A REVIEW OF STATIC WIRELESS ELECTRIC VEHICLE CHARGING SYSTEM

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Abstract— The principal element of wireless charging is to transmit power by an electromagnetic field across specified space. As electric vehicles are a superior choice to control continuous contamination, it is essential to make revisions in the battery charging cycle to achieve a more prominent and unwavering quality. Electric vehicle battery charging should be possible by plugging in at charging stations or by wireless power transfer. Wireless power transfer can be carried out as a static or dynamic charging system. A dynamic charging system can be carried out to charge the vehicle in any event, when it is moving. By utilizing inductive power, the power from the source can be moved to the chargeable batteries through the transformer windings. For preplanned courses, such powerful charging stations can be set up for charging batteries. This won’t just expand the utilization of electric vehicles yet, in addition, make them productive and dependable for huge distances too. This paper presents an assessment of how future EV advancement and wireless charging techniques can be carried out.

Index Terms— Wireless charging, EV (electric vehicles), static and dynamic charging, Plug-in Electric Vehicles (PEVs), Wireless Power Transmission (WPT).

I. INTRODUCTION

The cost of energy sources like petroleum and diesel has been consistently increasing due to the rising number of vehicles and excessive fuel consumption. The depletion of these exhaustible sources of energy is also a significant cause for concern. Conventional vehicles are major contributors to greenhouse gas emissions.

However, the future of automobile technology is changing, with electric vehicles being seen as a replacement for traditional combustion engine vehicles, leading to a reduction in CO2 emissions. Plug-in electric vehicles, which are powered by alternate sources of energy, have been proposed as a solution for eco-friendly transportation.

Although the usage of plug-in electric vehicles is increasing, there is a need for further advancements to overcome the current limitations of battery technology. Moreover, charging-related issues have prevented many consumers from choosing plug-in electric vehicles. This is the most significant issue being investigated in this field currently.

To address this problem, this proposed project uses Faraday's laws of electromagnetic induction to transfer power without physical force connectors. According to Faraday's law, when a coil is stimulated, electromagnetic field lines are induced in the coil, which can be connected to the magnetic field lines generated by another coil.

The transfer of electrical power without physical connections is known as Wireless Power Transfer. The proposed Wireless Power Transfer system is activated when the vehicle arrives at the charging area. The primary coil is activated, and it induces the secondary coil available in the EV, which is then connected to the battery, leading to its charging.

The above Figure 1 depicts an essential wireless Charging (WC) unit for a vehicle. Wireless Power Transfer (WPT) for electric vehicle charging offers many benefits compared to wired PEV charging. The burdens in the wired PEV charging process are significant hindrances in acquiring buyers’ interest.
Although the number of researchers working on WPT technology is increasing, there are various challenges to overcome in making it a commercial level. Achieving adequate power transfer efficiency at a high transfer range, increasing power level, misalignment resistance, and safety considerations are significant technical challenges. Our project deals with the charging of a miniature model of an electric vehicle using WPT. The project aims to make this technology, which is the focal point of this field, achievable and accessible to all.

II. LITERATURE REVIEW

Nikola Tesla was a pioneer in the field of wireless power transfer (WPT) and he developed the concept of WPT in the late 19th and early 20th centuries. Tesla envisioned a future where power could be transmitted wirelessly, without the need for wires and cables. Tesla’s original experiments with WPT involved the use of high-frequency electromagnetic fields to transfer power over short distances. However, the technology at the time was not advanced enough to make widespread use of this concept [1].

A.C. Bagchi, A. Kamineni, R. A. Zane and R. Carlson, "Review and Comparative Analysis of Topologies and Control Methods in Dynamic Wireless Charging of Electric Vehicles," DWPT systems have been developed to solve EV range and battery size limitations, there are still significant challenges to achieving stability and interoperability [2].

S. Manurkar, H. Satre, B. Kolekar, P. Patil, S Bailmare, “Wireless Charging of Electric Vehicle,” wireless power transfer can be implemented as either a static or dynamic charging system, with the latter allowing for charging of vehicles even when in motion [4].

P. Magudeswaran, G Pradeeba, S. Priyadarshini, M. Sherline Flora, “Dynamic Wireless Electric Vehicle Charging System.” This paper presented a design for wireless charging of electric cars, which offers many benefits compared to wired charging systems [5].

Darshana wagh, “Wireless Charging Station for Electric Vehicle.” The paper discusses the development of wireless charging methods for electric vehicles, including both static and dynamic charging systems [6].

