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Closed Loop Control of PV fed High Voltage Gain DC-DC converter with Two-Input Boost-Stages

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Abstract: DC-DC converter is a device which produces a dc output voltage when a dc input is given. If output voltage needed is higher than input voltage we go for boost converter. 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. Generally conventional boost converters have been used to obtain higher output voltage than the input voltage. When these boost converters are operated for high ratios it leads to high voltage and current stress on the switch. Hence an interleaving technique of boost converter has been presented. This method of approach can be used in high power applications to produce high voltage gain when compared to the conventional boost converter. A simple dc-dc boost converter are unable to provide high step-up voltage gains due to the effect of power switches, rectifier diodes, and the equivalent series resistance of inductor and capacitors. In this paper proposes new dc-dc converter to achieve high voltage gain without an extremely high duty ratio. In the proposed converters, two inductors with the same level of inductance are charged in parallel during the switch –on period and are discharged in series during the switch-off period. In this converter mainly proposed converter. That is used for PV system. To achieve high-voltage conversion ratios, a new family of high-voltage-gain dc–dc power electronic converters has been introduced. The proposed converter can be used to draw power from two independent dc sources as a multiport converter or one source in an interleaved manner. They draw continuous input current from both the input sources with low current ripple which is required in many applications, e.g., solar. Several diode-capacitor stages are cascaded together to boost up the voltage which limits the voltage stresses on the switches, diodes, and capacitors.

I. 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 (see Fig.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.

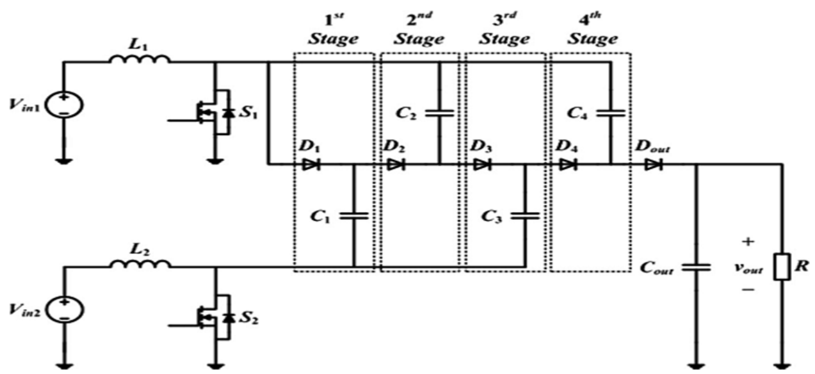

Fig.1. Proposed high-voltage-gain dc–dc converter with four VM stages.

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A. Mode-I

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

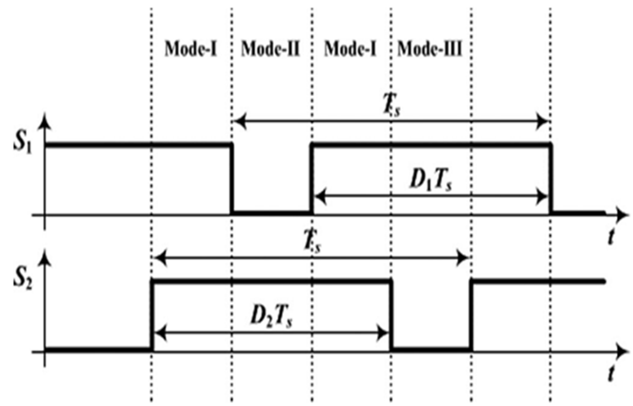

Fig.2. Switching signals for the input boost stage for the proposed converter.

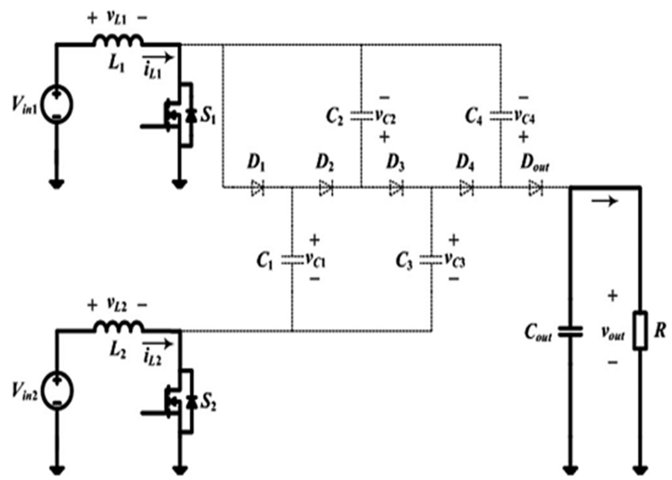

Fig.3. Mode-I of operation for the proposed converter with four VM stages.

