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Design & Simulation of Speed Control for DC Drives using Smart Controller

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***Abstract*-- This paper presents a hybrid PID-MRAC control system for the speed control of a DC motor. The proposed method incorporates PID and MARC controllers with utilization of Gradient Descent method & control technique. This method combines the advantages of PID controller and MARC controllers to improve the speed response of the DC motor. Simulation & modeling of DC Motor and Speed control for DC Motor using Smart Controller (PID Controller and MRAC) was done. The mathematical model of DC motor with independent armature/filed control can be obtained by considering the electrical system, electromagnetic interaction and mechanical system. Simulation models for DC motor speed control methods and feedback control system using DC motor drives have been developed with Model Reference Adaptive Control in Simulink/Matlab using Gradient Descent method. Model Reference Adaptive Control method is implanted in Modeling of armature voltage control DC motor to find the results of speed v/s time to stimulate discrete model and also simulate the DC Motor model and DC Motor Model with PID Controller**

Index: - DC Motor, Existing tuning, MRAC, Steady State Error, PID controller, Simulink, MATLAB

I. INTRODUCTION

During the nineteenth century, when power supply was dc, dc motors were used extensively to draw power direct from the dc source. The advent of thyristors capable of handling large current has revolutionized the field of electric power Control. DC motor drives are used for many speed and position control systems where their excellent performance, ease of control and high efficiency are desirable characteristics.

DC motor are generally controlled by conventional Proportional – Integral – Derivative (PID) controllers, since they designed easily, have low cost, inexpensive maintenance and effectiveness. It is necessary to know system's mathematical model or to make some experiments for tuning PID parameters. Due to its excellent speed control characteristics, the DC motor has been widely used in industry even though its maintenance costs are higher than the induction motor. As a result, position control of DC motor has attracted considerable research and several methods have evolved. Proportional-Integral Derivative (PID) controllers have been widely used for speed and position control of DC motor.

Automation control, motion control and machine automation systems are used to improve manufacturing performance and flexibility. Engineering assistance with machine safety, energy efficiency, and breakthrough motion control and automation concepts. Reduce energy consumption. Improve worker safety. Make more effective use of new, integrated approaches to complex engineering challenges.

Computer modeling and simulation tools have been extensively used to support and enhance electric machinery courses. MATLAB with its toolboxes such as Simulink [1] and Sim Power Systems [2].Traditionally rheostatic armature control method was widely used for the speed control of low power DC motors. The desired torque-speed characteristics could be achieved by the use of hybrid conventional proportional-integral-derivative (PID) and MRAC controllers.

II. DC MOTOR MODEL

The resistance of the field winding and its inductance of the motor used in this study are represented by R_f and L_f, respectively. The resistance of the armature and its inductance are shown by R_a and L_a respectively in dynamic model. Armature reaction effects are ignored in the description of the motor. This negligence is justifiable to minimize the effects of armature reaction since the motor used has either interlopes or compensating winding. The fixed voltage V_f is applied to the field and the field current settles down to a constant value. A linear model of a simple DC motor consists of a mechanical equation and electrical equation as determined in the following equations

$$V_a - E_b = R_a I_a + L_a \frac{dI_a}{dt} \quad (1)$$

$$T_m = f_m w_m + J_m \frac{dw_m}{dt} \quad (2)$$

$$T_m = f_m \frac{d\theta_m}{dt} + J_m \frac{d^2 w_m}{dt^2} \quad (3)$$

From the above three equations we can get in S domain equation (4) as given below

$$\frac{\theta(s)}{V(s)} = \frac{K_b}{JL_a S^3 + (R_a J + BL_a)S^2 + K^2{}_b + (R_a B)S}$$

Put all parameters values in equation no. (4) as shown in just above

R_a = 2.45 ohm
L_a = 0.035 H
K_b = 1.2 volt/ (rad/sec)
J = 0.022Kg-m^2/rad
B = 0.5*10^3 N-m/ (rad/sec)

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$$\frac{\theta(s)}{V_a(s)} = \frac{1.2}{0.00077s^3 + 0.0539s^2 + 1.441s}$$

Simulation of transfer function of equation (4)

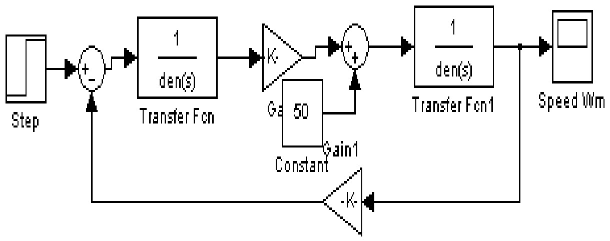

Fig.1: Simulink Model of DC Motor Uing Transfer Function

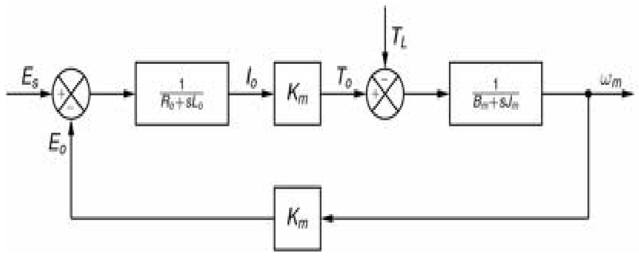

Fig.2: Simulink Model of DC Motor Transfer Function of equation (4)

