COMPUTER SCIENCE & IT

DIGITAL LOGIC

Lecture No. 10

Combinational Circuit

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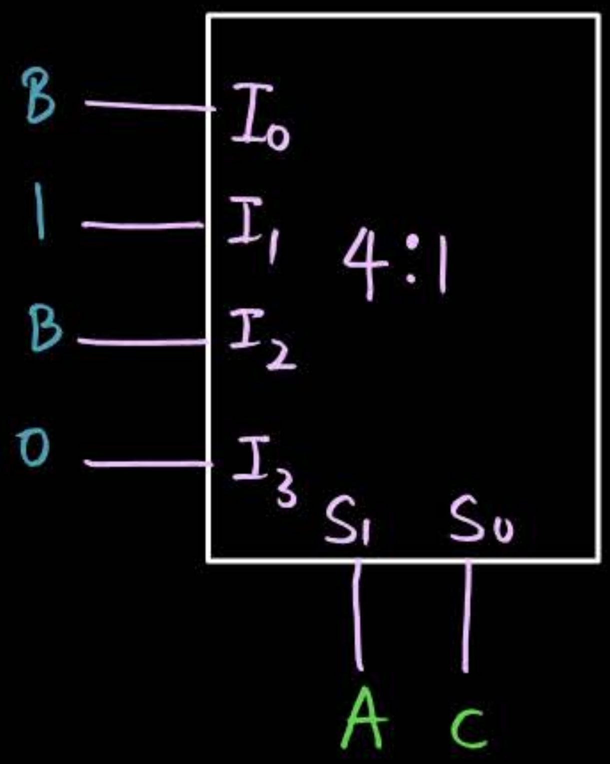
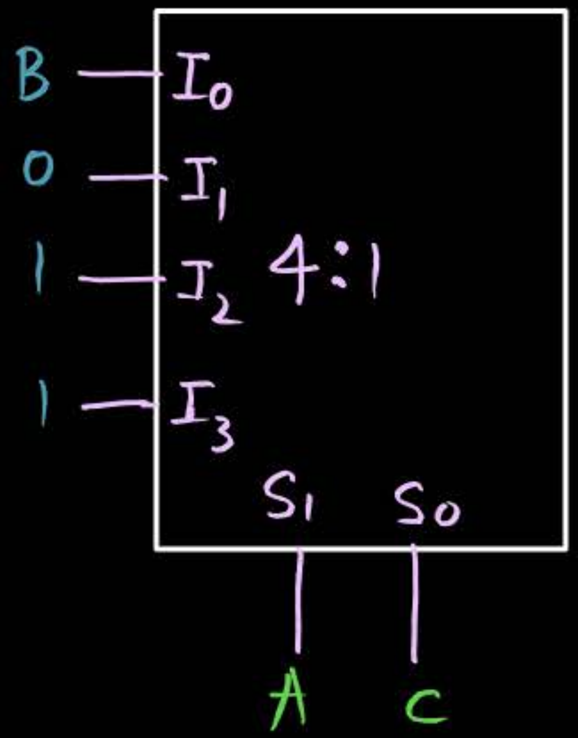
MUX

MUX cont.



