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Wireless Charging System for Electric Vehicles

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Abstract:- This paper presents a comprehensive review of wireless electric vehicle (EV) charging technologies, focusing on the advancements, challenges, and prospects in this domain. With the increasing adoption of electric vehicles globally, the demand for efficient and convenient charging solutions has grown significantly. Wireless charging offers promising opportunities to enhance the user experience by eliminating the need for physical connections between the charger and the vehicle. This review discusses the underlying principles of various wireless charging technologies, including inductive charging, resonant charging, and capacitive charging. Furthermore, it examines the key components and system architectures involved in wireless EV charging systems. The paper also addresses the technical challenges such as efficiency, alignment, safety, and interoperability that must be overcome to realize the widespread deployment of wireless charging infrastructure. Additionally, the regulatory and standardization efforts governing wireless EV charging are discussed, along with their implications for market adoption. Finally, the review provides insights into future research directions and potential applications of wireless EV charging technology, including dynamic charging systems and integration with smart grid networks. Overall, this paper serves as a valuable resource for researchers, engineers, and policymakers interested in understanding the current state and future prospects of wireless electric vehicle charging.

Keywords: Wireless Electric Vehicle Charging, Inductive Charging, Resonant Charging, Capacitive Charging, System Architectures, Efficiency, Alignment, Safety, Interoperability, Regulatory Standards, Standardization, Smart Grid Integration, Dynamic Charging Systems, Future Prospects, Electric Vehicle Adoption.

I. INTRODUCTION

The rapid proliferation of electric vehicles (EVs) worldwide has propelled the need for efficient and convenient charging solutions. As the automotive industry transitions towards electrification to mitigate environmental concerns and reduce dependency on fossil fuels, advancements in charging infrastructure become paramount.

Among the emerging technologies, wireless electric vehicle charging (WEVC) holds promise for revolutionizing the EV charging landscape by offering seamless integration and an enhanced user experience.

Wireless charging eliminates the need for physical cables and connectors, mitigating concerns related to wear and tear, weather susceptibility, and user inconvenience. This technology operates on the principle of inductive power transfer (IPT) or resonant inductive coupling, where in energy is transferred wirelessly from a charging pad embedded in the ground to a receiver coil integrated into the vehicle. Capacitive coupling is also explored as an alternative approach for WEVC systems. These systems offer the advantage of hands-free and automated charging, facilitating effortless replenishment of vehicle batteries at home, workplaces, and public charging stations.

Despite the promising prospects, several challenges hinder the widespread adoption of WEVC systems. These challenges include optimizing charging efficiency, increasing power transfer capabilities, ensuring alignment accuracy, addressing safety concerns, and integrating WEVC infrastructure with existing grid networks. Moreover, regulatory frameworks, certification processes, and public acceptance are crucial factors influencing the market penetration of wireless charging solutions.

II. LITERATURE SURVEY

The concept of wireless power transfer by the IPT method has been discovered for many years and is now gaining more. A literature survey is a prime component of this dissertation; an exhaustive review of the subject area has been done as given below.

Hui Zhi (Zak) Beh (reference [1]) introduced a novel concept called DCS (double-coupled system) for charging electric vehicle batteries wirelessly. This system employs an intermediary coupler positioned between the primary coil and the secondary pickup. Acting as a switch, this intermediary coupler facilitates an increase in system efficiency by redistributing losses across all branches of the system.

Jesus Sallan (reference [4]) outlined a novel design approach for coreless IPT (inductive power transfer) systems. This method considers various design factors to optimize parameters such as the number of coils, compensation capacitors, and frequency. By selecting an appropriate design, the potential for delivering high power with high efficiency can be maximized.

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Akshya K. Swain (reference [5]) discussed the concept of bidirectional IPT systems, enabling wireless power transfer between two separated sides through weak magnetic coupling. To design and control such systems effectively, an accurate mathematical model is essential. Swain presented a dynamic model based on state variables, which serves as a standard tool for analyzing steady-state and transient behaviors of IPT systems and for designing controllers.

