

Lecture 6

ARITHMETIC CIRCUITS

- Binary Adder
- Binary Subtractor
- Magnitude Comparator

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ARITHMETIC CIRCUITS



Binary Adder/Half Adder

Half Adder

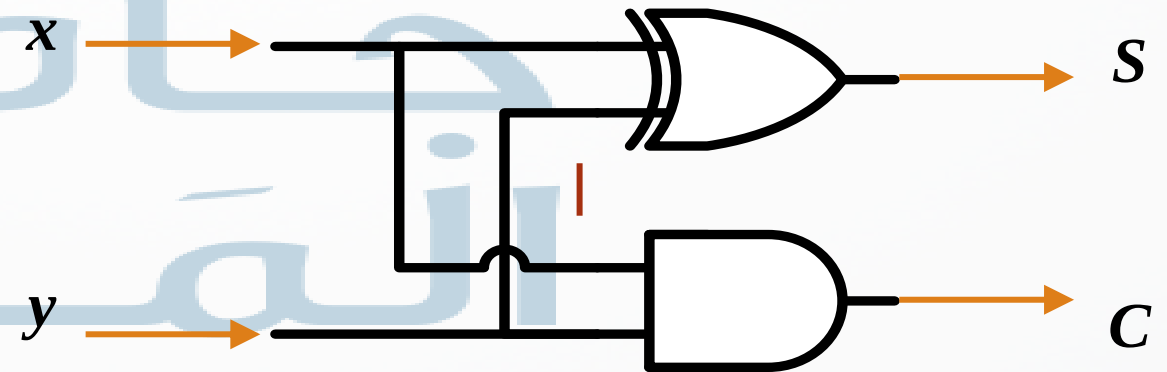
- Adds 1-bit plus 1-bit
- Produces **Sum** and **Carry**

