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A New Cascaded Quasi-Z Source Based Single Phase Seven Level Inverter

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Abstract—**This paper presents a new quasi-z source based single phase seven level inverter for residential applications. This topology interfaces two separate quasi-z source DC-DC (qZs) networks between DC source and multilevel inverter with reduced switches. This topology uses two different controllers for qZs networks and seven level inverter to regulate both AC and DC bus voltages under input voltage disturbances, reference DC link voltage variations and dynamic load variation with enhanced reliability and power density. One cycle control method(OCC) is used for the control of peak DC link voltage in qZs networks and Multi-carrier SPWM technique for seven level output voltage generation. The performance of the proposed topology is developed in MATLAB/Simulink environment and the results are presented for different loads.**

Keywords—Quasi-Z source DC-DC network, One cycle control, pulse width modulation.

I. INTRODUCTION

Z-source inverter has emerged as a new research area in the power electronics field, ever since it was proposed by F.Z.Peng in 2002. Z- source inverter overcomes the limitations of conventional voltage source and current source inverters and provide an efficient means of all possible types of power conversion (dc-ac, dc-ac, ac-dc, ac-ac) [1]. Over the years, a lot of research has been done in terms of topology, shoot through control techniques and control of peak DC link voltage to cater the needs of various applications [2].

The DC-link voltage of a Z-source network is pulsating in nature due to the shoot through states. Therefore, direct measurement of DC link voltage requires additional special circuitry, increasing the cost and complexity of control. Indirect measurement of DC link voltage is done by sensing both the capacitor voltages and input voltages. However, due to the non-linear relationship between capacitor voltage and shoot through duty ratio, the control becomes difficult. One cycle control method can be used, which offers simple control of DC link voltage and capacitor voltages by average control of the switched variable and also rejects the power perturbations[3].

Quasi-Z source inverters enables single-stage power conversion with buck-boost capability reduced passive component ratings and continuous input current which makes them suitable for renewable energy systems [4]. Multilevel inverters offer the possibility to handle larger supply or load voltages that are much higher than the components voltages. It can also improve the compromise between switching losses and reduction of lower harmonics. It enables better quality output voltage and output current, reduces switching losses and dv/dt stress. Incorporation of multilevel approach with quasi-z source concept leads to better results in renewable energy systems where enhanced reliability is required.

Quasi–Z source based multilevel inverter topology for DC-AC power conversion has attracted a lot of interest due to its obvious advantages of voltage bucking and boosting capability, high gain when compared to the conventional multilevel inverter (MLI) topologies. Quasi-Z source cascade multilevel inverter (qZS-CMI) was presented in [5] for PV based distributed generation. However it requires more number of active switches and passive components for seven level operation which increases the system size and cost. A three-level neutral-point clamped quasi-Z- source inverter is presented in [6] which combines the properties of both quasi Z-Source Inverter and three level NPC VSI topologies with advantages of reduced voltage stress across switches, short circuit withstandability, single stage buck-boost power conversion and low THD of output voltage and current. A novel MLI topology is presented in [7], which is capable of obtaining all possible algebraic combinations from given input DC sources. It requires less device count when compared with cascaded H-Bridge topology. A special modulation technique based on Multi carrier SPWM is also being presented to optimize the switching frequencies with respect to the voltage stress of the switches.

Therefore, in this paper, a new Quasi-Z source based single phase seven level inverter is presented for residential applications. Here two quasi-z-source networks are cascaded through seven level inverter with reduced switches compared to conventional cascaded H-bridge inverter. Two control schemes are used to regulate the qZs DC-DC network and inverter output voltage as per the desired values. The detailed

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operation and performance of the proposed topology is evaluated in MATLAB/Simulink environment and the results are presented for different loads.

II. Proposed Topology

Fig. 1 shows the schematic arrangement of the proposed topology with two qZs networks interfaced with the seven-level inverter for residential applications and capable of supplying DC and AC loads. The seven-level inverter requires binary source arrangement (ratio of the magnitude of the two DC sources is ½) to synthesize the 7-level output voltage waveform. The different modes of operation of the seven level inverter along with the Multi carrier Sinusoidal Pulse width modulation switching scheme is presented in [8].

