Chapter 11

INTRODUCTION TO DIGITAL COMPUTERS

INTRODUCTION

Basically, there are two types of computers - analog and digital. This section will address the digital general-purpose computer.

First, we will examine the major equipment blocks, which comprise a typical general-purpose computer. Next, we will study the general data flow and, finally, briefly analyze the functions of programming.

REFERENCES

INTRODUCTION TO COMPUTERS AND NUMBERING SYSTEMS, Collins Radio Company, 27 June 1968.

INFORMATION

INTRODUCTION TO COMPUTERS

The digital computer has become one of the most effective tools available to business, industry, engineering and science; therefore, understanding its essential characteristics is quite necessary. A digital computer is a device, which can solve complete problems by arithmetic and/or logical operations using information supplied to it. The precision of the resultant computation is usually defined as being proportional to the number of integers the computer will accept.

TYPES OF COMPUTERS

Digital computers are normally divided into two basic classes: general-purpose and special-purpose. A general-purpose digital computer may be defined as a digital computer that has the ability to perform arithmetic and/or logical operations and modify its operational sequence as a result of some significant intermediate decision. Although the general-purpose digital computer is only capable of simple arithmetic and logic operations, its speed in accomplishing the desired resultant makes it a versatile device. The general-purpose digital computer may be utilized to perform many different problems; i.e., payroll processing, data communications, linguistic applications, etc.

A special-purpose digital computer is designed for a special function that cannot be classified as a general-purpose computer function. One type of the special-purpose computers is the digital differential analyzer. It is designed to solve problems involving ordinary differential equations. A digital differential analyzer may be utilized in conjunction with general-purpose digital computers and/or analog computers; i.e., in aircraft or marine navigation systems.

Analog computers solve equations representing physical variables whose resultant is also represented by a physical variable; for example, voltage or shaft position. An analog computer may be utilized to simulate some physical system; i.e., an aircraft or guided missile in flight. The everyday example of a simple analog computer is the automobile speedometer, which computs velocity versus time to indicate miles/kilometers per hour.

ORGANIZATION OF COMPUTERS

The function of a general-purpose digital computer (figure 11-1) is to accept information, perform a logical or arithmetical operation, and produce the resultant in a usable form. To accomplish this function, a typical general-purpose digital computer consists of five major components: input, control, memory (storage), arithmetic, and output.

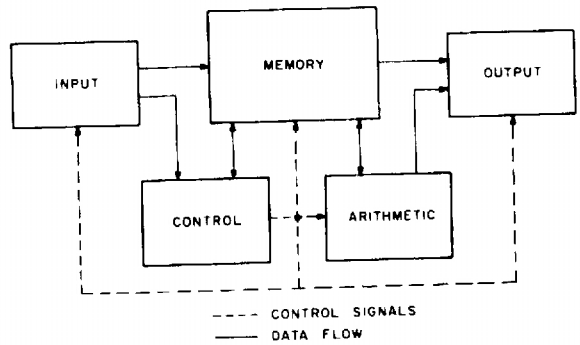

Figure 11-1. Typical General-Purpose Digital Computer

COMPONENT FUNCTIONAL DESCRIPTION

Although general-purpose digital computers are not exactly identical, the functions of the various components are generally the same. Thus, a general description of each component can be given.

Input Component

The function of the input component is to accept and present the necessary data to the other components that utilize it. Usually, the instructions or commands, which make up the program, must be read into the computer along with the data. Some of the more common input devices are punched cards, punched paper tape, magnetic tape, and various manual input devices such as pushbuttons and toggle switches. One function of the input component is generally to convert the incoming data into a form usable in the computer.

Control Component

The function of the control component is to sequence the operation of the computer by controlling all the other units. The control circuit interprets the instructions that make up the program and then controls the operation of the computer. Since digital computers are time-sequentially controlled, the time-base generation function is usually part of the control components.

Memory Component

The memory component of a computer is used to store the program of instructions, the data to be processed, and the final results as the computer proceeds through the program.

The storage capacity of memory components varies from one computer to another; that is, the memories are expandable in various increments of "words" of information. The storage capacity of one computer word, as determined by the number of binary digits it contains, also varies among computers. Word sizes vary from several binary digits to about 50 binary digits.

The time required to extract information from the memory is called access time, which varies from a fraction of a millionth of a second to several millionths of a second. The access time has a profound effect on the overall speed of the computer.

Arithmetic Component

The arithmetic component performs the four basic arithmetical operations of addition, subtraction, multiplication, and division, as well as some "logical" operations, which will be described later. The control component directs the arithmetic component as to which operation to perform as well as ensuring that the proper data is supplied to it.

