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Practical : Modeling of Digital Circuits

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LOGIC GATES

A **logic gate** is an idealized model of computation or physical electronic device implementing a Boolean function, a logical operation performed on one or more binary inputs that produces a single binary output. Depending on the context, the term may refer to an **ideal logic gate**, one that has for instance zero rise time and unlimited fan-out, or it may refer to a non-ideal physical device

Logic circuits include such devices as multiplexers, registers, arithmetic logic units (ALUs), and computer memory, all the way up through complete microprocessors, which may contain more than 100 million gates. In modern practice, most gates are made from MOSFETs (metal–oxide–semiconductor field-effect transistors).

BASICS

- Digital electronics represent signals by discrete bands of analog levels, rather than by a continuous range.

- There are only two signal levels 0 or 1 (Binary)

- Circuits which works on this is called as Logic circuits.

- Circuits need design, which can be done by some set of equations, called as Boolean equation.

- A variable is called as Boolean variable Example: A represents 1 and A represents 0 Various operations can be done with these variables, which are called as OR (+), AND (.) ,NOT (basic operations). NOR, NAND,XOR,XNOR are derived from the basic operations.

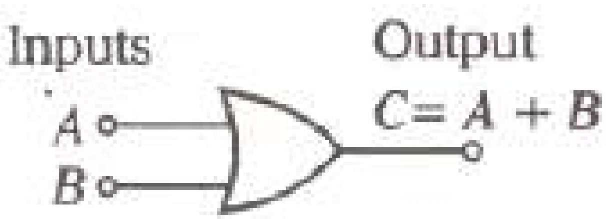
LOGIC GATES

Types of Gates:

1) OR Gate
2) AND Gate
3) NOT Gate
4) NAND Gate
5) NOR Gate
6) EX-OR Gate
7) EX-NOR Gate

OR GATE

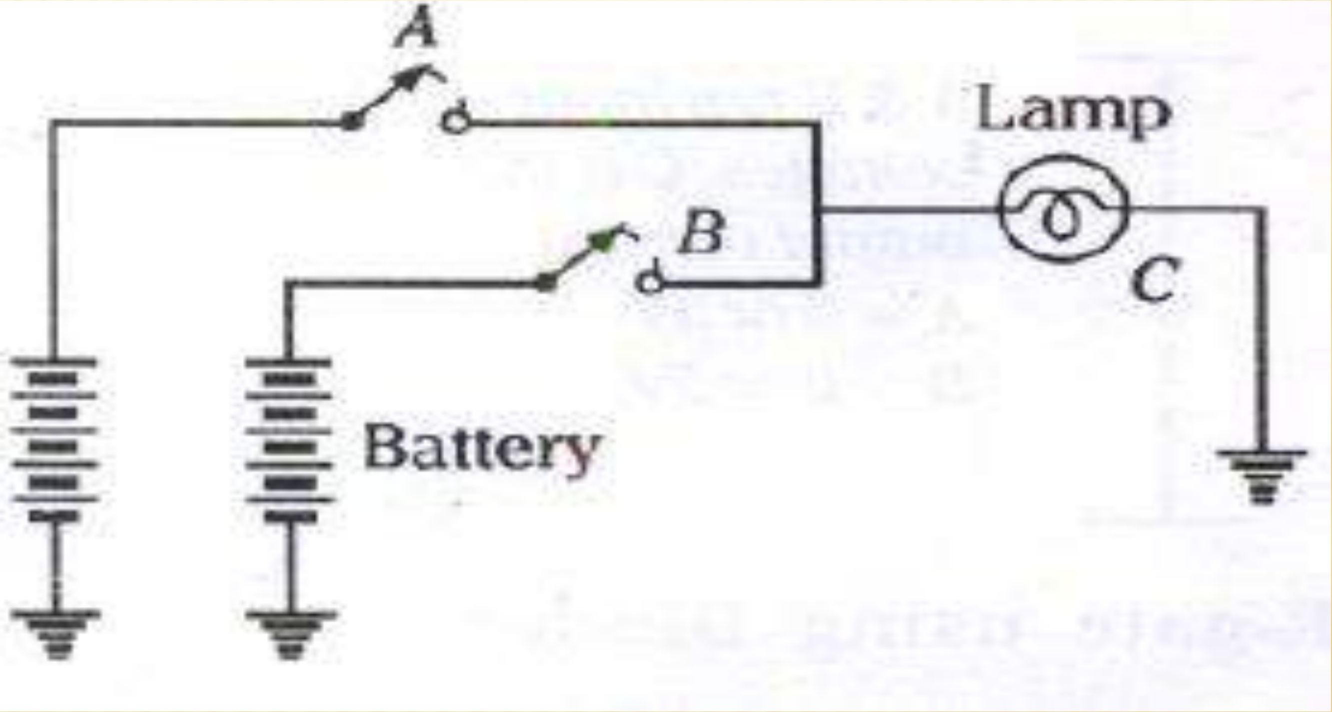
- OR gate performs logical addition.
- The OR operator is indicated by a plus (+) sign.