x y	C S
0 0	0 0
0 1	0 1
1 0	0 1
1 1	1 0



$$\begin{array}{r} x \\ + y \\ \hline \end{array}$$

C S



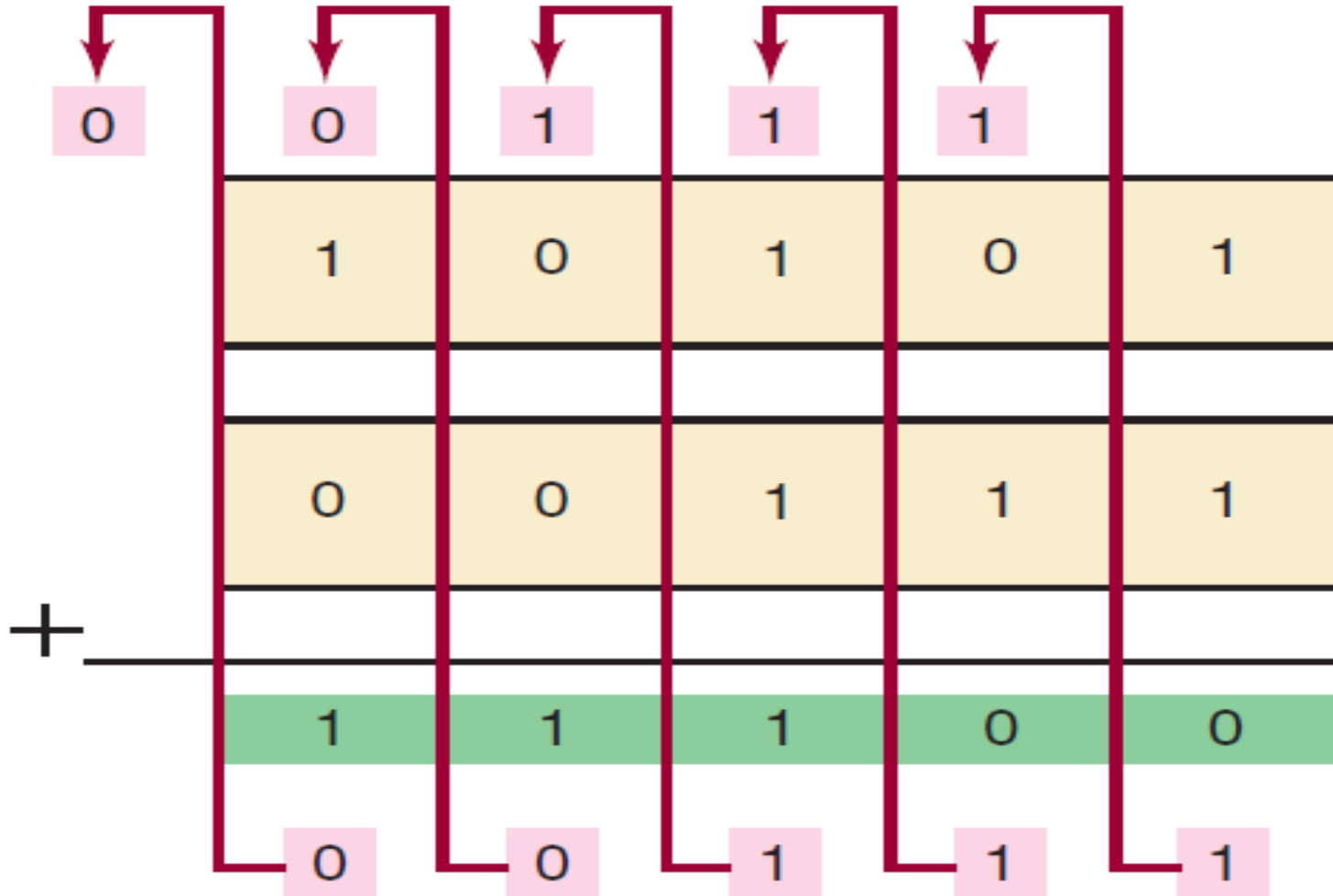
ARITHMETIC CIRCUITS



Full Adder

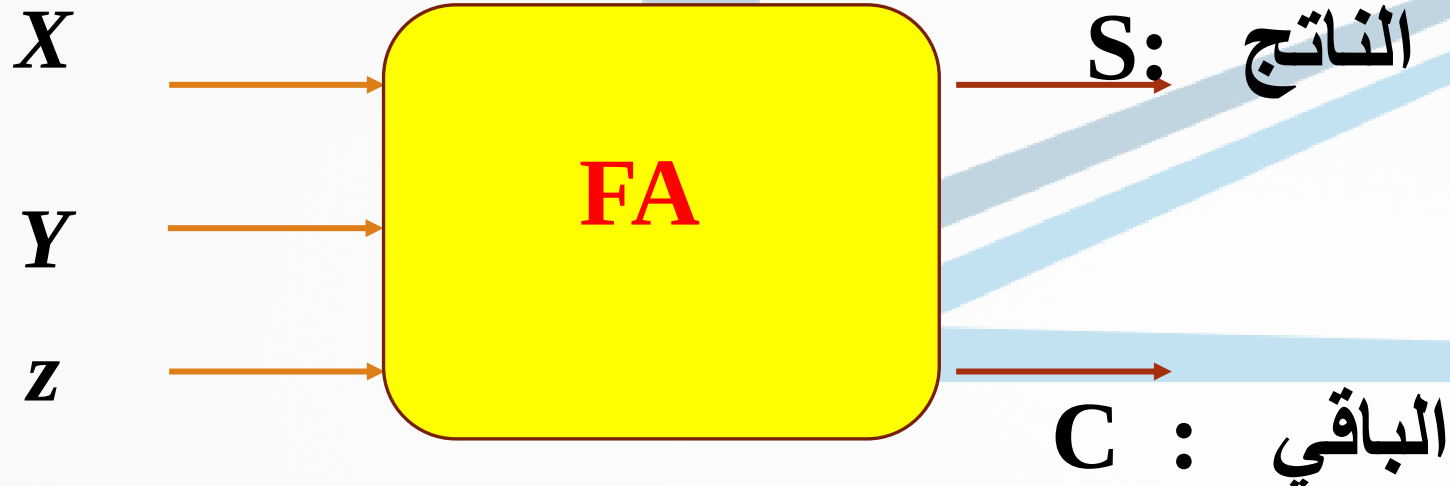
