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WIRELESS ELECTRIC VEHICLE CHARGING USING INDUCTIVE COUPLING

[1]Prof. Patole. S. S, [2]Rohan Sanjay Lokhande, [3]Omkar Vikas Shinde, [4]Nishant Chhgan Mane

[1]Assistant Prof., Department of Electrical Engineering, HSBPVT's GOI Kashti,Ahilyanagar
[2]UG Scholar, Department of Electrical Engineering, HSBPVT's GOI Kashti, Ahilyanagar
[3]UG Scholar, Department of Electrical Engineering, HSBPVT's GOI Kashti, Ahilyanagar
[4]UG Scholar, Department of Electrical Engineering, HSBPVT's GOI Kashti, Ahilyanagar

rohanlokhande0106@gmail.com

ABSTRACT - The goal of the article "Wireless Electric Vehicle Charging Using Inductive Coupling" is to create a frictionless, effective, and secure electric vehicle (EV) charging system. Conventional plug-in charging techniques require direct physical contact, which frequently results in issues like connector wear, the potential for electric shock, and user inconvenience. This project uses the idea of Inductive Power Transfer (IPT), a method that wirelessly transmits electrical energy between two coils separated by an air gap using magnetic fields, to get around these restrictions. A transmitter unit and a receiver unit are the two primary components of the system's architecture. Powered by a DC source and managed by an Arduino Uno microcontroller, the transmitter coil produces an alternating magnetic field. The receiver coil, mounted under the vehicle, captures this magnetic flux and converts it back into electrical energy for battery charging. To improve safety and efficiency, infrared sensors are used to detect vehicle presence, activating only the corresponding transmitter coil. A relay driver circuit ensures that energy is transmitted only when necessary, reducing wastage and preventing overheating.

I. INTRODUCTION

The desire for clean, sustainable, and environmentally friendly transportation has led to a sharp rise in the demand for electric cars (EVs) in recent years. The wired charging methods used by conventional electric vehicles need the vehicle to be physically linked to a power source via a socket or cable. Despite its effectiveness, this approach has a number of drawbacks, such as connection wear and tear, the possibility of electric shock, and user discomfort. These problems have prompted scientists and engineers to investigate wireless charging technology as a more practical and effective substitute. The foundation of wireless electric vehicle charging is the inductive power transfer (IPT) principle, which is also utilized in transformers and involves the transmission of electrical energy from one coil to another via a magnetic field. Within this system, generates a varying magnetic field when alternating current flows through it. The receiver coil mounted on the vehicle captures this magnetic flux and induces an electromotive force (EMF), which is then rectified and used to charge the vehicle's battery. The inductive coupling technique eliminates the need for physical connectors, making the charging process automatic, safe, and weatherproof. When a vehicle with a receiver coil parks over a transmitter coil, charging begins automatically without any manual connection.

Additionally, the system can be enhanced using infrared (IR) sensors and microcontrollers to detect vehicle presence and activate specific transmitter coils, improving overall energy efficiency. This project focuses on designing and developing a prototype model of wireless EV charging using inductive coupling. The system aims to transfer power wirelessly from the transmitter side to the receiver side through resonant magnetic induction. It also integrates IR sensors and relay-based coil switching to activate only the coils directly under the vehicle, thereby reducing power losses and improving safety. The proposed system not only demonstrates the feasibility of wireless charging for electric vehicles but also provides insight into future advancements such as dynamic charging, where EVs can charge while in motion, and smart grid integration, enabling intelligent energy management. The global shift towards sustainable transportation has accelerated the adoption of Electric Vehicles (EVs). With EVs provide a greener and more energy-efficient substitute for internal combustion engine cars in light of growing worries about climate change, environmental pollution, and the depletion of fossil fuels. But one of the biggest obstacles to EV adoption is the infrastructure for charging, which must be scalable, safe, and convenient. Conventional plug-in charging methods are prone to wear and tear, need physical connections, and need human involvement. The investigation of wireless charging methods, which offer a smooth and automated charging experience, has been prompted by these constraints. Energy transmission is made possible by a new technology called Wireless Electric Vehicle Charging (WEVC) from a power source to an EV without physical contact. Among various wireless methods, Inductive Coupling stands out due to its reliability, safety, and efficiency over short distances. It uses electromagnetic fields to transfer power between coils—one embedded in the ground and the other mounted on the vehicle. This technology not only simplifies the charging process but also opens doors for dynamic charging (charging while driving), smart grid integration, and autonomous vehicle compatibility.

