DIGITAL CONTROL SYSTEMS
(AEIE 4243)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The z-transform of $(0.01)^K$; for K≥0 is
(a) $\frac{0.01}{z}$ (b) $\frac{z-0.01}{z}$ (c) $\frac{z}{z-0.01}$ (d) 0.01z

(ii) The equation of ZOH in the interval between the sampling instants kT and (k+1)T is
(a) fk(t)=f(kT) (b) fk(t)=f(k+1)T
(c) fk(t)= f(kT)+ f(1)(kT) (d) fk(t)=f(k+1)T - f(kT)

(iii) Repeated roots on the unit circle contour makes the system
(a) Absolutely stable (b) Unstable
(c) Conditionally stable (d) Stable

(iv) What is the number of roots of the polynomial $F(z) = 4z^3-8z^2-z+2$, lying outside the unit circle?
(a) 0 (b) 1 (c) 2 (d) 3

(v) Choose the correct one regarding mapping from s-plane to z-plane:
(a) Right side of the s-plane maps into circumference of the unit circle in z-plane
(b) Left half of s-plane maps into inside of the unit circle
(c) Imaginary axis of s-plane maps into the outside of the infinite circle
(d) Imaginary axis of s-plane maps into the inside of the unit circle

(vi) If an error signal be *e(t) >0* in an ON-OFF controller, what would be its output?
(a) 0% (b) 50% (c) 75% (d) 100%

(vii) The impulse function is a derivative of _____ function
(a) parabolic (b) step (c) ramp (d) linear

(viii) If the time sequence x(z) delayed by 5 unit then its z-transform represented in the form

(a) $-5x(z)$ (b) $z^{-5}x(z)$ (c) $5x(z)$ (d) $-z^{5}\frac{dx(z)}{dz}$

(ix) A system has a single pole at origin. Its unit step response will be

(a) Constant (b) Ramp (c) Exponential (d) Oscillatory

(x) If the gain of the system is reduced to a zero value, the roots of the system in the s-plane,

(a) Coincide with zero (b) Move away from zero

(c) Move away from poles (d) Coincide with the poles

Group – B

2. (a) What is sample and hold circuit? Explain the importance of sample and hold circuit in flat –top sampling to generate PAM signal.

(b) Find the inverse z-transform of the function $F(z)=\frac{z}{(z+0.1)(z+0.2)(z+0.3)}$.

(c) Plan a computer control scheme of an aircraft turbojet engine. You need to measure and control both aircraft state and engine state using suitable sensors and controllers respectively.

(1 + 4) + 4 + 3 = 12

3. (a) Solve the linear difference equation: $x(k+2)-1.5x(k+1)+0.5x(k)=1(k)$ with initial conditions $x(0)=1$ and $x(1)=2.5$.

(b) Find the z-transform of the casual sequence $f(k)=2\times1(k)+4\delta(k)$, k=0, 1, 2, ……..

(c) Explain a scheme to control a 3-DOF robot manipulator using digital control system.

5 + 3 + 4 = 12

Group – C

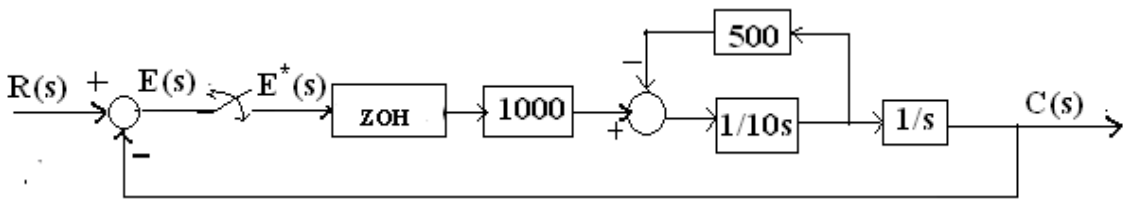
4. (a) Derive the correlation between root locations in s-plane and z-plane.

