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Wireless Charging for Moving Electric Vehicle

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ABSTRACT: Wireless power transmission (WPT) is a popular and gaining technology finding its application in various fields. The power is transferred from a source to an electrical load without the need for interconnections. WPT is useful to power electrical devices where physical wiring is not possible or inconvenient. The technology uses the principle of mutual inductance. One of the future applications is found in the automotive sector, especially in Electric Vehicles. This manuscript focuses on the exploration of an Inductive charging system for electric cars using wireless transmission. The main goal is to transmit power using resonance coupling and to build the charging systems. The systems deal with an AC source, transmission coil, reception coil, converter, and electric load which are batteries. It delves into various wireless charging methods, including inductive and resonant systems, highlighting their advantages and limitations.

KEYWORDS: Dynamic wireless charging, Static wireless charging, Magnetic Field, Wireless charging technology, Inductive charging, Resonant inductive coupling, Wireless power transfer (WPT), Magnetic resonance charging.

I. INTRODUCTION

People are using automotive vehicles for transportation from one place to another. vehicles use internal combustion (IC) engines to drive them. Due to the increased number of vehicles, there is environmental pollution caused by IC engines and a reduction in fossil fuels. The latest innovations in the Automotive Industry are helping to improve fuel efficiency and reduce emissions. One such technological advancement is Hybrid vehicles which use both IC engines and electric motors to drive the vehicles or a car in simple words, helping to reduce the amount of emissions produced and maintaining the performance of the engine. However, in the future, the focus will be on clean and green energy producing zero emissions. The design and manufacture of electric vehicles have led to major interest in the current industry. Since these vehicles run on battery The primary disadvantages include elevated expenses, short-distance travel, and long charging time. Buyers are consistently seeking a better solution to improve travel efficiency. Hence wired charging systems were built at every gas station. Wired charging also has certain constraints such as socket points, spacing occupied by the charging station, limited range of wire, vehicle has to change its orientation to connect to the charger. These can be addressed by inductive charging systems for electric vehicles. This provides flexible and hassle-free charging and also systems can be built at home, in the parking lot, garage, etc. Numerous wireless power transfer methods are employed to implement this technology. These methods use coils to transmit power. The coil will produce a short-range magnetic field when a second coil is placed an electric current will flow through it. The magnetic force field facilitates power transfer between coils. called Induction. It is necessary to analyze these techniques based on the application to obtain optimum results for the system to function correctly.

The energy is transmitted from the transmitter coil to the receiver coil the energy is then converted into a DC form from the AC which is done by the AC to DC converter. Then the power is retained in the battery pack and it is derived to Motors. In the car system the other components like the controlling unit and managing unit require power, so the power is transmitted from the battery pack through the voltage converter, which converts High-voltage DC to low-voltage DC.

II. THE TWO TYPES OF WIRELESS EV CHARGING

Static Wireless Charging: Static wireless charging is a technology that allows electric vehicles (EVs) to charge their batteries free from physical cable connections. This occurs at the time the vehicle is parked over a designated charging pad, eliminating the inconvenience of plugging and unplugging cables.

Dynamic Wireless Charging: Static wireless charging offers convenience for parked EVs, but the true game-changer in EV charging lies in dynamic wireless charging (DWC). This technology enables EVs to charge their batteries while driving, eliminating the need for dedicated charging stops and potentially revolutionizing the way we think about EV range and infrastructure.

III. WORKING PRINCIPLES OF WIRELESS CHARGING FOR MOVING EVS

Wireless charging for EVs utilizes the principles of electromagnetic induction, similar to how wireless phone chargers operate. The core components involved are:

Charging Pad: Embedded in the ground or integrated into the road surface, the charging pad houses transmitting coils that generate a magnetic field.

Vehicle Receiver: Installed underneath the car, the receiver coil captures the magnetic field and converts it into electrical energy, charging the vehicle's battery. Resonant magnetic induction is the key principle at play. The transmitting and receiving coils resonate at the same frequency, facilitating efficient energy transfer despite minor misalignments between the pads. This allows for "dynamic charging," where EVs can top up their batteries while driving on designated charging lanes or zones.

So, we have two systems which are given:

1. Car System

In-Vehicle Receiver Coil:

Location: The receiver coil is the heart of the car's wireless charging system. It's typically mounted on the underside of the vehicle, strategically positioned to align with the charging pads embedded in the road or designated charging zones. Common locations include the centre of the car's floor pan or spread across a wider area for better misalignment tolerance.

Design and Materials: The receiver coil is a flat, spiral-shaped conductor made of highly conductive materials like copper or aluminium. The specific design factors influencing efficiency include:

Number of Turns: More turns generally increase efficiency but also raise resistance, requiring careful optimization.

Wire Gauge: Thicker wires minimize resistance losses but add weight.

