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Implementation of Pmsg Based Wind Turbine Generator Using With and Without Quasi Z-Source Inverter for Application of Grid System

KEYWORDS: PMSG, Rectifier, Quasi Z-Source inverter, Wind Power Generation, MPPT.

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ABSTRACT *Wind Turbines using Synchronous generator towards generate power and transferred to reliable grid system. This paper proposed with and without Quasi Z-Source inverter in PMSG based wind turbine. The closed loop control of shoot through duty cycle is designed to get desired dc bus voltage. Voltage Fluctuations and high harmonics generated in without Quasi Z-Source inverter. Integration of generator side three switch buck type rectifier and grid side Quasi Z-Source inverter is employed towards buck and boost capabilities as well as suppress the harmonics of wind system. Maximum Power Point Tracker (MPPT) is implemented by adjusting shoot through duty cycles of the Quasi Z-Source network. The proposed system has verified by using MATLAB/SIMULINK Environment.*

I. INTRODUCTION

PMSG wind power generation system is considered to be one of the mainstream systems in today's variable speed constant frequency wind generation technology area due to its lower weight and volume, high efficiency and stability [1]. In the traditional PMSG-WPGS, the AC outputs from generator are transformed to grids via AC / DC / AC converters. Thus high-capacity C-filter is needed in the DC link and voltage source inverter (VSI) is applied to convert DC to AC [2]-[3]. However, the traditional VSI is a buck converter, whose input dc voltage must be greater than the peak ac output voltage. Therefore, the voltage of VSI needs to be designed high enough, leading to high voltage stress and capacity of devices. To solve this issue, the boost circuit is usually added in DC link to keep the DC bus voltage constant and reduce the inverter stress, especially in the situations that the ranges of dc source voltage are relatively wide. Whereas, it will increase the cost as well as reduce the efficiency of wind power generation system.

The voltage-fed quasi-Z-Source inverter, exhibiting both voltage buck and boost capabilities, has been presented advantageous for overcoming the barriers and limitations of traditional VSI [4]. As the additional LC impedance network, QZSI beneficially utilizes the shoot through states to boost the dc bus voltage by gating on both the upper and lower switches of a phase leg. In this way, it can buck and boost voltage to a desired output voltage greater than the available DC bus voltage. The introduction of quasi-Z-Source network provides a reliable, highly efficient and low-cost structure for buck and boost power conversion [5]-[6]. For these reasons, the QZSI is well suitable for wind power systems due to the fact that the wind turbine output power varies widely along with wind speed changes [7]. In order to reduce DC link voltage fluctuations, it is necessary to bring in the closed-loop control of peak DC-link voltage in QZSI.

II. BASIC PRINCIPLES OF QUASI Z-SOURCE INVERTER

The topology of voltage fed QZSI with continuous input current is shown in Figure 1. The quasi-Z-Source network is made of an LC impedance network, which can boost the DC link voltage of inverter in respect to the interval of shoot through zero state during a switching cycle. In the QZSI, there is an addition shoot-through state than traditional VSI which is advantageously utilized to boost the DC bus voltage. The equivalent circuits of QZSI in two basic operation modes are illustrated in Figure 2&3. In Figure 2, the inverter bridge is equivalent to short circuit when shoot-through zero vectors are working in Figure 3, the inverter bridge is replaced by a constant current source in non-shoot-through states. In the figure, R is the series resistance of capacitors and r is the parasitic resistance of inductors.

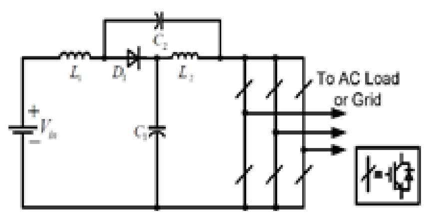

Fig.1. Quasi Z-Source Inverter

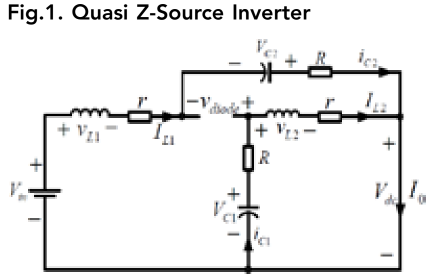

Fig.2. Equivalent Circuit of QZSI Shoot through State

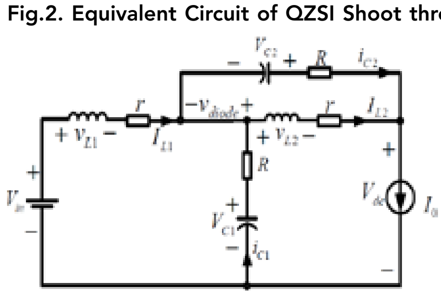

Fig.3. Equivalent Circuit of QZSI Non-Shoot through State

As verified in the basic principles, the average values of capacitor voltages VC1and VC2 in quasi-Z-Source network are

