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Transient Modelling and Analysis of Advanced Inverter Model

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ABSTRACT

The usage of active switches in the chopper circuit have lead to switching losses which in turn produces harmonics in the output waveform hence the concept of Quasi-Impedance Source Inverter have been introduced. The efficiency and voltage gain of the Q-ZSI are limited and comparable with the conventional system of a voltage source inverter with the auxiliary step-up DC/DC converter in the input stage. Hence we introduce the concept of extending the Q-ZSI gain without increasing the number of active switches commonly referred to as the Extended boost Q-ZSI and could be generally implemented as capacitor assisted Q-ZSI. In this paper different extended boost Q-ZSIs with continuous input current will be presented, analyzed and compared.

Key words: Q-ZSI, voltage dc-dc booster, Advanced Inverter, PWM based inverter control.

INTRODUCTION

More efforts are now being put into distributed power generation of renewable energy sources (RESs), such as photovoltaic (PV), wind power, and fuel cells, which are sustainable and environmental friendly. Practically, several distributed generations (DGs) consist of distributed power grid and further construct micro grid with local loads and managements. To ensure proper performance of the micro grid, DG is usually required to work in two modes: stand-alone or grid connected. As an interface between RES and distributed power grid, the performance of power electronic converters becomes critical.

Z-source inverter (ZSI) is known as a single-stage buck/boost inverter. With an impedance network coupling the inverter main circuit to the dc source, the ZSI achieves voltage buck/boost in one stage, without introducing more switching devices. Shoot-through state enables energy to be stored in current for PV application. inductors, which is released when at non-shoot through state, followed by the voltage boost feature [1]. For the voltage – fed type ZSI (abbreviated as ZSI), voltage boost methods based on pulse width modulation (PWM) have been first investigated as simple boost control, maximum boost control, and maximum constant boost control. Because of its single-stage voltage buck/boost properties, the ZSI can deal with input voltage fluctuation in a wide range, which is conventionally achieved by a two-stage dc–dc converter cascaded by dc–ac structure.

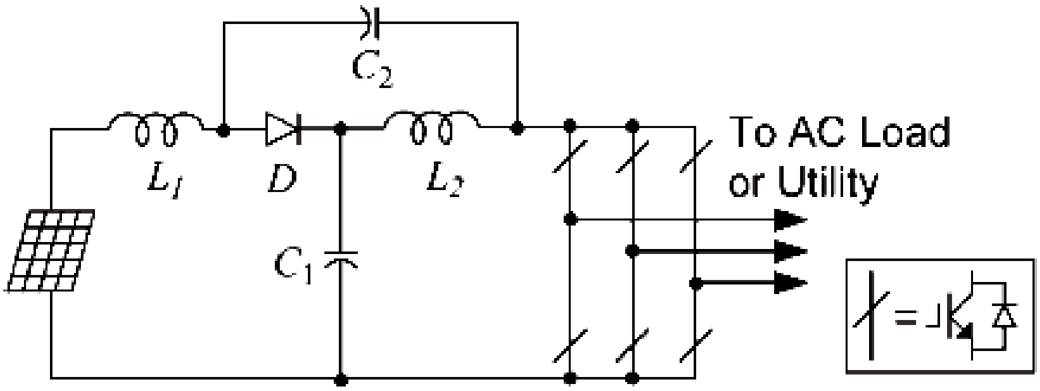

Fig. 1 Basic diagram of qZSI

Purpose
Quasi-Z-source inverter (qZSI) is a new promising power conversion technology perfectly suitable for interfacing of renewable (i. e., photovoltaic, wind turbines) and alternative (i. e., fuel cells) energy sources. The qZSI has the following advantages:
 Boost-buck function by the one-stage conversion
 Continuous input current
 Excellent reliability due to the shoot-through with standing capability
 Low in-rush current during start up.

It should be noted here that this paper provides a general coverage of the extended boost voltage-fed qZSIs with continuous input current. It means that during the continuous conduction mode (CCM) the input current of the converter never drops to zero[9].

