

Contents

Preface xi

Acknowledgments xv

About the Authors xxi

PART 1 DC Circuits 2

Chapter 1 Basic Concepts 3

- 1.1 Introduction 4
- 1.2 Systems of Units 5
- 1.3 Charge and Current 6
- 1.4 Voltage 9
- 1.5 Power and Energy 10
- 1.6 Circuit Elements 14
- 1.7 Applications 16
 - 1.7.1 TV Picture Tube
 - 1.7.2 Electricity Bills
- 1.8 Problem Solving 19
- 1.9 Summary 22
- Review Questions 23
- Problems 24
- Comprehensive Problems 26

Chapter 2 Basic Laws 29

- 2.1 Introduction 30
- 2.2 Ohm's Law 30
- 2.3 Nodes, Branches, and Loops 35
- 2.4 Kirchhoff's Laws 37
- 2.5 Series Resistors and Voltage Division 43
- 2.6 Parallel Resistors and Current Division 44
- 2.7 Wye-Delta Transformations 51
 - Delta to Wye Conversion
 - Wye to Delta Conversion
- 2.8 Applications 57
 - 2.8.1 Lighting Systems
 - 2.8.2 Design of DC Meters
- 2.9 Summary 63
- Review Questions 64
- Problems 65
- Comprehensive Problems 77

Chapter 3 Methods of Analysis 79

- 3.1 Introduction 80
- 3.2 Nodal Analysis 80
- 3.3 Nodal Analysis with Voltage Sources 86
- 3.4 Mesh Analysis 91
- 3.5 Mesh Analysis with Current Sources 96
- 3.6 Nodal and Mesh Analyses by Inspection 98
- 3.7 Nodal Versus Mesh Analysis 102
- 3.8 Circuit Analysis with *PSpice* 103
- 3.9 Applications: DC Transistor Circuits 105
- 3.10 Summary 110
- Review Questions 111
- Problems 112
- Comprehensive Problem 124

Chapter 4 Circuit Theorems 125

- 4.1 Introduction 126
- 4.2 Linearity Property 126
- 4.3 Superposition 128
- 4.4 Source Transformation 133
- 4.5 Thevenin's Theorem 137
- 4.6 Norton's Theorem 143
- 4.7 Derivations of Thevenin's and Norton's Theorems 147
- 4.8 Maximum Power Transfer 148
- 4.9 Verifying Circuit Theorems with *PSpice* 150
- 4.10 Applications 153
 - 4.10.1 Source Modeling
 - 4.10.2 Resistance Measurement
- 4.11 Summary 158
- Review Questions 159
- Problems 160
- Comprehensive Problems 171

Chapter 5 Operational Amplifiers 173

- 5.1 Introduction 174
- 5.2 Operational Amplifiers 174

- 5.3 Ideal Op Amp 178
- 5.4 Inverting Amplifier 179
- 5.5 Noninverting Amplifier 181
- 5.6 Summing Amplifier 183
- 5.7 Difference Amplifier 185
- 5.8 Cascaded Op Amp Circuits 189
- 5.9 Op Amp Circuit Analysis with *PSpice* 192
- 5.10 Applications 194
 - 5.10.1 Digital-to-Analog Converter
 - 5.10.2 Instrumentation Amplifiers
- 5.11 Summary 197
 - Review Questions 199
 - Problems 200
 - Comprehensive Problems 211

Chapter 6 Capacitors and Inductors 213

- 6.1 Introduction 214
- 6.2 Capacitors 214
- 6.3 Series and Parallel Capacitors 220
- 6.4 Inductors 224
- 6.5 Series and Parallel Inductors 228
- 6.6 Applications 231
 - 6.6.1 Integrator
 - 6.6.2 Differentiator
 - 6.6.3 Analog Computer
- 6.7 Summary 238
 - Review Questions 239
 - Problems 240
 - Comprehensive Problems 249

Chapter 7 First-Order Circuits 251

- 7.1 Introduction 252
- 7.2 The Source-Free *RC* Circuit 253
- 7.3 The Source-Free *RL* Circuit 257
- 7.4 Singularity Functions 263
- 7.5 Step Response of an *RC* Circuit 271
- 7.6 Step Response of an *RL* Circuit 278
- 7.7 First-Order Op Amp Circuits 282
- 7.8 Transient Analysis with *PSpice* 287
- 7.9 Applications 291
 - 7.9.1 Delay Circuits
 - 7.9.2 Photoflash Unit
 - 7.9.3 Relay Circuits
 - 7.9.4 Automobile Ignition Circuit
- 7.10 Summary 297
 - Review Questions 298
 - Problems 299
 - Comprehensive Problems 309

