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Research Article

A Soft Switched Safety Enhanced Single Output Flyback Converter

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Abstract: Flyback converters are the more suitable choice for low power supply because of their simple design, low cost and high efficiency. Other advantages are that in Flyback converters the load is isolated from supply and one can obtain multiple outputs without need for separate regulators. The soft switching of controlled switches enhances the efficiency in the power converters due to reduction of switching losses. Snubbers are small networks of parts in the power switching circuits whose function is to control the effects of circuit reactances. Snubbers enhance the performance of the switching circuits and result in higher reliability, higher efficiency, higher switching frequency, smaller size, lower weight and lower EMI. Therefore this study presents the performance of and Zero Voltage and Zero Current Switched (ZVZCS) Flyback converter with RCD snubber.

Keywords: Flyback converter, Pulse Width Modulated (PWM) power supplies, RCD snubber, snubber protection, soft switching, switched mode power supply

INTRODUCTION

Despite large output voltage ripple, single-stage AC-DC conversion is a more attractive solution than two-stage conversion from the standpoint of the cost and power density. Especially in applications like battery chargers, Plasma Display Panel (PDP)-sustaining power supplies and LED lighting; low frequency, 100 or 120 Hz, large output voltage ripple is inconsequential (Bellur and Kazimierczuk, 2008; Hua *et al*., 1994; Wang, 2008; Lin and Hsieh, 2007; Chung *et al*., 1999, 1997; Adib and Farzanehfard, 2008a, b, 2009; Yuri and and Milan, 2002, Majid and Abbas, 2013; Venkanna *et al*., 2014). Linear regulators are used predominantly in ground-based equipments where the generation of heat and low efficiency are not of major concern and also where low cost and a short design period are desired. PWM switching power supplies are much more efficient and flexible in their use than linear regulators. Resonant technology power supplies are the variation on the basic PWM switching power supply finds its place in applications where still lighter weight and smaller size are desired and most importantly, where a reduced amount of radiated noise is desired (Bellur and Kazimierczuk, 2008; Hua *et al*., 1994; Wang, 2008; Lin and Hsieh, 2007; Chung *et al*., 1999. Mayakkannan and Rajapandian, 2009; Sivachidambaranathan and Subhransu, 2010).

The higher the maximum voltage the power switches experience, the greater the likelihood that they will exceed their Safe Operating Areas (SOA). Voltage spikes are very common within switching power supplies and the opportunity of these spikes exceeding the avalanche voltage rating of the power switch becomes more likely. For transformer isolated topologies, the industry has settled into certain topologies that they use within the different ranges of applications. The flyback topology is the ideal choice below 100 to 150 W because of its low parts count, cost and intrinsically better efficiency. But because its peak currents are much higher than the forward-mode converters, it reaches the SOA limits of the power switches at a relatively low output power.

Switching converters are divided into two categories. The first group is hard switching due to overlapping of voltage and switch current during switching instance and therefore the switching loss is high. The other type is soft switching converter, in this method; the problems of hard switching can be solved by adding circuit or control procedure. Also in this method switching losses and EMI and RFI noises are reduced. The soft switching converters can be divided into three.; Zero Voltage Switching (ZVS), Zero Current Switching (ZCS) and Zero Voltage and Zero Current Switching (ZVZCS). The switching under ZCZVS condition has better function than the other two methods (Bellur and Kazimierczuk, 2008; Hua *et al*., 1994; Lin and Hsieh, 2007; Adib and Farzanehfard, 2008b; Sukhi and Padmanabhan, 2008; Samuel Rajesh Babu and Henry, 2011).

The soft switching of a flyback converter can be achieved by operating the circuit in the critical conduction mode. However, the critical-mode operation at light loads cannot be maintained due to a very high switching frequency and the loss of the output voltage

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regulation. A control which regulates the output down loads was proposed in Yuri and Milan (2002). A soft switching pulse-width-modulated fly back dc/dc converter with a simple auxiliary circuit was proposed by Majid and Abbas (2013). A multi-output Fly-back converter using a simple auxiliary circuit for soft switching was proposed in Venkanna *et al*. (2014). This study presents a soft switched flyback converter with snubber protection and snubber capacitor which helps in achieving ZVS without additional capacitor in the circuit.

