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High Efficient Loaded Resonant Converter With Feedback for DC– DC Energy Conversion

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Abstract:- Energy shortages and increasing oil prices have created the demand for high energy conversion efficiency and performance. This paper presents a high efficient loaded resonant converter with feedback for dc-dc energy conversion applications. This paper deeply analyses the converter configuration and MATLAB simulation results and compare with conventional converter topologies. The proposed converter consists of a half-bridge Inductor Capacitor Inductor resonant inverter and a load which is connected across the bridge rectifier. The output stage is filtered by a loss pass filter which is minimize the loading effect and ensure that the voltage across it is almost constant. The soft switching concepts used in this converter helps to reduce the switching losses ,EMI and increase reliability and makes the circuit simple by reducing the size and weight of components.. MATLAB software is used to simulate the model. The feedback circuit provides accurate output with an energy conversion efficiency reaches up to 85.8% and all the test results demonstrate a satisfactory performance.

Keywords: - Loaded resonant converter, Zero voltage switching (ZVS), Pulse width modulation (PWM).

I. INTRODUCTION

The dc- dc converters are extensively adopted in commercial, industrial and residential equipments. These converters are used to convert dc voltage into a different level, often provides a regulated output. Switching power converters are extensively used in power electronics application [1]. The simplest way to control power semiconductor switches is pulse width modulation (PWM), in which the current or voltage across the switch is interrupted by means of switch action. As a result the switching stress, losses and EMI are increased. Modern dc-dc converters demand small in size, light weight and high energy conversion efficiency. Although using a high switching frequency in power converter yields these results the EMI and switching losses increases with increasing frequency. Soft switching concepts like zero voltage switching (ZVS) and zero current switching (ZCS) are introduced to eliminate these losses and the converter using these topologies are known as soft switching converters. Soft switching dc- dc converter consists of a resonant dc-ac inverter and a rectifier in which inverter convert dc voltage into a less harmonic sinusoidal voltage. To do so a switch network is needed which typically produce a square wave voltage and is applied to a resonant tank tuned to the fundamental component of the square wave [2]. Among the many advantages that parallel loaded resonant converter has over series and series-parallel resonant converter include inherently short circuit protection, control of output voltage at no load by operating at a frequency above resonance and reduction of conduction loss and ripple voltage[3].. But the large filter inductor at the output side of the bridge rectifier in a parallel loaded resonant converter might add significant weight, volume and cost. Based on parallel loaded resonant converter here proposes a loaded resonant converter with feedback to improve the performance and energy conversion efficiency.

II. PROPOSED CIRCUIT CONFIGURATION AND OPERATION

The diagram of loaded resonant converter is shown in the figure. The resonant dc-dc converter is able to provide dc power to a load by rectifying and filtering the ac output of a resonant inverter. The two capacitors (c1 and c2) on the input side are large enough to split the voltage of the input dc source. The elements L_{r1}, L_{r2} and C_r form the resonant tank. Resonant inductor current i_{lr2} is rectified to obtain the dc bus voltage. the dc bus voltage can be varied and closely regulated by controlling the switching frequency. A pair of MOSFET (m_1 and m_2) is used as the power switching device in which operating at a 50% duty ratio over a switching period T .The switches are driven by non overlapping rectangular trigger signals v_{g1} and $v_{g2.}$ The load resistance is connected across a bridge rectifier via a low pass filter c_o.The voltage across the bridge rectifier is $+V_0$ when the current through the inductor l_{r2} is positive and $–V_0$ when current through l_{r2} is negative.

