Digital Techniques

1. Binary System

The digital computer is the best example of a digital system. A main characteristic of digital system is its ability to manipulate discrete elements of information.

Discrete elements of information are represented in a digital system by physical quantities called signals. Electrical signals such as voltages and currents are the most common. A block diagram of the digital computer is shown in Figure (1). The memory unit stores programs as well as input, output, and intermediate data. The processor unit performs arithmetic and other data processing tasks as specified by a program. The control unit supervise the flow of information between the various units. The programmed data prepared by the user are transferred into the memory unit by means of an input device such as keyboard, punch-card reader. An output device such as a printer.

The central processor unit (CPU) is enclosed in a small integrated circuit that is called a microprocessor. The memory unit, as well as the part that controls the interface between the microprocessor and the I/O devices is called a microcomputer. The digital computer manipulates discrete elements of information and that that these elements are represented in the binary form.

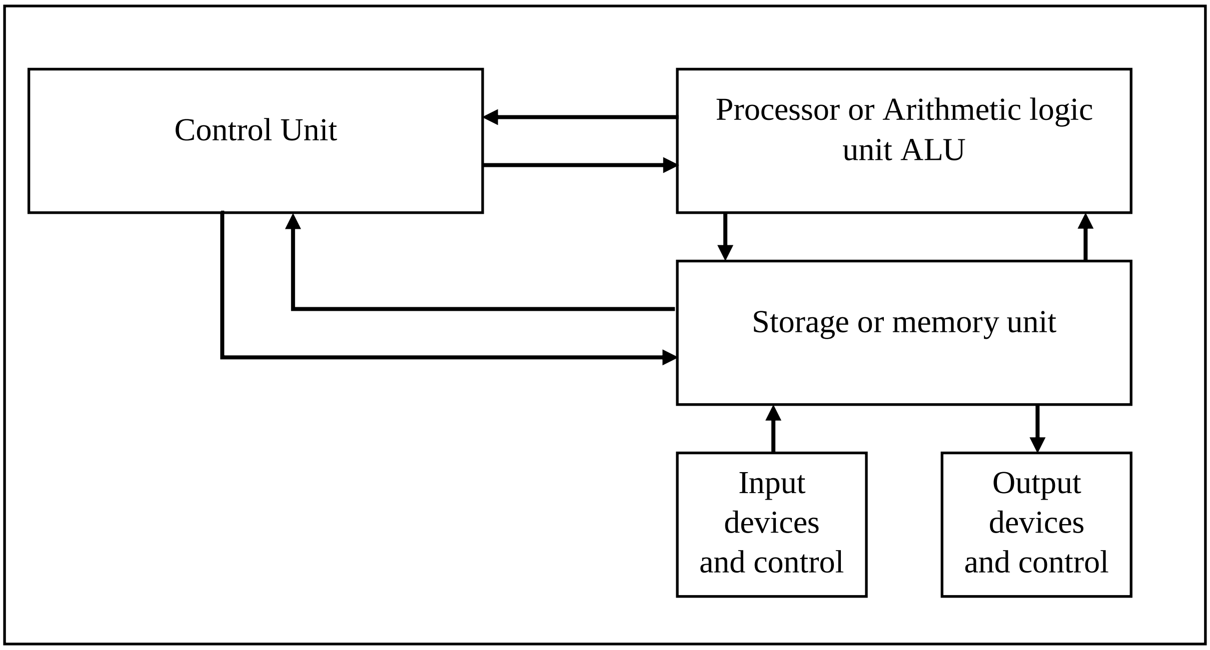


Figure 1: Block diagram of digital computer

2. Binary numbers

The binary numbers system has two possible values: “0” and “1”, called a **Bit**. The physical manifestation of these binary quantities may be one of two voltages, for example, “0” volts or ground for logic “0” and “5” volts for logic “1”. Each coefficient a_j is multiplied by 2^j. For example, the decimal equivalent of the binary number $110)_2$ is $6)_{10}$ as shown from the multiplication of the coefficients by powers of 2:

$$2^2 \times 1 + 2^1 \times 1 + 2^0 \times 0 = 4 + 2 + 1 = 6$$

So **$110)_2$ equals to $6)_{10}$**

The conversion from decimal to binary by dividing of by “2” to give an integer quotient of no. and a remainder. The division quotient is again divided by “2” to give a new quotient and remainder. The process is continued until the integer quotient becomes “0”.

