

DYNAMIC CAR CHARGING SYSTEM OF ELECTRIC CARS

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Abstract

The rapid growth of electric vehicles (EVs) has created a strong demand for efficient, safe, and continuous charging technologies that can reduce range anxiety and dependence on large battery packs. This project presents the design and implementation of a Dynamic Wireless Charging System that enables electric vehicles to charge while in motion using Inductive Power Transfer (IPT). The system consists of transmitting coils embedded under the road surface and a receiving coil mounted beneath the vehicle, supported by high-frequency power electronics, compensation networks, and control circuitry. When the vehicle passes over the transmitter coil, an alternating magnetic field is generated and efficiently coupled to the receiver to transfer energy wirelessly without physical contact. The project focuses on system design, coil geometry, resonant compensation, alignment challenges, power transfer efficiency, and safety considerations. The proposed model aims to reduce the need for frequent charging stops, enhance driving range, and support the development of sustainable smart-transportation infrastructure. Experimental results and simulations demonstrate the feasibility of dynamic wireless charging for future EV mobility, highlighting its advantages in convenience, reliability, and scalability.

Keywords- Electric Vehicles (EVs), Dynamic Wireless Charging, High-Frequency Power Electronics, Power Transfer Efficiency, Dynamic Charging System, EV Charging Technology

1. Introduction

The transportation sector contributes over half of the oil consumption and a quarter of the CO₂ emissions, which is considered one of the factors resulting in the Greenhouse effect. Electric vehicles (EVs), by reducing the dependency on crude oil and minimizing the transportation-related pollutants emissions, are regarded as an effective component in a sustainable transportation system and are becoming increasingly popular. However, the massive penetration of EVs brings the big challenge of EV recharge-related issues. As EVs grow in popularity and are used in a variety of applications, such as delivery vehicles, corporate fleets, and personal trips, it will be critical to keep EV batteries charged without hindering vehicle range. Although the capacity and driving range of EV batteries has expanded significantly in recent years, charging solutions can also make EVs more

viable for widespread use. Therefore, it is helpful for EV professionals to understand industry developments to help implement innovative approaches in creating a carbon-neutral world.

This section reviews relevant literature related to computing, electronics, and artificial intelligence. Existing methods and their limitations are critically analyzed. The review highlights the need for improved techniques addressed by the proposed work.

As the global shift towards electric vehicles (EVs) accelerates, the need for efficient, convenient, and innovative charging solutions has become more critical than ever.

Traditional plug-in charging methods, though effective, present limitations in terms of user convenience, infrastructure scalability, and time

efficiency. In response to these challenges, next-generation wireless charging technology is emerging as a groundbreaking solution poised to revolutionize the way EVs are powered up.

Wireless charging for EVs, also known as inductive charging, eliminates the need for physical cables and connectors. Instead, it enables energy transfer coils sector between a power source and an EV through electromagnetic fields, typically using resonant inductive coupling. This technology has the potential to simplify the user experience significantly, reduce wear and tear on physical connectors, and open up possibilities for dynamic charging where vehicles can be charged while in motion, such as on specially equipped roadways, which is the separate tracks setup.

Recent advancements in wireless power transfer (WPT) are pushing the boundaries of what's possible. Higher efficiency coils, smart alignment systems, bi-directional energy flow, and integration with renewable energy sources are the key features being developed in next-generation wireless charging systems. These technologies promise to make EV charging not only faster and more efficient but also smarter and more adaptable to the needs of modern transportation infrastructure. Moreover, this implementation of wireless charging could be drastically reshaped in urban planning at smart cities and fleet management. For instance, public buses and taxis could be wirelessly charged during brief stops, reducing downtime and increasing operational efficiency. Similarly, wireless charging embedded in residential garages or commercial parking spaces can make charging seamless for everyday users.

However, there are still challenges to overcome before wide-scale adoption becomes feasible. These include standardization across manufacturers, electromagnetic interference concerns, cost of installation and maintenance, and ensuring safety and efficiency across different usage. Despite these hurdles, the rapid pace of research and the increasing investment in wireless EV charging technologies signal promising for good future. In conclusion, next-generation wireless charging stands at the forefront of EV innovation. By addressing current limitations and enhancing the practicality of EV ownership, this technology not only supports

the transition to cleaner transportation but also lays the foundation for a more connected, intelligent, and sustainable mobility ecosystem. As research and development continue to mature, wireless charging system is set to become an integral component of the future electric vehicle landscape.

