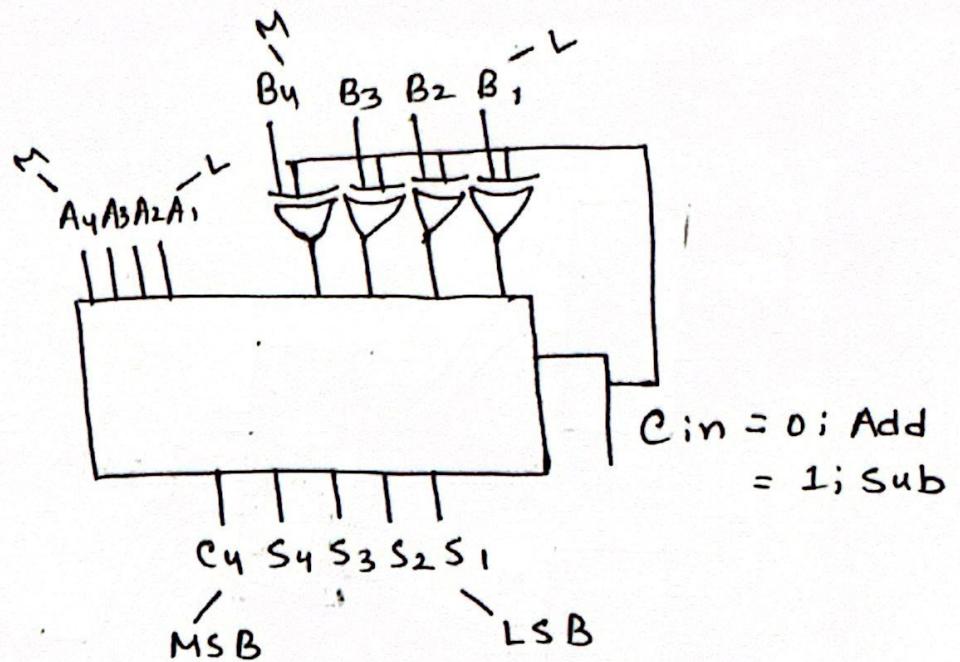


For all the following: Make sure that your circuit is efficient, meaning you should use the lowest number of components. You may use external gates if required.

- Build an adder cum subtractor (4 bits)
- Draw the block diagram of a 20 bits parallel adder.
- Build a 13 person voting system using full and parallel adders.
- Build a 8 person voting system using full and parallel adders.
- Build a 15 person voting system using full and parallel adders.
- Consider A is a 4 bit number. Design $A - 3$ using a 4 bit parallel adder. Use external gates if required.
- Consider A is a 4 bit number. Design $A + 3$ using a 4 bit parallel adder. Use external gates if required.
- Consider two numbers: 7 and 5. You can only calculate addition and subtraction between those two numbers. Design a circuit that can perform the above calculations based upon the user's intention.

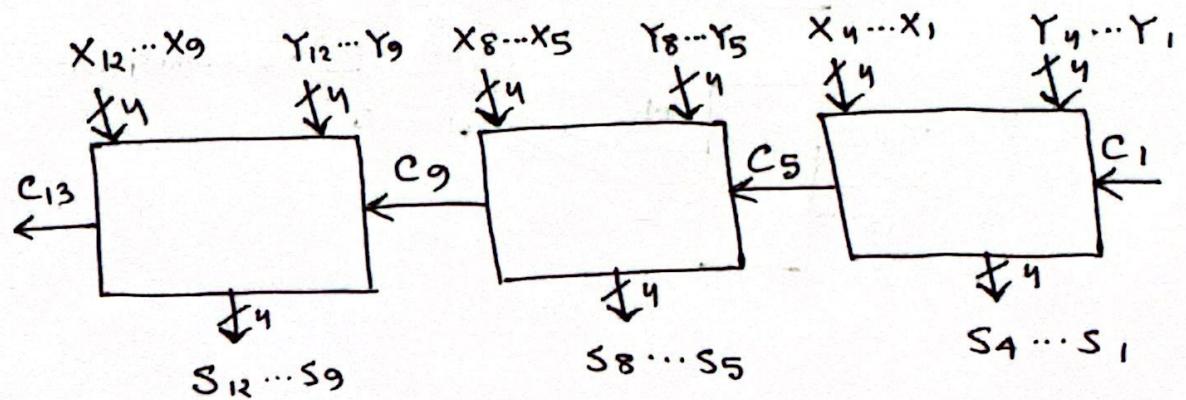
- Design a full adder using two half adders. You must use two NOR gates and no OR gates.
- Design a full adder using two half adders. You must use three NAND gates and no OR gates.
- Build a circuit that implements the 2's complement number system (3 bits) using encoder(s) and decoder(s).
- Design an Octal to Binary encoder.
- Design a 4x2 priority encoder prioritizing MSB.
- Design a 4x2 priority encoder prioritizing LSB.

(1)

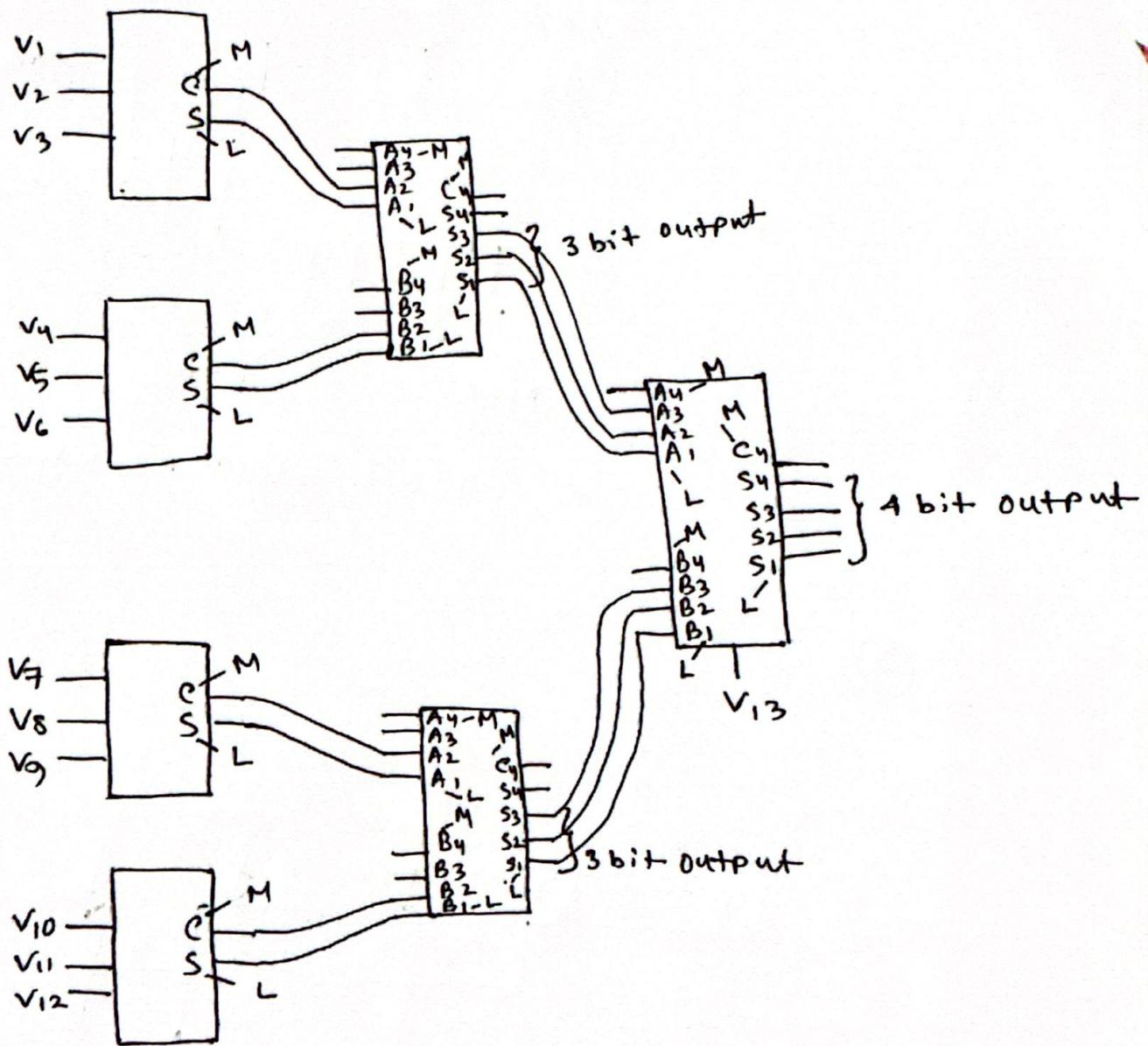


A bit adder - subtractor

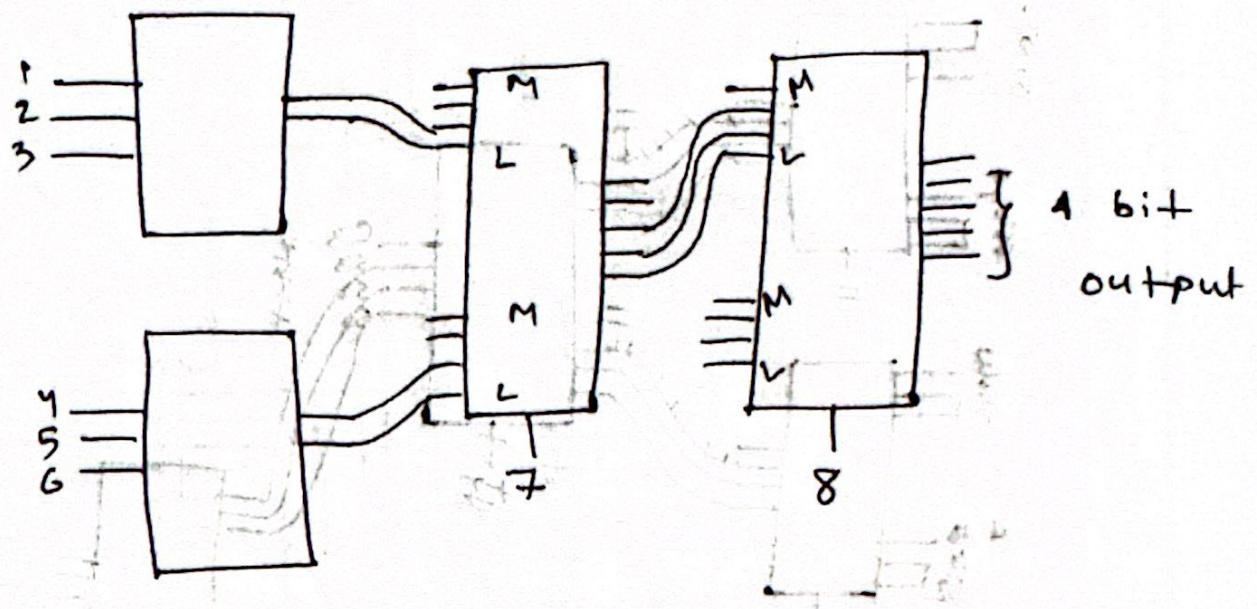
(2)



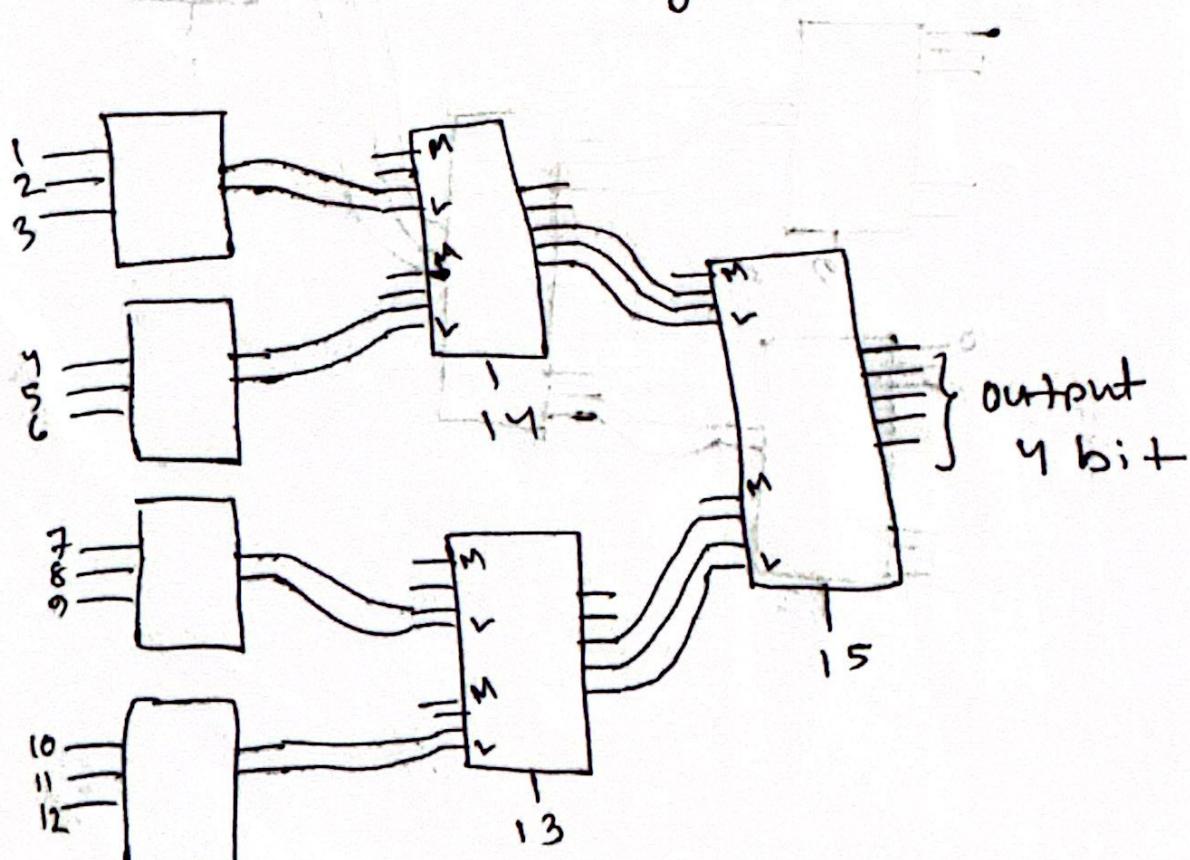
(3)



Build a 8 person voting system using full and parallel adder.



