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Research Article

Modeling and Analysis of Cascade Multilevel DC-DC Boost Converter Topologies Based on H-bridge Switched Inductor

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Abstract: In this study investigation is done on an H-bridge switched inductor base cascade multilevel DC-DC boost converter. The proposed multilevel DC-DC boost converter topology improves the conversion efficiency of traditional topology. The proposed boost converter topology is differing from the traditional topology by the addition of switched inductor circuit. The switched inductor improved the conversion ratio gain of the boost converter circuit. The switched inductor provides a very large output voltage with different output DC levels which makes it suitable for multilevel application. Then, the mode I and mode II of operation of switched inductor are analyzed. The use of proposed switched inductor base multilevel DC-DC boost converter improved the power quality and reduced the switching frequency. The proposed DC-DC boost converter topology simulated in MATLAB/Simulink working platform and the conversion performance is evaluated. Then, the conversion performance of proposed H-bridge switched inductor based topology is compared with single level and multilevel cascade boost converter topologies.

Keywords: Cascade multilevel, DC-DC boost converter, operation mode, switched inductor

INTRODUCTION

Now-a-days, for power conversion multilevel converters have attracted interest in power industry (Rosas-Caro *et al*., 2008; Lai and Peng, 1996), since; the multilevel converters already are a very important alternative in high power applications (Rodriguez *et al*., 2002). In almost all power conversion processes such as ac-dc, dc-ac, dc-dc and ac-dc-ac, it has been shown that multilevel converters are advantageous (Peng, 2001). Low harmonic distortion, low voltage stress, low EMI noise, low switching frequency, high efficiency, ability to operate without magnetic components are some of the advantages of multilevel converters contrary to traditional topologies (Rosas-Caro *et al*., 2010a; Ortuzar *et al*., 2006). All these advantages make multilevel converters one of the best important topics in power electronics and industrial application research and in some applications they can get modular topologies (Nilkar *et al*., 2011). There are several advantages for multilevel DC-DC boost converter (Samosir *et al*., 2011; Hwu and Yau, 2010) such as fewer components, self-voltage balancing and high voltage gain without using an extreme duty ratio and without employing a transformer (Mayo-Maldonado *et al*., 2011a, b; Kouro and Wu, 2009). Furthermore, without modifying the main circuit more levels can be added (Mayo-Maldonado *et al*., 2010a).

The multilevel converter derived from the basic types of dc-dc converters which are buck, boost (Park and Choi 2010), buck-boost, cuk, sepic and Zeta (Axelrod *et al*., 2008; Hwu and Yau, 2009). In the high power application, the transformer based converter is necessary, as in a power converter the voltage conversion ratio is a purpose of the modulating control signal of the active switch (Leyva-Ramos *et al*., 2011a). For implementing a transformer less dc-dc converter with high efficiency and high boost ratios, a number of topologies are presented (Mayo-Maldonado *et al*., 2010b). A multilevel converter consists of principally an array of power semiconductors and converters that produce an output voltage of stepped shape by linking its output terminals to more than one different voltage sources (Cecati *et al*., 2010). Neutral point clamped, flying capacitor and cascaded H-bridges multi-level structures are also included in the class of DC-DC converters (Karugaba *et al*., 2008).

The switched inductor multilevel boost converter is a high gain DC-DC converter to feed any applications that require high DC voltage or to feed multilevel inverter that is used in AC applications that requires low total harmonic distortions. Similarly, it can achieve high gain without increasing the duty cycle and it is the main advantage of the multilevel boost converter (Mousa *et al*., 2010). In the conventional converter, a very good and probably expensive driver circuit is

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needed; when extreme duty cycle is applied (Jiao and Luo, 2011). Only one switch is used for reducing the cost effect in multilevel DC to DC boost converter (Mousa *et al*., 2010). But, that increased the switching frequency of the MOSET hence, the conversion voltage is deviated from the expected level and the output voltage is affected high oscillation (Lopez *et al*., 2008). To achieve better dynamic performance, multi switch interleaved converters are used with small inductors and high switching frequency (Wang *et al*., 2011).

In literature several related works are already available which is based on multilevel DC-DC boost converters. Some of them are reviewed here. Shen *et al*. (2008) have proposed a multilevel dc-dc power conversion system with multiple dc sources. Very high temperature operation was possible with this magnet-less system. Power loss and efficiency analysis was provided. Rosas-Caro *et al*. (2010b) have proposed a DC-DC converter topology. The DC-DC multilevel boost converter (MBC) was a pulse-width modulation (PWM)-based DC-DC converter. To provide different output voltages and a self-balanced voltage using only one driven switch, one inductor, diodes and capacitors for an Nx MBC, which combines the boost converter and the switched capacitor function.

Mayo-Maldonado *et al*. (2011c) have proposed several dynamic models. The model is mainly developed for a DC-DC multilevel boost converter. Zhao *et al*. (2011) have proposed multilevel circuit topologies. Based on switched-capacitor and diode-clamped converters (MCT-BSD), they are called multilevel circuit topologies. Rosas-Caro *et al*. (2011) have presented a topological derivation of PWM DC-DC converters. The structure of the converters is very simple and provides high-voltage gain. Boost, buck-boost, Cuk and SEPIC are the traditional topologies that are discussed.

Nami *et al*. (2011) has proposed H-bridge multilevel pulse width modulation converter topology. This topology is developed based on a series connection of a high-voltage diode-clamped inverter and a low-voltage conventional inverter. Liu *et al*. (2012) have proposed a cascade active-front-end converter. It was developed based on dual-boost/buck converters, since it allows regulating the power factor to control both the active and reactive powers between medium and low voltage levels. It has much enhanced system reliability compared to the traditional cascade H-bridge converter.

Leyva-Ramos *et al*. (2011b) have proposed an average current-mode controller design methodology for an N-stage cascade boost converter. This class of converters has n-LC filters; thus, it would exhibit 2n-order characteristic dynamics. The proposed scheme employs the inductor current of the input stage and the capacitor voltage of the output stage; thus, there were (n-1) capacitor voltages and (n-1) inductor currents that were not used for feedback purposes. The sensed current could also be used for one-cycle overload protection; therefore the full benefits of current-mode control were maintained. The reason is used for only a reduced set of scheme as feedback variables the system. Also, the LC filters are used to reduce the oscillation of output conversion.

