

AI Based Wireless Charging Station For Electrical Vehicles

Mohamed Halith¹, HarishAdithya², Mohamed Haris³, Stephy Angelin . J(Mentor)⁴

^{1,2,3}Dept of Electronics Engineering

^{1,2,3} Mohamed Sathak A.J College of Engineering Chennai

Abstract- As The production of electric vehicles (EVs) has significantly increased in recent years, driven by the need to reduce carbon emissions and promote environmentally friendly transportation. This transition from traditional internal combustion engine vehicles to battery-powered electric vehicles has been further accelerated by the rise in petroleum and diesel prices, resulting in a growing market share for EVs.

Consequently, the rapid increase in EV adoption has highlighted the need for widespread charging infrastructure. However, establishing conventional charging stations can be challenging, particularly in densely populated urban areas where space is limited and the initial investment cost is high.

To address this issue, this project proposes an innovative AI-based Mobile Wireless Charging System for Electric Vehicles. The system provides a cost-effective and reliable charging solution, especially suitable for high-traffic locations such as parking facilities, shopping malls, parks, theaters, and other public areas.

To enhance system effectiveness and adaptability, a Wireless Sensor Network (WSN) is integrated with the charging infrastructure. The AI-enabled control system continuously monitors charging requirements and optimizes charging operations, thereby improving accuracy, efficiency, reliability, and modularity. This approach contributes to the development of a smarter and more sustainable EV charging ecosystem.

Keywords: Electric Vehicle (EV), Wireless Charging, Artificial Intelligence (AI), Wireless Sensor Network (WSN), Sustainable Transportation, Smart Charging Infrastructure .

I. INTRODUCTION

The rapid growth of Electric Vehicles (EVs) has increased the demand for efficient, intelligent, and user-friendly charging infrastructure. Conventional plug-in charging methods suffer from limitations such as cable wear, environmental exposure, user inconvenience, and maintenance requirements. Wireless Power Transfer (WPT) technology has

emerged as a promising alternative by enabling contactless charging through electromagnetic fields.

Recent advancements in Internet of Things (IoT) technologies have further enhanced EV charging systems by enabling real-time monitoring, remote control, energy management, and smart communication between vehicles, charging stations, and power grids. The integration of WPT and IoT creates a smart charging ecosystem capable of improving charging efficiency, user convenience, and grid reliability.

This paper presents a comprehensive review of wireless EV charging technologies, IoT integration, implementation challenges, safety concerns, cybersecurity issues, and future research directions. The objective is to evaluate current developments and identify opportunities for creating scalable and sustainable EV charging infrastructures.

II. IDENTIFY, RESEARCH AND COLLECT IDEA

The transition toward sustainable transportation has motivated extensive research in wireless charging systems for EVs. Various WPT technologies such as Inductive Power Transfer (IPT), Resonant Inductive Coupling, Capacitive Power Transfer (CPT), and Magnetic Gear Transmission have been proposed to improve charging convenience and efficiency.

The major objectives of the study are:

1. To analyze different wireless charging techniques for EVs.
2. To investigate the role of IoT in smart charging infrastructure.
3. To identify implementation challenges and safety concerns.
4. To study cybersecurity issues in IoT-enabled charging systems.
5. To recommend future research directions for large-scale deployment.

The research was conducted by reviewing recent journal papers, IEEE publications, and industry standards

related to EV charging technologies, wireless power transfer, and smart grid communication systems.

III. WRITE DOWN YOUR STUDIES AND FINDINGS

A. Wireless Power Transfer Technologies

Wireless Power Transfer serves as the foundation of contactless EV charging. Energy is transferred from a transmitting coil to a receiving coil through electromagnetic fields without physical connectors.

1. Inductive Power Transfer (IPT)

IPT is the most widely adopted wireless charging technology. It operates using electromagnetic induction between transmitter and receiver coils. Advantages include high efficiency, safety, and commercial maturity. However, efficiency decreases when coil alignment is poor.

2. Resonant Inductive Coupling

This technique uses resonant circuits at both transmitter and receiver ends to maximize power transfer. It provides higher efficiency over larger air gaps and better tolerance to coil misalignment compared to conventional IPT systems.

3. Capacitive Power Transfer (CPT)

CPT transfers energy using electric fields generated between conductive plates. The system offers compact design and lower electromagnetic interference but is limited by lower power transfer capability.

4. Magnetic Gear Transmission

Magnetic gear systems transfer torque without physical contact using magnetic coupling. Although primarily used in mechanical power transmission, they have potential applications in advanced EV charging architectures.

B. IoT Integration in EV Charging

IoT technology enables intelligent monitoring and control of wireless charging systems. Sensors and communication modules collect real-time operational data and transmit it to cloud platforms for analysis.