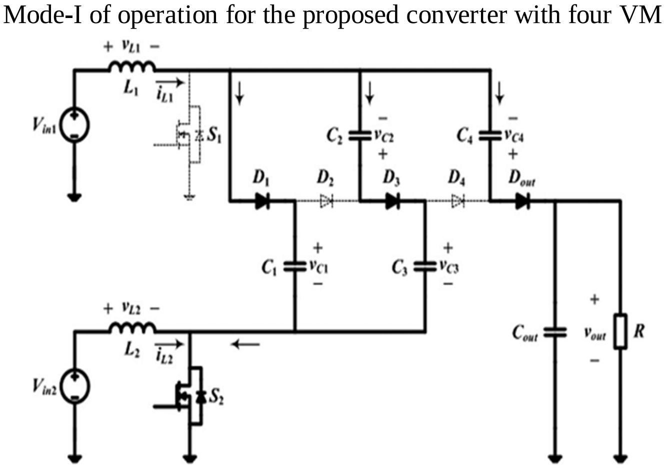

Fig.4. Mode-II of operation for the proposed converter with four VM stages.

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 VM stages 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.

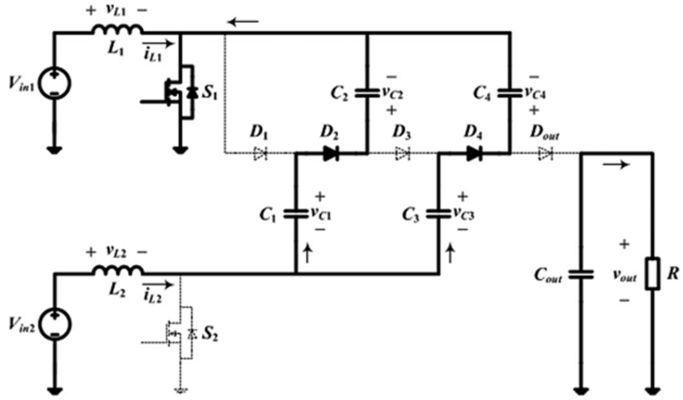

Fig.5. Mode-III of operation for the proposed converter with four VM stages.

In the particular case considered here, since there are four VM stages, 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

$$\langle v_{L1} \rangle = 0 \tag{1}$$

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

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

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) in terms of lower boost switching node voltage as

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

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

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

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

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

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

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

$$V_{\text{out}} = V_{C4} + \frac{V_{\text{in}1}}{(1-d_1)} = \frac{3V_{\text{in}1}}{(1-d_1)} + \frac{2V_{\text{in}2}}{(1-d_2)} \tag{6}$$

Since in proposed converter we are taking n number of stages (n=4) .the ouput voltage for four V_m stages has been derived and this topology provides a higher output voltage. In the other words the average currents of Dout1 and Dout2 are equal.In this topology with two input sources boost stages will always have symmetrical inductor and switch currents with respective of the number of Vm stages.

