FUNDAMENTALS OF ELECTRONICS

Charles M. Thomson

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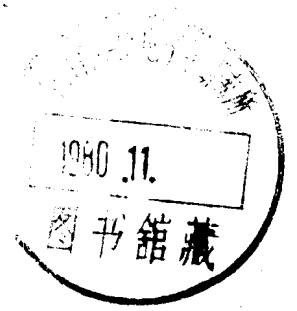

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PREFACE

Electronics is an essential part of our modern world. It is hard to imagine what our lives would be like without electrical and electronic devices. Similarly, it is difficult to visualize how electronics will affect our future.

Electronics had its real beginning in the early 1900s. Since that time, the changes that electronics has brought about have been truly wondrous. In the 1950s, the idea of placing men on the moon and returning them to earth was pure science fiction. In the mid-1960s, the thought of our present hand-held calculators and desktop computors was just plain fantasy. The changes that electronics will bring into our lives in the next ten or twenty years are almost beyond our imagination.

The remarkable developments in electronics in the past few years, and the exciting prospects for the future, make the study of this subject an interesting one, indeed. It is essential that a solid background in the fundamentals of electronics be established. On this strong foundation, current and future theory and practice may be built.

In this text, a sound background in the theory of electronics will be presented, and, much more than that, a working knowledge of the subject will be developed. Practical examples and problems are provided throughout the text.

The text is developed in a logical and systematic manner. Its sequence should match the course sequence offered in most electronic program curricula. The arrangement of the material, however, is flexible enough to provide for program variations, and to meet the requirements of the individual instructors.

The text is principally intended for electronics programs offered at the community college and technical institute level. It should also be suitable for use in programs offered in technical high and commercial electronics schools. The text should be suitable for many industrial training programs. Although not intended primarily for self-instruction, the text arrangement and presentation should make it suitable for this purpose.

Many practical examples are provided throughout the text. Exercises are included at appropriate points, within individual chapters. A summary is provided at the end of each chapter. Each chapter also includes either fill-in or true–false questions. Finally, chapter problems, plus essay-type questions, are provided.

The study of electronics should be a fascinating one for most students. It is hoped that this text will make the subject matter interesting, understandable, and rewarding.

The author is deeply indebted to his wife, Dorothy, for her encouragement, understanding, and assistance in the preparation of the manuscript. In addition, the author wishes to express his thanks to Mary Ellen Hatfield for her assistance in typing the manuscript.

CHARLES M. THOMSON

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INTRODUCTION

All material is composed of matter, and all matter has present in its structure millions of extremely small, invisible particles called *electrons*. It is from these tiny quantities, which contain an electrical charge, that the word *electronics* has evolved. The use and control of electrons has made possible the many conveniences and wonders of our modern world.

The science of electronics deals with the harnessing of electrons for particular applications. Such operations involve the movement and control of electrons through partial vacuums, gases, and solids. Devices such as electron tubes, gas tubes, and transistors are used for these purposes.

It is of interest to know a little of how our present knowledge of electronics evolved. A look at electronics in the past, present, and future will be presented in the following sections:

1.1 THE EARLY BEGINNINGS

The science of electronics had its beginnings as early as 600 B.C. in Greece. These inquisitive experimenters found that when the substance amber was rubbed, it attracted small bits of material such as paper and straw. Amber was called

"elektron" by these early Greeks. It is from this word that many of our present electrical and electronic words originated.

About 1600 an English physicist, William Gilbert, found that other materials, such as glass and sulfur, had properties similar to that of amber. He believed that these materials exuded a "fluid" that attracted small particles. This fluid was called *electricity*.

In the early 1700s, French experimenters concluded that there were two types of "fluids" instead of just one. They called the fluid, or electricity, present in glass and similar materials, *vitreous*. The fluid, or electricity, present in such materials as amber, rubber, and wax was called *resinous*.

About 1750, Benjamin Franklin's experiments led him to conclude that there was only one type of fluid. He believed that the vitreous and resinous electricity were two characteristics of a *single* fluid. He called the vitreous electricity, or charge, *positive* (+). The resinous electricity, or charge, he called *negative* (−).

