

Contents

CHAPTER 1: CONTROL SYSTEM MODELING.....	1.1 – 1.185
1.1. Introduction.....	1.1
1.2. Control System.....	1.1
1.2.1. Classification of Control System	1.2
1.2.2. Open Loop System.....	1.3
1.2.3. Closed Loop System	1.4
1.2.4. Transfer Function.....	1.6
1.3. Electrical System.....	1.6
Solved Problems.....	1.7
1.4. Mechanical System	1.18
1.4.1. Mechanical Translation System.....	1.19
Solved Problems.....	1.23
1.4.2. Electrical Analogous of Mechanical Translational System	1.37
Solved Problems.....	1.41
1.4.3. Mechanical Rotational System	1.71
1.4.4. Electrical Analogous of Mechanical Rotational System	1.84
Solved Problems.....	1.88
1.5. Electro-Mechanical System.....	1.103
1.5.1. Transfer Function of Armature Controlled d.c motor.....	1.103
1.5.2. Transfer Function of Field Controlled d.c Motor	1.105
1.6. Block Diagram Reduction Technique.....	1.107
1.6.1. Construction of Block Diagram for Electrical Circuit.....	1.108

Solved Examples	1.108
1.6.2. Block Diagram of Armature controlled DC Motor.....	1.113
1.6.3. Block Diagram of Field Controlled DC Motor.....	1.115
1.6.4. Rules to Reduce the Block Diagram.....	1.116
Solved Problems.....	1.119
Exercise Problems	1.141
1.7. Multiple Input and Multiple Output Systems	1.143
Solved Examples	1.143
Exercise Problems	1.154
1.8. Signal Flow Graphs (SFG).....	1.155
1.8.1. Properties of Signal Flow Graph.....	1.156
1.8.2. Rules to Reduce Signal Flow Graph.....	1.156
1.8.3. Signal Flow Graph for Armature Controlled DC Motor	1.158
Solved Problems.....	1.160
1.8.4. Conversion of Block Diagram in Signal Flow Graph.....	1.174
Solved Problems.....	1.174
Two Mark Questions And Answers.....	1.179
Exercise Problems	1.184
<hr/> CHAPTER 2: TIME RESPONSE ANALYSIS	2.1 – 2.95
2.1. Time Response.....	2.1
2.2. Standard Test Signals.....	2.2
2.2.1. Step Input	2.2
2.2.2. Impulse input	2.2

Contents

2.2.3. Ramp Input.....	2.3
2.2.4. Parabolic Input	2.4
2.3. Order of a System	2.5
2.4. Time Response Analysis of a First Order System.....	2.6
2.4.1. Time Response of First Order System for Unit Step Input.....	2.6
2.4.2. Time Response of First Order System for Unit Impulse Response	2.8
2.4.3. Time Response of First Order System for Unit Ramp.....	2.8
2.5. Time Response Analysis of Second Order System.....	2.10
2.5.1. Time Response Analysis of Second Order System for Unit Step Input.....	2.11
2.5.2. Time Response Analysis of Second Order System for Unit Impulse Input	2.20
Solved Examples	2.23
2.6. Time Domain Specifications	2.32
2.6.1. Mathematical Expression for Time Domain Specifications	2.33
Important Formulae	2.37
Solved Problems.....	2.38
Exercise Problems	2.60
2.7. Steady State Error	2.60
2.8. Static Error Constants.....	2.62
2.8.1. Static Position Error Constant (K_p)	2.62
2.8.2. Static Velocity Error Constant (K_v)	2.64
2.8.3. Static Acceleration Error Constant (K_a)	2.66

2.9.	Dynamic Error Coefficients (or) Generalised Error Coefficients	2.68
<i>Exercise Problems</i>		2.86
2.10.	Controllers.....	2.87
2.10.1.	ON-OFF Controller	2.88
2.10.2.	Proportional Controller (P).....	2.88
2.10.3.	Integral Controller (I)	2.89
2.10.4.	Proportional Plus Integral Controller (PI)	2.90
2.10.5.	Proportional Plus Derivative Controller (PD)	2.91
2.10.6.	PID Controller	2.91
2.10.7.	Comparison of Proportional, Integral and Derivative Action	2.92
<i>Two Mark Questions and Answers</i>		2.92
CHAPTER 3: FREQUENCY RESPONSE ANALYSIS		3.1 – 3.100
3.1.	Introduction.....	3.1
3.2.	Frequency Response of Closed Loop System	3.2
3.3.	Frequency Response Specification	3.3
3.4.	Frequency Domain Specification of Second Order System	3.5
3.5.	Correlation between Frequency and Time Response.....	3.7
<i>Solved Problems.....</i>		3.9
3.6.	Bode Plots	3.14
3.6.1.	Slope and Phase Angle of Standard Functions	3.15
<i>Important Definitions</i>		3.20

