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Dynamic Wireless Charging for Electric Vehicles in Electrified Roads with Toll Collection

Gedela Sri Harsha[1], Chokkakula Sagar[2], Addanki Gunasree[3], Darla Naga Sai Krishna[4], Chandrapudi Sesi Vamsi[5], Jalli Ravi Kumar[6]

*[1,2,3,4,5] **Student at GMR Institute of Technology***

*[6] **Assistant at GMR Institute of Technology***

Electrical and Electronics Engineering Department, GMR Institute of Technology, Rajam, Andhra Pradesh, India

ABSTRACT:

This project introduces a Dynamic wireless charging for (EVs) on electrified roads. Electric vehicle (EV) dynamic wireless charging systems have drawn a lot of interest as a potential solution to the drawbacks of conventional charging methods, specifically infrastructure constraints and range anxiety. This concept suggests a revolutionary solution to dynamic wireless charging for EVs by incorporating the technology into electrified roads, allowing for continuous charging while the vehicle is on motion the battery get charge. Furthermore, the proposed system has toll collecting capabilities, allowing for the commercialization of energy transfer services. This abstract describes the conceptual framework, main components, and expected advantages of a dynamic wireless power transfer for EVs on electrified roadways with toll collection, emphasizing its potential to transform the future of electric mobility and transportation infrastructure.

Keywords: - Dynamic wireless charging, electric vehicle, boost converter, transmitter & receiver coil, state of charge, electric vehicle specifications, electrified roads.

1. Introduction

This dynamic wireless charging is a game changer for electric vehicles, this technology enables wireless charging. As electric vehicles become more popular, the demand for effective and efficient charging solutions becomes more apparent. Dynamic wireless charging, also called wireless charging while driving or on the go, has the potential to address some of the largest problems associated with the electric vehicle industry. Solar panels convert heat energy into electrical energy. Primary circuit receives power from grid and solar panelsThe concept of dynamic wireless power transfer pertains to electric vehicles can charge dynamically while moving on road or stored in special areas, both of which are equipped with a charging station. This approach eliminates the necessity of manually connecting the car to a charger. It employs the electromagnetic and inductive principles of communication to wirelessly transmit energy from the road to the vehicle's batteries without necessitating a physical link. This provides an opportunity to study dynamic wireless charging, a concept that has the potential to hasten electric vehicle industry’s acceptance and bring about a new era of sustainable and efficient transportation. The most widely studied method of Dynamic Wireless Power Transfer (DWPT). There is no requirement to wait until the battery is fully charged thanks to the dynamic wireless electrical charging system for electric vehicles. In this paper we are adding toll collection system, which means that when the car enters the electrified road some embedded systems will be present along with the transmitting coils. The toll collection systems receive the data of battery which is in the car. According to data of battery it calculates the how much it was charged during the car travels in the electrified road and toll was collects according to how much power is transferred to price per unit.

2. Literature Survey

The Dynamic wireless transfer for charge the electric vehicle in motion a design for wireless charging for electric vehicle using mutual induction power transfer. The main supply provides alternating current (AC) to the system. The AFE which means Active front end is power electronic circuit that conditions the AC from the source. AFE consists Inverter and rectifier. The AC voltage is changed to DC voltage using a rectifier. The high frequency AC voltage in AFE is produced by an inverter that transforms DC electricity. The high frequency AC that flows through primary coil. The resonant capacitors Cp and Cs provide energy to the primary as well as the secondary coils of a resonant tank. Through a mutual inductance, primary and secondary coils are magnetically connected. This allows energy to move wireless from the primary to secondary side. The rectifier transforms the high frequency AC that the secondary coil induces into DC. Before being used to charge a battery, the rectified Dc is smoothed down by the filter, which consists of an inductor and capacitor. The electrical energy has been stored in the battery [1].

