

Speed Control of BLDC Motor by using PWM Technique

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ABSTRACT: BLDC motors are becoming more popular in industrial, traction and household appliance because it has high efficiency, high power density and low maintenance cost. Brushless DC motors having a permanent magnet rotor with a three-phase stator winding. BLDC motors do not use brushes for commutation so that the commutation is performed electronically by using an array of switching devices. In this we are using 3 phase inverter to control the BLDC motor using PWM on basis the feedback of hall sensor. Pulse Width Modulation (PWM) technique is used where its signal is generated in microcontroller.

KEYWORDS: BLDC motor, Ardiuno-UNO microcontroller, Matrix converter

I. INTRODUCTION

Now a day, many problems arises because of using brush DC motor for commutation. Such type of motors are much bulky and indirectly affect on the performance of speed control of motor, so it is not suitable. In this paper, brushless DC motor is used to avoid the brushes for commutation and make the motor very much useful for the speed control and make it more efficient and reliable. Brushless DC motors are widely used in various applications likes , Aerospace, Automotive, Medical, Consumer, Industrial Automation equipment's and instrumentation. In such application the BLDC motors are used to achieve the good efficiency during the speed control. BLDC motor offers number of advantages over the brush DC motor including noiseless operation, higher speed ranges, better speed torque characteristics and faster dynamic response The BLDC motor is also called as synchronous motor because the magnetic field is generated by the stator and rotor revolve at the same frequency and the benefits of this arrangement is that the BLDC motor does not experience slip like that of the induction motor. A BLDC motor accomplishes commutation electronically using the rotor position feedback to determine when to switch the current. Feedback usually entails an attach hall sensor or rotary encoder. The stator winding works in conjunction with permanent magnets on the rotor to generate a nearly uniform flux density in the air gap. This allows the stator coils to be driven by constant DC voltage (hence the name brushless DC), which simply switches from one stator coils to the next to generate an AC voltage waveform with a trapezoidal shape. The speed and torque of the motor is depends upon the strength of magnetic field and it is generated by energized winding of the motor, which depends on the current through the winding. Therefore adjusting the rotor voltage (and current) will change the speed of motor.

Usually, BLDC motor are uses three or more Hall Effect sensors for obtain rotor position and speed measurements. Therefore to obtain the reliable speed measurements, it would be necessary to inverse the time difference between two successive Halls - sensor signals. BLDC motor consist of rotor with permanent magnets and a stator with windings. It is also called as electronically commutated motor and it driven by DC electric source through inverter, which produces AC electric signal to drive the motor. Therefore the brushes and commutator have been eliminated. The control electronics switches the function of the commutator and energize the proper winding. BLDC motor is driven by DC voltage but current commutation is controlled by solid state switches. The rotor position is used to determine the commutation instant. The rotor position is sensed by a Hall Effect Sensor and provides signal to the respective switches.

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Brushless DC motors are traditionally driven by Pulse Width Modulated Voltage Source Inverters (PWM-VSI). However it has certain disadvantages like need of additional filter elements at input and output, the poor quality of output waveforms, harmonics depends on stability of DC link voltage and so on. Compared with these conventional converters matrix converters has the most desirable features-sinusoidal input and output currents, regeneration Capability, generation of load voltage with arbitrary amplitude and frequency and so on. Earlier, Matrix converter was employed for driving induction motor and permanent magnet synchronous motors. Many control methods of matrix converters have been proposed which includes AlesinaVenturini (AV) method, Pulse Width Modulation (PWM) method, Space Vector Modulation Technique (SVM) etc. Matrix converter can also be used to drive Brushless DC motor.

II. CONTROL OF BLDC MOTOR

The BLDC motor is characterized by a two phase ON operation to control the inverter. In this control scheme, torque production follows the principle that current should flow in only two of the three phases at a time and that there should be no torque production in the region of Back EMF zero crossings. The following figure describes the electrical wave forms in the BLDC motor in the two phases ON operation.

The principle of the BLDC motor is, at all times, to energize the phase pair which can produce the highest torque. To optimize this effect the Back EMF shape is trapezoidal. The combination of a DC current with a trapezoidal Back EMF makes it theoretically possible to produce a constant torque. In practice, the current cannot be established instantaneously in a motor phase; as a consequence the torque ripple is present at each 60 degree phase commutation.