A	B	C = A + B
0	0	0
0	1	1
1	0	1
1	1	1

EXAMPLE:

- Consider the switching circuits shown below.
- A and B are switches, both are connected in parallel.



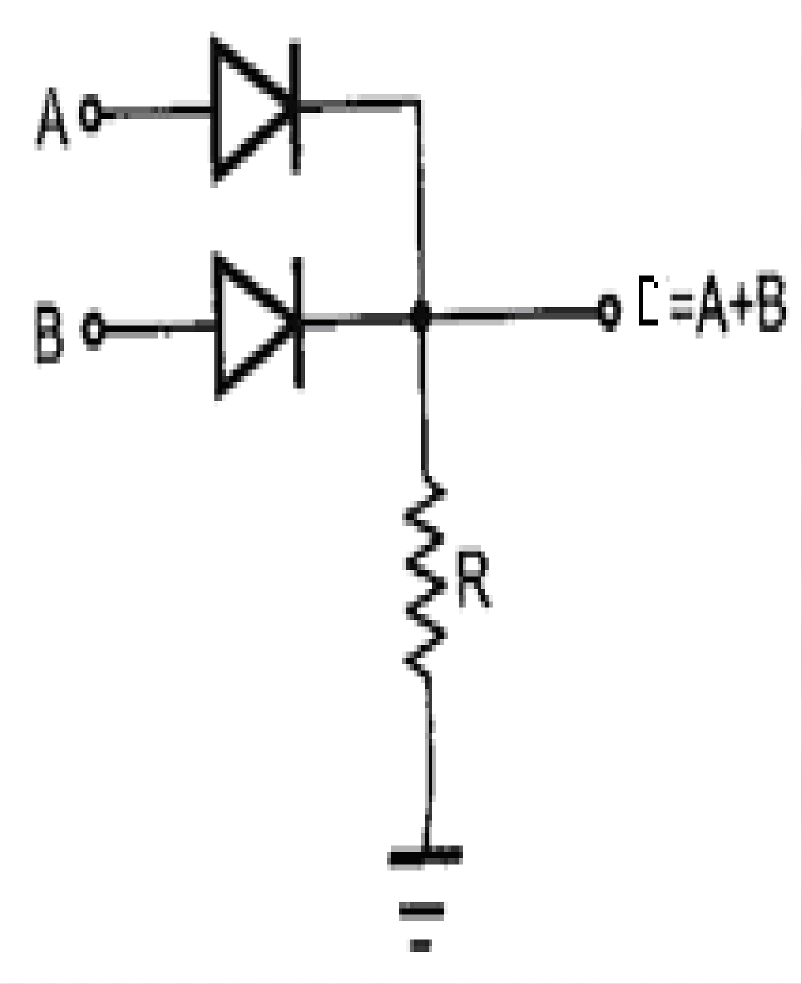
OR GATE USING DIODES:

Operation:

- Assume the input voltages are either 0V (low) or 5V (high).

Both A and B are low:

- The diodes are off and we can replace the diodes by open circuit equivalent.
- Hence no current in the circuit and output C = 0V.



A is low and B is high:

- When A is low the corresponding diode will be off and, B is high so the diode corresponds to the input B will be ON.

- Now we can replace the ON diode by the short circuit equivalent and the output C=5V.

B is low and A is high:

- When B is low the corresponding diode will be off and, A is high so the diode corresponds to the input A will be ON.

