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Wireless Energy Transfer on Road for Electric Vehicles

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ABSTRACT

Electric vehicles (EVs) are gaining traction as a cleaner alternative to traditional fossil-fuel-powered transportation. However, their widespread use is hindered by issues such as limited driving range, lengthy charging times, and insufficient charging infrastructure. This project investigates a potential solution through wireless energy transfer (WET) technology, which allows EVs to charge while moving via energy transmitted from coils embedded beneath the road surface. Using the principle of resonant inductive coupling, power is wirelessly transmitted from the road to a receiver coil mounted on the vehicle. This system aims to reduce dependency on large, expensive batteries and eliminate the need for frequent charging stops. The project involves modeling and analyzing the wireless charging process, studying the impact of variables like vehicle speed, coil distance, and alignment on energy transfer efficiency. Additionally, the integration of this system with renewable power sources and smart grid technologies is explored. Overall, the project presents a step toward creating efficient, sustainable, and intelligent transportation systems for the future.

Keywords - Electric Vehicles (EVs), Vehicle Automation, Embedded Systems, Obstacle Detection, Collision Avoidance, Automatic Braking System, GPS Tracking, GSM Communication, Battery Management System (BMS).

INTRODUCTION

The increasing demand for sustainable transportation has led to rapid advancements in electric vehicle (EV) technology. However, one of the major challenges faced by EVs is limited battery capacity and the need for frequent recharging, which restricts long-distance travel and convenience. To overcome these limitations, Wireless Energy Transfer (WET) on roads has emerged as a promising solution. Wireless Energy Transfer on road for electric vehicles is a technology that enables EVs to charge their batteries dynamically while in motion, without the need for physical contact or stopping at charging stations. This system uses electromagnetic induction or resonant magnetic coupling to transfer power from coils embedded under the road surface to a receiver coil installed in the vehicle. As the vehicle moves over the road, energy is continuously transmitted, ensuring an extended driving range and improved efficiency. This innovative approach not only reduces charging downtime but also minimizes dependence on large battery packs, thereby decreasing vehicle weight and cost. Moreover, it supports the development of smart cities by integrating intelligent transportation systems with renewable energy sources. In conclusion, Wireless Energy Transfer on road for electric vehicles represents a significant step toward the future of sustainable transportation — providing a seamless, efficient, and eco-friendly method of powering electric mobility.

PROBLEM STATEMENT

The rapid adoption of electric vehicles (EVs) is essential for reducing global carbon emissions and dependence on fossil fuels. However, the widespread use of EVs is limited by challenges such as long charging times, limited driving range, and the lack of sufficient charging infrastructure. Traditional plug- in charging methods are time-consuming, inconvenient, and require frequent stops for recharging, especially during long-distance travel.

To overcome these limitations, there is a need for a system that can charge electric vehicles dynamically— that is, while they are in motion. Wireless Energy Transfer (WET) technology offers a promising solution by enabling continuous power delivery to EVs through electromagnetic induction or resonant coupling as they move along specially designed roads.

However, implementing such a system poses significant challenges, including efficient power transfer over distance, alignment between transmitting and receiving coils, infrastructure cost, and safety concerns related to electromagnetic exposure.
Therefore, this project aims to design and demonstrate a wireless energy transfer system for electric vehicles on roads, focusing on improving power transfer efficiency, maintaining alignment during motion, and ensuring safe and reliable energy delivery to vehicles without physical contact.

OBJECTIVE:
The main objective of this project is to develop and demonstrate a wireless energy transfer system that can charge electric vehicles dynamically while they are in motion on the road. This project aims to overcome the limitations of conventional plug-in charging methods by providing a continuous, efficient, and contactless power supply using electromagnetic induction or resonant coupling. The goal is to enhance the convenience, range, and sustainability of electric vehicles, ultimately contributing to the development of smart transportation infrastructure and reducing dependency on fossil fuels. The specific objectives of the project are as follows:

1. **To investigate different wireless power transfer methods for EV charging.**
2. **To design and analyses transmitter and receiver coil arrangements for efficient power transfer.**
3. **To develop a simulation model of the wireless charging system under road conditions.**
4. **To study the effect of coil alignment, vehicle speed, and distance on charging efficiency.**