Example 1: Convert decimal $6)_{10}$ to binary

Integer			Remainder	
6	2	→	0	L.S.B Least Significant Bit
3	2	→	1	
1		→	1	M.S.B Most Significant Bit

So **$6)_{10}$ equals to $110)_2$**

Example 2: Convert $41)_{10}$ to binary

Integer			Remainder	
41	2	→	1	L.S.B Least Significant Bit
20	2	→	0	
10	2	→	0	
5	2	→	1	
2	2	→	0	
1		→	1	M.S.B Most Significant Bit

So **$41)_{10}$ equals to $101001)_2$**

32	16	8	4	2	1
1	0	1	0	0	1

1+8+32=41

Example 3: Convert $0.75)_{10}$ to binary

	Integer	Fraction
o.75×2 = 1.5	1	0.5
0.5×2 = 1	1	0

So **$0.75)_{10}$ equals to $0.11)_2$**

Example 4: Convert $9.6875)_{10}$ to binary

The integer

Integer			Remainder	
9	2	→	1	L.S.B Least Significant Bit
4	2	→	0	
2	2	→	0	
1		→	1	M.S.B Most Significant Bit

The fraction

	Integer	Fraction
o.6875×2 = 1.375	1	0.375
0.375×2 = 0.75	0	0.75
0.75×2=1.5	1	0.5
0.5×2=1	1	0

So **$9.6875)_{10}$ equals to $1001.1011)_2$**

Example 4: Convert $11010.11)_2$ to decimal

$$[(2^4\times1)+(2^3\times1)+(2^2\times0)+(2^1\times1)+(2^0\times0)].[(2^{-1}\times1)+(2^{-2}\times1)]=$$

$$[16+8+0+2+0].[0.5+0.25] = 26.75$$

So **$11010.11)_2$ equals to $26.75)_{10}$**

3. Logic Gates

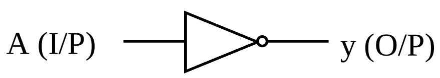
A gate is a circuit with one output that implements one of the basic functions such as inverter, OR and AND gates. Gates are available with one, two, three, four, and eight inputs.

<u>Truth table (T.T):</u> is a table of all possible combination of the variables showing the relation between the values that the variables may take and the result of the operation.

3.1. Inverter "Not" gate

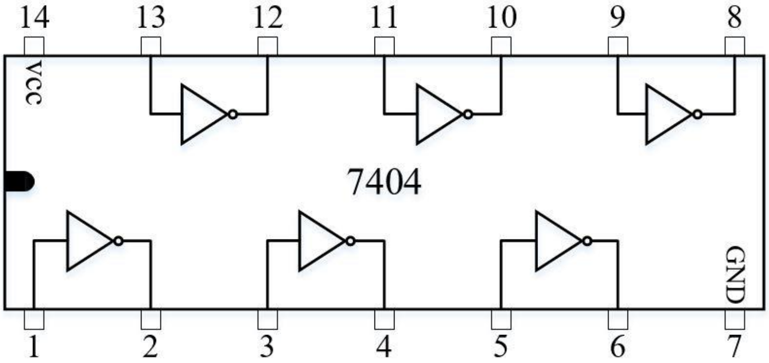
An inverter is a gate with only one input and one output. It is called an inverter because the output state is always the opposite of the input state. Specifically, when the input voltage is high the output is low. On the other hand, when the input voltage is low the output is high.

T.T (Truth Table)	
I/P (A)	O/P (y)
0	1
1	0



Symbol for digital logic cct.

$y=\bar{A}$ **Algebraic Function**

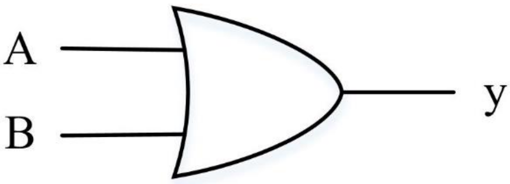


Integrated Circuit IC

3.2. OR Gate

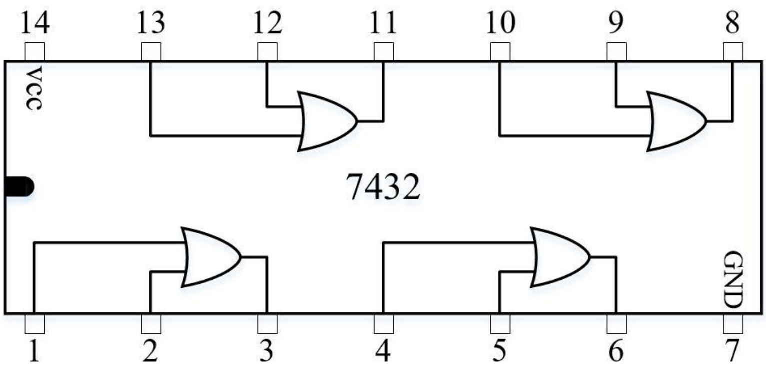
An OR gate has two or more input signals but only one output signal. It is called an OR gate because the output voltage is high if any or all of the input voltages are high.

