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Minimization of Torque Ripple of Brushless DC Motor Using HCC with DC-DC Converter

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Abstract *- This paper shows the Minimization of Torque Ripple of Brushless DC Motor Using Hysteresis Current Control. The speed of the BLDC motor is controlled by varying the dc-bus voltage of a voltage source inverter (VSI) which uses a low frequency switching of VSI for low switching losses. A diode bridge rectifier followed by a DC-DC converter working in a discontinuous conduction mode (DCM) is used for control of dc-link voltage with unity power factor at ac mains. Performance of the DC-DC converter is evaluated under four different operating conditions of discontinuous and continuous conduction modes (CCM). This project deals with a DC-DC converter-fed brushless dc motor (BLDC) drive as a cost-effective solution for low-power applications. Moreover, two control strategies for BLDC motor drive have been implemented. One of the control strategies is based on DC-DC converter fed BLDCM drive and another one is Hysteresis current controller fed BLDC motor drive. Comparison has been made between the two control strategies is in terms of minimization of Torque ripple for different operating speeds. The proposed work has been implemented under MATLAB/Simulink environment.*

Keywords: *Bridgeless (BL) Buck–Boost Converter, Brushless Direct Current (BLDC) Motor, Discontinuous Inductor Current Mode (DICM), Hysteresis Current Control (HCC).*

I. INTRODUCTION

Brushless DC motor (BLDCM) has been widely used in industrial fields that require high reliability and precise control due to its simple structure, high power density, and extended speeding range. The performance of such motors has been significantly improved due to the great development of power electronics, microelectronics, magnetic performance of magnets, and motion control technology in recent years. However, commutation torque ripple, which usually occurs due to the loss of exact phase current control, has always been one major factor in preventing BLDCM from achieving high performance. So far, many studies have been performed to reduce commutation torque ripple. This paper deals with the Hysteresis Current Control is used to control the phase current and also minimized the torque ripple

of BLDCM. Brushless dc motor offer many attractive features like low maintenance, fast response, high efficiency, high power density, good reliability and compact construction. As a result, the brushless dc motor is increasingly being used in military, industrial and commercial applications. Its market is rapidly expanding. But these motors still suffer from commutation torque ripple. The primary disadvantage of brushless dc motor is higher torque ripples compared with conventional machines. So far, many research studies have been performed to reduce commutation torque ripple. This paper discusses a novel circuit topology and a dc link voltage control strategy to keep incoming and outgoing phase currents changing at the same rate during commutation. A DC – DC Bridgeless Buck Boost converter and a switch selection circuit are employed in front of the commutation circuit. In this work, a novel digital PWM controller is proposed for the BLDC motor. This controller treats the BLDC motor as a digital system. The circuit analysis involves acquiring the period of freewheeling region and the voltage value to be varied. A new torque control method for reducing the torque ripple of the BLDC motor with un-ideal back EMF waveforms is reported. The duty cycle of the corresponding switches is pre-calculated in the torque controller about the actual back EMF waveforms in both normal conduction period and commutation period. The literature describes an improved implementation of direct torque control (DTC) to the brushless DC drive. It adaptively adjusts the phase current waveform to maintain constant electromagnetic torque, so that commutation torque ripple is eliminated. An analytical study is developed concerning the torque ripple due to phase commutation on brushless dc motors. The desired dc voltage is accomplished by using the Bridgeless Buck Boost converter which is used to control the input of the inverter. MATLAB/Simulink is used to perform simulation. Cost and efficiency are considered in design of the low power motor dives which used in applications like fans, water pumps, blowers, etc. using brushless direct current (BLDC) motor in specific applications is common due to high flux density per unit volume, high efficiency, low maintenance. BLDC motors are not only applicable to household applications but also for other applications like HVAC, motion control, medical equipment, and industrial tools. The proposed converter of BLDC motor drive uses pulse-width modulated voltage source inverter (PWM-VSI) with constant dc link voltage for speed control. But, this will have high switching losses in VSI as

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losses are square of switching frequency. As speed is directly proportional to the voltage, hence speed control is done by the variable dc link voltage of VSI. So, fundamental frequency switching of VSI (i.e., electronic commutation) will have reduced switching losses.

