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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Department of Electronics and Instrumentation Engineering

SUBJECT: 1907701–COMPUTER CONTROL OF PROCESSES
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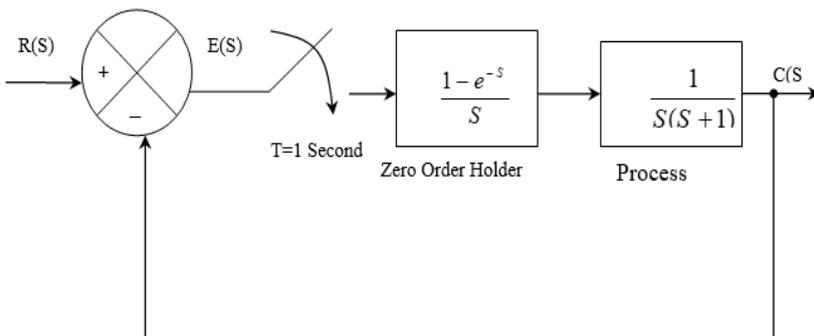| UNIT I - DISCRETE STATE-VARIABLE TECHNIQUE			
SYLLABUS			
State equation of discrete data system with sample and hold – State transition equation – Methods of computing the state transition matrix – Decomposition of discrete data transfer functions – State diagrams of discrete data systems – System 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 the term state.	**BTL-1**	**Remember**
2.	Define the term state variable.	**BTL-1**	**Remember**
3.	Mention the methods to find state transition matrix.	**BTL-1**	**Remember**
4.	Write the general form of the state space Model for discrete system.	**BTL-1**	**Remember**
5.	Distinguish between discrete time systems and continuous time systems.	**BTL-1**	**Remember**
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-1**	**Remember**
9.	How the Z-plane stability is related with S-Plane? What are the method we are having to find the discrete system stability analysis.	**BTL-1**	**Remember**
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-1**	**Remember**
14.	Write the general form of the State space model of continuous systems. How the transfer function model can be converted into State space model.	**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-1**	**Remember**
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-1	Remember

	PART – B		
1	Find the Z-transfer function for the given function a. $Y(t) = 1 - e^{-2t}$ with Sampling Time (T) =0.5 Second b. $Y(t) = 1 - e^{-8t}$ with Sampling Time (T) =0.5 Second **(7+6)**	BTL-3	**Apply**
2	Find the pulse transfer function and stability analysis by i. Jury's Test ii. Bilinear transform method. The pulse transfer function for the sampled data control system is as shown in Fig. with the Sampling Time (T)= 1 Second. **(13)** 	BTL-3	**Apply**
3	A discrete time system is represented by the differential equation $y(n+2) + 6y(n+1) + 8y(n) = u(n)$ in which the initial condition y(0)=y(1)=0 with T=1Second (i) Obtain the Canonical discrete state space model. (ii) And also obtain the State transition matrix **(6+7)**	BTL-3	**Apply**
4	Find the state transform matrix for the given discrete system matrix $A = \begin{bmatrix} 0 & 1 \\ -12 & 7 \end{bmatrix}$ By the (i) Z-transform technique (ii) Cayley-Hamilton's theorem. **(6+7)**	BTL-3	**Apply**
5	Solve the discrete system difference equation and find the value of Y(n); n≥0. $Y(n) + \frac{1}{4}Y(n-1) = U(n) + \frac{1}{3}U(n-1)$ where the reference input u(n) is unit step sequence. **(13)**	BTL-3	**Apply**
6	Find the state transition matrix for the given discrete system matrix $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ By the method of i. Z-transformation technique ii. Cayley - Hamilton's theorem. **(6+7)**	BTL-3	**Apply**

