Design of Electronic Speed controller of Brushless DC Motor

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Abstract- *This paper discusses the construction and working principle of Brushless DC motor. The speed control of the BLDC motor can be done using PWM technique. The block diagram for speed control of BLDC motor is explained in this paper. A circuit design is proposed which contains arduino/controller, optocoupler, MOSFET inverter bridge. Six step control of BLDC motor using bridge inverter is simulated in Multisim.*

Keywords- BLDC, Electronic Speed Controller, PWM, Optocoupler, MOSFET, Multisim

I. INTRODUCTION

Drive systems are widely used in large number of industrial and domestic applications. Among various types of drives electric drives are undergoing technological advances. BLDC motor is one of the recent advancement which is gaining popularity in wide range of applications. The major advantage of BLDC motor over DC motor is its commutation technique. Conventional DC motor consists of commutator and brushes. However due to frictional losses at the brush-commutator surface, heat is generated, hence it is major drawback. In BLDC motor commutation is done electronically and as brushes are absent there is no scope of sparking and heat generation. Thus BLDC motors are more efficient and have noiseless operation.

BLDC motor has different construction than other conventional motors. The rotor is made up of permanent magnet and surrounds the stator which has windings.

In almost every motor driven application, speed control of motor is vital part of the design of that drive. Speed control of BLDC motor is dependent on electronic commutation circuit. It consists of microcontroller, driver circuit and feedback taken position sensors of motor. This speed control can be performed using various techniques. [4]
Simulation of BLDC motor using six step control is performed. In simulation results, the speed and torque characteristics of motor with respect to time are observed. By changing the duty cycle of PWM signal the voltage across the motor can be controlled and hence the speed of the motor.

II. CONSTRUCTION AND WORKING OF BLDC MOTOR

CONSTRUCTION

The construction of BLDC Motor is explained below

- STATOR – The stator of BLDC Motor is similar to that of induction motor. It is made of stacked steel lamination with windings which are placed in the slots. The windings are wound such that various number of phases are formed. As the number of phases increases the percentage of ripple present in the torque decreases.[5]

- ROTOR – The material used for the construction of BLDC Motor is permanent magnet. The magnet is arranged such that it forms pole pair that alternate between north and south pole.[1]

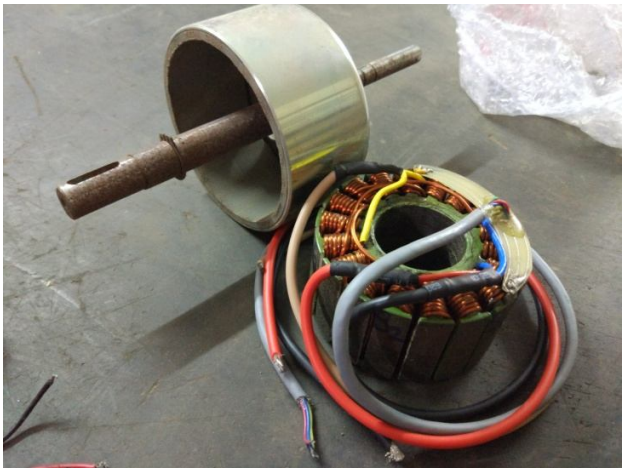


Fig 1: Constructional details

WORKING

The working principle of BLDC is attraction and repulsion between magnetic poles. The diagram shown below explains the operation of 3 phase motor. When one

of the phase is energized it generates a electromagnetic pole and attracts the nearest permanent magnet of opposite pole present in the rotor. Energizing the stator phases in particular sequence, will cause the rotation of rotor. The direction of rotation depends on the sequence of energisation of phases. This energisation process is done by using the PWM pins of microcontroller. Driver circuit is placed in between motor and microcontroller for amplifying the signal generated from PWM pins of microcontroller.[1]

Speed of the motor can be controlled by adjusting the duty cycle of the PWM signals. If the time for which one phase is energized is varied the speed of the motor will also vary. The motor is also dependent on supply voltage.But in this method, input voltage to the motor is kept constant.

Speed control is of two types, one is sensored control and other is sensorless control. In case of sensored control, hall sensors are used which determine the position of the rotor. And then this sensed position of rotor is given as a feedback to the microcontroller. Then PWM signal is generated based on this feedback signal. In case of sensorless control, Back EMF of the stator windings is taken as a feedback.[2]

III. BLOCK DIAGRAM FOR SPEED CONTROL OF BLDC MOTOR

The electronic control circuit used for controlling the speed of BLDC motor consists of microcontroller/arduino, driver and MOSFET bridge inverter circuit.[2][3]

- Arduino/controller: It is an open source electronic platform based on easy to use hardware and software. It reads the feedback from the BLDC motor and generates the required PWM signal.
- Driver Circuit: It consists of an optocoupler. Optocoupler is used for amplifying the signal generated by the PWM pins. Optocoupler gives the electrical isolation between motor and controller circuitry due to which the electronic circuit is protected from the transient currents drawn by the motor.
- MOSFET bridge inverter: It is used for energizing the motor phases in required sequence. By changing the triggering sequence of the MOSFETS in appropriate manner the direction of rotation as well as speed of the motor can be varied.
- Qx: MOSFET
- Ux: Opto-coupler
- CLx: Clock Pulses

