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Implementation Of Soft-Switching Boost Converter With A Resonant Circuit

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ABSTRACT: In this paper a soft-switching boost converter with auxiliary resonant circuit is implemented in mat lab. The conventional boost converter generates high switching losses during turn ON and OFF, and this causes a reduction in the whole system's efficiency. The implemented boost converter utilizes a soft switching method using an auxiliary circuit with a resonant inductor and capacitor, auxiliary switch, and diodes. Therefore, the system efficiency is improved.

Keywords: Auxiliary resonant circuit, boost converter, soft-switching boost converter, zero-current switching (ZCS), zero-voltage switching (ZVS), power factor correction.

1 INTRODUCTION

Conventional boost converter provides high power density and fast transient response at higher switching frequency but at this frequency the switching losses and electromagnetic interference are increased. But the converters become smaller and lighter at this high frequency. In order to overcome switching losses many converters are designed with resonant circuit which use resonance to reduce switching losses [1]–[7].However the auxiliary circuit for resonant increases the complexity of circuit and the circuit cost. For some resonant converter the main switch performs the soft switching but the auxiliary switch performs the hard switching which reduces the circuit efficiency [2]. In this paper an auxiliary resonant circuit is used for soft switching. In this circuit both main and auxiliary switch on and off at zero voltage. This zero voltage switching increases the system efficiency.

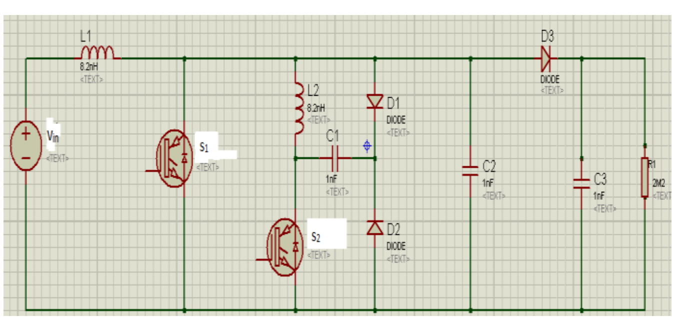
II. LOW-LOSS SOFT-SWITCHING BOOST CONVERTER

(A) Configuration of soft switching boost converter

The converter is shown in Fig. 1.It consist of two IGBT switches main switch (S_1) and auxiliary (S_2), two resonant capacitors (Cr and C_{r2}), a resonant inductor (Lr), and two diodes (D_1 and D_2).

(B) Operational Analysis of the soft switching boost Converter

The operational principle of the proposed converter can be divided into nine stage of operation

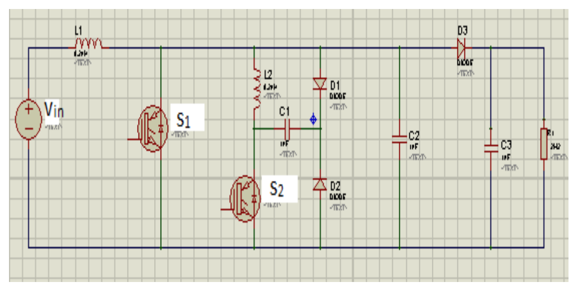


Fig,1. Proposed Boost Converter

Mode 1 ($t_0 \le t < t_1$): In this mode main switch and auxiliary switch is turned off. The energy of main inductor is transferred to load through main diode. The voltage across the main inductor is given by following equation.

$$v_L(t) = V_{in} - V_o \quad (1)$$

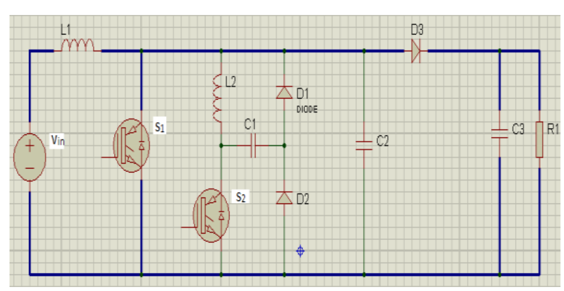
$$i_L(t) = 1/L \int v_L dt \quad (2)$$



Mode 2 ($t_1 \le t < t_2$):In this mode the auxiliary switch is turned on and the current of the resonant inductor starts increasing linearly. at the end of this mode the main inductor current is equal to resonance inductor .main inductor current is given by following equation:

$$i_{Lr}(t) = Vo/L_r(t - t_1) \quad (3)$$

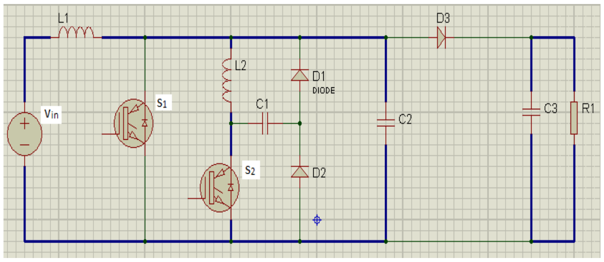
$$i_L(t_2) \approx I_{min} \quad (4)$$



Mode 3 ($t_2 \le t < t_3$): When main inductor current and resonance inductor current equal the diode is turned off and the resonance starts between C_r and Lr .and the resonance capacitor completely discharged during this mode. The main resonant inductor current is given by the following equation.

