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A Power Factor Corrector DC-DC Buck-Boost Converter fed BLDC Motor

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Abstract* — This paper proposes a buck-boost converter, controlling scheme with reduced number of switches in inverter and design of power factor controller for Brushless DC motor. BLDC motors are the most recent choice of researchers, for their high efficiency, silent operation, high reliability and low maintenance requirements. The proposed Power Factor Controller topology improves Power Quality by improving performance of BLDCM drive such as reducing the current harmonics at AC mains near to unity power factor according to the IEC 61000-3-2 standard. PFC converter requests the drive to draw sinusoidal supply current in phase with the supply voltage. The position sensors used in BLDC drives have drawbacks of additional cost, mechanical alignment problems. These bottle necks results in sensorless technique. The voltage or speed controllers can be realized using proportional integral and Derivative (PID) controller. The proposed drive is simulated in MATLAB/Simulink, the obtained results are validated.

***Keywords* — PFC DC-DC Buck-Boost Converter, BLDC Motor, Power Quality, Sensorless Control, Power Factor Correction**

I. INTRODUCTION

BLDC Motor is recently used for many medium and low power applications like fans, Electrical Vehicles, refrigerators, Washing Machines, air conditioners due to its benefit of higher efficiency, high torque-inertia ratio, less maintenance and broad range of speed control. A motor drive system in general consists of a power circuit, a control unit and the Motor [1]. For a BLDC motor drive, the power circuit consists of a Diode Bridge Rectifier, a DC-DC converter and a Voltage Source Inverter.

The Buck–Boost converter is a type of DC to DC converter that has an output voltage magnitude which is either greater than or less than the input voltage magnitude. It is correspondent to a flyback converter using a single inductor instead of a transformer. Two altered topologies are known as Buck–Boost converter [2]-[5]. Both can create a range of output voltages from an output voltage much higher than the input voltage almost to zero. The output voltage is typically of the same polarity of the input and can be lesser or higher than the input. Such a converter may use a single inductor which is used for both the Buck inductor and the Boost inductor. An AC-AC converter with approximately sinusoidal input currents and bidirectional power flow can be realized by coupling a pulse-width modulation (PWM) rectifier and a PWM inverter to DC link. The DC link measure is then amazed by an energy storage element that is common to the stages, in which a capacitor, C for the voltage DC link or an inductor, L for the DC link current. The PWM rectifier is guarded in a way so as to a sinusoidal AC line current is drawn which is in phase or anti-phase with the corresponding AC line phase voltage. Due to the DC link storage element, there is the benefit of both converter stages are to a large extent decoupled for control purpose. In addition a constant AC line free input quantity exists for the PWM inverter stage which results in high utilization of the converters power capability.

In general, inverters are utilized in applications requiring direct conversion of electrical energy from DC to AC or indirect conversion from AC to AC. DC to AC conversion is helpful for numerous fields, as well as power condition, harmonic reduction, motor drive and renewable energy integration with grid [6]. Here the BLDC motor is supplied by the Voltage source Inverter with high quality of voltage. A proportional-integral-derivative controller (PI controller) is a control loop feedback mechanism (controller) widely used in many control system applications [8]-[10]. The controller will calculate an error value as the difference between a measured process variable and a estimated set value. To sense the rotor position BLDC motors utilize Hall Effect sensors to afford absolute position sensing, which results in more wires and high cost. Sensorless BLDC control eliminates the want for Hall Effect sensors, by means of the back-EMF (electromotive force) of the motor as an alternative to estimate the rotor position [12]. Sensorless control is necessary for low-cost variable speed applications. A power factor of one or unity power factor is the objective of every electric utility company because if the power factor is a lesser than one, they has to supply more current to the user for a given amount of power draw on. Hence, they acquire more line losses. Hence this paper proposes the for speed control and supply voltage variation with power quality indices within the acceptable limits of IEC 61000-3-2.

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II. PROPOSED DC-DC BUCK-BOOST CONVERTER

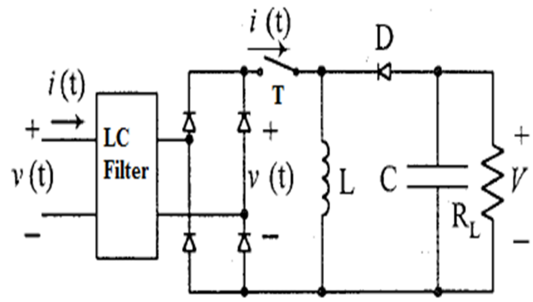

Fig. 1 Circuit for Proposed DC-DC Buck-Boost Converter

A buck-boost DC-DC Converter is shown in Fig. 1. Only a switch T is employed for which a device belong to transistor family is generally used. Also, a diode in series to the load. The diode connection is noted, as comparing with the connection with a boost converter. The inductor, L is connected in parallel after the switch and previous to the diode. The load is same type as given before. A capacitor, C is connected in parallel with the load. The polarity of the output voltage is opposite to that of input voltage here. When the switch, T is put ON, the supply current (*is*) flows through the path V, S and L during the time interval TON . The currents through both source and inductor (*iL*) increase and are same with ($^{di_L}/_{dt}$) being positive. The polarity of the induced voltage is same as that of the input voltage.

