Logic Gate

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Level 1 , Semester 1
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Binary Adders , Compotators , Decoders

The majority of this course material is based on text and presentations of :

Some Application of Digital Logic circuits

Digital Electronics - Binary Arithmetic

Binary arithmetic is one of the fundamental concepts in the field of digital electronics. It is basically the **mathematics on binary digits (bits).**

Inputs		Outputs	
A	*B*	C_{out}	Σ
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

Rules of Binary Addition

0 + 0 = 0 **0 + 1 = 1** **1 + 0 = 1**

1 + 1 = 0 with carry 1 **(Sum = 0 & Carry = 1)**

1 + 1 = 10

1 + 1 + 1 = 1 with carry 1 **(Sum = 1 & Carry = 1)**

1 + 1 + 1 = 11

Binary Addition

```
  0 1 1 1
  00111     7
  10101    21
 ------   ---
 11100  = 28
```

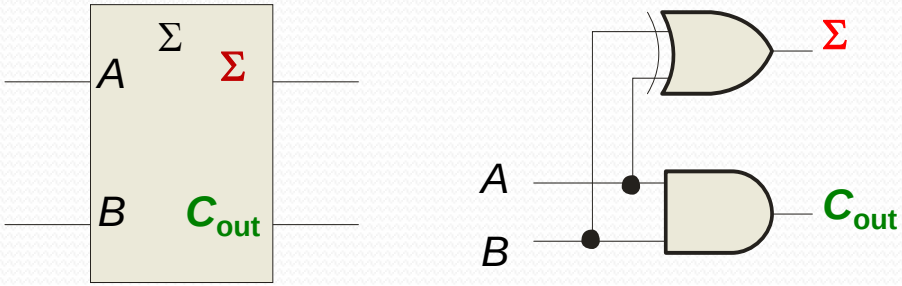
```
  1111.11
  1101.101
  1101.001
 ----------
 10101.000
```

Half-Adder

Basic rules of binary addition are performed by a **half adder**, which has two binary inputs (*A* and *B*) and two binary outputs (Carry out and Sum).

The inputs and outputs can be summarized on a truth table.

The logic symbol and equivalent circuit are:



Inputs		Outputs	
A	*B*	C_{out}	Σ
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

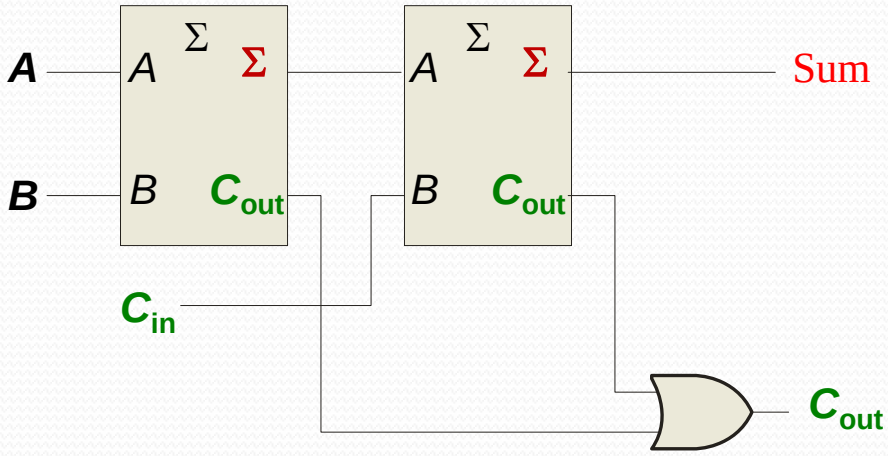
Full-Adder

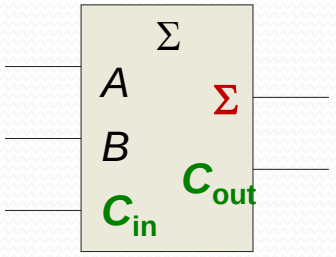
By contrast, a **full adder** has three binary inputs (*A*, *B*, and **Carry in**) and two binary outputs (**Carry out** and **Sum**).

The truth table summarizes the operation.

