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A Dual Output Dc-Dc Sepic Converter Fed Multi Level Inverter for Solar Applications

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Abstract: Now days many countries are concentrating on electricity power generation from renewable energy sources (RESs) as it is pollution free. The RESs are wind turbine, photo voltaic cells, tidal etc. Photo Voltaic (PV) power generation system is more attractive due to its advantages among all the RESs. Solar energy is extracted with the help of PV panels and power electronics converter. It is then fed to an inverter that produces an AC power. A dual output Single Ended Primary Inductance Converter (SEPIC) is proposed for DC to DC energy conversion in PV system. It charges two batteries, which in turn feeds a new modified cascaded multi level inverter. The proposed system is a fusion of dual output SEPIC converter and Multi Level Inverter (MLI). It can be used for power generation in remote areas, large residential buildings and standalone systems. The circuit simulation is carried out in MATLAB/Simulink.

Keywords: Renewable Energy Sources (RESs), Photo voltaic (PV) cells, SEPIC converter, Multi level inverter (MLI).

I. INTRODUCTION

Power generation form RESs is increased because, it is environmental friendly. PV system is a most popular RES for electricity generation. For PV power generation it usually consists of an array of PV panels and power converter [1]. PV power generation system is a fusion of DC to DC converter and inverter. In this paper dual output SEPIC converter fed multi level inverter is presented for PV application. For the PV generation branch solar energy is directly converted into electricity by PV panel and then controlled by a SEPIC converter. The two outputs from the multi output SEPIC converter is used to charge two batteries which in turn are fed to the cascaded MLI [7]. SEPIC converter is fourth order nonlinear system and it is extensively used in step-down or step-up DC-DC switching circuits [8]. The inverter is utilized to convert the DC voltage to AC voltage so that typical house hold can freely utilized electricity from the grid. There are three basic MLI topologies; diode clamped, Flying capacitor and cascaded H-bridge MLI. Among all these topologies, cascaded H-bridge MLI has gained more popularity due to its simple structure.

Due to modular structure of this inverter, it can be easily extend to higher level. Cascaded H-bridge MLI has been widely applied in DC transmission, FACTS devices and high rating motor drives. [5] Presents, the isolated SEPIC converter for photovoltaic application. The suitability of other types of DC-DC converters such as buck, buck-boost and their disadvantages are presented. The mathematical analysis and design guidelines for isolated SEPIC converter are discussed. [6] Presents SEPIC based dual output converter for solar application. Multi output converters are useful in case of two or more outputs are required from single input. The proposed converter is a combination of SEPIC and high gain multi level boost converter. It requires more number of components and circuit become complex. This converter does not produce equal output voltage.

II. PROPOSED CONVERTER

The circuit diagram of conventional SEPIC converter is shown in fig1. It allows fixed input DC and generates DC output voltage either greater than or less than input voltage depending on duty cycle. This converter has no electrical isolation between input and output. The dual output SEPIC converter is proposed which has the electrical isolation.

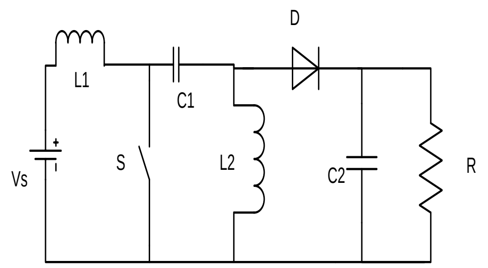

Fig.1. Circuit diagram of conventional SEPIC converter

The proposed SEPIC converter is shown in fig2. It is derived from replacing inductor L2 by three winding transformer in conventional SEPIC converter. Transformer consists of one winding on primary and two windings on secondary. The proposed converter is having a electrical isolation between input and output.

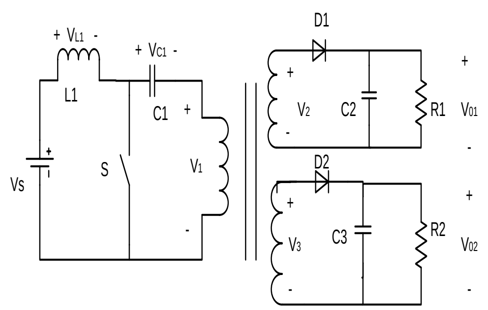

Fig.2. Circuit diagram of proposed SEPIC converter

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It has more advantages compare to conventional converter.

- No change in voltage polarity
- It has dual output
- Step down and step up operation is easy
- Low input ripple current

Two outputs of proposed converter are connected to rectifier and filter capacitor. The DC voltages V_{01} and V_{02} across load resistors R1 and R2 respectively. With two outputs, proposed converter can supply cascaded five level and seven level inverter. Therefore THD can be reduced significantly by using seven level inverter. Based on requirement proposed converter can be utilized to feed either five or seven level inverter. The proposed converter operates in two modes.

