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# Speed and Position Control of DC Motor using LabVIEW

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***Abstract:*** ***New applications requiring both speed and position control have emerged as a result of technological advancements. In many applications, a DC motor's speed and position can be adjusted. The PID controller controls the speed and position of individually stimulated DC motors. Using LabVIEW software, this study attempts to control the speed and position of a DC motor as well as calculate the closed loop system model. Nonlinearity in any system has undesirable implications in normal operation. Unwanted outcomes including dead zones, saturation, and system reaction.***

## I. INTRODUCTION

DC motors have been widely used in the industry control field for a long time because they possess a number of advantageous properties, such as strong start torque characteristics, high response performance, and the ability to be controlled linearly with more ease. There are various control options available, each of which is dependent on the performance of the motor in question. A larger application in the industry control system is possible since there are adequate peripheral control devices available for this purpose. It is the fundamental attribute of a DC motor that its speed can be controlled by adjusting the terminal voltage. As a result, DC motor control outperforms other types of motors in both theoretical and practical studies, as well as in the research and development of application technologies. It is necessary to fine-tune the PID parameters in order to achieve the best response. It is one of the most often used control algorithms because of its simplicity to use and the fact that it requires little understanding of the system that is being controlled.

A PID controller is designed in this work to supervise and control the speed response of a DC motor using the virtual instrument graphic monitor LabVIEW, and it is implemented in LabVIEW. To tune the PID controller, numerous algorithms/methods have been proposed in the literature. In a closed loop control system, the required angular position of the DC motor is obtained. The control motor is coupled in a closed loop system with the plant. Compensators, integrators, comparators, gears, amplifiers, and other position control accessories are connected in the same loop. The comparator receives the desired angular position as a reference signal.

The comparator's other input is the motor's angular position. The comparator compares the desired and actual signals and outputs an error signal to the controller, which actuates the DC motor, causing it to move to the desired position. It has several advantages, including the fact that it does not require any additional packages to be installed alongside the basic product in order to generate a standalone executable.

It has a greater number of instruments supported. This mode can be used to replace typical instruments such as oscilloscopes, signal generators, power supplies, and other similar devices, and the test operation is straightforward. The LabVIEW software product line, which includes software solutions with a wide range of functionality, helps engineers and scientists boost their productivity when designing test, control, and design systems. LabVIEW is a graphical development environment that allows you to create flexible and scalable test, measurement, and control applications in a short amount of time and at the lowest possible cost. Engineers and scientists can interact with real-world signals, evaluate data for useful information, and exchange discoveries and applications by utilizing LabVIEW, which is an interface between them. The primary sections of this study are organized into the following categories:

*A.* Motor analogy using mathematic modelling
*B.* Controlling the PID for each parameter
*C.* Tuning algorithm with PID controller
*D.* Computer simulation results in LabVIEW

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## II. MOTOR ANALOGY USING MATHEMATIC MODELLING

Until control systems were introduced, no system could be designed using a block diagram since each block represented a single component of the system, and the lines linking each block was used to indicate connectedness between each component. A block schematic diagram of a DC motor may also be used to illustrate the motor. DC motors are frequently employed for speed adjustment and position regulation. Fig. 1 shows how to build a DC motor control using the armature voltage control approach. The term here for armature resistance is $R_A$, $L_A$ Indicates armature inductance, $I_A$ Indicates armature current, $I_F$ Indicates field current, $E_A$ Indicates input voltage, $E_B$ Indicates back electromotive force (EMF).

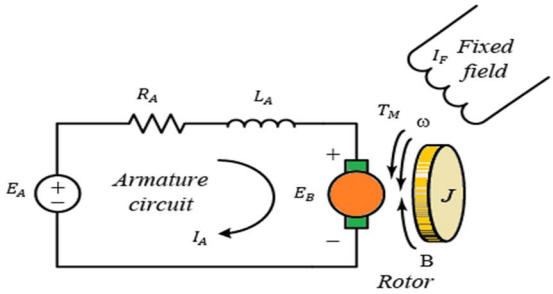



Fig.1 The DC motor's control equivalent circuit.

As speed is related to the back EMF, $E_B$. it can be seen that

$$E_B(t) = K_B \frac{d\theta(t)}{dt} = K_B \omega(t) \qquad (1)$$

With the use of the KCL voltage law, we can obtain

$$E_A(t) = R_A I_A(t) + L_A \frac{dI_A(t)}{dt} + E_B(t) \qquad (2)$$

The motor torque can be calculated using Newton's laws.

$$T_M(t) = J \frac{d^2\theta(t)}{dt^2} + B \frac{d\theta}{dt} = K_T I_A(t) \qquad (3)$$

Fig 2 depicts the functional block diagram of the DC motor armature control system derived from equations (1) to (3) after taking Laplace transform.