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$$V_{c1} = \frac{1-D}{1-2D} V_{in}$$

$$V_{c2} = \frac{D}{1-2D} V_{in}$$

Where V_{in} is the dc source voltage of QZSI
D is the shoot through duty cycle

III. SYSTEM CONFIGURATIONS AND CONTROL STRATEGIES

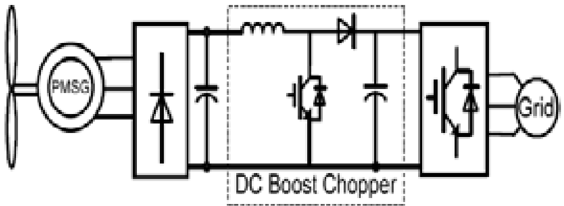

Fig.4. Traditional PMSG-WPGS with DC boost chopper

The traditional PMSG-WPGS with DC boost chopper is shown in Figure 4. While in the QZSI based Permanent Magnet Synchronous Generator – Wind Power Generation System, the DC boost chopper is replaced by the quasi-Z-Source network, as illustrated in Figure 5. Through MPPT control of wind turbine, the maximum power P_{Wmax} generated by wind turbine is delivered to the direct-drive PMSG. The three phase AC is converted to DC as the dc source voltage V_{in} of QZSI by diode rectifier with input capacitors C as shown in Figure 6.

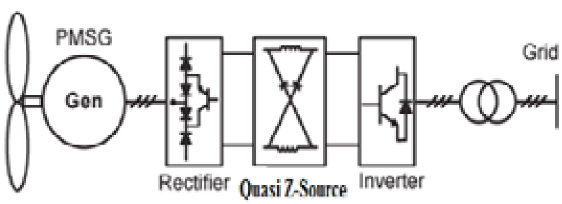

Fig.5. QZSI based PMSG Wind Power Generation System

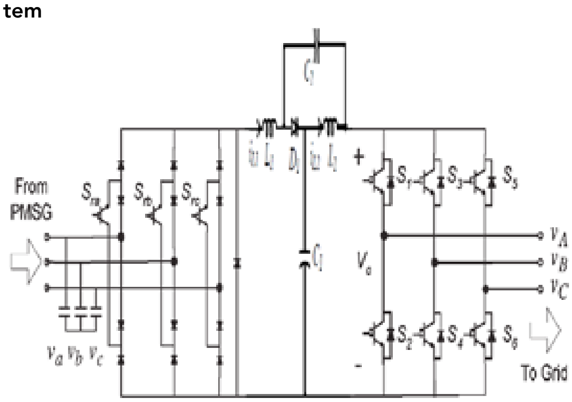

Fig.6. Complete Structure of Proposed PMSG-WPG System with QZSI

The main function of the generator-side PWM rectifier is to regulate the power factor of the PMSG and to ensure sinusoidal generator currents. A small LC input filter can be designed to absorb the high frequency harmonics injected into the generator by the rectifier switching action.

The grid-side Quasi Z-source inverter is chosen to be an alternative to conventional inverter topologies due to its many merits. For example, it has inherent voltage buck and boost capability using the shoot-through states in each phase leg of the inverter. This function relies on a unique impedance network, which, in practice, is implemented using split inductors (L_1 and L_2) and capacitors (C_1 and C_2) connected in quasi-shape. This enables the proposed wind generation system to achieve variable-speed operation. The proposed configuration has eliminated the dc–dc chopper and thereby simplified the system structure. The system operation reliability is also improved since there is no shoot-through risk in both generator- and grid-side converters.

