Tuning of PI and PID Controller for Speed Control of DC Motor

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Abstract- *In this paper the armature controlled DC Motor model is designed in Matlab/Simulink. Simulation graph of motor is studied. After that to overcome the fluctuations the DC motor is Tuned first with PI controller and then with PID controller. The response of both controller studied by varying values of K_p, K_i, K_d respectively. And their effects are concluded on rise time , settling time, and steady state error. Also studied that PID having better response than PI controller.*

Keywords- DC Motor, PI, PID, Matlab/Simulink.

I. INTRODUCTION

DC Motor is a machine which converts electric energy into mechanical energy[1]. They are widey used energy converters in modern machine tools and robots[3]. But due to some non linear effects in motor behavior it exhibits fluctuations. To overcome these effects some conventional controllers are employed. PI and PID controllers are the most widely used conventional controllers in the industry. They can provide best results for the user if they are properly tuned. Here the tuning of these conventionl controller is done in order to having desired response.

II. DC MOTOR MODEL

DC Motor model of armature controlled motor is shown below in figure 1.

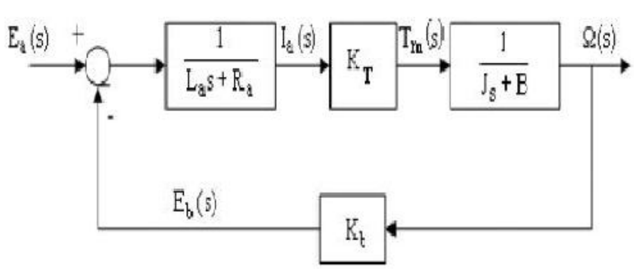

Figure1: Block Diagram of DC Motor

A linear model of a simple DC motor consists of an electrical equation and mechanical equation as determined in the following equations (1) and (2) in order to built the transfer function[2].

$$Va = E_b + IaRa + La\,(dIa/dt) \quad (1)$$

$$Tm = Jm^* \, d\omega/dt + B_m w + T_l \quad (2)$$

Where,

R_a: armature resistance (Ω)
L_a: armature inductance (H)
I_a: armature current (A)
E_a: input voltage (V)
E_b: back electromotive force (V)
T_m: motor torque (Nm)
ω : angular velocity of rotor (rad/s)
J : rotor inertia (kgm2)
B: friction constant (Nms/rad)
K_b: EMF constant (Vs/rad)
K_T: torque constant (Nm/A)

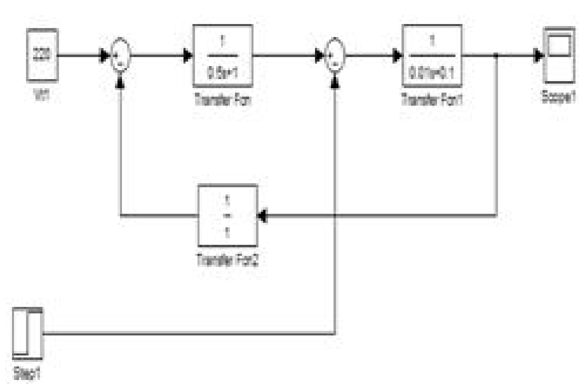

Figure 2: Simulink Model of DC Motor used without any controller

III. PI CONTROLLER

PI is a controller in which two parameters caller P (Proportional) and I(Integral) are involved as shown in figure 3. In proportional control action, the output of controller is proportional to the error. When the error is zero, controller output is constant. In integral control action, the output of controller is change at the rate which is proportional to the actuating error signal. And in derivative control action the output of controller depends on time rate of change of actual errors. The characteristics of PI control action are

