

Implementation of Full Bridge AC-DC Series Parallel Resonant Converter

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Abstract

High-frequency operation and inherent soft switching techniques are implemented in Resonant converters. Low power loss in the switches, smaller size, reduced EMI are the some of the advantages of Resonant converters. One of the such resonant AC-DC converters is a Series-Parallel Resonant Converter (SPRC) also called an LCC converter. The LCC-Series Parallel Resonant Converter takes on the desirable characteristics of the pure series and the pure parallel converter. Full bridge converters are well suitable for medium and high power applications. In the present work Series Parallel Resonant Converter are designed and the simulation results are presented. Hardware is developed and the results are also presented. This converter is suitable for low voltage DC applications such as space technology, CPU Chips, Car radio, mobile phones, etc.

Key Words : LCC High frequency Converter; ZVS bi-directional converter; AC-DC Converter;

1 INTRODUCTION

High frequency dual-bridge isolated DC/DC AC/DC converters are used in renewable energy system due to small size and high-power density. For medium and high power applications full bridge converters are well suitable. Many research on AC-to-DC converters with power factor correction and low Total Harmonic Distortion (THD) are considered for the demand of Industrial applications. For the reduction of switching loss and EMI interference resonant converters have been used with high switching frequency.

The switching losses in the power switches like the rectifier diodes, which are greatly reduced so that the operation at high frequency is possible with increased efficiency and reliability (Marian K. Kazimierczuk and Manikantan K. Jutty, 1995) (1). The Switching loss and voltage stress are reduced by using Zero Voltage Switching (ZVS) boost converter with Continuous Conduction Mode (CCM) (2).

The switching losses are reduced in resonant DC-DC converter. Bi-Directional Series Parallel Resonant Converter for Power Factor Correction discussed (3) Increase of switching frequency up to 100 KHz and reduction of EMI interference resonant converters have to be applied (4). Resonant converters topology has been used for telecommunications and aerospace applications and it has been recently proposed for electric vehicles (Ricardo Barrero, 2010) (5).

HFAC power distribution systems have been widely investigated and used for applications such as personal computers, space stations, aerospace and telecommunications (Zhongming Ye, 2010) (6)

In this present work AC to DC full bridge series parallel resonant converter are designed and the circuit is implemented.

2 SERIES PARALLEL INVERTER

A Series parallel resonant Full bridge inverter is shown in Fig 1. The circuit consists of full bridge MOSFET inverter with resonant inductor L_r , capacitor C_s and C_r . The resonant capacitor C_s is in series with resonant inductor L_r and the load, C_r is in parallel with the load and they form a Series Parallel LC circuit. From this configuration, the resonant tank and the load circuit act as a voltage divider. By changing the frequency of the input voltage,

the impedance of the tank will change. This impedance will drive the input voltage with the load. The resonant frequency f_r of the LCC resonant converter is given by,

$$f_r = \frac{1}{2\pi\sqrt{L_r(C_s+C_p)}}$$

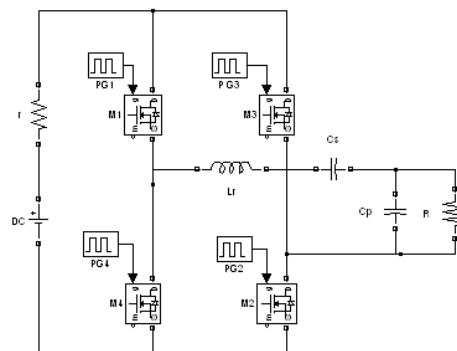


Figure 1: Basic series parallel full bridge inverter

3 CIRCUIT DESCRIPTION FOR SERIES PARALLEL RESONANT CONVERTER

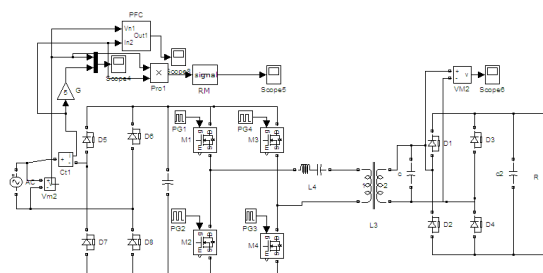


Figure 2: Simulation circuit for series parallel resonant converter

Fig.2 shows the full bridge series parallel resonant converter. The circuit consists of a AC input source, full bridge uncontrolled rectifier, filter circuit, full bridge MOSFET inverter having a HF resonant circuit. A HF transformer provides voltage transformation and isolation between the source and the load. A load is connected to the high frequency link circuit with secondary full bridge rectifier and smoothing filter circuits.