In this topology, there are two quasi-Z source DC-DC (qZs) networks, fed by two DC sources of V and 2V voltages either from Photovoltaic or Fuel cell, typically in the range of 48 V or even higher values and are capable of realizing the required input DC voltages (binary source configuration) for the seven level inverter based on the load demand.

Each qZs network consists of two switches Si and Sii (i=1, 2). When the qZs network operates in buck operation mode, Switch Si conducts and Sii does not conduct. When the qZs network operates in boost operation mode, both the switches Si and Sii conducts. Switch Sii is used for realizing the boost operation by controlling the shoot through duty cycle. The filtering components Lfi, Cfi (i=1, 2) enables constant DC to be fed to the seven level inverter. In this topology, reliability is improved due to independent DC link voltage control across the qZs networks based on the application.

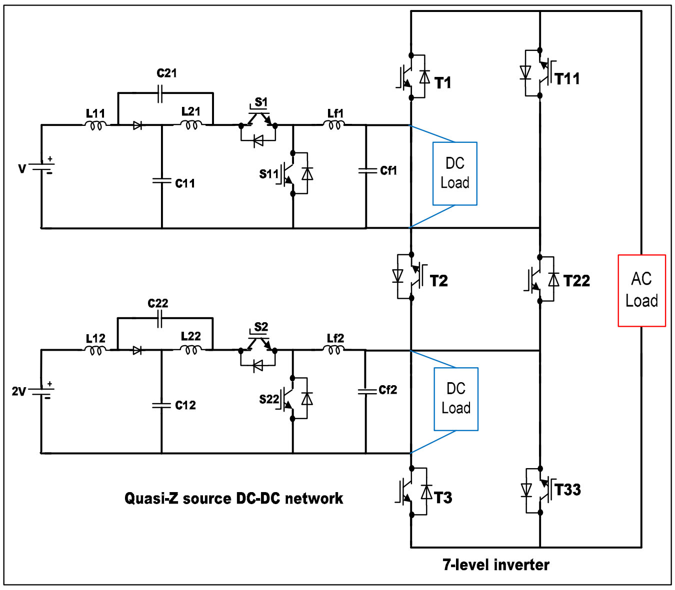


Fig. 1. Proposed Topology.

III. Switching Scheme

Fig. 2 shows a schematic diagram for the qZs network along with One cycle control method (OCC)[9],[10]. Therefore, two control loops are required for each qZs network for its gating with same control logic and only difference in parameter values. The DC link voltage (Vdclink) and diode voltage (Vdiode) are switched variables (pulsating dc) and are complementary to each other. In OCC, the average value of the switched variables are used as control variables for tracking the reference DC link voltage Vref variations and input disturbances within one switching cycle.

The reference DC link voltage Vref is varied in the form of a step signal with transition at 0.5 sec, keeping the input voltage Vin constant. The reference DC link voltage variation is such that the qZs network operation changes from buck mode to boost mode. The control achieves instantaneous tracking of the reference DC link voltage variations and input voltage disturbances simultaneously by changes in duty cycle of the switches Si and Sii (i=1, 2).

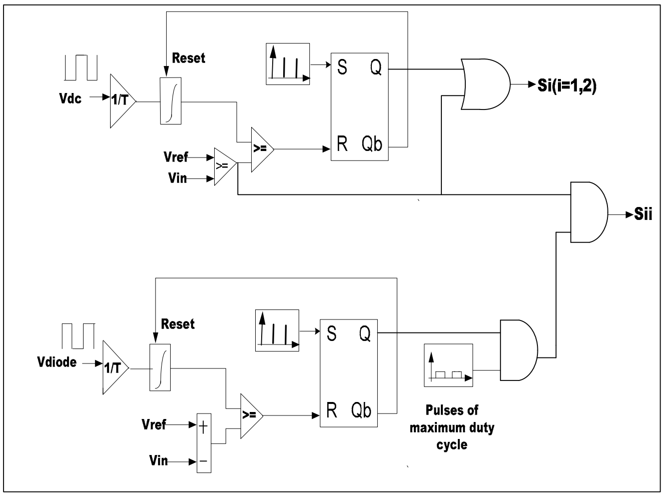


Fig. 2.One cycle control.

