Speed Control Strategy of Brushless DC Motor using Asymmetric Bridge Converter Topology

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Abstract- Power electronic devices with front-end rectifier and it is mostly used for industry, commerce and transportation, which result in low PF. The proposed system of this paper is controlled the speed of Brushless DC motor using asymmetric bridge converter because the Brushless DC motor is widely used in industrial application. It has different advantage over other conventional motor such as better speed and torque characteristics, better dynamic response, high efficiency, high speed range, no noise operation. The main objective of this project is controlling speed of BLDC motor by asymmetrical methodology in that PWM signal is given to MOSFET to produce 3 phases. Brushless Direct Current motors (BLDC), also known as permanent magnet motors and it has wide applications in many industries due to their higher performance, reliability and ease of control. This paper proposed a hardware model for speed control of BLDC drive by using prototype hardware. The speed control results obtained from hardware are satisfactory. The benefit of good modelling for implementation of hardware has been shown in this project. And this project when vary the potentiometer knob to control the level of speed. Thus, prototype development of hardware model for speed control strategy using asymmetric bridge converter topology of BLDC drive is successfully implemented in this paper.

Indexed Terms- BLDC Motor, MOSFET, PWM, Potentiometer.

I. INTRODUCTION

A Brushless DC (BLDC) motors are extensively used nowadays due to their improved performance and lower maintenance. These motors are available indifferent power ratings from small motors in hard disks to large motors in electric vehicles, actuators, robotics, etc. The main component of this project is SMPS (Switch Mode power Supply) and it has converted 120 Volt AC to 10 Volt DC at the rating of 5A. Driver circuit is used for low and high side of driving function. From there it goes to controller and directly connected to the Arduino. The same 12 Volt supply has given to the 2 Channel relay module and its rating has 10 A. MOSFET has triggered and it's shown the result of gate Pulse. The PWM signal is given by the controller. Then working of the MOSFET has to generate the waveform. Then in this project has present 6 MOSFET and it has 6 phases and Couple of phases in MOSFET is connected to the three phases of the BLDC motor. The main working of the controller is detecting the analog voltage to convert the pulse.

When supply has given by the BLDC motor then relay has been turned on that time and DC is fed to the motor and back emf is occur in phase and triggering is started in the next phase. If the vary the potentiometer duty level (Pulse Width Modulation) has been vary the amplitude voltage level of waveform has been decreases.

The stator of a BLDC motor is similar to that of an induction machine but the windings are distributed quite differently. The two different common distributions of the windings are distributed and sinusoidal. A distributed winding will have a trapezoidal back EMF while a sinusoidal winding will have a sinusoidal back EMF. This application note will focus on BLDC motors with distributed stator windings. The rotor of a brushless DC motor is different in the fact that the rotor contains permanent magnets instead of additional windings. Unlike a brushed DC motor, the commutation of a BLDC motor

in controlled electronically. To rotate the BLDC motor, the stator windings should be energized in a sequence. In order to make sure the motor controller is energizing coils in the correct sequence.

II.   MATERIALS AND METHODS

The hardware and software components used for this project are listed below.

III.   Hardware components

- Arduino Uno
- Potentiometer
- MOSFET
- BLDC Motor
- Relay module
- SMPS

IV.   SOFTWARE COMPONENTS
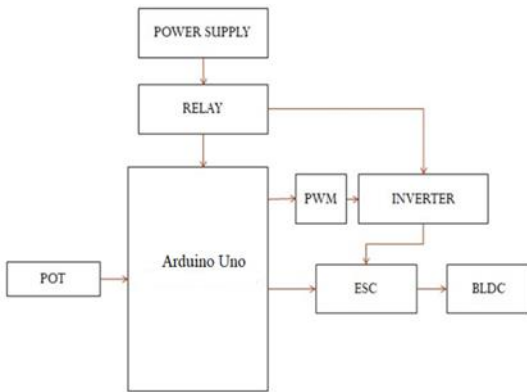
- Arduino IDE

V.   BLOCK DIAGRAM

Figure 1 Block Diagram

The block diagram representing the project is shown in the figure 1. Arduino Uno is the central microcontroller which controls the whole process. And SMPS play a main role in this project. When varying the Potentiometer Knob speed will increase and it can be controlled. As per the programming done the controller generates 6 PWM sequence which is given as inputs to the switches of the inverters which converts dc supply to ac required for running the motor.

