SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF
ELECTRONICS AND INSTRUMENTATION ENGINEERING

QUESTION BANK

VII SEMESTER

1907701–COMPUTER CONTROL OF PROCESSES

Regulation – 2019

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Prepared by

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Department of Electronics and Instrumentation Engineering

SUBJECT: 1907701–COMPUTER CONTROL OF PROCESSES
SEM / YEAR: VII / IV

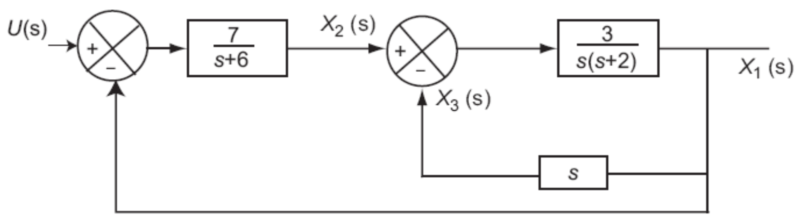
UNIT I - DISCRETE STATE-VARIABLE TECHNIQUE

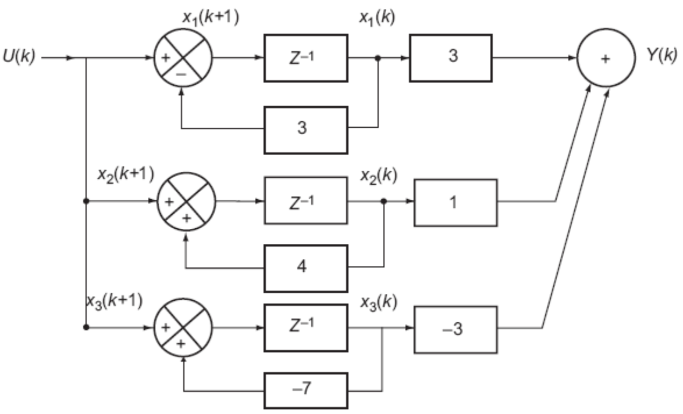
SYLLABUS

State equation of discrete data system with sample and hold – State transition equation – Methods of computing the state transition matrix – Decomposition of discrete data transfer functions – State diagrams of discrete data systems – System with zero-order hold – Controllability and observability of linear time invariant discrete data system–Stability tests of discrete-data system.

PART –A

Q.No.	Questions	BT Level	Competence
1.	Define state.	BTL-1	Remember
2.	Define state variable.	BTL-1	Remember
3.	What is state space Analysis?	BTL-1	Remember
4.	Write the advantages of state space Analysis?	BTL-1	Remember
5.	Distinguish between discrete time systems and continuous time systems.	BTL-4	Analyze
6.	Explain the term sampler and hold circuit?	BTL-2	Understand
7.	Write the drawbacks of practical Sample/Hold circuit?	BTL-1	Remember
8.	State (Shannon's) sampling theorem	BTL-2	Understand
9.	How is the state model of the multivariable system represented?	BTL-4	Analyze
10.	Define state transition matrix.	BTL-1	Remember
11.	What is state transition matrix of discrete time system?	BTL-1	Remember
12.	Write the properties of the state transition matrix of discrete time system?	BTL-1	Remember
13.	What are the different methods available for computing A^k?	BTL-4	Analyze
14.	Define state diagram.	BTL-1	Remember
15.	How the state diagram of the system is represented?	BTL-2	Understand
16.	Write the fundamental elements are used to construct the state diagram.	BTL-1	Remember
17.	What is zero-order hold?	BTL-1	Remember
18.	Define complete state controllability.	BTL-1	Remember
19.	Write the features of controllability?	BTL-1	Remember
20.	Definition of observability.	BTL-1	Remember
21.	Write the features of observability?	BTL-1	Remember
22.	What are the two methods are used to find controllability and observability?	BTL-4	Analyze
23.	Write the types of stability analysis of discrete-data system.	BTL-1	Remember
24.	What are the necessary and sufficient conditions to be satisfied for the stability of sampled data control systems using Jury's stability test.	BTL-4	Analyze

PART – B				
1	A discrete time system has the transfer function $\frac{Y(z)}{U(z)} = \frac{6z^3 - 15z^2 + 7z + 5}{(z-2)^2(z+1)}$. Determine the state model of the system in		BTL-5	Evaluate
	(i)	Phase variable form. **(6)**		
	(ii)	Jordon canonical form. **(7)**		
2	A discrete time system has the transfer function. $\frac{Y(z)}{U(z)} = \frac{3z^2 + 2z + 1}{z^2 - 3z + 2}$ Determine the state model of the system in		BTL-5	Evaluate
	(i)	Phase variable form. **(6)**		
	(ii)	Jordon canonical form. **(7)**		
3	Write the state equations and output equations of the following difference equation, and draw the state model of the system. y(k+3)+5 y(k+2)+3y(k+1)+2y(k) = u(k). **(13)**		BTL-1	Remember
4	Consider that a digital system is described by the difference equation. $y(k+2) + 2y(k+1) + 3y(k) = 2u(k)$. Determine the state model, and write the state & output equations. **(13)**		BTL-5	Evaluate
5	A discrete time system is described by the difference equation y(k+2)+5y(k+1)+4y(k) = 5u(k). y(0) = y(1)=0; T=1 sec		BTL-5	Evaluate
	(i)	Determine a state model in canonical form. **(7)**		
	(ii)	Find the state transition matrix. **(6)**		
6	Find the state transition matrix for the system matrix $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$. **(13)**		BTL-3	Apply
7	The system matrix A of a discrete time system is given by $A = \begin{bmatrix} 0 & 1 \\ -4 & -5 \end{bmatrix}$. Compute the state transition matrix e^{At} using Cayley- Hamilton theorem. **(13)**		BTL-3	Apply
8	Derive the state equation for the system shown below in which x_1, x_2 and x_3 constitute the state vectors. Examine whether the system is completely controllable and observable. **(13)** 		BTL-6	Create
9	(i)	Sketch the block diagram of a typical sampled data control system and explain the function performed by each block.**(8)**	BTL-3	Apply

