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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belgaum)

Seventh Semester, B.E. - Electrical and Electronics Engineering

Semester End Examination; Dec - 2016/Jan - 2017

Design of Analog Control System

Time: 3 hrs *Max. Marks: 100*

***Note**: Answer **FIVE** full questions, selecting **ONE** full question from each unit.*

UNIT - I

1 a. Derive the transfer function and design parameters of, (i) two and (ii) three operational amplifier circuit realization of the PI and PD controllers with the circuits. 10

b. Mention the effects of P, PI, PD and PID controllers on the following :
(i) Steady state error of the system (ii) Relative stability
(iii) Change in type number (iv) Change in system order. 10

2. For the unity feedback system, $G(S)H(S)=\dfrac{20}{S(S+2)(S+4)}$. Design a PD controller with ξ = 0.8 and ω_n = 2 rad/s. Explain the effects of the PD controller by drawing root Loci (without and with controller). 20

UNIT - II

3 a. Discuss briefly the dynamic characteristics of PI, PD and PID controllers. 10

b. Show that the transfer function $\dfrac{U(S)}{E(S)}$ of the PID controller shown in Fig. 3b is,

$$\frac{U(S)}{E(S)}=K_0\frac{T_1+T_2}{T_1}\left[1+\frac{1}{(T_1+T_2)S}+\frac{T_1T_2S}{T_1+T_2}\right]$$ Assume K >> 1 10

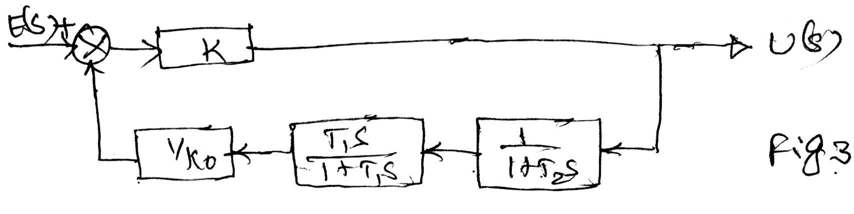

Fig.3b.

4. A unity feedback system with $G(S)=\dfrac{4}{(S+1)(S+2)}$ will have a phase margin of 50° at a frequency of 1.7 rad/sec. Design a PI controller and explain the effects and performance and stability of a system by drawing Bode diagram for both the cases (without and with controllers). 20

UNIT - III

5 a. Discuss the effects and limitations of LAG compensators. 10

b. Explain the behaviour in terms of unit step and ramp response curves for uncompensated and compensated (LAG, LEAD, LAG-LEAD) systems. 10

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6. Design a lead compensator for a system whose open loop transfer function is $G(S)=\dfrac{10}{S(S+6)}$. It will fulfill the following requirements : 20

(i) Static velocity error constant $K_v = 20\ \text{sec}^{-1}$

(ii) Phase margin is at atleast 50º

(iii) Gain margin is atleast 10 db.

Draw the Bode diagram only for the uncompensated system and determine the compensator transfer function.

UNIT - IV

7 a. Explain the control system design via pole placement technique by state feedback and determine the state feedback gain matrix '*K*' by any one method. 10

b. Determine the State feedback gain matrix '*K*' by using Ackermann's formula for the regulator system $A=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 0\\ -1 & -5 & -6\end{bmatrix}$, $B=\begin{bmatrix}0\\0\\1\end{bmatrix}$ with $u=-Kx$ choose the closed loop poles at $S=-2+j4,\ S=-2-j4$ and $S=-10$. 10

8 a. Design a type 1 servo system when the plant transfer function has an integrator. Assume that the plant transfer function is given by, $\dfrac{Y(S)}{U(S)}=\dfrac{1}{S(S+1)(S+2)}$. 10

The desired closed loop poles are $S=-2\pm j2\sqrt{3}$ and $S=-10$. Assume that the reference input is a step function. Obtain the unit step response of the designed system.

b. Explain how to design type 1 servo system when the plant has no integrator. 10

UNIT - V

9 a. What is the state observer and explain the need for state observer. Explain the different methods of evaluating the state observer gain matrix Ke. 10

b. For the system $\dot{X} = Ax + bu, Y = Cx$, where $A=\begin{bmatrix}0 & 20.6\\ 1 & 0\end{bmatrix}$, $B=\begin{bmatrix}0\\1\end{bmatrix}$; $C=\begin{bmatrix}0 & 1\end{bmatrix}$ use $u=-K\hat{X}$. Design a full order observer, if the desired Eigen values of the observer matrix are $\mu_1 = -10$, $\mu_2 = -10$ (Use Ackermann's formula). 10

10 a. Write a note on Quadratic optimal regulator system with Riccatti equation. 10

b. Determine the optimal feedback gain matrix *K* for the performance index *J* to minimize for $A=\begin{bmatrix}0 & 1\\ 0 & 0\end{bmatrix}$, $B=\begin{bmatrix}0\\1\end{bmatrix}$ & $Q=\begin{bmatrix}1 & 0\\ 0 & \mu\end{bmatrix}$, where $\mu \ge 0$ for the float $\dot{X} = Ax + Bu$, with the use of reduced matrix Riccatti equation in the design of optimal control system. 10

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