



# SNS COLLEGE OF TECHNOLOGY

Coimbatore-35  
An Autonomous Institution



Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A++' Grade  
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

## DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

### 19ECB231 – DIGITAL ELECTRONICS

II YEAR/ III SEMESTER

#### UNIT 2 – COMBINATIONAL CIRCUITS

#### TOPIC 5 - BCD ADDER, BINARY MULTIPLIER



## BCD ADDER



A 4-bit binary adder that is capable of adding two 4-bit words having a BCD (binary-coded decimal) format. The result of the addition is a BCD-format 4-bit output word, representing the decimal sum of the addend and augend, and a carry that is generated if this sum exceeds a decimal value of 9.

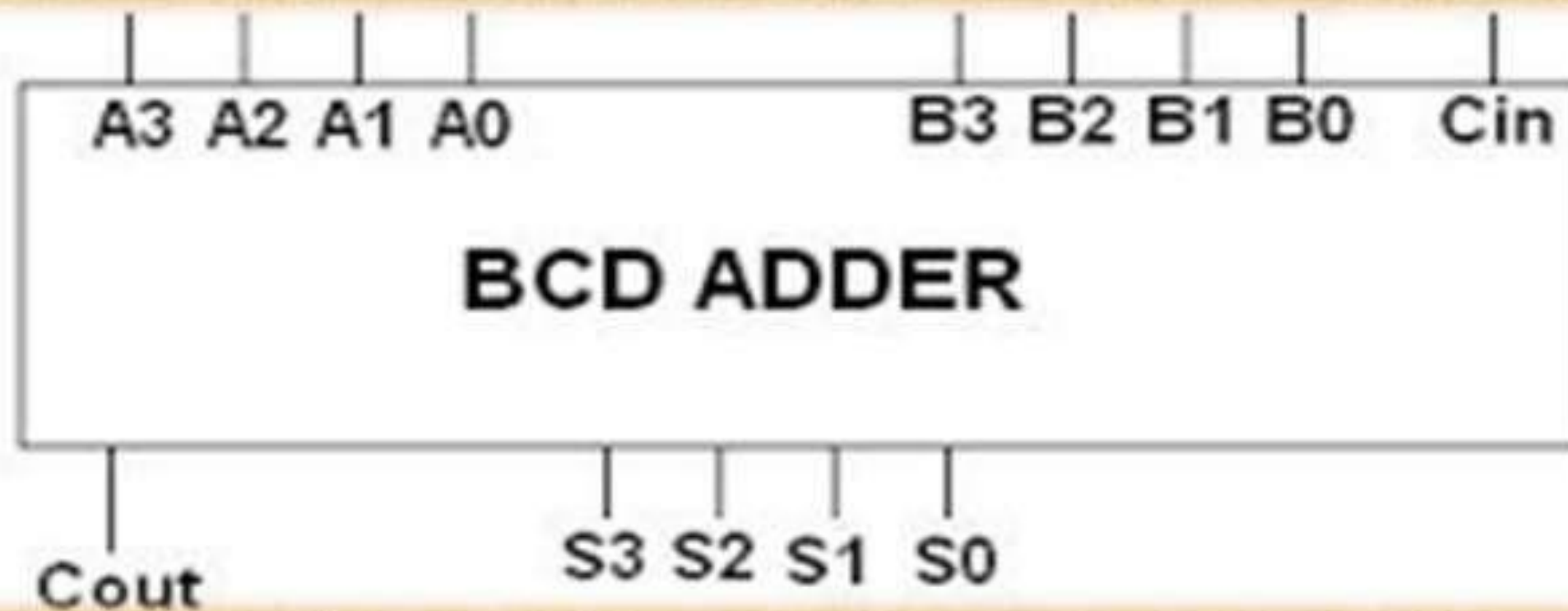


# BCD ADDER



## FUNCTIONS OF BCD ADDER

- A 4-bit BCD code's used to represent 0 to 9 digits.
- Adding BCD numbers using BCD addition.
- Adding 6 with the sum while exceeding 9 and generating a carry.
- By adding 6 to the sum, make an invalid digit valid.