IV. MATLAB/SIMULINK RESULTS:

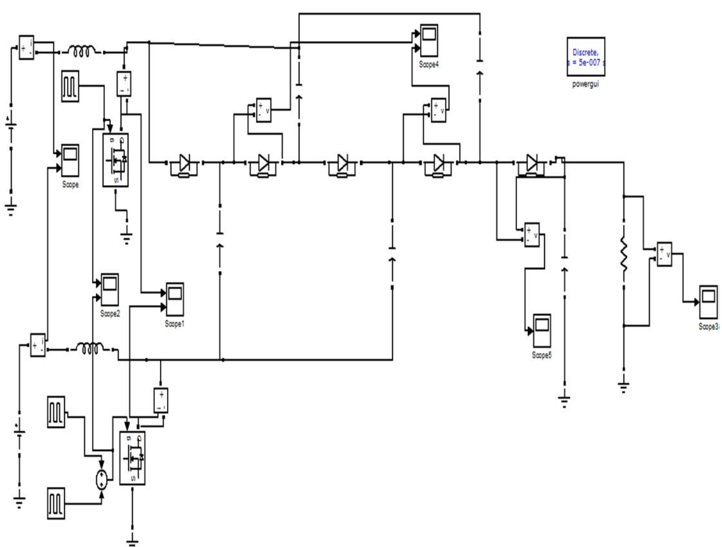

Fig.10. Matlab/simulink Model for Proposed with Two Input Boost Stages

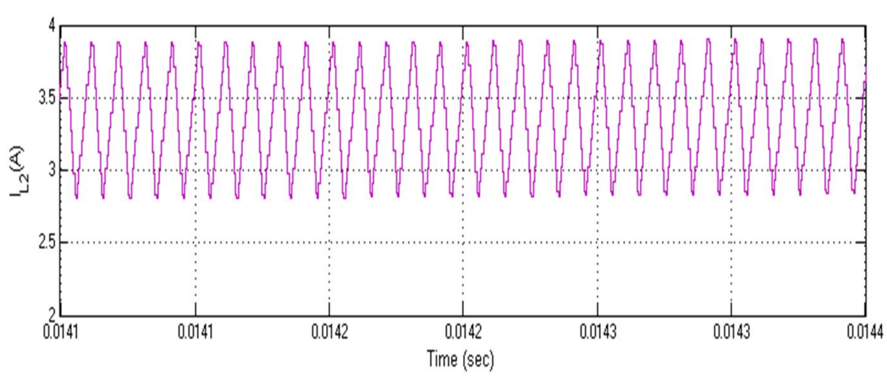

Fig.11. Inductor Current (I_{L2})

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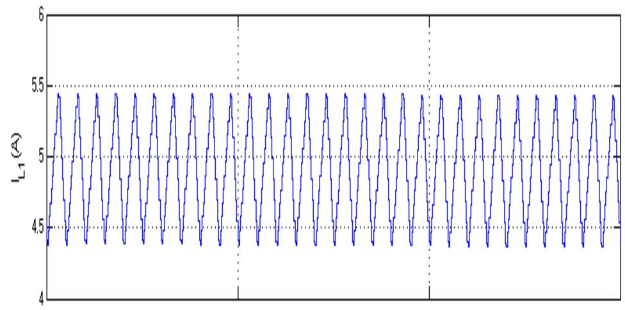

Fig.12. Inductor Current (I_{L1})

