CS & IT ENGINEERING

DIGITAL LOGIC

Combinational Circuit

Lecture No. 3

By- CHANDAN SIR

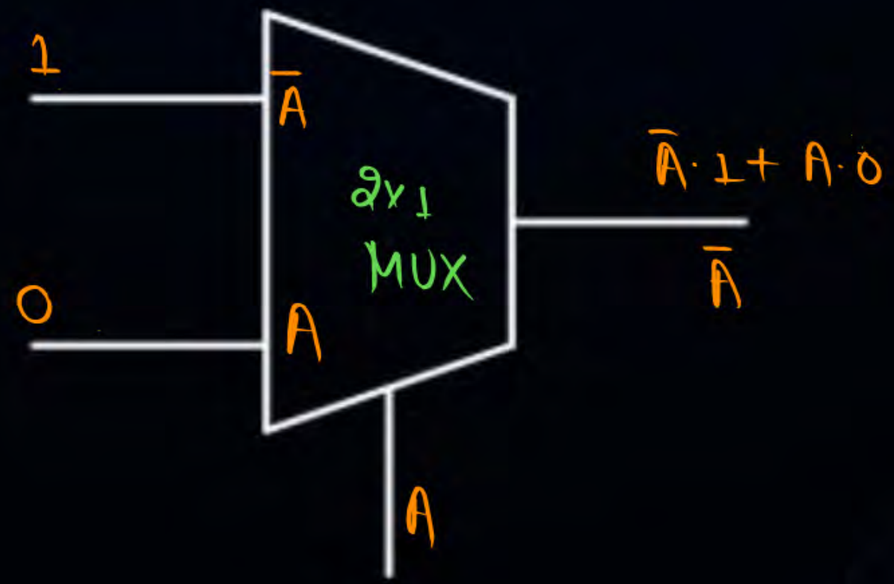
01 MULTIPLEXER

02 QUESTION PRACTICE

03 DISCUSSION

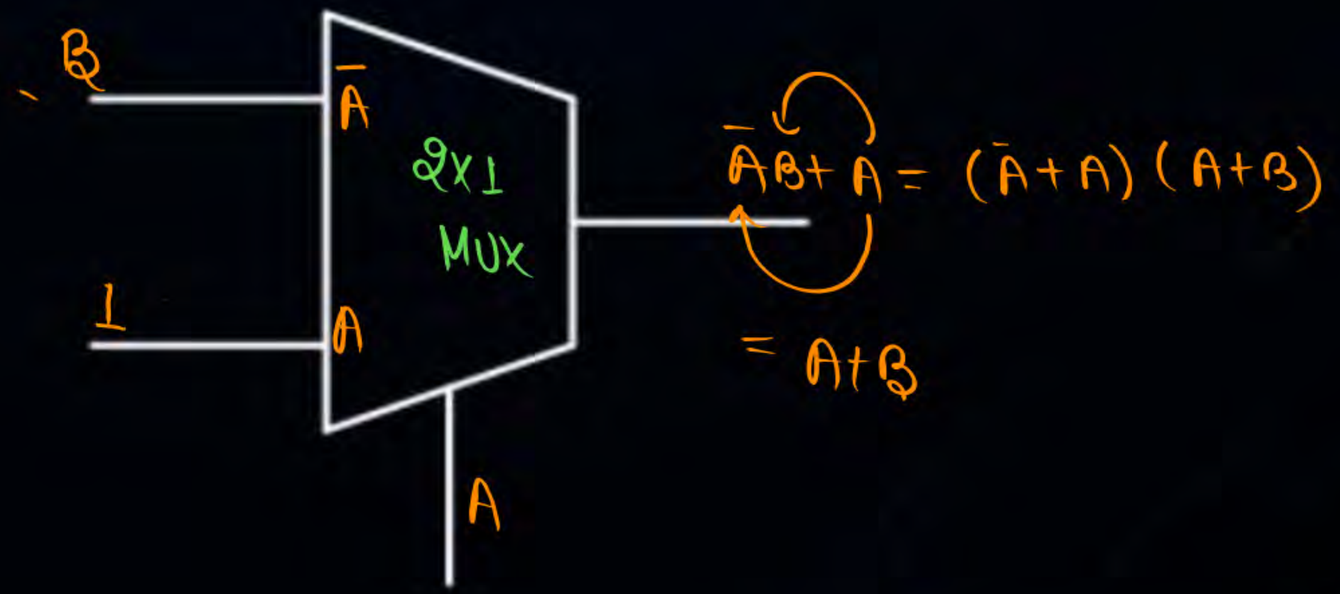
Type-2 MUX as a Universal Logic

1. Not GATE



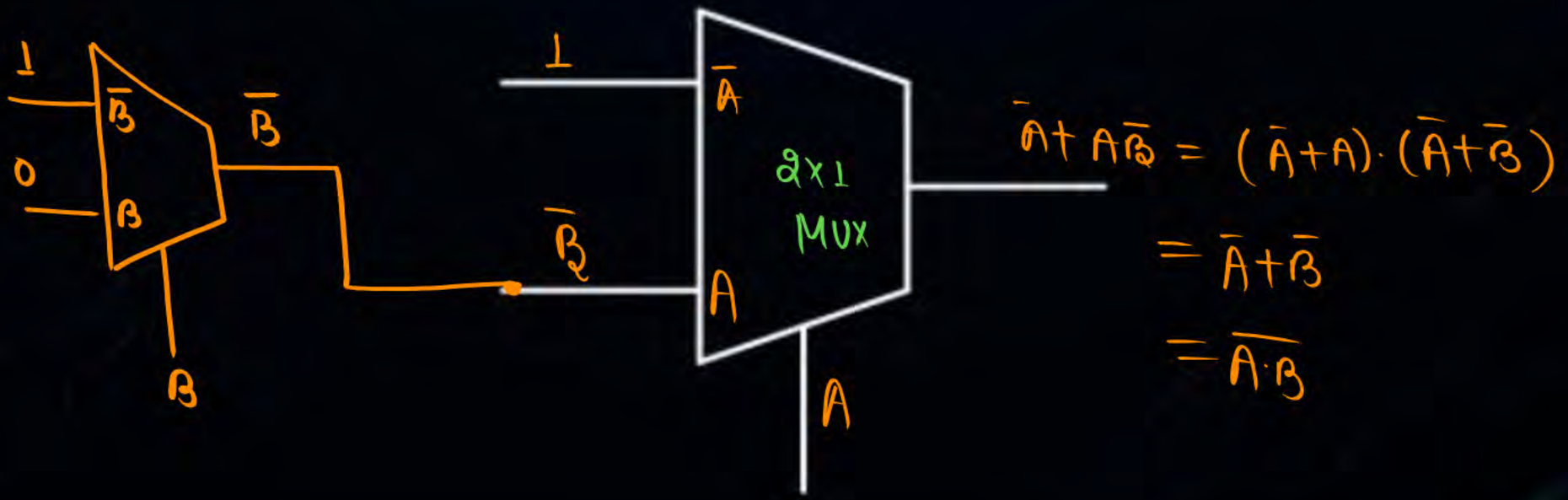
2. AND GATE

3. OR GATE



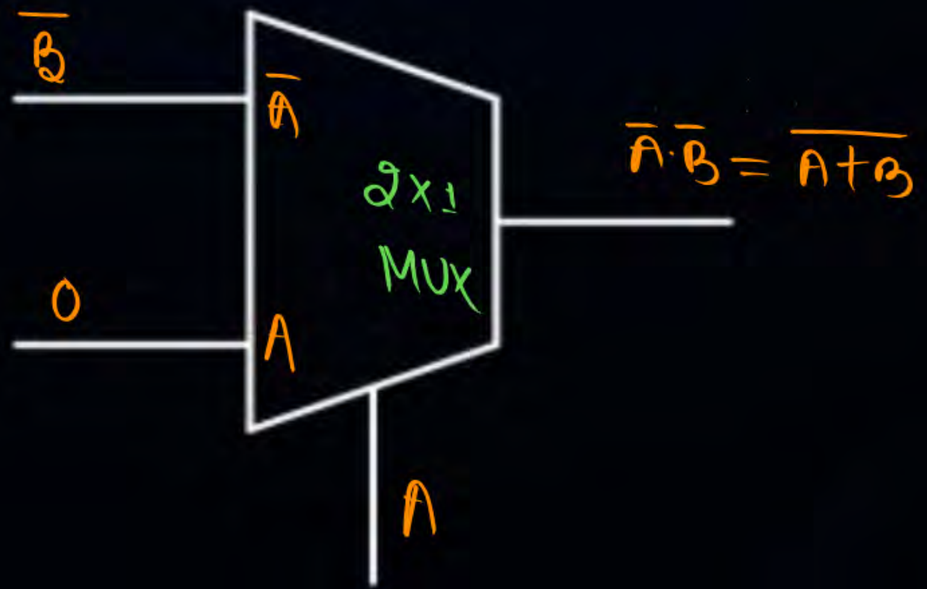
4. NAND GATE


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


1
0
$\bar{B}$
B
$\bar{B}$
B
1
$\bar{A}$
$\bar{B}$
A
2x1
MUX
A
$\bar{A} + A\bar{B} = (\bar{A}+A) \cdot (\bar{A}+\bar{B})$
$= \bar{A} + \bar{B}$
$= \overline{A \cdot B}$

