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Performances and Analysis of D.C Machine using PID Controller

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ABSTRACT: An intelligent PID Controller has been developed for speed control DC Motor. The aims of proposed scheme improve the tracking performance of separately excited DC Motor as compared to the conventional PID Control strategy. Performance of this new control has been verified through the simulation using MATLAB / Simulink. In the present work of PID concept is applied for both control strategy current control and speed control strategy for DC Separately excited motor. Excellent result added to the simplicity of the drive system make the PID Based control strategy suitable for large number of industries paper mills etc. The performance of the proposed system has been compared with traditional one using conventional one controller. The entire system has been modal by matlab. D.C motors drives are widely used in application requiring adjustable speed, good speed regulation and frequent starting, breaking and reversing applications

Keyword: - *D.C. Motor, Controller, Response, Transfer Function, Simulation.*

I INTRODUCTION

Direct Current Motor have been widely used in many industrial application such as electric vehicle, steel rolling mill, electric crane and robotic manipulator due to precise wide simple and continuous and control characteristic the control liability cheapness higher efficiency, higher current carrying capability of static power convertor. The desired torque speed characteristics could be achieved by the used of conventional proportional integral derivative (PID Controller). PID Controller required exact mathematical modeling the performance of the system.

The PID control algorithm is used for the control of almost all loops in the process industries, and is also the basis for many advanced control algorithms and strategies. In order for control loops to work properly, the PID loop must be properly tuned. Standard methods for tuning loops and criteria for judging the loop tuning have been used for many years, but should be reevaluated for use on modern digital control systems.

PID CONTROLLER

The P stands for proportional control, I for integral control and D for derivative control. This is also what is called a three term controller. The basic function of a controller is to execute an algorithm based on the control engineer's input (tuning constants), the operator's desired operating value (set point) and the current plant process value. In most cases, the requirement is for the controller to act so that the process value is as close to the set point as possible. In a basic process control loop, the control engineer utilizes the PID algorithms to achieve this.

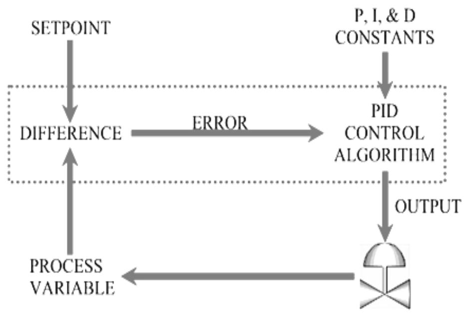

Figure.1 Block Diagram of PID

Brief of PID Controller: With its three-term functionality covering treatment to both transient and steady-state responses, proportional-integral-derivative (PID) control offers the simplest and most efficient solution to many real-world control problems. The PID controllers are usually standard building blocks for industrial automation. The most basic PID controller has the form:

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{d}{dt}(e(t))$$

Where
$u(t)$ is the control output and the error
$e(t)$ is defined as $e(t)$ = desired value – measured value of quantity being controlled.
K_p, K_i, and K_d are the control gains.
Diagrammatically, the PID controller can be represented as Figure

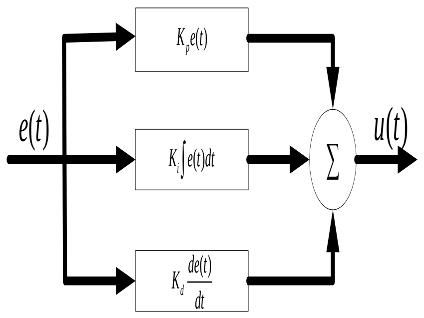

Figure 2 Structure of PID Controller

II TRANSFER FUNCTIONS

The differential equations and transfer functions of DC and AC motors are crucial to the analysis of the control of these machines. The transfer functions are derived from the differential equations using Laplace transforms, a method all too familiar to most engineers.

