Research Paper on ElectroLane Wireless EV Platform

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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 paper 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).

By leveraging sensor-based automation, real-time data tracking, and mobile connectivity, the system offers a modern alternative to traditional plug-in charging methods. The use of dual microcontrollers enables efficient separation of control and communication tasks, ensuring reliable performance. Features such as automatic gate operation, live charging status via QR code, and battery overcharge protection collectively contribute to a safer and smarter charging experience. This solution not only reduces human intervention but also aligns with future-ready infrastructure demands in the electric mobility sector.

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

I. INTRODUCTION

With the increasing adoption of electric vehicles (EVs) as a sustainable mode of transportation, the demand for smart and efficient charging infrastructure has become a critical area of development. Rising concerns over fossil fuel depletion, greenhouse gas emissions, and urban air pollution have accelerated the shift toward electric mobility worldwide. However, the effectiveness of this transition largely depends on the availability of reliable, safe, and user-friendly charging solutions. Traditional plug-in charging stations often require human intervention, physical connectors, and precise handling, which can be inconvenient, time-consuming, and prone to wear and maintenance issues. Furthermore, longer charging durations and limited automation reduce the overall usability of such systems.

In addition, conventional charging stations generally lack real-time monitoring, intelligent access control, and seamless user interaction, limiting their adaptability to modern digital ecosystems. Users often have minimal visibility into charging status, energy consumption, or system health, which affects transparency and user confidence. These limitations highlight the need for advanced charging systems capable of autonomous operation, enhanced safety mechanisms, and effective communication with users in real time.
In response to these challenges, modern engineering solutions are increasingly focusing on wireless charging and embedded system integration to enhance the overall EV charging experience. Wireless power transfer eliminates the need for physical connectors, reducing mechanical losses and improving operational safety, especially in automated or unattended environments.

A system that can autonomously detect a vehicle, initiate charging wirelessly, and provide live feedback to users via mobile platforms effectively addresses many of the shortcomings of traditional charging methods. The incorporation of embedded controllers, sensors, and IoT-based communication enables real-time data acquisition, intelligent decision-making, and remote monitoring.

This approach not only improves operational efficiency but also ensures better safety, energy management, and user convenience through features such as overcharge protection and live charging status updates. By combining embedded electronics with smart communication protocols and automation techniques, such systems pave the way for future-ready, scalable, and intelligent charging infrastructure that aligns with the broader vision of smart cities and sustainable transportation networks.

II. LITERATURE REVIEW

[1] Vijayashanthi, R. S., et. al 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 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 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]Bishwajit Banik, et. al 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]Shalom Richard, et. al, presented a system designed to facilitate the existing power grid infrastructure. The system employs the Raspberry Pi as primary controller board and hosts the User Interface on the LCD Display mounted on the Charger Housing. The Pi Board interfaces with 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 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. proposes 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, 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, aims 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 with 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 model-driven development method, which enables fast and more efficient development and maintenance of the device.

[10] Nethravathi, S. et. al, 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 presents an intelligent and fully automated EV charging solution, powered by two integrated microcontrollers: Arduino Nano and ESP32 NodeMCU. By using a single IR sensor, which detects the arrival of the vehicle at the station. Upon detection, a servo motor (SG90) automatically lifts the gate, allowing the vehicle to proceed to the charging position—thus combining detection and access control in one mechanism.

Once the car is positioned correctly, the Arduino Nano controls the wireless charging coil, initiating charging to a 3.7V battery placed in the vehicle. A voltage sensor and a current sensor monitor the charging parameters in real-time. To ensure safety, a battery overcharge protection mechanism is implemented: when the battery reaches full charge (100%), a relay module immediately disconnects the power supply to prevent overheating or damage.

Simultaneously, the ESP32 NodeMCU collects live sensor data and generates a QR code on a 0.96-inch OLED display. This QR code links the user to an Android application, where they can monitor real-time voltage, current, and charging status remotely via Wi-Fi.

This paper merges automation, IoT, and wireless energy transfer, providing a modern, secure, and user-friendly charging experience without any physical contact or manual control.

