BLDC Motor Drive with Zeta Converter based NPC Inverter

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Abstract— Now a days, Brushless DC motors are extensively used in various applications such as fuel pumping, automotive, aeronautical, robotics etc because of its highly advantageous features. Here for the control of BLDCM a topology which consists of a zeta converter for DC link voltage control and a neutral point clamped inverter is used. The inverter delivers a half dc link voltage across the motor windings and this helps in eliminating the torque ripple.

Key words: BLDC, PWM, NPC

I. Introduction

BRUSHLESS DC (BLDC) motors are becoming popular due to their advantages of high efficiency, high energy density, high torque/inertia ratio, variable speed operation, and low electromagnetic interference (EMI). The development of an efficient and low cost motor drive is required which focuses on low and medium power equipments. Moreover, requirement of high efficiency aims at reducing the losses in the drive system components such as DBR (Diode Bridge Rectifier), front end converter and VSI (Voltage Source Inverter). The control of bldc motor by replacing conventional bridge converter with zeta converter that gives a regulated output through a single power processing stage is presented here. Also a three level neutral point clamped inverter is implemented for reducing torque ripple and harmonics.

II. Zeta Converters

Zeta converters are fourth orderDC-DC converters capable of operating in both step-up and step-down modes and do not suffer from polarity reversal problem. It performs a non-inverting buck boost function and requires a P-channel MOSFET as the primary switch as shown in figure 1 below. It has various advantages such as stable output response and reduced circuit losses when compared to SEPIC converter. The main attractive feature of zeta converter is that it has a naturally isolated structure, which allow a regulated output voltage with only one power processing stage.

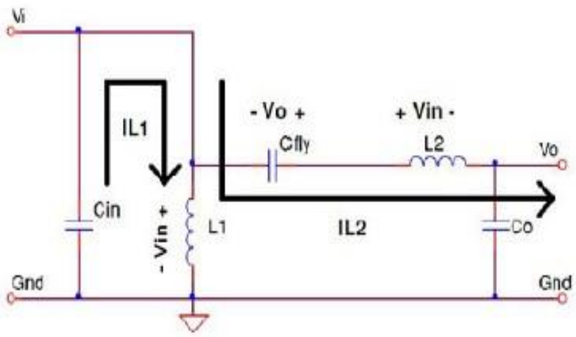


Fig. 1: Zeta Converter Configuration

III. Neutral Point Clamped Inverters

The Neutral Point Clamped Converter (NPC) Pulse width modulation (PWM) VSCs have replaced thyristor-based converters in a wide range of applications. This is largely due to substantial system advantages, such as increased availability due to ride through capability , a redundant converter design, drastically improved dynamic performance, extended operating range, reduced line harmonics, and an adjustable power factor at the point of common coupling.

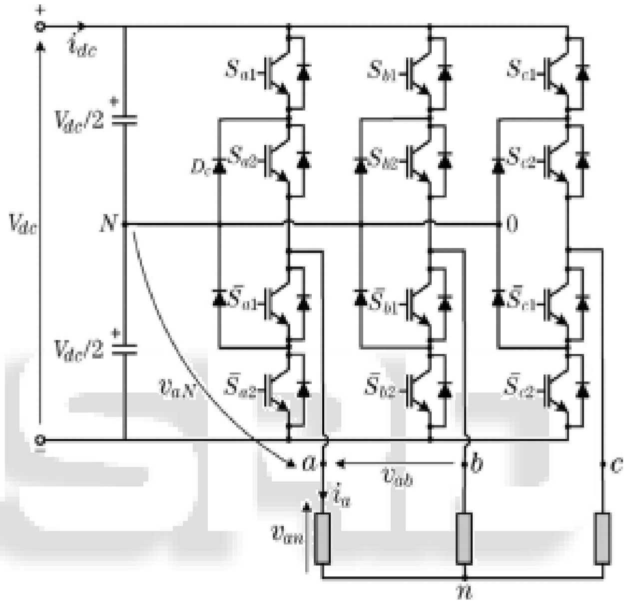


Fig. 2: Neutral Point Clamped Inverter

Figure 2 shows the power circuit of a three level diode neutral clamped inverter.

