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Comparative Analysis of Bridgeless CUK and SEPIC Converter

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ABSTRACT

This paper presents a comparative analysis between bridgeless SEPIC and CUK topology. The CUK and SEPIC converters operate on the principle of energy transfer by using capacitors and the inductors which are used to reduce the current ripples. The turn on and turn off time of the MOSFET is used to reduce the conduction loss. In this paper, the detailed analysis of efficiency, input ripple current and total harmonic distortion of both the converters are compared.

INTRODUCTION

In recent power quality issues is the major issue in our applications. To eliminate the problem various topology have been proposed. Normally,in a DC-DC converter due to the switching device high voltage dress and also there is a presence of common mode noise due to interference.To overcome this issue,Bridgeless DC-DC converter is used in the application.This PFC rectifier allows the minimal allow of current allow to flow through the switching device.But in Bridgeless Boost converter have the disadvantage that the DCoutput voltage is higher than the peak input voltage.Hence the Bridgeless CUK and SEPIC rectifier is more efficient than the conventional circuit.In this rectifier coupling of inductor reduces the ripple current and avoid interference in the circuit.

I.CUK CONVERTER

Bridgeless rectifier consists of two switches S_1 and S_2 for controlling the output voltage.When compared to the conventional topology, it utilizes additional inductors and capacitor to achieve the thermal performance. To operate the converter in steady state mode the following assumption should be made: Should contain pure sinusoidal input voltage, Zero crossing must be achieved. To maintain the voltage for entire period in line the capacitor value to be chosen is very large.Bridgeless CUKconverter ,is differentiated into three types of circuit. By using the type 3 rectifier the following circuit is explained.

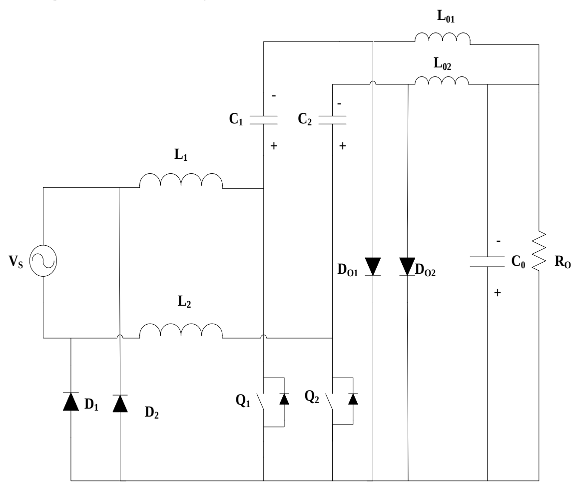

Figure 1: Bridgeless CUK converter

Mode 1

The converter is operated in DCM mode to reduce the ripples .During positive cycle the diode D_1 in forward biased and switch S_1 is conducting,the circuit path is Vs-L_1-Q_1-C_1-D_1-L_{01}-R.

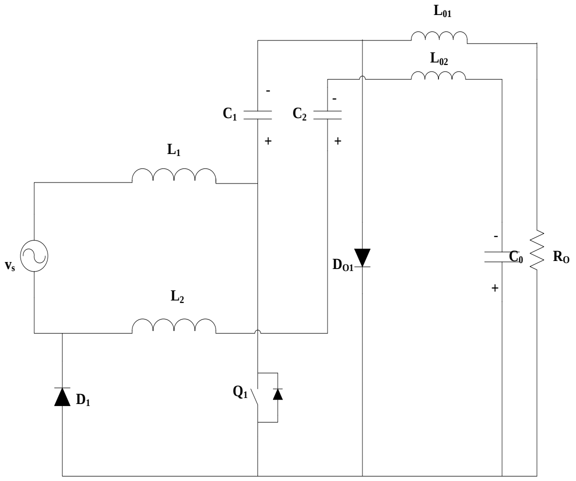

Figure 2: Mode 1 operation of Bridgeless CUK converter

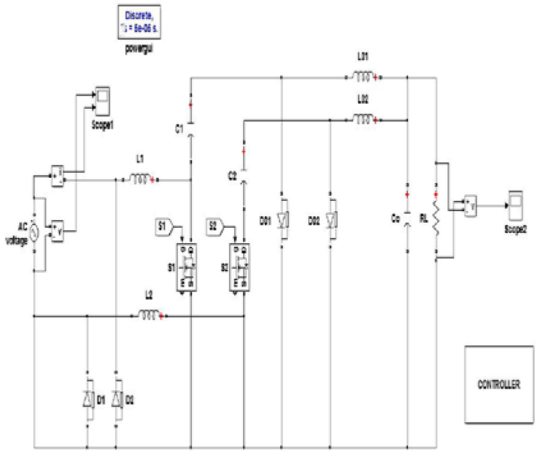

Figure 4: Circuit for cuk converter

Mode 2

During negative cycle the diode D_2 starts to conduct and switch S_2 is conducting therefore the circuit path is V_s-L_2-Q_2-C_2-D_2-L_{o2}-C_0-R.The capacitor voltage is discharged to the load.

