COMPUTER SCIENCE & IT

DIGITAL LOGIC

Lecture No. 02

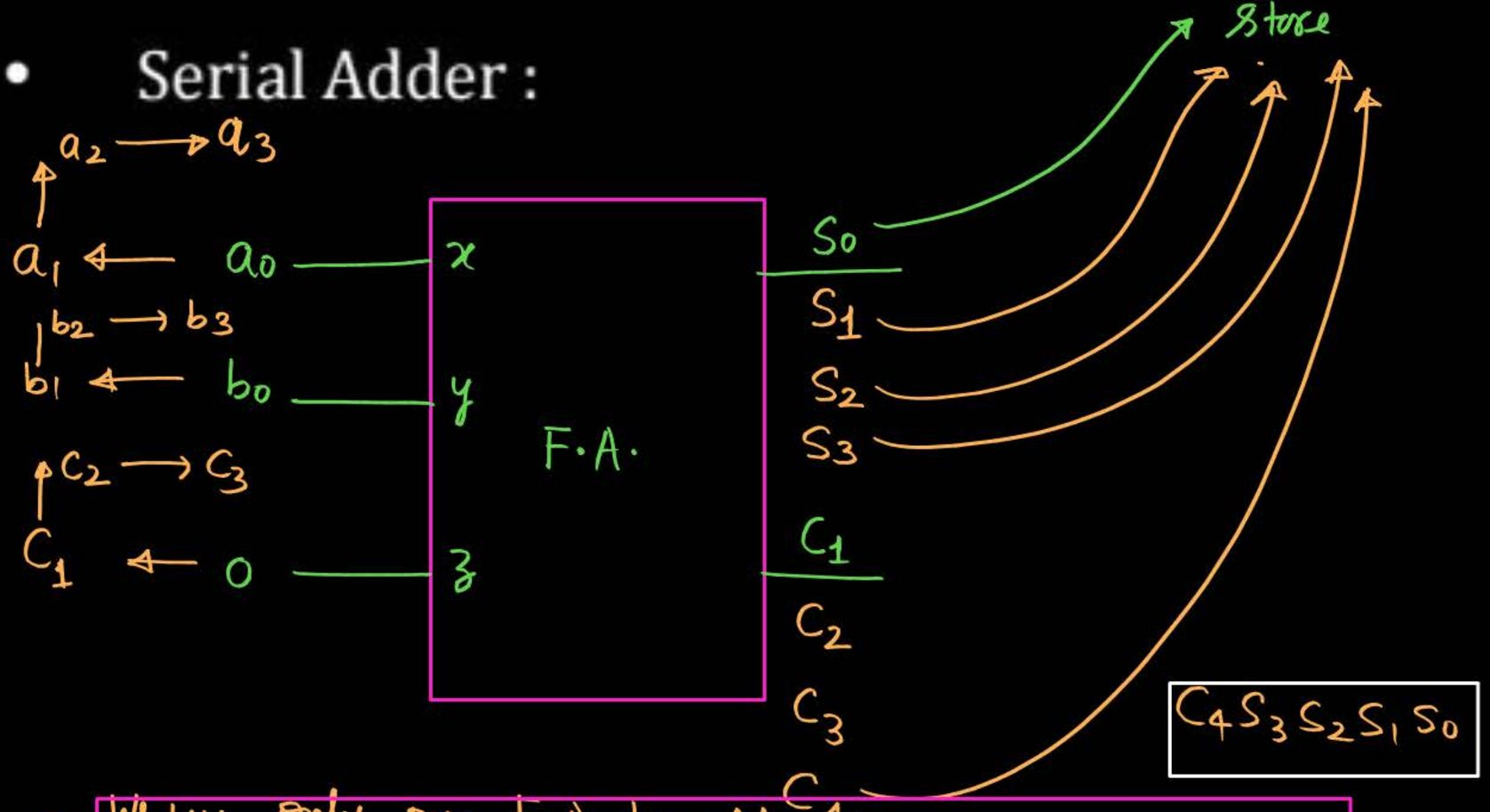
Combinational Circuit

By- Chandan Gupta Sir

H.A. , F.A

- F.A Cont.
- H.S., F.S.