Chapter 8 Second-Order Circuits 311

- 8.1 Introduction 312
- 8.2 Finding Initial and Final Values 313
- 8.3 The Source-Free Series *RLC* Circuit 317
- 8.4 The Source-Free Parallel *RLC* Circuit 324
- 8.5 Step Response of a Series *RLC* Circuit 329
- 8.6 Step Response of a Parallel *RLC* Circuit 334
- 8.7 General Second-Order Circuits 337
- 8.8 Second-Order Op Amp Circuits 342
- 8.9 *PSpice* Analysis of *RLC* Circuits 344
- 8.10 Duality 348
- 8.11 Applications 351
 - 8.11.1 Automobile Ignition System
 - 8.11.2 Smoothing Circuits
- 8.12 Summary 354
 - Review Questions 355
 - Problems 356
 - Comprehensive Problems 365

PART 2 AC Circuits 366

Chapter 9 Sinusoids and Phasors 367

- 9.1 Introduction 368
- 9.2 Sinusoids 369
- 9.3 Phasors 374
- 9.4 Phasor Relationships for Circuit Elements 383
- 9.5 Impedance and Admittance 385
- 9.6 Kirchhoff's Laws in the Frequency Domain 387
- 9.7 Impedance Combinations 388
- 9.8 Applications 394
 - 9.8.1 Phase-Shifters
 - 9.8.2 AC Bridges
- 9.9 Summary 400
 - Review Questions 401
 - Problems 401
 - Comprehensive Problems 409

Chapter 10 Sinusoidal Steady-State Analysis 411

- 10.1 Introduction 412
- 10.2 Nodal Analysis 412
- 10.3 Mesh Analysis 415

- 10.4 Superposition Theorem 419
- 10.5 Source Transformation 422
- 10.6 Thevenin and Norton
Equivalent Circuits 424
- 10.7 Op Amp AC Circuits 429
- 10.8 AC Analysis Using *PSpice* 431
- 10.9 Applications 435
 - 10.9.1 Capacitance Multiplier
 - 10.9.2 Oscillators
- 10.10 Summary 439
 - Review Questions 439
 - Problems 441

Chapter 11 AC Power Analysis 455

- 11.1 Introduction 456
- 11.2 Instantaneous and Average Power 456
- 11.3 Maximum Average Power Transfer 462
- 11.4 Effective or RMS Value 465
- 11.5 Apparent Power and
Power Factor 468
- 11.6 Complex Power 471
- 11.7 Conservation of AC Power 475
- 11.8 Power Factor Correction 479
- 11.9 Applications 481
 - 11.9.1 Power Measurement
 - 11.9.2 Electricity Consumption Cost
- 11.10 Summary 486
 - Review Questions 488
 - Problems 488
 - Comprehensive Problems 498

Chapter 12 Three-Phase Circuits 501

- 12.1 Introduction 502
- 12.2 Balanced Three-Phase Voltages 503
- 12.3 Balanced Wye-Wye Connection 507
- 12.4 Balanced Wye-Delta Connection 510
- 12.5 Balanced Delta-Delta
Connection 512
- 12.6 Balanced Delta-Wye Connection 514
- 12.7 Power in a Balanced System 517
- 12.8 Unbalanced Three-Phase
Systems 523
- 12.9 *PSpice* for Three-Phase Circuits 527
- 12.10 Applications 532
 - 12.10.1 Three-Phase Power Measurement
 - 12.10.2 Residential Wiring

- 12.11 Summary 541
 - Review Questions 541
 - Problems 542
 - Comprehensive Problems 551

Chapter 13 Magnetically Coupled Circuits 553

- 13.1 Introduction 554
- 13.2 Mutual Inductance 555
- 13.3 Energy in a Coupled Circuit 562
- 13.4 Linear Transformers 565
- 13.5 Ideal Transformers 571
- 13.6 Ideal Autotransformers 579
- 13.7 Three-Phase Transformers 582
- 13.8 *PSpice* Analysis of Magnetically
Coupled Circuits 584
- 13.9 Applications 589
 - 13.9.1 Transformer as an Isolation Device
 - 13.9.2 Transformer as a Matching Device
 - 13.9.3 Power Distribution
- 13.10 Summary 595
 - Review Questions 596
 - Problems 597
 - Comprehensive Problems 609

