EC/EE/CS & IT/IN

Digital Electronics

Combinational Circuit-

COMPARATOR,

HA,FA,Multipler

LECTURE NO. 5

Chandan Jha Sir (CJ Sir)

मंजिल यूँ ही नहीं
मिलती राही को,
जूनून सा दिल में
जगाना पड़ता है,
पूछा चिड़िया से
कि घोसला कैसे बनता है
वो बोली कि तिनका-तिनका
उठाना पड़ता है.

ABOUT ME

- Cleared Gate Multiple times with double Digit Rank (AIR 23, AIR 26)
- Qualified ISRO Exam
- Mentored More then 1 Lakhs+ Students (Offline & Online)
- More then 250+ Motivational Seminar in various Engineering College including NITs & Some of IITs

Chandan Jha

Logic GATE

↳ INVERTER

$$f = \frac{1}{2N \times \tau_{pd}}$$

AND

OR

$Y = A \cdot B$

$Y = A + B$

TTL → 1

ECL → 0

Sunday

↳ Monday

NAND

NOR ?

$Y = \overline{A \cdot B}$

$Y = \overline{A + B}$

POS

SOP

$\rightarrow$ AND-OR

NAND-NAND

AOI

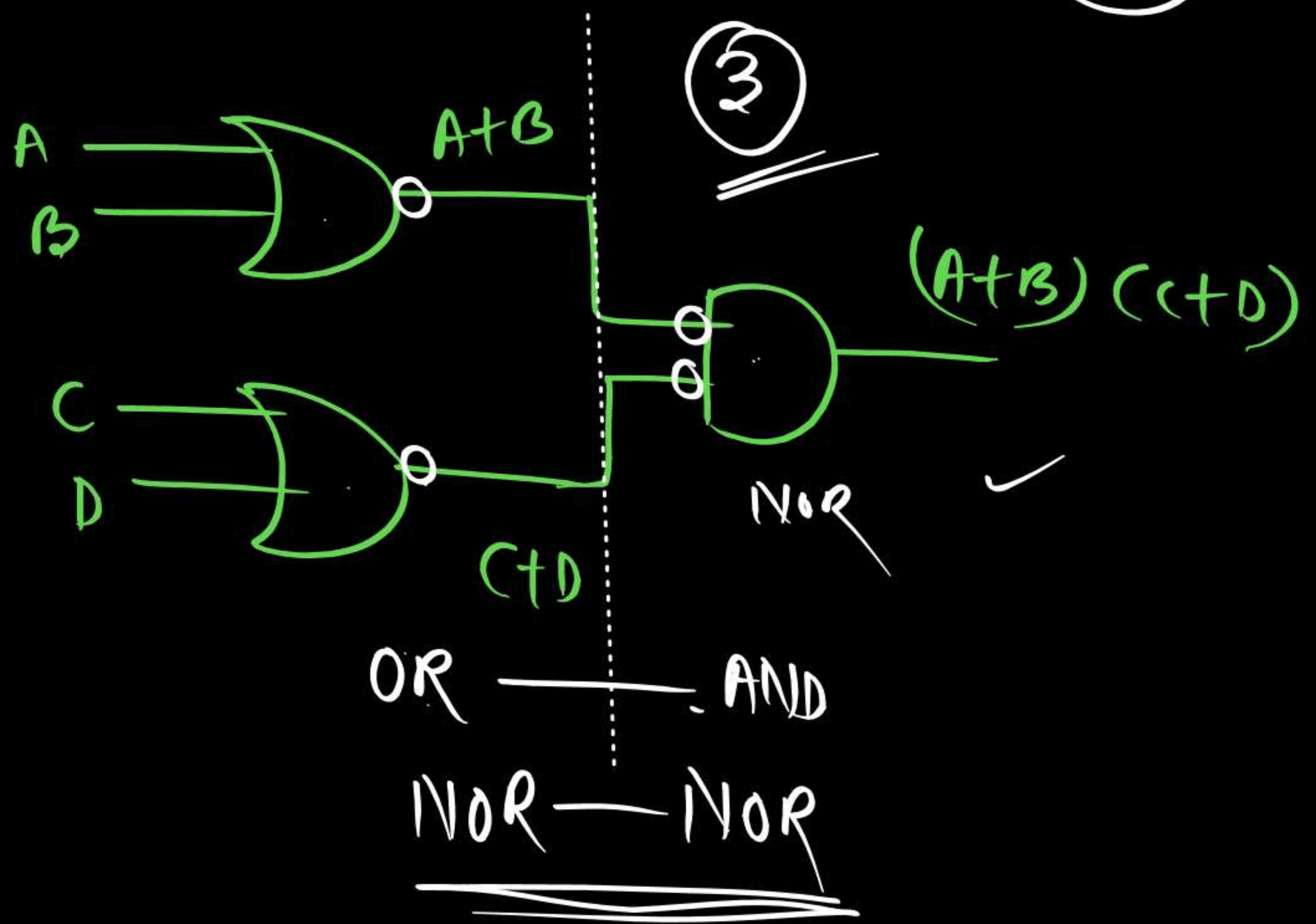
$\rightarrow$ OR-AND

NOR-NOR

AB+CD $\rightarrow$ 3

$f = (A+B)(C+D) \longrightarrow$ POS

NOR = ?



XOR

$$\left\{\begin{aligned} A \oplus A &= 0 \\ A \oplus 0 &= A \\ A \oplus \bar{A} &= 1 \\ A \oplus 1 &= \bar{A} \end{aligned}\right\}$$

1947

BJT

X-NOR

$$\left\{\begin{aligned} A \odot A &= 1 \\ A \odot 1 &= A \\ A \odot \bar{A} &= 0 \\ A \odot 0 &= \bar{A} \end{aligned}\right\}$$

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

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

Boolean algebra:

$\Rightarrow A + BC = (A+B)\cdot(A+C)$

$\Rightarrow AB + \bar{A}C + BC = AB + \bar{A}C$

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

$\Rightarrow \overline{ABC} = \bar{A} + \bar{B} + \bar{C}$

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

SOP

POS

K-MAP

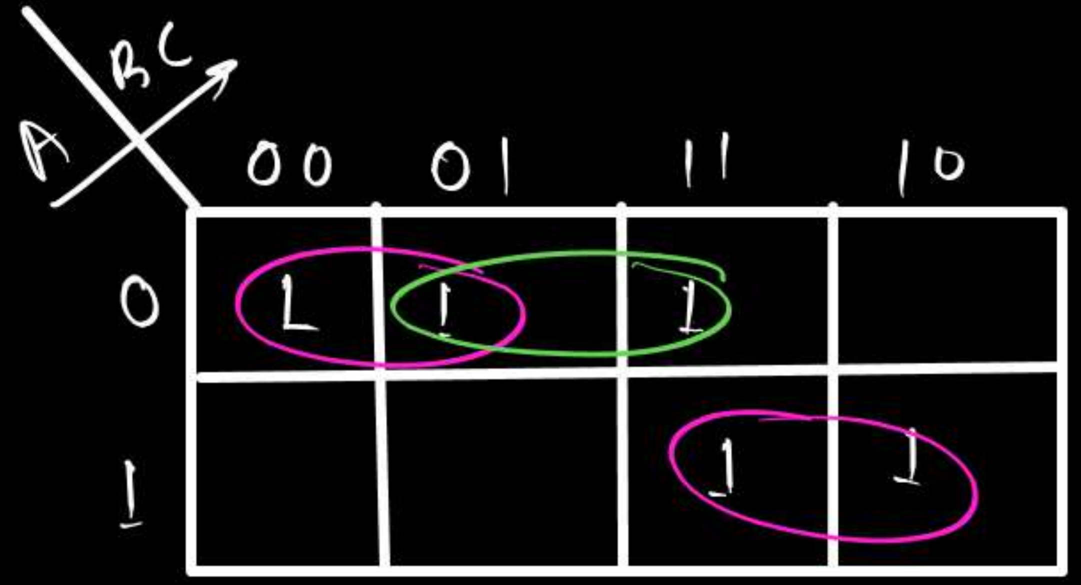
- Gray code
  - cyclic
  - Reflecting code
  - unity hamming distance code