A. Objectives

The primary objectives of this work are:

- **Dynamic Wireless Charging Advantage:** Unlike static charging stations where vehicles must stop to recharge, dynamic wireless charging allows electric vehicles (EVs) to charge while in motion, enhancing travel efficiency and reducing downtime.
- **Technology Behind Charging on the Move:** Embedded wires beneath road surfaces generate electromagnetic fields using magnetic induction. As the vehicle drives over these sections, its onboard receiver captures this energy and charges the battery in real time in motion.
- **Basic Principle of Wireless Power Transmission:** A transmitter, powered up by an external electric source, creates a time-varying electromagnetic field. A receiver in the EV picks up this field and converts it into usable power.
- **Elimination of Physical Connections:** Wireless power transmission removes the need of cables and physical plugs, offering greater convenience and safety, particularly in adverse environments or for moving vehicles.
- **Applications in Challenging Scenarios:** This technology is especially valuable in situations where wires are impractical or dangerous, such as moving vehicles, medical implants, or wet environments, ensuring safe and continuous power delivery with it's criteria.

B. Problem Statement

The wide spread adoption of the electric vehicles (EVs) is hindered by the limitations of current charging infrastructure, leading to range of anxiety and decreased practicality for long-distance travel. The charging systems require EVs to be stationary and connected to a power source, resulting Limited range and flexibility Increased charging time and decreased convenience Insufficient infrastructure to support widespread EV adoption

The goal of this project is to design and develop a dynamic car charging system that enables EVs promoting the widespread adoption of EVs.

- Developing efficient and reliable charging technology
- Integrating charging infrastructure into existing roads and parking areas
- Ensuring safety and compatibility with various EV models
- Optimizing charging speed and energy transfer

Charging infrastructure Charge while in motion or parked, addressing the limitations of current

2. Related Work

Kavitha, M. S., et al. International Journal of Creative Research Thoughts (IJCRT). WIRELESS POWER TRANSMISSION FOR ELECTRIC VEHICLE. Integrating features of all the hardware components used have been developed in it. Presence of every module has been reasoned out and placed carefully, thus contributing to the best working of the unit. Secondly, using highly advanced IC's with the help of growing technology, the project has been successfully implemented. Thus the project has been successfully designed and tested. The offered solution produced less ripple in input/ output voltage and current while utilizing a low value of dc link, and filter capacitance values, respectively [1].

Mou, Xiaolin, et al. International Journal of Creative Research Thoughts (IJCRT). Coupled Wireless Power Transmission For Electric Automobile. This project presents wireless power charging to an electric vehicle (EV). The concept of wireless power transmission was introduced by nikola tesla. Now-a-days electric vehicles involves in large range of vehicles which includes two-Wheeler, three-wheeler and cars. This paper deals with research and development of wireless charging systems for Electric vehicle using wireless power transmission [2].

Aziz, Muhammad, and T. Donato, et al. International Journal of Creative Research Thoughts (IJCRT).

ADVANCED CHARGING SYSTEM FOR AUTOMOBILES. Wireless charging is one of the most convenient charging infrastructures for electric vehicles. It is expensive, but still attracts many researchers.

Because electric vehicles can drive for many hours without stopping to charge, they become truly autonomous. Perhaps the most exciting aspect is that electric vehicles equipped with wireless charging technology on the go can have significantly smaller batteries. As a result, this technology reduces both the environmental impact and the cost of introducing electric vehicles [3].

Lukic, Srdjan, and Zeljko Pantic, et al. International Journal of Creative Research Thoughts (IJCRT) STATIC WIRELESS CHARGING STATION FOR ELECTRIC VEHICLES. This paper proposes a wireless charging system for electric vehicles (EVs) that aims to address the limitations of traditional plug-in charging systems. The wireless charging system utilizes inductive power transfer technology to transfer energy wirelessly between the charging pad and the EV battery [4]

Shanmugam, Yuvaraja, et al. "A systematic review of dynamic wireless charging system for electric transportation." It provides a comprehensive review of static and dynamic wireless charging systems for electric vehicles (EVs). It explains key technologies such as inductive and resonant power transfer, highlighting the advantages of wireless charging like convenience and reduced range anxiety. The review contrasts static systems, where vehicles are stationary, with dynamic systems that charge vehicles in motion. It also addresses challenges such as alignment, efficiency, infrastructure cost, and safety. The paper concludes by emphasizing the potential of wireless charging to support the broader adoption of EVs in the future [5].

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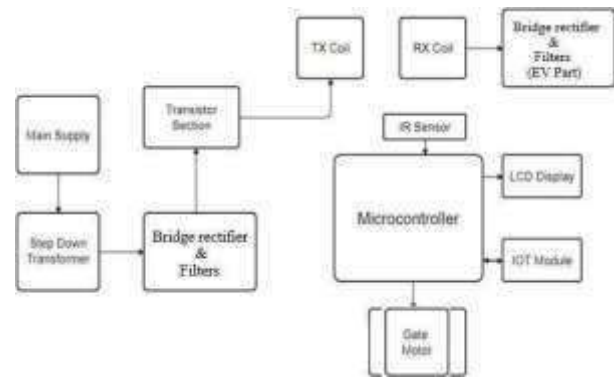
Zhang, Xian, et al. "Coil design and efficiency analysis for dynamic wireless charging system for electric vehicles." In dynamic wireless charging, the design of coils both in the road transmitter measure parameters like coupling, efficiency, and power transfer under misalignment. The design provides a feasible way to build a practical dynamic wireless charging system. Coil design is central to wireless power transfer. This work bridges theory and experiment, showing how practical coil topologies can be engineered for a dynamic system [7].

