

# Smart Vehicle-to-Vehicle Wireless Charging System with IoT-Based Location Tracking

Gayathri Priya S.<sup>1</sup>, Lokesh M.<sup>2</sup>, Tejesh P.<sup>3</sup>, Baluchandu P.<sup>4</sup>,  
Sravan P.<sup>5</sup>

Department of Electronics and Communication Engineering, R. M. D. Engineering College, Anna University, Kavaraipeetai, India.

**Email:** <sup>1</sup>sgp.ece@rmd.ac.in, <sup>2</sup>211041096@rmd.ac.in, <sup>3</sup>21104104@rmd.ac.in, <sup>4</sup>21104106@rmd.ac.in,  
<sup>5</sup>21104107@gmail.com

## Abstract

The increased use of Electric Vehicles (EVs) provides smart charging solutions to prevent limitations and dependence on fixed charging stations. This research work presents a Smart Vehicle-to-Vehicle (V2V) wireless charging system with IoT based location tracking to allow direct energy transmission between vehicles. This system integrates a dual-switch method to control the energy transfer. One switch will initiate a charging request and the other switch will allow or reject the request. The Wireless Power Transfer (WPT) method is used for efficient power transmission and an ESP32 microcontroller allows real-time data collection and system management. The main hardware components used in this research are a voltage and current sensor, a temperature sensor, and a GPS module for monitoring energy flow, safety and tracking the vehicle's location. This work also improves the charging range, reduces dependency and allows decentralized energy transmission. This study provides a cost effective solution to improve EV charging performance and access by combining IoT technology with wireless charging.

**Keywords:** Wireless Power Transfer, Vehicle-to-Vehicle Energy Sharing, IoT-Based Tracking, Real- Time Charging Monitoring, Smart Electric Vehicle Charging.

## 1. Introduction

The rapid global transition to electric vehicles (EVs) has been recognized as an essential approach for reducing emissions of greenhouse gases, fossil fuel dependence and air pollution. As the usage of electric vehicles increases, it will create an effective, adaptable and scalable charging infrastructure. Traditional charging methods that focus on physical charging stations will face limited availability, unbalanced distribution across regions, expensive installation and maintenance and prolonged charging times. These challenges will increase range anxiety among EV users and prevent the use of electric vehicles, particularly in remote and highly populated urban areas.

New charging models will solve these challenges by reducing the dependency on permanent charging stations. Vehicle-to-vehicle (V2V) charging establishes an effective solution for allowing electric vehicles to transfer energy. It increases flexibility, accessibility and decentralized energy distribution by permitting one vehicle to operate as a portable power source for another. When paired with wireless power transfer (WPT) technology, this technique removes the demand for physical connections and leads to reduced damage, security risks, and operational complexity compared to traditional connected charging systems.

Wireless power transfer using resonant inductive coupling provides automatic and efficient energy transmission over short distances suitable for V2V charging systems. However, implementing this system requires advanced control, real-time monitoring and secure coordination among electric vehicles. The application of Internet of Things (IoT) technology is vital in achieving these requirements because it enables continuous connectivity, sensor-based monitoring, data collection and cloud-based visualization. The Internet of Things (IoT) provides real-time tracking of charging, power flow parameters and vehicle location to improve dependency, safety and user transparency.

This research proposes a smart vehicle-to-vehicle wireless charging system with IoT-based location tracking designed to provide controlled and secure wireless energy transfer among electric vehicles. This system uses a dual-switch request-accept technique where one vehicle sends a request for charging and the other vehicle automatically accepts or rejects it by confirming user permission and preventing unauthorized power transfer. An ESP32 microcontroller manages the communication protocol, sensor data and charging process.

Wireless power transfer provides inductive energy transfer and Zigbee communication offers short-range, low-power data transmission between vehicles.

The system includes a GPS module for real-time vehicle tracking and an IoT-based application dashboard shows electrical parameters, charging status and location data to improve usability and transparency. Additional safety and monitoring functions, such as voltage, current and temperature detection helps to prevent system components from electrical or thermal issues. The proposed technology combines wireless charging with IoT-based monitoring and location tracking providing a cost-effective, scalable and decentralized alternative compared to traditional EV charging infrastructure.

The proposed Smart V2V wireless charging system aims to increase charging accessibility, reduce physical dependence and improve sustainable transportation networks. The following section of this research explains the related work, system design, hardware and software implementation, experimental results, and possible improvements to the proposed system.

