CSE-209 (DLD)

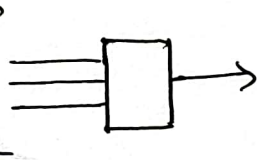
Basic Logic Gates –

(1) AND (2) OR (3) NOT

T → 1 → 5 Volts → High

F → 0 → 0 Volt → Low

(1) And Gate ⇒ [Conjunction]

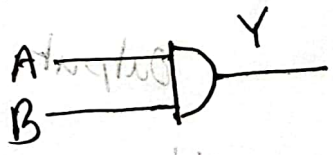
Many inputs {  → 1 output

Output will be High when all the inputs are HIGH, otherwise output will be Low.

Truth Table –

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

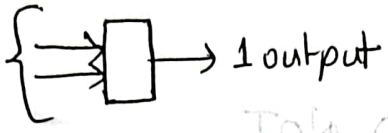
Symbol ⇒



$Y = A \cdot B$

(2) OR Gate ⇒ [Disjunction]

Many inputs



Output will be Low when all the inputs are low, otherwise output will be High.

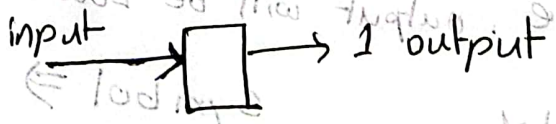
Truth table ⇒

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

Symbol ⇒

$Y = A + B$

(3) NOT Gate [Negation]

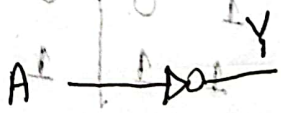


Output is opposite of input

Truth table -

A	Y
0	1
1	0

Symbol ⇒



$Y = \overline{A}$

Compound Logic Gate :

(4) NAND (5) NOR (6) ~~A~~ Ex-OR (7) Ex-NOR

(4) NAND Gate –

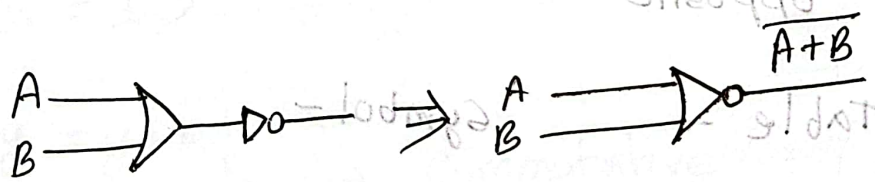
NOT AND ⇒ NAND

Truth Table –

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

(5) NOR Gate –

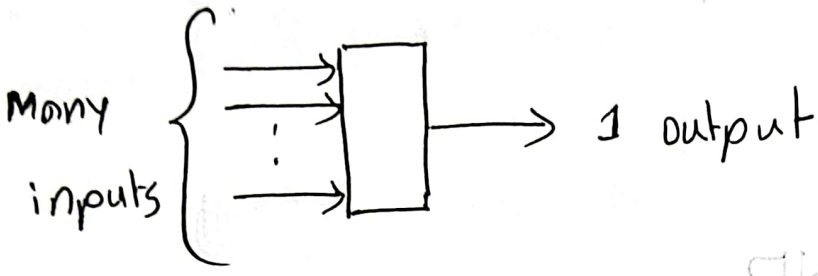
NOT OR ⇒ NOR



Truth table –

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

(6) Exclusive OR / Ex-OR / X-OR :

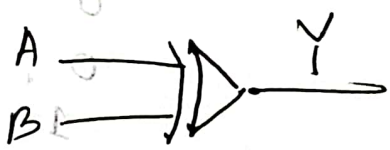


Output will be HIGH when inputs are different, otherwise output will be low.

Truth Table :

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

Symbol ⇒



$Y = A \oplus B$

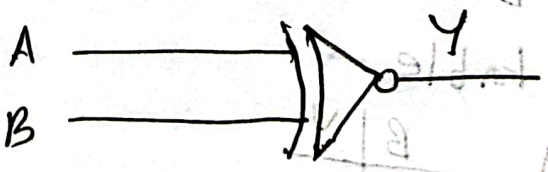
(7) Exclusive NOR / X-NOR / EX-NOR :

Opposite of X-OR.

Truth Table –

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

Symbol –



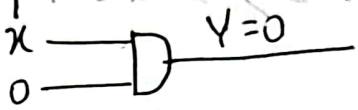
$Y = \overline{A \oplus B}$

SIMPLIFICATION OF Logic Expression ⇒

Boolean Algebra formula ⇒

Don't care input [Because output x এর উপর depend করে না]

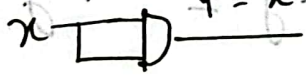
(1) $x \cdot 0 = 0$



(2) $x \cdot 1 = x$

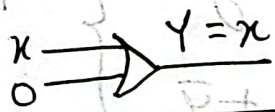
AND

(3) $x \cdot x = x$



(4) $x \cdot \bar{x} = 0$

(5) $x + 0 = x$



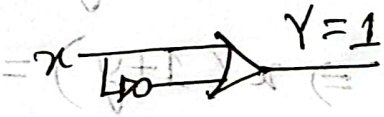
Don't care input

(6) $x + 1 = 1$

OR

(7) $x + x = x$

(8) $x + \bar{x} = 1$



(9) $x + y = y + x$

(10) $x \cdot y = y \cdot x$

→ Commutative law

(11) $x + (y + w) = (x + y) + w = x + y + w$

(12) $x \cdot (y w) = (x y) \cdot w = x y w$

→ Assosiative Law

(13) $x(y+z) = xy + xz$

(14) $(x+y)(w+z) = xw + xz + yw + yz$

Distributive Law

(15) (a) $x + \bar{x}y = x+y$

(b) $\bar{x} + xy = \bar{x} + y$

(16) $x + xy = x$

(17) $\overline{x+y} = \bar{x} \cdot \bar{y}$

(18) $\overline{xy} = \bar{x} + \bar{y}$

De Morgan's Law

Formula 16 $\Rightarrow$ $x + xy = x$

Proof $\Rightarrow$ $x(1+y) = x \cdot 1 = x$

Formula 15 $\Rightarrow$ $x + \bar{x}y = x+y$

Proof $\Rightarrow$ $x + \bar{x}y = x + xy + \bar{x}y$

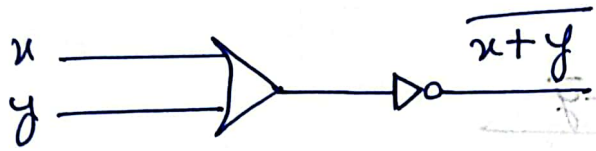
$= x + y(x+\bar{x})$

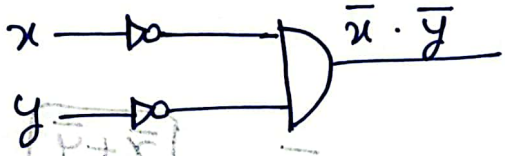
$= x + y \cdot 1$

$= x + y$

De Morgan's Law ⇒

(1) $\overline{x+y} = \bar{x} \cdot \bar{y}$





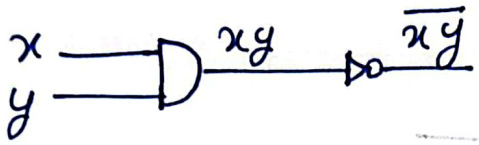
Truth Table :

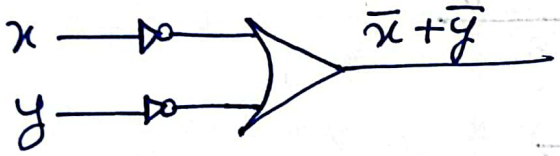
x	y	$x+y$	$\overline{x+y}$	$\bar{x}$	$\bar{y}$	$\bar{x} \cdot \bar{y}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

From the truth table, we can say that,

$\overline{x+y} = \bar{x} \cdot \bar{y}$.

(2) $\overline{x \cdot y} = \bar{x} + \bar{y}$





Truth Table :

x	y	xy	$\overline{xy}$	$\bar{x}$	$\bar{y}$	$\bar{x}+\bar{y}$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	0	0	1	0	1	1
1	1	1	0	0	0	0

From the truth table, we can say that,

$\overline{xy} = \bar{x} + \bar{y}$

Simplification of logic gate using Boolean Algebra ⇒ [Note – $x+\bar{x}$ অথবা $x+\bar{x}y$ এর format আকারে common নিবে।]

* $Y = A\bar{B}D + A\bar{B}\bar{D}$

$= A\bar{B}(D+\bar{D})$ $[D+\bar{D}=1]$

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

$= A\bar{B}$

* $Y = ACD + \bar{A}BCD$

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

$= CD(A+B)$ $[A+\bar{A}B = A+B]$

* $Y = \overline{(\bar{A}+C)\cdot(B+\bar{D})}$

$= \overline{\bar{A}+C} + \overline{B+\bar{D}}$ [De Morgan's Law]

$= \bar{\bar{A}}\cdot\bar{C} + \bar{B}\cdot\bar{\bar{D}}$ ["]

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

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

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

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

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

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

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

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

$= \bar{A}BC + A\bar{B}C + AB$ $\quad [C+\bar{C} = 1]$

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

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

$= \bar{A}BC + AB + AC$ $\quad$ [Distributive Law]

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

$= B(A+C) + AC$ $\quad [A+\bar{A}C = A+C]$

$= AB + BC + AC$ $\quad$ [Distributive Law]

* Sum of product form ⇒

Design the circuit from a given truth table.

A	B	C	Y	
0	0	0	1	$\rightarrow \bar{A}\bar{B}\bar{C}$
0	0	1	1	$\rightarrow \bar{A}\bar{B}C$
0	1	0	0	
0	1	1	0	
1	0	0	0	
1	0	1	1	$\rightarrow A\bar{B}C$
1	1	0	0	
1	1	1	1	$\rightarrow ABC$

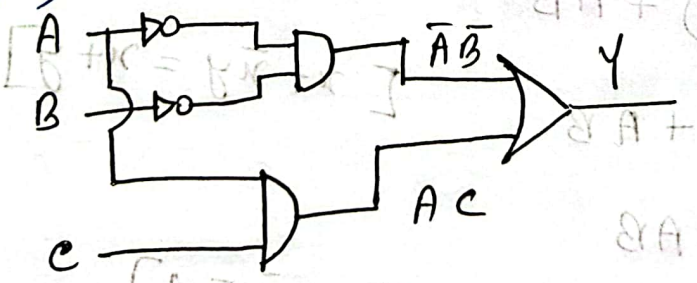
Sum of product form –

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

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

$$= \bar{A}\bar{B} + AC \qquad [x+\bar{x}=1]$$

Circuit ⇒



Design the circuit from a given truth table.

A	B	C	Y	
0	0	0	1	$\rightarrow \bar{A}\bar{B}\bar{C}$
0	0	1	0	
0	1	0	0	
0	1	1	0	
1	0	0	1	$\rightarrow A\bar{B}\bar{C}$
1	0	1	1	$\rightarrow A\bar{B}C$
1	1	0	1	$\rightarrow AB\bar{C}$
1	1	1	1	$\rightarrow ABC$

Sum of product form $\Rightarrow$

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

$$= \bar{B}\bar{C}(\bar{A}+A) + A\bar{B}C + AB(\bar{C}+C) \qquad [x+\bar{x}=1]$$

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

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

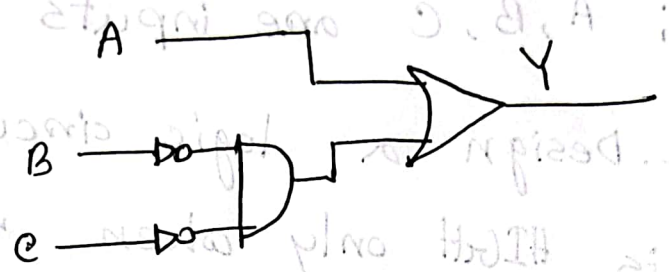
$$= \bar{B}(\bar{C}+A) + AB \qquad [x+\bar{x}y = x+y]$$

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

$$= \bar{B}\bar{C} + A(\bar{B}+B) \qquad [x+\bar{x}=1]$$

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

circuit ⇒



* From X-OR and Ex-NOR Truth Table –

Ex-OR ⇒

A	B	y
0	0	0
0	1	1 → $\bar{A}B$
1	0	1 → $A\bar{B}$
1	1	0

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

Ex-NOR ⇒

A	B	Y
0	0	1 → $\bar{A}\bar{B}$
0	1	0
1	0	0
1	1	1 → AB

$$\boxed{\overline{A \oplus B} = \bar{A}\bar{B} + AB}$$

* Designing logic circuit from a given statement

Example-1: A, B, C are inputs and Y is the output. Design a logic circuit whose output is HIGH only when majority of inputs are HIGH.

