Comparative Analysis of Sepic and Buck Converter Fed BLDC Motor Drive

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Abstract – In this paper novel technique of controlling electronically commutated motor drive (PMBLDCMD) using sepic converter explain. A DC-DC converter topology is employed for speed control BLDC MOTOR and operated with voltage follower Approach in discontinuous conduction mode . This paper give comparative performance of Buck and sepic converter fed BLDC motor. Result are shown in Matalab Simulink Environment.

Index Terms – VSI, Sepic Converter, Buck, PWM Electronic Commutation.

1. INTRODUCTION

High torque and low power applications mostly prefer low voltage PMBLDCMs operated at constant current. Such applications require the DC link voltage lower than the average output of a DBR fed from a single-phase AC mains. A DC-DC converter is connected between the VSI and the DBR fed from single phase AC supply to provide controlled voltage at DC link capacitor. There are many DC –DC converter topologies available such as buck, boost, buck-boost, sepic converter amongst which the sepic converter topology is used in this work. It provides controlled DC voltage to the PMBLDCM drive from an uncontrolled DC output of a single phase AC mains fed DBR while improving the PQ at AC mains [1]. The sepic converter topology has advantages of its simplest construction and minimum component requirement over other topologies. The merits of sepic converter topology has input and output Current is ripple free. So that smooth speed control of BLDC Motor is possible .The sepic converter is designed for DCM operation to result in reduced sensor requirement with the desired speed control. it suitable for household application such as , water pump, fan, mixers, etc.[2]. It not only used in household application but also these are suitable for other application such as computer automobile starter ,disc drives, , automobile wipers, medical equipment and many other industrial tools. The BLDC motor is also known as electronically commutated motor because an electronic commutation based on rotor position is used for controlling the speed Permanent magnet brushless DC motors (PMBLDCMs) are preferred motors for a compressor of an air-conditioning system due to its features like high efficiency, wide speed range and low maintenance requirements. The operation of the compressor with the speed control results in an improved efficiency of the system while maintaining the temperature in the air-conditioned zone at the set reference consistently. Whereas, the existing air conditioners mostly have a single-phase induction motor to drive the compressor in on/off control mode. This results in increased losses due to frequent on/off operation with increased mechanical and electrical stresses on the motor, thereby poor efficiency and reduced life of the motor. Moreover, the temperature of the air conditioned zone is regulated in a hysteresis band. Therefore, improved efficiency of the Air-Conditioning system will certainly reduce the cost of living and energy demand to cope up with ever-increasing power crisis . Because of numerous application of BLDC motor in low power need to be smooth speed control. Propose methodology use dc dc sepic converter for smooth speed controlling and compare with buck converter topology.[2].

2. PROPOSED MODEL

DC-DC converter feeding permanent magnet brushless motor drive is proposed here for low power application. A sepic converter comes under the category of DC to DC converter. In proposed circuit single phase supply is feeding to uncontrolled rectifier and DC converter is to control the voltage of DC link capacitor. Voltage of DC link capacitor is used to control the speed of BLDC motor. The output of DC link capacitor is fed to inverter and then BLDC motor to control the speed. A voltage follower technique is used to control the speed of BLDC motor.

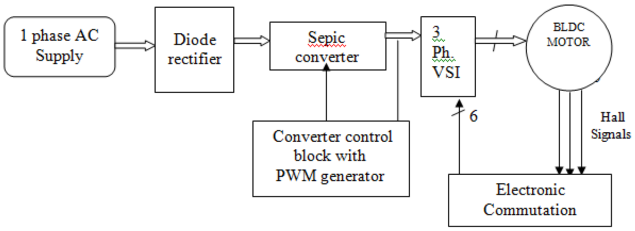

Fig1.block diagram sepic converter fed BLDC motor drive.

3. CONTROL OF SEPIC CONVERTER FED BLDC MOTOR

The control for dc-dc sepic converter is given below. The following are the three block give the control of sepic converter for Electronically commuted motor drive.