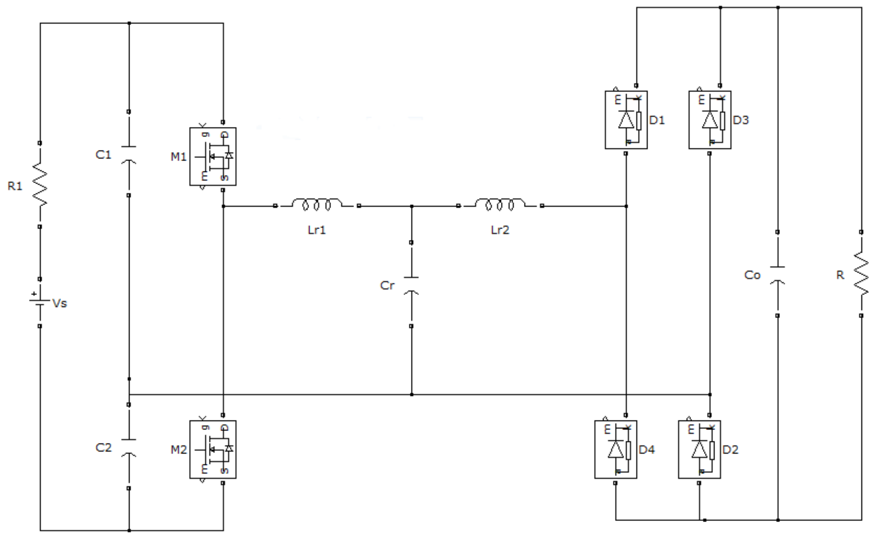


Fig.1: loaded resonant converter

The above given figure shows the circuit implementation of typical loaded resonant converter used in the application of dc- dc energy conversion. the capacitors split the input dc voltage and the period switching of MOSFET M1 and M2 at 50% duty ratio over a switching period T enable us to represent the effect of switches by an equivalent square wave voltage source with an amplitude equals to $\pm V_s/2$. Since the rectified output voltage also depends on the sign of inductor current i_{lr2} ,we have to represent the simplified equivalent circuit of the loaded resonant converter shown in fig. **2**.

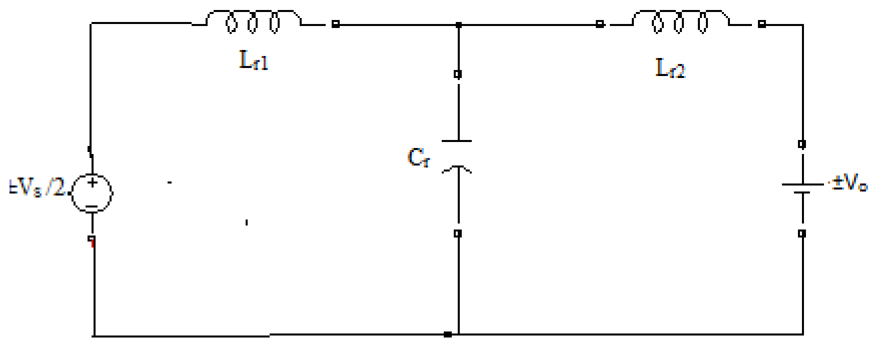


Fig.2: equivalent circuit of loaded resonant converter

When the inductor current i_{lr2} is positive, the power is supplied to the load through diodes D1 and D2 and when the inductor current i_{lr2} is negative the power is supplied to the load through diodes D3 and D4.Assume that the switching currents are ideal and stray capacitance are negligible, the operation of the proposed converter has four modes of operation.

The four modes of operation of the resonant converter is described below:

