Digital Logic Design :

Lecture 10

The Half Adder :

Basic rules for binary addition

0 + 0 = 0

0 + 1 = 1

1 + 0 = 1

1 + 1 = 10

These operations are performed by a logic circuit called a half-adder.

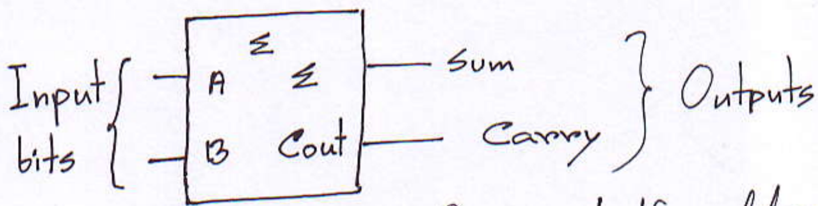


Fig : Logic symbol for a half-adder

Half-adder truth table :

A	B	Cout	Σ
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

The sum bit can be expressed as

$$\Sigma = A \oplus B$$

The carry bit can be expressed as

$$C_{out} = AB$$

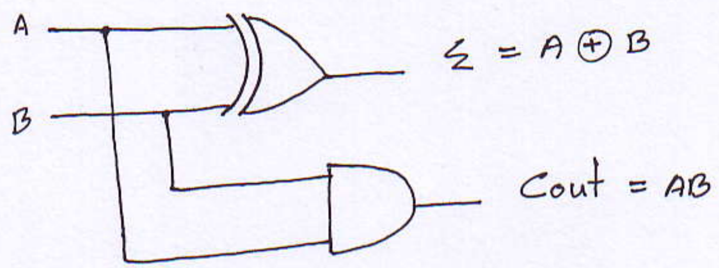


Fig : Half-adder logic diagram

The Full-Adder :

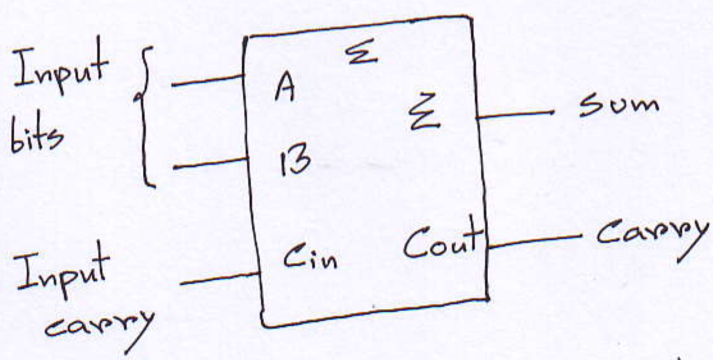
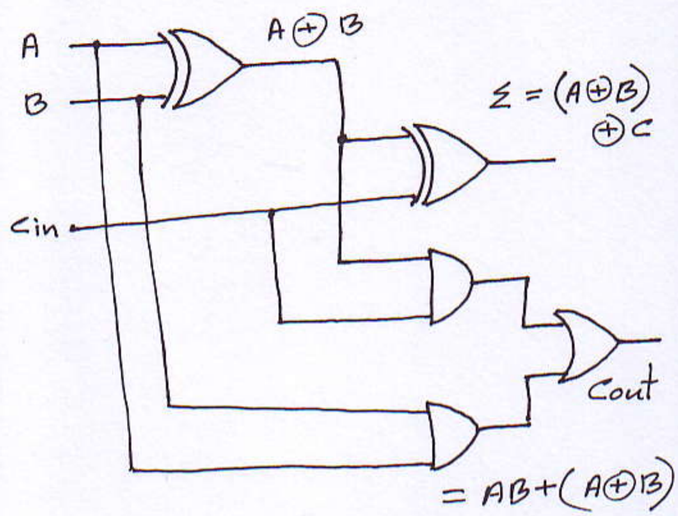


Fig : Logic symbol for a full-adder

Full-adder truth table :

