

***Electronics***

FOR

**DUMMIES<sup>®</sup>**

**by Gordon McComb  
and Earl Boysen**



WILEY

Wiley Publishing, Inc.

# Contents at a Glance



<b><i>Introduction</i></b> .....	<b>1</b>
<b><i>Part I: Getting Started in Electronics</i></b> .....	<b>7</b>
Chapter 1: From Electrons to Electronics .....	9
Chapter 2: Keeping Humans and Gadgets Safe.....	29
<b><i>Part II: Aisle 5, Component Shack: Stocking Up</i></b> .....	<b>41</b>
Chapter 3: Outfitting Your Electronics Bench .....	43
Chapter 4: Getting to Know You: The Most Common Electronic Components .....	63
Chapter 5: Filling Out Your Parts Bin.....	93
<b><i>Part III: Putting It on Paper</i></b> .....	<b>121</b>
Chapter 6: Reading a Schematic.....	123
Chapter 7: Understanding the Basics of Electronics Circuits.....	141
<b><i>Part IV: Getting Your Hands Dirty</i></b> .....	<b>159</b>
Chapter 8: Everything You Need to Know about Soldering .....	161
Chapter 9: Making Friends with Your Multimeter .....	175
Chapter 10: Getting Down with Logic Probes and Oscilloscopes .....	207
<b><i>Part V: A Plethora of Projects</i></b> .....	<b>231</b>
Chapter 11: Creating Your Own Breadboard Circuit.....	233
Chapter 12: Building Your Own Printed Circuit Boards .....	249
Chapter 13: The Exciting World of Microcontrollers .....	281
Chapter 14: Great Projects You Can Build in 30 Minutes or Less.....	299
Chapter 15: Cool Robot Projects to Amaze Your Friends and Family .....	323
<b><i>Part VI: The Part of Tens</i></b> .....	<b>359</b>
Chapter 16: Ten (Or So) Cool Electronics Testing Tool Tips .....	361
Chapter 17: Ten Great Electronics Parts Sources .....	369
Chapter 18: Ten Electronics Formulas You Should Know .....	375
<b><i>Appendix: Internet Resources</i></b> .....	<b>383</b>
<b><i>Glossary</i></b> .....	<b>389</b>
<b><i>Index</i></b> .....	<b>399</b>

# Table of Contents

.....  
**Introduction..... 1**

Why Buy This Book?.....	1
Why Electronics?.....	1
Foolish Assumptions.....	2
Safety Is Number 1.....	3
How This Book Is Organized.....	3
Part I: Getting Started in Electronics.....	3
Part II: Aisle 5, Component Shack: Stocking Up.....	4
Part III: Putting It on Paper.....	4
Part IV: Getting Your Hands Dirty.....	4
Part V: A Plethora of Projects.....	4
Part VI: The Part of Tens.....	5
Icons Used in This Book.....	5

**Part 1: Getting Started in Electronics..... 7**

**Chapter 1: From Electrons to Electronics..... 9**

Just What Is Electricity?.....	9
First, you take an electron.....	10
Moving electrons around through conductors.....	10
Voltage, the driving force.....	11
An important combo: Electrons, conductors, and voltage.....	12
Where Do You Get Electricity?.....	12
They just keep on going: Batteries.....	13
Garden-variety electrical outlets.....	13
Solar cells.....	15
Where Do Electrical Components Fit In?.....	15
Controlling electricity.....	16
Controlling electricity even better (ICs).....	16
Sensing with sensors.....	17
Powering up.....	18
How Electricity Becomes Electronics.....	19
Creating a simple circuit.....	19
Deciding what to build.....	20
Along the Way You Get to Play with Tools.....	21
Tools to build things.....	21
Tools to measure things.....	21
The Wonderful World of Units.....	22
Measuring things in units.....	22
Getting to bigger or smaller units.....	22
Prefixes + units = ?.....	23

