SEPIC CONVERTER FED BLDC DRIVE WITH CLOSED LOOP SPEED CONTROL

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Abstract—Out of various motors BLDC drive is mostly preferred because of its efficiency and high power density now a day's BLDC motor is preformed for low voltage fan application, a 3-phase voltage source inverter is used as electronic commutator connected to the stator winding of the BLDC motor, since the input side requires low voltage dc normally the household fan application single-phase AC is converted into DC to feed the BLDC motor to convert the available single-phase AC supply into low voltage DC we need a DC-DC converter, a SEPIC converter is used for convection into low voltage DC this paper mainly proposes a PV cell integrated SEPIC converter feeding a low voltage BLDC motor. A closed loop speed control for controlling the speed of the motor, Matlab/Simulink based model is developed and simulation results are presented.

Index Terms— BLDC, SEPIC, Hall Sensors, power factor correction, Power Quality

I. Introduction

The day by day increasing demand in electrical energy imposes a constraint on efficiency of the electrical equipment in household fan application induction motor is used in recent days induction motor is replaced by permanent magnet DC motor.

BLDC has high starting torque, high efficiency, high density compared to other motors, but this drive need a electronic commutator for switching the winding in home applications the single-phase AC supply in converted to DC to diode bridge rectifier and feeding as input to the BLDC converter [1][2].

To have low speed and high torque low voltage BLDC drive has preferred to convert available AC into low voltage DC we need as DC-DC SEPIC converters to provide back-up or reduce the electrical consumption from grid renewable energy sources (RES's) are used [3].

This paper proposes a PV system integrated SEPIC converter feeding the BLDC drive, BLDC drive is operated with closed loop speed control the simulation results are presented for various speed cases.

II.SEPIC converter fed BLDC drive.

The BLDC drive consists of a VSI and the BLDC motor, which is usually powered through a diode bridge rectifier fed from a single-phase AC mains followed by a DC link capacitor. This arrangement suffers from power quality disturbances such as poor power factor, increased total harmonic distortion of current at input AC mains. This is due to the uncontrolled charging of the DC link capacitor which results in a pulsed current waveform, which has a peak value higher than the amplitude of the fundamental input current at AC mains. So here we used a SEPIC converter to mitigate those pulsed waveform problem, with this DC_DC converter the output efficiency also raised [4] [5].

A). PV cell based SEPIC converter fed BLDC drive.

Fig.1 shows the conventional block diagram of PV cell fed SEPIC converter with BLDC motor. Here the PV cell powered to DC-DC converter is SEPIC throughout this converter maintains the voltage is with proper gain [6]. This SEPIC output is connected to BLDC motor drive. The controlling action done with taking an reference current signal from BLDC motor is given to electronic commutation , is nothing but a converter is placed here is connected to stator of BLDC motor.

B). SEPIC converter.

The SEPIC converter is known as Single ended primary inductor converter. SEPIC is formed from the Boost converter design in between boost converter another capacitor and inductor is connected it will formed as SEPIC converter. The SEPIC has high voltage ratings compared to boost converter it has very good output voltage characteristics so in low and high power applications we prefer this converter. Here the IGBT is used as switch here for a low power application MOSFET is used and high power applications IGBT is used [7].

Fig 1 shows the PV cell integrated SEPIC converter fed BLDC drive closed loop control. SEPIC converter is used to step down the PV cell voltage and feeding to low voltage BLDC drive, the BLDC converter is commutated based on hall sensor signal information.