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



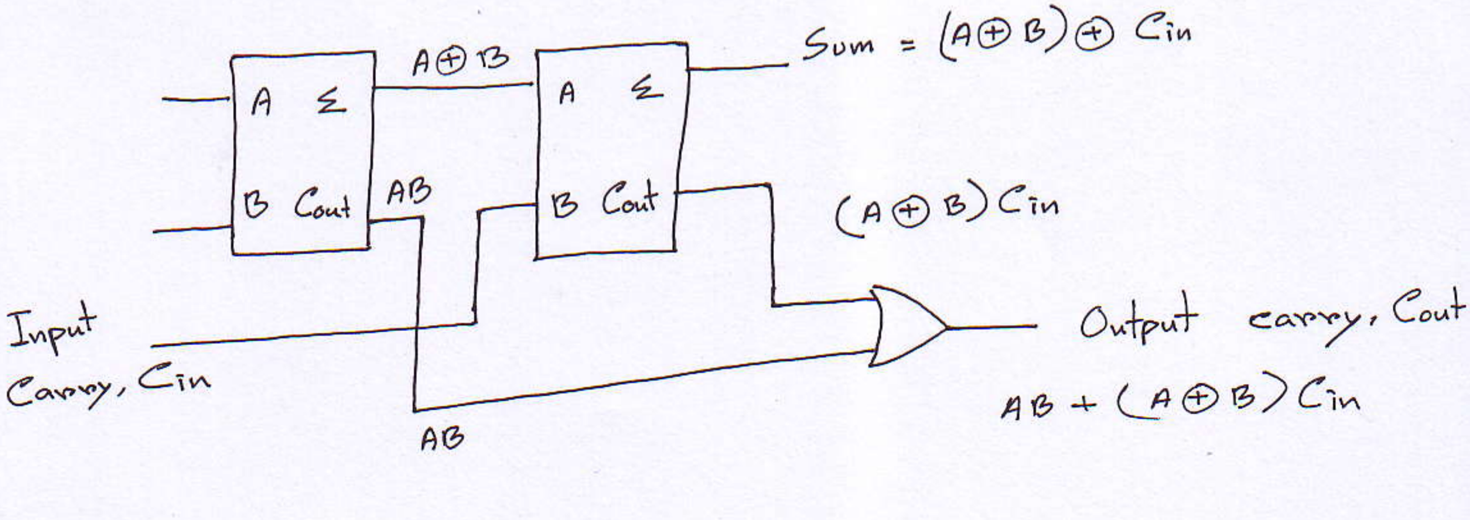
$$\Sigma = (A \oplus B) \oplus C_{in}$$

$$C_{out} = AB + (A \oplus B)\, C_{in}$$

Fig : Complete logic circuit for a full adder

Full-adder implemented using Half-adder

Half-adder → $\Sigma = A \oplus B$, $C_{out} = AB$



Parallel Binary Adders :