III. SPEED CONTROL OF DC MOTOR

The DC motor can be controlled by controlling armature voltage and armature current. We know that speed control is possible by varying

- Flux per pole (controlling of flux).
- Resistance Ra of armature (By Rheostat Control).
- Applied voltage.

The above methods have some demerits like a large amount of power is dissipate in the controller resistance hence efficiency decreased. And also it requires very complicated and expensive arrangement for dissipations of heat produced in the controller resistance. It also gives very low speed below the normal speed. So by this we can conclude that these electrical and electromechanical methods are less economical, efficient and not of much use as these methods are having multiple drawbacks, so electronic methods and techniques are used for controlling of speed. These methods provide higher efficiency and feasibility, good reliability and quick response. One such very widely used technique is smart controller which the combination of PID controller and MRAC controller. We apply this technique in our work to control the speed of DC motor.

IV. SPEED CONTROL WITH PID CONTROLLER

Proportional-Integral-Derivative, PID, controller is widely used in industrial control system. PID controller has all the necessary dynamics: fast reaction on change of the controller input (D controller), increase in control signal to lead error towards zero (I controller) and suitable action inside control error area to eliminate oscillations (P controller). Derivative mode improves stability of the system and enables increase in gain Kp, which increases speed of the controller response. The output of PID controller consists of three terms the error signal, the error integral and the error derivative. Fig.3 shows the block diagram of PID controller. PID controller combines the advantage of proportional, derivative and integral control action.

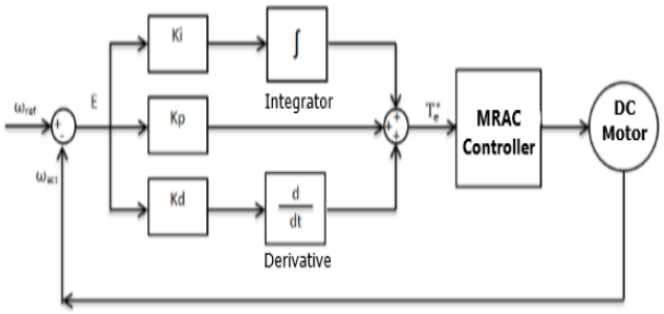

Fig.3 PID controller block diagram.

Table1: The effects of gain coefficients on the performance of PID controller system.

Type	Rise Time	Overshoot	Settling Time	Steady State Error
K_p	*Decrease*	*Increase*	*Small change*	*Decrease*
K_i	*Decrease*	*Increase*	*Increase*	*Eliminate*
K_d	*Small change*	*Decrease*	*Decrease*	*Small change*

V. SPEED CONTROL WITH MRAC CONTROLLER

Model reference adaptive control (MRAC) is one of the main approaches to adaptive control. The basic structure of a MRAC scheme is shown in Fig. 4. The reference model is chosen to generate the desired trajectory, y_m that the plant output, y_p has to follow. The tracking error $e = y_p - y_m$ represents the deviation of the plant output from the desired trajectory. The closed-loop plant is made up of an ordinary feedback control law that contains the plant and a controller $C(\theta)$ and an adjustment mechanism that generates the controller parameter estimates $\theta(t)$ on the line. This design methodology allows the use of a wide class of adaptive algorithms that includes gradient, least-squares and those based on the SPR Lyapunov design approach

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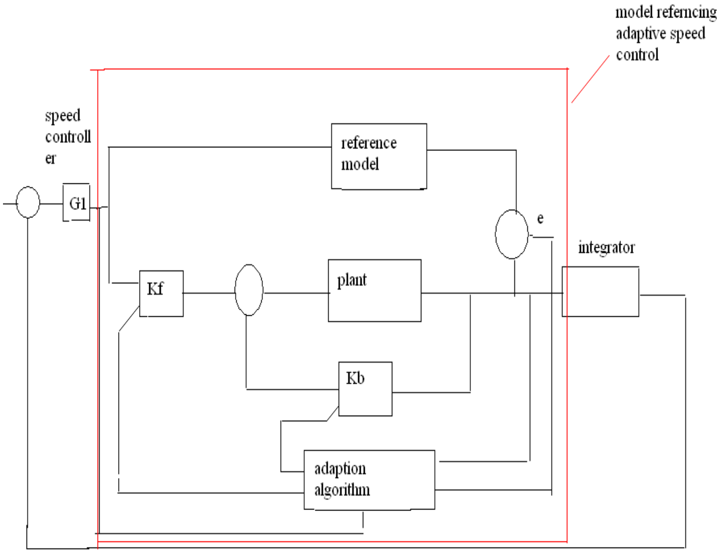

