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BRIDGELESS BUCK-BOOST CONVERTER DRIVEN BY VARIABLE-SPEED BLDC MOTOR DRIVE WITH FIXED POWER FACTOR

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ABSTRACT: This paper provides a low-power cost-effective alternative, namely a brushless direct current (BLDC) motor drive driven by a bridgeless buck-boost converter with power factor correction (PFC). The BLDC motor speed regulation method employs a single voltage sensor to manage the dc link voltage of the voltage source inverter (VSI). The use of electronic commutation in the BLDC motor, which results in lower switching losses, allows the VSI to operate at the fundamental frequency switching. The use of a BL architecture for the buck-boost converter is advocated due to its ability to omit the diode bridge rectifier, resulting in lower conduction losses. A buck-boost converter with PFC capability is designed to operate in discontinuous inductor current mode (DICM) to accomplish intrinsic power factor correction (PFC) at alternating current (AC) mains. In the presence of increased power quality at the ac mains, the performance of the suggested drive is examined throughout a wide range of speed control and varying supply voltages (universal ac mains at 90-265 V). The collected power quality indices are found to be within acceptable limits set by international power quality standards such as IEC 61000-3-2. The recommended drive's performance is simulated using the MATLAB/Simulink environment, and the findings are validated by experimentation on a drive prototype.

Index Terms: Bridgeless (BL) buck–boost converter, brushless direct current (BLDC) motor, discontinuous inductor current mode (DICM), power factor corrected (PFC), power quality.

1. INTRODUCTION:

Making low-power motor drives for residential usage such as fans, water pumps, blowers, mixers, and more is difficult these days since they must be efficient and inexpensive. Brushless direct current (BLDC) motors are becoming more common in these applications due to their high efficiency, high flux density per unit volume, ease of maintenance, and lack of electromagnetic interference.These BLDC motors are not only suitable for residential use, but also for medical equipment, transportation, HVAC, motion control, and a variety of industrial instruments. The stator of a BLDC motor has three-phase windings, and the rotor contains fixed magnets.

To reduce sparking and wear and tear on the brushes and commutator assembly, the BLDC motor employs electronic commutation based on rotor position. As a result, the motor is also known as an electrically commutated motor. Since several international standards, such as the International Electrotechnical Commission (IEC) 61000-3-2, state that harmonics in source current should not be too high, power quality issues have become particularly important to consider. IEC 61000-3 restricts several types of harmonic current in class-A equipment (600 W, 16 A per phase), which includes home appliances, so that the total harmonic distortion (THD) of the source current is less than 19%.

2. EXISTING SYSTEM:

When the power supply is alternating current, the BL buck-boost converter is configured to operate in discontinuous inductor current mode (DICM) to naturally correct the power factor. The BL buck-boost converter manages the VSI's dc link voltage, which regulates the speed of the BLDC motor. Because it operates at a low frequency for BLDC motor electrical commutation, VSI has switching losses. This reduces those losses.

We examined the performance of the suggested drive over a wide range of speed adjustments and discovered that it performed best with alternating current mains. Changes in supply voltage at universal alternating current mains are also investigated to demonstrate how well the drive performs under real-world supply situations. The voltage and current loads on the PFC converter switch are also examined to determine the switch's grade and heat sink design. Finally, the proposed BLDC motor drive is tested on hardware to demonstrate that it operates across a wide range of speed controls and with improved power quality at alternating current mains.

3. PROPOSED SYSTEM:

The PFC BL buck boost converter operates in two stages: during the positive and negative half cycles of the source voltage, and during the entire switching cycle.

Operation During Positive and Negative Half Cycles of Supply Voltage

In the BL buck boost converter design, it is advised that switches Sw1 and Sw2 work for the positive and negative half cycles of the source voltage. Diodes D1 and Dp, as well as switch Sw1, are turned on during the positive half cycle of the input voltage. As seen in Fig. 2(a)-(c), this transfers energy to the dc link capacitor Cd. When the source voltage is negative, the switch Sw2, inductor Li2, and diodes D2 and Dn all operate.