A. Advantages of NPC:

Some of the important merits of neutral clamped inverter are that it minimizes the capacitance requirement via common DC bus balancing, precharging of DC bus capacitors as group, high efficiency for fundamental frequency switching.

Adding to that, use of three level inverter has several remarkable features such as the converter can operate grid friendly by means of incorporation of additional sine filters. The simple inclusion of specific options like brake choppers or dv/dt on the machine or transformer side causes extraordinarily high flexibility. An excellent dynamic behavior can be attained through advanced control techniques like vector control or DTC for applications with very high dynamic requirements, i.e., rolling mill.

IV. Proposed System

An outline of the proposed system is as shown in figure 3.

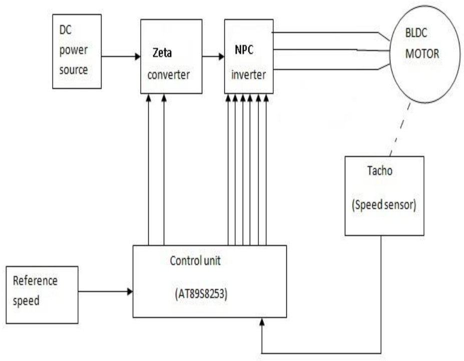
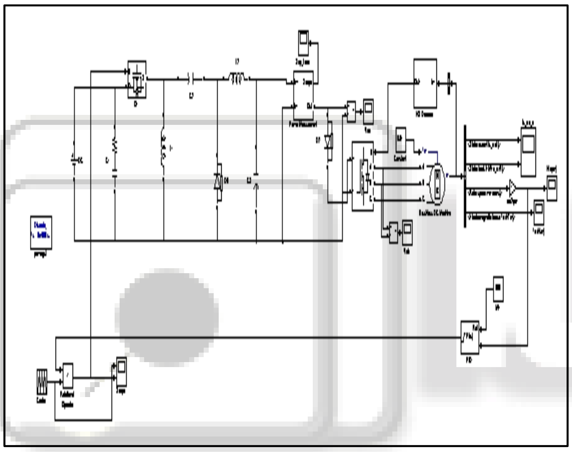


Fig. 3: Proposed Topology

It consists of a DC power source, a zeta converter, a NPC inverter, an microprocessor (ATMEL -AT89S8253) unit and a BLDC motor.

V. SIMULINK MODEL

The Simulink model of the proposed scheme is shown in fig 4.



It consists of a zeta converter for providing constant dc bus voltage across the inverter input side, then a neutral point clamped three phase inverter configuration for the purpose of reducing the torque ripples, a decoder subsystem of the hall sensor signals of the bldc motor, a bldc motor module and a PID controller as feedback loop for speed regulation.

VI. SIMULATION RESULTS

The output waveforms obtained from the simulink model designed in MATLAB/Simulink-13as shown in figure 5.

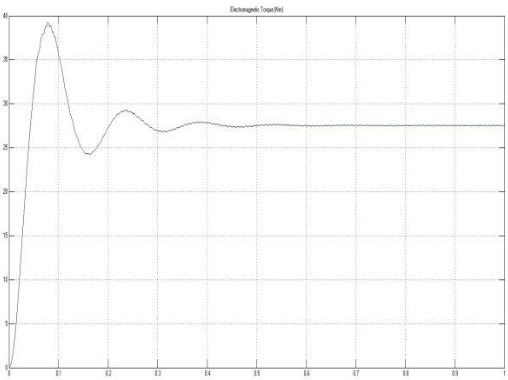


Fig. 5: DC Bus Volyage Waveform

The zeta converter has performed a boost operation and has provided a constant DC bus voltage that settles at a value of 28V in about 0.4 seconds.

