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DEVELOPMET IN BRUSHLESS SPEED CONTROL OF DC MOTOR BY USING MICROCONTROLLER

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ABSTRACT:
In this paper we are designing a low cost microcontroller based brushless speed control of DC Motor. Speed Control of BLDC motor using micro controller requires more hardware, and with the availability of PIC microcontrollers with versatile features motivated to develop a cost effective and reliable control with variable speed range. A DC Brushless Motor uses a permanent magnet external rotor, three phase of driving coils, one or more Hall Effect devices are used to sense the position of rotor, and the associated drive electronics. The coils are activated, one phase after the other, by the drive electronics as queued by the signals from the Hall effect sensors, they act as three phase synchronous motors containing their own variable frequency drive electronics. This proposed system provides a very precise and effective speed control system. The user can enter the desired speed and the motor will run at that exact speed. In order to maintain a constant speed, the pulse width modulation signal generated via the microcontroller is sent to the motor driver so as to vary the voltage supply to motor.

Keywords: BLDC Motor, Microcontroller, sensors,

INTRODUCTION:

Brushless dc (BLDC) motors are preferred as small horsepower control motors due to their high efficiency, silent operation, compact form, reliability, and low maintenance. However, the problems are encountered in these motor for variable speed operation over last decades continuing technology development in power semiconductors, microprocessors, adjustable speed drivers control schemes and permanent-magnet brushless electric motor production have been combined to enable reliable, cost-effective solution for a broad range of adjustable speed applications. In general, Brushless DC motors such as fans are smaller in size and weight than AC fans using shaded pole or Universal motors. Since these motors have the ability to work with the available low voltage sources such as 24-V or 12-V DC supply, it makes the brushless DC motor fans convenient for use in electronic equipment, computers, mobile equipment, vehicles, and spindle drives for disk memory, because of its high reliability, efficiency, and ability to reverse rapidly. Brushless dc motors in the fractional horsepower range have been used in various types of actuators in advanced aircraft and satellite systems.

LITERATURE:

Ms Sarita S Umadi (2016) The aim of this paper is to control the speed of DC motor. The main advantage in using a DC motor is that the Speed-Torque relationship can be varied to almost any useful form. To achieve

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the speed control an electronic technique called Pulse Width Modulation is used which generates High and Low pulses. These pulses vary the speed in the motor. For the generation of these pulses a microcontroller (AT89c51) is used.

SanthoshKumar G., et al (2015) The hardware project is designed to control the speed of a BLDC motor using closed loop control technique. BLDC motor has various application used in industries like in drilling, lathes, spinning, electric bikes etc. The speed control of the DC motors is very essential. This proposed system provides a very precise and effective speed control system.

M Sandeep et al (2014) The present work deals with speed control of BLDC motor in which an Inverter is controlled using PWM techniques and checked the performance of sinusoidal PWM and Space Vector PWM schemes and simulated to produce the desired dynamic and static speed-torque characteristics. The speed can be controlled in a closed loop by measuring the actual speed of the motor.

Pindoriya R. M, et al (2014) Efficiency and Reliability are the key features for the development of advanced motor drives. Residential and commercial appliances such as refrigerators and air conditioning systems use conventional motor drive technology. A brushless DC (BLDC) motor drive is characterized by higher efficiency, lower maintenance, and higher cost.

Devendra P. et al (2011) This paper introduces a novel method which is intended to assist in the design and control of cost effective, efficient Brushless Direct Current (BLDC) motors with additional features like auto restart and auto power down while maintaining constant speed. In the present paper, an algorithm which uses the Hall sensor signals acquired from the motor is developed and the program has been written using MPLABIDE v 7.52. This program generates the firing pulses required to drive the MOSFETs of three phase fully controlled bridge converter driven by IR2101 FET drivers.

METODOLOGY:

OPERATING PRINCIPLE OF BLDC MOTOR

BLDC motor consists of stator, rotor and position sensor as shown in Fig. 1. Rotation of BLDC motor requires position feedback of relative rotor position. Mostly used BLDC motor uses Hall sensors as the position feedback. In order to produce a rotating field (driving torque), respective phases of stator have to be turned on and off in sequence through the six switches (usually MOSFET of IGBT) of the three phase full bridge inverter, depending on the position of the rotor. Position signals from the three Hall sensors are fed back to the controller. Hall signals carry either 0V (logic low) or +5V (logic high) depending on the rotor position.