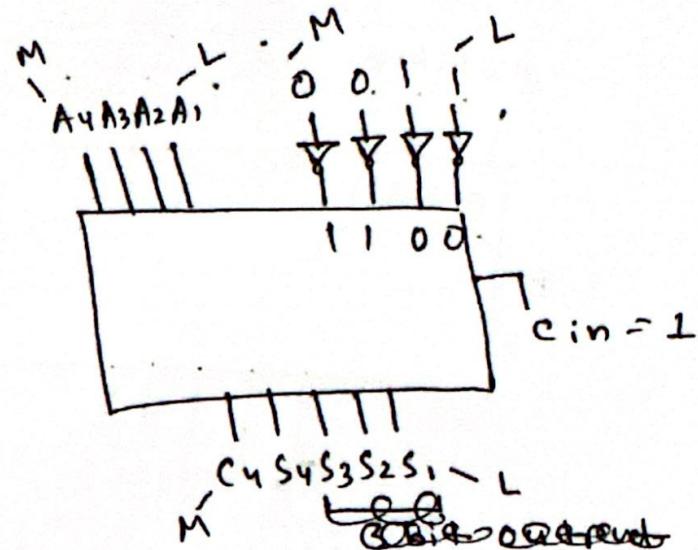
Build a 15 person voting system



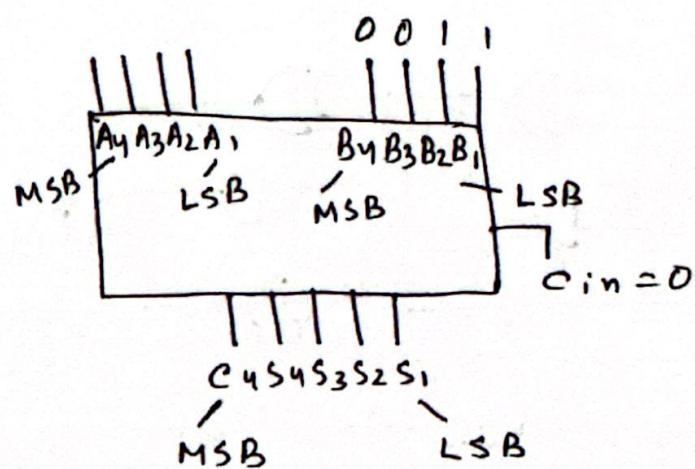
(A) $A \rightarrow 1$ bit

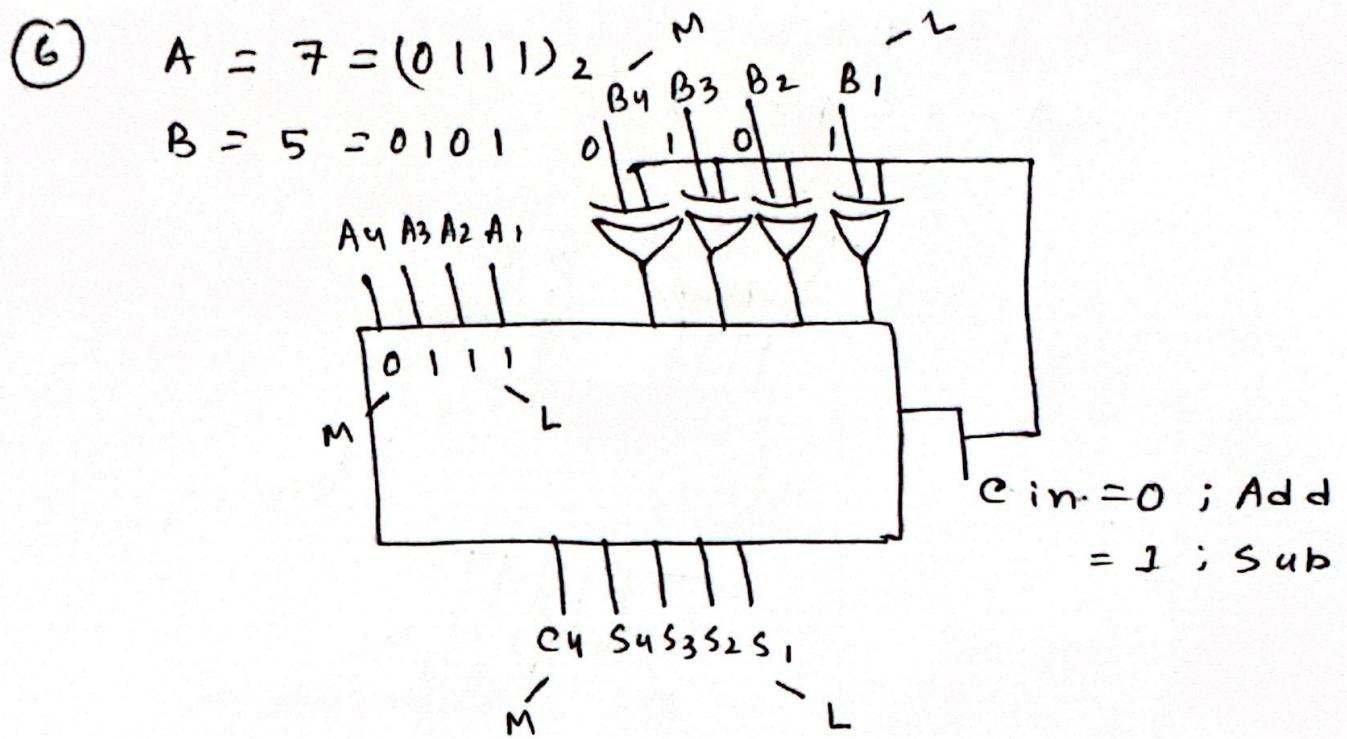
$$A - 3 = A + (-3)$$

$$\begin{array}{r} 3 \\ \downarrow \\ \begin{array}{r} 0011 \\ 1100 \\ +1 \\ \hline \end{array} \end{array}$$

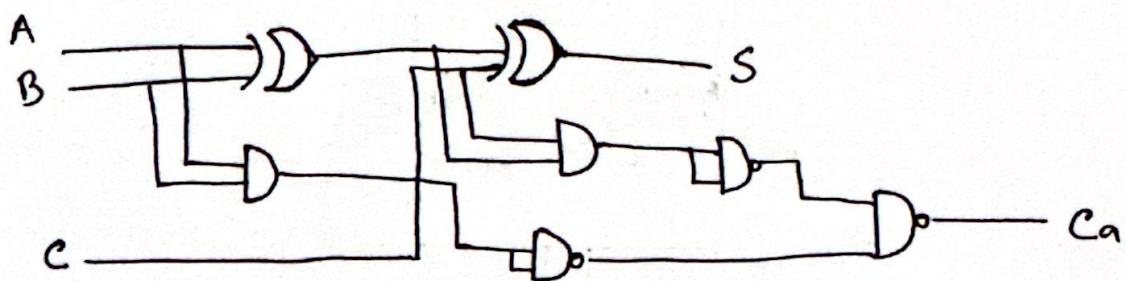


(5)

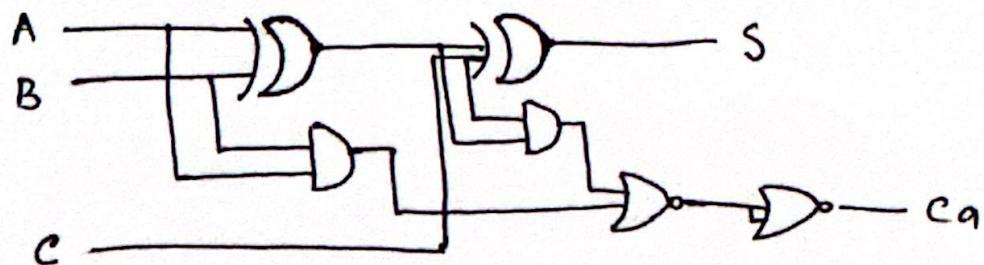




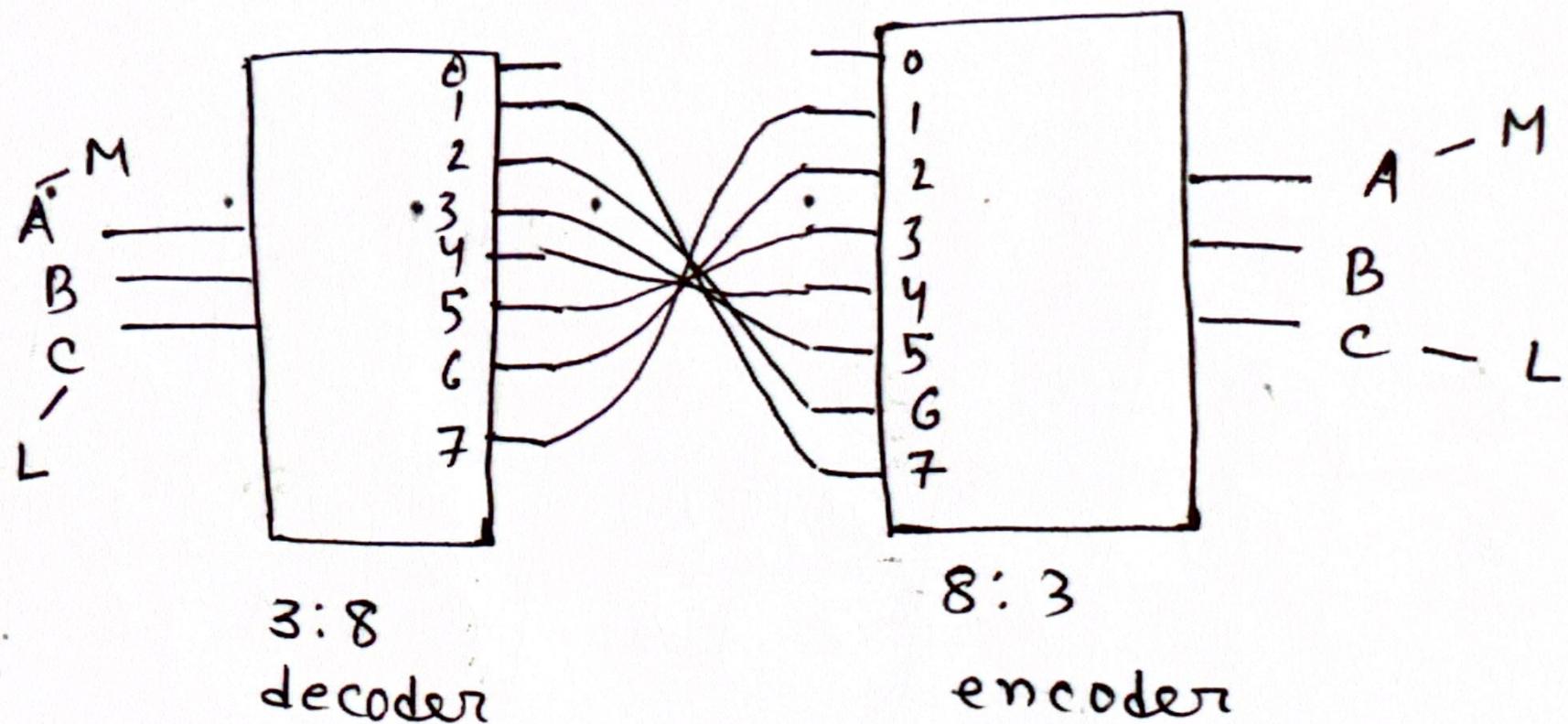
(7) Using 3 NAND gate and no OR gates



Using 2 NOR gates and no OR gates



⑨



Example: Octal-binary encoder

TABLE 5-3
Truth Table of Octal-to-Binary Encoder

Inputs								Outputs		
D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	x	y	z
1	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	0	1	0	1	1	0
0	0	0	0	0	0	0	1	1	1	1

$$z = D_1 + D_3 + D_5 + D_7$$

$$y = D_2 + D_3 + D_6 + D_7$$

$$x = D_4 + D_5 + D_6 + D_7$$

Example: Octal-binary encoder

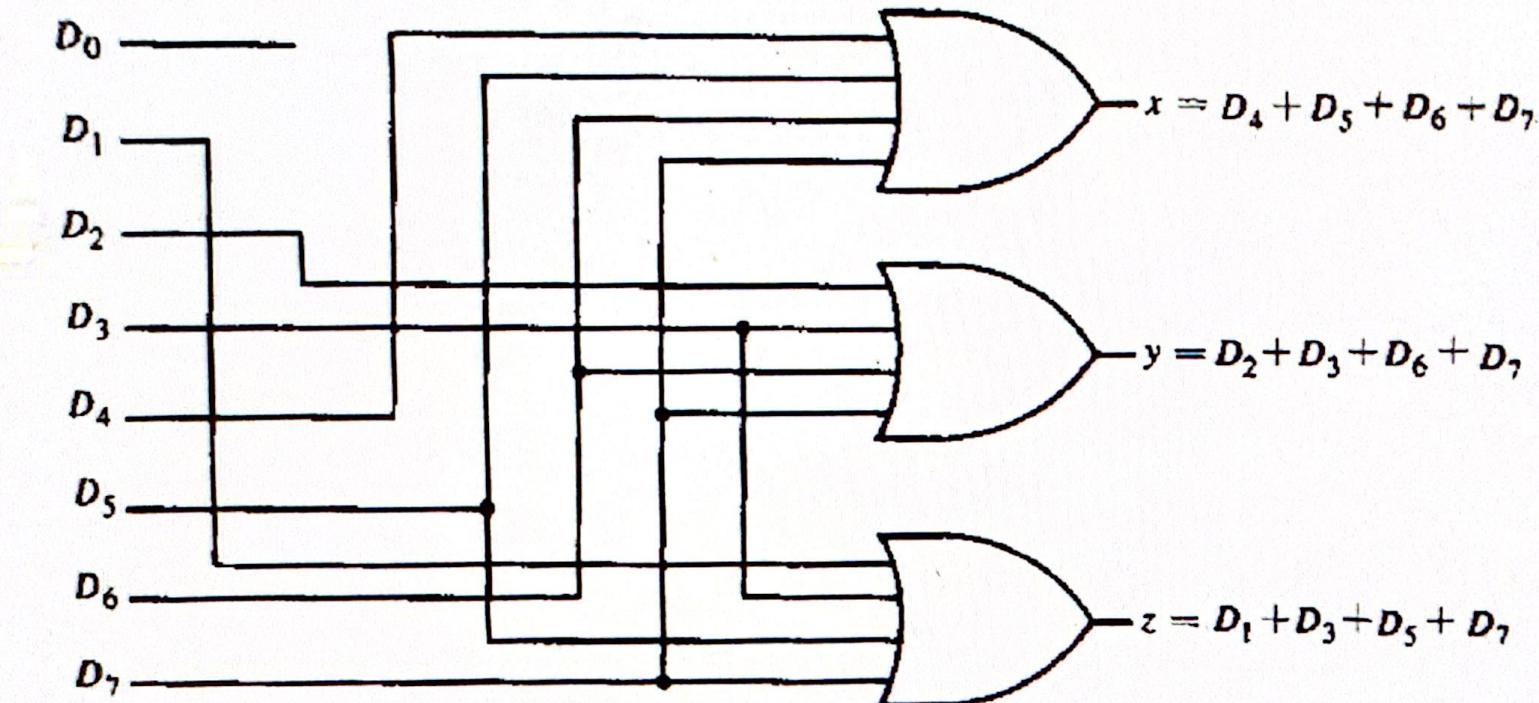


FIGURE 5-13

Octal-to-binary encoder

There are 8 input variables so there will 2^8 input combination, amongst which in Octal-binary encoder only 8 are useful

Design a 1×2 priority encoder prioritizing MSB.