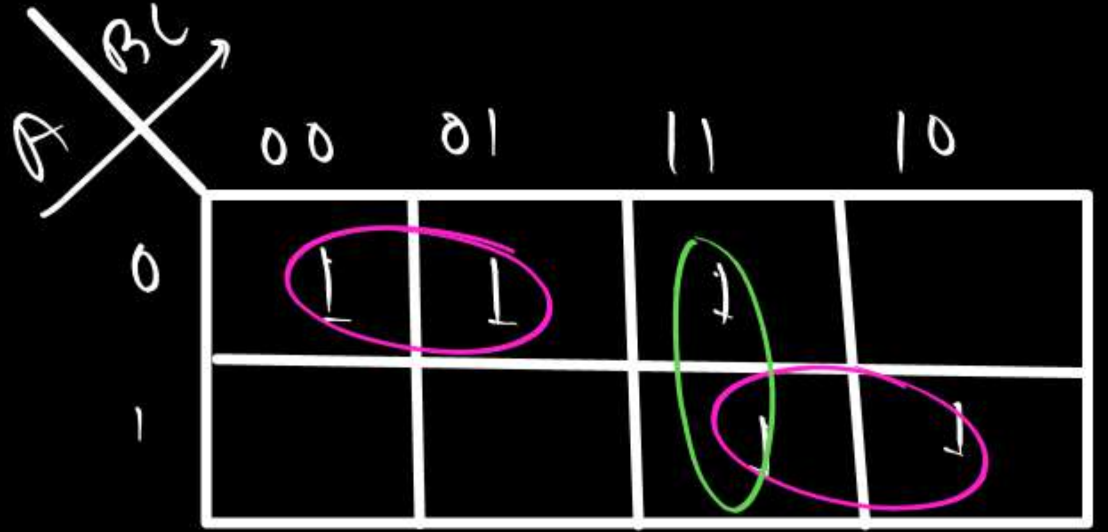
CJ BABA RULE

SOP, dont

POS

I, PI, EPI





$\{\bar{A}\bar{B}, AB, \bar{A}C, BC\}$

EPI

$= \bar{A}\bar{B} + AB + \bar{A}C$ → SPI

$= \bar{A}\bar{B} + AB + BC$ → RPI

I = 5

PI = 4

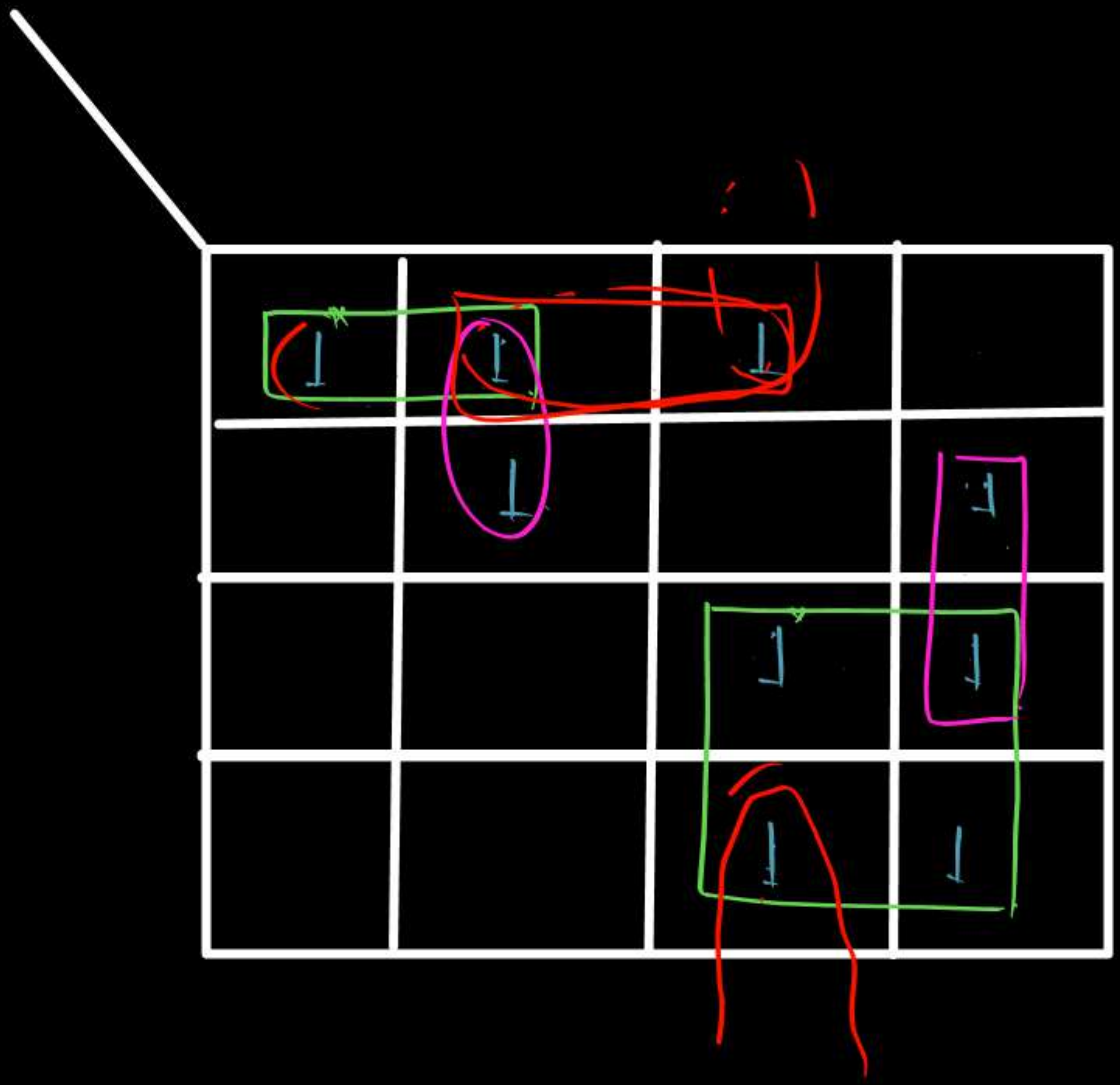
EPI = 2

SPI

RPI

SPI → Selective prime Implicant

RPI → Reduced prime Implicant



PI = 6

I = 9

EPI = 4

SPI = 1

RPI = 1

Combinational circuit

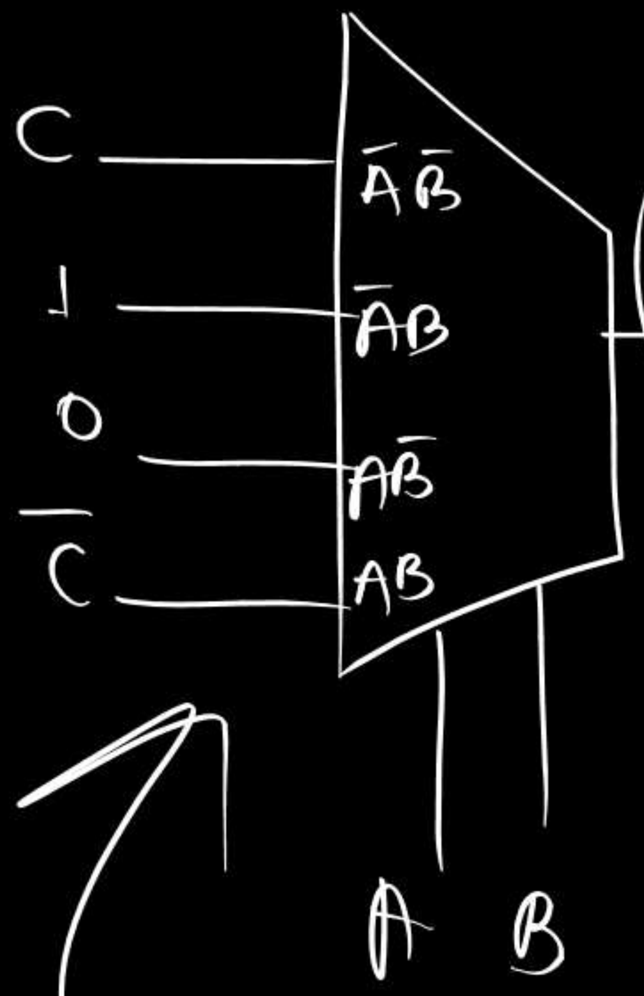