7		The system matrix A of a discrete time system is given by the matrix $A = \begin{bmatrix} 0 & 1 \\ -4 & -5 \end{bmatrix}$ Compute the state transition matrix e^{At} using Cayley- Hamilton theorem. (13)	BTL-3	Apply
8		Consider the following characteristic equation of a discrete data system. $F(z) = z^4 - 1.2z^3 + 0.22z^2 + 0.066z - 0.008 = 0$. Check whether the system is stable or not. (13)	BTL-3	Apply
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 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)	Check whether the discrete data system represented by the characteristic polynomial $F(Z) = 2Z^4 + 7Z^3 + 10Z^2 + 4Z + 1$ is able or not. (7)	BTL-4	Analyze
	(ii)	Determine the stability of the sampled data control systems represented by the following characteristic equation $F(Z) = Z^3 - 1.3Z^2 - 0.08Z + 0.24 = 0$ (6)	BTL-4	Analyze
11		Determine the state controllability and observability of the following system. $$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \\ x_3(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 2 & -3 & -2 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} [u(k)]$$ $$[y(k)] = \begin{bmatrix} 3 & 4 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix}$$ (13)	BTL-3	Apply
12		Check whether the given discrete characteristic equation of the system is stable or not by Bilinear transform $i. F(Z) = Z^2 - 1.2Z - 0.363 = 0$ $ii. F(Z) = Z^2 - 0.4Z + 0.8 = 0$ $iii. F(Z) = Z^3 - 0.5Z^2 + 0.25Z + 0.5 = 0$ (4+4+5)	BTL-3	Apply

13	(i)	Derive the transfer function of zero-order Hold and comment on selection of sampling period. (8)	BTL-4	Analyze
	(ii)	Derive the general form of the state space Model for the discrete system. (5)		

14	Obtain the state model for the given differential equation $\dfrac{d^3Y}{dt^2}+6\dfrac{d^2Y}{dt^2}+11\dfrac{dY}{dt}+6Y=U(t)$ by (i) Canonical form (ii) Bush or companion form (iii) Signal flow graph method. $\qquad$ (5+4+4)	BTL-4	Analyze
15	Check the stability of the sampled data control system represented by the following characteristic equation.	BTL-4	Analyze
	(i) $F(Z)=Z^2-1.21Z+0.368=0$ $\qquad$ (6)		
	(ii) $F(Z)=Z^3-1.3Z^2-0.08z+0.24=0$ $\qquad$ (7)		
16	Check the stability of the sampled data control system represented by the following characteristic equations using bilinear transformation. $\qquad$ (13)	BTL-4	Analyze
	(i) $F(Z)=Z^3-0.2Z^2-0.25z+0.05=0$ $\qquad$ (6)		
	(ii) $F(Z)=Z^3+0.5Z^2+0.25Z+0.5=0$ $\qquad$ (7)		
17	Obtain the unit step response of the system as shown in Fig. $\qquad$ (13)	BTL-4	Analyze

<div align="center">PART – C</div>

1.	Explain the following terms (i) Sampler and Holder (ii) Zero order Holder with process. $\qquad$ (7+8)	BTL-4	Analyze
2.	A discrete time system is described by the difference equation. $Y(n+3)-3Y(n-1)+2Y(n)=0$ with the initial conditions Y(0)=4; Y(1)=0; Y(2)=8. Solve the difference equation by Z-transform method. $\qquad$ (15)	BTL-3	Apply
3.	Solve the differential equation $Y(n+2)+3Y(n+1)+2Y(n)=U(n)$. where $Y(0)=0, Y(1)=1$ and the applied input is step. $\qquad$ (15)	BTL-4	Analyze
4.	Explain the controllability and observability concept by (i) Gilbert's Method (ii) Kalman's Method. $\qquad$ (7+8)	BTL-4	Analyze
5.	Explain discrete system stability analysis by (i) Jury's Test (ii) Bilinear Transform. $\qquad$ (7+8)	BTL-3	Apply

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 meant by model?	BTL-1	Remember
2.	Mention the advantages of model.	BTL-1	Remember
3.	What is mathematical modeling?	BTL-1	Remember
4.	What are the different approaches to modeling?	BTL-1	Remember
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-1	Remember
9.	Write the advantages of transient analysis method.	BTL-1	Remember
10.	Examine the drawbacks of transient response analysis.	BTL-2	Understand
11.	What is meant by frequency analysis?	BTL-1	Remember
12.	Briefly explain the first order system parameter estimation using impulse response method.	BTL-2	Understand
13.	When correlation analysis is required?	BTL-1	Remember
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-1	Remember
20.	What are the limitations of LS method?	BTL-1	Remember

