International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Automatic Closed Loop Speed Control of DC Motor

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Abstract: ***The electric drive systems used in industrial applications are increasingly required to meet higher performance and reliability requirements. Purpose of motor speed controller is to take a signal representing the required speed and to drive a motor at that speed. In this paper we have suggested an Embedded based system, consisting of a DC Motor, an infrared sensor and a microcontroller. Here we have used pulse width modulation (PWM) or duty-cycle variation method, which are commonly used in speed control of DC motors. The PWM makes possible the use of microcontroller to drive the motor, which gives enormous versatility. This paper provides a platform for further advancement in the field of industrial use of DC motors. DC motors have speed control capabilities which means that speed, torque and even direction of rotation can be changed at any time to meet a new condition.***

Keywords: DC Motor, MOSFET, Microcontroller, IR Sensor.

1. Introduction

As we know that, a DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. Controlled power is a basic & wide requirement in industries. Most of the method of controlling power are based on controlling firing angles of SCRs using different techniques like RC time constant triggering, UJT relaxation oscillation triggering etc.

In this work, development of hardware and software of the closed loop DC motor speed control system have been explained and illustrated. The desired objective is to achieve a system with the constant speed at variable load condition. That means motor will run at a fixed speed instead of varying with amount of a load. Our object is to satisfy the 0% to 100% duty cycle using microcontroller.

Various requirements are actually leading to a growing demand for high speed permanent magnet motors and generators. First of all, the continuous need for an increased power density. Permanent magnet motor elements contribute partly to the ongoing development of green energy applications. A motor controller converts DC to AC. This design is mechanically simpler than that of brushed motors because it eliminates the complication of transferring power from outside the motor to the spinning rotor. We also can use an Inverter for controlling a continuous switching of voltage or current, which are working on base of the pulse wide modulation method. But the inverter leads also to a few drawbacks especially because of fast switching transients which can be understood as a significant source of stray losses. Advantages of Permanent Magnet DC motor (PMDC) are:

- No need of field excitation arrangement.
- No input power in consumed for excitation which Improve efficiency of dc motor.
- No field coil hence space for field coil is saved which reduces the overall size of the motor.
- Cheaper and economical for fractional kw rated applications.

Direct current (DC) motors have variable characteristics and are used extensively in variable-speed drives. DC motor can provide a high starting torque and it is also possible to obtain speed control over wide range. Conventionally DC motors are highly efficient and their characteristics make them suitable for use of servomotors. However their only drawback is that they need a commutator and brushes which are subjected to wear and required maintenance.

There is a method of controlling speed of a DC motor using Field Programmable Gate Array. FPGA controller is used to generate the firing pulses required for full wave phase control rectifier. Pulses are synchronized with AC input the delay of pulses determines the firing angle of driver circuit and hence the speed of rotation. There are also some different methods which are used to control the speed of a DC motor. The Kalman filter is used to estimate the instantaneous speed and position with low precision. Disturbance suppresser is used in robust position control scheme for DC motors. In Wrap digital position control around analog servos, the Microcontroller is used to control speed and to send the motion commands to the analog motor controllers. The Neural networks and Fuzzy logic control systems are also used to control the position of DC motors.

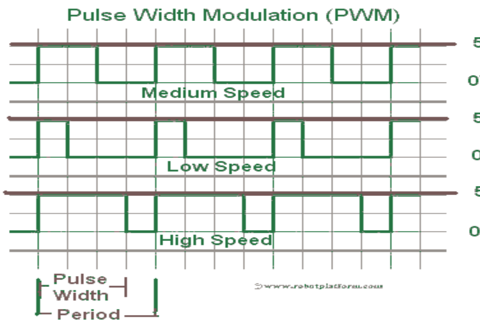

Figure 1: Pulse Width Modulation

2. Pulse Width Modulation (PWM)

PWM switching control methods improve speed control and reduce the power losses in the system, which increases the mean time between charge cycles of the battery. The reduced losses also help reduce the weight of the system as smaller thermal management components are needed. These two factors are portable equipment. PWM save Energy. It also regulates the voltage signal between fully on and fully off, controlling the speed of a fan. The main advantage is that power loss in the switching device is very low. When a switch is off, there is practically no current, and when it is on, there is almost no voltage drop across the switch. Therefore, power loss is close to zero.

