Total number of printed pages–7

53 (IE 506) CNTH

2017

CONTROL THEORY

Paper : IE 506

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

Answer ***any five*** *questions out of* ***seven.***

1. *(a)* Draw the schematic diagram of a DC field controlled servomotor. Write its governing equations and draw the detailed block diagram. Discuss whether it represent an open loop or closed loop control system. 2+2+2=6

   (b) Draw the schematic diagram and explain the working of a synchro error detector. 4

   (c) With the help of a schematic diagram, explain the working of a DC tachometer. 4

Contd.

(d)

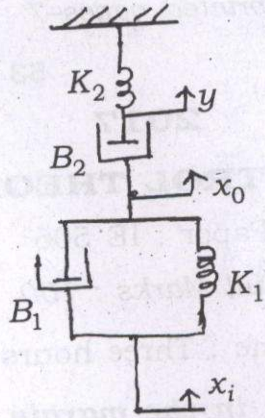

Fig.(1)

Write the differential equations for the mechanical system shown in *Fig.(1)*. Draw the analogous electrical circuit based on force-current analogy. Here x_i is the input displacement and x_0 is the output. 3+3=6

2. (a) A system is described by the following set of linear algebraic equations :

$$x_2 = a_{12}x_1 + a_{22}x_2 + a_{32}x_3$$

$$x_3 = a_{23}x_2 + a_{43}x_4$$

$$x_4 = a_{24}x_2 + a_{34}x_3 + a_{44}x_4$$

$$x_5 = a_{25}x_2 + a_{45}x_4$$

Draw the signal flow graph and obtain the transfer function of the system using Mason's gain formula. 8

(b) Determine the steady-state error of a type-2 control system for unit-step, unit-ramp and unit-parabolic input. 6

(c) The open-loop transfer function of a unity feedback system is as $G(s)=\frac{4}{s(s+1)}$. Evaluate the unit step response of the closed-loop system, and determine the rise time, peak time, peak overshoot and settling time. 6

3. (a) The block diagram of a second-order unity feedback control system is shown in *Fig. (2)*.

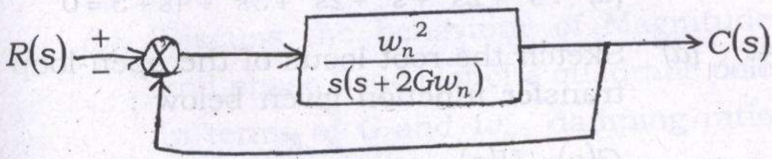

Fig. (2)

Discuss the effect on the performance parameters if we introduce a PD control in the feedback loop. 6

(b) Determine the values of K and P of the closed-loop system shown in *Fig. (3)* so that the maximum overshoot in the unit step response is 25% and the peak time is 2 seconds. 6

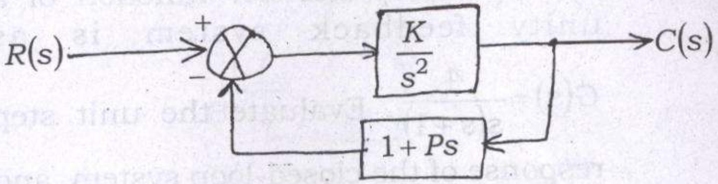

Fig. (3)

(c) Using Routh's criterion, determine the stability of the systems represented by the following characteristic equations. 2×4=8

(i) $s^5 + 4s^4 + 8s^3 + 8s^2 + 7s + 4 = 0$

(ii) $s^6 + 2s^5 + s^4 + 2s^3 + 3s^2 + 4s + 5 = 0$

4. (a) Sketch the root locus of the open-loop transfer function given below :

$$G(s) + H(s) = \frac{K}{s(s+2)(s^2+2s+5)}$$

Determine the value of K for which the system will be marginally stable and also determine the frequency of sustained oscillation.

Clearly describe the procedure to determine break points, angle of departure, point of intersection of asymptotes etc. 12

(b) Discuss and plot the nature of frequency response of an under-damped second order system. Evaluate magnitude of resonant frequency in terms of w_n and G_1 the undamped natural frequency and damping co-efficient, respectively. 8

5. (a) Sketch the polar plot of the transfer function, $G(s) = \frac{1}{s^2(1+s)(1+2s)}$.

Determine whether the plot cross the real/imaginary axis. If so, determine the frequency and the corresponding magnitude $|G(jw)|$. 8

(b) Discuss the behaviour of Magnitude and phase Bode plot of a quadratic pole in terms of G and w_n, damping ratio and undamped natural frequency, respectively. Plot the same for various values of G. 8

(c) Define the quantities phase margin and gain margin and explain its significance in the performance of closed loop system performance. 4

6. *(a)* Explain with proper justifications how one can determine the stability of a closed loop control system by looking at the contour of the function $G(s)H(s)$ corresponding to the Nyquist contour in the s-plane. 8

(b) Sketch the Nyquist plot and there from assess the stability of the closed-loop system whose open loop transfer function is

$$G(s)H(s)=\frac{K(s+4)}{s^2(s+1)}$$ 8

(c) What do you understand by M-circle and discuss its one application. 4

7. *(a)* Explain how a lead compensator can be used to stabilize an otherwise unstable system. 6

(b) Draw the Bode plot of a system with open loop transfer function

$G(s)=\frac{10}{s^2(1+.1s)}$ and determine its phase margin. Design an R-C compensator circuit which can improve the phase margin to $\phi_{PM}=30^o$. 8

(c) Discuss the advantage of PI controller with the example of a type-1 first order system driven by a ramp input. 6

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