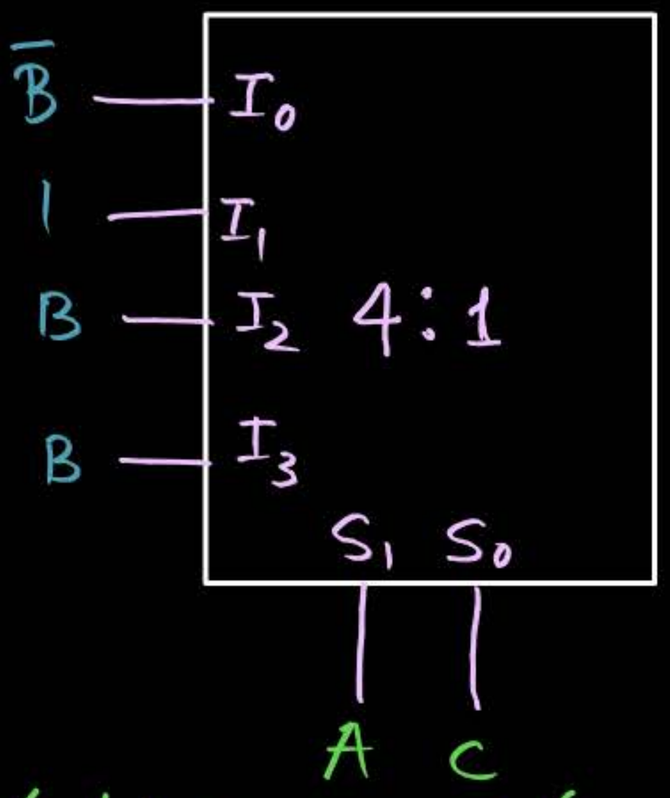
$f_1(A,B,C) = \sum(1,2,3,6)$

	I_0	I_1	I_2	I_3
$\bar{B}$	0	1	4	5
B	2	3	6	7
	B	1	B	0



$f_2(A,B,C) = \sum(2,4,5,6,7)$

	I_0	I_1	I_2	I_3
$\bar{B}$	0	1	4	5
B	2	3	6	7
	B	0	1	1



$f_3(A,B,C) = \sum(0,1,3,6,7)$

	I_0	I_1	I_2	I_3
$\bar{B}$	0	1	4	5
B	2	3	6	7
	$\bar{B}$	1	B	B

- 4 : 1 MUX can be used to implement

$2^2 : 1$

$\boxed{\text{All 2-Variable function}}$

$\boxed{\text{Some of the 3-variable function}}$

- 4 : 1 MUX + 1 NOT GATE can be used to implement

  $\boxed{\text{All 3-variable function}}$

- 8 : 1 MUX can be used to implement

$2^3 : 1$

$\boxed{\text{All-3-Variable function}}$

Some of the 4-variable function

- 8 : 1 MUX + 1 NOT GATE can be used to implement

  $\boxed{\text{All - 4 - variable function}}$

- $2^n : 1$ MUX can be used to implement

All n-variable function

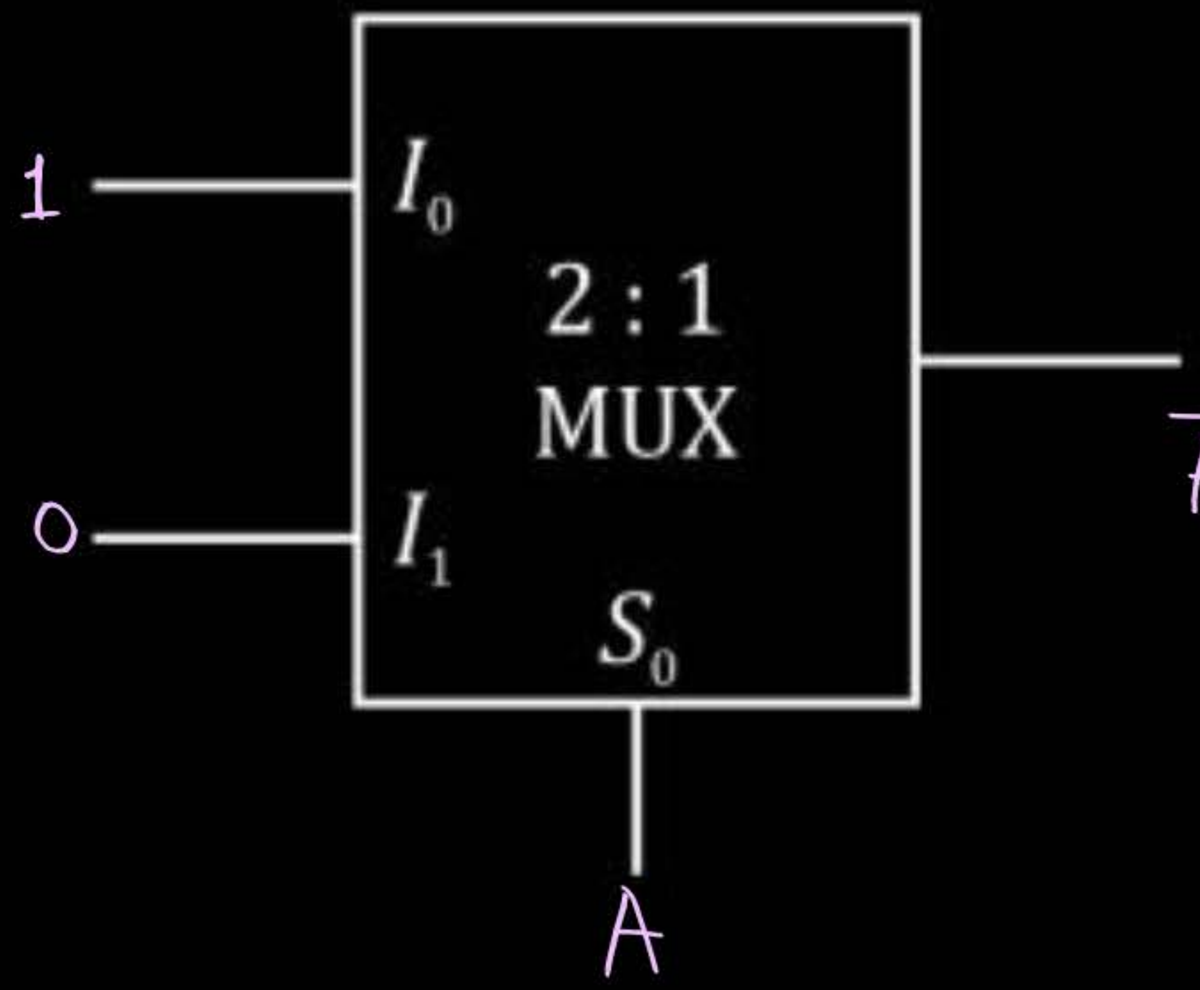
Some of the (n+1) variable function

- $2^n : 1$ MUX + 1 NOT GATE can be used to implement

  ↳ All $(n+1)$ variable function

MUX as Universal Circuit

- NOT GATE : $f(A) = \bar{A} = \sum(0)$

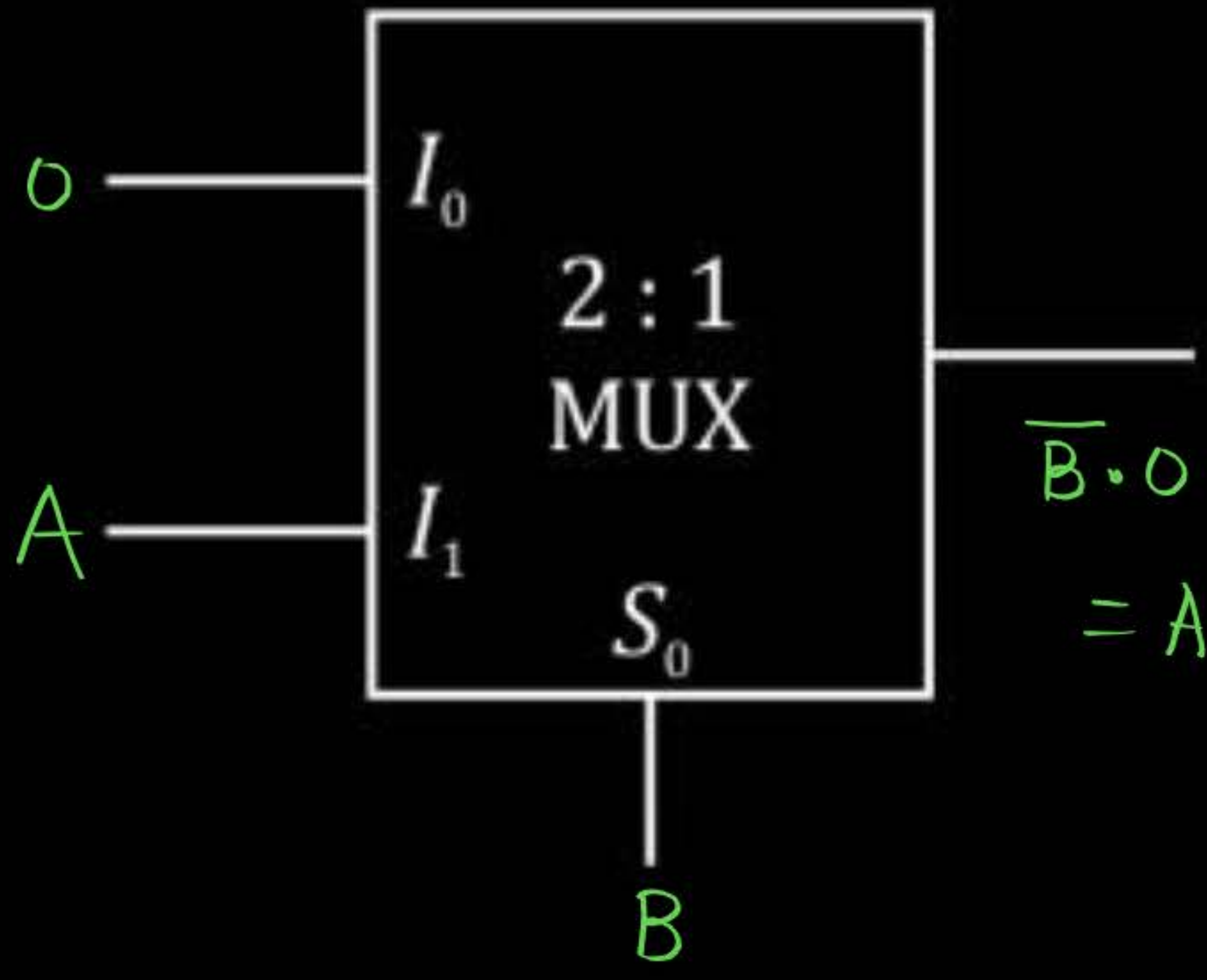


$f(A=0) = 1, \quad I_0 = 1$

$f(A=1) = 0, \quad I_1 = 0$

$\bar{A}\cdot 1 + A\cdot 0 = \bar{A}$

- AND GATE : $f(A,B) = A.B = \Sigma(3) = \pi(0,1,2)$



$f(A,0) = A\cdot 0 = 0$, $I_0 = 0$