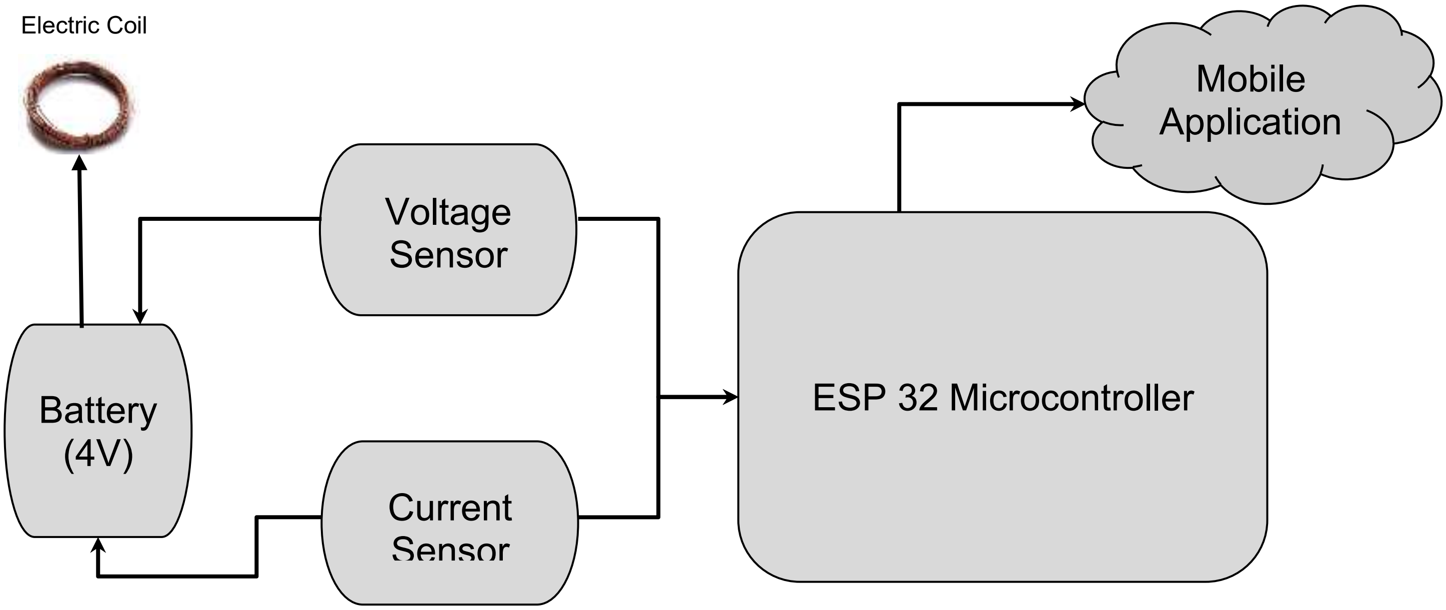

Fig. 1. Wireless Charging System Using ESP32

DESCRIPTION

- **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 Wi-Fi, allowing real-time monitoring and control of the charging process. It ensures safety, efficiency, and seamless operation of the wireless charging mechanism.