Further improvement in efficiency we use bridgeless (BL) converter which allows elimination of the DBR in front end. Buck-boost converter is best suited among various BL converters for application which required wide range speed control. A new proposed concept with BL SEPIC and CUK converter are reported in literature but requires the large number of components and also losses in it. This thesis explains about a new concept of BL buck-boost converter fed BLDC motor with variable dc link voltage of VSI for improving power quality at ac mains.

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.

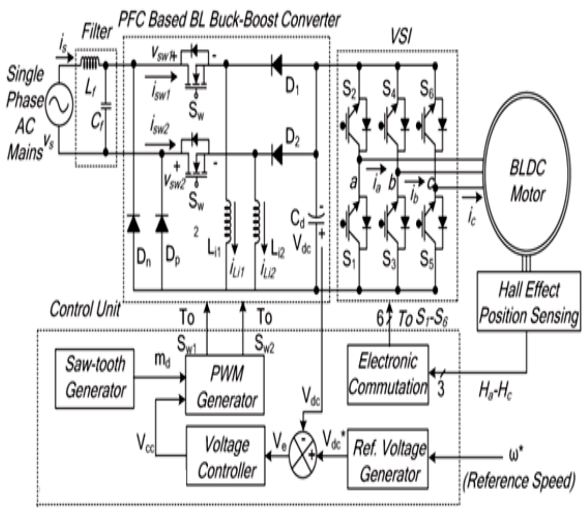

Fig.1.Block diagram of BL Buck Boost Converter-fed BLDC motor drive

In the proposed arrangement of bridgeless buck boost 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.

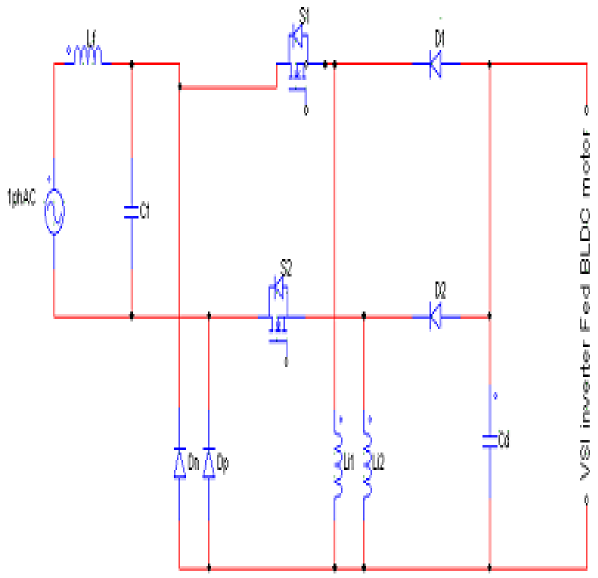

Fig.2. Proposed Circuit diagram of the Buck-boost converter fed BLDC.

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 join capacitor Cd. Thus in negative half cycle of supply voltage switches Sw2, inductor Li2 and diode D2 In Irregular 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 three 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 join capacitor Cd is released by VSI nourished BLDC engine

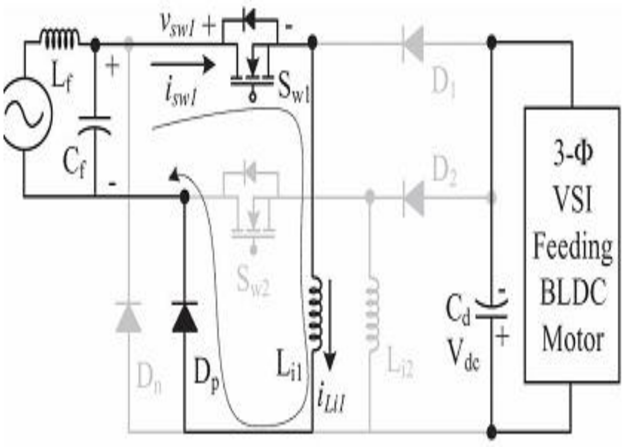

Fig.3. mode 1 operation.

