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ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 4, Issue 6, June 2016

Speed Control of a BLDC Motor Using PWM Control Technique

Arjun V N[1], Akhilesh H Nair[1], Balakrishnan G[1], Vishnu T S[1], Vidya Sojan[2]

UG Scholar, Dept of Electrical & Electronics Engineering, College of Engineering Munnar, India[1]

Assistant Professor, Dept. of Electrical & Electronics Engineering, College of Engineering Munnar, India[2]

Abstract: This paper describes a simpler way to control the speed of PMBLDC motor using pwm control method. The performances of the PMBLDC system are found from the hardware implementation. The speed is regulated by PI controller. The method proposed suppresses torque oscillations. This drive has high accuracy, robust operation from near zero to high speed. This paper deals with control method to reduce speed oscillations.

Keywords: Hall position sensors, permanent magnet brushless DC motor, pwm, PI controller.

1. INTRODUCTION

Latest advance in permanent magnet materials, solid state devices and microelectronic have resulted in new energy efficient drives using permanent magnet brushless DC motors (PMBLDCM). Brushless DC motors are very popular in a wide array of applications in industries such as appliances, automotive, aerospace, consumer, medical, industrial automation for its reliability, high efficiency, high power density, low maintenance requirements, lower weight and low cost. As the name implies, BLDC motor do not have brushes for commutation.

A BLDC motor finds numerous applications in motion control. A BLDC motor has windings on stator and alternate permanent magnets on rotor. Electronic commutation of stator windings is based on rotor position with respect to the stator winding. A new generation of microcontrollers and advanced electronics has overcome the challenge of implementing required control functions, making the BLDC motor more practical for a wide range of uses. In this method the speed is controlled in a closed loop by measuring the actual speed of the motor. The error in the set speed and actual speed is calculated. A proportional plus integral (PI) controller is used to amplify the speed error and dynamically adjust the pwm duty cycle. When using pwm outputs to Control the six switches of the three- phase bridge, variation of the motor voltage can be got by varying the duty cycle of the pwm signal. For low-cost, low-resolution speed requirements, the Hall signals are used to measure the speed feedback

2. TYPES OF CONTROL TECHNIQUES OF BLDC MOTOR

Basically there are two methods are available for controlling PMBLDC motor. They are sensor control and sensor less control. To control the machine using sensors, the present position of the rotor is required to determine the next commutation interval. In BLDC motors the commutation is done by electronic switches which need the rotor position. The appropriate stator windings have to be energized when rotor poles align with the stator winding. The BLDC motor can also be driven with predefined commutation interval. But to achieve precise speed control and maximum generated torque, brushless commutation should be done with the knowledge of rotor position. In control methods using sensors, mechanical position sensors, such as a hall sensor, shaft encoder or resolver have been utilized in order to provide rotor position information. In sensor less control BLDC motors can be commutated by monitoring the back EMF signals instead of the Hall sensors. Back EMF is proportional to the speed of rotation, at a very low speed, the back EMF would be at a very low amplitude to detect zero-crossing. The motor has to be started in open loop, from standstill and when sufficient back EMF is built to detect the zero-cross point, the control should be shifted to the back EMF sensing. The minimum speed at which back EMF can be sensed is calculated from the back EMF constant of the motor. With this method of commutation, the Hall sensors can be eliminated and in some motors, the magnets for Hall sensors also can be eliminated. This simplifies the motor construction and reduces the cost as well.

3. BLDC MOTOR SPEED CONTROL

A BLDC motor is driven by voltage strokes coupled by rotor position. The rotor position is measured using Hall sensors. By varying the voltage across the motor, we can control the speed of the motor.

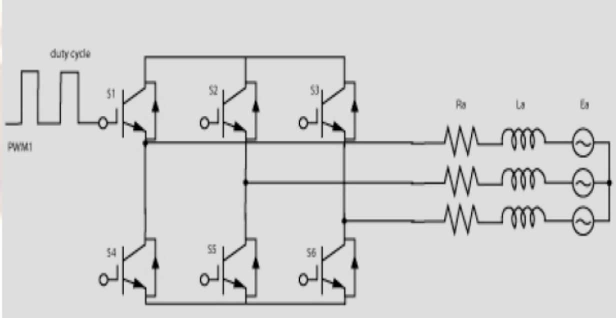

Fig 1: PWM Speed Control

When using PWM outputs to control the six switches of the three-phase bridge, variation of the motor voltage can be obtained by varying the duty cycle of the PWM signal. The speed and torque of the motor depend on the strength of the magnetic field generated by the energized windings of the motor, which depend on the current through them. Hence adjusting the rotor voltage and current will change motor speed.