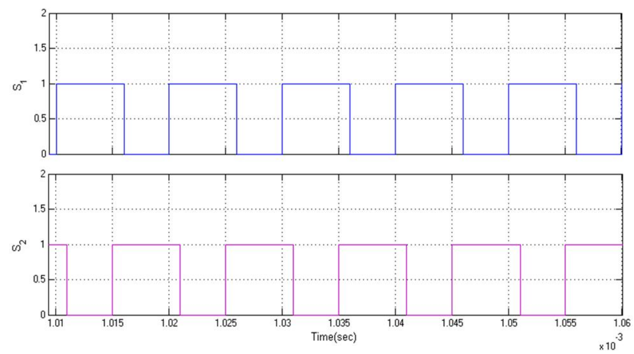

Fig.13. Switch Gating Pulses S_1, S_2

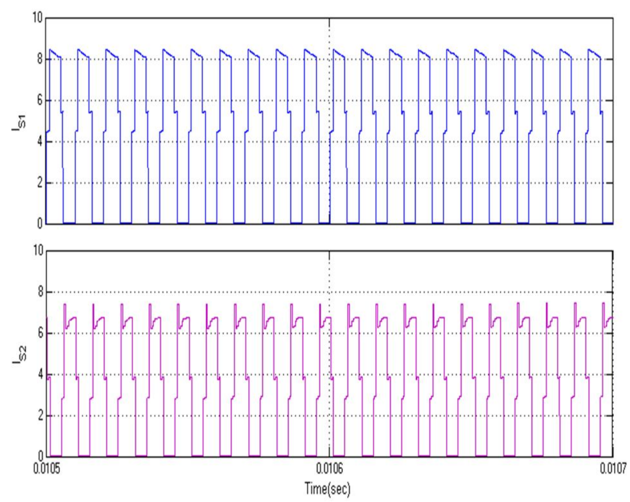

Fig.14. Switching Currents I_{S1}, I_{S2}

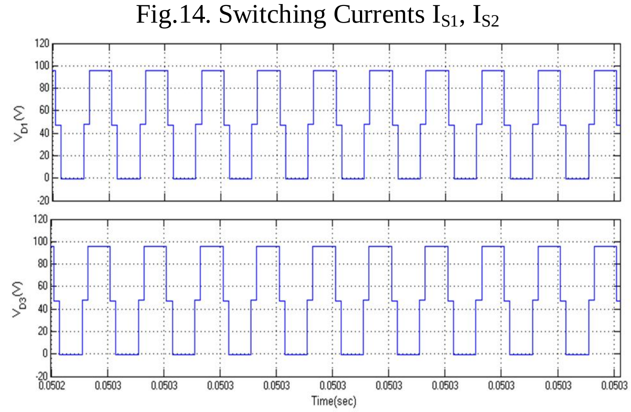

Fig.15. Diode Voltages V_{D1}, V_{D3}

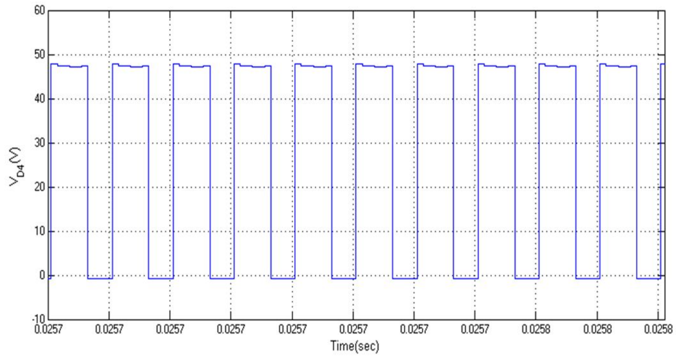

Fig.16. Diode Voltage V_{D4}

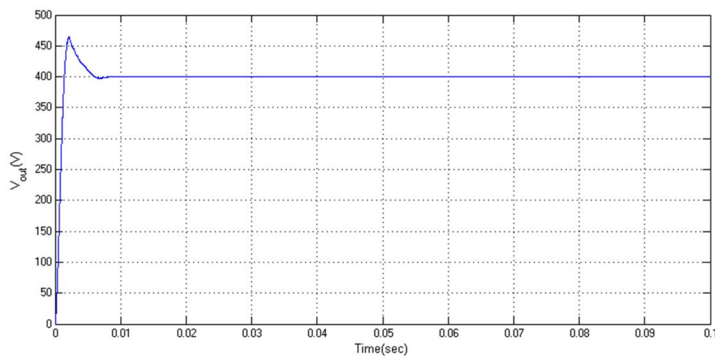

Fig..17. Output Boost Voltage V_0.

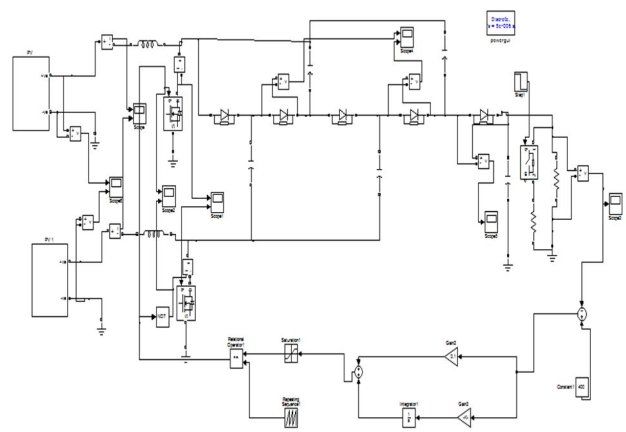

Fig.18. Matlab/simulink Model of Proposed converter with PV Fed Closed loop operation.

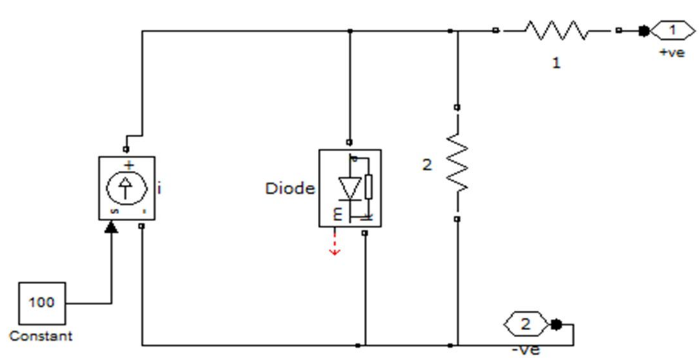

Fig.19. Matlab/simulink Model for PV System.

