Simulation of AC-DC Converter for High Power Application

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Article Info

ABSTRACT
This manuscript deals with the simulation of DC - DC Zeta converter for high power drive application with greater efficiency, lesser losses and power factor correction. It involves simpler control circuitry with less external components. The explanation of Fundamental function of Zeta converter is given in this paper. To condense the harmonic content the PI, PID and Fuzzy Logic controller are used. The operation of Zeta converter in open loop, closed loop is obtained. Closed loop system of zeta converter proves better performance over open loop system. Open and closed loop circuits are simulated by using MATLAB simulink. By giving disturbance in closed loop and open loop systems, feat of Zeta converter is compared

Keyword:
Fuzzy logic controller
PI controller
PID controller
Power Factor correction
Zeta converter

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1. INTRODUCTION
The conventional system of AC-DC translation by a diode rectifier with bulkiness capacitor is not using due to several difficulties, such as high crest current, low power factor, increased electromagnetic interfering, low order harmonics injection into AC supply, line voltage distortion, extra burden on lines, and supplementary losses. Solid-state switch mode rectifier converters have arrived at a established level for enlightening power quality in terms of power-factor improvement (PFI) and reduced total harmonic distortion (THD). The control of output voltage and improving the power factor is major challenge. The basic dc-to-dc converter topologies using Boost converter, Buck-converter and Buck-Boost converter have their inherent boundaries when used for power factor correction beside with voltage regulation purposes.

In the proposed method a comparatively new class of AC to DC converter, and Zeta converter is used for active PFC and voltage regulation having advantages of being normally inaccessible structure, can operate as both step up/down voltage converter and having only one stage power processing for both voltage regulation and PFC. A Zeta converter performs a non-inverting buck-boost function similar to that of a SEPIC. But in application which implies high power, the operation of a converter in discontinuous mode is not attractive because it results in high rms values of the currents causing high levels of stress in the semiconductors. In this paper, an active power factor correction (PFC) is performed by using a Zeta converter operating in continuous conduction mode (CCM), where the inductor current must follow a sinusoidal voltage waveform. This method provides nearly unity power factor with low THD. The conventional boost converters are not preferred, because at high voltage duty ratio it causes severe losses in power devices and high voltage stress across the switching devices. The diode reverse recovery problem increases the conduction losses, degrade the efficiency and limit the power level of conventional boost converter. Owing to this scenario integrated boost fly back converter is designed to reduce these problems and to interface with renewable energy system.

2. ZETA CONVERTER

A zeta converter is a fourth order non linear system being that, with regard to energy input, it can be seen as buck-boost-buck converter and with regard to the output, it can be seen as boost-buck-boost converter.

![Diagram of Zeta Converter Circuit]

The ideal switch based realization of zeta converter is depicted. A non-isolated zeta converter circuit is shown in the fig.1 above. Although several operating modes are possible for this converter depending on inductance value, load resistance and operating frequency, here only continuous inductor current “iL1” analyzed using the well known state-space averaging method [3]. The analysis uses the following assumptions.

1. Semiconductors switching devices are considered to be ideal.
2. Converter operating in continuous inductor current mode.
3. Line frequency ripple in the dc voltage is neglected.

3. MODES OF OPERATION

Zeta converter exhibits two different modes as follows:
- **Mode1**: The first mode is obtained when the switch is ON (closed) and instantaneously, the diode D is OFF. An equivalent circuit of zeta converter is shown in Figure 2. During this period, the current through the inductor L1 and L2 are drawn from the voltage source Vs. This mode is the charging mode.
- **Mode2**: The second mode of operation starts when the switch is OFF and the diode D is ON position, the equivalent circuit shown in Figure 3. This stage or mode of operation is known as the discharging mode since all the energy stored in L2 is now transferred to the load R.

![Diagram of Equivalent Circuits]

4. SIMULATION MODELS AND RESULTS

The zeta converter is driven by a single switch. The zeta converter is simulated in both open and closed loop, without and with disturbance using MATLAB simulink and the results are taken. The output parameters are displayed by the Scope.

The experimental circuits and their results of ZETA converter in open loop and closed loop systems are given below.

