A NEW SCHEME FOR DIRECT ESTIMATION OF PID CONTROLLER PARAMETERS

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a novel scheme for the direct estimation of a PID (Proportional Integral Derivative) controller parameters (K_p, T_i, T_d).The proposal discussed here is only applicable to first and second order stable systems. The formulation begins with system parameter identification (Transfer function of the process), which has been obtained using system identification toolbox of MATLAB. The pole zero cancellation technique is applied to estimate PID controller parameters which in-turn results into the matched coefficients of the system parameters to the Controller parameters. An additional tuning parameters α is proposed in our method, which provides an additional flexibility of tuning the response time of the controller without disturbing the controller parameters. The proposed scheme is bench marked using real time case of dc motor speed control. The effectiveness and robustness of the proposed auto tuning algorithm are verified by the simulation results.

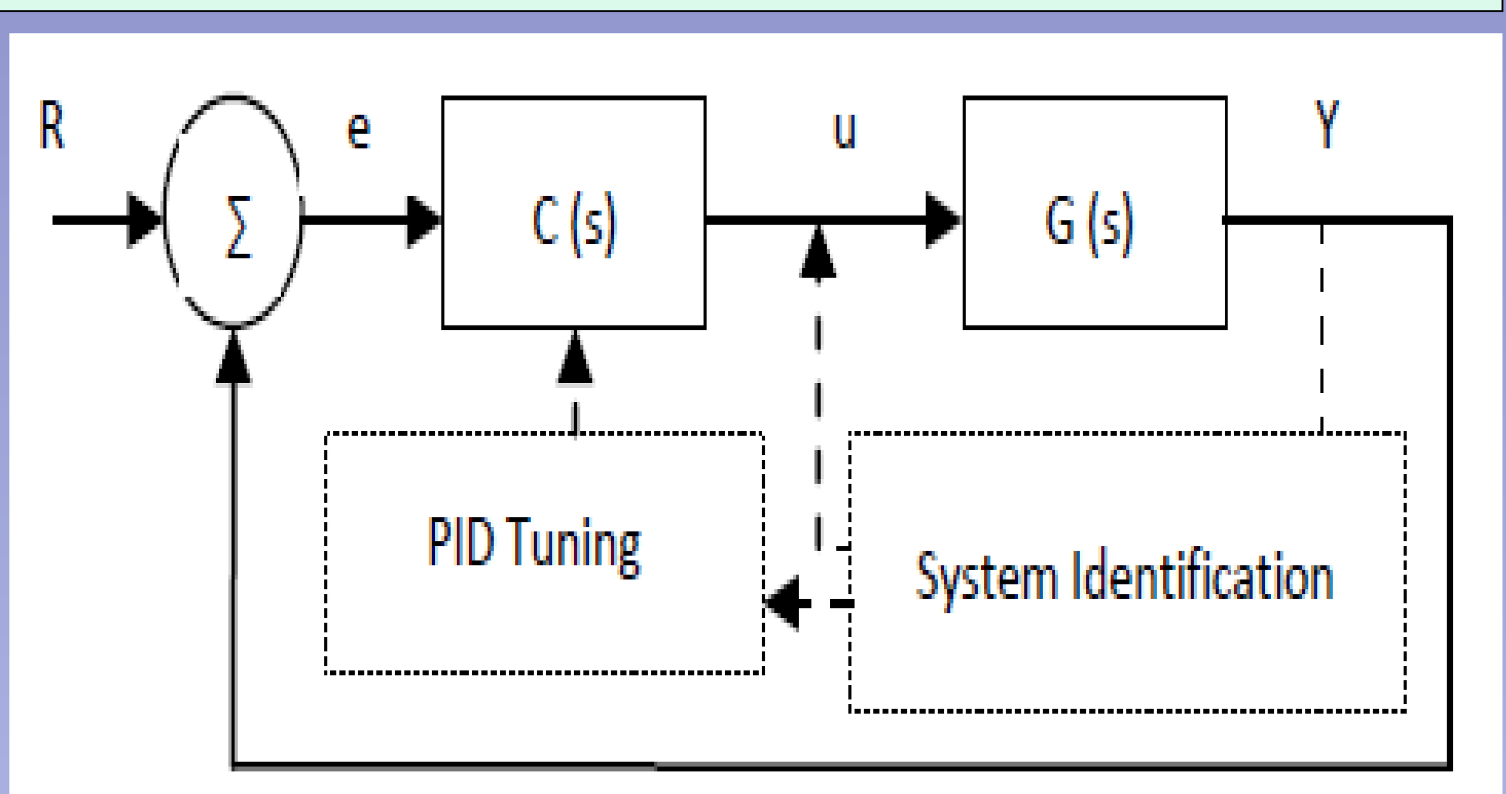

Figure 1: Auto Tuning Scheme of PID Controller

PID TUNING

•PID tuning comprises the selection of best value of K_p, T_i and T_d of the PID controller so that the system performance can be increased .

•The tuning basically based on the logic that if we can be able to make the closed loop transfer function of the system in such a way that the poles of the open loop TF of the system exactly cancelled by the zeroes of the PID controller.

• Arranging the PID parameter in that way leads the closed loop transfer function (CLTF) of first order and then there should be no overshoot.

•Rise time and settling time can be tuned by introducing an extra parameter 'α' in cascade with the input of controller as shown below :-

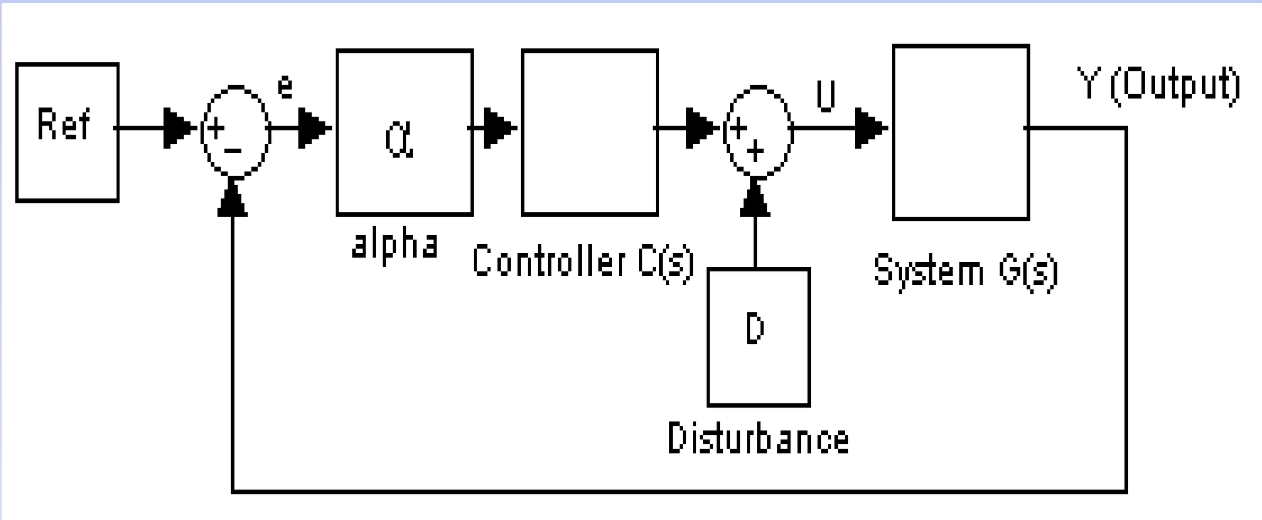

Figure 2: Block Diagram of the Closed Loop system with PID and parameter 'α'

AUTO TUNED PID CONTROLLER

•Auto tuned means the controller has the ability to tune its PID parameter automatically.

•Auto tuning comprises two parts consistently first one is auto estimation of transfer function (TF) by system identification toolbox of MATLAB and after that matching the coefficients of PID parameter with the estimated transfer function.

• The PID parameter that's comes out for second order transfer function with no zeroes are:-

$$\begin{bmatrix} K_p \\ T_d \\ T_i \end{bmatrix} = \begin{bmatrix} a/K \\ 1/a \\ a/b \end{bmatrix}$$

•Where *a*,*k* and *b* are the plant transfer function coefficients that is:-

$$G(s) = \frac{K}{s^2 + as + b}$$

•When these values are put in Figure 2 then the CLTF becomes:-

$$\frac{Y_{o/p}}{R_{ef}} = \frac{\alpha}{s+\alpha}$$

RESULTS

•For the verification of the above proposed PID tuning we have taken a case study of the speed control of the DC motor.

• The original transfer function of the DC motor speed control [4] are:-

$$\frac{speed(\dot{\theta})}{Voltage(V)} = \frac{K}{JLs^2 + (JR+Lb)s + bR + K^2}$$

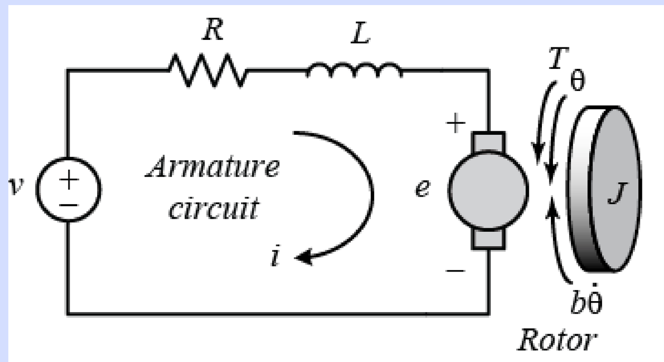

Figure 3. DC Motor

where,

Moment of Inertia of rotor (J) = 0.01Kgm^2/s^2
Damping ratio of mechanical system (b) =0.1*Nms*
Electromotive force constant (K) =0.01 *Nm/A*
Electric resistance (R) = 1
Electric Induction (L) = 0.5 H
Output velocity $\dot{\theta}$ =*m/s*