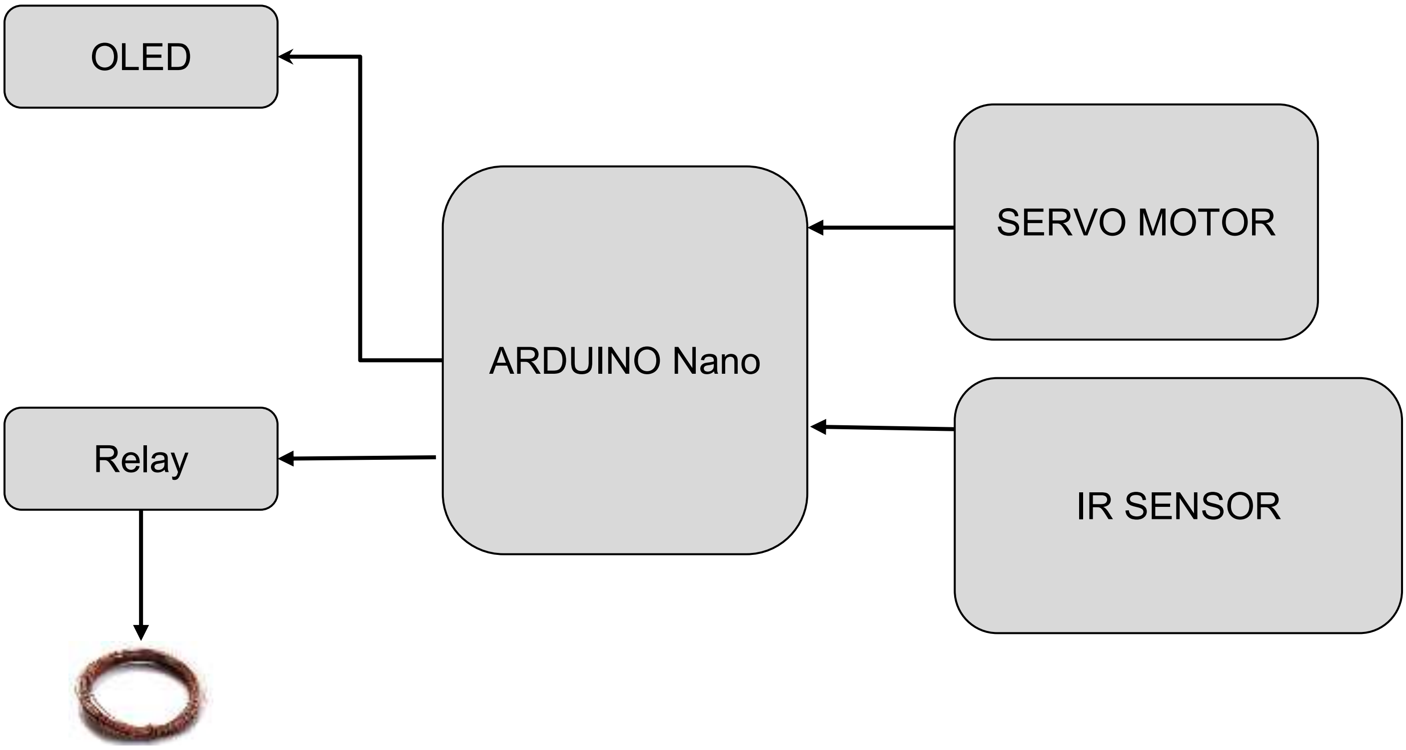

Fig.2. Control System Using Arduino Nano

DESCRIPTION

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.

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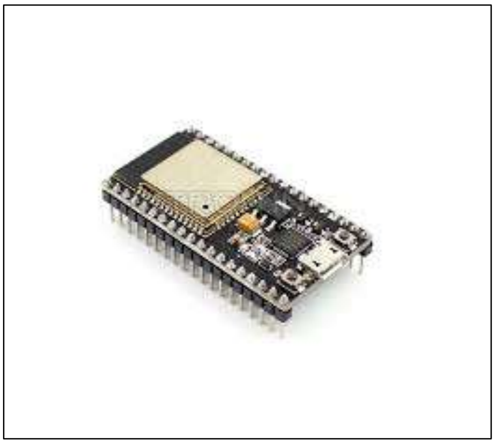
HARDWARE REQUIREMENT

1. Arduino Nano

Fig.3 Arduino Nano

- Operating Voltage: 5V
- Input Voltage: 7–12V
- Digital I/O Pins: 14 (6 PWM)
- Analog Inputs: 8
- Flash Memory: 32 KB
- SRAM: 2 KB
- Clock Speed: 16 MHz

2. NodeMCU ESP32 Module



1. Fig.4 NodeMCU ESP32 Module

- Microcontroller: ESP32 (dual-core)
- Operating Voltage: 3.3V
- Input Voltage: 5V (via USB)
- Clock Speed: Up to 240 MHz
- Flash Memory: Typically 4 MB
- Wi-Fi: 802.11 b/g/n
- Bluetooth: Classic + BLE

