

Contents

| | |
|--------------------------------|-------------|
| <i>Foreword</i> | <i>xv</i> |
| <i>Preface</i> | <i>xvii</i> |
| <i>Roadmap to the Syllabus</i> | <i>xix</i> |

1. CIRCUIT ELEMENTS AND KIRCHHOFF'S LAWS 1.1

| | | |
|------|---------------------------------------|------|
| 1.1 | Voltage | 1.1 |
| 1.2 | Current | 1.2 |
| 1.3 | Power and Energy | 1.2 |
| 1.4 | The Circuit | 1.3 |
| 1.5 | Resistance Parameter | 1.5 |
| 1.6 | Inductance Parameter | 1.6 |
| 1.7 | Capacitance Parameter | 1.7 |
| 1.8 | Energy Sources | 1.9 |
| 1.9 | Kirchhoff's Voltage Law | 1.11 |
| 1.10 | Voltage Division | 1.14 |
| 1.11 | Power in Series Circuit | 1.15 |
| 1.12 | Kirchhoff's Current Law | 1.16 |
| 1.13 | Parallel Resistance | 1.19 |
| 1.14 | Current Division | 1.20 |
| 1.15 | Power in Parallel Circuit | 1.22 |
| | <i>Solved Problems</i> | 1.22 |
| | <i>Practice Problems</i> | 1.35 |
| | <i>Objective-type Questions</i> | 1.39 |

2. METHODS OF ANALYSING CIRCUITS 2.1

| | | |
|-----|--|------|
| 2.1 | Introduction | 2.1 |
| 2.2 | Tree and Co-Tree | 2.3 |
| 2.3 | Twigs and Links | 2.4 |
| 2.4 | Incidence Matrix (A) | 2.5 |
| 2.5 | Properties of Incidence Matrix A | 2.6 |
| 2.6 | Incidence Matrix and KCL | 2.8 |
| 2.7 | Link Currents: Tie-Set Matrix | 2.9 |
| 2.8 | Cut-Set and Tree Branch Voltages | 2.14 |
| 2.9 | Mesh Analysis | 2.20 |

| | | |
|-----------|--|------------|
| 2.10 | Mesh Equations By Inspection Method | 2.24 |
| 2.11 | Supermesh Analysis | 2.26 |
| 2.12 | Nodal Analysis | 2.28 |
| 2.13 | Nodal Equations by Inspection Method | 2.31 |
| 2.14 | Supernode Analysis | 2.33 |
| 2.15 | Source Transformation Technique | 2.35 |
| | <i>Solved Problems</i> | 2.38 |
| | <i>Practice Problems</i> | 2.52 |
| | <i>Objective-type Questions</i> | 2.56 |
| 3. | USEFUL THEOREMS IN CIRCUIT ANALYSIS | 3.1 |
| 3.1 | Star-Delta Transformation | 3.1 |
| 3.2 | Superposition Theorem | 3.5 |
| 3.3 | Thevenin's Theorem | 3.8 |
| 3.4 | Norton's Theorem | 3.10 |
| 3.5 | Reciprocity Theorem | 3.12 |
| 3.6 | Compensation Theorem | 3.14 |
| 3.7 | Maximum Power Transfer Theorem | 3.15 |
| 3.8 | Duals and Duality | 3.16 |
| 3.9 | Tellegen's Theorem | 3.19 |
| 3.10 | Millman's Theorem | 3.20 |
| | <i>Solved Problems</i> | 3.21 |
| | <i>Practice Problems</i> | 3.47 |
| | <i>Objective-type Questions</i> | 3.50 |
| 4. | INTRODUCTION TO ALTERNATING CURRENTS AND VOLTAGES | 4.1 |
| 4.1 | The Sine Wave | 4.1 |
| 4.2 | Angular Relation of a Sine Wave | 4.3 |
| 4.3 | The Sine Wave Equation | 4.5 |
| 4.4 | Voltage and Current Values of a Sine Wave | 4.6 |
| 4.5 | Phase Relation in Pure Resistor | 4.10 |
| 4.6 | Phase Relation in a Pure Inductor | 4.10 |
| 4.7 | Phase Relation in Pure Capacitor | 4.11 |
| | <i>Solved Problems</i> | 4.12 |
| | <i>Practice Problems</i> | 4.18 |
| | <i>Objective-type Questions</i> | 4.20 |
| 5. | COMPLEX IMPEDANCE | 5.1 |
| 5.1 | Impedance Diagram | 5.1 |
| 5.2 | Phasor Diagram | 5.3 |
| 5.3 | Series Circuits | 5.5 |
| 5.4 | Parallel Circuits | 5.11 |

