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Wireless Energy Transfer on Road for Electrical Vehicles using multiple transfer units

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ABSTRACT
Our project, "Wireless Energy Transfer on Road for Electrical Vehicles using Multiple Transfer Units," aims to address the limitations of electric vehicles (EVs) such as long charging times and limited battery capacity. This project explores dynamic wireless charging, where power is transmitted wirelessly to EVs while they are in motion. The system utilizes inductive coupling, where high-frequency AC power is converted into a resonating magnetic field by transmitting coils embedded under the road. The receiving coils in the vehicle capture this energy, converting it back to DC to charge the battery while driving.
By implementing this technology, EVs can travel longer distances without frequent charging stops, reducing dependency on large battery packs. The prototype is designed using Arduino, microcontrollers, and embedded C programming, ensuring efficient energy transfer. This innovative approach enhances sustainable transportation and promotes the widespread adoption of electric vehicles by offering a seamless and automated charging solution.

I. INTRODUCTION

Electric Vehicles (EVs) are a promising solution to reduce carbon emissions and combat climate change. However, despite their environmental benefits, EV adoption faces significant challenges, including limited battery capacity, long charging durations, and range anxiety. These factors discourage many potential users from switching to EVs, as they fear running out of power during long-distance travel.

Currently, most EVs rely on plug-in charging stations, which require hours to fully charge a vehicle. This inconvenience leads to long waiting times and restricts travel flexibility. Additionally, large battery packs are needed to ensure sufficient driving range, making EVs heavier, costlier, and less energy-efficient.

To address these issues, Wireless Power Transfer (WPT) has emerged as an innovative charging solution. Dynamic wireless charging allows EVs to receive power wirelessly while in motion, eliminating the need for frequent charging stops. This technology not only enhances the convenience of EVs but also reduces dependency on large batteries, making them more affordable and sustainable.

Governments and researchers worldwide are investing in smart road infrastructure, integrating wireless charging technology to support future transportation. Inspired by this vision, our project proposes a wireless energy transfer system using multiple transfer units, enabling continuous and efficient power delivery to EVs on the road.

Our motivation stems from the desire to create a sustainable, efficient, and practical EV charging system that promotes widespread EV adoption. By implementing multiple transfer units embedded in roads, we aim to demonstrate a scalable and cost-effective solution that enhances the feasibility of EVs for everyday use. This project contributes to the advancement of smart transportation systems, reducing fossil fuel dependency and paving the way for a cleaner, greener future.

II. Related work

Manoj D. Patil [1] explored the application of solar energy in wireless power transfer for electric vehicles. The study highlighted that traditional power transmission using cables leads to 25–30% energy loss and increases the risk of electrical accidents. The research demonstrated that WPT is safer, more reliable, and environmentally friendly, making it a viable alternative to conventional wired charging methods. The findings from this study underscore the importance of wireless power infrastructure for enhancing EV adoption.

Fangcheng Liu [2], in his study presented at the IEEE Applied Power Electronics Conference and Exposition (APEC, 2012), introduced the hybrid energy storage system for electric vehicles. His research focused on minimizing power consumption, enhancing battery durability, and optimizing energy resources to improve the efficiency of electric vehicles. The study also demonstrated how energy storage systems can extend battery life and reduce system complexity, making WPT systems more effective for road-based charging applications.

Luis M. Fernández-Ramírez, Francisco Llorens, and Carlos A. García-Vázquez [3] proposed the implementation of a Dynamic Wireless Power Transfer (DWPT) system on a 7.3kilometer stretch of the A-381 Highway in Cádiz, Spain. Their study examined the power and energy requirements of a Nissan Leaf electric vehicle while driving on the dynamically charged road. The research demonstrated that the DWPT system can supply energy to the vehicle's motor, charge the battery, and increase the vehicle's operational range, reducing the need for frequent charging stops.

