© December 2020| IJIRT | Volume 7 Issue 7 | ISSN: 2349-6002

Speed Control of BLDC Motor Using Microcontroller

Aviral Kumar[1], Shripad G. Desai[2]

[1]*Student, Department of Electrical Engineering, Bharati Vidyapeeth (Deemed to Be University), College of Engineering, Pune, India*

[2]*Assistant Professor, Department of Electrical Engineering, Bharati Vidyapeeth (Deemed to Be University), College of Engineering, Pune, India*

***Abstract* - In this paper we are designing a low-cost microcontroller-based speed control of BLDC motor. 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.**

INTRODUCTION

Electric motors possess an integral part of both the industrial and the domestic sectors. Motors used in abundance are mostly induction motors and brushed DC motors which suffer from low efficiency and high maintenance, respectively. Brushless Direct Current (BLDC) motor has gained immense popularity in recent era due to its ease in control, less maintenance due to the absence of brush-commutator arrangement and higher efficiency. They also have high power density especially due to the employment of high energy density permanent magnets used in the rotor. Compared to the most popular induction machine, BLDC motor has lower inertia, allowing faster dynamic response. The only hindrance behind its massive use is the higher cost involved in designing its most imperative controller. Microcontroller based drive system are Nowadays gaining immense popularity for designing cost effective and robust controllers due to its integrated peripherals like PWM generators, Analog to Digital Converter (ADC) etc., lesser requirement of components, increased reliability, very high-speed operation, more adaptability to modern control technique and more flexibility of design. This paper describes the use of a Brushless DC Motor (BLDC). Although the brushless characteristic can be apply to several kinds of motors – AC synchronous motors, stepper motors, switched reluctance motors, AC induction motors - the BLDC motor is conventionally defined as a permanent magnet synchronous motor with a trapezoidal Back EMF waveform shape. Permanent magnet synchronous machines with trapezoidal Back EMF and (120 electrical degrees wide) rectangular stator currents are widely used as they offer the following advantages first, assuming the motor has pure trapezoidal Back EMF, and that the stator phases commutation process is accurate, the mechanical torque developed by the motor is constant; secondly, the Brushless DC drives show a very high mechanical power density.

BLDC MOTOR BACKGROUND

BLDC motor drives, systems in which a permanent magnet excited synchronous motor is fed with a variable frequency inverter controlled by a shaft position sensor. There appears a lack of commercial simulation packages for the design of controller for such BLDC motor drives. One main reason has been that the high software development cost incurred is not justified for their typical low cost fractional/integral kW application areas such as NC machine tools and robot drives, even it could imply the possibility of demagnetizing the rotor magnets during commissioning or tuning stages. Nevertheless, recursive prototyping of both the motor and inverter may be involved in novel drive configurations for advance and specialized applications, resulting in high developmental cost of the drive system. Improved magnet material with high (B.H), product also helps push the BLDC motors market to tens of kW application areas where commissioning errors become prohibitively costly. Modelling is therefore essential and may offer potential cost savings. A brushless dc motor is a dc motor turned inside out, so that the field is on the rotor and the armature is on the stator. The brushless dc motor is actually a permanent magnet ac motor whose torque "current characteristics mimic the dc motor. Instead of commutating the armature current using brushes, electronic commutation is used. This eliminates the problems associated with the brush and the commutator arrangement, for example, sparking and wearing out of the commutator" brush arrangement, thereby, making a BLDC more rugged as compared to a dc motor.

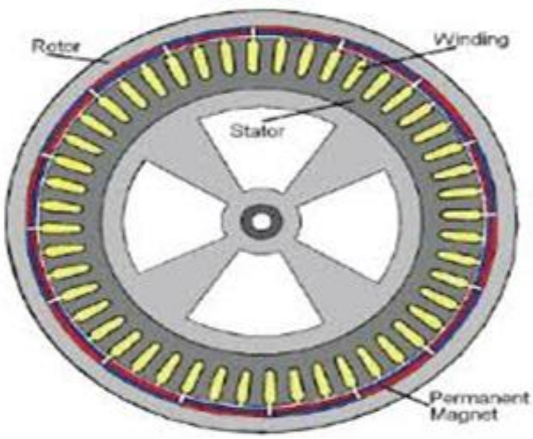

Figure 1 Cross-section view of a brushless dc motor

In effect, a BLDC motor is a modified PMSM motor with the modification being that the back Emf is trapezoidal instead of being sinusoidal as in the case of PMSM. The “Commutation region” of the back Emf of a BLDC motor should be as small as possible, while at the same time it should not be so narrow as to make it difficult to commutate a phase of that motor when driven by Current Source Inverter. The flat constant portion of the back Emf should be 120° for a smooth torque production.

