# SIMULATION OF SEPIC CONVERTER FED LEDs

Vivek Naithani[1] and Dr.A.N.Tiwari[2] and Smita Dobhal[3]
[1,2]Department of Electrical Engineering
Madan Mohan Malaviya Engineering College, Gorakhpur, U.P., INDIA
[3]Department of Electrical Engineering
Govind Ballabh Pant Engineering College, Pauri, U.K., INDIA
vivnai.44012@gmail.com and amarndee@rediffmail.com

## Abstract

A current-shaper SEPIC converter for high brightness LEDs is presented. Due to the recent advancement in the light emitting diode (LED) technology, high brightness white LED becomes feasible in residential, industry and commercial applications to replace the incandescent bulbs, halogen bulbs, and even compact fluorescent light bulbs. In these offline applications, high power factor, and low harmonics are of primary importance. A SEPIC converter is particularly suitable for non-isolated application since it is single-stage, and can step up or step down, and high power factor as it is run in discontinuous conduction mode. A current feedback loop is proposed to control the LED brightness. This circuit has the advantages of one stage of power conversion, no need to sense the input voltage, simple feedback control, and voltage step-up and down, high power factor and dimmable LED current.

## *KEYWORDS*

SEPIC Converter, LED, MATLAB.

## I. Introduction

No doubt those illumination applications have played the important role in the electrical energy consumption in the world. Therefore, more efficient system is an essential task today. The main point to be achieved are the rapid advances in the material and manufacturing technologies that would enable significant development in high – luminance Light emitting diode (LEDs) for lighting application. In the present time, most of bulbs have been replaced by LEDs as an efficient way to reduce the energy consumption. LED Lamp offer many advantages such as: extremely long life, i.e. 10,000 hours, it is more than 10 times that of CFL, extreme robustness as there are no glass component or filament , no external reflector, a modular construction, relatively high efficiency, no UV or IR output and they can be dimmed smoothly from full output to off. The main objective in the design of a LED lamp driver using the SEPIC converter two - fold. The first goal is the reduction of overall power consumption within the converter. This lead to minimum heat is dissipation which in turn ensures minimal thermal management and cooling requirement, and improved reliability. The second consideration pertains to the reduce component count and simple controller but the component voltage stress are high. There are two types of regulated DC power supply- linear power supply and switched mode power supply. The linear power supply operates as an active resistance controlled circuit. In switch mode power supply, ac power is rectified to get a dc power and this dc power is chopped to regulate the output voltage by turning ON and OFF controlled silicon switches.

## II. SEPIC Converter

The single-ended primary-inductance converter (SEPIC) is a DC/DC-converter topology that provides a positive regulated output voltage from an input voltage that varies from above to below the output voltage. Unfortunately, the SEPIC topology is difficult to understand and requires two inductors, making the power-supply footprint quite large. The coupled inductor not only provides a smaller footprint but also, to get the same inductor ripple current, requires only half the inductance required for a SEPIC with two separate inductors. The LED Lamp driver proposed in Fig.4 relies on using the conventional SEPIC PFC converter shown in Fig.1 operating it in DCM has the advantages of one single stage power conversion, high power factor, reduced component count and simple controller but the components voltage stresses are high e.g. the switch has voltage stress of ($V_{in}$+ $V_{out}$)[5].

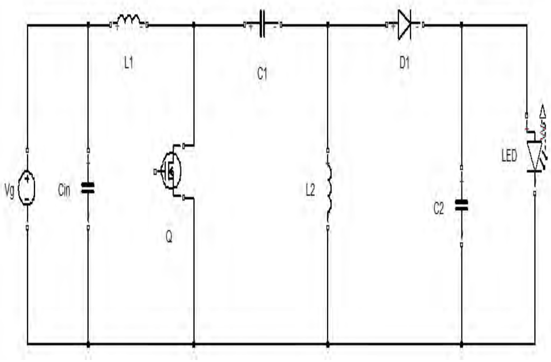

Fig.1: Conventional SEPIC Converter

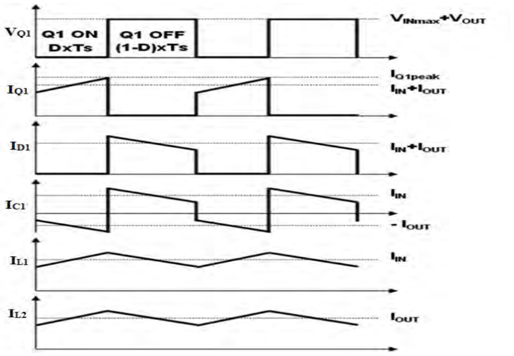

Fig.2: SEPIC Component current during CCM

Fig.2 shows the different current and voltage waveform during when the switch is ON and OFF. In this time the current flowing in the inductor $L_1$ and $L_2$ is continuous in nature. When switch is ON then the current is continuously.

