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قسم علوم الحاسبات

Logic Design Circuit

المرحلة الاولى – الفصل الدراسي الاول

المحاضرة الاولى

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Outline

1. Introduction of analouge and digital systems
2. Understanding decimal, binary, octal, and hexadecimal numbers.
3. Counting in decimal, binary, octal, and hexadecimal systems.
4. Convert a number from one number system to another system.
5. Advantage of octal and hexadecimal systems.

1. **Definitions**

- System: A set of related components work together to achieve a goal.
- Components are electronic components: digital, analog, and mixed signals.
- Analog signals are a type of signal sent in a continuous wave representing real-world phenomena like sound and temperature.
- Digital signals are signals that are represented in discrete values, there are a wide range of devices that use digital signals. These include devices such as smartphones, smartwatches, and digital clocks.

1.1 *Advantages and Drawbacks of digital techniques compared with analog.*

- ***Advantages***

- Digital systems are generally easier to design (automated design and fabrication on IC chips).
- Information storage is easy.
- Digital representation is very well suited for numerical and non-numerical information processing.
- Accuracy and precision are greater.
- Operations can be programmed.
- Digital circuits are less affected by noise.
- Low cost.

- ***Disadvantages of Digital Techniques:***

- Lower speed (extra time required to perform conversions)
- The major drawback is The physical world is analog such as temperature, pressure, talk. So we need to convert digital to analog and vice versa to communicate with real world.

- Three steps must be followed 1. Convert the real- world analog inputs to digital form. 2. Process the digital information. 3. Convert the digital outputs back to real-world analog form.

2. Decimal number systems:

- Decimal numbers are made of decimal digits: (0,1,2,3,4,5,6,7,8,9 --------10-base system)
- The decimal system is a "positional-value system" in which the value of a digit depends on its position.
- Examples: 453→4 hundred, 5 tens, and 3 units.
- number of items that a decimal number represent: $9261=(9\times10^{3})+(2\times10^{2})+(6\times10^{1})+(1\times10^{0})$
- The decimal fractions: $3267.317=(3\times10^{3})+(2\times10^{2})+(6\times10^{1})+(7\times10)+(3\times10^{-1})+(6\times10^{-2})+(1\times10^{-3})$.

2.1 Binary numbers system

- Base-2 system (0 or 1)
- We can represent any quantity that can be represented in decimal or other number systems using binary numbers.
- Binary number is also positional–value system (power of 2)
- Example: 1101.011
-

2^3	2^2	2^1	2^0		2^{-1}	2^{-2}	2^{-3}
↑	↑	↑	↑		↑	↑	↑
1	1	0	1	.	0	1	1

- To find the equivalent of binary numbers in the decimal system , we simply take the sum of products of each digit value (0,1)and its positional value:
- Example (1011.101)

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

$$=8+0+2+1+\frac{1}{2}+0+\frac{1}{8}=11.625_{10}$$

3. Why we need conversion?

1. We need a decimal system for the real world (for presentation and input): for example: we use a 10-based numbering system for input and output in the digital calculator.
2. We need a binary system inside the calculator for calculation.

3.1 Binary to decimal conversions example

Convert the binary whole number 1101101 to decimal.

Solution

Determine the weight of each bit that is a 1, and then find the sum of the weights to get the decimal number.

$$\text{Weight: } 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$$

$$\text{Binary number: } 1\ 1\ 0\ 1\ 1\ 0\ 1$$

$$1101101 = 2^6 + 2^5 + 2^3 + 2^2 + 2^0$$

$$= 64 + 32 + 8 + 4 + 1 = \mathbf{109}$$

Binary weights.

Positive Powers of Two (Whole Numbers)									Negative Powers of Two (Fractional Number)					
2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}
256	128	64	32	16	8	4	2	1	1/2 0.5	1/4 0.25	1/8 0.125	1/16 0.625	1/32 0.03125	1/64 0.015625

Convert the fractional binary number 0.1011 to decimal.

Solution

Determine the weight of each bit that is a 1, and then sum the weights to get the decimal fraction.