## BCD ADDER



(i) **Case I:** Sum equal to or less than 9 but carry = 0

Decimal	BCD	
7	0 1 1 1	
+ 1	0 0 0 1	
8	1 0 0 0	← Sum

Here, the sum is correct and is in the true BCD form.

(ii) **Case II:** Sum greater than 9 but carry = 0

Decimal	BCD		
7	0 1 1 1		
+ 4	0 1 0 0		
11	1 0 1 1		
	Invalid BCD number		



# BCD ADDER



Combinational Logic

Here, it may be noted that the sum 1011 is invalid BCD number, so, the answer is not correct. Hence, to correct the answer, we add six (0110) to the invalid BCD answer as under :

$$\begin{array}{r}
 \phantom{000}1011 \leftarrow \text{Invalid BCD answer} \\
 + \phantom{000}0110 \leftarrow \text{Add } (6)_{10} \text{ for correction} \\
 \hline
 00010001 \leftarrow \text{Correct answer} \\
 \underbrace{\phantom{000}1000}_1 \quad \underbrace{\phantom{000}0001}_1
 \end{array}$$

(iii) **Case III:** Sum less than or equal to 9 but carry = 1  
 Let us consider the following addition:

Decimal	+	BCD
9		1 0 0 1
+ 8	+	1 0 0 0
-----		-----
17	1	0 0 0 1

Final carry ←
Wrong result of addition ←

Sum is invalid BCD number

The result of addition is 0001 0001 = (11)<sub>10</sub> which is not correct. Hence, to correct the wrong result, we have to add six (0110) as shown below:

$$\begin{array}{r}
 0001 \quad 0001 \leftarrow \text{Incorrect answer} \\
 + 0000 \quad 0110 \leftarrow \text{Add 6 for correction} \\
 \hline
 0001 \quad 0111 \leftarrow \text{Correct BCD answer} \\
 \underbrace{\phantom{000}1000}_1 \quad \underbrace{\phantom{000}0111}_7
 \end{array}$$



## WHY BCD ADDER IS USED?



The BCD-Adder is used in the computers and the calculators that perform arithmetic operation directly in the decimal number system. The BCD-Adder accepts the binary-coded form of decimal numbers. The Decimal-Adder requires a minimum of nine inputs and five outputs.



## WHY BCD IS CALLED 8421 CODE?



The  $BCD_{8421}$  code is so called because each of the four bits is given a 'weighting' according to its column value in the binary system.





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## TRUTH TABLE



Inputs				Output
$S_3$	$S_2$	$S_1$	$S_0$	Y
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

Sum is invalid BCD number. Hence Y= 1



# BCD ADDER



K-map:

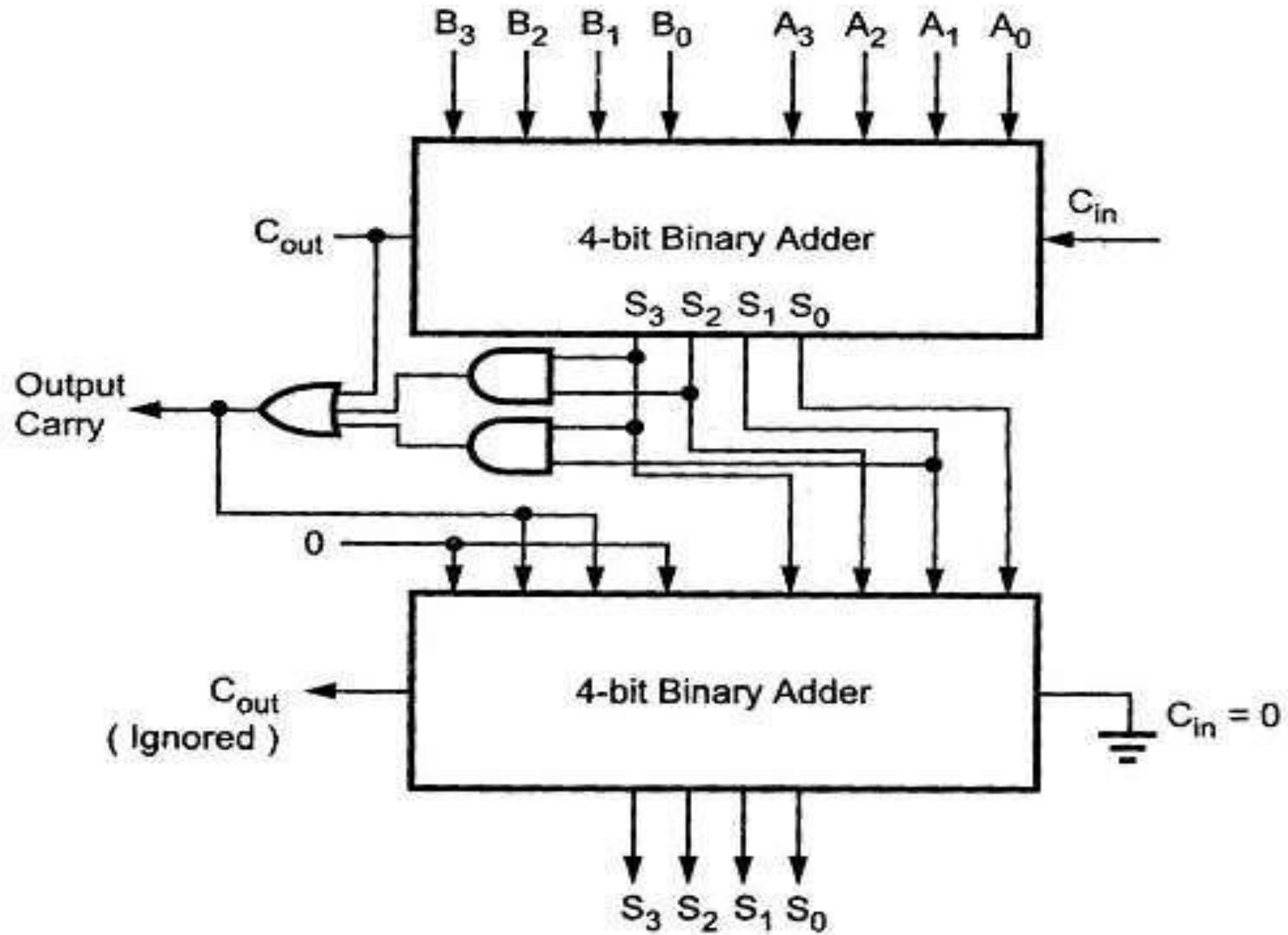
$S_3S_2$ \ $S_1S_0$	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	1	1	1	1
10	0	0	1	1

Annotations: A horizontal group of four 1s in the row where  $S_3S_2 = 11$  is circled and labeled  $S_3S_2$ . A vertical group of two 1s in the column where  $S_3S_1 = 10$  is circled and labeled  $S_3S_1$ .

The Boolean expression is  
 $Y = S_3S_2 + S_3S_1$



# BCD ADDER







## BCD ADDER



### Case II: Sum $> 9$ and carry = 0

If  $S_3 S_2 S_1 S_0$  of adder-1 is greater than 9, then output Y of combinational circuit becomes 1.

Therefore,  $B_3 B_2 B_1 B_0 = 0110$  (of adder-2)

Hence, six (0110) will be added to the sum output of adder-1. We get the corrected BCD result at the output of adder-2.

### Case III: Sum $\leq 9$ but carry = 1

As carry output of adder-1 is high, we have,  $Y' = 1$ .

Therefore,  $B_3 B_2 B_1 B_0 = 0110$  (of adder-2)

Hence, 0110 will be added to the sum output of adder-1. We get the corrected BCD result at the output of adder-2. This is carried out using the binary adder.





