WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Optimizing Electric Vehicle Charging with Smart LCC Compensation Strategies

[1]Potnuru. Deepthi, [2]Kuppila Sneha, [3]Mr. J. Ravi Kumar

[1]B. Tech Student, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India
[2] Professor, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India.
[3]B. Tech Student, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India
[4]B. Tech Student, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India

ABSTRACT:

Electric vehicle (EV) charging options that are both efficient and easy are becoming more and more necessary in today's rapidly changing electric mobility scene. Dynamic Wireless Power Transfer (DWPT), sometimes referred to as "on-the-go" charging, is a cutting-edge technology that has the potential to completely transform the way we sustainably charge our electric vehicles. With regard to range anxiety and energy usage, DWPT is a wireless charging solution that allows EVs to be charged while they are in motion. The system, which is capable of supplying energy to an electric vehicle at a rate that exceeds its usual consumption, allows it to be able to store excess energy in the battery. Adequate features include the efficient transfer of energy, and a broad lateral misalignment tolerance. The design of the system is Investigated in this paper with a focus on specifications for electric vehicles, an i.N.C. link configuration, compensatory networks and power electronic circuits. With the potential to improve energy efficiency, decrease range anxiety, and increase convenience, this research makes a substantial contribution to the advancement of on-the-go EV charging.

Keywords: Dynamic charging of EV, Smart Charging, LCC- Compensation , Alignment

Introduction:

Transport is an essential necessity of life in the 21st century, yet traditional combustion engines are rapidly getting out of date. Driving a petrol or diesel car, which is increasingly being replaced by entirely electric cars, is very environmentally harmful. Fully electric vehicles do not emit tailpipe emissions, which is significantly more environmentally friendly. The electric car revolution is about to take place. Electric cars are in the midst of a revolution. In order to mitigate concerns about limited range and reduce reliance on bulky batteries, dynamic electric vehicle charging is an innovative technology that allows electric vehicles to be charged while on the move. In order to provide an ongoing source of energy and increase the convenience and afford ableness of electric vehicles, this technology is using Wireless Power Transfer Systems. An inductive technology, with coils in the road and vehicle, is used to charge wireless electric vehicles. A dynamic magnetic field is created when the vehicle approaches, and this creates an electric current in the motor's coil to charge it. This enables the vehicle to charge continuously when it is in motion without a physical connection. Safe and effective power transfer is ensured by modern control systems and communication technologies that allow the process to adapt and respond in an intelligent way.

Dynamic wireless charging of EVs is a significant force in the motor vehicle industry. This technology presents a future in which electric mobility is both sustainably and economically feasible for all, starting with more convenience to extend range, addressing anxiety over the distances, joining smart grids, improving battery efficiency, revolutionizing public transportation, cutting infrastructure costs, prioritizing safety, and introducing various tariff options. The journey to a greener and more effective the prospective outlook for electrical vehicle is only beginning as we mark the one year anniversary of this breakthrough technology.

Methodology:

The development of a DWPT system that can stabilize output power and increase misalignment tolerance, or achieve maximum energy transfer efficiency. In the event of misalignment it may be necessary to improve the induction coupling design in order to achieve better performance. Provide guidelines for designing a high-power, high-efficiency, misalignment-tolerant

Dynamic Wireless Charging (EV DWC) system, considering road and vehicle specifications and a desired minimum received energy level for typical EV energy demands. The optimum power transfer and the appropriate high efficiency of energy transfer between couplings under different conditions are to be optimised for the LCC compensation components in order to achieve resonance operation.

Primary Side: The power from the mains shall be converted to DC energy through an AC circulator and a circuit of voltage factor correction. Using an inverter, the signal from DC power will transfer to high frequency AC. Compensatory networks shall be used for the purpose of creating resonance between inductive connections.