	(ii)	Test the controllability of the following system. **(5)** $\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} -2 & -1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k),$ $y(k) = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}.$	**BTL-4**	**Analyze**
10	**(i)**	Determine the state controllability and observability for the following system. **(6)** $\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & - \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(k),$ $y(k) = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}.$	**BTL-5**	**Evaluate**
	(ii)	Determine the stability of the sampled data control systems represented by the following characteristic equation $\Delta(Z) = Z^3 - 1.3Z^2 - 0.08Z + 0.24 = 0$. **(7)**	**BTL-5**	**Evaluate**
11	Determine the state controllability and observability of the following system. **(13)** $\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \\ x_3(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 1 \\ 0 & -3 & -2 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(k)$ $y(k) = \begin{bmatrix} 3 & 4 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix}.$		**BTL-5**	**Evaluate**
12	**(i)**	Determine the state model of the discrete time system represented by the block diagram. **(6)**  	**BTL-5**	**Evaluate**
	(ii)	Determine the stability of the sampled data control system whose open loop pulse transfer function is given by $G(Z) = \frac{z(z-1)}{(5z+1)(5z-1)}.$ **(7)**	**BTL-5**	**Evaluate**

13	(i) Derive the transfer function of zero-order Hold and comment on selection of sampling period. **(8)**		BTL-6	Create
	(ii) Give the state space representation of Discrete Data System.**(5)**			
14	Explain in detail about Decomposition of discrete data transfer functions. **(13)**		BTL-2	Understand
15	Check the stability of the sampled data control system represented by the following characteristic equation.		BTL-4	Analyze
	(i)	$6Z^2 - 2z + 1 = 0$. **(6)**		
	(ii)	$Z^3 - 1.3Z^2$-0.08z+0.24=0. **(7)**		
16	Check the stability of the sampled data control system represented by the following characteristic equations using bilinear transformation. **(13)**		BTL-4	Analyze
	(i)	$Z^3 - 0.2Z^2 - 0.25z + 0.05$ **(6)**		
	(ii)	$2Z^4 + 7Z^3 + 10Z^2 + 4z + 1 = 0$ **(7)**		
17	(i)	Draw the block diagram of the discrete time system described by the state model. **(7)** $\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \\ x_3(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & 6 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} u(k)$ $y(k) = \begin{bmatrix} 1 & 3 & 6 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix} + 5u(k).$	BTL-2	Understand
	(ii)	Give the Block diagram representation and Signal flow graph representation of discrete time system using state diagram. **(6)**		

PART – C

1.	Determine the STM for the system having system matrix of 3x3 Jordon block with eigenvalues λ_1. **(15)**		BTL-5	Evaluate
2.	A discrete time system is described by the difference equation. $y(k + 4) + 2y(k + 2) - y(k + 1) + y(k) = 5u(k)$. Write the state equation output equation and draw the state model of the system. **(15)**		BTL-3	Apply
3.	The matrix $A = \begin{bmatrix} 0 & 1 \\ -4 & -5 \end{bmatrix}$, Determine A^2,A^3,A^4 and A^{-1} using the Cayley- Hamilton technique. **(15)**		BTL-5	Evaluate
4.	(i)	Check whether the discrete data system represented by the characteristic polynomial $p(z) = 2z^4 + 7z^3 + 10z^2 + 4z + 1$ is stable or not. **(7)**	BTL-4	Analyze

	(ii)	Consider the following characteristic equation of a discrete data system. $\Delta(z) = z^4 - 1.2z^3 + 0.22z^2 + 0.066z - 0.008 = 0$. Check whether the system is stable or not. **(8)**	**BTL-2**	**Understand**
5.	Examine the controllability and observability of the systems given below **(15)** $$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \\ x_3(k+1) \end{bmatrix} = \begin{bmatrix} 1 & 1 & -1 \\ 1 & 3 & -1 \\ -2 & 2 & 3 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix} + \begin{bmatrix} -2 \\ 5 \\ 7 \end{bmatrix} u(k)$$ $$y(k) = \begin{bmatrix} -6 & -1 & 3 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix}.$$		**BTL-2**	**Understand**

UNIT II - SYSTEM IDENTIFICATION

SYLLABUS

Identification of Non Parametric Input-Output Models:-Transient analysis–Frequency analysis–Correlation analysis– Spectral analysis – Identification of Parametric Input- Output Models:-Least Squares Method – Recursive Least Square Method.

