ELECTRICITY AND ELECTRONICS

SECOND EDITION

REX MILLER
FRED W. CULPEPPER, JR.

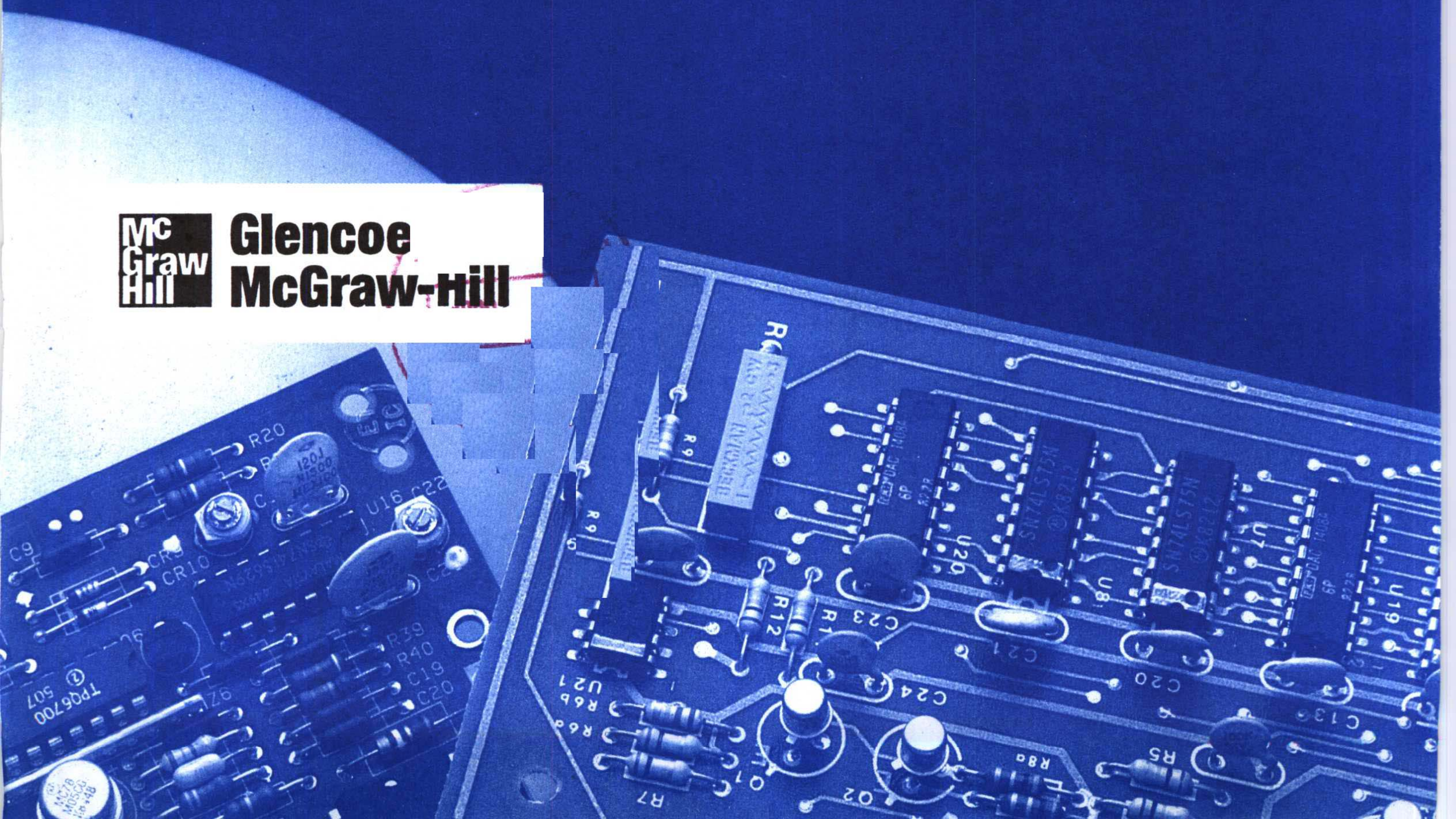
ELECTRICITY AND ELECTRONICS

SECOND EDITION

REX MILLER
State University College
Buffalo, New York

FRED W. CULPEPPER, JR.
Old Dominion University
Norfolk, Virginia

Glencoe
McGraw-Hill



NOTICE TO THE READER

Publisher does not warrant or guarantee any of the products described herein or perform any independent analysis in connection with any of the product information contained herein. Publisher does not assume, and expressly disclaims, any obligation to obtain and include information other than that provided to it by the manufacturer.