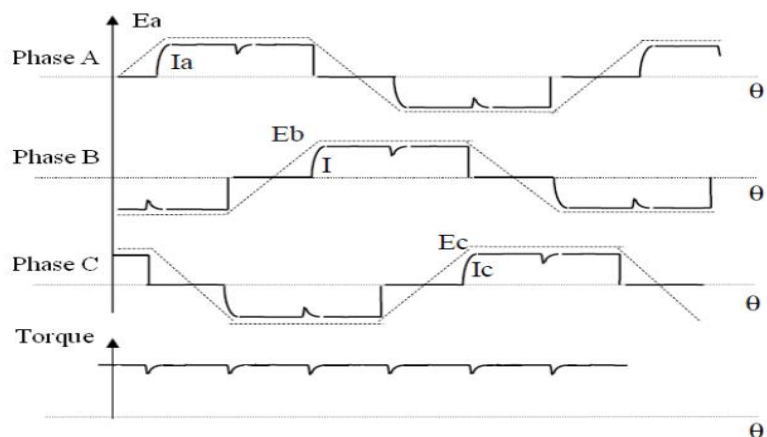


Figure. 1- on-off operation BLDC motor

III. FOUR QUADRANT OPERATION OF BLDC MOTOR

There are four possible quadrants of operation of Brushless DC motor is shown in Fig 2. When the BLDC motor is operating in the first and third quadrant the value of supplied voltage is greater than back EMF generated by the motor which are the forward motoring and reverse motoring modes of operation respectively, but the direction of current flow is differ in first and third quadrant. When BLDC motor operating in the second and fourth quadrant, the supplied voltage is less than the back EMF which is forward braking and reverse braking modes of operation respectively, here also the direction of current flow is reversed.

Initially, Motor is rotate in a clockwise direction, when phase reversal command is obtained, control goes into the clockwise regeneration mode, and due to this rotor is rapidly slows down to the standstill position. We are not waiting for the exact standstill position. Hall Effect sensor is used to sense the exact position of rotor.

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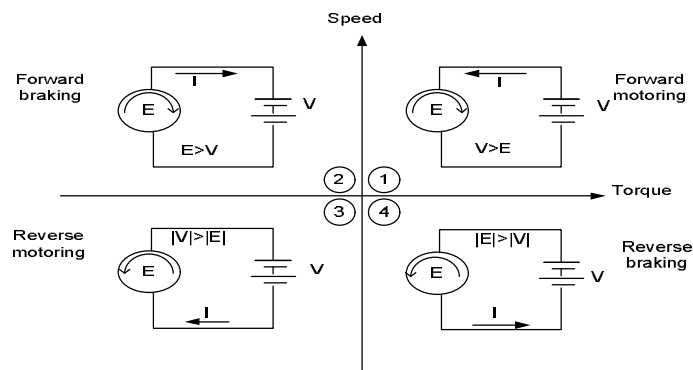


Figure. 2. Four quadrant operation of BLDC motor

IV. MATRIX CONVERTER TECHNOLOGY

In general, power electronic converters can be classified into two sub-categories.

- 1) Indirect Converters - The input is rectified, smoothed by an intermediate DC link capacitor and inverted using an array of power electronic switches.
- 2) Direct Converters - The output is synthesized directly from the input by piecewise sampling of input signal using an array of power electronic switches. Indirect converter consists of two stages of conversion. The first stage consists of a bridge rectifier, in which, the three phase AC supply is fed to the rectifier so that the rectifier performs the operation of AC to DC conversion. This DC conversion was fed to the energy storage element which is usually a capacitor. The inverter performs the operation of DC to AC conversion which is provided at the second stage. The most common and widely used type is the indirect conversion topology. Indirect matrix converter needs more sophisticated and complex control and driving techniques. The intermediate DC link capacitor used in indirect conversion topologies, requires a large space for its installation, which results in heavier and bulkier converter housing. So because of such reason instead of indirect converter, we choose direct converter technology in our project for the implementation of speed control of BLDC motor.

