# THE MEMORY SYSTEM AND I/O INTERACTION

The most important characteristic of a programmable controller is the user's ability to change the control program quickly and easily. The PLC's architecture makes this programmability feature possible. The memory system is the area in the PLC's CPU where all of the sequences of instructions, or programs, are stored and executed by the processor to provide the desired control of field devices. The memory sections that contain the control programs can be changed, or reprogrammed, to adapt to manufacturing line procedure changes or new system start-up requirements

## MEMORY SECTIONS

The total memory system in a PLC is actually composed of two different memories (see Figure 5-1): • the executive memory • the application memory

The **executive memory** is a collection of permanently stored programs that are considered part of the PLC itself. These supervisory programs direct all system activities, such as execution of the control program and communication with peripheral devices. The executive section is the part of the PLC's memory where the system's available instruction software is stored (i.e., relay instructions, block transfer functions, math instructions, etc.). This area of memory is not accessible to the user.

The **application memory** provides a storage area for the user-programmed instructions that form the application program. The application memory area is composed of several areas, each having a specific function and usage. Section 5-4 covers the executive and application memory areas in detail.

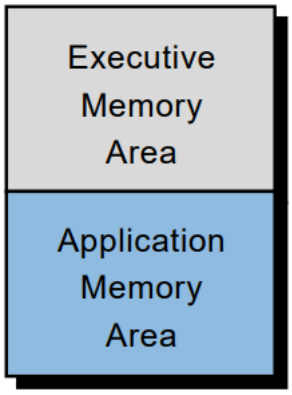


**Figure 5-1.** Simplified block diagram of the total PLC memory system.

## MEMORY TYPES

- **Read-only memory (ROM)**
- **Random-access memory (RAM),**
- **Programmable read-only memory (PROM)**
- **Erasable programmable read-only memory (EPROM)**
- **Electrically alterable read-only memory (EAROM)**

### MEMORY STRUCTURE AND CAPACITY

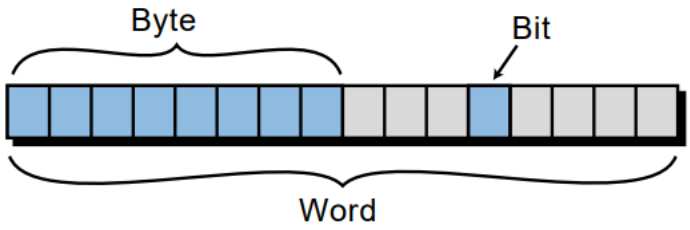


**Figure 5-4. Units of PLC memory: bits, bytes, and words.**

## MEMORY CAPACITY AND UTILIZATION

- Memory capacity is nonexpandable in small controllers (less than 64 I/O capacity) and expandable in larger PLCs. Small PLCs have a fixed amount of memory.
- Larger controllers allow memory expandability, since the scope of their applications and the number of their I/O devices have less definition.

  Application memory size is specified in terms of K units, where each K unit represents 1024 word locations. A 1K memory, then, contains 1024 storage locations, a 2K memory contains 2048 locations, a 4K memory contains 4096 locations, and so on. Figure 5-5 illustrates two memory arrays of 4K each; however, they have different configurations—the first configuration uses one-byte words (8 bits) and the other uses two-byte words (16 bits).

