January - February 2020
ISSN: 0193 - 4120 Page No. 14961 - 14964

Power Factor Correction and Speed Control of Bldc Motor using Zeta Converter

[1]S. Janani [2]T.V.Narmadha [3] P.Pavithra
[1]jananisundar2020@gmail.com, [2]nar_velu@yahoo.co.in, [3]pavithraparthiban2016@gmail.com
[1,3]Student , [2]Professor
Department of EEE, St.Joseph's College of Engineering

Article Info
Volume 82
Page Number: 14961 - 14964
Publication Issue:
January-February 2020

Article History
Article Received: 18 May 2019
Revised: 14 July 2019
Accepted: 22 December 2019
Publication: 28 February 2020

Abstract
The paper presents the power factor correction and speed control of BLDC motor using isolated zeta converter. The proposed topology is based on zeta converter with high frequency transformer isolation and a single low side switch on the primary side of transformer. The most distinctive feature of the proposed converter is its ability to work in continuous conduction mode over a wide load range, which results in high efficiency. The BLDC motors are employed in low power applications due to features of high efficiency and wide speed range. The pulsed current from AC mains has various power quality disturbances such as poor power factor and increased total harmonic distortion. Therefore, the use of a suitable power factor correction converter topology is essential for a BLDCM drive. The performance of the proposed system is simulated in a MATLAB/Simulink environment and a hardware prototype of the proposed drive is developed to validate its performance over a wide range of speed with improved power factor at ac mains.

Keywords: *Zeta Converter, PMBLDC, Power Factor, THD, Settling time*

I. Introduction

Brushless DC (BLDC) motors is more popular due to high efficiency,, high torque to inertia ratio, wide variable speed operation, and less electromagnetic interference and it is highly useful in many applications such as medical equipments, robotics and automation, transportation, [1]–[6]. Novel Direct Back EMF detection for sensorless PMBLDC Motor drives was proposed [7]. The sensorless technique by model's prediction of a voltage or current and the actual value was proposed [8].Power quality problems has prompted the use of power factor correction converters with a Brushless DC motors for numerous low power applications. These motors are fed from a single-phase AC supply through a diode bridge rectifier followed by a DC capacitor. However, this practice results in a pulsed current from AC mains having various power quality disturbances such as poor power factor, increased total harmonic distortion and high crest factor of current. This is due to uncontrolled charging of the DC capacitor leading to a peak value higher than the amplitude of the fundamental input current at AC mains. Commutation torque ripple reduction strategy of Z-source inverter fed brushless DC motor employs the same modulation mode in both the normal conduction period and the commutation period, and the commutation torque ripple is reduced by regulating the shoot-through vector and active vector duty cycles [9]. A Single Sensor Based PFC Zeta Converter Fed BLDC Motor Drive for Fan Applications is proposed [10]. In this proposed work uncontrolled bridge rectifier and a Zeta DC-DC converter is used to control the voltage of a DC link capacitor which is lying between the Zeta converter and a VSI torque ripple analysing due to phase commutation was discussed [11]. A low-pass LC filter is used to avoid the reflection of higher order harmonics in supply system. The maximum value of filter capacitance (Cmax) is given as [12] The power factor corrected (PFC) [13] buck bridge DC-DC converter for a permanent magnet brushless DC motor (PMBLDCM) for an air conditioner was proposed

January - February 2020
ISSN: 0193 - 4120 Page No. 14961 - 14964

II. Zeta Converter

The proposed ZETA convertor performs the PFC action and DC link voltage control in single stage and needs only one controller. Fig 1 shows the block diagram of Isolated Zeta Converter This converter operates on the principle of a buck-boost converter and has inherent power factor correction capability. It is also known as an inverse SEPIC converter.

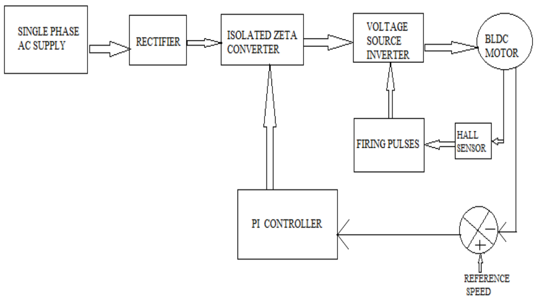

Fig 1.Block diagram of Isolated Zeta Converter

Fig 2 shows the closed loop diagram with PI controller of Isolated Zeta converter fed PMBLDC drive. This converter utilizes two approaches for their control, the current multiplier approach and voltage follower approach. The current multiplier approach is used in ZETA DC –DC Convertor. It has average current control which employs PFC controller that is designed for continuous conduction mode of operation. The voltage follower approach is used in ZETA AC-DC convertor. This converter has inherent advantages of the voltage follower approach, such as elimination of input current and voltage sensors, a simple control scheme, with only one control loop.

