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REVIEW ON CASCADED QUASI-Z-SOURCE NETWORK

Aryasree G

AP, Electrical and Electronics Engineering Department, VJCET, Vazhakulam

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Abstract - This paper presents a cascaded quasi-Z-source converter that is suitable as a power conditioning unit, to interconnect low dc voltage producing fuel cells or solar panels to residential loads. The proposed converter have reduced energy loss, reduced shoot through duty cycle and reduced component values as compared to traditional single stage qZS converter. The comparison of single stage and cascaded stage qZS converter is given in this paper with same input/output conditions. A closed loop control scheme is also used for the comparison. The entire system is simulated in Matlab/Simulink. The simulation results were presented and analyzed. Based on the results which showed the effectiveness of the proposed cascaded quasi-Z-source inverter some applications are discussed.

Keywords: Quasi-Z-Source, Voltage Source Inverter, Z Source Inverter

I. INTRODUCTION

Due to environmental demands , the renewable energy systems are the one that will become wide spread in future. As a result of dispersed nature of the renewable energy systems, the electric power will have distributed generation. Distributed power is a concept that covers a wide scheme used for the local electric power generation from renewable and non-renewable sources of energy in an environmentally responsible way. The schemes are mainly based on wind energy , solar energy and fuel cells .A Fuel Cell (FC) is the most efficient modern approach to distributed power generation. The efficiency of conversion could be as high as 65%-70%.The interconnection of FC to residential load demand a special voltage matching converter [1] .

When fully implemented, this can provide a high quality, reliable, cheap electric power. It offers savings in cost for the reduction of the losses. The renewable sources when compared to hydro and nuclear power plant require a power conditioning when connected to the domestic loads .Traditional VSI s which is used for power conditioning have the disadvantage that it always bucks the output voltage and due to this demerit its operation are limited to low voltage . To prevent this a ZSI can be employed which again cause disadvantage of the discontinuous input current .So the qZSI is proposed which make high voltage operation possible and also makes the current continous.

Quasi-Z-Source inverter is a LC network which will boost the input voltage. It have two modes of operation that is the normal mode and the shoot-through mode .In the normal mode the network act as a normal inverter and in the shoot-through mode it will act as a short circuit which cannot be employed in the VSI . In the shoot-through mode the inductors will save energy as short circuit carry high current in the circuit .This stored energy is delivered to the output load in the normal inverter operation [2].

It is advisable to decrease the time for which the shoot-through mode comes into picture as energy loss can be prevented. Also with the increase in the number of inductor which acts as an energy storage medium the higher energy can be delivered to load that collected in the short time of the shoot through mode . So the proposal of a cascaded qZS converter will be an efficient method for obtaining the above said merit .For that a cascaded converter is designed with same legal values of the single stage and simulation model of the circuits of single and cascaded is tried with same input/output values and results obtained are discussed.

II. QUASI-Z-SOURCE DC/DC CONVERTER

The qZS converter consists of a qZS network, an inverter, an isolation transformer and voltage doubler rectifier. The circuit diagram of the qZS converter is shown in Figure 1.

The qZS converter can be used as a matching converter for interconnecting low voltage producing renewable energy sources to domestic loads.

Here two modes of operation are there .The normal mode operation and the shoot-through mode operation. The total time duration can be split into shoot-through and non-shoot through time. So the shoot through duty cycle will come into picture which is the ratio of shoot through time period and the total time period. The circuit analysis of qZS is described in the previous papers from which we can find the advantages lower stress or capacitor rating of C_2, continous input current ,reduction in EMI problems as the circuit have common dc rail between source and load .

The main features of the qZS converter is that it can compensate the input voltage variations by providing the boost and buck functions in a single stage. In the qZS inverter, the shoot-through states are used to boost the magnetic energy stored in the dc-side inductors L1 and L2 without short circuiting the dc capacitors C1 and C2. This increase in magnetic energy, in turn, provides the boost of the voltage seen on the inverter output during traditional operating states. If the input voltage is high enough, the shoot-through states are eliminated, and the qZS inverter begins to operate as a traditional VSI [3].