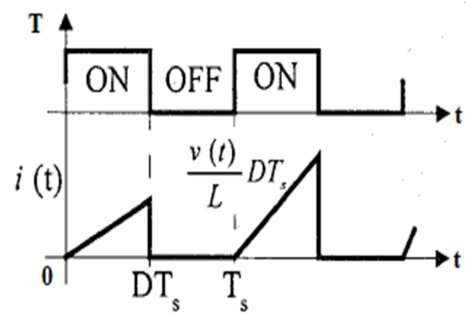

Fig. 2 Input waveform

Then, the switch T is turned OFF. The inductor current tends to decrease with the polarity of the induced emf reversing. ($^{di_L}/_{dt}$) is negative now, the polarity of the output voltage being opposite to that of the input voltage, . The path of the current is through L, parallel combination of load & C and diode D during the time interval, . The output voltage remains approximately constant, since the capacitor is connected across the load.

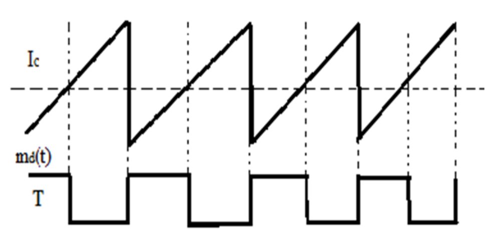

Fig. 3 PWM signals for PFC Buck-Boost Converter

For the Voltage Controller, the DC link voltage is compared with the reference DC link voltage. The error voltage is passed through a PI Controller and multiplied with a unit template of absolute input voltage so as to generate the reference current signal. This signal is compared with sensed converter current which gives the modulating wave for the PWM. This current error is the modulating signal and a triangular wave is taken as the carrier signal so as to generate the PWM gate pulses for turning on/off the Buck Boost converter switch. The control of BLDC motors can be proficient by control algorithm using usual six

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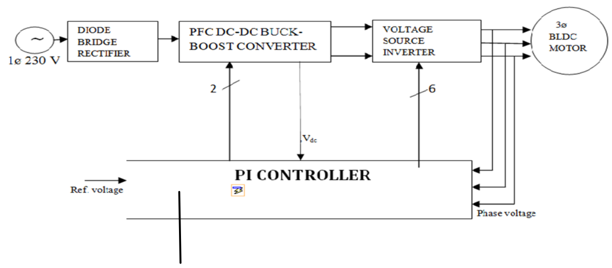
pulse inverters which can be either VSI or CSI. The control of these inverters for PMBLDCM needs rotor position information only at the commutation points, for example, every 60° electrical in the three phases; therefore comparatively simple controller is required for commutation and control.



The speed of the motor is measured and is compared to the reference speed. This error signal is given through a PI controller to give a reference signal. This reference signal is compared with the Buck-Boost converter output current so as to give modulating signal to PWM. The obtained signal is compared to the triangular carrier signal to produce the PWM pulses for turning on/off the VSI switches.