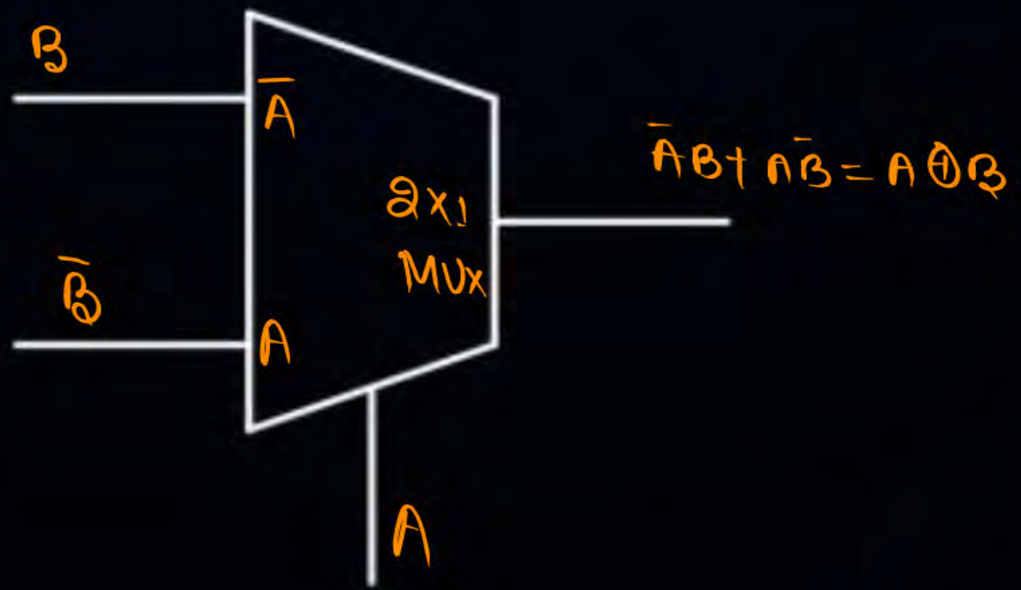
5. NOR GATE


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


$\bar{B}$
$\bar{A}$
2x1
MUX
0
A
A
$\bar{A}\cdot\bar{B} = \overline{A+B}$

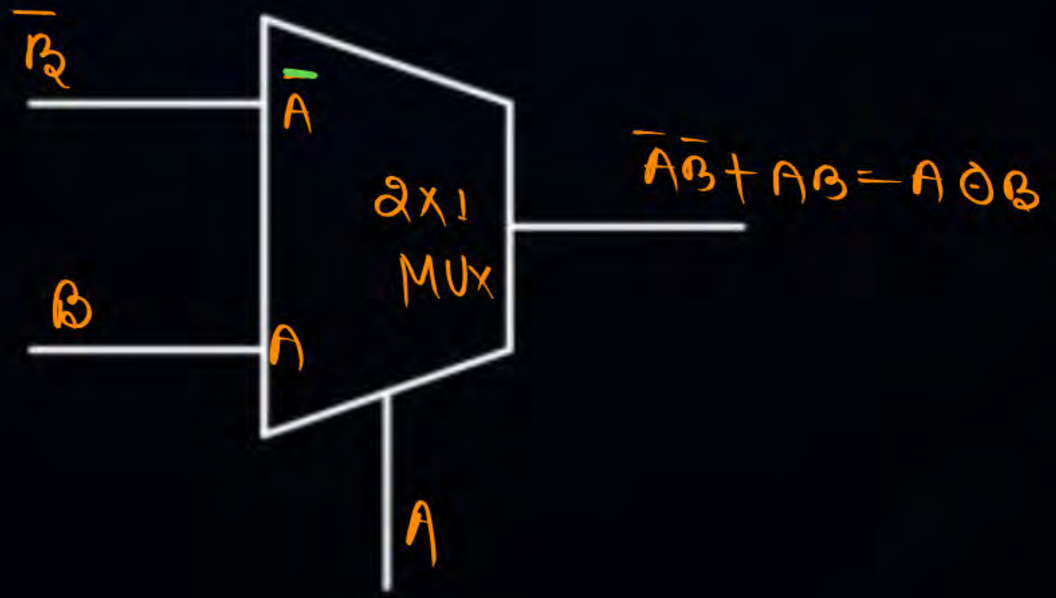
6. X-OR GATE


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


B
$\bar{A}$
$\bar{B}$
A
2x1
MUX
A
$\bar{A}B + A\bar{B} = A \oplus B$

7. X-NOR GATE


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


$\bar{B}$
$\bar{A}$
2x1
MUX
B
A
A
$\bar{A}\bar{B} + AB = A \odot B$

To Design NOT, AND, OR ⟶ One 2x1 MUX Required.

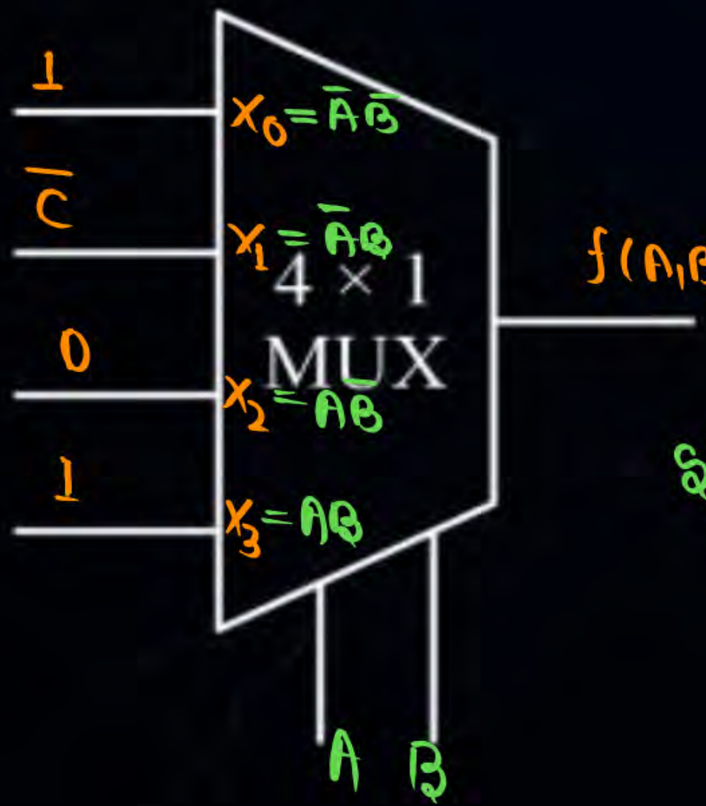
To Design NAND, NOR, X-OR, X-NOR ⟶ Two 2x1 MUX Required.

