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POWER QUALITY IMPROVEMENT IN A ZETA CONVERTER FOR BLDC MOTOR DRIVES

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ABSTRACT

Due to the advantages of lower energy consumption, the use of commutation-less motor drives has increased fast in residential and industrial applications in recent years, leading to the advancement of the Permanent Magnet Brushless Dc Motor, also known as BLDC motor. As a result, for power factor correction and speed regulation of BLDC motors, we employed a zeta converter operating in Discontinuous Inductor Current Mode (DICM) with a voltage follower technique, as described in the paper following.

Improving of power factor and reduction of voltage regulation is done by closed loop zeta converter. Zeta converter has an isolated structure and it can be operated as both step up (boost) and step down(buck) converter. By adjusting the DC link voltage of the voltage source inverter (VSI) feeding the BLDC motor controls the speed of the BLDC motor drive. To achieve electronic commutation and lower switching losses, low frequency switching is employed.

The proposed method provides approximately unity power factor with decreased total harmonic distortion (THD) and a wide range of BLDC motor speed control.

Key words: *BLDC motor, VSI, THD, Zeta converter and DICM*

I. INTRODUCTION

The need for better power quality at the AC mains is becoming progressively important. International Power Quality Standards imposed a limit or boundary on the permitted harmonic current taken from ac mains, which in turn bounds the THD of supply current and the Power Factor (PF) at AC mains. As a result, increased power quality converters may be used to attain a unity power factor (UPF) at AC mains while reducing harmonic components in the supply current.

When the BLDC motor drive is energized from single 1-ϕ AC supply through DBR trailed by a large value of smoothening condenser at dc link which attracts a distorted current from ac mains due to unrestrained charging and discharging of the dc link condenser. This outcomes in a high value of THD of supply current in the order of 65-70%, as well as a deprived PF within in the range of 0.7 to 0.75 at AC mains. As a result, in order to increase the power quality of BLDC motor drives, a power factor correction (PFC) converter is required.

Following that, two-stage Power Factor Correction converters are widely utilized, with the 1st stage used for PFC and the 2nd stage used for voltage control. This 2-stage topology has a larger number of components and has a more complicated construction, the amount of losses acquired by the equipment will be higher, and the cost will rise as well.

There are a few topologies for enhancing the power factor of BLDC motor drives that are already in use. SEPIC converter fed BLDC motor drives and buck boost converter fed BLDC motor drives are two examples, although due to typical PWM switching, these approaches have substantial losses in the VSI, and the voltage across the dc capacitor connection remains constant. Another architecture is a CUK converter-based BLDC motor drive with adjustable DC link voltage, which decreases losses because only fundamental frequency switching is employed, but it requires additional current sensors, which raises the cost. This sort of system is appropriate for high-power applications, but not for low-power or low-cost ones.

So the proposed technique in this paper is suitable for low power applications. Hence a "Single stage zeta converter operating in DICM using a voltage follower approach is proposed which is used for enhancing the power quality by decreasing the THD and improving the power factor to unity and by regulating the DC link voltage of VSI connecting the BLDC motor, the speed of motor can be controlled".

The Zeta converter may also be used in Continuous Inductor Current Mode (CICM), which uses a current multiplier technique and necessitates supply voltage, DC link voltage, and input current sensing. When used in DICM with a voltage follower technique, however, just the DC link voltage must be sensed, necessitating the use of a single voltage sensor.

II. EXISTING SYSTEM

The CUK PFC converter is widely used to provide BLDC motor to improve power factor correction technique in existing system. PWM is used to supply pulses to the switches. The DC link voltage fluctuates as it approaches VSI. Switches operate at a high frequency, resulting in significant switching losses at the switches. The system cost is also higher as more sensors are required. The CICM mode of the PFC CUK converter is used, which requires 3 sensors to monitor the 3-phase AC supply. It is only suitable for high power applications.

III. PROPOSED SYSTEM

In this suggested system, the motor will be driven by a single phase supply. On the input side and in the DBR, filters are employed to prevent ripples. Through the VSI circuit, the Zeta converter supplies a 3-phase supply to the BLDC motor. The switches are triggered by low-frequency pulses. The BLDC motor speed is monitored by a single sensor. In the converter, a single voltage sensor is designed to manage the dc link voltage for BLDC motor speed regulation.

IV. BLOCK DIAGRAM

4.1 Diode Bridge Rectifier (DBR)

The diode bridge rectifier is a bridge circuit arrangement consisting of four diodes that produce the same output polarity for both polarities of the input. It's a device that converts AC to DC.

