

# A SEPIC Based Dual Output DC-DC Converter for Solar Applications

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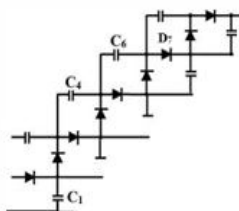
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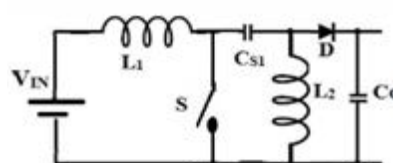
**ABSTRACT:** This paper presents the topic on obtaining dual output from the single input source. Here we using the combination of single ended primary inductance converter and high gain multilevel boost converter. One output is obtained from sepic converter and the other output is obtained from high gain multilevel boost converter. High gain multilevel boost converter is used for the step up purpose and the sepic converter is used as the step up or step down purpose depending upon the duty cycle applied to the switch. If the duty cycle is below 0.5 it works for step down purpose and if it is greater than 0.5 it works for step up purpose. Here the duty cycle applied to the switch is 0.75 hence for step up purposed. The input applied to the converter is 12V and the output from the sepic is 33V and from the boost converter is 220V. The simulation results are obtained in MATLAB/SIMULINK.

## I. INTRODUCTION

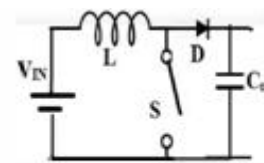
Electricity generation from renewable energy is increasing day to day. The electricity generated from fossil fuels causes rising of toxic gases in the atmosphere but these are decreasing largely in the environment. Solar energy is one of the most abundant renewable energy resource, eco-friendly, and pollution free. Sun light is converted into electricity via solar cell using the photovoltaic effect. For solar energy system installation cost only needed, if once installed it can run for a long duration and it can also save the overall maintenance cost. Solar energy having versatile in nature, it can be used for different power applications from tiny torch to satellite. Dual converters are useful when dual output voltage levels are required from single input supply voltage. Flyback converter is capable to produced dual output voltage levels but it required transformer. The gain of flyback converter is depends upon the turns ratio of transformer. Sepic converter is used for step up step down application. High gain multi level boost converter is used to step up the voltage level with large conversion ratio. More number of switches and elements are required for generating dual output voltage level from conventional converters. Due to increases in number of switches and elements, converter circuit becomes more expensive and complex sepic based dual output converter is proposed which is suitable for solar applications. The proposed converter topology is the combination of sepic and high gain multilevel DC-DC boost converter. High gain multilevel DC-DC boost converter combines the conventional boost converter and voltage multiplier functions. The gain of voltage multiplier circuit can be increases by adding diodes and capacitors. Circuit diagram of boost converter, voltage multiplier and sepic converter are depicted in Fig1. The main advantages of proposed circuit topology are (i) dual output (ii) transformer less based design (iii) single switch.



