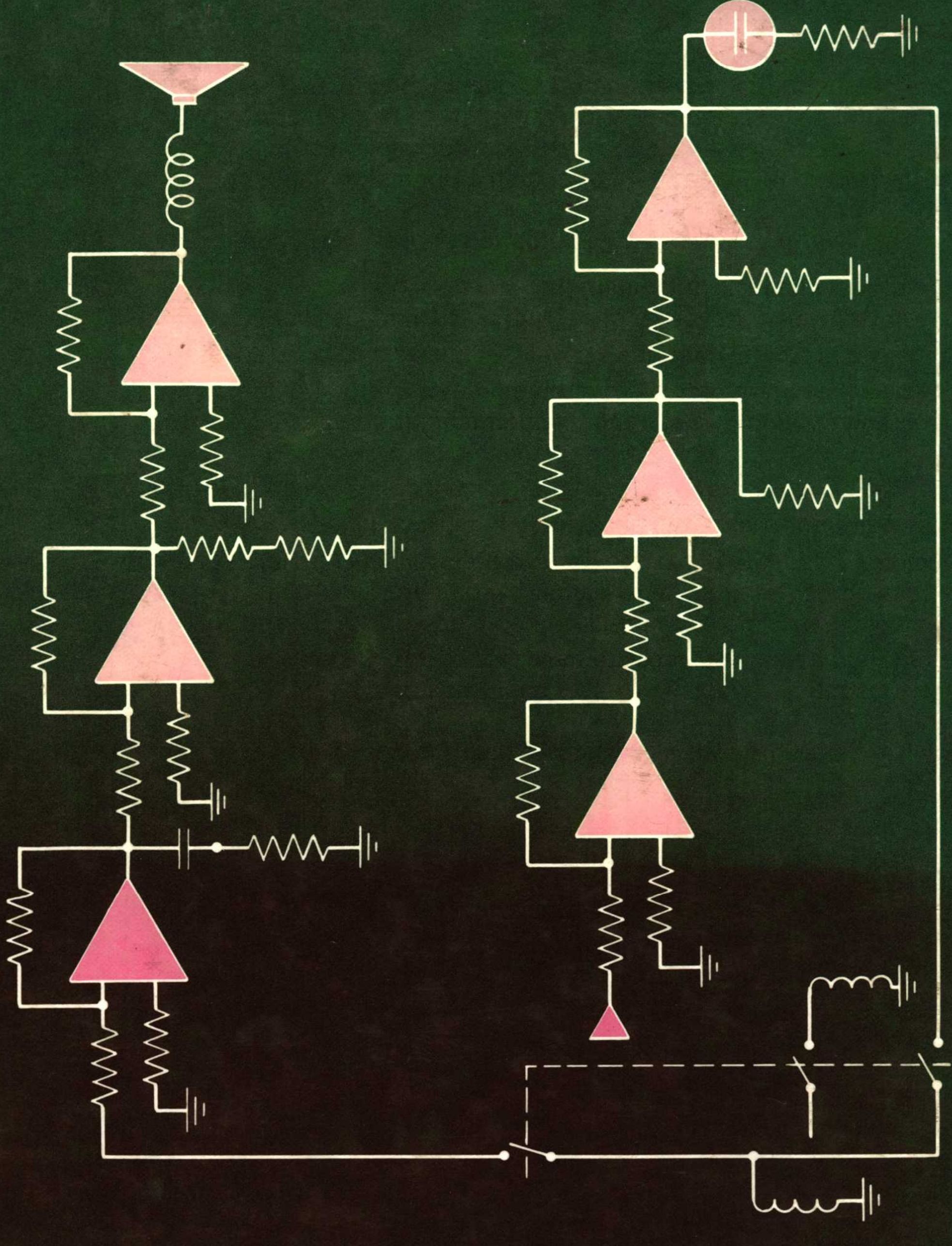
A User's Guide to Computer Peripherals

Donald Eadie



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Preface

The purpose of this book can be summarized as follows:

1. Briefly review the characteristics of peripheral devices which could be considered for use with computer systems of various type and used for different applications.
2. Catalog briefly those devices to be used for newer systems.
3. Indicate the methods and magnitude of the interfacing problem.