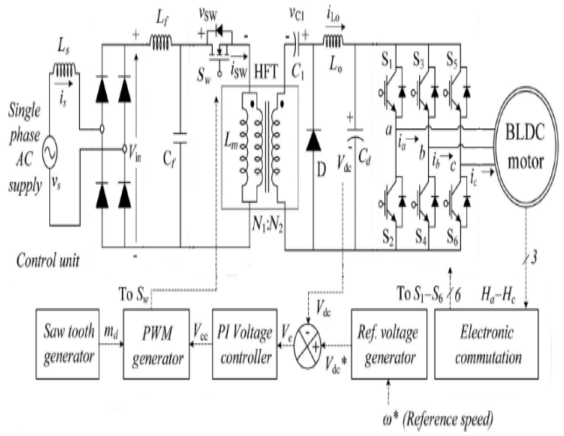

Fig 2. Closedloop with PI controller of Isolated Zeta converter fed BLDC Drive

III. DIFFERENT MODES OF OPERATION

MODE 1

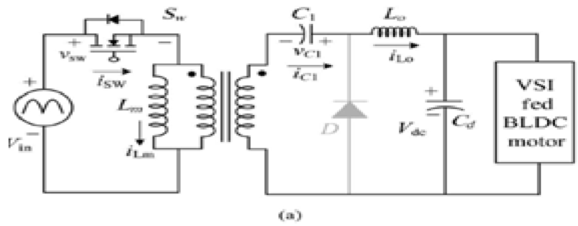

Fig 3. Mode 1 operation

When switch (*Sw*) is turned “ON,” a current in magnetizing inductance (*Lm*) of high frequency transformer (HFT) increases. The intermediate capacitor (*C*1) supplies energy to an output inductor (*Lo*) and the dc link capacitor (*Cd*). Hence, voltage across intermediate capacitor (*V*C1) reduces, and the current in output inductor (*iLo*) and dc link voltage (*V*dc) are increased .

MODE 2

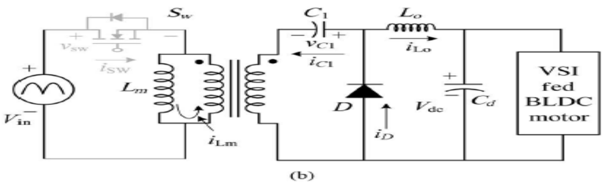

Fig 4 Mode 2 operation

When switch (Sw) is turned “OFF,” the current in magnetizing inductance (Lm) of HFT and output inductor (Lo) starts reducing. This energy of HFT is transferred to the intermediate capacitor (C1),and therefore voltage across it increases. Diode (D) conducts in this mode of operation, and the dc link voltage (Vdc) increases.

MODE 3

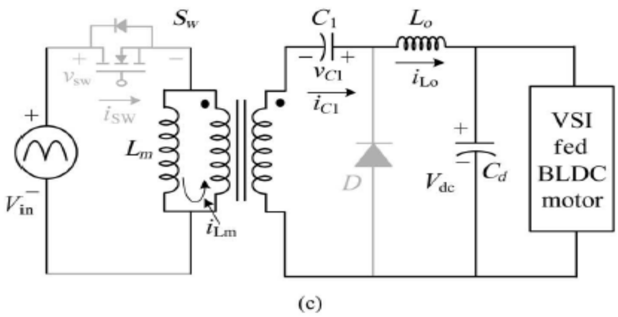

Fig 5 Mode 3 operation

January - February 2020
ISSN: 0193 - 4120 Page No. 14961 - 14964

This mode is DCM such that the energy of HFT is completely discharged .The intermediate capacitor (*C*1) and the dc link capacitor (*Cd*) supply the energy to the output inductor (*Lo*) and the load, respectively. Hence, the dc link voltage (*V*dc) and intermediate capacitor's voltage(*V*C1) are reduced, and the output inductor current increases in this mode of operation.

IV. SIMULATION RESULTS

Fig.7 shows the simulink model of PMBLDC fed from Isolated Zeta Converter with PI controller. Gain values of Kp and Ki is obtained by Z-N tuning algorithm. The controller is capable of obtaining the desired target speed under normal operating condition and even in the presence of disturbance.