$f(A,B=1) = A\cdot 1 = A$, $I_1 = A$

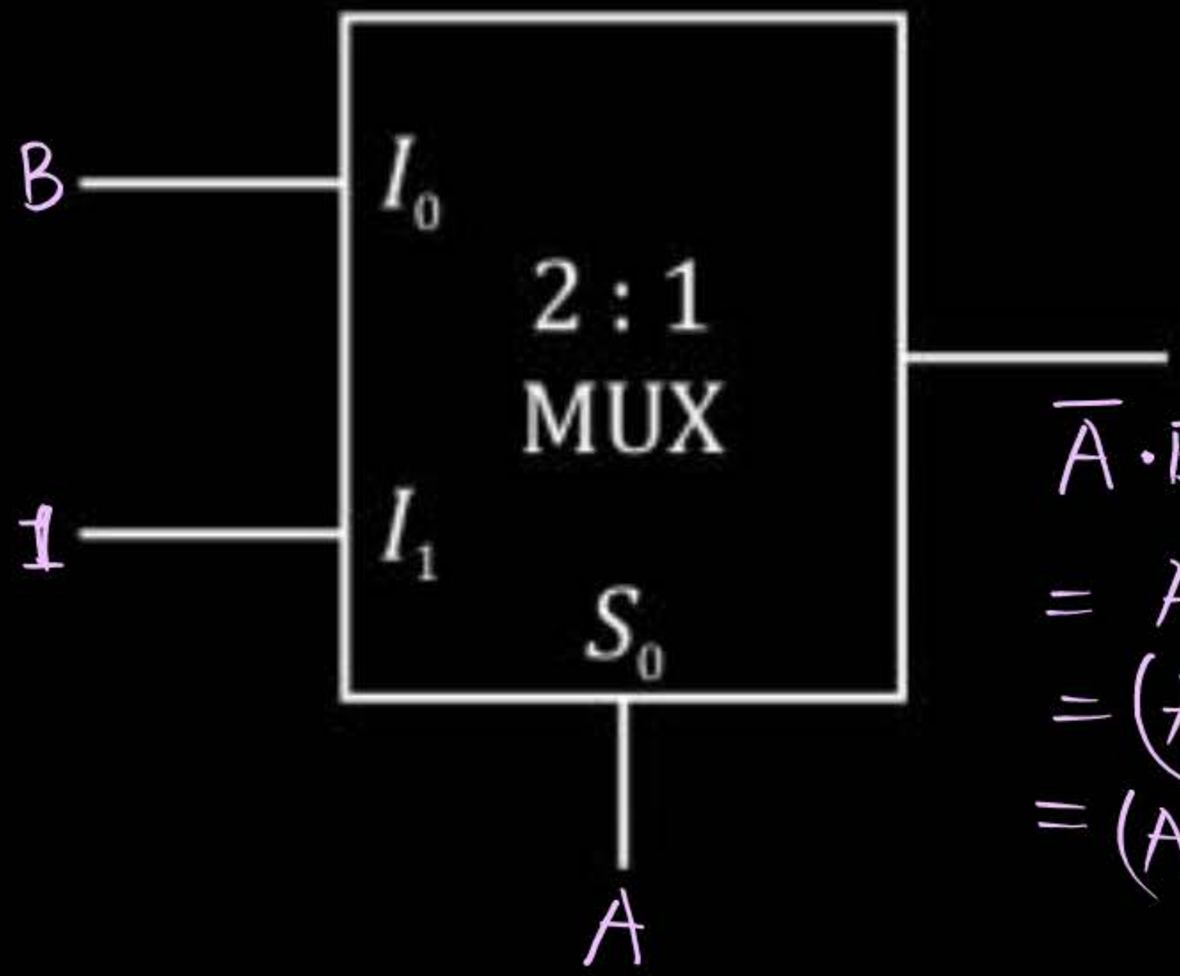
$\overline{B}\cdot 0 + B\cdot A$

$= A\cdot B$

- OR GATE : $f(A, B) = (A + B) = \Sigma(1,2,3) = \Pi(0)$

$f(A=0, B) = 0 + B = B, \quad I_0 = B$

$f(A=1, B) = 1 + B = 1, \quad I_1 = 1$



$\bar{A} \cdot B + A \cdot 1$

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

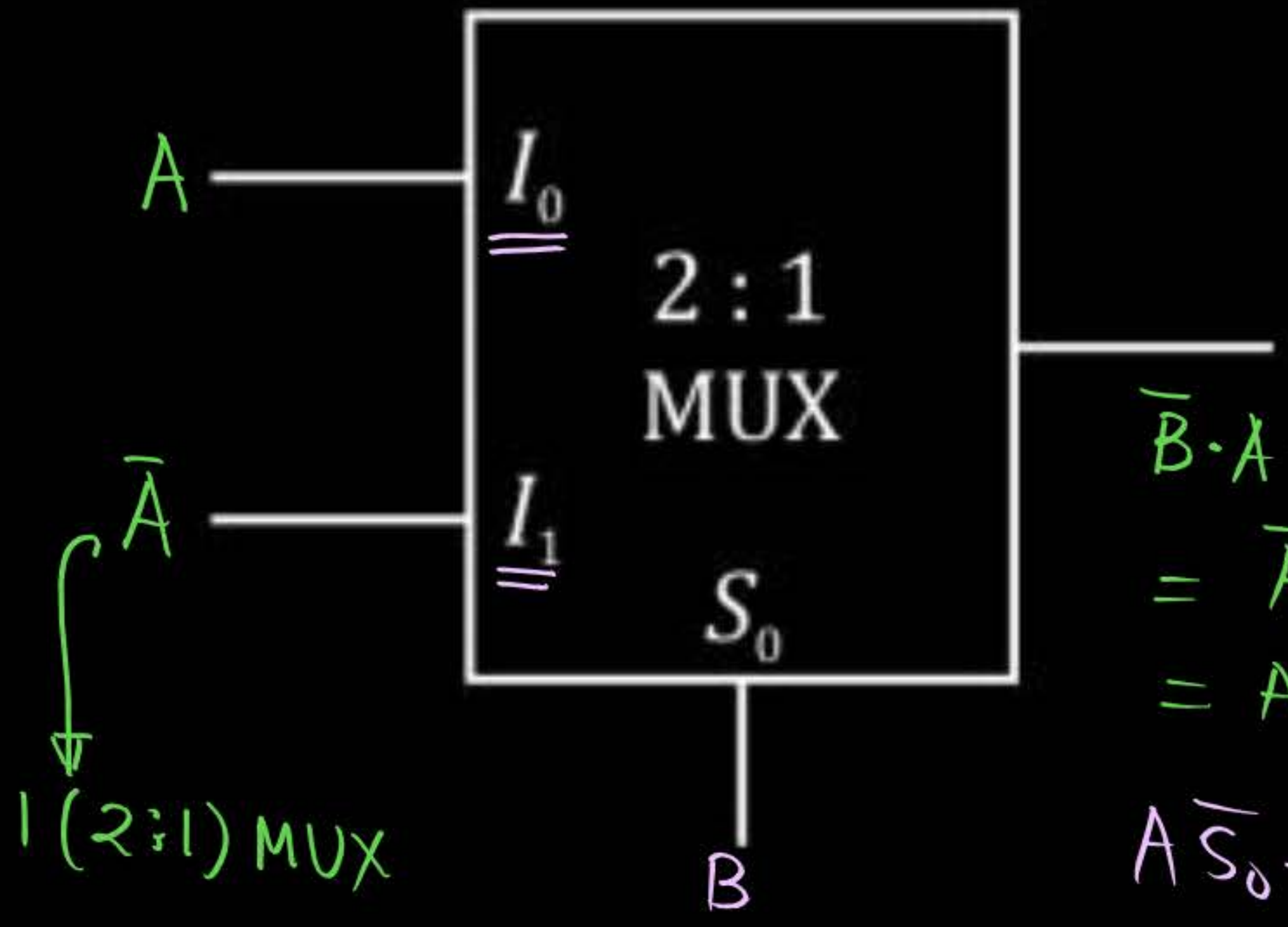
$= (A + \bar{A}) \cdot (A + B)$

$= (A + B)$

- XOR GATE : $f(A,B) = (A \oplus B) = \Sigma(1,2) = \pi(0,3)$

$f(A, B=0) = A \oplus 0 = A \; , \quad I_0 = A$

$f(A, B=1) = A \oplus 1 = \bar{A} \; , \quad I_1 = \bar{A}$



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

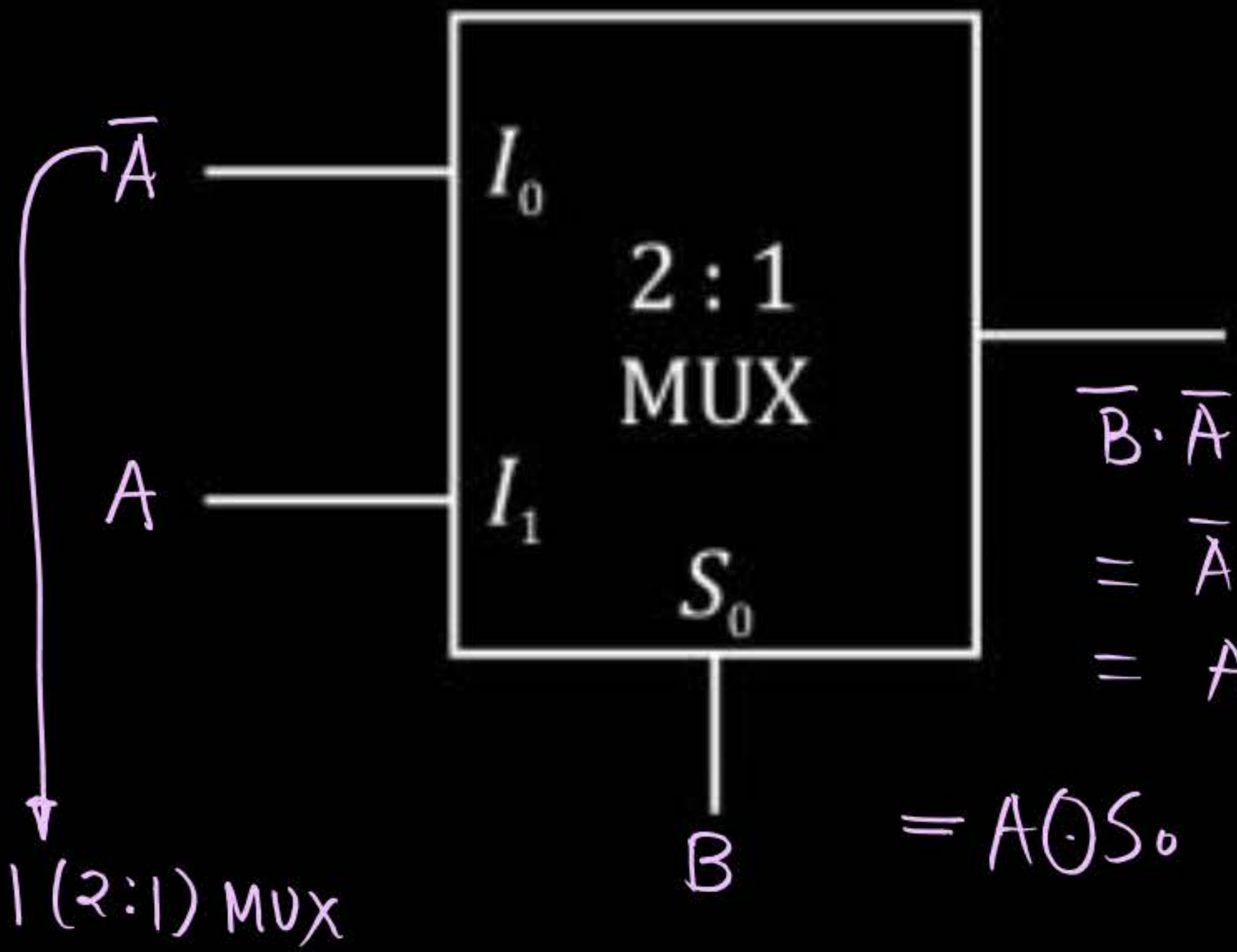
$= \bar{A}B + A\bar{B}$

$= A \oplus B$

$\Rightarrow A \oplus S_0$

$A\bar{S_0} + \bar{A}S_0 = A \oplus S_0$

- XNOR GATE : $f(A, B) = (A \odot B) = \Sigma(0,3) = \pi(1,2)$



$f(A, B=0) = A \odot 0 = \bar{A}$, $I_0 = \bar{A}$

$f(A, B=1) = A \odot 1 = A$, $I_1 = A$

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

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

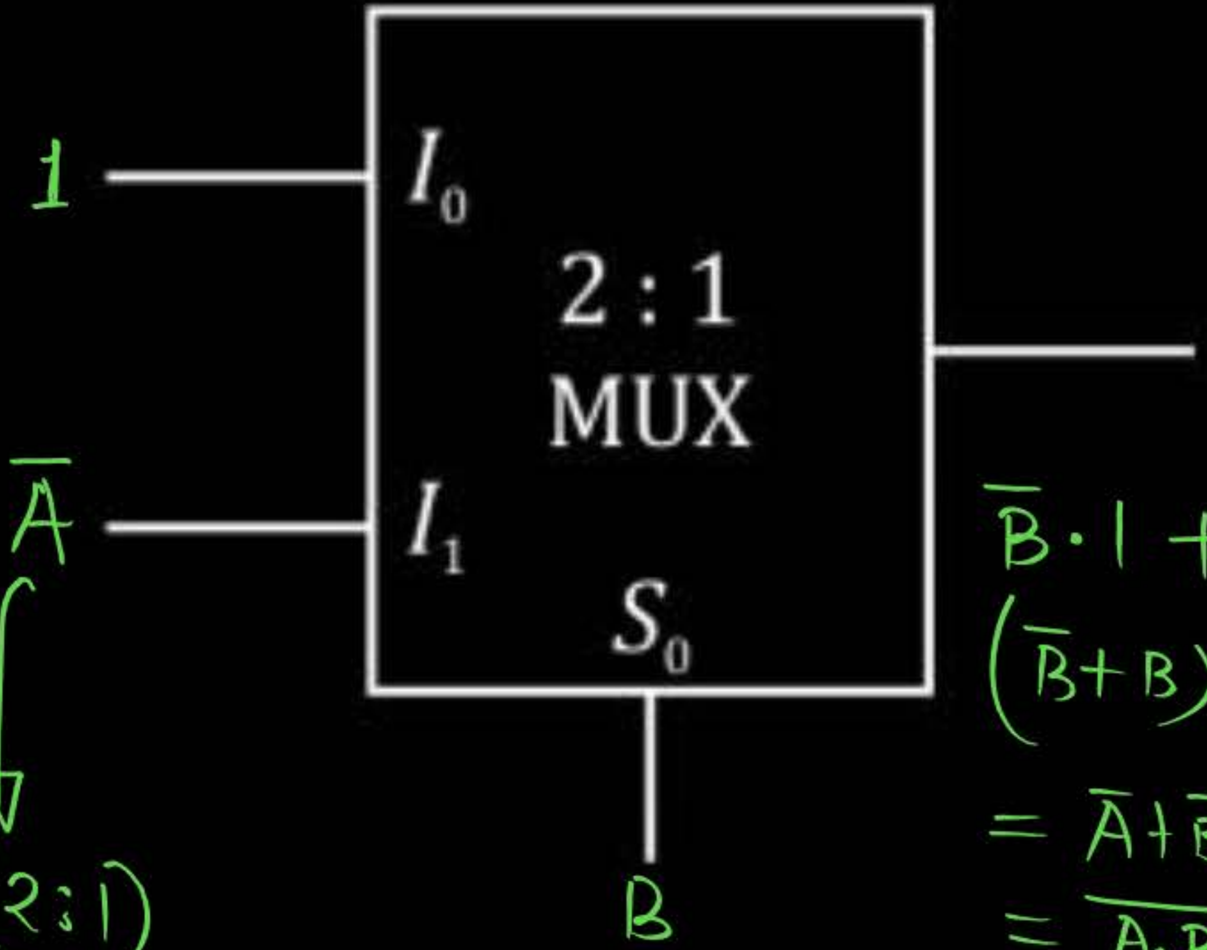
$= A \odot B$

$= A \odot S_0$

$\bar{A}\,\bar{S_0} + A S_0$

$= A \odot S_0$

- NAND GATE : $f(A,B) = \overline{A \cdot B} = \Sigma(0,1,2) = \Pi(3)$



1(2:1)
MUX

$f(A, B=0) = \overline{A \cdot 0} = 1$, $I_0 = 1$

