TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Digital Control System *(EE 652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the process of data acquisition, conversion and distribution system applied in discrete time system. [6]

   b) What are the problem associated with the quantization and how it can be improved? Also write the advantage of digital control system over analog control system. [4+2]

2. a) Obtain the z-transform of $x(t)$ for which time response is given by, {assume sampling period T=1s} [4]

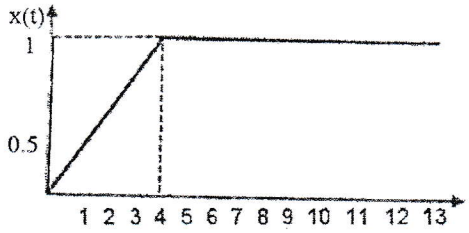


Figure: Continuous time signal

   b) Obtain the inverse z-transform of [6]

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

   by using partial fraction expansion method.

   c) Consider the difference equation: [6]

   $x(k+2) - 1.3679x(k+1) + 0.3679x(k) = 0.3679\,u(k+1) + 0.2642u(k)$ where $x(k)$ is the output and $x(k)=0$ for $k \leq 0$ where $u(k)$ is the input and is given by

   $u(k) = 0, \quad k<0$

   $u(0) = 1$

   $u(1) = 0.2142$

   $u(2) = 0.2142$

   $u(k) = 0, k = 3,4,5,6.....$

   Determine the output x(k).

3. a) Determine the stability of system having characteristics equation using jury test. [6]

$P(z) = 2z^4+7z^3+10z^2+4z+1 = 0$

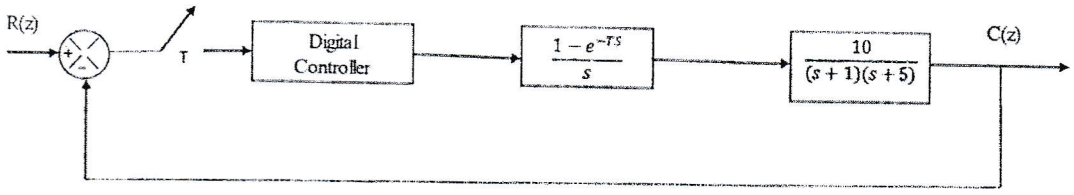
b) Consider the digital filter defined by: [8]

$$G(z) = \frac{2 + 2.2z^{-1} + 0.2z^{-1}}{1 + 0.4z^{-1} - 0.12z^{-2}}$$

Realize this filter in the ladder scheme.

c) What do you mean by Zero Order Hold (ZOH) and First Order Hold? Determine the transfer function for ZOH. [6]

4. a) Design a suitable digital controller that includes an integral control action. The design specifications are that the damping ratio of the closed loop poles be 0.5 and there will be at least eight samples per cycle of the damped sinusoidal oscillations. The sampling time is assumed to be 0.2 sec. [12]



b) Consider the digital filter defined by parallel programming [4]

$$\frac{Y(z)}{X(z)} = \frac{4(z-1)(z^2+1.2z+1)}{(z+0.1)(z^2-0.3z+0.8)}$$

5. a) What do you mean by state representation and why is it required? [8]

Consider the following system:

$$\frac{Y(z)}{U(z)} = \frac{z+1}{z^2+1.3z+0.4}$$

Obtain the state representation of the above pulse transfer function in the controllable canonical form.

b) Obtain Pulse transfer function matrix of the following state space representation: [8]

$$x(k+1) = Gx(k) + Hu(k)$$

$$y(k) = Cx(k) + Du(k)$$

Where $G = \begin{bmatrix} -a1 & 1 & 0 \\ -a2 & 0 & 1 \\ -a3 & 0 & 0 \end{bmatrix}$, $H = \begin{bmatrix} h1 \\ h2 \\ h3 \end{bmatrix}$, $C = [1\ 0\ 0]$ and $D = b_0$

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2077 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Digital Control System *(EE 652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) With the help of discrete time control system block diagram, explain data acquisition conversion and distribution system. [8]

   b) Compare different types of sampling operations used for sampling of continuous time signal. Also mention the advantages of digital control system over analog. [6+2]

2. a) Obtain z-transform of [4]

$$X(t) = \sin wt; \quad t >= 0$$
$$= 0; \quad t < 0$$

   b) Obtain the inverse z-transform of

$$X(Z) = \frac{z(1 - e^{-\alpha T})}{(z-1)(z - e^{-\alpha T})}$$

   using Inversion integral method. [4]

   c) Consider the difference equation $x(k+3) - 2.2\,x(k+2) + 1.57x(k+1) - 0.36x(k) = u(k)$, where $u(k) = 1$ for $k \geq 0$ and x(0)=x(1)=x(2)=0. Obtain the general solution x(k) in a closed form. Find the limiting value of x(k+2)/x(k) when sequence variable approaches infinity. [8]

3. a) Determine the stability of system having characteristics equation using jury test. [8]

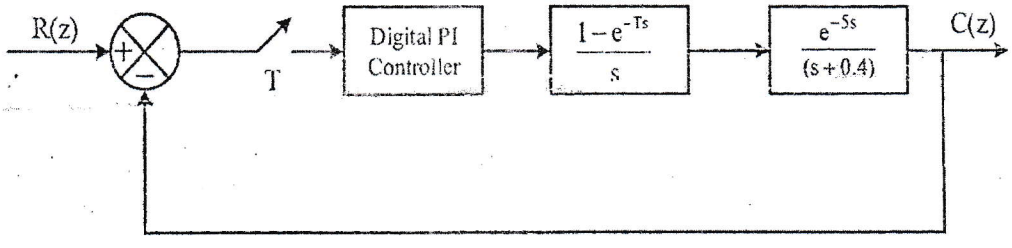
$$P(z) = z^3 - 1.1z^2 - 0.1z + 0.2 = 0$$

   b) Derive the pulse transfer function of PID controller. [8]

4. a) Realize the given digital controller by series programming. [4]

$$\frac{Y(z)}{X(z)} = \frac{4(z-1)(z^2 + 1.2z + 1)}{(z+0.1)(z^2 - 0.3z + 0.8)}$$

   b) Consider a digital control system shown below. By choosing a reasonable sampling period 'T', design a digital PI controller such that the dominant closed loop poles have a damping ratio ξ of 0.5 and the number of samples per cycle of damped sinusoidal oscillation is 10. Also find the static velocity error constant. [12]



5. a) Obtain the state space representation of following pulse transfer function: [8]

$$\frac{Y(z)}{U(z)} = \frac{1 + 3z^{-1} + 5z^{-2} + 4z^{-3}}{1 + 2z^{-1} + 7z^{-2} + 5z^{-3}}$$ in Controllable conical form.

b) Obtain Pulse transfer function matrix of the following state space representation: [8]

$$X(k+1) = GX(K) + Hu(k)$$
$$Y(k) = CX(k) + Du(k)$$

Where $G = \begin{bmatrix} -\alpha 1 & 1 & 0 \\ -\alpha 2 & 0 & 1 \\ -\alpha 3 & 0 & 0 \end{bmatrix}$, $H = \begin{bmatrix} h1 \\ h2 \\ h3 \end{bmatrix}$, $C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$ and $D = b_0$.