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4.1. Open Loop Circuit of Zeta Converter with C Filters without Disturbance:

The simulated diagram of open loop zeta converter (with C filter) with R load is shown in Figure 4. And its output parameters are measured.

![Figure 4. Circuit Diagram for Zeta Converter with C Filter](image)

The Figure 5 shows the input voltage of zeta converter (with C filters) with R load. The Figure 6 shows the input power and Figure 7 shows the switching pulse of zeta converter with R load. And also Figure 8, 9 and 10 shows the output voltage, output ripple voltage, output current respectively.

![Figure 5. Input Voltage](image)

![Figure 6. Input Power](image)

![Figure 7. Switching Pulse For Zeta Converter](image)

![Figure 8. Output Voltage](image)
4.2. Open Loop Circuit of Zeta Converter with Π Filters Without Disturbance.

The simulated diagram of open loop zeta converter (with π filters) with R load is shown in Figure 11. And its output parameters are measured.

The Figure 12 shows the input voltage of zeta converter (with π filters) with R load. The Figure 13 shows the input power and Figure 14 shows the switching pulse of zeta converter with R load. And also Figure 15, 16 and 17 shows the output voltage, output ripple voltage and output current respectively.

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From the above results, the output voltage ripple is very less in π filter. And also from π filter combinations LCL filter is giving very less voltage ripple.

### 4.3. Closed Loop Circuit with PI Controller.

The simulated diagram of closed loop zeta converter (with π filters) with R load is shown in Figure 18. Here the PI controller is used. And its output parameters are measured.
The Figure 19 shows the input voltage of zeta converter (with π filters) with R load. The Figure 20 shows the output voltage. And also Figure 21 shows the output current.

4.4. Closed loop circuit with PID controller.
   The simulated diagram of closed loop zeta converter (with π filters) with R load is shown in Figure 22. Here the PID controller is used. And its output parameters are measured.
The Figure 23 shows the output current of zeta converter (with π filters) with R load. The Figure 24 shows the output voltage of the closed loop with PID controller.

4.5. Closed loop circuit with Fuzzy Logic controller.

The simulated diagram of closed loop zeta converter (with π filters) with R load is shown in Figure 25. Here the fuzzy logic controller is used. And its output parameters are measured.
The Figure 26 shows the output voltage of zeta converter (with π filters) with R load. The Figure 27 shows the output current of closed loop with fuzzy logic controller.

![Figure 26. Output voltage](image1)

![Figure 27. Output current](image2)

<table>
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<tr>
<th>Controller</th>
<th>$T_r$</th>
<th>$T_s$</th>
<th>$T_p$</th>
<th>$Ess$</th>
</tr>
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<td>0.08</td>
<td>0.3</td>
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<tr>
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<tr>
<td>FUZZY</td>
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<td>0.05</td>
<td>0.04</td>
<td>0.08</td>
</tr>
</tbody>
</table>

From the above results, the Fuzzy Logic Controller is best controller. Because in this controller the rise, settling time and peak overshoot is very less. So Fuzzy logic controller is very best controller for zeta converter.

5. **EXPERIMENTAL RESULTS**

The Experimental setup of zeta converter is shown in Figure 28. In this AC is converted as DC supply and that DC supply is given as an input of the zeta converter. Here the fuzzy logic controller is used as a controller circuit for zeta converter. The output of zeta converter is given to the Resistive Load.

![Figure 28. Experimental Setup of Zeta Converter.](image3)

6. **CONCLUSION**

The Mathematical analysis of ZETA converter is carried out for design values of the capacitor and inductor. A simple power electronic controller with load has been simulated using ZETA converter. The subsystems of overall scheme such as controller model, ZETA converter model have been built and tested individually before integrating to the overall system. The simulation studies of the proposed scheme of PI, PID and Fuzzy controllers carried out and the results are furnished. The values of parameters used for simulation are listed.
REFERENCES


BIOGRAPHIES OF AUTHORS

Mr. S. Ramarajan has completed B.E from Anna University in 2008. He obtained M.E degree in the field of Power Electronic & Industrial Drives from Sathyabama University in 2012. Presently he is working as Assistant Professor in Jeppiaar Engineering College, Chennai and doing his research in power electronics. His areas of interest are power electronics, electrical machines speed control and intelligent controller.

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