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Flexible Speed and Torque Control of BLDC Motor Drive with Z-Source Inverter with Power Factor Correction

TESSA THERASSA JOSE[1], C. H. SANTOSH KUMAR[2]

[1]PG Scholar, Dept of EEE, Sridevi Women's Engineering College, Gandipet, Hyderabad, TS, India,
E-mail: tessatjose@gmail.com.

[2]Assistant Professor, Dept of EEE, Sridevi Women's Engineering College, Gandipet, Hyderabad, TS, India,
E-mail: chksantosh@yahoo.com.

Abstract: This paper shows an effect issue upgraded by misuse buck-support convertor for BLDC engine drive as a quality convincing reaction for low power applications. A procedure of speed organization of BLDC engine by prevalent the DC join voltage of Z-source inverter is used. This empowers the operation of Z-source inverter at vital change by abuse the electronic reward of BLDC engine that offers lessened change hardships. A buck-support convertor is proposed to work in DICM (Discontinuous electrical contraption Current Mode) to supply A solidarity Power issue at AC mains. The execution of the expected drive is surveyed more than an extraordinary movement of rate organization and running offer voltages with improved power quality at AC mains. The execution of foreseen drive is reproduced in MATLAB/Simulink environment.

Keywords: Bridgeless (BL) Buck–Boost Converter, Brushless Direct Current (BLDC) motor, Discontinuous Inductor Current Mode (DICM), Power Factor Corrected (PFC), Z-Source Inverter.

I. INTRODUCTION

This venture can be upgraded by actualizing Z-source inverter rather than ordinary Voltage source inverter at the stator side of BLDC drive. This enhances the SC ride through ability in the circuit. The shoot-through issue in Voltage source inverter and open circuit issue in current source inverter by electromagnetic impedance (EMI) clamors decrease the inverter's dependability. This is not present in Z-source inverter. Since 1980's another arrangement thought of invariable magnet brushless engine has been made. The Changeless magnet brushless engines are requested into two sorts based upon the back EMF waveform, brushless Air molding (BLAC) and brushless DC (BLDC) engine [1]. BLDC engine has trapezoidal back EMF and semi rectangular current waveform. BLDC engine are rapidly getting the chance to be no doubt understood in organizations, for instance, Appliances, HVAC industry, helpful, electric balance, auto, planes, military apparatus, hard plate drive, mechanical computerization rigging and instrumentation because of their high viability, high power component, silent operation, minimized, steadfastness and low backing [2]. To supplant the limit of commutator and brushes, the BLDC engine requires an inverter and a position sensor that recognizes rotor position for real substitution of current. The upset of the BLDC engine is in light of the feedback of rotor position which is gotten from the hallway sensors.

BLDC engine customarily businesses three anteroom sensors for choosing the reward gathering. In BLDC engine the power hardships are in the stator where warmth can be successfully traded through the edge or cooling systems are used as a piece of sweeping machines. BLDC engine have various central focuses over DC engine and provoking engine as shown in Fig.1. A rate of the good circumstances are better speed versus torque qualities, high component response, high capability, long meeting expectations life, calm operation; higher pace ranges [3]. This paper exhibits a BL buck–boost converter-sustained BLDC engine drive with variable dc join.

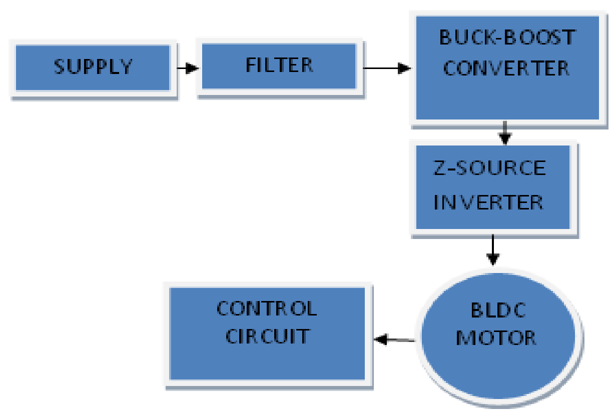

Fig.1. Proposed System Block Diagram.