The reader is expressly warned to consider and adopt all safety precautions that might be indicated by the activities described herein and to avoid all potential hazards. By following the instructions contained herein, the reader willingly assumes all risks in connection with such instructions.

The publisher makes no representations or warranties of any kind, including but not limited to, the warranties of fitness for particular purpose or merchantability, nor are any such representations implied with respect to the material set forth herein, and the publisher takes no responsibility with respect to such material. The publisher shall not be liable for any special, consequential or exemplary damages resulting, in whole or in part, from the readers' use of, or reliance upon, this material.

Cover photo credit: Bruce Parker photographer
Cover design by Juanita Brown

Glencoe/McGraw-Hill
A Division of The McGraw-Hill Companies

Send all inquiries to:
Glencoe/McGraw-Hill
3008 W. Willow Knolls Drive
Peoria, IL 61614

ISBN 0-8273-4419-8

Printed in the United States of America

2 3 4 5 6 7 8 9 10 042 01 00 99 98 97

PREFACE

Electricity and Electronics is an introductory text. It is intended for use in courses that introduce students to the principles—and to the practical applications—of electricity and electronics.

On completing readings and work assignments of this integrated learning program, students should build a level of knowledge and understanding that will enable them to make meaningful decisions about further studies in electricity and electronics. Knowledge gained from the experiences within this program should also help students determine whether they are interested in careers related to the electrical or electronics fields.

For all students, whether or not they are interested in further study or in work opportunities, the background built through this program will help equip them as more discerning consumers. Another assured learning result for all students is a consciousness of household and occupational safety.

ORGANIZATION

As can be readily seen through a review of the Table of Contents, this book uses a building-block approach in the presentation of information. The organization of this book assumes no previous knowledge or experience on the part of the student.

Information presentations start with the very basics: A history of electricity and electronics, followed by a description of the basic skills in electricity, is provided in the initial chapter. To this foundation, the book adds—one increment at a time—explanations about the different properties and functions of electricity and about different types of circuits and devices.

By the time students have completed the first half of the book, they should have formed a theoretical foundation of knowledge. This understanding, in turn, is applied to a series of practical applications of electricity and electronics presented in the remainder of the text.

New to the second edition is expanded coverage of generators, electric motors, power supplies, amplifiers, oscillators, and integrated circuits. The chapter on electronic communications has been revised to include descriptions of up-to-date technologies. A chapter on robotics has also been included in this edition.

The body of the text ends with a chapter on career opportunities.

The content concludes with an extensive glossary of terms that can be used as a reference tool throughout the study program.

FEATURES

All technical terms are defined in context at the time of their first use. After that, all new terms are used in context at least twice within the first page or two of text after their initial introduction. Meanings of previously used terms are repeated for reinforcement throughout the text to assure ease of reading and comprehension.

Similar techniques are used to help assure student understanding of the mathematical content of this book. Equations and mathematical formulae are used only as necessary. In addition, the math that is used has been selected because it builds a basis for students to move ahead with additional study in this field. To make the math clear, actual examples, using figures from illustrations and the text, are provided to show how all mathematical problems are solved.

Further, all content—verbal and mathematical—is reviewed both in context and at the end of each chapter. The text itself is presented in a series of topical units. At the end of each topical unit, a series of review/discussion questions is provided. This provides an opportunity to monitor student progress on a learn-as-you-go basis.

Throughout the book, textual presentations are illustrated extensively. These illustrations are positioned and cited in the text in a manner designed specifically to promote comprehension.

Within each chapter, there is a series of reinforcement aids. Some of these features are as follows:

- Each chapter now begins with a listing of specific learning objectives that should be met, and ends with a summary. This provides both opportunity and stimulus for review if an individual student is unsure of any element of subject content.
- At the end of each chapter, there is a list of key terms taken from the text. Students should know the meanings of these terms and be able to use them. There is an incentive for review if an individual is unsure of the meaning of an important term.
- Scattered throughout the second edition are numerous hands-on activities and projects that are designed to build understanding by giving students the opportunity to apply their newly acquired knowledge. Each chapter contains a list of suggested activities to further this understanding.
- Selected chapters contain problems that enable the students to apply mathematical formulae presented in the text.
- Strong emphasis is placed—throughout this book—on safety in the use of electrical and electronic devices. Chapter 2 is devoted entirely to safety. Then, within most chapters, there is a list of safety tips that deal specifically with the content areas covered.

