ISSN 2347 - 3983
Volume 8. No. 10, October 2020
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter1078102020.pdf
https://doi.org/10.30534/ijeter/2020/1078102020

Design Aspects of Zeta Converter And Interleaved Boost Converter

Nancy Mary J S[1], Inba Rexy A[2]
[1]Assistant Professor, Department of Electrical and Electronics Engineering,
Loyola-ICAM College of Engineering and Technology, Chennai, Tamil Nadu, India, nancymary.js@licet.ac.in
[2]Associate Professor, Department of Electrical and Electronics Engineering,
Loyola-ICAM College of Engineering and Technology, Chennai, Tamil Nadu, India, inbarexy.a@licet.ac.in

ABSTRACT

Solar powered converters were employed for conversion of electrical energy from solar cells to a constant and dependable power source. The objective of this paper is to compare and analyse dc to dc converters such as zeta and interleaved boost converter (IBC) converter. Simulation work has been carried out for zeta converter and interleaved boost converter using MATLAB/SIMULINK.

Key words : DC-DC Converter, IBC, Solar, ZETA

1. INTRODUCTION

We have relied on fossil fuels for generating electrical energy for many years. Climate change is one of the major crisis in today's challenge and also burning of fossils leads to air and water pollution. Demand of fossil fuels is increasing each year, which is not abundantly available. The renewable sources of energy such as solar, wind, tidal etc., never run out. Renewably energy helps us to safeguard our globe by considerably reducing the amount of carbon emissions. PV system converts sun radiation into electrical energy. Usually dc to dc converters are used to improve the performance of PV system. The comparative study envisages the topologies of two DC-DC converters; Zeta and IBC converter.

DC voltage is given as input to the ZETA converter which delivers a positive output voltage above or below the input voltage. This converter is also known as flying capacitor. It requires a series capacitor and inductors. This converter is redesigned from a buck regulator which will regulate the unregulated supply. The benefits of the ZETA converter are input to output isolation, buck-boost ability, uninterrupted output current and low ripple voltage.

IBC is Interleaved boost converter which is half the power rating boost converter. The ripples in the current is reduces by the capacitor. Interleaved boost converters (IBC) could be very useful for high power applications. These types of converters have reduced size and EMI along with the improved efficiency and reliability. The IBC system consists of two boost converters that are connected in parallel and controlled by interleaved method which has the identical frequency and 180-degree phase shift. The components used in IBC are MOSFET module, power diode, inductor and capacitor. The ripples in the output voltage reduced by the capacitor. The instigation permits the IBC to perform and gives the desired output voltage. [1-3]

2. ZETA CONVERTER

Use either SI (MKS) or CGS as primary units. (SI units are strongly encouraged.) English units may be used as secondary

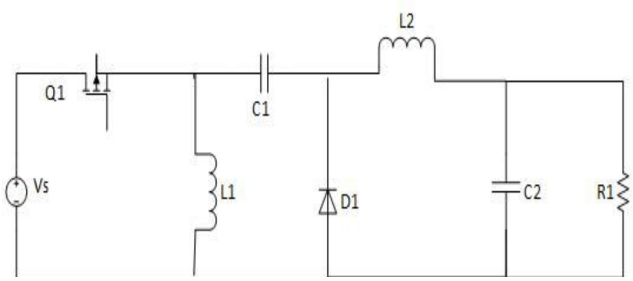

Figure 1: ZETA Converter

The circuit of ZETA converter is shown below. It requires inductors L11 and L12 & Capacitors C11 and C12, MOSFET acting as switch and a diode. Consider the Zeta converter acting in continuous conduction mode. The modes of operation is given for Q1 is ON and Q1 is OFF.[4-7]

A. Mode 1:

When Q1 ON; Capacitor C11 charged to Vout and it is connected in series with L12, so the voltage across L11 is Vin and Diode D realizes Vin and Vout.

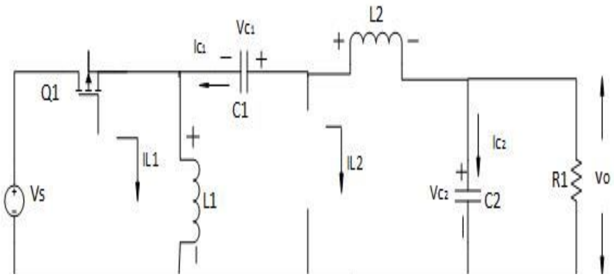

Figure 2: Mode 1 of Zeta Converter

B. Mode 2:

When Q1 OFF; the voltage across L11 must be Vout , the voltage across Q is Vin + Vout , hence the voltage across L11 is – Vout.