Coil Size: Larger coils offer better misalignment tolerance but may be less efficient.

Functionality: The receiver coil interacts with the magnetic field generated by the charging pad. When aligned, the coil induces an electric current within itself due to electromagnetic induction.

2. Power Electronics Unit (PEU):

Function: The PEU acts as the brains of the car's wireless charging system. It plays several crucial roles:

Rectification: The induced AC from the receiver coil is rectified by the PEU into DC suitable for charging the vehicle's battery.

Voltage Regulation: The PEU regulates the voltage of the rectified DC to match the battery's voltage requirements, ensuring safe and efficient charging.

Communication: The PEU communicates with the charging pad (if applicable) via wireless protocols to exchange information about power levels, charging status, and potential safety concerns.

Safety Features: The PEU integrates safety features like overcurrent protection, overheating protection, and unfamiliar matter recognition to safeguard the system and prevent damage.

3. Battery Management System (BMS):

Integration: The PEU interacts with the car's existing Battery Management System (BMS).

Function: The BMS monitors the battery's health, state of charge, and temperature. It communicates with the PEU to ascertain the appropriate charging rate based on these factors. This ensures safe and optimal battery charging while preventing overcharging or exceeding thermal limits.

4. User Interface and Control System:

Dashboard Display: The driver receives visual information regarding the wireless charging status on the car's dashboard. This may include indicators for charging initiation, power transfer rate, estimated charging time remaining, and potential warnings or error messages.

5. Vehicle Communication System (V2X):

Advanced Functionality: Future systems might integrate Vehicle-to-Everything (V2X) communication protocols. This allows the car to communicate with the charging infrastructure in real time.

Benefits: V2X enables features like:

Automatic Charging Initiation: The car automatically initiates charging upon entering a designated wireless charging zone.

Dynamic Power Adjustments: Real-time communication allows for adjusting charging rates based on grid availability, traffic congestion, or vehicle battery needs.

Optimized Charging Schedules: V2X can integrate with smart grid systems to schedule charging during off-peak hours when electricity demand is lower.

Heat Management: Efficient power transfer during wireless charging generates heat. The car system needs effective thermal management strategies to dissipate heat from the receiver coil and PEU, preventing overheating and ensuring optimal performance.

Foreign Object Detection: The system should incorporate mechanisms to detect foreign objects lodged between the receiver coil and the charging pad. This prevents potential damage from metallic objects getting caught and ensures safe operation.

Electromagnetic Interference (EMI): Wireless charging systems operate at high frequencies and can potentially generate electromagnetic interference with other electronic systems in the vehicle. Careful design and shielding techniques are crucial to mitigate EMI and maintain the functionality of sensitive electronic components.

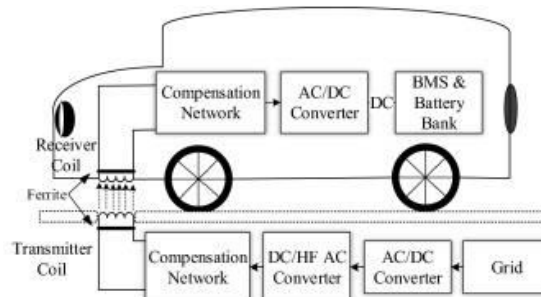


Fig:1 Car and Road Systems

2. Road System

Infrastructure Components:

The road system for wireless charging comprises several key components:

Charging Pads: These pads are embedded within the road surface or strategically placed along designated charging zones. They house transmitting coils that generate a magnetic field when powered. The design and material of these pads are vital for optimized power transfer and durability. Factors like coil design, spacing between pads, and substance exhibiting elevated magnetic are considered for optimal performance.

Power Delivery System: This system provides electricity to the charging pads. It can involve.

Underground Power Cables: A network of buried cables delivers electricity from the power grid to the charging pads.

Inductive Power Transfer (IPT): In some concepts, adjacent charging pads transfer power to each other using IPT, potentially reducing the necessity of extensive underground cabling.

Wireless Power Transfer from Overhead Lines: In certain proposals, overhead power lines could wirelessly transmit energy to charging pads on the road, similar to how some wireless charging systems work for phones.

Communication Network: A communication network connects the charging pads to a central control system. This allows for:

Real-time Monitoring: Monitoring power levels, system health, and potential issues with individual charging pads.

Dynamic Power Adjustments: Adjusting power output based on traffic density, vehicle needs, and grid availability.

Safety Features: Enabling communication protocols for foreign object detection, fault identification, and emergency shutdowns.

2. Proposed Charging Lane Designs:

Various methods are under investigation for integrating charging pads into the road system:

Lane-Based Charging: Dedicated lanes on highways or designated charging zones within cities would be embedded with charging pads. These pads could be segmented to maintain power transfer efficiency over short distances as vehicles drive over them.

