Hysteresis Current Controller Based Grid Connected Wind Energy Conversion System for Permanent Magnet Synchronous Generator and Quasi Z-Source Inverter Using Power Quality Improvement

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***Abstract*— Wind energy is a leader area of application for variable-speed generators operating on the constant grid frequency. This paper depicts the power quality enhancement in wind power system using permanent magnet synchronous generator (PMSG) and Quasi Z-source Inverter. The PMSG is connected to the power network by means of a quasi z-source inverter (qZSI). The PMSG are used by these technologies due to extraordinary characteristics such as a smaller amount weight and volume, superior performance, eradicate the gear box and no need of peripheral power in permanent magnet excitation. The PMSG overcome the induction generator and other generators, because of their splendid performances without take up the grid power. But Induction Generator always needs the grid connection for getting power to start. In this paper the quasi Z-source inverter is a present that is a novel topology conjugated from the traditional Z source Inverter. The qZSI inherits all the advantages of the ZSI, that is performs buck-boost, inversion and power control in wind energy conversion system (WECS) Moreover, the proposed qZSI the matchless advantages of less component ratings and stable dc current from the source. All over boost control methods are built for the ZSI can be used by the qZSI .This Paper presents hysteresis current control technique for the quasi Z- source inverter.**

Keyword- Wind Energy Conversion System (WECS), Permanent Magnet Synchronous Generator (PMSG) and quasi Z-Source Inverter (qZSI).

I. Introduction

In current years, a group of profession has been done in enhancement of power quality using variable generators and power electronic devices. Small scale stand-alone wind energy systems are a major another source of electrical energy, judgment applications in locations where conventional generation is not sensible. Unluckily, most of these systems are not catching power at every wind speed particularly low wind speeds which are low in power but can be very common**.**

But fresh permanent magnet synchronous generator technology gives high efficiency power conversion that is mechanical energy into electrical power. Furthermore, it allows for special machine design with very low speed e.g. in gearless wind and hydro application and at very high speed for micro-gas turbines, which is of interest for several regenerative or co-generative power conversion technologies. A survey of already realized prototypes or in use PM generator systems is presented for that purpose. From all the generators that are used in wind turbines the PMSG's have the highest advantages because they are stable and secure during normal operation and they do not need an additional DC supply for the excitation circuit (winding) . Initially used only for small and medium powers the PMSG's are now used also for higher powers.

In the conventional voltage-source inverter (VSI) and current source inverter (CSI) are used to convert DC to AC and act as a boost or a buck converter. But the DC side cannot be boosted in the conventional inverters. That is, their accessible output voltage range is limited to either greater or smaller than the input voltage. But the quasi Z-source inverter (qZSI) was proposed as an alternative power conversion concept as it can have both voltage buck and boost capabilities. In addition to that it has the following advantages: Immune to EMI noise and misfiring, no in-rush current compared with the voltage source inverter and with a reduction of common mode noise.

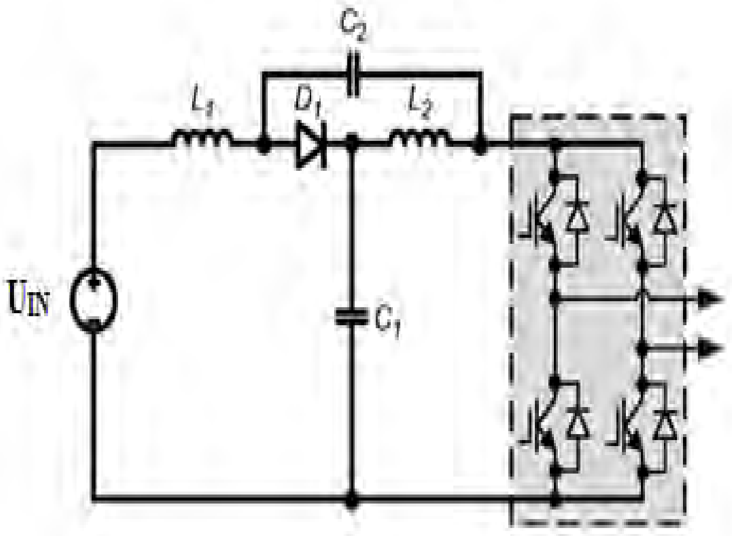

Fig 1: Quasi Z-Source Inverter.