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2076 Bhadra

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Digital Control System *(EE 652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the process of data acquisition, conversion and distribution system applied in discrete time system. [8]

   b) What is quantization noise and quantization error in digital control system? Explain with appropriate example. [4]

   c) Find the z-transform of the following: [4]

$$x(t)=\begin{cases}0, & t<0\\ 0, & t\le 4\\ 1, & t>4\end{cases}$$

2. a) By using inversion integral method, obtain Inverse Z-transform of: [4]

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

   b) Higher order pulse transfer functions are generally realized by decomposing it in to several lower order pulse transfer function why? Consider a digital filter shown below. Realize this filter in ladder scheme.

$$G(z)=\frac{2+2.2z^{-1}+0.2z^{-2}}{1+0.4z^{-1}-0.12z^{-2}}$$ [2+6]

   c) Realize the given digital controller by direct Programming [4]

$$\frac{Y(z)}{X(z)}=\frac{6z^2+7z+16}{10z^3+8z^2+9z+15}$$

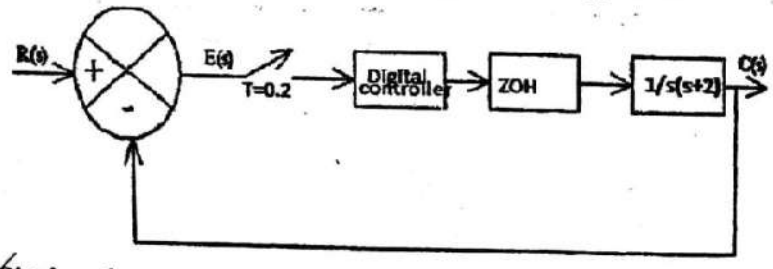
3. a) Consider a closed loop system with gain factor K. Determine the value of K for which system is stable. The closed loop pulse transfer function is following: [8]

$$1+\frac{(0.368z+0.264)K}{z^2-1.368z+0.368}=0$$

   b) Show that the transfer function of first order hold circuit is given by [8]

$$Gh_1(S)=\frac{Ts+1}{T}\left(\frac{1-e^{-Ts}}{s}\right)^2$$

4. a) Design a digital controller such that the compensated system should have damping ratio ζ=0.5 and settling time t_s = 2sec using root locus approach. [12]



b) Obtain time sequence solution for difference equation shown below: [4]
$x(k+2)+3x(k+1)+2x(k)=0, x(0)=0, x(1)=1$

5. a) Obtain the state space representation of following pulse transfer function in observable canonical form.

$$\frac{Y(z)}{U(z)}=\frac{0.3z^{-1}+0.6z^{-2}}{1-0.2z^{-1}+0.5z^{-2}}$$ [8]

b) Derive the pulse transfer function of a given state space representation. [8]

$x(k+1) = G\,x(k) + H\,u(k)$

$y(k) = C\,x(k) + D\,u(k)$

where,

$$G=\begin{bmatrix}-4 & 1\\ -2 & -1\end{bmatrix},\quad H=\begin{bmatrix}1\\ 1\end{bmatrix}$$

$$C=\begin{bmatrix}1 & 1\\ 2 & 1\end{bmatrix} \text{ and } D=[0]$$

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16 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Digital Control System *(EE652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

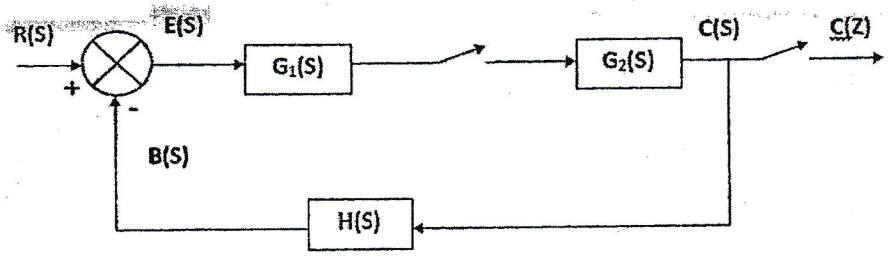
1. a) Explain the Operation of Digital System with suitable block diagram. [4]
   b) What do you mean by sample and hold circuit? Explain how tracking and hold mode are employed in digital control system. [8]
   c) Find the region of convergence for $x(k) = -a^k u(-k-1)$, where u(k) is the unit step function. [4]
2. a) State and prove final value theorem of z-transform. [1+3]
   b) Obtain z-transform of [4]

$$x(t) = \sin wt \quad ;t >= 0$$
$$= 0 \quad ;t < 0$$

   c) Obtain the inverse z-transform of: [8]

$$X(z) = \frac{z^2}{(z-1)^2(z-e^{-at})}$$

3. a) Find the discrete time output C(z) of the following closed loop system. [4]



   b) Examine the stability of the following characteristics equation. [6]

$$p(z) = z^4 - 1.2z^3 + 0.07z^2 + 0.3z - 0.08$$

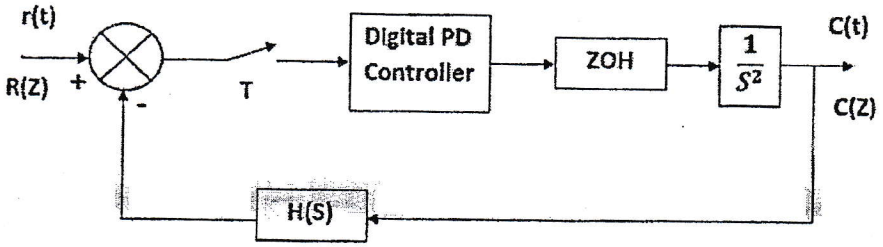
   c) Assume that a digital filter is given by the following difference equation: [6]

$$y(k) + a_1 y(k-1) + a_2 y(k-2) = b_1 x(k) + b_2 x(k) + b_2 x(k-1)$$

Draw block diagrams for the filters using (i) standard programming and (ii) ladder programming.

4. a) Discuss the situations where you prefer phase lag/lead controllers and PID controllers. [4]

b) Design a digital proportional-plus-derivative controller for the plant as shown in figure below. It is desired that the damping ratio ξ of the dominant closed loop poles be 0.5 and the undamped natural frequency be 4 rad/sec. the sampling period is 0.1 sec. [12]



5. a) Obtain the state space representation of following pulse transfer function: [8]

$$\frac{Y(z)}{U(z)} = \frac{0.368z^{-1} + 0.264z^{-2}}{1 - 1.368z^{-1} + 0.36z^{-2}}$$

i) Controllable canonical form
ii) Observable canonical form

b) Determine pulse transfer function matrix for the system which is described by state space representation as: [8]

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 3 & 1 \\ -2 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(k) \text{ and}$$

$$\begin{bmatrix} y_1(k) \\ y_2(k) \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 2 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(k)$$

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Baisakh

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Digital Control System *(EE652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) With the help of block diagram, explain digital control system in detail. Also mention the advantages of digital control system over analog. [8]

   b) Derive the transfer function of ZOH and also find the Pulse transfer function. [8]

2. a) Find the z-transform of the following: [4+4]

   (i) $x(t)=\frac{1}{4}t-\frac{1}{4}(t-4)1(t-4)$ (ii) $x(t)=\begin{cases}0, & t<0\\ \sin\omega t, & t\geq 0\end{cases}$

   b) Solve the difference equation:

   X(k+2)+1.379X(k+1)+0.3679X(k)=0.3679u(k) where u(k) is step input and x(0)=0, x(1)=0.3679. [8]

3. a) Explain with suitable diagram how constant damping ratio line in s-plane is mapped into z-plan? [4]