A full-adder can be constructed from two half adders as shown:

Inputs			Outputs	
A	*B*	C_{in}	C_{out}	Σ
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1



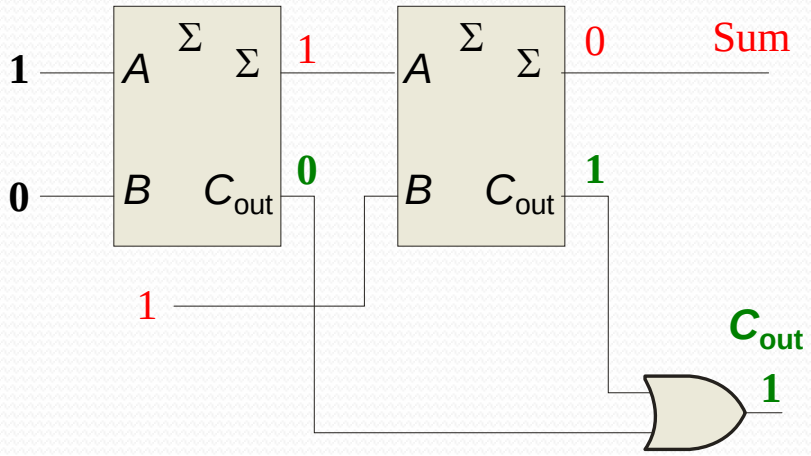


Symbol

Full-Adder

Example

For the given inputs, determine the intermediate and final outputs of the full adder.



Solution

The first half-adder has inputs of 1 and 0;

therefore the Sum =1 and the Carry out = 0.

The second half-adder has inputs of 1 and 1;

therefore the Sum = 0 and the Carry out = 1.

The OR gate has inputs of 1 and 0,

therefore the final carry out = 1.

Inputs			Outputs	
A	B	C_{in}	C_{out}	Σ
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

Comparators

The function of a comparator is to compare the magnitudes of two binary numbers to determine the relationship between them.

In its simplest form, a comparator circuit determines whether two numbers are equal.

وظيفة جهاز المقارنة هي مقارنة مقادير رقمين ثنائيين (binary) لتحديد العلاقة بينهما. في أبسط صورها، تحدد دائرة المقارنة ما إذا كان الرقمان متساويان أم لا.

In exclusive-NOR gate, the output is a 0 if the two input bits are not equal and a 1 if the input bits are equal.

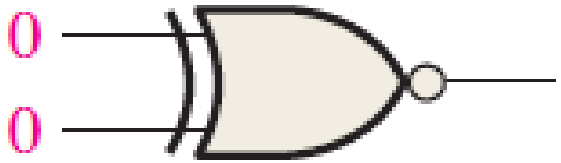
في بوابة NOR الحصرية (XNOR) ، تكون المخرجات (0) إذا كانت البتات المدخلة (two input bits) غير متساوية ، و (1) إذا كانت بتات الإدخال متساوية.

Thus, in the simplest form, a comparator can test for **equality** using **exclusive NOR gates**. (**why ?**)

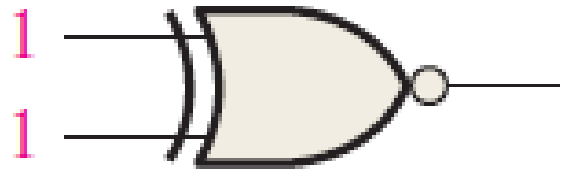
ولذلك، في أبسط صوره فان دائرة جهاز المقارنة **للمساواة بين الارقام الثنائية** يمكن ان تكون عبارة عن بوابة NORالحصرية (XNOR)

A Basic Comparator

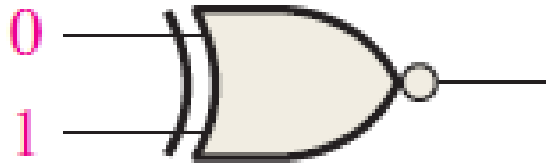
A	B	Q
0	0	1
0	1	0
1	0	0
1	1	1



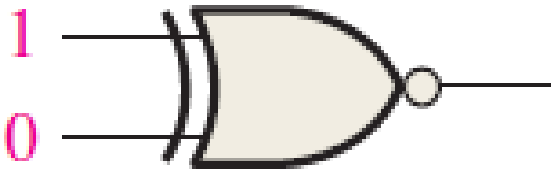
The input bits are equal.



The input bits are equal.



The input bits are not equal.



The input bits are not equal.

Comparators

In order to compare binary numbers containing two bits each, an additional exclusive-NOR gate is necessary.