The above figure (1), the major construction is quasi Z-source inverter. It employs a matchless impedance network fixed between the power source and the circuit for converter that contain a split-inductor L_1 and L_2 and capacitors C_1 and C_2 connected parallel. The quasi Z-source networks join the inverter to a DC voltage source. The voltage source will be a battery, a diode rectifier or a wind generator. The qZSI can boost the input voltage by introducing a exceptional shoot through switching state. This state, the qZSI as instantaneous conduction of the same inverter phase leg.

This switching state is prohibited for the conventional voltage source inverter, because it causes of short circuit of the DC link capacitor. But in the qZSI, the shoot through state are used to boost up the voltage by using DC side inductors (L_1 and L_2) and DC side capacitors (C1 and C_2). It is also called as impedance network. This unique impedance network allows the quasi Z-source inverter to boost the voltage which is getting from wind side.

If the input voltage is sufficient from wind, the shoot through state is not required to boost the voltage. At that time only the qZSI starts to operate as a usual voltage source inverter. The DC power from qZSI section is directly fed to the inverter section. This inverter section converts DC power to required AC grid power. This variety of quality grid power, capacity is to be distributed in the respected customers

II. MATERIALS AND METHODS

Nowadays the permanent magnet synchronous generators are used for distribution system to improve the moment of power in the system and also to diminish the losses of power in the system. Moreover it has some features such as low weight and volume, high performance, reduced the gear box size, and no need of external power supply for permanent magnet excitation. Here a new variable-speed WECS with a PMSG and hysteresis control technique based quasi *Z*-source inverter is proposed. The two main objectives of PMSG are extracting highest power from wind and feeding the grid with high-quality electricity. Characteristics of quasi Z-source inverter are used for maximum power point tracking control and deliver the quality power to the grid, concurrently.

The below figure (2) is composed of blades, Permanent Magnet Synchronous Generator, quasi Z-source network, quasi Z-source inverter and grid. When the wind is exploding to the blade, the blade will be rotate. The rotating blade is straightly coupled with the shaft of the PMSG. So whenever blade is turn, the rotor of the PMSG is also get turn. The getting AC power from PMSG is directly fed to the rectifier. The main purpose of rectifier is changing the AC supply to DC supply. Then after performing of DC conversion, the DC supply is given to the quasi Z-source network. Here the quasi Z-source inverter is control by hysteresis current controller. The main purpose of this hysteresis current controller technique is control the quasi Z-source inverter as well as current from the source. Then the quality power supply from the quasi Z-source inverter is directly connected to grid for different applications. If any harmonics present in the transmission line, we can rectify it by using second order low pass filters that is detailed in simulink diagram.

The below figure (3) is Simulink diagram of wind energy conversion system using PMSG and quasi Z-Source Inverter. The figure consist of wind turbine, quasi Z-source network, quasi Z-source inverter, subsystem for hysteresis current controller, second order Low pass filter, generating station and load. The wind turbine has the PMSG and rectifier in inside of their subsystem (1). The AC power produced by PMSG and by using rectifier AC power converted into DC power. The DC power directly fed to the quasi Z-Source Network as well as quasi Z-Source Inverter. The Simulink diagram for quasi Z-source inverter is given in below figure. In this quasi Z-source Inverter is controlled by hysteresis current control technique. The thyristor station change the AC supply into DC supply. The illustration of hysteresis current controller is given in subsystem.