⇒ Truth Table for the given statement —

A	B	C	Y	
0	0	0	0	
0	0	1	0	
0	1	0	0	
0	1	1	1	$\rightarrow \bar{A}BC$
1	0	0	0	
1	0	1	1	$\rightarrow A\bar{B}C$
1	1	0	1	$\rightarrow AB\bar{C}$
1	1	1	1	$\rightarrow ABC$

Sum of product form ⇒

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

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

$$= \bar{A}BC + A\bar{B}C + AB \qquad [x+\bar{x}=1]$$

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

$= \bar{A}BC + A(B+C]$ $\quad [x+\bar{x}y = x+y]$

$= \bar{A}BC + AB + AC$

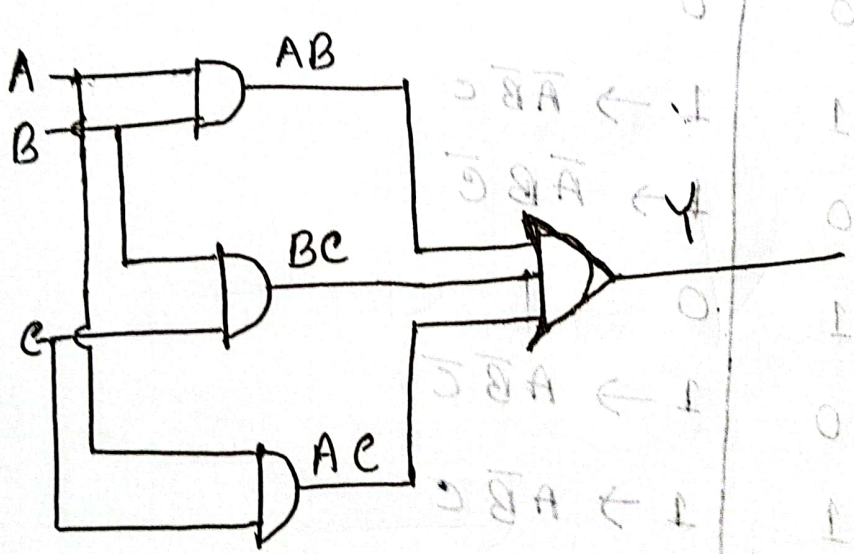
$= C(A+\bar{A}B) + AB$

$= C(A+B) + AB$

$= AC + BC + AB$ $\quad$ [Distributive Law]

$= AB + BC + AC$

Circuit :



Example-2: Design a logic circuit that follows the following requirements –

(i) Output X will equal A, when B and C are same.

(ii) X will remain HIGH when B & C are different.

⇒ Truth table for the given statement –

A	B	C	X
0	0	0	0
0	0	1	1 → $\bar{A}\bar{B}C$
0	1	0	1 → $\bar{A}B\bar{C}$
0	1	1	0
1	0	0	1 → $A\bar{B}\bar{C}$
1	0	1	1 → $A\bar{B}C$
1	1	0	1 → $AB\bar{C}$
1	1	1	1 → ABC

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sum of product form ⇒

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

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

$$= \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + \bar{A}\bar{B}C + AB \qquad [x+\bar{x}=1]$$

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

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

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

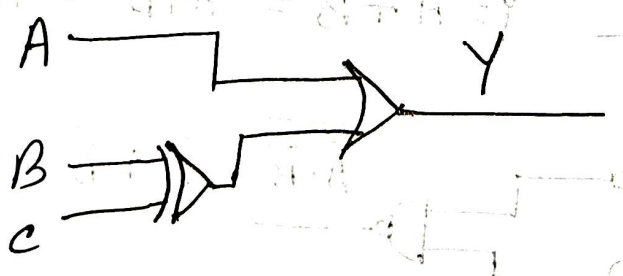
$$= \bar{A}\bar{B}C + \bar{A}B\bar{C} + A$$

$$= \overset{x}{\boxed{A}} + \overset{\bar{x}}{\boxed{\bar{A}}}\,\overset{y}{\boxed{(\bar{B}C + B\bar{C})}}$$

$$= A + (\bar{B}C + B\bar{C}) \qquad [x+\bar{x}y = x+y]$$

$$= A + B \oplus C$$

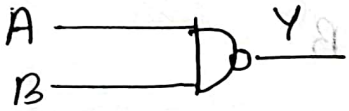
Circuit ⇒



Universality of NAND Gate ⇒

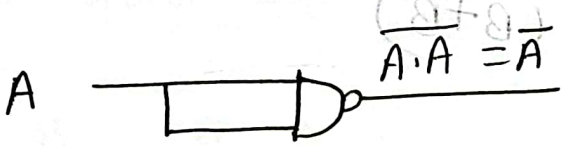
NAND → NOT
NAND → AND
NAND → OR

(i) NAND TO NOT ⇒

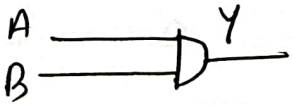


$Y = A\overline{B}$

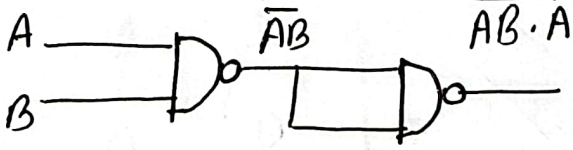
$Y = \overline{A} = \overline{A \cdot A}$



(ii) NAND TO AND ⇒

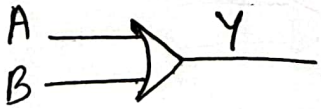


$Y = AB = \overline{\overline{AB}}$

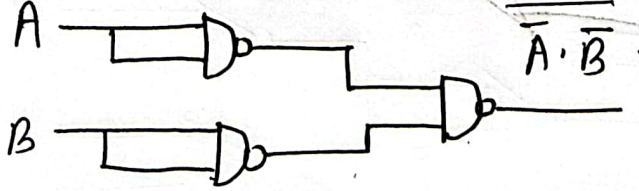


$\overline{\overline{AB} \cdot \overline{AB}} = \overline{\overline{AB}} = AB$

(iii) NAND TO OR ⇒



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

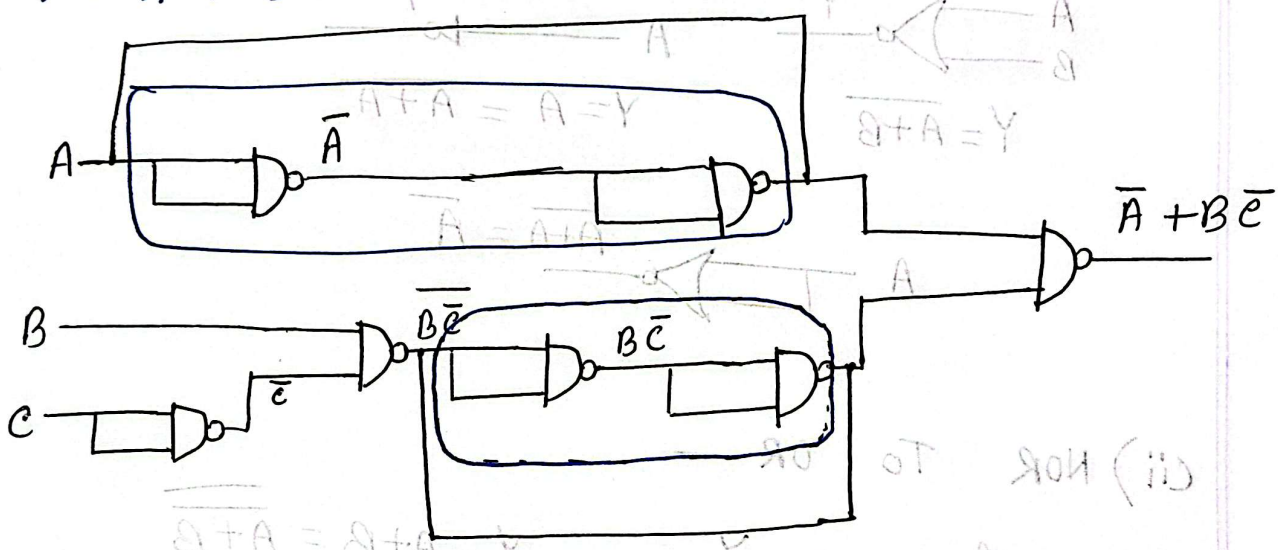


$\overline{\overline{A} \cdot \overline{B}} = \overline{\overline{A}} + \overline{\overline{B}} = A + B$

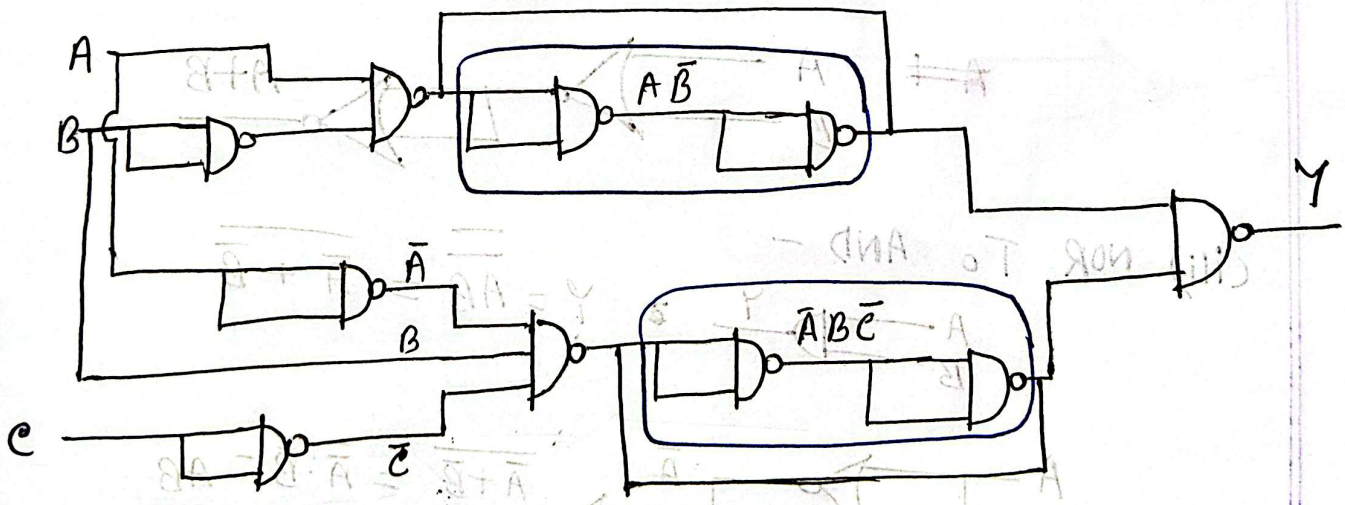
Therefore, we can design all the basic gates using NAND gate only. That's why, NAND Gate is called universal gate.

Drawing circuits using NAND Gate only.

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



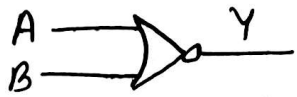
* $Y = A\bar{B} + \bar{A}B\bar{C}$



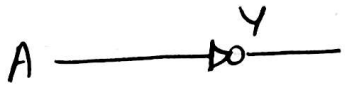
Universality of NOR Gate –

NOR → NOT
NOR → OR
NOR → AND

(i) NOR To NOT –



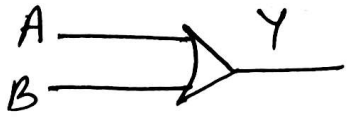
$Y = \overline{A+B}$



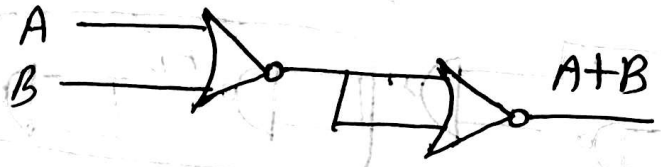
$Y = \bar{A} = \overline{A+A}$

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

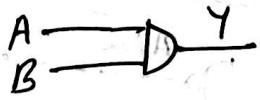
(ii) NOR To OR –



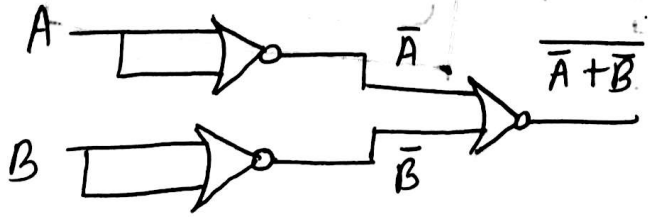
$Y = A+B = \overline{\overline{A+B}}$



(iii) NOR To AND –



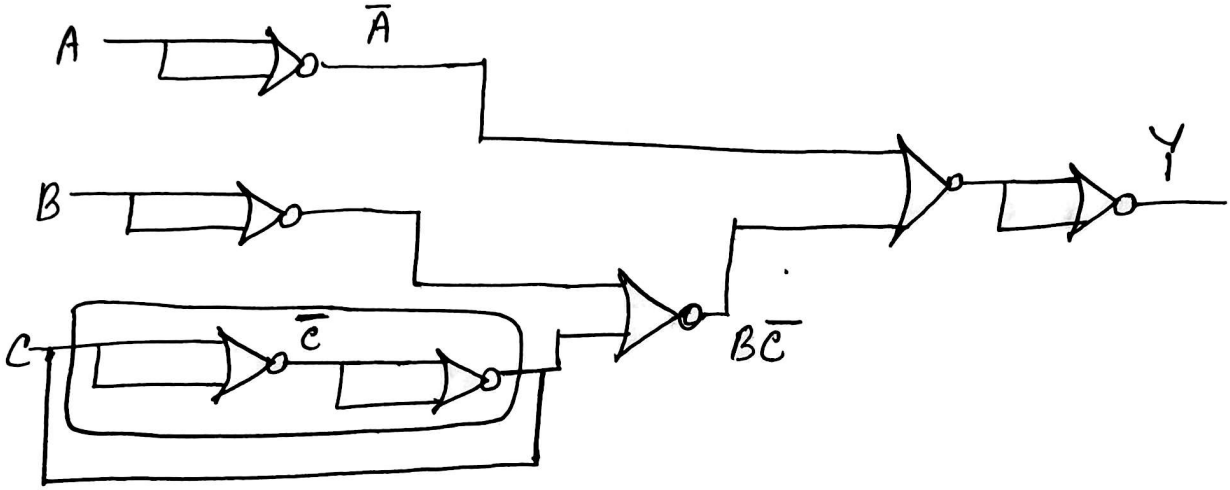
$Y = \overline{\overline{AB}} = \overline{\bar{A} + \bar{B}}$



