جَامعة المَنارة
MANARA UNIVERSITY

Lecture 8

ARITHMETIC CIRCUITS

- Binary Adder
- Binary Subtractor
- Magnitude Comparator

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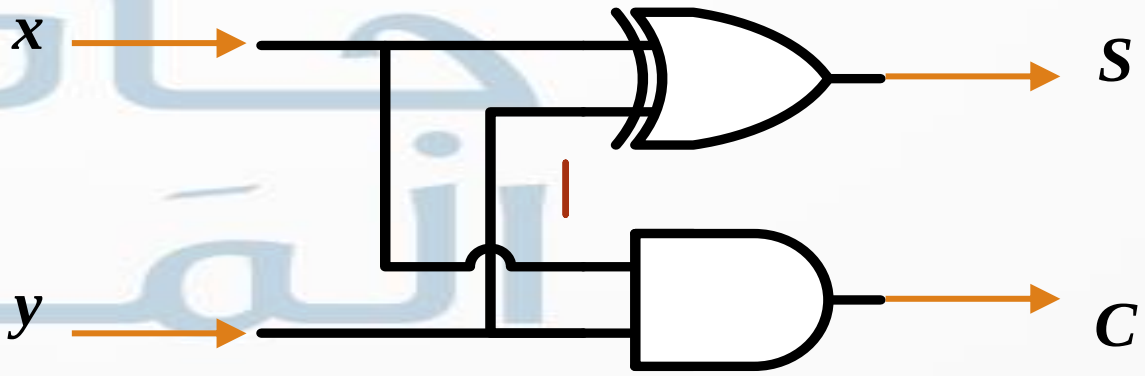
ARITHMETIC CIRCUITS

Binary Adder/Half Adder

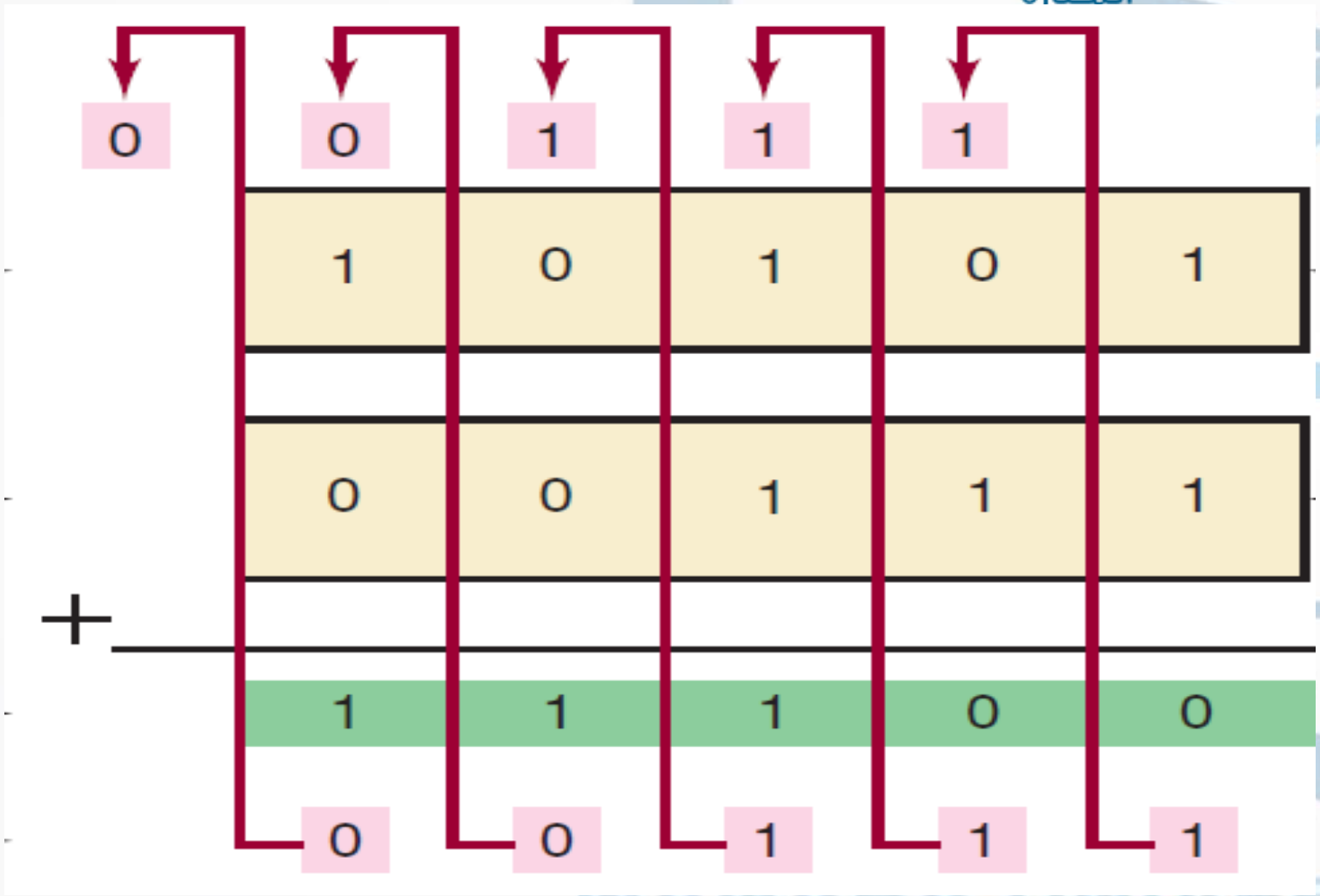
- Half Adder
  - Adds 1-bit plus 1-bit
  - Produces Sum and Carry