T.T (Truth Table)		
I/Ps		O/P
A	B	y
0	0	0
0	1	1
1	0	1
1	1	1



Symbol for digital logic cct.

$y=A+B$ **Algebraic Function**

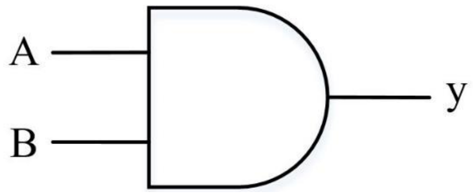


Integrated Circuit IC

3.3. AND Gate

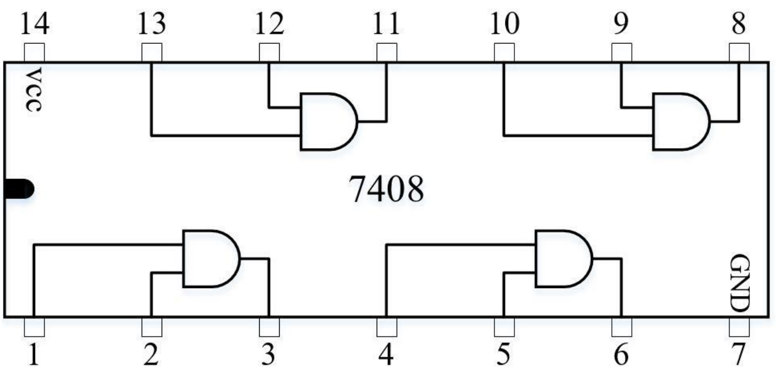
The AND gate has a high output only when all inputs are high. In other words the AND gate is an all or nothing gate, a high output occurs only when all inputs are high.

T.T (Truth Table)		
I/Ps		O/P
A	B	y
0	0	0
0	1	0
1	0	0
1	1	1



Symbol for digital logic cct.

y=A.B **Algebraic Function**

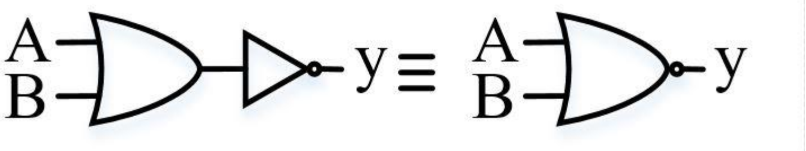


Integrated Circuit IC

3.4. NOR Gate

Read this as **y equals Not(A OR B)**. The only way to get a high output is to have both inputs low.

T.T (Truth Table)		
I/Ps		O/P
A	B	y
0	0	1
0	1	0
1	0	0
1	1	0

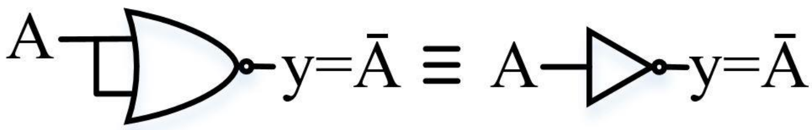


Symbol for digital logic cct.

$y=\overline{A+B}$ **Algebraic Function**

If A=B i.e. I/Ps are shorted

T.T (Truth Table)		
I/Ps		O/P
A=	B	y
0	0	1
1	1	0
0	0	1
1	1	0

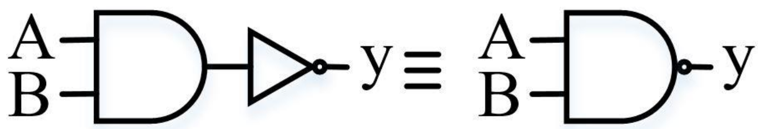


So, we get an inverter (Not gate)

3.5. NAND Gate

Read this as **y equals Not(A AND B)**. The only way to get a low output is for both inputs to be high.

T.T (Truth Table)		
I/Ps		O/P
A	B	y
0	0	1
0	1	0
1	0	0
1	1	0

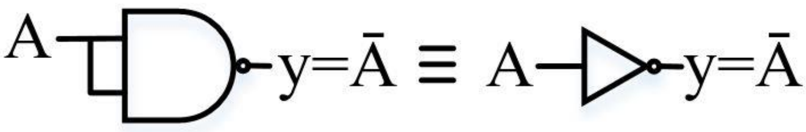


Symbol for digital logic cct.

$y=\overline{A.B}$ **Algebraic Function**

If A=B i.e. I/Ps are shorted

T.T (Truth Table)		
I/Ps		O/P
A=	B	y
0	0	1
1	1	0
0	0	1
1	1	0



So, we get an inverter (Not gate)