

# CONTENTS

---

*Preface*

*vii*

*List of Symbols Abbreviations*

*xxiii*

---

## **CHAPTER 1: Introduction**

**1.1–1.8**

- 1.1 Introduction to Circuits and Networks 1.1
  - 1.1.1 Basic Phenomena 1.1
  - 1.1.2 Ideal Elements 1.1
  - 1.1.3 Electric Circuits 1.1
  - 1.1.4 Units 1.4
  - 1.1.5 Definitions of Various Terms 1.5
  - 1.1.6 Symbols Used for Average, RMS and Maximum Values 1.7
  - 1.1.7 Steady State Analysis and Transient Analysis 1.7
  - 1.1.8 Assumptions in Circuit Theory 1.8

---

## **CHAPTER 2: Basic Concepts of DC Circuits**

**2.1–2.50**

- 2.1 Basic Elements of Circuits 2.1
- 2.2 Nodes, Branches and Closed Path 2.2
- 2.3 Series, Parallel, Star and Delta Connections 2.4
- 2.4 Open Circuit and Short Circuit 2.7
- 2.5 Sign Conventions 2.8
- 2.6 Voltage and Current Sources 2.9
- 2.7 Ideal and Practical Sources 2.9
- 2.8 DC Source Transformation 2.10
- 2.9 Dependent Sources 2.11
- 2.10 Power and Energy 2.12
- 2.11 Ohm's and Kirchhoff's Laws 2.12
  - 2.11.1 Ohm's Law 2.12
  - 2.11.2 Kirchhoff's Current Law (KCL) 2.13
  - 2.11.3 Kirchhoff's Voltage Law (KVL) 2.13
- 2.12 Resistive Elements 2.14
  - 2.12.1 Resistance 2.14
  - 2.12.2 Resistance Connected to DC Source 2.14
  - 2.12.3 Resistances in Series 2.15
  - 2.12.4 Resistances in Parallel 2.15

- 2.12.5 Analysis of Resistors in Series-Parallel Circuits 2.16
- 2.12.6 Single Loop Circuit 2.18
- 2.12.7 Single Node Pair Circuit 2.18
- 2.13 Solved Problems 2.19
- 2.14 Summary of Important Concepts 2.37
- 2.15 Short-Answer Questions 2.39
- 2.16 Exercises 2.44

**CHAPTER 3: Basic Concepts of AC Circuits****3.1–3.28**

- 3.1 AC Circuits 3.1
  - 3.1.1 AC Voltage and Current Source 3.1
  - 3.1.2 AC Source Transformation 3.3
- 3.2 Sinusoidal Voltage 3.3
  - 3.2.1 Average Value 3.6
  - 3.2.2 RMS Value 3.6
  - 3.2.3 Form Factor and Peak Factor 3.7
- 3.3 Sinusoidal Current 3.7
- 3.4 Inductance 3.8
  - 3.4.1 Voltage-Current Relation in an Inductance 3.9
  - 3.4.2 Energy Stored in an Inductance 3.10
- 3.5 Capacitance 3.10
  - 3.5.1 Voltage-Current Relation in a Capacitance 3.11
  - 3.5.2 Energy Stored in a Capacitance 3.11
- 3.6 Voltage-Current Relation of R, L and C in Various Domains 3.12
  - 3.6.1 Voltage-Current Relation of Resistance 3.12
  - 3.6.2 Voltage-Current Relation of Inductance 3.13
  - 3.6.3 Voltage-Current Relation of Capacitance 3.14
- 3.7 Impedance 3.15
  - 3.7.1 Impedance Connected to Sinusoidal Source 3.16
- 3.8 KVL, KCL and Ohm's Law Applied to AC Circuits 3.17
- 3.9 Current and Voltage Division Rules for Impedances 3.18
  - 3.9.1 Current Division in Parallel Connected Impedances 3.18
  - 3.9.2 Voltage Division in Series Connected Impedances 3.18
- 3.10 Solved Problems 3.19
- 3.11 Summary of Important Concepts 3.23
- 3.12 Short-Answer Questions 3.25
- 3.13 Exercises 3.27

