CS & IT ENGINEERING

DIGITAL LOGIC

Combinational Circuit

By- CHANDAN SIR

Lecture No. 06

01 HS

02 FS

03 SERIAL ADDER

04 PARALLEL ADDER

HA

$Sum = A \oplus B$

$Carry = AB$

NAND/NOR = 5

FA

$Sum = A \oplus B \oplus C$

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

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

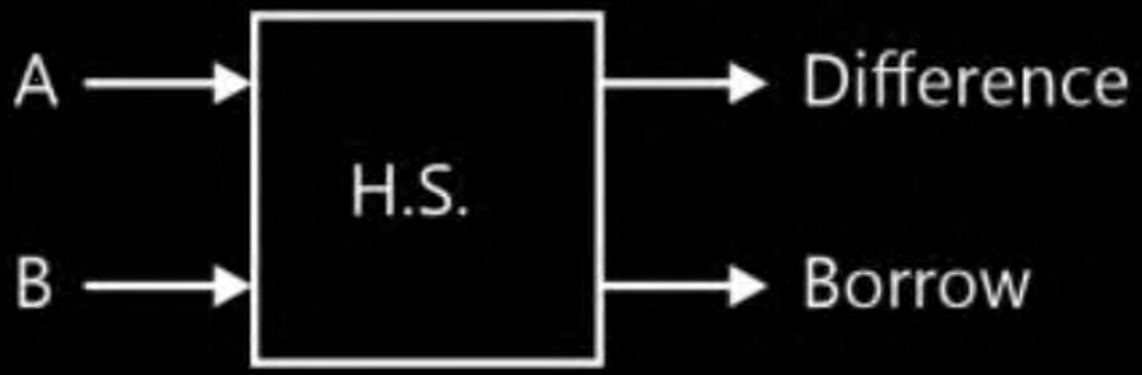
$= AB + BC + AC$

NAND/NOR = 9

HS, FS, Serial Adder

