



Modelling and Simulation of DC Motor using Matlab

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Abstract

An overview of proportional integral control, or PI, is given in this study. Software called Matlab [Simulink] is used to analyse PI controller. Because of its simplicity of controllability, the DC motor is a desirable piece of machinery in many industrial applications requiring changing speed and load characteristics. This paper's primary goal is to demonstrate how various controllers can be used to control the DC motor's speed. The simulation findings reveal that a DC motor with a PID has good well-damped control performance in its responses. The findings indicate that the Industrial DC Motor model can be utilised as a controller for a real-time DC motor as it was developed utilising the physical parameters of the motor and was given improved responsiveness when it was controlled by a controller.

Keywords: Matlab, PID, Fuzzy, Low Speed, High Speed, DC Motor.

1. Introduction

With the discovery of Faraday's law in 1831, the history of the development of electric machine construction began. It continued until the middle of the eighth decade of the previous century. The DC motors are devices that rotate by converting electrical energy into mechanical energy. The sustained appeal of DC motors can be attributed to a number of factors. One was that even in cars, trucks, and aeroplanes, DC power systems are typical. It

seems sense to employ DC motors in vehicles using DC power systems. When a wide range of speeds was needed, DC motors were also used. Before electronic power rectifier inverters became widely used, dc motors were unmatched in applications requiring speed control.

The PID controller is responsible for correcting the error it receives from the difference of the input signal and the output signal of the tachometer, the corrected error enters an amplification stage before entering the plant. In this paper the development of a speed and direction motor for an autonomous race robot is presented. Both controls use the PID control algorithm.

2. Design of PID Controller

2.1. PID Controller

The PID controller calculates a control signal (output) based on the difference (error) between the desired speed (setpoint) and the actual motor speed (feedback). The control signal is then sent to the motor driver, regulating the power delivered to the motor and influencing its speed.

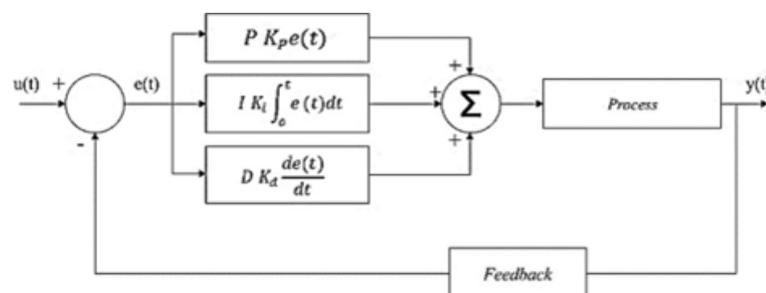


Figure.1. Block Diagram of PID Controllers

2.2. PID Controller Tuning

PID control is a popular and adaptable feedback control method utilised in many different automation systems, such as motor speed control. The difference (error) between a planned setpoint and the actual system measurement (feedback) is used to calculate a control signal, or output. After that, the system's behaviour is modified with the help of this control signal to get it closer to the intended state. For This Split Range Control Ziegler Nichols Method has Been

Used.

2.3. Types of PID Controllers

1) *PID not interacting or ideal form* :

$$G_c(p) = K_c \cdot \left(1 + \frac{1}{T_i} + \frac{1+T_d \cdot p}{1+\alpha \cdot T_d \cdot p} \right)$$

2) Interactive PID or series form :

$$G_c(p) = K_c \cdot \left(1 + \frac{1}{K_i \cdot p} \right) \cdot \left(\frac{1+T_d}{1+\alpha \cdot T_d \cdot p} \right)$$

3) PID industrial form :

$$u(t) = K_c \cdot \left(1 + \frac{1}{T_d \cdot p} \right) \cdot \left(r(t) - \frac{1+T_d \cdot p}{1+\alpha \cdot T_d \cdot p} \cdot y(t) \right)$$

3. Methodology

3.1. Simulation of Controller Model in Matlab

- Develop the controller model using Simulink, Integrate it with the system being controlled.
- Configure simulation settings and scenarios, Analyze results to evaluate controller performance.

3.2. Process parameters Analyzing

- Through the utilization of MATLAB, we acquire and analyze the process parameters of simulation model.
- Through this process, we can calculate the performance of the controller and identify areas for improvement to achieve a more stable controller model.
- Monitoring and Maintenance: Monitor the performance of your deployed system and address any issues or anomalies that arise. Periodically update your models and algorithms with new data and improvements to maintain their effectiveness over time.

Continuously gather feedback from users and stakeholders to refine and enhance the system's functionality and usability.

3.3. Mathematical Model of DC Motor

A mathematical model of a DC motor represents its electrical and mechanical behavior through a set of equations. This model allows us to predict the motor's speed, torque, and current based on the applied voltage and to analyze the system's performance under various conditions.

