

# Speed Control of DC Motor using PID Controller

Ramesh Chandra Chourasia, Navneet Verma\*, Puranjan Singh and Shashi Kant

Department of Electrical Engineering, Meerut Institute of Engineering and Technology, Meerut, Uttar Pradesh, India

## Abstract

The purpose of this paper is to design a speed controller for a dc car. DC car is widely used in various applications, such as cranes, milling machines, elevators, lathe machines, blowers, fans, drilling rigs, etc. This paper proposes the construction of a PID controller and the selection of PID control parameters. Here, the PID controller is used to control the speed of the DC vehicle and to simulate and calculate MATLAB is used. The selection of PID parameters is indicated by several ongoing tests and the PID parameter setting method is discussed.

**Key words:** Milling machines • PID • MATLAB • Horsepower

## Introduction

The PID (Proportional-Integral-derivative) controller is a well-known controller for its simple and powerful operation in a wide range of operating conditions. The design of such a control that requires the specification of three parameters for a limited time, a limited time period and a time from the other [1]. Setting the PID parameter is called tuning. PID control adjustment using a variety of methods. In the Ziegler Nicholas Tuning method, the integrated and derivative method is maintained consistently, the constant equivalent of the various simulations of the performance of your identity in this method was Parliament overshoot and time Ts defined. The genetic algorithm is repeated several times until the best values come from Mp and Ts. There are three categories in this algorithm, namely selection, crossover and genetic modification. PID controller parameters kp, ki and kd can be controlled to generate various response curves from a given process [2].

## Literature Review

### The DC motor model

A DC motor is any of a class of rotary electrical motors that converts direct current electrical energy into mechanical energy. It is used for a wide variety of industrial, commercial and residential operations [3].

Figure 1 shows the connection of the shunt car type dc. It consists of a shunt field connected similarly to the armature. The shunt field curve is constructed with several turns of a small gauge fence and has a low current flow and very high compared to a series fence field. Therefore, these types of motors have excellent speed and position control. These motors are therefore widely used in applications that require five or more horsepower. The Figure 2 describes the dynamic performance of a DC car based on a scheme diagram.

$$V_a = R_a \cdot i_a(t) + L_a \cdot \frac{di_a(t)}{dt} + e_b(t) \quad (1)$$

\*Address for Correspondence: Navneet Verma, Department of Electrical Engineering, Meerut Institute of Engineering and Technology, Meerut, Uttar Pradesh, India; E-mail: navneetverma0108@gmail.com

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Received: 28 July, 2021, Manuscript No. gjto-21-38111; Editor assigned: 30 July, 2021, PreQC No. P-38111; Reviewed: 13 January, 2022, QC No. Q-38111; Revised: 18 January, 2022, Manuscript No. R-38111; Published: 23 January, 2022, DOI: 10.37421/2229-8711.2022.13.274

$$e_b(t) = K_b \cdot \omega(t) \quad (2)$$

$$T_m(t) = K_T \cdot i_a(t) \quad (3)$$

$$T_m = J_m \cdot \frac{d\omega(t)}{dt} + B_m \cdot \omega(t) \quad (4)$$

Then,

$$T_m = J_m \cdot \frac{d\theta^2(t)}{dt} + B_m \cdot \frac{d\theta(t)}{dt} \quad (5)$$

Now, the transfer function will become:

$$\theta(s) / v(s) = K_b / [J La S^3 + (Ra J + B La)S^2 + (Kb2 + Ra B)S]$$

Where,

Va = armature voltage (V) Ra = armature resistance

La = armature inductance (H) Ta = armature current (A)

Eb = back emf ω = angular speed

The DC motor under study has the following specifications and parameters

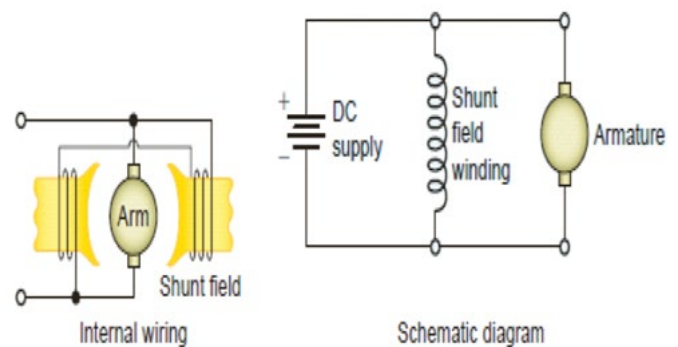


Figure 1. Diagram of DC shunt motor.