## WHAT IS BINARY MULTIPLIER?



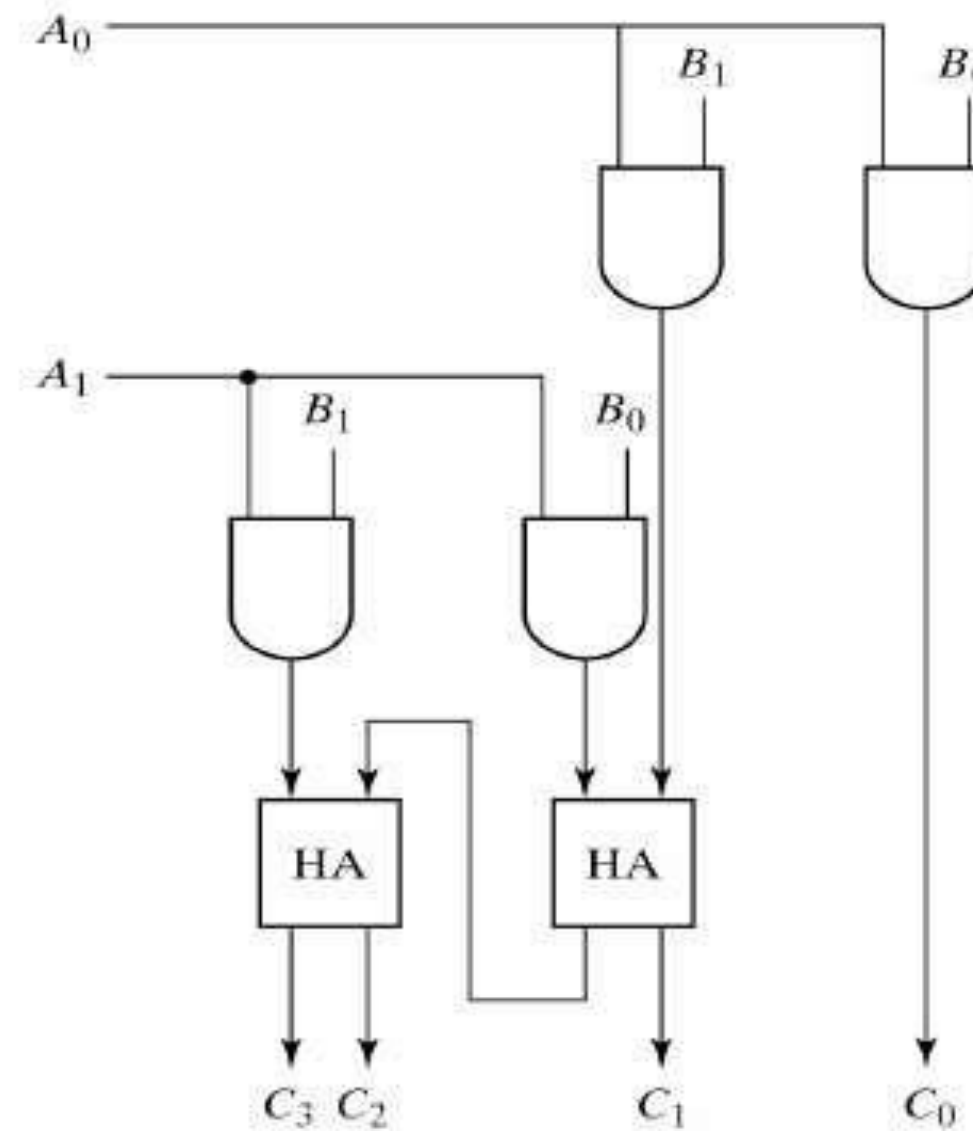
Multiply two binary numbers. It is built using binary adders. A variety of computer arithmetic techniques can be used to implement a digital multiplier.