HALF SUBTRACTOR → Two bit subtractor

Step - 1



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

Borrow ↑ ↑ Diff

HS, FS, Serial Adder

HALF SUBTRACTOR

Step - 1

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

HS, FS, Serial Adder

HALF SUBTRACTOR

Step – 3

Diff. - $Diff = \bar{A}B + A\bar{B}$

$= A \oplus B$

Borrow -

$Borrow = \bar{A}B$

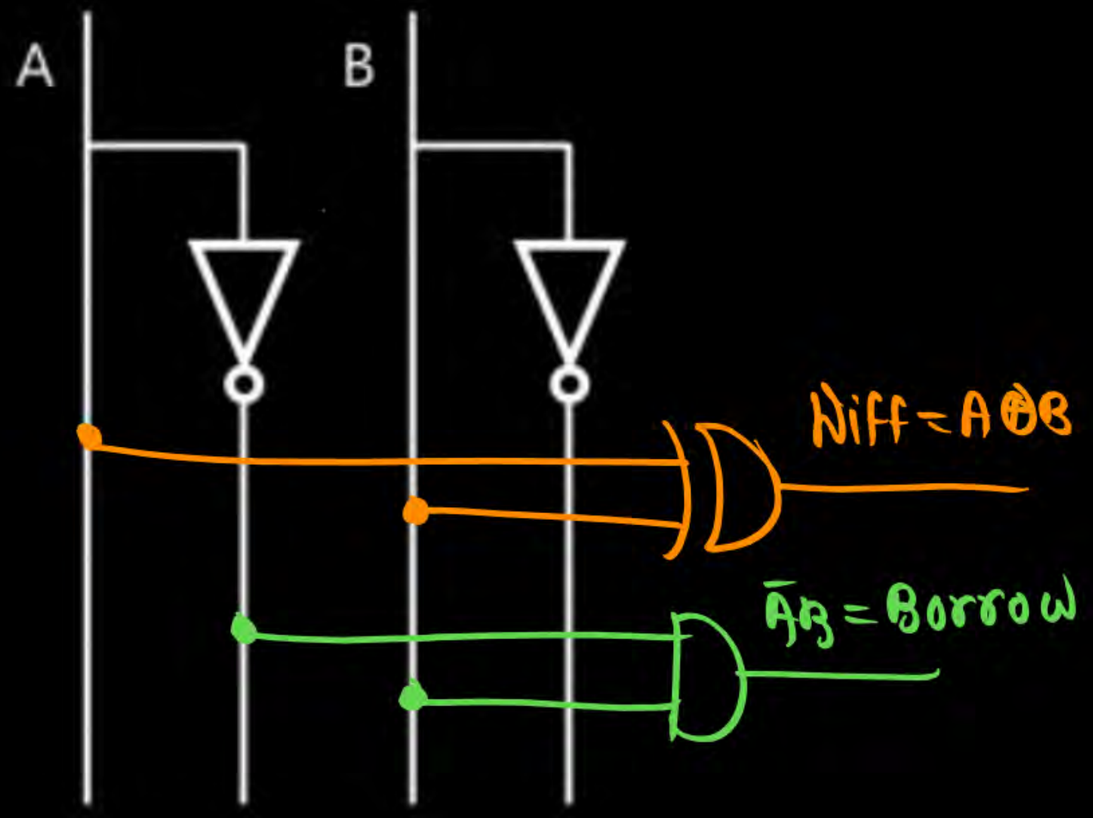
HS, FS, Serial Adder

