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IoT-Based Wireless EV Charging Station Using Arduino Uno

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Abstract: The rapid growth of embedded systems and automation has increased the demand for intelligent monitoring and control solutions in low-power electrical applications. This project presents the design and implementation of an Arduino Uno–based monitoring and control system for a copper winding charging station. The system integrates voltage and current sensors to continuously monitor electrical parameters, ensuring safe and efficient operation. An IR module is employed for object or position detection, while a relay and servomotor provide controlled switching and mechanical actuation, respectively. Wireless communication capability is enabled through the ESP8266 module, allowing Internet of Things (IoT)–based data transmission and remote monitoring. A 16×2 LCD is used to display real-time system parameters such as voltage, current, and operational status. The Arduino Uno serves as the central controller, processing sensor data and executing control logic programmed using the Arduino IDE. The proposed system offers a low-cost, reliable, and scalable solution for automated charging station applications, with potential extension to smart energy management and industrial automation systems.

Keywords: Arduino UNO, LCD Display, Voltage Sensor, Current Sensor, IR Sensor, ESP8266, Servomotor, Copper Coil, Connecting Wires, Arduino IDE – C Programming

I. INTRODUCTION

Electric vehicles are vehicles powered by electric motors using electricity from batteries. The electrical vehicle (EV) is the most suitable alternative of petrol vehicles. The rise in electric vehicle adoption has created a need for advanced, efficient, and user-friendly charging methods. Integrating this system with the IoT brings intelligence, connectivity, and automation to the charging process. This system eliminates the need for physical cables, providing a more convenient and efficient charging solution. An innovative system that enables electric vehicles to charge wirelessly using electromagnetic induction, enhanced by the IoT technology for smart monitoring and control.

II. LITERATURE SURVEY

In one study [1] The reviewed paper shows that creating an electric vehicle (EV) wireless charging station that leverages IoT technology to manage and control the charging process. The key components used in this project include a NodeMCU, IR sensors, relays, transfer and receiver coils, and an LCD display as shown in figure-1. The blynk app is utilized for remote control and monitoring. The NodeMCU microcontroller is the central unit of the system, responsible for executing the program that controls the entire operation. It is programmed to interface with the IR sensors, relay, and LCD Display. The Node MCU also connects to the blynk IOT app, allowing for remote control and monitoring of the charging process. Two IR sensors are used in the project to detect` the presence of a vehicle at the charging spots. When a vehicle is detected at a specific spot, the corresponding IR sensor sends a signal to the NodeMCU. For instance, if IR sensor1 detects a vehicle, it indicates that spot1 is occupied. Similarly, IR sensor 2 indicates the status of spot2. This information is crucial for the system to know when a vehicle is in position for charging. Relays are used to control the power transfer from the charging station to the vehicle.

In another paper [2] The study indicates that existing prepaid electricity IoT Integrated Dynamic Wireless Charging System for Electric Vehicles consists of an intelligent energy-metering and control architecture that continuously measures electrical parameters such as voltage, current, power, and energy transfer during wireless charging as shown in figure-2. The meter system is embedded with IoT-enabled sensors and a microcontroller that acquires real-time data from the wireless power transmission unit and communicates it to a centralized monitoring platform via the internet. This system enables dynamic billing, charging status visualization, fault detection, and usage analytics, thereby eliminating the need for conventional wired meters and connectors.

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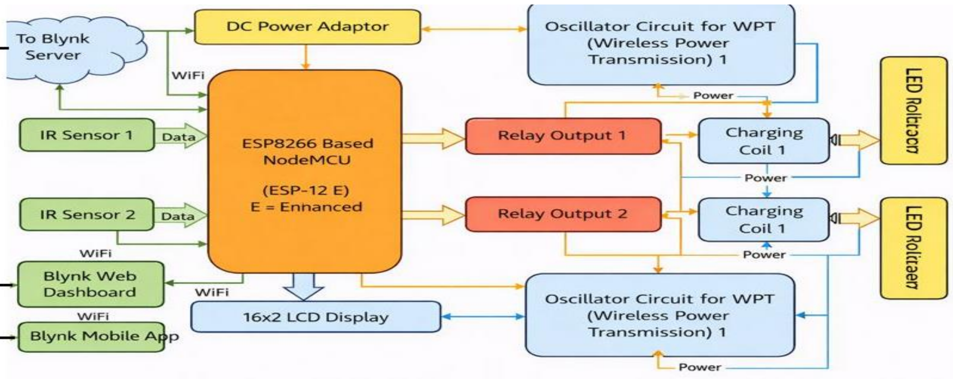