(b) Derive transfer function of ZOH.

(c) From the diagram below calculate the following:

i) Steady state errors for unit step, unit ramp and unit parabolic inputs.

ii) Position, velocity and acceleration error coefficients.



2 + 4 + (3 + 3) = 12

5. (a) Find the equivalent sampled impulse response sequence and the equivalent z-transfer function for the cascade of the two analog systems with sampled inputs $H_1(s)=\frac{1}{S+2}$ and $H_2(s)=\frac{2}{S+4}$
(i) If the systems are directly connected and
(ii) If the systems are separated by a sampler.

(b) Draw a negative feedback digital closed loop control system and find error at z-domain E(z). Use this E(z), find steady state error for (i) type-0 system, (ii) type-1 system and (iii) type-2 system.

(3 + 3) + (1 + 2 + 3) = 12

Group – D

6. (a) The characteristic equation of a system is given as $1+\frac{K(0.084z^2+0.17z+0.019)}{(z^3-1.5z^2+0.553z-0.05)}=0$.
Find the range of K of the given characteristic equation using bilinear transformation and Routh stability criterion for which system will be stable.

(b) The characteristic equation $P(z)$ of a system is given as, $P(z)=z^3+0.25z^2+z+0.25=0$. Check the stability of the system using Jury Stability criterion.

6 + 6 = 12

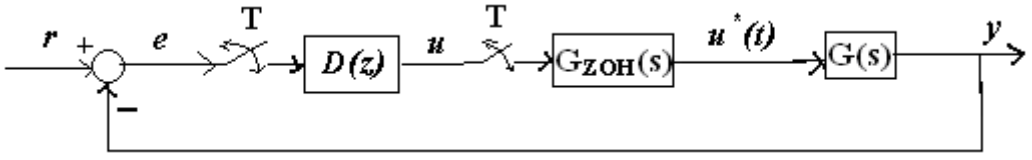
7. (a) The characteristic equation of a system is given as: $1+\frac{Kz(1-e^{-T})}{(z-1)(z-e^{-T})}=0$. Draw the root locus of the system for T=0.5 sec. Find (i) Break away / break in points and (ii) the range of K for which system will be stable.

(b) What is singular case in a Jury Table and how it can be avoided?

(4 + 2 + 2) + 4 = 12

Group – E

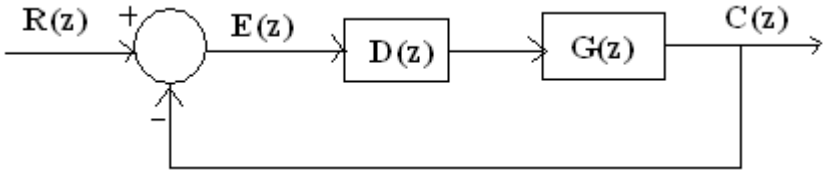
8. The plant of sampled-data system of Fig. below is described by the transfer function $G(s)=\frac{1}{s(10s+1)}$ and the sampling period is 1 sec.
Considering the following specifications:
- $K_v \geq 1$
- $\zeta = 0.5$ and
- t_s (2% tolerance band) ≤ 8 sec.



(i) Find $G_{ZOH}(s) \times G(s)$ in z-domain.
(ii) Draw the pole-zero map to compute angle contribution.
(iii) Design the digital controller D(z).

(4 + 4 + 4) = 12

9. As shown in Fig. below, a digital controlled process G(z) is described by $G(z) = \frac{0.0004(z+0.2)(z+2.8)}{(z-1)^2(z-0.28)}$.



(i) Design a dead beat response controller D(z)
(ii) Derive the output sequence c(z) or c(KT) which will track the unit step perfectly after few sampling periods.
(iii) Draw the deadbeat response of the system.

(7 + 3 + 2) = 12

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AEIE	https://classroom.google.com/c/Mjk5MzM5Nzk3OTk5/a/MzYwMDI4ODMxNTg3/details