J. Smith and R. Brown [4] explored the efficiency of resonant inductive coupling in wireless power transfer. Their study demonstrated that optimizing coil alignment and frequency tuning enhances power transfer efficiency. The research findings were incorporated into this project by using a wireless power transfer module for contactless battery charging, ensuring seamless energy transmission to moving electric vehicles.

M. Lee and K. Patel [5] investigated energy-efficient power management for IoT devices using boost converters. Their research emphasized the importance of voltage regulation in optimizing battery performance. Inspired by their work, this project integrates an XL6009 boost converter to step up voltage and maintain a stable power supply, ensuring efficient energy transfer in the wireless charging system for electric vehicles.

By referring to these research papers, we gain valuable insights into existing wireless power transfer technologies and energy management systems, helping us design and implement an efficient wireless energy transfer system for electric vehicles on roads.

III. PROPOSED SYSTEM

To overcome the limitations of existing charging systems, we propose a wireless energy transfer system for electric vehicles (EVs) using multiple transfer units embedded in roads. This system enables dynamic wireless charging, allowing EVs to receive power while in motion. By integrating inductive coupling technology, energy is transmitted from charging coils placed under the road to receiver coils in the vehicle, ensuring a seamless and efficient power transfer. This eliminates the need for frequent charging stops and reduces dependency on large battery packs, making EVs more practical and cost-effective.

The proposed system consists of multiple transfer units, each embedded with transmitting coils that activate when an EV is detected. IR sensors identify the presence of a vehicle, triggering the respective wireless charging module. High-frequency AC power is supplied to the transmitting coils, creating a resonant magnetic field that is captured by the vehicle’s receiver coils. The induced voltage is then rectified and used to charge the battery while driving, ensuring continuous power supply without interruptions.

IV. DESIGN AND IMPLEMENTATION

BLOCK DIAGRAM

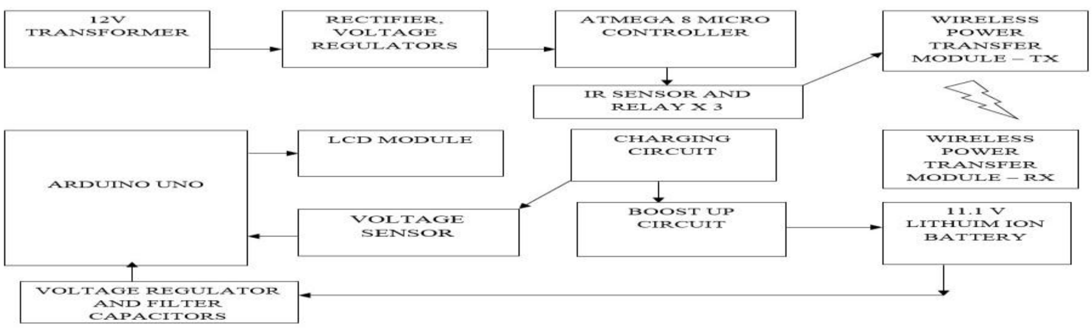

FIG Block Diagram

- Upon powering on the system, the Arduino Uno initializes all connected components, including the wireless power transfer modules (TX & RX coils), voltage sensors, IR sensors, boost-up circuit, and LCD module.
- GPIO pins or other communication protocols (SPI, I2C) are configured to establish communication with each module.
- The ATmega 8 microcontroller controls the transmitter (TX) coils and manages the wireless energy transfer process.
- The receiver (RX) coils capture energy wirelessly and transfer it to the charging circuit, which regulates the voltage before sending it to the 11.1V lithium-ion battery.

- The IR sensors detect the presence of an electric vehicle (EV) in the charging zone and activate the respective relay to begin wireless power transfer.
- The boost-up circuit steps up the battery voltage to meet the EV's power requirements.
- The voltage sensor monitors the battery voltage and sends data to the Arduino Uno, which then displays the charging status on the LCD module.
- If any issues occur, such as low battery voltage, charging failure, or system faults, the system can trigger an alert mechanism (e.g., LED indicator, buzzer, or wireless notification).
- This project aims to provide seamless wireless charging for EVs on the road, reducing dependency on charging stations and promoting efficient and continuous energy transfer while the vehicle is in motion.