ACKNOWLEDGMENTS

Governmental and business organizations in electrical and electronics fields have provided many illustrations used in this book. Contributions of illustrations and information are acknowledged in context throughout the book.

We would also like to acknowledge the contributions of David Gunzel of Radio Shack and Toni Lenuzza of PCB Piezotronics, Inc.

Special acknowledgment is also in order for reviews provided in their respective areas of expertise by Dr. Robert Eversol and Ernest Ezel, both of Western Kentucky University, Richard S. Miller of Northeast Independent School District, San Antonio, Texas, and Mark R. Miller of Texas A & M University, College Station, Texas.

Dr. J. Kenneth Cerny, Oakland School District, Pontiac, Michigan, conducted the content readability analysis that helped establish comprehensibility of this book.

— Rex Miller

Reviewers

Gregory Bazinet
University of Southern Maine
Gorham, Maine

Ward Belliston
Utah State University
Logan, Utah

John A. Cappella
Kalamazoo, Michigan

John Conboy
Alton, New Hampshire

John Cooper
Liverpool Central Schools
Liverpool, New York

Michael Grimes
Chillicothe High School
Chillicothe, Ohio

Raymond Jung
San Gabriel High School
San Gabriel, California

George Legg
Ossining High School
Ossining, New York

Richard McCammack
O'Fallon High School
O'Fallon, Illinois

Dirk Mroczek
Great Bridge High School
Chesapeake, Virginia

Phillip N. Pfeiffer
J. M. Tate Senior High School
Gonzalez, Florida

Dave Pullias
Richardson Independent School District
Richardson, Texas

Dick Robinson
Rutland Area Vo-Tech Center
Rutland, Vermont

C. Guenn Williams
New Braunfels, Texas

CONTENTS

ACTIVITIES AND PROJECTS

Chapter 1

INTRODUCTION TO ELECTRICITY AND ELECTRONICS

OBJECTIVES

After studying this chapter, you will know

- *the impact of electricity and electronics on modern life.*
- *the many uses of electricity/electronics in communications systems, production systems, construction systems, and manufacturing systems.*
- *how the technologies are interdependent.*
- *the various handtools needed for electrical/electronics work.*
- *how to use handtools safely.*
- *how to solder correctly.*
- *how to read a schematic.*
- *how to make wire wrap connections.*
- *how to plan the layout for a printed circuit.*
- *how to make a printed circuit.*

INTRODUCTION

It is hard to imagine life without electricity. Electricity is needed to start a car, to keep the engine running, and to light the way when the car is on the road at night. Without electricity, there would be no television, computers, calculators, radio, radar, microwave ovens, or any number of other things we call "necessities" today.

In the days before electricity, muscle power had to be used to build things. It was also a slow and laborious task to get from one place to another or to ship things. Wind power aided in getting some things done, such as pumping water, moving ships, and grinding grain.

1.1 DEVELOPMENT OF ELECTRICITY AND ELECTRONICS

Hundreds of years passed between the Chinese discovery of magnetism in about 80 A.D. and William Gilbert's scientific analysis of the phenomenon in 1600 A.D. From 1600 on, the developments increased in frequency. In 1879, Thomas Edison was successful in creating the carbon-filament light bulb. Soon it was distributed to many people for their comfort and enjoyment.

By the end of the 1800s, a number of fundamental equations, laws, and relationships had been established in electricity. These developments made it possible for the field of electronics to flourish, Figure 1-1. Figure 1-2 lists some of the primary contributors to the field of electricity and electronics.

Impact of Electricity and Electronics on Modern Life

The impact of the electrical age was felt throughout the world. Old methods were replaced by new ones. People were relieved of back-breaking labor by electrical machines that could do the job better and at less cost. Fears that new inventions or methods would take the place of manpower and create mass unemployment were proved unfounded. Instead of unemployment, electricity brought new industries, each needing more employees than those replaced by electrical machines.

Two important developments that had a great impact were the discovery of the properties of electromagnetic waves and the invention of the vacuum tube. These led to the development of the radio.

Radio developed rapidly, soon becoming the major entertainment medium. By the 1930s, almost every U.S. household had a radio. The use of radio for communications became popular during the days before World War II. Experiments in other fields were also being conducted at that time and some progress was made in the development of television.

Before World War II, there were only two major classifications in the field of electricity. One related to power generation, distribution, and utilization, and the other related to radio transmission and reception. Television was available only on an experimental basis at that time.

World War II was the turning point in the development of electronics. Fantastic electronic devices, such as radar, sonar, and infrared detectors, were then developed. Equipment using these principles was developed for automatic aiming of artillery and for navigation of ships and aircraft.