- Steady state accuracy improves
- Rise time increases

- Bandwidth decreases
- Response is oscillatory

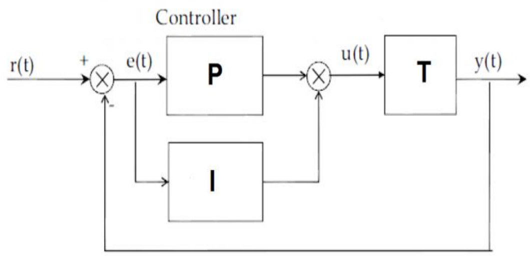

Figure 3 Block Diagram of PI Controller

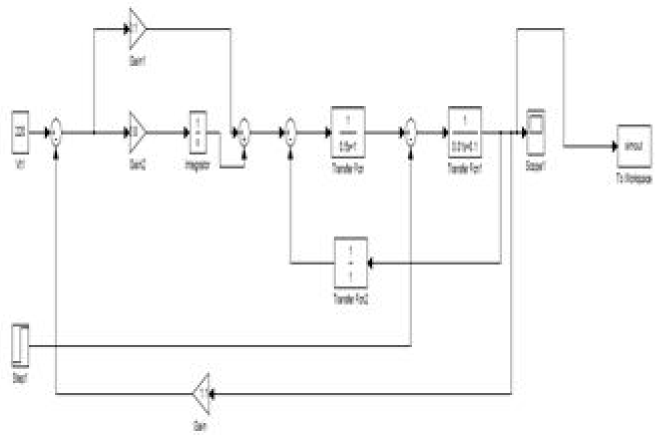

Figure 4: Simulink model of DC Motor with PI Controller

IV. PID CONTROLLER

PID controller is a generic control loop feedback mechanism (controller) widely used in industrial control system. A PID is the most commonly used feedback controller Calculates an error value as the difference between measured process variable and a desired response. The controller attempts to minimize the error by adjusting the process control input. The PID controller calculation (algorithm) involves three constant parameters called the proportional (P), integral (I) and derivative (D) values, these values can be interpreted in terms of time. P depends on the present error, I on the accumulation of past error, and D is a prediction of future error, based on current rate of change .The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, or power supplied to a heating element.

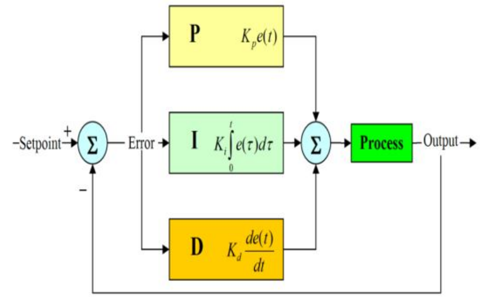

Figure.5 Block diagram of PID Controller

The characteristics of PID Controller are

- No oscillations
- Improves the transient response
- Improves steady state response

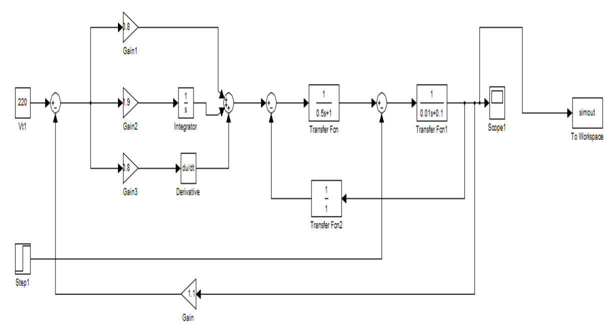

Figure 6:Simulink model of DC Motor using PID Controller

V. SIMULINK RESULTS

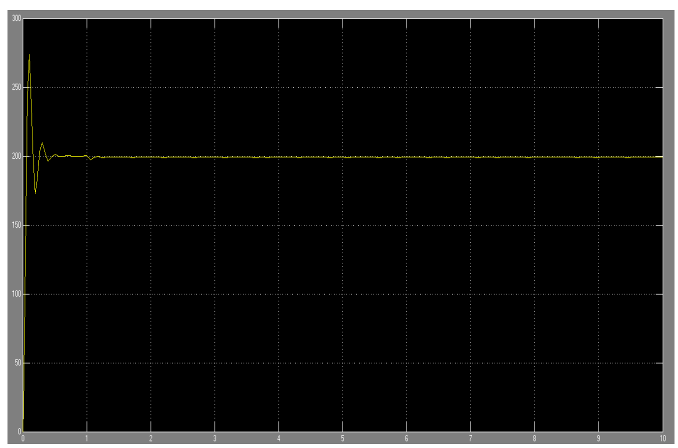

Figure 7: Speed response of motor without any controller

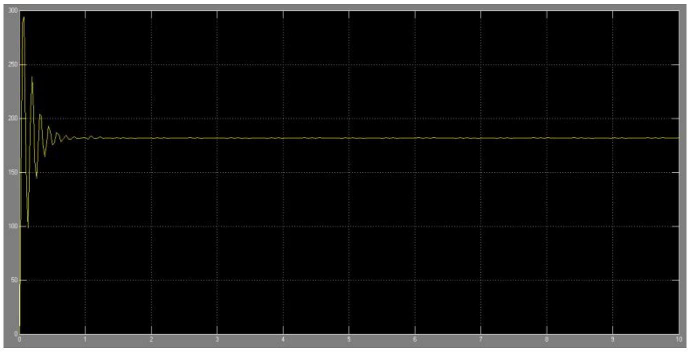

Figure 8: Speed Response of Motor with PI Controller when K_p=10 and K_i=0

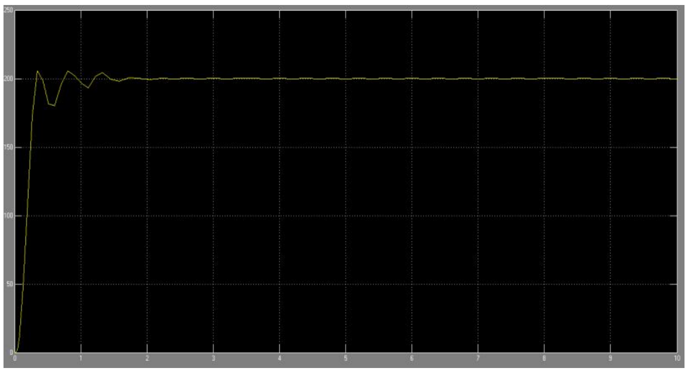

Figure 9: Speed Response of Motor with PI Controller when K_p=0 and K_i=5

Table 1: result for PI control motor

K_p	K_i	Rise time	Settling Time	Overshoot	Steady State Error
5	0	Decreases	Little change	Increases	Increases
10	0	Decreases	Little change	Increases	Decreases

