

Combinational Circuits

- Combinational circuit is a circuit in which we combine the different gates in the circuit, for example encoder, decoder, multiplexer and demultiplexer.
- Some of the characteristics of combinational circuits are following –
- The output of combinational circuit at any instant of time, depends only on the levels present at input terminals.

Adders

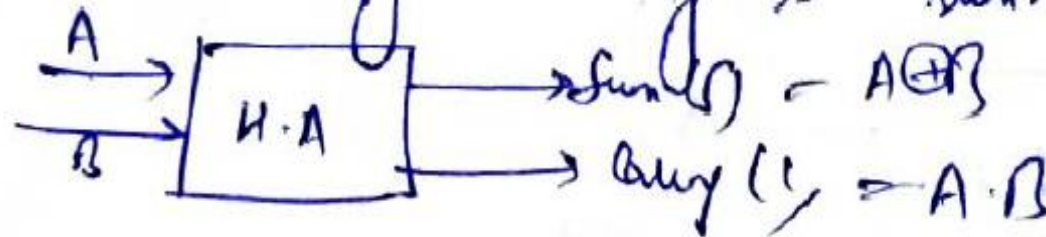
- Addition of binary bits is the most basic operation.

Types of Binary Adders

(i) Half Adder :- Half adder is a combinational logic circuit with two inputs & two outputs.

It is the basic building block for addition of two single bit numbers.

This circuit has two outputs namely carry & sum.



table

Truth Table

Input		Output	
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Since A & B are two inputs so two variables K-map.

A	B	
	\bar{B}	B
0 \bar{A}	0 ₀	1 ₁
1 A	1 ₂	0 ₃

Sum $\rightarrow 1 \rightarrow (1, 2)$

$\bar{A}B$

$$S = AB + A\bar{B} = A \oplus B$$

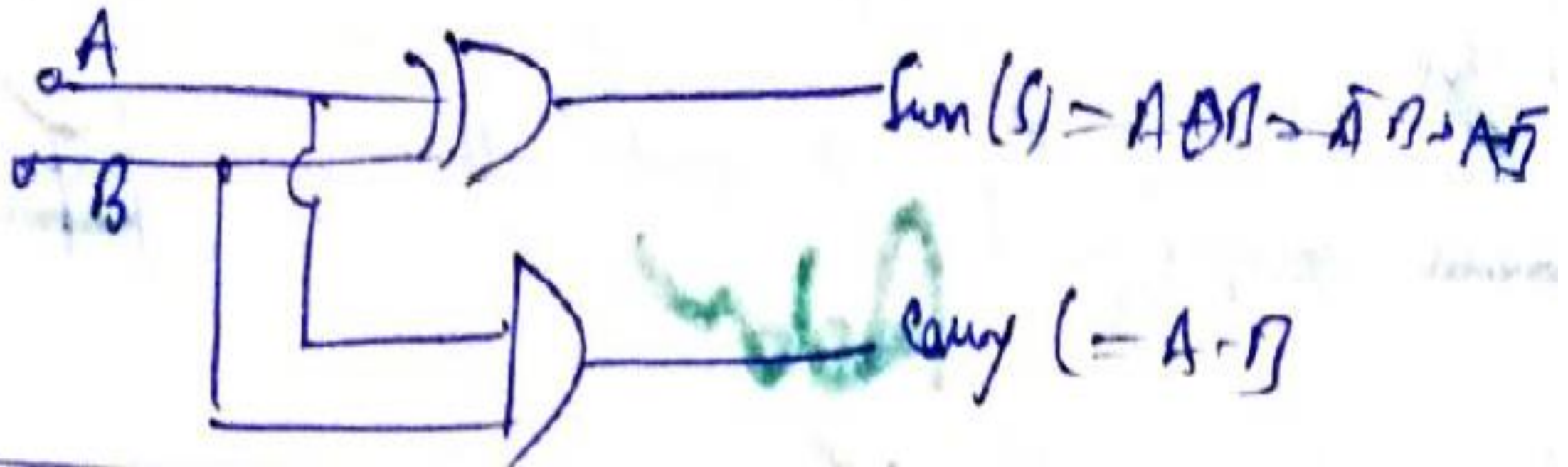
A	B	
	\bar{B}	B
0 \bar{A}	0 ₀	0 ₁
1 A	0 ₂	1 ₃