$f(A, B=1) = \overline{A \cdot 1} = \bar{A}$, $I_1 = \bar{A}$

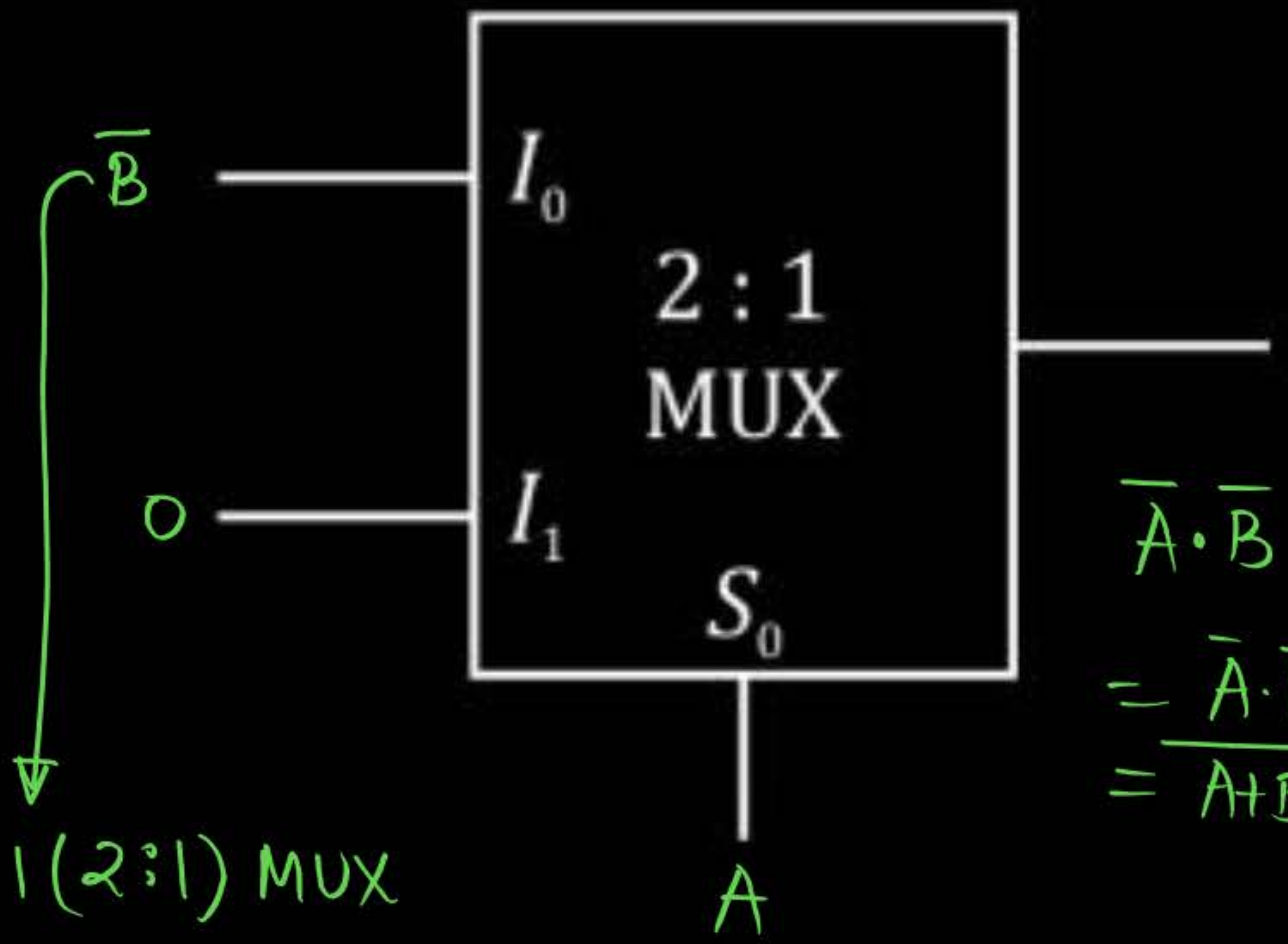
$\bar{B} \cdot 1 + (B \cdot \bar{A})$

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

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

$= \overline{A \cdot B}$

- NOR GATE : $f(A,B) = \overline{A+B} = \Sigma(0) = \pi(1,2,3)$



$f(A=0,B) = \overline{0+B} = \bar{B}$, $I_0 = \bar{B}$

$f(A=1,B) = \overline{1+B} = 0$, $I_1 = 0$

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

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

$= \overline{A+B}$

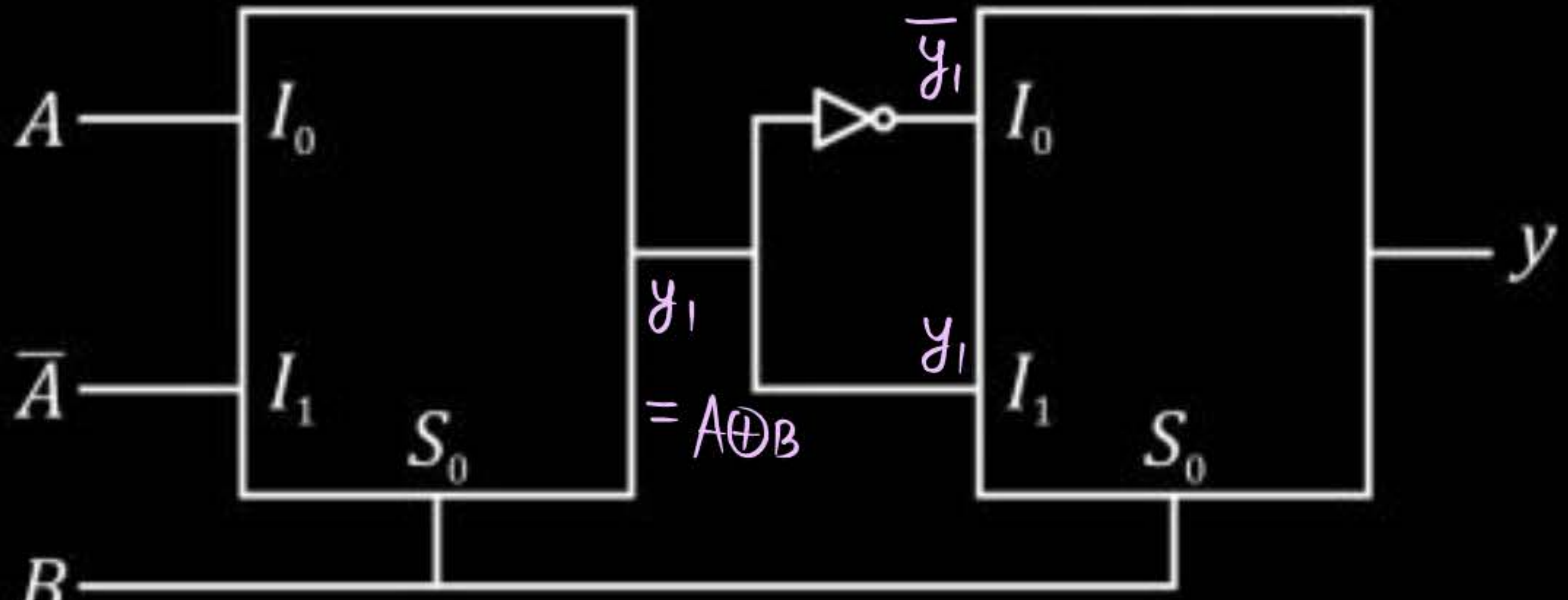
- IMP Notes :

- For implementing basic gates (NOT, AND, OR) we require only one (2:1) MUX.

- For implementing non-basic gates (XOR, XNOR, NAND, NOR), we require two (2:1) MUX.

[Questions On MUX]

A digital circuit is as given below :



$$y = y_1 \odot B$$
$$= A \oplus B \odot B$$
$$= A \oplus 1$$
$$= \overline{A}$$

Output y is

(a) $A \oplus B$

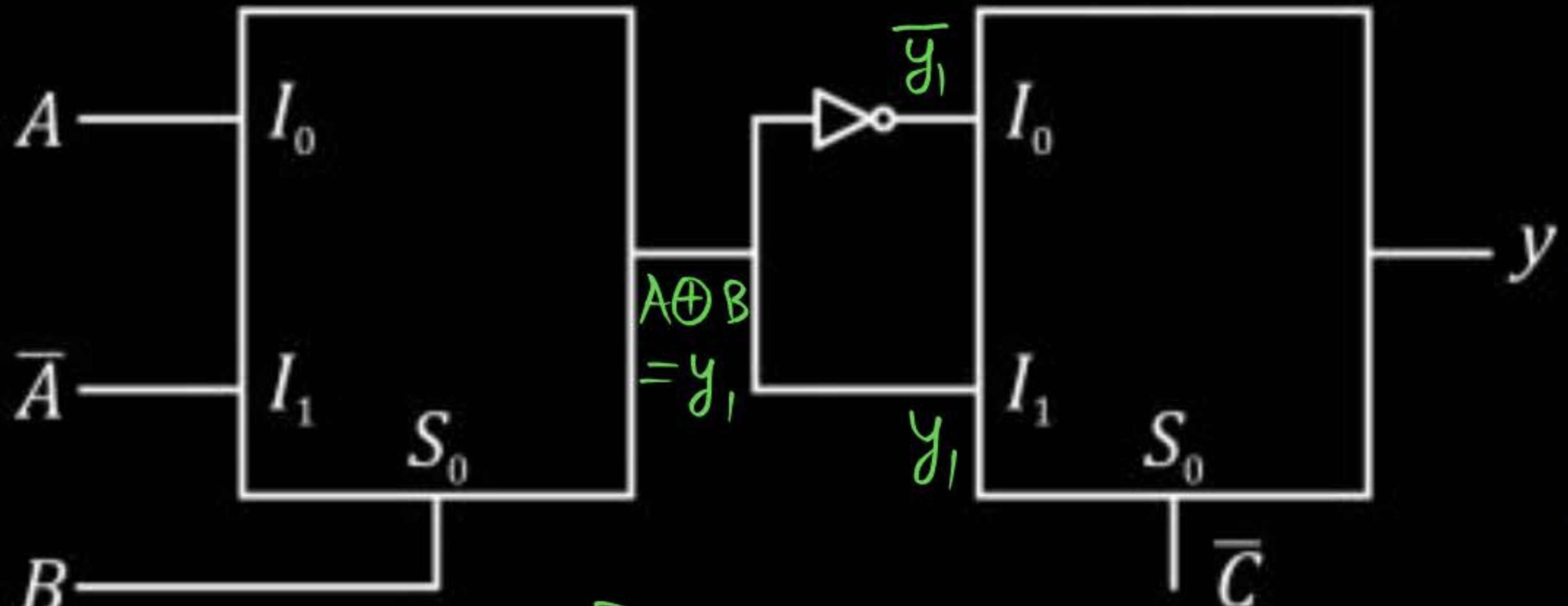
(b) $A \odot B$

(c) $C . A$

(d) $\bar{A}$

Question 2

A digital circuit is as given below :



$$
\begin{aligned}
y &= y_1 \odot S_0 \\
&= y_1 \odot \overline{C} \\
&= A \oplus B \odot \overline{C} \\
&= \overline{A \oplus B \odot C} \\
&= A \odot B \odot C \\
&= A \oplus B \oplus C
\end{aligned}
$$