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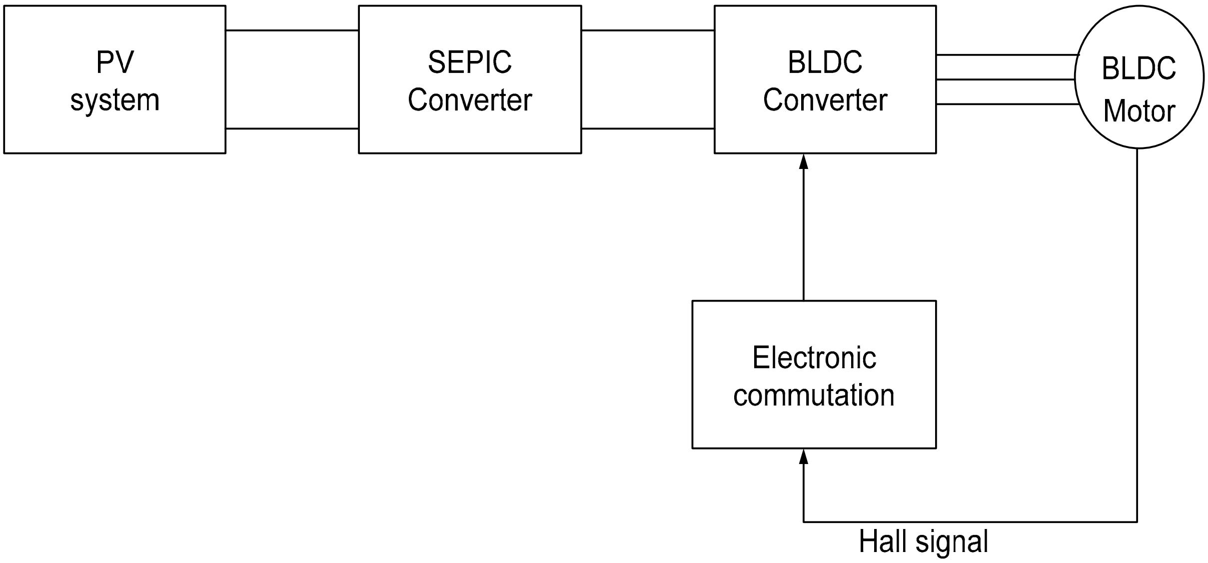

Fig 1: Conventional PV cell feeding SEPIC converter fed BLDC drive

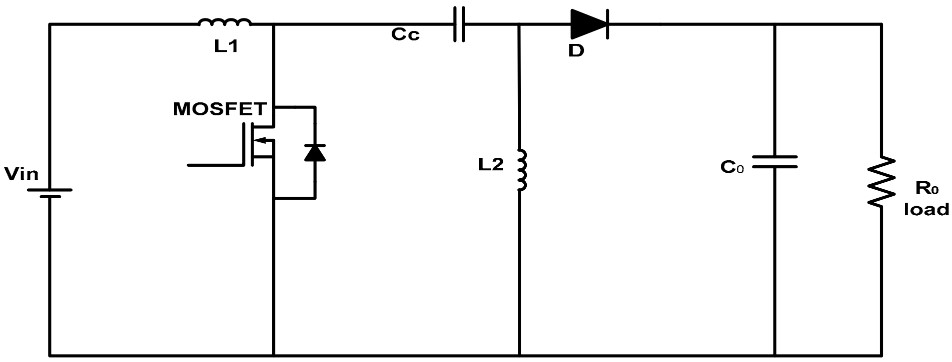

Fig 2: SEPIC Converter.

C). VSI fed BLDC drive.

The BLDC motor controlling action is done with electronic commutator, the purpose of commutator in motors is used to reverse the current feed to motor. This electronic commutator is designed with voltage source inverter. The fig.3 shows the VSI fed BLDC motor the VSI is connected to stator of BLDC motor when the top switches of VSI is conducts gives a positive pulse and below switches conducts it generates negative pulse to motor [8], [9].

This VSI is controlled by electronic controller the electronic controller is having an signals from hall sensors placed on stator of BLDC motor. This hall sensors senses the rotor position and gives signal to controller , that controller will giving PWM signals to certain switches of VSI is gives an voltage to motor [10][11].

The VSI fed BLDC motor is showed in below fig.3

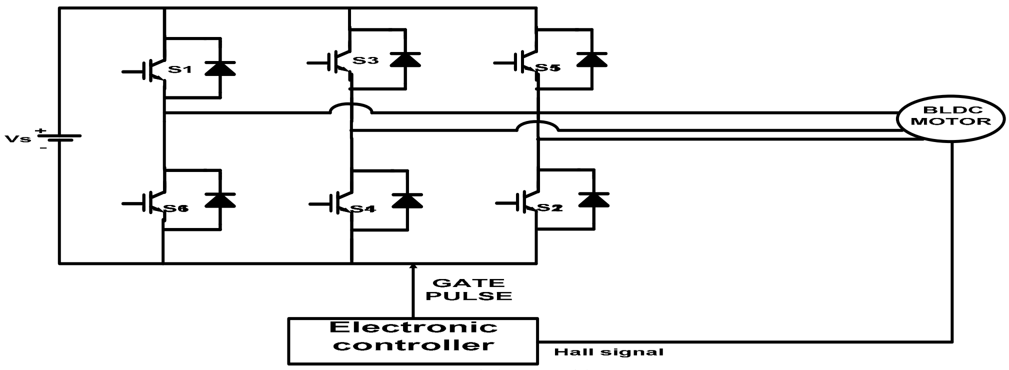

Fig 3 VSI fed BLDC drive.