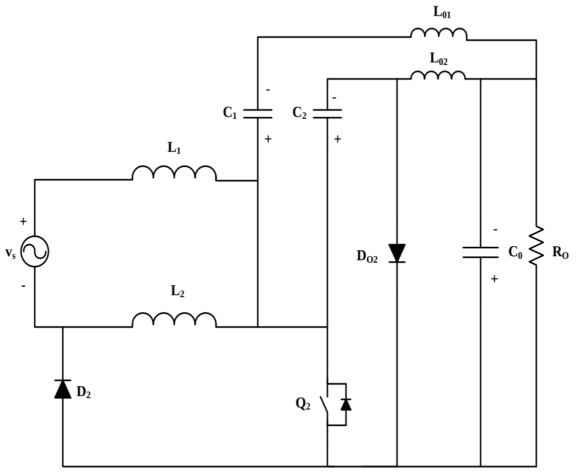

Figure 3: Mode 2 operation of bridgeless CUK converter

Equation for CUK Converter

$$Vc = \frac{Vin}{1-\delta} \qquad \text{.....................(1)}$$

$$Vo = \frac{-\delta Vin}{1-\delta} \qquad \text{....................(2)}$$

The average current can be taken from the following equation

$$iL1 = \frac{-\delta Vin}{1-\delta .R} \qquad \text{...................(3)}$$

Simulation result of CUK converter

By using the MATLAB the circuit is designed and shown in Fig.4.For the input voltage of   the waveform for output voltage is described below.

For the input voltage 130 V shown in Fig. 5.The input current and THD is measured in belowwaveform.

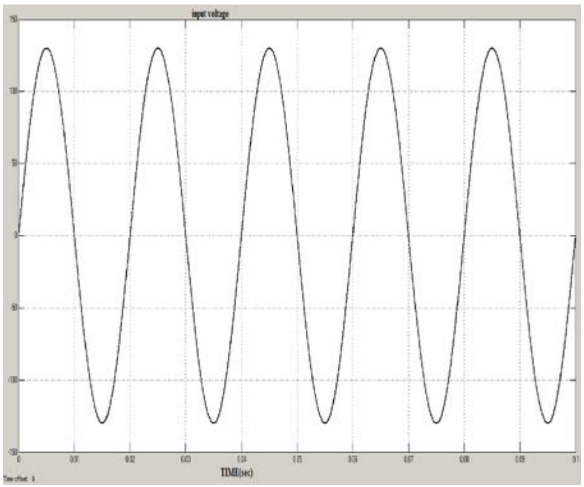

Figure 5: Input Voltage of Bridgeless CUK converter

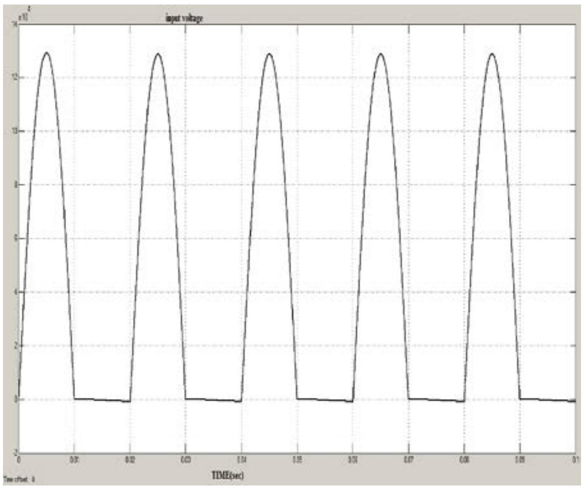

Figure 6: Input current of Bridgeless CUK converter

For the Bridgeless CUK converter the output voltage 48V is measured in Fig 7.This converter operated in a switching frequency of 50 KHz.