Figure 1: Simulation of IoT based EV wireless charging

By integrating smart metering with dynamic wireless charging, the system improves charging efficiency, enhances user convenience, and supports scalable, customizable energy management, making it suitable for modern electric vehicle infrastructure as highlighted in the IEEE conference publication

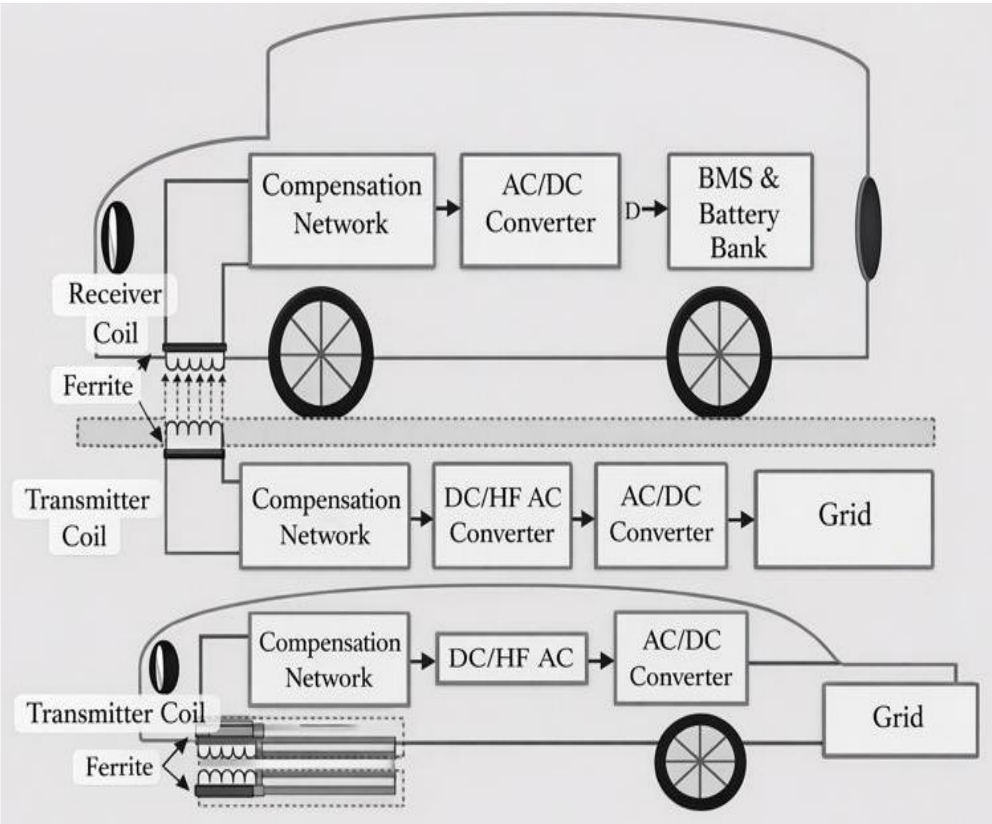

Figure 2: The dynamic wireless charging system

In another paper [3] The Paper highlight consistent shift from traditional. Implementation of Battery Management and Wireless Charging in Electric Vehicles Using IoT presents a block-diagram-based architecture in which the system is divided into sensing, control, communication, and power-transfer modules. The battery management system (BMS) block continuously monitors battery parameters such as voltage, current, temperature, and state of charge using dedicated sensors, and this data is processed by a central microcontroller as shown in figure-3. The wireless charging block consists of a transmitter coil powered by a controlled AC source and a receiver coil coupled to the EV battery through a rectifier and regulation unit, ensuring safe and efficient energy transfer. An IoT communication block enables real-time data transmission to a cloud or mobile application, allowing remote monitoring, diagnostics, and control of charging operations. The coordinated interaction of these blocks ensures optimized charging, improved battery health, enhanced safety, and a better user experience.