$t_1 = I_L/(Vo/L_r)$ (5)

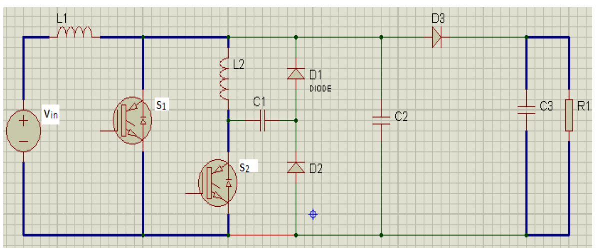
$iL_r(t) = i_{min}(t) + Vo/Z_r \sin \omega_r(t - t_2)$ (6)



Mode 4 ($t_3 \le t < t_4$): Iin this mode the voltage of resonant capacitor is reached zero. So the body diode of main switch is naturally on .so this is the condition of zero voltage for main switch. at this zero voltage condition the PWM signal is applied to main switch and the main switch is turned on at zero voltage condition.

$i_{Lr}(t) = i_{min}.+V_{in}/L\,(t - t_4)$ (7)

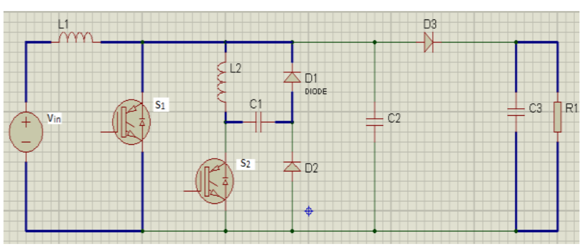
$vC_r\,(t) = 0,\ vC_{r2}\,(t) = 0$. (8)



Mode 5 ($t_4 \le t < t_5$):In this mode the main switch is turned on at zero voltage condition and the auxiliary switch is turned of at same condition. At this stage the resonance start between resonance inductor L_r andC_{r2}.at the end of this mode the C_{r2} is fully charged by resonance.

$i_{Lr}(t) = i_{Lr}(t_3) \cos\omega_a(t - t_4)$ (9)

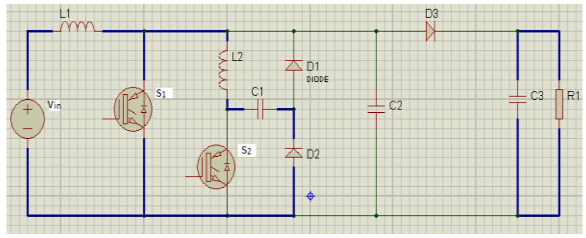
$\omega_a=1/ \sqrt{}L_rC_{r2},\quad Z_a=\sqrt{}L_r/C_{r2}.$ (10)



Mode 6 ($t_5 \le t < t_6$): In this mode the reverse resonance start between L_r and C_{r2} through diode D_2 and main switch. C_{r2} is completely discharged at the end of this mode. Capacitor voltage is charged and discharged,

$v_{Cr2}\,(t) = Z_a i_{Lr}(t_3) \sin\omega_a(t - t_4)$ (11)

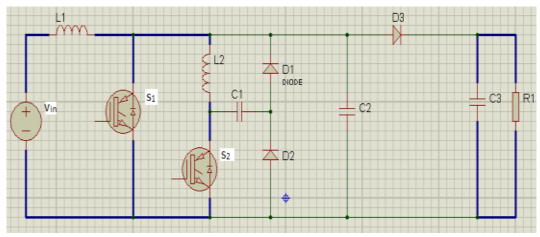
$v_{Cr2}\,(t_5) = Z_a i_{Lr},\ vC_{r2}\,(t_6) = 0$ (12)



Mode 7 ($t_6 \le t < t_7$): In this mode the C_{r2} is completely discharged by resonance and the voltage of C_{r2} is zero ,the body diode of auxiliary switch is turned on naturally. Main switch is turned off by applying PWM signal at zero voltage condition. the main and auxiliary inductor currents are given by the following equation :

$i_L(t) = I_{min}+ V_{in}/L(t - t_3)$ (13)

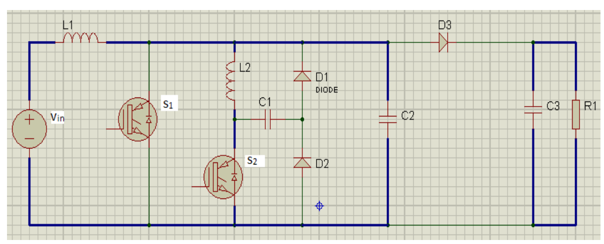
$i_{Lr}(t_7) = -i_{Lr}(t_3)$. (14)



Mode 8 ($t_7 \le t < t_8$): When the main switch is turned OFF under the zero-voltage condition, mode 8 starts, in this mode the C_r start to charged by main inductor current and resonant inductor current.