The review shows that, the multilevel DC-DC converter devices have been used in switch power semiconductors at increasingly high frequencies in order to minimize harmonics and reduce passive component sizes. However, the increase in switching frequency increases the switching losses which become especially significant at high power levels. For increasing the conversion efficiency of DC-DC converter several topologies are used. The three main topologies used are the diode-clamped multilevel, capacitor-clamped multilevel and cascaded multilevel. The diode-clamped multilevel converter is relatively simple, but needs a large number of diodes to clamp the switch voltage stress.

The capacitor-clamped multilevel converter is more flexible than the diode-clamped multilevel converter, but it need large number of capacitors to clamp the voltage. Both the diode-clamped and capacitor-clamped multilevel converter have a key drawback that there are no voltage boosting feature, namely the output peak-to-peak ac voltage, which must be the same as the input dc voltage. The cascade converter is required in many isolated dc-dc converters. In this study, the multilevel cascade DC to DC boost converter with H-bridge switched inductor based topology is proposed.

In this study, a switched inductor based multilevel cascade bridge DC to DC boost converter is proposed to overcome this problem. Each bridge has one switch and the switch is connected with switched inductor, in the proposed converter. For reducing the switching frequency and improving the conversion voltage, the switch inductor is used.

PROPOSED MULTILEVEL CASCADE DC TO DC BOOST CONVERTER

The multilevel cascade dc to dc boost converter is the extension topology of single level boost converter. The use of multilevel converter is to improve the conversion ratio and efficiency of the converter. The main advantage of the multilevel topology is that the voltage conversion ratio is directly enhanced by the addition of levels. The multilevel cascade dc to dc boost converter is illustrated in Fig. 1. Figure 1, the input source of boost converter is denoted as V_s. The 1^{th} level of the dc to dc converter inductance, diode, switch and capacitor are denoted as L_1, D_1, S_1 and C_1 respectively. Then, the N^{th} level of the converter components are denoted as L_n, D_n, S_n and C_n respectively.

When the switches (S_1, S_2…S_n) ON in Fig. 1, the inductors L_1, L_2,….L_n are connected to the input

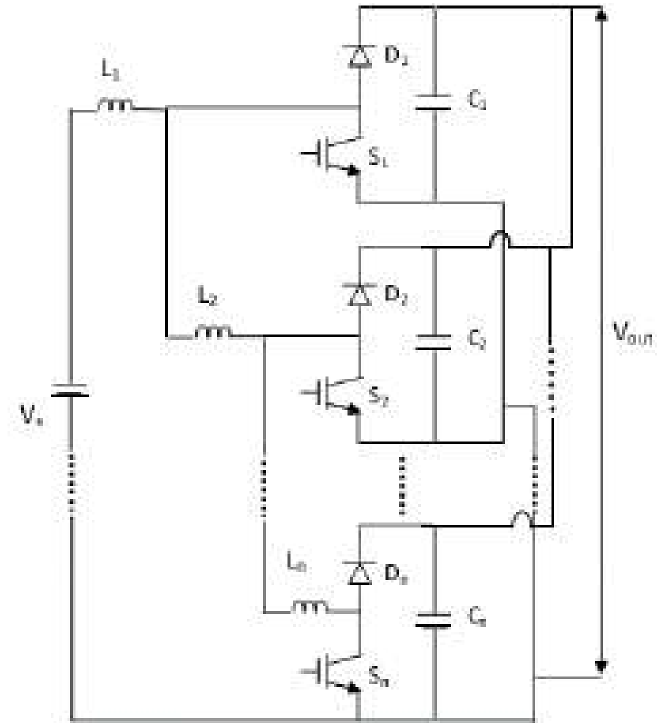


Fig. 1: Structure of cascade DC-DC boost converter

voltage (Vs). The output voltage of C_1 is smaller than voltage through D_2, … D_n. At the same time, the negative level of voltages of C_2, … C_n is equal to the positive level value of C_1. Hence, the total voltage across C_2..C_n is smaller than C_1. During the turns off condition of switches, the inductor current is closed to D_1 of all switched diodes. Throughout the switch off condition, the inductor current closes D_1 charging C_1 and the output voltage level is resulted as the converter voltage. The voltage on the C_1 is equal to the summing up voltage on the input source and the voltage level of C_2..C_n. Thus, it is possible to achieve high voltage gain against the duty cycle. But, when include the switched inductor circuit; the switching frequency level is limited with high gain (Liu *et al*., 2013). Therefore, the proposed converter is suitable for charging power in photovoltaic applications (Deivasundari *et al*., 2013). Moreover, the peak current of inductor is limited by switched inductor so no additional protection circuit is required (Chen, 2013).

According to the consideration of general converter operation, these converters work in the steady state with the condition of Continuous Conduction Mode (CCM). Here, the conduction duty ratio is denoted as D, the switching frequency is f, the switching period is $T = \frac{1}{f}$ and the load is RL load. The input voltage and current are denoted as V_{in} and I_{in} respectively. The output voltage and current are V_O and I_O. During the conversion process, the conversion output without power loss is $V_{in} I_{in} = V_{out} I_{out}$. The voltage transfer ratio gain is denoted as G which is described as following them:

$$G = \frac{V_o}{V_{in}} \tag{1}$$

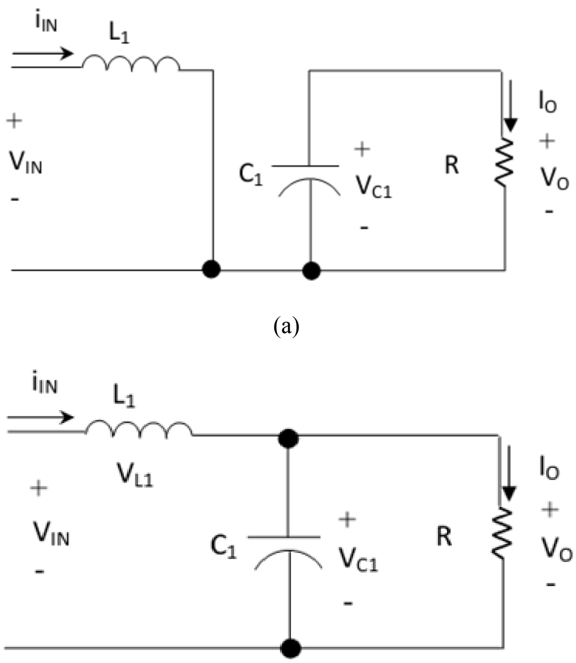
The equivalent circuit diagram on one level boost converter circuits during switch-ON and switch-OFF are illustrated in Fig. 2 as follows:

The charged voltage across the capacitor C_1 is denoted as V_O. The current flowing through the inductor is denoted as iL_1. The current (iL_1) flowing through inductor L_1 increases with voltage V_{in} during switch-ON period DT and decreases with voltage $-(V_o - V_{in})$ during switch-off period $(1 - D)T$. Hence, the ripple of the inductor current Δi_{L_1} is expressed as follows:

$$\Delta_{i_{L_1}} = \frac{V_{IN}}{L_1} DT = \frac{V_o - V_{in}}{L_1} (1 - D) T \tag{2}$$

Then, the average current through the inductor i_{L_1} is expressed as follow:

$$i_{L_1} = (1 - D) \frac{V_o}{R} \tag{3}$$



(a)

(b)

Fig. 2: Equivalent circuit of (a) switch-ON and (b) switch-OFF

From the above expression, the inductor current variation (ε_1) is determined. The inductor current variation is the ratio of the ripple current of the inductor (Δi_{L_1}) and the average current of the inductor (i_{L_1}) which is expressed as following them:

$$\varepsilon_1 = \frac{\left(\Delta i_{L_1} / 2 \right)}{i_{L_1}} \tag{4}$$

In the above equation, the values of Δi_{L_1} and i_{L_1} are substitute. Then, the equation is expressed as follow:

$$\varepsilon_1 = \frac{\left(\left(\frac{V_o - V_{in}}{L_1} (1 - D) T \right) / 2 \right)}{\left(1 - D \frac{V_o}{R} \right)} \tag{5}$$

In the above equation, the output voltage V_0 is expressed as follows:

$$V_o = \frac{1}{1 - D} V_{IN} \tag{6}$$

This value is substitute in equation (1) and the gain equation is described as follows:

$$G = \frac{1}{1 - D} \tag{7}$$

Similarly, the output voltage variation (ϵ) is determined. That is expressed as follows:

$$\varepsilon = \frac{\left(\Delta V_o / 2 \right)}{V_o} = \frac{1 - D}{2 R f C_1} \tag{8}$$

where,
D = The duty cycle
f = The frequency in Hz

The above described equations are the corresponding equation of single stage DC to DC boost converter.

CASCADE MULTILEVEL DC-DC BOOST CONVERTER WITH H-BRIDGE SWITCHED INDUCTOR

Then, the multilevel cascade boost DC to DC converter with H-bridge switched inductor topology is described. Here, the purpose of the switched inductor is used to reduce the switching frequency of the converter. Hence, the power loss is reduced during conversion process, so the power quality got improved. The switched inductor provided a very large output voltage with different output DC levels which makes it suitable for multilevel application. The H-bridge switched inductor based multilevel boost converter topology is illustrated in the following Fig. 3.

For multilevel n^{th} stage boost converter, the output voltage, the gain, current variation and the voltage variation equations are written as follows:

$$V_o = \left(\frac{1}{1 - D} \right)^n V_{IN} \tag{9}$$

$$G = \left(\frac{1}{1 - D} \right)^n \tag{10}$$

$$\varepsilon = \frac{\left(\Delta i_{L_i} / 2 \right)}{i_{L_i}} = \frac{\left(\left(\frac{V_o - V_{in}}{L_i} (1 - D)^{2(n-i+1)} T \right) / 2 \right)}{(1 - D) \frac{V_o}{R}} \tag{11}$$

$$\varepsilon = \frac{\left(\Delta V_o / 2 \right)}{V_o} = \frac{1 - D}{2 R f C_1} \tag{12}$$