$A \cdot B$

$$C = A \cdot B$$

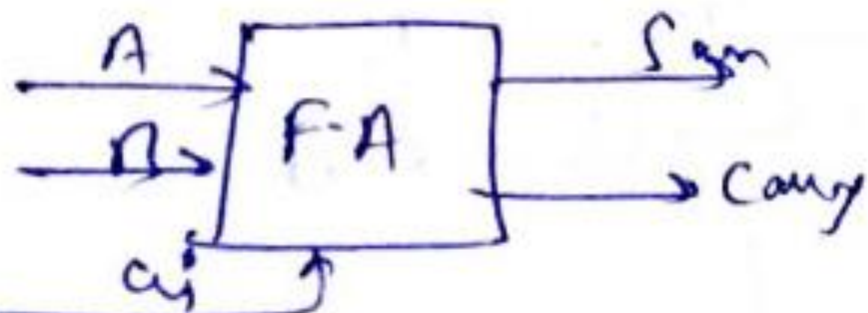
Diagram

$$S = \bar{A}B + A\bar{B} = A \oplus B$$



Full Adder

- (1) Full adder is a 3 single bit adder circuit.
(2) It can add two one bit no. A & B & carry in.
The full adder is a three input two output combinational CK.



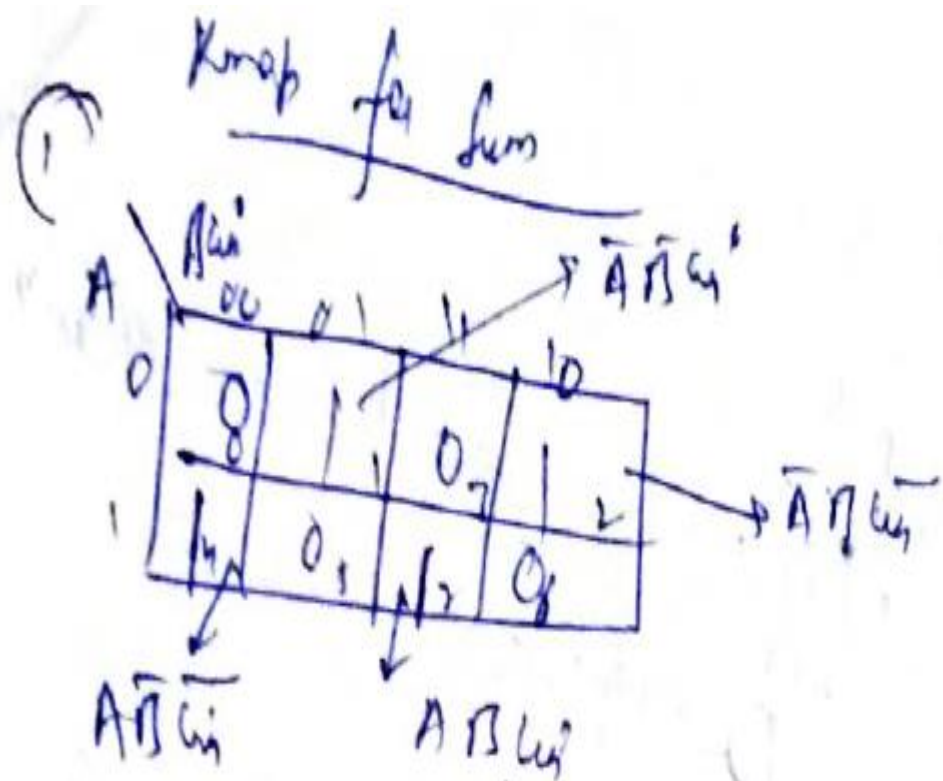
Three

Truth table

Truth
table

	A	B	$\neg A$	S	C
0	0	0	0	0	0
1	0	0	1	1	0
2	0	1	0	1	0
3	0	1	1	0	1
4	1	0	0	1	0
5	1	0	0	0	1
6	1	1	0	0	1
7	1	1	1	1	1