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4.2 FILTER

A filter is connected to DBR to convert the pulsating DC into pure DC. The filter is made up of combination of components such as capacitors and inductors. The filter used is LPF which removes the unwanted ripples.

4.3 ZETA CONVERTER

The Zeta converter is a 4th order DC-DC converter, designed with 2 inductors and 2 capacitors, and can function in step-up or step-down mode. The filtered DC voltage is applied to the Zeta converter and this increases the input voltage.

4.4 VSI

A VSI is a device that converts unidirectional voltage waveform into a bidirectional voltage waveform. An ideal VSI keeps the voltage constant through-out the process.

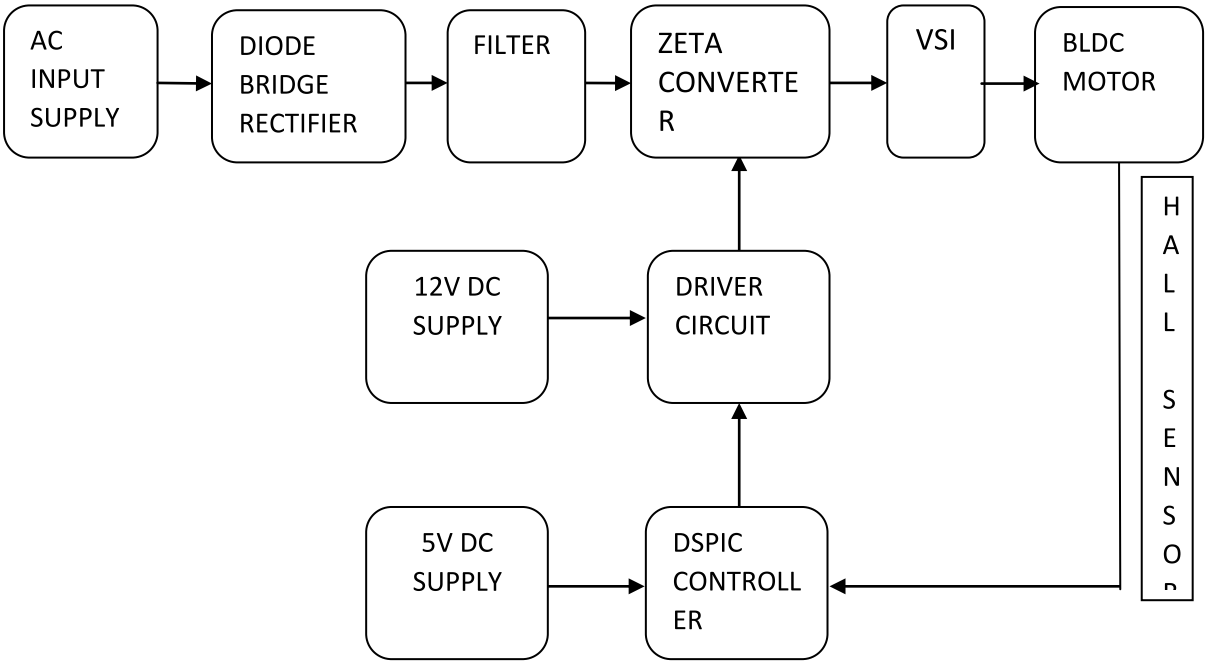

Fig 1: BLOCK DIAGRAM

4.5 BLDC MOTOR

It's a three-phase synchronous motor with dc motor like torque and speed characteristics. The stator contains three phase windings that are activated by VSI, while the rotor includes permanent magnets. Electronic commutation is employed instead of brushes and commutators, and it is dependent on the rotor position as sensed by the Hall effect position sensors. As a result, issues like sparking, brush wear, EMI, and noise interference in BLDC motors are no longer an issue. In comparison to brushed DC and induction motors, BLDC motors provide a number of benefits.

4.6 DPSIC CONTROLLER

The DPSIC controller is responsible for producing PWM pulses for the converter and inverter circuits. The driving circuit receives DSPIC controller pulses. The driver board's primary function is to isolate and

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amplify controller input signals. The output of the amplified driver is linked to the main power circuit components.

4.7 DRIVER CIRCUIT

The opto coupler is used for driver circuit to enhance the pulses while also providing isolation. Isolation and amplification are the two functionalities of this device.

4.8 HALL SENSOR

Hall effect sensors replace the mechanical commutator and brushes in BLDC motors. Hall sensors are magnetic field sensors that are solid-state. The hall sensor feedback is used to create the three phase inverted PWM.

