Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS / B.TECH (EE-NEW) / SEM-6 / EE-603/ 2011

2011

CONTROL SYSTEM – II

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following :

$10 \times 1 = 10$

i) A system is described by

$$\frac{dx}{dt} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = [1 \;\; 0]\, x$$

The system is

a) controllable & observable

b) uncontrollable & observable

c) controllable & unobservable

d) uncontrollable & unobservable.

ii) The state variable description of a linear autonomous system is $\dot{X} = AX$ when X is a state vector & $A = \begin{bmatrix} 0 & 2 \\ 2 & 0 \end{bmatrix}$

The poles of the system are located at

a) –2 and + 2 b) –2 j and + 2 j

c) –2 and – 2 d) + 2 and + 2.

iii) The value of a matrix in $\frac{dx}{dt} = AX$

for the system described by the differential equation

$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + 3y = 0$$

a) $\begin{bmatrix} 1 & 0 \\ -2 & -1 \end{bmatrix}$ b) $\begin{bmatrix} 1 & 0 \\ -1 & -2 \end{bmatrix}$

c) $\begin{bmatrix} 0 & 1 \\ -2 & -1 \end{bmatrix}$ d) $\begin{bmatrix} 1 & 0 \\ -3 & -2 \end{bmatrix}$.

iv) The transfer function of a Z0H is

a) $\frac{1-e^{st}}{s}$ b) $\frac{1-e^{st}}{s^2}$

c) $\frac{1-e^{sT}}{s}$ d) $\frac{1-e^{sT}}{s^2}$.

v) Describing function is based on

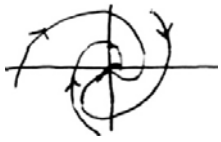
a) first harmonic approximation

b) approximation at an operating point

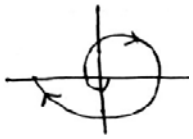
c) stability of an operating point

d) finding of Lyapunov function.

vi) Stable focus is represented by

a) 

b) 

c) 

d) 

vii) The variable gradient method is used to find

a) Lyapunov function

b) describing function

c) state transition matrix

d) eigenvectors.

viii) Nonlinear system can display

a) only one equilibrium point & limit cycle

b) multiple equilibrium point & limit cycle

c) only one equilibrium point

d) only one limit cycle.

ix) The curve traced out by all possible point $[x_1(t), x_2(t)]$ is called phase trajectory

a) at t is varied from 0 to α

b) at t is varied from $-\alpha$ to α

c) as t is varied from 0 to $-\alpha$

d) as t is varied from any value.

x) The characteristic equation of a system is $KG(s)H(s) = -1$. Stability condition for such system is

a) $|G(j\omega)H(j\omega)| < 1/K$

and $< G(j\omega)H(j\omega) = -180°$

b) $|G(j\omega)H(j\omega)| < K$

and $< G(j\omega)H(j\omega) = 180°$

c) $|G(j\omega)H(j\omega)| < 1$

and $< G(j\omega)H(j\omega) = -180°$

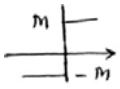
d) $|G(j\omega)H(j\omega)| > 1/K$

and $< G(j\omega)H(j\omega) = -180°$.

xi) The example of positive semi definite function is

a) $(x_1 + x_2)^2$ b) $x_1^2 + x_2^2$

c) $-x_1^2 - (x_1 + x_2)^2$ d) $x_1x_2 + x_2^2$.

xii) The describing function for 

with input $X \sin \omega t$ is

a) $\frac{4M}{\pi X}$ b) $\frac{2M}{\pi X}$

c) $\frac{4}{\pi X}$ d) $\frac{4M}{\pi}$.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. The overall transfer function of a SISO system is given by $\frac{Y(s)}{U(s)} = \frac{s^2 + 4s + 4}{s^3 + 5s^2 + 4s}$. Obtain state model of the system.

3. The state space representation of a system is

$\dot{x}_1 = -x_1 + v$

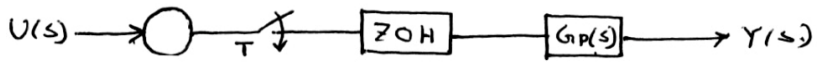
$\dot{x}_2 = x_1 - 2x_2 + v$

Comment on controllability and observability of the system.

4. Solve the difference equation given below :

$y(k+2) + 3y(k+1) + 2y(k) = 0$ for $y(-1) = -\frac{1}{2}$, $y(-2) = \frac{3}{4}$.

5. Obtain pulse transfer function of the system shown below with $T = 0 \cdot 5\ s$ and $G_p(s) = \frac{20}{s(s+5)}$.



6. Find state-transition matrix for the homogeneous state equation

$X(k+1) = F\,X(k)$, where $F = \begin{bmatrix} 0 & 1 \\ -0 \cdot 16 & -1 \end{bmatrix}$.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) For the system represented by

$$\dot{X} = \begin{bmatrix} -7 & 1 \\ -12 & 0 \end{bmatrix} x + \begin{bmatrix} 2 \\ -1 \end{bmatrix} u$$

$$Y = \begin{bmatrix} 3 & -4 \end{bmatrix} x + \begin{bmatrix} 2 \end{bmatrix} u$$

Compute output response when $u(t) = 3e^{-t}$ and $X[0] = \begin{bmatrix} -6 \\ 1 \end{bmatrix}$.

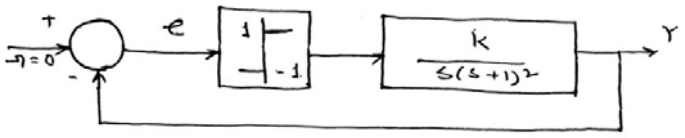
b) Determine the state feedback gain matrix so that the closed loop poles of the following system are located at $-2 \pm J3 \cdot 464$, -5. Give a block diagram of the control configuration.

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix} u$$

$$Y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} x.$$ 7 + 8

8. a) Derive describing function of a relay with saturation & dead zone nonlinearity.

b) Investigate stability of a system shown below using describing function technique.



7 + 8

9. a) Explain jump resonance of a nonlinear system.

b) Explain the concept of limit cycle with a suitable example.

c) For a spring mass system, construct the phase trajectory on $X - \dot{X}$ plane using isocline method with initial conditions $x(0) = -1$ and $\dot{x}(0) = 0$. Comment on the kind of singularity obtained. 3 + 3 + 9

10. a) Discuss the concept of Lyapunov's first and second stability analysis.

b) Investigate stability using Laypunov's second method for the system represented by

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix} x$$

c) Consider the system $\dot{X}_1 = -x_1$

$$\dot{X}_1 = x_1 - x_2 - x_2^3 .$$

Investigate stability of the equilibrium points. 4 + 5 + 6

11. Write short notes on any *three* of the following : $3 \times 5 = 15$

i) Harmonic linearization

ii) Anti-aliasing filters

iii) Properties of state transition matrix

iv) Characteristics of common nonlinearities

v) Digital compensator design using frequency response.

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