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Design of PV Based Dual input SEPIC Converter for Uninterrupted Power Supply

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Abstract: This paper explores the performance of the dual input, Single Ended Primary Inductor converter (DISEPIC) converter. Instead of using two separate Dc-Dc converter for different power supplies, the use of a dual input SEPIC (DISEPIC) reduces the filter size, cost and losses. The Proposed configuration allows one input from a PV panel while the other from Ac source. Incremental conductance (IC) based Maximum Power Point Tracking (MPPT) technique used to get a maximum power from a PV panel. The tracking algorithm automatically changes the duty cycle of the DISEPIC converter connected to the solar panel. The Multi Input DC-DC converters such as Buck-Boost and Cuk converters provide a limited range of output voltages with an inverted polarity whereas DISEPIC gives positive output. This scheme is more flexible as it provides a wide range and choice of input sources.

Key words: Dual input single ended primary inductor converter (DISEPIC) · Photovoltaic panel (PV) · Maximum power point tracking (MPPT) · Incremental conductance (IC)

INTRODUCTION

In a power electronic interface, there will be mismatches between input power and output demand at any instant of time. Therefore, there is a need to effectively interconnect them by matching their characteristics. Multiple-input system employing such an interface will further increase its complexity. The traditional way of connecting multiple energy sources was done in a series or through parallel connection [1]. A solution to harvest power from multiple sources of different characteristics is a multiple input power electronic converter integrated into a single system [2]. The DC-DC converters that operate in parallel have several advantages, such as low component stress, good thermal management, more reliability and less maintenance than single DC-DC converters. The single-ended primary-inductor Converter (SEPIC) is a DC-DC converter that possesses reduced output ripple, high efficiency and high-voltage transfer gain [3]. Integration of different sources can be achieved in a variety of ways. Among them, use of multiple-input converters is a promising option because it may reduce the total number of system components and provide an adequate operational flexibility [12]. Impediments to increasing this percentage further stem from (i) the need to install expensive spinning reserves, (ii) the resulting wear and tear of thermal units and (iii) the inability to achieve adequate voltage [4]. Among these the PV power generation is the rapidly developing technology. The Proposed system allows two inputs instead of multi inputs. Another potential advantage of the proposed topology when compared with other DC-DC converter is that outputs can be added in a simpler way.

Design of Pv Panel and Mppt Tecnique: A photovoltaic cell is a device which converts light energy to electrical energy. If band gap is less than energy of photon of light, electron is emitted and creates current. Photovoltaic cell is forward biased [3].Group of PV cells arranged in series and parallel to generate a high range of electrical energy. In this paper Solar panel is designed for 40W. Solar panel consists of number of Solar cell in series and parallel connection. The Voltage of the module increased by increase the series connection, whereas current increased by increasing the parallel connection. A Single solar cell can be modelled by utilizing a current source, a diode and two resistors. This model is known as a single diode model of solar cell it is shown in Fig. 1.

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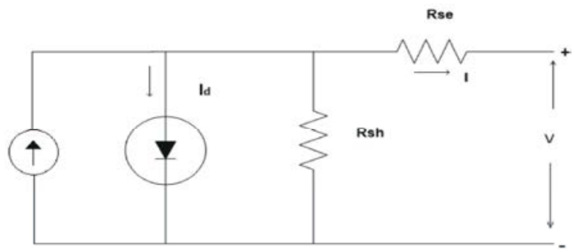

Fig. 1: Equivalent circuit of PV cell

The output current from the photovoltaic array is

$$I = I_{ph} - I_0\left[\exp\left(\frac{V+IR_s}{a}\right)-1\right]-\left[\frac{V+IR_s}{R_p}\right] \quad (1)$$

