WIRELESS CHARGING SYSTEM FOR EV VEHICLES WHILE DRIVING ON ROAD

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ABSTRACT

The rapid growth of electric vehicles has created a strong need for efficient and user-friendly charging solutions. Conventional charging methods require vehicles to stop and connect to charging stations, which increases waiting time and limits travel convenience. To overcome these challenges, this paper presents a dynamic wireless charging system that enables electric vehicles to charge while moving.

The proposed system is based on electromagnetic induction, where power is transferred wirelessly from transmitter coils embedded in the road to receiver coils placed in the vehicle. A solar energy source is used to supply power to the system, making it more sustainable and environmentally friendly. The received energy is converted into usable electrical power and used to charge the vehicle battery continuously during motion.

An embedded control system is integrated to monitor important parameters such as voltage and current, ensuring safe and efficient power transfer. In addition, a battery management system regulates the charging process, preventing overcharging and improving battery life. Sensors are used to detect the presence of vehicles and activate the charging system only when required, reducing unnecessary energy loss.

The results demonstrate that the proposed system can reduce charging downtime, extend driving range, and improve overall efficiency of electric vehicles. This approach provides a promising solution for future smart roads and sustainable transportation systems by enabling continuous, contactless, and energy-efficient charging.

INTRODUCTION

The global transition towards sustainable energy solutions has accelerated the adoption of electric vehicles (EVs) as an alternative to conventional fuel-based transportation. EVs play a vital role in reducing greenhouse gas emissions, minimizing environmental pollution, and decreasing dependence on fossil fuels. Despite these advantages, the growth of EVs is still limited by challenges related to charging infrastructure, including long charging times, limited availability of charging stations, and user inconvenience during travel.

Conventional charging systems mainly rely on plug-in methods, where vehicles must be connected to a power source through cables. Although widely used, this approach has several drawbacks such as increased waiting time, infrastructure dependency, and reduced operational efficiency, especially for long-distance and commercial applications. These limitations have created a need for advanced charging technologies that can provide continuous and efficient power supply without interrupting vehicle operation.

Wireless power transfer (WPT) technology has emerged as a promising solution to overcome these challenges. By enabling energy transfer without physical contact, WPT improves safety, reduces maintenance issues, and enhances user convenience. Among its various applications, dynamic wireless charging is gaining significant attention, as it allows vehicles to charge while in motion. This technology can significantly reduce charging downtime and extend the driving range of EVs, making them more practical for everyday use.

The proposed system is based on the principle of electromagnetic induction, where an alternating magnetic field generated by transmitter coils embedded in the road induces current in receiver coils installed in the vehicle. This induced energy is then converted into a stable DC supply to charge the vehicle battery. The system is designed to ensure efficient power transfer with minimal energy loss, even when the vehicle is moving.

To promote sustainability, solar energy is integrated into the system as a primary power source. Solar panels installed along the roadside capture sunlight and convert it into electrical energy, which is stored and supplied to the transmitter coils. This approach not only reduces dependency on conventional power sources but also supports the use of renewable energy in transportation systems.

Furthermore, an intelligent control system is incorporated using a microcontroller to monitor and regulate system performance. Parameters such as voltage, current, and power flow are continuously observed to ensure stable and safe operation. A Battery Management System (BMS) is also included to protect the battery from overcharging, undercharging, and other potential risks, thereby enhancing battery life and reliability.

In addition, sensors are used to detect the presence and position of vehicles, enabling selective activation of transmitter coils. This improves overall system efficiency by reducing unnecessary power consumption. The integration of such smart features makes the system suitable for future applications in smart cities, highways, and automated transportation networks.

In conclusion, the proposed dynamic wireless charging system offers an efficient, reliable, and eco-friendly solution to modern EV charging challenges. By enabling continuous charging during motion and incorporating renewable energy sources, this system represents a significant step toward the development of intelligent and sustainable transportation infrastructure.

2. LITERATURE SURVEY

In recent years, significant research has been carried out in the field of electric vehicle (EV) charging technologies, with a focus on improving efficiency, convenience, and sustainability. Traditional conductive charging methods have been widely used due to their simplicity and reliability. However, several studies highlight their limitations, such as dependency on charging stations, long charging durations, and user inconvenience. These drawbacks have encouraged researchers to explore alternative solutions like wireless power transfer (WPT).