- **Serial Adder :**



$C_4 S_3 S_2 S_1 S_0$

→ We use only one F.A to add two n-bit numbers and addition is performed serially and due to this delay is very high in serial adder to complete one addition.

$A = a_3 a_2 a_1 a_0$

$B = b_3 b_2 b_1 b_0$

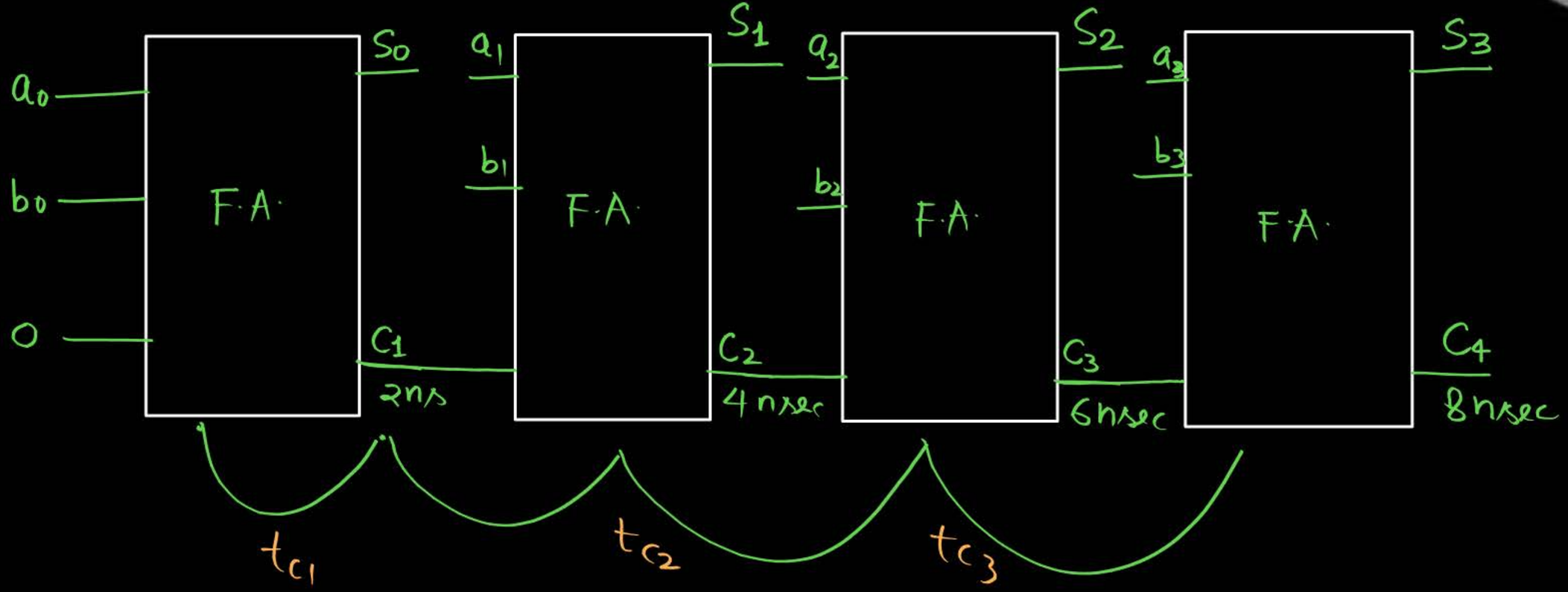
$+ \; c_3 c_2 c_1 0$

$C_4 S_3 S_2 S_1 S_0$

↓

Final result of addition

- Parallel Adder : or ripple carry adder



Case - I

Each F.A has sum delay $t_s = 3$ ns
& carry delay $t_c = 2$ nsec

6ns	4ns	2ns	
a_3	a_2	a_1	a_0
b_3	b_2	b_1	b_0
c_3	c_2	c_1	0
C_4	S_3	S_2	S_1	S_0
8ns	9ns	7ns	5ns	3ns

Overall delay $\Rightarrow T_d = 9$ ns

Case - II

Each F.A has sum delay $t_s = 1.5$ ns
Carry delay $t_c = 2$ nsec

6ns	4ns	2ns	
a_3	a_2	a_1	a_0
b_3	b_2	b_1	b_0
c_3	c_2	c_1	0
C_4	S_3	S_2	S_1	S_0
8 nsec	7.5 nsec	5.5 nsec	3.5 nsec	1.5 nsec