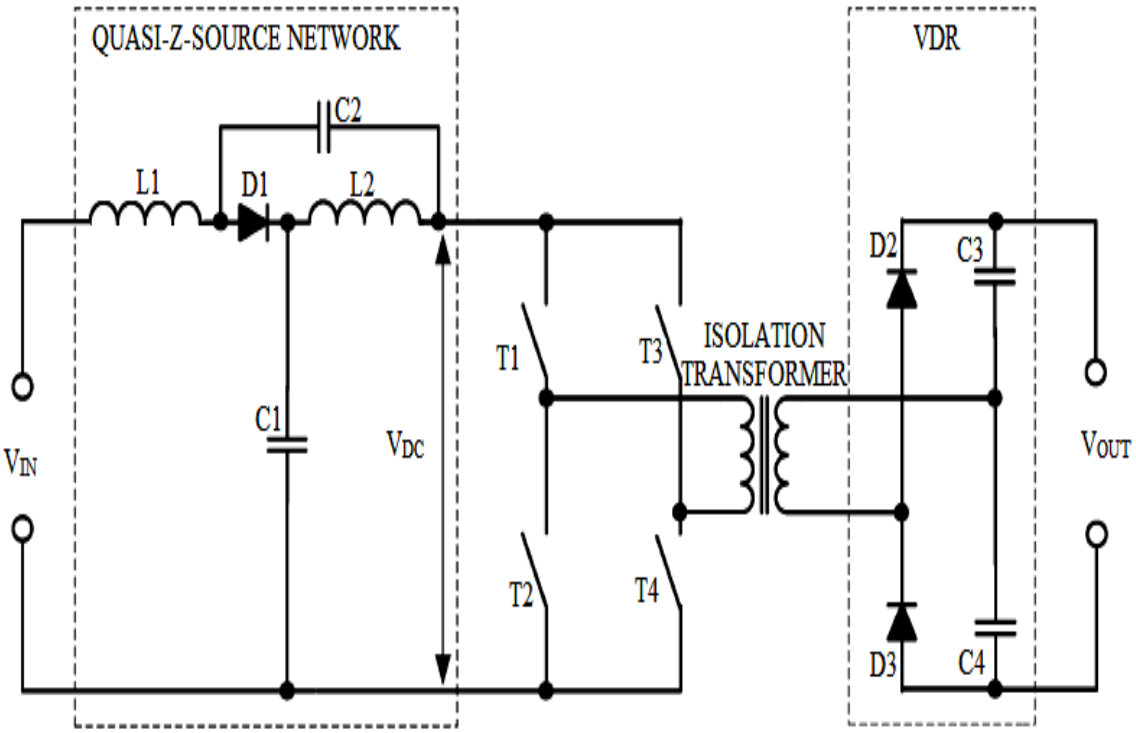

Fig. 1. Quasi-Z-Source DC/DC converter

III. PROPOSED CASCADED QUASI-Z-SOURCE CONVERTER

The qZS converter circuit can be improved by the introduction of a cascaded qZS network. The cascaded (two-stage) qZS network is derived by the adding of one diode (D2), one inductor (L3), and two capacitors (C3 and C4) to the traditional qZS inverter. The circuit diagram of the cascaded qZS inverter is shown in Figure 2.The proposed cascaded qZS converter also have the same working ways of the traditional qZS converter. But it can reduce the component values of the capacitor and inductor and also can minimise the shoot-through duty cycle thereby minimizing the energy loss in the shoot-through time. The mathematical equations will be in the same way as that of the single stage qZS converter that are discussed in previous paper [3]. Due to the decreased shoot-through duty cycle that can obtained in the cascaded circuit, the values of the inductors and capacitors of the cascaded qZS network could also be decreased. On the other hand, for the same component ratings and voltage and current stresses, the qZS coverter with the proposed cascaded qZS network will ensure a higher voltage boost factor than with traditional solutions. Because of its higher boost factor the cascaded qZS inverter can be used for the interconnection of low voltage producing renewable energy sources to the grid, solar water pumping system etc.. The proposed converter can be used for for a solar pump system and also for the interconnection of the renewable energy sources to the grid.