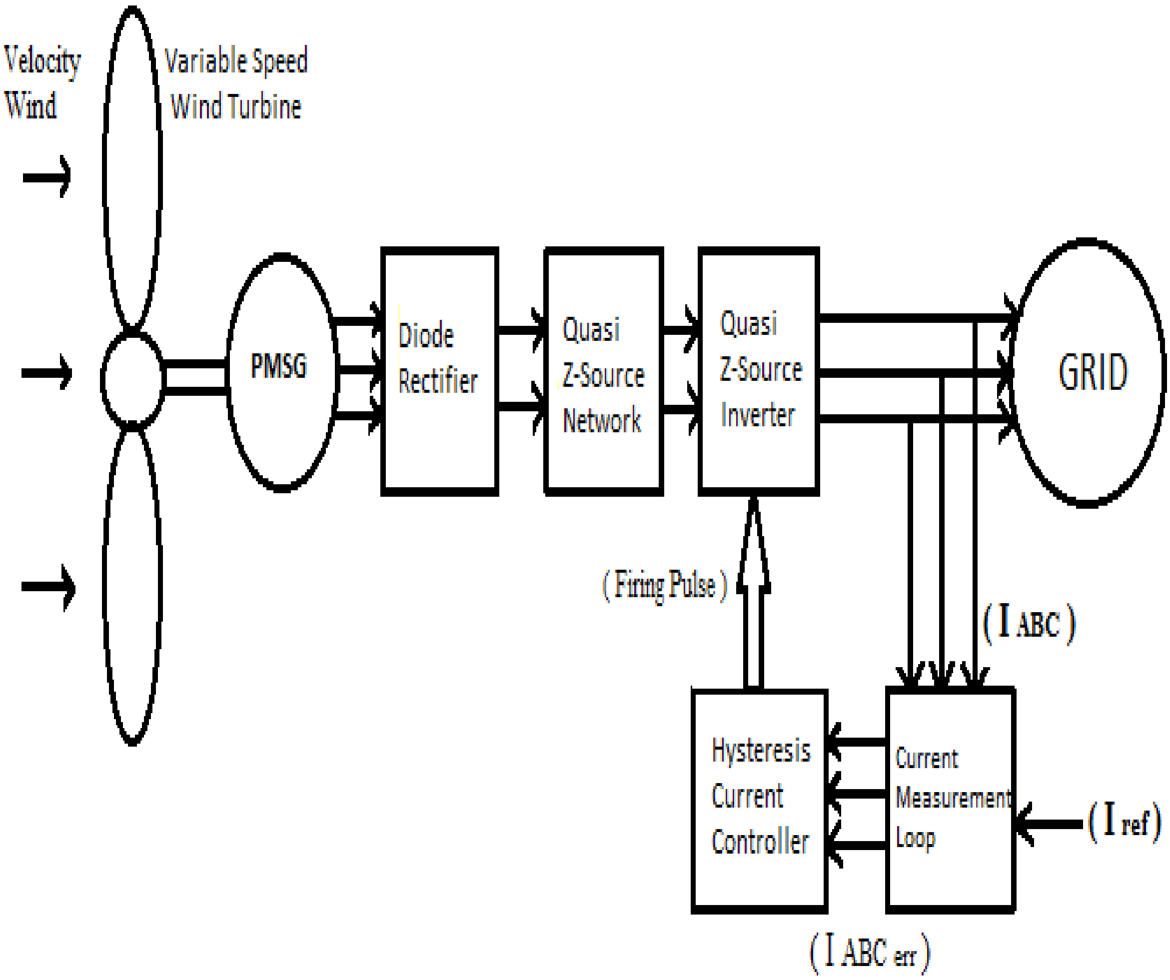

Fig 2: Block Diagram of Proposed Wind Energy Conversion system.

