3.2 Numerical information: the binary world of computers

Now you have learned that numerical information can be expressed in different ways. We are accustomed to using decimal numbers in our everyday life, but it is the binary numbering system that is THE numbering system in the world of computers. The binary numbers can be written with only two symbols, 0 and 1, but they are equally as adequate numbers as our common decimal numbers. Everything that can be written down as a decimal number can also be expressed as a binary number.

Binary numbers are convenient for computers because they need only two symbols. Binary numbers can be stored in the memory of computers in the form of electric phenomena. For example, a voltage present in a certain part of an electronic component can mean the binary 1. No voltage present can then mean a binary 0, and thereby we have all binary symbols expressed in electric form.

The most important electronic components inside modern computers are integrated circuits, the black components on greenish boards. Integrated circuits contain many transistors that are connected to each other in a special way. Transistors are the basic electronic elements inside integrated circuits. A single integrated circuit may contain thousands if not millions of transistors. The transistors inside integrated circuits are used to store information in binary form. By setting a voltage to a certain wire it is possible to store binary information into an integrated circuit, and by setting a voltage to another wire, it is possible to read the previously stored binary information.

Although computers are rather complex electronic constructions, a person who wants to write programs to be run on computers does not have to understand all the electronic details of computers. A programmer needs merely a logical view of a computer's electronics. A computer can be considered a device that contains very many logical memory cells which are able to store one bit of information. The memory cells are made of transistors. A bit (binary digit) is the smallest unit of information inside a computer. A memory cell which can hold a bit of information can contain a zero, 0, or one, 1. The key idea in electronic computing is that, although information is stored in small bits, it is possible to handle large amounts of information when there are very many of these single-bit memory cells.

Figure 3-2 shows a simple memory cell which is capable of storing one bit of information. The memory cell operates with a +5V voltage and it has lines (wires) for writing and reading information. The information that can be stored is either 0 or 1. We can assume that zero Volts means 0 and +5 Volts means 1. The memory cell is capable of holding the voltage that has been stored in it, and it simply outputs 0V or +5V voltage depending on which of these two voltages has been stored in the memory cell. Information can be stored in the memory cell by switching a +5V voltage to the WRITE MEMORY line and simultaneously setting the INPUT line to the voltage that represents the information which is being stored. Information can be read from the memory cell by switching a +5V voltage to the READ MEMORY line. As long as the READ MEMORY line has the active +5V voltage, the OUTPUT line has the voltage (0V or +5V) that has previously been stored in the memory cell. The lines WRITE MEMORY and READ MEMORY are control signals which are used to transfer information to or from the memory cell. The actual data transfer occurs via the INPUT and OUTPUT lines. The GROUND line is the basis for which all voltages are measured. The line that connects the memory cell to the operating voltage is also marked in Figure 3-2, though that line does not affect the logical operation of the cell.

Figure 3-3 shows a timing diagram that describes the operation of the single-bit memory cell. It is assumed that the memory cell is somewhere among the other electronic circuitry and the outside circuitry changes the voltages on the lines that are connected to the memory cell. Note that the line OUTPUT has a defined voltage only when the line READ MEMORY has a voltage with which the memory cell is ordered to deliver its contents to the outside world.

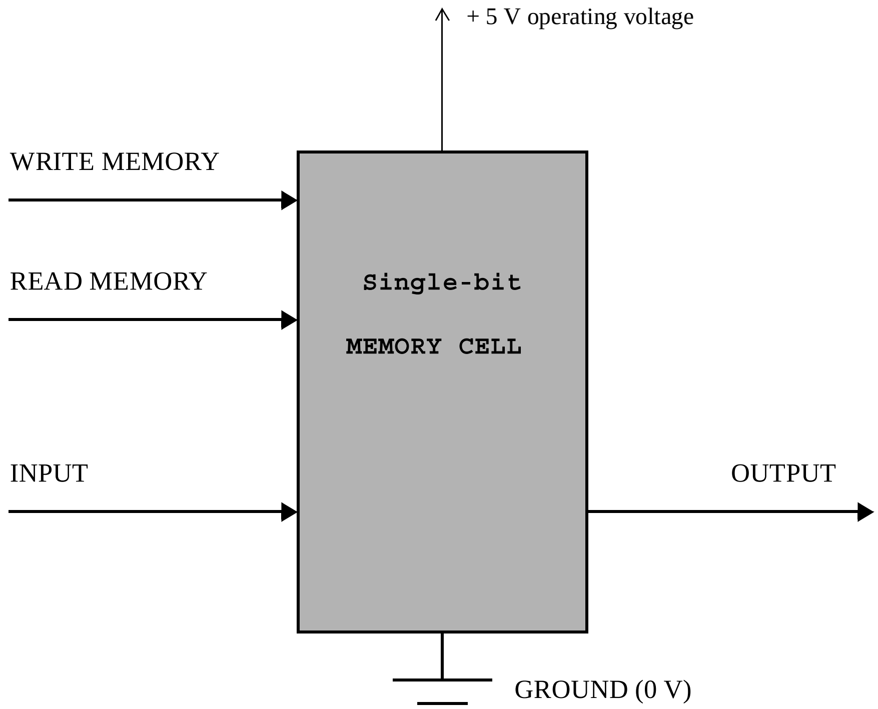

Figure 3-2. A logical model of a single-bit memory cell.

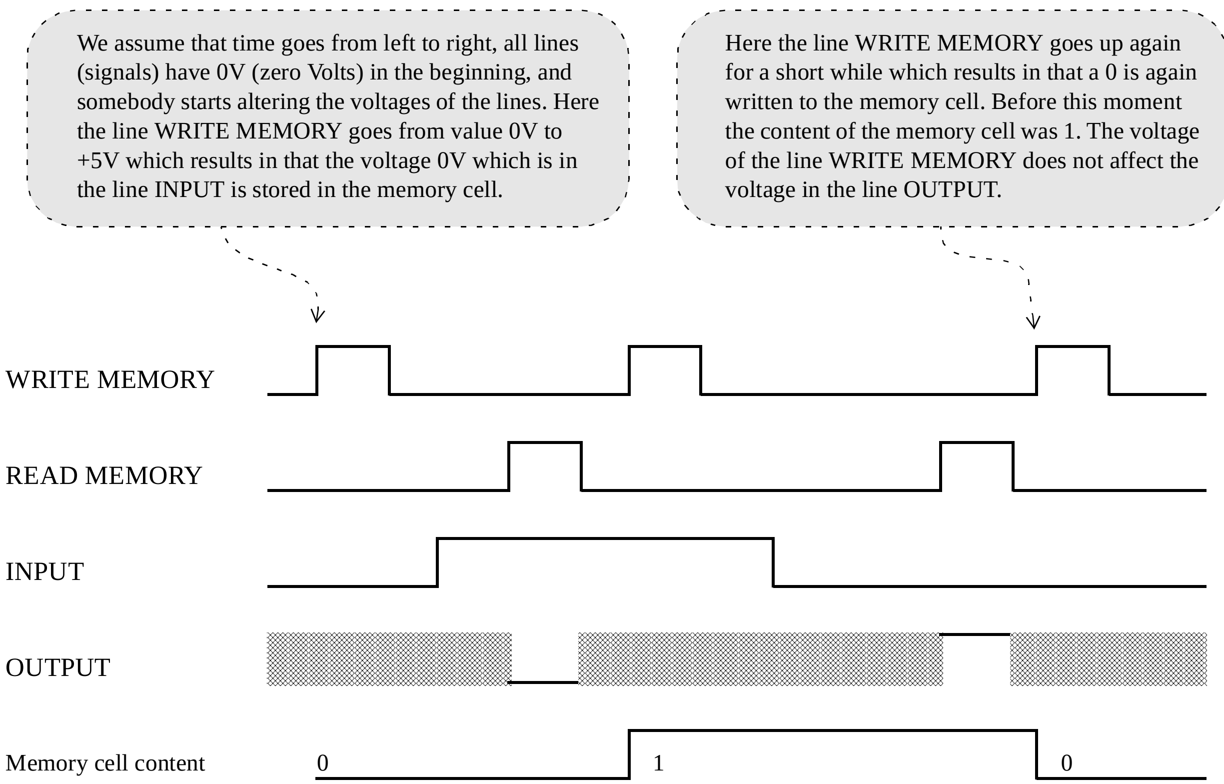

Figure 3-3. Writing and reading a single-bit memory cell.