AN ADJUSTABLE SPEED PFC BRIDGELESS BUCK BOOST CONVERTER FED BLDC MOTOR DRIVES WITH SIX SWITCH VSI INVERTER

A. Anitha¹, S. Kamachi²

¹PG Scholar, Department of Electrical and Electronics Engineering, Dhanalakshmi Srinivasan College of Engineering & Technology, Chennai.
²Assistant Professor, Department of Electrical and Electronics Engineering, Dhanalakshmi Srinivasan College of Engineering & Technology, Chennai

Abstract: This paper presents a power factor corrected (PFC) bridgeless (BL) Sepic converter-fed brushless direct current (BLDC) motor with multi drive option as a cost-effective solution for low-power application. An approach of speed control of the BLDC motor by controlling the dc link voltage of the voltage source inverter (VSI) is used with a single voltage sensor. A BL configuration of the Sepic converter is proposed which offers the elimination of the diode bridge rectifier, thus reducing the conduction losses associated with it. A PFC BL Sepic converter is designed to operate in discontinuous inductor current mode (DICM) to provide an inherent PFC at ac mains.

Index Terms—Bridgeless (BL) buck-boost converter, brushless direct current (BLDC) motor, discontinuous inductor current mode (DICM), power factor corrected (PFC), power quality.

1. INTRODUCTION

Efficiency and cost are the major concerns in the development of low-power motor drives 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 flux density per unit volume, low maintenance requirements, and low electromagnetic-interference problem. These BLDC motors are not limited to household applications, but these are suitable for other applications such as medical equipment, transportation, HVAC, motion 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 commutated motor because an electronic commutation based on rotor position is used rather than a mechanical commutation which has disadvantages like sparking and wear and tear of brushes and commutator assembly.

Brushless DC electric motor (BLDC motors, BL motors) also known as electronically commutated motors (ECMs, EC motors) are synchronous motors that are powered by a DC electric source via an integrated inverter/switching power supply, which produces an AC electric signal to drive the motor. In this context, AC, alternating current, does not imply a sinusoidal waveform, but rather a bi-directional current with no restriction on waveform. Additional sensors and electronics control the inverter output amplitude and waveform (and therefore percent of DC bus usage/efficiency) and frequency (i.e. rotor speed).

The rotor part of a brushless motor is often a permanent magnet synchronous motor, but can also be a switched reluctance motor, or induction motor [citation needed].
Brushless motors may be described as stepper motors; however, the term stepper motor tends to be used for motors that are designed specifically to be operated in a mode where they are frequently stopped with the rotor in a defined angular position. This page describes more general brushless motor principles, though there is overlap. Two key performance parameters of brushless DC motors are the motor constants $K_v$ and $K_m$.

Electrical equipment often has at least one motor used to rotate or displace an object from its initial position. There are a variety of motor types available in the market, including induction motors, servomotors, DC motors (brushed and brushless), etc. Depending upon the application requirements, a particular motor can be selected. However, a current trend is that most new designs are moving towards Brushless DC motors, popularly known as BLDC motors.

2. PROPOSED BLDC MOTOR DRIVE WITH BL BUCK–BOOST CONVERTER

The proposed BL buck–boost converter-based VSI-fed BLDC motor drive is shown in the fig. The parameters of the BL buck–boost converter are designed such that it operates in discontinuous inductor current mode (DICM) to achieve an inherent power factor correction at ac mains. The speed control of BLDC motor is achieved by the dc link voltage control of VSI using a BL buck–boost converter. This reduces the switching losses in VSI due to the low frequency operation of VSI for the electronic commutation of the BLDC motor. The performance of the proposed drive is evaluated for a wide range of speed control with improved power quality at ac mains.

![Fig.1 Proposed BLDC motor drive with BL buck–boost converter](image-url)
3. SIMULATION DIAGRAM

The MATLAB-Simulink model of the BLDC Motor drive with BL Buck-Boost converter fig. 2. As shown in the MATLAB-Simulink circuit, a total of 9 MOSET’s are used and each MOSET is given separate pulses via the pulse generator block present in MATLAB.

![Fig.2 Simulation Diagram](image)

4. RESULTS AND DISCUSSION

The performance of the proposed BLDC motor drive is simulated in MATLAB/Simulink environment using the Sim-Power-System toolbox. The performance evaluation of the proposed drive is categorized in terms of the performance of the BLDC motor and BL buck-boost converter and the achieved power quality indices obtained at ac mains.

![Fig.3 BLDC Output Stator Current](image)
4.1 Steady-State Performance

The steady-state behavior of the proposed BLDC motor drive for two cycles of supply voltage at rated condition (rateddc link voltage of 200 V). The discontinuous induc- tor currents (iLi1 and iLi2) are obtained, confirming the DICM operation of the BL buck–boost converter. The performance of the proposed BLDC motor drive at speed control by varying dc link voltage from 50 to 200 V is tabulated in Table III. The harmonic spectra of the supply current at rated and light load conditions, i.e., dc link voltages of 200 and 50 V which shows that the THD of supply current obtained is under the acceptable limits of IEC 61000-3-2.

4.2 Dynamic Performance of Proposed BLDC Motor Drive

The dynamic behavior of the proposed drive system during a starting at 50 V, step change in dc link voltage from 100 to 150 V, and supply voltage change from 270 to 170 V. A smooth transition of speed and dc link voltage is achieved with a small overshoot in supply current under the acceptable limit of the maximum allowable stator winding current of the BLDC motor.
5. COMPARATIVE ANALYSIS

5.1 Comparison on Basis of Losses and Efficiency

The losses in the complete BLDC motor drive are classified as losses in various sections such as DBR, PFC converter, VSI, and the BLDC motor. The losses in different parts of the BLDC motor are measured for three different configurations of the BLDC motor drive. The losses in two conventional schemes of the BLDC motor drive are higher in VSI due to the use of PWM-based switching of VSI which increases the switching losses in the system. The conventional scheme of the BLDC motor drive with PFC has the lowest efficiency due to the high amount of losses in the VSI as well as in the DBR and PFC converter.

5.2 Comparison on Basis of Power Quality

The harmonic distortion in a conventional scheme of the DBR-fed BLDC motor drive is as high as 80%–100%, which is not a recommended solution as per the guidelines of IEC 61000-3-2 [7]. The power quality will be increased.

6. CONCLUSIONS

A PFC BL Sepic converter-nine switch based VSI-fed BLDC motor drive has been proposed targeting low-power applications. A new method of speed control has been utilized such as hysteresis control and by controlling the voltage at dc bus and operating the VSI at fundamental frequency for the electronic commutation of the BLDC motor for reducing the switching losses in VSI.

7. FEATURES

- Switching losses and Conduction losses are reduced.
- Power factor is improved.
- Power quality will be high.
- Sensorless control is possible.

REFERENCES


4. E. Afjei*, O. Hashemipour, M. A. Saati and M. M. Nezamabadi “A New Hybrid Brushless Dc Motor/Generator without Permanent Magnet”IEEE. Received: July 31, 2006 – Accepted in Revised Form: March 18 2007


