EC/EE/CS & IT/IN

Digital Electronics

Combinational Circuit

MULTIPLEXER

LECTURE NO. 4

Chandan Jha Sir (CJ Sir)

बिना संघर्ष कोई महान नही होता
बिना कुछ किये जय जय कार नही होता
जब तक नहीं पड़ती हथोड़े की चोट
तब तक कोई पत्थर भी
लोगों के लिए भगवान नही होता

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

DON'T CARE CONDITION

Sunday → Evening 6:00 PM.

Combination of inputs on which the output may or may not depends are called don't care condition.

Ex. 9. Find the minimized Boolean expression for the function given as

$$f(A, B, C) = \sum m(0, 2, 3, 4) + \sum d(1, 6, 7)$$

A \ BC	00	01	11	10
0	1	X	1	1
1	1		X	X

Ex. 10. Find the minimized Boolean expression for the function given as

$f(A, B, C, D) = \sum m\,(0, 2, 4, 6, 7, 8, 10, 11, 12, 14, 15) + \sum d(1,3)$

$AB \backslash CD$	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	1	X	X	1
$\bar{A}B$ 01	1		1	1
AB 11	1		1	1
$A\bar{B}$ 10	1		1	1

C

$\bar{D}$

$C + \bar{D}$

Ans

Ex. 11 Find the minimized Boolean expression for the function given as $f(A, B, C, D) = \sum m(0,3,6,7,9,14) + \sum d(1,4,5,11,13,15)$

$AB \backslash CD$	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	1	X	1	
$\bar{A}B$ 01	X	X	1	1
AB 11		X	X	1
$A\bar{B}$ 10		1	X	

$\bar{A}\bar{C}$

D

BC

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

Ans

POS FORM Question

Product of Sum

Ex. 12. Find the minimized Boolean expression for the function given as

$$f(A, B, C) = \underbrace{\pi M}_{POS}(0, 2, 3, 4, 6, 7)$$

Method-1

A \ BC			$B+C$ $\bar{B}\bar{C}$ 00	$B+\bar{C}$ $\bar{B}C$ 01	$\bar{B}+\bar{C}$ BC 11	$\bar{B}+C$ $B\bar{C}$ 10
A	$\bar{A}$	0	0		0	0
$\bar{A}$	A	1	0		0	0

C

$\bar{B}$

$\bar{B}\cdot C$

Method-2

A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	0		0	0
A 1	0		0	0

$\bar{C}$

B

$$\bar{F} = \bar{C} + B$$

$$F = \overline{\bar{C} + B} = \bar{\bar{C}} \cdot \bar{B} = \bar{B} \cdot C \text{ Ans}$$

$$f(A,B,C) = \Pi M(0,2,3,4,6,7) \longrightarrow \text{POS}$$

$$= \Sigma m(1,5)$$

$A \backslash BC$	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	0	1	0	0
A 1	0	1	0	0

$\bar{B}C$

Ans

Ex. 13. Find the minimized Boolean expression for the function given as

$f(A, B, C, D) = \pi M(0, 2, 3, 4, 7, 8, 10, 11, 13, 14, 15)$

$A+C+D$

$\bar{C}+\bar{D}$

$AB \backslash CD$	$C+D$ $\bar{C}\bar{D}$ 00	$C+\bar{D}$ $\bar{C}D$ 01	$\bar{C}+\bar{D}$ CD 11	$\bar{C}+D$ $C\bar{D}$ 10
$\bar{A}\bar{B}$ 00 $A+B$	0	1	0	0
$\bar{A}B$ 01 $A+\bar{B}$	0	1	0	1
AB 11 $\bar{A}+\bar{B}$	1	0	0	0
$A\bar{B}$ 10 $\bar{A}+B$	0	1	0	0

$B+D$

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

$\bar{A}+\bar{B}+\bar{D}$

POS

$(\bar{A}+\bar{B}+\bar{D})\cdot(\bar{A}+\bar{C})\cdot(A+C+D)$

$(B+D)\cdot(\bar{C}+\bar{D})$

SOP

$A \backslash B$	$\bar{B}$ (0)	B (1)
$\bar{A}$ (0)	1	1
A (1)	0	1

$\bar{A} \cdot 1 = \bar{A}$

$B \cdot 1 = B$

$\bar{A} + B$

$$f(A,B) = \bar{A}\bar{B} \cdot 1 + \bar{A}B \cdot 1 + \cancel{A\bar{B} \cdot 0} + AB \cdot 1$$

$$= \Sigma m(0, 1, 3)$$

Ex

$A \backslash B$	$\bar{B}$ (0)	B (1)
$\bar{A}$ (0)	C	C
A (1)		

$\rightarrow \bar{A} \cdot C$

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

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

$$= \bar{A}C$$

$\bar{A}C$

Ans

$A \backslash BC$	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	1	1		
A 1			$\bar{D}$	$\bar{D}$

→ standard canonical

Q $f(A,B,C,D) = \bar{A}\bar{B}\bar{C}\cdot 1 + \bar{A}\bar{B}C\cdot 1 + ABCD + AB\bar{C}\bar{D}$

$$f(A,B,C,D) = \bar{A}\bar{B}\bar{C}(\bar{D}+D) + \bar{A}\bar{B}C(\bar{D}+D) + ABCD + AB\bar{C}D$$

$$= \overset{0000}{\bar{A}\bar{B}\bar{C}\bar{D}} + \overset{0001}{\bar{A}\bar{B}\bar{C}D} + \overset{0010}{\bar{A}\bar{B}C\bar{D}} + \overset{0011}{\bar{A}\bar{B}CD} + ABCD + \overset{1101}{AB\bar{C}D}$$

$$= \Sigma m(0,1,2,3,13,15)$$

$$f(A,B,C,D) = \sum m(0,1,2,3,13,15)$$

AB \ CD	$\bar C \bar D$ 00	$\bar C D$ 01	CD 11	$C\bar D$ 10
$\bar A \bar B$ 00	1	1	1	1
$\bar A B$ 01				
AB 11		1	1	
$A\bar B$ 10				

$\rightarrow \bar A \bar B$

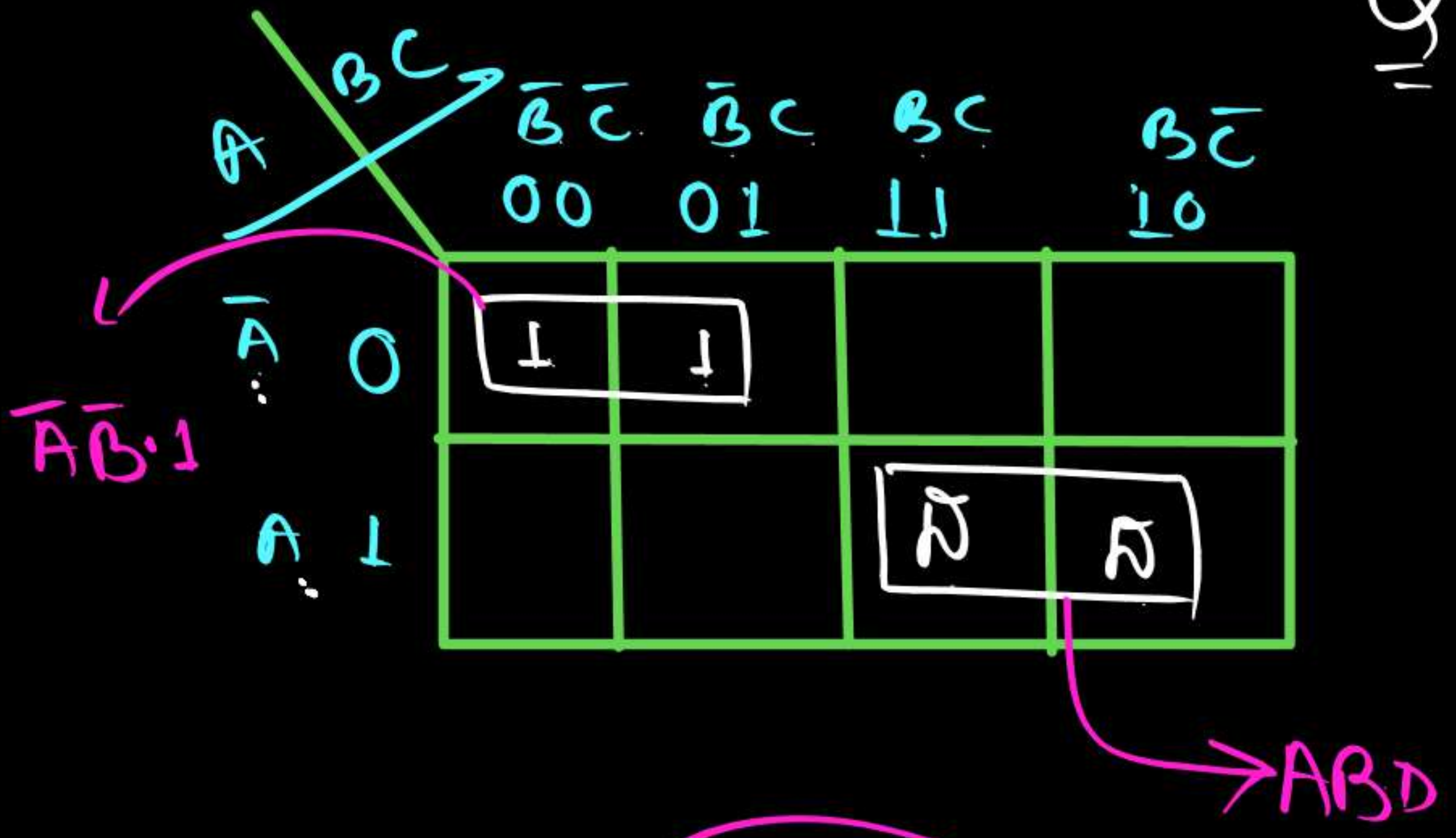
$\rightarrow ABD$

$$= \bar A \bar B + ABD$$

Ans

Q $f(A,B,C,D) = \bar{A}\bar{B}\bar{C}\cdot 1 + \bar{A}\bar{B}C\cdot 1 + ABCD$
$+ AB\bar{C}D$

3 Variable



$\bar{A}\bar{B} + ABD$

Ans

Implicants , Prime Implicants, Essential Prime Implicants

$= \Sigma m(0, 1, 3, 6, 7)$

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

A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	1	1	1	
A 1			1	1

$= \bar{A}\bar{B} + AB + \bar{A}C$ ✓

A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	1	1	1	
A 1			1	1

$= \bar{A}\bar{B} + AB + BC$ ✓

Implicants = 5

Prime Implicants = 4

Essential prime Implicants = 2

Ex

$A \backslash BC$	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	1	1		1
A 1		1	1	1

$= \bar{A}\bar{B} + B\bar{C} + AC$ ✓

$A \backslash BC$	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	1	1		1
A 1		1	1	1

$= \bar{A}\bar{C} + \bar{B}C + AB$ ✓

Implicants = 6

Prime Implicants = 6

EPI = 0

Ex

$$\boxed{= \bar{A}\bar{C}D + \bar{A}BC + AB\bar{C} + ACD}$$

RPI

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00		1		
$\bar{A}B$ 01		1	1	1
AB 11	1	1	1	
$A\bar{B}$ 10			1	

I = 8

PI = 5

EPI = 4

RPI = 1

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	1	1		
$\bar{A}B$ 01		1	1	
AB 11			1	1
$A\bar{B}$ 10				1

$I = 7$

$PI = 6$

$EPI = 2$


Mountain Dew
Darr
ke aage
jeet
hai

Designing of Combinational Circuit

Step 1. Find the number of inputs & output

Step 2. Write the truth table.

