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AN EFFICENT IMPLEMENTATION OF ADJUSTABLE BUCK-BOOST CONVERTER FOR BLDC MOTOR DRIVE

[#1]KOKKULA JYOTHI, M.Tech Student, Dept of EEE,
[#2]N.ARPANA, Assistant Professor, Dept of EEE,
SAHAJA INSTITUTE OF TECHNOLOGY & SCIENCES FOR WOMEN, KARIMNAGAR, T.S., INDIA.

Abstract: This paper presents an influence issue improved by victimization buck-boost convertor for BLDC motor drive as a value effective answer for low power applications. AN approach of speed management of BLDC motor by dominant the DC link voltage of VSI (Voltage supply Inverter) is employed. This facilitates the operation of VSI at fundamental change by victimization the electronic commutation of BLDC motor that offers reduced change losses. 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 buck–boost converter is designed to operate in discontinuous inductor current mode (DICM) to provide an inherent PFC at ac mains. The performance of the proposed drive is evaluated over a wide range of speed control and varying supply voltages (universal ac mains at 90–265 V) with improved power quality at ac mains. A buck-boost convertor is meant to work in DICM (Discontinuous electrical device Current Mode) to supply AN unity Power issue at AC mains. The performance of the projected drive is evaluated over a good vary of speed management and ranging offer voltages with improved power quality at AC mains. The performance of projected drive is simulated in MATLAB/Simulink atmosphere.

Keywords— *Buck-Boost converter, power factor correction (PFC), permanent-magnet brushless dc motor (PMBLDCM), voltage control, voltage source inverter (VSI).*

I.INTRODUCTION

Efficiency and cost are the major concerns in the development of low-power motor drives targeting household applications such as fans, water pumps, blowers, mixers, etc. The use of the BLDC motor in these applications is becoming very common due to features of high efficiency, high flux density per unit volume, low maintenance requirements, and low electromagnetic-interference problem. These BLDC motors are not limited to household applications, but these are suitable for other applications such as medical equipment, transportation, HVAC, motion control, and many industrial tools. A BLDC motor has three phase windings on the stator and permanent magnets on the rotor. The BLDC motor is also known as an electronically commutated motor because an electronic commutation based on rotor position is used rather than a mechanical commutation which has disadvantages like sparking and wear and tear of brushes and commutator assembly.

Power quality problems have become important issues to be considered due to the recommended limits of harmonics in supply current by various international power quality standards such as the IEC 61000-3-2.A BLDC motor when fed by a DBR with a high value of dc link capacitor draws peaky current which can lead to a THD of supply current of the order of 65% and power factor as low as 0.8. Hence, a DBR followed by a PFC converter is utilized for improving the power quality at ac mains. The choice of mode of operation of a PFC converter is a critical issue because it directly affects the cost and rating of the components used in the PFC converter. The continuous conduction mode and discontinuous conduction mode are the two modes of operation in which a PFC converter is designed to operate. IN CCM, the current in the inductor or the voltage across the intermediate capacitor remains continuous, but it requires the sensing of two voltages (dc link voltage and supply voltage) and input side current for PFC operation, which is not cost-effective. On the other hand, DCM requires a single voltage sensor for dc link voltage control, and inherent PFC is achieved at the ac mains, but at the cost of higher stresses on the PFC converter switch; hence, DCM is preferred for low-power applications.

The use of a permanent-magnet brushless dc motor (PMBLDCM) in low-power appliances is increasing as a result of its options of high potency, wide speed vary, and low maintenance[1]–[4]. it's a rugged 3 part electric motor thanks to the employment of PMs on the rotor. The commutation in an exceedingly PMBLDCM is accomplished by solid state switches of a 3 part voltage supply electrical converter (VSI). Its application leads to AN improved potency of the system if operated beneath speed management. the assorted load area unit exerts constant torsion (i.e., rated torque) on the PMBLDCM whereas operated in speed management mode. The PMBLDCM has low running price, long life, and reduced mechanical and electrical stresses compared to one part induction motor. A PMBLDCM has developed torsion proportional to its part current and its back electrical

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phenomenon (EMF), that is proportional to the speed. Therefore, a relentless current in its mechanical device windings with variable voltage across its terminals maintains constant torsion in an exceedingly PMBLDCM beneath variable speed operation.

