

A Peer Reviewed Open Access International Journal

An Adjustable speed PFC and Torque Ripple Reduction Using Bridgeless Buck-Boost Converter Fed HCC BLDC Motor Drive

G.Sree Lakshmi

M.Tech Student Scholar, Department of Electrical & Electronics Engineering, Kottam Karunakar Reddy Institute of Technology, Chinna Tekur,Kallur, Kurnool (Dt), Andhra Pradesh, India.

Abstract:

The devices generally used in industrial, commercial and residential applications need to undergo rectification for their proper functioning and operation. Hence there is a need to reduce the line current harmonics so as to improve the power factor of the system. This has led to designing of Power Factor Correction circuits. This project presents a power factor corrected (PFC) bridgeless (BL) buck-boost converter-fed brushless direct current (BLDC) motor drive as a cost-effective solution for lowpower applications. The conventional PFC scheme of the BLDC motor drive utilizes a pulse width-modulated voltage source inverter (PWM-VSI) for speed control with a constant dc link voltage. This offers higher switching losses in VSI as the switching losses increase as a square function of switching frequency. A BL configuration of the buck-boost converter is proposed which offers the elimination of the diode bridge rectifier, thus reducing the conduction losses associated with it. A PFC BL buckboost converter is designed to operate in discontinuous inductor current mode (DICM) to provide an inherent PFC at ac mains. The simulation results are presented by using Matlab/Simulink software.

Keywords:

Bridgeless (BL) Buck–Boost Converter, Brushless Direct Current (BLDC) Motor, Power Factor Corrected (PFC) and Hysteresis Current Controller (HCC).

I. INTRODUCTION:

The conventional PFC scheme of the BLDC motor drive utilizes a pulse width-modulated voltage source inverter (PWM-VSI) for speed control with a consistent dc link voltage. This offers higher switching losses in VSI while the switching losses increase as a square function of switching frequency.

S.Chandra Sekhar

Assistant Professor, Department of Electrical & Electronics Engineering, Kottam Karunakar Reddy Institute of Technology, Chinna Tekur,Kallur, Kurnool (Dt), Andhra Pradesh, India.

While the speed of the BLDC motor is directly proportional to the applied dc link voltage, hence, the speed control is accomplished by the variable dc link voltage of VSI. This enables the fundamental frequency switching of VSI (i.e., electronic commutation) and offers reduced switching losses. Singh and Singh have proposed a buck-boost converter feeding a BLDC motor on the cornerstone of the idea of constant dc link voltage and PWM-VSI for speed control which includes high switching losses. A single-ended primary-inductance converter (SEPIC)-based BLDC motor drive has been proposed by Gopalarathnam and Toliyat but has higher Losses in VSI as a result of PWM switching and an elevated level of current and voltage sensors which restricts its applicability in low-cost application. Singh and Singh have proposed a Cuk converter-fed BLDC motor drive with the idea of variable de link voltage.

This reduces the switching losses in VSI as a result of fundamental switching frequency operation for the electronic commutation of the BLDC motor and to the variation of the speed by controlling the voltage at the dc bus of VSI. For further improvement in efficiency, bridgeless (BL) converters are employed which permit the elimination of DBR in the front end. A buck-boost converter configuration is most effective among various BL converter topologies for applications requiring a wide selection of dc link voltage control (i.e., bucking and boosting mode). Jang and Jovanovi'c and Huber et al. have presented BL buck and boost converters, respectively. These may provide the voltage buck or voltage boost which limits the operating selection of dc link voltage control. Wei et al. have proposed a BL buck-boost converter but use three switches which will be not a cost-effective solution. A fresh group of BL SEPIC and Cuk converters has been reported in the literature but takes a large quantity of components and has losses connected with it. This paper presents a BL buckboost converter-fed BLDC motor drive with

Volume No: 3 (2016), Issue No: 2 (February) www.ijmetmr.com February 2016 Page 161



A Peer Reviewed Open Access International Journal

variable dc link voltage of VSI for improved power quality at ac mains with reduced components. In this paper after closed loop speed control done by using voltage controller finally the hysteresis current controller loop is added with current feedback loop and it is observed that there is a reduction in the current ripple hence torque ripple are minimized. Simulation analysis has been done to shows that current ripple and torque ripple are minimized which enhance the performance of the drive.

