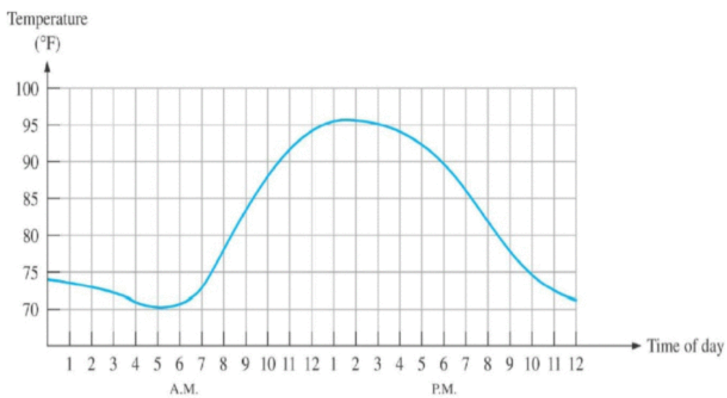
Al-Mustaqbal University
College Of Engineering Technology
Department Of Cyber Security Techniques Engineering
Class: 1st
Subject: Digital Logic Design
Lecturer: Dr. Rami Qays Malik
2nd term – Lecture: 1- Number system

DIGITAL AND ANALOG QUANTITIES

Introduction:

Electronic circuits can be divided into two broad categories, digital and analog. Digital electronics involves quantities with discrete values, and analog electronics involves quantities with continuous values. Most things that can be measured quantitatively occur in nature in analog form. For example, the air temperature changes over a continuous range of values. During a given day, the temperature does not go from, say, 70_ to 71_ instantaneously; it takes on all the infinite values in between. If you graphed the temperature on a typical summer day, you would have a smooth, continuous curve similar to the curve in Figure below. Other examples of analog quantities are time, pressure, distance, and sound.

Graph of an analog quantity (temperature versus time).



Rather than graphing the temperature on a continuous basis, suppose you just take a temperature reading every hour. Now you have sampled values representing the temperature at discrete points in time (every hour) over a 24-hour period, as indicated in Figure below.

Digital Quantity

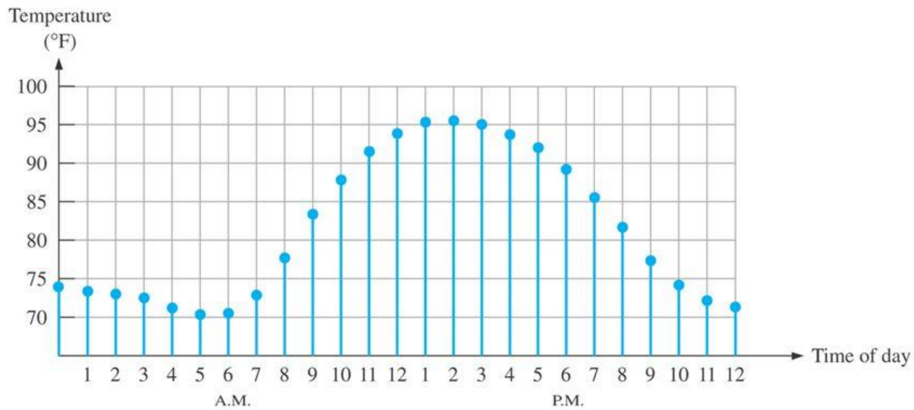


Figure 1–2 Sampled-value representation (quantization) of the analog quantity in Figure 1–1. Each value represented by a dot can be digitized by representing it as a digital code that consists of a series of 1s and 0s.

The Digital Advantage:

Digital representation has certain advantages over analog representation in electronics applications. For one thing, digital data can be processed and transmitted more efficiently and reliably than analog data. Also, digital data has a great advantage when storage is necessary. For example, music when converted to digital form can be stored more compactly and reproduced with greater accuracy and clarity than is possible when it is in analog form. Noise (unwanted voltage fluctuations) does not affect digital data nearly as much as it does analog signals..

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An Analog System:

A public address system, used to amplify sound so that it can be heard by a large audience, is one simple example of an application of analog electronics. The basic diagram in Figure 1-3 illustrates that sound waves, which are analog in nature, are picked up by a microphone and converted to a small analog voltage called the audio signal. This voltage varies continuously as the volume and frequency of the sound changes and is applied to the input of a linear amplifier. The output of the amplifier, which is an increased reproduction of input voltage, goes to the speaker(s). The speaker changes the amplified audio signal back to sound waves that have a much greater volume than the original sound waves picked up by the microphone.

