

VOL. 1.

Charles Platt

# Encyclopedia of Electronic Components



## Power Sources & Conversion

Resistors • Capacitors • Inductors  
Switches • Encoders • Relays • Transistors



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# Encyclopedia of Electronic Components Volume 1

Charles Platt

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# Encyclopedia of Electronic Components Volume 1

by Charles Platt

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[TI]

To Mark Frauenfelder, who reacquainted me with the pleasures of Making.

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# Preface

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At a time when information is widely and freely available in greater quantities than ever before, the reader may wonder whether *The Encyclopedia of Electronic Components* is really necessary. Surely, anything you want to know can be found online?

Well, yes and no. Let's consider the available resources.

## 1. Datasheets

---

Datasheets are indispensable, but they have limitations. Some are detailed; others are skimpy. Some show you sample schematics as a guide to using a component; many don't. None of them tells you much about how a component works, because that's not their purpose. Often they don't mention other components that must be added. Some datasheets for DC-DC converters, for instance, say nothing at all about bypass capacitors, even though the capacitors may be essential. A datasheet for an optocoupler says nothing about the pullup resistor required by the open-collector output.

Datasheets don't facilitate comparison shopping. A datasheet from one manufacturer will not compare its products with those from another manufacturer, and may not even provide much guidance about alternatives that are available from the same manufacturer. For example, a da-

tasheet for a linear voltage regulator won't suggest that you might do better to use a DC-DC converter in an application where high efficiency is important.

Most of all, datasheets don't tell you how to avoid common mistakes. What actually happens if you connect that tantalum capacitor the wrong way around? A datasheet gives you the customary list of absolute maximum values, and after that, you are on your own, burning things out, encountering mysterious electronic behavior, and discovering limitations that are so well known, the datasheet didn't bother to mention them. In my experience, relying on datasheets creates a significant risk of reinventing the wheel.

## 2. Wikipedia

---

Wikipedia's coverage of electronics is impressive but inconsistent. Some entries are elementary, while others are extremely technical. Some are shallow, while others are deep. Some are well organized, while others run off into obscure topics that may have interested one of the contributors but are of little practical value to most readers. Many topics are distributed over multiple entries, forcing you to hunt through several URLs. Overall, Wikipedia tends to be good if you want theory, but not-so-good if you want hands-on practicality.

### 3. Manufacturers' Tutorials

---

A few helpful and enlightened manufacturers have compiled highly authoritative, instructional overviews of the components that they sell. Lit-telfuse, for instance, publishes an excellent series of documents telling you everything you could possibly want to know about fuses. But now you encounter a different problem: There is so much information, you'll need a couple of hours to dig through it all. Also, because the tutorials tend not to receive high page rankings on Google, they can be hard to find. And if a manufacturer has gaps in its product line, its tutorial is unlikely to mention them. Consequently, you won't know what's missing.

### 4. Personal Guides

---

It is a well-known attribute of the Web that many individuals feel the impulse to share everything they know (or think they know) about a particular topic. These personal guides can present surprisingly thorough online coverage of relatively obscure issues, such as the types of capacitors most suitable for loudspeaker crossover circuits, or the correct derivation of amp-hour numbers for lead-acid batteries. Unfortunately, on some sites you can also find errors, unsubstantiated opinions, plagiarism, and eccentricity. My general rule is that three or more guides generally have to agree with each other before their statements can be trusted—and even then, I have a small residue of doubt. The search-inspect-and-verify process can take a while.

So—yes, the information that you want usually does exist somewhere online, but no, it may not be easy to find. The vastness of the Web is not organized like an encyclopedia.

What about books? Generally speaking, they tend to be entry-level, or they specialize in narrow areas. A few broad-ranging books are truly excellent, but they are primarily educational, organized in an instructional sequence. They are not reference books.

### The Encyclopedic Solution

---

Scarcity or inaccessibility of information ceased to be a problem many years ago. Its vast quantity, inconsistency, and dispersal have become the new barriers to acquiring knowledge. If you have to go hunting among datasheets, Wikipedia, manufacturers' tutorials (which may or may not exist), personal guides (which may have unrevealed bias), and multiple educational books, the process will be inconvenient and time-consuming. If you plan to revisit the topic in the future, you'll have to remember which URLs were useful and which ones weren't—and you may find that many of them are not even there anymore.

