CS & IT ENGINEERING

DIGITAL LOGIC

Combinational Circuit

Lecture No. 8

By- CHANDAN SIR

01 HA

02 FA

03 HS

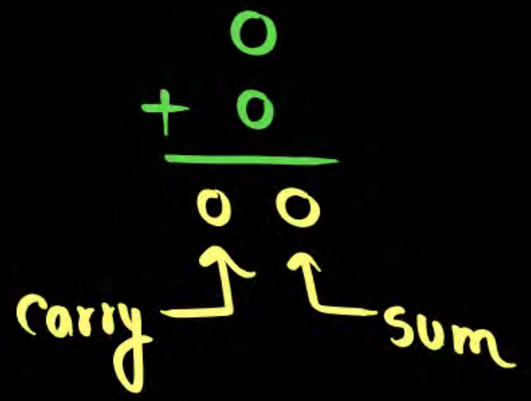
04 FS

05 Discussion

Half Adder

HALF ADDER

0	0	1	1
+0	+1	+0	+1
00	01	01	10



- Two bit adder are known as half adder.

Half Adder

Step 1.

Half Adder

Step 2.

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

$Sum = \bar{A}B + A\bar{B}$

$= A \oplus B$

$Carry = AB$

Half Adder

HALF ADDER

Step 3.

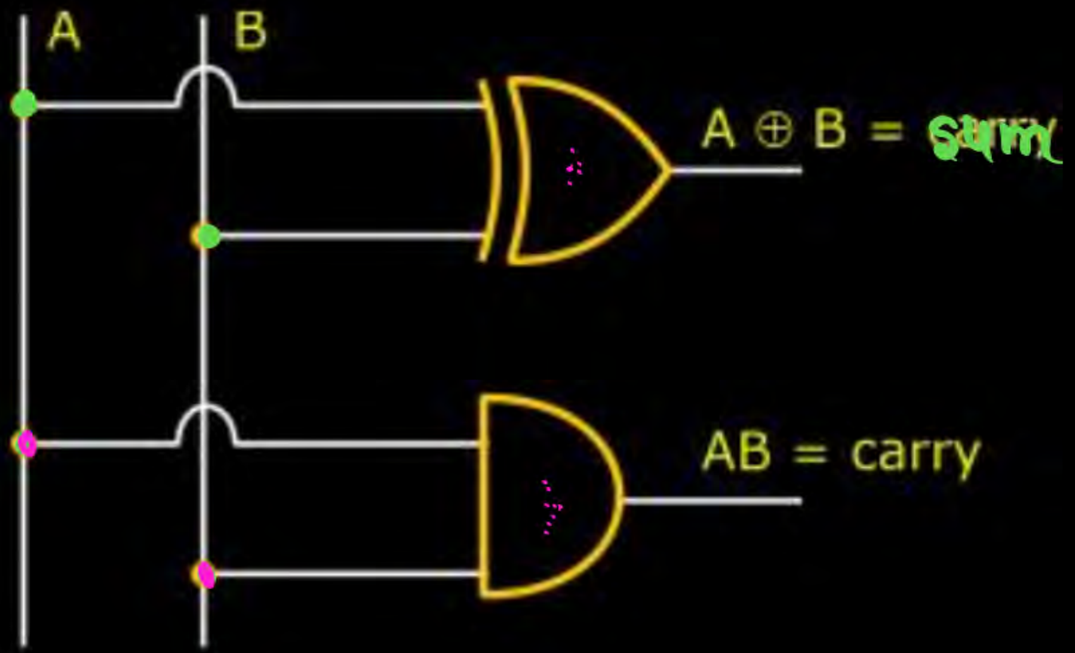
$$\text{sum} = \overline{A}B + A\overline{B} = A \oplus B$$
$$\text{carry} = AB$$

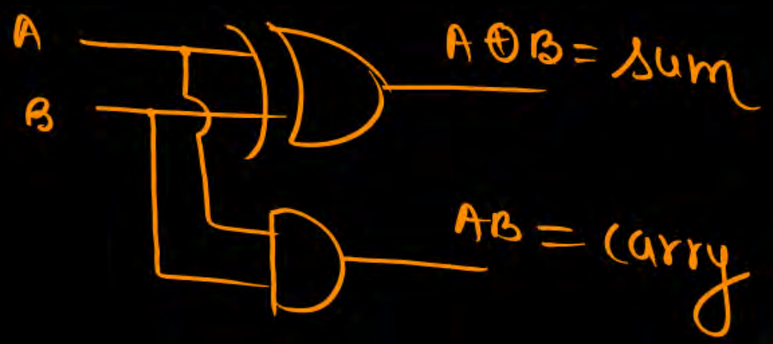
Step 4. Minimization

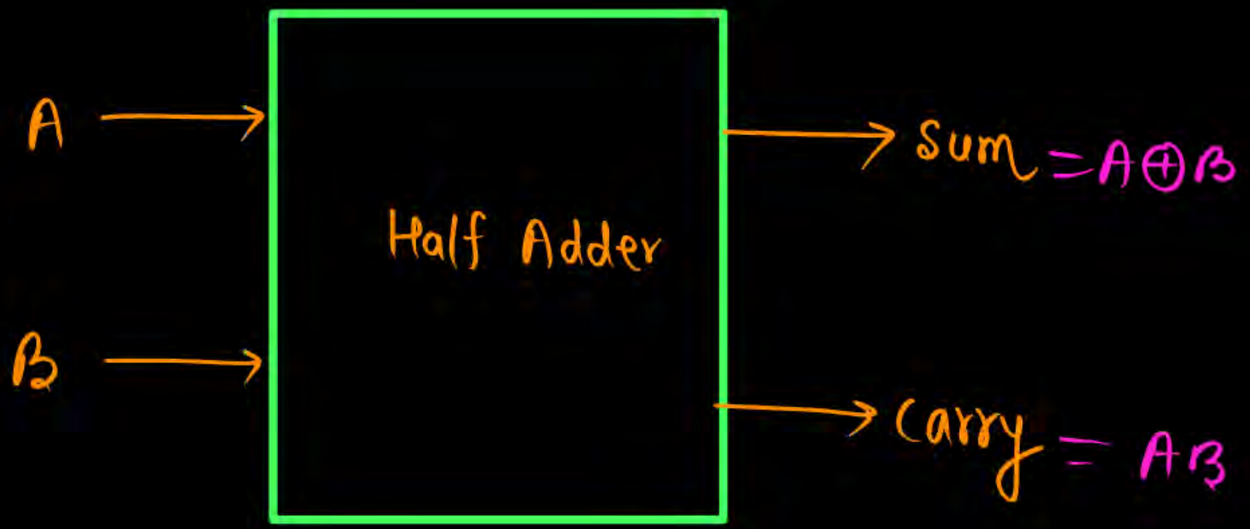
Half Adder

HALF ADDER

Step 5.

