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A Sensor-Less BLDC Control for Power Factor Correction using Back EMF

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Abstract— **The speed control of the BLDC motor is well achieved by controlling the DC link voltage of the voltage source inverter (VSI) which is used with a single voltage sensor. This facilitates the switching by using the electronic commutation of the BLDC motor which offers reduced switching losses. In this paper, a Bridgeless (BL) configuration of the buck-boost convertor using fuzzy logic controller is proposed which offers the elimination of the diode bridge rectifier, thus reducing the conduction losses associated with it. The performance of this proposed drive is simulated in environment, and the obtained results are validated experimentally on a developed prototype of the drive. In the existing system, a power factor corrected (PFC) bridgeless (BL) buck-boost converter-fed brushless direct current (BLDC) motor drive is used as a cost-effective solution for low-power applications by using proportional integral derivative (PID) & proportional integral (PI) controller. The conventional PFC scheme of BLDC motor drive utilizes a pulse width modulated voltage source inverter (PWM-VSI) for speed control with a constant DC like voltage. In the proposed system, the motor phase angle is calculated by using fuzzy logic controlled back EMF of the motor. The switching part of BLDC is based on switching table that we have formed in the matrix format. One for speed controlling of BLDC and another controller for buck-boost power factor correction of primary side of converter section.**

Keywords— Bridgeless(BL)buck–boost converter,brushless direct current(BLDC) motor, discontinuousinductor current mode(DICM),powerfactorcorrected(PFC),powerquality.

I. INTRODUCTION

The development and availability of very high-energy density permanent magnet materials has been contributed to an increased use of the Bladeless dc motor in high performance applications. High-speed electric machines are of interest now a day as direct drives for high-speed milling machines, compressors and pumps, yielding a high output power at rather small machine dimensions. The high- speed BLDC (Blade less dc motor) with sinusoidal currents is the best choice for high-speed operation because of its high efficiency, low torque ripple, low noise, and excellent control performance. The BLDC eliminates rotational cogging torque due to permanent magnet preferred positions, decreases core loss and thus it increases efficiency, provider; excellent torque-to volume and power-to volume ratios, and hasa linear current versus torque relation. In the BLDC, in order to generate smooth torque and to reduce noise and vibration, the current waveform should match the shape of the motor electromotive force (EMF). The 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 brushless direct current (BLDC) motor in these applications is becoming very common due to its features of high efficiency, high flux density per unit volume, low maintenance requirements, and low electromagnetic-interference problems. 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 its stator and permanent magnets on its 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 commentator assembly. Power quality problems have now 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 International Electro technical Commission (IEC).

The choice of mode of operation of a PFC converter is a plays a vital issue because it directly affects the cost and rating of the components used in the PFC converter. The continuous conduction mode (CCM) and the discontinuous conduction mode (DCM) 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 namely, 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 now preferred for low-power applications.

The conventional PFC scheme of the BLDC motor drive uses a pulse width modulated voltage source inverter (PWM-VSI) for speed control with a constant dc link voltage. This offers higher switching losses in VSI as the switching losses increase as a square function of the switching frequency. As the speed of the BLDC motor is directly proportional to the applied dc link voltage, the speed control is achieved by the variable dc link voltage of VSI. This allows the fundamental frequency switching of VSI, i.e., electronic commutation and it offers reduced switching losses.

The trapezoidal current drive systems are popular because of its simplicity in their control circuits but suffer from a torque ripple problem during commutation. But the trapezoidal commutation is inadequate to provide smooth and precise motor control of PMSM, particularly at low speeds. The sinusoidal commutation solves this problem. In order to generate smooth sinusoidal current waveform, a high resolution rotor position feedback is required. This high resolution rotor position is typically provided by an incremental encoder or a resolver attached to the shaft of the motor.Also the hall sensors which are installed in the stator by the motor manufacturer are often used. Hall sensors require little volume in comparison to the resolver or Encoder, but provide low resolution rotor angle feedback, usually 60 electrical degrees resolution. The use of hall sensors along with these BLDC results in a torque ripple and vibration whose frequency is RPM dependent. Also the sinusoidal commutation results in smoothness of control that is generally unachievable with trapezoidal commutation.

II. SENSORLESS BLDC CONTROL WITH POWER FACTOR CORRECTION

A. FUZZY CONTROLLER BASED BLDC MOTOR SYSTEM

In the proposed system, back EMF concept is used for finding the rotor positions as the existing system has the limitation of settling time & time complexity problems. So the proposed method is been analyzed and worked out using fuzzy logic controller. Hence the stability of the entire system is increased.