III. MULTI LEVEL INVERTER

Multi level inverter synthesizes higher level AC voltage from several DC voltage sources. The main objective of implementing the multi level inverter is to reduce Total Harmonic Distortion (THD) and improve power quality. There are three basic types of MLIs; diode clamped, flying capacitor and cascaded H bridge inverter. Among all these topologies cascaded H-bridge and its derivatives are more popular due to their simple structure. It can be easily extend to higher level.

In this novel, a seven level inverter with reduced number of switching device and DC source is presented. A Seven level inverter is implemented by using same circuit as that of a cascaded H-bridge five level inverter. But input voltage magnitudes are in 1:2 ratio and switching states are as in table1. The outputs of proposed SEPIC converter are fed to input of a seven level inverter. A Seven level inverter synthesizes voltage levels of 0Vdc, ±1Vdc, ±2Vdc and ±3Vdc. In circuit diagram of fig 3, V1=1Vdc and V2=2Vdc.The switching pulses and output voltage waveforms are shown in fig 4 and fig 5 respectively.

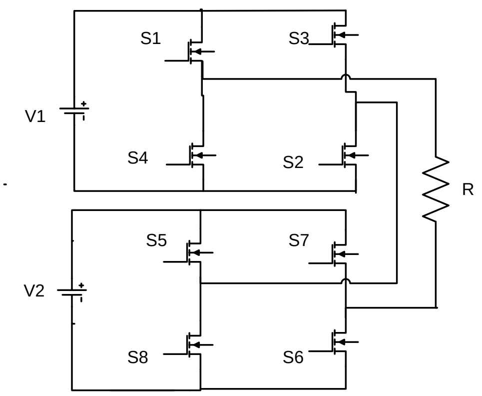

Fig.3. Circuit diagram of multi level inverter

Table1.Switching states for a seven level inverter

Modes	Output Voltage	Switches							
		S1	S2	S3	S4	S5	S6	S7	S8
1	+1Vdc	1	1	0	0	0	1	0	1
2	+2Vdc	0	1	0	1	1	1	0	0
3	+3Vdc	1	1	0	0	1	1	0	0
4	0Vdc	0	0	0	0	0	0	0	0
5	-1Vdc	0	0	1	1	1	0	1	0
6	-2Vdc	1	0	1	0	0	0	1	1
7	-3Vdc	0	0	1	1	0	0	1	1

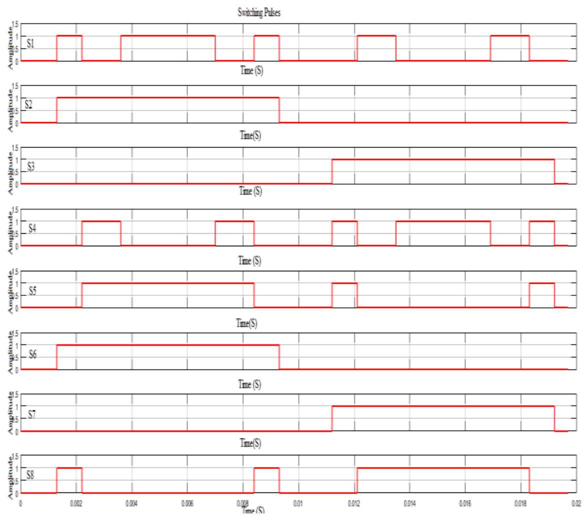

Fig 4: Switching pulses of seven level inverter

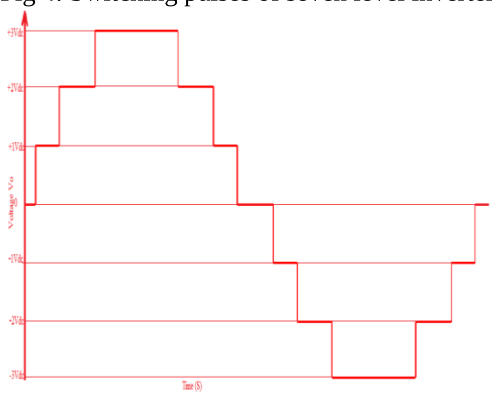

Fig 5: Waveform of seven level output voltage

IV. MAIN CIRCUIT

The main circuit is fusion of dual output SEPIC converter and a seven level inverter. This system is utilized to convert DC voltage available at PV panel to AC voltage. The voltage across secondary and tertiary windings is in 1:2 ratio. The output of SEPIC converter is fed to inverter. The output of MLI depends on converter output voltage. The output voltage of SEPIC can be controlled by controlling duty cycle. Thus, MLI output is also controlled. The converter outputs charges batteries. Battery storage is useful for supplying the power in case of power outages. A dual output SEPIC converter fed MLI produces constant DC voltage without peak overshoot. It gives desirable output for both R and RL load.