21.	Define recursive identification method.	BTL-1	Remember
22.	What are the advantages of recursive identification method?	BTL-1	Remember
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.	Point out 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.		Explain various model representation for an LTI system? **(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-4**	**Analyze**
	(ii)	Explain the identifying second order model. **(7)**	**BTL-4**	**Analyze**
7.	(i)	Describe the frequency analysis method of system parameter estimation. **(8)**	**BTL-4**	**Analyze**
	(ii)	Briefly describe the improved frequency analysis. **(5)**	**BTL-4**	**Analyze**
8.	(i)	How impulse response identification using step response 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-3**	**Apply**
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-3**	**Apply**
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-4**	**Analyze**

17.	(i)	Write the general features of recursive identification methods. **(6)**	**BTL-3**	**Apply**
	(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-4**	**Analyze**
2.	(i)	Design the second order system impulse response. **(12)**	**BTL-4**	**Analyze**
	(ii)	Discuss the limitations of transient analysis. **(3)**	**BTL-4**	**Analyze**

3.	Explain Nonl inear Least-square Estimation and its iterative solution. **(15)**	BTL-2	Understand
4.	Design Transfer Function and Equation error model in Dynamic systems. **(15)**	BTL-4	Analyze
5.	Derive the expression for Finite Impulse Response Model (FIR model). **(15)**	BTL-4	Analyze

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 (i) Two sided Z-transform (ii) One 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-1	Remember
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-1	Remember
10.	How the Z-Plane is related with S-Plane ?	BTL-1	Remember
11.	Define Pulse transfer function .	BTL-1	Remember
12.	Write the transfer function of Zero Order Holder (ZOH)	BTL-1	Remember
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-1	Remember
15.	Give the steps involved in determining the pulse transfer function of G(z) from G(s).	BTL-1	Remember

16.	What is meant by bilinear transform?	BTL-1	Remember
17.	How the Microprocessor based system can be controlled by Digital PID algorithm and also write the algorithm equation.	BTL-1	Remember
18.	What are the features of digital PID controller?	BTL-1	Remember
19.	What is meant by Digital controller? Give any 4-types of digital control algorithm.	BTL-1	Remember

20.	List the advantages and disadvantages of Dahlin's controller.	BTL-1	Remember
21.	For which situation the Deat beat controller is selected as a controller? And also write the output equation.	BTL-1	Remember
22.	What is meant by ringing? How the ringing occurs in Dahlin's controller? Write the output equation?	BTL-1	Remember
23.	What is Smith Predictor Algorithm?	BTL-1	Remember
24.	How does a Smith Predictor work?	BTL-1	Remember

