جامعة كلكامش

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النظام الرقمي

Lecture 4

1. Arithmetic circuits

A combinational circuit is one where the output at any time depends only on the present combination. More complex combinational circuits such as adders and subtractors, multiplexers and demultiplexers, magnitude comparators, etc., can be implemented using a combination of logic gates.

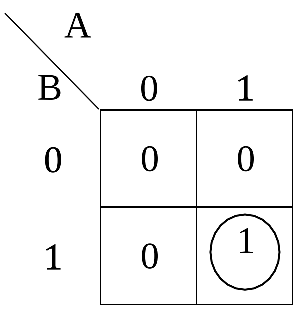
1.1. Adder circuits

The most basic arithmetic operation is addition. The circuit, which performs the addition of two binary numbers is known as **Binary adder**. First, let us implement an adder, which performs the addition of two bits.

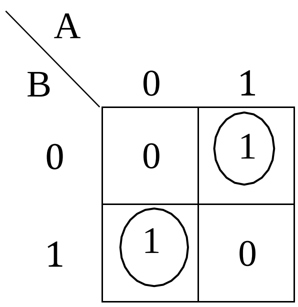
1.1.1. Half adder

Half adder is a combinational circuit, which performs the addition of two binary numbers A and B are of single bit. It produces two outputs sum, S & carry, C. The Truth table of Half adder is shown below.

Input		**Output**	
A	**B**	**S**	**C**
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1



k-map for C output

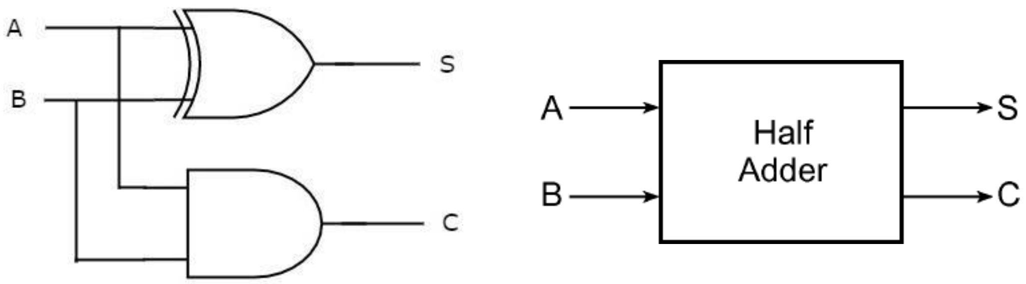


k-map for S output

The Boolean algebra of half adder is:

$$\mathbf{S} = \mathbf{A\overline{B}} + \mathbf{\overline{A}B} = \mathbf{A} \oplus \mathbf{B}$$

$$\mathbf{C} = \mathbf{AB}$$



(a) (b)

Figure 1 (a) Logic circuit for Half adder. (b) Block Diagram For half adder.

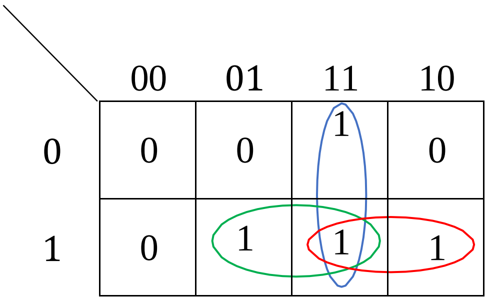
The above circuit, a two input Ex-OR gate & two input AND gate produces sum, S & carry, C respectively. Therefore, Half-adder performs the addition of two bits.

1.1.2. Full adder

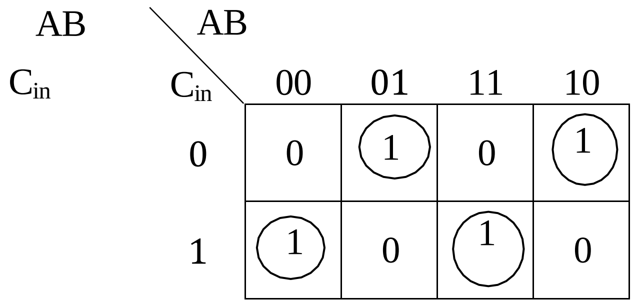
Full adder is a combinational circuit, which performs the **addition of three bits** A, B and C_{in}. Where, A & B are the two parallel significant bits and C_{in} is the carry bit, which is generated from previous stage. This Full adder also produces two outputs sum, S & carry, C_{out}, which are similar to Half adder.

The **Truth table** of Full adder is shown below.

Input			**Output**	
A	**B**	**C_{in}**	**C_{out}**	**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



k-map for C_{out} output



k-map for S output

The Boolean algebra of Full adder is:

$$C_{out} = AB + C_{in}A\,\overline{B} + C_{in}\overline{A}\,B$$

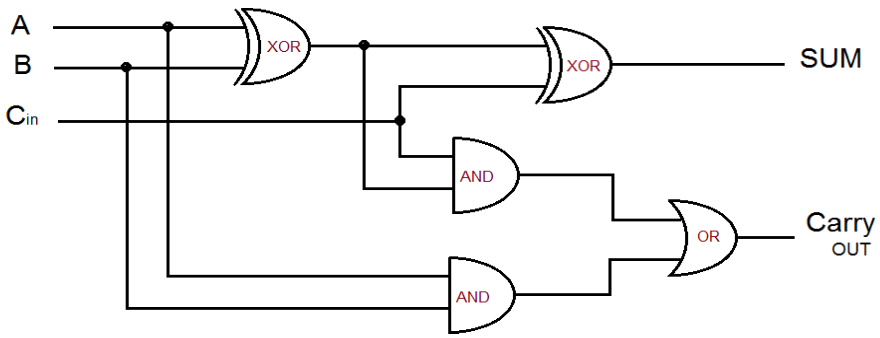
$$= \mathbf{AB + C_{in}(A \oplus B)}$$

$$S = \overline{AB}C_{in} + A\,B\,C_{in} + \overline{A}\,B\,\overline{C_{in}} + A\,\overline{BC_{in}}$$

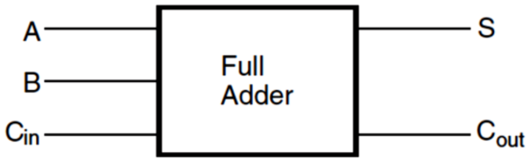
$$= C_{in}(\overline{AB} + A\,B) + \overline{C_{in}}(\overline{A}\,B + A\,\overline{B}\,)$$

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

$$= \mathbf{C_{in} \oplus A \oplus B}$$



(a)



(b)

Figure 2 (a) Logic circuit for Full adder. (b) Block Diagram for Full adder.