Digital Logic Design

CHAPTER - III
Logic Gates

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Logic Gates

- Are the building blocks of digital electronics.
- The term gate is used to describe a circuit that performs a basic logic operations.
- The fundamental logic gates include the NOT, AND, OR, NAND, NOR, X-OR, X-NOR gates.
- Each of these gates performs a different logical operations.

Basic Logic Gates

THE INVERTER:

Definition: Performs the operation called inversion or complementation

Operation: The Inverter changes one logic level to the opposite level

THE AND GATE:

Definition: composed of two or more inputs and a single output

Operation: for a 2-input AND gate, output X is HIGH only when inputs A and B are HIGH; X is LOW when either A or B is LOW, or when both A and B are LOW.

THE OR GATE

Definition: has two or more inputs and one output

Operation: for a 2-input OR gate, output X is HIGH when either input A or input B is HIGH; or when both A and B are HIGH; X is LOW only when both A and B are LOW.

Universal Gates

THE NAND GATE

Definition: the term NAND is a contraction of NOT-AND and implies an AND function with a complemented output.
Operation: for a 2-input NAND gate, output X is LOW only when inputs A and B are HIGH; X is HIGH when either A or B is LOW, or when both A and B are LOW.

THE NOR GATE

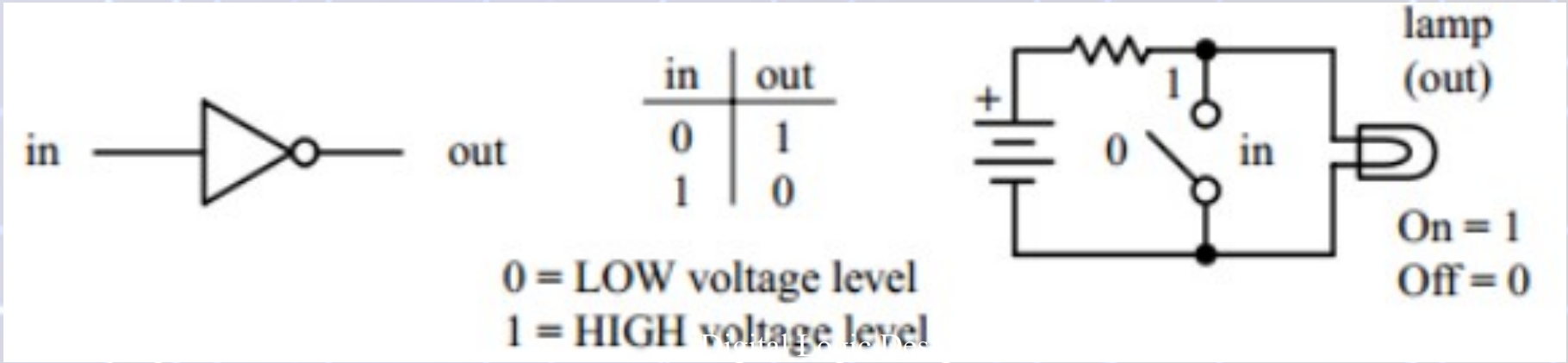
Definition: the term NOR is a contraction of NOT-OR and implies an OR function with a Inverted output.
Operation: for a 2-input NOR gate, output X is LOW when either input A or input B is HIGH; or when both A and B are HIGH; X is HIGH only when both A and B are LOW.

THE EXCLUSIVE-OR AND EXCLUSIVE-NOR GATES

The INVERTER

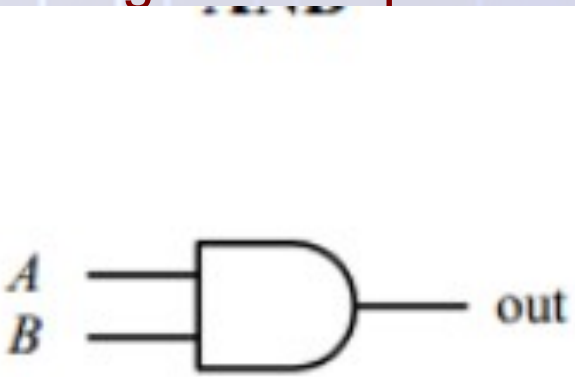
- The inverter (**NOT**) performs the operation called inversion or complementation.
- The inverter changes one logic level to the opposite level.
- In terms of bits, it changes a 1 to a 0 or a 0 to a 1.