SOFT SWITCHED FLYBACK CONVERTER

The proposed circuit is shown in Fig. 1. The AC supply is rectified using uncontrolled rectifier and the rectifier output is smoothened using a capacitor and regulated using zener diode. This DC voltage is fed to flyback converter. The load is connected in the secondary of flyback transformer. RCD snubber is used as turnoff snubber and a capacitor snubber is used as turn on snubber.

to the zero load and maintains soft switching at light

The circuit operates in two modes. When the switch is closed, energy is stored in the primary within the core material. The transformer secondary connections are made such a way that the diode in the secondary is reverse biased when the switch in the primary is closed. The equivalent circuit is during Mode 1 is shown in Fig. 2a. Therefore no energy is transferred from source to load during this interval. When the switch is turned off, the polarity of the primary voltage reverses due to the weakening of the magnetic field. Therefore the polarity of the secondary voltage of the transformer reverses which in turn forward biases the diode and hence energy stored in the core material is transferred to the load in Mode 2 as shown in Fig. 2b.

The RCD Voltage Snubber is applicable only to the clamp operation. A typical application of a resistor-capacitor-diode snubber is to control the rate of rise of voltage on the drain or collector of a switching

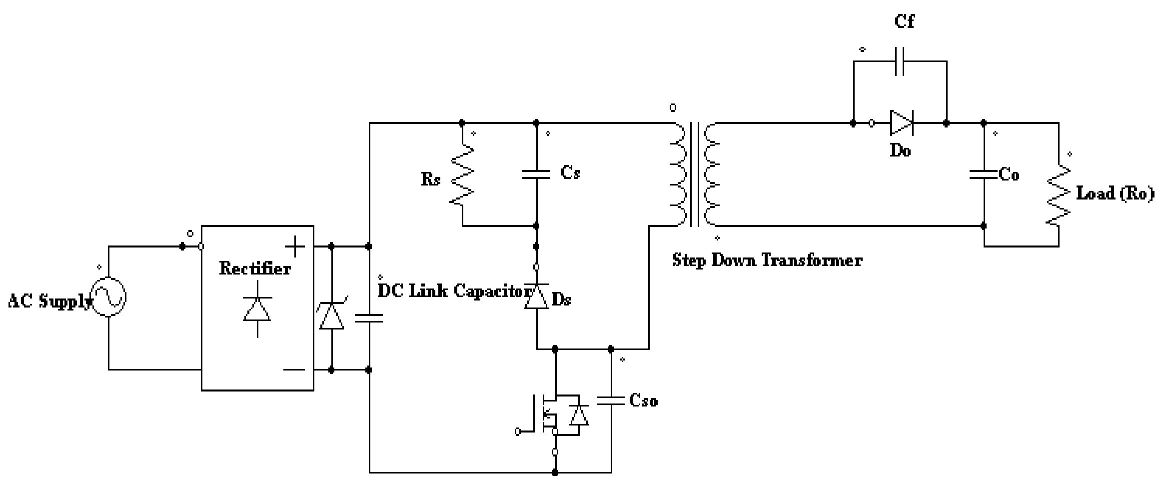
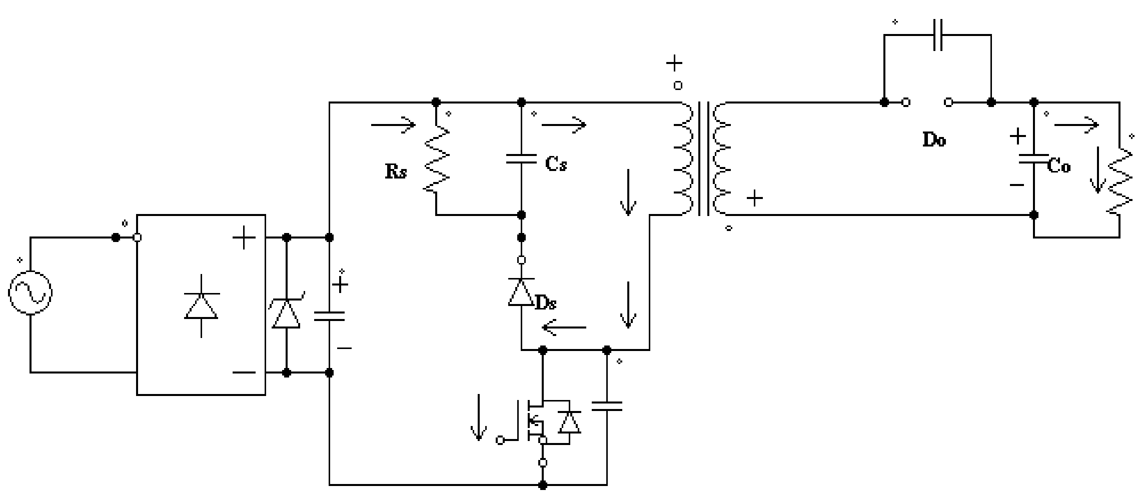