PART – B

1.	Find the Z-transform and their Region of Convergence (ROC) of the following discrete sequences: i. $f(n) = \{2,3,5,6,7\}$ ii. $f(n) = \{1,2,3,4,5,6\}$ iii. $f(n) = \{3,4,5,6,8\}$ iv. $f(n) = \{8,10,7,4,1,-1,0,3,6\}$ (3+3+3+4)	BTL-3	Apply
2.	Find the Modified Z-transform for the following function (i) Unit step function U(t)=1 (ii) Expenential function e^{-at} (iii) $G(S) = \dfrac{a}{S(S+a)}$ (iv) $G(S) = \dfrac{1}{S(S+a)}$ (3+4+3+3)	BTL-4	Analyze
3.	Find the Z-transform for the following function and also find the Region Of Convergence (i) f(n)=1 ii) $f(n)=(-1)^n$ iii) $f(n) = \left(\dfrac{1}{2}\right)$ iv) $f(n) = \dfrac{1}{n}$ (3+3+3+4)	BTL-3	Apply
4.	Find the inverse Z-transform for the following functions using Partial Fraction Expansion method: a. $F(Z) = \dfrac{Z^2+Z^3}{(Z-1)(Z-3)}$ b. $F(Z) = \dfrac{Z(Z^2-4Z+5)}{(Z-1)(Z-2)(Z-3)}$ (6+7)	BTL-3	Apply
5.	Find the inverse Z-transform for the following transfer functions: (i). $F(Z) = \dfrac{(Z+1)}{(Z+0.2)(Z-1)}$ (ii) . $F(Z) = \dfrac{Z^2}{Z^2+Z+2}$ (6+7)	BTL-3	Apply
6.	Evaluate z-transform and ROC of $x(n)=r^n\cos(n\theta)u(n)$ **(7)** (ii) Evaluate the Inverse z-transform of $X(z) = z/[3z^2-4z+1]$, ROC $|z|>1$, $|z|<1/3$, $1/3<|z|<1$. **(6)**	BTL-3	Apply
7.	Solve the difference equation $Y(n+2)-3Y(n+1)+2Y(n)=4^n$ y(0)=0; y(n)=1 with initial conditions. **(13)**	BTL-3	Apply

8.	Obtain the unit step response of the system is as shown in Fig. **(13)**	BTL-3	Apply

9.	Find the inverse Z-transform for the following transfer functions: a. $F(Z) = \dfrac{Z}{3Z^2 - 4Z + 1}$ in which the ROC of i. $\|Z\| > 1$ ii. $\|Z\| < \dfrac{1}{3}$ b. $F(Z) = \dfrac{Z^2 + Z}{Z^2 - 2Z + 1}$ in which the ROC of i. $\|Z\| > 1$ ii. $\|Z\| < \dfrac{1}{2}$ **(7+6)**	**BTL-3**	**Apply**
10.	**Obtain the pulse transfer function for the given diagram** **(13)** 	**BTL-3**	**Apply**
11	Design of Dahlin's Controller for the process $G_P(S) = \dfrac{e^{-1.46S}}{3.34S + 1}$ with Sampling Time (T) = 5 Seconds. **(13)**		
12.	Design of Dead beat Controller for the given process $G_P(S) = \dfrac{e^{-1.46S}}{3.34S + 1}$ with Sampling Time (T) = 5 Seconds. **(13)**	**BTL-4**	**Analyze**
13.	Find the Z-Transform for the input signals (i) Step Input Signal (ii) Impulse Input Signal (iii) Ramp Input Signal (iv) Parabolic Input signal. **(3+3+3+4)**	**BTL-4**	**Analyze**
14.	Design a Kalman's algorithm for the process $G(S) = \dfrac{e^{-1.46S}}{3.34S + 1}$ with Sampling Time T=5 Seconds. **(13)**	**BTL-4**	**Analyze**

15.	Explain the following types of digital PID algorithm (i) Position algorithm (ii)Velocity algorithm. (7+6)	BTL-4	Analyze
16.	Sketch the block diagram for IMC and Explain the IMC design methods to design of controllers. (13)	BTL-4	Analyze
17.	Explain the Industrial control application with Smith predictor algorithm for distillation column control. (13)	BTL-4	Analyze

	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-4	Analyze
2.	Explain the concept of Digital PID Controller Implementation through Position and Velocity algorithm. (15)	BTL-4	Analyze
3.	Write the Design Procedure Algorithm for (i) Dead beat Controller (ii) Dahlin's Controller. (8+7)	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-4	Analyze
5.	Design a Dahlin's controller algorithm for $G_p(s) = \dfrac{e^{-0.8s}}{0.6s + 1}$, T = 0.1 sec. (15)	BTL-4	Analyze

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-2	Understand
5.	What are the methods used in selecting manipulated variables & controlled variables?	BTL-1	Remember
6.	How many relative gains do you compute in order to specify complete relative gain array of a process?	BTL-2	Understand

