A single-ended primary-inductor converter (SEPIC)

Anjali Papansingh Thakur

Department Of Electrical Engineering

Shri Guru Gobind Singhji Institute of Engineering and Technology, Nanded

ABSTRACT

The Non-Conventional sources such as solar energy has been replacement and best exploited electric source. The solar electric power required DC-DC converter for production, controllable and regulation of variable solar electric energy. The single ended boost converter has been replaced by SEPIC converter to overcome the problem associated with DC-DC converter. The problem associated with DC converter such as high amount of ripple, create harmonics, invert the voltage, create overheating and effective efficiency can be minimized and achieved best efficiency by SEPIC converters. This paper has been focused on design, comparison of DC-DC solar system with the SEPIC converter as using closed loop feedback control. In comparison DC-DC converter to SEPIC converter, it has highly efficient more than 1 -5 %.

INTRODUCTION

A Single-Ended Primary Inductor Converter (SEPIC) is a DC-DC converter that can step up or step down the input voltage while maintaining the same polarity at the output. It consists of two inductors, two capacitors, a diode, and a switching device, typically a MOSFET. The SEPIC topology transfers energy through a coupling capacitor, ensuring a stable output even with fluctuating input voltage. This makes it suitable for applications like solar power systems, battery-operated devices, and LED drivers. Unlike traditional buck or boost converters, SEPIC provides greater flexibility but requires precise component selection for optimal efficiency.

WORKING PRINCIPAL

The working principle of a SEPIC (Single-Ended Primary Inductor Converter) is based on the energy storage and transfer between two inductors, a capacitor, and a switch. In operation, the switch (typically a MOSFET) alternates between two states: ON and OFF.

When the switch is ON, the input voltage is applied to both inductors. The first inductor stores energy while the second inductor is in the process of transferring energy to the output capacitor, ensuring that the output voltage is regulated. The coupling capacitor plays a crucial role in isolating the output from the input while transferring energy.
When the switch is OFF, the first inductor's stored energy is released to the output through a diode, while the second inductor continues to transfer energy through the coupling capacitor to maintain the output voltage.

This continuous cycle of energy storage and transfer allows the SEPIC converter to either step up or step down the input voltage based on the duty cycle of the switch, while ensuring that the output voltage is stable and of the same polarity as the input. This working principle makes the SEPIC converter highly versatile for applications requiring a wide range of input voltages.

CIRCUIT SCHEMATIC

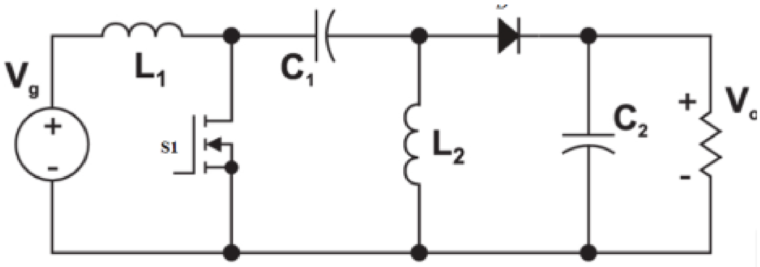

Figure 1: A single-ended primary-inductor converter (SEPIC)

MATLAB Simulation Schematic:

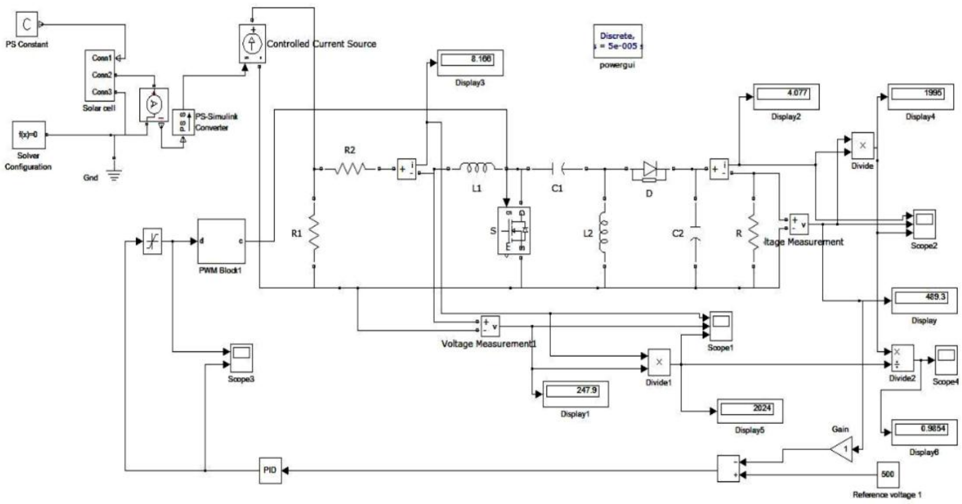

Figure 2: Simulation diagram of closed loop SEPIC converter solar energy system

eSim Schematic

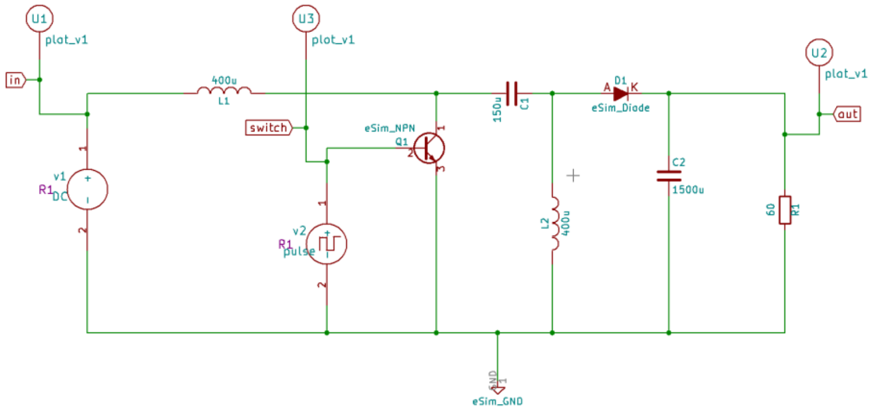

Figure 3: A single-ended primary-inductor converter (SEPIC) using eSim

CALCULATIONS FOR BOOST CONVERTER:

Given Values

Input Voltage = 12v

Time period = 10u

Pulse width = 6u

Step 1: Duty Cycle Calculation

The duty cycle (D) is the ratio of the ON time to the total switching period:

D = Ton/T

D = 6u/10u = 0.6u

Step 2: Calculate Frequency

Fs = 1/T

*Fs = 1/10*10^-6*

Fs = 100KHZ

Step 3: Output Voltage Determination

The SEPIC converter follows the voltage conversion ratio similar to a buck-boost converter:

*Vout = (D/1-D)*vin*

Substituting the Values:

*Vout = (0.6/1-0.6)*12v = 18v*

Here it will act like boost converter

Input Waveform

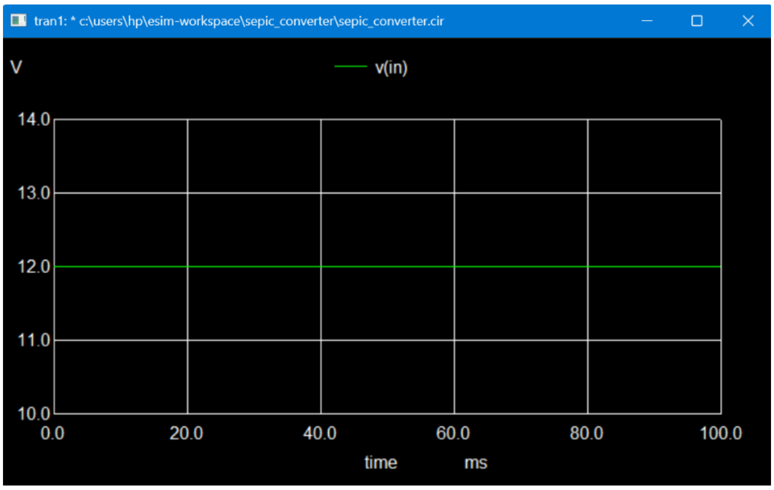

Figure 4: Input waveform of SEPIC Converter

Output Waveform

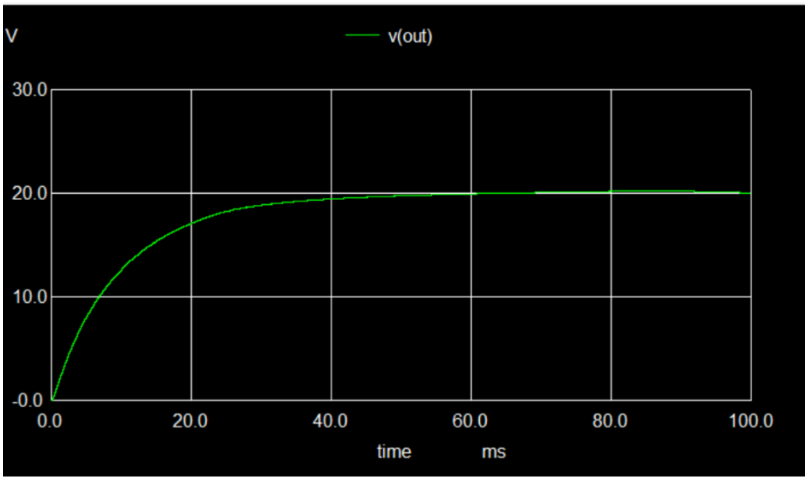

Figure 5: Output Waveform of SEPIC for Boost Converter

CALCULATIONS FOR BUCK CONVERTER:

Given Values
Input Voltage = 12v
Time period = 10u
Pulse width = 4u

Step 1: Duty Cycle Calculation
The duty cycle (D) is the ratio of the ON time to the total switching period:
D = Ton/T

D = 4u/10u = 0.4u

Step 2: Output Voltage Determination
The SEPIC converter follows the voltage conversion ratio similar to a buck-boost converter:

*Vout = (D/1-D)*vin*

Substituting the Values:
*Vout = (0.4/1-0.4)*12v = 8v*

Here it will act like buck converter

Output Waveform

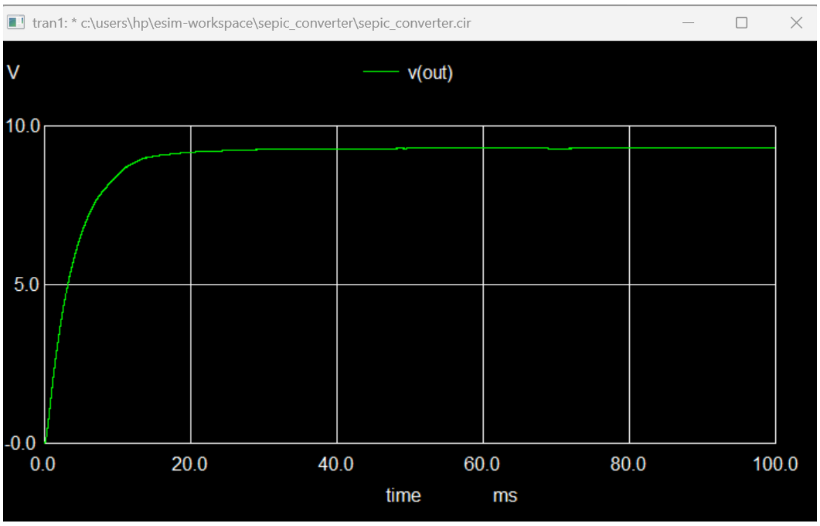

Figure 6: Output Waveform of SEPIC for Buck Converter

Pulse Waveform

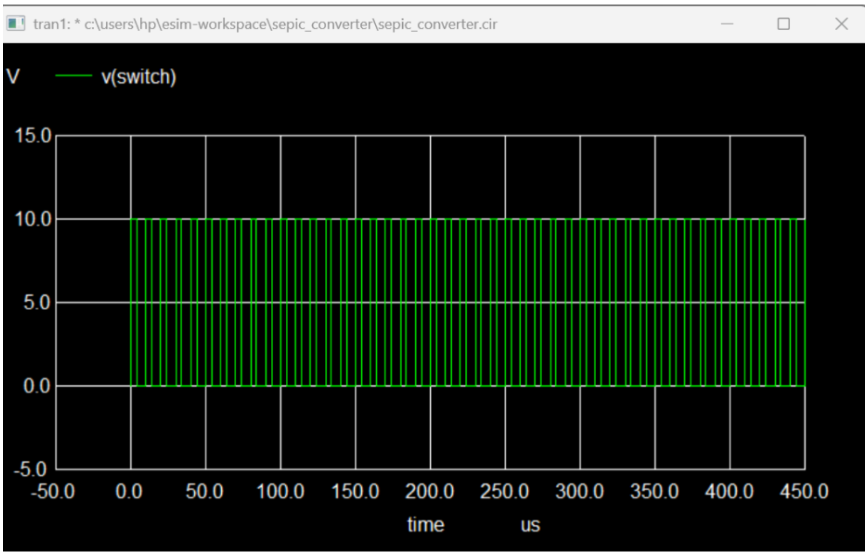

Figure 7: Pulse Waveform of SEPIC Converter

CONCLUSION:

In conclusion, the SEPIC converter is a versatile DC-DC converter that can efficiently step up or step down input voltage while maintaining a stable, non-inverted output voltage. It operates through energy storage in inductors and transfers energy via a coupling capacitor, making it suitable for applications where the input voltage fluctuates. With its ability to handle a wide range of input voltages and provide a regulated output, the SEPIC converter is particularly useful in renewable energy systems, battery-powered devices, and other power-sensitive applications. However, optimal performance requires careful design and selection of components to minimize losses and ensure efficiency.

REFERENCE:

[1] S. S. Martin, A. Chebak and N. Barka, "Development of renewable energy laboratory based on integration of wind, solar and biodiesel energies through a virtual and physical environment," 2015 3rd International Renewable and Sustainable Energy Conference, Marrakech, 2015, pp. 1-8.

[2] Y. Mahmoud, W. Xiao, and H. H. Zeineldin, "A simple approach to modeling and simulation of photovoltaic modules," IEEE Trans. Sustain. Energy, vol. 3, no. 1, Jan. 2012, pp. 185–186.

[3] R. A. Mastromauro, M. Liserre, and A. Dell'Aquila, "Control issues in single-stage photovoltaic systems: MPPT, current and voltage control,"IEEE Trans. Ind. Informat., vol. 8, no. 2, May. 2012, pp. 241– 254. [4] S. Venkatanarayanan and C. Sakthivinayagam, "MPPT for PV using coupled inductor SEPIC converter for standalone power system," 2016 International Conference on Energy Efficient Technologies for Sustainability, Nagercoil, 2016, pp. 596-602.