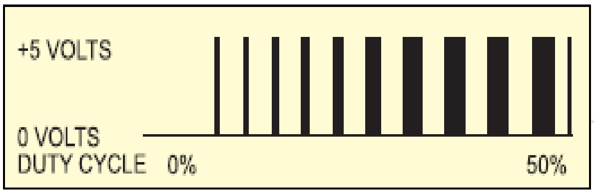

Figure 2: Pluses with 0% through 50% duty cycle

Pulse-width modulation (PWM) or duty-cycle variation methods are commonly used in speed control of DC motors. The duty cycle is defined as the percentage of digital 'high' to digital 'low' plus digital 'high' pulse-width during a PWM period. Fig. 1 shows the 5V pulses with 0% through 50% duty cycle.

We can definitely control Speed of a motor with a Potentiometer, but this wastes power and energy in the form of heat across the resistor, as having a resistor in series does have a voltage drop, hence heat loss. Furthermore, a resistor wastes excess power as heat. There is another reason why a resistor is not a good choice for controlling the power delivered to a large load. As the power requirements increase, it will quickly exceed the power rating on a resistor or potentiometer. The electronic component will get very hot and then will likely fail permanently. Having a PWM, means you do not have a resistor in series, meaning no waste in the form of heat. We just shuttle the Motor between ON & OFF, and the average gives us the voltage. So, there is no waste of power.

3. Control Strategy

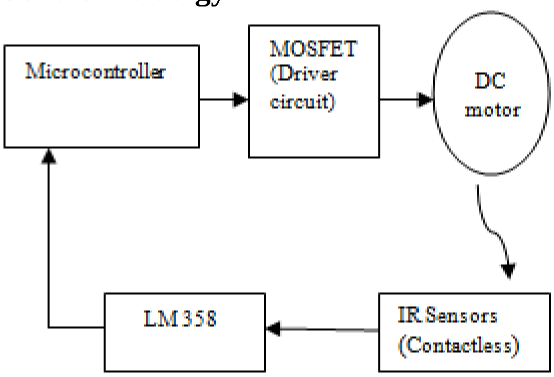

Figure 3: Blocks for Control Strategy

Here we have design a system through which we can control the speed of a DC motor for that we have used feedback system. A microcontroller AT-mega 128 is used for programming. Firstly we give manually input to microcontroller then it will generate voltage regarding to that. Here we are using PWM. According to the input voltage, microcontroller will generate a specific PWM signal. This signal is fed to a MOSFET, which will drive a DC motor at a particular speed. When we applied some load, the speed of motor will vary according to the weight. But this is not we want, our system is design to rotate a motor at a fixed speed. So for controlling the speed of motor we have measure it and compared with the actual value. Due to the quasi linear relation between rotational speed and shaft power of an electrical machine, increasing the rated speed is an effective way to boost power density and efficiency.

When designing a PWM unit using the microcontroller two factors should be consider "PWM duty cycle" and "PWM frequency". PWM block has two inputs, one is "Duty Cycle" which is the output of the speed control algorithm and other is the "Frequency", which is entered through keypad by user. PWM directly affects the DC motor stability and sensibility to changes its input voltage. However the frequency can be changed manually within upper and lower limits to the system flexible and able to operate motors with different ratings and speeds.

