

# An Improved Voltage Gain Employing Three-State Switching Cell and Voltage Multiplier Cell

S.Rajendran<sup>#1</sup> M.Annalakshmi<sup>\*2</sup>

<sup>#1</sup> Department of Electrical and Electronics Engineering, Kalasalingam University, India.

<sup>\*2</sup> Department of Electrical and Electronics Engineering, Kalasalingam University, India.

**ABSTRACT**— Normally, the boost converter is used to improve the output voltage than the input voltage. A new topology of dc-dc converter is introduced for getting maximum voltage gain. The boost converter employing 3-state switching cell and voltage multiplier cell is used for improving the voltage gain and efficiency. It can be used in uninterruptible power supplies, fuel cell systems, and renewable energy systems. It is suitable in cases where dc voltage step-up is needed, such as electrical fork-lift, audio-amplifier and many other applications.

**KEYWORDS** - Boost converters, dc-dc converters, high voltage gain, voltage multiplier cells (VMCs).

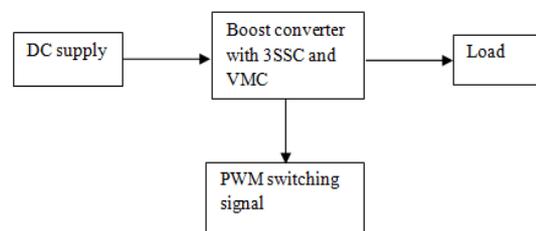
## I. INTRODUCTION

Several types of converters are necessary for the adequate conversion of the energy provided by primary sources such as photovoltaic arrays, wind turbines and fuel cells. But the overall cost of renewable energy system is high. The different type of dc-dc converters are buck, boost, buck-boost, Cuk, SEPIC, and zeta. SEPIC converter can easily achieve high voltage gain. It consists of more number of inductors and capacitors. Hence the circuit is complex and cost is also high [5]. In boost, many numbers of diodes and capacitors are used for voltage step-up applications. This boost converter is able to operate in overlapping mode (when a duty cycle  $D$  is higher than 0.5). The input current of the boost converter has small amount of ripple. The output voltage is higher than the input voltage [4]. The advantages of this boost converter has reduced size, weight and volume. So that the overall cost of this circuit is low. It reduced blocking voltages across the switches. The losses across the

switches are also reduced by using these switching cells.

## II. PROPOSED BLOCK DIAGRAM

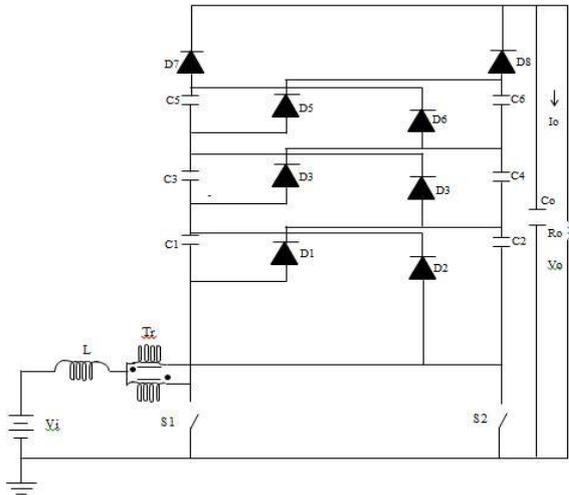
Figure 1 shows that the basic block diagrams of boost converter with 3-state switching cell and voltage multiplier cell. It consists of DC supply, Boost converter with 3-SSC and VMC, PWM switching signal and Load. The DC supply is produced by sources such as batteries, thermocouples and solar cells. The DC supply of the electric circuit is constant. The supply is given to the boost converter with 3-SSC and VMC. This converter takes the input voltage, inverts it to an AC voltage, and then rectifies it back to a different DC voltage. A voltage multiplier cell is an electrical circuit that converts AC from a lower voltage to a higher DC voltage.



