❖ Logic Gates

A large number of electronic circuits (in computers, control units, and so on) are made up of logic gates. These logic gates process signals, and provide outputs (true or false). The input values for digital logic circuits may be *+ 5* and *-5* volts, or the values may be ***0.5*** and ***3.5*** volts. In digital, these signals represent the values of (*0* and *1*).

❖ Truth table

A truth table will define the logical outputs (***0*** or ***1***) of the logic gate for all possible logical inputs.

The basic logic gates are (***NOT, AND,*** and ***OR***) gates and other logic gates can be obtained from these gates such as (***NOR, NAND, X-OR,*** and ***X-NOR***).

1- NOT Gate

This gate is an electronic circuit that produces an inverted version of the input at its output. It is also known as an inverter. The logic symbol of this gate is shown in figure (1)

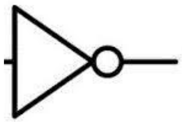
Input  Output

Fig 1 NOT gate

The truth table of ***NOT*** gate is shown below by assuming the input is A then the output will be $\bar{A}$.

i/p	o/p
A	$\bar{A}$
0	1
1	0

The electrical circuits shown in figure (*2a*) & (*2b*) can represent the ***NOT*** gate, where the switch represents input and the light represents the output of the logic cct.

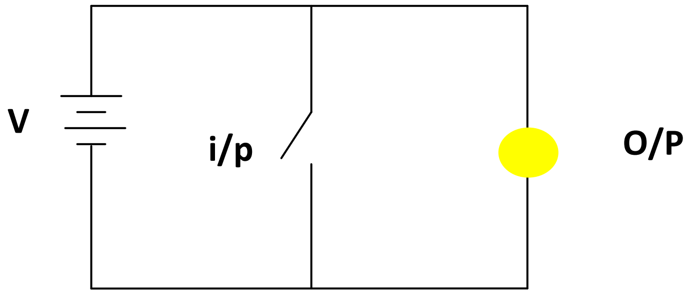


Fig 2a

When the switch is off then the current is follow in the cct. towards the light and this mean that the O/P is logic (*1*) Fig(*2a*). While if the switch is on this lead to short cct. on the light and this mean that the O/P is logic (*0*) Fig(*2b*).

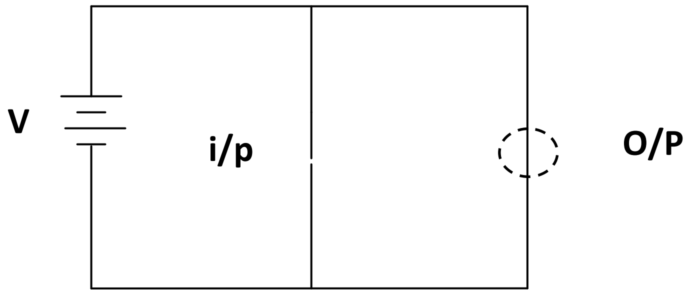


Fig 2b

2- OR Gate

This gate is an electronic circuit that gives a true output (*1*) if one or more of its inputs are true. A plus (+) is used to show the (OR) operation. The logic symbol is shown in figure (3) for ***OR*** gate with two inputs, this gate can take *N* inputs.

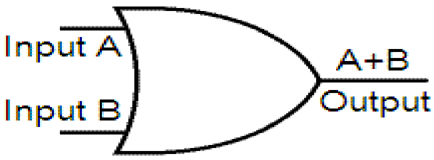


Fig 3 OR gate

The truth table of ***OR*** gate is shown in the following table with ***A*** and ***B*** inputs.

i/p	i/p	o/p
A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

To express ***OR*** gate using electrical cct. Two switch that represent inputs and light to represent the output as shown in figure (4)

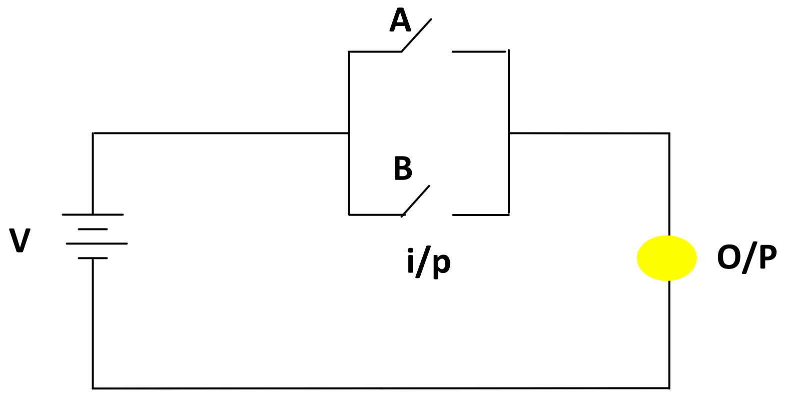


Fig 4

If one of the two switches is on then the light flares, which mean that the o/p is logic (*1*).

