With this book, you are about to begin your study of electronics. Your goal is no doubt a job and career in electronics. You could not have chosen a better career path. Not only is the electronics industry one of the largest, most dynamic and exciting, but also it can be one of the most lucrative. Jobs continue to be plentiful, and there is a lifetime of interesting jobs to be had. The electronics industry changes daily with a blizzard of innovative new products, components, technologies, and applications. This industry is one that will challenge you as well as keep you interested. This chapter introduces you to the industry, as well as to the jobs and the education you will need to succeed.

学习目标

在学习本章后，你应该能够：

- 列出电子行业的五大主要部门，并命名每个部门的三个例子。
- 命名电子行业中的两种主要工作。
- 描述你将为每种主要工作类型所需的专业教育。
- 命名让你的知识和技能在职业生涯中保持更新的那一件事。
- 列出电子行业的主要参与者以及它们如何相互作用。
- 解释所有电子电路可以表示的两种方式。

Chapter 1
Survey of Electronics
1.1 Life Impact
Just so you understand how important electronics is to our lives, take a minute and think about how electronics affects you personally. As a starting point, do the following:

- Make a comprehensive list of all the electronic products and services you own and use daily. Do it now.
- Make an hour-by-hour diary especially identifying things you do with electronics daily. Again, do it now.

Now, study your results. Are you astonished? Electronics is so pervasive that we simply take most of it for granted. It just is. We are not surprised or amazed anymore by even the most sophisticated electronic devices although we use them and perhaps covet some of them. And even common everyday appliances are loaded with electronics.

Now think about where all that equipment comes from. Someone has to design and build it, sell it, install it, and otherwise support it. And it must usually be operated, maintained, and serviced later. Lots of job opportunities are involved. Electronics is fun and interesting, and many engage in electronics as a hobby. Maybe that is how you became interested in electronics. Electronics is a great hobby because it helps you learn while having fun. Table 1-1 lists the most popular electronic hobbies. If you do not have an electronics hobby, you should consider starting one, as it is engaging, challenging, and educational. And more often than not your hobby becomes your career.

1.2 Major Segments of the Electronics Industry
The electronics industry is enormous and diverse. One estimate has the total of all electronic goods sold annually worldwide at over $1.5 trillion. And the industry continues to grow under the toughest economic conditions, attesting to its diversity and importance in our lives. To get a handle on how the industry is structured, it is best to divide it into segments, or areas of specialization. Then you can see how they are all interrelated. The five major divisions are components, communications, computers, control, and instrumentation. See Fig. 1-1. All electronic equipment and applications fall into one of these sectors if not several.

**Components**
Components are the individual parts that make up all circuits and equipment. These include resistors, capacitors, inductors, transformers, connectors, wire and cable, and printed circuit boards. The largest segment of the components field is semiconductors like integrated circuits (chips), transistors, diodes, solar cells, and many other specialty parts. These parts are used by the engineers to design all types of electronic equipment.

**Communications**
The oldest and one of the largest segments of electronics is communications. It began with the telegraph and telephone in the mid- to late 1800s. In the early 1900s, radio was developed, then the vacuum tube came along and the rest as they say is history. It was specifically the vacuum tube that created the electronics industry as we know it today. The vacuum tube brought us amplification and electronic switching, neither of which existed in the telegraph and telephone. Later on we got TV, satellites, and many other communications applications. Broadcast radio and TV dominated the early years, then two-way radio became commonplace, and radar was invented during World War II.

<table>
<thead>
<tr>
<th>Table 1-1 Popular Electronic Hobbies</th>
</tr>
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<tbody>
<tr>
<td>1. Amateur radio. Amateur radio operators, or hams, build and operate radio equipment to make contact with other hams to exchange signal reports, technical information, and personal experiences. A Federal Communications Commission (FCC) license is required.</td>
</tr>
<tr>
<td>2. Computers. Computer hobbyists build personal computers, write programs, work with peripheral equipment, interface computers to other gadgets, and boost computer performance. Software and programming are a major part of this hobby.</td>
</tr>
<tr>
<td>3. Robots. Building and experimenting with robots has become a huge hobby in the past few years.</td>
</tr>
<tr>
<td>4. Model radio control. Building model airplanes, boats, cars, and other objects that can be controlled remotely by radio will also get your outdoors.</td>
</tr>
<tr>
<td>5. Audio. Building and experimenting with high-fidelity stereo and surround sound equipment, speakers, and music is popular. Electronic music instruments and sound systems are also a part of this hobby.</td>
</tr>
<tr>
<td>6. Home entertainment centers. Building and using high-definition television and audio systems are indoor hobbies. Cable TV, satellite TV, Internet TV, wireless connectivity, gaming, and 3D TV are popular elements of this hobby.</td>
</tr>
<tr>
<td>7. Home monitoring and control. Electronic components and systems to monitor and control heating and air conditioning, lighting, appliances, and electrical systems (sprinklers, garage doors, security, etc.) provide energy savings, safety, and convenience.</td>
</tr>
<tr>
<td>8. General experimenting. Curiosity can lead to kit building, miscellaneous projects, and experimentation with various electronic gadgets and equipment.</td>
</tr>
</tbody>
</table>
Communications refers to all the various types of wired and wireless technologies you use every day. Typical wired technologies include cable TV, computer networks, the telephone system, and the Internet. Typical wireless communication technologies include radio of all types, including broadcast and two-way radio, cell phones, satellites, and wireless networks. Today the communications industry continues to dominate with the huge telecommunications system, the Internet and networking, and of course the huge wireless industry with its cell phones, wireless networks, and links of all kinds. Leading the industry is the smartphone like the Apple iPhone and others that are not only phones but also full-blown computers in a handset with Internet access and other communications features.

