© May 2025 | IJIRT | Volume 11 Issue 12 | ISSN: 2349-6002

IoT-Driven Wireless Charging System for Electric Vehicles

Sribhuvaneshwari H[1], Kishore K[2], Krishna Kumar S[3], Maheswar D[4], Narendran K[5]
[1,2,3,4,5] *Sri Shakthi Institute of Engineering and Technology,Coimbatore, India*

***Abstract*—This article explores the transformation of electric vehicle (EV) charging through innovative vehicle-to-vehicle wireless technology, enabled by GPS integration. Users can effortlessly request charging assistance via a dedicated portal, initiating the precise tracking of their EV's location. The location data is transmitted to a web portal service, facilitating the deployment of wireless charging solutions. A standout feature of this approach is the integration of wireless charging lanes, setting it apart from conventional static charging methods. As users approach their designated charging points, the wireless charging process is automatically activated, extending the driving range of EVs and reducing dependency on stationary charging infrastructure. This technology promises enhanced accessibility, convenience, and efficiency, ultimately advancing the adoption and practicality of electric vehicles.**

***Index Terms*—IOT, Wireless Charging, Electric Vehicles (EVs), Dynamic Charging, GPS Tracking.**

I. INTRODUCTION

The growing adoption of electric vehicles (EVs) marks a significant step toward reducing greenhouse gas emissions and achieving a more sustainable transportation sector. However, this widespread adoption also presents challenges, primarily related to charging infrastructure. Traditional EV charging systems, which rely heavily on static charging stations, have notable limitations [1],[2]. The availability of these stations can be sparse in certain areas, leading to range anxiety and inconvenience for EV owners. Additionally, static charging stations often require specific connectors and adapters, resulting in compatibility issues. Range anxiety—the fear of depleting battery power before reaching a charging station—is a significant barrier to EV adoption [5]. A dynamic vehicle-to-vehicle (V2V) wireless charging system can address this concern by providing continuous, on-the-go charging [5][9], thereby effectively extending the driving range of EVs and enhancing their practicality.

This article introduces the pioneering concept of vehicle-to-vehicle (V2V) wireless charging, enabled by GPS technology, which empowers electric vehicles (EVs) to charge dynamically while in motion. This innovative approach addresses the growing demand for efficient and accessible charging solutions within the expanding EV market. The envisioned system is designed to be user-friendly, allowing EV owners to request charging assistance via a dedicated application. Real-time location tracking ensures precise service delivery. Furthermore, the integration of wireless charging lanes sets this proposal apart from traditional static charging methods, offering extended driving ranges, reduced reliance on stationary charging, and improved accessibility for EV users.

Wireless charging for electric vehicles (EVs) operates on the principle of inductive power transfer [2],[4]. It utilizes electromagnetic fields to transfer energy between two coils—one installed within the EV and the other embedded in the road's charging infrastructure. This innovative technology eliminates the need for physical connectors and cables [1],[3], providing EV owners with a more convenient and seamless charging experience.

To ensure efficient and safe wireless charging, robust control and communication systems are indispensable [4]. These systems oversee the power transfer process, monitor charging progress, and enable seamless communication between the electric vehicle (EV) and the charging infrastructure. This communication is crucial for maintaining safety and optimizing efficiency, as it facilitates real-time adjustments to charging parameters and the exchange of critical data. Wireless charging technology continues to evolve rapidly [2], [5], with diverse standards and power levels emerging to cater to various vehicle types and charging requirements.

II. METHODOLOGY

Fig.1 displays the block diagram of the proposed methodology for wireless charging system based on IOT for EV. The proposed wireless charging concept seeks to transform electric vehicle (EV) charging by introducing a dual-system approach: the power transfer system (transmitter) and the receiver system [2],[4]. The receiver system, seamlessly integrated into the EV, incorporates GPS technology, a receiver coil, a voltage sensor, and a Wi-Fi-enabled controller. Meanwhile, the transmitter system, housed within the service team's vehicle, includes a high-frequency inverter, a transmitter coil, and a battery. This comprehensive framework offers an in-depth exploration of the design, implementation, and operation of this cutting-edge dynamic wireless charging system. A detailed description of all the components used in both the transmitter and receiver systems is provided below. [4][6]

A. Transmitter System:

The transmitter system is composed of three essential components: a high-capacity battery, a high-frequency inverter, and a transmitter coil. Together, these elements enable efficient wireless energy transfer for dynamic charging applications[1][2].

a) Battery: The transmitter system in the service team's vehicle is equipped with a high-capacity battery that acts as the primary energy source for wireless charging. This battery powers both the transmitter coil and the high-frequency inverter, ensuring a consistent and reliable energy supply.

b) High-Frequency Inverter: The high-frequency inverter plays a pivotal role in creating the alternating magnetic field required for wireless charging. It transforms the stored energy from the battery into high-frequency alternating current (AC), which energizes the transmitter coil and facilitates efficient power transfer [1],[2].

c) Transmitter Coil: The transmitter coil, housed within the service team's vehicle, is designed to generate a strong electromagnetic field to transfer energy to the receiver coil in the electric vehicle. Its strategic placement within the vehicle ensures optimal power transfer efficiency and effectiveness.