II. OBJECTIVE

The scope of this project covers the design, development, and testing of a small- scale prototype that demonstrates:

To create a wireless power transfer system
Implementing vehicle detection using infrared sensors
To include intelligent control based on microcontrollers
To demonstrate safe and contactless power transfer
In order to get effective energy conversion
To offer approval for prototypes
To improve automation and user ease
To evaluate performance and constraints

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2.1 BLOCK DIAGRAM

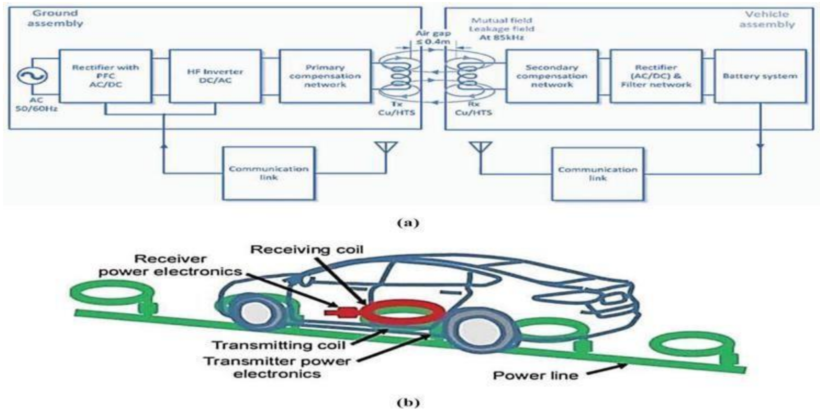

Fig. 1 - Block diagram

2.2 WORKING

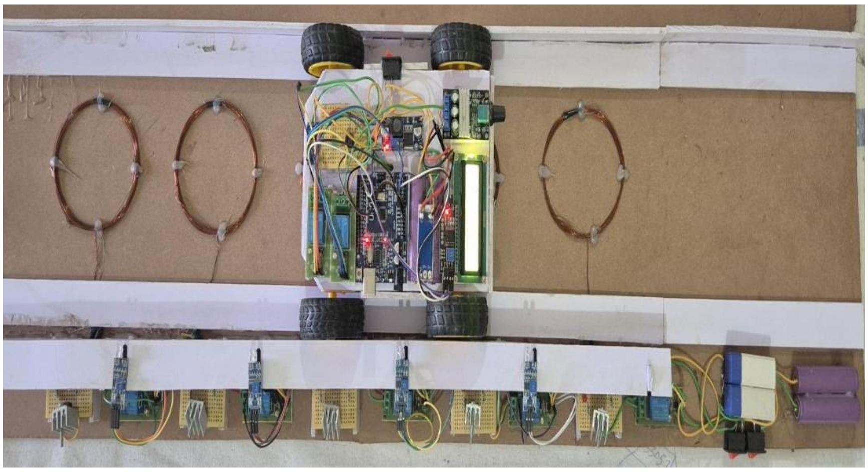

Fig.2 - Working

Wireless Electric Vehicle (EV) charging using inductive coupling works on the principle of **electromagnetic induction**, where electrical energy is transferred from a charging station to an electric vehicle without any physical electrical connection.

1. **AC Power Supply**
   The charging station receives electrical power from the utility grid. This AC power is first converted into high-frequency AC using a power electronic inverter.
2. **Generation of Magnetic Field**
   The high-frequency AC current flows through the **transmitter coil** (primary coil) embedded in the charging pad placed on the ground. As current passes through the coil, it generates an alternating magnetic field around it.
3. **Magnetic Coupling**
   A **receiver coil** (secondary coil) is mounted underneath the electric vehicle. When the vehicle is parked above the charging pad, the magnetic field produced by the transmitter coil links with the receiver coil.
4. **Electromagnetic Induction**
   According to Faraday's law of electromagnetic induction, the changing magnetic field induces an AC voltage in the receiver coil.
   The induced voltage can be represented by: V=MdIdtV=M\frac{dI}{dt}V=MdtdI where:

- VVV = Induced voltage
- MMM = Mutual inductance between coils
- III = Current in the transmitter coil