IV. Simulation Results

The proposed quasi-z-source based seven level inverter is simulated in Matlab/Simulink environment and the model is tested for different loads of 500 W DC load and 1 KVA AC load (RL load). The parameters and the specifications considered for the simulation is given in Table I. Simulation is performed for a DC link voltage variation from 40V to 140V in qZS1 and 80V to 240V in qZS2 at 0.5 sec in order to validate the one cycle control method. The qZs network changes its operation from buck to boost operation mode at 0.5 sec. The controller takes a maximum of one switching cycle to attain steady state under DC link voltage variation as seen in Fig. 3 which depicts the load voltage across the DC load. It can also achieve instantaneous fast dynamic response under input disturbances and load variation. The model is tested for a maximum DC load of 500W.

TABLE I. SPECIFICATIONS OF THE PARAMETERS

Parameters	Values
DC voltage (V)	50 V
Inductor L1i,L2i (1=1,2)	0.5mH
Capacitor C1i,C2i (i=1,2)	1000 μF
Filter Inductor Lfi (i=1,2)	0.1mH
Filter Capacitor Cfi (i=1,2)	500μF
Switching Frequency	10KHz
DC load (R)	45Ω
AC load (RL)	66+ j176 Ω

Most of the residential and commercial AC loads require 230Vrms AC Supply. When the qZs network operates in boost mode it can supply 230 Vrms voltage. The measured load voltage and current waveforms for RL load as shown in Fig. 4(a)&(b). The regulated 230Vrms is obtained by operating the quasi-z-source in boost mode. The time taken for settling the distortions during step changes is less that shows the performance of the developed model. The harmonic profile of load voltage and load current is shown in Fig. 5. It is observed that the dominant harmonic order is occurs at the higher order side which reduces the filter size at the output of inverter.

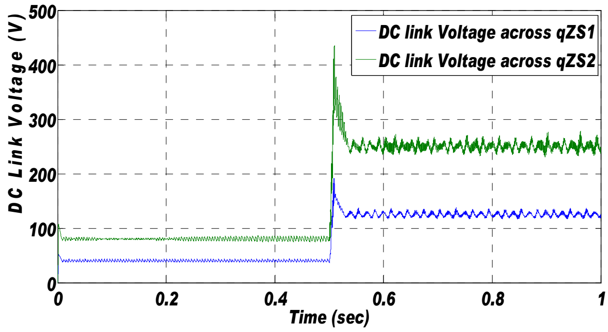
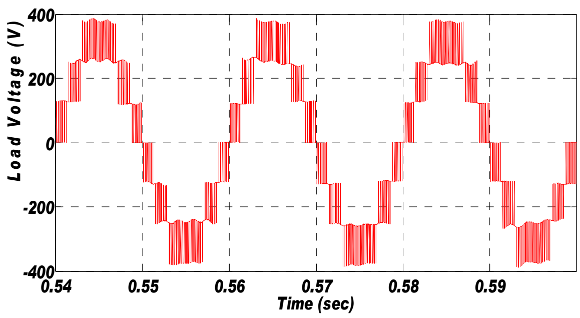
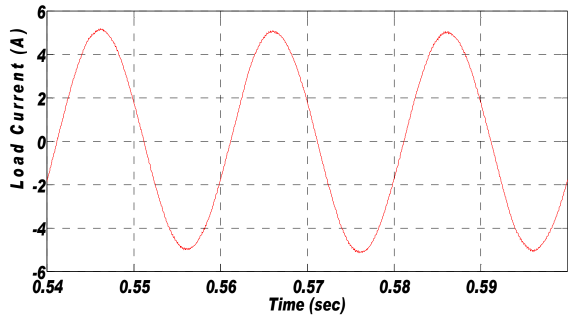


Fig. 3. DC link voltages across qZS1 and qZS2.

