Performance Analysis Of SEPIC And Zeta Converter For Power Quality Improvement

Fakirrao T.Chavan, Shrikant S.Mopari , Panchayya S. Swami

Abstract: In recent trends the rapid evolution in power semiconductor devices is increased a wide series of applications such as robotics, industrial, and several others. A harmonics distortion produced by power converter is becoming a serious concern for reliable operation of the system. All the same, a usual method by means of rectifier with capacitor has adverse consequences and supplementary losses. This paper enlightens the relative performance analysis of SEPIC and Zeta converter for power quality improvement. The suggested topologies provide the reduction of THD by employing proportional integral technique with voltage follower approach. The performance for proposed converter has simulated in MATLAB that provided an improved power quality at AC mains.

Index Terms: SEPIC, Zeta, DCM, DBR, PWM MOSFET,THD

1. INTRODUCTION

NOWADAYS, a DC-DC converters being commonly used everywhere. They are employed for power supplies, robotics, lightning, industrial applications. These are also applied as power converters for photovoltaic power systems too, as concluded in [1]. A new topology using SEPIC converter is designed in DCM for supply mains of arc welding provides inherent power factor correction along with decrease in conduction losses and enhancement in efficiency provided the THD of 5.36% [2] The authors of [3] designed a high frequency secluded converters for linking the output side of bridge towards the load for achieving higher power factor and advanced frequency isolation along with compact size provided a THD of 8.25%.In [4] the authors investigated the performance of Solar Energy Transformation System intended to sustain grid power and augmentation power quality by employing H Bridge, multilevel inverter and the SIMO-SEPIC converter providing a lower THD of 1.65%. While some author discussed the performance for Zeta converter which has been operated in DCM along with HFT seclusion for SMPS to explore steady state and dynamic behavior, which provided the current at supply nearly a sinusoidal one with lower THD 1.09%.[5] Several researches have shown analysis with a decreased sensor configuration for PFC Zeta converter feeding a DC motor drive intended for lower power applications has been investigated to achieve the enhanced quality of power at AC mains providing a THD of 3.03%.[6] In [7] author investigated single phase Zeta converter along with one switch is employed to improve power factor and efficiency by using HCC method which gives reduced THD of 1.85 % with power factor nearly unity and lesser harmonics distortions at ac supply.

Another author analyzed the performance bridgeless Zeta converter operating in DCM feeding SRM drive for lesser power application provided THD of 5.66% [8]

DC-DC converters provide a high efficiency and fast dynamic response. They can also be used for voltage regulations and for generating direct current.

In this paper, the converters SEPIC and Zeta are used for the performance analysis. Their topologies are investigated and result analysis provided their aptness for reduction in THD leading to power quality improvement.

2 CONVERTER ANALYSIS

Figure 1 depicts the block diagram of desired converter circuitry. It contains a diode bridge rectifier supplied by ac mains, a converter, and load and control circuit.

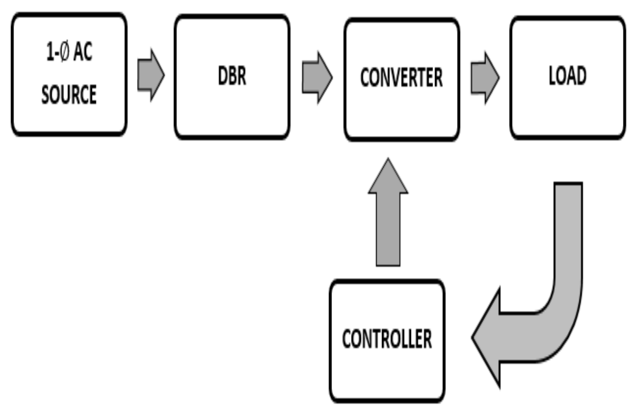

***Fig.1**. Block Diagram of the Proposed Converter Circuit*

In this topology an AC source is supplied to the DBR (Diode Bridge Rectifier) it converts ac into dc. This DC voltage is fed to respective converter. By employing necessary control techniques PWM pulse are provided for triggering the switch of converter. Converter can be any converter such as SEPIC, Zeta etc.

2.1 SEPIC Converter

The Switching circuitry for SEPIC converter depicted in Fig.(2). It comprises of two coupled inductors, MOSFET as a switch operating at higher frequency, two capacitors and diode for freewheeling.