HARDWARE COMPONENTS

The main components required in implementing the project are:

1. Brushless DC Motor
2. Hall Sensors
3. Inverter
4. Microcontroller

BLDC MOTOR

The BLDC motor is an AC synchronous motor with permanent magnets on the rotor (moving part) and windings on the stator (fix part). Permanent magnets create the rotor flux and the energized stator windings create electromagnet poles. The rotor (equivalent to a bar magnet) is attracted by the energized stator phase. By using the appropriate sequence to supply the stator phases, a rotating field on the stator is created and maintained. This action of the rotor - chasing after the electromagnet poles on the stator - is the fundamental action used in synchronous permanent magnet motors. The lead between the rotor and the rotating field must be controlled to produce torque and this synchronization implies knowledge of the rotor position.

On the stator side, three phase motors are the most common. These offer a good compromise between precise control and the number of power electronic devices required to control the stator currents. For the rotor, a greater number of poles usually create a greater torque for the same level of current. On the other hand, by adding more magnets, a point is reached where, because of the space needed between magnets, the torque no longer increases. The manufacturing cost also increases with the number of poles. As a consequence, the number of poles is a compromise between cost, torque, and volume.

Permanent magnet synchronous motors can be classified in many ways, one of these that is of particular interest to us is that depending on back-emf profiles: Brushless Direct Current Motor (BLDC) and Permanent Magnet Synchronous Motor (PMSM). This terminology defines the shape of the back-emf of the synchronous motor. Both BLDC and PMSM motors have permanent magnets on the rotor but differ in the flux distributions and back-emf profiles

BLDC MOTOR CONROL

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. This control structure has several advantages:

1. Only one current sensor is necessary.
2. The positioning of the current sensor allows the use of low-cost sensors as a shunt.

We have seen that 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.

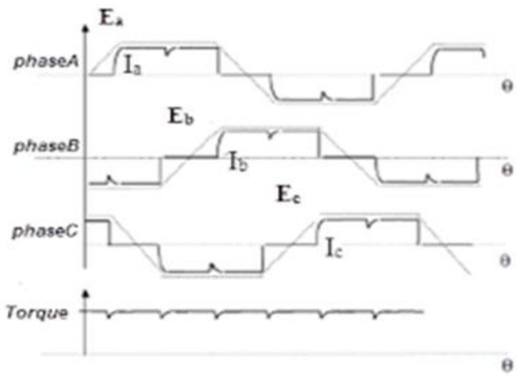

Figure 2 Electrical Waveforms in the Two Phase ON Operation and Torque Ripple

HALL SENSORS

A Hall Effect sensor is a transducer that varies its output voltage in response to a magnetic field. Hall Effect sensors are used for proximity switching, positioning, speed detection, and current sensing applications. In its simplest form, the sensor operates as an analogue transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined. Using groups of sensors, the relative position of the magnet can be deduced.

Figure 3 Hall Sensor

Electricity carried through a conductor will produce a magnetic field that varies with current, and a Hall sensor can be used to measure the current without interrupting the circuit. Typically, the sensor is integrated with a wound core or permanent magnet that surrounds the conductor to be measured. Frequently, a Hall sensor is combined with circuitry that allows the device to act in a digital (on/off) mode and may be called a switch in this configuration. Commonly seen in industrial applications such as the pictured pneumatic cylinder, they are also used in consumer equipment; for example, some computer printers use them to detect missing paper and open covers. When high reliability is required, they are used in keyboards. Hall sensors are commonly used to time the speed of wheels and shafts, such as for internal combustion engine ignition timing, tachometers, and anti-lock braking systems. They are used in brushless DC electric motors to detect the position of the permanent magnet. In the pictured wheel with two equally spaced magnets, the voltage from the sensor will peak twice for each revolution. This arrangement is commonly used to regulate the speed of disc drives.

INVERTER

INTRODUCTION

The main objective of an inverter is to produce an ac output waveform from a dc power supply. These are the types of waveforms required in adjustable speed drives (ASDs), uninterruptible power supplies (UPS), static VAR compensators, active filters, flexible ac transmission systems, and voltage compensators, which are only a few applications. For sinusoidal ac outputs, the magnitude, frequency, and phase should be controllable. According to the type of ac output waveform, these topologies can be considered as voltage source inverters (VSIs), where the independently controlled ac output is a voltage waveform. These structures are the most widely used because they naturally behave as voltage sources as required by many industrial applications, such as adjustable speed drives (ASDs), which are the most popular application of inverters.

