Series Parallel Resonant Converter for Low Power Applications

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ABSTRACT *Resonant converters are very attractive in practice because they have high efficiency, small size, light weight, fast dynamic response, low component stresses and low noise. One of the relatively new resonant DC-DC converters is a Series-Parallel Resonant Converter (SPRC) also called an LCC converter. The use of soft-switching techniques, alleviates switching loss problems and allows a significant increase in the converter switching frequency. The trend in power converters is towards increasing power densities. In order to achieve this goal, it is necessary to reduce power losses, overall system size and weight by increasing the switching frequency. In the present work Series Parallel Resonant Converter are designed and the simulation results are presented for low power applications.*

Introduction

Resonant converters eliminate most of the switching losses encountered in Pulse Width Modulation converters. The active device is switched with either Zero Current Switching or Zero Voltage Switching at its terminals. When current through the switch is made zero, it is turned on /off, it is known as zero current switching and when voltage across the switch is made zero, it is turned on / off, it is known as zero voltage switching.

High frequency operation is necessary to reduce the size of reactive components which in turn reduce the size of power supplies. Further, for MOSFET-based converters, ZVS is required for efficient operation to reduce or eliminate heat sink requirements. Resonant converters have been well documented to meet both of these requirements [1]. Buck converter operated in discontinuous conduction mode and at constant frequency providing an input power factor high enough to satisfy the present standard requirements [2].

In the design of the pulse-width-modulated DC-DC converters, a high power packing density and a high power conversion efficiency are extremely desirable. In order to obtain a high power packing density, engineers prefer increasing the switching frequency to minimise the size of the magnetic components in the converter. However, significant switching loss can occur due to high voltage and high current overlaps during the switching period. The advantage of high switching frequency can easily be cancelled out by the low conversion efficiency[3].

The switching losses in the power switches the rectifier diodes are greatly reduced so that the operation at high frequencies is possible with increased efficiency and reliability [4]. (Marian K. Kazimierczuk and Manikantan K. Jutty, 1995). Low-voltage MOSFETs have low on-resistances, resulting in low conduction losses and yielding high efficiency [5]. (Marian K. Kazi Mierczuk, 1993).

In MOSFETs, because of high drain–source capacitance, ZVS is more effective than ZCS. On the other hand, in IGBTs, because of the tail-current characteristic at turnoff, ZCS is more effective than ZVS. To apply IGBTs for ZVS cases, an additional lossless turn-off snubber should be added in parallel with IGBTs [6]. Three-Phase (LC)(L)-Type Series-Resonant Converter With Capacitive Output Filter was explained in [7].

It is possible to retain the advantages of SRC and PRC, while eliminating / minimizing their disadvantages. This is achieved by the addition of third resonant element that modifies in-put output characteristics substantially resulting in load independent operation. In this present work series parallel resonant converter is modeled and the performance for the same are presented for low power applications.

CIRCUIT DESCRIPTION

Fig.1 shows the simulation circuit for full bridge series parallel resonant converter. The circuit consists of a AC input source, full bridge diode rectifier, filter circuit, full bridge MOSFET inverter having a high frequency (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 MOSFET. When $M_1 M_2$ conducts, $M_3 M_4$ 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.
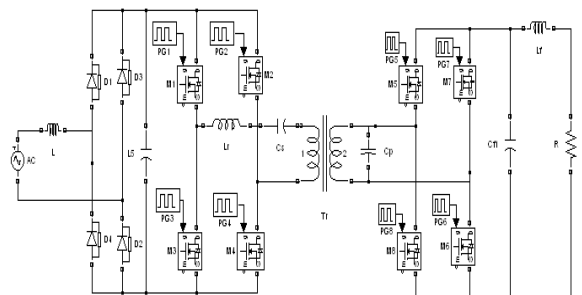

Fig.1 Simulation circuit for series parallel resonant converter

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. Scopes are connected to display the input current and voltage, gate pulses, output voltage, current, etc.