V. RESULTS &VALIDATIONS

PROTOTYPE OF THE PROPOSED SYSTEM

The prototype is successfully designed and tested. The objectives of the project are satisfactorily realized. Following are the major results obtained. The prototype system for Wireless Energy Transfer on Road for Electric Vehicles using Multiple Transfer Units consists of key components, including an IR sensor array, relays, transmitter circuit, receiver circuit, and an LCD display. The system works by detecting the electric vehicle's movement using IR sensors, which trigger the activation of corresponding relays. These relays control multiple inductive coils embedded on the road to wirelessly transfer power to the vehicle.

The power transmission circuit converts AC to DC and supplies energy to the coils, which generate an alternating magnetic field. The receiving coil on the vehicle picks up the energy and charges the battery. An Arduino-based control system manages sensor input, relay switching, and energy transfer, displaying system status on an LCD screen.

This prototype demonstrates efficient dynamic wireless charging for electric vehicles, eliminating the need for plug-in charging stations and extending vehicle range with continuous on-road power transfer.

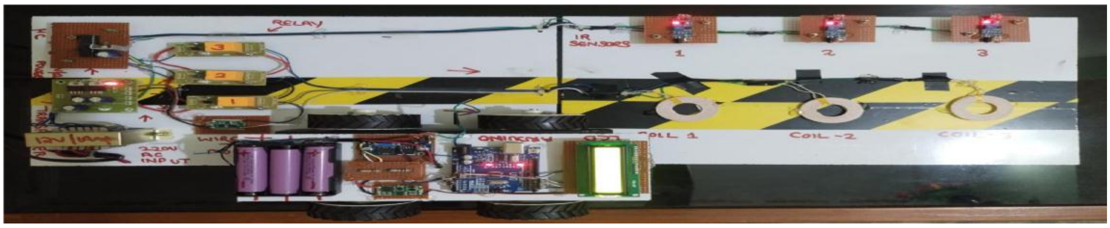

Fig Prototype Model

6.2 IR SENSOR DETECTION & RELAY ACTIVATION:

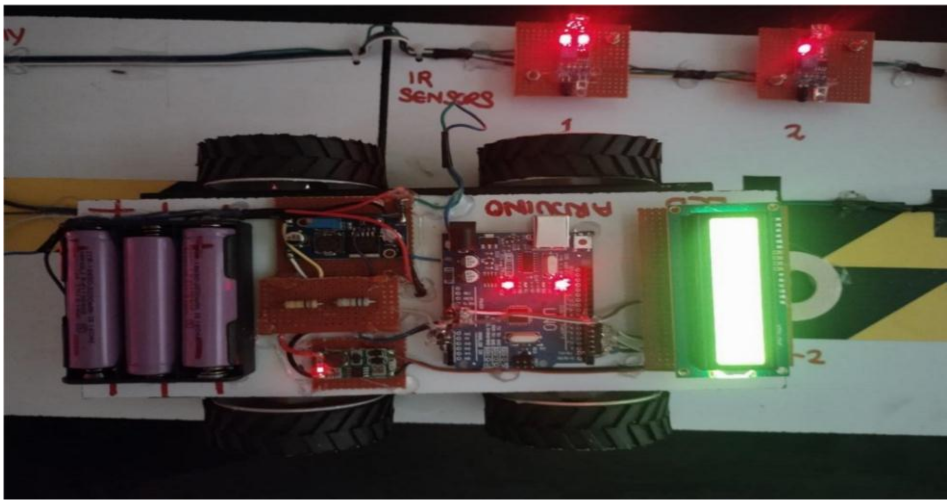

FIG IR sensor detection

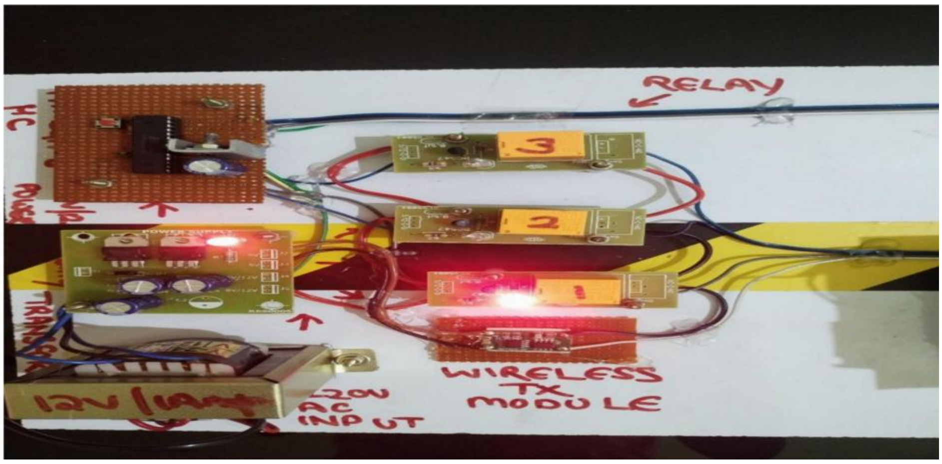

FIG Relay Activation

6.3 LCD DISPLAY OUTPUT :

FIG Initial LCD Display Output

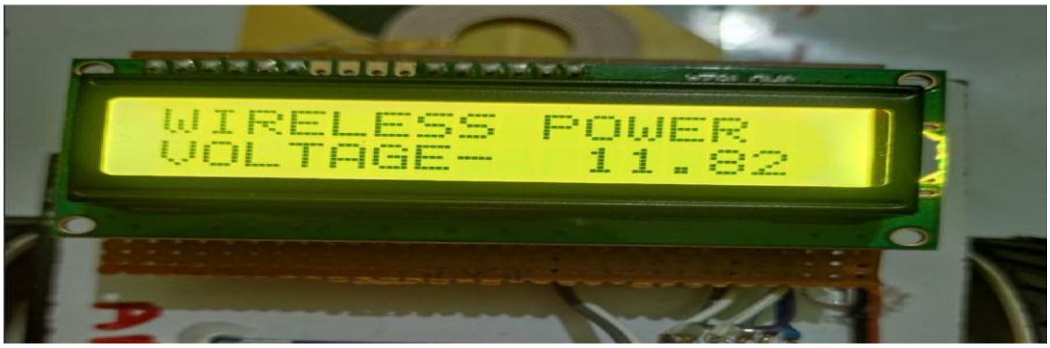

FIG LCD Display Output During WPT

6.4 WIRELESS RECEIVING MODULE ACTIVATION:

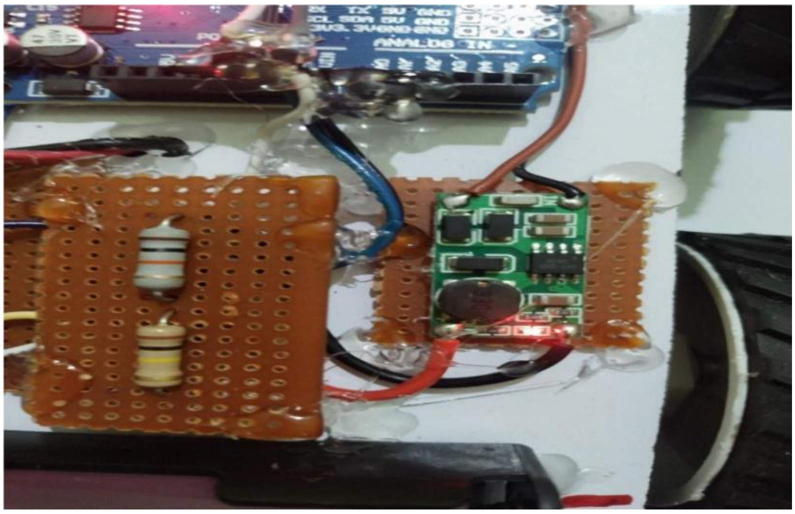

FIG Receiving Module Activation During WPT

VI. CONCLUSION &FUTURE SCOPE

CONCLUSION

In this project, we have successfully designed and implemented a Wireless Energy Transfer on Roads For Electrical Vehicles using multiple Transfer units . The system incorporates various sensors and modules to ensure the safe dynamic and seamless charging.