## **2. Related Work**

The integration of Internet of Things (IoT) technologies into electric vehicle (EV) ecosystems has significantly transformed vehicle optimization, charging infrastructure, energy management, and health monitoring systems. IoT-enabled recommender systems have been proposed to optimize EV performance by analyzing real-time driving patterns, battery conditions, and environmental factors, thereby enhancing energy efficiency and user experience through intelligent decision support [1]. Expanding this connectivity, vehicle-to-vehicle (V2V) IoT-based charging solutions enable dynamic energy sharing between EVs, offering an innovative approach to mitigate range anxiety and improve charging accessibility, especially in emergency or infrastructure-limited scenarios [2]. Complementing this, IoT-enabled charging station integration facilitates real-time monitoring, scheduling, and load balancing, allowing seamless interaction between EVs, charging points, and grid systems for improved operational efficiency [3]. Wireless communication systems further enhance EV charging by enabling contactless wireless power transfer, reducing physical connector constraints while supporting autonomous and smart charging mechanisms [4]. From an industrial perspective, the Industrial IoT (IIoT) plays a crucial role in advancing EV technologies by enabling predictive maintenance, real-time diagnostics, and intelligent

manufacturing processes, thereby improving system reliability and lifecycle management [5]. Smart charging and battery management systems leverage IoT sensors, cloud platforms, and advanced analytics to monitor battery health, optimize charging cycles, and extend battery lifespan while addressing challenges such as thermal management and grid stability [6]. Machine learning-based IoT energy management systems further enhance hybrid and electric vehicles by dynamically optimizing power distribution between energy sources, improving efficiency under varying driving conditions [7]. Additionally, microcontroller-based solar wireless vehicle-to-vehicle charging prototypes demonstrate the feasibility of integrating renewable energy sources with IoT-enabled monitoring for sustainable and decentralized EV charging solutions [8]. Comprehensive reviews highlight that IoT-based EV charging solutions improve interoperability, scalability, and real-time decision-making across charging infrastructures while supporting smart grid integration [9]. Finally, intra-vehicular IoT communication protocols play a vital role in vehicle health monitoring systems by enabling reliable data exchange between sensors and control units, addressing challenges related to latency, security, and scalability to ensure robust EV operation [10].

**Table 1.** Relative Study

References	Charging Approach	Focusing Area	Problems Identified	Limitation
Patel et al. [2]	Wired V2V charging	Emergency energy sharing	Requires physical connectors, safety risks, limited mobility	Uses contactless wireless power transfer to eliminate physical coupling
Wu [4]	Wireless EV charging	Static wireless charging	Does not support vehicle-to-vehicle energy exchange	Enables direct V2V wireless energy sharing
Kulkarni et al. [3]	IoT-enabled charging stations	Grid-based monitoring	Depends on fixed infrastructure	Removes dependency on charging stations
Priyadarshini et al. [8]	Solar-assisted V2V charging	Renewable integration	Limited discussion on real-time safety monitoring	Implements continuous voltage, current, and temperature monitoring

Review works [9]	IoT-based EV charging	System-level surveys	Lacks hardware validation	Demonstrates experimentally validated hardware prototype
Proposed work	Wireless V2V charging with IoT	Prototype implementation	Limited to low-power prototype scope	Validated safe and controlled V2V wireless charging using a 12 V battery system

### 3. Existing Work

Energy management and Electric Vehicle (EV) charging based on centralized and cloud-based systems have limited real-time data. The existing chargers, based on permanent charging stations, include basic features like voltage monitoring, scheduled vehicle charging, and inaccurate battery status. They also lack a connection with Internet of Things (IoT) technology, resulting in delayed data processing, improper energy usage, and limited response to changing conditions such as varied grid load, traffic density, and access to renewable energy. Furthermore, previous techniques provided low resources for vehicle-to-vehicle (V2V) charging and limited charging mobility in locations with low network access. Battery management in existing systems is based on rules without detailed analytics for prediction, resulting in battery degradation, excessive heat, and a limited lifespan.

