Lecture 2-3

Introduction to basic logic operations and basic digital circuits:

Logic circuit/Digital circuit/switching circuit: A circuit whose input and output signals are two state, either low or high voltages.

The basic logic circuits are OR, AND and NOT gates.

Gate: A logic circuit with one or more input signals but only one output signal (Logic 1 or Logic 0).

Truth table: A table that shows all inputs and output possibilities for a logic circuit. The input words are listed in binary progression.

Word: A string of bits that represent a coded instruction or data.

For n inputs, there are 2^n input combinations. Truth table contains one row for each one of the input combinations.

1. **The AND operation:**
   The AND operation is defined as: the output of an AND gate is 1 if and only if all the inputs are 1.
   Mathematically, it is written as: X=A AND B AND C….AND N
   = A.B.C…………..N
   = ABC……………N
   Where A,B,C,….,N are input variables and X is the output variable. The variables are binary, i.e each variable can assume only one of the two possible values: 0 or 1.

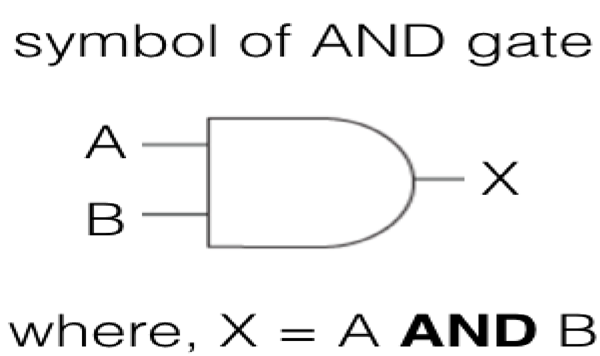


Figure: A two input AND gate

Truth table: For an AND gate with two inputs A,B and the output X, the truth table is given below:

Inputs		Output
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

Logical equation is: X = AB

2. **The OR operation:**

The OR operation is defined as: the output of an OR gate is 1 if and only if one or more inputs are 1. Its logical equation is given by:

X= A OR B OR C………… OR N

  = A+B+C+………………+N

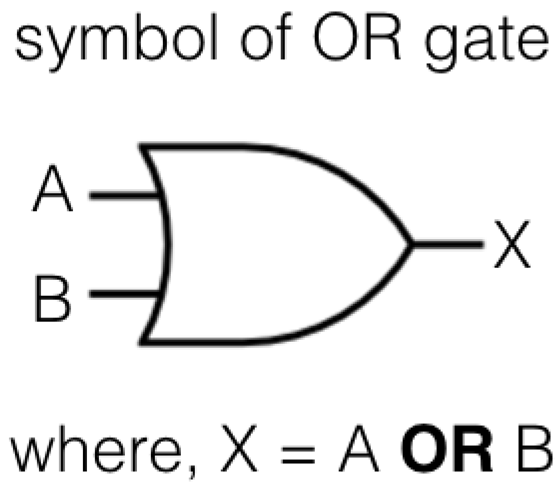


Figure: A two input OR gate

Truth table:

Inputs		Output
A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

Logical equation is: X = A+B

3. **The NOT operation:**
   The NOT operation changes one logic level to the opposite logic level. When the input is HIGH (1) the output is LOW(0). When the input is LOW (0) the output is HIGH(1). In either case, the output is not the same as the input. Following figure shows a NOT gate which is also known as an inverter. It has one input (A) and one output (Y).

Symbol of NOT gate

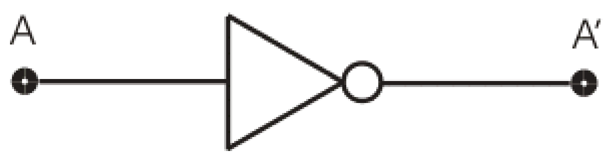


Figure: The standard symbol for a NOT gate

Its **logical equation** is: X= NOT A= A′ or $\overline{A}$

Truth table:

Input (A)	Output (X= A′)
0	1
1	0

NAND and NOR operations:

Any Boolean (or logic) expression can be realized by using the AND, OR and NOT gates. From these three operations two more operations have been derived: The NAND operation and NOR operation. These operations have become very popular and are widely used, the reason being the only one type gates, either NAND or NOR are sufficient for the realization of any logical expression. Because of this reason, NAND and NOR gates are known as **universal gates.**

