# MODELLING AND ANALYSIS OF SEPIC CONVERTER BASED PHOTOVOLTAIC SYSTEM

**T Alex Stanley Raja[1], R Senthil Kumar[2], A Nandhakumar[3], K V Santhoshkumar[4]**

[1,3,4] Asst Prof, Department of EEE, Bannari Amman Institute of Technology
[2] Professor, Department of EEE, Bannari Amman Institute of Technology

---

**Abstract** - *There has been an increase in demand for clean and sustainable energy sources, and solar energy is currently considered to be one of the most valuable and abundant yet low-maintenance clean sustainable energy source. Photovoltaic solar energy systems require DC-DC converter in order to regulate and control the varying output of the solar panel. The single ended Primary inductance Converter topology performs the operation of a buck-boost converter but with no voltage polarity reversal. This paper suggests a converter design that will ensure high performance and cost efficiency. The converter has been simulated in MATLAB and the hardware was done by choosing the design values appropriately. This design aims to have lower losses for higher switching frequencies, and maximize the added advantages of the proposed converter, such as low ripple, high efficiency and low electrical stress on the components.*

***Keywords*** - *Solar; SEPIC; Buck-Boost; DC/DC Converter; MATLAB*

## 1. INTRODUCTION

The world's excessive dependence on fossil fuels and other non-renewable energy sources have lead to their depletion. Hence, today we look up to renewable energy sources, which are reliable and plentiful and will be easy to harness once the right kind of technology and infrastructure is made available. Solar energy, among them, is the most readily available one all around the world. According to trends seen in USA and Japan, in the next few years, it is predicted that millions of households all around the world will be using solar energy. In India, the Indian Renewable Energy Development Agency and the Ministry of Non-Conventional Energy Sources are formulating a program to have solar energy in more than a million households within the next few years. In such a country as this with plentiful sunshine all throughout the year, it is possible to harness solar energy for a wide range of applications.

While dealing with application of renewable energy sources, the electrical equipment designs require converters. The energy is harnessed from the source, and then it goes through the conversion stage, which is required to deal with the fluctuating and lower output voltage characteristics of renewable energy. While many converter topologies are available today, the SEPIC topology is integrated into the design of solar powered street lamps due to specific advantages. [1-4]

There are five main DC-DC converter topologies available today. Buck converter can reduce input voltage, Boost can increase voltage, while Buck-Boost, Cuk and SEPIC converters can both reduce and increase voltage. However, the Single-Ended Primary-Inductor Converter (SEPIC) is the only DC/DC converter that can essentially function like a Buck-Boost converter but with the added advantage of producing a non-inverted output. It can be argued that Buck-Boost converters are cheaper as they only require a single inductor and capacitor, but these converters also suffer from high input current ripple. [5-8] Current ripple can create harmonics, which in many cases will necessitate the use of large capacitors or an LC filter. This makes buck-boost inefficient and costly.

Cuk converter can compensate for the shortcomings of Buck-boost converters, and simultaneously can also produce non-inverted output voltage. However, his converter causes large amounts of electrical stress on its components, resulting in device failure or overheating. SEPIC converters are able to solve all these problems. Furthermore, in SEPIC, the coupling capacitor energy from input to output enables the device to handle short circuits in a more controlled manner when compared to the traditional converter topologies. The SEPIC design uses minimal active components and 'clamped' switching waveforms that produce reduced noise from high frequency switching operations, hence dealing with issues causes my electromagnetic interferences.

## 2. SEPIC CONVERTER

Single-ended primary inductor converter (SEPIC) is a type of DC-DC converter, that allows the voltage at its output to be more than, less than, or equal to that at its input. The output voltage of the SEPIC is controlled by the duty cycle of the MOSFET. A SEPIC converter shown in Fig.1 is similar to a traditional buck-boost converter, but has advantages of having non-inverted output, by means of coupling energy from the input to the output is via a series capacitor. When the switch is turned off output voltage drops to 0 V. SEPIC is useful in applications like battery charging where voltage can be above and below that of the regulator output.

