ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 7, April 2016

Improvement of Gain Analysis in Bridgeless SEPIC Converter in Universal Applications

P.Vinodha[1], R.Punithavathy[2]

PG Student, Dept. of EEE, M.A.M College of Engineering, Trichy, Tamilnadu, India[1]

Assistant Professor, Dept. of EEE, M.A.M College of Engineering, Trichy, Tamilnadu, India[2]

ABSTRACT: In this paper, a new single phase ac-dc PFC bridgeless rectifier is used to improve the efficiency at low input voltage. It also reduces switch-voltage stress. Because they have low cost and have high performance in terms of efficiency, power factor, and its simplicity. For universal input voltage applications, the boost converter suffers from lower efficiency and higher total harmonic distortion at low input voltage. The boost rectifier has some practical drawbacks, such that, input–output isolation cannot easily be implemented. During overload conditions there is a lack of current limitation because of high start-up inrush current. Boost converter operating in discontinuous current mode can offer a number of advantages. They have very simple control, soft turn-on of the main switch, reduced diode reversed-recovery losses and inherent PFC. The DCM operation requires a high-quality boost inductor to switch extremely high peak ripple currents and voltages. Hence they have an inverting output. The idea used in this project is to operate the SEPIC in discontinuous conduction mode (DCM) to achieve almost a unity power factor and low total harmonic distortion (THD) of the input current. Index Terms- Bridgeless rectifier, SEPIC rectifier, power factor correction, discontinuous current mode (DCM), total harmonics distortion (THD).

KEYWORDS: Bridgeless rectifier, SEPIC rectifier, power factor correction, discontinuous current mode (DCM), total harmonics distortion (THD)

I. INTRODUCTION

To meet the challenges of ever-increasing power densities of today's AC/DC power supplies, designers are continuously looking for opportunities to maximize the power-supply efficiency, minimize its component count, and reduce the size of components. Full bridge diode rectifier has long been used in AC/DC conversion due to its simple and robust circuit. A single DC/DC converter, which is connected after the rectifier, is then able to perform power factor correction (PFC) and output voltage regulation .When an electric load has a PF lower than 1, the apparent power delivered to the load is greater than the real power that the load consumes. Only the real power is capable of doing work, but the apparent power determines the amount of current that flows into the load, for a given load voltage. Power factor correction (PFC) is a technique of counter acting the undesirable effects of electric loads thatcreate a power factor PF that is less than 1. Most of the research on PFC for nonlinear loads is actually related to the reduction of the harmonic content of the line current. There are several solutions to achieve PFC. There are two types of PFC 1) Passive PFC 2) Active PFC. The Active PFC is further classified into low-frequency and high-frequency Active PFC depending on the switching frequency. Power supply with Active PFC network has an active PFC and a DC-DC converter which works as a power conditioner and the load is connected. The load may be a DC load or an AC load connected through an inverter. The operating principle of the proposed circuit is explained in detail in the following sections the circuit is divided into two sections: the PFC stage and the converter stage. Design of the components is also explained briefly.

II. SEPIC RECTIFIER

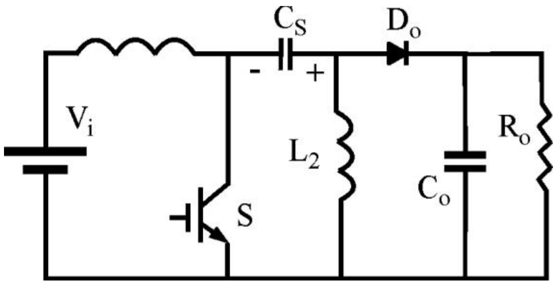


Fig 1. Classic SEPIC Converter

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. This type of conversion is handy when the designer uses voltages from an unregulated input power supply such as a low-cost wall wart. Unfortunately, the SEPIC topology is difficult to understand and requires two inductors, making the power-supply footprint quite large. Recently, several inductor manufacturers began selling off-the-shelf coupled inductors in a single package at a cost only slightly higher than that of the comparable single inductor. 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 Single-ended primary-inductor converter (SEPIC) is a type of DC-DC converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input. The output of the SEPIC is controlled by the duty cycle of the control transistor. A SEPIC is similar to a traditional buck-boost converter, but has advantages of having non-inverted output (the output voltage is of the same polarity as the input voltage), the isolation between its input and output (provided by a capacitor in series). On the other hand, power factor correction converters are extensively used in the industrial life. These converters aim at increasing the power factor and decreasing the total harmonic distortion of the supply current. 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. This type of conversion is handy when the designer uses voltages from an unregulated input power supply. Hence this is very much preferred in applications such as battery chargers, power electronic circuits, home appliances, aircraft due to its less electromagnetic interference, inherent inrush current, reduced noise disturbances and less switching losses**.**