II. PROPOSED SYSTEM:

The proposed BL buck-boost converter based VSI fed BLDC motor drive is shown in fig.1. The parameters of the BL buck-boost converter are made such that it operates in discontinuous inductor current mode (DICM) to attain an inherent power factor correction at ac mains. The speed control of BLDC motor is accomplished by the dc link voltage control of VSI using a BL buck-boost converter. This reduces the switching losses in VSI because of the low frequency operation of VSI for the electronic commutation of the BLDC motor.



Fig.1.Block diagram of PFC BL Buck-boost converter-fed BLDC motor drive without Hysteresis current controller.

In the proposed arrangement of bridgeless buck help converter has the base number of parts and slightest number of conduction gadgets amid every half cycle of supply voltage which administers the decision of BL buck boost converter for this application. The operation of the PFC bridgeless buck-help converter is ordered into two parts which incorporate the operation amid the positive and negative half cycles of supply voltage and amid the complete exchanging cycle.

A.Operation during Positive and Negative Half Cycle of Supply Voltage:

In this mode converter switches Sw1 and Sw2 are work in positive and negative half cycle of supply voltage individually. A mid positive half cycle switch SW1, inductor Li1 and diodes D1 and D2 are worked to exchange vitality to DC link capacitor Cd. Thus in negative half cycle of supply voltage switches Sw2, inductor Li2 and diode D2 In discontinuous Inductor Current Mode(DICM) operation of converter the present in the inductor Li gets to be irregular for certain term in an exchanging period.

B. Operation during Complete Switching Cycle:

In this exchanging cycle there are two methods of operation.

Mode I:

In this mode, switch Sw1 conducts for charging the inductor Li1, thus the inductor current iLi1 increments in this mode. Diode D 1 finishes the information side and the DC link capacitor Cd is released by VSI nourished BLDC motor.



Fig.2: mode 1 operation.

Mode II: In this method of operation switch Sw1 is killed furthermore, the put away vitality from the inductor Li1 is exchanged to DC link capacitor Cd till the inductor is completely released furthermore, current in the inductor is completely lessened to zero.



Fig.3.:mode 2 operation.

Volume No: 3 (2016), Issue No: 2 (February) www.ijmetmr.com



A Peer Reviewed Open Access International Journal

III.HYSTERESIS CURRENT CONTROL OF INVERTER:



Fig.4: Hysteresis Current controlled Inverter fed BLDC drive.

Fig.4 shows the block diagram of hysteresis current controller which will generate the gating signals for inverter. The input currents, ia, ib, ic are measured and compared with the reference currents, ia*, Ib*, Ic*. The error is fed to a comparator with a prescribed hysteresis band. Switching of the power semiconductor devices (S1 ON and S2 OFF) occurs when the current attempts to exceed a set value corresponding to the desired current. The reverse switching (S1 OFF and S2 ON) occurs when the current attempts to become less than iaref . Hysteresis controller is simple to implement and produces a very good quality of waveform. The drawback of this method is that the switching frequency does not remain constant but varies along different portions of the desired current.



Fig.5:Iref and Iact given to Hysteresis current control

The switching pattern is given as:

If $\Delta Ia > H$, S1 is on and S2 is off. If $\Delta Ia < L$, S1 is off and S2 is on. If $\Delta Ib > H$, S3 is on and S4 is off. If $\Delta Ib < L$, S3 is off and S4 is on. If $\Delta Ic > H$, S5 is on and S6 is off. If $\Delta Ic < L$, S5 is off and S6 is on.



Fig.6: Hysteresis Band switching.