Wireless charging technology, based on electromagnetic induction and magnetic resonance coupling, has gained attention as a safer and more flexible method of energy transfer. Early research focused on static wireless charging, where vehicles are charged while parked over a charging pad. Although this method eliminates the need for cables, it still requires vehicles to remain stationary, which does not fully solve the problem of charging downtime.

To overcome this limitation, recent studies have introduced the concept of dynamic wireless charging, where power is transferred to the vehicle while it is in motion. Researchers have demonstrated that embedding transmitter coils beneath road surfaces and installing receiver coils in vehicles can enable continuous energy transfer. This approach significantly improves driving range and reduces the need for large battery capacity. However, challenges such as coil alignment, energy efficiency, and infrastructure cost remain areas of active research.

Several works have also focused on improving power transfer efficiency by optimizing coil design, compensation techniques, and operating frequency. Advanced configurations such as double-D (DD) coils and resonant circuits have been proposed to enhance coupling efficiency and reduce power loss. In addition, studies suggest that proper shielding and alignment techniques can minimize electromagnetic interference and improve system performance.

The integration of renewable energy sources, particularly solar energy, into EV charging systems has also been widely explored. Researchers have demonstrated that solar-powered charging systems can reduce dependency on the electrical grid and support environmentally friendly transportation. Combining solar energy with wireless charging further enhances sustainability and reduces operational costs in the long term.

Another important area of research is the development of intelligent control and monitoring systems. Microcontroller-based systems, along with sensors, are used to monitor parameters such as voltage, current, and temperature in real time. Battery Management Systems (BMS) play a crucial role in ensuring safe charging by preventing overcharging, overheating, and deep discharge conditions. Recent advancements also include IoT-based monitoring and data analysis for improving system reliability and performance.

Overall, the literature indicates that dynamic wireless charging is a promising technology for the future of electric mobility. While significant progress has been made in improving efficiency and system design, further research is required to address challenges related to scalability, cost, and real-world implementation.

3.1 PROBLEM IDENTIFICATION

The rapid increase in the adoption of electric vehicles (EVs) has created a strong demand for efficient, reliable, and easily accessible charging infrastructure. However, the existing charging systems are not fully capable of meeting this growing demand. Most EVs rely on conventional plug-in charging methods, where vehicles must be connected to a power source using cables. This process is time-consuming and often inconvenient, especially during long-distance travel or in areas with limited charging facilities.

One of the major issues associated with traditional charging systems is the significant downtime required for charging. Vehicles need to remain stationary for extended periods, which reduces their operational efficiency. This limitation becomes more critical for commercial applications such as public transport, delivery services, and fleet management, where continuous operation is essential.

Another important concern is the limited availability and uneven distribution of charging stations. In urban areas, high demand leads to congestion and waiting times, while in rural or highway locations, the lack of infrastructure creates range anxiety among users. This uncertainty discourages potential users from adopting electric vehicles.

In addition, conventional charging systems involve physical connectors and cables, which are prone to wear and tear, safety risks, and maintenance issues. Exposure to environmental conditions such as dust, moisture, and heat can further reduce system reliability. There is also a risk of electrical hazards due to improper handling or damaged equipment.Energy efficiency and battery safety are also critical challenges. Improper charging control can lead to power losses, overheating, overcharging, or deep discharge, which negatively affects battery performance and lifespan. The absence of real-time monitoring and intelligent control systems further limits the effectiveness of current solutions.

Therefore, there is a need to develop an advanced charging system that eliminates the dependency on physical connections, reduces charging time, and allows continuous power transfer. A dynamic wireless charging system that enables electric vehicles to charge while in motion can effectively address these challenges. Such a system should ensure efficient energy transfer, improved safety, reduced downtime, and better user convenience, thereby supporting the widespread adoption of electric vehicles.

3.2 SCOPE OF THE PROJECT

The scope of this project focuses on the design and development of a dynamic wireless charging system for electric vehicles that enables power transfer while the vehicle is in motion. The system aims to overcome the limitations of conventional charging methods by providing a continuous, contactless, and efficient charging solution. It mainly involves the implementation of wireless power transfer using electromagnetic induction between transmitter coils embedded in the road and receiver coils mounted on the vehicle.

The project also includes the integration of renewable energy sources, particularly solar energy, to power the charging infrastructure. This enhances sustainability and reduces dependence on conventional power grids. The use of energy storage and power conditioning units ensures a stable and reliable power supply for the system.

Another important aspect within the scope is the development of a control and monitoring system using a microcontroller. This system is responsible for tracking parameters such as voltage, current, and power flow, ensuring safe and efficient operation. The inclusion of a Battery Management System (BMS) further improves battery performance by preventing overcharging, undercharging, and other unsafe conditions.