Swaraj Ravindra Jape, Archana Thosar “Comparison of Electric Motors for Electric Vehicle Application.” the study compares five different electric motors for electric vehicle applications based on various criteria such as power-to-weight ratio, torque-speed characteristics, efficiency, cost of the controller, and cost of the motor. The purpose of the comparative evaluation is to determine which motor would be the most suitable for use in electric vehicles [7].

Christ and M G. Douglas, "Evaluation of Wireless Resonant Power Transfer System with Human Electromagnetic Exposure Limits.” This study investigates the potential exposure of individuals in the reactive near-field of wireless power transfer systems, with the objective of providing scientifically sound recommendations for the evaluation of such systems in terms of human exposure limits. The study seeks to guide the evaluation of potential risks associated with wireless power transfer systems and ensure compliance with established safety standards [8].

III. IMPLEMENTATION OF WIRELESS CHARGING

Wireless charging does not require conductive wires, and as a result, conduction losses, which can occur through wires, can be completely eliminated. Additionally, the human handling of wires during the charging process for plug-in and plug-out can sometimes be dangerous if not done correctly [1].

Although wireless charging is efficient and viable, it comes with certain constraints. After the plug-in charging station, the first wireless charging was created the "WiTricity" system, which is designed to charge EVs in parking areas or garages when the vehicle isn't operated for an extended period [2-3-4].

Wireless charging innovation can potentially address the limitations of the charging systems for EVs. The benefits of wireless charging include its safety and convenience of charging while the vehicle is stationary or moving. Wireless charging enables the automated charging of vehicles, which can be achieved through three different modes [5].

a. STATIC WIRELESS CHARGING SYSTEM

Static WEVCs (Wireless Electric Vehicle Charging System) can undoubtedly replace the plug-in charger with minimal driver involvement, and it addresses related security issues, such as trip hazards and electric shock.

As the name suggests, the vehicle gets charged when it is in a static position and can easily replace the plug-in charger with minimal driver effort. Therefore, we could simply park the vehicle and charge its battery, which is integrated with a wireless charging system [6].

In EVs, electrical energy is the primary source of power for propelling a vehicle. Electrical energy is converted into mechanical energy, specifically rotational energy, by electric motors. This rotational energy is then transferred to the wheels of the vehicle via an appropriate transmission system, which in turn generates the vehicle’s drive [7].
b. QUASI-DYNAMIC CHARGING SYSTEM

The power that a wireless power transfer (WPT) system in electric vehicles (EVs) can deliver has significantly increased, reaching up to several kilowatts [8]. The quasi-dynamic wireless charging system provides charging to EVs as they halt for brief timeframes, such as at traffic signals, which extends the vehicle's range while on the way and reduces the energy capacity requirements of the vehicle. Quasi or semi-dynamic wireless charging (QWC), also known as static on-the-way charging in, is mainly beneficial for vehicles that stop at regular intervals, such as traffic signals, bus stops, or taxi stands [9]. For example, in the case of buses halting at the bus stop, they start charging wirelessly through underground fitted technology. Ahmad et al have proposed a QWC system for traffic lines, where vehicles stop at traffic lights [10].

c. DYNAMIC WIRELESS CHARGING SYSTEM

The term "dynamic WPT charge" refers to wireless power transfer charging that occurs while a vehicle is in motion along a WPT-enabled roadway. WPT technology for electric vehicles has the potential to overcome the limitations of wired chargers and remove certain barriers to vehicle electrification and sustainable mobility. In addition to being more convenient than wired chargers, WPT can enable significant reduction in the size of the onboard EV battery [11]. and the purpose of the review presented in this paper is to develop a system that can transmit 15kW of power continuously (with a frequency of 85 kHz) to a secondary pad installed underneath an electric vehicle traveling on a road [12].

IV. METHODS OF WIRELESS POWER TRANSMISSION FOR EVs

a. Induction Coupling WPT

The Inductive Wireless Power Transfer (IWPT) system works using electromagnetic waves. Its operation can be understood in terms of conventional transformer activity. According to Ampere's law, an alternating current generates a magnetic field around the primary coil. The resulting time-varying magnetic field induces an electromagnetic coupling effect in the secondary coil. This induced field creates a voltage across the secondary loop, which is in accordance with Faraday's law [13]. The primary coil, commonly referred to as the charging paddle or inductive coupler in Magne-Charge systems, is integrated into the vehicle's charging port. This enables the secondary loop to receive power and charge the electric vehicle [14]. Typically, utility power is first corrected before a converter is used to convert it to the desired frequency and amplitude. On the secondary side, a reactive compensation network is utilized to further enhance the power transfer at the system frequency. Fig. 2 portrays a schematic of induction WPT.

