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CLOSED LOOP CONTROL OF PV HIGH VOLTAGE GAIN DC-DC CONVERTER WITH TWO-INPUT BOOST-STAGES

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Abstract-In recent years, with increasing development of power electronics technology, the boost DC-DC converters are more widely used for the electricity-supply applications. Battery operated systems such as hybrid vehicles have become more and more popular, these devices along with industrial grade machines today depend on reliable and efficient DC – DC converters. A conventional boost converter is used to obtain higher output voltage than the input voltage. Hence the conventional boost converter is to avoid high input current stress on the switch. The conventional boost converter can be used for step up applications because of low conduction loss, simple structure and low cost. However, it is not suitable for high step-up applications.But the main challenge faced by such dc distribution systems is the use of power electronic converters for integrating renewable sources into the dc bus. So a high-voltage-gain dc-dc converter is introduced in this paper. This technique also allows the operation with a high static gain and high efficiency, making possible the design a compact circuit. The proposed concept presents DC-DC converters with closed loop control to achieve high step up voltage without an extremely high duty ratio thereby proving that a converter is a possible improvement topology to offer compact design without compromising any advantages readily offered by a basic boost converter.Simulation results are obtained using MATLAB/ Simulink.

Index Terms—Diode-capacitor voltage multiplier stages, high voltage-gain dc-dc power electronic converters,Closedloop,controller.

I. INTRODUCTION

High boost dc-dc converter operating at high voltage regulation is mainly required in many industrial applications. High gain dc-dc boost converter play a important role in renewable energy sources such as solar energy system, fuel energy system, DC [1] back up energy system of UPS, High intensity discharge lamp and automobile applications. The rapid increase in the demand for electricity and the recent change in the environmental conditions such as global warming led to a need for a new source of energy that is cheaper and sustainable. Solar energy has offered promising results in the quest of finding the solution to the problem. Converters without transformers can be used as high step up dc-dc converters as [2-4] they can achieve high efficiency. These converters can be divided into coupled and non-coupled inductor type. A number of coupled inductor-based high step-up converters have been developed.By increasing the turn's ratio of the coupled inductor similar to that in isolated converters,high voltage can be achieved.However the leakage inductance of the coupled inductor is inevitable. Like in isolated converters, it may cause voltage spike which increases the voltage stress across main switches.The non coupled inductor type converters can achieve high voltage gain with minimum number of magnetic components. Moreover the switch voltage and current stress are very high [5-6].When the output voltage is high, it becomes necessary to reduce the voltage stress on the active switches and diodes; otherwise, [7] it will cause high conduction loss and becomes more expensive. Due to the presence of parasitic parameters such as the equivalent series resistance of inductor,conventional boost converters cannot provide a high voltage gain and thus results in high duty ratio. However this extreme duty ratio can cause serious reverse recovery problems and electromagnetic interferences [8-9]. The extremely narrow turn-off time will result in large peak current and considerable conduction and switching losses. A typical choice would be using two cascaded converters; but it results in inefficient operation, reduced reliability, increased size, and can even result in stability issues .Another option is the use of isolated topologies like [10-11], half-bridge, full-bridge, fly back, forward and push-pull converters; but it has a disadvantage that it will produce discontinuous input currents and hence would require bulky input capacitors. Lots of research work has been done to provide a high step-up voltage without an extremely high duty ratio. The isolated converters can boost the voltage ratio by using high frequency transformer by increasing the turn's ratio.However, the leakage inductor must be handled carefully; otherwise, it will cause large voltage spike across the power switches or diodes.Therefore, the DC system with multiple DC/DC converters may play an important role in the future power systems and industrial applications In addition, the design of high power DC-DC converters and their Controller plays an important role to control power regulation particularly for a common DC bus [12]. Basically there are two types of topology dc-dc converter present, one is transformer less topology and other one is with transformer [13]. According to the efficiency the transformer less topology is better than with transformer topology. Theoretically, a dc –dc boost converter can achieve a high step-up voltage gain with an extremely high duty ratio near to 100%. However, in practice, the step up voltage gain is limited due to the effect of power switches, rectifier diode, the equivalent series resistance (ESR) of inductors and capacitors. Many topologies have been presented to provide a high step up voltage gain without an extremely high duty ratio. However, these types are all complex and have a high cost. The coupled inductor technique provides solution to achieve a high voltage gain, low voltage stress on the active switch, and high efficiency without the penalty of high duty ratio [14]. Thus switching inductor boost type provides high gain and high efficiency.