The proposed dynamic wireless charging system for electric vehicles (EVs) represents a significant advancement in overcoming the challenges associated with traditional plug-in and static charging methods. By leveraging resonant magnetic coupling and multiple transfer modules, the system enables efficient and continuous on-road charging, reducing the reliance on large battery storage and improving energy utilization.

Additionally, the integration of real-time voltage monitoring enhances operational safety and user convenience, ensuring a stable and secure charging process. This clean, contactless, and scalable solution not only enhances the practicality of EVs but also promotes their widespread adoption, contributing to a sustainable and resource-efficient future in transportation.

As technology progresses, the implementation of wireless energy transfer on roads can revolutionize the EV industry, reducing charging downtime, minimizing infrastructure requirements, and increasing the overall efficiency of electric mobility.

FUTURE SCOPE

The advancement of Wireless Energy Transfer (WET) technology on roads has the potential to revolutionize electric vehicle (EV) charging. The integration of multiple transfer units enhances efficiency, scalability, and adaptability for real-world deployment. The future scope of this technology includes:

- **Smart Infrastructure Development :** Implementation of dynamic charging roads in urban and highway networks to support continuous EV charging while in motion. Government and privatesector investments in smart city initiatives for integrating WET into public and commercial transportation systems.
- **Improved Energy Efficiency & Transfer Technology :** Development of high-efficiency inductive power transfer (IPT) systems to minimize energy losses.Use of resonant coupling and optimized coil designs to improve power transfer distance and efficiency.