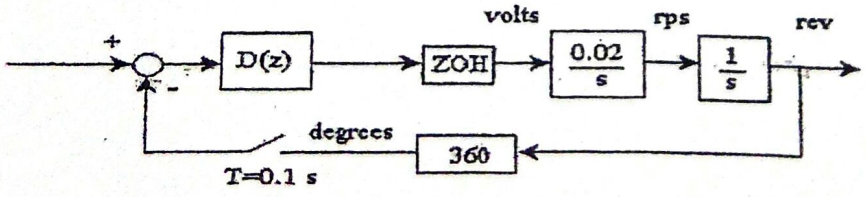
   b) Realize the digital filter by ladder programming. [8]

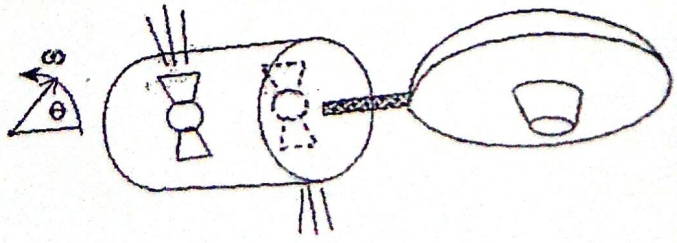
   $$G(z)=\frac{128z^{-3}+224z^{-2}+106z^{-1}+11}{128z^{-3}+160z^{-2}+34z^{-1}+1}$$

   c) Examine stability of characteristic equation. [4]

   $$P(z)=z^3-1.1z^2-0.1z+0.2=0$$

4. A control system block diagram shown in figure below is of satellite communication system. Design a lead compensator D(z) to stabilize a satellite position. The sampling rate of digital controller is 10 samples per second. Consider design criteria: (i) damping ratio must be greater than 0.6, (ii) damped natural frequency should not exceed 1 Hz. i.e. $\omega_d < 0.1\omega_n$, and the time constant for the closed loop control system should be less than 0.5 second with 5% criterion for settling time. [16]





5. a) Obtain the state space representation of the following pulse transfer function in controllable canonical form. [6]

$$\frac{Y(z)}{X(z)} = \frac{4z^3+3z^2+5z+4}{2z^3+5z^2+2z+3}$$

b) Obtain Pulse transfer function matrix of the following state space representation: [10]

$$x(k+1) = Gx(k) + Hu(k)$$

$$y(k) = Cx(k) + Du(k)$$

Where $G = \begin{bmatrix} -a1 & 1 & 0 \\ -a2 & 0 & 1 \\ -a3 & 0 & 0 \end{bmatrix}$, $H = \begin{bmatrix} h1 \\ h2 \\ h3 \end{bmatrix}$, $C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$

And $D = b_0$

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Digital Control System *(EE652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the data acquisition system in digital control system? Define tracking mode and hold mode in Sample-and-hold circuits. [8]

   b) Compare different types of sampling operations used for sampling of continuous time signal. [4]

   c) Write the advantages of digital control system over analog control system. [4]

2. a) Obtain the inverse z-transform of

$$x(z) = \frac{z(1-e^{-aT})}{(z-1)(z-e^{-aT})}$$ [4]

   using Inversion integral method.

   b) Obtain X(z) by the use of convolution Integral in the Left Half of s-plane of the transfer function. [4]

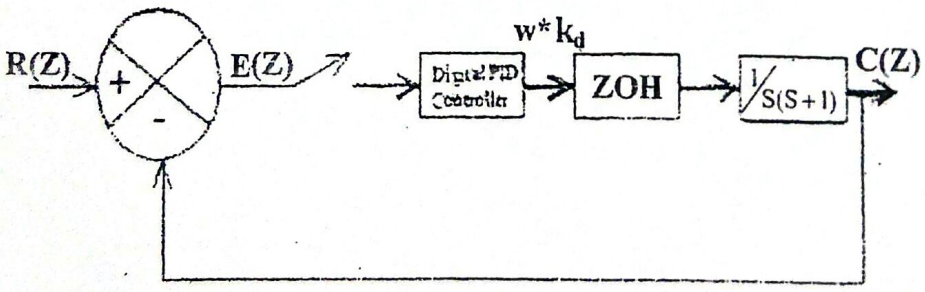
$$X(S) = \frac{1}{S^2(S+1)}$$

   c) Solve the following difference equation using z transform method. Also determine the value of $x(k+2)/x(k+1)$ as k approaches to infinity. [8]

$$x(k+3) - 2.2x(k+2) + 1.57x(k+1) - 0.36x(k) = u(k)$$

   where, $u(k) = 1$ for all $k \geq 0$, and $x(0) = x(1) = x(2) = 0$.

3. a) Obtain the closed loop transfer function of the system shown in figure below. Assume proportional gain (k_p) = 1, Integral gain (k_i) = 0.2. [8]
   Derivative gain (k_d) = 0.2. [Take T = 1 sec]

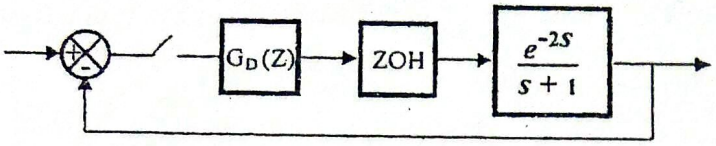


   b) Realize the given digital controller by Ladder Programming. [8]

$$G(z) = \frac{2z^2 + 2.2z + 0.2}{z^2 + 0.4z - 0.12}$$

4. a) Examine the stability of the characteristic equation given by $P(z) = z^3 - 1.1z^2 - 0.1z + 0.2 = 0$. [4]

b) Design a digital PI controller such that the dominant closed loop poles have damping ratio $\xi = 0.5$, sampling period T = 1, and $\frac{wd}{ws} = \frac{1}{10}$ and dead time of 2 sec. Also find KV and ess in response to unit ramp input. [12]



5. a) Obtain the state space representation of the system shown below in Jordan canonical form: [4]

$$\frac{Y(z)}{U(z)} = \frac{5}{(z+1)^2(z+2)}$$

b) Obtain the state space representation of the following pulse transfer function by observable canonical form: [6]

$$\frac{Y(z)}{X(z)} = \frac{(0.368z^{-1} + 0.264z^{-2})}{(1 - 1.368z^{-1} + 0.368z^{-2})}$$

c) Derive the pulse transfer function of the given state space representation form

$x(k+1) = G\,x(k) + H\,x(k)$ and $y(k) = C\,x(k) + D\,u(k)$ [6]

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Digital Control System *(EE652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
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1. a) With the help of block diagram, explain the principle feature of discrete time control system. [6]

   b) Show that the minimum sampling rate required to recover a signal whose band spectrum is limited to w_m is equal to $2w_m$. [6]

   c) Obtain the inverse transform of the function $x(z) = \dfrac{-3.894.z}{(z^2 + 0.6065)}$ [4]

