

Contents

Preface ix

Chapter 1 Introduction 02

1-1	The Three Kinds of Formulas	1-4	Current Sources
1-2	Approximations	1-5	Thevenin's Theorem
1-3	Voltage Sources	1-6	Norton's Theorem
		1-7	Troubleshooting

Chapter 2 Semiconductors 28

2-1	Conductors	2-8	The Unbiased Diode
2-2	Semiconductors	2-9	Forward Bias
2-3	Silicon Crystals	2-10	Reverse Bias
2-4	Intrinsic Semiconductors	2-11	Breakdown
2-5	Two Types of Flow	2-12	Energy Levels
2-6	Doping a Semiconductor	2-13	Barrier Potential and Temperature
2-7	Two Types of Extrinsic Semiconductors	2-14	Reverse-Biased Diode

Chapter 3 Diode Theory 56

3-1	Basic Ideas	3-7	How to Calculate Bulk Resistance
3-2	The Ideal Diode	3-8	DC Resistance of a Diode
3-3	The Second Approximation	3-9	Load Lines
3-4	The Third Approximation	3-10	Surface-Mount Diodes
3-5	Troubleshooting	3-11	Introduction to Electronic Systems
3-6	Reading a Data Sheet		

Chapter 4 Diode Circuits 86

4-1	The Half-Wave Rectifier	4-7	Peak Inverse Voltage and Surge Current
4-2	The Transformer	4-8	Other Power-Supply Topics
4-3	The Full-Wave Rectifier	4-9	Troubleshooting
4-4	The Bridge Rectifier	4-10	Clippers and Limiters
4-5	The Choke-Input Filter	4-11	Clampers
4-6	The Capacitor-Input Filter	4-12	Voltage Multipliers

Chapter 5 Special-Purpose Diodes 140

- | | | | |
|-----|---------------------------------------|------|------------------------------|
| 5-1 | The Zener Diode | 5-7 | Load Lines |
| 5-2 | The Loaded Zener Regulator | 5-8 | Light-Emitting Diodes (LEDs) |
| 5-3 | Second Approximation of a Zener Diode | 5-9 | Other Optoelectronic Devices |
| 5-4 | Zener Drop-Out Point | 5-10 | The Schottky Diode |
| 5-5 | Reading a Data Sheet | 5-11 | The Varactor |
| 5-6 | Troubleshooting | 5-12 | Other Diodes |

Chapter 6 BJT Fundamentals 188

- | | | | |
|-----|---------------------------|------|----------------------------|
| 6-1 | The Unbiased Transistor | 6-9 | Surface-Mount Transistors |
| 6-2 | The Biased Transistor | 6-10 | Variations in Current Gain |
| 6-3 | Transistor Currents | 6-11 | The Load Line |
| 6-4 | The CE Connection | 6-12 | The Operating Point |
| 6-5 | The Base Curve | 6-13 | Recognizing Saturation |
| 6-6 | Collector Curves | 6-14 | The Transistor Switch |
| 6-7 | Transistor Approximations | 6-15 | Troubleshooting |
| 6-8 | Reading Data Sheets | | |

Chapter 7 BJT Biasing 240

- | | | | |
|-----|---------------------------------------|------|------------------------------|
| 7-1 | Emitter Bias | 7-6 | Accurate VDB Analysis |
| 7-2 | LED Drivers | 7-7 | VDB Load Line and Q Point |
| 7-3 | Troubleshooting Emitter Bias Circuits | 7-8 | Two-Supply Emitter Bias |
| 7-4 | More Optoelectronic Devices | 7-9 | Other Types of Bias |
| 7-5 | Voltage-Divider Bias | 7-10 | Troubleshooting VDB Circuits |
| | | 7-11 | PNP Transistors |