Secondary side: At the other end of the cable, an AC DC rectifier is used after LCC's compensation for converting combined AC and DC power into electric vehicle batteries that can be charged. A DC to DC converter may be used to assist in the control of the output power between the rectifier and the battery.

A method that involves the design and installation of a DWPT system to charge moving electric vehicles is used. For efficient transfer of electrical energy, inductive links, compensation systems and power electronics are used. Stability of the output voltage and high efficiency are ensured by a compensation network based on an LCC topology. The specification of the coil shall be optimized for maximum performance and an increase tolerance to misalignments in order to maximizes. FEM simulations validate assumptions and refine the inductive link design. The aim of the system is to be more than 90% efficient, and it can deal with lateral misalignments up to 200 mm. The purpose of this design is to provide stable and efficient power transfer by means of a practical on the move EV charger.

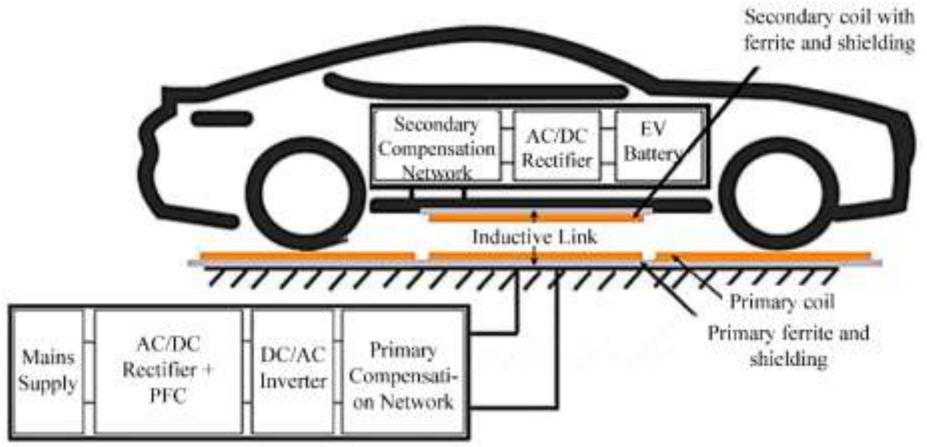

Figure 1. Block diagram of an EV wireless charging system.

Parameters And Components:

Misalignment tolerance, transfer efficiency, and energy targets are the main design considerations for the DWPT EV charging system. Power electronics, the compensation network, and the inductive link are some of its constituent parts. The features of coils, such as their size and turns, enhance their figure-of-merit (FoM) and misalignment tolerance. It is essential to optimize the load by varying efficiency with load resistance. To create a comprehensive and effective system, FEM simulations validate hypotheses and improve the inductive link design.

Simulation

In order to verify and improve the inductive link design of our system, we use FEA simulations. The simulation deals with a configuration that consists of multiple identical primary circuits. We consider a variable called mutual inductance (Mpis), which accounts for the connection within both primary and secondary aspects, including misalignments. These simulations help determine the necessary compensation components for effective transfer of power in a resonant frequency. The results are guiding us to design and optimize a system that can efficiently transfer power at high levels of efficiency while also being able to tolerate misalignments.

Literature Review:

This study evaluates a 5 kW inductive charging system for electric vehicles (EVs) with a focus on its efficiency and dual-directional control capabilities. The design and implementation of this system, aimed at improving the electric vehicle industry through increased efficiency in collecting electricity charges, is examined. The study emphasizes advancements in EV charging, particularly in convenience and energy efficiency. Ultimately, the research contributes to the development of a practical charging infrastructure for EVs, crucial for promoting widespread EV adoption.[1]

It explores the concept of transmitting electrical power to vehicles without traditional cables It emphasizes that, by simplifying the charging process, this wireless power transfer technology can benefit vehicles, in particular electric cars. The present state of electric vehicle wireless transmission is described in the paper, with a summary of recent knowledge and developments within this area. It surveys the challenges that need to be addressed if practical use of wireless power transfers in vehicles is to take place, concerns about effectiveness, security and necessary infrastructure. [2].