★ Full Adder

- Adds 1-bit plus 1-bit plus 1-bit
- Produces Sum and Carry



$$\begin{array}{r} x \\ + y \\ + z \\ \hline C \quad S \end{array}$$

Binary Adder



x	y	z	C	S
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

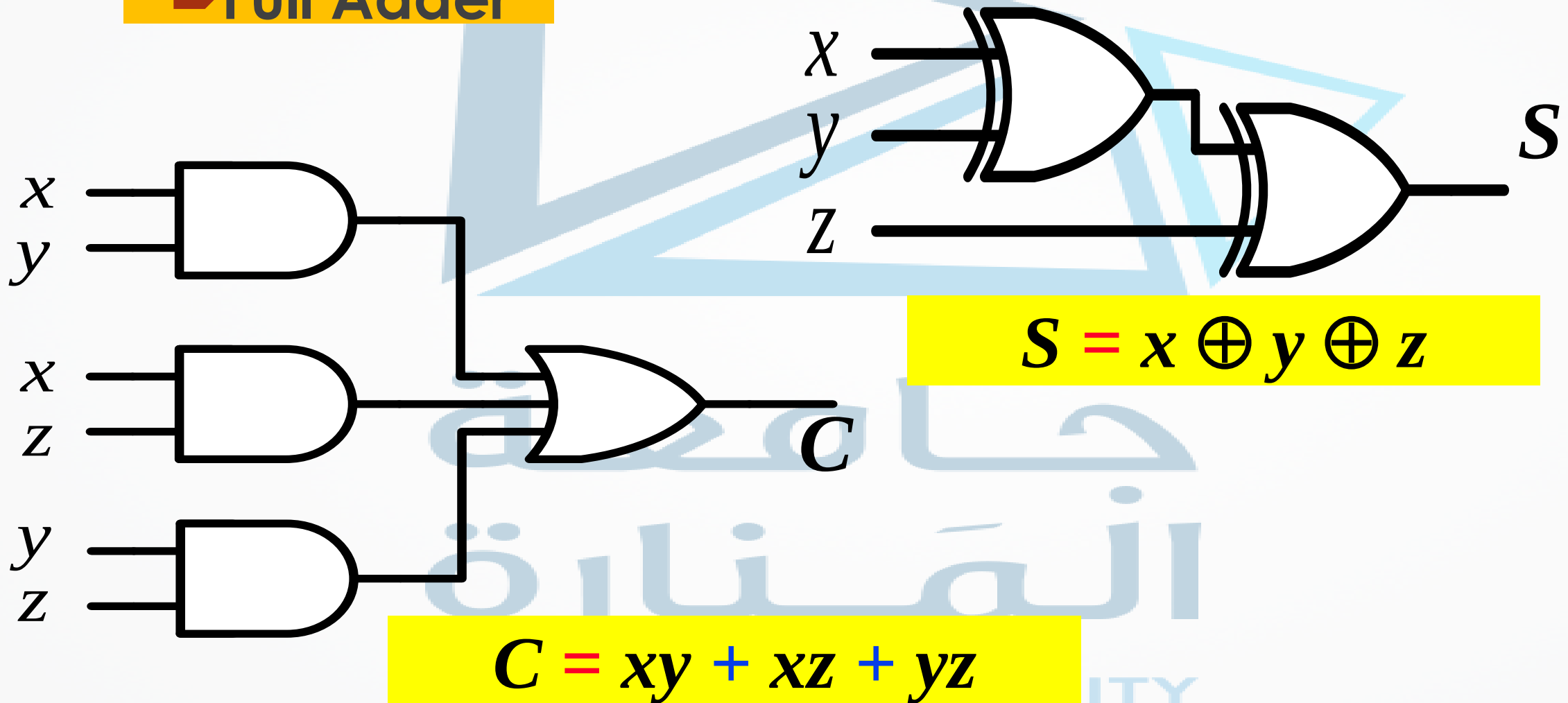
$$S = xy'z' + x'yz' + x'y'z + xyz$$

$$S = x \oplus y \oplus z$$

$$C = xy + xz + yz$$

Binary Adder

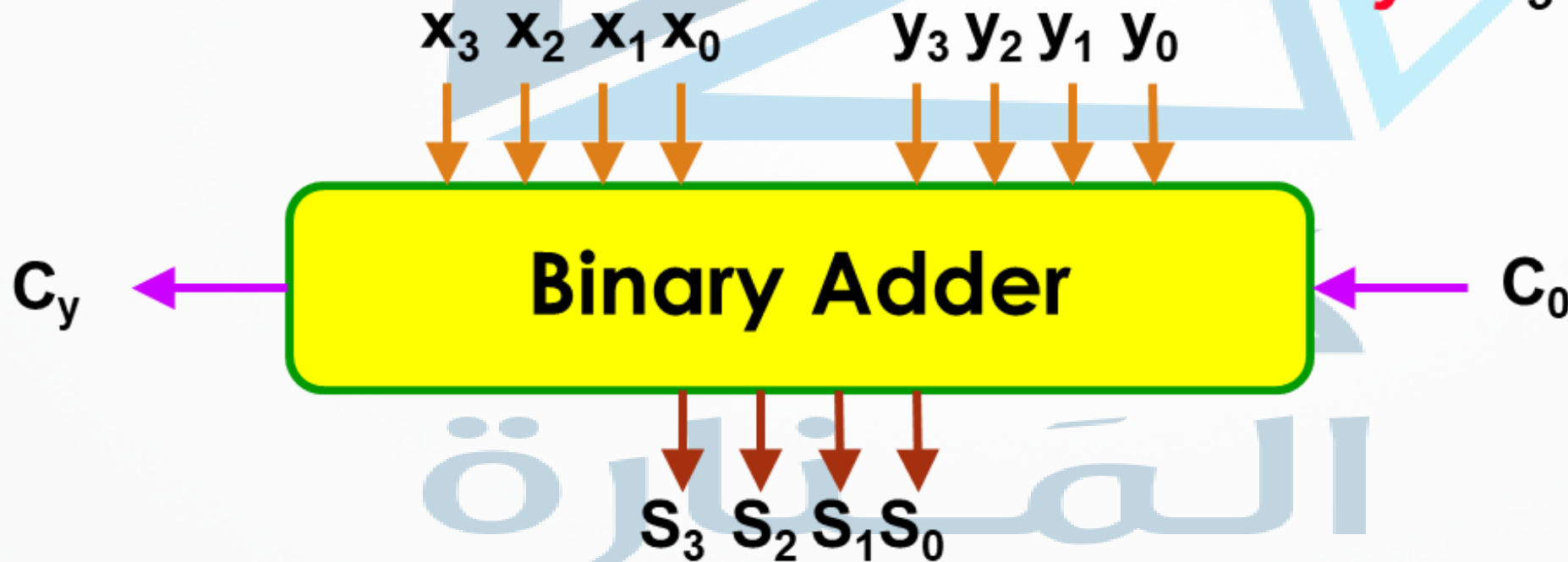
➡ Full Adder



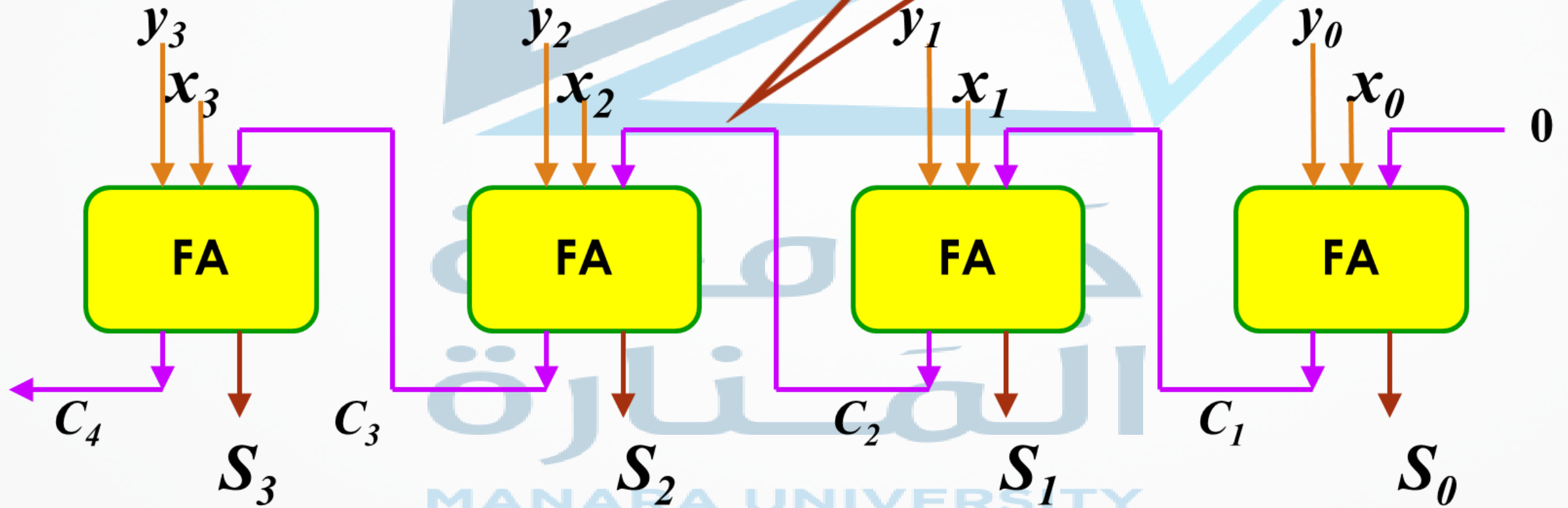
Binary Adder



$$\begin{array}{r} C_3 \quad C_2 \quad C_1 \\ + \quad x_3 \quad x_2 \quad x_1 \quad x_0 \\ + \quad y_3 \quad y_2 \quad y_1 \quad y_0 \\ \hline Cy \quad S_3 \quad S_2 \quad S_1 \quad S_0 \end{array}$$