II. TOPOLOGY INTRODUCTION AND MODES OF OPERATION

The proposed converter is inspired from a Dickson charge pump [20]. Diode-capacitor VM stages are integrated with two boost stages at the input. The VM stages are used to help the boost stage achieve a higher overall voltage gain. The voltage conversion ratio depends on the number of VM stages and the switch duty ratios of the input boost stages. Fig.1 shows the proposed converter with four VM stages. For simplicity and better understanding, the operation of the converter with four multiplier stages has been explained here. Similar analysis can be expanded for a converter with N stages.For normal operation of the proposed converter, there should be some overlapping time when both the switches are ON and also one of the switches should be ON at any given time (seeFig.2). Therefore, the converter has three modes of operation. The proposed converter can operate when the switch duty ratios are small and there is no overlap time between the conduction of the switches. However, this mode of operation is not of interest as it leads to smaller voltage gains.

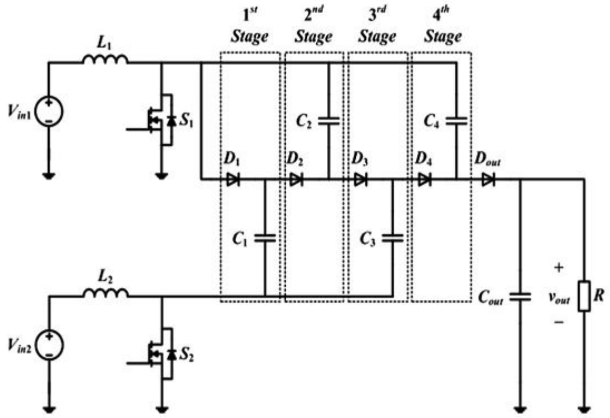

Fig.1. Proposed high-voltage-gain dc–dc converter with four VM stages

a). Mode-I

In this mode, both switches S1 and S2 are ON. Both theinductors are charged from their input sources Vin_1 and Vin_2.The current in both the inductors rise linearly. The diodes indifferent VM stages are reverse biased and do not conduct. TheVM capacitor voltages remain unchanged and the output diode outis reverse biased (see Fig.3); thus, the load is supplied bythe output capacitor Cout.

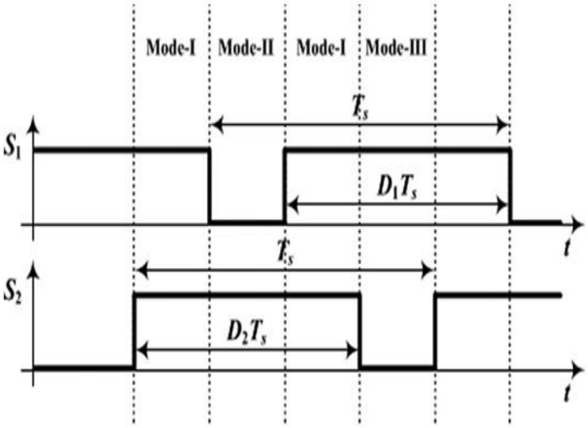

Fig.2. Switching signals for the input boost stage for the proposed converter

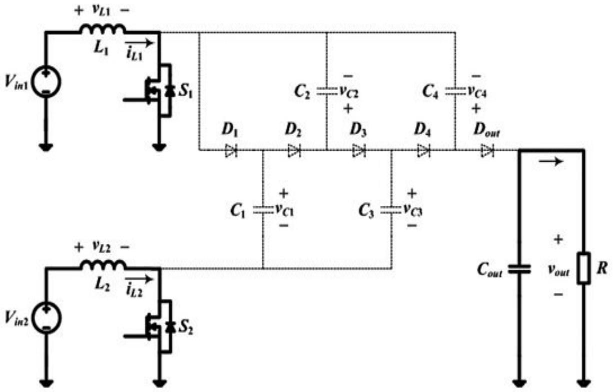

Fig.3. Mode-I of operation for the proposed converter with four VM stages

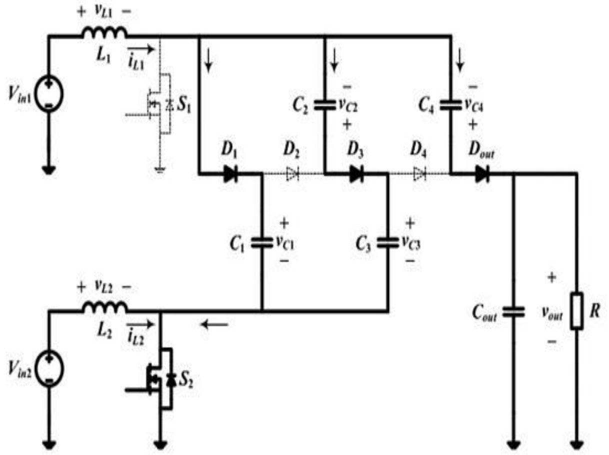

Fig.4. Mode-II of operation for the proposed converter with four VM stages

b). Mode-II

In this mode, switch S1 is OFF and S2 is ON (see Fig.4).All the odd numbered diodes are forward biased and the inductor current IL1 flows through the VM capacitors charging the odd numbered capacitors (C1,C3,...) and discharging the even numbered capacitors (C2,C4,...). If the number of VMstages is odd, then the output diode Dout is reverse biased and the load is supplied by the output capacitor. However, if the number of VM stages is even, then the output diode is forward biased charging the output capacitor and supplying the load.

