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2014

Control Systems - II

Time Allotted : 3 Hours *Full Marks : 70*

The figure 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 questions : 10x1=10

   i) A 5x7 matrix has all entries equal to –1, the rank of the system is

      a) 5 b) 1 c) 7 d) 0

   ii) Parallel decomposition gives :

      a) Diagonalisation

      b) Eigen values of the given system

      c) It gives the Jordan canonical form

      d) all of the above

   iii) A system is represented by the state equation given below–

$$\dot{x} = \begin{bmatrix} -3 & -2 \\ -1 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$$

   The poles of the system are :

      a) 2 & 3 b) 1 & 4 c) –1 & –4 d) –6 & 3

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iv) A system describe by the state equation is –

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$$

The state transition matrix of the system is

a) $\begin{bmatrix} e^{-t} & 0 \\ 0 & e^{t} \end{bmatrix}$ b) $\begin{bmatrix} e^{-2t} & 0 \\ 0 & e^{-t} \end{bmatrix}$

c) $\begin{bmatrix} e^{2t} & 1 \\ 1 & e^{2t} \end{bmatrix}$ d) $\begin{bmatrix} e^{-2t} & 1 \\ 1 & e^{-t} \end{bmatrix}$

v) **Which one of the following statements regarding the state transition matrix is correct?**

a) $\Phi(0) = 0$

b) $\Phi^{-1}(t) = \Phi(1/t)$

c) $\Phi(t_1 + t_2) = \Phi(t_1) + \Phi(t_2)$

d) $\Phi(t_2 - t_1)\,\Phi(t_1 - t_0) = \Phi(t_2 - t_0)$

vi) **The inverse z-transform of the function** $\frac{Tz}{(Z-1)^2}$ **is**

a) KT b) $(KT)^2$ c) e^{-KT} d) e^{KT}

vii) **Consider the system** $\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & -4 \end{bmatrix} x + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u$

$y = [0 \quad 2]x$

The system is

a) Not controllable, observable

b) controllable, observable

c) Controllable, not observable

d) not controllable, not observable

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viii) **The device which converts a continuous signal into a sequence of pulses is termed as**

a) Synchro b) amplifier

c) Sampler d) none of the above

ix) **If the z-transformation of a function is z sinwT/z^2 –2zcoswT+1, its corresponding Laplace transform will be**

a) s/s^2+w^2 b) w/s^2+w^2

c) $1/s^2+w^2$ d) $s+w/s^2+w^2$

x) **The transfer function of ZOH is given by**

a) $G_{ho}(s) = 1-e^{-Ts}/s$ b) $G_{ho}(s) = 1-e^{-T}/s$

c) $G_{ho}(s) = 1-e^{-Ts}$ d) $G_{ho}(s) = s(1-e^{-Ts})$

xi) **A non linear control system is described by the equation $d^2x/dt^2+k\sin x=0$. the type of singular points at A=(0, 0) and B=(π 0) will be respectively**

a) Centre and saddle b) Centre and focus

c) Focus and saddle d) Saddle and centre

xii) **Lyapunov function is**

a) Energy function b) work function

c) state function d) output function

xiii) **For the difference equation**

x[K+2] + 4x [K+1] + 5x [K] = 0, the initial conditions are x[0] = 0 and x[1] = 1. the value of x[2] is

a) 4 b) 3

c) –4 d) –9

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Group-B
(Short type answer questions)
Answer any *three* questions

3X5=15

2. The transfer function of a dynamic system is given by

$$\frac{Y(s)}{U(s)} = \frac{2(s+5)}{(s+2)(s+3)(s+4)}$$

Obtain the diagonal canonical state model of the system. Also determine the output *y(t)*.

3. Develop the state model for an armature controlled separately excited dc shunt motor, considering the state variables as $x_1(t) = i_a(t)$, $x_2(t) = \theta(t)$ and $x3(t) = \frac{d\theta(t)}{dt} = \omega(t)$.

4. Draw the phase plane trajectory analytically for the system $\ddot{x}+2\xi\omega_n \dot{x}+x = 0$, considering $\omega=1$ and $\xi=0.5$.

5. Determine whether the following quadratic form is positive definite.

$$Q = x_1^2 + 4x_2^2 + 2x_1x_2 - 6x_2x_3 - 2x_1x_3$$

6. Obtain the z-transform of

$$x(t) = \begin{cases} \sin \omega t, & t \geq 0 \\ 0, & t < 0 \end{cases}$$

7. Write down the advantages of state space techniques, what is asymptotic stability and limit cycles?

Group – C
(Long Answer Type Questions)
Answer any *three* of the following

3x15=45

8. a) Solve the following difference equation with the initial conditions x(0) = 0 and x(1) = 1.

X(k+2) + 3x(k+1) + 2x(k) = 0

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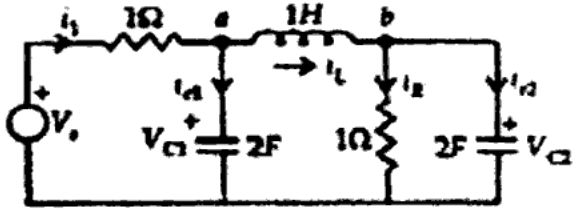
b) Obtain the inverse z-transform of

$$X(z) = \frac{2z^3 + z}{(z-2)^2(z-1)}$$

9. a) Write the state equation for circuit shown in figure below.



b) Determine the state feedback gain matrix so that close loop poles of the following linear system are located at –2, –5 & –6.

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -30 & -11 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t), \quad y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

7.5+7.5

10. a) Consider the dynamic equation of a non-homogeneous system as

$$\dot{x}(t) = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} x(t) = \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t) \text{ and output } y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} x(t)$$

Given the initial condition x(0) =$[1 \quad 0]^T$, where u(t) is a unit-step input. Determine the output y(t) at t=1 sec.

b) Determine x(k) of the system given below :

$$x(k+1) = \begin{bmatrix} 0 & 1 \\ -3 & -5 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k); \quad \text{Where} \quad x_1(0) = 1, x_2(0) = 1$$

10+5

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11. a) State Lyapunov's direct method of investigating stability of non-linear system.

b) Determine whether or not the following quadratic form is positive definite.

$$Q(x_1, x_2) = 10x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$$

c) A linear system is described by the state equation $\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x$. Investigate the stability of this using Lyapunov's method.

[4+5+6]

12. a) Determine the amplitude and frequency of the limit cycle of the non-linearity shown in fig below.

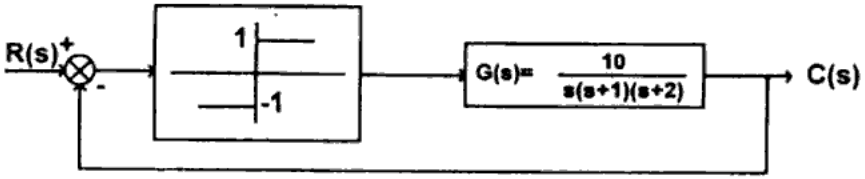

Fig 12 a

b) Draw the phase plane trajectory of a standard linear second order system when ξ =0.5, ω_n=1 rad/sec for two times of unit step input and comment on the stability of the system by finding singular point. [7+8]

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13. Write short notes on the following (any *three*) :

i) Non-linear relay

ii) Describing function of Saturation type of nonlinearity

iii) Harmonic linearization

iv) Anti-aliasing filter

v) Pole placement.

[5+5+5]

____x-x-x____

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