III. CLOSED LOOP CONTROL OF BLDC DRIVE.

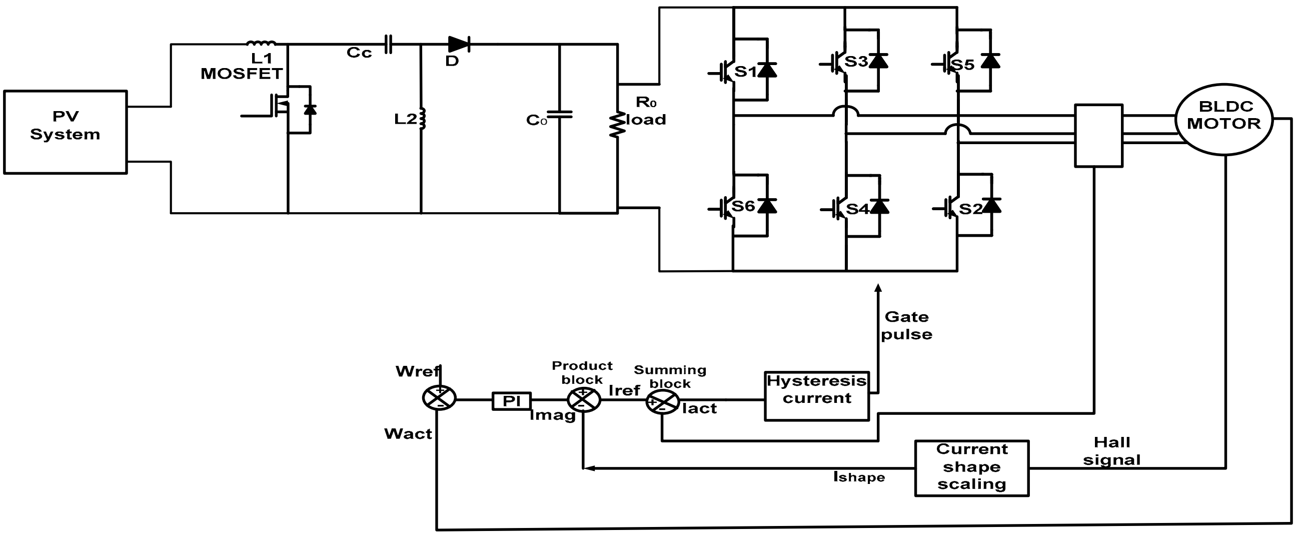

Fig 4: Speed control of SEPIC converter fed BLDC drive.

The fig.4 shows the Speed control of BLDC motor the BLDC is connected by SEPIC converter. The SEPIC converter is having an source voltage from PV cell, the SEPIC output is connected to voltage source inverter. The VSI is fed to BLDC motor the rotor position of BLDC motor is sensed by hall sensor is connected on stator of motor. This signal is given to current shape scaling then is connected to product block similarly actual speed is compared with reference speed is error is modified with PI controller then compared with current shape. The output of actual current is compared to reference current is connected to hysteresis controller it generates the gate pulses for VSI [12][13].

IV. MATLAB\SIMULATION RESULTS

Case.1 SEPIC converter.

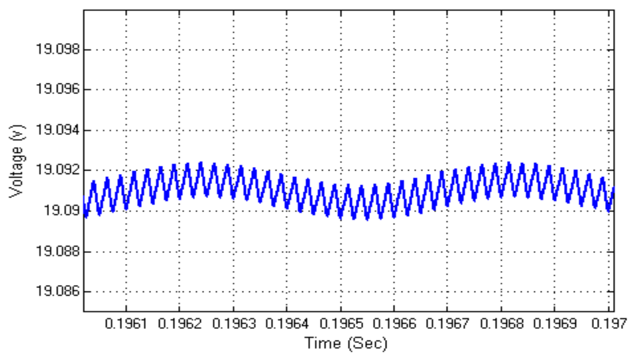

Fig.5 Input voltage of SEPIC converter

Fig.5 shows the waveform of SEPIC converter Input voltage fed from PV cell, it has around 19.1v magnitude. Here the output load is resistive load.