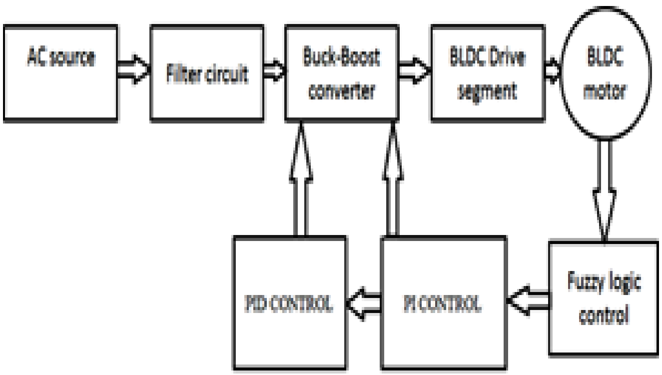

Fig. 1. Block diagram

B. OPERATION DURING POSITIVE AND NEGATIVE HALF CYCLE

In the proposed scheme of the BL buck–boost converter, Switches *Sw*1 and *Sw*2 operate for the positive and negative half cycles of the supply voltage. During the positive half cycle of the supply voltage, switch *Sw*1, inductor *Li*1, and diodes *D*1 and *Dp*are operated to transfer energy to dc link capacitor *Cd* .

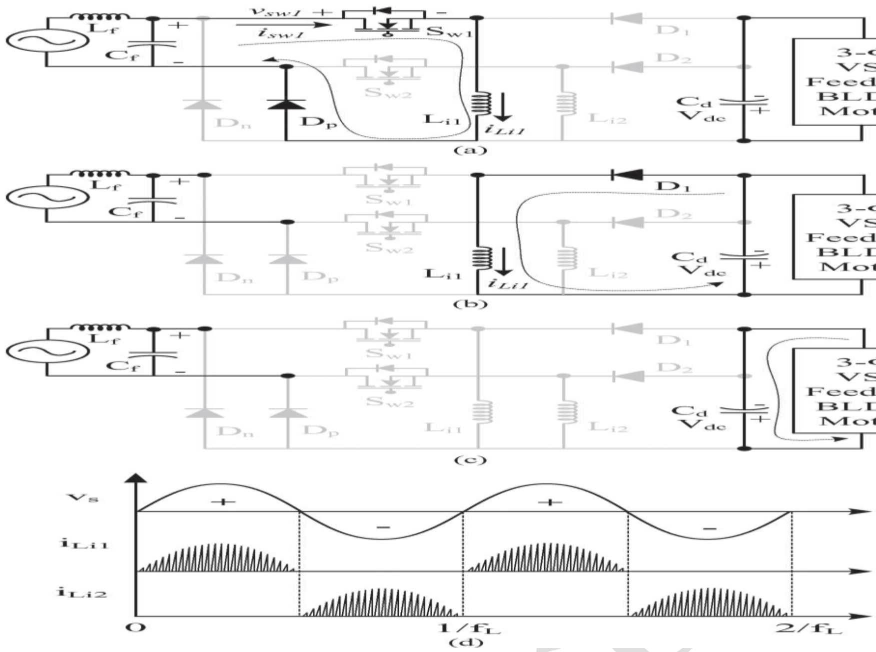

Fig. 2. Buck–Boost converter (positive half cycle)

Similarly, for the negative half cycle of the supply voltage, switch *Sw*2, inductor *Li*2, and diodes *D*2 and *Dn*conduct.

III. SIMULATION RESULTS

A. PI CONTROLLER BASED BLDC MOTOR

The simulation results obtained from the MATLAB/SIMULINK for a sensor less BLDC control with PI controller using power factor correction is explained below.

