

SIMULATION OF SEPIC DC-DC CONVERTER USING LABVIEW

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Abstract

The DC-DC converters are nowadays widely used in most of the electronic equipment such as personal computers, office equipment, spacecraft power systems, laptop and telecommunication. In the process of AC-DC conversion system the narrow pulse current drawn from the input ac supply results in lower power factor and higher THD (Total Harmonic Distortion). To overcome these problems SEPIC (Single Ended Primary Inductance Converter) topology is used which produces output voltage greater or lesser than the input voltage without polarity reversal. In this paper a closed loop PFC algorithm is implemented to improve power factor and the simulation is carried out to analyze the performance of close loop PFC using SEPIC converter in labview and multisim software.

Keyword: DC-DC converter, duty cycle, THD, power factor, PI controller, SEPIC, output voltage

1.INTRODUCTION

DC-DC converters converts unregulated input voltage to regulated output voltage efficiently. DC-DC converters uses high frequency switching, inductors and capacitors to reduce noise and produce regulated output voltage. The common five DC-DC converter topologies are Buck converter, Boost converter, Buck-Boost converter, Cuk converter and Single Ended Primary Inductance Converter (SEPIC). The Buck converter produces regulated output voltage lesser than the input voltage. The Boost converter produces regulated output voltage greater than the input voltage.

The Buck-Boost and Cuk converter produces regulated output voltage lesser or greater than the input voltage with polarity reversal. The SEPIC converter produces regulated output voltage lesser or greater than the input voltage without polarity reversal than the input voltage. The output voltages of all the DC-DC converters are shown in Table 1.

The power factor correction aims at shaping the input current to improve the availability of real power from the mains. Ideally, in a pure resistive load the reactive power drawn by any electrical appliance is zero i.e., the current and voltage drawn from the supply are in phase and harmonics are absent. In such cases the losses are minimum and the cost of not only of distribution power but also with the generation of power and the involved capital equipment. Hence the passive components present in the SEPIC DC-DC converter helps in improving the power factor of the circuit.

Table 1 : Output voltage of DC-DC converters

DC-DC CONVERTERS	OUTPUT VOLTAGE (V _o)
BUCK	$V_s D$
BOOST	$\frac{V_s D}{1 - D}$
BUCK-BOOST	$-V_s \left(\frac{D}{1 - D} \right)$
CUK	$-V_s \left(\frac{D}{1 - D} \right)$
SEPIC	$V_s \left(\frac{D}{1 - D} \right)$

2. BLOCK DIAGRAM

The block diagram of closed loop PFC using SEPIC converter shown in Fig 2 consists of a bridge rectifier with a smoothing capacitor circuit to convert AC to DC. The SEPIC converter converts unregulated input DC voltage to regulated DC output voltage at the load. The tuned PI controller at the feedback helps in obtaining desired output voltage.

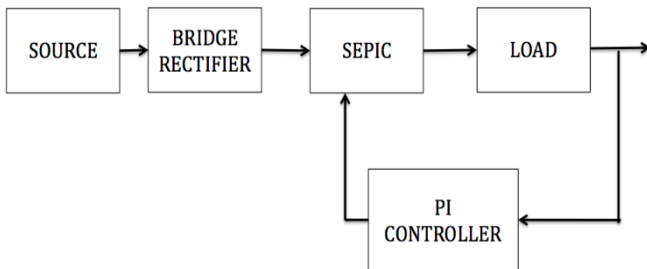


Fig 2 : Block diagram of closed loop PFC using SEPIC

3. DESIGN OF SEPIC DC-DC CONVERTER

The initial assumptions to be made to derive the relation between input and output voltages are :

1. Inductors value should be very large to maintain constant current.
2. Capacitors value should be very large to maintain constant voltage.
3. The duty ratio D, the switch is closed for time DT and open for (1-D)T.
4. The switch and the diode are ideal.

Working : The circuit diagram of SEPIC is shown in fig 3.1 (a) . The SEPIC operates in two modes.

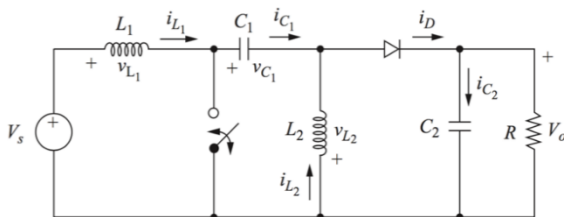


Fig 3.1 (a) : Circuit diagram of SEPIC

Mode 1 : When switch is closed and diode is reverse biased.

