Logic Gate

College of
Engineering & Technology

Al-Mustaqbal
University

Level 1 , Semester 1
@ Department of prosthetic and orthotic Engineering

Prepared by
Dr. Samir Badrawi

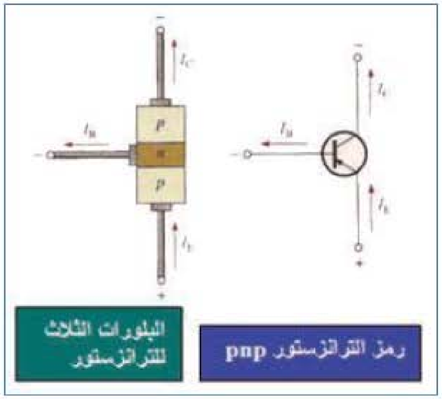
مراجعة عامة

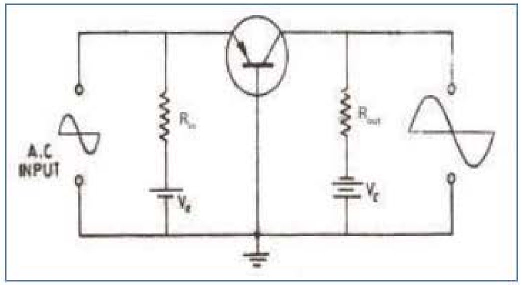
The majority of this course material is based on text and presentations of :
Floyd, Digital Fundamentals, 10Th ed., © 2009 Pearson Education, Upper Saddle River, NJ 07458. All Rights Reserved

فيزياء الصف السادس

- الأشارات (Signal)
- دوائر الترانسستر
- التجريد (Abstraction)

10-7 الترانزستور Transistor





11-7 الدوائر المتكاملة Integrated circuits

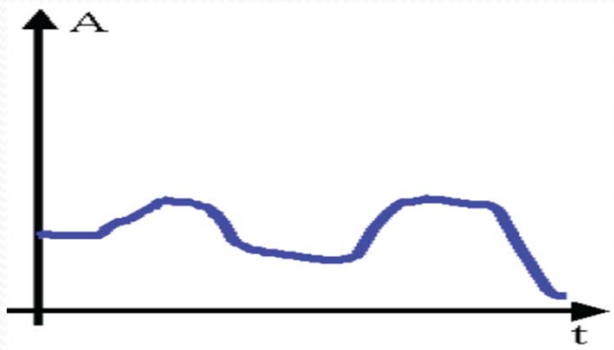
هي جهاز (نبيطة device) صغير جدا يستعمل للسيطرة على الإشارات الكهربائية في كثير من الأجهزة الكهربائية كالحاسبات الالكترونية ، أجهزة التلفاز ، الهاتف الخلوي ، وبعض اجزاء السيارات ، الأقراص المدمجة والمركبات الفضائية، لاحظ الشكل (41).

شكل (41)

تحتوي الدوائر المتكاملة الآلاف من العناصر المعقدة التي تصنع بعملية واحدة، إذ تصنع عناصرها على شريحة صغيرة (chip) منفردة من رقاقة (wafer) من السيلكون (Si) وهذه العناصر تشمل الثنائيات البلورية والترانزستورات والمقاومات والمكثفات لتكوّن منظومات الكترونية تؤدي وظيفة معينة.

(Signal) الإشارات

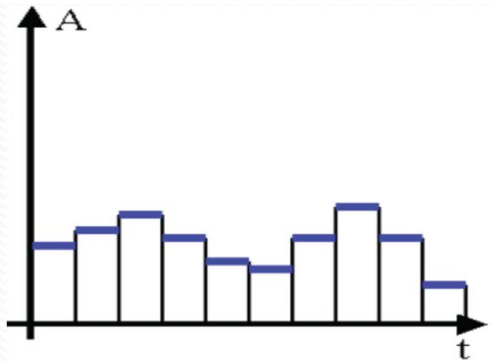
Analog signal is ***time-varying*** and generally bound to a range (e.g. +12V to -12V, if we are talking about **voltage signal**), but there is an infinite number of values within that continuous range.



Analog signal – continuously varying

A digital signal is a signal that represents data as a sequence of ***discrete values***.

A **digital signal** can only take on one value from a finite set of possible values at a given time.