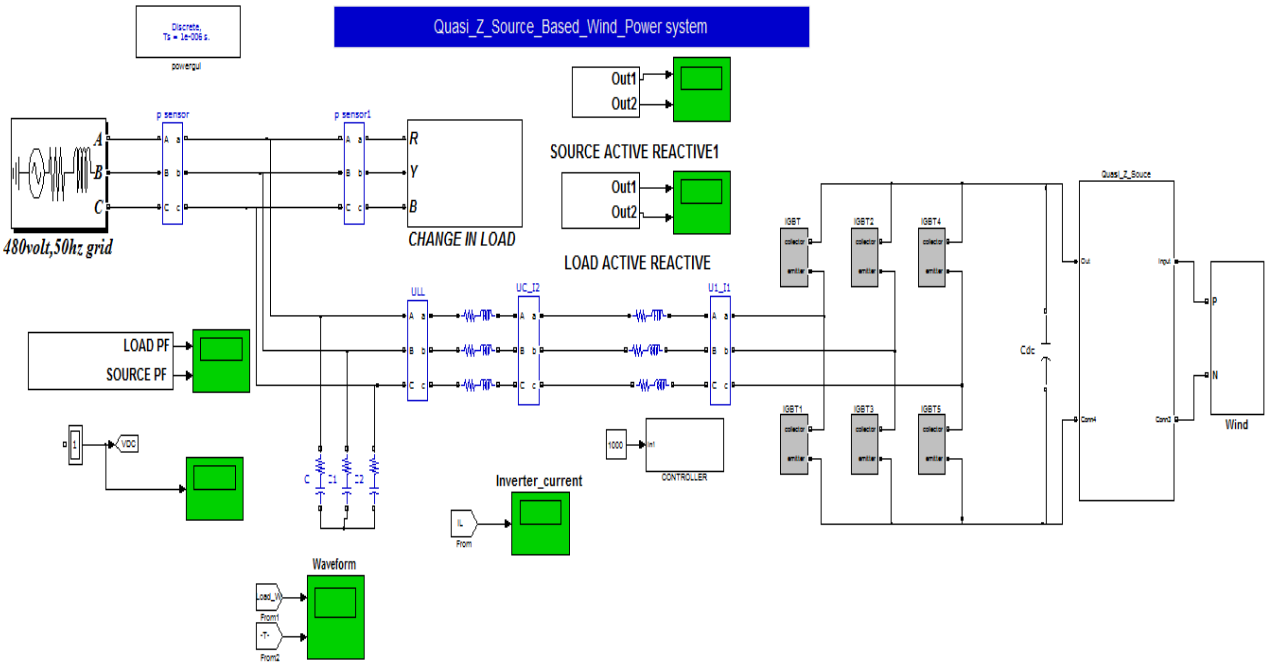

Fig 3: Simulink Diagram of Wind Energy Conversion System.

The power from the inverter is given to the voltage and current measurement through the second order low pass filter. After that, high frequency resonant wave from the step up transformer is connected to one thyristor station. The subsystem of quasi Z-source Inverter denoted in above figure (3) consist of quasi Z-source inverter which is connected to the step up transformer for improve our power supply. Owing to the square wave from inverter output, it should change into purified sine wave by using this LC filter. Then the quality power is connected to the grid. On other hand same level power generating station is connected to the grid. So we should merge our newly produced quality power supply to that grid through the quasi Z- source inverter. So by using PMSG and quasi Z-source inverter, the newly produced power supply has been merged to the grid effectively is shown in above figure (3). Remaining power is in spinning reserve. Whenever power demand takes place, at that time utilized.

III. HYSTERESIS CURRENT CONTROLLER

The hysteresis current control methods play a significant role in power electronic circuits, predominantly in ac motor drives and continuous ac power supplies where the machine is to produce a pure sinusoidal ac output. Among the different current control technique, the hysteresis current control is used very frequently owing to its simplicity of execution. Also, moreover quick response current loop, the technique does not need any knowledge of burden parameters.

The main role of the control systems in current regulated inverters is to compel the current vector in the three phase load according to a reference curve. In this paper, hysteresis current control method based quasi Z-source inverter has been implemented. The proposed control technique retains the advantage of the hysteresis control having very quick dynamic response. The concept is based on predicting the current reference, system dynamic performance, and precedent time to formulate the switching function for dictating the switching times of the switches in the inverter within a predefined Switching period.

The crucial execution of hysteresis current control is depends on deriving the signals from the current error with a predetermined tolerance band. This control technique is depends on the relationship of the actual phase current with the tolerance band approximately the reference current linked with that phase. On other words, this kind of control is disapprovingly affected by the phase Current interactions which is typical in three-phase systems. This is mainly caused by the intrusion between the commutations of the three phases, since each and every phase current not only based on the consequent phase voltage but is also artificial by the voltage of the other two phases. Based on burden situation switching frequency may differ during the essential period, resulting in irregular inverter operation.