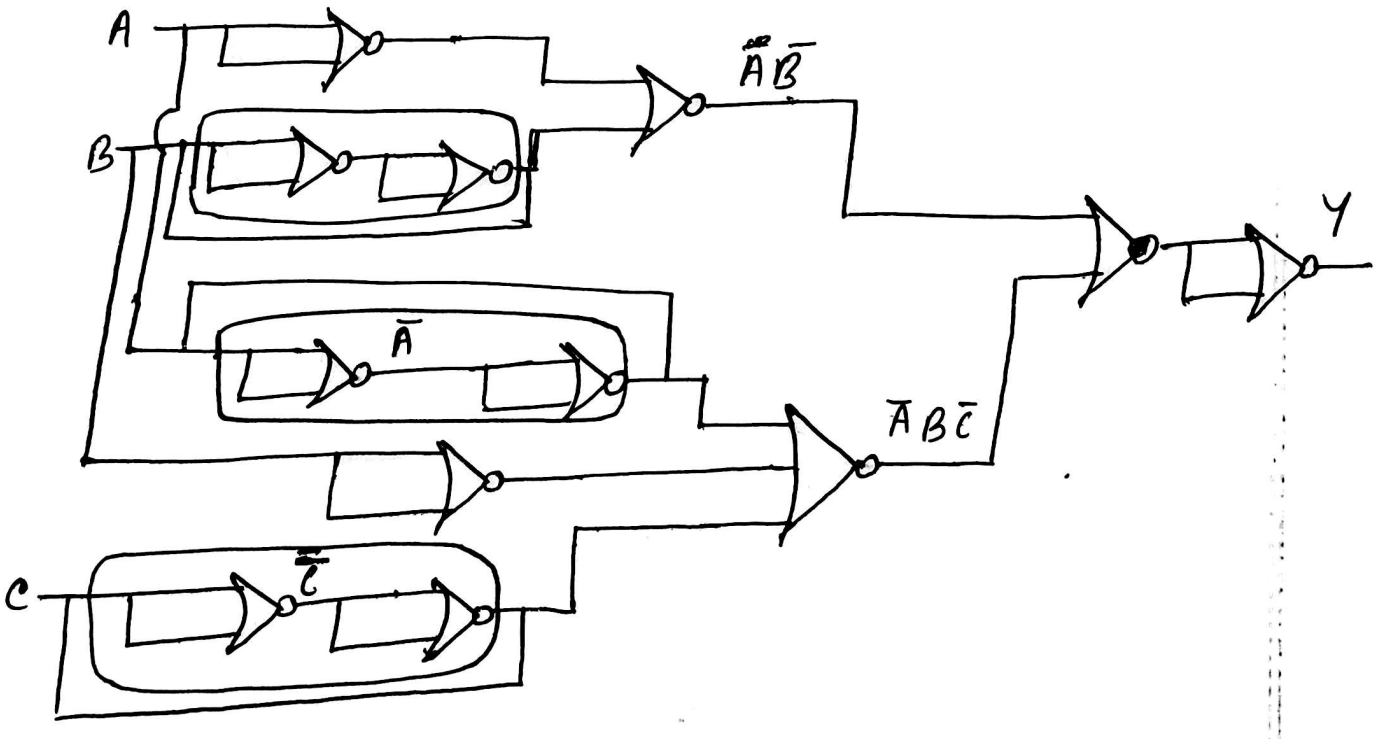
$\overline{\bar{A} + \bar{B}} = \bar{\bar{A}} \cdot \bar{\bar{B}} = AB$

Drawing circuits using NOR Gate only.

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



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



Simplification of logic expression using k-map -

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

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}$	0	0	1	1
C	0	0	1	1

→ Quad Example

$2 \times 4 \rightarrow$ k-map {3 inputs হয় তখন}

* $Y = \bar{A}\bar{B}CD + A\bar{B}CD + ABCD + A\bar{B}\bar{C}D + \bar{A}BC\bar{D} + \bar{A}\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}\bar{D}$

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}\bar{D}$	1	1		
$C\bar{D}$				1
CD	1	1	1	
$\bar{C}D$		1		

→ Pair example

4×4 k-map {4 inputs হয় তখন}

Looping ⇒

(i) Pair (ii) Quad (iii) Octec

(1) Pair → 2 adjacent 1's

(2) Quad → 4 " 1's

(3) Octec → 8 " 1's

1	1	0	0

Octec > Quad > Pair > Nothing

Algorithm of k-map ⇒

(1) Draw the k-map according to no of inputs and insert 1's in appropriate position.

(2) Find 1's that has no adjacent 1. That 1 is called isolated 1. If so then loop itself.

(3) Find 1's that has only one adjacent 1. If so, then pair

(4) Find octec, if any.

(5) Find Quad, if any.

(6) Find pair, if any

(7) Write the sum form of the ~~resean~~ result of each loop

Simplifying logic expression using k-map.

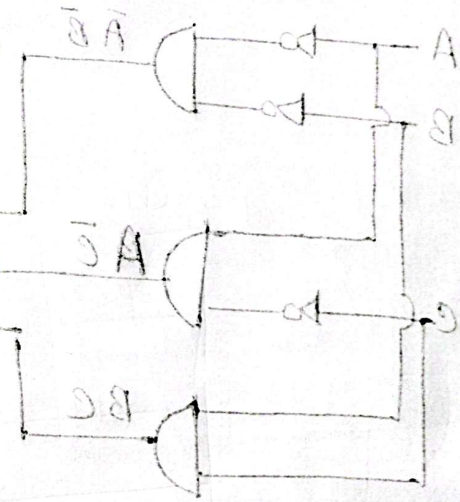
* $Y = AB\bar{C} + \bar{A}BC + A\bar{B}C + ABC$

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}$			1	
C		1	1	1

$Y = AB + BC + AC$

* Design circuit from the given truth table using k-map.

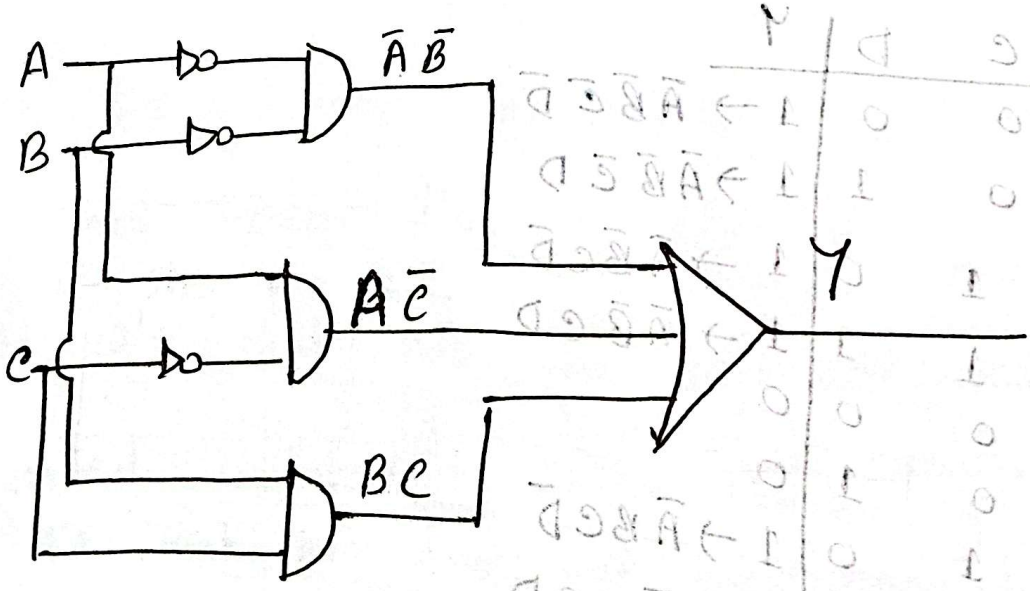
A	B	C	D	Y
0	0	0	0	1 → $\bar{A}\bar{B}\bar{C}\bar{D}$
0	0	0	1	1 → $\bar{A}\bar{B}\bar{C}D$
0	0	1	0	1 → $\bar{A}\bar{B}C\bar{D}$
0	0	1	1	1 → $\bar{A}\bar{B}CD$
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1 → $\bar{A}BC\bar{D}$
0	1	1	1	1 → $\bar{A}BCD$
1	0	0	0	1 → $A\bar{B}\bar{C}\bar{D}$
1	0	0	1	1 → $A\bar{B}\bar{C}D$
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1 → $AB\bar{C}\bar{D}$
1	1	0	1	1 → $AB\bar{C}D$
1	1	1	0	1 → $ABC\bar{D}$
1	1	1	1	1 → $ABCD$



	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}\bar{D}$	1	1	1	
$C\bar{D}$	1		1	1
CD	1		1	1
$\bar{C}D$	1	1	1	

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

Circuit ⇒



* Find output of the given k-map.

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}\bar{D}$	1	1	1	1
$C\bar{D}$	1	1	0	0
CD	0	0	0	1
$\bar{C}D$	0	0	1	1

loop-3

loop-2

loop-1

$$Y = \bar{B}\bar{D} + B\bar{C} + \bar{A}BD$$

* Design circuit from the given truth table using k-map ⇒

A	B	C	Y
0	0	0	1 → $\bar{A}\bar{B}\bar{C}$
0	0	1	1 → $\bar{A}\bar{B}C$
0	1	0	0
0	1	1	1 → $\bar{A}BC$
1	0	0	0
1	0	1	0
1	1	0	1 → $AB\bar{C}$
1	1	1	1 → ABC

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}$	1	0	1	0
C	1	0	1	1

L1

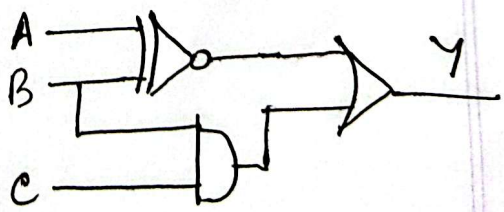
L2

L3

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

$$= \overline{A \oplus B} + BC$$

circuit:



* Find output of the given K-map.

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}\bar{D}$	1	0	1	1
$C\bar{D}$	1	0	0	1
CD	0	0	0	0
$\bar{C}D$	1	0	1	1

L_1 L_2 L_3

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

Example - 4 : A 4 bit binary number is represented as DCBA, where D, C, B and A represent the individual bits and A is equal to LSB. Design a logic circuit that will produce a HIGH output where the binary number is greater than 0010 and less than 1010.

