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# Implementation of MPPT Based SEPI (Single Ended Primary Inductance) Converter Using Perturb and Observe Algorithm

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***Abstract***

*The single ended primary inductance (SEPI) converter topology performs operation like buck-boost converter but with no reversal of polarity and no electrical stress on components. Input voltages of SEPI converter are kept 20 volts and maintained a constant voltage of 12V at output side. This converter circuit is simulated in MATLAB/SIMULINK using perturb and observe and observe algorithm for maximum power point tracking and hardware implementation is also carried out by choosing appropriate values of electronic components. It reduces the ripples of input current. The system is also able to work on different loads with different values of operating voltages up to 30V.*

***Keywords:*** *SEPI Converter, Buck-Boost, Ripples.*

## Introduction

Now days the world is moving towards renewable energy because excessive use of non-renewable energy sources have made their depletion. So solar is the best option as renewable energy source because it is free of cost and we can get benefit of it for six to seven hours in a day [1]. But problem is that, it does not provide constant power due to variation in weather and temperature conditions. To overcome this issue maximum power point tracking technique has been used. At this point a converter is required which can step up, step down or maintain the voltage level according to load requirement. Efficiency of energy flow, cost and flexibility are the main consequences to select a proper DC/DC converter for PV system. The energy source used to implement a DC/DC “single ended primary inductance converter” is solar energy. The “Perturb and Observe” algorithm is used in the presented research work will find the suitable duty cycle to track maximum power point of sunlight. This supply then given to circuit of SEPI converter and there is no reversal in polarity like buck boost converter. A maximum power point tracker (MPPT) is needed to operate the PV array at its maximum power point. In this paper perturb and observe algorithm [2] is used to extract maximum efficiency under varying conditions.

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Both Buck Boost operations are possible in SEPI converter used in the research work.

## 1. Problem Statement

Photovoltaic panels do not provide us constant voltages that’s why need of converters is necessary to get constant output. Usually Buck-Boost dc-dc converter causes reverse polarity of voltages at output. This inverted output causes complexity in feedback circuit and we may need an inverting operational amplifier for feedback purpose.

Normally in Buck Boost Converters we need to attach a filter to minimize input current ripples. These current ripples cause the lower efficiency of power at load side. There is electrical stress on components in buck-boost converters which may cause over heating of components or may short circuit occur.

## 2. Description of Test System

The main system used to implement the improved algorithm with SEPI converter as shown in Figure.1. It’s sub-systems consist of following:

1) PV Panel
2) MPPT control unit
3) SEPI converter

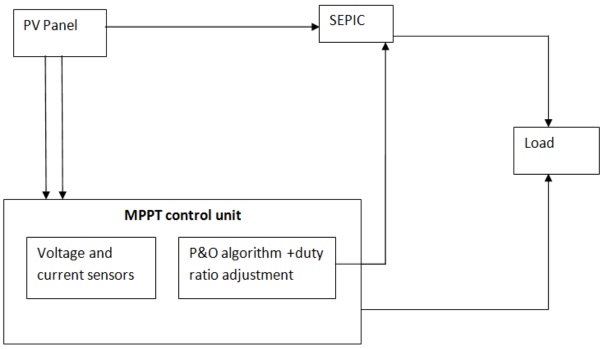


**Fig.1** Main System Block Diagram

*1.1. PV Panel*

The block of PV panel consists of PV module. The values of irradiance and temperature are assigned in coding of PV module. The extraction of current signal from PV module is done by controlled current source in an equivalent source of current. After that voltage and current measurement blocks are attached to get values of current and voltages at the output scope of PV array as shown in Figure. 2.