Understanding Ohm's Law .....	26
Taking Ohm's Law farther .....	26
Dealing with numbers both big and small .....	27
The power of Ohm's Law .....	27
<b>Chapter 2: Keeping Humans and Gadgets Safe .....</b>	<b>29</b>
The Sixth Sense of Electronics .....	29
The Dangers of Electrical Shock .....	30
Electricity = voltage + current.....	30
Is it AC or DC? .....	31
Trying to not get electrocuted.....	31
Getting a first aid chart.....	32
Zaps, Shocks, and Static Discharge .....	33
That guy from the \$100 bill again.....	34
How static can turn components to lumps of coal .....	34
Tips for reducing static electricity.....	35
Grounding your tools.....	37
Working with AC Current .....	37
The Heat Is On: Safe Soldering .....	39
Wearing Body Armor .....	40
<b>Part II: Aisle 5, Component Shack: Stocking Up .....</b>	<b>41</b>
<b>Chapter 3: Outfitting Your Electronics Bench .....</b>	<b>43</b>
Oh, the Hand Tools You Will Use.....	43
Screwdrivers (the tool, not the cocktail) .....	44
Take it off: Wire cutters and strippers.....	46
Getting a grip with needle-nosed pliers.....	47
Magnifiers: The better to see you with.....	48
A place for everything, and everything in its place .....	49
Filling out the toolbox.....	50
Where to Park Your Tools .....	51
Tools You Don't Absolutely Need (But May Find Handy) .....	52
Getting 'hole-istic' with a drill press .....	52
Cutting things to size with a table saw or circular saw.....	53
Getting intricate with a motorized hobby tool.....	53
Keeping Things Clean and Well-Oiled.....	54
Spic-and-span electronics.....	54
Oil and grease to keep parts slippery.....	55
Yet more cleaning and construction supplies .....	56
Sticky Stuff to Keep Things Together .....	57
Setting Up Your Electronics Lab.....	58
The top ingredients for a great lab.....	58
Picking a perfect place to practice electronics .....	59
Triple threat: Heat, cold, and humidity .....	60
Workbench basics .....	61

**Chapter 4: Getting to Know You: The Most Common Electronic Components ..... 63**

- Viva la Resistors .....64
  - Ohming in on resistor values .....65
  - Color me red, green, and blue.....66
  - Understanding resistor tolerance .....67
  - Let there be heat .....68
  - Dialing with potentiometers .....69
- Capacitors: Reservoirs for Electricity .....70
  - A quick look inside a capacitor .....70
  - Farads big and small .....71
  - Keeping an eye on the working voltage.....71
  - Dielectric this, dielectric that .....71
  - How much capacity does my capacitor have? .....73
  - When a microfarad isn't quite a microfarad .....75
  - Tolerating hot and cold .....76
  - Being positive about capacitor polarity .....77
  - Changing capacitance.....78
- Diode Mania .....78
  - Important ratings for diodes: Peak voltage and current .....80
  - Which way is up?.....81
  - Fun, fun, fun with light-emitting diodes.....81
  - Resistors, meet LEDs .....82
- The Transistor: A Modern Marvel .....83
  - Slogging through transistor ratings .....84
  - On the case of transistor cases .....85
  - Making connections .....86
  - Transistor types .....87
- Packing Parts Together on Integrated Circuits .....88
  - Linear, digital, or combination plate? .....88
  - IC part numbers.....90
  - Understanding IC pinouts .....90
  - Exploring ICs on your own .....91

**Chapter 5: Filling Out Your Parts Bin ..... 93**

- Making the Connection.....93
  - Wire .....94
  - Making connections with connectors.....97
- Powering Up.....98
  - Turning the juice on with batteries.....98
  - Turning on power with solar cells .....102
- Turning Electricity On and Off .....103
  - Turning current on and off with switches .....103
  - Let a relay flip the switch .....105
- Making Decisions with Logic Gates .....106
  - Using logic in electronics .....107
  - Common logic gates .....107



- Controlling Frequency with Inductors and Crystals .....109
  - Storing energy in inductors.....109
  - Making frequencies crystal clear .....111
- Making Sense of Things .....111
  - Can you see the light? .....111
  - Sensing the action with motion detectors .....112
  - You're getting warmer: Temperature sensors .....113
- Good Vibrations with DC Motors .....115
- So You Want to Make Some Noise? .....116
  - Speaking of speakers.....117
  - Buzzers .....118