Novas, Nuria, et al. "Energies and its worldwide research." There is a large variety of research on wireless power transfer (WPT) for EVs, but few papers comprehensively review the dynamic (on-the-go) case. This survey consolidates architectures, topologies, and challenges. The paper systematically covers: transmitter system architectures, compensation network topologies (like LCC, series, parallel), power converters, control strategies, and also looks into standardization and R&D. It also discusses research challenges and future directions. Presents different compensation circuit topologies and how they influence performance. Explains the trade-offs in inverter design, control complexity, and how to maintain good efficiency during vehicle motion. Points out the necessity for standardization and infrastructure planning. As a broad survey, this is very useful for anyone starting in dynamic wireless charging research; it gives a structured map of the field [8].

3. Materials and Methods

Next-gen wireless charging for EVs uses embedded coils and high-frequency power transfer to enable contactless energy delivery. The system integrates IoT for real-time control and secure payments, supporting both stationary and dynamic charging. This design enhances efficiency, user convenience, and paves the way for smarter transportation infrastructure.

A. BLOCK DIAGRAM



Main current supply generally refers to the electrical power provided to a building, home, or machine from the main power source.

Step-Down Transformer Reduces the high AC mains voltage (230V) to a safer low AC voltage (e.g., 12V or 24V) for further processing and circuit operation.

Bridge Rectifier & Filters Converts the low AC voltage from the transformer into DC voltage. Filters help smoothen the DC supply to reduce ripples and provide stable DC power.

Transistor Section (Power Amplifier/Driver) This section amplifies or switches the DC power to produce high-frequency AC needed for wireless power transfer. It helps drive the Transmitter (TX) coil efficiently.

Transmitter Coil (TX Coil) Generates a magnetic field using high-frequency AC. This magnetic field is used to wirelessly transfer power to the receiver coil on the electric vehicle.

Receiver Coil (RX Coil) Receives the magnetic flux from the TX coil and converts it back into AC power through electromagnetic induction.

Bridge Rectifier & Filter (EV Side) Converts the received AC (from RX coil) into DC power. This DC is then used for charging the EV battery or powering the small prototype load.

Microcontroller Works as the brain of the system. It monitors sensors, controls gate motor, displays data, and manages communication (IoT module). Also helps control charging operations.

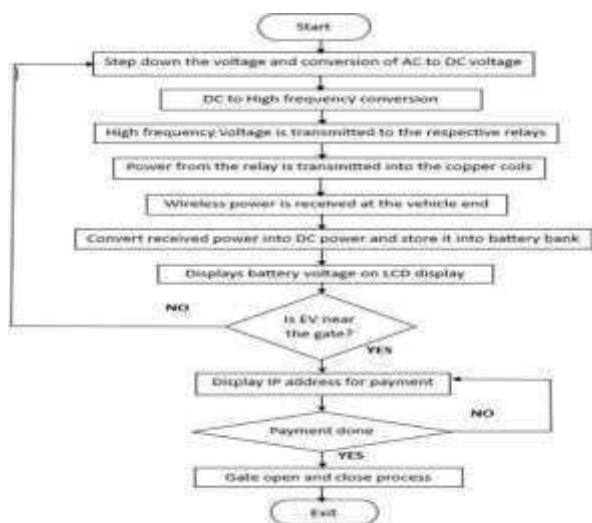
IR Sensor Used to detect the presence or position of the vehicle. When the EV comes into the charging zone, the IR sensor activates charging or opens the gate.

LCD Display Displays system information such as charging status, voltage, vehicle detection, and any alerts

IoT Module (Optional) Allows wireless monitoring of charging parameters like voltage, current, battery charge level, or remote control via mobile app or cloud.

Gate Motor Opens or closes automatically when the vehicle is detected or when charging starts. Used in your prototype to show automation and entry control.

B. FLOW CHART



The proposed smart wireless EV charging system enables contactless power transfer using high-frequency electromagnetic induction while monitoring battery status in real time. An IR sensor and microcontroller manage vehicle detection, charging operation, and automated gate control. The system also integrates IP-based digital payment verification before allowing vehicle exit, providing a seamless, secure, and efficient charging experience for future smart transportation.