Fig. 1: Soft switched safety enhanced flyback converter



(a)

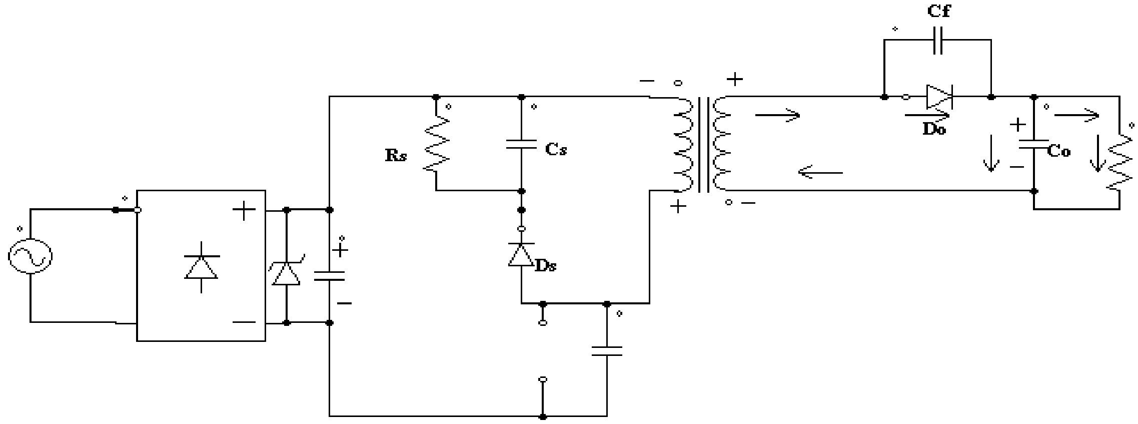


Fig. 2: (a) Mode 1-when the switch is closed (b) mode 2-when the switch is turned OFF

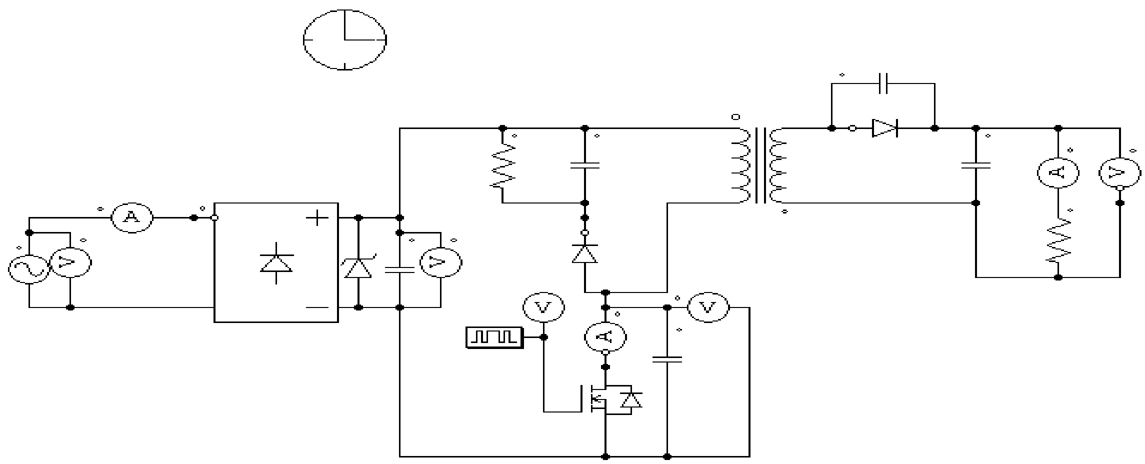


Fig. 3: Simulation circuit

Table 1: System parameters

Parameter	Value
Output power	265 W
Input voltage	230 V AC (peak)
Output voltage	85 V
Output current	3.15 A
Duty ratio	0.6
Switching frequency	50 kHz
Efficiency	85%
Magnetizing inductance	295 μH
N1	44
N2	17
Load resistance	27 Ω
Rs	8.16 k Ω
Cs	7 nF
Cso	4.7 nF
Cf	200 pF
Co	1000 μF

transistor in a forward, flyback or boost converter. At turn-off, the snubber will carry a major portion of the switch current and this transfers the power dissipation of the switch into the snubber. The reliability of the switch increases since its peak power dissipation is reduced and the controlled rate of rise of voltage also lowers the high frequency EMI which the uncontrolled switching generates. When the resistor-capacitor-diode snubber is used to control the rate of rise of voltage, the RC time constant must be short compared to the switching frequency because the capacitor must be charged and discharged in each cycle:

$$\text{The output voltage } V_o = V_{dc}\frac{N2}{N1} \quad (1)$$

where,
$N2$ = Number of turns in the secondary
$N1$ = The number of turns in the primary
V_{dc} = The DC link voltage

The applied system parameters are given in Table 1.