5. **Resonance Compensation**
   Capacitors are connected to both transmitter and receiver coils to create a resonant circuit. Resonance improves magnetic coupling and significantly increases power transfer efficiency, often above 90%.
6. **AC to DC Conversion**
   The induced AC voltage received by the secondary coil is converted into DC using a rectifier circuit.
7. **Battery Charging**
   The DC output is regulated by a charge controller and supplied to the EV battery for charging.
8. **Communication and Control**
   A communication system continuously exchanges information between the vehicle and charging station to:

- Monitor charging status
- Control power flow
- Detect foreign objects
- Ensure safety and efficiency

ESP32 Microcontroller:-

Fig. 3- ESP32 Microcontroller

The ESP32 is a powerful, low-cost, dual-core microcontroller developed by Espressif Systems. It features a 240 MHz Xtensa LX6 dual-core processor, built-in Wi-Fi and Bluetooth connectivity, multiple ADC channels, PWM output capabilities, and a rich set of digital I/O pins. In this system, the ESP32 acts as the central controller, reading analog signals from the joystick, communicating with the Blynk server via Wi-Fi, and generating PWM control signals for the BTS7960 motor drivers.

BTS7960 Motor Driver (x2)

The BTS7960 is a fully integrated H-bridge motor driver capable of driving DC motors with currents up to 43A continuously. It features PWM input control, over-temperature protection, short-circuit protection, and current sense feedback. Two BTS7960 modules are used in thisproject, one for each geared drive motor, enabling independent bidirectional speed control of both wheels. The ESP32 drives the RPWM, LPWM, R_EN, and L_EN pins of each BTS7960 module to control motor direction and speed.

Relay Module

The relay module acts as an electrically operated switch that allows the ESP32 to control the main power supply to the motor driver circuit. The relay operates on a low-power control signal from the ESP32 and can switch high-current DC loads from the 12V 40A battery. It provides a safety disconnect feature, ensuring that the motor circuit can be de-energized when needed without removing the battery.

III. ADVANTAGES, APPLICATION

- **Convenience**
  Charging occurs automatically without plugging in cables, making the process simple and user-friendly.
- **Enhanced Safety**
  Since there are no exposed electrical contacts, the risk of electric shock, short circuits, and sparking is reduced.
- **Reduced Wear and Tear**
  Eliminates mechanical wear of charging connectors and sockets, increasing system lifespan.
- **Weather Resistance**
  Operates safely in rain, dust, snow, and other harsh environmental conditions because there is no direct electrical connection.

APPLICATION

Home Charging

- Convenient charging in residential garages and parking spaces.
- Eliminates the need to handle charging cables.
- Useful for elderly or physically challenged users.

Public Parking Area

- Charging stations can be installed in shopping malls, airports, hotels, and office parking lots.
- Vehicles charge automatically while parked.

Commercial Fleet Vehicles

- Taxis, delivery vans, and ride-sharing vehicles can recharge during short stops.
- Reduces downtime and improves fleet efficiency.

Public Transportation

- Electric buses can be charged wirelessly at bus stops or terminals.
- Enables opportunity charging without lengthy charging breaks.

Dynamic Wireless Charging

- Charging coils embedded beneath roads transfer power while vehicles are moving.
- Extends driving range and may reduce the need for large battery packs.

Autonomous Vehicles

- Self-driving vehicles can charge automatically without human intervention.
- Supports fully automated transportation systems.

Electric Two-Wheelers and Micro-Mobility

- Wireless charging for electric scooters, e-bikes, and mobility devices.
- Simplifies charging infrastructure in urban environments.

Industrial and Warehouse Vehicles

- Automated Guided Vehicles (AGVs) and forklifts can charge wirelessly during operation pauses.
- Improves productivity and reduces maintenance.

IV. CONCLUSION

A potential technique that overcomes many of the drawbacks of traditional plug-in charging methods is wireless EV charging via inductive coupling. Power electronics, dynamic charging applications, coil design, and resonant compensating techniques have all advanced significantly. Ongoing research and industry advancements suggest that inductive charging will play a significant part in future smart transportation systems, despite obstacles including infrastructure expense, misalignment sensitivity, and uniformity. Wireless EV charging systems are anticipated to become more widely used as efficiency, compatibility, and dynamic charging infrastructure continue to progress.

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