IV. RESULT AND DISCUSSION

The above figure (3) 350 v AC input voltage is given to the rectifier by means of wind source that is permanent magnet synchronous generator. Then the rectifier converts the 350v AC input into DC output. The DC output voltage is directly fed to the quasi Z-source network. Before convert DC to AC, The shoot through state is carried out by quasi Z-source inverter. As a result, the voltage is boosted up to 1000v DC. It is denoted as Vdc (capacitor voltage) shown in above Simulink diagram figure (3). The result of V_{dc} is shown in below figure (4). Then the 1000v DC voltage is directly fed to the inverter circuit for purpose of convert the DC supply into AC supply. That is the 1000v DC supply converted into 480v AC supply and here current is maintained as constant by using Hysteresis controller.

Then the 480 v AC supply is given to the second order low pass filter for remove the harmonics if it is presented in 480v AC supply. The inverter maintained the current if any change in power factor of our power supply. The power factor for load and source is shown in below figure (5). The inverter current for various power factor is shown in figure (6). The load requires 121KVA active power and 118KVAR reactive power is shown in figure (7). But the other generating station i.e. source (1) produced only 120KVA active power and 12 KVAR negative reactive powers. It is shown in below figure (8). The remaining active and reactive power lagging is managed by PMSG and quasi Z-source network. Here the load current is not maintained equal to the voltage. But in the proposed system, it is maintained as equal is also shown in figure (9). The harmonics are reduced more and that the harmonics levels are maintained up to 0.62% in this proposed scheme. It is shown in below figure (10). The illustrations of results and controlled technique are mentioned in below comparison Table.1.