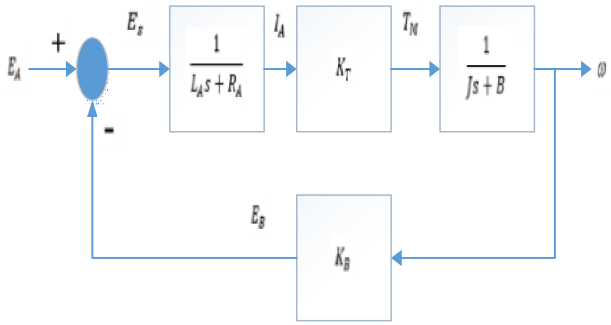



Fig.2 A functional block diagram of a DC motor's armature control system.

The transfer function [11] of DC motor speed with respect to the input voltage can be written as follows,

$$\frac{\omega(s)}{E_A(s)} = \frac{K_T}{(L_A s + R_A)(Js+B) + K_B K_T} \qquad (4)$$

The numerous components of a DC motor can be seen in the different blocks in the above block diagram, including the armature circuit, field circuit, and frictional resistance.

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## III. CONTROLLING THE PID FOR EACH PARAMETER

The process-interaction diagram-driven PID control theories have been in use for about 60 years, and this way of control system design is among the methodologies with the longest historical track record. Despite its drawbacks, though, this strategy is still utilized today. A PID controller has three terms: a proportional term, an integral term, and a derivative term. The proportional term handles the control system's overall error by balancing it out with the entire system, the integral term neutralizes the system's steady state error and increases the response time, and the derivative term mitigates an expected increase in error and speeds up the transient response. Most control processes have been completely addressed by this set of features. Because the PID controller's structure is straightforward, it has been the most widely applied control system in industry to date. The PID controller is mainly to adjust an appropriate proportional gain ($K_P$), integral gain ($K_i$), and differential gain ($K_d$) to achieve the optimal control performance. The PID controller system block diagram of this paper is shown in Fig 3.

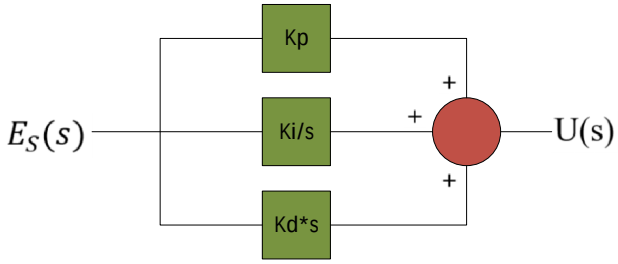



Fig. 3 Block diagram for PID controller system

The relationship between the input $E_S(t)$ and output $U(t)$ can be formulated in the following,

Here $E_S(t) = e(t)$

$$U(t) = K_P e(t) + K_i \int_0^t e(t)dt + K_d \frac{de(t)}{dt} \quad (5)$$

The transfer function is expressed as follows,

$$K_P + \frac{K_I}{s} + K_D s = \frac{U(s)}{E(s)} = \frac{K_P s + K_I + K_D s^2}{s} \quad (6)$$

The controlled plant in this paper is a DC motor. The PID DC motor speed control system block diagram is shown in Fig. 4.

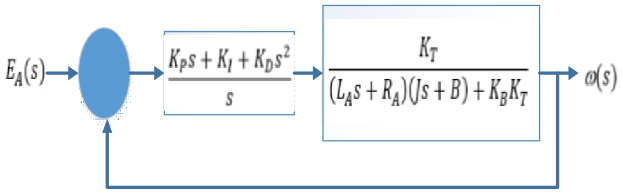



Fig. 4 The block diagram for a PID DC motor control system.

## IV. TUNING ALGORITHM WITH PID CONTROLLER

PID controllers which use proportional integral derivative elements are commonly used in industrial processes, and these controllers are a leading strategy for the feedback control of industrial processes. Errors in the past, present, and future are taken into consideration. This controller provides process-specific control action via the tuning of three parameters proportional gain ($K_P$), integral gain ($K_I$), and differential gain ($K_D$) in PID controller, the controller output is proportional to the error input.

