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SPEED CONTROL OF THREE PHASE BLDC MOTOR FOR FOUR QUADRANT OPERATION USING MATRIX CONVERTER TOPOLOGY

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Abstract: Brushless DC (BLDC) motor drives find wide application in industries due to their high power density and control capabilities. Four quadrants method is use to control the BLDC motor in all the four quadrants without any loss of power so the energy is conserved during the regenerative period. This paper deals with matrix converter based drive techniques for control of three phase BLDC motor. Hall Effect sensor sense the signals obtained from rotating position of BLDC motor and send it to the microcontroller embedded with PWM technique. Microcontroller provides PWM signals to the appropriate switching devices, which have to be turn on and off in accordance with switching algorithm table. The need of the proposed work is to make simple hardware circuit which is more reliable, more efficient, less noisy, excellent speed control and smooth transition between the quadrants.

Keywords: Speed Control, BLDC, Microcontroller

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INTRODUCTION

Permanent Magnet Brushless DC Motor is a kind of three phase synchronous motor, having a rotor with permanent magnet, that replacing the commutation and brushes. Stator winding of BLDC motor is wound such that back electromotive force is trapezoidal.BLDC motor is driven with trapezoidal or rectangular voltage coupled with rotor position. The voltage stroke is properly aligned with flux, so that angle between stator and rotor flux is kept close to 900,to get maximum torque. In some applications, when speed control is require, large size of DC Brushed motors are use and have a much maintenance, lower efficiency and also it has a very high temperature etc. In material science and electric technology development it comes to achievement of new motor for speed control - Brushless DC motor. In BLDC motor, the brushes are not present, so that it is maintenance free, better performance no matter in high or low speed region. When the power output is same, half size of BLDC motor is use as compare to DC Brushed motor.

Usually, BLDC motor uses three or more Hall Effect sensors to obtain the actual 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 consists of rotor with permanent magnets and a stator with windings. It is also known as electronically commutated motor that are powered by DC electric source via inverter, which produces ac electric signal to drive the motor. The brushes and commutator have been eliminated and the windings are connected to the control electronics. The control electronics replaces the function of the commutator and energize the proper winding. The motor has less inertia, therefore, it is easy to start and stop. Some of the qualities of BLDC motor are good potential, more efficient, comparatively faster and more reliable. 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, which provides signal to the respective switches. BLDC motors are used in Automotive, Aerospace, Consumer, Medical, Industrial Automation equipment and instrumentation [1].

II. FOUR QUADRANT OPERATION OF BLDC

MOTOR

There are four possible modes or quadrants of operation of Brushless DC motor is shown in Fig. 1.

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 slow 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. required duty cycle and the reference speed can be fed into the controller.