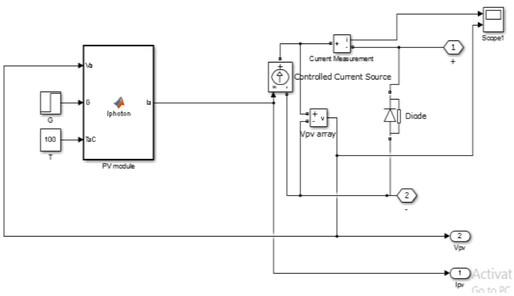


**Fig.2** PV Panel Sub-system

*3.2 MPPT Control Unit*

MPPT Controller subsystem executes the P&O algorithm to track peak power point. The input blocks are used to connect voltage and currents from output of PV module subsystem to MPPT Controller subsystem. Product block is used to multiply current and voltages coming from PV module to get power as shown in Figure. 3. A duty signal is generated in this subsystem execution of Perturb and Observe code. after exec

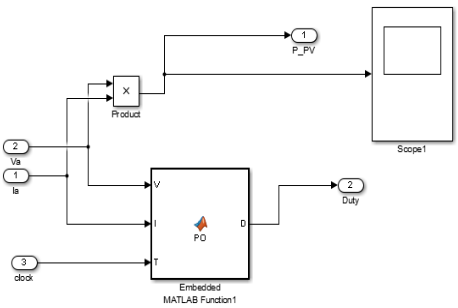


**Fig.3** MPPT Control Unit

*3.3 Perturb and Observe Algorithm*

Perturb and observe algorithm actually identifies the duty ratio by tracking maximum power point from sunlight according to that SEPIC is supposed to be operate to maximize the power at output. It measures the variation in power due to previous voltages as well as atmosphere change and keeps PV panel voltages constant for next period as shown in Figure. 4. According to [4] simply we can say that P&O algorithm measure the variation in power and determines the new PV voltages based on present and previous power variation. Firstly, the controller reads the initial voltage and current and calculates the initial power.

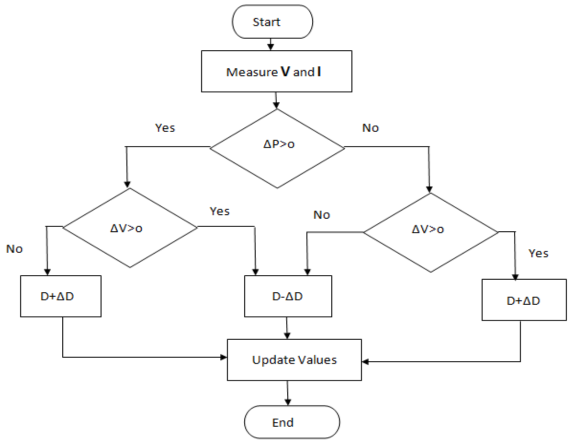


**Fig.4** Flowchart of Perturb and Observe Algorithm

**Case 1: Change in power is positive**

If the new power is greater than the previous power then the controller checks the change in voltages. If change in voltages are positive then the controller decreases PWM, if negative then increases PWM.

**Case 2: Change in power is negative**

If the change in power is negative then the controller checks the change in voltages. If change in voltages are positive then the controller increases PWM, if negative then decreases PWM. Physical modeling connections (PMC Ports) are used to connect output voltage of PV array to input of SEPIC circuit. SEPIC circuitry has an input capacitor of 2200uF to minimize input current ripple, to inductors L1 of 400uH and L2 of 470uH, a coupling capacitor of 2200uF, a MOSFET 75n75 as switching device having controlled duty cycle at it's gate and collector with inductor L1, a diode D1 and output capacitor of 2200uF. Voltage and current measurement blocks are used here to measure voltage and current signals respectively at scope blocks. Product block is used to multiply current and voltage to get output power at scope. A resistive load is attached at the output side of SEPIC circuit shown in Figure. 5.