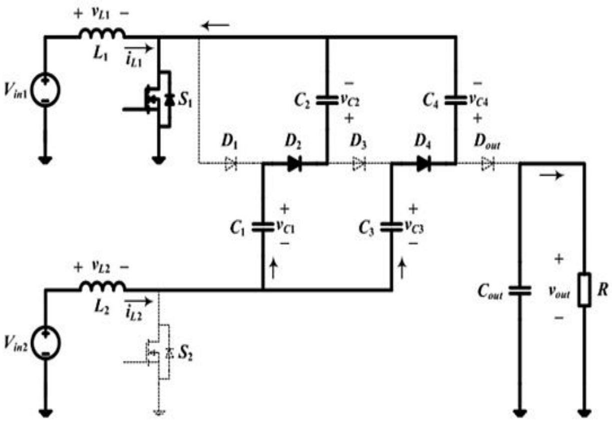

Fig.5. Mode-III of operation for the proposed converter with four VM stages

In the particular case considered here, since there are four VMstages, the output diode is forward biased.

c). Mode-III

In this mode, switch S_1 is ON and S2 is OFF (see Fig.5).Now, the even numbered diodes are forward biased and the inductor current IL_2 flows through the VM capacitors charging the even numbered capacitors and discharging the odd numbered capacitors. If the number of VM stages is odd, then the output diode D_{out} is forward biased charging the output capacitor and supplying the load. However, if the number of VM stages is even, then the output diode is reverse biased and the load is supplied by the output capacitor.

III. VOLTAGE GAIN OF THE CONVERTER

The charge is transferred progressively from input to the output by charging the VM stage capacitors. For a converter with four stages of VM (see Fig.1), the voltage gain can be derived from the volt-sec balance of the boost inductors. For L_1, one can write

$$\langle v_{L1} \rangle = 0 \qquad (1)$$

Therefore, from Fig.4, it can be observed that the capacitor voltages can be written in terms of upper boost switching node voltage as

$$V_{C1} = V_{C3} - V_{C2} = V_{out} - V_{C4} = \frac{V_{in1}}{(1-d_1)} \qquad (2)$$

Where d1 is the switching duty cycle for S_1.Similarly, from the volt-sec balance of the lower leg boost inductor L_2, one can write the capacitor voltages (see Fig.5) interms of lower boost switching node voltage as

$$V_{C2} - V_{C1} = V_{C4} - V_{C3} = \frac{V_{in2}}{(1-d_2)} \qquad (3)$$

Where d_2 is the switching duty cycle for S_2.

From (2) and (3), the capacitor voltages for the proposed converter with four VM stages can be derived as

$$V_{C1} = \frac{V_{in1}}{(1-d_1)} \qquad (4)$$

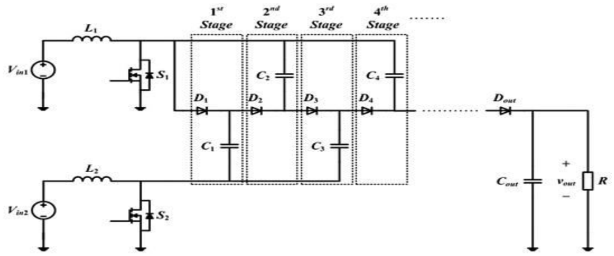

Fig.6. Proposed converter with N number of VM stages

$$V_{C2} = \frac{V_{\text{in}1}}{(1-d_1)} + \frac{V_{\text{in}2}}{(1-d_2)}$$

$$V_{C3} = \frac{2V_{\text{in}1}}{(1-d_1)} + \frac{V_{\text{in}2}}{(1-d_2)}$$

$$V_{C4} = \frac{2V_{\text{in}1}}{(1-d_1)} + \frac{2V_{\text{in}2}}{(1-d_2)} \qquad (4)$$

The output voltage is derived from (2), which is given by

$$V_{\text{out}} = V_{C4} + \frac{V_{\text{in}1}}{(1-d_1)} = \frac{3V_{\text{in}1}}{(1-d_1)} + \frac{2V_{\text{in}2}}{(1-d_2)} \qquad (5)$$