PART – A

Q.No.	Questions	BT Level	Competence
1.	What is model?	**BTL-1**	**Remember**
2.	What are the advantages of model?	**BTL-4**	**Analyze**
3.	What is mathematical modeling?	**BTL-1**	**Remember**
4.	What are the different approaches to modeling?	**BTL-4**	**Analyze**
5.	What is empirical model?	**BTL-2**	**Understand**
6.	Discuss briefly system identification.	**BTL-1**	**Remember**
7.	List the non parametric methods of system identification.	**BTL-1**	**Remember**
8.	Differentiate parametric and non parametric method of system identification.	**BTL-3**	**Apply**
9.	Write the advantages of transient analysis method.	**BTL-3**	**Apply**
10.	Examine the drawbacks of transient response analysis.	**BTL-4**	**Analyze**
11.	What is meant by frequency analysis?	**BTL-1**	**Remember**
12.	Briefly explain the first order system parameter estimation using impulse response method.	**BTL-4**	**Analyze**
13.	When correlation analysis is required?	**BTL-6**	**Create**
14.	What is spectral analysis?	**BTL-1**	**Remember**
15.	Define parametric method of system identification.	**BTL-1**	**Remember**
16.	Write the requirements of a parameter estimation problem.	**BTL-1**	**Remember**
17.	Define least squares estimation method.	**BTL-1**	**Remember**
18.	What is the principle of least squares in an estimator? Give the expression for penalty function J.	**BTL-1**	**Remember**
19.	What are the advantages of LS method?	**BTL-4**	**Analyze**
20.	What are the limitations of LS method?	**BTL-4**	**Analyze**

21.		Define recursive identification method.	**BTL-1**	**Remember**
22.		What are the advantages of recursive identification method?	**BTL-4**	**Analyze**
23.		Write the recursive least square algorithm which uses Kalman filter as parameter estimator.	**BTL-1**	**Remember**
24.		Write the features of recursive identification method.	**BTL-1**	**Remember**
		PART – B		
1.		What are the properties of a Mathematical model? **(13)**	**BTL-4**	**Analyze**
2.		Define System identification? Explain its procedure. **(13)**	**BTL-3**	**Apply**
3.		Why we use Simulation models? Explain any two prediction models. **(13)**	**BTL-5**	**Evaluate**
4.		What are various model representation for an LTI system? Explain. **(13)**	**BTL-4**	**Analyze**
5.		Describe any two identification methods with the help of the algorithm used. **(13)**	**BTL-3**	**Apply**
6.	**(i)**	Explain the identifying First-Order-Dead-Time (FODT) model. (6)	**BTL-2**	**Understand**
	(ii)	Explain the identifying second order model. (7)	**BTL-2**	**Understand**
7.	**(i)**	Describe the frequency analysis method of system parameter estimation. **(8)**	**BTL-2**	**Understand**
	(ii)	Briefly describe the improved frequency analysis. **(5)**	**BTL-2**	**Understand**
8.	**(i)**	How impulse response identification using step response is is done? **(8)**	**BTL-4**	**Analyze**
	(ii)	Explain the procedure involved. **(5)**	**BTL-2**	**Understand**
9.		Discuss a detailed account on correlation analysis method of system identification. **(13)**	**BTL-2**	**Understand**
10.		Discuss a detailed account on Spectral analysis method of system identification. **(13)**	**BTL-2**	**Understand**
11.		With an example for each, explain any one parametric and non-parametric methods of system identification. **(13)**	**BTL-2**	**Understand**
12.	**(i)**	Convert the following first order linear discrete model in to linear regression model. Y(t) + ay(t-1) = b u(t-1). (5)	**BTL-3**	**Apply**
	(ii)	Find the least square error for a given truncated weighting function model, $Y(t) = H_0\, u(t) + h_1\, u(t-1) + \ldots + h_{m-1}\, u(t-M+1)$. (8)		
13.		Derive and explain the steps of the least square algorithm. **(13)**	**BTL-6**	**Create**
14.		Explain in detail in what way spectral densities influence the deviation of estimate from true value. **(13)**	**BTL-2**	**Understand**
15.		Derive and explain the steps of the Recursive least square estimation method. **(13)**	**BTL-6**	**Create**
16.	**(i)**	List and explain the least square algorithm for real time identification which uses a forgetting factor λ. **(8)**	**BTL-2**	**Understand**
	(ii)	Give and discuss the properties of LSE. **(5)**	**BTL-2**	**Understand**

17.	**(i)**	Write the general features of recursive identification methods. **(6)**	**BTL-6**	**Create**
	(ii)	Derive the recursive least square algorithm which uses Kalman filter as parameter estimator. **(7)**		

PART – C

1.	**(i)**	What is meant by Linear regression? How such model predicts a moving object. **(15)**	**BTL-2**	**Understand**
2.	**(i)**	Design the second order system impulse response. **(12)**	**BTL-6**	**Create**
	(ii)	Discuss the limitations of transient analysis. **(3)**	**BTL-2**	**Understand**
3.	Explain Non linear Least-square Estimation and its iterative solution. **(13)**		**BTL-2**	**Understand**
4.	Design Transfer Function and Equation error model in Dynamic systems. **15)**		**BTL-2**	**Understand**
5.	Derive the expression for Finite Impulse Response Model (FIR model). **(15)**		**BTL-6**	**Create**

UNIT III - DIGITAL CONTROLLER DESIGN

SYLLABUS

Review of z-transform – Modified of z-transform – Pulse transfer function – Digital PID controller– Dead-beat controller and Dahlin’s controller – IMC - Smith Predictor.

