ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

SEPIC Converter Based BLDC Motor

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Abstract

This paper observes a new technique drive for speed control of BLDC motor. In this mode, it has both voltage and current, observes the line voltage waveform to a certain period. With this we can achieve the deduction in harmonics with lower order, along with this there may be improvement of cosine angle of voltage and current and is not having both voltage and current sensing devices. Front-end SEPIC and a switch in series with each phase is proposed for driving a permanent magnet brushless dc (BLDC) motor with unipolar currents. The supply voltage can be obtained for better current regulation, which is an advantage of having lower voltage applications. The SEPIC converter is designed to operate in the irregular conduction mode for an ac supply. The present topology is simulated and verified by using MATLAB/SIMULINK.

INTRODUCTION

In this we are using BLDC motors, have gained with popular range.These motors are used in various types such as appliances, automotive, aerospace, consumer, medical, industrial areas. From the name itself these motors are not use brush for commutation, butthey have commutated electronically [1-3]. As compared to BLDC motorsand induction motors, BLDC motors have better speed and high dynamic response, high efficiency, noiseless operation, high speed range. The main technique is cost minimization which is the only one for manufacturing and application of BLDC motors in variable speed drives. BLDC motors having conventionally excited nature having bipolar current which obtained a six-switch inverter, but unipolar motor needs fewer electronic parts anduse a simpler circuit.

The simplest unipolar drive consisting of single switch in series or dump resistorsis given in Fig.1. This drive is not efficient because the energy is dissipated which is presented in the phases [4-5]. The performance of the c-dump converter is given in Fig. 2, which offers regenerative control mode.A buck converter dependent on BLDC motor drive was proposed.Both these topologies obtained a greater voltage than what is applied to the motor phasesduring turn-on condition. While this is the existence for the SRM motor to obtain a fast turn-off of the currents to avoid negative torque spikes, it is not so for the BLDC motor. In fact, by allowing the currents having periodshaving torque reflections can be deduced. It has the lower voltage on the dump capacitor. A threeswitch converter having the unipolar nature having ac supply operation. But it wants the changes in thewindings and a split-capacitor voltage balancing controlscheme.

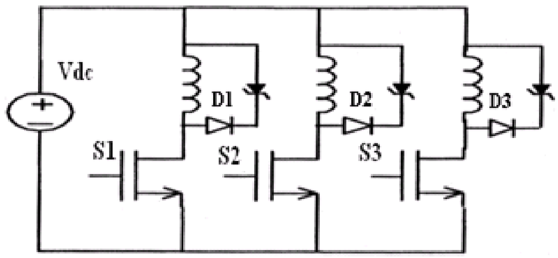

Fig.1.Simpleunipolarconverter

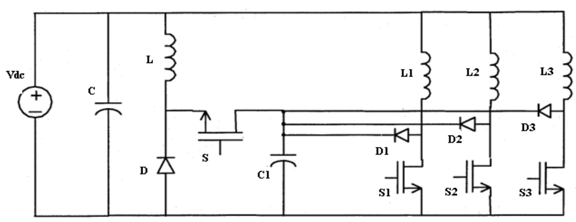

Fig.2.C-dumpconverter

Cite this article as: Babaiah Suguri, "SEPIC Converter Based BLDC Motor", International Journal & Magazine of Engineering, Technology, Management and Research, Volume 4 Issue 11, 2017, Page 291-295.

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BLDC motors have many advantages, having dc brushes on induction motors. A few of these are:
• Good speed having torque characteristics
• Dynamic response with high nature
•Good efficiency
•Life period is long
• Operation without noise
• Higher speed ranges

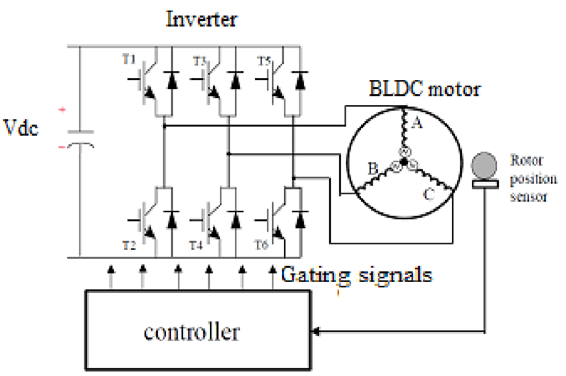

Fig.3. Basic BLDC motor control system with position sensors

The triggering angle foreach phase is 120˚ by electrical angle. Each operating period is called one step. Therefore, they are having two phases to conduct current [6, 7]. In order to obtain torque the inverter should be triggered per 60˚ sothat production of current is related with Back EMF. The triggeringtiming is required having rotor position which can be required by hall sensors or estimation from motor i.e., the BackEMF on the coil of the motor if it is sensor less system.

