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Transfer distance optimization with high frequency transformer based on CMR-WPT

PradumanAmroliya[1], Dr. Santosh Kumar Sharma[2]

[1]Student (Power System),[2]Assistant Professor, Department of Electrical Engineering,
Rajasthan Technical University, Kota, Rajasthan, India
praduman.am800@gmail.com, sksharma@rtu.ac.in

ABSTRACT

For decades, distance has been the most important aspect in the WPT method. It's difficult to maintain steady output power & efficiency over a long distance. Both inductive or microwave plus coupling types are typically regarded key characteristics in a regularly used system. In a broad sense, capacitive coupling, magnetic resonance coupling, microwave radiation, but also inductive coupling are the four types of coupling. At MIT, this coupled magnetic resonances wireless power transfer (CMR-WPT) system was developed, with features such as a long transmission distance, increased power transfer efficiency (PTE), and reduced directivity requirements. As a result, WPT is now available in a variety of industries, including portable components, medical implant devices, and electric vehicles (EVs). Furthermore, the quality factor allows for increased coupling efficiency over higher frequencies and voltages. It has been proved throughout the years that obtaining a wide range of terms and conditions leads to optimizing the wireless power transfer system. On the main side, the suggested control approaches are applied to maximize the resistance control for negative compensation in this article. Furthermore, the control strategy over inverter, which is built upon that saturation mechanism, necessitates the monitoring of voltage inside the transmitter and reception coils. The high-frequency transformer, on the other hand, fulfilled the specified distance at Megahertz by stepping up the regulated voltage and frequency using coil parameters. With the assistance of optimization in coil settings, this suggested work approaches a novel high energy efficiency experiment and control upon coupled magnetic resonance across a large range of load power with such a transformer that can increase the voltage at a quite high value and have the wide range. In a WPT system, this simple way can obtain optimal distance. The simulation was tested with the MATLAB-2019b environment.

Keywords* –*CMR-WPT, high frequency transformer, mutual inductance coil parameters, power transfer distance, primary-side control, Transformer, design and optimization

I. INTRODUCTION

Wireless power transfer system contains coupling-independent with the stable output based on Parity-time (PT) symmetry. The coupled magnetic resonances achieve a wide range of distance and power efficiency by the influences of coil parameters [1]-[2]. As a result the power regulation focus on the operating frequency to control the switched phase in implantable biomedical devices, energy model proposed for household appliance, portable wireless charging platforms [3]-[5]. Whereas the double-sided coil controls integrate the LCC, LCL, CCL types of compensation topologies. Specifically, this work can touch the aspects like improvement in EMI performance and design a foreign object detection [6]. The proposed technologies for load identification have series-series compensation to realize that secondary-side current/voltage [7]. Wireless power transfer (WPT) system maintains a power output throughout the soft switching controls and power factor correction [8]. While the optimization techniques are important to analyze its transfer characteristics to control power from voltage tuning and frequency tuning [9]. In actual WPT via Resonant magnetic coupling attracts the research to analyze by changing load resistance for small mutual inductance. The variation in ratios of power and other components analyze the result by the optimal load resistance value [10]. Besides, the emerging output power and system frequency follow the impedance to match the changes in coupling factor and mutual impedance under different distance or misalignment conditions [11]. The Qi wireless power standard makes it possible to use in widely aligned coupling at proximity between transmitters and receivers based standards [12]. To make a WPT system adaptive coil tuning is also necessary to focus on the single-coil, parallel coil, or intermediate operations in a controlled manner [13]. Whereas for widening the range with the control of quality factor to transmit and receive coils. The Reconfigurable resonant coil system proposes techniques such that frequency tracking and varying coupling which increased the transfer efficiency above 100% from its past results [14]. For better performance of the WPT system, the coil loop also has to adjust the configuration through a multi-loop to determine the measured values [15]. Coil designs are the most influencing factor to obtain desired wireless output and it can obtain through coil radius, coil impedance, area, volume, etc [16]. From prospective of the distance through genetic algorithms manage complexity however thepower transfer efficiency (PTE) maintains the preferable result in order to Automatic Impedance Matching and Back Propagation (BP) neural networks [17]. The sequence of charging to electric vehicles (EVs) for the constant voltage (CV) and constant current (CC) topologies have also designated to by soft-switching devices and the zero phase angle (ZPA) can be achieved in both the topologies [18]. An intermediate resonator proposed resonators accessary the optimal configuration.The evolution to command through relay by intermediating the WPT systemintermediate resonator deploys from the receiver side and the intermediate resonator also proposed three coils magnetically coupled resonant WPT system for stability with deliberate adjustments in the position of the coil. It converge the norms of axial, lateral, and angular misalignments [19]-[20]. If the use through base of previous researches the Tesla's resonators in domino forms waved with simple techniques of power flow control [21]. The WPT system's quality factor always needs important focus for high efficiency as well as proportionate identical magnetic field distribution and it can be maintained as asymmetric coil structures which reveals variation in efficiency and degree of freedom [22]. The strong focus is Megahertz frequency with the optimal distance to optimize the Q-factor and efficiency for a better-fabricated system [23]. After all, that high frequency demands strong transformers to endure the output voltage and output power.

