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, DECEMBER 2018

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) Basic elements of a discrete -data control system. (6)

Block diagram – 2 marks, Explanation -- 2 marks, Advantages (Any four) –2 marks

b) Sample and hold circuit. (5)

Block diagram – 2 marks, Explanation -- 3 marks

c) Explanation of step motor control system—4 marks (4)

2 Derivation – 12 marks, Amplitude spectrum plot – 3 marks (15)

3 a) Expression (z transform) – 1 mark, (6)

Expansion – 3 marks,

Final answer $X(z) = \frac{1}{4}\frac{z^{-1}(1-z^{-4})}{(1-z^{-1})^2}$; – 2 marks (Final answer can be in terms of positive powers of z also)

b) Z transform expression – 2 marks (9)

$X(z) = \frac{z^3}{(z-1)(2z^2-2z+1)}$; -- 2 marks (This can be in terms of negative powers of z also)

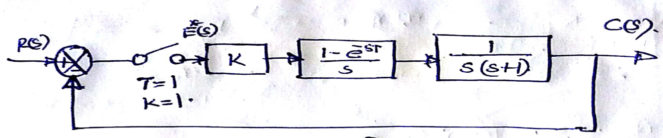
Partial fractions -- 2 marks

Finding inverse $x(k) = 1 - \frac{1}{2}\left(\frac{1}{\sqrt{2}}\right)^k \cos\frac{k\pi}{4} + \frac{1}{2}\left(\frac{1}{\sqrt{2}}\right)^k \sin\frac{k\pi}{4}$; -- 3 marks

PART B

Answer any two full questions, each carries 15 marks.

4 (15)



$$G(s) = \left(\frac{1-e^{-sT}}{s}\right)\frac{1}{s(s+1)} \cdot 1, \quad H(s) = 1.$$

$$\frac{C(z)}{R(z)} = \frac{G(z)}{1+GH(z)} \; ; \quad H(s) = 1, \quad GH(z) = G(z).$$

Therefore

$$\frac{C(z)}{R(z)} = \frac{G(z)}{1+G(z)} \Rightarrow \frac{Z[G(s)]}{1+Z[G(s)]}.$$

5 mark

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

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

$$= \frac{z-1}{z}\left[\frac{z}{(z-1)^2} - \frac{z}{z-1} + \frac{z}{z-0.368}\right] \quad T=1.$$

$$= \frac{1}{z-1} - 1 + \frac{z-1}{z-0.368} \Rightarrow \frac{0.368z + 0.264}{(z-1)(z-0.368)}$$

5 mark

$$\frac{C(z)}{R(z)} = \frac{\frac{0.368z+0.264}{(z-1)(z-0.264)}}{1+\frac{0.368z+0.264}{(z-1)(z-0.264)}} \Rightarrow \frac{0.368z+0.264}{z^2-z+0.632}.$$

5 mark

5 a) Intermediate steps – 8 mark (10)

Final Answer

$$C(z) = \frac{G_1(z)G_2(z)R(z)}{1+G_1(z)G_2H(z)}$$

2 marks

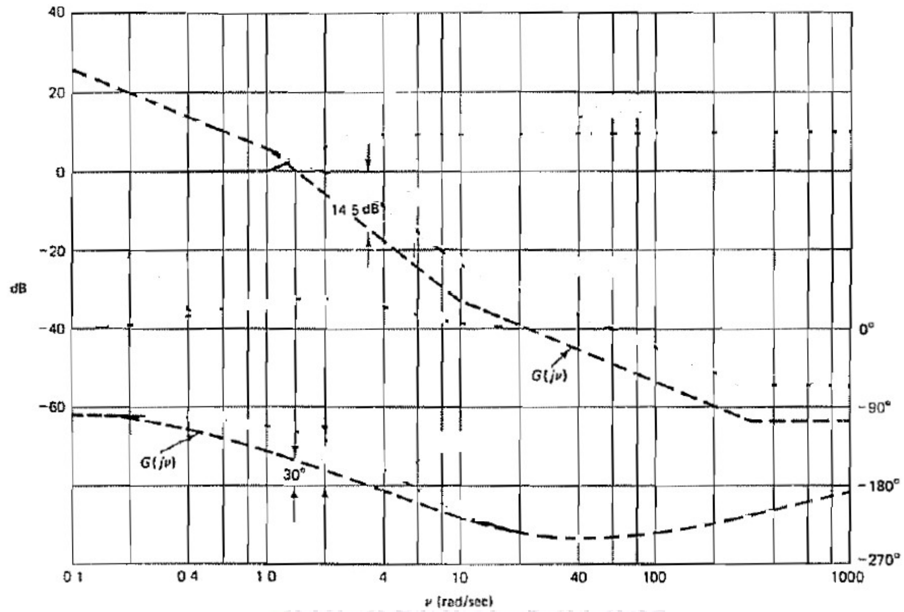
b) Stability (3), unit circle (2) (5)

6 (15)

Applying bilinear transformation $z = \frac{1+(T/2)w}{1-(T/2)w}$

$$G(w) = 2\frac{\left(1+\frac{w}{300}\right)\left(1-\frac{w}{10}\right)}{w(w+1)}$$ -------------- 5 mark

Bode Plot - 5 mark



Phase margin = 30 degree, Gain margin = 14.5 dB ---- 5 mark

PART C

Answer any two full questions, each carries 20 marks.

7 a) Expression for state transition matrix --- 2 marks (10)

Finding $(zI\text{-}G)^{-1}$; ---4 marks

State Transition matrix $\begin{bmatrix} \frac{4}{3}(-0.2)^k - \frac{1}{3}(-0.8)^k & \frac{5}{3}(-0.2)^k - \frac{5}{3}(-0.8)^k \\ \frac{-0.8}{3}(-0.2)^k + \frac{0.8}{3}(-0.8)^k & \frac{-1}{3}(-0.2)^k + \frac{4}{3}(-0.8)^k \end{bmatrix}$; ---

4 marks

b) Partial Fraction Expansion – 3 marks (10)

Block Diagram (Diagonal Canonical Form)– 4 marks

State space Representation – 3 marks

8 a) z-transform of state equation and output equation --- 4 marks (10)

Expression of $Y(z) = C(zI - G)^{-1} zx(0) + (C(zI - G)^{-1} H + D)U(z)$ ---4 marks

Transfer Function expression (z-transform) $\frac{Y(z)}{U(z)} = C(zI - G)^{-1} H + D$;---2 marks

b) State space representation --- 2 marks (10)

Explanation with block diagram representation --- 6 marks

State space representation for time varying system – 2 marks

9 a) Expression – 2 marks (5)

Explanation – 3 marks

b) (15)

State Controllability Matrix $\begin{bmatrix} 0 & 1 \\ 1 & -2 \end{bmatrix}$, State Controllable (5 marks)

Output Controllability Matrix $\begin{bmatrix} -1 & 1 \end{bmatrix}$, Output Controllable (5 marks)

Observability Matrix $\begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix}$, Observable (5 marks)

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