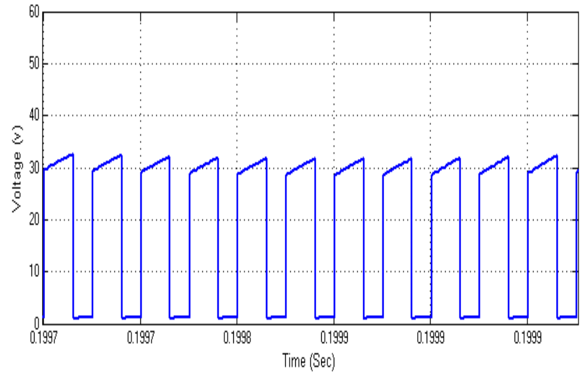

Fig.6 voltage across the switch of SEPIC converter.

Fig.6 shows the voltage across the switch of SEPIC converter it has average magnitude is 31v.

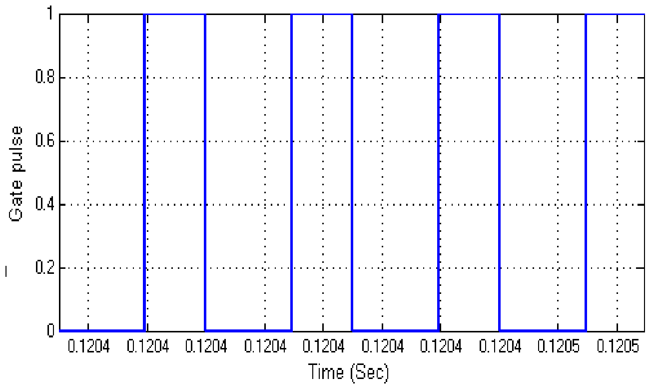

Fig.7 Gate pulse for switch 1 of SEPIC converter

Fig.7 shows the Gate pulse for switch 1 of SEPIC converter magnitude is 1.

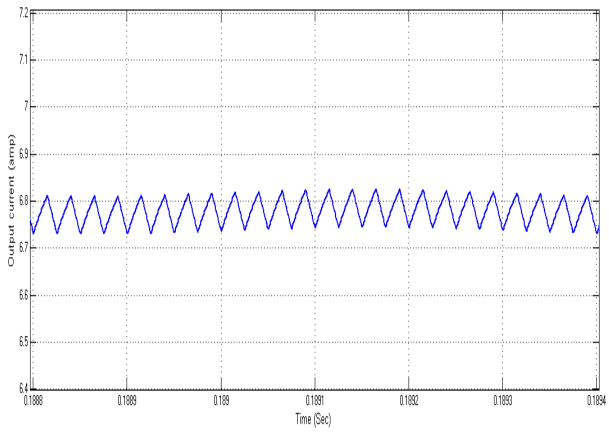

Fig.8 output current of SEPIC converter

The fig.8 shows the output current of SEPIC converter. From the fig it is clear that the ripple current is negligible in the output.

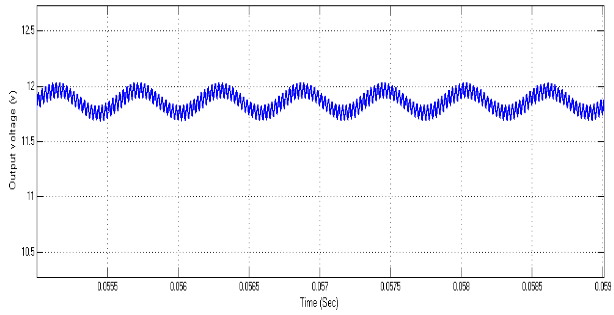

Fig.9 output voltage of SEPIC converter

Fig.9. shows the output voltage of SEPIC converter. From the fig it is clear that ripple voltage is 0.2 Volts.

Case.2 Speed control of SEPIC converter fed BLDC drive AT 1000 RPM.