- *Fakirrao T.Chavan, Electrical Engineering Department, Government college of Engineering, Aurangabad, India.* dyeeg343@mahatransco.in
- *Shrikant S.Mopari , Assistant Professor Electrical Engineering Department, Government college of Engineering, Aurangabad, India.* mopari1977@gmail.com
- *Panchayya S. Swami, Associate Professor, Electrical Engineering Department, Government college of Engineering, Aurangabad, India.* psswami@rediffmail.com

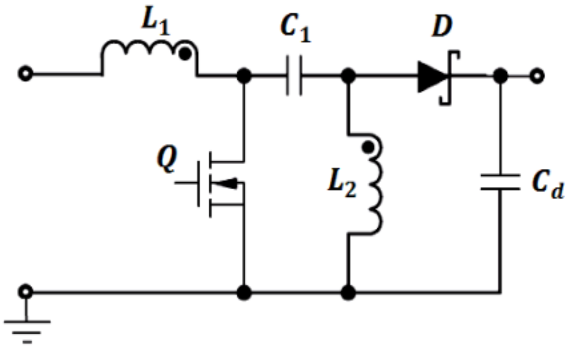

Fig.2. *SEPIC Converter*

During stable state, the voltage which across inductor is zero hence magnitude of Capacitor voltage at C1 is VC1=Vs. It is having two modes of operation mode 1 and mode2 according to operating condition of switch. During mode 1 when switch is closed, diode is in open circuit condition, inductor L1 is fed by sources Vs i.e. Vi, and inductor L2 charges C1. The output is maintained by capacitor C2. The voltage across L1 will be VL1 = Vs. [7]

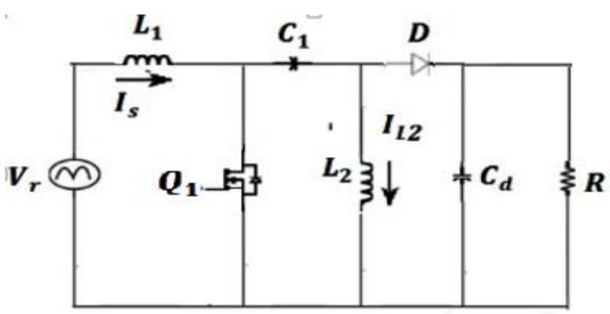

Fig.3. *Mode1*

On the other hand while the switch is opened, diode is comes into action and L1 feeds C1 and L2 transfers power to the load. Voltage across L1 is VL1= -Vo.

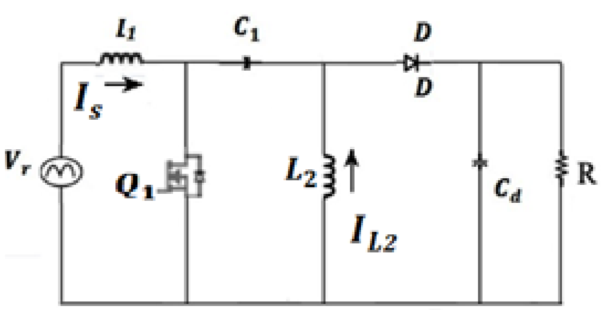

Fig.4. *Mode2*

The voltages and current waveform for the components of the SEPIC converter are shown in fig.5

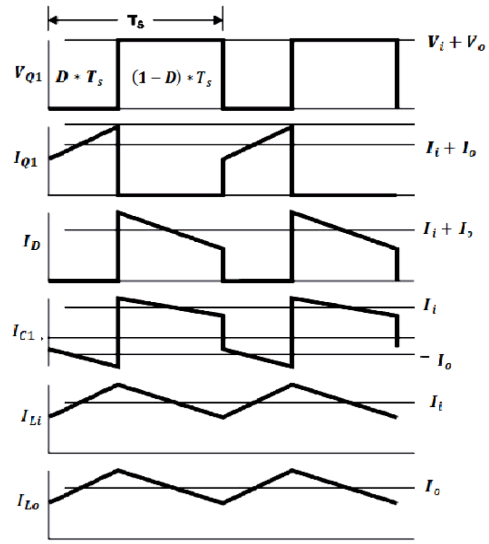

Fig.5. *Waveform of Components*

2.2 Zeta Converter

The circuitry is designed for Zeta working at DCM. The output side inductor is preferred so as to retain current as intermittent for a cycle. The respective topology consist of two coupled inductor a dc link capacitor and a coupling capacitor with diode and single switch as MOSFET.

