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Performance evaluation of SEPIC, Luo and ZETA converter

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ABSTRACT

DC-DC converters are devices which convert direct current (DC) from one voltage level to another by changing the duty cycle of the main switches in the circuits. These converters are widely used in switched mode power supplies and it is important to supply a constant output voltage, regardless of disturbances on the input voltage. In this work, the performance of three different converters such as Single-Ended Primary-Inductance Converter (SEPIC), Luo converter and ZETA converter have been analyzed. Further, the parameters values such as ripple voltage, switching losses and efficiency of the proposed three different converters were compared with each other. Also, the simulation work has been carried out using MATLAB/SIMULINK software. From the comparison of obtained results, it is observed that the ZETA converter has high significance than the SEPIC and Luo converter.

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1. INTRODUCTION

In recent years, personal computers play vital role in human day to day activities such as education, business etc [1]. DC-DC converters can be used as power supplies which convert AC supply to any number of suitable DC voltages to power computer peripherals [1]. Also, DC-DC converters are widely used in industrial applications, vehicle auxiliary power supplies, Electric vehicles etc [2]–[6].

SEPIC converters are widely used in industrial applications due to its better performance compared to other conventional step up or step down converters [7]. The voltage and power transfer efficiency of the SEPIC converter is limited by its voltage transfer function. Narasimha and Alamuru [8] have proposed high gain multi level dual load SEPIC converter for incremental conductance MPPT. Further, the authors have concluded that the proposed converter exhibits higher efficiency when compared to the conventional converters.

Luo converters performs DC-DC voltage step up conversion with low output voltage ripple, high efficiency, high power density and simple in structure [9]. Also, the Luo converter has very high voltage transfer gain and is well suited for applications such as industrial, high output voltage projects etc. Luo [10] has designed and developed a Luo converter. Further, the author has demonstrated that the developed converters can perform positive to positive DC-DC voltage increasing conversion with high power density, high efficiency and cheap topology with simple structure.

Zeta converter topology is similar to that of a buck-boost converter which provides non-inverted output. Further, the zeta converter can be used to regulate an unregulated input-power supply and has several advantages such as low output current ripple, low input current distortion, wide output-power range etc. Baek *et al.* [11] have proposed Asymmetrical Half-Bridge Zeta (AHBZ) converter for LED applications. Further, the authors have concluded that the proposed converters has high efficiency over a wide output voltage range when compared to the conventional converters. Vashist and Bhim [12] have designed and developed power factor correction-based modified zeta converter fed brushless DC (BLDC) motor drive. Further, the authors have demonstrated that the modified zeta converter operating in discontinuous inductor current mode acts as an inherent power factor pre-regulator. Also, the authors have concluded that the power quality indices of the proposed converter are under the recommended limits of international power quality standard IEC 61000-3-2. The objective of this work is to compare and analyze the performance characteristics of SEPIC, Luo and ZETA converters.

2. RESEARCH METHOD

In this work, the performance of DC-DC converters such as SEPIC, Luo and Zeta converters were analyzed. Further, the performance parameters such inductor ripple voltage, switching loss and efficiency were compared for all the three converters.

2.1. SEPIC converter

Figure 1 shows the elementary circuit of SEPIC converter. The single-ended primary inductance converter (SEPIC) is derived from the boost converter. The SEPIC converter consists of an input filter capacitor, an output capacitor, coupled inductors and, ac coupling capacitor, a power switch (MOSFET) and a diode.

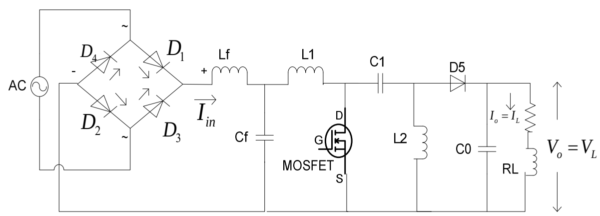


Figure1. Elementary circuit diagram of SEPIC converter

The output voltage is given by,

$$V_0 = \frac{\alpha}{1-\alpha} V_{in}$$

where, α is the duty cycle.

2.2. Luo converter

Figure 2 shows the elementary circuit diagram of Luo converter. The capacitor C_0 acts as the primary means of storing and transferring energy from the input source to the output load via the pump inductor L_1. Assuming capacitor C_o to be sufficiently large, the variation of the voltage across capacitor C_o from its average value V_C can be neglected in steady state, i.e., $V_C(t) \approx V_C$, even though it stores and transfers energy from the input to the output.