It can be used to generate a few volts for electronic appliances to millions of volts for purposes such as high-energy physics experiments and lightning safety testing. The PWM signal is given to the thyristors of boost converter. The output of this boost converter is given to load. Load affects the performance of circuits that output

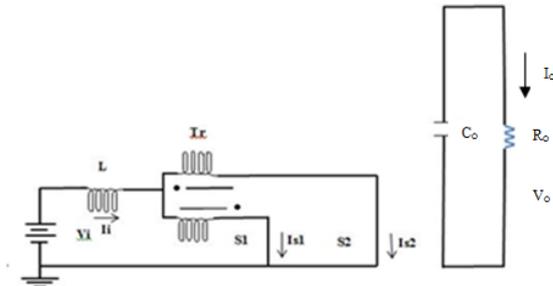
## An Improved Voltage Gain Employing Three-State Switching Cell and Voltage Multiplier Cell

voltages or currents, such as sensors, voltage sources and amplifiers. In a domestic environment, switching on a heating appliance may cause incandescent lights to dim noticeably. Figure 2 shows that the boost converter using 3-state switching cell and voltage multiplier cell. It consists of two switches S1 and S2. In this figure, the controlled switches can be represented by MOSFETs, JFETs, IGBTs, BJTs, etc..., In this boost converter, more number of diodes and capacitors are used.



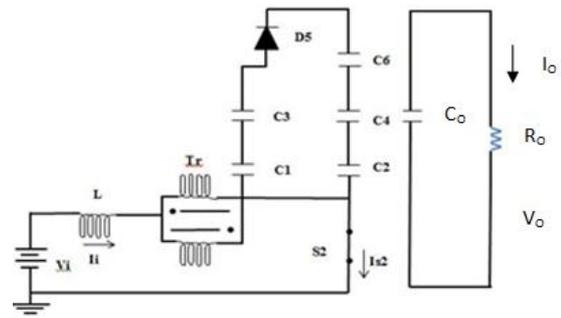
**Figure 1. Boost converter using 3SSC and VMC**

### III. OPERATING PRINCIPLE OF 3SSC



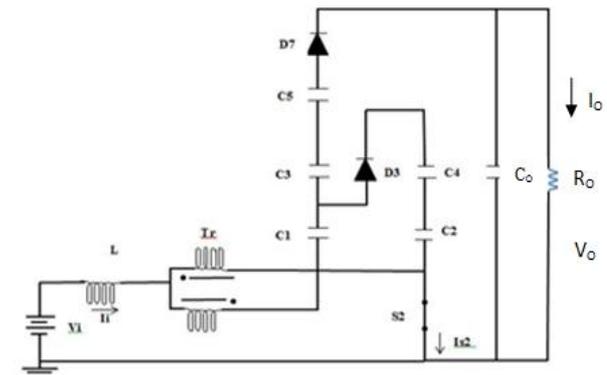
**Figure 2. First Stage of operation**

Figure 3 shows that switches S1 and S2 are turned ON, while all diodes are reverse biased. Energy is stored in inductor L and no energy is transmitted to the load. The output capacitor provides energy to the load. This stage finished when switch S1 is turned OFF. Figure 4 shows that switch S1 is turned OFF, while S2 is still turned ON and diode D5 is forward biased. There is no energy transmit to the load. Inductor L stores energy, capacitors C1 and C3 are discharged, and capacitors C2, C4 and C6 are charged.

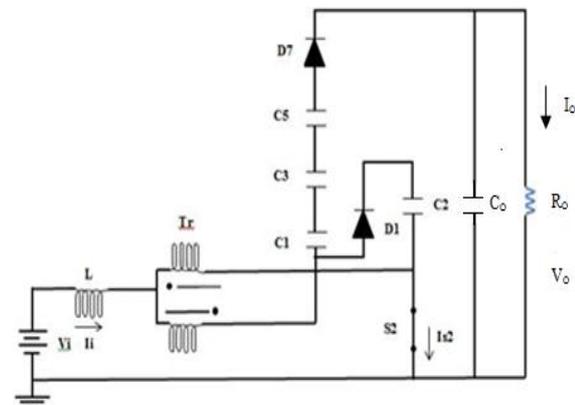


**Figure 3. Second Stage of operation**

Figure 5 shows that the switch S1 and S2 stay turned OFF and ON, respectively. Diodes D3 and D7 are forward biased, while all the left over ones are reverse biased. Energy is transferred to the output stage through D7. The inductor provisions energy and capacitors C2 and C4 are still charged. Capacitors C1, C3 and C5 are discharged. Energy is stored in inductor L. The output capacitor provides energy to the load. Figure 6 shows that switch S2 remains turned ON, diode D3 is reverse biased, and diode D1 is forward biased. Energy is transferred to the load through D7. The inductor is discharged, and so are capacitors C1, C3, and C5, while C2 is charged.



