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PWM BASED ON DC MOTOR CLOSED LOOP SPEED CONTROLLER IN VEHICLE'S

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ABSTRACT

In industrial applications, electric drive systems are expected to meet increasingly higher performance and reliability standards. A crucial aspect of this is motor speed control, where the objective is to take a signal representing the desired speed and adjust the motor accordingly. This paper presents an embedded system-based solution for DC motor speed control, incorporating a DC motor, an infrared (IR) sensor, and a microcontroller. The system employs Pulse Width Modulation (PWM), a widely-used method for controlling DC motor speed by varying the duty cycle. PWM enables the microcontroller to drive the motor with great flexibility and precision. The proposed system offers a foundation for further advancements in DC motor applications, especially in industrial settings. By leveraging the inherent speed control capabilities of DC motors, this system allows for real-time adjustment of speed, torque, and even rotational direction to suit operational requirements. The embedded design not only enhances efficiency but also offers scalability for various industrial uses, ensuring optimal motor performance under varying load conditions.

Keywords: DC Motor, PWM, MOSFET, Microcontroller, IR Sensor, Speed Control, Industrial Automation

I.INTRODUCTION

The DC motor, a well-known electrical machine, is widely used in industrial and commercial applications due to its ability to convert direct current into mechanical power. DC motors are favored for their speed control capabilities, making them suitable for applications that require precise control over torque, speed, and direction. Small DC motors find use in household

appliances, tools, and toys, while larger DC motors power systems like elevators, hoists, and electric vehicles. These versatile motors are also integral to driving machinery in industries like steel rolling mills.

Given the demand for efficient, high-speed performance in various applications, the development of advanced motor speed control systems is crucial. Traditional methods, such as firing angle control of silicon-controlled rectifiers (SCRs) or variable resistors, lead to inefficiencies and power losses. In this context, a closed-loop motor speed control system, combining hardware and software, offers a modern, optimized solution.

This paper presents the development of a microcontroller-based system that maintains constant motor speed under variable load conditions using PWM. By adjusting the duty cycle, the system ensures that the motor operates at a fixed speed, irrespective of load changes, achieving high precision and efficiency. This system aligns with industrial demands for reliable, scalable, and efficient motor control solutions.

1. 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.

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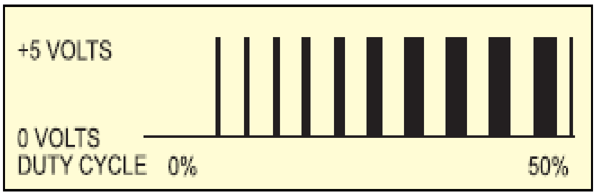

Figure 1: Pluses with 0% through 50% duty cycle

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.

2. Control Strategy

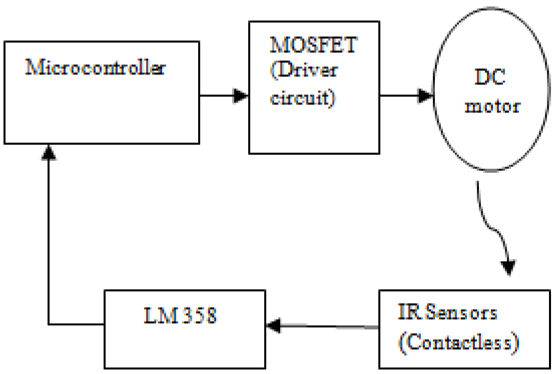

Figure 2: Blocks for Control Strategy

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.

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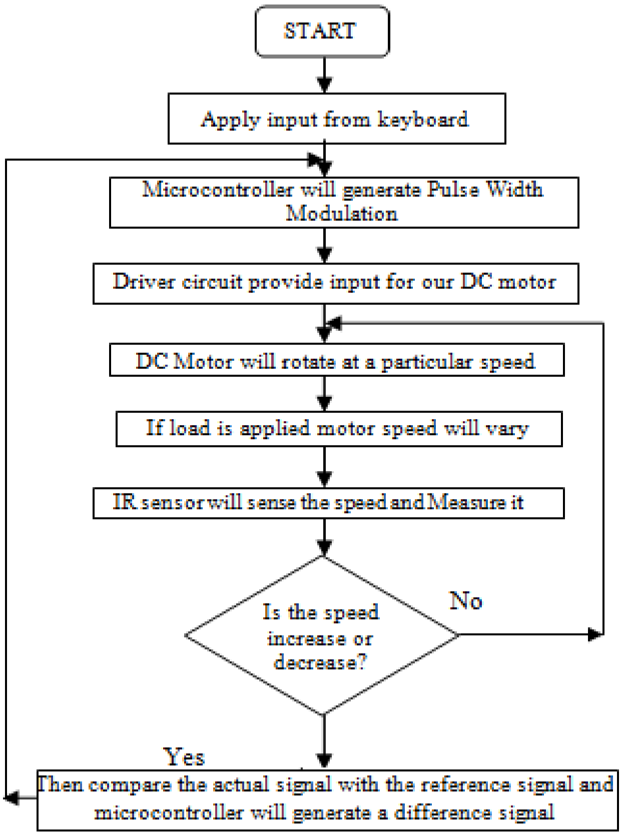

Figure 3: Flowchart

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.

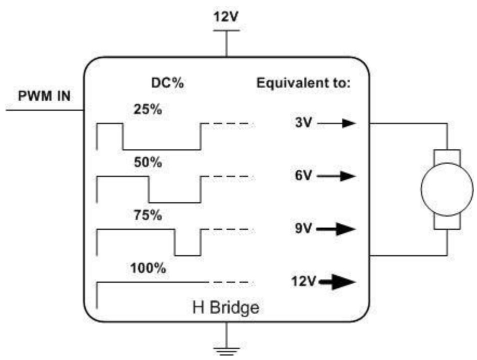

Figure 4: Voltages regarding duty cycle

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.

III.PROBLEM STATEMENT

Efficient motor speed control is essential for many industrial applications, where precision, reliability, and energy efficiency are paramount. Traditional speed control methods often involve power losses, inefficiency, and manual intervention, making them impractical for modern, large-scale industrial uses. Additionally, the unpredictable nature of load variations can lead to fluctuating motor speeds, which may compromise system performance. These issues highlight the need for a more advanced, automated, and energy-efficient solution to control DC motor speed.

The challenge lies in developing a closed-loop control system that ensures the motor maintains a constant speed regardless of load conditions. This must be achieved while minimizing power loss, improving efficiency, and providing flexibility in controlling different motor parameters such as speed, torque, and direction. Therefore, the objective of this project is to create an embedded system that leverages PWM to control motor speed, providing a more accurate and energy-efficient solution than traditional methods.

IV.CONCLUSION

The microcontroller-based adjustable closed-loop DC motor speed control system developed in this project offers a highly efficient and scalable solution for various industrial applications. By utilizing PWM to control motor speed, the system ensures minimal power loss, high precision, and the ability to maintain constant speed under varying load conditions. The integration of an IR sensor for real-time feedback and the use of a MOSFET as a driving circuit further enhance the system's performance. The project demonstrates the effectiveness of embedding modern microcontroller technology in industrial motor control, setting the stage for future advancements in high-speed, high-performance DC motor applications.

The proposed system's flexibility, scalability, and energy efficiency make it a valuable tool in industrial automation, where motor speed control is critical. Additionally, the system's design can be adapted for motors of various sizes and specifications, offering broad applicability. Through this project, we have provided a robust, user-friendly, and cost-effective solution that addresses the modern demands of precision motor control.

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