$$\begin{array}{r} 11 \\ 01 \\ \hline 100 \end{array}$$

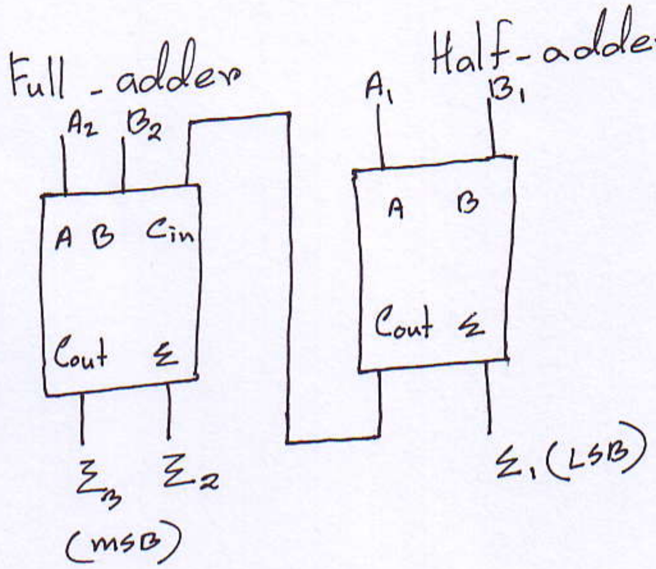


Fig : 2- bit parallel adder

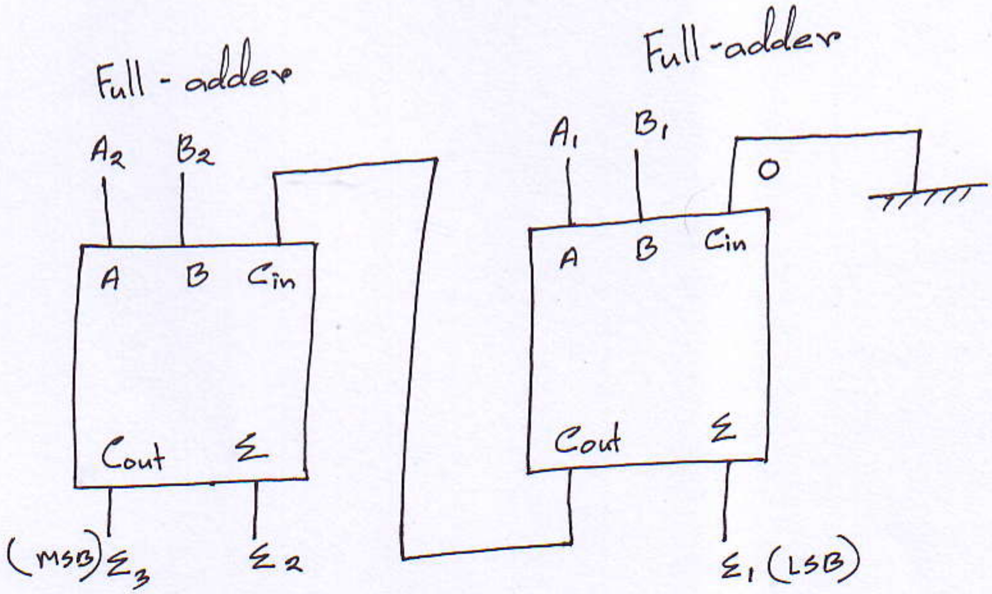


Fig : Block diagram of a basic 2- bit parallel adder.