$\bar{A} \oplus B \odot C$

$\bar{A} \odot B \oplus C$

Output y is

(a) $A \oplus B \oplus C$

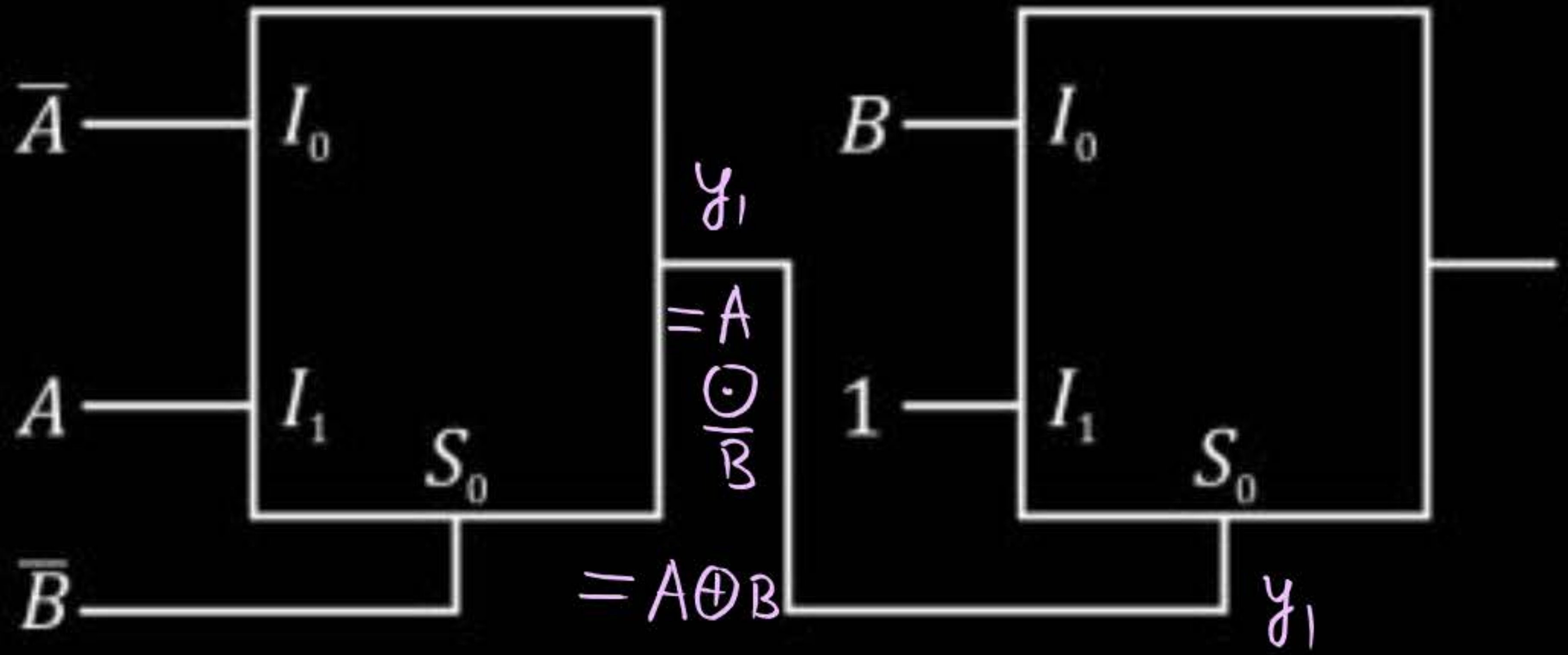
(b) $A \oplus B \odot C$

(c) $A \oplus C$

(d) $A \oplus B$

[Question 3]

A digital circuit is as given below :



$y = \bar{y}_1 \cdot B + y_1 \cdot 1$

$= y_1 + (\bar{y}_1 \cdot B)$

$= (y_1 + \bar{y}_1) \cdot (y_1 + B)$

$= A \oplus B + B$

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

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

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

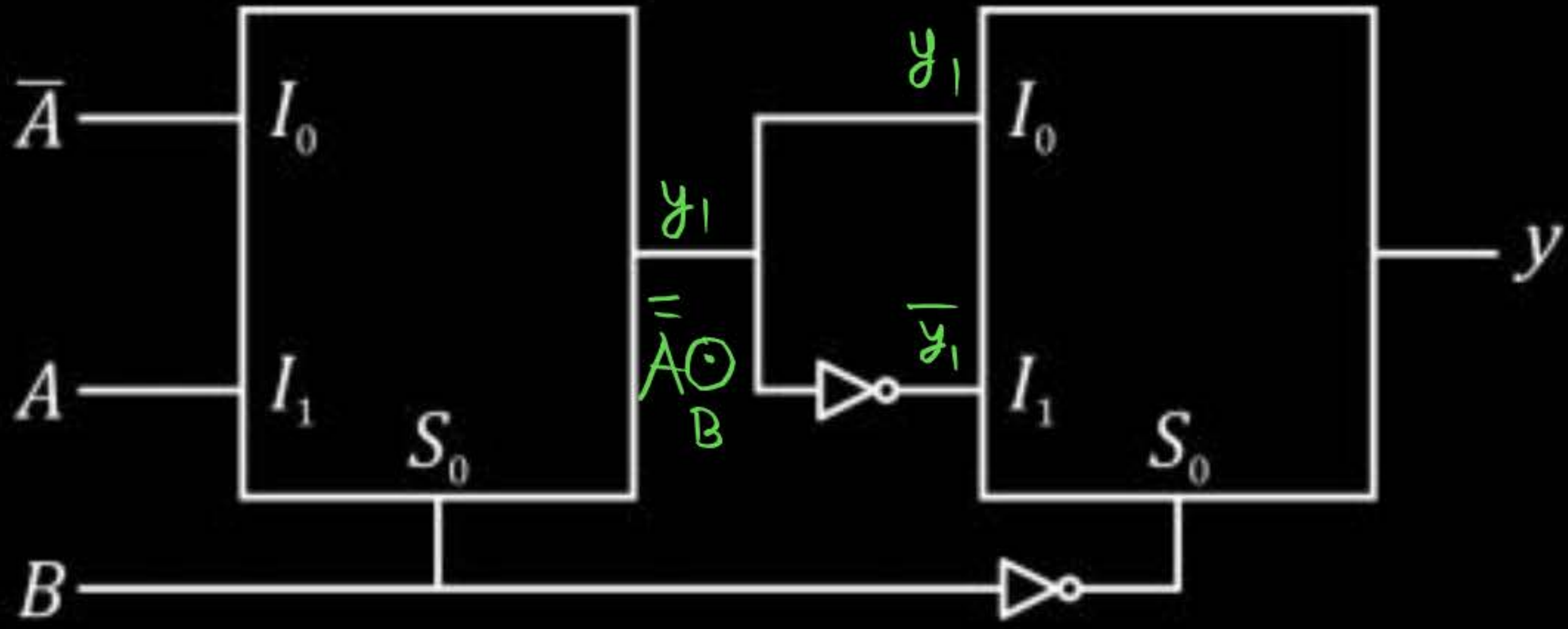
Output y is

(a) $A \oplus B$ (b) $A \odot B$

(c) $(A + B)$ (d) $A . B$

Question 4

A digital circuit is as given below :



$$y = y_1 \oplus S_0 = y_1 \oplus \overline{B}$$
$$= A \odot B \oplus \overline{B}$$
$$= A \odot 1$$
$$= A$$