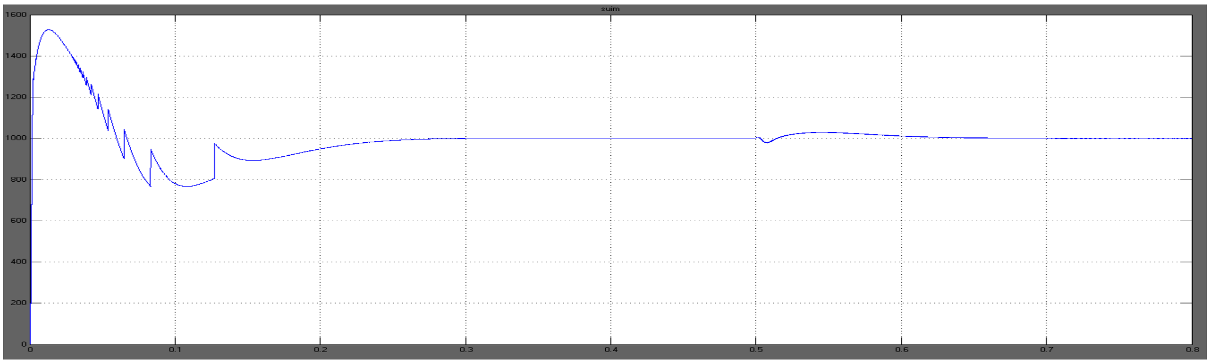

Fig 4: Capacitor Voltage

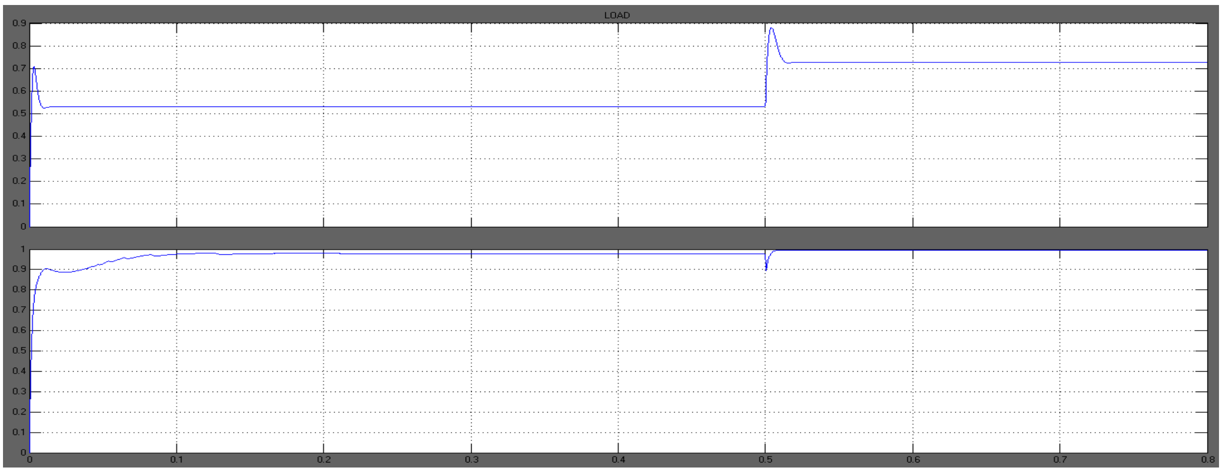

Fig 5: Power Factor for Load and Source (1).

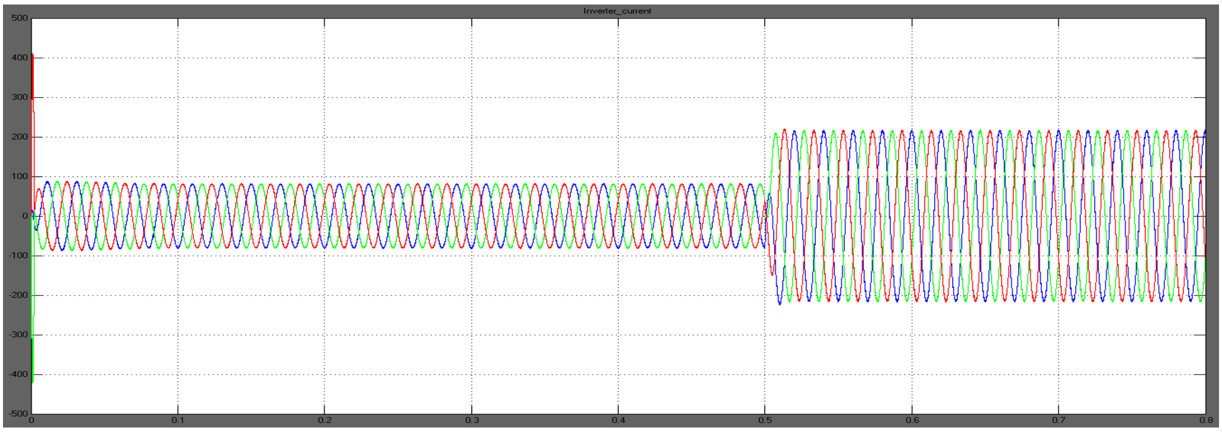

Fig 6: Inverter Current.