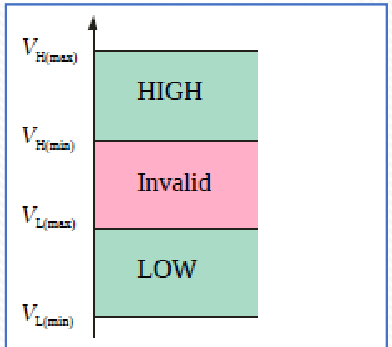
Digital signal – large time divisions

In *Digital Electronic Devices*, signals which can have just **two voltage values (two states)**:

HIGH Voltage or LOW Voltage …

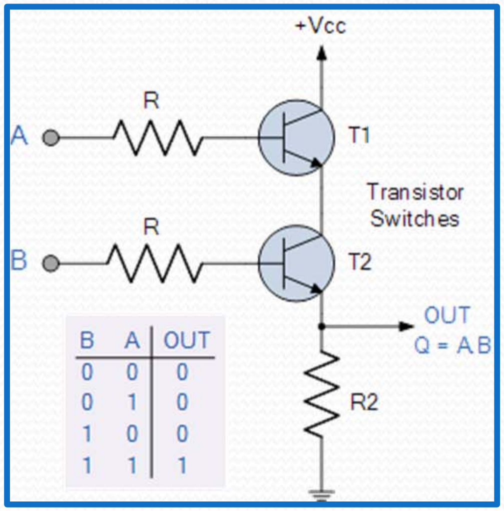
(true or false … 0 or 1).

This is why we say "Logic" ..

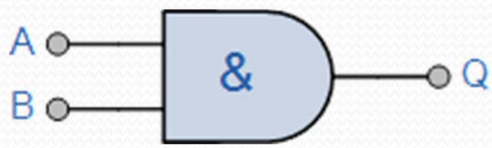


Digital System functions only in the green zone

Abstraction in Electronics



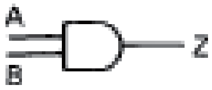
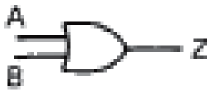
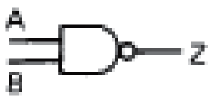
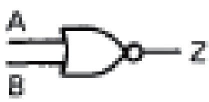
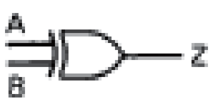
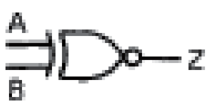
AND circuit Abstraction



AND Logic Abstraction

```
entity AND_Gate1 is
    port(A,B:in
    bit:Q:out bit);
end entity AND_Gate1
```

Programming Language Abstraction

Name	Symbol	Equation	A	B	Z
AND		$Z = A.B.$	0	0	0
			0	1	0
			1	0	0
			1	1	1
OR		$Z = A + B$	0	0	0
			0	1	1
			1	0	1
			1	1	1
NOT		$Z = \overline{A}$	0		1
			1		0
NAND		$Z = \overline{A.B}$	0	0	1
			0	1	1
			1	0	1
			1	1	0
NOR		$Z = \overline{A + B}$	0	0	1
			0	1	0
			1	0	0
			1	1	0
EXCLUSIVE OR		$Z = A \oplus B$	0	0	0
			0	1	1
			1	0	1
			1	1	0
EQUIVALENCE (EXCLUSIVE NOR)		$Z = \overline{A \oplus B}$	0	0	1
			0	1	0
			1	0	0
			1	1	1

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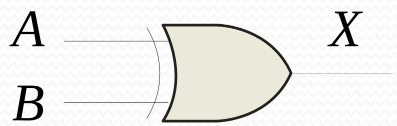
New numbering system .. “Binary”.