Contents

3.6.2. Steps to Draw the Bode Plot	3.20
Solved Examples	3.21
Exercise Problem	3.59
3.7. Polar Plot	3.60
3.7.1. Magnitude and Phase Angle for Standard Functions.....	3.61
3.7.2. Procedure to Draw Polar Plots.....	3.65
Solved Problems.....	3.66
Exercise Problem	3.88
3.8. Necessity of M and N Circles in Control System	3.89
3.8.1. Analysis of M and N Circles.....	3.89
3.8.2. M Circle Constitute Magnitude Loci in $G(j\omega)$ Plane	3.90
3.8.3. N Circles Constitute Phase Loci in $G(j\omega)$ Plane	3.92
3.9. Nichol's Chart	3.94
3.9.1. Solved Problems in Nichols Chart.....	3.95
Two Mark Questions and Answers	3.98
CHAPTER 4: COMPENSATION OF CONTROL SYSTEM.....	
4.1. Compensation.....	4.1 – 4.64
4.2. Basic Characteristics of Lag, Lead and Lag-lead Network	4.3
4.3. Lag Compensation	4.3
4.3.1. Realization of Lag Compensator using Electrical Network	4.3
4.3.2. Design Procedure for Lag Compensator using Bode Plot	4.5
Solved Examples	4.7
4.4. Lead Compensation.....	4.22

4.4.1.	Realization of Lead Compensation using Electrical Network	4.22
4.4.2.	Design Procedure for Lead Compensator using Bode Plot	4.25
4.5.	Lag-Lead Compensator.....	4.43
4.5.1.	Realization of Lag-Lead Compensation using Electrical Network	4.44
4.5.2.	Design Procedure for Lag-Lead Compensator using Bode Plot.....	4.46
<i>Solved Examples</i>		4.62
4.6.	Limitations and Effect of Phase Lag Compensation	4.63
4.7.	Limitations and Effect of Phase Lead Compensation	4.63
4.8.	Comparison of Lead Network and Lag Network	4.63

CHAPTER 5: STABILITY ANALYSIS		5.1 – 5.122
5.1.	Concept of Stability	5.1
5.2.	Stability Condition of the Control System.....	5.2
5.3.	Routh Hurwitz Criterion	5.4
<i>Solved Examples</i>		5.5
5.3.1.	Special Cases in R-H Criterion	5.11
<i>Solved Examples</i>		5.12
<i>Exercise Problems</i>		5.21
5.4.	Nyquist Plot Analysis.....	5.25
5.4.1.	Pole-Zero Configuration	5.25
5.4.2.	Concept of Encirclement and Enclosed	5.26

5.4.3. Analytic Function and Singularities.....	5.29
5.4.4. Principle of Argument.....	5.29
5.5. Nyquist Stability Criterion.....	5.33
5.5.1. Procedure to Analyse the Stability using Nyquist Stability Criterion.....	5.36
Solved Examples	5.37
Exercise Problems	5.67
5.6. Relative Stability	5.67
5.7. Gain Margin and Phase Margin.....	5.69
5.8. Root Locus Technique.....	5.70
5.8.1. Concept of Root Locus Technique	5.71
5.8.2. Procedure to construct Root Locus	5.73
5.8.3. Effect of adding Poles and Zeros	5.116
Two Mark Questions and Answers	5.119
Exercise Problems	5.122

CHAPTER 6: STATE VARIABLE ANALYSIS	6.1 – 6.82
6.1. Introduction.....	6.1
6.2. State Model of Linear System.....	6.2
6.3. Relation Between the State Equation and Transfer Function	6.4
Solved Examples	6.5
6.4. State-Space Representation	6.8
6.4.1. Electrical System Procedure to obtain the State-Equation	6.8
Solved Examples	6.8

6.4.2. Mechanical System	6.14
Solved Examples	6.14
6.4.3. Block Diagram	6.21
Solved Examples	6.21
6.4.4. Signal Flow Graph	6.26
Solved Examples	6.27
6.5. State Space Representation using Phase Variables	6.31
6.5.1. Controllable Canonical Form.....	6.32
6.5.2. Observable Canonical Form	6.38
6.5.3. Diagonal Canonical Form	6.40
6.5.4. Jordan Canonical Form	6.43
6.6. Solution of State Equation	6.43
6.6.1. Homogeneous State Equation.....	6.44
6.6.2. Non-Homogeneous State Equation.....	6.44
6.6.3. Properties of State Transition Matrix.....	6.45
6.6.4. Computation of State Transition Matrix by Laplace Transformation.....	6.46
6.7. Concepts of Controllability and Observability	6.51
6.7.1. Controllability.....	6.51
6.7.2. Observability.....	6.52
6.7.3. Output Controllability.....	6.63
6.7.4. Effect of Pole-Zero Cancellation in Transfer Function	6.64
6.8. State Space Representation for Discrete Time Systems	6.66
6.8.1. State Models from Linear z-Transfer Functions.....	6.66

6.8.2. Derivation of Z-Transfer Function.....	6.69
6.8.3. Solution of State Equation in Discrete Case	6.73
6.9. Sampled Data Control System.....	6.73
6.10. Sampling Process	6.74
6.11. Signal Reconstruction.....	6.75
6.12. Open Loop Sampled Data System.....	6.76
6.13. Closed Loop Sampled Data System.....	6.76
<i>Two Mark Questions and Answers</i>	6.78

CHAPTER 7: COMPONENTS OF CONTROL SYSTEM 7.1 – 7.11

7.1. Introduction.....	7.1
7.2. Potentiometers.....	7.1
7.2.1. Characteristic of Potentiometer.....	7.3
7.3. Synchros.....	7.3
7.3.1. Synchro-Error Detector.....	7.5
7.4. A.C Servomotor	7.6
7.5. D.C Servomotor	7.7
7.5.1. Field Controlled D.C Motor.....	7.7
7.5.2. Armature Controlled D.C Motor.....	7.9
7.6. Comparison Between D.C Servomotor and A.C Servomotor	7.11

MATLAB PROGRAMS MAT.1 – MAT.20

Solved Anna University Question Papers..... SQ.1 – SQ.26