Wireless Power Transfer For Charging Of Electric Vehicles

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Abstract. Wireless power transfer system (WPTS) for charging of Electric vehicles (EVs) can be classified into static charging, i.e. when the vehicle is at stationary and nobody is inside it but this is very time consuming and requires human input. Another is dynamic charging, it can easily get charged from the road while moving. In this research we design a dynamic mode of charging for Electric vehicle. It requires a powerful transmitting coil and a receiving coil to transfer power. The transmitting coil is embedded on the roads and each electric vehicle will be equipped with a receiving coil that will charge its battery by capturing the transmitted power using induced coupling. Our findings demonstrate that the model is reliable and its performance can be improved by lowering the vehicle's ground clearance. However, we found that problems can be addressed because of the vehicle's high weight, high speed and restricted driving area. Electric Vehicles (EVs) is fully dependent on plug in mode of charging and get easily discharged and there is a drastic difference between the number of EVs sale and the number of charging stations. So, it is very difficult to find a charging station near us. This can be a proper technology or solution for this static charging problem.

Keywords: Electric Vehicles, Wireless power transfer system (WPTS), Induced coupling.

1 Introduction

Ever since Nikola Tesla created the method of wireless power transfer[4], it has been a technology of significant interest. Researchers like Li, Yong[1] and Zhou[2] have examined wireless power transfer(WPT) in great detail. Inductive charging EVs are a specific kind of electric vehicle (EV) that are charged utilizing wireless power transfer (WPT) technology, which eliminates the need for physical touch to transfer electricity. Various handheld gadgets, including medical equipment, electronic toothbrushes, and smartphones, have been charged successfully using WPT[5]. But opportunities for recharging the vehicle away from home have become a crucial concern as electric vehicles (EVs) have gained popularity as a mainstream transportation option. Creating a standardized framework that provides smooth compatibility between EV models and charging infrastructure will speed up adoption and give EV owners with additional wireless charging alternatives. The electric vehicle (EV) wireless power transfer system intends to overcome the shortcomings of the present charging techniques, such as tangled cables, safety concerns in wet conditions, and the requirement of physical connections. Its objective is to develop a charging system that is easy to use, efficient, and safe. The system's objectives include creating a dependable wireless power transmission system that makes it simple to charge EVs, meeting the high-power transfer specifications for charging EV batteries, guaranteeing safety through adherence to rules and safeguards against electrical shocks and short circuits, increasing charging efficiency to cut down on energy losses, and enabling wireless charging in a variety of environmental settings without compromising performance.

2. Literature Survey

To wirelessly charge an electric car, the magnetic induction connection makes advantage of the electromagnetic induction principle. The set-up consists of two coils. A fluctuating magnetic field is created as electricity is delivered through the receiving coil, and this induces a current in the transmitting coil that can be utilized to charge the electric battery. The transmitting and receiving coils need to be close by and well oriented in order to increase the effectiveness of inductive coupling. IPT systems do not require maintenance because they are not affected by the environment. They are also very useful in any circumstances. Ferrites are required by the IPT for flux guiding, allowing it to function at low frequencies, hence the size is diminished as a result of core losses. Additionally, in the magnetic induction approach, power is wirelessly sent from a fixed transmitter to numerous moving secondary receivers by magnetic coupling. The magnetic coupling effect between the transmitter and reception coils changes because of the wide air space between them.
Wireless power transfer (WPT) systems for electric vehicles (EVs) have seen substantial study and development in recent years, including insights from multiple studies and existing literature. Improving power transfer efficacy by optimising power conversion, gearbox distance, and alignment between charging and receiving pads is critical for WPT systems. Using modern technology such as resonant inductive coupling can be advantageous. Furthermore, improving functionality and interoperability is critical, as is addressing compatibility concerns caused by different EV manufacturers and charging standards. Creating a standardised framework that provides smooth compatibility between EV models and charging infrastructure will speed up adoption and give EV owners with additional wireless charging alternatives.
Aside from the above mentioned problems, guaranteeing security in wireless power transmission systems is critical, necessitating steps to handle electromagnetic interference and prevent electric shock. My suggested method prioritises user safety by utilising sophisticated shielding methods and stringent safety measures. Scalability and deployment of wireless charging infrastructure are other critical factors to consider. The proposed technique focuses on enabling the installation and scalability of wireless charging stations in public parking lots, commercial buildings, and residential locations in order to encourage wider adoption of EVs. Intelligent charge scheduling, load control, and energy optimisation are enabled through integration with smart charging technologies and vehicle-to-grid communication systems, making the charging process even more user-friendly and accommodating for EV owners.