PROPOSED CONTROL STRATEGY

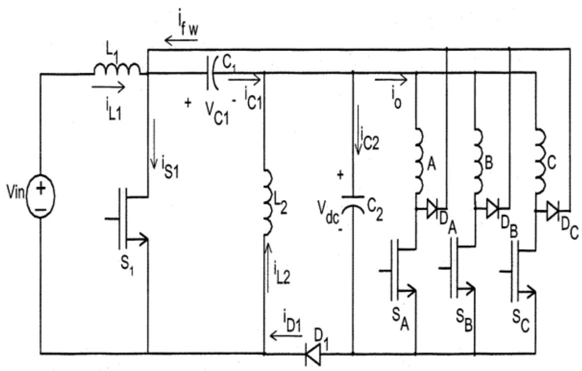

Fig.4. Schematic of SEPIC

The planned converter with four controlled switches anddiodes is given in Fig. 4. The front-end consists of a SEPICcomprises L1 and L2; switch S1 and the capacitors C1,C2.The diode D1 is placed in the reverse path having the positive direction because to deduce the flow of current during the interval of negative Back-EMF. Since there is only oneswitch per phase, the currents are unidirectional. The diodes DA, DB, and DC serve to free wheel the winding currents when the switches are turned off duringcurrent regulation and phase commutation. The output of theconverter is used to energize the phases of motor,and the voltage of capacitor C1 is used to demagnetize thephases during turn-off and for current control. Each phase is energized by turning on the corresponding switch in serieswith it.

This applies a voltage of -VC1 across the machinewinding, enabling a fast decay of the phase current. Forproper magnetizing of the phase having conduction interval and to prevent conduction during periods ofnegative Back-EMF, the instantaneous value of VC1 shouldbe higher than the peak value of the Back-EMF E, or

$Vc1 > E$ (1)

By applying mesh loop,

$$Vin = VL1 + Vc1 + VL2$$

Since the average voltages in the inductor is zero, and aswhen diode is in conduction we get

$Vin = Vc1$ (2)

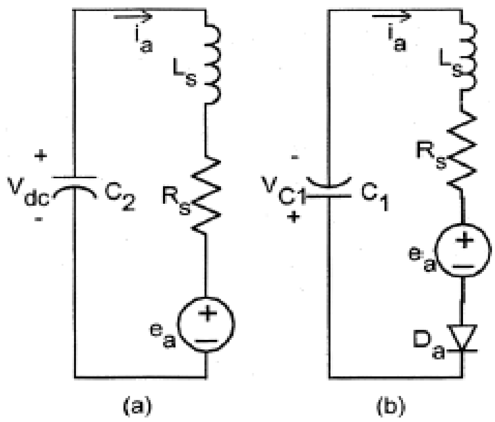

Fig.5. Equivalent circuits of each machine phase when (a) switch is on and (b) when the diode is conducting

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From (1) and (2), we observe the highest back-emf at highest speed of the motor, which is given by

$$Emax = Vin$$

Observing the pulsations in the intermediate capacitor voltageis negligible. The maximum operating speed is then given by $Wmax = Vin/Ke$ whereKeis the phase Back-EMF constant of themotor. If the motor is induced and generated at this maximum speed it gives torque repulsions on it.The minimum voltage Vdcrequired is $Vdc = E + IRs + Ls(dI/dt)$ where series resistance and series inductance are the phase resistance and inductance, and Iis phase current. The switchingfrequency and hence it has losses at the range of lower speeds can beminimized by bucking the induced voltage having input to lower levels atthe output. At higher speeds, the current regulation having power losses especially during turn on. The ability of the converter to boost the required input voltage having current-regulated operation of the driveat larger speeds. This feature makes particularly available for less voltage dc applications such asautomotive circuits.

The converter having front-end can be available for operation either in the regular triggering mode (CCM) or in the irregular conduction mode (DCM). In CCM the voltage conversion ratio is given by

$$m = \frac{Vdc}{Vin} = D/(1 - D)$$

where D is the duty cycle of S1.