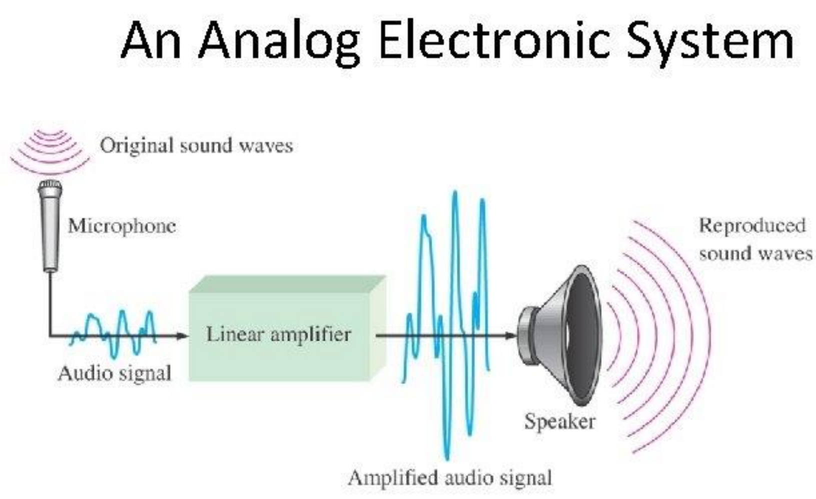

Figure 1–3 A basic audio public address system.

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A System Using Digital and Analog Methods:

The compact disk (CD) player is an example of a system in which both digital and analog circuits are used. The simplified block diagram in Figure 1–4 illustrates the basic principle. Music in digital form is stored on the compact disk. A laser diode optical system picks up the digital data from the rotating disk and transfers it to the digital-to-analog converter (DAC). The DAC changes the digital data into an analog signal that is an electrical reproduction of the original music. This signal is amplified and sent to the speaker for you to enjoy. When the music was originally recorded on the CD, a process, essentially the reverse of the one described here, using an analog-to-digital converter (ADC) was used.

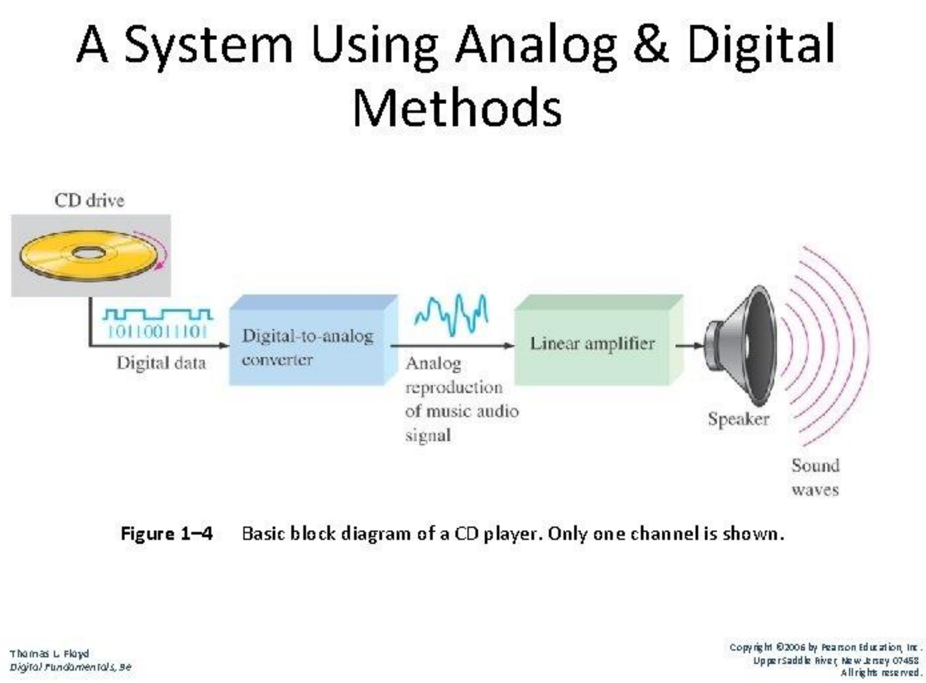

Figure 1–4 Basic block diagram of a CD player. Only one channel is shown.

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NUMBER SYSTEM

Introduction:

Numbers are used to express quantities. There are many numerations systems used in the field of digital electronics, one of the most important being the binary system of numeration on which is based the computer science. Each of the various numerations systems and codes has its advantages but also inconvenient.

