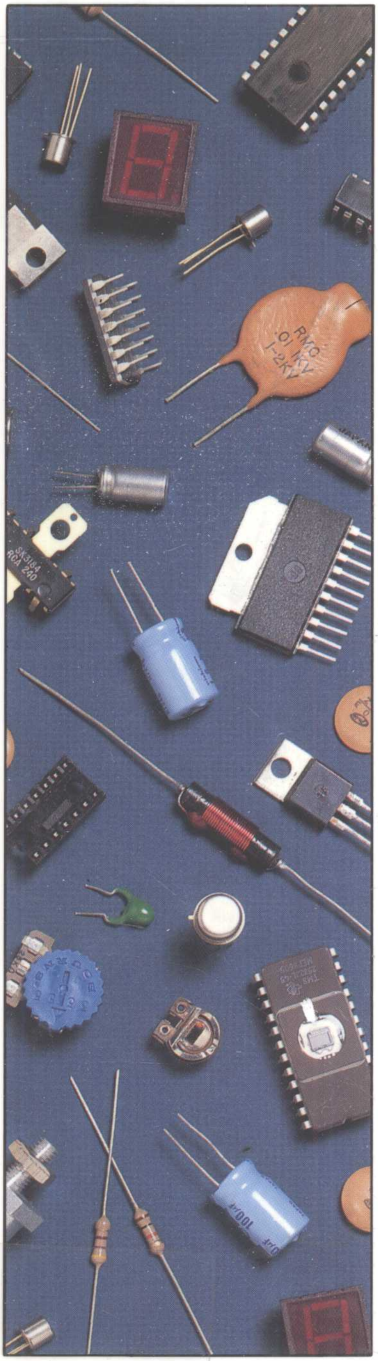

ELECTRONIC COMPONENTS

A Complete Reference for Project Builders

Delton T. Horn

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Preface

THIS BOOK IS INTENDED AS A SINGLE-SOURCE HANDBOOK FOR the electronics experimenter and technician, compiling information on a wide variety of common electronic components. Most of this information is available from other sources, of course, but here it is gathered in one convenient reference.

You can read this book as an introductory or refresher text, or you can simply look up the type of electronic component you are interested in the table of contents and quickly have the relevant information right at your fingertips.

The functioning of basic electronic components is covered, along with the differences between the various subtypes of each major class of component. The important factors to consider when making substitutions in existing circuits are also discussed.

Just a glance at the table of contents will give you an idea of the range of topics covered in this volume. The book is divided into three major sections. Part 1 deals with passive, nonamplifying components, beginning with the simple wire and solder that is part of every electronic circuit (chapter 1). This is followed by an in-depth examination of the three major types of passive components and related devices—resistors (chapter 2), capacitors (chapter 3), and inductors (chapter 4). Specific types within each of these broad categories are covered. For example, there are many different types of capacitors, yet few electronic hobbyists know which type to use in what kind of circuit or which types are interchangeable and which aren't.

Part 2 covers active devices, which are capable of amplification. The focus here is entirely on semiconductor components. This includes diodes (chapter 5) and transistors (chapter 6) of many different types, including zener diodes, four-layer diodes, LEDs, laser diodes, UJTs, FETs, and SCRs, among others. We will also look at integrated circuits (ICs), although practical limitations restrict the extensiveness of this section. Chapter 7 deals with linear ICs, such as amplifiers, op amps, timers, and more. Digital ICs are covered in chapter 8, ranging from simple gates to common digital devices, such as flip-flops, counters, and shift registers.

Part 3 includes some miscellaneous devices that don't really fit into the other categories. Chapter 9 discusses transducers, which convert some external condition into an electrical signal or vice versa. Finally, chapter 10 discusses switches.

Of course, it would be impossible to discuss every electronic component available. There are literally millions, and more are being developed every week. This is especially true in the case of ICs. This book discusses major component types, dealing with specific components only as examples of more general principles.

Armed with this book and a manufacturer's spec sheet, the electronics experimenter or technician can get the most out of almost any electronic component.

