SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECB231 – DIGITAL ELECTRONICS

II YEAR/ III SEMESTER

UNIT 2 – COMBINATIONAL CIRCUITS

TOPIC - BCD ADDER,BINARY MULTIPLIER

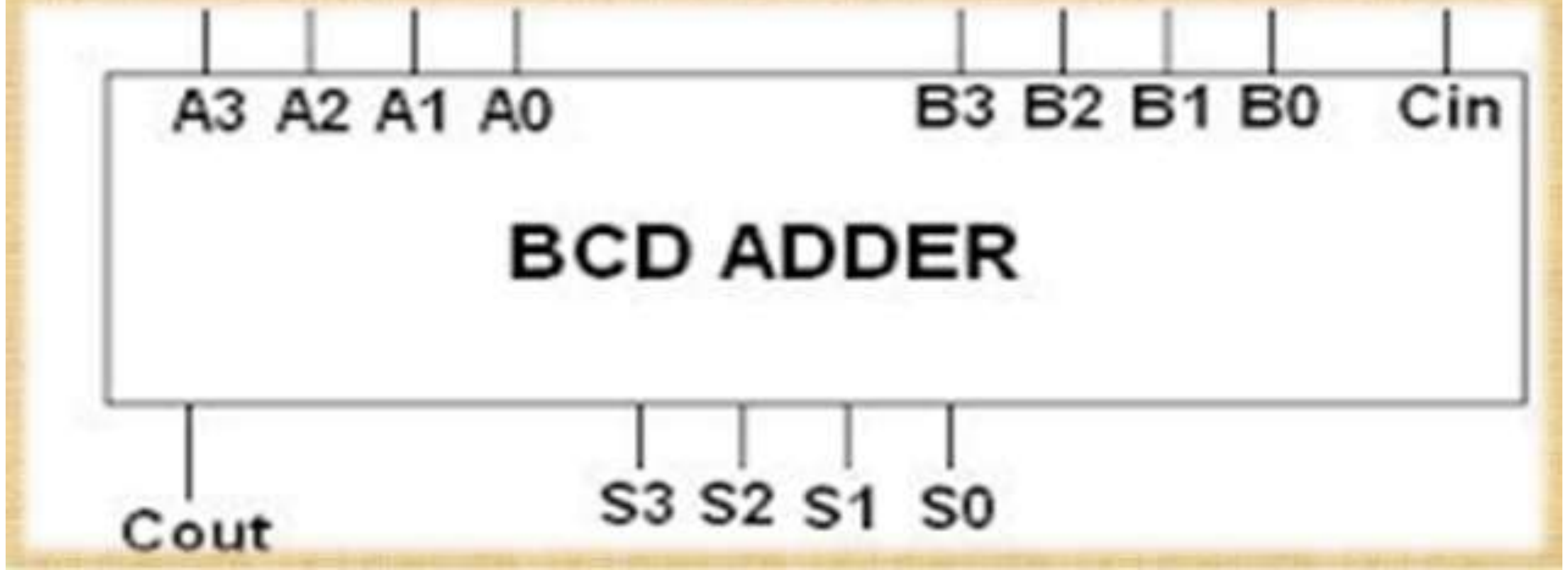
BCD ADDER

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	$\underbrace{1\ \ 0\ \ 1\ \ 1}_{\text{Invalid BCD number}}$

BCD ADDER

Here, it may 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 :

```
              1 0 1 1   ← Invalid BCD answer
            + 0 1 1 0   ← Add (6)10 for correction
      ------------------
      0 0 0 1 0 0 0 1   ← Correct answer
      \_____/ \_____/
         1       1
```

(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   ← Wrong result of addition
                 |  \___/
                 |    └──→ Sum is invalid BCD number
Final carry ←────┘
```

The result of addition is 0001 0001 = $(11)_{10}$ which is not correct. Hence, to correct the wrong result, we have to add six (0110) as shown below:

```
   0 0 0 1     0 0 0 1   ← Incorrect answer
 + 0 0 0 0     0 1 1 0   ← Add 6 for correction
 ---------     -------
   0 0 0 1     0 1 1 1   ← Correct BCD answer
   \_____/     \_____/
      1           7
```

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

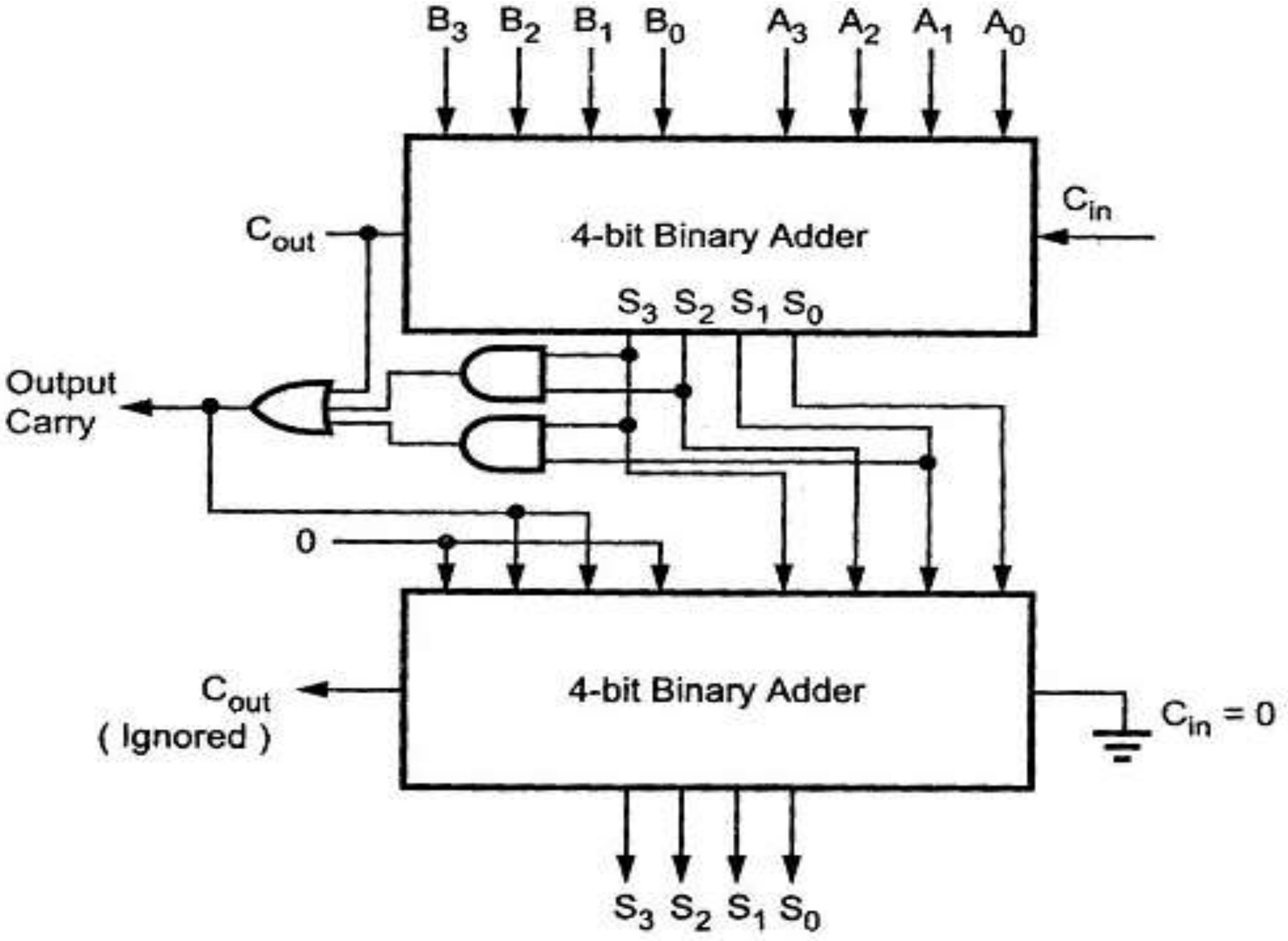
K-map:

$S_3S_2 \backslash S_1S_0$	00	01	11	10	
00	0	0	0	0	
01	0	0	0	0	
11	1	1	1	1	S_3S_2
10	0	0	1	1	S_3S_1

The Boolean expression is

$Y = S_3S_2 + S_3S_1$

BCD ADDER



B3 B2 B1 B0 A3 A2 A1 A0
4-bit Binary Adder
Cout
Cin
S3 S2 S1 S0
Output
Carry
0
4-bit Binary Adder
Cout
(Ignored)
Cin = 0
S3 S2 S1 S0

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 ≤ 9 but carry = 1

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

Therefore, $B_3\ B_2\ B_1\ B_0 = 0\ 1\ 1\ 0$ (of adder-2)

Hence, 0 1 1 0 will be added to the sum output of adder-1. We get the corrected BCD result at the output of adder-2. Th