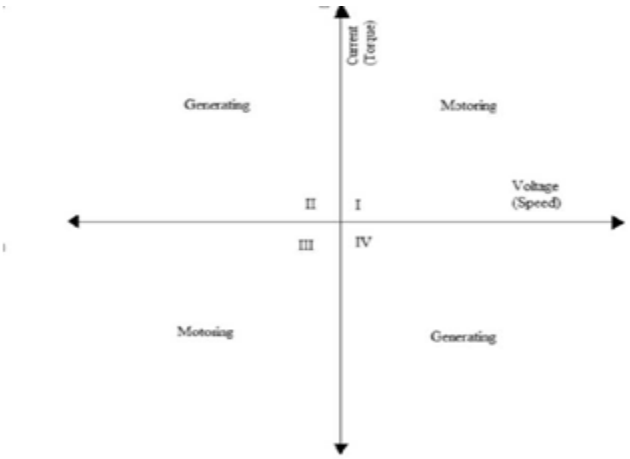


Fig.1. Operating Modes

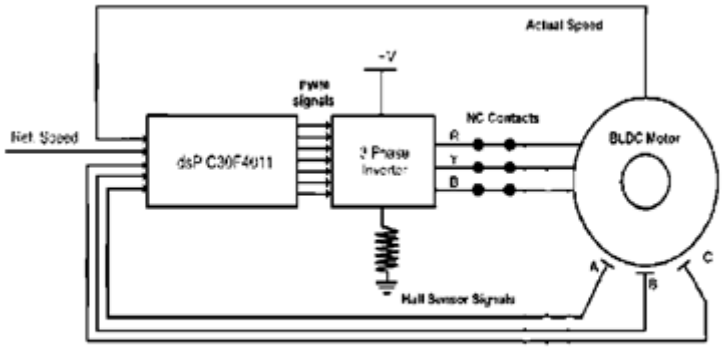
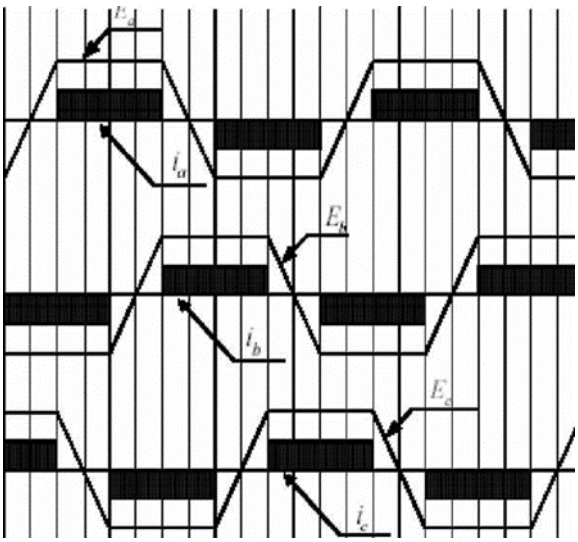


Fig.2. Close Loop Drive



COMPLETE DRIVE SYSTEM

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. The digital controller combines the digital signal processor features and PIC microcontroller features, making it versatile. The

The schematic diagram of the drive arrangement of the three phase BLDC motor is shown in Fig.2. BLDC motor is a brushless motor it do not use brushes for the commutation. 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 120° 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. In three phase inverter circuit proposed matrix converter is used shown in Fig.2.in which switching devices have to be turn on and off in accordance with the switching algorithm table which is consider.

IV. CONTROLLING DC WITH PWM

PWM is a pulse width modulation to change the width of pulses and then adjusting the amount of power delivered to the load. Smooth speed variation without reducing the starting torque and eliminates harmonics can be allowing the PWM technique. In PWM method, power required to operate the motors is turned on and off to modulate the current to the motor. The Speed of the motor is determined by the term duty cycle. It is the ratio of on to off time.PWM technique embedded in microcontroller to achieve the desired speed by controlling the duty cycle of DC motor drive.

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.

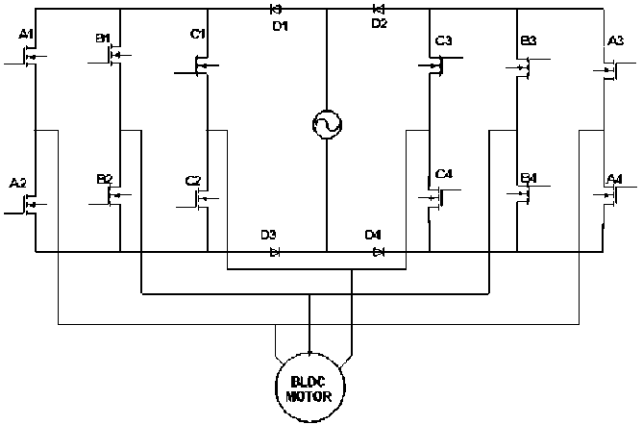


Fig.3. Proposed Matrix Converter based BLDC motor Drive

Fig.3. consist of two single phase to three phase matrix converter of proposed matrix converter based BLDC Motor drive. It consist of two single phase to three phase Inverter for positive and negative half cycle of input single phase voltage source.Inverter-1 comprised of switches A1, A2, B1, B2, C1 and C2. Inverter-2 comprised of switches A3, A4, B3, B4, C3 and C4. During the positive half cycle, power supplied to the load by inverter-1 and freewheeling path are provided by inverter-2. During negative half cycle, power Supplied to the load by inverter-2 and freewheeling path are provided by inverter-1. Reverse voltage applied to the switching devices can be avoided by applying the proper input voltage half cycle for selected inverter. At the

correct instant of time freewheeling path are provided at the force commutation of appropriate switching devices.

The precaution should be taken to operate the converter in safe mode to avoid the occurrence of high current due to supplying input voltage. In case of safe operating mode, don't turn on both switches at a time. Second precaution is to avoid the higher voltage, don't open circuited the output lines at a time. The matrix converter is the most popular and widely used converter topology in the family of direct converters.

