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Digital PID Controller based Speed Control of DC Motor

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***Abstract*—** PID controllers are commonly utilised in industry because of their ease of use and adaptability. To adjust these controllers for desirable responses, a number of tuning rules have been developed. This work aims to regulate a robotic vehicle's speed by utilising a PID controller to adjust the motor speed in reaction to impediments. We offer a technique that uses an Arduino microcontroller to automatically tune the PID controller to control the speed of a DC motor. An Arduino Uno device interfaces the DC motor with Simulink and functions as an affordable data collecting device. In order to maintain the motor speed within setpoint limitations, the PID controller modifies it in response to object distance data obtained from sensors. The study suggests utilising a PID controller to regulate the DC motor's angular speed and a microcontroller to implement it in hardware. The L298 motor controller is utilised, the encoder sensor determines angular speed, while the Arduino Uno is utilised for data processing. The proportional controller affects rising time, overestimation, and steady-state errors in the hardware implementation. Overshoot and undershoot are impacted by the integral controller, although overshoot is very slightly impacted by the derivative controller.

Keywords*— *Arduino Controller, LCD Display, PID Controller, DC Motor, Motor Driver etc.

I. INTRODUCTION

Electric motors are now an essential component of mechanical motions all around the world, acting as energy converters. They convert electrical power into mechanical energy; one common tool used for this function in many different sectors is the direct current, or DC, motor. Since most applications require motor speed control, a variety of alternatives for this purpose are made possible by the accessibility of speed controllers. For example, steady power application alone is unable to maintain the intended speed in a radio-controlled automobile using a DC motor, causing changes in speed over diverse terrains. As a result, managing the DC motor's speed is crucial. In order to evaluate the multifunction DC motor's compatibility with the controller, the researcher used a Shunt Wound DC power connection in this study.

Microprocessors, digital electronics, and power electronics have advanced to provide more compact, effective, and adaptable electric drive systems. Power electronic converters make it simple to adjust the voltage and current supplied to the motor. DC motors were the best choice for speed control applications prior to the widespread adoption of power electronic rectifiers. However, rectifiers are needed in order to run these DC motors. Active rectifiers are frequently employed in industrial applications because of their benefits, which include unity power factor, minimal DC voltage ripple, and a low total harmonic distortion.

High-performance electrical drives frequently employ DC motors, yet they might have efficiency problems. This project designs a Proportional-Integral-Derivative (PID) control to handle this. One popular control loop feedback method in industrial systems of control is the PID controller. It computes and outputs a corrective measure to modify the system in order to rectify the error among a measured systems parameter and the set point of choice. By integrating a PID controller, a DC motor may be precisely controlled to reach the required speed and faults can be corrected.

PID Controller

In a feedback-controlled system, measurements provide information that is used as a control mechanism. The controller senses the output and acts accordingly. PID is often used for industrial process feedback control. One way to think of the pid controller is as an algorithm that considers the error's history, present, and future. A closed loop control technique is the proportional-integral-derivative (PID) controller. Three controllers are used in this method-

1. Proportional Controller
2. Integral Controller
3. Derivative Controller.

II. OBJECTIVES

The primary goals are to examine the implementation of a PID controller with DC motor speed control and to provide information on the features of PID controllers in hardware implementation. This work ensures that high-speed DC motor drives, which are employed in many different industrial applications, are easily controlled and monitored continuously. By guaranteeing the dependability of the system, anomalous states may be quickly detected and fixed.

- To use the PID approach with an Arduino controller to monitor and regulate the speed of a DC motor.
- To use both automatic and manual methods of control to gently begin or cease the DC motor drives in order to prevent system breakdowns.

• To use PID to distinguish between various speed variations.
• Examine the design and output of the proportionally integral differential (PID) controller.

III. LITERATURE SURVEY

The objective of this paper is to control the speed of a DC motor using an Arduino-based PID controller. The PID controller is implemented through an Arduino program to regulate the motor's speed effectively.

Arduino serves as a low-cost data acquisition board in this setup, facilitating the integration of sensors like LM393, which measures the motor's revolutions.