II. SYSTEM STRUCTURE AND THEORETICAL ANALYSIS

Wireless power transfer systems elaborate the magnetic coupling laws to enhance the power to consume. In this paper, the system structure is shown in figure 1. which describes that the property to get the wide range at Megahertz frequency through the primary side control technique, high-frequency transformer, and coil optimization. In this proposed work it acquires the suitable output power and efficiency at a long distance.

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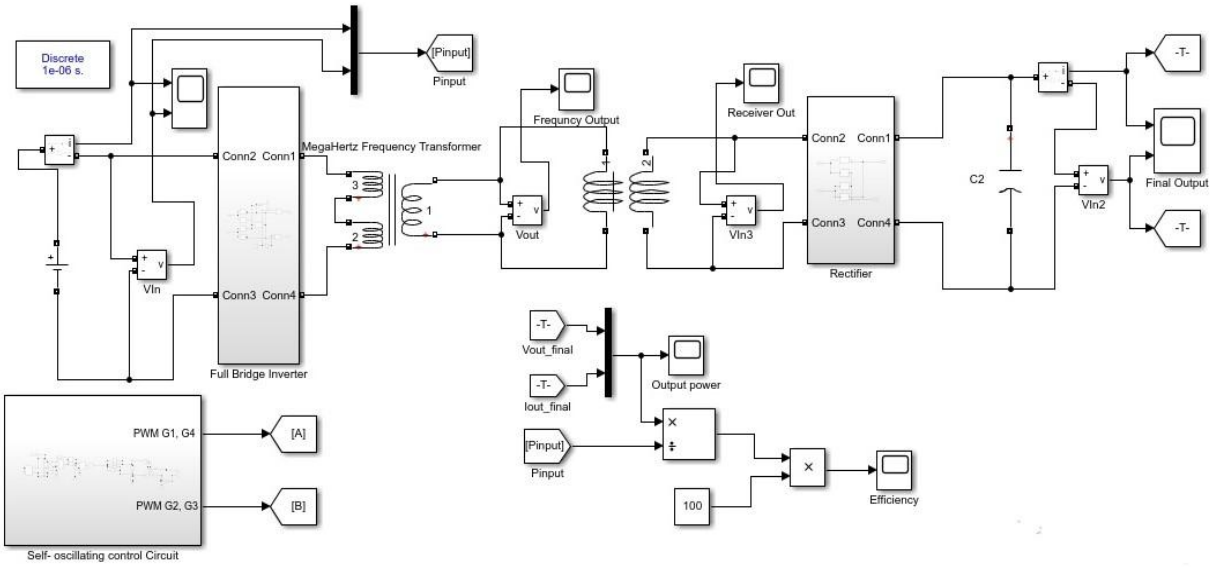