⇒

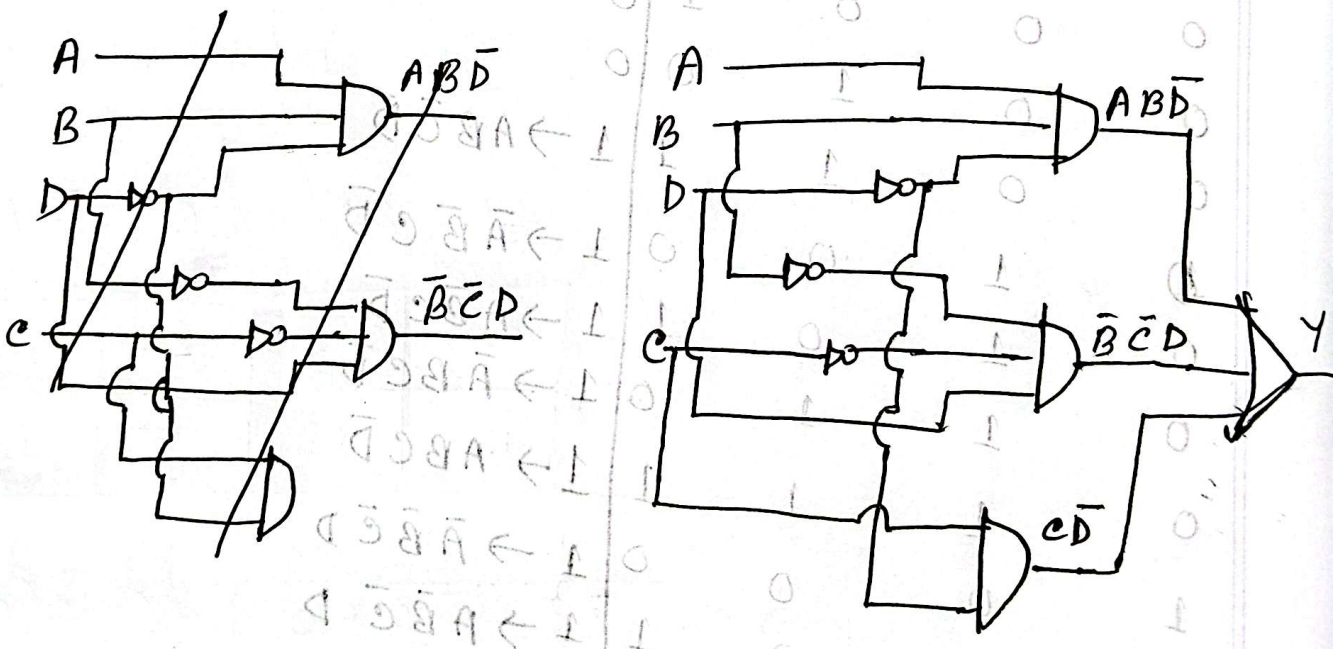
D	C	B	A	Y
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1 → $AB\bar{C}\bar{D}$
0	1	0	0	1 → $\bar{A}\bar{B}C\bar{D}$
0	1	0	1	1 → $A\bar{B}C\bar{D}$
0	1	1	0	1 → $\bar{A}BC\bar{D}$
0	1	1	1	1 → $ABC\bar{D}$
1	0	0	0	1 → $\bar{A}\bar{B}\bar{C}D$
1	0	0	1	1 → $A\bar{B}\bar{C}D$
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}\bar{D}$	0	0	1	0
$C\bar{D}$	1	1	1	1
CD	0	0	0	0
$\bar{C}D$	1	1	0	0

L_1 L_2 L_3

$$Y = AB\bar{D} + \bar{B}\bar{C}D + C\bar{D}$$

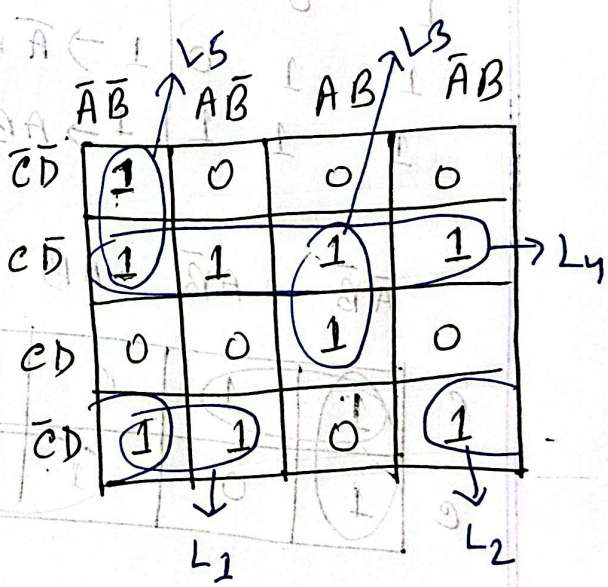
Circuit ⇒



Example-5: A four bit binary number is represented as DCBA where D, C, B and A represent the individual bits and A is equal to LSB. Design a logic circuit that will produce a HIGH output where the binary number is greater than 0011 and Less than 1011 or all the inputs are low or all the inputs are HIGH.

⇒ Truth table of the given statement –

D	C	B	A	Y
0	0	0	0	1 → $\bar{A}\bar{B}\bar{C}\bar{D}$
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	1 → $\bar{A}\bar{B}C\bar{D}$
0	1	0	1	1 → $A\bar{B}C\bar{D}$
0	1	1	0	1 → $\bar{A}BC\bar{D}$
0	1	1	1	1 → $ABC\bar{D}$
1	0	0	0	1 → $\bar{A}\bar{B}\bar{C}D$
1	0	0	1	1 → $A\bar{B}\bar{C}D$
1	0	1	0	1 → $\bar{A}B\bar{C}D$
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1 → ABCD



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

[Draw the circuit]

Xm a circuit আঁকতে হবে।

* Implement $F(A,B,C) = \Sigma(0,1,4,6,7)$ (MSB)

using k-map.

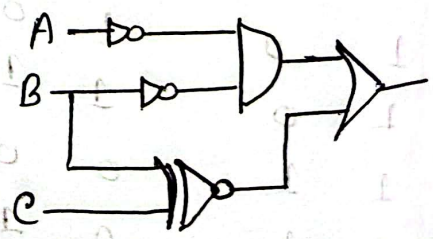
⇒ Truth table for the given statement –

C	B	A	Y
0	0	0	1 → $\bar{A}\bar{B}\bar{C}$
0	0	1	1 → $A\bar{B}\bar{C}$
0	1	0	0
0	1	1	0
1	0	0	1 → $\bar{A}\bar{B}C$
1	0	1	0
1	1	0	1 → $\bar{A}BC$
1	1	1	1 → ABC

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}$	1	1	0	0
C	1	0	1	1

$$F(A,B,C) = BC + \bar{A}\bar{B} + \bar{B}\bar{C}$$
$$= \bar{A}\bar{B} + BC + \bar{B}\bar{C}$$
$$= \bar{A}\bar{B} + \overline{B \oplus C}$$

Circuit:



Example-7 : Implement $F(A,B,C,D) = \Sigma(0,1,2,3,6,7,9,11,14,15)$ using k-map.

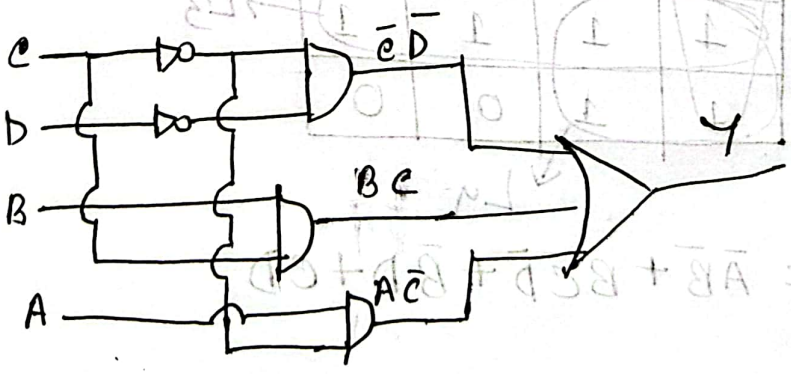
⇒ Truth table for given statement ⇒

D	C	B	A	Y
0	0	0	0	$1 \rightarrow \bar{A}\bar{B}\bar{C}\bar{D}$
0	0	0	1	$1 \rightarrow A\bar{B}\bar{C}\bar{D}$
0	0	1	0	$1 \rightarrow \bar{A}B\bar{C}\bar{D}$
0	0	1	1	$1 \rightarrow AB\bar{C}\bar{D}$
0	1	0	0	0
0	1	0	1	0
0	1	1	0	$1 \rightarrow \bar{A}BC\bar{D}$
0	1	1	1	$1 \rightarrow ABC\bar{D}$
1	0	0	0	0
1	0	0	1	$1 \rightarrow A\bar{B}\bar{C}D$
1	0	1	0	0
1	0	1	1	$1 \rightarrow AB\bar{C}D$
1	1	0	0	0
1	1	0	1	0
1	1	1	0	$1 \rightarrow \bar{A}BCD$
1	1	1	1	$1 \rightarrow ABCD$

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$	
$\bar{C}\bar{D}$	1	1	1	1	$\rightarrow L_1$
$C\bar{D}$	0	0	1	1	$\rightarrow L_2$
CD	0	0	1	1	
$\bar{C}D$	0	1	1	0	$\rightarrow L_3$

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

Circuit :



Indexing :

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

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}\bar{D}$	0	1	3	2
$C\bar{D}$	4	5	7	6
CD	12	13	15	14
$\bar{C}D$	8	9	11	10

* Implement $F(A,B,C,D) = \Sigma(0, 2, 3, 4, 8, 9, 12, 13, 14, 15)$ using k-map.

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$	
$\bar{C}\bar{D}$	1	0	1	1	L_1
$C\bar{D}$	1	0	0	0	
CD	1	1	1	1	L_3
$\bar{C}D$	1	1	0	0	
		L_4			

$$Y = \bar{A}\bar{B} + B\bar{C}\bar{D} + \bar{B}D + CD$$

Ex-6: Design a logic circuit which has 4 inputs A, B, C, D. Output Y will be HIGH only when A is HIGH, at the same time at least 2 other inputs are HIGH. Design the circuit.

Solve ⇒

D	C	B	A	Y	
0	0	0	0	0	
0	0	0	1	0	
0	0	1	0	0	
0	0	1	1	0	
0	1	0	0	0	
0	1	0	1	0	
0	1	1	0	0	
0	1	1	1	1	→ 7
1	0	0	0	0	
1	0	0	1	0	
1	0	1	0	0	
1	0	1	1	1	→ 11
1	1	0	0	0	
1	1	0	1	1	→ 13
1	1	1	0	0	
1	1	1	1	1	→ 15

So, $F(A,B,C,D) = \Sigma(7, 11, 13, 15)$

By applying indexing,

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}\bar{D}$	0	0	0	0
$C\bar{D}$	0	0	1	0
CD	0	1	1	0
$\bar{C}D$	0	0	1	0

$$Y = ABC + ABD + ACD$$

Ex-7: Implement the following function

$F(A,B,C,D) = \Sigma(0, 1, 2, 4, 6, 7, 9, 10, 14, 15)$

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}\bar{D}$	1	1	0	1
$C\bar{D}$	1	0	1	1
CD	0	0	1	1
$\bar{C}D$	0	1	0	1

L_1 L_2 L_3 L_4

$$Y = A\bar{B}\bar{C} + \bar{A}\bar{D} + BC + \bar{A}B$$

* $F(A, B, C, D) = \Sigma(0, 1, 6, 7, 8, 9, 12, 13, 14, 15)$.

Solve ⇒

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$A\bar{B}$
$\bar{C}\bar{D}$	1	1	0	0
$C\bar{D}$	0	0	1	1
CD	1	1	1	1
$\bar{C}D$	1	1	0	0

L1 L2 L3

$$Y = \bar{B}\bar{C} + \bar{B}D + BC$$

* Simplify the given expression using k-map –

$$Y = ABCD + \bar{A}\bar{B}CD + A\bar{B}\bar{C}D + ABC + BCD + AB$$

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}\bar{D}$	0	0	1	0
$C\bar{D}$	0	0	1	0
CD	1	0	1	1
$\bar{C}D$	0	1	1	0

$$Y = \bar{A}CD + A\bar{C}D + AB$$
$$= D(\bar{A}C + A\bar{C}) + AB$$
$$= D(A \oplus C) + AB$$

Chapter - 06

Digital Arithmetics operation and Circuit -

Binary Addition -

	C	Sum
$0+0=$	0	0
$0+1=$	0	1
$1+0=$	0	1
$1+1=$	1	0

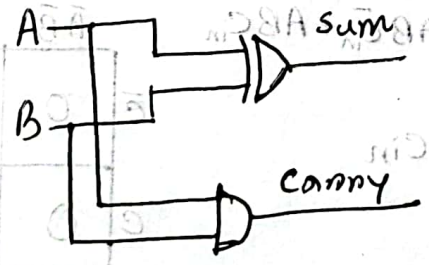
HALF ADDER :

A	B	Sum	Carry
0	0	0	0
0	1	$1 \rightarrow \bar{A}B$	0
1	0	$1 \rightarrow A\bar{B}$	0
1	1	0	$1 \rightarrow AB$

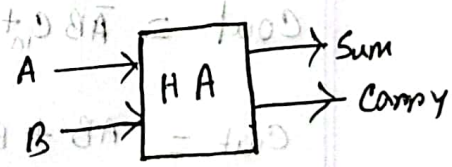
$$Sum = \bar{A}B + A\bar{B} = A \oplus B$$

$$Carry = AB$$

Circuit ⇒



Block Diagram:



FULL ADDER :