1) *Ziegler Nichols Method (Closed-loop):* This continuous cycle method is also known as Ziegler- Nichols. In continuous cycling, the amplitude of the oscillation continuously changes while the amplitude stays constant. This is an iterative process based on trying out different gains until the desired output is achieved. The reduction of the value of $K_P$ to the point where the continuous oscillations occur, is called breaking even. To this end, system operating frequency is referred to as the ultimate operating frequency $K_u$ and oscillation period is called the ultimate time period ($K_u$). Using the largest possible gain value, $K_u$, and the longest possible period of oscillation ($P_u$), we can determine the largest possible output, $K_u$ The controller (P, PI, or PID) controller loop-tuning constants are discovered by computing, $K_u$ and, $P_u$ via the formula in Table.3.

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| Parameters | $K_P$ | $\tau_I$ | $\tau_D$ |
|---|---|---|---|
| P | $0.5K_u$ | $\infty$ | 0 |
| PI | $0.45K_u$ | $0.8333P_u$ | 0 |
| PID | $0.6K_u$ | $0.5P_u$ | $0.125P_u$ |

Table.3 shows Ziegler Nichols parameters.

This technique incorporates all of the many dynamics of the system and, as a result, presents a more realistic image of how the system is functioning. This causes some issues with the procedure and requires plenty of trial and error. Only tuning procedures that cannot function in an open-loop environment can utilize this closed-loop tuning strategy.

2) *For Position Control:* It is necessary to use a closed-loop control system to control the DC motor's angular position. In this circuit, a variety of accessories that are necessary for and advantageous in control activities have been incorporated. A motor block diagram such as the one pictured below would include functional blocks such as the armature block, the load block, the torque constant, and the back emf constant. Tachometers are used to measure angular speed, which is then fed into an integrator, resulting in the output of the DC motor. The integrator will give an output in the form of angular position due to the integration of angular speed and time. The comparator will utilize this angular location as one of the inputs. The second input to the controller contains the angular position that's desired. When there is a difference between the present position and the anticipated position, the comparator generates an error signal. This amplifier amplifies the error. The control system that includes the closed-loop DC motor regulator mentioned above regulates the position of the DC motor.

## V. COMPUTER SIMULATION RESULTS IN LABVIEW

Fig. 5 depicts the representation of the DC motor model in the LabVIEW Math Script Node.

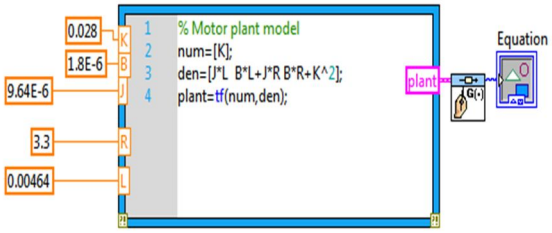



Fig. 5 shows model of DC motor

QNET DC Motor board utilizes a direct-drive motor along with a rotary encoder on the shaft, and an inertia disc mounted on the motor shaft. A magnetic connector can be used to attach the inertia disc. The power amplifier is run utilizing a PWM modulation of the pulse width. The header and the connectors for the control of the system are provided as standard inputs to and outputs from the system. Inertia disc speed is the output; and angle of inertia disc is the control variable. manipulating the wheel, or through LabVIEW software, can introduce disturbances.

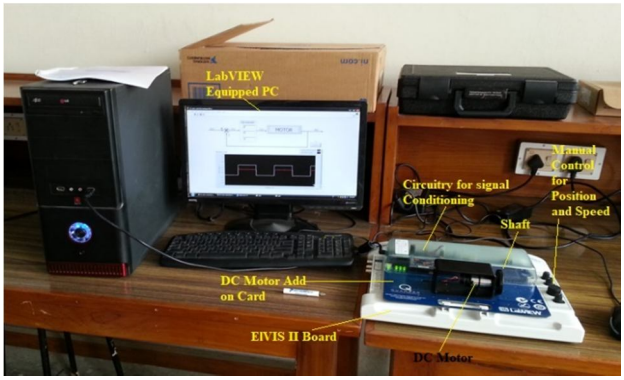



Fig. 6 Hardware setup for speed and position control

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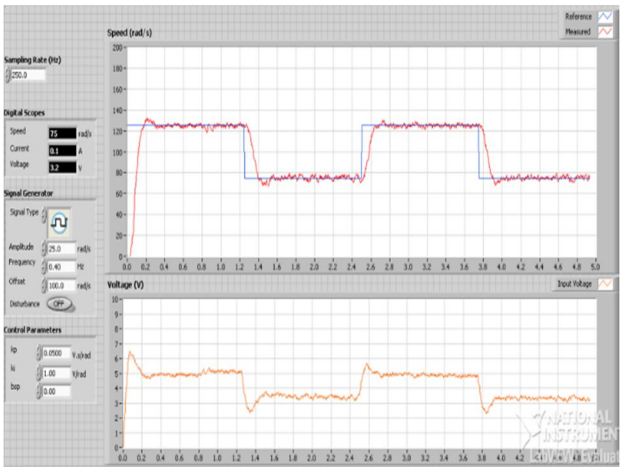