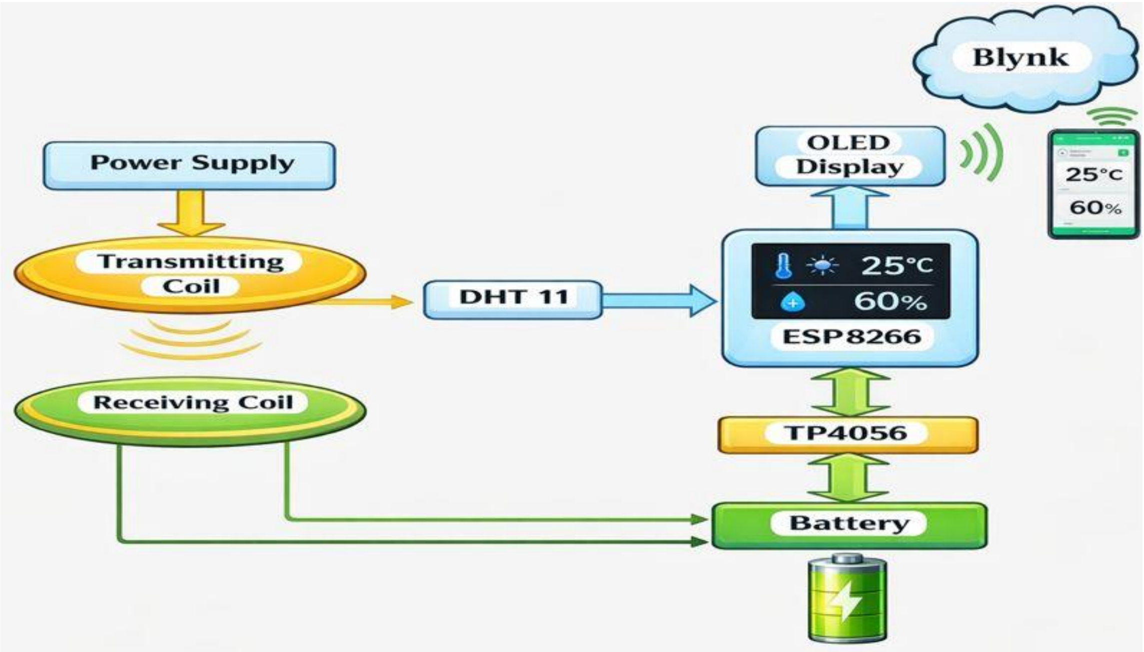

Figure 3: Proposed block diagram

In another paper [4] Existing studies show that traditional an architecture centered on an IoT-enabled smart charging infrastructure. The system architecture comprises a power supply unit that can draw energy from renewable or non-renewable sources, a power conditioning stage for voltage regulation and conversion, and a wireless power transmission module consisting of transmitter coils embedded in the charging station and receiver coils mounted on the EV as shown in figure-4. An IoT control and communication layer is integrated to manage station discovery, charging authorization, and real-time monitoring of charging status, thereby reducing the time users spend locating available charging stations. The architecture also supports data exchange between the charging station, vehicles, and cloud servers for operational analytics and user convenience. This modular and scalable design aligns with IEEE-based smart charging concepts, facilitating efficient energy transfer, improved accessibility, and seamless adoption of wireless EV charging systems.