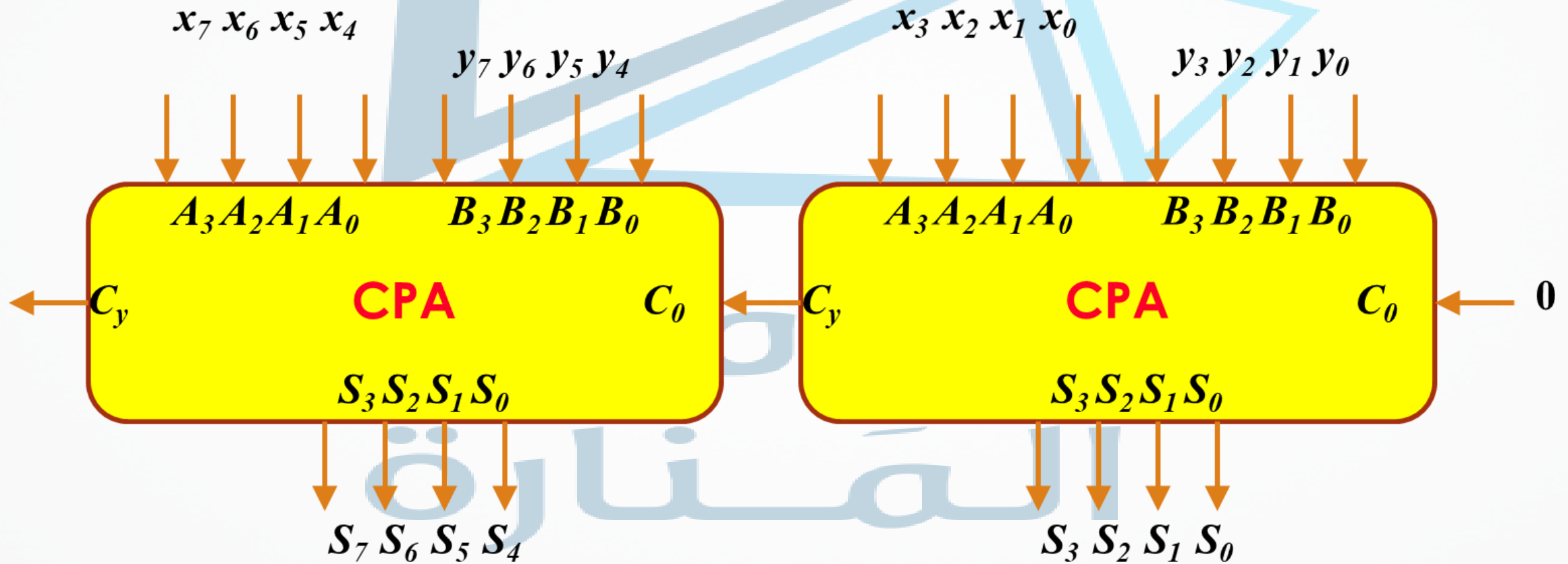


Carry Propagate Addition



Binary Adder

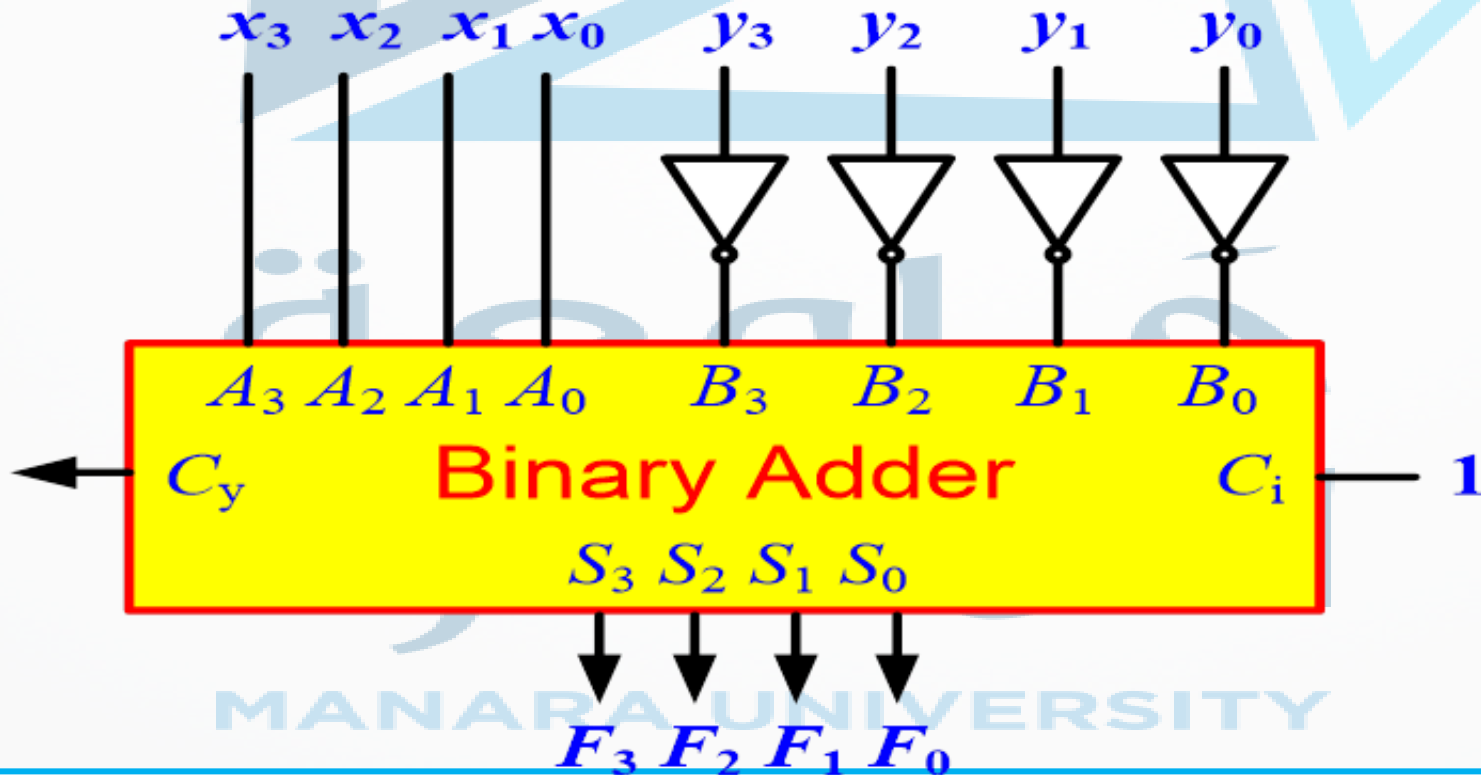
➡ Carry Propagate Adder



Binary Subtractor

► Use 2's complement with binary adder

$$x - y = x + (-y) = x + y' + 1$$



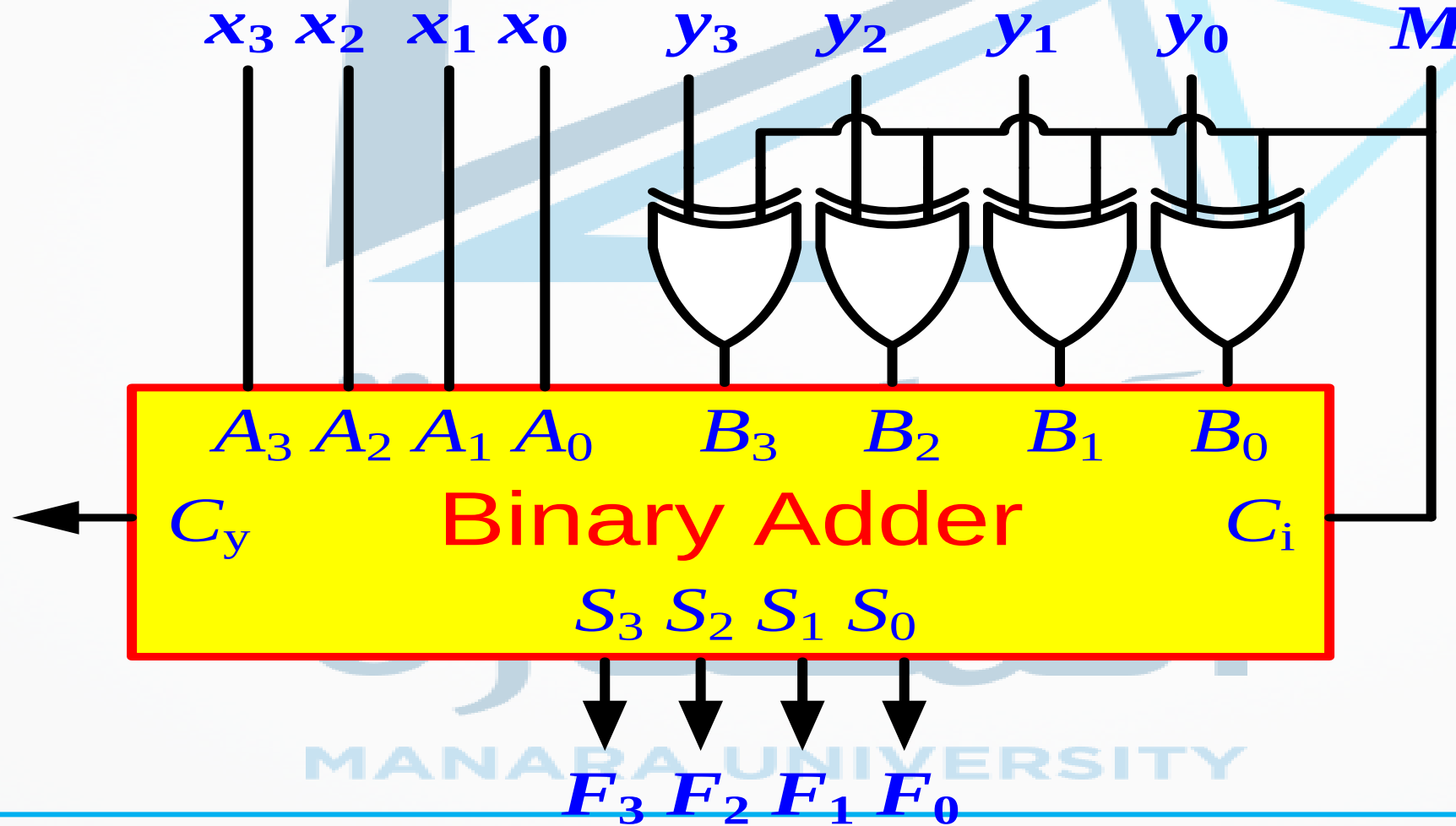
Binary Adder/Subtractor



➡ M : Control Signal (Mode)

➡ $M=0 \rightarrow F = x + y$

➡ $M=1 \rightarrow F = x - y$



Magnitude Comparator

- Compare 4-bit number to 4-bit number
- 3 Outputs: $<$, $=$, $>$
- Expandable to more number of bits

$$x_3 = \overline{A_3} \overline{B_3} + A_3 B_3$$

$$x_2 = \overline{A_2} \overline{B_2} + A_2 B_2$$

$$x_1 = \overline{A_1} \overline{B_1} + A_1 B_1$$

$$x_0 = \overline{A_0} \overline{B_0} + A_0 B_0$$

$$(A = B) = x_3 x_2 x_1 x_0$$

$$(A > B) = \overline{A_3} \overline{B_3} + x_3 \overline{A_2} \overline{B_2} + x_3 x_2 \overline{A_1} \overline{B_1} + x_3 x_2 x_1 \overline{A_0} \overline{B_0}$$

$$(A < B) = \overline{A_3} B_3 + x_3 \overline{A_2} B_2 + x_3 x_2 \overline{A_1} B_1 + x_3 x_2 x_1 \overline{A_0} B_0$$