In this paper presents the magnetic resonant wireless charging system and mutual induction which non resonant coupling. In IPT wireless power transfer system with non res coupling. It consists of two coils which are coupled with coupling coefficient. The primary circuit includes AC source and resistance which represents losses in primary coil. The secondary side consists resistance representing losses in secondary coil and load resistance. Two coils create magnetic field and emf will induce then power will transfer from primary to secondary circuit. The efficiency and amount power transferred depends on coupling coefficient and load. The resonant coupling wireless power transfer system is similar like IPT, but with addition of capacitor on both the transmitter and receiver sides. These capacitors created resonance. Then the transmitter and receiving coils are tuned to same frequency[2].

The methods included in the paper "Wireless Charging of Electric Vehicles" by Chun T. Rim are as follows:

Active Methods to Eliminate Electromagnetic Field: This study presents three design concepts to eliminate electromagnetic interference (EMF) in inductive power transmission systems (IPTS). These methods include Leakless EMF Elimination (LFEC), Independent Self-EMF Elimination (ISEC), and 3dB Dominant EMF Elimination (3DEC). They require adding active EMF cancellation coils to the pickup and power supply rails in order to allow the independent cancellation of the EMF produced by each primary coil.

Power Rail Segmentation: It is based on the roadways is covered in this study. It illustrates why these rails must be segmented in order for each segment to have independent on and off controls. When designing a power rail, length is an important consideration that takes into account factors including cost, power loss, cable usage, electromagnetic field (EMF) levels, and car length.

Gyrator Circuit Analysis: A circuit analysis method called gyrator-based circuit analysis is introduced in this paper. This method simplifies the analysis process and provides analytical results without manipulating complex equations. It is especially useful for evaluating electric circuits in IPTS that have multiple energy storage elements.

Resonant Frequency Variation: The research focuses on the change of resonance frequency in IPTS. It explains how changes in the longitudinal movement, lateral misalignment, or air-gap can modify the magnetic coupling and cause significant variations in the roadway subsystem's and onboard subsystem's resonance frequencies. To handle these frequency changes, the research suggests using an inverter or smart coil design, or altering the frequency in-situ. [3].

Their study centers on devising a nonlinear state-space model specifically tailored for the DWPT system, with a primary focus on optimizing power delivery and autonomously tracking resonance frequency for enhanced efficiency. Initially, the paper introduces wireless power transfer and its applicability within EV charging scenarios. The authors underscore the necessity for a sophisticated control system capable of dynamically adjusting coupling coefficients between emitter and receiver coils to optimize power transmission. Additionally, they stress the importance of implementing soft switching techniques within power electronic components to uphold operational efficiency.

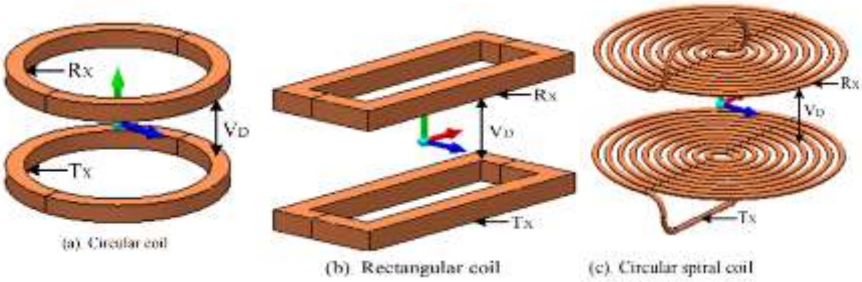
To model the DWPT system accurately, the authors employ the state-space averaging approach, which facilitates the conversion of AC state variables to DC values characterized by slow dynamics. This methodology proves advantageous for modeling resonant converters and enables controller design in the presence of significant signal variations. Through their work, the authors showcase the efficacy of this approach in achieving precise modeling and control of the DWPT system. [4].