| | | |
|-----------|---|------------|
| 5.5 | Compound Circuits | 5.13 |
| | <i>Solved Problems</i> | 5.15 |
| | <i>Practice Problems</i> | 5.29 |
| | <i>Objective-type Questions</i> | 5.33 |
| 6. | POWER AND POWER FACTOR | 6.1 |
| 6.1 | Instantaneous Power | 6.1 |
| 6.2 | Average Power | 6.3 |
| 6.3 | Apparent Power and Power Factor | 6.5 |
| 6.4 | Reactive Power | 6.6 |
| 6.5 | The Power Triangle | 6.7 |
| | <i>Solved Problems</i> | 6.8 |
| | <i>Practice Problems</i> | 6.18 |
| | <i>Objective-type Questions</i> | 6.22 |
| 7. | STEADY STATE AC ANALYSIS | 7.1 |
| 7.1 | Mesh Analysis | 7.1 |
| 7.2 | Mesh Equations by Inspection | 7.3 |
| 7.3 | Nodal Analysis | 7.5 |
| 7.4 | Nodal Equations by Inspection | 7.8 |
| 7.5 | Superposition Theorem | 7.11 |
| 7.6 | Thevenin's Theorem | 7.13 |
| 7.7 | Norton's Theorem | 7.15 |
| 7.8 | Maximum Power Transfer Theorem | 7.17 |
| | <i>Solved Problems</i> | 7.18 |
| | <i>Practice Problems</i> | 7.35 |
| | <i>Objective-type Questions</i> | 7.40 |
| 8. | FREQUENCY DOMAIN ANALYSIS | 8.1 |
| 8.1 | Immittance | 8.1 |
| 8.2 | Complex Immittance | 8.1 |
| 8.3 | Loci of RLC Networks | 8.3 |
| 8.4 | Immittance Loci of Single Elements | 8.3 |
| 8.5 | Immittance Loci of Combined Elements | 8.4 |
| 8.6 | Locus Diagrams of Series, Parallel Circuits | 8.7 |
| 8.7 | Frequency Response of RLC Networks | 8.18 |
| 8.8 | Frequency Response Plots | 8.19 |
| 8.9 | Resonance Phenomena | 8.21 |
| 8.10 | Parallel Resonance | 8.34 |
| 8.11 | Frequency Response from Poles and Zeros | 8.40 |
| 8.12 | Bode Plots | 8.45 |
| | <i>Solved Problems</i> | 8.52 |
| | <i>Practice Problems</i> | 8.60 |
| | <i>Objective-type Questions</i> | 8.62 |

| | |
|---|-------------|
| 9. COUPLED CIRCUITS | 9.1 |
| 9.1 Introduction | 9.1 |
| 9.2 Conductivity Coupled Circuit and Mutual Impedance | 9.2 |
| 9.3 Mutual Inductance | 9.2 |
| 9.4 Dot Convention | 9.4 |
| 9.5 Coefficient of Coupling | 9.7 |
| 9.6 Ideal Transformer | 9.10 |
| 9.7 Analysis of Multi-Winding Coupled Circuits | 9.15 |
| 9.8 Series Connection of Coupled Inductors | 9.17 |
| 9.9 Parallel Connection of Coupled Coils | 9.18 |
| 9.10 Tuned Circuits | 9.20 |
| 9.11 Analysis of Magnetic Circuits | 9.25 |
| 9.12 Series Magnetic Circuit | 9.27 |
| 9.13 Comparison of Electric and Magnetic Circuits | 9.28 |
| 9.14 Magnetic Leakage and Fringing | 9.29 |
| 9.15 Composite Series Circuit | 9.31 |
| 9.16 Parallel Magnetic Circuit | 9.32 |
| 9.17 Electromagnetic Induction | 9.32 |
| <i>Solved Problems</i> | 9.34 |
| <i>Practice Problems</i> | 9.47 |
| <i>Objective-type Questions</i> | 9.50 |
| 10. DIFFERENTIAL EQUATIONS | 10.1 |
| 10.1 Basic Concepts | 10.1 |
| 10.2 Homogeneous Linear Differential Equations | 10.3 |
| 10.3 Non-Homogeneous Differential Equations | 10.5 |
| 10.4 Applications to Electrical Circuits | 10.7 |
| <i>Solved Problems</i> | 10.11 |
| <i>Practice Problems</i> | 10.18 |
| <i>Objective-type Questions</i> | 10.21 |
| 11. TRANSIENTS | 11.1 |
| 11.1 Steady State and Transient Response | 11.1 |
| 11.2 DC Response of an R-L Circuit | 11.2 |
| 11.3 DC Response of an R-C Circuit | 11.6 |
| 11.4 DC Response of an R-L-C Circuit | 11.8 |
| 11.5 Sinusoidal Response of R-L Circuit | 11.11 |
| 11.6 Sinusoidal Response of R-C Circuit | 11.14 |
| 11.7 Sinusoidal Response of R-L-C Circuit | 11.17 |
| <i>Solved Problems</i> | 11.22 |
| <i>Practice Problems</i> | 11.34 |
| <i>Objective-type Questions</i> | 11.38 |