A direct AC-to-AC converter does not contain DC link capacitor. Converter has a simple structure and many attractive features. The three phase matrix converter is a single stage converter which has nine bi-directional switches, to connect, directly a three phase voltage source to a three phase load. In contrast, direct converters, which do not employ reactive intermediate elements, offer very reliable and compact. However, the additional control cost and the complexity of the controller are becoming irrelevant, mainly due to the availability of inexpensive and powerful processors. Capacitor technology is relatively stable, and the price is limited by the cost of materials. So the price of a capacitor is more or less static compared to the prices associated with processors and switches. Furthermore, switch costs are driven by the developments in silicon processing, and continue to fall. Therefore the capacitor is becoming the most expensive and most vulnerable element in the circuit compared to other circuit elements. Hence the direct converters are becoming an attractive and reliable solution over their Counterpart.

The matrix converter (MC) is the most popular and widely used converter topology in the family of direct converters. Matrix converter consists of an array of bidirectional switches, which are used to directly connect the power supply to the load without using any DC-link or large energy storage elements.

V. METHODOLOGY

The schematic diagram of the drive arrangement of the three phase BLDC motor is shown in Fig.3. The digital pulse width modulation control of BLDC motor will be efficient and cost effective. The digital control of the four quadrant operation of the three phase BLDC motor is achieved with microcontroller arduino UNO. The arduino UNO is

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8 bit microcontroller with PWM generation pins. The required duty cycle and the reference speed can be fed into the controller.

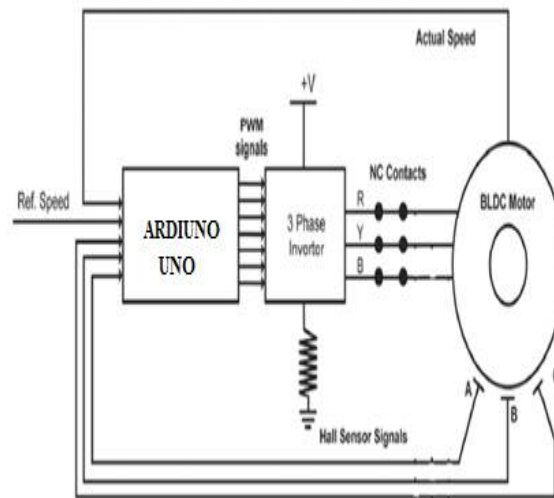


Figure.3-Block diagram of BLDC motor

BLDC motor means brushless DC motor as it doesn't have brushes for commutation so its control by switching operation. So that the commutation is performed electronically by using an array of switching devices based on the rotor position information and the rotor position information is obtained from the Hall Effect sensors. Whenever the rotor magnetic poles pass near the Hall Effect sensors, indicating either North Pole or South Pole, the rotor position is sensed by the Hall Effect sensors which provides signal to the respective switches and according to that exact sequence of commutation is determined. These signals are decoded by combinational logic to provide the firing signals for 1200 conduction on each of the three phases.

The hall sensor inputs which gives the position of rotor is fed to the microcontroller. The microcontroller compares it with the reference speed and generates an error signal. The PWM module of the controller generates appropriate PWM signals, which are applied to the three phase inverter at the appropriate time to trigger the appropriate switches. The table of Hall Effect sensor and inverter switch is given below. This sequence properly activates the magnet to keep rotating the BLDC motor.

TABLE I
Chart of clockwise rotation BLDC motor

Phase	Hall sensors			Switches						Phases			Windings		
	H3	H2	H1	Q1L	Q1H	Q2L	Q2H	Q3L	Q3H	P1	P2	P3	V ₁₋₂	V ₂₋₃	V ₃₋₁
I	1	0	1	0	1	1	0	0	0	+V _m	Gnd	NC	-V _m	-	-
II	0	0	1	0	1	0	0	1	0	+V _m	NC	Gnd	-	-	+V _m
III	0	1	1	0	0	0	1	1	0	NC	+V _m	Gnd	-	-V _m	-
IV	0	1	0	1	0	0	1	0	0	Gnd	+V _m	NC	+V _m	-	-
V	1	1	0	1	0	0	0	0	1	Gnd	NC	+V _m	-	-	-V _m
VI	1	0	0	0	0	1	0	0	1	NC	Gnd	+V _m	-	+V _m	-

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VI. PWM TECHNIQUE

PWM is an effective method for adjusting the amount of power delivered to the load. PWM technique allows smooth speed variation without reducing the starting torque and eliminates harmonics. In PWM method, operating power to the motors is turned on and off to modulate the current to the motor. The ratio of on to off time is called as duty cycle. The duty cycle determines the speed of the motor. The desired speed can be obtained by changing the duty cycle. The Pulse Width Modulation (PWM) in microcontroller is used to control duty cycle of DC motor drive.