III. BRIDGELESS SEPIC PFC RECTIFIER

The bridgeless PFC circuits based on SEPIC with low conduction losses, is shown in Fig. Unlike the boost converter, the SEPIC converters offer several advantages in PFC applications, such as easy implementation of transformer isolation, inherent inrush current limitation during start-up and overload conditions, lower input current ripple. The topologies in Figure 1are formed by connecting two DC–DC SEPIC Converter one for each half-line period of the input voltage The operational circuits during positive and negative half-line period for the proposed bridgeless SEPIC rectifier of Fig.2 is shown respectively. Note that, by referring to Fig.1there are one or two semiconductors in the current flowing path. Each of the rectifiers utilizes two power switches (Q1 and Q2), two low-recovery diodes (Dp and Dn), and a fast diode (Do). However, the two power switches can be driven by the same control signal, which significantly simplifies the control circuitry. Moreover, the structure of the proposed topologies utilizes one additional inductor compared to the conventional topologies, which are often described as a disadvantage in terms of size and cost.

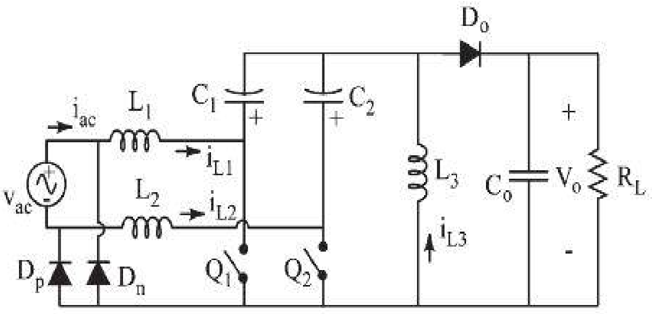


Fig 2. Bridgeless SEPIC PFC Rectifier

IV. PRINCIPLE OF OPERATION

During the positive half-line cycle, the first DC–DC SEPIC circuit L1-Q1-C1-L3-Do is active through diode Dp, which connects the input ac source to the output ground. During the negative half-line cycle, the second DC-DC SEPIC circuit, L2-Q2-C2-L3-Do, is active through diode Dn, which connects the input ac source to the output ground.Thus, due to the symmetry of the circuit, it issufficient to analyse the circuit bridgeless rectifier is constructed by connecting two DC–DC converters. Referring to during the positive half-line cycle, the first DC–DC SEPIC circuit L1-Q1-C1-L3-Do is active through diode Dp, which connects the input ac source to the output ground.During the negative half-line cycle, the second DC-DC SEPI circuit, L2-Q2-C2-L3-Do, is active through diode Dn, which connects the input ac source to the output ground. Thus, due to the symmetry of the circuit, it is sufficient toanalyse the circuit during thepositive half-period of the input voltage. The rectifier is operated when the switch Q1 is turned on then diode Dp is forward biased by the sum inductor currents iL1 and iL2. As a result, diodeDn isreversed biased by the input voltage. The output diodeis reversed biasedby the reverse voltage (Vac+ Vo). Thus, the loss due to the turn-onswitching losses and the reverse recovery of the output diode are considerably reduced.The single-phase bridgeless rectifiers with low input currentdistortion and low conduction losses have been presented and analysed.The bridgeless rectifieris derivedfrom the conventional SEPICconverter. Comparing withconventional SEPICand Power Factor Correction circuits, due to the lower conduction loss and switching loss. Bridgeless SEPIC PFC rectifier topologies can further improve the conversion efficiency. To maintainsame-efficiency, the improved circuits could operatewith higherswitching frequency.To simplify the analysis, it is assumed that the converter is operating in steady state, and the following assumptions are madeduring one switching cycle:

1) The input voltage vac is considered to be an ideal rectified sine wave, i.e., $vac = Vm \sin(\omega t)$,where Vm is the peak amplitude and ω is the line angular frequency.
2) All components are ideal; thus, the efficiency is 100%.
3) The switching frequency (fs) is much higher than the ac line frequency (fL), so that the input voltage can be considered constant during one switching period (Ts).
4) All the capacitors are big enough such that theirswitching voltageripples are negligible during theswitching period Ts. Moreover, thecapacitor voltagesC1 and C2 followthe input voltage vac, while the output voltage Vo is equally divided between Co, i.e., $Vo1 = Vo2 = Vo/2$.