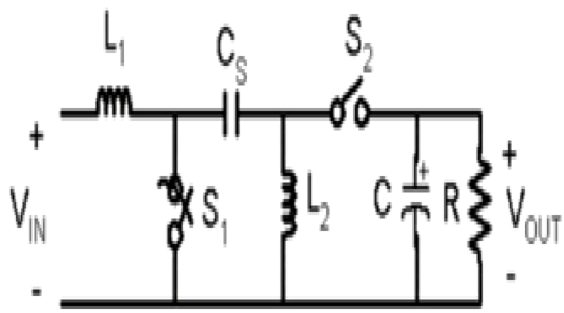


Fig.1. SEPIC Converter Model

### 2.1 Continuous Conduction Mode

A SEPIC is said to be in continuous-conduction mode if the current through the inductor L1 never go down to zero. During a SEPIC's steady-state operation, the average voltage across capacitor Cs (VCs) is equal to the input voltage (VIN). Because capacitor Cs blocks direct current, the average current across it (ICs) is zero, making inductor L2 the only source of load current. Hence the average current through inductor L2 is the same as the average load current and hence independent of the input voltage. Looking at average voltages, the following can be written:

$$VIN=VL1+VCs+VL2$$

Because the average voltage of VCs is equal to VIN

$$VL1 = -VL2.$$

For this reason, the two inductors can be wound on the same core. Since the voltages are the equal in magnitude, their mutual inductance effect will be zero. Here it is assumed that the polarity of the coil is correct. As the voltages are the equal in magnitude, the ripple currents of the two inductors will be equal in magnitude. The average currents can be summed as follows:

$$ID1= IL1 - IL2$$

When switch Q1 is turned on, current IL1 increases and the current IL2 increases in the negative direction. The energy to increase the current IL1 comes from the input source. Since Q1 is a short while closed, and the instantaneous voltage VCs is approximately VIN, the voltage VL2 is approximately –VIN. Therefore, the capacitor Cs supplies the energy to increase the magnitude of the current in IL2 and thus increase the energy stored in L2.

When switch Q1 is turned off, the current ICs becomes the same as the current IL1, as the inductors will not allow instantaneous changes in current. Current IL2 will continue in the negative direction, in fact it never reverse direction. It can be seen from the diagram that a negative IL2 will add to the current IL1 to increase the current delivered to the load.

By Using Kirchhoff's Current Law

$$ID1 = ICs - IL2.$$

So while Q1 is off, power is delivered to the load from both L2 and L1. Coupling capacitor (Cs), is charged by L1 during this off cycle, and will recharge L2 during the on cycle. The boost/buck capabilities of the SEPIC are possible because of capacitor Cs and inductor L2. Inductor L1 and switch Q1 create a standard boost converter, which generates a voltage (VQ1) that is higher than 15 VIN. Its magnitude is determined by the duty cycle of the switch Q1. Since the average voltage across Cs is VIN, the output voltage (VOUT) is

$$VOUT=VQ1-VIN.$$

If VQ1 is less than double of VIN, then the output voltage will be less than the input voltage. If VQ1 will be greater than double of VIN, then the output voltage will be greater than the input voltage. The power dissipation in diode is equal to the output current multiplied by the forward voltage drop of the diode. Schottky diode is used to minimize the switching loss.

Diode peak current =2.475A

### 2.2 Discontinuous Conduction Mode

During the Discontinuous mode of conduction the current through the inductor Ll is able to fall to zero.

## 3. PROPOSED SYSTEM

In existing system, the boost converter is used to boost the voltage to required output level. So boosting capacity is limited by duty cycle. LL and LC filters are used to eliminate the harmonics generated in inverter side. Usage of those filters creates resonance problem which make the closed-loop control system unstable and resonant with the supply grid. Such a resonant problem is a special type of system instability that is becoming more common in distribution systems with a high penetration of sustainable energy integrations interfacing with VSC. The overall setup of the proposed system is shown in Fig.2.