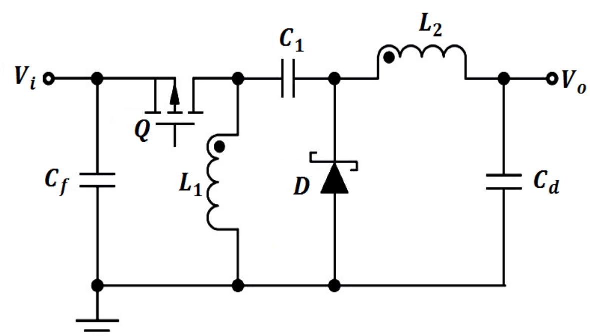

Fig.6. *Zeta Converter*

It is having two operating modes with respect to ON and OFF condition of switch. In mode 1when switch is closed inductors L1 and L2 are charged.

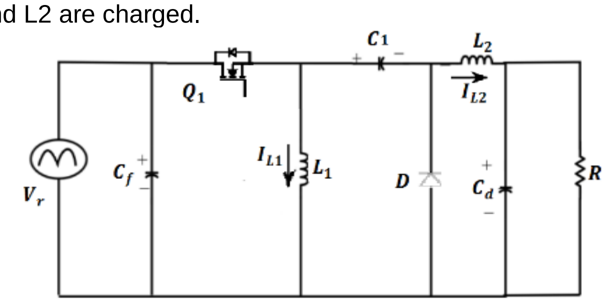

Fig. 7. *Mode 1*

During mode 2 when Switch is opened the inductors L1 and L2 are on the verge to release the stored energy by themselves.I_{L1} charges the capacitor C1and L2 feeds the output circuit connected to the load.

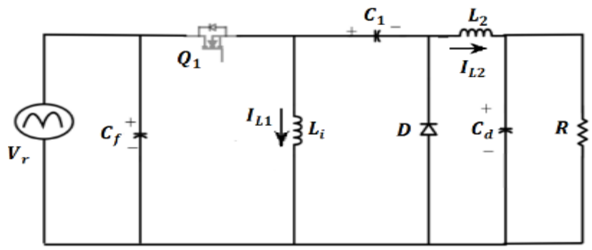

***Fig. 8**. Mode 2*

The waveforms for voltages and current flowing through the components of the Zeta topology are shown in fig. 9

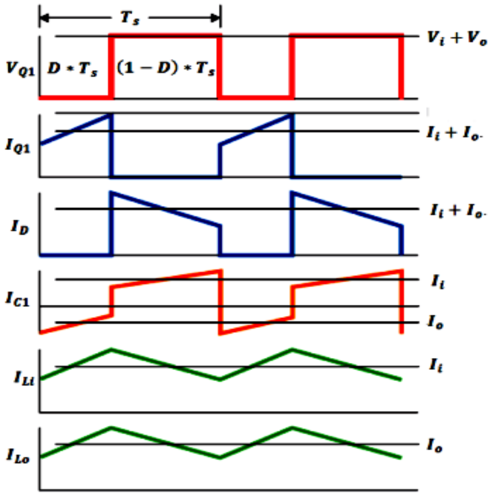

***Fig. 9**. Waveform of Components*

3 SIMULATIONS AND RESULTS

The topology is investigated in MATLAB environment in order to check their behavior in open loop as well as closed loop configurations.

3.1 Simulink Model for SEPIC Converter

The Simulink model for the respected SEPIC converter is shown in fig.10

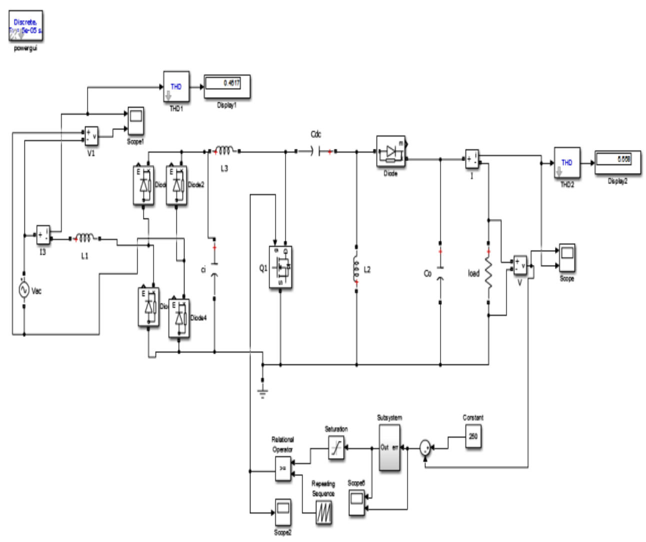

***Fig.10**. Simulink Model for SEPIC Converter*

The voltage and current waveform for open loop SEPIC converter is depicted by fig.11 (a) and fig.11 (b) correspondingly.