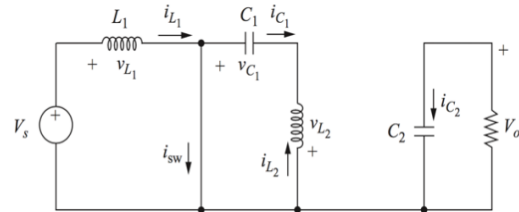


Fig 3.1 (b) : Circuit diagram of Mode 1

Applying Kirchoff's voltage law around the path containing Vs, L1, C1, and L2 gives

$$-V_s + v_{L1} + v_{C1} - v_{L2} = 0$$

Using the average of these voltages,

$$-V_s + 0 + V_{C1} - 0 = 0$$

showing that the average voltage across the capacitor

$$V_{C1} = V_s \quad (1)$$

When the switch is closed, the diode is off, and the circuit is as shown in Fig-b. The voltage across L1 for the interval DT is

$$v_{L1} = V_s \quad (2)$$

Mode 2 : When switch is open and diode is forward biased.

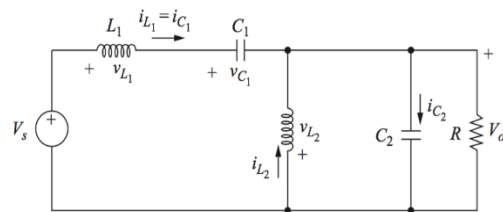


Fig 3.1 (c) : Circuit diagram of Mode 2

Kirchoff's voltage law around the outermost path gives

$$-V_s + v_{L1} + v_{C1} + V_o = 0 \quad (3)$$

Assuming that the voltage across C_1 remains constant at its average value of V_s

$$-V_s + v_{L1} + V_s + V_o = 0 \quad (4)$$

Or

$$v_{L1} = -V_o \quad (5)$$

for the interval $(1 - D)T$. Since the average voltage across an inductor is zero for periodic operation, Eqs. (2) and (5) are combined to get

$$(v_{L1,SWclosed})(DT) + (v_{L1,SWopen})(1 - D)T = 0$$

$$V_s(DT) - V_o(1 - D)T = 0$$

where D is the duty ratio of the switch. The result is

$$V_o = V_s \frac{D}{1 - D}$$

which can be expressed as

$$D = \frac{V_o}{V_o + V_s}$$

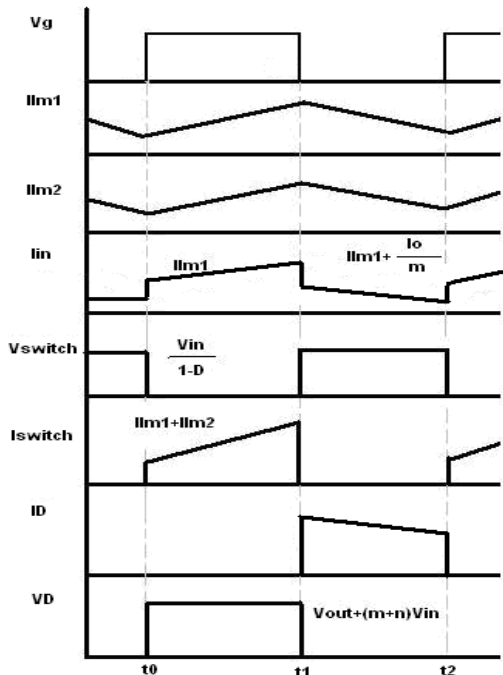


Fig 3.1 (d) : Key waveform of SEPIC

4.SIMULATION AND RESULTS

To analyze the performance of closed loop PFC using SEPIC converter the simulation is carried out in MULTISIM and LABVIEW softwares.

MULTISIM SIMULATION : First multisim software is used to create the open loop circuit with all analog inputs.

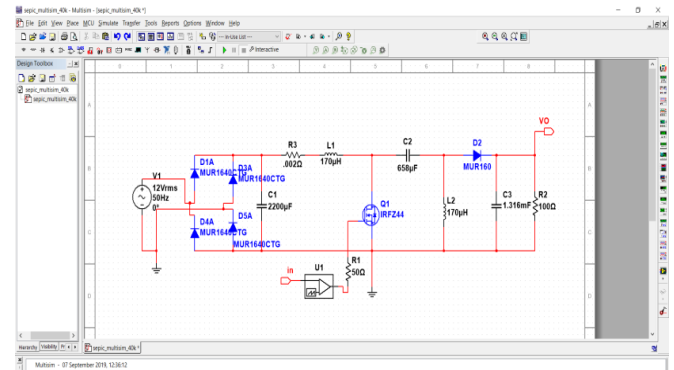


Fig 4.1 : Multisim simulation of SEPIC

LABVIEW SIMULATION :Labview software is used to create the closed loop circuit. A control & simulation loop is created to interface multisim with labview software