The differential equations and transfer functions for DC motors are more complicated than those of AC motors, due to the fact that DC motors have time lags because of both the armature inductance and the winding, while AC motors have only a single time constant. DC motors are described by three differential equations:

The developed torque T (t) is described by

$$T(t) = K_2 \cdot i_f(t) \quad , \tag{1}$$

Where $i_f(t)$ is the current through the field and K_2 is constant [2]. The field voltage ($v_f(t)$) is described by

$$v_f(t) = R_f \cdot i_f(t) + L_f \cdot \frac{d}{dt} i_f(t) \quad , \tag{2}$$

Where R_f is the field resistance and L_f is the field inductance [2]. Lastly, the mechanical torque T(t) is described by

$$T(t) = I \cdot \frac{d^2}{dt^2}\theta(t) + B \cdot \frac{d}{dt}\theta(t) \tag{3}$$

Where I is the motor's moment of inertia, B is the motor's viscous damping, and θ(t) is the motor's angular position . By assuming zero initial conditions and then Laplace transforming each of these equations, s-domain equations are reached. The developed torque is now

$$T(s) = K_2 \cdot I_f(s) \tag{4}$$

The field voltage is now

$$V_f(s) = \left(L_f \cdot s + R_f\right) \cdot I_f(s) \tag{5}$$

And the mechanical torque is now

$$T(s) = \left(I \cdot s^2 + B \cdot s\right) \cdot \Theta(s) \tag{6}$$

Where all of the constants have the same meaning as in the time-domain differential equations, I_f is used in place of i_f and Θ is used in place of θ . By substituting and solving, the transfer function of the motor is found to be

$$\frac{\Theta(s)}{V_f(s)} = \frac{K_m}{s \cdot \left(\tau_m \cdot s + 1\right) \cdot \left(\tau_e \cdot s + 1\right)} \tag{7}$$

Where

$$\tau_m = \frac{I}{B} \tag{8}$$

The mechanical time constant of the motor,

$$\tau_e = \frac{L_f}{R_f} \tag{9}$$

The electrical time constant of the motor, and

$$K_m = \frac{K_2}{B \cdot R_f} \tag{10}$$

K_m is another constant . This is the transfer function that will be used for the control analysis of the DC motor in the next section.

The differential equations and transfer functions for AC motors are considerably less complicated than those for DC motors, owing to the fact that AC motors only have a single time constant while DC motors have two. AC motors are described by two differential equations:

The torque (T(t)) is described by

$$T(t) = K \cdot v(t) - m \cdot \frac{d}{dt}\theta(t) \tag{11}$$

Where K is a constant, v(t) is the voltage provided to the motor, θ(t) is the angular position of the motor, and m is described by

$$m = \frac{\text{"stall torque (at rated voltage)"}}{\text{"no-load speed (at rated voltage)"}} \tag{12}$$

Where stall torque (at rated voltage) and no-load speed (at rated voltage) are characteristics of any specific AC motor . The torque is also described by

$$T(t) = I \cdot \frac{d^2}{dt^2}\theta(t) + B \cdot \frac{d}{dt}\theta(t) \tag{13}$$

Which is identical to the third differential equation that describes DC motors, and has the same meaning [2]. By equating the two AC motor equations, assuming zero initial conditions, and then taking the Laplace transform of the resultant equation, the transfer function of an AC motor is found to be

$$\frac{\Theta(s)}{V(s)} = \frac{K_m}{s\cdot(\tau\cdot s + 1)}, \qquad (14)$$

Where

$$K_m = \frac{K}{m + B} \qquad (15)$$

is a constant, and

$$\tau = \frac{I}{m + B} \qquad (16)$$

is the time constant of the motor . This is the transfer function that will be used for the control analysis of the AC motor in the next section.

CONTROL

A control method which is popular because of its robustness, its simplicity, and its reusability is PID control. A PID controller contains a proportional gain, an integrator, and a differentiator (hence its name), all of which are summed together to produce the output of the controller. The transfer function of a PID controller has the form

$$PID = K_P + \frac{K_I}{s} + K_D\cdot s = \frac{K_D\cdot s^2 + K_P\cdot s + K_I}{s} \qquad (17)$$

Where K_P is the proportional gain coefficient, K_I is the integrator coefficient, and K_D is the differentiator coefficient. The proportional gain is used to amplify the input signal. The integrator is used to improve the accuracy of the control system, that is, to minimize the steady-state error as much as possible. The differentiator is used to increase the damping in the system, which will decrease both the peak time and the settling time of the system.

Classification of Control Systems

Control systems are basically classified as –

- Open-loop control system
- Closed-loop control system

In open-loop system the control action is independent of output. In closed-loop system control action is somehow dependent on output. Each system has at least two things in common, a controller and an actuator. The input to the controller is called reference input. This signal represents the desired system output.

Open-loop control system is used for very simple applications where inputs are known ahead of time and there is no disturbance. Here the output is sensitive to the changes in *disturbance* inputs. Disturbance inputs are undesirable inputs that tend to deflect the plant outputs from their desired values. They must be calibrated and adjusted at regular intervals to ensure proper operation.