Key functions include:

- Remote monitoring of charging status.

- Battery health analysis.
- Dynamic energy management.
- Load balancing.
- Predictive maintenance.
- User authentication and billing.

IoT-based charging systems improve operational efficiency while providing better user experience and grid coordination.

IV. IMPLEMENTATION CHALLENGES

Despite significant technological progress, several challenges limit the widespread adoption of Wireless EV Charging Systems (EVWCS).

A. Alignment Sensitivity

Wireless charging efficiency depends heavily on proper alignment between transmitter and receiver coils. Misalignment reduces coupling efficiency and increases power losses.

B. Air Gap Limitations

Vehicle ground clearance creates air gaps that affect magnetic coupling. Larger air gaps lead to reduced charging performance.

C. Thermal Management

High-power wireless charging generates heat in coils and power electronic components. Effective cooling systems are necessary to maintain reliability and safety.

D. Electromagnetic Interference (EMI)

Wireless charging systems generate electromagnetic fields that may interfere with nearby electronic devices and communication systems.

E. Infrastructure Cost

Installation of wireless charging infrastructure, especially dynamic charging lanes, requires substantial investment in road modifications and power systems.

F. Standardization Issues

Lack of globally accepted standards creates interoperability challenges between vehicles and charging stations from different manufacturers.

V. HEALTH, SAFETY AND CYBERSECURITY CONCERNS

A. Health and Safety Concerns

Wireless charging systems generate electromagnetic fields that raise concerns regarding long-term human exposure. International organizations such as IEEE and ICNIRP have established exposure limits to ensure public safety.

Foreign Object Detection (FOD) systems are required to identify metallic objects placed between charging coils. Failure to detect such objects may result in overheating, burns, or fire hazards.

Additional safety requirements include:

- Automatic shutdown mechanisms.
- Thermal protection systems.
- Fault detection algorithms.
- Emergency isolation procedures.

B. Cybersecurity in IoT-Based Charging Systems

The integration of IoT increases system connectivity but also introduces security vulnerabilities.

Potential threats include:

- Unauthorized access.
- Data interception.
- Identity spoofing.
- Malware attacks.
- Grid manipulation.

To mitigate these risks, advanced cybersecurity measures such as encryption, authentication protocols, intrusion detection systems, and secure firmware updates must be implemented.

C. Policy and Regulatory Framework

Successful deployment of wireless charging systems requires compliance with international standards and regulations. Organizations such as IEEE, IEC, ISO, and SAE develop guidelines covering:

- Wireless charging safety.
- Electromagnetic compatibility.
- Communication protocols.

- Interoperability requirements.
- Cybersecurity frameworks.

Government policies promoting clean transportation and renewable energy integration further support EV charging infrastructure development.

VI. CONCLUSION

Wireless Power Transfer combined with IoT technology represents a transformative solution for future electric vehicle charging infrastructure. Technologies such as Inductive Power Transfer, Resonant Inductive Coupling, Capacitive Power Transfer, and Magnetic Gear Transmission provide various approaches to achieving efficient and convenient wireless charging.

IoT integration enables intelligent energy management, real-time monitoring, predictive maintenance, and improved user interaction. However, challenges including alignment sensitivity, thermal management, infrastructure costs, cybersecurity risks, and lack of standardization must be addressed before large-scale deployment becomes practical.

Future research should focus on improving charging efficiency, developing dynamic wireless charging systems, strengthening cybersecurity mechanisms, enhancing interoperability standards, and integrating renewable energy sources into charging networks.

The successful convergence of Wireless Power Transfer and IoT technologies will contribute significantly to sustainable transportation, smart cities, and next-generation intelligent energy systems.

VII. ACKNOWLEDGMENT

The authors express their sincere gratitude to the Department of Electrical and Electronics Engineering, Mohamed Sathak AJ College of Engineering, Chennai, for providing support and guidance throughout this research work.

REFERENCES

- [1] S. Karim et al., "Wireless Power Transfer and IoT in EV Charging: Opportunities, Challenges, and Future Directions," *IEEE Access*, 2026.
- [2] C. Panchal, S. Stegen, and J. Lu, "Review of Static and Dynamic Wireless Electric Vehicle Charging Systems," *Engineering Science and Technology*, 2018.
- [3] K. Dimitriadou et al., "Current Trends in Electric Vehicle Charging Infrastructure," *Energies*, 2023.

- [4] B. A. Rayan et al., “Wireless Power Transfer in Electric Vehicles: A Review,” *Energies*, 2023.
- [5] S. Iqbal et al., “Smart and Sustainable Wireless Electric Vehicle Charging Strategy with Renewable Energy and IoT Integration,” *Sustainability*, 2024.