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

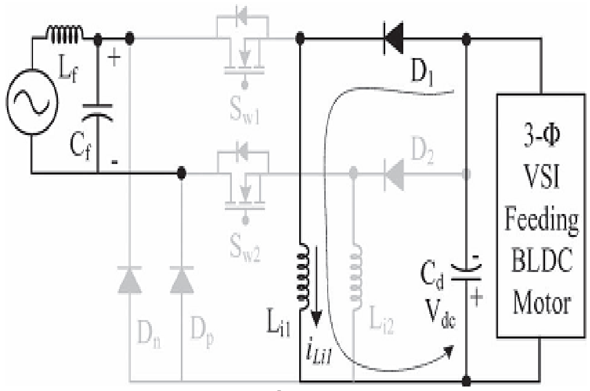

Fig.4. mode 2 operation.

Mode III: In this method of operation inductor Li1 work in intermittent conduction mode and diodes and switch are in off condition. As of now DC join capacitor Cd begins releasing. This operation can be proceeding up to switch Sw1 is turned on once more.

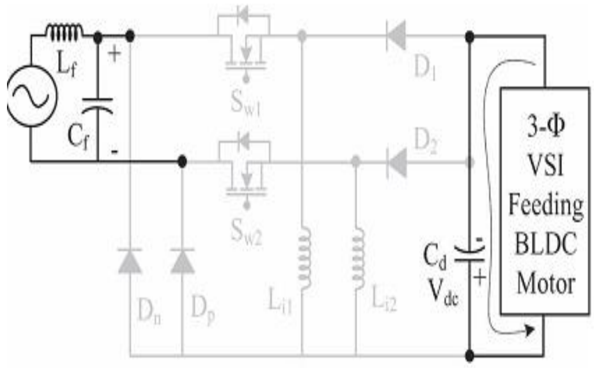

Fig.5. mode 3 operation.

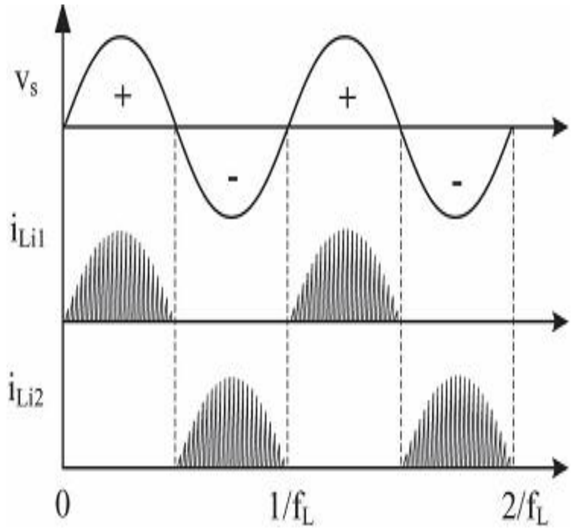

Fig.6. Waveforms for positive and negative half cycles of supply voltage.

Similarly, for the negative half cycle of the supply voltage, switchSw2, inductor Li2, and diodes DnandD2operate for voltage control and PFC operation.

III. MATLAB/SIMULINK RESULTS

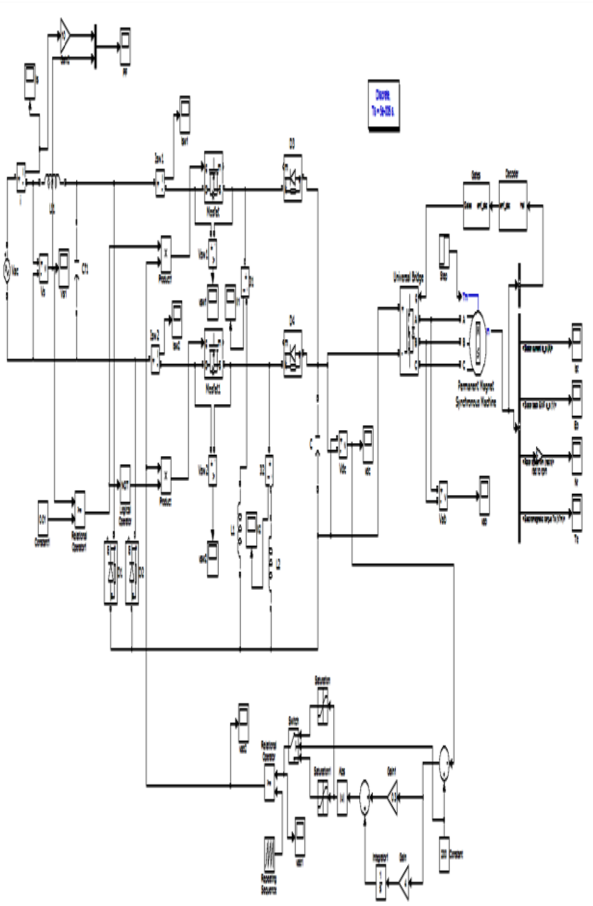

Fig.7.Simulink circuit for proposed BLDC drive with bridgeless buck boost converter.

