Reg. No. :

Question Paper Code : 40723

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2021.

Sixth Semester

Electrical and Electronics Engineering

IC 8651 – ADVANCED CONTROL SYSTEM

(Common to Instrumentation and Control Engineering)

(Regulations 2017)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define singular points with their importance.

2. Define controllability and observability of the linear time-invariant system.

3. Explain the describing function of non-linear systems.

4. Explain the performance measure in optimal control problem.

5. Explain the different types of nonlinearities in control systems.

6. Differentiate between the transfer function and pulse transfer function.

7. Explain the state transition matrix. How is it useful for the state evolution for a given initial state?

8. Explain the usefulness of the state observer for the control of dynamic systems.

9. What is phase-plane method for the non-linear system, explain it by giving example?

10. Explain the usefulness of optimal control techniques for real world problems.

PART B — (5 × 13 = 65 marks)

11. (a) (i) Examine the observability of the system given below (7)

$\dot{x} = Ax + bu,$

$y = c^T x,$

Where

$$A = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 16.31 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ -1.063 & 0 & 0 & 0 \end{pmatrix}, \; b = \begin{pmatrix} 0 \\ -1.44 \\ 0 \\ 9.6 \end{pmatrix}, \; c = \begin{pmatrix} 1 & 0 & 0 & 0 \end{pmatrix}^T$$

(ii) Differentiate between dynamic observer and Kalman filter in control. (6)

Or

(b) (i) Consider the system $\dot{x} = \begin{pmatrix} 0 & 1 \\ -2 & -3 \end{pmatrix}, \; x(0) = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$ (7)

Calculate the free response of the system.

(ii) Write the statement of Cayley-Hamilton technique and its two usefulness in control system design. (6)

12. (a) (i) Define the following

(1) Linear time-invariant system

(2) Linear time – varying system

(3) Causality

(4) Linearity (6)

(ii) Write down the relationship between s-*plane* and $z-$*plane* with appropriate. Explain bilinear transformation for a mapping between two plane. (7)

Or

(b) (i) Define the following

(1) Stationarity

(2) Stability

(3) Memory less system

(4) Non-memory less system (7)

(ii) Write the stability of the discrete-time LTI system by discussing the location of the zeros of the associated characteristic polynomial in an approximate plane. (6)

13. (a) (i) Derive the pulse transfer function of PID control action. (7)

(ii) Write the difference between the Routh stability and Jury Stability. (6)

Or

(b) (i) Write the state transition matrix for the discrete time LTI system. Write the z – transform of the associated state-transition matrix. (7)

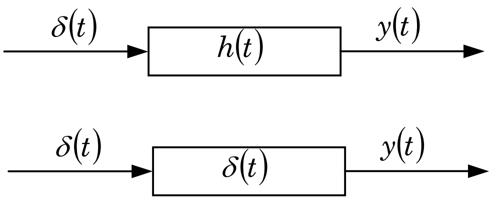
(ii) Examine the stability of the following characteristic equation using Jury Stability test $P(z) = z^4 - 1.2z^3 + 0.07z^2 + 0.3z - 0.08 = 0$. (6)

14. (a) (i) Write the solution of the following (7)

$\dot{x}_t = AX_t + Bu_t$

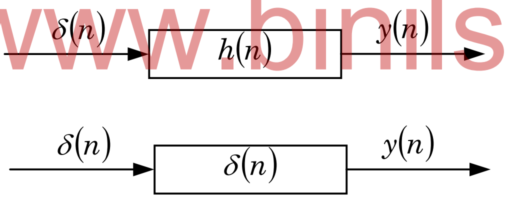
Then find the impulse response for the linear measurement equation association with the above state equation.

(ii) Calculate the output $y(t)$ (6)



Or

(b) (i) Calculate the output $y(n)$ (6)



(ii) Calculate the following (7)

(1) $z^{-1}(zI - G)^{-1}G$

(2) $z^{-1}(zI - G)^{-1}BU(z)$, where G is the state matrix. B is the input matrix and $U(K)$ is the arbitrary input sequence and its z – transform is $U(z)$.

15. (a) (i) Construct the solution of the following discrete-time state model (7)

$x(n+1) = Gx(n) + Hx(n)$

$y(n) = C^T x(n)$

Then write the impules response sequence.

(ii) Explain the Ackerman's formula for the state feedback design. Write the restrictions that ensure the validity of the Ackerman's formula. (6)

Or

(b) (i) Consider the system defined by (7)

$x(k+1) = Gx(k) + Hu(k)$

$y(k) = Cx(k)$

$u(k) = K_0 r(k) - Kx(k)$

where, $G = \begin{pmatrix} 0 & 1 \\ -.16 & 1 \end{pmatrix}, H = \begin{pmatrix} 0 \\ 1 \end{pmatrix}, C = (1 \quad 0).$

Design a control system such that the desired closed-loop poles of the characteristic equation are at $z_1 = 0.5 + j0.5 z_2 = 0.5 - j0.5$.

(ii) Consider a unity feedback system with the plant (6)

$\dot{x} = Ax + bu,$

$y = c^T x.$

$A = \begin{pmatrix} 0 & 1 \\ 0 & -2 \end{pmatrix}, b = \begin{pmatrix} 0 \\ K \end{pmatrix}, c = (1 \quad 0)^T$

(1) Find the range of values of K for which the closed – loop system is stable.

(2) Introduce now a sampler and zero-order hold in forward path of closed loop system show that sampling has destabilizing effect on the stability of the closeds loop system. To establish this result you may find the range of value K for which the closeds-loop digital system is stable when $T = 3\,\text{sec}$.

PART C — (1 × 15 = 15 marks)

16. (a) Consider the non-linear system (15)

$\dot{x} = -x_1 - \varepsilon x_2^2$

$\dot{x}_2 = -x_1$

Invoke the condition on parameter ε and investigate the stability of the equilibrium points.

(b) Design the regulator for the $\dot{x}_t = Ax_t + Bu_t$ and write the explicit expression of the feedback system. Sketch the answer via beginning from the Hamiltonian setting. In addition to the above, write the properties of the associated matrices. (15)