**CHAPTER 4: Network Reduction****4.1–4.72**

- 4.1 Network Reduction 4.1
  - 4.1.1 Resistances in Series and Parallel 4.1

- 4.1.2 Voltage Sources in Series and Parallel 4.3
- 4.1.3 Current Sources in Series and Parallel 4.5
- 4.1.4 Inductances in Series and Parallel 4.8
- 4.1.5 Capacitances in Series and Parallel 4.10
- 4.1.6 Impedances in Series and Parallel 4.13
- 4.1.7 Reactances in Series and Parallel 4.15
- 4.1.8 Conductances in Series and Parallel 4.16
- 4.1.9 Admittances in Series and Parallel 4.18
- 4.1.10 Susceptances in Series and Parallel 4.20
- 4.1.11 Generalised Concept of Reducing Series/Parallel-connected Parameters 4.21
- 4.2 Voltage and Current Division 4.24
  - 4.2.1 Voltage Division in Series-Connected Resistances 4.24
  - 4.2.2 Voltage Division in Series-Connected Impedances 4.25
  - 4.2.3 Current Division in Parallel-Connected Resistances 4.25
  - 4.2.4 Current Division in Parallel-Connected Impedances 4.26
- 4.3 Source Transformation 4.27
- 4.4 Star-Delta Conversion 4.28
  - 4.4.1 Resistances in Star and Delta 4.28
  - 4.4.2 Impedances in Star and Delta 4.29
- 4.5 Solved Problems 4.37
- 4.6 Summary of Important Concepts 4.59
- 4.7 Short-Answer Questions 4.60
- 4.8 Exercises 4.66

**CHAPTER 5: Sinusoidal Steady State Response****5.1–5.58**

- 5.1 Sinusoidal Voltage and Current in Frequency Domain 5.1
- 5.2 Phasor Diagram 5.1
  - 5.2.1 Phase and Phase Difference 5.1
  - 5.2.2 Phasor Representation of Sinusoidal Quantities 5.3
  - 5.2.3 Phasor Diagram of a Circuit 5.4
- 5.3 Power, Energy and Power Factor 5.5
- 5.4 Resistance Connected to Sinusoidal Source 5.7
- 5.5 Inductance Connected to Sinusoidal Source 5.10
- 5.6 Capacitance Connected to Sinusoidal Source 5.12
- 5.7 Impedance 5.15
  - 5.7.1 Impedance Connected to Sinusoidal Source 5.16
- 5.8 Conductance, Susceptance and Admittance 5.17
  - 5.8.1 Conductance 5.17
  - 5.8.2 Admittance 5.18
  - 5.8.3 Admittance Connected to Sinusoidal Source 5.19
- 5.9 RL Circuit Excited by Sinusoidal Source 5.20

- 5.10 RC Circuit Excited by Sinusoidal Source 5.28
- 5.11 RLC Circuit Excited by Sinusoidal Source 5.33
- 5.12 Summary of Important Concepts 5.53
- 5.13 Short-Answer Questions 5.54
- 5.14 Exercises 5.56

**CHAPTER 6: Network Topology****6.1–6.70**

- 6.1 Network Terminology 6.1
  - 6.1.1 Graph of a Network 6.1
  - 6.1.2 Trees, Link, Twig and Cotree 6.2
  - 6.1.3 Network Variables 6.3
  - 6.1.4 Solution of Network Variables 6.4
  - 6.1.5 Link Currents (Independent Current Variables) 6.4
  - 6.1.6 Twig Voltages (Independent Voltage Variables) 6.5
- 6.2 Incidence and Reduced Incidence Matrices 6.5
  - 6.2.1 Network Analysis Using Incidence Matrix 6.7
- 6.3 Cut-Sets 6.12
  - 6.3.1 Fundamental Cut-Sets 6.12
  - 6.3.2 Cut-Set Matrix and Cut-Set Schedule 6.16
  - 6.3.3 Node Analysis using Cut-Sets 6.20
- 6.4 Tie-Set 6.32
  - 6.4.1 Tie-Set Matrix and Tie-Set Schedule 6.33
  - 6.4.2 Mesh Analysis using Tie-Sets 6.35
- 6.5 Duality 6.46
  - 6.5.1 Dual Graphs 6.48
  - 6.5.2 Duality of Network 6.50
- 6.6 Summary of Important Concepts 6.60
- 6.7 Short-Answer Questions 6.61
- 6.8 Exercises 6.64

