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B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2024

Third Semester

Electronics and Communication Engineering

EC 3351 – CONTROL SYSTEMS

(Common to: Electronics and Telecommunication Engineering)

(Regulations 2021)

Time : Three hours — Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define the following terms in a control system configuration:
   (a) Manipulated variable,
   (b) Plant.

2. Give examples for multivariable control systems.

3. Draw the unit step input and the corresponding output signal for first order system.

4. What is the effect of PI controller on the performance of a system?

5. What are the frequency domain specifications?

6. Why frequency domain compensation is normally carried out using the Bode plots?

7. Mention two notions of system stability to be satisfied for a linear time-invariant system to be stable.

8. Distinguish between absolute stability and relative stability.

9. For a first order differential equation described by $x(t) = ax(t) + bu(t)$, draw the block diagram form of state diagram.

10. What is the necessary condition to be satisfied for control system design using state feedback?

PART B — (5 × 13 = 65 marks)

11. (a) (i) Determine the transfer function of the mechanical translational system shown in Fig.Q11(a)(i), where $f(t)$ is the input and $y(t)$ is the output. (7)

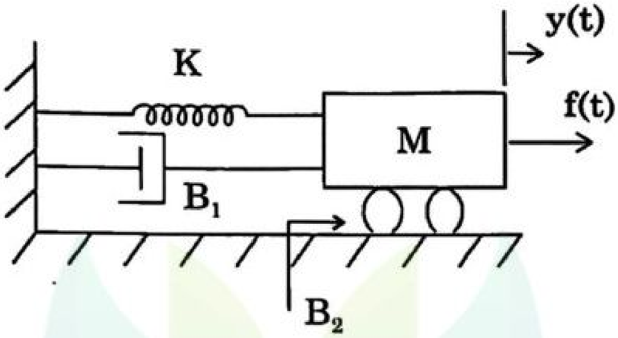

Fig. Q 11(a)(i)

(ii) Explain the symbolic representation of an AC servomotor. Draw its

(1) Torque-speed and

(2) Torque-Control voltage curves (6)

Or

(b) (i) State any four rules of block diagram algebra. (7)

(ii) Obtain the transfer function $\frac{E_0(s)}{E_i(s)}$ for the electrical network shown in Fig.Q11(b)(ii) using Mason's gain rule. (6)

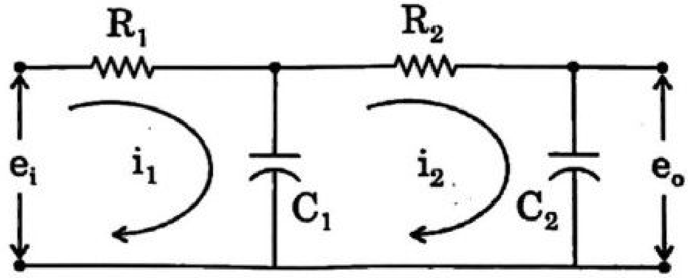

Fig. Q11(b)(ii)

12. (a) A unity negative feedback system has $G(s) = \frac{16}{s(s+4)}$. Find the response $c(t)$ to unit step input. Determine rise time, peak time, maximum overshoot and settling time. (13)

Or

(b) For Type 0, Type 1 and Type 2 unity feedback control systems with forward path transfer function $G(s)$, obtain the static error constants (K_p, K_v, K_a) and steady state errors for unit step and unit ramp input signals. (13)

13. (a) Sketch the Bode magnitude plot for the following transfer function and determine the system gain K for the gain crossover frequency ω_{gc} to be 5 rad/sec. (13)

$$G(s)H(s) = \frac{Ks^2}{(1+0.2s)(1+0.02s)}$$

Or

(b) A unity feedback system has $G(s) = \frac{0.5}{s(s+1)(s+0.5)}$. Sketch the polar plot and determine the gain margin and phase margin. (13)

14. (a) A unity feedback system has $G(s)H(s) = \frac{K}{s(s+3)(s+4)(s^2+s+1)}$. By applying the Routh stability criterion, find the range of values of K for the closed loop system to remain stable. Determine the frequency of sustained oscillations under limiting conditions. (13)

Or

(b) Explain briefly the guidelines for sketching the root locus. (13)

15. (a) (i) Obtain the state space representation of the system whose differential equation is given by $\dddot{y}+2\ddot{y}+3\dot{y}+6y=\ddot{u}-\dot{u}+2u$ (3)

(ii) Obtain the transfer function model of the system whose state space model is described by (10)

$$[\dot{x}(t)]=\begin{bmatrix}-1 & 0 & -1\\ 0 & -1 & 1\\ 1 & -2 & -3\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\\ x_3(t)\end{bmatrix}+\begin{bmatrix}0\\1\\1\end{bmatrix}u(t); \qquad y(t)=[1\ 0\ 1]\begin{bmatrix}x_1(t)\\ x_2(t)\\ x_3(t)\end{bmatrix}$$

Or

(b) (i) Find the homogeneous solution of the system whose state space model is described by (9)

$$[\dot{x}(t)]=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}\begin{bmatrix}x_1 t\\ x_2(t)\end{bmatrix} \text{ with the initial conditions } \begin{bmatrix}x_1(0)\\ x_2(0)\end{bmatrix}=\begin{bmatrix}1\\0\end{bmatrix};$$

(ii) Define the terms: Controllability and Observability. (4)

PART C — (1 × 15 = 15 marks)

16. (a) Explain the procedure for the design of a lag compensator. (15)

Or

(b) Consider the open loop transfer function $G(s)=\dfrac{K}{(s+1)(s+2)(s+3)}$ in which the scalar gain $K>0$ can be varied. Using the Nyquist stability criterion, find the range of values of K over which the unity feedback closed loop system will be stable. (15)

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