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1
Wire and solder

SOME READERS MIGHT FIND IT A LITTLE ODD THAT A BOOK ON electronic components would begin with a chapter on wire and solder. Surely those things aren't actual components, are they? Yes, in a way they are. They are an essential part of every electronic circuit. If they are not properly selected and used, the circuit might not function as desired. Wire and solder might be rather mundane, but they are not unimportant topics.

The basics of wire

The main function of wire in an electric or electronic circuit is to conduct electricity from one place to another. Component leads are a form of wire. Often in practical circuits, some additional wire will be required. In some cases, wire might be used for physical reinforcement. Special types of wires are used to make lamp filaments, heating elements, wire-wound resistors (see chapter 2), and coils (see chapter 4).

Basically, a wire is a long, narrow cylindrical piece of conductive metal. Common metals used in wires include copper, silver, steel, iron, aluminum, and even gold. Most standard wire is made from copper because it is the most efficient conductor for a reasonable cost. In some cases silver or gold wires might do a better job than a copper wire, but such metals are far more expensive.

Insulation

Sometimes a wire will be bare, especially if it is used as a short jumper. In many practical cases, however, bare wires are highly undesirable. If two (or more) bare wires (including component leads) touch, a short circuit can occur. That is, the electrical current won't go where it's supposed to go, but instead it goes someplace where it is unwanted.

To prevent such shorts, most wires (especially if more than an inch or two long) are insulated. This means the conductive wire is enclosed in a nonconductive (insulator) shell. Rubber, certain types of fabric, nylon, and various plastics are often used as insulation on wires.

Remember, no practical insulator is perfect. If very large currents are flowing through a wire, some of the current can leak through the insulation. This is why it is dangerous to touch any ac power lines, even if they are insulated.

An insulated wire is first cut to length, then a small amount of insulation is stripped off the ends of the wire. Usually about 0.5 in. to 0.75 in. of insulation will be removed from each end. The bare end of the wire is used to make the appropriate circuit connection by soldering it in place. The insulation cannot be soldered. At best, it will just melt and make a mess. However, some of the melted insulation could easily get in the way of the desired joint connection, preventing good electrical contact. Some fabric insulations may be slightly flammable, while some plastics may cause dangerous fumes if they are melted.

There is one exception to this rule. Some wires used for wire wrapping (a specialized type of circuit construction) use a special vaporizing insulation. When heated, this insulation vaporizes into harmless fumes. A solder joint can be made in the middle of a length of wire. However, when in doubt, assume that the insulation must be removed before any soldering can be done.

Insulation can be stripped off of a wire with a pocket knife, but it is important to avoid nicking the wire. A nicked wire is mechanically weak and may break at the weakened point. Special wire-stripping tools are available. One of the most popular and inexpensive types of wire stripper is a very simple pliers-like device with notched shear-type blades. The wire is placed in the notch and the jaws of the tool are held closed as the wire is pulled through. The notch blades cut into the insulation and yank it off as the wire is pulled through the narrow notch. The notch can be manually set for various widths to accommodate different sizes of wire. Often it is necessary to use a pair of long-nose pliers to hold the wire securely with one hand, while using the wire stripper with the other hand.

A variation on this device is a combination tool used for both wire stripping and for crimping solderless terminals. Not unexpectedly, this more versatile tool tends to be a bit more expensive. There are some household uses for solderless connectors, so it might not be a bad investment.

The best and most efficient type of wire stripper is a rather nightmarish-looking pair of specialized pliers with a viselike arrangement in one set of jaws to hold the body of the wire and a set of knife edges in the other jaw with notches in them to fit different sizes of wire. When the handles of this tool are squeezed together, the wire is gripped snugly by the vise jaws and pulled away from the knife jaws, which cut into and neatly strip away the insulation. This type of semiautomatic tool is much more expensive than a simple manual wire stripper, but it is faster, more convenient, and does a better job. A semiautomatic wire stripper like this never nicks wires. It is also fascinating to watch it in action. The price range for such wire-stripping tools runs from about $7 to more than $25, depending on the size and sophistication of the design.

