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A Soft Switched Isolated High Voltage Gain DC-DC Converter

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ABSTRACT

DC-DC switched mode power supplies are very widely used now days. Many safety agency bodies and customers require a separation from the applied input voltage and the output voltage which is often user accessible. An isolated DC-DC converter will have a high frequency transformer providing that barrier. This barrier can withstand anything from a few hundred volts to several thousand volts, as is required for medical application. A second advantage of an isolated converter is that the output can be configured to be either positive or negative. Soft switching will help to operate the switches at high frequency at reduced penalty due to reduced switching losses. High switching frequency will enable in compactness of the converter with reduced volume of passive components with better dynamic performance. Therefore a novel isolated high voltage gain DC-DC converter which is Zero Current Switched (ZCS) during turn on and Zero Voltage Switched (ZVS) during turn off is presented in this paper. The simulation results and analysis are also presented.

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INTRODUCTION

Renewable energy sources such as solar energy, fossil fuel cells are capturing the market because of their availability worldwide in abundance, however the output voltage from these sources is very low. Therefore in order to produce high voltages, it is necessary to combine several of these photovoltaic (PV) or fuel cells in series and parallel form. But increasing in the number of cells will decrease the efficiency. Therefore for increasing of output voltage, DC–DC booster converters with high gain are needed (B. Weerachat Khadmuna, 2013; A. Freitas, 2012; A. Tomaszuk, 2011; Omar Hegazy,2011; S. M. El-Ghanam1, 2013; Qun Zhao 2003; Shamim Choudhury,2011; Priscila Facco de Melo,2009; Theodore Soong,2011; Dmitri Vinnikov,2012; S. Dwari,2011; H.L. Do,2012). A non-isolated boost converter, which can level up DC voltage from 24 V input voltage to 130 V output voltage was proposed in (B. Weerachat Khadmuna and Wanchai Subsingha,2013). This is adequate suitable in order to develop and apply with any dc output renewable energy source, such as PV generation system and etc. The converter in this paper has power rating of 350W. A Soft Switching PWM DC-DC Converter with Auxiliary Circuit and Centre-Tapped Transformer Rectifier was proposed in (A. Freitas *et al*.,2012). But in practice the gain decreases at the higher duty cycles due to parasitic components. In addition, its control and stability at high duty cycles is very complex. One alternative is utilizing of cascaded boost converters. A cascaded boost converter with soft switching (ZVS) is proposed in (Priscila Facco de Melo *et al*.,2009).But the drawback is that the voltage stress on switching component is equal to high output voltage. Also the quadratic converters can achieve to high voltage gain but the drawback is that the voltage stress on switches is high yet. Thus no advantage is resulted compared to common boost converters. Some converters based on high frequency transformers or coupled inductors have been proposed to achieve high voltage gain without extreme duty cycles (Theodore Soong, 2011; Dmitri Vinnikov, 2012; S. Dwari,2011; H.L. Do, 2012). These converters are designed based on soft switching technique or leakage inductor energy recovery to improve efficiency. However, the design of high frequency coupled inductors is relatively complex compared to conventional transformerless boost converters. Combining conventional boost converters and flyback converter, boost-flyback converter is achieved [S. M. El-Ghanam1, 2013; Shamim Choudhury, 2011). In this converter the leakage energy of inductors is absorbed without losses and

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the voltage stress on switches is reduced. But due to series connection of capacitors at the output, their voltage balance should be considered. Converters with active clamps which proposed in (S. Dwari, 2010; H.L. Do, 2011) can recover leakage current and also decrease the voltage stress on main switch.. However the losses are increased due to clamp circuit. Structures based on diode-capacitor voltage multiplier cells are able to solve the drawbacks of previous converters. The main drawback of these converters is that they cannot attain to high voltage gain at duty cycles lower than moderate values. Therefore an isolated ZCS and ZVS, high voltage gain DC-DC converter is proposed in this paper.