Outline
The reminder of this paper is structured as follows. Section II presents an overview of the main characteristics of extended boost qZSI. . Section III presents the modeling analysis of circuit. Section IV says about experimental and simulation results. While Section V describes the applications details of the extended boost qZSI. Finally, Section VI is concludes the paper[9].

EXTENDED BOOST QZSI – BASIC TOPOLOGY

However, the efficiency and voltage gain of the qZSI are limited and comparable with the conventional system of a voltage source inverter with the auxiliary step-up DC/DC converter in the input stage. The concept of extending the qZSI gain without increasing the number of active switches was recently proposed by several authors. These new converter topologies are commonly referred to as the extended boost qZSI or cascaded qZSI could be generally given as capacitor assisted topology.

Fundamentals Of qZSI

With a set of new topologies of the impedance networks, a class of quasi-Z-source inverter (qZSI) has been derived from the original ZSI and applied to DG applications. A voltage-fed qZSI was proposed in for PV applications because of continuous input current and reduced passive component (capacitor) rating—capacitor voltage on C2 is much less than that on C1 during operating and this feature leads to lower manufacture cost. This paper further investigates the detailed modeling and control issues of the qZSI to be applied in DG applications. The dynamic model of the asymmetric quasi-Z-source network is constructed by small-signal analysis. System characteristics are carefully investigated in terms of component parameter and system operating condition. Based on the dynamic model, a two-stage control method is proposed with detailed design concerns. Constant capacitor voltage is maintained to avoid the overlap ofd0 and M throughout the whole operating condition. With the proposed control strategy, qZSI shows promising application future to couple the RES that features a wide voltage variable range to a distributed power grid.

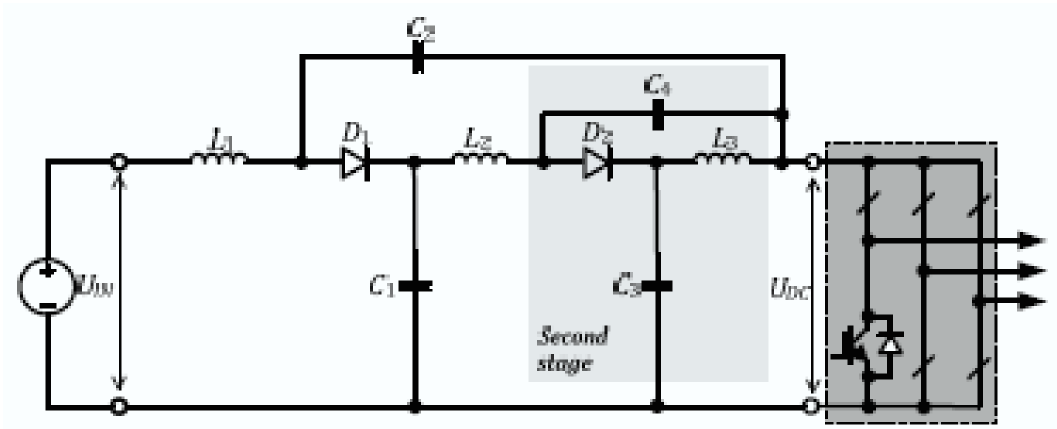

Fig. 2 Capacitor assisted extended boost qZSI topology

Specification of CAEB qZSI

The investigated topology is presented in Fig. 2. The basic topology of a capacitor assisted extended boost qZSI could be derived by the adding of one diode (D2), one inductor (L3) and two capacitors (C3and C4) to the traditional qZSI with continuous input current. The modified topology of a capacitor assisted extended boost qZSI

(CAEB qZSI) could be derived from the CAEB qZSI simply by the changing of the connection points of capacitors C2 and C3, as shown.