Where

$$I_{ph} = \frac{G}{G_{ref}}[I_{ph,ref} + (\mu_{sc} * \Delta T)] \quad (2)$$

$$I_0 = I_{o,ref}\left(\frac{T_C}{T_{C,ref}}\right)^3 \exp[(\frac{q.\varepsilon_G}{A.K})(\frac{1}{T_{C,ref}}-\frac{1}{T_C})] \quad (3)$$

$$I = I_{ph} - I_d \quad (4)$$

Diode current can be expressed as,

$$I_d = I_o\,[\exp\left(\frac{V}{A\,V_T N_s}\right)-1] \quad (5)$$

Ipv - PV Current (A)
Is - Saturation Current (A)
q - Electron Charge (1.60217×10-19 C)
k - Boltzmann constant (1.38065×10-23 J/K)
a - Diode ideality constant
Rs - Series Resistance of cell (?)
Rp - Parallel Resistance of cell (?)
Ns - No. of Cells in series
T - Temperature (K)

Maximum Power Point Tracking technique is used to obtain maximum power from the solar panel so that the solar energy can be utilized in high level. In this paper Incremental Conductance Algorithm is used to track the maximum power point. In the incremental Conductance method, the array terminal voltage is always adjusted according to the MPP voltage it is based on the incremental and the instantaneous Conductance of the PV module.

Dual Input Topology: Dual input topologies use two inputs for a Load. Since there are two inputs, even if one source is not available the other source can be utilized. Dual input converter topologies reduce the filter size as well as losses, thus increasing the efficiency.

Conventional System: Many Dual input converters use a Dc source as inputs. They have used multiple Dc sources. Two Separate DC-DC converter (boost, buck and buck boost) is used, which can increase or decrease the input voltage according to the Load. Using of two converters will increase the filter size, losses and cost.

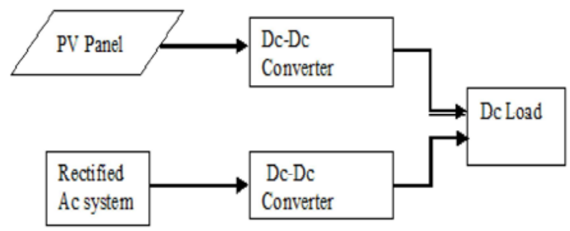

Fig. 2.1: Block Diagram of Conventional System

Proposed System: In Proposed system DC input sources replaced by renewable resources..This configuration allows the two sources to supply the load separately (PV/AC supply) or simultaneously together (Hybrid) depending on the availability of the energy sources. The main purpose of this hybrid topology is to meet our daily demand effectively and to get an uninterrupted power supply. Filter size and losses are reduced considerably in this proposed system.

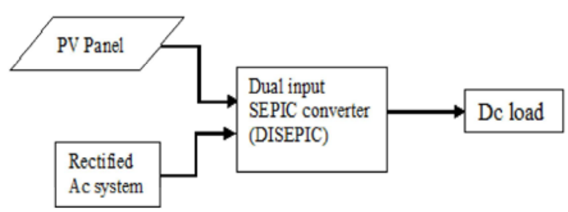

Fig. 2.2: Block Diagram of Proposed System

Proposed System Converter: Circuit Diagram of the dual input SEPIC (DISEPIC) converter shown in Fig.3. Assume that the converter operates in continuous conductance mode (CCM). Input voltage from source one is greater than the source two $V_{in1} > V_{in2}$. Here two SEPIC converter connected in parallel, different switching period is given to the switches S_1 and S_2. There are three operational modes. Equivalent circuit diagram of three modes are shown in Fig. 3(a), 3(b), 3(c).

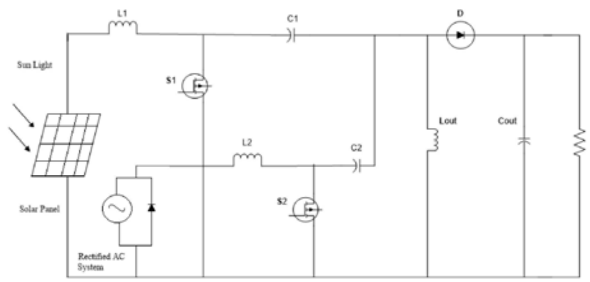

Fig. 3: Circuit Diagram of Dual input SEPIC Converter

Mode 1 (0<t<D_1T): Equivalent circuit of converter in this state is as shown in Fig. 3 (a). In this Mode Switches S1 and S2 are in ON. Though both the switches are ON, switch S2 does not conduct because it is reverse biased. The switch S2 is reverse biased because voltage across the capacitor C1 is greater than C2 that is Vc1>Vc2. Inductors L1 and L2 are energized from input sources Vin1 and Vin2 respectively. Freewheeling diode D does not conduct any current through it because it is reverse biased.