![Fig. 2 Induction wireless power transmission](image)

b. Capacitive Coupling WPT:

Coupling capacitors are used in Capacitive Wireless Power Transfer (CWPT) to transfer energy from the power source to the receiver. This technology offers better performance and more precise field constraints between plates, even with a small air gap. A laboratory model of over 1 kW running at 540 kHz can achieve an efficiency of approximately 83% from the DC power supply to the lithium battery [14]. This approach overcomes the limitation of magnetic energy being obstructed by metal shields or plates. It achieves this while reducing energy losses, maintaining a safe level of magnetic field interference, and avoiding field impedance [15]. The system operates in a saturated state, which enhances the strength of the field, and can function even in the presence of an electric field. However, it poses a significant risk to human safety due to the sudden release of high voltage during power transmission[16]. We see an illustration of this in Figure 3.
FUTURE CHALLENGES AND OPPORTUNITIES

The wireless car charging system has the potential to revolutionize the way we charge electric vehicles. However, like any new technology, it has challenges and opportunities for the future. Some of the challenges and opportunities are as follows:

a. CHALLENGE:

Efficiency: The primary challenge facing wireless car charging systems is improving their efficiency. Current systems have lower efficiency rates compared to traditional wired charging systems, which can lead to longer charging times and lower overall range.

Standardization: The lack of standardization in wireless charging technology is another challenge. There are several competing wireless charging standards, which can make it challenging for automakers and consumers to select the best option.

Cost: The cost of implementing wireless charging technology is another challenge. The technology is currently more expensive than traditional wired charging systems, which could make it less accessible to consumers.

Infrastructure: A significant investment in infrastructure is required to make wireless charging systems widely available. This includes the installation of charging pads in public spaces and the development of a network of charging stations.

b. OPPORTUNITIES:

Convenience: The primary opportunity presented by wireless charging technology is convenience. By eliminating the need for physical cables and plugs, drivers can simply park their cars over a charging pad, which can save time and hassle.

Flexibility: Wireless charging systems can also provide more flexibility in terms of where and how electric vehicles can be charged. With wireless charging, charging pads can be installed in a wider range of locations, including parking lots, garages, and even on the street.

Sustainability: Wireless charging systems have the potential to be more sustainable than traditional wired charging systems. They can use renewable energy sources like solar power and wind power to charge vehicles, reducing their carbon footprint.

Innovation: The development of wireless charging technology also presents an opportunity for innovation. As the technology improves, we may see new applications emerge, such as dynamic wireless charging that can charge electric vehicles while they are in motion.

VI. CONCLUSION

In conclusion, wireless car charging systems face challenges, but they also present exciting opportunities for the future of electric vehicles. Continued investment in research and development can lead to significant improvements in the efficiency, standardization, and affordability of this technology in the coming years.

This paper presents an efficient model for examining the switch-on course of dynamic remote EV charging frameworks. The proposed model considers the underlying value of the switch-on target current before transferring, which is crucial to the transient cycle. Additionally, identical sources of both the switch-on unit and dynamic unit are included. Through the system transfer capabilities, full responses of the selected currents under the excitation of identical sources are obtained to approximately depict
the switch-on process. Based on the developed dynamic remote EV charging model, the analysis results show that the proposed model can quantitatively calculate switch-on processes with good accuracy.

Moreover, switch-on transient characteristics are examined to discuss the system boundary effects, and the effects of vehicle speed have been found to be small. Finally, the discussion on the switching position effect shows that the appropriate switching position is where the load coil has a long enough distance with the switch-on target, and using a gap between the switch-on track and the dynamic track will be helpful to reduce EMF and additional power losses before switching.

Although the model and analysis methods are proposed based on the specific system, they have been proven to be suitable for the conditions of different track sizes, numbers, unique segment gaps, and independent DC transport for each inverter. Moreover, they can be extended to other applications, such as switch-off process analysis, the effects of other compensation networks on transient interaction, etc. They will be helpful for system design to avoid large transient pulses, which may exceed device tolerance limits and cause damage to system protection.

REFERENCES