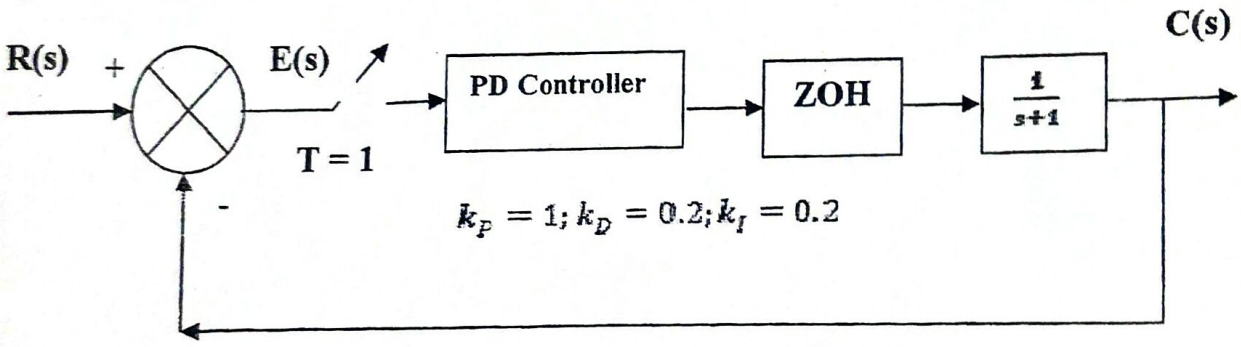
2. a) Solve the following difference equation and hence determine the output x(k) [8]

   $x(k+2) - x(k+1) + 0.25x(k) = u(k+2)$

   Where, $x(0) = 1$ and $x(1) = 2$

   $u(k) = 1, k = 0,1,2,.....$

   b) Determine the pulse transfer function of the system shown below. [8]



[**ZOH**= Transfer Function of Zero Order Hold Circuit]

3. a) Check the stability of system having characteristic equation as follows using jury criterion. [8]

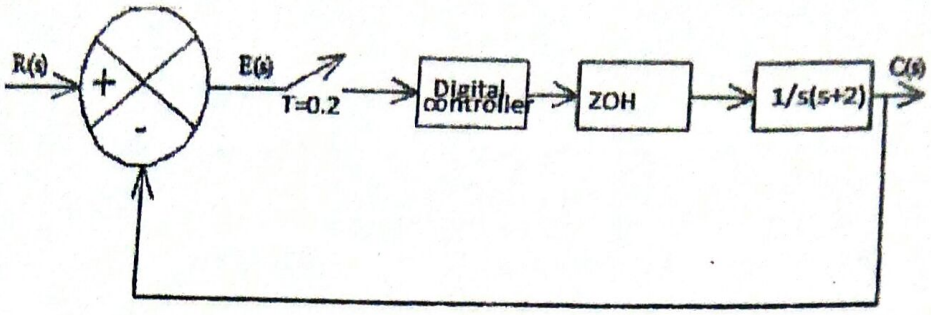
   $P(z) = 2z^4 + 7z^3 + 10z^2 + 4z + 1 = 0$

   b) Realize the given digital controller by ladder programming whose transfer function is [8]

   $\dfrac{8z^3 + 7z^2 + 10z + 6}{4z^3 + 6z^2 + 9z + 10}$

4. a) Explain one of the method for mapping plane to z plane. [4

b) Design a digital controller such that the compensated system should have damping ratio ζ=0.5 and settling time t_s = 2 sec using root locus approach. [12



5. a) Obtain the state space representation of the system shown in figure below in Jordan canonical form: [8]

$$\frac{Y(z)}{U(z)} = \frac{5}{(z+1)^2(z+2)}$$

b) State space representation of a system is given by [8]

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \text{ and } y = [0.1] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Discretize the above system and also find the pulse transfer function matrix.

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Digital Control System *(EE652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the process of data acquisition, conversion and distribution system applied in discrete time system. [8]

   b) Define the term tracking and hold mode in sample and hold circuit. [4]

   c) Obtain the z-transform of x(t) for which time response is given by [4]

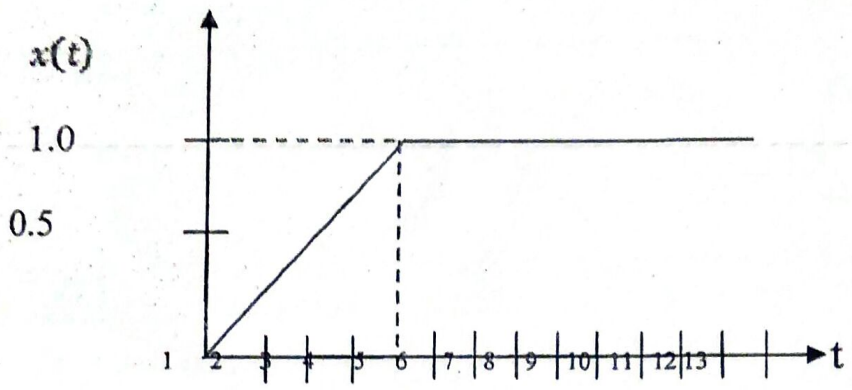


Figure : Continuous time Signal

2. a) Obtain the inverse z-transform of the following system using partial fraction expansion method. [6]

$$x(z)=\frac{z(1-e^{aT})}{(z-1)(z-e^{aT})}$$

   b) Find X(K) when $x(k+2)=x(k+1)+x(k), x(0)=0$ and x(1)=1 and show that the limiting value of $x(k+1)/x(k)=1.6180$ when k tends to infinity. [8]

3. a) Solve the following difference equation and hence obtain x(k). [8]

   $X(K+2)+3X(K+1)+2X(K)=0$, Given that $X(0)=0, X(1)=1$

   b) Determine pulse Transfer function $\frac{y(z)}{x(z)}$ of the given system as shown in figure (a) and (b). [4×2]

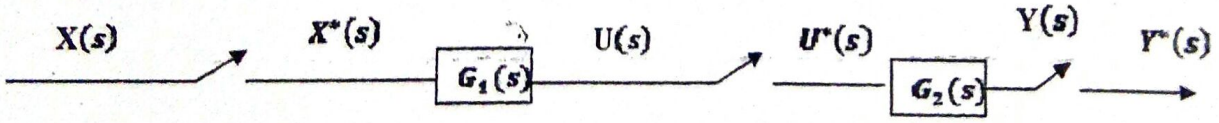


figure (a)

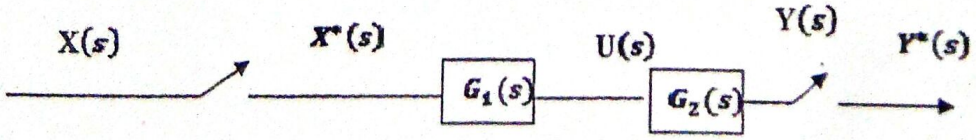


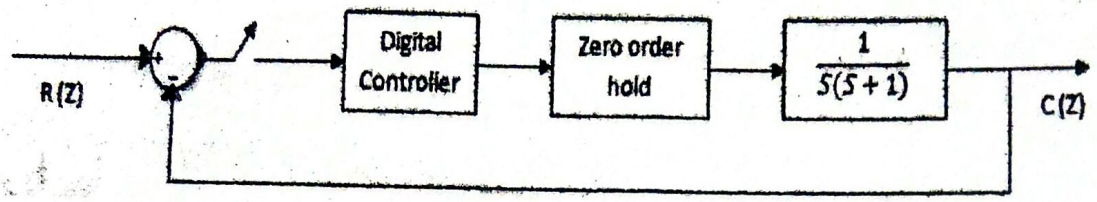
figure (b)

4. a) Consider the digital filter defined by [6]

$$G(z)=\frac{2+2.2z^{-1}+0.2z^{-1}}{1+0.4z^{-1}-0.12z^{-2}}$$

Realize this filter in the parallel scheme.

b) Using the root locus method in z-plane determine a digital controller for a system shown in below so that the dominant closed loop poles of the compensated system will have damping ratio of 0.5 and number of sample per cycle of damped sinusoidal oscillation to be 8. Assume that the sampling period T as 0.2 sec. [12]



5. a) Consider the following system: [8]

$$\frac{Y(z)}{U(z)}=\frac{z+1}{z^2+1.3z+0.4}$$

Obtain the state space representation of the above pulse transfer function in the controllable canonical form and observable canonical form.

b) Check the stability of given system by Liapnuov stability test. [8]

$$\begin{bmatrix}x_1(k+1)\\x_2(k+1)\end{bmatrix}=\begin{bmatrix}0 & 1\\-0.5 & 1\end{bmatrix}\begin{bmatrix}x_1(k)\\x_2(k)\end{bmatrix}$$

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Ashwin

Exam.			
Level	BE	Full Marks	100
Programme	BEL	Pass Marks	45
Year / Part	IV / II	Time	3 hrs.