Chapter 8 Basic BJT Amplifiers 280

- | | | | |
|-----|------------------------------------|------|---------------------------------------|
| 8-1 | Base-Biased Amplifier | 8-7 | Analyzing an Amplifier |
| 8-2 | Emitter-Biased Amplifier | 8-8 | AC Quantities on the Data Sheet |
| 8-3 | Small-Signal Operation | 8-9 | Voltage Gain |
| 8-4 | AC Beta | 8-10 | The Loading Effect of Input Impedance |
| 8-5 | AC Resistance of the Emitter Diode | 8-11 | Swamped Amplifier |
| 8-6 | Two Transistor Models | 8-12 | Troubleshooting |

Chapter 9 Multistage, CC, and CB Amplifiers 326

- | | | | |
|-----|-----------------------|-----|---------------------------------------|
| 9-1 | Multistage Amplifiers | 9-6 | Darlington Connections |
| 9-2 | Two-Stage Feedback | 9-7 | Voltage Regulation |
| 9-3 | CC Amplifier | 9-8 | The Common-Base Amplifier |
| 9-4 | Output Impedance | 9-9 | Troubleshooting Multistage Amplifiers |
| 9-5 | Cascading CE and CC | | |

Chapter 10 Power Amplifiers 366

- | | | | |
|-------------|------------------------------------|--------------|-------------------------------|
| 10-1 | Amplifier Terms | 10-6 | Biasing Class-B/AB Amplifiers |
| 10-2 | Two Load Lines | 10-7 | Class-B/AB Driver |
| 10-3 | Class-A Operation | 10-8 | Class-C Operation |
| 10-4 | Class-B Operation | 10-9 | Class-C Formulas |
| 10-5 | Class-B Push-Pull Emitter Follower | 10-10 | Transistor Power Rating |

Chapter 11 JFETs 414

- | | | | |
|-------------|------------------------------|--------------|-------------------------|
| 11-1 | Basic Ideas | 11-6 | Transconductance |
| 11-2 | Drain Curves | 11-7 | JFET Amplifiers |
| 11-3 | The Transconductance Curve | 11-8 | The JFET Analog Switch |
| 11-4 | Biasing in the Ohmic Region | 11-9 | Other JFET Applications |
| 11-5 | Biasing in the Active Region | 11-10 | Reading Data Sheets |
| | | 11-11 | JFET Testing |

Chapter 12 MOSFETs 470

- | | | | |
|-------------|----------------------------------|--------------|--------------------------------|
| 12-1 | The Depletion-Mode MOSFET | 12-6 | Digital Switching |
| 12-2 | D-MOSFET Curves | 12-7 | CMOS |
| 12-3 | Depletion-Mode MOSFET Amplifiers | 12-8 | Power FETs |
| 12-4 | The Enhancement-Mode MOSFET | 12-9 | High-Side MOSFET Load Switches |
| 12-5 | The Ohmic Region | 12-10 | MOSFET H-Bridge |
| | | 12-11 | E-MOSFET Amplifiers |
| | | 12-12 | MOSFET Testing |

Chapter 13 Thyristors 524

- | | | | |
|-------------|----------------------------------|-------------|--------------------------|
| 13-1 | The Four-Layer Diode | 13-5 | Bidirectional Thyristors |
| 13-2 | The Silicon Controlled Rectifier | 13-6 | IGBTs |
| 13-3 | The SCR Crowbar | 13-7 | Other Thyristors |
| 13-4 | SCR Phase Control | 13-8 | Troubleshooting |

Chapter 14 Frequency Effects 568

- | | | | |
|-------------|------------------------------------|--------------|---|
| 14-1 | Frequency Response of an Amplifier | 14-8 | The Miller Effect |
| 14-2 | Decibel Power Gain | 14-9 | Risetime-Bandwidth Relationship |
| 14-3 | Decibel Voltage Gain | 14-10 | Frequency Analysis of BJT Stages |
| 14-4 | Impedance Matching | 14-11 | Frequency Analysis of FET Stages |
| 14-5 | Decibels above a Reference | 14-12 | Frequency Effects of Surface-Mount Circuits |
| 14-6 | Bode Plots | | |
| 14-7 | More Bode Plots | | |

