A PFC BASED BRIDGELESS ZETA CONVERTER FED BLDC MOTOR DRIVE

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*Abstract -*This paper deals with a PFC (Power Factor Corrected) Bridgeless Zeta converter based VSI (Voltage Source Inverter) fed BLDC (Brushless DC) motor drive. The speed control is achieved by controlling the voltage at the DC bus of VSI using a single voltage sensor. This facilitates the operation of VSI in fundamental frequency switching mode (Electronic Commutation of BLDC motor) in place of high frequency PWM (Pulse Width Modulation) switching for speed control. This leads to low switching losses in VSI and thus improves the efficiency of the drive. Moreover, a bridgeless configuration is used to reduce the conduction losses of DBR (Diode Bridge Rectifier). The bridgeless Zeta converter working in DCM (Discontinuous Conduction Mode) is used which utilizes a voltage follower approach thus requiring a single voltage sensor for speed control and PFC operation. The proposed drive is designed to operate over a wide range of speed control and under wide variation in supply voltages with high power factor and low harmonic distortion in the supply current at AC mains. An improved power quality is achieved with performance indices satisfying the international PQ (Power Quality) standards such as IEC-61000-

Index Terms – Power Factor Corrected - Zeta converter - voltage source inverter - BLDC motor- conduction modes - Power quality.

I.   INTRODUCTION

Power quality is becoming emerging problem in power transmission. The development of an efficient and low cost motor drive is required which focuses on low and medium power equipment's like refrigerators, air conditioners, fans and many appliances used in medical and industrial applications. The development of such motor drive which can fit for the above mentioned applications with high efficiency and minimum cost is the main objective of this work.

A BLDC (Brushless DC) motor is well suited in large
Number of applications because of its high efficiency, high reliability, high torque and watt per unit weight, low noise level, low EMI (Electro-Magnetic Interference), low maintenance requirements and long lifetime. This motor is also known as an (Electronically Commutated Motor) since it has no brushes and commutator, rather an electronic commutation through VSI is used with switching sequence of VSI's switches depending upon the rotor position as sensed by Hall Effect position sensors.

A two stage PFC converters have been widely used, in which two different stages i.e. a boost PFC stage and a buck/ buck boost stage for voltage control. This suffers from a major disadvantage of high number of components thus high losses and two independent control circuits for PFC and voltage control. Single stage PFC converters have gained importance due to simplicity in design and low amount of losses due less count of components. Single stage isolated PFC converters use high frequency isolation transformer which is compact in size and thus reducing the space requirement of the PFC converter and provides isolation between input and output.

An isolated Zeta converter operating in CCM (Continuous Conduction Mode) or DCM (Discontinuous Conduction Mode) is widely used for PFC applications. DCM is preferred for low and medium power applications.

This paper explores the potential of Zeta converter for BLDC motor drive targeting special class of applications. The drive system is needed to be developed which must incorporate features like low cost, high efficiency and satisfactory performance with improved power quality at the AC mains for a wide range of speed control.
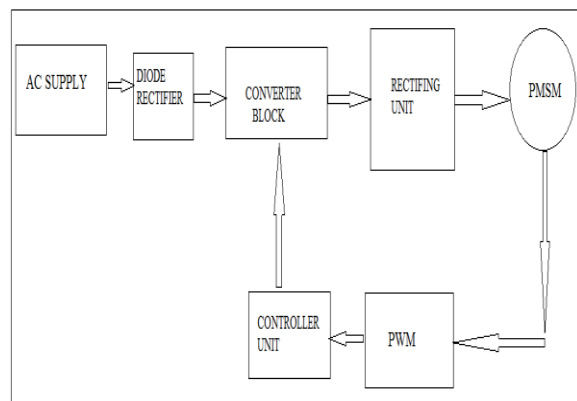
II.   BLOCK DIAGRAM EXPLANATION

Fig.2.1 Block Diagram

This paper describes about the Power Factor Correction and this objective is done with the help of parts mentioned in the block diagram.