H.W Design all the Logic by 4x1 MUX ?

Type-3 Minimization

Q.

Find the output f.



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

$0 \rightarrow 000$ $\quad$ 010 $\quad$ $110 \rightarrow 6$

$1 \rightarrow 001$ $\quad$ 2 $\quad$ $111 \rightarrow 7$

$= \Sigma m(0,1,2,6,7)$

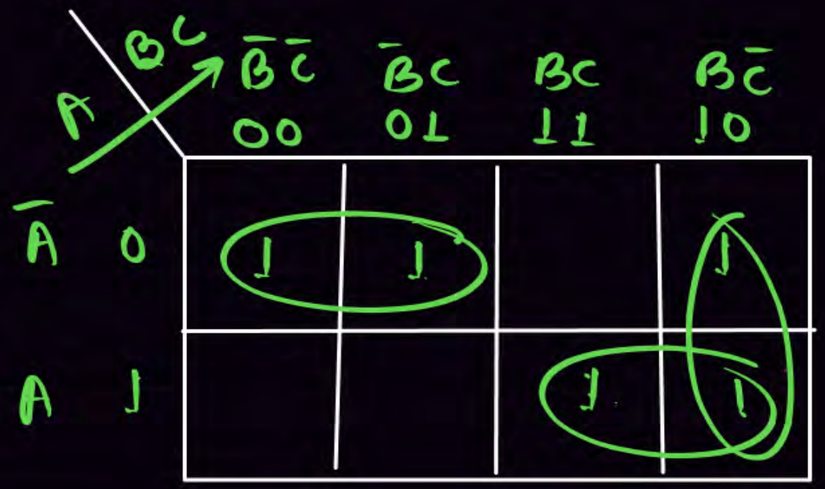
$f(A,B,C) = \bar{A}\bar{B}\cdot 1 + \bar{A}B\bar{C} + A\bar{B}\cdot 0 + AB\,1$

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

Standard canonical form

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

$= \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + \bar{A}B\bar{C} + AB\bar{C} + ABC = \Sigma m(0,1,2,6,7)$



I = 5

PI = 4

EPI = 2

SPI = 1

RPI = 1

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

OR

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

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

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

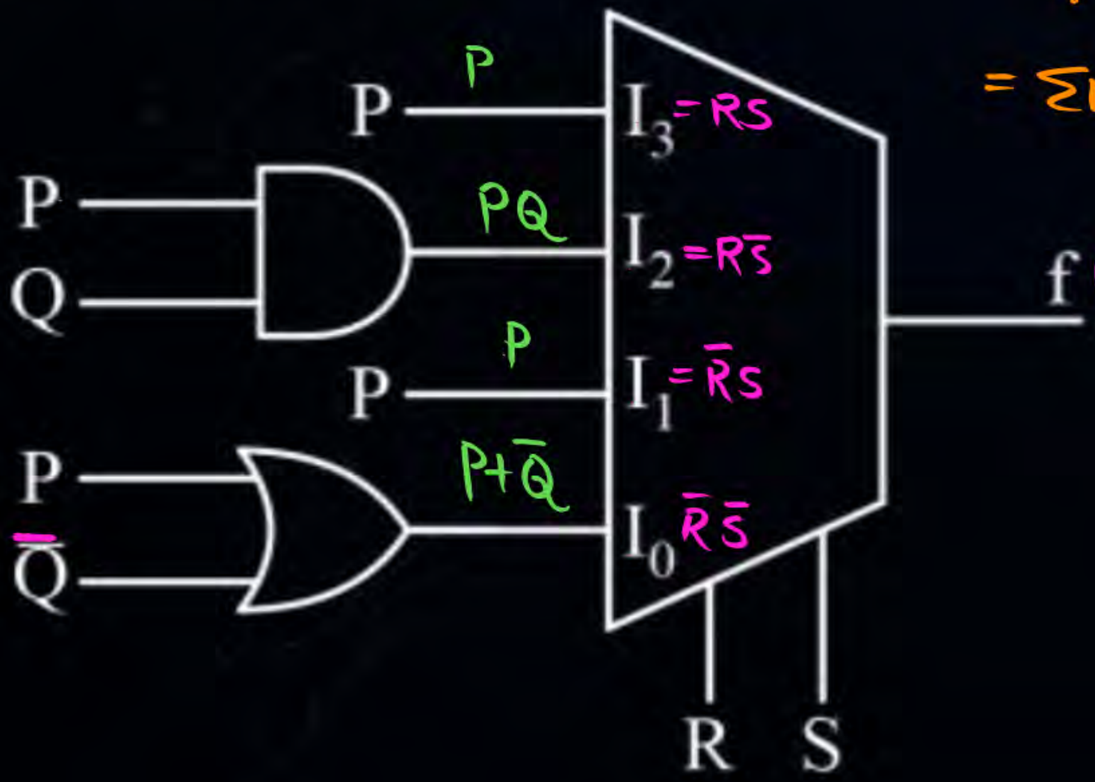
(C) EPI = 2

(D) SPI = RPI = 1

MULTIPLEXER

Q.

Find the output f.



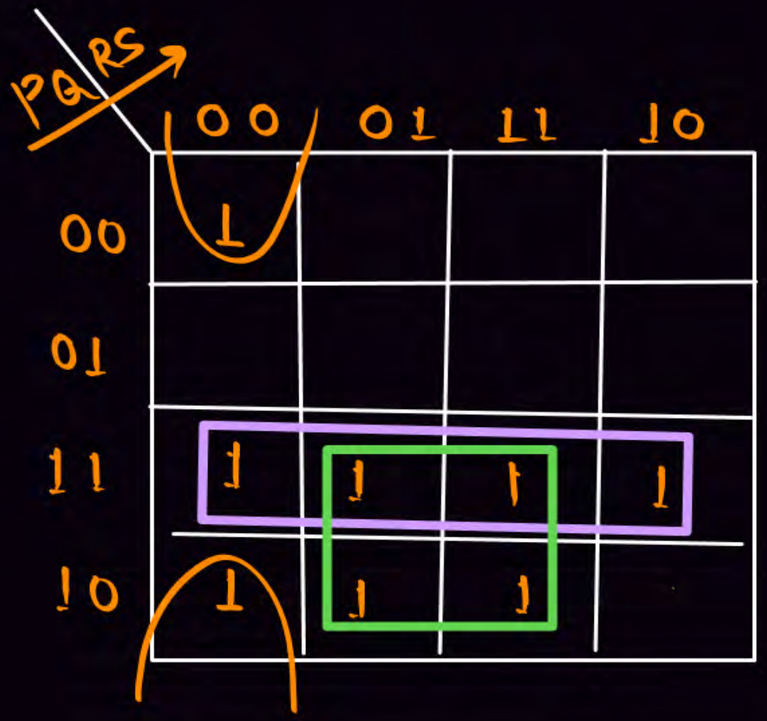
$\Sigma m($

$f(P,Q,R,S) = (P+\bar{Q})\bar{R}\bar{S} + P\bar{R}S + PQR\bar{S} + PRS$

$= P\bar{R}\bar{S} + \bar{Q}\bar{R}\bar{S} + P\bar{R}S + PQR\bar{S} + PRS$

$= 1000 \quad 0000 \quad 1001 \quad 1110 \quad 1011$
$1100 \quad 1000 \quad 1101 \quad 1111$