The paper discusses the use of Android apps as a seamless interface for controlling, monitoring, and visualizing the motor's operation. By utilizing a Bluetooth terminal application and Arduino compiler, the authors successfully operated and controlled a 5V DC motor remotely within a range of ten meters.

In another approach presented in the paper, LabVIEW is interfaced with Arduino for speed control of a Permanent Magnet DC (PMDC) motor. This method is highlighted for its cost-effectiveness and simplicity compared to other speed control techniques like FPGA, fuzzy control, and PID controllers, which are often characterized by complicated designs and unreliable performance.

Additionally, the paper describes a technical system for DC motor speed control using Arduino programming platform and MATLAB's Simulink coder. It introduces the concept of using an Arduino board and Simulink PI controller in a closed-loop system, detailing the programming process and presenting results obtained from the PI controller for DC motor speed control.

Finally, the paper outlines the hardware setup, which includes an Arduino Uno microcontroller interfaced with an 8-channel relay module and an 8-bit RF receiver on the receiver side. A DC solid-state relay (SSR) is employed between the H-Bridge and the DC source, controlled by PWM signals from the Arduino Uno board. The console is connected to a personal computer via a USB cable for communication and monitoring purposes.[5]

- Pirah Peerzadaa et. al. 2021 "Using a PID controller and an Arduino board, control the speed of a DC motor. In this study, we discuss how developing technologies like electric automobiles demand highly efficient electric drives. A DC (direct current) motor is more effective in this scenario due to its attractive speed-torque characteristics and ease of regulation. In this study, a DC motor model is created, and its speed control under different loads is examined. PID controllers are employed to control the Mac's speed.

- Dodi Saputra, et al. 2023 "Design and Implementation of PID using Identification System with MATLAB Tuner for PLC-based Speed Control of DC Motor " This work used the PID control approach to develop a controller, and MATLAB Tuner and trial-and-error were used to fine-tune the controller gains in conjunction with an identification method. The hardware implementation of the suggested controller architecture made use of the PLC OMRON CP1E NA20DRA. To compare and enhance the system performances, every tuning technique was carried out five times. The trial-and-error approach produced findings that were acceptable but had steady-state faults based on the hardware implementation results.

- Bagus Setya Rintyarna et al. 2021. "Fuzzy-PID Controller Implementation as an Arduino UNO-Based DC Motor Rate ControllerIn this paper, speed controllers—which include several types of conventional as well as numerical controllers—are designed to control a DC motor's speed in order to perform a variety of tasks. These controllers can be either proportional (P), proportional integral (PI), proportional derivative (PD), or a combination of the three—which is known as proportional integral derivative (PID). The non-linearity impact on DC motors is the primary issue with using traditional control methods (PI, PD, and PID) in speed controllers.

- Thirupathi Allam et al. 2016. " PID controllers are the most widely used and well-liked controllers in industry, according to this study, "Design of PID controller with DC Motor Speed Control Utilising Arduino Microcontroller." PID controllers are widely used because of their broad operating condition range and straightforward functionality. Various tuning criteria have been presented to fine-tune the system in order to get the desired response. The purpose of this work is to manage the speed of robotic vehicles by utilising PID to adjust motor speed in relation to the challenges the vehicle will encounter. Here, we'll show you how to use an Arduino microcontroller to automatically tune a PID controller to regulate the speed of a DC motor.

- Prof. P. P. Mahajan et. al. 2017. "In this paper, we will discuss the extensive usage of DC motors in industries that demand high torque through the use of Arduino for speed control. It is highly sought after because to its excellent speed-torque characteristics and versatility in speed management. An Arduino programme generates the PID controller, which is used to regulate the speed of a DC motor. The purpose of this paper is to use Arduino to control the DC motor's speed. An inexpensive data acquisition board is the Arduino board. The sensor that detects revolutions is called LM393. The output is returned to the controller from the sensor. The controller does a comparison between the DC motor's real speed and its preset speed. Should the velocity differ, the controller will try to minimize the error and bring the motor to the set point value.