After World War II, development continued in electronics equipment and the introduction of television dominated the home-entertainment field for years. High-quality sound reproduction gained popularity, as did high-definition color television. FM stations increased the quality of sound broadcasting and stereo records and tapes offered music lovers a greater realism than early phonographs did.

Year A.D.	Event
80	Chinese discover magnetism.
1600	William Gilbert states the basic principles of magnetism, experiments with static electricity, and establishes the use of the word *electron*.
1752	Benjamin Franklin invents the lightning conductor.
1770	John Cuthbertson develops the electric battery.
1789	Galvani performs the frog-leg experiments.
1800	Alessandro Volta develops first electric cell.
1819	Hans Christian Oersted discovers the relationship between electricity and magnetism.
1826	Andre Marie Ampere develops a mathematical basis for electrodynamics.
1827	Georg Simon Ohm establishes the relationship between voltage, current, and resistance.
1829	Joseph Henry discovers self-inductance.
1831	Michael Faraday explains electromagnetic induction.
1837	Telegraph demonstrated by Cooke and Watson in England; electric motor developed by Thomas Davenport.
1838	Morse devises his code for the telegraph; first submarine cable is laid.
1842	Robert Wilhelm Bunsen demonstrates the carbon-electrode battery.
1862	James Clerk Maxwell develops mathematical equations setting forth his electromagnetic theory of light.
1876	Bell invents the telephone; Edison invents the phonograph.
1878	Hertz experiments with radio waves; William Crookes experiments with the cathode-ray tube.
1879	Thomas A. Edison and Joseph W. Swan demonstrate the carbon-filament light bulb.
1882	The Edison effect is noted.
1888	Hertz makes the first transmitter and receiver of radio waves.
1898	Ferdinand Braun constructs the first cathode-ray scanning device; Marconi sends and receives wireless messages.
1904	Fleming invents the rectifier tube.
1905	DeForest invents the triode amplifier tube.
1911	Theory of atomic structure is developed by Ernest Rutherford.
1915	AM radio is developed.
1921	First commercial radio broadcast, from KDKA, Pittsburgh, takes place.
1924	Zworykin obtains a patent on a TV camera tube.
1927	First TV station permit is issued.
1928	First color TV is produced.
1933	FM radio is developed.
1937	First radio telescope is developed.
1938	Klystron tube is invented; fluorescent lighting is developed.
1939	TV is demonstrated at World's Fair in New York.
1940	Radar is invented.
1941	First commercial FM broadcasts occur.
1946	Printed circuit board is developed; Electronic vacuum-tube computer (EVIAC) is developed.
1948	Transistor is invented.
1954	Color TV broadcasts begin; transistor radio is developed.
1957	Citizens Band is created; stereo records are introduced; *Sputnik* is launched.
1958	First laser is developed.
1959	Integrated circuit is developed.
1960	First weather satellite is used.
1962	MOA integrated circuits are developed (Hofstein).
1963	Products with integrated circuits are introduced; first Pulse Code Modulating Circuit is introduced.
1965	First word processor is developed.
1970	Computer floppy disc is developed.
1971	Liquid crystal display (LCD) is introduced.
1973	First microcomputer is developed.
1974	First video home recorder is introduced; first fiber-optic circuits are developed.
1977	Video disc becomes available.
1980	Satellite TV becomes popular.
1981	Silicon 32-bit chip is introduced.
1982	First Megabit IC is developed; flat screen for personal TV is introduced.
1985	CD-ROM (compact-disc, read-only memory) is introduced.
1987	Superconductivity is confirmed.

Figure 1-1. Developments in electricity and electronics time line.

Development of the transistor made equipment smaller, and, eventually, with the aid of space exploration, the integrated circuit and the microprocessor were developed. The computer dominated public consciousness and became a popular home installation. Many microwave ovens and washing machines utilizing the microprocessor in the timing of various operations brought into the home the latest in electronics systems technology.

Environmental Considerations

Electronics has been used in reducing the air pollution caused by the internal-combustion engine. Computer control of combustion has also led to the production of the catalytic converter and of engines that can perform as required and still not produce large quantities of harmful gases that pollute the air.