MODELING AND ANALYSIS OF CAEB qZSI

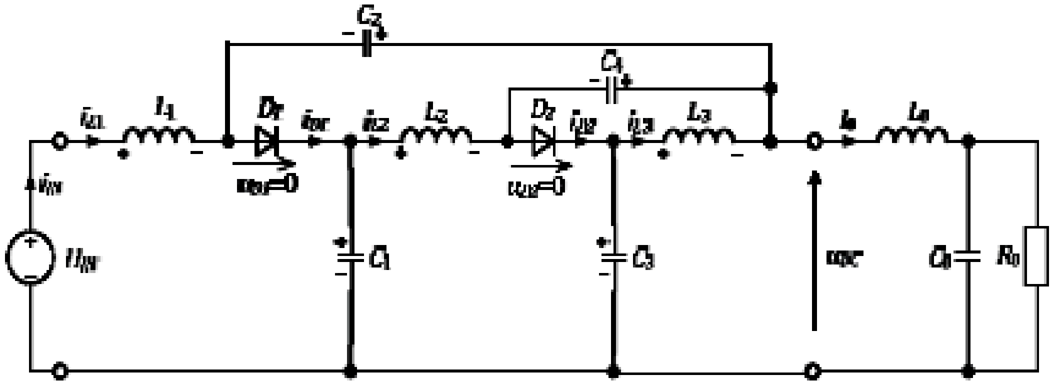

Fig. 3. Simplified power circuit of the extended boost qZSI used in the analysis

Generally, the topologies shown in Fig. 3 could be represented by the PWM inverter coupled with the cascaded qZS-network. In the same manner as the traditional qZSI, the extended boost qZSI has two types of operational states at the DC side: the non-shoot-through states (i. e., the six active states and two conventional zero states of the traditional three-phase voltage source inverter(VSI)) and the shoot-through state (i. e., both switches in atleast one phase conduct simultaneously). To simplify our analysis the inverter bridge was replaced by a switch S (Fig. 3). When the switch S is closed, the shoot-through state occurs and the converter performs the voltage boost action. When the switch S is open, the active (non-shoot through) state emerges and previously stored magnetic energy in turn provides the boost of voltage seen on the load terminals.

In order to verify theoretical assumptions the laboratory setups corresponding to the investigated topology was assembled. 600 V/200 A IGBT with extra low saturation voltage was selected for S (see Fig. 4 for the details). Components used in the qZS-networks had the following properties:

L1…L3 = 65 µH, type: toroidal inductors;
C1, C3 = 470 µF, type: polypropylene capacitors;
C2, C4= 1000 µF, type: polypropylene capacitors;
D1…D3 = PN Diodes

In the first experiment, main operating waveforms of the proposed topology was acquired and compared. The shoot-through duty cycle was set at 0. 167. Due to the losses in the components of the qZS network the capacitor assisted topology could provide only a 90% of a theoretically predicted input voltage (DC link voltage is 54V instead of 60V when the input is 30V DC). Due to the input inductor L1 all the proposed topology feature the continuous input current in the CCM, as predicted in the analysis.

EXPERIMENTS AND RESULTS

There are many topologies related to this qZSI networks were proposed and presented. But the advanced concept extended boost qZSI had been simulated using pSIM and Proteus softwares, analyzed using hardware setup. In this paper, the proposed structure has been tested.

Simulation using pSIM software

pSIM is one of the simulink software which is used to simulate the electrical and electronics circuit with easy way of using. It is reliable one in order to get the overall idea about the concept. A simulation diagram is shown in Fig. 4.