The practical implementation of the four quadrant control of three phase BLDC motor based on advanced matrix switching will be developed. The hardware model consists of BLDC motor, MOSFET gate drive, power supply, Hall Effect sensor. The simulation model of the proposed matrix converter based on BLDC motor will be modeled using MATLAB and the simulation results will be analyzed.

TABLE I: SWITCHING ALGORITHM FOR A BRUSHLESS DC MOTOR WITH TRAPEZOIDAL BACK EMF

Supply voltage	Switches in main path	Switches in freewheeling path	Hall sensor output
Positive	Al C2	A4 C3	100
Positive	Gl C2	B4 C3	110
Positive	Bl A2	B4 A3	0 10
Positive	Cl A2	C4 A3	0 11
Positive	Cl G2	C4 B3	00 1
Positive	Al B2	A4 B3	10 1
Negative	A4 C3	A1C2	100
Negative	G4 C3	B1C2	110
Negative	B4 A3	B2 A2	0 10
Negative	C4 A3	Cl A2	0 11
Negative	C4 B3	Cl B2	00 1
Negative	A4 B3	Al B2	1 0 1

IV. CONCLUSION

The mentioned four quadrant method for BLDC motor is used to detect the forward and reverse direction of motor. This work is to make simple hardware circuit which is more reliable, more efficient, less noisy, excellent speed control and smooth transition between quadrants. If mentioned method is implemented in higher rating motors, arcing might occur during the

switching on and off of the relay contacts. But if the mentioned method is implemented in low power motors like motors used in sewing/ embroidery machine, arcing will be very less which is not even visible.

It is also useful method to run the motor without brushes, so that commutation is done using control electronics circuitry. In the above method matrix converter topology is used to control the current and supplied the power to the three phase BLDC motor during the entire input cycle. By using the above mentioned method we must have to improve the performance of motor.

REFERENCES

1. C.S. Joice, Dr. S.R. Paranjothi, and Dr. V.J.S. Kumar, "Digital control strategy for four quadrant operation of three phase BLDC motor with load variation," IEEE Trans. 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. C. S. Joice, Dr. S. R. Paranjothi, and Dr. V. J. S. Kumar, "Practical implementation of four quadrant operation of three phase Brushless DC motor using dsPIC," in Proc. IConRAEeCE 2011, 2011, pp. 91¬94, IEEE.

4. B. Singh and S. Singh, "State of the art on permanent magnet brushless DC Motor drives," J. Power Electron., vol. 9, no. 1, pp. 1-17, Jan. 2009.

5. T. Saito, M. Takeshita and N. Matsui, "A single to three phase matrix converter with a power decoupling capability," in Power Electronics Specialists Conference, 2004. PESC 04.2004 IEEE35th Annual, vol. 3, June 2004, pp. 2400 - 2405 Vol.3.

6. Xiaoyan Huang, Andrew Goodman, Chris Gerada, Youtong Fang,Qinfen Lu, "A Single sided matrix converter drive for a brushless dc motor in Aerospace applications, " IEEE Trans. on industrial electronics, vol.59, no.9, September 2012.

7. Vashit Bist and Bhim singh, "A PFC - based bldc motor drive using a canonical Switching cell converter," IEEE Trans. on industrial informatics, vol.10, no.2 May 2014.

8. C. Xia, Z. Li, and T. Shi, "A control strategy for four - switch three phase brushless DC motor using single current sensor," IEEE Trans.Ind. Electronics, vol. 56, no. 6, pp. 2058-2066, June 2009.

9. A. Sathyan, M. Krishnamurthy, N. Milivojevic, and A. Emadi, " A low cost digital control scheme for brushless DC motor drives in domestic applications," in Proc. Int. Electric Machines Drives Conf., 2009, pp. 76-82.

10. R. Krishnan, S.-Y. Park, and K. Ha, "Theory and operation o fa four quadrant Switched reluctance motor drive with a single controllable switch—the lowest Cost four - quadrant brushless motor rive," IEEE Trans. Ind. Appl., vol. 41,no. 4, pp. 1047¬1055, 2005.

11. V. U, S.Pola, and K. P. Vittal, "Simulation of four quadrant operation & speed control of BLDC motor on MATLAB/SIMULINK," in Proc.IEEE Region 10 Conference, 2008, pp. 1-6.