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Design and Control of Buck-Boost Converter Fed Electronically Commutated Motor Drive

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Abstract-In this paper, DC – DC Converter feeding PMBLDC Motor drive is proposed here with adjustable speed operation for low power application. DC – DC Converter provide controlled DC voltage to the PMBLDC Motor drive for an uncontrolled DC output of a single phase AC mains. In proposed circuit, single phase supply is feeding to uncontrolled rectifier and DC – DC Converter is used to control the voltage of DC link capacitor. Voltage of DC link capacitor is used to control the speed of DC motor. The output of DC link capacitor fed to inverter and speed of PMBLDC Motor can be controlled by changing switching pattern of inverter switches. A voltage follower and current follower technique is proposed for operation of BLDC motor under wide range of speed control. There are different types of DC – DC Converter topology used for controlling of BLDC Motor are explain in this paper

Keywords- Current multiplier, DC – DC converter, Power quality, PMBLDCM, Speed control, Voltage multiplier.

1. INTRODUCTION

The fundamental qualities of a Permanent magnet brushless DC motor (PMBLDCM) such as wide speed range, high efficiency, rugged construction and ease of control make it suitable for air conditioning compressor application and other household application such as fan, water pump, mixers, etc.. The BLDC motor not only used in household application but also these are suitable for other application such as computer disc drives, automobile starter, 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. A BLDC motor has three phase winding on the stator and permanent magnets on the rotor. A low power PMBLDC motor is fed from a single phase AC supply through a diode bridge rectifier (DBR) followed by a DC capacitor and a voltage source inverter (VSI) which draws a pulsed current from ac mains having peaks higher than the amplitude of the fundamental input current due to uncontrolled charging of DC link capacitor. Due to draws of peak current which results in Power Quality disturbances in AC mains such as Power factor is low and increased total harmonic distortion (THD) due to these reason PFC Converter is used for improving the Power Quality at AC mains.

The mode of operation of PFC Converter are of two types out of which is suitable for these application is the main issue because it affects the cost and the components used in the PFC Converter. The continuous conduction mode (CCM) and discontinuous conduction mode (DCM) are the two modes of operation amongst which the DCM is used because it requires a single voltage sensor for dc link voltage control, and inherent PFC is achieved at the ac mains, but at the cost of higher stresses on the PFC converter switch hence, DCM is preferred for low-power applications.

A DC – DC Converter is connected between the VSI and the DBR fed from single phase AC supply to provide control voltage at DC link capacitor. There are many DC –DC Converter topologies available such as buck, boost, buck – boost converter topology is used. The buck – boost converter topology has advantages of its simplest construction and minimum component requirement over other topologies. The buck – boost converter is designed for DCM operation for controlling the speed of BLDC motor.

2. OVERVIEW

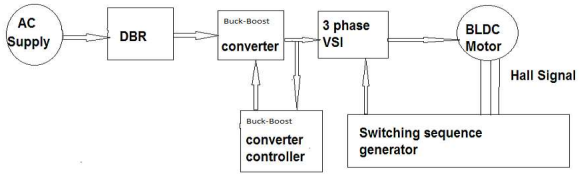

Fig. 2.1 Block Diagram.Controlling of permanent magnet brushless DC motor using buck - boost converter with voltage follower

DC-DC converter feeding permanent magnet brushless motor drive is proposed here for low power application. A buck-boost 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 linkcapacitor. Voltage of DC link capacitoris 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 BLDCmotor.

2.1. Buck-Boost Converter

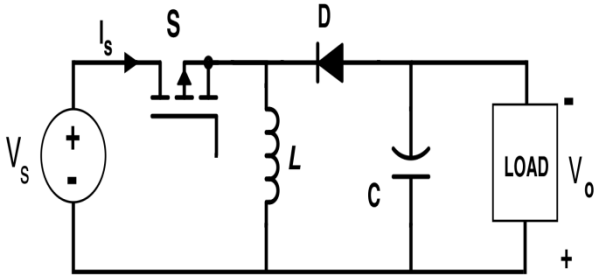

Fig. 2.2: Circuit diagram of Buck-Boost Converter

A Buck converter is a switch mode DC to DC converter in which the output voltage can be transformed to a level less than or greater than the input voltage. The magnitude of output voltage depends on the duty cycle of the switch.It is also called as step up/step down converter. The name step up/step down converter comes from the fact that analogous to step up/step down transformer the input voltage can bestepped up/down to a level greater than/less than the input voltage. By law of conservation of energy the input power has to be equal to output power (assuming no losses in the circuit) [3].