In the comprehensive review of wireless charging technologies for electric vehicles, different types of wireless charging are considered and their use is discussed. It highlights benefits and challenges, including the advantages of convenience and adoption. The use of electromagnetic resonance and inductive charges is also being examined in addition to emerging dynamic wireless charging technologies. This paper also addresses standardisation issues, safety and effectiveness of wireless charge systems. In summary, this report contains a very comprehensive overview of the electric vehicle charging landscape and its potential impact on mobility within the next decade[3].

Its objective is to focus on the need for cleaner energy, but it also shines a light on limitations of existing electric vehicles that include bulky batteries, high costs and limited driving range. To tackle these issues, it introduces the idea of EVs powered by the road wirelessly while they're in motion. In particular, the OLEV system, which has demonstrated an impressive 100 kW of power with 80% efficiency in a 26 cm air gap, is examined in detail in the framework of major initiatives such as the PATH project at UC Berkeley and the OLEV system of KAIST. The paper also provides a detailed breakdown of its structure and design components, offering valuable insights into the advancing field of wireless EV charging. [4].

In order to enhance the performance of power transmission over various coupling conditions, a more efficient compensation network on dynamic wireless charging is proposed in this paper. It offers more flexibility in design and reduces the need for a large number of control systems through addition of reactive elements. In order to ensure an effective dynamic charging, the experimental results show that power transfer can be smoothly moved with high degree of tolerance for changes in position and coupling factor.[5].

This paper deals with dynamic wireless charging through LCC's compensation networks for electric vehicles. It provides an overview of the theoretical design of LCC networks for both the primary and secondary sides, as well as the effects of division of segments. The study validates the approach with a two-segment LCC compensated dynamic EV charging system, achieving 2.34 kW output power and 91.3% efficiency. These results are consistent with the suitability of LCC networks for dynamic EV charging and support cleaner, easier to use EV technologies[6].This comprehensive review focuses on wireless power transfer systems using magnetic coupled resonances. It examines compensation topologies crucial for efficient power transfer when coils aren't perfectly aligned. The study also covers resonator structures for misalignment scenarios. It addresses managing electromagnetic noise during power transfer, particularly through Electromagnetic Interference Diagnostics. This review report contributes significantly to research and development efforts, aiming to enhance the reliability and effectiveness of Wireless Power Transmission Systems for applications like Consumer Electronics and Electric Vehicles[7]

This study aimed at increasing the efficiency of Wireless Power Transfer, which is a technology plagued with shortcomings in performance. It introduces a method to enhance efficiency and power extraction in non resonant WPT systems by actively adjusting the secondary-side load impedance. A hardware prototype including a wireless charger and an dc converter to charge batteries is put through its paces [8]. This study explores an innovative approach for electric cars, emphasizing Second Side Control without signal communication to simplify ground facilities. It utilizes a DCDC converter and a Half Active Rectifier (HAR) to improve energy control and efficiency. By controlling the DCDC converter by means of a HAR, it optimises transmission efficiency. This method shall regulate battery power current directly, address the problem of irregular voltage in DC connections and guarantee stable transmission efficiency. [9]. It deals with an inductive power transfer system that is controlled by two sides. However, this system can be operated effectively where there are significant differences between the coupling of the transmitter with the transmitting coils and if only parts of the load are connected to each other. In simple terms, the paper deals with a technology that ensures efficient transfer of power in situations where the connection between devices may change and when devices do not use all the power they receive [10].