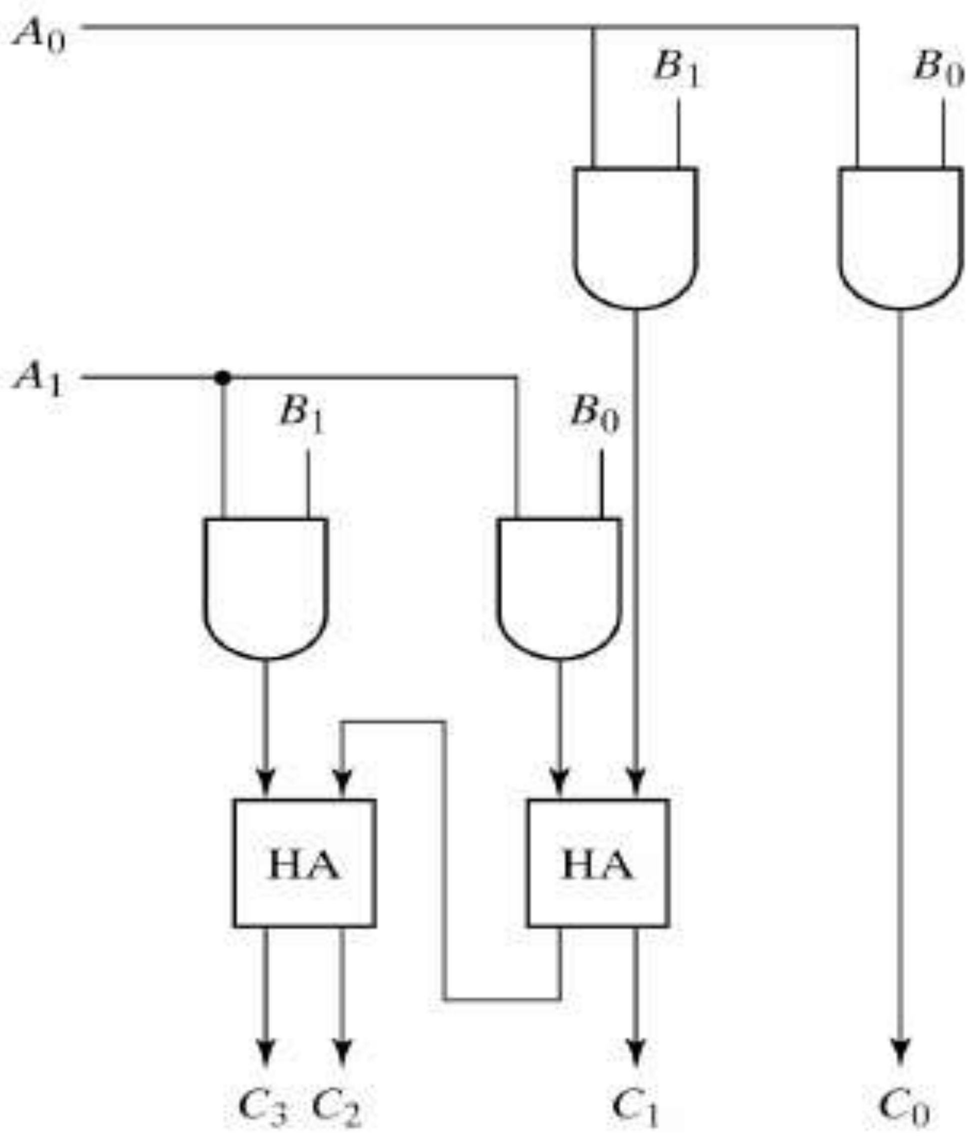
carried out using the binary adder.

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_0
		A_0B_1	A_0B_0
	A_1B_1	A_1B_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 $A = A_3A_2A_1A_O$ and $B = B_3B_2B_1B_O$

$A_3\ \ A_2\ \ A_1\ \ A_O$	Multiplicand
$B_3\ \ B_2\ \ B_1\ \ B_O$	Multiplier
$B_OA_3\ \ B_OA_2\ \ B_OA_1\ \ B_OA_O$	Partial Product 1
$B_1A_3\ \ B_1A_2\ \ B_1A_1\ \ B_1A_O$	Partial Product 2
$C_2\ \ C_1\ \ C_O$	
$C_3\ \ S_3\ \ S_2\ \ S_1\ \ S_O$	Partial Sum 1
$B_2A_3\ \ B_2A_2\ \ B_2A_1\ \ B_2A_O$	Partial Product 3
$C_6\ \ C_5\ \ C_4$	
$C_7\ \ S_7\ \ S_6\ \ S_5\ \ S_4$	Partial Sum 2
$B_3A_3\ \ B_3A_2\ \ B_3A_1\ \ B_3A_O$	Partial Product 4
$C_{10}\ \ C_9\ \ C_8$	
$C_{11}\ \ S_{11}\ \ S_{10}\ \ S_9\ \ S_8$	Partial Sum 3
$\downarrow P_7\ \ \downarrow P_6\ \ \downarrow P_5\ \ \downarrow P_4\ \ \downarrow P_3\ \ \downarrow P_2\ \ \downarrow P_1\ \ \downarrow P_O$	Final Result

THANK YOU