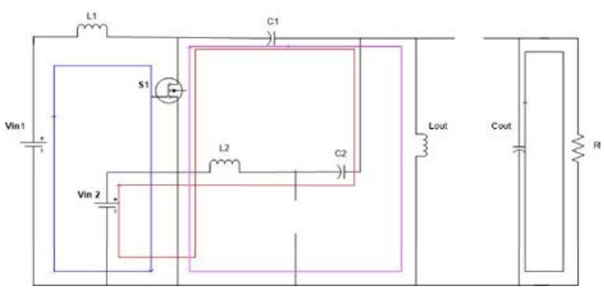

Fig. 3(a): Equivalent circuit for Mode 1

Mode 2(D_1T<t<D_2T): Equivalent circuit of converter in this state is as shown in Fig. 3 (b). During this mode switch S1 I turned OFF. Switch S2 remains ON and it starts to conduct in this mode. Current through L1 and L2 increased continuously and the freewheeling diode D still in reverse biased so it does not conduct any current through it.

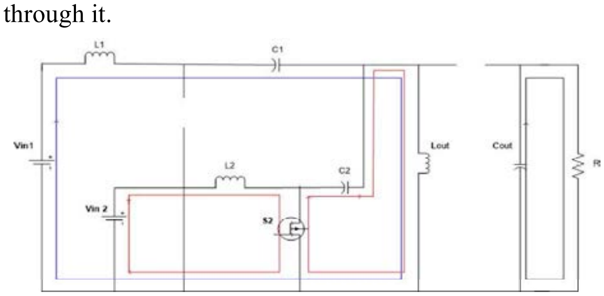

Fig. 3(b): Equivalent circuit for Mode 2

Mode 3 (D_2T<t<T): Equivalent circuit of converter in this state is as shown in Fig. 3 (c). During this mode switches S1 and S2 are in OFF state. Thus the gate signals of both switches are absent during this time period. Freewheeling Diode D is forward biased. The energy stored in the inductors L_1 and L_2 used to drive the load through the Freewheeling Diode D.

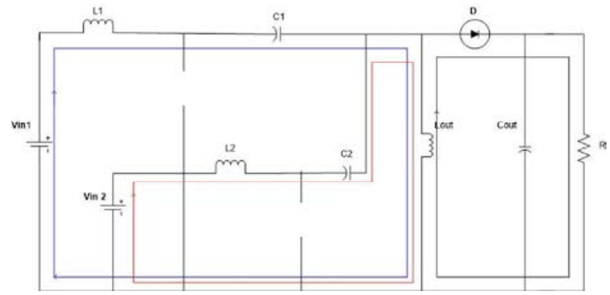

Fig. 3(c): Equivalent circuit for Mode 3

Equilibrium point equation can be derived by taking integral form of the switching equations with variable function. Change in switching variable over a switching period is zero in steady state operation.

$$i_{L1}(t) = \begin{cases} i_{L1min} + \frac{V_1}{L_1} & (0 < t < D_1T) \\ i_{L1min} + \frac{V_1 D_1 T}{L_1} + \frac{(V_1 - V_{c1} + V_{c2})(t - D_1T)}{L_1} & (D_1T < t < D_2T) \\ i_{L1min} + \frac{V_1 - V_{c1} - V_0}{L_1}(t - T) & (D_2T < t < T) \end{cases} \quad (6)$$

$$i_{L1} = \frac{D_1V_0}{(1-D_2)R} - \frac{D_1D_{eff}V_2T(L_1L_2+L_2L_0+L_0L_1)}{2L_1L_2L_0} \quad (7)$$

$$i_{L2} = \frac{D_{eff}V_0}{(1-D_2)R} - \frac{D_1D_{eff}V_1T(L_1L_2+L_2L_0+L_0L_1)}{2L_1L_2L_0} \quad (8)$$

Design of Converter: Dual input SEPIC Converter is a DC-DC converter, it generates output voltage greater or lesser than the input Voltage. Simulation diagram of DISEPC shown in Fig.3. Various components of converter are inductor, capacitor, switching period and filter components designed using given formulas as follows.