$$out = \overline{in}$$

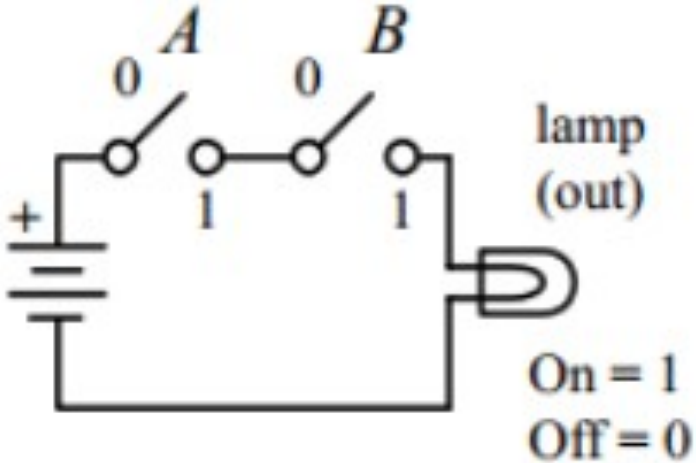


The AND Gate

- An AND gate can have two or more inputs and performs what is know as logical multiplication.



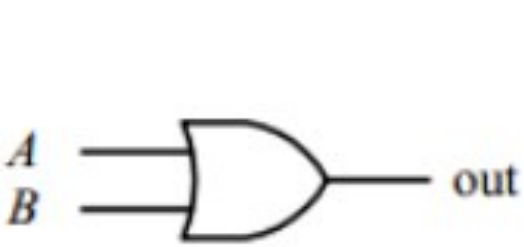
A	B	out
0	0	0
0	1	0
1	0	0
1	1	1



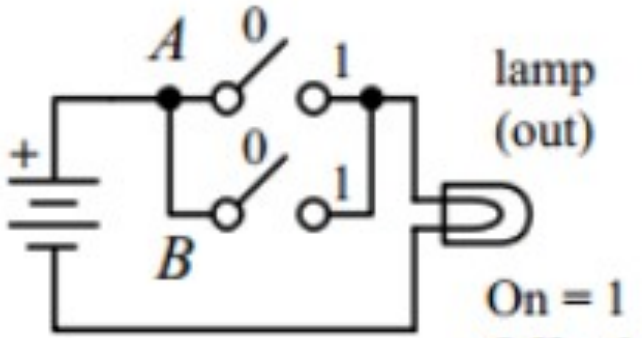
- The output of AND gate is HIGH only when both inputs are HIGH.
- The AND operation is usually shows with a dot between the variables but it maybe implied (no dot). Thus, the AND operations is written as X = A.B or X = AB

The OR Gate

- An OR gate can have two or more inputs and performs what is know as logical addition.



A	B	out
0	0	0
0	1	1
1	0	1
1	1	1

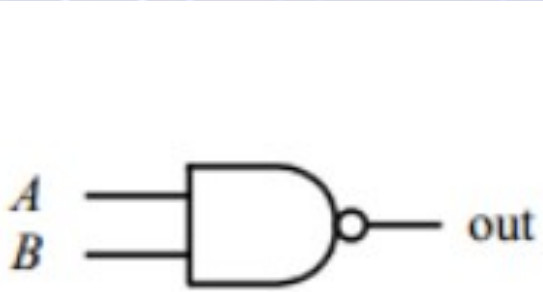


- The output of OR gate will go HIGH if one or both inputs go HIGH. The output goes LOW when both inputs are LOW.
- The OR operation is shown with a plus sign (+) between the variables. Thus, the OR operations is written as X = A + B.