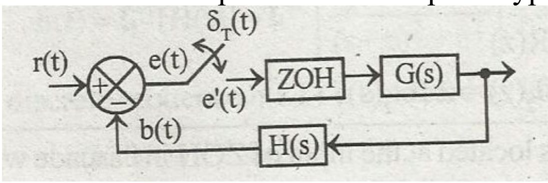
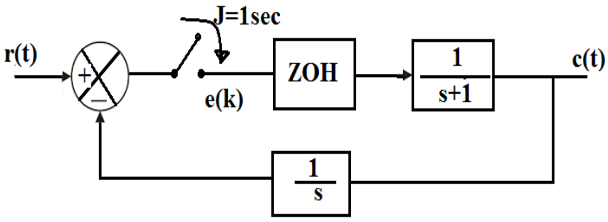
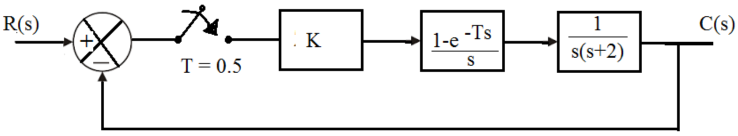
PART – A

Q. No.	Questions	BT Level	Competence
1.	Define Z-transform.	**BTL-1**	**Remember**
2.	State the final value and initial value theorem with regard to z-transform.	**BTL-2**	**Understand**
3.	What is region of convergence (ROC)?	**BTL-2**	**Understand**
4.	Define one sided and two sided Z transform?	**BTL-1**	**Remember**
5.	Define z-transform of unit step signal.	**BTL-1**	**Remember**
6.	What are the different methods available for inverse z-transform?	**BTL-4**	**Analyze**
7.	Define modified Z-transform.	**BTL-1**	**Remember**
8.	Write the application of modified *z*-transform?	**BTL-1**	**Remember**
9.	Find the modified Z transform of a unit step function u(t).	**BTL-5**	**Evaluate**
10.	Find the modified Z-transform of e^{-at}.	**BTL-3**	**Apply**
11.	Find the modified Z-transform of $\frac{a}{s(s+a)}$.	**BTL-3**	**Apply**
12.	What is pulse transfer function?	**BTL-3**	**Apply**
13.	What is the equivalent representation of pulse sampler with ZOH?	**BTL-1**	**Remember**
14.	When the z-transfer function of the system can be directly obtained from s-domain transfer function?	**BTL-3**	**Apply**
15.	Give the steps involved in determining the pulse transfer function of G(z) from G(s).	**BTL-1**	**Remember**

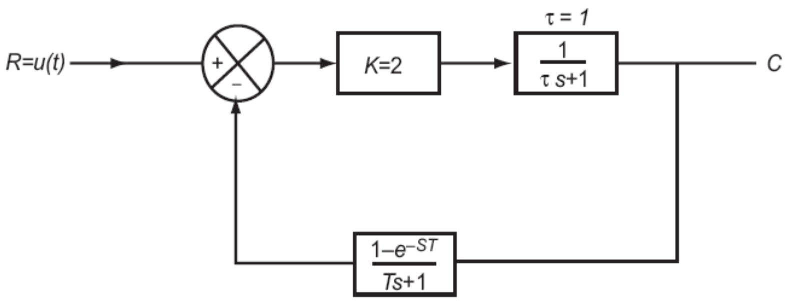
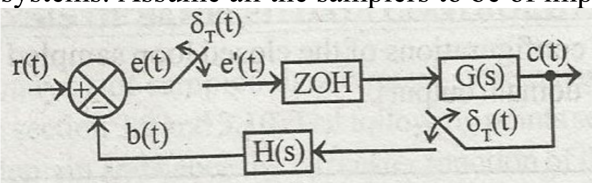
16.	How the s-plane is mapped into z-plane? Or What is the relation between s and z domain?	**BTL-4**	**Analyze**
17.	Draw the basic structure of a digital control system.	**BTL-6**	**Create**
18.	What are the features of digital PID controller?	**BTL-4**	**Analyze**
19.	What are the limitations of dead beat algorithm?	**BTL-4**	**Analyze**
20.	List the advantages and disadvantages of Dahlin's controller.	**BTL-5**	**Evaluate**
21.	State closed loop specification for Dahlin's control algorithm.	**BTL-4**	**Analyze**
22.	What is IMC in control system?	**BTL-1**	**Remember**
23.	What is Smith Predictor Algorithm?	**BTL-1**	**Remember**
24.	How does a Smith Predictor work?	**BTL-4**	**Analyze**