Output current

$$i_O = \frac{V_O}{R} \quad (9)$$

Inductor values

$$L_1 = \frac{V_1 D_1}{\Delta I_{L1} f} \quad (10)$$

$$L_2 = \frac{V_2 D_2}{\Delta I_{L2} f} \quad (11)$$

Capacitor values

$$C_1 = \frac{V_0 D_1}{R \Delta V_0 f} \quad (12)$$

$$C_2 = \frac{V_0 D_2}{R \Delta V_0 f} \quad (13)$$

Output voltage

$$V_0 = \frac{V_1 D_1 + V_2 D_{eff}}{(1 - D_2)} \quad (14)$$

Where

$$D_{eff} = D_2 - D_1 \quad (15)$$

Duty cycle D2 Calculated from equation (15) by making V1=0V. Capacitor and Inductor values calculated by using equations (10), (11) and (12), (13) respectively.

Table 1: Design Specification of DISEPIC

S.NO	PARAMETERS	VALUE
1	Voltage Source 1&2	18V & 12V
2	Switching frequency(S1,S2)	25kHz
3	Duty cycle (S1)	Get from MPPT
4	Duty cycle (S2)	0.65
5	Output Voltage	42V
6	Load	25ohm

Simulation and Results

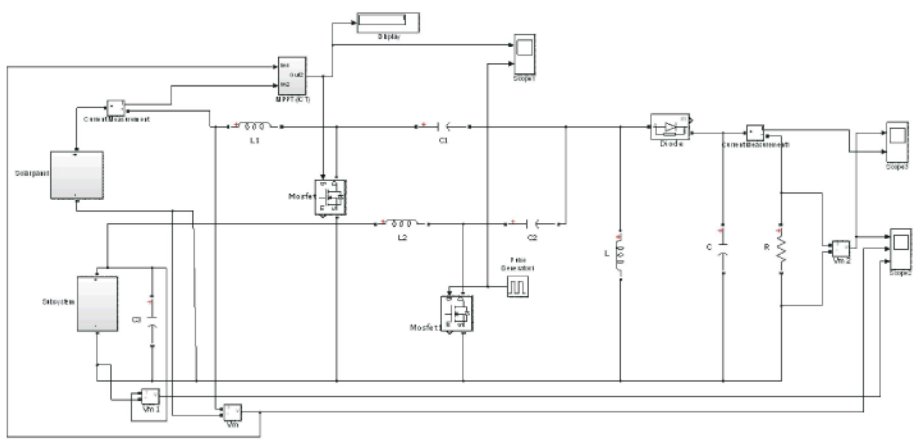

Fig. 6: Simulation Diagram of DISEPIC