I_3	I_2	I_1	I_0	A	B
0	0	0	0	X	X
0	0	0	1	0	0
0	0	1	0	0	1
0	0	1	1	0	1
0	1	0	0	1	0
0	1	0	1	1	0
0	1	1	0	1	0
0	1	1	1	1	0
1	0	0	0	1	1
1	0	0	1	1	1
1	0	1	0	1	1
1	0	1	1	1	1
1	1	0	0	1	1
1	1	0	1	1	1
1	1	1	0	1	1
1	1	1	1	1	1

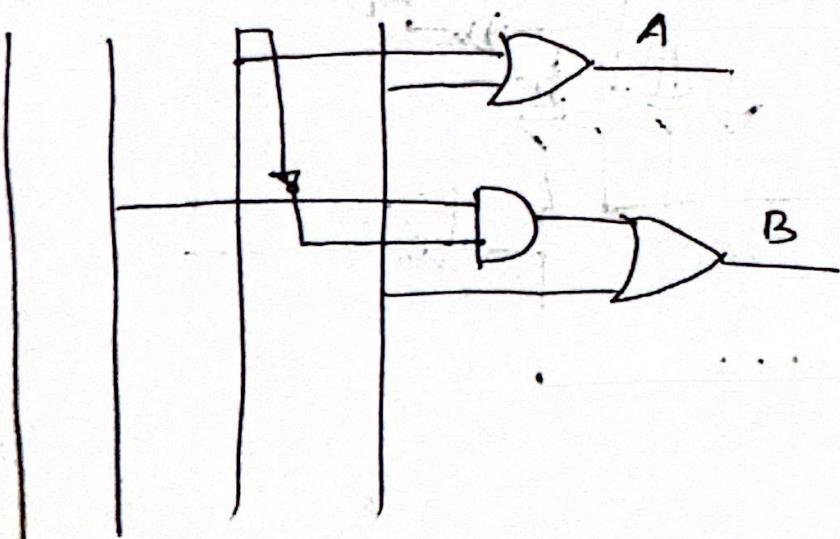
$\bar{I}_3\bar{I}_2$	\bar{I}_3I_2	\bar{I}_3I_1	\bar{I}_3I_0	$I_3\bar{I}_2$	I_3I_1	I_3I_0
.	.	.	3	2		
1, 1	1, 1	1, 1	1, 1			
1, 1	1, 1	1, 1	1, 1			
1, 1	1, 1	1, 1	1, 1			

$$A = I_2 + I_3$$

		1	1
1	1	1	1
1	1	1	1

$$B = I_3 + I_1, \bar{I}_2$$

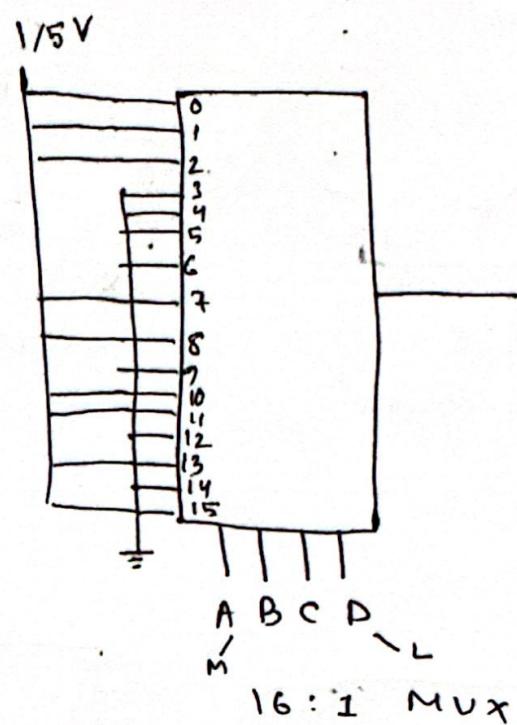
$I_0 \quad I_1 \quad I_2 \quad I_3$



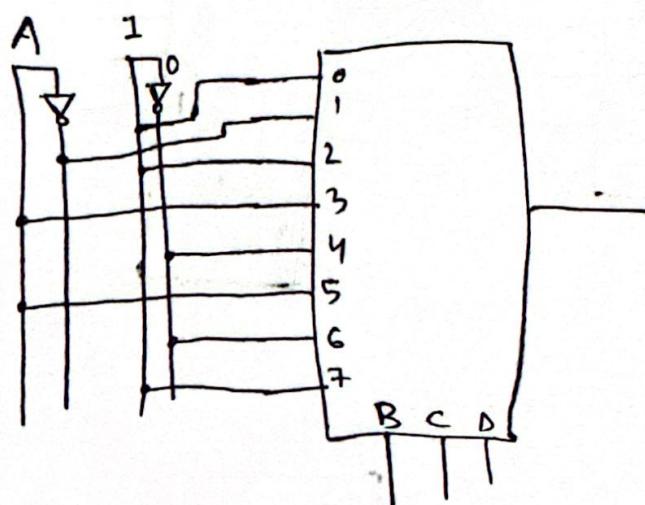
- Implement the following boolean function using a single 16:1 mux .
 $F(A,B,C,D) = \sum(0,1,2,7,8,10,11,13, 15)$. Use external gates if required.
- Implement the following boolean function using a single 8:1 mux.
 $F(A,B,C,D) = \sum(0,1,2,7,8,10,11,13, 15)$. Use external gates if required.
- Implement the following boolean function using a single 4:1 mux.
 $F(A,B,C,D) = \sum(0,1,2,7,8,10,11,13, 15)$. Use external gates if required.
- Implement the following boolean function using both 4:1 and 2:1 mux in a single circuit
 $F(A,B,C,D) = \sum(0,1,2,7,8,10,11,13, 15)$. Use external gates if required.
- Implement the following boolean function using **a**) 4x16 decoder(s) only **b**) 2x4 decoder(s) only
 $F(A,B,C,D,E) = \sum(0,1,2,7,8,10,11,13, 15,18,21,24,25)$. Use external gates if required.
- Build a full adder using encoder(s) and decoder(s).
- Build a BCD to Excess-3 code converter using encoder(s) and decoder(s).
- Build a BCD to Excess-5 code converter using encoder(s) and decoder(s).
- Design the circuit diagram for a 3x8 decoder.
- Design the circuit diagram for a 2x4 decoder.
- Design the circuit diagram for a 4:1 mux.
- Design a 8:1 mux using both 4:1 mux and 2:1 mux in a single circuit.
- Design AND, OR, NOT gate using 4:1 mux.
- Design AND, OR, NOT gate using 2:1 mux.
- Design a circuit that can demonstrate the usage of ENABLE pin in decoders.

(10)

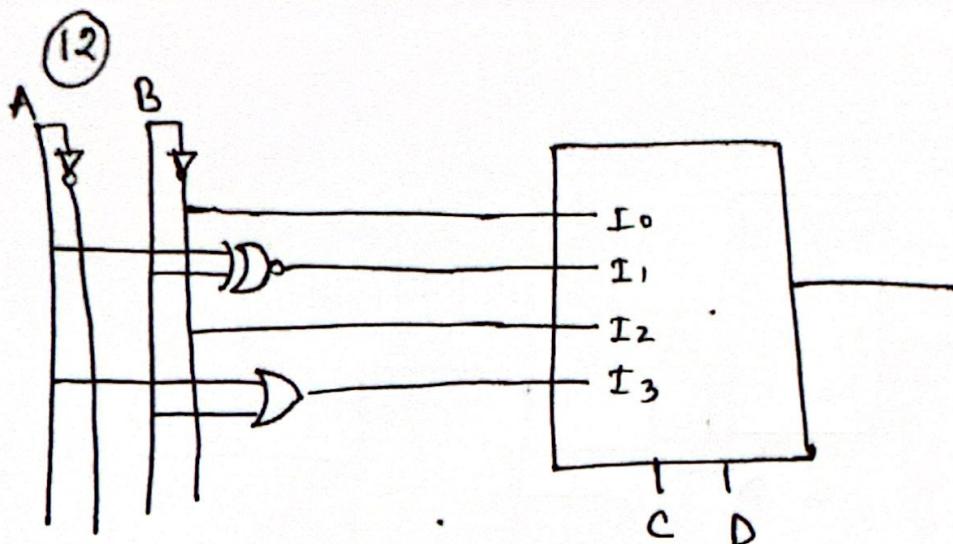
$$F(A, B, C, D) = \Sigma(0, 1, 2, 7, 8, 10, 11, 13, 15)$$



(11)



	I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7
A'	0	1	2	3	4	5	6	7
A	8	9	10	11	12	13	14	15
	1	A'	1	A	0	A	0	1



	I_0	I_1	I_2	I_3
$A'B'$	0	1	2	3
$A'B$	4	5	6	7
AB'	8	9	10	11
AB	12	13	14	15
	B'	$A \odot B$	B'	$A + B$

$I_0 \Rightarrow$

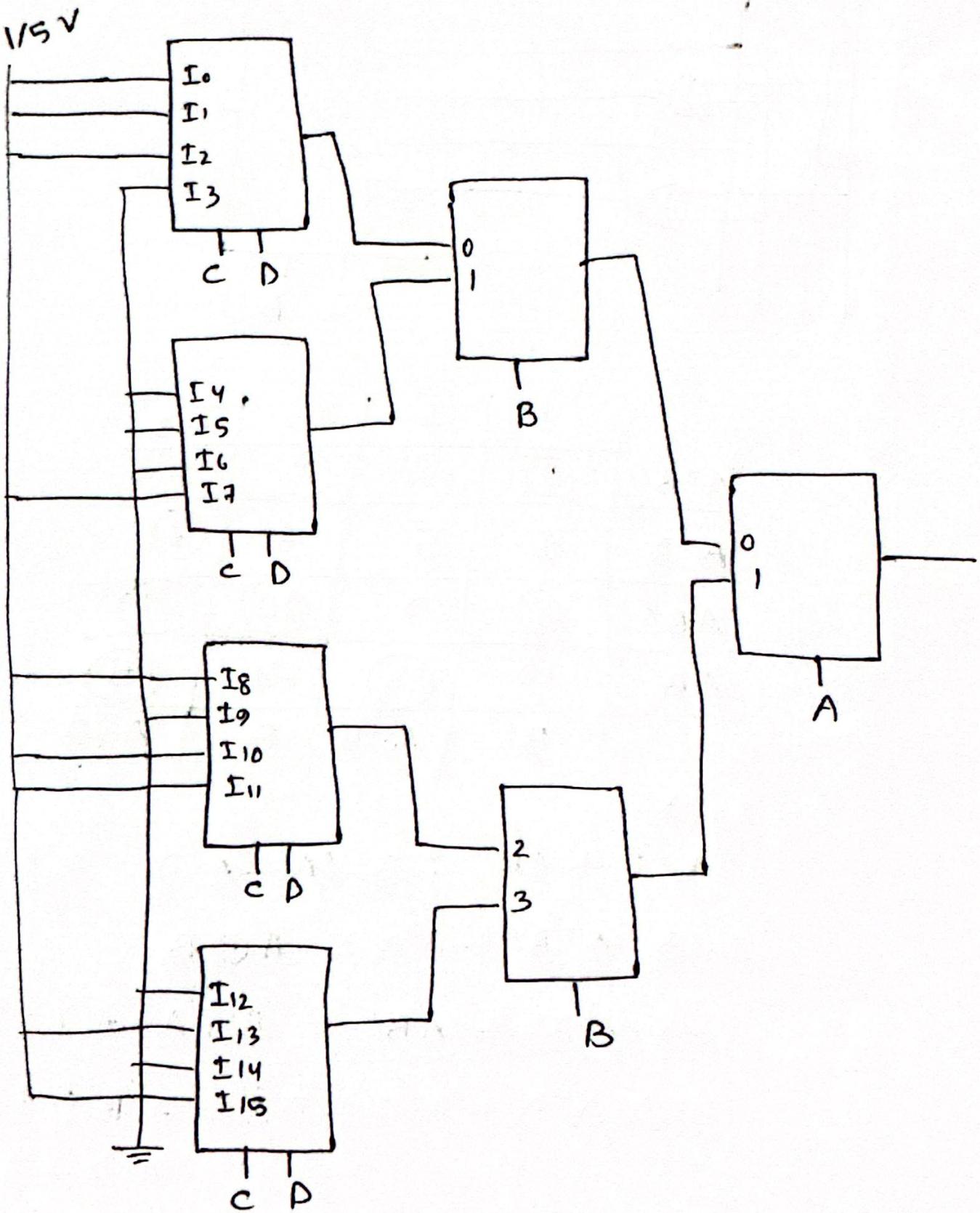
$$A'B' + AB' = B'(A + A') = B'$$

$$I_1 \Rightarrow A'B' + AB = A \odot B$$

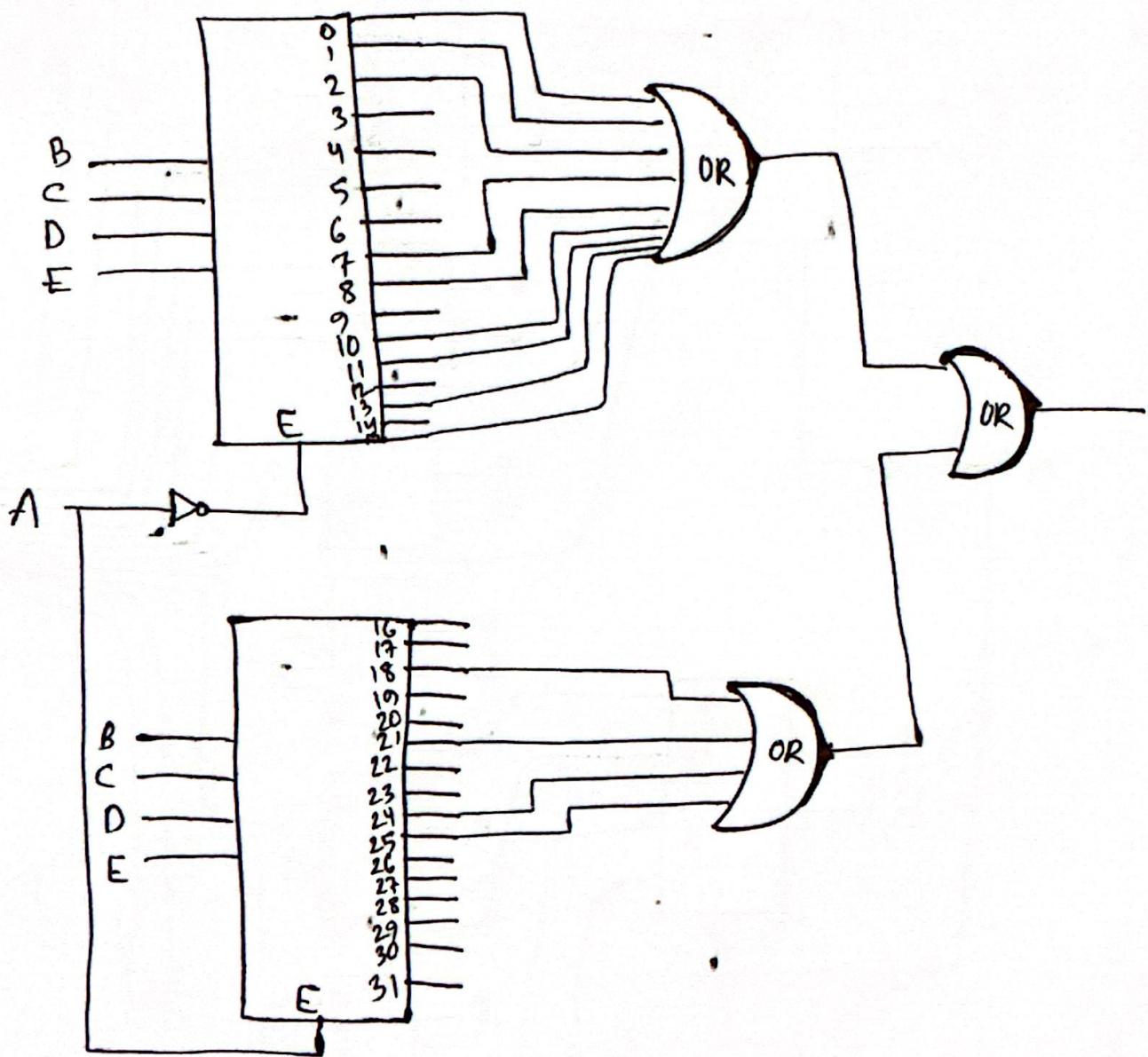
$$I_2 \Rightarrow A'B' + AB' = B'(A + A') = B'$$

$$\begin{aligned}
 I_3 \Rightarrow A'B + AB' + AB &= A'B + A(B + B') \\
 &= A'B + A \\
 &= (A' + A)(B + A) \\
 &= A + B
 \end{aligned}$$