Step 3. Write the logical Expression.

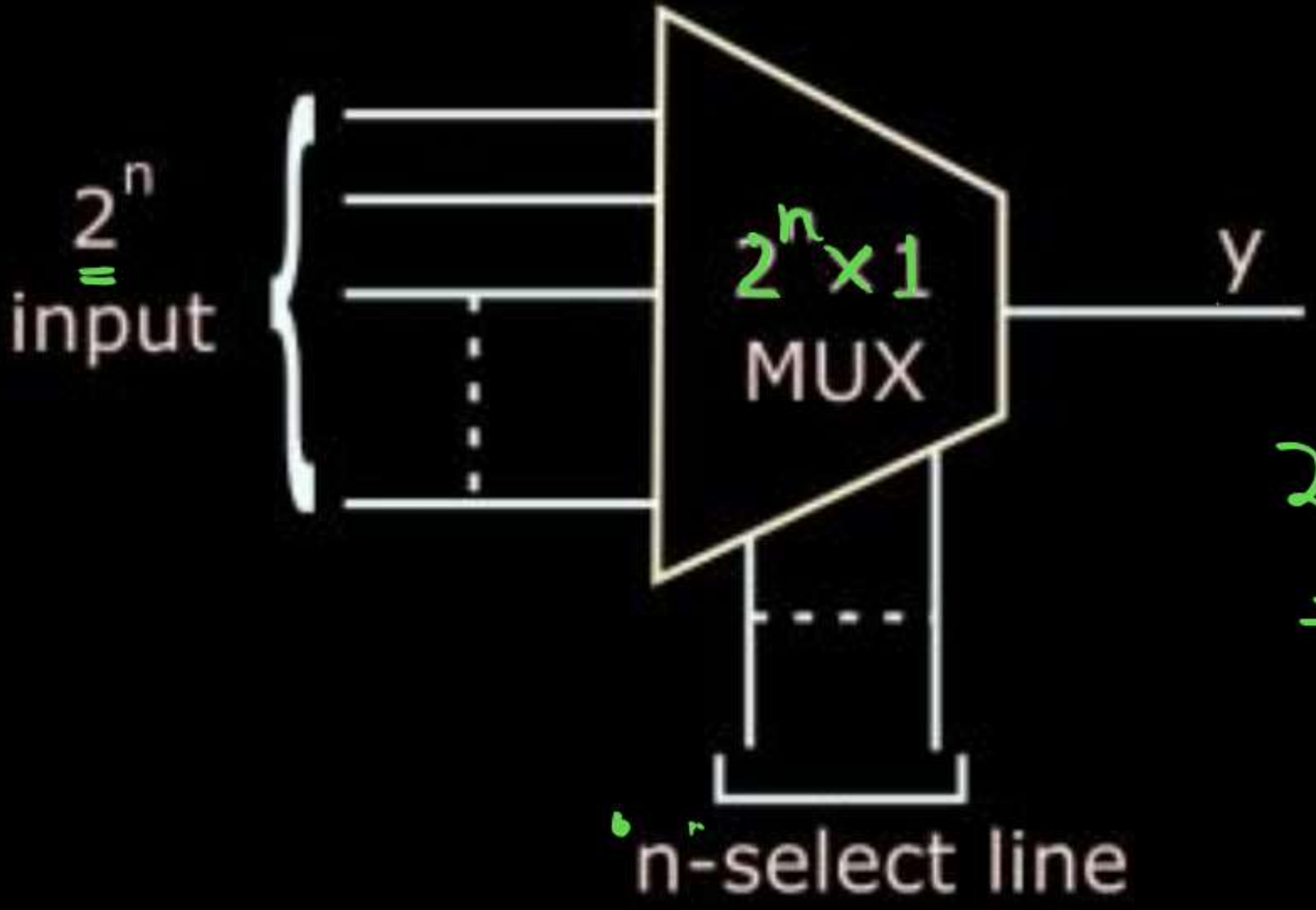
Step 4. Minimize the logical Expression.

Step 5. Hardware Implementation.

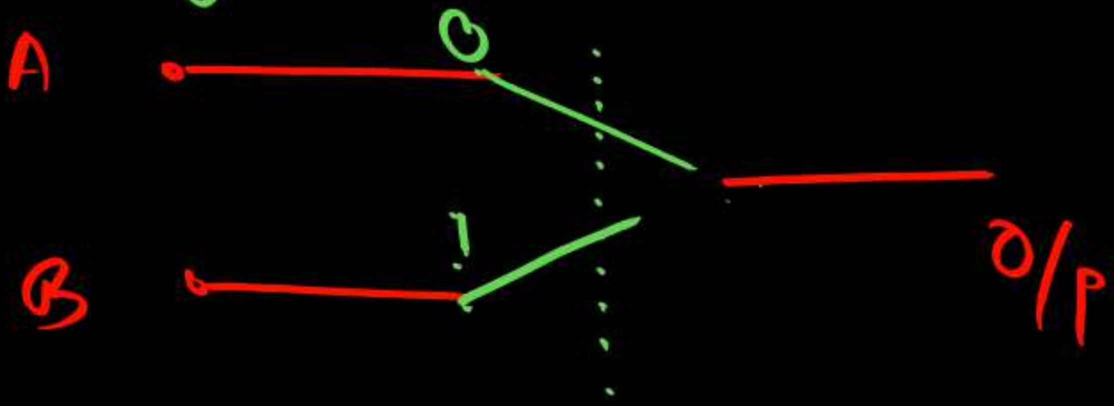
MULTIPLEXER

→ MUX → universal logic ✓

→ MUX → AND-OR logic ✓



$2^n \longrightarrow 1$



Select line

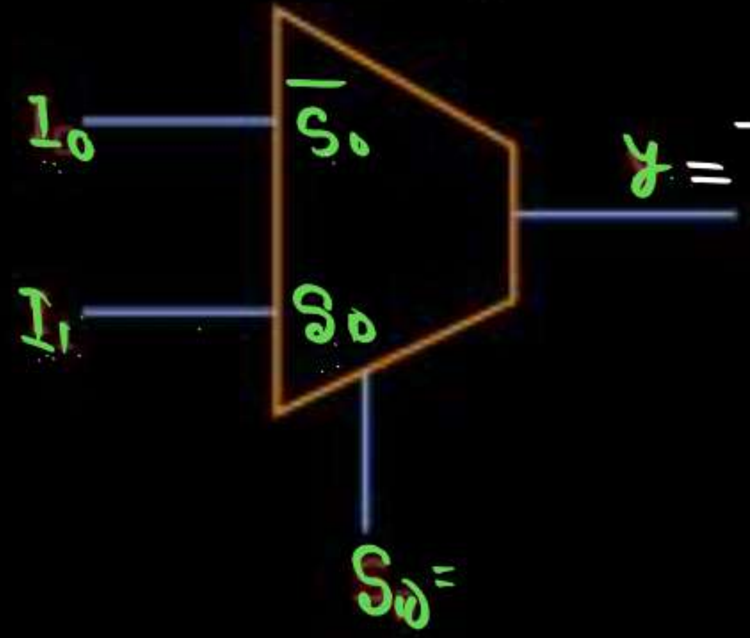
$x = 0, 1$

2

Ex. 1. Design a 2 x 1 MUX?

$$y = \overline{S_0} I_0 + S_0 I_1$$

Step-1. Number of input 2 outputs



$y = \overline{S_0} I_0 + S_0 I_1$

Step 2. Truth table.

S_0	Y
0	I_0
1	I_1

Step 3. Logical expression

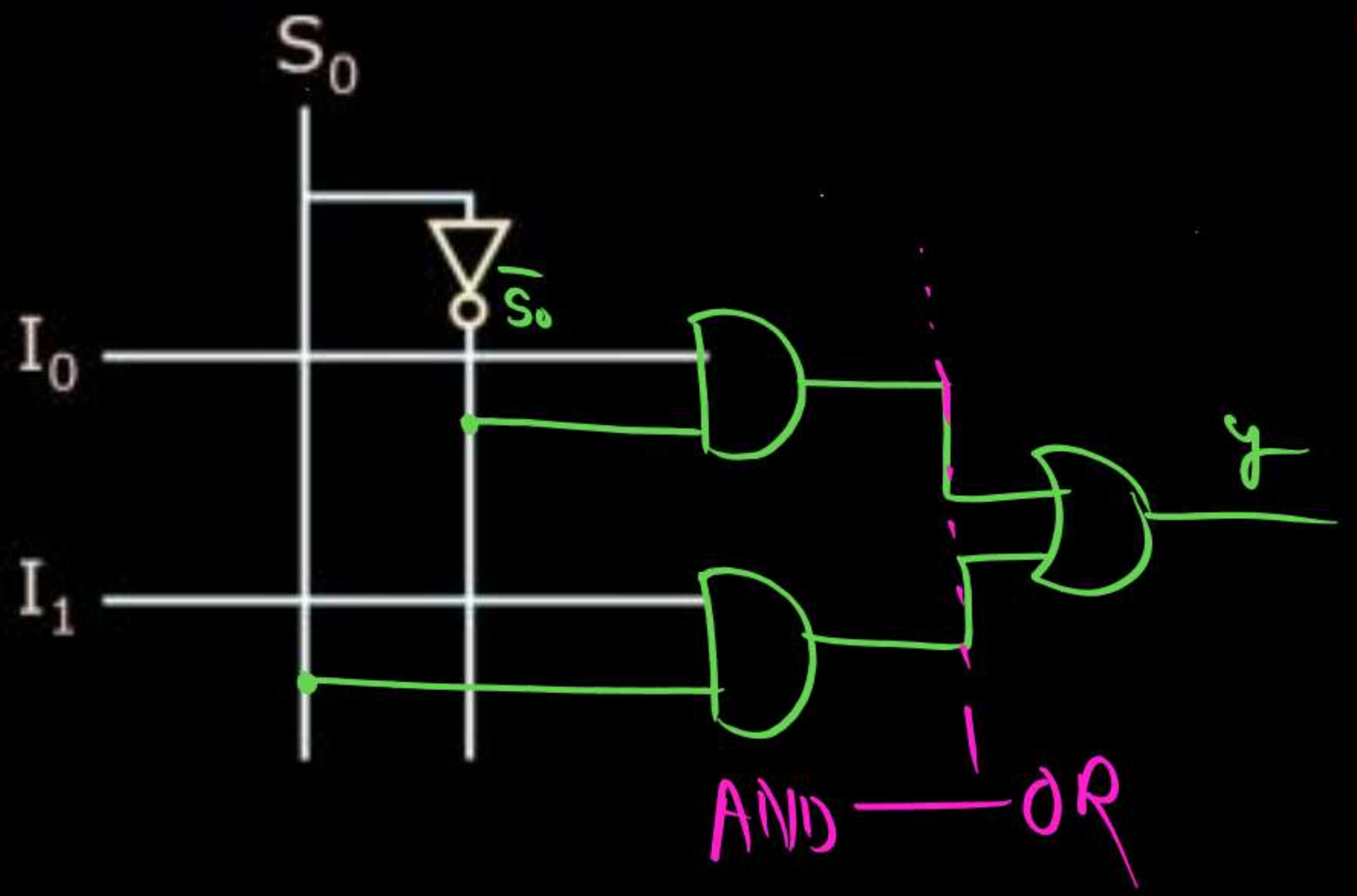
$$y = \bar{S_0} I_0 + S_0 I_1 \longrightarrow \text{SOP}$$