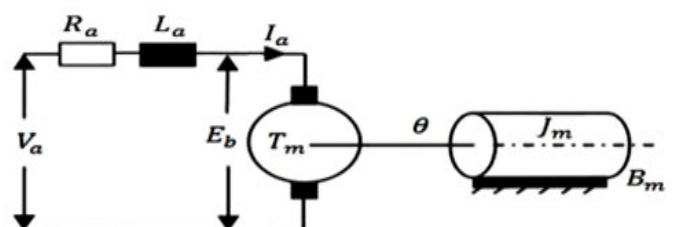


Figure 2. The schematic diagram of DC motor.

(Table 1).

**Simulink modeling of DC motor:** Simulink modeling of DC motor was shown in Figure 3.

**Tuning of PID controller using different methods**

**Ziegler-Nichols tuning method:** The Ziegler-Nichols Act is a PID amendment law that seeks to produce fair values for the three parameters of obtaining a PID:

Kp - is the advantage of the control system

Ti - is the integration time of the controller

Td - is the time from the controller

Given the two parameters for measuring the measured response obtained from the ratings:

- Tu time of oscillation frequency at the intensity level
- The margin gain loop stability

**For the purpose of obtaining good regulation (refusal to be disturbed):**

Ziegler-Nichols law considers that the system has a transfer function of the following form:

$$\frac{K \cdot e^{-\sigma t}}{(a + s)}$$

The model is similar to the system response to 0 waves and the stability limit, with everything else almost done below. If the actual system is straightforward, looks isolated and lazy, it does not make much difference that the model is fake, and the results are good enough.

**The necessary steps for this approach are:**

1. The combined and derived coefficient must be zero.
2. The corresponding coefficient increases gradually from zero until the system begins to flow continuously. At this point, a coefficient equal to it is called the maximum gain (Ku) and the downtime is called the end time (Tu) (Table 2).

If we choose the classical Ziegler-Nichols tuning rule, we can determine that the PID gains should be:

Loop gain  $K_p = 0.6 * K_u = 6.7$

Integral time constant  $T_i = 0.5 * T_u = 0.033$

Derivative time constant  $T_d = 0.125 * T_u = .0083$

**Effects of increasing the parameters of PID controller**

From the Table 3, we can examine the following parameters:

1. Maximum overshoot (Mp)
2. Setting time (Ts)

The maximum overshoot of the system is approximately 47.4% and the setting time is in relation to 0.837 sec.

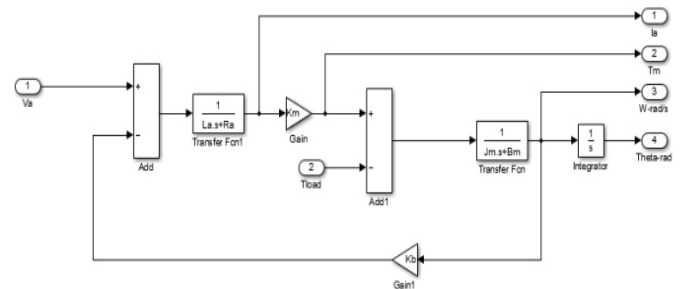
The Figure 4 shows the DC motor speed with PID tuning using Ziegler-nicholas method [4,5].

