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Reduction of Lower Harmonics and Improve the Efficiency of a Wireless Charging System by using Quasi-z-source Converter

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Abstract

Objective: In this paper we presented the concept of power transfer without using any type of conductor or wire i.e. Wireless Power Transmission (WPT) for charging a battery or other devices like cell phones and tablets. **Methods/Statistical analysis:** The WPT has been avoided because, it provides less efficiency. But in this paper quazi z-source converter has been used, so that we can improve the efficiency and reduce the harmonics which are caused by using wireless charging system. **Findings:** By using MATLAB software, the wireless charging system has been designed and tested. The results obtained by using the proposed method have an increase in efficiency when compared to the conventional method. **Improvements:** By using the proposed method, there is also an increase in its input factor and achieves superior performance.

Keywords: Inductive Power Transmission, Quasi-z-source Converter, Wireless Charging System

1. Introduction

Now-a-days transmitting power wirelessly used in various applications from few mille watts to several kilowatts of output power. Presently the WPT systems are used in electronic devices and cell phones, tablets. But less attention has been paid to the optimization of wireless charging system from input to dc source to charging battery. But todays only the commercial components will be used but no one applied to advanced optimization methods. Consumers are avoiding WPT system due to some de merits. They are lower efficiency and less air gap and higher charging times. In order to overcome the above problem various methods have been suggested by different authors in the different articles. Coming to conventional method the author suggested some techniques regarding to wireless power.so conventional method assuming that the system parameter are fully stable and load impedance considered only resistive so that here considered only resistive part of the system and applied techniques for improve efficiency on primary of the wireless charging system. So that reactive part of the system not taken in to considiration.so here total amount of power can be transferred by adjusting load impedance to match the complex conjugate of impedance source it is an advanced optimized technology for a total wireless charging system including the rectifier operation and DC to DC converter, charging battery here. the system totally operated at non resonant and basically Qi standard here. The proposed method will synchronous rectification approach the present technology is to control and adjust the resistive and reactive part and also reduce lower harmonic currents and ripples in sine wave improve the efficiency obtained by adding quasi z source converter to conventional method. The conventional WPT system in its first harmonic approximation is shown in Figure 1.

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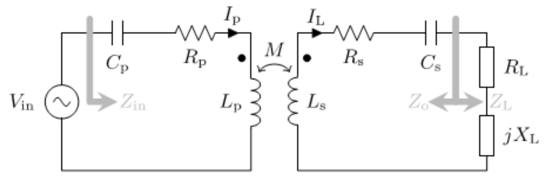

Figure 1. Equivalent circuit model of a series-series tuned WPT system based on the first harmonic approximation.

2. Conventional Method

In conventional method of synchronous rectification, the concept of controlled equivalent load impedance has optimized the efficiency, increased the power capability and controls the switches of full bridge rectifier, so that they can be operated according to zero input current of the rectifier. So in order to increase the efficiency and performance of a wireless charging transmission system by applied a phase-shift between the primary and secondary side of system voltages. But coming to the present system does not allowed the separate control of the resistive and reactive part.so in order to control the resistive and reactive part of the system at a time the proposed concept is made. In order to define the phase-shift ϕ between in IL and VL i.e. input current and voltage of the first harmonic.so here derived an expression for the equivalent load impedance of the active rectifier[1,2].

$$\mathbf{Z}_L(\varphi, \mathbf{V}_r) = \mathbf{R_L} + j\mathbf{X_L} = \frac{\mathbf{V}_L^{(1)}}{\mathbf{I}_L^{(1)}} = \frac{4}{\pi}\frac{\mathbf{V_r}}{\mathbf{I}_L^{(1)}}\mathbf{e}^{-\mathbf{j}\varphi} = \frac{4}{\pi}\frac{\mathbf{V_r}}{\left(\mathbf{I}_L^{(1)}\right)(\cos(\varphi) - j\sin(\varphi))}$$

In the above equation V_L represents the first harmonic voltage and IL represents the first harmonic current. So analyzing[3] the above equation we can observe the variation and change of impedance of the resistance and reactive part of the system. By the observation here is concluded that only one thing the parameters only control the active part of the system not the reactive part. It can possible by another parameter V_R i.e. rectified voltage. So there are two possibilities are there for to control rectified voltage. One is that to control alternator current and another one is that duty cycle D of active rectifier. The above two parameters can be adjusted by voltage regulator at system output. The fallowing schematic diagram represents phase shift concept of dc – dc converter by adjusting duty cycle D rectified voltage V_R of an active rectifier.

