Digital Electronic

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Chapter Two

Lecture 4

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Logic Gates

- This chapter is devoted to practically apply the concept of binary digits to circuits.
- Logic gates are “elementary bricks” used in the construction of digital circuits.
- A logic gate is a special type of circuit designed to accept (inputs) and generate (outputs) voltages signals corresponding to binary digits (1 and 0).

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Digital signals and gates:

- Let us consider the following circuit:
- When the switch is connected to the ground (0V), the light emitting diode (LED) does not shine.
- If we were using this circuit to represent binary digits, that means the input signal is a binary “0” and the output is a binary “0” or that the output is at the low logic level.
- Moving the switch to the other position (Vcc), Means a binary “1” is the input and receive a binary “1” at the output. The output is also said to be at the high logic level.

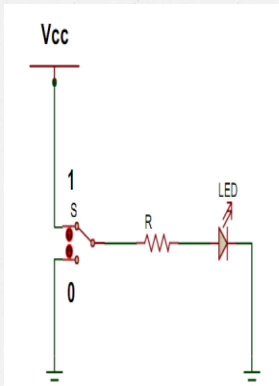

Figure 2.1: Logic circuit.

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Digital signals and gates:

- This gate shown by this simple circuit is a "buffer" or "yes" gate, because the logic state of its input is identical to that of its output.
- Many types of gates are used in digital electronics: single input gates like the buffer and the NOT gates; multiple inputs gates like AND, NAND, OR, NOR and XOR gates.
- The aim of this chapter is to study the functioning of each of those logic gates and also how they can be combined to design a simple logic function.

➢2.3 The NOT gate:

- The NOT gate or Inverter is a logic gate which functions in such a way that the logic state of the output is exactly the opposite of that of the input.
- **Remark 2.1: The truth table**

A truth table is a standard way of representing the Inputs/outputs relationships of a digital circuit, listing all the possible input logic level combinations with their respective output logic levels.

- The NOT gate truth table:

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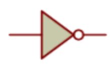
- **The NOT gate truth table:**

Input	Output
0	1
1	0

- **Symbol**

Input  **Output**

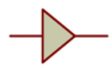
Remark 2.2: the buffer gate

- If two inverter gates were connected together, the output of one fed into the input of another.
- The two inversion functions would "cancel" each other out so that there would be no inversion from input to final output.

Figure 2.2: Principle of the buffer gate

- A buffer is a special logic gate manufactured to perform the same function as two inverters connected together.
- Buffer gates serve to amplify signals, taking a weak signal source that is not capable of providing much current, and boosting the current capacity of the signal so as to be able to drive a load.

- **Symbol of a buffer gate:**

Input  Output

- **Truth table of the buffer gate:**

Input	Output
0	0
1	1

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2.4 Multiple input gates:

- With a single input gate such as the inverter or buffer, there can only be two possible input states: either 1 or 0.
- With multiple input gates, many possibilities are available for input states.
- The number of possible input states is equal to two to the power of the number of inputs. So, if a gate has n inputs, therefore there are 2^n possible input combinations.

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2.4.1 The AND gate:

- The output of the AND gate is high if and only if all inputs are high.
- If any input is low, the output is guaranteed to be in a low state as well.
- **Truth table:**
- Let us draw the truth table of a two inputs AND gate

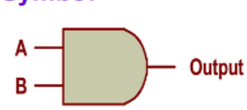
2.4.1 The AND gate Truth table:

- Let us draw the truth table of a two inputs AND gate

A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

- The output is high only when all the two inputs are high.

• Symbol



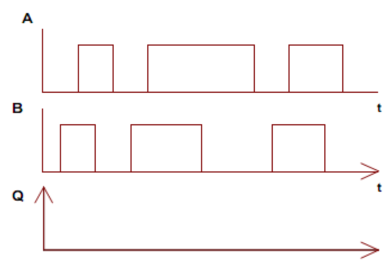
Exercises

Exercise 2.1:

Draw the truth table of a three inputs AND gate.

Exercise 2.2:

Complete the chronogram of the output Q of a two inputs AND gate.



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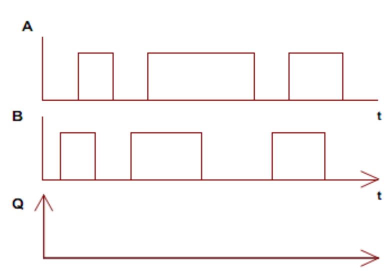

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Changing of base:

We have already seen in the previous section **how to change from binary to decimal, octal or hexadecimal systems of numeration.** The present section is intended to show how to move from a given system of numeration to any other system.

From octal and hexadecimal to binary and decimal:

- The octal and hexadecimal systems are actually used by computer engineer just to obtain a "shorthand" representation of binary numbers (because octal and hexadecimal representations take a few numbers of ciphers or symbols as compared to binary system).
- Only binary system is implemented in the electronic circuits of digital systems (through two levels of voltages or currents: high (1) and low (0)), the others systems being used by engineers just for simplification issues.
- However, we sometimes have the need to convert either of those systems to binary or decimal forms.

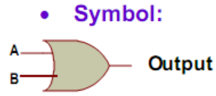
2.4.3 The OR gate:

- The output of the OR gate is high if any of the inputs is high.
- The output of an OR gate goes low if and only if all inputs are low.

- **Truth table:**

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

- **Symbol:**



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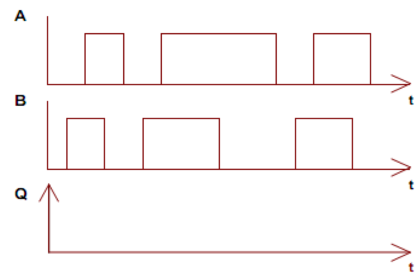
Exercise 2.4:

Draw the truth table of a three inputs OR gate.

Exercise 2.5:

Complete the chronogram of the output Q of a two inputs OR gate.



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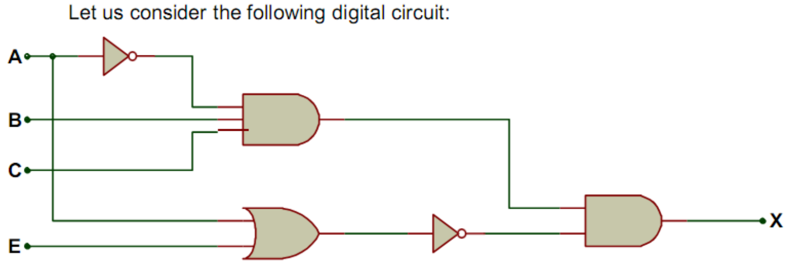
Exercise 2.6:

Let us consider the following digital circuit:



a. Give the expression of the output X.
b. Draw the truth table of the digital circuit.

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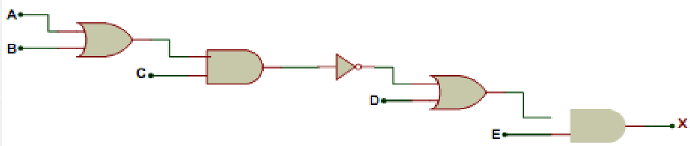
Exercise 2.7:

Draw the truth table of the digital circuit described by the following equation:

$X = AB + AB\overline{C} + \overline{AC}$

Exercise 2.8:

Let us consider the following digital circuit:



a. Give the expression of the output X.
b. Draw the truth table of the circuit.
c. Answer the two previous questions considering the following digital circuit: