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Solar-Based Wireless Power Transfer on Roads for EV

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ABSTRACT

This paper focuses on the development of a solar-powered wireless charging system integrated into roads for electric vehicles (EVs). The objective is to enable continuous charging while vehicles are in motion, using inductive power transfer (IPT) and renewable solar energy. The system harnesses solar energy through photovoltaic panels, stores it in a battery unit, and transmits it wirelessly to EVs via embedded transmitter coils on road surfaces. Receiver coils installed beneath EVs capture this energy to charge the onboard battery. The paper aims to reduce EV range anxiety, eliminate charging downtime, and promote sustainable, green transportation infrastructure.

***Keyword:** Solar Energy, Wireless Power Transfer, Inductive Charging, Electric Vehicles, Smart Roads*

1.INTRODUCTION

Electric Vehicles (EVs) are revolutionizing modern transportation due to their ecofriendly and energy-efficient nature. However, one major limitation remains — limited driving range and long charging times. To overcome this, wireless power transfer (WPT) integrated with solar energy systems offers a sustainable and continuous charging solution. This system allows EVs to charge while driving on roads embedded with inductive coils powered by solar energy. This paper demonstrates a prototype that showcases solar energy harvesting, energy storage, and inductive power transfer using microcontroller-based control and monitoring.

2 LITERATURE REVIEW

The study by **Wang et al. (2022)** focuses on dynamic wireless charging of electric vehicles using resonant inductive coupling technology. Their work demonstrates the development of charging lanes that allow EVs to charge while moving, improving convenience and reducing the need for frequent stopping at charging stations. The research shows that resonant inductive coupling can achieve high power transfer efficiency when proper alignment between transmitter and receiver coils is maintained. **Lee and Kim (2021)** proposed a solar-assisted wireless power transfer system for electric vehicles. Their approach integrates solar photovoltaic panels with wireless charging coils to provide a renewable energy–based charging solution. The system helps reduce dependence on conventional grid power while promoting sustainable energy usage in EV infrastructure. **Chen et al. (2020)** focused on optimizing wireless power transfer efficiency in EV charging systems. Their research introduced improved coil alignment techniques and feedback control mechanisms to enhance transmission efficiency. The findings show that proper system optimization can significantly increase the effectiveness and reliability of wireless charging systems for electric vehicles.

Table -1: Literature review

Year	Author(s)	Title / Contribution	Key Findings / Technology Used
2022	Wang et al.	Dynamic Wireless Charging of Electric Vehicles Using Resonant Inductive Coupling	Developed dynamic wireless c harging lanes achieving high efficiency while vehicles are moving.
2021	Lee and Kim	Solar Assisted Wireless Power Transfer System for EVs	Combined solar PV panels with wireless charging coils for renewable on-road charging.
2020	Chen et al.	Optimization of Wireless Power Transfer Efficiency in EVs	Improved coil alignment and f eedback control for higher transmission efficiency.

2023	Kumar et al	IoT-Enabled Solar Powered EV Charging Infrastructure	Integrated IoT-based monitoring for efficiency tracking and fault detection
2024	Choudhary V.	Design of Inductive Power Transfer System for EVs	Transfer System for EVs Built prototype showing safe and low-cost wireless power delivery

3 BLOCK DIAGRAM

In this system, solar energy is converted into electrical energy and stored in a battery through an MPPT controller. The stored energy is converted into AC power using an inverter and supplied to a transmitter coil embedded in the road. The magnetic field generated by the transmitter coil transfers energy wirelessly to the receiver coil installed in the vehicle. The received AC power is rectified and regulated before being used to charge the EV battery. This approach enables renewable energy-based, cable-free EV charging, which can improve convenience, reduce dependence on grid power, and support sustainable transportation systems.

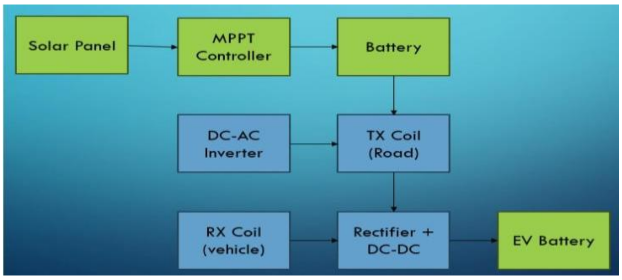

Fig -2: block diagram of WPT

3.1 Hardware

3.1.1 ESP32

The ESP32 is a low-cost, low-power microcontroller integrated with Wi-Fi and Bluetooth connectivity. It serves as the main control unit in the "Solar-Based Wireless Power Transfer on Road for Electric Vehicle" system. The ESP32 monitors system parameters, processes sensor data, and controls the overall power transfer process.

