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B.E. / B.Tech. (Full Time) DEGREE AND END SEMESTER EXAMINATION. APR/ MAY 2012

ELECTRICAL AND ELECTRONICS ENGINEERING

EIGTH SEMESTER

EE 9048– ADVANCED CONTROL SYSTEMS

(REGULATION 2008)

Time : 3 hr **Max Mark: 100**

Answer ALL Questions

PART – A (10 x 2 = 20 Mark)

1. Compare the frequency responses of a PI controller to a Lag compensator.
2. Distinguish the usage of the first and second method of Zeigler-Nichol's process equivalent models.
3. Relate pole placement and controllability in linear time invariant systems.
4. What is the restriction introduced by not observable but detectable systems in reducing the estimation error dynamics.
5. Mention the role of Q and R weighting matrices in the performance measure of an LQR problem.
6. Consider a system with its open loop poles at -1 and +2. Determine the location of the closed loop poles when optimal (with R=∞ and Q=0) LQR control is applied.
7. Determine the discrete equivalent of a PI controller using backward difference approximation.
8. Obtain the discrete equivalent when the output is sampled at intervals T and the input is driven through ZOH for $G(s) = k/(s+2)$
9. Name standard test signals used for identification of systems. Explain their relative merits and demerits.
10. Write down the equations used (do not derive) for estimation of a second order parametric model in the least square sense.

PART – B (5 x 16 = 80 Mark)

11. Consider a system whose state equation is given by

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$$

(i)Check the controllability and observability of the system. (6)

(ii) Design a suitable asymptotic estimator to observe the states so that the error dynamics dies out within one millisecond. (5)

(iii)Determine the estimated state feedback law that places the closed loop poles at -5 and -10. (5)

12. (a) (i) Show through suitable example that both a lag and lead compensator can improve the phase margin for a given system. (6)

(ii) Design a suitable compensator for the system whose open loop transfer function is given by G(s)=k/[s(s+1)(s+2)] to meet the following specifications { Hint: use Bode's plot]. Velocity error constant to be greater than 10 /s, Phase margin >= 60 deg and Band width to be less than 10 rad/s (10)

(OR)

12(b) (i) Explain how root-locus or Zeigler-Nichol's method is useful in the design of controllers. (6)

(ii) Design a suitable controller for the system whose open loop transfer function is given by G(s)=k/[s(s+1)(s+2)] to meet the following specifications [Hint: use either Root-locus or Zeigler Nichols tuning rules. Phase margin >= 60 deg and Bandwidth to be greater than 10 rad/s. (10)

13.(a) (i) Derive the optimal control law for an infinite time linear quadratic regulator problem (8)

(ii) Determine optimal control solution for the following problem

$$J = \frac{1}{2}\int_0^\infty (x^2 + u^2)dt$$

(8)

$$\dot{x} = 2x + u$$

(OR)

13.(b) (i) Write the State equations of an optimal estimator and the Ricatti's type equation to be solved. [Do not derive] (6)

(ii) Consider the optimal control problem discussed in problem 13a(ii). Show that the closed loop poles move from -2 to negative infinity, as the relative gain between X and U, increase from 0 to infinity. (10)

14.(a) (i) Consider the state equation of a linear time invariant system. Obtain the discrete equivalent when input is driven through ZOH and the output is sampled at intervals T.

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 1 \end{bmatrix} x$$

(10)

(ii) Show that the controllability of the discretised system is dependent on the choice of T. (6)

(OR)

14(b) (i) State the merits and demerits of applying digital control over analog control. (5)

(ii) State the relationship between the sampling interval T and the discretised poles of linear time invariant system. (5)

(iii)Determine the pole of the following discrete time system which cannot be changed by state feedback.

$$x_{k+1} = \begin{bmatrix} 0 & -0.02 \\ 1 & -0.3 \end{bmatrix} x_k + \begin{bmatrix} 0.1 \\ 1 \end{bmatrix} u_k$$

(6)

$$y_k = \begin{bmatrix} 0 & 1 \end{bmatrix} x_k$$

15. (a) (i) Write down the prediction- correction type of estimating the states using Kalman's gain, in the presence of input disturbance and measurement noise. (8)

(ii) Derive an expression for prediction and correction error covariance.(8)

(OR)

15.(b) Consider the ARMAX model of a system given as follows

$$y_{k+1} + a_0 y_{k+1} = b_0 u_k + d_k$$

(i) Derive an expression for estimation of coefficients a0 and b0, for the stochastic case namely, when dk and uk are zero mean white noises respectively. (10)

(ii) Derive an expression for estimation of coefficients a0 and b0 in the deterministic case namely, when dk=0 and uk is an unit step input.(6)