ID.No./Seat No.

MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO.

SECOND TERM THIRD YEAR (6^{TH} TERM) B.E.(ELECTRONIC) REGULAR EXAMINATION 2012 OF 10-BATCH.

MODERN CONTROL SYSTEMS

Dated: . Time Allowed: 03 Hours. Max.Marks 80

NOTE: ATTEMPT ANY **FIVE** QUESTIONS.

Q.No. **Marks**

01 A D.C motor control system has the form shown in figure-1. The two state variables (angular speed and angular position) are available for measurement. **[16]**

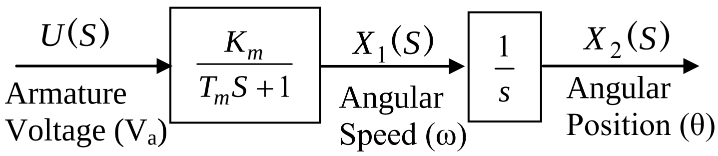


Figure-1

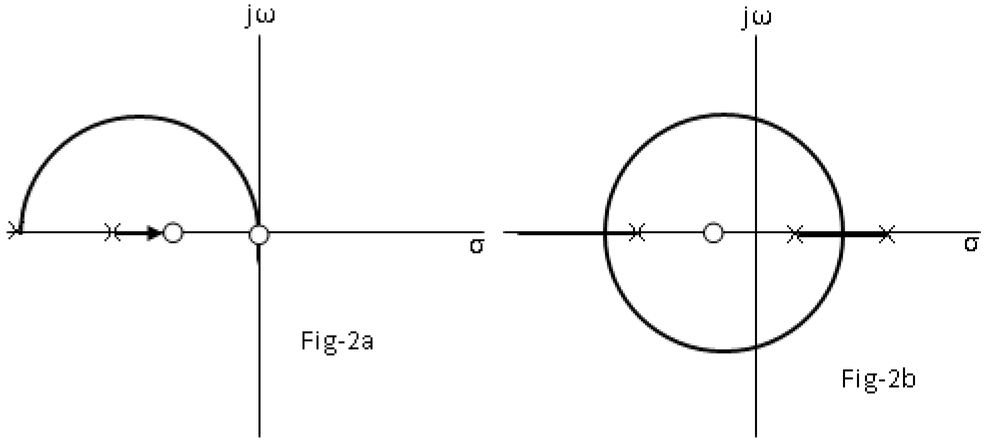
Where,

$$Km = \frac{K}{R_a B + KK_b} = 62 \quad and \quad Tm = \frac{R_a J}{R_a B + KK_b} = 0.05$$

Select the feedback gain so that for a step input the system has percent overshoot less than 15%. The state space representation in observability canonical form for unity feedback system is given below.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & -1240 \\ 1 & -20 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(t)$$

02 For each of the following root loci, tell whether or not the sketch can be a root locus. If sketch cannot be a root locus, explain why? **[16]**



