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Invigilator's Signature : ....

CS/M.TECH(EIE)/SEM-2/CIM-203/2012

2012

DIGITAL CONTROL SYSTEMS

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer Q. No. 1 and *two* from each of Group-B & Group-C.

GROUP – A
(Multiple Choice Type Questions)

1. Answer the following questions : $7 \times 2 = 14$

A. Choose the correct alternatives for the following :

i) $\lim_{k \to \infty} F(KT)$ is

a) $\lim_{z \to 1} (1 - Z^{-1}) F(z)$

b) $\lim_{z \to 1} (1 + Z^{-1}) F(z)$

c) $\lim_{z \to \infty} (1 - Z^{-1}) F(z)$

d) none of these.

ii) The static velocity error constant is

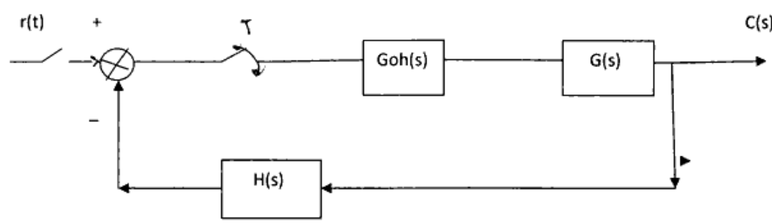
a) $Kv = \frac{1}{T} \lim_{z \to 1} (Z - 1) GH(z)$

b) $Kv = \frac{1}{T} \lim_{z \to 1} (Z + 1) GH(z)$

c) $Kv = \frac{1}{T} \lim_{z \to 0} (Z + 1) GH(z)$

d) none of these.

iii) The pulse transfer function of a closed loop system shown in the figure is



a) $\frac{1}{1 + z[Goh(s)G(s)H(s)]}$

b) $\frac{z[Goh(s)G(s)]}{1 + z[Goh(s)G(s)H(s)]}$

c) $\frac{z[Goh(s)G(s)]}{1 - z[Goh(s)G(s)H(s)]}$

d) none of these.

iv) A practical PID controller would have a derivative term in its transfer function of the form

a) $K_D \frac{T}{2} \frac{z+1}{z-1}$

b) $K_D \left(\frac{Tz}{z-1} \right)$

c) $K_D \left(\frac{z-1}{Tz} \right)$

d) $K_D \frac{T}{2} \frac{z-1}{z+1}$.

v) The *z*-transfer function $f(t) = te^{-2t}$ is given by

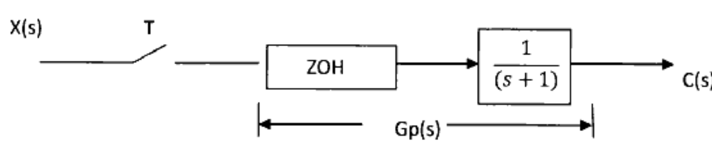
a) $\frac{e^{-2t}}{(z-1)^2}$

b) $\frac{Tz}{(z-2)^2}$

c) $\frac{ze^{-2t}}{(z-e^{-2t})^2}$

d) $\frac{Tze^{-2t}}{(z-e^{-2t})^2}$.

vi) The pulse transfer function $G_p(z)$ of the system shown in figure is



a) $\frac{1-e^{-T}}{z-e^{-T}}$

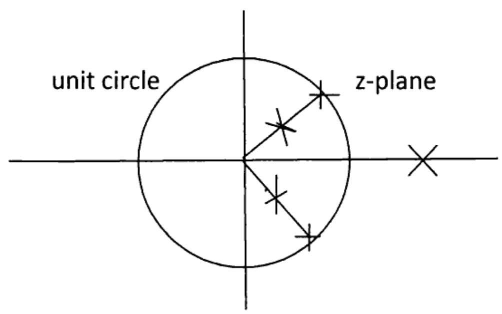
b) $\frac{1-e^{-T}}{(z-e^{-T})(z-1)}$

c) $\frac{z(1-e^{-T})}{z-e^{-T}}$

d) $\frac{Tz}{z-e^{-T}}$.

B. Answer the following question in brief :

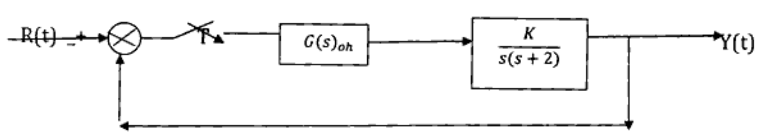
vii) State and draw the nature of responses as functions of time for the two pairs of complex Z plane pole locations and a pole on the real axis as shown in the figure.