**CHAPTER 7: Mesh Analysis****7.1–7.64**

- 7.1 Mesh Current Method of Analysis for DC and AC Circuits 7.1
- 7.2 Mesh Analysis of Resistive Circuits Excited by DC Sources 7.1
- 7.3 Mesh Analysis of Circuits Excited by Both Voltage and Current Sources 7.28
- 7.4 Supermesh Analysis 7.29
- 7.5 Mesh Analysis of Circuits Excited by AC Sources (Mesh Analysis of Reactive Circuits) 7.37
- 7.6 Mesh Analysis of Circuits Excited by Independent and Dependent Sources 7.45
  - 7.6.1 Circuits with Dependent Voltage Source 7.45
  - 7.6.2 Circuits with Dependent Current Source 7.46
- 7.7 Summary of Important Concepts 7.56

7.8 Short-Answer Questions 7.57

7.9 Exercises 7.59

## **CHAPTER 8: Node Analysis**

**8.1–8.60**

8.1 Node Voltage Method of Analysis for DC and AC Circuits 8.1

8.2 Node Analysis of Resistive Circuits Excited by DC Sources 8.1

8.3 Node Analysis of Circuits Excited by Both Voltage and Current Sources 8.19

8.4 Supernode Analysis 8.19

8.5 Node Analysis of Circuits Excited by AC Sources (Nodal Analysis of Reactive Circuits) 8.39

8.6 Node Analysis of Circuits Excited by Independent and Dependent Sources 8.45

8.6.1 Circuits with Dependent Current Source 8.45

8.6.2 Circuits with Dependent Voltage Source 8.46

8.7 Summary of important Concepts 8.50

8.8 Short-Answer Questions 8.52

8.9 Exercises 8.54

## **CHAPTER 9: Network Theorems**

**9.1–9.154**

9.1 Network Theorems 9.1

9.2 Thevenin's and Norton's Theorems 9.1

9.3 Superposition Theorems 9.43

9.4 Maximum Power Transfer Theorem 9.76

9.5 Reciprocity Theorem 9.103

9.5.1 Reciprocity Theorem Applied to Mesh Basis Circuit 9.103

9.5.2 Reciprocity Theorem Applied to Node Basis Circuit 9.105

9.6 Millman's Theorem 9.113

9.7 Substitution Theorem 9.117

9.8 Compensation Theorem 9.125

9.9 Tellegen's Theorem 9.131

9.10 Summary of Important Concepts 9.136

9.11 Short-Answer Questions 9.137

9.12 Exercise 9.145

## **CHAPTER 10: Transient Analysis**

**10.1–10.142**

10.1 Transient Response 10.1

10.1.1 Natural and Forced Response 10.1

10.1.2 First and Second Order Circuits 10.2

10.2 Transient Analysis using Laplace Transform 10.3

10.2.1 Some Standard Voltage Functions 10.3

10.2.2 s-Domain Representation of R, L, C Parameters 10.5

10.2.3 Solving Initial and Final Conditions Using Laplace Transform 10.8

- 10.3 Transient Response of RL Circuit 10.10
  - 10.3.1 Natural or Source-Free Response of RL Circuit 10.10
  - 10.3.2 Step Response of RL Circuit (Response of RL Circuit Excited by DC Supply) 10.11
