International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Review on RPM Display for BLDC Motor with Speed Control

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Abstract:- *The low cost of manufacturing having higher performance is main goal of upcoming and present applications. However, its possible to achive these aims using brushless DC motors (BLDC), due to its use in many applications. The applications such as sppining, drilling, elevators, lathes, etc can be exicuted using BLDC motor and can replace conventional DC brush motor. The effective vechiel control required for applications of variable speed can be achived using BLDC motors. This paper presents speed control of BLDC motor for open loop using PID and neural network techniques and their comparative study. From the simulation study it is observed that neural network gives better performance compaiered to other technique.*

Keywords: *Artificial Neural Network, PID, Open Loop, Control of Speed etc.*

I. INTRODUCTION

In electromechanical energy conversion, the electric machine acts as an energy conversion bridge between the mechanical and electrical systems as represented in Fig. 1.1. Electrical machine can work as an either generator or a motor. For any electrical motor, the voltage and the current behave as representative of the incoming electrical energy and the output is the mechanical energy transferred to a mechanical load, which is portrayed by the speed and the torque.

A simple and clear block diagram of an electric unit shown in Fig. It consists mainly of power supply, converter, machine (motor), detection module and control module. Energy can be provided from either an AC power source or a DC source battery. The engine has the desired characteristics demanded by the load and with its ability to share energy from the source to the load. The most frequently used electric machines are DC motors, BLDC motors, stepper motors and switched reluctance motors

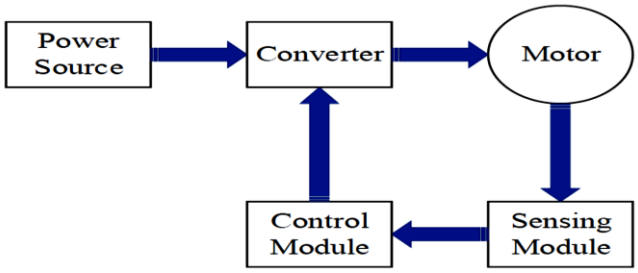


Fig. 1.2Block Diagram of an Electrical Drive

The converters are used to convert the electrical energy from the input source into desirable form for the machine. Relying on the energy demanded by the input power supply and the motors, by the AC to DC converters, by the DC to DC converters (upper or lower converters), the inverters and the cycle converters are commonly used in the design of electric drives. The detection module is assigned to sense the rotor position, speed and motor terminal voltages. It is necessary for the requested manipulated closed-loop operation. The control module is the central component of the entire drive unit. In last one decade, due to the rapid development in the area of power electronics and

semiconductor tools, the adaptable speed unit, like the BLDC motor units, has been well progressed and extensively used for various applications. The utilization of the BLDC motor BLDCM for low-power devices is on the rise due to its elevated efficiency, broad speed range and very little maintenance. Switching to a Permanent Magnet BLDC Motor (brushless DC motor with permanent magnets) is performed by solid-state switches of a three-phase supply voltage inverter (VSI).

II. LITERATURE REVIEW

- **Rizal et al. (2007) :-** It proposed consolidating novel model reference versatile control (MRAC) and neural system (NN) to accomplish high following accuracy for servo frameworks. Broke down impact of non-direct and dubious factors on the execution of the plant. The neural system is utilized to repay the impacts brought about by non-linearity and vulnerability in this manner the blunder between the speed circle and the reference model can be decreased. To clarify adequacy of the proposed control conspire, tests were conveyed in a 3-hub pilot test program. Tests results show that the proposed control plan can decrease the plant's affectability to parameter variety and unsettling influence and improve the following execution successfully.
- **P. Singh and A.K. Pandey et al. (2013) :-** He introduced neural system based model reference versatile control approach (MRAC) for ship directing frameworks. For the nonlinearities of ship directing framework, exhibitions of conventional versatile control calculations are not acceptable. The introduced MRAC framework uses RBF neural system to rough the obscure nonlinearities so as to get a high versatile control execution. Creator likewise talked about solidness of the framework with Lyapunov steadiness hypothesis. Reenactment additionally demonstrates the adequacy and superior of the proposed calculation.
- **G. Prasad and N. S. Ramya et al. (2012) :-** presented neural system control are contrasted and the relating fluffy PI controller and ordinary PI controller. Neural system improves speed reaction and furthermore decreases torque swells. By utilizing this controller, its yield dependent on a lot of guidelines to keep up fantastic control execution even within the sight of parameter variety and drive non-linearity. This basic plan has altogether improved the execution of the BLDC framework while in the meantime keeping up the basic control structure of the BLDC.
- **T. Fu and X. Wang et al. (2016) :-** discussed about drive of dc brushless engine framework for two different speed controllers in particular controller based on technique firefly and PI, utilizing resounding post inverter. He utilizes fluffy rationale based delicate exchanging full shaft inverter utilizing transformer, which can create dc connect voltage scores amid hacking. Consequently all switches work in zero voltage exchanging condition
- S. Sivakotiah and J. Rekha **et al. (2011) :-**] introduced dynamic conduct framework of drive for two controllers exhibited and analyzed for operation of speed. In this fluffy rationale provides better control action and powerful reaction for framework. The back emf stator current, torque and speed waveform was contemplated related with PI control of BLDC drive engine.