7.	What are the degrees of freedom with respect to multiloop control?	BTL-1	Remember
8.	What is the result of dynamic interaction?	BTL-2	Understand
9.	What is a Pairing of inputs and outputs? How it is represented?	BTL-1	Remember
10.	What are the criteria to select the best loop configuration?	BTL-2	Understand
11.	What is a MIMO system? Explain with an example.	BTL-1	Remember
12.	What is RGA?	BTL-2	Understand
13.	Examine the applications of RGA.	BTL-1	Remember
14.	Write any two important properties of RGA.	BTL-2	Understand
15.	What are the implications when the RGA element $\lambda_{ij} = 0$ and $\lambda_{ij} = 1$?	BTL-1	Remember
16.	Classify the different types of Tuning of Multi-loop PID control systems.	BTL-2	Understand
17.	Define Biggest Log-modulus tuning (BLT) method.	BTL-2	Understand
18.	Compose the mathematical representation of closed –Loop stability.	BTL-2	Understand
19.	What is failure sensitivity?	BTL-1	Remember
20.	Illustrate De-tuning method.	BTL-2	Understand
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-3	Apply
2.		Derive and explain how to obtain process interaction. (13)	BTL-3	Apply
3.	(i)	Give remarks on nature of interaction between two control loops. (6)	BTL-3	Apply
	(ii)	Give the properties and applications of RGA. (7)	BTL-3	Apply

4.	(i)	Summarize the possible pairing rules for selection of input-output variables. (6)	BTL-4	Analyze
	(ii)	Explain the concept of relative gain array. (7)	BTL-3	Apply
5.	(a)	Explain the concept of Multiple Input and Multiple Output of the system with example. (6)	BTL-3	Apply

	(b)	Consider the following RGA for a process with following matrices. How would you choose input-output pairing for the above process? **(7)** $$\Lambda = \begin{array}{c} \\ y_1 \\ y_2 \\ y_3 \\ y_4 \end{array}\begin{array}{c}u_1 \quad\quad u_2 \quad\quad u_3 \quad\quad u_4\\\left[\begin{array}{cccc} 0.931 & 0.150 & 0.080 & -0.164 \\ -0.011 & -0.429 & 0.286 & 1.154 \\ -0.135 & 3.314 & -0.270 & -1.910 \\ 0.215 & -2.030 & 0.900 & 1.919 \end{array}\right]\end{array}$$		
6.		Explain how the distillation column act as 5x5 Process. **(13)**	BTL-4	Analyze
7.		Describe the control operation of Boiler drum as 4x4 Process with neat diagram. **(13)**	BTL-3	Apply
8.		Write in detail about RGA and selection of loops. **(13)**	BTL-3	Apply
9.	**(i)**	Explain the strategies for reducing control loop interactions. **(6)**	BTL-3	Apply
	(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.		Describe the control operation of Decondense as 3x3 Process with neat diagram. **(13)**	BTL-3	Apply

12.		Explain the Biggest Log Modulus tuning method for	BTL-3	Apply
	(i)	Multiple loop. **(10)**		
	(ii)	Single loop. **(3)**		
13.		Explain how to design decoupler for two input two output processes. **(13)**	BTL-3	Apply
14.	**(i)**	What is meant by decoupling? Explain the types of decoupling. **(10)**	BTL-3	Apply
	(ii)	Comment on the Dynamic Considerations while calculating RGA. **(3)**		
15.		What is RGA? Explain with examples. **(13)**	BTL-3	Apply
16.		Enumerate on the design of non-interacting control loops. **(13)**	BTL-3	Apply
17.		Derive RGA for three input- three output systems. **(13)**	BTL-3	Apply
		PART-C		
1.	**(i)**	Explain the significant differences between partial decoupling and static decoupling. **(10)**	BTL-3	Apply
	(ii)	Explain the Stability Theorem. **(5)**		
2.		With neat diagram explain how the distillation column how act as 5x5 Process. **(15)**	BTL-4	Analyze
3.		Write note on Singular Value Analysis. **(15)**	BTL-3	Apply

4.	Explain the concept of decoupling? Explain the types of decoupling with suitable diagram. (15)	BTL-4	Analyze
5.	Derive RGA for n input- n output system. (15)	BTL-3	Apply