Output y is

(a) B

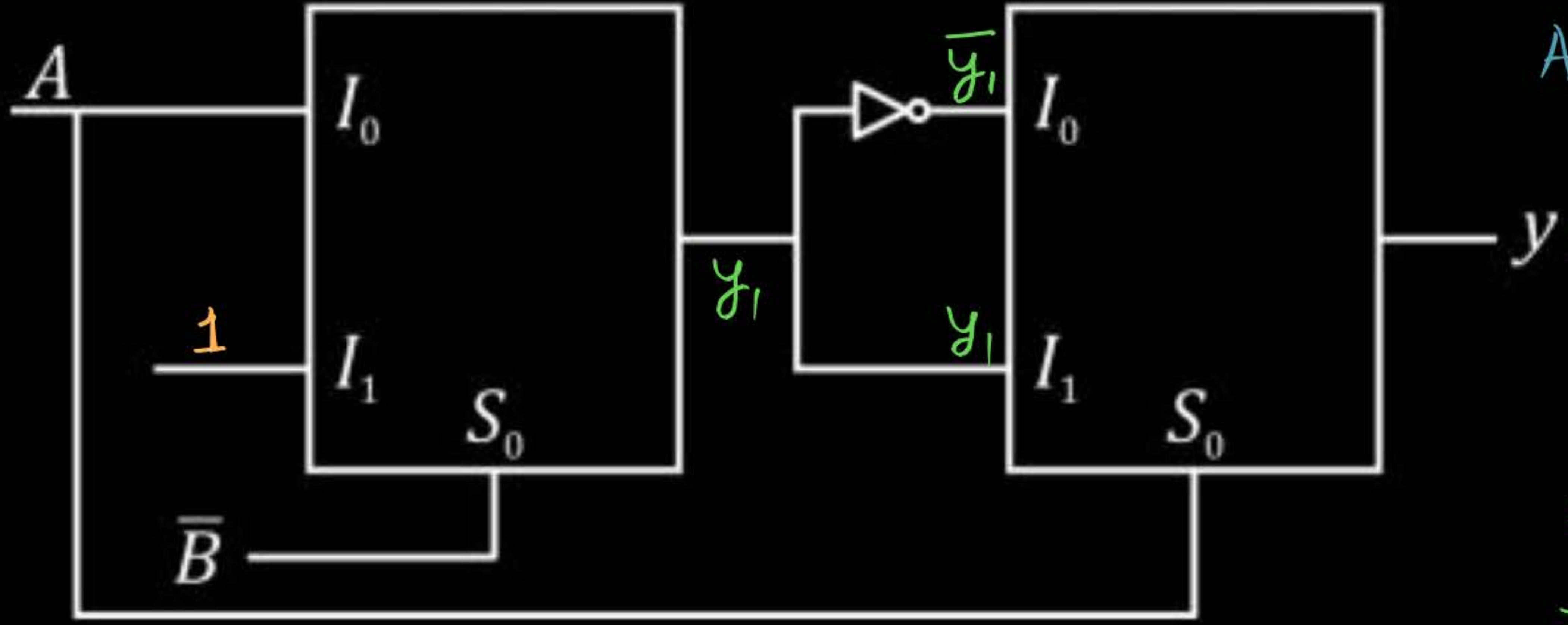
(b) A

(c) $(A + B)$

(d) $A \, . \, B$

[Question 5]

A digital circuit is as given below :



The output y is

(a) $A \odot B$

(b) $\bar{A}B$

(c) $(A + B)$

(d) $A\bar{B}$

$y_1 = \overline{S_0}A + S_0 \cdot 1 = B\cdot A + \overline{B}$

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

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

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

$A + A\overline{B} = A(1+\overline{B})$

$= A$

$y = y_1 \odot A$

$= (A+\overline{B}) \odot A$

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

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

$= \overline{A}B + A$

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

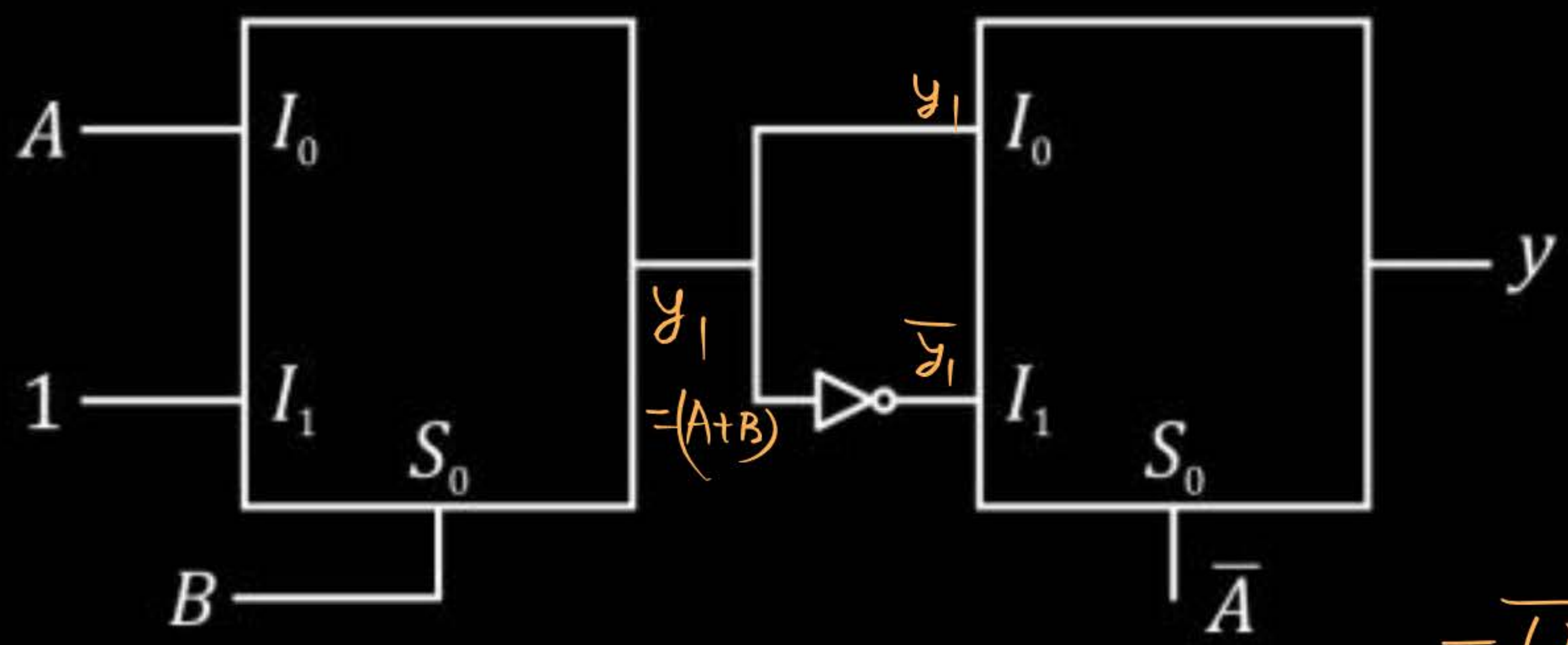
$= (A+\overline{A})(A+B)$

$= (A+B)$

[Question 6]

$$y_1 = \overline{S_0}\cdot A + S_0\cdot 1 = (\overline{B}\cdot A) + B$$
$$= (B+\overline{B})\cdot(B+A)$$
$$= (A+B)$$

A digital circuit is as given below :



$$y = y_1 \oplus S_0$$
$$= y_1 \oplus \overline{A}$$
$$= (A+B) \oplus \overline{A}$$
$$= \overline{(A+B)}\cdot\overline{A} + (A+B)\cdot\overline{\overline{A}}$$
$$= \overline{A}\,\overline{B}\cdot\overline{A} + A$$
$$= \overline{A}\,\overline{B} + A$$
$$(A+\overline{B}) = A + (\overline{A}\,\overline{B}) = (A+\overline{A})\cdot(A+\overline{B})$$

Output y is

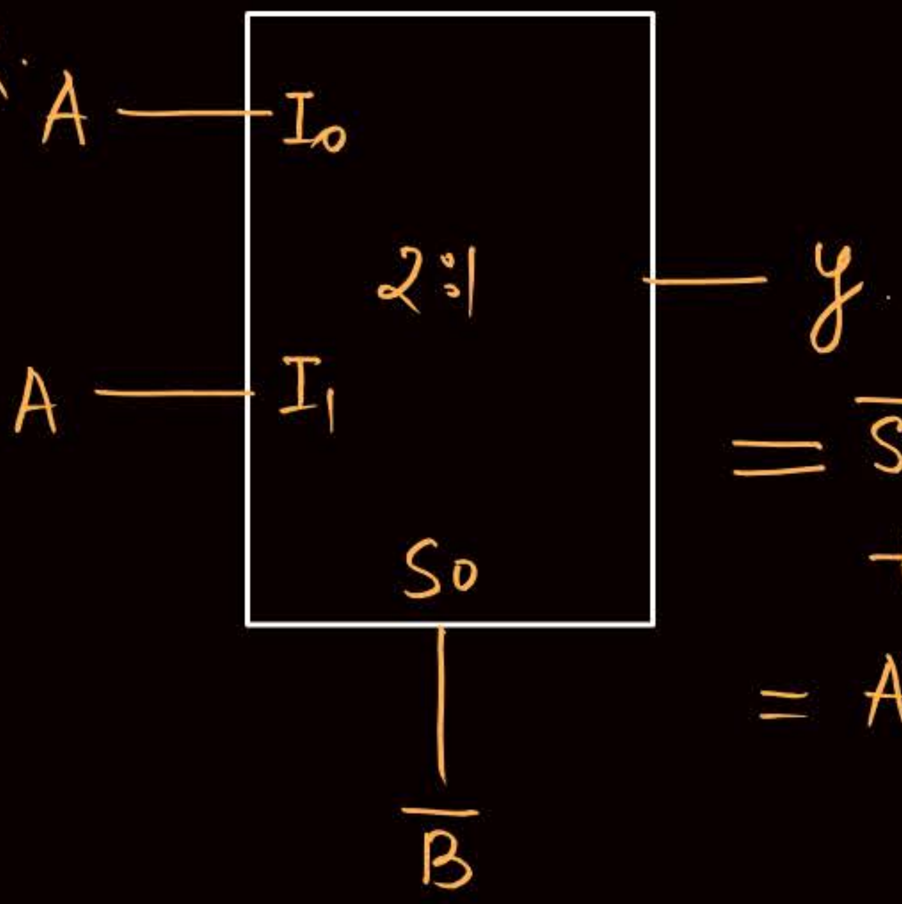
(a) 1

(b) $A \odot B$

(c) $\overline{\overline{A}B} = (A+\overline{B})$

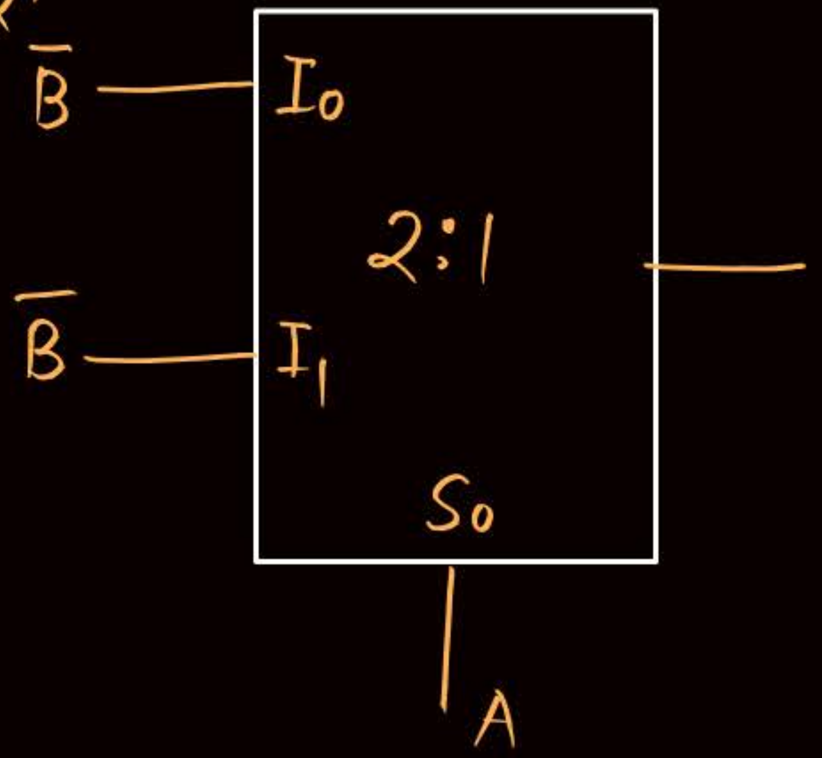
(d) $\overline{A\cdot B}$

#Q.