Subject: - Digital Control System *(EE652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) With the help of discrete time control system block diagram, explain data acquisition, conversion and distribution system. [8]

   b) Define the term tracking mode and hold mode in simple and hold circuit. [4]

2. a) Find x(k) for k = 0,1,2,3,4 when X(z) is given by [6]

$$X(z)=\frac{10z+5}{(z-1)(z-2)}$$

   b) Obtain the inverse z-transform of $X(z)=\frac{z^2}{(z-2)^2(z-e^{-aT})}$ [4]

   c) Consider the difference equation $x(k+2)=x(k+1)+x(k)$ where x(0) = 0, x(1) = 1 and x(2) = 2. Obtain the general solution x(k) in a closed form. Find the limiting value of x(k+2)/x(k) when sequence variable approaches infinity. [8]

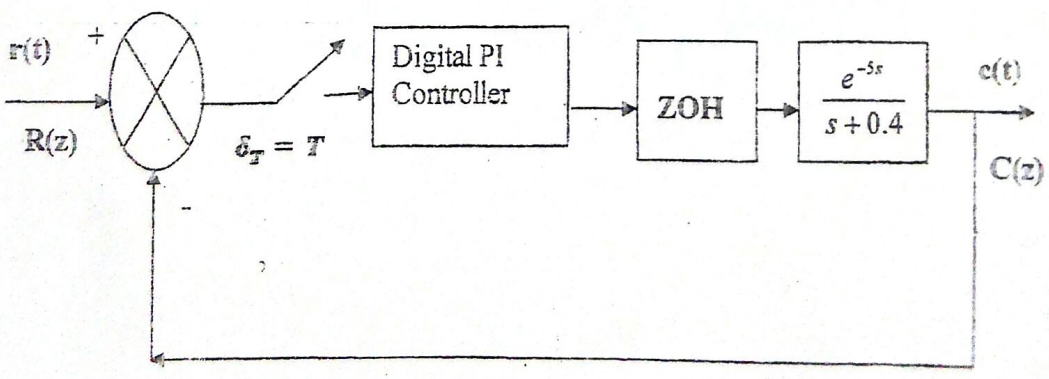
3. a) Examine the stability of given system with characteristics equation by Jury stability test. $p(z)=z^4-1.2z^3+0.07z^2+1.5z-0.06=0$ [8]

   b) Consider the digital filter defined by [8]

$$G(z)=\frac{2+2.2z^{-1}+0.2z^{-1}}{1+0.4z^{-1}-0.12z^{-2}}$$

   Realize this filter in the parallel scheme and ladder scheme.

4. a) Consider the digital control system as shown in figure below, where the plant is of the first order and has a dead time of 5 second. By choosing reasonable sampling time T, Design a digital PI controller such that the dominant closed loop poles have a damping ratio ς of 0.5 and the number of samples per cycle of damped oscillation is 10. After the controller is designed, determine the response of the system to a unit step input. [12]



   b) Write down the general procedures for frequency response design in discrete time control system. [6]

5. a) Consider the system defined by [10]

$$\frac{Y(z)}{U(Z)} = \frac{z+1}{z^2+z+0.6}$$

Obtain state-space representation for this system in the following three different forms:

i) Controllable canonical form
ii) Observable canonical form
iii) Diagonal canonical form

b) State space representation of a system is given by: [6]

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

Obtain the pulse transfer function matrix.

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23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs

Subject: - Digital Control System *(EE652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Why sample and hold circuits are important in discrete time control system? Explain operation of sample and hold circuit in detail. [8]

   b) Define problems associated with quantization. How can it be improved? [4]

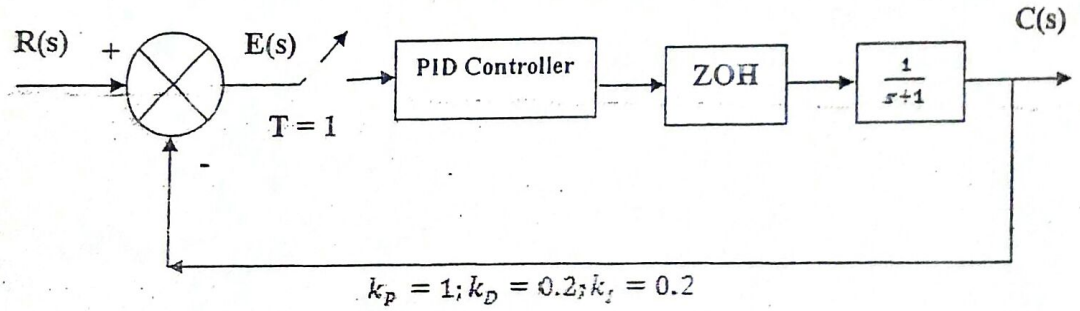
2. a) State **Complex Translation** theorem. Obtain the z-transform of $e^{-at}\sin wt$ by using Complex Translation theorem. [4]

   b) If $x(k)=\frac{1}{2^k}$, for $-4 \le K \le 4$, then find $Z[x(k)]$ [4]

   c) Obtain inverse z-transform of $X(Z)=\frac{z(z+2)}{(z-1)^2}$ by inversion integral method. [4]

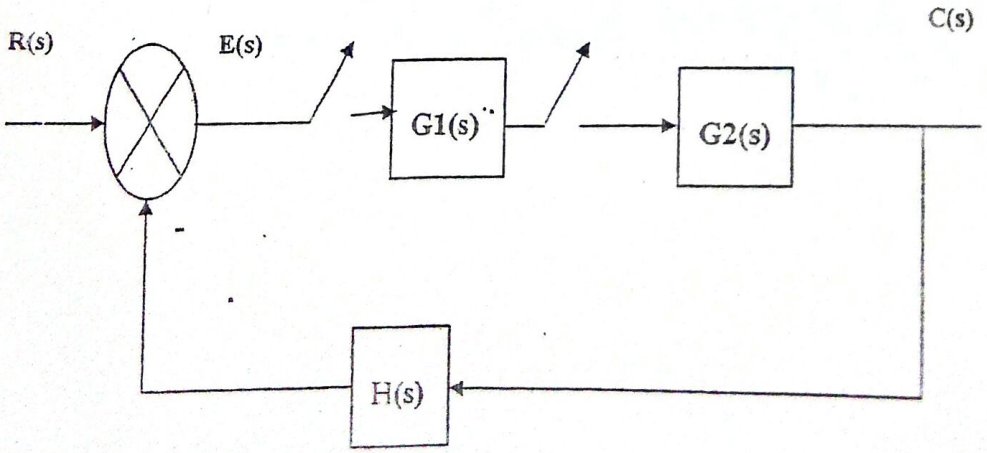
   d) Obtain z-transform of $f(s)=ZOH\frac{1}{S(S+1)}$ [4]