In DCM, its voltage conversion ratio is given by

$$md = \frac{Vdc}{Vin} = D/\sqrt{K}$$

Where K=2L1L2/RT(L1+L2),R is the equivalent load resistance and T is the time period of switch S1.The limits of K between CCM and DCM, Kcrit can be calculated(m=md) as

$$Kcrit = (1 - D)^2$$

The SEPIC operates in CCM whenK>Kcrit and in DCM when K<Kcrit. In both CCM and DCM operation, Vdc can be regulated at a value bigger or lower than the input voltage Vin.For the controls viewpoint,it is advantage to be the SEPIC operating in the same mode below all load conditions.

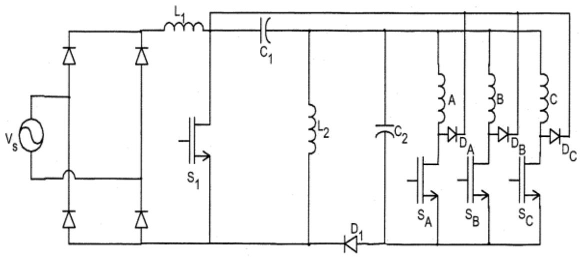

Fig.6.Schematic of the SEPIC operating from an ac supply

By the operation of the SEPIC front-end in DCM the following desirable characteristics are obtained.The converter behaves like voltage follower,that means the supply current follows the supply voltage and the theoretical cosine angle of voltage and current is unity.

BLOCK DIAGRAM OF THE DRIVE SYSTEM

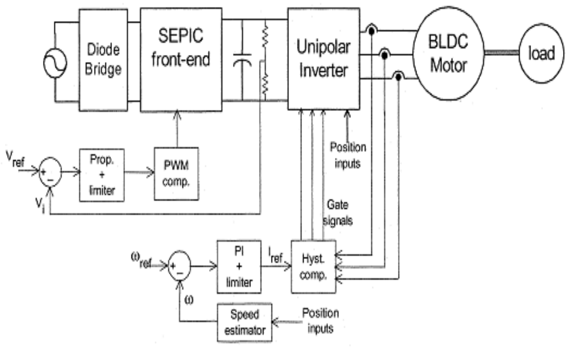

Fig.7.Drive system block diagram

The figure of the drive system implementation is given in Fig.7. AC supply is rectified using diode bridge and changed to DC supply.This DC power is regulated using SEPIC.This DC-DC converter is applied to minimize the harmonics in the input current.Then the DC power is supplied to BLDC motor through unipolar inverter.The rotorposition is detected by hall sensors, and the position information is used to determine the phasewinding to be excited. The speed of the motor is derived from the position inputs and is compared with the speedreference to create the current references. Hysteresis control is used to observe the phase currents to the reference current. The dc bus voltage is regulated by PWM of the switch S1. The motor shaft is coupled to a hysteresis brake acting as a load.

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MATLAB BASED MODEL:

The simulation block diagram for unipolar motor load for present topology is given in fig.8.

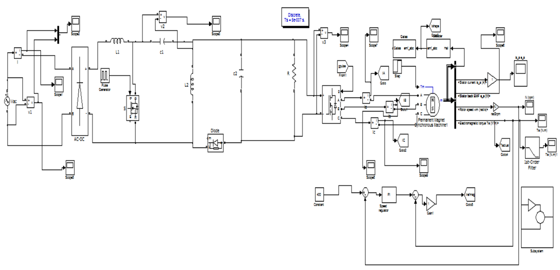

Fig.8.Simulation block diagram for unipolar motor load for present topology

RESULTS AND DISCUSSION

A PI controller is used to comparethe reference and actual speed and generates the currentreference.The Back EMF having the reversedirection of the energized voltage. Back electromotive force having three factors:

- Rotor having angular velocity
- Rotor magnets have been generated by magnetic field
- Stator windings having number of turns

The operation of the present topology has beenverified by simulation.