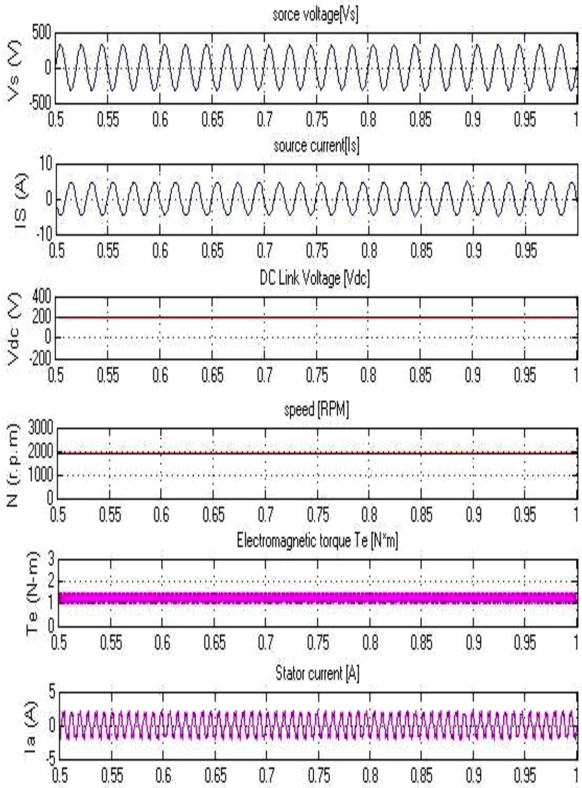

Fig.8.Siumulation results for source voltage, current, dc link voltage, and speed, torque, stator current of BLDC motor under steady state performance.

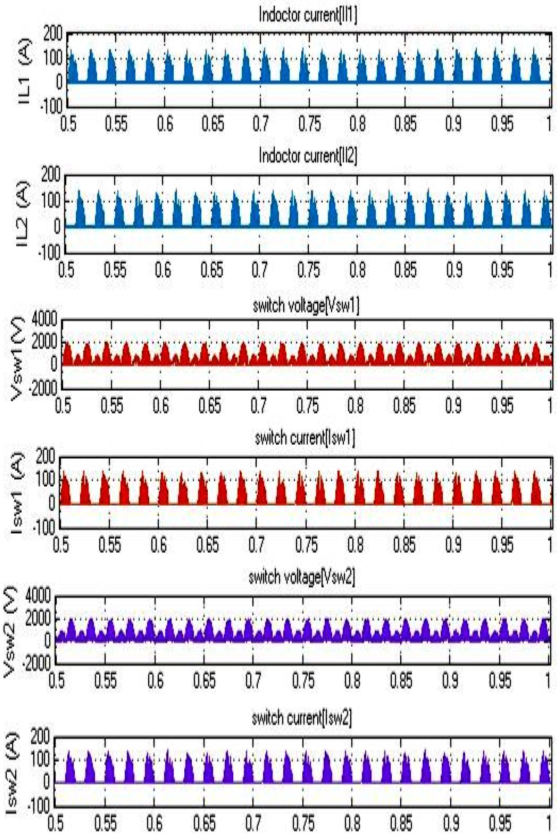

Fig.9.Simulation results for i_{Li1}, i_{Li2}, V_{sw1}, i_{sw1}, V_{sw2}, i_{sw2} of PFC converter under steady state performance