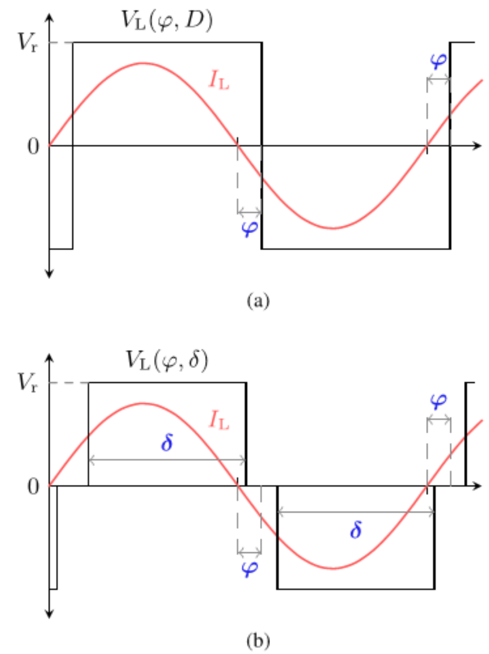

Figure 2. Schematic illustration of the key waveforms of the proposed method. (a) Voltage VL and current IL at the input of the rectifier utilizing the duty cycle D of the dc–dc converter to control the amplitude of the rectified voltage Vr (b) Voltage VL and current IL at the input of the rectifier using the duty cycle δ of the active rectifier to adjust the rectified voltage Vr.

So here the conclusion is that the equivalent resistance R_L can be obtained by after adjusting and correction by the duty cycle D with respect to rectified voltage V_L. The below expression explains the component of load voltage VL with respect to control the duty cycle D.

$$\mathbf{V}_L^{(1)}(\varphi, D) = \frac{4}{\pi}\mathbf{V_r}\mathbf{e}^{-\mathbf{j}\varphi} = \frac{4}{\pi}\frac{\mathbf{V}_L}{D}e^{-j\varphi}$$

where $0 \le D \le 1$ and $0 \le \delta \le \pi$.

3. Proposed Concept

In the conventional method the amplitude, phase shift controlled by duty cycle of dc-dc converter. The proposed concept is that ac to ac power conversion with dc link is also called quasi-z-source converter. This traditional z source ac/ac converter maintaining the single phase and also having the some additional features as that they are continuous current mode operation and the distortion currents of lower harmonics very low and operated at higher efficiency, the proposed converter such have good advantages so that in proposed method the quasi- z-source converter has been added to conventional circuit at the secondary side of inductive transformer before receiver. Initially some of authors has been proposed z-source ac/ac converters[5,6], but due to some drawbacks in previous method so here as proposed quasi z source inverter[7,8] and applied to dc/ac voltage fed inverters. For dc/ac power conversion, the quasi z source inverter compared to the traditional z source inverters, this converter has more features like lower dc voltage on capacitor as well as continuous input current so when the quasi z source applied to dc/dc converters, a family of quasi z source dc/dc converters is proposed in [8] with minimum number of switches and passive devices. The proposed quasi z source converters some more advantage to remaining proposed converters. The proposed quasi z source converter is shown in Figure 3.

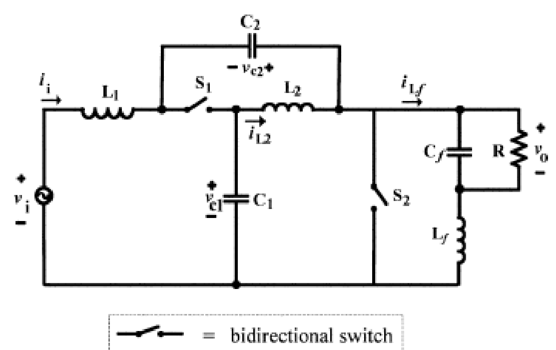

Figure 3. Proposed quasi z source ac/ac converter.

There are many other controllers which are used to reduce the harmonics[9–13]. The traditional z source ac/ac converter proposed to dc link because for larger range of output voltage with minimum no of switches and lower harmonic current, input and output voltages is sharing same ground. So the proposed circuit dc voltage is fed to a quasi z source converter, which consists of two inductors L_1 and L_2, two capacitors C_1 and C_2, two bilateral switches S_1 and S_2 which is implemented by the connections of two diodes', two IGBT's in anti-parallel. Here PWM scheme is proposed where D is an equivalent duty ratio. The parameters taken here are

L_1=L_2=1MH

C_1=C_2=6.8µF

Cf=10µF

Frequency=20 kHz

Input voltage = output dc voltage of conventional circuit

4. MATLAB Circuits and Simulation Results

The MATLAB circuit for conventional wireless charging system is shown in Figure 4.

