Power Factor Improvement and Torque Ripple Minimization in BLDC Motor using Zeta Converter

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Abstract:

This paper presents a comparative analysis of speed control of brushless DC motor (BLDC) drive fed with conventional voltage source inverter (VSI). The performance of the drive system is successfully evaluated using MPC (model predictive control) based speed controller. The control structure of the proposed drive system is described. The speed and torque characteristic of conventional two-level inverter is compared with the VSI for various operating conditions. The VSI are simulated using IGBT's and the mathematical model of BLDC motor has been developed in MATLAB/SIMULINK environment. The simulation results show that the MPC based speed controller eliminate torque ripples and provides fast speed response. The developed MPC Logic model has the ability to learn instantaneously and adapt its own controller parameters based on disturbances with minimum steady state error, overshoot and rise time of the output voltage.

Methods/Analysis:

According to the reference values we give to the zeta converter, Operation of zeta converter has two modes of conduction mode are Continuous and discontinuous conduction modes. In order to minimize the torque ripples most methods are complicated and do not consider the stator flux lin kage control, therefore, possible high -speed operations are not feasible. In this project a simple approach to achieve a low frequency torque ripple-free direct control with maximu m efficiency is presented**.** Simu lation results are presented using MATLAB software.

Keywords: Brushless dc (BLDC) motor, discontinuous conduction mode (DCM), isolated zeta converter, power factor correction (PFC), power quality, voltage source inverter (VSI).

I. INTRODUCTION

Efficiency and cost are the major concerns in the development of low-power motor d rives targeting household applications such as fans, water pumps, blowers, mixers, etc The use of the brushless direct current (BLDC) motor in these applications is becoming very common due to features of high efficiency, high flu x density per unit volume, low maintenance requirements, and low electro magnetic-interference problem. These BLDC motors are not limited to household applications, but these are suitable for other applications such as medical equipment, transportation, HVAC, mot ion control, and many industrial tools A BLDC motor has three phase windings on the stator and permanent magnets on the rotor.

The BLDC motor is also known as an electronically co mmutated motor because an electronic commutation based on rotor position is used rather than a mechanical co mutation which has disadvantages like sparking and wear and tear of brushes and commutator assembly. Many topologies of the single-stage PFC converter are reported in the literature which has gained importance because of high efficiency as compared to t wo-stage PFC converters due to low component count and a single switch for dc link voltage control and PFC operation. The choice of mode of operation of a PFC converter is a critical issue because it directly affects the cost and rating of the components used in the PFC converter.

The continuous conduction mode (CCM) and discontinuous conduction mode (DCM) are the two modes of operation in which a PFC converter is designed to operate In CCM, the current in the inductor or the voltage across the intermediate capacitor remains continuous, but it requires the sensing of two voltages (dc link voltage and supply voltage) and input side current for PFC operation, which is not cost-effective. On the other hand, DCM requires a single voltage sensor for dc link voltage control, and inherent PFC is achieved at the ac mains, but at the cost of higher stresses on the PFC converter switch; hence, DCM is preferred for lo w-power applicat ions. The conventional PFC scheme of the BLDC motor drive ut ilizes a pulse width-modulated voltage source inverter (PWM-VSI) for speed control with a constant dc link vo ltage. This offers higher switching losses in VSI as the switching losses increase as a square function of switching frequency. As the speed of the BLDC motor is directly proportional to the applied dc link voltage, hence, the speed control is achieved by the variable dc lin k voltage of VSI. This allows the fundamental frequency switching of VSI (i.e., electronic commutation) and offers reduced switching losses.

II. Block diagram and its description

AC Input of 270V 50Hz supply is given to Diode Bridge Rectifier and DC output is connected to input of zeta converter where it is dc-dc converter and buck boost converter. The Dc-Dc voltage is connected to the voltage source inverter. From VSI to BLDC motor this BLDC motor we can know speed torque characteristics of BLDC Motor. The speed of the BLDC motor is sensed by the hall sensors from the rotor and those signals are converted into phase signals by electronic commutation. The reference voltage is compared to the voltage at zeta converter. The carrier signal and reference signal is compared in PWM Generator.