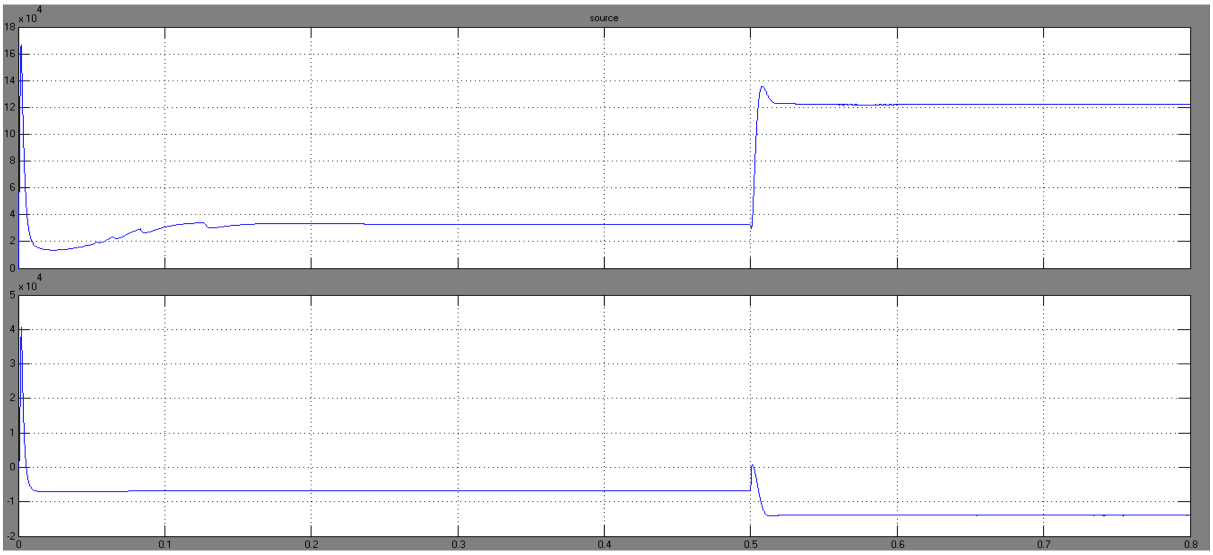

Fig 7: Active and Reactive Power for Source (1).

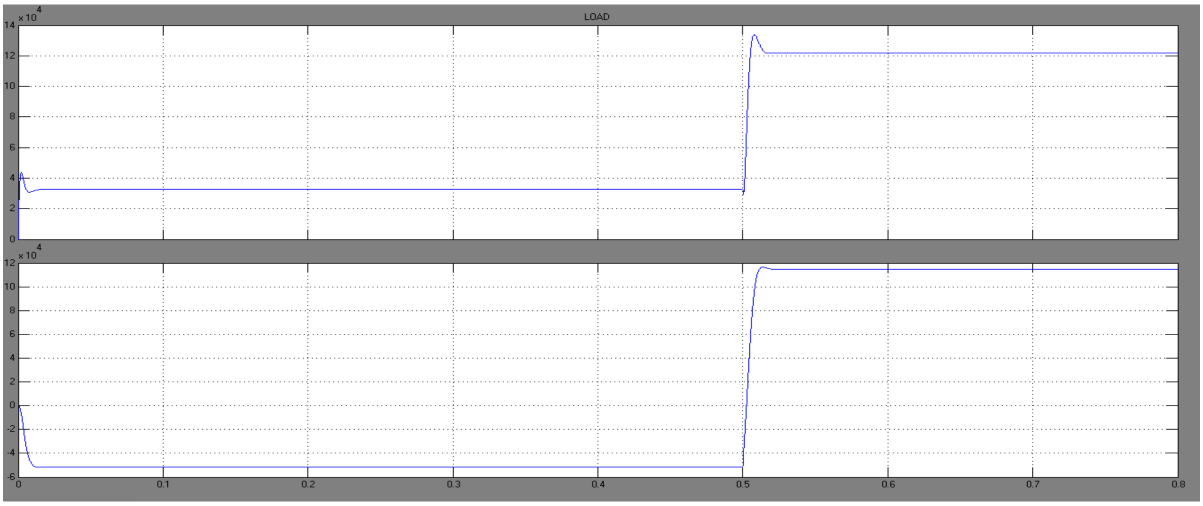

Fig 8: Active and Reactive Power for Load.