II. PROPOSED PFC BL BUCK–BOOST CONVERTER-FED BLDC MOTOR DRIVE WITH Z-SOURCE INVERTER

Fig2 demonstrates the proposed BL buck–boost converter-based VSI-sustained BLDC motor drive. The variable of the BL buck–boost converter are composed such that it works in discontinuous inductor current mode (DICM) to accomplish a natural force element rectification at ac mains. The speed control of BLDC motor is accomplished by the dc join voltage control of ZSI utilizing a BL buck–boost converter. This decreases the exchanging misfortunes in VSI because of the low recurrence operation of VSI for the electronic replacement of the BLDC motor. The execution of the proposed commute is assessed for an extensive variety of pace control with enhanced force quality at ac mains. Moreover, the impact of supply voltage variety at general ac mains is likewise concentrated on to exhibit the execution of the drive in reasonable supply conditions. Voltage and current weights on the PFC converter switch are additionally assessed for deciding the switch rating and warmth sink outline. At long last, an equipment execution of the proposed BLDC motor drive is done to show the achievability of the proposed commute more than an extensive variety of rate control with enhanced force quality at ac mains.

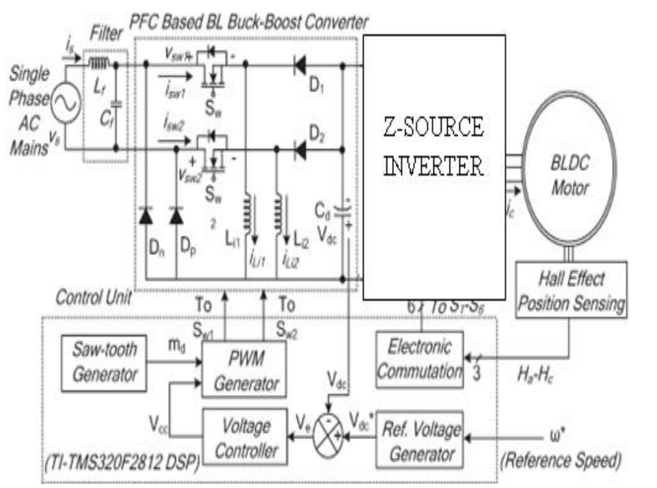

Fig.2. Proposed BLDC engine drive with front-end BL buck–boost converter with Z-Source.

A. Z-Source Inverter

A Z-source inverter is a sort of power inverter, a circuit that converts direct currentto alternating current. It works as a buck-boost inverter without making utilization of DC-DC Converter Bridge because of its exceptional circuit topology. Ordinarily, three stage inverters have 8 vector expresses (6 dynamic states and 2 zero states). But ZSI along with these 8 normal vectors has an extra state known as the shoot through state, amid which the switches of one leg are short circuited. In this state, vitality is put away in the impedance system and when the inverter is in its dynamic express, the put away vitality is exchanged to the heap, consequently giving support operation. Though, this shoot through state is denied in VSI. To accomplish the buck-boost office in ZSI, obliged Pulse-width adjustment is as demonstrated in figure. The ordinary Sinusoidal PWM (SPWM) is produced by contrasting transporter triangular wave and reference sine wave. For shoot through heartbeats, the bearer wave is contrasted and two correlative DC reference levels. These heartbeats are included the SPWM, highlighted in fig.3. ZSI has two control flexibilities: tweak of the reference wave which is the proportion of plenty fullness of reference wave to sufficiency of bearer wave and shoot through obligation proportion which can be controlled by DC level.

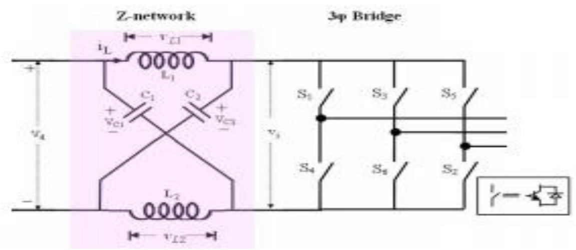

Fig.3. Z-source inverter.

