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An Integrated Power Converter-Based Brushless DC Motor Drive System

Mr. Sukdeo L. Patil and Dr. Kishor Porate

PG Student, Department of Electrical Engineering[1]

Assistant Professor, Department of Electrical Engineering Department [2]

Priyadarshini College of Engineering, Nagpur, India

Abstract: *Brushless DC (BLDC) are replacing DC motors in wide range of applications such as household appliances, automotive and aviation. These applications require a very robust, high power density and efficient motor for operation. BLDCs are commutated electronically unlike the DC motor. BLDCs are controlled using a microcontroller which powers a three phase power semiconductor bridge. This semiconductor bridge provides power to the stator windings based on the control algorithm. The motor is electronically commutated, and the control technique/ algorithm required for commutation can be achieved either by using a sensor or a sensorless approach. To achieve the desired level of performance the motor also can be controlled using a velocity feedback loop. Sensorless control techniques such as Direct Back Electromotive Force (BackEMF), Indirect Back EMF Integration and Field Oriented Control (FOC) are studied and discussed. To achieve a desired level of performance in various applications that require the motor to operate at constant speed over various loads, the motor has to be operated using a suitable velocity control loop. These types of controllers are achieved by using a conventional proportional- integral (PI) controller.*

Keywords: Speed Controller, Boost Converter, Current Quality , Power Electronics Circuits

I. INTRODUCTION

Household appliances are one of the fastest growing markets for BLDCs[1]. Common household appliances which use electric motors include air conditioners, refrigerators, vacuum cleaners, washers and dryers. These appliances have relied on traditional electric motors such as single phase AC motors including capacitor- start, capacitor- run motors, and universal motors. However, consumers now demand better performance, reduced acoustic noise and higher efficient motor for their appliances. Hence, BLDC have been introduced in order to fulfill these requirements.

Brushless DC motors (BLDC) are usually small horsepower control motors that provide various advantages such as high efficiency, quiet operation, high reliability, compact form and low maintenance. However, there are disadvantages for the BLDC because of variable speed, and therefore adjustable speed drives are used to overcome this.

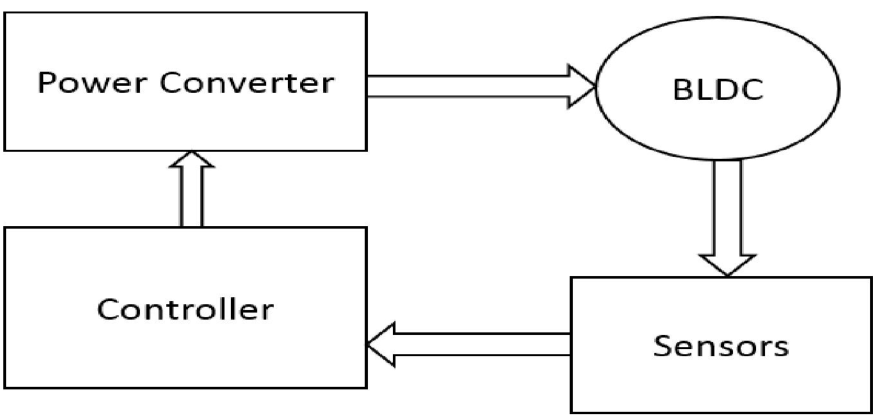

Fig. 1 - Block diagram

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II. ODEL PREDICTIVE CONTROL OPERATING PRINCIPLE

The chapter focuses on various sensorless and sensored commutation techniques required to drive the motor. Earlier BLDC controllers required the use of Hall Effect devices to sense the angular position of the rotor magnets. Sensorless control techniques are introduced to reduce the cost of the system. Some of the sensorless control techniques explained in this chapter use Back- EMF and current sensing, which provide enough information to determine the position of the rotor and, therefore, to operate the motor with synchronous phase currents. Various concepts are discussed and advantages and disadvantages are included.

The techniques discussed in this chapter are:

- Hall Sensors – Sensored Technique
- Back- EMF Method:

Stability and system performance design.