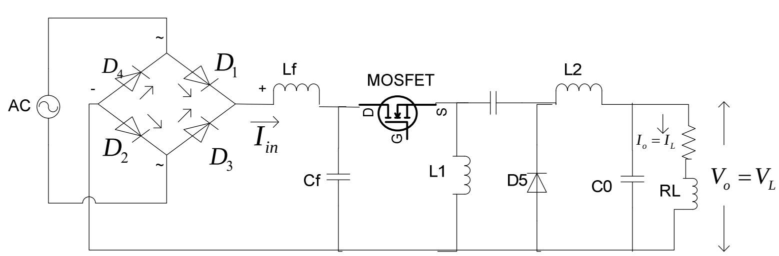


Figure 2. Elementary circuit diagram of Luo converter

The output voltage is given as,

$$V_0 = \frac{\alpha}{1-\alpha} V_{in}$$

where, α is the duty cycle. The voltage transfer gain in continuous mode is given by,

$$VTG = \frac{V_0}{V_{in}} = \frac{\alpha}{1-\alpha}$$

2.3. ZETA converter

Figure 3 shows the circuit diagram for elementary zeta converter. The ZETA converter is a transformer type converter with a low-pass filter and its output voltage ripple is small.

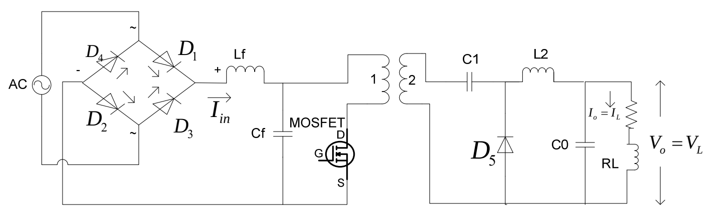


Figure 3. Elementary circuit diagram of ZETA converter

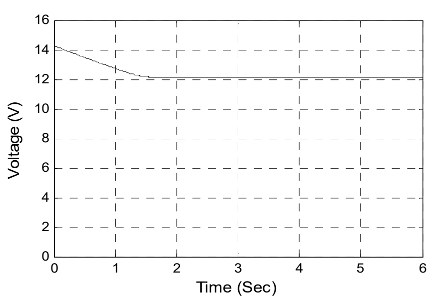
The output voltage equation is given as,

$$V_0 = \frac{\alpha}{1-\alpha} nV_{in}$$

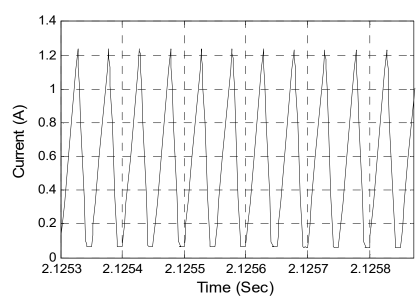
where n is the transformer turn ratio and α is the duty cycle $\alpha = t_{on} / T$

3. RESULTS AND ANALYSIS

Figure 4(a) and (b) show the input voltage and input current of the elementary SEPIC converter respectively. Figure 5(a) and (b) show the output voltage and output current of the elementary SEPIC converter respectively. It is seen that the average voltage of 12v was supplied to the proposed SEPIC converter and output voltage is maintained at 24v with respective resistive load of 100 ohm.

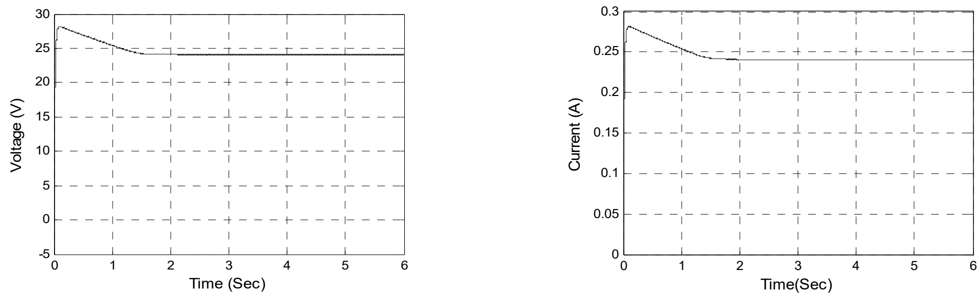


(a)



(b)

Figure 4. Elementary SEPIC converter (a) Input voltage (b) Input current



(a) (b)

Figure 5. Elementary SEPIC converter (a) Output voltage (b) Output current

Figure 6 shows the switching waveform of power switch or MOSFET of the elementary SEPIC converter. The switching frequency of the proposed SEPIC converter is fixed at 20kHz throughout the simulation process. Initially, the duty cycle is varied to get the desired output voltage of 24v. Once the desired output voltage is produced, the duty cycle will be kept fixed. This procedure has been followed common for all the three different converters.