3. a) Obtain the pulse transfer function of the system shown below: [8]

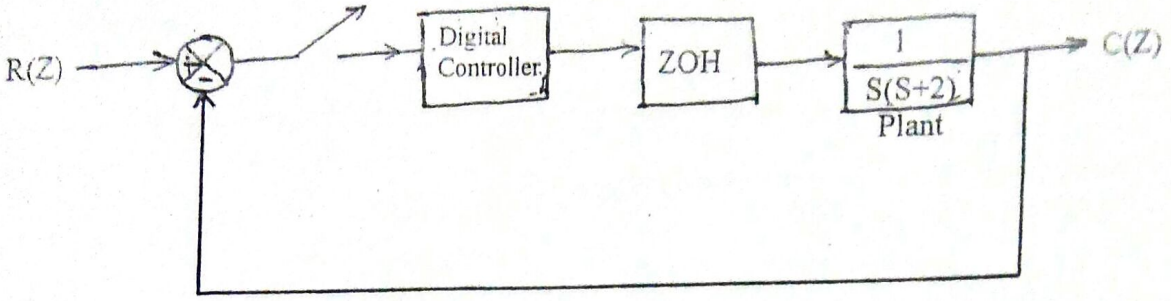


   b) Discuss with example an absolute stability analysis method of a closed loop system in the Z-plane. [8]

4. a) Obtain the closed loop pulse transfer function of the system shown below. [4]



b) Design a digital controller for the system shown below. Use the Bode diagram approach in 'S' plane. The design specifications are that the phase margin be 55°, the gain margin be at least 10dB and the static velocity error constant be 5 sec^{-1}. The sampling period is specifies as 0.1 sec. [16]



5. a) Obtain the state space representation of the following pulse transfer function [8]

$$\frac{Y(z)}{U(z)} = \frac{0.368z^{-1} + 0.264z^{-2}}{1 - 1.368z^{-1} + 0.368z^{-2}}$$

i) Controllable canonical form

ii) Observable canonical form

b) Obtain the discrete-time state and output equations and pulse transfer function(when the sampling period T=1) of the following continuous-time system: [8]

$$G(s) = \frac{Y(s)}{U(s)} = \frac{1}{s(s+2)}$$

which may be represented in state space by the equations

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

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

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22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Bhadra

Exam.		Full Marks	80
Level	BE	Pass Marks	32
Programme	BEL	Time	3 hrs.
Year / Part	III / II		

Subject: - Digital Control System *(EE652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt <u>All</u> questions.*
- ✓ *The figures in the margin indicate <u>Full Marks</u>.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the process of data acquisition, conversion and distribution system applied in discrete time system. [6]

   b) Explain about reconstruction of original signal from sampled signal with the help of figure and necessary. [6]

   c) What are the advantages of digital control system over analog control system? [4]

2. a) Solve the following differential equation: [6]

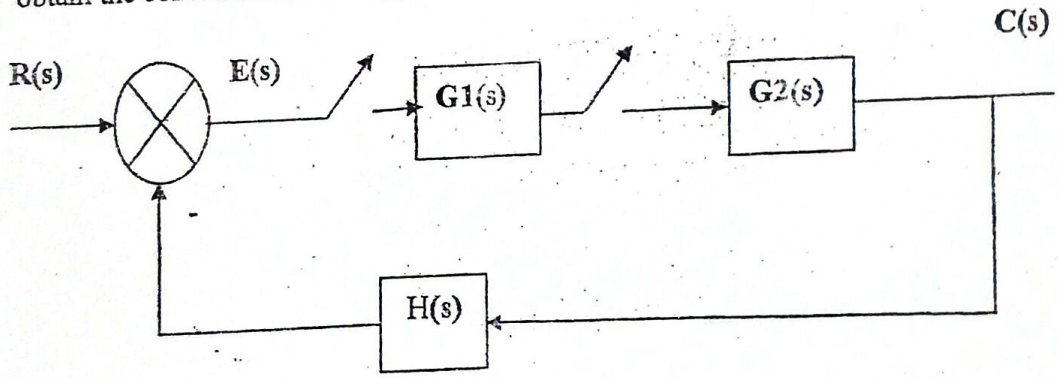
   $2x(k) - 2x(k-1) + x(k-2) = u(k)$; where $x(k) = 0$ for $k < 0$ and $u(k)$ is unit step function.

   b) What are the methods of inverse z-transform? Explain each of them using suitable example. [6]

   c) Obtain the inverse z-transform of the following X(z) by using suitable method. [4]

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

3. a) Evaluate the closed loop pulse transfer function of the system shown below. Hence obtain the continuous time output C(s) of the system. [8]



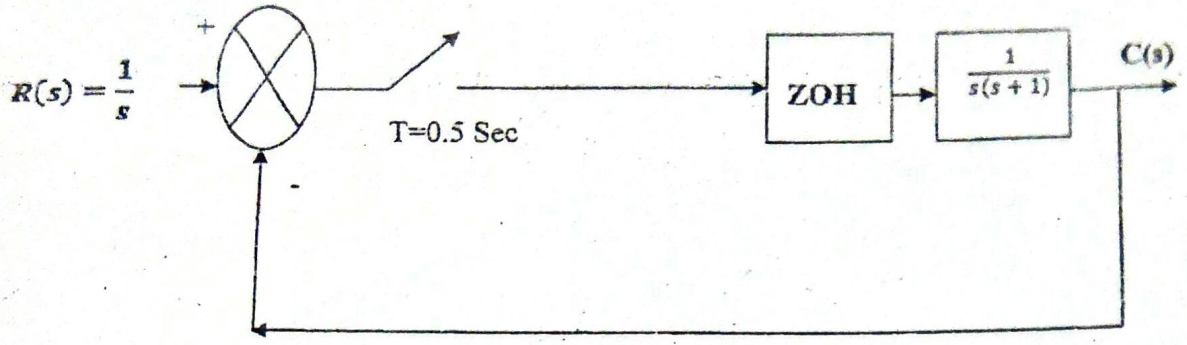
   b) Explain the stability of the following characteristics equation by using Jury test: [8]

   $P(z) = z^4 - 1.2z^3 + 0.07z^2 + 0.3z - 0.08 = 0$

4. a) Construct the block diagram for the following pulse-transfer function system (a digital filter) by direct programming. [5]

   $G(z) = (2 - 0.6z^{-1}) / (1 + 0.5z^{-1})$

b) Draw root locus plot for the given system below. [6]



c) Explain PID controller in realized in discrete time domain? Discuss the role of P, I and D parts. [5]

5. a) Obtain the state space representation of the following pulse transfer function by observable conical form: [8]

$Y(z) / X(z) = (0.368z^{-1} + 0.264z^{-2}) / (1 - 1.368z^{-1} + 0.368^{-2})$

b) Obtain the pulse transfer function matrix for the system represented by the following state space equation. [8]

$x(K + 1) = G.x(K) + H.u(K)$
$y(K) = C.x(K) + D.u(K)$

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25 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Digital Control System *(EE652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) What do you mean by sample and hold circuit? Explain how tracking mode and hold mode are employed in digital control system. [8]

   b) Draw a schematic block diagram for Digital Control System signal and blocks. Explain the function of each block in detail. [8]

2. a) Obtain the z-transform [4×2]

   i) $x(t) = \cos wt \;;\; t \geq 0$
   $= 0 \;;\; t < 0$

   ii) $X(s) = \dfrac{1}{s(s+1)}$

   b) Find ROC for $x(k) = \left(\dfrac{1}{2}\right)^k .u(k) + \left(\dfrac{-1}{3}\right)^k u(k)$, [4]
   where u(k) = 2, for t >= 0 and u(k) = 0 for t < 0

   c) Consider the difference equation [4]

   $x(k+2) - 1.3679.x(k+1) + 0.3679.x(k) = 0.3679.u(k+1) + 0.2642.u(k)$

   Where x(k) is the output and x(k) = 0 for k ≤ 0 where u(k) is the input and is given by

   u(k) = 0, k < 0
   u(0) = 1,
   u(1) = 0.2142,
   u(2) = –0.2142,
   u(k) = 0, k = 3,4,5,6.....