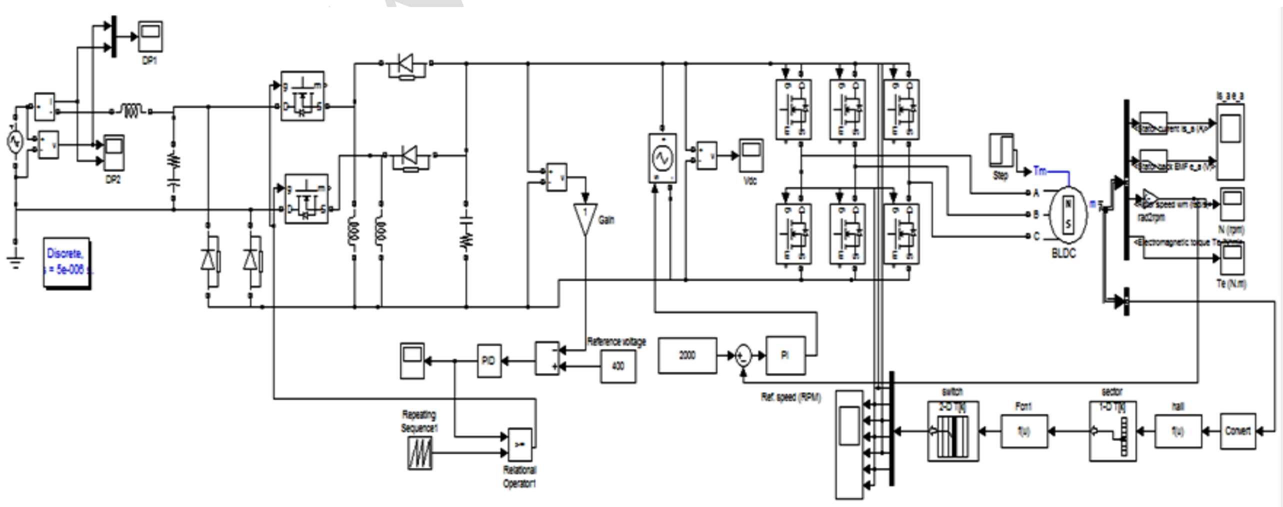

Fig. 3. Simulation of PI controller based BLDC motor

Output waveform of Buck-Boost DC output voltage

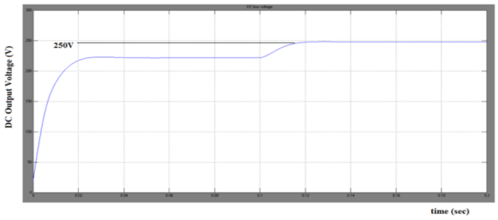

Fig. 4. Output waveform of buck-boost dc output voltage

Output waveform of the Buck-Boost DC output voltage using PI controller is shown in Fig.4.This output waveform is plotted between voltage and time and it gives the output about 250v.

Output waveform of VSI output voltage

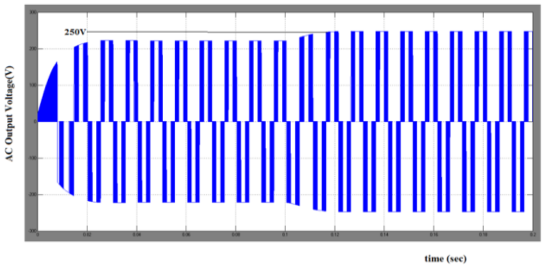

Fig. 5. Output waveform of VSI output voltage

Output waveform of VSI (voltage sources inverter) is shown in Fig.5.
This output waveform is plotted between voltage and time and it gives the output about 250v.

Electromagnetic torque (Nm)

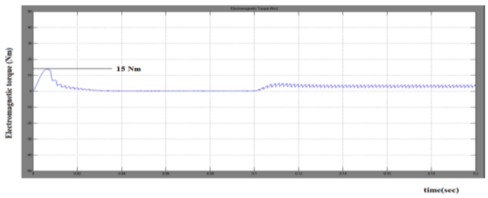

Fig. 6. Waveform of electromagnetic torque

The electromagnetic torque is obtained using PI controller and is show in Fig.6.This output waveform is plotted between torque and time and it gives the output about 15Nm.

Output waveform of rotor speed

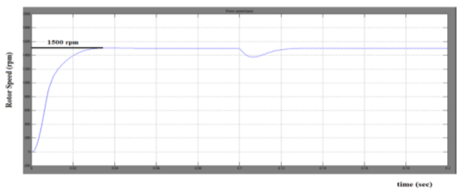

Fig.7. Output waveform ofrotor speed

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The output waveform of rotor speed is shown in Fig.7.This output waveform is plotted between speed and time and it gives the output about 1500rpm.

B. *FUZZYLOGIC CONTROLED BASED BLDC MOTOR*

The simulation results obtained from the MATLAB/SIMULINK for a Sensor lessBLDC control using fuzzy logic controller with power factor correction is shown below.