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

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



Full Adder

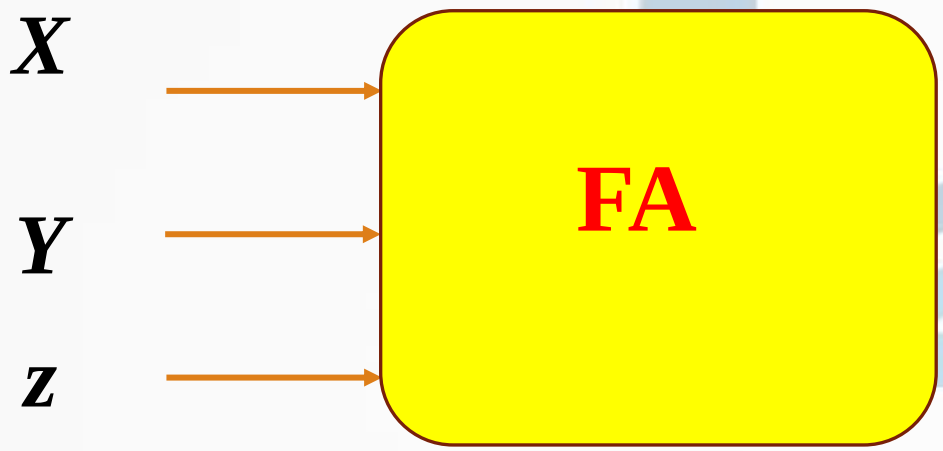


★ Full Adder

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