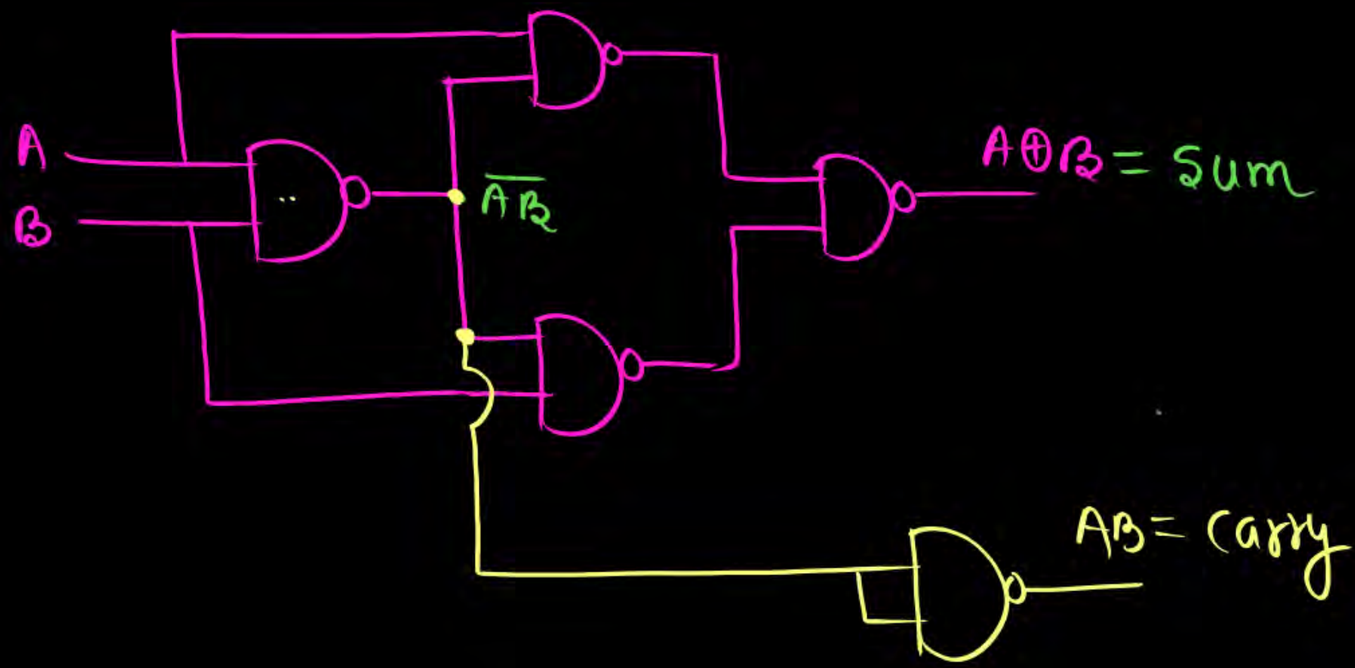





A
B
Half Adder
Sum = A ⊕ B
Carry = AB

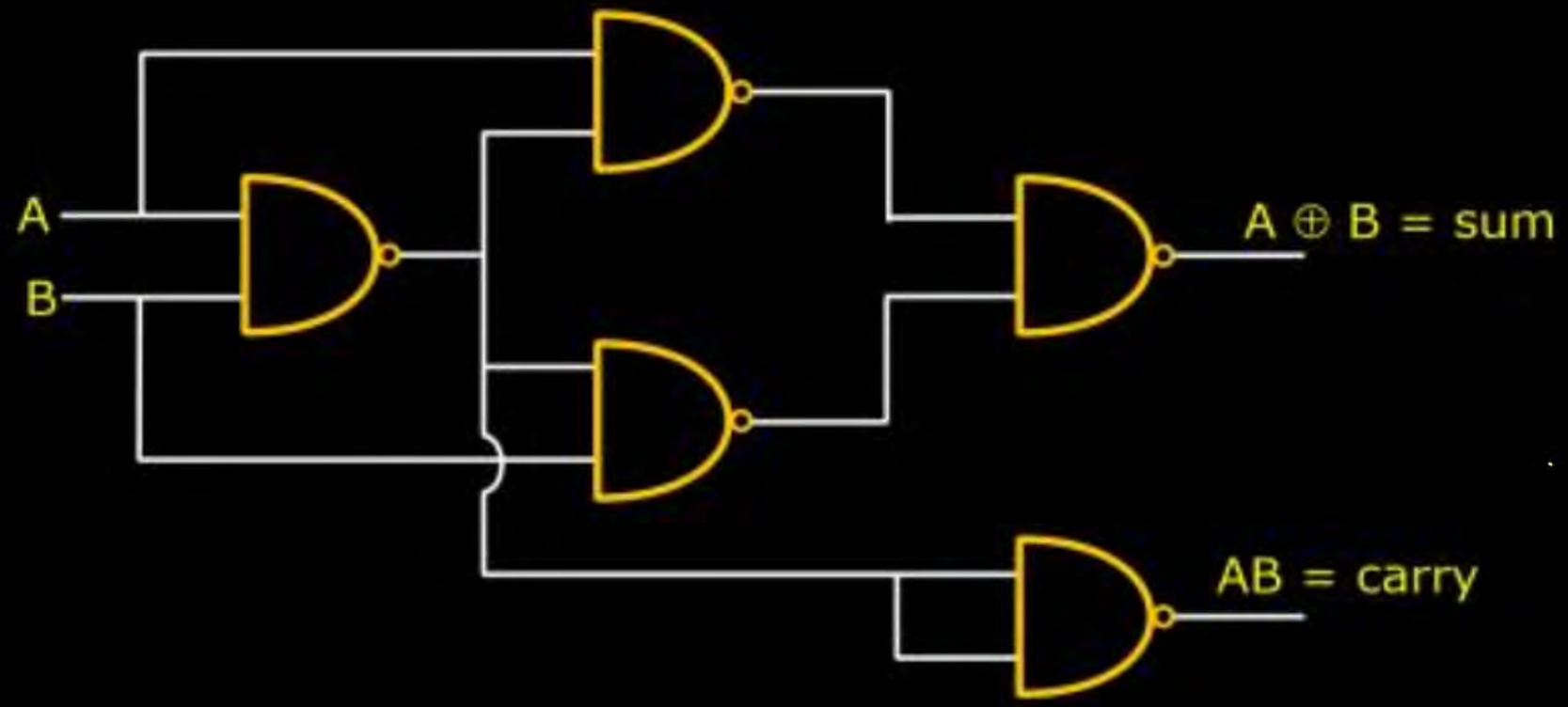
HA

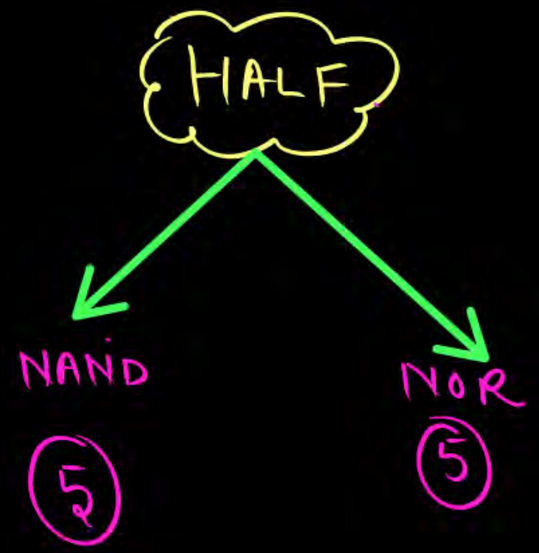
NAND = 5

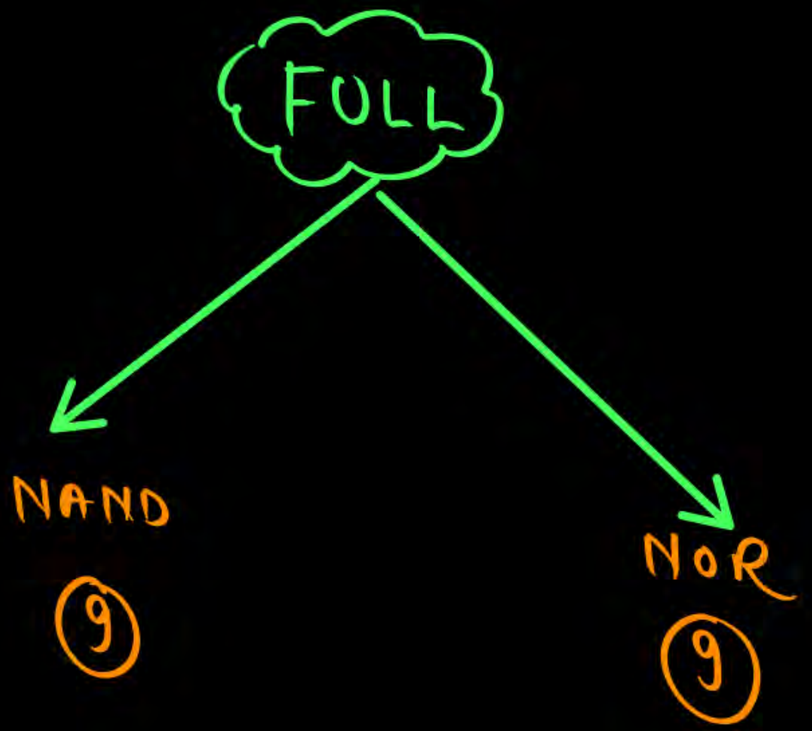


Half Adder

By NAND GATE

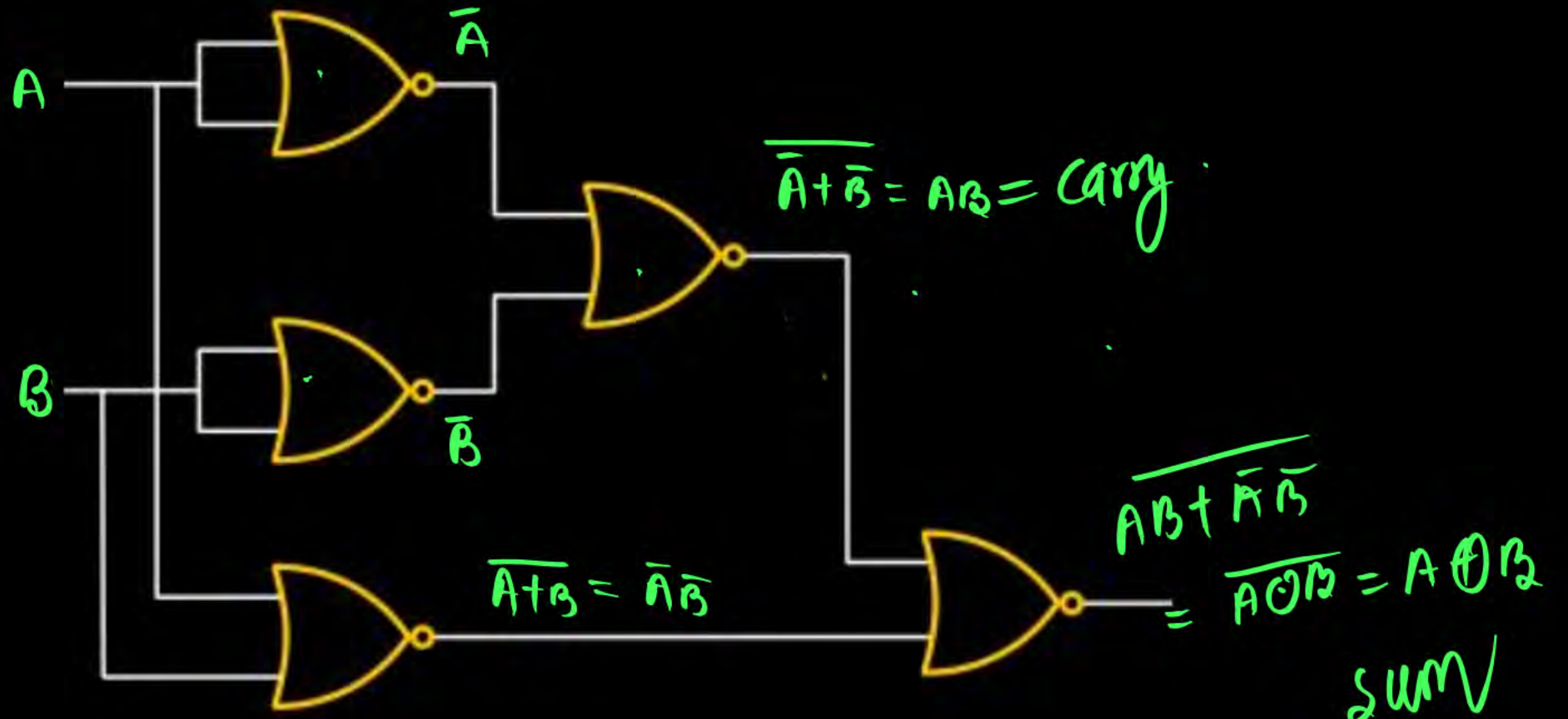