For first order transfer function for the process Station is defined as :

$$\frac{H(s)}{Q(s)} = \frac{R}{[\tau s + 1]}$$

For DC Motor :

The torque is proportional to current as a following.

$$T = K_t i$$

The back emf e , is related to the rotational velocity by the following equation:

$$e = K_e \dot{\theta}(t)$$

In SI units *Type equation here.* (which we will use), K_t (armature constant) is equal to K_e

(motor constant).

From the figure above we can write the following equations based on Newton's law combined with Kirchhoff's law can be written as follows:

$$J. \ddot{\theta}(t) + b. \dot{\theta}(t) - K_e .i(t)$$

$$L. \frac{di}{dt}(t) + R. i(t) = V(t) - K. \dot{\theta}(t)$$

Using Laplace Transforms, the above modeling equations can be expressed in terms of operator(s)

$$(Js + b). \theta(s) = K. I(s)$$

$$(Ls + R).I(s) = V(s) - K. \dot{\theta}(s)$$

From equation (5):

$$I(s) = \frac{(Js+b)\theta(s)}{K}$$

Substitute equation (7) into equation (6) to get:

$$\frac{(Ls+R)(Js+b)\theta(s)}{K} = V(s) - K \theta(s)$$

From equation (8):

$$\frac{\theta(s)}{V(s)} = \frac{K}{(Ls+R)(Js+b)+K}$$

Table.1. Operating Parameters

Parameters	Values
R	5.2 Ω
L	1.1 mH
J	0.01 kg.m
B	0.02 N.m.sec/rad.s ⁻¹

The First Order Transfer Function of DC Motor

$$G(s) = 32.9 s/\tau s + 1$$

Where K = 32.9

4. Simulation Results

The entire system—which comprises of a DC motor fed by a DC source voltage via a chopper transistor circuit—is modelled using the MATLAB/SIMULINK toolbox. The chopper circuit consists of a single GTO-1 thyristor with a complete control circuit and a freewheeling diode. The GTO-1 is a modelled switch.

Three terminals make up the switch block model: the middle terminal determines which of the other two terminals is connected to the output. While the control input signal is zero, which will lead to the output, the control input signal is one, which will lead to the output voltage (DC V).

The torque of the load (TL), friction coefficient (B), and inertia (J) of the mechanical load are the characteristics of the DC motor drives system. A speed control loop makes up the DC motor system's control circuit.

The speed of the control loop is measured by a proportional-integral-derivative (PID) that controls the real speed of the DC motor, and ascertains the reference armature current that the DC motor will need by comparing the measuring speed with the reference speed (constant value). It should be noted that any variation in actual speed indicates how much current the engine needs to run the motor.