Computers

Computers didn’t really come along until World War II and later. And these were the huge vacuum tube monsters called mainframes. Transistors and integrated circuits made them smaller, faster, and better. During the 1970s, thanks to digital integrated circuits (ICs), we got the minicomputers. Then later in the 1970s the microcomputer was created. This put most of a computer’s circuitry on a single chip of silicon. Called a microprocessor or central processing unit (CPU), it formed the basis for newer personal computers. They created a whole new industry making computers available and affordable for everyone. Today, PCs, laptops, and tablets are as common as the TV set.

The computer segment encompasses an enormous range of different types of computers. Computers process data. The largest and most powerful (meaning fast with lots of storage) computers are known as supercomputers that solve massively difficult scientific, engineering, and mathematical problems. Other large powerful computers are the mainframes that still serve the data processing needs of large business and government. Small but very powerful computers known as servers are the workhorse of our computer networks, from the Internet to local area networks to which most computers are connected today. The personal computer is probably the most visible and widespread. Laptop computers have now passed desktop personal computers in total volume of computers shipped. The tablet market is also growing, taking market share from laptops.

But the real breakthrough was the single-chip computer with the processor, memory, and input/output circuitry in one integrated circuit. This device, called an embedded controller or microcontroller, permits the power of a computer to be packaged into other electronic devices, expanding their functionality, versatility, and power. Today, virtually every electronic product in existence contains an embedded controller as its central control point. These small computers handle all monitoring and control functions in cell phones, TV sets, DVD players, and MP3 music players. In fact, you can say that every electronic piece of equipment made today is simply an embedded microcontroller surrounded by peripheral devices that perform the functions of the equipment.

This puts computers everywhere, in our cars, consumer electronics products, and appliances. It is impossible to name an electronic product that does not contain one. As you will find out, all electronic products are mainly an embedded controller surrounded by other circuits that customize it to the specific application.

The computer part of the electronics industry is also huge but dispersed. And with computers readily available in all forms from mainframes to PCs and to micros on a chip, the focus in the industry has turned to software. Software is the
term used to describe the programs that a computer uses to perform as desired. There continues to be a great demand for people who can program computers.

Control
Control is a huge and diverse part of electronics. Think of electronics as that field of science that is used to monitor and control physical functions. Monitoring means observing and measuring physical things like temperature, pressure, mechanical position, liquid level, or light intensity. Sensors turn these physical characteristics into electrical signals that can be processed by electronic circuits. We may want to record the physical phenomena or, better still, use the information they provide as signals to tell electronic circuits what to do. That is the control part.

Control is simply the execution of various duties with electronic circuits. Some common control functions are turning lights off or on, turning motors off or on, operating pumps or valves, or controlling the transmission of data over a network.

Electronic controls are everywhere, in home appliances, cars and trucks, vending machines, military weapons, aircraft of all types, and most factories. Think of robots, garage door openers, traffic lights, remote keyless entry on a car, and the autopilot on an unmanned aerial vehicle (UAV). The examples are broad and diverse.

Monitoring and control is a very large segment of electronics involved in performing monitoring operations of various physical characteristics. Components called sensors or transducers are used to measure temperature, light intensity, pressure, and literally hundreds of other physical characteristics. These measurements are then used in control systems to activate appliances, robots, chemical plants, automotive systems, and hundreds of other devices. The signals being monitored are processed in various ways, and embedded controllers or computers produce outputs that control other devices, such as factory automation, manufacturing plants, security systems, appliances, and toys.

Instrumentation
Instrumentation is that segment of electronics involved with testing electronic circuits and equipment or other equipment using electronics and in making precise measurements of electrical and electronic signals. Working in electronics, you will eventually use a wide variety of electronic test instruments like multimeters, oscilloscopes, signal generators, and analyzers of all sorts. You cannot design, build, troubleshoot, or service electronic equipment without the need to measure voltage, current, power, frequency, or other electronic characteristics.