When I considered these issues during my own work as an electronics columnist for *Make* magazine, I saw a real need for a fact-checked, cross-referenced encyclopedia that would compile the basic information about components concisely, in an organized, consistent format, with informative photographs, schematics, and diagrams. It might save many people a lot of search time if it could summarize how components work, how to use them, what the alternatives are, and what the common errors and problems may be.

That is the modest ambition of *The Encyclopedia of Electronic Components*.

### The Audience

---

Like any reference work, this one hopes to serve two categories of readers: The informed and the not-yet-informed.

Perhaps you are learning electronics, and you see a part listed in a catalog. It looks interesting, but the catalog doesn't tell you exactly what the part does or how it is commonly used. You need to look it up either by function or by name, but you're not sure where to start. An encyclopedic reference can simplify the fact-finding process, can save you from ordering a part that may be inappropriate, and can tell you how it should be used.

Perhaps, instead, you are an electronics engineer or hobbyist, thinking about a new circuit. You remember using a component three or four years ago, but your recollection may not be reliable. You need to refresh your memory with a quick summary—and so, you open the encyclopedia, just to make sure.

## Completeness

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Obviously, this book cannot include every component that exists. Mouser Electronics claims to have more than 2 million products listed in its online database. *The Encyclopedia of Electronic Components* only has room for a fraction of that number—but still, it can refer you to the primary types. The electronic edition of this book should allow easy insertions and updates. My hope is that it can become an ever-expanding resource.

## Acknowledgments

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Any reference work draws inspiration from many sources, and this one is no exception. Three were of special importance:

*Practical Electronics for Inventors* by Paul Scherz (second edition) McGraw-Hill, 2007

*Electronic Devices and Circuit Theory* by Robert L. Boylestad and Louis Nashelsky (ninth edition) Pearson Education Inc., 2006

*The Art of Electronics* by Paul Horowitz and Winfield Hill (second edition) Cambridge University Press, 2006

I also made extensive use of information gleaned through Mouser Electronics and Jameco Electronics. And where would any of us be without *Getting Started in Electronics* by Forrest M. Mims III, or *The TTL Cookbook* by Don Lancaster?

In addition, there were individuals who provided special assistance. My editor, Brian Jepson, was immensely helpful in the development of the project. Michael Butler contributed greatly to the early concept and its structure. Josh Gates did resourceful research. My publishers, O'Reilly Media, demonstrated their faith in my work. Kevin Kelly unwittingly influenced me with his legendary interest in “access to tools.”

Primary fact checkers were Eric Moberg, Chris Lirakis, Jason George, Roy Rabey, Emre Tuncer, and Patrick Fagg. I am indebted to them for their help. Any remaining errors are, of course, my responsibility.

Lastly I should mention my school friends from decades ago: Hugh Levinson, Patrick Fagg, Graham Rogers, William Edmondson, and John Witty, who helped me to feel that it was okay to be a nerdy kid building my own audio equipment, long before the word “nerd” existed.

—Charles Platt, 2012

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# How to Use This Book

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# 1

To avoid misunderstandings regarding the purpose and method of this book, here is a quick guide regarding the way in which it has been conceived and organized.

## Reference vs. Tutorial

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As its title suggests, this is a reference book, not a tutorial. In other words, it does not begin with elementary concepts and build sequentially toward concepts that are more advanced.

You should be able to dip into the text at any point, locate the topic that interests you, learn what you need to know, and then put the book aside. If you choose to read it straight through from beginning to end, you will not find concepts being introduced in a sequential, cumulative manner.

My book *Make:Electronics* follows the tutorial approach. Its range, however, is more circumscribed than that of this encyclopedia, because a tutorial inevitably allocates a lot of space to step-by-step explanations and instructions.

## Theory and Practice

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This book is oriented toward practicality rather than theory. I am assuming that the reader mostly wants to know how to use electronic components, rather than why they work the way they

do. Consequently I have not included any proofs of formulae, any definitions rooted in electrical theory, or any historical background. Units are defined only to the extent that is necessary to avoid confusion.

Many books on electronics theory already exist, if theory is of interest to you.

## Organization

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The encyclopedia is divided into entries, each entry being devoted to one broad type of component. Two rules determine whether a component has an entry all to itself, or is subsumed into another entry:

1. A component merits its own entry if it is (a) widely used or (b) not-so-widely used but has a unique identity and maybe some historical status. A widely used component would be a **bipolar transistor**, while a not-so-widely-used component with a unique identity would be a **unijunction transistor**.
2. A component does not merit its own entry if it is (a) seldom used or (b) very similar in function to another component that is more widely used. For example, the *rheostat* is sub-

sumed into the **potentiometer** section, while *silicon diode*, *Zener diode*, and *germanium diode* are combined together in the **diode** entry.