HALF SUBTRACTOR

Step – 4 : Minimization

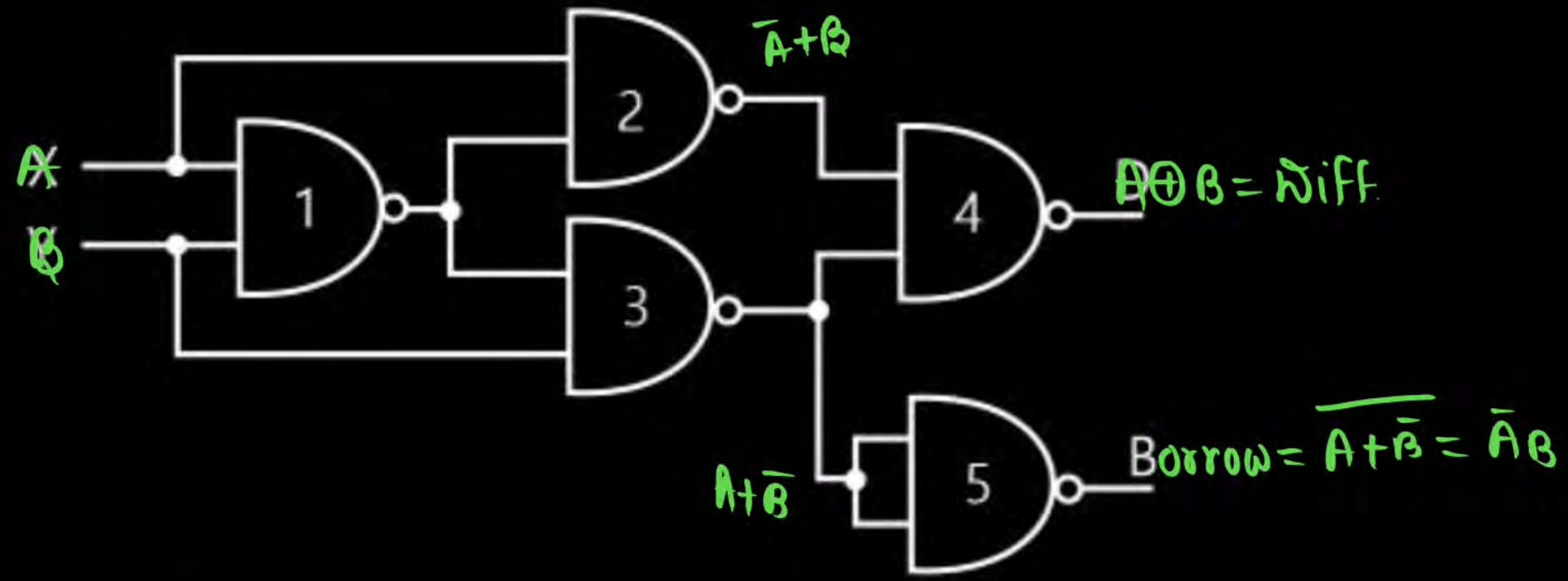
↳ Already minimized

Step - 5 : Hardware Implementation



HS, FS, Serial Adder

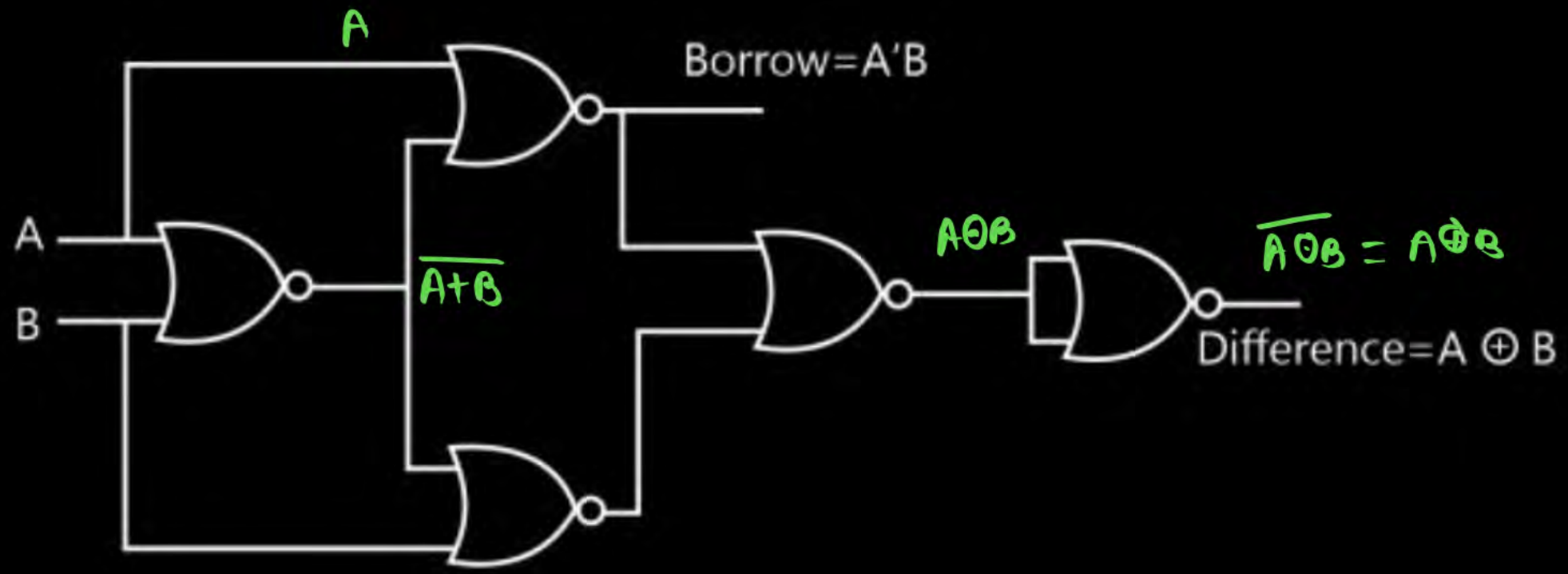
HALF SUBTRACTOR



Half-Subtractor using NAND gates

HS, FS, Serial Adder

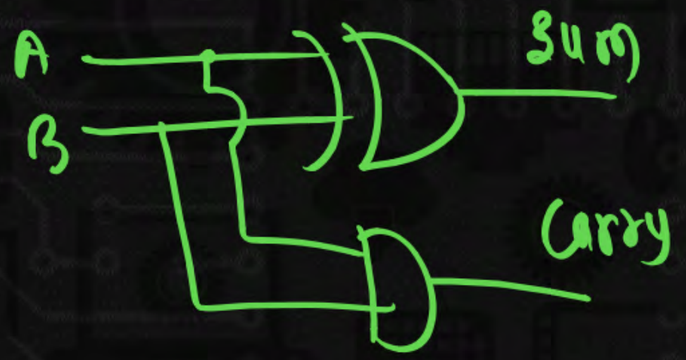
HALF SUBTRACTOR



HA

Sum = $A \oplus B$

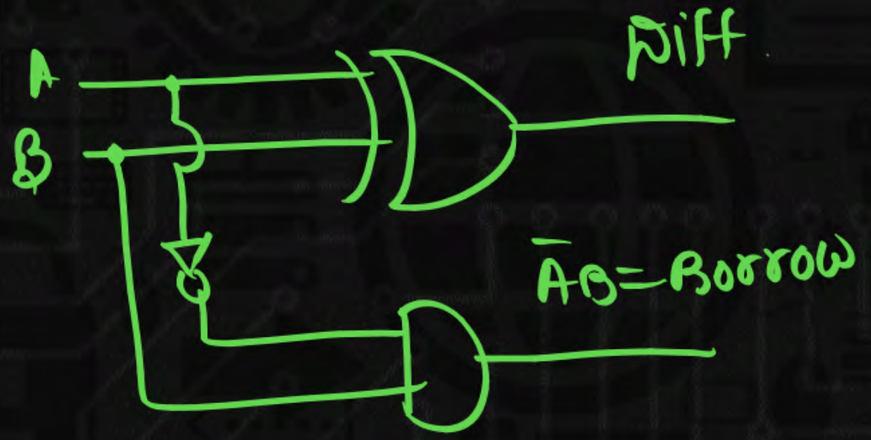
Carry = AB



H.S.