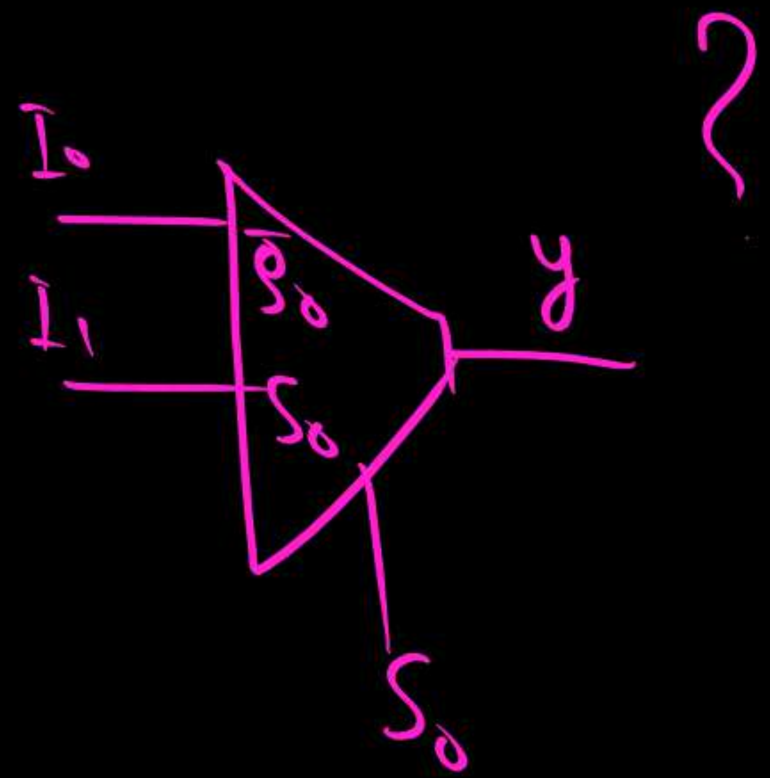
Step 4. Minimization

Step 5. Hardware implementation

MUX → AND-OR Logic

De-MUX → AND Logic

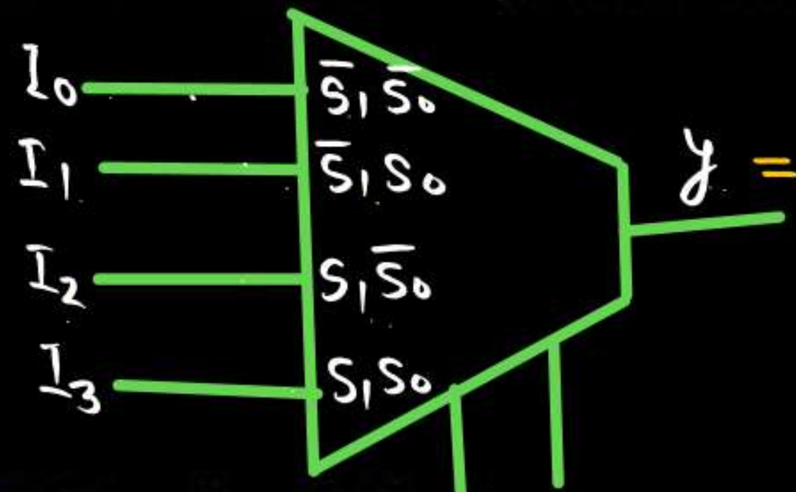




Ex. 2. Design a 4x1 MUX?

8

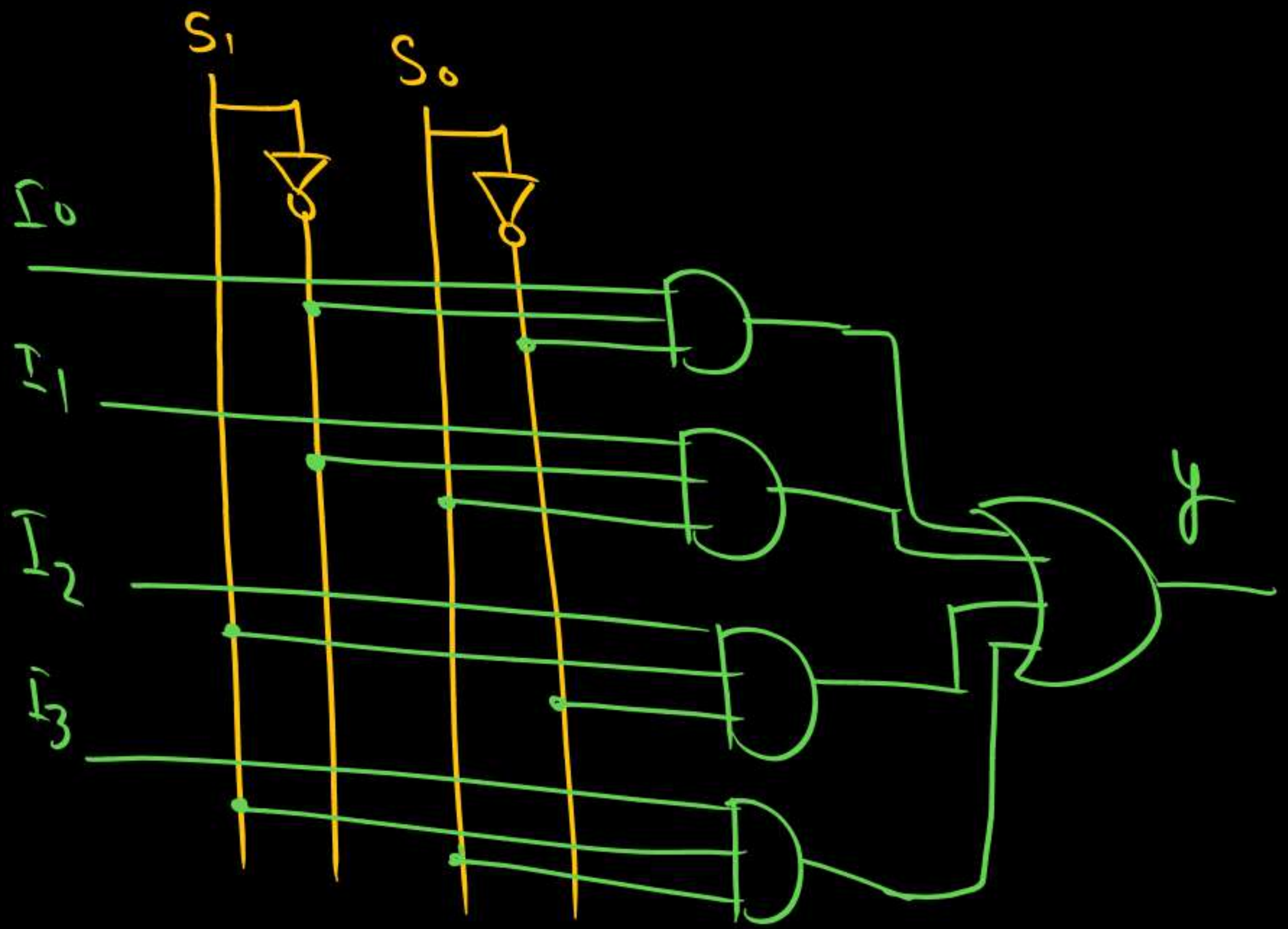
Step-1. Number of input & outputs



$$y = \bar{S}_1\bar{S}_0 I_0 + \bar{S}_1 S_0 I_1 + S_1\bar{S}_0 I_2 + S_1 S_0 I_3$$

Step 2. Truth table.

S1	S_0	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3



Step 3. Logical expression

Step 4. Minimization

Step 5. Hardware implementation

Design a $\boxed{8 \times 1 \text{ MUX}}$

TYPE -1 Designing of higher order MUX by using lower order MUX

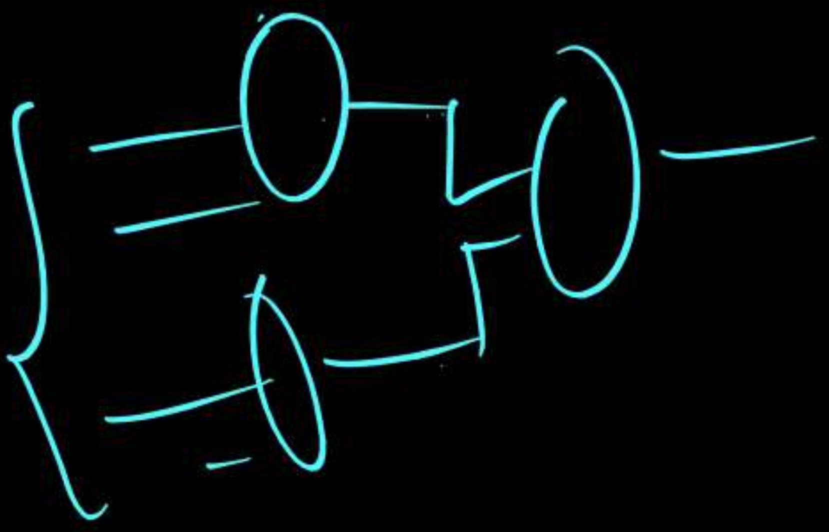
$\frac{4}{2} + \frac{2}{2}$

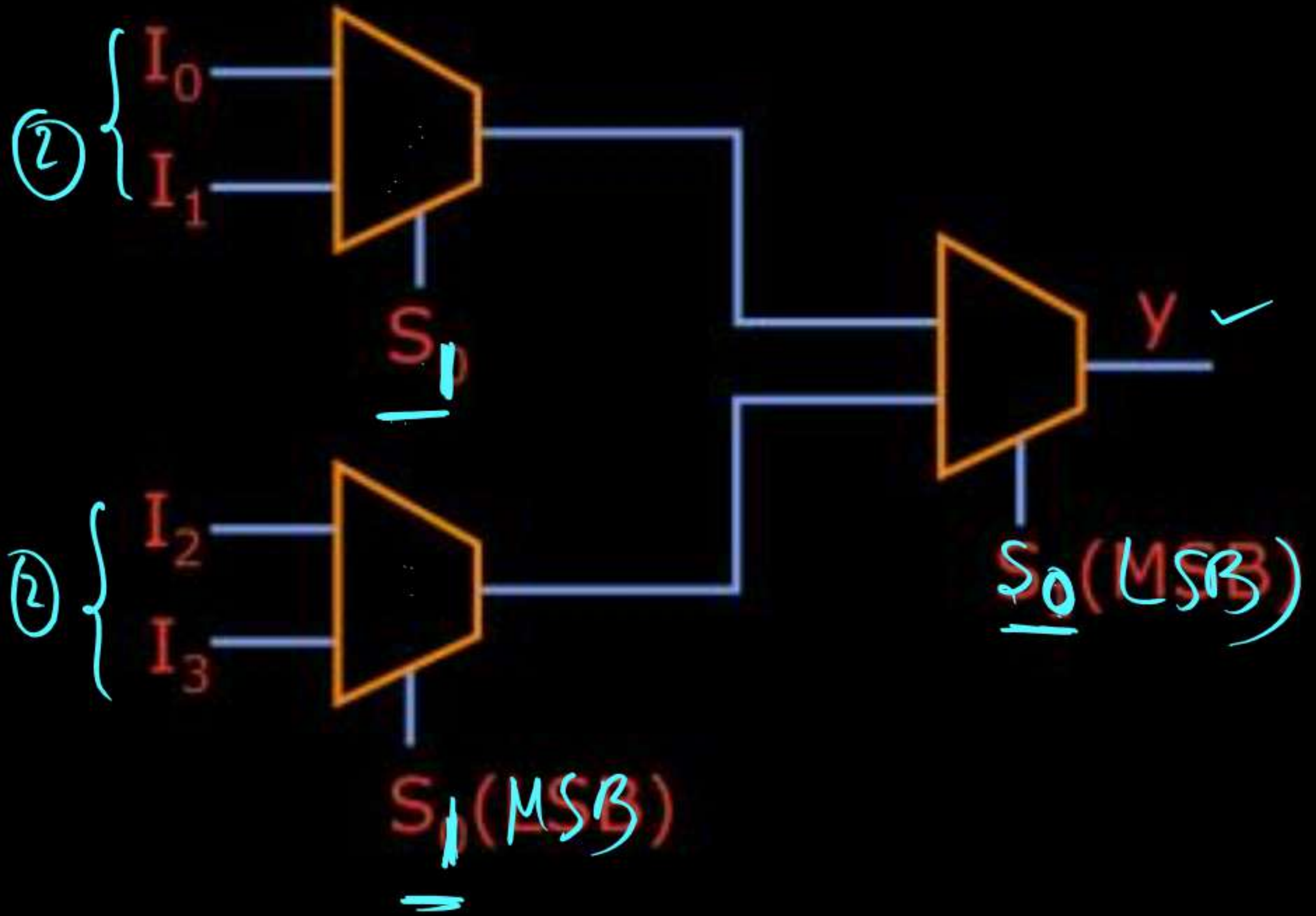
Ex. 1. 2x1 MUX ------------------------→ 4x1 MUX