A speed management theme is projected that uses a reference voltage at dc link proportional to the required speed of the static magnet brushless electrical energy (PMBLDCM) motor. However, the management of VSI is just used for electronic commutation supported the rotor position signals of the PMBLDC motor. The PMBLDCMD is fed from one part ac offer through a diode bridge rectifier (DBR) followed by a electrical device at dc link. It attracts a periodic current with a peak more than the amplitude of the elemental input current at ac mains thanks to AN uncontrolled charging of the dc link electrical device. This leads to poor power quality (PQ) at ac mains in terms of poor power issue (PF) of the order of zero.728, high total harmonic distortion (THD) of ac mains current at the worth of eighty one.54%. Therefore, a PF correction (PFC) device among varied obtainable convertor topologies is sort of inevitable for a PMBLDCMD.

These area unit only a few publications relating to greenhouse gas in PMBLDCMDs despite several greenhouse gas topologies for switched mode power offer.This paper deals with AN application of a greenhouse gas convertor for the speed management of a PMBLDCMD.

II.INVERTER

The word „inverter‟ in the context of power-electronics denotes a class of power conversion (or power conditioning) circuits that operates from a dc voltage source or a dc current source and converts it into ac voltage or current. The „inverter‟ does reverse of what ac-to-dc „converter‟ does (refer to ac to dc converters). Even though input to an inverter circuit is a dc source, it is not uncommon to have this dc derived from an ac source such as utility ac supply. Thus, for example, the primary source of input power may be utility ac voltage supply that is „converted‟ to dc by an ac to dc converter and then „inverted‟ back to ac using an inverter. Here, the final ac output may be of a different frequency and magnitude than the input ac of the utility supply. According to the type of ac output waveform, these topologies can be considered as voltage source inverters (VSIs), where the independently controlled ac output is a voltage waveform. These structures are the most widely used because they naturally behave as voltage sources as required by many industrial applications, such as adjustable speed drives (ASDs), which are the most popular application of inverters. Similarly, these topologies can be found as current source inverters (CSIs), where the independently controlled ac output is a current waveform. These structures are still widely used in medium-voltage industrial applications, where high-quality voltage waveforms are required. Static power converters, specifically inverters, are constructed from power switches and the ac output waveforms are therefore made up of discrete values. This leads to the generation of waveforms that feature fast transitions rather than smooth ones. Here we have use Voltage Source Inverter. The simplest dc voltage source for a VSI may be a battery bank, which may consist of several cells in series parallel combination. Solar photovoltaic cells can be another dc voltage source. An ac voltage supply, after rectification into dc will also qualify as a dc voltage source. A voltage source is called stiff, if the source voltage magnitude does not depend on load connected to it.

III. PROPOSED PFC BL BUCK–BOOST CONVERTER-FEDBLDC MOTOR DRIVE

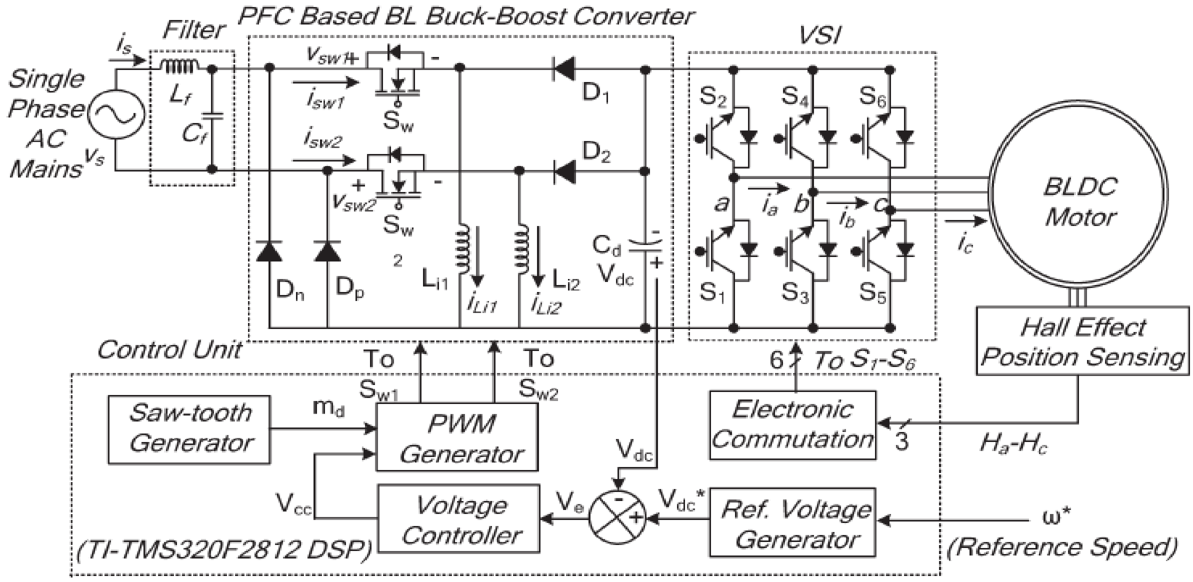

Fig. 1. Proposed BLDC motor drive with front end BL buck– boost converter.

