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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION, JUNE/JULY 2018

Branch: **Electrical &Electronics Engineering**

Stream(s): **Control Systems, Guidance And Navigation Control**

Course Code & Name: 01EE6103 **DIGITAL CONTROL SYSTEMS**

Answer *any two full* questions from *each* part

Limit answers to the required points.

Max. Marks: 60 | Duration: 3 hours

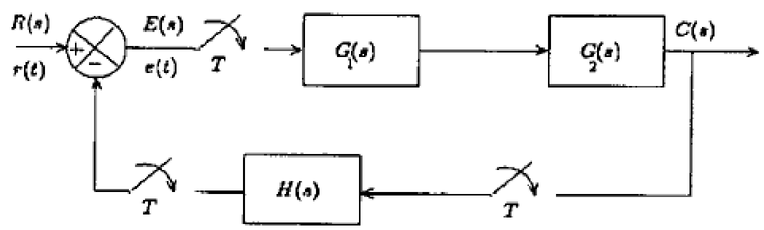
PART A

1. a. Explain the sampling process and loss of information and noise due to sampling — 3

   b. Obtain the z-transform of the function $f(k) = k^2u(k), where, u(k) = 1, k \geq 0, k < 0$ — 3

   c. Find the inverse z transform of $\dfrac{2z^3 + z}{(z-2)^2(z-1)}$ — 3

2. a. Obtain the pulse transfer function of the system shown below: — 3



   b. Explain the mapping between s-plane and z-plane — 4

   c. For the following analog controller, find the transfer function of the corresponding digital controller using pole-zero matching method — 2

$$G(s) = \frac{s+1}{s^2 + 5s + 6}, T = 0.01$$

3. a. For a unity feedback system, with sampling time T=1sec, open loop pulse transfer function is $G(z) = \dfrac{K(0.3679z + 0.2542)}{(z-0.3679)(z-1)}$. Determine the value of K for stability by use of Jury's stability test. Also determine the frequency of oscillations at the output — 4

   b. Explain Schur-Cohn test to determine the conditions for stability of a second order system — 2

   c. Derive the expression for pulse transfer function of systems with ZOH — 3

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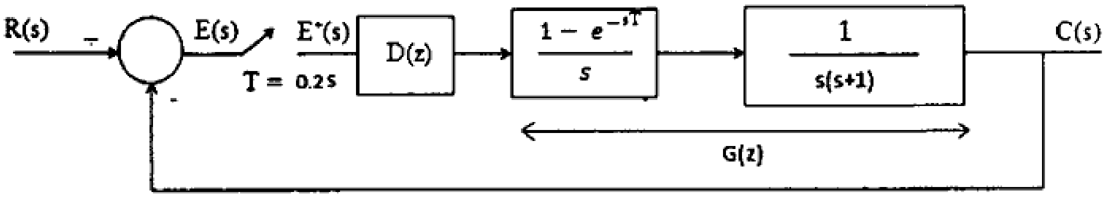
PART B

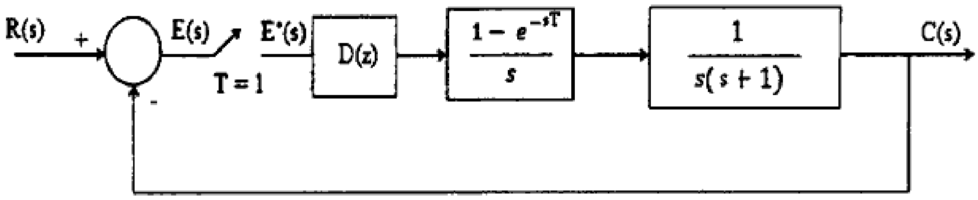
4. Consider the digital control system shown in figure. Design a digital controller D(z) such that the closed loop system has a damping ratio 0.5 and the number of samples per cycle of damped sinusoidal oscillation to be 0.8 — 9



5. For the system shown, find — 9

(i) Phase margin of the system when D(z) =1

(ii) Design a unity dc gain phase lag compensator D (z) that yields a phase margin of approximately 45 degrees.