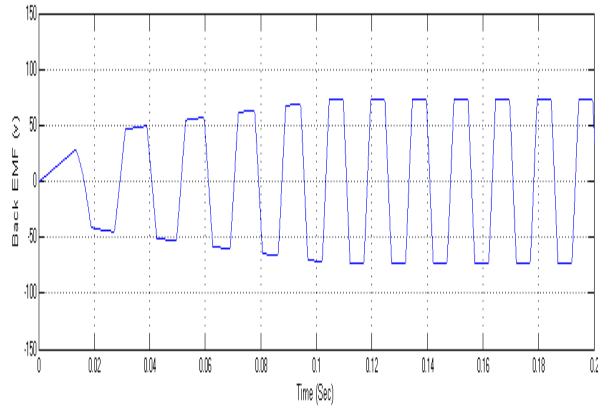

Fig.10 Back EMF of SEPIC converter fed BLDC drive AT 1000 RPM.

Fig. 10 shows the Back EMF of SEPIC converter fed BLDC drive AT 1000 RPM. The back EMF of BLDC motor is in trapezoidal in shape.

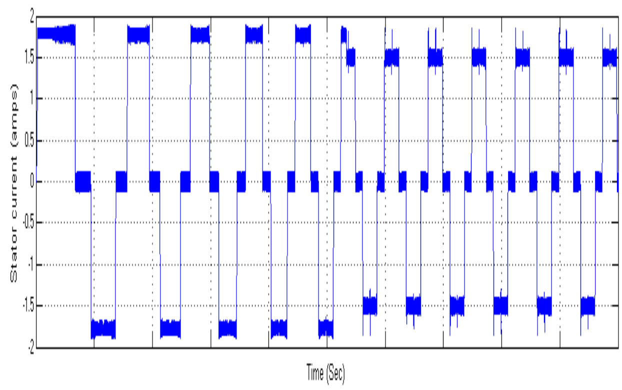

Fig.11 Stator current of SEPIC converter fed BLDC drive AT 1000 RPM.

Fig.11 shows the wave form of Stator current of SEPIC converter fed BLDC drive AT 1000 RPM. When the drive speed reaches to reference speed current reaches to rated value.

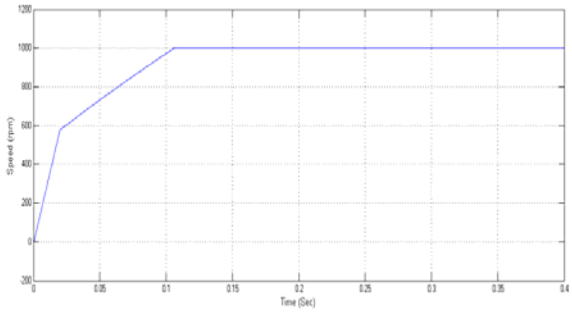

Fig.12 Speed of SEPIC converter fed BLDC drive AT 1000 RPM.

Fig.12 shows the wave form of Speed of SEPIC converter fed BLDC drive AT 1000 RPM. At T=0.2sec 2 N-M load torque is applied it causes fall in the slope of speed drive.

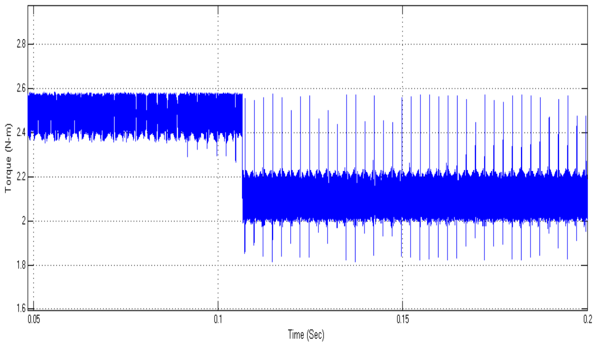

Fig.13 Torque of SEPIC converter fed BLDC drive AT 1000 RPM.

Fig.13 shows the wave form of Torque of SEPIC converter fed BLDC drive AT 1000 RPM. When the drive actual speed reaches to reference speed the torque reaches to rated value of 2 N-M.

Case.3 Speed control of SEPIC converter fed BLDC drive AT 1500 RPM.