Output Component

The function of the output component is to pass on processed data to an external device for presentation to the "outside world." The external device may be magnetic tape, paper tape, a typewriter or a high-speed printer. The output component, or adapter, may be required to convert the processed information to a form acceptable by the external device.

The operation of a digital computer and its component parts can be likened to a human accountant with an adding machine and worksheet. The accountant is acting as the program control unit, moving input data from memory (the worksheet) to the arithmetic unit (the adding machine). The results, which correspond to output data, are printed by the adding machine.

As far as expanding the analogy to include the concept of a program, one could think of an additional sheet of paper (representing another portion of memory), which held a sequence of instructions for the accountant to follow; such as:

1. Clear Calculator
2. Enter Hourly Pay Rate From Column 2
3. Multiply by Hours Worked in Column 3
4. Subtract Withholding Tax in Column 4
5. Record Result in Column 5

The above instructions form what could be called a program, which is stored in another area of memory and which is interpreted and carried out by the program control. This program was written by a "programmer" who knew the step-by-step procedure required by the control unit and who also knew where the data to be processed was held (hourly rate in column 2, hours worked in column 5, etc.) A similar computer program might look like the following:

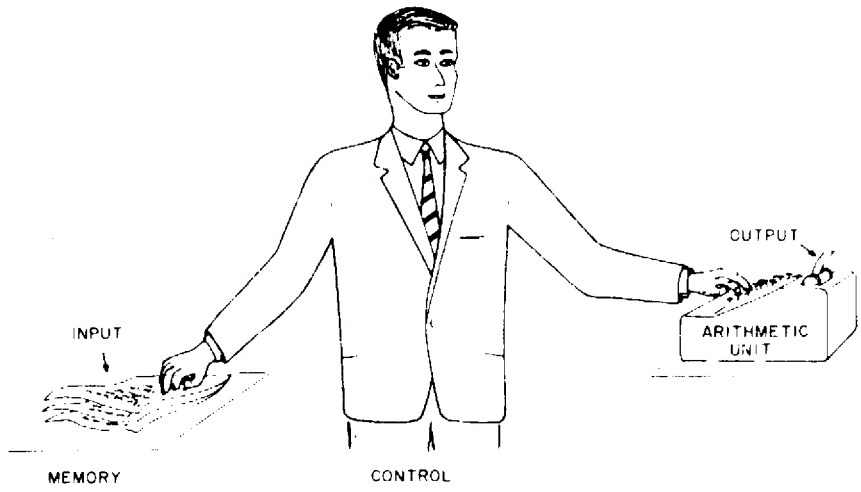

Figure 11-2

ZAR ..... =0
AR 560
MR 7251
SR 304
STR 1000

Each computer instruction above performs basically the same English instruction except that it is expressed in a code understood by the computer rather than a code understood by humans.

A programmer, then, has the role of arranging a sequence of computer instructions so that a solution to a given problem is obtained in the most efficient manner.

Program

In the AN/TSC-60(V) system, the programmer had to write a sequence of instructions (program) that would cause the computer to control a complete radio system and its associated maintenance display panel. To accomplish this task, the computer has to act as an interface between the radio operator and the radio equipment and also between the radio equipment and the maintenance person. It was the programmer's responsibility to ensure that the computer would carry out its tasks in a logical sequence, without error, and with a minimum of instructions.

To perform its task, the computer must interpret the radio operator's wishes, convey those instructions *in a logical sequence* to the radio equipment, determine the operational status of the radio equipment and give the operator a visual indication of that status. In addition, and with no interference with the control functions, the computer must determine which data maintenance personnel wants displayed on the maintenance display panel and provide it. Some of the instructions contained in the program include:

1. Input the transmit control head switch data.

2. Input the receive control head switch data.

3. Determine the significance of the transmit and receive control head switch data (many separate instructions).

4. If required, send control data to the exciter, power amplifier, and antenna coupler.

5. Store the monitor data (operational status) from the exciter, power amplifier, and antenna coupler.

6. Analyze the monitor data (many separate instructions).

7. Send operational status to the transmit control head.

8. If required, repeat steps 4 - 7 for the receiver system.

9. Send operational status to the maintenance display panel.

10. Store monitor data (maintenance requests) from the maintenance display panel.

11. Analyze maintenance display monitor data.

12. Send requested data to the maintenance display.

The above list of instructions might be called a rough "block diagram" of the program for the AN/TSC-60(V) computer. The computer is a special purpose digital read only memory (ROM) type, and as such contains a *hard-wired* program. The computer could perform some function other than controlling the AN/TSC-60(V), but to do so would require a different hard-wired program.