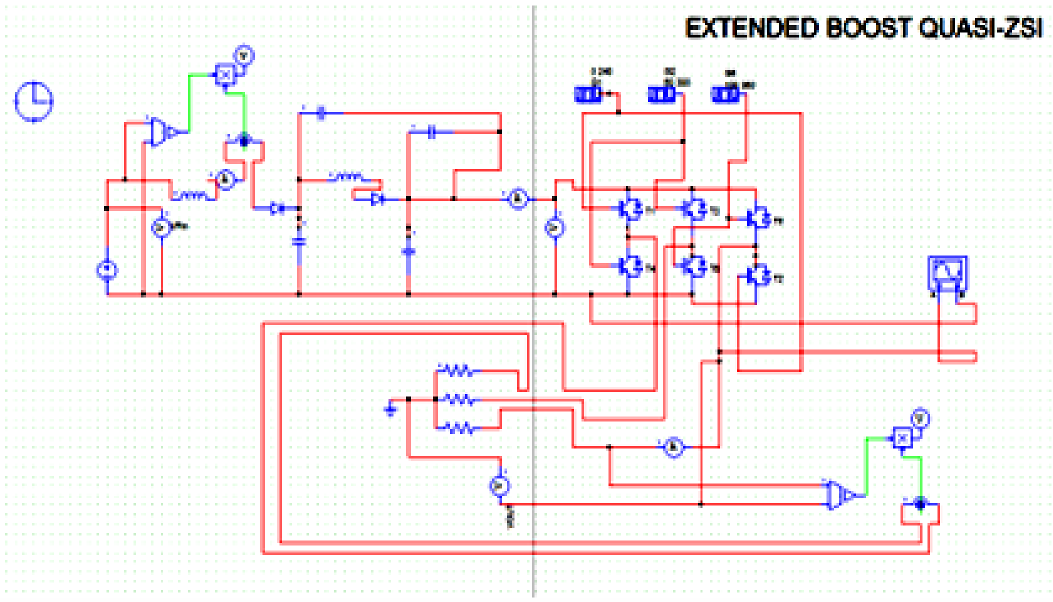

Fig. 4. A screen shot of simulation diagram using pSIM simulink software

Results in pSIM

In pSIM software the resultant waveforms can be determined by using simulate icon. Fig. 5 represents waveform of voltage which involves input voltage of DC part, output voltage of DC boosted part and output voltage of inverter circuit. Whenever the constant DC supply is given to DC boosting part it boosted that input value as two times and fed it into the input of inverter circuit. It further just converts the DC into AC.

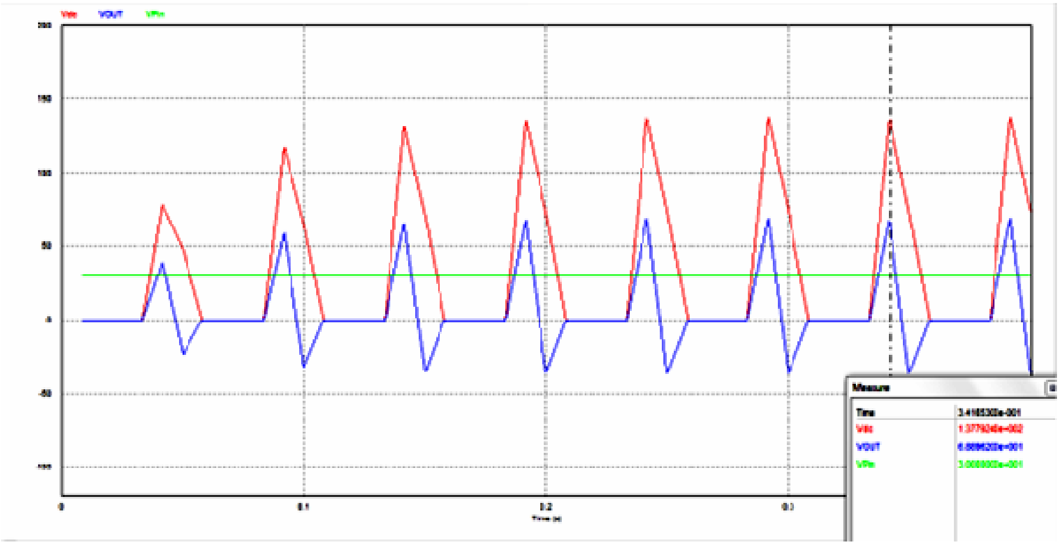

Fig. 5. represents the simulation waveform of voltage

In this project Fig. 5 indicates the tested input DC voltage is 30V. It is further converted onto 61. 24V DC at the end of DC boosting circuit. And we could get the exact value of DC output voltage from the AC inverter part but in sinusoidal in nature.