Closed-loop systems are also called feedback control systems. Feedback is the property of the closed-loop systems which permits the output to be compared with the input of the system so that appropriate control action may be formed as a function of inputs and outputs. Feedback systems have the following features:
Reduced effect of nonlinearities and distortion
Increased accuracy
Increased bandwidth
Less sensitivity to variation of system parameters
Tendency towards oscillations
Reduced effects of external disturbances

The general block diagram of a control system is shown below.

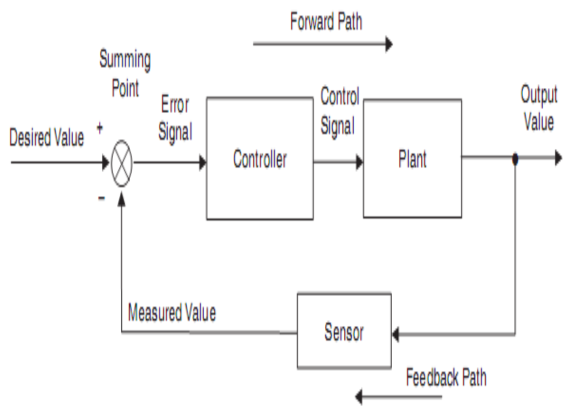

Figure2.1 Closed-loop control system

SPEED CONTROL TECHNIQUES IN SEPARATELY EXCITED DC MOTOR

The speed of a motor is given by the relation

$$N = \frac{V_t - I_a R_a}{Z\emptyset}\left(\frac{60A}{P}\right)$$

$$N = K\frac{V_t - I_a R_a}{\emptyset}$$

Where
Ra is the armature resistance
Ia is the armature current
V is the applied voltage
K= (60A)/(ZΦP)
Φ is the flux

III SIMULATION RESULT

In this paper best result may be obtain by the using the variation of proportional constant gain K_p

The speed response of PID Controller parameters using particle group optimization strategy is shown in lists the performance of PID controller

Conventional PI Controller using current and speed control. In this control strategy current control and speed are applying for improving the performance of DC Motor drive. The conventional PID Regulator is a most widely used control strategy in the industry process because of the remarkable, effectiveness, simplicity of implementation and broadly effectiveness.

At first a PID Controller is design with Simulink than we should through it have a good performance but it is not so robust with system parameter deviation and disturbance and noise.