| | |
|---|-------------|
| 12. INTRODUCTION TO LAPLACE TRANSFORM | 12.1 |
| 12.1 Definition of the Laplace Transform | 12.1 |
| 12.2 The Step Function | 12.2 |
| 12.3 The Impulse Function | 12.6 |
| 12.4 Functional Transforms | 12.10 |
| 12.5 Operational Transforms | 12.13 |
| 12.6 Shifting Theorem | 12.20 |
| 12.7 Laplace Transform of Periodic (or Non-Sinusoidal) Functions | 12.23 |
| 12.8 Inverse Transforms | 12.24 |
| 12.9 Initial and Final Value Theorems | 12.30 |
| <i>Solved Problems</i> | 12.32 |
| <i>Practice Problems</i> | 12.46 |
| <i>Objective-type Questions</i> | 12.49 |
| 13. APPLICATION OF THE LAPLACE TRANSFORM IN CIRCUIT ANALYSIS | 13.1 |
| 13.1 Circuit Elements in the S-Domain | 13.1 |
| 13.2 Applications | 13.3 |
| 13.3 The Transfer Function | 13.13 |
| 13.4 Use of Transfer Function in Circuit Analysis | 13.14 |
| 13.5 The Transfer Function and the Convolution Integral | 13.14 |
| 13.6 The Transfer Function and the Steady State Sinusoidal Response | 13.19 |
| 13.7 The Impulse Function in Circuit Analysis | 13.20 |
| <i>Solved Problems</i> | 13.25 |
| <i>Practice Problems</i> | 13.53 |
| <i>Objective-type Questions</i> | 13.57 |
| 14. NETWORK FUNCTIONS | 14.1 |
| 14.1 Singularity Functions | 14.1 |
| 14.2 Unit Functions | 14.1 |
| 14.3 Shifter Functions | 14.4 |
| 14.4 Gate Function | 14.5 |
| 14.5 Network Functions | 14.5 |
| 14.6 Transfer Functions of Two-Port Network | 14.6 |
| 14.7 Poles and Zeros | 14.7 |
| 14.8 Necessary Conditions for Driving Point Function | 14.8 |
| 14.9 Necessary Conditions for Transfer Functions | 14.9 |
| 14.10 Time Domain Response from Pole Zero Plot | 14.9 |
| 14.11 Amplitude and Phase Response from Pole Zero Plot | 14.11 |
| 14.12 Stability Criterion for Active Network | 14.12 |
| 14.13 Routh Criteria | 14.13 |
| <i>Solved Problems</i> | 14.15 |
| <i>Practice Problems</i> | 14.27 |
| <i>Objective-type Questions</i> | 14.31 |