Electronic devices are utilized in monitoring the qual-

Scientist	Dates of Birth and Death	Contribution
Franklin, Benjamin	(1706-1790)	Kite experiments
Galvani, Luigi	(1737-1798)	Frog-leg experiment (electrophysiology)
Volta, Alessandro	(1745-1827)	Electric battery
Ampere, Andre Marie	(1775-1860)	Laws of magnetism
Oersted, Hans Christian	(1777-1851)	Magnetism-electric-current relationship
Gauss, Karl Friedrich	(1777-1855)	Unit of strength of magnetic field
Sturgeon, William	(1783-1850)	Electromagnet (solenoid)
Ohm, Georg Simon	(1787-1854)	Ohm's law
Faraday, Michael	(1791-1867)	Electromagnetic induction
Morse, Samuel F. B.	(1791-1872)	Telegraph in U.S.
Henry, Joseph	(1797-1878)	Fundamentals of electromagnetism
Wheatstone, Charles	(1802-1875)	Telegraph in England, Wheatstone bridge
Cooke, William F.	(1806-1879)	Telegraph engineering
Maxwell, James Clerk	(1831-1879)	Electromagnetic fields
Hughes, David Edward	(1831-1900)	Carbon microphone
Crookes, Sir William	(1832-1919)	Cathode-ray tube and vacuum tube
Fleming, Sir John Ambrose	(1840-1945)	Rectifier tube/Fleming valve
Bell, Alexander Graham	(1847-1922)	Telephone, wax records
Edison, Thomas	(1847-1931)	Electric light, phonograph, and other inventions
Braun, Karl Ferdinand	(1850-1918)	Cathode-ray tube as measuring device (Nobel Prize with Marconi in 1909)
Hertz, Henrich Rudolph	(1857-1894)	Electromagnetic waves
DeForest, Lee	(1873-1961)	Triode amplifier tube
Marconi, Guglielmo	(1874-1937)	Wireless telegraphy (radio) (Nobel Prize in 1909)
Armstrong, Edwin Howard	(1890-1954)	FM radio
Watson-Watt, Sir Robert Alexander	(1892-1973)	Practical radar
Zworykin, Vladimir Kosma	(1899-1982)	TV camera tube

Figure 1-2. People who contributed to the development of electricity and electronics.

ity of the air and water. Such devices have been developed to aid in many ways the fight against pollution of our environment.

Cost of Energy versus Environmental Damage

Of course, the generation of electricity has also been of concern to those involved in monitoring the quality of air and water. Low-sulfur coal has been utilized in fueling steam-powered generating stations, and electronic scrubbers have been employed in cleaning up emissions in power plants.

Atomic-power plants are also sources of environmental concern. The return of the water used to cool the reactors is of particular concern. The temperature and contents of the returned water have to be carefully monitored. Here again, electronics plays a part in the monitoring and alarm systems.

The cost of electrical energy and of the electronics products being manufactured has to be considered in any debate concerning environmental safety: What price will we have to pay for the power generated and the products manufactured in terms of environmental damage? Agencies have been established to study such questions and to protect the environment from damage.

Future of Electricity and Electronics

Any consideration of or projection into the future of electricity and electronics has to be tempered with concern for the long-term impact on the environment and on society. Satellite communications that can cover the world will make their contribution to education, entertainment, and world development as time progresses. The only limitations will be people's imaginations. It is amusing to note that in the early 1800s, the head of the U.S. Patent Office said it was time to close the office because everything had been invented! Since he made his statements, it has become clear that the frontier of unlimited electronics development is limitless. We have before us possibilities as yet unknown in the medical, space, and communications fields.

We have to consider ways to produce electricity without polluting the atmosphere and the land on which we live. We also have to think in terms of smaller products, thanks to the computer and calculator, which have changed our attitudes about the size of electronics products.

Technologies Interdependence

Technologies are interdependent, partially because of the ways in which electrical and electronic systems are developed and manufactured. As the world becomes more complex, its systems for communicating and doing business become more complex. Electricity and electronics play an important role in the expansion of any technology as it may be applied to scientific endeavors.

There is no way to separate the study of mathematics from the development of communications skills in the area of electricity and electronics. Since both of the latter involve the study of many aspects of the physical properties of nature, they can be largely reduced to mathematical concepts. Their interactions can then be stated as laws, formulas, or theories. Once a theoretical base is established and mathematical formulas are applied to the laws of physics, it becomes possible to make practical use of this base in the development of electricity control. Electronics can actually be considered the science of control of electricity by use of the vacuum tube, transistor, and chip, or integrated circuit.

Communications technology involves all aspects of the electrical and electronics means of communicating. This term can cover everything from electronic print to computer-aided drafting, television pictures, video recording and playback, radio, and space communications.

Production technology can be used in reference to electrical power inasmuch as it takes much electrical energy to produce the products we use every day. The electricity is used at the assembly line and for manufacturing processes, as well as to power robots.

