High Step-Up Cascade Boost DC-DC Converter With Lossless Passive Snubber

C.Latha[1], Dr. V. Geetha[2]
[1] Dept of EEE
[2]Professor and Head, Dept of EEE
[1, 2] Government College of Engineering, Salem, India.

Abstract- *In this paper, a high step-up coupled-inductor cascade boost DC-DC converter with lossless passive snubber is proposed. Although a conventional cascade boost converter has larger voltage gain compared to a boost converter, it is still not suitable for high step-up voltage conversion. In the proposed converter, a coupled inductor is adopted for the cascaded boost converter to further increase voltage gain. However, a leakage inductance of the coupled inductor causes a high voltage spike at a main switch. A resistor-capacitor-diode (RCD) snubber is commonly used to simply solve this problem, but it is also the cause of additional power loss. Therefore, the lossless passive snubber is suggested in this paper in order to prevent efficiency drop by a snubber circuit. In conclusion, the proposed converter has high voltage gain and improved power efficiency. Simulation results of the proposed DC-DC converter with an output of 400V, 200W at a constant switching frequency of 50 kHz is presented to verify the performance of the proposed converter.*

Keywords- Boost Converter, Coupled inductor, Snubber circuit, Voltage gain.

I. INTRODUCTION

As of late, the interest for a high step up DC-DC converter has expanded quickly. The high advance up DC-DC converter is particularly required for the fields of new and sustainable power source. So as to lessen the creation of CO2, which is created by the utilization of petroleum derivatives, sustainable vitality sources, for example, photovoltaic (PV), wind turbine, waves, and geothermal, are embraced to create electric power. What's more, energy components, batteries, and ultra capacitors are used as force hotspots for electric vehicles (EVs)[1]. In any case, these force sources have a significant downside in that they create low voltages.

The ordinary lift converter is usually utilized for step-up applications to its straightforward structure and low cost. Be that as it may, it doesn't accomplish enough voltage gain for a high advance up application. Lift converters utilizing a coupled inductor are proposed for high advance up applications. From a voltage gain perspective, these converters are like the separation type converter. Normally, for example, the flyback converter, is to accomplish a high voltage gain. These sort converters have a coupled inductor (or a transformer), which is generally used to change voltage gain. Be that as it may, to get a high voltage gain by a coupled inductor, a high turn proportion is required, which can bring about more conduction loss [4]. What's more, the size and weight of the coupled inductor can be expanded. Also, these converters have a significant disadvantage in that high voltage stress may be produced at the principle change from a spillage inductance of the coupled inductor. When all is said in done,[5] a resistor-capacitor-diode (RCD) snubber is used to voltage stress. Be that as it may, the RCD snubber shows a few power loss because of the resistor. A lift converter with an dynamic brace of the buck-help type is proposed to settle the snubber issues. [6] This converter has no force misfortune delivered by the snubber circuit. Likewise, it zero-voltage switch (ZVS) in switches just as a diminished flood voltage, however an extra switch is required and the control circuit is perplexing. There are a few considers that look at the snubber circuit power loss, which recommend the utilization of snubber circuits made out of uninvolved segments the resistor to with the power loss. Be that as it may, an substantial coupled inductor is still required to get high voltage gain by utilizing a high turn proportion.

Course support converters are proposed. Both help cells are essentially associated in arrangement to improve voltage gain. Be that as it may, this technique requires more control circuits and parts for every cell. Further, its voltage gain is likewise inadequate for high advance up applications. Lift converters can be converged through shared switches by utilizing just one control circuit for the course converter. The course converter actualizes at least three lift cells to additionally expand the voltage gain. The course converter additionally requires numerous segments because of the high number of help cells. Thus, a converter cell can likewise be piled up on another converter cell in corresponding to improve the voltage gain, as proposed. [10] In the piled up strategy is embraced in a course converter for a high voltage gain, and in, a flyback converter is piled up on a lift converter utilizing the coupled inductor. In this converter, the voltage parity of the yield capacitors to be thought of since the capacitor is associated in arrangement.