VOLTAGE MULTIPLIER



SEPIC CONVERTER

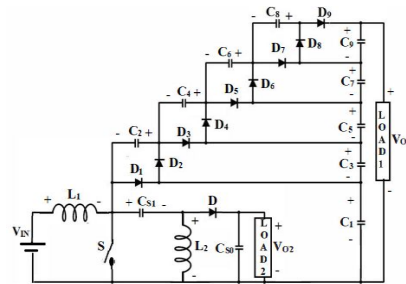


BOOST CONVERTER

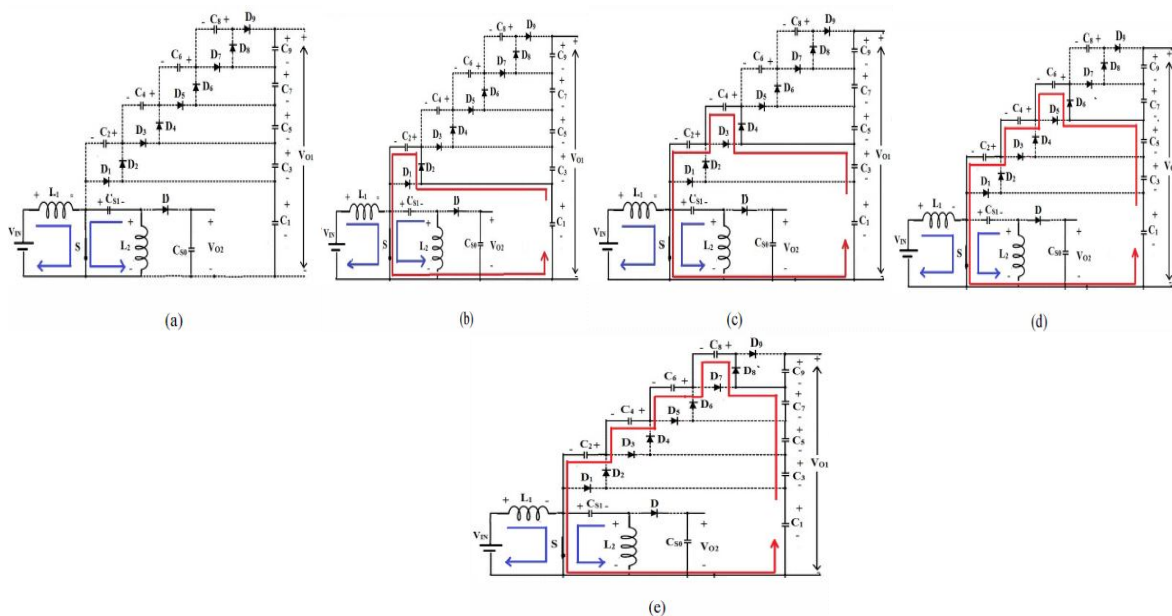
## II. CIRCUIT DESCRIPTION

### A. Powercircuit

Power circuit diagram of proposed sepic based dual output DC-DC converter is depicted in Fig2. In the proposed converter only one input source and switch is required to obtain two output voltages at the same time. One output voltage is obtained through 5-level multi level boost converter and other output voltage is obtained through sepic converter. Sepic converter operates in two modes, step-up or step-down depending on duty cycle. When duty cycle is less than 0.5, sepic converter is operated in step-down mode. When duty cycle is greater than 0.5, sepic converter is operated in step-up mode. The output voltage levels of high gain multi level boost converter can be increases by adding diodes and capacitors without disturbing main sepic converter circuit.



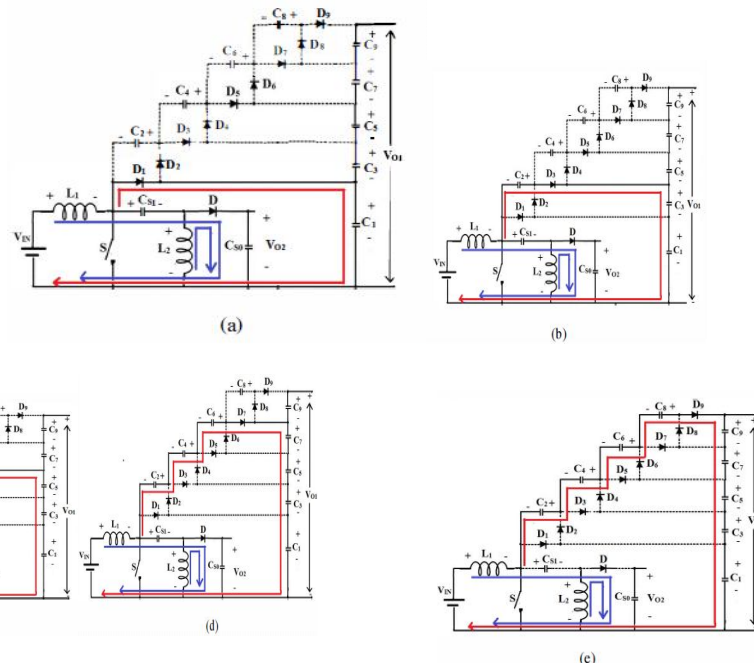
CIRCUIT DIAGRAM



### B. Modes of operation

The operation of the sepic based dual output DC-DC converter can be divided into two modes, when switch S is tuned ON and another when switch S is turned OFF. In mode1, switch S is tuned ON, the inductors L1 and L2 are discharges through the input source and capacitor Cs1 respectively. Capacitor C1 clamps the voltage across capacitor C2 through D2 and switch S, when D2 is forward biased. Voltage VC1+VC3 clamp

