

Simulation of Reduced Component Count Quasi Z-Source Inverter Fed BLDC Motor for Renewable Energy Applications

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Abstract—The paper proposes a cost effective four-switch inverter fed Brushless DC motor using quasi z-source network with variable voltage control method. The quasi z-source network has applications in the field of renewable energy as it acts as a power conditioning circuit. This four switch quasi z-source structure decreases the switching losses, total harmonic distortion and cost in comparison with traditional six switch structures. Simulation of the proposed model was done in MATLAB/SIMULINK.

Keywords—BLDC motor, Quasi z-source converter

I. INTRODUCTION

Renewable energy sources like solar and wind power have a huge potential to provide solution to the increasing energy crisis and pollution due to the use of conventional fossil fuels. The biggest challenge in using renewable energy is their intermittent nature. So, renewable energy is less frequently used in motor drive applications.

Brushless DC Motors are extensively used in servo systems and low power drive systems due to the advantages such as simple construction, high torque to weight ratio, high reliability and high power density. A typical brushless motor is characterized by permanent magnets which rotate around a fixed armature, eliminating problems associated with commutation such as sparking that occurs in the carbon brushes. The brush/ commutator assembly of the brushed DC motor is efficiently replaced by an electronic controller, which switches the phase to keep the motor turning according to the output of the Hall Effect sensors. Brushless DC (BLDC) motors have replaced conventional induction motors in almost all applications such as servo systems, Fans, Pumps, HVAC blowers and compressors, Computer disk drives and peripherals etc.

There are many challenges when a BLDC motor is driven using renewable energy sources such as solar and wind power. The intermittent supply provided by the renewable energy sources needs to be modified to a DC with superior output quality for BLDC motor drive applications. For obtaining balanced three phase output voltages, the existence of a ripple free DC supply is necessary. Also bulky and heavy capacitors must be avoided as they lead to slower response and increase in cost.

A quasi z-source network may be used to solve the problem of variable dc supply in renewable energy sources. Similar to the z-source topology, the quasi z-source network has a superior LC circuit with many advantages such as reduced component number, reduced supply voltage stress, easy control algorithms and improved power factor.

A reduced component count quasi z-source inverter fed BLDC motor drive is presented in this paper. The conventional six switch voltage source inverter is replaced by a four switch inverter. The speed of the motor drive is controlled by varying the DC bus voltage according to the difference between actual and reference speeds by adjusting the duty ratio of a parallel switch. This is done by utilizing the shoot through mode of the quasi z source network.

The speed control of BLDC motor fed by a four switch quasi z-source network and the advantage of the proposed system is explained and simulated using MATLAB/SIMULINK.

II. QUASI Z-SOURCE INVERTER

The topology of z-source inverter was proposed to overcome the traditional inverters such as boosting mode and short circuit problems. The quasi z-source inverter, derived from and the z source inverter uses an impedance network to achieve voltage boost and inversion operation by working in shoot through mode.

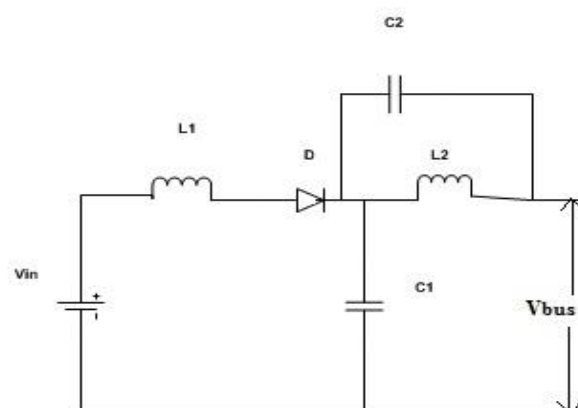


Fig 1. Quasi z-source inverter

Conventional VSI has a disadvantage that triggering two switches of the same phase leg simultaneously leads to the short circuit of the source. Also the conventional voltage source inverter is a buck inverter the maximum obtainable output voltage cannot exceed the DC input. The quasi z – source inverter was introduced to overcome these drawbacks by permitting shoot through states. The shoot through states in a quasi z-source converter can be used to accomplish the boost operation. The quasi z-source inverter has wide applications in renewable energy sources like PV array where it draws a constant current from the supply and is capable of handling wide input voltage range. It provides a good isolation between the load and the source and thus causes less EMI and improves the power factor.

Quasi z-source inverter has two modes of operation

- Active mode

In non shoot through mode the quasi z-source inverter acts similar to a conventional VSI. Here the four switch inverter bridge acts as a current source.