### III. Modeling of SEPIC Converter with LEDs

Voltage across the LEDs varies depending upon the isolation, temperature at which they are operating. This voltage can vary over a wide range, so it can be higher or lower than the DC bus voltage. To keep the output voltage at DC bus voltage we may need to step up or step down the voltage. This can be done using either BUCK-BOOST converter or SEPIC converter. SEPIC converter is chosen because its output voltage is of same sign as that of input. Connection diagram shown in Fig.3

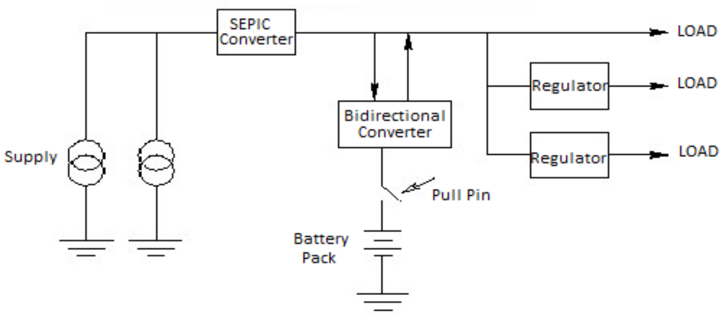

Fig.3: Block Diagram of the System

Modified SEPIC converter has known by its advantage for lower voltage stresses. Fig.4 shows the proposed LED Lamp driver. Compared to the conventional SEPIC converter; the proposed Modified SEPIC converter differs in two ways. The capacitor $C_P$ is a large bulk capacitor; a diode is placed in series with the inductor $L_1$. The bulk capacitor serves to decouple the pulsating input power, and the diode insures that the inductor $L_1$ can be operated in discontinuous mode (DCM) without the capacitor $C_1$ being charged to above the peak line voltage [3]. The inductor $L_1$ does not necessarily have to be operated in DCM but by insuring that no current can flow in the off' direction of $D_2$, the voltage $V_{C1}$can arbitrarily be controlled by the ratio of $L_1$ to $L_2$, as long as the sum of the output voltage and $V_{C1}$is higher than the line peak voltage.

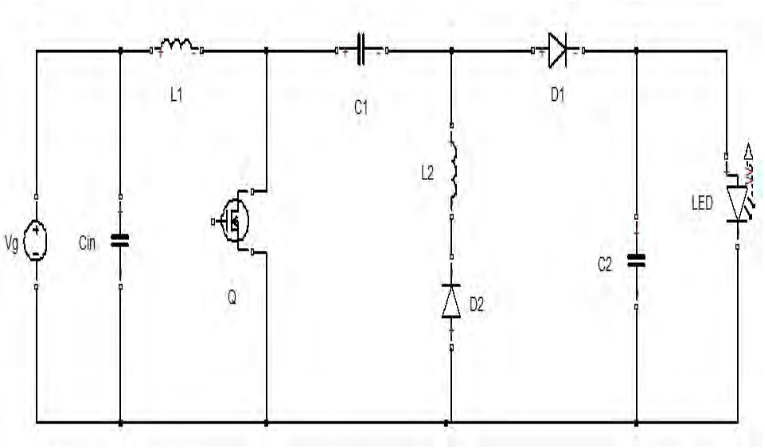

Fig.4: Modified SEPIC Converter

Fig.4 shows a simple circuit diagram of a Modified SEPIC converter, consisting of an input capacitor $C_{in}$; an output capacitor $C_2$; coupled inductors $L_1$ and $L_2$; an AC coupling capacitor $C_1$; a power FET $Q_1$ and a diode $D_1$. Capacitor $C_2$ is charged to the input voltage $V_{in}$. For the Fig.6, When $Q_1$ is off; the voltage across $L_1$ must be $V_{out}$. Since $C_{in}$ is charged to $V_{in}$, the voltage across $Q_1$ when $Q_1$ is off is $V_{in} + V_{out}$, so the voltage across $L_1$ is $V_{out}$. For the Fig.5, When $Q_1$ is on; capacitor $C_1$, charged to $V_{in}$, is connected in parallel with $L_1$, so the voltage across $L_2$ is $-V_{in}$. The currents flowing through various circuit components are shown in Fig.2.

