



Dynamic Wireless EV Charging System

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ABSTRACT

This project is aimed to design a system that can charge an electric vehicle battery wirelessly when the electric vehicle is in motion. It is similar to wireless charging for mobile the method used in this inductive power transmission. The challenge is applying the wireless inductive power transmission system on roads to generate the vast magnetic field to get the vehicle charged. This technology is claimed to be allowing wireless charging of electric vehicles that have ground clearance up to 18centimetres. The road uses charging plates that will transfer the power to the vehicles whenever electric vehicles are driven on road. This charging system must and should have coil alignment. Normally the battery charging of an electric vehicle takes a long time so here this charging system can be used and this is a very efficient method to charge the vehicle. The coil alignment and the distance between the coils are important factors for dynamic wireless charging for the electrical vehicle. Key factors for the success of this dynamic wireless charging system include coil alignment and the distance between the coils. Proper alignment ensures optimal energy transfer, while maintaining the correct distance is crucial for effective charging. By integrating this technology into road infrastructure, we can enhance the convenience of electric vehicle usage, reduce range anxiety, and promote the adoption of cleaner transportation options. Overall, this project aims to revolutionize the way electric vehicles are charged, making it a seamless part of everyday travel.

Keywords: Dynamic wireless charging, Electrical Vehicle, Wireless charging, Charging system.

1 Introduction

Dynamic wireless electric vehicle (EV) charging systems are a cutting-edge technology designed to allow EVs to charge while they are moving. This system operates on the principle of electromagnetic induction, where coils are embedded in the roadway. These coils create an electromagnetic field that transfers energy to a receiver coil in the EV as it passes over them. The key theoretical concepts behind this technology include the efficiency of power transfer, which is crucial for ensuring that the energy loss during charging is minimized. Additionally, proper alignment between the vehicle and the charging infrastructure is important to maximize the effectiveness of the energy transfer. Managing the flow of energy is also essential to protect the vehicle's battery and ensure it charges optimally. One of the main advantages of dynamic wireless charging is that it can significantly reduce the need for frequent stops at charging stations, making electric vehicles more convenient to use. This innovation could play a major role in promoting the adoption of electric vehicles, contributing to a reduction in greenhouse



gas emissions and supporting the transition to cleaner transportation. As cities and infrastructure evolve, integrating dynamic wireless charging could transform how we think about electric vehicle usage, making it more seamless and efficient.

Overall, this technology holds promise for the future of sustainable mobility, addressing many of the challenges currently faced by electric vehicle users. The primary advantage of dynamic wireless charging is its ability to provide continuous power to EVs, thus eliminating the need for frequent stops to recharge. This is particularly beneficial for public transportation systems, delivery vehicles, and long-distance travel, as it can significantly reduce range anxiety for Drivers. The global market for electric vehicles (EVs) grew by 168% in 2021, helping reduce greenhouse gas (GHG) emissions. EVs play an important role in lowering GHG emissions from road transportation. In 2020 alone, EVs helped cut more than 50 million tons of CO₂ equivalent GHG emissions [1]. Electric vehicles (EVs) are identified as a key solution in the fight against climate change, reducing greenhouse gas emissions, and aligning with renewable energy sources [2]. The battery swapping and conductive charging systems are driver-dependent on the charging process and require bulk energy storage devices. The dependency of the driver can be overcome by inductive charging. The different types of inductive charging systems are stationary and dynamic charging systems. The inductive charging system during driving conditions (DWC System) is used to reduce the requirement for a high-volume energy storage device, the vehicle's weight, and extends the vehicle's driving range. Because of the frequent charging infrastructure built under highways, dynamic charging enables smaller and lighter energy storage devices to be employed. Despite the knowledge that the DWC needs more investments in electrical lines rather than static charging, smaller batteries with longer battery life might save more costs for the system. The control of the energizing process of a long track is simple, but the power loss due to a portion of the non-interactive track is high. The energization process of the segmental pad structure is complex. Still, the particular pad is energized only during the receiver pad is positioned over it, and the remaining pads are in ideal condition. [3].