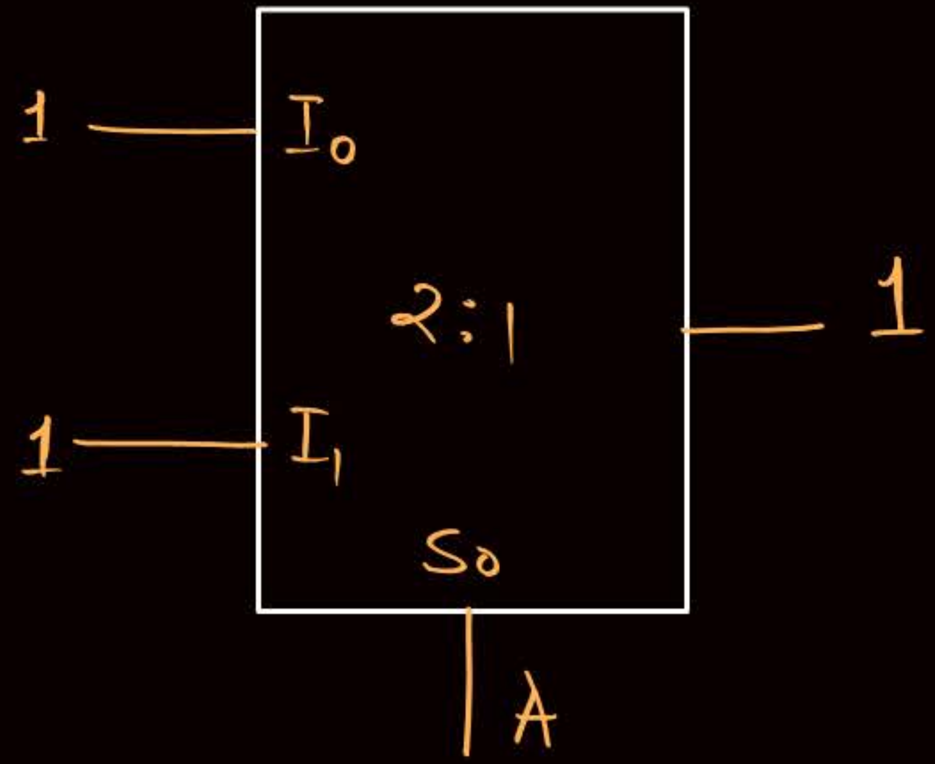
$$y = \overline{S_0}\cdot A + S_0\cdot A$$
$$= A$$

#Q.

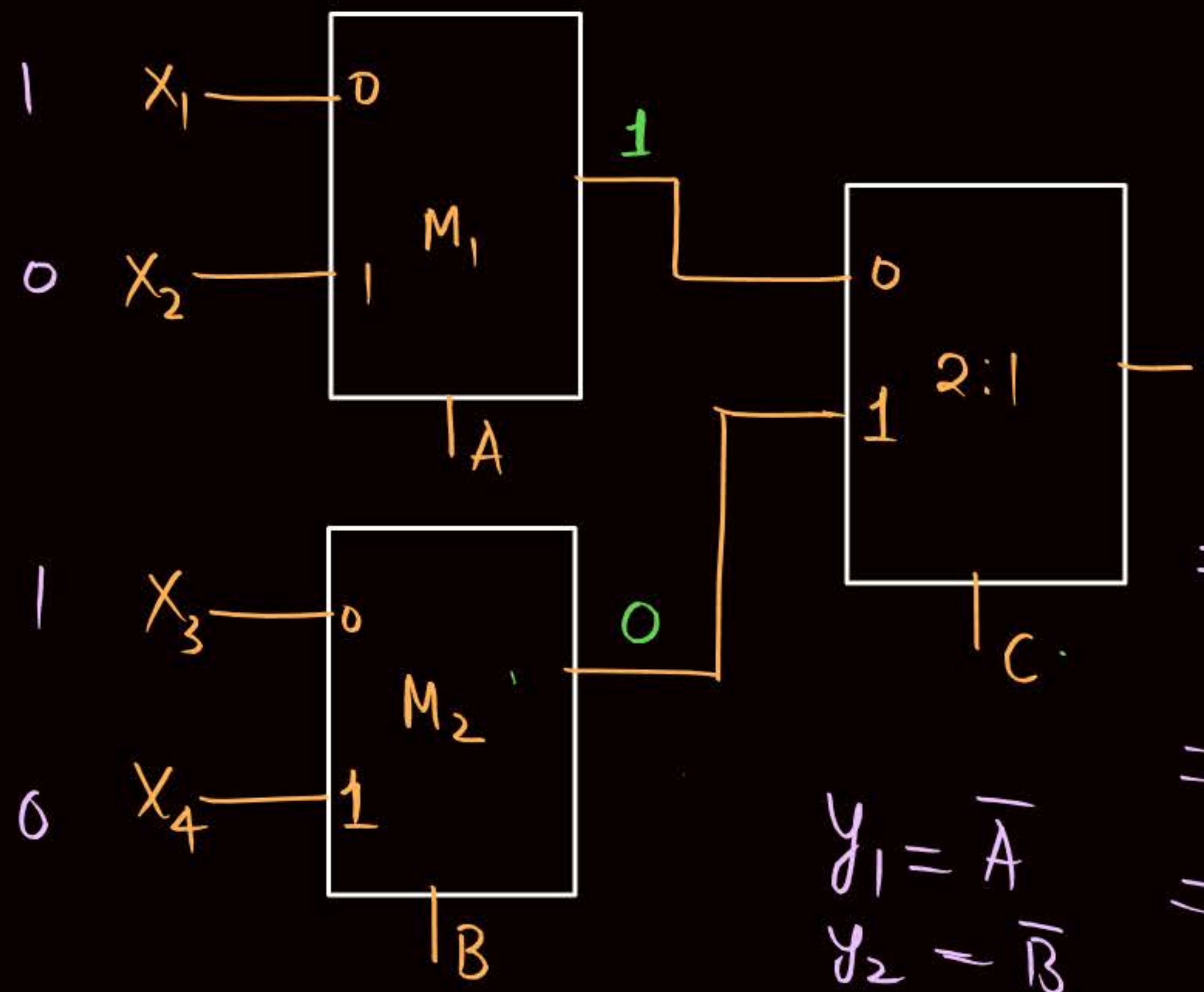


$$\overline{S_0}\cdot\overline{B} + S_0\cdot\overline{B}$$
$$= \overline{B}(\overline{S_0} + S_0) = \overline{B}$$

Q.



Q. Consider a digital circuit consisting of three 2:1 MUX M_1, M_2 & M_3 as shown. X_1 & X_2 are input of M_1, X_3 & X_4 are input of M_2. A, B, C are select lines of M_1, M_2 & M_3 respectively



For an instance $X_1 = 1$, $X_2 = 1$, $X_3 = 0$, $X_4 = 0$

the number of combinations (A, B, C) that gives O/P $y = 1$ ______.

$$y = \bar{C}\cdot 1 + C\cdot 0$$
$$= \bar{C}$$
$$= \bar{C}\cdot\bar{A} + C\bar{B}$$
$$= \bar{A}\bar{C} + \bar{B}C$$
$$= \Sigma(0, 1, 2, 5)$$