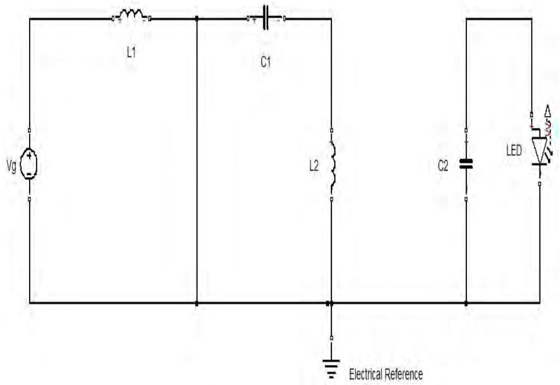

Fig.5: CCM during when Q1 is on

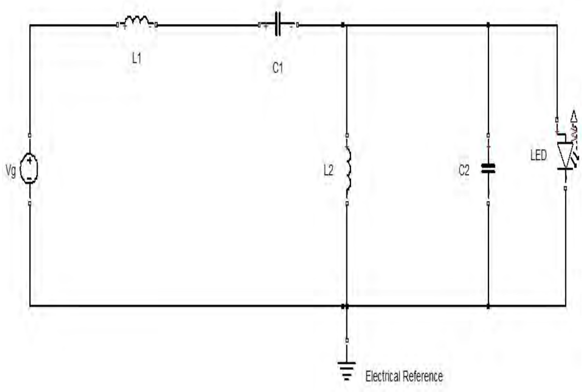

Fig.6: CCM during whenQ1 is off

On State Equations,

$$L_1\frac{di_1}{dt} = v_g$$

$$L_2\frac{di_2}{dt} = v_{c1}$$

$$C_1\frac{dv_{c1}}{dt} = -i_2$$

$$C_2\frac{di_1}{dt} = -\frac{V_{c2}}{R} \qquad (1)$$

Off State Equation,

$$L_1\frac{di_1}{dt} = v_g - v_{c1} - v_{c2}$$

$$L_2\frac{di_2}{dt} = -v_{c2}$$

$$C_1\frac{dV_{c1}}{dt} = -i_1$$

$$C_2\frac{di_1}{dt} = -\frac{V_{c2}}{R} + i_1 + i_2 \qquad (2)$$

## IV. Simulation Result

The simulink model of the closed loop SEPIC converter shown if Fig.7. For the closed loop system check the output at light load and full load and get the result of voltage and current of different component. In the case of closed loop system the controller has been used for controlling the output.

During the simulation time the input voltage is 140V and switching frequency is 75kHz.The PI Controller is used in the feedback loop and the Kp= 0.045 and Ki= .91.

