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Electronics FOR DUMMIES®

Learn to:

- **Get to grips with electronics theory**
- **Start working with electrical parts and equipment**
- **Read schematics and build simple circuits**
- **Create your own projects, from flashing lights to infrared detectors**

Dickon Ross
Editor-in-Chief, Electronics & Technology Magazine

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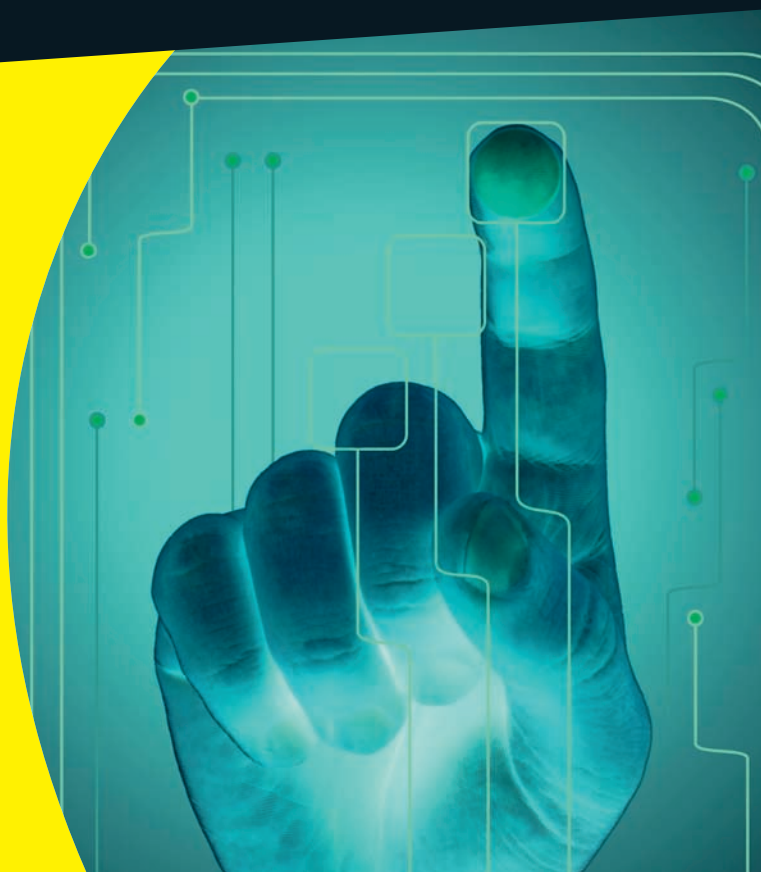
Gordon McComb
Electronics experts



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by Dickon Ross, Cathleen Shamieh, and Gordon McComb

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About the Authors

Dickon Ross, adapting author of the UK edition, has been a science and technology journalist for 20 years, working on titles ranging from *Electronics Times* to *Focus*. Dickon is now Editor-in-Chief of *Engineering & Technology* magazine and *Flipside* – the magazine he launched for teenagers – for the Institution of Engineering and Technology.

Cathleen Shamieh is a writer with an engineering background who specialises in creating communication materials focused on technology and its business benefits. She received an outstanding education in electrical engineering at Manhattan College and MIT, and enjoyed working as an engineer for several years in the medical electronics and telecommunications industries. Accepting a challenge from a respected colleague, she shifted her career into business consulting with a focus on technology implementation, eventually migrating into marketing and communications consulting for high-tech companies. Cathleen enjoys leveraging her technical and business background to create white papers and other materials for not-so-technical audiences.

Gordon McComb has penned 60 books and over a thousand magazine articles. More than a million copies of his books are in print, in over a dozen languages. For 13 years, Gordon wrote a weekly syndicated newspaper column on personal computers. When not writing about hobby electronics and other fun topics, he serves as a consultant on digital cinema to several notable Hollywood clients.

Dedication

To my parents, Beth and Jim Corbett, who taught me that I can do anything I put my mind to; to Sister Eustelle, who made a writer out of me; to my wonderful husband, Bill, who's always there to support me; and to my four fantastic sons, Kevin, Peter, Brendan, and Patrick, who make life a fun, loving adventure every single day.

C.S.

To my father, Wally McComb, who instilled in me a fascination with electronics; and to Forrest Mims, who taught me a thing or two about it.

G.M.