Input power (P_{in}) = output power (P_{out})

In step up mode $V_{in}<V_{out}$ in a Buck Boost converter, it follows then that the output current will be less than the input current. Therefore for a Buck Boost converter in step up mode

$V_{in}<V_{out}$ and $I_{in}>I_{out}$

In step down mode $V_{in}>V_{out}$ in a Buck Boost converter, it follows then that the output current will be greater than the input current. Therefore for a Buck Boost converter in step down mode

$V_{in}>V_{out}$ and $I_{in}<I_{out}$

2.1.2: Brushless DC (BLDC)

Brushless Direct Current (BLDC) motors are one of the motor types rapidly gaining popularity. BLDC motors are used in industries such as Appliances, Automotive, Aerospace, Consumer, Medical, Industrial Automation Equipment and Instrumentation. As the name implies, BLDC motors do not use brushes for Commutation; instead, they are electronically commutated. BLDC motors have many advantages over brushed DC motors and induction motors. A few of these are:

1. Better speed versus torque characteristics
2. High dynamic response
3. High efficiency
4. Long operating life
5. Noiseless operation
6. Higher speed ranges

2.3 Hall Sensors

Unlike a brushed DC motor, the commutation of a BLDC motor is controlled electronically. To rotate the BLDC motor, the stator windings should be energized in a sequence. It is important to know the rotor position in order to understand which winding will be energized following the energizing sequence. Rotor position is sensed using Hall effect sensors embedded into the stator. Most BLDC motors have three Hall sensors embedded into the stator on the non-driving end of the motor. Whenever the rotor magnetic poles pass near the Hall sensors, they give a high or low signal, indicating the N or S pole is passing near the sensors. Based on the combination of these three Hall sensor signals, the exact sequence of commutation can be determined.

3. ADVANTAGES AND DISADVANTAGE

3.1 Advantages

1. The cost of this drive is very low.
2. This drive has better performance.
3. Wide range of speed controller.
4. Controlling is easy.
5. Rugged construction.

3.2Disadvantage

External circuit is required for controlling the BLDC Motor. Thus circuit is complex and required additional components.

4. PROPOSED METHODOLOGY

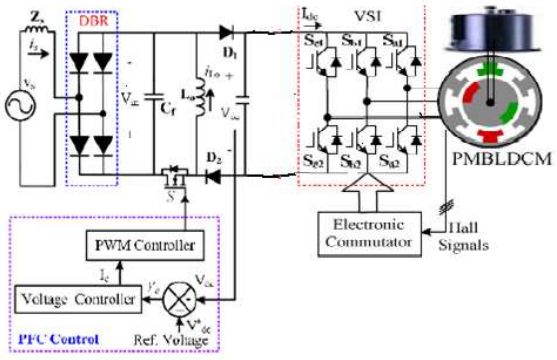

Fig. 4.1: DC-DC converter fed PMBLDCM drive with voltage follower control

4.1 Working

The proposed buck-boost 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.

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.

4.2. Applications

The cost of the Brushless DC Motor has declined since its introduction, due to advancements in materials and design. This decrease in price, coupled with the many advantages it has over the Brush DC Motor, makes the Brushless DC Motor a popular component in many different applications

1. Heating and ventilation
2. Industrial automation
3. Motion control
4. Positioning and actuating system
5. Aero modeling
6. Cooling fan

5.RESULTS

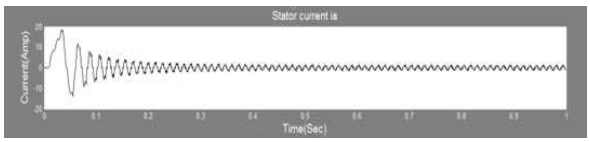

Fig 5.1(a): Stator current

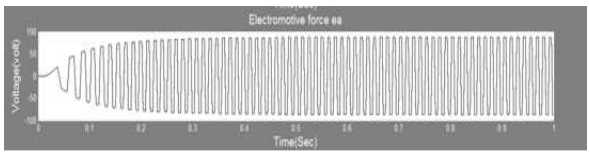

Fig 5.1(b): Electromotive Force

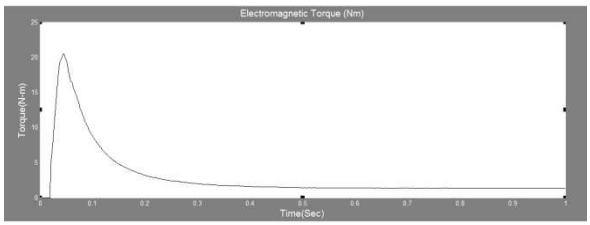

Fig 5.1(c): Torque

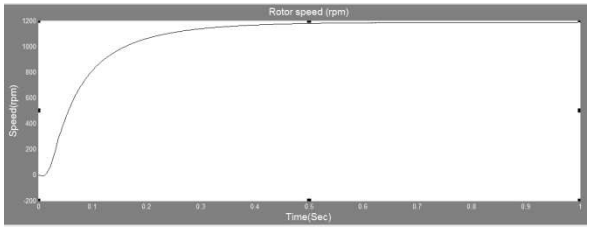

Fig 5.1(d): Rotor speed

6. CONCLUSION

The design, modeling and simulation of a buck-boost converter fed PMBLDCM drive has been carried out in detail for its operation under speed control. The buck - boost converter is operated with voltage follower control to get a sensor controller. Therefore, the non-isolated buck-boost converter fed PMBLDCM drive on voltage follower control has potential for many low cost and low voltage speed control application operated for utility AC mains. It is conclude that the proposed drive has demonstrated best performance with sensor as a variable speed and improved power quality at input AC mains.

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