| | |
|---|-------------|
| 15. TWO-PORT NETWORKS | 15.1 |
| 15.1 Two-Port Network..... | 15.1 |
| 15.2 Open Circuit Impedance (Z) Parameters | 15.2 |
| 15.3 Short Circuit Admittance (Y) Parameters | 15.5 |
| 15.4 Transmission (ABCD) Parameters | 15.8 |
| 15.5 Inverse Transmission (A' B' C' D') Parameters | 15.12 |
| 15.6 Hybrid (h) Parameters | 15.12 |
| 15.7 Inverse Hybrid (g) Parameters | 15.15 |
| 15.8 Inter Relationships of Different Parameters—Conversion of One Parameter to Another..... | 15.16 |
| 15.9 Inter Connection of Two-Port Networks | 15.21 |
| 15.10 T and π Representation | 15.24 |
| 15.11 Terminated Two-Port Network | 15.28 |
| 15.12 Lattice Networks | 15.34 |
| 15.13 Image Parameters | 15.37 |
| <i>Solved Problems</i> | 15.42 |
| <i>Practice Problems</i> | 15.59 |
| <i>Objective-type Questions</i> | 15.63 |
| 16. S-DOMAIN ANALYSIS | 16.1 |
| 16.1 The Concept of Complex Frequency | 16.1 |
| 16.2 Physical Interpretation of Complex Frequency | 16.2 |
| 16.3 Transform Impedance and Transform Circuits | 16.4 |
| 16.4 Series and Parallel Combination of Elements | 16.9 |
| 16.5 Terminal Pairs or Ports | 16.13 |
| 16.6 Network Functions for the One-Port and Two-Port | 16.14 |
| 16.7 Poles and Zeros of Network Functions | 16.17 |
| 16.8 Significance of Poles and Zeros | 16.18 |
| 16.9 Properties of Driving Point Functions | 16.19 |
| 16.10 Properties of Transfer Functions | 16.23 |
| 16.11 Necessary Conditions for Driving Point Function | 16.25 |
| 16.12 Necessary Conditions for Transfer Functions | 16.26 |
| 16.13 Time Domain Response from Pole Zero Plot | 16.26 |
| 16.14 Amplitude and Phase Response from Pole Zero Plot | 16.28 |
| 16.15 Stability Criterion for Active Network | 16.29 |
| 16.16 Routh Criteria | 16.30 |
| <i>Solved Problems</i> | 16.32 |
| <i>Practice Problems</i> | 16.42 |
| <i>Objective-type Questions</i> | 16.44 |
| 17. FILTERS AND ATTENUATORS | 17.1 |
| 17.1 Classification of Filters | 17.1 |
| 17.2 Filter Networks | 17.3 |

| | | |
|---|---|------------|
| 17.3 | Equations of Filter Networks | 17.4 |
| 17.4 | Classification of Pass Band and Stop Band | 17.9 |
| 17.5 | Characteristic Impedance in the Pass and Stop Bands | 17.12 |
| 17.6 | Constant—K Low Pass Filter | 17.13 |
| 17.7 | Constant K-High Pass Filter | 17.17 |
| 17.8 | m-Derived T-section | 17.20 |
| 17.9 | Band Pass Filter | 17.29 |
| 17.10 | Band Elimination Filter | 17.33 |
| 17.11 | Composite Filter | 17.37 |
| 17.12 | Terminating Half-Sections | 17.38 |
| 17.13 | Attenuators | 17.41 |
| 17.14 | T-Type Attenuator | 17.42 |
| 17.15 | π -Type Attenuator | 17.44 |
| 17.16 | Lattice Attenuator | 17.45 |
| 17.17 | Bridged-T Attenuator | 17.48 |
| 17.18 | L-Type Attenuator | 17.50 |
| 17.19 | Equalizers | 17.51 |
| 17.20 | Inverse Network | 17.52 |
| 17.21 | Series Equalizer | 17.54 |
| 17.22 | Full Series Equalizer | 17.55 |
| 17.23 | Shunt Equalizer | 17.57 |
| 17.24 | Full Shunt Equalizer | 17.58 |
| 17.25 | Constant Resistance Equalizer | 17.60 |
| 17.26 | Bridge-T Attenuation Equalizer | 17.60 |
| 17.27 | Bridged-T Phase Equalizer | 17.61 |
| 17.28 | Lattice Attenuation Equalizer | 17.63 |
| 17.29 | Lattice Phase Equalizer | 17.64 |
| | <i>Solved Problems</i> | 17.65 |
| | <i>Practice Problems</i> | 17.77 |
| | <i>Objective-type Questions</i> | 17.79 |
| <i>Appendix A—Fourier Series</i> | | A.1 |
| <i>Appendix B—Fourier Transforms</i> | | B.1 |
| <i>Appendix C—The j Factor</i> | | C.1 |
| <i>Appendix D—Answers</i> | | D.1 |
| <i>Appendix E—Solved Question Papers May/June 2006</i> | | E.1 |
| <i>Appendix F—Solved Question Papers April/May 2007</i> | | F.1 |