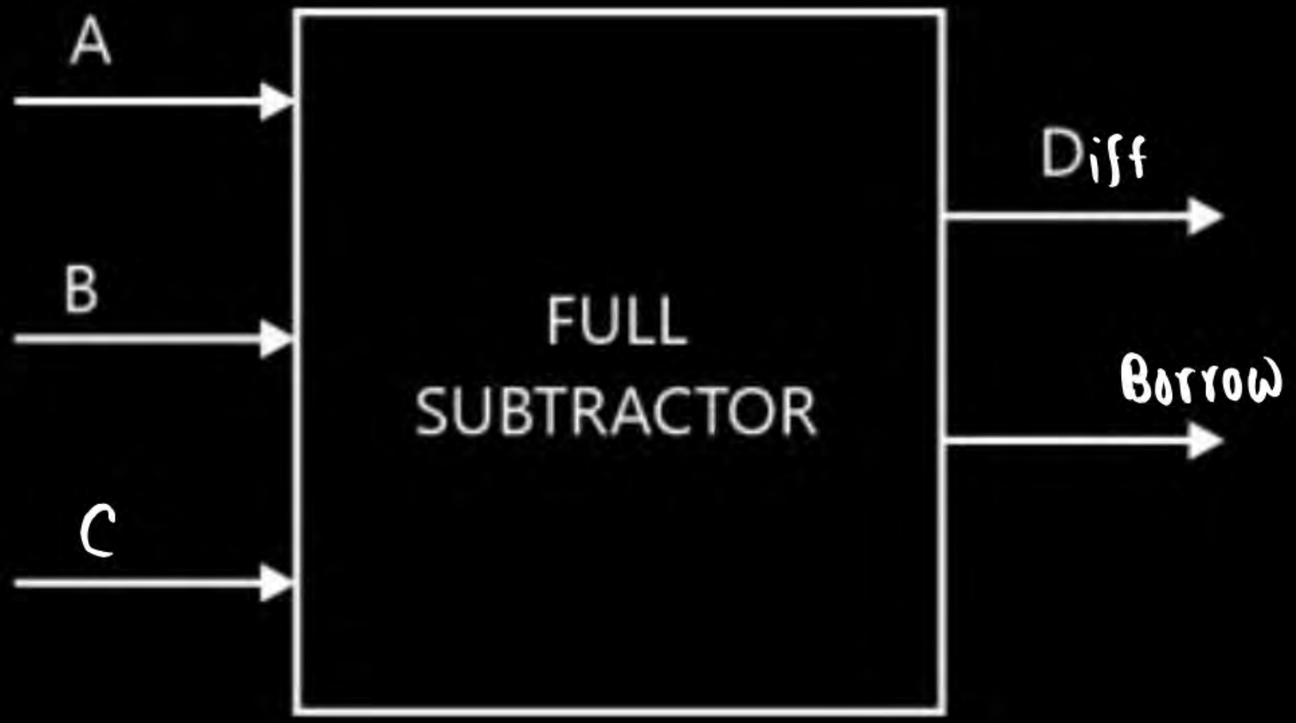
Diff = $A \oplus B$

Borrow = $\bar{A}B$



HS, FS, Serial Adder

FULL SUBTRACTOR → three bit subtractor



HS, FS, Serial Adder

FULL SUBTRACTOR (A-B)-C

INPUT			OUTPUT	
A	B	C	Diff.	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

Step 3.

Step 4.