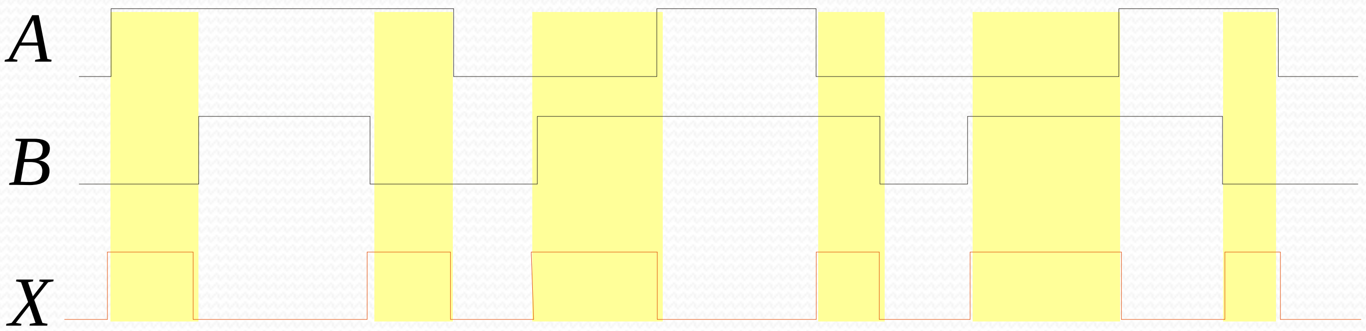
Then need new mathematics That can deal with binary system

This will be Boolean Algebra

The XOR Gate



Example waveforms:



Notice that the XOR gate will produce a HIGH only when exactly one input is HIGH.

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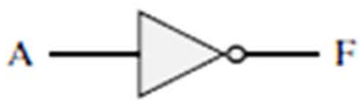
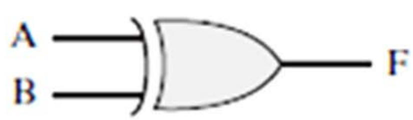
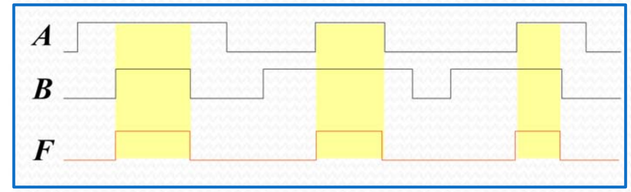
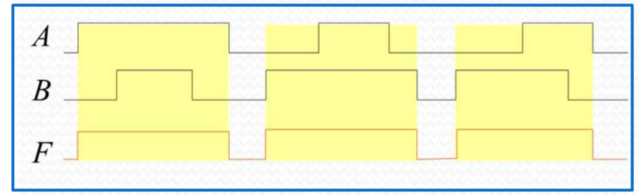
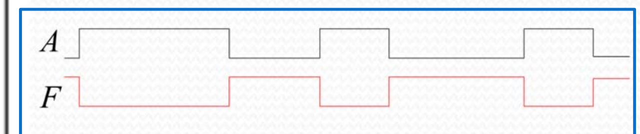
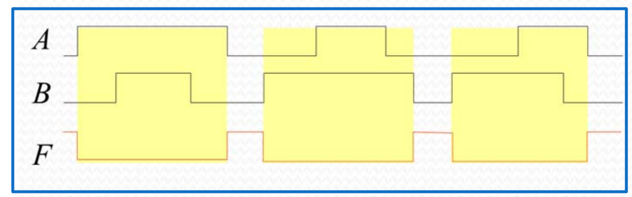
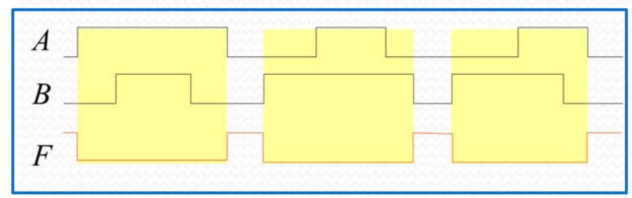
Name	Graphical Symbol	Algebraic Function	Truth Table
AND		$F = A \bullet B$ or $F = AB$	A B | F 0 0 | 0 0 1 | 0 1 0 | 0 1 1 | 1
OR		$F = A + B$	A B | F 0 0 | 0 0 1 | 1 1 0 | 1 1 1 | 1
NOT		$F = \overline{A}$ or $F = A'$	A | F 0 | 1 1 | 0
NAND		$F = \overline{AB}$	A B | F 0 0 | 1 0 1 | 1 1 0 | 1 1 1 | 0
NOR		$F = \overline{A + B}$	A B | F 0 0 | 1 0 1 | 0 1 0 | 0 1 1 | 0
XOR		$F = A \oplus B$	A B | F 0 0 | 0 0 1 | 1 1 0 | 1 1 1 | 0

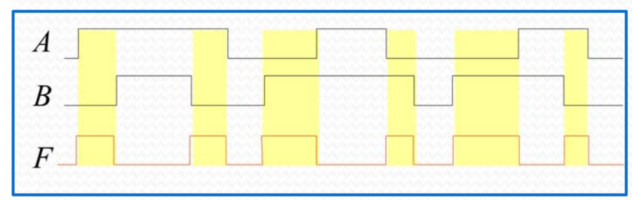












Basic Logic Gated

F : Output Waveforms

Decimal Numbers

In the decimal number system, **ten symbols** are used.
They are 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 giving **the base of 10**.
A complete number is the weighted sum of the powers of the base.