# 2\*2 BIT BINARY MULTIPLIER



		$B_1$	$B_0$
	$A_1$	$A_1 B_1$	$A_1 B_0$
	$A_0$	$A_0 B_1$	$A_0 B_0$
$C_3$	$C_2$	$C_1$	$C_0$

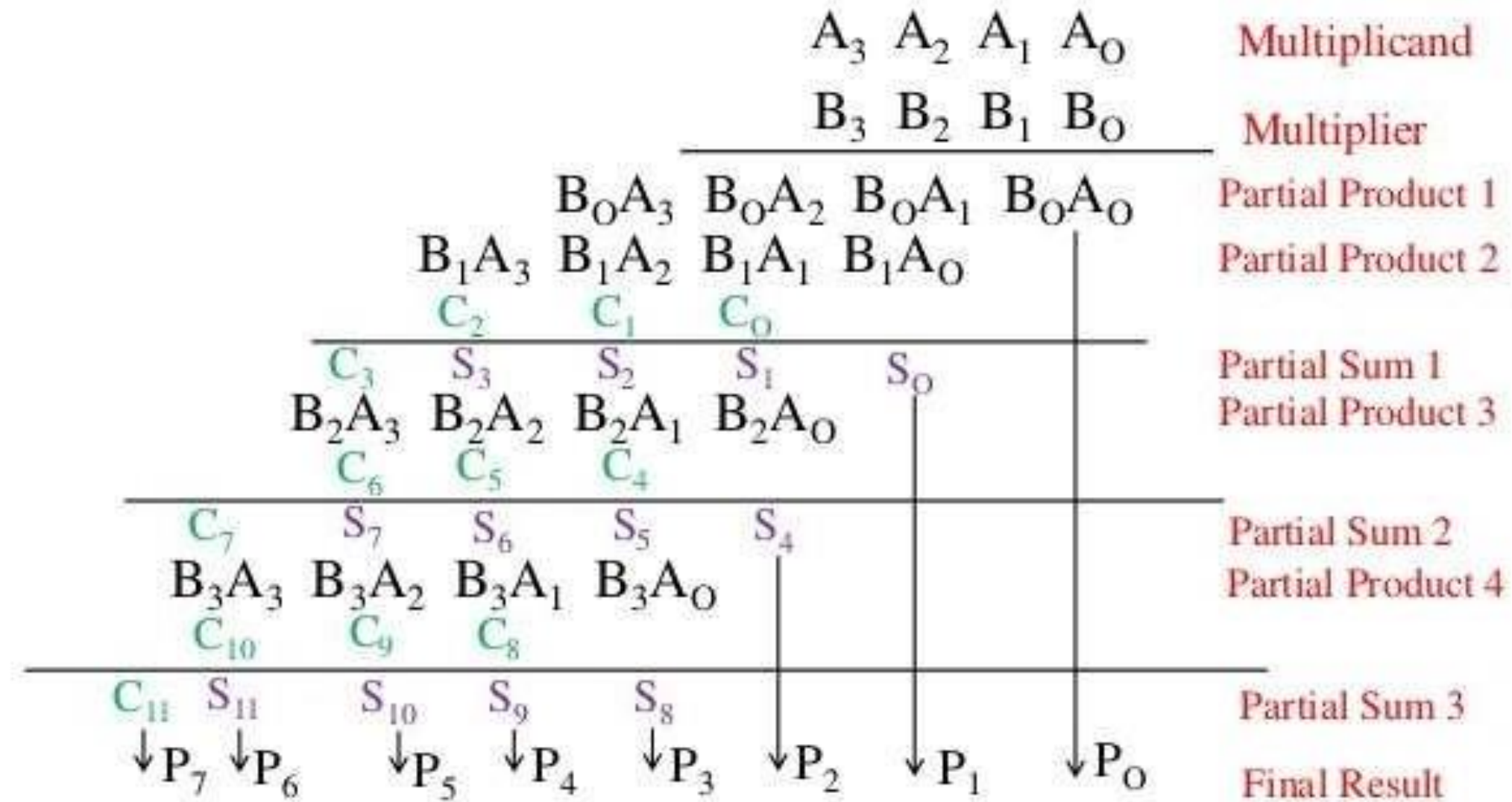




# 4\*4 BIT BINARY MULTIPLIER

## (iii) 4- Bit By 4-Bit Binary Multiplier:

- ❖ It is a combinational circuit. This logic circuit is implemented to perform multiplication of two 4-bit binary numbers  $A = A_3A_2A_1A_0$  and  $B = B_3B_2B_1B_0$





**THANK YOU**