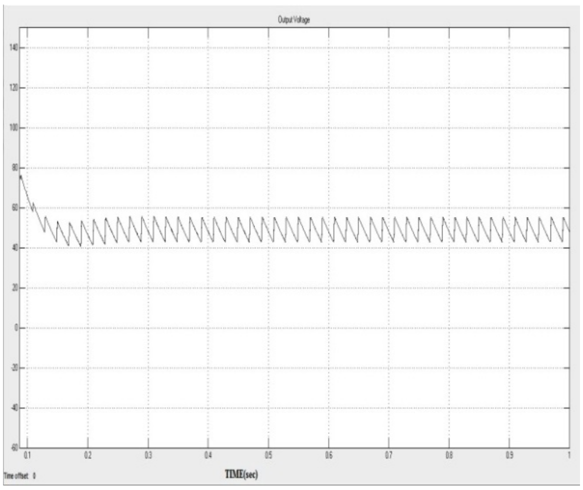

Figure 7: Output voltage of Bridgeless CUK converter

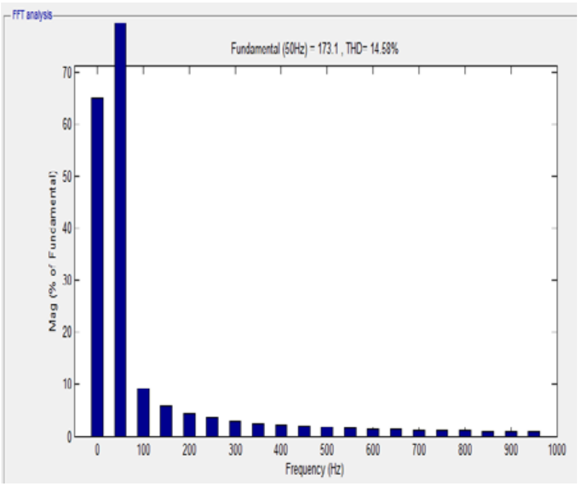

Figure 8: THD results of Bridgeless CUK converter

II. SEPIC CONVERTER

SEPIC converter can provide high power factor regarding the input voltage. The inductor Ls is connected with the input source to reduce the input ripples. To improve the efficiency, bridgeless SEPIC converter is used. Bridgeless SEPIC converter can be explained by three modes.

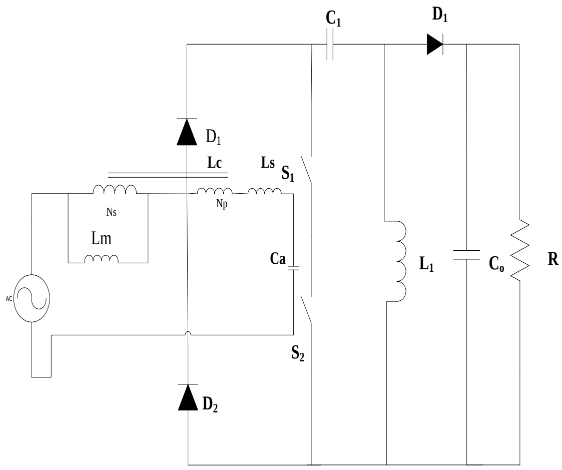

Figure 9: Circuit Diagram of Bridgeless SEPIC Converter

Mode 1:

When the switches S_1 and $S_2$are turned on at time t_o, the capacitor C_1 and the inductor $L_1$are charged by negative polarity and the diode D_o gets reversed biased. Hence the inductor current decreases form I_{L1} to $I_{L2.}$ The capacitor voltage discharges through the load.

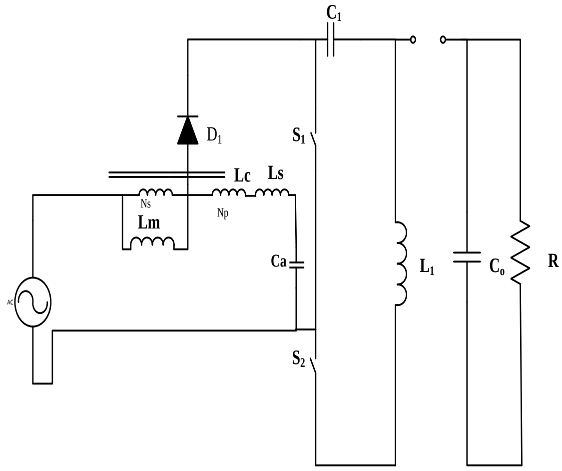

Figure 10: Mode 1 operation of Bridgeless SEPIC Converter

Mode 2:

During the time period t_1, switch S_1 is turned off but S_2 is still conducting .The capacitor C_1 and indictor L_1 gets positive polarity and charges by source voltage. Therefore the inductor current increases from I_{L2} to I_{L1} and the diode D_o become forward biased. Through the diode conduction the capacitorC_0 get charged**.**