Similar analysis can be extended to a converter with N number of VM stages (see Fig.6). Thus, the VM stage capacitor voltages are given by

$$V_{Cn} = \left(\frac{n+1}{2}\right)\frac{V_{\text{in}1}}{(1-d_1)} + \left(\frac{n-1}{2}\right)\frac{V_{\text{in}2}}{(1-d_2)}$$

If n is odd &n ≤ N,

$$V_{Cn} = \left(\frac{n}{2}\right)\frac{V_{\text{in}1}}{(1-d_1)} + \left(\frac{n}{2}\right)\frac{V_{\text{in}2}}{(1-d_2)} \qquad (6)$$

If n is even & n ≤ N

The output voltage equation of the converter with N number of VM stages depends on whether N is odd or even and is given by

$$V_{\text{out}} = V_{CN} + \frac{V_{\text{in}2}}{(1-d_2)} \qquad \text{if } N \text{ is odd}$$

$$= \left(\frac{N+1}{2}\right)\frac{V_{\text{in}1}}{(1-d_1)} + \left(\frac{N+1}{2}\right)\frac{V_{\text{in}2}}{(1-d_2)} \qquad (7)$$

$$V_{\text{out}} = V_{CN} + \frac{V_{\text{in}1}}{(1-d_1)}$$

If N is even

$$= \left(\frac{N+2}{2}\right)\frac{V_{\text{in}1}}{(1-d_1)} + \left(\frac{N}{2}\right)\frac{V_{\text{in}2}}{(1-d_2)} \qquad (8)$$

When the converter operates in an interleaved manner with single input source, if d_1 and d_2 are also chosen to be identical, i.e., $d_1 = d_2 = d$, then the output voltage is given by

$$V_{\text{out}} = (N+1)\frac{V_{\text{in}}}{(1-d)} \qquad (9)$$

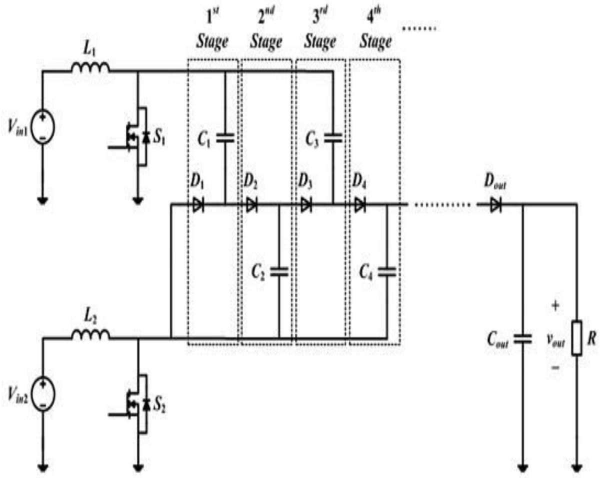

Fig.7. Alternative to the proposed converter with N number of VM stages

In, an interleaved boost power factor corrected converter with voltage-doubler characteristics is introduced. It can be observed that it is a special case of the proposed converter with a single VM stage (N = 1).It is worth noting that there is an alternative to the proposed converter (see Fig.7) where diode D1 of the first VM stage is connected to the lower boost switching node and capacitor C1is connected to the upper boost switching node (compare with Fig.6).

The output voltage equation for this alternative topology is given by

$$V_{\text{out}} = \left(\frac{N+1}{2}\right)\frac{V_{\text{in}1}}{(1-d_1)} + \left(\frac{N+1}{2}\right)\frac{V_{\text{in}2}}{(1-d_2)} \qquad \text{if } N \text{ is odd} \qquad (10)$$

$$V_{\text{out}} = \left(\frac{N}{2}\right)\frac{V_{\text{in}1}}{(1-d_1)} + \left(\frac{N+2}{2}\right)\frac{V_{\text{in}2}}{(1-d_2)} \qquad \text{if } N \text{ is even.} \qquad (11)$$

For N = 1, if one combines the topology depicted in Fig.6 with its alternative (see Fig.7), then the resulting converter in Fig.8 is similar to the multiphase converter introduced.