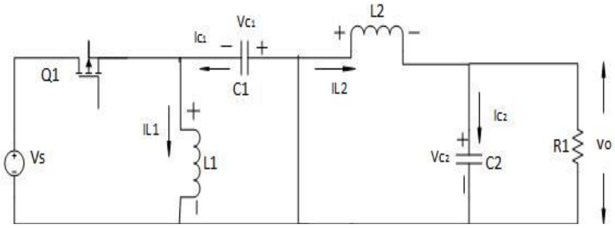

Figure 3: Mode 2 of Zeta Converter

The figure shows the schematic representation of ZETA converter is given below. It includes Capacitors C11 and C12, inductors L11 and L12, MOSFET acting as switch and a diode. Consider the Zeta converter acting in continuous conduction mode. The modes of operation is given for Q1 is ON and Q1 is OFF.[4-7]

3. INTERLEAVED BOOST CONVERTER

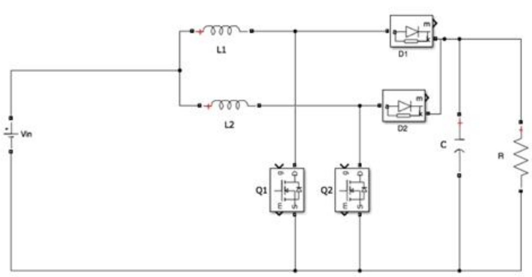

Figure 4: Interleaved Boost converter

Figure 4 shows a interleaved boost converter with separated inductors which is two-phase uncoupled. The number of inductors and switches equal to the number of phases is always. [8-12]

A. Mode 1:

During mode 1 the switches Q1 and Q2 switched on and diodes D1 and D2 are OFF condition

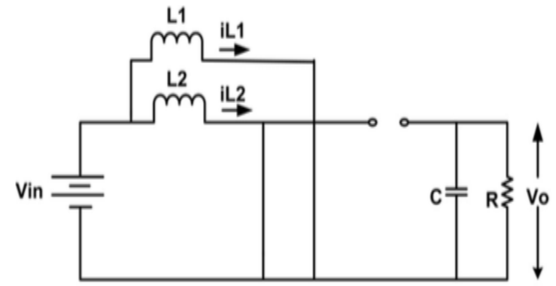

Figure 5: Mode 1 of Interleaved Boost Converter

B. Mode 2:

In mode 2, MOSFET Q1 is switched ON and Q2 is in non -conducting mode, D1 is OFF and D2 is ON respectively.

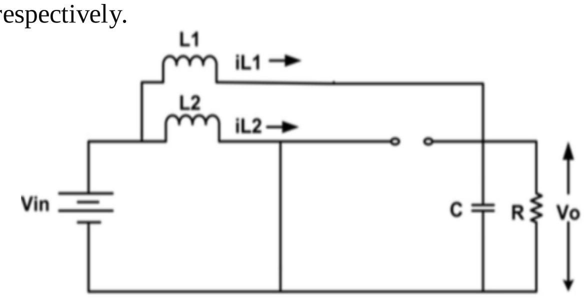

Figure 6: Mode 2 of Interleaved Boost Converter

C. Mode 3:

During mode 3, switch Q1 is switched OFF and Q2 is switched ON, D1 is ON and D2 is OFF respectively.

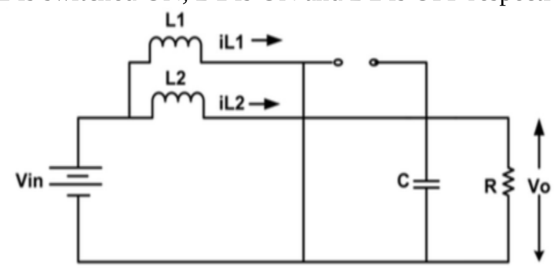

Figure 7: Mode 3 of Interleaved Boost Converter

D. Mode 4:

During mode 4, switch Q1 is switched OFF and Q2 is switched OFF, D1 is ON and D2 is ON respectively.