Weight:	2^{-1}	2^{-2}	2^{-3}	2^{-4}
Binary number:	0 . 1	0	1	1

$$0.1011 = 2^{-1} + 2^{-3} + 2^{-4}$$
$$= 0.5 + 0.125 + 0.0625 = \mathbf{0.6875}$$

Practices & self test

1. Convert the binary number 10.111 to decimal.
2. Convert the binary number 10010001 to decimal.
3. What is the largest decimal number that can be represented in binary with eight bits?
4. Determine the weight of the 1 in the binary number 10000.
5. Convert the binary number 10111101.011 to decimal.
6. Convert the following decimal numbers to binary: (a) 19 (b) 45

3.1.1 Octal Number System

▶ Octal number system has a base of 8 : (0,1,2,3,4,5,6,7)

Examples:

. $(1101.011)_8$

8^3	8^2	8^1	8^0		8^{-1}	8^{-2}	8^{-3}
↑	↑	↑	↑		↑	↑	↑
1	1	0	1	.	0	1	1

- $(4327)_8$

$= (4\times8^3) + (3\times8^2) + (2\times8^1) + (7\times8^0)$

- 372.36_8

$= (3\times8^2) + (7\times8^1) + (2\times8^0) + (3\times8^{-1}) + (6\times8^{-2})$

Note: octal number don't use digits 8 or 9

3.1.2 *Octal to Decimal conversion*

$$\begin{aligned} 2374_8 &= (2\times8^3) + (3\times8^2) + (7\times8^1) + (4\times8^0) \\ &= (2\times512) + (3\times64) + (7\times8) + (4\times1) \\ &= 1024 + 192 + 56 + 4 = 1276_{10} \end{aligned}$$

3.1.3 Hexadecimal number system (16-base)

- Hexadecimal numbers are made of 16 digits, it uses the digits 0 through 9 plus the letters A, B, C, D, E, F. Example

- $(A29)_{16}$

$= (10\times16^2) + (2\times16^1) + (9\times16^0) = (2601)_{10}$

- $(2c7.38)_{16}$

$= (2\times16^2) + (12\times16^1) + (7\times16^0) + (7\times16^0) + (3\times16^{-1}) + (8\times16^{-2})$

3.1.4Hexa to decimal conversion

Convert the following hexadecimal numbers to decimal:

(a) $1C_{16}$ (b) $A85_{16}$

Solution Remember, convert the hexadecimal number to binary first, then to decimal.

(a)
$$\overbrace{0001}^{1}\overbrace{1100}^{C} = 2^4 + 2^3 + 2^2 = 16 + 8 + 4 = \mathbf{28_{10}}$$

(b)
$$\overbrace{1010}^{A}\overbrace{1000}^{8}\overbrace{0101}^{5} = 2^{11} + 2^9 + 2^7 + 2^2 + 2^0 = 2048 + 512 + 128 + 4 + 1 = \mathbf{2693_{10}}$$

Hint:

16^3	16^2	16^1	16^0
4096	256	16	1

3.1.3 Binary-to-Octal Conversion

Convert each of the following binary numbers to octal:

(a) 110101 (b) 101111001 (c) 100110011010 (d) 11010000100

Solution

(a) 110101 → 6 5 = 65_8

(b) 101111001 → 5 7 1 = 571_8

(c) 100110011010 → 4 6 3 2 = 4632_8

(d) 011010000100 → 3 2 0 4 = 3204_8

3.1.4 Octal-to-Decimal Conversion

Octal is also a weighted number system. The column weights are powers of 8, which increase from right to left.

Example: Express 3702_8 in decimal.

Solution:

Start by writing the column weights:

512 64 8 1

3 7 0 2_8

$3(512) + 7(64) + 0(8) + 2(1) = 1986_{10}$

Hint

Column weights $\begin{cases} 8^3 & 8^2 & 8^1 & 8^0 \\ 512 & 64 & 8 & 1 \end{cases}$:

3.1.5 Binary-to-Hexadecimal Conversion

Example:

Determine the binary numbers for the following hexadecimal numbers:

(a) $10A4_{16}$ (b) $CF8E_{16}$ (c) 9742_{16}

Solution

(a) 1 0 A 4 → 1000010100100

(b) C F 8 E → 1100111110001110

(c) 9 7 4 2 → 1001011101000010

In part (a), the MSB is understood to have three zeros preceding it, thus forming a 4-bit group.

Practices & self-test

1. **What weight does the digit 7 have in each of the following numbers?**
   a. **1370 (b) 6725 (c) 7051 (d) 58.72 2.**
2. **Express each of the following decimal numbers as a sum of the products obtained by multiplying each digit by its appropriate weight: (a) 51 (b) 137 (c) 1492 (d) 106.58**