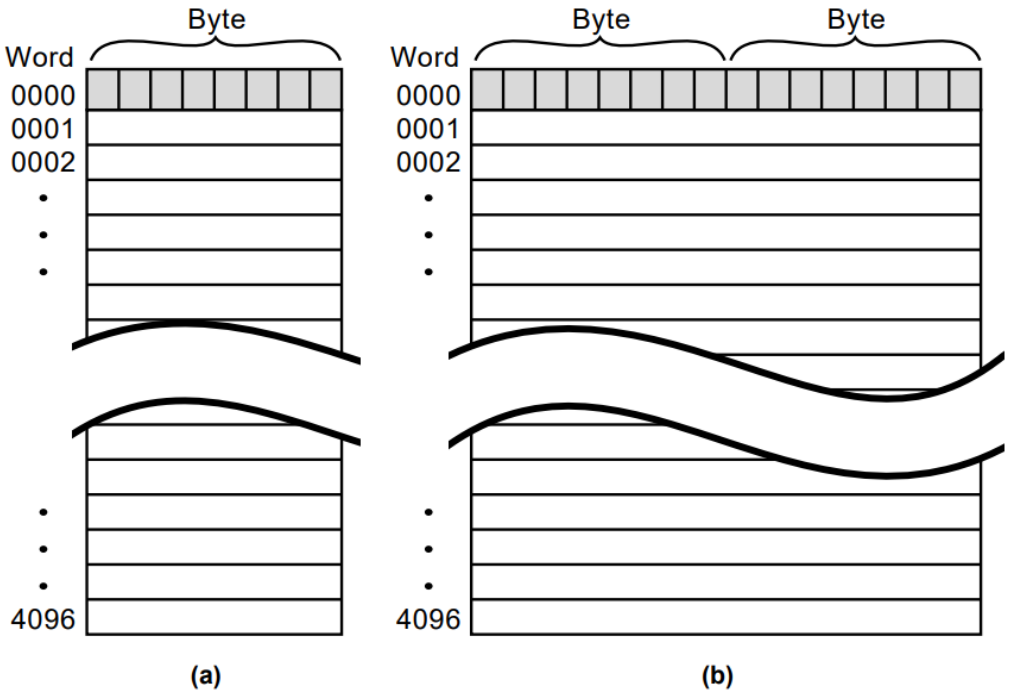


**Figure 5-5.** Block illustration of **(a)** a 4K by 8 bits storage location and **(b)** a 4K by 16 bits storage location.

The memory capacity of a programmable controller in units of K is only an indication of the total number of storage locations available. Knowing this maximum number alone is not enough to determine memory requirements. Additional information concerning how program instructions are stored will help to make a better decision.

The term **memory utilization** refers to the amount of data that can be stored in one location or, more specifically, to the number of memory locations required to store each type of instruction.

To illustrate memory capacity, let's refer to following example

**EXAMPLE 1** Determine the memory requirements for an application with the following specifications:

- 70 outputs, with each output driven by logic composed of 10 contact elements.
- 11 timers and 3 counters, each having 8 and 5 elements, respectively
- 20 instructions that include addition, subtraction, and comparison, each driven by 5 contact elements.

Table 1 provides information about the application's memory utilization requirements.

| Instruction | Words of Memory Required |
|---|---|
| Examine ON or OFF (contacts) | 1 |
| Output coil | 1 |
| Add/subtract/compare | 1 |
| Timer/counter | 3 |

**Table 1.** Memory utilization requirements.

**SOLUTION** Using the given information, a preliminary estimation of memory is:

(a) Control logic = 10 contact elements/output rung
Number of output rungs = 70

(b) Control logic = 8 contact elements/timer .
Number of timers = 11.

(c) Control logic = 5 contact elements/counter
Number of counters = 3

(d) Control logic = 5 contact elements/math and compare
Number of math and compare = 20

Based on the memory utilization information from Table 5-1, the total number of words is:

| | | | |
|---|---|---|---|
| **(a)** | Total contact elements | (70 x 10) | 700 |
| | Total outputs | (70 x 1) | 70 |
| | Total words | | 770 |
| **(b)** | Total contact elements | (11 x 8) | 88 |
| | Total timers | (11 x 3) | 33 |
| | Total words | | 121 |
| **(c)** | Total contact elements | (3 x 5) | 15 |
| | Total counters | (3 x 3) | 9 |
| | Total words | | 24 |
| **(d)** | Total contact elements | (20 x 5) | 100 |
| | Total math and compare | (20 x 1) | 20 |
| | Total words | | 120 |

Thus, the total words of memory required for the storage of the instructions, outputs, timers, and counters is 1035 words (770 + 121 + 24 + 120), or just over 1K of memory.

## SUMMARY OF MEMORY, SCANNING, AND I/O INTERACTION

Assume that we have a simple PLC memory, organized as shown in Figure 5-20, and a simple circuit (see Figure 5-21), which is connected to a PLC via I/O interfaces.