4. The NAND operation:

The NOT-AND operation is known as the NAND operation. The operation of this circuit can be described in the following way:

The output of the AND gate (*Y1*) can be written as:
Y1= AB……N
Now the output of the NAND gate (Y) is:
Y= $\overline{Y1} = \overline{(AB......N)}$

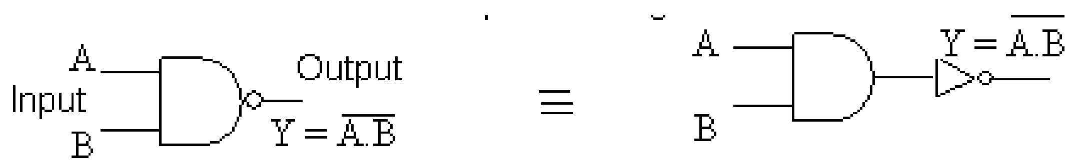


Fig.3.6:Graphic symbol of NAND Gate

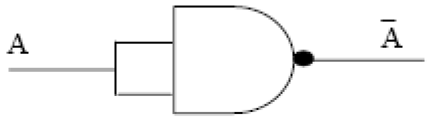
INPUTS		OUTPUT
A	B	$Y=\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

Table 3.4 : Truth Table for NAND Gate

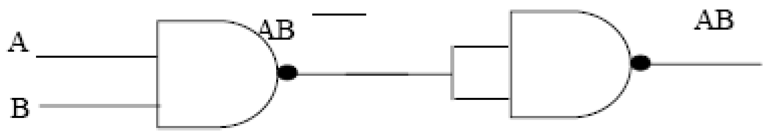
* If at least one input is 0,output is 1 always.
NAND operation is written as: Y= $\overline{AB}$.

Realization of basic logic operations using NAND gates:

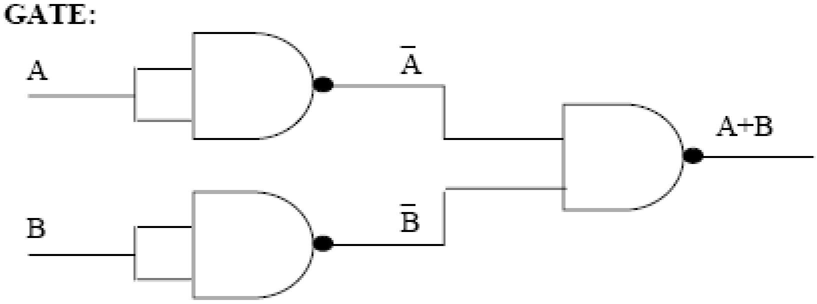
NOT GATE:



AND GATE:



OR GATE:



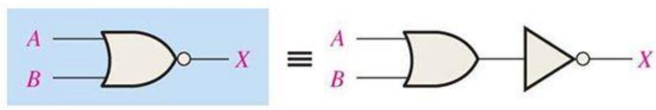
5. The NOR operation:

The NOT-OR operation is known as the NOR operation. The operation of this circuit can be described in the following way:

The output of the OR gate (*X1*) can be written as:
X1= A+B+……+N

Now the output of the NOR gate (X) is:
X= $\overline{X1} = \overline{(A+B+.......+N)}$

NOR gate



NOR = NOT-OR

Truth table for a 2-input NOR gate

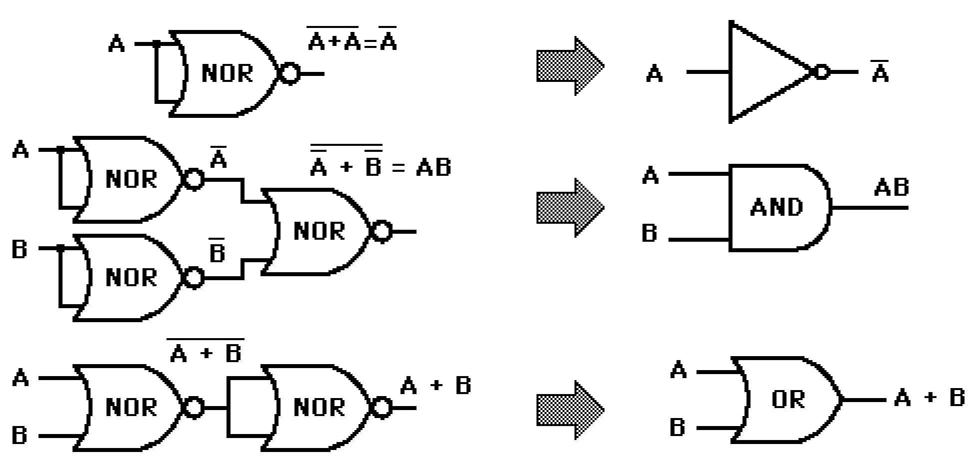
Inputs		Output
A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