MUX → universal logic

2x1

4x1

8x1

AND-OR



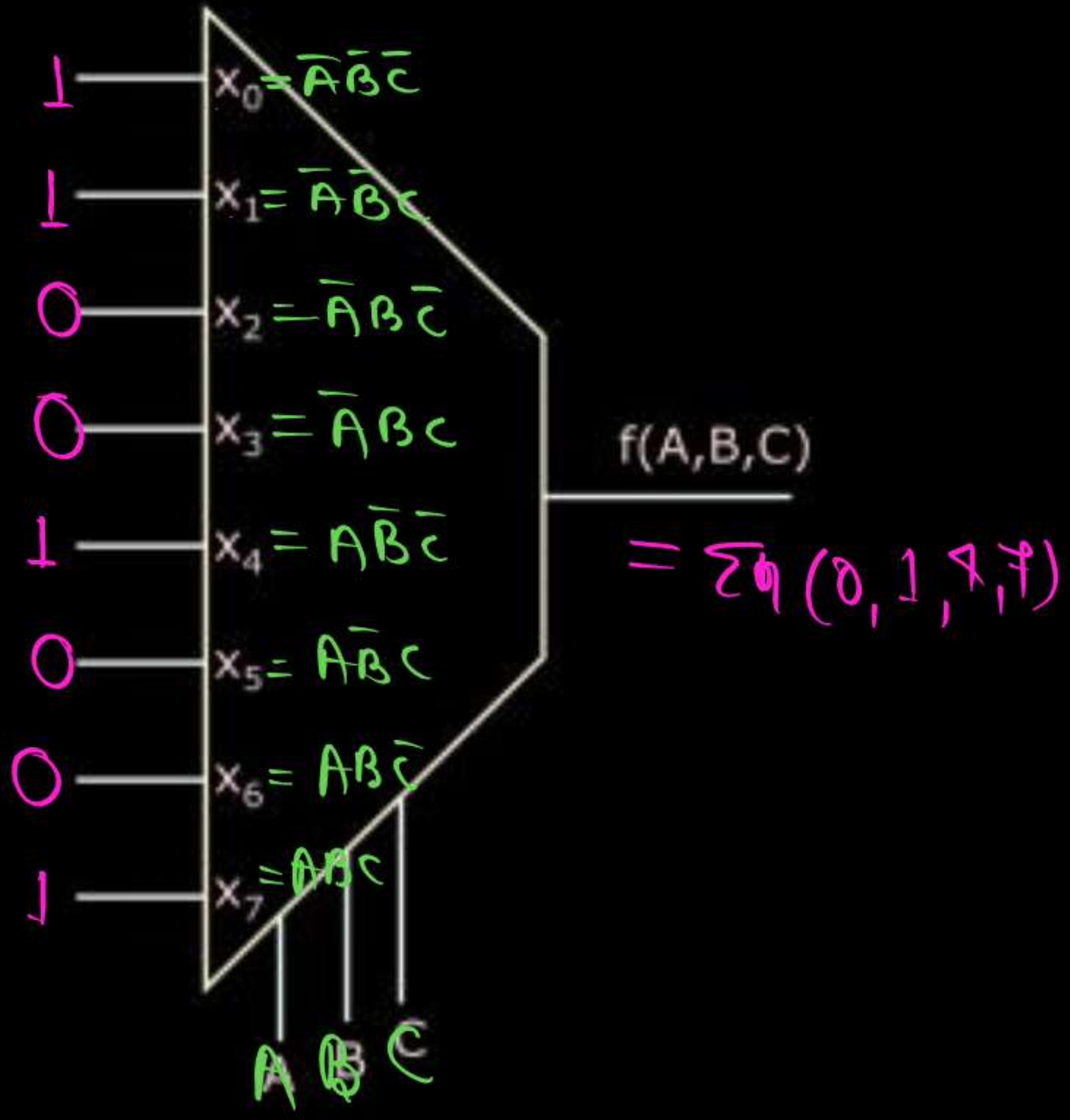
$$\bar{A}\bar{B}C + \bar{A}B + AB\bar{C}$$

Type -5. Implementation of function

Ex. Implement the function given below by using 8x1 Mux

$$f(A,B,C) = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$$

$$= \Sigma m(0,1,4,7)$$



Type -5. Implementation of function

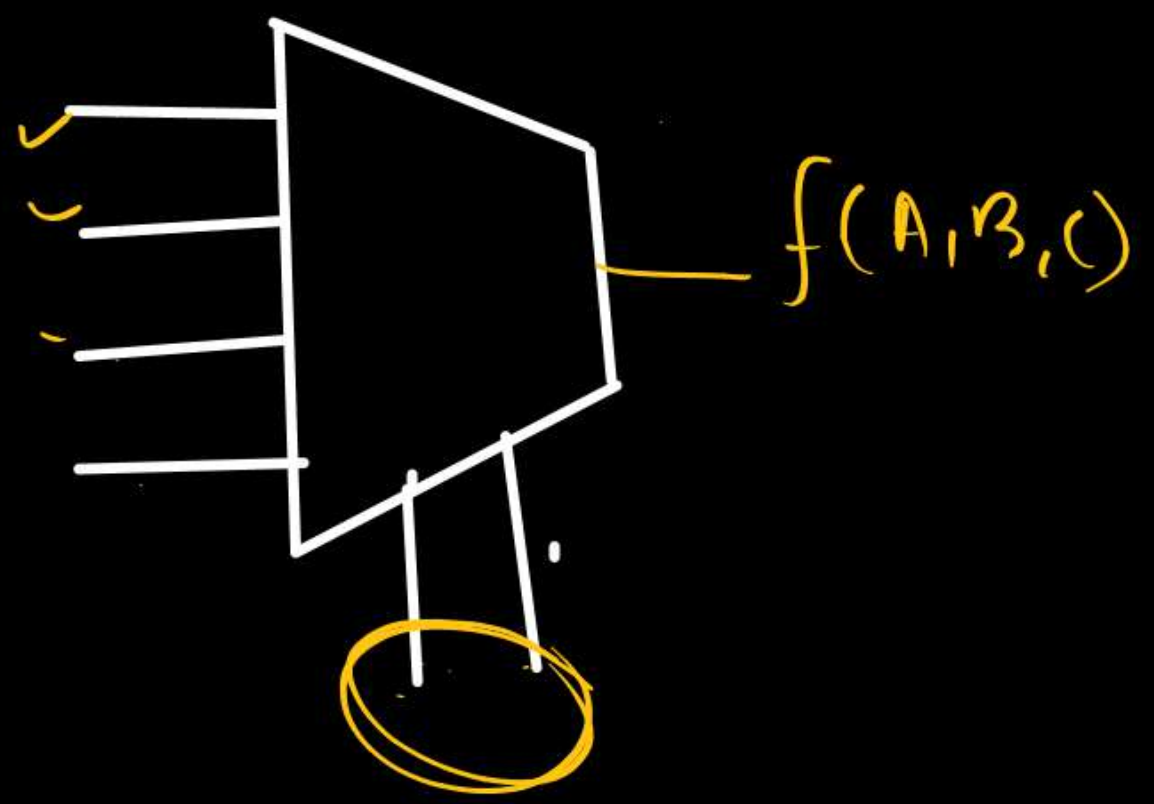
Ex. Implement the function given below by using 4x1 Mux