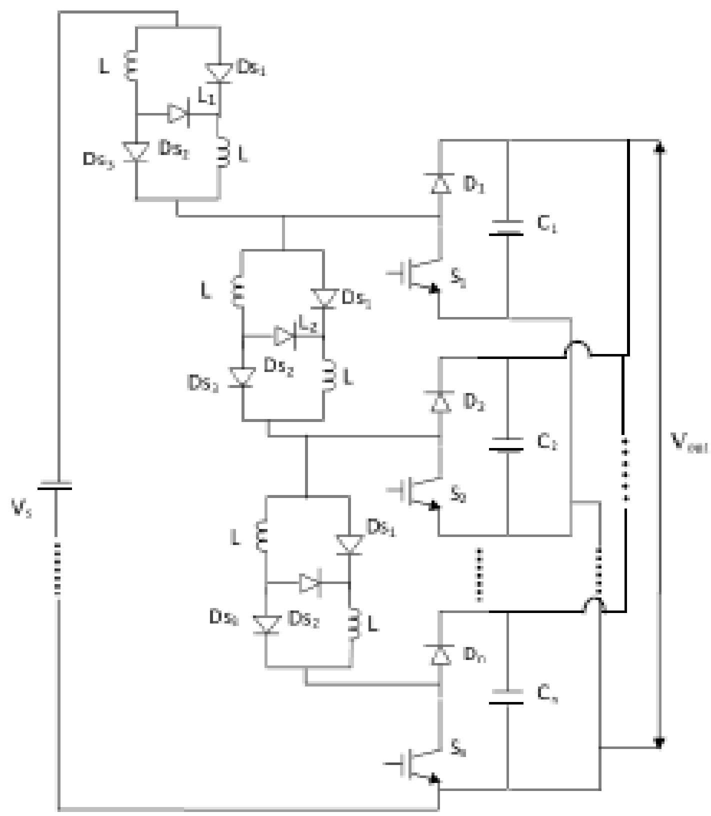
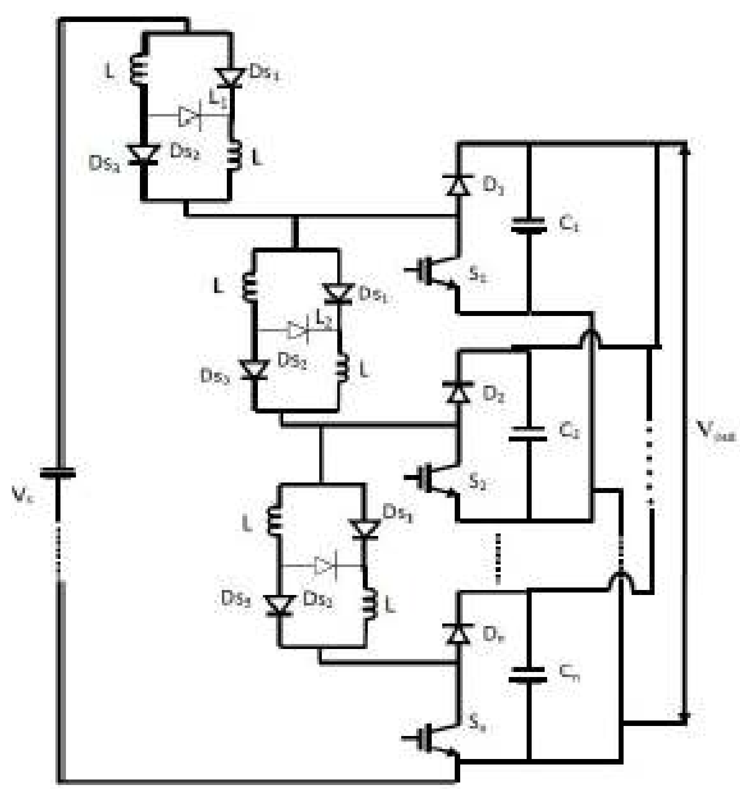
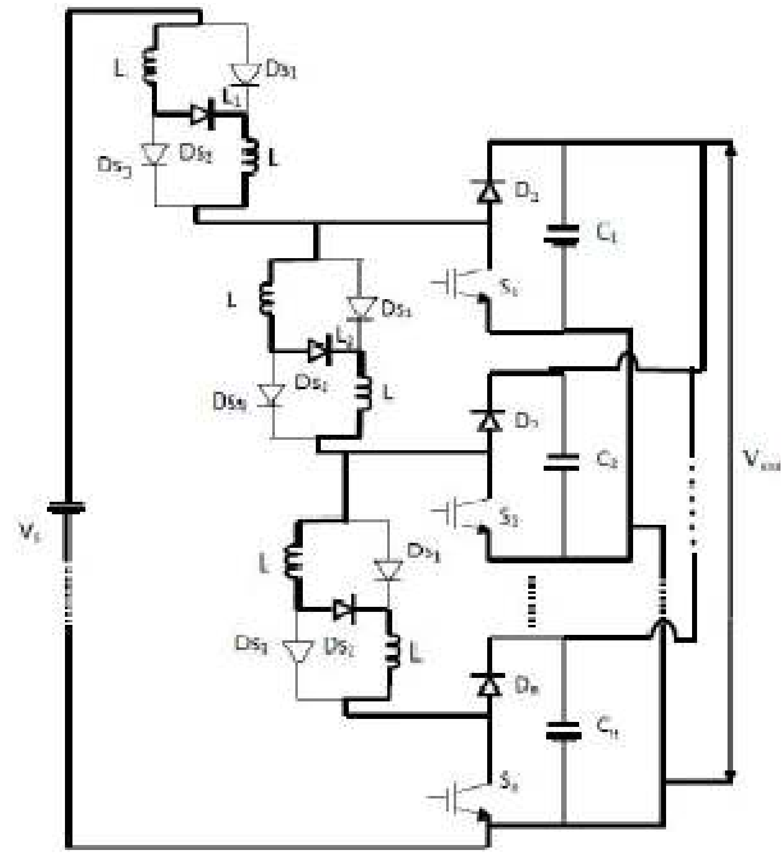


Fig. 3: Proposed H-bridge switched inductor base cascade dc-dc boost converter



(a)



(b)

Fig. 4: H-bridge switched inductor base cascade dc-dc boost converter while (a) Mode I operation and (b) Mode II operation

In the proposed multilevel DC to DC boost converter model, the inductor resistance R_L and the capacitor resistance R_C are described as below:

$$C\frac{dV_{c_i}}{dt} = (1 - S_n)i_{L_i} - \left(\frac{\left(\left(\frac{1}{1-D} \right)^n V_{IN} \right)}{R - i_o} \right) \quad (13)$$

$$L\frac{d_{i_{L_i}}}{dt} = S_n V_{in} - (1 - S_n)\left(\left(\frac{1}{1-D} \right)^n V_{IN} \right) - R_L i_{L_i} \quad (14)$$

$$V_0 = \frac{R_L V_{C_i}}{R_L + R_C} + \frac{R_L R_C}{R_L + R_C}\left((1 - S_n) i_{L_i} - i_o \right) \quad (15)$$

where, $i - 1,2,\ldots n$. Then, S_i is the switch which used in the converter topology. C_i is the ith capacitor and L_i is the ith inductor. The V_O and i_O are the output voltage and current, respectively.

The above described switched inductor operation is same as the traditional cascade converter. But, here the switched inductor operation is only different from the nominal circuit operation. The switched inductor is operated by inductive principle which consists of two operation modes. The mode of operation of switched inductor is based on the D_{s1}, L and S_n. The detailed description of H-bridge switched inductor is given in the following section.

Mode of operation of h-bridge switched inductor circuit: The switched inductor simple switching dual structures, formed by either two 2-3 diodes, or two inductors and 2-3 diodes are defined. These circuit blocks can provide either a step-down of the input voltage or a step-up of it. They are inserted in classical boost converters to provide new power supplies with a steep voltage conversion ratio. As their complexity in terms of circuit elements is comparable to that of the quadratic converters, their performances (voltage ratio, stresses, efficiency) will be compared to that of available quadratic circuits. According to the conduction of inductor and diode, the mode of operation of switched inductor is categorized into two types which are illustrated in Fig. 4.

Mode I: In mode I operation (Fig. 4a), the diodes D_{S_1} D_{S_3} are conducted, D_{S_2} not conducted and also, the current flows through the both inductors. During this mode, the switches S_n are directly conducted and the capacitor is charged indirectly. The current flows through the switched inductor (Mode I) is expressed as below:

$$i_L = i_{L_1} + i_{L_2} = \int_0^t \left(\frac{(V_1 + V_2) - V(D_{S_1} + D_{S_3})}{L_1 + L_2} \right) \qquad (16)$$

$$L\frac{di_{L_i}}{dt} = \frac{R_L V_{C_i}}{R_L + R_C} + \frac{R_L R_C}{R_L + R_C}((1 - S_n)) \int_0^t \left(\frac{(V_1 + V_2) - VD_{S_{2n-3}}}{L_n} \right) \qquad (17)$$

The Eq. (17) is the output voltage of multilevel cascade boost converter with switched inductor. Where, $D_{S_{2n-3}}$ is the combination of diode D_{S_1} and D_{S_2}, L_n is the combination of inductor L_1 and L_2 respectively.