3- AND Gate

The ***AND*** gate is an electronic circuit that gives a true output (*1*) only if all its inputs are true. All other cases gives zero output. The logic symbol of ***AND*** gate with two inputs is shown in figure (5)

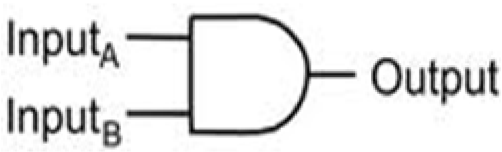


Fig 5 AND gate

The truth table of ***OR*** gate is shown in the following table with ***A*** and ***B*** inputs.

i/p	i/p	o/p
A	**B**	**AB**
0	0	0
0	1	0
1	0	0
1	1	1

To express ***OR*** gate in an electrical circuit we can use circuit shown in figure (6), the current can reach to the light only when the two switches are on.

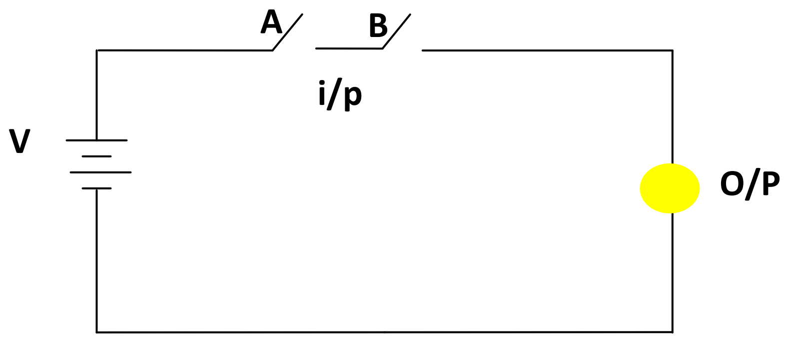


Fig 6

4- NOR Gate

The ***NOR*** gate represents the complement of the ***OR*** operation. The logic symbol of ***NOR*** gate with two inputs is shown in figure (7).

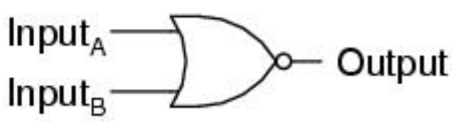


Fig 7 NOR gate

The equivalent logic cct. is ***OR*** gate with ***NOT*** gate. The truth table that represent the relation between the inputs and outputs is given below.

i/p	i/p	o/p
A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

The electrical cct. of ***NOR*** gate is shown in figure (8)

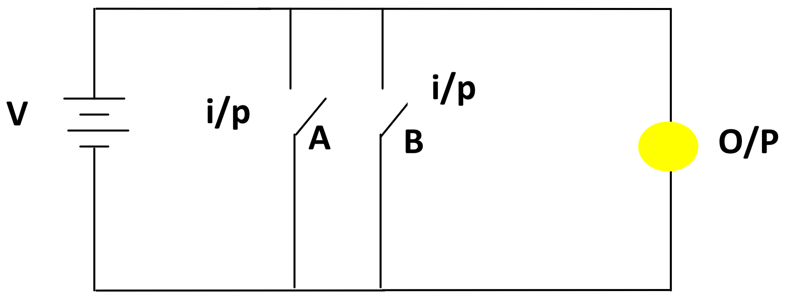


Fig 8

5- NAND Gate

NAND gate is the complement of ***AND*** gate, the logic symbol of this gate is shown in figure (9).

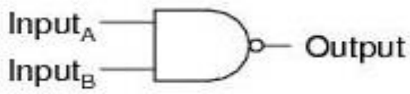


Fig 9 NAND gate

The equivalent logic cct. is ***AND +NOT*** operation, and the electrical cct. that represents ***NAND*** gate is shown in figure(10).