$$\begin{array}{rr} & x \\ + & y \\ + & z \\ \hline C & S \end{array}$$

Binary Adder



S: الناتج

C : الباقي

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

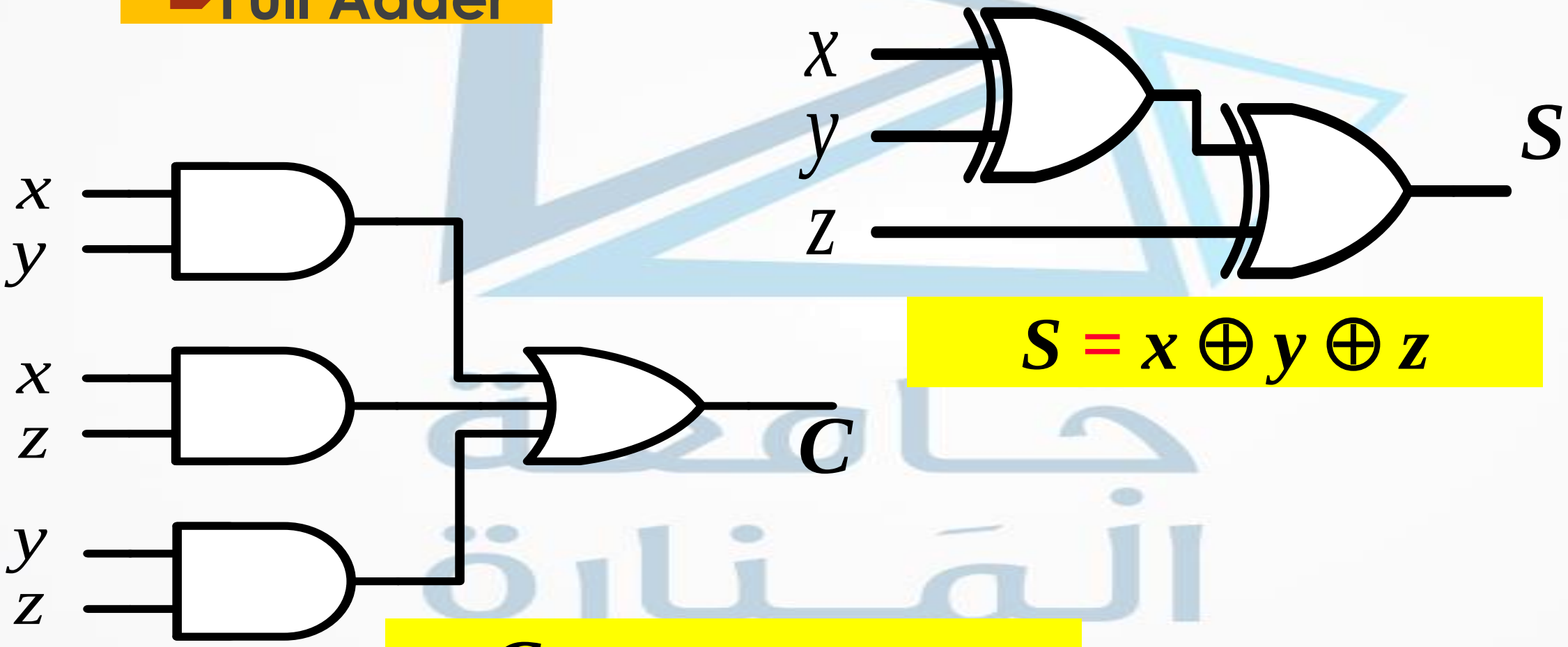
$$S = x \oplus y \oplus z$$