$$f(A,B,C) = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$$

no. of select line = 2.

$= \Sigma m(0,1,4,7)$

1. AB as a select line
2. BC as a select line
3. AC as a select line



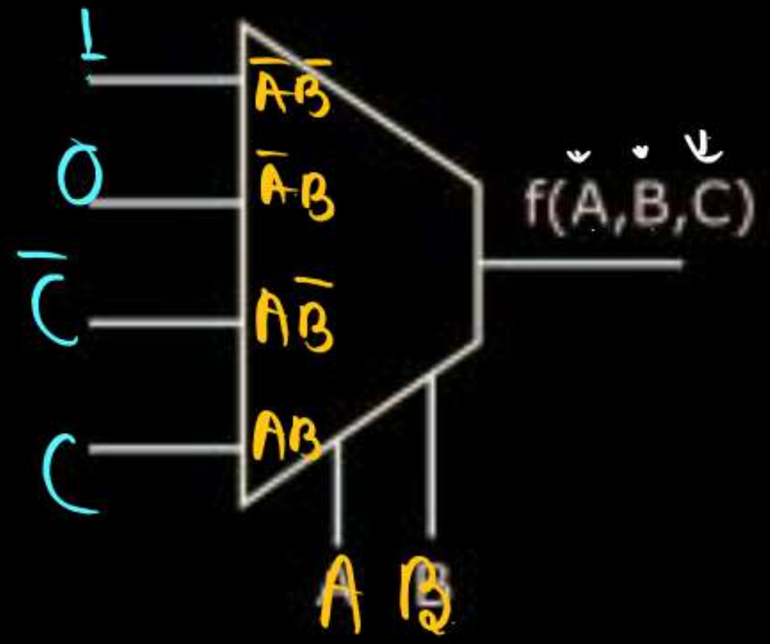
Type -5. Implementation of function

Ex. Implement the function given below by using 4x1 Mux

$$f(A,B,C) = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$$

$$= \Sigma m(0,1,4,7)$$

1. AB as a select line



	$\bar{A}\bar{B}$	$\bar{A}B$	$A\bar{B}$	AB
$\bar{C}$	$\bar{A}\bar{B}\bar{C}$ 0	$\bar{A}B\bar{C}$ 2	$A\bar{B}\bar{C}$ 4	$AB\bar{C}$ 6
C	$\bar{A}\bar{B}C$ 1	$\bar{A}BC$ 3	$A\bar{B}C$ 5	ABC 7
	1	0	$\bar{C}$	C

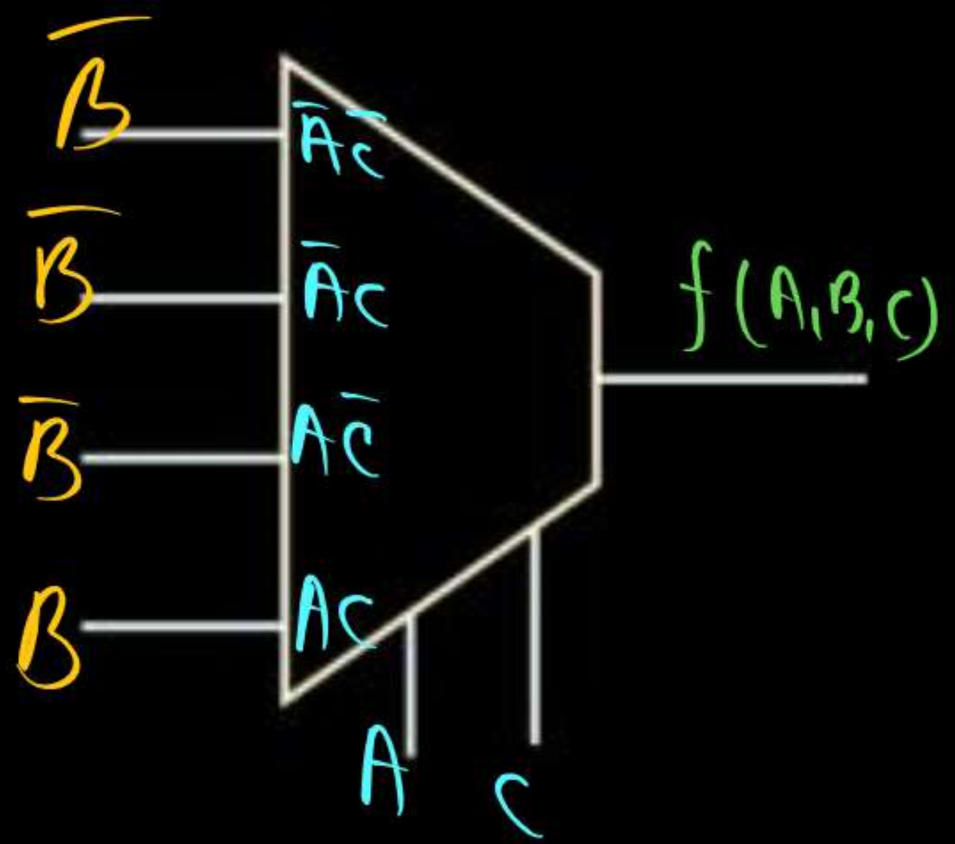
Type -5. Implementation of function

Ex. Implement the function given below by using 4x1 Mux

$$f(A,B,C) = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$$

$$= \Sigma m(0,1,4,7)$$

3. AC as a select line



	$\bar{A}\bar{C}$	$\bar{A}C$	$A\bar{C}$	AC
$\bar{B}$	$\bar{A}\bar{B}\bar{C}$ 0	$\bar{A}\bar{B}C$ 1	$A\bar{B}\bar{C}$ 4	$A\bar{B}C$ 5
B	$\bar{A}B\bar{C}$ 2	$\bar{A}BC$ 3	$AB\bar{C}$ 6	ABC 7
	$\bar{B}$	$\bar{B}$	$\bar{B}$	B

HW

$f(A,B,C) = \Sigma m(0, 1, 4, 7$

Q BC as a select line.