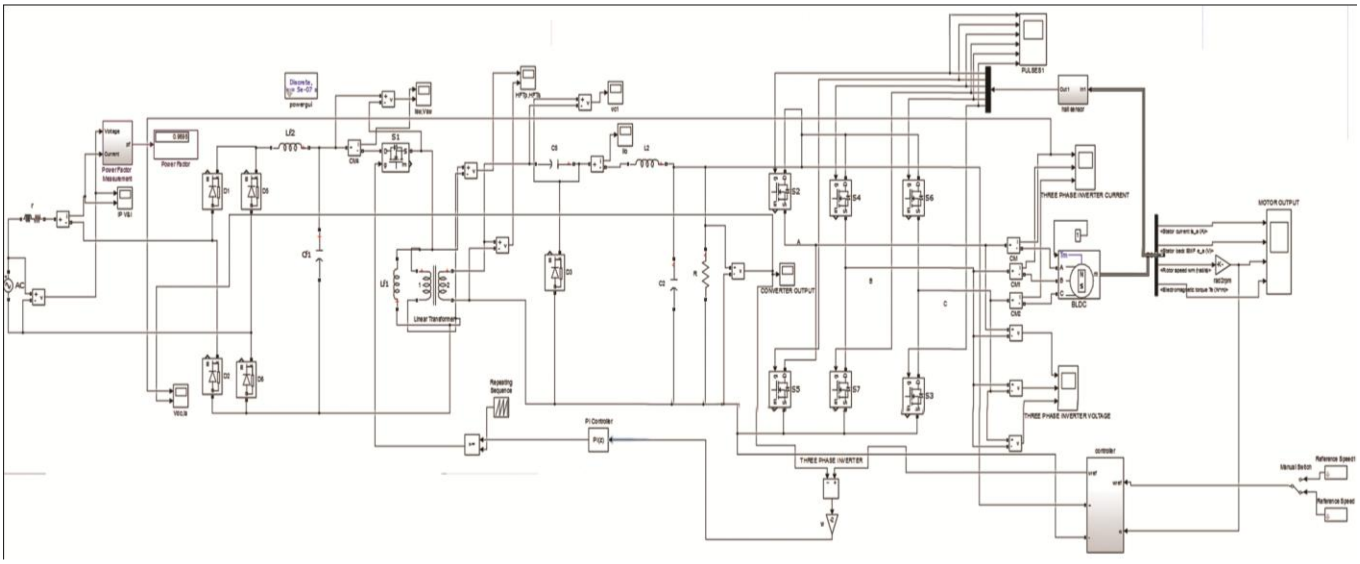

Fig.7 Simulink model of PMBLDC fed from Isolated Zeta Converter

Fig 8 shows the response of three phase stator current of PMBLDC drive. The obtained peak to peak current is 5 A. Fig 9 shows the speed response of BLDC motor. From the closed loop response of speed it was found the PI controller is capable of tuning to obtain the desired set sped of 1500rpm, The settling time to obtain the desired set speed is 0.18 seconds.

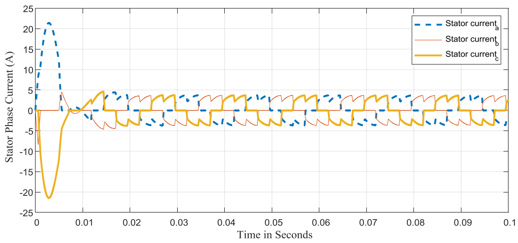

Fig.8 Response of Stator Current without load disturbance

Fig. 9 Speed response of PMBLDC motor without load disturbance

Fig 10 shows the response of three phase stator current of PMBLDC drive with a load disturbance at 0.1 seconds. The obtained peak to peak current is 5 A. Fig 11 shows the speed response of BLDC motor with load disturbance at 0.1 second. The load disturbance at 0.1 seconds is observed at 0.1 seconds in speed response It was found the PI controller is capable of tuning to obtain the desired set sped of 1500rpm by taking 0.02 seconds to get back to the desired set speed., The settling time to obtain the desired set speed is 0.13 seconds

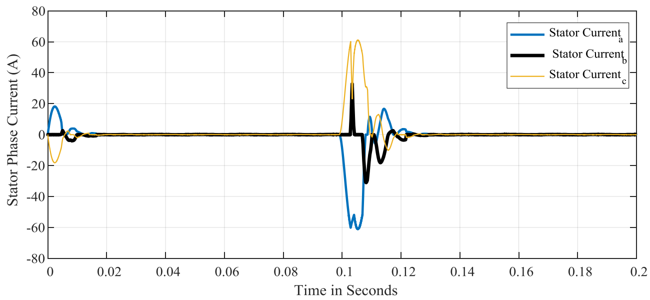

Fig.10 Response of Stator Current with T_L at 0.1 sec

Table 1 Performance Measures of Zeta Converter fed PMBLDC Drive

Parameters	Analysis
Settling Time (Seconds)	0.015
Power Factor	0.9815
Total Harmonic Distortion (%)	48.2

Published by: The Mattingley Publishing Co., Inc.

January - February 2020
ISSN: 0193 - 4120 Page No. 14961 - 14964

Table 1 shows the performance analysis of various parameters.