II. PROPOSED HIGH GAIN CONVERTER TOPOLOGY

The proposed high step up coupled-inductor course support DC-DC converter with lossless uninvolved snubber is appeared. The proposed lossless uninvolved snubber incorporates a snubber inductor Lsn, two snubber capacitors C2 and C3, and three snubber diodes Da, Db, and Dc. It is expected that the two capacitors C2 and C3 have the equivalent capacitance Csn. The coupled inductor T1 is displayed as a polarizing inductance Lm, a spillage inductance Lk, and an perfect transformer that has a turn proportion of 1:n1 (n1 = Ns/Np). A capacitor CS1 and a diode DS1 are the parasitic output capacitance and the parasitic diode of S1, separately. In expansion, a capacitor CDo is the parasitic yield capacitance of Do. Different parts, L1, C1, Co, D1, D2, and Do, are like those of the traditional course help converter. Since the capacitances of C1, C2, C3, and Co are enormous enough that their voltages are viewed as steady, the voltages across C1, C2, C3, and Co can be considered as VC1, VC2, VC3, and Vo.

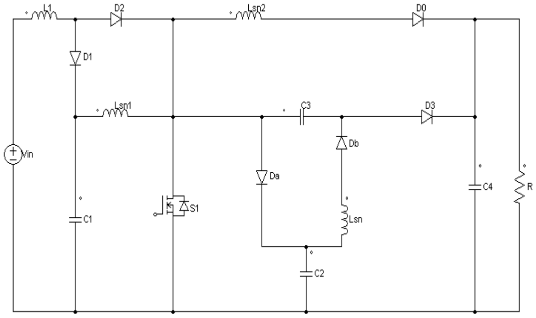


Figure 1 Proposed circuit diagram

III. MODES OF OPERATION

Mode 1: At t0, the principle switch S1 is turned on. Diode D1 is opposite one-sided as VC1. CS1 begins releasing until the voltage vS1 arrives at zero. By expecting that CS1 is very small, then the time span somewhere in the range of t0 and t1 is short, and the inductor flows, i.e., iL1 and iLm, are accepted to have consistent qualities IL1.min and ILm.min, individually. In addition, CDo begins charging until the voltage vDo comes to Vo + n1VC1. The yield diode current iDo decrease straightly with a difficult slope in light of the little spillage inductance.

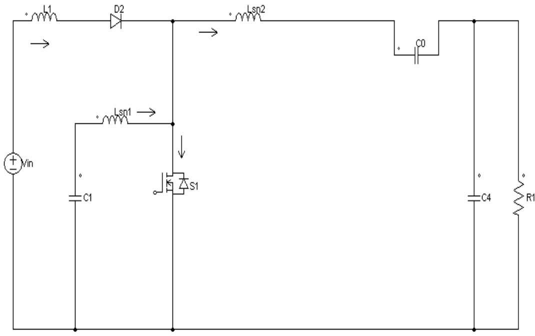


Figure 2 Mode 1 operation

Mode 2: At the point when voltage vS1 come at zero, this mode starts. The inductor L1 and the polarizing inductance Lm store energy. Since the voltage vL1 over the inductor L1 is Vin, the inductor current iL1 increments directly with an slope of Vin/L1 as follows:

$$i_{L1}(t) = \frac{V_{in}}{L_1}(t - t_1) + I_{L1.min} \qquad (1)$$

Since the complete voltage across both the segments Lm also, Lk is VC1, the current iLk increments directly with a slant of VC1/(Lm+ Lk) as follows:

$$i_{LK}(t) = i_{LM}(t) = \frac{V_{c1}}{L_m + L_k}(t - t_1) + I_{Lm.min}$$

As the snubber diode Db begins directing, reverberation happens between the snubber inductor Lsn and the snubber capacitors C2 and C3. The snubber diode current iDb is given by

$$i_{Db}(t) = \frac{V - V_{c1}}{Z_0}\sin\omega_0 (t - t_2)$$

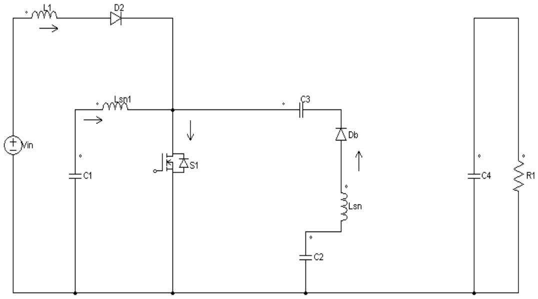


Figure 3 Mode 2 operation

$$Z_0 = \sqrt{\frac{2L_{sn}}{C_{sn}}}$$

$$\omega_0 = \frac{1}{\sqrt{L_a C_{sn}/2}}$$

where both snubber capacitors C2 and C3 have same capacitance Csn.