**Genetic algorithm method**

Genetic algorithm is a random search method that can be used to solve incompatible mathematical systems and improve complex problems. GA uses the rules of possible modification instead of determining the rules and regulates the number of possible solutions known as human or chromosomes that change in sequence. Each duplication of the algorithm is called a generation. The emergence of solutions is done through solid work with genetic suppliers such as reproduction, crossover, and genetic modification. The genetic algorithm as shown in Figure 5 usually starts with a random number. This number (mating

**Table 1.** Shows the parameters taken for the DC motor.

Parameters	Value
Armature inductance (Henry)	$L_a = 0.1215 \text{ H}$
Armature resistance (ohm)	$R_a = 11.2 \ \Omega$
Rotor inertia (kg m <sup>2</sup> )	$J_m = 0.002953 \text{ Nms/rad}$
Armature Voltage (Volt)	$V_a(t) = 240 \text{ V}$
Viscous friction coefficient (N <sub>m</sub> s/rad)	$B_m = 0.002953 \text{ Nms/rad}$
Motor Torque constant (Nm/A)	$K_m = 1.28 \text{ Nm/A}$
Back emf constant (V s/rad)	$K_b = 1.28 \text{ Vs/rad}$
Speed	$W = 1500 \text{ rpm}$



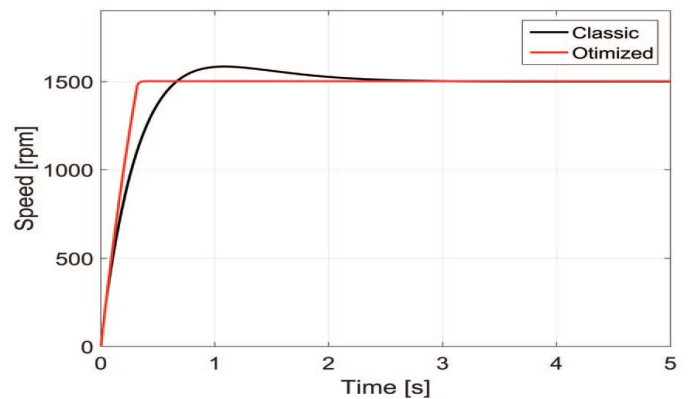
**Figure 3.** Simulink modelling of DC motor.

**Table 2.** Shows the values taken for the controller.

Controller Type	PID
Kp	$K_u/1.7$
Ki	$T_u/2$
Kd	$T_u/8$

**Table 3.** Shows effects of increasing the PID controller parameters.

Parameter	Rise Time	Overshoot	Setting Time	Steady-state Error	Stability
Kp	Decrease	Increase	Small change	Decrease	Degrade
Ki	Decrease	Increase	Increase	Eliminate	Degrade
Kd	Minor change	Decrease	Decrease	No effect in theory	Improve if Kd small



**Figure 4.** Speed response with PID controller using fixed set point.

lake) is represented by a truly equal number or two-dimensional series called a chromosome. Personal performance is measured and evaluated by purposeful work, which gives each person a corresponding number called their suitability [6,7]. The proposed PID controller with applying Genetic Algorithm Method is given in Figure 6, and also the genetic algorithm gain values for the tuning is given below in Table 4.

**Simulation and Discussion**

The range of Kp, ki and Kd is taken in between (0-100) KP Ki and Kd

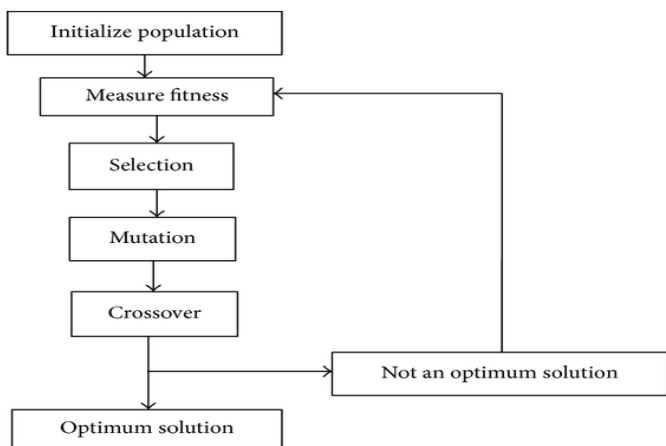


Figure 5. Genetic algorithm method.