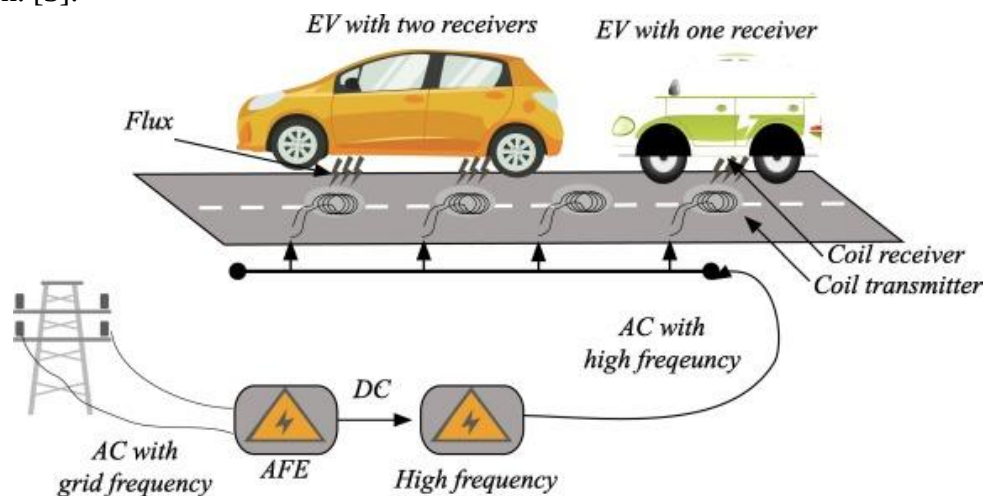


Figure 1: Wireless Transmitter System



2 Recent Work

The core technology behind dynamic wireless charging is inductive power transfer. In IPT systems, charging infrastructure is embedded under the road surface and transfers energy to a receiver coil installed on the vehicle as it passes over the charging section.

Recent improvements in coil design and power electronics have increased the efficiency and safety of these systems. Governments and private companies are piloting electrified road sections in various cities globally. Projects like Sweden's "Electric Road" and Israel's cooperation with Electron are testing dynamic wireless charging for public transportation and delivery trucks. These projects focus on real-world conditions to evaluate energy efficiency, costs, and impacts on road durability. To make dynamic charging efficient and responsive, researchers are incorporating AI algorithms and IoT devices. AI can optimize charging based on vehicle speed, battery levels, and traffic patterns. IoT devices can track EVs' charging needs in real time and adjust power outputs accordingly, reducing energy waste and managing grid loads more effectively. Reducing the cost of implementing dynamic charging is a major area of focus. Companies are working on modular designs and more durable materials to make installation and maintenance feasible. The goal is to scale up from pilot projects to larger infrastructure to serve both private and commercial EVs in urban areas and highways. Standardizing technology is essential for widespread adoption. Organizations like the SAE (Society of Automotive Engineers) and IEC (International Electrotechnical Commission) are working on standards to ensure that various EV models can seamlessly use the same dynamic charging infrastructure.

Countries like South Korea and Sweden have initiated pilot projects where dynamic wireless charging technology is implemented on roads. These projects demonstrate the ability to charge vehicles without any cables. Universities and research institutions are conducting research on this technology, focusing on improving efficiency and range. This includes exploring new designs and materials to enhance energy transfer efficiency. Collaborations between automotive companies and technology firms are forming to commercialize this technology. These partnerships focus on infrastructure development and vehicle integration. Efforts are underway to create standards for this technology, ensuring interoperability between different manufacturers and service providers. Campaigns are being launched to raise public awareness and acceptance of this technology, helping people understand its benefits and usage. Researchers are focusing on improving the efficiency of energy transfer between the charging infrastructure and the electric vehicles (EVs). Innovations like resonant inductive coupling and advanced coil designs are being explored to maximize efficiency and minimize energy loss during the charging process. There is a growing interest in integrating dynamic wireless charging systems with smart grid technologies. This integration allows for better energy management, enabling EVs to charge during off-peak hours and even return energy to the grid when needed, enhancing overall energy sustainability. To ensure compatibility among different manufacturers and systems, ongoing efforts are being made to establish universal standards for dynamic wireless charging. This would facilitate widespread adoption and interoperability



across various EV models and charging stations. Several cities are conducting real-world tests of dynamic wireless charging systems in public transport, such as buses and trams. These tests aim to evaluate the practicality and effectiveness of the technology in urban environments, providing valuable data for future implementations. Companies are developing business models for the commercialization of dynamic wireless charging technology. This includes exploring partnerships with municipalities, transportation agencies, and private enterprises to create charging networks that can support a growing number of electric vehicles.