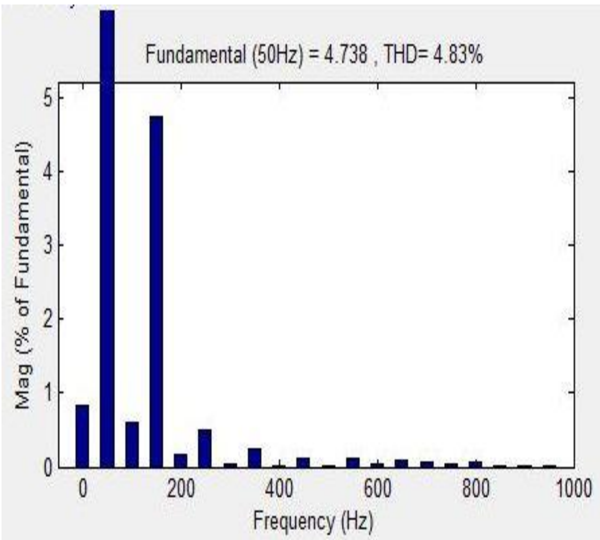

Fig.10: harmonic spectra of BLDC drive using buck-boost converter

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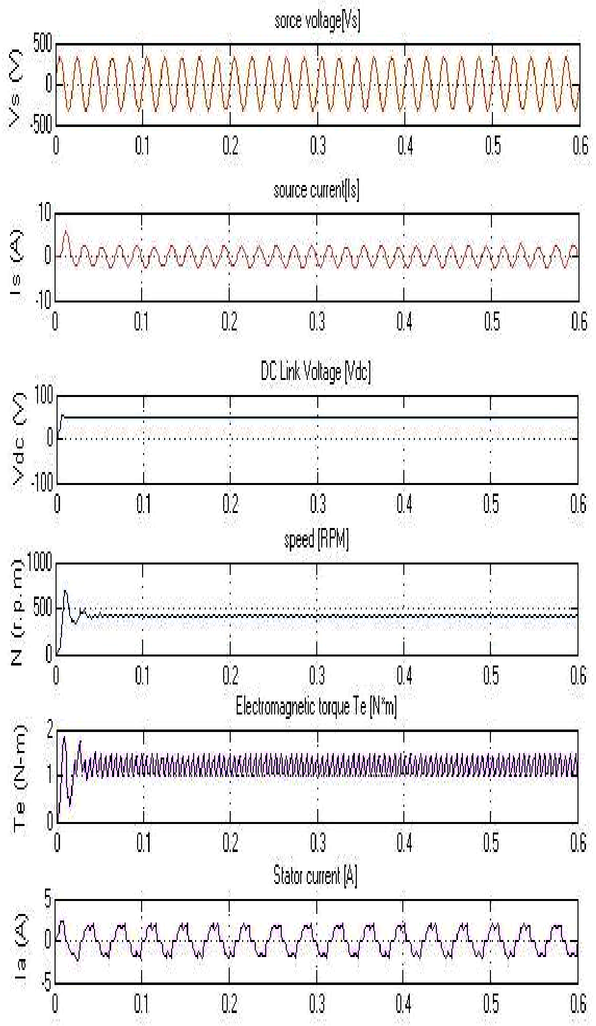

Fig.11.Simulation result of proposed system under dynamic performance during starting condition

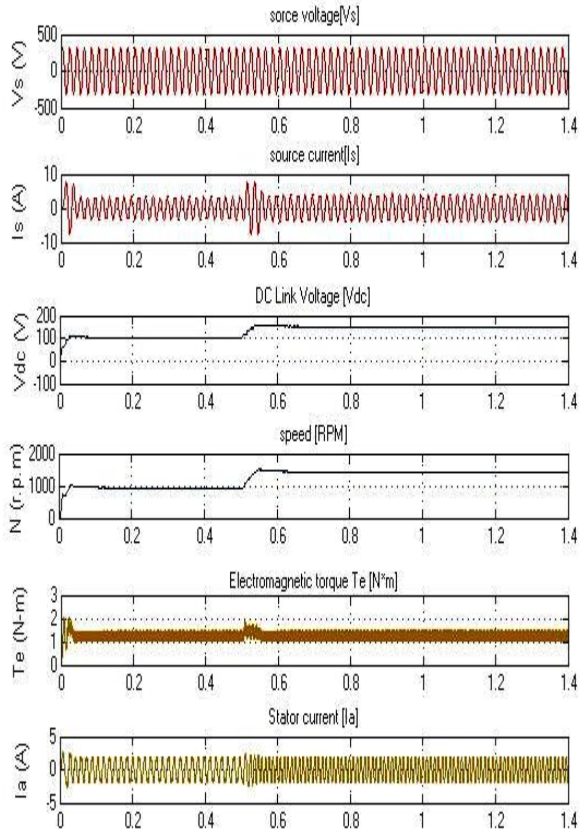

Fig.12.Simulation result of dynamic performance of proposed system during Speed control condition.

