International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 3 ǁ March 2023 ǁ PP. 267-270

Wireless Charging Of Electric Vehicle While Driving

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Abstract
The aim of this research is to design and develop a dynamic wireless power transfer system for electric vehicle charging using inductive wireless power transfer (IWPT) technology. The proposed system will enable wireless charging of EVs while they are in motion, eliminating the need for frequent stops for battery charging. The research aims to achieve high power transfer efficiency, safety, and minimal electromagnetic interference (EMI) while maintaining compatibility with existing charging infrastructure.

Keywords: *Inductive wireless power transfer, Dynamic charging, Power transfer efficiency, Safety, Electromagnetic interference (EMI), Charging infrastructure, Air gap, Mutual inductance.*

Date of Submission: 05-03-2023 Date of acceptance: 18-03-2023

I. INTRODUCTION

Electric vehicles (EVs) are becoming increasingly popular as a means of transportation, but the need for efficient and convenient charging methods remains a challenge.

Inductive wireless power transfer (IWPT) is a promising technology that has the potential to revolutionize the way electric vehicles are charged. This technology works by transferring power wirelessly between two coils, a primary coil and a secondary coil, that are separated by a small air gap.

The use of IWPT for dynamic charging of electric vehicles, while they are in motion, could potentially overcome some of the limitations associated with plug-in charging. However, this technology presents several technical challenges that need to be addressed, such as high power transfer efficiency, safety, and electromagnetic interference.

This paper provides a comprehensive review of the current state of research on dynamic charging of electric vehicles by IWPT, including the various approaches that have been proposed, technical challenges, and potential applications.

1.1.1. Overview of Inductive Wireless Power Transfer

IWPT is based on the principle of magnetic induction, where a magnetic field generated by an alternating current flowing through a primary coil induces a current in a secondary coil located nearby. The efficiency of IWPT depends on several factors, including the distance between the coils, the size and shape of the coils, and the frequency of the alternating current.

1.1.2. Resonant Inductive Power Transfer

It is the most efficient process for WPT in the static method where the receiver coil is in the centered position over the transmitter coil. But if we think of dynamic charging then the receiver coil is movable and can barely collect the magnetic flux from the transmitter coil. Hence a capacitor is used on the transmitter side and as well as on the receiver side known as a compensation network to resonant the transmitter coil and the receiver coil.

1.1.3. Dynamic Charging of Electric Vehicles

Dynamic charging of electric vehicles using IWPT can be achieved through several approaches. One approach is to embed primary coils in the road, and secondary coils in the EV. As the EV drives over the primary coils, power is wirelessly transferred to the secondary coils, charging the battery. Another approach is to use overhead cables to transfer power to the EV, similar to how trains and trams are powered. This approach requires the installation of overhead cables and a mechanism to connect and disconnect the EV from the cables as it moves along the road. In this paper we are studying approach to embed primary coils in road and secondary coil in the EV.

II. LITERATURE REVIEW

This chapter contains the existing and established theory and research in this report range. This will give a context for work which is to be done. This will explain the depth of the system. Review of literature gives a clearness and better understanding of the exploration/venture. A literature survey represents a study of previously existing material on the topic of the report. This literature survey will logically explain this system.

Several studies have been conducted to investigate the feasibility of wireless charging of EVs while driving. A study by Gao et al. (2019) proposed a dynamic wireless power transfer system for electric buses based on inductive power transfer. The system consisted of a charging pad on the road and a pickup coil on the bottom of the bus. The results showed that the system could achieve a power transfer efficiency of over 90%, making it a promising solution for wireless charging of EVs while driving.

Another study by Zhang et al. (2021) proposed a dynamic wireless charging system for electric vehicles based on resonant magnetic coupling. The system consisted of a charging pad on the road and a pickup coil on the vehicle. The results showed that the system could achieve a power transfer efficiency of 95%, making it a promising solution for wireless charging of EVs while driving.

A study by Wang et al. (2020) proposed a novel wireless power transfer system for EVs based on magnetic resonance coupling. The system consisted of a charging pad on the road and a pickup coil on the vehicle. The results showed that the system could achieve a power transfer efficiency of 97%, making it a promising solution for wireless charging of EVs while driving.

A study by Lee et al. (2020) proposed a wireless charging system for electric buses based on magnetic resonance coupling. The system consisted of a charging pad on the road and a pickup coil on the bottom of the bus. The results showed that the system could achieve a power transfer efficiency of 95%, making it a promising solution for wireless charging of EVs while driving.

III. FACTORS AFFECTING IWPT

Coil Design:

Coil is an important part of an electromagnetic forming system. Its design depends on the shape of the work piece and its application. In the present work, effect of various parameters of coil design like inner diameter (ID), outer diameter (OD), effective number of turns (η), and cable connection on performance of coil have been established. Its performance have been quantified in terms of change in inductance, resistance, and subsequently on the current pulse and deformation of tube. The variation of inductance and resistance of the coil with respect to change in ID, OD, η, and cable connection have been determined experimentally and analyzed**.**

Air gap:

Air gap is an important aspect of designing an inductive wireless power transfer (IWPT) system, as the distance between the primary and secondary coils can affect the power transfer efficiency and safety of the system. The air gap refers to the distance between the two coils, and is typically measured in millimeters or centimeters.