NOR operation is written as $X = \overline{A + B}$ or $X = (A + B)'$

17

- If at least 1 input is 1,output is always 0.

Realization of basic logic operations using NOR gates:



6. **The Exclusive OR (EX-OR\X-OR) operation:**
   This circuits finds application where two digital signals are to be compared. When both the inputs are same (0 or 1) the output is 0, whereas when the inputs are not same (one of them is 0 and the other one is 1) the output is 1.

   Logic equation: Y= A Ex-OR B = A$\oplus$ B = $\bar{A}B + A\bar{B}$

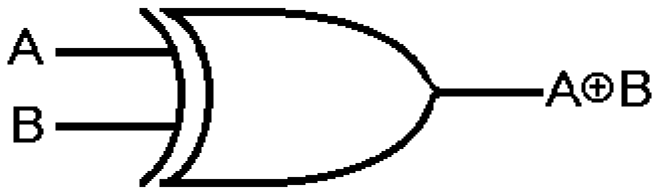


Figure: Standard symbol for two input Ex-OR gate.

Truth table:

Inputs		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

X-OR for more than two inputs:
- If the total number of '1' is odd, output will be 1.
- If the total number of '1' is even, output will be 0.

7. **The Exclusive NOR (EX-NOR\X-NOR) operation:**
   The NOT-XOR operation is known as the X-NOR operation.
   Logical equation: Y= A Ex-NOR B = (A$\oplus$ B) ′ = A$\odot$B= $\bar{A}\bar{B} + AB$

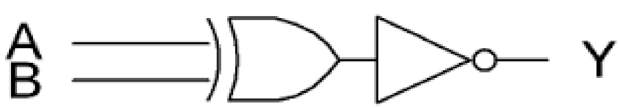


Figure: X-NOR as NOT X-OR

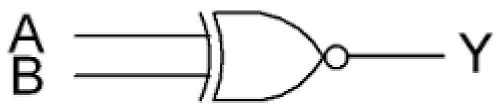
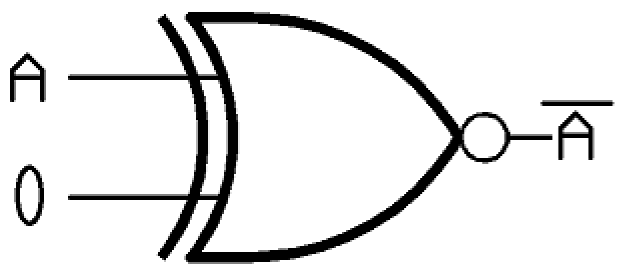


Figure: Standard symbol for two input X-NOR gate

Truth table:

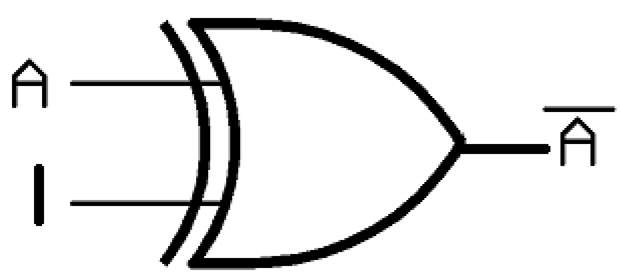
Inputs		Output
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

Realization of NOT operation using X-NOR gate:



A$\odot$B= $\overline{A}\overline{B} + AB = \overline{A}.\overline{0} + A.0 = \overline{A}.1 + 0 = \overline{A}$

Realization of NOT operation using X-OR gate:



A$\oplus$ B = $\overline{A}B + A\overline{B} = \overline{A}.1 + A.\overline{1} = \overline{A} + A.0 = \overline{A} + 0 = \overline{A}$