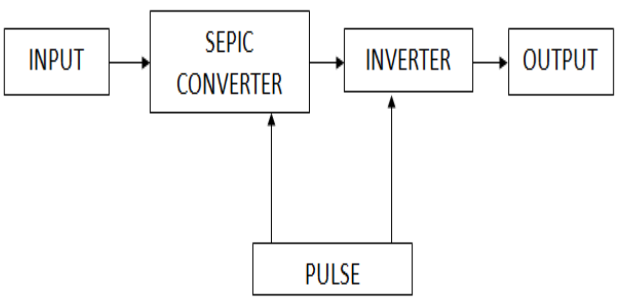


Fig.2. Block Diagram of Proposed System

In proposed system, SEPIC Converter is used instead of boost converter which reduces the harmonic generation and improves the system performance in closed loop system. SEPIC converter is used as a impedance matching network. The switching pulse for the converter and the inverter is generated by a microcontroller.

The proposed system is simulated using MATLAB as shown in Fig.3. The simulation results are presented and analyzed to validate the effectiveness of the system. The steady state output voltage waveform of the inverter is shown in Fig.4.

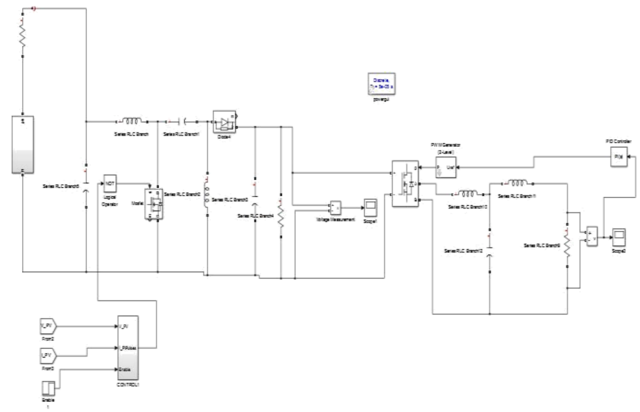

Fig.3. MATLAB model of the Proposed System

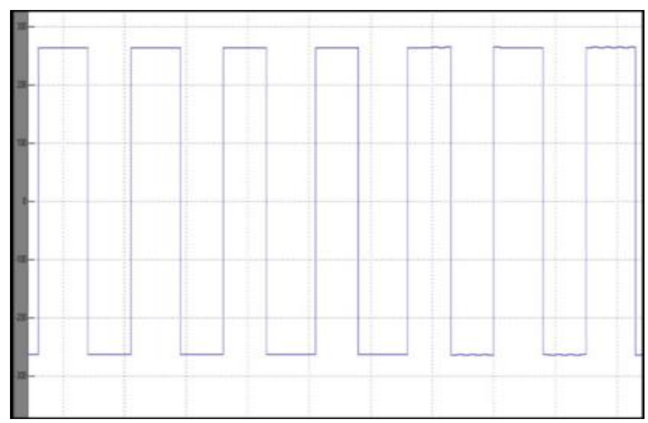

Fig.4. Output waveform of the System

The hardware model of the proposed system is fabricated as shown in fig.5 and the steady state output voltage waveform of the same is shown in Fig.6.