A. *Reference Voltage Generator*

It generates voltage which is proportional to the output speed of BLDC motor. The reference voltage generator produces a voltage(Vdc*) by multiplying the speed with a constant value known as the voltage constant (Kb) of the BLDC motor. This voltage is compare with dc link voltage(Vdc) of sepic converter for required speed.

B. *Voltage Controller*

The errors produces by the Vdc* and Vdc is given to a

Proportional Integral(speed controller) which generates a controlled output corresponding to the error signal. The valueKi and Kp is set by using trial and errors method in matalab simulink.

C. *PWM Generator*

The output of the PI controller Vc is given to the PWM

generator which produces a PWM signal of fixed frequency and varying duty ratio. A saw tooth waveform is compared with the output of PI controller .

If md(t)<Vc(t) then S= 1 else S= 0

where S denotes the switching signals as 1 and 0 for MOSFET to switch on and off respectively.

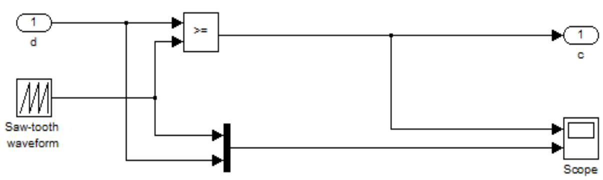

Fig.2.Simulation of PWM generator

Where d is output of PI controller and c is input to gate terminal of MOSFET of Sepic converter.

4. ELECTRONICS COMMUTATION

The BLDC motor employ a voltage source inverter & a trapezoidal PMAC motor is shown in fig.3.4. The stator winding of star connected .it will have rotor position sensor which are not shown in figure. Let the stator winding is fed with current pulses which are 120° duration. Since the air gap flux is constant, the voltage induced is proportional to the speed of rotor.[3] During period 0 to 60°,switch T1 & T4 are ON at that time winding A & B connected to dc source. For next 60° operation,T1 & T6 is ON, at that time winding A & C is connected to dc source. The operation for next duration is similar. There is a hall effect sensor is used to detect the rotor position. The sensor are mounted at 60° electrical interval. The sensor used in trapezoidal motor is cheaper than sinusoidal PMAC motor.

The switching sequence of VSI for different positions of the rotor is shown in Table I and II. Decoder module in the simulation diagram implements the following truth table.

TABLE.1.

h_a	h_b	h_c	Emf_a	Emf_b	Emf_c
0	0	0	0	0	0
0	0	1	0	-1	+1
0	1	0	-1	+1	0
0	1	1	-1	0	1
1	0	0	+1	0	-1
1	0	1	+1	-1	0
1	1	0	0	+1	-1
1	1	1	0	0	0

The gate pulse generation for inverter implements the Following truth table.

Truth table for gate pulse generation

TABLE .2

emf a	emf b	emf c	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6
0	0	0	0	0	0	0	0	0

0	-1	+1	0	0	0	1	1	0
-1	+1	0	0	0	1	1	0	0
-1	0	1	0	1	0	0	1	0
+1	0	-1	1	0	0	0	0	1
+1	-1	0	1	0	0	1	0	0
0	+1	-1	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0

All the mathematical equations should be numbered as shown above.

The Brushless DC motor normally consists of stator windings, where the arrangement is determined by rotor pole pairs made of permanent magnets. In the Brushless DC motor, the commutation sequence plays an important role in enabling the rotor rotation.[2] Each commutation has one of the stator windings energized to positive power (current enters into the winding), the second winding as negative. In order to keep the motor running, the magnetic field produced by the windings should shift position, as the rotor moves to catch up with the stator field. Hens we have to excite winding sequentially for maintaining rotor in running condition .This is done by electronic switches, ON& OFF sequentially. In other words, the process of activating current flow in six directions through the appropriate motor phase windings to produce an outputtorque is called as commutation.[8]