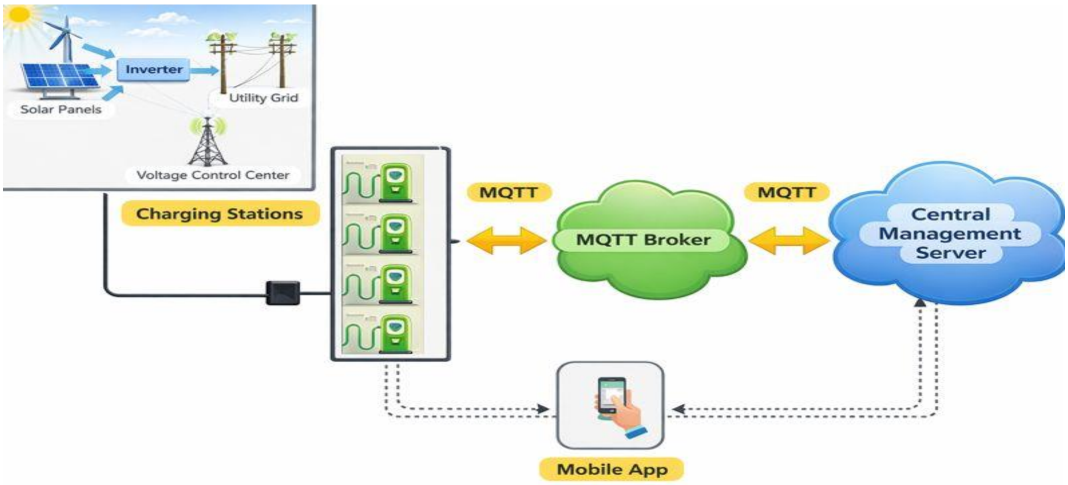

Figure 4: Architecture of IoT enabled infrastructure

In another paper [5] IoT Based Wireless Electric Vehicle Charging Station System presents a comprehensive architecture for a smart wireless EV charging station that leverages magnetic resonance–based wireless power transfer to eliminate the need for physical charging cables. The system architecture consists of a regulated power source feeding a high-frequency inverter, which drives a transmitter coil installed at the charging station to generate an alternating magnetic field. A resonant receiver coil mounted on the electric vehicle captures this energy and delivers it through a rectifier, filter, and voltage regulation stage to safely charge the vehicle battery as shown in figure-5 & 6. An embedded IoT control unit continuously monitors key parameters such as charging status, power flow, alignment condition, and

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battery state, and transmits this data to a cloud platform for real-time supervision and user interaction via a mobile or web application. The integration of IoT enables remote monitoring, fault detection, and efficient energy management.

