Sensor Less Speed Control of BLDC Motor Drive With Power Factor Correction Converter Using Modified BL-CSC Converter

I.Beulah[1], S.Tamilmani[2]
[1, 2] Dept of Electrical and Electronics Engineering
[1, 2] Anna University Regional Campus, Coimbatore, India.

Abstract- *This project presents a power factor correction (PFC)-based modified bridgeless canonical switching cell (BL-CSC) converter-fed brushless dc (BLDC) motor drive. The proposed Modified BL-CSC converter operating in a discontinuous inductor current mode is used to achieve a unity power factor at the ac mains using a single voltage sensor. The speed of the BLDC motor is controlled by varying the dc bus voltage of the voltage source inverter (VSI) feeding the BLDC motor via a PFC converter. Therefore, the BLDC motor is electronically commutated such that the VSI operates in fundamental frequency switching for reduced switching losses. Moreover, the bridgeless configuration of the CSC converter offers low conduction losses due to partial elimination of diode bridge rectifier at the front end. The proposed configuration will considerable with increased in efficiency as compared with the conventional scheme. Improved power quality can be achieved at the ac mains for a wide range of control speeds and supply voltages.*

Keywords- Power Factor Correction (PFC), Bridgeless Canonical switching Cell (BL-CSC) Converter.

I. INTRODUCTION

Brushless dc (BLDC) motors are preferred as small horsepower control motors due to their high efficiency, silent operation, compact form, reliability, and low maintenance. However, problems are encountered in these motors for variable speed operation over last decades. But continuing technology development in power semiconductors, microprocessors, adjustable speed drives and control schemes and permanent-magnet brushless electric motor production have been combined to enable reliable, cost-effective solution for a broad range of adjustable speed applications

Although DCM operation seems simpler than CCM, since it may operate in constant frequency operation, DCM has the disadvantage that it has the highest peak current compared to CCM, but with no performance advantage compared to CCM, and one potential disadvantage

In the last decade, bridgeless PFC converters have gained importance due to low conduction losses at the front end. This is achieved due to partial or complete elimination of the DBR, thereby reducing the conduction losses associated with it .The canonical switching cell (CSC) converter, although it has excellent performance as a power factor preregulator, a small component count (compared with the non isolated Cuk converter), and good light load In the conventional CSC converter, a combination of a switch (*Sw*),a capacitor (*C*1) and a diode (*D*) is known as a ‘canonical switching cell,’ and this cell, combined with an inductor (*Li*)and a dc link capacitor (*Cd*), is known as a CSC converter. With proper design and selection of parameters, this combination is used to achieve PFC operation when fed by a single phase supply via a DBR and a dc filter.

This work aims at the development of a modified bridgeless configuration of a CSC converter, which offers partial elimination of DBR at the front end for reducing the conduction losses associated with it. Moreover, the application of this converter for feeding a BLDC motor drive is discussed to develop a low cost solution for low-power applications.

A modification of a CSC converter for limiting the current ripples in the output side capacitor has been proposed. Circuit configuration of Modified BL-CSC converter is also shown in Fig. 1. In CSC converter, due to the operation ofan inductor in discontinuous conduction, the input and output currents have higher current ripple which is a major drawback of this CSC converter. Interestingly, the addition of a small inductance at the output of this conversion stage yields a true switched-mode topology. These yield to low-output ripple current in the DC link.

II. PFC BL-CSC CONVERTER-FED BLDC MOTOR DRIVE

Fig.1shows the proposed BL-CSC-converter-based VSI fed BLDC motor drive. As shown in this figure, the DBR is eliminated in this BL-CSC converter, thereby reducing the conduction losses associated with it. This BL-CSC converter is designed to operate in a discontinuous inductor current mode(DICM) such that the currents flowing through inductors *Li*1and *Li*2 are discontinuous, whereas the voltage across the intermediate capacitors *C*1 and *C*2 remains continuous in a switching period. An approach of variable dc link voltage for controlling the speed of the BLDC motor is used, and it is electronically commutated for reduced switching losses in the VSI.

The operation, design, and control of this BL-CSC converter fed BLDC motor drive are explained in the following sections. Performance of the proposed drive is verified with test results obtained on a developed prototype with improved power quality at the ac mains for a wide range of speeds and supply voltages.

The bridgeless buck [20] and boost converter [21], [22] configurations are not suitable for the required application due to requirement of high voltage conversion ratio (i.e., voltage bucking and boosting) for controlling the speed over a wide range.

As compared with the various bridgeless configurations of Cuk, SEPIC and Zeta converters, the proposed BL-CSC converter has the relatively lower number of components and least number of conducting devices during each half-cycle of the supply voltage, whereas the proposed configuration exhibits the minimum conduction losses due to the conduction of minimum number of components during each half cycle.

III. OPERATING PRINCIPLE OF THE PFC BL-CSC CONVERTER

The operation of the BL-CSC converter is classified into two major categories.