***Part III: Putting It on Paper* ..... 121**

**Chapter 6: Reading a Schematic . . . . .123**

- What's a Schematic, and Why Should I Care?.....123
- Getting a Grip on Schematic Symbols .....124
  - Getting the scoop on basic schematic symbols.....125
  - Symbols for electronic components .....129
  - Logic gate symbols.....133
  - Miscellaneous symbols.....134
- Getting Component Polarity Right.....136
- One Size Fits All: Adjustable Components .....138
- Photo-Sensitive Components Help You See the Light .....139
- Alternative Schematic Drawing Styles.....139

**Chapter 7: Understanding the Basics of Electronics Circuits . . . . .141**

- What the Heck Is a Circuit?.....142
- A Very Basic Circuit .....142
  - Powering a light bulb.....142
  - Controlling the current with a resistor .....143
- Parallel (or Series) Parking Your Light Bulbs .....144
  - Circuits: The series .....144
  - Parallel circuits .....145
- Exploring a Voltage Divider Circuit.....146
- Measuring Current with Voltage.....148
- What a Team: Capacitors and Resistors .....149
  - How the dynamic duo of resistors and capacitors works .....149
  - Turning things on and off.....150
- Talking of Transistors .....151
  - Using a transistor as a switch.....151
  - When is a transistor an amplifier? .....152
  - What else can you do with transistors? .....154
- An Operational Amplifier .....155
- Simplifying a Project with an Integrated Circuit .....156

**Part IV: Getting Your Hands Dirty ..... 159****Chapter 8: Everything You Need to Know about Soldering ..... 161**

To Solder or Not to Solder .....	161
Things You Absolutely, Positively Need for Soldering .....	163
Choosing just the right soldering pencil .....	166
Selecting a soldering tip .....	166
Preparing Your Soldering Pencil .....	167
Successful Soldering .....	167
Avoiding Cold Solder Joints like the Plague .....	169
Avoiding Static Discharge While Soldering .....	170
Thwarting discharge before it begins .....	170
Stocking up on anti-static supplies .....	171
Unsoldering and Resoldering .....	172
Putting a spring-loaded plunger desolder pump to work .....	172
This bulb desolder pump definitely sucks .....	173
Soldering Tips and Techniques .....	174

**Chapter 9: Making Friends with Your Multimeter ..... 175**

The Basics of Multimeters .....	175
Remember: Safety First! .....	177
Which to choose: Digital or analog? .....	177
Taking a Close-Up Look at Multimeters .....	179
Basic features of every meter .....	179
Making sense of all the inputs and dials .....	181
Accuracy, resolution, and sensitivity .....	183
The well-stocked multimeter .....	183
Maximum range: Just how much is enough? .....	185
Home on the automatic range .....	186
Extra nice-to-have functions .....	188
Setting Up the Meter .....	189
Five Basic Tests That You Can Make with Your Multimeter .....	191
Testing voltage .....	191
Testing current .....	193
Testing wires and cables for continuity .....	194
Testing switches .....	196
Testing fuses .....	199
Testing Resistors, Capacitors, and Other Electronic Components .....	200
Gee, it looks all burned out! .....	200
Testing resistors .....	201
Testing potentiometers .....	202
Testing diodes .....	202
Testing capacitors .....	204
Testing transistors .....	205

