient energy transfer to the vehicle battery while the overcharge protection mechanism safeguards battery life and system reliability. The integration of a QR-code-based mobile interface allows users to track live charging parameters remotely, improving usability and transparency. Overall, the project demonstrates a low-cost, scalable, and user-friendly solution that aligns with the evolving needs of electric mobility and smart infrastructure.

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