Kmap



$$S = \overline{A}\overline{B}C + \overline{A}B\overline{C} + A\overline{B}C + A\overline{B}\overline{C}$$

$$S = C(\overline{A}\overline{B} + A\overline{B}) + \overline{C}(\overline{A}B + AB)$$

$$S = C(\overline{A} + A)\overline{B} + C(A + \overline{A})B$$

$$S = C(\overline{A} + A)\overline{B} + C(A + \overline{A})B$$

{ Sum = Carry }

$$S = C\overline{X} + C X$$

$$S = C \oplus X \Rightarrow C \oplus (A \oplus B)$$

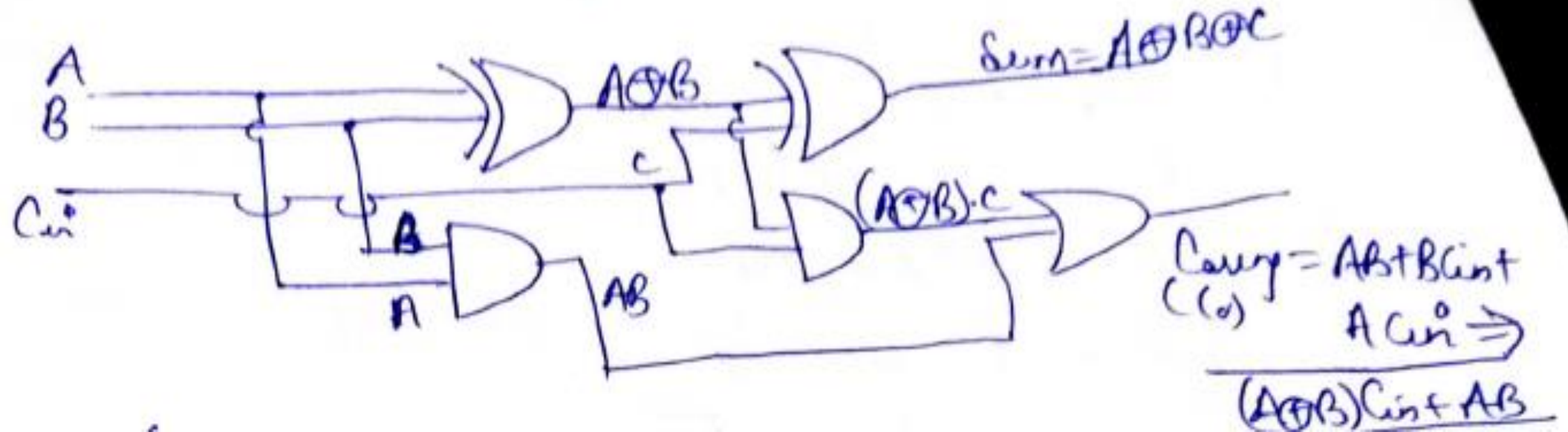
C_i

A	00	01	11	10
0	0	0	1	0
1	0	1	1	1

$$C_i = AB + AC_i + BC_i$$

Full adders using half adders

Full adder using half adder



Carry calculations

$$C_0 = (A \oplus B)C_{in} + AB$$

$$\Rightarrow \bar{A}BC_{in} + A\bar{B}C_{in} + AB(1 + C_{in})$$

$$\Rightarrow \bar{A}BC_{in} + A\bar{B}C_{in} + AB + AB C_{in}$$

$$\Rightarrow \bar{A}BC_{in} + A\bar{B}C_{in} + A\bar{B}C_{in} + AB$$

$$\Rightarrow BC_{in}(\bar{A} + A) + A\bar{B}C_{in} + AB$$

$$\Rightarrow BC_{in} + A\bar{B}C_{in} + AB(1 + C_{in})$$

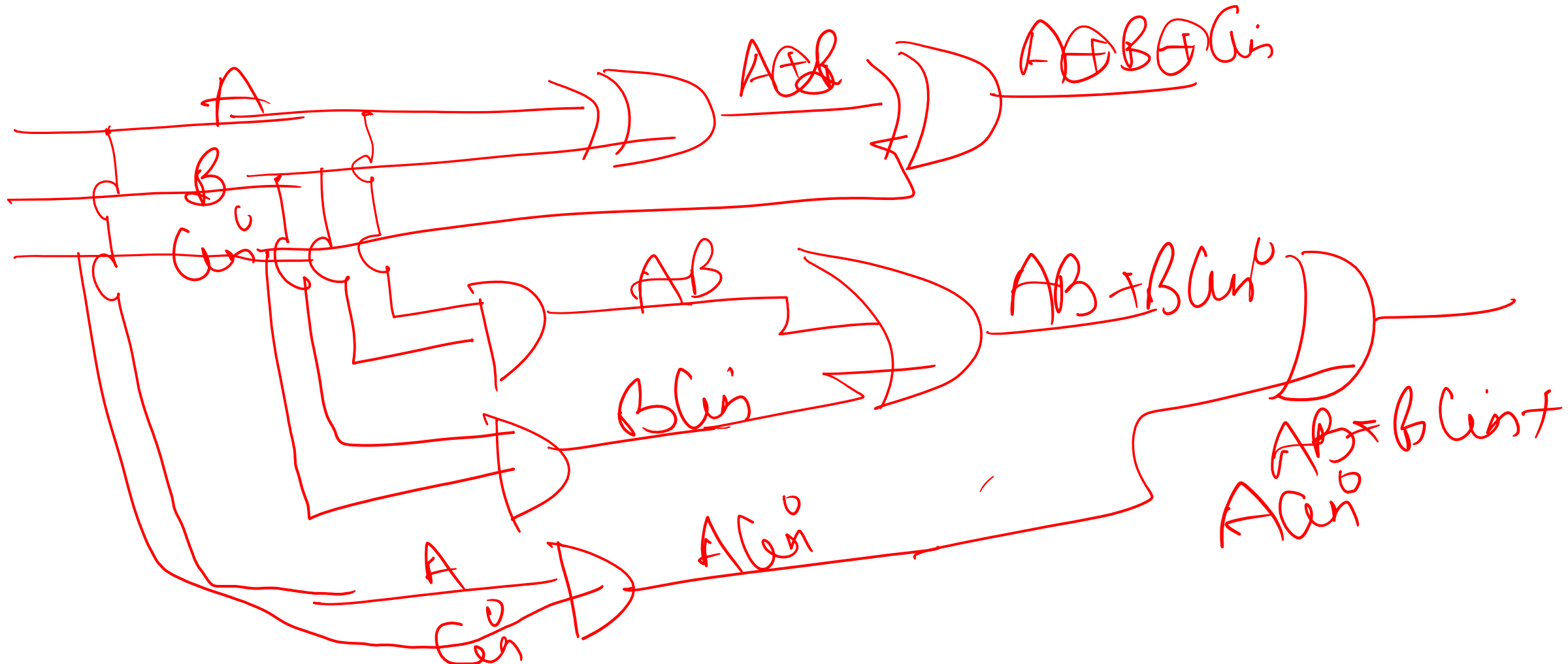
$$\Rightarrow BC_{in} + A\bar{B}C_{in} + AB + \overbrace{AB C_{in}}^{A\bar{B}C_{in}}$$