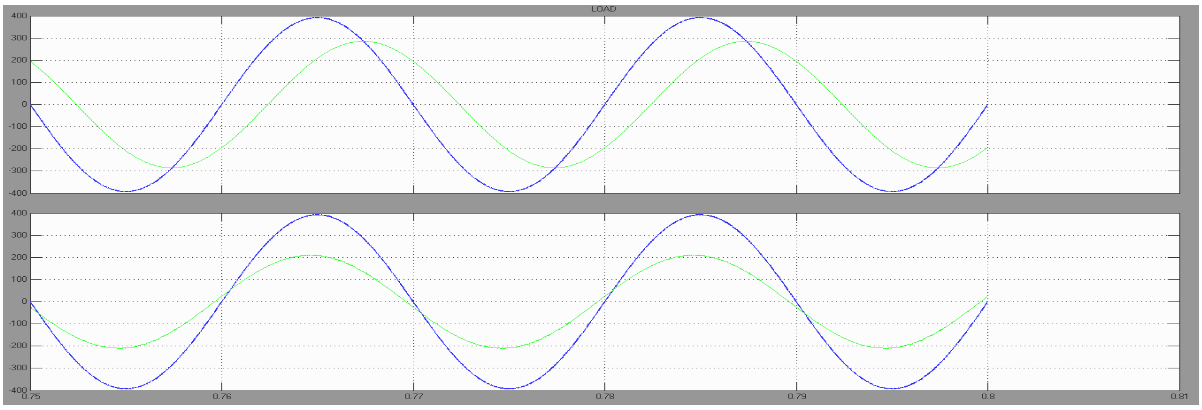

Fig 9: Current and Voltage for Load and Proposed Inverter System

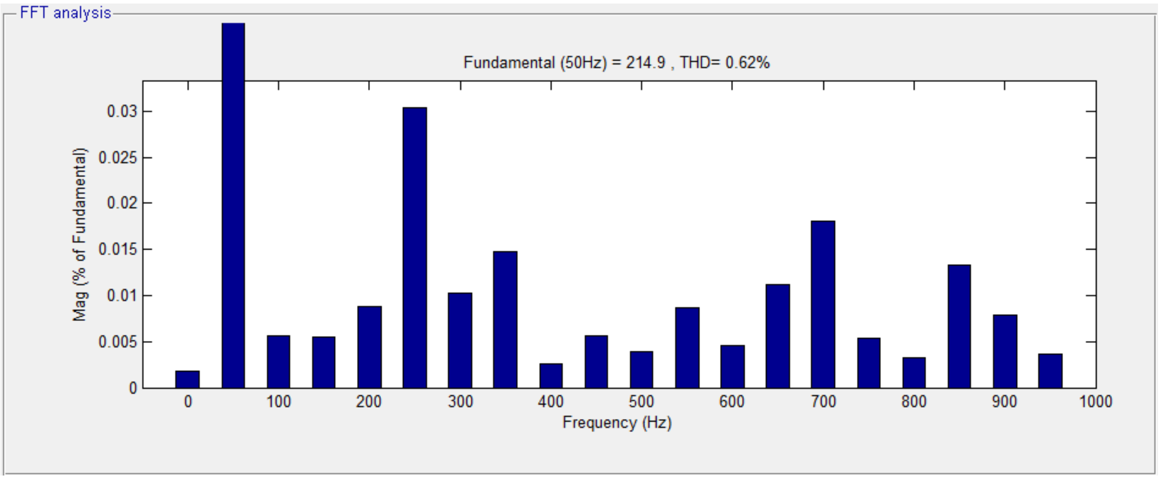

Fig 10: Harmonic Spectrum for Proposed System.

Table 1.Comparision Table

S.No	Parameter	Conventional Method	Proposed Method
1.	Input / Output Voltage Profile	50V / 200V	350V / 1000V
2.	Inverter Output Current	1.2A	Required Grid Level (Approximately 200A)
3.	Total Harmonics Distortion	1.49%	0.62%
4.	Inverter Type	Z-source Inverter	Quasi Z-Source Inverter
5.	Inverter Controlled Technique	Maximum constant boost Control with third harmonic injection Technique	Hysteresis current Control Technique

V. CONCLUSION

The acquired results indicate that the proposed control method could stabilize the DC bus voltage without any extra circuits, providing a significant method to increase the performances of wind energy conversion systems. The two main objectives for WECSs are extracting greatest power from wind and feeding the grid with high-quality electricity. This paper has offered a novel proposed scheme of hysteresis Control based quasi Z- source inverter for connect the output power to the grid. Compare to conventional Maximum boost control with pulse width modulation technique based Z-source inverter method, in this proposed method produced the more voltage as well as current declared in above comparison table 1. The simulation results for 350v AC input and 480v (phase-to-phase) output has been verified, and the simulation results show that the proposed quasi Z- source inverter has maximum boost capability. The proposed hysteresis control based quasi Z-source inverter method is reduced the harmonics up to 0.62% Compared to conventional method.

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BIOGRAPHY

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