Until the early 1900s, Franklin's fluid theory served as a reasonable explanation of electrical phenomena. Although by no means universally acceptable, there were no more logical theories presented. At about this time, the characteristics of matter began to occupy the interests of scientists. The structure of the basic building block of matter, the atom, began slowly to evolve. Our present theories of the nature of electricity have been developed based on the characteristics and structure of the atom.

1.2 ELECTRONICS—THE PAST

In the early 1800s, Oersted and Faraday performed experiments with electricity and developed a basic understanding of the character and behavior of magnetism.

In 1887, the German physicist Hertz was able to transmit electromagnetic energy through space. The practical application of this phenomenon was not shown until 1895, when Marconi developed the wireless method of communication. In 1905, Marconi was able to span the Atlantic Ocean with his wireless transmissions.

In 1906, the vacuum tube was developed by Deforest. This device enabled electrical signals to be amplified. This led to the development of radio broadcasting, which began on a scheduled basis about 1920.

Refinements in the vacuum tube and associated technology led to the development of television. Commercial television had its beginnings in the early 1940s.

In 1948, Schockly, Brattain, and Bardeen of Bell Laboratories developed the transistor. This device was superior to the vacuum tube in many ways. The transistor and other solid-state devices has resulted in the development of many of the wonders of our modern society.

1.3 ELECTRONICS—THE PRESENT

Electronics has affected our lives in many ways. The use of electronic devices has made our work easier and safer. They have made our calculations faster and

more accurate. They have extended our lives. Electronics is truly a wonder of the age, which holds even greater promises for tomorrow.

In our home, we are aware of the use of the electrical and electronic devices used in the preparation and preservation of our foods. Such devices include refrigerators, freezers, ranges, microwave ovens, mixers, pumps, and blenders.

Our homes are heated, cooled, and lighted using electrical and electronic devices. Trash compactors, dishwashers, polishers, and vacuum cleaners are available for our convenience. Burglar alarms and smoke- and fire-detection devices are used for our protection.

Electrical and electronic devices are available in variety, for our entertainment. These include radios, television sets, stereo sets, tape recorders, and electronic organs, as well as other musical devices.

For our personal needs, electrical and electronic devices include digital watches, razors, hair dryers, and toothbrushes. For our hobbies, drills, saws, sanders, sprayers, CB radios, trimmers, and mowers are available.

To maintain and prolong our life a variety of electronic devices are used in medicine. These include heart pacemakers and monitors, and a wide variety of instruments for diagnosis, analysis, and treatment of our illnesses.

In business and industry, such devices as lathes, motors, generators, controllers, drills, welders, and presses help to supply our needs. Computers, data-processing devices, copiers, typewriters, teletypes, and a wide variety of similar devices are used for business purposes.

Our communications systems involve many electronic devices. These include radios, telephones, and a wide variety of information transmitting and receiving devices.

We are involved with electrical and electronic devices from the time an electronic clock-radio awakens us in the morning until the "late" show on television finally puts us to sleep at night. In between, in our daily activities, we are almost constantly involved with one type of an electronic device or another. Our dependence on such devices is nearly total. It only takes a minute's thought to think how difficult it would be to manage in our modern world without electricity or electronics.

1.4 ELECTRONICS—THE FUTURE

The electrical and electronic devices in our future seem to have limitless possibilities. Twenty-five years ago the landing of men on the moon and returning them safely to earth was only possible in science fiction. Twenty-five years ago the hand-held pocket calculators of today would also have been pure fantasy.

Electricity and electronics have made possible many of the wonders of our present world. The future uses of such devices seem limited only by man's initiative and ingenuity. Used properly, they give every promise of a brighter and brighter tomorrow.

2

ELECTRICITY

As observed in Chapter 1, man's use of electricity has produced a variety of marvelous devices. With all of our knowledge of science, electricity still remains an invisible and somewhat mysterious force. We have been able to harness it for our various needs and purposes, and yet our knowledge of it is incomplete. Our present understanding of electricity will be used in explaining the nature, behavior, and application of electricity. In this chapter we shall examine:

2.1 THE ATOM AND ITS STRUCTURE

All material in the world around us is composed of matter. The paper of this book, the clothes we wear, the food we eat, and, yes, even our bodies are composed of matter. All matter has one thing in common: its structure is made up of atoms.