SIMULATION RESULTS

The simulation is carried out in PSIM platform. The simulation circuit is shown in Fig. 3. The ac supply voltage is shown in Fig. 4. The Supply voltage and currents are shown in Fig. 5. The output of the rectifier/DC link voltage is shown in Fig. 6. The

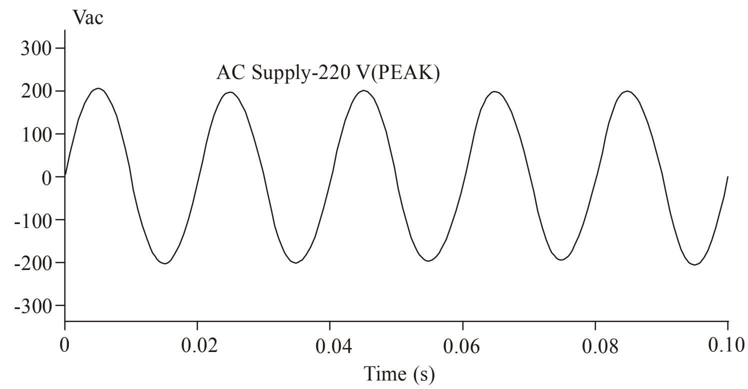


Fig. 4: AC supply voltage

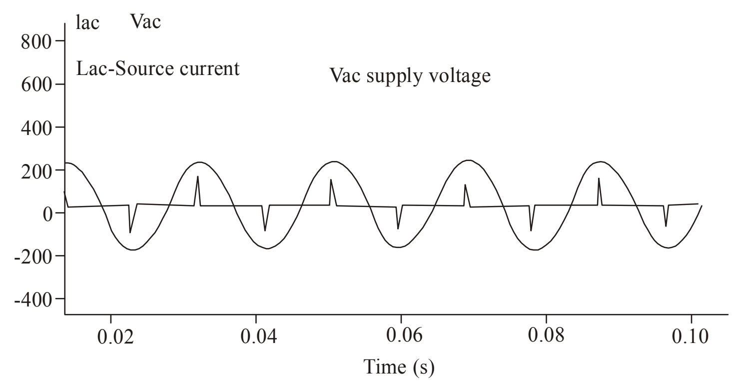


Fig. 5: Supply voltage and current

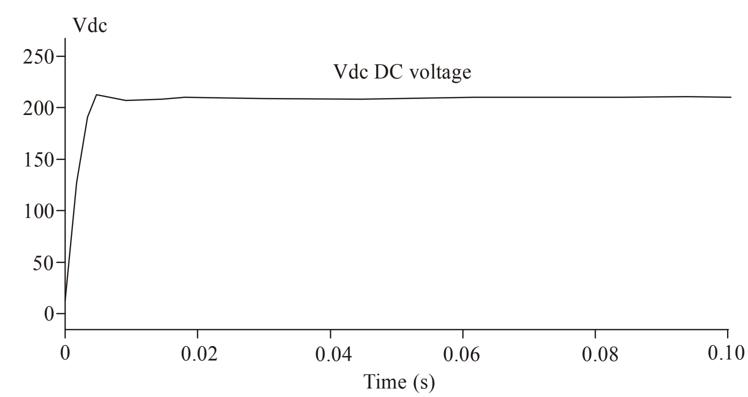


Fig. 6: DC link voltage

MOSFET switching pulses, current through the switch and switch voltages are shown in Fig. 7. The load voltage and load currents are shown in Fig. 7. Figure 8 shows output voltage and output currents.

As observed from Fig. 7, during the instant of turn On of the switch the current through the switch is zero. Therefore the product of switch voltage and current is zero. This ensures that the turn ON power losses are zero. It is also observed from the figure that at the instant of turning OFF of the switch, the voltage across the switch is zero which ensures zero voltage turn off.

The output voltage is 80 V and the output current is 2.9 A (Fig. 8). Though the converter is designed for 85 V output, since is voltage drop in the snubber circuit, the output voltage is reduced.

