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Power Quality Improvement By A Bl-Csc Converter Fed Bldc Motor Drive

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ABSTRACT: Power Quality Improvement is a major focus in recent electricity quality improvement technologies. Power factor correction is applied to the circuits that include induction motors as a means of reducing the inductive component of the current and thereby reduce the losses in the supply. The proposed BL-CSC converter is operating in a discontinuous inductor current mode; The Brushless DC Motor speed is controlled by varying the dc bus voltage of the voltage source inverter (VSI). Via a PF converter. Therefore, the BLDC motor is electronically commutated such that the VSI operates in fundamental frequency switching for reduced switching losses. Moreover, the bridgeless configuration of the CSC converter offers low conduction losses due to partial elimination of diode bridge rectifier at the front end. The proposed method is simulated in MAT Lab tool and achieved the expected results.

Keywords : BLDC motor, PF correction, BL-CSC Converter, Electronic Commutation, Power quality improvement

1 INTRODUCTION

Brushless dc (BLDC) motor drives have gained importance in the last decade due to power quality improvements Brushless dc electric motor (BLDC motors, BL motors) also known as electronically commutated motors (ECMS, EC motors) are that are powered by a dc electric source via an integrated 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). BLDC motors have the following advantages longer life-2 to 3 times longer than brushed motors, no maintenance-no carbon brushes to be changed, cleaner, quieter, no arcing (spark-free)- safe and less radio interference ,very high reliability-no commutation or brushes to wear out. In the view of bus operators, downtime is not only troublesome but also costly. Smart bus operation companies are willing to pay higher prices in exchange for reducing the maintenance burden, in our case the time spent on changing brushes and replacing faulty motors from time to time. the cost and trouble saved on maintenance are the main criteria that will drive them to switch to reliable BLDC motors.
Unlike other products, our targeted customers will only consider switching to our product after careful calculation. This means it takes some time for the market to understand the benefits of using BLDC motors. Brushless motors fulfill many functions originally performed by brushed dc motors, but cost and control complexity prevents brushless motors from replacing brushed motors completely in the lowest-cost areas. Nevertheless, brushless motors have come to dominate many applications particularly devices such as computer and CD/DVD players. Small cooling fans in electronic equipment are powered exclusively by brushless motors. They can be found in cordless power tools where the increased efficiency of the motor leads to longer periods of use before the battery needs to be charged. Low speed, low power brushless motors are used in for gramophone record.

2 LITERATURE SURVEY

S. B. Ozturk, O. Yang, and H. A. Toliyat (2007) have developed a “Power factor correction of direct torque controlled brushless dc motor drive”. This topology uses constant dc link voltage and pulse width modulation (PWM)-based control of VSI for speed control of BLDC motor. This suffers from high switching losses in six solid-state switches of the VSI due to the higher switching frequency of PWM pulses. L. Cheng, (2000) have developed “DSP-based variable speed motor drive with power factor correction and current harmonics compensation,” has proposed an active rectifier- based BLDC motor drive fed by a three-phase VSI, which requires a complex control and is suitable for higher power applications. B. K. Lee, B. Fahimi, and M. Ehsani,(2001) have developed “Overview of reduced parts converter topologies for ac motor drives,” have explored the possibilities of various reduced part configurations for PFC operation, which also uses a PWM-based VSI and therefore have high switching losses in it. A. Barkley, D. Michaud, E. Santi, A. Monti, and D. Patterson, (2006) have developed “Single stage brushless dc motor drive with high input power factor for single phase applications,” a buck chopper operation as a front-end converter for feeding a BLDC motor drive. It also has high switching losses associated with it due to high frequency switching. These switching losses are reduced by using a concept of variable dc link voltage for speed control of BLDC motor from “Electric Motor Drives: Modeling, Analysis and Control,” developed by R. Krishnan, (2001) This utilizes the VSI to operate in low frequency switching required for electronic commutation of BLDC motor, and it reduces the switching losses associated with it. A front-end single-ended primary-inductor converter (SEPIC) feeding a BLDC motor using a variable voltage control has been proposed from “A new topology for unipolar brushless dc motor drive with high power factor,” by T. Gopalarathnam and H. A. Toliyat (2003), but at the cost of two current sensors for the operation of BLDC motor. This paper presents the development of a reduced sensor-based BLDC motor drive for low-power application. Y. Jang and M. M. Jovanovi´c (2011) “Bridgeless high-power-factor buck converter,” This is achieved due to partial or complete elimination of the DBR, thereby reducing the conduction losses associated with it. L. Huber, Y. Jang, and M. M. Jovanovic (2008) have developed