Fig.4: DC drive with model referencing adaptive speed control Scheme

VI. DESIGNED MODEL FOR DC MOTOR SPEED CONTROLLER

The Simulink model used to get desired speed characteristic for a DC Motor is shown in fig.5. This system (plant) under control is a continuous-time system. The 'heart' of the controller is a PID. The problem of realizing this system is mainly one of simulating dc motor with the help of its transfer function equations as shown in above.

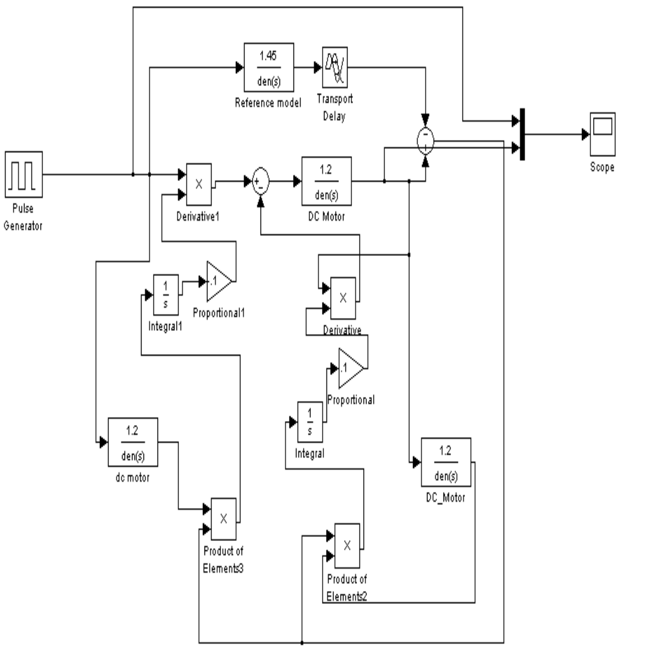

Fig.5: Simulink model of DC motor with controllers

VII. SIMULATION RESULTS

This section discussed the results generated with different condition of load applications for the validation of work. Here Simulation results of speed control of DC motor using controller are shown in figure nos. 6 to 9.