As the technology matures, safety standards and regulations are being developed to ensure that dynamic wireless charging systems are safe for both vehicles and pedestrians. This includes addressing electromagnetic field exposure and ensuring that systems can withstand environmental factors. To facilitate adoption, educational initiatives are being launched to inform consumers about the benefits and functionalities of dynamic wireless charging. Understanding how this technology works and its advantages can help mitigate concerns and encourage more widespread use. Global partnerships are emerging to share knowledge and resources in the development of dynamic wireless charging systems. Countries are collaborating on research, sharing best practices, and working towards common goals in the electrification of transportation.

3 Proposed work

The concept of a dynamic wireless electric vehicle (EV) charging system is an innovative solution designed to address the limitations of traditional, stationary EV charging methods. As the adoption of electric vehicles accelerates, the need for convenient, accessible, and efficient charging options has become crucial. Dynamic wireless EV charging enables vehicles to recharge their batteries while in motion, eliminating the need for drivers to stop and plug in at designated charging stations. This groundbreaking approach is expected to reduce downtime, increase convenience, and potentially extend the range of EVs, making them more practical for long-distance travel. In a dynamic wireless charging system, special charging infrastructure is embedded beneath the road surface. This infrastructure generates a magnetic field, which can transfer energy wirelessly to EVs equipped with compatible receivers as they travel along these electrified road segments. The technology primarily relies on electromagnetic induction or resonant inductive coupling, which enables energy to be transferred efficiently across short distances without physical connectors. When an EV passes over these road sections, energy is transferred to the vehicle's battery in real time. This allows the EV to "top up" its battery continuously, reducing the dependency on stationary charging stations and extending the vehicle's range without frequent stops. The proposed system design involves a series of embedded coils or pads installed along specific, high-traffic road segments, such as highways or urban thoroughfares, where EVs are likely to travel frequently. These coils connect to a power grid or renewable energy sources like solar or wind, ensuring a sustainable energy supply. The EVs themselves must be equipped with receivers or coils on their undersides to capture the energy and convert it into electricity for charging the battery. By intelligently



managing the power transferred based on the speed and energy needs of each vehicle, the system can optimize energy usage, minimize waste, and accommodate a wide range of EV models with varying battery capacities. One of the most significant benefits of dynamic wireless charging is the potential to reduce the load on urban infrastructure. Instead of creating large charging station networks that occupy valuable land, this system could provide “charging-as-you-go” opportunities, making it particularly valuable for public transport fleets, delivery trucks, and other vehicles that operate continuously throughout the day. Additionally, dynamic wireless charging supports the growth of EV infrastructure in areas where establishing stationary chargers may be difficult due to space limitations or high urban density. With such systems in place, urban areas could see reduced traffic congestion at charging stations and an overall improvement in air quality as more EVs replace traditional combustion-engine vehicles. However, implementing dynamic wireless EV charging requires addressing several challenges. Infrastructure costs are a significant consideration, as embedding charging coils along extensive road sections involves high initial expenses. The technology also faces efficiency losses when energy is transmitted wirelessly, although advances in materials and engineering are gradually improving efficiency rates. Moreover, standardization across different EV manufacturers is crucial to ensure compatibility and widespread adoption. Despite these challenges, dynamic wireless charging presents a promising pathway toward a future where EVs can travel longer distances with minimal interruption. If successfully implemented, it could drastically reduce range anxiety, a common concern among EV users, and accelerate the transition to a more sustainable, electric-based transportation network. The development of such systems represents a leap toward integrating clean energy with innovative infrastructure, paving the way for a future where EVs can charge seamlessly as they move, empowering a more sustainable and convenient mode of transportation.