The input AC source is rectified by full bridge diode rectifier. The DC voltage is filtered by using capacitor. The DC voltage is inverted by high frequency MOSFET full bridge inverter. Pulse generators are connected to the gate of the MOSFETs. When M1 M4 conducts, M2 M3 should be in off state and vice versa, to avoid short circuit.

Output of the inverter is connected to primary of the transformer through resonant inductor L_r and capacitor C_s in series. The secondary of the transformer is then connected to MOSFET full bridge rectifier. The resonant capacitor C_p is connected in parallel with secondary instead of primary. The LC tank circuit is called as Resonant Circuit.

The resonant link circuit is driven with either square waves of voltage or current in the inverter. The voltage or current in the resonant components becomes minimum at the resonant frequency and by altering the frequency around the resonant point, the voltage on the resonant components can be adjusted to any desired value. By rectifying the voltage across the secondary of the transformer, a DC voltage is obtained which is filtered to achieve smooth DC.

4 SIMULATION RESULTS

The simulation of full bridge series resonant converter is done using Matlab and results are presented here for the switching frequency of 50 KHz.

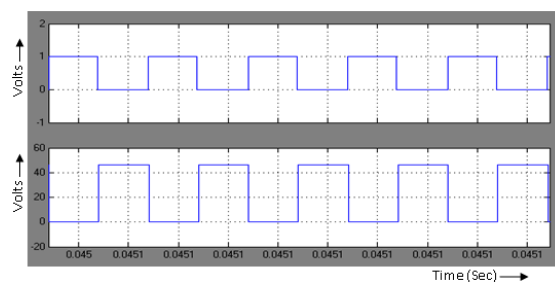


Figure 3: Gate pulse and Drain source voltage for MOSFETs M_1 & M_4

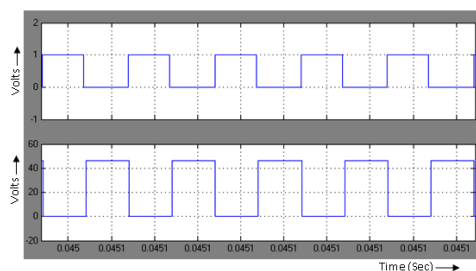


Figure 4: Gate pulse and Drain source voltage for MOSFETs M_2 & M_3

Fig.3 shows the gate pulse and Drain source voltage waveforms for MOSFETs M_1 and M_4 . Fig.4 shows the gate pulse and Drain source voltage waveforms for MOSFETs M_2 and M_3 . From the waveform it is clear that when the pulse to the MOSFET is high, the output is low. (ie) the switch is in conduction state. When the device conducts the voltage across the device is very less.

The output of series resonant inverter, primary side voltage and current waveforms are shown in Fig 5. Secondary side voltage and

current waveforms are shown in Fig.6. The sinusoidal current waveforms are obtained at the output of LC circuit. The LLC resonant inverter reduces harmonics of the transformer.