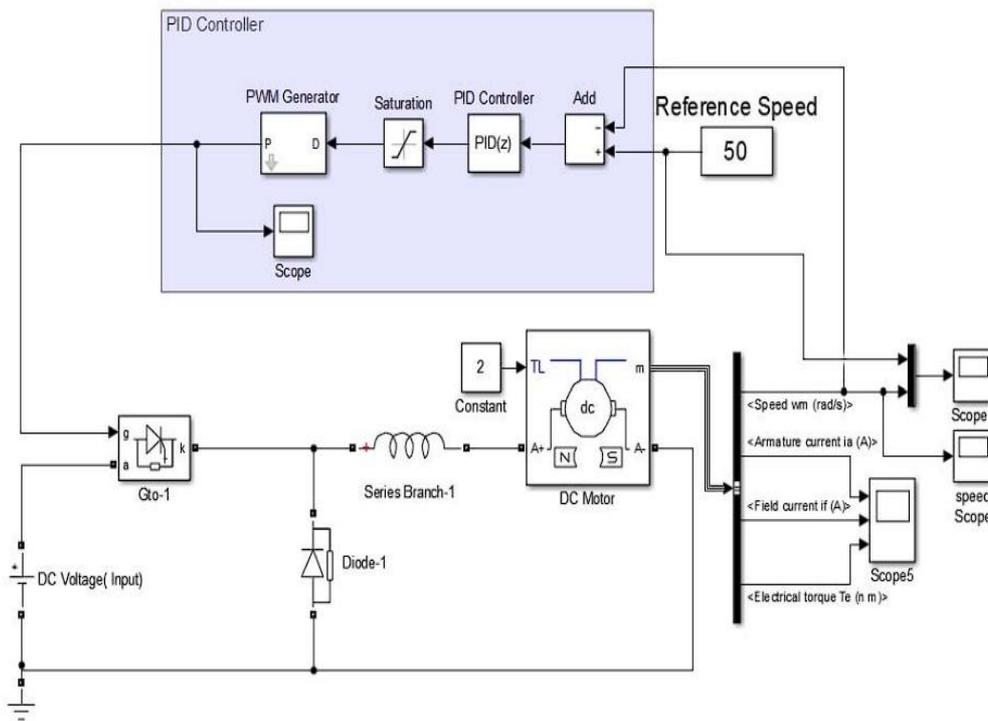


Figure.2. The Simulation of DC Motor in Matlab

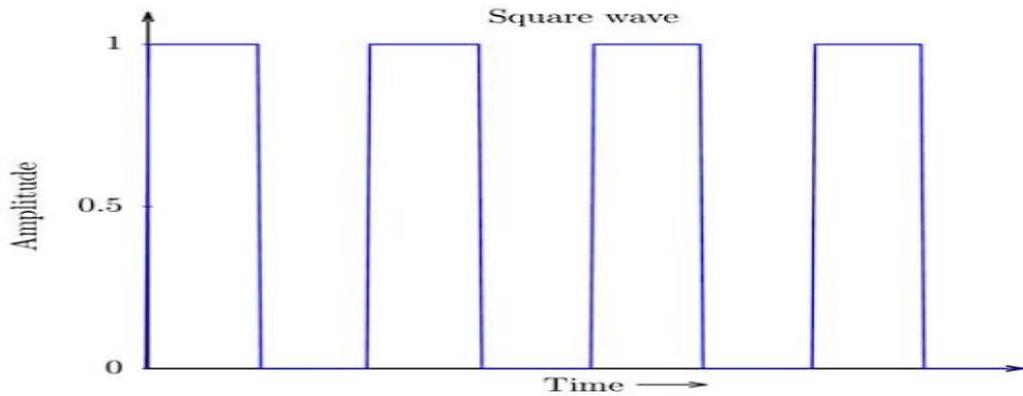


Figure.3. The PWM Signals of GTO – 1

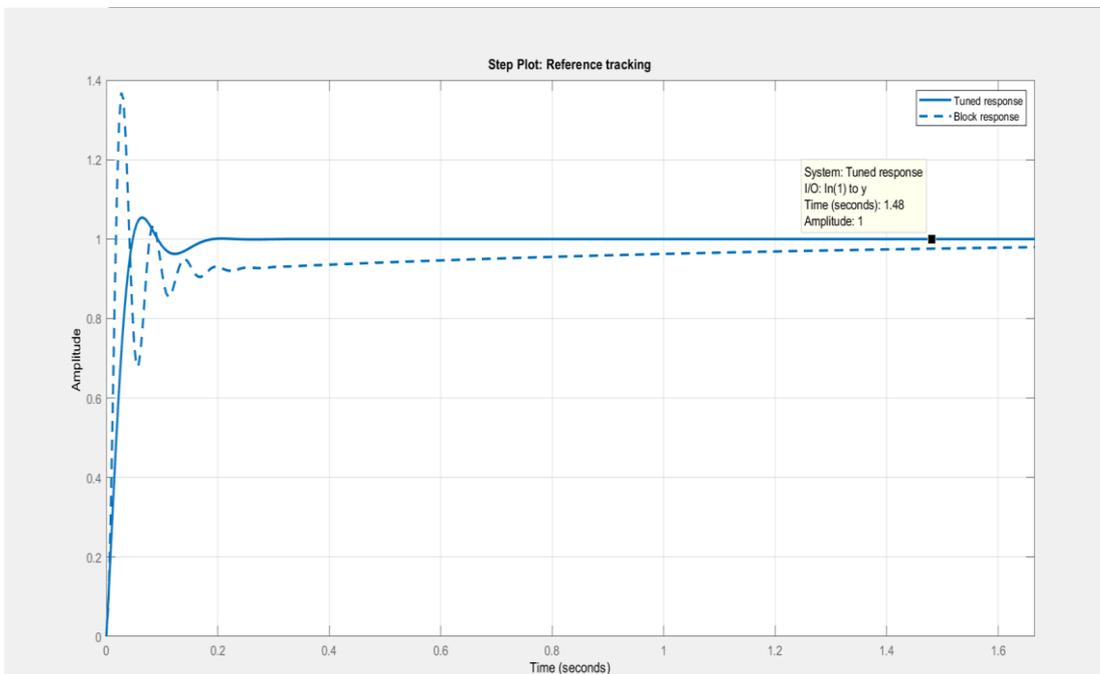


Figure.4. Step response Obtained from the Simulation model

5. Conclusions

The explanation of a DC motor's operation, together with an analysis of the various features of its operation and the parameters influencing its speed regulation, was the first topic covered in this book. Next, the PID controllers' system was put into action, and their use in the management of the DC motor's speed.

It is crucial to keep in mind that the kind of controller—PID in this instance—and how it functions—as a regulatory system or a server mechanism have a direct impact on the dynamic behaviour of a control loop.

It is essential to understand the variations in the equations utilised by manufacturers to depict the PID algorithm in their loop controllers, direct digital control programmes, and other equipment in order to compute the necessary parameters there of appropriately and accomplish the control loop's desired dynamic behaviour. When switching out one controller for another, especially if it's made by a different company, the aforementioned is crucial information to remember.

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