

ZETA CONVERTER SIMULATION FOR CONTINUOUS CURRENT MODE OPERATION

Sujo Oommen

Assistant Professor, School of Electrical & Electronics Engineering
REVA University, Bangalore, India

Adithya Ballaji

Assistant Professor, School of Electrical & Electronics Engineering
REVA University, Bangalore, India

Burri Ankaiah

Assistant Professor, School of Electrical & Electronics Engineering
REVA University, Bangalore, India

Ananda M H

Assistant Professor, School of Electrical & Electronics Engineering
REVA University, Bangalore, India

ABSTRACT

To extract regulated power supply from the inputs of unregulated conditions, the zeta converter topology is the major application in the power electronics current mode operation. Zeta convertor can interfaced for high frequency application with a less switching stress and also it obtains regulated output voltage from the given input voltage which varies below and above output voltage, When compared with buck, boost, buck-boost and cuk converter, it gives non pulsating current with reduced settling time with adaptability. For different duty cycles and constant switching frequencies, the zeta converter with resistive load gives better results for buck and boost application.

Keywords: Zeta converter, Duty cycle

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1. INTRODUCTION

In the application of power system there are so many limitations especially in basic DC-DC converter. To maintain power quality with good improvement with respect to harmonic reduction, PFC etc and also the output voltage is controlled [1]. A non linear non - inverting

forth order converter called Zeta converter can be operated as buck – boost – buck with respect to input and operated as boost - buck – boost w.r.t energy output [2].

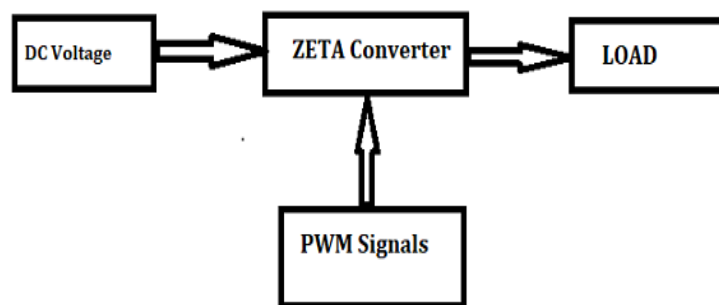


Figure 1 Functional Block Diagram of Zeta Converter.

Any renewable sources as input, the power electronic converter is the basic requirement, like zeta converter which has more advantages than over other converters like boost, buck, buck-boost, sepic and also cuk converter. The zeta converter main advantages are less stress in switching, adaptability, output current is non pulsating. It depends on the duty cycle which can be operate in any mode of operations like boost and buck. If the Photo voltaic system as input, irrespective of alternatives in irradiance, it maintains constant output voltage [2][5].

2. ZETA CONVERTER

2.1. Basic operation of zeta converter

Zeta converter consists of switch MOSFET, two Capacitors (C1 & C2), two Inductors (L1 & L2), only one Diode (D) and the load Resistor (R). Zeta converter circuit is operating under continuous conduction mode (CCM) for switching condition like ON & OFF.

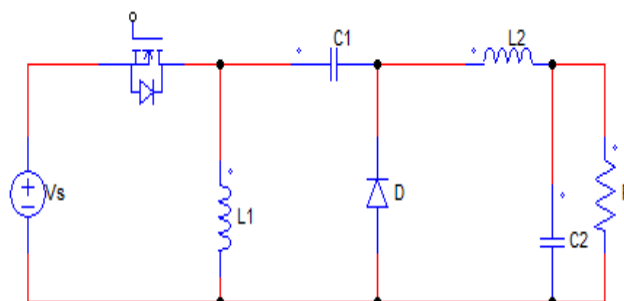


Figure 2 Basic circuit diagram of Zeta Converter

2.2. Modes of operation with equivalent circuits

Mode 1: In ON condition the switch, the diode is reverse biased and inductor draws current from the source voltage (V_s), these current through the inductor starts increasing linearly and stored energy in ON condition mode of operation. The inductor voltage across will be almost equal to the input voltage or source voltage [3]. At the same time capacitor C1 starts charged to output voltage. When MOSFET is in ON condition, energy from the supply will be stored in the two inductors (L_1, L_2) and also C1 and L2 provides output currents [2].