Mode II: In mode II operation (Fig. 4b), the diodes D_{S_1}, D_{S_3} are not conducted and D_{S_2} is conducted. Then, the current flows through the both inductors. During this mode, the switches S_n are OFF stage so, the capacitor is charged directly. The current flows through the switched inductor (Mode II) is expressed as below:

$$i_L = i_{L_1} + i_{L_2} = \int_0^t \left(\frac{(V_1 + V_2) - VD_{S_2}}{L_1 + L_2} \right) \qquad (18)$$

$$V_o = \frac{R_L V_{C_i}}{R_L + R_C} + \frac{R_L R_C}{R_L + R_C}((1 - S_n)) \int_0^t \left(\frac{(V_1 + V_2) - VD_{S_{2n-2}}}{L_n} \right) \qquad (19)$$

The switch S_n is rotated ON; the diodes D_{Sn-3} are furthermore rotated ON at the similar time in the suggested converter. Over through this operating state, the diodes D_{S1} and D_{S3} are offered a consecutive current path for corresponding inductors of the n[th] stage of the converter. On the subsequent phase, the switch S_n is turned OFF, the diodes D_{S2} is furthermore turned ON at

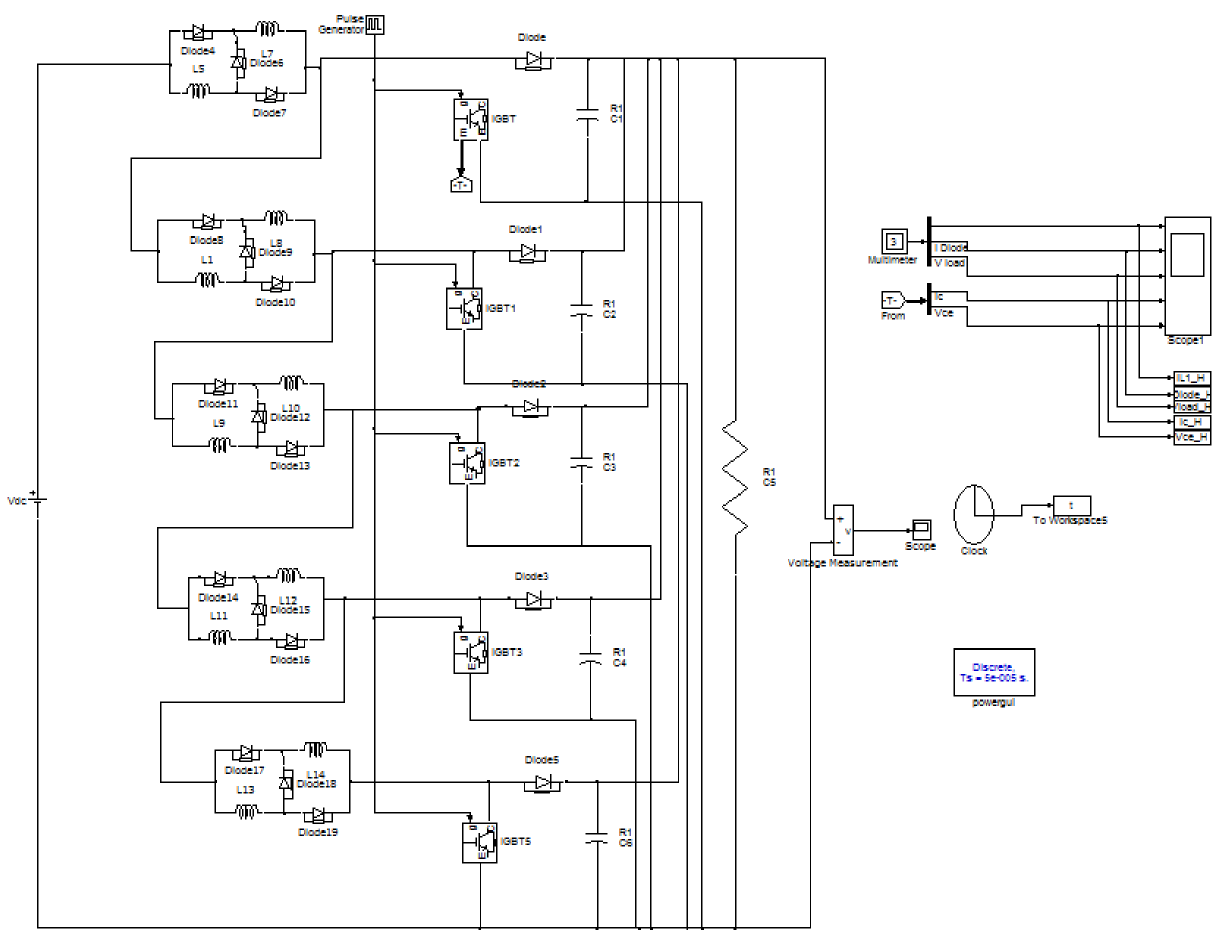


Fig. 5: Simulink model of H-bridge switched inductor with multilevel DC to DC boost converter topology

the similar time. The diodes D_{S2} supply a consecutive current path for corresponding inductors of the n^{th} stage of the converter through this operating condition; whereas in this operating condition, diodes D_{S1} and D_{S3} are rotated OFF. Hence, the operation of the multilevel cascade is the same at the final level of the converter and the resulting conversion proportion is found out.

IMPLEMENTATION RESULTS AND DISCUSSION

The proposed H-bridge switched inductor based DC to DC boost converter topology was simulated in MATLAB/Simulink working platform. Then, the conversion performances of single level, multilevel and H-bridge switched inductor topologies are analyzed. The switching frequencies of IGBT switching voltage are analyzed by different simulation time. Also, the voltage conversion capability of the proposed topology is analyzed with conversion gain and duty cycles correspondingly. The performance of the cascade bridge circuit was tested with five level output series cascading capacitor bridges. The simulink model of H-bridge switched inductor based cascade DC to DC boost converter topology is illustrated in Fig. 5. The implementation parameters of the DC to DC boost converter model is described in Table 1 as follow.