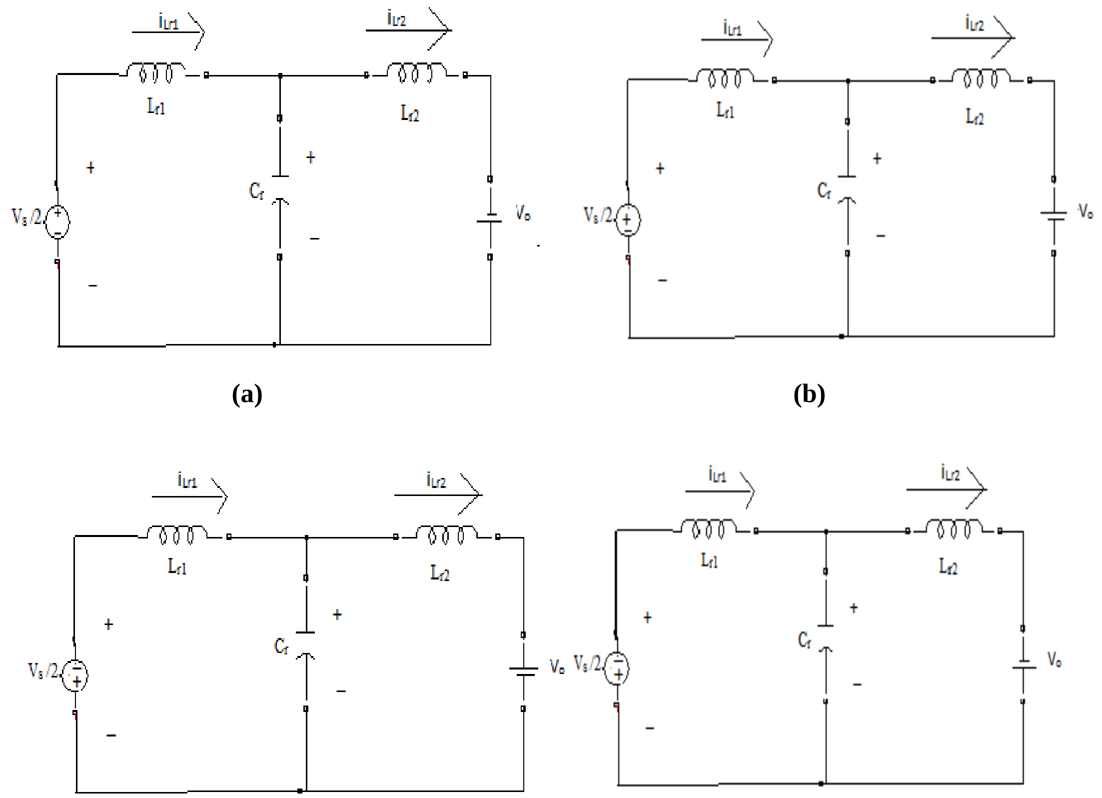
Mode 1;-fig.3(a) shows the equivalent circuit during mode 1. Here M1 is turned on but resonant tank current i_{lr1} is negative at that instant it flows through the diode D1.When i_{lr1} inverses and cross zero point the current naturally commutates from diode D1 to M1.so the power switch is turned on naturally at zero voltage and zero current.

Mode 2:- fig.3(b) shows the equivalent circuit during mode 2. Mode 2 starts when M1 conducts and i_{lr1} becomes positive. When i_{lr1} reaches maximum S1 is forced to turn off and forcing the positive current to flow through the diode D2.

Mode 3:- fig.3(c) shows the equivalent circuit during mode 3. Here the inductor current i_{lr1} decreses through diode D2 and a trigger signal V_{g2} excites the switch M2.When i_{lr1} inverses its direction M2 turns on and conducts.

Mode 4:- fig.3(d) shows the equivalent circuit during mode 4. Here switch M2 conducts and a negative i_{lr1} flows through the circuit and the cycle repeats.

Thus switches M1 and M2 are turned on naturally at zero voltage and zero current there by switching stress and losses are reduced. Advantage of soft switching technology is that it reduce losses thereby increasing efficiency, it also helps to achieve high performance in terms of wide control of band width, high power density, and low THD which are the problems faced in a high switching frequency circuits.



(a) **(b)**

(c) **(d)**

Fig. 3 (a) mode 1operation. (b).mode 2 operation. (c).mode 3 operation. (4).mode 4 operation

III. CLOSED LOOP CONFIGURATION

In order to increase the performance of the system closed path is provided. PI controller is used for controller purpose. The figure 3 shows the closed loop configuration of inverter using PI controller, with K_p=0.5 and K_i=99. Pulse is created with the help of relational operator. Direct output of relational operator is given to M1 and inverted pulse is given to M2.