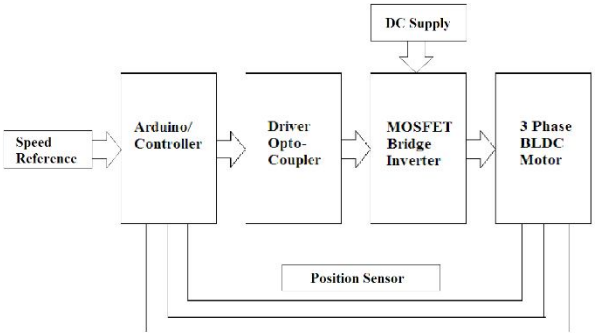


Fig 3: Block diagram of electronic speed controller

IV. CIRCUIT DIAGRAM OF ELECTRONIC SPEED CONTROLLER

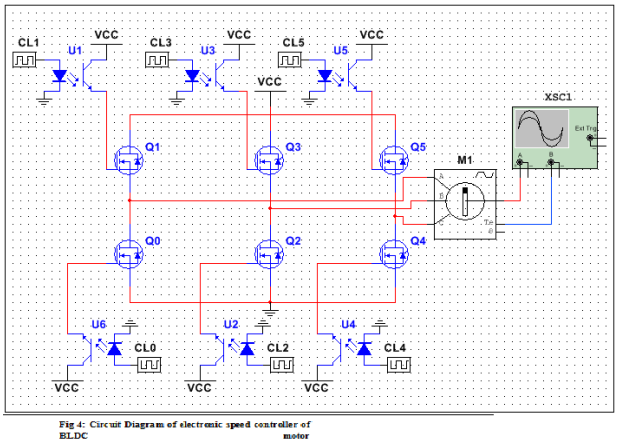


Fig 4: Circuit Diagram of electronic speed controller of BLDC motor

The circuit used for the design of controller is drawn using Multisim software.

- M1: BLDC Motor
- VCC: DC supply voltage
- XSC1: Oscilloscope

Instead of PWM pins of micro-controller, the clock pulses are shown for controlling the speed of the BLDC motor. As signal coming from PWM pins/clock pulses is of very low value. It is not sufficient to trigger the MOSFETs. Driver circuit helps to amplify the PWM signal. Optocouplers are used in driver circuit. Optocouplers provides electrical isolation which prevents microcontroller/arduino from drawing excess current from motor. MOSFET bridge inverter gives the six step control for BLDC motor.

Channel A of oscilloscope is connected to the shaft of the motor and the speed characteristics are observed. Channel B is used for observing the motor torque characteristics.

V.SIMULATION RESULTS

The circuit used for the design of six step control of BLDC motor is simulated in Multisim software, the speed and torque of the motor is observed for a particular period of time.

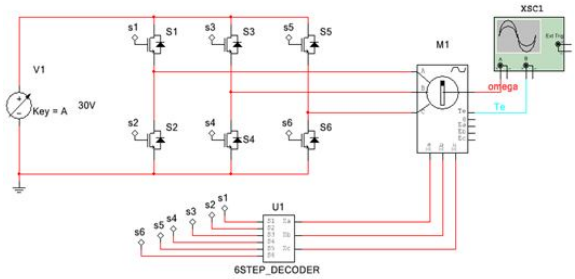
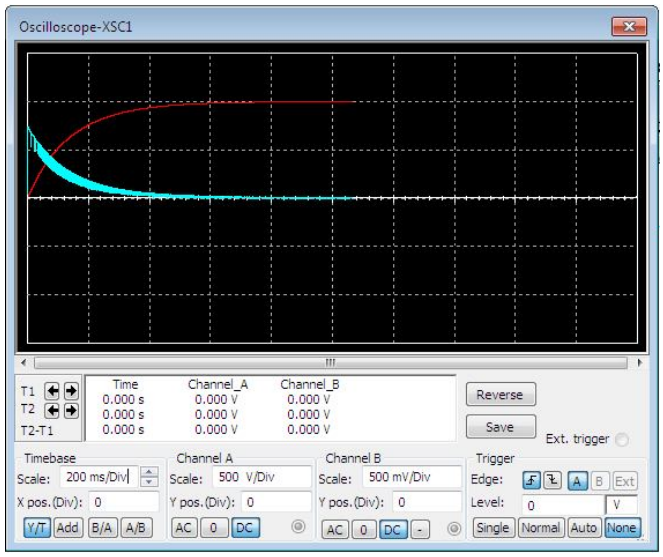


Fig 5: Six step control for brushless DC motor

VI. CONCLUSION

In this paper, three phase BLDC motor is studied which requires electronic commutation circuit. Internal circuit diagram of this electronic controller is designed using microcontroller, opto-coupler and MOSFETs. The six step control of BLDC motor using positioning sensor feedback is simulated in Multisim software. Speed and Torque characteristics with respect to time are shown in simulation results. Circuit designed for speed control gives satisfactory results. Hence design can be implemented practically.



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