Full Order Observer Based Speed Control of DC Motor

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ABSTRACT- *The control of DC motor system is difficult and mathematically tedious due to their non linearity properties. To overcome this difficulty, a new approach has been required. This paper presents a systematic procedure to develop PI based speed controller for DC motor. The design of speed controller based on full order observer. The performances and characteristics of DC motor are observed. The simulation results verify that steady state error is reduced, the rising time is improved and the disturbances affect is reduced hence the better performances of DC motor.*

KEYWORDS: - *DC motor, Linear, Full order Observer, Speed Controller.*

1. INTRODUCTION

The DC motors are in general much more adaptable speed drives than AC motors which are associated with a constant speed rotating field. It is observed that most of the industry is operating under stress condition further load parameter and control variable exhibit uncertainness in real practice and in fact these are random variables. Calculated values of load variable normally contain various inaccuracies.

It has been observed that error may vary in the range of 5-10%. A few percentage error may be required tolerable in the area of the load speed controlling where these inaccuracies in the entire controller. In such situation minor inaccuracy in speed control are of little concern. Further the speed controller can always be designed to have sufficiently low effect on the non linearity of DC motor; so as to worst effect of parameter uncertainty can be accounted. In real time operation, the situation is different; design controller may encounter situation never imagined by designer before it took its present shape. Hence, in real time operation condition, risk of affecting nonlinearity of motor is always present. Here it is designed a controller which not affects the nonlinearity in DC motor.

Dynamic behavior of DC motor followed by:

2. DC MOTOR

The stator of the DC motor has poles, which are excited by DC current to produce Magnetic fields. The rotor has a ring-shaped laminated iron-core with slots. Coils with several turns are placed in the slots. The distance between the two legs of the coil is about 180 electric degrees. DC motors are characterized by their versatility. By means of various combinations of shunt, series and separately excited field winding they can be designed to display a wide variety of volt ampere or speed torque characteristics for both dynamic and steady state operation. The separately excited dc motor model is chosen for its good electrical and mechanical performances rather than other DC motor models. The DC motor is driven by applied voltage. In DC motor, the torque may be controlled by varying the armature current or field current. One of these is varied to control the torque while the other is held constant.

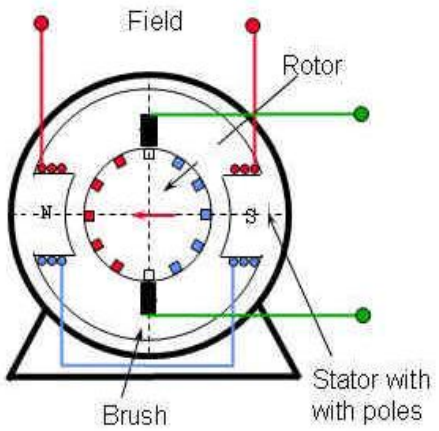

Fig. 1: Basic diagram of DC motor

$\frac{di_a}{dt} = V/L_a - K\Phi\omega/L_a - R_a\, i_a/L_a$ .....(1)

$\frac{d\omega}{dt} = -B_1/J + K\Phi\, i_a/J - T_L/J$ .....(2)

State-Space Equation For DC Motor:

$dx/dt = Ax + Bu, \quad y = Cx + Du$ .....(3)

$$A = \begin{bmatrix} -R_a/L_a & -K\phi/L_a \\ K\phi/J & -B_1/J \end{bmatrix}$$

$$B = \begin{bmatrix} 1/L_a \\ 0 \end{bmatrix}$$

C = [0 1]

D = [0 0]

The parameters of a DC motor taken below:

J_m 0.02215 Kg-m^2

B_m 0.002953 N-m/rad/sec

K_m 1.05 N-m/ A

K_b 1.05 V/rad/sec

R_a 2.581 Ω

L_a 0.028 H

3. FULL ORDER OBSERVER

A state observer estimates the state variables based on the measurement of the output and control variables. State observer can be designed if and only if the observability condition is satisfied which is –

$W_O = [C^T, A^TC^T, (A^T)^2 C^T \ldots (A^T)^{n-1}C^T]$ ...(4)

Assume that the state X is to be approximated by the state $\tilde{x}$ of the dynamic model

$\dot{\tilde{x}} = (A + LC)\tilde{x} + Bu - Ly$ ....(5)

Which represent the state observer the state observer has y and u as input and $\tilde{x}$ as output and L is the observer gain.

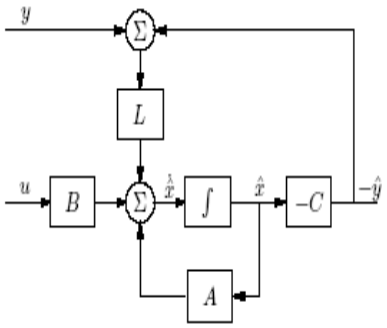

Fig. 2: Basic Block diagram for observer

4. PI CONTROLLER

PID tuning is a complex problem, even though there are only three parameters and in principle is easy to evaluate, because it must satisfy complex criteria within the limitations of PID control. PI control with its two term functionality covering treatment to both transient and steady stet response, offers the simplest and yet most efficient solution to many real world control problems. In spite of the simple structure and robustness of this controller, optimally tuning gains of PI controllers have been quite difficult. When the control problem is to regulate the process output around a set point, it is natural to consider error as an input, and it follows that the integral of the error.