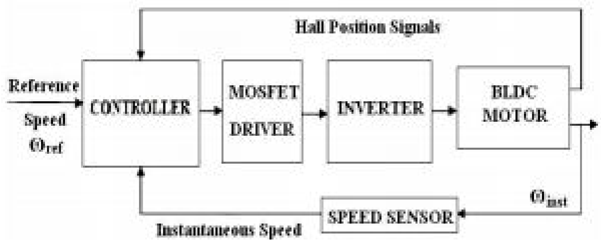

Fig 2. Schematic diagram of BLDC motor drive

MICROCONTROLLER BASED BLDC MOTOR DRIVE

Fig. 3 describes the operation of a BLDC motor drive circuit. Here the digital pulses (bit pattern) from Hall sensors are fed to the microcontroller. External interrupt is generated on each bit change of any of the three Hall position signal inputs. Special

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interrupt on bit change is an inherent feature of PIC184331 microcontroller which in very useful in designing the motor control algorithm.

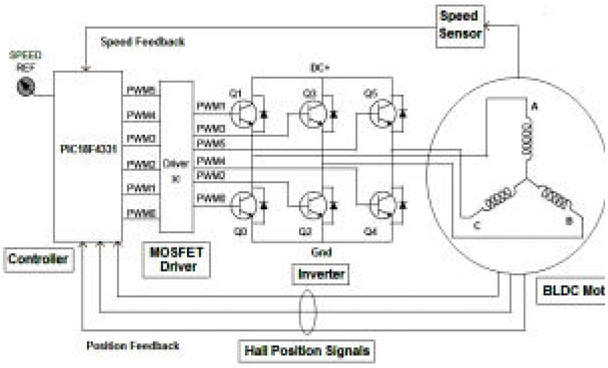

Figure 3. PIC184331 microcontroller based BLDC motor drive

As soon as any bit change occurs on any of the three Hall input signals, the program execution sequence skips to interrupt address. Another aspect of this particular microcontroller is that it has eight dedicated PWM signals, out of which six PWM signals [8] are required to drive six MOSFET gates of the three phase full bridge inverter. This inverter directly drives the three phases of the BLDC motor. Depending on the rotor position, respective PWM channels are turned on which in turn drive the respective phases of the BLDC stator through the MOSFETs of the inverter. The proper commutation sequence (Clock Wise or Counter Clock Wise) for the respective Hall bit pattern should be stored in a look up table format in the controller itself after carrying out proper experiments on the motor. This sequence allows proper phase energizing for one directional rotation continuously performing electronic commutation. In this present work, PIC184331 microcontroller has been used to incorporate its useful features.

BLDC MOTOR SPEED CONTROL:

Pulse-width modulation (PWM) is a commonly used technique for controlling power to an electrical device, made practical by modern electronic power switches. The average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load on and off at a fast pace. The longer the switch is on compared to the off periods, the higher the power supplied to the load is. The PWM switching frequency has to be much faster than what would affect the load, which is to say the device that uses the power. Typically switching's have to be done several times a minute in an electric stove, 120 Hz in a lamp dimmer, from few kilohertz (kHz) to tens of kHz for a motor drive and well into the tens or hundreds of kHz in audio amplifiers and computer power supplies.

CONTROL STRATEGY:

PWM technique is one of the most popular speed control techniques for BLDC motor. In this technique a high frequency chopper signal with specific duty cycle is multiplied by switching signals of VSI. Therefore it is possible to adjust output voltage of inverter by controlling duty cycle of switching pulses of inverter. The disadvantages of analog methods are that they are prone to noise and they change with voltage and temperature change. Also they suffer changes due to component variation. They are less flexible as compared to digital methods. PWM signals are generated from the Spartan-3A processor by writing VHDL program to control the inverter switches. The principle of generating PWM waveform is shown in Fig 5. Counter is used to generate triangular wave. The value of compare register is compared with triangular wave. If the value of compare register is less than the value of

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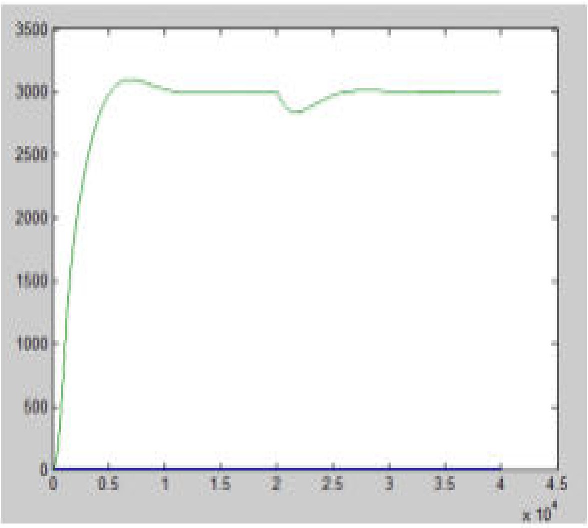
triangular wave, then PWM is ‘1’, else PWM is ‘0’.