This means that only one of the switching devices can be on at any given time. However, the switching frequency in the HCC method is not constant.HCC technique is based on minimizing the error between reference and actual current. The technique adaptively adjusts the phase-current waveform to maintain ripple less electromagnetic torque, so that commutation torque ripples, particularly at high rotational speeds, are effectively eliminated. With the implementation of the proposed hysteresis current controller loop with current feedback loop and it is observed that there is a reduction in the current ripple hence torque ripple are minimized. Simulation analysis has been done to shows that current ripple and torque ripple are minimized which enhance the performance of the drive.

IV. MATLAB/SIMULINK RESULTS: Case I: Implementation of BLDC with Power factor correction and without Hysteresis current controller.



Fig.7.Simulink circuit for proposed BLDC drive with bridgeless buck boost converter without Hysteresis Current Controller.

Volume No: 3 (2016), Issue No: 2 (February) www.ijmetmr.com February 2016 Page 163



A Peer Reviewed Open Access International Journal



Fig.8.Siumulation results for source voltage, current, dc link voltage, and speed, torque, stator current of BLDC motor under steady state performance.



Fig.9.Simulation results for iLi1, iLi2, Vsw1, isw1, Vsw2, isw2 of PFC converter under steady state performance



Fig.10: harmonic spectra of PFC BLDC drive using buck-boost converter.



Fig.11.Simulation result of proposed system under dynamic performance during starting condition



Fig.12:Simulation result of dynamic performance of proposed system during Speed control condition.



A Peer Reviewed Open Access International Journal



Fig.13:Simulation result of dynamic performance of proposed system during supply voltage variation.

Case II: Implementation of the Inverter fed BLDC with Hysteresis current controller.



Fig.14: Simulink Circuit for Proposed System using Hysteresis Current Control.



Fig.15: Control strategies for hysteresis current control.



Fig.16: harmonic spectra of current control and PFC BL- buck boost converter fed BLDC motor drive.



Fig.17Siumulation results for source voltage, current, dc link voltage, and speed, torque, stator current of BLDC motor under hysteresis current control.



Fig.18:Simulation results for iLi1, iLi2, Vsw1, isw1, Vsw2, isw2 of PFC converter under hysteresis current control.

Volume No: 3 (2016), Issue No: 2 (February) www.ijmetmr.com



A Peer Reviewed Open Access International Journal

V. CONCLUSION:

The dynamic characteristics of the brushless DC motor such as speed, torque, current and voltage of the inverter components are observed and analyzed using the developed MATLAB model. Proposed hysteresis current controller system has a good adaptability and strong robustness whenever the system is disturbed. The simulation model which is implemented in a modular manner with HCC under MATLAB environment allows dynamic characteristics such as phase currents, rotor speed, and mechanical torque ripple has been effectively reduced.

REFERENCES:

 G. Sakthival, T.S. Anandhi and S.P. Natarjan.
2010. Real time implementation of DSP based Fuzzy logic controller for Speed control of BLDC motor. International Journal of Co mputer Applications (0975 - 8887). 10(8).

[2] K. Naga Sujatha, K. Vaisakh and Anand. G. 2010. Artificial Intelligence based speed control of brushless DC motor. IEEE 978- 1- 4244- 6551-4/10. [3] 2003. AN885 - Brushless DC (BLDC) Motor Fundamentals. Microchip Technology Inc.

[4] R. Akkaya, A.A. Kulaksız, and O Aydogdu, DSP implementation of a PV system with GA -MLP- NN based MPPT controller supplying BLDC motor drive, Energy Conv. and Management 48, 210 -218, 2007.

[5]. P. Pillay and R. Krishnan, Modeling, simulation, and analysis of permanent -magnet motor drives, part II: the brushless DC motor drive, IEEE Trans. on Industry Applications 25, 274–279, 1989.

[6]. P.D. Evans and D. Brown, Simulation of brushless DC drives, Proc. of the IEE 137, 299–308, 1990.

[7]. R. Carlson, M. Lajoie -Mazenc, and C.D.S. Fagundes, Analysis of torque ripple due to phase commutation in brushless DC machines, IEEE Trans. on Industry Applications 28, 632–638, 1992