The main advantage of the PWM strategy is that the chopping frequency is a fixed parameter; hence, acoustic and electromagnetic noises are relatively easy to filter. There are also two ways of handling the drive current switching: hard chopping and soft chopping. In the hard chopping technique, both phase transistors are driven by the same pulsed signal: the two transistors are switched-on and switched-off at the same time.

The soft chopping approach allows not only a control of the current and of the rate of change of the current but a minimization of the current ripple as well. In this soft chopping mode, the low side transistor is left ON during the phase supply and the high side transistor switches according to the pulsed signal. In this case, the power electronics board has to handle six PWM signals. The duty cycle determines the speed of the motor. The desired speed can be obtained by changing the duty cycle. The PWM in microcontroller is used to control the duty cycle of BLDC motor.

Average voltage = D * Vin

The average voltage obtained for various duty cycles is also mentioned and as the duty cycle percentage decreases average voltage also decreases from the supply voltage. Duty cycle is defined as the percentage of time the motor is ON. Therefore, the duty cycle is given as

Duty Cycle = 100% x Pulse Width/Period

Where, Duty Cycle in (%) Pulse Width = Time the signal is in the ON or high state (sec) Period = Time of one cycle (sec). The program for the closed loop control of BLDC motor operation is written in embedded C and executed in keil software.
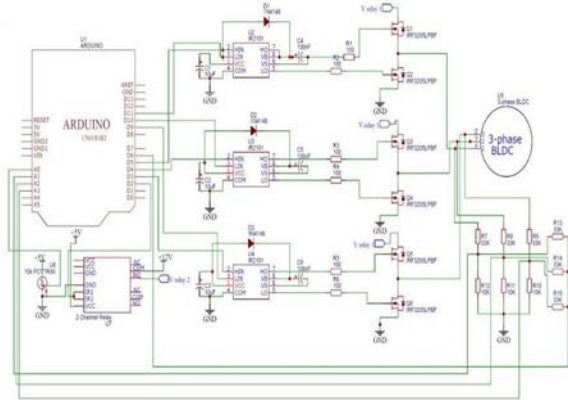
VI. CIRCUIT DIAGRAM

Figure 2 Circuit Diagram

The proposed asymmetric bridge converter topology is shown in Figure 4.19. Arduino Uno is the central microcontroller which controls the whole process. Then the 2-channel relay of VCC is connect to the Arduino of the 5 Volt supply and the pin of A0 is connected to the potentiometer after Arduino ground should be connected to the relay module. ESC of the circuit has connected to the 3 phase BLDC motor for the pin of X, Y and Z and also connect to the Analog pin of A1, A2 and A3. In the ESC should have present 6 (33K Ohms) and 3(10K Ohms) connected for series and parallel and it has reduced the supply.

After the connection process is over the 3 Ø BLDC of the pin Z has connected to Q5 and Q6. Y has connected to Q4 and Q3. X has connected to Q2 and Q1 for the MOSFET. Each of the MOSFET ground pin should connect to the Arduino of the ground pin. After complete connection has done in the BLDC the pin of H0 and L0 of each rectifier connect to 100 Ω through the MOSFET. Couple of MOSFET has to connect for the relay module. Hb and Vs has to connect with 100 nF capacitor it has to store some amount of charge.

The pin of each rectifier 1 and 4 to connect with the ground pin of the Arduino. Pin 1 of the rectifier connected to the forward bias diode through the pin 8 of the rectifier. Pin 2 and 3 of each rectifier, ESC and relay connect to the digital pin of the Arduino D0-D13. And relay has to get 12-volt supply from the Arduino.

VII. WORKING

The circuit consists of components such as Arduino Uno, SMPS, MOSFET, Rectifier, BLDC Motor, ESC, 2 Channel Relay module and Potentiometer. Arduino Uno is a microcontroller which controls the whole process. The main component of this project is SMPS (Switch Mode power Supply) and it has converted 120 Volt AC to 10 Volt DC at the rating of 5A. Driver circuit is used for low and high side of driving function. From there it goes to controller and directly connected to the Arduino. The same 12 Volt supply has given to the 2 Channel relay module and its rating has 10 A.

MOSFET has triggered and it's shown the result of gate Pulse. The PWM signal is given by the controller. Then working of the MOSFET has to generate the waveform. Then in this project has present 6 MOSFET and it has 6 phases and Couple of phases in MOSFET is connected to the three phases of the BLDC motor. The main working of the controller is detecting the analog voltage to convert the pulse.