$\Rightarrow$ Overall delay $T_d = 8$ nsec

Overall delay $T_d = [t_{c1} + t_{c2} + t_{c3} + \cdots (n-1)\ F.A.] + \max[t_{cn}, t_{sn}]$ ✓

$t_{c1} = t_{c2} - - - - = t_{cn} = t_c$

$t_{s1} = t_{s2} - - - = t_{sn} = t_s$

$$T_d = (n-1)t_c + \max(t_c, t_s)$$

↓ overall delay or worst case delay or maximum delay

↳ time taken to complete one complete addition of two n-bit numbers.

Question 1

We have to add two 4-bit numbers A and B using parallel adder. Sum delay and carry delay of each F.A. is 3-nsec and 2-nsec respectively, then time required to perform complete addition

(a) 9 nsec
(b) 8 nsec
(c) 12 nsec
(d) 20 nsec

$t_s = 3ns$
$t_c = 2ns$

$T_d = 3t_c + \max(t_c, t_s) = 3 \times 2 + t_s = 9 nsec$

Question 2

If in above question sum delay is 2 nsec and carry delay is 3 nsec then time require to perform complete addition will be __12__ nsec.

$t_s = 2ns$

$t_c = 3ns$

$T_d = 3t_c + \max(t_c, t_s) = 9 + 3 = 12 nsec$

Question 3

We have two 100 bit numbers added using parallel adder. Sum and carry delay of each F.A. used are 2.24 nsec and 1.24 nsec respectively, then number of addition performed by this parallel adder in 1 sec

8 $\times 10^6$/sec.

$t_s = 2.24ns$
$t_c = 1.24ns$ $\longrightarrow$ $T_d = 99t_c + \max(t_c, t_s) = 99 \times 1.24 + 2.24 = 125ns$

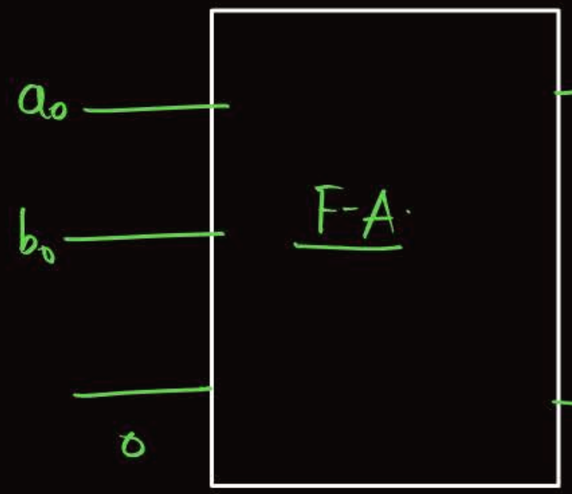
no. of addition in 1 sec $N = \frac{1\,sec}{125\,nsec} = \frac{1 \times 10^9\,nsec}{125\,nsec} = 8 \times 10^6$ additions

To add two n-bit numbers, how many H.A's & OR gates required :

$a_3\ a_2\ a_1\ a_0$

$b_3\ b_2\ b_1\ b_0$

$C_3\ C_2\ C_1\ 0$



$a_0 \oplus b_0 \oplus 0$

$= a_0 \oplus b_0$

$a_0 \cdot b_0 + (a_0 \oplus b_0) \cdot 0$

$= a_0 \cdot b_0$

$= (n-1)$ F.A + 1 H.A

$= (n-1)[2\text{ H.A} + 1\text{ OR}] + 1\text{ H.A}$

$= 2(n-1)$ H.A $+ (n-1)$ OR $+ 1$ H.A

$= (2n-1)$ H.A $+ (n-1)$ OR

Question 4

To add two 4-bit numbers, minimum number of H.A.s require is m and minimum number of OR gates require is n then value of $(m + n)$ is _____.

10

$\Rightarrow$ 3FA + 1H.A

6H.A + 3OR + 1H.A

7HA + 3OR

$m = 7$

$n = 3$

$(m+n) = 10$

2 Minute Summary

→ Delay in F.A.

Thank you

GW

Soldiers !