Fig. 7 Speed control using $k_p$ = 0.05 *and* $k_i$ = 1

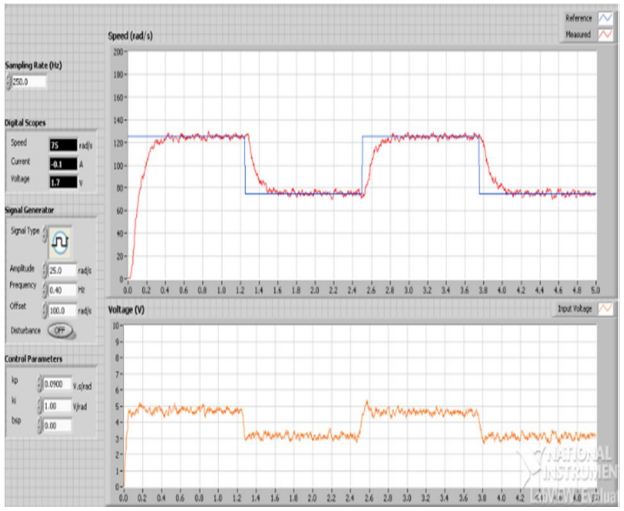



Fig. 8 Speed control using $k_p$ = 0.09 *and* $k_i$ = 1

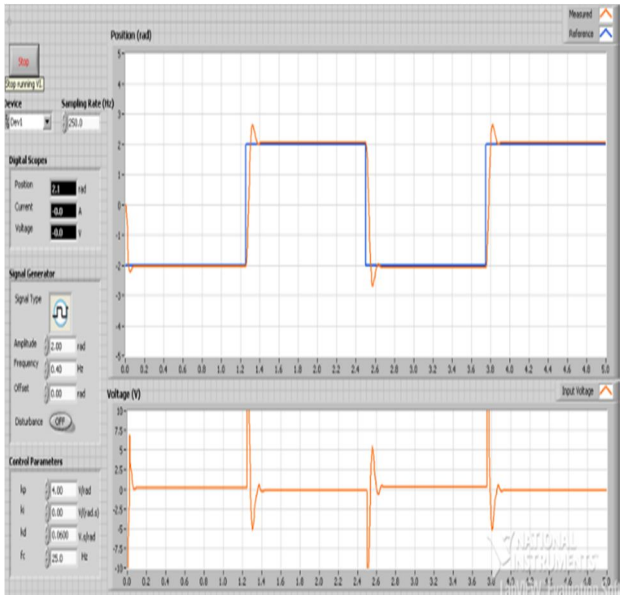



Fig. 9 Position control using $k_p$ = 4 *and* $k_d$ = 0.06

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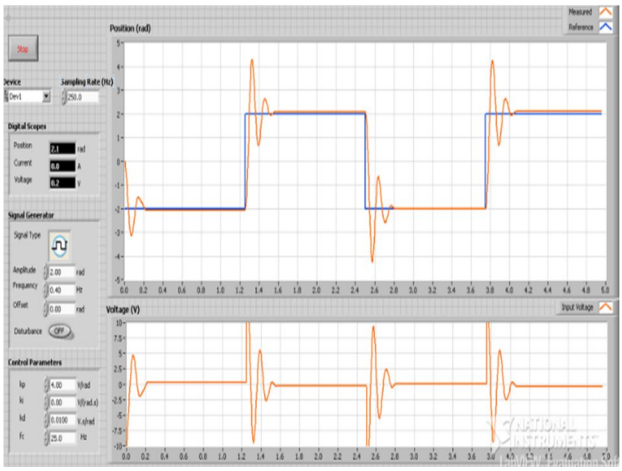



Fig. 10 Position control using $k_p = 4$ *and* $k_d = 0.01$

Figures 7 and 8 demonstrate the behavior of a DC motor when it is subjected to speed control with various PID parameter settings. As shown in Figures 9 and 10, the behavior of a DC motor under position control when different PID parameters are utilized is shown in Figure 9.