This study introduces a structured method for seamlessly integrating on board receiver units within wireless charging systems for electric vehicles. The primary aim is to enhance the interoperability and charging options of WPTS by minimizing the vertical profile of the receiver unit. Initially, the paper underscores the advantages of WPTS, such as streamlining user interaction and offering convenience compared to traditional conductive charging methods. However, existing vehicle designs pose constraints on receiver unit placement, typically confined to the front or rear underbody region, limiting charging flexibility for drivers. To overcome this challenge, novel concepts are proposed for on-board receiver units with reduced vertical dimensions, enabling installation across the entire underbody spectrum.

In pursuit of functional integration while concurrently minimizing weight and bulk, the paper advocates for a methodical lightweight design strategy. This strategy entails a comprehensive consideration of the complete product lifecycle, encompassing both the product and production system, along with the assembling and mounting process. The intricate functional relationships among the receiver unit's macro-scale components add complexity, necessitating a problem-tailored and objective-oriented approach [5].

3. Shapes of coils

Various coil designs were utilized, including square, rectangular, and circular shapes. In this portion of the study, the focus is on analysing the performance in terms of magnetic coupling for each coil shape.



Circular coil design: This shape is widely used due to its ability to create a uniform magnetic field and efficient power transfer. The circular coil ensures that the magnetic flux is evenly distributed, resulting in an optimized charging efficiency for electric vehicles. With this design, the electric vehicle can seamlessly receive power as it moves along the electrified road, providing a hassle-free and convenient charging experience. The distance between the coils are 5cm, 10cm and 15cm. The inductance of the coils is determined when the distance is 5cm, the value obtained is 0.0614mH. For 10cm, the inductance values are 0.00349mH. For 15cm, the inductance value is 0.0682mH. the values shift slightly to 0.0651 mH for LP and LS, 0.00316 mH for M, and 0.04484 for k. Finally, at VD = 15 cm, the values are measured at 0.0682 mH for both LP and LS, with a significant decrease in M to only 0.00135 mH and a startling drop in k to just 0.00601. These findings suggest that there is little room for an airgap in WPTS systems if they are to be used in electric vehicles (EVs), as even in the best-case scenario (VD = 15 cm) the resulting value of k is far too low for practical use in EVs.

Rectangular coil design: It offers a different set of benefits. This shape allows for a larger surface area, which means a greater amount of power can be transferred to the electric vehicle. The rectangular coil also enables a more precise alignment between the charging pad on the road and the receiving pad on the vehicle, ensuring an efficient and reliable charging process. This design is particularly useful for high-power applications where a fast and robust charging system is required. Coils with rectangular forms are used in the design of stationary wireless power transfer, or WPT, systems. Because the selected coils are concentric, the fill factor is 0.11. At a vertical separation between transmitting and receiving coils. The results show that these values are, in order, a value of 0.0041mH, 0.0015 mH, and 0.037. It has been noted that the parameters of WPTS decrease with increasing coil distance because of increased leakage and reluctance in the system. Because of the resulting decreased coupling factor, this structure is not suitable for more powerful applications.

Circular spiral coil:

The present work centers on the examination of circular spiral coil structures, with a particular emphasis on the variations in their properties for varying VD values, namely 5 cm, 10 cm, and 15 cm. Important parameters like LP, LS, M, and k are found using the finite element approach and are subsequently confirmed by a simple numerical analysis. According to preliminary findings, the values obtained at VD = 5 cm are 0.0614 mH for both LS and LP, plus an extra value of 0.00439 mH for M and 0.0715 for k. VD = 10 cm at that point, the values shift slightly to 0.0651 mH for LP and LS, 0.00316 mH for M, and 0.04484 for k. Finally, at VD = 15 cm, the values are measured at 0.0682 mH for both LP and LS, with a significant decrease in M to only 0.00135 mH and a startling drop in k to just 0.00601. These findings suggest that there is little room for an airgap in WPTS systems if they are to be used in electric vehicles (EVs), as even in the best-case scenario (VD = 15 cm) the resulting value of k is far too low for practical use in Evs.