This survey is divided into ten chapters. Chapter 1 contains an introduction and a short history, introduces some symbology associated with diagrams in chapters to follow, and includes other general information. Chapter 2 introduces minicomputers and microcomputers. Chapter 3 describes peripherals that load and unload the computer's memory with programs and data. Chapter 4 portrays external peripherals that extend the internal memory of the processor. Chapter 5 covers those devices that allow an operator to view the processing results. Chapter 6 indicates the interfacing problem, describes methods and functions of peripheral control units (PCUs), and describes the relationship between analog and digital systems. Chapter 7 explains the various aspects of digital communication. Chapter 8 describes special systems—that is, when all peripherals are *not* located at a central computer. Chapter 9 defines some of the newer single chip interfaces, fiber optics, etc. Chapter 10 covers the steps that lead to the determinations of new systems and the problems that must be considered. Basics of number systems have been delegated to Appendix A.

Many thanks to those that supplied photographs, permissions, and data—including Reston Publishing Company, Inc., for providing much material from my other book, *Minicomputers—Theory and Operation*; thanks to the reviewers, and those that encouraged me, including R. W. Lowery of Smith Industries, Inc., and D. V. Wilson of Honeywell, Inc. I am especially indebted to my editor, David Boelio, Prentice-Hall, Inc., who saw the need for this book, and for his help and encouragement in so many ways. I would like to thank my wife, who helped me in numerous ways—including help with spelling and getting some xerox copies at critical times.

Donald Eadie

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1

Introduction and History

1-1 INTRODUCTION

In this chapter we introduce the subject of computer peripherals by first defining what is meant by the term *peripheral*, followed by one method of classification of such devices. Then a brief history of computers and associated gear precedes comments on basic computer organization, an introduction to logic elements and blocks, interfacing, maintenance, choosing peripherals, and finally a summary of the material covered.

1-2 DEFINITION OF A PERIPHERAL

The computer processor, its logic, and internal memory perform at speeds amounting to millions of operations per second. To use a computer, an operator, or process, must slow down a computer to a few operations per second, or at most to a few operations per millisecond. That is the job of a peripheral, in general terms: namely, to communicate between a device (the processor) working at tremendously high speeds and doing considerable calculating in microseconds to electromechanical equipment operating at considerably slower rates. Such peripheral devices may be a printer or a tape reader or a display cathode-ray tube (CRT) being observed by a technician. The processor may control an automatic factory process or perhaps an aircraft in flight or the operation of a weapons system. All of these, insofar as the processor is concerned, are peripherals. In other words, all equipment which permits one to review the results of computations visually or to control some process automatically by a processor is a peripheral. In any event, additional equipment performs the connecting process, and such equipment is known as *computer peripherals*, the subject of this book. As mentioned previously the following sections acquaint the reader with some of the basics, such as the possible classifications, diagrams, and definitions of logic symbols, a brief history of computers, and other assorted topics. This book does not deal in depth with logic; thus a reader interested in that subject is advised to consult a detailed book on that topic. The same is true for details on programming although an example of programming in the language BASIC is provided in a later chapter.

1.2.1 Further Readings

Klingman, E., *Microprocessor System Design.* Englewood Cliffs, NJ: Prentice-Hall, Inc., 1977.

Eadie, D., *Modern Data Processors and Systems.* Englewood Cliffs, NJ: Prentice-Hall, Inc., 1972.

Eadie, D. *Minicomputers: Theory and Operation.* Reston, VA: Reston Publishing Company, Inc., 1979.

Veronis, A., *Microprocessors: Design and Application.* Reston, VA: Reston Publishing Company, Inc., 1978.