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Contents at a Glance

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Introduction

Are you curious to know what makes your iPod tick? How about your mobile phone, laptop, stereo system, digital camera, plasma TV – or, well, just about every piece of electronics you use for work or play, in the office, at home or on the move?

Perhaps you've even thought that you could design and build your own little electronic circuit or gadget to do something you want it to do?

If you've ever wondered how transistors, capacitors and other building blocks of electronics work, or if you've been tempted to try building your own electronic devices, you've come to the right place!

Electronics For Dummies is your entry into the electrifying world of modern electronics. No dry, boring or incomprehensible tome, this; what you hold in your hands is *the* book that enables you to understand, create and trouble-shoot your own electronic devices. We're getting excited already!

Why Buy This Book?

All too often, electronics seems like a mystery, because it involves controlling something you can't see – electric current – which you've been warned repeatedly not to touch. That's enough to scare most people away. But as you continue to experience the benefits of electronics on a daily basis, you may begin to wonder how so many incredible things can happen in such tight spaces.

This book is designed to explain electronics in ways you can relate to. It gives you a basic understanding of exactly what electronics is, provides down-to-earth explanations of how major electronic components work and gives you just what you need to build and test working electronic circuits and projects. Although this book doesn't pretend to answer all your questions about electronics, it does give you a good grounding in the essentials.

We hope that when you're done with this book, you'll realise that electronics isn't as complicated as you may have thought. And we want to arm you with the knowledge and confidence you need to go deeper into the exciting world of electronics.

Why Electronics?

Electronics is everywhere. You find electronics in your phones, audio and video systems, and kitchen appliances. Electronic systems control traffic lights, Internet commerce, medical devices – even many toys. You can't see most of them, but electronic systems also proliferate throughout your car. Try for just one minute to imagine your life without electronics; you may as well be living in the Dark Ages!

So what does all this mean to you as you peruse this book? After all, you don't expect to be able to design satellite communication systems after a sit-down session with this humble *For Dummies* book.

Remember though that even the most complicated electronics systems consist of no more than a handful of different electronic component types governed by the same set of rules that make simple circuits work. So if you want to understand complex electronic systems, you start with the basics – just like the designers of those systems did when they started out.

More importantly, understanding the basics of electronics can enable you to create some really useful, albeit somewhat simple, electronic devices. You can build circuits that flash lights at just the right time, sound a buzzer upon sensing an intruder or even move an object around the room. And when you know how to use integrated circuit (IC) chips, which are populated with easy-to-use fully functioning circuits, you can create some rather clever designs for just a few well-spent pounds.

Technology development being what it is – lightning fast, smaller and cheaper year after year – you can now hold the ingredients for very advanced electronic systems in the palm of your hand. With a little knowledge and a willingness to experiment, you can build a unique musical birthday card, fantastic flashing decorations or an alarm that senses someone trying to get into your bedroom or biscuit tin.

Also, you may have another hobby that can be enriched by electronics. If you're into model railways, you can build your own automated switching points. If your hobby is racing radio-controlled cars, electronics know-how may enable you to improve the performance of your car and win the next championship. Knowing more about electronics can really enhance your hobbies.

Last but not least, electronics is fun. Finding out about and messing with electronics is its own reward.

Foolish Assumptions

This book assumes that you're curious about electronics, but you really don't know much, if anything, about its inner workings. You chose this book, rather than a book consisting exclusively of recipes for electronic circuits, and therefore we assume that you want to discover more about how parts such as resistors, capacitors and transistors actually work.

So we take the time (and more than half the book) to explain the basics to you, distilling fairly technical information down into easy-to-understand concepts. You don't need to be well-versed in physics or mathematics to benefit from reading this book, although a little bit of school algebra is helpful (but we do our best to refresh that possibly painful memory).

We assume you may want to jump around this book a bit, diving deep into a topic or two that holds special interest for you, and possibly skimming through other topics. For this reason, we provide loads of chapter cross-references to point you to information that can fill in any gaps or refresh your memory on a topic. And although the first half of the book is devoted to how electronic circuits and individual parts work, we include cross-references to simple circuits and projects that appear later in the book. That way, as soon as you find out about a component, you can jump ahead, if you like, and build a circuit that uses that very component.

The table of contents at the front of the book provides an excellent resource that you can use to find quickly exactly what you're looking for. Finally, the good people at Wiley have thoughtfully provided a thorough index at the back of the book to help you find what you want fast.

Safety Is Number 1

Reading about electronics is pretty safe. About the worst that can happen is that your eyes get tired from too many late nights with this book. But actually building electronic projects is another matter. Lurking behind the fun of your electronics hobby are high voltages that can electrocute you, soldering irons that can burn you and little bits of wire that can fly into your eyes when you snip them off with sharp cutters. Aaaagh!

Safety comes first in electronics. It's so important, in fact, that we devote a major section of Chapter 9 to it – and continually refer you to this section. If you're brand new to electronics, please be sure to read this section thoroughly. Don't skip over it, even if you think you're the safest person on earth.

Even if you've dabbled in electronics before, we still say you should read this bit as you may be surprised by some of the information. When you follow proper precautions, electronics is a very safe and sane hobby. Be sure to keep it that way!

Although we try to give you great advice about safety throughout, we can't possibly give you every safety precaution in the world in one book. In addition to reading our advice, use your own common sense, read manufacturer's instructions for parts and tools that you work with and always stay alert.

How This Book Is Organised

Electronics For Dummies is organised so that you can quickly find, read and understand the information that you want. Also, if you have some experience with electronics, or want to deepen your knowledge of one particular topic, you can skip around and focus on the chapters that interest you.

The chapters in this book are divided into parts to help you zero in on the information that you're looking for quickly and easily.

Part 1: Understanding the Fundamentals of Electronics

Turn to Part I if you want to get a thorough grounding in basic electronics theory. Chapter 1 gives you the big picture of exactly what electronics is and the amazing things it can do for you. You discover the fundamentals of electronic circuits and get introduced to voltage, current and sources of electrical energy in Chapter 2.

In Chapters 3–6, you dive deep into the heart of all the major electronic components, including resistors, capacitors, inductors, transformers, diodes and transistors. You find out how each component works, how it handles electric current and what role it plays in electronic circuits.

Chapter 7 introduces you to integrated circuits (ICs) and explains a bit about digital logic and how three popular ICs function. Chapter 8 covers sensors, speakers, buzzers, switches, wires and connectors.

Throughout Part I, we point you to introductory circuits you can build in Part III to see what each component does.

Part II: Getting Your Hands Dirty

Part II is all about tooling-up, constructing real circuits and probing around working (and non-working) circuits – without electrocuting yourself.

In Chapter 9, you find out how to set up an electronics workbench, what electronic components, tools and other supplies you need to build circuits, and how to protect yourself and your electronic components as you work on circuits. Chapter 10 explains how to interpret circuit diagrams (known as *schematics*) so that you know how to connect components together when you build a circuit.

You discover various methods of wiring up temporary and permanent circuits in Chapter 11, including how to solder. Finally, Chapter 12 explains how to use the most important testing tool in electronics – the multimeter – to explore and analyse your circuits. This chapter also introduces you very briefly to two other tools: the logic probe and oscilloscope.

Part III: Putting Theory into Practice

If you're anxious to wire up some circuits and get your electronic juices flowing, Part III is the place to be.

Chapter 13 shows you some elementary circuits that you can build to demonstrate the principles of electronics and observe specific electronic components functioning as advertised. Turn to this chapter if you want to reinforce your theoretical knowledge of electronics or gain experience building simple circuits.

When you're ready for more involved circuits, explore Chapter 14. Here, you find several projects that you can have fun building and exploring. You may even decide to put one or two of them to good use in your home or office.

Part IV: The Part of Tens

As you may expect, Part IV is where you can find further information laid out in top-ten list format.

Chapter 15 offers pointers to help you expand your electronics horizons. Here, you can find information on all-inclusive project kits and circuit simulation software, suggestions for additional testing tools and tips on how to get great deals on electronics supplies.

When you're ready to shop for all things electronic, turn to Chapter 16 for a list of the top electronics suppliers in the UK and abroad.

Icons Used in This Book

We can't place dozens of Post-it notes in each and every copy of *Electronics For Dummies*, so we use icons to draw your attention to critical information.

Tips alert you to information that can really save you time, headaches or money (or all three!). If you use our tips, your electronics experience is that much more enjoyable.

When you tinker with electronics, you're bound to encounter situations that call for extreme caution. Enter the Warning icon: a not-so-gentle reminder to take extra precautions to avoid personal injury or prevent damage to your tools, components, circuits – or your bank balance.

This icon reminds you of important ideas or facts that you really need to keep in mind. Occasionally, we use this icon to note where in the book an important concept is originally introduced, so that you can flick back to more detailed information for a refresher, if you need one.