$= \Sigma m(0, 8, 9, 11, 12, 13, 14, 15)$

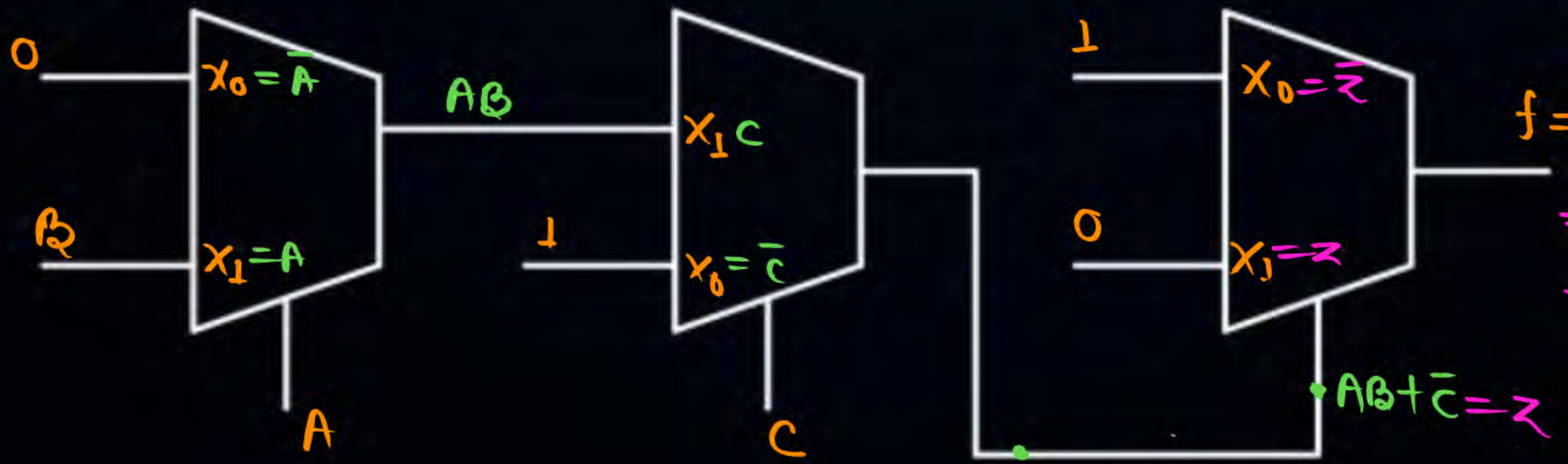


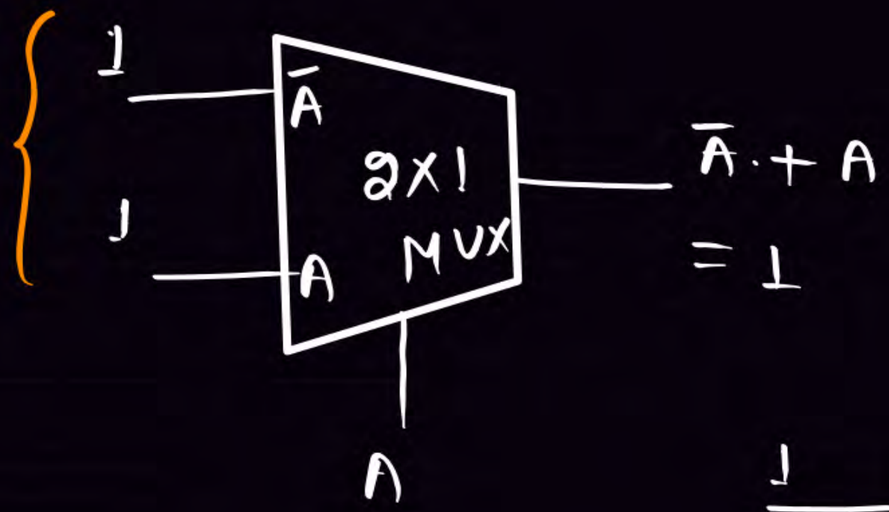
$$PQ + PS + \bar{Q}\bar{R}\bar{S}$$

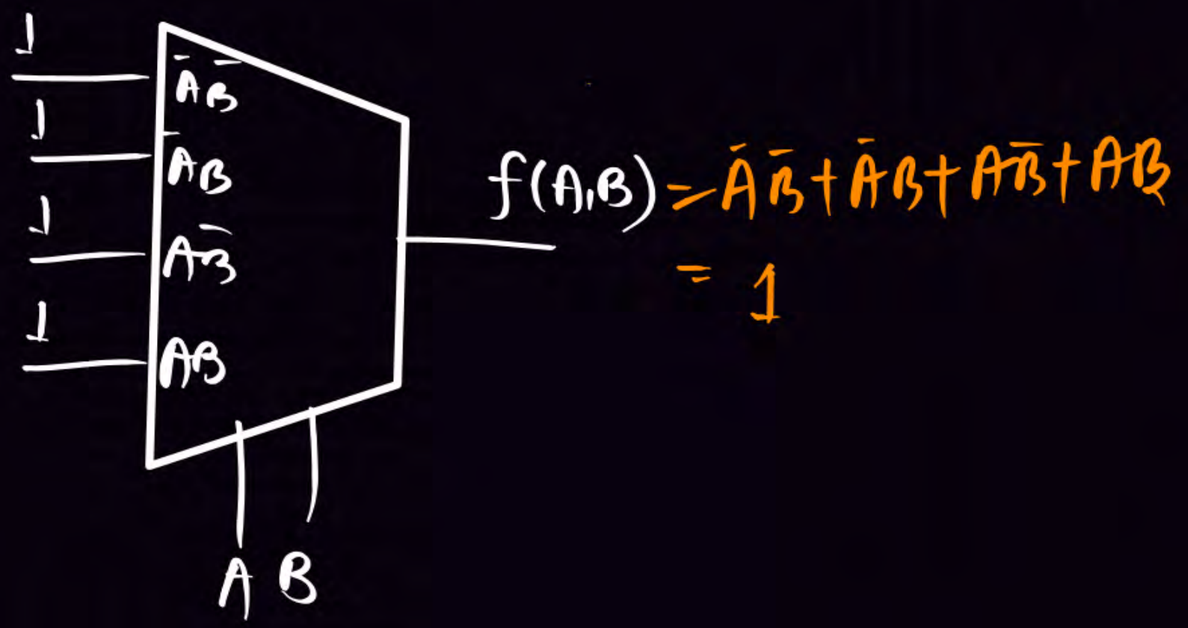
Ans

TYPE 4- CASCADING OF MUX

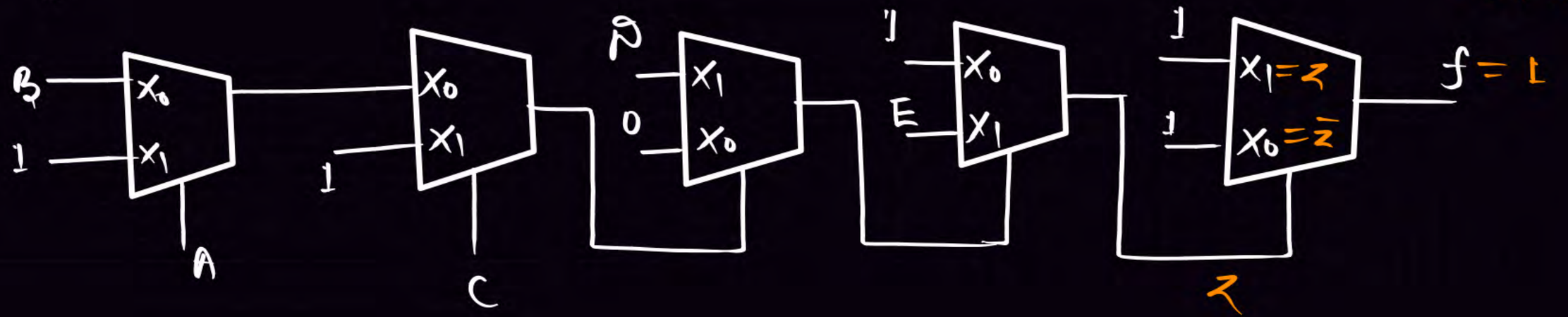
Example:→ Find the value of f ?