The benefits of Z-source inverter are recorded as takes after,

- The source can be either a voltage source or a present source. The DC wellspring of a ZSI can either be a battery, a diode rectifier or a thyristor converter, an energy component stack or a blend of these.
- The primary circuit of a ZSI can either be the customary VSI or the conventional CSI.
- Works as a buck-boost inverter.

The heap of a ZSC can either be inductive or capacitive or another Z-Source system.

III. OPERATING PRINCIPLE

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.

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

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, respectively. During the positive half cycle of the supply voltage, switch Sw1, inductor Li_1, and diodes D_1 and D_p are operated to transfer energy to dc link capacitor Cd as shown in Fig. 4(a)–(c). Similarly, for the negative half cycle of the supply voltage, switch Sw_2, inductor L_{i2}, and diodes D_2 and D_n conduct as shown in Fig. 4(a)–(c). In the DICM operation of the BL buck–boost converter, the current in inductor Li becomes discontinuous for certain duration in a switching period. Fig. 4(d) shows the waveforms of different parameters during the positive and negative half cycles of supply voltage.

B. Operation During Complete Switching Cycle

Three modes of operation during a complete switching cycle are discussed for the positive half cycle of supply voltage as shown hereinafter.

Mode I: In this mode, switch Sw_1 conducts to charge the inductor Li_1; hence, an inductor current iLi_1 increases in this mode as shown in Fig. 2(a). Diode Dpcompletes the input side circuitry, whereas the dc link capacitor C_d is discharged by the VSI-fed BLDC motor as shown in Fig. 4(d).

Mode II: As shown in Fig. 4(b), in this mode of operation, switch Sw_1 is turned off, and the stored energy in inductor Li_1 is transferred to dc link capacitor C_d until the inductor is completely discharged. The current in inductor Li_1 reduces and reaches zero as shown in Fig. 4(d).

Mode III: In this mode, inductor Li_1 enters discontinuous conduction, i.e., no energy is left in the inductor; hence, current iLi1 becomes zero for the rest of the switching period. As shown in Fig. 2(c), none of the switch or diode is conducting in this mode, and dc link capacitor C_d supplies energy to the load; hence, voltage V_{dc} across dc link capacitor C_d starts decreasing.

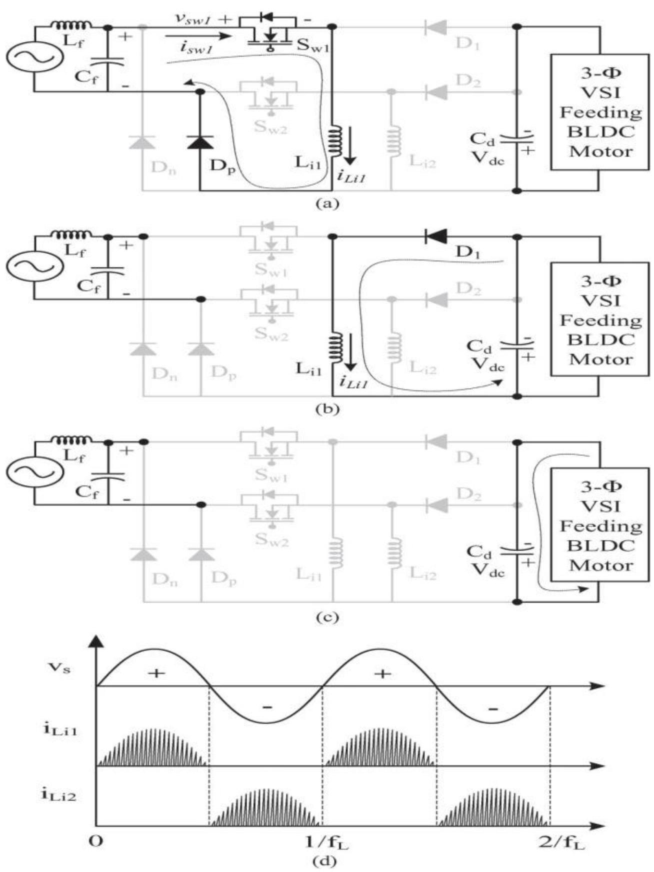

Fig. 4. Operation of the proposed converter in different modes (a)–(c) for a positive half cycles of supply voltage and (d) the associated waveforms. (a) Mode I. (b) Mode II. (c) Mode III. (d) Waveforms for positive and negative half cycles of supply voltage.

The operation is repeated when switch Sw1 is turned on again after a complete switching cycle.

IV. SIMULATION RESULTS

Simulation is performed using MATLAB/SIMULINK software. Simulink liabrary files include inbuilt models of many electrical and electronics components and devices such as diodes, MOSFETS, capacitors, inductors, motors, power supplies and so on. The circuit components are connected as per design without error, parameters of all components are configured as per requirement and simulation is performed as shown in Figs.5 to 12.

Simulation Parameters:

Input supply= 1-ph, 230V, 50Hz
Lf=1.6mH
Cf=330nF
L1=42.6uH
L2=42.6uH
Cd=2200mF

Similarly, for the negative half cycle of the supply voltage, switch Sw_2, inductor Li_2, and diodes D_n and D_2 operate for voltage control and PFC operation.

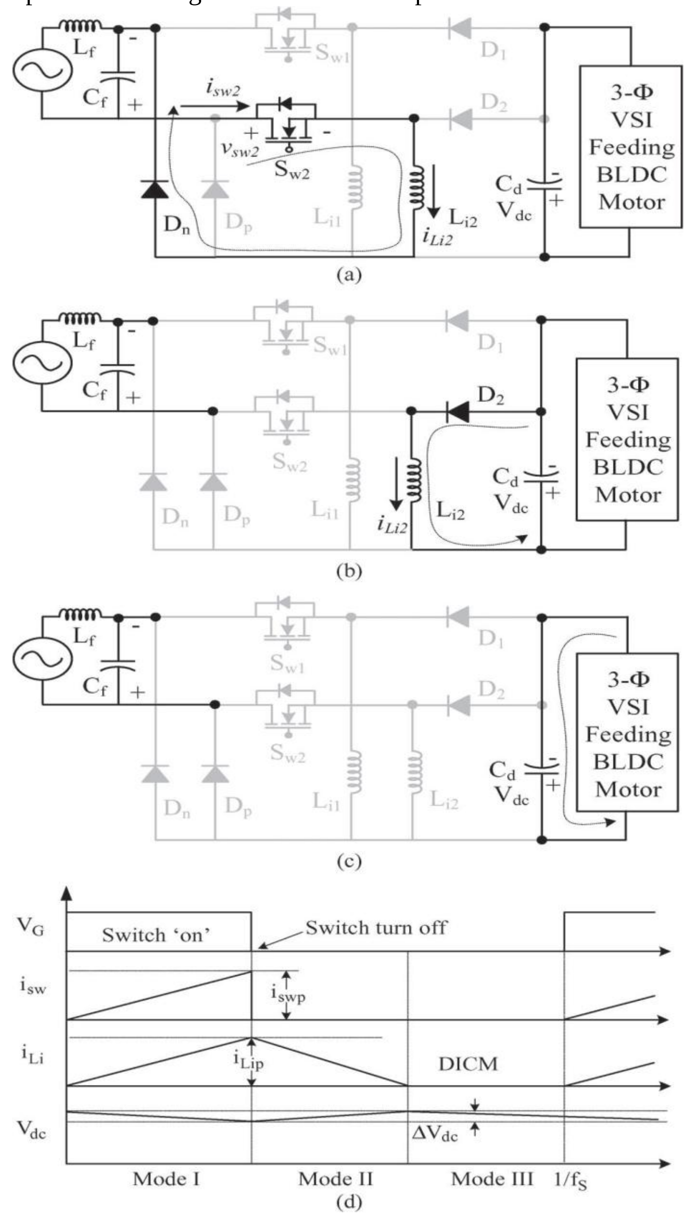

Fig. 5. Operation of the proposed converter in different modes (a)–(c) for a negative half cycles of supply voltage and (d) the associated waveforms. (a)Mode I. (b)Mode II. (c)Mode III. (d) Waveforms during complete switching cycle.

Z-source impedance network parameters:
L=4uH
C=1000uF

BLDC Motor Used In The Project:

Three phase-415 Volt,0.5HP
Stator ph resistance RS= 2.8Ohm
Inductances, Ld=8.5mH, Lq= 8.5mH
Flux linkage=0.175Vs
Voltage constant=126.966 V_peak L-L/Krpm
Torque constant=1.05 Nm/A_peak
Poles= 4
Friction factor=0.001Nms
Inertia=0.0008 J(kg m^2)

A. Waveforms

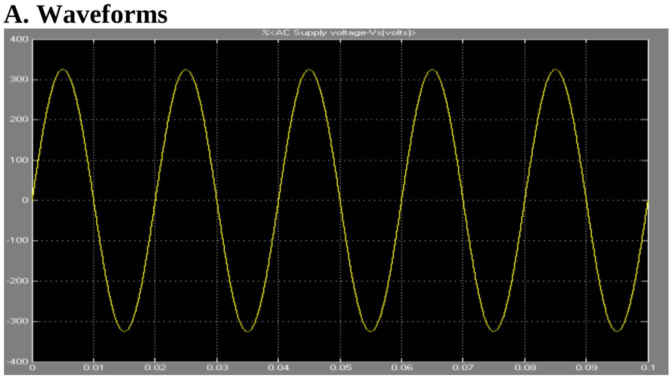

Fig.6. Input supply voltage.

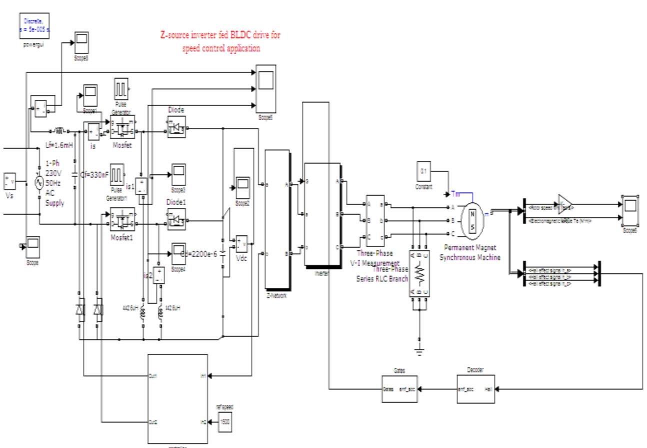

Fig.7.

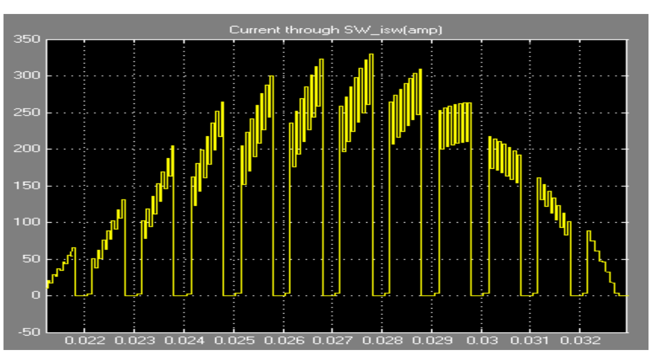

Fig.8. Current through Switches.

