

Contents

1	Practical Applications of Electrical Engineering Principles	8
2	Preface	13
1	Introduction	21
1.1	Overview of Electrical Engineering	22
1.2	Circuits, Currents, and Voltages	26
1.3	Power and Energy	33
1.4	Kirchhoff's Current Law	36
1.5	Kirchhoff's Voltage Law	40
1.6	Introduction to Circuit Elements	43
1.7	Introduction to Circuits	51
	Summary	55
	Problems	56
2	Resistive Circuits	66
2.1	Resistances in Series and Parallel	67
2.2	Network Analysis by Using Series and Parallel Equivalents	71
2.3	Voltage-Divider and Current-Divider Circuits	75
2.4	Node-Voltage Analysis	80
2.5	Mesh-Current Analysis	100
2.6	Thévenin and Norton Equivalent Circuits	110
2.7	Superposition Principle	123
2.8	Wheatstone Bridge	127
	Summary	130
	Problems	131
3	Inductance and Capacitance	147
3.1	Capacitance	148
3.2	Capacitances in Series and Parallel	155
4	14.3 Inductance and Mutual Inductance	161
4.1	Magnetic Materials	173
4.2	Transformers	179
4.3	Series and Parallel Inductors	187
4.4	Inductance and Mutual Inductance	193
4.5	Symbolic Integration and Differentiation Using MATLAB	197
4.6	Summary	201
4.7	Problems	202
5	DC Machines	264
5.3	Physical Characteristics of Capacitors	158
5.4	Inductance	162
5.5	Inductances in Series and Parallel	167
5.6	Practical Inductors	169
5.7	Mutual Inductance	172
5.8	Symbolic Integration and Differentiation Using MATLAB	173
	Summary	177
	Problems	178
6	Transients	187
6.1	First-Order RC Circuits	188
6.2	DC Steady State	193
6.3	RL Circuits	195
6.4	RC and RL Circuits with General Sources	200
6.5	Second-Order Circuits	206
6.6	Transient Analysis Using the MATLAB Symbolic Toolbox	219
	Summary	225
	Problems	225
7	Steady-State Sinusoidal Analysis	235
7.1	Sinusoidal Currents and Voltages	236
7.2	Phasors	242
7.3	Complex Impedances	248
7.4	Circuit Analysis with Phasors and Complex Impedances	253
7.5	Power in AC Circuits	259
7.6	Thévenin and Norton Equivalent Circuits	272
7.7	Balanced Three-Phase Circuits	278
7.8	AC Analysis Using MATLAB	290
	Summary	294
	Problems	295

6**Frequency Response, Bode Plots, and Resonance 307**

- 6.1 Fourier Analysis, Filters, and Transfer Functions 308
 - 6.2 First-Order Lowpass Filters 316
 - 6.3 Decibels, the Cascade Connection, and Logarithmic Frequency Scales 321
 - 6.4 Bode Plots 326
 - 6.5 First-Order Highpass Filters 329
 - 6.6 Series Resonance 333
 - 6.7 Parallel Resonance 338
 - 6.8 Ideal and Second-Order Filters 341
 - 6.9 Bode Plots with MATLAB 348
 - 6.10 Digital Signal Processing 351
- Summary 360
Problems 361

7**Logic Circuits 375**

- 7.1 Basic Logic Circuit Concepts 376
 - 7.2 Representation of Numerical Data in Binary Form 379
 - 7.3 Combinatorial Logic Circuits 387
 - 7.4 Synthesis of Logic Circuits 395
 - 7.5 Minimization of Logic Circuits 401
 - 7.6 Sequential Logic Circuits 406
- Summary 417
Problems 418

8**Computers, Microcontrollers and Computer-Based Instrumentation Systems 428**

- 8.1 Computer Organization 429
- 8.2 Memory Types 432
- 8.3 Digital Process Control 434
- 8.4 Programming Model for the HCS12/9S12 Family 437
- 8.5 The Instruction Set and Addressing Modes for the CPU12 441
- 8.6 Assembly-Language Programming 450
- 8.7 Measurement Concepts and Sensors 455