Chapter 15 Differential Amplifiers 624

- | | | | |
|-------------|------------------------------------|-------------|---------------------|
| 15-1 | The Differential Amplifier | 15-5 | Common-Mode Gain |
| 15-2 | DC Analysis of a Diff Amp | 15-6 | Integrated Circuits |
| 15-3 | AC Analysis of a Diff Amp | 15-7 | The Current Mirror |
| 15-4 | Input Characteristics of an Op Amp | 15-8 | The Loaded Diff Amp |

Chapter 16 Operational Amplifiers 666

- | | | | |
|-------------|----------------------------|-------------|----------------------------------|
| 16-1 | Introduction to Op Amps | 16-5 | Two Op-Amp Applications |
| 16-2 | The 741 Op Amp | 16-6 | Linear ICs |
| 16-3 | The Inverting Amplifier | 16-7 | Op Amps as Surface-Mount Devices |
| 16-4 | The Noninverting Amplifier | | |

Chapter 17 Negative Feedback 710

- | | | | |
|-------------|---------------------------------|-------------|--------------------|
| 17-1 | Four Types of Negative Feedback | 17-4 | The ICVS Amplifier |
| 17-2 | VCVS Voltage Gain | 17-5 | The VCIS Amplifier |
| 17-3 | Other VCVS Equations | 17-6 | The ICIS Amplifier |
| | | 17-7 | Bandwidth |

Chapter 18 Linear Op-Amp Circuit Applications 740

- | | | | |
|-------------|---------------------------------|--------------|------------------------------------|
| 18-1 | Inverting-Amplifier Circuits | 18-6 | Summing Amplifier Circuits |
| 18-2 | Noninverting-Amplifier Circuits | 18-7 | Current Boosters |
| 18-3 | Inverter/Noninverter Circuits | 18-8 | Voltage-Controlled Current Sources |
| 18-4 | Differential Amplifiers | 18-9 | Automatic Gain Control |
| 18-5 | Instrumentation Amplifiers | 18-10 | Single-Supply Operation |

Chapter 19 Active Filters 788

- | | | | |
|-------------|---|--------------|--|
| 19-1 | Ideal Responses | 19-7 | VCVS Equal-Component Low-Pass Filters |
| 19-2 | Approximate Responses | 19-8 | VCVS High-Pass Filters |
| 19-3 | Passive Filters | 19-9 | MFB Bandpass Filters |
| 19-4 | First-Order Stages | 19-10 | Bandstop Filters |
| 19-5 | VCVS Unity-Gain Second-Order Low-Pass Filters | 19-11 | The All-Pass Filter |
| 19-6 | Higher-Order Filters | 19-12 | Biquadratic and State-Variable Filters |

Chapter 20 Nonlinear Op-Amp Circuit Applications 850

20-1	Comparators with Zero Reference	20-6	Waveform Conversion
20-2	Comparators with Nonzero References	20-7	Waveform Generation
20-3	Comparators with Hysteresis	20-8	Another Triangular Generator
20-4	Window Comparator	20-9	Active-Diode Circuits
20-5	The Integrator	20-10	The Differentiator
		20-11	Class-D Amplifier

Chapter 21 Oscillators 902

21-1	Theory of Sinusoidal Oscillation	21-7	The 555 Timer
21-2	The Wien-Bridge Oscillator	21-8	Astable Operation of the 555 Timer
21-3	Other RC Oscillators	21-9	555 Circuit Applications
21-4	The Colpitts Oscillator	21-10	The Phase-Locked Loop
21-5	Other LC Oscillators	21-11	Function Generator ICs
21-6	Quartz Crystals		

Chapter 22 Regulated Power Supplies 958

22-1	Supply Characteristics	22-5	Current Boosters
22-2	Shunt Regulators	22-6	DC-to-DC Converters
22-3	Series Regulators	22-7	Switching Regulators
22-4	Monolithic Linear Regulators		

Appendix A	Data Sheet List 1010
Appendix B	Mathematical Derivations 1011
Appendix C	Multisim Primer 1017
Appendix D	Thevenizing the R/2R D/A Converter 1063
Appendix E	Summary Table Listing 1065
Appendix F	Digital/Analog Trainer System 1067
Glossary	1070
Answers	Odd-Numbered Problems 1083
Index	1089