1.Decimal numeration system:

Decimal system is the most common numeration system for daily uses. The decimal number system is a radix-10 number system and therefore has 10 different digits or symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. Each digit represents an integer quantity and each place from right to left in a decimal notation represents a weight for each integer quantity.

Example 1:

Let's consider the decimal notation 1253. This number can be broken into its constituent weight-products as such:

$1253 = 1000 + 200 + 50 + 3$

$1253 = 1\times1000 + 2\times100 + 5\times10 + 3\times1$

We can easily notice that the cipher 1 is more weighted than the cipher 2 which in his turn is more weighted than the cipher 5. The cipher 3 is the less weighted. The position of each digit in a decimal number indicates the magnitude of the quantity represented and can be assigned **a weight**. The weights for whole numbers are positive powers of ten that increase from right to left, beginning with $10^0 = 1$.

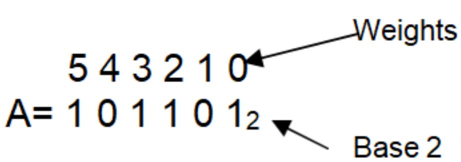
$10^5\ 10^4\ 10^3\ 10^2\ 10^1\ 10^0$

2. Binary numeration system:

The binary numeration system uses only two ciphers instead of ten as the decimal numeration system. Those two ciphers are “0” and “1”. In binary system of numeration, ciphers are called bit (Binary Digit). Cipher are arranged right to left in doubling values of weight (instead of multiplying the weight by 10 as in the case of decimal system).

Example 2:

Let’s consider the following binary number



$$A = 1\times 2^5 + 0 \times 2^4 + 1\times 2^3 + 1\times 2^2 + 0 \times 2^1 + 1\times 2^0$$
$$A = 32 + 0 + 8 + 4 + 1$$
$$A = 45_{10}$$

Each weight is 2 that of the one in the immediate right. The less weighted cipher carries the Ones place (2^0), the cipher at the immediate left carries the twos place (2^1), the following cipher carries the fourth place (2^2).

Exercise 1.1:

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Convert the following binary numbers to decimal numbers:

A = 110101 B = 100110101 C = 11110111101 D = 101100001111

Remark 1: Conversion from binary to decimal

To convert a number written in binary numeration system to its equivalent in decimal, we just have to calculate the products of the bits with their respective weights, as in example 1.3 above. For binary numbers with "binary point" (equivalent of decimal point for decimal numbers), the conversion is done as follow.

```
    2 1 0 -1 -2 -3
A=  1 0 1.  1  0  1
```

$A= 1\times2^2 + 0\times2^1+1\times2^0 +1\times2^{-1}+0\times2^{-2}+1\times2^{-3}$

$A = 5.625_{10}$

Octal numeration system:

The octal numeration system is a place weighted system with a base of eight. Valid ciphers include the symbols "0","1","2","3","4","5","6", and "7". To convert from binary to octal numeration system, we just have to divide the number into groups of binary numbers having 3 bits each. And each group of 3 bits is replaced by its equivalent in octal.

Example 3:

Let's convert the following binary numbers in octal:

A = 10110101

B = 11010111.01

A = 010 110 101

2 6 5_8

$10110101_2 = 265_8$

The bits are grouped from the right to the left. A zero has been added to the two firs bits to form a group of 3 bits. That zero is called an implied zero.

B = 011 010 111 . 010

3 2 7 . 2_8

$11010111.01_2 = 327.2_8$

Two implied zeros have been added to the number to form groups of 3 bits.

Hexadecimal numeration system:

The hexadecimal numeration system is a place weighted system with a base of sixteen. Valid ciphers include the normal decimal symbols “0”,”1”,”2”,”3”,”4”,”5”,”6”,”7”;”8”;9” plus six alphabetical characters A, B, C, D, E, and F. The following table summarizes the equivalence between decimal, binary, octal and hexadecimal systems.

Decimal	Binary	Octal	Hexadecimal
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8

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9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

To convert from binary to hexadecimal numeration, we group bits in fours. Each group of four bit is replaced by its hexadecimal equivalent.

Example 4:

Convert the following binary numbers in hexadecimal.

A = 1101011101

As explained above, we just have to group the binary number in groups of four bits each:

A = 0011 0101 1101

3 5 D_{16}

$$1101011101_2 = 35D_{16}$$

The binary number has been grouped is groups of four bits each, from the right to the left two implied zeros have been added at the extreme left.