In general, when both topologies with N number of VM stages are combined, then the resulting converter is shown in Fig.3.10.When N is odd, then from (7) and (10), the voltage gain of the combined topology is given by

$$V_{out} = \left(\frac{N+1}{2}\right)\frac{V_{in1}}{(1-d_1)} + \left(\frac{N+1}{2}\right)\frac{V_{in2}}{(1-d_2)}$$

$$\text{if } N \text{ is odd.} \qquad (12)$$

In this case, the original topology and its alternative each process half of the output power. In other words, the average currents of Dout1 and Dout2 are equal.When N is even, the output voltage of the combined topology would be either (8) or (11) and will be dictated by the topology that provides a higher output voltage. Both legs (see Fig.9)would compete with each other and only one of the output diodes (Dout1 and Dout2) would process the entire power while the other will be reverse biased. When N is even, putting the converters in parallel only makes sense if there is only one source used and $d_1 = d_2$. In that case both (8) and (11) determine the output voltage to be

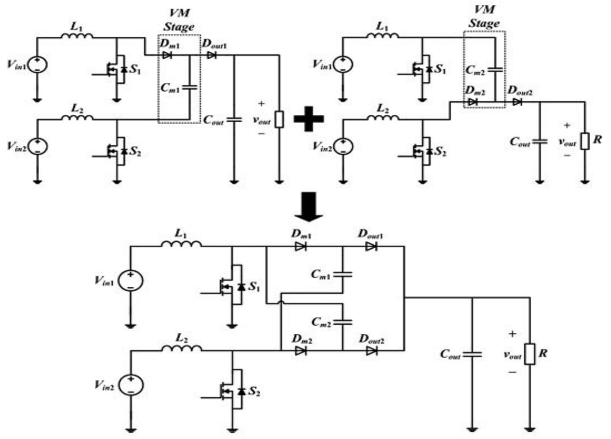

Fig.8. Combined topology with single VM stage

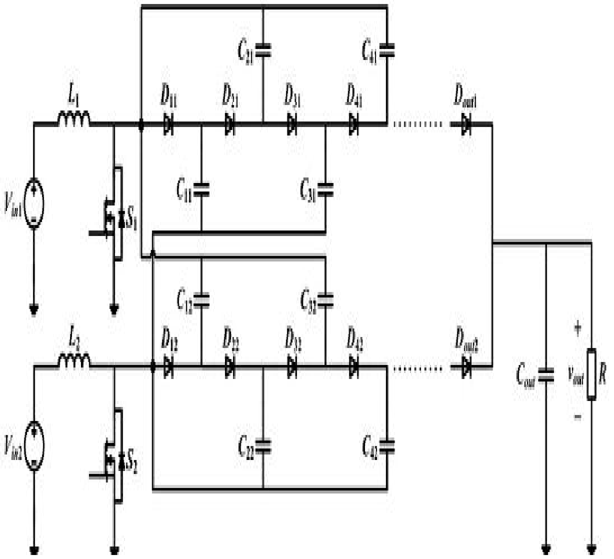

Fig.9. Combined topology with N number of VM stages

$$V_{out} = (N+1)\frac{V_{in}}{(1-d)} \quad \text{if } N \text{ is even} \qquad (13)$$

For the combined topology with a single input source and identical duty ratios d1 and d2, i.e., d1= d2 = d, both the boost stages will always have symmetrical inductor and switch currents irrespective of the number of VM stages.