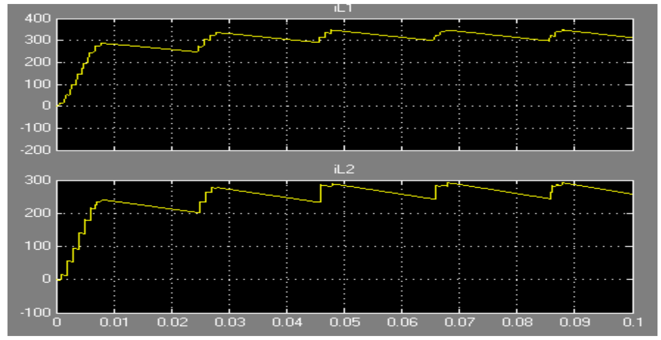

Fig.9. Inductor Currents.

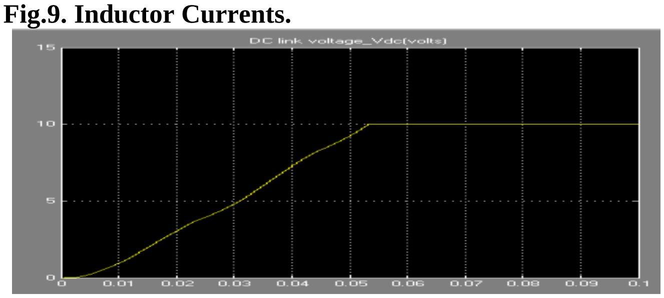

Fig.10. DC link voltage.

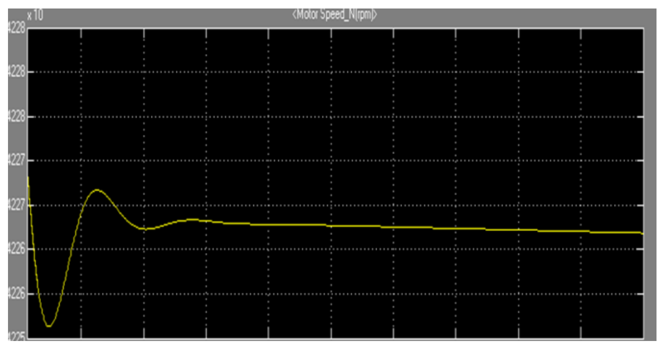

Fig.11. Motor Speed.

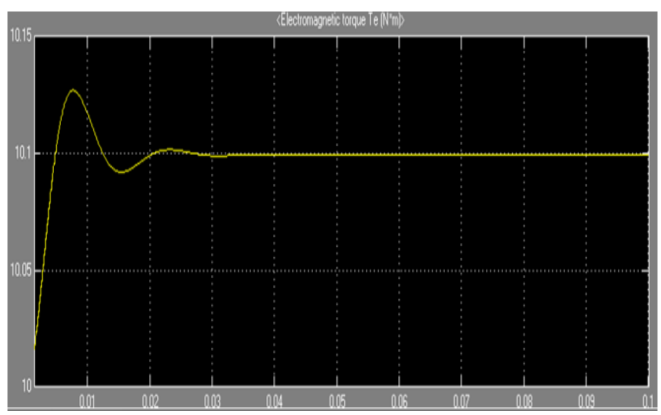

Fig.12. Motor Torque.

Speed Calculation:

Motor speed is given by
N=120*f/P rpm
Frequency f=50Hz
No. of poles P=4
Therefore,
N = 120*50/4
= 1500

This speed is achieved for DC link voltage of 10V.

TABLE I: Comparison b/w Extension & Present Systems

DC LINK VOLTAGE Vdc_VOLTS	MOTOR SPEED N_(RPM)
Present system 60V	1500rpm
Extension system 10V	1500rpm

V. CONCLUSION

Performance of given BLDC motor system is validated through simulation study using MATLAB/SIMULINK software. Motor here is driven by ZSI which has capability of both voltage boost and buck. Because of inherent boost capability of Z-source inverter, BLDC motor runs at given rated speed even with less dc link voltage of 10V. Comparison between convectional VSI drive and ZSI drive is mentioned in the table.

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