International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 02 Issue 11
November 2015

Enhancement of PFC and Torque Ripple Reduction using BL Buck-Boost Converter fed HCC BLDC Drive

Bugatha ram vara prasad
M-tech Student Scholar Department of Electrical & Electronics Engineering, Dadi Institute of Engineering and Technology, Anakapalle; Visakhapatnam (Dt); A.P, India.
Ramvaraprasad205@gmail.com
R. Amala Dolly
Assistant Professor Department of Electrical & Electronics Engineering, Dadi Institute of Engineering and Technology, Anakapalle; Visakhapatnam (Dt); A.P, India.
amaladolly208@gmail.com

Abstract –
This paper shows another PFC bridgeless (BL) buck–boost converter for brushless direct current (BLDC) motor drive application in low -power applications with hysteresis current controller is implemented for torque ripple minimization. The number of components in the converter circuit is less. In the converter part resonant mode of operation gives zero current switching. Since this topology operates in discontinuous conduction mode it is suitable only for low power applications. BLDC Motors found applications in air conditioners etc. Here the BLDC motor speed control is achieved by DC link control. So the stress on the switches used in electronic commutation part of BLDC motor gets reduced. The BLDC has a few preferences compared with the other kind of motors; however the nonlinearity of the BLDC motor drive attributes, in light of the fact that it is hard to handle by utilizing customary relative basic (PI) controller. So as to tackle this fundamental issue, the current control turns into a suitable control. To give an inborn PFC at supply ac mains a converter based on buck-boost type is intended to work in discontinuous inductor current mode (DICM). Finally the hysteresis current controller (HCC) is implemented with current feedback loop and it is observe that torque ripples are minimized. The execution of the proposed system is in MATLAB/Simulink software.

Keywords: Bridgeless (BL) Buck–Boost Converter; Brushless Direct Current (BLDC) Motor; Power Factor Corrected (PFC) ; 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. 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 dc 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.

International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 02 Issue 11
November 2015

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 buck–boost converter-fed BLDC motor drive with 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.

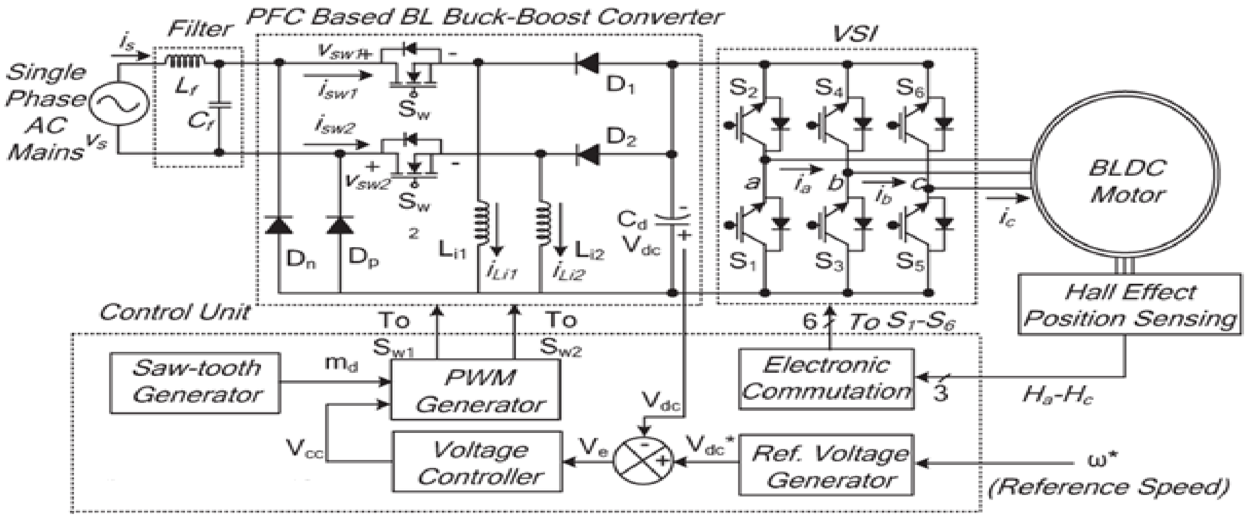

Fig.1.Block diagram of PFC BL Buck-boost converter-fed BLDC motor drive without Hysteresis current controller.