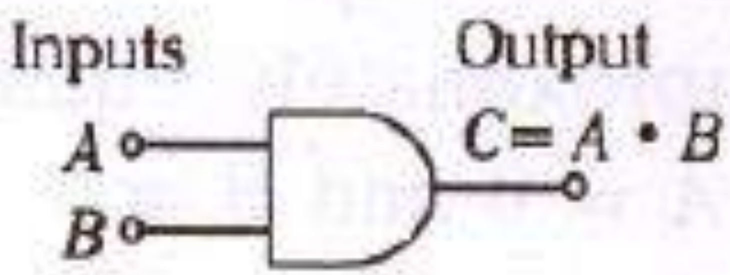
- Now we can replace the ON diode by the short circuit equivalent and the output C=5V.

Both A and B are high:

- When both the inputs are high both the diodes will be ON and the output C=5V.

AND Gate:

- The AND gate performs logical multiplication.
- The AND operator is indicated by using a dot (.) sign or by not showing any operator symbol at all.

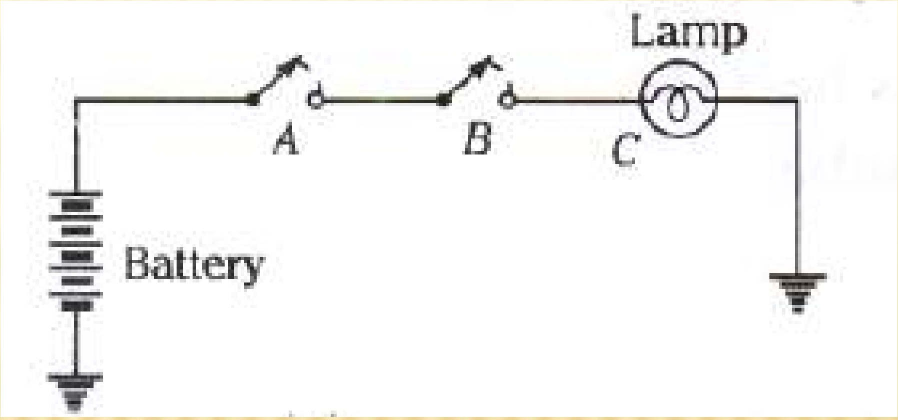


A	B	$C = A \cdot B$
0	0	0
0	1	0
1	0	0
1	1	1

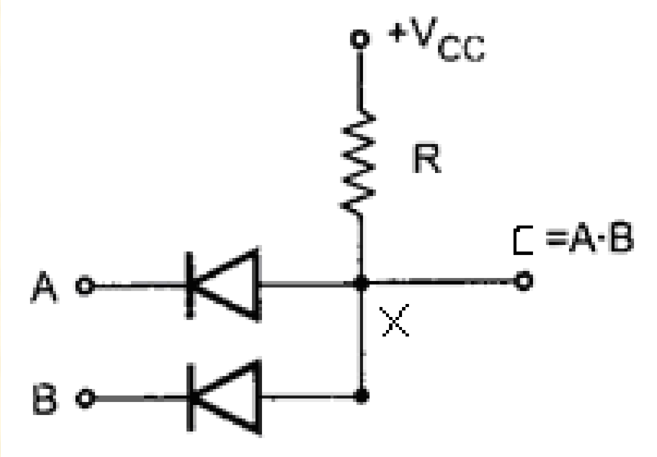
EXAMPLE:

- Consider the switching circuit shown below:

- A and B are switches, both are connected in series.



AND GATE USING DIODES:



Operation:

Assume the input voltages are either 0V (low) or 5V (high).

Both A and B are low:

- When both A and B are low both the diodes are ON and we can replace the diodes by short circuit equivalent.
- Hence point X is connected to ground and output C = 0V.

A IS LOW AND B IS HIGH:

- When A is low the corresponding diode will be ON and, B is high so the diode corresponds to the input B will be OFF.

- Now we can replace the ON diode by the short circuit equivalent; hence point X is connected to ground and the output C=0V.

B is low and A is high:

- When B is low the corresponding diode will be ON and, A is high so the diode corresponds to the input A will be OFF.
- Now we can replace the ON diode by the short circuit equivalent; hence point X is connected to ground and the output C=0V.