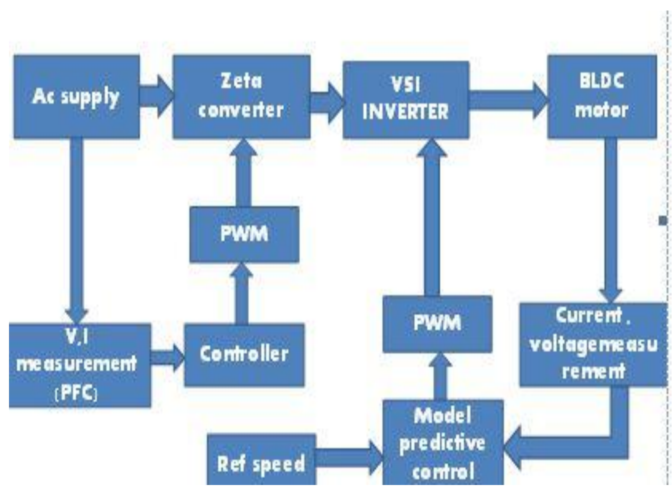

Fig:1 Block diagram of power factor improvement and torque ripple minimization in BLDC motor using Zeta converter

III. The Main blocks are

Voltage Source Inverter: The above losses are reduced by Voltage Source Inverter(VSI) in fundamental frequency switching by electronically co mutating the BLDC motor. Moreover, the speed is controlled by varying the dc link voltage of VSI. This reduces the switching losses of VSI and eliminates the requirement of current sensors for PWM based current control of BLDC motor for speed control.

Isolated Zeta Converter: The improved power factor and closed loop speed control of PMBLDCM using closed loop Zeta converter are proposed. In the proposed model, a closed loop zeta converter is used for active Power Factor Correct ion as well as for voltage regulation. It is having advantages of being naturally isolated structure, can operate as both step-up and step-down voltage converter and having a single stage processing for both voltage regulation and power factor correction. The wide range of speed control of PMBLDC motor is achieved by controlling the voltage of DC link capacitor of zeta converter. An active power factor correction is performed by using a zeta converter operating in Continuous Conduction Mode (CCM), where the inductor current must follow a sinusoidal voltage waveform. In addition to this, the sensor less scheme of feedback control is implemented in PM BLDC motor which reduces the usage of Hall position sensors. This method provides nearly unity power factor and also the implemented scheme improves the power factor and wide range of speed control of Permanent Magnet Brushless DC (PM BLDC) motor.