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

$$\text{Borrow} = \Sigma m(1,2,3,7)$$

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

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

$$= \overline{A \oplus B}\,C + \bar{A}B$$

$$= \overline{(A \oplus B)}\,C + \bar{A}B \leftarrow \text{semiminimized}$$

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

HS, FS, Serial Adder

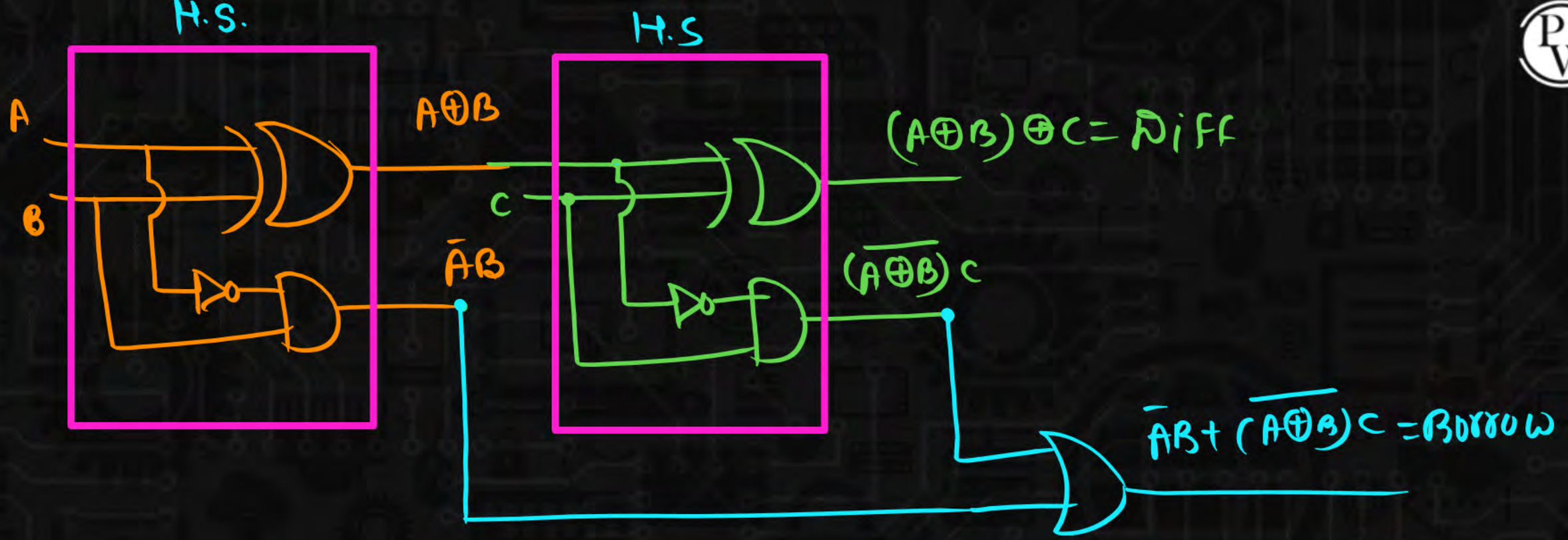
FULL SUBTRACTOR

$$\text{Diff} = A \oplus B \oplus C$$

$$\text{Borrow} = \Sigma m(1,2,3,7)$$

$$= \bar{A}B + (\overline{A \oplus B}) \cdot C$$

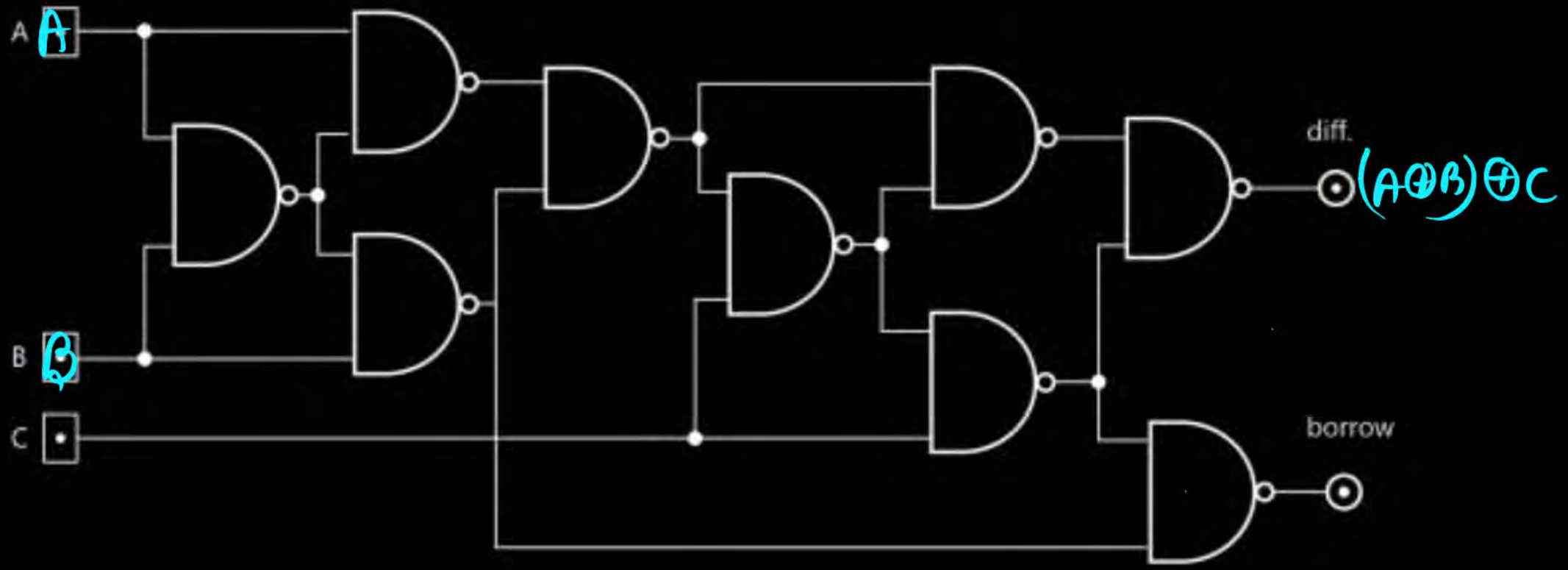