III.   PROPOSED BRIDGELESS ZETA CONVERTER FED BLDC MOTOR DRIVE

The Simulink model shows the proposed bridgeless Zeta converter based VSI fed BLDC motor drive. A single stage, bridgeless Zeta converter is used for the DC link voltage control and PFC operation. A front-end converter operating in DCM utilizes a voltage follower approach which requires a single voltage Sensor for PFC and voltage control. This eventually, reduces the cost of the drive system on behalf of sensor reduction. Since, the speed is controlled by controlling the DC link voltage of the VSI, hence fundamental frequency switching of the VSI is used which offers low switching losses.

The conduction losses of the DBR are reduced to half by using a bridgeless topology which also offers improved thermal utilization of the converter's switches. The performance of the proposed drive is evaluated for wide range of speed control with improved power quality at AC mains. Performance is also evaluated for wide variation in supply voltages to demonstrate the performance for practical supply systems. The power quality indices thus obtained are observed within the prescribed limits by international power quality standards such
as IEC-61000-3-2.

IV.   OPERATION OF ZETA CONVERTER

A bridgeless topology is designed such that two switches conduct independently for the positive and negative half cycle of the supply voltage. The conduction losses of the DBR are reduced to half as compared to conventional topology due to the bridgeless configuration. Moreover, this also improves the thermal utilization of switches.

This operates in two stages. One is Operation during Complete Cycle of Supply Voltage. The second one is Operation during Complete Switching Cycle. In the first operation mode, the Magnetizing inductance (L) is designed to operate in DCM such that a discontinuous conduction is achieved for a wide range of DC link voltage control to achieve an inherent power factor correction. Whereas in the second mode DC link capacitor C supplies the required energy to the load. When switch is turned off, the HFT discharges through Diode D and inductor L supplies the required energy to the DC link capacitor. In the DCM mode of operation the HFT is completely discharged, whereas inductor L continues to supply the required energy to the DC link capacitor.

V.   CONTROL OF BLDC MOTOR FOR ELECTRONIC COMMUTATION

An electronic commutation of the BLDC motor includes proper switching of VSI in such a way that a symmetrical DC Current is drawn from the DC link capacitor for 120° and is placed symmetrically at the centre of back emf of each phase. A Hall-Effect position sensor is used to sense the rotor position on a span of 60°. A switching logic generates a switching states for the VSI to attain electronic commutation based on Hall-Effect position signals. The different switching states of the VSI feeding a BLDC motor based on the Hall Effect position signals The conduction states of two switches .A line current is drawn from the DC link capacitor which magnitude depends on the applied DC link voltage (Vdc), back emfs (ean and ebn), resistances (Ra and R) and self induced mutual inductance (La, Lba-Hbc and M) of the stator windings.