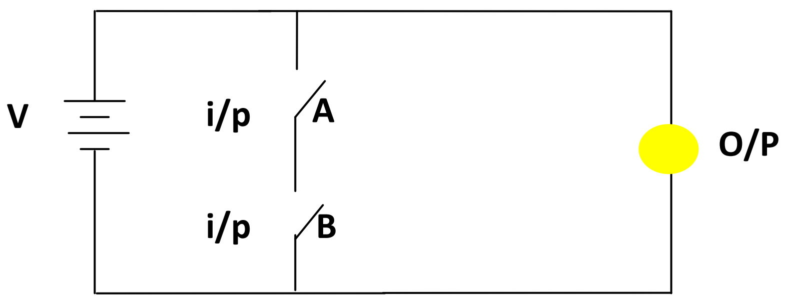


Fig 10

6- Exclusive OR (X-OR)

The ***XOR*** and ***XNOR*** gates play the major role in various circuits that used to perform the arithmetic operations such as full adders, compressors, comparators, Parity generators/checkers etc. the logic symbol of this gate is given in figure (11).

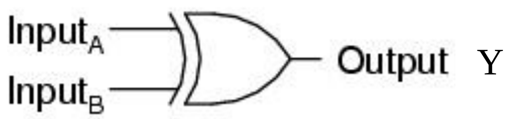


Fig 11 X- OR gate

The exclusive ***OR*** (***XOR***) function is an important Boolean function used extensively in logic circuits. The ***XOR*** function is:

$Y = A \oplus B = \bar{A}B + A\bar{B}$

The logic circuit that express the output of equivalent ***X-OR*** is given in figure (12).

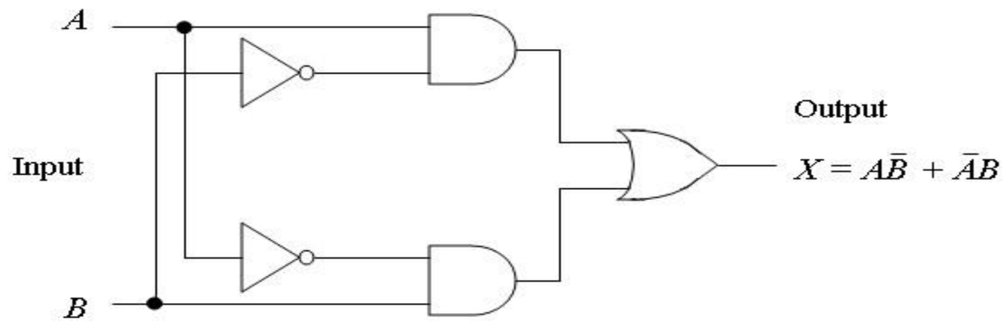


Fig 12 equivalent X-OR

The truth table of ***X-OR*** gate is given below:

i/p	i/p	o/p
A	**B**	**$A \oplus B$**
0	**0**	**0**
0	**1**	**1**
1	**0**	**1**
1	**1**	**0**

7- **Exclusive NOR (X- NOR)**

X- NOR gate represent the complement of ***X- OR*** gate, logic symbol is shown in figure (13).

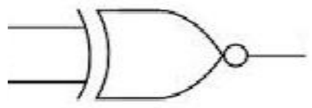


Fig 13 X-NOR gate

The logic circuit that express the output of equivalent ***X-NOR*** is given in figure (14).

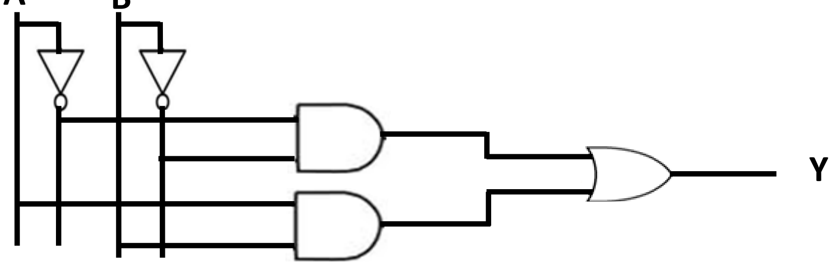


Fig 14 equivalent X-NOR

The truth table of ***X-OR*** gate is given below:

i/p	i/p	o/p
A	**B**	**A ⊙B**
0	**0**	**1**
0	**1**	**0**
1	**0**	**0**
1	**1**	**1**

❖ ***Applications of X-OR gate***

X-OR gate is an important gate and can be used widely in the design of the logic circuits. The most two important logic circuits are:

1- Conversion from Binary to Gray and vice versa

To convert any binary number to gray system, ***X-OR*** gate can be used as illustrated in the following example.