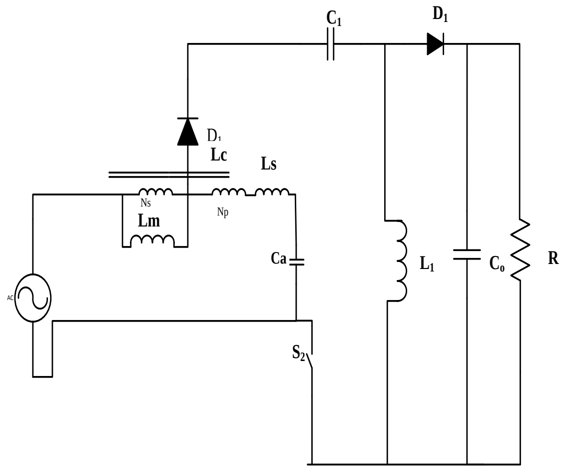

Figure 11: Mode 2 operation of Bridgeless SEPIC Converter

Mode 3

During the time period t_2, switch S_2 is still in conduction period and the switch S_1 remains in off position. The diode current I_{DO} becomes zero make the diode reverse biased. Hence the capacitor C_O discharges to the load $V_{O.}$

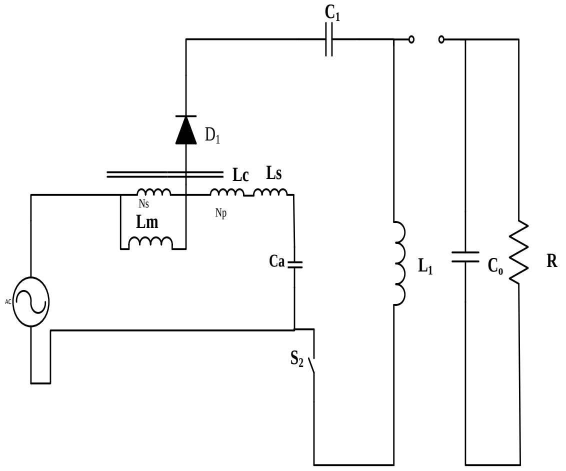

Figure 12: Mode 3 Operation of Bridgeless SEPIC Converter

Equation for SEPIC Converter

$$Vc = \frac{Vin}{1-\delta} \qquad \text{………….(4)}$$

The capacitor C_o must be large enough to minimize the voltage ripple,

$$Co = \frac{Po}{4f_L V_0 \Delta V_0} \qquad \text{………….(5)}$$

By using duty ratio δ

$$Vout = \frac{\delta}{1-\delta} Vin \qquad \text{……….(6)}$$

Simulation result of SEPIC converter

The Simulation circuit for Bridgeless SEPIC converter is given below in Fig.13 design by using the MATLAB. In a controller circuit, input signal is compared and given to the switches using logic gates, hence the switch conduct continuously.