$$\Rightarrow BC_{in} + AB + AC_{in}(B + \bar{B})$$

$$\boxed{\text{Carry} \Rightarrow AB + BC_{in} + AC_{in}}$$

$$\text{Sum} \rightarrow A \oplus B \oplus C_{in}$$

$$\text{Carry} \rightarrow AB + BC_{in} + AC_{in}$$



Poll

2. Total number of inputs in a half adder is _____

a) 2

b) 3

c) 4

d) 1

Solutions

2. Total number of inputs in a half adder is _____

- a) 2
- b) 3
- c) 4
- d) 1

 View Answer

Answer: a

Explanation: Total number of inputs in a half adder is two. Since an EXOR gates has 2 inputs and carry is connected with the input of EXOR gates. The output of half-adder is also 2, them being, SUM and CARRY. The output of EXOR gives SUM and that of AND gives carry.

Poll

4. If A and B are the inputs of a half adder, the sum is given by _____

a) A AND B

b) A OR B

c) A XOR B

d) A EX-NOR B

4. If A and B are the inputs of a half adder, the sum is given by _____

- a) A AND B
- b) A OR B
- c) A XOR B
- d) A EX-NOR B

 View Answer

Answer: c

Explanation: If A and B are the inputs of a half adder, the sum is given by A XOR B, while the carry is given by A AND B.