$i_{Lr}(t) = i_L(t_7) - \{i_L(t_7) + {}_{iLr}(t_3)\} \cos\omega_r\, t$ (15)

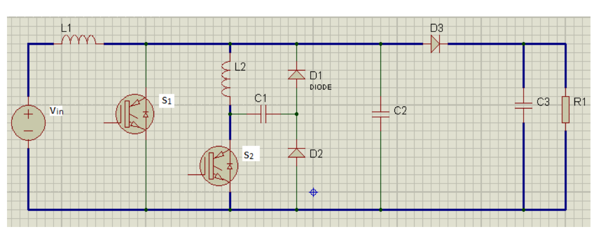
$Z_r\{i_L(t_7) + i_{Lr}(t_3)\} > V_o.$ (16)



Mode 9 ($t_8 \le t < t_9$) :In this mode the capacitor is charged and the diode is turned on at zero voltage condition. after this next cycle is start.

$i_L(t) = i_L(t_7) - V_o - V_{in}/Lt$ (17)

$i_{Lr}(t) = -iLr(t_3) + Vo/Lrt.$ (18)



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III. SIMULATION

This paper simulated the soft switching boost converter by MATLAB software. The simulation was done under a 30-kHz switching frequency and a 135 input voltage. Figs. 4 and 5 show the simulation waveforms of the main and auxiliary switch voltage and current, respectively. At an input voltage of 135 V, the output voltage is 450 V.

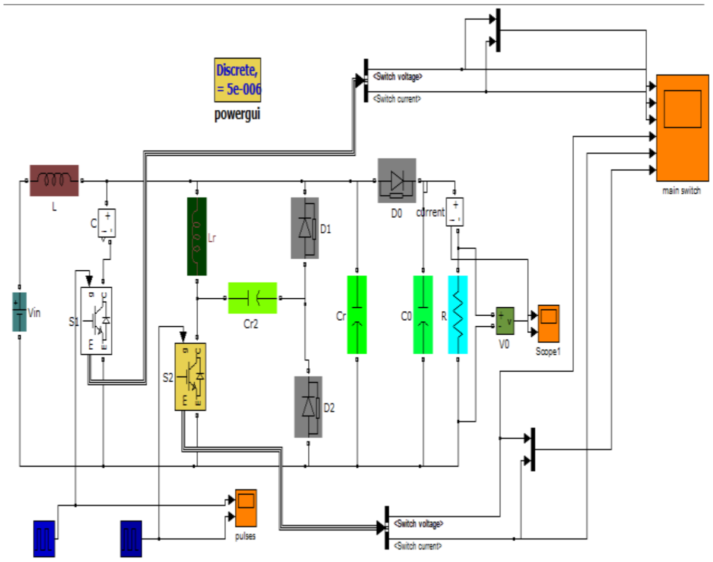

Fig.2. Simulink Circuit of Soft Switching Boost Converter

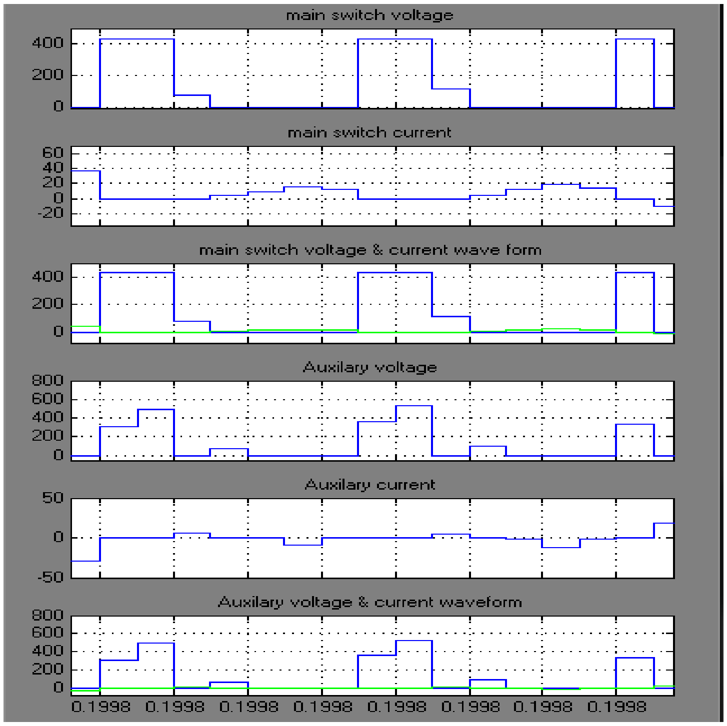

Fig.3: Simulation Waveform of Main and Auxiliary Switch

IV. CONCLUSION

In this paper, a new soft-switching boost converter has been implemented that uses an auxiliary switch and resonant circuit. The main switch performs soft switching under the zero-voltage condition by using a resonant capacitor and inductor, as does the auxiliary switch. The proposed converter can be applied for high-efficiency converters, photovoltaic dc/dc converters, a power-factor-correction circuit, and battery chargers.

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