Operation During Complete Switching Cycle

This article discusses three ways in which the positive half cycle of source voltage might affect the entire switching cycle.

In Mode I, the switch Sw1 conducts to charge the inductor Li1, as shown in Fig. 2(a). This raises the inductor current iLi1. The diode Dp on the input side completes the circuit, and the VSI-fed BLDC motor drains the dc link capacitor Cd.

4.DESIGN OF PFC BL BUCK–BOOST CONVERTER

A PFC BL buck-boost converter is configured to operate in DICM, causing the current in inductors Li1 and Li2 to cease and start throughout the switching time. For a BLDC motor with a power level of 251 W, a 350 W (Po) power converter is required (the full specs of the BLDC motor may be found in the Appendix). The recommended converter changes the dc link voltage from 50 V (Vdc min) to 200 V (Vdcmax), with a default value of 100 V (Vdc des). The minimum and maximum duty ratios are so known.

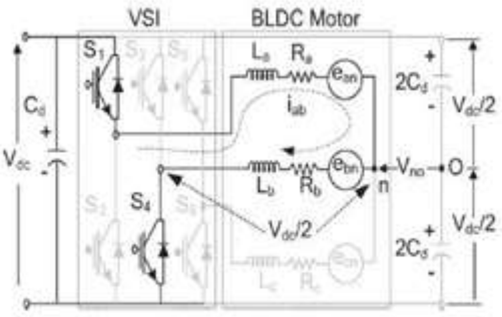

Fig.1. When switches S1 and S2 are conducting, a VSI-fed BLDC motor operates..

5.SIMULATED PERFORMANCE OF PROPOSED BLDC MOTOR DRIVE

The Sim Power System toolbox in MATLAB/Simulink is used to simulate the performance of the proposed BLDC motor drive. The performance of the recommended drive is determined by how well the BLDC motor and BL buck-boost converter work, as well as the power quality levels that can be achieved on alternating current mains. The properties of the BLDC motor are examined to ensure good operation. Speed (N), electromagnetic torque (Te), and stator current (ia) are examples. The supply voltage (Vs), supply current (is), dc link voltage (Vdc), inductor currents (iLi1, iLi2), switch voltages (Vsw1, Vsw2), and switch currents (isw1, isw2) are measured to demonstrate how the PFC BL buck-boost converter should perform.

Steady-State Performance

Figure 6 depicts the suggested BLDC motor drive in steady-state mode for two cycles of supply voltage at rated condition, which is a rated dc link voltage of 200 V. To ensure that the BL buck boost converter's DICM works, we monitor the irregular inductor currents (iLi1 and iLi2). Table III demonstrates how effectively the proposed BLDC motor drive performs when the dc link voltage is varied from 50 V to 200 V to control the speed. The harmonic waveforms of the supply current for rated and low load situations, which are dc link voltages of 200 V and 50 V, are shown in Figs. 7(a) and (b). These results show that the THD of the supply current is within the IEC 61000-3-2 limitations.

6.HARDWARE VALIDATION OF PROPOSED BLDC MOTOR DRIVE

The recommended PFC BL buck-boost converter-fed BLDC motor drive is built with a digital signal processor (DSP) based on the TI-TMS320F2812. The 6N136 optocoupler is utilized in the fabrication of the hardware that connects the DSP to the gate drivers of solid-state switches. A prefiltering and isolation circuit is also built for the Hall-Effect sensor so that it can take up Hall-effect position data. The test findings are discussed in the following sections.