Poll

5. If A and B are the inputs of a half adder, the carry is given by _____
- a) A AND B
 - b) A OR B
 - c) A XOR B
 - d) A EX-NOR B

5. If A and B are the inputs of a half adder, the carry is given by _____

- a) A AND B
- b) A OR B
- c) A XOR B
- d) A EX-NOR B

 View Answer

Answer: a

Explanation: If A and B are the inputs of a half adder, the carry is given by: $A(AND)B$, while the sum is given by $A XOR B$.

POII

7. The difference between half adder and full adder is _____
- a) Half adder has two inputs while full adder has four inputs
 - b) Half adder has one output while full adder has two outputs
 - c) Half adder has two inputs while full adder has three inputs
 - d) All of the Mentioned

Solutions

7. The difference between half adder and full adder is _____

- a) Half adder has two inputs while full adder has four inputs
- b) Half adder has one output while full adder has two outputs
- c) Half adder has two inputs while full adder has three inputs
- d) All of the Mentioned

^ View Answer

Answer: c

Explanation: Half adder has two inputs while full adder has three outputs; this is the difference between them, while both have two outputs SUM and CARRY.

Binary Subtractor

- Half subtractor is a combinational circuit with two inputs and two output.

② It produces the diff b/w two binary bits
③ For subtraction $(A-B)$; A is called minuend bit &
 B is called as subtrahend bit.

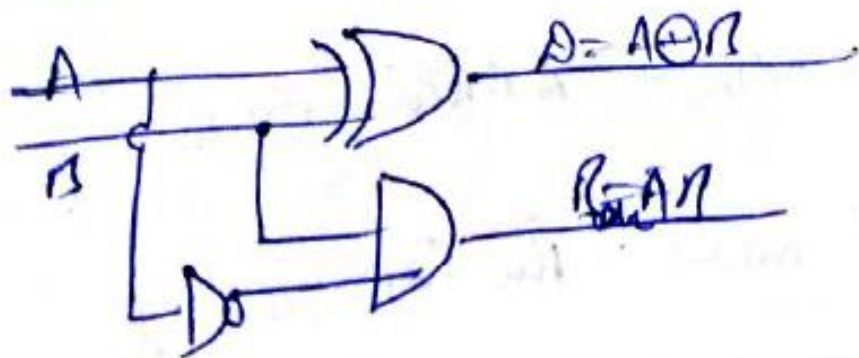
	A	B	sy A B	Рано R0
0	0	0	0	0
1	0	1	1	1
2	1	0	1	0
3	1	1	0	0