5. CIRCUIT DESCRIPTION

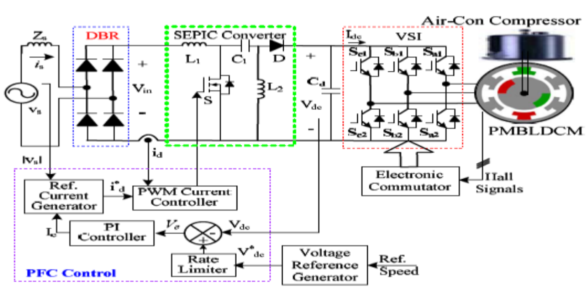

Fig.3 sepic converter fed BLDC MOTOR Drive

The proposed Sepic converter based PMBLDCM drive operated with voltage follower control. The proposed controller is operated to maintain a constant DC link voltage with PFC action at AC mains. The DC link voltage is sensed and compared with a reference voltage which results in a voltage error. This voltage error is passed through a voltage controller to give a modulating signal which is amplified and compared with saw-tooth carrier wave of fixed frequency to generate a pulse width modulated signal for the switching device of the DC-DC converter .For the speed control, the speed signal derived from rotor position of the PMBLDCM, sensed using Hall effect sensor, is compared with a reference speed. The resultant speed error is passed through a speed controller to get the torque equivalent which is converted to an equivalent current signal using motor torque constant [8]. This current signal is multiplied with a rectangular unit template waveform which is in phase with top flat portion of motor's back EMF so that reference three phase current of the motor are generated .These reference current are compared with the sensed motor current and current error are generated which is amplified and compared with triangular carrier waves to generate the PWM signals for the VSI switches [4]

6. SIMULATION AND RESULT OF BUCK CONVERTER FED BLDC MOTOR

The MATLAB simulation of Buck converter fed BLDC motor drive is as shown in fig.4. Diode bridge rectifier is fed by 220 Volts AC supply. The output of Diode bridge rectifier is fed to buck converter. The duty cycle for Sepic converter is provided by pulse generator. Three phase voltage source inverter is fed output of sepic converter. The BLDC motor is fed by this three phase voltage source inverter