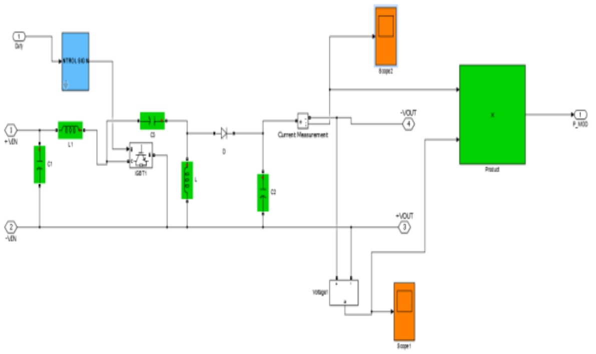

**Fig.5** SEPI Converter

### 4. SEPI Converter

Single ended primary inductor converter is a DC-DC converter having two inductors with one coupling capacitor and two other capacitors as shown in Fig. 6. It gives the output greater or less than the input by changing duty cycle of MOSFET using arduinouno. Its output is non-inverted, less electric stress on components and clamped switching waveforms results in less noise operation. It has two modes.

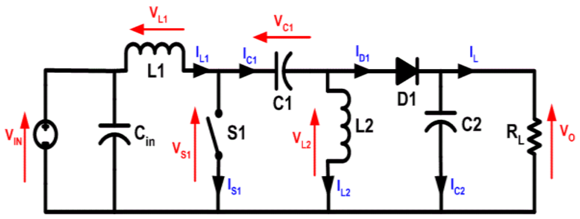


**Fig. 6** SEPI Circuit

**Continuous Mode**: In continuous mode the current through $L_1$ never drop to zero. During steady state the voltage across $C_1$ is equal to input voltages. As capacitor $C_1$ blocks the direct current so the average current of $C_1$ is zero. The inductor $L_2$ becomes independent of input current and supplies current to load. When the switch closes current flows through MOSFET and hence the current of $L_2$becomes negative. The capacitor $C_1$ gives the energy to increase the magnitude of current in $L_2$

**Discontinuous Mode:** Discontinuous mode occurs when the current through inductor $L_2$ becomes zero.

**Volt-second Balance:** During the first cycle when MOSFET conducts as shown in Figure. 7. The average voltage across inductor should be equal to zero,

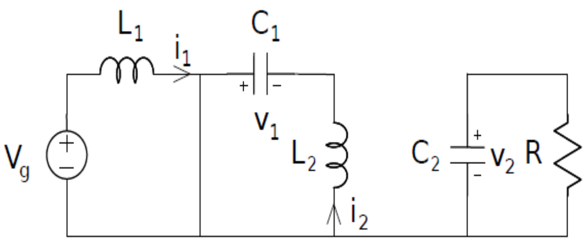


**Fig. 7** When MOSFET Conducts

$$< V_{L1} >= 0 < V_{L2} >= 0$$

The voltage across the first conductor equals to the input voltage

$$V_{L1} = V_g$$

The voltage across the second inductor equal to the voltage across first capacitor

$$V_{L2} = V_{C1}$$

During the second duty cycle when diode conducts and the MOSFET turns off circuit is shown in Figure. 8.

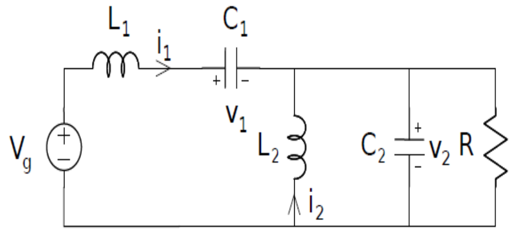


**Fig. 8** When Diode Conduct

The voltage across the first inductor equals

$$V_{L1} = V_g - V_{C1} - V_{C2}$$

The voltage across the second inductor equals

$$V_{L2} = -V_{C2}$$

Now by volt sec balance$< V_{L1} >= DV_g + D'(V_G - V - V_{C1}) = 0$

$$V_g = D'(V + V_{C1})$$

$$V_{C1} = \frac{V_g}{D'} - V$$

$$< V_{L2} >= DV_{C1} - D'V = 0$$

$$V_{C1} = \frac{D'V}{D}$$

$$V_{C1} = V_g$$

**Inductor Charge Balance:** The average current through capacitor is zero. During the first cycle when MOSFET conducts, circuit is shown in Figure. 9.