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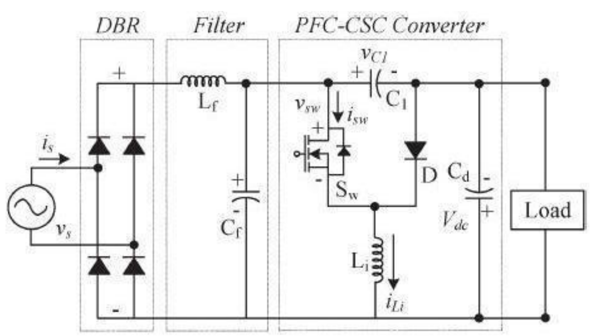
"Performance evaluation of bridgeless PFC boost rectifiers," and A. A. Fardoun, E. H. Ismail, M. A. Al-Saffar, and A. J. Sabzali (2012) have developed "New real" bridgeless high efficiency ac–dc converter," A bridgeless buck and a bridgeless boost converters suffer from a limited voltage conversion ratio and therefore cannot be used for a wide voltage control. To overcome this, a bridgeless buck–boost converter has been proposed in "A novel bridgeless buck–boost PFC converter," by W. Wei, L. Hongpeng, J. Shigong, and X. Dianguo (2008), but it has high switching losses corresponding to three switches. A two-switch bridgeless buck–boost PFC converter is proposed in "An adjustable speed PFC bridgeless buck–boost converter-fed BLDC motor drive," by V. Bist and B. Singh (2014), which has low losses compared with conventional method.

3 EXISTIG SYSTEMS

The conventional PFC based CSC converter. In this, a combination of a switch (Sw), a capacitor (C1) and a diode (D) is known as a 'canonical switching cell,' and this cell, combined with an inductor (Li) and a dc link capacitor (Cd), is known as a CSC converter. With proper design and selection of parameters, this combination is used to achieve PFC operation when fed by a single phase supply via a DBR and a dc filter.



This work aims at the development of a bridgeless configuration of a CSC converter, which offers partial elimination of DBR at the front end for reducing the conduction losses associated with it. Moreover, the application of this converter for feeding a BLDC motor drive is discussed to develop a low cost solution for low-power application. The DBR is eliminated in this BL-CSC converter, thereby reducing the conduction losses associated with it. This BL-CSC converter is designed to operate in a discontinuous inductor current mode (DICM) such that the currents flowing through inductors Li1 and Li2 are discontinuous, whereas the voltage across the intermediate capacitors C1 and C2 remains continuous in a switching period. An approach of variable dc link voltage for controlling the speed of the BLDC motor is used, and it is electronically commutated for reduced switching losses in the VSI. The operation, design, and control of this BL-CSC converter fed BLDC motor drive are explained in the following sections. Performance of the proposed drive is verified with test results obtained on a developed prototype with improved power quality at the ac mains for a wide range of speeds and supply voltages.

4 BL-CSC FED BLDC MOTOR DRIVE

BL-CSC-converter-based VSI fed BLDC motor drive. As shown, the DBR is eliminated in this BL-CSC converter, thereby reducing the conduction losses associated with it. This BL-CSC converter is designed to operate in a discontinuous inductor current mode (DICM) such that the currents flowing through inductors Li1 and Li2 are discontinuous, whereas the voltage across the intermediate capacitors C1 and C2 remains continuous in a switching period. An approach of variable dc link voltage for controlling the speed of the BLDC motor is used, and it is electronically commutated for reduced switching losses in the VSI. The operation, design, and control of this BL-CSC converter fed BLDC motor drive are explained in the following sections. Performance of the proposed drive is verified with test results obtained on a developed prototype with improved power quality at the ac mains for a wide range of speeds and supply voltages. A brief comparison of the proposed configuration with the existing bridgeless converter configurations is tabulated in Table. It shows the total number of components (Switch- Sw, Diode-D, Inductor-L, and Capacitor-C) and the components conducting during each half-cycle of supply voltage. The bridgeless buck and boost converter configurations are not suitable for the required application due to requirement of high voltage conversion ratio (i.e., voltage bucking and boosting) for controlling the speed over a wide range. As compared with the various bridgeless configurations of Cuk, and Zeta converters, the proposed BL-CSC converter has the relatively lower number of components and least number of conducting devices during each half-cycle of the supply voltage, whereas the proposed configuration exhibits the minimum conduction losses due to the conduction of minimum number of components during each half line cycle.

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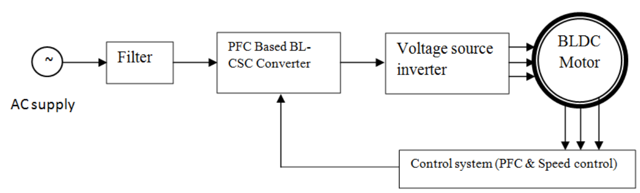
5 PROPOSED SYSTEM

The operation of the proposed BL-CSC converter for positive and negative half-cycles of the supply voltage, respectively.

