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Optimizing Wireless Power Systems: Comparative Analysis of Electronic Converters and Techniques

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Abstract

The objective of this research is to enhance the technology of wireless power transfer (WPT) by augmenting its efficiency and transmission range between the sending and receiving coils. This study will investigate the use of sophisticated power-electronic converters to convert direct current to alternating current with the greatest possible power transfer. Three different classes of inverters-class-E, class-D, and H-bridge-were examined in order to create a comparison between them using the same system parameters. Following the formulation of the suggested system, a Matlab simulation has been run for distances that vary for three different variables. Based on the results of this simulation, the class-E inverter is found to have the best efficiency and power transfer of any of the suggested systems.

Introduction

Wireless power transfer (WPT) facilitates a convenient and more secure method of providing power, which offers commendable efficiency and reliability. The emergence of various significant obstacles has been observed as a result of the implementation of cable charging mechanisms in electric automobiles, including the potential hazards associated with worn cables that may pose a risk of electric shock. Despite the undeniable advantages that wireless power transfer brings to the table in terms of simplicity and flexibility for charging electric vehicles, it is crucial to recognize the substantial reduction in power and efficacy that could arise due to diverse factors including the notable separation between the sender and receiver, alignment concerns, and potential alterations in the transmission distance based on the specific circumstances of the original system design, the utilization of wireless power presents the opportunity for connector-free devices, thereby enhancing both the size and reliability.

Methodology

The proposed system is shown in fig(1)

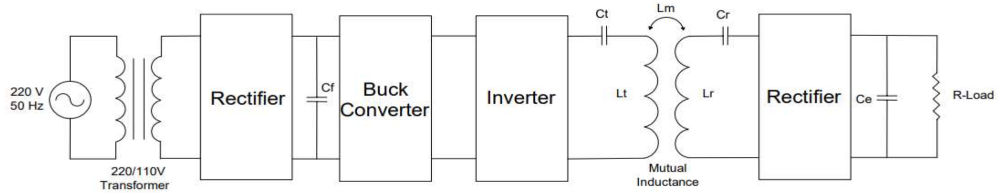

Figure 1. Typical block diagram of proposed ICWPT system.

Fig(2) illustrated the equivalent circuit of WPT.

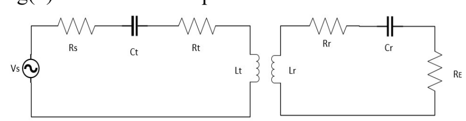

Figure 2. Equivalent ideal circuit of ICWPT system.

Among the coil structures widely employed in electric vehicle (EV) applications, the circular spiral configuration is particularly favored due to its favorable power transmission performance and ability to tolerate misalignment.

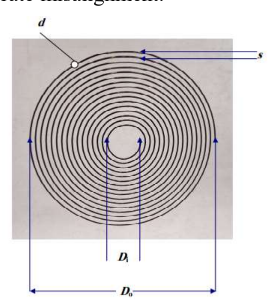

Figure 3. Real printed wireless coil by CNC machine.

1. *Class-E Inverter Design*

Designing the inverter parameters shown in(Figure 4) for 25Ω resistive load.

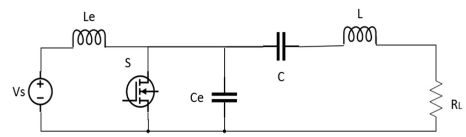

Figure 4. Circuit topology of class-E inverter.

2. *Class-D Inverter Design*

The configuration of an enhanced Class D ZVS invertir demonstrated in (Figure 5).

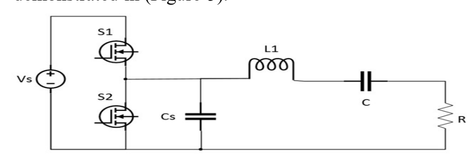

Figure 5. Circuit diagram of class-D ZVS inverter.

3. *H-Bridge Inverter Design*

In a full bridge inverter configuration four power switches (typically MOSFETs or IGBTs) are arranged in a bridge configuration.

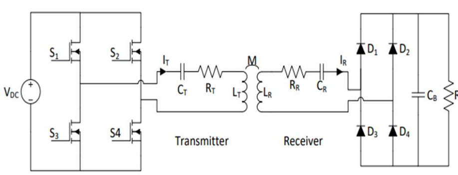

Figure 6. ICWPTS with H-bridge inverter.

Results

Table 1.- simulation results and calculated efficiency for WPT system with class-E inverter.

d(cm)	K	Pin (W)	Pout (W)	Calculated equivalent circuit η (%)	Simulated system η (%)
10	0.498	109.7	102.8	96.7	93.7
13	0.353	112.2	102.8	93.4	91.68
16	0.25	121.5	102.7	88.1	84.54

Table 2.- simulation results and calculated efficiency for WPT system with class-D inverter.

d(cm)	K	Pin (W)	Pout (W)	Calculated equivalent circuit η (%)	Simulated η (%)
10	0.498	110	102.8	96.7	92.63
13	0.3536	118.8	102.7	93.4	86.43
16	0.25	134.1	102.3	88.1	76.28

Table 3. - simulation results and calculated efficiency for WPT system with H-bridge inverter.

d(cm)	K	Pin (W)	Pout (W)	Calculated equivalent circuit η (%)	Simulated η (%)
10	0.498	111.1	102.6	96.7	92.37
13	0.3536	118.7	102.3	93.4	86.21
16	0.25	134.7	102.6	88.1	76.18

Conclusion

For a separation of 10 centimeters, the overall effectiveness of the wireless power transfer (WPT) system reached 93.7% when employing a class-E inverter. Conversely, when utilizing a class-D inverter, the efficiency dropped to 92.63%, while with an H-bridge inverter, it decreased even further to 92.37%. Based on the results it can be concluded that the system equipped with the class-E inverter exhibited the highest efficiency and the most power transferred compared to the other two inverters. This finding holds true for all three cases, where the parameters of the system were kept constant.