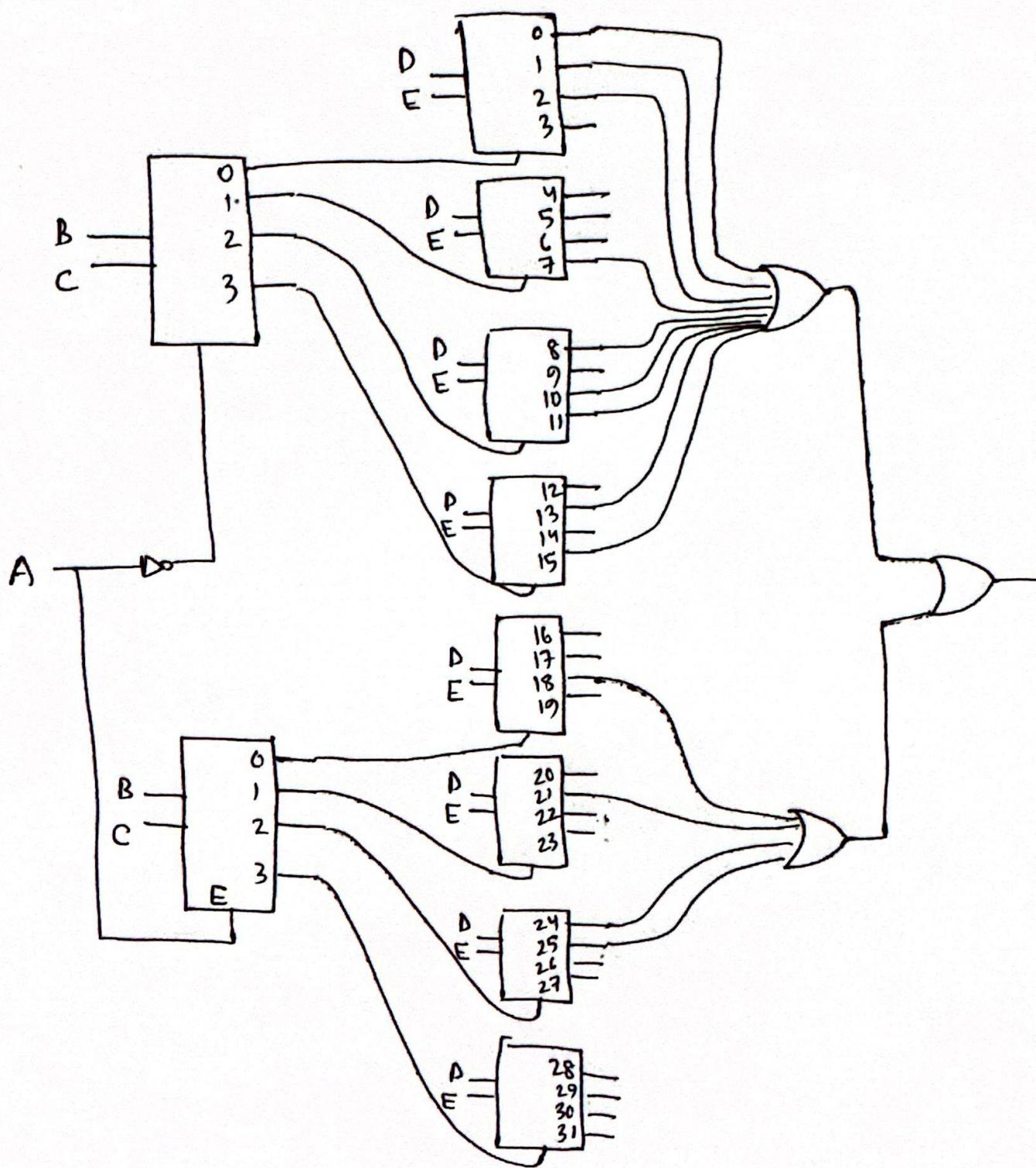
(13)



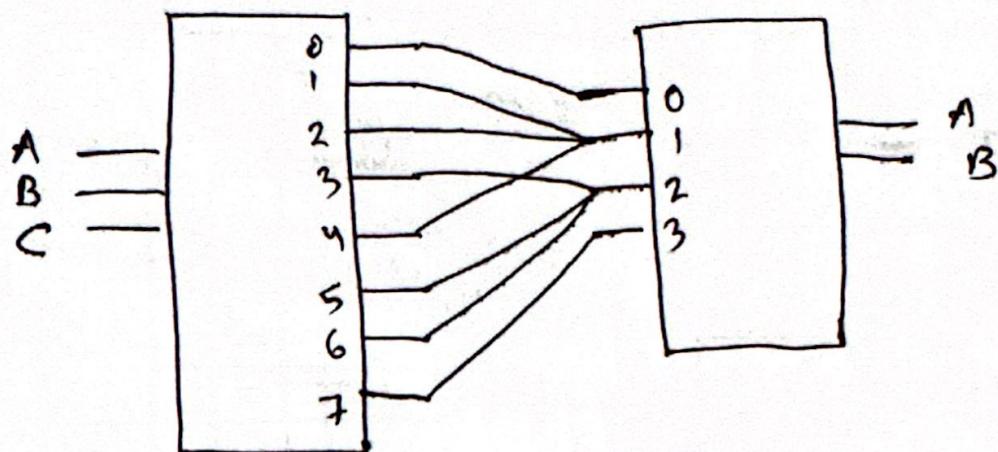
(H) a)



b)

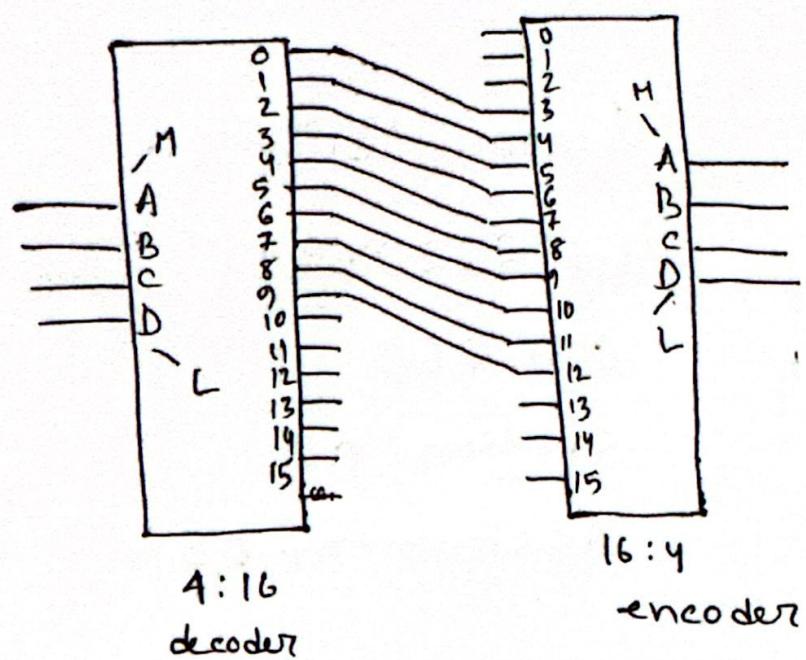


7 Design a full adder using encoder and decoder.



A	B	c	ca	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

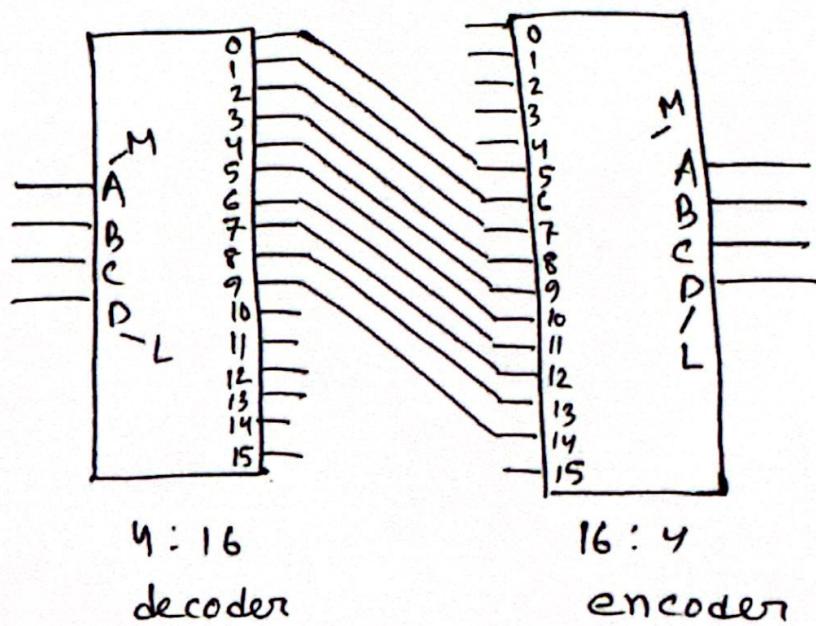
(15)



4:16
decoder

16:4
encoder

(16)



4: 16
decoder

16 : 4
encoder

* Design the circuit diagram for a
3x8 decoder.

M	A	B	C	0 ₀	0 ₁	0 ₂	0 ₃	0 ₄	0 ₅	0 ₆	0 ₇
0	0	0	0	1	0	0	0	0	0	0	0
1	0	0	1	0	1	0	0	0	0	0	0
2	0	1	0	0	0	1	0	0	0	0	0
3	0	1	1	0	0	0	1	0	0	0	0
4	1	0	0	0	0	0	0	1	0	0	0
5	1	0	1	0	0	0	0	0	0	1	0
6	1	1	0	0	0	0	0	0	0	0	1
7	1	1	1	0	0	0	0	0	0	0	1

$$O_0 = A'B'C'$$

$$O_1 = A'B'C$$

$$O_2 = A'BC'$$

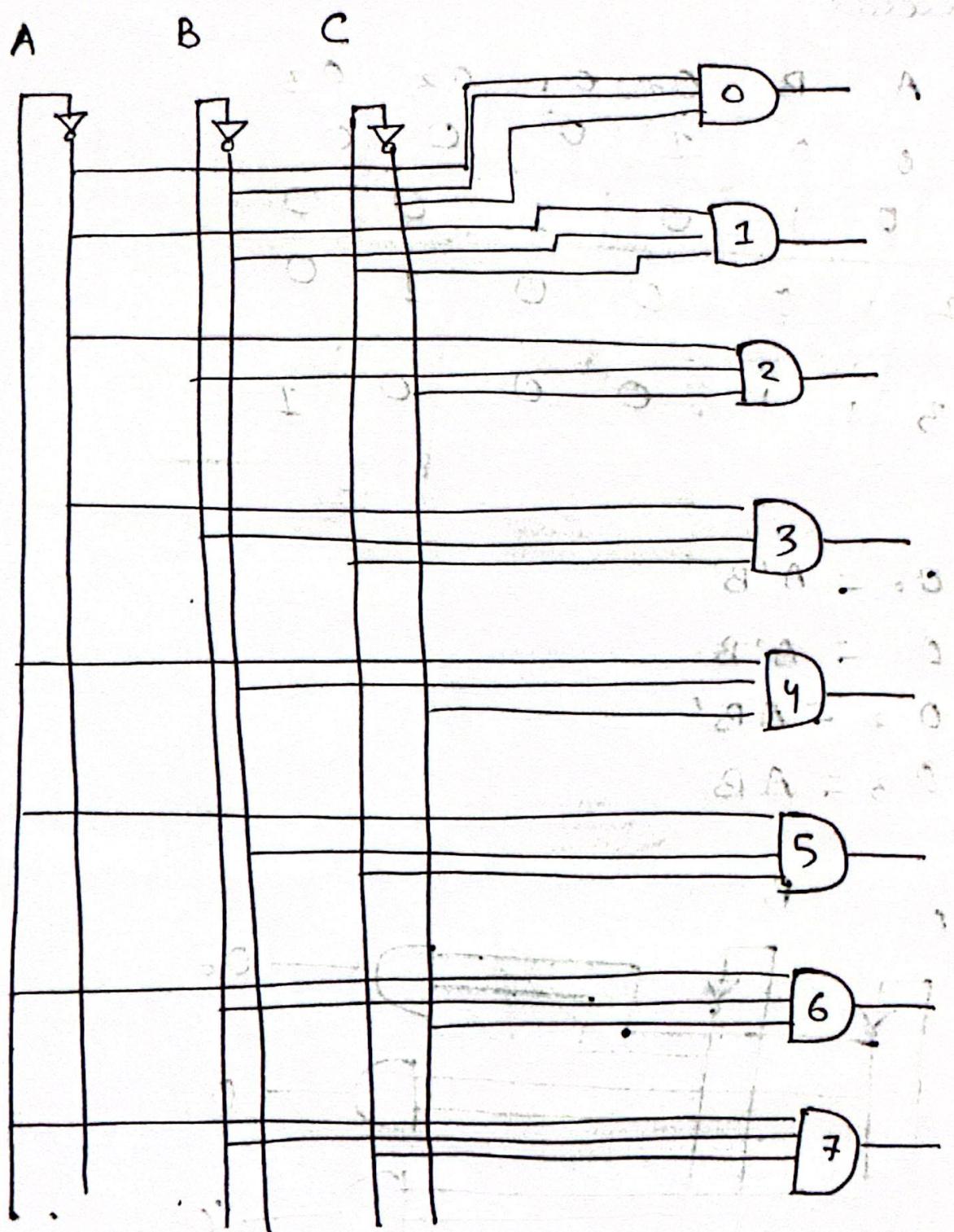
$$O_3 = A'BC$$

$$O_4 = AB'C'$$

$$O_5 = AB'C$$

$$O_6 = ABC'$$

$$O_7 = ABC$$



Design the circuit diagram for a 2×4 decoder.

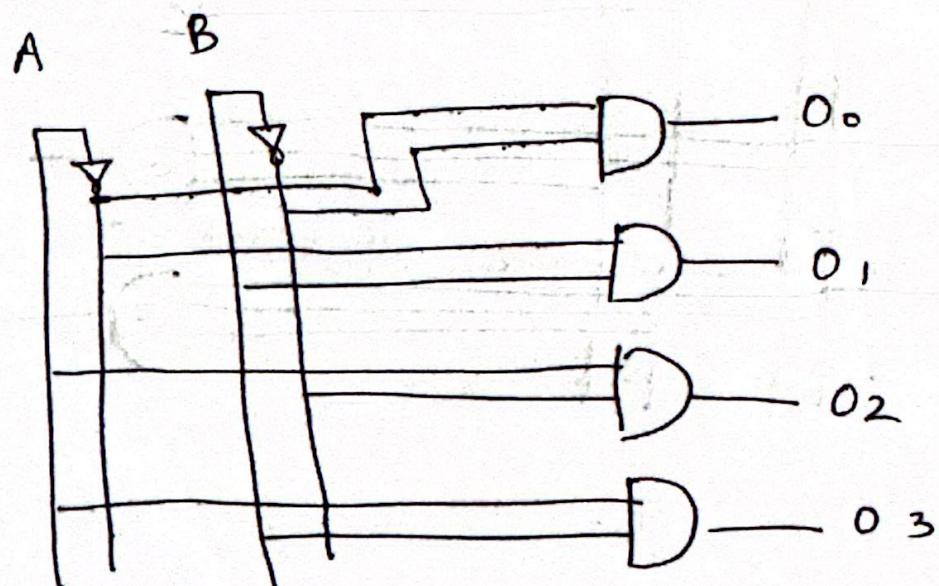
A	B	0 ₀	0 ₁	0 ₂	0 ₃
0	0	1	0	0	0
1	0	0	1	0	0
2	1	0	0	0	1
3	1	1	0	0	0