Mode 3:At the point when the snubber diode current iDb comes to zero by reverse bias, this mode starts. In Mode 3, the zero-current exchanging (ZCS) of diode Db is accomplished. Toward the finish of this mode, the inductor flows iL1, iLm, and Kind show up at their most extreme qualities IL1.max, ILm.max, and ILk.max, individually. Since the time span somewhere in the range of t0 and t1 is short, their most extreme qualities can be gotten by

$$I_{L1.max} = I_{L1.min} + \frac{V_{in}}{L_1} DT_s$$

$$I_{Lm.max} = I_{Lk.max} = I_{Lm.min} + \frac{V_{C1}}{L_m + L_k} DT_s$$

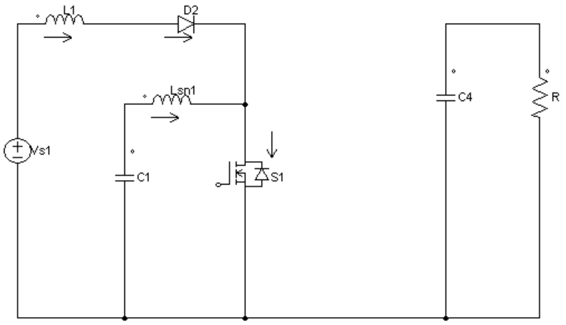


Fig 4:Mode 3 operation

Mode 4: At t3, the primary switch S1 is killed. CS1 begins charging until the voltage vS1 comes to VC2. By accepting that CS1 is little, the time stretch somewhere in the range of t3 and t4 is short and the inductor flows, i.e., iL1, iLm, and iLk, are considered to have consistent qualities IL1.max, ILm.max, and ILk.max, separately.

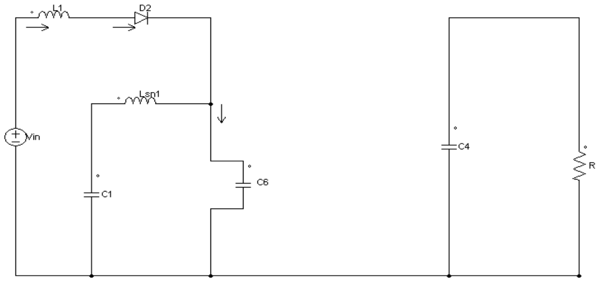


Figure 5 Mode 4 operation

Mode 5:At the point when the switch voltage vS1 comes to VC2, the snubber diode Da and Dc are turned on by the spillage inductance current iLk and this mode starts. Since the switch voltage vS1 is braced to VC2, a high voltage spike of S1 is lightened. Since Da and Dc are turned on in this mode, the follow condition can be gotten as follow:

$$V_{C2} + V_{C3} = V_0$$

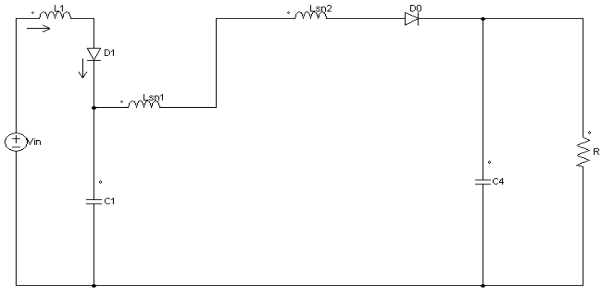


Figure 6 Mode 5 operation

By expecting that CDo is little, at that point the time stretch somewhere in the range of t3 and t4 is short. The yield diode current iDo increments directly with a precarious slant on account of the little spillage inductance. The put away vitality of the inductor L1 is moved to C1 through diode D1. Since the voltage vL1 over the inductor L1 is – VC1, the inductor current iL1 diminishes directly with a slant of – VC1/L1 as follows:

$$i_{L1}(t) = \frac{-V_{C1}}{L_1}(t - t_4) + I_{L1.max}$$

Mode 6:At t5, the yield diode Do is turned on. Through diode Do, the put away vitality of the charging inductance Lm is moved to the heap. Since the voltage vLm over the charging inductance Lm is – (Vo + VLk – VC1)/(1 + n1), the current iLm decrease straightly as follows:

$$i_{Lm}(t) = \frac{V_0 + V_{Lk} - V_{C1}}{(1 + n_1)L_m}(t - t_5) + I_{Lm.max}$$

In this mode, the voltage vLk across the leakage inductance Lk can be obtained as follows:

$$V_{Lk} = -\frac{1}{n_1}[(1 + n_1)V_{C2} - V_0 - n_1 V_{C1}$$

The leakage inductance current iLk decrease linearly as follows:

$$i_{Lk}(t) = \frac{V_{Lk}}{L_k}(t - t_5) + i_{Lk}(t_5)$$

The coupled inductor T1, the output diode current iDo(t) is obtained as follows:

$$i_{D0}(t) = \frac{1}{n_1}[i_{Lm}(t) - i_{Lk}(t)]$$

Snubber diodes currents iDa and iDc can be obtained as follows:

$$i_{Da}(t) = i_{Dc}(t) = \frac{i_{Lk}(t) - i_{D0}(t)}{2} = \frac{(1+n_1)i_{Lk(t)} - i_{Lm}(t)}{2n_1}$$

Mode 7:At the point when the snubber diode flows iDa and iDc arrive at zero, this mode starts. Along these lines, the ZCS of diodes Da and Dc is accomplished. In this mode, the spillage inductance current iLk is same as the yield diode current iDo. From (13), the flows iLk and iDo decrease directly as follows:

$$i_{Lk}(t) = i_{D0}(t) = \frac{i_{Lm}(t)}{1 + n_1}$$

In this mode, the voltage vLk across the leakage inductance Lk can be obtained as follows:

$$V_{Lk} = \frac{V_{Lm} L_k}{(1 + n_1)L_m}$$

voltage vLm across the magnetizing inductance Lm can be obtained as follows:

$$V_{Lm} = \frac{(1 + n_1)L_m}{(1 + n_1)^2 L_m + L_k}(V_{C1} - V_0)$$

Toward the finish of this mode, the inductor flows iL1, iLm, and show up at their base qualities IL1.min, ILm.min, and ILk.min, separately.

IV. SIMULATION RESULTS AND DISCUSSION

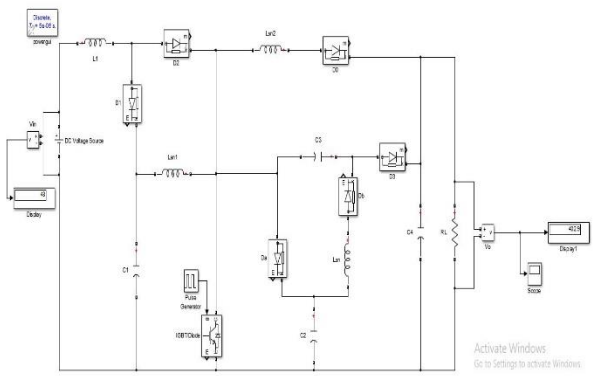
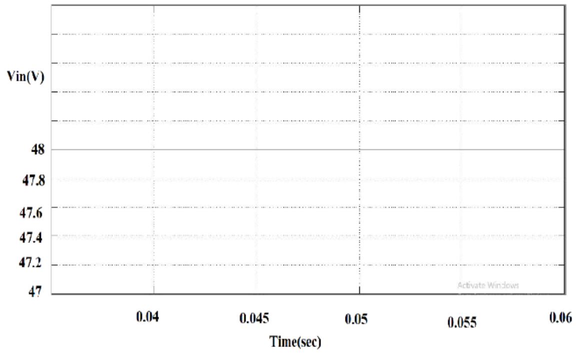