  - 10.3.3 Impulse Response of RL Circuit 10.16
  - 10.3.4 Response of RL Circuit Excited by Exponential Signal 10.17
  - 10.3.5 RL Transient with Initial Current  $I_0$  10.19
- 10.4 Transient Response of RC Circuit 10.21
  - 10.4.1 Natural or Source-Free Response of RC Circuit 10.21
  - 10.4.2 Step Response of RC Circuit (Response of RC Circuit Excited by DC Supply) 10.23
  - 10.4.3 Impulse Response of RC Circuit 10.27
  - 10.4.4 Response of RC Circuit Excited by Exponential Signal 10.29
  - 10.4.5 RC Transient with Initial Voltage  $V_0$  10.30
- 10.5 Transient Response of RLC Circuit 10.33
  - 10.5.1 Natural or Source-Free Response of RLC Circuit 10.33
  - 10.5.2 Step Response of RLC Circuit (Response of RLC Circuit Excited by DC Supply) 10.34
  - 10.5.3 s-Domain Current and Voltage Equation of RLC Circuit 10.40
  - 10.5.4 Initial Conditions in RLC Circuit 10.41
  - 10.5.5 Final Conditions in RLC Circuit 10.43
- 10.6 Complete Response of Circuits Excited by Sinusoidal Source 10.45
  - 10.6.1 RL Circuit Excited by Sinusoidal Source 10.45
  - 10.6.2 RC Circuit Excited by Sinusoidal Source 10.46
  - 10.6.3 RLC Circuit Excited by Sinusoidal Source 10.49
- 10.7 Solved Problems in RL Transient 10.51
- 10.8 Solved Problems in RC Transient 10.75
- 10.9 Solved Problems in RLC Transient 10.104
- 10.10 Summary of Important Concepts 10.129
- 10.11 Short-Answer Questions 10.131
- 10.12 Exercises 10.134

## CHAPTER 11: RESONANCE

11.1–11.60

- 11.1 Resonance 11.1
- 11.2 Series Resonance 11.1
  - 11.2.1 Resonance Frequency of Series RLC Circuit 11.1
  - 11.2.2 Variation of Current and Impedance with Frequency in Series RLC Circuit 11.2
  - 11.2.3 Q-Factor (Quality Factor) of RLC Series Circuit 11.3
  - 11.2.4 Bandwidth of Series RLC Circuit 11.6
  - 11.2.5 Selectivity of Series RLC Circuit 11.10
  - 11.2.6 Variation of Voltage Across L and C with Frequency 11.11
  - 11.2.7 Solved Problems in Series Resonance 11.12

- 11.3 Parallel Resonance 11.17
  - 11.3.1 Resonant Frequency of Parallel RLC Circuits 11.17
  - 11.3.2 Variation of Current and Impedance with Frequency in Parallel RLC Circuit 11.25
  - 11.3.3 Q-Factor (Quality Factor) of RLC Parallel Circuit 11.26
  - 11.3.4 Bandwidth of RLC Parallel Circuit 11.28
  - 11.3.5 Selectivity of Parallel RLC Circuit 11.35
  - 11.3.6 Variation of Current through L and C with Frequency 11.35
  - 11.3.7 Solved Problems in Parallel Resonance 11.37
- 11.4 Summary of Important Concepts 11.46
- 11.5 Short-Answer Questions 11.49
- 11.6 Exercises 11.54