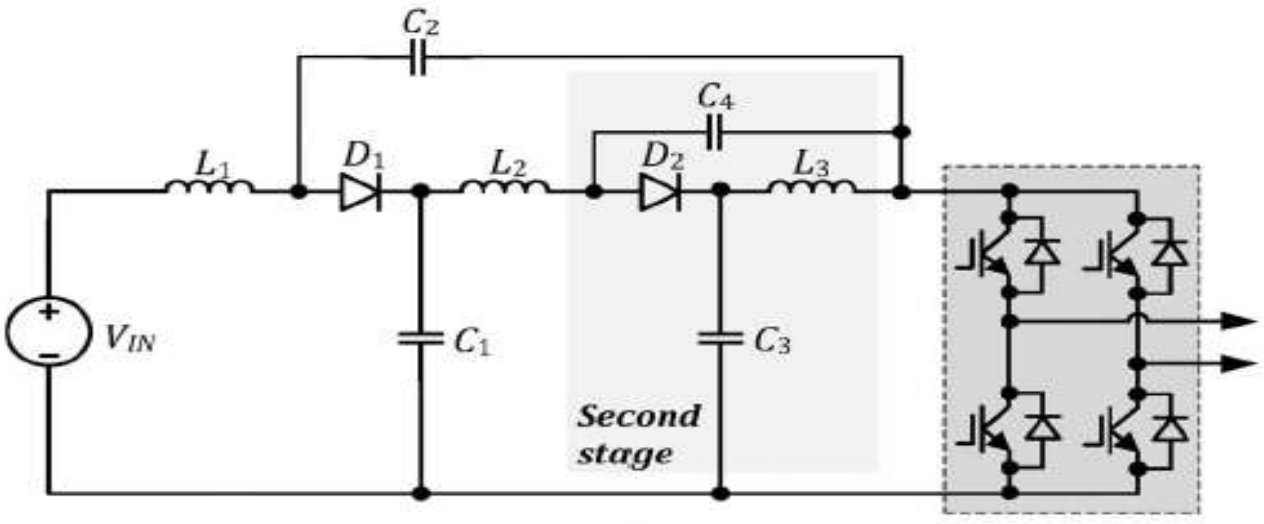

Fig. 2. Cascaded Quasi-Z-Source coverter

The proposed converter can use the logic that derived from the control principle of single phase qZS converter .The switching states means the one in which one switch in the leg conduct and in the shoot through mode the two switch in the same leg conduct .To generate this shoot through state two reference signals $_{Up}$ and $_{Un}$ can be used .If the triangular waveform is greater than $_{Up}$ or lower than $_{Un}$ the shoot through state will be in the picture .So for this logic we have to develop a control scheme using gates . The active states are controlled by two pulse generator phase shifted by 180^{o} . NOT gates are used in between to prevent the simultaneous conduction of the two switch in same leg .The shoot through states are produced by triangular wave generator ,two comparators and reference signal .The operating graph is given in Figure 3 . The control circuit based on the operating graph for obtaining the normal mode and shoor-through mode is given in Figure 4 .

The PWM1 and PWM2 are the two phase generators that are phase shifted by 180^{o} . NOT gate is provided to prevent the simultaneous conduction . These input are given to the four switches T1 , T2 , T3 , T4 . Thus a normal inverter mode can be made by means of these logic .The shoot through mode can be obtained by the comparison of the triangular wave G with the positive and reference signal $_{Up}$ and $_{Un}$. Whenever the triangular wave go above the positive reference signal $_{Up}$ and go below the negative reference signal $_{Un}$ it will enter the shoot through mode . Entering the shoot through mode means it have to develop a shortcircuit . It means the two switches in same leg conduct simultaneously .For that the triangular wave generator , reference signals $_{Up}$ and $_{Un}$ and comparators are used and by means an OR gate the pulse signal are given to the four switches .