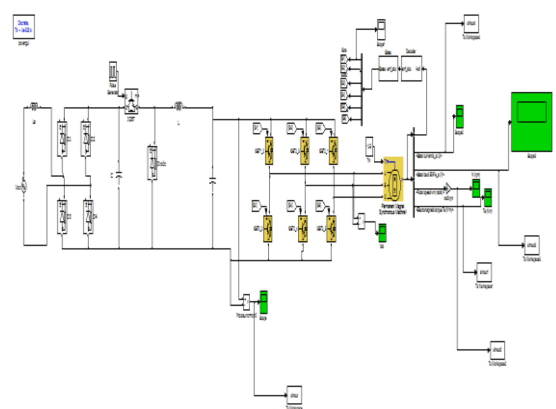

Fig.4..Simulation diagram of Buck converter fed BLDC motor

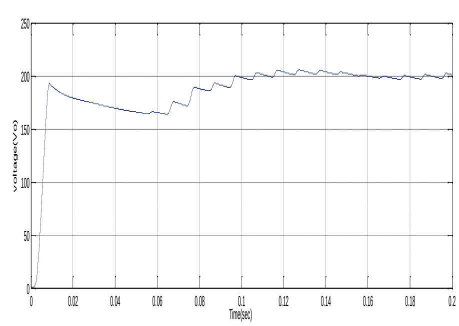

Fig.5. Output Voltage of buck converter

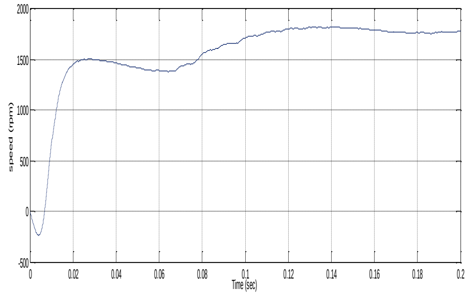

Fig.6. rotor speed of buck converter fed BLDC

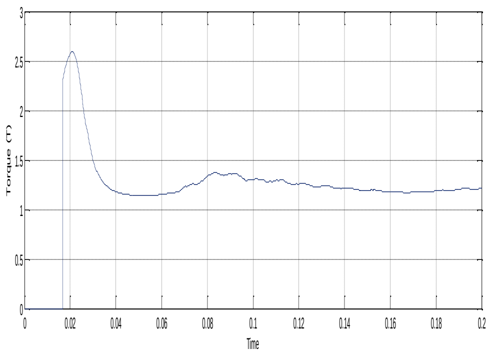

Fig.7. Torque of buck converter fed BLDC

7. SIMULATION AND RESULT OF SEPIC CONVERTER FED BLDC MOTOR

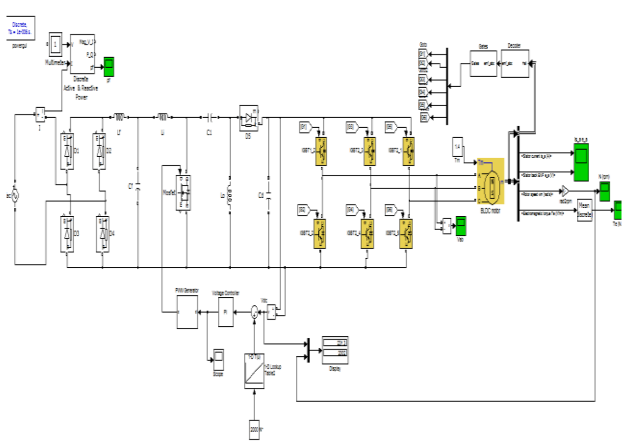

Fig.8.Simulation diagram of Sepic converter fed BLDC motor

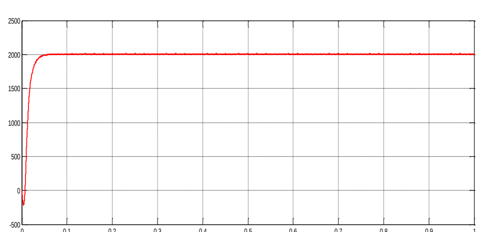

Fig.9. rotor speed of sepic converter fed BLDC

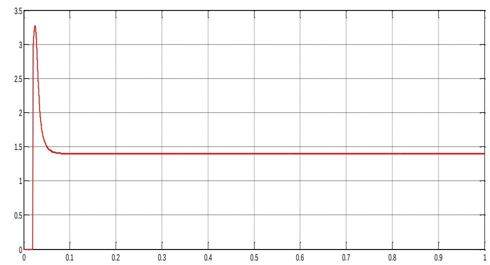

Fig:10. Electromagnetic torque sepic converter fed BLDC

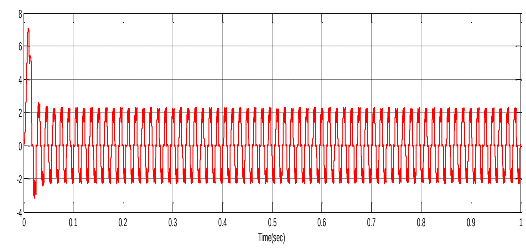

Fig:11 Stater current sepic converter fed BLDC

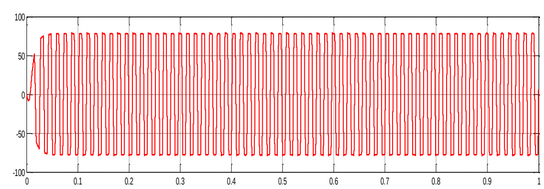

Fig .12 voltage

8. CONCUSION

The proposed drive system has been found a suitable control technique among various adjustable speed drives for many low power applications. With help of comparison with buck converter it can be concluded that the Sepic converter fed BLDC motor gives better performance.

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