The simulation results of output currents by using conventional method are shown in Figure 5.

The MATLAB circuit for proposed wireless charging system is shown in Figure 6.

The simulation results of output currents obtained by using the proposed method is shown in Figure 7.

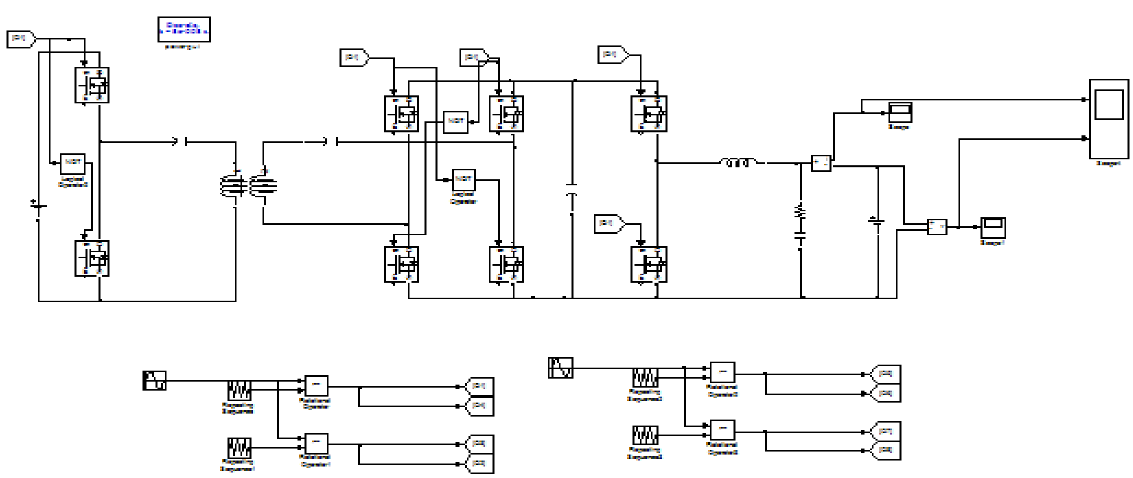

Figure 4. MATLAB circuit for conventional wireless charging system.

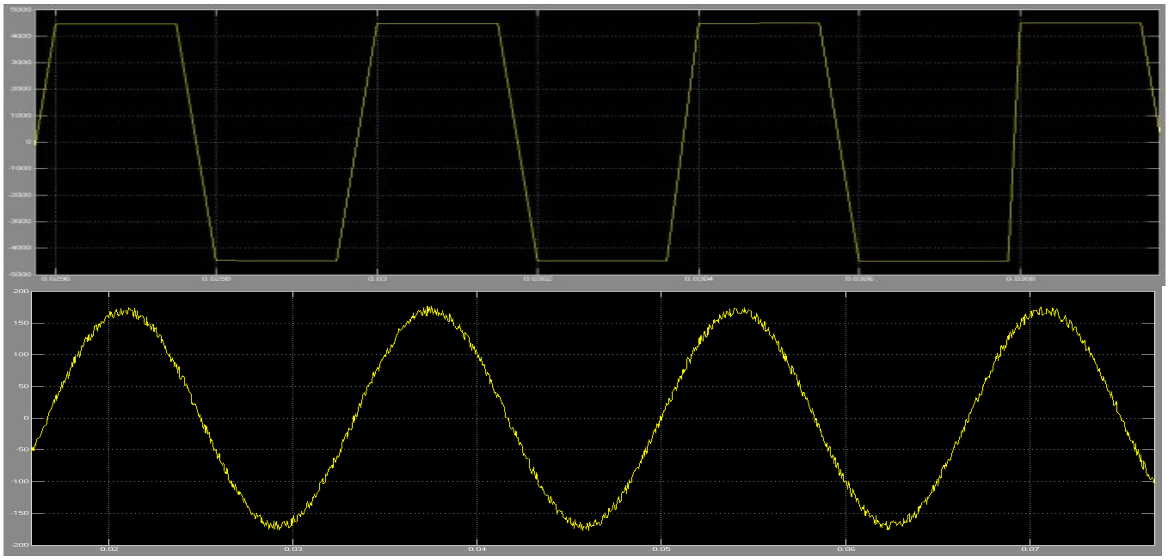

Figure 5. Simulation results of output currents by using conventional method.