**Figure 4. Third Stage of operation**



**Figure 5. Fourth Stage of operation**

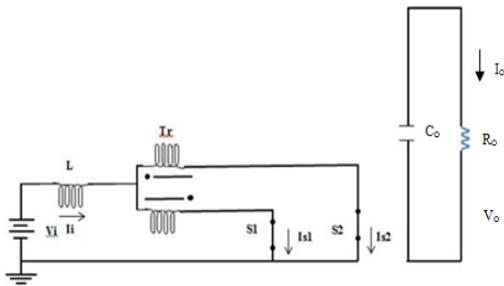


Figure 6. Fifth stage of operation

Figure 7 show this stage is alike to the first one. Energy is stored in inductor L and there is no energy relocates to the load. The output capacitor provides energy to the load. This stage finished when switch S1 is turned OFF.

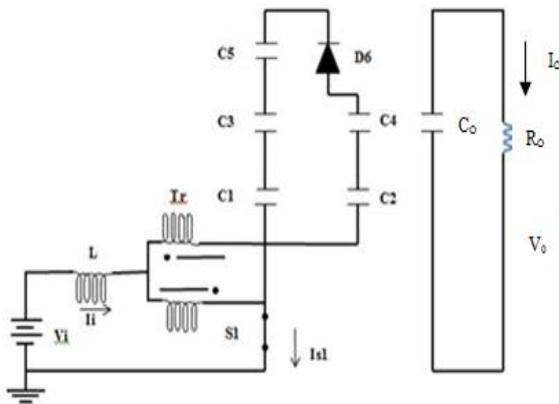


Figure 7. Sixth Stage of operation

Figure 8 show that the switch S2 is turned OFF and switch S1 is still switched ON. Diode D6 is forward biased. The inductor is exciting by the input source, although capacitors C2 and C4 are discharged instead abbreviations in the title unless they are unavoidable (for example, “IEEE” in the title of this article).

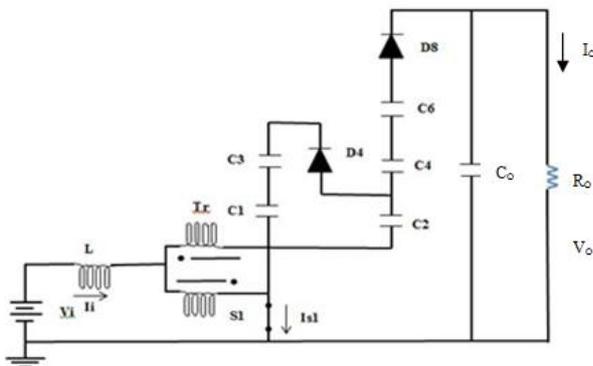


Figure 8. Seventh Stage of operation

Figure 9 show that this stage is parallel to the third one. Switches S1 and S2 stay behind turned OFF and ON, correspondingly. Diode D6 is forward biased. Energy is stored in inductor L and there is no energy transmit to the load .Capacitors C1, C3, C5 are charged. Capacitors

C2 and C4 is discharged. The output capacitor provides energy to the load. Figure 10 shows that the switch S1 is turned ON, while S2 remains turned OFF. Diodes D2 and D8 are forward biased, while D4 is reverse biased as well as the enduring diodes. Energy is shift to the load occurs through D8, and capacitor Co is still charged. The inductor is discharged, while capacitor C1 is charged and capacitors C2, C4, and C6 are discharged.