PART – B

1.	**(i)**	Write the properties of one sided Z – transform. (8)		
	(ii)	Determine the z-tansform and their ROC of the following discrete sequence $f(k) = \{3,2,5,7\}$. **(5)**	**BTL-5**	**Evaluate**
2.		Determine the z-transform of the following discrete sequences. (i) $f(k) = u(k)$ (ii) $f(k) = (1/2)^k u(k)$ (iii) $f(k) = \alpha^k u(-k-1)$	**BTL-5**	**Evaluate**
3.		Find the one sided z-transform of the discrete sequences generated by mathematically sampling the following continuous time function, (i) $e^{-at} \cos \omega t$ **(7)** (ii) $e^{-at} \sin \omega t$ **(6)**	**BTL-3**	**Apply**
4.		Determine the inverse z-transform of the following function.	**BTL-5**	**Evaluate**
	(i)	$F(z) = \dfrac{z^2}{z^2 - z + 0.5}$. **(6)**		
	(ii)	$F(z) = \dfrac{1+z^{-1}}{1+z^{-1}+0.5z^{-2}}$. **(7)**		
5.		Determine the inverse z-transform of $F(z) = \dfrac{1}{1+\frac{3}{2}z^{-1}+\frac{1}{2}z^{-2}}$. When (i) ROC : IZI > 1.0 **(7)** (ii) ROC : IZI < 0.5 **(6)**	**BTL-5**	**Evaluate**
6.		The input-output relation of a sampled data system is described by the equation c(k+2)+3c(k+1)+4c(k)=r(k+1)-r(k). (i) Determine the z-transform function. **(5)** (ii) Also obtain the weighting sequence of the system. **(8)**	**BTL-5**	**Evaluate**
7.		Solve the difference equation c(k+2)+3c(k+1)+2c(k)=u(k) Given that c(0)=1; c(1)=-3; c(k)=0 for k < 0. **(13)**	**BTL-3**	**Apply**

<table>
<tr><td>8.</td><td colspan="2">Find C(z)/R(z) for the following closed loop sampled data control systems. Assume all the samplers to be of impulse type. (13)

</td><td>BTL-3</td><td>Apply</td></tr>
<tr><td>9.</td><td colspan="2">(i) Consider a system described by the difference equation C(K+1)+2C(K)=r(K); C(0)=0. Obtain the system's impulse response. (6)
(ii) For the sampled data control system, discover the output C(K) for r(t) = unit step (7)

</td><td>BTL-3</td><td>Apply</td></tr>
<tr><td>10.</td><td colspan="2">A digital control system is shown in Figure.


When the controller gain K is unity and the sampling time is 0.5 seconds, determine
(i) The open-loop pulse transfer function (4)
(ii) The closed loop pulse transfer function (4)
(iii) The difference equation for the discrete time response(5)</td><td>BTL-5</td><td>Evaluate</td></tr>
<tr><td rowspan="2">11.</td><td>(i)</td><td>Design the dead beat controller algorithm for a first order process $G_p(s)=\frac{10}{0.5s+1}$. (6)</td><td>BTL-6</td><td>Create</td></tr>
<tr><td>(ii)</td><td>Design a digital deadbeat control algorithm for $G(s)=\frac{10e^{-2s}}{0.2s+1}; T=1$ sec. Then the process dead time T_d=2T. (7)</td><td>BTL-6</td><td>Create</td></tr>
<tr><td>12.</td><td colspan="2">Design a deadbeat controller for the following second order process. $G_p(s)=\frac{1}{(s+1)(5s+1)}$.Use a unit step change in the set point and assume a ZOH. (13)</td><td>BTL-6</td><td>Create</td></tr>
<tr><td>13.</td><td colspan="2">Consider a process with the following transfer functions, $G_p(s)=\frac{e^{-1.6s}}{s+3}$, T = 1 sec. Design a deadbeat controller. (13)</td><td>BTL-6</td><td>Create</td></tr>
<tr><td>14.</td><td colspan="2">Design a Dahlin's controller algorithm for $G_p(s)=\frac{e^{-1.4s}}{3.34s+1}$, T = 1 sec. (13)</td><td>BTL-6</td><td>Create</td></tr>
</table>

15.	Design a Dahlin's algorithm for the process of $G_p(s) = \dfrac{1}{(s+1)(5s+1)}$, T = 1 sec. **(13)**	**BTL-6**	**Create**
16.	Sketch the block diagram for IMC and Explain the IMC design methods to design of controllers.**(13)**	**BTL-3**	**Apply**
17.	Describe the simplified Smith Predictor scheme with the steps.**(13)**	**BTL-6**	**Create**
	PART – C		
1.	Design the transfer function model in Z domain by solving the difference equation c(k+3) + 4.5c(k+2) + 5c(k+1) + 1.5c(k) = u(k). Given that c(0) = 0; c(1) = 0; c(2) = 2; c(k) = 0; k < 0. **(15)**	**BTL-6**	**Create**
2.	For the control system shown in Fig., determine the response between sampling for the case *m* = 0.4, by use of the modified z- transform. Assume *T* = 1 sec, *K* = 2. **(15)** 	**BTL-4**	**Analyze**
3.	Find C(z)/R(z) for the following closed loop sampled data control systems. Assume all the samplers to be of impulse type. **(15)**  **(15)**	**BTL-3**	**Apply**
4.	Design a smith predictor algorithm for computer control of a first order process having dead time whose transfer function is given by $G_p(s) = \dfrac{K_p e^{-\theta_d s}}{\tau s+1}$. **(15)**	**BTL-6**	**Create**
5.	Design a Dahlin's controller algorithm for $G_p(s) = \dfrac{e^{-0.8s}}{0.6s+1}$, T = 0.4 sec. **(15)**	**BTL-6**	**Create**

UNIT IV - MULTI-LOOP REGULATORY CONTROL

SYLLABUS

Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs –The Relative Gain Array (RGA) – Properties and Application of RGA - Multi-loop PID Controller – Biggest Log Modulus Tuning Method – De-coupler.