3. IR Sensor

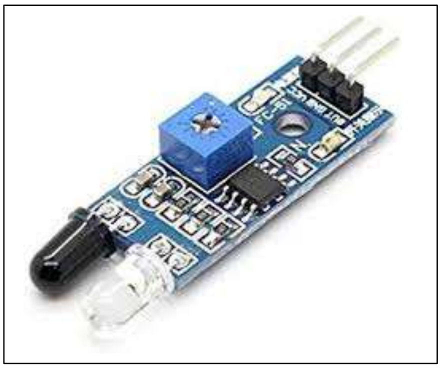


Fig.5 IR Sensor

- Operating Voltage: 3.3V–5V
- Operating Current: ~20 mA
- Detection Range: 2 cm – 30 cm (adjustable)
- Output Type: Digital (HIGH/LOW)
- IR Transmitter & Receiver: Built-in

4. Current Sensor

Fig.6 ACS712

- Operating Voltage: 5V
- Current Range: ±5A / ±20A / ±30A (varies by model)
- Output Type: Analog Voltage
- Sensitivity:
  - 185 mV/A (5A version) [We use this]
  - 100 mV/A (20A version)
  - 66 mV/A (30A version)
- Isolation: Built-in electrical isolation

5. Voltage Sensor

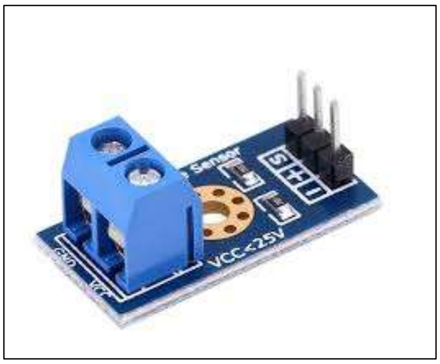


Fig. 7 Voltage sensor

- Input Voltage Range: 0–25V DC
- Operating Voltage: 5V
- Output Type: Analog (scaled voltage output)
- Based on: Resistive voltage divider circuit

6. 0.96 inch OLED Display

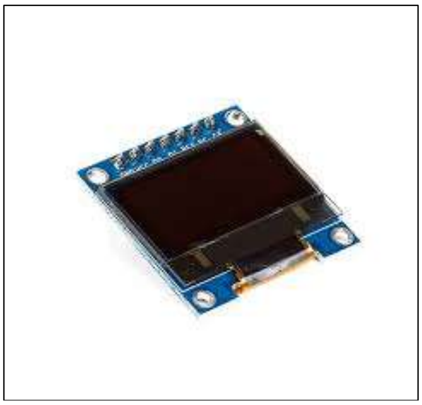


Fig.8 0.96 inch OLED Display

- Display Size: 0.96 inch
- Resolution: 128 × 64 pixels
- Operating Voltage: 3.3V–5V
- Communication: I2C (commonly)
- Driver IC: SSD1306 (in most modules)

7. <u>3.7V Battery</u>

Fig. 9 3.7v battery

- Nominal Voltage: 3.7V
- Fully Charged Voltage: 4.2V
- Typical Capacity: 500 mAh – 3000 mAh (varies by model)
- Rechargeable: Yes
- Battery Type: Lithium-ion or Lithium-polymer
- Discharge Current: Depends on rating (C-rating)
- Lightweight and compact
- High energy density
- Rechargeable with proper charging module
- Suitable for portable and IoT devices
- Provides stable power for microcontroller-based systems