$2 + 1 = 3$

2 inputs

4 inputs





$\frac{4}{2} + \frac{2}{2}$

$2\times1 \longrightarrow 4\times1$

$2+1$

1 line

2 select line

Ex. 2. 2x1 MUX $\xrightarrow[4+2+1=7]{\frac{8}{2}+\frac{4}{2}+\frac{2}{2}}$ 8x1 MUX

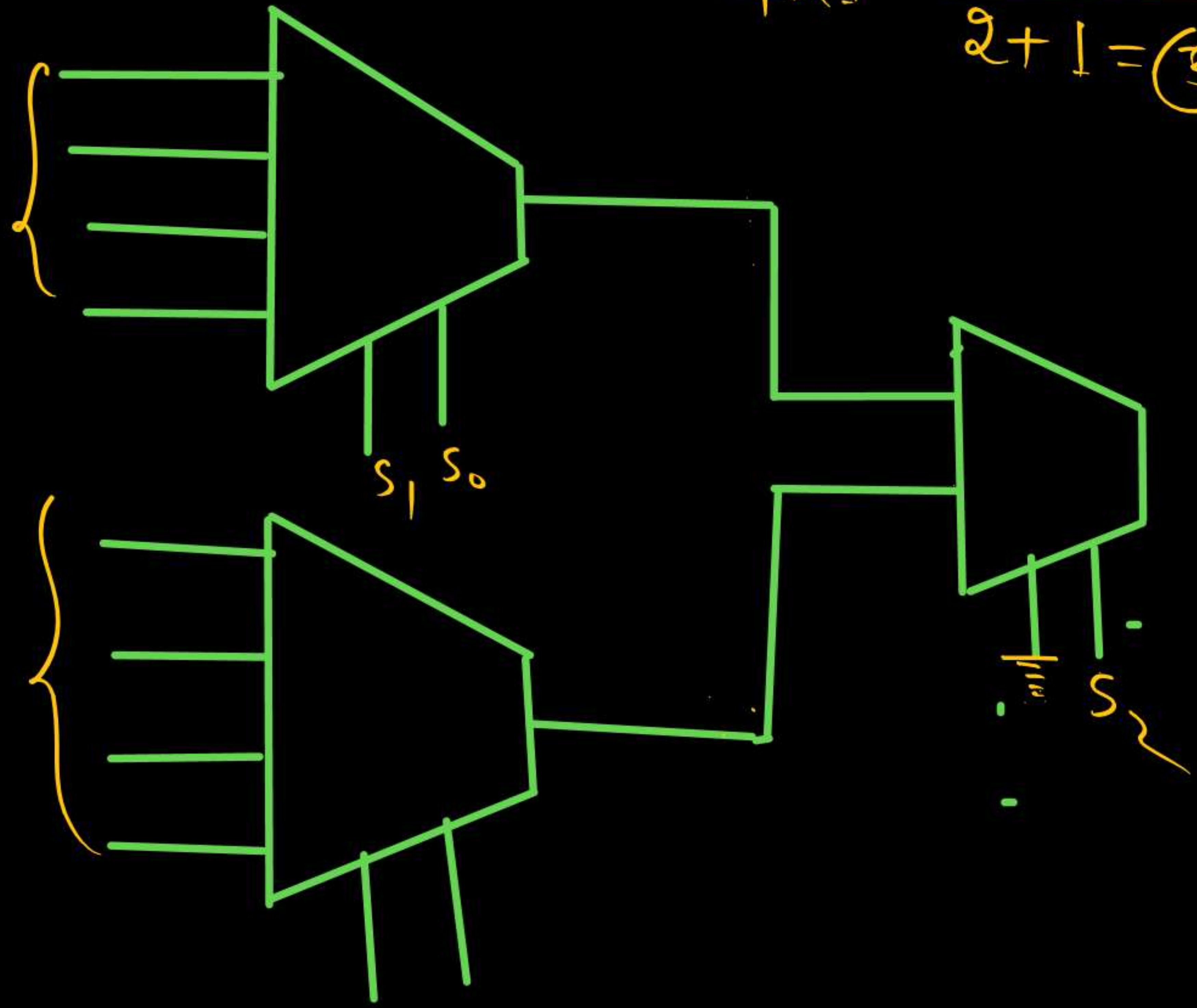
Ex. 3. 2x1 MUX $\xrightarrow[8+4+2+1=15]{\frac{16}{2}+\frac{8}{2}+\frac{4}{2}+\frac{2}{2}}$ 16x1 MUX

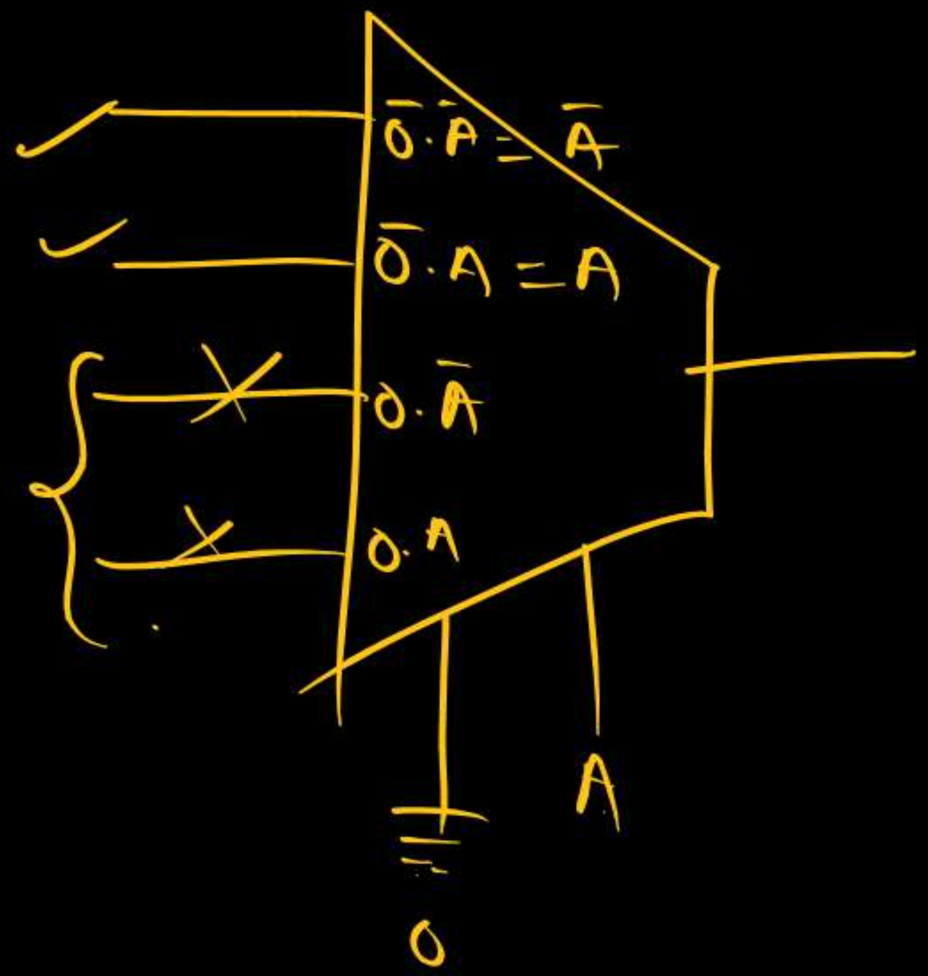
$2\times 1 \text{ MUX} \xrightarrow{2^n-1} 2^n \times 1 \text{ MUX}$

Ex. 3. 4 x 1 MUX $\xrightarrow[4 + 1 = 5]{\frac{16}{4} + \frac{4}{4}}$ 16 x 1 MUX

Ex. 4. 4 x 1 MUX $\xrightarrow[2 + 1 = 3]{\frac{8}{4} + \frac{2}{4}}$ 8 x 1 MUX

$$4\times1 \xrightarrow[2+1=3]{\frac{8}{4}+\frac{2}{4}} 8\times1 \text{ MUX}$$





$\bar{0}\cdot\bar{A} = \bar{A}$
$\bar{0}\cdot A = A$
$0\cdot\bar{A}$
$0\cdot A$
A
0