The project also considers the use of sensors to detect vehicle presence and activate the charging system only when required. This feature helps in minimizing energy loss and improving overall system efficiency. The model developed in this project can be tested on a small-scale prototype to analyze performance and feasibility.

Furthermore, the scope extends to future applications such as smart roads, highways, and urban transportation systems where dynamic charging can be implemented on a larger scale. The system can be adapted for public transport, electric buses, and commercial fleets to improve operational efficiency. Integration with advanced technologies such as IoT and automation can further enhance system monitoring, control, and scalability.

Overall, this project provides a foundation for developing an efficient, eco-friendly, and intelligent charging infrastructure that supports the future growth of electric mobility.

3.METHODOLOGY & MODELLING

The proposed system is designed to enable dynamic wireless charging of electric vehicles using electromagnetic induction and renewable energy integration. The methodology focuses on efficient power transfer, real-time monitoring, and safe battery charging while the vehicle is in motion. The overall system is divided into two main sections: the transmitter side (road infrastructure) and the receiver side (vehicle unit), along with a control and monitoring system.

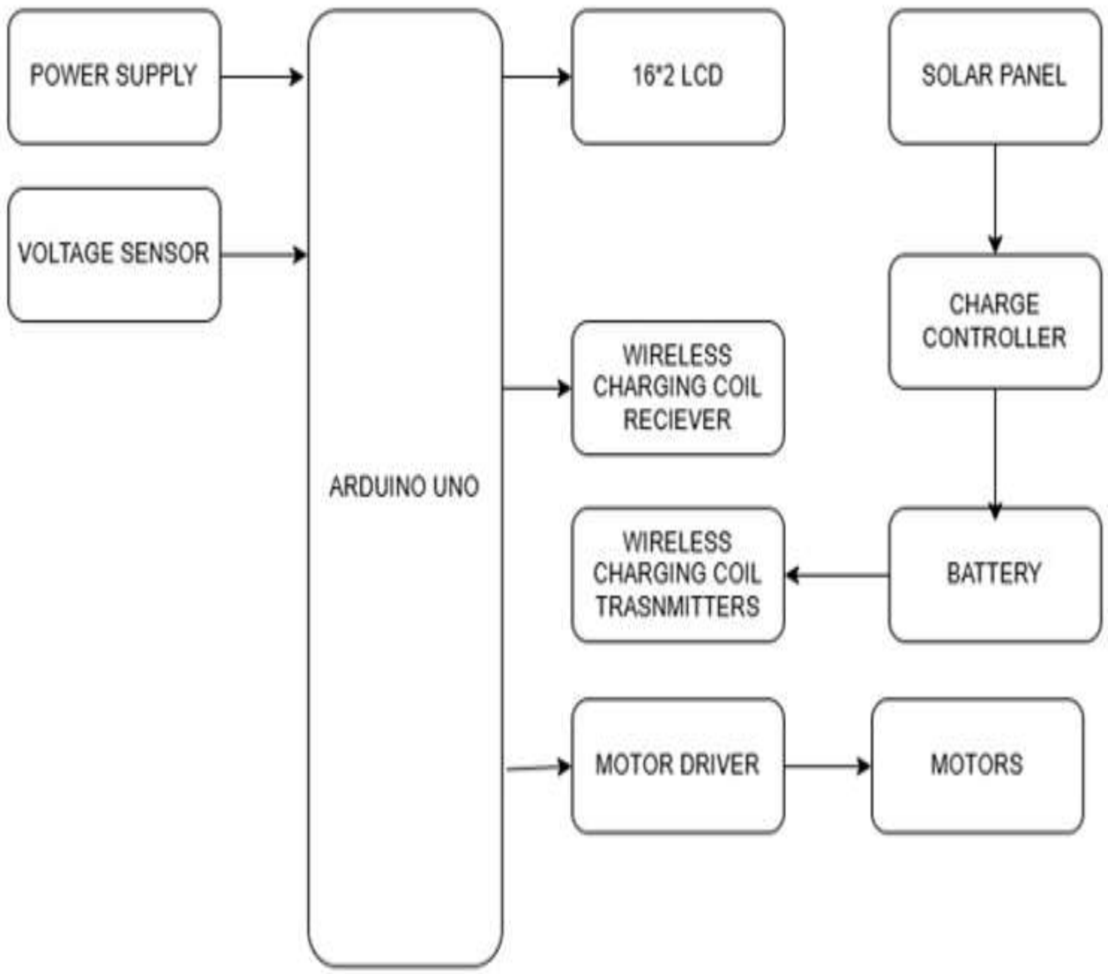


Fig 1. Block Diagram

1. System Architecture

The transmitter section consists of solar panels, energy storage units, power conditioning circuits, and transmitter coils embedded beneath the road surface. Solar panels convert sunlight into electrical energy, which is stored in batteries to ensure continuous operation even during low sunlight conditions. The stored energy is then processed using converters and supplied to the transmitter coils.