4. Circuit design and components

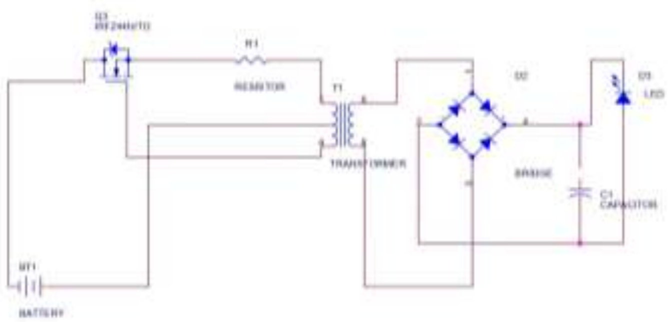


Figure 4.1 Circuit design

Circuit Explanation:

In this circuit the primary circuit which will be placed under the roads. The function of MOSFET is used as switch as well as it increases the frequency of the supply. Another function of MOSFET is to convert the dc supply into pulsating DC. Due to that pulsating dc mutual Induction will happen. In secondary side there will be a converter which is used to convert the pulsating dc into constant dc. Here there will be a capacitor which will reduces the harmonics. The work of voltage regulator is to supply the constant required voltage. After that the output will be taken from ports. Now we use Arduino and other equipment for toll collection. Here we will charge based on the time and units consumed by the vehicle. In the toll collection we will take inputs such as vehicle's battery percentage, vehicle model. After that we will verify whether the user given information. At last based on the time the vehicle entered and units it consumed it will charge. Integration with solar panel will also be a part of it where it is the input source for electrified roads.

Solar Panels:

Fig 4.2 solar panel

1. The solar panel is one of the power sources. The output is 12V.
2. Here solar panels work is converts the heat energy into electrical energy.
3. That Electrical energy will be given to the battery of primary coil.

Battery For Primary Coil:

Fig 4.3 LIPO battery

1. Electrical Energy from the solar panels will charge this battery.
2. Energy from this battery will passes through the primary coil which is acts as transmitter.

Primary coil:

Fig 4.4 primary coil

1. Primary coil which has 30 number of turns, where primary coil has different shapes, the significance of the shape is depend on output of the coil.
2. This primary coil contains three terminals, one of the terminals connected to resistor, second terminal connected to the gate terminal of MOSFET and the mid terminal is connected to positive terminal of the battery.
3. The power from the battery will charge the primary coil and electromagnetic flux will be produced in primary coil.

MOSFET:

Fig 4.5 MOSFET

1. IRZ44N MOSFET is used for this project according to requirement.
2. From Battery dc voltage will be passed through MOSFET.
3. For Generation of alternating flux for mutual induction whether voltage or current has to be varied or alternated.
4. As its DC which is not alternating when it passes through MOSFET, it converts Normal DC to Pulsating DC which is alternating will help for generating alternating flux.

Resistor:

Fig 4.6 1k ohm resistor

1. The working of the resistor here is to limit the current.
2. One Kilo Ohm resistor is used as per the requirement.

Secondary Coil:

Fig 4.7 secondary coil

1. Mutual Induction will happen between primary and secondary coils and flux cutting takes place, power transfer will happen.
2. Pulsating DC voltage will get as output from secondary coil after power transfer.
3. Shape of the coils will be same as Primary coils.
4. Secondary coil has two terminals, they are connected to the Full wave bridge rectifier.

Full wave bridge rectifier:

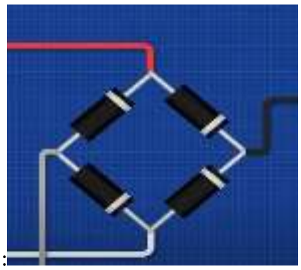


Fig 4.8 Full wave rectifier

1. The Pulsating DC voltage from Secondary coil will get into this Full wave rectifier.
2. When pulsating DC voltage passed through this Full wave rectifier then pulsating DC will get converted into normal DC voltage.
3. This normal DC voltage is required voltage for vehicle charging.