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

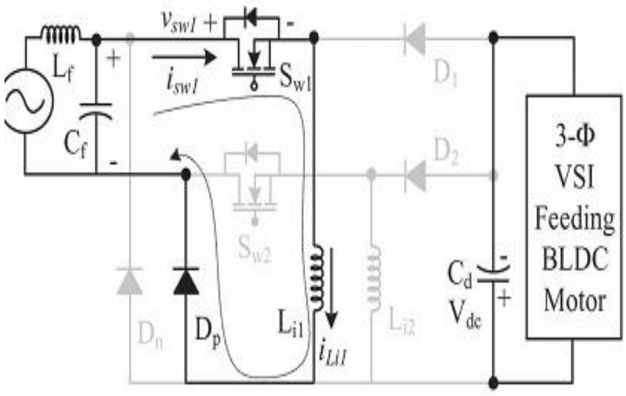

Fig.2: mode 1 operation.

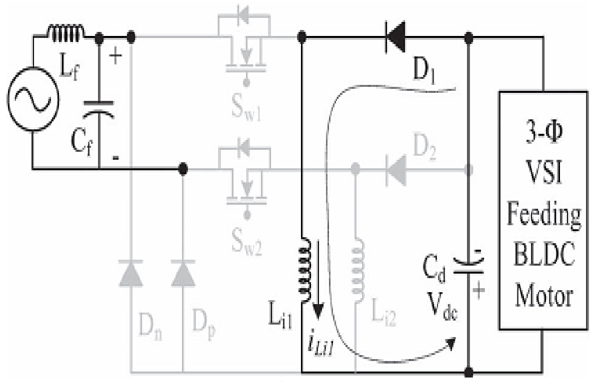

Fig.3.:mode 2 operation.

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.

III. HYSTERESIS CURRENT CONTROL OF INVERTER

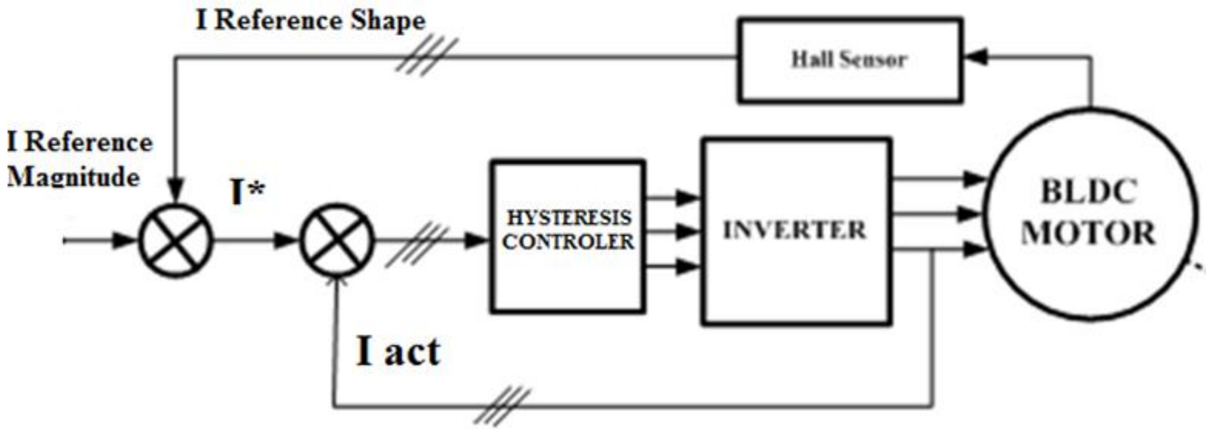

Fig.4: Hysteresis Current controlled Inverter fed BLDC drive.