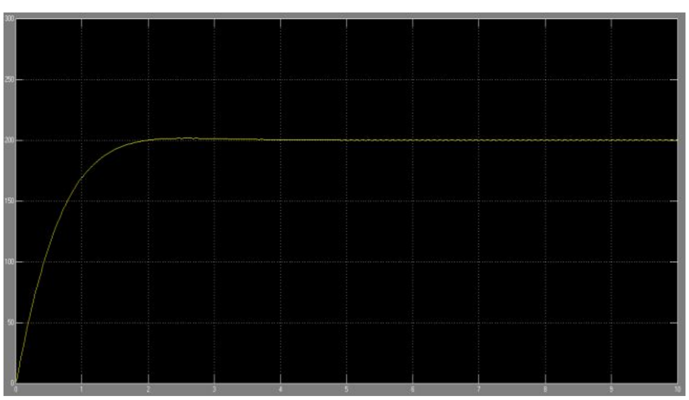

Figure 10: Speed Response of Motor with PID Controller when k_p=0.8,K_i=1.9 and K_d=0.5

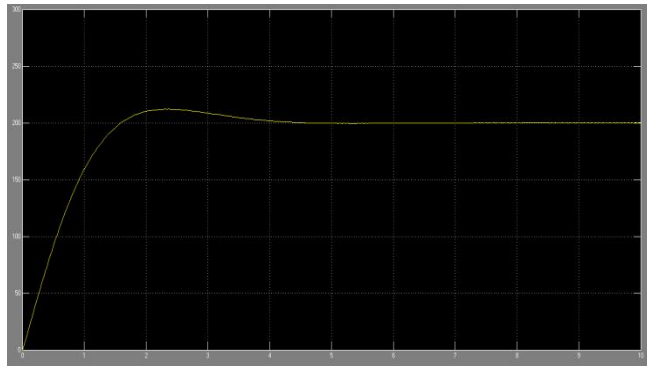

Figure 11: Speed Response of Motor with PID Controller when k_p=0.8,K_i=1.9 and K_d=0.8

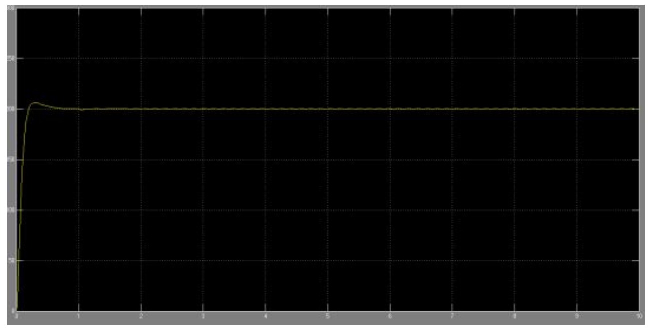

Figure 12: Speed Response of Motor with PID Controller when k_p=2.3,K_i=15 and K_d=0.15

Table 2: Results for PID Controlled DC Motor

K_P	K_I	K_D	Rise time	Settling time	Overshoot	Steady State Error
0.8	1.9	0.5	Increases	Increases	Decreases	Reduces
0.8	1.9	0.8	Little change	Increases	Little Increases	Little Change
2.3	15	0.15	Decreases	Decreases	Decreases	Reduces

VI. CONCLUSION

In this workt, firstly a Simulink model of a DC Motor was designed and then simulation was done. The Speed response graph was then generated. While using PI and PID Controller, some of the important observations that were made are:

- With the increase in K_p the rise time decreases, settling time undergoes small change, overshoot increases.
- With increase in K_I the rise time decreases, settling time increases and overshoot increases.
- With increase in K_D the rise time undergoes small change, settling time decreases and overshoot also decreases.

Table 3: Effect of K_P, K_I and K_D

	Rise time	Overshoot	Settling Time	Steady State Error
K_P	Decreases	Increases	Small change	Decreases
K_I	Decreases	Increases	Increases	Decreases
K_D	Small change	Decreases	Decreases	Decreases

The Speed Response curve was best generated while using PID Controller when the values of all three constants were - K_P=2.3, K_I=15 and K_D=0.15. MATLAB/Simulink Software used for simulation of entire work is user friendly in nature and furthermore other controlling techniques can be employed on this platform.

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