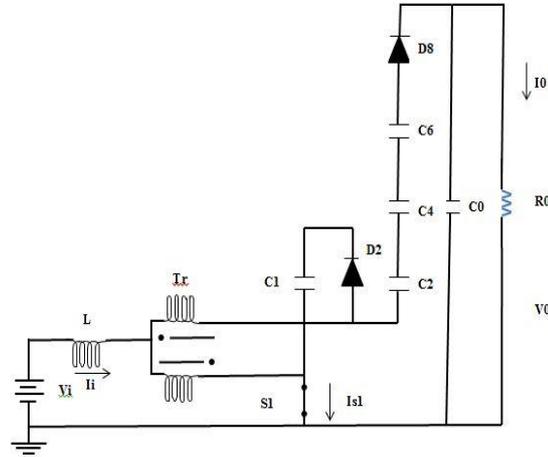


Figure 9. Eighth Stage of operation

IV. PRELIMINARY CALCULATIONS

The maximum input power is

$$P_i = \frac{P_o}{\eta} = 1052.3W.$$

Where, Pi = Input power.  
Po = Output power.  
η = Efficiency.

INDUCTOR:

Besides, the normalized ripple current β as a function of the duty cycle is given by

$$\beta = \frac{2L\Delta I I f_s}{V_o} = \frac{(1 - D)(2D - 1)}{MC + 1}$$

Where it can be seen that for curve (Multiplier Cell) MC=3 and duty cycle D=0.75 the maximum normalized. Ripple current is β= 0.03125. The respective inductance is calculated.

$$L = \frac{V_o \beta}{2f_s \Delta I I} \cong 70\mu H.$$

Where, L = Inductor.  
Vo = Output voltage.  
fs = Switching frequency

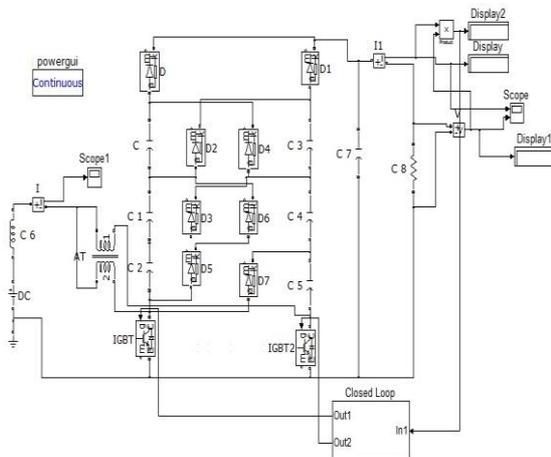
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TABLE-I CALCULATION FOR EFFICIENCY

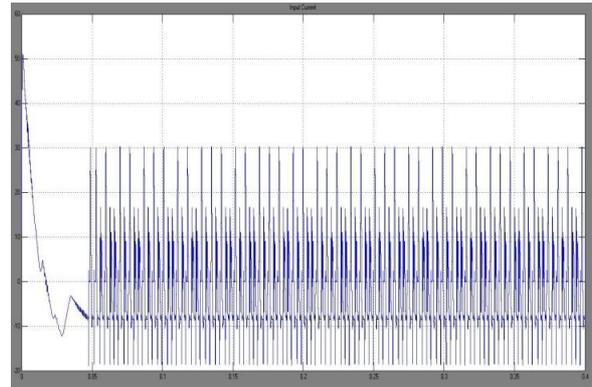
Sl.no	Parameter	Specification
1	Input voltage (VI)	50V
2	Input current (Ii)	22A
3	Input power (Pi)	$50 * 22 = 1100W.$
4	Output voltage (VO)	400V
5	Output current (Io)	2.5A
6	Output power (Po)	$400 * 2.5$ $1000W.$
8	Efficiency ( $\eta$ ) $Po/Pi$	$1000/1100$ $90.90\%.$