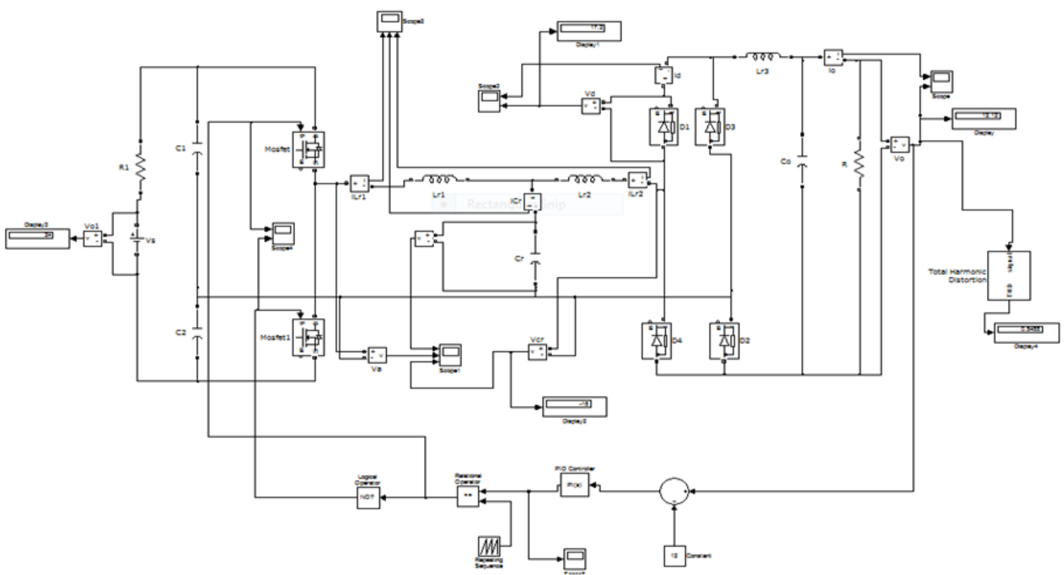
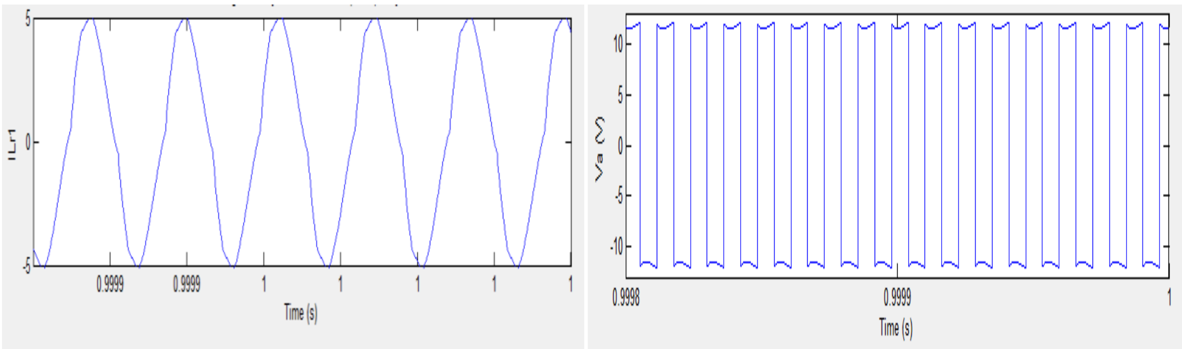


Fig.4: SIMULINK model of closed loop loaded resonant converter

IV. SIMULATION RESULTS

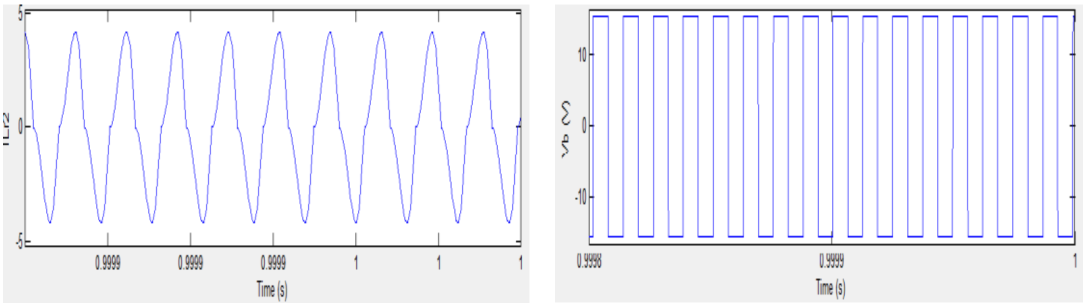
For simulation of the proposed hybrid converter Parameters of the different circuit components are taken as: resonant inductor:- L_{r1}=8μh, L_{r2}=3.5μh. Resonant capacitor C_r =0.5μf, input voltage V_s=12V, filter capacitor C_o=100 μf, output resistor R=6Ω,Switching frequency= 80khz, Resonant frequency is taken as 81khz.