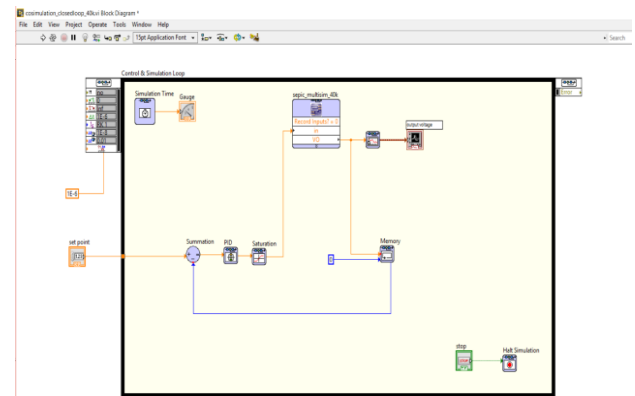


Fig 4.2 : Labview simulation of SEPIC

Simulation parameters

Input supply Voltage	Vs: 12 V
Output Voltage Reference	Vo: 24 V
Switching Frequency	fs: 2 KHz
Inductors	L1: 1.325mH, L2: 1.325 mH
Capacitors	C1: 658 μ F C2: 1.316 mF
Resistors	RL: 100 Ohm
PI controller Gain	Kp: 0.2 Ki: 0.05

5.RESULTS :

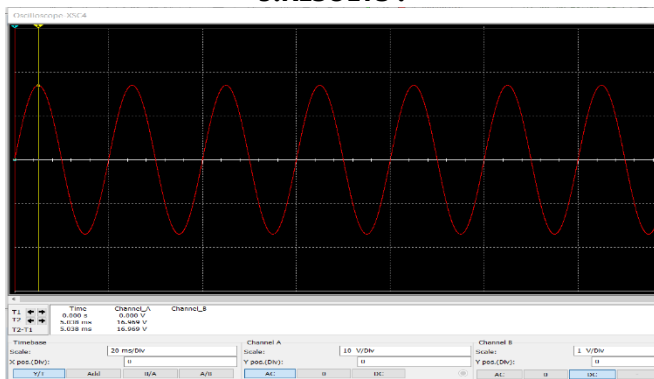


Fig 4.3 : Input ac voltage

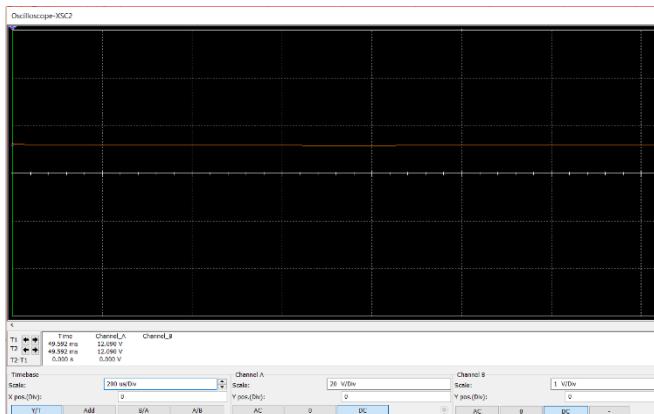


Fig 4.4 : Output rectified dc voltage

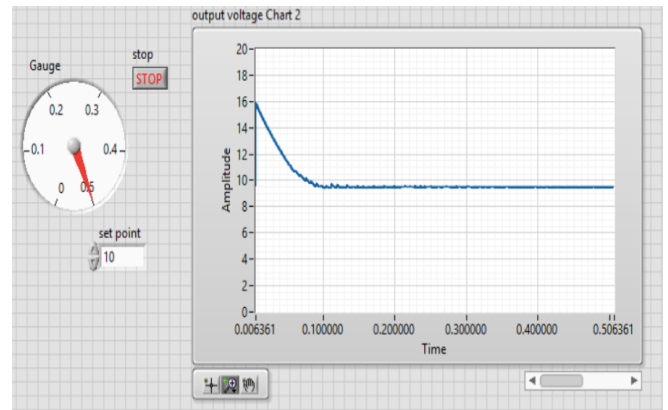


Fig 4.5 : Output voltage Vref = 10V (buck operation)

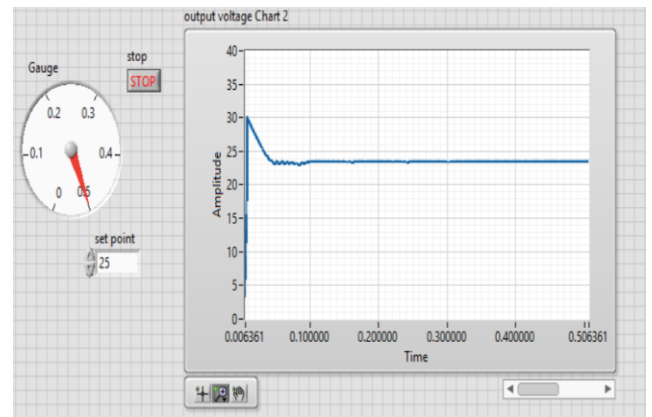


Fig 4.3 : Output voltage Vref = 25V (boost operation)

6.CONCLUSION

The performance of closed loop PFC using SEPIC converter performance is implemented in labview and multisim software. The proposed converter improves power factor of the circuit and also reduces total harmonic distortion. cycle. The power factor improvement in the electrical circuit results in lower THD and higher efficiency. The tuned PI controller produces desired output voltage with proper duty. The proposed system is analysed for both buck and boost operations and the simulation results are shown in fig. 4.3, 4.4, 4.5 & 4.6.

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