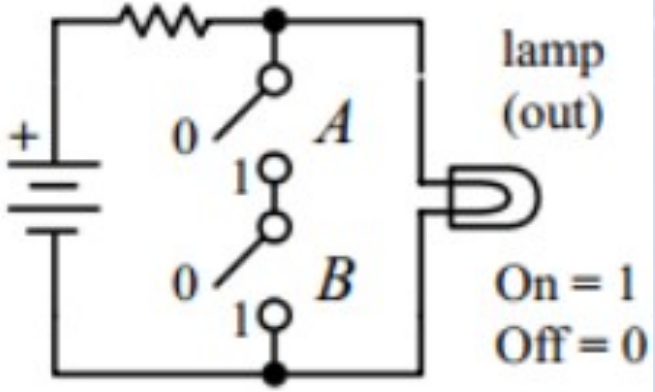
The NAND Gate

Can be used as a **universal logic** gate.

- **Universal logic gates** → can be used in combination to perform the AND, OR and NOT operations.



A	B	out
0	0	1
0	1	1
1	0	1
1	1	0



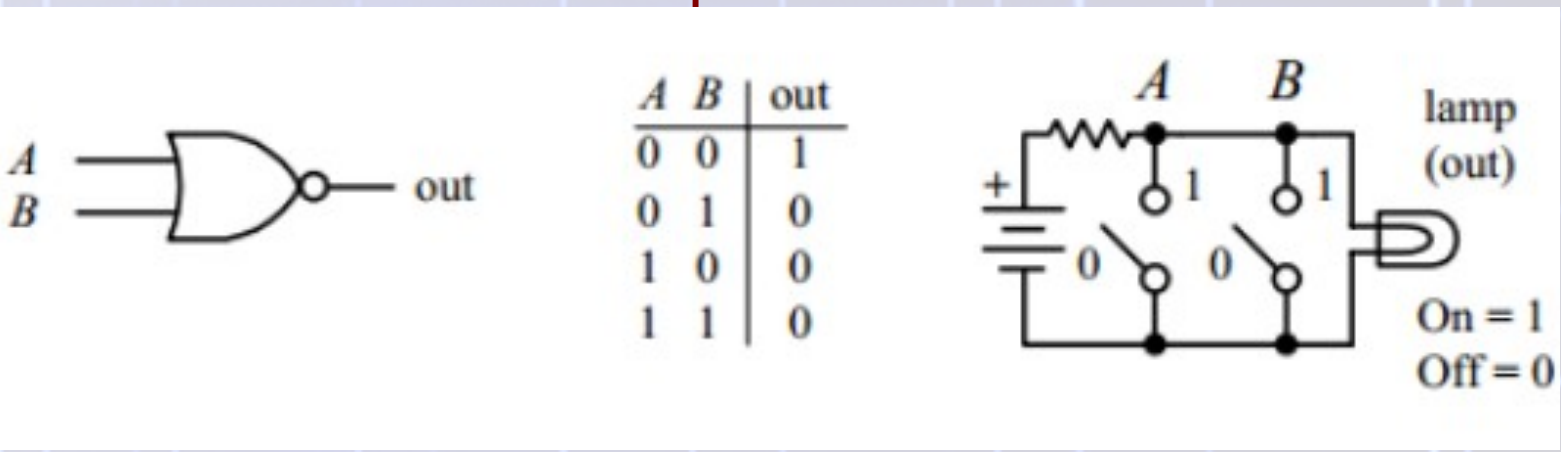
- The term NAND is a contraction of NOT-AND and implies an AND function with a complemented (inverted) output.
- Input _1=A, inpuy_2=B, output= out
- An NAND is inversion of AND gate :

$$out=\overline{A.B}\ ,$$

- The NAND operation is shown with a dot between the variables and an overbar covering them.

The NOR Gate

- Can be used as a **universal logic** gate.
- The term NOR is a contraction of NOT-OR and implies an OR function with an inverted output.

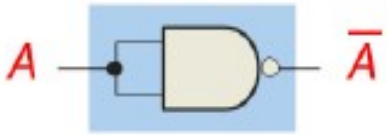


- The output goes LOW if one or more inputs are HIGH. Output goes HIGH if both input are LOW.
- The NOT operation is shown in a plus (+) sign between the variables and an overbar covering them.