As we said before in order to provide a reliable operation of inverter the output current should be constant one which is shown in Fig. 6. This can be vary according to the duty cycle. his could be implemented by using PWM techniques. But whatever may be duty ratio, the output the DC boosted circuit gives continuous DC current. For this 30V DC input the source current is boosted up to 8. 45A.

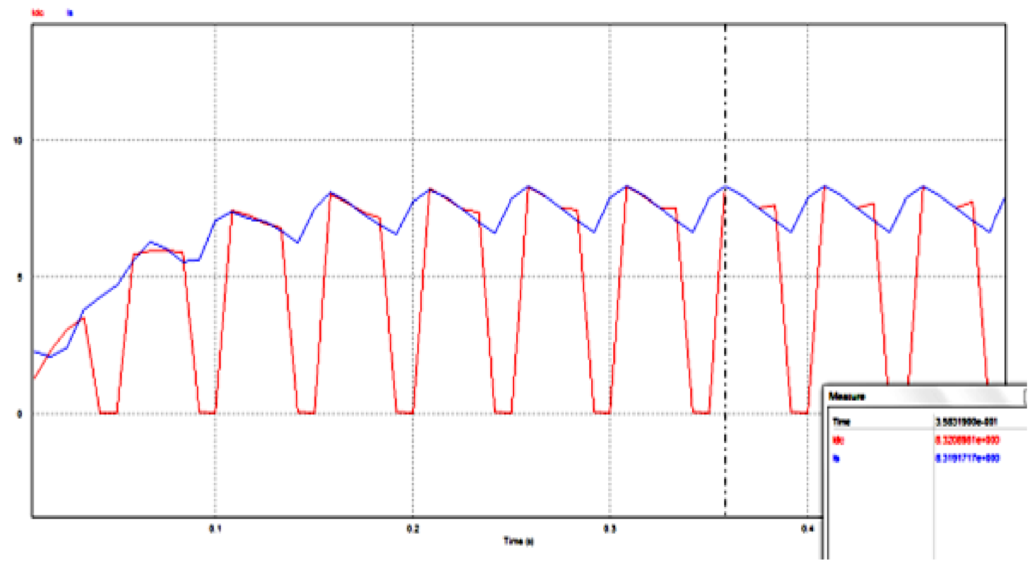

Fig. 6. represents simulation waveform of DC output current and source current

The output AC current is not purely sinusoidal in nature. It is depends upon the load mainly. In this simulation we gave load of 3 phase star connected resistive load which has the range of 12KΩ. This was indicated in Fig. 7. Here the output AC current is 67. 35 mA as we expected.