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Fig. 1 shows the proposed BL buck–boost converter-based VSI-fed BLDC motor drives. The parameters of the BLbuck–boost converter are designed such that it operates in discontinuous inductor current mode (DICM) to achieve an inherent power factor correction at ac mains. The speed control of BLDC motor is achieved by the dc link voltage control of VSI using a BL buck–boost converter. This reduces the switching losses in VSI due to the low frequency operation. A hardware implementation of the proposed BLDC motor drive is carried out to demonstrate the feasibility of the proposed drive over a wide range of speed control with improved power quality at ac mains. of VSI for the electronic commutation of the BLDC motor. The performance of the proposed drive is evaluated for a wide range of speed control with improved power quality at ac mains. The proposed configuration of the BL buck–boost converter has the minimum number of components and least number of conduction devices during each half cycle of supply voltage which governs the choice of the BL buck– boost converter for this application.

IV. PRINCIPLES OF OPERATION

The operation of the PFC BL buck–boost converter is classified into two parts which include the operation during the positive and negative half cycles of supply voltage and during the complete switching cycle.

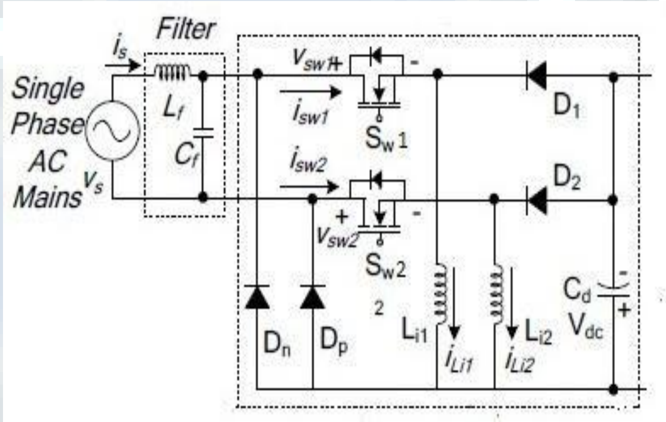

Fig. 2 PFC based bridgeless Buck-Boost Converter

In the proposed configuration of bridgeless buck-boost converter has the minimum number of components and least number of conduction devices during each half cycle of supply voltage which governs the choice of BL buck boost converter for this application. The operation of the PFC bridgeless buck-boost converter is classified into two parts which include the operation during the positive and negative half cycles of supply voltage and during the complete switching cycle.

A. Operation during Positive and Negative Half Cycles of Supply Voltage

In this mode converter switches Sw1 and Sw2 are operate in positive and negative half cycle of supply voltage respectively. During positive half cycle switch SW1, inductor Li1 and diodes D1 and Dp are operated to transfer energy to DC link capacitor Cd. Similarly in negative half cycle of supply voltage switches Sw2, inductor Li2 and diode D2 and D2 conducts. In Discontinuous Inductor Current Mode(DICM) operation of converter the current in the inductor Li becomes discontinuous for certain duration in a switching period..

B. Operation During Complete Switching Cycle

In this switching cycle there are three modes of operation.

Mode I: In this mode, switch Sw1 conducts for charging he inductor Li1, hence the inductor current iLi1 increases in this mode. Diode Dp completes the input side and the DC link capacitor Cd is discharged by VSI fed BLDC motor.

Mode II: In this mode of operation switch Sw1 is turned off and the stored energy from the inductor Li1 is transferred to DC link capacitor Cd till the inductor is fully discharged and current in the inductor is fully reduced to zero.

Mode III: In this mode of operation inductor Li1 operate in discontinuous conduction mode and diodes and switch are in off condition. At this time DC link capacitor Cd starts discharging. This operation can be continue up to switch Sw1 is turned on again.