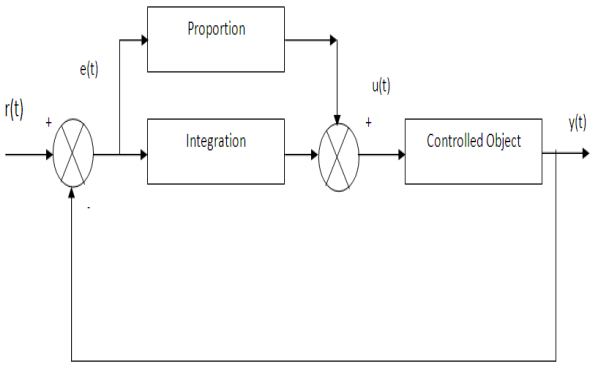

Fig. 3: PI Controller

5. SIMULATION & RESULTS

The DC motor model as defined in equations above is simulated by using MATLAB. The PI controller is introduced in system and performance is observed.

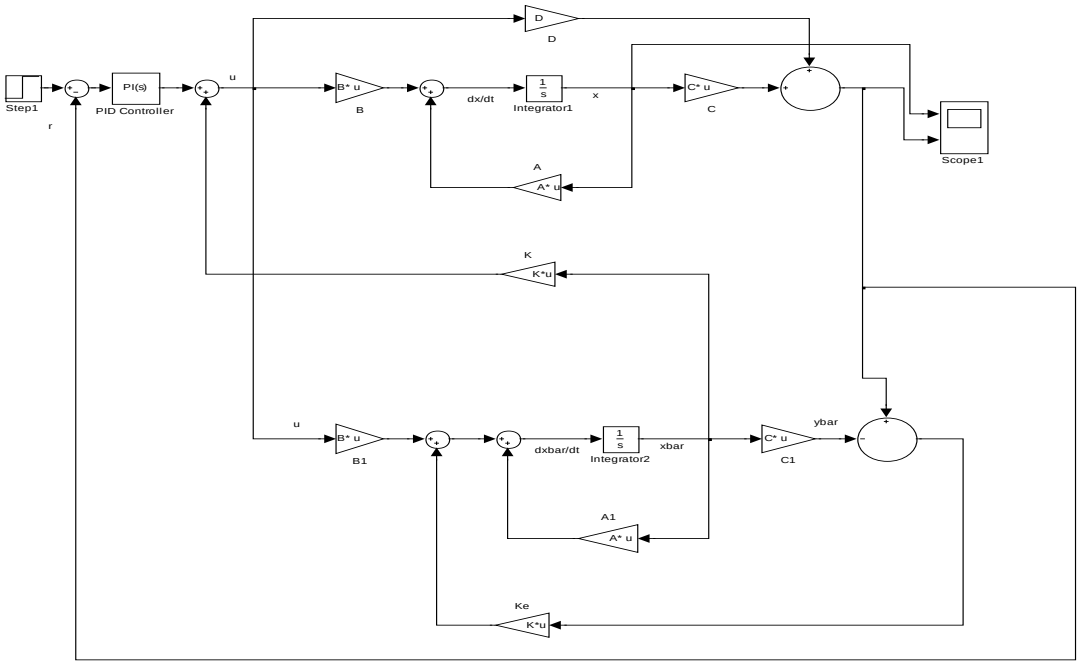

Fig. 4: Matlab model of full order based speed controller of DC motor

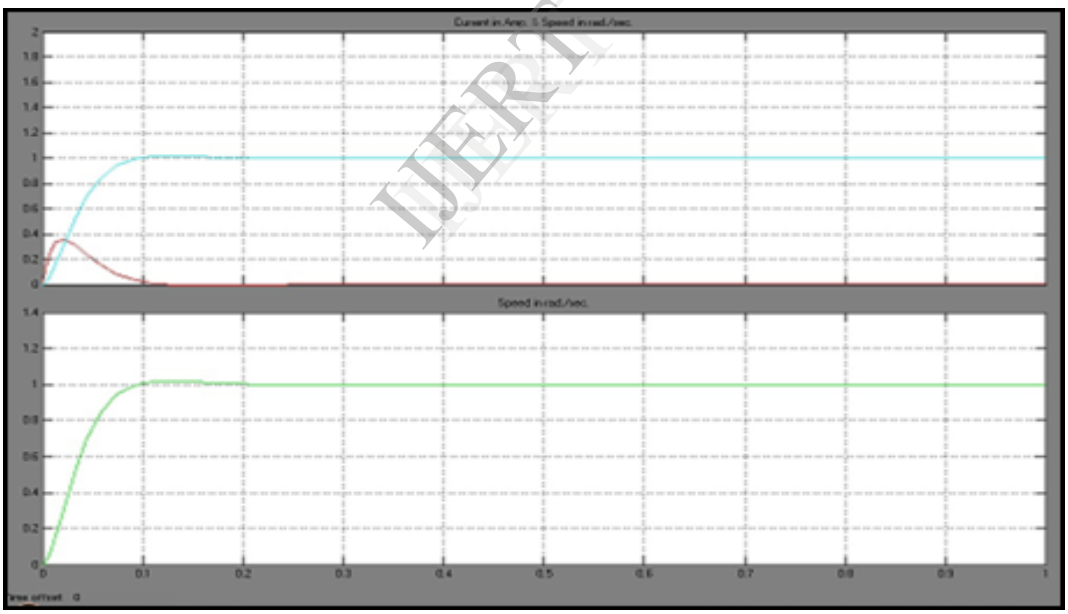

Fig. 4: Current & Speed characteristic of DC motor

6. CONCLUSION

The behavior of DC motor with Full order observer based PI controller is studied. This model presented to find out optimal parameter of PI controller using the full order observer. The results show that the proposed PI controller can perform an efficient performance for speed controlling of DC motor. This model can improve the dynamic performance of the system in a better way. The proposed model presented satisfactory performances and possesses good robustness (no overshoot, minimal rise time, Steady state error = 0).

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