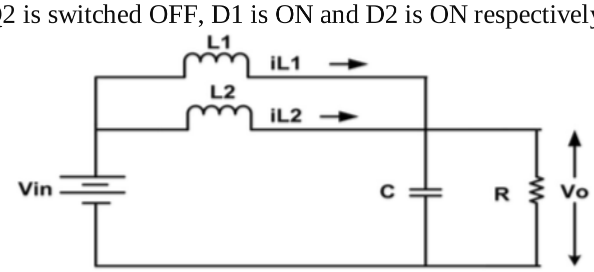

Figure 8: Mode 4 of Interleaved Boost Converter

4. DESIGN CONSIDERATIONS

4.1. ZETA Converter

A. Choice of Duty Ratio

75% of the duty cycle is chosen . D = 0.75 which results in low ripple voltage in the output when compared to other duty ratios. The duty ratio is calculated as,

$$D = \frac{V_{out}}{V_{out}+V_{in}} \quad (1)$$

B. Choice of Inductance

20% of the output current is selected as ripple current

$$L_{11} = L_{12} = \frac{V_{in}D}{f_s \Delta I_o} \quad (2)$$

C. Choice of Capacitance

1% of output voltage is selected ripple voltage .

$$C_{12} = \frac{I_O D}{f_s \Delta V_o} \quad (3)$$

D. Load Resistance

$$Po = \frac{{V_{out}}^2}{R} \quad (4)$$

4.2. Interleaved Boost Converter

A. Choice of Duty Ratio

75% of the duty cycle is chosen . D = 0.75 which results in low ripple voltage in the output when compared to other duty ratios. The duty ratio is calculated as,

$$D = \frac{V_{out}-V_{in}}{V_{out}} \quad (5)$$

B. Choice of Inductance

The ripple current was chosen as 20% of the output current.

$$L_{11} = L_{12} = \frac{V_{in}D}{f_s \Delta I_o} \quad (6)$$

C. Choice of Capacitance

The ripple voltage was chosen as 1% of output voltage

$$C_0 = \frac{I_O D}{f_s \Delta V_o} \quad (7)$$

D. Load Resistance:

$$Po = \frac{{V_O}^2}{R} \quad (8)$$

5. SIMULATION RESULTS

5.1. ZETA Converter

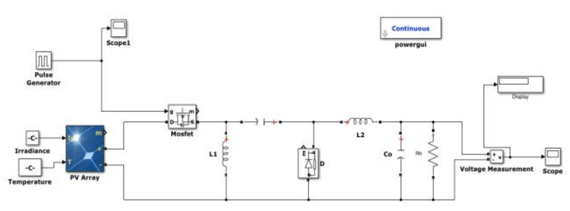

Figure 9: Simulation model of ZETA Converter

Table 1: Simulation Parameters Of Zeta Converter

Attributes	Values
Input voltage(V_{in})	20 V
Output voltage(V_{out})	60 V
Output power (P_O)	18W
Load (R)	200 Ω
Switching frequency (F_S)	100 KHz
Duty ratio (D)	75%
Inductor L11=L12	2.5 mH
Output capacitor C12	2 μF

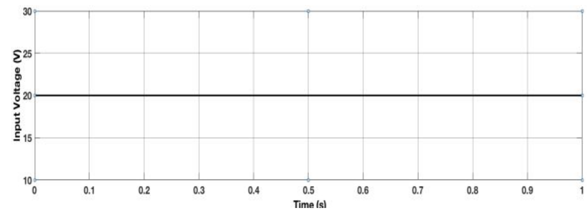

Figure 10: Input voltage of ZETA converter

The figure 10 shows the input voltage of Zeta converter which is 20V DC.

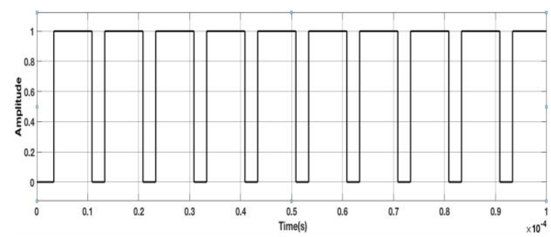

Figure 11: Pulses of ZETA converter

The switching pattern of the zeta converter is shown in fig.11. for duty ratio of 0.75 with 100KHz as switching frequency.