   Determine the output x(k)

3. a) Consider the digital filter defined by [8]

   $$G(z) = \frac{2 + 2.2z^{-1} + 0.2z^{-1}}{1 + 0.4z^{-1} - 0.12z^{-2}}$$

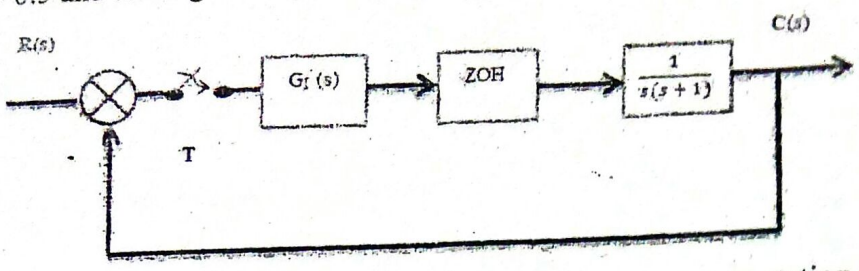
   Realize this filter in ladder scheme.

   b) Write short notes on: (any two) [4×2]

   i) Mapping from S-plane to Z-plane
   ii) Impulse sampling
   iii) General procedure for obtaining pulse transfer function

4. a) What is Jury stability test in digital control system? Explain. [6]

b) Design a digital controller such that the compensated system should have damping ratio = 0.5 and settling time = 2 seconds of the system using root locus approach. [10]



5. a) Derive the pulse transfer function of the given state space representation form [8]

$x(k+1) = G\,x(k) + H\,u(k)$ and $y(k) = c\,x(k) + D\,u(k)$ [8]

b) Consider the following system:

$$\frac{Y(z)}{U(z)} = \frac{z+1}{z^2+1.3z+0.4}$$

Obtain the state space representation of the above pulse transfer function in the diagonal canonical form.

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5. a) Represent system having pulse transfer function $G(z) = \frac{4z^2 + 3z + 5}{5z^2 + z - 4}$ in observable canonical form. [8]

b) Determine pulse transfer function matrix for the system which is describe by state space representation as: [8]

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 3 & 1 \\ -2 & +1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(k) \text{ and } \begin{bmatrix} y_1(k) \\ y_2(k) \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 2 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(k).$$

6. Write short note on: [4×4]

a) Data acquisition system
b) Stability analysis in Z-domain
c) Phase-lead/phase-lag compensator
d) Advantage of digital filter

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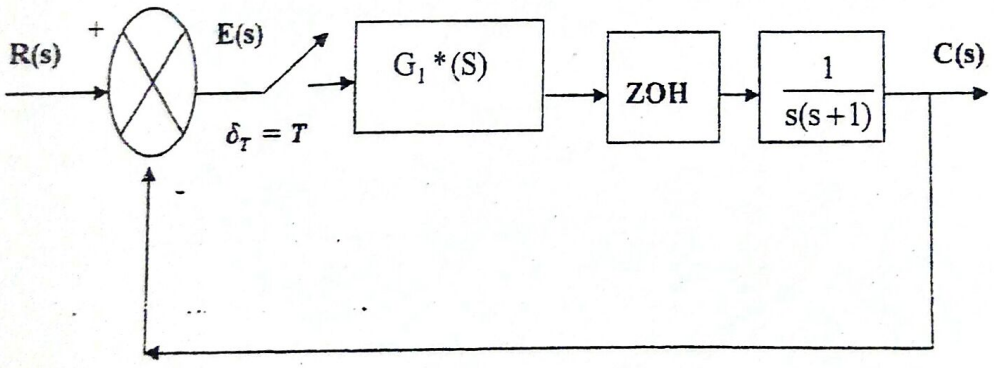
22 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Digital Control System *(EE652)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) What are the advantages of digital control system over analog? [4]
   b) Explain data acquisition system with its block diagram representation. Also state advantages of digital control system. [6+2]
2. a) Solve the following difference equation by use of Z-transform method.
   $x(k+2)+1.379 \cdot x(k+1)+0.3679$, $x(k)=0.3679 \cdot u(k)$ where u(k) is step input and x(0)=0, x(1)=0.3679 [8]
   b) Find the z-transform of $x(t) = e^{-at} \sin\omega t$ [4]
   c) Find the inverse Z-transform of the function $x(z) = \frac{z(z+2)}{(z-1)^2}$ [4]
3. a) Determine the transfer function of zero order hold circuit. [8]
   b) Determine the stability of system having characteristic equation using jury test. [8]
   $P(z) = 2z^4 + 7z^3 + 10z^2 + 4z + 1 = 0$
   c) How s-plane can be converted into z-plane and vice versa? [4]
4. a) Derive the pulse transfer function of digital PID controller. [8]
   b) Design a digital controller such that the compensated system should have damping ratio = 0.5 and settling time = 2 second of the following system using root locus approach. [12]



5. a) Obtain the state space representation of the following pulse transfer function in observable canonical form. [6]
   $$\frac{Y(z)}{U(z)} = \frac{0.368z^{-1} + 0.264z^{-2}}{1 - 1.368z^{-1} + 0.368z^{-2}}$$
   b) Check the stability of given system by Liapnuov Stability test [6]
   $$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -0.5 & -1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

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5. a) Represent $X(z) = \dfrac{3z^2 + 7z + 15}{z^2 + 2z + 4}$ in controllable canonical form. [8]

b) Determine pulse transfer function matrix for the following state space representation [8]

$$x(k+1) = Gx(k) + Hu(k)$$
$$y(k) = Cx(k) + Du(k)$$

Where,

$$G = \begin{bmatrix} -4 & 1 \\ -2 & -1 \end{bmatrix},\ H = \begin{bmatrix} 1 \\ 1 \end{bmatrix},\ C = \begin{bmatrix} 1 & 1 \\ 2 & 1 \end{bmatrix},\ D = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Magh

Exam.		Back	
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Digital Control System

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt <u>All</u> questions.*
- ✓ *Attempt any <u>Five</u> questions. <u>Question No. 4 is compulsory</u>.*
- ✓ *The figures in the margin indicate <u>Full Marks</u>.*
- ✓ *Assume suitable data if necessary.*

1. a) Briefly describe digital control system with the help of block diagram. Also mention the advantages of digital control system over analog. [6+4]

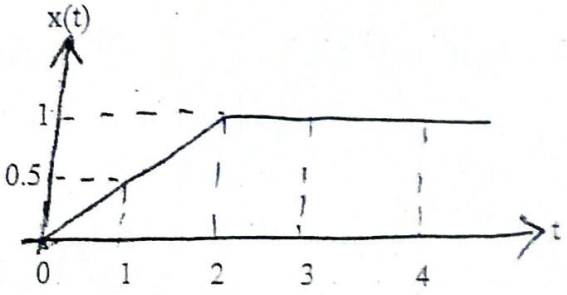
   b) Compare different types of sampling operations used for sampling of continuous time signal. [6]

2. a) Solve the following difference equation: [8]

   $x(K+2) - 1.379\,x(K+1) + 0.3679x(K) = 0.3679\,u(K+1) + 0.2642u(K)$ where, u(K) is input which has initial values.