$A_3 A_2 A_1 A_0 B_3 B_2 B_1 B_0$

Magnitude Comparator

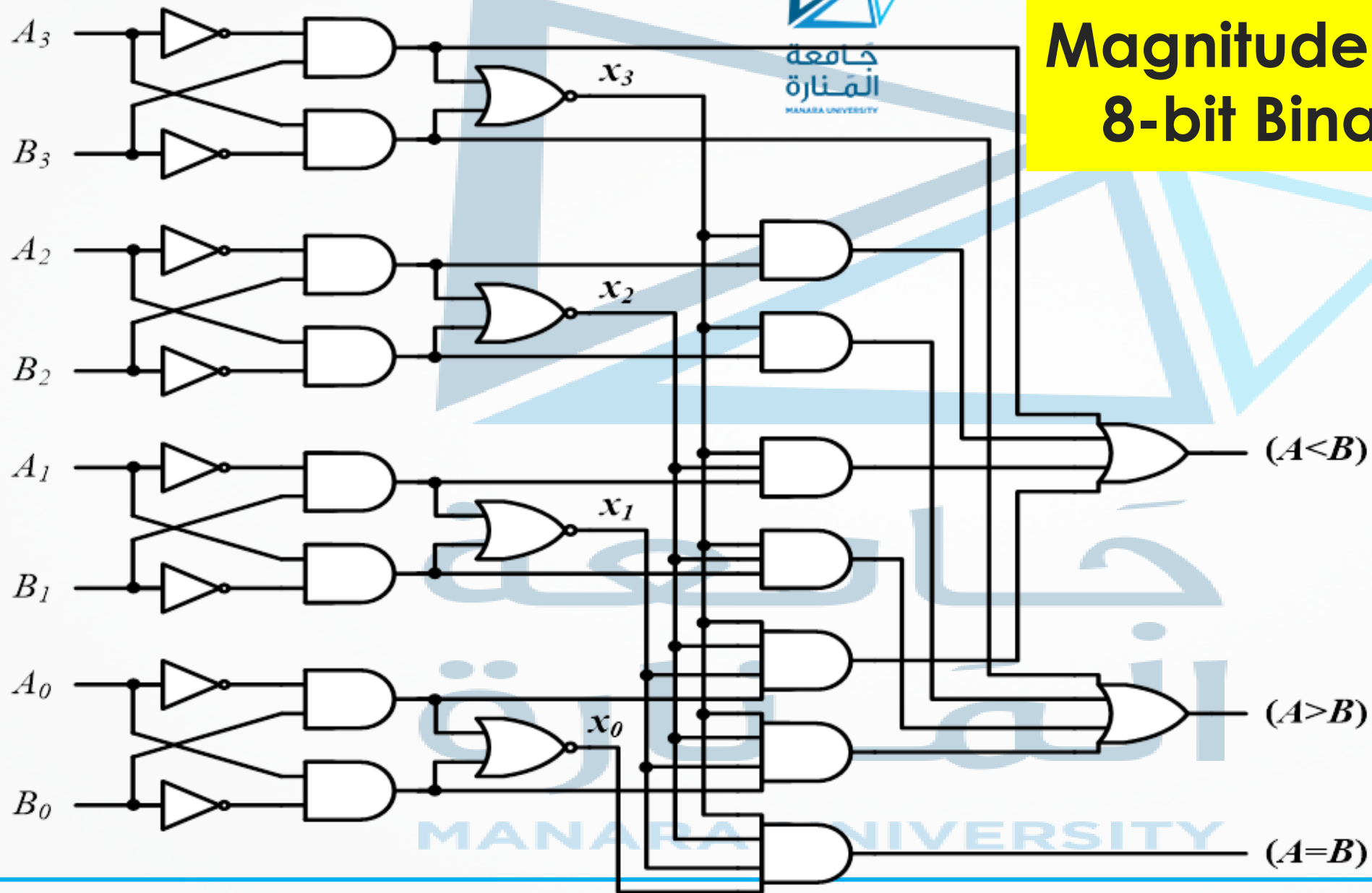
$A < B$

$A = B$

$A > B$



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Magnitude Comparator

8-bit Binary Number

Magnitude Comparator

8-bit Binary Number