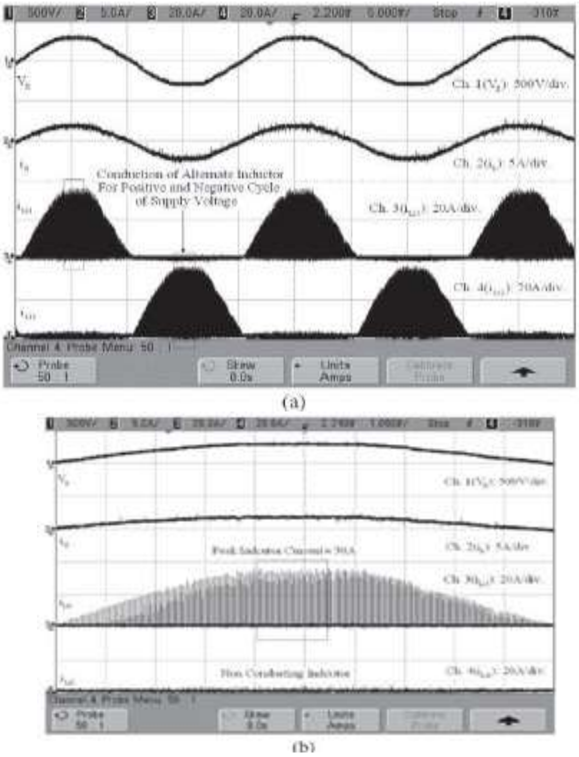

Fig.2. (a) The variation of inductor current (iLi1 and iLi2) with source voltage and current, as well as (b) its broadened waveforms.

7.COMPARATIVE ANALYSIS OF DIFFERENT CONFIGURATIONS

A comparison of the planned BL buck-boost converter-fed systems Standard systems can be used to power BLDC motors.DBR feeds two standard techniques.

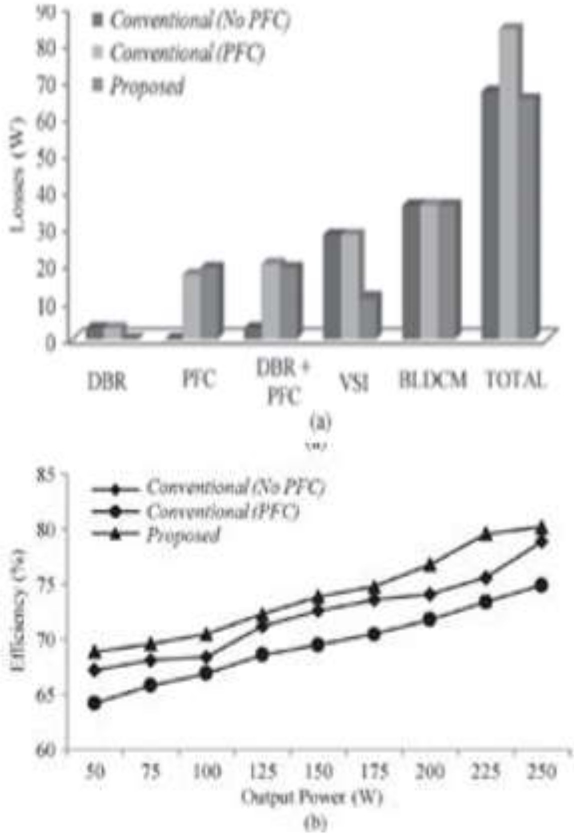

Fig.3. (a) An examination of the losses and (b) the effectiveness of the intended and conventional configurations.

Table VII compares three alternative BLDC motor driving strategies. The evaluation examines the requirement for control, the requirement for sensors, and the losses in the PFC converter and the VSI-fed BLDC motor. The recommended technique takes the least amount of sensing and is the least expensive, but it performs the best of the three setups, making it the greatest choice for low-power applications.

8.CONCLUSION

A VSI-fed BLDC motor drive based on a PFC BL buck-boost converter for low-power applications has been shown. A new method of managing speed was employed to reduce switching losses in the VSI. This entails altering the voltage on the dc bus and running the VSI at its fundamental frequency for electronic commutation of the BLDC motor. To obtain power factor adjustment at alternating current mains, the BL buck-boost converter at the front end was run in DICM. Controlling the speed and the source voltage worked well, and the power quality scores were within the IEC 61000-3-2 standards. Furthermore, voltage and current strains on the

PFC switch have been investigated to see whether the proposed technique is feasible. Finally, a trial model of the suggested drive was created in order to test the suggested BLDC motor drive's ability to control speed and deliver higher power quality at alternating current mains. We recommend the suggested solution for low-power BLDC motor drives because it works well enough.

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