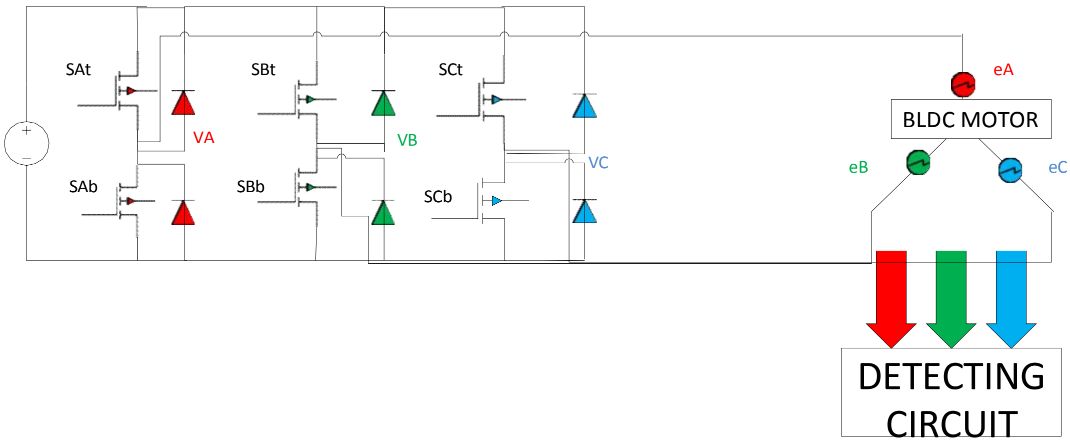

Fig. 2 – Circuit Diagram

III. PREDICTION MODEL

A general block diagram for the closed loop speed control of a brushless DC motor is shown in figure. The motor is driven from a DC source through an inverter. The controller takes the error between the reference speed and the actual speed as its input.

There are additional calculations inside the controller, e.g. in case of a classical PI controller, it has to calculate the integral of the error, whereas for a controller it requires calculation of the change in speed error.

The controller then generates the reference voltage to achieve the desired performance based on its control algorithm. This reference voltage is the input to the PWM signal generator for the inverter. A simple PWM generator compares a saw-tooth voltage versus reference voltage in order to generate the pulses for the inverter.

IV. COST FUNCTION ISSUES

The terminal voltage of the non-conducting/floating phase is given by equation

$$Vc = ec + VN = ec + (VCE - \ )/2 - (eA + eA)/2$$

Where ec-is the Back- EMF of the open phase (C), VN is the potential of the 3- Phase motor neutral point, and VCEandVF are the forward voltage drops of the transistors and diodes, respectively [9].

Since the Back- EMF of the two conducting phases (A and B) have the same amplitude but opposite signs, the terminal voltage of the non-conducting phase/floating phase is given by equation (3.2):

$$Vc = ec + VN = ec + (VCE - \ )/2 = ec + (VB + VA\ )/2 \qquad (3.2)$$

Where, $VCE = VB$ (Collector emitter voltage of transistor SBb)

$-VF = VA$

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Since the zero-crossing point detection is done at the end of the pulse width modulation (PWM) on- state and only the high side of the inverter is chopped, VCE is similar for the SAt and SBb transistors (Fig 3-3), and the detection formula can be represented by the following equation [9],

$$VC = ec + VN = ec + (VB- + \quad - (VA+)_{CE}/2 \cong + (V_C DC)/2_{CE}$$

Therefore, the zero crossing occurs when the voltage of the floating phase reaches one half of the DC rail voltage[6].This zero crossing point is detected at the end of the PWM period.

MODEL AND SIMULATION RESULTS FOR Converter-Based Brushless DC Motor Drive System:

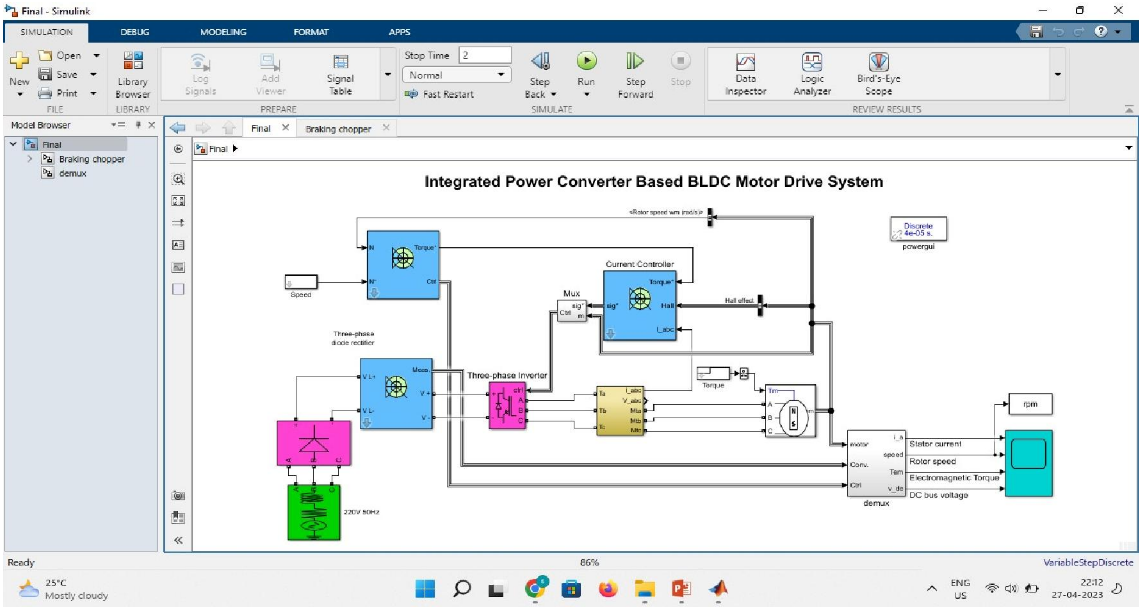

Fig. 3 – MODEL AND SIMULATION

MODEL AND SIMLATION RESULTS OF speed and torque Characteristic

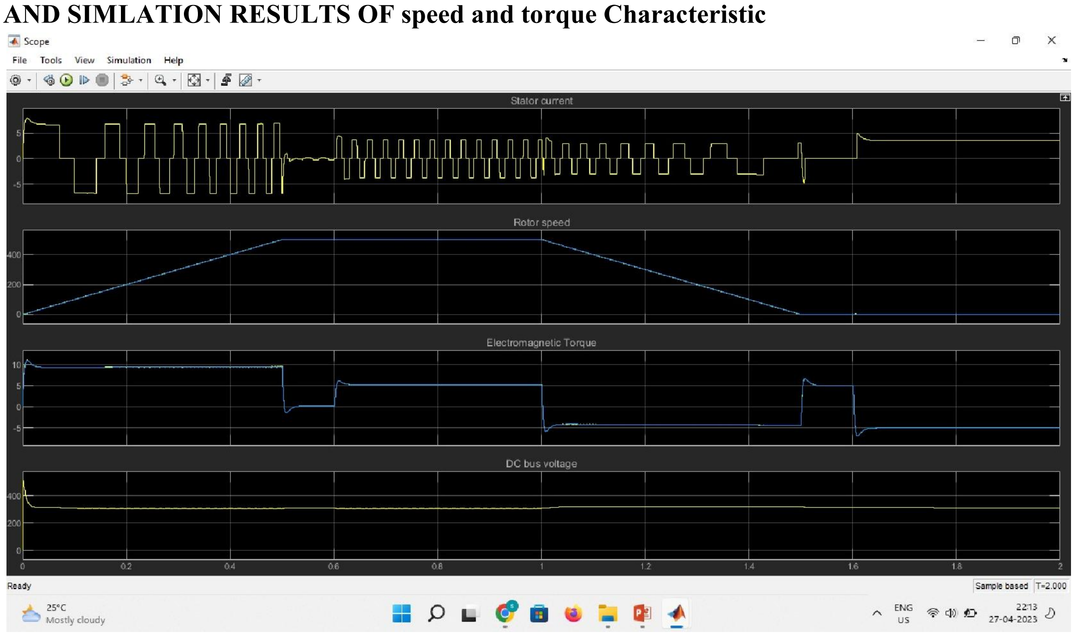

Fig. 3 – MODEL AND SIMLATION

Speed and torque Characteristic

V. CONCLUSION

BLDC are constantly replacing DC motors in various applications. These applications vary from fans, pumps, steering wheel and blowers to name a few. A typical BLDC behaves as a PM DC motor with linear speed vs. torque characteristics where the speed decreases as the load increases. Some applications, such as an automobile (Windscreen wiper), require the motor to have a fairly constant speed for different loads. DC motors such as shunt and compound work reasonably well in these applications, but a BLDC with a PI controller improves the performance. The speed vs. torque characteristics shown in Figure 5-9 and 10 show that the speed remains virtually constant across the torque range. These curves are more similar to a separately excited DC motor, but they are actually much better because of the feedback control.

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BIOGRAPHY

I , Mr.Sukdeo Patil , a students of Post graduate program in Engineering at Priyadarshini college of Engineering , Nagpur (Maharashtra)