A \ B	0	1
0	0 ₀	1 ₁
1	1 ₂	0 ₃

$$D = A \oplus B$$

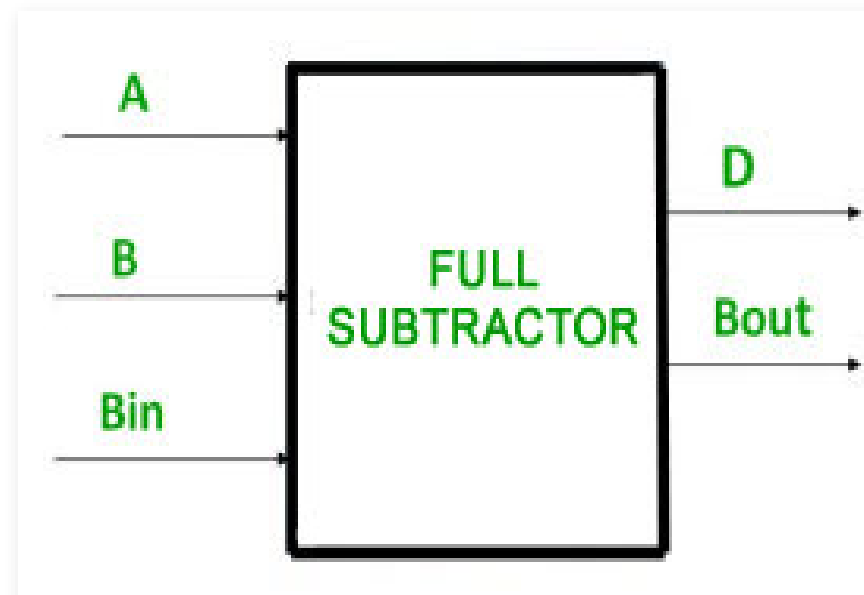
A \ R0	0	1
0	0	1
1	1	0

$$\bar{A} B$$



Full Subtractor

A full subtractor is a **combinational circuit** that performs subtraction of two bits, one is minuend and other is subtrahend, taking into account borrow of the previous adjacent lower minuend bit. This circuit **has three inputs and two outputs**. The three inputs A, B and Bin, denote the minuend, subtrahend, and previous borrow, respectively. The two outputs, D and Bout represent the difference and output borrow, respectively.



Truth Table

From above table we can draw the K-Map as shown for "difference" and "borrow".

INPUT			OUTPUT	
A	B	Bin	D	Bout
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

		B Bin			
		00	01	11	10
A	0	0	1	0	1
	1	1	0	1	0

$$D = A'B'Bin + AB'Bin' + A'BBin' + ABBin$$

Logical expression for difference -

$$\begin{aligned} D &= A'B'Bin + A'BBin' + AB'Bin' + ABBin \\ &= Bin(A'B' + AB) + Bin'(AB' + A'B) \\ &= Bin(A \text{ XNOR } B) + Bin'(A \text{ XOR } B) \\ &= Bin(A \text{ XOR } B)' + Bin'(A \text{ XOR } B) \\ &= Bin \text{ XOR } (A \text{ XOR } B) \\ &= (A \text{ XOR } B) \text{ XOR } Bin \end{aligned}$$

INPUT			OUTPUT	
A	B	Bin	D	Bout
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