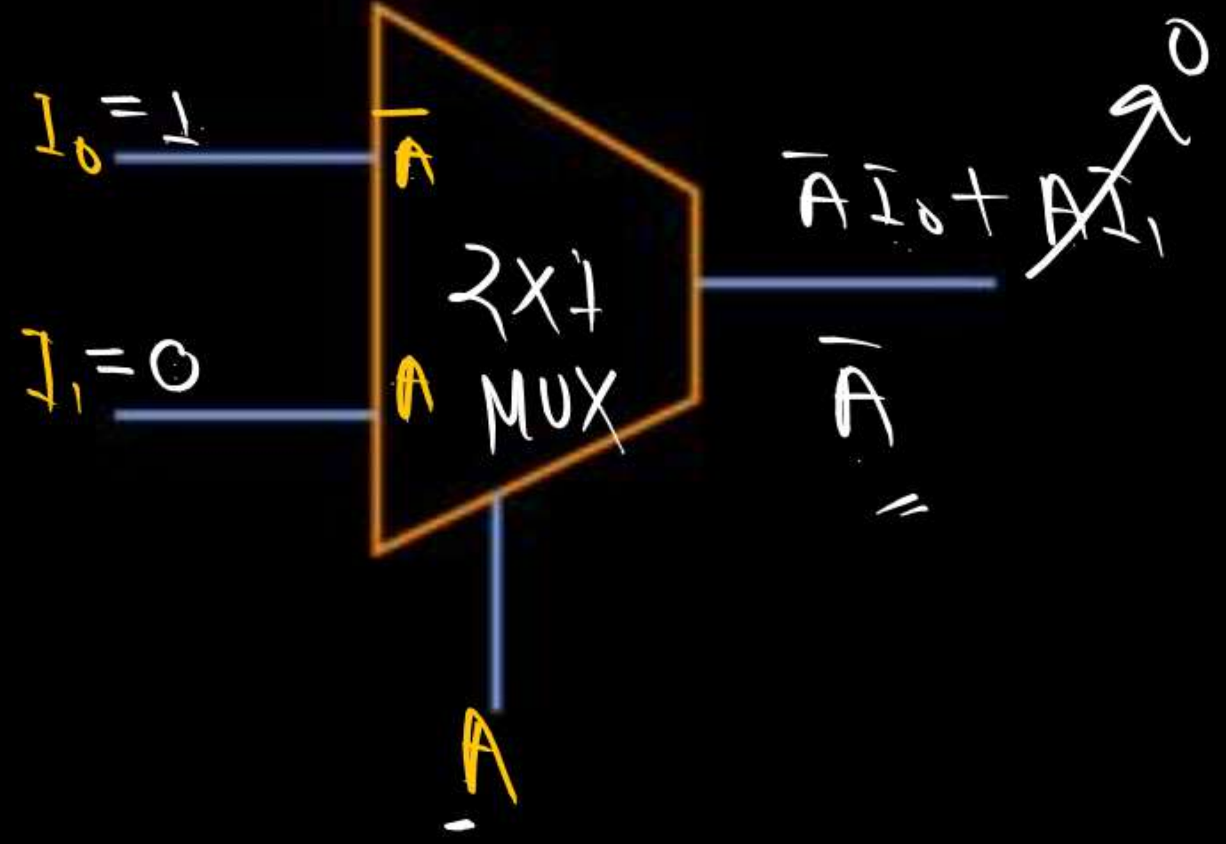
Ex. 5. 4 x 1 MUX --→ 64 x 1 MUX

$$\frac{64}{4} + \frac{16}{4} + \frac{4}{4}$$

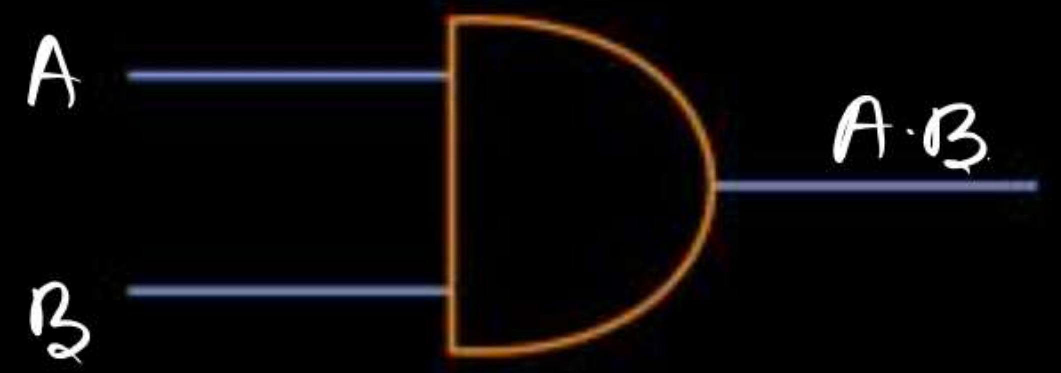
$$16 + 4 + 1 = \underline{\underline{21}}$$