LITERATURE SURVEY

Research into wireless power transfer (WPT) began with the foundational work of Nikola Tesla in the early 1900s, who demonstrated that electrical energy could be transmitted without wires using resonant inductive coupling. Although his early experiments were limited by technology and infrastructure constraints, they laid the conceptual groundwork for modern wireless charging systems. During the late 20th and early 21st centuries, Inductive Power Transfer (IPT) became a major focus in wireless charging research. Studies explored its efficiency, coil design, electromagnetic field behavior, and power electronics for short-range applications. This led to commercial adoption in consumer electronics (mobile phones, accessories) and stationary charging for electric vehicles (EVs). IPT systems proved stable, safe, and relatively easy to implement, though limited by their short effective distance.

A significant advancement came with research into dynamic wireless charging, where vehicles receive power while in motion. The KAIST OLEV project in South Korea was one of the earliest large-scale implementations. It used long segments of buried transmitting coils and demonstrated that buses could be powered on the move using resonant magnetic coupling, reducing the need for large onboard batteries. The OLEV trials validated the concept's feasibility but also highlighted challenges such as infrastructure cost, alignment tolerance, and power transfer optimization.

In recent years, global research efforts have expanded, with Germany, Japan, Italy, Israel, and the USA conducting pilots on wireless charging roadways. These studies focus on resonant inductive or magnetic coupling methods due to their higher power transfer efficiency, tolerance to misalignment, and suitability for moving vehicles. Work includes improvements in coil geometry, interoperability standards, dynamic power control, and electromagnetic safety. Several EU and US Department of Transportation projects have demonstrated successful energy transfer to vehicles traveling at normal traffic speeds.

Across past studies, a recurring conclusion is that resonant inductive coupling offers the best trade-off between efficiency, scalability, and practical deployment for dynamic EV charging systems. Research emphasizes continuous improvements in resonance tuning, coil optimization, and integration with smart-grid infrastructure to support real-world deployment of electrified roadways.

METHODOLOGY

Multiple infrared sensors and transmitting coils embedded along a road simulation make up the system. Each infrared sensor senses the presence of the vehicle above it as the electric vehicle advances and signals the Arduino microcontroller. The Arduino turns on the matching relay that is attached to that sensor based on this input. The relay powers the transmitting coil that is located underneath the car and serves as an electronic switch. By ensuring that only the particular coil beneath the car is ever energized, this configuration lowers power waste and increases energy efficiency. Through inductive coupling, the energized coil wirelessly transmits energy to a receiver coil positioned beneath the car. A battery inside the car is charged using the rectified power that was received, which then powers the DC motors attached to the wheels. In order to show the charging voltage in real time and give a clear indication that power is being successfully transferred and stored, a voltmeter is also connected across the battery terminals. A continuous wireless charging system is created as the car advances by repeating the procedure with the subsequent set of sensors, relays, and coils. This dynamic charging technique lays the groundwork for smart highways and future electric vehicle infrastructure while illuminating the operation of an automated road-based energy transfer system.

