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Speed Control of DC Motor Using PI Controller

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Abstract
This paper introduces a DC motor speed control using PI controller. The proportional and integral (KP, KI) gains of the PI controller are adjusted using Ziegler–Nichols and optimized with trial and error methods. The simulation and results investigation of PI controller is done using MATLAB/SIMULINK software. The simulation development of the PI controller with the mathematical model of DC motor is light out. The performance result of the PID controller is compared in term of response and the assessment is presented.
Keywords: *DC motor, PID controller, Ziegler–Nichols, Optimization.*

1. Introduction

Separately exited direct current motor have been widely use in high-performance electrical drives and servo system. There are many difference DC motor types in the market and all with it good and bad attributes. Such bad attribute is the lag of efficiency. In order to overcome this problem a controller is introduce to the system. DC drives are less complex with a single power conversion from AC to DC. Again the speed torque characteristics of DC motors are much more superior to That of AC motors. A DC motors provide excellent control of speed for acceleration and deceleration.

A PID controller or proportional–integral–derivative controller is a generic control loop feedback mechanism widely used in industrial control systems. A PID controller attempts to correct the error between a measured process variable and a desired set point by calculating and then outputting a corrective action that can adjust the process accordingly. So by integrating the PID controller to the DC motor were able to correct the error made by the DC motor and control the speed or the position of the motor to the desired point or speed.

2. Mathematical Model

To find the transfer function or the block diagram of the open and closed loop system, a differential equation is to describe the system dynamic.

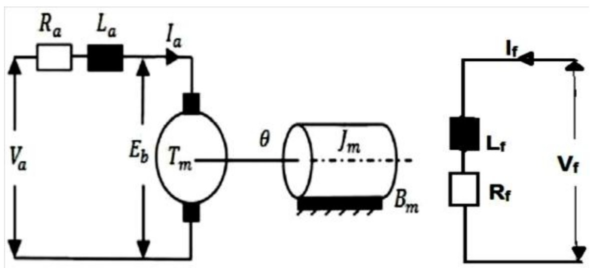

Figure 1: DC Motor Model

Kirchhoff's voltage is use to map the armature circuitry dynamic of the motor in figure (1).

$$\frac{di_a}{dt} = \frac{R_a}{L_a} i_a - \frac{K_m}{L_a}\omega_r + \frac{1}{L_a}V_a \qquad \text{(i)}$$

$$\frac{d\omega_a}{dt} = \frac{K_a}{J_m} i_a - \frac{B_m}{J_m}\omega_r - \frac{1}{J_m}T_L \qquad \text{(ii)}$$

The block diagram of DC motor open loop system is shown in figure (2).

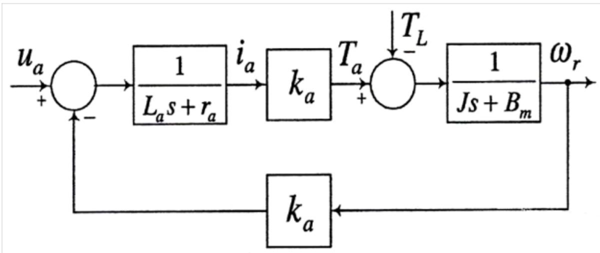

Figure 2: DC Motor Open Loop System

3. PID Controller

PID Control (proportional-integral-derivative) is by far the widest type of automatic control used in industry. Even though it has a relatively simple algorithm/structure, there are many subtle variations in how it is applied in industry A PID controller will correct the error between the output and the desired input or set point by calculating and give an output of correction that will adjust the process accordingly.

The structure of PID controller and process is given in figure (3).

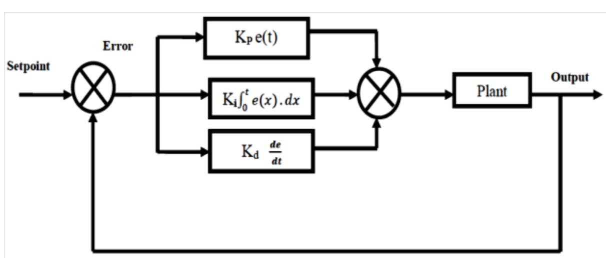

Figure 3: PID Controller Structure

The output of PID is calculated according to the following equation:

$$u(t) = K_D \frac{de(t)}{dt} + K_p e(t) + K_I \int_0^{\tau} e(\tau) d\tau$$

4. Simulation Result

Table (1) shows the parameters of DC motor used in simulation.

Table 1: DC Motor Parameters

Parameter	Value
Armature Resistance R_a	0.55 Ω
Armature Inductance L_a	0.01 H
Armature Voltage V_a	250 V
Mechanical inertia J_m	0.05 Kg.m^2
Friction coefficient B_m	0.02 N.m/rad/sec
Back EMF constant K_a	1.32 V/rad/sec
Torque constant T_a	1.07 N.m/A

Using the same structure as in figure (3) of DC motor and PID controller, the simulation of speed of motor is shown in figure (4). And tracking error is shown in figure (5). This gives better tracking for command signal.

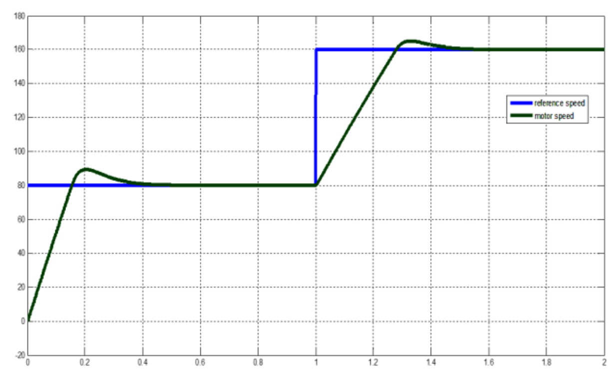

Figure 4: Tracking for Command Signal

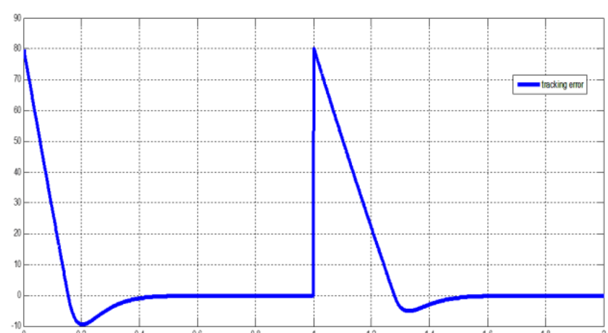

Figure 5: Tracking Error

5. Conclusion

The results show that PID controller can perform efficiently search and gives dynamic performance of the system in a better way as indicated in table.

Table 2: Transient Response Specifications

Characteristic	Value
Rise time	0.1 sec
Settling time	0.5 sec
Peak time	0.2 sec
Overshoot	8 %
Steady state error	zero

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