Converter Description:

The proposed converter circuit is shown in Fig 1. The DC source is connected to the transformer primary. The current through the primary of the transformer is controlled by the switch **S**. A capacitor **C6** is shunted across the switch S for active clamping. When the switch **S** is closed capacitor **C5** feeds the load, when switch is turned off, the load is fed from secondary of the transformer. Capacitor **C4** is used as an active clamp for the MOSFET switch **S.** The leakage inductance is presented externally in the secondary of the transformer.

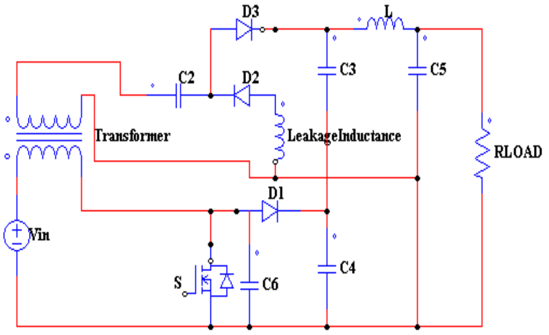

Fig. 1: Circuit Diagram of Proposed High Voltage Gain ZCS DC-DC Converter.

Design Specifications:

The circuit is designed to get 320 V output from 12 V input supply. The output power is considered to be 300 W.

$V_{out} = 320\ V$

$I_{out} = 0.94\ A$

The load resistance $R_{load} = \frac{V_{out}}{I_{out}} = \frac{320}{0.94} = 340\Omega$

Switching frequency f_s is taken as 20 kHz

Transformer Design:

Assuming Duty ratio $D_{max} = 0.8$

Therefore switch on time $T_{on} = 40\mu\ secs$ and off time $T_{off} = 10\mu\ secs$

Assuming Output ripple as 5% of output voltage V_{out} and

supply fluctuation as ±5% of supply voltage V_{in}

Transformer turns ratio is given by

$$\frac{N_2}{N_1} = \left(\frac{V_{out}+V_D}{V_{inmin}}\right)\left(\frac{1-D_{max}}{D_{max}}\right) = 7 \qquad (1)$$

Minimum duty ratio $D_{min} = \frac{D_{max}}{D_{max}+(1-D_{max})\frac{V_{inmax}}{V_{inmin}}}$ =0.78

(2)

$$\Delta I_n = 0.75 \qquad (3)$$

$$\frac{I_{1-}}{I_{1+}} = 1 - \Delta I_n = 0.25 \qquad (4)$$

$$I_{1+} + I_{1-} = \frac{2N_2}{N_1}\frac{I_{out}}{D_{min}} = 16.87\ A \qquad (5)$$

$$I_{1+} = \left(\frac{2N_2}{N_1}\frac{I_{out}}{D_{min}} \Big/ (2-\Delta I_n)\right) = 13.5\ A \qquad (6)$$

$$\Delta I_1 = (I_{1+})\Delta I_n = 10.13\ A \qquad (7)$$

$$\Delta I_2 = \frac{\Delta I_1}{\left(\frac{N_2}{N_1}\right)} = 1.45\ A \qquad (8)$$

Secondary VA $P_{02} = (V_{out} + V_D)I_{out}\left(\frac{1-D_{min}}{D_{min}}\right) = 85.03$ watts

(9)

The area product for this converter configuration is given by A_p

$$A_p = P_{02}\left(\frac{1}{\eta}\sqrt{\frac{4D\alpha}{3}} + \sqrt{\frac{4(1-D)\alpha}{3}}\right) \Big/ (K_w J\ \Delta B f_s) \qquad (10)$$

Where $\alpha = 0.84$ and $\Delta B = 0.1$ for ferrites and efficiency η is assumed to be 80%.