III. PROPOSED SYSTEM AND BLOCK DIAGRAM

The proposed block diagram is shown in figure 1. The blocks of which and control strategies is explained in this section.

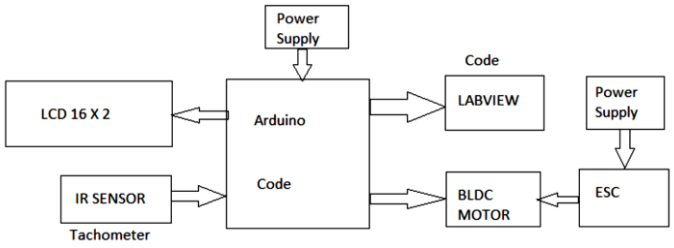


Fig. 3.1 Block Diagram

3.1 BLDC and ESC: Brushless DC electric motor (BLDC motors also known as electronically commutated motors are synchronous motors powered by DC electricity via an inverter/ switching power supply which produces an AC/ bi-directional electric current to drive each phase of the motor via a closed loop controller. The motor structural elements of a brush less motor system is typically permanent magnet synchronous motor, but can also be a switched reluctance motor, or induction motor. Regard less of the type used, an ESC interprets control information not as mechanical motion as would be the case of a servo, but rather in a way that varies the switching rate of a network of field effect transistors. ESC systems for brushed motors are very different by design; as a result brushed ESC's are not compatible with brushless motors. Brushless ESC systems basically create a tri-phase AC power output of limited voltage from an onboard DC power input, to run brushless motors by sending a sequence of AC signals generated from the ESC's circuitry, employing very low impedance for rotation.

3.2 Controlling Technique:- 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. The principle of generating PWM Counter is used to generate triangular wave. If the value of compare register is less than the value of triangular wave, then PWM is 1, else PWM is 0. The supply voltage is chopped at a fixed frequency with a duty cycle depending on the current error. Therefore, both the current and the rate of change of current can be controlled. The two phase supply duration is limited by the two phase commutation angles. 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.

Fig. 3.2 Typical Project Circuit

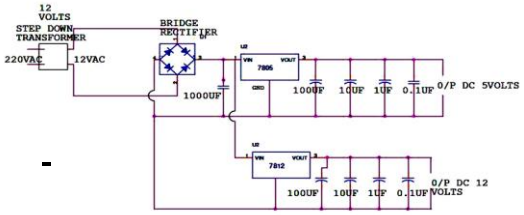
In the hard chopping technique, both phase transistors are driven by the same pulsed signal: the two transistors are switched-on and switched-off at the same time. The soft chopping approach allows not only a control of the current and of the rate of change of the current but a minimization of the current 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. An electronic Brushless DC Controller (also known as a Driver, or Electronic Speed Controller), replaces the mechanical commutation system utilized by a Brush DC Motor, and is required by most Brushless DC Motors to operate. In a Brushless DC Motor controller, either a IR Sensor or Back EMF (Electromotive Force) is used to identify the position of the rotor. Understanding the orientation of the rotor is crucial to operating the Brushless DC Motor. The Controlling Effect uses IR Sensor within the Brushless DC Motor to help detect the position of the rotor. This method is primarily used in speed detection, positioning, current sensing, and proximity switching.

3.3 ARDUINO Uno board type:- Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++.

IV. HARDWARE IMPLEMENTATION

4.1 Power Supply: Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others This power supply section is required to convert AC signal to DC signal and also to reduce the amplitude of the signal. The available voltage signal from the mains is 230V/50Hz which is an AC voltage, but the required is DC voltage(no frequency) with the amplitude of +5V and +12V for various applications.In this section we have Transformer, Bridge rectifier, are connected serially and voltage regulators for +5V and +12V (7805 and 7812) via a capacitor (1000µF) in parallel are connected parallel as shown in the circuit diagram below. Each voltage regulator output is again is connected to the capacitors of values (100µF, 10µF, 1 µF, 0.1 µF) are connected parallel through which the corresponding output(+5V or +12V) are taken into consideration.