$y_1 = \bar{A}$

$y_2 = \bar{B}$

0	0	0
0	1	0
1	0	0
1	1	0

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

0 0 0 = 0

0 1 0 = 2

$\bar{B}$ C

0 0 1 → 1

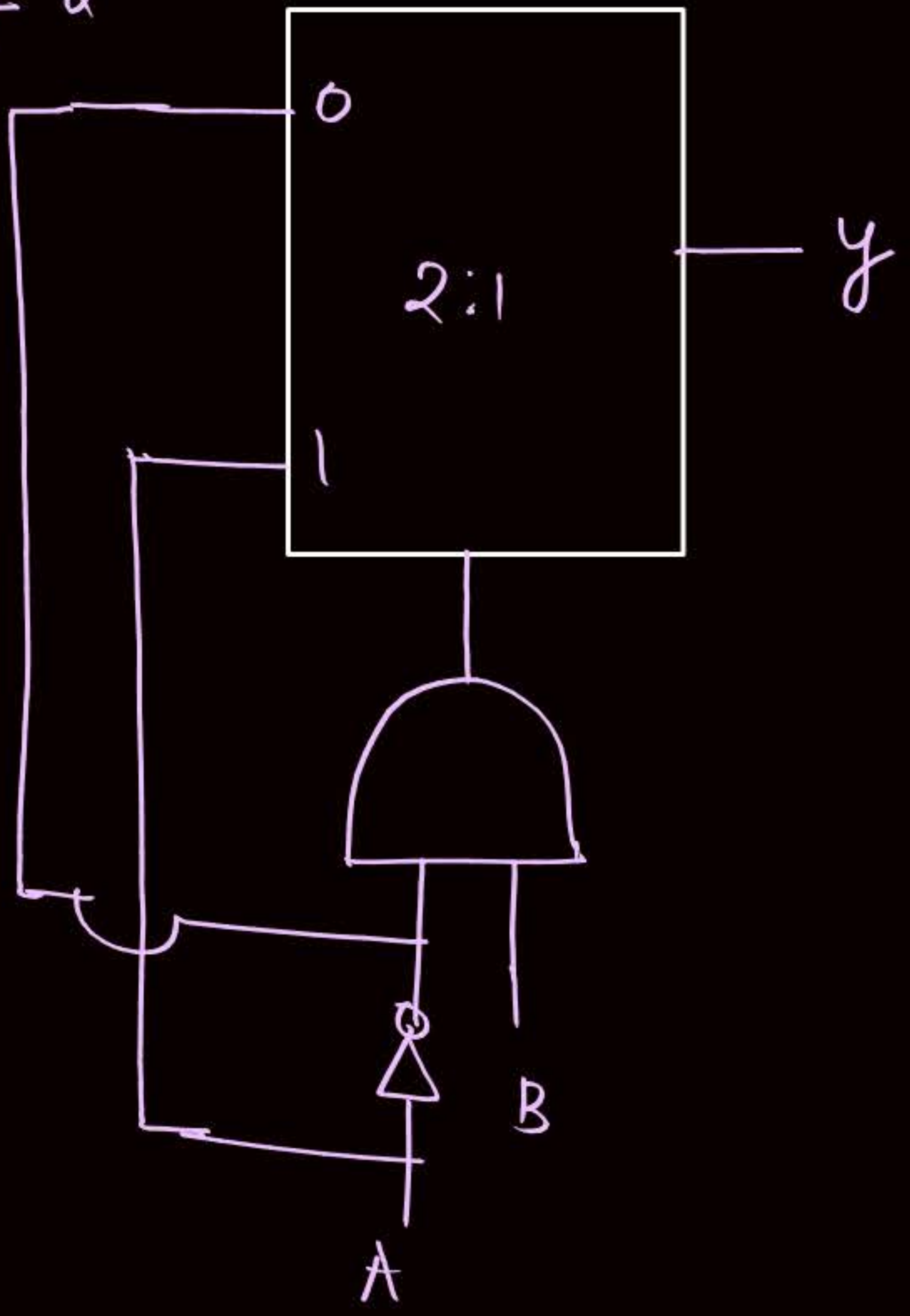
1 0 1 → 5

$y = \bar{C}$

$= \Sigma(0, 2, 4, 6)$

		$\bar{C}$
0	0	0
0	1	0
1	0	0
1	1	0

#Q.



O/P y is

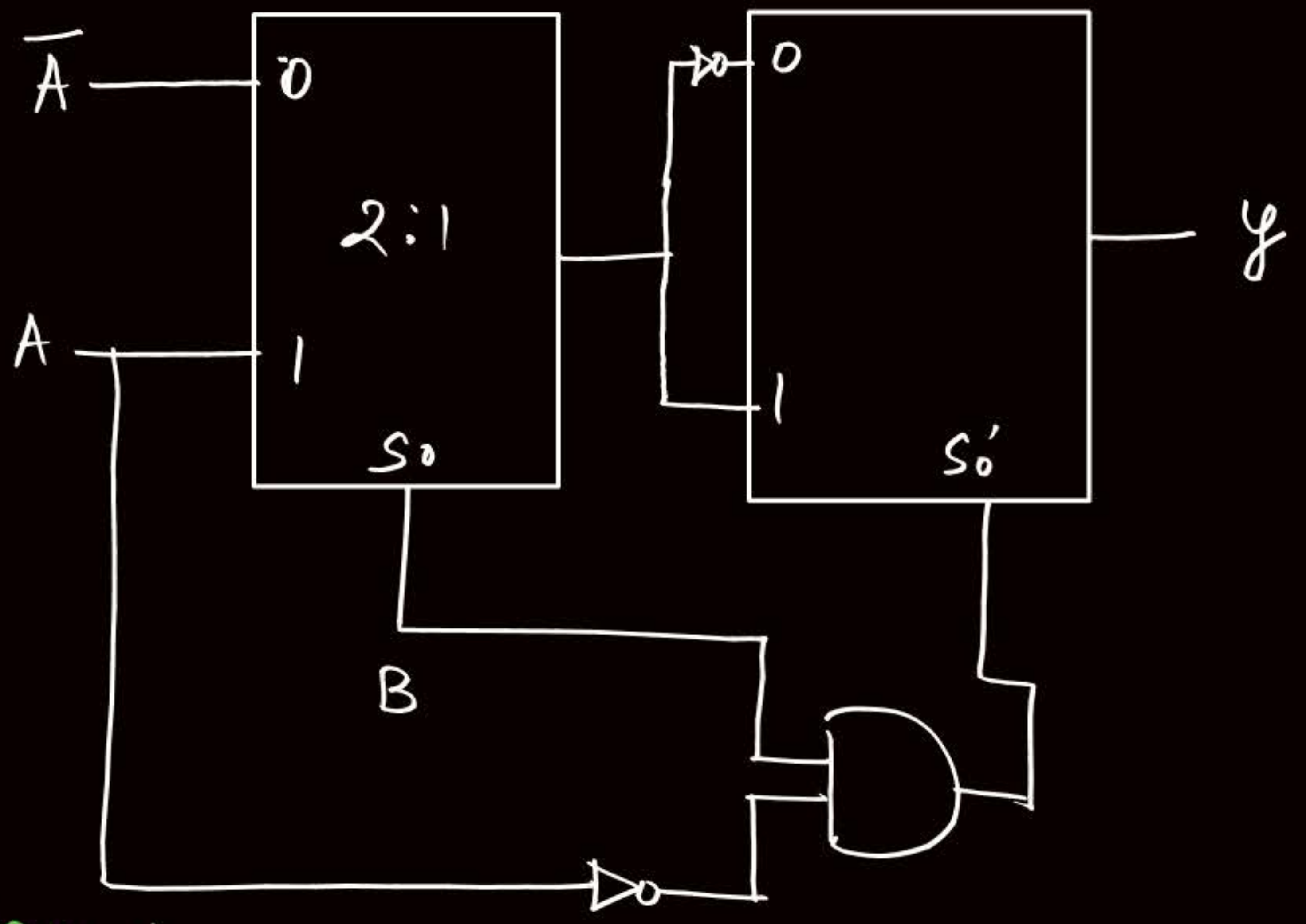
a. $\overline{A+B}$

b. $\overline{A\cdot B}$

c. $A\overline{B}$

d. $\overline{A}\cdot B$

#Q.



O/P y is

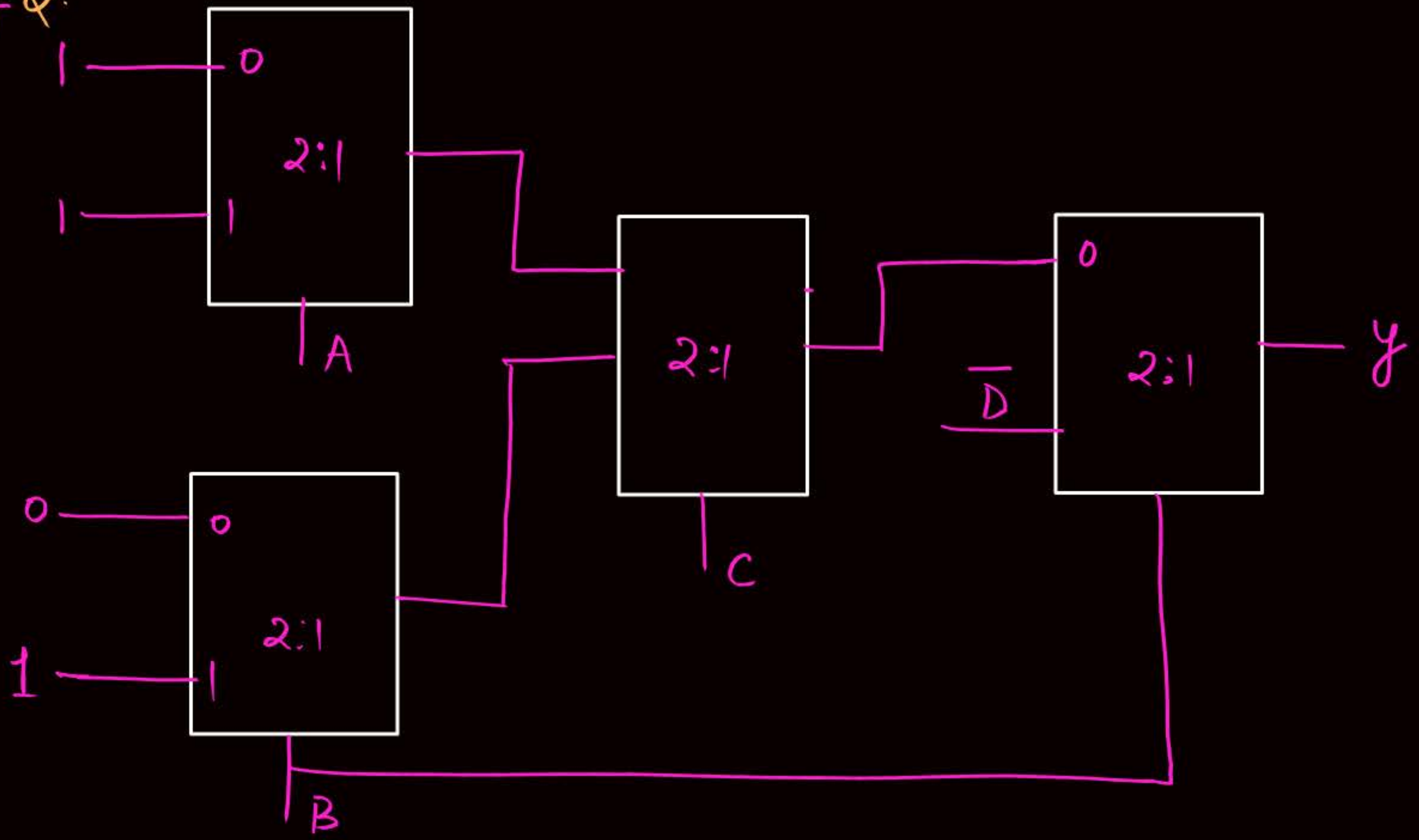
a. $\overline{AB}$

b. $\overline{A+B}$

c. $A\overline{B}$

d $\overline{A}B$

Q.



No. of combinations of A, B, C, D for which O/P $y = 0$ ______.

2 Minute Summary

→ MUX & Question discussion.

Thank you

GW Soldiers !