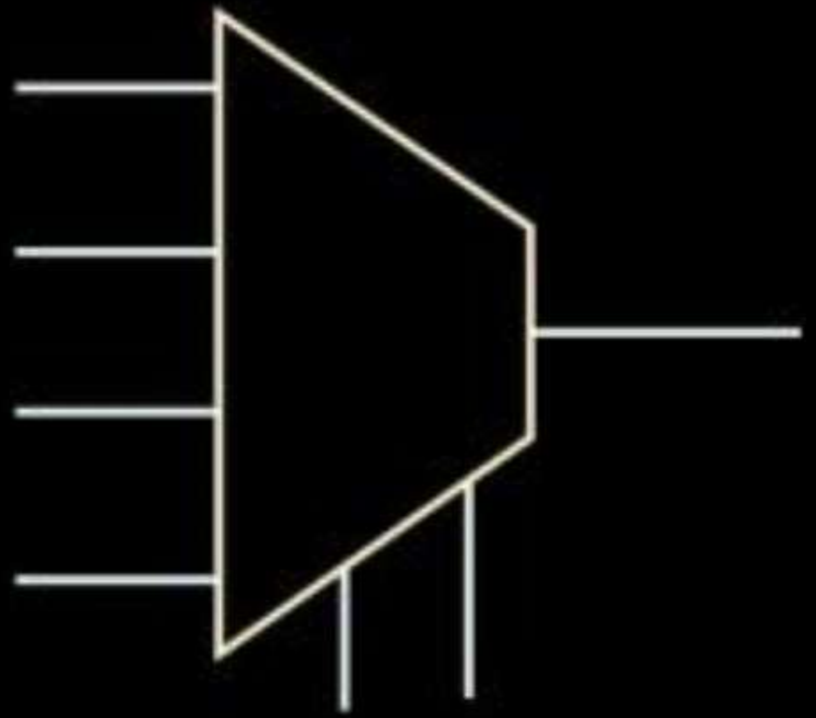
$\boxed{\text{Comment Box}}$

Type -5. Implementation of function

Ex. Implement the function given below by using 4x1 Mux

$$f(A,B,C) = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$$

2. BC as a select line



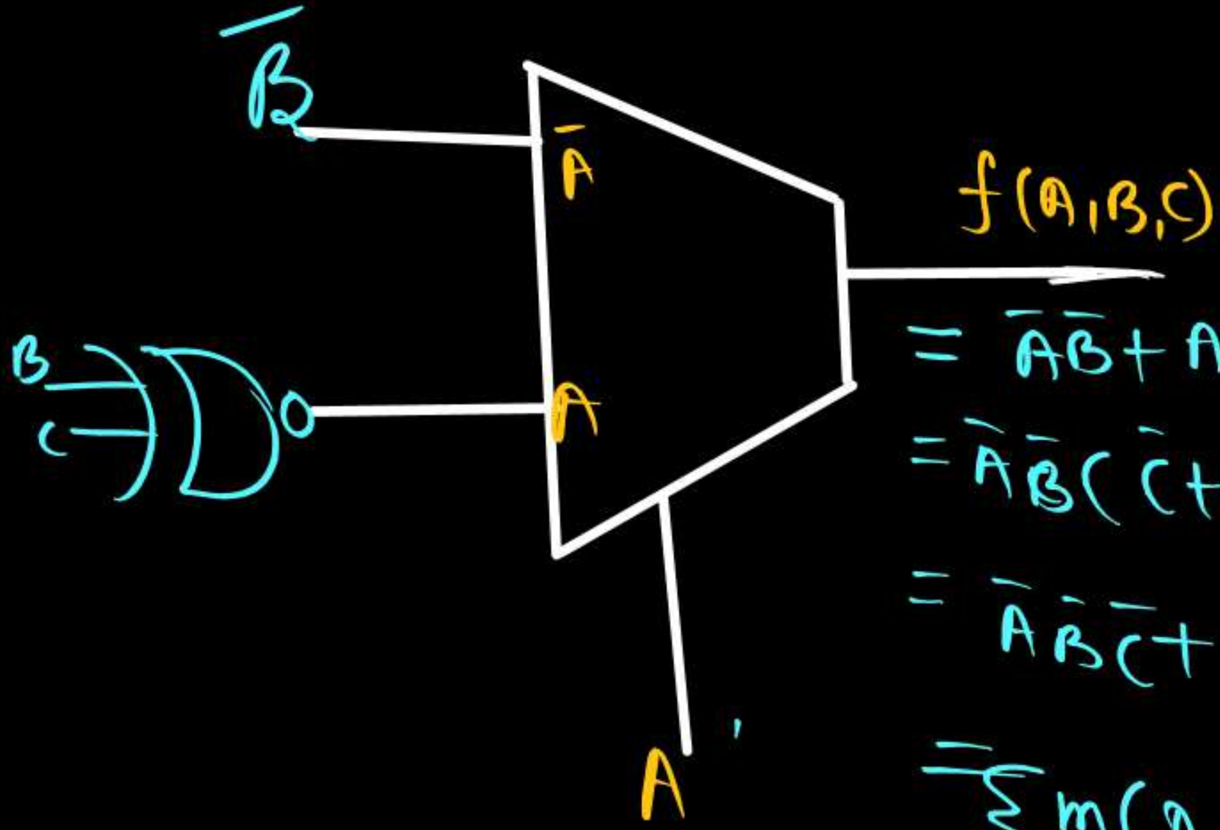
Type -5. Implementation of function

Ex. Implement the function given below by using 2x1 Mux

$$f(A, B, C) = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$$

Q $f(A,B,C) = \sum m(0,1,4,7) = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$

Implement by using 2X1 MUX ?