A 4-bit parallel adder

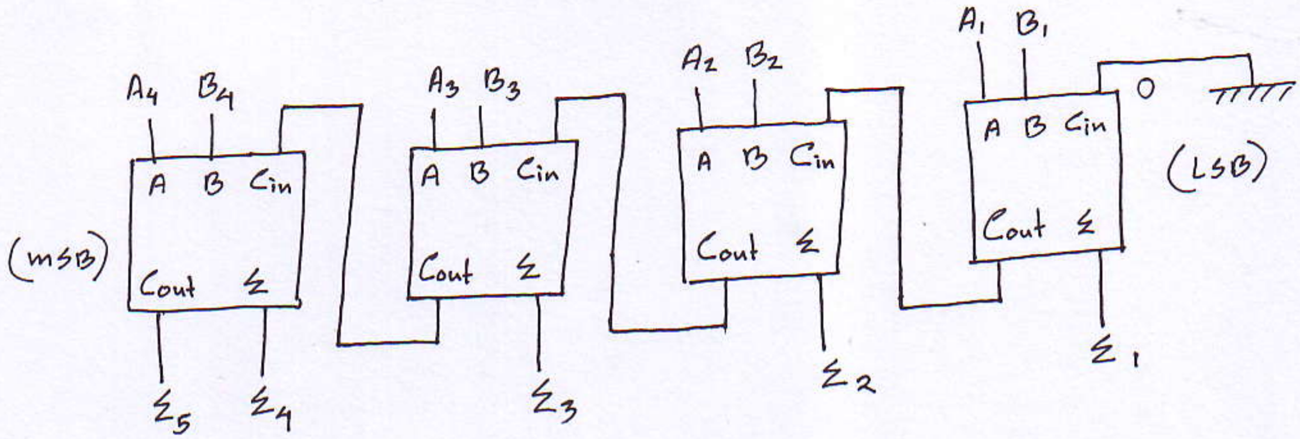


Fig : Block diagram of a 4 bit parallel adder

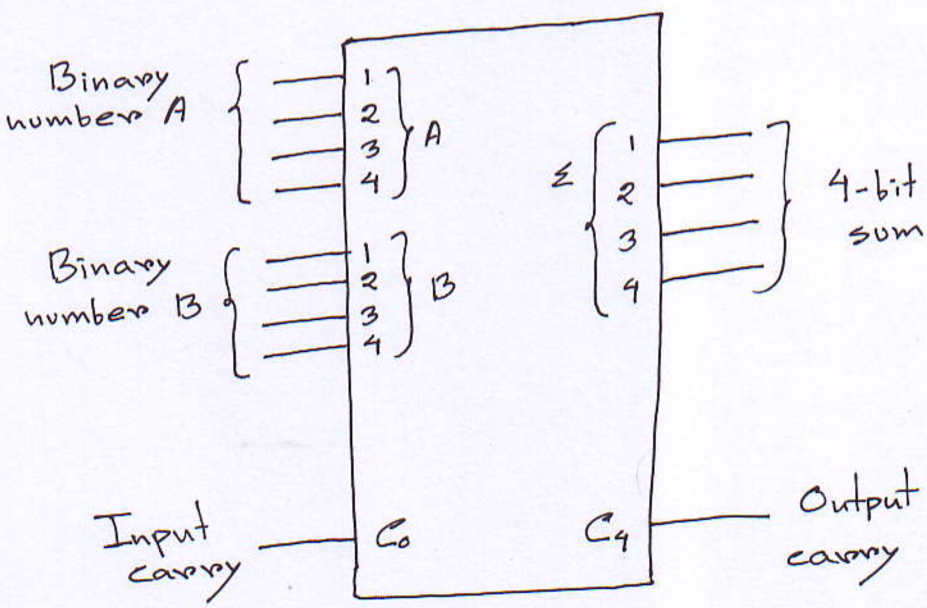


Fig : Logic symbol of a 4 bit binary adder

Adder Expansion :

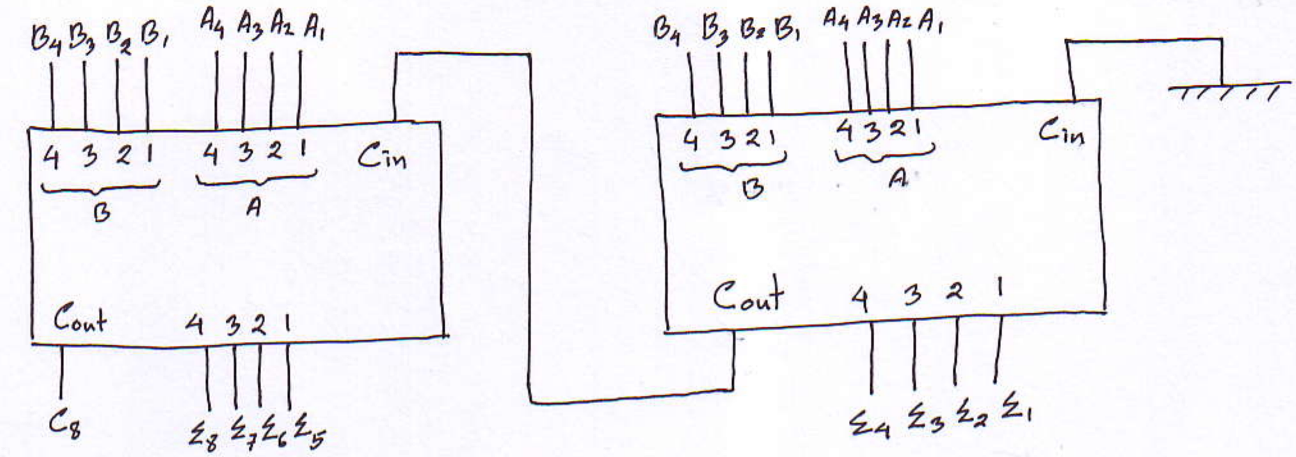
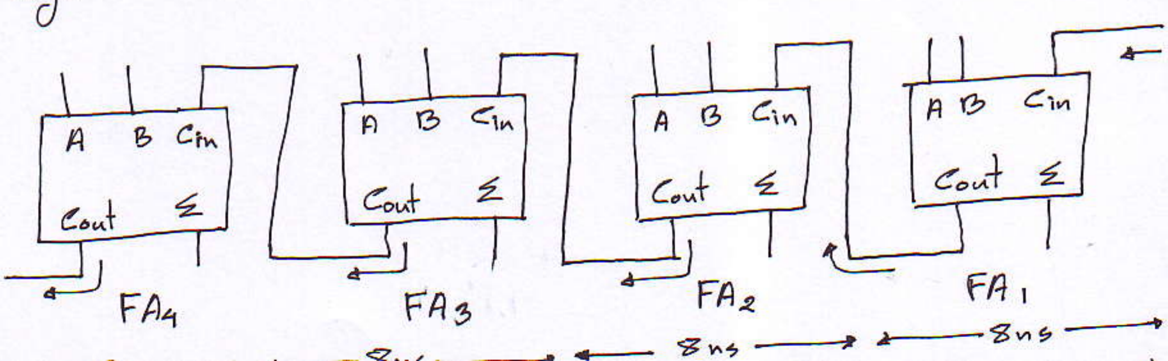