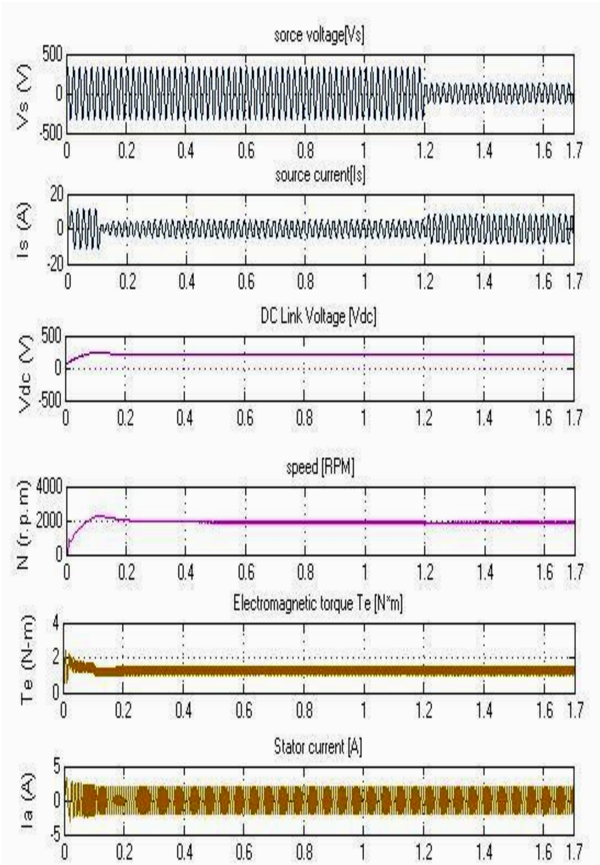

Fig.13.Simulation result of dynamic performance of proposed system during supply voltage variation.

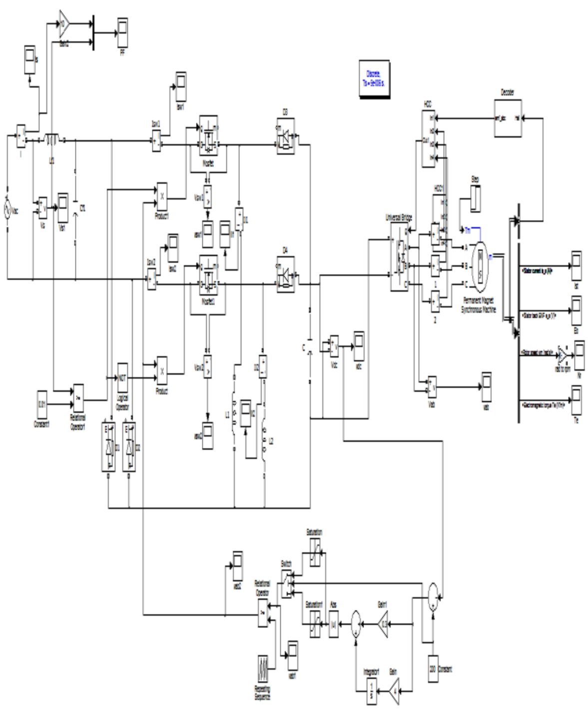

Fig.14.Simulink Circuit for Proposed System using Hysteresis Current Control.

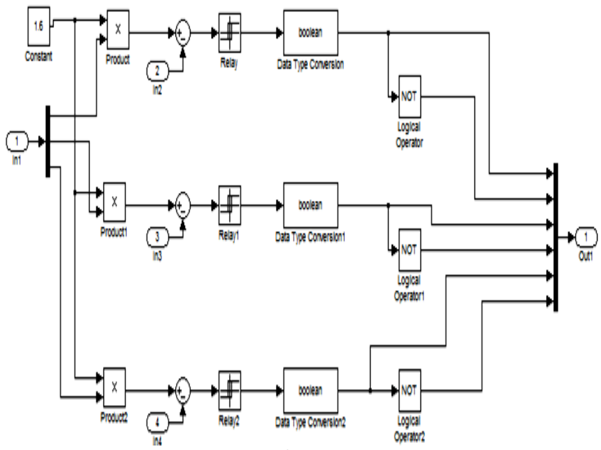

Fig.15.Control strategies for hysteresis current control.