1
1
$\bar{A}$
A
2X1
MUX
A
$\bar{A}\cdot + A$
$= 1$


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

Q

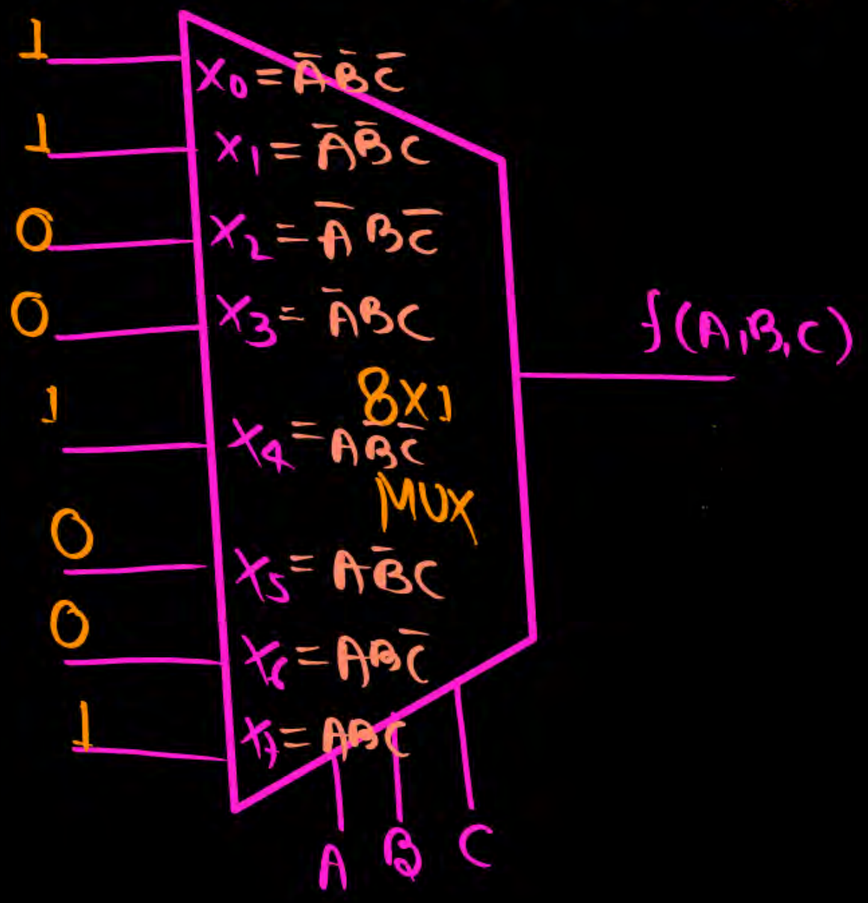


TYPE 5- IMPLEMANTATION OF FUNCTION

Example:.

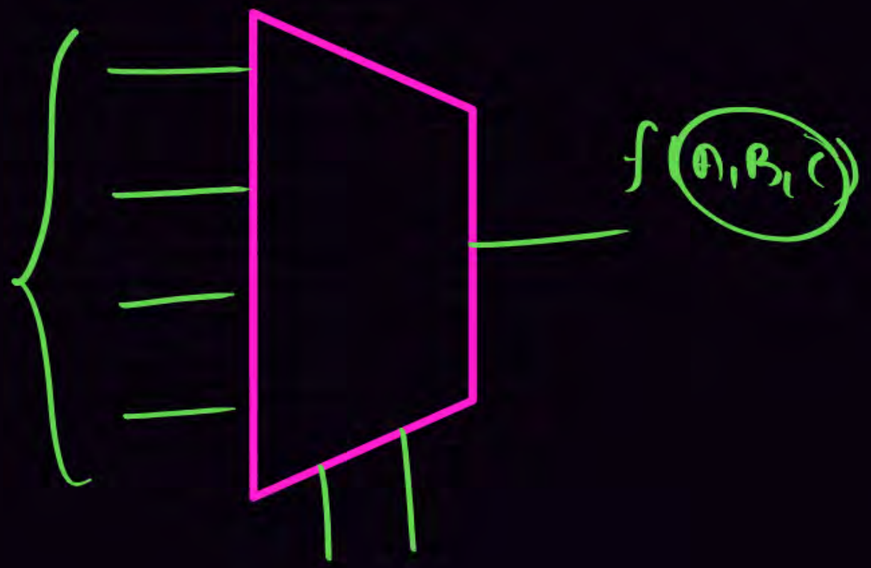
$f(A, B, C) = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC = \Sigma m(0, 1, 4, 7)$

By 8x1 MUX :→



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

Implement by using 4x1 MUX?



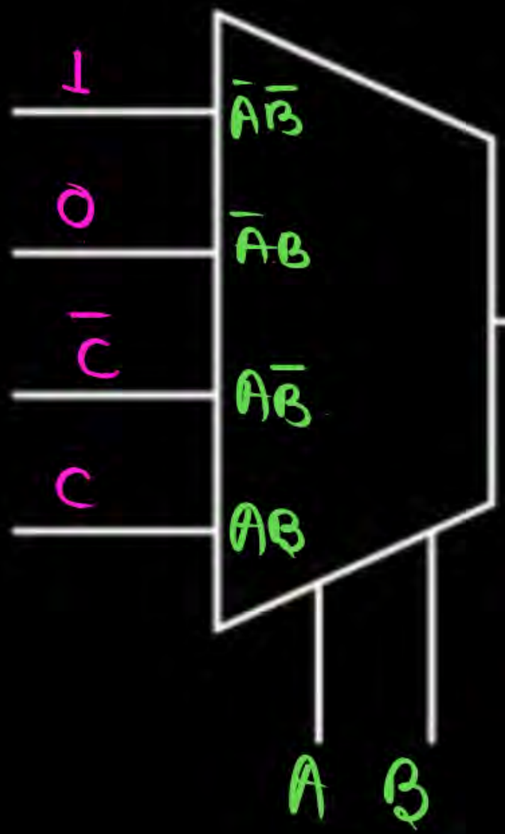
✓ 1> AB as a select line

2> BC as a select line

3> AC as a select line

1. AB is select line $f(A, B, C) = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$

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



$f(A,B,C)$

$= \bar{A}\bar{B}\cdot 1 + A\bar{B}\bar{C} + ABC$

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

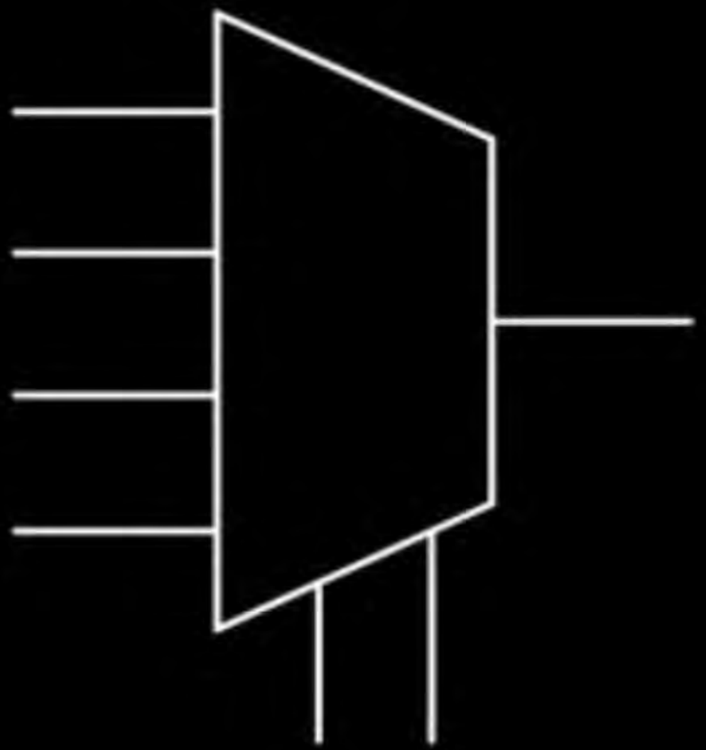
$= \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$