Instrumentation and measurement relate to precisely and accurately measuring electronic characteristics. One of the largest categories is test equipment, such as meters, oscilloscopes, signal generators, spectrum analyzers, and other general-purpose instruments that are used to test and measure all other electronic equipment. Test systems used for automated component or equipment testing for complete systems also fall into this category.

Instrumentation and measurement also include the category known as data acquisition, by which systems are used to collect data from a variety of sensors and other sources. A major segment of instrumentation and measurement is medical diagnosis and testing. Medical instruments measure EEG, EKG, temperature, blood characteristics, and chemical compositions and include MRI, CT, and x-ray machines.

Some examples of instrumentation besides generic test equipment are the instruments in a jet aircraft, the electronics in a chemical or process control plant, or an automated test system for cell phones.

1.3 A Converged Industry
As you can see, the electronics industry is enormous and diverse. Yet all these segments of electronics have a significant impact on our lives. They provide us with instantaneous information and communications, speed up and simplify our work with computers, and protect us at home and office.

While we still view electronics as being comprised of these basic sectors, as you can easily see, there are lots of crossovers and overlaps. The different segments converge in different devices and applications. Tablet computers contain wireless transceivers to connect to hot spots or the cellular network, and iPods and MP3 music players contain a control computer and lots of memory to store songs. Factory automation and control systems contain instrumentation, computers, and networking for communications. And almost everything contains an embedded controller. Home appliances like washers, dryers, refrigerators, dishwashers, blenders, toasters, coffeemakers, and most others are all loaded with electronic controls. Our consumer entertainment equipment like HD TV sets, DVD players, cable and satellite TV sources, stereo audio systems, and others are totally electronic. The modern automobile contains an ever-increasing number of electronic components, control systems, and safety features. It is difficult to name something today that does not include some electronic segment. Nevertheless, it is still best to keep these divisions separate in your mind as you decide what interests you most and how you wish to focus in your electronics career.

1.4 Jobs and Careers in the Electronics Industry
As you saw in the previous section, the electronics industry is roughly divided into five major specializations. The largest in terms of people employed and the dollar value of equipment
purchased is the communications field, closely followed by the computer field. The components, industrial control, and instrumentation fields are considerably smaller. Hundreds of thousands of people are employed in these fields, and billions of dollars’ worth of equipment is purchased each year. The growth rate varies from year to year depending on the economy, technological developments, and other factors. All segments of electronics have grown steadily over the years, creating a relatively constant opportunity for employment. If your interests lie in electronics, you will be glad to know that there are many opportunities for long-term jobs and careers. This section outlines the types of jobs available and the major kinds of employers.

The two major types of technical positions available in the electronics field are engineer and technician.

**Engineers**

Engineers design electronic components, equipment, and systems. Engineers work from specifications and create new components, equipment, or systems that are then manufactured. For example, some engineers specialize in integrated circuit design. They use sophisticated computer software called electronic design automation (EDA) to create the detailed circuits that ultimately become the chips making up the electronic equipment we use. Other engineers use the chips and other components to design the electronic end products like cell phones, DVD players, network routers, industrial controllers, or medical instruments like a pacemaker.

But while most engineers specialize in design, others work in manufacturing, testing, quality control, and management, among other areas. Engineers may also serve as field service personnel, installing and maintaining complex equipment and systems. If your interest lies in the design of electronic equipment, then an engineering position may be for you.

It is important to note that what engineers do is design and analyze. They use their heavy math and science knowledge to model electronic circuits and systems and use computer software to simulate the behavior of circuits, equipment, and systems. While engineers do indeed work with the end products they design and analyze, mostly they work at this higher abstract level.

**Technicians**

Technicians are most often employed in service jobs. The work typically involves equipment installation, troubleshooting and repair, testing and measuring, maintenance and calibration, or operation. Technicians in such positions are sometimes called field service technicians, field service engineers, or customer representatives. Today, the jobs for technicians are so diverse that the generic term electronic technician is rarely used. When you are looking for a job as a technician, you need to look at not only the job titles given above but also those using the terms mechanic, installer, associate, assistant, assembler, manufacturing tester, troubleshooter, and similar titles.

Technicians can also be involved in engineering. Engineers may use one or more technicians to assist in the design of equipment. They build and troubleshoot prototypes and in many cases actually participate in equipment design. A great deal of the work involves testing and measuring. In this capacity, the technician is known as an engineering technician, lab technician, engineering assistant, or associate engineer. Engineering technician positions were once widely available, but because of the widespread use of ICs and design software, engineers rarely need technicians to the extent they once did. Engineering technician jobs are rarely available today.

Technicians are also employed in manufacturing. They may be involved in the actual building and assembling of the equipment but, more typically, are concerned with final testing, measurement, and quality assessment of the finished products. Other positions involve quality control or repair of defective units. Online and telephone help and support is another common opportunity.