4.2 Transformer:- A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled electrical conductors. A changing current in the first circuit (the primary) creates a changing magnetic field; in turn, this magnetic field induces a changing voltage in the second circuit (the secondary). The transformer is based on two principles: firstly, that an electric current can produce a magnetic field (electromagnetism) and secondly that a changing magnetic field within a coil of wire induces a voltage

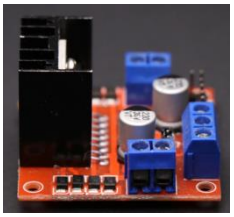
across the ends of the coil (electromagnetic induction). By changing the current in the primary coil, it changes the strength of its magnetic field; since the changing magnetic field extends into the secondary coil, a voltage is induced across the secondary.

4.3 Bridge Rectifier:- A diode bridge or bridge rectifier is an arrangement of four diodes in a bridge configuration that provides the same polarity of output voltage for any polarity of input voltage. When used in its most common application, for conversion of alternating current (AC) input into direct current (DC) output, it is known as a bridge rectifier. A bridge rectifier provides full-wave rectification from a two-wire AC input, resulting in lower cost and weight as compared to a center-tapped transformer design, but has two diode drops rather than one, thus exhibiting reduced efficiency over a center-tapped design for the same output voltage. When the input connected at the left corner of the diamond is positive with respect to the one connected at the right hand corner, current flows to the right along the upper colored path to the output, and returns to the input supply via the lower one.

4.4 Diode:- A diode is a dispositive made of a semiconductor material, which has two terminals or electrodes (di-ode), that act like an on-off switch. When the diode is “on”, it acts as a short circuit and passes all current. When it is “off”, it behaves like an open circuit and passes no current. The two terminals are different and are marked as plus and minus in figure 1. If the polarity of the applied voltage matches that of the diode (forward bias), then the diode turns “on”. When the applied voltage polarity is opposite (reverse bias), it turns “off”. Of course this is the theoretical behavior of an ideal diode, but it can be seen as a good approximation for a real diode.

4.5 Voltage Regulators:- Voltage Regulators with Working Principle In the power supply, voltage regulators play a key role. So before going to discuss a voltage regulator, we have to know that what is the role of a power supply while designing a system?. For instance, in any working system like a smart phone, wristwatch, computer, or laptop, the power supply is an essential part to work the owl system, because it provides consistent, reliable, and continuous supply to the inside components of the system. In electronic devices, the power supply provides a stable as well as regulated power to work the circuits properly. The sources of power supply are two types like the AC power supply that gets from the mains outlets and the DC power supply that gets from the batteries. So, this article discusses an overview of different types of voltage regulators and their working.

4.6 Motor Drive Circuit:- Motor drive means a system that includes a motor. An adjustable speed motor drive means a system that includes a motor that has multiple operating speeds. A variable speed motor drive is a system that includes a motor and is continuously variable in speed. If the motor is generating electrical energy rather than using it – this could be called a generator drive but is often still referred to as a motor drive.



A variable frequency drive (VFD) or variable speed drive (VSD) describes the electronic portion of the system that controls the speed of the motor. More generally, the term drive, describes equipment used to control the speed of machinery. Many industrial processes such as assembly lines must operate at different speeds for different products. Where process conditions demand adjustment of flow from a pump or fan, varying the speed of the drive may save energy compared with other techniques for flow control.

4.7 Speed Sensor:-A speed sensor is a type of position sensor which is used to measure rotational speed. They are present in various types of commercial and motorsport vehicles. Like many devices, a speed sensor is an integral part of onboard systems. They work by providing a voltage measurement corresponding to the magnetic rotational speed. They can be found in applications where contact-free speed measurement is required in areas that can be hard to access. Different speed sensors use different types of technology, the sensors that we can offer use magnetic or hall effect position sensing technology. A Hall Effect sensor uses a magnetic field-dependent semiconductor. The *Hall Effect* is caused by the Lorentz force, this acts on the moving charge carriers within the magnetic field. When an electric current is flowing through any material, the electrons within that current will naturally move in a straight line. The electricity creates its magnetic field as it becomes electrically charged – known as a semiconductor. If the semiconductor material is then placed between the two poles of a magnet, instead of moving in a straight line as before, the electrons will be pushed to one side and into a curved line, forming a curved path as they move through the material. This is caused by their magnetic field reacting to the different fields of the magnet. As a result of the now curved movement, there are more electrons present on one side of the semiconductor material. Because of this, a potential difference appears across the semiconductor material at right angles to the magnetic field, from both the magnet and the flow of the electric current.

4.8 Brushed DC Motor:- The simplest type of motor is the brushed DC motor. In this type of motor, electrical current is passed through coils that are arranged within a fixed magnetic field. The current generates magnetic fields in the coils; this causes the coil assembly to rotate, as each coil is pushed away from the like pole and pulled toward the unlike pole of the fixed field. To maintain rotation, it is necessary to continually reverse the current—so that coil polarities will continually flip, causing the coils to continue “chasing” the unlike fixed poles. Power to the coils is supplied through fixed conductive brushes that make contact with a rotating commentator; it is the rotation of the commentator that causes the reversal of the current through the coils. The commentator and brushes are the key components distinguishing the brushed DC motor from other motor types. Figure 1 illustrates the general principle of the brushed motor.