$$0_0 = A'B'$$

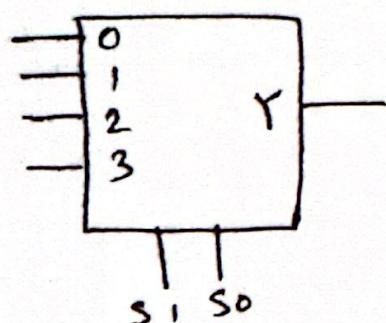
$$0_1 = A'B$$

$$0_2 = AB'$$

$$0_3 = AB$$

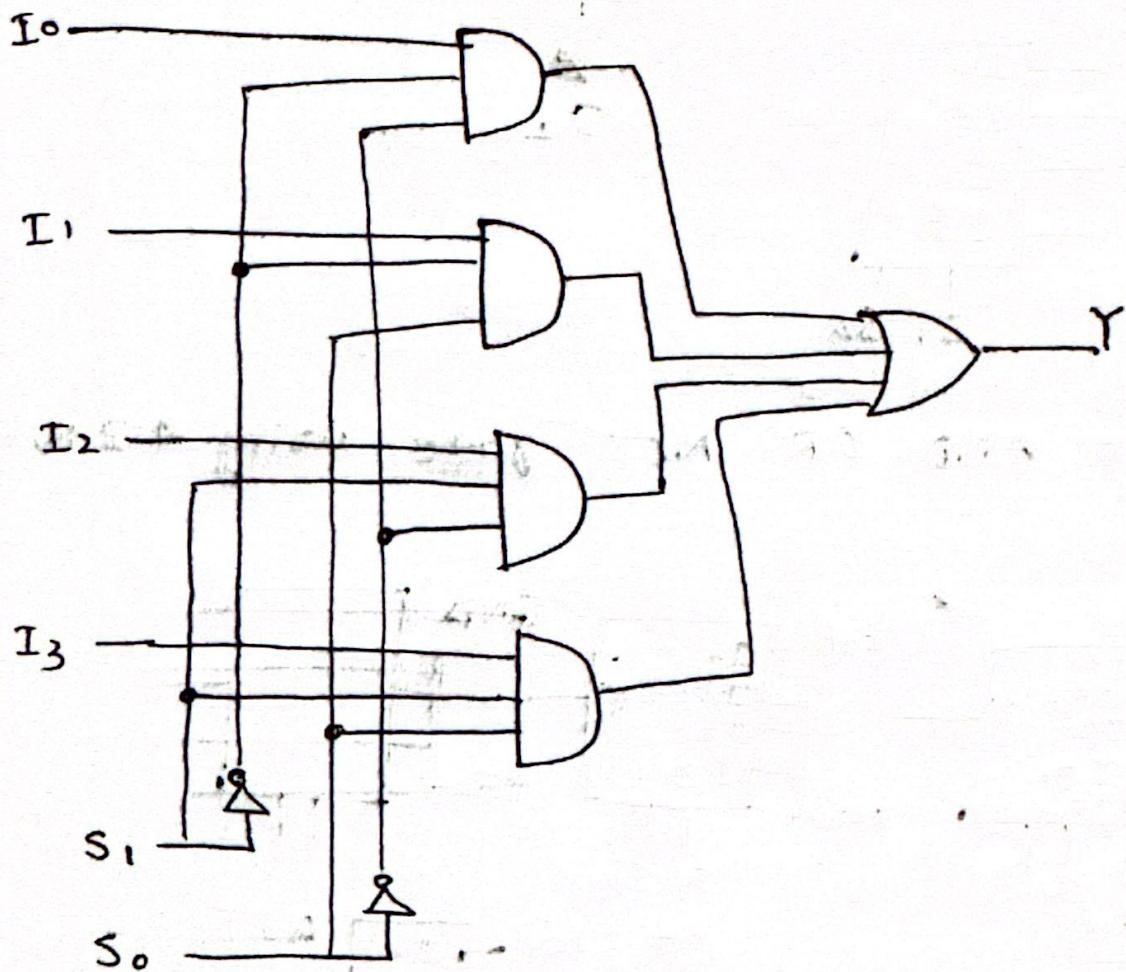


Design the circuit diagram for a 4:1 mux

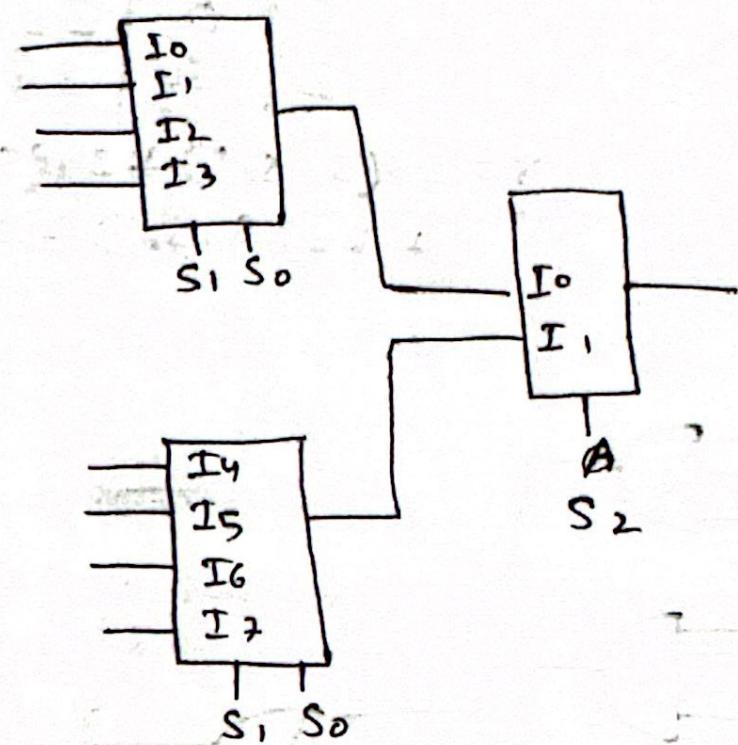


S_1	S_0	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

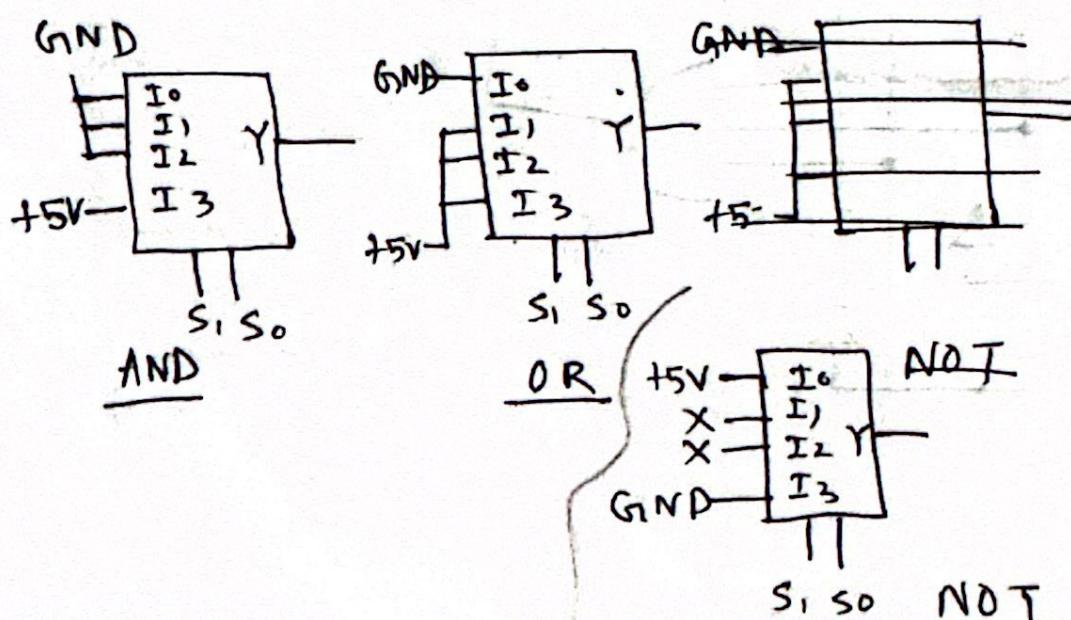
$$Y = I_0(S_1'S_0') + I_1(S_1'S_0) + I_2(S_1S_0') + I_3(S_1S_0)$$



Design 8:1 mux using both 1:1 mux and 2:1 mux in a single circuit.

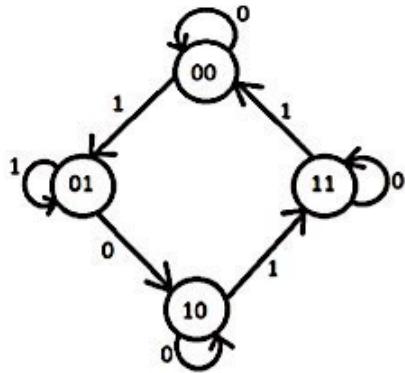


Design AND, OR, NOT gate using 4:1 mux



- Design a D FF using SR FF.
- Design a T FF using JK FF.
- Design a D FF using JK FF.
- Design a SR FF.
- Write down the excitation table for SR, D, JK and T FF.
- Write down the characteristics table for SR, D, JK and T FF.

- Given the state diagram as follows, get the sequential circuit using SR flipflop.

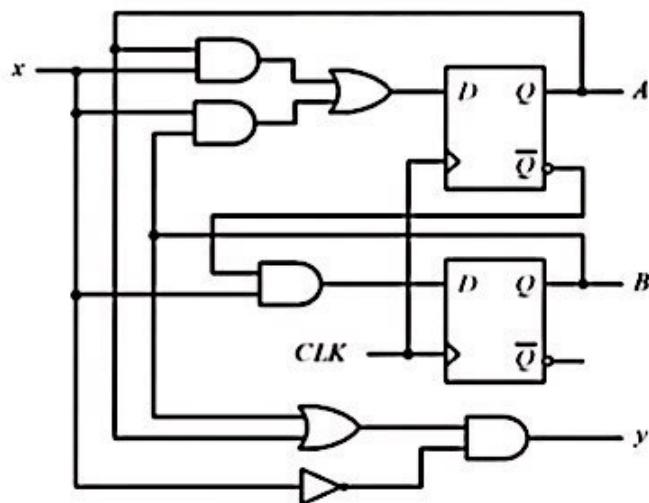


- Implement the following counter using T flip flop
CSE110 -> CSE111 -> CSE220 -> CSE221 -> CSE331 -> CSE221 -> CSE321 -> CSE110
- 3->4->6->10->12->13->15->3

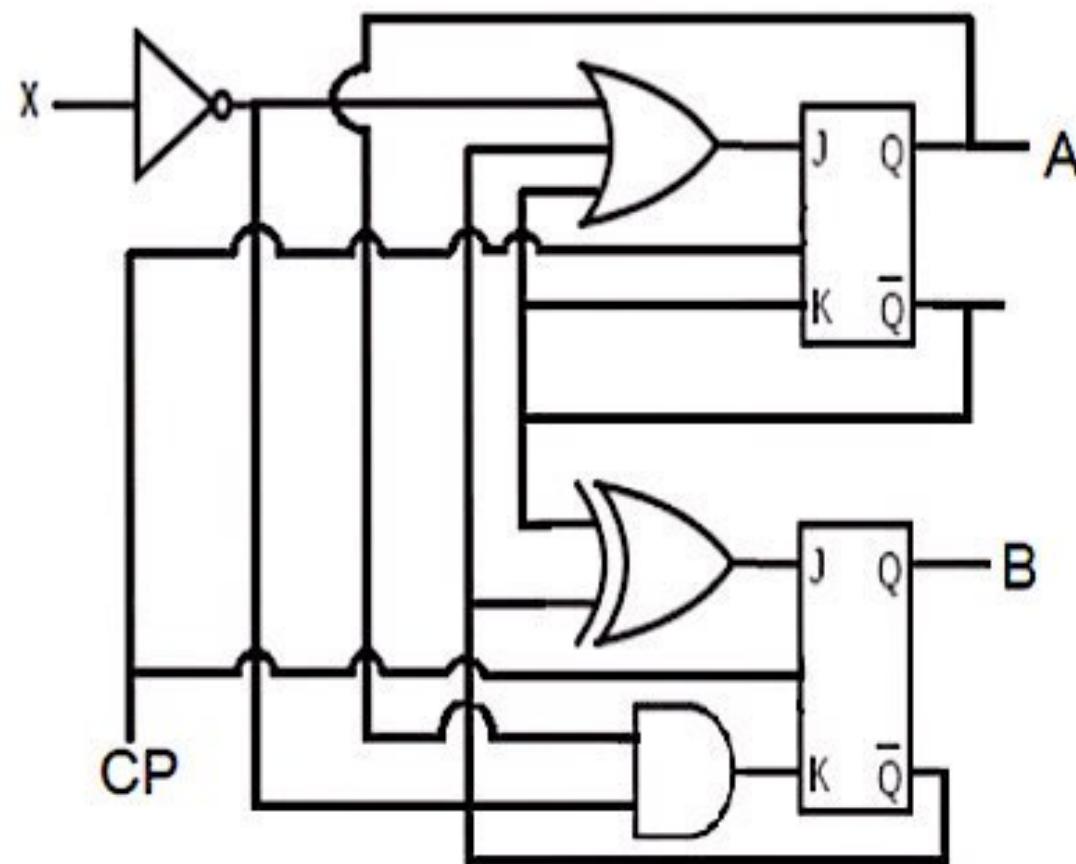
1. Implement the given counter using JK flip-flop.
2. Implement the given counter using T flip-flop.

NB: For states not given in question, please move to the initial state as per question.

- Implement 4 bit up counter using JK flip flop
- Implement 4 bit down counter using JK flip flop
- Implement 2 bit up/down counter using D flip flop
- Implement 3 bit up/down counter using T flip flop
- Implement 2 bit up/down counter using SR flip flop
- Implement 3 bit up/down counter using JK flip flop
- Implement the following counter using T FF:
Green->Orange->Yellow->Red->Yellow->Orange->Yellow->Green
- Implement the following counter using JK FF: Green->Yellow->Red->Yellow->Green
- Implement the following counter using JK FF: 1->2->3->5->7->11->13->1
- Implement the following counter using SR FF: 2->3->6->8->10->12->2
- Draw the state diagram for the given circuit.



- Draw the state diagram for the given circuit.

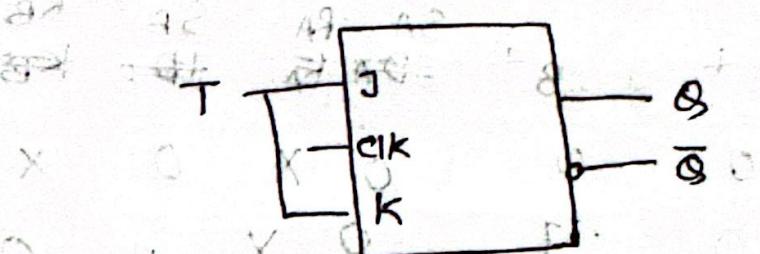


Assignment 1

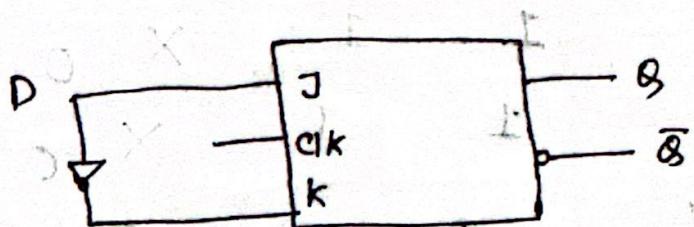
1. Design a D FF using SR FF



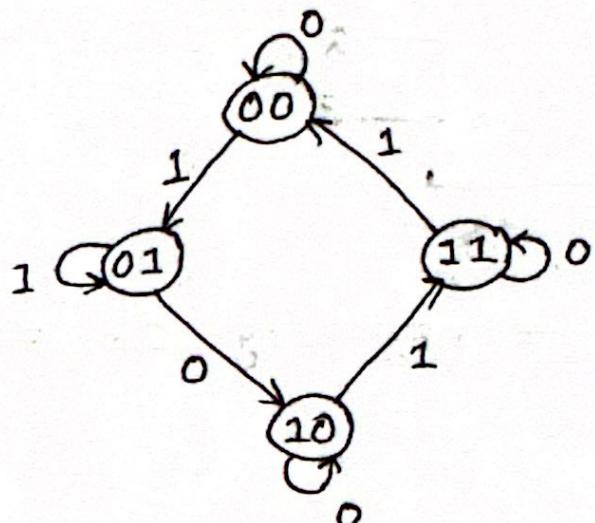
2. Design a T FF using JK FF.



3. Design a D FF using JK FF



④ Given the state diagram as follows, get the sequential circuit using SR flipflop.