Chapter 14 Frequency Response 611

- 14.1 Introduction 612
- 14.2 Transfer Function 612
- 14.3 The Decibel Scale 615
- 14.4 Bode Plots 617
- 14.5 Series Resonance 627
- 14.6 Parallel Resonance 632
- 14.7 Passive Filters 635
 - 14.7.1 Low-Pass Filter
 - 14.7.2 High-Pass Filter
 - 14.7.3 Band-Pass Filter
 - 14.7.4 Band-Stop Filter
- 14.8 Active Filters 640
 - 14.8.1 First-Order Low-Pass Filter
 - 14.8.2 First-Order High-Pass Filter
 - 14.8.3 Band-Pass Filter
 - 14.8.4 Band-Reject (or Notch) Filter
- 14.9 Scaling 646
 - 14.9.1 Magnitude Scaling
 - 14.9.2 Frequency Scaling
 - 14.9.3 Magnitude and Frequency Scaling

- 14.10 Frequency Response Using *PSpice* 650
- 14.11 Computation Using *MATLAB* 653
- 14.12 Applications 655
 - 14.12.1 Radio Receiver
 - 14.12.2 Touch-Tone Telephone
 - 14.12.3 Crossover Network
- 14.13 Summary 661
 - Review Questions 662
 - Problems 663
 - Comprehensive Problems 671



PART 3 Advanced Circuit Analysis 672

Chapter 15 Introduction to the Laplace Transform 673

- 15.1 Introduction 674
- 15.2 Definition of the Laplace Transform 675
- 15.3 Properties of the Laplace Transform 677
- 15.4 The Inverse Laplace Transform 688
 - 15.4.1 Simple Poles
 - 15.4.2 Repeated Poles
 - 15.4.3 Complex Poles
- 15.5 The Convolution Integral 695
- 15.6 Application to Integrodifferential Equations 703
- 15.7 Summary 706
 - Review Questions 706
 - Problems 707

Chapter 16 Applications of the Laplace Transform 713

- 16.1 Introduction 714
- 16.2 Circuit Element Models 715
- 16.3 Circuit Analysis 720
- 16.4 Transfer Functions 724
- 16.5 State Variables 728
- 16.6 Applications 735
 - 16.6.1 Network Stability
 - 16.6.2 Network Synthesis
- 16.7 Summary 743
 - Review Questions 744
 - Problems 745
 - Comprehensive Problems 756

Chapter 17 The Fourier Series 757

- 17.1 Introduction 758
- 17.2 Trigonometric Fourier Series 759
- 17.3 Symmetry Considerations 766
 - 17.3.1 Even Symmetry
 - 17.3.2 Odd Symmetry
 - 17.3.3 Half-Wave Symmetry
- 17.4 Circuit Applications 776
- 17.5 Average Power and RMS Values 780
- 17.6 Exponential Fourier Series 783
- 17.7 Fourier Analysis with *PSpice* 789
 - 17.7.1 Discrete Fourier Transform
 - 17.7.2 Fast Fourier Transform
- 17.8 Applications 795
 - 17.8.1 Spectrum Analyzers
 - 17.8.2 Filters
- 17.9 Summary 798
 - Review Questions 800
 - Problems 800
 - Comprehensive Problems 809

Chapter 18 Fourier Transform 811

- 18.1 Introduction 812
- 18.2 Definition of the Fourier Transform 812
- 18.3 Properties of the Fourier Transform 818
- 18.4 Circuit Applications 831
- 18.5 Parseval's Theorem 834
- 18.6 Comparing the Fourier and Laplace Transforms 837
- 18.7 Applications 838
 - 18.7.1 Amplitude Modulation
 - 18.7.2 Sampling
- 18.8 Summary 841
 - Review Questions 842
 - Problems 843
 - Comprehensive Problems 849

Chapter 19 Two-Port Networks 851

- 19.1 Introduction 852
- 19.2 Impedance Parameters 853
- 19.3 Admittance Parameters 857
- 19.4 Hybrid Parameters 860
- 19.5 Transmission Parameters 865
- 19.6 Relationships Between Parameters 870

19.7	Interconnection of Networks	873
19.8	Computing Two-Port Parameters Using <i>PSpice</i>	879
19.9	Applications	882
	19.9.1 Transistor Circuits	
	19.9.2 Ladder Network Synthesis	
19.10	Summary	891
	Review Questions	892
	Problems	892
	Comprehensive Problem	903

Appendix A	Simultaneous Equations and Matrix Inversion	A
-------------------	--	---

Appendix B	Complex Numbers	A-9
-------------------	-----------------	-----

Appendix C	Mathematical Formulas	A-16
-------------------	-----------------------	------

Appendix D	Answers to Odd-Numbered Problems	A-21
-------------------	-------------------------------------	------

<i>Selected Bibliography</i>	<i>B-1</i>
------------------------------	------------

<i>Index</i>	<i>I-1</i>
--------------	------------