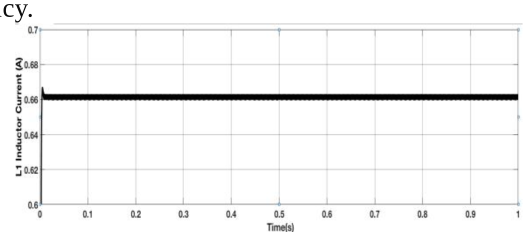

Figure 12: Inductor current L11

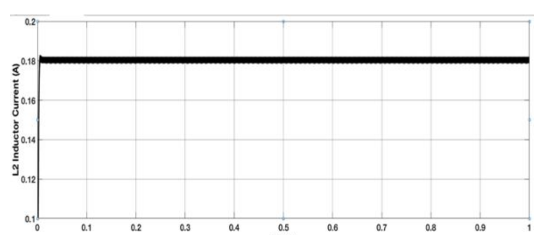

Figure 13: Inductor current L12

Figures 12 and 13 shows the inductor current for L11 and L12 of the ZETA converter with low ripple current.

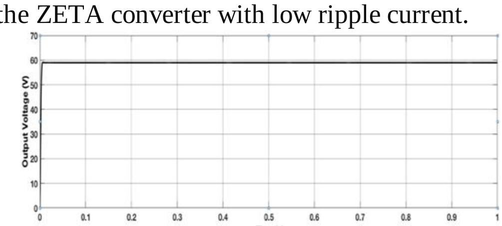

Figure 14: Output voltage of ZETA converter

Figure 14 shows the output voltage of the ZETA converter. An output voltage of 59V is obtained for the input voltage of 20V with 75% duty ratio.

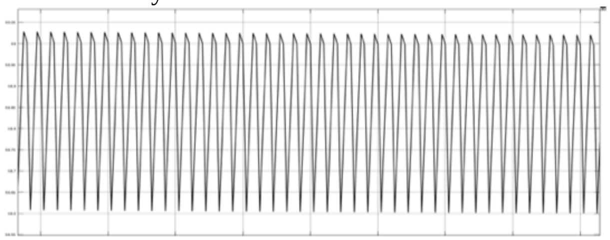

Figure 15: Output ripple of ZETA converter

Figure 15 shows the ripple voltage of the output ZETA converter.

5.2. Interleaved Boost Converter

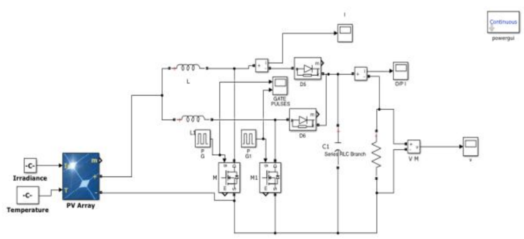

Figure 16: Simulation model of Interleaved Boost Converter

Table 2: Simulation Parameters of IBC

Attributes	Values
Input voltage(V_{in})	20 V
Output voltage(V_{out})	60 V
Output power (P_O)	18W
Load (R)	200 Ω
Switching frequency (F_S)	100 KHz
Duty ratio (D)	75%
Inductor L11=L12	2.5 mH
Output capacitor C12	2 μF

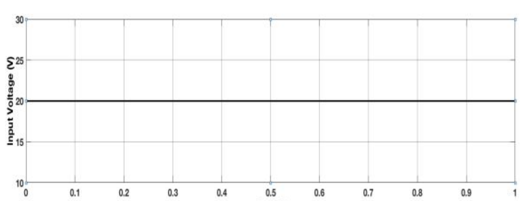

Figure 17: Input voltage of IBC

The figure 17 shows the input voltage of interleaved boost converter which is 20V DC

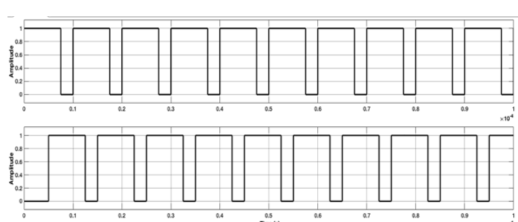

Figure 18: Pulses of IBC

The switching pattern of the interleaved boost converter is shown in figure 18 for duty ratio of 0.75 with 100KHz as switching frequency

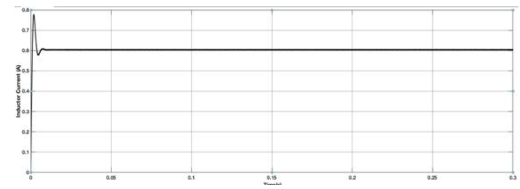

Figure 19: Inductor current of IBC

Figure 19 shows the inductor current for L11 and L12 of the interleaved boost converter with low ripple current.

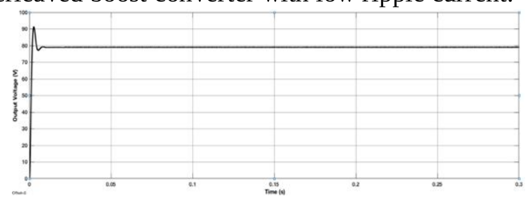

Figure 20: Output voltage of IBC

Figure 20 shows the output voltage of the Zeta converter. An output voltage of 79V is obtained for the input voltage of 20V with 75% duty ratio.