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

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

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

$= \sum m(0,1,4,7)$

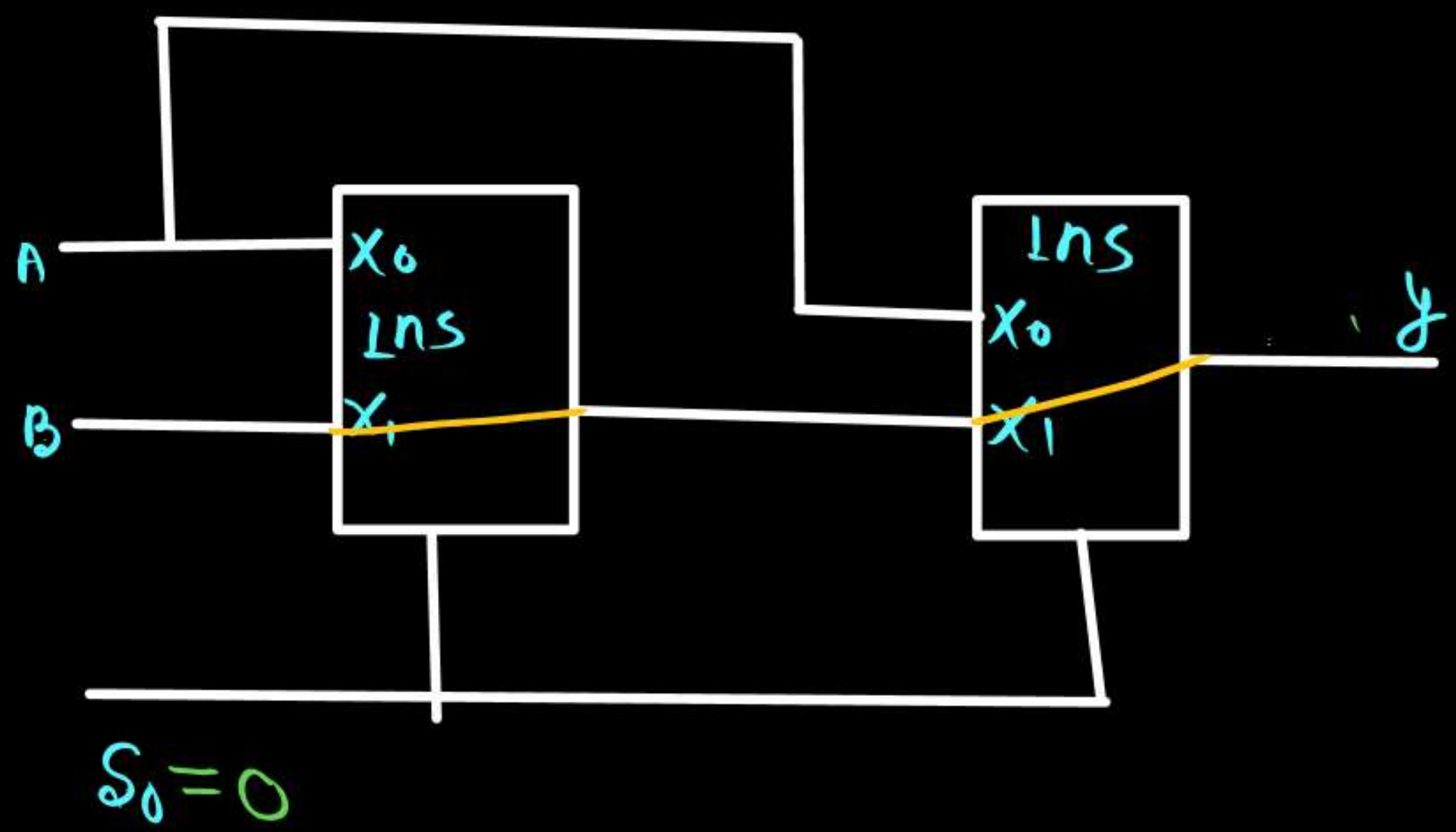
	$\bar{A}$ ✓	A ✓
$\bar{B}\bar{C}$	$\bar{A}\bar{B}\bar{C}$ 0	$A\bar{B}\bar{C}$ 4
$\bar{B}C$	$\bar{A}\bar{B}C$ 1	$A\bar{B}C$ 5
$B\bar{C}$	$\bar{A}B\bar{C}$ 2	$AB\bar{C}$ 6
BC	$\bar{A}BC$ 3	ABC 7
	$\bar{B}\bar{C} + \bar{B}C$ $\bar{B}(\bar{C} + C)$ $\bar{B}$ ✓	$\bar{B}\bar{C} + BC$ $B \odot B$ ✓

HW

Ex. $f(A,C,B,D) = \Sigma m\,(0, 1, 3, 5, 7, 9, 12, 15)$

1. ABD as select line

2. ACD as a select line.



Minimum Delay = 1ns.

Maximum Delay (Delay) = 2ns

Case (1) $S_0 = 0$

Delay = 1ns.

Case (2) $S_0 = 1$

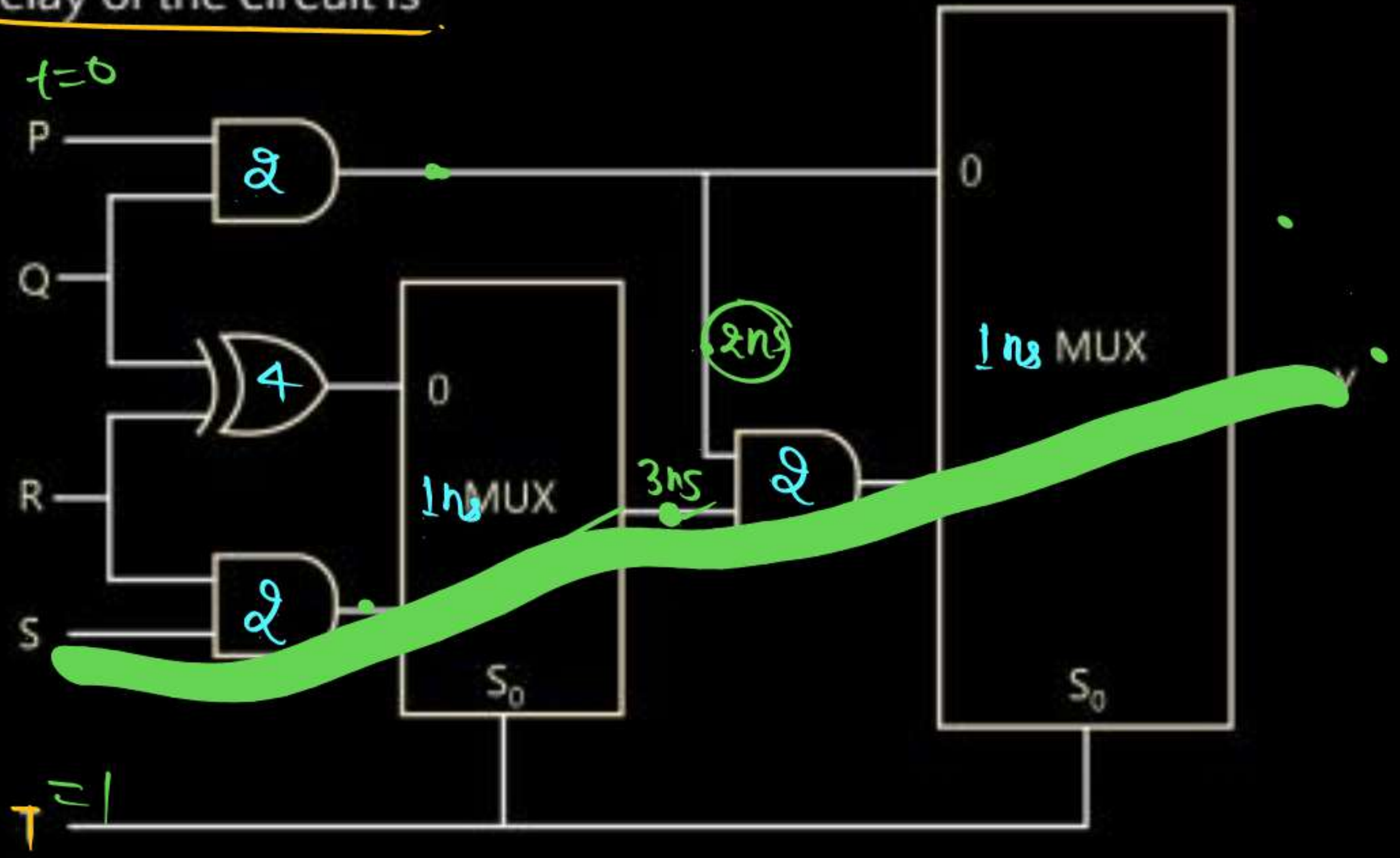
Delay = 2ns

Type -6. Delay in MUX

Q. The propagation delays of the XOR gate, AND gate and multiplexer (MUX) in the circuit shown in the figure are 4 ns, 2 ns and 1 ns, respectively.

If all the inputs P, Q, R, S and T are applied simultaneously and held constant, the maximum propagation delay of the circuit is

6ns



case(1) T=0

AND + MUX(2)

2+1 = 3ns

case(2) T=1

AND + MUX(1) + AND + MUX(2)

2+1+2+1 = 6ns

DESIGNING OF COMBINATIONAL CIRCUIT

Step 1. Find the number of inputs and outputs.

Step 2. Write the truth table.

Step 3. Write the logical expression.

Step 4. Minimize the logical expression.