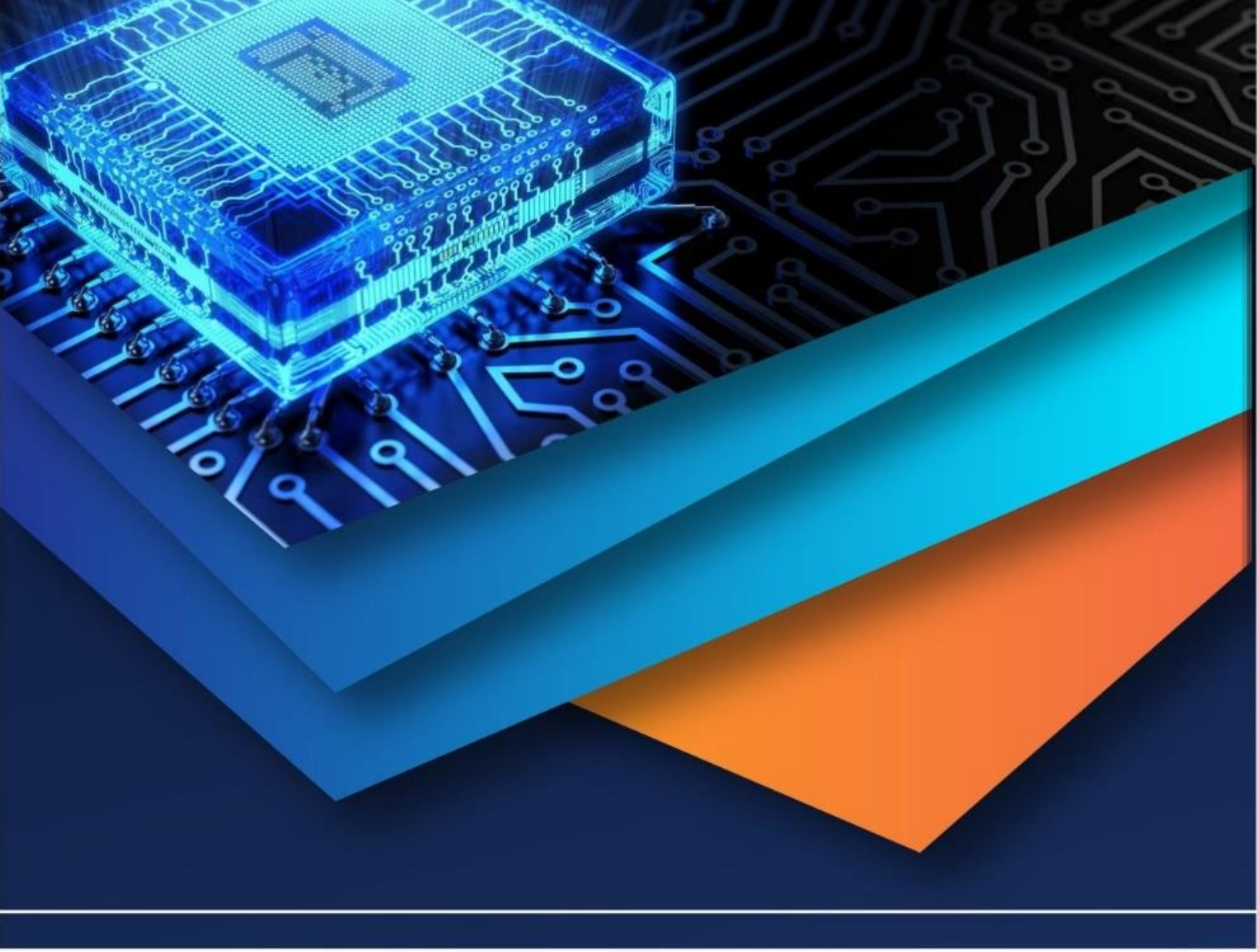
## VI. CONCLUSIONS

In this paper we have studied about speed control and position control of DC motor. From the simulation results it is concluded that by Z-N rule method results in less oscillation at the control system response. Less oscillations means better controllability, robustness and less sensitivity to change in system condition. In order to lower the rising time, $K_P$ must be reduced, $K_D$ improves the overshoot and $K_I$ eliminates steady-state error. To test the approach used in this thesis, a LabVIEW simulation of speed control of an independently stimulated DC motor was performed. This method can be used on various motors. PID controller parameters can be modified using genetic algorithm (GA) or fuzzy logic. This project work can be extended to different types of motors combined with different sorts of controllers. Using the Ziegler-Nichols algorithm, a stochastic genetic algorithm technique may be built, giving more accurate results than results obtained without adjusting PID Controllers. The planned linear quadratic had the best steady state and transient responses. In the shortest time possible, it eradicated the steady state error. Aside from that, the system is stable.

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