Efficiency has a vital role to play in wireless charging because it affects the speed at which you can charge something and how much energy is wasted. Researchers are working to ensure the highest possible efficiency of this recharging system, taking into account any changes and movements typical for electric vehicles. [11]. This paper presents a control approach for dynamic wireless power transfer that operates without the need for direct communication between the transmitter and receiver. The strategy involves controlling current on the transmitter side and regulating power . They'll probably talk about strategies and designs of the circuits so that this efficiency can be achieved. Understanding what can be done to increase the charging capability of mobile phones. They'll probably talk about strategies and designs of the circuits so that this efficiency can be achieved. Understanding what can be done to increase the charging capability of mobile phones. For the purpose of matching vehicle power requirements, on the receiver side. The research aims at understanding how this system operates under different reference powers, mutual inductances and frequencies. The effectiveness of that control method has been confirmed by simulation testing, which provides important insight to the efficiency and performance of dynamic wireless charger systems [12].

This study compares two compensation methods for electric vehicle wireless chargers, assessing their sensitivity to mistuning. Double-sided LCC compensation proves less affected by mistuning. The research is supported by a 7.7kW EV charger, achieving a peak 96% efficiency from DC source to the battery load [13] The paper introduces a design approach for inductive EV chargers that enables effective and reliable charging through constant current/constant voltage (CC/CV) methods. Without requiring additional switches under the zero phase angle ZPA condition, this method continues to perform exceptionally well. In the CC mode, an 6.6 kW prototype charger has been successful in achieving a very high peak efficiency of 96.1% and confirms that this technology is feasible for electric vehicles. [14].

The benefits of a balanced three phase, four wire distribution system for accommodating more distributed generation and electric vehicles are discussed in this literature review. It highlights the use of three-phase photovoltaic (PV) inverters and electric vehicle (EV) chargers to transfer power between phases, improving grid stability and allowing for increased PV panels and EV connections. The paper also mentions a coordinated EV charging strategy that becomes more effective with power transfer between phases using PV inverters. Load flow simulations with real data confirm positive effects on system losses, grid voltage, and voltage balance. The review suggests a local controller for phase balancing without real-time communication [15]. The financial implications of different charging strategies for electric vehicles in the context of smart grids are examined in this review. It compares strategies to minimize network peak loads and charging costs, highlighting the importance of network-aware strategies, especially in scenarios with high wind energy integration [16]. Issues related to EV charging in urban areas are dealt with in this paper. It provides for a coordination algorithm that optimises the EV integration, reduces losses in energy supply, maintains stability of voltage and stabilizes load via phase switching equipment. The results of the simulations are confirmed as effective [17].

The LCC topology is discussed in detail in this paper for the transport of electric vehicles using Dynamic Power Transfers over Wireless Networks. LCC offers independent regulation and allows several transmitter coil to be switched on a single Inverter. The study optimised the load condition for concurrent operations, approximated LCC topologies and improved transmission efficiency by up to 7% in experiments [18]. [19].

A paper titled 'Innovative Approach to Modelling and Managing Electric Vehicles' explores a new methodology to enhance the energy efficiency of electric vehicles (EVs). The goal is to reduce energy consumption and promote the adoption of eco-friendly EVs. The study involves creating advanced mathematical models and implementing various control methods to boost EV energy efficiency. Ultimately, this research contributes to cleaner and more sustainable transportation by making electric vehicles more energy-efficient [20].

Results: The proposed dynamic wireless power transfer of electrical vehicle charging system efficiently in order to meet the demand for electricity from electric vehicles, 308 Wh of electricity is delivered per km, while allowing additional storage. Operating at over 90% efficiency, it accommodates lateral misalignment up to ±200 mm. FEA simulations confirm that there is a small reciprocal inductance of the neighboring coils. The mutual inductance Mpis contribute to the misalignment of the secondary coil, which affects the overall performance of the system. The lack of alignment in the second coil, which affects the overall system performance, is caused by a joint inductance MPis.

Conclusion :

In this study, we outline the process of designing a wireless charging system (DWPT) for electric vehicles. The primary goal is to maximise the amount of power received, while maintaining a high degree of effectiveness at different degrees of misalignment. That is achieved by using the LCCLCC compensation mechanism, which has a proven track record in resolving misalignment issues. In order to make sure the system is always functioning at its optimal power level without losing efficiency, we have also set up a control loop.

