Contents

Chapter 1: Signals and Systems 1

1.1 Signal Analysis 1
1.2 Complex Frequency 4
1.3 Network Analysis 7
1.4 Network Synthesis 14

Chapter 2: Signals and Waveforms 20

2.1 General Characteristics of Signals 20
2.2 General Descriptions of Signals 24
2.3 The Step Function and Associated Waveforms 28
2.4 The Unit Impulse 33

Chapter 3: The Frequency Domain: Fourier Analysis 46

3.1 Introduction 46
3.2 Orthogonal Functions 47
3.3 Approximation Using Orthogonal Functions 48
3.4 Fourier Series 50
3.5 Evaluation of Fourier Coefficients 52
3.6 Evaluation of Fourier Coefficients Using Unit Impulses 58
3.7 The Fourier Integral 63
3.8 Properties of Fourier Transforms 67

Chapter 4: Differential Equations 75

4.1 Introduction 75
4.2 Homogeneous Linear Differential Equations 76
4.3 Nonhomogeneous Equations 82
4.4 Step and Impulse Response 85
4.5 Integrodifferential Equations 91
4.6 Simultaneous Differential Equations 93

Chapter 5: Network Analysis: I 100

5.1 Introduction 100
5.2 Network Elements 103
5.3 Initial and Final Conditions 106
5.4 Step and Impulse Response 111
5.5 Solution of Network Equations 114
5.6 Analysis of Transformers 122

Chapter 6: The Laplace Transform 134

6.1 The Philosophy of Transform Methods 134
6.2 The Laplace Transform 135
6.3 Properties of Laplace Transforms 137
6.4 Uses of Laplace Transforms 144
6.5 Partial-Fraction Expansions 148
6.6 Poles and Zeros 155
6.7 Evaluation of Residues 162
6.8 The Initial and Final Value Theorems 165

Chapter 7: Transform Methods in Network Analysis 175

7.1 The Transformed Circuit 175
7.2 Thévenin's and Norton's Theorems 180
7.3 The System Function 187
7.4 The Step and Impulse Responses 194
7.5 The Convolution Integral 197
7.6 The Duhamel Superposition Integral 201

Chapter 8: Amplitude, Phase, and Delay 212

8.1 Amplitude and Phase Response 212
8.2 Bode Plots 221
8.3 Single-Tuned Circuits 229
8.4 Double-Tuned Circuits 238
8.5 On Poles and Zeros and Time Delay 245

Chapter 9: Network Analysis: II 253

9.1 Network Functions 253
9.2 Relationships Between Two-Port Parameters 264
9.3 Transfer Functions Using Two-Port Parameters 266
9.4 Interconnection of Two-Ports 271
9.5 Incidental Dissipation 276
9.6 Analysis of Ladder Networks 279

Chapter 10: Elements of Realizability Theory 290

10.1 Causality and Stability 290
10.2 Hurwitz Polynomials 294
10.3 Positive Real Functions 299
10.4 Elementary Synthesis Procedures 308

Chapter 11: Synthesis of One-Port Networks with Two Kinds of Elements 315

11.1 Properties of *L-C* Immittance Functions 315
11.2 Synthesis of *L-C* Driving-Point Immittances 319
11.3 Properties of *R-C* Driving-Point Impedances 325
11.4 Synthesis of *R-C* Impedances or *R-L* Admittances 329
11.5 Properties of *R-L* Impedances and *R-C* Admittances 331
11.6 Synthesis of Certain *R-L-C* Functions 333

Chapter 12: Elements of Transfer Function Synthesis *341*

12.1 Properties of Transfer Functions *341*
12.2 Zeros of Transmission *345*
12.3 Synthesis of Y_{21} and Z_{21} with a 1-Ω Termination *347*
12.4 Synthesis of Constant-Resistance Networks *352*

Chapter 13: Topics in Filter Design *365*

13.1 The Filter Design Problem *365*
13.2 The Approximation Problem in Network Theory *365*
13.3 The Maximally Flat Low-Pass Filter Approximation *368*
13.4 Other Low-Pass Filter Approximations *373*
13.5 Transient Response of Low-Pass Filters *388*
13.6 A Method to Reduce Overshoot in Filters *392*
13.7 A Maximally Flat Delay and Controllable Magnitude Approximation *395*
13.8 Synthesis of Low-Pass Filters *397*
13.9 Magnitude and Frequency Normalization *402*
13.10 Frequency Transformations *404*

Chapter 14: The Scattering Matrix *413*

14.1 Incident and Reflected Power Flow *413*
14.2 The Scattering Parameters for a One-Port Network *415*
14.3 The Scattering Matrix for a Two-Port Network *419*
14.4 Properties of the Scattering Matrix *426*
14.5 Insertion Loss *429*
14.6 Darlington's Insertion Loss Filter Synthesis *431*

Chapter 15: Computer Techniques in Circuit Analysis *438*

15.1 The Uses of Digital Computers in Circuit Analysis *438*
15.2 Amplitude and Phase Subroutine *450*
15.3 A Fortran Program for the Analysis of Ladder Networks *453*
15.4 Programs that Aid in Darlington Filter Synthesis *457*

Appendix A: Introduction to Matrix Algebra 461

A.1 Fundamental Operations 461
A.2 Elementary Concepts 462
A.3 Operations on Matrices 464
A.4 Solutions of Linear Equations 468
A.5 References on Matrix Algebra 469

Appendix B: Generalized Functions and the Unit Impulse 470

B.1 Generalized Functions 470
B.2 Properties of the Unit Impulse 476

Appendix C: Elements of Complex Variables 481

C.1 Elementary Definitions and Operations 481
C.2 Analysis 483
C.3 Singularities and Residues 486
C.4 Contour Integration 487

Appendix D: Proofs of Some Theorems on Positive Real Functions 490

Appendix E: An Aid to the Improvement of Filter Approximation 493

E.1 Introduction 493
E.2 Constant Logarithmic Gain Contours 494
E.3 Constant Phase Contours 495
E.4 Contour Drawings 496
E.5 Correction Procedure 498
E.6 Correction Network Design 502
E.7 Conclusion 504

Bibliography 505

Name Index 509

Subject Index 511