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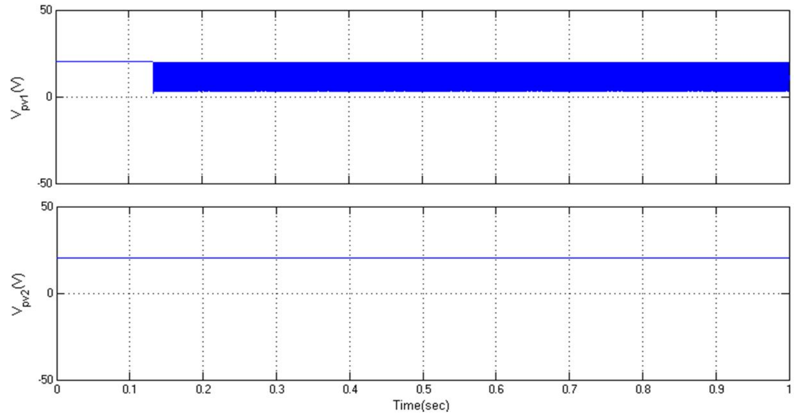

Fig.20. Source Voltages V_{PV1}, V_{PV2}

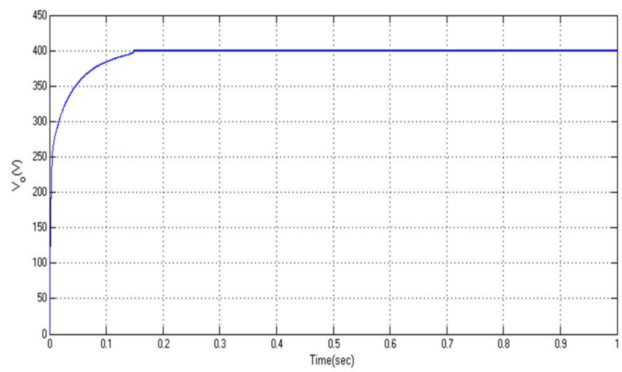

Fig.21. Output Voltage.

COMPARSION WITH THE PROPOSED CONVERTER

Topology	[1]	[2]	[3]	[4]	Proposed Converter
No. of switches	1	1	2	2	2
No. of inductors	1	1	2	2	2
No. of capacitors	4	3	3	3	5
No. of diodes	4	3	3	3	5
Vout/Vin	$\frac{3-d}{1-d}$	$\frac{2}{1-d}$	$\frac{3+d}{1-d}$	$\frac{1}{d(1-d)}$	$\frac{5}{(1-d)}$
VSwitch/Vout	$\frac{1}{3-d}$	$\frac{1}{2}$	$\frac{1}{3+d}$	d	$\frac{1}{5}$
Input current	Discontinuous	Continuous	Discontinuous	Continuous	Continuous

A. W. Bin, L. Shouxiang, L. Yao, and K. M. Smedley, "A New Hybrid Boosting Converter for Renewable Energy Applications," Power Electronics, IEEE Transactions on, vol. 31, pp. 1203-1215, 2016. The second order hybrid boosting converter proposed in offers relatively low voltage gain in comparison to its voltage multiplier component count. It also has a very large input current ripple in proportion to its average.

B. W. Gang, R. Xinbo, and Y. Zhihong, "Nonisolated High Step-Up DC-DC Converters Adopting Switched-Capacitor Cell," Industrial Electronics, IEEE Transactions on, vol. 62, pp. 383-393, 2015. High step-up converters using single-inductor-energy-storage-cell-based switched capacitors proposed in do not offer voltage gains high enough to boost a 20V input to 400V at an reasonable switching duty cycle. The multiple-inductor-energy-storage-cell-based switched capacitor based high voltage converters offer a relatively low voltage gain in proportion to its component count

C. T. Yu, W. Ting, and H. Yaohua, "A Switched-Capacitor-Based Active-Network Converter With High Voltage Gain," Power Electronics, IEEE Transactions on, vol. 29, pp. 2959-2968, 2014.

1) The switched-capacitor-based active-network converter proposed in has a discontinuous input current ripple due to the series and parallel connection of the inductors in its two modes of operation.

D. 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," Industrial Electronics, IEEE Transactions on, vol. 60, pp. 4492-4499, 2013.