3. System Description

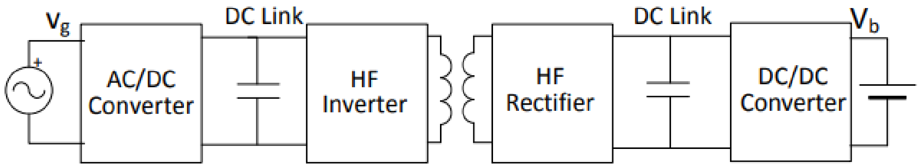

Fig. 3.1. Scheme of principle for battery chargers

An AC-DC converter is utilised in the power electronics circuits of battery chargers to convert alternating current from the power grid to direct current voltage. Following that is a DC-DC converter, which adjusts the voltage/current provided to the battery based on the charging profile. Typically, an insulating stage consisting of a high-frequency inverter, coupling transformer, and high-frequency rectifier separates the two stages. While basic diode-based AC-DC converters are inexpensive, they produce high current distortion and require extra input filters to meet grid harmonic injection regulations. More complicated AC-DC converters with Power Factor Correction (PFC) circuits are employed to circumvent these restrictions. PFC circuits regulate the rectifier's output voltage and strive for a high power factor by assuring sinusoidal and in-phase grid current. PFC circuits, on the other hand, have downsides such as the requirement for greater output voltage and a restricted capacity to manage bidirectional power flow. For bidirectional power flow or vehicle-to-grid applications, additional circuitry or conversion stages would be necessary.

4. Wireless Inductive Power Transmission(WIPT)

Inductive electricity Transfer (IPT) technology, which transfers electricity between two linked coils, is the foundation for wireless EV charging. A primary coil at a wireless charger is connected to the electrical grid, while a secondary coil is placed at the EV with a substantial air gap between them.
In this type of near-field charging method, the wireless charger's transmitting coil creates a magnetic field that transmits energy to an electric vehicle's nearby receiving coil via induction. The power transfer is aided by a portion of the magnetic flux produced by the transmitting coil that enters the receiving coil. Additionally, the connection between the coils and their quality factor affect the transfer efficiency.
There are primarily two forms of IPT for wireless.

- When the car is spotted in a parking lot, static IPT is activated.
- Depending on whether the vehicle is moving or making a brief stop at a traffic red light, dynamic or quasi-dynamic IPTs are deployed.

It should be highlighted that the WPT would be the only option for dynamic or quasi-dynamic charging because wired charging would be impossible while the EVs are in motion.

4.1 Stationary Charging

With wireless inductive EV charging, alternating current (AC) is transmitted to the car's inductive 'pick-up' through a coil in the charging plate via a magnetic field. The battery pack is then charged as a result of the voltage converter in the car converting the alternating current into direct current (DC). A power adapter positioned on the wall is connected to a charging pad that is placed on the floor. It is covered by the parked car. A receiver is located on the back of the vehicle, and when the charger determines the receiver is within range, it automatically begins charging.

4.2 Dynamically Charging

The resonant coil is used to charge EVs similarly to the stationary charging system, although this method allows for on-the-go charging. Alongside the roads, there will be a charging lane where drivers can move to charge their cars. The WPTs are needed to provide the dynamically charging system because wired systems cannot give this type of charging. There is a wireless charging receiver on every electric bus. At regular intervals, wireless chargers are inserted beneath or into the hard surface of a road. No need to connect to wireless chargers or plug in while the bus is stopped. It will have charged on its own. These electric buses are already being tested in South Korea, Netherlands, UK, and Italy.

5. Circuit

5.1 Transmitter

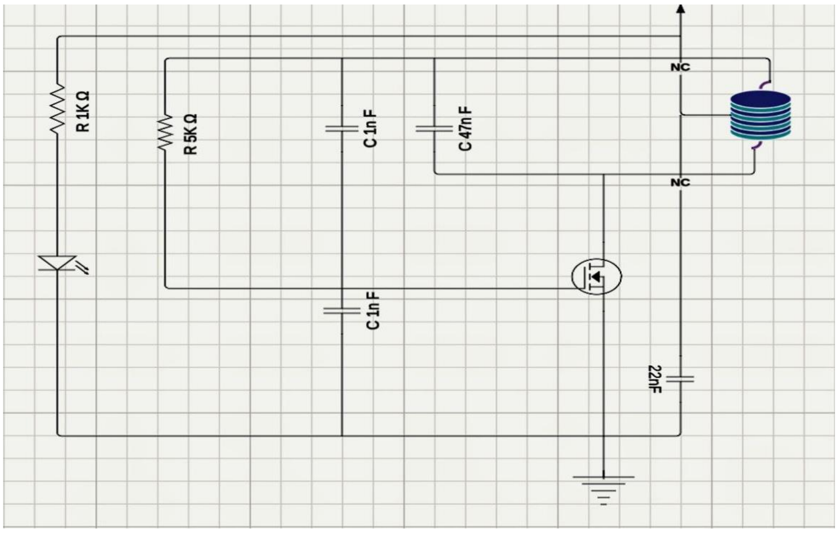

Fig. 5.1. Circuit diagram for Transmitter side of WPT for charging of EV battery

A wireless power transfer system (WPTS) power converter is made up of a front-end power factor correction (PFC) rectifier coupled to an inverter. The transmitter converter is a combination that supplies an alternating voltage to the transmitting equipment. Five 3 cm radius, 30-turn, circular rounded coil has been designed for the transmitter. The above Fig.3.2 shows a schematic of the transmitter circuit used in this study.