The receiver section is mounted on the vehicle and includes a receiver coil, rectifier circuit, voltage regulator, battery, and load. When the vehicle moves over the transmitter coils, energy is transferred wirelessly and used to charge the battery.

2. Working Principle

The system operates based on electromagnetic induction. When alternating current flows through the transmitter coil, it generates a varying magnetic field. As the receiver coil comes within this magnetic field, an electromotive force is induced in it, resulting in the flow of current. This induced current is then converted into direct current using a rectifier and supplied to the battery.

3. Power Transfer Mechanism

Efficient power transfer is achieved by proper alignment of transmitter and receiver coils and by maintaining suitable operating frequency. The use of high-frequency AC supply improves coupling efficiency and reduces transmission losses. Compensation circuits may also be used to stabilize the output and enhance system performance.

4. Control and Monitoring System

A microcontroller-based system (such as Arduino) is used to monitor and control system parameters. Sensors are employed to measure voltage, current, and power flow in real time. Based on these readings, the controller ensures stable energy transfer and prevents abnormal conditions. The system can also display real-time data using an LCD or transmit it for further analysis.

5. Battery Management System (BMS)

The Battery Management System plays a key role in maintaining battery safety and efficiency. It continuously monitors the state of charge, voltage, and current of the battery. The BMS prevents overcharging, deep discharge, and overheating, thereby improving battery life and ensuring safe operation of the vehicle.

6. Vehicle Detection and Energy Optimization

Sensors such as infrared (IR) sensors are used to detect the presence of a vehicle over the charging coils. The transmitter coils are activated only when a vehicle is detected, which reduces unnecessary power consumption and improves overall system efficiency.

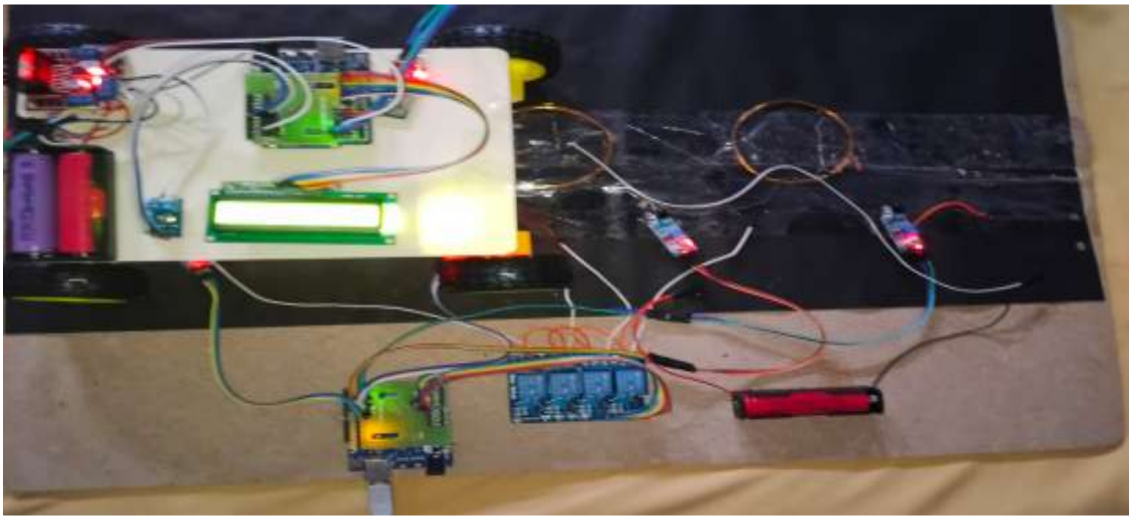
7. Modelling of the System

The system can be modeled as a coupled inductive circuit consisting of primary (transmitter) and secondary (receiver) coils. The efficiency of power transfer depends on the coupling coefficient, coil geometry, and distance between coils. The induced voltage in the receiver coil is directly related to the rate of change of magnetic flux.