PART-A

Q. No	Questions	BT Level	Competence
1.	Define Multi-loop Control.	**BTL-1**	**Remember**
2.	Compare multiloop with multivariable PID controller.	**BTL-2**	**Understand**
3.	What is process interaction?	**BTL-1**	**Remember**
4.	What are the problems arising from interactions?	**BTL-4**	**Analyze**
5.	What are the methods used in selecting manipulated variables & controlled variables?	**BTL-4**	**Analyze**
6.	How many relative gains do you compute in order to specify complete relative gain array of a process?	**BTL-4**	**Analyze**
7.	What are the degrees of freedom with respect to multiloop control?	**BTL-4**	**Analyze**
8.	What is the result of dynamic interaction?	**BTL-1**	**Remember**
9.	What is a Pairing of inputs and outputs? How it is represented?	**BTL-3**	**Apply**
10.	What are the criteria to select the best loop configuration?	**BTL-4**	**Analyze**
11.	What is a MIMO system? Explain with an example.	**BTL-1**	**Remember**
12.	What is RGA?	**BTL-1**	**Remember**
13.	Examine the applications of RGA.	**BTL-1**	**Remember**
14.	Write any two important properties of RGA.	**BTL-1**	**Remember**
15.	What are the implications when the RGA element $\lambda_{ij} = 0$ and $\lambda_{ij} = 1$?	**BTL-4**	**Analyze**
16.	Classify the different types of Tuning of Multi-loop PID control systems.	**BTL-6**	**Create**
17.	Define Biggest Log-modulus tuning (BLT) method.	**BTL-2**	**Understand**
18.	Compose the mathematical representation of closed –Loop stability.	**BTL-6**	**Create**
19.	What is failure sensitivity?	**BTL-1**	**Remember**
20.	Illustrate De-tuning method.	**BTL-4**	**Analyze**
21.	What is decoupling?	**BTL-1**	**Remember**
22.	What is static decoupling?	**BTL-1**	**Remember**
23.	What is partial decoupling?	**BTL-1**	**Remember**
24.	What is the function of a decoupler?	**BTL-1**	**Remember**

PART – B

1.	Derive and explain the nature of interaction between two control loops when a loop is open and another is closed and vice versa. **(13)**		**BTL-6**	**Create**
2.	Derive and explain how to obtain process interaction. **(13)**		**BTL-6**	**Create**
3.	**(i)**	Give remarks on nature of interaction between two control loops. **(6)**	**BTL-1**	**Remember**
	(ii)	Give the properties and applications of RGA. **(7)**	**BTL-1**	**Remember**

4.	**(i)**	Summarize the possible pairing rules for selection of input-output variables. **(6)**	**BTL-1**	**Remember**
	(ii)	Find the loops using the Relative Gain Array. Consider a process with the following input output relationships. $y_1 = \frac{1}{s+1} m_1(s) + \frac{1}{(0.1s+1)} m_2(s)$ $y_2 = \frac{-0.2}{0.5s+1} m_1(s) + \frac{0.8}{(s+1)} m_2(s)$. **(7)**	**BTL-3**	**Apply**
5.		Consider the following RGA for a process with following matrices.	**BTL-3**	**Apply**
	(a)	$[\lambda] = \begin{bmatrix} 1 & 1 & -1 \\ 3 & 4 & 2 \\ -3 & 4 & 0 \end{bmatrix}$	**BTL-3**	**Apply**
	(b)	$\Lambda = \begin{array}{c} \\ y_1 \\ y_2 \\ y_3 \\ y_4 \end{array} \begin{array}{c} \begin{array}{cccc} u_1 & u_2 & u_3 & u_4 \end{array} \\ \begin{bmatrix} 0.931 & 0.150 & 0.080 & -0.164 \\ -0.011 & -0.429 & 0.286 & 1.154 \\ -0.135 & 3.314 & -0.270 & -1.910 \\ 0.215 & -2.030 & 0.900 & 1.919 \end{bmatrix} \end{array}$		
		How would you choose input-output pairing for the above process? **(6+7)**		
6.		Decide a suitable multi-loop control strategy for a process with the following steady-state gain matrix which has been scaled by dividing the process variables by their maximum values. **(13)** $\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} 0.48 & 0.90 & -0.006 \\ 0.52 & 0.95 & 0.008 \\ 0.90 & -0.95 & 0.020 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \\ u_3 \end{bmatrix}$	**BTL-5**	**Evaluate**
7.		Describe the control operation of a flash drum. **(13)**	**BTL-1**	**Remember**
8.		Write in detail about RGA and selection of loops. **(13)**	**BTL-1**	**Remember**
9.	**(i)**	Explain the strategies for reducing control loop interactions. **(6)**	**BTL-2**	**Understand**
	(ii)	Illustrate the methods in Tuning of Multi-loop PID Controllers with examples.**(7)**		
10.		How is RGA useful for determination of variable pairing? **(13)**	**BTL-4**	**Analyze**
11.	**(i)**	Consider the following process with three inputs and three outputs. $y_1 = \frac{1}{s+1} m_1(s) + \frac{2}{(s+2)(s+3)} m_2(s) - \frac{0.1}{3s+1} m_3(s)$ $y_2 = \frac{5}{s^2+2s+1} m_2(s) + \frac{1}{(s+1)} m_3(s)$ $y_3 = \frac{10}{5s+1} m_1(s) + \frac{7}{(4s+1)(0.1s+1)} m_2(s) + \frac{15}{(s+1)(s+5)} m_3(s)$ Using Bristol's relative gain array, select the control loops with minimum steady state interaction. **(6)**	**BTL-2**	**Understand**