the voltage  $V_{C2}+V_{C4}$  through  $O_4$  and Switch  $S$ , when  $D_4$  is forward biased. Voltage across  $V_{C2}+V_{C4}+V_{C6}$  is clamp by voltage  $V_{C1}+V_{C3}+V_{C5}$  through  $O_6$  and switch  $S$ , when  $D_6$  is forward biased. Similarly voltage  $V_{C2}+V_{C4}+V_{C6}+V_{C8}$  is clamp by  $V_{C1}+V_{C3}+V_{C5}+V_{C7}$  through  $L_2$  and switch  $S$ , when  $D_8$  is forward biased. The current direction and operating modes, when switch is turned ON is shown in Fig.3 (a-e). In mode 2, switch  $S$  is turned OFF, the inductors  $L_1$  and  $L_2$  are discharges through  $D$  and  $D_1$ . Capacitors of the sepic converter  $C_{S1}$  and  $C_{S0}$  are charges from the input voltage. And inductors current through  $D$ . when  $O_3$  is forward biased, voltage  $V_{IN}+V_{U1}+V_{C2}$  clamps the voltage  $V_{C1}+V_{C3}$ . Voltage  $V_{C1}+V_{C3}+V_{C5}$  is clamp by voltage  $V_{TN}+V_{U1}+V_{C2}+V_{C4}$  through  $O_5$ , when  $O_5$  is forward biased. When  $O_7$  is forward biased, voltage  $V_{TN}+V_{U1}+V_{C2}+V_{C4}+V_{C6}$  is clamp the voltage  $V_{C1}+V_{C3}+V_{C5}+V_{C7}$  through  $O_7$ . Similarly, when  $O_9$  is forward biased, voltage  $V_{C1}+V_{C3}+V_{C5}+V_{C7}+V_{C9}$  is clamp by voltage  $V_{IN}+V_{C2}+V_{C4}+V_{C6}+V_{C8}$  through  $O_9$ . The current direction and operating modes, when switch is turned OFF is shown in Fig A (a-e).



### ANALYSIS OF PROPOSED CONVERTER

When switch  $S$  is closed, both inductors  $L_1$  and  $L_2$  will charges from input voltage and capacitor  $C_{S1}$  respectively

$$V_{L1} = V_{IN} \quad (1)$$

$$V_{L2} = -V_{CS1} \quad (2)$$

Voltage  $V_{C2}$  is charges from voltage  $V_{c1}$

$$V_{c1} = V_{c2}$$

Similarly,

$$V_{c1} + V_{c2} = V_{c2} + V_{c4}$$

$$V_{c1} + V_{c3} + V_{c5} = V_{c2} + V_{c4} + V_{c6}$$

$$V_{c1} + V_{c3} + V_{c5} + V_{c7} = V_{c2} + V_{c4} + V_{c6} + V_{c8}$$

When switch  $S$  is open, both inductors will discharges

$$V_{L1} = V_{IN} - V_{cs1} - V_{O2}$$

$$V_{L1} = V_{IN} - V_{c1} \quad (9)$$

$$V_{L2} = V_{O2}$$

By inductor volt second balance for inductor  $L_1$ ,

$$V_{L1}(D) + V_{L1}(1-D) = 0$$

From equation (1) and (7)

$$V_{IN}(D) + (V_{IN} - V_{CS1} - V_{02})(1-D) = 0$$

$$V_{IN} + (-V_{CS1} - V_{02})(1-D) = 0$$

$$V_{C1}/V_{IN} = 1/(1-D)$$

By inductor volt second balance for inductor L2,

$$V_{L2}(D) + V_{L2}(1-D) = 0$$

$$-V_{CS1}(D) + V_{02}(1-D) = 0$$

$$V_{CS1} = V_{02}(1-D)/D$$

Put  $V_{CS1}$  in equation (12)