Fig.1 System Structure in the form of MATLAB Simulink model with the proposed connections in WPT

A. PRIMARY SIDE INVERTER AND SECONDARY SIDE RECTIFIER MODEL

At the primary side of the coil, the work proposed the DC-AC inverter with the control triggering mechanism to retaliate against negative resistance control. The front-end DC-to-AC converter, which is voltage source type (VSI) and this is used as recommendable to utilize high voltage. This inverter obtained the DC input to the high voltage AC output with the proposed primary side controllers [1]. On the secondary side, the full-bridge rectifier is connected with the capacitive output filter. After the result is obtained at the secondary side of the coil, the AC input to the rectifier is converted into the DC for the use of many applications. This paper proposed the purpose of both primary and secondary side converters with suitable results to gain the distance between transmission and receiver coil at a high resonant frequency.

B. TRANSFORMER

To obtain the frequency at high voltage to maintain the distance between transmitter and receiver coil.There are numerous benefits of the higher frequency operations. Secondly, use of less copper is preferable due to smaller size of transformer, and by reduction of losses and assisting to make the more efficient transformer.Also, typically ferrite is the core since decades, applications of the transformer having a broad variety of geometries are accessible and it may be tailor-made. Whether the form factor in specific form or an additional shielding is required, ferrite core have the good chances of existing meeting with the requirements. From numerous equations the demonstrated equation below allowed transformers to narrow the size, harnessing a smaller A_e(cross section of core) under higher frequencies for whichever given number of turns.In practice, design engineers need toscale this equation so that on the increment of frequency a smaller origin and turns are necessary required to actuate at the aspired flux density.

$$N = V \, x10^8/(4.44)(F)(B)(A_e)$$

Where N = Primary turns

V = Input voltage

F = Frequency in Hz

B = Flux density in Gauss

A_e = Core cross sectional area(cm^2).

C. COIL DESIGN AND OPTIMIZATION

In this paper, the proposed coil and circuit model is used in a wide range. Coil design is also important to generate resonant magnetic coupling between Tx and Rx coil by the retaliation of the mutual inductance. The requirement for efficiency and long transfer distance to the Coil configuration method with the quality factor obtain forward and realized.As long as the coil parameters like coil radius, the number of turns, and pitch are theeasiest to coordinate and extremely intuitive, but unsystematic research is related to the optimization.

III. SIMULATION RESULTS

WPT through the coupled magnetic resonances an experimental platform was simulated based on system structure. In figure 1, the proposed system structure is measured through MATLAB-2019b to get the optimized power. The coils parameters of the coil are based on the maximizing transfer distance [2]. Now, the full-bridge inverter simulates at the frequency with primary side control to handle the negative resistance control and generate high voltage value to forward the results to the transformer. The output result from the full-bridge inverter proposed in figure 2.

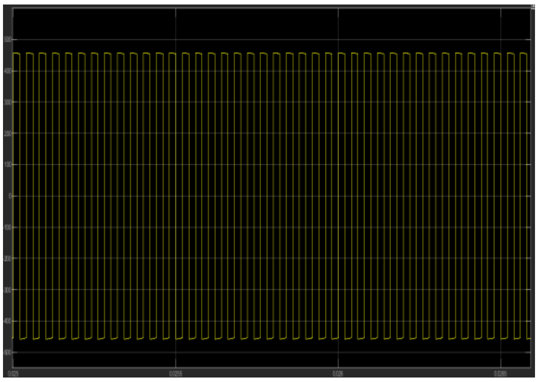

Fig. 2 Output results from the proposed Full bridge Inverter

While the primary side control technique is proposed based on [1] to enhance the triggering from $PWM_{1,4}$and $PWM_{2,3}$ to the MOSFET which gives the output with control operations. In the primary-side controller, the converted voltage signal by a current transformer through output current and voltage of the VSI. The proposed result of the controller is enlisted in figure 3 and figure 4.