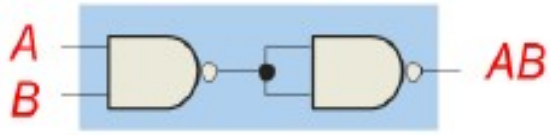
Universal Gate - NAND

Universal Gates

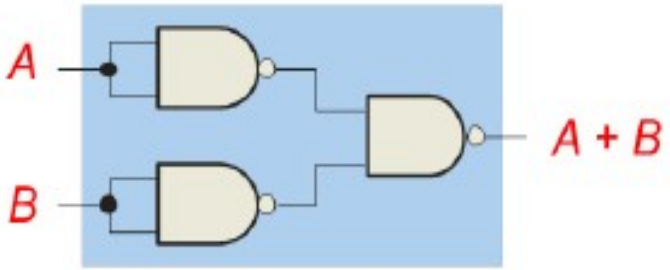
NAND gates are sometimes called **universal** gates because they can be used to produce the other basic Boolean functions.



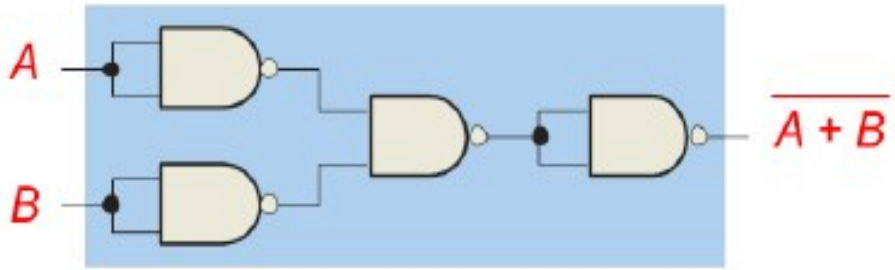
Inverter



AND gate



OR gate

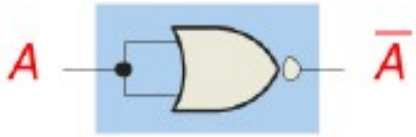


NOR gate

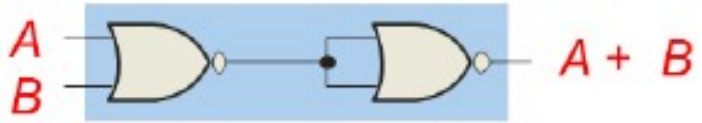
Universal Gate - NOR

Universal Gates

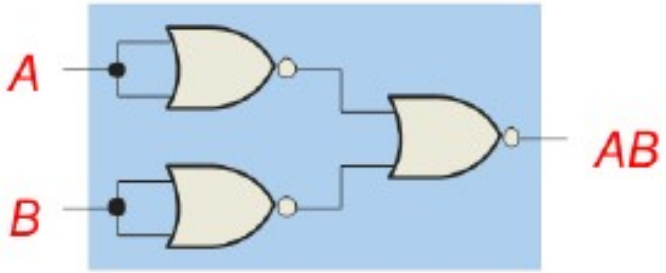
NOR gates are also **universal** gates and can form all of the basic gates.



