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DESIGN OPTIMIZATION OF RESONANT DC-DC CONVERTERS

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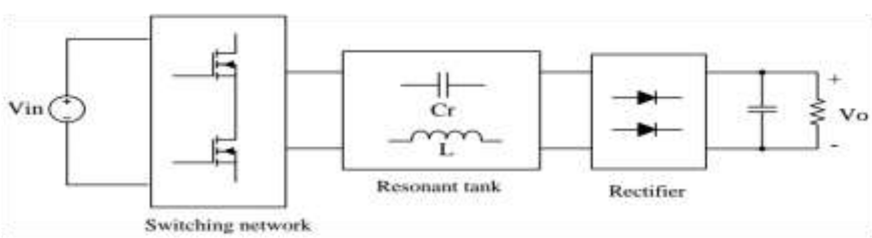
ABSTRACT
Resonant DC/DC converters are the class of converters, which have L-C resonant tank serving as a major part of the power conversion process. The fundamental concept of the resonant converter is that the circulating energy in an L-C resonant circuit is manageable by changing the operating frequency, and therefore the converter can condition the input power to the desired output voltage. The development in power conversion technology is steady demand for high power efficiency and high power density. A high efficiency is achieved by using series resonant converter (SRC) topology. It may operate in either continuous or discontinuous conduction modes. After exploring the advantages of using a resonant converter, the series resonant converter is implemented. Increasing the frequency is desirable for power converters operation. However, the switching losses will increase by increasing the frequency of operation. Hence, the efficiency of the system reduces drastically. In order to reduce switching losses and increasing high frequency operation, a series resonant converter has been developed. The resonant tank of SRC consists of a resonant capacitor and a resonant inductor connected in series. The output load resistance is in series with the resonant tank and the impedance of the resonant tank is a function of the switching frequency, and hence the voltage across the output impedance can be modulated by the switching frequency.

KEYWORDS: Resonant DC/DC converters, ZVS condition, and switching frequency.

INTRODUCTION
Resonant DC/DC converters are the class of converters, which have L-C resonant tank serving as a major part of the power conversion process. The fundamental concept of the resonant converter is that the circulating energy in an L-C resonant circuit is manageable by changing the operating frequency, and therefore the converter can condition the input power to the desired output voltage [1]. A resonant converter consists of a switch network, a resonant tank and a rectifier as seen in Fig.1. The switch network could be a full-bridge configuration is used to generate a square voltage excitation to the next resonant tank part. The resonant tank is used to circulate and deliver the energy, which usually exhibits sinusoidal current and voltage waveform during some subintervals of a switching cycle. The rectifier and the output low-pass filter will convert the AC to DC [1]. Moreover, low-pass filter eliminates the entire ripple passing through the load.

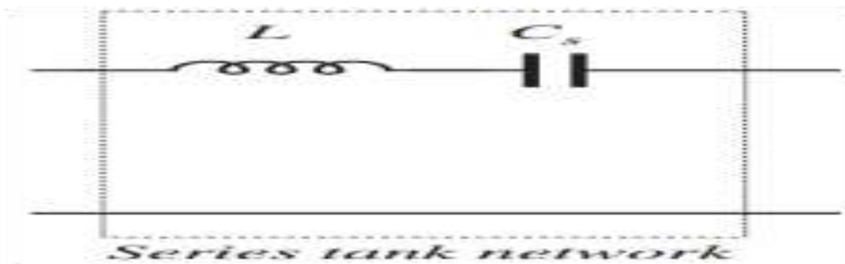


General scheme of a DC-DC resonant converter

TYPE OF RESONANT CONVERTER

Series of Resonant Converter

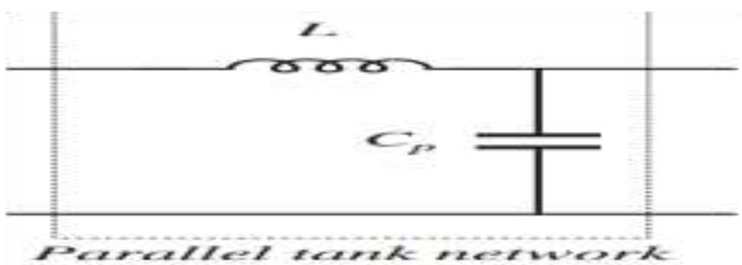
In the series resonant converter circuit is illustrated in Fig.2, the resonant tank is formed by a resonant inductor (Lr) and resonant capacitor (Cr) and they constitute a series resonant tank. Moreover, the resonant tank is also connected in series with the load, and it works as a voltage divider. The impedance of the resonant tank is a function of the switching frequency [2]. Therefore, the voltage across the output impedance can be modulated by the switching frequency. Since the impedance of series resonant tank will be lower at this frequency, the maximum gain is obtained at a resonant frequency. Series resonant converter is appropriate for full-bridge high power applications because of series resonant capacitors on the primary side act as a DC blocking capacitor. High load efficiency is preserved because of the current in the power devices decrease as the load decreases [3].



Series resonant converter

Parallel of Resonant Converter

The parallel resonant converter (PRC) topology as it can be seen in Fig.3 has two resonant components the capacitor is in parallel with the output rectifier. In fact, the parallel resonant converter more suitable for the applications, which have a narrow input voltage range and a relatively constant load to maintain the working point near the maximum design power [4]. The parallel resonant converter is appropriate for low-output-voltage and high-output current applications. The resonant inductor is limited the current and making the PRC desirable for applications with high short-circuit requirements.



Parallel resonant converter

Soft switching in resonant converters

Soft switching can alleviate some of the mechanisms of switching loss and reduce the generation of EMI. Two kinds of soft switching are switched on or off at the zero crossing of their voltage or current waveforms:

Zero-current switching: Zero current switching eliminates the switching loss caused by IGBT current tailing and by stray inductances. It can also be used to regulate SCR’s.

Zero-voltage switching: transistor turn-on transition occurs at zero voltage. Also, the diodes may work with zero-voltage switching. Zero-voltage switching completely removes the switching loss induced by diode stored charge and device output capacitances.

ADVANTAGES OF USING RESONANT CONVERTER

The major advantage of the resonant converter is their ability to achieve zero voltage switching (ZVS) or zero current switching (ZCS). In addition, there are an extensive variety of the L-C resonant tank topologies [1]. The most common two are the parallel resonant converter (PRC) and the series resonant converter (SRC) [5].

CONCLUSIONS

Resonant converters have a lot of advantages such as reduction in cost, size, and weight of the power supply. In addition, fast transient response, and it also reduces Electro-Magnetic Interference (EMI).

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