Figure 7 (a) and (b) show the input voltage and input current of the elementary Luo converter respectively. Figure 8 (a) and (b) show the output voltage and output current of the elementary Luo converter respectively. Figure 9 shows the switching waveform of power switch or MOSFET of the elementary Luo converter.

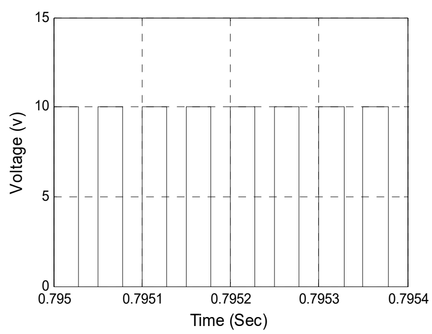
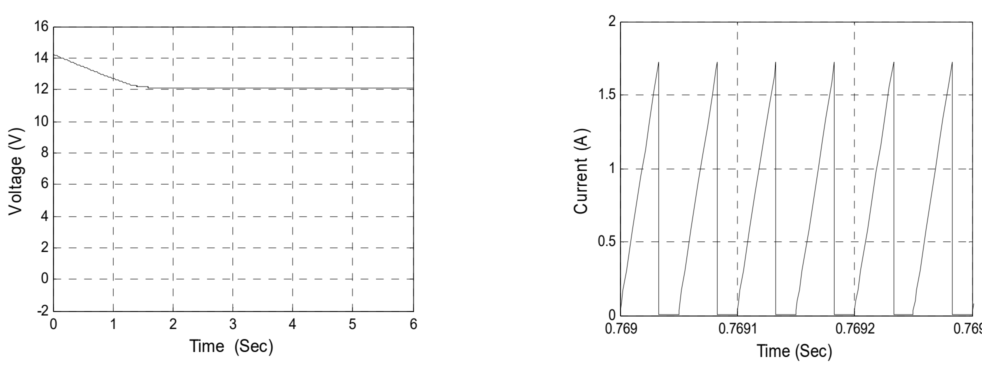
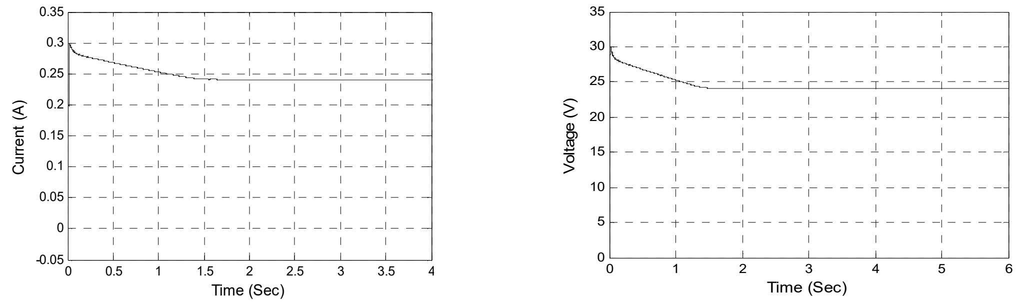


Figure 6. Switching waveform



(a) (b)

Figure 7. Elementary Luo converter (a) Input voltage (b) Input current



(a) (b)

Figure 8. Elementary Luo converter (a) Output voltage (b) Output current

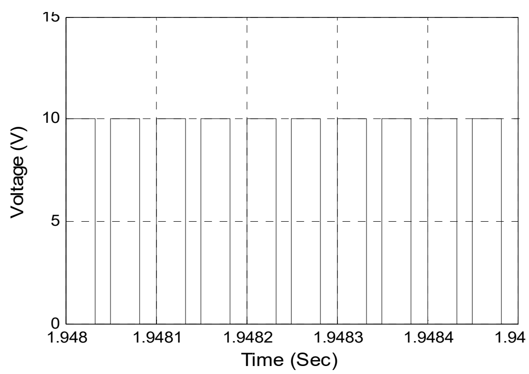
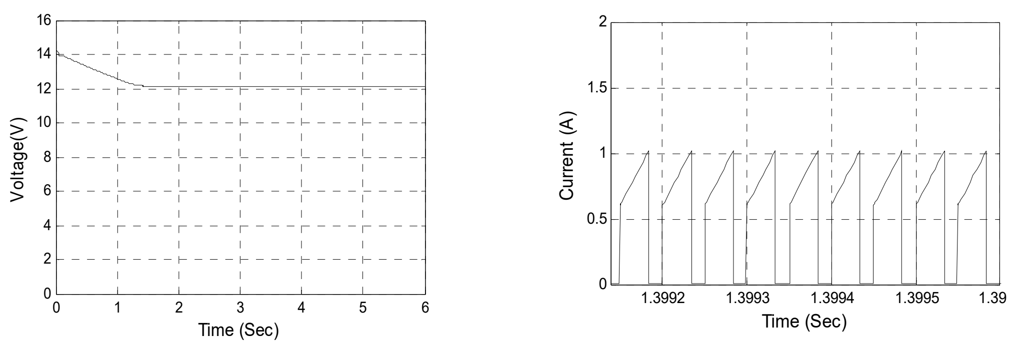