III. SIMULATION RESULT

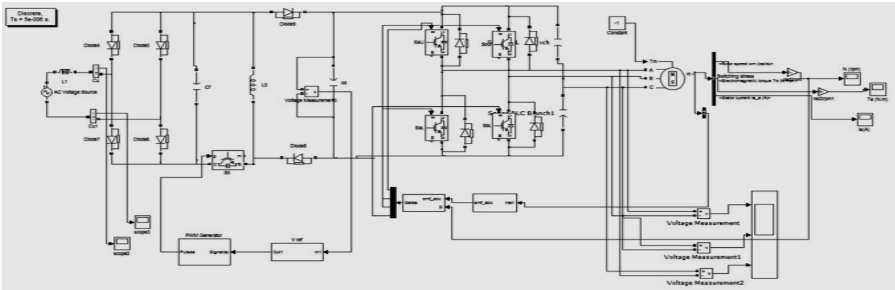


Fig. 4 Simulink model of the proposed converter

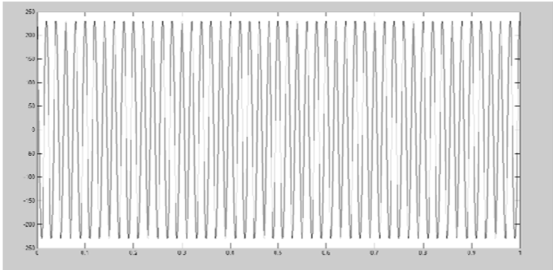


Fig. 5 Output Voltage waveform of the proposed converter

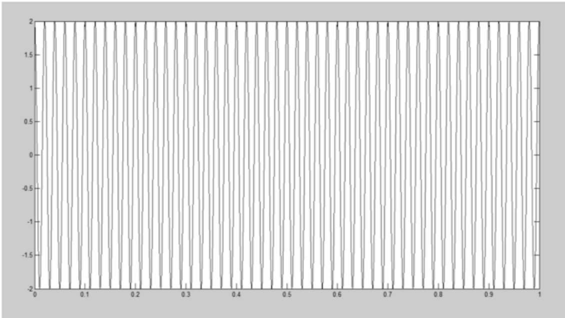


Fig. 6 Output Current waveform of the proposed converter

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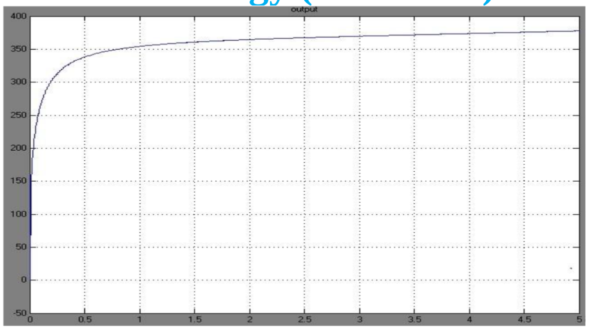

Fig. 7 DC link Voltage of the proposed Converter

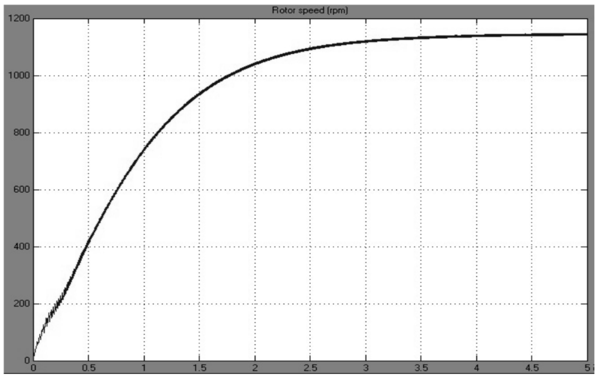

Fig. 8 Speed of the Rotor

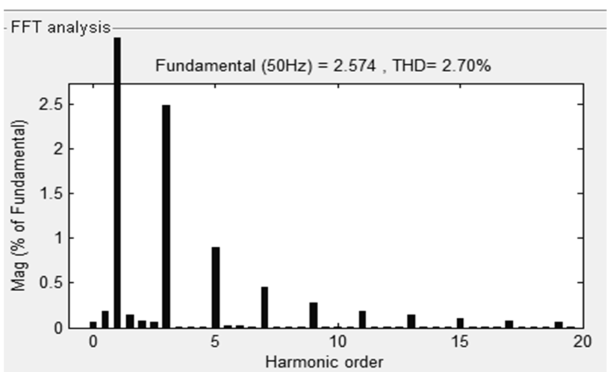

Fig. 9 Harmonic Spectra

TABLE I
PERFORMANCE OF PFC BUCK-BOOST CONVERTER-FED BLDC MOTOR DRIVE UNDER VARIOUS SUPPLY VOLTAGES

V_{in}	THD of I_{in} (%)	PF	I_{in} (A)	V_{dc}(V)
100	2.99	0.9978	2	200
130	2.84	0.9982	2	200
150	2.79	0.9984	2	200
180	2.70	0.9986	2	200

TABLE II
PERFORMANCE OF PFC BUCK-BOOST CONVERTER-FED BLDC MOTOR DRIVE UNDER SPEED CONTROL

V_{dc}	N(rpm)	THD of $I_{in\ (\%)}$	I_{in} (A)	PF	Load(Nm)
140	1120	3.62	2	0.9850	5
145	1150	3.45	2	0.9899	4
150	1165	3.09	2	0.9920	3
155	1283	2.70	2	0.9953	1