Table 1: Implementation parameters and values

Components	Parameters	Values
	Series inductance	400 e-6H
IGBT	Resistance (R_{on})	0.01 Ohms
	Forward voltage (V_f)	1V
	Current 10% fall time (T_f)	1e-6 sec
	Current tail time (T_t)	1e-6 sec
	Snubber resistance (R_s)	10000 Ohms
Diode	Resistance (R_{on})	0.05 Ohms
	Forward voltage (V_f)	0.8 V
	Snubber resistance (R_s)	1e5 Ohms
Switched inductor	Series inductance (L_1 and L_2)	400e-6 H
Diode (D_{s1}, D_{s2} and D_{s3})	Resistance (R_{on})	0.05 Ohms
	Forward voltage (V_f)	0.8 V
	Snubber resistance (R_s)	1e5 Ohms

From the simulink model, the performance of inductor current, capacitor current, diode current, load voltage and switching voltage of the IGBT are examined. The performances of single level model, multilevel model and H-bridge switched inductor model are illustrated in Fig. 6 to 9 respectively. The comparison of converter voltage is illustrated in Fig. 10. Then, the gains of the single level, multilevel and H-bridge level (proposed) topologies are analyzed at different duty cycles. The duty cycle and gain are tabulated in Table 2. After that, the performance of the gain vs. duty cycle and the deviation chart are given in

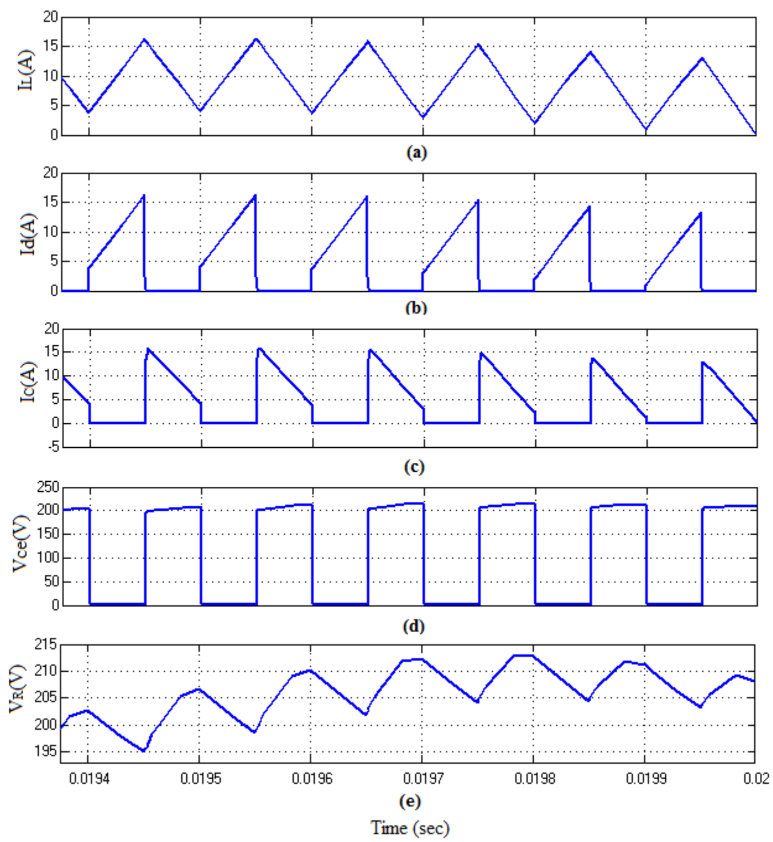


Fig. 6: Theoretical performance of; (a): Inductor current (I_L); (b): Capacitor current (I_C); (c): Diode current (I_d); (d): Load voltage (V_{ce}) and; (e): IGBT switching voltage (V_R)

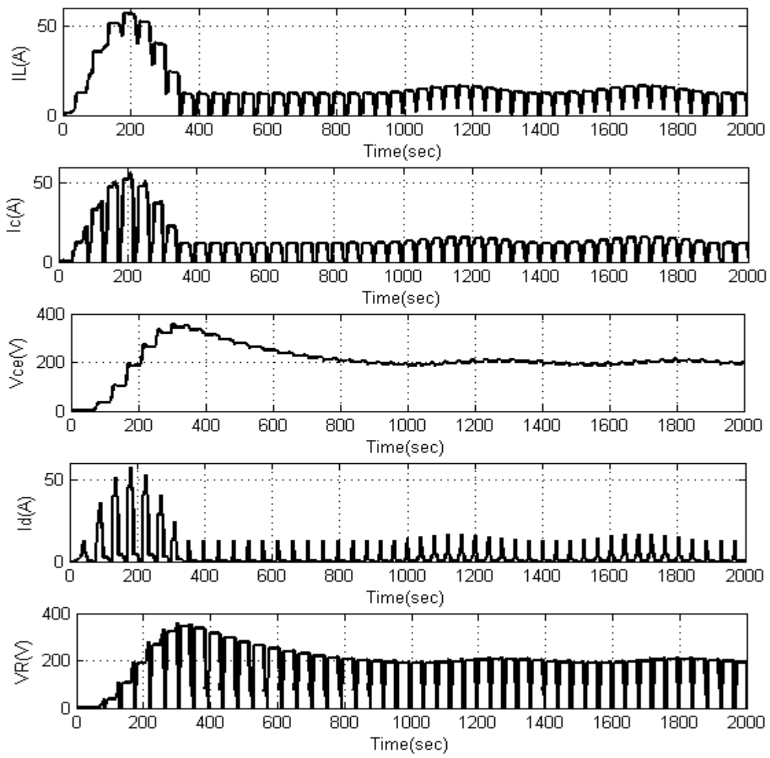


Fig. 7: Performance of inductor current (I_L), capacitor current (I_C), load voltage (V_{ce}), diode current (I_d) and IGBT switching voltage (V_R) by single level dc-dc boost converter