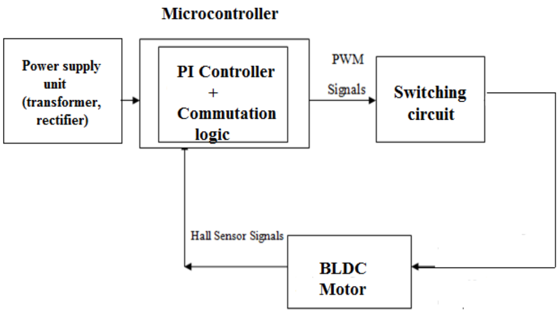

Fig.2.Closed Loop Speed Control

Commutation ensures only proper rotation of the rotor. The motor speed depends only on the amplitude of the applied voltage. This can be adjusted using PWM technique. The required speed is controlled by a speed controller. This is implemented as a conventional proportional-Integral controller. The difference between the actual and required speeds is given as input to the controller. Based on this data PI controller controls the duty cycle of the PWM pulses which correspond to the voltage amplitude required to maintain the desired speed. When using PWM outputs to control the six switches of the three-phase bridge, variation of the motor voltage can be achieved easily by changing the duty cycle of the PWM signal. In case of closed loop control the actual speed is measured and compared with the reference speed to find the error speed. This difference is supplied to the PI controller, which in turn gives the duty cycle PMBLDC motor is popular in applications where speed control is necessary and the current must be controlled to get desired torque. The basic structure for closed loop control of the PMBLDC motor drive is shown in the figure 2. It consists of an outer speed control loop, an inner current control loop for speed and current control respectively. Speed loop is relatively slower than the current loop.

3.1 Power supply Unit

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units

3.2 Microcontroller

The Microcontroller is used to produce the PWM signal according to the PI controller and the commutation logic. The PI controller is implemented as program in microcontroller.

3.3 BLDC Motor

BLDC motors are a kind of synchronous motor. This indicates the magnetic field produced by the stator and the magnetic field produced by the rotor twirls at the same frequency. BLDC motors do not experience the “slip” that is normally observed in induction motors. BLDC motor is built with a permanent magnet rotor and wire wound stator poles. The stator of a BLDC motor comprises of stack steel laminations with windings kept in the slots that are axially cut along the inner periphery. Most BLDC motors have three stator windings linked in star fashion. Each of these windings is assembled with various coils interconnected to derive a winding. One or more coils are kept in the slots and they are interconnected to form a winding. Each of these windings is distributed over the stator periphery to form an even of poles. The rotor is formed from permanent magnet and can alter from two to eight pole pairs with alternate North (N) and South (S) poles.

3.4 Switching circuit

The switching circuit used to energies the exact stator winding according to the rotor position. N channel MOSFET and its drivers are used for switching purpose. If the actual speed is greater than the set speed the duty ratio of the PWM signals reduces so the speed regulation occurs. If the actual speed is less than the set speed the duty ratio of the PWM signals increases so the speed regulation occurs

4. SIMULATION RESULTS

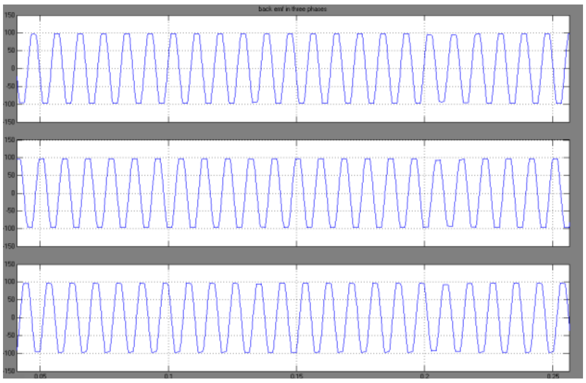

Fig3. Back emf waves in three phases

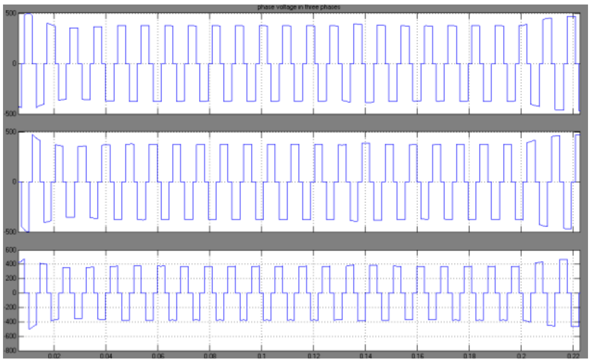

Fig 4 phase voltage in three phases

DOI 10.17148/IJIREEICE.2016.4605

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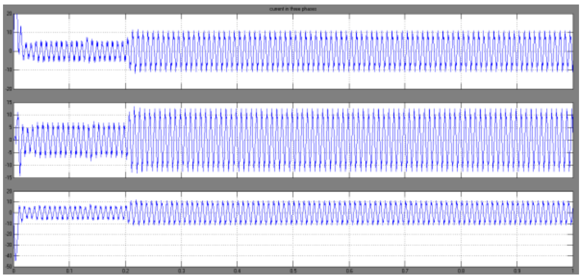