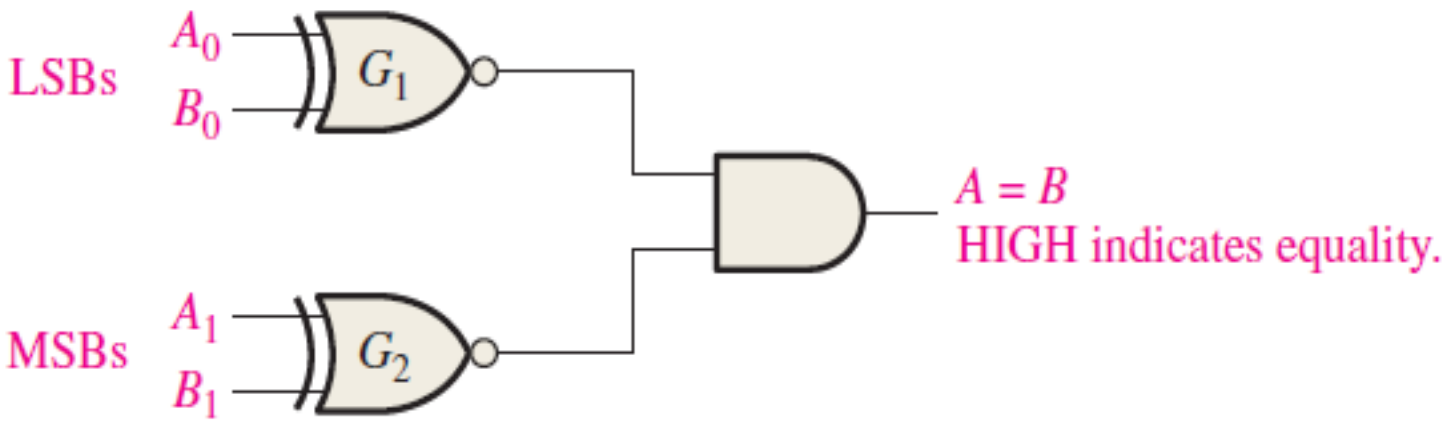
من أجل مقارنة الأرقام الثنائية التي تحتوي كل منها على بتتين (يعني A=A1A0)، فمن الضروري وجود بوابة NORحصرية إضافية.

The two least significant bits (LSBs) of the two numbers are compared by gate *G*1, and the two most significant bits (MSBs) are compared by gate *G*2.