TYPE -2 MUX AS A UNIVERSAL LOGIC

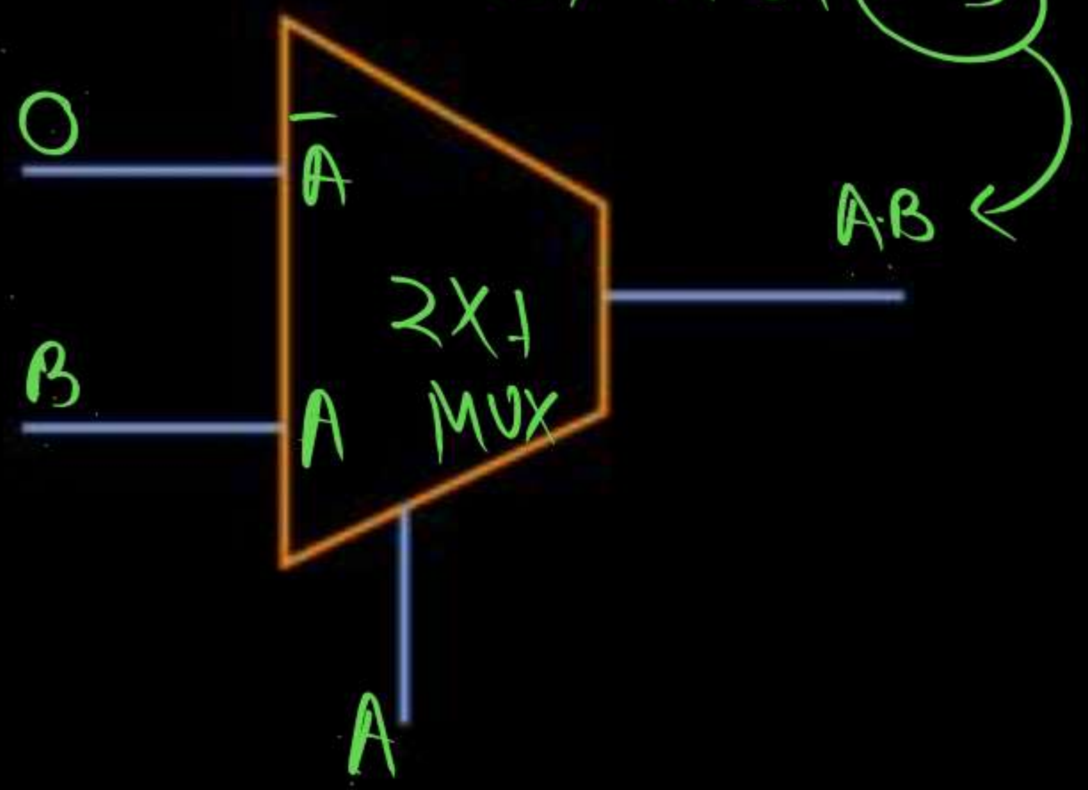
1. Not Gate



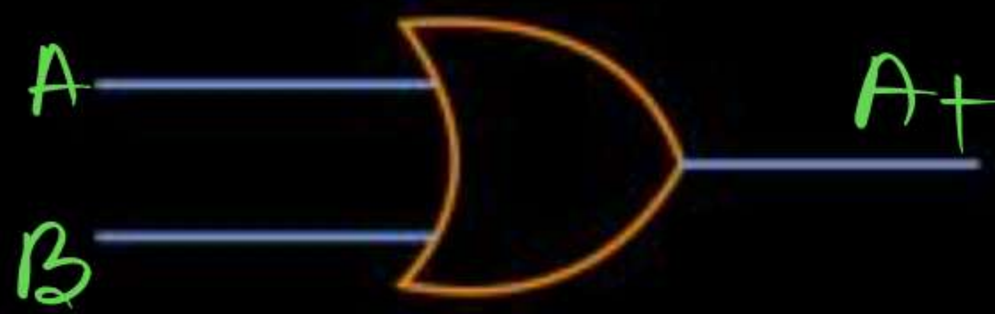
2. AND GATE

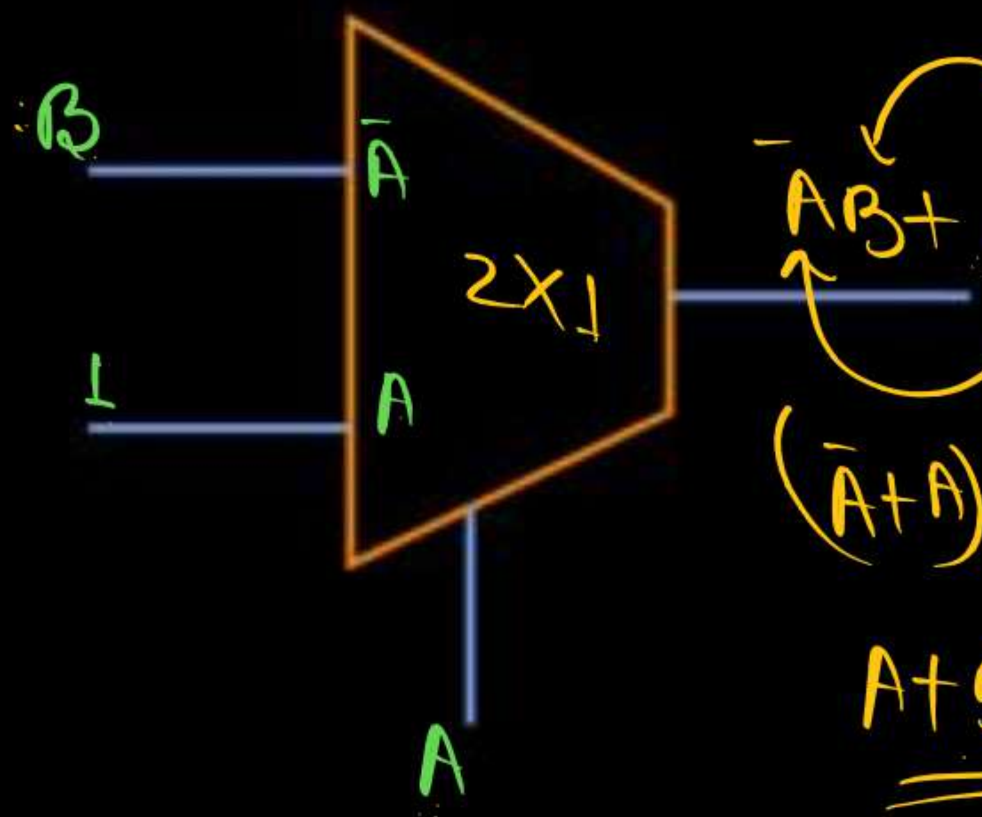


$$\Rightarrow \bar{A}\cdot 0 + A\cdot B$$



3. OR GATE





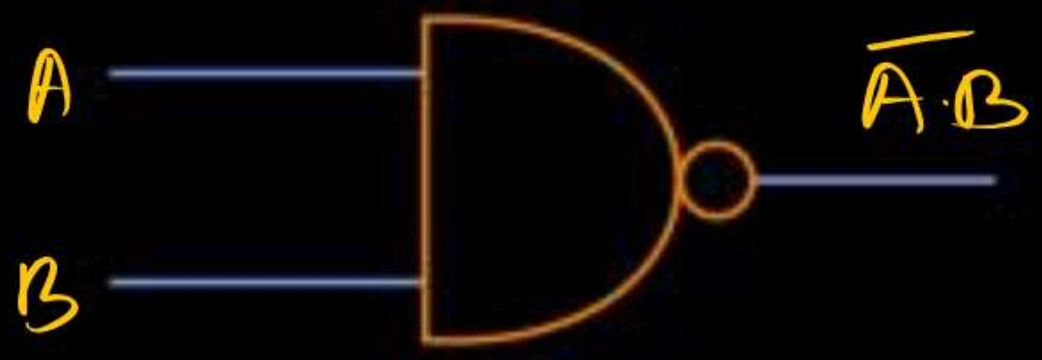
$\bar{A}B + A$

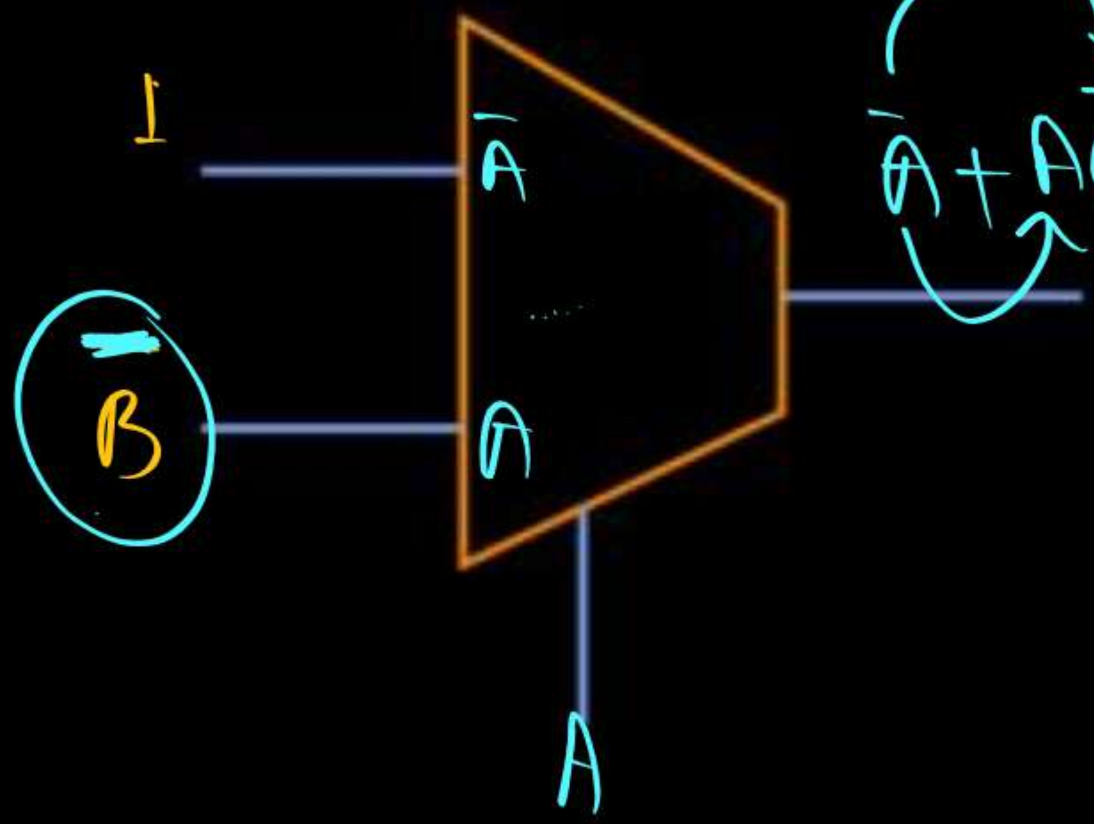
$(\bar{A}+A)\cdot(A+B)$

$A+B$

4. NAND GATE

2

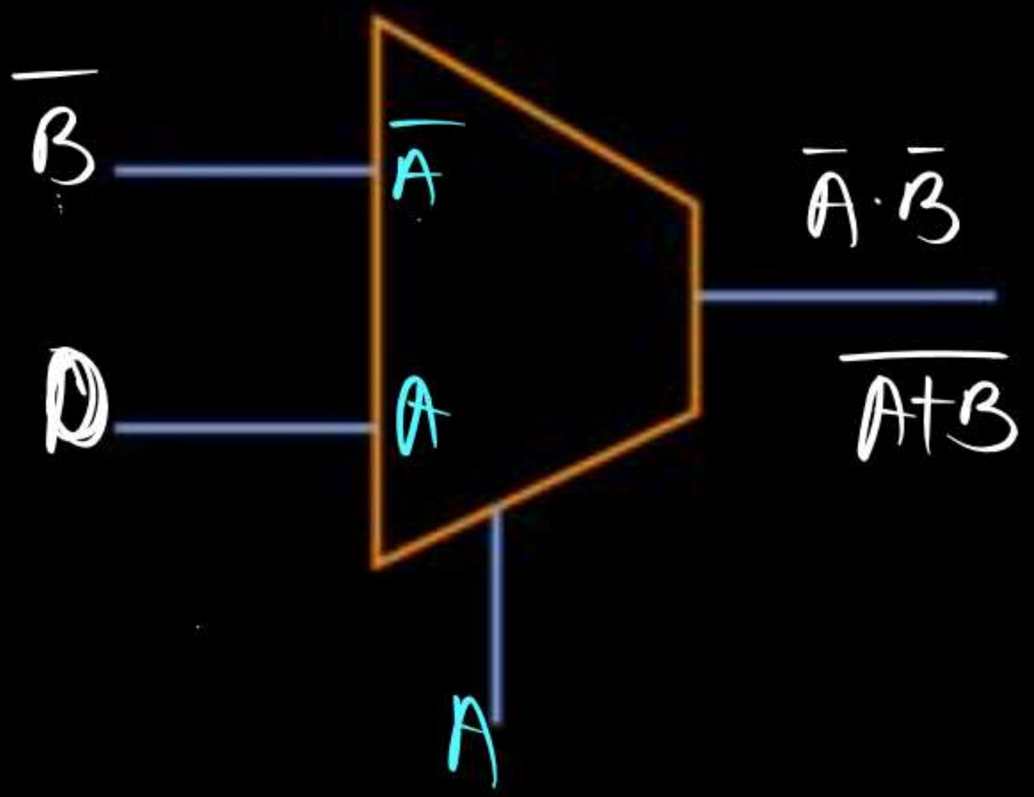




$$\bar{A} + A\bar{B} = (\bar{A} + A)(\bar{A} + \bar{B})$$
$$= \bar{A} + \bar{B}$$
$$= \overline{A \cdot B}$$

5. NOR GATE

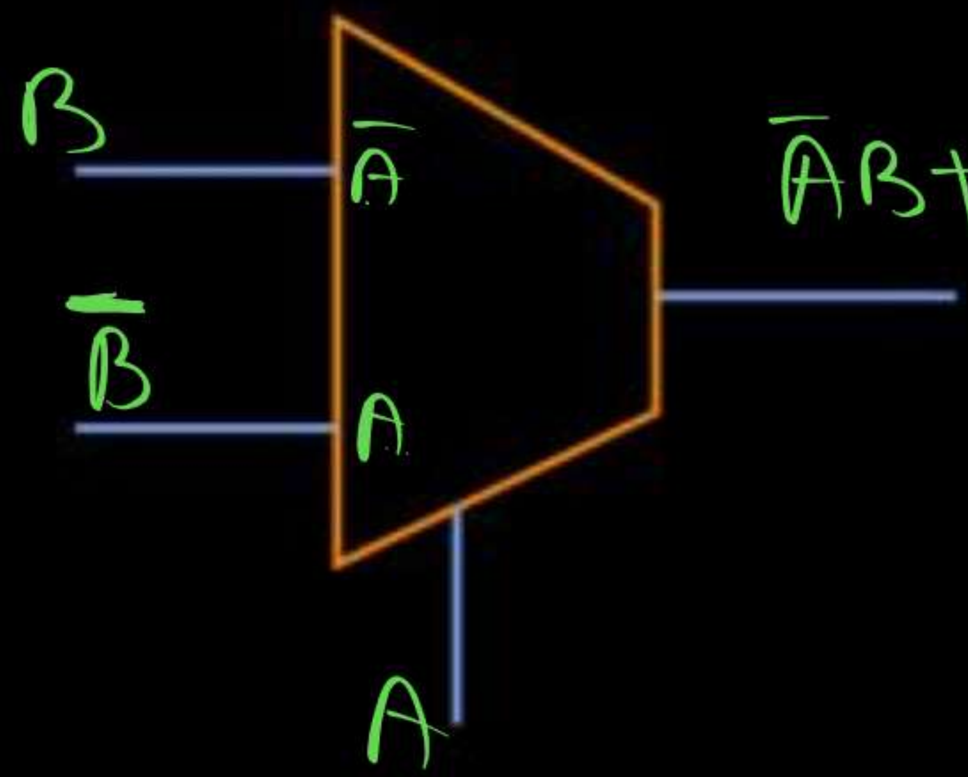
2



6. XOR GATE

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

(2)