CONCLUSION

A ZVZCS Flyback converter was designed to deliver a power of 265 W. From the simulation results it is observed that the switching losses are zero. Since the turn on and turn off snubbers are used, it ensures the safety of the power device. Therefore the proposed configuration offers good efficiency. Further work can be extended to reduce the switching transients.

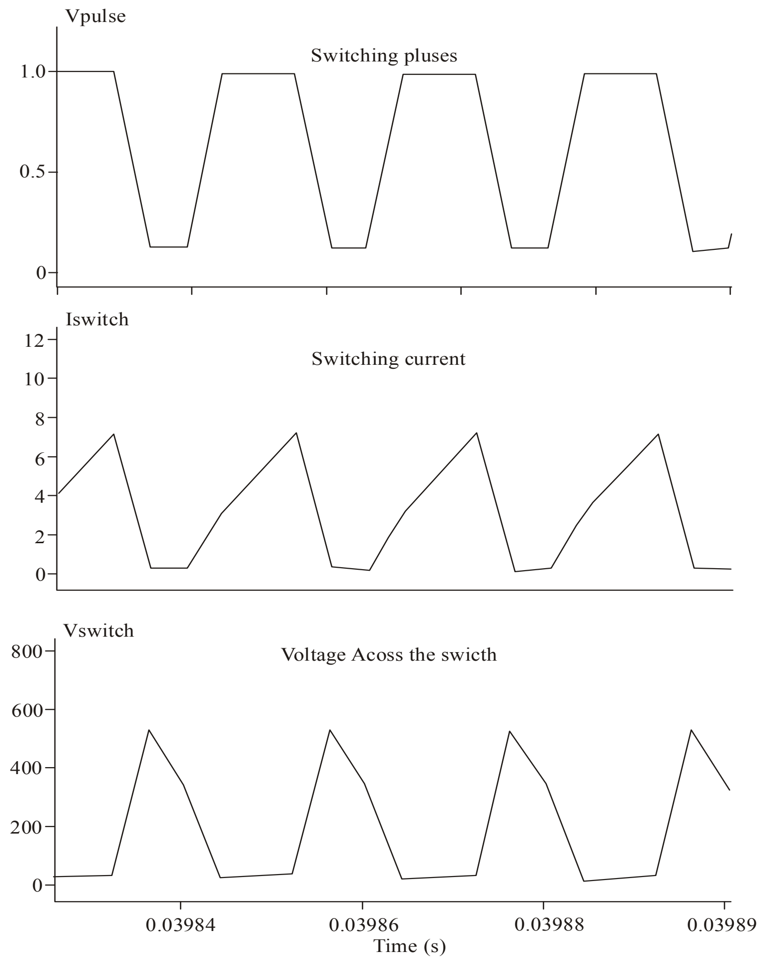


Fig. 7: MOSFET switching pulses, current through the switch and switch voltages

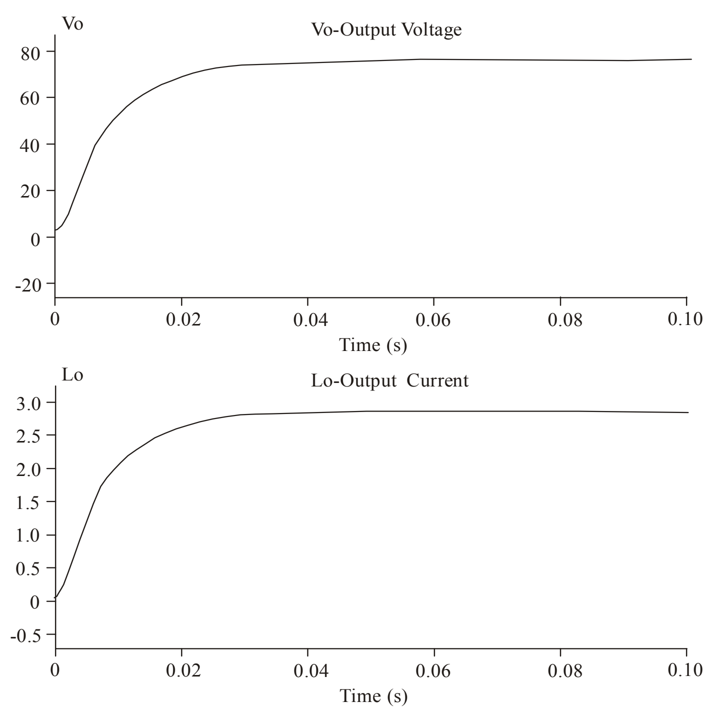


Fig. 8: Output voltage and output current

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