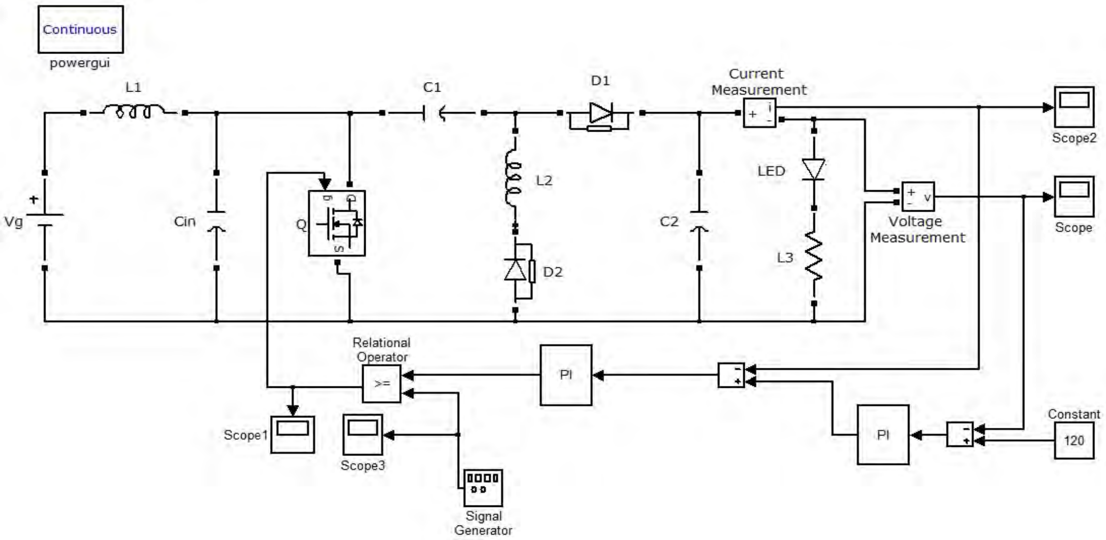

Fig.7: Closed loop SEPIC system

Closed loop system of SEPIC system shown in Fig.7. Result of voltage and current of different component at full load R=240 ohm and R= 20 ohm shown below. The value of $K_p$= 0.045 and $K_i$= 0.91. Reference voltage is fixing at 120 V.