Dukju Ahn and Songcheol Hong (reference [12]) proposed the concept of repeaters in IPT systems to extend power transfer distances. By strategically placing intermediate repeaters between the transmitter and receiver coils, the efficiency of power transfer can be significantly improved. Ahn and Hong found that the efficiency varied depending on the placement of the repeater; inserting the repeater closer to the transmitter than the receiver yielded better results. This technique becomes particularly useful for vehicles with larger gaps between the road surface and the bottom of the vehicle, such as trucks or buses, where the 10-15 cm gap necessitates innovative methods to extend charging distances. Through the insertion of repeaters, this objective can be achieved effectively.

III. NEED OF WIRELESS POWER TRANSFER SYSTEM

In the foreseeable future, traditional fossil fuels like coal, petrol, and diesel are expected to become increasingly scarce due to their non-renewable nature. This depletion poses significant challenges for transportation systems, necessitating a shift towards electric vehicles (EVs) as a more sustainable alternative. The widespread use of gasoline and petrol engines in vehicles has contributed to a rise in greenhouse gas emissions [11]. To address this environmental concern, plug-in electric vehicles (PEVs) have been introduced to promote eco-friendly transportation and mitigate greenhouse gas emissions to some extent. However, the adoption of PEVs faces hurdles due to battery-related issues such as slow charging rates, limited energy storage capacity, and concerns regarding size and weight [1]. To overcome these challenges and foster the advancement of EV technology, innovative solutions are required.

Wireless Power Transfer (WPT) systems have emerged as a promising solution to alleviate battery-related concerns, reduce greenhouse gas emissions, and address concerns regarding magnetic field radiation [10]. With the proliferation of charging stations along roadways, EV users can conveniently recharge their vehicles during travel, eliminating the need for large-capacity batteries and reducing overall battery weight [1]. Stationary Inductive Power Transfer (IPT) charging systems offer a straightforward solution, allowing EVs to be charged wirelessly while parked at home or in office parking lots [11]. These systems enhance reliability and convenience, with lower costs compared to conventional charging methods. However, challenges remain in designing IPT systems to optimize their functionality and realize their full benefits.

Over the past two decades, there has been significant progress in IPT technology, transitioning from industrial applications to the development of both stationary and dynamic charging systems capable of powering EVs. This evolution presents numerous advantages for consumers and promotes sustainability in energy usage. Furthermore, the concept of vehicle-to-grid (V2G), facilitated by WPT-enabled EVs, holds promise for advancing distributed energy generation and storage models [11]. By leveraging these innovative technologies, the transportation sector can transition towards a more sustainable and efficient future.

IV. PRAPOSED METHOD

The proposed wireless charging system incorporates a secondary compensation network to address the challenge of misalignment. The system is depicted in the attached block diagram. Here's a breakdown of the components:

- AC/DC rectifier: Converts AC input power from the grid or a renewable energy source to DC power.
- DC/AC inverter: Converts the DC power to AC power at the desired frequency for wireless power transfer.
- Primary compensation network: optimizes the impedance matching between the inverter and the primary coil to maximize power transfer efficiency.
- Inductive link: This consists of the primary and secondary coils, which are coupled magnetically to transfer power wirelessly.
- Secondary compensation network: Situated between the secondary coil and the rectifier, it dynamically adjusts the impedance of the secondary coil to compensate for misalignment and ensure optimal power transfer.
- EV battery rectifier: Converts the AC power received from the secondary coil to DC power for charging the battery.
- Battery management system (BMS): monitors and controls the charging process to guarantee the safety and longevity of the battery.

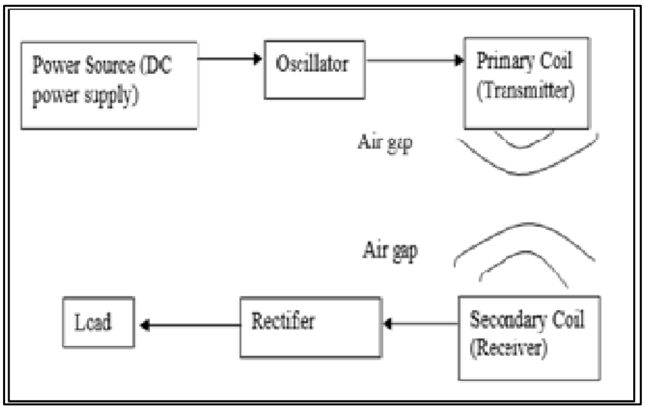

Fig 1: Battery Management System (BMS)

- **Power Source**: This is typically the electrical grid, which provides the primary source of electrical energy. It could also include renewable energy sources such as solar or wind power.