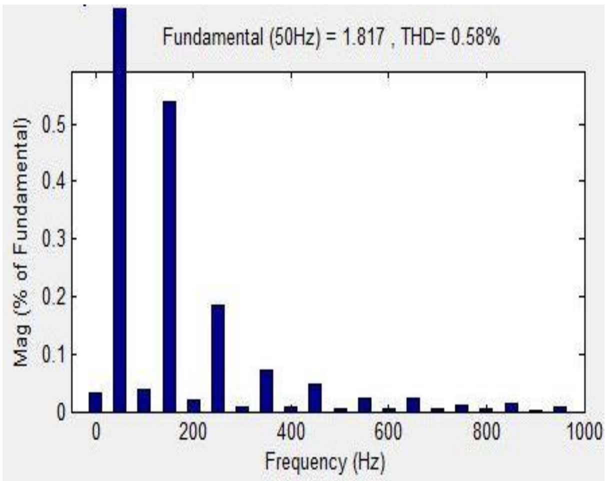

Fig.16: harmonic spectra of current control and PFC BL- buck boost converter fed BLDC motor drive.

Analysis of	WITHOUT HCC	WITH HCC
Current Harmonics	**4.83 %**	**0.58 %**
Torque Ripple	**39.04%**	**11.60%**

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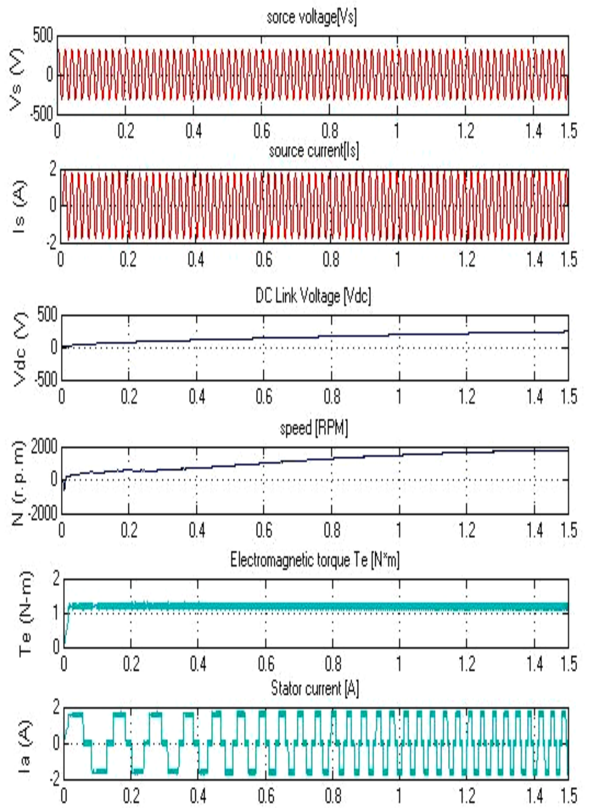

Fig.17.Siumulation results for source voltage, current, dc link voltage, and speed, torque, stator current of BLDC motor under hysteresis current control.