$$= \bar{A}B + \bar{A}C + BC$$

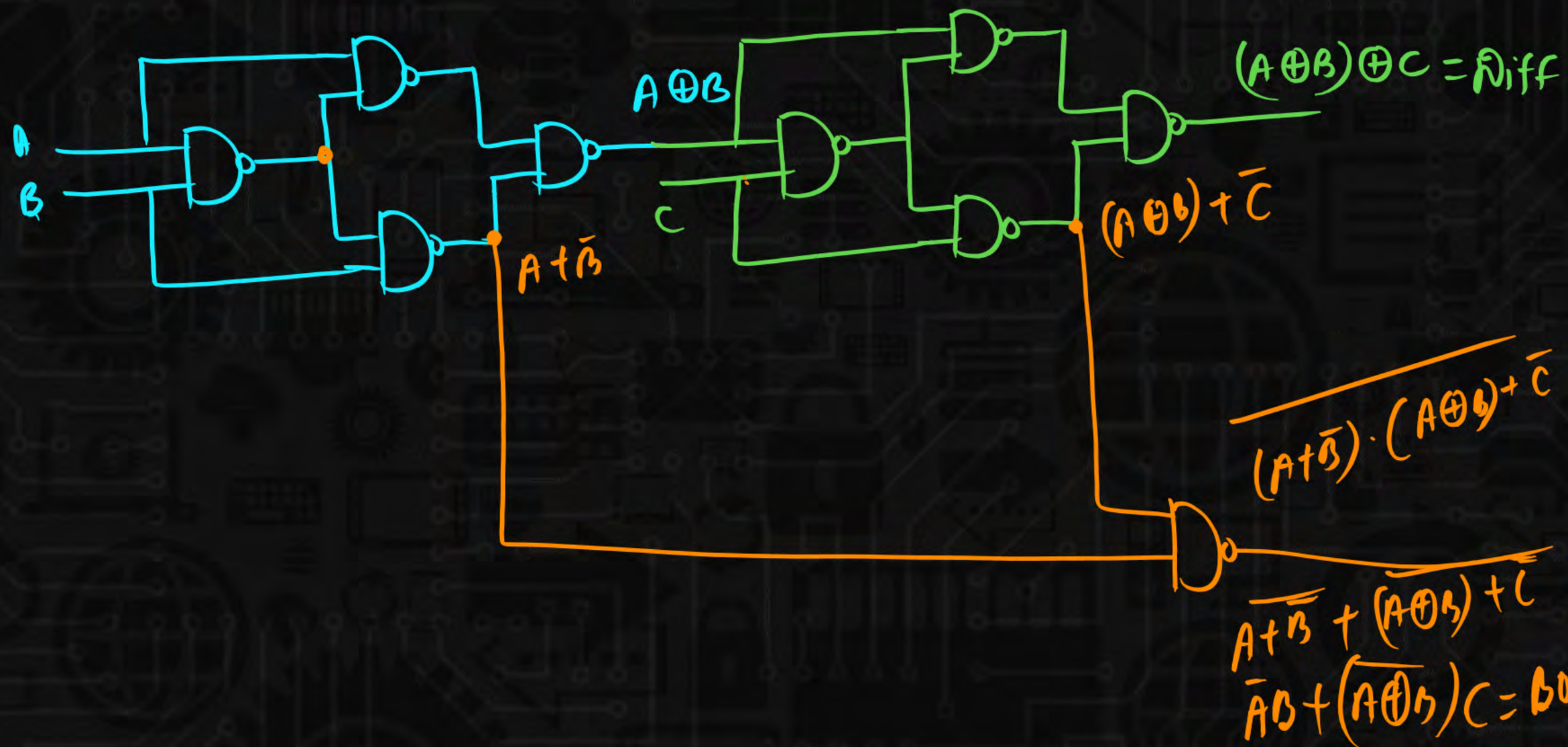


1 FS = 2 H.S + 1 OR GATE

HS, FS, Serial Adder

FULL SUBTRACTOR




A
B
A⊕B
C
A+B̄
(A⊕B)⊕C = Diff
(A⊕B)+C̄
(A+B̄)·(A⊕B)+C̄
Ā+B + (A⊕B)+C
ĀB + (A⊕B)C = Borrow

FA

$Sum = A \oplus B \oplus C$

$Carry = \Sigma m(3,5,6,7)$ ✓

$= AB + (A \oplus B)C$ ✓

$= AB + AC + BC$ ✓

NAND/NOR = 9

F.S.

$Diff = A \oplus B \oplus C$

$Borrow = \Sigma m(1,2,3,7)$ ✓

$= \bar{A}B + \overline{(A \oplus B)}C$ ✓

$= \bar{A}B + \bar{A}C + BC$ ✓

NAND/NOR = 9

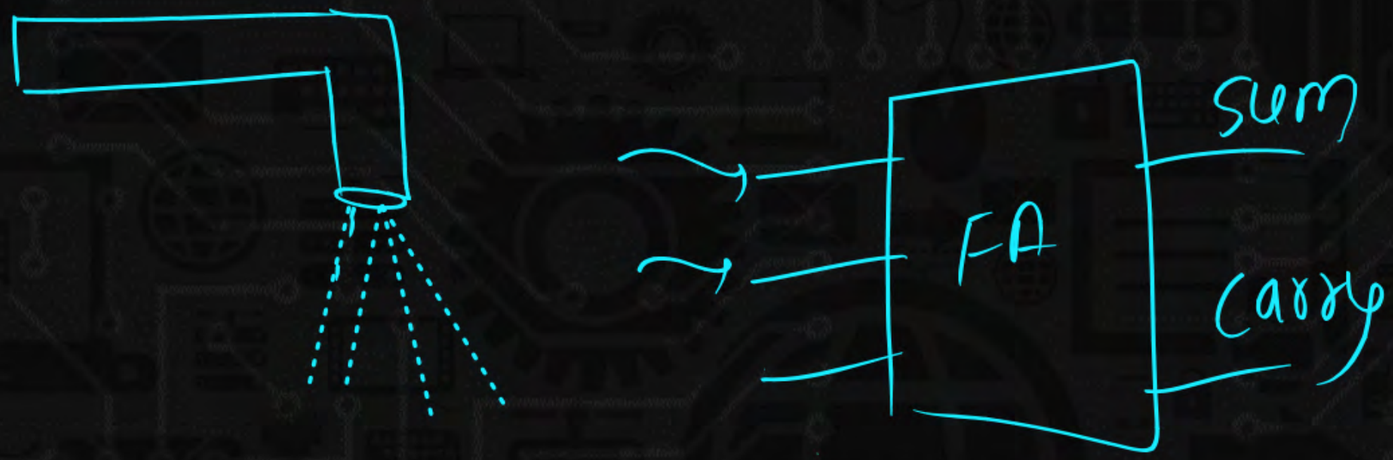
Comparator

MUX, DE-MUX

Encoder, Decoder.

HA, FA

H.S, F.S.