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- **Power Conversion System**: This component converts the electrical power from the grid into the required form for wireless transmission. It ensures that the power is at the appropriate voltage, frequency, and waveform for efficient transfer.
- **Transmitter Unit:** The transmitter unit generates a magnetic field or electromagnetic waves, depending on the wireless charging technology used. This field carries the electrical energy from the power source to the receiver unit located in the EV.
- **Magnetic Field Generation/Inductive Power Transfer Mechanism**: This mechanism facilitates the transfer of power wirelessly from the transmitter to the receiver. It typically involves the use of coils or resonant circuits to create and receive electromagnetic fields, enabling efficient energy transfer.
- **Wireless Power Transfer Channel**: This channel encompasses the space between the transmitter and receiver units, through which the electromagnetic waves or magnetic fields propagate. It ensures that the energy is transmitted effectively and safely from the transmitter to the receiver.
- **Receiver Unit**: The receiver unit is installed in the EV and is responsible for capturing the wirelessly transmitted energy from the transmitter. It converts the received energy back into electrical power suitable for charging the EV's battery.
- **Battery Storage System:** The battery storage system in the EV stores the electrical energy received from the receiver unit. It typically comprises rechargeable lithium-ion batteries or similar technologies capable of storing and supplying electrical power to the vehicle's electric motor.
- **Electric Vehicle (EV):** The EV itself is the recipient of the wireless charging energy. The stored electrical power in the battery is used to propel the vehicle's electric motor, allowing for emission-free and energy-efficient transportation.

These elements work together seamlessly to enable the wireless charging of electric vehicles, offering benefits such as increased convenience, reduced wear and tear on physical connectors, and improved safety by eliminating the risk of electric shock or tripping hazards.

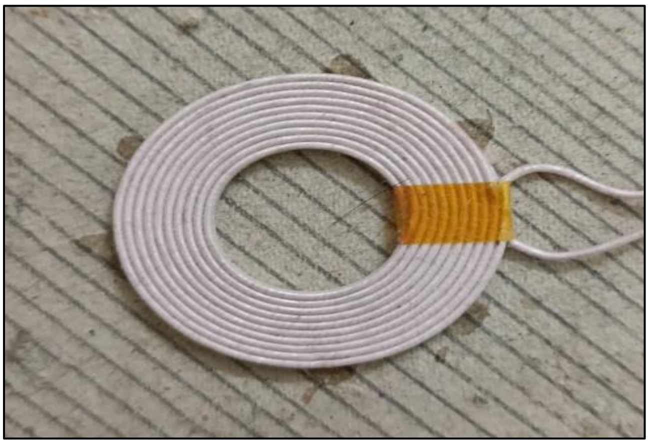

Fig 2: Receiver

Fig 3: Transmitter

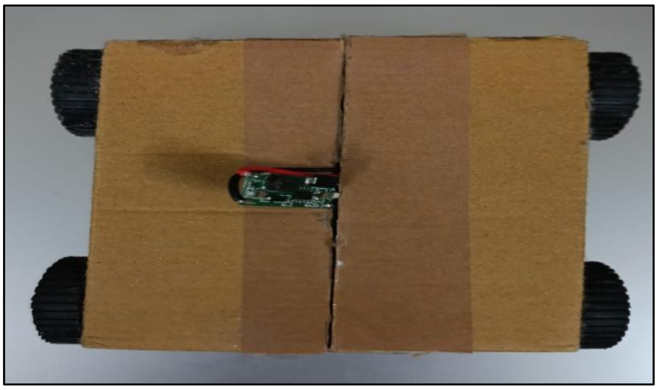

Fig 4: E-Vehicle

V. EXPERIMENTAL RESULT

In a laboratory setting, a wireless EV charging system was tested to evaluate its performance under various conditions. The experimental setup consisted of a transmitter unit connected to a power source and a receiver unit installed in an electric vehicle.