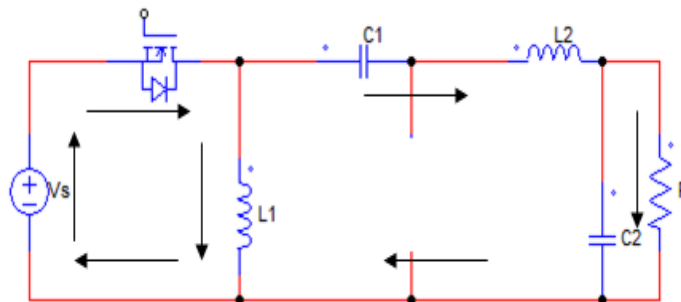


Figure 3 Equivalent circuit diagram during switch is ON

Mode 2: In case 2 or mode 2 the switch is OFF condition, now diode is in forward biased, capacitor will be parallel to L2 inductor and across the inductor output voltage will be available, since C1 is discharged and C2 is charged to voltage in output. Whatever energy stored in the inductor (L) will be carry forward to the load resistor. So this kind of mode of operation is discharging conditions. [2][3]

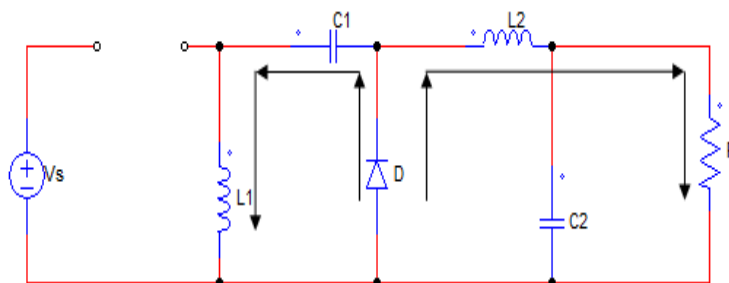


Figure 4 Equivalent circuit diagram during switch is OFF

3. DESIGN OF L AND C PARAMETERS

In loss less condition zeta converter act as CCM with given specific duty cycle is given as,

$$D = \frac{V_o}{V_i + V_o} \quad \dots \quad (1)$$

[6]For two switching modes of operations KVL is applied and assuming 30% of ripple content current in the inductor with respect to input current(I_{in}).The inductor values can be calculated with assumption that magnetically coupled with inductors are used with same content of ripple current for two both inductors (L_1 & L_2) by the equation given below,

$$L_1 = L_2 = \frac{DV_{in}}{F * \Delta I} \quad \dots \quad (2)$$

For both the switching modes KCL can be apply, the capacitor values can be calculated. Assuming ripple voltage of capacitor is 0.02 times the output voltage[3]. Thus equation for capacitors are given as,

$$C_1 = \frac{DV_o}{F * R * \Delta V} \quad \dots \quad (3)$$

$$C_2 = \frac{DV_{in}}{8 * F^2 * L_2 * \Delta V} \quad \dots \quad (4)$$

Table 1 Design Specification of Zeta Converter

| Parameters | Calculated Values |
|-----------------|---------------------------|
| V _{in} | 100V |
| V _o | 230V (Boost) & 42V(Buck) |
| D | 70% (Boost) 30% (Buck) |
| F | 10 kHz |
| R | 40 Ω |
| L1 | 25 mH |
| L2 | 25 mH |
| C1 | 4 *10 ⁻⁴ F |
| C2 | 7.6*10 ⁻⁴ F |

4. SIMULATION & RESULTS

Simulation circuit for Zeta converter is carried out with an input voltage of 100V to boost up to 230V and step-down (buck) to 42V with a duty cycle of 70% and 30% respectively. Output voltage to operate as buck and boost mode by changing the duty cycle of gate pulse to the MOSFET switch.

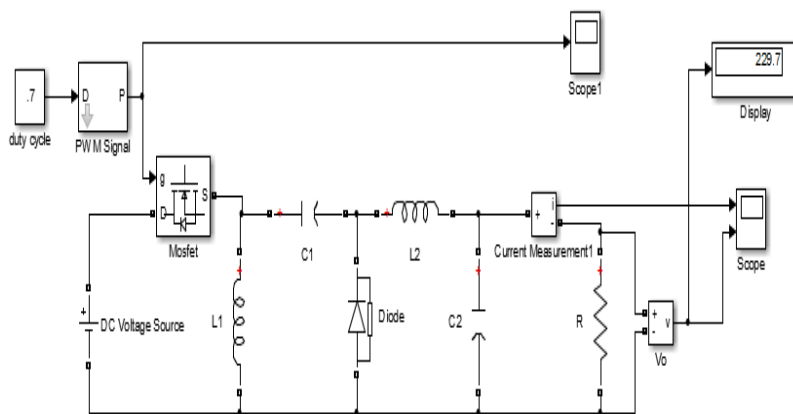


Figure 5 Simulation of ZETA converter for Boost Mode.