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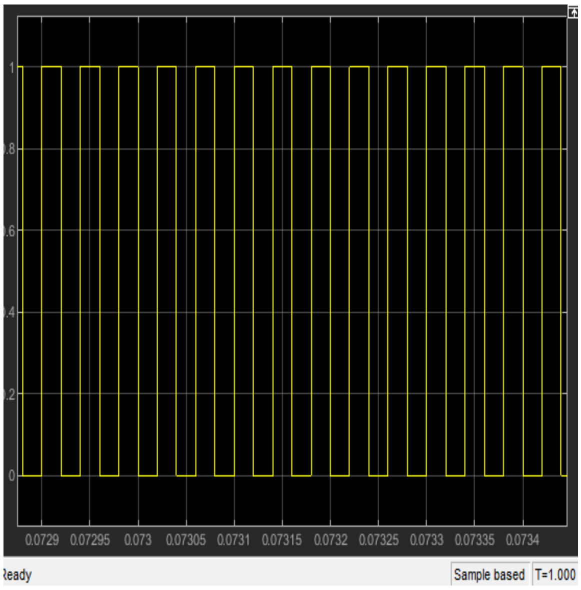

Fig. 3 Triggering through $PWM_{1,4}$

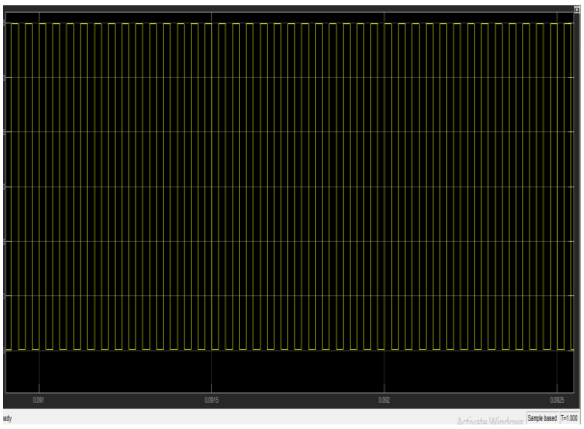

Fig.4 Triggering through $PWM_{2,3}$

To get the result from the high-frequency transformer it generated the waveform with high voltage to forward through the transmitter coil. The paper also proposed, selection of appropriate core certainly needed the calculation of primary side turns based on the flux density selected to prevail with estimation of the secondary turns numbers, and that ratio of primary side to secondary side voltage is represented.The switching conditions to the high voltage enabled through step up transformer.The dependency of High Voltage, High-Frequency Transformers on consumptions ranging from power supplies to laser apparatusand particle accelerators**.**The characteristics of HF transformer suitable for a variety of power electronics applications such as EV, charging points, and renewable energy systems.The introduced high frequency is generated with the results in figure 5.

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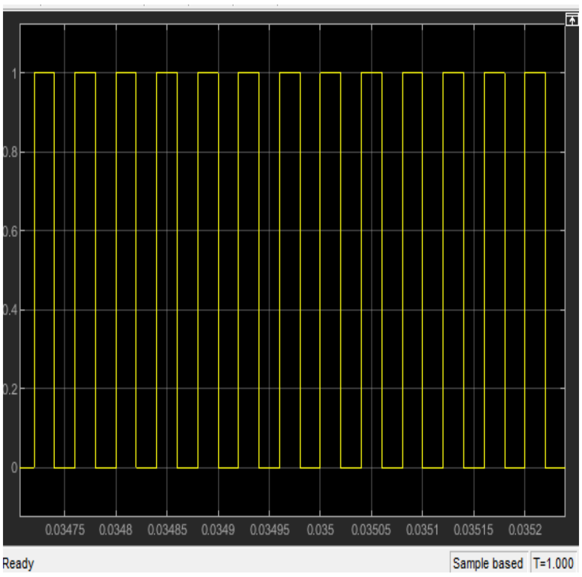

Fig.5 Output waveform High frequency Transformer

Whereas, the transmitter and receiver coil result is important to get the desired distance by focusing on the mutual impedance and self impedancewith the high frequency. By means of the plane spiral coil atshifting the inner diameters,Tx and Rx coils, one can discipline the strengths of coil radius on the effective transfer distance and PTE [2]. The simulated outcomes of coil parameters are figured in figure 6.