4.2 Receiver

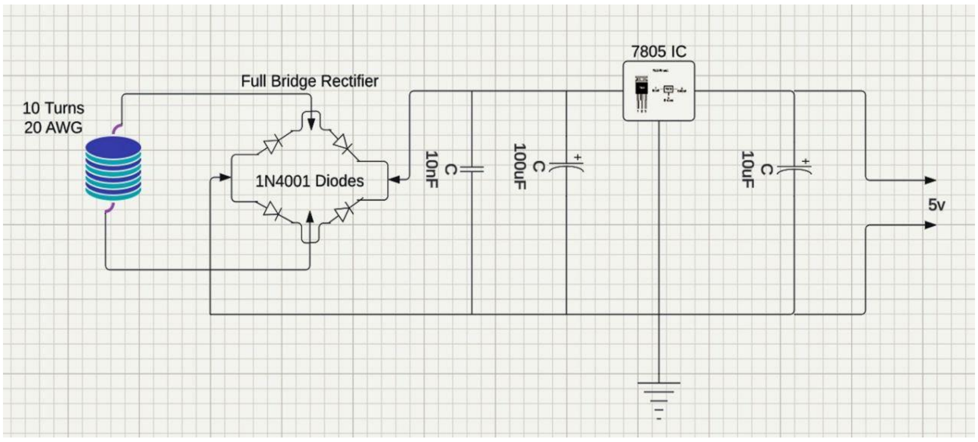

Fig. 4.2 Circuit diagram for Receiver side of WPT for charging of EV battery

The received AC signal at the receiver coil is then passed through a full bridge rectifier which is used to convert the AC to DC signal and by using some other components as shown in the above Fig.3.3 we can get our required filtered DC signal to charge the Electric Vehicle. And at the power sector level, the WPTS is managed by a single electronic control unit (ECU).

5 Result and Discussion

The outcomes of our experiment show that wireless power transfer for EV charging is both practical and efficient. The wireless technology appears to be a competitive alternative to traditional wired charging techniques given its high charging efficiency and comparable charging periods. Additionally, the system's safety measures handle issues with electromagnetic radiation and overheating, guaranteeing user safety.

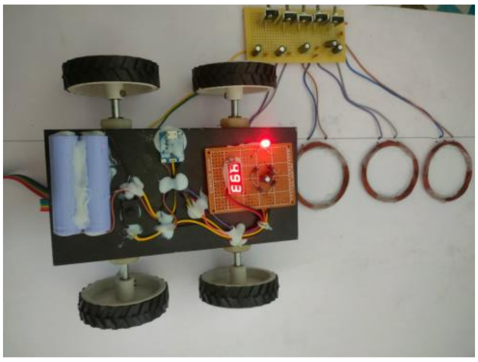

Fig.5.1.Prototype of WPT for electrical vehicle battery charging

WPT for charging electric vehicles (EVs) has various benefits over standard cable charging techniques. It improves use and convenience by removing the requirement for physical connection and handling of wires and plugs. WPT may be installed in a variety of settings, boosting EV owners' access to charging. It decreases infrastructure requirements by integrating charging pads into existing infrastructure, decreasing upfront expenses and simplifying implementation. WPT systems provide equivalent efficiency to cable charging while including safety precautions and lowering the danger of accidents or connection breakage. It supports sustainability by encouraging the adoption of zero-emission vehicles. WPT systems may also be attractively incorporated into urban environments, maintaining the visual attractiveness of public places.

6 Conclusions and Future Works

This paper has presented the design and evaluation of a wireless power transfer system with road embedded transmitter coils for dynamic charging of an electric vehicle. Wireless power transfer (WPT) systems have emerged as a promising technology with numerous applications and benefits. Throughout this study, we have explored the key aspects and implications of WPT systems. Here are the main conclusions drawn from our analysis:

- **Efficiency and Convenience:** Wireless power transfer offers the convenience of eliminating the need for physical connections between power sources and devices. This technology enables seamless charging of electronic devices.

- **Scalability and Flexibility:** WPT systems can be designed to accommodate various power requirements, ranging from low-power applications to high-power applications.
- **Future Prospects:** The future of wireless power transfer looks promising. As technology continues to evolve, we can expect further advancements in WPT efficiency, extended operating ranges, and integration into a broader range of applications. WPT has the potential to revolutionize various industries, including consumer electronics, transportation, healthcare, and infrastructure.

Fig.6.1.Photograph of the constructed test road

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