Step 5. Hardware implementation.

single digit 75-80 EC 20

Magnitude Comparator

GATE ISRO

World Q-1 K-MAP

Network

ONE BIT MAGNITUDE COMPARATOR

Step-1

Step 2. Truth table

A	B	X (A>B)	Y (A<B)	Z (A=B)
0	0	0	0	1
0	1	0	1	0
1	0	1	0	0
1	1	0	0	1

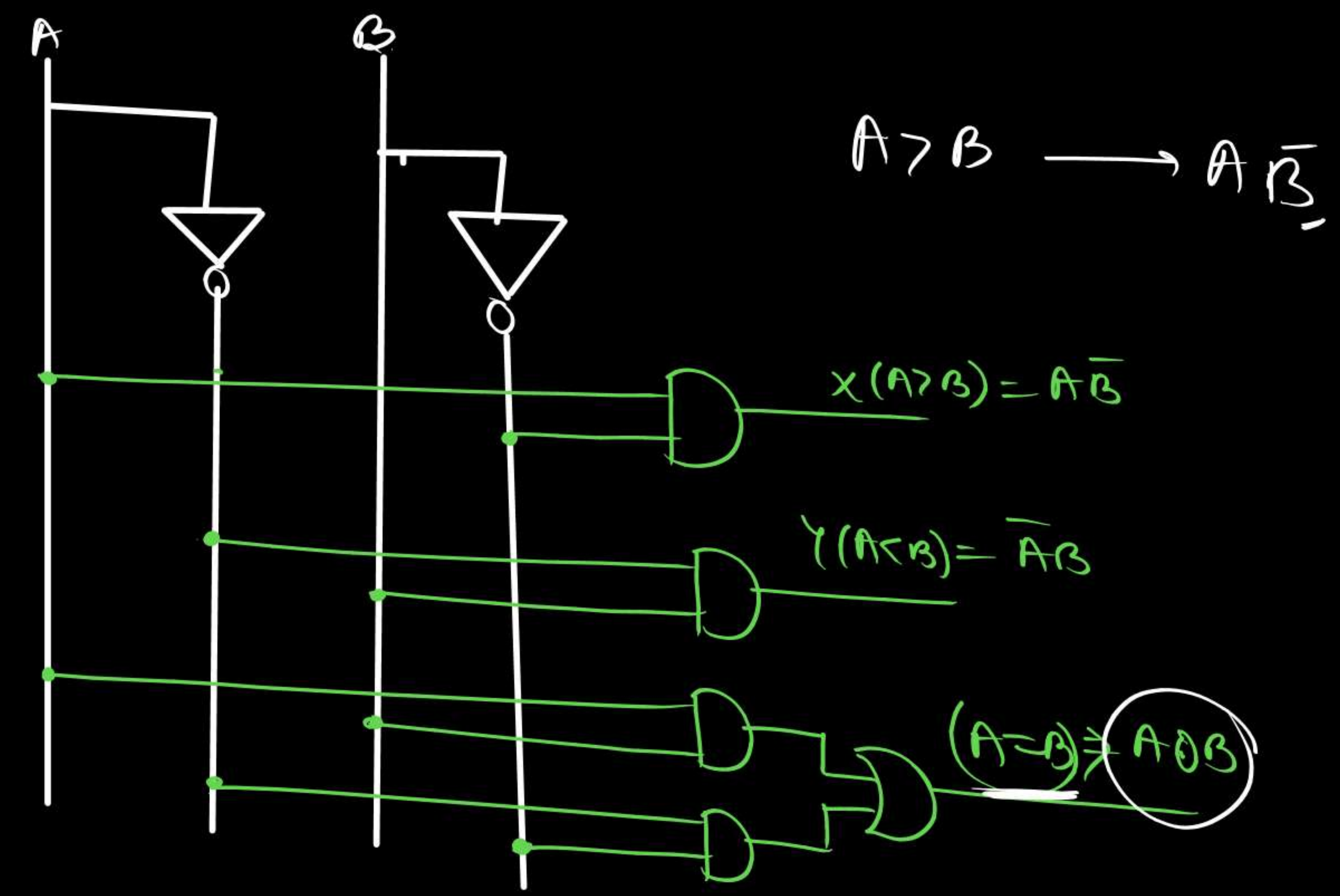
Step 3.

$X(A>B) = A\bar{B}$

$Y(A<B) = \bar{A}B$

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

Step 4:


A
B
A>B ⟶ AB̄
X(A>B) = AB̄
Y(A<B) = ĀB
(A=B) = A⊙B

One bit comparator

Total combination = 4

Equal combination = 2

Unequal combination = 2

Greater = Less = 1

TWO BIT MAGNITUDE COMPARATOR

Step-1

Step 2.

	A		B		A>B	(A<B)	(A=B)
	A_1	A_0	B_1	B_0	x	y	Z
0	0	0	0	0	0	0	1
1	0	0	0	1	0	1	0
2 →	0	0	1	0	0	1	0
3 →	0	0	1	1	0	1	0
4 →	0	1	0	0	1	0	0
5 →	0	1	0	1	0	0	1
6 →	0	1	1	0	0	1	0
7 →	0	1	1	1	0	1	0
8 →	1	0	0	0	1	0	0
9 →	1	0	0	1	1	0	0
10 →	1	0	1	0	0	0	1
11 →	1	0	1	1	0	1	0
12 →	1	1	0	0	1	0	0
13 →	1	1	0	1	1	0	0
14 →	1	1	1	0	1	0	0
15 →	1	1	1	1	0	0	1

$$X(A>B) = \Sigma m(4, 8, 9, 12, 13, 14)$$

$A_1A_0 \backslash B_1B_0$	00	01	11	10
00				
01	1			
11	1	1		1
10	1	1		

$$y(A<B) = \Sigma m(1, 2, 3, 6, 7, 11)$$

$A_1A_0 \backslash B_1B_0$	00	01	11	10
00		1	1	1
01			1	1
11				
10			1	

$$X(A>B) = A_1\bar{B}_1 + A_0\bar{B}_1\bar{B}_0 + A_1A_0\bar{B}_0$$ ← minimized expression