Existing charging systems depend on interconnection with Level-2 AC chargers and DC fast chargers, which fail to provide vehicle-to-vehicle energy transfer. Permanent charging stations operate in a unidirectional manner, with energy flow from the electrical grid to the vehicle. The current EV model lacks an emergency power-sharing feature, and the limited wired vehicle-to-load (V2L) or vehicle-to-home (V2H) systems require physical connections and fixed charges. The proposed work addresses the technologies that cannot provide mobile, wireless V2V charging, indicating an important functional problem.

Overall, the current system is challenged by a lack of intelligence, limited automated functions, low scalability, and inefficient energy optimization, making it inappropriate for future smart transportation systems.

## 4. Proposed Work

The proposed method includes a hardware-tested vehicle-to-vehicle (V2V) wireless charging model combined with IoT-based monitoring and location tracking to prevent the limitations of traditional electric vehicle charging systems. This study focuses on the design, implementation and experimental evaluation of a low-power wireless charging system instead of algorithmic prediction or data-based learning models.

Each vehicle in the system has an ESP32 microcontroller, a wireless power transfer system, voltage and current sensors, a temperature sensor, a Zigbee communication module and a GPS unit. These modules allow real-time sensing, communication and controlled energy transfer between vehicles. The rule-based charging methods implemented using the microcontroller lead to predictable and safe operations.

The proposed system uses a request-accept method. One vehicle requiring energy will transmit a charging request to nearby vehicles using Zigbee communication. The other vehicle manually authorizes or ignores the request based on its battery capacity. Once authorized, the relay module switches on the wireless charging circuit to allow inductive power transmission under specified conditions. When the charging time or a safety threshold exceeds, power transfer will automatically stop.

The wireless charging works on resonant inductive coupling suitable for the transmission of low-range energy. Real-time electrical characteristics such as voltage, current, transmitted power and temperature are constantly tracked to maintain consistent and secure electrical charging. A web-based IoT platform displays real-time data for charging status and vehicle location, increasing accessibility and system transparency. All system functions depend on real-time sensor inputs and specified control rules implemented by the ESP32 microcontroller. The system was tested using 12 V lithium-ion battery packs commonly found in prototype and laboratory-scale electric vehicle platforms. It wasn't developed for rapid charging for commercial high-voltage EV battery systems.

### 4.1 Wireless Power Transfer Parameters

Wireless charging uses resonant inductive coupling, which is appropriate for short-range V2V energy transmission.

**Table 2.** Wireless Charging Specifications

Parameter	Value
Operating frequency	85 kHz
Transfer distance	$\leq 5$ cm
Nominal input voltage	12 V DC
Output power transferred	18–25 W
Maximum charging current	1.5–2 A
Peak efficiency (aligned)	78–82 %
Efficiency at 2 cm lateral misalignment	~65 %
Efficiency at 4 cm lateral misalignment	~50 %
Coupling type	Resonant inductive
Alignment requirement	Manual (prototype)

The experimental results of wireless power transmission are highly dependent on coil alignment, as mentioned in Table 2. The system has 80% efficiency when the transmitter and receiver coils are aligned accurately. As lateral misalignment exceeds 2 cm, it reduces the magnetic coupling efficiency. It decreases the efficiency to 50% when there is 4cm of misalignment.

#### 4.1.1 IoT- Based Real-Time Monitoring System

The system constantly evaluates the charging process and provides real-time data and status notifications to ensure accurate energy transmission. The proposed system consists of a Vehicle-to-Vehicle (V2V) wireless charging system combined with an IoT-based monitoring and location tracking system. The main objective is to allow authorized energy sharing among electric vehicles without relying on permanent charging stations. This research focuses on hardware, real-time sensing, energy transfer and communication using data-based model training instead of algorithm-based prediction or classification systems.

The system consists of two electric vehicles:

1. Source Vehicle (Energy Provider)
2. Destination Vehicle (Energy Receiver)

Energy transfer is performed only after authorization using a request-accept system to maintain safety and prevent illegal charging.

#### **4.1.1.1 Hardware Integration and Charging Process**

- ESP32 Microcontroller: It acts as the central processing unit, handling data processing and communication.
- Wireless Power Transfer (WPT): It enables inductive energy exchange between the transmitter and receiver vehicles.
- Zigbee (CC2500) Module: It facilitates secure wireless communication between vehicles, managing charging requests and responses.
- GPS Module: It provides real-time location tracking, allowing EVs to locate nearby charging vehicles. Although wireless power transfer occurs over a short distance, GPS is incorporated for vehicle discovery, coordination, and location logging, rather than fine alignment. GPS enables a vehicle requiring charge to identify nearby donor vehicles within a defined radius and share its approximate location via the IoT dashboard. Once vehicles are co-located, manual positioning is used for short-range alignment. Thus, GPS supports macro-level vehicle coordination, not micro-level coil alignment.
- Relay Module: It controls the switching mechanism to ensure safe energy transfer during charging.
- Push Button: It allows users to manually initiate or stop the charging process.