A	B	Cin	Sum	Cout
0	0	0	0	0
0	0	1	$1 \to \bar{A}\bar{B}C$	0
0	1	0	$1 \to \bar{A}B\bar{C}$	0
0	1	1	0	$1 \to \bar{A}BC$
1	0	0	$1 \to A\bar{B}\bar{C}$	0
1	0	1	0	$1 \to A\bar{B}C$
1	1	0	0	$1 \to AB\bar{C}$
1	1	1	$1 \to ABC$	$1 \to ABC$

$$Sum = \bar{A}\bar{B}C_{in} + \bar{A}B\bar{C}_{in} + A\bar{B}\bar{C}_{in} + AB\,C_{in}$$

$$= \bar{A}(\bar{B}C_{in} + B\bar{C}_{in}) + A(\bar{B}\bar{C}_{in} + BC_{in})$$

$$= \bar{A}(B \oplus C_{in}) + A(\overline{B \oplus C_{in}})$$

$$= \bar{A}X + A\bar{X} \qquad [B \oplus C_{in} = X]$$

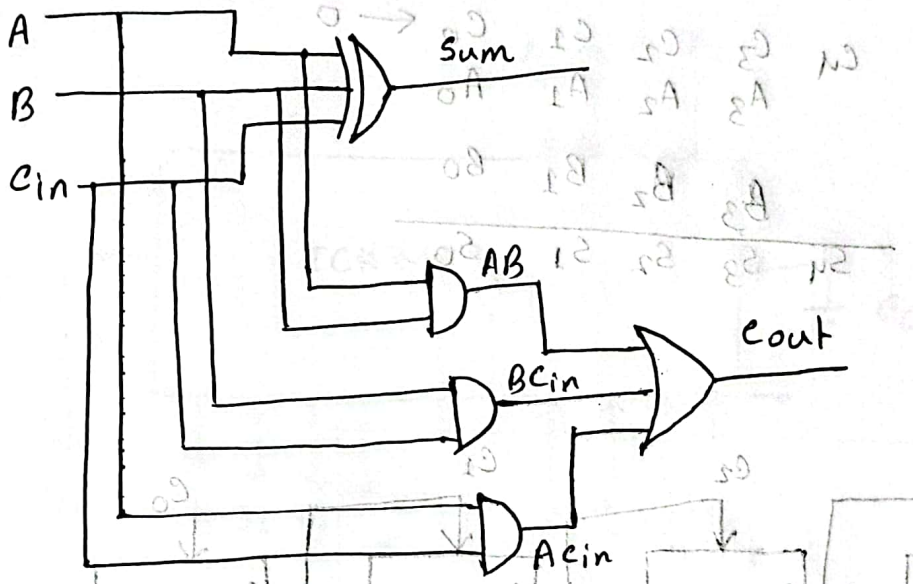
$$= A \oplus B \oplus C_{in}$$

$$Cout = \bar{A}BC_{in} + A\bar{B}C_{in} + AB\bar{C}_{in} + ABC_{in}$$

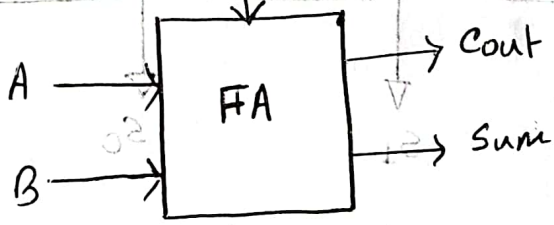
$$Cout = AB + BC_{in} + AC_{in}$$

	$\bar{A}\bar{B}$	$A\bar{B}$	AB	$\bar{A}B$
$\bar{C}$	0	0	1	0
C	0	1	1	1

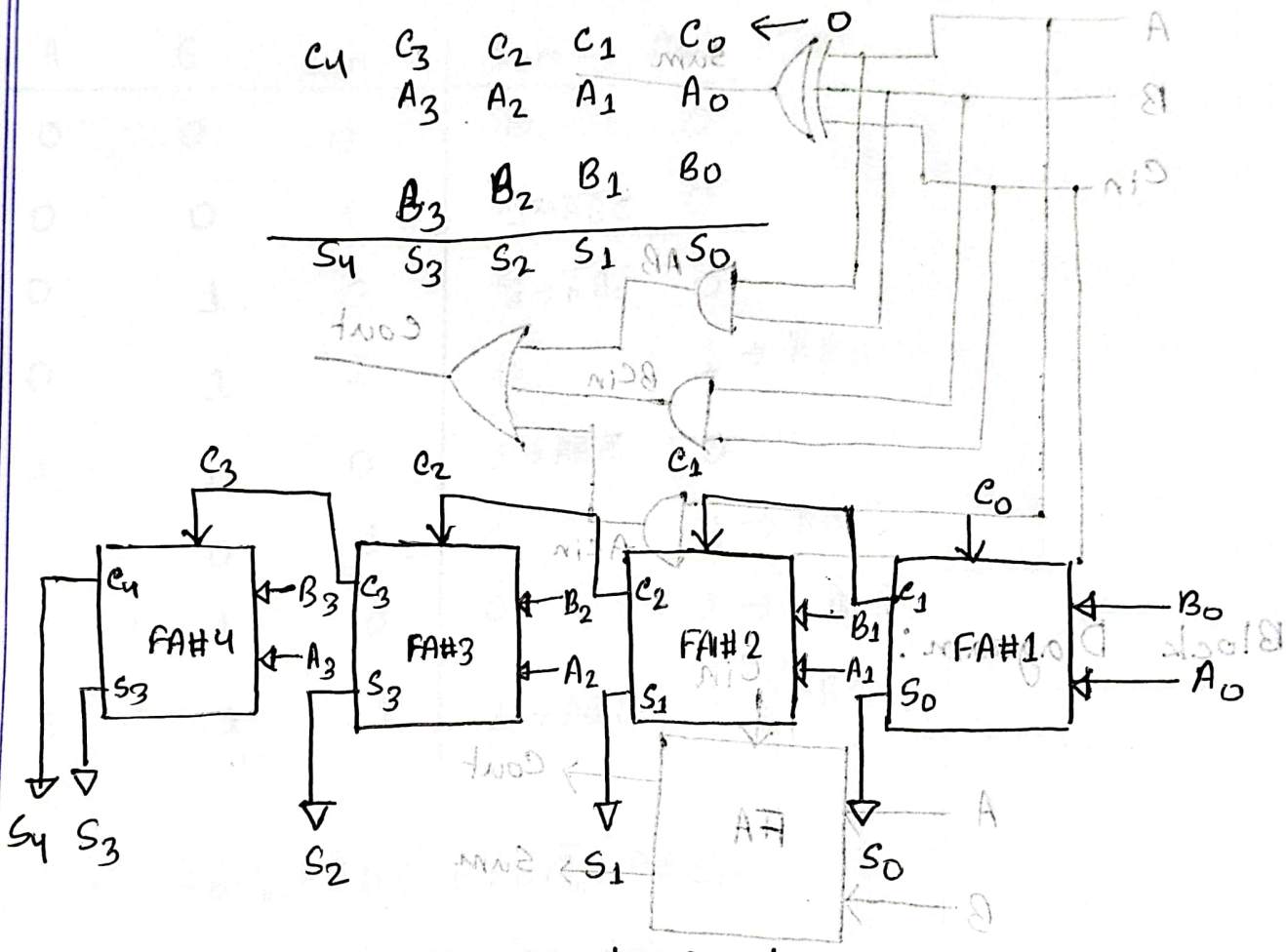
Circuit:



Block Diagram:

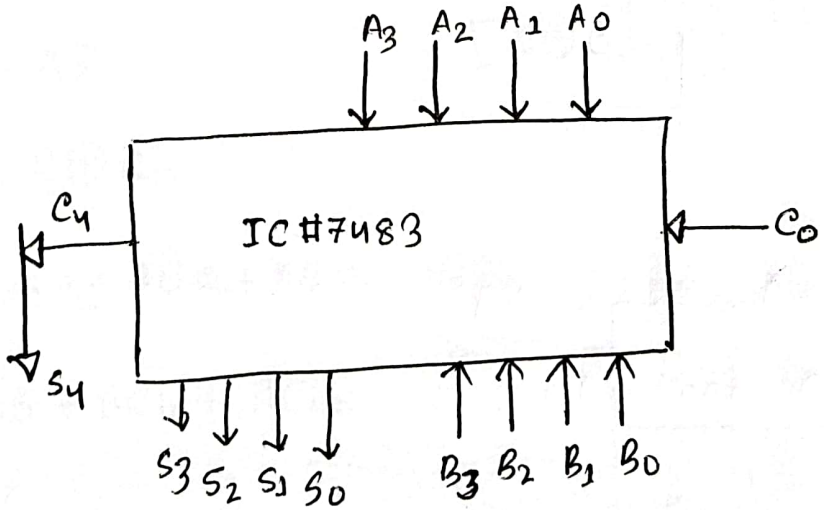


4 bit parallel adder (IC #7483) :

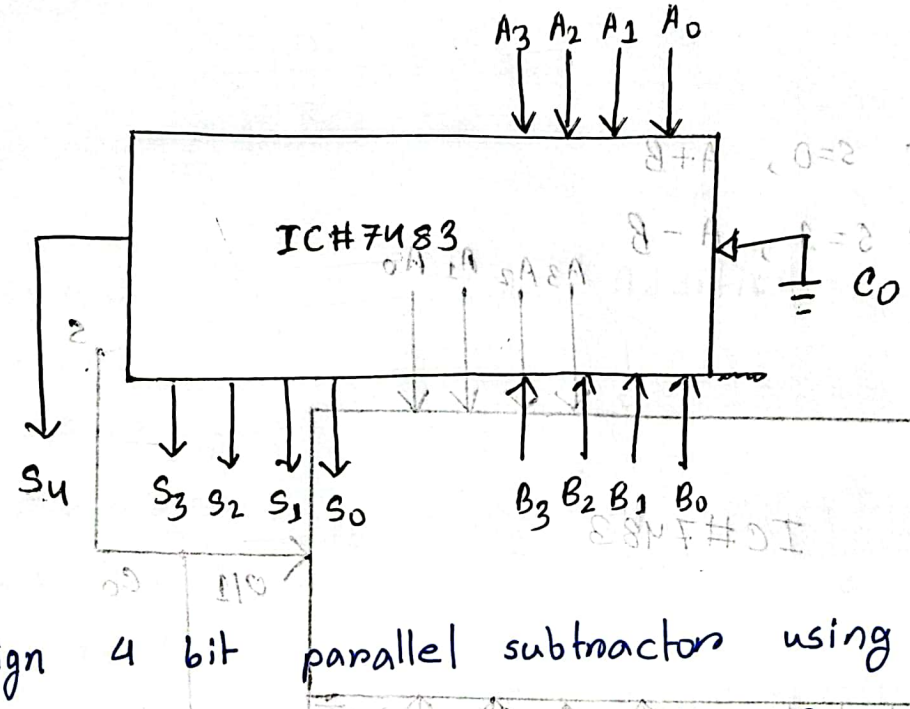


Block diagram of IC #7483 :

9 inputs, 5 outputs –



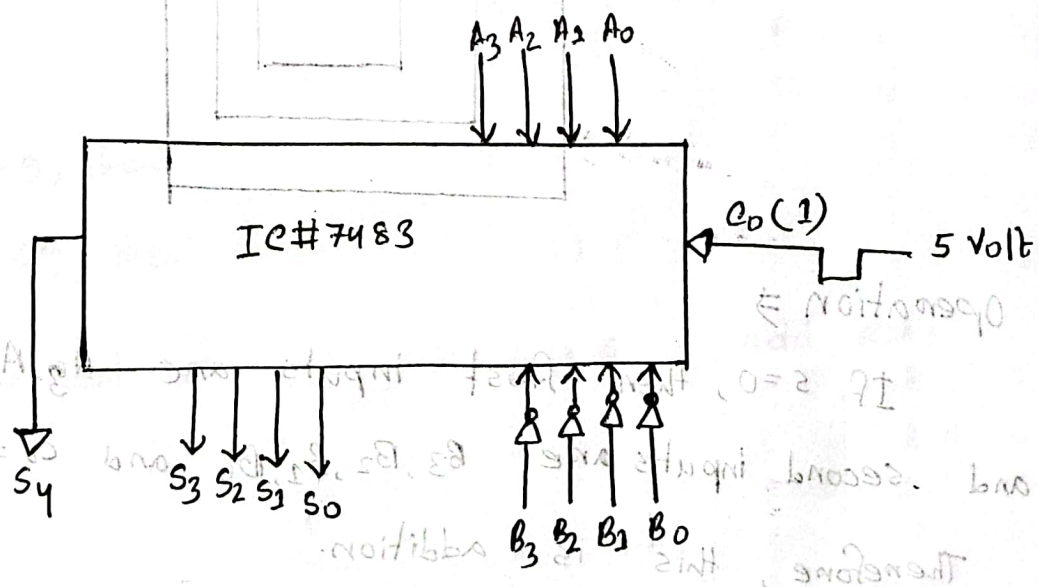
* Design 4 bit parallel adder using IC#7483-



* Design 4 bit parallel subtractor using IC#7483.

You can use other logic gates if necessary.