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IV. PROPOSED SYSTEM

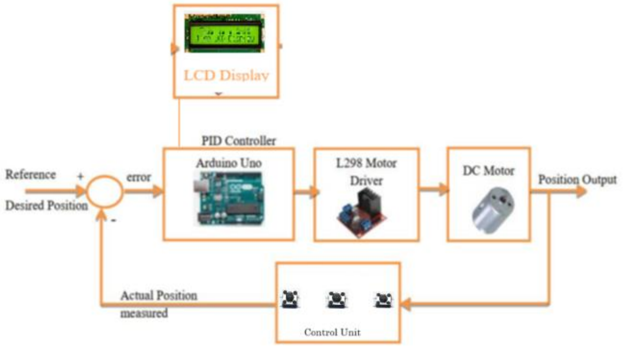

Fig.1. Block Diagram of system

V. WORKING

The operation of our designed system is shown by the block diagram in Fig. 1. The three main parts of this block diagram are the DC motor with encoder, PID algorithm, and Arduino UNO. After being processed, the Arduino UNO microcontroller supplies voltage input to the plant (motor). However, the Arduino UNO's programmed PID gains are in charge of making up the difference and determining how much more voltage should be sent to our plant. The Arduino UNO supplies electricity to the DC motor, the third main component in this system, using the motor driver L298N. In order to help Arduino regulate the input voltage to the DC motor, the encoder connected to the DC motor is delivering feedback of the response of the output to the microcontroller.

VI. CIRCUIT DIAGRAM

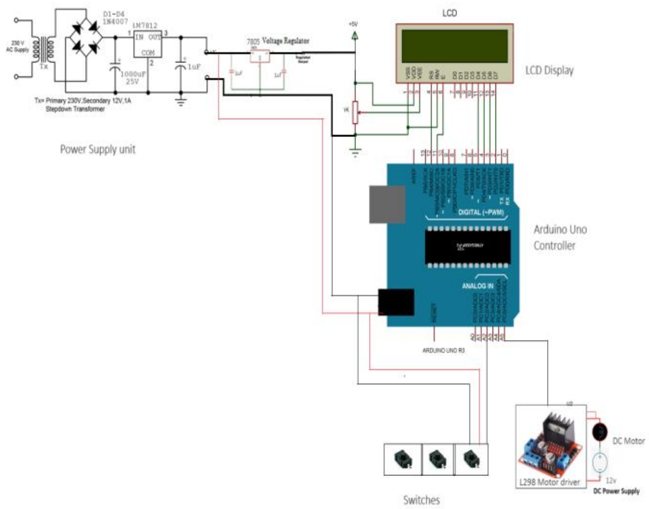

Fig.2. Circuit Diagram of system

VII. RESULT AND DISCUSSION

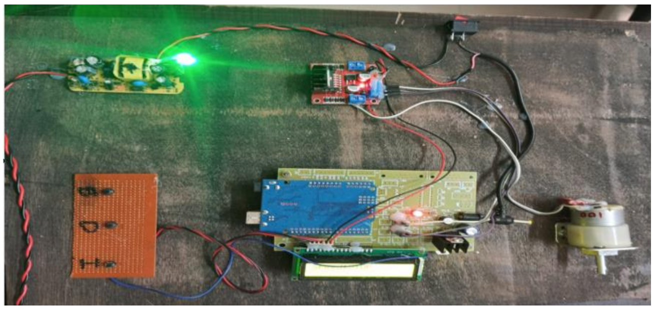

Fig.3. Prototype Model

- In this system, voltage is input while the speed of the DC motor is our output. Voltage supply is connected with the motor driver. The voltage that is being supplied to the DC motor is controlled through PWM.
- Now here, output speed of the DC motor is our actual value of output, it will vary as per speed increase or dereseae. When it is equal to the setpoint which we have already set in our controller, the controller will not vary the input.
- However, when the actual speed level sensed by the encoder attached with the DC motor, change from the setpoint value, a value of speed level and voltage use will display on LCD.
- The controller, through the PID algorithm, tunes the error signal with proportional, integral, and derivative gains.
- Furthermore, that error signal, that is basically a difference of actual and set values, triggers the controller to vary the input voltage to the DC motor through the motor driver L298N. Consequently, the output is varied in accordance with the voltage on the input side of the DC motor.
- This process continues as long as the actual speed level of the motor varies from the setpoint speed of the motor.