$K_w = 04\ and\ J = 3\ X\ 10^6 \mathrm{A/mm^2}$

$A_p = 5.8572\ X\ 10^{-8} \mathrm{m^4}$

Therefore selecting E42/21/20 EE core for which $A_c = 235\mathrm{mm^2}, A_w = 256\mathrm{mm^2}$ and $A_p = 60160\mathrm{mm^2}$

Number of turns in primary are given by $N_1 = \frac{V_{inmax} D_{min}}{\Delta B A_c f_s} = 2091$

Number of turns in secondary are $N_2 = 7X\ N_1 = 14637$

Simulation results:

The simulation is carried out in PSIM software platform. The simulation results are presented in this section. The specifications are listed in Table 1. The simulation circuit is shown in Fig 2.

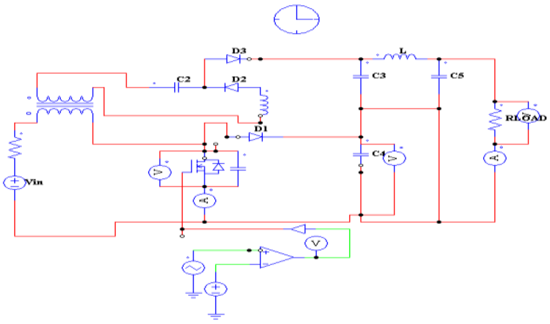

Fig. 2: Simulation Mode.

Table 1: Converter Specifications.

Parameter	Value
Input Voltage	12 V
Output Voltage	320 V
Switching Frequency	20 kHz
Duty Ratio	0.8
Load Resistance	340 Ω
Output Power	300 W.

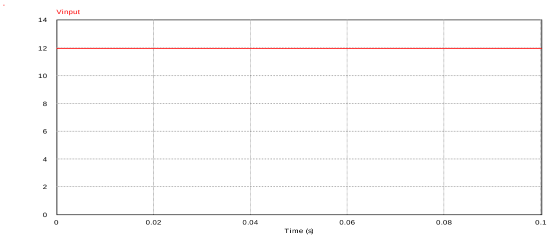

Fig. 3: Input Supply Voltage.

The input of 12 V can be taken from PV cells or fuel cells. The supply voltage is shown in Fig 3. The switching pulse, current through the MOSFET switch S and voltage across the switch are shown in Fig 4.

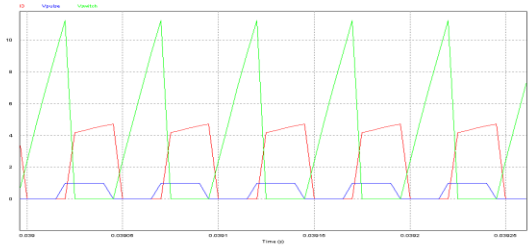

Fig. 4: Switching Pulse, Voltage across the switch and current through the switch S.

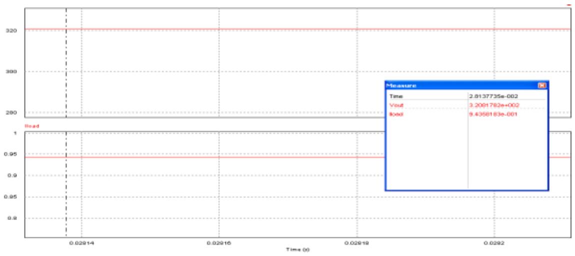

Fig. 5: Output Voltage and Output current.

As observed from the Fig 4, the switch is subjected to maximum voltage stress of 12 V which is supply voltage. Therefore the stress across the switch is reduced by larger extent due to active clamping. At the instant of turning on of the switch, the current through the switch is zero (Ref. Fig 4). Therefore the switching loss at the instant of turn on is zero. Also as observed from Figure 4, at the instant when switch is turned off, the voltage across the switch is zero, this ensures zero voltage switching during turn off. Therefore the switching losses during turn off of the switch are zero. Hence the switching losses are alleviated. Therefore proposed topology can be used at high frequencies without scarifying the converter efficiency. The output voltage and currents are shown in Fig 5.

As observed from Figure 5, the voltage across the resistive loadof 340Ω is 320V and load current is 0.943 A.