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V. CONTROL OF BLDC MOTOR: ELECTRONIC COMMUTATION

An electronic commutation of the BLDC motor includes the proper switching of VSI in such a way that a symmetrical current is drawn from the dc link capacitor for 120◦ and placed symmetrically at the center of each phase. A Halleffect position sensor is used to sense the rotor position on a span of60◦, which is required for the electronic commutation of the BLDC motor. The conduction states of two switches (S1 andS4) are shown in Fig. 4. A line current iab is drawn from thedc link capacitor whose magnitude depends on the applied dclink voltage (Vdc), back electromotive forces (EMFs) (ean andebn), resistances (Ra and Rb), and self inductance and mutualinductance (La, Lb, and M) of the stator windings. Table Ishows the different switching states of the VSI feeding a BLDCmotor based on the Hall-effect position signals (Ha − Hc).

It attracts a periodic current with a peak more than the amplitude of the elemental input current at ac mains thanks to AN uncontrolled charging of the dc link electrical device. This leads to poor power quality (PQ) at ac mains in terms of poor power issue (PF) of the order of zero.728, high total harmonic distortion (THD) of ac mains current at the worth of eighty one.54%.

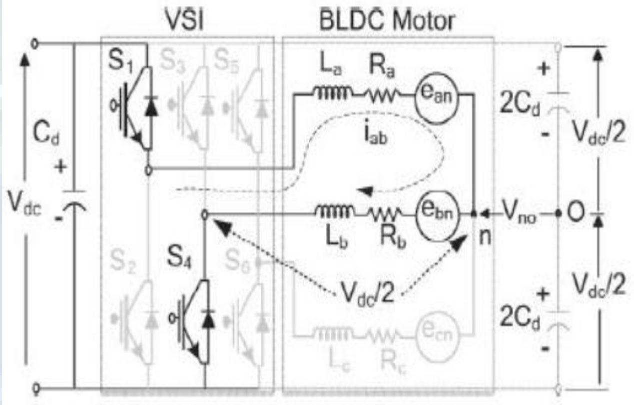


Fig.3. Operation of a VSI-fed BLDC motor when switches S1 and S4 are conducting.

TABLE I SWITCHING STATES FOR ACHIEVING ELECTRONIC COMMUTATION OF BLDC MOTOR BASED ON HALL-EFFECT POSITION SIGNALS

θ (°)	Hall Signals			Switching States					
	H_a	H_b	H_c	S_1	S_2	S_3	S_4	S_5	S_6
NA	0	0	0	0	0	0	0	0	0
0-60	0	0	1	1	0	0	0	0	1
60-120	0	1	0	0	1	1	0	0	0
120-180	0	1	1	0	0	1	0	0	1
180-240	1	0	0	0	0	0	1	1	0
240-300	1	0	1	1	0	0	1	0	0
300-360	1	1	0	0	1	0	0	1	0
NA	1	1	1	0	0	0	0	0	0

VI.POSITION AND SPEED CONTROL OF BLDC MOTORS USING SENSORS

PM motor drives require a rotor position sensor to properly perform phase commutation or current control. For BLDC motor six phase-commutation per electrical cycle is needed, therefore Hall-effect sensors are usually used.