IV. CONCLUSION

The PFC converter topology in Power quality improvement for BLDC motor drives is calculated and their performance is simulated to provide the depth understanding of various aspects of the drive. This performance topology has been evaluated through simulation in validating from the design. PFC DC-DC Buck Boost topology is worn as the best option for applications having rated DC voltage superior than the single phase RMS supply voltage. The PFC Buck-Boost Converter has attained near unity power factor in broad range of the speed and the input AC voltage. In addition, Power quality parameter of the proposed BLDC motor drive is in conformity to the international standard of IEC 61000-3-2. The proposed drive has confirmed very excellent performance with no sensor as a variable speed drive for small power applications having enhanced power quality at the supply. The reduced number of switches in inverter topology further reduces the cost of drives.

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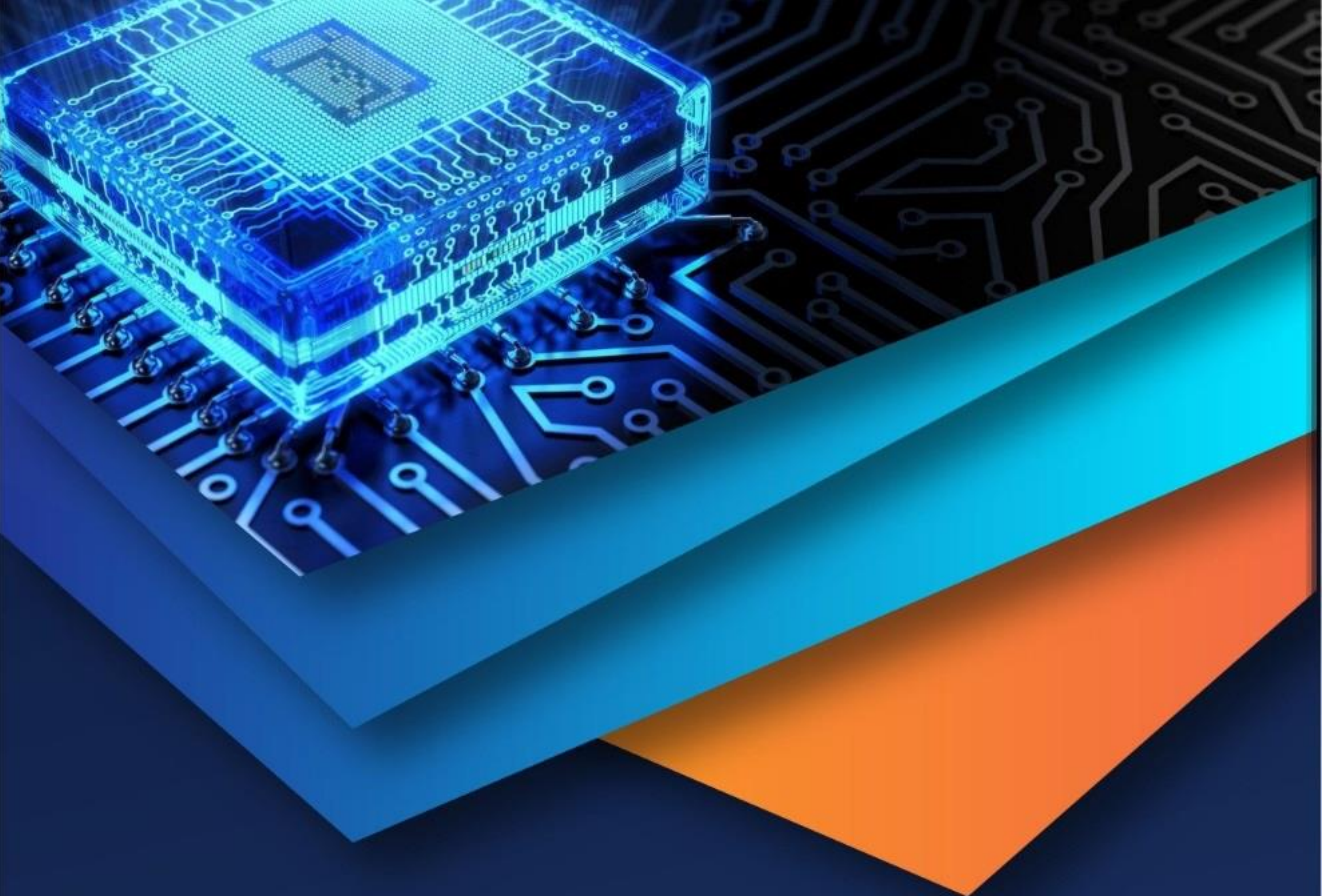

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