While our design is to focus on a specific inductive link structure, and we can use the general design process that we describe in order to apply it to other inductive link designs if they have good data of merit. Essentially, the key to an optimal DWPT system is to design compensation components that meet ZPA design objectives, maximize the kQ figure-of-merit of the inductive link, and fine-tune the power electronic circuits to make all system components work together seamlessly.

Our paper can be a useful guide for developers of DWPT systems, especially those who want to create dynamic wireless charging systems for electric vehicles based on specific design requirements and objectives.

REFERENCES

1. Wu, H.H.; Gilchrist, A.; Sealy, K.D.; Bronson, D. A 5 kW Inductive Charger with Dual Side Control for Electric Vehicles Demonstrating High Efficiency. IEEE Transactions on Industrial Informatics, 2012, 8, 585–595. [CrossRef]

2. Patil, D.; McDonough, M.K.; Miller, J.M.; Fahimi, B.; Balsara, P.T. Overview and Challenges of Wireless Power Transfer in Vehicular Applications. IEEE Transactions on Transportation Electrification, 2018, 4, 3–37. [CrossRef]

3. Ahmad, A.; Alam, M.S.; Chabaan, R. Comprehensive Review of Wireless Charging Technologies for Electric Vehicles. IEEE Transactions on Transportation Electrification, 2018, 4, 38–63. [CrossRef]

4. Shin, J.; Shin, S.; Kim, Y.; Ahn, S.; Lee, S.; Jung, G.; Jeon, S.; Cho, D. Design and Implementation of Shaped Magnetic-Resonance-Based Wireless Power Transfer System for Roadway-Powered Moving Electric Vehicles. IEEE Transactions on Industrial Electronics, 2014, 61, 1179–1192. [CrossRef]

5. Ng, H.; Cai, T.; Duan, S.; Zhao, J.; Zhang, X.; Chen, C. LCC-Compensated Resonant Converter Optimized for Robust Reaction to Large Coupling Variation in Dynamic Wireless Power Transfer. IEEE Transactions on Industrial Electronics, 2016, 63, 6591–6601. [CrossRef]

6. Zhu, Q.; Wang, L.; Guo, Y.; Liao, C.; Li, F. Application of LCC Compensation Network to Dynamic Wireless EV Charging System. IEEE Transactions on Industrial Electronics, 2016, 63, 6557–6567. [CrossRef]

7. Abou Houran, M.; Yang, X.; Chen, W. Magnetically Coupled Resonance WPT: Review of Compensation Topologies, Resonator Structures with Misalignment, and EMI Diagnostics. Electronics, 2018, 7, 296. [CrossRef]

8. Hata, K.; Imura, T.; Hori, Y. Dynamic Wireless Power Transfer System for Electric Vehicles to Simplify Ground Facilities—Power Control and Efficiency Maximization on the Secondary Side. In Proceedings of the 2016 IEEE Applied Power Electronics Conference and Exposition (APEC), Long Beach, CA, USA, 20–24 March 2016; pp. 1731–1736. [CrossRef]

9. Diekhans, T.; De Doncker, R.W. Dual-Side Controlled Inductive Power Transfer System Optimized for Large Coupling Factor Variations and Partial Load. IEEE Transactions on Power Electronics, 2015, 30, 6320–6328. [CrossRef]

10. Hu, X.; Wang, Y.; Jiang, Y.; Lei, W.; Dong, X. Maximum Efficiency Tracking for Dynamic Wireless Power Transfer System Using LCC Compensation Topology. In Proceedings of the 2018 IEEE Energy Conversion Congress and Exposition (ECCE), Portland, OR, USA, 23–27 September 2018; pp. 1992–1996. [CrossRef]