Control of manufacturing processes is carried out completely by electrical or electromechanical means.

Production planning and data storage rely completely upon the ability of electricity to perform inexpensive operations and store information as electrical charges.

Transportation technology relies heavily upon electronics for control and routing. Airplanes as we know them would be useless without radar, computers, and communications equipment. Trains also use electronics for communications and control of trains and cargo. Automobiles and trucks rely upon electronics to control their engine combustion and resulting pollutants. Monitoring of engine operation is done through use of electricity and electronics. On the road and in the car, telephone and radio communications speed up the movement and handling of people and goods. The efficiency of modern transportation systems is a result of the proper utilization of electronics.

Construction technology is beginning to use computers for scheduling and for estimating costs. Electronics packages designed especially for the construction industry provide heat, light, and conditioned air for buildings, as well as power for elevators and escalators and for running water.

Today's home relies upon an electrically controlled kitchen, fans for ventilation, and furnaces and air conditioning for temperature comfort. Construction systems have to accommodate these necessities when a house is built. Lighting is provided by electricity. Television, stereo music, and telephones are all objects of the construction system's concern and must be properly planned for correct installation.

In short, energy, electricity and electronics are woven into the fabric of modern-day society. Without controlled electrical energy, we would not be able to function as we do. Our standard of living would be much lower than it is today. The future thus depends on electricity and its applications. That is why it is so important for everyone to have a working knowledge of the concepts and applications of electricity and electronics.

REVIEW QUESTIONS FOR SECTION 1.1

1. What did William Gilbert do to advance our knowledge of electricity?
2. What did Thomas Edison do to make electricity useful?
3. What did people fear about electricity and the advent of electrical machines?
4. What two important discoveries introduced the electronics age?
5. What was the turning point in the development of electronics?
6. How has electronics changed the automobile's environmental impact?
7. How is electronics used to control atomic-powered generator plants?
8. What changed our way of thinking about the size of electronics products?
9. What is electronics?

1.2 BASIC SKILLS IN ELECTRICITY AND ELECTRONICS

This chapter has introduced you not only to the essential elements of any study of electronics and electricity, but also to the basic skills you need to perform on the level expected of you in school.

You will need to learn a number of things before you can become an electricity or electronics employee. The field is always in need of high-quality persons who like to learn and keep pace with everyday developments in the field.

A good place to start is with your own project. Much can be learned by doing such a project. Learning to plan and to read schematics is also very important, as are safe work practices. Read Chapter 2, on safety, before you get underway with your first project.

To handle projects on your own, you will have to be able to read schematic drawings. Schematic drawings are plans. They show the current paths and components for circuits. The symbols presented throughout this book are used in schematic drawings.

In this chapter, you will learn how to use some basic tools safely.

You are ready to begin work on projects. The experience you gain will help you decide about continuing your studies in this field. The exposure you get will also help you decide whether you are interested in electrical or electronics careers.

Planning

It is valuable to look ahead in anything you do. Planning is a method for looking ahead. There is value in planning. It provides a chance to prepare for the work to be done. You determine what parts, equipment, and tools are needed. Potential problems that might come up are identified. Identifying problems can be valuable. Once you know what to expect, you can avoid the problems. You can prepare to deal with them. Or you can take alternative courses to avoid them.

It takes only minutes to plan a project. Planning will save time in the long run. So, planning is a good investment. To plan well, you should use a planning tool. This can be a form like the one illustrated in Figure 1-3. This form gives you an opportunity to list the materials you need. You also list the steps you will take to complete a job. The form provides space to develop a schematic of the circuits involved. As you complete these steps, you will have a chance to identify potential problems. The form then provides space to list both problems and solutions.

Reading a Schematic

In electrical or electronics work, you are often required to read schematic drawings. A **schematic** is a diagram of the circuit to be built. Schematics are drawn with stan-

Plan Sheet (front)

Date ________ Instructor's O.K. ________ Grade ________

Name ________

Name of Project ________

Date Project Started ________ Date Completed ________

Work Hours Required for Construction ________

Bill of Materials

Check	Quantity	Part	Description of Dimensions	Material	Cost

Steps in Construction

1. ________
2. ________
3. ________
4. ________
5. ________
6. ________
7. ________
8. ________
9. ________
10. ________

Figure 1-3A. Project plan sheet, front.