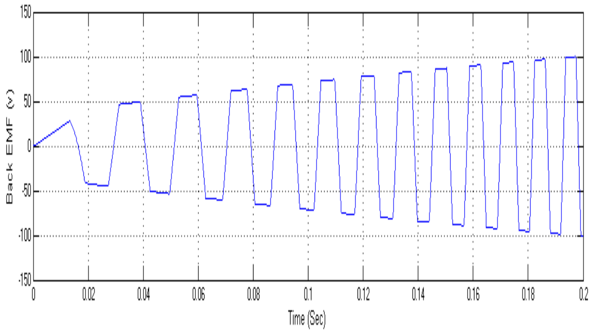

Fig.14 Back EMF of SEPIC converter fed BLDC drive AT 1500 RPM.

Fig 14 shows the back EMF increases from zero to rated value of 100volts with increases in speed from zero to rated value.

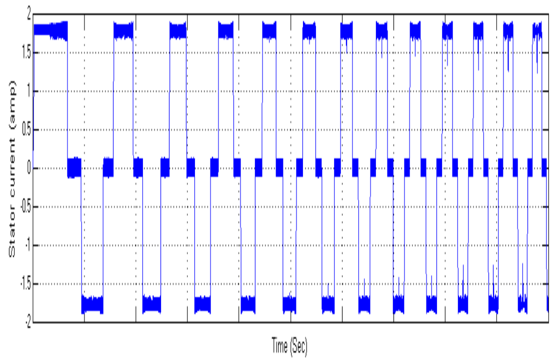

Fig.15 Stator current of SEPIC converter fed BLDC drive AT 1500 RPM.

Fig.15 shows the wave form of stator current of SEPIC converter fed BLDC drive AT 1500 RPM. The steady state current of the drive is 1.8 Amps.

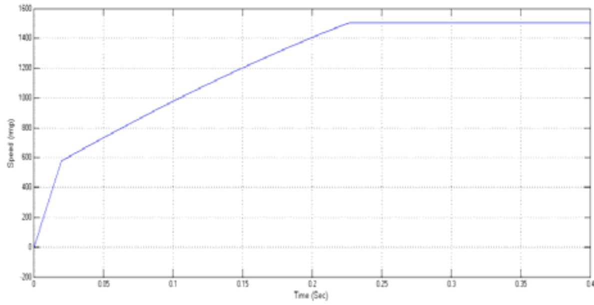

Fig.16 Speed of SEPIC converter fed BLDC drive AT 1500 RPM.

Fig.16 shows the wave form of speed of SEPIC converter fed BLDC drive AT 1500 RPM. At T=nearly 0.3 sec the drive reaches the rated speed.

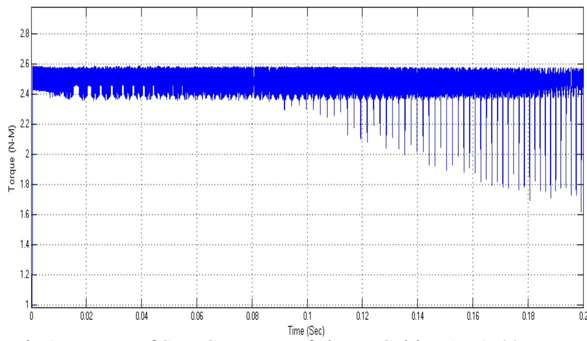

Fig.17 Torque of SEPIC converter fed BLDC drive AT 1500 RPM.

Fig.17 shows the wave form of Torque of SEPIC converter fed BLDC drive AT 1500 RPM.

Case.4 Speed control of SEPIC converter fed BLDC drive AT 2000 RPM.

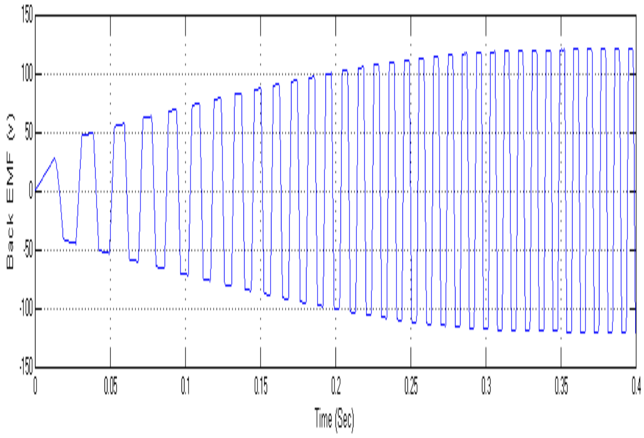

Fig.18 Back EMF of SEPIC converter fed BLDC drive AT 2000 RPM.

