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 - 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.
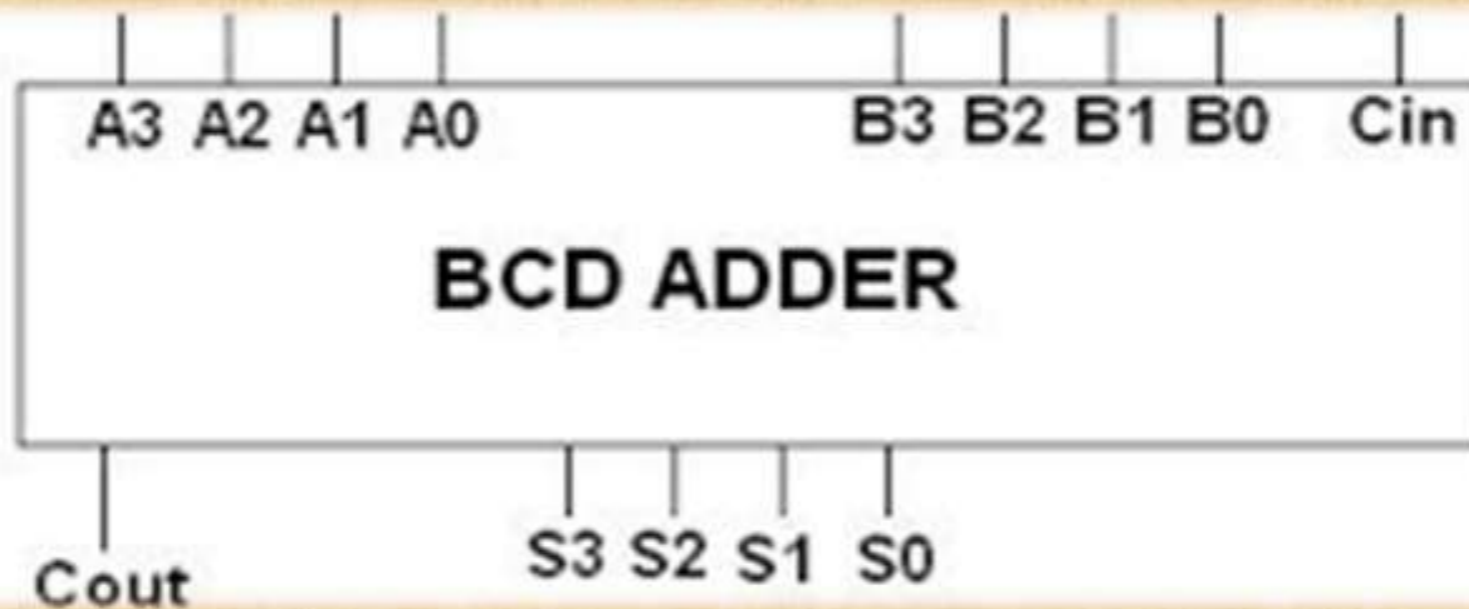
BCD ADDER

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 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
```
$$\text{Add } (6)_{10} \text{ for correction}$$

(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

Final carry ←

Sum is invalid BCD number →

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.

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.
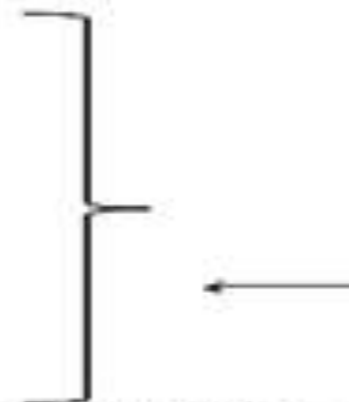
WHY BCD IS CALLED 8421 CODE?

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.

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

K-map:

The Boolean expression is

$$Y = S_3 S_2 + S_3 S_1$$

BCD ADDER

BCD ADDER,BINARY MULTIPLIER /19ECB231/ Digital Electronics / K.SURIYA,AP/ECE/SNSCT
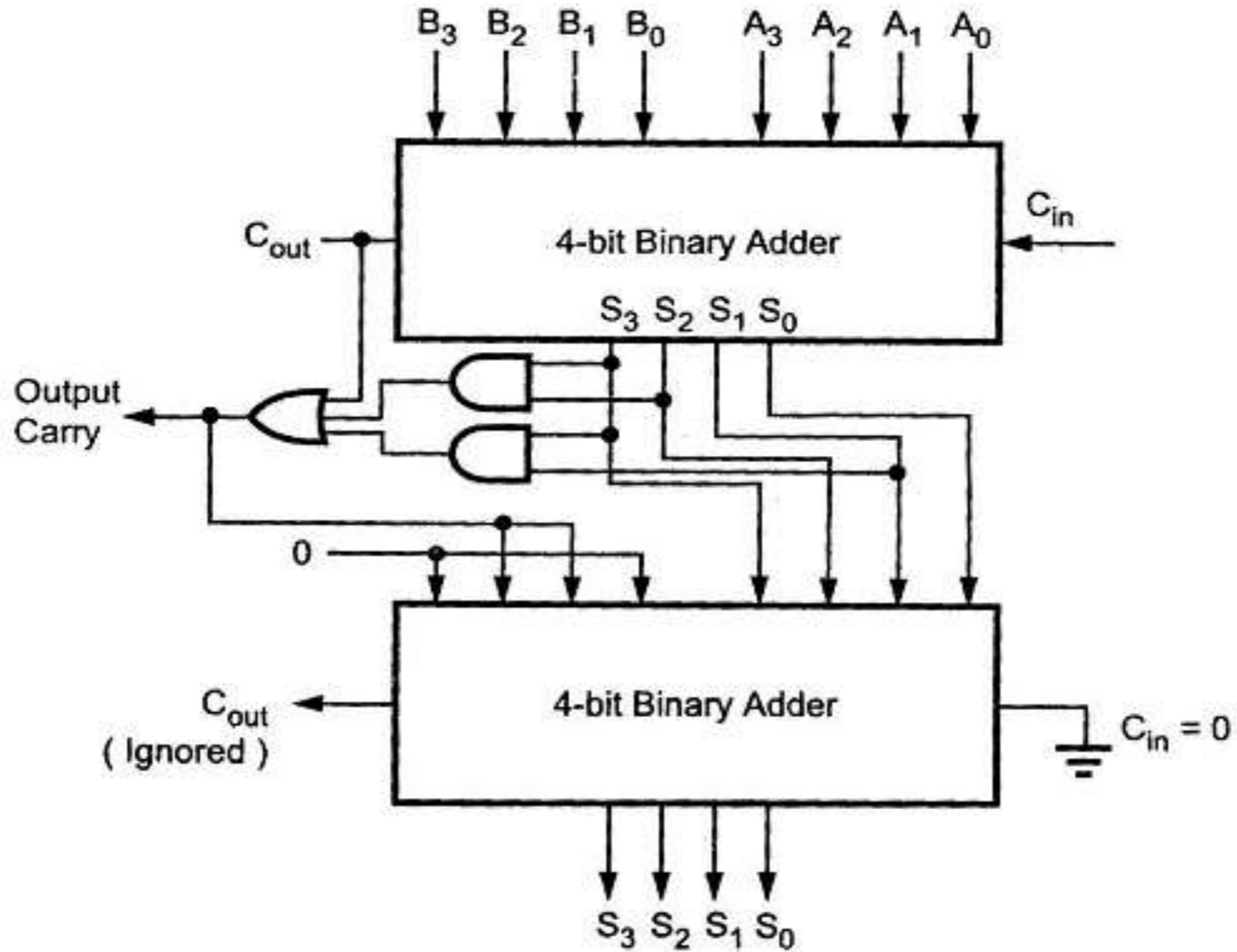