Inevitably, these guidelines required judgment calls that in some cases may seem arbitrary. My ultimate decision was based on where I would expect to find a component if I was looking for it myself.

## Subject Paths

Entries are not organized alphabetically. Instead they are grouped by subject, in much the same way that books in the nonfiction section of a library are organized by the Dewey Decimal System. This is convenient if you don't know exactly what you are looking for, or if you don't know all the options that may be available to perform a task that you have in mind.

Each primary category is divided into subcategories, and the subcategories are divided into component types. This hierarchy is shown in [Figure 1-1](#). It is also apparent when you look at the top of the first page of each entry, where you will find the path that leads to it. The **capacitor** entry, for instance, is headed with this path:

power > moderation > capacitor

Any classification scheme tends to run into exceptions. You can buy a chip containing a *resistor array*, for instance. Technically, this is an *analog integrated circuit*, but should it really be included with solid-state relays and comparators? A decision was made to put it in the **resistor** section, because this seemed more useful.

Some components have hybrid functions. In Volume 2, in the *integrated circuit* subcategory, we will distinguish between those that are *analog* and those that are *digital*. So where should an **analog-digital converter** be listed? It will be found under *analog*, because that category seems better associated with its primary function, and people may be more likely to look for it there.

Primary Category	Secondary Category	Component Type
power	source	battery
	connection	jumper
		fuse
		pushbutton
		switch
		rotary switch
		rotational encoder
	moderation	relay
		resistor
		potentiometer
		capacitor
		variable capacitor
	conversion	inductor
		AC-AC transformer
		AC-DC power supply
		DC-DC converter
		DC-AC inverter
regulation	voltage regulator	
electro-magnetism	linear output	electromagnet
		solenoid
	rotational output	DC motor
		AC motor
		servo motor
		stepper motor
	discrete semi-conductor	single junction
unijunction transistor		
multi-junction		bipolar transistor
		field-effect transistor

**Figure 1-1.** The subject-oriented organization of categories and entries in this encyclopedia.

## Inclusions and Exclusions

There is also the question of what is, and what is not, a component. Is wire a component? Not for



the purposes of this encyclopedia. How about a **DC-DC converter**? Because converters are now sold in small packages by component suppliers, they have been included as components.

Many similar decisions had to be made on a case-by-case basis. Undoubtedly, some readers will disagree with the outcome, but reconciling all the disagreements would have been impossible. Speaking personally, the best I could do was create a book that is organized in the way that would suit me best if I were using it myself.

## Typographical Conventions

Throughout this encyclopedia, the names of components that have their own entries are presented in **bold type**. Other important electronics terms or component names are presented in *italics* where they first appear in any one section.

The names of components, and the categories to which they belong, are all set in lower-case type, except where a term is normally capitalized because it is an acronym or a trademark. *Trimpot*, for instance, is trademarked by Bourns, but *trimmer* is not. **LED** is an acronym, but *cap* (abbreviation for **capacitor**) is not.

Where formulae are used, they are expressed in a format that will be familiar to computer programmers but may be unfamiliar to others. The \* (asterisk) symbol is used in place of a multiplication sign, while the / (slash symbol) is used to indicate division. Where pairs of parentheses are nested, the most deeply nested pair identifies the operations that should be performed first.

## Volume Contents

Practical considerations relating to book length influenced the decision to divide *The Encyclopedia of Electronic Components* into three volumes. Each volume deals with broad subject areas as follows.

### Volume 1

Power, electromagnetism, and discrete semiconductors.

The *power* category includes sources of power and methods to distribute, store, interrupt, and modify power. The *electromagnetism* category includes devices that exert force linearly, and others that create a turning force. *Discrete semiconductors* include the main types of diodes and transistors.

### Volume 2

Integrated circuits, light sources, sound sources, heat sources, and high-frequency sources.

*Integrated circuits* are divided into analog and digital components. *Light sources* range from incandescent bulbs to LEDs and small display screens; some reflective components, such as liquid-crystal displays and e-ink, are also included. *Sound sources* are primarily electromagnetic.

### Volume 3

Sensing devices.

The field of sensors has become so extensive, they easily merit a volume to themselves. *Sensing devices* include those that detect light, sound, heat, motion, pressure, gas, humidity, orientation, electricity, proximity, force, and radiation.

At the time of writing, volumes 2 and 3 are still in preparation, but their contents are expected to be as described above.

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