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SPEED CONTROL OF DC MOTOR USING CAPTURE PULSE WIDTH MODULATION MODULE OF PIC MICROCONTROLLER

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ABSTRACT- DC motors are widely used in industrial and domestic applications due to their simple construction, high efficiency, and easy speed control. Speed control of DC motors is an important requirement in automation, robotics, conveyor systems, and electric vehicles. Conventional speed control techniques such as rheostat control or armature voltage variation lead to high power losses and reduced efficiency. Pulse Width Modulation (PWM) provides an efficient and economical method for controlling motor speed by varying the duty cycle of the applied voltage. In this research paper, a microcontroller-based PWM speed control system is proposed. The microcontroller generates PWM pulses which are applied to a motor driver circuit to regulate motor speed smoothly. The proposed system offers high efficiency, reduced power loss, and precise control suitable for industrial automation.

Keywords: DC Motor, PWM, Microcontroller, Speed Control, Motor Driver, Automation.

I. INTRODUCTION

A crucial component of contemporary electrical and electronic systems is DC motor speed regulation. The ability to vary the motor speed according to load and operating conditions is required in many industrial processes. Accurate speed regulation guarantees seamless operation and boosts total productivity in applications like automated manufacturing units, robotic arms, electric traction, and conveyor belt systems.. Since DC motors provide high starting torque and easy speed adjustment, they are preferred in variable speed drive applications. Traditional techniques for controlling DC motor speed include armature resistance control, field control, and variable voltage methods. Despite their simplicity, these techniques are ineffective since they

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produce energy losses and temperature issues due to power dissipation in resistive components. This limits the drive system's usefulness for energy-saving applications and lowers its efficiency. Therefore, industries demand efficient and reliable control techniques that provide better performance with minimum power wastage. Pulse Width Modulation (PWM) is one of the most widely used techniques for DC motor speed control. In PWM, the motor supply is switched ON and OFF at a high frequency, and the average voltage applied to the motor is controlled by changing the duty cycle of the pulses. This method provides smooth speed control and significantly reduces power loss compared to conventional methods. PWM control also improves torque characteristics and ensures stable motor operation even under varying load conditions.Microcontroller-based implementation of PWM control offers additional advantages such as programmability, flexibility, compact design, and automation. Modern microcontrollers such as PIC, AVR, and Arduino controllers have built-in PWM modules that can generate accurate switching pulses. By using a microcontroller, the motor speed can be controlled digitally, making the system more reliable and cost-effective. Moreover, microcontroller-based systems can easily integrate sensors and feedback mechanisms to develop closed-loop control for improved accuracy. This research work focuses on the design and development of a PWM-based DC motor speed control system using a microcontroller. The proposed system aims to provide efficient, smooth, and precise speed regulation with reduced energy losses. Such systems are highly suitable for industrial automation, robotics, and electric vehicle applications where performance and efficiency are critical requirements.

II. IMPORTANT OF SPEED CONTROL METHOD FOR DC MOTOR

In contemporary industrial and residential applications, DC motor speed management is crucial because various processes call for the motor to run at varying speeds under shifting load conditions. Accurate speed regulation is crucial for attaining the required performance and efficiency in systems like electric cars, robots, conveyor belts, pumps, fans, and machine tools. Without proper speed control, the motor may run at undesired speeds, leading to poor operation, reduced productivity, and mechanical stress on the equipment. Moreover, efficient speed control methods help in reducing energy consumption and minimizing power losses. Conventional techniques such as resistance- based speed control waste a significant amount of electrical energy in the form of heat, resulting in low efficiency. Modern techniques like PWM-based speed control provide smooth and efficient operation by controlling the average voltage applied to the motor. Additionally, safe starting, regulated acceleration, overheating protection, and a longer motor lifespan are all guaranteed by speed control. For DC motor-driven systems to operate precisely, dependably, and efficiently in automation and industrial applications, speed control .