V. SIMULATION RESULT

The simulation of proposed circuits is carried out in MATLAB/SIMULINK software. The switch S is operated at 50kHz frequency and duty cycle 45%. The frequency of MLI is 50Hz. The circuit parameters for simulation are given in table2.

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Table2. Simulation circuit parameters

Circuit parameters	Values
Input DC voltage	48V
Inductor L1	50mH
Capacitance C1	100uF
Capacitance C2 &C3	1000uF

The inductance and capacitance values are chosen based on following equations.

$$\Delta i_{L1} = \frac{V_s . D}{L_1 . f} \ldots \ldots \ldots \ldots (1)$$

$$C_1 = \frac{D}{R\left(\frac{\Delta V_{c1}}{V_0}\right) . f} \ldots \ldots \ldots \ldots (2)$$

$$C_2 = C_3 = \frac{V_p}{R . C . f} \ldots \ldots \ldots \ldots (3)$$

The fusion system of dual output SEPIC converter and MLI circuit simulation analysis is carried out in MATLAB/Simulink. The Simulink model for open loop operation is shown in fig 6.

The SEPIC output voltages obtained are 110V and 220V are shown in fig8. The output voltage V_0 across the load is 326V as shown in fig9.The THD of output voltage is 12.83% as shown in fig10.

The closed loop circuit is implemented with PI controller. The simulink model for closed loop operation is shown in fig 7. The feedback system consists of PI controller, adder and voltage sensors. With fine tuning of PI controller switching pulse is generated. The output voltage is constant even there is 10% load variation. In this closed loop operation SPEIC output voltages obtained are 107V and 213V are shown in fig 11. The output voltage V_0 obtained is 320V as shown in fig 12.