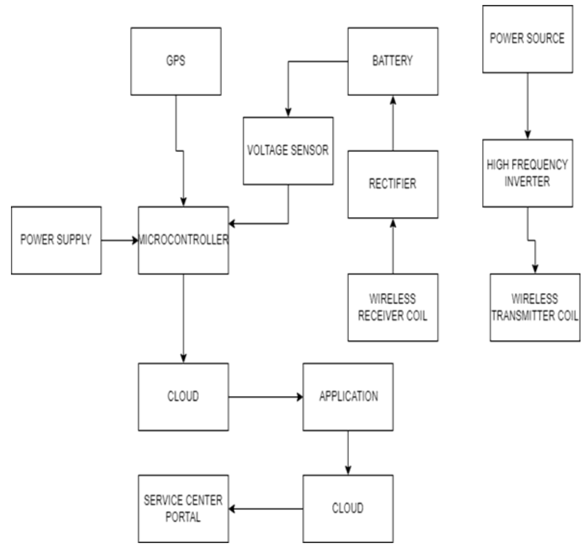

Fig. 1. Block Diagram of Proposed Methodology.

B. Receiver System:

The receiver system comprises four key components: GPS technology, a receiver coil, a voltage sensor, and a Wi-Fi-integrated controller. These components work in harmony to facilitate seamless and efficient wireless energy transfer, driving the success of dynamic charging applications.

a) GPS Technology: The receiver system integrates GPS technology to accurately determine the current location of the electric vehicle (EV). This location data is vital for enabling dynamic wireless charging, ensuring that the charging process is initiated as soon as the EV arrives at its designated charging point.

b) Receiver Coil: The receiver coil, a key component of the system, is embedded within the electric vehicle. Its primary function is to capture the electromagnetic energy emitted by the transmitter coil in the service team's vehicle [2]. This induced current is then utilized to charge the EV's battery.

c) Voltage Sensor: A voltage sensor continuously monitors the battery's state of charge and voltage levels. This data is essential for maintaining safe and efficient charging [1],[3]. When the voltage drops to a predefined level, signaling a low battery, the system automatically activates the charging process.

d) Wi-Fi Integrated Controller: The Wi-Fi integrated controller acts as the central hub for managing the receiver system. It facilitates seamless communication with the service portal [4], [5], allowing users to request charging assistance through a mobile web application. Upon receiving a request, the controller transmits the EV's current location and user details to the service portal, ensuring prompt service delivery.

III. OPERATION AND WORKING PRINCIPLE

The operation of the dynamic wireless charging system hinges on the seamless interaction between the transmitter system and the receiver system, supported by advanced control and communication technologies [4], [5]. Below is a detailed breakdown of transmitter and receiver system's functionality.

A. Transmitter system functionallity

a) Battery Charging: The transmitter system's battery is regularly charged to maintain sufficient energy for wireless charging operations. This can be achieved through standard charging infrastructure or, where available, renewable energy sources. [5]

b) Charging Request Acknowledgment: When a user initiates a charging request via the service portal, the transmitter system promptly acknowledges and prepares for service deployment.

c) Wireless Charging Activation: Upon arriving near the electric vehicle, the transmitter system activates its high-frequency inverter. The inverter converts stored battery energy into high-frequency alternating current (AC), which generates an alternating magnetic field [2], [4].

d) Power Transfer: The alternating magnetic field produced by the transmitter coil induces an electric current in the receiver coil embedded in the electric vehicle. This current is then transformed into usable electrical energy, effectively charging the EV's battery.

e) Communication with Receiver System: The transmitter system maintains continuous communication with the receiver system to monitor charging progress, ensure operational safety, and execute real-time adjustments when needed.

f) Charging Completion: Once the EV's battery reaches an adequate charge level, the transmitter system deactivates the high-frequency inverter, ceasing electromagnetic field generation. The receiver system is notified of the completion, and the user receives an update via the service portal.