Figure 5: Charging status on mobile app

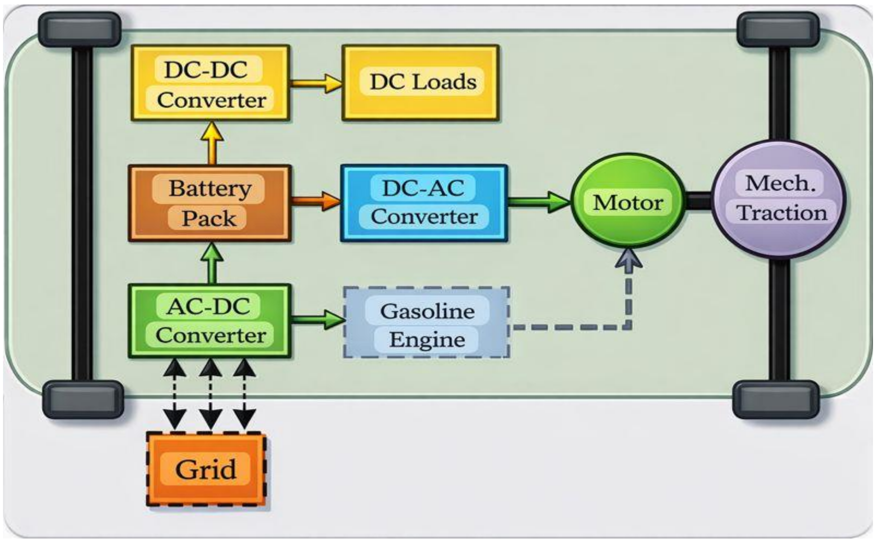

Figure 6: Functional block diagram of EV

III. METHODOLOGY

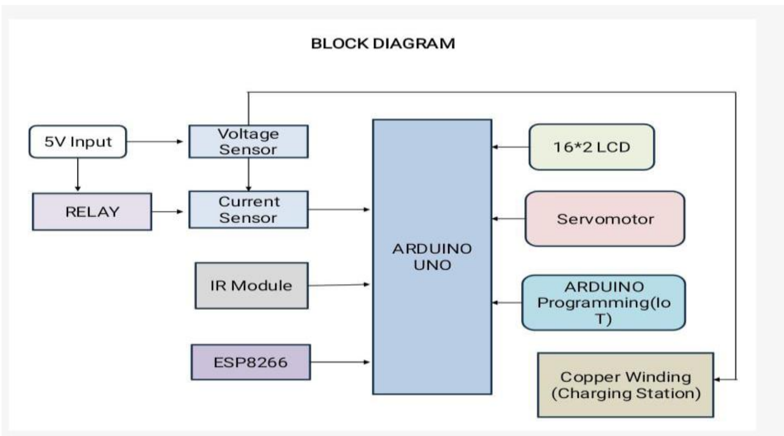

Figure 7: Proposed system block diagram

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The proposed system presents the development of an IoT-based EV wireless charging station using an ESP8266 microcontroller as shown in figure-7. The system measures operates by supplying a regulated 5 V input to the system, which is controlled through a relay for safe switching of the charging process. The voltage and current sensors continuously monitor the electrical parameters of the wireless charging unit and send real-time data to the Arduino Uno. An IR module detects vehicle presence and enables charging only when proper alignment is achieved. The Arduino processes all sensor inputs, controls the copper winding of the charging station, and operates the servomotor for alignment or switching actions. Charging status and measured parameters are displayed on the 16×2 LCD, while the ESP8266 module transmits data to an IoT platform for remote monitoring and control of the EV wireless charging station.

IV. HARDWARE INSTALLATION

The overall components used in this work is illustrated with proposed system diagram as shown in figure-8.

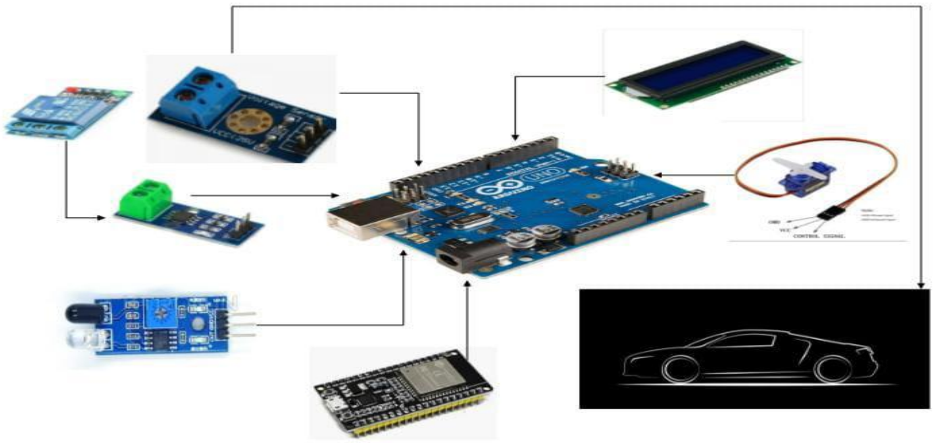

Figure 8: Proposed system diagram

4.1 ESP8266Microcontroller

The ESP8266 is an advanced microcontroller that integrates Wi-Fi connectivity. It functions as the main controller by acquiring sensor inputs, operating the relay, computing power usage, and delivering alerts via Telegram, allowing real-time IoT-enabled monitoring and automation.

4.2 Arduino Uno

The Arduino Uno is a microcontroller platform designed for connecting various sensors and peripheral modules. It offers multiple digital and analog I/O pins, enabling reliable interaction with sensors, relays, and display units, while supporting the ESP8266 in system control and precise data collection.

4.3 Current Sensor (ACS712)

The ACS712 measures current by allowing the charging current to pass through an internal low-resistance copper path. The resulting signal is internally processed and converted into a proportional analog voltage at the output pin. This output voltage is read by the IoT controller to calculate and monitor the current in the EV wireless charging station.