**CHAPTER 12: Coupled Circuits****12.1–12.72**

- 12.1 Coupled Circuits 12.1
- 12.2 Self-Inductance and Mutual Inductance 12.2
  - 12.2.1 Self-Inductance 12.2
  - 12.2.2 Mutual Inductance 12.2
  - 12.2.3 Coefficient of Coupling 12.4
- 12.3 Analysis of Coupled Coils 12.5
  - 12.3.1 Dot Rule 12.6
  - 12.3.2 Expression for Self- and Mutual Induced EMFs in Various Domains 12.9
  - 12.3.3 Writing Mesh Equations for Coupled Coils 12.10
  - 12.3.4 Electrical Equivalent of Magnetic Coupling (Electrical Equivalent of a Transformer or Linear Transformer) 12.11
  - 12.3.5 Representation of Mutual Induced EMF by Dependent Voltage Sources 12.14
  - 12.3.6 Writing Mesh Equations in Circuits with Electrical Connection and Magnetic Coupling 12.16
  - 12.3.7 Analysis of Multiwinding Coupled Coils (Coupled Inductors) 12.18
- 12.4 Series and Parallel Connections of Coupled Coils (Coupled Inductors) 12.19
  - 12.4.1 Series Aiding Connection of Coupled Coils 12.19
  - 12.4.2 Series Opposing Connection of Coupled Coils 12.20
  - 12.4.3 Parallel Aiding Connection of Coupled Coils 12.21
  - 12.4.4 Parallel Opposing Connection of Coupled Coils 12.23
- 12.5 Tuned Coupled Circuits 12.25
  - 12.5.1 Single Tuned Coupled Circuits 12.25
  - 12.5.2 Double Tuned Coupled Circuits 12.30
- 12.6 Solved Problems 12.33
- 12.7 Summary of Important Concepts 12.60
- 12.8 Short-Answer Questions 12.63
- 12.9 Exercises 12.66

**CHAPTER 13: Analysis of Circuits Using Laplace Transform****13.1–13.66**

- 13.1 Laplace Transform 13.1
  - 13.1.1 s-Plane (or Complex Frequency Plane) 13.2
  - 13.1.2 Definition of Laplace Transform 13.3
  - 13.1.3 Existence of Laplace Transform 13.3
  - 13.1.4 Poles and Zeros Rational Function of s 13.4
  - 13.1.5 Laplace Transform of Some Importance Functions 13.5
- 13.2 Region of Convergence 13.8
  - 13.2.1 ROC of Continuous Time Signal 13.8
  - 13.2.2 ROC of Rational Function of s (ROC Using Poles) 13.10
  - 13.2.3 Properties of ROC 13.12
- 13.3 Inverse Laplace Transform 13.22
  - 13.3.1 Inverse Laplace Transform by Partial Function Expansion Method 13.22
- 13.4 Properties and Theorems of Laplace Transform 13.27
  - 13.4.1 Inverse Laplace Transform Using Convolution Theorem 13.35
  - 13.4.2 Evaluation of Convolution of Integral Using Laplace Transform 13.35
- 13.5 Network Functions 13.40
  - 13.5.1 Network Functions of One Port Network 13.41
  - 13.5.2 Network Functions of Two Port Network 13.41
  - 13.5.3 Transfer Functions 13.43
  - 13.5.4 Time Domain Function from Pole-Zero Plot 13.43
  - 13.5.5 Natural Response and s-plane 13.45
- 13.6 Mesh and Node Analysis of s-Domain Circuits 13.50
  - 13.6.1 Mesh Analysis of s-Domain Circuit 13.50
  - 13.6.2 Node Analysis of s-Domain Circuit 13.51
- 13.7 Summary of Important Concepts 13.61
- 13.8 Short-Answer Questions 13.62
- 13.9 Exercises 13.64

**CHAPTER 14: Fourier Series and Fourier Transform****14.1–14.108**

- 14.1 Introduction 14.1
  - 14.1.1 Trigonometric Form of Fourier Series 14.1
  - 14.1.2 Dirichlet's Conditions for Existence of Fourier Series 14.2
  - 14.1.3 Exponential Form of Fourier Series 14.3
  - 14.1.4 Negative Frequency 14.4
  - 14.1.5 Conversion of Trigonometric to Exponential Fourier Coefficients 14.4
  - 14.1.6 Derivation of Equations for  $a_0$ ,  $a_n$ ,  $b_n$  and  $c_n$  14.5
  - 14.1.7 Properties of Fourier Series 14.9
- 14.2 Fourier Coefficients of Signal with Symmetry 14.10
  - 14.2.1 Even Symmetry 14.10
  - 14.2.2 Odd Symmetry 14.11