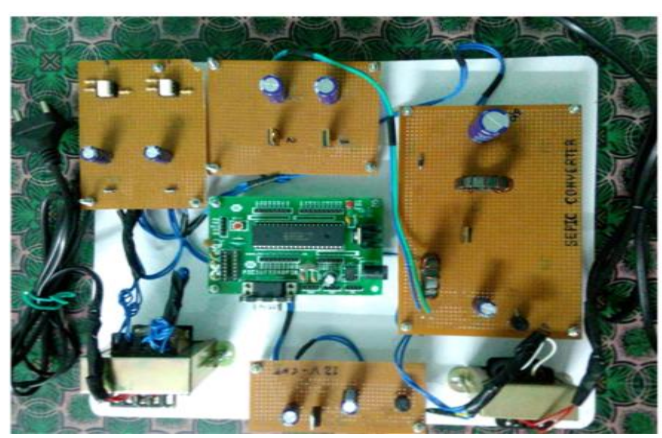


Fig.5. MATLAB model of the Proposed System

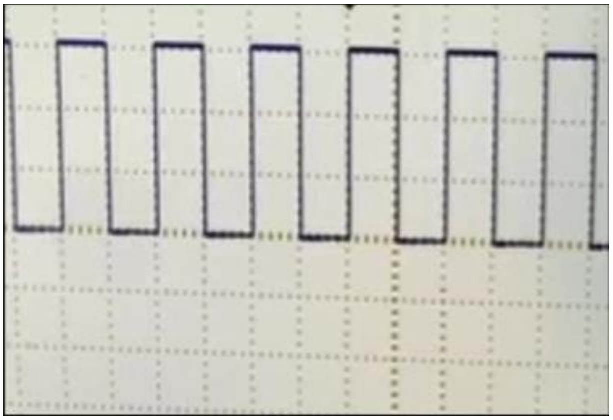

Fig.6. Output waveform of the System

## 4. CONCLUSION

A novel technique using a SEPIC converter to efficiently boost the input voltage to the system has been presented. The technique is simple and elegant and does not require complicated mathematical computation. MATLAB/Simulink software has been used to simulate SEPIC converter. Hardware model was fonned for the same and was tested for 40W giving an efficiency of 93.9% which are evident from the hardware waveforms.Compared to many existing methods, the proposed technique is unnecessary to

1. Perform digital sampling of the converter parameters.
2. Perform sophisticated mathematical computations of the panel output power.
3. Approximate the panel output characteristics. Hence, it can be used under a wide range of meteorological conditions.

The main problem of Resonance is neglected and its gives higher boosting capability.

## REFERENCES

[I] Adhikari, Neha, Bhim Singh, and A.L Vyas. "Performance Evaluation of a Low Power Solar-PV Energy System with SEPIC Converter." IEEE PEDS (2011).

[2] Banaei, M.R, M.R Shirinabady, and Mehdi Mirzaey. "MPPT Control of Photovoltaic Using SEPIC Converter to Reduce the Input Current Ripples." Journal of Engineering Research and Applications 4. I (Versions 2) (2014): 160-66.

[3] "Electric Characteristics of Solar Panels (PV Modules." Green Time (2010). [4] Falin, Jeff. "Designing DC/DC Converters Based on SEPIC Topology." Analog Instrumentation Journal. Texas Instruments. Web. 12 Jan. 2016.

[4] James Dunia, Bakari. "Performance Comparison between CUK and SEPIC Converts for Maximum Power Point TRacking Using Incremental Conductance Technique in Solar Power Applications."International Journal of Electrical, Electronics and Communications Engineering 7.12 (2013) ..

[5] Maglin, J.R, R. Ramesh, and Vaigundamoorthi. "Design and Analysis of SEPIC Converter Based MPPT for Solar PV Module with CPWM." J Electr Eng Technol 9.4 (2014).

[6] Naithani, Vivek, Madan Mohan Malaviya, and Govind Ballah. "Simulation Of SEPIC Converter FED LEOs." International Journal of Engineering Science and Technology 4.3 (2012).

[7] Raj, T. Ajith Bosco, J.R Maglin, M. Vaigundamoorthi, and William Christopher. "Grid Connected Solar PV System with SEPIC Converter Compared with Parallel Boost Converter Based MPPT." International Journal of Photo energy (2014).