Technicians are the hands-on electronic workers. Their duties involve the equipment and systems and their service, installation, maintenance, calibration, and repair. Technicians do not design or do any significant amount of analysis. Therefore, their knowledge of math and science does not have to be as great as that of an engineer. Practical hands-on job training, work experience, and specific equipment or system training are far more important.

**Other Technical Positions**

There are many jobs in the electronics industry other than those of engineer or technician. For example, there are many outstanding jobs in technical sales. Selling complex electronic equipment or systems usually requires a strong technical education and background. The work may involve determining customer needs and related equipment specifications, writing technical proposals, making sales presentations to customers, and attending conferences and exhibits where equipment is sold. The pay potential in sales is generally much higher than in the engineering or service positions.

Another position is that of technical writer. Technical writers generate the technical documentation for electronic equipment and systems, producing installation and service manuals, maintenance procedures, and customer operations manuals. Most of this material is web-based today. This important task requires considerable depth of education and experience as well as a knack for writing, organizing, and categorization.
Finally, there is the position of trainer. Engineers and technicians are often used to train other engineers and technicians or customers. With the high degree of complexity that exists in electronic equipment today, there is a major need for training. Many individuals find education and training positions to be very desirable and satisfying. The work typically involves development of curriculum and programs, generating the necessary training manuals, presentation materials and lab exercises, creating online training, and conducting classroom training sessions in-house, online, or at a customer site.

1.5 Engineering and Technology Education

To get a good job in electronics today, you need some formal postsecondary education at a college or university. This education varies widely with the type of job but can be categorized as engineering education or technology education. They are similar because they both involve electronics, but they are not the same simply because the jobs they prepare the graduates for are so vastly different and require different levels of knowledge and skills. Education is essential to being successful in getting a job in electronics, but it is also the one single ingredient of continuing success in the field. Continuing personal education is the key to staying on the top of your job and field.

Engineering Education

Engineers need a bachelor’s (BSEE), master’s (MSEE), or doctoral (PhD) degree in electrical or electronic engineering. Figure 1-2 shows the general paths through college to a job. Such an education starts with a strong science and mathematics background, including physics, chemistry, calculus, statistics, and other advanced math courses. This is followed by specialized education in electronic circuits and equipment. The education is largely design- and analysis-oriented with an emphasis on computer simulation and software development.

Some jobs require additional education beyond the bachelor’s degree. Figure 1-2 shows the path to graduate school that may include more advanced electrical or electronic courses leading to a master of science in electrical engineering (MSEE) degree. This prepares you for more advanced jobs with better pay. An alternative path is to pursue a master in business administration (MBA) degree. Some BSEE graduates find that their greater interest lies in the business side of the industry, such as finance, economics, marketing and sales, or management.

A doctorate degree or doctor of philosophy (PhD) is an advanced degree usually with a specialization in one specific area of electronics. It is the path to take to emphasize research or teaching.

Some engineers have a bachelor’s degree in electronics technology from a technical college or university. Some typical degree titles are bachelor of technology (BT), bachelor of engineering technology (BET), and bachelor of science in engineering technology (BSET).

Bachelor of technology degrees often begin with a two-year associate degree program followed by two additional years required for a bachelor of technology degree. During those last two years, the student takes more complex electronics courses along with additional science, math, and humanities courses. The main difference between the BT graduate and the BSEE engineering graduate is that the technologist usually takes courses that are more practical and hands on than engineering courses. Holders of BT degrees can generally design electronic equipment and systems, but do not typically have the depth of background in analytical mathematics or science that is required for complex design jobs. However, BT graduates are generally employed as engineers. Although many do design work, others are employed in engineering positions in manufacturing and field service rather than design.

Although a degree in electrical engineering is generally the minimum entrance requirement for engineering jobs in most organizations, people with other educational backgrounds (e.g., physics and math) also become engineers. Technicians who obtain sufficient additional education and appropriate experience may go on to become engineers as well.
Technology Education

Technology education is usually less stringent in the areas of math and science and more practical than engineering education. Usually less education is required to be a technician than an engineer. Engineers do far more math, design, and analysis, making their jobs far more mental. Technician jobs do not require the heavy math, science, and analytical background, but they do require clear logical thinking as well as good hands-on skills.

Technicians have some kind of postsecondary education in electronics, from a vocational or technical school, a community college, or a technical institute. The typical technology education paths are illustrated in Fig. 1-3. Many technicians are also educated in military training programs. Most technicians have an average of two years of formal post-high school education and an associate degree. Common degrees are associate in arts (AA), associate in science (AS), or associate of science in engineering technology (ASET) or associate of science in electronic engineering technology (ASEET), and associate in applied science (AAS). The AAS degree tends to cover more occupational and job-related subjects; the AA and AS degrees are more general and are designed to provide a foundation for transfer to a bachelor degree program. The math level is typically algebra and trigonometry, rather than calculus although some AAS programs may require an introduction to calculus. As for science, AAS programs do not commonly require engineering-level physics or chemistry although some introductory courses may be included.

Technicians with an associate degree from a community college can usually transfer to a bachelor of technology program and complete the bachelor’s degree in another two years. Just keep in mind that associate degree holders are usually not able to transfer to an engineering degree program. If you decide to become an engineer, you must literally start over at an engineering school because of the big differences in math and science backgrounds needed. That is a choice few make because the BSET degree is far faster to achieve and the chance of working as an engineer just as good in most cases.

Many BSET graduates do go on to some kind of engineering job. Another path is an MBA degree if a business slant to your education is desired. Another alternative is a master in technology (MT) degree, which is available at a limited number of colleges and universities. Such degrees generally focus on teaching or some specialty subject.

Continuing Education

Continuing education refers to the education you obtain after graduating from college. And don’t think it is not necessary. You should know up front that you cannot survive in the field of electronics without a continuous process of personal self-education. Electronics changes fast and furiously. New components, products, technologies, and methods are developed daily, and all have an impact on how products are designed and used. Usually what was current yesterday is often obsolete tomorrow. You always need to know the latest products and techniques to stay competitive in your job. When you enter the electronics field, consider the fact that you will immediately need to engage in some form of continuing education as soon as possible. The half-life of an engineering or technology degree is only a few years today, meaning that within those few years, half of what you learned will be obsolete or irrelevant. That may be depressing to some extent, but think of the bright side. Learning new stuff is fun, and that is half the excitement with electronics.
There is always something new, interesting, and exciting to learn and get involved with. Besides learning more usually means earning more.

Where do you get continuing education? Outlined below are the most common sources that most engineers and technicians use today.

**Advanced Degrees**

If you have an AAS degree, think of going back to school to get a BSET degree. If you live near a college or university that will accept your previous college work, you are generally halfway to the bachelor’s degree anyway. Maybe you can even complete the degree at night, and amazingly many employers will help you pay for that.

If you already have a bachelor’s degree, think of going for a master’s degree. Your BSEE or BSET will lead you to an MSEE or MT as described earlier.

A good option for both BSEE and BSET degree holders is a master of business administration (MBA). If you decide you like the business side of electronics more than the technical side, this is a good choice. You can parlay that degree into very high end marketing, financial, or management positions.

A PhD is the ultimate degree in engineering, but it is rarely worth the long process and very high cost. If you plan to teach engineering or do advanced research, then you will need it, of course. For most good jobs a master’s is more than enough today.

**Alternative Forms of Education**

In addition to adding a degree, there are other methods for continuing education or staying current.

**University Courses** Sometimes you only need to take a course here or there to learn what you need. You can take regular university courses toward a master’s degree or university-sponsored continuing education courses.

**Seminars** Many companies offer specialized seminars. Such seminars last from two days to a week and focus on a specialty like programming skills, RF design, or computer networking. You will have to ferret these out for yourself with Internet searches or magazine announcements, but often they will be just what you need on the job. Many employers will pay for them.

**Company-Sponsored Classes** Many larger companies offer internal courses for their employees. Training employees helps the company. You should take as many of these as you can, depending how relevant they are to your situation and available time.

**Webinars** Webinars are online seminars. They consist of a presentation over the Internet via PC and sometimes a telephone connection for audio. They are like a lecture and typically run about an hour. The subject is very focused, but there are lots of them online. Many are sponsored by companies which want to promote the use of their products in new designs. These are mostly free, so do as many as time allows, assuming they are relevant.

**Books** Books are still a good choice for self-education. You rarely need to read the entire book anyway. Mostly if you can find the books related to the subject you want to read, you will buy them for reference and specific knowledge. Check out your local bookstore and especially the college bookstore for relevant materials. Also search for the books you want online by going to sites like Amazon or Barnes & Noble. Go directly to technical book publishers websites to see what is available. Some good technical book publishers are Artech House, Elsevier, McGraw-Hill, Morgan Kaufman, Newnes, Prentice Hall, and Wiley. Also look for good used books to save a few dollars.

**Magazines** There are lots of electronic magazines written for engineers and technicians. These are what are called controlled circulation magazines or business-to-business (B2B) magazines. They are free to the subscriber and are paid for by advertisers who want to get their products in front of a targeted audience like engineers. These magazines come out at least monthly and sometimes two times a month. Many also include online newsletters weekly. These magazines have in-depth technical articles, new product information, and a whole range of business- and technology-related information. Subscribe and read them regularly. Some popular electronic magazines for engineers are *Electronic Design, EDN, EETimes,* and *Electronic Products.* The *IEEE Spectrum* is a great magazine, but it does require that you be a member of the Institute of Electrical and Electronic Engineers (IEEE), a professional association you should eventually look into after graduation.

Don’t forget the hobby-oriented electronic magazines. These are excellent on the practical side as they cover not only theory and practice but often include construction projects. A couple of popular electronic magazines are *Circuit Cellar, Elektor, Make,* and *Nuts & Volts.* Amateur radio magazines like *CQ, QEX,* and *QST* are also excellent sources of new learning. These are paid subscriptions but worth the price.

**The Internet** If you ask any working engineer or technician how and where he or she learns new stuff, their first answer is usually, “The Internet.” The Internet offers a huge worldwide source of information and learning materials. And it is free in most cases. All you have to do is search for it. You have probably already done some of this so it may already be second nature. Just type in what you want to know; do a Google, Yahoo, or Bing search; and within seconds you will
The Federal Communications Commission (FCC) also offers its popular general radiotelephone operators license (GROL) that is obtained by passing a comprehensive exam on electronic fundamentals, communications techniques, and FCC rules and regulations. It is required for working on certain types of radio equipment but is also useful as a job-getting credential. There are also many specialty certifications in the fields of communications and industrial control. After you get your AAS degree, a good next step is a license or certification that will go a long way to giving you new knowledge as you prepare for the exams but also a great credential that is appreciated by many employers.

Hobby and Personal Experimentation

Finally, don’t forget that just enjoying electronics as a hobby can lead to learning and experience. While you cannot really document such involvement or claim it as experience, the knowledge and skills you gain are invaluable and show up in your work. So don’t hesitate to build your own lab bench and build kits and things of your own design. Become involved with embedded controllers, personal computers, robots, radio, audio, video, or whatever interests you.

1.6 The Major Employers

The overall structure of the electronic industry is shown in Fig. 1-4. The four major segments of the industry are manufacturers, resellers, service organizations, and end users.

Manufacturers

It all begins, of course, with customer needs. Manufacturers translate customer needs into products and purchase components and materials from other companies to use in creating the products. Note that there are three types of manufacturers: component, equipment, and system manufacturers. Component manufacturers buy the raw materials like copper and other metals, plastic, and chemicals to create the

Manufacturers Resources

Component and equipment manufacturers want you to buy their products, so they offer tons of literature to help sell them. Most of this is on the Internet, but some is available in hard copy like data sheets, brochures, reference manuals, books, or other literature, usually free for the asking. Then there are the usual massive databases on their websites. Most offer product data sheets, application notes, white papers, and tutorials—all available for free. Here is one other resource you can begin using to educate yourself.

Licensing and Certification Programs

There are numerous programs that offer to prepare you for a wide range of certifications, licenses or registration. Engineers can seek registration in their state as a professional engineer (PE). You have to be a BSEE graduate, have a certain number of years of experience as an engineer, and pass a rigorous exam. It is a tough process, but you learn a great deal in the process of preparing. Having a PE license opens new doors of employment and higher pay. For most jobs a PE license is not required.

There are similar programs for technicians. Numerous organizations offer certification programs that examine your knowledge and experience to certify you as knowledgeable and proficient in your field. Generic certifications are offered by organizations like the International Society for the Certification of Electronic Technicians (ISCET) and the Electronic Technicians Association–International (ETA-I).
various resistors, capacitors, inductors, and transformers. Semiconductor manufacturers buy silicon and other materials like germanium, gallium, arsenic, phosphorus, indium, and other chemicals to make the transistors, diodes, and integrated circuits.

Then there are the equipment manufacturers that make complete products, which may be computers, cell phones, TV sets, cable boxes, military radios and radars, or automobile components like ignitions, fuel injectors, and fuel control computers. You will often hear these companies referred to as original equipment manufacturers (OEMs). Engineers design the products and manufacturing produces them. There are jobs for engineers, technicians, production workers, salespeople, field service personnel, technical writers, and trainers.

The final category is system manufacturers or integrators that put together larger, more complex systems like processes controls for petroleum processing, military aircraft, or satellite systems like GPS. Other system examples are air traffic control, broadband Internet access, wireless base stations, and electrical utility monitoring and control. Again, there are many jobs for engineers and technicians.

**Resellers**

Manufacturers that do not sell products directly to the end users sell the products to reselling organizations, which in turn sell them to the end user. For example, a manufacturer of marine communication equipment may not sell directly to a boat owner but instead to a regional distributor or marine electronics store or shop. This shop not only sells the equipment but also takes care of installation, service, and repairs. A cellular telephone or copy machine manufacturer also typically sells to a distributor or dealer that takes care of sales and service. Most of the jobs available in the reselling segment of the industry are in sales, service, and training.

Other sales organizations are sales representatives that sell components or equipment, or system integrators that buy equipment from others and assemble it into a more complex system for a specific application.

**Service Organizations**

These companies usually perform some kind of service, such as repair, installation, or maintenance. One example is an avionics company that does installation or service work on electronic equipment for private planes. Another is a systems integrator, a company that designs and assembles a piece of communication equipment or more often an entire system by using the products of other companies. Systems integrators put together systems to meet special needs and customize existing systems for particular jobs. Best Buy and similar retail organizations also perform service and repair.

**End Users**

The end user is the ultimate customer—and a major employer. Today, almost every person and organization is an end user of electronic equipment. The major categories of end users are:

- Consumers
- Government (national, state, county, and city)
- Military
- Transportation (airlines, railroads, trucking, and shipping)
- Education (schools, colleges, and universities)
- Hospitals and health care organizations
- General business
- Industry, manufacturing, process control, and automation.
- Telecommunications (telephone, broadcast, satellite, cellular, and networking)

What you will most likely find is that most of the good electronic technician jobs are not directly in the electronics industry itself but in the end user category.

**1.7 Where Are You Headed?**

Hopefully this chapter has given you some ideas and at least a working knowledge of the industry. And if you did not have any idea of what you wanted to do in electronics, perhaps you now have a better feel for what is available and what you may be doing on the job. If not, then continue to explore the field on your own, so when you do graduate from college, you will have a starting point. Once you get some real-world experience, you may want to change and you will readily identify new jobs and opportunities as you work.

One key to success in electronics is to find the most promising emerging technologies and find or prepare for jobs in those areas where the growth will be greatest. When growth is fast, many jobs open up as do opportunities for learning and advancement. Some of the more promising areas offering potential future growth are:

- **Alternative energy.** Solar, wind, geothermal, and other so-called green energy jobs are sparse now but slowly increasing and will ultimately offer some interesting new opportunities.
- **Biomedical.** The health care industry is huge and still growing. Electronic equipment is an enormous part of this industry.
- **Wireless.** The cellular industry continues its amazing growth with many opportunities.
- **Broadband Internet connectivity.** Cable TV and broadband wireless services are also growing. Fiber optics is a continuing growth area.
• Electric utilities. Retiring baby-boom generation personnel are leaving this legacy field wide open. The emergence of the smart grid and alternative energy sources makes electric utility jobs more exciting than ever.

1.8 How Electronic Equipment and Circuits Work

The study of electronics is one of learning electrical theories, electronic device characteristics, and circuit operation. But before venturing into those details, here is a simplified overview of how all electronic gadgets work.

Figure 1-5 shows the big picture. It is a relatively simple concept overall but becomes more complex as you dig deeper into the various elements. Inputs that are electrical signals representing some type of information—such as voice, video, sensor data, computer data, or other intelligence—are applied to circuits or equipment to be processed. These signals are voltages. A voltage is an electrical quantity that causes current to flow. The overall goal in electronics is to create the input voltages and then process them into other voltages called outputs. The result is some useful end result.

The processing takes many forms. Some common processes are amplification, attenuation, filtering, computation, conversion, decision making, interpretation, or translation. The process then generates new output signals that do something useful.

A simple example is given in Fig. 1-6. This public address system allows sound to be distributed over a wider area than that normally covered by a human voice. A person speaks into a microphone. The microphone is a sensor that generates electric voltage that represents the voice. The voice voltage is amplified by several amplifier circuits, and a larger stronger voice signal is generated. This output signal is applied to one or more speakers. The speaker is a transducer that converts the signal into sound waves.

Another example is shown in Fig. 1-7. A compact disc (CD) player gets its inputs from a compact disk which has embedded music or other sounds. A laser light is shined on the bottom of the spinning CD, and reflections from the embedded music produce digital or pulse signals in the photo detector. These signals are then amplified, converted, and translated into the audio signals that drive the speakers or headphones. A DVD player works the same way, although the information on the DVD disc includes video and audio. The outputs are audio to speakers and video to a liquid-crystal display (LCD) or other TV screen.

A computer or laptop is a good example. See Fig. 1-8. The inputs to the computer are voltages developed from keyboards, mouse, disk drives, digital cameras, microphones, video cameras, or the Internet. These inputs are stored in a memory and processed by the computer in some way. The processing is defined by software. Software consists of many programs that define how to process the inputs and create new outputs. These programs are also stored in a memory. The computer then generates output signals that drive the LCD screen, speakers, disk drives, a printer, or other peripheral device. The computer also works with modems and interfaces to connect to networks and the Internet. The diagram in Fig. 1-8 is also representative of the new tablet computers.

An industrial control example is given in Fig. 1-9. A tank holds a liquid for some type of chemical process that is part of manufacturing an end product. The liquid must be kept at a specific temperature, so a heating element is attached to the bottom of the tank and a temperature sensor is used to...
Another way to view electronic circuits is shown in Fig. 1-10. It begins with a voltage source. Remember that a voltage is a form of electric energy that causes current to flow. The measure the temperature. The tank also has an output valve that can be opened to allow the liquid to pass on to the next process. An input valve lets more liquid into the tank as it drains. A liquid-level sensor is used to detect when the tank is full.

In this example, the inputs come from the temperature sensor and liquid-level sensor. The outputs are the heating element, input valve, and the output valve. These inputs and outputs attach to a computer or some specialized control circuit. If the liquid-level sensor detects that the tank is not full, it tells the control circuit to open the input valve and let the liquid in. The input valve is closed when the tank is full. The process here is decision making based on the liquid level.

When the tank is full, the controller next reads the temperature. If the liquid is not hot enough, it generates a signal that turns on the heating element until the desired higher temperature is reached. The control circuits turn off the heater. Finally, a signal to the output valve opens it to let the liquid flow to the next stage of the process. All the processing is built into a program in a computer or an electronic circuit.

Figure 1-10 An electric current model of electronics.
A voltage is an input. Current is electrons, subatomic particles that move through wires and electric components. The current flows through a load that produces the desired output. Some form of control element or circuit is used to vary the current in some way to produce the desired output. Another input causes the desired control. As indicated earlier, the whole objective of electronic circuits is to use a voltage to create current that is then controlled in a specific way to produce an output in the load.

Some simple examples are given in Fig. 1-11. Figure 1-11a shows a flashlight. The voltage comes from a battery. The load is a light-emitting diode (LED). A simple on-off switch is the control element. In Fig. 1-11b, the standard alternating current (ac) voltage from a wall outlet is the voltage source. The load is the motor on an electric drill. The speed is controlled by an electric circuit that varies the current in the motor.

While these are simple examples, they illustrate the concept. Remember, all electronic circuits operate this way. And electronic equipment is made up of many such circuits operating concurrently to do more complex things.

**CHAPTER 1 REVIEW QUESTIONS**

1. Which of the following is not one of the major segments of electronics?
   a. Medical electronics.
   b. Communications.
   c. Instrumentation.
   d. Computers.

2. Which of the following is the oldest segment of electronics?
   a. Control.
   b. Communications.
   c. Instrumentation.
   d. Computers.

3. Which of the following is the largest segment of electronics?
   a. Components.
   b. Communications.
   c. Instrumentation.
   d. Control.

4. Which of the following is not used in military electronics?
   b. Communications.
   c. Control.
   d. All are used.

5. An integrated circuit is a component.
   a. True.
   b. False.

6. The duties of a technician do not usually involve
   a. troubleshooting.
   b. installation.
   c. analysis and design.
   d. equipment testing.

7. The main duties of an engineer are
   a. equipment maintenance.
   b. troubleshooting.
   c. design and circuit analysis.
   d. equipment operation.

8. An engineer requires at least which degree for a job?
   a. Associate’s.
   b. Bachelor’s.
   c. Master’s.
   d. PhD.

9. The primary degree of technician jobs is the
   a. associate’s.
   b. bachelor’s.
   c. master’s.
   d. high school’s.
10. A core difference between technician and engineer education is primarily
   a. the humanities.
   b. management training.
   c. math and science.
   d. electronics.

11. A graduate with an AAS degree in electronics technology can transfer directly to a BSEE program.
   a. True.
   b. False.

12. What must you do to stay competent and employable electronics?
   a. Get a master’s degree.
   b. Work more than three jobs in your career.
   c. Find a mentor.
   d. Engage in some form of continuing education.

13. Which of the following is not a type of process that an electronic input signal may encounter?
   a. Stretching.
   b. Amplification.
   c. Filtering.
   d. Conversion.

14. The result of electronic processing is
   a. new inputs.
   b. removal of inputs.
   c. new outputs.
   d. a change in process.

15. What causes current to flow?
   a. Electric power.
   b. Voltage.
   c. Electrons.
   d. Magnetism.

16. Current flow is
   a. like atoms in motion.
   b. molecules.
   c. liquid atoms.
   d. moving electrons.

17. Which is not a major part of a simple electrical system?
   a. Load.
   b. Control element.
   c. Voltage source.
   d. Protection device.

18. What is a good supplement to an AAS degree in getting a job in electronics?
   a. A second AAS degree.
   b. A license or certification.
   c. A bachelor’s degree.
   d. Any job experience.

19. A BSET degree is considered as part of which field of education?
   a. Technology.
   b. Engineering.
   c. Business.
   d. Science.

20. What is your best immediate source of learning in electronics?
   b. Magazines.
   c. The Internet.
   d. Other people.

CHAPTER 1 ESSAY QUESTIONS

1. What do you think is the single most important electronic invention?
2. What is your favorite electronic product?
3. What electronic product could you not do without?
4. Of the major segments of electronics, which interests you the most?
5. Would you rather be an engineer or a technician? Why?
6. Do you prefer hands-on work with electronic equipment or more abstract thinking about and analyzing of electronic products?
7. Does the business side of electronics (finance, accounting, economics, marketing, management, etc.) interest you? Why?
8. Which of the newer growth segments of electronics interests you most? Why?
9. Name the inputs, outputs, and main processes that take place in a smartphone like an Apple iPhone.
10. What is your main goal in pursuing a career in electronics? A good job, money, interest, security, fascination, contribute to society, or what?
11. What is your electronic hobby?
12. What hobby would you like to pursue?