• So, the Transfer Function becomes:-

$$G(s) = \frac{\dot{\theta}}{V} = \frac{2}{s^2 + 12s + 20.02}$$

• The estimated TF are :-

$$G(s) = \frac{\dot{\theta}}{V} = \frac{1.8}{s^2 + 10.8s + 18}$$

• AutoTuned PID parameters are:-

$$\begin{bmatrix} K_p \\ T_d \\ T_i \end{bmatrix} = \begin{bmatrix} 6 \\ 0.0926 \\ 0.6 \end{bmatrix}$$

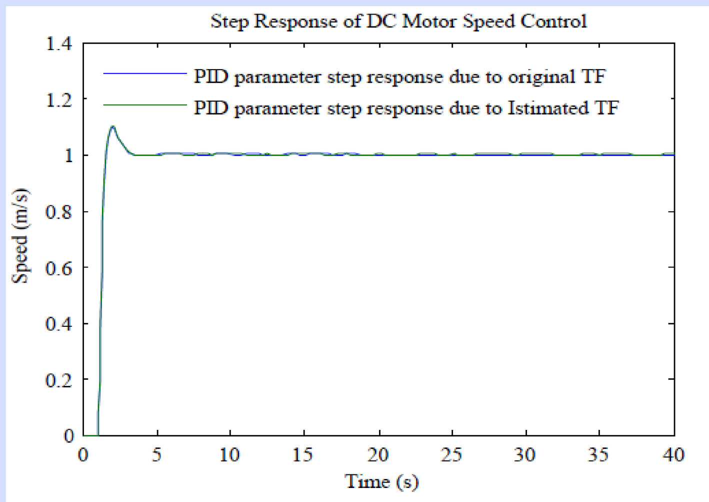

Figure 4: Comparison of step response between the PID parameters calculated for original and Istimated transfer function (TF).

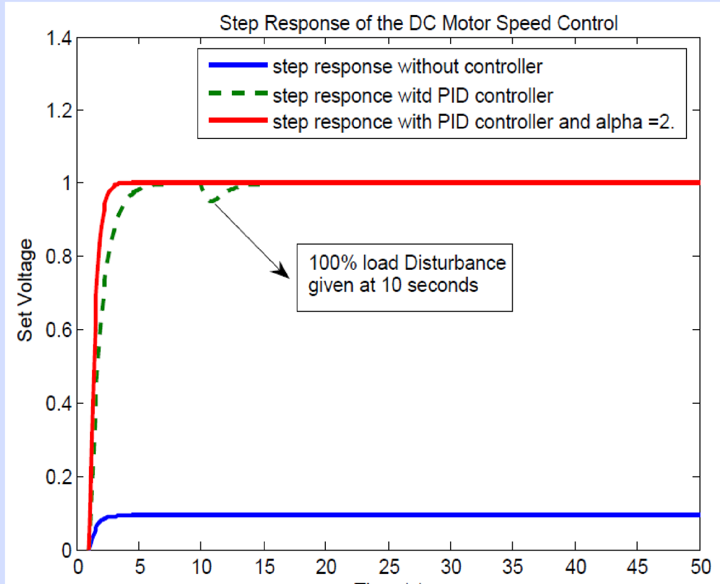

Figure 5: Step Response of the DC motor speed control

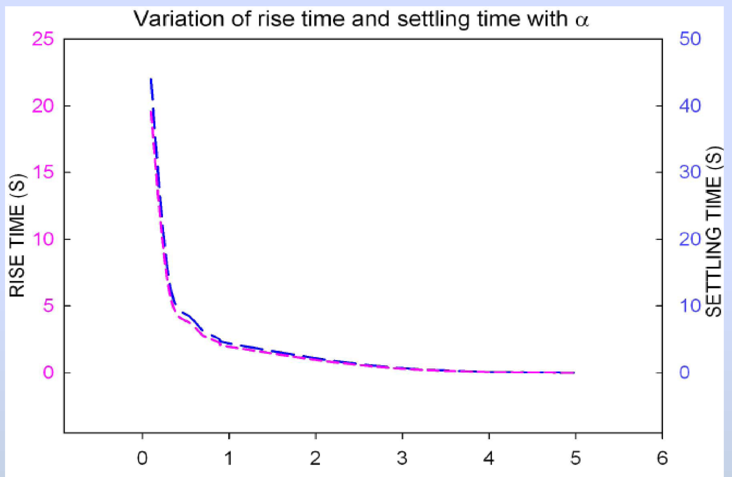

Figure 6: Effect of α over the rise time and settling time.

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