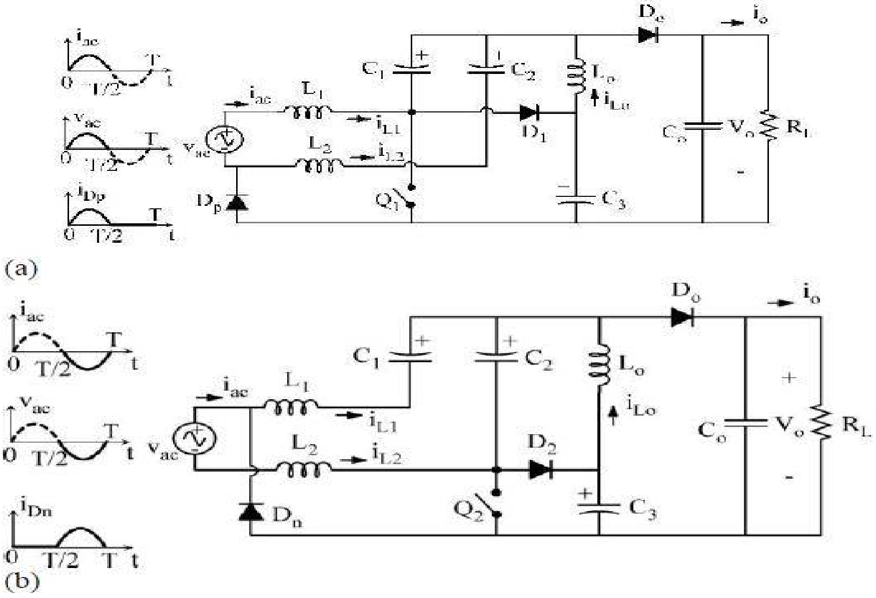


Fig 3. Operation Of SEPIC

V. HARMONIC DISTORTION

The total harmonic distortion, or THD, of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. THD is used to characterize the linearity of audio systems and the power quality of electric power systems. Distortion factor is a closely related term, sometimes used as a synonym. In audio systems, lower distortion means the components in a loudspeaker, amplifier or microphone or other equipment produce a more accurate reproduction of an audio recording. In radio communications, lower THD means pure signal emission without causing interferences to other electronic devices. Moreover, the problem of distorted and not eco-friendly radio emissions appears to be also very important in the context of spectrum sharing and spectrum sensing.

VI. MEASUREMENT

The distortion of a waveform relative to a pure sine wave can be measured either by using a THDAnalyser to analyse the output wave into its constituent harmonics and noting the amplitude of each relative to the fundamental; or by cancelling out the fundamental with a notch filter and measuring the remaining signal, which will be total aggregate harmonic distortion plus noise. Given a sine wave generator of very low inherent
Distortion, it can be used as input to amplification equipment, whose distortion at different frequencies and signal levels can be measured by examining the output waveform. There is electronic equipment both to generate sine waves and to measure distortion; but a general-purpose digital-computer equipped with a sound card can carry out harmonic analysis with suitable software. Different software can be used to generate sine waves, but the inherent distortion may be too high for measurement of very low-distortion amplifiers. For a signal y, the total harmonic distortion (THD) is defined by the equation

VII. CURRENT AND VOLTAGE THD

The THD measures the nonlinearity of a system, while applying a single sinusoidal to it. The sinusoidal, when applied to a nonlinear system, will produce an output with the same fundamental frequency as of the sinusoidal input, but will also generate harmonics at multiples of the fundamental frequency.