$$= A_1\bar{B}_1 + \bar{A}_1A_0\bar{B}_1\bar{B}_0 + A_1A_0B_1\bar{B}_0$$

$$= A_1\bar{B}_1 + (\bar{A}_1\bar{B}_1 + A_1B_1)\cdot A_0\bar{B}_0$$

$$\boxed{= A_1\bar{B}_1 + (A_1 \odot B_1)\cdot A_0\bar{B}_0}$$ → Semimized

$$Y(A<B) = \bar{A}_1B_1 + \bar{A}_1\bar{A}_0B_0 + \bar{A}_0B_1B_0$$

→ Minimized

$$\boxed{Y(A<B) = \bar{A}_1B_1 + (A_1 \odot B_1)\bar{A}_0B_0}$$

$$\boxed{Z(A=B) = (A_1 \odot B_1)\cdot(A_0 \odot B_0)}$$

Two bit comparator

Total combination = 16

Equal combination = 4

Unequal combination = 12

Greater = Less = 6

Three bit comparator

Total combination = 64

Equal combination = 8

unequal combination = 56

Greater = Less = 28

"n" bit comparator

Total combination = 2^{2n}

Equal combination = 2^n

unequal combination = $2^{2n} - 2^n$

Greater = Less = $\dfrac{2^{2n} - 2^n}{2}$

Seminimized

$$A \quad = \quad B$$

$A_1 \quad A_0 \qquad B_1 \quad B_0$

$2 \quad 3 \qquad 2 \quad 3$

$A > B \rightarrow A\bar{B}$

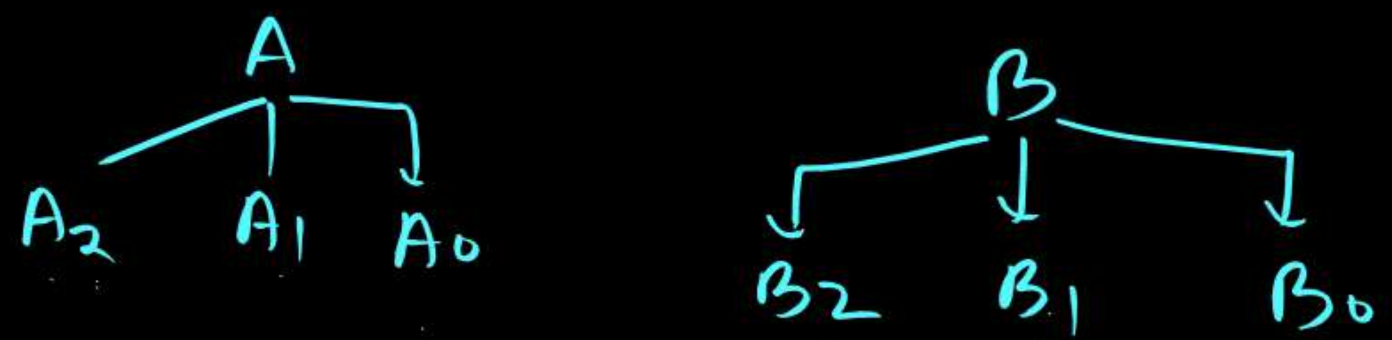
$A < B \Rightarrow \bar{A}B$

$A = B \Rightarrow A \odot B$

$$A > B \Rightarrow A_1\bar{B}_1 + (A_1 \odot B_1)\cdot A_0\bar{B}_0$$

$$A < B \Rightarrow \bar{A}_1 B_1 + (A_1 \odot B_1)\bar{A}_0 B_0$$

$$A = B \Rightarrow (A_1 \odot B_1)\cdot(A_0 \odot B_0)$$



$A > B$ $\quad A_2\overline{B_2} + (A_2 \odot B_2)\,A_1\overline{B_1} + (A_2 \odot B_2)\cdot(A_1 \odot B_1)\,A_0\overline{B_0}$

$A < B$ $\quad \overline{A_2}B_2 + (A_2 \odot B_2)\,\overline{A_1}B_1 + (A_2 \odot B_2)\cdot(A_1 \odot B_1)\cdot\overline{A_0}B_0$

$A = B$ $\quad (A_2 \odot B_2)\,(A_1 \odot B_1)\cdot(A_0 \odot B_0)$

$\longrightarrow 2^{2^n}$

$\longrightarrow 2^n$

$\longrightarrow 2^{2^n} - 2^n$

$\longrightarrow \dfrac{2^{2^n} - 2^n}{2}$

जुनून होना चाहिए
लक्ष्य को पाने के लिए,
सपना तो हर कोई देखता है
दूसरों को बताने के लिए.

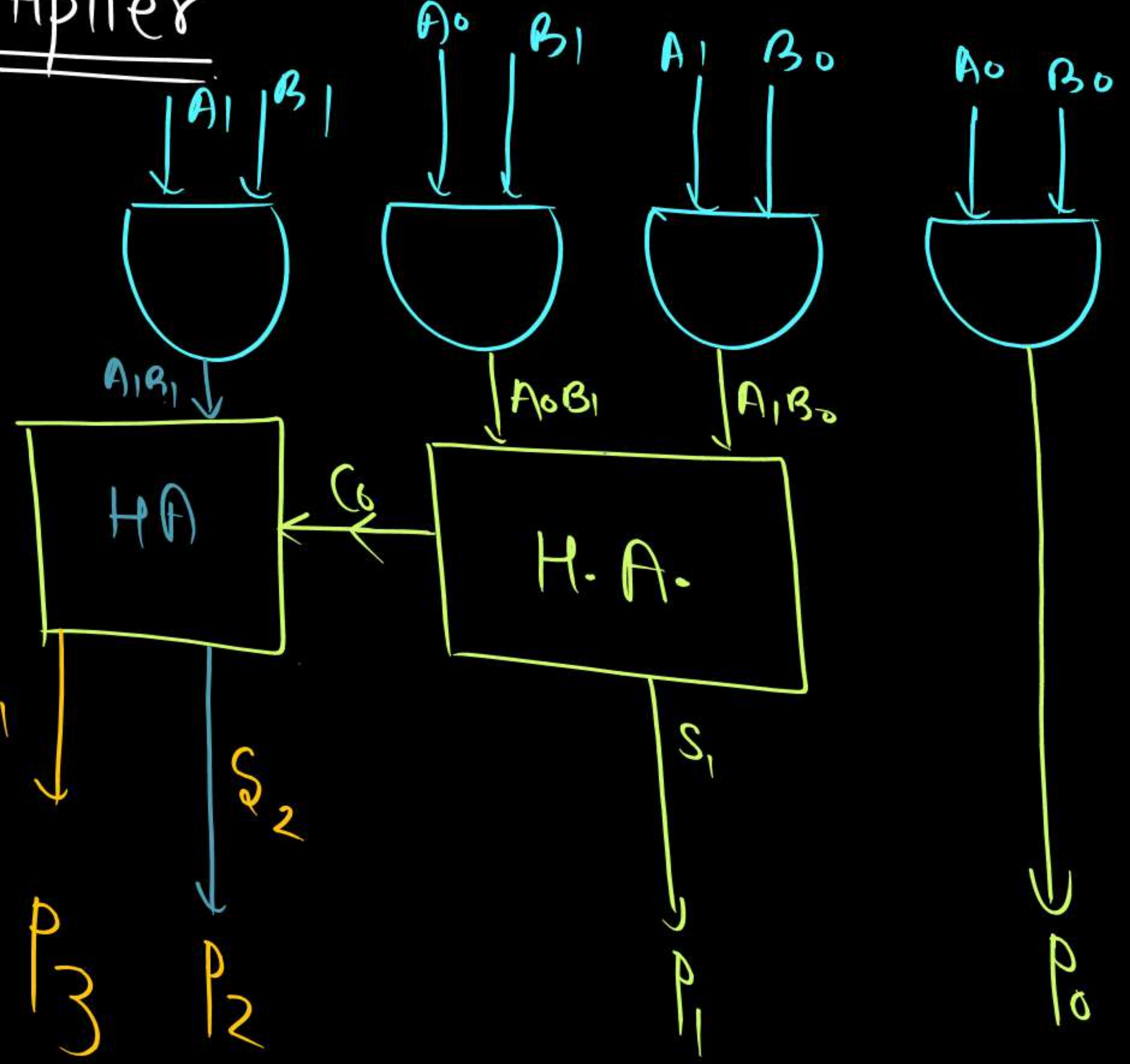
Multiplier

2 bit multiplier

$A \longrightarrow A_1 \quad A_0$

$B \longrightarrow B_1 \quad B_0$

	C_0	A_1B_0	A_0B_0
	A_1B_1	A_0B_1	$\times$
C_1	S_2	S_1	S_0
P_3	P_2	P_1	P_0



"सोचने से मिलते नहीं तमन्नाओं के शहर मंज़िल को पाने के लिए चलना भी जरूरी है"

$f = A + \overline{BC}$

NAND = ?

NOR = ?

8:00AM

4P

THANK YOU!