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

	$\bar{A}\bar{B}$	$\bar{A}B$	$A\bar{B}$	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

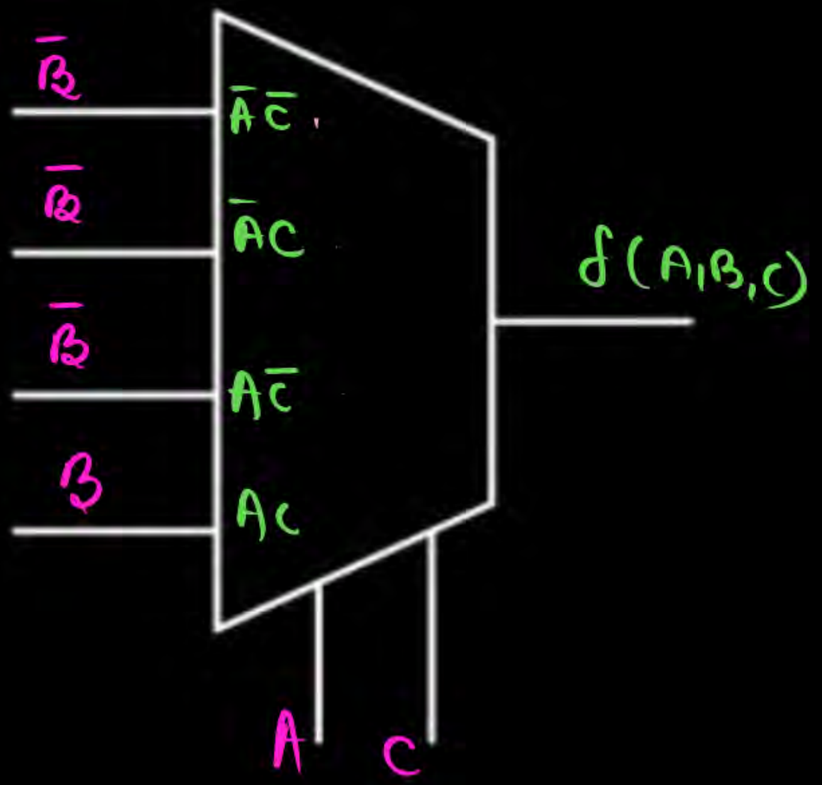
2. BC is select line $f(A, B, C) = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$

HW:



3. AC is select line $f(A, B, C) = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$

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

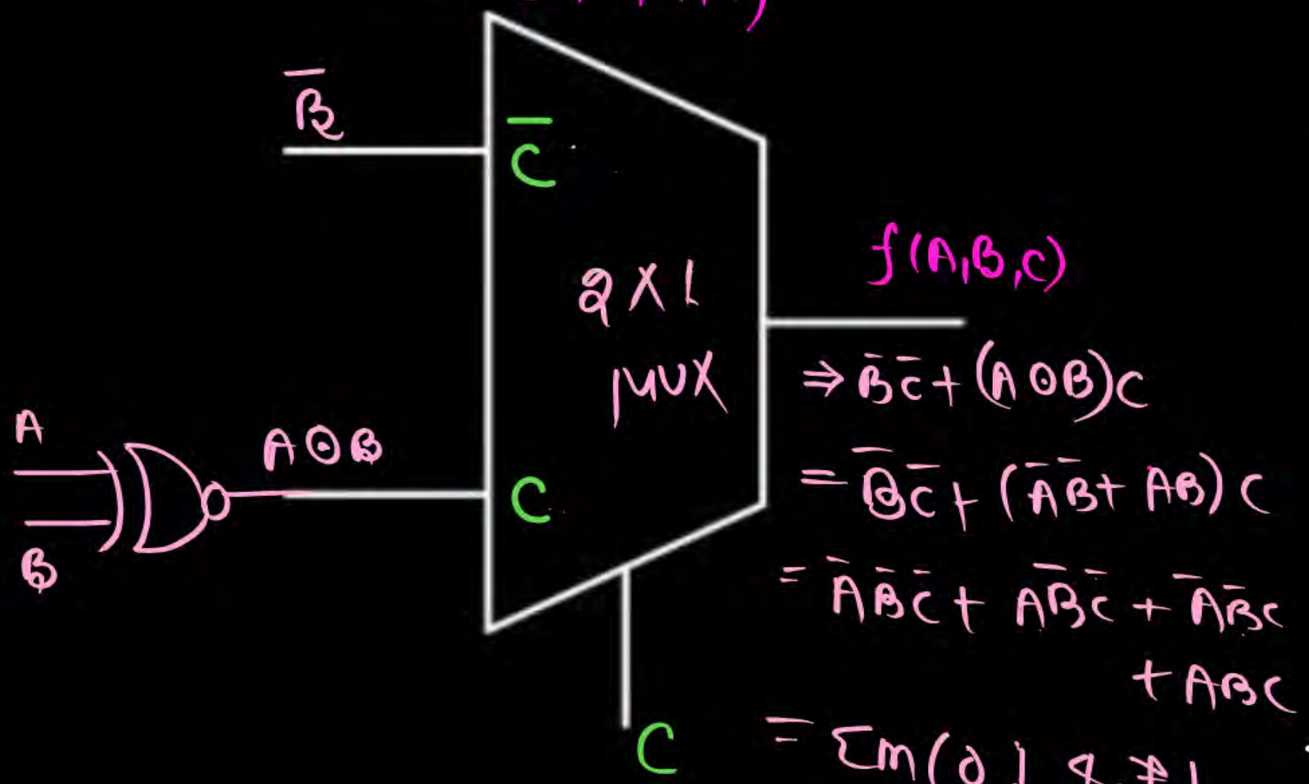


	$\bar{A}\bar{C}$	$\bar{A}C$	$A\bar{C}$	AC
$\bar{B}$	$\bar{A}\bar{B}\bar{C}$ (0)	$\bar{A}\bar{B}C$ (1)	$A\bar{B}\bar{C}$ (4)	$A\bar{B}C$ 5
B	$\bar{A}B\bar{C}$ 2	$\bar{A}BC$ 3	$AB\bar{C}$ 6	ABC (7)
	$\bar{B}$	$\bar{B}$	$\bar{B}$	B

By using 2 × 1 MUX

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

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



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

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

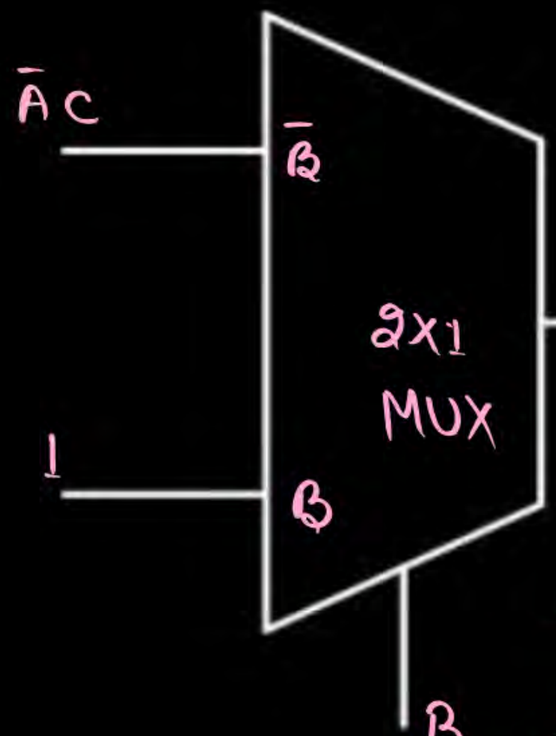
$= \bar{A}\bar{B}\bar{C} + A\bar{B}\bar{C} + \bar{A}\bar{B}C + ABC$

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

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

By using 2 × 1 MUX

$f(A,B,C) = \Sigma m(1,2,3,6,7)$



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

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

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

$B = \Sigma m(1,2,3,6,7)$

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

Q.