HALF
NAND
5
NOR
5

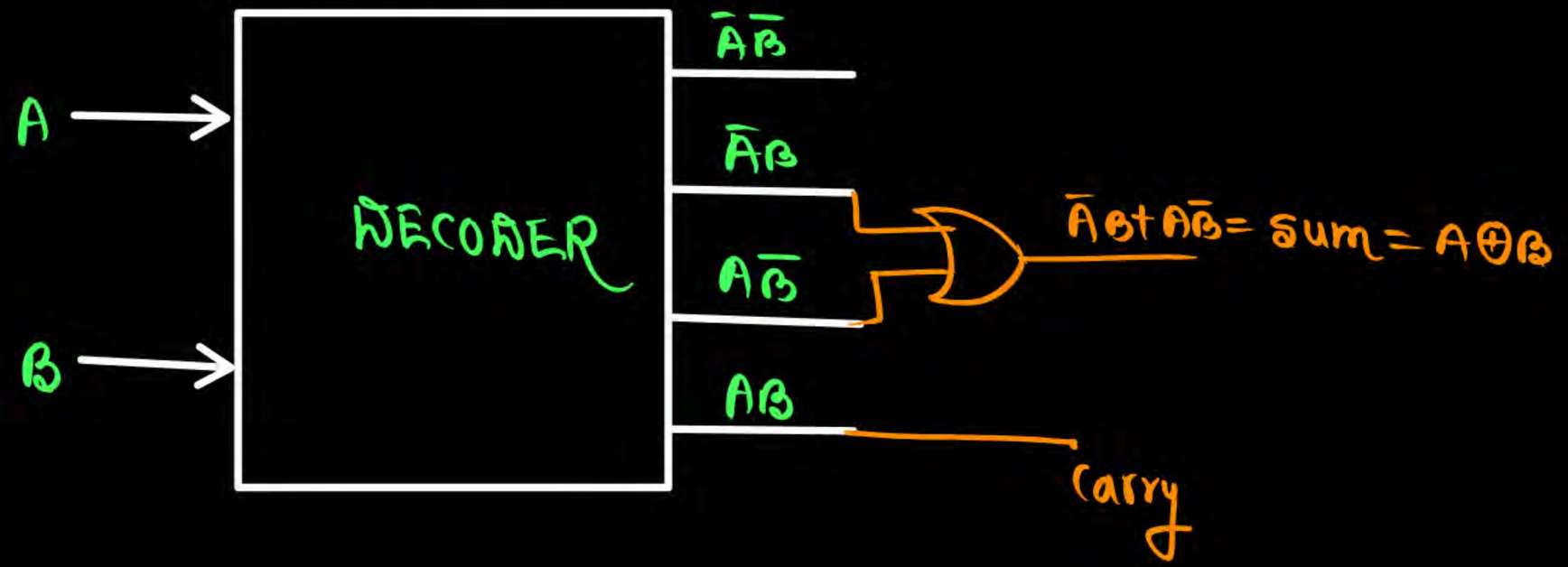

FULL
NAND
9
NOR
9

Half Adder

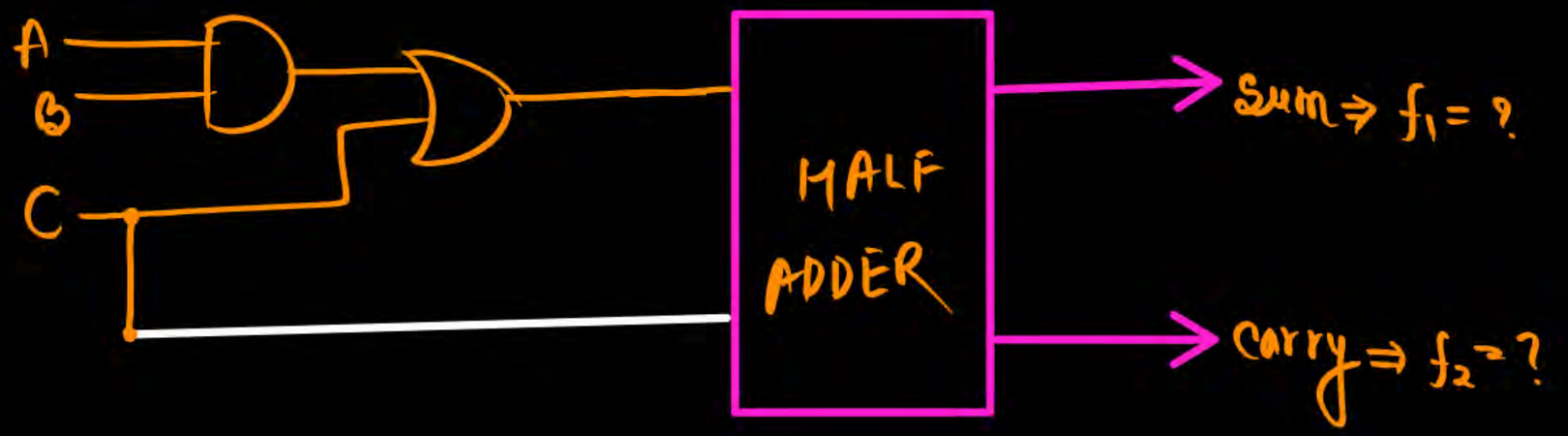
By NOR GATE



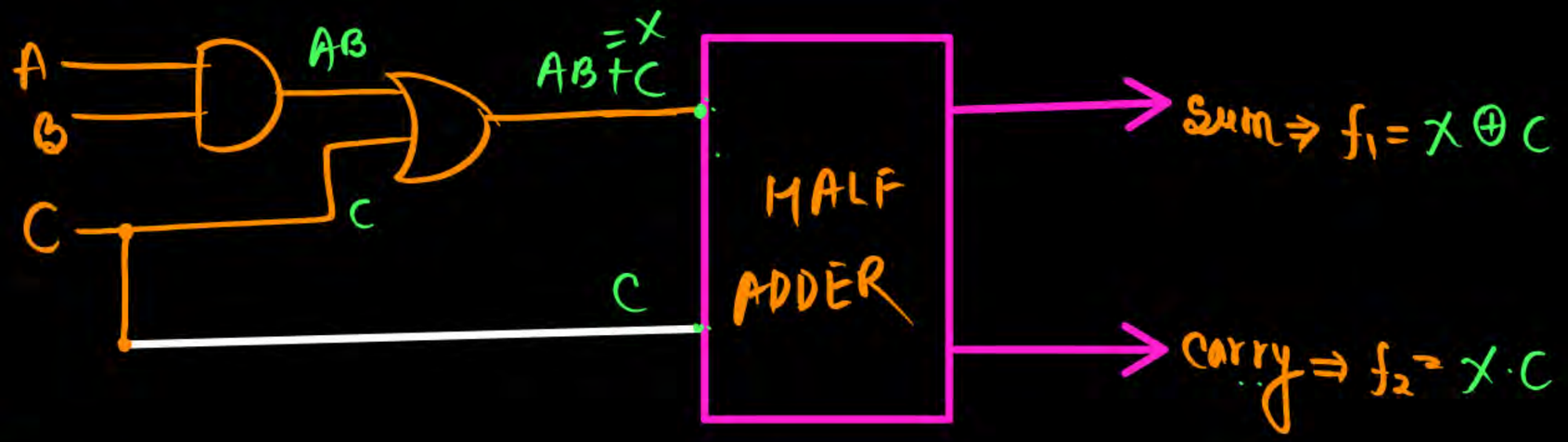
HALF ADDER BY USING DECODER



Q What is the value of f_1 and f_2 ?