IV.Mode 1: Continuous conduction mode

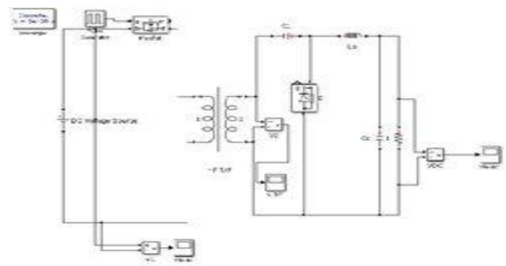

Fig:2 Continuous conduction mode

Output for Continuous conduction mode

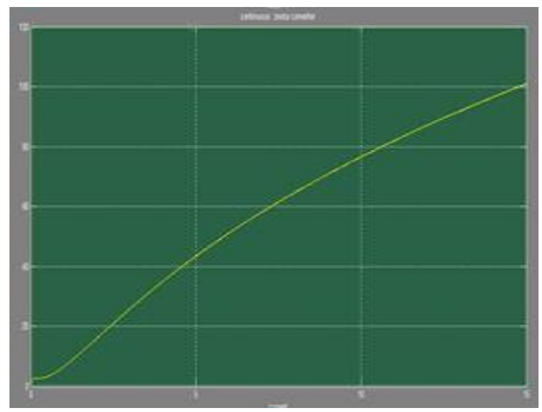

Fig:3 output for Continuous conduction mode

V. Mode 2: Discontinuous conduction mode

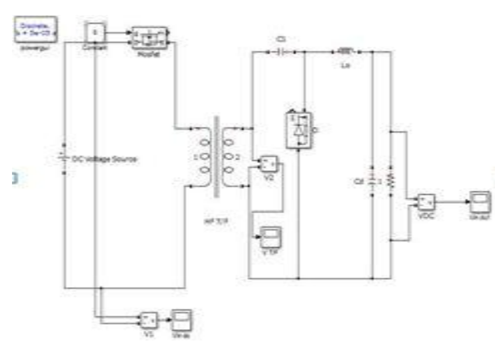

Fig: 4 Discontinuous conduction mode

Output for Continuous conduction mode

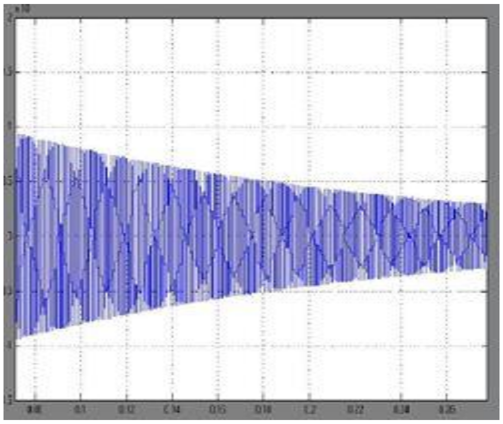

Fig: 5 output for Discontinuous conduction mode

BLDC Motor: A typical brushless motor has permanent magnets which rotate around a fixed armature, eliminating problems associated with connecting current to the moving armature. An electronic controller rep laces the brush/commutator assembly of the brushed DC motor, which continually switches the phase to the windings to keep the motor turning. The controller performs similar timed power distribution by using a solid -state circuit rather than the brush/commutator system.

Hysteresis current controller: A novel hysteresis current control for active power filter (APF) is suggested which is based on optimal voltage vector and in the meantime with constant switching frequency. In the method the location region of the reference voltage vector is detected quickly by a set of hysteresis comparators through one try-and-error process. Two appropriate switches are then selected to control the corresponding two line - to-line currents independently with constant switching frequency. The new method has the advantages of fast allocation of reference voltage space vector, good current tracking accuracy, and constant switching frequency. Therefore, it is efficient and safe in operation.

VI. Simulation and its Results

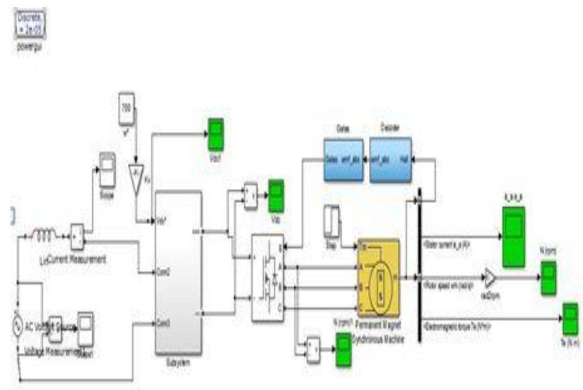

Fig: 6 simulation block diagram of Zeta converter.

Output

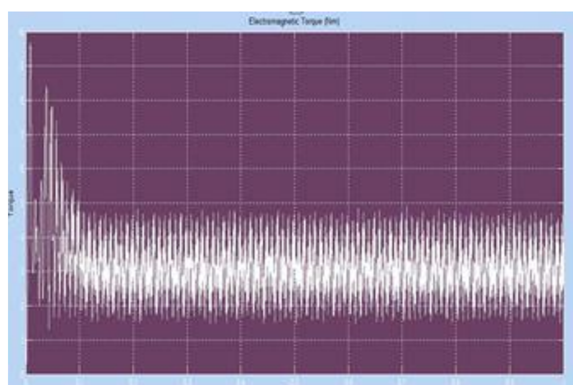

Fig: 7 output for simulation block diagram of Zeta converter.

VII. Conclusion:

- comparing both the simulation results ripple minimization is clearly shown in Isolated Zeta Converter for BLDC Motor Control using Hysteresis Current Controller.

- As in Hysteresis Current Controller Stating with high torque ripples are reduced and stabilizes within the range of 0 to 2Nm.

- Two appropriate switches are used to control the corresponding two line-to-line currents independently with constant switching frequency.

VIII. References:

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