Block Diagram:-



During the positive half-cycle of the supply voltage, the input side current flows through switchSw1, inductor Li1, and a fast recovery diode Dp. Similarly, switch Sw2, inductor Li2, and diode Dn conduct for a negative half-cycle of the supply voltage. The proposed BL-CSC converter is designed to operate in DICM such that current in inductors Li1 and Li2 becomes discontinuous for a switching period. Figure shows different modes of operation during a complete switching period for positive and negative half-cycles of the supply voltage respectively.

Operating Modes:-

Mode I-A: when switch Sw1 is turned on, the input side inductor Li1 starts charging via diode Dp, and current iLi increases, whereas the intermediate capacitor C1 starts discharging via switch Sw1 to charge the dc link capacitor

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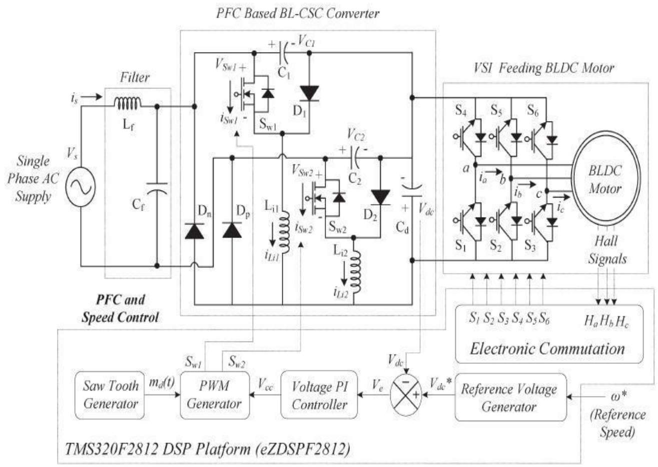


Cd. Therefore, the voltage across intermediate capacitor Vc1 decreases, whereas the dc link voltage Vdc increases.

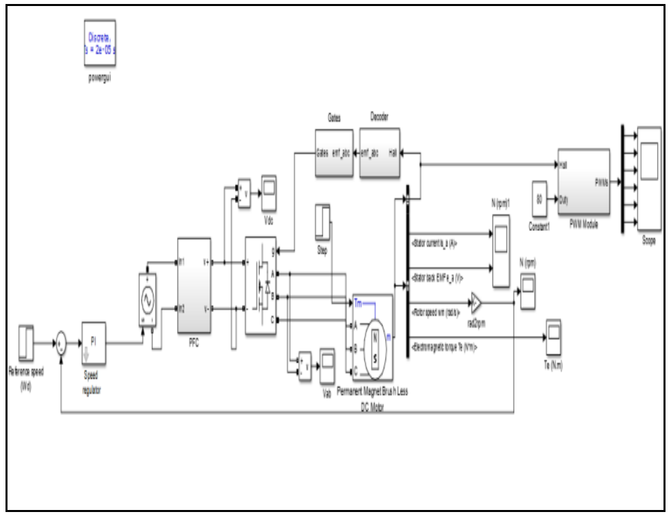
Mode I-B: When switch Sw1 is turned off, the energy stored in inductor Li1 discharges to dc link capacitor Cd via diode D1. The current iLi reduces, whereas the dc link voltage continues to increase in this mode of operation. Intermediate capacitor C1 starts charging, and voltage Vc1 increases.

Mode I-C: This mode is the DCM of operation as the current in input inductor Li1 becomes zero. The intermediate capacitor C1 continues to hold energy and retains its charge, whereas the dc link capacitor Cd supplies the required energy to the load. The similar behavior of the converter is realized for the other negative half-cycle of the supply voltage. An inductor Li2, an intermediate capacitor C2, and diodes Dn and D2 conduct outside a similar way.

CONFIGURATION	NO. OF DEVICES					1/2 PERIOD COND
	SW	D	L	C	Total	
BL-Buck	2	4	2	2	10	5
BL-Boost	2	2	1	1	6	4
BL-Boost	2	2	1	2	7	7
BL-Buck-Boost	2	4	1	3	11	8
BL-Buck-Boost	2	4	2	1	9	5
BL-Cuk T-1	2	3	3	3	11	7
BL-Cuk T-2	2	2	3	4	11	11
BL-Cuk T-3	2	4	4	3	13	7
BL-Cuk	2	3	3	2	10	8
BL-SEPIC	2	3	1	3	9	7
BL-SEPIC	2	3	2	2	9	7
BL-Zeta	2	4	4	3	13	7
Proposed BL-CSC	2	4	2	3	11	6