Q What is the value of f_1 and f_2 ?



$f_1 = (AB+C) \oplus C$

$= \overline{AB+C} \cdot C + (AB+C)\bar{C}$

$= \bar{A}\bar{B} \cdot \bar{C} \cdot C + AB\bar{C} + C \cdot \bar{C}$

$= AB\bar{C}$

$f_2 = (AB+C)\,C$

$= ABC + C \cdot C = ABC + C$

$= C[AB+1]$

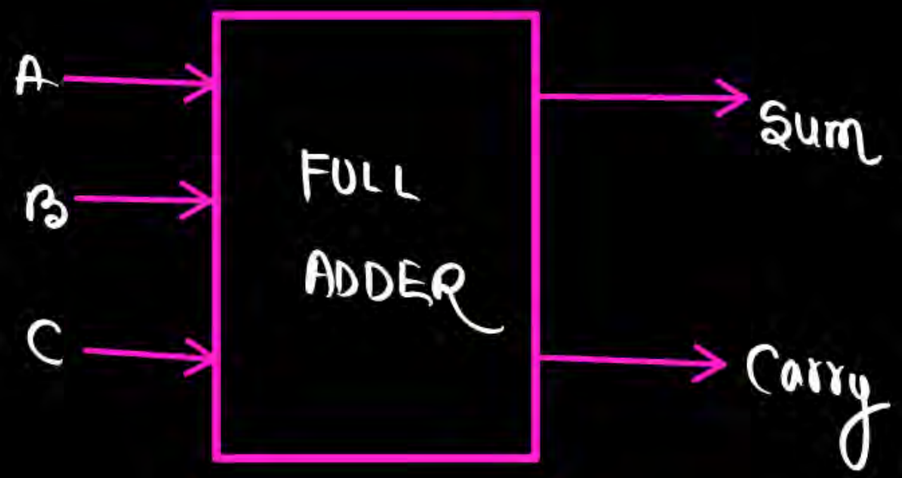
$= C_{AB}$

FULL ADDER :→

↳ Three bit adder are known as full adder.

0	0	0	1
0	0	1	1
+0	+1	+1	+1
00	01	10	11

Step 1:



Full Adder

majority high input logic

FULL ADDER

Step 2.

	A	B	C	Sum	Carry
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	1	0	1
6	1	1	0	0	1
7	1	1	1	1	1

Full Adder

FULL ADDER

Step 3. Sum (A, B, C) $= \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$

$= \Sigma m(1,2,4,7)$

$= A \oplus B \oplus C$

Step 4. Carry (A, B, C) $= \Sigma m(3,5,6,7) = \bar{A}BC + A\bar{B}C + AB\bar{C} + ABC$

$= AB + BC + AC \rightarrow$ minimized expression

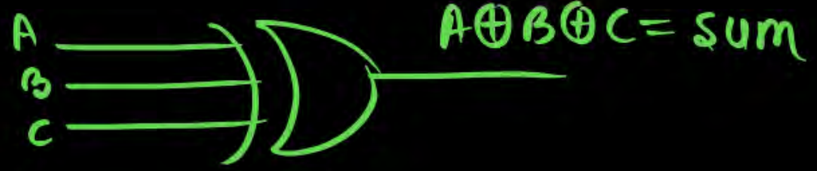
$= (\bar{A}B + A\bar{B})C + AB(\bar{C} + C)$

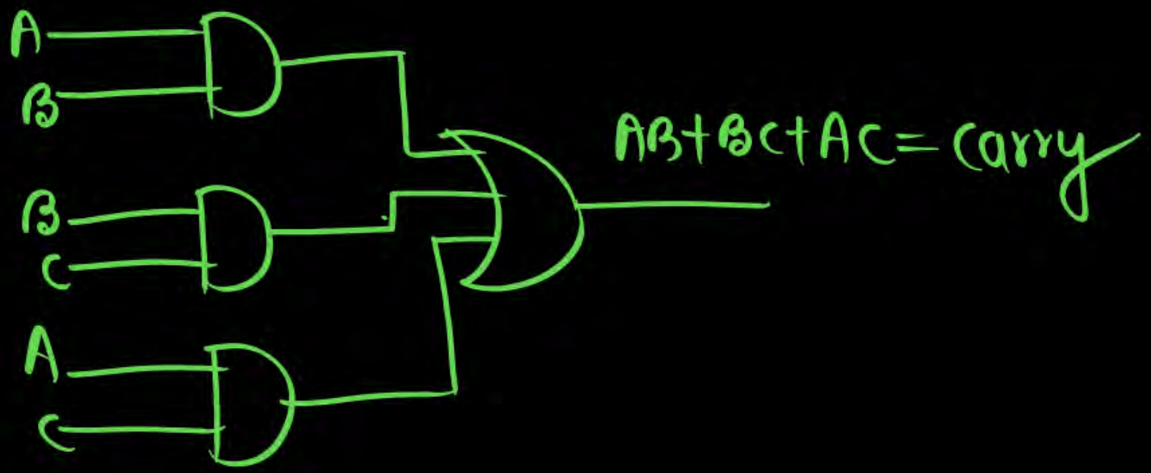
$= (A \oplus B)C + AB \rightarrow$ semiminimized.