Plan Sheet (back)

Schematic

Problems Encountered in Construction

1. ________
2. ________
3. ________
4. ________
5. ________
6. ________
7. ________
8. ________
9. ________
10. ________

Answers to Questions About Project

1. ________
2. ________
3. ________
4. ________
5. ________
6. ________
7. ________
8. ________
9. ________
10. ________
11. ________

Figure 1-3B. Project plan sheet, back.

dard symbols. You will learn these symbols as you work your way through this book. Many of these symbols are shown in Figure 1-4.

These symbols tell you what components are needed for a project. They show how all components within a circuit or device are connected to each other. So, it is important for you to learn these basic symbols. You should also learn to read schematic diagrams in which the symbols are used.

Look at the schematic in Figure 1-5. This is a half-wave power supply. Its function, in general, is to supply a 12-V DC power source. To do this, the power supply transforms 120-V AC current to 12-V DC.

A power supply of this type might be used in a shop

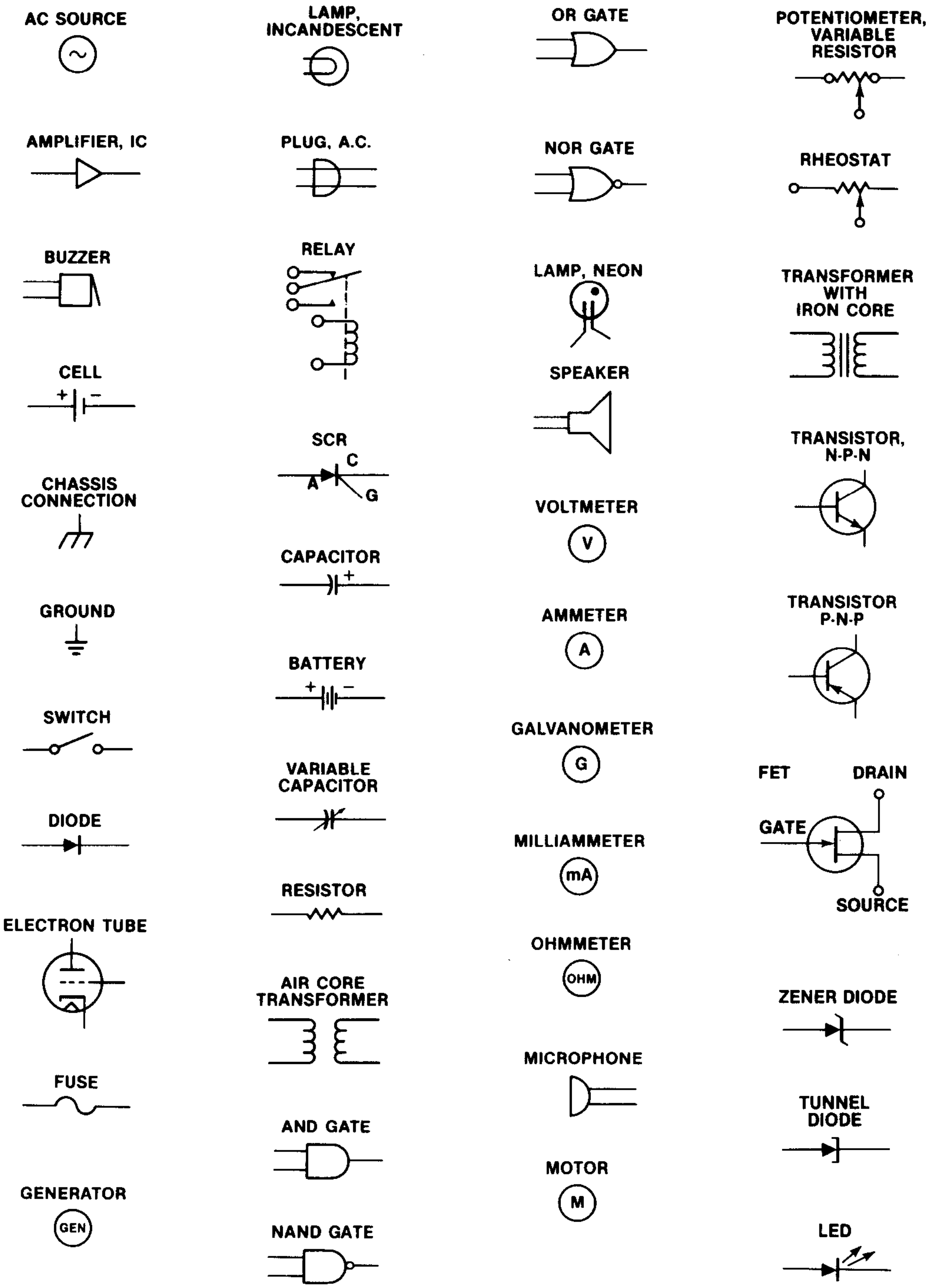


Figure 1-4. Schematic symbols.