PWM is an entirely different approach to controlling the speed of a DC motor. Power is supplied to the motor in square wave of constant voltage but varying pulse-width or duty cycle. Duty cycle refers to the percentage of one cycle during which duty cycle of a continuous train of pulses. Since the frequency is held constant while the on-off time is varied, the duty cycle of PWM is determined by the pulse width. Thus the power increases duty cycle in PWM.

In this project we had implemented the analysis using load cell, current sensor and voltage sensor. These sensor is used to calculate the torque, power of system in different condition i.e. No load and load.

VII. HARDWARE DETAILS

a) Arduino UNO

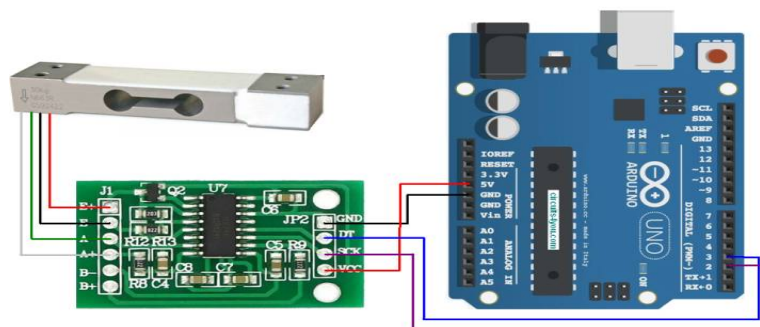


Figure.4:-Arduino UNO and load cell with HX 117 amplifier.

Arduino UNO is 8-bit microcontroller with 14 digital pin, 6 analog pin and 6 PWM pin. Its use 16MHz clock for processing. It is mainly use because it's very user friendly.

b) Load cell

The basic principle of load cell is the change in the length of internal resistance. This resistance shows the change in Whetstone Bridge. This change is amplified using HXII7 and used detect the weight of load.

c) ACS 712

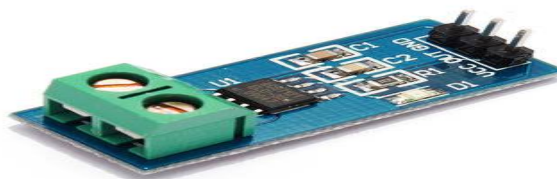


Figure.5:-ACS 712 is hall sensor based current sensor.

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ACS712 is used as current sensor which senses the field due to current carrying conductor. This field is use to detect the current in that conductor

VIII. EXPERIMENTAL SETUP AND RESULT



Figure.6 :- hardware connections BLDC motor and inverter with microcontroller.

In the setup we are using a 3 phase inverter which is controlled by arduino pulse which generated according to hall sensor. The hall output is connected to arduino from BLDC motor. The pot is use to control the PWM and direction of motor.

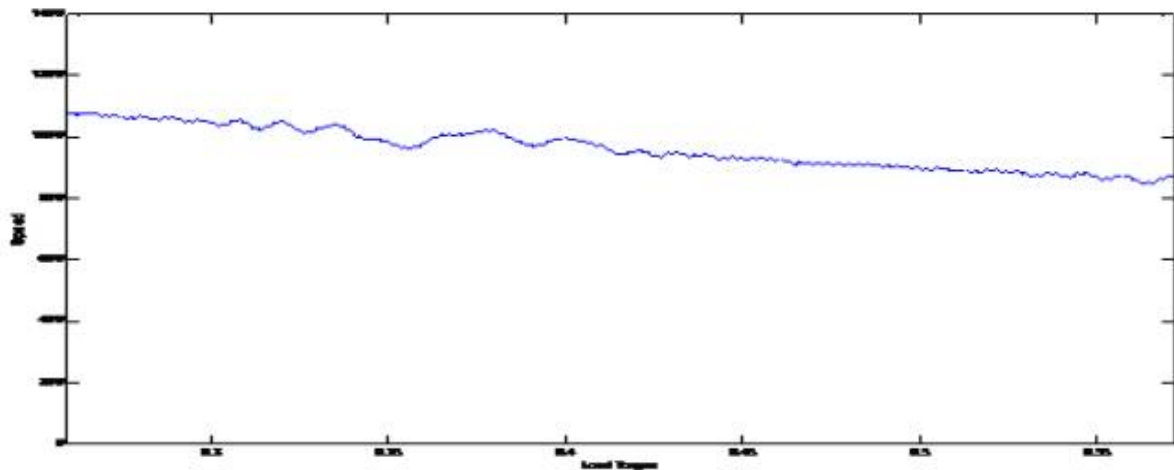


Figure.7: Simulated Speed torque characteristics of BLDC motor in forward direction.