A	B	α	A^+	B^+	SA	RA	SB	RB
0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	X	1	0
0	1	0	1	0	1	0	0	1
0	1	1	0	1	0	X	X	0
1	0	0	1	0	X	0	0	X
1	0	1	1	1	X	0	1	0
1	1	0	1	1	X	0	X	0
1	1	1	0	0	0	1	0	1

SR flip-flop excitation table

$S(t)$	$S(t+1)$	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

$$S_A = \Sigma (2, 7, 4, 5, 6)$$

$$R_A = \Sigma (0, 1, 3, 7)$$

$$S_B = \Sigma (1, 3, 5, 6)$$

$$R_B = \Sigma (1, 3, 5, 8)$$

	$\bar{B}X$	$B\bar{X}$	BX	$B\bar{X}$
\bar{A}	0	1	3	2
A	X ₄	X ₅	X ₇	X ₆

$. \quad S_A = B\bar{X}$

	$\bar{B}X$	$B\bar{X}$	BX	$B\bar{X}$
\bar{A}	X ₀	X ₁	X ₃	X ₂
A	X ₄	X ₅	X ₇	X ₆

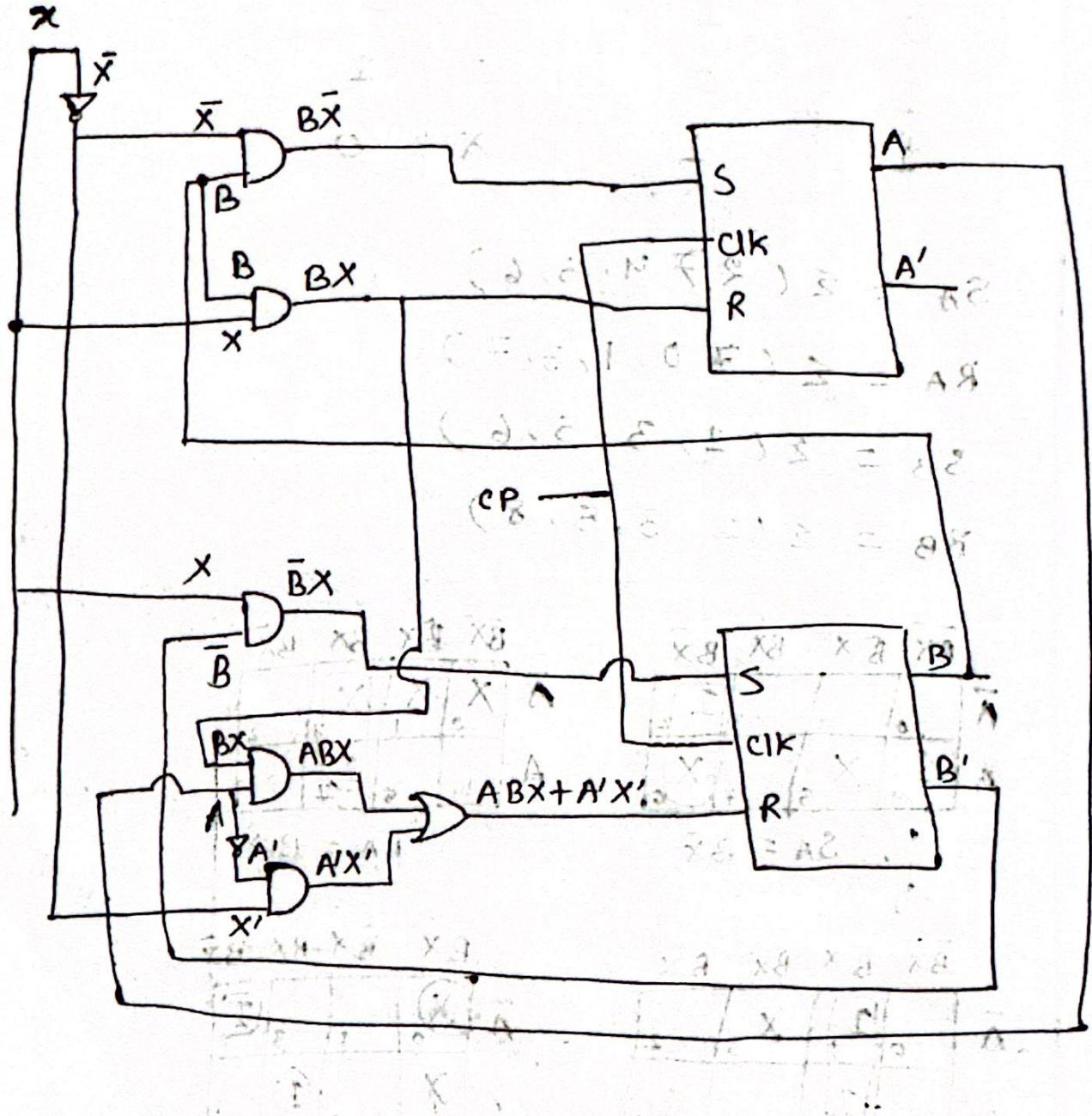
$. \quad R_A = B\bar{X}$

	$\bar{B}X$	$B\bar{X}$	BX	$B\bar{X}$
\bar{A}	0	1	X ₃	X ₂
A	X ₄	X ₅	X ₇	X ₆

$$S_B = \bar{B}X$$

	$\bar{B}X$	$B\bar{X}$	BX	$B\bar{X}$
\bar{A}	X ₀	1	3	2
A	X ₄	5	1	6

$$R_B = ABX + \bar{A}\bar{B}\bar{X}$$



8

CSE 110 → 000

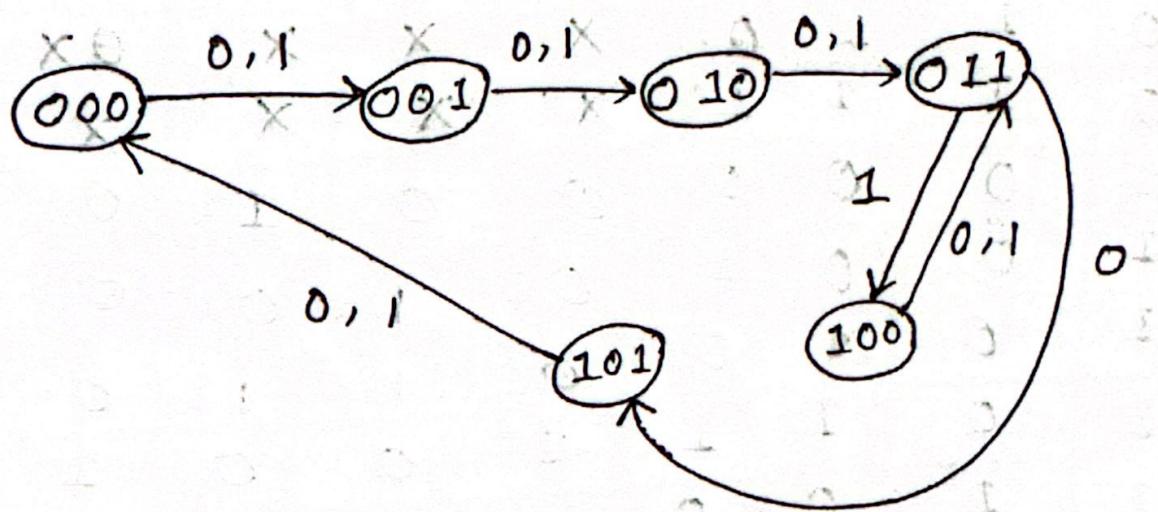
CSE 111 → 001

CSE 220 → 010

CSE 221 → 011

CSE 331 → 100

CSE 321 → 101



x	A	B	C	A^+	B^+	C^+	T_A	T_B	T_C
0 0	0 0	0 0	0 0	0 0	0 1	0 1	0 0	0 0	1 1
0 0	0 0	0 1	0 0	1 0	1 0	0 0	0 0	1 1	1 1
0 0	1 0	0 0	0 0	1 1	1 1	0 0	0 0	1 1	1 1
0 0	1 1	1 1	1 1	0 0	1 1	1 1	1 1	1 1	0 0
0 1	0 0	0 0	0 0	0 0	1 1	1 1	1 1	1 1	1 1
0 1	0 1	0 0	0 0	0 0	0 0	1 1	0 1	0 0	1 1
0 1	1 0	0 0	X 0	X 0	X 0	0 X	X X	X X	X X
0 1	1 1	1 0	X 0	X 0	X 0	X 0	X X	X X	X X
1 0	0 0	0 0	0 0	0 0	1 1	0 0	0 0	0 0	1 1
1 0	0 0	1 0	0 0	1 0	1 0	0 0	1 1	1 1	1 1
1 0	0 1	0 0	0 0	0 0	1 1	1 1	0 0	0 0	1 1
1 0	1 1	1 1	1 1	1 0	0 0	1 1	1 1	1 1	1 1
1 1	0 0	0 0	0 0	0 0	1 1	1 1	1 1	1 1	1 1
1 1	0 1	1 0	0 0	0 0	0 0	0 0	1 0	1 0	1 1
1 1	1 1	1 0	X 0	X 0	X 0	X X	X X	X X	X X
1 1	1 1	1 1	X 0	X 0	X 0	X X	X X	X X	X X

$$T_A = \{3, 4, 5, 11, 12, 13\}$$

$$T_B = \{1, 3, 4, 9, 11, 12\}$$

$$T_C = \{0, 1, 2, 4, 5, 8, 9, 10, 11, 12, 13\}$$

$\bar{x}A$	BC	$B'C'$	$B'C$	BC	BC'	
$x'A'$	0	1	1	2		
$x'A$	1	4	1	5	x_7	x_6
$\bar{x}A$	1	12	1	13	x_{15}	x_{14}
$x'A'$	8	9	1	11	10	

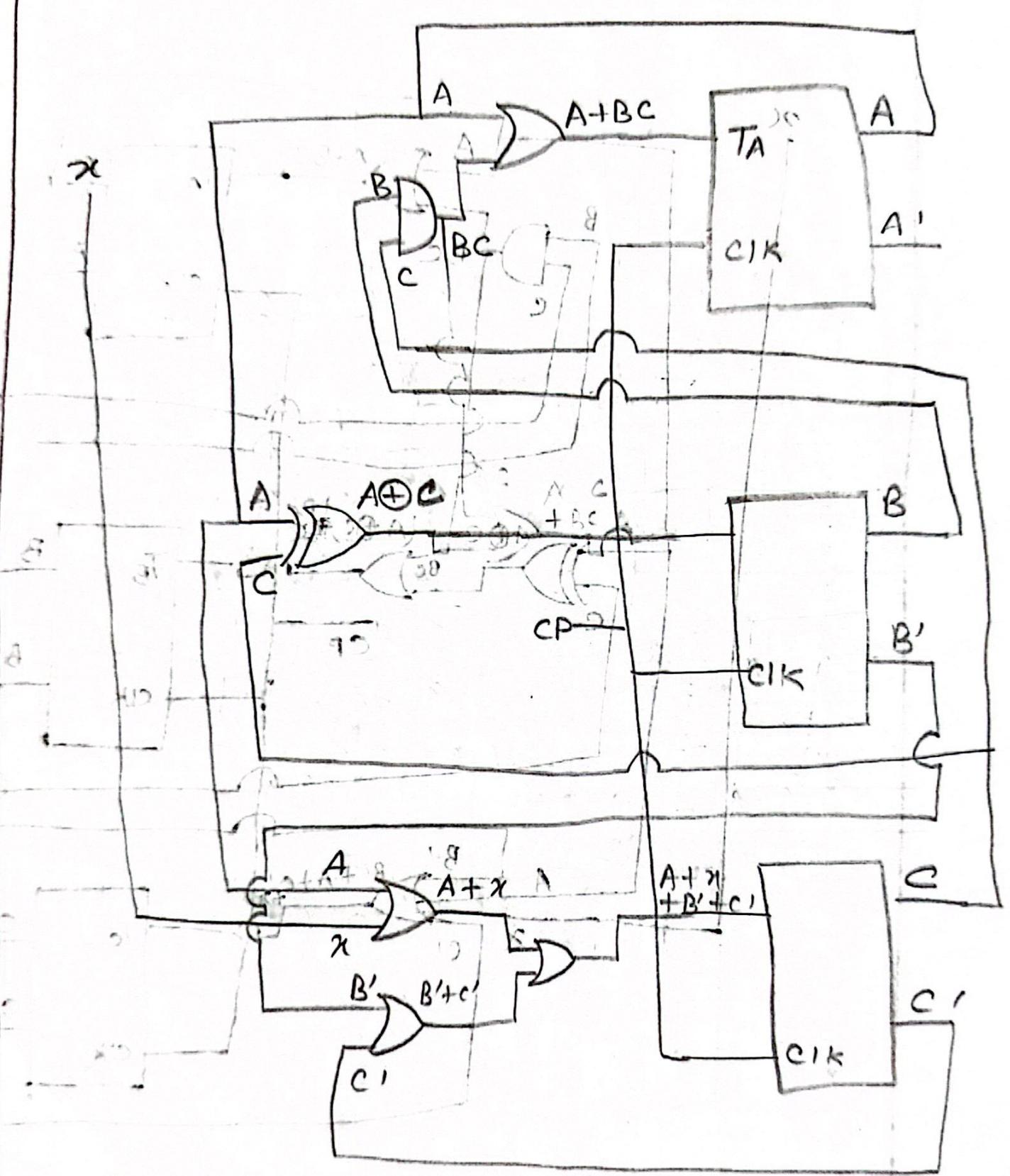
$$T_A = A + BC$$

$\bar{x}A$	BC	$B'C'$	$B'C$	BC	B,C'
$x'A'$	0	1	1	3	2
$x'A$	1	4	1	5	x_7
$\bar{x}A$	1	12	1	13	x_{15}
$x'A'$	8	1	9	11	10

$$\begin{aligned} T_B &= A'C + BC \\ &\quad + AC' \\ &= (A \oplus C) + BC \end{aligned}$$

$\bar{x}A$	BC	$B'C'$	$B'C$	BC	B,C'
$x'A'$	1	1	3	2	
$x'A$	1	4	1	5	x_7
$\bar{x}A$	1	12	1	13	x_{15}
$x'A'$	8	1	9	11	10

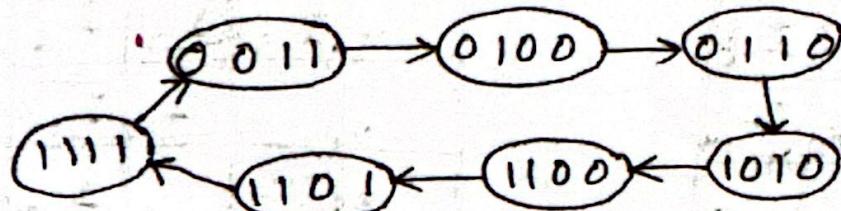
$$\begin{aligned} T_C &= B' + A \\ &\quad + C' + x \end{aligned}$$



⑨. $3 \rightarrow 4 \rightarrow 6 \rightarrow 10 \rightarrow 12 \rightarrow 13 \rightarrow 15 \rightarrow 3$

$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow$

0011 0100 0110 1010 1100 1101 1111 0011



A_3	A_2	A_1	A_0	A_3^+	A_2^+	A_1^+	A_0^+	T_{A_3}	T_{A_2}	T_{A_1}	T_{A_0}
0	0	0	0	0	0	1	1	0	0	1	1
0	0	0	1	0	0	1	1	0	0	1	0
0	0	1	0	0	0	1	1	0	0	0	1
0	0	1	1	0	1	0	0	0	1	1	1
0	1	0	0	0	1	1	0	0	0	1	0
0	1	0	1	0	0	1	1	0	1	1	0
0	1	1	0	1	0	1	0	1	1	0	0
0	1	1	1	0	0	1	1	0	1	0	0
1	0	0	0	0	0	1	1	1	0	1	1
1	0	0	1	0	0	1	1	1	0	1	0
1	0	1	0	1	1	0	0	0	1	1	0
1	0	1	1	0	0	1	1	1	0	0	0
1	1	0	0	1	1	0	1	0	0	0	1
1	1	0	1	1	1	1	1	0	0	1	0
1	1	1	0	0	0	1	1	1	1	0	1
1	1	1	1	1	0	1	1	1	1	0	0