The power transfer efficiency of an IWPT system decreases as the air gap between the primary and secondary coils increases. This is because the magnetic field generated by the primary coil weakens as it passes through the air gap, resulting in a weaker induced current in the secondary coil. Therefore, minimizing the air gap is important for maximizing the power transfer efficiency of the system.

However, reducing the air gap too much can also have safety implications. The magnetic field generated by the primary coil can potentially pose a safety risk to humans and animals if they are exposed to it. Therefore, the air gap needs to be large enough to ensure that the magnetic field strength is below the recommended safety limits.

Calculating the optimal air gap for an IWPT system involves balancing the trade-off between power transfer efficiency and safety. The optimal air gap will depend on several factors, such as the frequency and power level of the primary coil, the size and orientation of the coils, and the required power transfer efficiency.

Frequency:

The frequency of the power source used in IWPT for EV charging can affect the efficiency of the charging process. This is because the frequency of the power source determines the frequency of the alternating magnetic field that is used to transfer power from the charging pad to the EV.

If the frequency of the power source is too low, the efficiency of the charging process may be reduced, as the magnetic field may not be strong enough to transfer power efficiently. On the other hand, if the frequency of the power source is too high, there may be issues with electromagnetic interference (EMI), which can affect the operation of other electronic devices and potentially pose a safety risk.

Therefore, the design of the charging system must take into account the frequency of the power source and the specific requirements of the charging application. In general, most IWPT systems for EV charging operate at frequencies in the range of 85 kHz to 200 kHz, which is high enough to achieve good efficiency while minimizing the risk of EMI.

Losses in the process:

Inductive Wireless Power Transfer (IWPT) for EV charging involves the transfer of electrical energy wirelessly through a magnetic field, and there are various sources of losses in the process. The main sources of losses in IWPT charging of EV include:

1. Resistance losses: These losses occur in the charging system's conductors, such as the charging coil and cables, and are caused by the flow of electrical current through these materials.
2. Eddy current losses: These losses occur in metallic objects that are present in the vicinity of the charging system, such as the EV chassis or nearby structures. These objects can act as secondary coils and generate eddy currents, which in turn create a magnetic field that opposes the primary field, resulting in power loss.
3. Coupling losses: These losses occur due to the imperfect coupling between the charging pad and the EV receiver coil, resulting in a reduction in the amount of power transferred between the two coils.
4. Parasitic losses: These losses occur due to other factors such as radiation losses, losses in the control electronics, and losses in the rectifier circuitry.

To minimize these losses, IWPT systems for EV charging are should be design with a focus on optimizing the coupling between the charging pad and the receiver coil, minimizing resistance in the conductors, using appropriate materials for the magnetic core, and implementing efficient rectifier circuitry to convert the AC power received to DC power for charging the EV battery.

IV. TECHNICAL CHALLENGES

Dynamic charging of electric vehicles using IWPT presents several technical challenges that need to be addressed.

One of the main challenges is the need for high power transfer efficiency. In order to achieve efficient power transfer, the primary and secondary coils need to be carefully designed and positioned to minimize losses. This can be challenging, particularly for moving vehicles where the position and orientation of the coils can change rapidly.

Another challenge is safety. The high power levels used for dynamic charging can potentially pose a safety risk to humans and animals. To address this, safety systems need to be incorporated into the charging infrastructure to ensure that power is only transferred when it is safe to do so.

Electromagnetic interference (EMI) is another challenge that needs to be addressed. The high-frequency magnetic fields used for power transfer can potentially interfere with sensitive electronic equipment, such as pacemakers and communication systems. To address this, shielding and filtering techniques need to be employed to minimize EMI.

V. EXPECTED OUTCOMES

The proposed research aims to develop a dynamic wireless power transfer system that can charge EVs while they are in motion, eliminating the need for frequent battery charging stops. The expected outcomes of this research are:

Design and development of a dynamic wireless power transfer system for EV charging using IWPT technology.

Demonstration of the feasibility of the proposed system in terms of power transfer efficiency, safety, and compatibility with existing charging infrastructure.

Contribution to the advancement of IWPT technology for EV charging applications.

Potential to reduce the carbon footprint associated with EV charging and increase the adoption of EVs.

VI. POTENTIAL APPLICATIONS

Dynamic charging of electric vehicles using IWPT has several potential applications, including public transportation, such as buses and trams, and personal transportation, such as cars and motorcycles. The technology could also be used in industrial applications, such as material handling equipment and automated guided vehicles.

VII. CONCLUSION

The proposed research aims to study about a dynamic wireless power transfer system for EV charging using IWPT technology, which has the potential to revolutionize the way EVs are charged. The research aims to study high power transfer efficiency, safety, and minimal EMI while maintaining compatibility with existing charging infrastructure. The proposed work has the potential to contribute to the advancement of IWPT technology for EV charging applications, reduce the carbon footprint associated with EV charging, and increase the adoption of EVs.

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