مثلا

A= 1 0

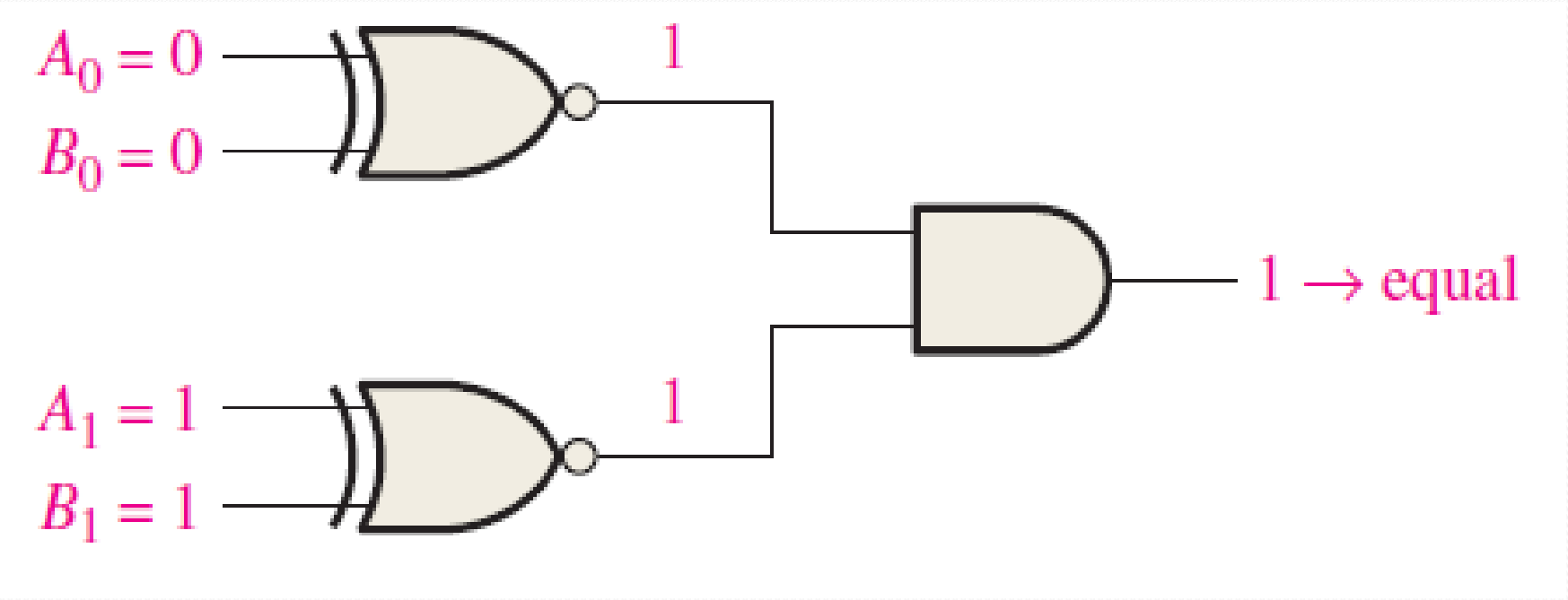
B = 1 0



General format: Binary number $A \rightarrow A_1A_0$
Binary number $B \rightarrow B_1B_0$

Comparators

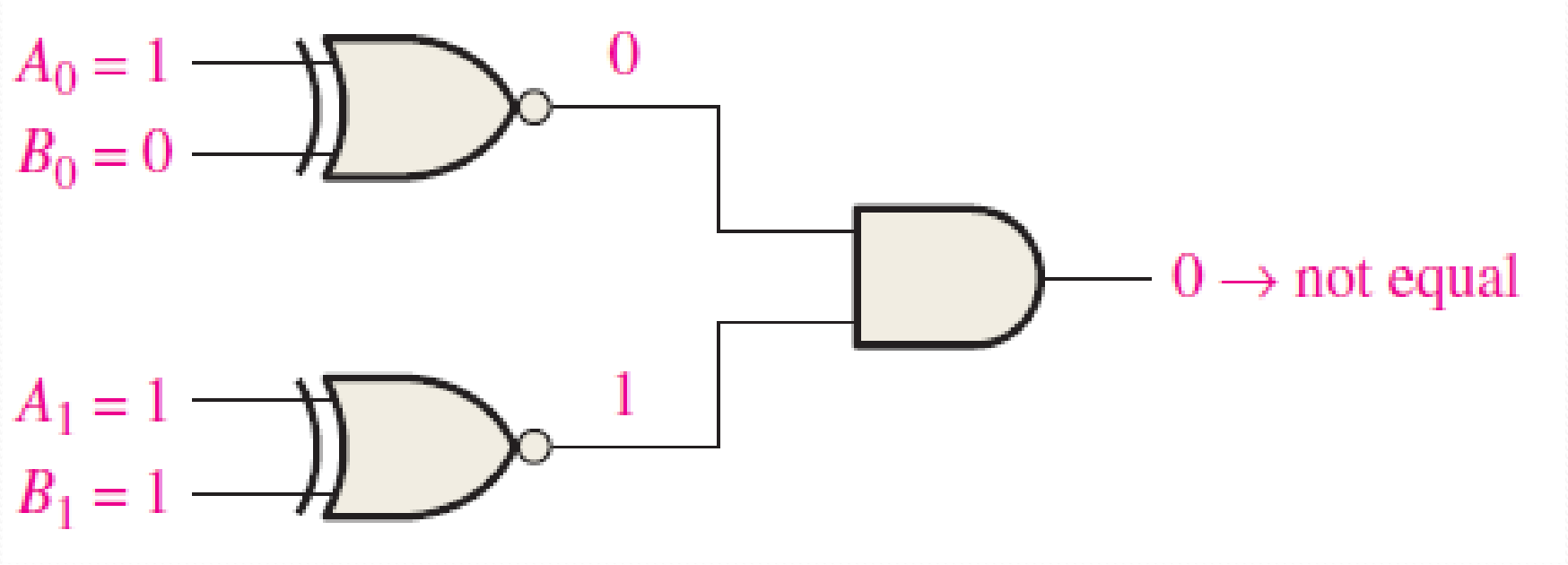
Example 1:- Apply the (**10**) and (**10**) binary numbers to the comparator inputs given below, and determine the output by following the logic levels through the circuit.