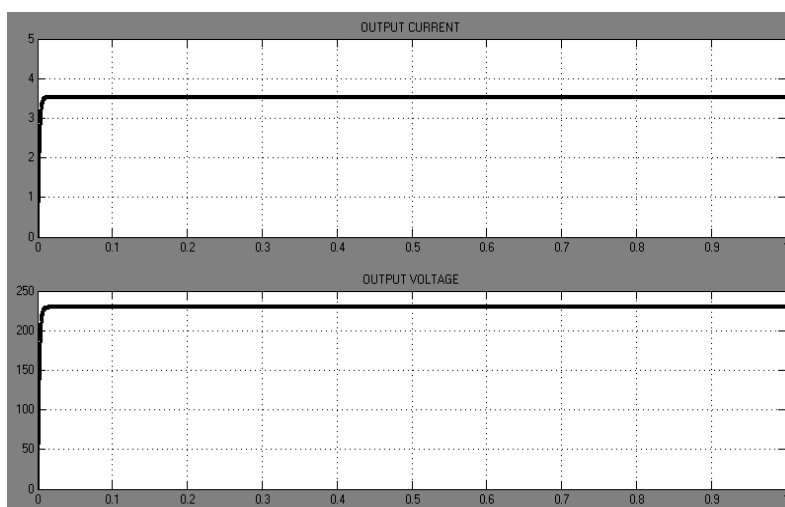


Figure 6 Output Voltage & Current waveforms of ZETA converter for Boost Mode.

Zeta Converter Simulation for Continuous Current Mode Operation

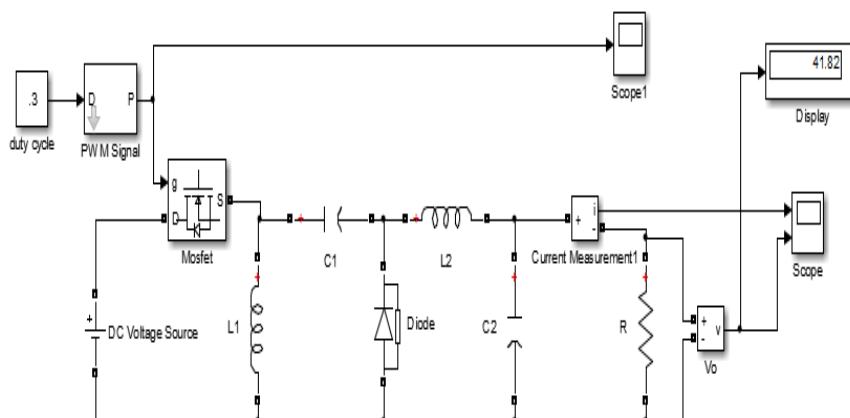


Figure 7 Simulation of ZETA converter for Buck Mode.

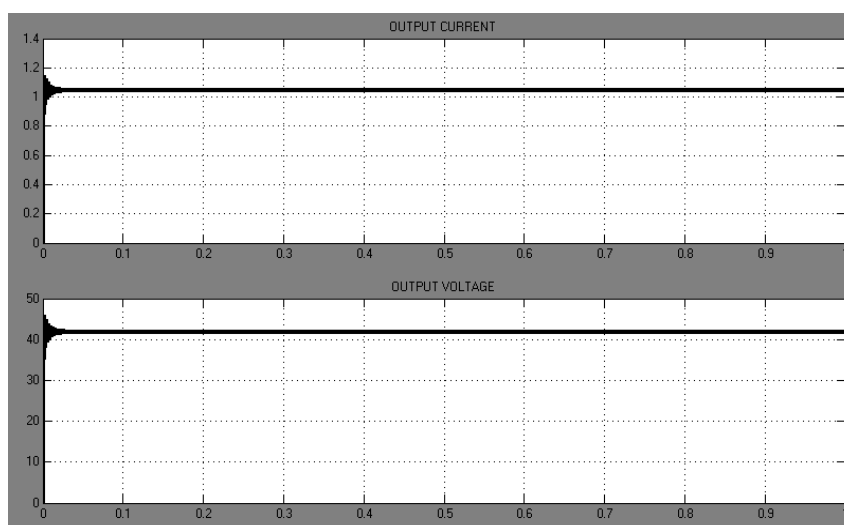


Figure 8 Output Voltage & Current waveforms of ZETA converter for Buck Mode.

5. CONCLUSIONS

In this paper deals with the operation principle of Zeta converter and different operating modes with equivalent circuits. Zeta converter parameters are designed and simulation is carried from the obtained values. From simulation circuit, it is observed that with the same parameter design boost and buck converter operation is taking place by changing the duty cycle of 70% and 30% respectively. Simulation is Output voltage obtained from both operation having less ripple and reduced settling time. This converter overcomes the drawbacks of other converters, providing lower output voltage ripple and better compensation.

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