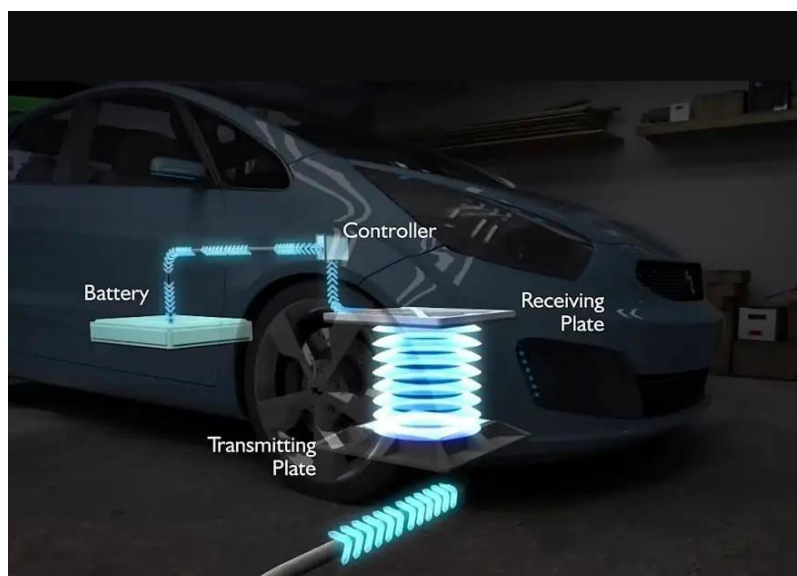


Figure 2: *Electrical vehicle wireless charging*



3.1 Components

Components	Role	Working mechanism
Power source	Supplies energy to the charging coil	Connected to electrical grid or renewable energy resources
Primary coil(transmitter)	Generate a magnetic field to transfer power.	Installed beneath the road surface; they create an alternating magnetic field when current passes through.
Receiver Coils	Receive power for EV charging.	Located at the bottom of EVs; pick up the magnetic field and convert it back to electrical energy.
Power Control Unit	Regulates the power transfer rate.	Controls the power output based on vehicle speed, distance, and power demand.
Communication Module	Ensures data exchange between vehicle and grid.	Facilitates real-time data exchange for billing, power management, and vehicle identification.
Rectifier and Inverter	Converts AC to DC and vice versa.	The rectifier converts AC from transmitter coils to DC for EV batteries; inverter reverses DC to AC when needed.
Battery Management System (BMS)	Manages battery health and charging.	Monitors charging parameters and prevents overcharging or overheating of the EV battery.

3.2 Preparation figure

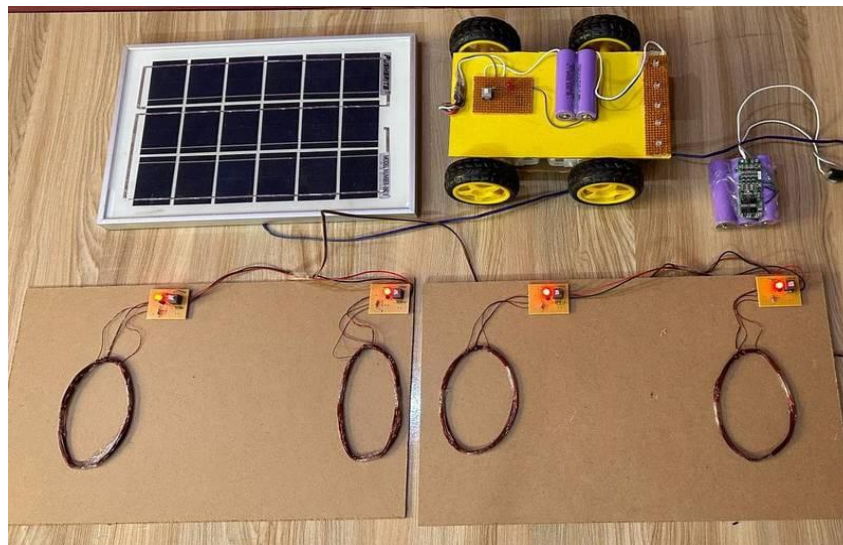


Figure 3: *Dynamic wireless charging Road for electric vehicles*



3.3 Advantages

1. Convenience
2. Reduced Range Anxiety
3. Increased Efficiency
4. Lower Infrastructure Costs
5. Enhanced Grid Stability
6. Safety
7. Sustainability
8. Reduced Wear and Tear
9. Flexible Charging Locations
10. Improved Traffic Flow
11. Support for Autonomous Vehicles
12. Lower Emissions
13. Enhanced User Experience