$A - B = A + (-B)$

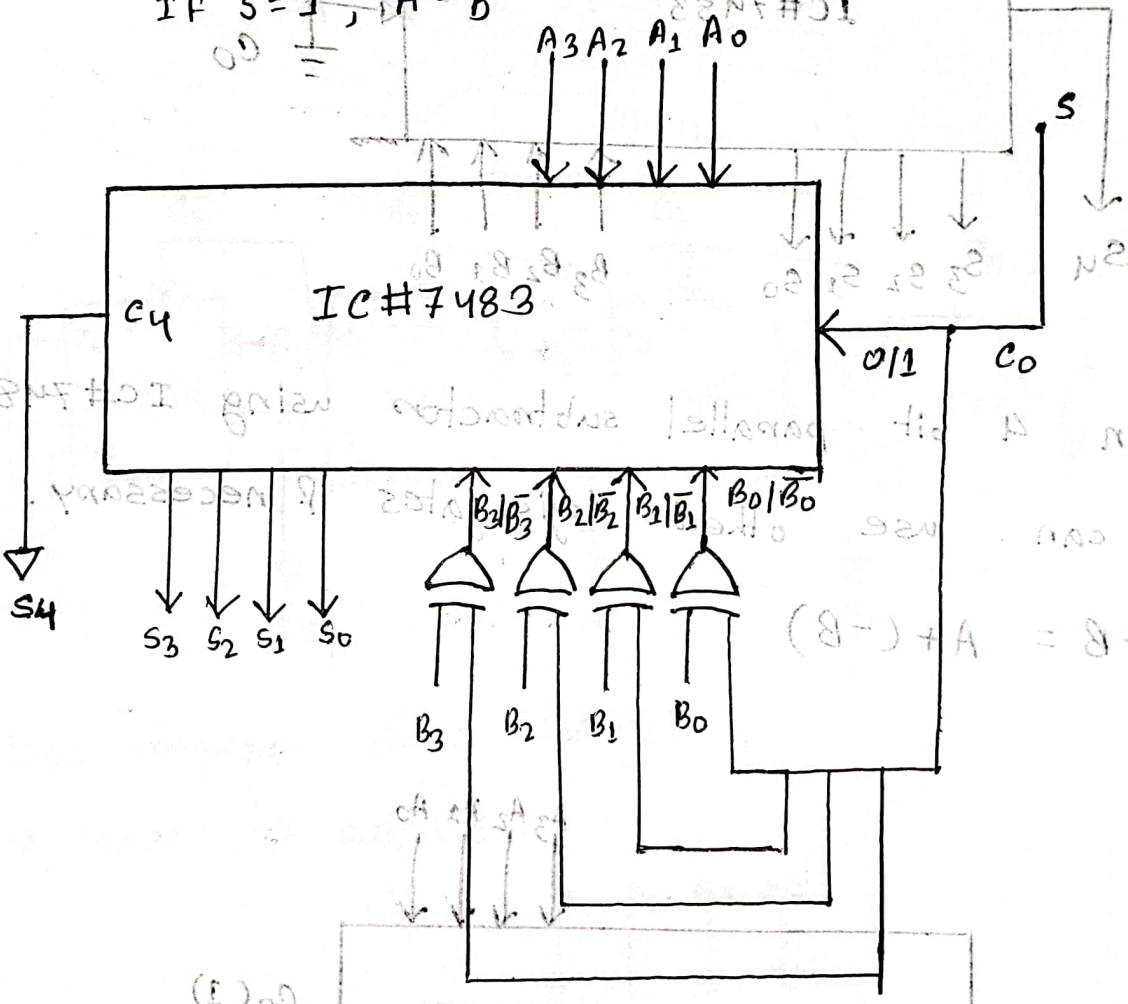


* Design 4 bit parallel adder/subtractor using IC #7483. You can use other logic gates if necessary.

Switch ⇒

If $S=0$, $A+B$

If $S=1$, $A-B$



Operation ⇒

If $S=0$, then first inputs are A_3, A_2, A_1, A_0 and second inputs are B_3, B_2, B_1, B_0 and $C_0 = 0$.

Therefore, this is addition.

If $S=1$, first inputs are A_3, A_2, A_1, A_0 and second inputs are $\overline{B_3}, \overline{B_2}, \overline{B_1}, \overline{B_0}$ and $C_0 = 1$. Therefore, this is subtraction.

BCD → Binary Coded Decimal -

0 → 0000
1 → 0001
2 → 0010
3 → 0011
4 → 0100
5 → 0101
6 → 0110
7 → 0111
8 → 1000
9 → 1001

BCD Addition —

$$
\begin{array}{rl}
32 \Rightarrow & 00110010 \\
26 \Rightarrow & 00100110 \\
\hline
58 \Rightarrow & \boxed{0101}\boxed{1000} \\
 & \quad 5 \qquad 8
\end{array}
$$

$$
\begin{array}{rl}
48 \Rightarrow & 01001000 \\
69 \Rightarrow & 01101001 \\
\hline
117 & 10110001 \\
 & 01100110 \\
\hline
117 \rightarrow & \boxed{0001}\boxed{0001}\boxed{0111} \\
 & \quad 1 \qquad 1 \qquad 7
\end{array}
$$

If sum > 9, then add 6 (0110)

If sum < 9, then add 0 (0000)

এখানে 1st part এ carry আসলে 6 add করি।

* Design BCD Adder using IC#7483. You can use other logic gates if necessary.

If sum > 9, then add 6.

If sum ≤ 9, then add 0.

A ⇒	A_3	A_2	A_1	A_0	≤ 9
B ⇒	B_3	B_2	B_1	B_0	≤ 9
	S_4	S_3	S_2	S_1	S_0 ≤ 18

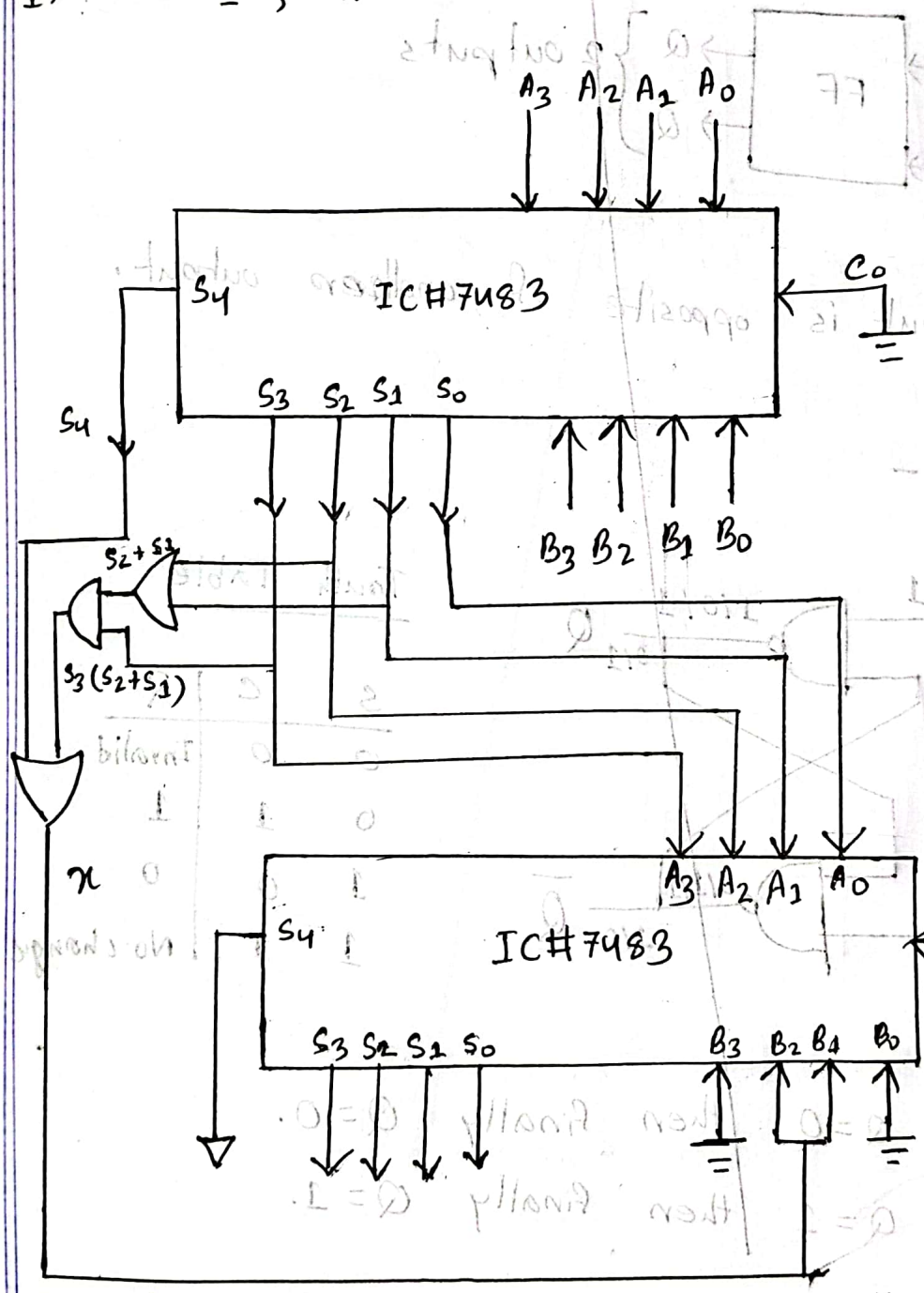
S_4	S_3	S_2	S_1	S_0	
0	0	0	0	0	
0	0	0	0	1	
0	0	0	1	0	
0	0	0	1	1	
0	0	1	0	0	
0	0	1	0	1	$x = 0$
0	0	1	1	0	
0	0	1	1	1	
0	1	0	0	0	
0	1	0	0	1	
0	1	0	1	0	
0	1	0	1	1	
0	1	1	0	0	$x = 1$
0	1	1	0	1	
0	1	1	1	0	
0	1	1	1	1	
1	0	0	0	0	
1	0	0	0	1	
1	0	0	1	0	

Here, $X = S_4 + S_3 (S_2 + S_1)$.

$X = 1$ if $S_4 = 1$ OR ($S_3 = 1$ AND (either $S_2 = 1$ OR $S_1 = 1$))

If sum > 9, $X = 1$

If sum ≤, $X = 0$



[2টি IC লাগবে sum > 9 হলে 6 আর sum ≤ 9 হলে 0 add করার জন্য]

[B_0 ও B_3 Ground করা bcz 0110 আর 0000 হবার ২-1st and 4th bit 0]

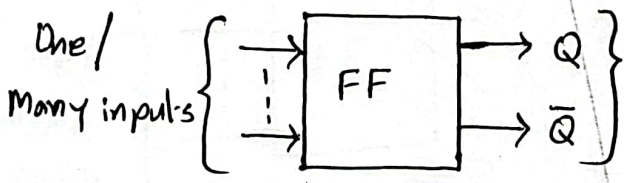
Operation ⇒ If sum > 9, then $x = 1$, then add 6.

If sum < 9, then $x = 0$, then add 0.

Chapter - 5

Flip Flop and Related devices

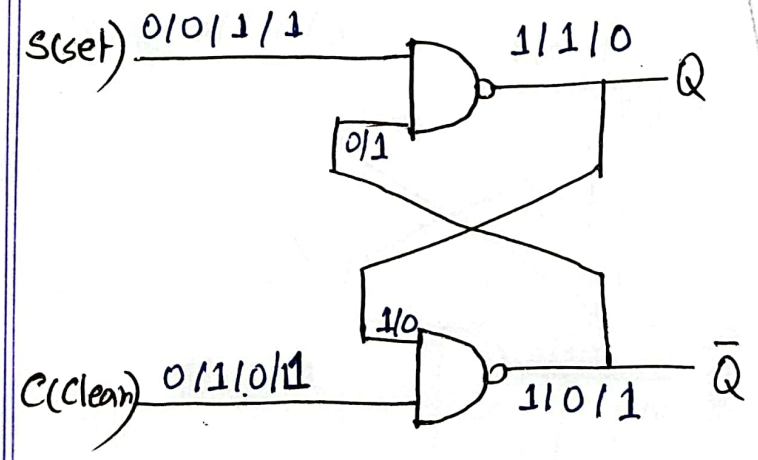
Flip Flop –



One / many inputs but only 2 outputs.

One output is opposite of another output.

NAND Latch

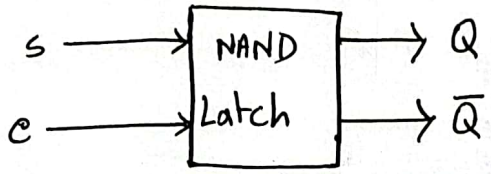


S	C	Q
0	0	Invalid
0	1	1
1	0	0
1	1	No change

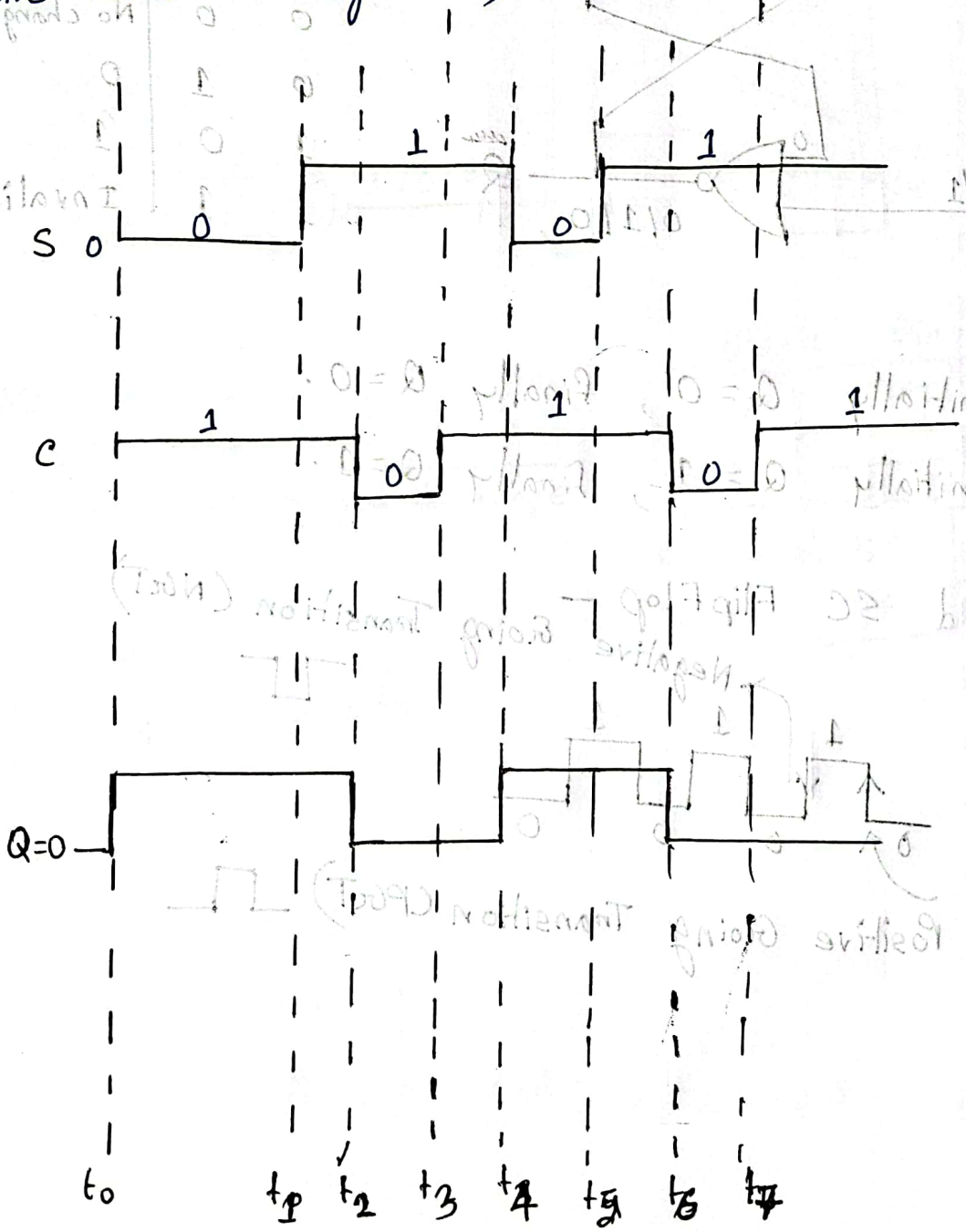
If initially $Q=0$, then finally $Q=0$.