6 RESULTS AND DISCUSSION

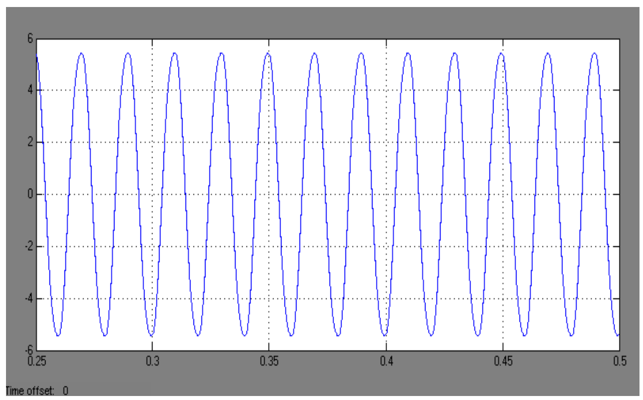
The performance of the proposed drive is experimentally validated on a developed hardware prototype of the proposed BLDC motor drive. A digital signal processor (DSP) TITMS320F2812 is used for the development of the proposed drive. Optoisolation is provided between the DSP and the gate driver of the VSI and PFC switches using 6N136 optocouplers.



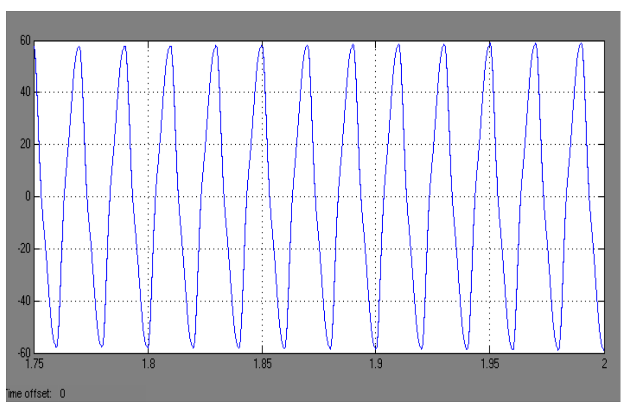
Simulation Diagram

Steady-State Performance

Figure shows test results of the proposed drive operation at rated load on the BLDC motor with supply voltage of 220 V and DC link voltages of 310, respectively. As shown in these figures, the dc link voltage is maintained at the desired reference value with different magnitude and frequency of the stator current demonstrating the BLDC motor operation at different speeds. A sinusoidal supply current in phase with supply voltage is obtained, which shows a near unity power factor at both the values of DC link voltages.



Output current



Output Voltage

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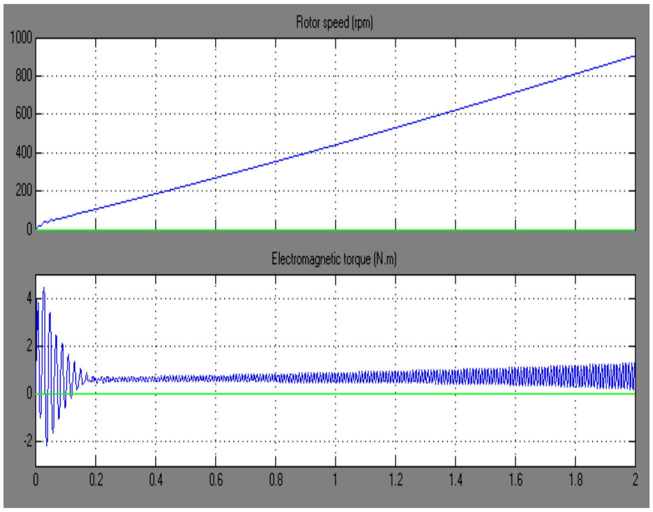

Speed Torque Curve

Performance of the PFC BL-CSC Converter as Power Factor Pre regulator The discontinuous inductor currents (iLi1 and iLi2) with supply voltage to verify the DICM operation of the BL-CSC converter. Inductors Li1 and Li2 conduct for the positive and negative half-cycles of the supply voltage, respectively. Moreover, a continuous voltage across the intermediate capacitor (VC1 and VC2) is obtained, as shown in Fig. 5.3 (a).The switching pulse of voltage source inverter is shown

7 CONCLUSIONS

A PFC-based BL-CSC converter-fed BLDC motor drive has been proposed with improved power quality at the ac mains. A bridgeless configuration of a CSC converter has been used for achieving reduced conduction losses in the PFC converter. The speed control of BLDC motor and PFC at ac mains has been achieved using a single voltage sensor. The switching losses in the VSI have been reduced by the use of fundamental frequency switching by electronically commutating the BLDC motor. Moreover, the speed of the BLDC motor has been controlled by controlling the dc link voltage of the VSI. The proposed drive has shown an improved power quality at the ac mains for a wide range of speed control and supply voltages. The obtained power quality indices have been found within the acceptable limits of IEC 61000-3-2. A satisfactory performance of the proposed drive has been obtained, and it is a recommended solution for low-power applications.

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