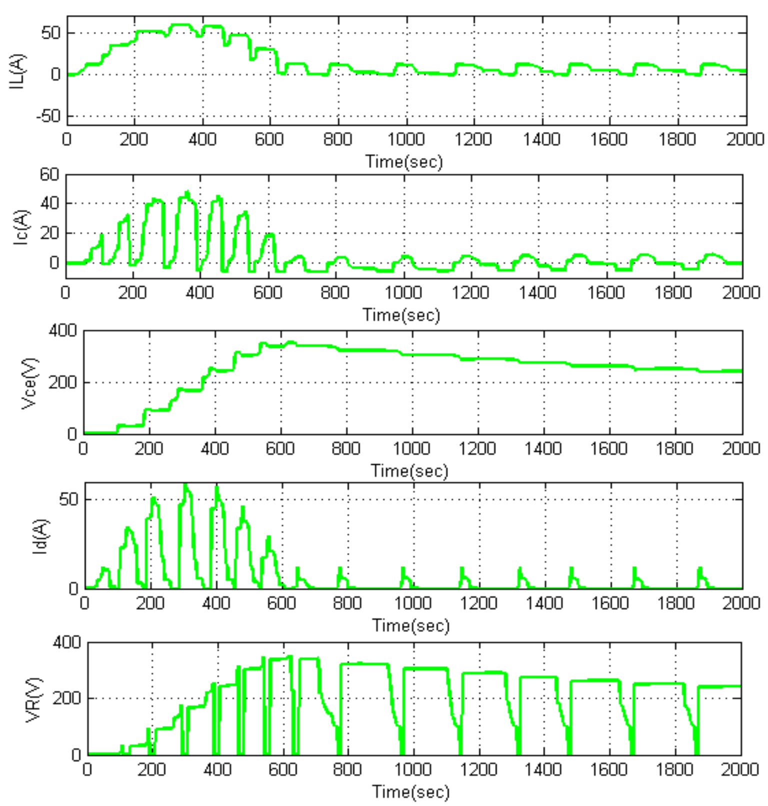


Fig. 8: Performance of inductor current (I_L), capacitor current (I_C), load voltage (V_{ce}), diode current (I_d) and IGBT switching voltage (V_R) by multilevel dc-dc boost converter

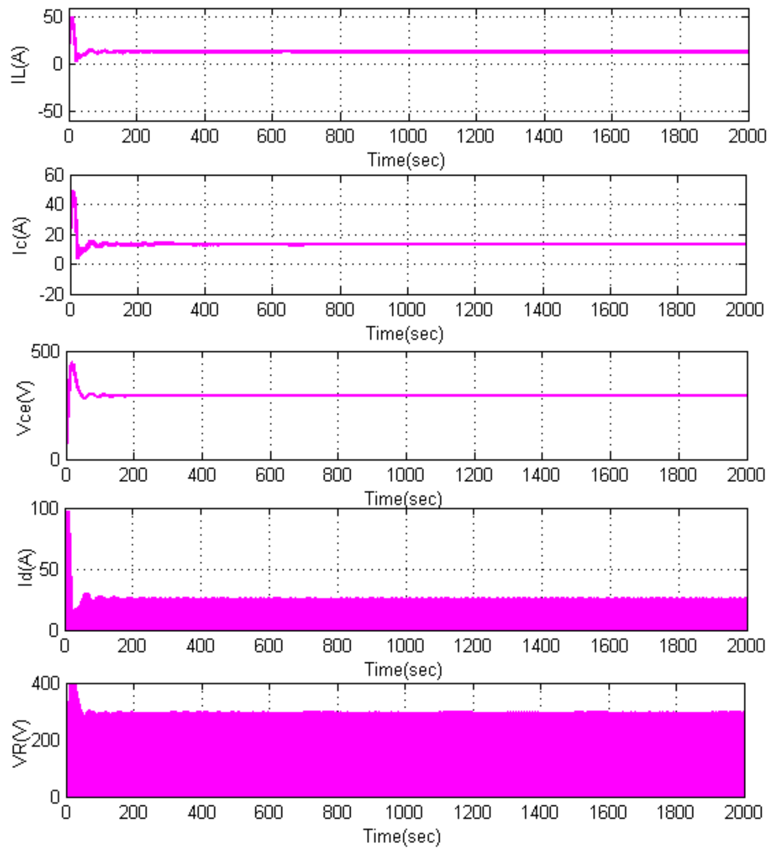


Fig. 9: Performance of inductor current (I_L), capacitor current (I_C), load voltage (V_{ce}), diode current (I_d) and IGBT switching voltage (V_R)