### V. SIMULATION DIAGRAM FOR CLOSED LOOP

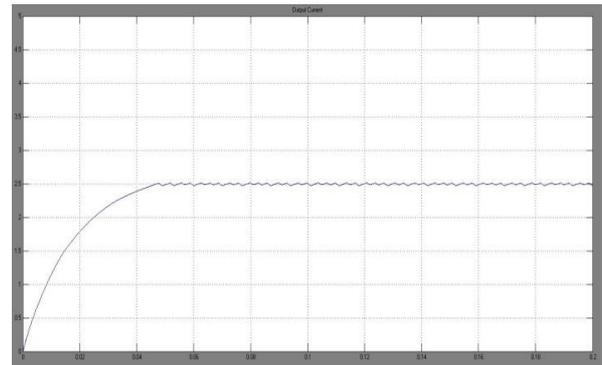
Figure 11 shows that the simulations of closed loop diagram. The dc voltage is given to the auxiliary drive circuit. The energy is stored in inductor also. The gate pulses are given to two switches. The output voltage and current is taken across the load. The output power is calculated from this output voltage and current measurements of closed loop condition.



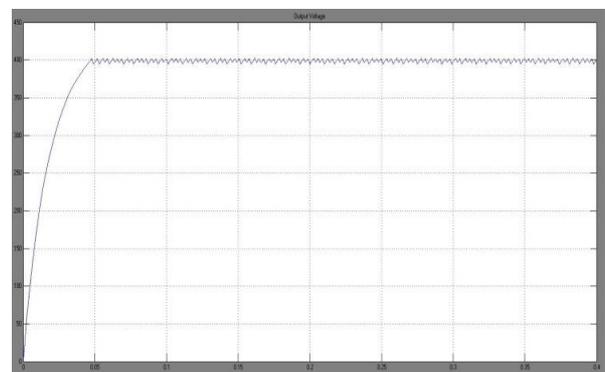
**Figure 11. Simulation Diagram for Closed Loop**



**Figure 12. Simulation Output for Closed Loop Input Current**



**Figure 13. Simulation Output for Closed Loop Output Current**



**Figure 14. Simulation Output for Closed Loop Output Voltage**

### VI. CONCLUSION

This paper is applied for six no. of non-isolated high gain voltage dc-dc converters. Here boost converter was chosen. This topology is suited for several applications such as photovoltaic systems, fuel systems, and UPSs, where high voltage gain between the input and output voltage is required. The advantages of 3-state switching and voltage multiplier cells are incorporated into the resulting topology. The part of energy from the input source flows through the active switches, while the

remaining part is directly transferred to the load without being processed by these switches. This boost converter achieves about 90.90% efficiency at rated load if compared to similar configurations that were previously proposed in the literature. It is also expected that non-isolated converters based on the 3-SSC and VMC may be competitive solutions for high-current-high-voltage-step-up applications if compared with some other isolated approaches.

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### REFERENCES

- [1] R. Kadri, J.-P. Gaubert, and G. Champenois, "An improved maximum power point tracking for photovoltaic grid-connected inverter based on voltage-oriented control," *IEEE Trans. Ind. Electron.*, vol. 58, no. 1, pp. 66–75, Jan. 2011.
- [2] M. Berkhout and L. Dooper, "Class-D audio amplifiers in mobile applications," *IEEE Trans. Circuits Syst. I, Reg. Papers*, vol. 57, no. 5, pp. 992–1002, May 2010.
- [3] S. V. Araujo, R. P. Torrico-Bascope, and G. V. Torrico-Bascope, "Highly efficient high step-up converter for fuel-cell power processing based on three-state commutation cell," *IEEE Trans. Ind. Electron.*, vol. 57, no. 6, pp. 1987–1997, Jun. 2010.
- [4] G. V. Torrico-Bascope, R. P. Torrico-Bascope, D. S. Oliveira Jr., S.V. Araujo, F. L. MAntunes, and C. G. C. Branco, "A generalized high voltage gain boost converter based on three-state switching cell," in *Proc. IEEE Int. Symp. Ind. Electron.* 2006, pp. 1927–1932.
- [5] E.H.Miller, "A note on reflector arrays (Periodical style-Accepted for publication)," *IEEE Trans. Antennas Propagat*, in press.
- [6] K. W. Ma and Y. S. Lee, "An integrated flyback converter for dc uninterruptible power supply," *IEEE Trans. Power Electron.*, vol. 11, no. 2, pp. 318–327, Mar. 1996.