Logical Design

Lecture 5: Logic Gates

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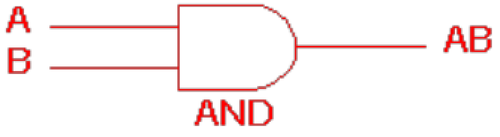
A logic gate is a device that acts as a building block for digital circuits. They perform basic logical functions that are fundamental to digital circuits. Most electronic devices we use today will have some form of logic gates in them. For example, logic gates can be used in technologies such as smartphones, tablets, or within memory devices.

In a circuit, logic gates will make decisions based on a combination of digital signals coming from its inputs. Most logic gates have two inputs and one output. Logic gates are based on **Boolean Algebra**. A logic gate can be thought of like a light switch, wherein in one position the output is **off -- 0**, and in another, it is **on -- 1**. Logic gates are commonly used in integrated circuits (ICs).

Basic Logic Gates

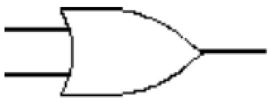
There are ***seven basic logic gates***: AND, OR, XOR, NOT, NAND, NOR, and XNOR.

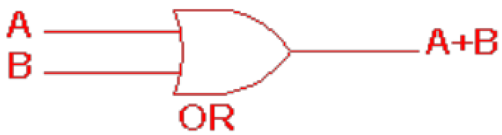
The ***AND gate*** is an electronic circuit that gives a high output (1) ***only if all its inputs are high***.



2 Input AND gate		
A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

The ***OR gate*** is an electronic circuit that gives a high output (1) ***if one or more of its inputs are high***. A plus (+) is used to show the OR operation.

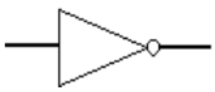


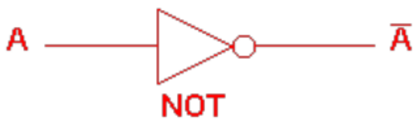


2 Input OR gate

A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

The ***NOT gate*** is an electronic circuit that produces an inverted version of the input at its output. It is also known ***as an inverter***. If the input variable is A, the inverted output is known as NOT A.

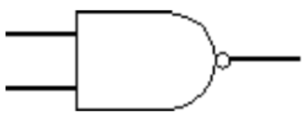




NOT gate

A	$\overline{A}$
0	1
1	0

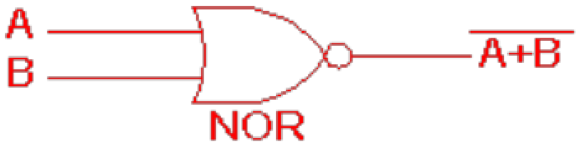
The ***NOT-AND (NAND) gate*** which is equal to an AND gate followed by a NOT gate. The outputs of all NAND gates are ***high if any of the inputs are low***.



2 Input NAND gate

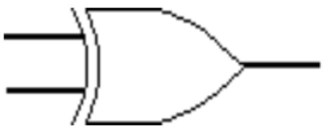
A	B	$\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

The ***NOT-OR (NOR) gate*** is equal to an OR gate followed by a NOT gate. The outputs of all NOR gates are low ***if any of the inputs are high***. The symbol is an OR gate with a small circle on the output. The ***small circle represents inversion***.



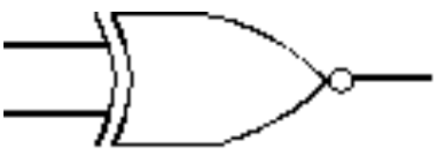
Inputs		Output
A	**B**	$Y=\overline{A+B}$
0	**0**	**1**
0	**1**	**0**
1	**0**	**0**
1	**1**	**0**

The ***'Exclusive-OR' (XOR) gate*** is a circuit that will give a high output ***if either, but not both, of its two inputs are high***. An encircled plus sign (⊕) is used to show the XOR operation.



2 Input EXOR gate		
A	B	A⊕B
0	0	0
0	1	1
1	0	1
1	1	0

The ***XNOR (exclusive-NOR) gate*** is a combination XOR gate followed by an inverter. Its output is "***true***" ***if the inputs are the same***, and "***false***" ***if the inputs are different***.