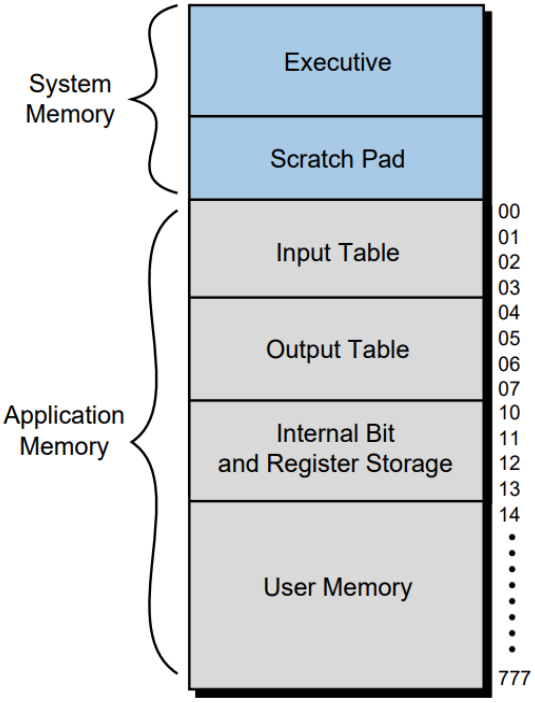


**Figure 5-20.** An example of a PLC memory map.

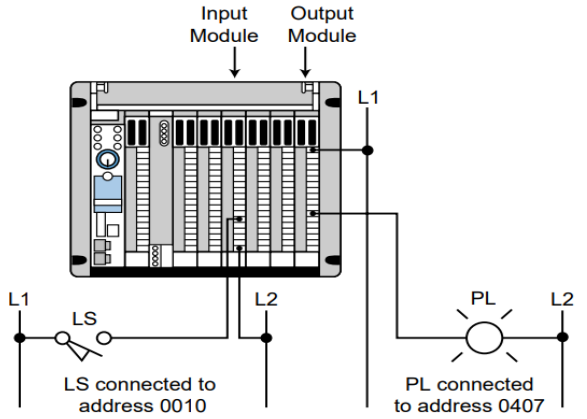


**Figure 5-21.** A simple circuit connected to a PLC via I/O interfaces.

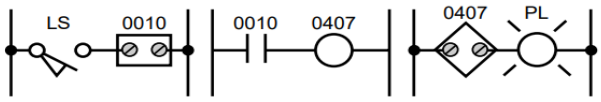


**Figure 5-22.** Instructions used to represent the control program.

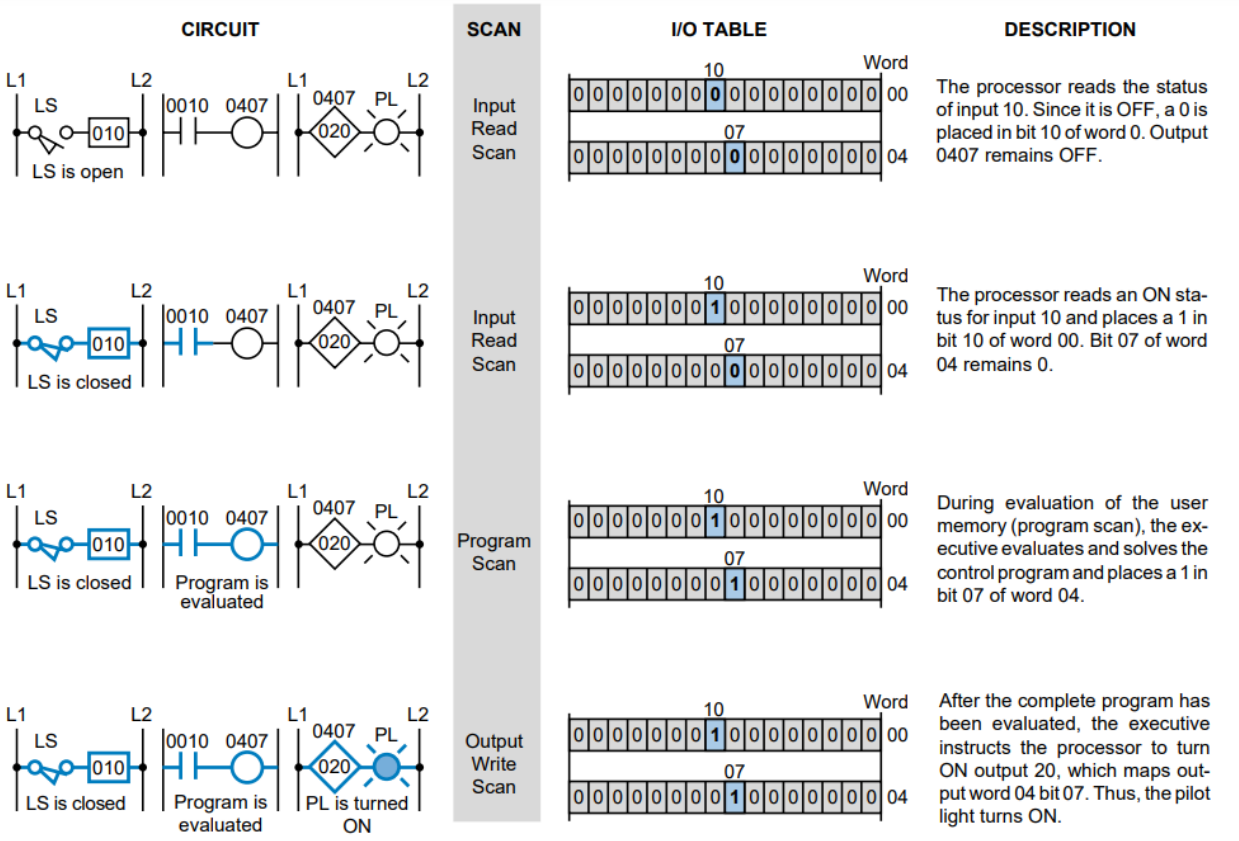


**Figure 5-23.** Steps in the evaluation of the PLC circuit shown in Figure 5-22.