Some wires are insulated with a thin coating of enamel. Such wire is called enameled wire, for obvious reasons. This type of insulation is very inexpensive and doesn't add much to the diameter of the wire. Other types of insulation can be quite thick. Unfortunately, enamel insulation is much more difficult to remove than other forms of insulation. Wire strippers, like those described above, probably won't work very well, if at all. Usually the enamel must be scraped off the wire with a knife or razor blade.

Enameled wire is most often used in making coils (see chapter 4) and wire-wound resistors (see chapter 2) where many closely spaced turns of wire must be electrically insulated from each other. Other types of insulation might make the wire too thick for this purpose.

Wire sizes

Wire is available in a number of sizes. The size refers to the diameter of the conductor (without the insulation). The maximum current a given wire can safely carry is determined by the conductor material used and the diameter of the wire. Generally speaking, the thicker the wire (larger the diameter), the greater the maximum current flow the wire can handle. This makes sense—there's "more room" for electrons to flow through a thicker wire.

The diameter of a wire can be expressed in inches (usually fractions of an inch), millimeters, or some other linear unit of measurement. Because the wires used in most electronic circuits are so thin, a very useful linear unit of measurement is the mil. One mil is equal to 0.001 in., or about 0.0254 mm. The mil isn't in common use today, but you may encounter the term occasionally, especially in reference to wire sizes.

In most electronics work, however, the size of wire is defined by a standard gauge number. There are three wire gauge standards in common use. They are the American Wire Gauge, the British Wire Gauge, and the Birmingham Wire Gauge. In the United States, the American Wire Gauge is most commonly used. This standard is often abbreviated AWG.

AWG values range from 1 to 40. The larger the AWG number, the thinner the wire. Table 1-1 lists the diameters (in millimeters) for each of the 40 standard AWG sizes. The diameter refers to the actual conductor only. Any insulation layers are not included in the gauge size because the thickness of the insulation does not affect the wire's current-handling capability.

Assuming the conductor material is not changed, decreasing the AWG number indicates an increase in the current-handling capability. Thick wires have low AWG numbers, and thin wires have high AWG numbers. The odd-number AWG sizes don't seem to be in very widespread use.

For general purpose low-power electronics work, AWG 22 wire is often the best choice. It is light and flexible and doesn't eat up a lot of space, yet it is large enough to be sturdy and reliable. This size wire can also conduct a reasonable amount of current without problems.

For high-power applications, a heavier gauge wire may be required. Some electronic circuits may use AWG 20, AWG 18, AWG 16, or even AWG 14 wire.

Table 1 – 1 American Wire Gauge system sizes.

AWG number	Wire diameter (mm)	AWG number	Wire diameter (mm)
1	7.35	21	0.723
2	6.54	22	0.644
3	5.83	23	0.573
4	5.19	24	0.511
5	4.62	25	0.455
6	4.12	26	0.405
7	3.67	27	0.361
8	3.26	28	0.321
9	2.91	29	0.286
10	2.59	30	0.255
11	2.31	31	0.227
12	2.05	32	0.202
13	1.83	33	0.180
14	1.63	34	0.160
15	1.45	35	0.143
16	1.29	36	0.127
17	1.15	37	0.113
18	1.02	38	0.101
19	0.912	39	0.090
20	0.812	40	0.080

For very low-power applications, a thinner gauge wire may be used, particularly when the physical space of the circuit must be kept as compact as possible. Wire-wrapping wire is usually AWG 30.

In England and certain other countries the British Wire Gauge system is normally used instead of the AWG system. The abbreviation NBS SWG is commonly used to indicate the British Wire Gauge system.

Like the AWG system, the NBS SWG system employs 40 gauge sizes from 1 to 40. The conductor diameter decreases as the gauge number increases. Only the conductor diameter is measured. The thickness of the insulation (if any) is ignored in determining the gauge size.

The NBS SWG sizes are defined in terms of inches, rather than millimeters. This system is summarized in Table 1-2. The differences between the AWG and NBS SWG sizes are slight and can usually be ignored.

A third size system used in some parts of the world is the Birmingham Wire Gauge, abbreviated as BWG. Only 20 wire sizes (from 1 to 20) are identified in this system, which is summarized in Table 1-3.