U.S.N

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. - 2015

Design of Control Systems

Time: 3 hrs *Max. Marks: 100*

***Note**: Answer any **FIVE** full questions, selecting at least **TWO** full questions from each **part**.*

PART - A

1. a. Explain the need of a controller. Describe the following controller configuration with the help of block diagram. (i) Series Feedback compensation. 8

b. If the dynamics of a PI controller is given by $u_c(t) = K_p e(t) + \frac{K_p}{T_i}\int_0^t e(t)\,dt$, where *e(t)* is the actuating signal, find the unit step response of the controller and draw the same. 4

c. Mention the effects of P, PI, PD and PID Controller on the following :

(i) Steady state error of the system (ii) Relative stability

(iii) Change in type number (iv) Change in System order 8

2 a. Explain how a properly designed PD controller will affect the performance of a control system. 4

b. Consider the second-order model of the aircraft attitude control system represented by its forward-path transfer function $G(S) = \frac{4500\,K}{S(S+361.2)}$

Design a PD controller to meet the following performance specifications : 16

(i) Steady - state error due to unit ramp input ≤ 0.000433 (ii) Maximum overshoot $\leq 5\%$

(iii) Rise time $t_r \leq 0.005$ sec (iv) Settling time $t_s \leq 0.005$ sec

3. Design a PI controller for the position control system shown in Fig. Q.3 to meet the following design goals:

(i)Steady State Error (S.S.E.) for ramp input = 0 (ii) Peak overshoot for step input = 9.48%

Use frequency domain (Bodeplot) approach. 20

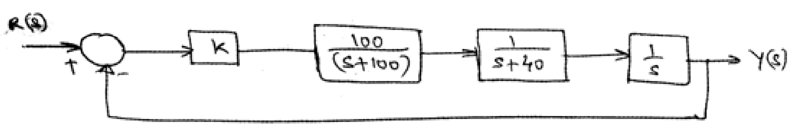

Fig Q.3.

4 a Realize a PD controller using 3-op- amps and also express K_p and K_D in terms of the circuit parameters. 10

b. Show that the transfer function $\frac{U(S)}{E(S)}$ of the PID controller shown in Fig. Q4(b) is

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

Contd…2

Assume that the gain K is very large compared with unity.

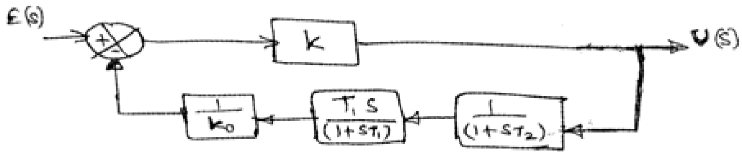

Fig. Q 4(b)

PART - B

5. Design a lead compensator for a unity feedback system whose loop transfer function is $G(S)=\dfrac{K}{S(S+2)}$, by employing time –domain design method. The design goals are : 20

(i) Peak overshoot $\le 16\%$ (ii) Settling time $\le 2\%$

6. Design a Phase - lag compensator for a unity feedback system whose loop-transfer function is $G(S)=\dfrac{K}{S(S+4)}$, to meet the following performance specifications : 20

(i) Steady state error to pump input ≤ 0.1 (ii) Phase margin, PM $>40^{o}$

Use frequency domain approach.

7 a. Define the following frequency domain specifications : 4

(i) Bandwidth (ii) Cut-off rate (iii) Gain margin (iv) Phase margin

b. Consider the system $\overset{\circ}{X} = Ax + Bu, Y = Cx$ where, $A=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -6\end{bmatrix}$; $B=\begin{bmatrix}0\\0\\1\end{bmatrix}$; $C=\begin{bmatrix}1 & 0 & 0\end{bmatrix}$ determine the observer gain matrix K_e by use of Ackermann's formula. Assume that the desired eigen values of observer gain matrix are, 12

$\mu_{1,2} = -2 \pm j2\sqrt{3}, \qquad \mu_3 = -5$

c. What are regulator poles? Explain their significance. 4

8 a. Design a type 1 servo system for a plant having the transistor function, 8

$\dfrac{Y(S)}{U(S)} = \dfrac{1}{S(S+1)(S+2)}$ to place the closed-loop poles at $-2 \pm j2\sqrt{3}$ and -10.

b. Consider the system shown in Fig. Q 8(b). Assuming the control signal to be *u(t) = - K x(t)* determine the optimal feedback gain matrix K such that the following performance index is minimized: $J=\int_0^\infty \left(X^T Q X + u^2\right)dt$, where $A=\begin{bmatrix}0 & 1\\0 & 0\end{bmatrix}$, $Q=\begin{bmatrix}1 & 0\\0 & \mu\end{bmatrix}$ $(\mu \ge 0)$, $B\begin{bmatrix}0\\1\end{bmatrix}$ 12

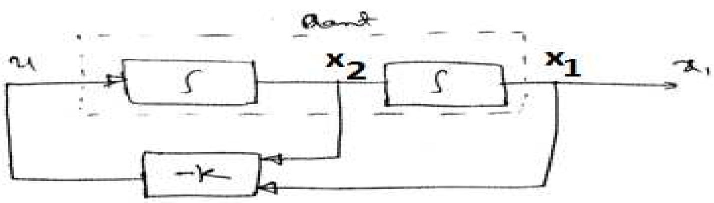

Fig. Q 8(b)

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