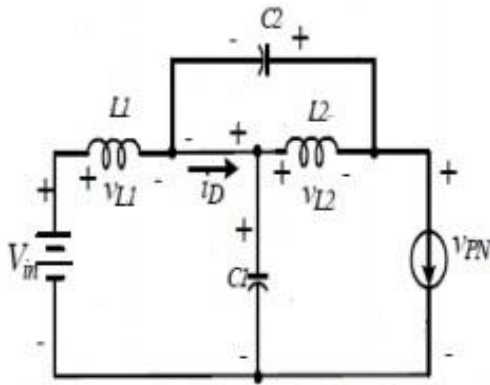


Fig 2. Non shoot through mode

- Shoot through mode

In shoot through mode switches of the same phase leg are turned on simultaneously for a short period. Due to the presence of the unique LC network the source do not get short circuited and results in boost action .

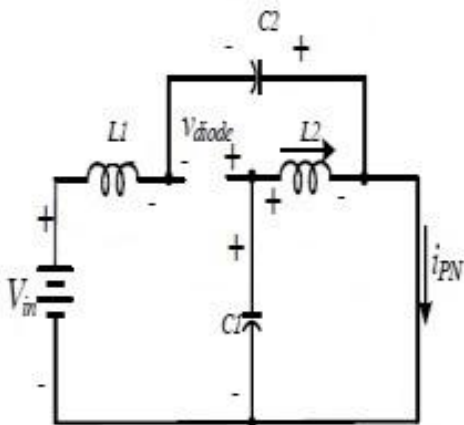


Fig 3.Shoot through mode

III. PROPOSED CONTROL SCHEME

Figure 4 shows the proposed scheme for a four switch quasi z –source inverter fed BLDC motor drive. The drive consist of a diode bridge rectifier, quasi z source network, MOSFET based four switch voltage source inverter, PWM controller, and switching logic from the hall effect signals.

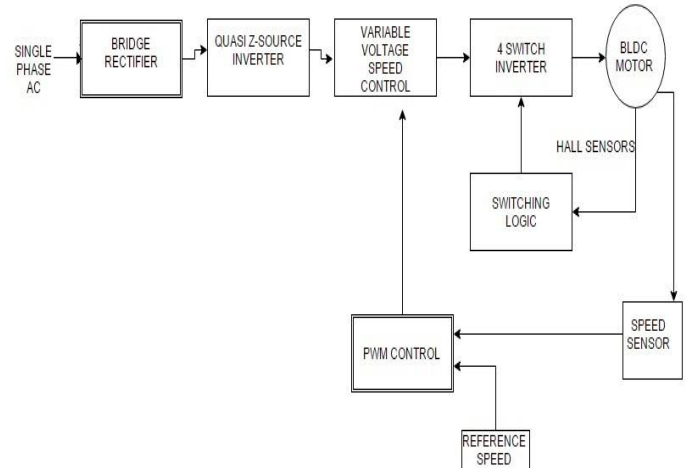


Fig 4.Proposed scheme

A. Four switch inverter

Four switch three phase BLDC motor drive is used to simplify the topological structure of the conventional six switch inverter.the reuction in the number of switches lead to decrease in switching losses and total harmonic distortion and thus improves the power factor. The voltage across the two split capacitors are exactly balanced by using a closed loop control so that BLDC motor functions normally.

B. BLDC motor drive

A four switch voltage source inverter is used to feed a BLDC motor. The rotor position at every instant is obtained with the help of hall sensors mounted on stator. From the hall sensor output the switching logic is determined to provide triggering pulses to the inverter switches.

For speed control the actual and reference is compared to produce an error signal, which is then fed to the PI ontroller, generated control signal will then modify the speed accordingly. The switching pulses for the proposed converter are obtained using pulse amplitude modulation method.

IV. SIMULATION

Figure 5 depicts the simulation circuit for the reduced component count quasi z-source inverter fed BLDC motor drive .The total simulation time was 3 seconds.

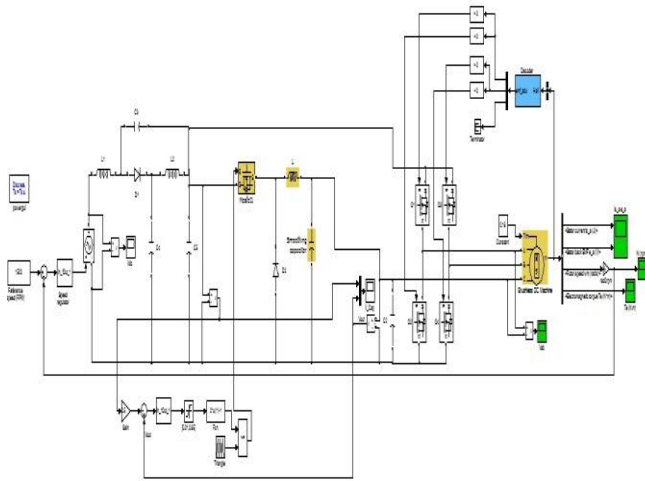


Fig 5.Simulation diagram of variable voltage speed control of four switch quasi z-source inverter fed BLDC motor

V. RESULTS

The results obtained on performing the simulation are as shown. The stator current waveform and the generated Back emf waveforms are as shown below

