Total number of printed pages–5

53 (IE 506) CNTH

2017

CONTROL THEORY

Paper : IE 506

(Compartmental)

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 block diagram of a closed loop control system and explain the function of each part in it. Discuss how stability of such a system can depend on the frequency of operation. 6

   (b) Find the force-current analogy of the mechanical system shown in Fig. 1. 8

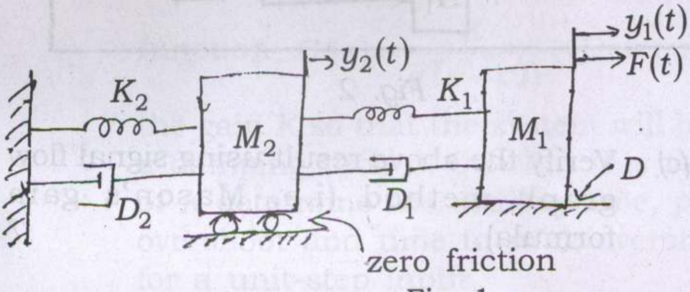

Fig. 1

Contd.

(c) Draw the block diagram and find the transfer function, $\frac{\theta(s)}{E(s)}$ of an armature controlled DC motor. Here $\theta(s)$ and $E(s)$ are the Laplace transform of rotor angular position and input voltage, respectively. 6

2. (a) Explain the working of synchro error detector. 5

(b) Using block diagram reduction method, find the transfer function of the control system shown in *Fig.* 2. 8

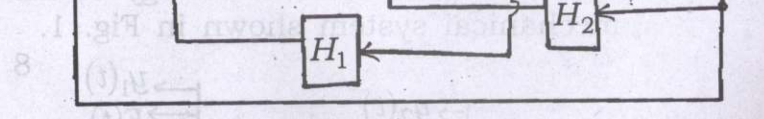

Fig. 2

(c) Verify the above result using signal flow graph method (i.e. Mason's gain formula). 7

3\. *(a)* For the circuit shown below, derive the expression for the output voltage when the input is a ramp function 6

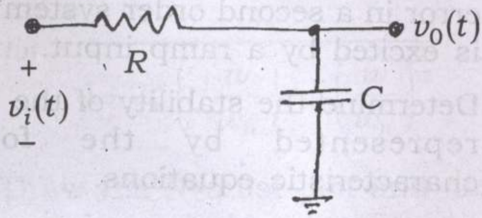

Fig. 3

(b) For a second-order system with transfer function $M(s) = \frac{w_n^2}{s^2 + 2\zeta w_n s + w_n^2}$, discuss the different types of step responses depending on the value of ζ. 6

(c) A unity feedback system is characterized by an open-loop transfer function $G(s) = \frac{K}{s(s+10)}$. Determine the gain K so that the system will have a damping ratio of 0·5. For this value of K determine the settling time, peak overshoot and time to peak overshoot for a unit-step input. 8

4. (a) Show that a PD controller reduces the oscillatory behaviour of a second order system step-response. Show also that a PI controller eliminates steady state error in a second order system when it is excited by a ramp input. 8

(b) Determine the stability of the systems represented by the following characteristic equations. 4×2=8

(i) $s^4 + 2s^3 + 10s^2 + 20s + 5 = 0$

(ii) $s^6 + 3s^5 + 5s^4 + 9s^3 + 8s^2 + 6s + 4 = 0$

(c) If $h(t)$ is the impulse response of a control system, discuss how it determines the stability of the system. 4

5. (a) With necessary steps show how the root locus plot of a system look, if the open loop transfer function is given as

$$G(s)H(s) = \frac{K}{s(s+2)(s^2+2s+2)}$$ 12

(b) Draw the polar plot of the system with open loop transfer function,

$$G(s)H(s) = \frac{1}{s^2(1+sT_1)(1+sT_2)}$$ 8

6. *(a)* Discuss how the bode plot of the following terms look like

(i) $$\frac{1}{(1+jwT)^n}$$

(ii) $$\frac{1}{1+2\zeta\left(j\frac{w}{w_n}\right)+j\left(\frac{w}{w_n}\right)^2}$$ 10

(b) Draw the Nyquist plot and assess the stability of the closed-loop system whose open-loop transfer function is given by—

$$G(s)H(s)=\frac{K}{s\,(2s+1)}$$ 10

7. *(a)* Derive the equations for constant M circles and constant N-circles of a unity feedback control system in the $G\,(jw)$ plane. 10

(b) Design a lead compensator for a unity feedback system with an open-loop transfer function $G_f(s)=\frac{K}{s\,(s+1)}$ for the specifications $K_V=10^{s^{-1}}$ and $\phi_m=35°$. 10