$A_3 A_2$	$A_1 A_0$	$\bar{A}_3 \bar{A}_2$	$\bar{A}_1 \bar{A}_0$	$A_1 \bar{A}_0$	$A_1 A_0$
0	1	3	10	2	
4	5	7	11	6	
8	13	15	1	14	
18	9	11	1	10	

$$T_{A_3} = A_3 \bar{A}_2 + A_1 A_0 + A_1 \bar{A}_0$$

$A_1 \bar{A}_0 \quad \bar{A}_1 A_0 \quad A_1 A_0 \quad A_1 \bar{A}_0$

$\bar{A}_3 \bar{A}_2$	10	11	13	2
14	1	5	7	6
12	1	13	15	14
18	9	11	1	10

$$T_{A_1} = \bar{A}_3 \bar{A}_1 + \bar{A}_1 A_0$$

$$+ A_3 \bar{A}_2 \bar{A}_0 + \bar{A}_3 \bar{A}_2 A_0$$

0	1	13	2
4	15	17	6
12	13	15	14
8	9	11	10

$$T_{A_2} = A_1 A_2 + A_3 \bar{A}_2 A_0 + A_1 A_0 \bar{A}_3$$

10	11	13	2
4	5	7	6
12		15	14
8	9	11	10

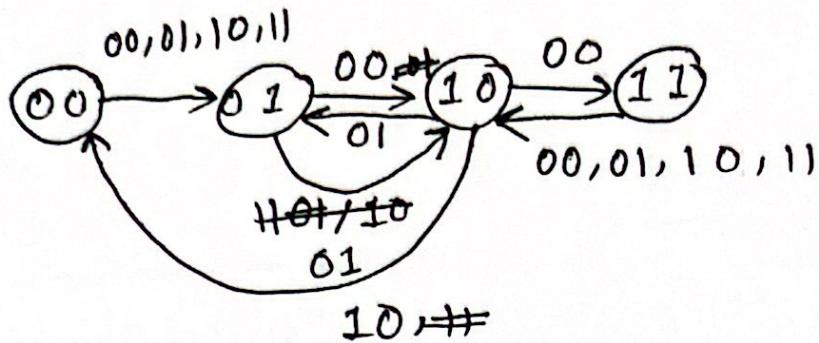
$$T_{A_0} = A_3 \bar{A}_1 \bar{A}_0$$

$$+ \bar{A}_3 \bar{A}_2 A_1$$

$$+ \bar{A}_3 \bar{A}_2 \bar{A}_0$$

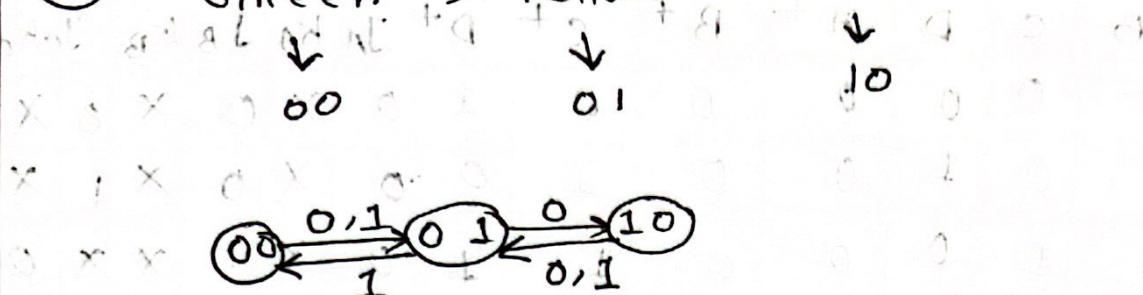
$$+ A_3 A_2 \bar{A}_0$$

(12) Green \rightarrow Orange \rightarrow yellow \rightarrow red \rightarrow yellow \rightarrow orange
 ↓ ↓ ↓ ↓
 00 01 10 11 \rightarrow yellow \rightarrow green



x	y	A	B	A^+	B^+	T_A	T_B
0	0	0	0	0	1	0	1
0	0	0	1	1	0	1	1
0	0	1	0	1	1	0	1
0	0	1	1	1	0	0	1
0	1	0	0	0	1	0	1
0	1	0	1	1	0	1	1
0	1	1	0	0	1	1	1
0	1	1	1	1	0	0	1
1	0	0	0	0	1	0	1
1	0	0	1	1 X	0 X	1 X	1 X
1	0	1	0	0	0	1	0
1	0	1	1	1	0	0	0 1
1	1	0	0	0	1	0	1
1	1	0	1	1 X	0 X	1 X	1 X
1	1	1	0	0 X	0 X	1 X	0 X
1	1	1	1	1	0	0	1

(13)

Green \rightarrow Yellow \rightarrow Red \rightarrow yellow \rightarrow green

m	A	B	A^+	B^+	J_A	K_A	J_B	K_B
0	0	X	0	0	1	0	X	1
0	0	X	10	1	0	1	X	1
0	1	X	00	0	10	X	1	1
0	1	X	11	X	0	X	X	X
1	0	X	0	0	1	0	X	1
1	0	X	1	0	0	10	X	1
1	1	X	0	0	1	X	1	1
1	1	X	1	X	0	X	X	X

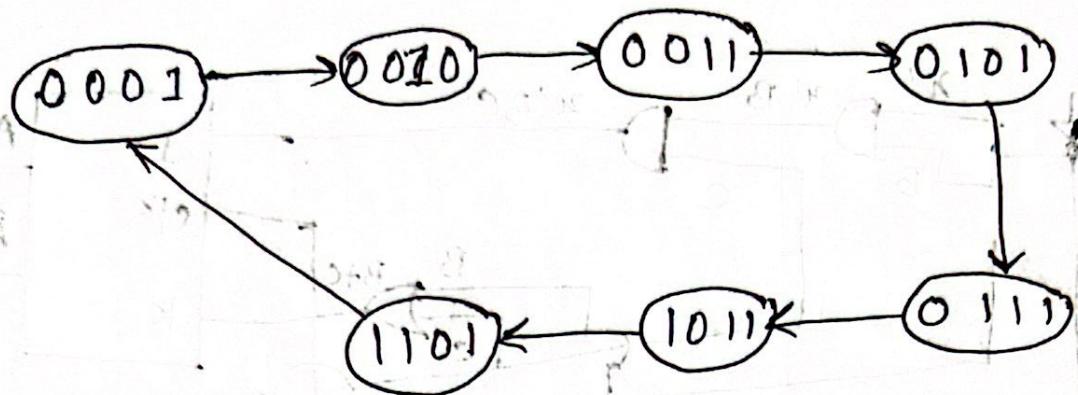
X 0 0 X 0 X 1 0 1 1 0 0

X 1 0 X 0 X 0 1 1 1 1 0

X 0 0 X 0 X 1 1 1 1 0 1

X 1 1 X 1 X 0 0 0 0 1 1

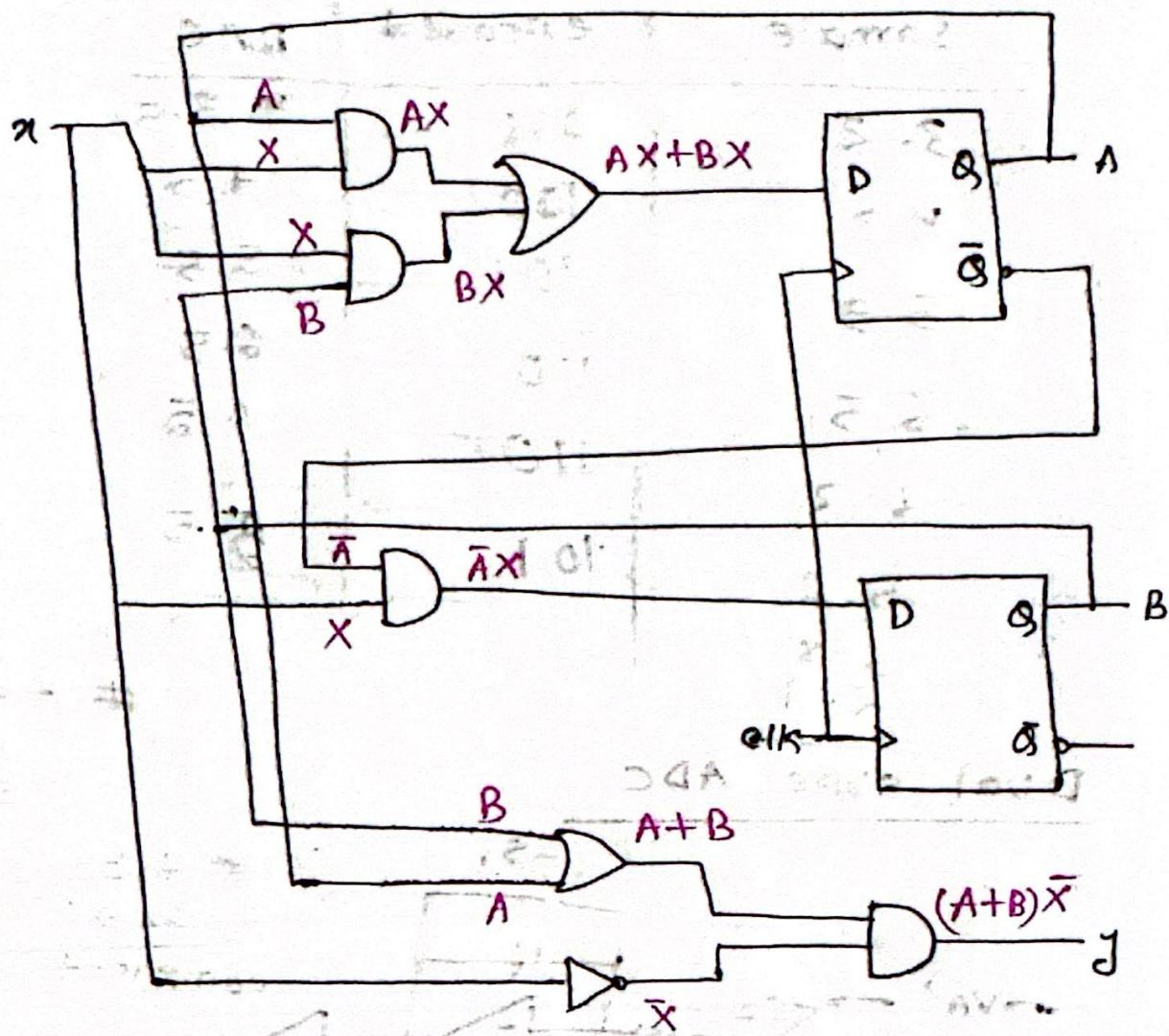
(11) $1 \rightarrow 2 \rightarrow 3 \rightarrow 5 \rightarrow 7 \rightarrow 11 \rightarrow 13 \rightarrow 1$



A	B	C	D	A^+	B^+	C^+	D^+	J_A	K_A	J_B	K_B	J_C	K_C	J_D	K_D
0	0	0	0	0	0	0	1	0	x	0	x	0	x	1	x
0	0	0	1	0	0	1	0	0	x	0	x	1	x	x	1
0	0	1	0	0	0	1	1	0	x	0	x	x	0	1	x
0	0	1	1	0	1	0	1	0	x	1	x	x	1	x	0
0	1	0	0	0	0	0	1	0	x	x	1	0	x	1	x
0	1	0	1	0	1	1	1	0	x	x	0	1	x	1	x
0	1	1	0	0	0	0	1	0	x	x	1	x	1	1	x
0	1	1	1	1	0	1	1	1	x	x	1	x	0	x	0
1	0	0	0	0	0	0	1	x	1	0	x	0	x	1	x
1	0	0	1	0	0	0	1	x	1	0	x	0	x	0	x
1	0	1	0	0	0	0	1	x	1	0	x	x	1	1	x
1	0	1	1	1	1	0	1	x	0	1	x	x	1	x	0
1	1	0	0	0	0	1	1	x	1	x	1	1	x	1	x
1	1	0	1	0	0	0	1	x	1	x	1	0	x	x	0
1	1	1	0	0	0	0	1	x	1	x	1	x	1	1	x
1	1	1	1	0	0	0	1	x	1	x	1	x	1	x	0

Assignment 4

⑥



i) 2 flip-flops are there

$$D_a : Ax + Bx$$

$$D_b : \bar{Ax}$$

$$Y : (A + B)\bar{x}$$

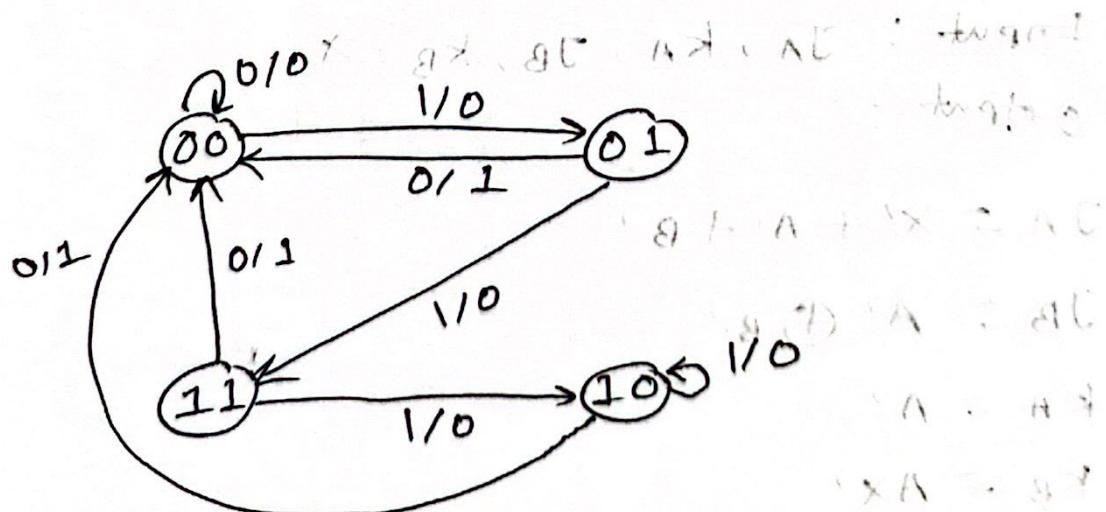
State table

A	B	π	D_a	D_b	y	A^+	B^+
0	0	0	0	0	0	0	0
0	0	1	0	1	0	0	1
0	1	0	0	0	1	0	0
0	1	1	1	1	0	1	1
1	0	0	0	0	1	0	0
1	0	1	1	0	0	1	0
1	1	0	0	0	1	0	0
1	1	1	1	0	0	1	0