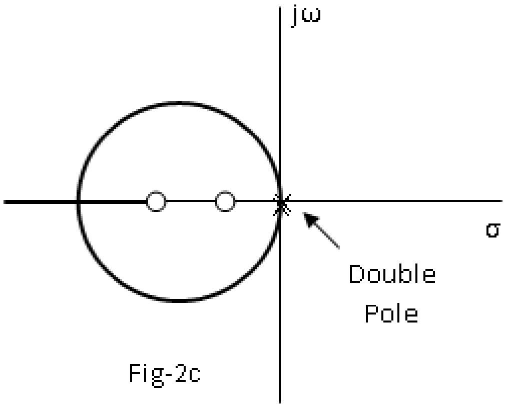


Fig-2c

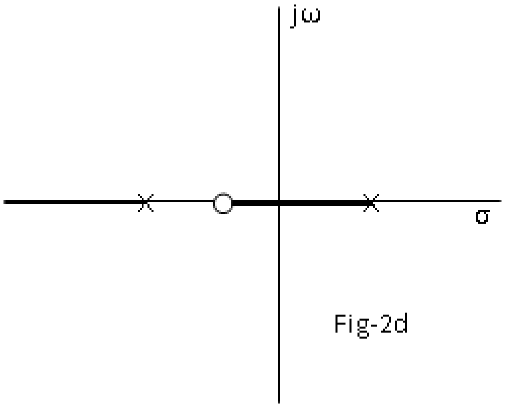


Fig-2d

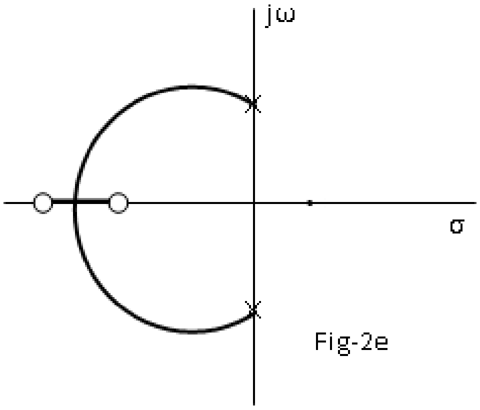


Fig-2e

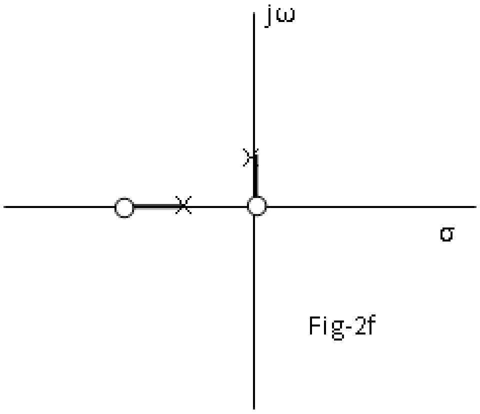


Fig-2f

03 Determine the values of K, T_1 and T_2 of the system depicted in figure-3 so that the dominant closed loop poles have the damping ratio 0.5 and undamped natural frequency 3 rad/sec. **[16]**

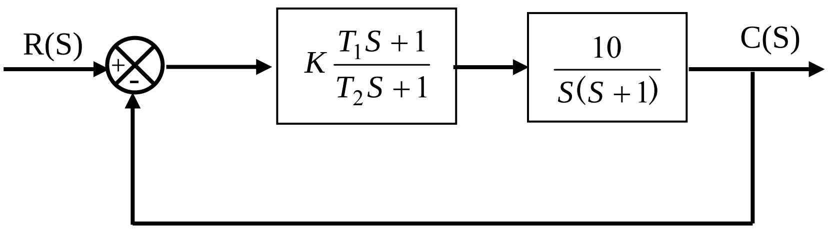


Figure-3

04 For the root loci shown in figure-4 determine the following. **[16]**

(a) Open loop transfer function

(b) Closed loop transfer function when gain K is 0.

(c) Closed Loop Transfer function when K is ∞.

(d) Damping ratio when natural undamped frequency of closed loop poles is 3 rad/sec?

(e) Natural undamped frequency when the damping ratio is 0.9.

(f) The value of gain K at which damping ratio and natural undamped frequency of the closed loop transfer function are 0.5 and 5 rad/sec respectively.

(g) Closed loop transfer function when ζ=0.5 and ω_n=5 rad/sec.

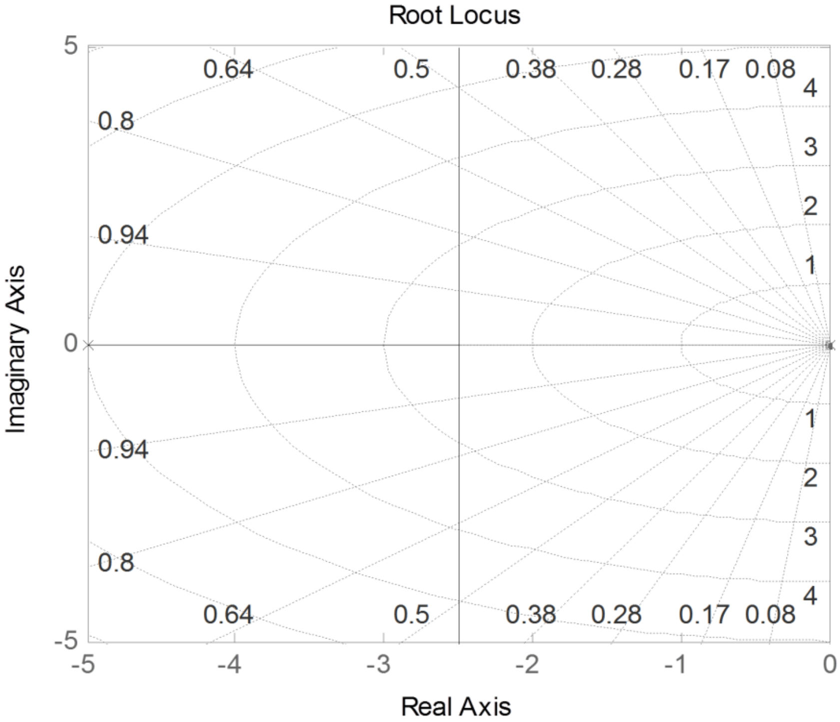


Figure-4

05 The driver assistance system (DAS) in vehicles uses real time data from installed sensors to adjust the traction and braking forces. For a railway vehicle it would not be economically feasible to use the bank of sensors to provide real time information to DAS. It is therefore desired to estimate train dynamics from available measurement(s). The train dynamics are given by the following equation. **[16]**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -4 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t)$$