The proposed solution was developed for low-voltage electric vehicle batteries that are found in prototype EV platforms.

Battery safety during wireless charging is ensured through a multi-layer protection mechanism implemented at the hardware level. Voltage and current sensors continuously monitor charging parameters to prevent overvoltage and overcurrent conditions. A temperature sensor situated near the battery pack monitors thermal increase during charging. If the

temperature exceeds an assigned safety level, the ESP32 microprocessor rapidly disables the relay, leading to the termination of energy transfer.

Additionally, relay-based energy isolation provides the energy to send after specific user authorization using the request-accept method. The constant-voltage (CV) charging technique maintains the maximum battery voltage at 12 V to prevent overcharging. These combined safety measures confirm that wireless charging is a safe, dependable and controlled system suitable for the development of lithium-ion batteries.

**Table 3.** Battery Characteristics Used in the System

Parameter	Specification
Battery type	Lithium-ion
Nominal voltage	12 V
Capacity	7–12 Ah
Charging method	Constant Voltage (CV)
Protection	Relay-based isolation

The ESP32 microprocessor manages each charging request, confirms availability, and provides a safe power supply using a relay-based switching mechanism. The LCD display and online dashboard provide users with current details about the charging process.

It is important to highlight that the proposed system is developed and verified with 12 V lithium-ion batteries found in electric car models and laboratory-scale test platforms. The method wasn't designed for the rapid charging of high-voltage industrial EV battery packs (300-800 V). The proposed design and control methods were developed for high power levels using suitable electrical components, insulation and safety compliance measures.

#### 4.1.1.2 Web-Based Charging Location Monitoring

The system allows users to include a web-based application developed using JavaScript, HTML and CSS:

- View the real-time location of the vehicle while it is being charged. Monitor motor efficiency and health status.

- Track the exact position where the charging process is taking place.

This dashboard helps users monitor charging locations, ensuring better visibility of the charging process.

## 4.2 Request-Based Charging Mechanism

The system follows a structured request-accept model to ensure a controlled and secure energy exchange between vehicles.

### 4.2.1 Charging Request Process

- Request for Initiation – A vehicle in need of power sends a charging request via Zigbee to nearby vehicles.
- Request for Acceptance/Rejection – The recipient vehicle evaluates the request and can either accept or deny it based on available battery capacity.
- Power Transfer Initiation – If accepted, the relay module activates to enable safe wireless power transfer.
- Charging Completion – Once the session is completed, the system automatically stops power transfer to prevent overcharging

The models are trained on real-time sensor data and placed on edge devices or cloud servers leading to optimized real-world performance. Predictive data enables regular maintenance reducing unexpected interruptions and repair expenses.

## 4.3 Automated Fault Handling and Safety Mechanism

The system ensures basic safety measures to support a secure and reliable charging process:

- Charging Location Monitoring → Users can track where the vehicle is being charged in real time.
- Manual Charging Control → The charging process can be started or stopped using a push button.

- Secure Charging Request → A vehicle can send a charging request, which must be manually accepted by the recipient vehicle.

#### 4.4 Advantages of Proposed System

- Real-time monitoring for secure and efficient power transfer.
- Wireless charging eliminates the need for fixed charging stations.
- Secure request-accept model prevents unauthorized charging.
- Cost-effective and scalable for urban and remote areas.
- Provides earning opportunities for jobless EV owners by sharing and selling excess energy.

#### 4.5 Block Diagram

The block diagram represents the architecture of a smart vehicle-to-vehicle charging system with IoT based location tracking in “Figure 1”. The block diagram begins with IoT-enabled EVs and charging stations, where sensors collect real-time data related to battery and energy usage. This data is transmitted to the edge processing unit, which takes rapid control measures such as controlling charging power and allowing V2V energy transfer. The analyzed data is sent to the IoT dashboard for real-time display and logging, when the charging actions are generated directly on the ESP32 microcontroller based on specific control rules and safety standards. Finally, commands for control and notifications are transmitted to the vehicles and user devices to complete this closed-loop smart control cycle.