<b>Chapter 10: Getting Down with Logic Probes and Oscilloscopes</b> .....	<b>207</b>
The Search for Spock: Using a Logic Probe .....	207
Sound, lights, action!.....	208
Signals that are too fast (even for Superman) .....	209
Know thy circuit .....	211
Putting the Logic Probe to Work .....	211
Observe the usual safety precautions, please.....	211
Connecting the probe to the circuit.....	212
What if the indicator doesn't indicate? .....	213
Scoping Out the Oscilloscope .....	214
So, exactly what does it do?.....	215
Sticking to common oscilloscope features .....	216
Bench, handheld, or PC-based?.....	217
Understanding oscilloscope bandwidth and resolution .....	219
The ins and outs of using an oscilloscope .....	219
What all the wiggly lines mean .....	221
So, When Do I Use an Oscilloscope?.....	223
Putting the Oscilloscope to Work: Testing, 1-2-3!.....	223
Basic setup and initial testing.....	224
Does your battery have any juice?.....	226
Dissecting your radio to display an audio waveform .....	227
Testing the frequency of an AC circuit .....	228
<b>Part V: A Plethora of Projects</b> .....	<b>231</b>
<b>Chapter 11: Creating Your Own Breadboard Circuit</b> .....	<b>233</b>
Taking a Look at Solderless Breadboards .....	234
Solderless breadboards, inside and out .....	234
All sizes, big and small.....	237
Creating a Circuit with Your Solderless Breadboard .....	238
Why you gotta get pre-stripped wires .....	238
Breadboarding techniques.....	240
Neatness counts .....	241
Making the Move from Your Circuit to a Solder Breadboard .....	243
Prototyping with Pre-Drilled Perf Boards .....	245
Getting Wrapped Up in Wire Wrapping .....	247
<b>Chapter 12: Building Your Own Printed Circuit Boards</b> .....	<b>249</b>
Anatomy of a Circuit Board .....	250
How the Copper Gets onto the Circuit .....	252
Ready, Set: Preparing to Build Your Board .....	253
Choosing the right copper clad.....	253
Cutting and cleaning .....	253
Creating a PCB Photographically .....	255
Making the mask.....	255



Positively or negatively sensitized.....	256
Mirror, mirror on the PCB .....	257
Preparing the PCB for etching .....	257
Let there be light: Exposing and developing the board .....	259
Creating a PCB by Using the Transfer Film Method .....	260
Flip-flop, flop-flip.....	261
Getting a good image .....	261
Transferring the layout to copper clad .....	262
Be sure to QC (Quality Control) your work!.....	263
Choosing a Method for Making Your Own Circuit Layouts .....	264
Showing You My Etchings: Etching the Circuit Board.....	265
First step: Inspecting the board.....	265
Cleaning the board — carefully, please! .....	266
Kvetching about etching .....	266
Mixing the etchant .....	267
Now that you're itching to etch . . . ..	269
Final Prep and Drilling .....	270
PCBs R Us: Using a PCB Service.....	272
Now you're a board designer .....	272
PCBs: Everybody's doing it (But will they do it for you?).....	273
Using CAD to Make Artwork .....	274
What you can do with Eagle Light CAD .....	274
Getting to work designing a board .....	274
<b>Chapter 13: The Exciting World of Microcontrollers . . . . .</b>	<b>281</b>
So, How Does It Work? .....	281
What's Inside a Microcontroller? .....	282
Discovering Microcontrollers for Hobbyists .....	284
How much is that microcontroller in the window?.....	285
PC calling microcontroller: Come in, please! .....	286
Microcontrollers That Stand Out from the Rest .....	287
Introducing the BASIC Stamp.....	287
Introducing the OOPic .....	290
Getting to Know the BASIC Stamp 2 .....	292
Step 1: Making the circuit.....	292
Step 2: Programming the darned thing.....	292
Step 3: Let 'er rip! .....	295
Making changes made easy.....	296
Adding a switch to the mix .....	296
Where to Go from Here.....	298
<b>Chapter 14: Great Projects You Can Build in 30 Minutes or Less . . . . .</b>	<b>299</b>
Getting What You Need Right Off the Bat .....	300
Creating Cool, Crazy, Blinky Lights.....	300
Taking a closer look at the 555 flasher .....	301
Running down the LED flasher parts .....	304

Putting the Squeeze on with Piezoelectricity .....	305
Piezo — what?.....	305
Experimenting with piezoelectricity .....	305
Gathering parts for the piezoelectricity circuit.....	307
Building the Amazing See-in-the-Dark Infrared Detector .....	308
Chasing down infrared light .....	308
Detecting parts for the infrared detector.....	310
Cheese It! It's the Cops!!.....	310
How your warbler works .....	310
Scoping out the 555 siren parts list.....	311
Get Lost . . . or Found, with the Electronic Compass .....	312
Peeking under the compass hood .....	312
Checking your electronic compass parts.....	314
When There's Light, You Hear This Noise . . . ..	314
Making your alarm work for you .....	314
Assembling a light alarm parts list .....	315
'Lil Amp, Big Sound.....	316
The ins and outs of 'Lil Amp .....	316
Sounding the roll call for little amplifier's parts.....	317
Building the Handy-Dandy Water Tester .....	317
How the water tester works .....	317
Gathering water tester parts.....	318
Creating a Very Cool Lighting Effects Generator.....	319
Arranging the LEDs .....	319
Going to the store for light chaser parts .....	321

