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(Pages : 4)

Reg. No. : ....

Name : ....

First Semester M.Tech. Degree Examination, February 2015
(2013 Scheme)
Branch : Electrical and Electronics Engineering
Streams : Control Systems, Guidance and Navigational Control
ECC 1002 : DIGITAL CONTROL SYSTEMS

Time : 3 Hours | Max. Marks : 60

Instructions : *Answer* ***any two full*** *questions from* ***each*** *Module.* ***Each*** *full question carries* ***10*** *marks.*

MODULE – 1

1. a) State and explain sampling theorem.

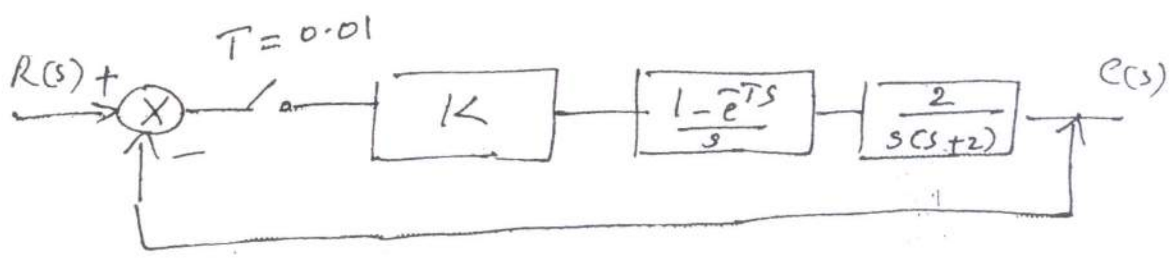
   b) Use Z – Transform to fixed the solution of the following difference equation
   $y(k + 3) - 2y(k + 2) - 4y(k + 1) = 2x(k + 2) - 4x(k + 1) + x(k)$

2. a) Obtain the inverse Z – Transform of the following (1) $X(Z) = Z^{-4}/(1 - z^{-1})^4$

   (2) $X(Z) = (z(z+4))/(z-1)^3$

   b) State and explain stability criterion with Schur-Cohn Analysis.

3. Consider the discrete time closed loop system shown in figure.



Determine the range of gain 'K' for stability by use of Jury stability criterion.

MODULE – 2

4. Design a digital controller $G_0(Z) = K.\frac{z}{(z-1)}$ based on Root Locus approach, sampling period T = 0.2 sec. $G(s) = \frac{1}{s(s+4)}$ and $ZOH = \left(\frac{1-e^{-Ts}}{s}\right)$. Investigate the effects of sampling period T on transient response characteristics. Draw the root locus for T = 0.2 and 0.5 sec. Find the critical value of gain in the above two cases.

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

$$G(Z) = \frac{0.368\,(Z+0.178)}{(z-1)(z-0.468)}$$ is given table 1. T = 0.15

Design a unity dc gain phase lead compensator that yields, a phase margin of approximately 45°.

6. a) Define controllability and derive the condition for rank test for complete state controllability.

   b) Obtain the discrete time equivalent of the system.

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 2 & -1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 & (t) \\ x_2 & (t) \end{bmatrix} + \begin{bmatrix} -1 \\ 5 \end{bmatrix} u(t)$$

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

sampling interval, T = 0.20 sec.

Table 1. Frequency response

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
10.00	2.746	0.06068	-24.33	-214.060
20.00	2.942	0.04455	-27.02	-203.020
30.00	3.008	0.04097	-27.75	-196.540
40.00	3.041	0.03964	-28.03	-192.770

MODULE – 3

7. Find the discrete state-space representation of the following system

$G(s) = \dfrac{1}{s^2 + 0.25 + 1}$. Assuming there is a ZOH and sample period, T = 0.5 Sec.

Find the full state digital feedback that provides equivalent s-plane poles at $W_n = 2$ rad/Sec with Y = 0.5.

8. a) Explain prediction observer.

b) A heat exchanger has the transfer for

$$G(s)=\frac{e^{-5s}}{(10s+1)(60s+1)},$$ where the delay is due to the sensor

(a) Write state equations for this system.

(b) Compute ZOH model with a sample period of 0.5 Sec.

(c) Design the compensation including the command i/p with the control poles at $0.8 \pm j\,0.25$ and the estimator poles at $0.4 \pm j\,0.40$.

9. Consider a system $x(k+1) = Gx(k) + H\,u(k)$, $Y(k) = C\,x(k)$ Assuming that the output $Y(k)$ is measurable.

Design a minimum order observer, such that the observer poles placed at $0.2 \pm j\,0.2$.

Where $G=\begin{bmatrix} 0 & 0 & -0.5 \\ 1 & 0 & 0 \\ 0 & 1 & 0.75 \end{bmatrix}$, $H=\begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}$; $C=\begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$.