If initially $Q=1$, then finally $Q=1$.

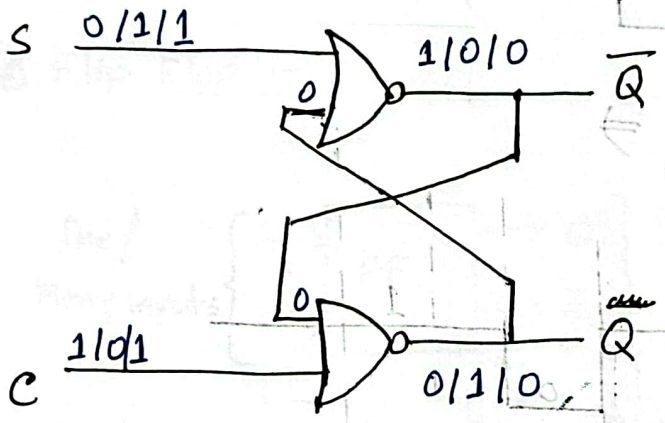
Block Diagram ⇒



Wave form diagram ⇒



NOR Latch

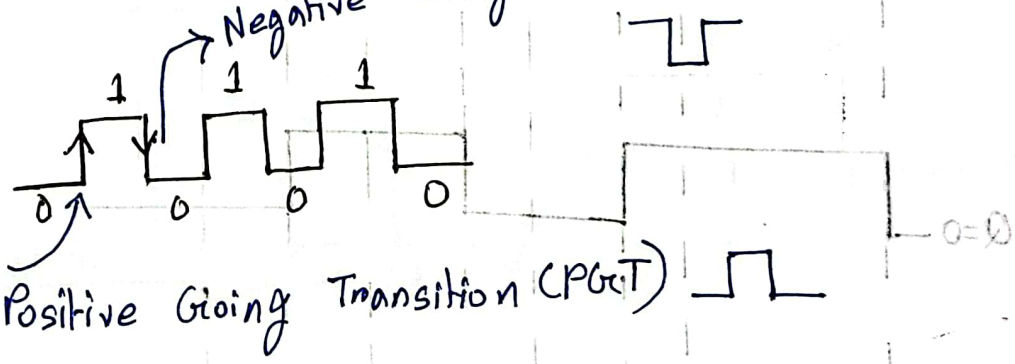


S	C	Q
0	0	No change
0	1	0
1	0	1
1	1	Invalid

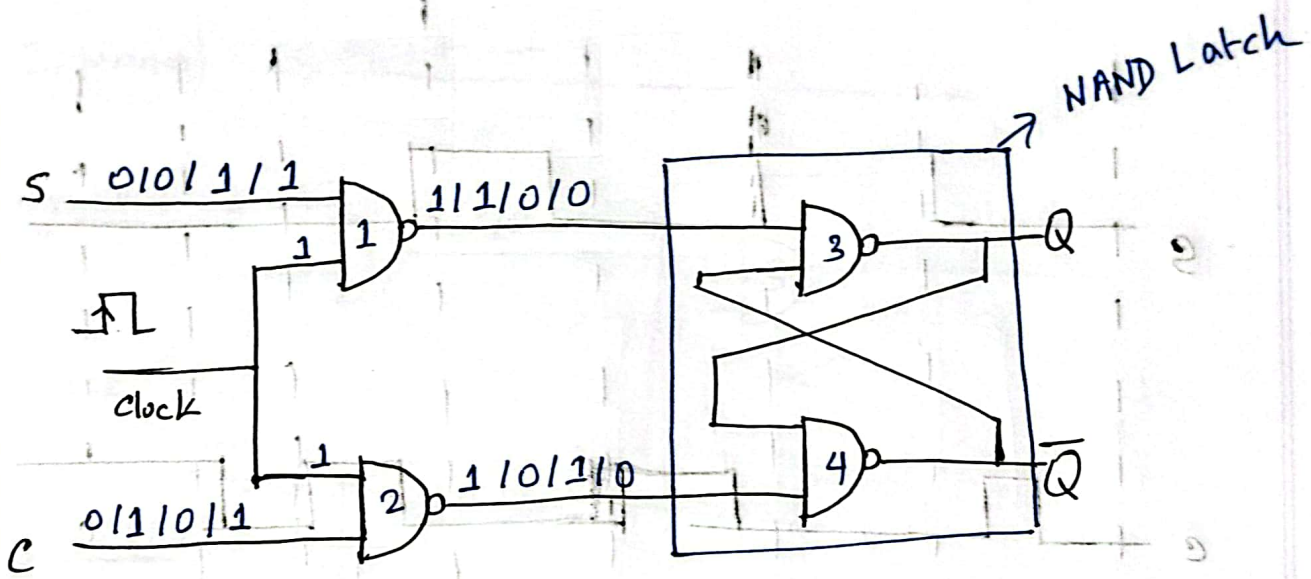
If initially $Q = 0$, finally $Q = 0$.

If initially $Q = 1$, finally $Q = 1$.

Clocked SC FlipFlop —



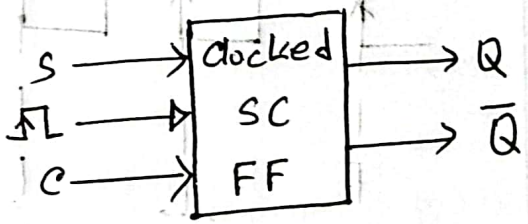
Clocked SC FlipFlop -



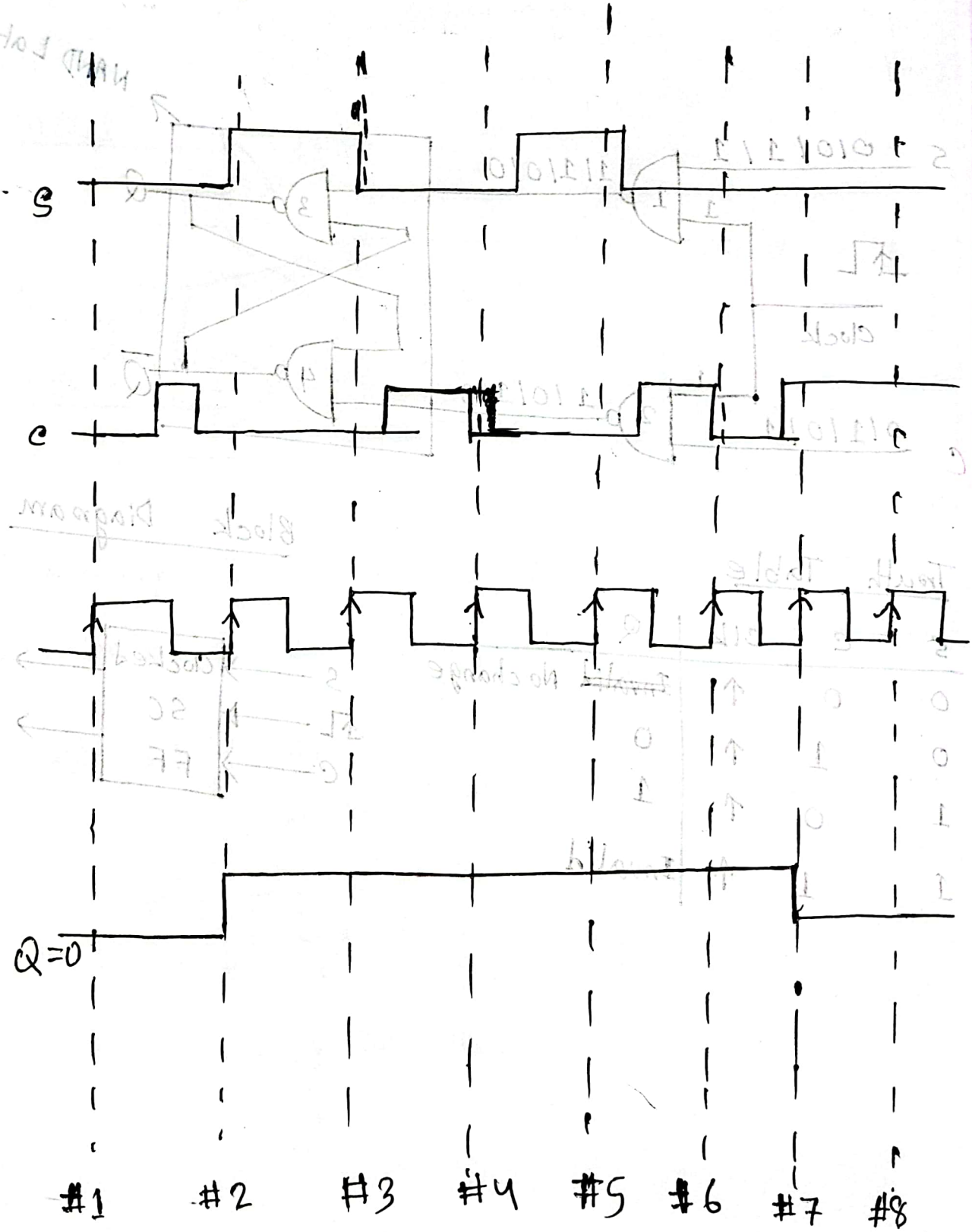
Truth Table

S	C	clk	Q
0	0	↑	~~Invalid~~ No change
0	1	↑	0
1	0	↑	1
1	1	↑	Invalid

Block Diagram

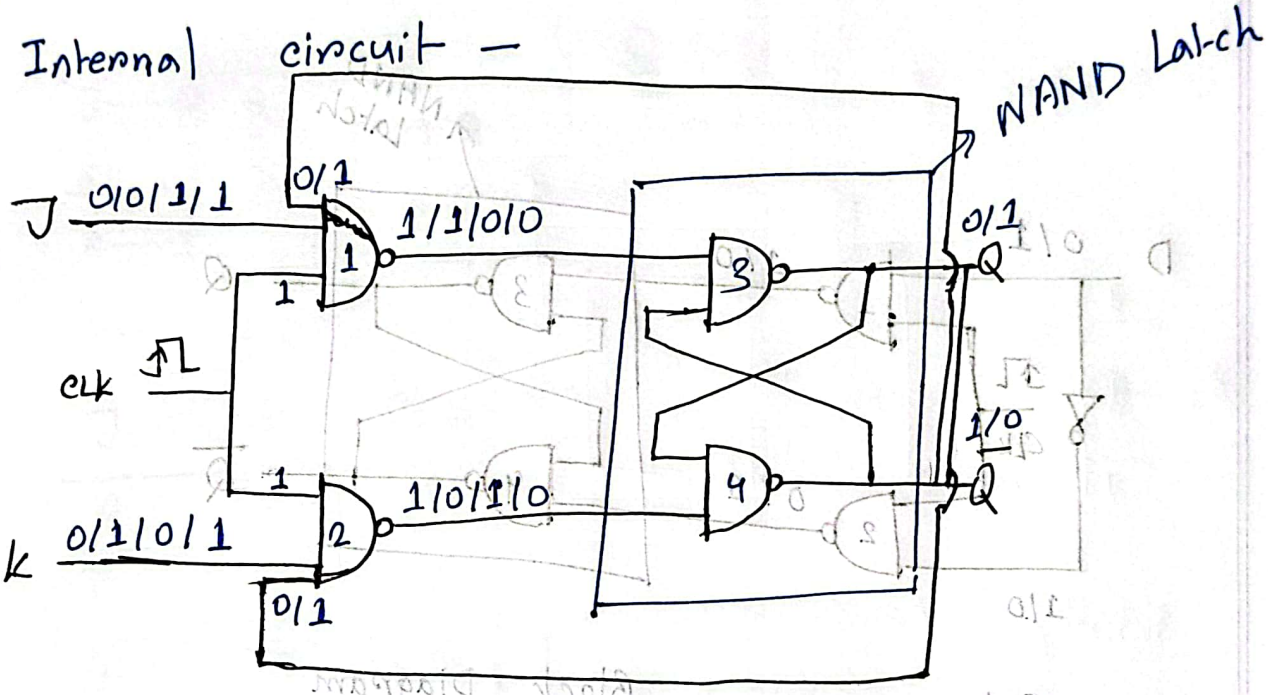


Waveform diagram —



Clocked JK Flip Flop :