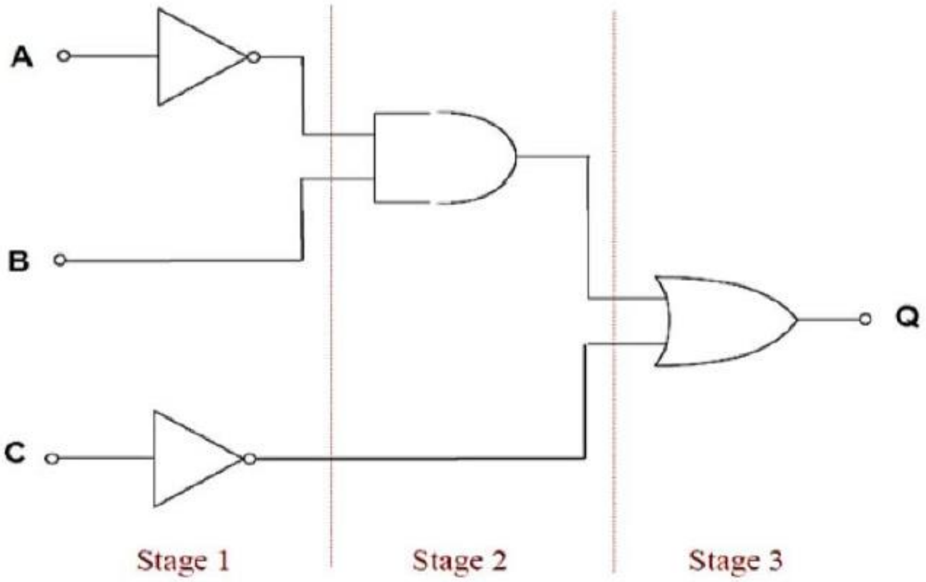


2 Input EXNOR gate		
A	B	$\overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

Converting between Equations and Logic Circuits

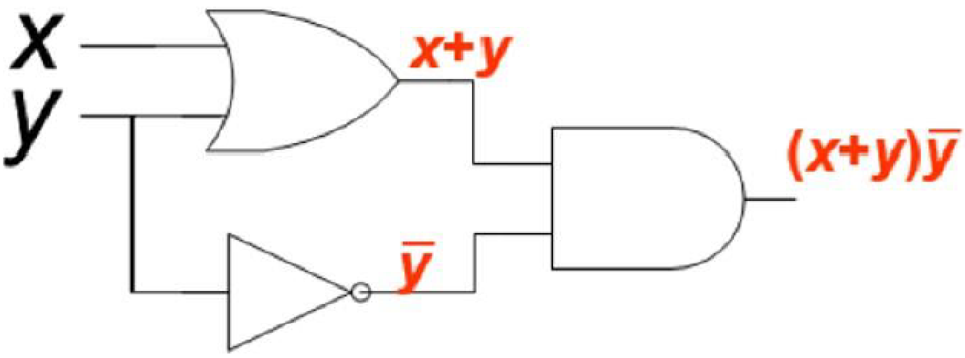
Example 1 :Draw the Boolean expression

$$Q=\overline{A}.B+\overline{C}$$



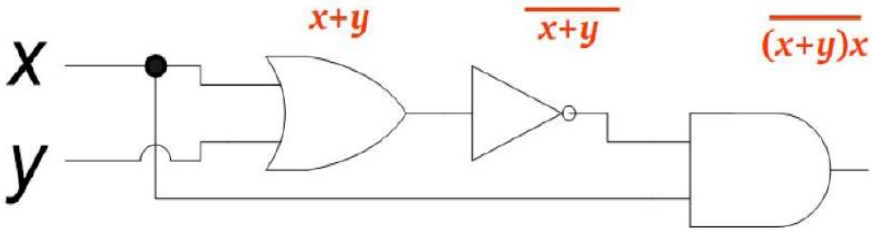
Example2:

$$Q = (x + y)\overline{y}$$



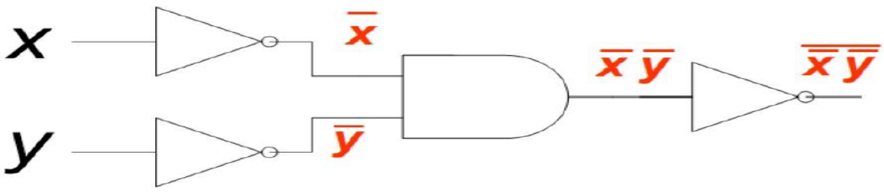
Example3:

$$Q = \overline{(x+y)x}$$

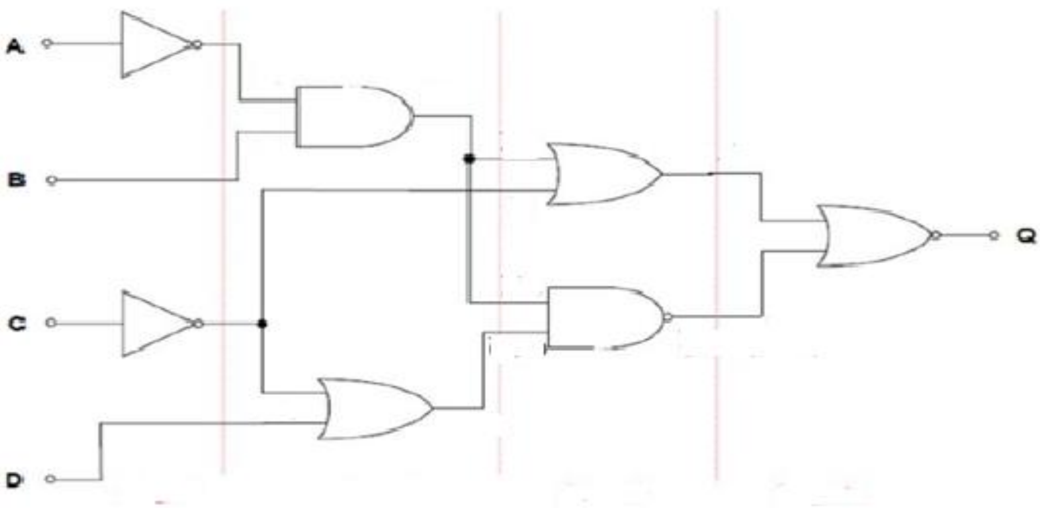


Example4:

$$Q = \overline{(\overline{x}\,\overline{y})}$$



H.W 1: Write the equation for the following logic circuit



H.W 2: Draw the logic circuit for the following equation

$A = ((X+\overline{YZ}) + (\overline{XY}+XZ)) + (\overline{XZ + XY})$