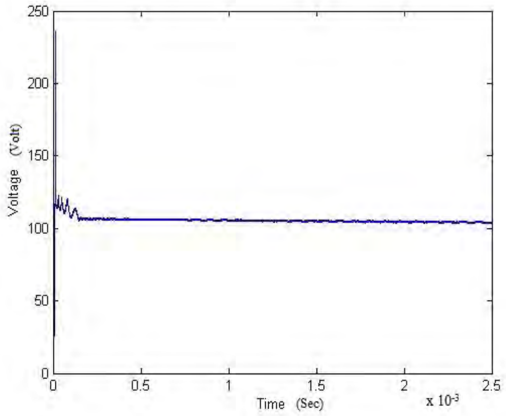

Fig.8: Output voltage across LEDs at light load

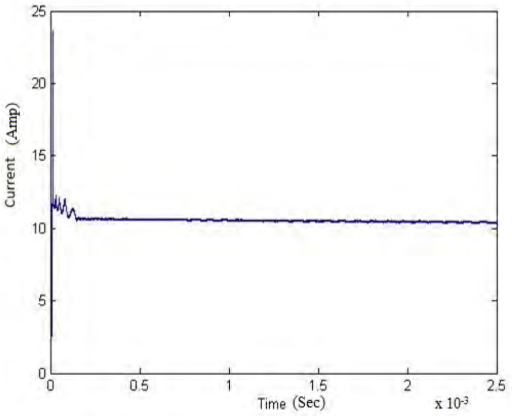

Fig.9: Output current across LEDs at light load

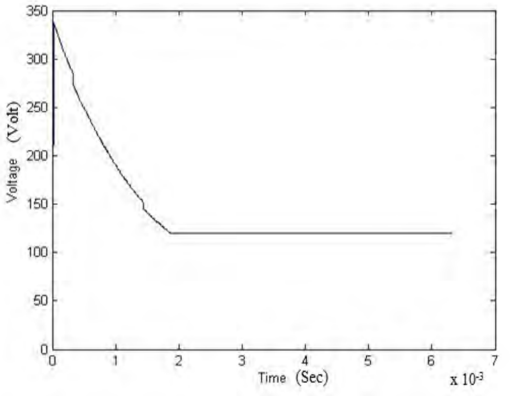

Fig.10: Output voltage across LEDs at full load

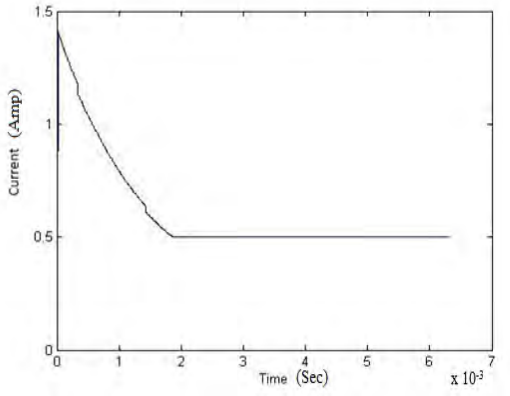

Fig.11: Output current across LEDs at full load

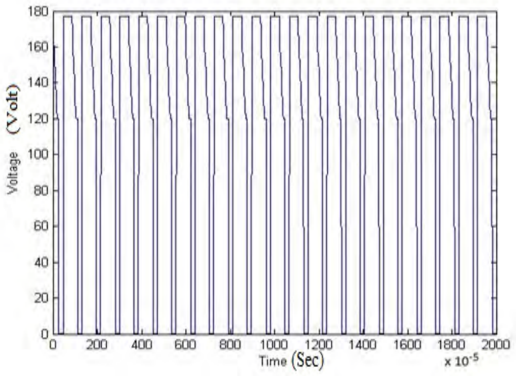

Fig.12: Voltage across switch at full load

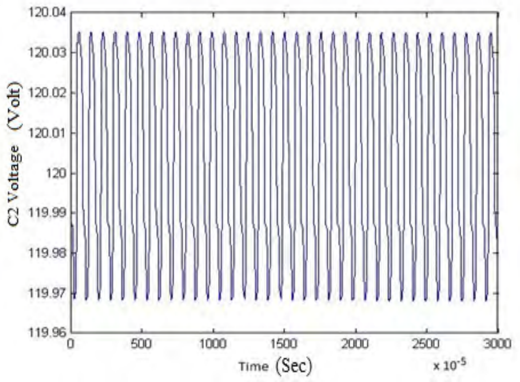

Fig.13: Capacitor voltage across C2 at full load

Fig.(8-9) shows output voltage and current for LEDs at light load. In this time the rise time is 0.0014 sec and settling time is 0.0041 sec.

Fig.(10-11) shows output voltage and current for LEDs at full load. In this time the rise time is 0.00021 sec and settling time is 0.018 sec.

Fig.(12-13) shows output voltage across switch is 178V and Capacitor voltage across $C_2$ is 120V.

## V. Conclusions

Suitable power supply structure is proposed for lighting applications. SEPIC converter has been selected to generate a step up or step down DC voltage. Modeling of SEPIC converter under perturbed conditions has been done. A current feedback loop is proposed to control the LED brightness. The gate drive signal of the switch is generated by comparing the saw-tooth carrier signal with the current feedback signal. This circuit has the advantages of non inverted output, simple feedback control, and voltage step-up and down, high power factor and dimmable LED current. The simulation results of the SEPIC converter obtained for the closed loop system at light and full load condition has been analyzed. It is observed that the output response of the closed loop system gives more correct result as compare to open loop system. It is analyzed from the closed loop system at light load response that the settling time is less as compared to closed loop system at full load.

## References

[1] Soo-SeokKim, Seung-PilMun, “*A New Sepic- Flyback Converter*” IEEE lnduslrial Electronics Soclety, November 2 - 6, ,Busan, Korea,2004.
[2] Pan TianFu, Chiu HuangJen, Cheng ShihJen, ChyngShihYen, “*An Improved Single - Stage Flyback PFC Converter for High-Luminance Lighting LED Lamps*," Electronic Measurement and Instruments, pp. 4-212 - 4- 215, Aug. 16 2007.
[3] Zhongming Ye, Greenfeld, F., Zhixiang Liang, “*Offline SEPIC converter to drive the high brightness white LED for lighting applications*", Industrial Electronics, pp. 1994 - 2000, Nov 2008.

[4] Shen, C.-L., Wu, Y.-E., Chen, M.-H., “*A modified SEPIC converter with soft-switching feature for power factor correction*," Industrial Technology pp. 1 - 6, April 2008.
[5] Zhongming Ye, Fred Greenfeld, and Zhixiang Liang, “*Single-Stage Offline SEPIC Converter with Power Factor Correction to Drive High Brightness LEDs*” 2009.
[6] Diego Gonz´alez Lamar,Diego Gonz´alez Lamar, “*A Very Simple Control Strategy or Power Factor Correctors Driving High-Brightness LEDs*” IEEE Transactions On Power Electronics, Vol. 24, No. 8, August 2009.
[7] Ying-Chun Chuang, Yu-Lung Ke “*Single-Stage Power-Factor-Correction Circuit with Flyback Converter to Drive LEDs for Lighting Applications*” IEEE 2010.
[8] Mokhtar Ali,Mohamed Orabi, “*Design Consideration of Modified SEPIC Convert for LED Lamp Driver*” 2010 2nd IEEE International Symposium on Power Electronics for Distributed Generation Systems, 2010.