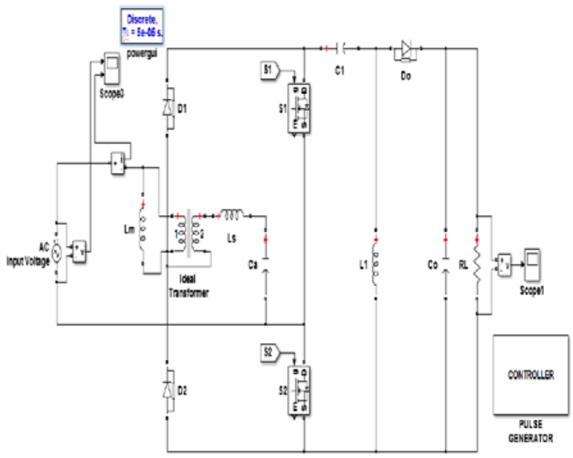

Figure 13: Simulation circuit of Bridgeless SEPIC converter

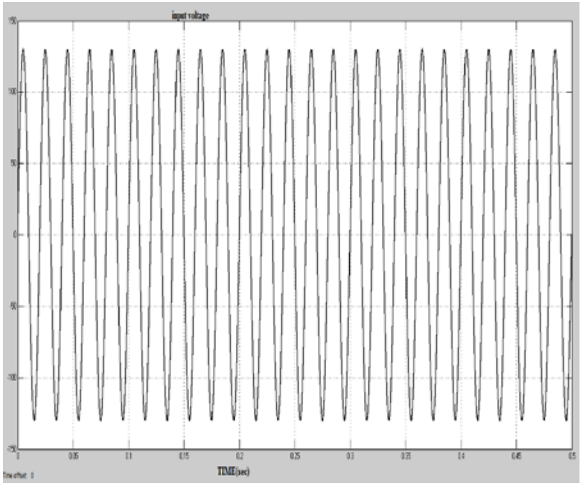

Figure 14: Input voltage of Bridgeless SEPIC converter

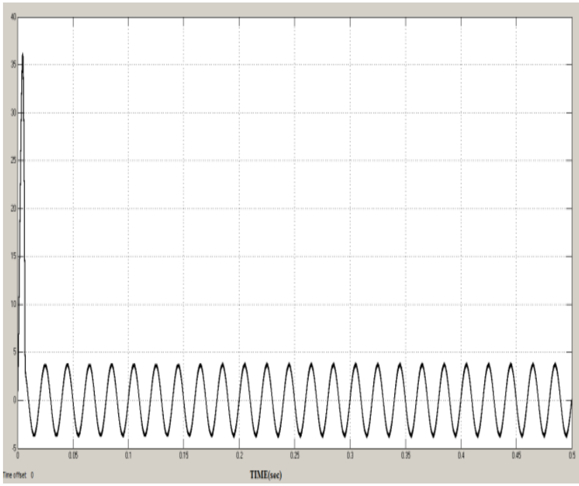

Figure 15: Input current of Bridgeless SEPIC converter

For the same input voltage of 140 V, the bridgeless converter produces the output of 128V,and also the ripple current is reduced which is shown in Fig 15.

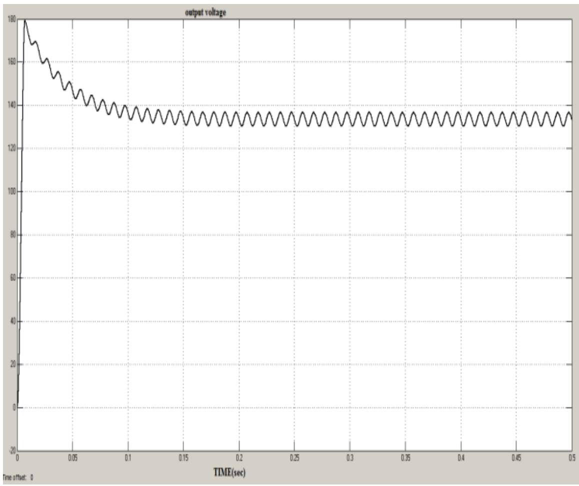

Figure 16: Output voltage of Bridgeless SEPIC converter

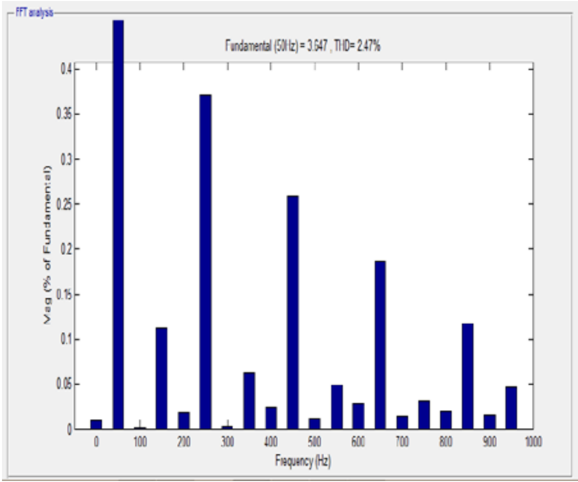

Figure 17: THD result of Bridgeless SEPIC converter

The THD result in the Fig.17 shows that the Bridgeless SEPIC converter have higher efficiency and reduced voltage stress compared to conventional circuit.[2]

III.COMPARISON RESULTS

On the above comparison for the same input voltage, the output voltage and efficiency is measured and compared in the tabulation given below Table.1. For the input voltage of 130V, the output voltage for Bridgeless CUK converter is 48 V and 128 V for SEPIC converter. So the voltage stress in CUK converter ishighwhen compared to the SEPIC topology.

Table.1 Comparison results of Bridgeless converter topology

Types of converter	Input Voltage	Output Voltage	THD
CUK converter	130 V	48V	14.58%
SEPIC converter	130 V	128V	2.47%

CONCLUSION

On the above results, for the same input voltage of 130 V, the THD is 14% for CUK converter and 2% for SEPIC converter. Based on the analysis, the SEPIC converter is convenient for using it in motor application.

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