APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Scheme of Valuation/Answer Key

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

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2018

Course Code:AE405

Course Name: ADVANCED CONTROL THEORY

Max. Marks: 100 Duration: 3 Hours

PART A

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

1 a) 1 mark for each (5)

b) Statespace 8mark, statediagram 2mark (10)

I b. $\frac{d^2y}{dt^2} + 6\frac{dy}{dt} + 8\,y(t) = r(t)$

$x_1 = y \quad ; \quad \dot{x}_1 = x_2$

$x_2 = \frac{dy}{dt} \quad ; \quad \dot{x}_2 = \frac{d^2y}{dt^2} = -6\frac{dy}{dt} - 8y + r(t)$

$\dot{x}_2 = -8y - 6\frac{dy}{dt} + r(t)$

$\dot{x}_2 = -8x_1 - 6x_2 + r$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -8 & -6 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}\begin{bmatrix} r_1 \\ r_2 \end{bmatrix}$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

2 a) Singularity 2 mark, type 3 mark (5)

b) 10 marks (10)

3 a) Singularity 3marks , Plot of trajectory 7 marks (10)

b) State transition matrix 5 marks (5)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Describing function of relay 5 marks (5)

b) (10)

Now, $G(j\omega)=\dfrac{1}{j\omega(1+j\omega)(2+j\omega)}=\dfrac{(1-j\omega)(2-j\omega)}{j\omega(1+\omega^2)(4+\omega^2)}=\dfrac{2-j3\omega-\omega^2}{j\omega(1+\omega^2)(4+\omega^2)}$

Separating $G(j\omega)$ into real and imaginary parts, we obtain

$$\text{Im}\ G(j\omega)=\frac{2-\omega^2}{j\omega(1+\omega^1)\omega(4+\omega^2)}=0$$

or

$$\omega^2=2 \quad\Rightarrow\quad \omega=\pm\sqrt{2}$$

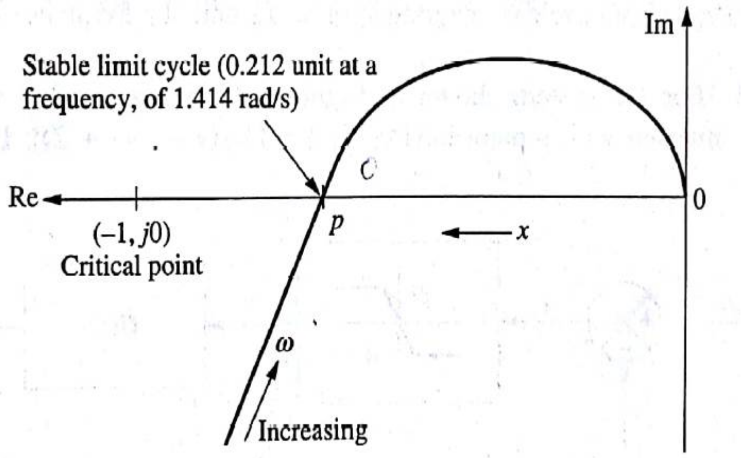
Now, $\text{Re}\ G(j\omega)=\dfrac{-j3\omega}{j\omega(1+\omega^2)(4+\omega^2)}=\dfrac{-3}{(1+\omega^2)(4+\omega^2)}=\dfrac{-3}{(1+2)(4+2)}=-\dfrac{3}{18}=-\dfrac{1}{6}$

Therefore, at the point of intersection

$$\frac{1}{k_{eq}}=-\frac{\pi E}{4}=-\frac{1}{6}$$

$\therefore\ E=\dfrac{4}{6\pi}=0.212$ unit and frequency = 1.414 rad/s.

So, the coordinate of P is $(-0.212, j0)$ and is very much within the critical point $(-1, j0)$.
Therefore, a stable limit cycle of magnitude of 0.212 unit at a frequency of 1.414 rad/s exists.



5 a) Stability 5 mark, lyapunov function 5 marks (10)

b) Sign definiteness with eg 5 mark (5)

6 a) 2.5 marks each comparison (5)

b) Explanation with diagram 10 marks (10)

PART C

Answer any two full questions, each carries 20 marks.

7	a)	Observability matrix 6 marks, checking Rank same or not 3 marks , comment on observability 1 mark	(10)
	b)	5 marks Pulse transfer function	(5)
	c)	Explanation 3 mark, diagram of mapping 2 marks	(5)
8	a)	15 marks	(15)
	b)	ROC 2 marks, properties 3 marks	(5)
9	a)	Controllability matrix 6 marks, Checking Rank same or not 3 marks, comment on controllability 1 mark	(10)
	b)	10 marks	(10)

9 (b) $x(k+2) + 3x(k+1) + 2x(k) = 0$; $x(0) = 0$; $x(1) =$

$$Z(x(k+2)) = z^2 X(z) - z^2 x(0) - z\,x(1)$$

$$Z(x(k+1)) = z\,X(z) - z\,x(0)$$

$$Z(x(k)) = X(z)$$

Applying this in eq

$$z^2 X(z) - z^2 x(0) - z\,x(1) + 3z(x(0) + 2(X(z) = 0$$

Substituting the initial data & simplifying gives.

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

$$x(k) = (-1)^k - (-2)^k \; ; \quad k = 0, 1, 2 \ldots$$

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