IV. MATLAB/SIMULINK RESULTS

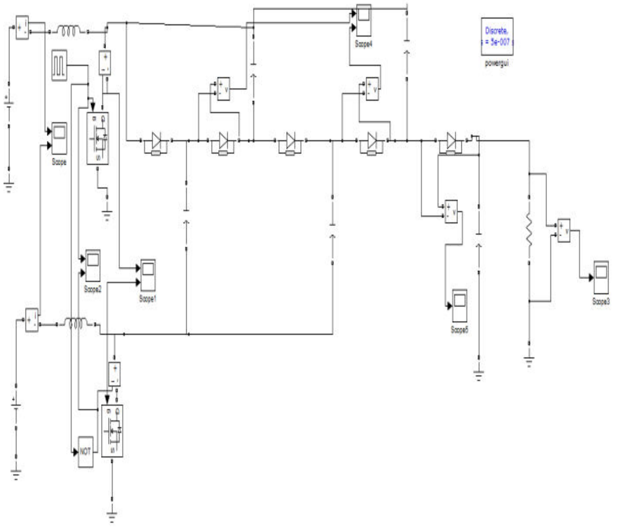

Fig.10 Proposed high-voltage-gain dc–dc converter with four VM stages

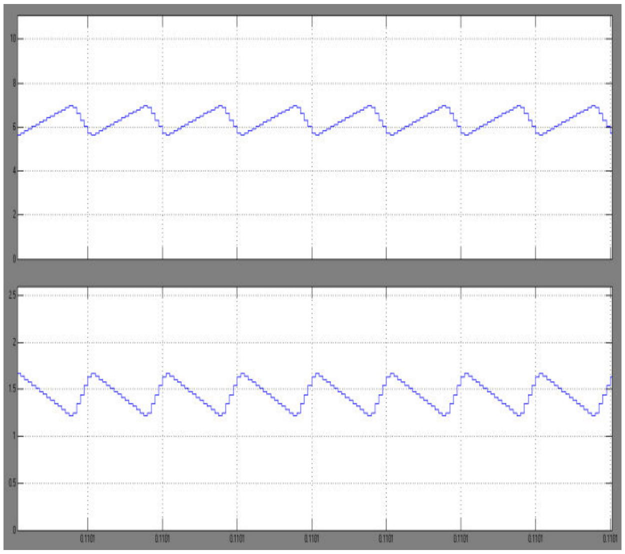

Fig.11 Output waveform of inductor currents

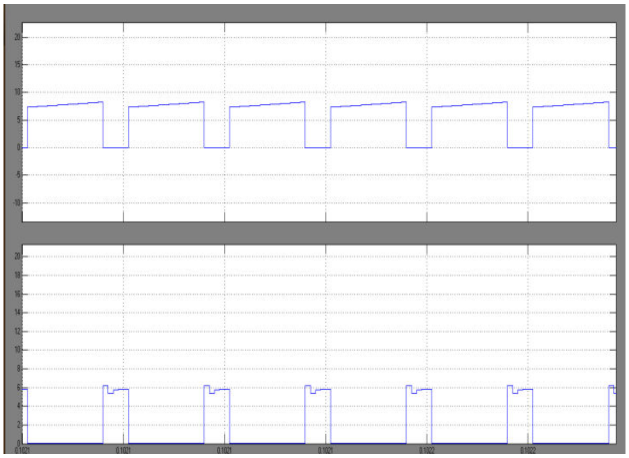

Fig.12 Output waveform of switch currents

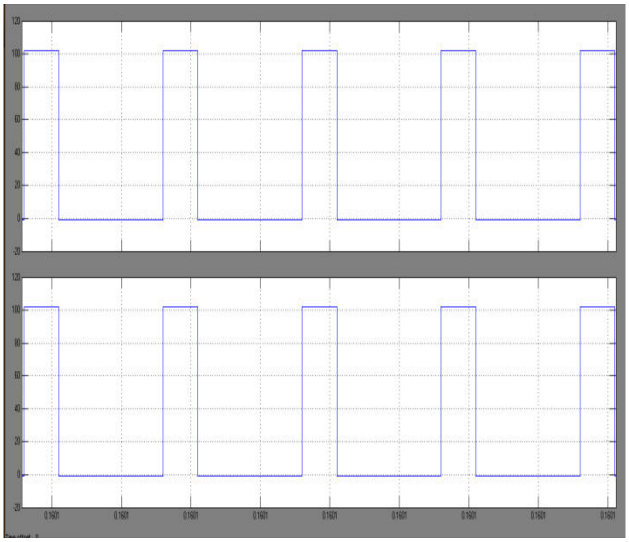

Fig.13 Voltage waveform of diode voltages

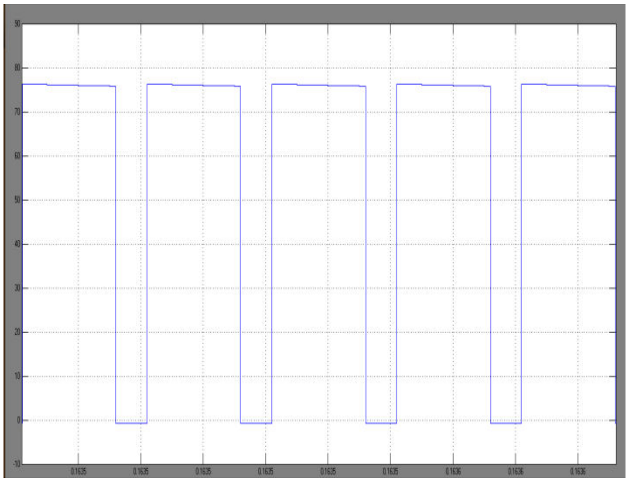

Fig.14 Voltage waveform across output diode

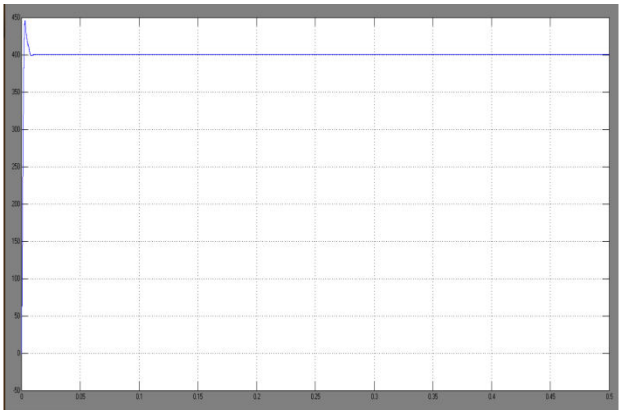

Fig.15 Output voltage waveform

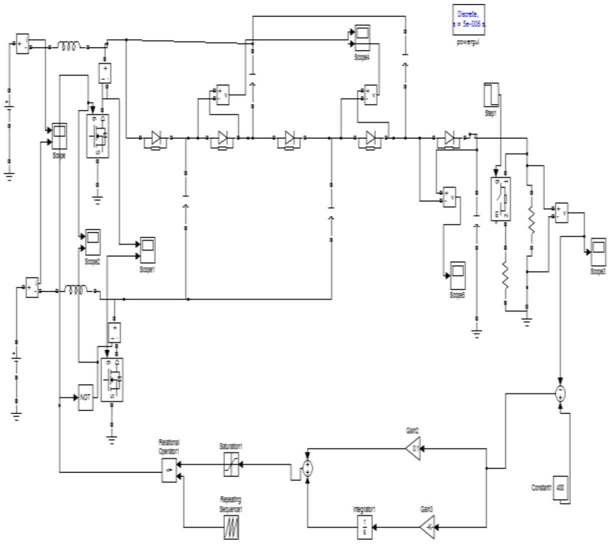

Fig.16 Proposed high-voltage-gain dc–dc converter with four VM stages with closed loop controller

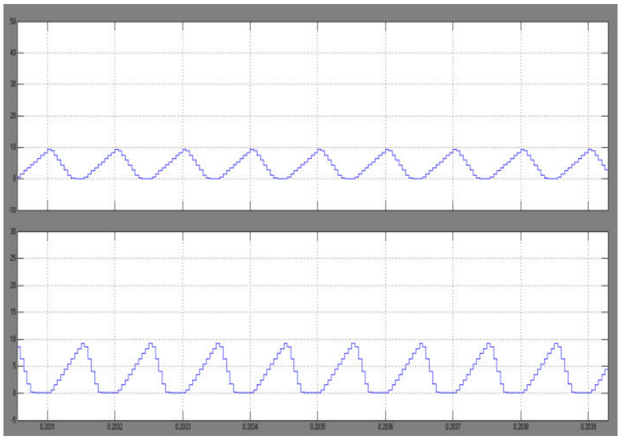

Fig.17 Output waveform of inductor currents

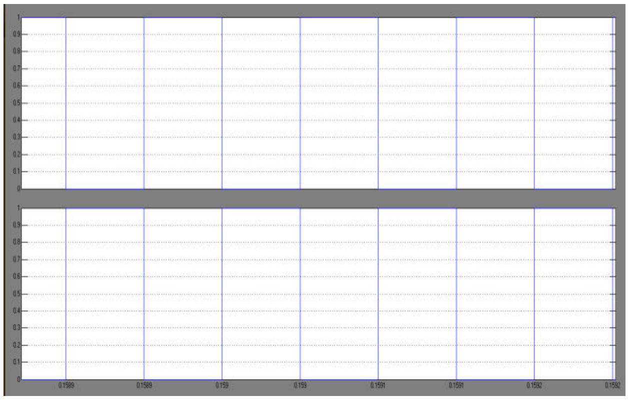

Fig.18 Output waveform of switch currents

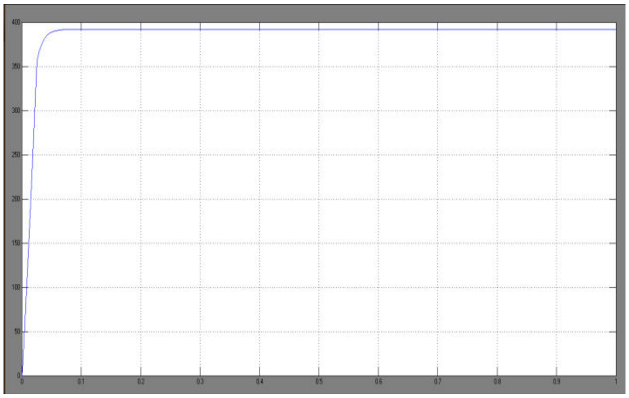

Fig.19 Output voltage waveform of closed loop controller

V. CONCLUSION

Thus a closed loop circuit of DC– DC converters based on the Three-States witching cell and voltage multiplier cells was introduced in this paper using PI controller.The proposed converter is based on diode–capacitor VM stages and the voltage gain is increased by increasing the number of VM stages. It can draw power from two input sources like a multiport converter or operate in an interleaved manner when connected to a single source. These problems can be reduced by using a converter based on voltage multiplier. Dc-dc converter can achieve a low voltage gain to step up a high voltage gain output. The proposed converter is based on a boost stage. Therefore work has been successfully carried out to make the design compact and to improve the performance of voltage controlled boost converter. To provide a better compact design and a converter which operates in low duty cycles a new modified method of closed loop control of boost converter with voltage control method have been developed which provides low ripple and compactness in the design.Closed loop control can be done by average current control method instead of voltage mode control.