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-2	Understand
5.	What are the difficulties in multivariable control?	BTL-1	Remember
6.	What are the features of full multivariable controller?	BTL-1	Remember
7.	How should the model be initialized to predict the future output?	BTL-1	Remember
8.	Formulate the poles and zeros of multivariable control with the mathematical expressions.	BTL-1	Remember
9.	Construct the block diagram of multivariable PID.	BTL-2	Understand
10.	How multivariable PID controller is differing from multi-loop PID?	BTL-1	Remember
11.	List few methods of tuning of multivariable PID controller?	BTL-1	Remember
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-1	Remember
14.	Briefly explain about Dynamic Matrix control.	BTL-2	Understand
15.	Write the objective function for multivariable DMC.	BTL-1	Remember
16.	What are the steps involved in implementing DMC on a process?	BTL-1	Remember
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-1	Remember
19.	What are the basic elements of a fuzzy logic control system?	BTL-1	Remember
20.	What are the assumptions to be made in a fuzzy control system design?	BTL-1	Remember
21.	Explain the steps in designing a fuzzy control system.	BTL-1	Remember

22.	List the features of fuzzy control system.	BTL-1	Remember
23.	List some of the applications of fuzzy logic control system.	BTL-1	Remember
24.	Draw a schematic diagram of a typical closed-loop fuzzy control situation.	BTL-2	Understand

PART B				
1.	Explain with suitable example the importance and challenges in multivariable control. **(13)**		BTL-3	Apply
2.	**(i)**	Explain multivariable PID controller with a neat block diagram. **(10)**	BTL-3	Apply
	(ii)	What is Bumpless Transfer. **(3)**		
3.	**(i)**	Derive the multivariable PID Controller transfer function. **(10)**	BTL-3	Apply
	(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-3	Apply
6.	Describe the multivariable Dynamic Matrix Control scheme with detailed algorithmic steps. **(13)**		BTL-3	Apply
7.	Explain single loop control of a 2×2 multivariable process. **(13)**		BTL-3	Apply
8.	Derive the Impulse and Step Response of the discrete time model and obtain it. **(13)**		BTL-3	Apply
9.	**(i)**	Explain the modelling concept of distillation column. **(6)**	BTL-3	Apply
	(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-3	Apply
10.	Write the procedure for tuning the PID controllers in single loop multivariable control. **(13)**		BTL-4	Analyze
11.	With a neat sketch discuss the major components of fuzzy logic controller. **(13)**		BTL-4	Analyze
12.	Discuss the Distillation Column system with neuro Control scheme. **(13)**		BTL-4	Analyze
13.	Identification and Control of an Industrial Distillation Column: A Case Study approach. **(13)**		BTL-4	Analyze
14.	A Case Study to Optimize Design in Linearization of Non-linear CSTR using Multiple Model Predictive Control Approach. **(13)**		BTL-4	Analyze
15.	Continuously Stirred Tank Reactor (CSTR) modelling and control case study. **(13)**		BTL-4	Analyze
16.	Derive the transfer function of four tank systems. **(13)**		BTL-4	Analyze

17.	Analyze the Performance of the Four Tank System using controller. **(13)**	**BTL-4**	**Analyze**

PART-C			
1.	Discuss the fuzzy logic Control scheme for inverted pendulum application. **(15)**	**BTL-3**	**Apply**
2.	Describe the multivariable Dynamic Matrix Control scheme with detailed algorithmic steps**. (15)**	**BTL-4**	**Analyze**
3.	Explain how Distillation Process can be controlled with Neuro tuned controller. **(15)**	**BTL-3**	**Apply**
4.	Explain the following control scheme for (i) Distillation Column (ii) CSTR Process. **(8+7)**	**BTL-3**	**Apply**
5.	**(i)** With a neat block diagram, explain the design of fuzzy logic controller. **(8)**	**BTL-4**	**Analyze**
	(ii) Compare and contrast fuzzy logic control and classical control system. **(7)**	**BTL-4**	**Analyze**