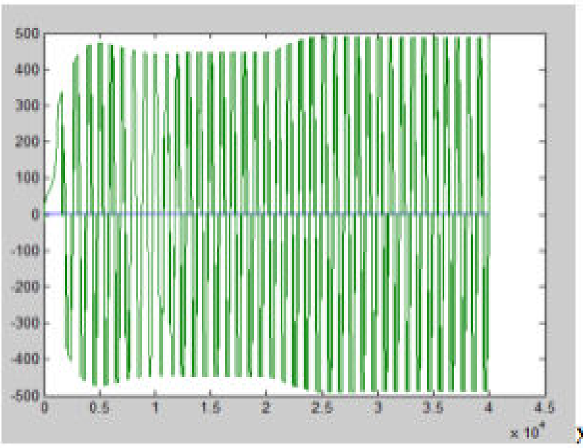
RESULTS:

The speed control technique employed here is pulse width modulation (PWM) technique 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 DC motor.



x-axis :- Time (sec) y-axis :- Speed (RPM)

Fig 4 Speed Characteristics of bldc



X-axis :- Time (sec) y-axis :- stator EMF(volt)

Fig 5. BLDC stator emf

The pulses generated from the microcontroller control circuit are

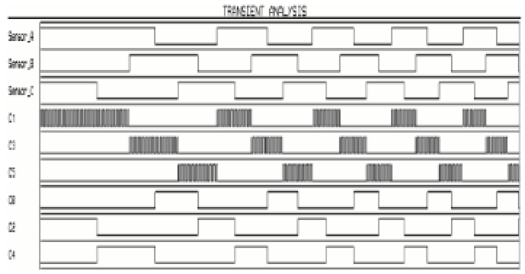


Fig. 6 Pulses to drive the MOSFETs The pulses shown in the figure are fed to the 24V, 80 W, 1500 rpm BLDC motor and the motor voltage equivalent to 1500 rpm speed is shown in figure.

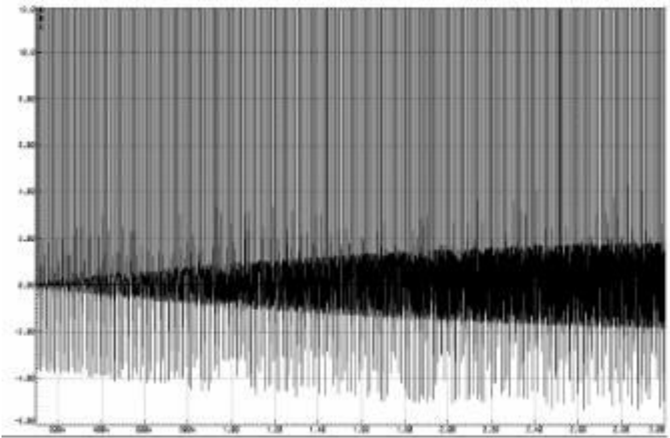


Fig.7 BLDC motor voltage waveform equivalent to 1500 rpm speed

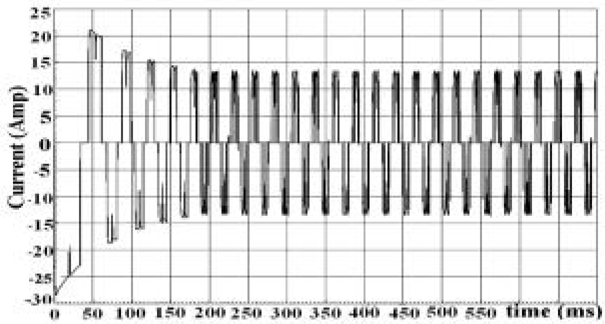


Fig 8. Simulation result for phase current response of BLDC motor on full load (1151 rpm)

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

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it effectively useful in design of BLDC motor drives with different control algorithms in different applications. By using the PWM technique speed of the BLDC motor was controlled and it was made to run at exactly entered speed. In future this hardware will be implemented in dSPACE and the speed control will be observed. The output from the converter is fed to the three phase stator winding of 24V, 80 W, 1500 rpm BLDC motor and the motor is found to run at constant speed which is set by the external potentiometer connected to the microcontroller circuit. The program is found to be efficient and the results with the designed hardware are promising.

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