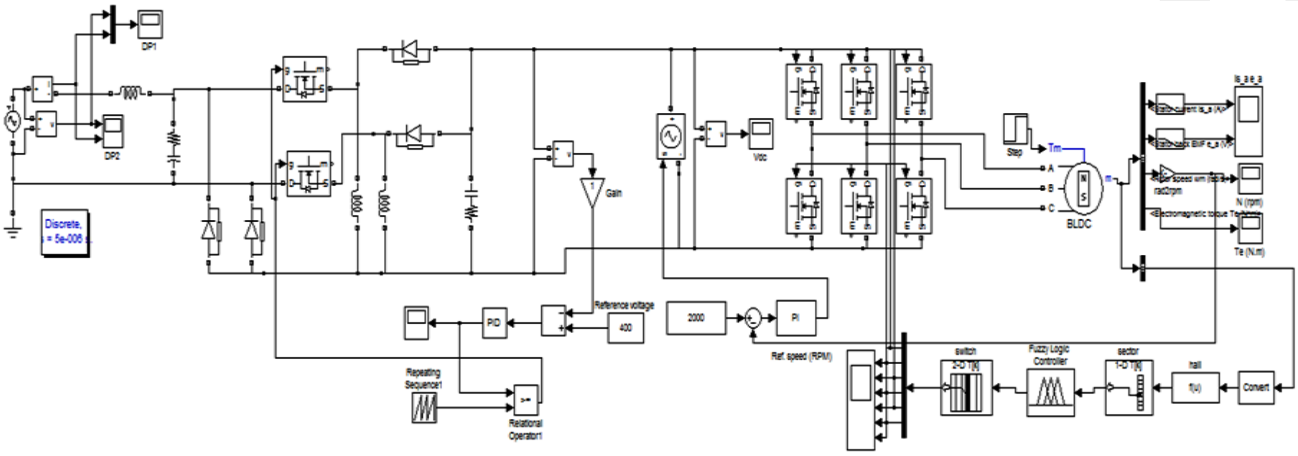

Fig 8. Simulation of fuzzy logic controlled based BLDC motor

Output waveform of Buck-Boost DC output voltage

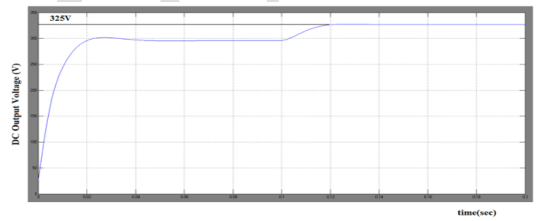

Fig9. Output waveform of buck-boost dc output voltage

Output waveform of Buck-Boost DC output voltage using PI controller is shown in Fig.9.This output waveform is plotted between voltage and time and it gives the output about 325v.

Output waveform of VSI output voltage

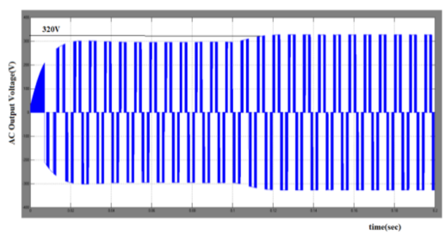

Fig 10. Output waveform of VSI output voltage

Output waveform of VSI (voltage sources inverter) output with switching operation voltage is shown in Fig.10.This output waveform is plotted between voltage and time and it gives the output about 310v.

Output waveform of stator current and stator back EMF waveform

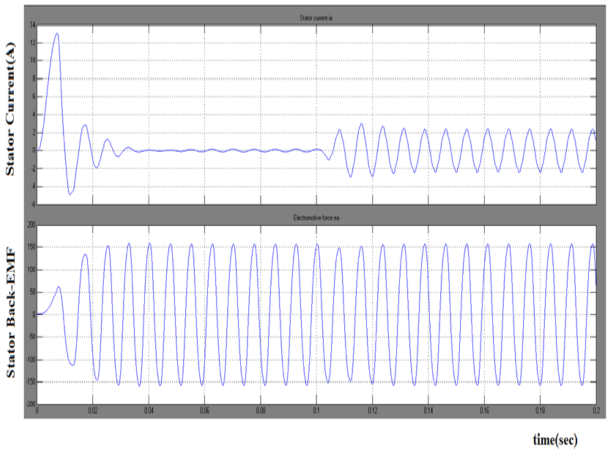

Fig 11. Output waveform of stator current and stator back EMF waveform

Electromagnetic torque (Nm)

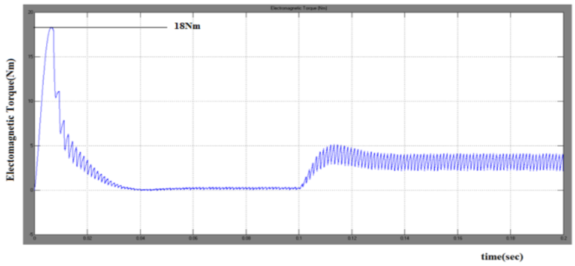

Fig 12. Waveform of electromagnetic torque

The electromagnetic torque using PI controller is shown in Fig.12. This output waveform is plotted between torque and time and it gives the output about 18Nm.