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.

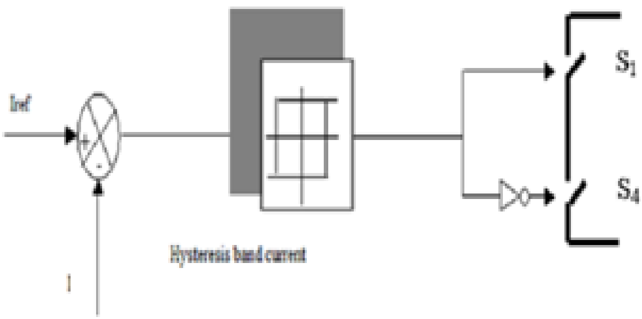

Fig.5:I_{ref} and I_{act} given to Hysteresis current control

The switching pattern is given as:

If ΔIa > H , S1 is on and S2 is off.
If ΔIa < L , S1 is off and S2 is on.
If ΔIb > H , S3 is on and S4 is off.
If ΔIb < L , S3 is off and S4 is on.
If ΔIc > H, S5 is on and S6 is off.
If ΔIc < L, S5 is off and S6 is on.

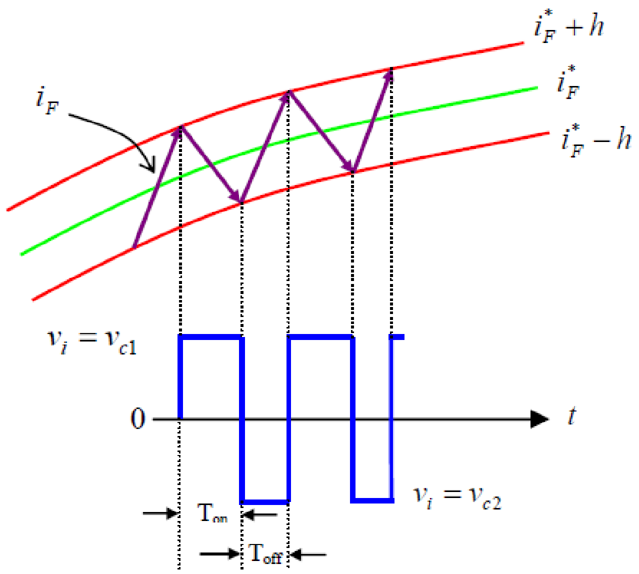

Fig.6: Hysteresis Band switching.

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.

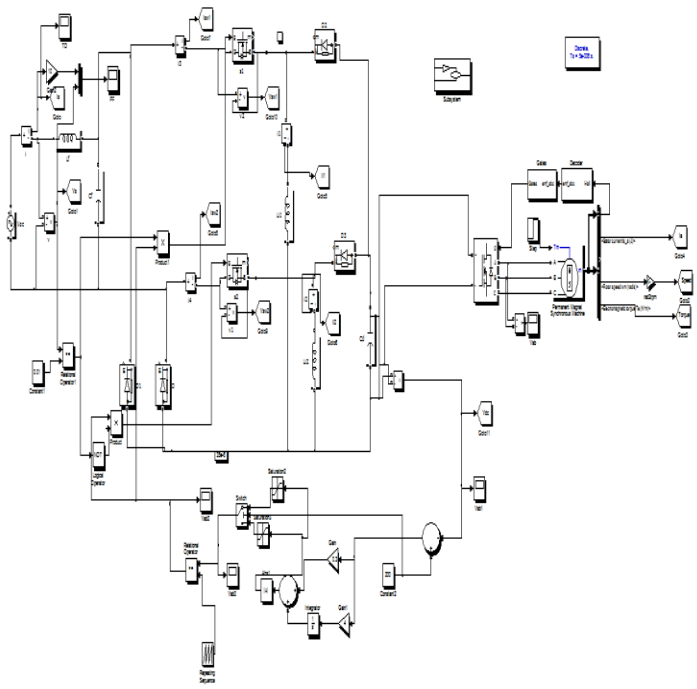

Fig.7.Simulink circuit for proposed BLDC drive with bridgeless buck boost converter without Hysteresis Current Controller.