Step 5 :→

$Sum = A \oplus B \oplus C$

$Carry = AB + BC + AC$

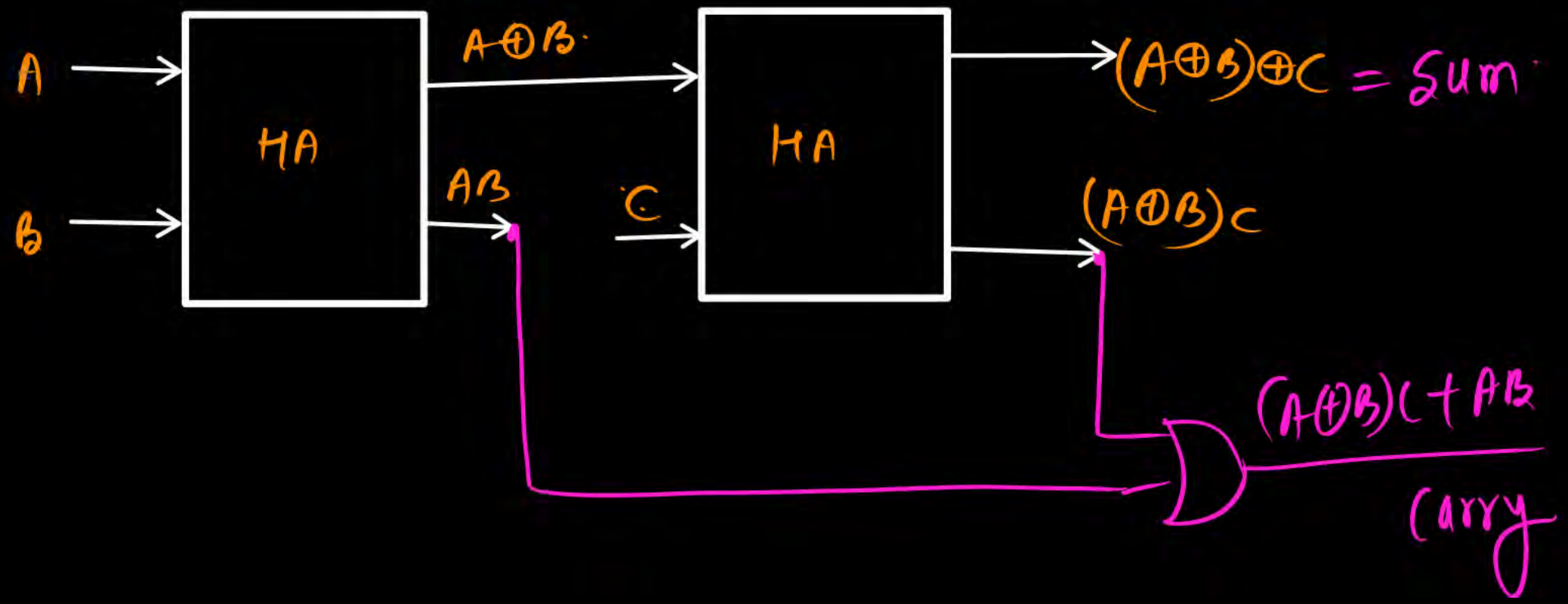




$Sum = (A \oplus B) \oplus C$

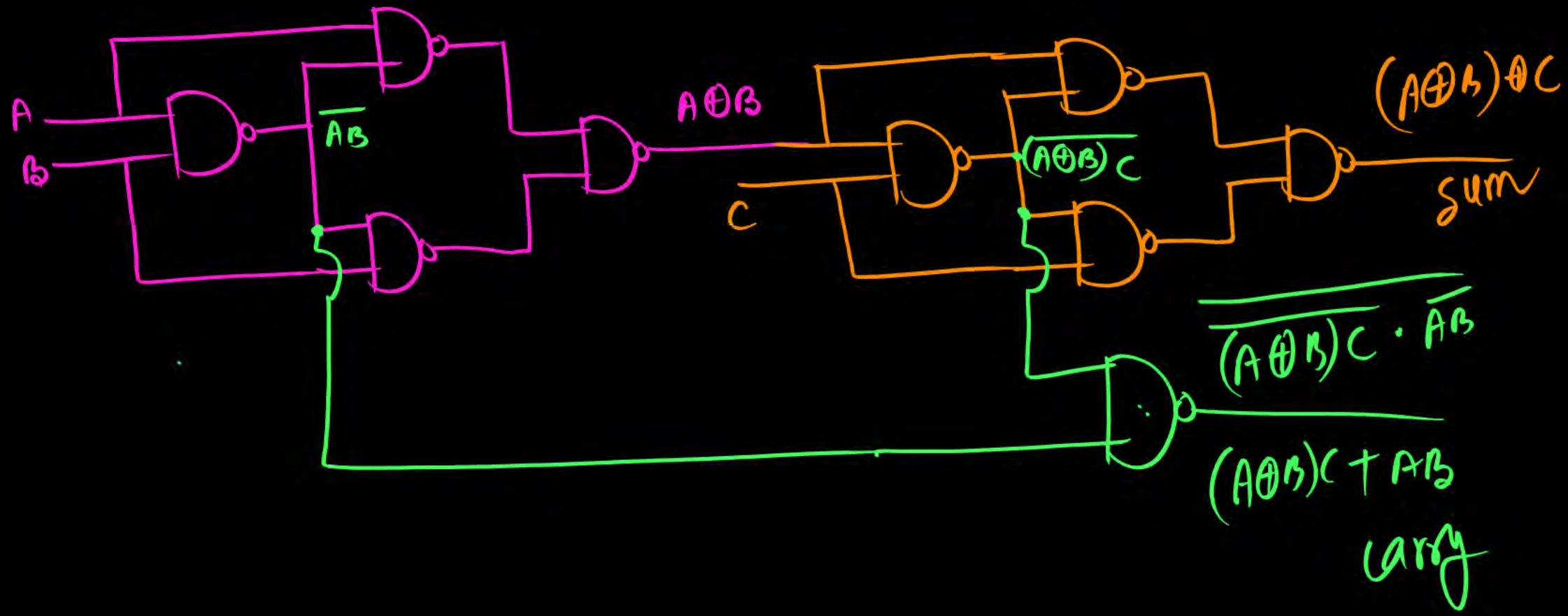
$Carry = (A \oplus B)C + AB$

1 Full adder = 2 HA + 1 OR


A
B
HA
A⊕B
AB
C
HA
(A⊕B)⊕C = Sum
(A⊕B)C
(A⊕B)C + AB
Carry

Full adder by using NAND GATE.

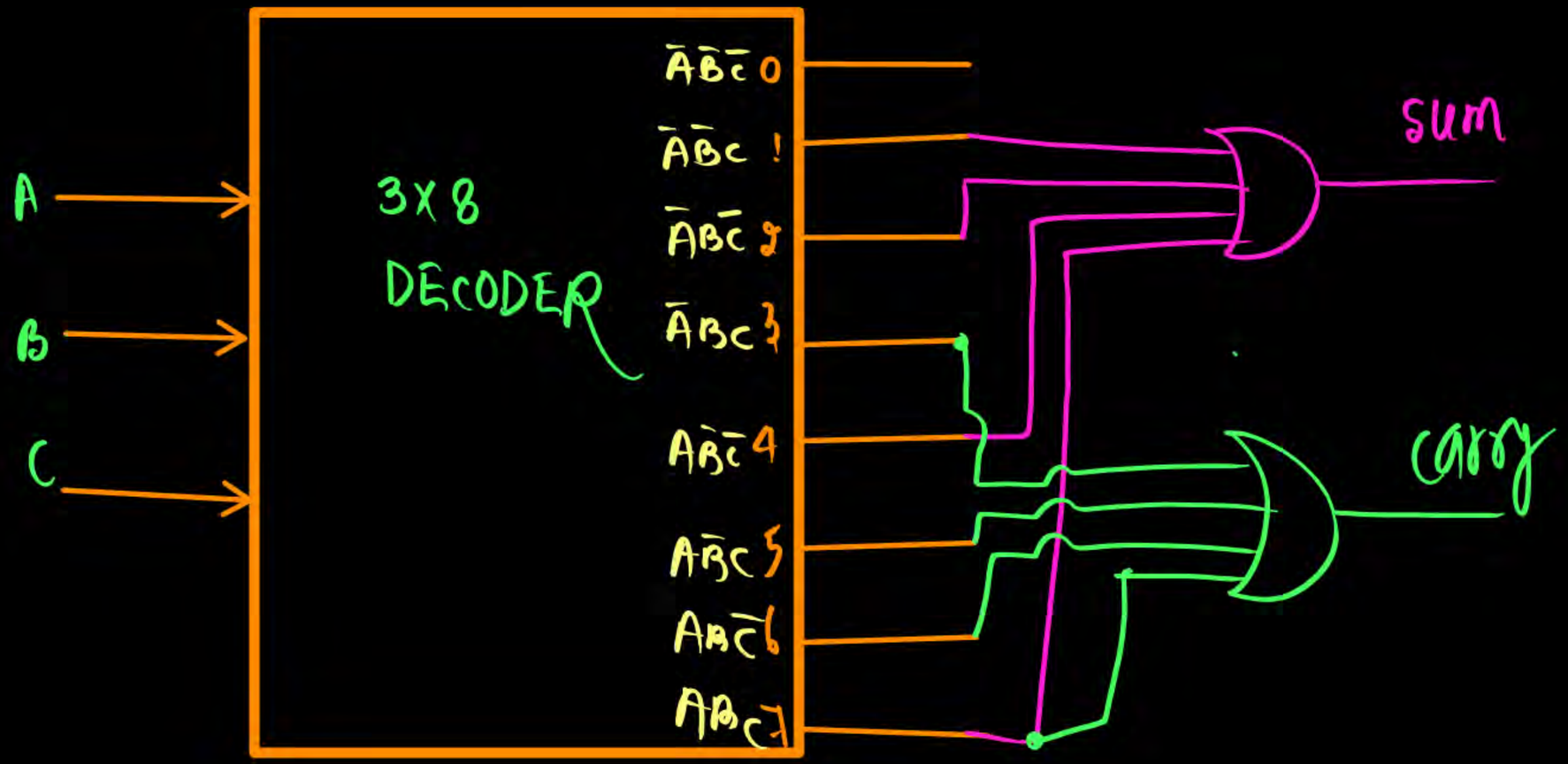
$(A \oplus B) \oplus C$

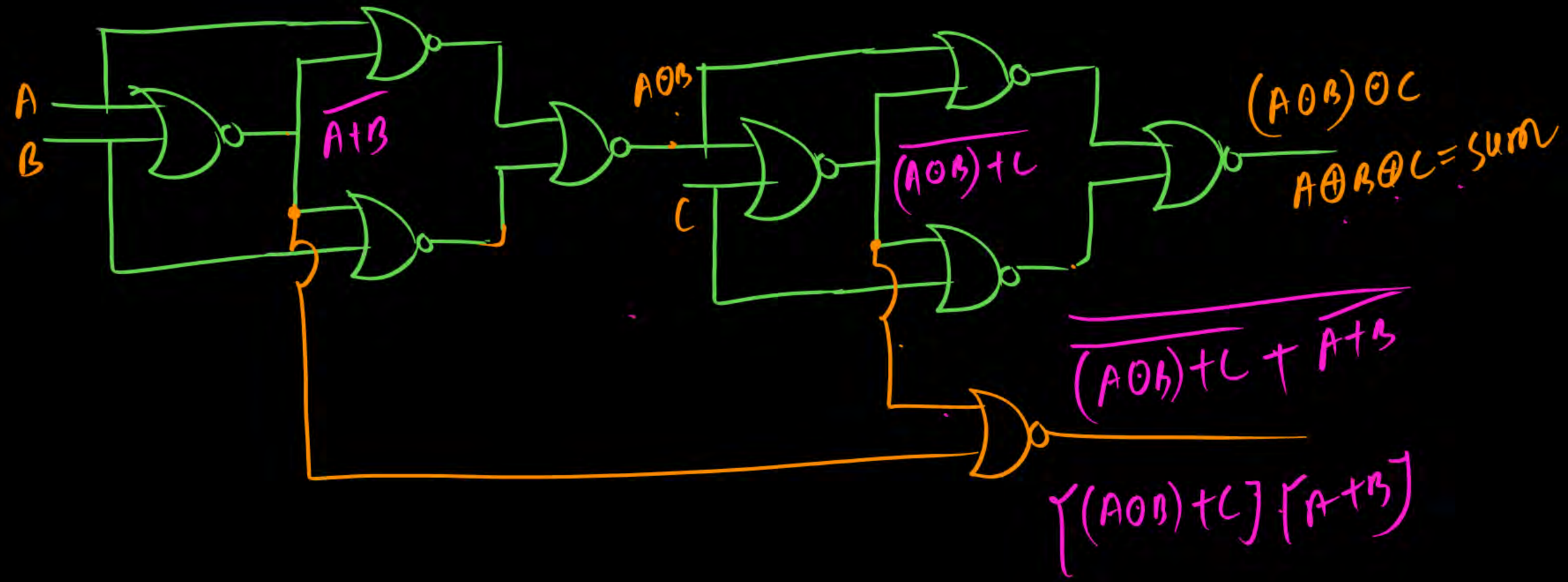


HW.