Fig : Cascading of 4-bit adders to form an 8-bit adder

The Ripple carry adder :

A ripple carry adder is one in which, the carry out-put of each full-adder is connected to the carry input of the next higher-order stage. The sum and the output carry of any stage cannot be produced until the input carry occurs, causing a time delay in addition process as illustrated in fig.



Subtractors :

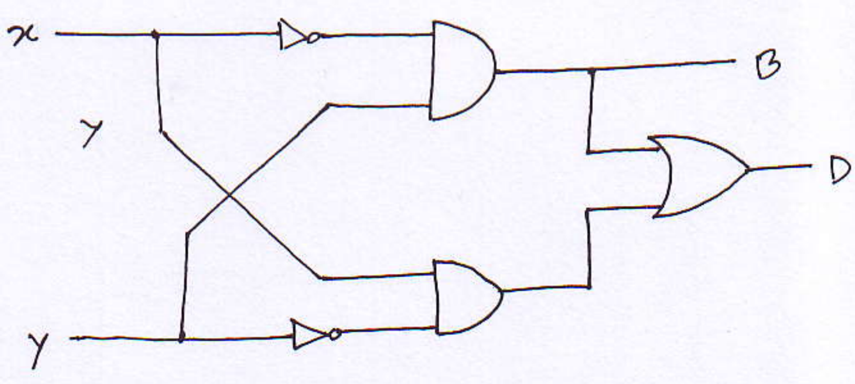
Half - Subtractor : A half-subtractor is a combinational circuit that subtracts two bits and produces their difference. It also has an output to specify if a 1 has been borrowed.

$x - y = ?$ let x and y are two minuend and subtract,

x	y	B	D
0	0	0	0
0	1	1	1
1	0	0	1
1	1	0	0

$$\therefore \; D = \bar{x}y + x\bar{y} = x \oplus y$$

$$B = \bar{x}y$$



Full Subtractor :

A full-subtractor is a combinational circuit that performs a subtraction between two bits, taking into account that a 1 may have been borrowed by a lower significant stage. Let the three inputs x, y and z denotes the minuend, subtrahend and previous borrow.

x	y	z	B	D
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	1	0
1	0	0	0	1
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

$$D = x \oplus y \oplus z$$

$$B = \bar{x}y + \bar{x}z + yz$$