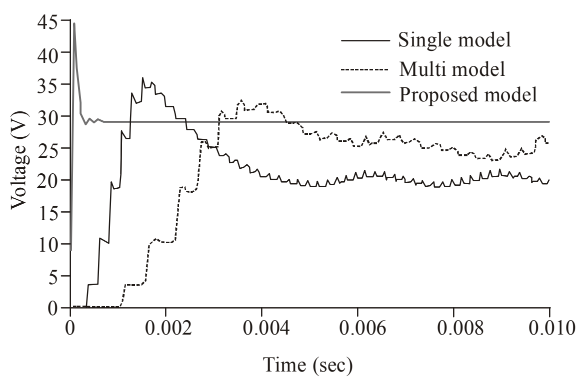


Fig. 10: Comparison of converter voltage

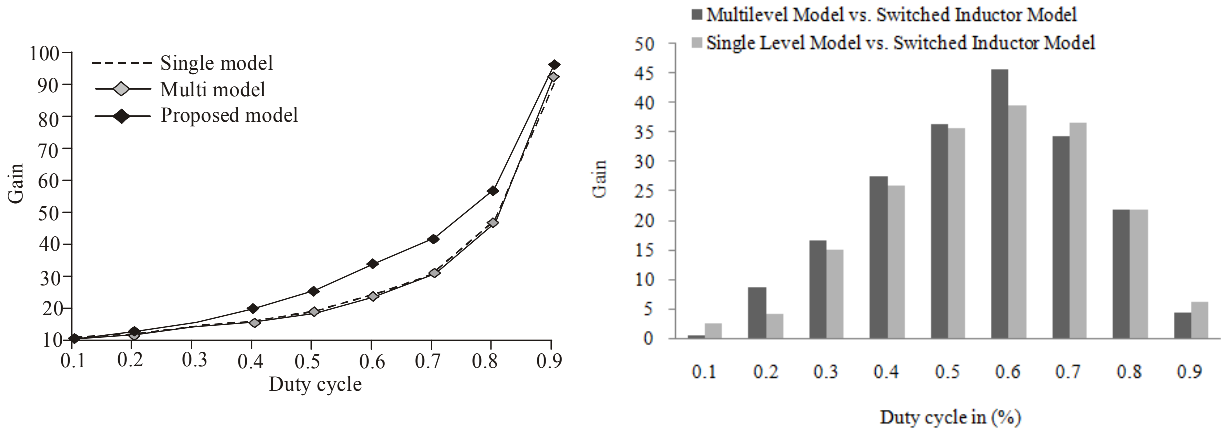
Table 2: Duty cycle and gain

Duty cycle in (%)	Output gain of different model		
	Single model	Multi model	H-bridge model
0.1	10.0	10.20	10.25
0.2	12.0	11.50	12.50
0.3	13.4	13.20	15.40
0.4	15.5	15.30	19.50
0.5	18.5	18.40	25.10
0.6	24.0	23.00	33.50
0.7	30.0	30.50	41.00
0.8	46.0	46.05	56.05
0.9	90.0	91.50	95.50

Fig. 11a and b. The theoretical periodic signal with symmetric property of inductor current, capacitor current, diode current, load voltage and IGBT Switching Voltage of DC-DC converter is analyzed at the steady state points which are illustrated in Fig. 6.

The converter output voltage is obtained at the simulation time 0.01 sec. When consider the settling time and the steady state of Fig. 10, the output voltage stability of proposed converter is enhanced and the time to reach the stability level of proposed converter is less when compared to multi-level and single level topologies. Therefore, the traditional converters need stabilizing controller to maintain the stability and design of stabilizing controller is difficult.

The inductor current (I_L), capacitor current (I_C), load voltage (V_{ce}), diode current (I_d) and IGBT switching voltage (V_R) of the proposed topology is analyzed. When the switch is turn on, two input inductor is charging in parallel which is shown as in the inductor current characteristics. Therefore, the input current equal to 12.5 A and when IGBT turn off the input inductor connect in series that described as shown in Fig. 4b. Because of that, the input current of the circuit is decreased to half of the actual value. So, the voltage stress is reduced by the proposed topology when compared to other topologies due to the inclusion of switch inductor. The voltage stress on a switch is



(a) (b)

Fig. 11: Comparison Performance of (a) Voltage gain and duty cycle and (b) Deviation of switched inductor model

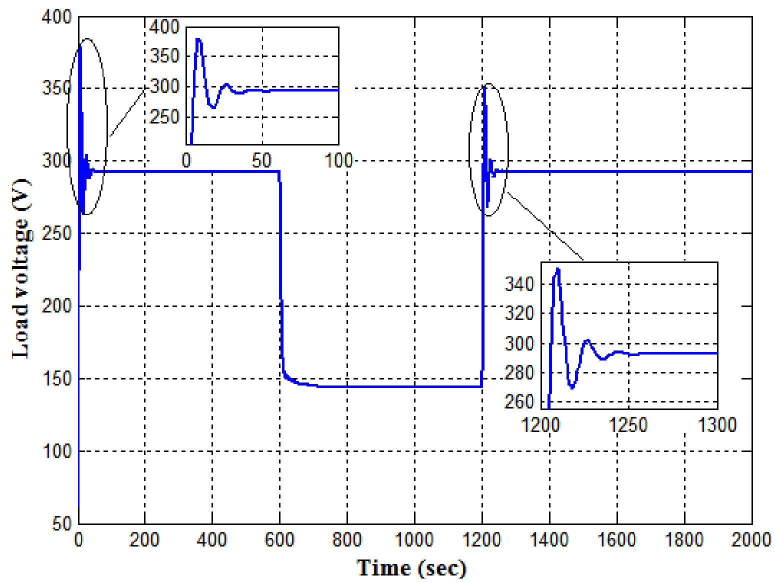


Fig. 12: Performance of load voltage under transient analysis

equal to 96.7 volt and the output is equal to 230 volt. In addition to that, the voltage stress on a switch in switched inductor boost converter is 230 volt. In Fig. 10, the conversion output oscillation of switched inductor based topology is reduced when compared to other two topologies. The comparison shows that, the proposed topology is achieved high DC voltage gain (230V/30V) which is proved by the proposed topology.

Figure 11a, the proposed H-bridge switched inductor topology is providing better gain when compared with other topologies. In the study, the PWM modulating frequency is selected as10kHz to analyze the performance of all topologies. Under this switching frequency, the oscillation of converter output is reduced. When varying the modulating frequency from 1kHz to 10kHz, the performance of the converter current is affected such as, inductor current, capacitor current and diode current respectively. But, the switched inductor based circuit reduces the effect of switching frequency and improves the converter current. In the switched inductor circuit, the diodes make sure the inductor and the capacitor are charged in parallel and discharged in series. The reason for improving the gain, the switching frequency effect of the converter is reduced by switched inductor which improved the conversion output. From Table 2, the conversion of the switched inductor based model how much deviated from the multilevel and single level model is analyzed. The analyzed conversion deviation is plotted in bar chart. The performance of deviation shows in Fig. 11b, the proposed switched inductor based model better than compared to single level and multilevel model.

Then, the transient response of the proposed model is analyzed by changing the load value from the actual value. Under this changing condition, actual load value is reduced as 50% from 600 sec to 1200 sec and the load voltage performance is given in Fig. 12. The performance shows that, the proposed model have good settling response and reached the stead state level with less overshoot after 1200 sec.

CONCLUSION

The proposed cascade multilevel DC to DC boost converter topology with H-bridge switched inductor was implemented in MATLAB working platform. Then, the conversion performance of proposed topology was analyzed at different gain and duty cycle level. Five level series cascading circuit was used to analyze the performance of proposed topology. The conversion performance of proposed topology was compared with single level and multilevel DC-DC converter topologies. The mode of operation of switched inductor with cascade model was analyzed during switch ON and OFF condition. From the duty cycle and gain comparison, the voltage conversion of proposed topology is analyzed and compared with tradition topologies. The comparison result shows that, the proposed topology was better for DC to DC for boosting purpose without using any driving circuit. The switching frequency effect of the converter is reduced by the switched inductor circuit and so the conversion gain of the circuit is improved. Also, the stability of the converter is increased and the switching stress is reduced. In addition, the proposed model has good response and reached steady state under transient analysis.

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