IV. SIMULATION RESULTS & DISCUSSION

A. SIMULATION CIRUCIT FOR PMSG BASED WIND TURBINE GENERATOR WITH QUASI Z-SOURCE INVERTER

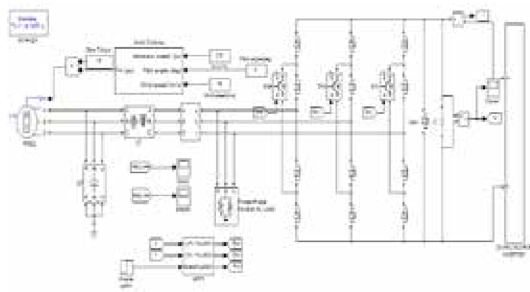

Fig.7. PMSG Based Wind Turbine Generator using Quasi Z-Source Inverter

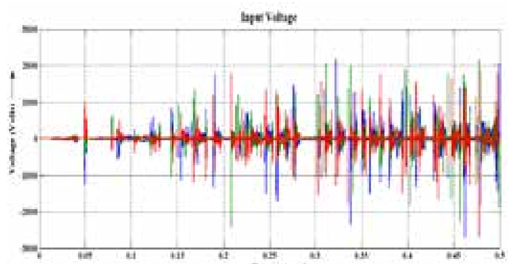

Fig.8. Input Voltage

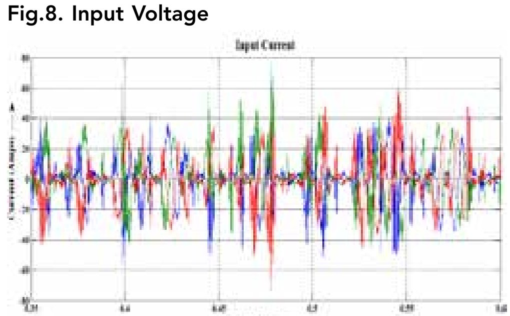

Fig.9. Input Current

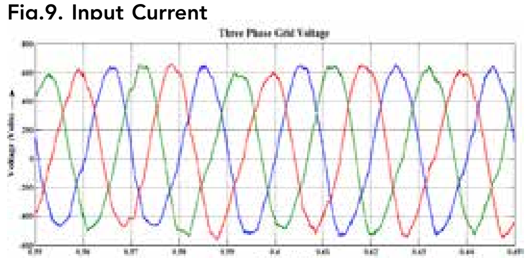

Fig.10. Three Phase Grid Output Voltage

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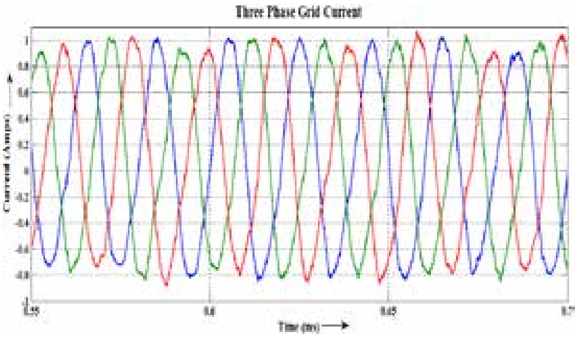

Fig.11. Three Phase Grid Output Current

B. SIMULATION CIRUCIT FOR PMSG BASED WIND TURBINE GENERATOR USING WITH OUT QUASI Z-SOURCE INVERTER

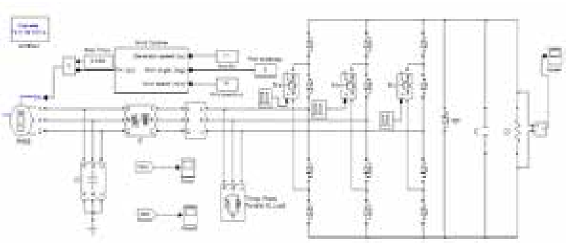

Fig.12. PMSG Based Wind Turbine Generator without using Quasi Z-Source Inverter

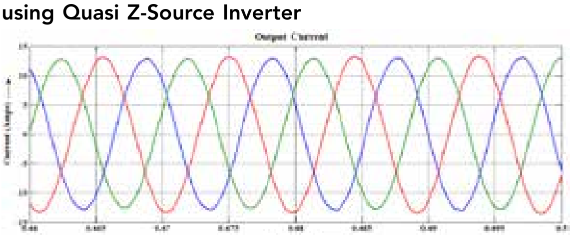

Fig.13. Three Phase Grid Output Current

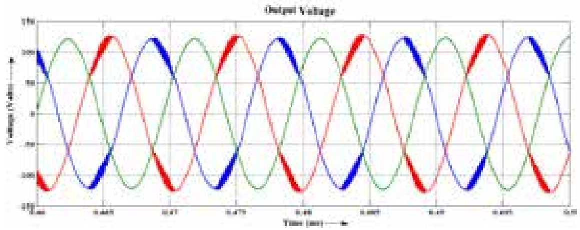

Fig.14. Three Phase Grid Output Voltage

V. CONCLUSION

This paper has presented PMSG Wind power generation system on Quasi Z-Source Inverter. Design methodology of an integrated generator side buck type rectifier and Grid side Quasi Z-Source inverter based PMSG wind system. The DC boost control and AC side output control are design to reduce the effect of voltage fluctuations on the grid and extracting the Maximum Wind Power by adjusting the shoot through duty cycle of Quasi Z-Source network. The simulation results are successfully implemented by MATLAB/SIMULINK.

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