GROUP – B

Answer any *two* of the following. $2 \times 14 = 28$

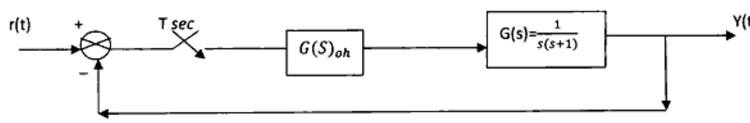
2. a) Determine the range of gain K which ensures the stability of the closed loop system shown in figure given below, taking T = 0·1 sec. Also determine the range of K for the continuous system in absence of sample and hold.



b) State and explain the Shannon's sampling theorem.

10 + 4

3. a) Show that the stability of the closed loop discrete data system shown in the figure given below, is dependent on the sampling period T. Comment on the stability performance when sampling period T is reduced from 0·1 sec.



b) What are folding phenomenon and aliasing ? 10 + 4

4. a) Solve the difference equation

$X(k+2)-3x(k+1)+2x(k)=4^k$, Given $x(0)=0, x(1)=1$

b) Compute the output $Y(kt)$ of the closed loop system in the figure given in Q. 3(a) for T = 0·1 sec (first five samples).

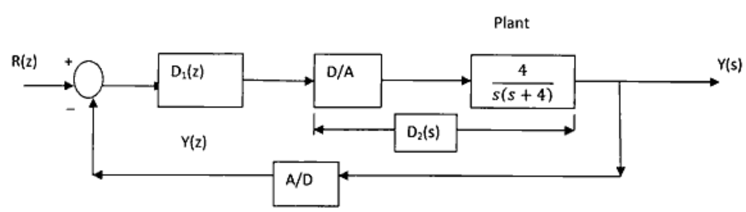
c) Briefly discuss the factors influencing the choice of sampling intervals in the performance of discrete control system. 6 + 5 + 3

GROUP – C

Answer any *two* of the following. 2 × 14 = 28

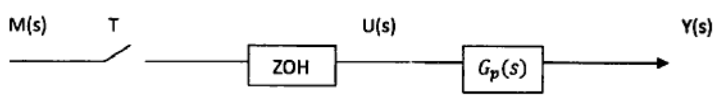
5. a) Briefly discuss the objectives of 'Dead beat' controllers used in discrete data systems. State the desired closed loop response characteristics of a dead beat system.

b) The model of a control system consisting of a digital controller $D_1(z)$ driving an analog positioning system $D_2(s)$ with a sampling interval $T = 0{\cdot}1$ sec is shown in figure given below. Design a controller transmittance $D_1(z)$ so that the overall digital system is 'dead beat' and the error between output and input to a step input is zero in the steady state.



3 + 11

6. a) The state equation for the continuous portion of the discrete data system shown in the figure below is



$$v(t) = A_c v(t) + B_c u(t)$$

$$Y(t) = C_c v(t) + D_c u(t)$$

Determine the discrete state equation of the system preserving the natural states of the continuous model.

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b) A closed-loop discrete system has to be realised by state variable feedback utilizing the position $X_1(k)$ and velocity $X_2(k)$ signal by pole assignment design with control input $u(k) = kx(k)$. The desired closed loop pole locations are $(0 \cdot 78 \pm j0 \cdot 40)$ and the discrete state model is

$$X(k+1) = \begin{bmatrix} 1 & 0 \cdot 07 \\ 0 & 1 \end{bmatrix} x(k) + \begin{bmatrix} 0 \cdot 005 \\ 0 \cdot 06 \end{bmatrix} u(k)$$

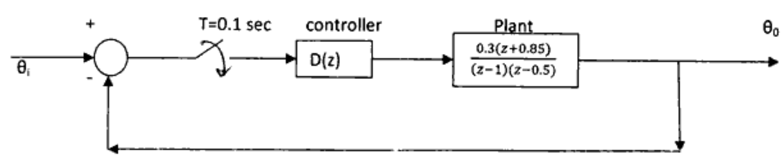
$$Y(k) = \begin{bmatrix} 1 & 0 \end{bmatrix} x(k)$$

Determine the gain matrix K and show how the gains may be implemented. 5 + 9

7. Design a PI controller $D(z)$ for a servo system shown in the figure below which should meet the following performance specifications :

i) $Kv \geq 15$

ii) Phase margin $\geq 60°$



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