---

14.2.3	Half Wave Symmetry (or Alternation Symmetry)	14.13
14.2.4	Quarter Wave Symmetry	14.13
14.3	Diminishing of Fourier Coefficients	14.18
14.4	Fourier Series for Electric Circuits Applications	14.19
14.4.1	Fourier Series Representation of Voltage and Current	14.19
14.4.2	RMS Value of Fourier Representation of Voltage and Current	14.20
14.4.3	Average Power in a Load Using Fourier Representation of Voltage and Current	14.21
14.5	Solved Problems in Fourier Series	14.23
14.6	Fourier Transform	14.42
14.6.1	Development of Fourier Transform from Fourier Series	14.42
14.6.2	Definition of Fourier Transform	14.43
14.6.3	Conditions for Existence of Fourier Transform (Dirichlet's Condition)	14.44
14.6.4	Definition of Inverse Fourier Transform	14.44
14.6.5	Frequency Spectrum Using Fourier Transform	14.44
14.6.6	Properties of Fourier Transform	14.45
14.6.7	Comparison of Fourier Series and Fourier Transform	14.55
14.7	Fourier Transform of Some Important Signals	14.55
14.7.1	Fourier Transform of Unit Impulse Signal	14.55
14.7.2	Fourier Transform of Single-Sided Exponential Signal	14.55
14.7.3	Fourier Transform of Double-Sided Exponential Signal	14.56
14.7.4	Fourier Transform of a Constant (Fourier Transform of DC Signal)	14.57
14.7.5	Fourier Transform of Signum Function	14.58
14.7.6	Fourier Transform of Unit Step Signal	14.59
14.7.7	Fourier Transform of Complex Exponential Signal	14.60
14.7.8	Fourier Transform of Sinusoidal Signal	14.61
14.7.9	Fourier Transform of Cosinusoidal Signal	14.61
14.7.10	Fourier Transform of Gaussian Pulse	14.62
14.7.11	Fourier Transform of Exponentially Decaying Cosinusoidal Signal	14.62
14.7.12	Fourier Transform of Rectangular Pulse	14.63
14.7.13	Fourier Transform of Sinc Signal	14.64
14.7.14	Fourier Transform of Shifted Impulse	14.65
14.8	Solved Problems in Fourier Transform	14.71
14.9	Fourier Transform of a Periodic Signal	14.77
14.10	Analysis of Linear System Using Fourier Transform	14.79
14.10.1	Transfer Function of Linear System in Frequency Domain	14.79
14.10.2	Impulse Response and Transfer Function	14.79
14.10.3	Response of Linear System using Fourier Transform	14.80
14.10.4	Impulse Response and Frequency Response of Linear System	14.81
14.11	Fourier Transform for Circuit Applications	14.82
14.12	Relation between Fourier Transform and Laplace Transform	14.83

- 14.13 Summary of Important Concepts 14.91
- 14.14 Short-Answers Questions 14.92
- 14.15 Exercises 14.101

## CHAPTER 15: One-Port and Two-Port Networks

15.1–15.68

- 15.1 Introduction 15.1
- 15.2 Parameters of a One-Port Network 15.2
- 15.3 Parameters of a Two-Port Network 15.3
- 15.4 Impedance Parameters (or Z-Parameters) 15.7
- 15.5 Admittance Parameters (or Y-Parameters) 15.8
- 15.6 Transmission Parameters (or ABCD-Parameters) 15.9
- 15.7 Inverse Transmission Parameters (or A'B'C'D'-Parameters) 15.10
- 15.8 Hybrid Parameters (or h-Parameters) 15.11
- 15.9 Inverse Hybrid Parameters (or g-Parameters) 15.12
- 15.10 Relationship between Parameter Sets 15.13
- 15.11 Properties of Two-Port Networks 15.19
- 15.12 Interconnection of Two-Port Networks 15.20
- 15.13 T and  $\Pi$  Networks 15.22
  - 15.13.1 Symmetrical Properties of T and  $\Pi$  Networks 15.22
- 15.14 Solved Problems 15.24
- 15.15 Summary of Important Concepts 15.58
- 15.16 Short-Answer Questions 15.59
- 15.17 Exercises 15.63