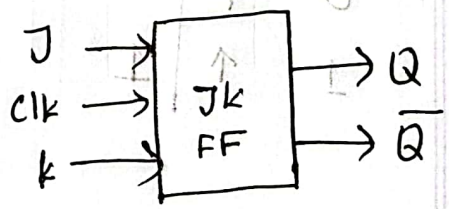
Internal circuit –



Truth Table

J	k	clk	Q
0	0	↑	No change
0	1	↑	0
1	0	↑	1
1	1	↑	Toggle

Block Diagram



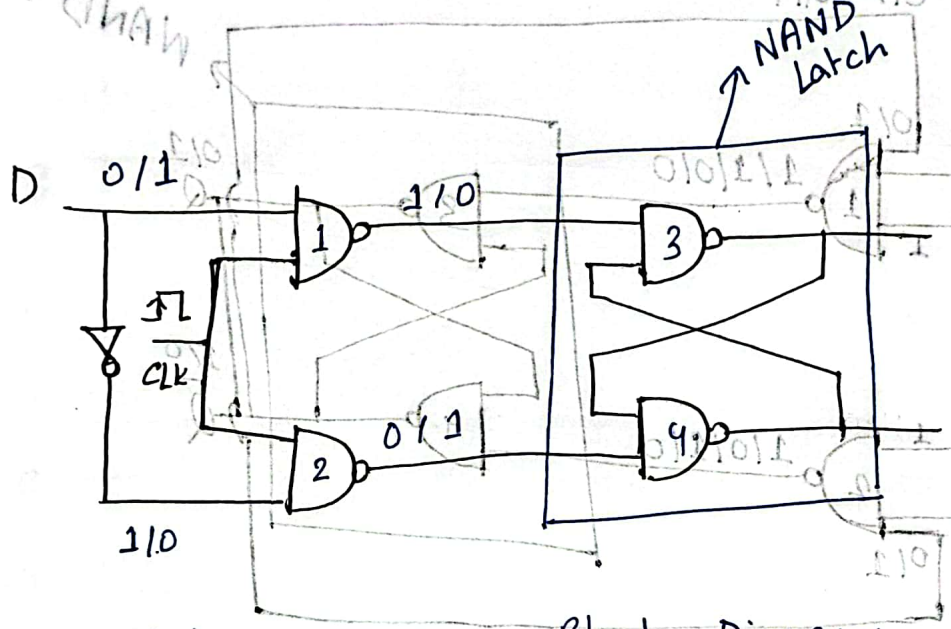
(0,1) ⇒ Initially Q = 0, finally Q = 0
" Q = 1, " Q = 0

(1,0) ⇒ Initially Q = 0, finally Q = 1
" Q = 1, " Q = 1

(1,1) ⇒ Initially Q = 0, finally Q = 1
" Q = 1, " Q = 0

CamScanner

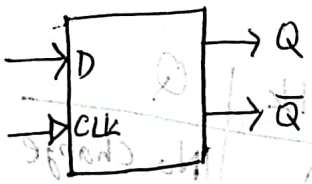
Clocked D Flip — :



Block Diagram

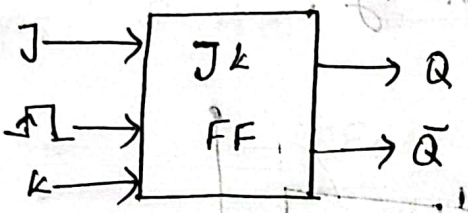
Truth Table

D	CLK	Q
0	↑	0
1	↑	1

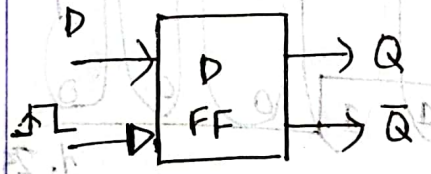


Important

Convert JK To D FF :

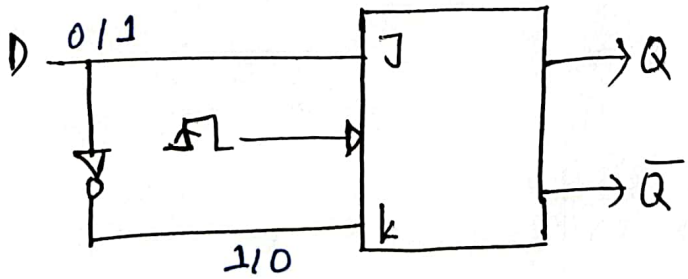


J	K	CLK	Q
0	0	↑	N.C.
0	1	↑	0
1	0	↑	1
1	1	↑	Toggle



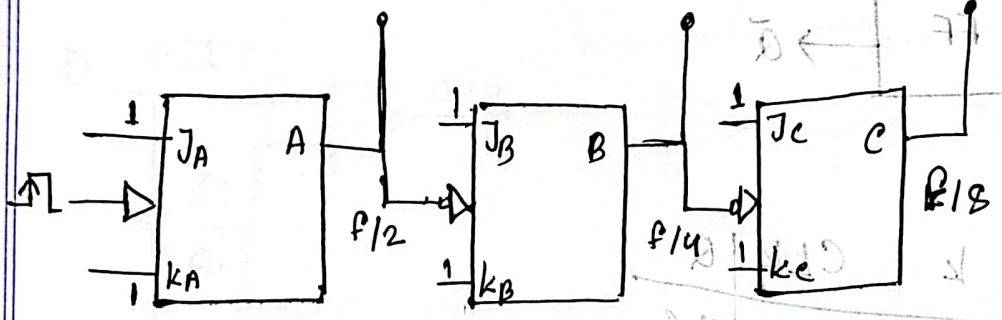
D	CLK	Q
0	↑	0
1	↑	1

JK To D ⇒

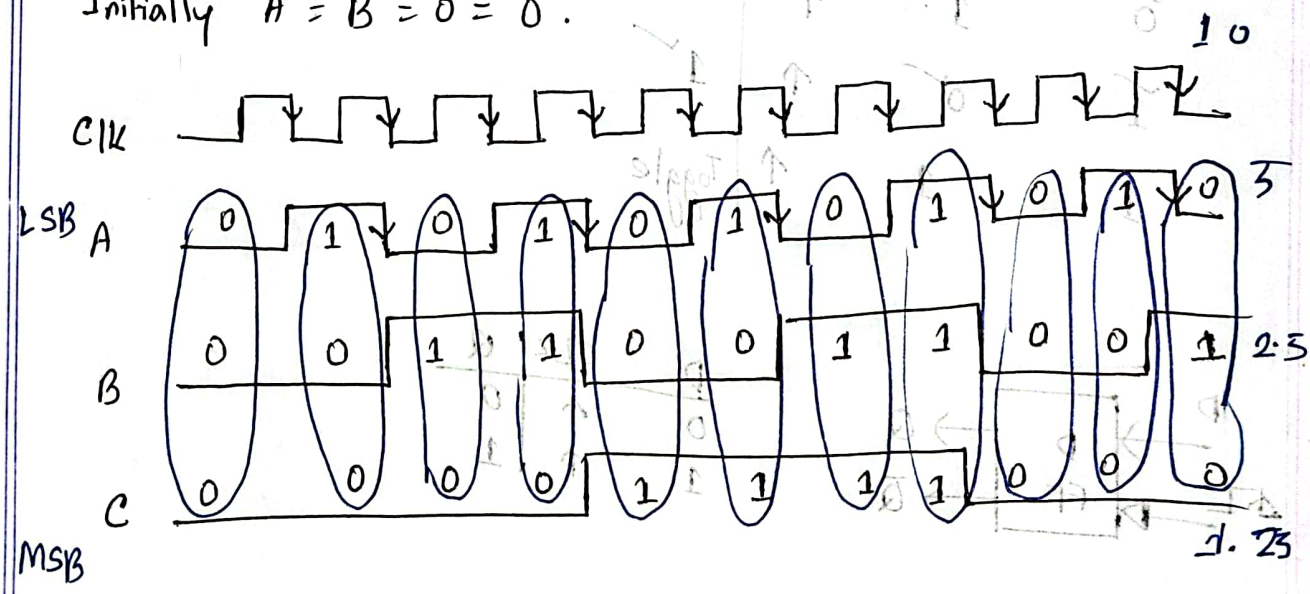


Application of FF::

Frequency division & Counting :



Initially A = B = 0 = 0.



It counts from 0 to 7.

~~Mod~~

MOD Number –

MOD number is the no of diffenent steps of the counter.

No of FFs	MOD Number
2	4
3	8
4	16
5	32
6	64

no of flipflops.

Mod number = 2

$$\text{Output Frequency} = \frac{\text{Input frequency}}{\text{Mod number}}$$

Range –

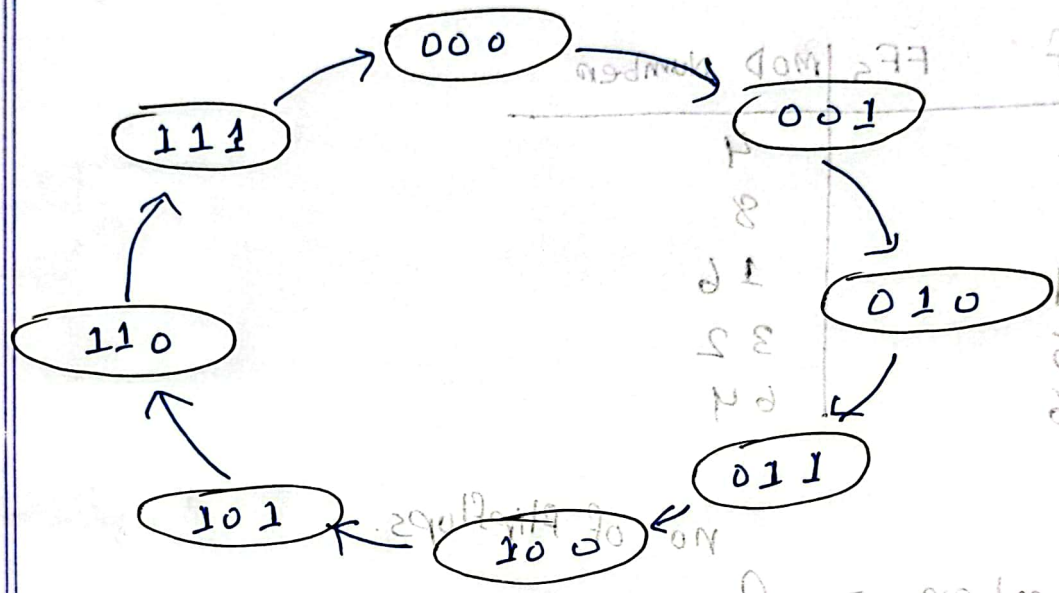
range = 0 to (mod number − 1)

= 0 to $2^N - 1$ where N is no of flipflop

mod → 8

range → 0 – 7

State transition diagram —



⊞ What is the state after 11th pulse

$$8\,\big|\,11\,\big|\,1$$
$$3 \longrightarrow 011$$

Ans. 011.

⊞ After 79th pulse —

$$8\,\big|\,79\,\big|\,9$$
$$7 \quad (111)$$

$\Rightarrow$ 111.

* If initial state is 101. Find the state after 79 pulse –

$\Rightarrow 79 + 5 = 84$

$$\begin{array}{r|l|l} 8 & 84 & 10 \\ & 8 & \\ \hline & 4 & \\ & 0 & \\ \hline & 4\ (100) & \end{array}$$

$\Rightarrow 100.$

Up Counter ⇒ The counter that counts from lowest to highest → mod 8 up counter [0 – 7]

Down Counter ⇒ counts from highest to lowest → mod 8 down counter [7 – 0]

Q – 1: Consider a circuit that contains six FFs $Q_5 Q_4 Q_3 Q_2 Q_1 Q_0$.

(a) Determine the mod number.

(b) " " output frequency in kHz if input frequency is 1MHz.

(c) What is the range of counter?

(d) Assume starting state is 001001. What is the state after ~~0010~~ 129 pulse?

⇒

(a)

Mod number $= 2^6 = 64$

(b)

$$\text{Output frequency} = \frac{\text{Input frequency}}{\text{Mod number}}$$

$$= \frac{1 \times 10^6 \times 10^{-3}}{64}$$

$$= 15.625 \text{ KHz}$$

(c)

Range = 0 to 63

(d)

$129 + 9 = 138$

$$\begin{array}{r|l|l} 64 & 138 & 2 \\ & 128 & \\ \hline & 10 & (001010) \end{array}$$

Ans. 001010.