	(ii)	Select the control loops with minimum steady state interaction for the following system with two outputs and three inputs, **(7)** $y_1 = \frac{3}{2s+1} m_1(s) + \frac{0.5}{(s+1)(s+3)} m_2(s) + \frac{1}{s^2+3s+2} m_3(s)$ $y_2 = -10\, m_1(s) + \frac{2}{(s+1)} m_2(s) + \frac{4}{(s+1)(3s+1)} m_3(s)$	**BTL-4**	**Analyze**
12.		Explain the Biggest Log Modulus tuning method for	**BTL-2**	**Understand**
	(i)	Multiloop. **(10)**		
	(ii)	Single loop. **(3)**		
13.		Explain how to design decoupler for two input two output processes. **(13)**	**BTL-2**	**Understand**
14.	(i)	What is decoupling? Explain the types of decoupling. **(10)**	**BTL-2**	**Understand**
	(ii)	Comment on the Dynamic Considerations while calculating RGA. **(3)**		
15.		What is RGA? Explain with examples. **(13)**	**BTL-2**	**Understand**
16.		Enumerate on the design of non-interacting control loops. **(13)**	**BTL-6**	**Create**
17.		Derive RGA for three input- three output systems. **(13)**	**BTL-6**	**Create**
		PART-C		
1.	(i)	Explain the significant differences between partial decoupling and static decoupling. **(10)**	**BTL-2**	**Understand**
	(ii)	Explain the Stability Theorem. **(5)**		
2.		Consider a following 2 x 2 process $\begin{bmatrix} X_D \\ X_B \end{bmatrix} = \begin{bmatrix} \frac{-18.9e^{-3s}}{21s+1} & \frac{-12.8e^{-s}}{16.7s+1} \\ \frac{-19.4e^{-s}}{14.4s+1} & \frac{6.6e^{-7s}}{10.9s+1} \end{bmatrix} \begin{bmatrix} S(s) \\ R(s) \end{bmatrix}$ Design a decoupler for the process. **(15)**	**BTL-4**	**Analyze**
3.		Write note on Singular Value Analysis. **(15)**	**BTL-3**	**Apply**
4.		A 2 x 2 process has the following steady-state gain matrix: $\boldsymbol{K} = \begin{bmatrix} 1 & K_{12} \\ 10 & 1 \end{bmatrix}$ Calculate the determinant, RGA, eigenvalues, and singular values of $\boldsymbol{K}$. Use $K_{12} = 0$ as the base case; then recalculate the matrix properties for a small change, $K_{12} = 0.1$. **(15)**	**BTL-4**	**Analyze**
5.		Derive RGA for n input- n output system. **(15)**	**BTL-6**	**Create**

UNIT V - MULTIVARIABLE REGULATORY CONTROL			
SYLLABUS			
Introduction to Multivariable control –Multivariable PID Controller – Multivariable Dynamic Matrix Controller – Fuzzy Logic Controller – Case Studies: - Distillation Column, CSTR and Four-tank system.			
PART – A			
Q.No	**Questions**	**BT Level**	**Competence**
1.	Identify any two challenges in the control of MIMO process.	**BTL-1**	**Remember**
2.	What is Centralised control and Decentralised control?	**BTL-1**	**Remember**
3.	Write the advantages and disadvantages of Decentralised (multi-loop) control.	**BTL-1**	**Remember**
4.	Write the advantages and disadvantages of Centralised (multivariable) control.	**BTL-1**	**Remember**
5.	What are the difficulties in multivariable control?	**BTL-4**	**Analyze**
6.	What are the features of full multivariable controller?	**BTL-4**	**Analyze**
7.	How should the model be initialized to predict the future output?	**BTL-4**	**Analyze**
8.	Formulate the poles and zeros of multivariable control with the mathematical expressions.	**BTL-3**	**Apply**
9.	Construct the block diagram of multivariable PID.	**BTL-2**	**Understand**
10.	How multivariable PID controller is differing from multi-loop PID?	**BTL-4**	**Analyze**
11.	List few methods of tuning of multivariable PID controller?	**BTL-5**	**Evaluate**
12.	Write the expression for Maciejowski method of tuning for PI controller.	**BTL-1**	**Remember**
13.	What are the two methods to control non square systems?	**BTL-4**	**Analyze**
14.	Briefly explain about Dynamic Matrix control.	**BTL-1**	**Remember**
15.	Write the objective function for multivariable DMC.	**BTL-1**	**Remember**
16.	What are the steps involved in implementing DMC on a process?	**BTL-4**	**Analyze**
17.	What is cross coupling in the multivariable processes?	**BTL-1**	**Remember**
18.	What are the two problems of controlling a multivariable process if the cross couplings are not counteracted by the multivariable controller:	**BTL-4**	**Analyze**
19.	What are the basic elements of a fuzzy logic control system?	**BTL-4**	**Analyze**
20.	What are the assumptions to be made in a fuzzy control system design?	**BTL-4**	**Analyze**
21.	Explain the steps in designing a fuzzy control system.	**BTL-4**	**Analyze**
22.	List the features of fuzzy control system.	**BTL-2**	**Understand**
23.	List some of the applications of fuzzy logic control system.	**BTL-6**	**Create**
24.	Draw a schematic diagram of a typical closed-loop fuzzy control situation.	**BTL-4**	**Analyze**