Even though this entire book is about technical stuff, we flag up some mini topics to alert you to deeper techie info that may require a little more brain power to digest. Of course, if you choose to skip over this info, that's absolutely fine; you can still follow along with no problem. Think of this techie stuff as extra material – a diversion off the main path, if you will – like bonus questions in a quiz.

Part I

Understanding the Fundamentals of Electronics

'The porch light packaging said it was the absolute ultimate in security lighting.'

In this part . . .

Do you ever wonder what makes electronic devices tick? Are you ever curious to know how speakers speak, motors move and computers compute? Well, then, you've come to the right place!

In the chapters ahead, we explain exactly what electronics is, what it can (and does) do for you and how all sorts of electronic things work. But don't worry. We don't bore you with long essays involving physics and mathematics. We use analogies and down-to-earth examples to make understanding electronics easy – fun, even. And while you're enjoying yourself, you're discovering how electronic components work and combine forces to make amazing things happen.

Chapter 1

What Is Electronics and What Can It Do for You?

In This Chapter

- Seeing electric current for what it really is
- Recognising the power of electrons
- Using conductors to go with the flow (of electrons)
- Making the right connections with a circuit
- Controlling the destiny of electrons with electronic components
- Applying electrical energy to loads of things

If you're like most people, you probably have some idea about what electronics is. You've been up close and personal with lots of so-called consumer electronics devices, such as iPods, stereo equipment, personal computers, digital cameras and televisions, but to you, they may seem like mysteriously magical boxes with buttons that respond to your every desire.

You know that underneath each sleek exterior nestles an amazing assortment of tiny components connected together in just the right way to make something happen. And now you want to understand how.

In this chapter, you discover that electrons moving in harmony constitute electric current, which is shaped by electronics. You take a look at what you need to keep the juice flowing, and you also get an overview of some of the things you can do with electronics.

Just What Is Electronics?

When you turn on a light in your home, you're connecting a source of electrical energy (usually supplied by your power company) to a light bulb in a complete path, known as an *electrical circuit*. If you add a dimmer or a timer to the light bulb circuit, you can control the operation of the light bulb in a more interesting way than simply switching it on and off.

Electrical systems, like the circuits in your house, use a standard electric current to make things such as light bulbs work. *Electronic systems* take this a step further: they *control* the electrical current, changing its fluctuations, direction and timing in various ways in order to accomplish a variety of functions, from dimming a light bulb to communicating with satellites (take a look at Figure 1-1). This control is what distinguishes electronic systems from electrical systems.

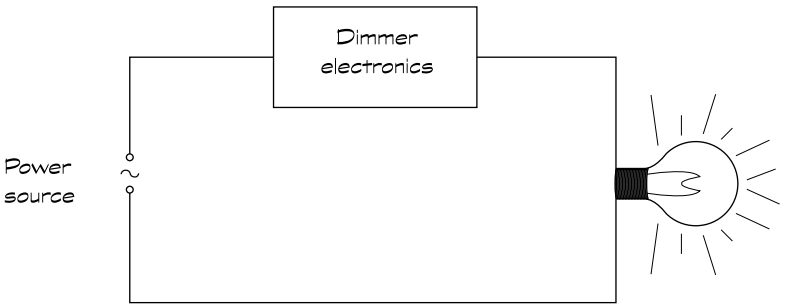

Figure 1-1: The dimmer electronics in this circuit control the flow of electric current to the light bulb.

To understand how electronics controls electricity, you need to first understand what electricity is and how it powers things like light bulbs.

Understanding Electric Current

Electric current is the flow of *electrical charges* carried by unbelievably small particles called *electrons*. So what on earth are electrical charges, where exactly do you find electrons and how do they move around? You find the answers by taking a peek inside the atom.

Getting a charge out of electrons

Atoms are the natural building blocks of everything. They're so tiny that you can find millions of them in a single speck of dust – so you can imagine how many exist in your average sumo wrestler! Electrons are found in every single atom in the universe, outside the atom's centre, or *nucleus*. All electrons have a negative electrical charge and are attracted to positively charged particles, known as *protons*, which exist inside the nucleus. *Electrical charge* is a kind of force within a particle, and the words 'positive' and 'negative' are somewhat arbitrary terms used to describe the two different forces that exhibit opposite effects. (We can call them 'north' and 'south' or 'Tom' and 'Jerry' instead, but those names are already taken.)