$$= 0$$

$$V_{IN} - (V_{02}(1-D)/D + V_{02})(1-D) = 0$$

$$V_{02}/V_{IN} = D/(1-D)$$

Voltage across all multiplier capacitors is equal

$$V_{01} = V_{C1} + V_{C3} + V_{C5} + V_{C7} + V_{C9}$$

$$V_{01} = 5V_{C1}$$

Thus, the conservation ratio of proposed converter is

$$V_{01}/V_{IN} = 5/(1-D)$$

$$V_{02}/V_{IN} = D/(1-D)$$

For N-level boost converter voltage gain is

$$G_{01} = N/(1-D)$$

For sepic converter voltage gain is

$$G_{02} = D/(1-D)$$

Thus, voltage gain for is depends upon duty cycle and the number of levels present in multiplier and voltage gain for load2 depends upon duty cycle only

### III. SIMULATION RESULTS

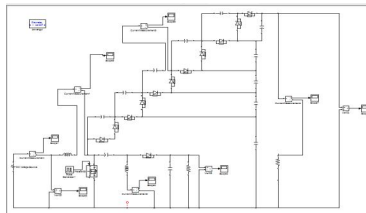
The proposed converter is designed for 12V input supply with rated output parameters 180W, 230V and 50W, 36V. Switching frequency of applied gate pulse is 50KHz with 75% duty cycle. Simulation results of proposed converter are verified through MATLAB/SIMULINK. Table shows the specification of proposed converter.

Tabled Specification of converter

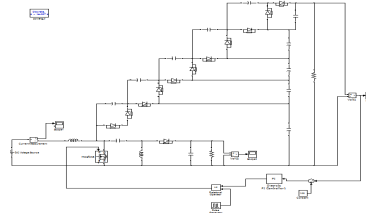
N0	Parameter	Value
1	Input voltage	12V
2	O/p voltage ( $v_{01}$ ) and ( $V_{02}$ )	230V and 36V
3	Power ( $P_{01}$ ) and ( $P_{02}$ )	180W and 50W
4	Inductor ( $L_1$ ) and ( $L_2$ )	700μH
5	capacitors	220μF
6	Switching frequency	50KHz
7	Duty cycle	75%
8	Number of Level in boost converter	5level

Graph of voltage gain versus duty cycle is shown in Fig5. Output voltage and output current waveform for load1 is shown in Fig6. Output voltage and output current wave form for load2 is shown in Fig7. Voltage stress across switch is 48V which is shown in Fig8. Output power wave form for load and load 2 is shown in Fig9. The current wave form through inductors with applied gate pulse is shown in Fig10. It is observed that

their sepic inductors current waveform is 0.3A. The voltage at output capacitors node is shown in Fig11