1) The transformer-less high-gain boost converter proposed in offers continuous input current but the switches experience a high voltage stress more than 2/3rd of its output voltage.

V. CONCLUSION

In this paper, the photovoltaic system with dc-dc converter has been designed with a constant input voltage 20v is maintained at ouput side of the converter voltage gain of 400v is achevied. It is concluded that this method achieve high voltage gain of the converter and we can achieve continuous current in a interleaved manner. The size of components has been reduced; it is economical and efficient converter. Therefore large duty ratio was also reduced.

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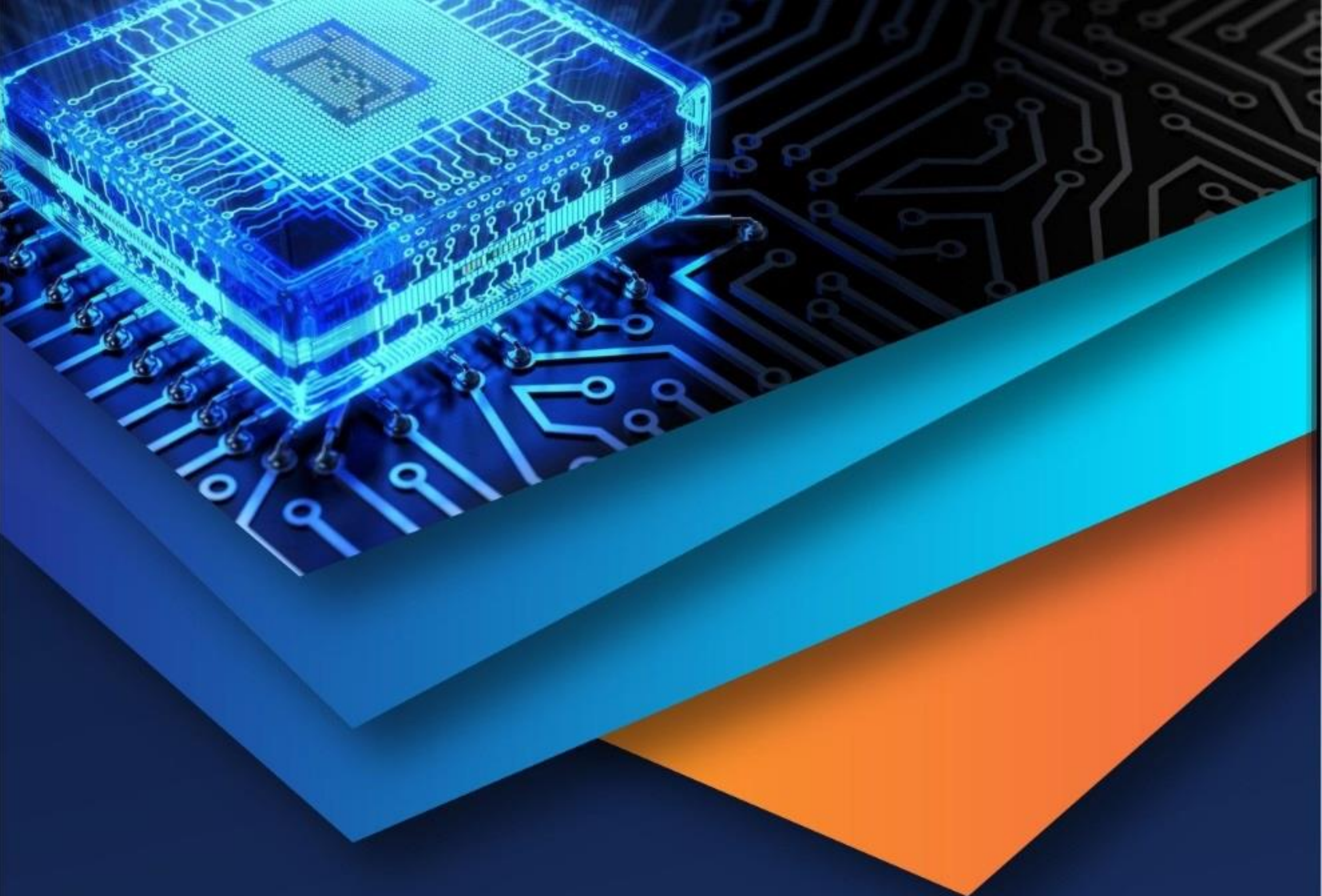

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