Full adder by using NOR GATE → (9)

Full adder by using decoder

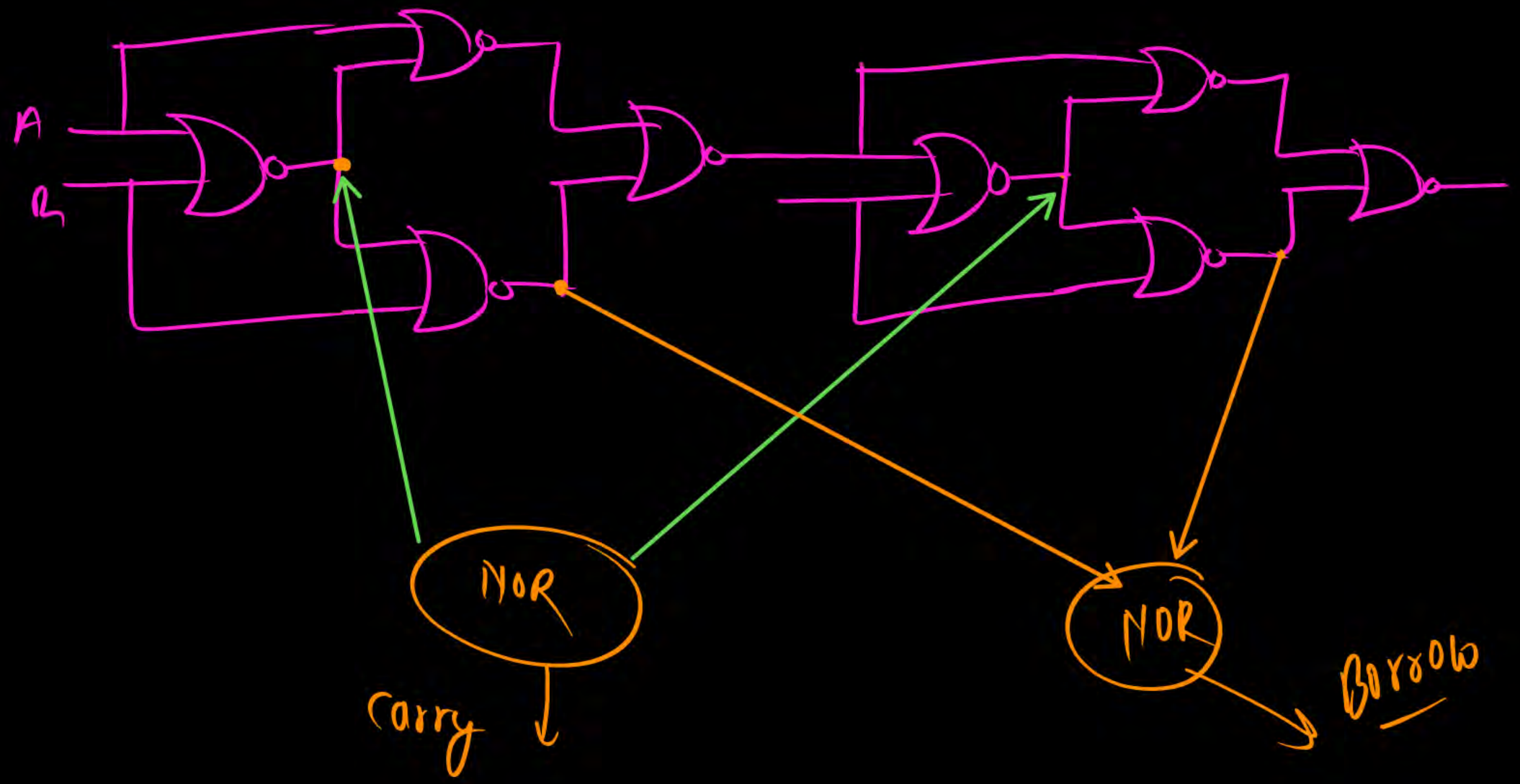



A
B
$\overline{A+B}$
A⊕B
C
$\overline{(A\oplus B)+C}$
(A⊕B)⊕C
A⊕B⊕C = Sum
$\overline{\overline{(A\oplus B)+C}+\overline{A+B}}$
$[(A\oplus B)+C][A+B]$

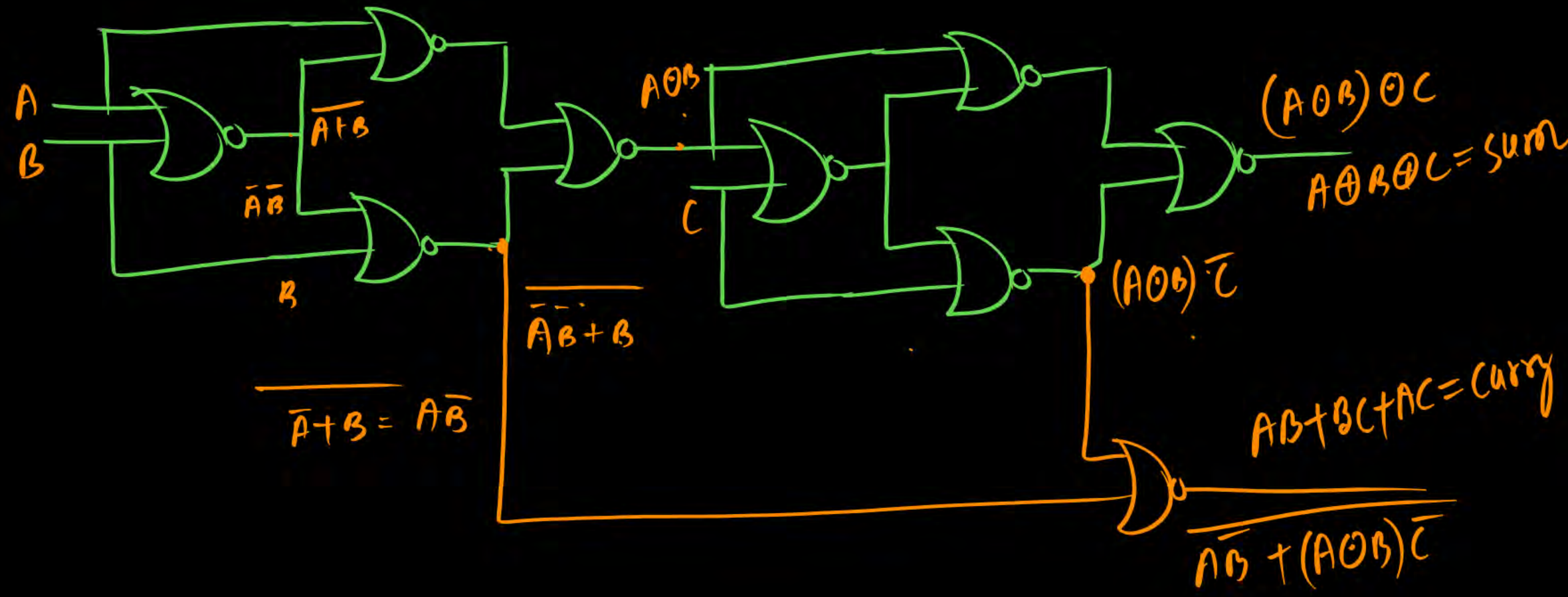
$$[(A \oplus B) + C] \cdot [A + B]$$

$$[(\bar{A}\bar{B} + AB) + C][A + B]$$

$$AB + AC + BC = \text{Carry}$$


A
B
NOR
NOR
Carry
Borrow

Full subtractor



$$\overline{A\bar{B} + (A \odot B)\bar{C}}$$

$$\overline{A\bar{B}} \cdot \overline{(A \odot B)\bar{C}}$$

$$(\bar{A} + B)\left[\overline{(A \odot B)} + C\right]$$

$$(\bar{A} + B)\left[\bar{A}B + A\bar{B} + C\right]$$

$$\bar{A}B + \bar{A}C + \bar{A}B + BC$$

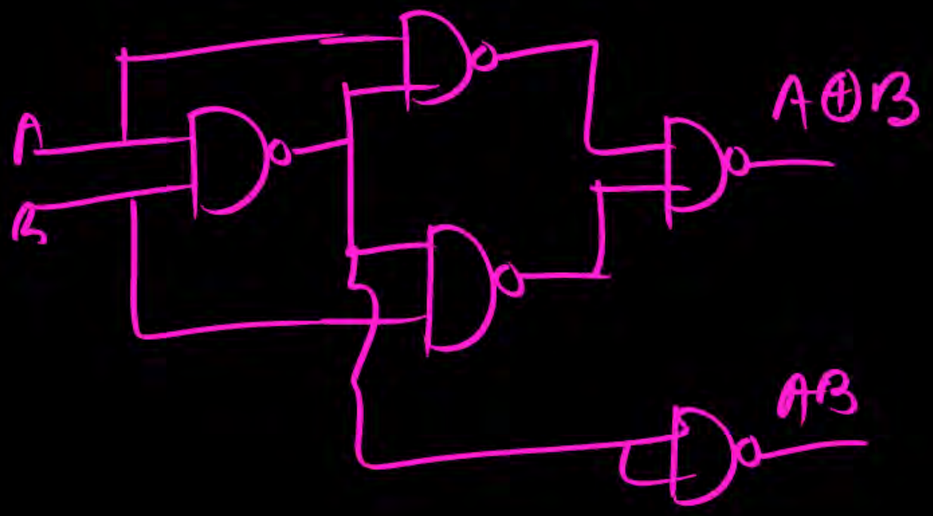
$$\bar{A}B + \bar{A}C + BC$$

↳ BORROW

HALF ADDER

$$\begin{cases} \text{Sum} = A \oplus B \\ \text{Carry} = AB \end{cases}$$

NAND / NOR = (5)