1-3 CLASSIFICATIONS

There are, of course, a variety of ways in which a particular device may be classified. In this book we have chosen the following approach. Chapter 2 discusses minicomputers and microcomputers to which peripherals are attached. Chapter 3 covers devices that load or unload either data or programs into or out of a computer. Chapter 4 concerns bulk-store devices, which in general back up the internal memory of a computer with additional storage capacity. The next chapter treats the classification of display peripherals, which includes printers, plotters, cathode-ray tubes, and the like. The object here is to display results directly to the observer without further processing. Chapter 6 describes methods for tying computers to peripherals and vice versa. Chapter 7 covers some aspects of digital communication, including a description of some of the equipment, transmission methods, data links, etc. Chapter 8 discusses special systems and some of the newer microcomputer buses now under consideration as possible standards. The next chapter covers briefly some of the newer devices such as one-chip interfaces, fiber optics, and others. In Chapter 10 we conclude with a consideration of what one must do to design a digital system. Number systems and codes are included in Appendix A. With the rapid advance of microcomputer techniques, it is almost impossible to imagine where the future will lead us, especially when one considers that a small circuit card now replaces the largest machines of the 1950s, 1960s, or 1970s. How advances will proceed is a subject of much speculation and debate.

1-4 A BRIEF HISTORY

The earliest device qualifying as a digital calculator is the abacus (sometimes called a *soroban*). This calculation aid, invented about 600 B.C., permits the positioning of beads on a rack. Simple addition and subtraction can be carried out rapidly and efficiently by appropriate positioning of the beads. The abacus is still widely used in the Orient; and its proficient users calculate with great speed.

The first mechanical adding machine was invented in 1642 by Blaise Pascal, a French customs official. Baron Gottfried Wilhelm von Leibniz invented in 1671 the first calculator for multiplication. It is still being developed to this day, but emphasis has shifted almost entirely to integrated circuit designs.

The father of the modern computer is considered to be Charles Babbage, a nineteenth-century professor at Cambridge University. He proposed to the British Admiralty the construction of a differential engine and was given funds and directed to proceed in 1823. In 1833 he started, on his own, the development of an analytical engine and worked on it until 1842. Neither of these devices were successful, mainly because of hardware shortcomings at that time. However, his efforts established a number of fundamental principles for the design of digital computers. Even scientists at Harvard studied his work before embarking on the Mark 1 effort in the late 1930s. Later, in 1853, a successful analytical engine appeared in Sweden, and one was produced in the United States in 1858.

Business machines and calculators, all mechanical, made their appearance in Europe and the United States toward the end of the nineteenth century, marking the beginning of some of the large manufacturers of today's calculators. Now there are hundreds of firms in the field, spurred on by the development of new minicomputers, microcomputers, and the development of newer and less expensive peripherals.

The development of components such as relays, vacuum tubes, transistors, and integrated circuits facilitated the development of the modern computer and its peripheral hardware. Harvard University, in conjunction with the International Business Machines Corporation (IBM) and the Bell Telephone Laboratories (BTL), developed between 1940 and 1942 a series of relay computers. Although exhibiting a high degree of reliability, they were quickly superseded by much faster all-electronic vacuum tube computers. The relay machine peripherals were limited to switches, lights, and teletype equipment. The first vacuum tube computer was ENIAC, designed by the University of Pennsylvania's Moore School of Engineering and installed at the Aberdeen Proving Ground in 1946 for the purpose of cleaning up the backlog of ballistics calculations that had accumulated during World War II. Although ENIAC was not basically a machine that operated with binary arithmetic, it admirably performed the task it had been designed for. The flip-flop circuit, patented in 1919 and used until then only in radar equipment, was the critical component in the design of ENIAC. Although all-electronic, ENIAC's design was never duplicated, because of the difficulty of assigning to it purely scientific problems. Retired from service in the late 1950s, it contained 33,000 vacuum tubes and occupied an entire room that had to be air-conditioned to keep the tubes cool. Peripheral equipment was the same as for the electromechanical machines, except for the addition of a magnetic drum memory (discussed in Chapter 3).