4.9 LCD (Liquid Cristal Display):- A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. Each pixel consists of a column of liquid crystal molecules suspended between two transparent electrodes, and two polarizing filters, the axes of polarity of which are perpendicular to each other. Without the liquid crystals between them, light passing through one would be blocked by the other. The liquid crystal twists the polarization of light entering one filter to allow it to pass through the other.

A program must interact with the outside world using input and output devices that communicate directly with a human being. One of the most common devices attached to an controller is an LCD display. Some of the most common LCDs connected to the controllers are 16X1, 16x2 and 20x2 displays. This means 16 characters per line by 1 line 16 characters per line by 2 lines and 20 characters per line by 2 lines, respectively. A program must interact with the outside world using input and output devices that communicate directly with a human being. One of the most common devices attached to an controller is an LCD display

V. CONSTRUCTION & WORKING

BLDC (Brushless DC) motor speed control with rpm display system is a system, that offers the BLDC motor to run at different speeds and display this speed on LCD display. The importance of BLDC motor is increasing day by day because it has been mostly used in industries for different applications such as spinning, drilling and elevators. Similarly, its speed control is also too much important. Different companies are making their motor drive circuits with different types of controllers such as VFD (very frequency drive) but their cost is so much high and its operating system is quite difficult. Here we are offering a system that is called a BLDC motor speed control with RPM display system with the help of PIC microcontroller 18F452, LCD display, transformer, voltage regulator, opto-coupler and IR sensors. In this system, the speed of BLDC motor is controlled by changing the duty ratio of supplying voltages. This system is less costly, quite simple and control the speed of BLDC motor more precisely with displaying of on LCD display.

6.1 Block Diagram

Here is the Block diagram of BLDC motor speed control with rpm display system with all essential components

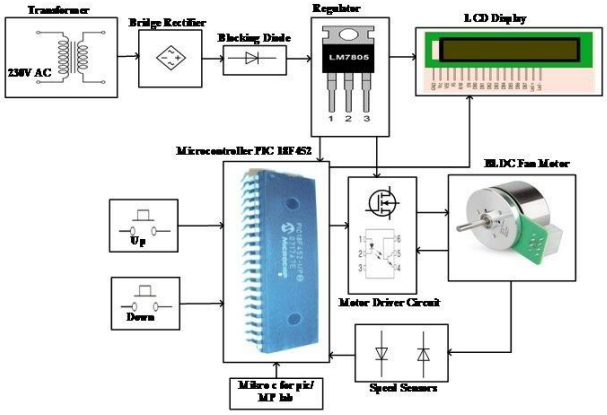


Fig. 6.1 Block Diagram

6.2 Working Principle:- This BLDC motor speed control with rpm display system works on the principle of switching dc supply. The switching dc supply is gained by changing the duty ratio of supplying voltages. In this system, motor drive circuit is triggered at different duty ratio and when it is triggered at different duty ratio then motor runs at different speeds. Here for demonstration purposes a fan speed is controlled through microcontroller. When up switch is pressed then microcontroller set the duty ratio from 10% to 80% and then this duty ratio voltages are given to motor drive circuit, which set the speed of motor from 0 to 100%. Similarly, for decreasing the speed of motor down switch is pressed again and again until the desired speed is acquired. For displaying the rpm of this motor at LCD display ir sensors have been used here which are interfaced with microcontroller. Microcontroller counts each revolution of motor after receiving the speed signal from ir sensors then displays this speed at LCD display

in form of percentage like 10%,20%80% or 100%. So, we can drive the BLDC motor at out desired speed.

6.3 Applications and Advantages:-This BLDC motor speed control with rpm display system could be used in spinning mills where spinning motors could be derived through this system.

- This BLDC motor speed control with rpm display system could be with elevators and drilling machine for controlling their speed.
- This system is more compact, more efficient and less costly as compared to other motor drive systems.
- This system changes the speed of motor more precisely as compared to other systems.
- This system is very easy to drive.

VI. CONCLUSIONS

In this thesis the modeling and simulation of the entire BLDC motor drive system is mentioned. Using the speed control software package, the inverter system based on Space Vector speed control was implemented which drives the BLDC motor (with the prediction of the power factor correction). Furthermore, the speed control technique used the intermediate circuit voltage more efficiently than the other speed control techniques. The BLDC motor speed control with the 120° switch in inverter mode and the use of the speed control inverter has been implemented in the PSIM software. With the speed control based inverter technique we get better control of the voltage and current supplied to the motor.

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