## CHAPTER 16: Three-Phase Circuits

16.1–16.94

- 16.1 Three-Phase Circuits 16.1
- 16.2 Three-Phase Sources 16.1
- 16.3 Representation of Three-Phase EMFs 16.2
- 16.4 Analysis of Three-Phase Star and Delta-Connected Source 16.4
  - 16.4.1 Star-Connected Source Three-Wire System 16.4
  - 16.4.2 Star-Connected Source Four-Wire System 16.7
  - 16.4.3 Delta-Connected Source 16.8
- 16.5 Three-Phase Loads 16.12
  - 16.5.1 Choice of Reference Phasor in Analysis of Three-Phase Circuits 16.13
- 16.6 Analysis of Balanced Loads 16.14
  - 16.6.1 Four-Wire Star-Connected Balanced Load 16.14
  - 16.6.2 Three-Wire Star-Connected Balanced Load 16.16
  - 16.6.3 Delta-connected Balanced Load 16.17
  - 16.6.4 Power Consumed by Three Equal Impedances in Star and Delta 16.19

16.7	Analysis of Unbalanced Loads	16.20
16.7.1	Four-Wire Star-Connected Unbalanced Load	16.20
16.7.2	Three-Wire Star-Connected Unbalanced Load	16.22
16.7.3	Neutral Shift in Star-Connected Load	16.23
16.7.4	Analysis of Three-Phase Unbalanced Load by Neutral Shift Method	16.24
16.7.5	Delta-Connected Unbalanced Load	16.27
16.8	Power Measurement in Three-Phase Circuits	16.28
16.8.1	Power Measurement in Balanced Load	16.29
16.8.2	Relation between Power Factor and Wattmeter Readings	16.31
16.8.3	Power Measurement in Unbalanced Star Connected Load	16.33
16.8.4	Power Measurement in Unbalanced Delta Connected Load	16.35
16.9	Solved Problems	16.37
16.10	Summary of Important Concepts	16.82
16.11	Short-Answer Questions	16.85
16.12	Exercises	16.89

**APPENDICES****A.1–A.32**

APPENDIX 1: Using Calculator in Complex Mode	A.1
APPENDIX 2: Important Mathematical Formulae	A.3
APPENDIX 3: Equivalent of Series/Parallel Connected Parameters	A.5
APPENDIX 4: Star-Delta Transformation	A.7
APPENDIX 5: Cramer's Rule	A.8
APPENDIX 6: Summary of Theorems	A.10
APPENDIX 7: Laplace Transform	A.11
APPENDIX 8: Initial and Final Conditions in RLC Circuits Excited by DC Supply	A.14
APPENDIX 9: R,L,C Parameters and V-I Relations in Various Domain	A.15
APPENDIX 10: Important Equations of Series Resonance	A.16
APPENDIX 11: Parallel Resonant Circuits	A.17
APPENDIX 12: Electrical Equivalent of Coupled Coils	A.18
APPENDIX 13: Equivalent of Series and Parallel Connected Coupled Coils	A.19
APPENDIX 14: Standard Continuous Time Fourier Transform Pairs	A.20
APPENDIX 15: Summary of Properties of Various Transforms	A.21
APPENDIX 16: Summary of Parameters of Two-Port Network	A.23
APPENDIX 17: Relationship between Parameters Sets	A.24
APPENDIX 18: Two-Port Network Parameters of T and $\pi$ -Networks	A.25
APPENDIX 19: Choice of Reference Phasor	A.26
APPENDIX 20: V-I Equation of Three-Phase Load	A.27
APPENDIX 21: Two Wattmeter Method of Power Measurement	A.32

**INDEX****I.1–I.6**