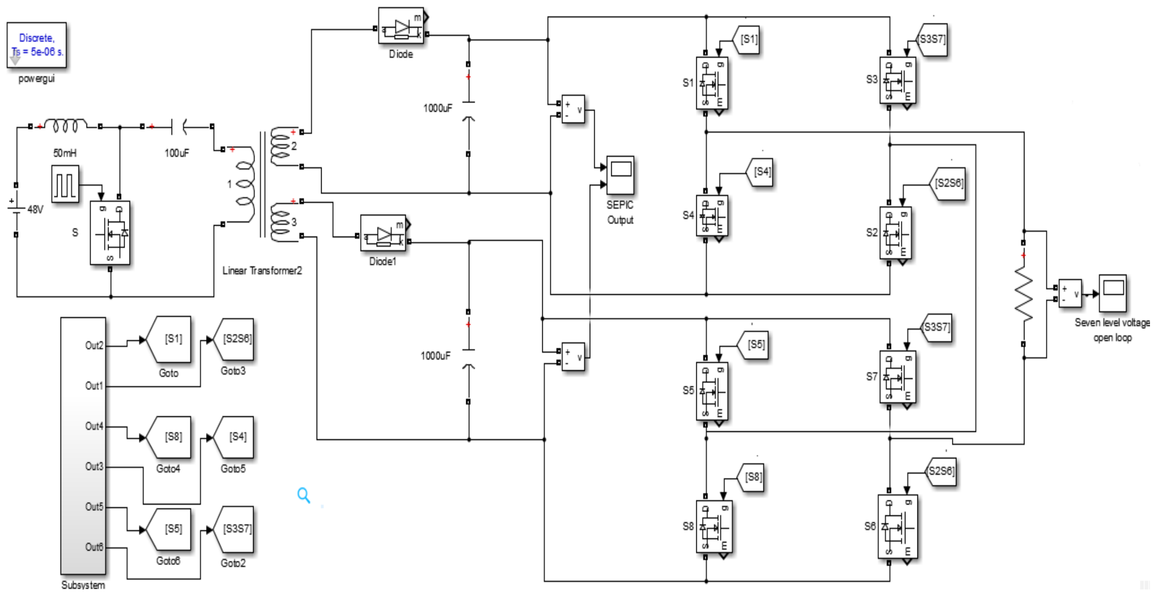

Fig 6: Simulink model of main ciruit diagram for open loop opeartion

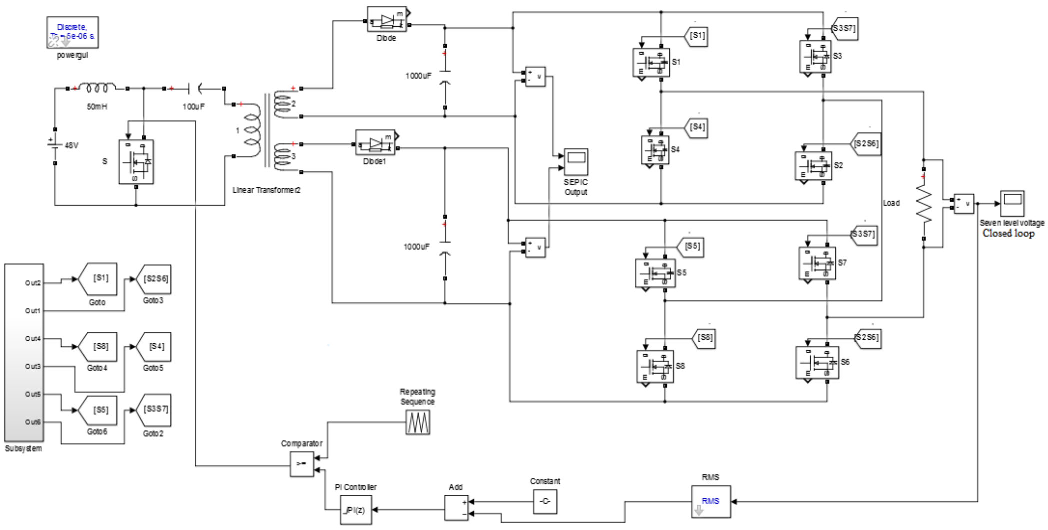

Fig7: Simulink model of main circuit diagram for closed loop operation

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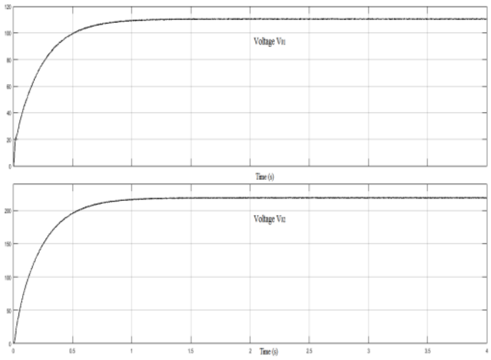

Fig 8: SEPIC output voltage in open loop

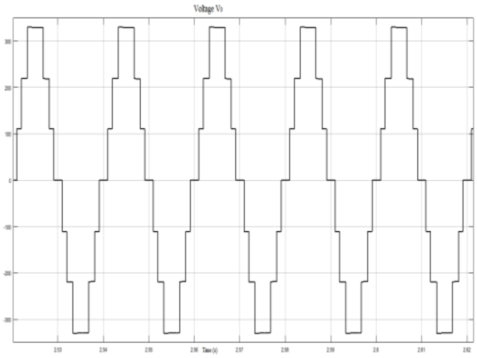

Fig 9: Seven level output voltage in open loop

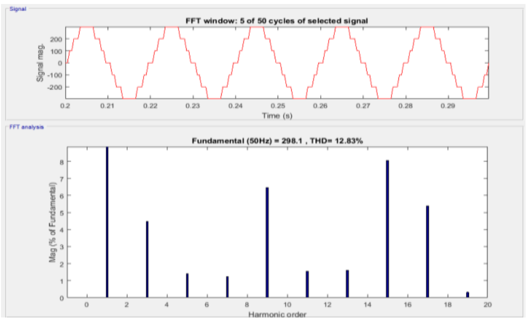

Fig 10: THD of output voltage

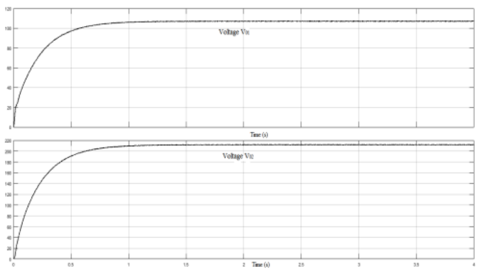

Fig 11: Output voltage of SEPIC converter under closed loop

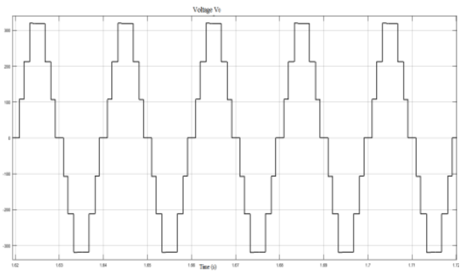

Fig 12: Seven level output voltage under closed loop

VI. CONCLUSION

In this paper a dual output SEPIC converter is presented. It is suitable for DC to DC conversion in solar applications. Its performance satisfies the requirement at input side of an inverter. A new seven level inverter is presented gives enhanced performance over a five level inverter. A dual output SEPIC converter fed multi level inverter is proposed. The batteries provide power when solar energy is unobtainable. Due to modular structure of inverter, it can be easily extended to higher level. Hence THD and filter dimension can be reduced. The proposed system is well suited for power generation in rural areas or isolated area where grid connection is not possible.

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