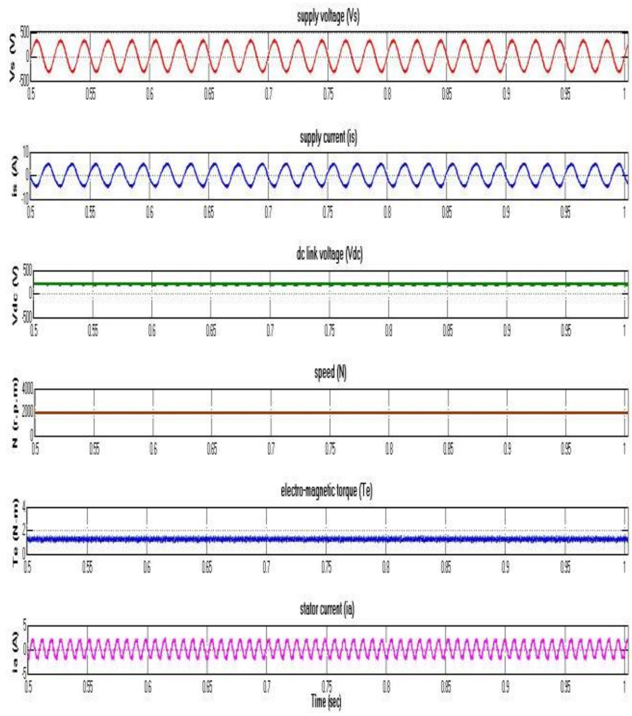

Fig.8.Siumulation results for source voltage, current, dc link voltage, and speed, torque, stator current of BLDC motor under steady state performance.

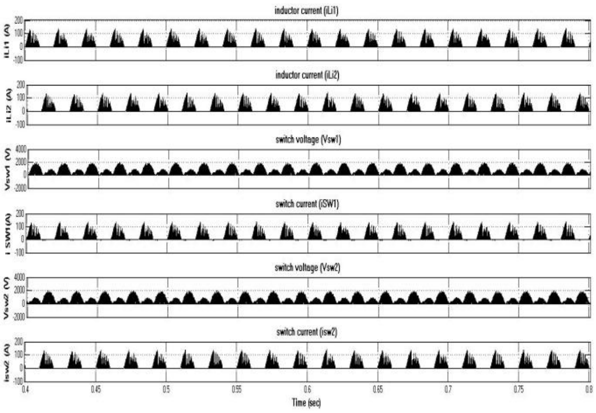

Fig.9.Simulation results for i_{Li1}, i_{Li2}, V_{sw1}, i_{sw1}, V_{sw2}, i_{sw2} of PFC converter under steady state performance