In above Figure 7 we are showing the change in torque with speed of motor according to varying speed.

IX. CONCLUSION

This paper we had proposed system that is controlling the BLDC motor according to given speed (pot). This shows the accuracy of because hall based communication. In project we had controlled the speed and also the torque

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using hall sensor based feedback system. Due to use of PWM technique we can control the BLDC motor speed from minimum to maximum.

REFERENCES

- [1] C.S. Joice, S.R. Paranjothi, and V. JawharSenthil Kumar, "Digital Control Strategy for Four Quadrant Operation of Three Phase BLDC Motor With Load Variation," IEEE Transactions on industrial informatics, Vol.9, No.2, May 2013.
- [2] H.K. SamithaRansara, U.K.Madawala, "A New Matrix Converter Based Three Phase Brushless DC Motor Drive," IEEE 2011.
- [3] R. Krishnan, Sung- Yeul Park and KeunsooHa, "Theory and Operation of a Four-Quadrant Switched Reluctance Motor Drive With a Single Controllable Switch-The Lowest Cost Four-Quadrant Brushless Motor Drive," IEEE transactions on industry applications, Vol.41, No.4, July/August 2005.
- [4] ShrutiShrivastava, JageshwarRawat and Amit Agrawal in International Journal of Engineering Research, 01 Dec. 2012 presented, "Controlling DC Motor using Microcontroller (PIC16F72) with PWM," Int. Journal of Engineering Research, Volume No.1, Issue No.2, pp : 45-47, 01 Dec. 2012 .
- [5] K. Shivanarayana, G. Anil, K. Srividya Savitri, "Simulation of Four Quadrant Operation & Speed Control of BLDC Motor on Matlab / Simulink," Int. Journal of Science and Modern Engineering (IJISME), ISSN: 2319-6386, Volume-1, Issue-8, July 2013.
- [6] Aswathy Paul, "Speed Control for Four Quadrant Operation of Three Phase BLDC Motor Using Digital Controller," IOSR Journal of Electrical and Electronics Engineering, e-ISSN: 2278-1676, ISSN: 23203331, Volume 9, Issue 1 Ver. V (Feb. 2014), PP 07-12.
- [7] Microchip, AN898, "Determining MOSFET Driver Needs for Motor Drive Applications," ©2003 Microchip Technology Inc.
- [8] Freescale semiconductor, Application note, "3-phase BLDC Motor Control with Sensorless Back EMF Zero Crossing Detection Using 56F80x," ©Freescale Semiconductor, Inc., 2001, 2005.
- [9] AnandSathyan, Nikola Milivojevic, Young-JooLee, Mahesh Krishnamurthy and Ali Emadi, "An FPGA-Based Novel Digital PWM Control Scheme for BLDC Motor Drives," IEEE transactions on industrial electronics, Vol.56, No.8, August 2009.
- [10] P.W. Wheeler, J. Rodriguez, J.C. Clare, L. Empringham and A. Weinstein, "Matrix Converters: A technological Review," IEEE transactions on Industrial Electronics, vol.49, No.2 April 2002.
- [11] Manali A. Pawar, N.T. Sahu, A.Y. Fadnis, S.Y. Ambatkar, "A Novel Topology of Matrix Converter for Driving a BLDC Motor," International Journal of Electrical, Electronics and Data Communication, ISSN: 2320-2084, Volume-2, Issue-2, Feb.-2014.
- [12] Jose Rodriguez, Marco Rivera, Johan W. Kolar, Patrick W. Wheeler in January 2012 Presented, "A Review of Control and Modulation Methods for Matrix Converters". IEEE trans. on industrial electronics, Vol.59, No.1, January 2012.