SIMULATION RESULTS

The simulation of full bridge series resonant converter is done using the blocks of simulink and the results are presented here. Fig.2 shows the gate pulse and drain source voltage waveforms for MOSFETs M_1 and M_4 From the waveform it is clear that the pulse to the MOSFETs are high, the output is low and vice versa. i.e. the MOSFET is conduction during the pulse given to the gate circuit. When the device conducts it act as a switch and the voltage across them is zero.
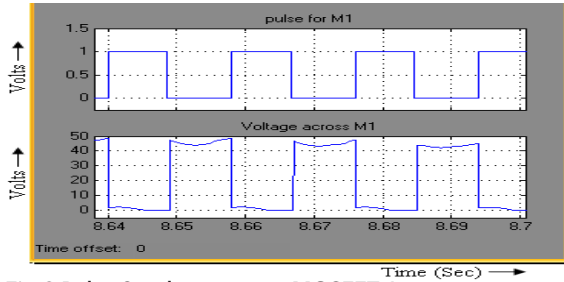

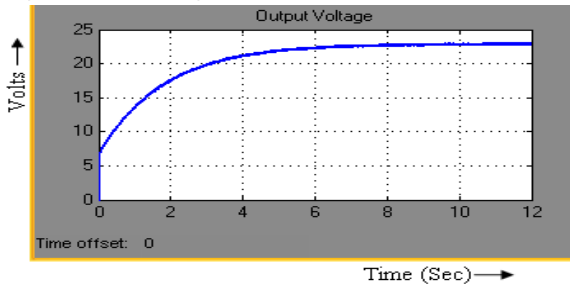Fig.2 Pulse & voltage across MOSFET 1
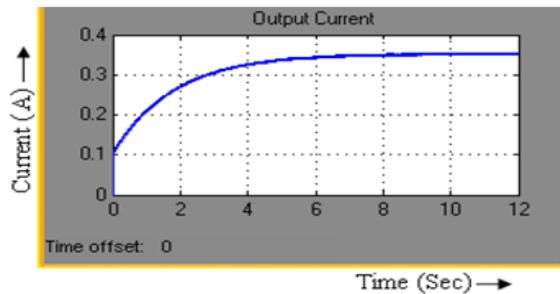

Fig..3 Output voltage

Fig..4 Output current

DC output voltage waveform is shown in Fig.3. The DC output voltage across the load is found to be 24V. Fig.4 shows output current. Output power waveform is shown in Fig.6. From the results it has been clear that, the constant steady state voltage is obtained. Ripple less output voltage and current waveforms are obtained for the series parallel resonant converter.
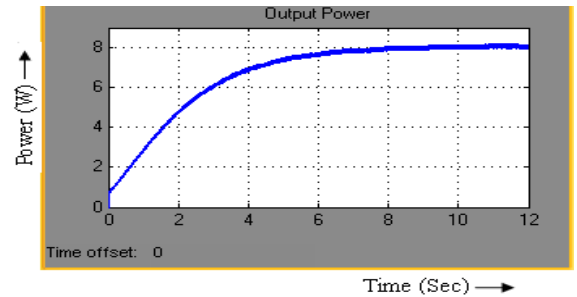

Fig..5 Output Power

CONCLUSION

Full bridge Series parallel resonant converter circuit is modeled and simulated using the blocks of imulink and the results are presented. The converter is designed for 24 V DC output voltage. The results shows that the output voltage wave form is smooth without ripple content. 24 V DC supply is widely used in the applications such as, battery chargers, PMBL DC motors, etc. Converter is designed to operated with high frequency, the switching losses are reduced. There by reducing the switching loss and voltage stress on the switch, the efficiency is improved. The series parallel converter has advantages like high power density, reduced EMI, reduced switching losses and stresses. This converter is suitable for low voltage low power DC applications.

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