## **Chapter 15: Cool Robot Projects to Amaze Your Friends and Family.....323**

Robots: The Big Picture.....	324
Rover the Robot parts list.....	325
The bits and pieces of a 'bot.....	326
Introducing Rover the Robot .....	326
Preparing to Build the 'Bot .....	327
First, get yourself a template .....	327
Gathering your materials .....	328
Getting to know the pieces.....	328
Building the Body of the 'Bot.....	330
Cutting and drilling the pieces of a robot body .....	330
Assembling and mounting the motors .....	332
Doing a wheelie.....	333
Mounting the caster .....	334
Adding the second deck.....	335
Control switches.....	336
Driving Miss Rover .....	338
Giving Rover Some Smarts.....	340
Mulling over microcontrollers .....	340

DC motors out, R/C servo motors in .....	341
Going inside a servo motor .....	342
Going shopping for servos .....	342
Making servos serviceable.....	343
Modifying the R/C servo motors .....	343
Mounting the servos to the Rover .....	347
Putting Your Servos on a Roll with Wheels .....	350
Sensing Things with a Bumper Car Switch .....	351
Connecting Up to the Board of Education .....	352
Making Switch and Power Connections .....	354
Making the Smart Rover Smart .....	355
Putting the program in place .....	355
Looking at the program up-close .....	356
Where Can I Go from Here?.....	358

***Part VI: The Part of Tens*.....359**

**Chapter 16: Ten (Or So) Cool Electronics Testing Tool Tips . . . . . 361**

Put a Pulse Here, Put a Pulse There.....	362
Counting Up Those Megahertz.....	363
A Power Supply with a Changeable Personality .....	364
Making All Kinds of Signals .....	365
Calling All Alien Worlds .....	365
Analyze This .....	366
A Trio of Testing Toys.....	366
Where to Get Testing Tool Deals .....	367

**Chapter 17: Ten Great Electronics Parts Sources . . . . . 369**

North America .....	369
All Electronics .....	369
Allied Electronics.....	370
B.G. Micro .....	370
Digikey .....	370
Electronic Goldmine.....	370
Fry's Electronics .....	371
Jameco Electronics .....	371
Mouser Electronics .....	371
RadioShack.....	371
Outside North America .....	372
Dick Smith Electronics (Australia) .....	372
Farnell (UK) .....	372
Maplin (UK) .....	372
Advice for Shopping Mail Order.....	372
Do .....	373
Don't.....	373
New or Surplus? .....	374

<b>Chapter 18: Ten Electronics Formulas You Should Know</b> .....	<b>375</b>
Calculating Relationships with Ohm's Law.....	375
Calculating Resistance.....	377
Calculating resistors in series.....	378
Calculating two resistors in parallel .....	378
Calculating Capacitance.....	379
Calculating capacitors in parallel.....	379
Calculating two capacitors in series.....	379
Calculating three or more capacitors in series .....	379
Calculating Units of Energy.....	380
Calculating RC Time Constants .....	380
Calculating Frequency and Wavelength .....	381
Calculating frequency of a signal .....	382
Calculating wavelength of a signal .....	382
<b><i>Appendix: Internet Resources</i></b> .....	<b>383</b>
Figuring Things Out with Calculators.....	383
Gabbing about Electronics in Discussion Forums .....	384
Surfing for Robot Parts.....	384
Getting Up to Speed with Tutorials and General Information .....	385
Trolling for Printed Circuit Board Chemicals and Supplies.....	386
Getting Things Surplus .....	387
Surfing for Circuits .....	387
<b><i>Glossary</i></b> .....	<b>389</b>
<b><i>Index</i></b> .....	<b>399</b>