Conclusion:

A novel isolated soft switch high voltage gain DC-DC converter was designed to boost the supply voltage of 12 V either from PV cells or fuels cells to an output voltage of 320 V. the converter was designed for a load of 300 watts. From the simulation results it is observed that the input voltage is boosted from 12 V to 320 V and there is zero current switching at the instant of tuning on of the switch and zero voltage switching at the instant of turn off. Therefore the switching losses are alleviated. Therefore proposed configuration can be used at higher switching frequencies with better compactness. Since active clamping is used, the voltage stress across the switched is limited to the supply voltage. Therefore the penalty on the switch is also reduced. Further the work can be extended derive a modular structure which is fed from multiple sources.

REFERENCES

Weerachat Khadmuna, B. and Wanchai Subsingha, 2013. “High Voltage Gain Interleaved DC Boost Converter Application for Photovoltaic Generation System,” Elsevier Energy Procedia, 34: 390 .

Freitas, A., F. Antun, E. Mineiro, A. Lima, A. Gadelha and F. Gualter, 2012. “DC-DC high gain converter applied to renewable energy with new proposed to MPPT search,” International Conference On Renewable Energies And Power Quality (ICREPQ’12) Santiago De Compostela (SPAIN), 28th.

Tomaszuk, A. and A. Krupa, 2011. “High Efficiency High Step Up DC-DC Converter” Bulletin of The Polish Academy of Sciences Technical Sciences, 59(4).

Omar Hegazy, Joeri Van Mierlo and Philippe Lataire, 2011. “Analysis, Control And Comparison Of Dc To Dc Boost Converter Topologies For Fuel Cell Hybrid Electric Vehicle Application”, Vrije Universiteit Brussel (VUB) Pleinlaan 2, B-1050 Brussels, Belgium.

Axelrod, B., Y. Berkovich, S. Tapuchi and A. Ioinovici, “Improved Circuit Of The Switching Coupled Inductor Cell For Dc To Dc Converters With Very Large Conversion Ratio”, Holon Institute Of Technology ,52 Golomb St., Holon 58102, Israel.

El-Ghanam1, S.M., W. Abdel Basit, M. Ismail1, S.A. Kamh1, H.A. Ashry and F.A.S. Soliman, 2013. “Enhanced switching characteristics of DC-DC boost converter systems,” Physical Sciences Research International, 1(2): 25-31.

Qun Zhao, 2003. “Performance Improvement of Power Conversion by Utilizing Coupled Inductors” Thesis, Doctor of Philosophy In Electrical Engineering Blacksburg, Virginia.

Shamim Choudhury, “Digital Control Design and Implementation of a DSP Based High-Frequency DC-DC Switching Power Converter,” Texas Instruments Inc. 12203 Southwest Freeway, MS 728 Stafford, Texas 77477, USA.

Priscila Facco de Melo, Roger Gules, Eduardo Felix Romaneli, Rafael Christiano Annunziato, 2009.“A Soft-Switching Universal-Input Voltage Hpf Rectifier Implemented With A Modified Sepic Converter,” IEEE Power Electronics Conference, 948- 955.

Theodore Soong and Peter Lehn, 2012. “A Transformerless High Boost DC-DC Converter for use in Medium / High Voltage Applications”, IECON 38th Annual Conference on IEEE Industrial Electronics Society, pp: 174- 179.

Dmitri Vinnikov, Janis Zakis, Oleksandr Husev and Ryszard Strzelecki, 2012. “New High-Gain Step-Up DC/DC Converter with High-Frequency Isolation”, IEEE Applied Power Electronics Conference and Exposition (APEC), 1204-1209.

Dwari, S., L. Parsa, 2011. “An efficient high step-up interleaved dc-dc converter with a common active clamp,” IEEE Trans. Power Electron, 26(1): 66-78.

Do, H.L., 2011-2012. “Improved ZVS DC–DC converter with a high voltage gain and a ripple-free input current,” IEEE Trans. Circuits Syst. I, 59(4): 846-853.