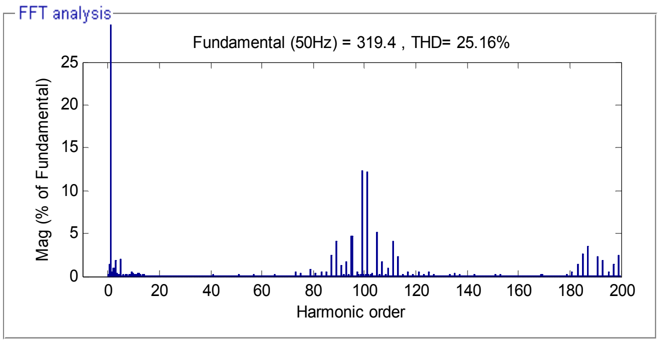


(a)

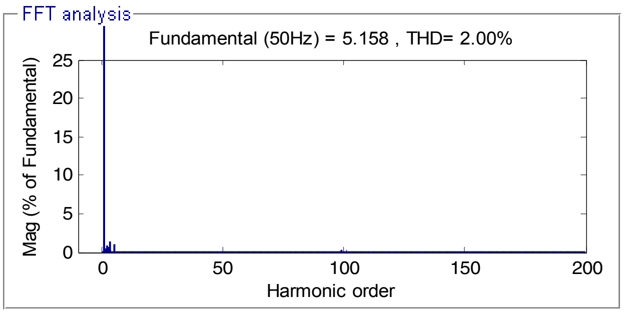


(b)

Fig. 4. Measured voltage and current waveforms for RL load.



(a)



(b)

Fig. 5. Harmonic Profile for voltage and current waveforms for RL load.

V. CONCLUSION

In this work, a newly constructed cascaded quasi-z-source based single phase seven level inverter is presented. Two different controls are used which gives relief to the system without affecting the performance and also system size is compact. The developed model is studied for variation in DC link voltages and their results are presented. The proposed model gives better response and can be extended its use for electric vehicle and nano-grid applications.

REFERENCES

[1] F.Z.Peng, “Z-source inverter,” *IEEE Trans.Ind.Appl*,vol.39,no 2,pp.504-510,March/April.2003.

[2] Y.P. Siwakoti, F.Z. Peng, F. Blaabjerg, P.C. Loh, and G.E. Town, “Impedance source network for electric power conversion –Part I :A topological review,” *IEEE Trans. Power Electronics*, Vol.30, No.2, pp. 699-716, 2015.

[3] Y.P. Siwakoti, F.Z. Peng, F. Blaabjerg, P.C. Loh, and G.E. Town, “Impedance source network for electric power conversion –Part II :Review of control,” *IEEE Trans. Power Electronics*, Vol.30, No.4, pp.1887-1906, 2015.

[4] J. Anderson, and F.Z Peng, “Four Quasi-Z-Source Inverters,” *in Proc.IEEE Power Electronics Specoalists Conference,* pp. 2743-2749, June 2008.

[5] Yushan Liu, Baoming Ge, Haitham Abu-Rub, and Fang Zheng Peng, “Phase-shifted pulse-width amplitude modulation for quasi-Z-source cascade multilevel inverter based photovoltaic power system,” *IET Power Electron*.,Vol.7, No.6, pp.1444-1556, 2014.

[6] Oleksandr Husev, Carlos Roncero-Clemente, Enrique Romero-Cadaval, Dmirtri Vinnikov, and Serhii Stepenko, “Single Phase three-level neutral-point-clamped quasi-Z source inverter,” *IET Power Electroni.*,Vol .8, pp. 1-10, 2015.

[7] K.K. Gupta, and S. Jain, “Toplogy for multilevel inverters to attain maximum number of levels from given DC sources,” *IET Power Electron.*,Vol.5 No.4, pp. 435-446, April 2012.

[8] Krishna kumar Gupta, Lalit kumar, and Shailendra Jain, “A New Seven-Level Hybrid Inverter”, *IEEE International Conference on Power Electronics, Drives and Energy systems (PEDES)*, pp.1-6, December 2012

[9] K. Patidar, and A.C. Umarikar, “One cycle control of Z-source and quasi Z-source DC-DC converters,” *National Power Electronics conference*, December 20-22, IIT kanpur, pp.1-6.

[10] K.M.Smedley, and S.Cuk , “One-cycle control of switching converters,” *IEEE Trans. on Power Electronics*,Vol.10, No.6, pp. 625-633, November 1995.