When dealing with current harmonics, the equation becomes:

$$THD_I = \frac{\sqrt{\sum_{h=2}^{\infty} I_h^2}}{I_1} \qquad (2)$$

The above equation is equivalent to the one below, which is more direct and easier to use when the total rms value is known:

$$THD_I = \sqrt{\left(\frac{I_{rms}}{I_1}\right)^2 - 1} \qquad (3)$$

When dealing with **voltage harmonics**, the equation becomes:

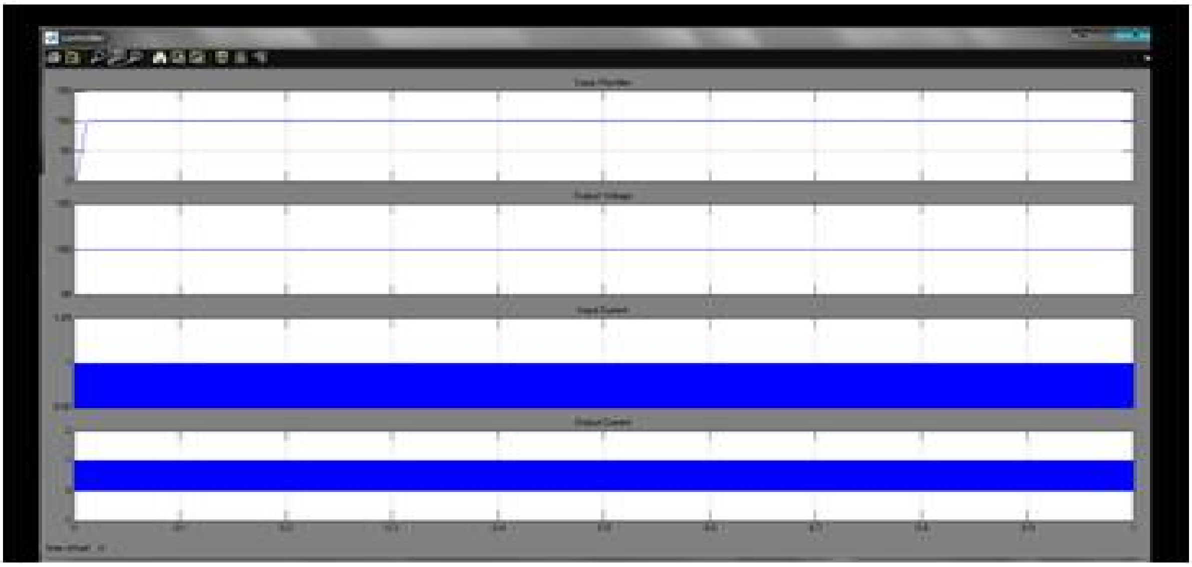
$$THD_u = \frac{\sqrt{\sum_{h=2}^{\infty} u_h^2}}{U_1} \qquad (4)$$