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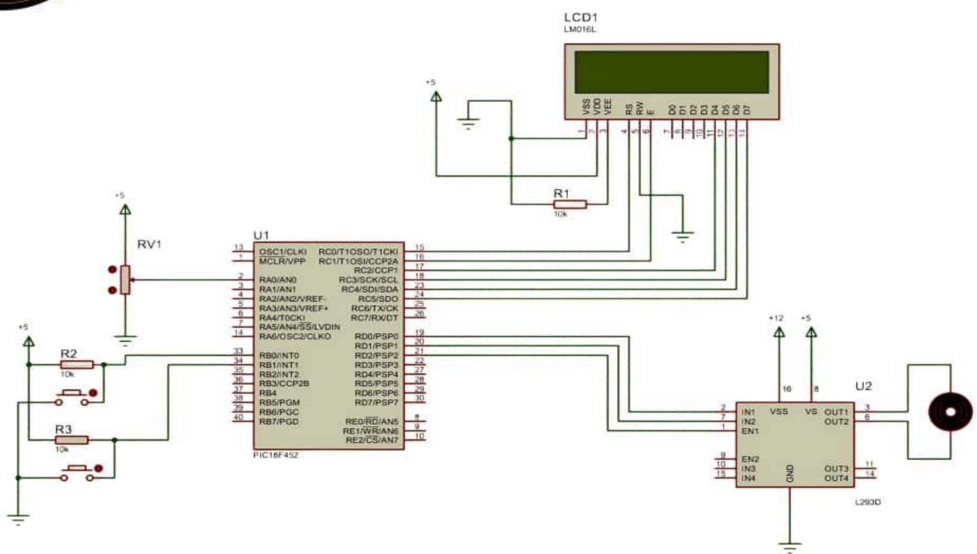

Fig.1- Speed control method for dc motor

2.1 Need for speed control method

Because various processes require the motor to run at multiple speeds under changing load conditions, speed control of a DC motor is necessary in many industrial and residential applications. Conveyor belts, robotic arms, electric cars, pumps, fans, and machine tools are examples of real-world systems where the motor speed needs to be changed based on the necessary output and operating circumstances. Without proper speed control, the motor may run at an undesired speed, resulting in poor performance, reduced efficiency, and mechanical stress on the system.The need for speed control also arises to improve energy efficiency and reduce power losses. Conventional speed control methods like resistance control waste electrical energy in the form of heat, making the system inefficient. Modern techniques such as PWM-based control provide smooth and efficient speed regulation by controlling the average voltage applied to the motor. Furthermore, speed control extends the motor's lifespan, keeps it from overheating, guarantees safe operation, and facilitates automation in contemporary industrial drive systems. For DC motor-driven systems to operate precisely, efficiently, and dependably, an efficient speed control technique is therefore necessary.

III. LITERATURE SURVEY

Sharma et al. (2017) used an 8051 microcontroller to implement a PWM-based open-loop control system for speed regulation of a DC motor. This approach increased voltage efficiency but lacked feedback, which made it less stable under changing load conditions. Closed-Loop Speed Regulation of DC Motor using AVR

Microcontroller Patel and Singh (2018) Introduced closed loop PID control on AVR microcontroller; achieved better accuracy and smooth response but increased algorithmic complexity. DC Motor Speed Measurement using Capture Module of PIC16F877A Reddy and Thomas (2019) Utilized the Capture module of PIC microcontroller to measure motor speed via encoder pulses; enabled precise real-time monitoring and digital feedback. PWM-Based Speed Control System using PIC Microcontroller Kumar et al. (2020) Designed hardwaretimed PWM signals through PIC peripherals for improved torque smoothness and reduced electrical noise; demonstrated efficient switching performance Fuzzy Logic Based Control of DC Motor Deshmukh and Verma (2021) Applied fuzzy logic algorithm for adaptive speed control; achieved fast dynamic response but required high processing power and complex rule sets.

IV. PWM TECHNIQUES FOR SPEED CONTROL

One of the most popular and effective methods for regulating a DC motor's speed in contemporary motor drive systems is pulse width modulation, or PWM. PWM quickly turns the supply voltage ON and OFF at a predetermined frequency to control the motor speed, in contrast to traditional approaches that use resistors to lower the supply voltage. This switching action produces a series of pulses whose width can be varied according to the required motor speed. The main principle of PWM is that the motor does not receive a continuous DC voltage. Instead, it receives pulses of voltage. The average value of these pulses determines the effective voltage applied to the motor terminals. By changing the width of the ON pulse, the average voltage changes, which directly affects the motor speed. Therefore, PWM provides a smooth and efficient way of speed regulation without significant power loss.

The most important parameter in PWM is the duty cycle, which is defined as the ratio of ON time (T_{ON}) to the total time period (T). It is expressed as:

Where:

T_{ON} = time during which the pulse remains ON

T_{OFF} = time during which the pulse remains OFF

When the duty cycle is increased, the motor receives higher average voltage, causing it to rotate faster. Similarly, a lower duty cycle reduces the average voltage, resulting in lower motor speed. For example, a duty cycle of 80% means the motor is supplied with voltage for 80% of the cycle time, giving a higher speed compared to a duty cycle of 30%. PWM technique is highly efficient because the switching device (such as MOSFET or transistor) operates either in fully ON state or fully OFF state. In these conditions, power dissipation is very low, which reduces heating and improves overall system efficiency. This makes PWM superior to resistance-based control

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methods where large amounts of power are wasted in the form of heat.Another major advantage of PWM control is that it provides better torque performance. The motor receives full voltage pulses even at low speeds, which aids in sustaining enough torque. As a result, PWM speed control is frequently chosen for applications that need high beginning torque and smooth operation. PWM signals are produced digitally in microcontroller-based motor control systems using integrated PWM modules found in controllers like PIC, AVR, Arduino, and ARM.. The duty cycle can be easily varied through software, making the system flexible, programmable, and suitable for automation. Thus, PWM combined with microcontroller technology provides an effective, low-cost, and reliable solution for DC motor speed control in modern industrial applications.

V. EXISTING BARRIERS AND LIMITATIONS

Although DC motor control technology has advanced significantly, conventional systems still face a number of obstacles and constraints that reduce system dependability and performance efficiency. Conventional speed control techniques that rely on analog parts like voltage regulators or variable resistors have issues with energy losses, low accuracy, and ineffective control when there is a dynamic load. These methods lack closed-loop feedback, making them unsuitable for applications that demand precise speed regulation. Microcontroller-based control systems have overcome some of these drawbacks, but they still face several limitations. Many existing systems rely on open-loop PWM control, where the duty cycle is fixed and cannot compensate for changes in load or supply voltage variations. As a result, the motor speed fluctuates, leading to instability and reduced efficiency. Additionally, simple PWM systems require human recalibration for various operating situations due to the lack of real-time input, which hinders automatic mistake correction. The usage of external sensors and circuits for speed measurement and control represents yet another significant drawback. These designs raise power consumption, component costs, and system complexity.Some approaches utilize advanced algorithms like PID or fuzzy logic controllers, but they often demand higher processing power, complex tuning, and additional hardware support, making them less suitable for low-cost or small-scale applications. Furthermore, timing inaccuracies in software-based PWM generation can lead to non-uniform motor speed and increased noise or torque ripple. The integration of capture and PWM modules within the same microcontroller remains underutilized in many existing designs, leading to inefficiencies in synchronization and feedback response. Hence, there is a clear need for a compact, integrated, and feedback-driven control system that can provide real-time speed adjustment using minimal hardware. The proposed work in this paper aims to address these limitations by combining the Capture and PWM modules of the PIC microcontroller to achieve precise, efficient, and cost effective DC motor speed control. V. CONCLUSION This research successfully demonstrates an efficient and reliable approach for DC motor speed control using the Capture and Pulse Width Modulation (PWM) modules of a PIC microcontroller. The system does not require complicated external hardware or softwareintensive methods since it successfully combines dynamic duty cycle adjustment and feedback monitoring into a single microcontroller platform. The PWM module modifies the output signal to provide steady operation even under changing load conditions, while the Capture module precisely measures the motor speed in real time and compares it to the intended set point.

VI . CONCLUSION

In this research work, the speed control of a DC motor using Pulse Width Modulation (PWM) technique with a microcontroller has been successfully studied and implemented. DC motors are widely used in industrial automation, electric vehicles, robotics, pumps, and conveyor systems where accurate and efficient speed regulation is essential. Conventional speed control methods such as armature resistance control result in significant power losses, reduced efficiency, and excessive heating. These drawbacks make traditional methods unsuitable for modern energy-saving applications.

The proposed microcontroller-based PWM speed control system provides an efficient and reliable solution by varying the duty cycle of the applied voltage. Since PWM control operates through high- frequency switching, it minimizes power dissipation and improves overall system efficiency. The use of a microcontroller offers additional advantages such as flexibility, programmability, compact design, and low- cost implementation. Smooth speed variation can be achieved easily by adjusting the PWM duty cycle through software, making the system highly suitable for automation and digital motor control applications.

Experimental observations confirm that motor speed increases with an increase in PWM duty cycle, demonstrating precise and stable speed regulation. The proposed method not only reduces energy losses but also enhances motor performance, reliability, and lifespan. Therefore, PWM-based speed control using a microcontroller is an effective approach for modern motor drive systems and provides a strong foundation for further development of advanced closed-loop control techniques.

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