8.8 Signal Conditioning 460

- 8.9 Analog-to-Digital Conversion 467
- Summary 470
- Problems 472

9**Diodes 479**

- 9.1 Basic Diode Concepts 480
 - 9.2 Load-Line Analysis of Diode Circuits 483
 - 9.3 Zener-Diode Voltage-Regulator Circuits 486
 - 9.4 Ideal-Diode Model 490
 - 9.5 Piecewise-Linear Diode Models 492
 - 9.6 Rectifier Circuits 495
 - 9.7 Wave-Shaping Circuits 500
 - 9.8 Linear Small-Signal Equivalent Circuits 505
- Summary 511
Problems 511

10**Amplifiers: Specifications and External Characteristics 523**

- 10.1 Basic Amplifier Concepts 524
 - 10.2 Cascaded Amplifiers 529
 - 10.3 Power Supplies and Efficiency 532
 - 10.4 Additional Amplifier Models 535
 - 10.5 Importance of Amplifier Impedances in Various Applications 538
 - 10.6 Ideal Amplifiers 541
 - 10.7 Frequency Response 542
 - 10.8 Linear Waveform Distortion 547
 - 10.9 Pulse Response 551
 - 10.10 Transfer Characteristic and Nonlinear Distortion 554
 - 10.11 Differential Amplifiers 556
 - 10.12 Offset Voltage, Bias Current, and Offset Current 560
- Summary 565
Problems 566

11**Field-Effect Transistors 577**

- 11.1 NMOS and PMOS Transistors 578
- 11.2 Load-Line Analysis of a Simple NMOS Amplifier 586

11.3	Bias Circuits	588
11.4	Small-Signal Equivalent Circuits	592
11.5	Common-Source Amplifiers	596
11.6	Source Followers	600
11.7	CMOS Logic Gates	605
	Summary	610
	Problems	611

12 Bipolar Junction Transistors 619

12.1	Current and Voltage Relationships	620
12.2	Common-Emitter Characteristics	623
12.3	Load-Line Analysis of a Common-Emitter Amplifier	624
12.4	pnp Bipolar Junction Transistors	630
12.5	Large-Signal DC Circuit Models	632
12.6	Large-Signal DC Analysis of BJT Circuits	635
12.7	Small-Signal Equivalent Circuits	642
12.8	Common-Emitter Amplifiers	645
12.9	Emitter Followers	650
	Summary	656
	Problems	657

13 Operational Amplifiers 666

13.1	Ideal Operational Amplifiers	667
13.2	Inverting Amplifiers	668
13.3	Noninverting Amplifiers	675
13.4	Design of Simple Amplifiers	678
13.5	Op-Amp Imperfections in the Linear Range of Operation	683
13.6	Nonlinear Limitations	687
13.7	DC Imperfections	692
13.8	Differential and Instrumentation Amplifiers	696
13.9	Integrators and Differentiators	698
13.10	Active Filters	701
	Summary	705
	Problems	706

14 Magnetic Circuits and Transformers 718

14.1	Magnetic Fields	719
14.2	Magnetic Circuits	728

14.3	Inductance and Mutual Inductance	733
14.4	Magnetic Materials	737
14.5	Ideal Transformers	740
14.6	Real Transformers	748
	Summary	753
	Problems	753

15 DC Machines 764

15.1	Overview of Motors	765
15.2	Principles of DC Machines	774
15.3	Rotating DC Machines	779
15.4	Shunt-Connected and Separately Excited DC Motors	785
15.5	Series-Connected DC Motors	790
15.6	Speed Control of DC Motors	794
15.7	DC Generators	798
	Summary	803
	Problems	804

16 AC Machines 814

16.1	Three-Phase Induction Motors	815
16.2	Equivalent-Circuit and Performance Calculations for Induction Motors	823
16.3	Synchronous Machines	832
16.4	Single-Phase Motors	844
16.5	Stepper Motors and Brushless DC Motors	847
	Summary	849
	Problems	850

APPENDICES

A Complex Numbers 856

Summary	863
Problems	863

B Nominal Values and the Color Code for Resistors 865

C

**The Fundamentals of Engineering
Examination** **867**

D

Answers for the Practice Tests **868**

12

E

On-Line Student Resources **877**

Index **878**

12