Here due to increase in reference speed steady state EMF is reached to 125volts

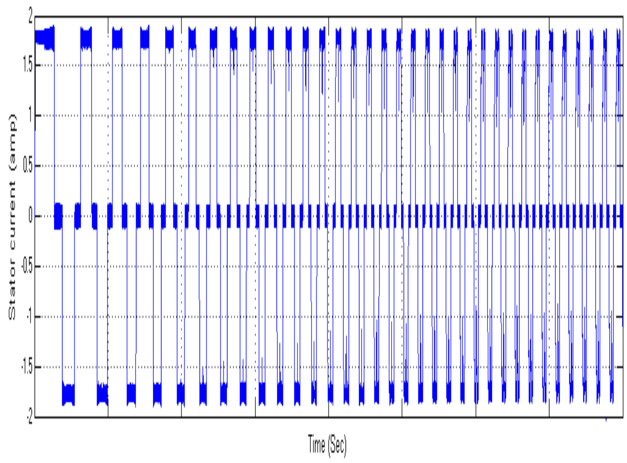

Fig.19 Stator current of SEPIC converter fed BLDC drive AT 2000 RPM.

Fig.19 shows the Stator current of SEPIC converter fed BLDC drive AT 2000 RPM

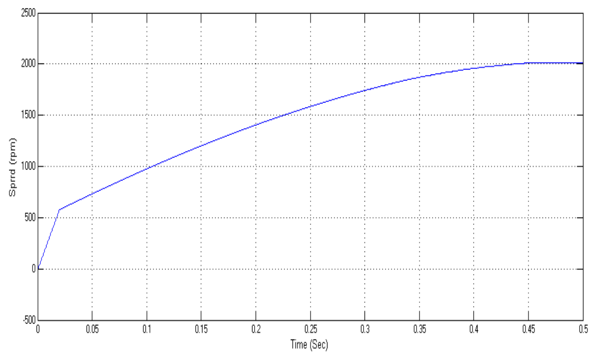

Fig.20 Speed of SEPIC converter fed BLDC drive AT 2000 RPM.

Fig.20 shows the speed of SEPIC converter fed BLDC drive AT 2000 RPM

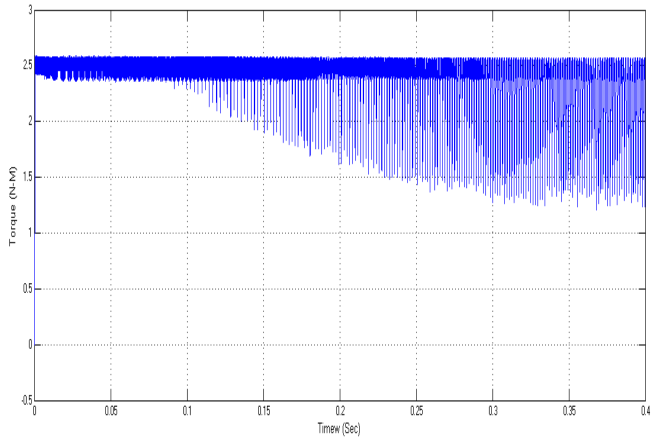

Fig.21 Torque of SEPIC converter fed BLDC drive AT 2000 RPM.

Fig.21 shows the Torque of SEPIC converter fed BLDC drive AT 2000 RPM

V.CONCLUSION

This paper proposes a SEPIC converter based VSI fed BLDC drive for low voltage electrical fan applications, conventionally used BLDC motor have no current and speed controls but this paper proposes the simplified speed control for BLDC motor. The performance of SEPIC converter is simulated in open loop and wave forms are presented. The dc-dc SEPIC converter is placed at the input of the commutation circuit, and the desired dc voltage is achieved through closed loop controllers. And also this system provides the regulation of speed of speed so that torque can respond immediately. The proposed method can reduce the torque ripples effectively with in a wide speed range by implementing a voltage follower approach; a simple control is implemented to control the voltage and hence controls the speed of the BLDC motor. A satisfactory performance has been achieved for speed control and supply voltage variation with power quality indices. The simulation results are showed for SEPIC converter and speed control BLDC motor at 1000, 1500, and 2000 RPM.

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