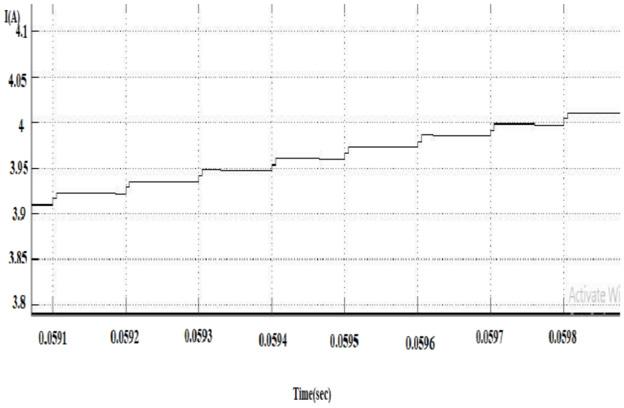
Fig 7: Proposed converter in SIMULINK

The switching frequency has trade-off relationship between performance and the size of inductors. Both the proposed converter and the conventional cascade boost converter have no soft-switching characteristics so switching losses can be significantly increased at high switching frequency. Therefore, the switching frequency was selected as 50kHz. To verify the theoretical analysis and effectiveness of the proposed high step-up coupled-inductor cascade boost DC-DC converter with lossless passive snubber, the laboratory prototype of the proposed circuit is implemented and tested in the previous section. Fig shows the laboratory prototype circuit diagram, which indicates the designed parameters and selected components of the laboratory prototype. The efficiency of the proposed converter is higher than that of the conventional converter because the power loss is significantly reduced by the proposed lossless passive snubber.

Input voltage waveform



Output current waveform



Output voltage waveform

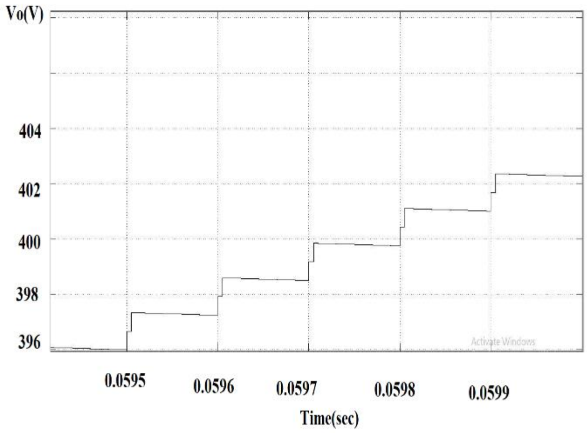
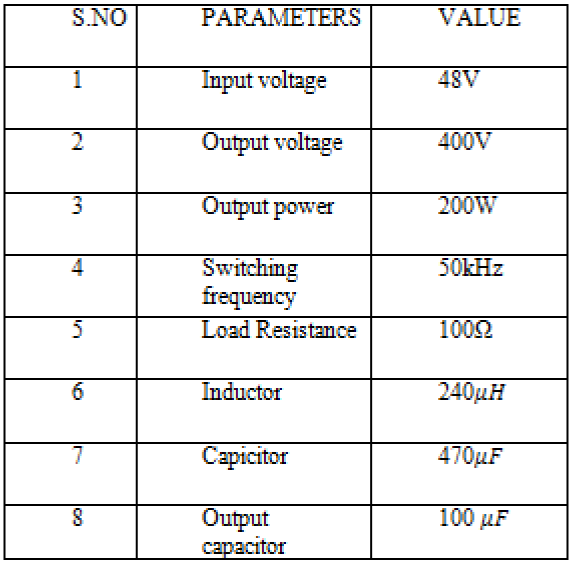


Table-I: Important characteristics of proposed converter



S.NO	PARAMETERS	VALUE
1	Input voltage	48V
2	Output voltage	400V
3	Output power	200W
4	Switching frequency	50kHz
5	Load Resistance	100Ω
6	Inductor	$240\mu H$
7	Capicitor	$470\mu F$
8	Output capacitor	$100\ \mu F$

V. CONCLUSION

The high advance up course help DC-DC converter with lossless uninvolved snubber was presented in this paper. This converter depends on the course help converter with single switch. In the converter, a coupled inductor was received to additionally expand voltage gain contrasted with regular converters. The proposed converter have utilized typical inductor rather than coupled inductor. That typical inductor give same voltage. Also, so as to power loss by a snubber circuit, the lossless inactive snubber was recommended. All in all, the proposed converter has high voltage gain and improved efficiency.

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