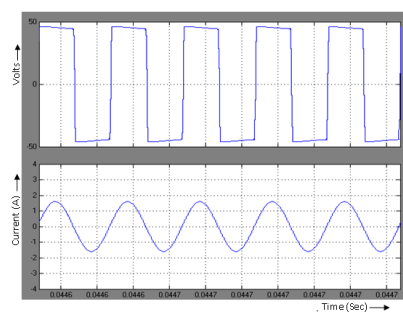


Figure 5: Primary voltage & Current

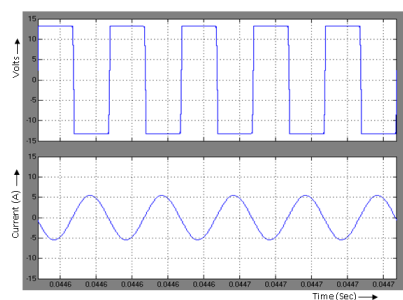


Figure 6: Secondary voltage & Current

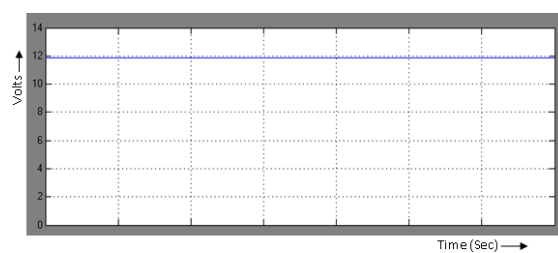


Figure 7: Output voltage

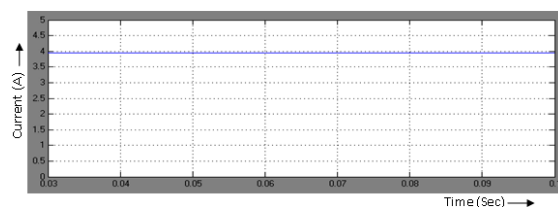


Figure 8: Output current

DC output voltage and current waveforms are shown in Fig.7 and Fig.8 respectively. DC output voltage across the load is found to be 12V. The performance measures are Settling time t_s : 0.57 sec, Delay time t_d : 0.025 sec, Rise time t_r : 0.054 sec and Peak time t_p : 0.18 sec respectively. It has been observed that, constant output voltage and current waveforms are obtained for the series parallel resonant converter.

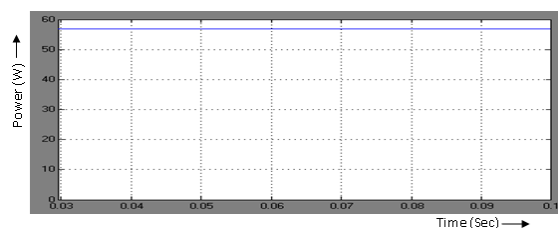


Figure 9: Input power

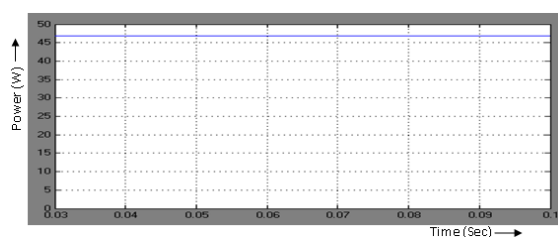


Figure 10: Output power

Input power and output power waveforms are shown in Fig. 9 and 10. Based on this power the efficiency of the converter has

calculated for various values of input voltage and the values are given in Table 1.

Table 1: Simulated results for series parallel resonant converter

Input Voltage (V)	Output Voltage (V)	Input Power (W)	Output Power (W)	Efficiency (%)
40	9	39	30	76.92
44	11	47	38	80.85
48	12	57	47	82.456
52	13	67	57	85.07

From the Table I it is found that, the efficiency of the converter is linear in behavior with the input voltage.

5 HARDWARE IMPLEMENTATION OF THE EXPERIMENTAL RESULTS

The Hardware is implemented and it is tested using microcontroller and the experimental results are presented. The top view of the hardware is shown in Fig.11. AC input voltage waveform is shown in Fig. 12. Its value is 48V, 50 Hz. Driving pulse to the MOSFETs for MOSFET M1 and M2 are shown in Fig.13. The amplitude is 10V and the switching frequency as 50KHz.