   $x(0) = 0$
   $x(1) = 0.3679$
   $u(K) = 1$ for $K \geq 0$

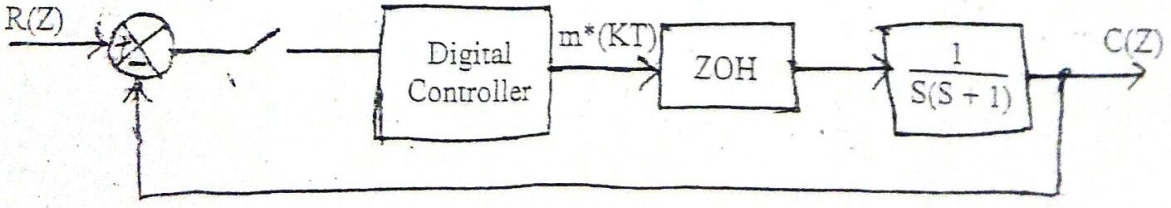
   b) Obtain Z transform of curve x(t) shown in figure below. [8]



3. a) What do you mean by convolution? Obtain Z-transform of $x(s) = \frac{1}{s^2(s+1)}$ by use of the convolution integral in the left half 's' plane. [8]

   b) Realize system having pulse transfer function, $G(z) = \frac{(z+3)(z^2-2z+10)}{(z-5)(z^2-z+8)}$ by series programming. [8]

4. Design a digital controller for the system shown in figure below that dominant closed loop poles of the system will have damping ratio of 0.5. It is required that the peak time of the response $t_p \leq 1.2$ sec. Assume sampling time, T = 0.2 sec. [16]



26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2067 Mangsir

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

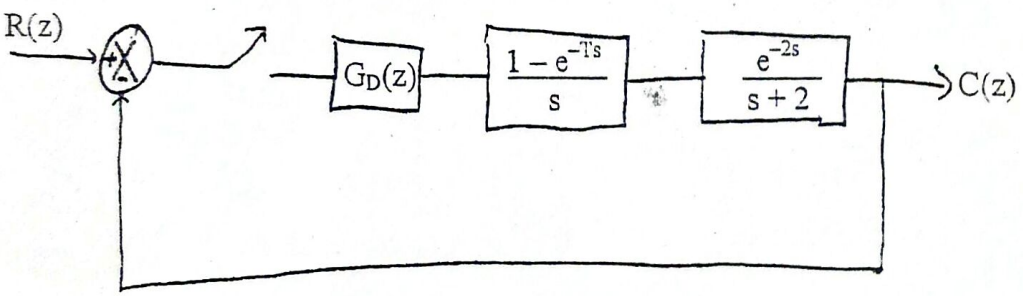
Subject: - Digital Control System

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***A normal graph paper will be provided.***
- ✓ *Assume suitable data if necessary.*

1. a) Explain digital control system along with the functions of each block. [10]
   b) Write short notes on sample and hold circuit. [6]
2. a) Starting from the z transform of unit step function, determine the z transform of K^2e^{-ak}. [8]
   b) Given $x(s) = \dfrac{1}{(s+1)^2(s+3)(s+2)}$ and T = 1. Obtain x(z) by using convolution integral in left half plane. [8]
3. a) Derive an expression for the transfer function of zero order hold. [6]
   b) Realize the following transfer function by ladder programming. [10]

$$X(Z) = \frac{Z^3 + 4Z^2 + 10Z + 7}{Z^3 + 3Z^2 + 11Z + 18}$$

4. Consider the system shown below. [16]



Design a digital PI controller such that the dominant closed loop poles have a damping ratio of 0.55 and number of samples per cycle of damped oscillation is 10. Also find Kv for the designed system.

5. a) Represent $X(Z) = \dfrac{3Z^2 + 7Z + 1}{Z^2 + 2Z + 4}$ in observable canonical form [8]
6. b) Determine the state transition matrix for the system given by: [8]

$$x(k+1) = G\,x(k) + H\,u(k)$$
$$y(k) = C\,x(k) + D\,u(k)$$

Where,

$$G = \begin{bmatrix} 0 & 1 \\ -0.21 & -1 \end{bmatrix},\ H = \begin{bmatrix} 1 \\ 1 \end{bmatrix},\ C = \begin{bmatrix} 1 & 0 \end{bmatrix},\ D = [1]$$

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2nd TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Jestha

Exam.		Back	
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs

Subject: - Digital Control System

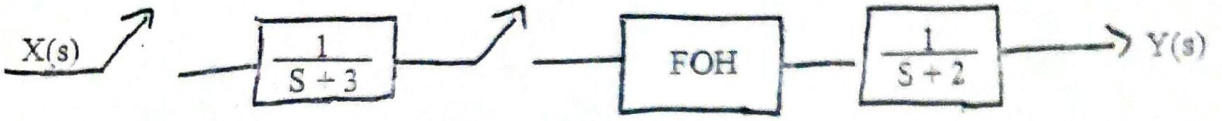
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***A normal graph paper will be provided.***
- ✓ *Assume suitable data if necessary.*

1. a) What is data acquisition system? Describe different blocks of data acquisition system. [8]

   b) Write short notes on: [4×2]

   i) Digital to Analog conversion
   ii) Data hold circuit

2. a) Consider the system shown below [8]



If transfer function of FOH is $\frac{Ts+1}{T}\left(\frac{1-e^{-Ts}}{s}\right)^2$ and T = 1. Determine $\frac{Y(z)}{X(z)}$.

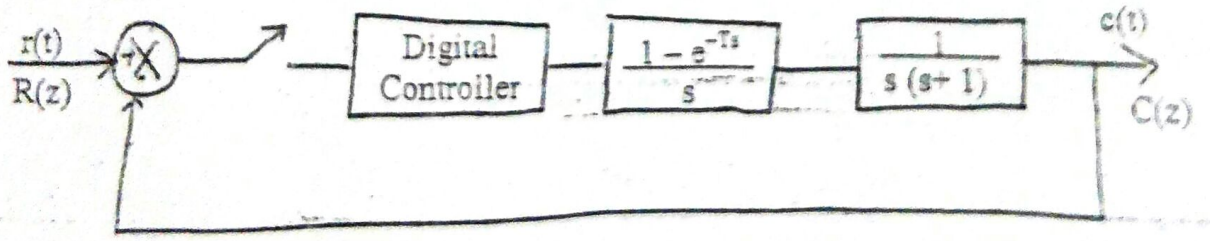
b) Find the inverse Z-transform of $X(z) = \frac{z^{-1}}{(1-z^{-1})(1+1.6z^{-1}+0.64z^{-2})}$ by inversion integral method. [8]

3. a) Derive an expression for the transfer function of first order hold. [8]

   b) Realize the following transfer function by series programming [8]

$$X(z) = \frac{(z+1)(z^2+3z+7)}{(z-2)(z^2+z+9)}.$$

4. Consider the system shown below: [16]



Design a digital controller such that the dominant close loop poles of the system will have damping ratio 'z' of 0.55. It is required that the peak time of the response be 1.2 sec. Assume that the sampling period T be 0.2. Also obtain K_v for the designed system.