$$C = xy + xz + yz$$

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

Binary Adder

Full Adder

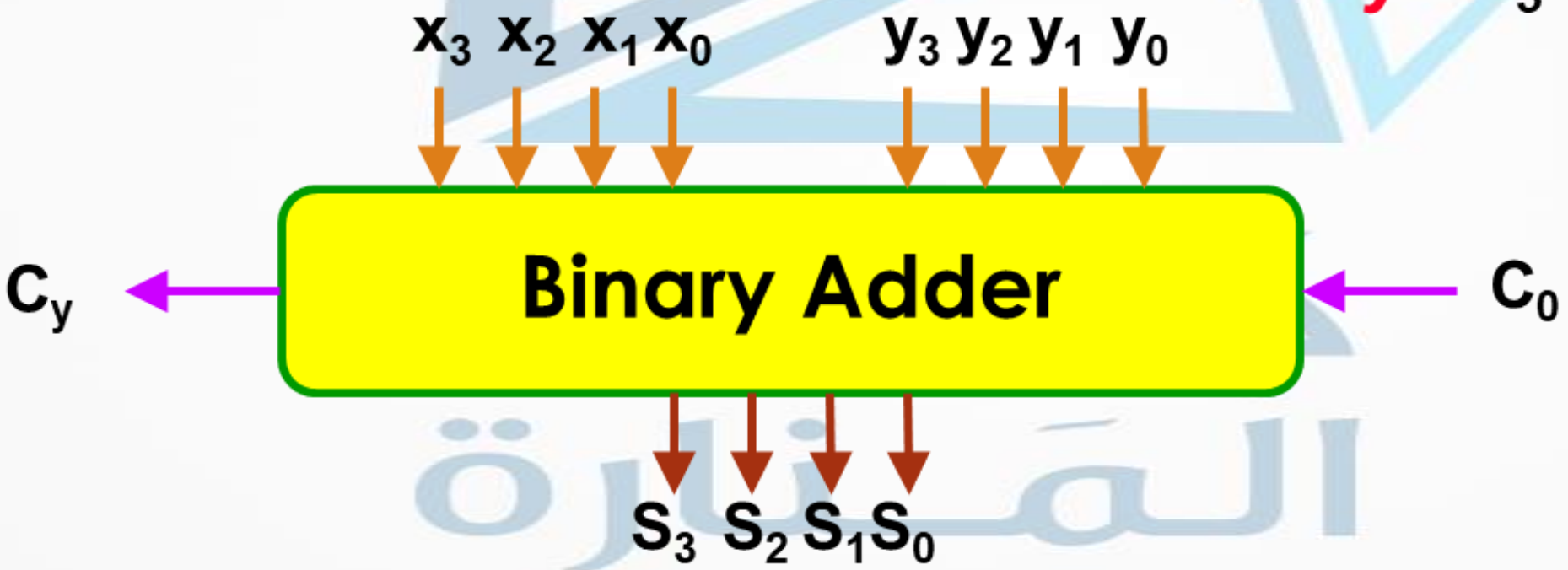


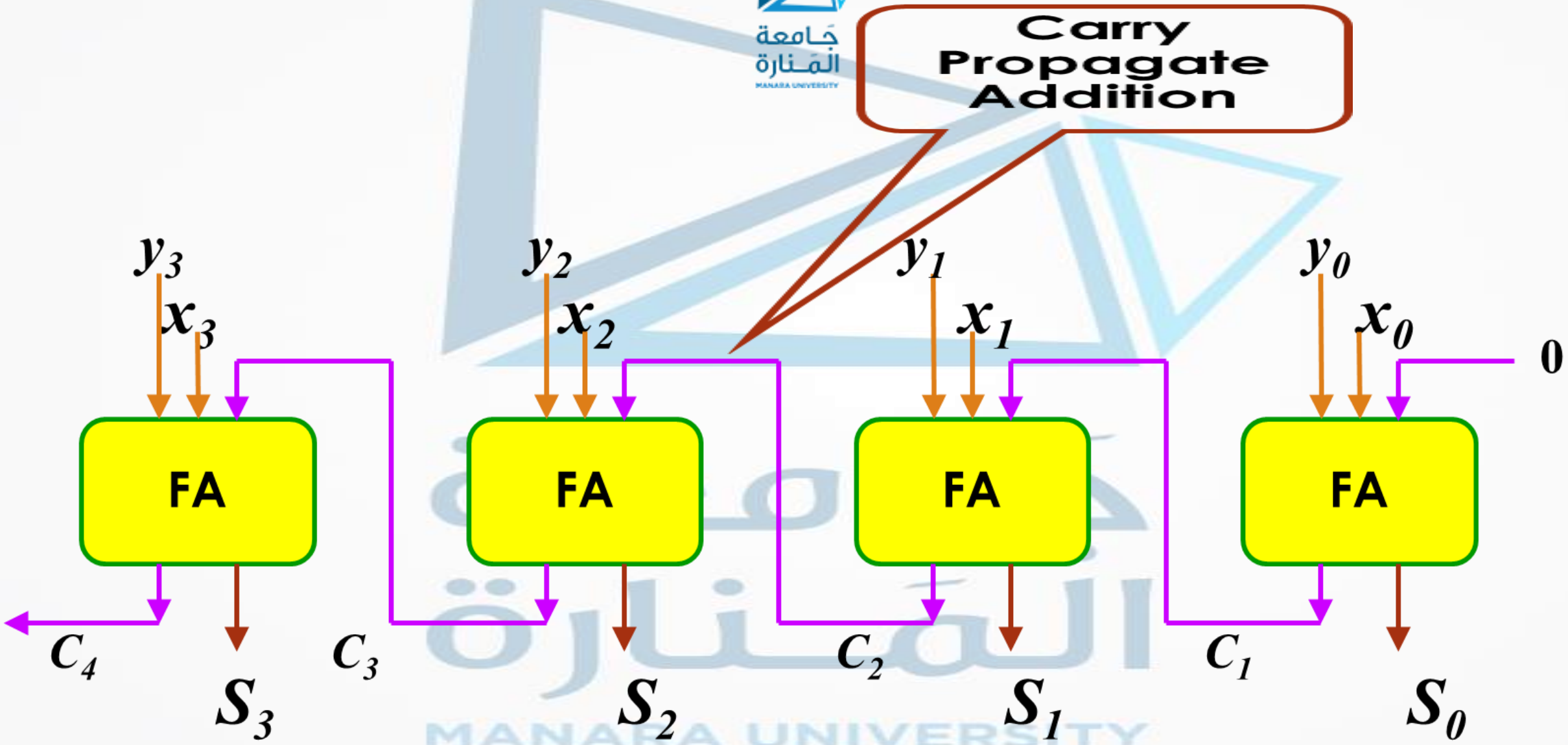
$$S = x \oplus y \oplus z$$

$$C = xy + xz + yz$$