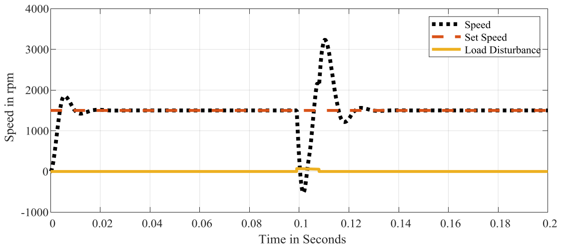

Fig. 11 Speed response of PMBLDC motor with T_L at 0.1 sec

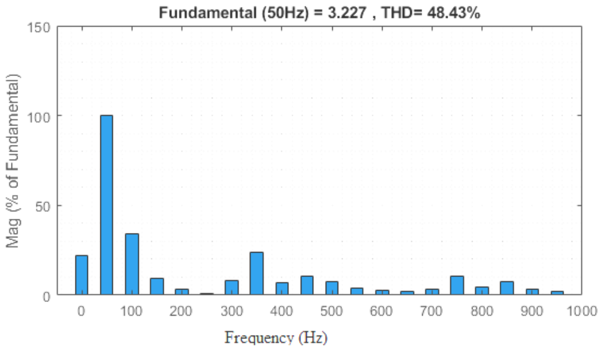

Fig.12 shows the FFT analysis of PMBLDC motor.

It was found approximately 48% total harmonic distortion occurs when the drive is operating at fundamental frequency,

Conclusion

An isolated zeta converter-fed BLDC motor drive has been proposed for targeting low-power household appliances. A variable dc link voltage of VSI feeding BLDC motor has been used for controlling the speed. With this PFC converter, three-phase VSI has been operated in low frequency switching mode with reduced switching losses. A front-end isolated zeta converter operating in DCM has been used for dc link voltage control and with PFC at ac mains. Performance of proposed drive has been found quite satisfactory for speed control over a wide range even in the presence of load disturbance and the results are validated by its performance measures.

Reference

[1] Xia G.L, Permanent Magnet Brushless DC Motor Drives and Controls. Hoboken, NJ, USA: Wiley, 2012.

[2] Chen,.Y Chiu C, . Jhang.Y, Tang.Z, and Liang.R, "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.

[3] Chan T.F, Yan L.T, and Fang S.Y, "In-wheel permanent-magnet brushless DC motor drive for an electric bicycle," IEEE Power Eng. Rev., vol. 22, no. 5, pp. 229–233, May 2002.

[4] Huang.X, Goodman. A, .Gerada .C, Fang.Y, and Lu.Q, "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.

[5] Moreno .J, Ortuzar M.E, and Dixon J.E, "Energy-management system for a hybrid electric vehicle, using ultra capacitors and neural networks," IEEE Trans. Ind. Electron., vol. 53, no. 2, pp. 614–623, Apr. 2006.

[6] Brekken T. K. A., Hapke H. M, Stillinger.C, and Prudell.J, "Machines and drives comparison for low-power renewable energy and oscillating applications," IEEE Trans. Energy Convers., vol. 25, no. 4, pp. 1162–1170, Dec. 2010.

[7] Microchip. Brushless, D.C. (BLDC) "Motor Fundamentals Application Note", AN885, AZ, USA. 2003.

[8] Hoque, M. A. "Speed and Position Sensorless Permanent Magnet Synchronous Motor Drives", IEEE Conf Proc., on Electrical and Computer Engineering, Vol. 2. pp. 689 - 692, 1994

[9] Li, X.M, Xia C.L, Cao Y.F, Chen.W, and Shi T.N "Commutation torque ripple reduction strategy of Z-source inverter fed brushless DC motor" IEEE Trans. Power Electron., vol. 31, no. 11, pp. 7677–7690,Nov. 2016

[10] Bhim Singh, Vashist Bist "A Single Sensor Based PFC Zeta Converter Fed BLDC Motor Drive for Fan Applications" IEEE Trans.Ind. Appl., vol.31, no. 5, pp. Oct 2012.

[11] Carlson.R, Lajoie-Mazenc.M, and Fagundes J.C.D.S, "Analysis of torque ripple due to phase commutation in brushless DC machines," IEEE Trans. Ind. Appl., vol. 28, no. 3, pp. 632–638, May/Jun. 1992.

[12] Vlatkovic.V, Borojevic D, and Lee F.C, "Input filter design for power factor correction circuits," IEEE Trans. Power Electron., vol. 11, no. 1, pp. 199–205, Jan. 1996.

[13] Sanjeev Singh and Bhim Singh, "A Voltage Controlled Adjustable Speed PMBLDM Drive using a Single- Stage PFC Half-Bridge Converter", IEEE Conference on Applied Power Electronics Conference and Exposition (APEC), pp.1976-1983, 2010