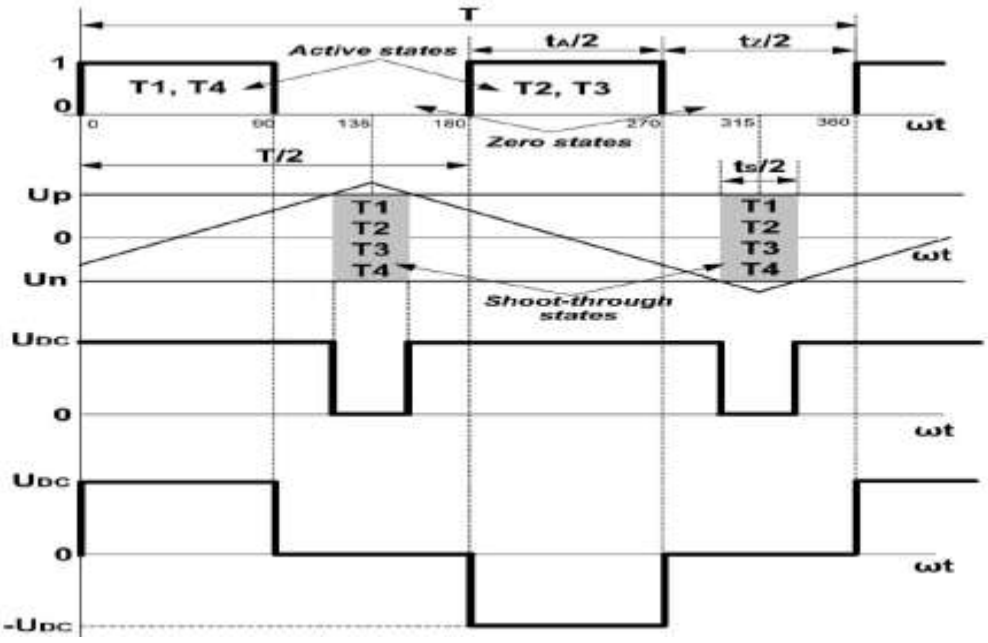

Fig. 3. Operating graph of the proposed converter

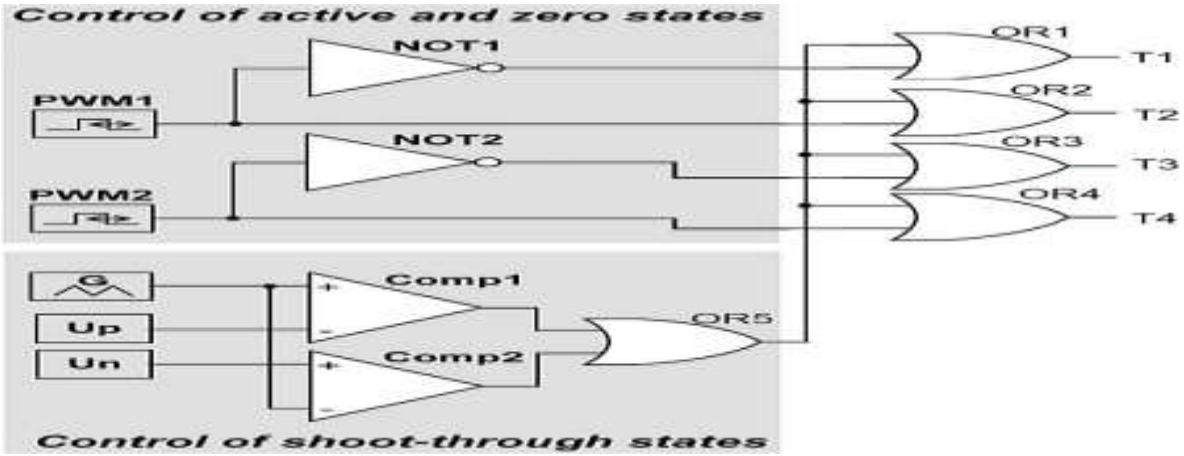

Fig. 4. Control circuit for the proposed inverter

IV. APPLICATIONS

The simulation results will prove that proposed converter is the one that have a better reliability. Based on the above concept two applications are suggested .One is a solar water pumping system and other is the connection of PV renewable energy connection to a micro grid .The schematic figure of solar water pumping system using cascaded qZS converter is given in Figure 5 .The control circuit for grid connection is given in Figure 6.

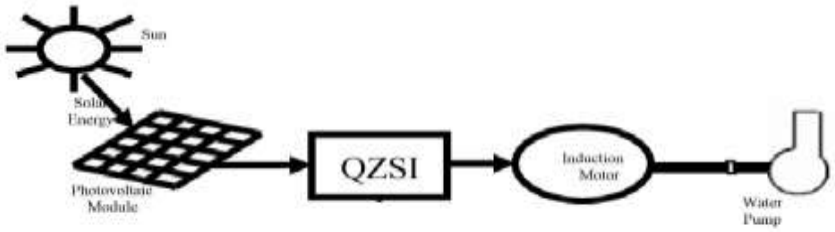

Fig. 5. Schematic figure of solar water pumping model using cascaded qZSI

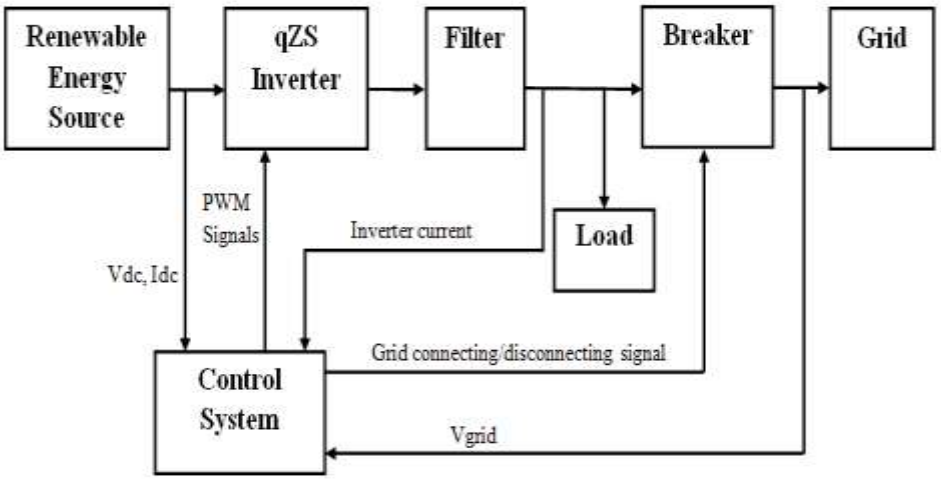

Fig. 6. Grid connected qZS converter

V. CONCLUSION

A cascaded quasi-z-source network based inverter is proposed in this paper. The proposed inverter shows a reduction in shoot-through duty cycle when compared with the traditional single stage quasi-z-source inverter. The proposed cascaded qZS inverters shoot-through duty cycle was reduced by 46%, when compared with the traditional single stage qZS inverter. The proposed converter can be used in solar water pumping system and in grid connected PV cell circuit.

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