Binary Adder

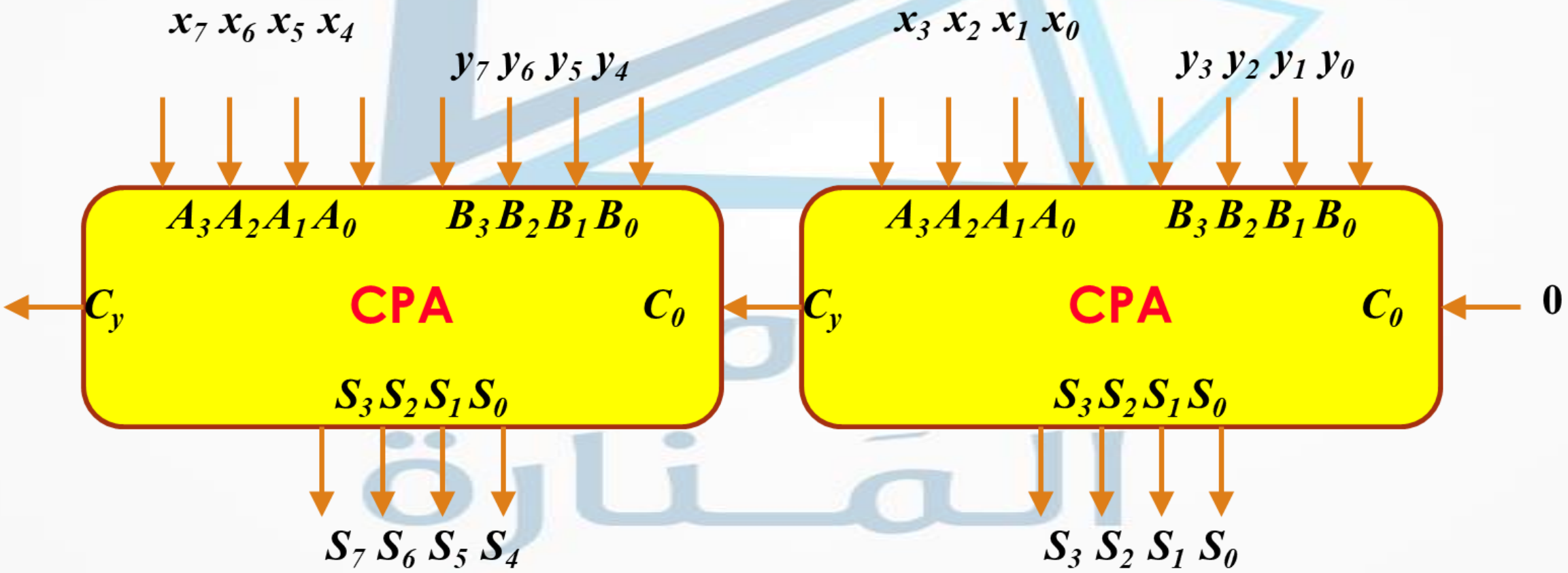
$$
\begin{array}{l}
\quad c_3\ \ c_2\ \ c_1 \\
+\ x_3\ \ x_2\ \ x_1\ \ x_0 \\
+\ y_3\ \ y_2\ \ y_1\ \ y_0 \\
\hline
\quad Cy\ \ S_3\ \ S_2\ \ S_1\ \ S_0
\end{array}
$$