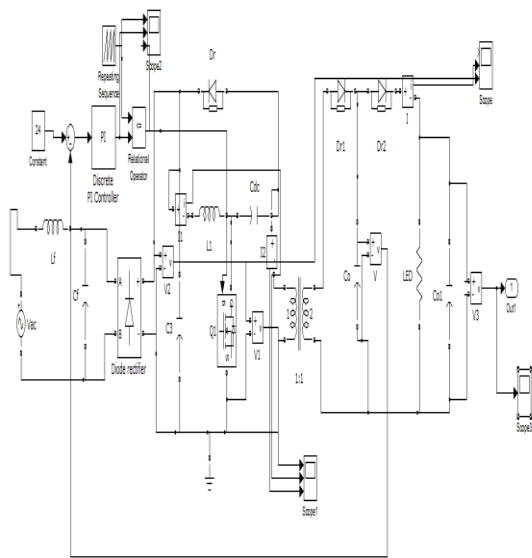### VI.   SIMULATION CIRCUIT

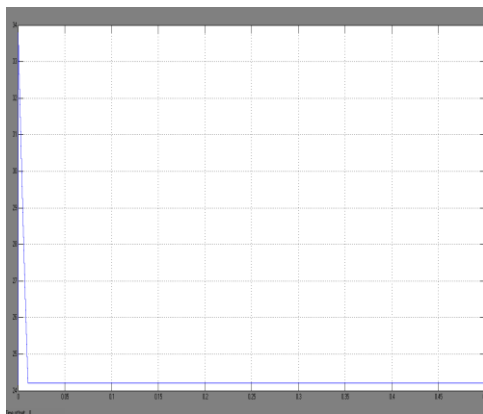Fig 6.1 Simulation Circuit

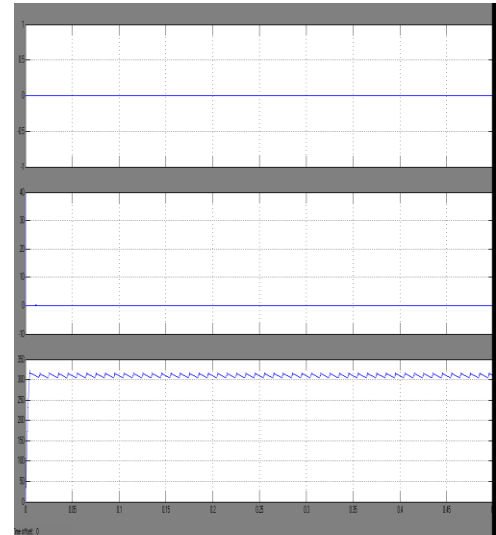VII.   SIMULATION OUTPUT

Fig 7.1 Scope output 1

Fig 7.2 Scope Output 2

These figures 7.1,7.2 gives the output for the conversion of AC to DC converter and the output waveforms.

VIII.   CONCLUSION

A PFC bridgeless Zeta converter based VSI fed BLDC motor drive has been proposed with reduced sensor configuration. A bridgeless configuration of a Zeta converter has been explored to feed a BLDC motor drive via a VSI. The speed of BLDC motor has been controlled by controlling the DC link voltage of the VSI. The front end bridgeless-Zeta converter operating in DCM has been used for DC link voltage control and PFC operation using a single voltage sensor. An electronic commutation of the BLDC motor has been used, which utilizes a fundamental frequency switching of the VSI for reduced switching losses.
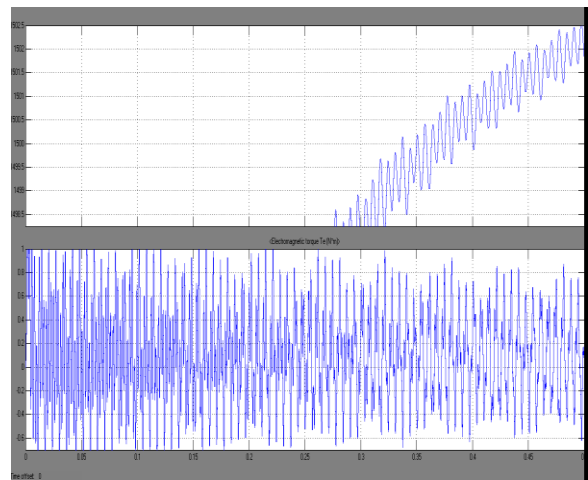

Fig 8.1 Scope output of PMSM

APPENDIX

BLDC Motor Rating: 4 pole, P(Rated Power) = 0.5 hp (376 W), Vrated (Rated DC link Voltage) = 130 V, T (Rated Torque) = 1.2 Nm, ωrated (Rated Speed) = 3000 rpm, K (Back EMF Constant) = 34 V/krpm, K(Torque Constant) = 0.32Nm/A, Rpht (Phase Resistance) = 2.68 O, L(Phase Inductance) = 5.31mH, J (Moment of Inertia) = 1.3 kg-cm.

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