FULL ADDER

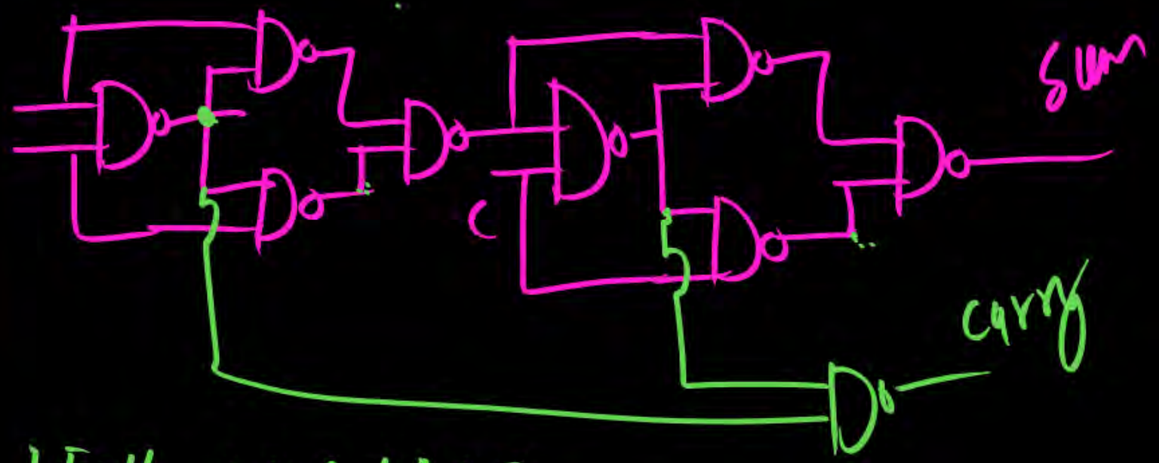
$\text{Sum} = \Sigma m(1,2,4,7) = A \oplus B \oplus C$

$\text{Carry} = \Sigma m(3,5,6,7)$

$= (A \oplus B)C + AB$

$= AB + BC + AC$

NAND / NOR = (9)



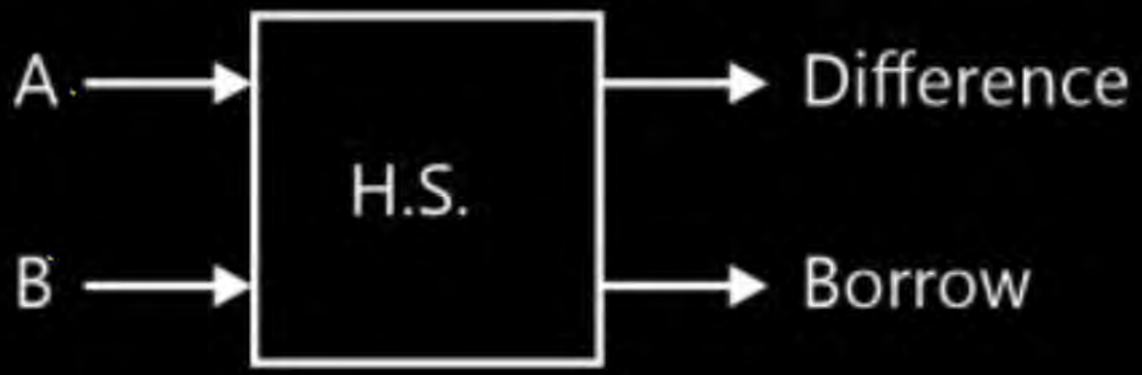
! Full = 2 HA + 1 OR

Q.1

A full adder is implemented with two half adders and one OR gate. OR gate is used to derive the final carry function of full adder. In each half adder, T_{sum} = 25 ns and T_{carry} = 20 ns and T_{OR} = 25 ns. The minimum time required to derive both the sum and carry function of a full adder after applying the inputs is _____ ns

HALF SUBTRACTOR → Two bit subtractor are known as half subtractor.

Step - 1



$$\begin{array}{r} 0 \\ -\,0 \\ \hline 0\ 0 \end{array} \qquad \begin{array}{r} 1 \\ -\,0 \\ \hline 0\ 1 \end{array} \qquad \begin{array}{r} 1 \\ -\,1 \\ \hline 0\ 0 \end{array}$$