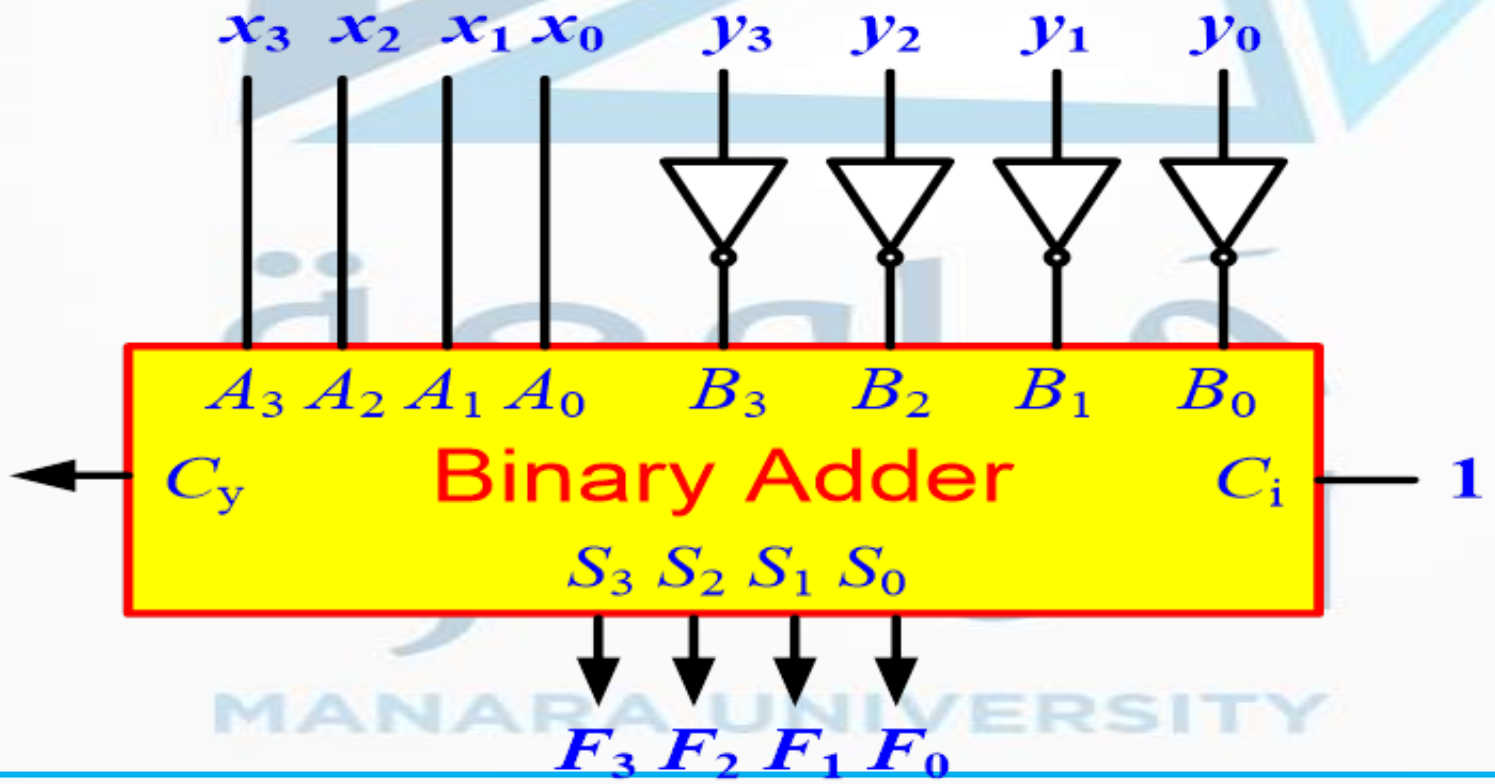
Binary Adder

Carry Propagate Adder



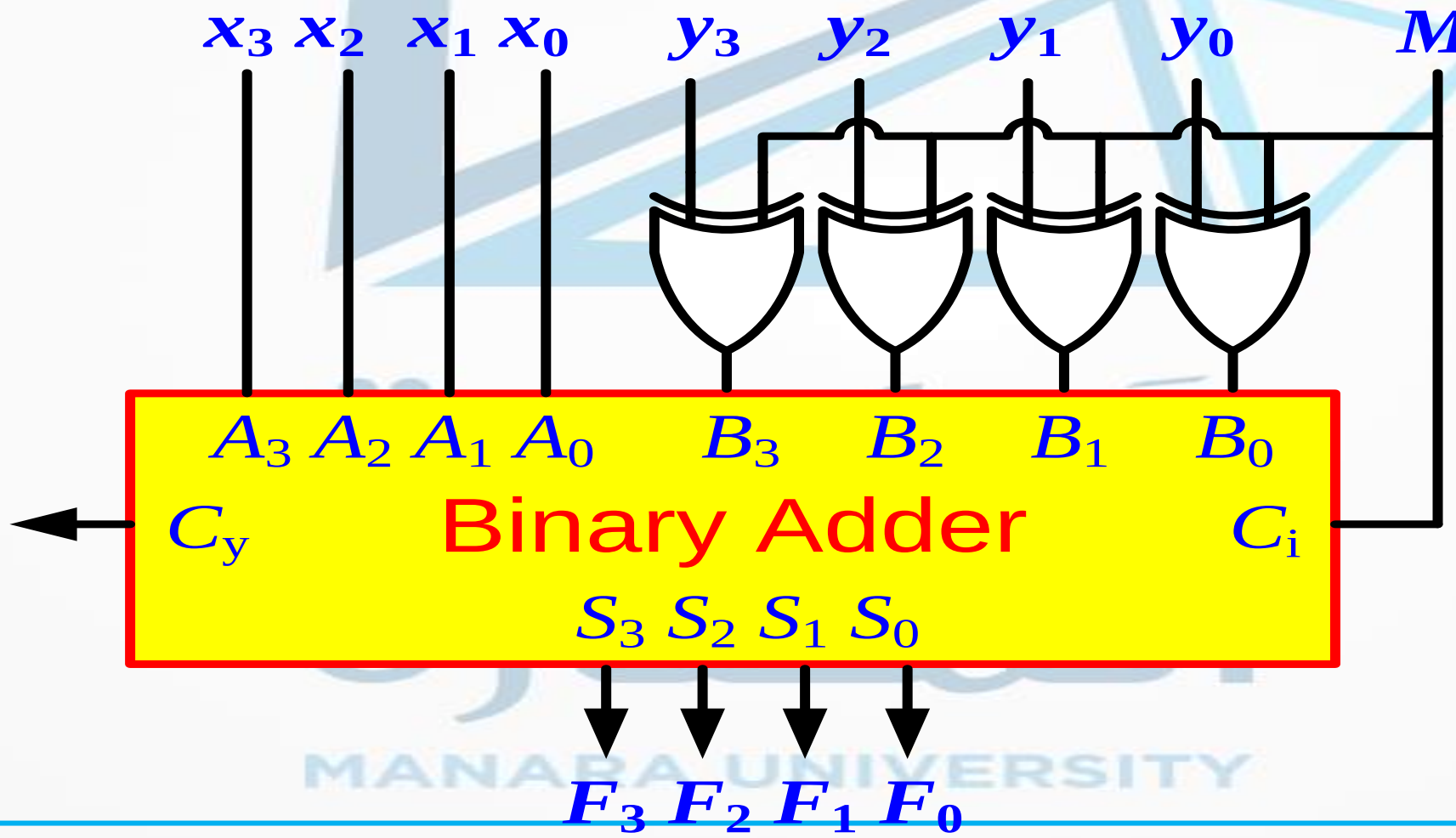
Binary Subtractor

- Use 2's complement with binary adder