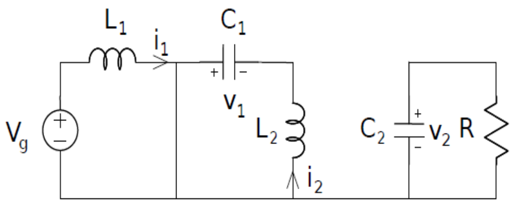


**Fig. 9**When MOSFET Conducts

$$< I_{C1} >= 0$$

$$< I_{C2} >= 0$$

Current through first capacitor equals$I_{C1} = -I_{L2}$

Current through second capacitor equals$I_{C2} = -\frac{-VC_2}{R}$

When diode conducts and the MOSFET turns off, the circuit of second duty cycle as shown in Figure. 10.

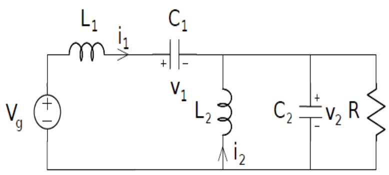


**Fig. 10**When Diode Conducts

Current through first capacitor equals$I_{c1} = I_{L1}$

Current through second capacitor equals$I_{C2} = I_{L1} + I_{L2} - \frac{V_{C2}}{R}$

Now using charge balance

$$< I_{C1} >= D'(I_{L1}) - D'(I_{L2}) = 0$$

$$I_{L1} = I_{L2}(\frac{D}{D'})$$

$$< I_{C2} >= D - \frac{V}{R} + D'(I_{L1} + I_{L2} - \frac{V}{R})$$

By using substitution

$$I_{L1} = \frac{V_g D_2}{RD'^2}$$

### 5. Working Methodology

The block of PV panel provides voltages and current which are supplied to MPPT Control units. At the same time voltages coming from PV panel are also directly supplied to input of SEPIC circuit. MPPT control unit has voltage and current sensors, by using these sensors MPPT algorithm works and tracks peak power point by varying duty cycle. The generated pulse of duty cycle by microcontroller is given to gate of switching device in SEPIC circuitry. So, this received signal increase or decrease ON/OFF time of switch by PWM technique. The increasing order of duty cycle will increase the ON time of switch to maintain stability at the output side of SEPIC. In this way the SEPIC will act as boost converter while in case of decreasing duty cycle the SEPIC will act as buck converter

### 6. Software Results

Input Voltage and Current: The input voltage and current appearing from solar PV panel are measured as 43V as shown in Figure. 11. and2.5A respectively. There were lot of current ripples at input of SEPIC as shown in figure.12.

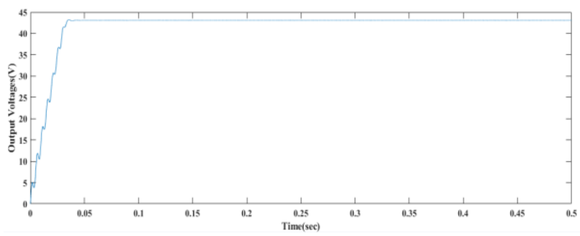


**Fig. 11** Input Voltage.

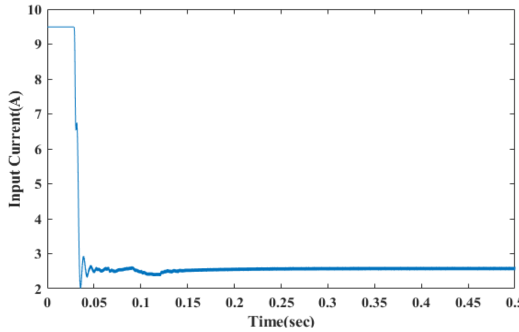


**Fig. 12**Input Current.

**Output Current of SEPI Converter**:

It is observed that output current of SEPI converter is decreased to 1.9A and there were very less ripples in current as shown in Figure. 13.