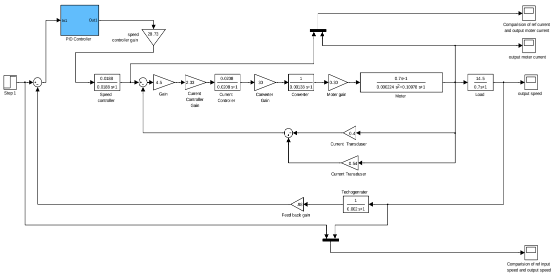

Figure3.1 SimulinK model of PID Controller

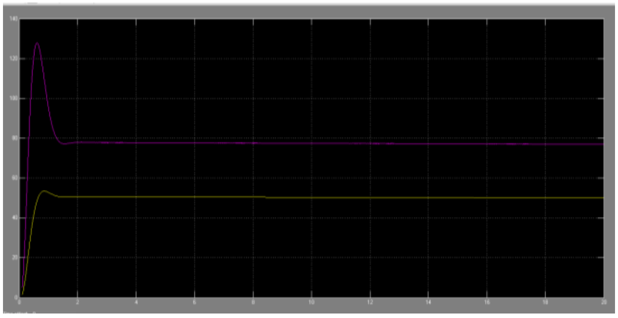

Figure3.2 Comparison of ref current and output motor current

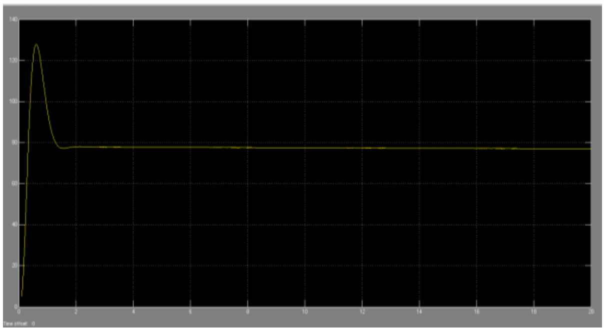

Figure3.3 Output motor current

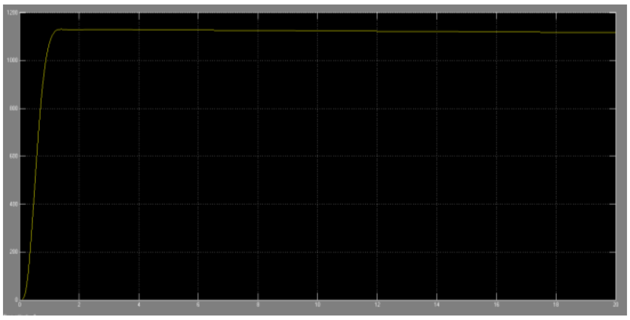

Figure3.4 Output speed at k=.8

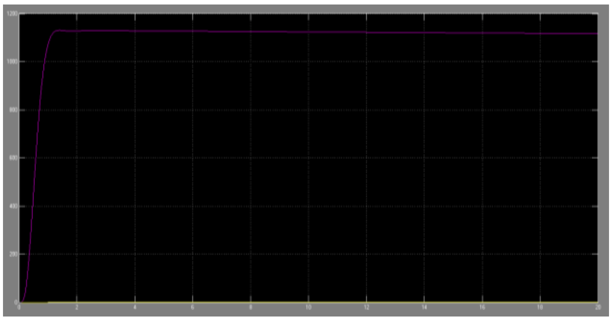

Figure3.5 Comparison of ref input speed and output speed

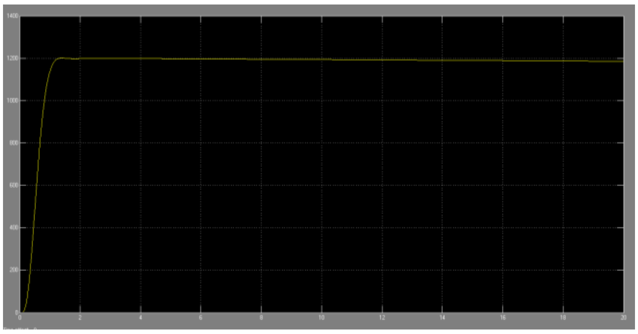

Figure3.6 Output speed at k=.8

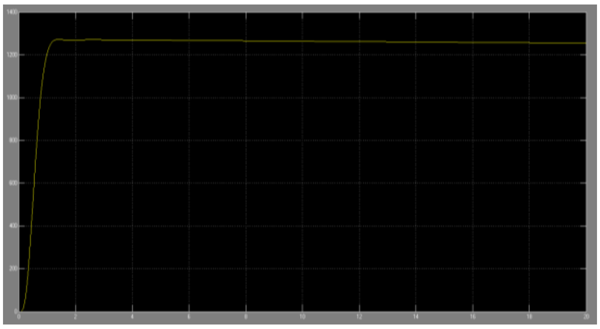

Figure3.7 Output speed at k=.85

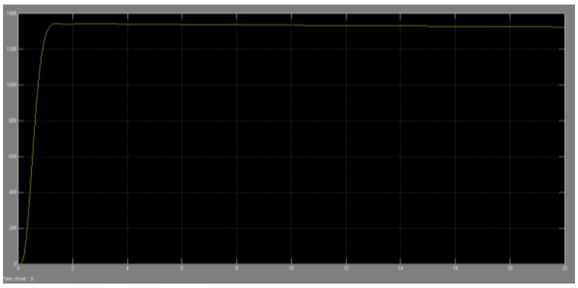

Figure3.8 Output speed at k=.90

The speed response of PID controller comparing with the base speed response. We obtain better speed response.

4.0 RESULTS

The simulation of the complete drive system is carried out based on training for different reference plant with different control strategy. The D.C. motor has been successfully controlled using a PID.

The simulation result shows that the response of the plant with both current and speed controller is better as compared to conventional methods. The results prove that the complete D.C. drive system is robust to parameter variations. The speed control loop of the drive is simulated with a Conventional PI controller; in order to compare the performances to those obtained from the respective PID based drive system. The dynamic and steady state performance of the PID based controlled drive is much better than the PI controlled drives. By using the PID controller concept with D.C. motor the performance and dynamics of the D.C. motor is improved in comparison to conventional PID controllers.

5.0 CONCLUSION

By using PID mode controller for the separately excited DC motor speed control, the following advantages have been realized. The speed response for constant load torque shows the ability of the drive to instantaneously reject. According to the simulation result the PID Controller has better performance and counting with noise and disturbance speed response and parameter variation. In PID controller no oscillation present & there no transient response & steady - state error reduced.

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