  - $x - y = x + (-y) = x + y' + 1$



Binary Adder/Subtractor

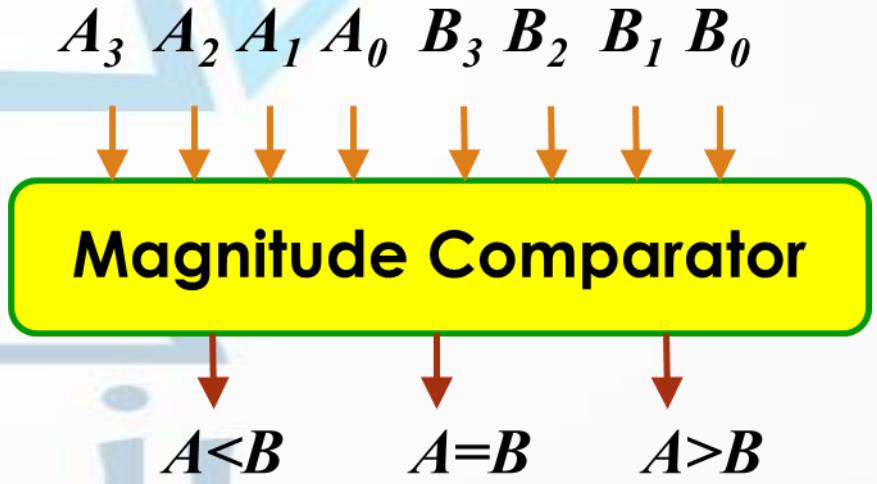
- M: Control Signal (Mode)
  - M=0 ➔ $F = x + y$
  - M=1 ➔ $F = x - y$