Fig 5 Current in three phases

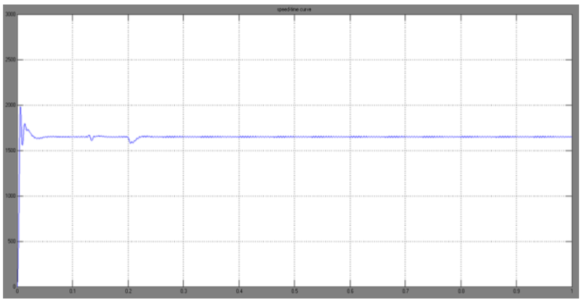

Fig 6 Speed time curve

5. HARDWARE IMPLEMENTATION AND EXPERIMENTAL RESULTS

Fig 7 full Hardware circuit implementation

Fig 8.Speed shown in LCD display

Fig 9 Speed shown in Tachometer

The speed of the rotor shown in the LCD and the tachometer states that the program we wrote on the microcontroller to find the actual speed is correct.
Our next motive is to find the pwm signal generated and the duty ratios and various actual speeds.

Pwm signal generated across the Mosfet G1 and various actual speeds

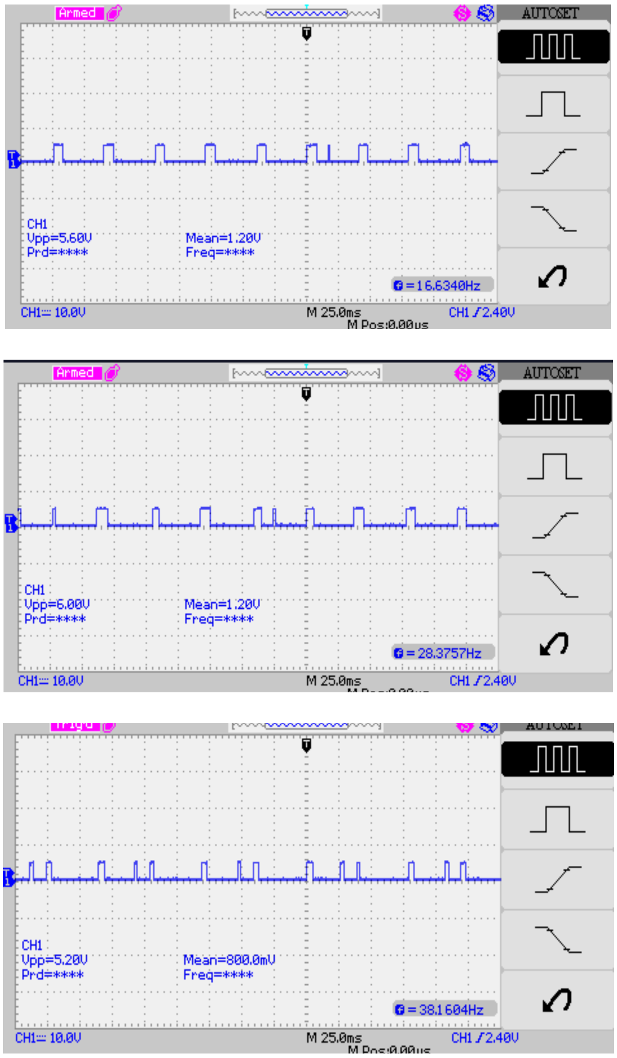

Fig10. PWM signal across Moseft G1 at various actual speed

5. CONCLUSION

BLDC motor is a good choice for various applications due to higher efficiency, higher power density and higher speed ranges compare to other motor types. The Output characteristics and simplicity of model make it effectively useful in design of BLDC motor drives with different control algorithms in different applications.

ACKNOWLEDGEMENT

The authors are thankful to **Mrs. Vidya Sojan** Assistant Professor Department of EEE and Teaching staffs of college of Engineering Munnar, for providing the necessary facilities for the preparation of the paper. We

ISSN (Online) 2321 – 2004
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would like to thanks our Parents and Friends for their support and encouragement

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