8x1

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

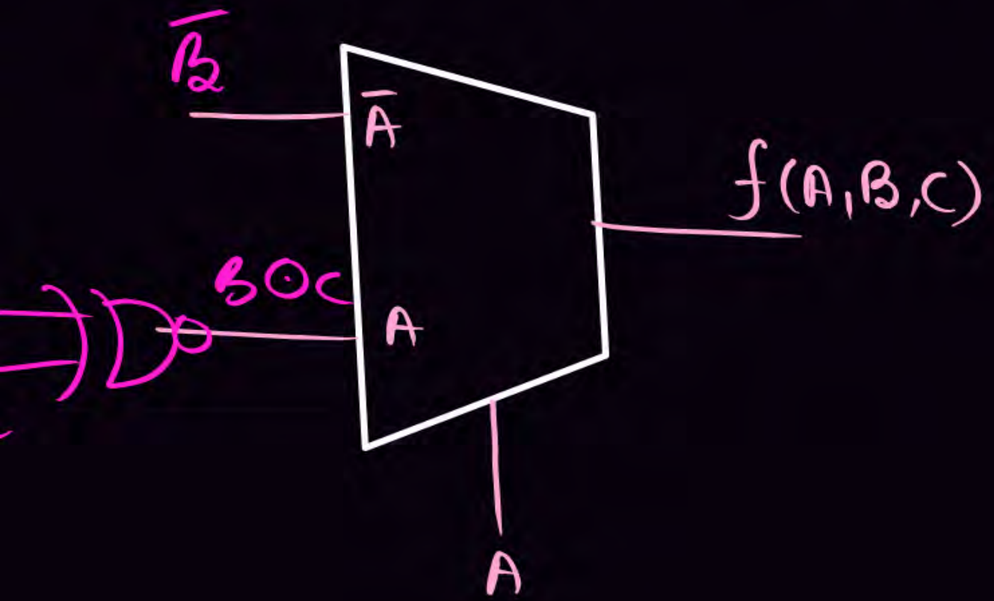
1. ABD as a select line
2. ACD as a select line

4x1 MUX

1) AB as a selectline

2) AC as a select line

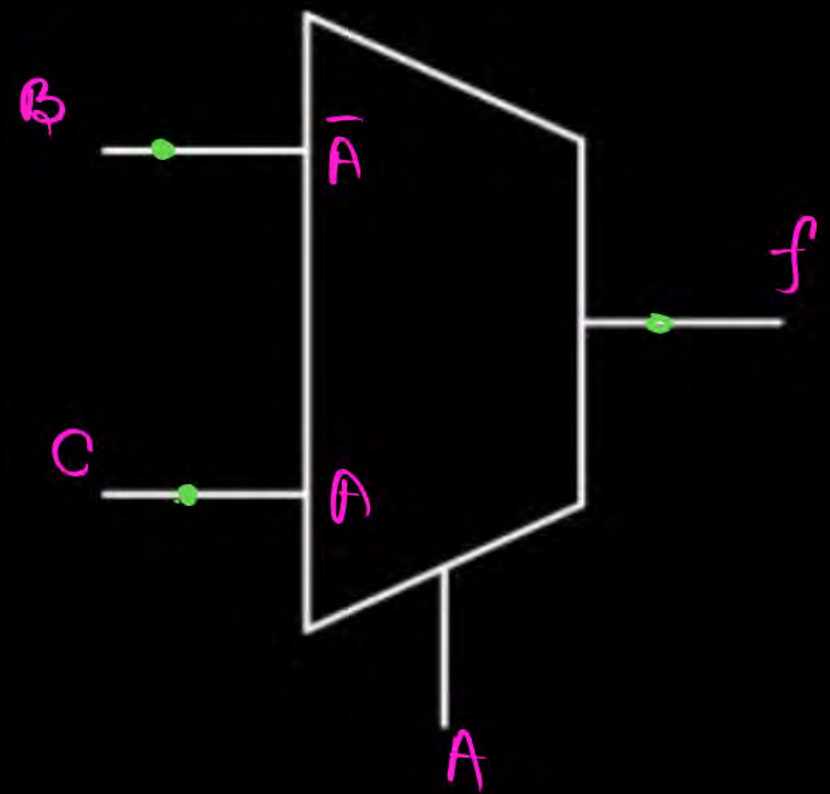
$$f(A,B,C) = \Sigma m(0,1,4,7)$$



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

Type-6 Delay

If MUX having Delay 1 μs.



Case(1) A = 0

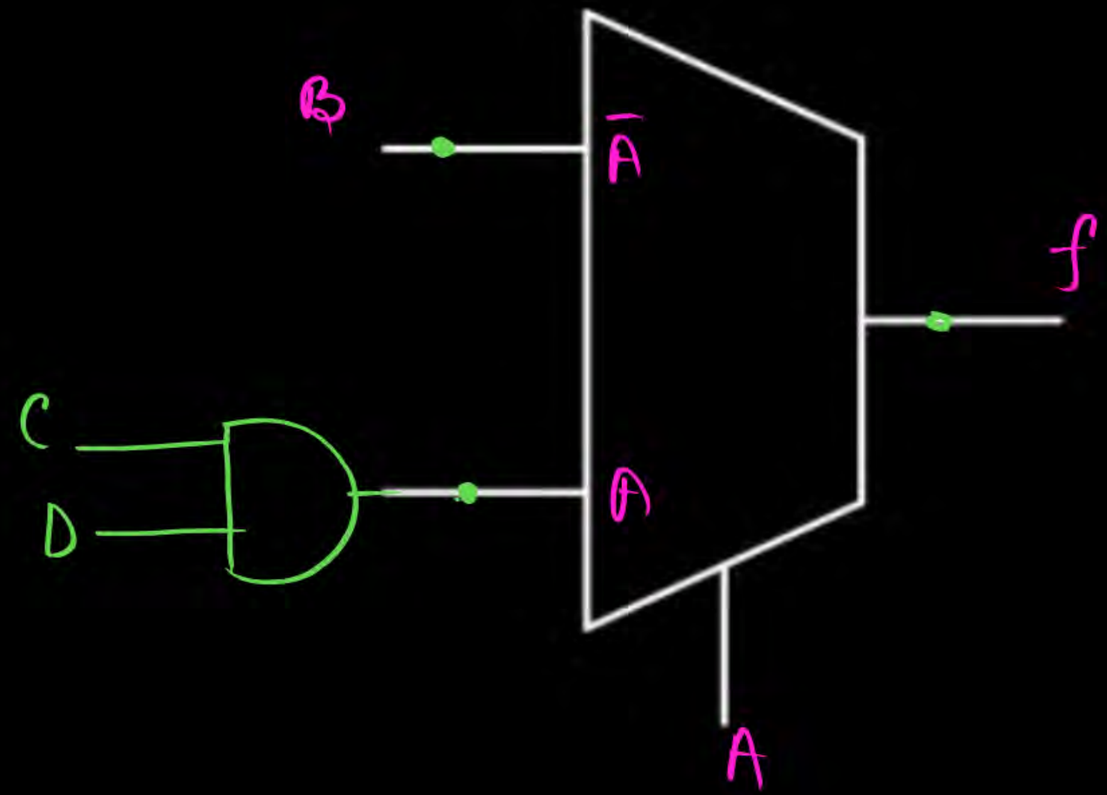
T_{MUX} = 1 μs

Case(2) A = 1

T_{MUX} = 1 μs

Type-6 Delay

If MUX having Delay 1 μs.
and AND having Delay 1 μs.