B. Receiver system functionallity[4][5]

The receiver system works seamlessly with the service portal and GPS technology to deliver a smooth and convenient charging experience for electric vehicle (EV) owners. The step-by-step operation of the receiver system is as follows:

a) User Requests Charging: When an EV owner needs to recharge their vehicle, they initiate a charging request via a dedicated mobile web application linked to the receiver system.

b) Transmission of User Details: The mobile application transmits the user's identification and real-time location to the receiver system using the Wi-Fi-integrated controller.

c) Location Tracking: GPS technology integrated into the receiver system continuously tracks the EV's location with precision. This data is updated in real-time and shared with the service portal [4], [5].

d) Low Battery Trigger: The receiver system actively monitors the vehicle's battery voltage. When the voltage drops below a predefined threshold, signaling the need for a recharge, the system prepares to receive energy from the transmitter system.

e) Service Portal Coordination: The receiver system maintains active communication with the service portal, providing updates on the vehicle's location and confirming the charging request.

f) Charging Initiation: As the EV approaches its designated charging point, the system detects its proximity to the transmitter system housed in the service team's vehicle. The charging process is then activated.

g) Wireless Charging: The transmitter coil in the service team's vehicle generates an alternating magnetic field, inducing an electric current in the receiver coil of the EV. This current is converted into electrical energy to recharge the vehicle's battery [1], [2], [5]. Continuous communication between the receiver and transmitter systems ensures safe and efficient energy transfer.

h) Charging Progress Monitoring: During the charging process, the receiver system monitors the battery's voltage and state of charge. It also communicates with the service portal to provide real-time updates on the charging status [4], [5].

i) Charging Completion: Once the EV's battery is fully charged, the receiver system automatically halts the charging process and notifies the service portal of its completion.

IV. RESULT AND ANALYSIS

The proposed dynamic wireless charging system, incorporating both receiver and transmitter systems, presents a groundbreaking solution to challenges faced by electric vehicle (EV) owners, such as limited charging infrastructure and range anxiety [1], [2]. By leveraging inductive power transfer and cutting-edge technologies like GPS, Wi-Fi, and high-frequency inverters, this system aims to enhance the accessibility and convenience of EV charging [2], [4], [5]. It eliminates the dependency on static charging stations, offering extended driving ranges, reduced reliance on stationary batteries, and improved charging accessibility [1], [3].

The receiver system, embedded within the EV, plays a crucial role in user interaction and real-time location tracking, while the transmitter system, housed in the service team's vehicle, facilitates wireless energy transfer. This close collaboration ensures a seamless and efficient charging experience, making EVs a more practical and sustainable choice for a broader range of users [4], [5]. As EV adoption continues to grow, this dynamic wireless charging system has the potential to revolutionize vehicle power solutions, contributing significantly to sustainable and environmentally friendly transportation. Fig. 2 shows the flow chart for the operation of wireless charging system for electric vehicles. The success of this dynamic wireless charging system depends on the efficient collaboration between the receiver and transmitter systems [2],[5]. Below is an overview of their operational workflow:

A. Charging Request:

EV owners initiate a charging request via a dedicated mobile web application, prompting the receiver system to collect user details and track the vehicle's real-time location using GPS.

B. Service Portal Communication:

The receiver system communicates with the service portal, sharing the user's information, location data, and charging assistance request.

C. Transmitter Activation:

The service portal alerts the transmitter system in the service team's vehicle about the charging request. Using GPS, the transmitter system positions itself accurately near the EV to initiate wireless charging.

D. Wireless Charging:

As the electric vehicle (EV) approaches the service team's vehicle, the receiver system detects the presence of the transmitter system and initiates the charging process. The transmitter coil generates an alternating magnetic field, which induces an electric current in the receiver coil embedded in the EV. This current is then used to charge the vehicle's battery seamlessly. [1],[3],[5],[14]

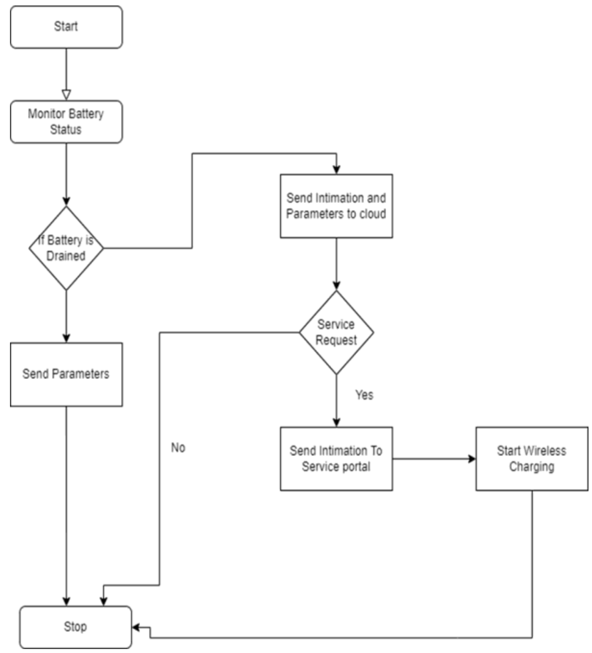

Fig. 2. Flow chart for the opertaion of wireless charging system for electric vehicles. [5],[8]