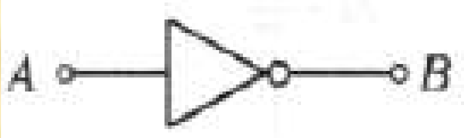
Both A and B are high:

- Both the diodes will be OFF and the output C=5V.

NOT Gate (INVERTER)

- The output of a NOT gate is the complement of the input.

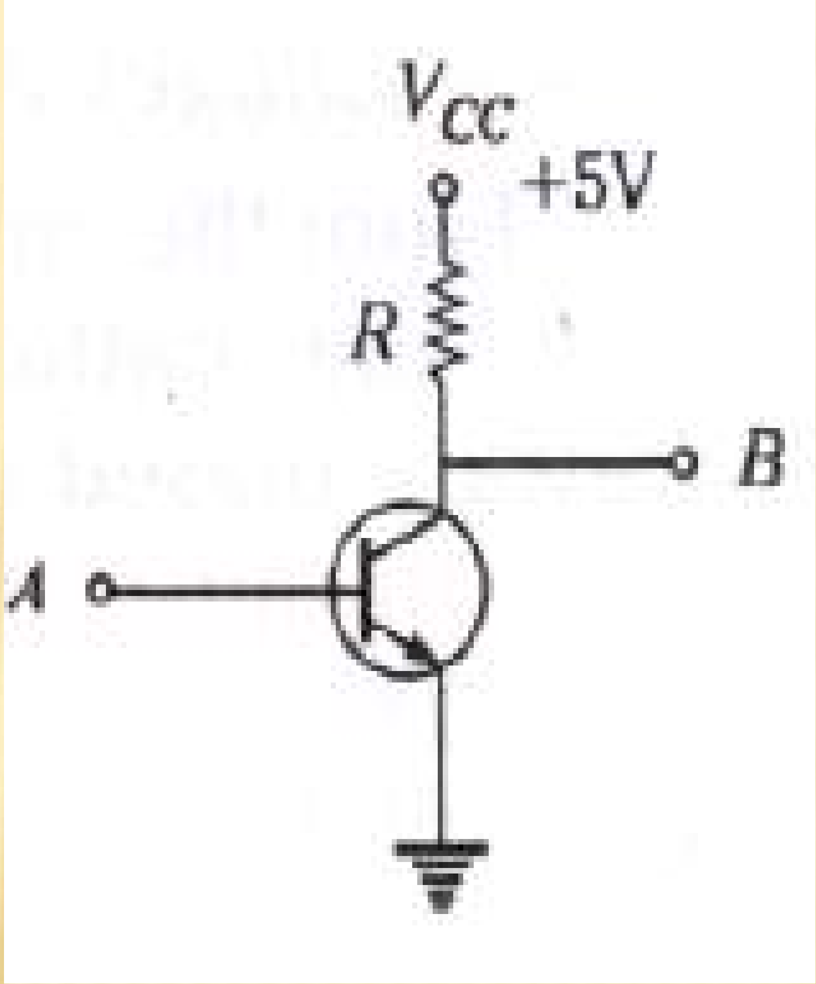
- The bubble represents inversion or complement.



A	B
0	1
1	0

REALIZATION OF NOT GATE USING TRANSISTOR:

A is high:



- When +5V is applied to A, the transistor will be fully ON.
- So maximum collector current will flow and VCC =ICR, making VC or voltage at point B as zero. [Recall CE loop KVL: VC=VCC-ICR].

A IS LOW:

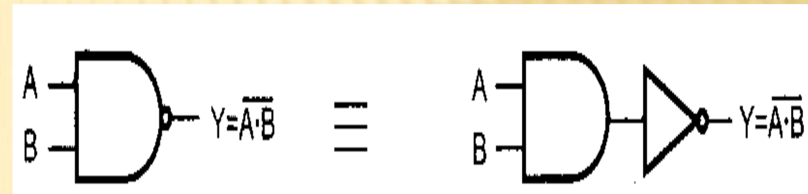
- When 0V is applied to A, the transistor will be cut-off.

- So IC=0mA and VC or voltage at point B is equal to VCC.