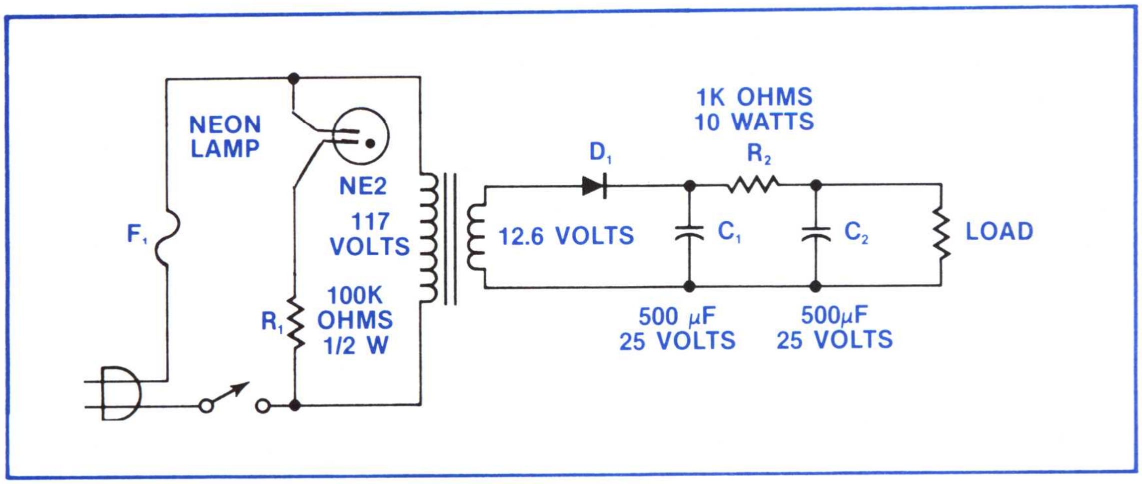


Figure 1-5. Schematic of half-wave power supply.

that repairs automotive radios. With experience and care, you could build a power supply of this type for your own use.

Check some of the important components of the circuit in Figure 1-5. First, notice the fuse and the switch. These are safety requirements. Never overlook them in your own work.

Now, look at the circuit branch with the neon lamp. The neon lamp is used as an indicator. It tells the user whether the power supply is on or off. This is also an important safety feature. If you are working with the power supply, this indicator light is useful. It tells you when the unit is on. And it helps remind you to turn the power off when the unit is not in use.

The neon lamp is connected in series with a resistor. The resistor is rated at 100,000 Ω.

Now notice the transformer. This is also a standard unit. It is called a filament transformer. It reduces voltage from 117 V to 12.6 V. For use in operating auto radios, DC is needed. The diode makes this conversion.

For use in radios, it is necessary to smooth out the flow of DC current. This is done by the two capacitors and a resistor. The capacitors and resistor are connected between the diode and the load.

The more schematics you read, the more you learn. Think of the electrical and electronic symbols as you do letters of the alphabet. With a little practice, reading schematics will come naturally.

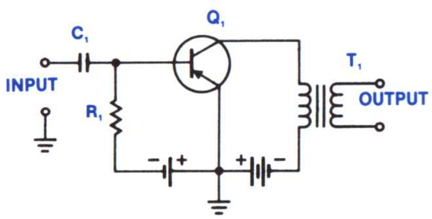


Figure 1-6. Practice schematic. Identify all components.

REVIEW QUESTIONS FOR SECTION 1.2

1. Where on the form in Figure 1-3 would you draw a schematic of your project?
2. What part of the planning form would you use to list the steps to follow in completing a project?
3. What is the function of a transformer?
4. How does diode D_1 work in Figure 1-5?
5. If fuse F_1 in Figure 1-5 blows, what may be the problem?
6. If the load is removed, will there be current flow in Figure 1-5?
7. Name the parts of the circuit in Figure 1-6.

1.3 TOOLS FOR ELECTRICAL AND ELECTRONICS WORK

To work with electricity or electronics, you need certain special tools. Each of these tools does one or more specific jobs. Some of the more important tools include:

- Diagonal-cutting pliers
- Side-cutting pliers
- Long-nose pliers
- Combination pliers
- Wire strippers and cutters
- Wire/screw cutters
- Screwdrivers
- Nut drivers
- Allen wrenches
- Scratch awls
- Chassis punches