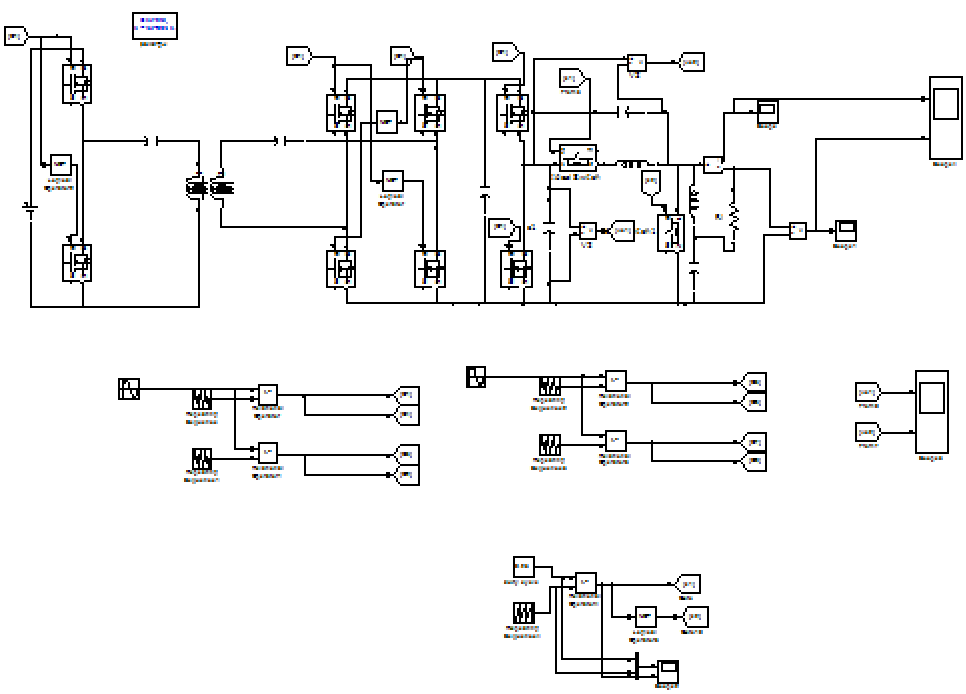

Figure 6. MATLAB circuit for proposed wireless charging system.

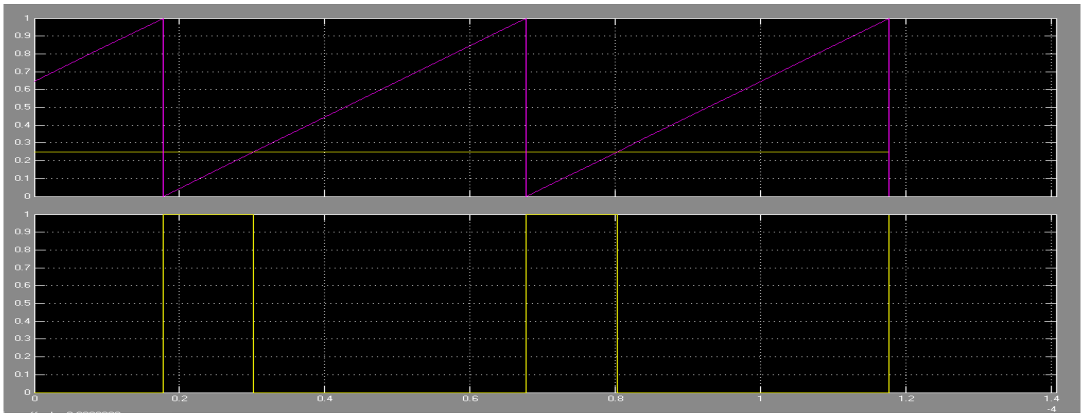

Figure 7. Simulation results of output currents obtained by using the proposed method.

5. Conclusion

The wireless power charging system was successfully designed and tested using MATLAB. From the obtained results we conclude that when compared to conventional method the proposed method efficiency has been increased up to 10%, i.e. by using the previous method we got 66% efficiency, whereas by using the proposed method the efficiency has been 76.12%. Similarly there is also an increase in its operating continuous current mode, input factor.

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