V. CIRCUIT DIAGRAM

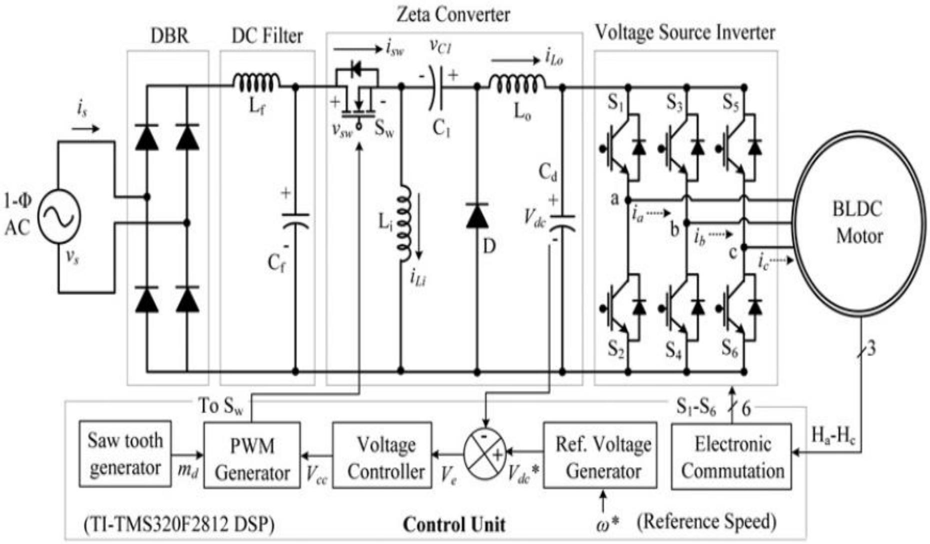


Fig 2: circuit diagram

VI. OPERATION OF ZETA CONVERTER

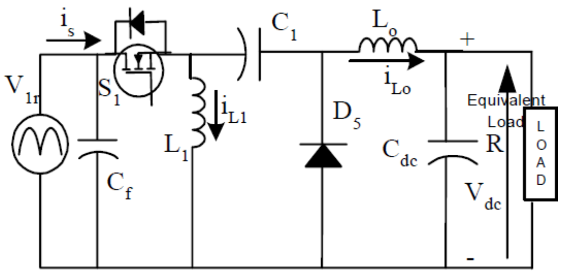
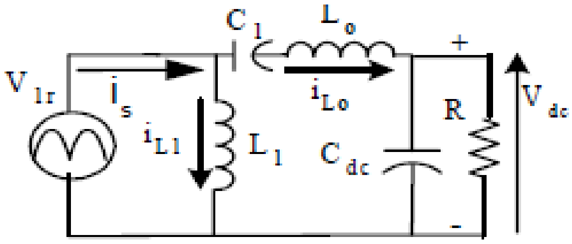


Fig 3: working of zeta converter

Three modes are shown in fig below. These modes are described as follows.

6.1 MODE I

In this case, switch S1 is closed therefore the input is connected to the inductor *L*1 and energy stored in it is transferred to inductor *Lo* via the capacitor *C1*. The current in the inductors *L0* and *L1* increases linearly. The voltage across the capacitors C1 and Cdc are constant and they are equal to the *Vdc*. The circuit diagram is shown below.

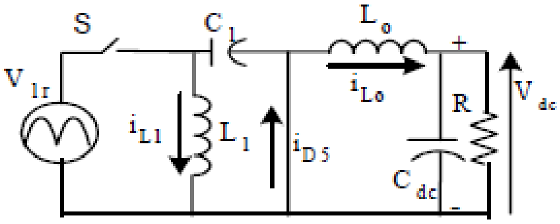


(i) First Stage

6.2 MODE II

In this case, switch S1 is opened and diode *D5* will start to operate because it is forward biased. The energy stored in the inductors L0 and L1 are transferred to the condensers *C1* and the Cdc. This phase continues until the iL1 is equal to the negative of iL0

The circuit diagram is shown below.

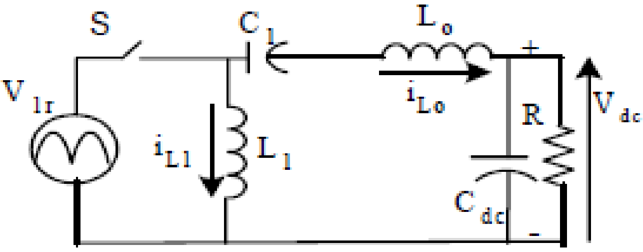


(ii) Second Stage

6.3 MODE III

In this case both the switch S1 and diode D5 will be in off state that is they are opened. Until the next switching cycle begins, the voltage across the inductors Lo and L1 is zero, and their currents remain constant.. In this stage the current through the diode D5 is zero.