A host of all-binary machines followed, among which were EDVAC, SEAC, and WHIRLWIND (primarily scientific computers), and the IBM 604. Late in the 1950s commercial machines appeared, including the IBM 704 and the Honeywell 400 and 800 series. With the implementation of integrated circuit production, numerous commercial/scientific computers were marketed with the introduction of the Honeywell 2200 series, the RCA Spectra series, and the IBM 360 series, followed later by the IBM 370 series—all the results of the integrated circuit trend starting in 1967. Peripherals now also included disk files, high-speed tape reader/recorders, printers, plotting equipment, cathode-ray tubes, and interfaces to control such devices as machines, aircraft navigation equipment, and weapon systems (all basically analog devices), that require interfacing devices usually called *converters*, which convert from or to a varying level of voltage variation or shaft rotation to or from a digital format. Devices working on voltage levels or shaft rotation are known as *analog devices*. Basically this conversion problem is easier to solve today, since the peripheral interface converters are much smaller, less expensive, and have a high degree of accuracy. Late in the 1960s the minicomputer made its initial appearance, and about 1972 the microcomputer (originally used for digital watches and hand calculators) made their initial appearances. Presently the microcomputer is replacing the minicomputer for most functions: either is as powerful and much faster than the earlier computers of the 1950s or 1960s. Costs are now quite low, which has also affected the pricing of peripherals, since they should be in a proportionately comparable price range.

1-5 BASIC COMPUTER ORGANIZATION

A diagram of a basic computer organization is shown in Fig. 1-1. Here the arithmetic unit performs all the calculations. Its operations, and in fact all data flow back and forth from both memory (internal) and the input/output (I/O) interfacing block, are under control of the control block which calls both data and instructions from memory under control of machine instructions. The memory, therefore, is the storage place for both the data and the machine instructions. Normally, both machine instructions and data are listed in sequence, stored in sequential cells, and given an address number (location specification). This permits the control to call for an address and to sequence the desired program step by step—or jump to a different starting address—completing a special program segment called a *subroutine*, then jumping back to the original program and continuing from the point following the subroutine jump. The control block thus (1) accepts machine instructions in sequence and decodes them, (2) causes data flow in or out of the arithmetic unit, (3) transfers data in or out of the memory and input/output block as well. Thus, since it also transfers the memory stored commands as well, it is the real commander of the computer. Lastly, there is the input/output block, which provides access to the outside world via the peripheral devices.

Machine instructions are of many types, differing with each com-

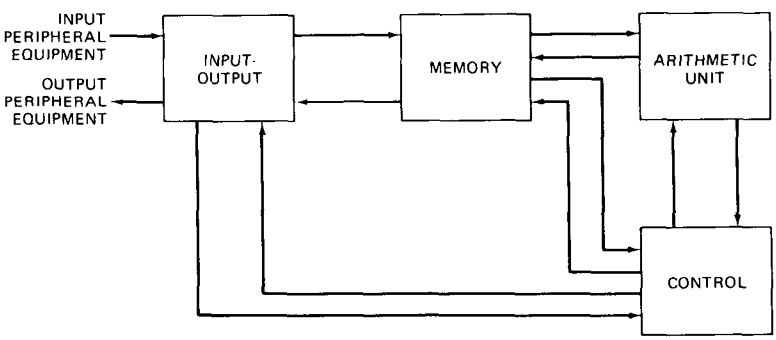


FIGURE 1-1 Basic computer organization.