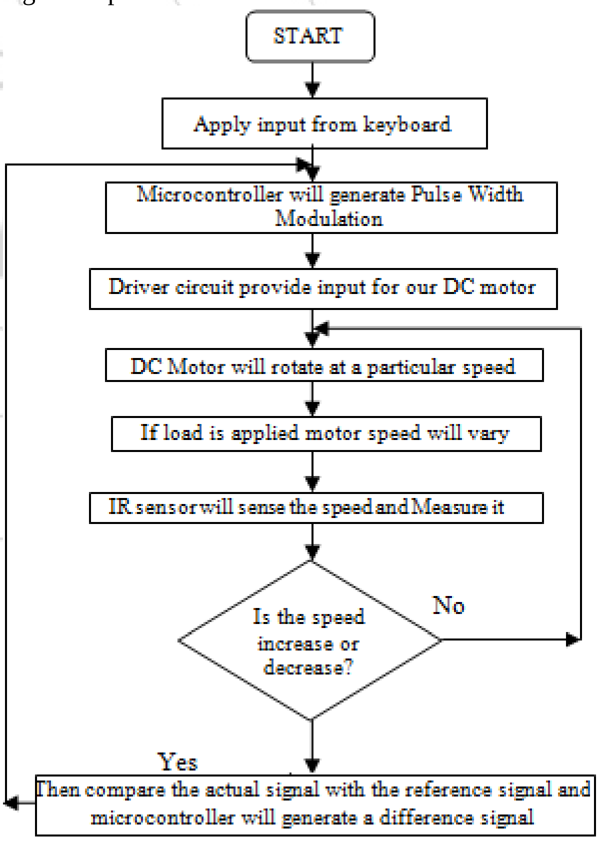

Figure 4: Flowchart

The project can be divided in two elements which are hardware and software. Software includes a routine to read the motor current and send emergency shutdown signal to protect a DC motor from over current, also this signal can be activate manually by inserting a designated character by the keypad, which causes a software interrupt and executes the emergency shutdown routine. Changing the terminal voltage of DC motor is controlled by the microcontroller generated PWM signal. For measuring the speed of a DC motors we have used Infrared sensor. From the speed sensor and speed reference (from key board) the microcontroller calculates the error and performs the calculation of control algorithm output and then it calculate the pulse width modulation signal.

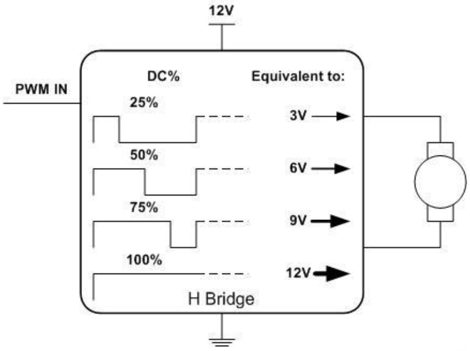

Figure 5: Voltages regarding duty cycle

The motor can be stopped manually by keeping a designated character at any time. Furthermore, an LCD display was fabricated to display the output; this kind of setup provides a complete user interface unit. Hence the system is complete stand-alone and user friendly. In case of sudden load drops, the speed of the motor will be very high. As a result, output voltage will be also very high. Therefore, controller unit will sense output voltage and will compare with the desired level of voltage. In case of excessive load, output voltage does not matches the desired level then microcontroller will send a message "OVERLOAD" using the LCD, so that the user can understand the condition and hence reduce the load of the motor.

4. Result and Discussion

The hardware system has been developed and tested under laboratory conditions. The microcontroller based closed loop control was implemented and applied on a DC motor. The voltage supplied to the motor is proportional to the PWM duty cycle generated and fed into MOSFET which is used as a drive circuit for DC motor. A pulse with fixed frequency is generated by the microcontroller, which is fed to the base of transistor. Transistor acts as a switch. The output voltage of the motor is dependent on the amount of the on time of the transistor. The more time transistor remain on more the voltage will produce. The system will adjust the duty cycle automatically according to the value inputted through the keypad.

5. Conclusion

The Microcontroller based adjustable closed loop DC motor speed controller system has been obtained for the purpose control system with a DC motor as a load. This system is applicable to different size of motors and capable of controlling the speed of motors with very high precision. Experimental results have been obtained for the proposed control system with a DC motor as a load. The advantage of high speed permanent magnet motors and generators can only be achieved by using high quality motor elements.

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