SIMULATION RESULTS

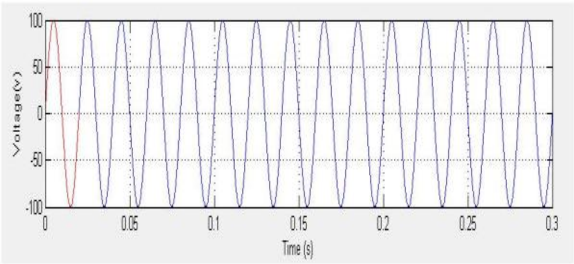

Fig.9.Waveform for Input Voltage

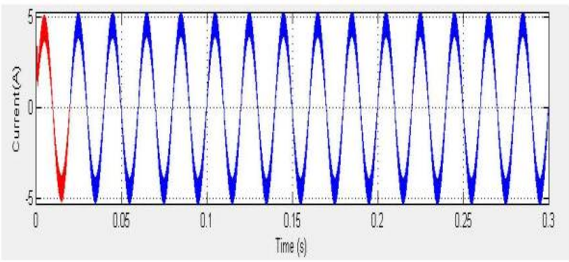

Fig.10.Waveform for Input Current

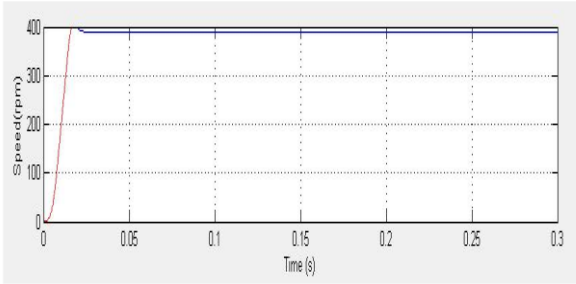

Fig.11.Waveform for Speed

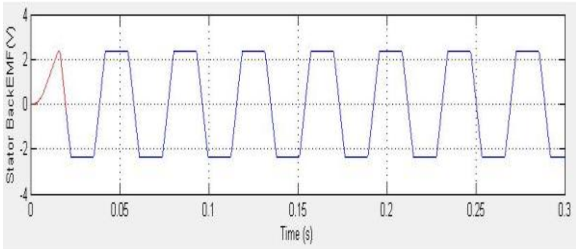

Fig.12.Waveform for Stator back EMF

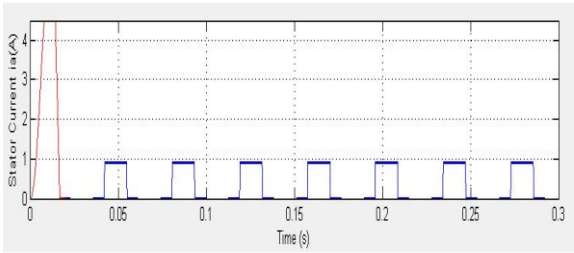

Fig.13.Waveform for Stator Current ia

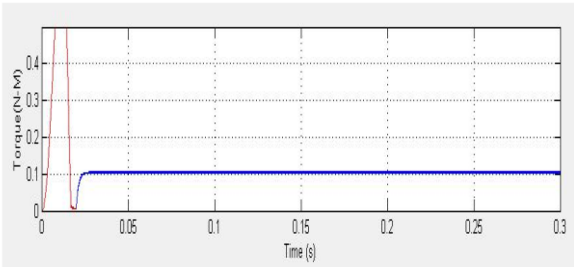

Fig.14.Waveform for Torque without using filter

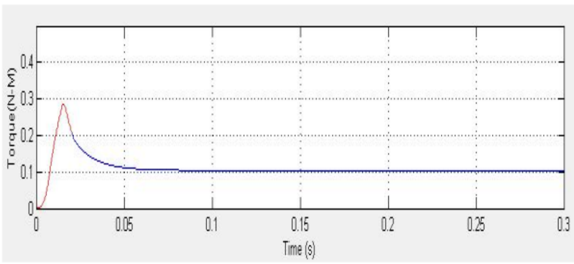

Fig.15.Waveform for Torque using filter

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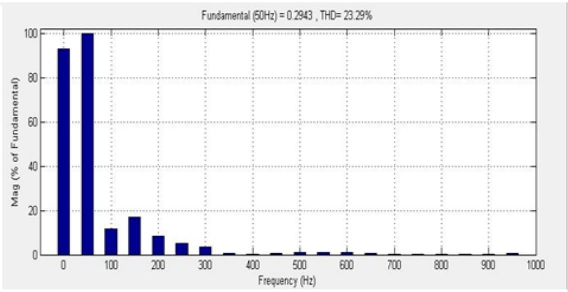

Fig.16.Total Harmonic Distortion for Torque using filter

CONCLUSION

It is based on a SEPIC operating in DCM has been proposed for unipolar excitation of BLDC motors. The planned scheme has the following advantages.

1. The planned converter uses only four controlled switches, all of which are referenced to ground. This Considerably simplifies their gate drive circuitry and results in minimizing the cost and compact in size.
2. It is having input dc voltage to have the current-regulated operation of the drive.
3. The current has input state naturally follows the supply voltage to a certain extent, reducing the amount of low order harmonics and resulting in low THD.
4. Eliminates the possibility of shoot-through faults which could occur in bipolar converters.
5. Lower triggering and turn on losses because of the presence of only one switch and diode per phase as opposed to two in the bipolar case.

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