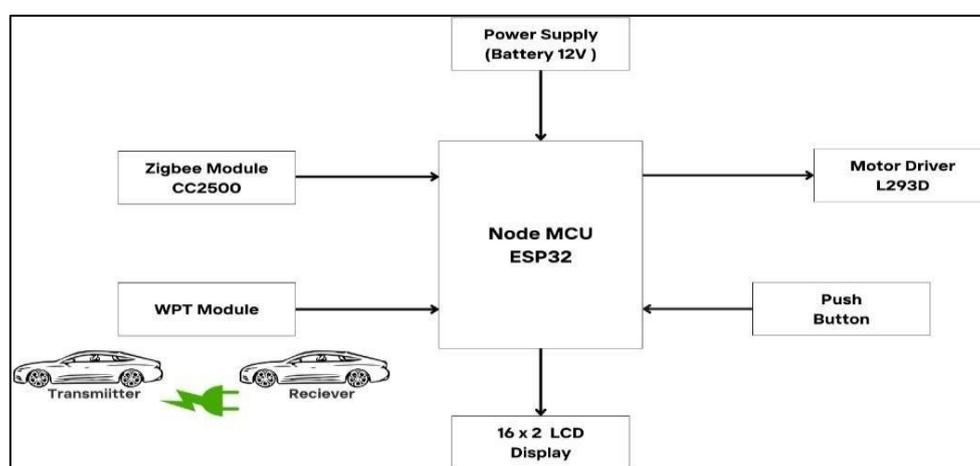


Figure 1. Block Diagram

## 5. Implementation

The ESP32 microcontroller is prepared and connected to a WiFi connection for IoT monitoring. The system remains inactive when a charging request received from a vehicle requires energy. Zigbee transmits the charging request, which is displayed to other vehicular device connections.

The relay module becomes functional and enables wireless power transmission between the transmitting and receiving coils after the confirmation of the charging request. Voltage, current and temperature data are continually recorded and displayed on both the LCD display and the web dashboard while the battery charges. If the system recognizes abnormal situations such as excessive current, overvoltage or increased temperature over the limits it will immediately disconnect the charging circuit to maintain the battery and its various parts.

Experimental testing confirms the reliability of wireless energy transfer under specified alignment conditions. The observed results show a constant power supply, suitable charging and safe thermal performance verifying the practical use of the proposed V2V wireless charging prototype.

1. WiFi Connection Phase: The system initializes and connects to a specified WiFi network ("iotbegin164") to communicate with cloud servers for real-time monitoring and data logging.



**Figure 2.** WiFi Connection Initialization

2. Charging Request Detection: The system detects a request for charging and transitions from an idle state ("S: OFF") to a pending charging request.



**Figure 3.** Charging Request Detection

3. Charging Activation: Once the system verifies the request, it turns on the charger ("S: ON CHARGER ON"), indicating the start of the charging process.

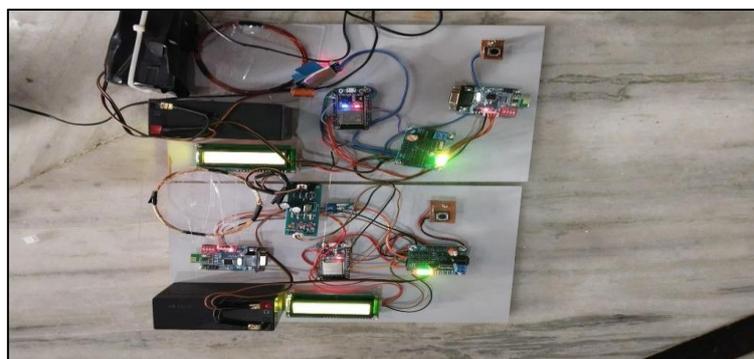


**Figure 4.** Charger Activation

4. Real-time Monitoring: The system continuously monitors voltage levels (e.g., "V: 13") and updates the charging status.