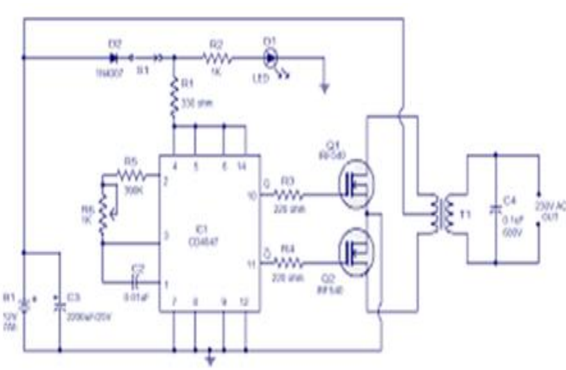

Figure 4 Basic Inverter Circuit

MICROCONTROLER

Description:

The AT89C52 is a low-power, high performance CMOS 8-bit microcomputer with 8Kbytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C52 is a powerful microcomputer which provides a highly flexible and cost-effective solution to many embedded control applications.

Features

- Compatible with MCS-51 Products
- 8K Bytes of In-System Reprogrammable Flash Memory
- Endurance: 1,000 Write/Erase Cycles
- Fully Static Operation: 0 Hz to 24 MHz
- Three-level Program Memory Lock
- 256 x 8-bit Internal RAM
- 32 Programmable I/O Lines
- Three 16-bit Timer/Counters
- Eight Interrupt Sources
- Programmable Serial Channel
- Low-power Idle and Power-down Modes

Figure 5 Microcontroller AT89C52

The AT89C52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89C52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next hardware reset.

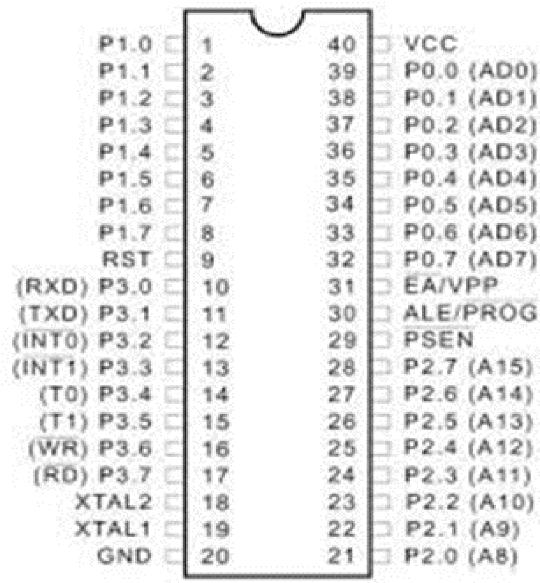

Figure 6 Pin Diagram of AT89C52

HARDWARE IMPLEMENTATION

The aim of the project is to control the speed of a BLDC motor using a microcontroller with the help of SVPWM-technique. As far as the hardware implementation is concerned, it is implemented for open loop of operation.

CIRCUIT SPECIFICATIONS

This section covers a BLDC motor drive controlled by microcontroller with the following specifications.

- Input: 12 volts to Motor Driver
- BLDC Motor AT2212 Motor
- Microcontroller: AT89C52
- Hall Sensors: 17X131
- Motor Driver: HW30A

OPERATION

The operation of the circuit can be explained in three parts.

Control circuit:

This gives out the switching signals to the converter bridge. A microcontroller is dedicated to generating the switching pulses. The microcontroller is programmed to give out pulse according to SVPWMM technique. Program is compiled in Keil software. The HEX code generated is loaded into the Microcontroller. The controller used is AT89C52. The controller is operated at 11.059 MHz frequency.

Motor driver and Gate driving circuit:

Instead of using an inverter and a regulator we have used a motor driver HW30A which acts as inverter to supply the voltage for the Motor. HW30A is an inbuilt Inverter which is having Inverter circuit as well as MOSFET Driver circuit. We are using this type of technique because of on using general inverter we are facing the difficulties like large Heat dissipation, so that this heat would cause a heat sinking problem which in turn results in the failure of the Inverter. SO, by using this motor driver the circuit complexity is reduced and the heat dissipation problem, is also reduced.