6. a. Obtain the discrete time equivalent of the system — 5

$$\begin{bmatrix}\dot{x}_1(t)\\ \dot{x}_2(t)\end{bmatrix}=\begin{bmatrix}-2 & 2\\ 1 & -3\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\end{bmatrix}+\begin{bmatrix}-1\\ 5\end{bmatrix}u(t)$$

$$y(t)=\begin{bmatrix}2 & -4\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\end{bmatrix}+6u(t)$$

with a sampling interval T=0.2s

b. Design a controller to place the poles at $-0.5 \pm j0.5, 0$ for the system — 4

$$\begin{bmatrix}x_1(k+1)\\ x_2(k+1)\\ x_3(k+1)\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -4 & -2 & -1\end{bmatrix}\begin{bmatrix}x_1(k)\\ x_2(k)\\ x_3(k)\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}u(k)$$

$$y(k)=\begin{bmatrix}1 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1(k)\\ x_2(k)\\ x_3(k)\end{bmatrix}$$

Assume any additional data required

PART C

7. The frequency response of the system with open loop transfer function 12

$G(z) = \dfrac{0.368(z+0.177)}{(z-1)(z-0.368)}$ is given in table 1. T=0.15 sec.

Design a unity gain phase lag compensator D(z) that yields, a phase margin of approximately 45° and draw frequency responses of the uncompensated and compensated system

ω_w	ω	$\lvert G(j\omega_w)\rvert$	$\lvert G(j\omega_w)\rvert_{dB}$	$\angle G(j\omega_w)$
0.10	0.099	9.95473	19.96	-98.530
0.20	0.199	4.91192	13.82	-106.980
0.30	0.297	3.20693	10.12	-115.100
0.40	0.394	2.34103	7.38	-122.830
0.50	0.490	1.81474	5.17	-130.100
0.60	0.582	1.46124	3.29	-136.870
0.70	0.673	1.20853	1.64	-143.140
0.80	0.761	1.02011	0.17	-148.920
0.90	0.845	0.8753	-1.15	-154.240
1.00	0.927	0.7614	-2.36	-159.130
2.00	1.570	0.30058	-10.44	-190.880
3.00	1.965	0.1822	-14.78	-205.370
4.00	2.214	0.13244	-17.55	-212.260
5.00	2.380	0.10579	-19.51	-215.430
6.00	2.498	0.08942	-20.97	-216.610
7.00	2.585	0.07849	-22.10	-216.680
8.00	2.651	0.07073	-23.00	-216.110
9.00	2.704	0.06502	-23.73	-215.180

8. a. Consider the discrete time system defined by the equation $\begin{matrix} x(k+1) = Gx(k) + Hu(k) \\ y(k) = Cx(k) \end{matrix}$ where 8

$G = \begin{bmatrix} 0 & 0 & -0.25 \\ 1 & 0 & 0 \\ 0 & 1 & 0.5 \end{bmatrix}, H = \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$. Assuming that the output y(k) is measurable, design a minimum order observer, such that the error will exhibit deadbeat response

b. Explain separation principle 4

9. a. Consider a multi output linear system described by the state model 3

$$x(k+1) = Fx(k) + Gu(k)$$
$$y(k) = Cx(k)\_Du(k)$$
$$where, F = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & 1 & -1 \end{bmatrix}, G = \begin{bmatrix} 0 & 1 \\ 1 & 0 \\ 1 & 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}, D = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Check whether the system is observable

b. Consider the digital control system shown in figure where the plant is of first order and has a dead time of 2sec. The sampling period is assumed to be 1 sec or T=1. Design a digital PI controller such that the dominant closed loop poles have a damping ratio of 0.5 and the no. of samples per cycle of damped sinusoidal oscillation is 10. Obtain the response of the system to a unit step input. Also obtain the static velocity error constant K_v and find the steady state error in the response to a unit ramp input. 9