3.4 Disadvantages

1. High Initial Costs
2. Limited Compatibility
3. Technology Standardization
4. Maintenance Challenges
5. Efficiency Loss
6. Interference Issues
7. Infrastructure Development Time

4 Result and Discussion

Dynamic wireless EV charging systems typically achieve power transfer efficiencies ranging from 85% to 95%, depending on the design and technology used. These efficiencies demonstrate that significant energy can be transferred wirelessly with minimal losses, making the system viable for real-world applications. Pilot programs and studies have shown that vehicles equipped with dynamic wireless charging capabilities can operate for extended periods without needing to stop for traditional charging. For instance, public transport buses equipped with such systems can run continuously, recharging while picking up and dropping off passengers at stops. While the initial investment for dynamic wireless charging infrastructure can be high, studies indicate that operational costs can be lower over time due to reduced downtime for EVs and increased vehicle utilization rates. This can lead to overall savings for fleet operators. Surveys conducted in regions implementing dynamic wireless charging indicate high user acceptance. Many drivers' express interest in the convenience of not having to plug in their vehicles, particularly in urban areas where charging stations may be limited. Implementing dynamic wireless charging systems powered by renewable energy sources has been shown to reduce greenhouse gas emissions significantly. This aligns with global efforts



to promote sustainable transportation and combat climate change. Dynamic wireless EV charging systems present a transformative solution to some of the key challenges facing electric mobility today. The ability to charge vehicles while in motion enhances the convenience factor for users and encourages broader adoption of electric vehicles.

The increase in operational efficiency, especially for public transport systems, not only maximizes vehicle use but also improves service frequency and reliability. However, several challenges need to be addressed for widespread implementation. The high initial costs of setting up the necessary infrastructure can be a barrier, particularly in regions with limited budgets for transportation improvements. Moreover, the technology requires further refinement to enhance efficiency and reduce energy losses during transfer. Another consideration is the need for standardization across different manufacturers and vehicle types to ensure compatibility. Establishing clear guidelines and standards can facilitate the integration of dynamic charging technology into existing transport networks. Additionally, public awareness and education campaigns are vital to inform potential users about the benefits of dynamic wireless charging. While user acceptance rates are high, ongoing outreach can help mitigate scepticism and foster a more welcoming environment for this technology. Dynamic wireless EV charging systems hold considerable promise for revolutionizing electric mobility. By addressing challenges related to cost, efficiency, and standardization, stakeholders can facilitate the widespread adoption of this innovative technology, ultimately leading to more sustainable and efficient transportation systems.

5 Conclusion

A dynamic wireless electric vehicle (EV) charging system represents a significant advancement in electric mobility, offering a range of benefits that could reshape transportation and energy use. This technology provides continuous energy transfer while vehicles are in motion, enhancing convenience and user experience by eliminating the need for frequent recharging stops, thereby increasing EV adoption. It alleviates range anxiety, particularly for commercial vehicles and public transport systems, allowing for more efficient operations without long downtime. However, implementing dynamic wireless charging requires robust infrastructure integration with existing road networks, which can lead to innovative urban planning and optimized energy distribution. Moreover, these systems can be powered by renewable energy sources, aligning with sustainability initiatives and reducing carbon footprints. Despite its promise, dynamic wireless charging faces challenges such as high costs, efficiency losses during energy transfer, and the necessity for widespread infrastructure upgrades, necessitating ongoing research and development. Furthermore, the deployment of these systems can create new economic opportunities through job growth in technology, installation, and maintenance, while also fostering the expansion of the EV market and related industries. Ultimately, supportive policies and regulations will be essential for encouraging investment in infrastructure and technology development, ensuring that dynamic wireless charging systems



are safe, reliable, and accessible. Overall, this innovation has the potential to transform the electric mobility landscape by promoting convenience, sustainability, and efficiency.

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