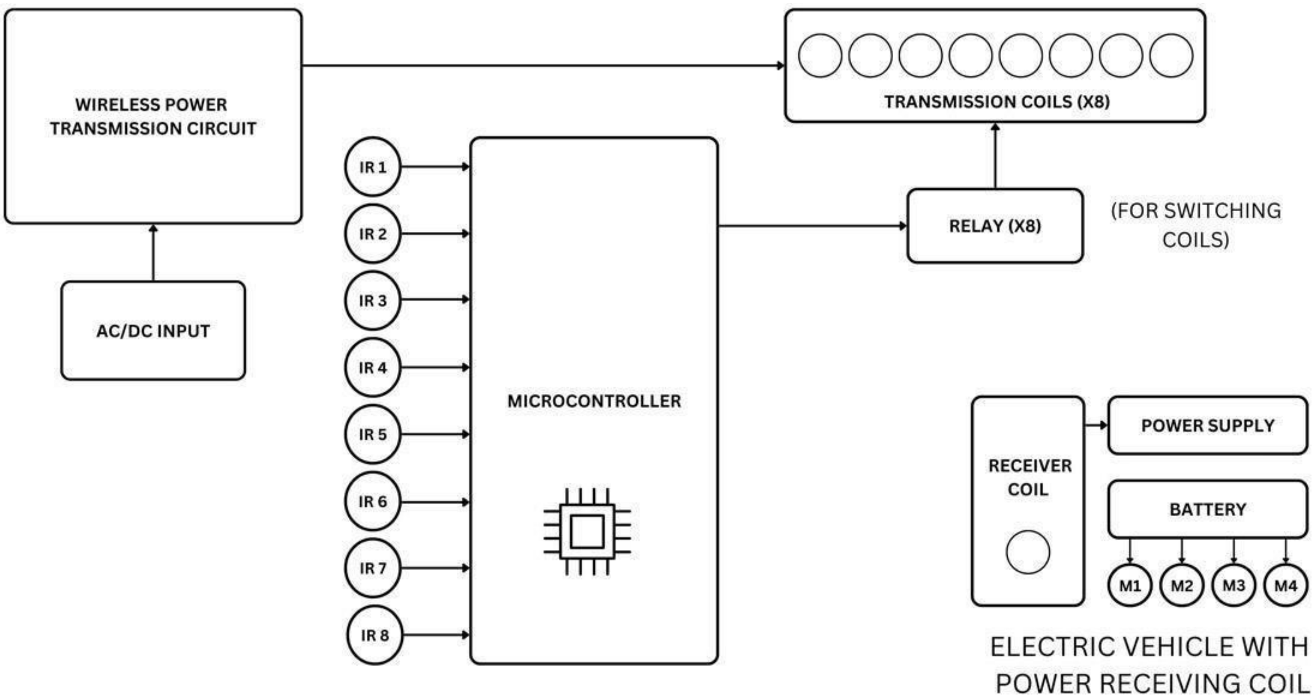

Fig.4.1: Block diagram of proposed system

The overall system operates as a dynamic or adaptive WPT system. The microcontroller uses the input from the IR sensors to identify which segment of the transmission coils is aligned with the vehicle's receiver coil. It then selectively activates only those necessary coils via the relays, maximizing the coupling coefficient and efficiency of the power transfer to charge the EV's battery.

Circuit Diagram

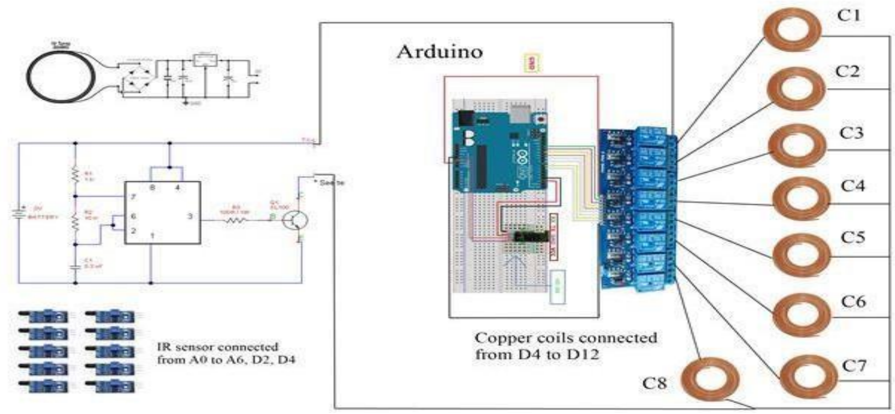

Fig. 5.1 Circuit diagram of Wireless Energy Transfer on Road for EV Vehicles

Transmitter Side (Ground/Charging Pad)

This side is responsible for generating the high-frequency magnetic field and managing which coils are active.

1. **AC/DC Input:** Takes the standard alternating current (AC) power from the grid and converts it into direct current (DC) for the next stage.
2. **Wireless Power Transmission Circuit:** This is the core power electronics. It takes the DC input and converts it back into a high-frequency alternating current (AC). This high-frequency AC is necessary to efficiently create the rapidly changing magnetic field required for inductive power transfer. This block typically contains an inverter circuit (often based on MOSFETs or IGBTs).
3. **Microcontroller (e.g., Arduino/PIC):** This is the **brain** of the system. Its primary role is to manage the selective activation of the transmission coils based on the vehicle's position.
    - It receives input from the **IR Sensors (IR1 to IR8)**.It processes this data to determine which specific transmission coil(s) the EV is aligned with. It sends digital signals to control the **Relay** unit.