A	B Bin			
	00	01	11	10
0	0	1	1	1
1	0	0	1	0

$$Bout = A'Bin + A'B + BBin$$

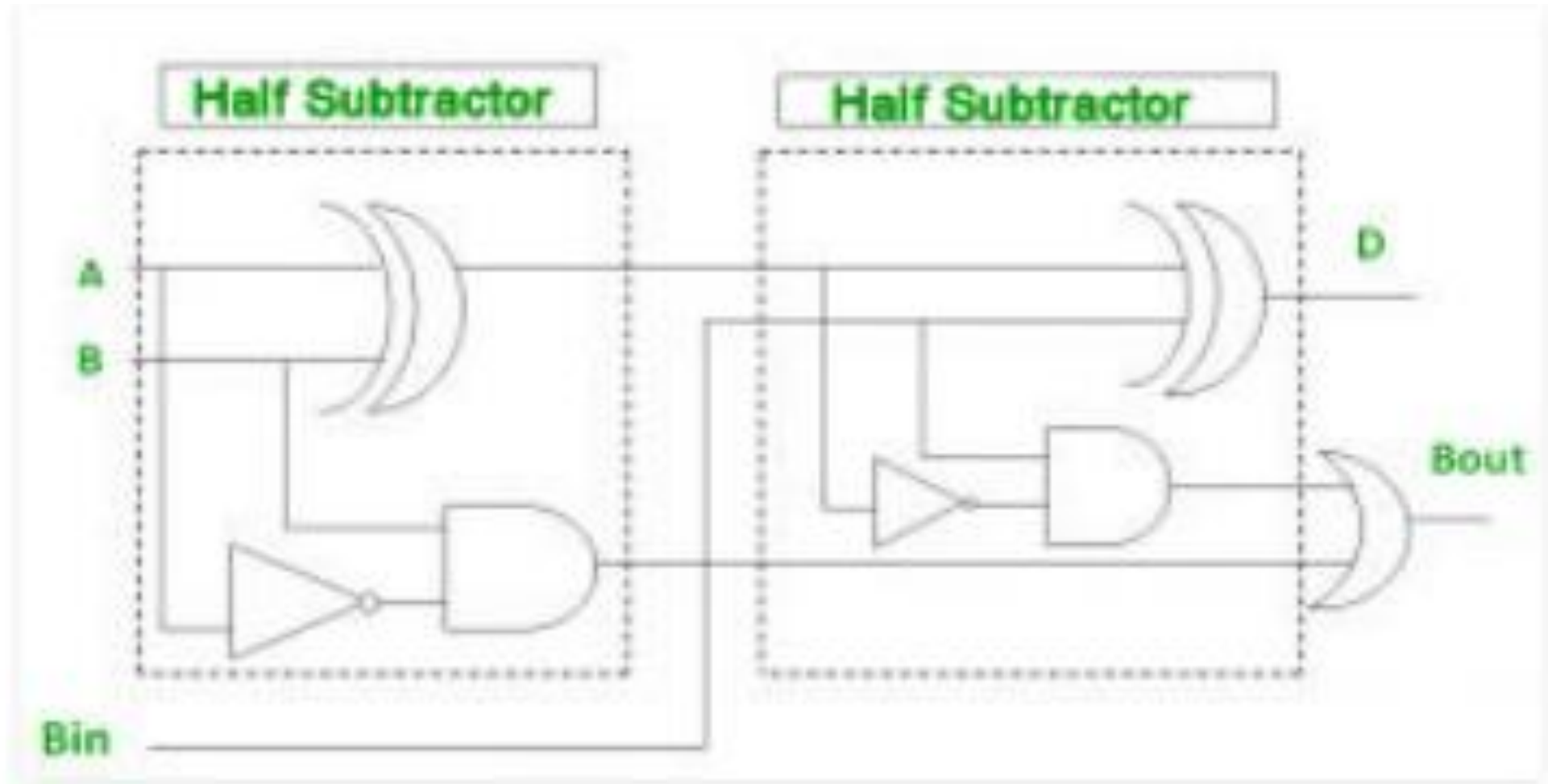
Logical expression for borrow -

$$\begin{aligned}B_{out} &= A'B'B_{in} + A'BB_{in}' + A'BB_{in} + ABB_{in} \\&= A'B'B_{in} + A'BB_{in}' + A'BB_{in} + A'BB_{in} + A'BB_{in} + ABB_{in} \\&= A'B_{in}(B + B') + A'B(B_{in} + B_{in}') + BB_{in}(A + A') \\&= A'B_{in} + A'B + BB_{in}\end{aligned}$$