Case (1) A=0

$T = 1\ \mu s.\ (T_{MUX})$

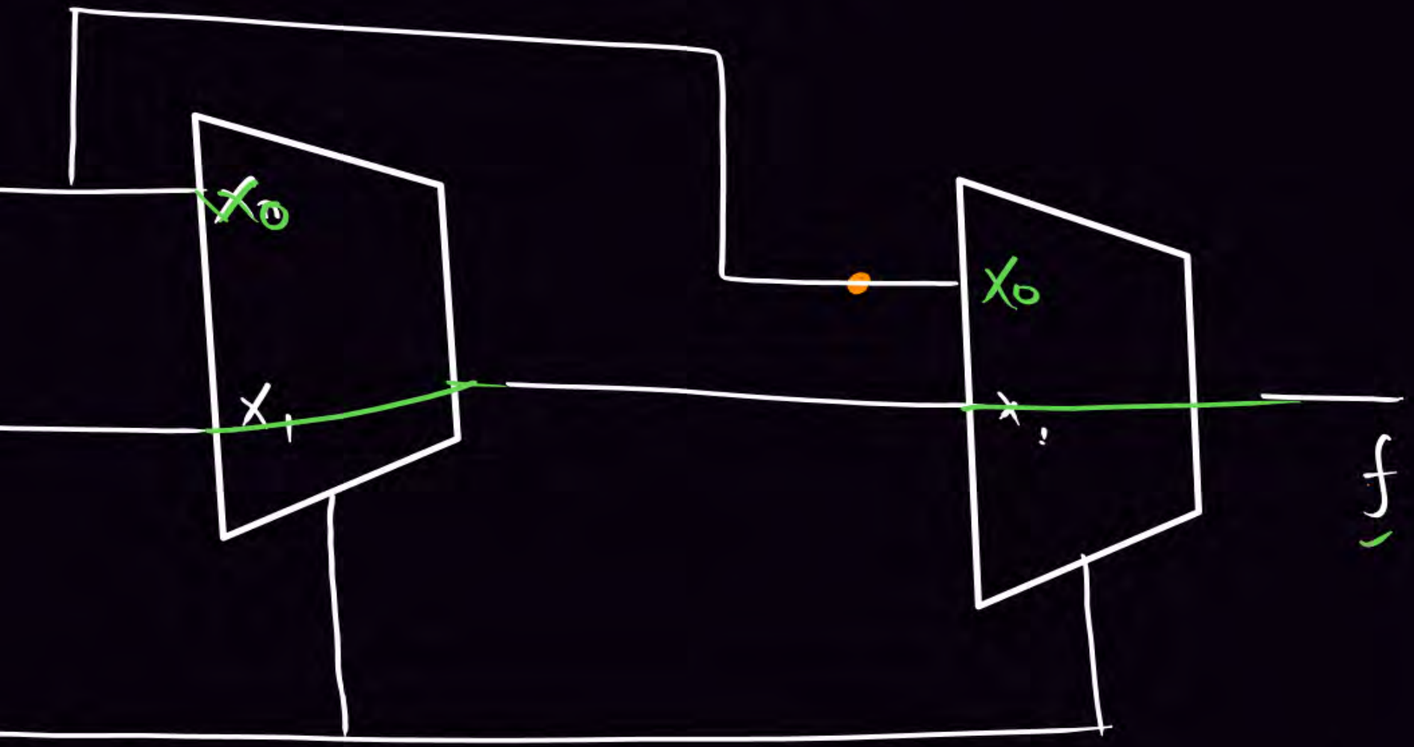
Case(2) A=1

$T = T_{AND} + T_{MUX}$

$T = 1\mu s + 1\mu s$

$T = 2\mu s$

$T_{MUX-1} = T_{MUX-2} = 1\ \mu s$



Case (1) Select line = 0

$T = T_{MUX-2} = 1\ \mu s.$ ✓

case(2) Select line = 1

$T = T_{MUX-1} + T_{MUX-2}$

$= 1 + 1 = 2\ \mu s.$

Q.

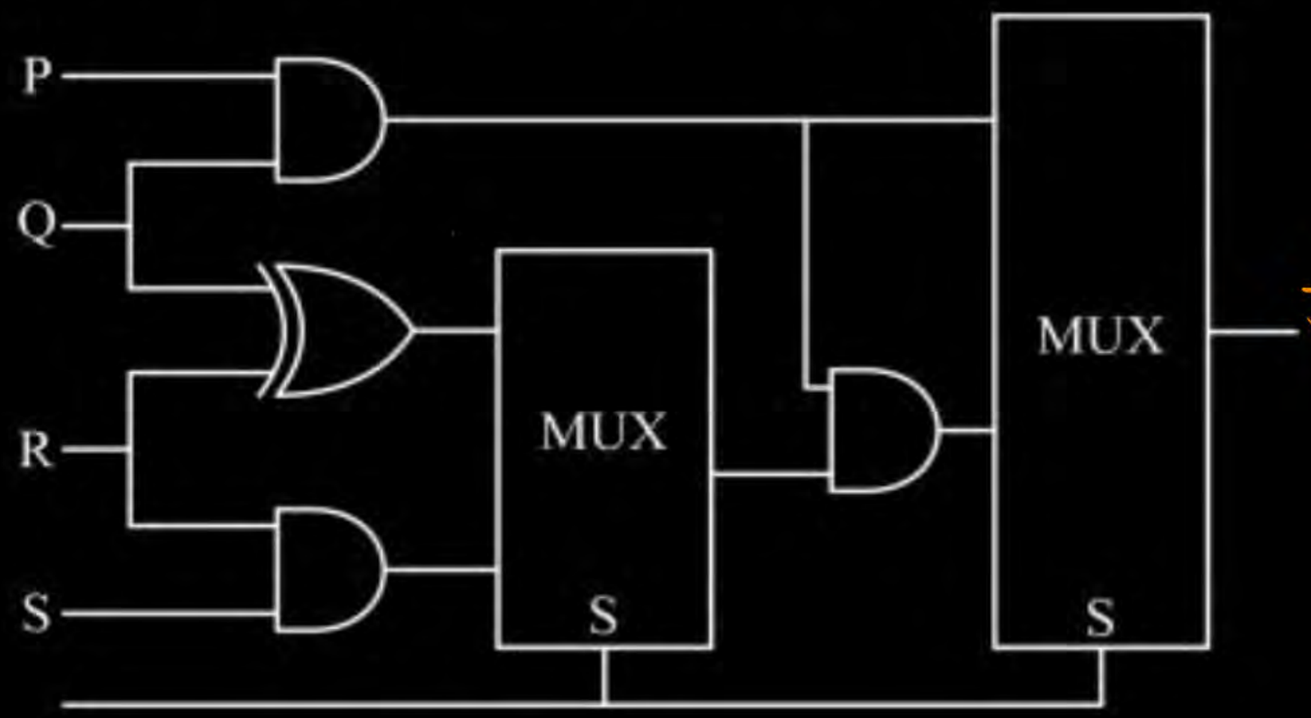
The propagation delay of the XOR gate, AND gate multiplexer (MUX) in the circuit shown in the figure are 4 ns, 2 ns and 1 ns, respectively. If all the inputs P, Q, R, S and T are applied simultaneously and held constant the maximum propagation delay of the circuit is

A 3 ns

B 6 ns

C 5 ns

D 7 ns



Case(1)

T = 3

Case(2)

T = 6

Thank you

GW

Soldiers !