Case II: Sum > 9 and carry = 0

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.
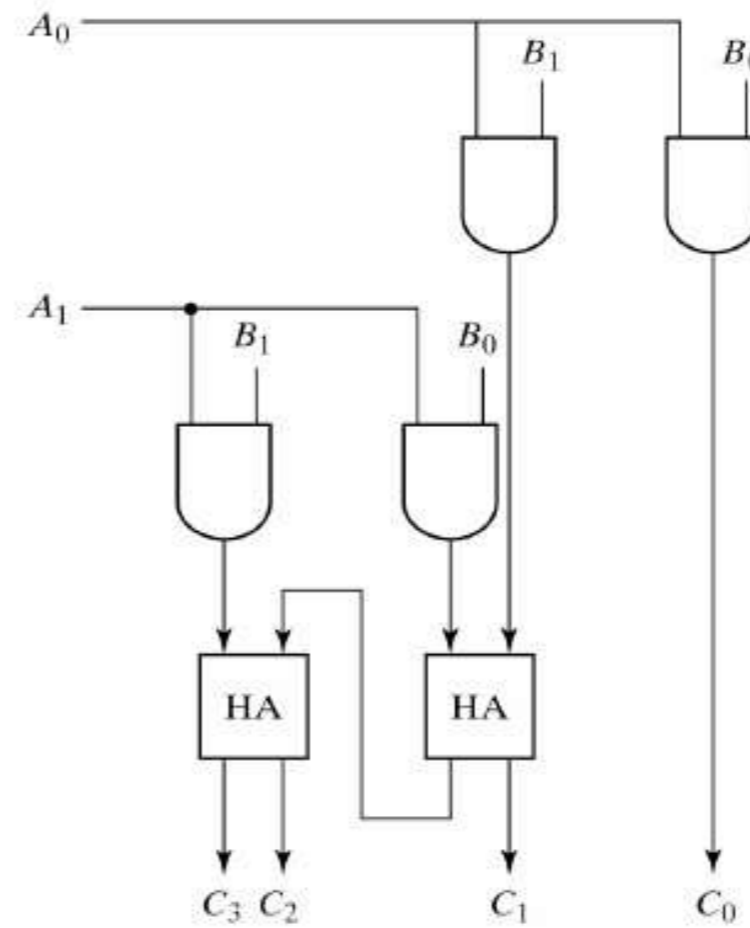
WHAT IS BINARY MULTIPLIER?

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

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 $B = B_3B_2B_1B_0$

					A_3	A_2	A_1	A_0	Multiplicand
					B_3	B_2	B_1	B_0	Multiplier
			B_0A_3	B_0A_2	B_0A_1	B_0A_0			Partial Product 1
		B_1A_3	B_1A_2	B_1A_1	B_1A_0				Partial Product 2
	C_2		C_1		C_0				
	C_3	S_3	S_2	S_1	S_0				Partial Sum 1
B_2A_3	B_2A_2	B_2A_1	B_2A_0						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_0						Partial Product 4
C_{10}	C_9	C_8							
C_{11} S_{11}	S_{10}	S_9	S_8						Partial Sum 3
$\downarrow P_7$ $\downarrow P_6$	$\downarrow P_5$	$\downarrow P_4$	$\downarrow P_3$	$\downarrow P_2$	$\downarrow P_1$	$\downarrow P_0$			Final Result

THANK YOU

BCD ADDER,BINARY MULTIPLIER /19ECB231/ Digital Electronics / K.SURIYA,AP/ECE/SNSCT