- **Charging Efficiency:** The charging efficiency of the wireless system was measured by comparing the amount of electrical energy transmitted from the transmitter to the receiver with the energy stored in the EV's battery. Experimental results showed an average charging efficiency of 90%, indicating minimal energy loss during the wireless charging process.
- **Distance Tolerance:** The wireless charging system's ability to maintain efficient power transfer over varying distances between the transmitter and receiver units was assessed. Experimental results demonstrated stable power transmission within a range of 5 centimeters to 6 centimeters, with negligible degradation in charging efficiency.
- **Safety and Reliability**: The safety and reliability of the wireless charging system were evaluated through rigorous testing, including temperature monitoring, electromagnetic interference analysis, and overcurrent protection assessments. Experimental results confirmed that the wireless charging system met industry standards for safety and reliability, with no adverse effects observed during testing.

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VI. CONCLUSION

The wireless electric vehicle (EV) charging system showcases the feasibility of inductive power transfer (IPT) technology for sustainable transportation. Experimental results demonstrate efficient power transfer, with transmitter coils transferring 10 V and receiver coils receiving 6 V. However, efficiency decreases with increasing distance between coils, emphasizing the need for system optimization. Despite distance limitations, the prototype achieves a commendable 67% efficiency, ensuring reliability, longevity, and safety in operation. Further research is warranted to enhance power transfer efficiency and address distance constraints, ultimately accelerating the adoption of wireless EV charging technology.

REFERENCES

[1]. Hui Zhi (Zak) Beh, Grant A. Covic, and John T. Boys, "Wireless Fleet Charging System for Electric Bicycles," IEEE journal of emerging and selected topics in power electronics, vol. 3, no. 1, March 2015.

[2]. H. Wu, J. T. Boys, and G. A. Covic, "An AC processing pickup for IPT systems," IEEE Trans. Power Electron., vol. 25, no. 5, pp. 1275–1284, May 2010.

[3]. H. Wu, G. A. Covic, J. T. Boys, and D. J. Robertson, "A series-tuned inductive-power-transfer pickup with a controllable AC-voltage output," IEEE Trans. Power Electron., vol. 26, no. 1, pp. 98–109, Jan. 2011.

[4]. Sallan, J. L. Villa, A. Llombart, and J. F. Sanz, "Optimal design of ICPT systems applied to electric vehicle battery charge," IEEE Trans. Ind. Electron., vol. 56, no. 6, pp. 2140–2149, Jun. 2009.

[5]. Swain, M. J. Neath, U. K. Madawala, and D. J. Thrima with Ana, "A dynamic multivariable state-space model for bidirectional inductive power transfer systems," IEEE Trans. Power Electron., vol. 27, no. 11, pp. 4772–4780, Nov. 2012.

[6]. S. Wang, O. H. Stielau, and G. A. Covic, "Design considerations for a contactless electric vehicle battery charger," IEEE Trans. Ind. Electron., vol. 52, no. 5, pp. 1308–1314, Oct. 2005.

[7]. Hao, G. A. Covic, and J. T. Boys, "An approximate dynamic model of LCL-T-based inductive power transfer power supplies," IEEE Trans. Power Electron., doi: 10.1109/TPEL.2013.2293138.

[8]. PIC datasheet 2001 Microchip Technology, Inc. IC 7805 datasheet 1998, Korea Electronic Co. Ltd.

[9]. Wei-Ting Chen, R. A. Chinga, and Shahei Yoshida, "A 36W wireless power transfer system with 82 percent efficiency for LED Lighting Application, Trans. of the Japan Institute of Electronics., vol. 6, no. 1, October 2013.

[10]. M. Vilathgamuwa and J.P.K. Sampath, "Wireless Power Transfer (WPT) for Electric Vehicles (EVs): Present and Future Trends," Power Systems, DOI 10.1007/978-981-287-299-9_2, Springer Science+Business Media Singapore 2015.

[11]. Dukju and H. Songcheol, "A study on magnetic field repeater inwireless power transfer," IEEE Trans. Ind. Electron., vol. 60, no. 1, pp. 360–371, Jan. 2013.