Thus, the number 9240 can be expressed as;

$$(9 \times 10^3) + (2 \times 10^2) + (4 \times 10^1) + (0 \times 10^0)$$

or

$$9 \times 1{,}000 + 2 \times 100 + 4 \times 10 + 0 \times 1$$

Example Express the number 480.52 as the sum of values of each digit.

Solution

$$480.52 = (4 \times 10^2) + (8 \times 10^1) + (0 \times 10^0) + (5 \times 10^{-1}) + (2 \times 10^{-2})$$

Binary Numbers

For digital systems, the binary number system is used. Binary has a base of two and uses the digits 0 and 1 to represent quantities.

The column weights of binary numbers are powers of two that increase from right to left beginning with $2^0 = 1$:

$$2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$$

For fractional binary numbers, the column weights are negative powers of two that decrease from left to right:

$$2^2\ 2^1\ 2^0.\ 2^{-1}\ 2^{-2}\ 2^{-3}\ 2^{-4}\ \ldots$$

Binary Conversions

The decimal equivalent of a binary number can be determined by adding the column values of all of the bits that are 1 and discarding all of the bits that are 0.

Example Convert the binary number 100101.01 to decimal.

Solution Start by writing the column weights; then add the weights that correspond to each 1 in the number.

2^5 2^4 2^3 2^2 2^1 2^0. 2^{-1} 2^{-2}

32 16 8 4 2 1 . ½ ¼

1 0 0 1 0 1. 0 1

32 +4 +1 +¼ = 37¼

Binary Conversions

You can convert a decimal whole number to binary by reversing the procedure. Write the decimal weight of each column and place 1's in the columns that sum to the decimal number.

Example

Convert the decimal number 49 to binary.

Solution

The column weights double in each position to the right. Write down column weights until the last number is larger than the one you want to convert.

2^6 2^5 2^4 2^3 2^2 2^1 2^0.

64 32 16 8 4 2 1.

0 1 1 0 0 0 1.

BCD

Binary coded decimal (BCD) is a weighted code that is commonly used in digital systems when it is necessary to show decimal numbers such as in clock displays.

The table illustrates the difference between straight binary and BCD. BCD represents each decimal digit with a 4-bit code. Notice that the codes 1010 through 1111 are not used in BCD.

Decimal	Binary	BCD
0	0000	0000
1 2	0001	0001
3	0010	0010
4	0011	0011
5	0100	0100
6	0101	0101
7	0110	0110
8	0111	0111
9	1000	1000
10	1001	1001
11	1010	0001 0000
12	1011	0001 0001
13	1100	0001 0010
14	1101	0001 0011
15	1110	0001 0100
	1111	0001 0101

Rules of Boolean Algebra

1. $A + 0 = A$
2. $A + 1 = 1$
3. $A \cdot 0 = 0$
4. $A \cdot 1 = \mathrm{A}$
5. $A + A = A$
6. $A + \overline{A} = 1$
7. $A \cdot A = A$
8. $A \cdot \overline{A} = 0$
9. $\overline{\overline{A}} = A$
10. $A + AB = A$
11. $A + \overline{A}B = A + B$
12. $(A + B)(A + C) = A + BC$

DeMorgan's Theorem

DeMorgan's 1st Theorem

The complement of a product of variables is equal to the sum of the complemented variables.

$$\overline{AB} = \overline{A} + \overline{B}$$

Rules of Boolean Algebra

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11. $A + \overline{A}B = A + B$
12. $(A + B)(A + C) = A + BC$

Prove Rule 10 by using Rule 2.
Prove Rule 11 by using Rule 6.

Rule 12 is called Distributive Law.
Prove Rule 12 …. How ??…later.

تمارين

Homework (team/group work)

using Boolean algebra Rules,

1. prove :

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

2. *Show that the function:*

$$F = A \overline{B} \overline{C} + A B \overline{C} + A \overline{B} C + A B C$$

equals 1 when A equals 1.