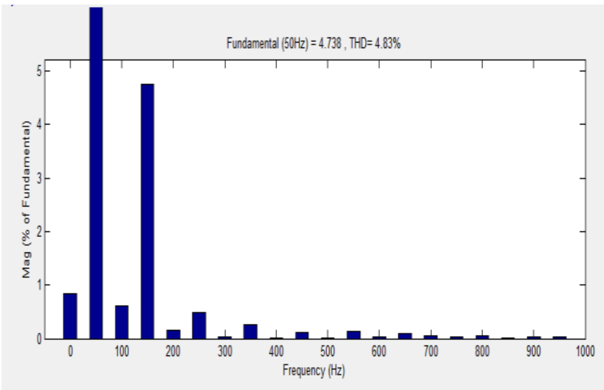

Fig.10: harmonic spectra of PFC BLDC drive using buck-boost converter

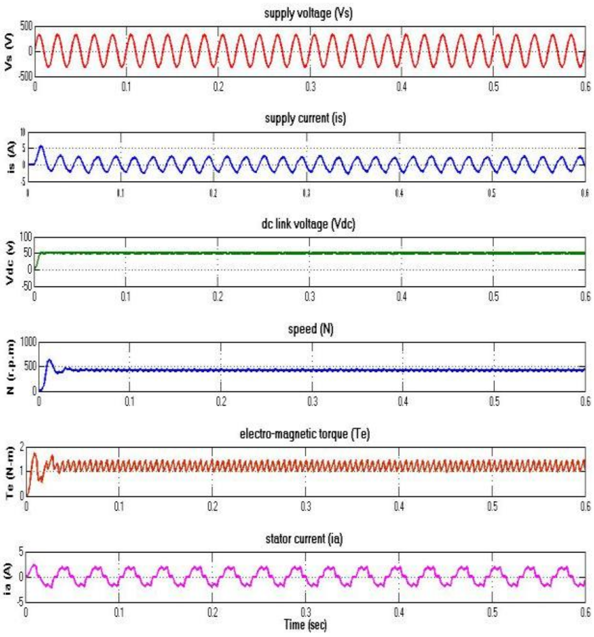

Fig.11.Simulation result of proposed system under dynamic performance during starting condition

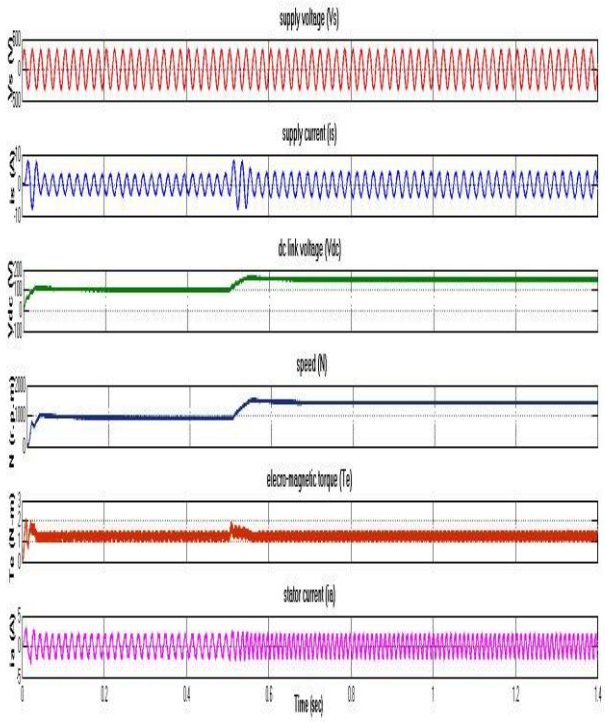

Fig.12:Simulation result of dynamic performance of proposed system during Speed control condition.

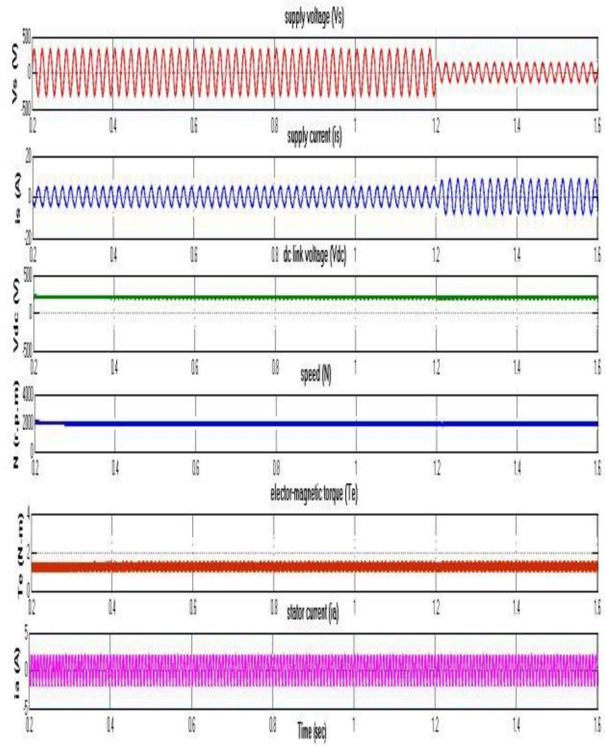

Fig.13:Simulation result of dynamic performance of proposed system during supply voltage variation.

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

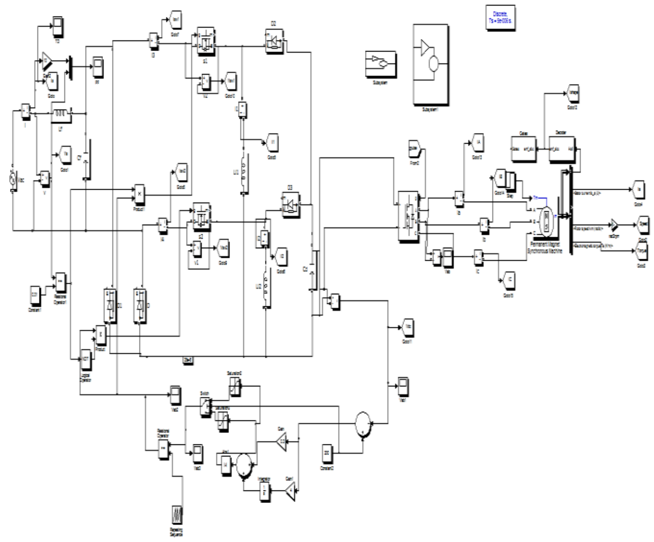

Fig.14: Simulink Circuit for Proposed System using Hysteresis Current Control.

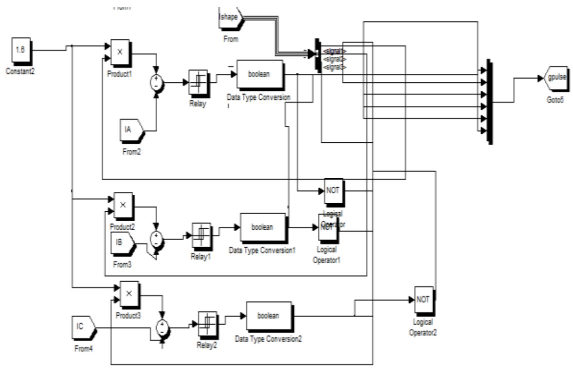

Fig.15: Control strategies for hysteresis current control.

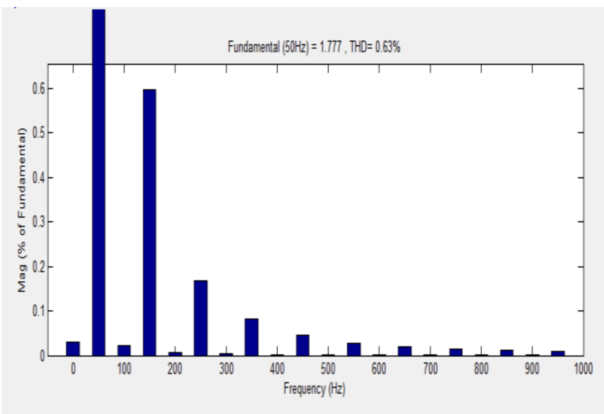

Fig.16: harmonic spectra of current control and PFC BL- buck boost converter fed BLDC motor drive.

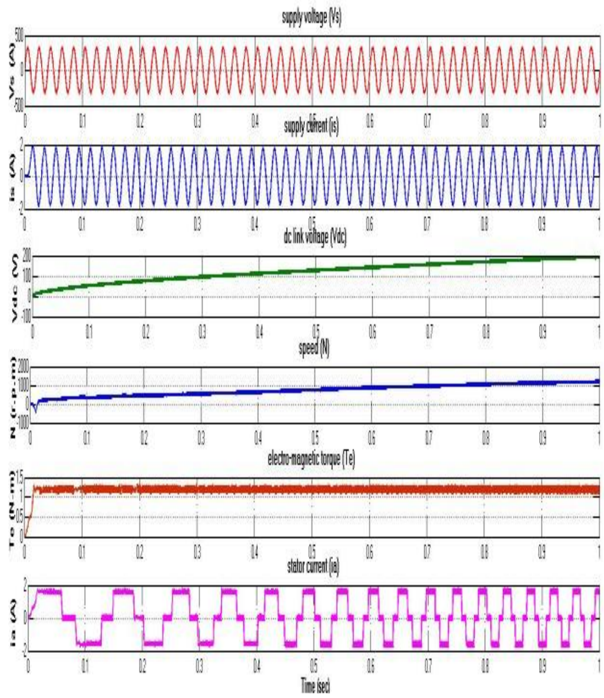

Fig.17Siumulation results for source voltage, current, dc link voltage, and speed, torque, stator current of BLDC motor under hysteresis current control.

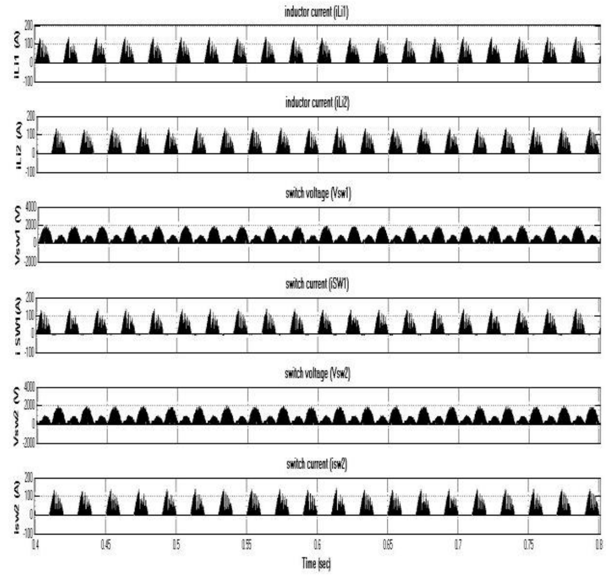

Fig.18:Simulation results for iLi1, iLi2, Vsw1, isw1, Vsw2, isw2 of PFC converter under hysteresis current control.

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

Analysis of	WITHOUT HCC	WITH HCC
Current Harmonics	**4.83 %**	**0.63 %**
Torque Ripple	**40%**	**12.75%**

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 from 40 % to 12.75 % .

REFERENCES

[1] G. Sakthival, T.S. Anandhi and S.P. Natarjan. 2010. Real time imp lementation 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, simu lation, 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

AUTHOR PROFILE

BUGATHA RAM VARA PRASAD Received his B.tech Degree in EEE from Coastal Institute of Technology and Management, Vizianagaram, India, in 2013. At present pursuing M.Tech in DADI Institute of Engineering and Technology, Anakapalle, Andhra Pradesh, India.

R.AMALA DOLLY has received the B.Tech (Electrical and Electronics Engineering) degree from Sri Prakash College of Engineering East Godavari, India, and the M.Tech degree in control systems from Malla Reddy College of Engineering, Hyderabad, India in 2011. She is currently working as an Assistant Professor in the Dept. of Electrical and Electronics Engineering, DADI Institute of Engineering and Technology, Anakapalle, Andhra Pradesh, India. Her areas of interests are Control Systems and Electrical Drives.