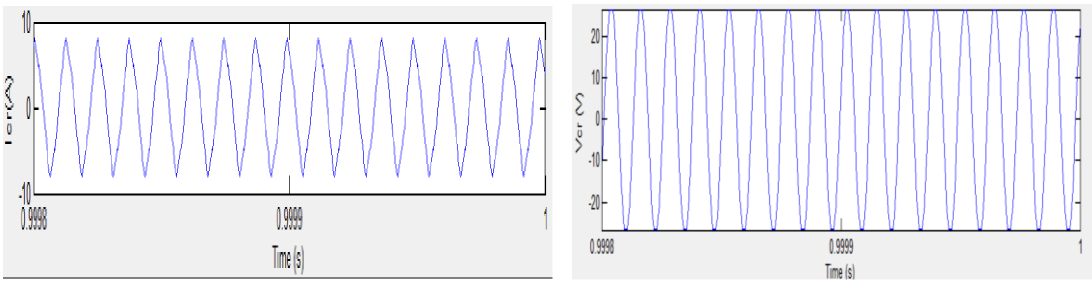
(a) (b)

Fig 5: (a) Input current of resonant tank (b) Input voltage of resonant tank

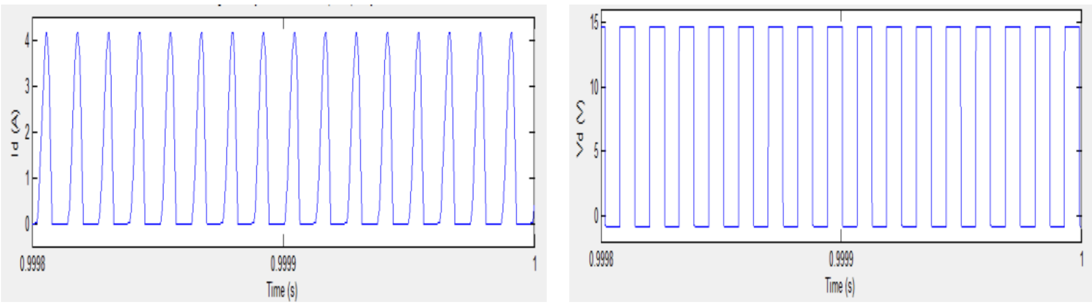
The simulation of the proposed loaded resonant converter is done with the help of MATLB SIMULINK. Fig 5(a) shows Input current and voltage of resonant tank. fig.6 (a) shows output current and voltage waveforms of resonant tank and fig 6(b) shows resonant capacitor current and voltage waveforms. In fig.6 (c) Diode current and voltage waveforms are shown. The load current and voltage waveforms are shown in fig.6 (d). From the simulated waveforms we can infer that the energy conversion efficiency is improved and the soft switching scheme adopted in the converter reduces the switching losses and performance of the converter is improved.



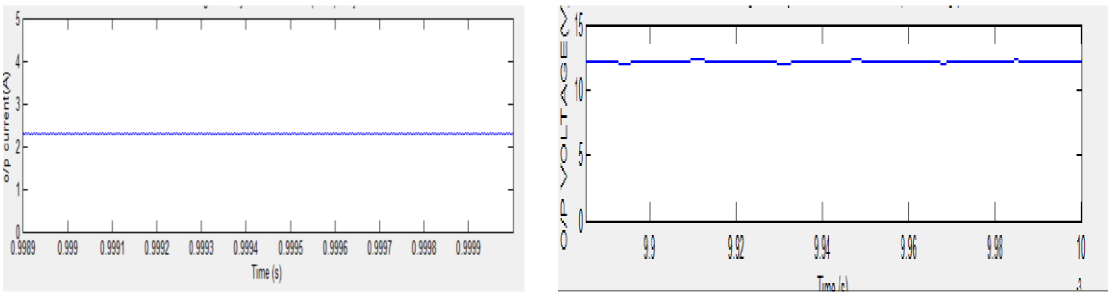
(a)



(b)



(c)



(d)

Fig.6 (a) Output current and voltage of resonant tank (b) Resonant capacitor current and voltage (c) Diode current and voltage (d) Output current and voltage.

V. CONCLUSION

This paper proposes a loaded resonant converter topology used to convert dc voltage into a different level or to provide a regulated output with high energy conversion efficiency and improved performance. .Modelling of loaded resonant converter with feedback is done and simulated the proposed system and different waveforms are obtained. The proposed system has the following advantages, simplicity of circuit configuration, low switching losses, high flexibility and easy realization of control scheme. The proposed converter has an accurate output with an energy conversion efficiency reaches up to 85.8% and the results demonstrates a satisfactory performance at lower cost and with fewer circuit components.

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