Contents

Preface, x

Network Elements

1

- 1.1 Introduction, *1*
- 1.2 Two-Terminal Resistors, 5
- 1.3 Two-Terminal Capacitors, 15
- 1.4 Two-Terminal Inductors, 23
- 1.5 Multiterminal Network Elements, 29 Problems, 43

Network Characterization 2

- 2.1 Introduction, 48
- 2.2 Introductory Matrix Algebra, 50
- 2.3 Norm of Vectors and Matrices, 59
- 2.4 Linear Versus Nonlinear n Ports, 63
- 2.5 Time-Varying Versus Time-Invariant n Ports, 72
- 2.6 Passive Versus Active *n* Ports, 77
- 2.7 Causal and Nonanticipative Networks, 81
- 2.8 Stable and Unstable Networks, 84 Problems, 87

Network Graph Theory 3

- 3.1 Notations and Definitions, 91
- 3.2 Incidence Matrix and Kirchhoff's Current Law, 96
- 3.3 Loop Matrix and Kirchhoff's Voltage Law, 104
- 3.4 Interrelationship Between Matrices of a Graph, 112
- 3.5 Tellegen's Theorem and Its Application, 116 Problems, 122

Analysis of Linear Time-Invariant Networks

- 4.1 Introduction, 126
- 4.2 Direct Analysis Methods, 127
- 4.3 Nodal Analysis, 139
- 4.4 Loop Analysis, 142
- 4.5 Analysis of Networks Containing Dependent Sources, 148
- 4.6 Sinusoidal Steady-State Analysis, 156
- 4.7 Network Functions, 161 Problems, 180

State-Variable Representation of Networks

- 5.1 Introduction, 186
- 5.2 Preliminary Considerations, 190
- 5.3 State-Variable Formulation of Proper Networks, 199
- 5.4 Concept of State and Order of Complexity of a Network, 216
- 5.5 State-Variable Formulation of General Networks, 221 Problems, 234

Time-Domain Solution of State Equations

- 6.1 Introduction, 242
- 6.2 Solution of Linear Time-Invariant State Equations, 243
- 6.3 Solution of Linear Time-Varying State Equations, 259
- 6.4 Solution of Nonlinear State Equations, 267 Problems, 276

4

5

6

7

9

Computer-Aided Network Analysis

- 7.1 Introduction, 282
- 7.2 Computer-Aided Analysis of Linear Resistive Networks, 284
- 7.3 Computer Solution of Sinusoidal Steady-State Response of Linear Time-Invariant Networks, 300
- 7.4 Computer Solution of Nonlinear Resistive Networks, 303
- 7.5 Computer Solution of State Equations, 314 Problems, 334

Passive and Active Network Synthesis 8

- 8.1 Introduction, 336
- 8.2 Positive Real Functions and Matrices, 337
- 8.3 Driving-Point Synthesis of Reactance Functions, 342
- 8.4 Synthesis of *RC* and *RL* Networks, 348
- 8.5 Synthesis of General RLC Networks (Brune Synthesis), 352
- 8.6 Bott-Duffin Synthesis (Transformerless Synthesis), 361
- 8.7 Active Network Synthesis, 365
- 8.8 Sensitivity Considerations in Network Design, 378 Problems, 383

Computer-Aided Network Design

- 9.1 Introduction, 387
- 9.2 Iterative Methods in Computer-Aided Design, 388
- 9.3 Mean Squared Error Optimization, 392
- 9.4 General Optimization Methods, 402
- 9.5 Application of Adjoint Network in Computing the Gradient, 406
- 9.6 Computer-Aided Design of Linear Time-Varying Networks, 410 Problems, 415

Small-Signal Analysis and Design of Nonlinear Networks 10

- 10.1 Introduction, 418
- 10.2 Small-Signal Analysis of Autonomous Networks, 419
- 10.3 Small-Signal Analysis of Nonautonomous Networks, 427
- 10.4 Frozen-Operating-Point Method of Small-Signal Analysis, 431
- Design of Nonlinear Networks, 439 Problems, 446

Stability Analysis of Linear and Nonlinear Networks

- 11.1 Introduction, 450
- 11.2 Zero-Input Stability, 451
- 11.3 Equilibrium Stability of Linear Autonomous Networks, 457
- 11.4 Equilibrium Stability of Nonlinear Autonomous Networks, 462
- 11.5 Lyaponov Stability of Nonautonomous Networks, 468
- 11.6 Bounded Input—Bounded Output Stability, 473 Problems, 479

Appendix: Laplace Transform

- A.1 Introduction, 482
- A.2 Basic Definition and Convergence Properties of Laplace Transform, 482
- A.3 Inverse Laplace Transform, 489