PART B				
1.	Explain with suitable example the importance and challenges in multivariable control. **(13)**		**BTL-2**	**Understand**
2.	**(i)**	Explain multivariable PID controller with a neat block diagram. **(10)**	**BTL-2**	**Understand**
	(ii)	What is Bumpless Transfer. **(3)**		
3.	**(i)**	Derive the multivariable PID Controller transfer function. **(10)**	**BTL-6**	**Create**
	(ii)	Write about Pole zero cancellation and ringing. **(3)**	**BTL-3**	**Apply**
4.	Discuss the various conventional centralized controller procedures for multivariable process. **(13)**		**BTL-3**	**Apply**
5.	Summarize various steps involved in DMC controller design. Derive the expression for an objective function for controller design. **(13)**		**BTL-6**	**Create**
6.	Describe the multivariable Dynamic Matrix Control scheme with detailed algorithmic steps. **(13)**		**BTL-4**	**Analyze**
7.	Explain single loop control of a 2×2 multivariable process.**(13)**		**BTL-2**	**Understand**
8.	Derive the Impulse and Step Response of discrete time model. **(13)**		**BTL-6**	**Create**
9.	**(i)**	Consider a first-order-plus-time-delay model: $\frac{Y(s)}{U(s)}=\frac{Ke^{-\theta s}}{\tau s+1}$, Derive the equivalent step-response model by considering the analytical solution to a unit step change in the input. **(6)**	**BTL-6**	**Create**
	(ii)	Derive the equivalent step-response model by considering the analytical solution to a unit step change in the input with time delay. **(7)**	**BTL-6**	**Create**
10.	Write the procedure for tuning the PID controllers in single loop multivariable control **(13)**		**BTL-6**	**Create**
11.	With a neat sketch discuss the major components of fuzzy logic controller. **(13)**		**BTL-1**	**Remember**
12.	Discuss the Distillation Column system with fuzzy logic control. **(13)**		**BTL-2**	**Understand**
13.	Identification and Control of an Industrial Distillation Column: A Case Study approach. **(13)**		**BTL-1**	**Remember**
14.	A Case Study to Optimize Design in Linearization of Non-linear CSTR using Multiple Model Predictive Control Approach. **(13)**		**BTL-6**	**Create**
15.	Continuously Stirred Tank Reactor (CSTR) modelling and control case study. **(13)**		**BTL-5**	**Evaluate**
16.	Derive the transfer function of four tank systems. **(13)**		**BTL-6**	**Create**
17.	Analyze the Performance of Four Tank System using controller. **(13)**		**BTL-4**	**Analyze**

PART-C				
1.		Sketch the design for two heat exchangers that can be used as condensers. For each design, explain how the heat transfer can be changed and indicate a valve or other element of the design that could be manipulated to change the heat transferred. What fluid medium is normally used for heat exchange in the condenser and why? **(15)**	**BTL-5**	**Evaluate**
2.		Describe the multivariable Dynamic Matrix Control scheme with detailed algorithmic step s**. (15)**	**BTL-4**	**Analyze**
3.		Given $(K_pG_p)_{11}$ = 1/[(6s+1)(3s+1)]; $(K_pG_p)_{12}$ = 1/(4s+1); $(K_pG_p)_{21}$ = 2/(3s+1); $(K_pG_p)_{22}$ = 1/[(4s+1)(2s+1)]; Design a multivariable controller using Davison method. Evaluate the time response of the closed loop system for step input changes in the set point. **(15)**	**BTL-6**	**Create**
4.		Design DMC for the Van de-vusse reactor problem. The state space model of reactor is given as A = [-2.4048 0; 0.8333 -2.2381], B = [7; -1.117], C = [0 1], D = [0]. **(15)**	**BTL-6**	**Create**
5.	**(i)**	With a neat block diagram, explain the design of fuzzy logic controller. **(8)**	**BTL-6**	**Create**
	(ii)	Compare and contrast fuzzy logic control and classical control system. **(7)**	**BTL-5**	**Evaluate**