Converter circuit:

The converter circuit is provided by the Motor driver. The D.C supply is fed through a bridge rectifier. The switches in the Motor driver are turned ON and OFF as per the program. The Motor Drive is capable carrying a continuous current of 30A at 25 degree centigrade. The rectifier circuit is made of diodes. The component used is IN4007 which is capable of blocking a reverse voltage of 1000 V DC and can carry a current of 10A continuous. All these components are placed on General PCB. Control circuit and gate driving circuit components are soldered directly on the pcb, whereas the power components as connected with suitable connectors as they carry larger currents.

OPERATION

Hall Sensors senses the magnetic field means when North pole of a magnet is nearer to the sensor it gives output is high and when south pole of a magnet is nearer to the sensor it gives output is low, we connect resistor between input and output terminal as shown in figure and output is shown with the help of LED and output value is measured with the help of multimeter.

In BLDC motor, supply given to the stator depend upon the rotor position and rotor position is sensed by the hall sensor and the output of the hall sensor output is given as input to the microcontroller. We use three hall sensors and the outputs of the three hall sensors are given as input to microcontroller with the help of microcontroller we generate six waveforms for the three-phase inverter circuit in120 degrees of mode of operation (output is six stepped waveform). Depends upon the rotor position microcontroller gives two pulses only means when one pulse is going to be OFF, at the same time another pulse is ON.

The output pulses from the microcontroller are 5V and it is not sufficient to drive the MOSFET gate, so we need to place the driver circuit for increasing the magnitude and to maintain the constant value in higher magnitude because gate pulse is maintained constant for the full time. When gate pulse is removed Mosfet turns off. Instead of using inverter and MOSFET driver we are using a Motor Driver HW30A

CONCLUSION

By this paper, the working of BLDC motor which is controlled by microcontroller is shown. Simulation of the inverter is done on the MATLAB Simulink. BLDC motors possess high efficiency. In BLDC motor PM are on the rotor & electromagnets are on the stator controlled by software

REFERENCES

[1] S.X. Chen, M.A. Jabbar, O.D. Zhang and Z.J. Lie. 1996. New Challenge: Electromagnetic design of BLDC motors for high-speed fluid film bearing spindles used in hard disk drives. IEEE Trans. Magnetics. l32(5): 3854-3856, Sep.

[2] M. George and A. R. Paul, "Brushless DC motor control using digital PWM techniques," in Proc. International Conference on Signal Processing, Communication, Computing and Networking Technologies, 2011.

[3] J.D. Ede, Z.Q. Zhu and D. Howe. 2001. Optimal split ratio control for high-speed permanent magnet brushless DC motors. In: Proceeding of 5thInternetaional Conference on Electrical Machines and Sytems. 2: 909912.

[4] M. Nasrul, A. Satar, and D. Ishak, "Application of proteus VSM in modelling brushless DC motor drives," in Proc. 4th International Conference on Mechatronics, IEEE, Kuala Lumpur, Malaysia, May17-19, 2011.

[5] B.K. Bose. Modern Power Electrics and AC Drives. Prentice-Hall, Inc., 2002.
[6] P.Pillay and R.Krishnan, "Modeling, Simulation and Analysis of a Permanent Magnet Brushless DC motor drive part II: The brushless DC motor drive," IEEE Transactions on Industry application, Vol.25, May/Apr 1989.
[7] V.H.Prasad D. Boroyevich and R. Zhang, "Analysis and Comparison of Space Vector Modulation Schemes for Three-Leg and Four Leg Voltage Source Inverters," IEEE Applied Power Electronics Conference and Exposition, Vol. 2, pp. 864871, February1997.
[8] F. Rodriguez and A. Emadi, "A novel digital control technique for brushless DC motor drives: Steady state and dynamics," in Proc. IEEE Ind. Electron. Conf., Nov 2006, pp. 1545–1550.
[9] P. Yedamale, Brushless DC (BLDC) Motor Fundamentals, AN885 Microchip Technology Inc., 2003.
[10] T. Kennjo and S. Nagamori, Permanent Magnet Brushless DC Motors, Oxford, U.K. Clarendon, 1985.
[11] M. George and A. R. Paul, "Brushless DC motor control using digital PWM techniques," in Proc. International Conference on Signal Processing, Communication, Computing and Networking Technologies, 2011.
[12] F. Rodriguez and A. Emadi, "A novel digital control technique for brushless DC motor drives: Steady state and dynamics," in Proc. IEEE Ind. Electron. Conf., Nov 2006, pp. 1545–1550.