Solution: The output is **1** for inputs 10 and 10

Comparators

Example 2:- Apply the (**10**) and (**11**) binary numbers to the comparator inputs given below, and determine the output by following the logic levels through the circuit.



Solution: The output is **0** for inputs 11 and 10

Comparators

اذا كان لدينا اكثر من (2) بت في الرقم الثنائي .. فلكل بت هناك بوابة (XNOR)

The function of a comparator is to compare the magnitudes of two binary numbers to determine the relationship between them. In the simplest form, a comparator can test for equality using XNOR gates.

Example

How could you test two 4-bit numbers for equality?

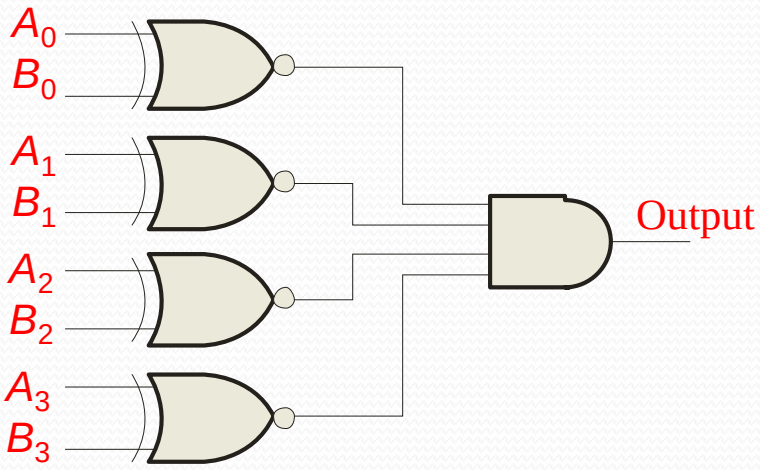
Solution

AND the outputs of four XNOR gates.

مثال

A = 1 0 1 0

B = 0 1 1 0

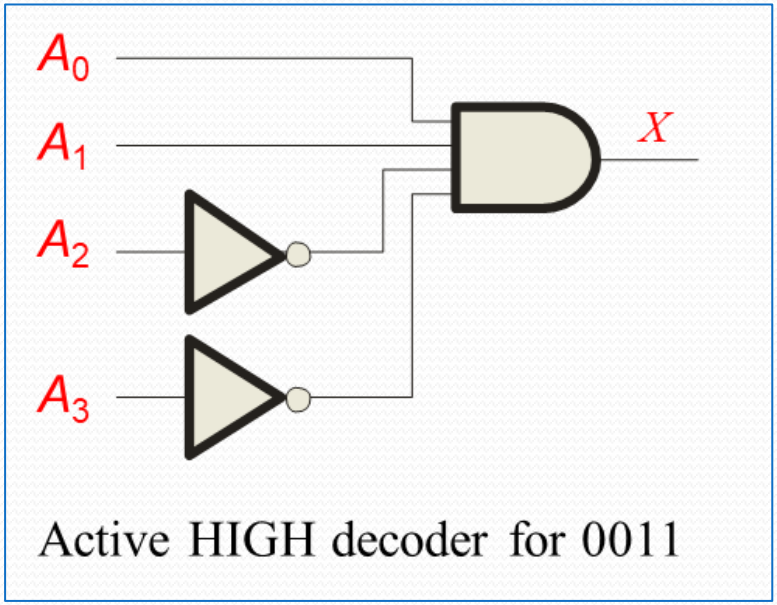


Decoders

A **decoder** is a digital circuit that detects the presence of a specified combination of bits (code) on its inputs and indicates the presence of that code by a specified output level.

جهاز فك التشفير عبارة عن دائرة رقمية تكتشف وجود مجموعة محددة من البتات (الكود) على مدخلاتها وتشير إلى وجود هذا الرمز من خلال مخرج محدد..

A simple decoder that detect the presence of the binary code (**A = 0011**) is shown below:-



Active HIGH decoder for 0011

ملاحظة (**Active HIGH**)
يعني ال مخرج هو(1)

Decoders

Question

Assume the output of the decoder shown is a logic 1. What are the inputs to the decoder?