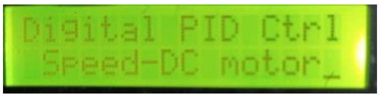

Fig.4. Initial project name written on LCD

Sr. No.	Speed Level	Volt	RPM
1	Speed level 1	12V	20 RPM
2	Speed level 2	11.9	40 RPM
3	Speed level 3	11.7	60 RPM
4	Speed level 4	11.5	80 RPM
5	Speed level 5	11.3	100 RPM

- **Speed Level vs Volt**

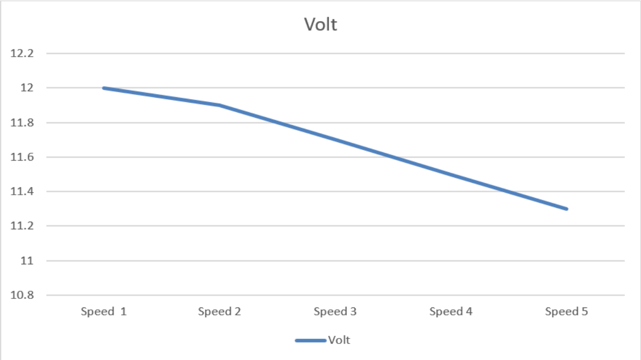

Fig.5. Graphical view Between Speed level and volt

- **Volt vs RPM**

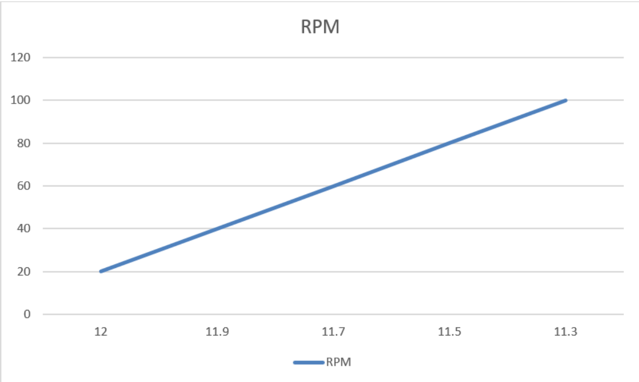

Fig.6. Graphical view Between Volt and RPM

VIII. ADVANTAGES

• Precise Motor Control: The DC motor speed controller offers precise control over motor rotational speed, enabling accurate adjustments to meet specific application requirements.
• Versatility: With bidirectional control capabilities, the DC motor speed controller provides versatility, allowing seamless control over motor rotation in both forward and reverse directions.
• Real-time Temperature Monitoring: Integrated with Arduino, the temperature sensor facilitates real-time temperature monitoring, ensuring prompt intervention in critical scenarios.
• Customization and Expandability: Leveraging the Arduino platform, the system enables easy customization and integration of additional sensors, modules, or displays, thereby expanding the system's functionality.
• User-Friendly Interface: The system features a user-friendly interface for effortless configuration of motor speed settings, temperature thresholds, and notification preferences.
• Cost-Effective Solution: Utilizing Arduino-based technology, the system offers a cost-effective solution compared to proprietary motor controllers and temperature monitoring systems.

IX. CONCLUSION

An effective and adaptable method for accurate motor control in a variety of applications has been demonstrated by the creation of PID-based DC motor controllers utilizing Arduino. It's clear from a thorough literature analysis that a lot has been accomplished in the area of Arduino-based DC motor control, with improvements in hardware integration, control algorithms, and system optimization. The methodical approach guarantees that the circuit design is optimized for dependable operation, the system needs are thoroughly examined, and the right motor and driver are chosen. With Arduino programming, control algorithms may be implemented more easily, leading to more accurate control over speed and direction.

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