FA
sum
carry

HS, FS, Serial Adder

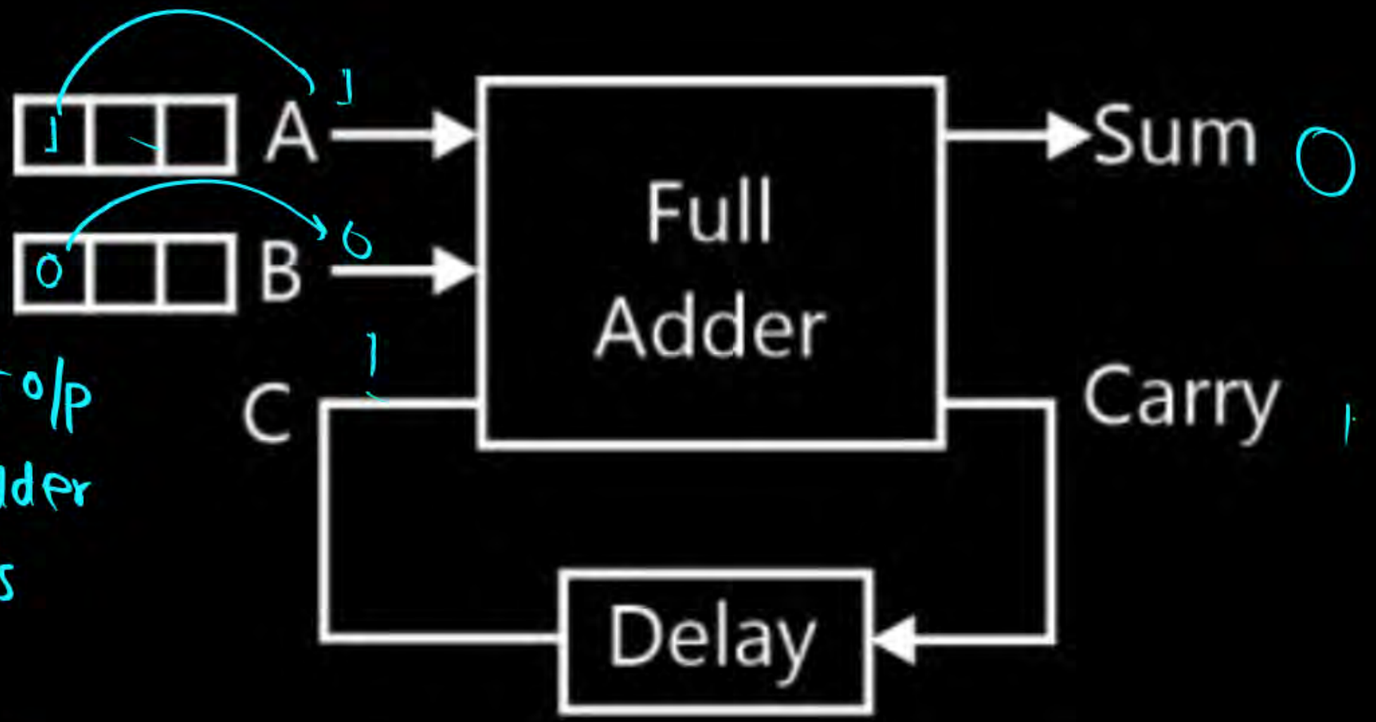
SERIAL ADDER → One by one.

- It is the slowest adder among all the adder.

If T_{FA} → Time to get o/p of Full adder

and n → no. of bits

$$T = n \cdot T_{FA}$$



Carry

1 0 0 0

PARALLEL ADDER

→ Inputs are connected simultaneously

4 bits

$$
\begin{array}{cccccc}
 & C_3 & C_2 & C_1 & & \\
 & A_3 & A_2 & A_1 & A_0 & \\
+ & B_3 & B_2 & B_1 & B_0 & \\
\hline
C_4 & S_3 & S_2 & S_1 & S_0 &
\end{array}
$$