The circuit diagram is shown below



(iii) Third Stage

VII. SIMULATION MODEL

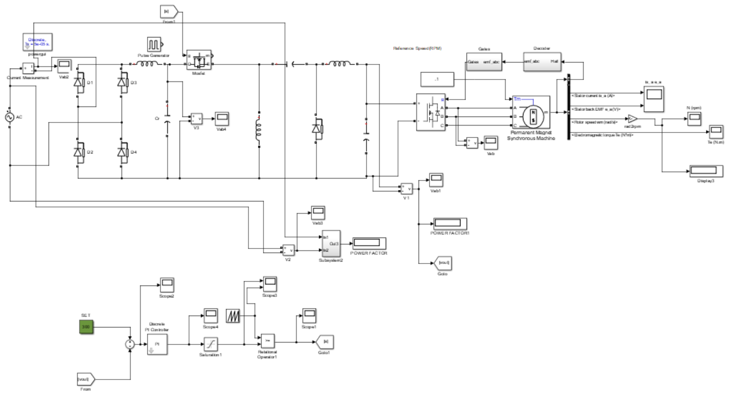


Fig 4: simulation model

VIII. SIMULATION RESULTS

8.1 ZETA CONVERTER VOLTAGE

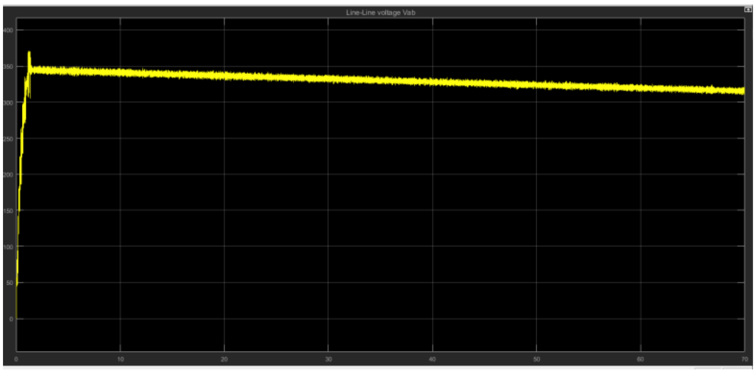


Fig 5: zeta converter output voltage

8.2 OUTPUT SPEED OF MOTOR:

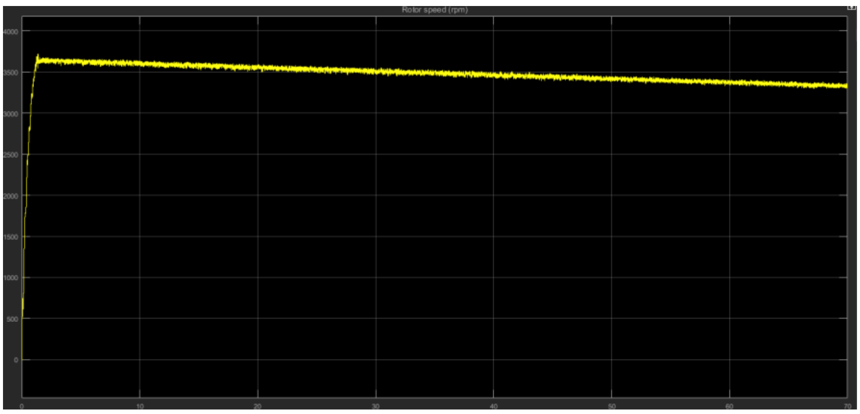


Fig 6: output speed of motor

IX. ADVANTAGES

- Good speed torque characteristics
- Reliable
- High efficiency
- Low maintenance
- Quiet operation

X. ACKNOWLEDGEMENT

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XII. CONCLUSION

BLDC motor drive controlled by zeta converter has been designed for low and medium-power applications. A VSI providing BLDC motor was used to regulate the speed. Thanks to this converter, the three-phase VSI was able to run in low-frequency switching mode, resulting in lower sensor and switching losses. An isolated zeta converter functioning in DCIM was used to regulate DC link voltage and provide PFC at the AC mains.

The simulation was used to enhance power factor correction and speed control for the BLDC motor. The suggested system's performance has been determined to be suitable for speed control across a wide range.

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