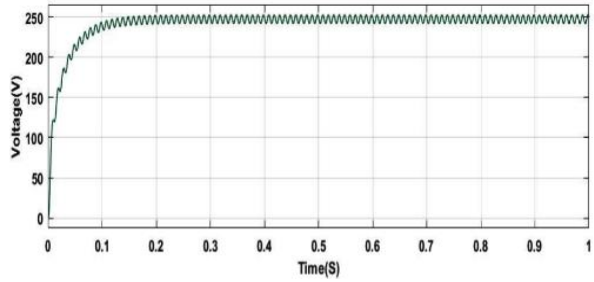

***Fig11 (a)** Output Voltage of Open Loop SEPIC Converter*

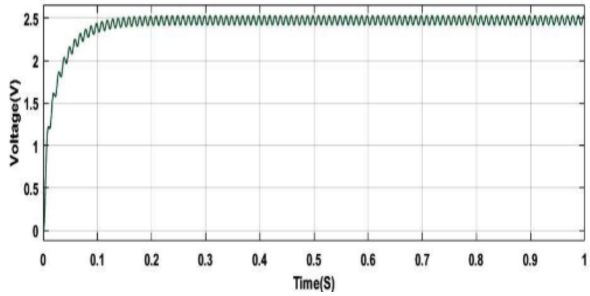

***Fig.11 (b**) Output Current of Open Loop SEPIC Converter*

The voltage and current waveform for closed loop SEPIC is depicted in fig.12(a) and fig.12 (b).The error voltage is controlled by using PI control which provides a feedback control loop that advances the operation of SEPIC converter.

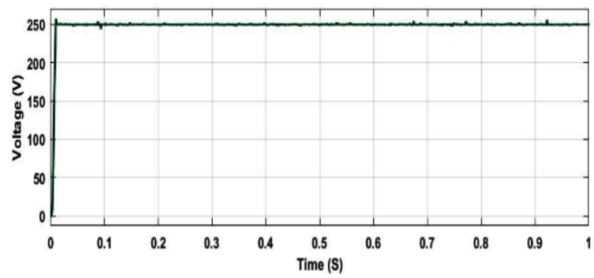

***Fig12 (a)** Output Voltage of Closed Loop SEPIC Converter*

During closed loop operation both the waveform of voltage and currents achieves the stability after 0.015 seconds for 251V and 2.51 A respectively.

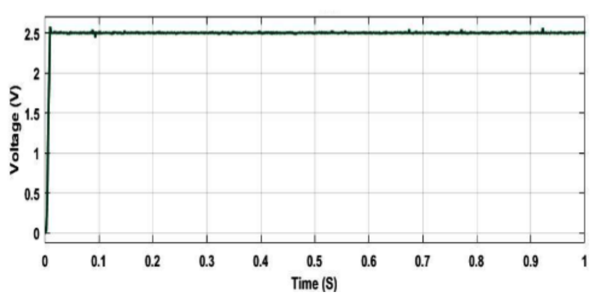

***Fig.12 (b)** Output Current of Closed Loop SEPIC Converter*

3.1 Simulink Model for Zeta Converter

The Simulated model of Zeta converter is revealed in fig.13.

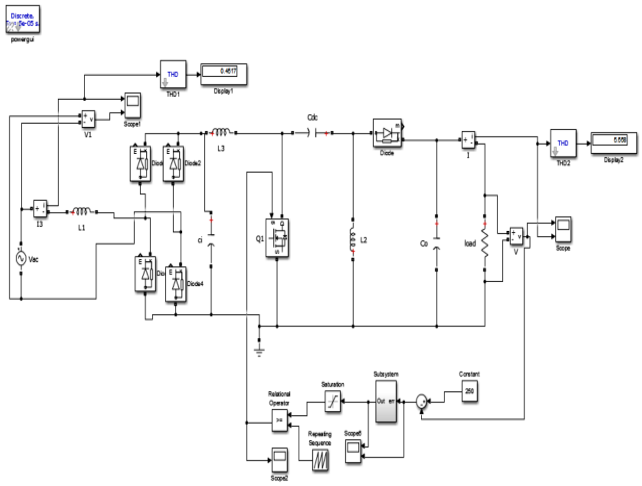

Fig.13. *Simulink System for Zeta Converter*

The output voltage and current waveform for open loop operation for Zeta is specified in fig.14 (a) and fig.14 (b) correspondingly.