**Figure 4.** Real-Time Charging Monitoring



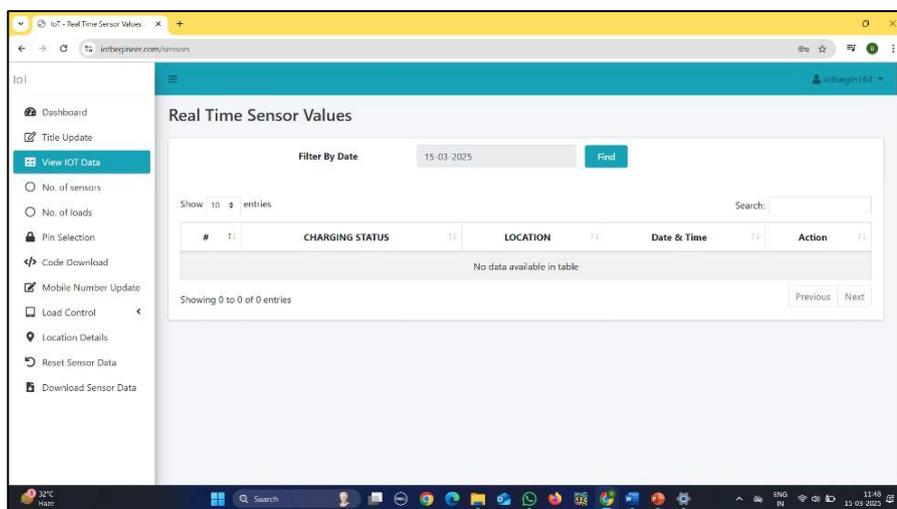
**Figure 5.** Hardware Setup

## 6. Results and Discussion

The proposed system combines IoT and wireless power transfer (WPT) to provide a unique solution to the challenges of wireless electric vehicle (EV) charging and real-time energy management. The system offers efficient, dependable and scalable EV charging by using IoT-based sensors to collect real-time data on battery voltage, current flow, charging time, and location monitoring, while utilizing WPT modules for continuous energy transfer.

In real-time power transfer, this method allows the transmitter vehicle to wirelessly recharge a receiving vehicle without the need for permanent charging stations. The accurate vehicle location and charging alignment improve vehicle connectivity using the Zigbee CC2500 module. The ESP32 controller handles the energy flow and transmits the energy consistently. Additionally, the L293D motor driver helps organize the charging for the vehicle.

This technology provides flexibility by allowing for portable energy sources and reducing charging time. The real-time location tracking offers accurate vehicle location and increased charging efficiency for the automated power transfer system.



**Figure 5.** Web Dashboard

In the proposed method, two vehicles are connected using a wireless connection for charging within a specific distance. The implementation of IoT-based location tracking to recognize and connect with the receiver vehicle provides optimal synchronization for energy transmission. The CC2500 module improves connectivity using Zigbee for real-time data sharing and verifies that the process works efficiently.

**Table 4.** Experimental Results of the Proposed V2V

Parameter	Measured Value
Input voltage	12 V
Average power transferred	22 W
Charging efficiency	78 %
Energy delivered	18 Wh
Charging duration	50 minutes
Temperature rise	< 6 °C

The wireless power transmission is aligned as indicated in the results. The system provides an average power transfer of 22 W and a charging efficiency of around 78%.

**Table 5.** Comparison Table of Existing vs Proposed System

Features	Existing System	Proposed System
Architecture	Centralized	Decentralized IoT-based prototype
Charging Type	Fixed grid-based	Grid, V2V, Wireless, Renewable
Intelligence	Rule-based	Rule-based (ESP32)
Battery Management	Basic monitoring	Sensor-based protection
Scalability	Limited	High
Security	Minimal	Encrypted and authenticated
Response Time	High latency	Low latency
Energy Efficiency	Moderate	High

## 7. Conclusion

This system proposes a cost-effective and environmentally friendly method for charging electric vehicles (EVs). It enables efficient energy transfer between vehicles reducing the dependence on permanent charging stations by using wireless power transfer (WPT)

technologies with IoT-based location monitoring. The energy flow is monitored by the ESP32 microcontroller. The Zigbee CC2500 device provides real-time communication for maintaining optimal vehicle alignment. This technique describes portable wireless charging. Future improvements could focus on power transfer efficiency, expanding charging distance and improved security features to develop smart and autonomous electric vehicle charging systems. Future advancements will focus on improving alignment accuracy, expanding transmission distance and updating renewable energy sources to make the system more environmentally friendly. It also transmits charging for electric vehicles, making it cost-effective for current transportation networks.

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