4.4 Voltage Sensor

The voltage sensor measures the charging voltage by sensing the electrical potential at the output of the wireless charging system. The sensor generates a proportional low-level signal corresponding to the applied voltage. This signal is read by the IoT controller to monitor the battery charging voltage. The measured voltage is used for system control, protection, and remote monitoring.

4.5 IR Sensor

The IR sensor works by transmitting infrared radiation and detecting the reflected signal from an object. When an electric vehicle is present near the wireless charging pad, the reflected IR signal is detected by the receiver. The sensor outputs a signal to the IoT controller indicating vehicle presence. This helps in enabling or disabling the wireless charging process automatically.

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4.6 Relay Module

The relay module works as an electrically operated switch in the EV wireless charging station.
It receives a low-power control signal from the IoT controller and uses it to switch high-power charging circuits.
When activated, the relay connects the power supply to the wireless charging system, and when deactivated, it disconnects it for safety.

4.7 16x 2 LCD display

The 16×2 LCD display shows the charging ON and OFF status of the EV wireless charging station. It receives control signals from the IoT controller and updates the display accordingly. This helps users easily identify whether the charging process is active or inactive.

4.8 Servomotor

The servomotor is used to control the mechanical movement in the EV wireless charging station. It receives control signals from the IoT controller to position or align the charging mechanism accurately. This ensures proper placement and efficient operation of the wireless charging system.

V. SOFTWAREINSTALLATION

The software structure for the prototype system adheres to the standard embedded C programming framework used within the Arduino IDE.
The IoT-based EV wireless charging station, the software setup involved three key aspects.

First, we installed **the Arduino IDE** and configured the **ESP8266** microcontroller to program the system and connect to WiFi using the ESP8266WiFi library, enabling seamless wireless communication.

Second, we integrated cloud computing platforms such as to store, monitor, and analyze real-time charging data, ensuring that system performance and energy usage could be tracked remotely.

Third, we implemented the **RemoteXY app** to create a mobile interface that displays the voltage and current status of the charging station, allowing users to monitor the system remotely and control charging operations as needed. This combined setup provided an efficient, automated, and user-friendly approach for managing and monitoring wireless EV charging, connecting the microcontroller, cloud, and mobile interface in a fully functional IoT ecosystem.

VI. RESULTS AND DISCUSSION

6.1 System Operation

The proposed IoT-based wireless EV charging station operates by integrating an Arduino Uno as the main controller with an ESP8266 module for internet connectivity and remote monitoring. When a vehicle arrives, the IR sensor detects its presence and triggers the servomotor to guide or allow proper alignment over the wireless charging pad. Once alignment is confirmed, the relay module is activated by the Arduino to initiate the charging process. Voltage and current sensors continuously measure the electrical parameters of the system to ensure safe and efficient power transfer, and these real-time values are displayed locally on an LCD display. Simultaneously, the ESP8266 transmits the sensed data to a cloud or IoT platform, enabling remote monitoring of charging status, energy consumption, and fault conditions. The entire system is programmed using the Arduino IDE, implementing control logic, safety thresholds, and communication protocols to provide an automated, reliable, and user-friendly wireless EV charging solution.

6.2 Observations

Key operational observations of an IoT-based EV wireless charging station using Arduino UNO, ESP8266, current and voltage sensors, LCD, and relay indicate that the system efficiently monitors and controls the charging process through real-time measurement of voltage and current. The relay ensures safe activation and deactivation of the wireless power transfer (WPT) system, while the LCD provides immediate local feedback on charging status and energy consumption. IoT connectivity via the ESP8266 allows remote monitoring and management, enabling users to track charging progress, receive alerts, and optimize energy usage. Overall, the system demonstrates stable performance, accurate measurement, responsive control, and seamless integration of IoT for enhanced user convenience and energy efficiency.