REFERENCES

[1] J.Zhang,J. Shao,P. Xu,F. C. Lee,and M. M. Jovanovic´, “Evaluation of input current in the critical model boost PFC converter for distributed power systems,” in Proc. IEEEAppl. Power Electron. Conf.(APEC), pp.130–136,2006.

[2] Yungtaek Jangand Milan M. Jovanovic ,”New Two-Inductor Boost Converter with Auxiliary Transformer”, IEEE TRANSACTIONSON POWER ELECTRONICS, VOL.19, NO.1, 2004.

[3] Yungtaek Jang, and MilanM. Jovanovic, “Inter- leaved Boost Converter with Intrinsic Voltage- Doubler Characteristics for Universal-Line PFC Front End”, IEEE TRANS-

ACTIONSON POWER ELECTRONICS, VOL.22, NO.4, 2007

[4] MarcosPrudente, LucianoL.Pfitscher, GustavoEmmendoer- fer, EduardoF. Romaneli, and Roger Gules, “Voltage Multiplier Cells Applied to Non-Isolated DC–DC Converters”, IEEE transactions on power electronics, vol. 23, no.2, 2008.

[5] R. N. A.L.Silva, G. A.L.Henn, P. P. Prac¸a,L.H. S. C. Barreto,D. S. Oliveira, Jr., andF. L.M. Antunes, “Soft-switching interleaved boostconverter withhigh voltage gain,”IEEEPowerElectron.Spec.Conf.(PESC), pp. 4157–4161, Jun. 2008.

[6].EduardoKazuhide Sato MasahiroKinoshita,YushinYa-mamotoandTatsuakiAmboh (2010),’Redundant High-Density High-Efficiency Double-Conversion Uninterruptible Power System”, IEEE TRANSACTIONS ON NDUSTRY APPLICATIONS, VOL.46, NO. 4, 2010..

[7] Samuel VasconcelosAraújo,RenéP. Torrico-Bascopé and Grover. Torrico-Bascopé,(2010),”Highly Efficient High Step-Up Converter for Fuel-Cell Power Processing Based on Three-State Commutation Cell” IEEE TRANSACTIONSON INDUSTRIAL ELECTRONICS, VOL.57, NO.6, 2010.

[8] SungsikPark, YohanPark, SewanChoi, Woojin Choi, and Kyo-BeumLee,” Soft-Switched Interleaved Boost Converters for High Step-Up and High-Power Applications” IEEETRANSACTIONSON POWER ELECTRONICS, VOL.26, NO.10, 2011.

[9] Yi-Ping Hsieh, Jiann-Fuh Chen, Tsorng-Juu (Peter) Liang, and Lung-Sheng Yang, “Novel High Step-Up DC–DC ConverterWithCoupled-Inductor and Switched-Capacitor Techniques for aSustainableEnergySystem,”IEEETransactionson Power Electronics, VOL.26, NO.12, 2011.

[10] W. Hongfei, M. Tiantian, G. Hongjuan, and X. Yan, "Full-Range Soft-Switching-Isolated Buck-Boost Converters With Integrated Interleaved Boost Converter and Phase-Shifted Control,", IEEE Trans.Power Electron, vol. 31, pp. 987-999, 2016.

[11] H. Xuefeng and G. Chunying, "A High Voltage Gain DC-DC Converter Integrating Coupled-Inductor and Diode-Capacitor Techniques," IEEE Trans.Power Electronics, vol. 29, pp. 789-800, 2014.

[12] W. Gang, R. Xinbo, and Y. Zhihong, "Nonisolated High Step-Up DC-DC Converters Adopting Switched-Capacitor Cell,", IEEE Trans. Ind Electron, vol. 62, pp. 383-393, 2015

[13] V. A. K. Prabhala, P. Fajri, V. S. P. Gouribhatla, B. P. Baddipadiga, and M. Ferdowsi, "A DC-DC Converter With High Voltage Gain and Two Input Boost Stages,", IEEE Tran. Power Electron, vol. 31, pp. 4206-4215, 2016.

[14] J. C. Rosas-Caro, F. Mancilla-David, J. C. Mayo-Maldonado, J. M. Gonzalez-Lopez, H. L. Torres-Espinosa, and J. E. Valdez-Resendiz, "A Transformer-less High-Gain Boost Converter With Input Current Ripple Cancelation at a Selectable Duty Cycle,", IEEE Trans.Ind Electron, vol. 60, pp. 4492-4499, 2013.