VIII. EXPERIMENTAL RESULT

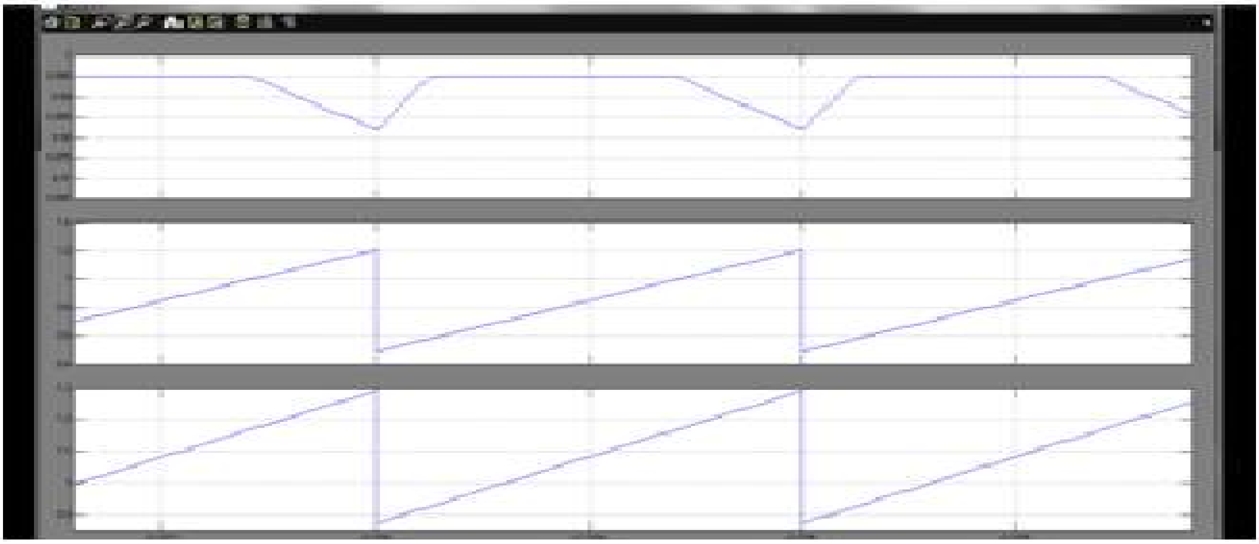
SIMULATION

The proposed converter has been simulated using the calculated components and power stage specification presented in the previous subsection.The simulated input voltage and current are in phase as it is shown, which ensures power factor correction property of the proposed circuit. It is clear that the desired output voltage (100 V) is met as it is illustrated. The DCM operation can be clearly noted by observing the switching current waveforms of the three inductors. Finally, the voltage across the intermediate capacitors and the input current and voltage for uncoupled and coupled inductors, respectively.

SEPIC Rectifier



DCM Output



IX. CONCLUSION

A new topology based on double boost SEPIC has been presented and simulated in Mat lab which ensures the performance of the converter. The proposed topology has a higher efficiency than the full bridge topology due to its bridgeless nature**.** The proposed converter is operated in DCM at high switching frequencies to reduce input current ripple. Hence, the overall advantages will be higher efficiency, reduced size and weight, simpler structure and control. In addition, the proposed topology exhibits lower voltage stress. Simulation and experimental results has been presented to validate the operation of the proposed circuit at open loop and closed loop conditions.

REFERENCES

[1] U. Kamnarn, and V. Chunkag, “Analysis and Design of a Modular Emissions guidelines to the standard EN 61000-3-2”, Nov. 2010 Three-Phase AC-to-DC Converter Using CUK Rectifier Module With edition. Nearly Unity Power Factor and Fast Dynamic Response”, IEEE Trans.

[2] H. Wang, Y. Tang, and A. Khaligh, “A Bridgeless boost rectifier for on Power Electron., vol. 24, no 8, Aug. 2009. Low-voltage energy harvesting applications,” IEEE Trans. on Power system

[3] M. Mahdavi, and H. Farzanehfard,”Bridgeless SEPIC PFC Rectifier Electron. vol. 28, no. 11, Nov. 2013. With Reduced Components and Conduction Losses”, IEEE Trans. Onpower system

[4] W. Choi, J. Kwon, E. kim J. Lee and B. Kwon, “Bridgeless boost Industrial Electron., Vol. 58, no, pp. 4153-4160, September 2011.

[5] A. Fardoun, E. Ismail, A. Sabzali and M. Al-Saffar, “Bridgeless problems,” IEEE Trans. Ind. Electron., vol. 54, no. 2, pp. 769-780, Resonant Pseudo Boost PFC Rectifier”, IEEE Transactions on Power April 2007. Electron. vol. 29, no. 11, pp. 5949-5960, Nov. 2014.

[6] Y. Kim, W. Sung, and B. Lee,“Comparative Performance Analysis of Bridgeless PFC Boost Rectifiers,” IEEE Trans. on Power Electron., High Density and Efficiency PFC Topologies,” IEEE Trans. on Power Vol. 23, No.3, May 2008 Electron., vol.29, no.6, pp. 2666-2679, June 2014.

[7] A. Sabzali, E. H. Ismail, M. Al-Saffar and A. Fardoun, “A New optimized magnetic utilization,” IEEE Trans. on Power Electron., vol. 24, no. 1, pp. 85-93, Jan. 2009.

[8] Domingos S. L. Simonetti, Jos´e Luiz F. Vieira and Gilberto C. D. Sousa, “Modeling of the High-Power-Factor Discontinuous Boost

[9] H. Wang, S. Dusmez, and A. Khaligh, "Design and Analysis of a Full Bridge LLC Based PEV Charger Optimized for Wide Battery Voltage Range." IEEE Trans. on Vehicular Technology, vol. 63, no. 4, pp. 1603-1613, May, 2014.

[10] K. Yao, X. Ruan, X. Mao and Z. Ye, "Reducing Storage Capacitor of a DCM Boost PFC Converter," IEEE Trans. on Power Electron., vol.27, no.1, pp.151-160, Jan. 2012.

[11] Y. Hu, L. Huber and M. M. Jovanović,"Single-Stage, Universal-Input AC/DC LED Driver With Current-Controlled Variable PFC Boost Inductor," IEEE Trans. on Power Electron., vol.27, no.3, pp.1579-1588, Mar. 2012.