4. **IR Sensors (IR1 to IR8):** Infrared sensors placed along the path or charging pad. They are used for **vehicle detection and positioning**. When the EV's receiving coil passes over a sensor, the sensor triggers, informing the microcontroller of the vehicle's location.
5. **Relay (x8) (for switching coils):** An array of electrical switches (relays) connected to the eight transmission coils. The microcontroller uses these relays to **selectively switch ON or OFF** the individual **Transmission Coils (x8)**. This segmented approach is critical for:
    - **Maximizing Efficiency:** Power is only sent to the coil(s) directly underneath the vehicle's receiver coil, ensuring optimal magnetic coupling.
    - **Safety:** It prevents generating strong magnetic fields unnecessarily over a wide area.
6. **Transmission Coils (x8):** These are the segmented primary coils embedded in the surface. When energized by the high-frequency AC, they create the alternating magnetic field that wirelessly transfers energy.

Receiver Side (Electric Vehicle)

This side is responsible for capturing the energy and charging the battery.

1. **Receiver Coil:** A secondary coil mounted on the underside of the EV chassis. It couples magnetically with the active transmission coil(s) on the ground. The changing magnetic field induces a high- frequency AC voltage across the receiver coil windings (based on the principle of **Faraday's Law of Induction**).
2. **Power Supply (AC to DC Converter/Rectifier/Regulator):** This circuit takes the induced high- frequency AC from the receiver coil, **rectifies** it back into DC, and then **regulates** it to the specific voltage and current levels required to safely charge the battery.
3. **Battery:** The vehicle's main energy storage system. The regulated DC power from the Power Supply is fed here to recharge the battery.
4. **M1, M2, M3, M4:** These represent the **motors** (and their associated controllers) that use the energy stored in the battery to drive the wheels and propel the vehicle.

WORKING PRINCIPLE

1. Power Source and Transmitter Coil (Roadside): Electrical power from the grid or renewable sources is converted into high-frequency alternating current (AC) using an inverter. This current flows through a transmitter coil embedded under the road surface, generating an oscillating magnetic field.
2. Magnetic Coupling with Receiver Coil (Vehicle): As the EV moves over the transmitter coil, a receiver coil installed on the underside of the vehicle comes into close proximity. Due to resonant tuning (both coils operating at the same frequency), the magnetic field efficiently induces an AC voltage in the receiver coil.
3. Power Conditioning and Battery Charging: The induced AC voltage in the vehicle's coil is rectified and regulated using a power conditioning circuit (rectifier + DC-DC converter). This regulated DC power is then used to charge the EV's battery or supply power directly to its motor.
4. Dynamic Charging: Multiple transmitter coils are placed in sequence along the road, allowing continuous or intermittent charging as the vehicle moves. Sensors and control systems may activate specific coils only when a vehicle is present to conserve energy and improve efficiency.

CONCLUSION

Wireless Energy Transfer for EVs on roadways represents a transformative leap in electric mobility. By enabling dynamic charging, it addresses major limitations such as range anxiety, battery cost, and charging downtime. Although infrastructure and standardization challenges exist, ongoing research and pilot projects worldwide prove its feasibility. With advancements in power electronics, renewable integration, and smart grid technologies, this innovation can redefine the future of sustainable transportation.

REFERENCES

[1] Covic, G. A., & Boys, J. T. (2013). Inductive Power Transfer. IEEE Transactions on Power Electronics.
[2] Budhia, M., Covic, G., & Boys, J. (2011). Design and Optimization of Magnetic Coupling for Dynamic Wireless Power Transfer. IEEE Transactions on Industrial Electronics.
[3] KAIST OLEV Project Reports, South Korea.
[4] U.S. Department of Energy – Wireless Charging Research.
[5] Bauer, P., et al. (2015). Wireless Power Transfer for Electric Vehicles: State-of-the-Art and Future Trends.