- **Integration with Renewable Energy Sources :** Powering wireless charging highways with solar panels or wind energy to reduce dependence on fossil fuels.Smart grid integration for efficient energy distribution and real-time load balancing.
- **Advanced Wireless Communication & IoT Integration :** Use of 5G and IoT-enabled monitoring systems to track EV energy consumption and optimize charging efficiency. Real-time vehicle-to-infrastructure (V2I) communication for dynamic power distribution.
- **Cost Reduction & Commercial Viability :** Mass production of standardized wireless charging components to lower installation and maintenance costs.Research in low-cost, high-efficiency materials to make WET systems more affordable.

- **Enhanced Safety & Reliability :** Development of advanced shielding techniques to prevent electromagnetic interference with other electronic systems.Implementation of real-time voltage monitoring and fault detection for improved operational safety.
- **Autonomous Vehicle Integration :** Enabling autonomous electric fleets with automatic charging capabilities to extend range without manual intervention.Integration of self-driving vehicle networks with dynamic charging roads for uninterrupted operation.
- **Multi-Vehicle Coordination & Traffic Management :** Development of multi-vehicle power distribution to charge multiple EVs simultaneously without overloading the grid. AI-driven traffic control systems to optimize energy distribution based on road congestion and EV demand.
- **Expansion to Other Modes of Transport :** Application of WET for electric buses, trucks, and trains, reducing downtime and improving efficiency. Potential implementation in aviation and marine industries for wireless charging of electric aircraft and ships.

By addressing these areas, Wireless Energy Transfer on Roads can become a mainstream technology, eliminating range anxiety, reducing EV battery size, and promoting a cleaner, more sustainable future for transportation.

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