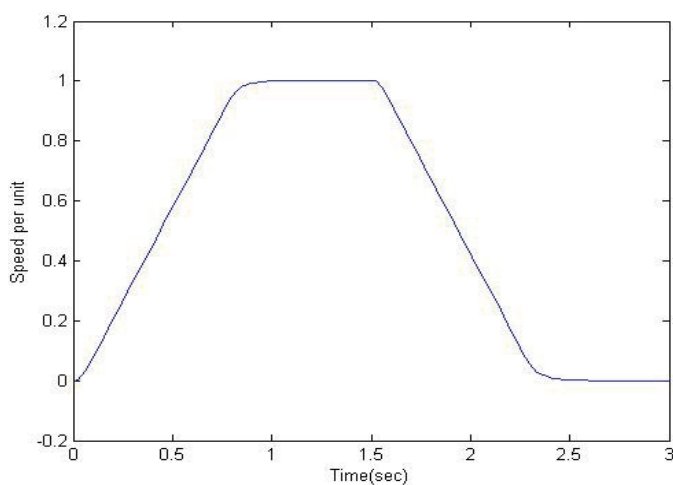


Figure 6. Response of genetic algorithm based PID controller.

Table 4. Shows the gain values for Kp, Ki and Kd.

Gain Parameters	Gain Values
Kp	19.88
Ki	0.1376
Kd	0.5578

Table 5. Shows performance parameters of PID and with GA.

Parameters	Turning Method	
	Conventional PID	Genetic Algorithm
$K_p$	14.7312	5.0916
$K_i$	105.15	80.8051
$K_d$	0.547	0.0549
Rise time(sec)	0.00622	0.0763
Settling time(sec)	0.0837	0.116
Overshoot (%)	47.4%	0%
Peak	1.41	1.02

values are divided by purpose function on Table 5. Figure 7 shows the variation of the best order at the time and the best order is given as the one that gives the zero and the fixed position error, the zero time and the setting time. With a well-planned system throughout the season to the most appropriate level of debt conversion has given us the states of honorable electoral strategies in a particular election-electing organization with elitism.

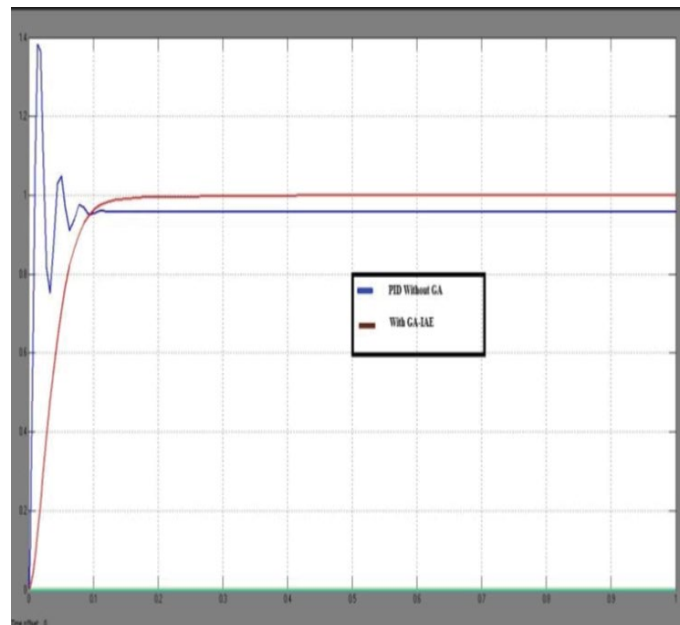


Figure 7. Step input of controlled DC motor drive system.

### Applications

- Electric bikes
- Electric trains
- Robotic control
- Swing machine
- Drill machines

### Conclusion

Obviously the PID controller doesn't get the desired result. A good PID control calculation setting is shown. The positive result of a closed circle is displayed. This paper Demonstrates strategies to plan speed control for DC vehicles with the use of GA and to improve using GA and to resolve over time and fixed condition error. The end result is further shown to make and reflect an increase in GA.

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**How to cite this article:** Chourasia, Ramesh Chandra, Navneet Verma, Puranjan Singh and Shashi Kant. "Speed Control of DC Motor using PID Controller." Global J Technol Optim 13 (2022): 274.