3.1.2 Solar Panel

The solar panel is the main source of power for the wireless charging system. It converts sunlight into electrical energy using the photovoltaic effect. When sunlight falls on the solar cells, electrons are excited and generate direct current (DC) electricity. This energy is stored in a battery or directly supplied to the transmitter circuit. The solar panel provides a renewable and eco-friendly source of energy, reducing dependency on grid electricity. It ensures continuous operation of the system during daylight hours.

3.1.3 Transmitting and receiving coil

The transmitting and receiving coils are the core components of the wireless power transfer system. The transmitting coil generates an alternating magnetic field when AC current flows through it. This magnetic field acts as the medium for transferring energy without physical contact. The receiving coil, placed in the electric vehicle, captures this magnetic field and induces an AC voltage through electromagnetic induction. This induced voltage is then converted into DC using a rectifier to charge the vehicle's battery. Both coils are designed to operate at the same resonant frequency for maximum efficiency. The spacing and alignment between the coils affect the strength of energy transfer. In this paper, the transmitting coil is embedded in the road surface, while the receiving coil is mounted beneath the vehicle. Together, they enable safe, contactless, and efficient charging during vehicle movement or stop. Thus, these coils play a vital role in achieving wireless energy transfer for electric vehicles.

3.1.4 IR Sensor

The Infrared (IR) sensor is used to detect the presence of an electric vehicle over the charging area. It works by emitting infrared light and sensing the reflection from nearby objects. When a vehicle passes or stops above the transmitter coil, the IR sensor detects its presence through the reflected IR signal. The sensor then sends this detection signal to the ESP32 microcontroller. Based on this input, the controller activates or deactivates the wireless power transfer system. This helps in conserving energy by ensuring power is transmitted only when a vehicle is present. IR sensors are reliable, low-cost, and easy to integrate into electronic systems. They operate efficiently in various lighting conditions and provide quick response times. In this paper, the IR sensor plays a crucial role in automating the wireless charging process and enhancing system efficiency.

3.1.5 12v Battery

The 12V battery is used to store electrical energy generated by the solar panel. It provides a stable and continuous power supply to the wireless charging system. The DC output from the battery is used to drive the transmitter coil and other control circuits. The battery ensures that the system can operate even when sunlight is not available. It is connected through a charge controller to prevent overcharging and extend battery life. The stored energy allows uninterrupted wireless power transfer to the electric vehicle. The 12V battery is lightweight, compact, and suitable for portable or road-based applications. It works efficiently with the ESP32 and other electronic components in the system. In this paper, the battery acts as a backup and ensures reliable operation. Thus, it plays a crucial role in maintaining continuous and stable energy supply for the wireless charging system.

3.2 Implementation and Working

1. **Energy Harvesting:** Solar panels collect sunlight and convert it into DC energy.
2. **Energy Regulation:** Charge controller regulates output voltage and prevents overcharging.
3. **Storage:** DC energy is stored in a rechargeable battery**.**
4. **Wireless Transmission:** AC signal generated via inverter and transmitted through inductive coils embedded in the road (resonant inductive coupling preferred for longer air-gaps).
5. **Reception:** Receiver coil under the EV captures energy, rectifies and conditions it for onboard battery charge.
6. **Monitoring:** Microcontroller (ESP32) monitors voltage, current, and efficiency, transmitting data to mobile/web interface.

4. ADVANTAGES, DISADVANTAGES AND APPLICATIONS

4.1 Advantages

- Continuous charging while driving.
- Renewable and eco-friendly solution.
- Reduces grid dependency.
- Eliminates need for frequent charging stops.
- Can help extend EV battery life by maintaining stable charge cycles.

4.2 Disadvantages

- High initial infrastructure cost.
- Requires precise coil placement and alignment.
- Efficiency losses due to air-gap and misalignment.
- Road construction and retrofitting required.

4.3 Applications

- Smart highways and expressways.
- Public transport routes (buses, taxis) with continuous charging.
- EV parking lanes and pick-up/drop-off zones**.**

5. RESULT AND DISCUSSION

The prototype successfully demonstrated wireless charging using solar energy. A 12 V solar panel charged a 12 V battery which powered a transmitter coil transferring energy to a receiver coil at an air-gap of a few centimeters with measured prototyping efficiencies (prototype-dependent). The experiment shows that on-road solar-based wireless power transfer is feasible with careful design of coils, resonant frequency tuning, and power electronics. Key performance metrics to measure in further work include transfer efficiency vs. gap, misalignment tolerance, PV-to-wheel round-trip efficiency, and cost per km

6. CONCLUSION

The proposed system successfully integrates solar energy harvesting with wireless power transmission to charge EVs dynamically. It presents a sustainable alternative to traditional plug-in charging systems and supports the idea of a green, self-sufficient transport network.

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