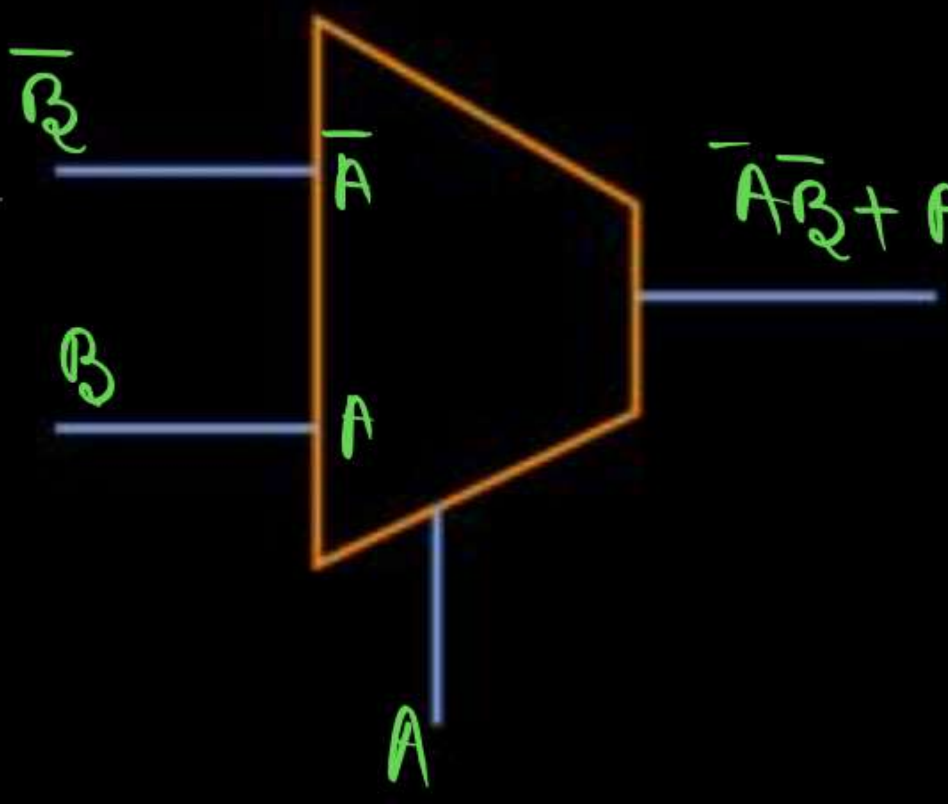


$\bar{A}B + A\bar{B} = A \oplus B$

7. XNOR GATE

$A \odot B = \bar{A}\bar{B} + AB$

2

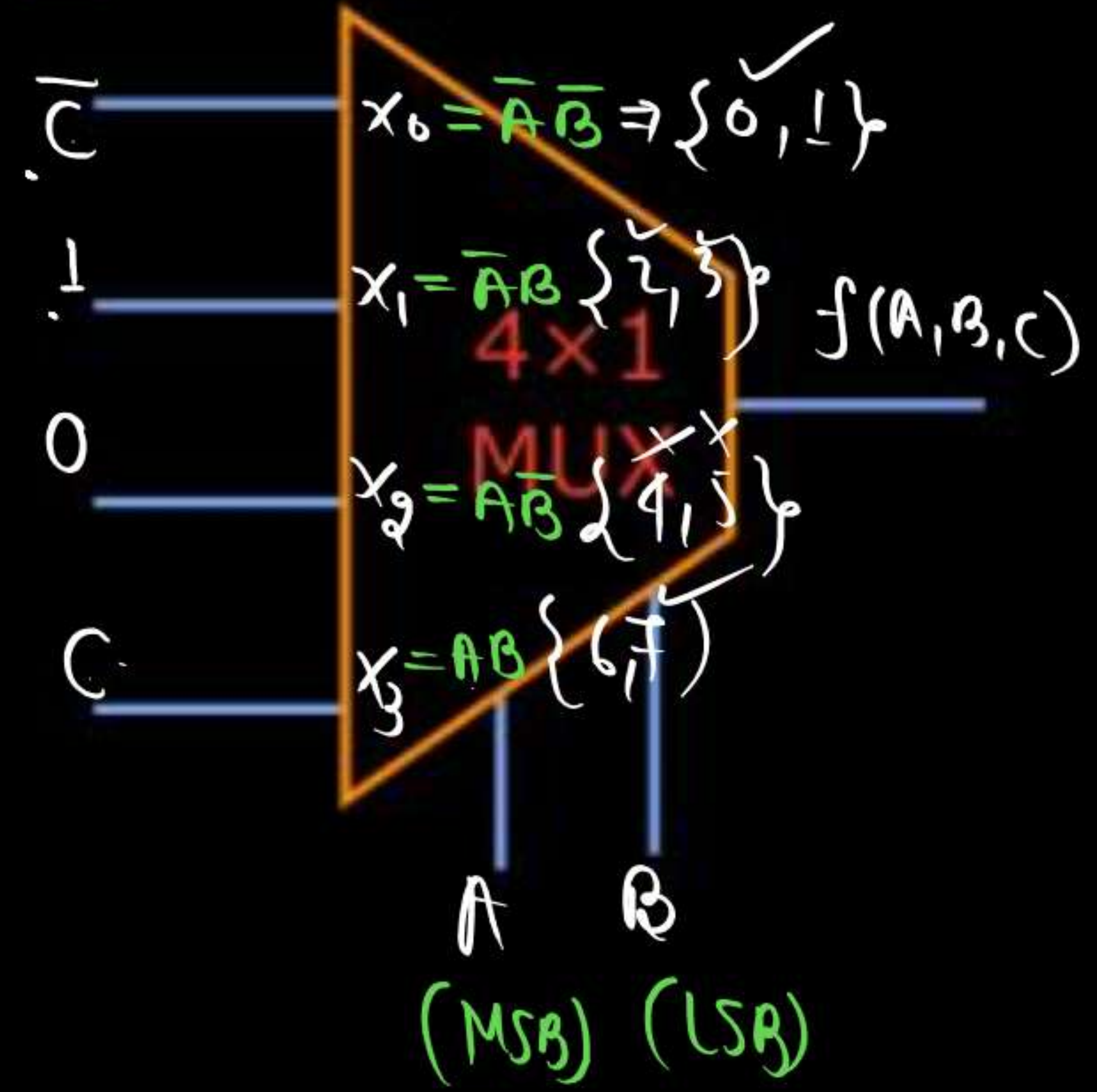


$\bar{A}\bar{B} + AB = A \odot B$

Q.

Type-3 Minimization

Ex. 1.



$$f(A,B,C) = \bar{A}\bar{B}\bar{C} + \bar{A}B\cdot 1 + A\bar{B}\cdot 0 + A\cdot B\cdot C$$

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

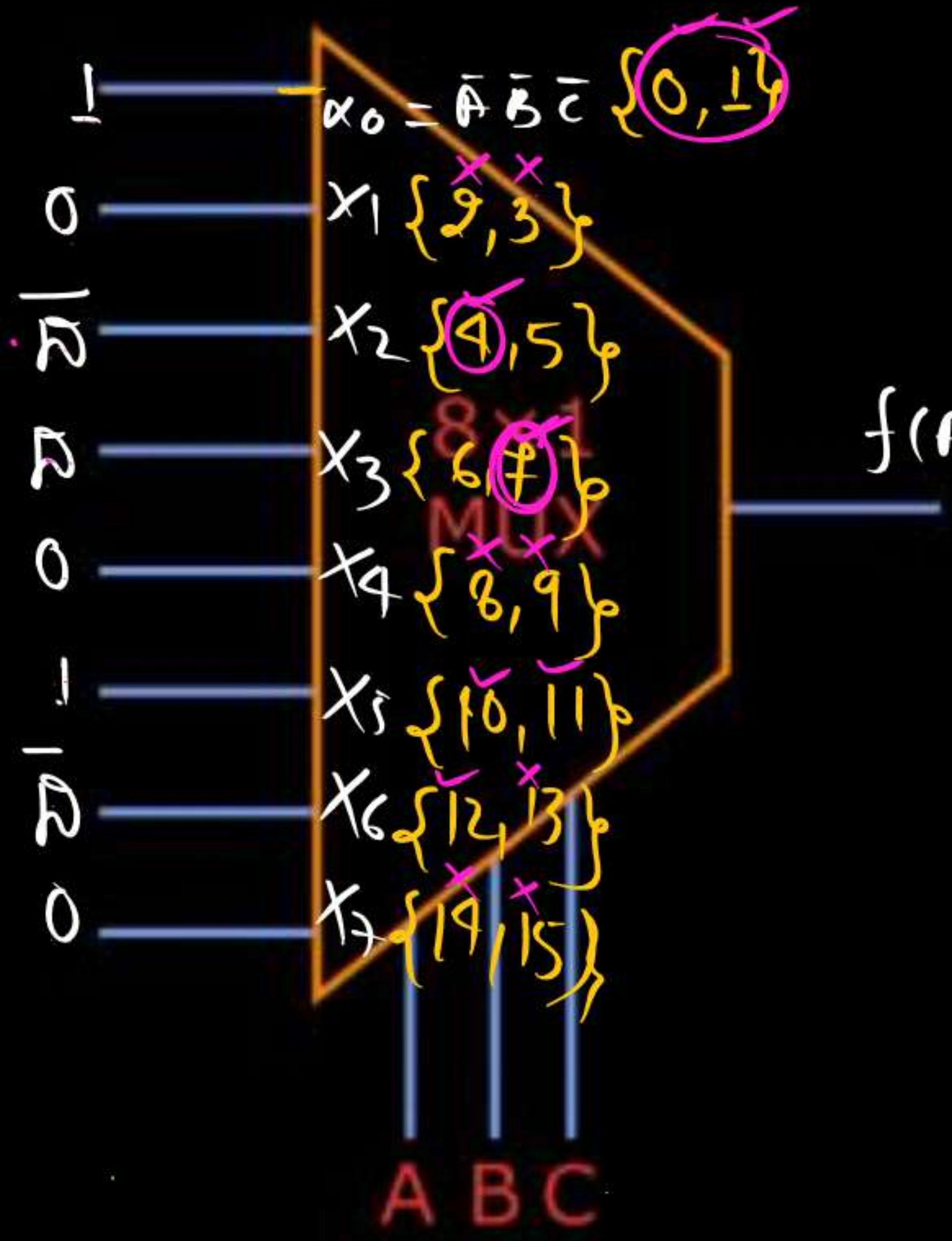
$$= \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}BC + ABC$$