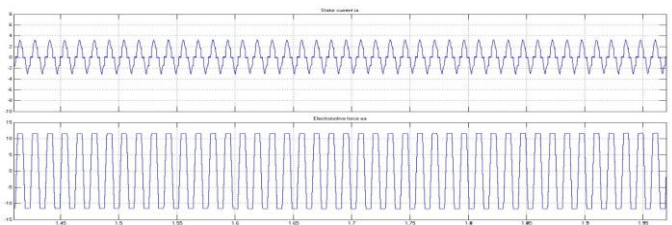


Fig 6.Stator current for phase a and Back emf waveform of phase a

Input DC bus voltage waveform when the reference speed is set at 1200 rpm

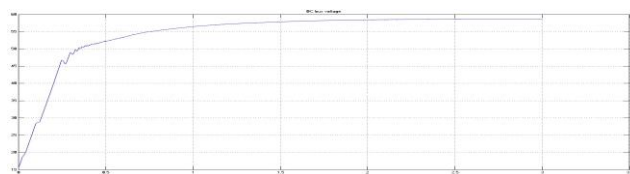


Fig 7.DC bus voltage at 1200 rpm

Speed waveform when reference speed is 1200 rpm

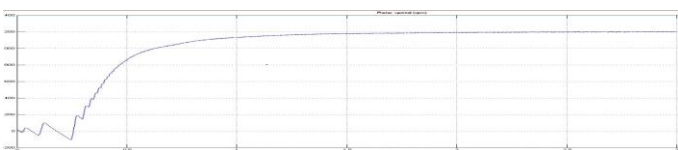


Fig 8.Speed curve at 1200 rpm

DC bus voltage(blue) and capacitor voltage(green) at speed 900 rpm

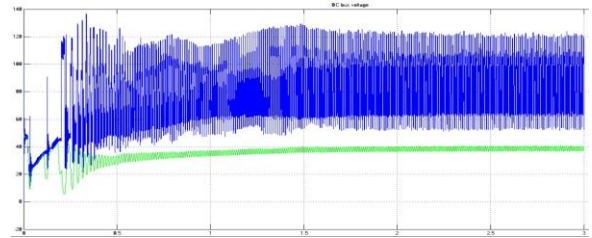


Fig 9.DC bus voltage at 900 rpm

Converter output when the reference speed is set at 900 rpm

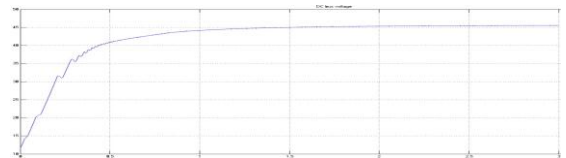


Fig 10.DC bus voltage at 900 rpm

Speed characteristic at set speed of 900 rpm

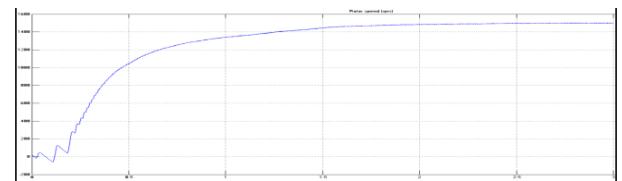


Fig 11.Speed curve at 1000 rpm

Converter output when the reference speed is set at 1500 rpm

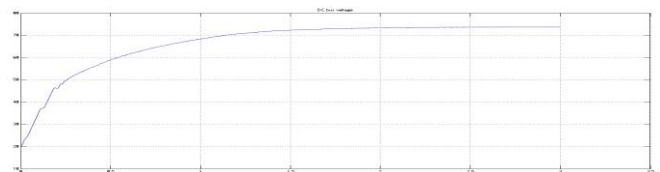


Fig 12.DC bus voltage at 1500 rpm

Speed characteristics at set speed of 1500 rpm

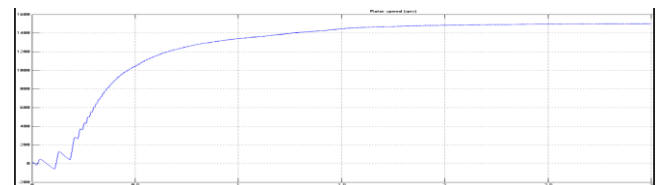


Fig 13.Speed curve at 1500 rpm

VI. CONCLUSION

The speed control of a BLDC motor fed by a quasi z-source four switch inverter was modeled using MATLAB/ SIMULINK. It can be concluded that the proposed model is most suitable for BLDC motor drive applications powered by renewable energy. The quasi z-source network is capable of dealing with a wide range of input voltage and it draws a constant current. It provides good isolation between load and the source side. Thus it reduces the total harmonic distortion of the input waveform and thereby improving the power factor. The quasi z-source inverter can also act as a boost converter as it permits the shoot through stage. The use of the four switch inverter instead of the conventional six switch voltage source reduces the switching losses and provides simple control technique.

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