1 HA
3 FA

'n' bit parallel adder

$\Rightarrow$ (n-1) FA + 1 HA ✓

$\Rightarrow$ n- FA

$\Rightarrow$ (2n-1) HA + (n-1) OR GATE

1 FA = 2 HA + 1 OR GATE

(n-1) FA + 1 HA

(n-1) [2 HA + 1 OR] + 1 HA

(2n-2) HA + (n-1) OR + 1 HA

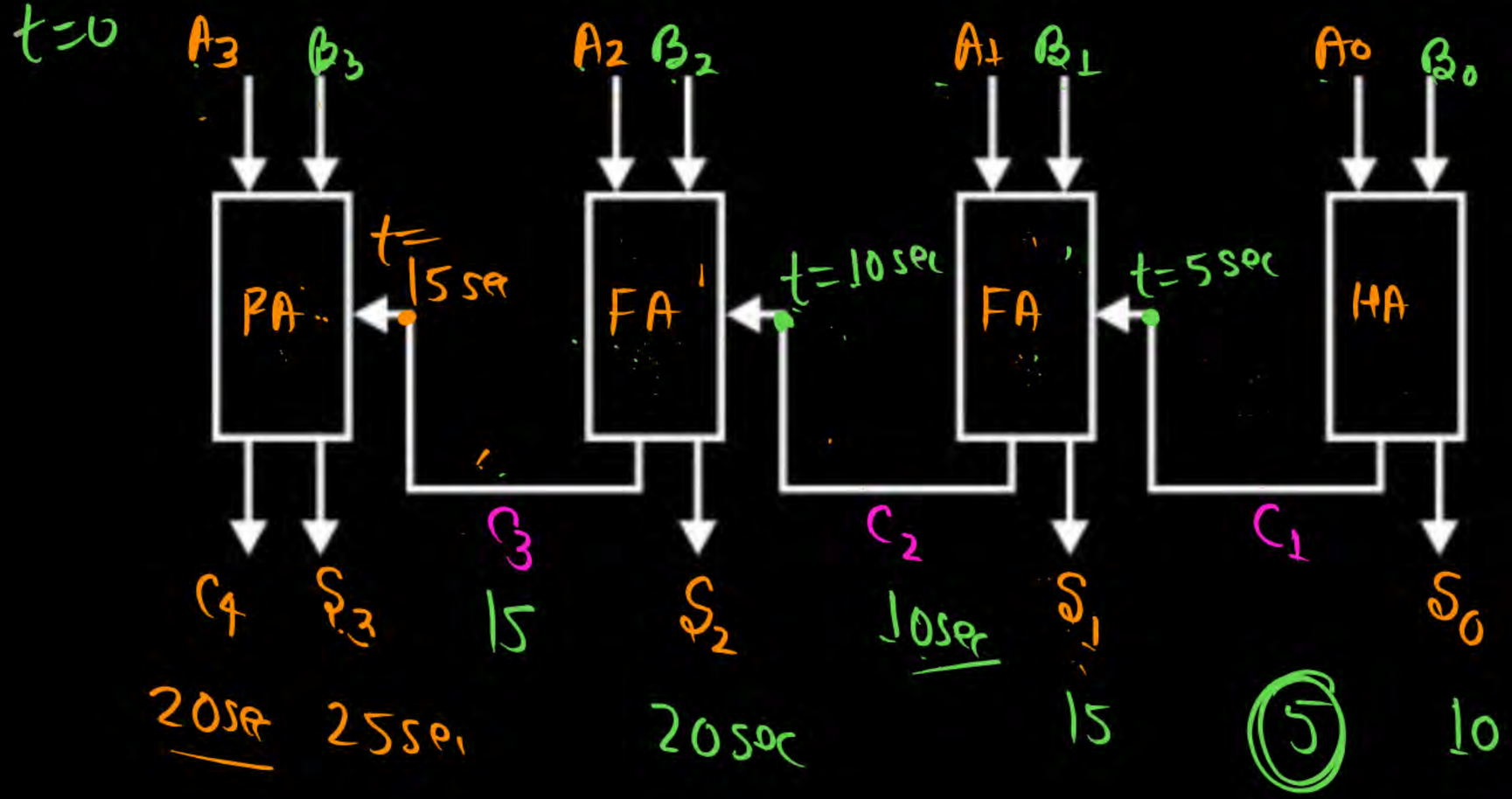
(2n-1) HA + (n-1) OR

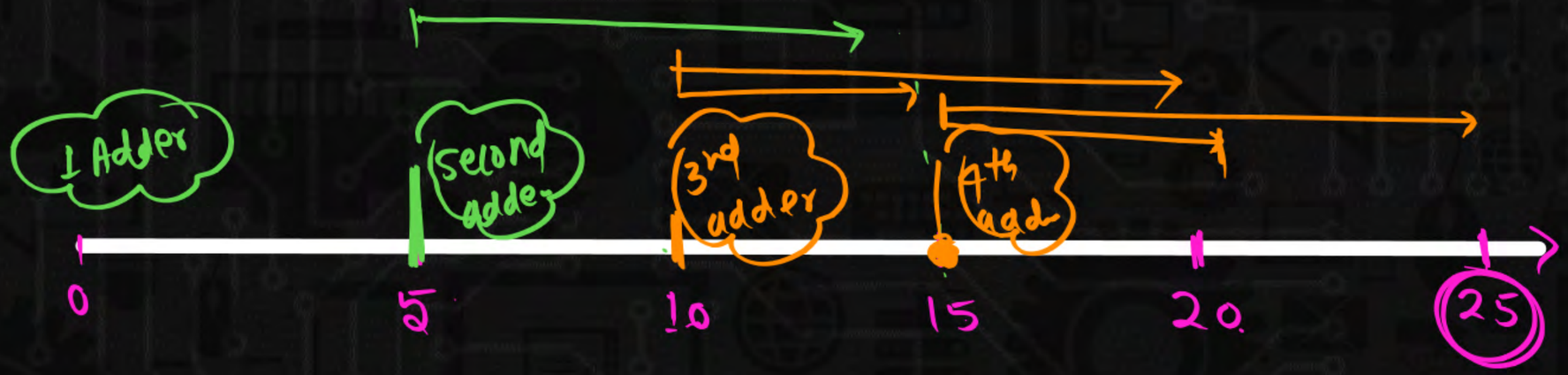
PARALLEL ADDER, LACA

PARALLEL ADDER [Ripple carry adder]

$T_{sum} = 10$ sec

$T_{carry} = 5$ sec





C_1 — S_0 — S_1 — S_2 ✓ S_3 ✓

C_2 — C_3 — C_4 —

→ number of bits.

$$T = (n-1)T_{carry} + Max\{T_{sum}, T_{carry}\}$$

Q ⇒ $T_{sum} = 10s \quad T_{carry} = 5s \quad n = 4$

$$T = (n-1)T_{carry} + Max\{T_{sum}, T_{carry}\}$$

$$= (4-1)5 + Max\{10, 5\}$$

$$= 3 \times 5 + 10$$

$$= 25 \text{ second}$$ Ans

Thank you

GW

Soldiers !