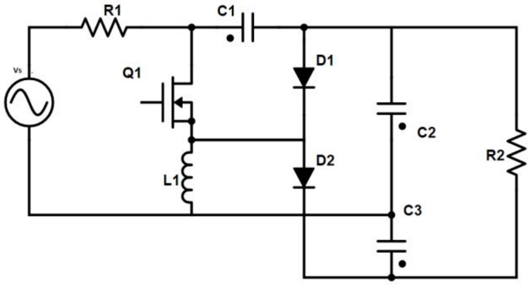

Fig. 1 Modified BL_CSC CSC converter

Operation in Positive and Negative Half-Cycles of Supply

This bridgeless converter is designed such that two switches operate for positive and negative half-cycles of the supply voltage. The operation of the proposed BL-CSC converter for positive and negative half-cycles of the supply voltage, respectively. During the positive half-cycle of the supply voltage, the input side current flows through switch Sw1, inductor Li1, and a fast recovery diode Dp. Similarly, switch Sw2, inductor Li2, and diode Dn conduct for a negative half-cycle of the supply voltage.

Supply voltage with inductor currents (iLi1) and intermediate capacitor voltages (VC1 and VC2). The proposed converter is operating in DICM, i.e., the inductor currents (iLi12) are discontinuous, and the voltages across the intermediate capacitor (VC1 and VC2) remain continuous with a permissible amount of voltage ripple in a complete switching period.

IV. PI CONTROLLER

PI controller will eliminate forced oscillations and steady state error resulting in operation of on-off controller and P controller respectively. However, introducing integral mode has a negative effect on speed of the response and overall stability of the system.

Thus, PI controller will not increase the speed of response. It can be expected since PI controller does not have means to predict what will happen with the error in near future.

This problem can be solved by introducing derivative mode which has ability to predict what will happen with the error in near future and thus to decrease a reaction time of the controller. PI controllers are very often used in industry, especially when speed of the response is not an issue.

A control without D mode is used when:

a) Fast response of the system is not required
b) Large disturbances and noise are present during operation of the process
c) There is only one energy storage in process (capacitive or inductive)
d) There are large transport delays in the system .

In control engineering, a PI Controller (proportional-integral controller) is a feedback controller which drives the plant to be controlled by a weighted sum of the error (difference between the output and desired set-point) and the integral of that value. It is a special case of the PID controller in which the derivative (D) part of the error is not used. The PI controller is denoted as

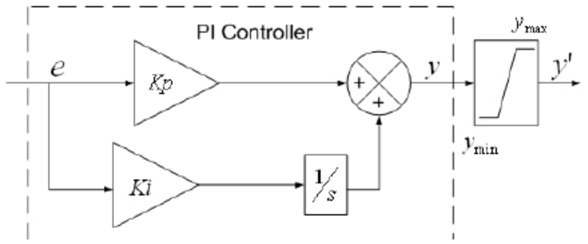

Figure 2 PI controller

Integral control action added to the proportional controller converts the original system into high order. Hence the control system may become unstable for a large value of K_p since roots of the characteristic eqn. may have positive real part. In this control, proportional control action tends to stabilize the system, while the integral control action tends to eliminate or reduce steady-state error in response to various inputs. As the value of T_p is increased, in the early history of automatic process control the PID controller was implemented as a mechanical device. These mechanical controllers used a lever, spring and a mass and were often energized by compressed air. These pneumatic controllers were once the industry standard. Electronic analog controllers can be made from a solid-state or tube amplifier, a capacitor and a resistance.

V. SIMULATION RESULTS:

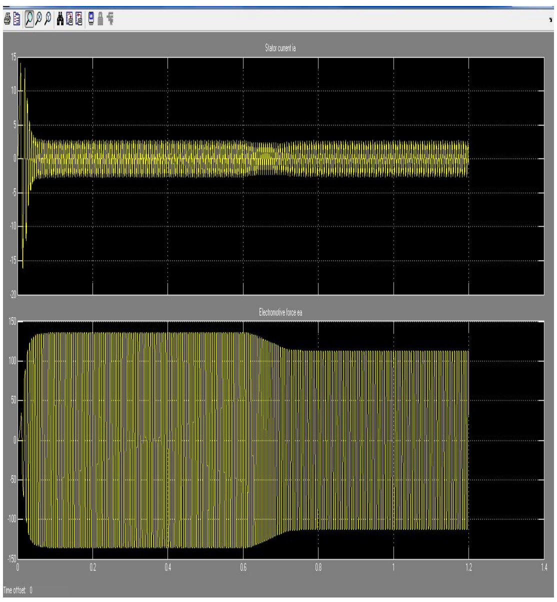

Figure 3 Output Simulation Model Of Back EMF Voltage and Stator Current

Figure.3 shows the result of back EMF and Stator current for BLDC motor drive system. The speed of the motor is varied and the back emf and stator current are analysed.