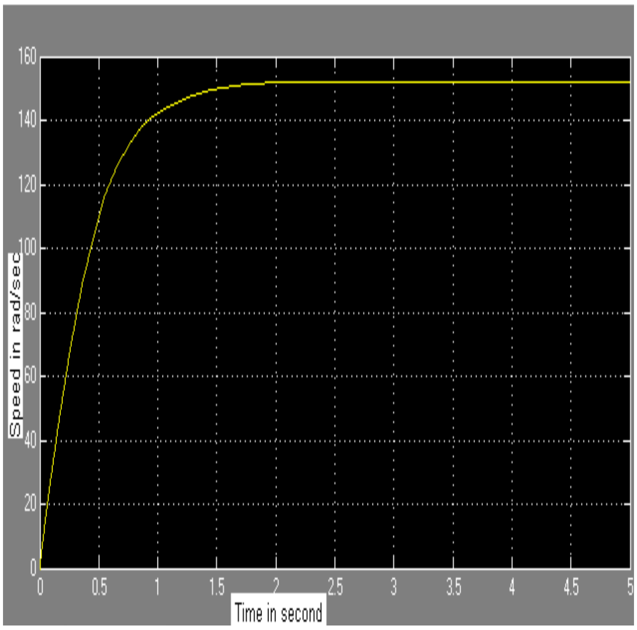

Fig.6: Simulink model of DC motor Transfer Function

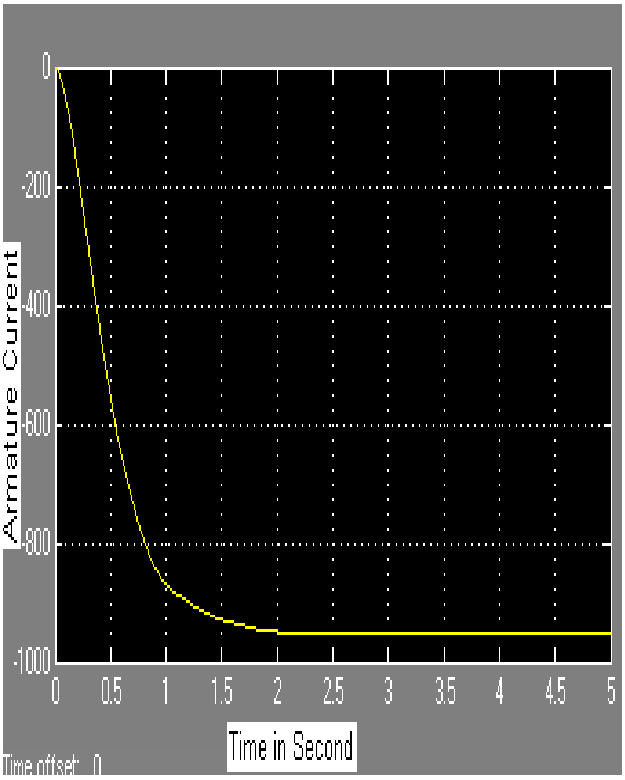

Fig.7:Simulink Result of DC Moter Transfer Function Armature Curent

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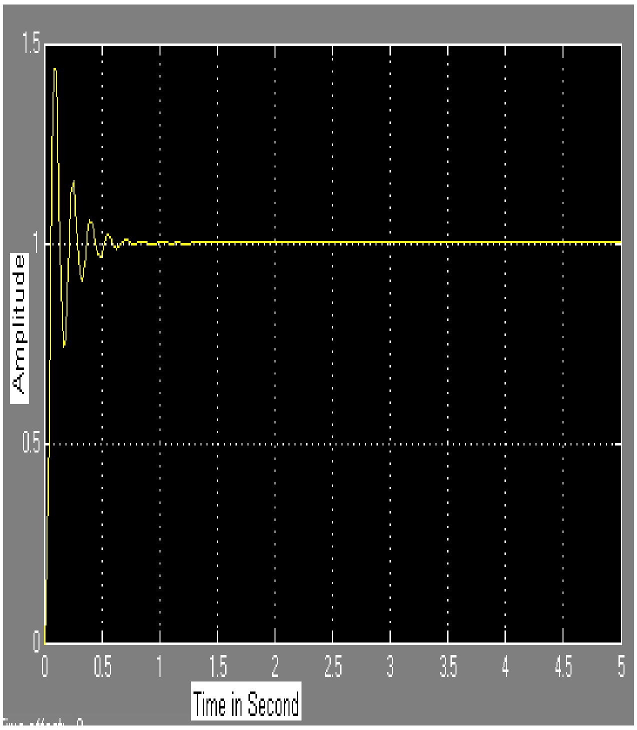

Fig.8: Simulink Result of DC Moter with PID Controller

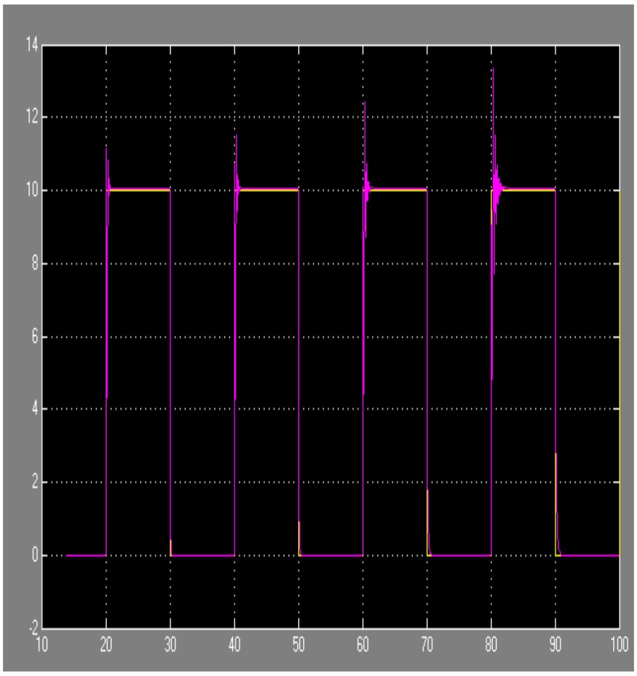

Fig.9: Simulink Model of DC Moter with PID in MRAC method

VIII. CONCLUSIONS

The speed of a dc motor has been successfully controlled by using smart Controller. A generalized modeling of dc motor is done. After that a complete layout of DC drive system is obtained. A DC motor specification is taken and corresponding parameters are found out from derived design approach. The effect of armature voltages, resistance, inductance and reaction on controlling of speed characteristic is observed. Ultimately simulation is done for model. The simulation speed/time plots show that, before steady state conditions are reached, the following occurs.

- The speed takes a certain time to initially reach the level of the final value (the rise time).
- The speed overshoots the level of the final value.
- The speed oscillates about the level of the final value.

The speed control of DC motor by modern adaptive control method is achieved.

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