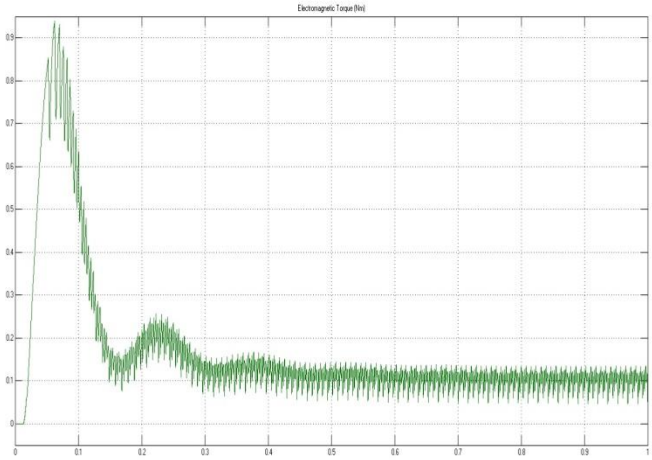


Fig. 6: Torque Waveform

The above waveform shows the torque output obtained. It depicts that the system obtains a constant torque of 0.18 Nm in 0.4 seconds.

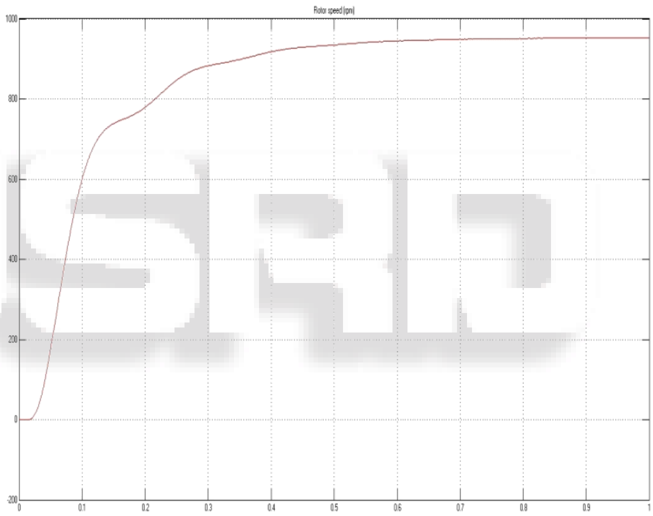


Fig. 7: Speed Waveform

The system is also observed to have a constant speed of 950 rps which is higher than the rated speed of the motor(700 rps), in the same 0.4 seconds.

Fig. 8: Stator current and Back EMF waveforms

These are the respective waveforms showing the stator current and back EMF of the BLDC motor.

VII. HARDWARE SETUP

The experimental setup of the proposed system is as shown in figure 9. It consists of an inverter board, zeta converter and the bldc motor. The sensors are held below the motor and the tacho unit feeds back the signal to the controller. There is a DC power source of 12V feeding the zeta converter. The output voltage which is either lower(buck operation) or higher (boost operation) is given to the inverter circuit which is used to feed the BLDC motor. The actual speed of the motor is sensed using a tacho circuit and is given to the controller(AT89S8253). Based on the algorithm coded in the controller, it generates the gating pulses. These are given to the switches to the converter and the neutral point clamped inverter.

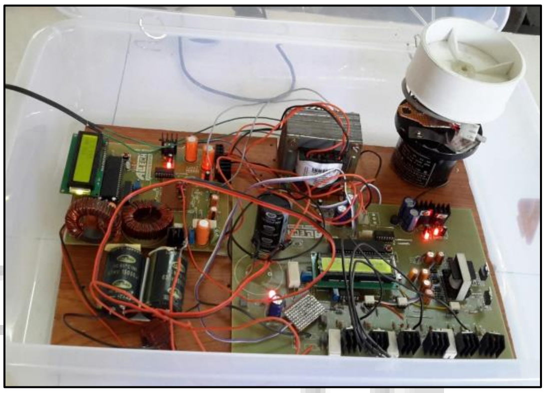


Fig. 9: Hardware Setup

The controller used in the system is AT89S8253. This is a 40-pin chip, which contains four input/output ports, 250 bit RAM,8 Kbytes of PROM.

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