

BASIC JAMES J. BROPHY  
ELECTRONICS  
FOR SCIENTISTS



FIFTH EDITION

---

# CONTENTS

---

Preface	xv
<b>Chapter 1</b> Direct-Current Circuits	1
Introductory Concepts	2
Current, Voltage, and Resistance / Ohm's Law / Joule's Law	4
Circuit Elements	4
Resistors / Batteries	9
Circuit Analysis	9
Series and Parallel Circuits / Networks / Kirchhoff's Rules / Wheatstone Bridge	20
Equivalent Circuits	20
Thévenin's Theorem / Norton's Theorem / Maximum Power Transfer	24
Electrical Measurements	24
D'Arsonval Meter / Ammeters and Voltmeters / Ohmmeters and Multimeters	30
Suggestions for Further Reading	31
Exercises	31
<b>Chapter 2</b> Alternating Currents	34
Sinusoidal Signals	35
Frequency, Amplitude, and Phase / RMS Value / Power Factor	38
Capacitance and Inductance	38
Capacitive Reactance / Capacitors / Inductive Reactance / Inductors	43
Simple Circuits	43
RL Filter / RC Filter / Differentiating and Integrating Circuits	

Transient Currents	49
Time Constant / AC Transients / Ringing	
Complex Waveforms	56
Fourier Series / Effective Value / Square-Wave Response / Oscilloscope	
Suggestions for Further Reading	68
Exercises	69
<b>Chapter 3 Diode Circuits</b>	<b>70</b>
Nonlinear Components	71
Current-Voltage Characteristics / The Ideal Rectifier / The Junction Diode	
Rectifier Circuits	75
Half-Wave Rectifier / Full-Wave Rectifier / Bridge Rectifier / Voltage Doubler	
Filters	78
Capacitor Filter / L-Section Filter / $\pi$ -Section Filter	
Diode Regulators	83
Zener Diodes / Controlled Rectifiers	
Diode Circuits	87
Clippers / Clamps / AC Voltmeters / Detectors	
Suggestions for Further Reading	94
Exercises	94
<b>Chapter 4 Semiconductor Devices</b>	<b>96</b>
Semiconductors	97
Energy Bands / Electrons and Holes / Extrinsic Semiconductors	
Semiconductor Diodes	101
The <i>pn</i> Junction / The Tunnel Diode / Minority-Carrier Injection / Light-Emitting Diodes	
Bipolar Transistors	108
Collector Characteristics / Silicon Controlled Rectifier / The Unijunction Transistor / Fabrication of Transistors	
Field-Effect Transistors	119
Drain Characteristics / The Transfer Characteristic / IGFETs and MOSFETs	
Integrated Circuits	125
Principles of Integrated Circuits / Fabrication Processes / Practical Circuits	
Suggestions for Further Reading	131
Exercises	131
<b>Chapter 5 AC-Circuit Analysis</b>	<b>133</b>
Impedance	134
Ohm's Law for Alternating Current / Complex Impedance	

RLC Circuits	137
Series Resonance / Parallel Resonance / Q Factor	
Bridge Circuits	146
Inductance and Capacitance Bridge / Wien Bridge / Bridged-T and Twin-T Networks	
Transformers	154
Mutual Inductance / Transformer Ratio / Practical Transformers	
Suggestions for Further Reading	158
Exercises	158

<b>Chapter 6</b>	<b>Transistor Amplifiers</b>	161
	FET Amplifiers	162
	The Operating Point / Small-Signal Parameters / Source Follower	
	Bipolar-Transistor Amplifiers	171
	Bias Circuits / Hybrid Parameters / Bipolar-Transistor Circuits	
	Special Amplifiers	181
	Difference Amplifier / Complementary Symmetry / Darlington Connection	
	Voltage Amplifiers	185
	Cascading / Low- and High-Frequency Gain / Decoupling / Transformer Coupling	
	Pulse Amplifiers	193
	Rise Time / Tilt	
	DC Amplifiers	195
	Direct Coupling / Chopper Amplifiers / Lock-in Amplifier	
	Suggestions for Further Reading	203
	Exercises	203

