APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Scheme for Valuation/Answer Key

Scheme of evaluation (marks in brackets) and answers of problems/key

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION (S), MAY 2019

Course Code: AE407

Course Name: -DIGITAL CONTROL SYSTEM

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two full questions, each carries 15 marks. Marks

1 a) Merits (any three) – 1.5 marks, Demerits (any three) -- 1.5 marks (3)

b) Figure (input and output S/H signal) – 1mark, Each characteristic – 2 marks each (7)

c) Figure (impulse response) – 2 marks, Derivation – 3 marks (5)

2 Diagrams – 2 marks each. (15)

Explanation – 2 marks each

Derivation – Zero order hold – 3 marks

First order hold – 4 marks

3 a) Partial fraction expansion – 3 marks (6)

Inverse z transform: $x(k) = 9k(2^{k-1}) - 2^k + 3$; -- 3 marks

b) Each mapping – 3 marks (9)

PART B

Answer any two full questions, each carries 15 marks.

4 a) The input-output relations can be formulated as (10)

$$\begin{aligned} E(s) &= R(s) - G(s)H(s)E^*(s) \\ C(s) &= G(s)E^*(s) \end{aligned}$$

------ 2 marks

Taking pulse transform on both sides

$$E^*(s) = R^*(s) - GH^*(s)E^*(s)$$

Taking pulse transformation on both sides of

$$\begin{aligned} C^*(s) &= [G(s)E^*(s)]^* \\ &= G^*(s)E^*(s) \\ &= \frac{G^*(s)R^*(s)}{1+GH^*(s)} \\ \therefore \frac{C^*(s)}{R^*(s)} &= \frac{G^*(s)}{1+GH^*(s)} \\ \Rightarrow \frac{C(z)}{R(z)} &= \frac{G(z)}{1+GH(z)} \end{aligned}$$

where $GH(z) = Z[G(s)H(s)]$.

------8 marks

b) Derivation (5)

5 (15)

$$\frac{C(z)}{R(z)} = \frac{G(z)}{1+G(z)}. \qquad T = 1.$$

5 marks

$$G(z) = Z\left[\left(\frac{1-e^{-sT}}{s}\right)^2 \cdot \frac{1+sT}{T} \cdot \frac{1}{s(s+1)}\right].$$

$$= [1-z^{-1}]^2 \left[Z\left(\frac{1+sT}{Ts^2} \cdot \frac{1}{s(s+1)}\right)\right]_{T=1}$$

$$= [1-z^{-1}]^2 \left[Z\left(\frac{1+s}{s^2} \cdot \frac{1}{s(s+1)}\right)\right]$$

$$= [1-z^{-1}]^2 \left[Z\left(\frac{1}{s^3}\right)\right]_{T=1}$$

$$= \left(\frac{z-1}{z}\right)^2 \cdot \left[\frac{T^2 \cdot z(z+1)}{(z-1)^3}\right]_{T=1}$$

5 marks

$$= \frac{1}{z} \cdot \frac{z+1}{z-1} = \frac{z+1}{z(z-1)}$$

$$\frac{C(z)}{R(z)} = \frac{\dfrac{z+1}{z(z-1)}}{1+\dfrac{z+1}{z(z-1)}} = \frac{z+1}{z(z-1)+z+1} = \frac{z+1}{z^2-z+z+1} = \frac{z+1}{z^2+1}$$

5 marks

6 a) Gain margin & Phase margin explanation (5)

b) Derivation for the velocity error constant ---- 5 marks (10)

Derivation for the acceleration error constant ---- 5 marks

PART C

Answer any two full questions,each carries 20 marks.

7 a) Splitting the transfer function into standard nested programming equations ---- 5 marks (10)

Framing state equation and output equation (nested programming method or observable canonical form) $\begin{matrix} x(k+1) = Gx(k) + Hu(k) \\ y(k) = Cx(k) + Du(k) \end{matrix}$; $G = \begin{bmatrix} 0 & -3 \\ 1 & -4 \end{bmatrix}$; $H = \begin{bmatrix} 5 \\ 1 \end{bmatrix}$;

$C = \begin{bmatrix} 0 & 1 \end{bmatrix}$; D = [0]; --5 marks

b) Definition --- 2 marks (10)

Explanation ---3 marks

Proof – 5 marks

8 a) Control Law equation u(k) = -kx(k) ; ----2 marks (10)

Design Procedure ----8 marks

b) State equation and output equation – 3 marks (10)

z-transform of state equation and output equation – 3 mark

State transition matrix derivation ---4 mark

9 a) (8)

i. Controllability Test matrix – $\begin{bmatrix} 2 & -2 \\ 3 & -6 \end{bmatrix}$, rank=2; State controllable ;---4 marks

ii. Controllability Test matrix - $\begin{bmatrix} 2 & -2 \\ 0 & 0 \end{bmatrix}$, rank=1; Not state controllable; ---4 marks

b) Explanation (8 marks) (12)

Deriving the expression (4 marks)

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