4. Results and Discussion

An electric vehicle in a dynamic wireless charging system involves the transfer of electrical energy from a charging source (embedded in the road) to the electric vehicle while it is in motion. This system typically uses magnetic induction. Coils are placed in the road and in the vehicle. When the vehicle passes over the charging coils, an alternating current flows through the road coils, creating a magnetic field. This field induces a current in the vehicle's coils, which then charges the battery. The efficiency of this system depends on several factors, including the distance

between the coils, the alignment of the coils, and the speed of the vehicle. The primary result is the continuous charging of the electric vehicle's battery while driving, which extends the vehicle's range and reduces the need for frequent stops at charging station for electric vehicles contribute to its operation and efficiency. The system's design must consider the power transfer rate, which is influenced by the frequency of the alternating current, the strength of the magnetic field and the size and the configuration of the coils. The alignment of the coils is crucial; precise positioning ensures optimal energy transfer, and any misalignment can significantly reduce efficiency.

The charging lane model explains how the electric vehicle receives power while moving through a dedicated lane embedded with dynamic wireless charging coils. The charging lane contains a series of transmitting coils embedded beneath the road surface. When the vehicle enters this lane, sensors detect its presence and activate only the coils directly underneath the vehicle to ensure efficient energy usage. An alternating current is then supplied to these coils, creating an electromagnetic field. The receiving coil mounted under the vehicle aligns with this field and induces an electrical current, which is converted and supplied to the battery for continuous charging. The model also considers key factors such as the vehicle's speed, coil alignment, and the distance between the road coils and the vehicle's receiving coil, as these factors influence the charging efficiency. As long as the vehicle remains within the charging lane, it experiences uninterrupted energy transfer, allowing the battery to charge while driving. This model helps demonstrate how dynamic wireless charging can extend driving range, reduce dependency on stationary charging stations, and improve energy utilization in real-time road conditions. A communication system is often included to manage the charging process, monitor energy transfer, and potentially communicate with the vehicle. The below shown figure tells us how dynamic wireless charging system works on the principle of electromagnetic induction, which is enabling the electric vehicle to receive power without any physical contact. This system consists of two main parts: the transmitting unit embedded under the road surface and the receiving unit is installed at the bottom of the electric vehicle. When the vehicle approaches or enters the charging lane, sensors detect its presence and activate the transmitting coils beneath the road.

An alternating current that flows through these coils, producing a rapidly changing magnetic field. As the vehicle moves over the coils, the receiving coil captures this magnetic field. According to the principle of electromagnetic induction, this magnetic field induces an electric current in the receiving coil. This induced current is then passed through a power conditioning circuit, which converts it into a stable DC output suitable for charging the vehicle's battery. Throughout this process, the system constantly monitors key factors such as coil alignment, vehicle speed, and the distance between the transmitter and receiver coils. These parameters directly affect the efficiency of energy transfer. The system's control unit ensures that only the coils directly beneath the vehicle are energized at any moment, which improves overall energy usage and minimizes losses.

FUTURE SCOPE

Wireless charging for EVs is expected to revolutionize transportation through dynamic charging, enabling vehicles to charge while in motion and reducing range anxiety. Future advancements in coil design, power electronics, IoT integration, and smart grids will improve efficiency, sustainability, and user convenience. Widespread deployment and standardization will support smart cities, autonomous vehicles, and next-generation electric mobility.

5. Conclusion

Next-generation wireless charging technology represents a major leap forward in the evolution of electric vehicle (EV) and its infrastructure. By eliminating the need for physical cables, wireless charging offers a more convenient and user-friendly method of transferring power to EV's. Advancements in resonant inductive coupling, magnetic alignment, and dynamic wireless charging are paving the way for faster charging times, improved energy transfer efficiency, and the possibility of charging while in motion. These innovations not only enhance the user experience but they also help in accelerating the adoption of electric vehicle by addressing the key concerns such as charging accessibility and the time constraints. The integrating wireless charging with smart grid systems can enable more sustainable energy management, allowing for optimized load balancing and reduced reliance on fossil fuels. Despite challenges like cost, infrastructure development, and

standardization, ongoing research and industry collaboration continue to drive this technology forward. In conclusion, the next-generation wireless charging holds the potential to revolutionize the EV ecosystem, making green transportation more practical and appealing. As this technology matures, it will play a crucial role in building a cleaner, and also the energy-efficient future. This sayings on dynamic wireless charging system for electric vehicles is an innovative solution that enables EV's to charge while moving, reducing range anxiety and eliminating the need for frequent stops to charge the vehicle. It also improves the convenience, supports continuous travel along while battery changing simultaneously, and can help the reduce battery size and cost. Although challenges like high infrastructure investment and safety concerns exist here, ongoing research and pilot projects show strong potential. In the future, this technology can greatly contribute to cleaner and more sustainable transportation systems..

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