Capacitor:

Fig 4.9 Capacitor

1. The main working of the capacitor here is to eliminate the ripples in the voltage.
2. The rating of the capacitor here is 1000 microfarads and 63V.

5. Result

Input voltage: 12V, 2.25Amps

Output Voltage: 7V, 2Amps

Expected Voltage: 12V, 5Amps

6. Conclusion

In conclusion, this study looks at wireless charging for electric vehicle while the vehicle is in motion particularly in the setting of electrified highways. By offering a fix for many of the present problems facing the electric vehicle sector, this technology might completely transform the market. The need for reliable and efficient charging options is rising as electric cars become more and more popular. The dynamic wireless charging system operates by wirelessly transferring energy from the road to the vehicle's batteries while it is in motion or stationed at designated areas with charging stations. This marks a significant shift from traditional methods of vehicle charging that require a physical link between the car and charger. By utilizing electromagnetic and inductive principles, the system can transfer energy without any manual connection. One unique aspect of this paper is its proposal for an integrated toll collection system within electrified roads. As vehicles enter these roads, embedded systems and transmitting coils collect data on their battery capacities. This data is then used to calculate the duration and amount of charging required, with tolls assessed based on the power transferred and corresponding price per unit. This innovative approach not only simplifies the charging process but also provides a new way to manage and generate revenue from electrified road infrastructure.

7. References

1. Mahesh, A., Chokkalingam, B., & Mihet-Popa, L. (2021). Inductive wireless power transfer charging for electric vehicles–a review. IEEE Access, 9, 137667-137713.

2. Mohamed, N., Aymen, F., Alqarni, M., Turky, R. A., Alamri, B., Ali, Z. M., & Aleem, S. H. A. (2022). A new wireless charging system for electric vehicles using two receiver coils. Ain Shams Engineering Journal, 13(2), 101569.

3. Mou, X., Gladwin, D. T., Zhao, R., & Sun, H. (2019). Survey on magnetic resonant coupling wireless power transfer technology for electric vehicle charging. IET Power Electronics, 12(12), 3005-3020.

4. Rim, C. T. (2018). Wireless Charging of Electric Vehicles. In Power Electronics Handbook (pp. 1113-1137). Butterworth-Heinemann.

5. Hata, K., Imura, T., & Hori, Y. (2016, March). Dynamic wireless power transfer system for electric vehicles to simplify ground facilities-power control and efficiency maximization on the secondary side. In 2016 IEEE applied power electronics conference and exposition (APEC) (pp. 1731-1736). IEEE.

6. Zimmer, S., Lucas, P., Helwig, M., Winkler, A., & Modler, N. (2020). Systematic engineering of functionally integrated wireless power transfer systems for electric vehicles. Procedia Manufacturing, 52, 241-249.

7. Boys, J. T., & Covic, G. A. (2012). IPT fact sheet series: no. 1–basic concepts. Jul18, 2013-Inductive Power Transfer systems (IPT) Fact Sheet: No. 1-Basic Concepts.

8. Onar, O. C., Campbell, S. L., Seiber, L. E., White, C. P., & Chinthavali, M. (2016, June). A high-power wireless charging system development and integration for a Toyota RAV4 electric vehicle. In 2016 IEEE Transportation Electrification Conference and Expo (ITEC) (pp. 1-8). IEEE.

9. Diep, N. T., Nguyen, K. T., & Tran, T. M. (2020). Wireless power transfer system design for electric vehicle dynamic charging application. International Journal of Power Electronics and Drive Systems, 11(3), 1468.

10. Galigekere, V. P., Pries, J., Onar, O. C., Su, G. J., Anwar, S., Wiles, R., ... & Wilkins, J. (2018, September). Design and implementation of an optimized 100 kW stationary wireless charging system for EV battery recharging. In 2018 IEEE Energy Conversion Congress and Exposition