Borrow ↑ ↕ Difference

$$\begin{array}{r} 0 \\ -\,1 \\ \hline 1\ 1 \end{array}$$

Borrow ↑ ↕ Diff

HALF SUBTRACTOR

Diff = $A \oplus B$

Borrow = $\bar{A}B$

Step - 1

A	B	Diff.	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Step - 2

HALF SUBTRACTOR

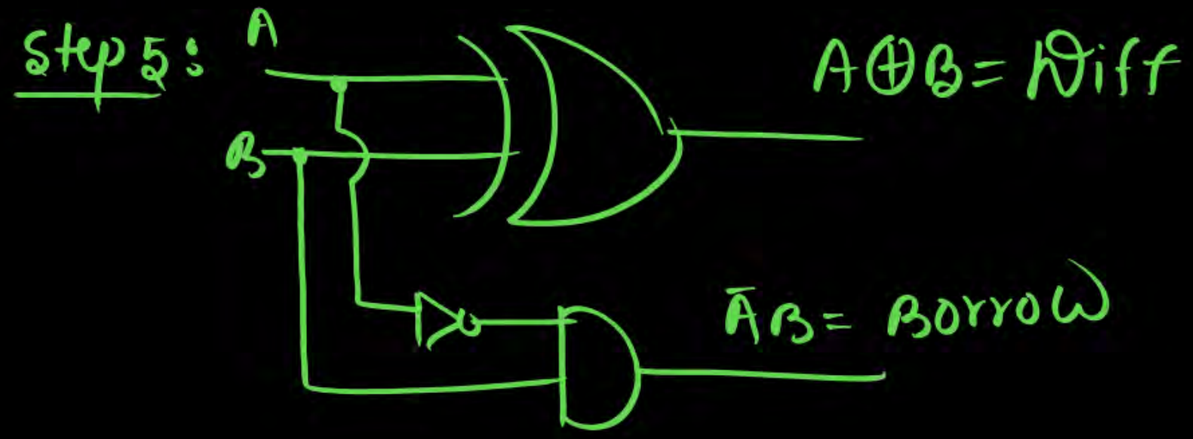
Step – 3

Diff. - $A \oplus B$

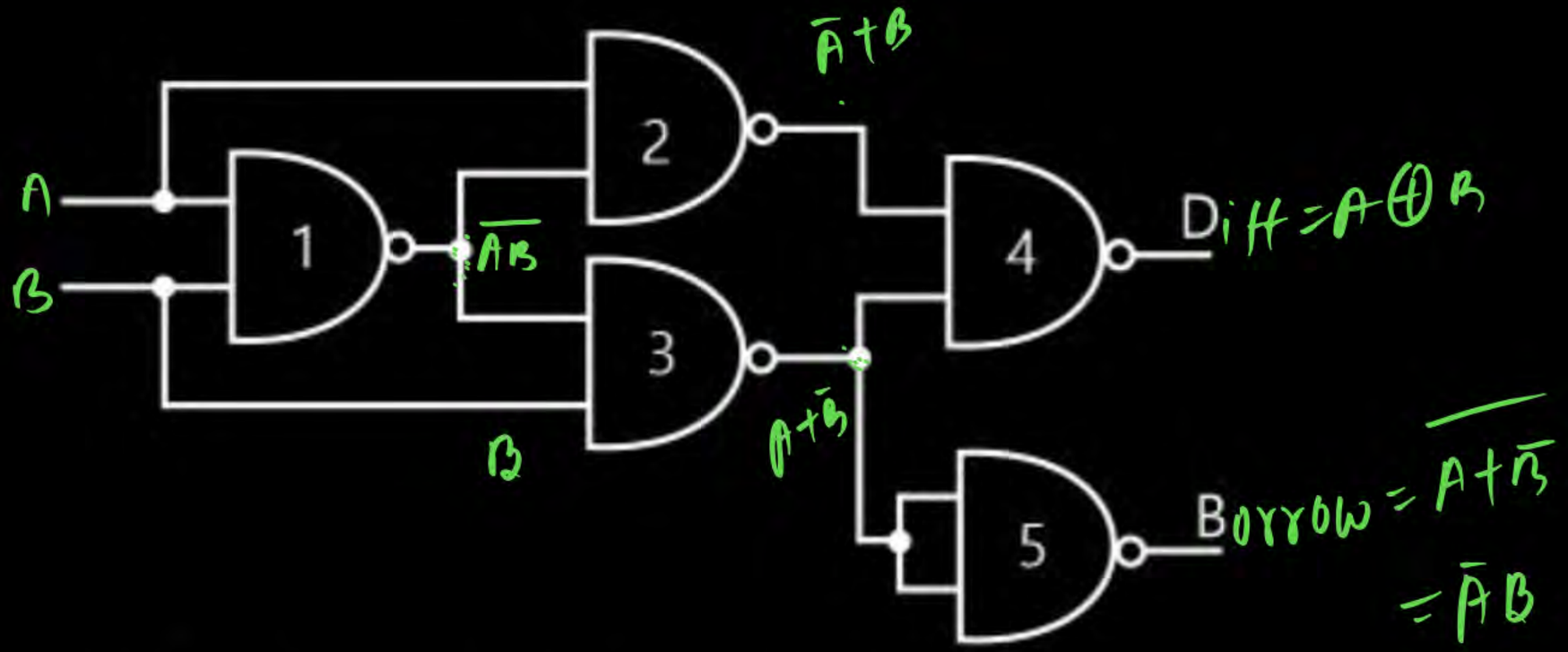
Borrow - $\bar{A}B$

Step 4 :

Step 5 :

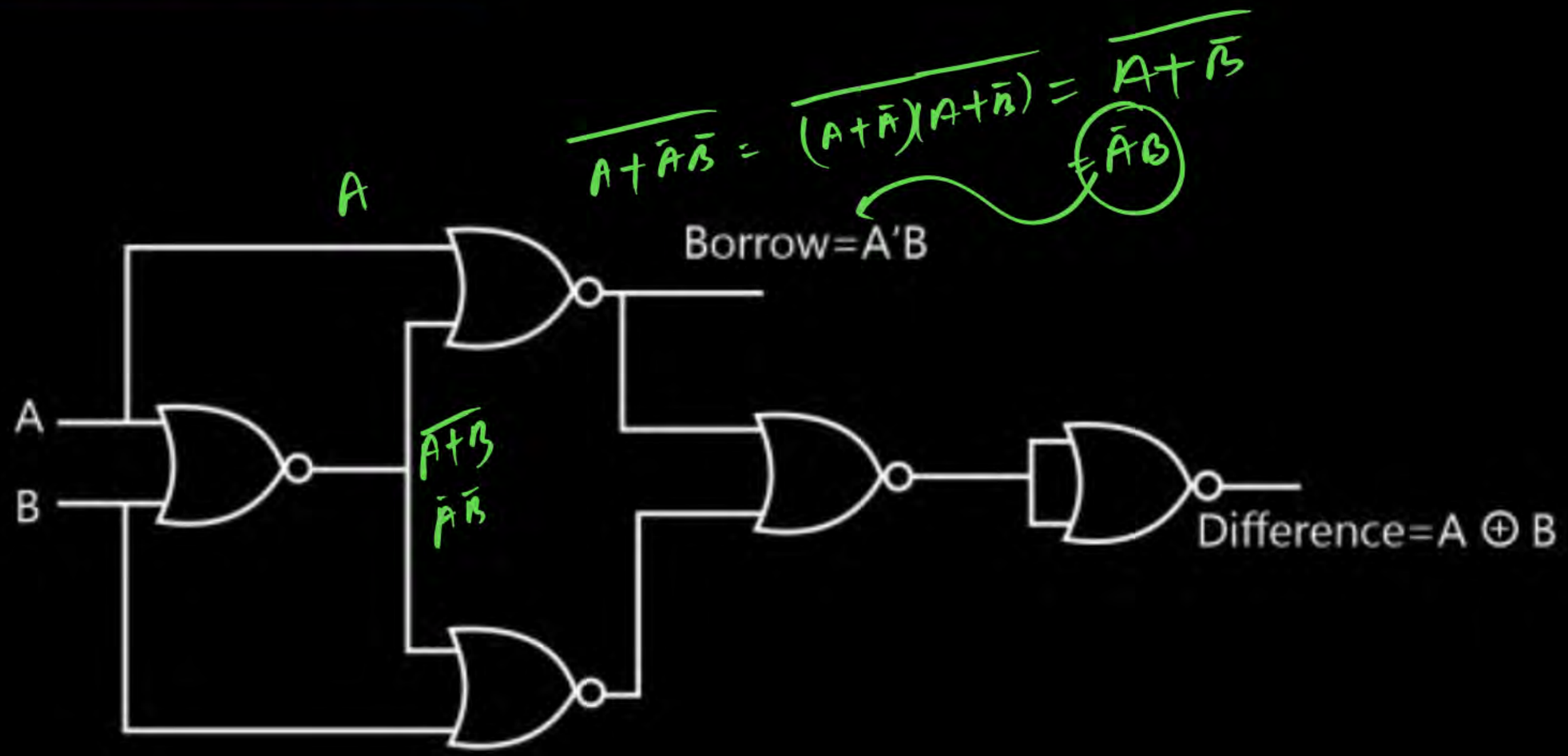


HALF SUBTRACTOR

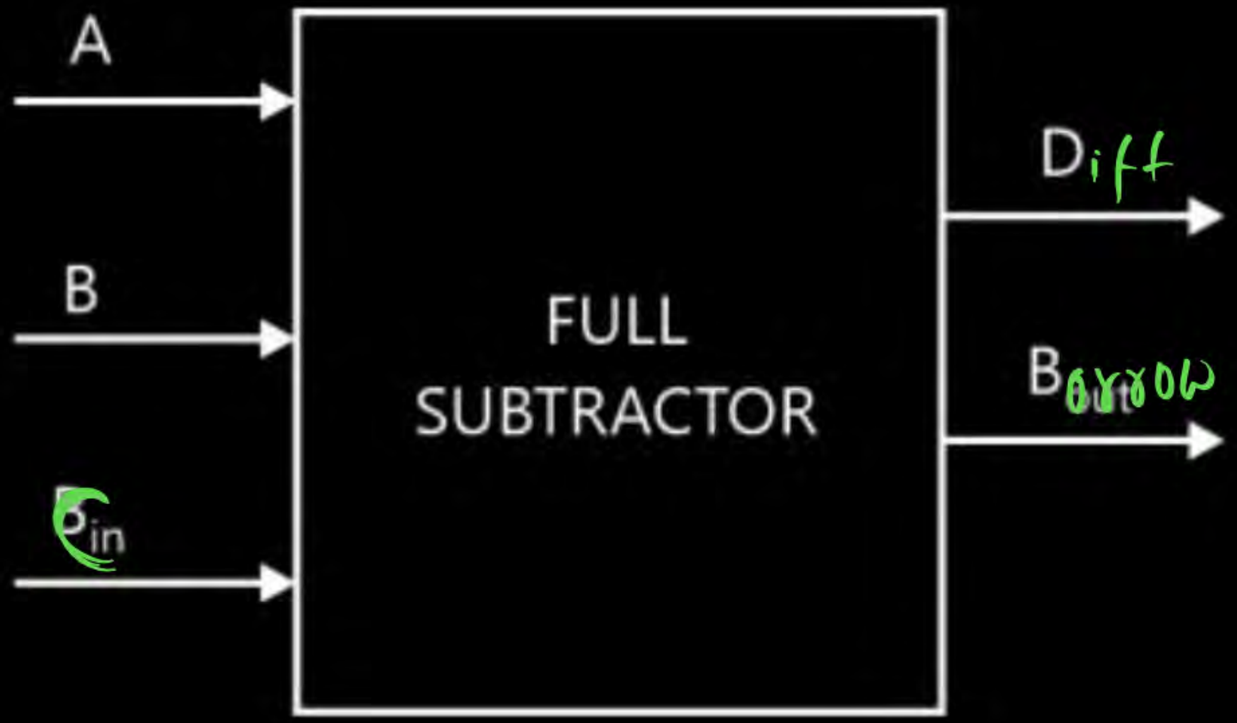


Half-Subtractor using NAND gates

HALF SUBTRACTOR



FULL SUBTRACTOR



FULL SUBTRACTOR

$(A-B)-C$

INPUT			OUTPUT	
A	B	C	D	Borrow
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

HA

$Sum = A \oplus B$

$Carry = AB$

$A \to \bar{A}$

H.S

$Diff = A \oplus B$

$Borrow = \bar{A}B$

FA

$Sum = A \oplus B \oplus C$

$Carry = AB + AC + BC$

$A \to \bar{A}$

F.S

$Diff = A \oplus B \oplus C$

$Borrow = \bar{A}B + \bar{A}C + BC$

t.me/CJSIR

Thank you GW Soldiers !