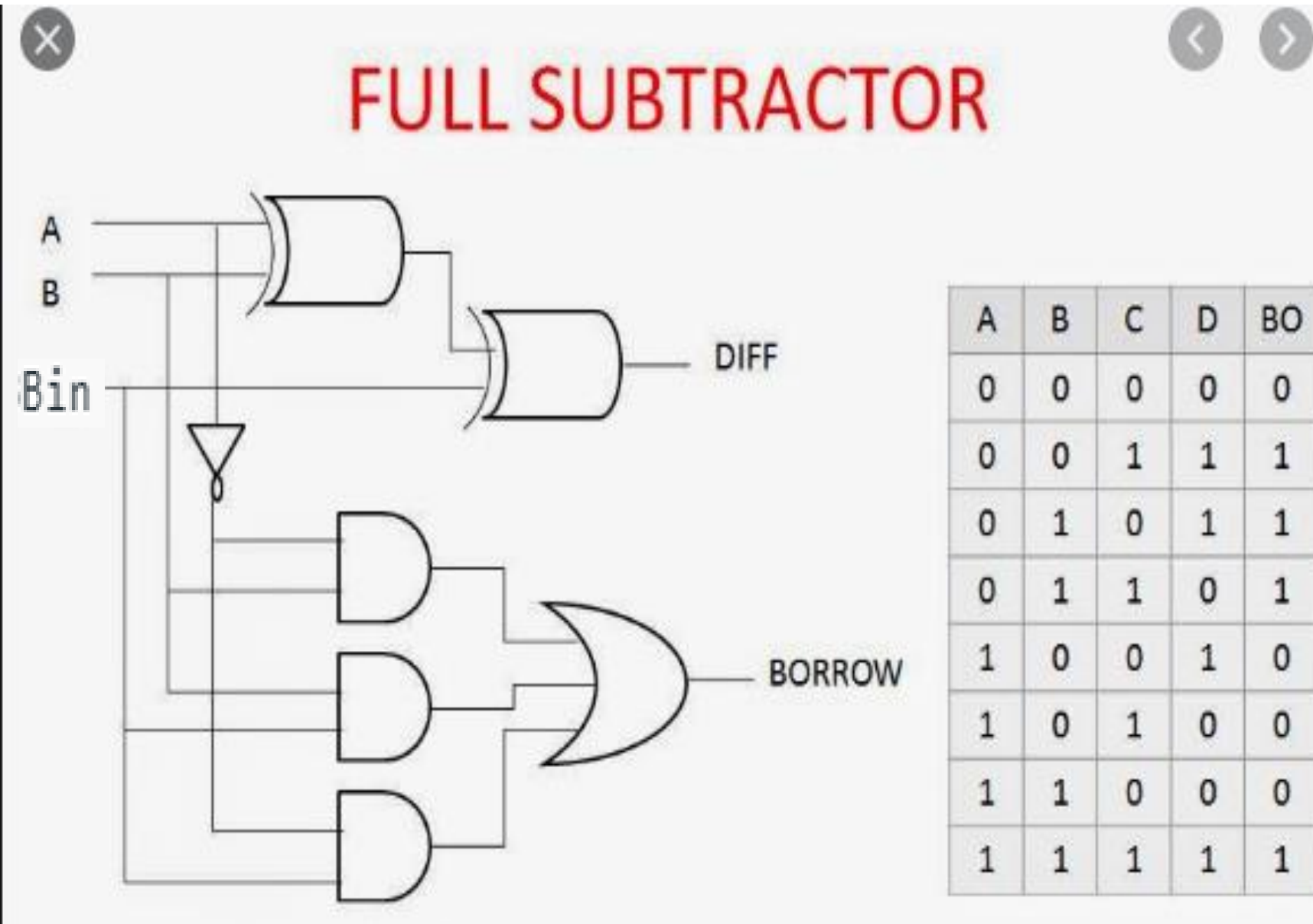
OR

$$\begin{aligned}B_{out} &= A'B'B_{in} + A'BB_{in}' + A'BB_{in} + ABB_{in} \\&= B_{in}(AB + A'B') + A'B(B_{in} + B_{in}') \\&= B_{in}(A \text{ XNOR } B) + A'B \\&= B_{in} (A \text{ XOR } B)' + A'B\end{aligned}$$

Diagram-Full Subtractor using Half Subtractor



Full subtractor using general logic diagram



Poll

1. Half subtractor is used to perform subtraction of _____

- a) 2 bits
- b) 3 bits
- c) 4 bits
- d) 5 bits

1. Half subtractor is used to perform subtraction of _____

- a) 2 bits
- b) 3 bits
- c) 4 bits
- d) 5 bits

 View Answer

Answer: a

Explanation: Half subtractor is a combinational circuit which is used to perform subtraction of two bits, namely minuend and subtrahend and produces two outputs, borrow and difference.

2. For subtracting 1 from 0, we use to take a _____ from neighbouring bits.

- a) Carry
- b) Borrow
- c) Input
- d) Output

2. For subtracting 1 from 0, we use to take a _____ from neighbouring bits.

- a) Carry
- b) Borrow
- c) Input
- d) Output

^ View Answer

Answer: b

Explanation: For subtracting 1 from 0, we use to take a borrow from neighbouring bits because carry is taken into consideration during addition process.

3. How many outputs are required for the implementation of a subtractor?

a) 1

b) 2

c) 3

d) 4

3. How many outputs are required for the implementation of a subtractor?

- a) 1
- b) 2
- c) 3
- d) 4

^ View Answer

Answer: b

Explanation: There are two outputs required for the implementation of a subtractor. One for the difference and another for borrow.

4. Let the input of a subtractor is A and B then what the output will be if $A = B$?

a) 0

b) 1

c) A

d) B

4. Let the input of a subtractor is A and B then what the output will be if $A = B$?

- a) 0
- b) 1
- c) A
- d) B

 View Answer

Answer: a

Explanation: The output for $A = B$ will be 0. If $A = B$, it means that $A = B = 0$ or $A = B = 1$. In both of the situation subtractor gives 0 as the output.