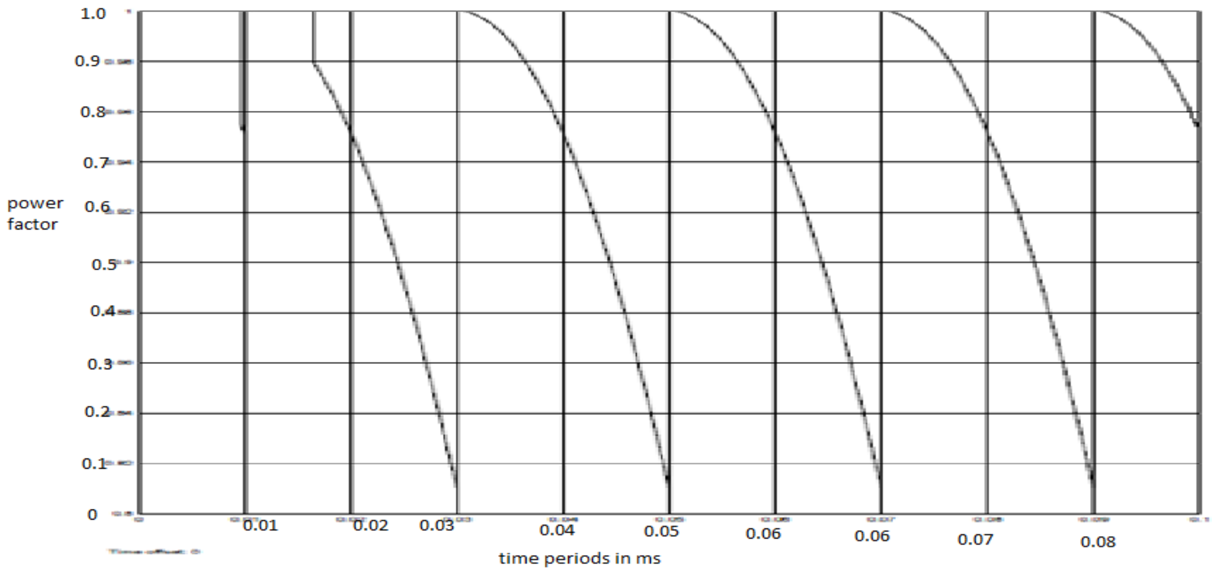
A. Hall-effect sensors:-

These kinds of devices are based on Hall-effect theory, which states that an electric current carrying conductor is kept in magnetic field exerts a transverse force on the moving charge carrier that tends to push them to one side of the conductor. A build-up of charge at the sides of the conductor will balance this magnetic influence producing a measurable voltage between the two sides of the conductor. The presence of this measurable transverse voltage is called the Hall-effect. Most BLDC motors have three Hall sensors inside the stator on non-driving end of the motor. Whenever the rotor magnetic poles pass near the hall sensors they give a high or low signal indicating the N or S pole is passing near the sensors. Based on the combination of these three hall sensor signals, the exact sequence of commutation can be determined.

B. Accelerometers:-

Accelerometers is a electromechanical devices that measures acceleration forces, which are related to the freefall effect. Several types are available to detect magnitude of the acceleration as a vector quantity, and can be used to sense the position, vibration and shock. The most common design is based on a combination of Newton‟s law of the mass acceleration and Hook‟s law of spring, which is depicted in Figure 4. When the accelerometer experiences acceleration, the mass is displaced to the point that the spring is able to accelerate the mass at the same rate as casing. The displacement is then measured to give the acceleration.

VII.SIMULATION RESULTS



The performance of the proposed BLDC motor drive is simulated in MATLAB/Simulink environment using the Sim-Power-System toolbox. The performance evaluation of the proposed drive is categorized in terms of the performance of the BLDC motor and BL interleaved converter and the achieved power quality indices obtained at ac mains. The parameters associated with the BLDC motor such as speed (N), electromagnetic torque (*Te*), and stator current (*ia*) are analyzed for the proper functioning of the BLDC motor.

Parameters such as supply voltage (*Vs*), supply current (*is*), dc link voltage (*V*dc), inductor‗s currents (*i*Li1, *i*Li2), switch voltages (*V*sw1, *V*sw2), and switch currents (*i*sw1, *i*sw2) of the PFC BL interleaved converter are evaluated to demonstrate its proper functioning. Moreover, power quality indices such as power factor (PF), displacement power factor (DPF), crest factor (CF), and THD of supply current are analyzed for determining power quality at ac mains. *Steady-State Performance* The steady-state behaviour of theProposed BLDC motor drive for two cycles of supply voltage at rated condition (rated dc link voltage of 200 V) is the discontinuous inductor currents (*i*Li1 and *i*Li2) are obtained, confirming the DICM operation of the BL buck–boost converter. The performance of the proposed BLDC motor drive at speed control by varying dc link voltage from 50 to 200 V. The harmonic spectra of the supply current at rated and light load conditions, i.e., dc link voltages of 200 and 50 V, also shown in Fig. 7(a) and (b), respectively, which shows that the THD of supply current obtained is under the acceptable limits of IEC 61000-3-2.The dynamic behaviour of the proposed drive system during a starting at 50 V, step change in dc link voltage from 100 to 150 V, and supply voltage change from 270 to 170 Voltage.

VIII.CONCLUSION

A PFC BL buck–boost converter-based VSI-fed BLDC motor drive has been proposed targeting low-power applications. A new method of speed control has been utilized by controlling the voltage at dc bus and operating the VSI at fundamental frequency for the electronic commutation of the BLDC motor for reducing the switching losses in VSI. The front-end BLbuck–boost converter has been operated in DICM for achieving an inherent power factor correction at ac mains. A satisfactory performance has been achieved for speed control and supply voltage variation with power quality indices within the acceptable limits of IEC 61000-3-2. Moreover, voltage and current stresses on the PFC switch have been evaluated for determining the practical application of the proposed scheme. Finally, an experimental prototype of the proposed drive has been developed to validate the performance of the proposed BLDC motor drive under speed control with improved power quality at ac mains. The proposed scheme has shown satisfactory performance, andit is a recommended solution applicable to low-power BLDC motor drives.

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