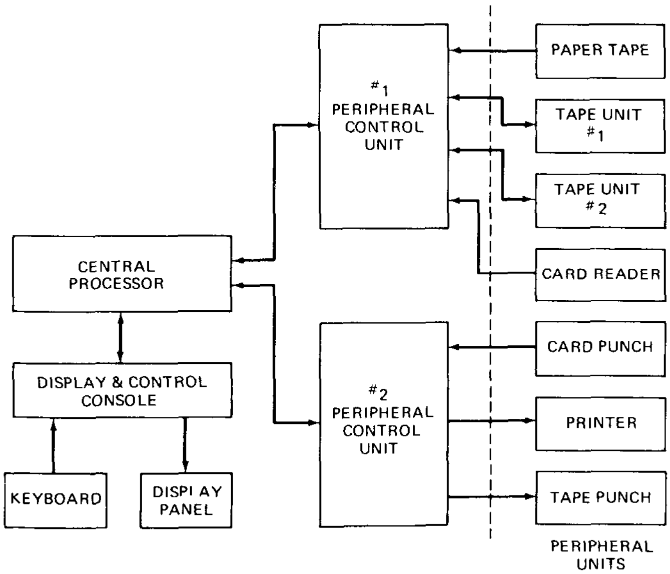


FIGURE 1-2 A sample computer with peripherals.

puter internal registers, automated transfers under peripheral control, control types, but also additional types that transfer data between computer internal registers, automated transfers under peripheral control, instructions that shift numbers within a register, instructions that test the operation of the computer and the peripherals, instructions to modify instructions, instructions that change the number system, and many others which vary with the computer's organization and anticipated operating programs.

All the computer sections mentioned above are built from digital logic, which has changed greatly during the past 25 years. A typical computer system is illustrated by Fig. 1-2. In this case the central processor and control are combined in an arithmetic logic unit (ALU), which incorporates both arithmetic processing and control. The peripheral control units (PCUs) are the input/output interfacing devices. They do their job of tying the high-speed computer to the slower peripherals. This is merely a typical example. Details are left to later chapters.

1-6 LOGIC BLOCKS AND DEFINITIONS

Although the subject of this book is peripherals and their controls, logic elements and blocks will be shown in the diagrams. The reader is referred to a good book on digital logic for details on that subject. Table 1-1 outlines the fundamental operations and devices as well as defining

Table 1-1

LOGIC ELEMENTS AND LOGIC BLOCKS

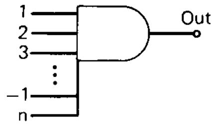
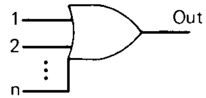
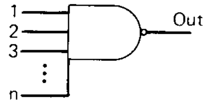
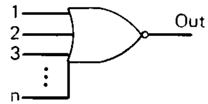
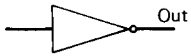
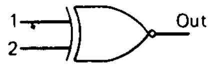
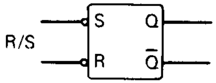
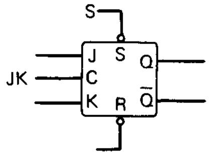
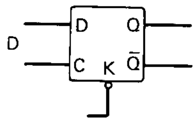
Element	Symbol	Explanation
A. Simple logic elements:		
1. AND gate (or coincident gate)		*If* all *inputs are* true *(1), then the output is (1).*
2. OR gate		*If* any *input is* true *(1), then the output is* true *(1).*
3. NAND gate (not-AND)		*If* all *inputs are true (1), then the output is (0).*
4. NOR gate (not-OR)		*If* any *input is* true *(1), then the output is (0). If no input is true, then the output is (1).*
5. Inverter		*Inverts **a** (1) to **a** (0) or **a** (0) to **a** (1).*

Table 1-1 *(Continued)*

Element	Symbol	Explanation
6. *Exclusive-OR*		*For two (1) inputs or two (0) inputs the output is (0). If one input is a (1) and the other a (0), the output is a (1).*
7. *Exclusive-NOR*		*The inversion of the exclusive-OR.*
8. *Flip-flops*		*A device that is set or reset. If set the Q output is (1) and the Q output is (0). If reset the outputs Q and Q are reversed.*
		*This is an R-S flip-flop. A J-K flip-flop changes its state only during a clock pulse.*
		*A D flip-flop changes its state during the rising edge of the clock pulse.*