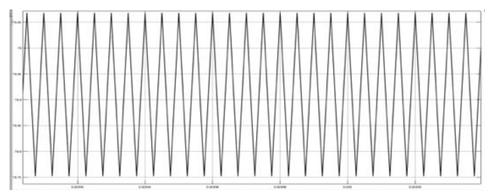

Figure 21: Output ripple of IBC

Figure 21 shows the output ripple voltage of the interleaved boost converter.

6. CONCLUSION

In this paper, the operation of the ZETA converter and interleaved boost converter were explained. The converter topologies have been analyzed and presented. The simulation results of both the converters are presented here. It is resulted that IBC effectively decreases the overall current ripple and gives a substantial boost of the input voltage which increases the overall efficiency of operation of this circuit. Comparative study between ZETA and IBC is presented in Table3.

Table 3: Simulation Parameters of IBC

Attributes	ZETA	IBC
Input voltage(V_{IN})	20V	20 V
Output voltage(V_O)	59V	79 V
Output Ripple Voltage (ΔV_O)	0.4V	0.3V

ACKNOWLEDGMENT

The authors thank the management of Loyola-ICAM College of Engineering and Technology for encouraging the research work.

REFERENCES

1. Ugo Farinelli, **A setting for the diffusion of renewable energies***Renewable Energy, volume 5*, issue 1-4 (1994)
2. Kumar, Rajan; Singh, Bhim**Solar photovoltaic array fed water pump driven by brushless DC motor using Landsman converter** IET Renewable Power Generation, DOI: 10.1049/iet-rpg.2015.0295
3. Narendranath, K V; Viswanath, Y; Babu, K Suresh; Arunkumar, G; Elangovan, D**, Solar fed DC-DC single ended primary inductance converter for low power applications,***IOP Conference Series Materials Science and Engineering,* volume 263, 2017
4. Viero, Renan Caron; dos Reis, Fernando Soares **"Dynamic modeling of a ZETA converter in DCM applied to low power renewable sources"***IEEE Energy Conversion Congress and Exposition (ECCE)* DOI: 10.1109/ECCE.2011.606383
5. Vuthchhay, E.; Bunlaksananusorn, C **The Modeling and control of a Zeta converter -** *2010 International Power Electronics Conference - ECCE ASIA* -DOI: 10.1109/IPEC.2010.5543332
6. Zhang, Hao;, Yuan; Ma, Xikui Distortion Behavior **Analysis of General Pulse-Width Modulated Zeta PFC Converter Operating in Continuous Conduction Mode**,*IEEE Transactions on Power Electronics*, volume 27, issue 10 (2012)
7. Reginaldo de Britto, Jonas; Elias Demian Junior, Aziz; de Freitas, Luiz Carlos; Farias, Valdeir J.; Coelho, Ernane A. A.; Joao Batista Vieira, **Zeta DC/DC converter used as led lamp drive***IEEE 2007 European Conference on Power Electronics and Applications* - DOI: 10.1109/epe.2007.4417412
8. Po-Wa Lee, Yim-Shu Lee, Cheng, D. K. W., &Xiu-Cheng Liu. (2000), **Steady-state analysis of an interleaved boost converter with coupled inductors**. *IEEE Transactions on Industrial Electronics*, 47(4), 787–795. doi:10.1109/41.857959
9. Genc, N., & Iskender, I. **Steady-state analysis of a novel ZVT interleaved boost converter**, *International Journal of Circuit Theory and Applications*, 39(10), 1007–1021. doi:10.1002/cta.683
10. Veerachary, M., Senjyu, T., &Uezato, K. **Maximum power point tracking of coupled inductor interleaved boost converter supplied PV system,***IEEE Proceedings - Electric Power Applications,* 150(1), 71. doi:10.1049/ip-epa:20020686
11. Genc, N., & Iskender, I. **An improved soft switched PWM interleaved boost AC–DC converter**,*Energy Conversion and Management,* 52(1), 403–413. doi:10.1016/j.enconman.2010.07.016.
12. Inba Rexy A, Seyezhai R, **"Investigation of Current Control Techniques of AC-DC Interleaved Boost PFC Converter"**, *Circuits and Systems*, vol. 7, pp. 307-326, 2016.