$$= \sum m(0,2,3,7)$$

A \ BC	00	01	11	10
0	1		1	1
1			1	

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

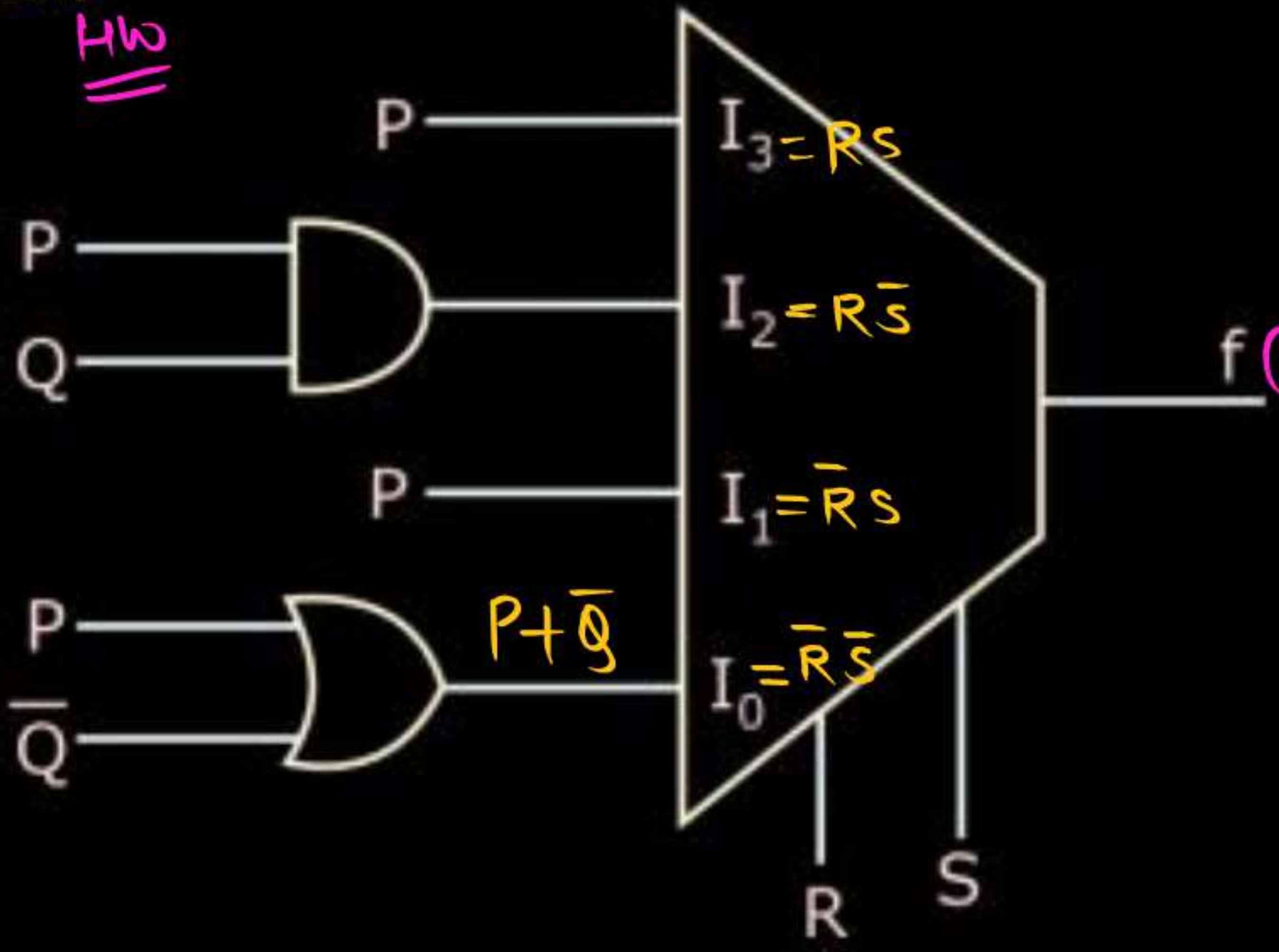
Ex



$$f(A,B,C,D) = \sum m(0,1,4,7,10,11,12)$$

Ex. GATE

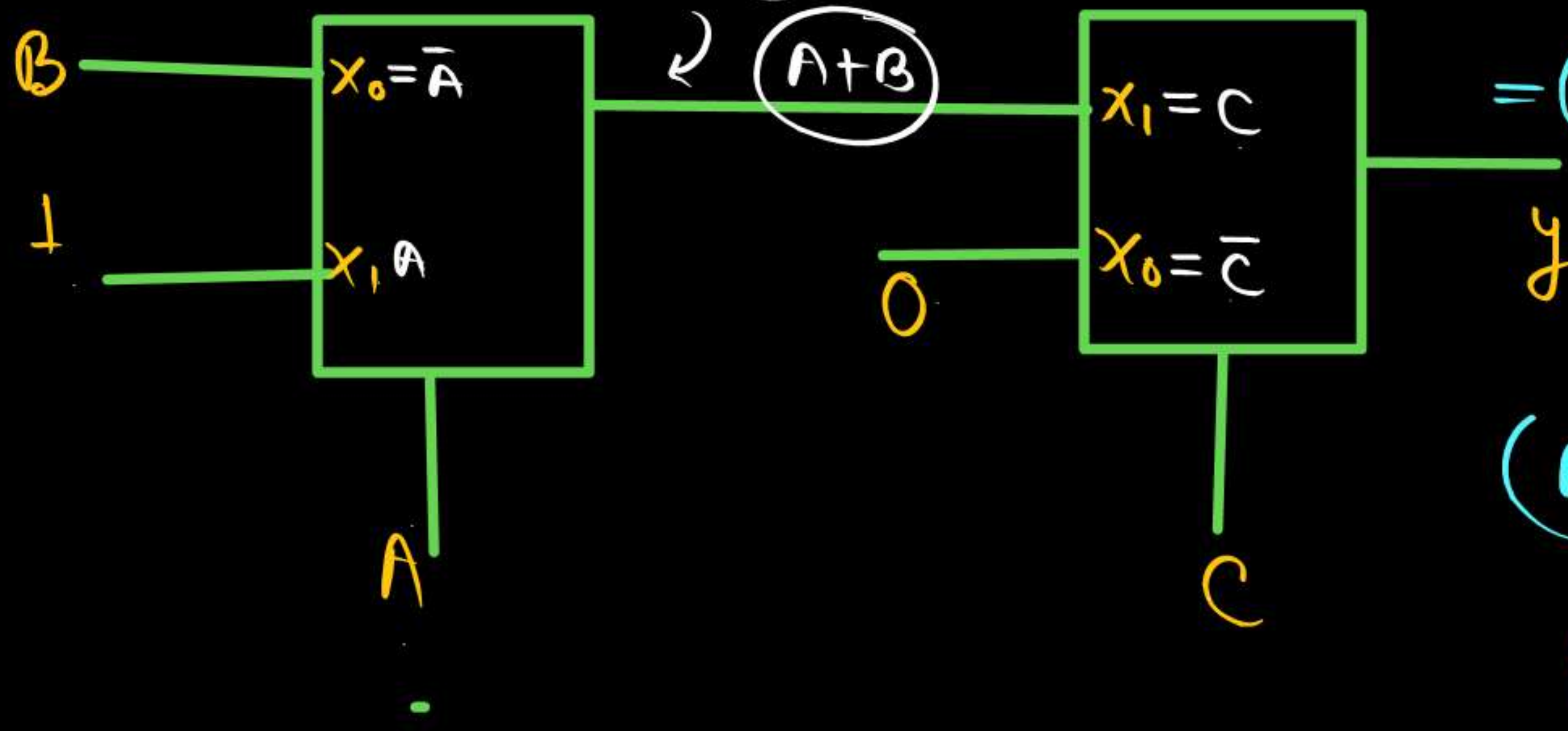
HW



$f(P, Q, R, S) =$

Ex.

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



$= (A+B)C + 0$

$y = (A, B, C) = ?$

$(A+B)C$

$AC + BC$

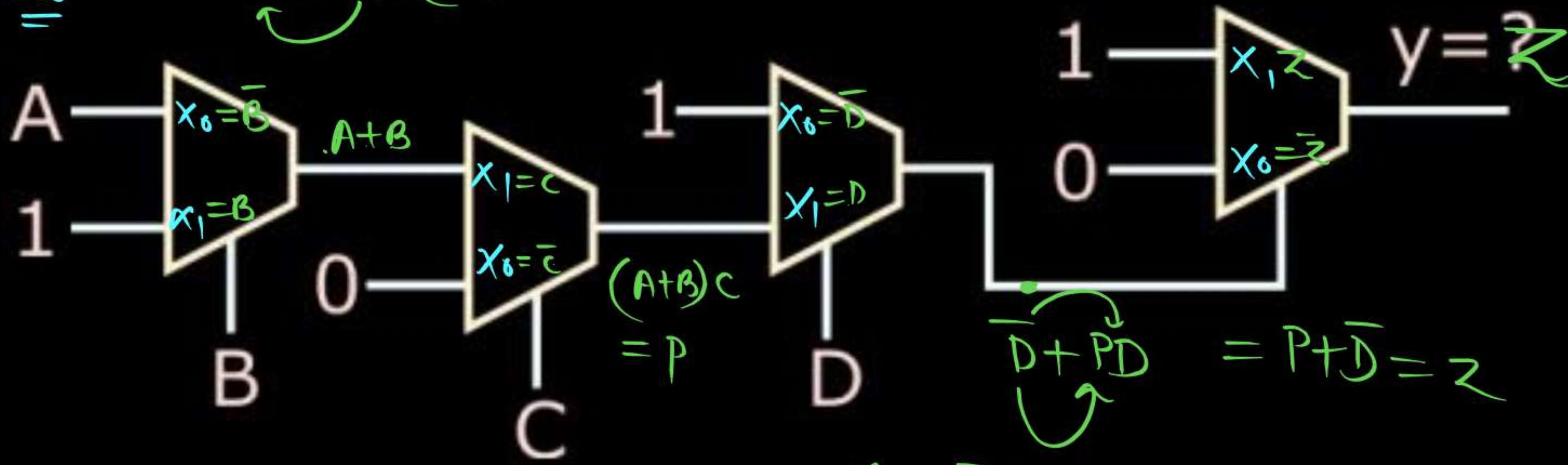
Ans

Type-4 Cascading of MUX

$(A+B)C = P$

Ex

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



$Z = P+\bar{D}$

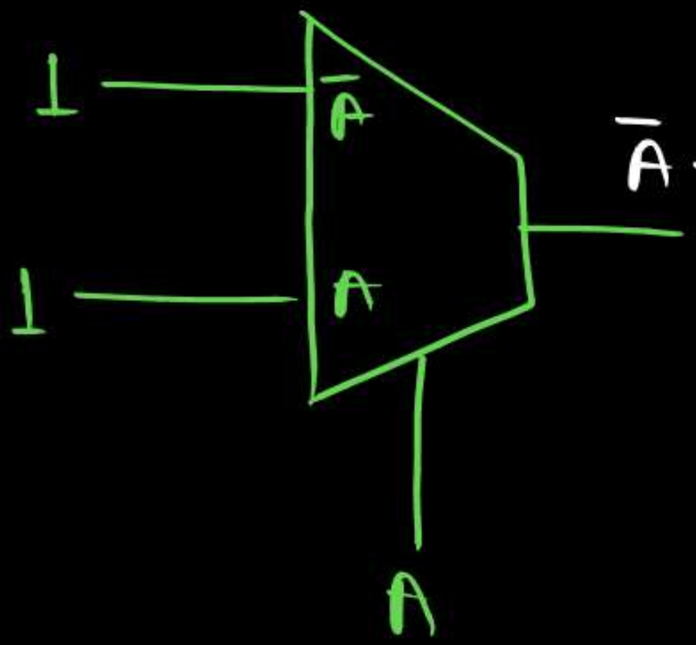
$(A+B)C+\bar{D}$

Ans

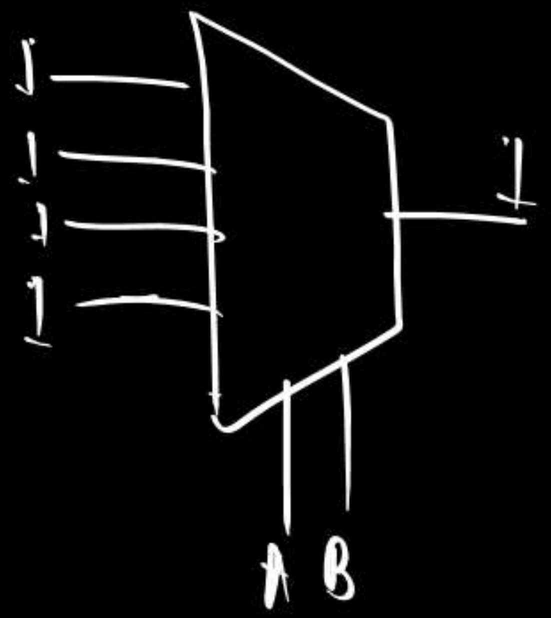
$\bar{D}+PD = P+\bar{D} = Z$

$(P+\bar{D})(\bar{D}+D)$

$P+\bar{D}$

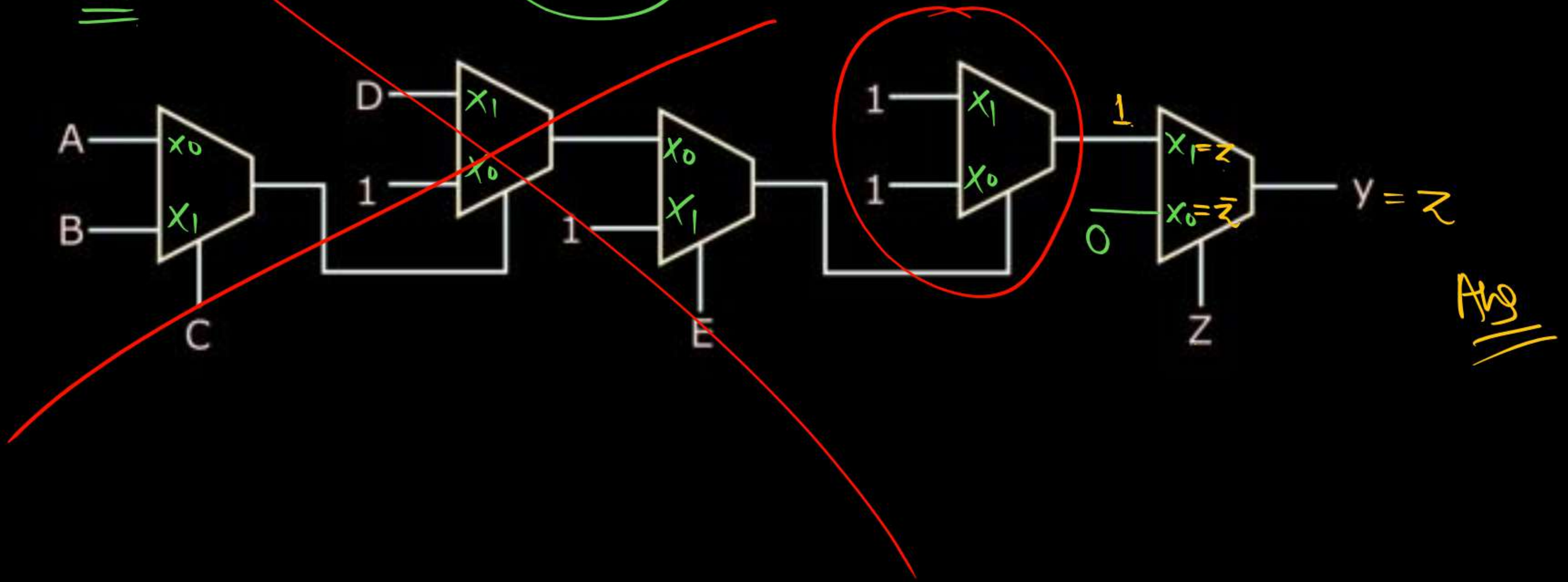


$\bar{A} + A = 1$



Ex.

3 Sec




THANK
YOU!