Ex1/ Draw the logic circuit that convert the following binary number to the Gray code. $(1\ 0\ 1\ 1\ 1)_B$

Sol: + + ++ +

$(1\ 0\ 1\ 1\ 1)_B$

↓ ↓ ↓ ↓ ↓

$(1\ 1\ 1\ 0\ 0)_G$

By using ***X-OR*** gates the same results can be obtained as illustrated in figure (15).

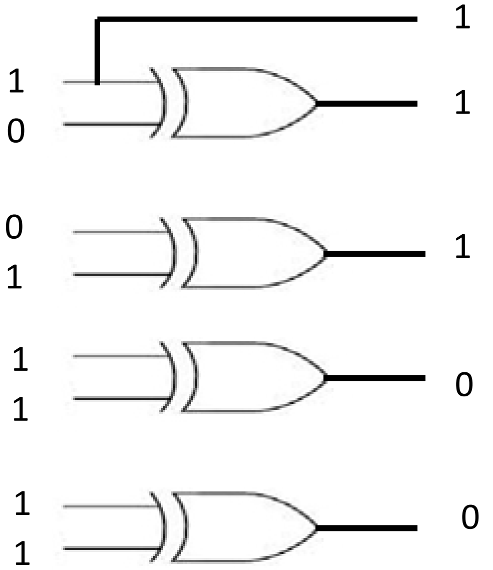


Fig 15 Binary to Gray logic circuit

Which is the same result of the adding each two binary bits.

Ex2/ Check the result of example one by converting the gray codes to the binary codes.

Sol:

$(1\ \ 1\ \ 1\ \ 0\ \ 0)_B$

↓ +↗ ↓ +↗ ↓ +↗ ↓ +↗ ↓

$(1\ \ 0\ \ 1\ \ 1\ \ 1)_G$

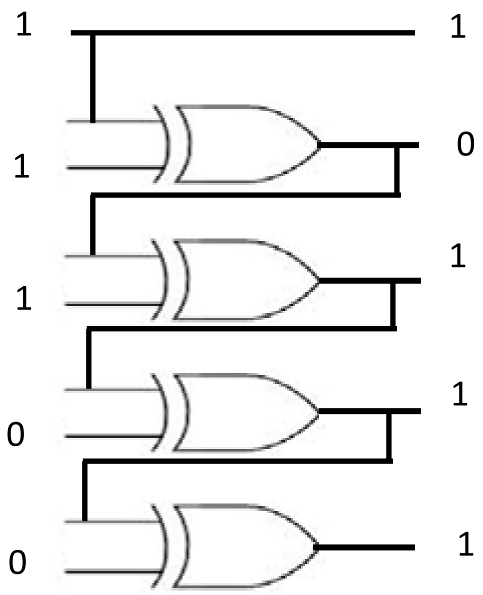


Fig 16 Gray to Binary logic circuit

2- Odd and Even Parity Cheek

To construct a logic circuit that produces a parity cheek for any inputs, ***X-OR*** and ***X-NOR*** gates can be used as illustrated in the following example.

Ex3/ For two input bits draw a logic circuit that finds the odd and even parity cheek for them.

Sol: Let the first bit is represented by ***A*** and the other is represented by ***B*** then odd parity is Symbolized by the ***O*** an even parity by ***E***. The truth table is:

A	B	C	E
0	0	1	0
0	1	0	1
1	0	0	1
1	1	1	0

The digital electronic circuit that performs this truth table can be drawn as shown in figure (17).

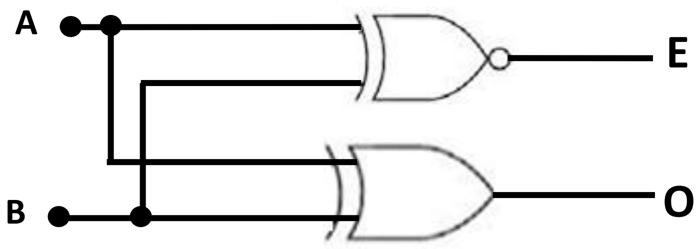


Fig 17 Even and Odd parity cheek