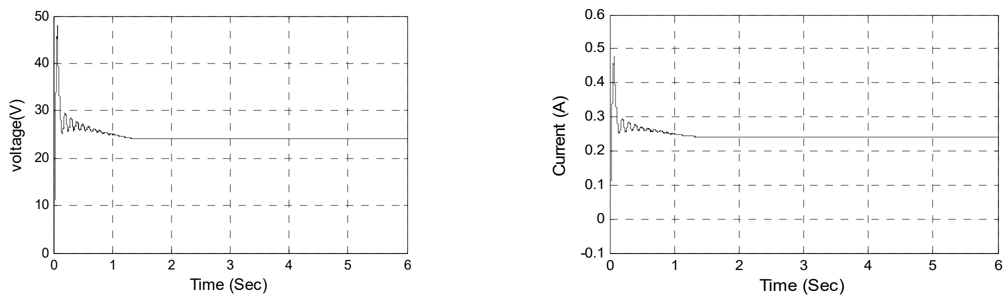
Figure 9. Switching waveform

Figures 10 (a) and (b) show the input voltage and input current of the elementary ZETA converter respectively. Figures 11 (a) and (b) show the output voltage and output current of the elementary ZETA converter respectively. Figure 12 shows the switching waveform of power switch or MOSFET of the elementary ZETA converter. All the three converters are connected to the 100 ohm resistive load, thereby draws load current of 0.24 A at the applied voltage of 24v.



(a) (b)

Figure 10. Elementary ZETA converter (a) Input voltage (b) Input current



(a) (b)

Figure 11. Elementary ZETA converter (a) Output voltage (b) Output current

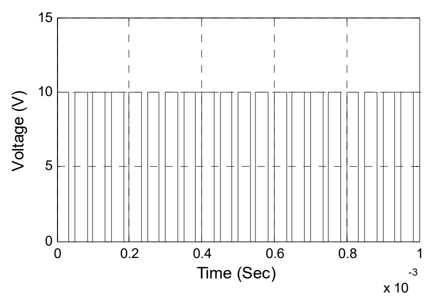


Figure 12. Switching waveform

Table 1 shows the performance parameters of three different converters from which it is seen that the losses and Output voltage ripple of ZETA converter is less when compared to the SEPIC and Luo converter.

Table 2 shows the Input and Output parameters of all the three different converters. It is observed that the input current of all the three proposed converters are different due to individuality in their performances. Further, the ZETA exhibits high efficiency than the other two proposed converters.

Table 1. Performance parameters of three different converters

Different Types of DC-DC Converters	Switching Count (Frequency)	Output Ripple Voltage (mV)	Switching loss(%)	Critical Value of L (uH)	Critical Value of C (uF)
Luo Converter	20 Khz	24.12	43	560.52	0.17
SEPIC Converter	20 Khz	20.52	29.5	615.39	0.14
Zeta Converter	20 Khz	17.23	20	551.04	0.17

Table 2. Input-output parameters of three different converters

Different Types of DC-DC Converters	Input Voltage	Input Current	Output Voltage	Output Current	Efficiency (%)
Luo Converter	12	0.85	24	0.24	57
SEPIC Converter	12	0.68	24	0.24	70.5
Zeta Converter	12	0.6	24	0.24	80

4. CONCLUSION

This paper deals with performance analysis of three different converters such as SEPIC, Luo and ZETA converters. Further, the performance parameters and Input-Output parameters were compared. For a fixed output voltage of 24v, the Input-Output parameters, output ripple voltage, switching losses, critical values of L and C, efficiency losses were analysed. Results demonstrate that the ZETA converter has low switching losses, higher efficiency when compared to the SEPIC and Luo converters. Further, it is concluded that the ZETA converter claims the efficiency of 80% and it is superior than the other two proposed converters such as SEPIC and Luo converter.

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