8. <u>Electric Coil</u>

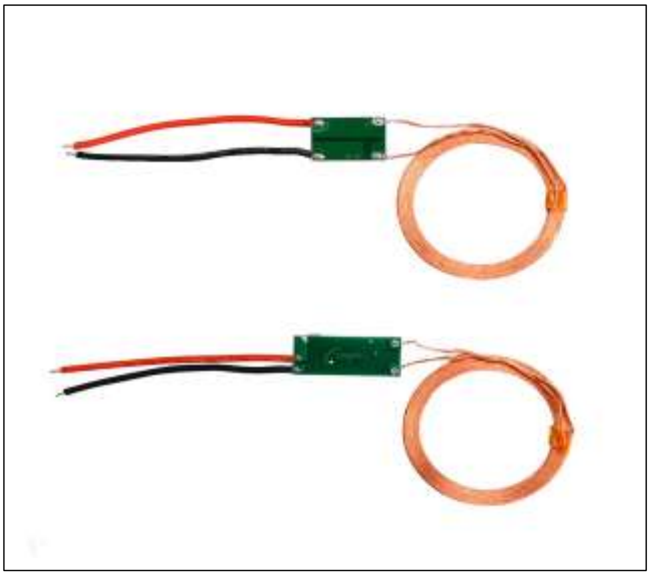


Fig. 10 Electric coil

- Operating Voltage: Depends on design (commonly 5V)
- Material: Copper winding
- Resistance: Varies as per wire gauge and turns
- Core Type: Air core or Iron core

9. Relay Module (Single channel)

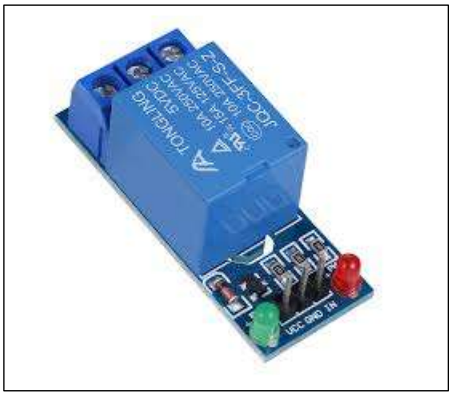


Fig. 11 Relay Module

- Operating Voltage: 5V (commonly)
- Trigger Type: LOW / HIGH level (depends on module)
- Relay Type: SPDT (Single Pole Double Throw)

10. Servo Motor SG90

Fig. 12 Servo Motor

- Operating Voltage: 4.8V–6V
- Operating Current: ~100–250 mA (no load)
- Torque: ~1.8 kg·cm at 4.8V
- Rotation Angle: 0°–180°
- Control Signal: PWM (50 Hz)

SOFTWARE REQUIREMENT

1. Arduino IDE
2. Proteus

The proposed Wireless EV Charging Station with QR Code–Based Live Charging Status demonstrates a practical integration of wireless power transfer, embedded systems, and IoT technologies to address limitations found in conventional plug-in EV charging systems. Compared to traditional charging stations that rely heavily on manual connections and limited monitoring, this system emphasizes automation, user convenience, and safety.

One of the key strengths of the proposed design is the dual-microcontroller architecture, where the Arduino Nano and ESP32 NodeMCU handle control and communication tasks separately. This separation improves system reliability and reduces processing load on a single controller, which is consistent with modern embedded system design practices. Similar approaches have been highlighted in prior works that stress modularity and scalability in EV charging infrastructure.

The wireless charging mechanism eliminates physical connectors, reducing wear, maintenance requirements, and user handling errors. Although wireless charging typically exhibits lower efficiency compared to wired charging, its advantages in safety, ease of use, and future smart-city compatibility make it a promising alternative, especially for low-power or short-range charging applications such as parking-based EV charging.

Actual documentary of project

1. IoT-Based Dynamic EV Charging Prototype

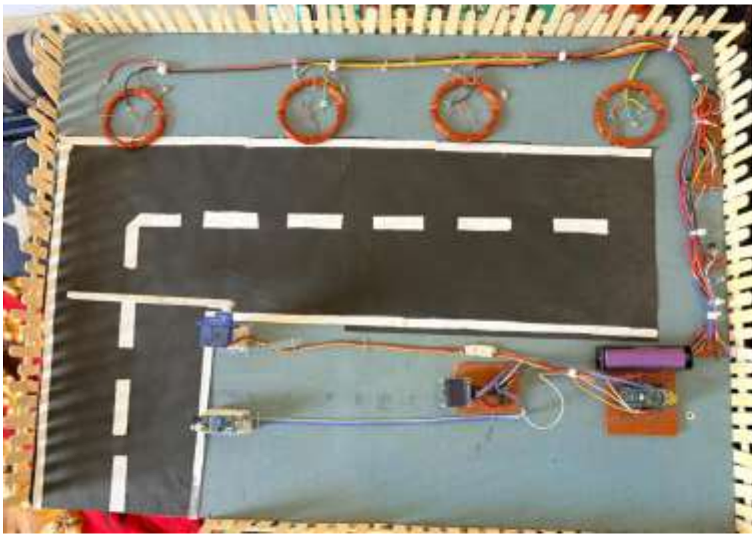


Fig.13 IoT-Based Dynamic EV Charging

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2. Electromagnetic Inductive Charging Road Model