The overall system can be represented using equivalent circuit models that include inductance, resistance, and compensation elements. Simulation tools can be used to analyze parameters such as output voltage, efficiency, and power transfer under different operating conditions.

8. Implementation Approach

A prototype model is developed to validate the system performance. The transmitter coil is powered using a controlled AC source, and the receiver coil is connected to a rectifier and battery. The microcontroller processes sensor data and controls the operation of the system. Experimental observations are used to evaluate charging efficiency, stability, and response under dynamic conditions.



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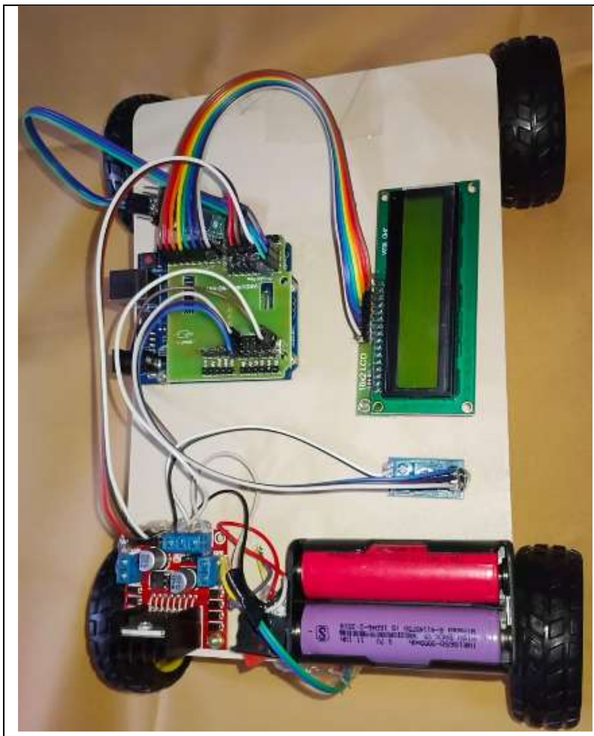

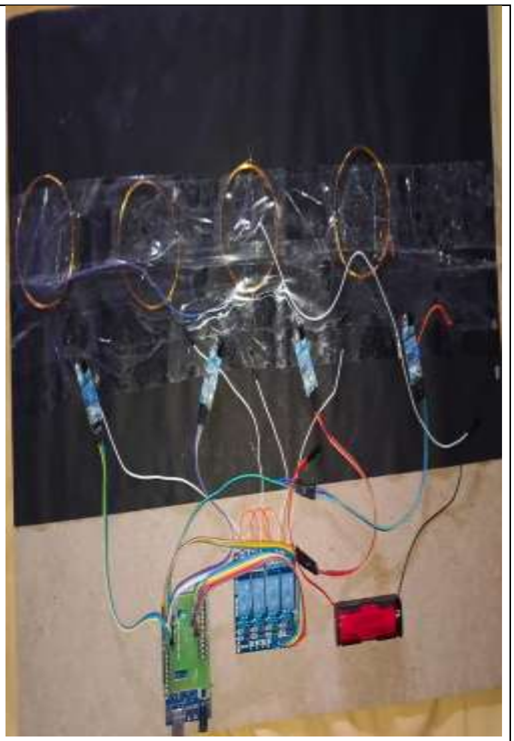

5. CONCLUSION

This work presents the design and development of a dynamic wireless charging system for electric vehicles, aimed at overcoming the limitations of conventional charging methods. By utilizing electromagnetic induction, the system enables contactless power transfer between road-embedded transmitter coils and vehicle-mounted receiver coils, allowing vehicles to charge while in motion. This significantly reduces charging downtime and improves overall convenience for users.

The integration of solar energy enhances the sustainability of the system by reducing dependence on conventional power sources. In addition, the use of a microcontroller-based monitoring system ensures stable and efficient operation by continuously tracking key parameters such as voltage and current. The inclusion of a Battery Management System further improves safety and battery performance by preventing overcharging and maintaining optimal operating conditions.

The proposed system demonstrates improved efficiency, reduced energy loss, and enhanced reliability compared to traditional charging methods. It also addresses key challenges such as range anxiety and infrastructure limitations, making electric vehicles more practical for long-distance and commercial applications.

Overall, the developed model highlights the potential of dynamic wireless charging technology as a future solution for smart transportation systems. With further advancements and large-scale implementation, this approach can contribute significantly to the development of sustainable, efficient, and intelligent mobility solutions.

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