When supply has given by the BLDC motor then relay has been turned on that time and DC is fed to the motor and back emf is occur in phase and triggering is started in the next phase. If the vary the potentiometer duty level (Pulse Width Modulation) has been vary the amplitude voltage level of waveform has been decreases. Motor has been running and that time it has shown the waveform of the speed control in DSO.
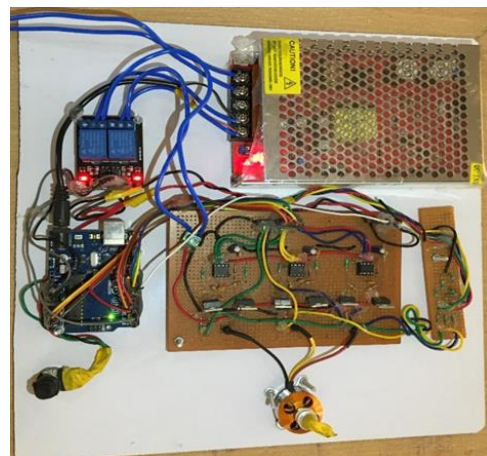
VIII. RESULTS

Figure 3 Hardware Snapshot

The duty cycle determines the speed of the BLDC motor. The desired speed can be obtained by changing the duty cycle. The PWM in ArduinounoR3 is used to control the duty cycle of BLDC motor to successfully vary the speed of BLDC motor. Controller generates PWM sequences which drive the BLDC motor. For control a speed of motor variable register is used which is work as variable frequency drive. To increase or decrease the duty cycle user can get the speed of motor exactly they want. Opto-couplers are used for isolating between controller side voltage and motor side voltage.

while providing an Android-based user interface that would enable control and supervision of the drive with minimal efforts on the user's part. The duty cycle determines the speed of the motor. The desired speed can be obtained by changing the duty cycle. The PWM in Arduino microcontroller is used to control the duty cycle. Speed control is achieved in three stages, input, processing and output stage.
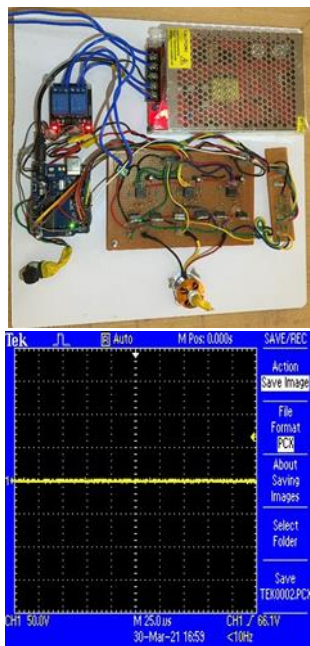
IX.   SIMULATION

Figure 4 Hardware Output (Without Speed)

When the circuit has been in ON condition without operating the potentiometer knob the speed has not varied and it has constant speed depends on the

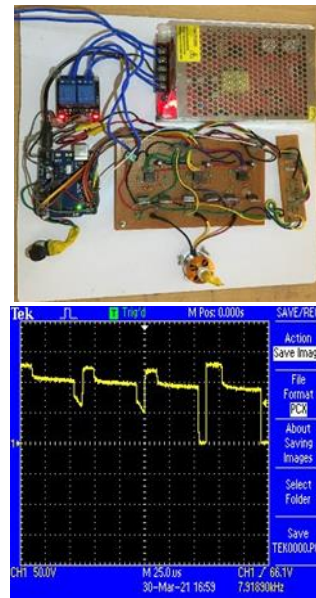amplitude and frequency and slightly speed has up and down.

Figure 4 Hardware Output (With Speed)

In this Figure 6.3 has shown when the Supply has given to the BLDC and the potentiometer knob has been slightly vary the amplitude depends on the time and it has shown by varying the knob to control the limit of speed and to vary the time limit.

CONCLUSION

This project proposed a hardware model for speed control of BLDC drive by using prototype hardware. The speed control results obtained from hardware are satisfactory. The benefit of good modelling for implementation of hardware has been shown in this project. BLDC is most suitable now a days for industry applications. Thus, prototype development of hardware model for speed control strategy using asymmetric bridge converter topology of BLDC drive is successfully implemented in this project.

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