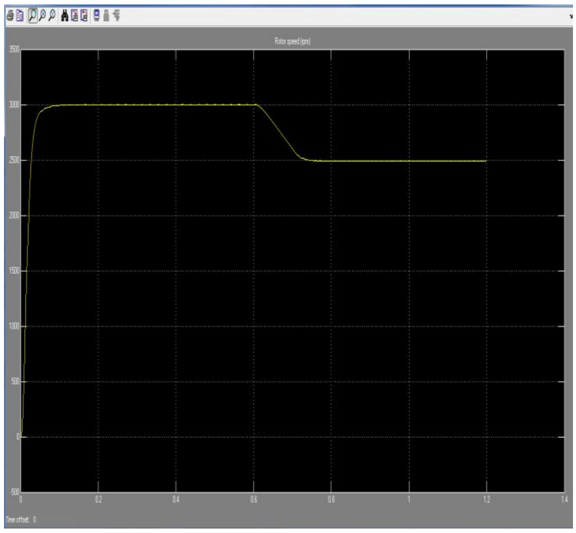

Figure 4 Output Simulation Model of Speed

Figure.4.shows speed response BLDC motor drive system. The steady state is achieved at 0.1sec with less oscillation. By controlling the speed, the system efficiency is improved. When compared to the existing system the speed oscillation is reduced so that the BLDC motor stability is not affected

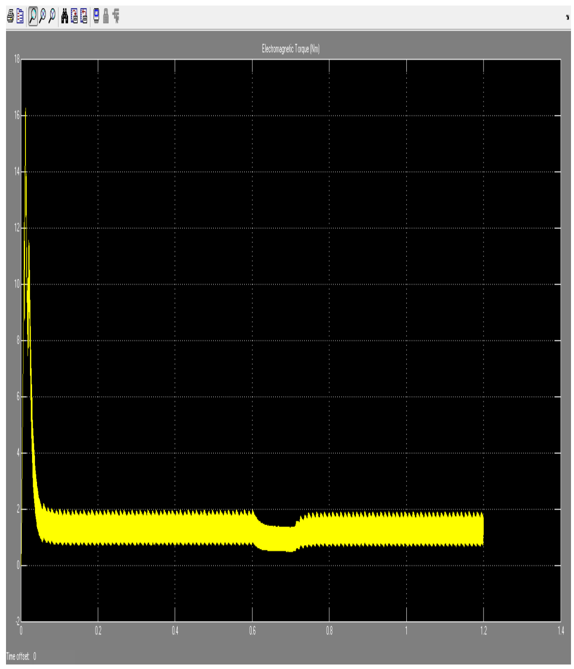

Figure 5 Output Simulation Model of Torque

Figure.5 shows the torque response for BLDC motor with low repulsion. Due to this less repulsion the system stability is improved. When compared to the existing system, the torque repulsion is less and does not affect the efficiency of the system.

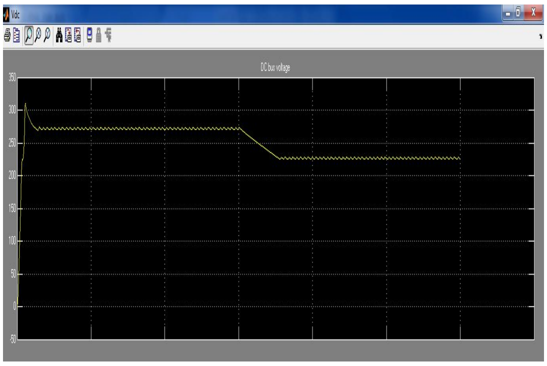

Figure 6 Output Simulation Model of DC Bus Voltage

Figure.6. shows the result of DC BUS Voltage for BLDC motor drive system

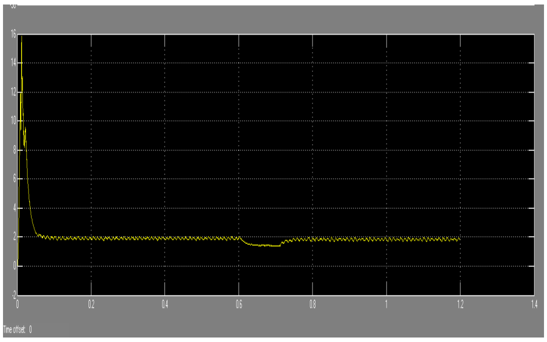

Figure 7 Output Simulation Model Of DC Bus Current

Figure.7. shows the result of DC BUS current for BLDC motor drive system

VI. CONCLUSION

A sensorless operation has been proposed for the elimination of sensor. A power factor corrected BLDC motor drive has been designed using a Modified BL-CSC converter. A front end Modified BL-CSC converter has been used for dc link voltage control and achieving a good power factor at ac mains as well as for speed controlling. To reduce the switching losses, the BLDC motor is commutated electronically to operate the MOSFETs of VSI in the fundamental frequency. The speed of the BLDC motor drive has been controlled by varying the dc-link voltage of VSI. The stator current, back EMF, speed and torque outputs were measured using MATLAB/SIMULINK Model and sensorless BLDC is of low cost compared to a BLDC with sensor. Performance and reliability of BLDC motor drivers have been improved because the conventional control sensing techniques have been improved through sensorless technology. This proposed system has been found for low power applications.

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