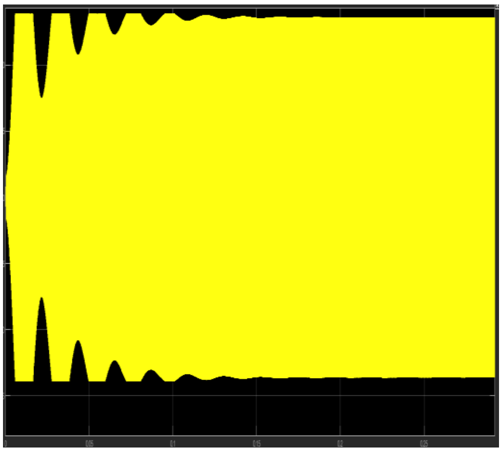

Fig.6 Receiver output waveform of the proposed coil

Wireless power transfer system always contained the variable output with the different stages to gain the wide range in coil, stable output power, and efficiency. The quality factor of the wireless system is always the issue with the efficiency so thefucntions with this paper regulated the efficiency to gain the better quality factor by maintaining high frequency. These proposed results of the final output of the series-series compensation system structure are suitable to show the saturation of the power, efficiency, and the quality factor and the terms which enhance the long transfer distance in figure 7.

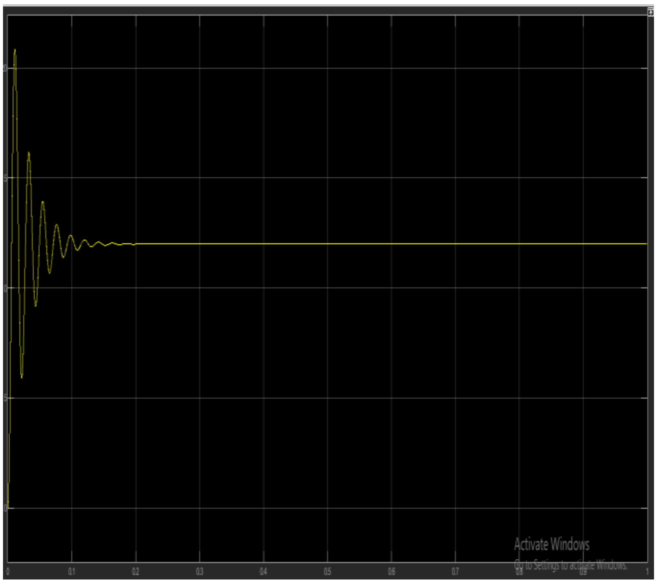

Fig. 7 Final output of the proposed system structure

IV. CONCLUSION

The effective long transfer distance by the coil optimization infest the output power and efficiency with. To condescend the theoretical analysis and feasibility of optimal formation modes, a proposed use of transformer with high frequency had been enquired. The CMR-WPT system with efficient coil design that is suitable for the applications with primary-side control of full bridge inverter was investigated. Fundamental to the theoretical analysis, the parametric optimization of the coil turns and phase-shifted angles to achieve ZVS for the driver inverter and stable output power characteristics were carried out. The consistency of the variation of system input power and load power is analyzed and verified. The parameter identification method can find the maximum power transfer point when the receiver stops at an arbitrary position, according to the way of solving equations. MATLAB is used to derive the required source voltage and the corresponding power transfer efficiency for different voltage and distance d, specific results are displayed.

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