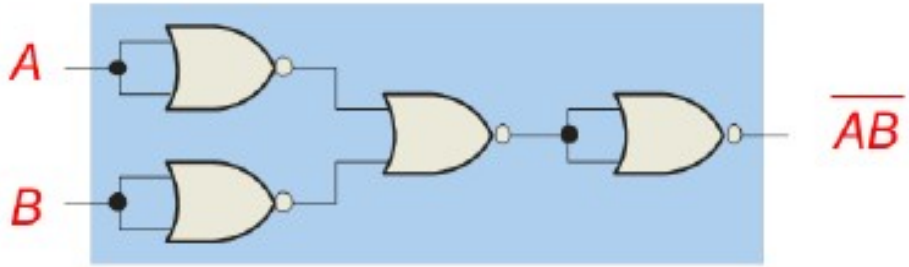
Inverter



OR gate



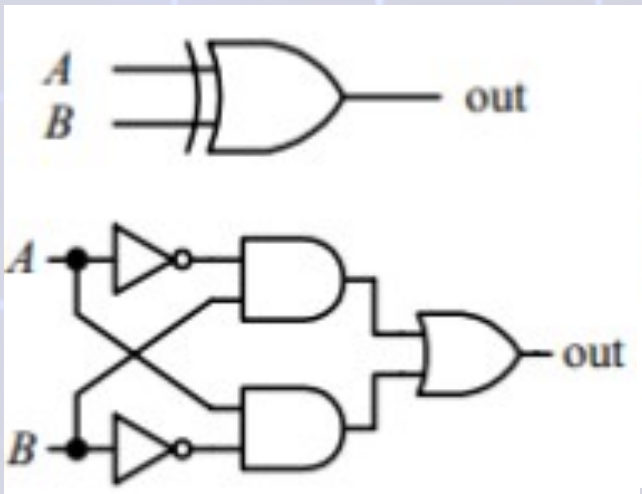
AND gate



NAND gate

The X-OR Gate

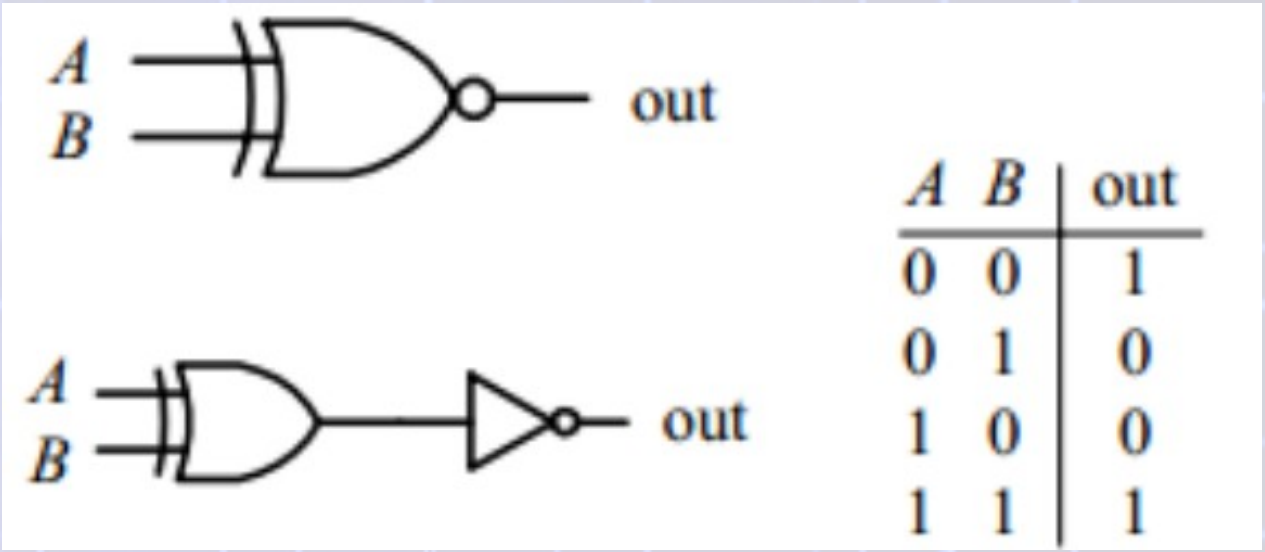
- X-OR → Exclusive OR
- X-OR are formed by a combinations of other gates that are already discussed.
- X-OR gates have only two inputs.
- The output of XOR gate is HIGH only when the two inputs are at opposite logic levels.



A	B	out
0	0	0
0	1	1
1	0	1
1	1	0

The X-NOR Gate

- X-NOR → Exclusive NOR
- X-NOR are formed by a combinations of other gates that are already discussed.
- X-NOR gates have only two inputs.
- The output of XOR gate is LOW only when the two inputs are at opposite logic levels.



A	B	out
0	0	1
0	1	0
1	0	0
1	1	1

End of Chapter III