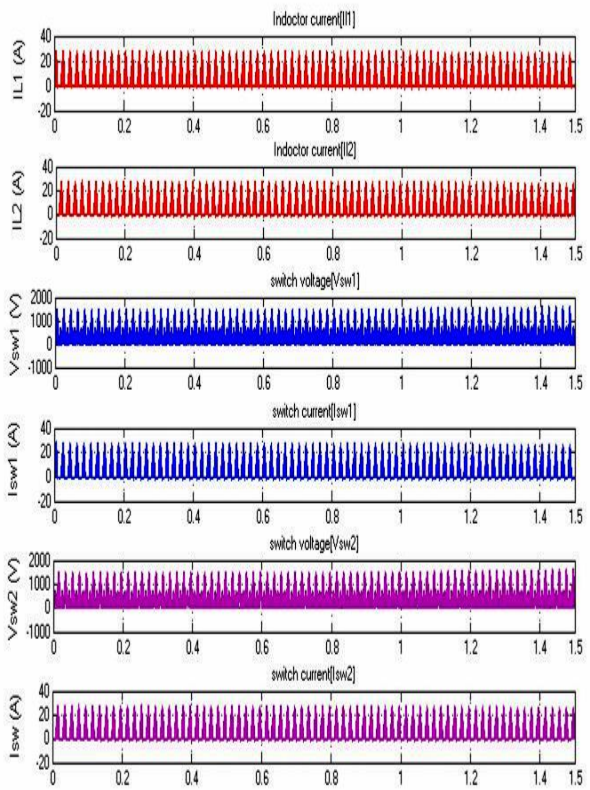

Fig.18.Simulation results for iLi1, iLi2, Vsw1, isw1, Vsw2, isw2 of PFC converter under hysteresis current control.

IV. CONCLUSION

In this paper, a torque ripple minimization method has been proposed for brushless dc motor using Hysteresis Current Control with Bridgeless Buck Boost converter. The Bridgeless Buck Boost converter is placed at the input of the commutation circuit, and the desired dc voltage is achieved through closed loop controllers. And also this system provides the regulation of speed so that torque can respond immediately. Finally the Hysteresis Current Control regulates the phase currents of BLDC motor. Hence, The proposed method can reduce the torque ripples effectively within a wide speed range. The simulated results show an improved performance of the proposed method.

Source current Harmonics and Torque Ripple of BLDC motor with and without HCC

REFERENCES

[1] Y. Chen, C. Chiu, Y. Jhang, Z. Tang, and R. Liang, “A driver for the single phase brushless dc fan motor with hybrid winding structure,”IEEE Trans. Ind. Electron., vol. 60, no. 10, pp. 4369–4375, Oct. 2013.

[2] X. Huang, A. Goodman, C. Gerada, Y. Fang, and Q. Lu, “A single sided matrix converter drive for a brushless dc motor in aerospace applications,” IEEE Trans. Ind. Electron., vol. 59, no. 9, pp. 3542–3552, Sep. 2012.

[3] S. Singh and B. Singh, “A voltage-controlled PFC Cuk converter based PMBLDCM drive for air-conditioners, ”IEEE Trans. Ind. Appl., vol. 48, no. 2, , Mar./Apr. 2012.

[4] B. Singh, B. N. Singh, A. Chandra, K. Al-Haddad, A. Pandey, and D. P. Kothari, “A review of single-phase improved power quality cads converters,” IEEE Trans. Ind. Electron., vol. 50, no. 5, pp. 962–981, Oct. 2003.

[5] S. Singh and B. Singh,“Power quality improved PMBLDCM drive for adjustable speed application with reduced sensor buck-boost PFC converter,” in Proc. 4th ICETET, Nov. 18–20, 2011, pp. 180–184.

[6] W. Wei, L. Hongpeng, J. Shigong, and X. Dianguo, “A novel bridgeless buck-boost PFC converter,” in IEEE PESC/ IEEE Power Electron. Spec. Conf., Jun. 15–19, 2008, pp. 1304–1308.

[7] Siva GangadharaRaoVenna, Sneha Vattikonda, Sravani Mandarapu, “Mathematical modeling and simulation of permanent magnet synchronous motor” in

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 8, August 2013,pp. 5900-5907.

[8] M. Prabu, Karkkinalderin. K, "An adjustable-speed PFC bridgeless buck–boost converter-fed BLDC motor drive with three switch leg VSI inverter" in International Journal For Technological Research In Engineering Volume 2, Issue 7, March-2015, pp. 670-673.

[9] A.Purna Chandra Rao, Y.P.obulesh, CH. Sai babu, "Performance Improvement of BLDC Motor with Hysteresis Current Controller" in International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 12, December 2013.

[10] R.shanthini, Dr.K.Boopathy, "Speed Control and Power factor Correction using Bridgeless Buck Boost Converter for BLDC Motor Drive" in International Journal of Science, Engineering and Technology Research (IJSETR) Volume 4, Issue 4, April 2015, pp. 846- 851.