Under-the-Road Charging: This concept proposes embedding charging pads beneath the entire road surface, creating a continuous charging zone. While technically complex and expensive, it offers seamless charging without designated lanes.

In-Road Resonant Cavities: Resonant cavities are embedded within the road surface, creating specific magnetic field patterns for power transfer. Vehicles with compatible receiver coils can utilize these cavities for charging while driving.

3. Challenges and Considerations:

Developing a robust road system for wireless charging presents several challenges:

Infrastructure Costs: Installing charging pads across vast road networks requires significant investment. Identifying cost-effective and scalable solutions is crucial.

Power Transfer Efficiency: Maintaining high efficiency during dynamic charging is critical. Research on coil design, power management, and electromagnetic field containment is necessary.

Safety Regulations: Establishing safety regulations for electromagnetic field exposure, potential electrical hazards, and potential impact on other infrastructure is crucial.

Grid Integration: Managing the additional power demand on the grid during widespread EV adoption with wireless charging needs careful planning and grid modernization.

4. Future Outlook and Potential Benefits:

Despite the challenges, advancements are continuously being made:

Pilot Projects: Several countries are conducting pilot projects to test the feasibility and effectiveness of various road system designs for wireless charging.

Technological Advancements: Ongoing research focuses on improving power transfer efficiency, reducing infrastructure costs, and optimizing coil design for dynamic charging.

Integration with Smart Grids: Wireless charging systems can potentially integrate with smart grids to optimize charging based on grid availability and renewable energy sources.

Block Diagram

Car System

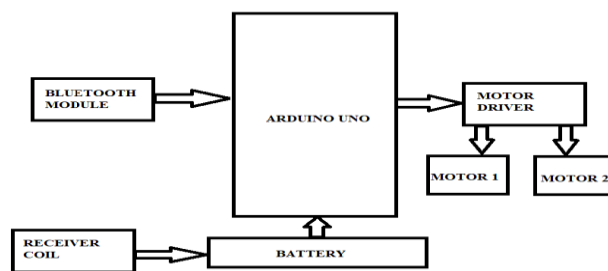


Fig 2: Car System

Bluetooth Module: This module enables wireless communication between the system and an external device, likely a smartphone or computer.

Arduino Uno: A microcontroller board that controls the overall operation of the system based on instructions received via Bluetooth.

Motor Driver: This component controls the direction and speed of the two motors (Motor 1 and Motor 2) connected to the system.

Receiver Coil: This coil likely receives a signal from a transmitter coil (not shown in the diagram) to control the motors. However, it does not refer to a wireless charging system as it doesn't transfer significant power to a battery.

Road System

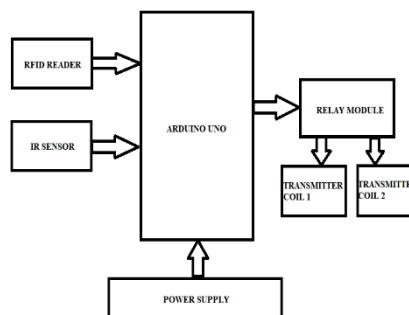


Fig 3: Road System

Power Supply: This supplies the entire system with the required electricity.

Arduino Uno: This is a microcontroller board that controls the overall operation of the system.

IR Sensor: An infrared sensor is employed to identify the presence of an object.

Relay Module: A relay module is utilized to command the on/off state of the transmitter circuit. When the IR sensor detects an object, the relay module is activated, which in turn turns on the transmitter circuit.

RFID Reader: An RFID reader is used to read data from RFID tags.

Transmitter Coil 1 and Transmitter Coil 2: These coils transmit electromagnetic waves to wirelessly charge the RFID tags.

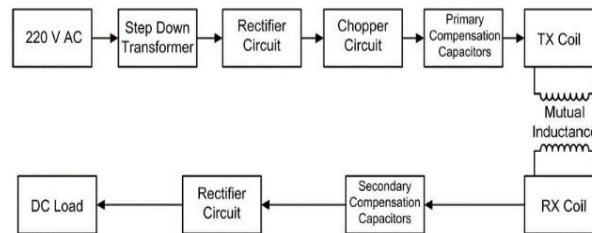


Fig 4: Diagram of all System

IV. CONCLUSION

Wireless charging for moving EVs represents a significant leap forward in the evolution of electric transportation. While challenges remain, ongoing research and development, coupled with growing industry interest and government support, pave the way for a future where wireless charging seamlessly integrates into our transportation systems, offering a more convenient, efficient, and sustainable way to power our electric vehicles.

This journal provides a comprehensive overview of the potential and challenges associated with wireless charging for moving EVs, highlighting its potential to revolutionize electric transportation and contribute to a more sustainable future.

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