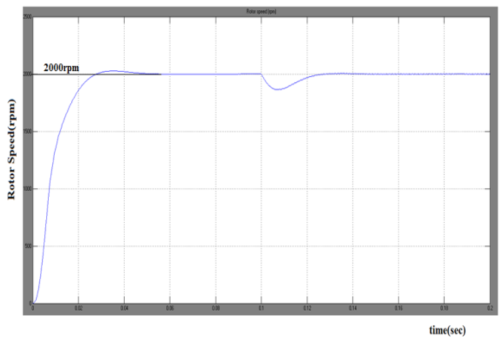

Fig 13. Output waveform ofrotor speed

The output waveform of rotor speed is shown in Fig.13. This output waveform is plotted between speed and time and it gives the output about 2000rpm.

IV. CONCLUSION

A PFC BL buck-boost converter-based VSI-fed BLDC motor drive has been proposed using fuzzy controller for speed improvement. A new method of speed control has been used 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 BL buck-boost converter has been operation in DICM for achieving an inherent power factor correction at AC mains. In this paper, a PLC BL buck –boost converter based VSI-fed BLDC motor drive has been proposed. Here the speed is increased by using the back EMF in each winding of the BLDC motor when compared to the existing work. In the existing system the power factor is not unity but by using this back EMF (proposed system), the power factor can be made unity. The proposed scheme has shown satisfactory performance, and it is a recommended solution applicable to low-power BLDC motor drive. Moreover,the voltage and current stresses on the PFC switch have been evaluated for determining the practical application of the proposed system.

References

[1] C. L. Xia, Permanent Magnet Brushless DC Motor Drives and Controls. Hoboken, NJ, USA: Wiley, 2012.
[2] J. Moreno, M. E. Ortuzar, and J. W. Dixon, "Energy-management system for a hybrid electric vehicle, using ultracapacitors and neural networks,"IEEE Trans. Ind. Electron., vol. 53, no. 2, pp. 614–623, Apr. 2006.
[3] Y. Chen, C. Chiu, Y. Jhang, Z. Tang, and R. Liang, "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.
[4] X. Huang, A. Goodman, C. Gerada, Y. Fang, and Q. Lu, "A single sidedmatrix converter drive for a brushless dc motor in aerospace applications,"IEEE Trans. Ind. Electron., vol. 59, no. 9, pp. 3542–3552, Sep. 2012.
[5] H. A. Toliyat and S. Campbell, DSP-Based Electromechanical Motion Control. Boca Raton, FL, USA: CRC Press, 2004.
[6] P. Pillay and R. Krishnan, "Modeling of permanent magnet motor drives," IEEE Trans. Ind. Electron., vol. 35, no. 4, pp. 537–541, Nov. 1988.
[7] C. L. Xia, Permanent Magnet Brushless DC Motor Drives and Controls. Hoboken, NJ, USA: Wiley, 2012.
[8] J. Moreno, M. E. Ortuzar, and J. W. Dixon, "Energy-management system for a hybrid electric vehicle, using ultracapacitors and neural networks,"IEEE Trans. Ind. Electron., vol. 53, no. 2, pp. 614–623, Apr. 2006.
[9] Y. Chen, C. Chiu, Y. Jhang, Z. Tang, and R. Liang, "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.
[10] X. Huang, A. Goodman, C. Gerada, Y. Fang, and Q. Lu, "A single sidedmatrix converter drive for a brushless dc motor in aerospace applications,"IEEE Trans. Ind. Electron., vol. 59, no. 9, pp. 3542–3552, Sep. 2012.
[11] H. A. Toliyat and S. Campbell, DSP-Based Electromechanical Motion Control. Boca Raton, FL, USA: CRC Press, 2004.
[12] P. Pillay and R. Krishnan, "Modeling of permanent magnet motor drives," IEEE Trans. Ind. Electron., vol. 35, no. 4, pp. 537–541, Nov. 1988.

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