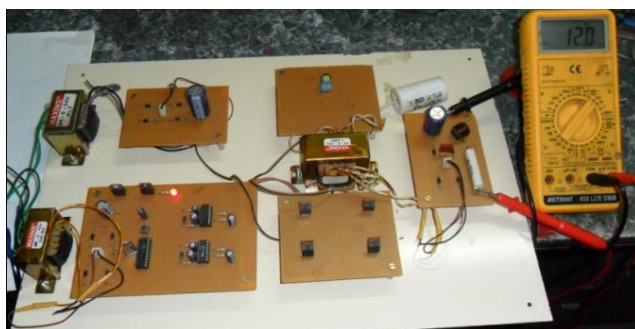


Figure 11: Top view of the hardware

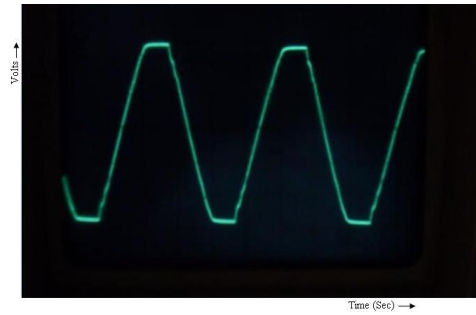
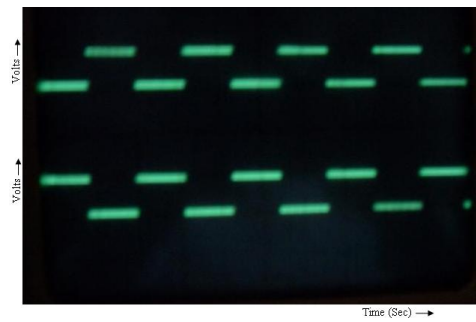
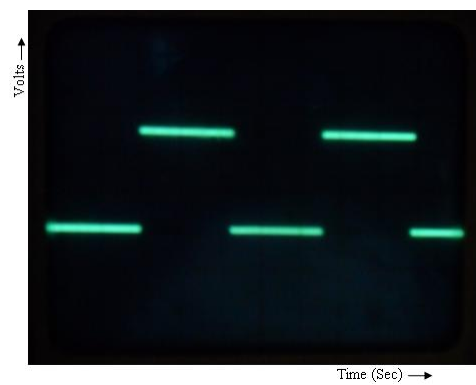


Figure 12: AC input voltage

Figure 13: Driving pulse for MOSFET M_1 and M_2 Figure 14: Input and Output voltage for MOSFET $M1_1$

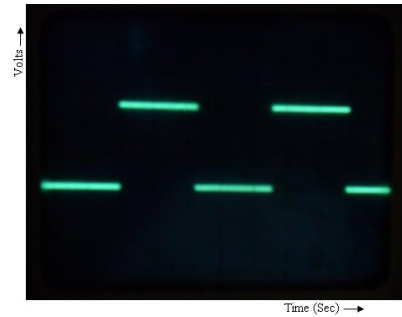


Figure 15: Transformer primary side AC voltage



Figure 16: Transformer secondary side AC voltage

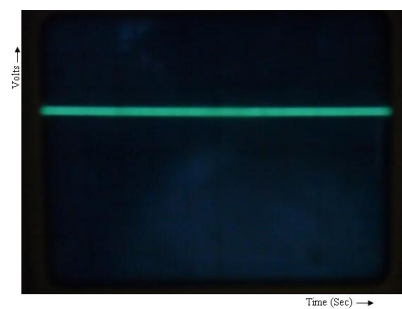


Figure 17: DC output voltage

The Driving pulse for MOSFET M_1 and voltage across M_1 are shown in Fig.14. High frequency AC output of the inverter primary and secondary side voltages are shown in Fig 15 and 16 respectively.

Its values are 24V and 12V respectively. DC output voltage is shown in Fig.17. Its value is 12V.

6 CONCLUSION

Series Parallel resonant converter circuit is modeled and simulated using Matlab simulink. The results are presented. The results shows that the output voltage wave form is smooth without ripple. The efficiency of the converter are also calculated for the different values of input voltage. It is found that the output voltage and efficiency are liner in behavior with the input voltage variation. Hardware is developed using microcontroller. The results presented. It is observed that the hardware results are very close with the simulated results.

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