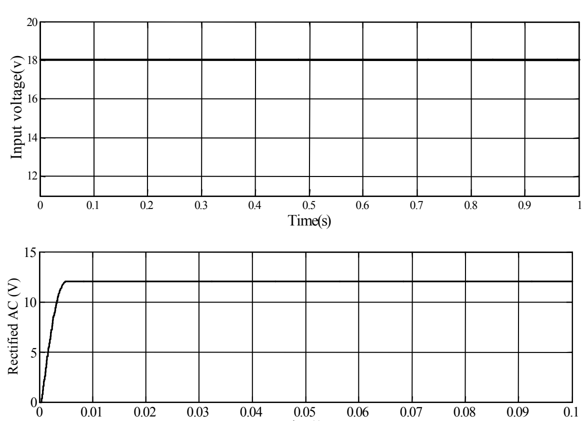

Fig. 6.1: Input Voltage of DISEPI

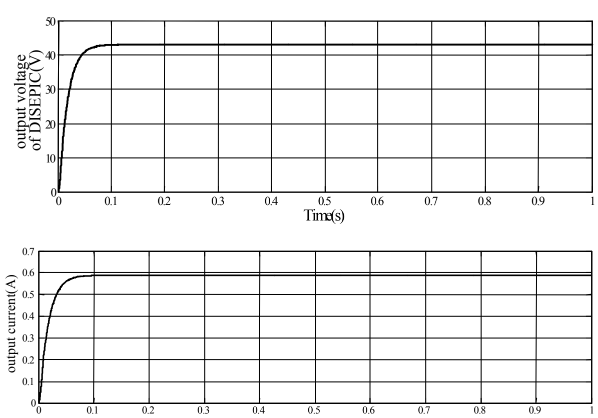

Fig. 6.2: Output Voltage and current of DISEPI

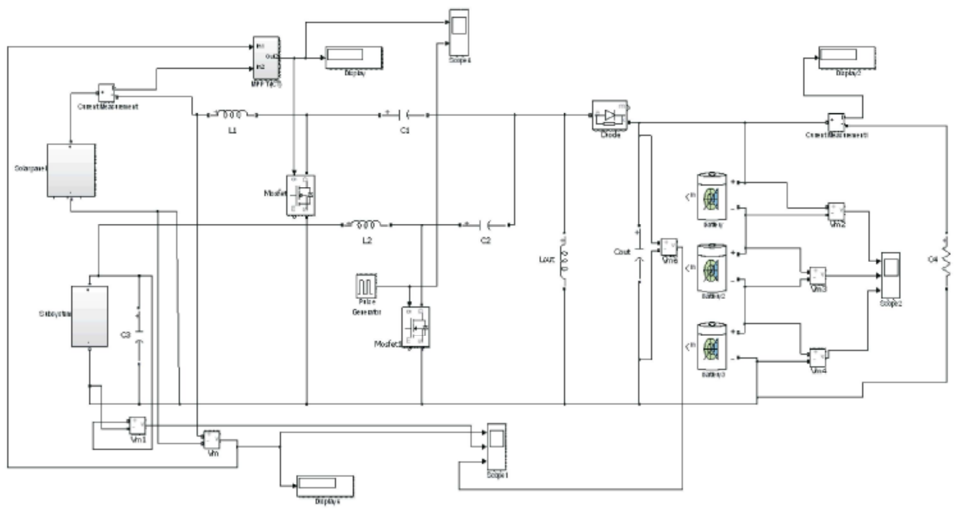

Fig. 7: Simulation of Battery connected DISEPIC

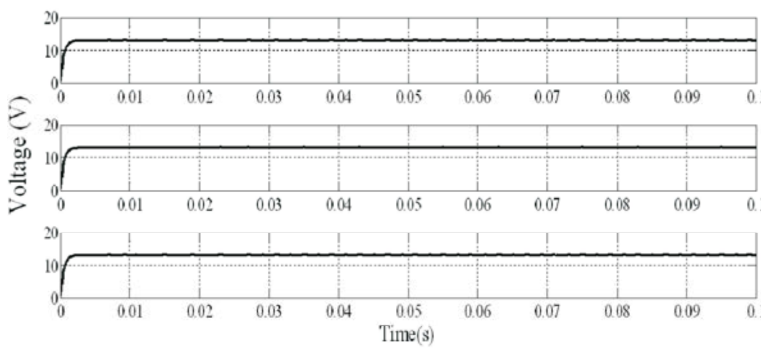

Fig. 7.1: Output voltage of Battery

CONCLUSION

The Dual input SEPIC converter has better voltage step up. This converter is analyzed with two different renewable sources. The incremental conductance algorithm is used to extract the maximum power from solar panel which is one of the two sources. This algorithm is to be simple and the voltage fluctuation near the MPP is to be reduced in the IC method. Rectified Ac is another one source both two inputs are added to give the output, which is higher than the sum of input. Proposed converter reduces the filter size and cost.

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