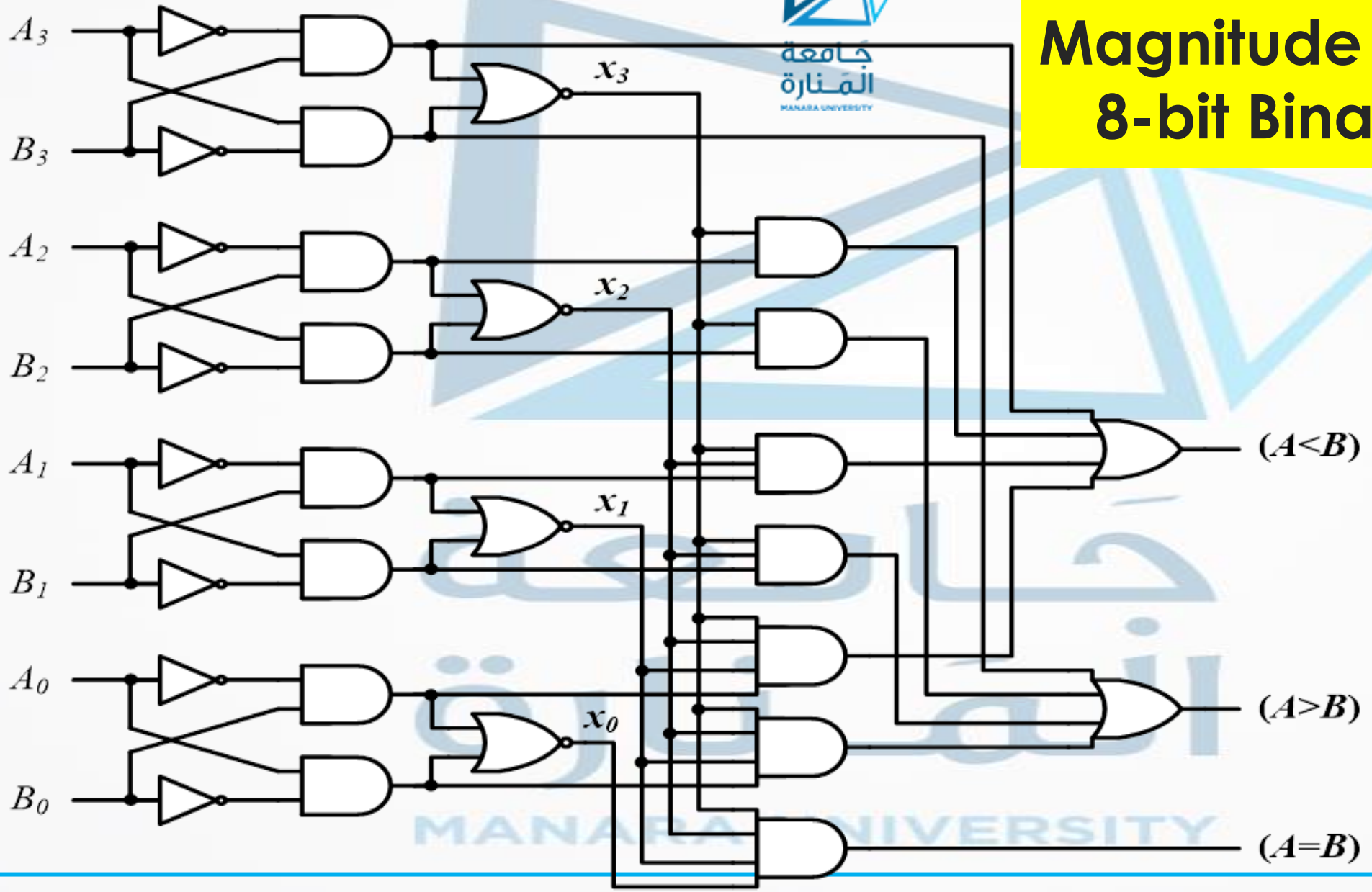
Magnitude Comparator

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

$$x_3 = \overline{A}_3\,\overline{B}_3 + A_3\,B_3$$
$$x_2 = \overline{A}_2\,\overline{B}_2 + A_2\,B_2$$
$$x_1 = \overline{A}_1\,\overline{B}_1 + A_1\,B_1$$
$$x_0 = \overline{A}_0\,\overline{B}_0 + A_0\,B_0$$
$$(A = B) = x_3\,x_2\,x_1\,x_0$$
$$(A > B) = A_3\,\overline{B}_3 + x_3\,A_2\,\overline{B}_2 + x_3\,x_2\,A_1\,\overline{B}_1 + x_3\,x_2\,x_1\,A_0\,\overline{B}_0$$
$$(A < B) = \overline{A}_3\,B_3 + x_3\,\overline{A}_2\,B_2 + x_3\,x_2\,\overline{A}_1\,B_1 + x_3\,x_2\,x_1\,\overline{A}_0\,B_0$$



Magnitude Comparator
8-bit Binary Number



Magnitude Comparator 8-bit Binary Number