NAND GATE

- The NAND gate is a **universal gate**, because it can be used to construct an AND gate, OR gate, inverter or any combination of these functions.

LOGIC SYMBOL



TRUTH TABLE

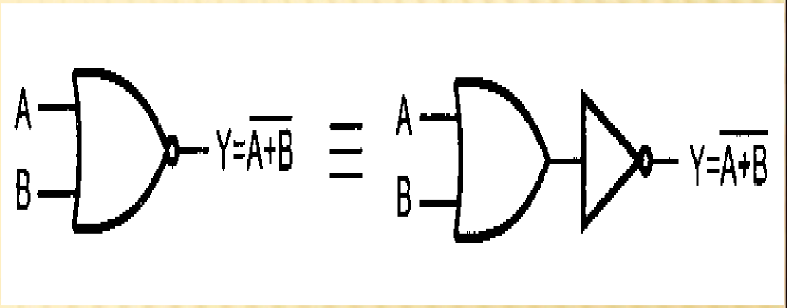
Input		Output
A	B	$Y=\overline{A \bullet B}$
0	0	1
0	1	1
1	0	1
1	1	0

NOR GATE

- NOR gate is a combination of a NOT gate and an OR gate.

- NOR gate is also a universal gate.

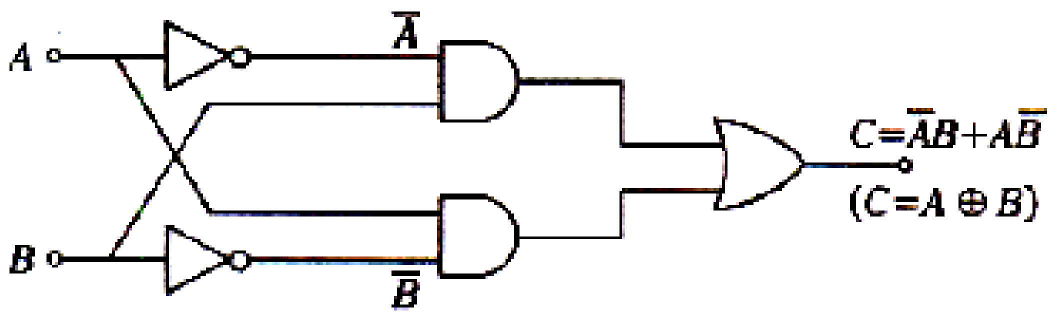
LOGIC SYMBOL

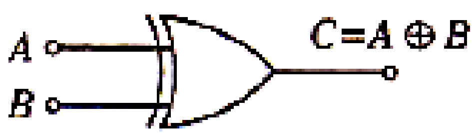


TRUTH TABLE

Input		Output $Y=\overline{A+B}$
A	B	
0	0	1
0	1	0
1	0	0
1	1	0

EXCLUSIVE-OR GATE (XOR GATE)



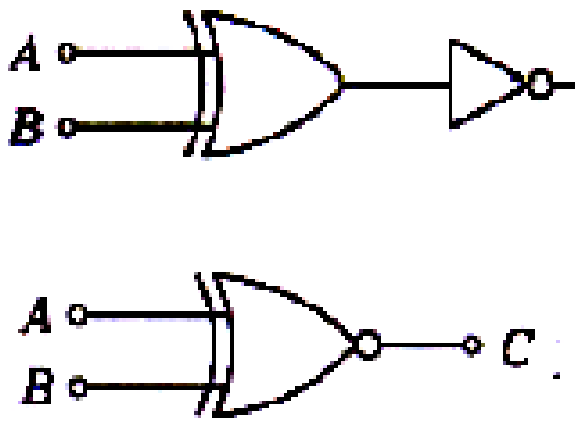


A	B	C
0	0	0
0	1	1
1	0	1
1	1	0

LOGIC SYMBOL AND TRUTH TABLE

EXCLUSIVE-NOR GATE (XNOR GATE)

- Exclusive-NOR gate is a combination of a NOT gate and XOR gate



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

BOOLEAN ALGEBRA:

- Boolean algebra is a system of mathematical logic.
- It has two values 0 and 1.
- It differs from both ordinary algebra and binary number system. For example: in Boolean, 1+1 = 1; in binary arithmetic 1 + 1 = 10.

Thank You