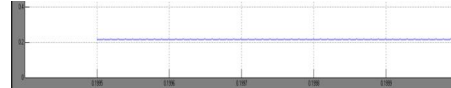
Open Loop Simulation Circuit



Closed Loop Simulation Circuit



Output Voltage At Load 1



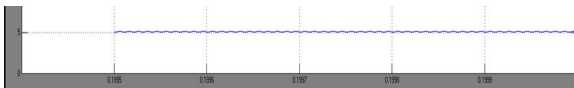
Output Current Through Load 1



Output Current Through Load 2



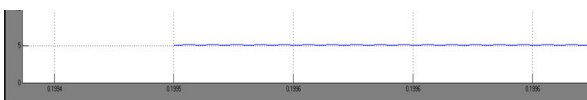
Output Voltage At Load 1



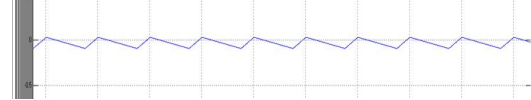
Input Current



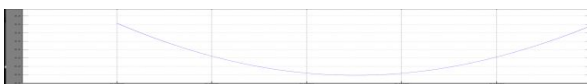
Input Voltage



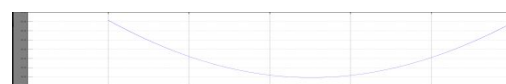
Current Through Inductor L1



Current Through Inductor L2



Output Voltage at Load 1



Output Voltage At Load 2

#### IV. CONCLUSION

The proposed sepic based dual output DC-DC converter is designed for solar application where two output voltages is needed at the same time. The converter was designed to supply 230V at 180W for load1 and 36V at 50W from supply input 12V. The proposed converter is designed by the combination of sepic converter and five level multi level boost converters. Voltage gain for load 1 depends upon duty cycle and the number of levels present in multiplier and voltage gain for load2 depends upon duty cycle only. The proposed

converter simulation results are verified by using MATLAB/SIMULINK. The simulation results show that the proposed converter is suitable for solar application where two output voltages are needed at the same time.

#### REFERENCES

1. Rong-Jong Wai, Wen-Hung Wang, Chung You Lin, "High Performance Stand-Alone Photovoltaic Generation System" IEEE Transactions on Industrial Electronics, vol.55, no.1, pp.240-250, Jan.2008.
2. Mahrous E. Ahmed, Mustafa Mousa "Development of high gain and efficiency photovoltaic system using multilevel boost converter topology" 2010 2<sup>nd</sup> IEEE International Symposium on Power Electronics for Distributed Generation System.
3. Yi Zhao, Wuhua Li, Van Deng, Xiangning He "Review of Non Isolated High Step-Up DC-DC Converters in Photovoltaic Grid Connected Applications" IEEE Transactions on Industrial Electronics, vol. PP, no.99, pp.1-1, 2010
4. Charanasomboon T., Devaney M.J., and Hot R.G., "Single switch dual output DC-DC converter" Industry Application Society Annual Meeting, IEEE, Vol.1, pp.793-795, 1988.
5. Wing Hung Ki, and Dongsheng Ma, "Single-inductor multiple output switching converters" Power Electronics Specialists Conference, PESC.2001, vol.3, pp.301-304, 6-9 May.2001
6. Kanthapayao Y, Rungruengphalanggul Y, and Chaisawadi A, "Dual output DC-DC power supply with Buck-Boost and Zeta converter" International Conference on Control Automation and Systems, pp.1154-1158, 2002
7. N.Vazquez, H.Lopez, C.Hernandez, H.Callej "Multiple Output DC-DC based on the Fly back Converter" 2008 IEEE.
8. M.Vazquez, E.de la Cruz, J.A.Navas and J.A.Cobos "Fixed Frequency Forward Flyback Converter with Two Fully Regulated Outputs" Telecommunications Energy Conference, INTELEC'95, 17<sup>th</sup> International, pp.161-166, 1995.
9. Huiming Chen, Wenhui Dong, Yingyan He and Zhaoming Qian "Secondary Side Post Regulation Application in Multiple Outputs Flyback Converter" IEEE PESC 2005.
10. Ki-Bum Park, Hyun-Wook Seong, Hyoung-Suk Kim, Gun-Woo Moon, and Myung-Joong Youn "Integrated Boost-Sepic Converter for High Step-up Applications" 2008 IEEE.
11. Soo-Seok Kim, Seung-Pil Mun, Jin-Tae Kim, Su-Jh Jang, Chung-Yuen Won "A New Sepic-Flyback Converter" Conference of the IEEE Industrial Electronics Society 2004.
12. Julio Cesar Rosas-Caro, Jonathan Carlos Mayo-Maldonado, Ruben Salas-Cabrera "A Family of DC-DC Multiplier Converters" Advance online publication: 10 February 2011.
13. Rosas Caro, T.e.; Ramirez, T.M.; Peng, F.Z.; Valderrabano, "ADC-DC multilevel boost converter," IET Power Electronics, vol.3, no.1, pp.129-137, 2010.