6.3 Performance Analysis

The performance analysis of the IoT-based EV wireless charging station reveals that the system operates with high reliability and efficiency, accurately monitoring voltage and current through the sensors to manage power delivery via

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the relay as shown in figure 8. The Arduino UNO processes sensor data in real time, ensuring precise control of the wireless power transfer (WPT) process, while the LCD provides clear local feedback on charging parameters. IoT connectivity through the ESP8266 enables remote monitoring and data logging, allowing users to track energy consumption and charging trends over time. Overall, the system demonstrates stable operation, minimal energy losses, quick response to load variations, and effective integration of hardware and IoT components, indicating strong potential for scalable and user-friendly EV charging applications.

Figure 8: LCD Display

6.4 Discussion

The proposed IoT-based wireless charging station for electric vehicles demonstrates the feasibility of integrating wireless power transfer (WPT) with intelligent monitoring and control mechanisms. Wireless charging eliminates physical connectors, thereby reducing mechanical wear, contact losses, and safety risks associated with conductive charging. Experimental observations show stable power transfer within a limited air gap; however, charging efficiency is highly dependent on coil alignment and coupling conditions. Although the efficiency is lower compared to conventional wired systems, the results align with existing literature, indicating that inductive WPT is suitable for low- to medium-power EV charging applications where user convenience and safety are prioritized. The integration of IoT significantly enhances system intelligence by enabling real-time monitoring of charging parameters such as voltage, current, power. These parameters are transmitted to a cloud platform, allowing remote access as shown in figure 9. IoT-based alerts for abnormal conditions, including overheating and misalignment, improve operational reliability and user safety.

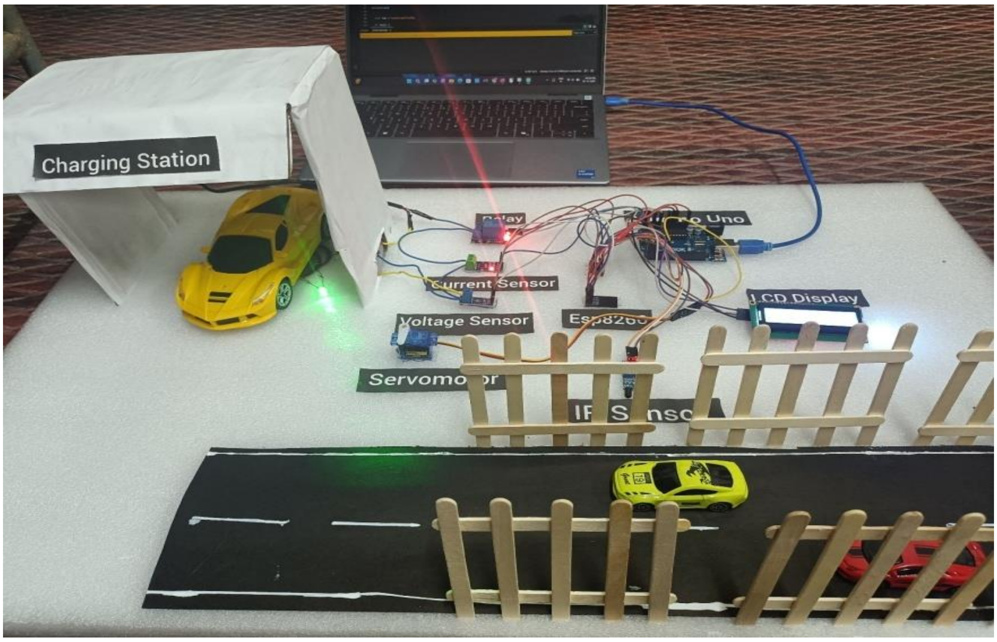

Figure 9 6.5: Proposed system circuit diagram

VII. CONCLUSION

This project successfully demonstrates the development of a microcontroller-based monitoring and control system using the Arduino Uno platform. By integrating voltage and current sensing, relay-based switching, servomotor control, and IoT connectivity through the ESP8266 module, the system ensures safe, automated, and efficient operation of a copper winding charging station. Real-time parameter display using a 16×2 LCD enhances system usability and fault awareness.

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The modular design allows easy expansion and customization for higher power levels or additional control features. Overall, the proposed system provides a cost-effective and practical solution for smart charging and monitoring applications, and it can be further enhanced by incorporating cloud-based data logging, mobile applications, and advanced protection algorithms.

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