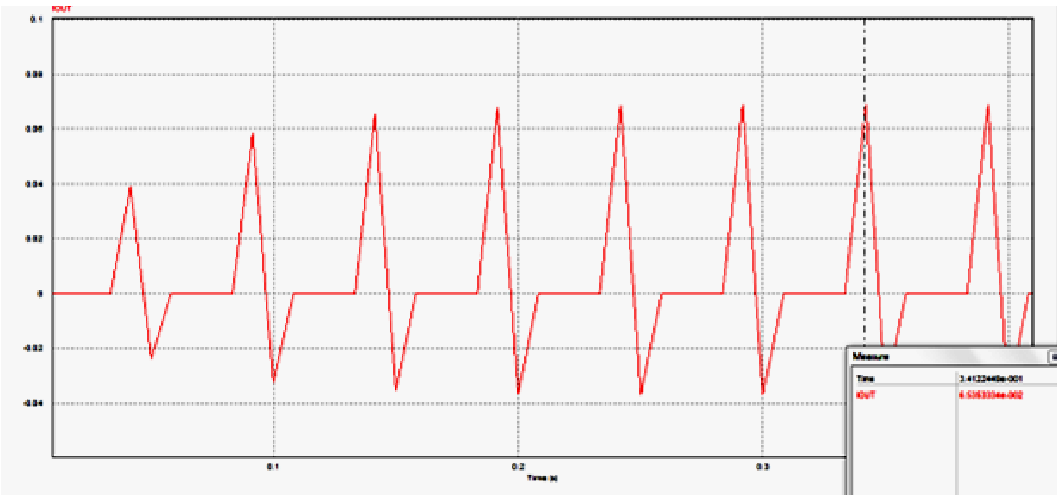

Fig. 7. Represents simulation waveform of AC output current

Simulation using Proteus software

Proteus is software for microprocessor simulation, schematic capture, and printed circuit board (PCB) design. It is a tool for entering the designs. says the overall design of Extended boosted Capacitor assisted qZSI circuit which has the interfacing with pic micro controller. That is PIC16F877A PIC micro controller is used to provide proper gate signals according to the PWM signals. Here we are using the drivers in order to provide a precise gating pulses for the switches.

In Proteus software the input is given as 7. 5V DC (test voltage). This was given by a constant voltage source. This voltage is given to the DC boosting circuit which has the capable of deliver the constant output DC voltage of 14. 76V with minimum distortion and harmonics. This was shown in the

In order to get a clear view, a single phase AC output voltage is shown in Fig. 9. It has the maximum peak voltage of 14. 71V AC. It is further can be used for any 3 phase or any single phase load (Fig. 9).

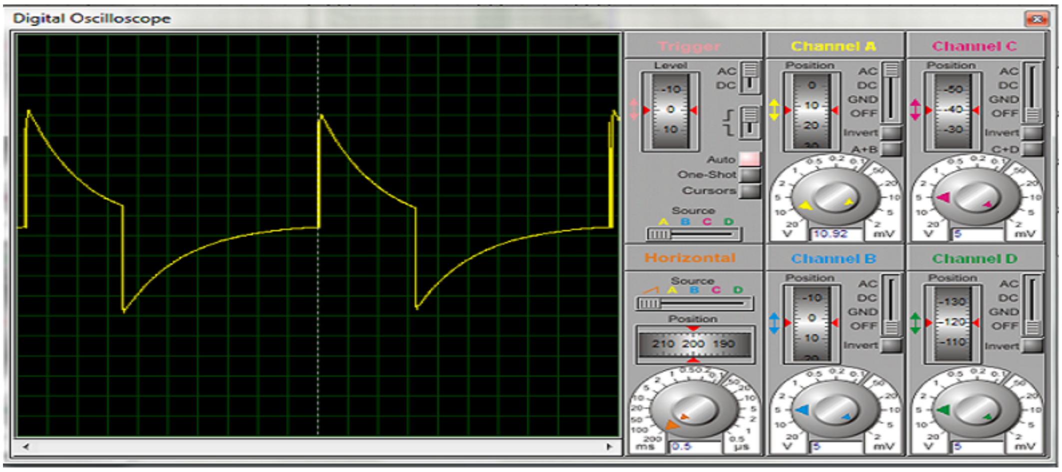

Fig. 9. Represents the simulation waveform of single phase AC output voltage without PWM

With the help of PWM technique we can vary the duty cycle according to the feedback from load side. If the load is a motor then feedback will be get back by some kind of speed sensors. For that purpose PWM pulses can be generated to the driver circuit (IR2101). These pulses can be generated by PIC16F877A micro controller by programming. So that we introduce the current and voltage sensors to measure the output current and we used one LCD display to displaying the corresponding voltage and current readings.

APPLICATIONS

The qZSI model can be used in places where the scarcity of sources like wind, solar etc.,

There are other applications like solar powered satellites, turbines attached railway systems, power generation techniques in liquid flow pipes, in automobile and industrial applications.

CONCLUSION

In this paper extended boost qZSI topology was proposed, discussed and compared with standard qZSI model. A steady state analysis of topology operating in the continuous conduction mode was performed. Theoretical study was validated by the simulations and experiments. It was experimentally stated that in similar operating conditions the discussed topology provide an identical boost factor of the input voltage within the shoot-through duty cycle range of 0…0. 15. Thanks to the presence of the input inductor L1 all the discussed extended boost qZSIs have continuous input current in the CCM, thus featuring the reduced stress of the input voltage source.

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