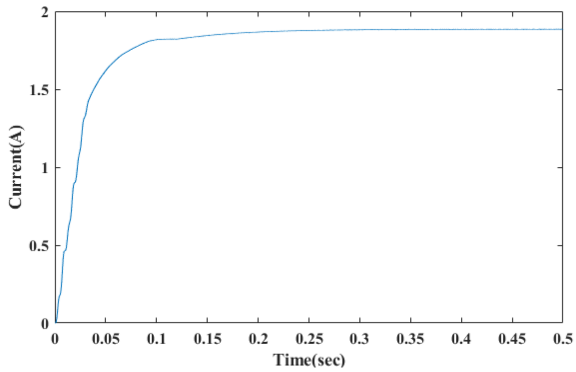


**Fig. 13**Output current of SEPI Converter.

**Output Voltage of SEPI converter:** It is observed that output voltage of SEPI converter are increased to 58V and stabilized after 0.25 seconds as shown in Figure. 14.

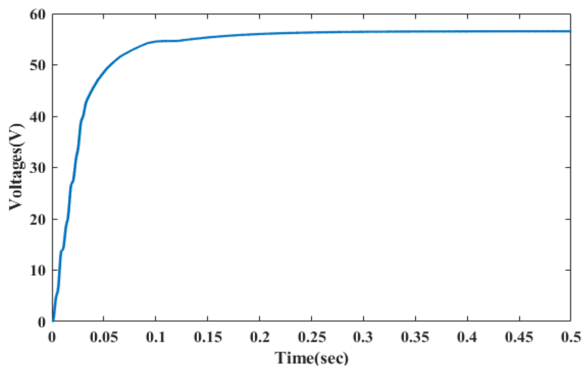


**Fig. 14** Output Voltage of SEPI Converter.

**Input and Output Power of SEPI Converter**

It is observed that to make the power constant output current decreased as compare to input while output voltages increased as compare to input. It is also shown in Fig. 4.8 that the output power is smooth as compare to input power due to reduction in input current ripples.

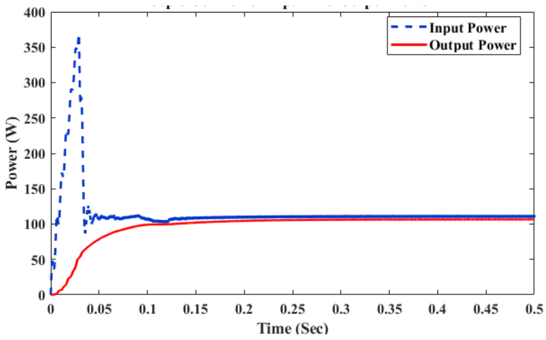


**Fig. 15**Input and Output Power of SEPI Converter

## 7. Hardware Implementation

The project involves implementation of SEPIC with two inductors and three capacitors. Solar panel gives the input power to the SEPIC. Controller works on the perturb and observe algorithm to extract maximum power from the solar panel and also gives the duty cycle to the MOSFET to increase or decrease the output voltages. SEPIC regulates the output by varying PWM. The PCB is designed by using Professional Proteus Software.

## Conclusion

The proposed "MPPT based SEPIC convertor" is to get maximum output from the solar PV panel. Perturb and Observe technique is used in this work. It has been observed that the Perturb and Observe technique is the simpler and easy to implement. Perturb and Observe technique is best and correctly implemented in SEPIC convertor. While performing tests on SEPIC it has been observed that the output power of solar PV panel increases with SEPIC converter as compared to directly connected with the load. We can regulate the voltages at output side according to our load requirement. In this work we implemented SEPIC by tracking maximum power point. We stepped down the voltages by keeping power constant at different angles readings are taken. It has been observed that EPIC provides constant output power for fixed load. SEPIC converter gives positive output voltages whereas the buck-boost gives negative with respect to ground.

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