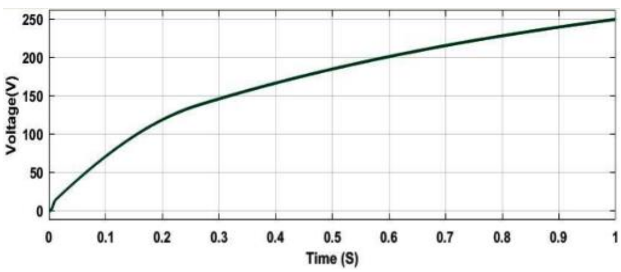

Fig. 14(a) *Output Voltage of Zeta Converter in Open Loop*

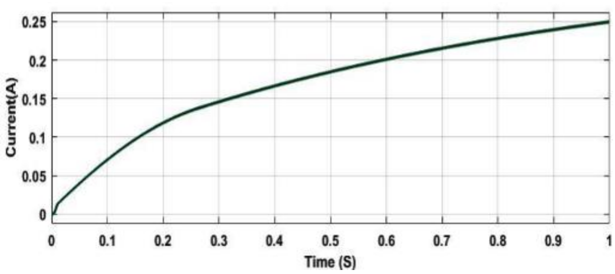

Fig. 14(b) *Output Current of Open Loop Zeta Converter*

The output waveform for Voltage and current of closed loop Zeta show n by means of fig.15 (a) and fig.15 (b) correspondingly.

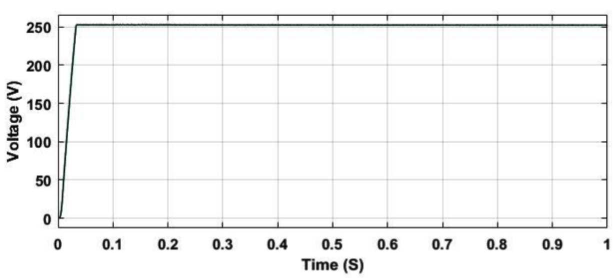

Fig.15 (a) *Closed Loop Output Voltage for Zeta Converter*

By implementing control system for error voltage with PI Control provides a feedback control that enhances the performance of Zeta converter.

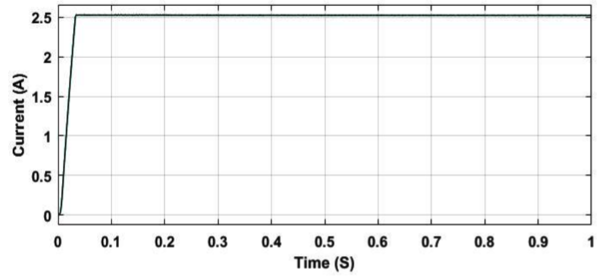

Fig.15 (b) *Closed Loop Output Current for Zeta Converter*

As in the fig.15 (a) and fig.15 (b), an output voltage and current reaches the stability at 0.03 seconds. The respected waveforms depict the values of output voltage and current are 250V and 2.5A respectively. The closed loop operation has an accuracy and reliability for desired outcomes of system results. The closed loop control operation is achieved by employing voltage follower approach with PI control.
The parameter selection for designing SEPIC and Zeta converter are given in table 1.

TABLE 1

CONVERTERS AND PARAMETERS

Parameters	SEPIC	Zeta
Vs	220 V	220 V
L1	3.6mH	2.463 mH
L2	5.43mH	60 µH
C1	1.38 µF	330nF
Cd	731 nF	2500 µF
fs	60 kHz	45 kHz

Where,
Vs - Supply Voltage
L1 - Input Inductor
L2 - Output Inductor
C1 - Input Capacitor
Cd - Output Capacitor
fs - Switching Frequency

The concludable summarized comparative result analysis is shown in table. 2

TABLE 2

COMPARATIVE RESULTS OF CONVERTERS

Converters	SEPIC	Zeta

Settling Time (Sec)	0.015	0.034
Voltage (V)	251.1	245.7
Current (A)	2.511	2.457
THD (%)	0.4386	0.7256
Output Ripples (%)	8.183	3.935
Efficiency (%)	82.63	77.15

4 CONCLUSION

Based on the analysis by simulations both SEPIC and Zeta converters can be used as converter for power quality improvement for the system. Both the converters are designed and simulated in MATLAB software in DCM to investigate their behavior in open loop and closed loop operation by employing voltage follower approach. The paper concludes the advantages of the Zeta converter over SEPIC that include the lower output-voltage ripple and easier compensation. While on the other side the SEPIC is having lesser THD by 39.55% to that of Zeta converter along with lower settling time as compared to Zeta Converter. The simulated results conceal the enhanced performance for Zeta and SEPIC converters that decreases the THD at AC input mains to attain the power quality improvement.

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