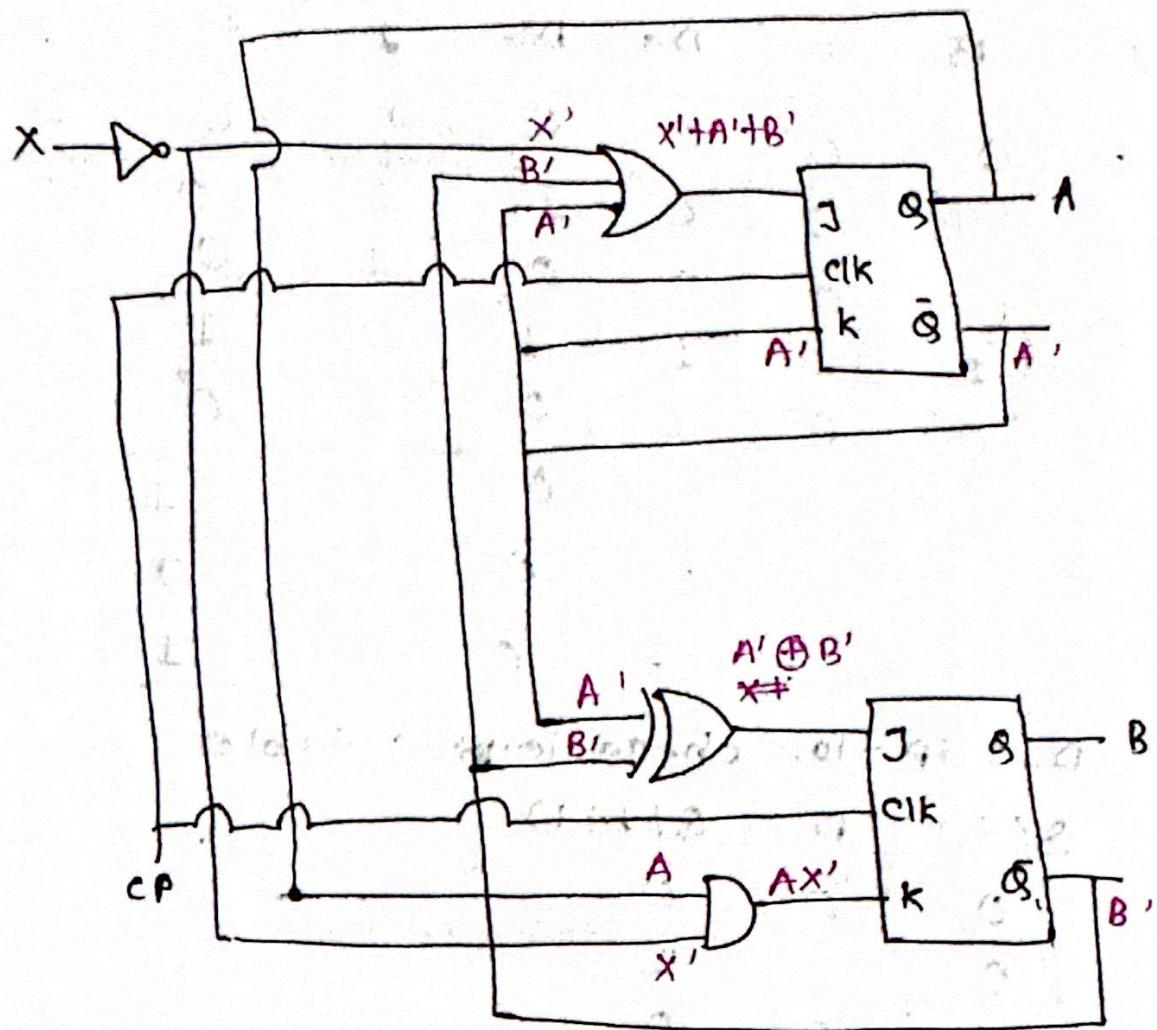
D flip flop characteristic table

$Q(+)$	D	$Q(++)$
0	0	0
0	1	1
1	0	0
1	1	1

state diagram: $g + A$: state transition



(7)



Present state : A, B

Next state : A+, B+

Input : JA, KA, JB, KB, X

Output :

$$J_A = X' + A' + B'$$

$$J_B = A' \oplus B'$$

$$K_A = A'$$

$$K_B = AX'$$

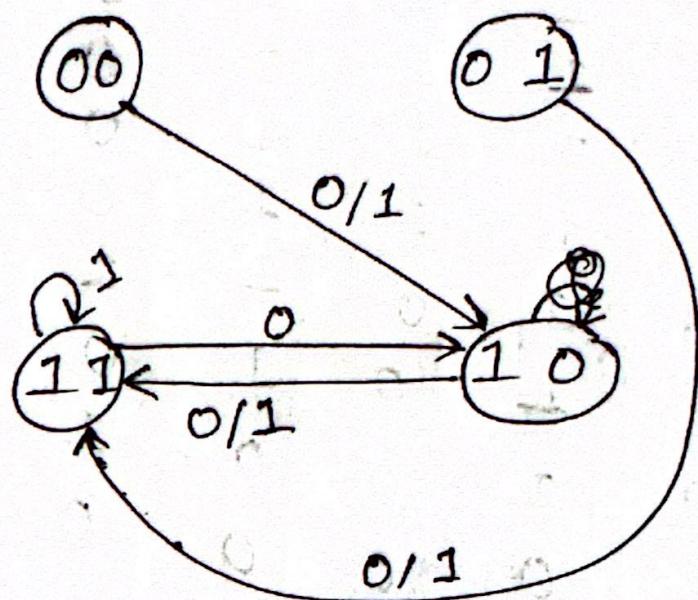
State table

A	B	x	J _A	K _A	J _B	K _B	A ⁺	B ⁺
0	0	0	1	1	0	0	1	0
0	0	1	1	1	0	0	1	0
0	1	0	1	1	1	0	1	1
0	1	1	1	1	1	0	1	1
1	0	0	1	0	1	0	1	0
1	0	1	1	0	1	1	1	1
1	1	0	1	0	0	1	1	0
1	1	1	0	0	0	0	1	1

JK characteristic table

Q(t)	J	K	Q(t+1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

State diagram :



Practice sheet (memory)

* How many address line do we need for a 64 MB RAM with 16 bit / word?

Capacity = no of word \times bit per word

$$\Rightarrow 64 \text{ MB} = Y \times 16$$

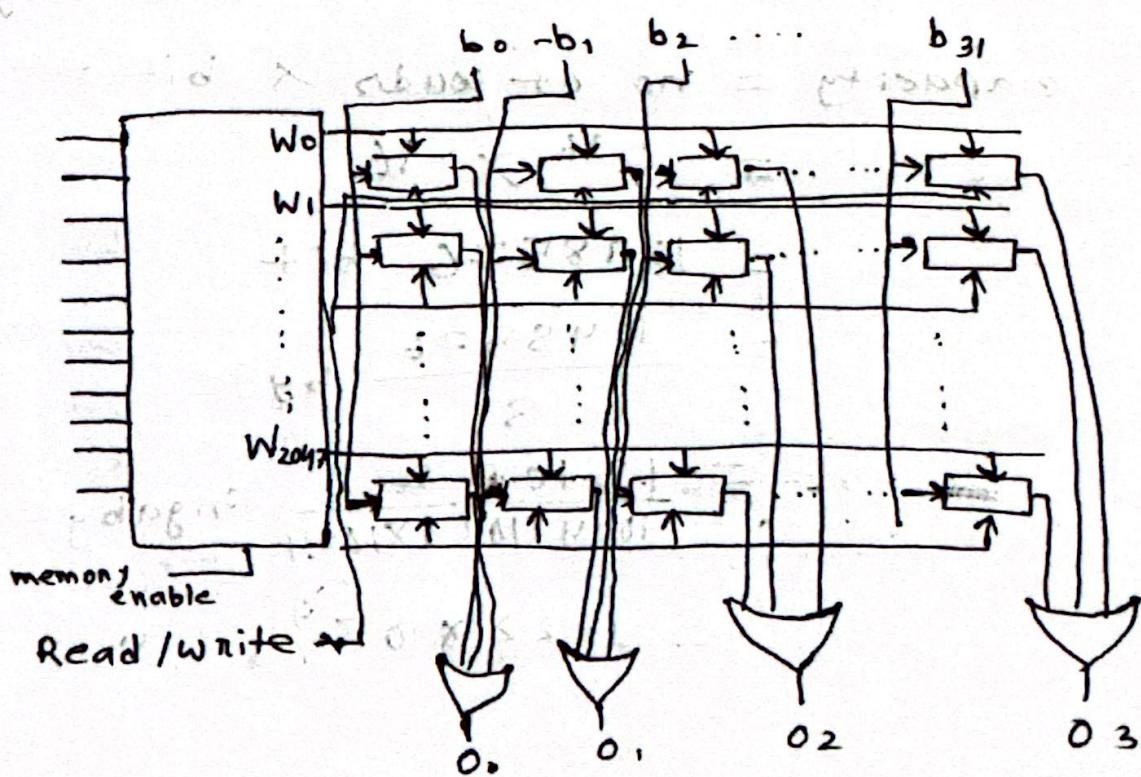
$$\Rightarrow 64 \times 8 \times 1024 \times 1024 = 16Y$$

$$\Rightarrow Y = 33554432$$

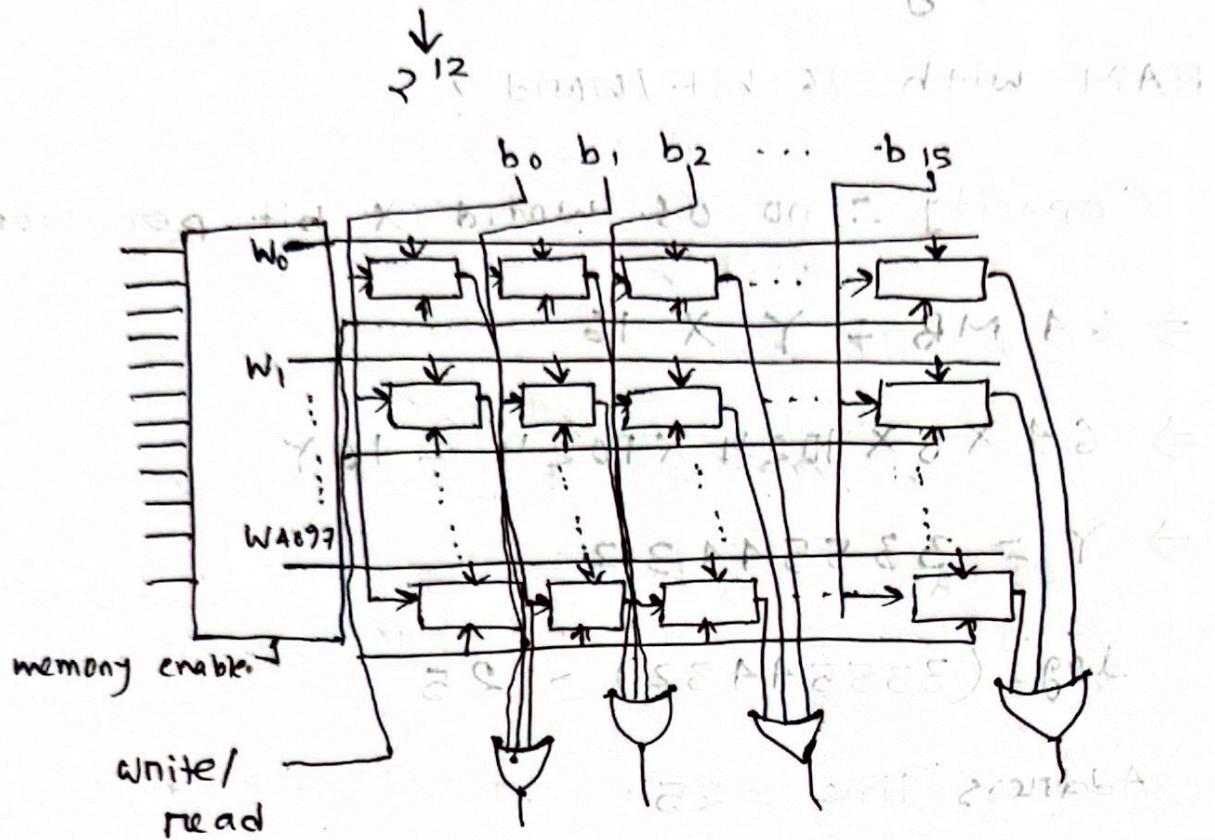
$$\log_2(33554432) = 25$$

Address line = 25

* Design a 2048×32 RAM showing internal details



* Design a 1024×16 RAM showing internal details



* What is the capacity for a $2^{16} \times 16$ RAM in Gigabytes?

capacity = no of words \times bit per word

$$= 2^{16} \times 16$$

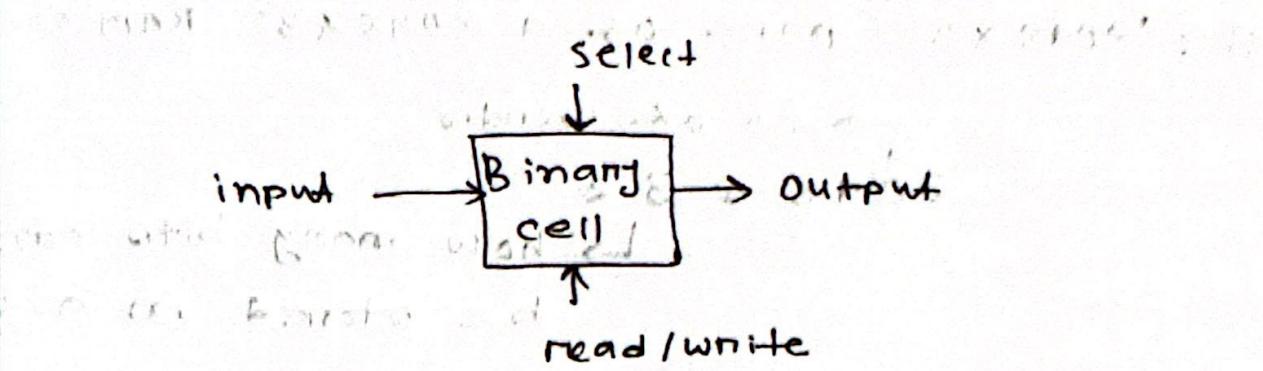
$$= 1048576 \text{ bit}$$

$$= \frac{1048576}{8} \text{ byte}$$

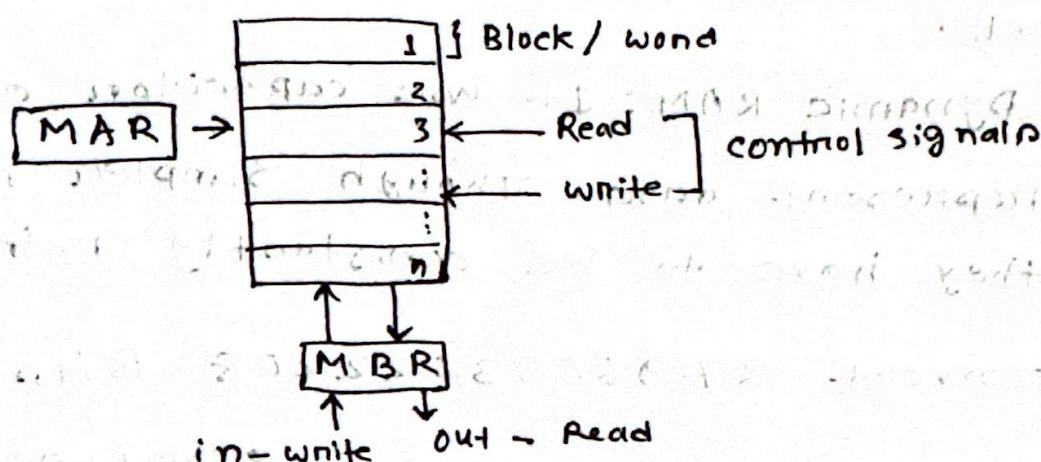
$$= \frac{131072}{1024 \times 1024 \times 1024} \text{ Gigabytes}$$

$$= 1.22 \times 10^{-4}$$

* Draw the block diagram of a binary cell.



* Draw and explain the functionalities of MAR and MBR.



* What type of information can you get from the '2048 x 32' part of a 2048 x 32 RAM?

→ no of words
2048 x 32 → 2¹¹ words
↳ how many bits can be stored in a word

* How many types of RAM are there? Explain

- There are two types of RAM.

i) Static RAM: It uses flip-flops as the memory cell.

ii) Dynamic RAM: It uses capacitors changes to represent data. Though simpler in circuitry, they have to be constantly refreshed.

* Convert 8796093022208 Bits to Gigabytes

$$8796093022208 \text{ bits} = \frac{8796093022208}{8 \times 1024 \times 1024 \times 1024} = 1024 \text{ Gigabytes}$$

* Convert 3 Terabytes to bits.

$$\begin{aligned}3 \text{ Terabyte} &= 3 \times 8 \times 1024 \times 1024 \times 1024 \times 1024 \\&= 3.64 \times 10^{13} \text{ bits.}\end{aligned}$$