<b>Chapter 7</b>	<b>Operational Amplifiers</b>	206
	Negative Feedback	207
	Voltage Feedback / Current Feedback / Stability	
	Operational Feedback	215
	The Virtual Ground / Mathematical Operations / Simple Amplifiers	
	Operational Amplifier Circuits	220
	Practical Amplifiers / Gain, Bandwidth, and Slew Rate / Input Offset and Drift	
	Operational Amplifier Applications	228
	Integrator-Differentiator Circuit / Logarithmic Amplifier / Active Filter / Comparator / Sample-and-Hold Amplifier	
	Analog Computers	235
	Simulation / Damped Harmonic Oscillator	
	Suggestions for Further Reading	237
	Exercises	237



<b>Chapter 8</b>	<b>Oscillators</b>	240
	Positive Feedback	241
	RC Oscillators	241
	Phase-Shift Oscillator / Wien Bridge Oscillator	
	Resonant-Circuit Oscillators	245
	LC Oscillators / Crystal Oscillators	
	Negative Resistance Oscillators	251
	Stability Analysis / Tunnel-Diode Oscillator	
	Relaxation Oscillators	254
	Sawtooth Generators / Multivibrators	
	Waveform Generators	265
	Diode Pump / Ramps / Pulses	
	Suggestions for Further Reading	269
	Exercises	269
<b>Chapter 9</b>	<b>Digital Electronics</b>	272
	Digital Logic	273
	Binary Numbers / Logic Gates / Boolean Algebra	
	Logic Circuits	282
	Logic Signals / Gate Circuits / ADD gates	
	Information Registers	290
	Flip-Flops / Counters / Shift Registers	
	Visual Displays	301
	Single-Element Displays / Seven-Segment Displays /	
	Decoder Logic	
	Memory Circuits	308
	Read-Only Memories / Shift-Register Memories /	
	Random-Access Memories	
	Suggestions for Further Reading	314
	Exercises	314
<b>Chapter 10</b>	<b>Analog and Digital Measurements</b>	317
	Transducers	318
	Mechanical Transducers / Radiation Detectors /	
	CHEMFETs	
	Feedback Control Circuits	326
	Voltage Regulators / Phase-Locked Loop / Servos	
	Analog Instruments	335
	Oscilloscopes / Waveform Analyzer / Magnetic	
	Recorder / Transmission Lines	
	Noise Signals	344
	Thermal Noise / Current Noise / Amplifier Noise /	
	Shielding and Grounding	
	Digital Instruments	352
	Time-Interval Meter / Frequency Meter /	
	Digital Voltmeter	

	A-D and D-A Conversion	355
	Dual-Slope Integration / Successive-Approximation Converter / Flash Converter / D-A Ladder Networks	
	Digital Processors	363
	Digital Filter / Signal Correlators / Digital Oscilloscope	
	Suggestions for Further Reading	368
	Exercises	368
<b>Chapter 11</b>	<b>Microprocessors</b>	371
	Digital Computers	372
	Organization / Programming Languages / Minicomputers and Microprocessors	
	Computer Architecture	376
	Memory Organization / Central Processing Unit / Input-Output	
	Programming Microprocessors	387
	Assembly Language / Move and Logic Instructions / Control and Operate Instructions / Memory Addressing	
	Practical Microprocessors	395
	4-Bit and 8-Bit Systems / 16-Bit and 32-Bit CPUs / Single-Chip Devices	
	I/O Peripherals	407
	Keyboard Scan / CRT Display / Disk Memories	
	Suggestions for Further Reading	411
	Exercises	411
<b>Chapter 12</b>	<b>Microprocessor Circuits</b>	414
	Processing Circuits	415
	A-D Converter / Event Counter / Lock-in Detector	
	Microcomputers	421
	Calculators / Personal Computers	
	Microcomputer Instruments	425
	Digital Voltmeter / Waveform Generator / Oscilloscope	
	Control Circuits	428
	Process Controller / Device Controllers	
	Suggestions for Further Reading	430
	Exercises	430
	<b>Appendixes</b>	431
<b>1</b>	<b>Vacuum Tube Circuits</b>	431
	The Vacuum Diode	432
	Thermionic Emission / Child's Law	

Vacuum Tubes	434
The Grid / Pentodes / Other Multigrid Tubes	
The Triode Amplifier	440
Cathode Bias / Small-Signal Parameters / Triode Equivalent Circuit	
<b>2 Binary Arithmetic</b>	<b>448</b>
Addition	449
Truth Table / ADD Gate	
Negative Numbers	449
Two's Complement / Sign Bit	
Subtraction	451
Subtrahend / Signed Difference	
Multiplication and Division	452
Shift Left / Shift Right	
Multiword Arithmetic	454
Addition / Subtraction	
Index	455