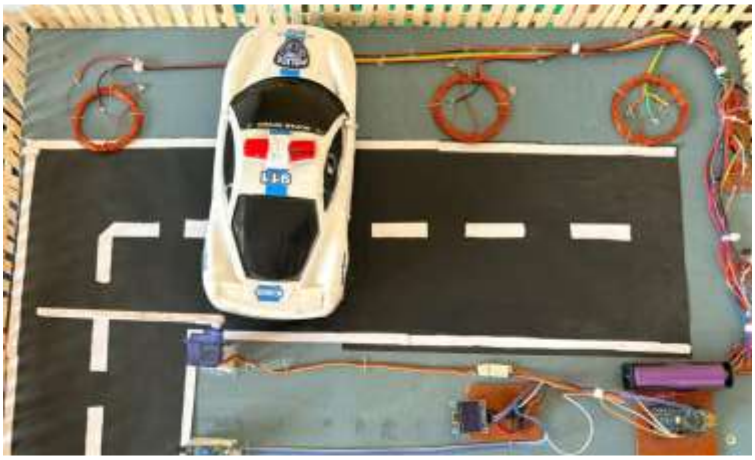

Fig.14 Electromagnetic Inductive Charging Road Model

3. Embedded-Based Smart Car

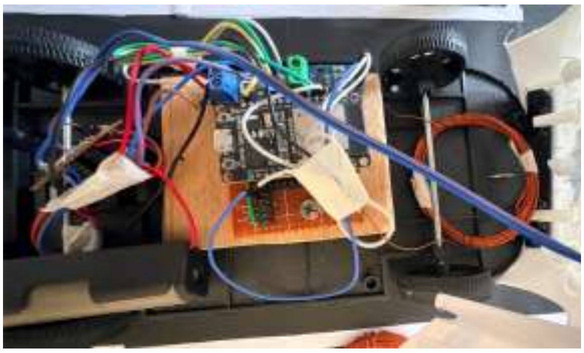

Fig.15 Embedded-Based Smart Car

IV. DISCUSSION

The proposed wireless EV charging station integrates embedded control, automation, and IoT-based monitoring to overcome several limitations of conventional plug-in charging systems. The use of a dual-microcontroller architecture, consisting of Arduino Nano and ESP32 Node MCU, enables efficient task distribution where control operations such as vehicle detection, gate automation, and relay switching are handled independently from communication and data visualization functions. This architectural separation enhances system stability, response time, and scalability. The wireless charging mechanism reduces mechanical wear and user dependency on physical connectors, thereby improving safety and reliability. Although wireless power transfer generally exhibits lower efficiency compared to wired charging, its contactless nature, reduced maintenance, and suitability for automated environments make it highly relevant for future smart parking and charging infrastructures.

In addition, the integration of real-time voltage and current sensing with automatic overcharge protection ensures safe battery operation and prevents thermal stress, addressing a major concern in EV charging systems. The QR-code-based live charging status provides a simple yet effective interface for users to remotely monitor charging progress through a mobile application, eliminating the need for constant physical supervision. Automation through IR-based vehicle detection and servo-controlled gate operation further minimizes human intervention, enabling seamless and secure access control. While the present implementation focuses on a low-power prototype using a 3.7V battery, the system successfully demonstrates the feasibility of combining wireless charging, IoT monitoring, and automation into a single platform. With future enhancements such as higher-power coils, improved alignment methods, and renewable energy integration, the proposed system has strong potential for real-world deployment in smart and sustainable EV charging networks.

V. CONCLUSION

This paper successfully implements a smart, wireless EV charging station equipped with automated control, real-time monitoring, and enhanced safety features. By utilizing a dual-microcontroller architecture ESP32 Microcontroller 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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