CHAPTER 1

INTRODUCTION

1.1 Digital Systems

A digital system receives, stores, processes, and produces digital information. Inputs are information received by the system. Outputs are information produced by the system. Digital information is represented by discrete, not continuous, values. Figure 1.1 shows a digital system with n inputs x_0, x_1, x_2, ……, x_{n-2}, x_{n-1}, and m outputs y_0, y_1, y_2, ……, y_{m-2}, y_{m-1}. A binary digital system is a system for two discrete values, which can be represented by 0 and 1. These two values may or may not have any numeric significance. In general, they represent two different states. Other terms such as HIGH and LOW, ON and OFF, TRUE and FALSE, are also used for these two states.

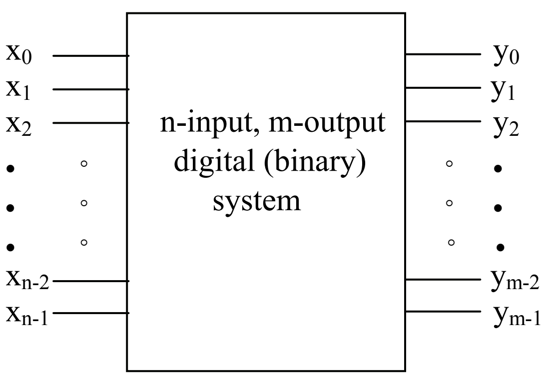

Figure 1.1 Block representation of a digital system.

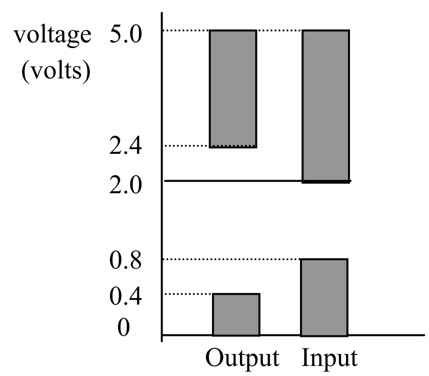

Figure 1.2 Voltage levels for TTL devices.

The binary states of an electronic digital system can be represented by voltages or currents. Figure 1.2 shows how two voltage ranges are used to represent the two states for transistor-transistor-logic (TTL) devices. The voltage ranges for input signal to a device and for output signal from a device are slightly different. For output signals, the low voltage range is from 0 to 0.4 volts and the high voltage range from 2.4 to 5.0 volts. When the high voltage range is used to represent 1 and the low voltage range for 0, the convention is called positive logic. Any signal between 0.4 and 2.4 volts is undefined. The voltage ranges for input signals are slightly different. The low range is from 0 to 0.8 volts and the high range from 2.0 to 5.0 volts. Because signals may be degraded by noise, the difference provides tolerance in noise for a signal to travel from the output of one device to the input of another device. Negative logic convention uses the high voltage range for 0 and the low range for 1.

1.2 Truth Table

A digital system in a much smaller scale is called a digital or logic circuit. The function or behavior of a digital circuit can be specified in various forms, such as a statement, a mathematical expression, a symbolic form called a circuit diagram, or in tabular form. Truth table is a tabular representation for a digital circuit. Table 1.1 is the format of a truth table for a circuit with n inputs and m outputs. A truth table lists all the possible combinations of the input values and their corresponding output values that are determined by the function of the circuit. Since each input can take on a value of either 0 or 1, there are 2^n different combinations of values for the n inputs. Each combination of input values is also called an input state. The truth table for a 3-input and 2-output circuit as shown in Figure 1.3 is given in Table 1.2. The value of y_1 is equal to 1 when two or three of the inputs are equal to 1. The value of y_0 is equal to 1 when an odd number of the inputs are equal to 1. Thus y_1 and y_0 are called majority function and odd parity function respectively.

Table 1.1 Truth table for a binary system with n inputs and m outputs.

Inputs							Outputs
x_{n-1}	x_{n-2}	x_{n-3}	………	x_2	x_1	x_0	y_{m-1} y_{m-2} y_{m-3} ……… y_2 y_1 y_0
0	0	0	……..	0	0	0	
0	0	0	……..	0	0	1	
0	0	0	……..	0	1	0	
0	0	0	……..	0	1	1	
0	0	0	……..	1	0	0	Output values depends on functions of system
		……………………..					
		……………………..					
		……………………..					
1	1	1	……..	0	1	1	
1	1	1	……..	1	0	0	
1	1	1	……..	1	0	1	
1	1	1	……..	1	1	0	
1	1	1	……..	1	1	1	

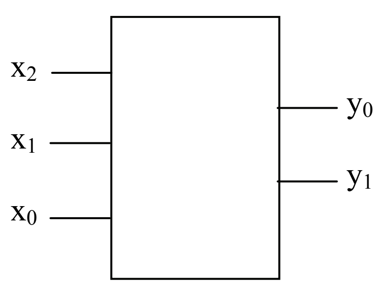

Figure 1.3 A 3-input, 2-output binary circuit.

Table 1.2 Truth table for the circuit in Figure 1.3.

x_2	x_1	x_0	y_1	y_0
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

1.3 Combinational Circuits versus Sequential Circuits

There are two types of digital circuits: combinational and sequential. The outputs of a combinational circuit are functions of present inputs. Past inputs to the circuit have no effect on the outputs. The basic elements for implementing combinational circuits are called “gates”. For sequential circuits, their outputs depend not only on present inputs but also on past inputs. Therefore a memory is required to store information related to past inputs. The structure of sequential circuits is given in Figure 1.4, which includes a combinational circuit and a memory. Sequential circuits can be divided into two classes: synchronous and asynchronous. Only synchronous sequential circuits are covered in this manuscript except the SR latch in Chapter 9. The memory elements for synchronous sequential circuits are flip-flops, which are controlled by a clock.

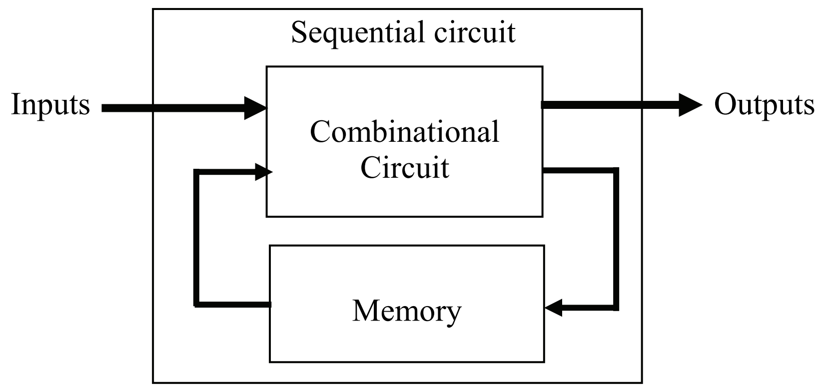

Figure 1.4 Structure of sequential circuits.