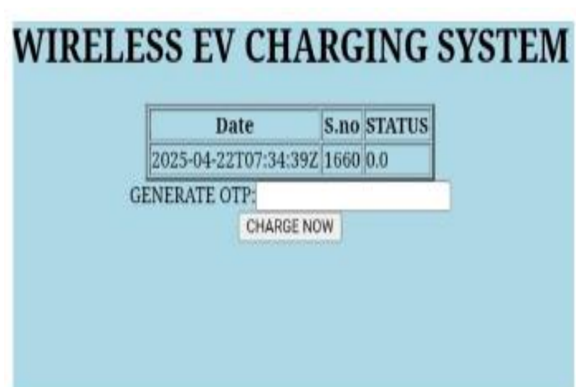

Fig. 3. Web page of transmitter EV station.

E. Progress Monitoring:

During the charging process, both the receiver and transmitter systems work in tandem to monitor the charging status, battery voltage, and state of charge. Their continuous communication ensures safe and efficient power transfer, optimizing the charging process.

F. Charging Completion:

Once the EV's battery reaches the desired charge level, the receiver system automatically halts the charging process, and the transmitter system deactivates the high-frequency inverter. The completion of the charging process is communicated to the service portal, and the user is promptly notified.

Fig. 3 and Fig. 4 show the web page for the transmitter EV station and receiver, respectively.

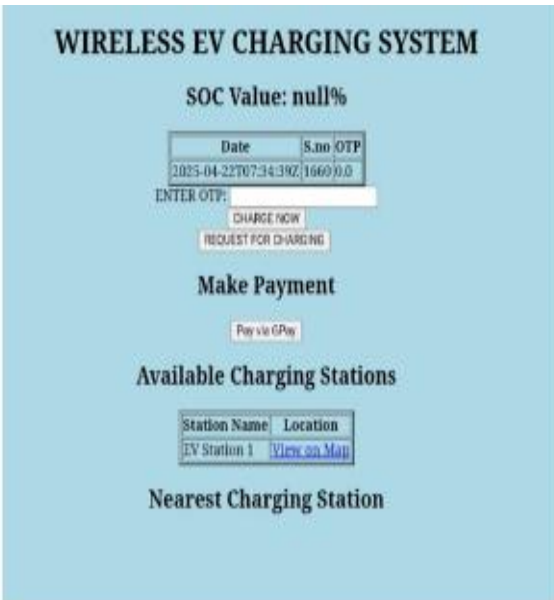

Fig. 4. Web page of receiver.

V. CONCLUSION

In conclusion, the proposed dynamic wireless charging system, integrating a receiver system within electric vehicles and a transmitter system housed in service team vehicles, offers a cutting-edge solution to address the challenges of limited charging infrastructure, range anxiety, and the demand for more accessible electric vehicle (EV) charging [1], [5]. By utilizing the principles of inductive power transfer and advanced technologies like GPS, Wi-Fi, and high-frequency inverters, this system provides an innovative and user-friendly charging experience [2], [4]. It eliminates reliance on static charging stations, extends driving ranges, minimizes battery dependence, and improves overall charging accessibility [2], [4]. The seamless collaboration between these two systems ensures an efficient and uninterrupted charging process, with the potential to transform the EV landscape [3], [5] and pave the way for a more sustainable and environmentally friendly transportation sector.

The future prospects of the dynamic wireless charging system are immensely promising. With the continued rise in electric vehicle (EV) adoption, this system holds the potential to eliminate range anxiety, lower infrastructure costs, and champion sustainable charging practices [5]. Ongoing research and development efforts could unlock significant advancements in power transfer efficiency, establish standardized protocols, and integrate dynamic wireless charging systems into urban planning and transportation networks [5]. These developments would ultimately accelerate the shift toward cleaner, more convenient mobility solutions. Furthermore, as the technology evolves, the possibility of dynamic wireless charging becoming a standard feature in EVs and public transportation systems appears increasingly viable. This advancement represents a transformative leap forward in creating sustainable, efficient, and eco-friendly transportation ecosystems [2], [5].

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