The only available measurement is the train speed given by the following equation.

$$y(t) = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Assume that the desired eigenvalues of observer gain matrix are

$$\mu_1 = -3 + j3, \quad \mu_2 = -3 - j3 \quad and \quad \mu_3 = -6$$

06 (a) Consider a linear time invariant system defined by following state equation **[08]**

$$\dot{x}(t) = Ax(t) + Bu(t)$$

where,

$$A = \begin{bmatrix} 0 & 1 \\ -a_2 & -a_1 \end{bmatrix}, \qquad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

It is desired to place the eigenvalues at β_1 and β_2 by means of state feedback. The characteristic equation of desired system is given as:

$$(S-\beta_1)(S-\beta_2) = S^2 + \mu_1 S + \mu_2 = 0$$

Show that the state feedback gain matrix K is

$$K = [\mu_2 - a_2 \qquad \mu_1 - a_1]$$

06 (b) Explain the procedure of finding out the model parameters experimentally. Consider for example a D.C motor, how would you determine the transfer function if you do not know D.C motor parameters (e.g. Winding resistance, winding inductance etc.)? **[08]**

07 For the system described by the following transfer function the static velocity error constant is 2 s^{-1}. It is desired to reduce the steady state error to half without changing the location of dominant closed loop poles. In order to do so an electronic circuit, given in figure-7, is added in series with the system to provide necessary pole-zero placement. Determine the values of R_1, C_1, R_2, C_2, R_3 and R_4 to yield the desired steady state response. **[16]**

$$G(S) = \frac{8}{S(S+1)(S+4)}$$

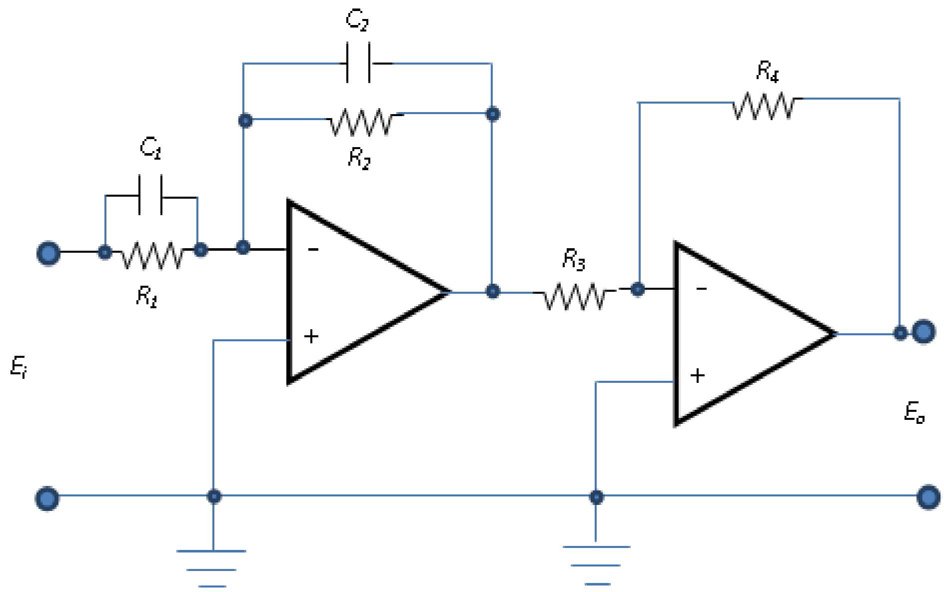


Figure-7

08 (a) For the problem given in question 05, since the train speed $y(t)$ is directly measured (which is equal to x_1), the state variable x_1 need not to be estimated. Therefore, it is desired to modify the state estimator design to estimate only x_2 and x_3. Assume that the desired eigenvalues of observer **[12]**

gain matrix in this case are:

$$\mu_1 = -1 + j7 \qquad and \qquad \mu_2 = -1 - j7$$

(b) Apply Ziegler-Nichols first or second method (if possible) to tune the PID Controller for the plant, whose dynamics are represented by the following transfer function. **[04]**

$$G(S) = \frac{(S+7)(S+10)}{S(S+2)(S+6)}$$

Ziegler-Nichols First Method		
K_p	T_i	T_d
$1.2\,\frac{T}{L}$	$2L$	$0.5L$
Ziegler-Nichols Second Method		
$0.6\,K_{cr}$	$0.5\,P_{cr}$	$0.125\,P_{cr}$

---------------THE END---------------