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20/July/2014

{Electronics}

Digital Electronics

* Boolean Algebra :-

It was developed by George Boolee by the help of switches [Relay circuits].

Boolean Algebra developed three theorems are called Basic theorem or Boolean Theorem.

1. NOT Theorem :-

$$1 \longrightarrow 0$$
$$0 \longrightarrow 1$$
$$A \longrightarrow \bar{A}$$
$$\bar{A} \longrightarrow \bar{\bar{A}} = A$$

2. AND Theorem (·) :-

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

3. OR Theorem (+) :-

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

* Distributive Theorem :-

$$U = (A+B).(A+C)$$
$$= A.A + A.C + A.B + B.C$$
$$= A + AC + AB + BC$$
$$= A(1+C+B) + BC \quad = A.1 + BC$$
$$\boxed{U = A + BC} \longrightarrow (*)$$

Short Trick :-

When two brackets are available and first term of both brackets are same the we apply distributive theorem like this-

$$U = (A+B)(A+C)$$

$$U = A.A + B.C$$
$$\boxed{U = A + BC} \longrightarrow (**)$$

Ques For the given expression find the minimise equation.

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

Sol^n

$$y = (A.A + B.\bar{B})(\bar{A}.\bar{A} + B.\bar{B})$$
$$y = (A+0)(\bar{A}+0)$$
$$= A.\bar{A} \quad = 0 \quad \underline{Ans}$$

Ques For the given expression find the minimise eq^n.

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

Sol^n $y = (A+B+C)(A+B+\bar{C})(A+\bar{B}+C)$

Let $A+B = x$

So,

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

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

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

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

Again let $\bar{B}+C = y$

So

$y = (A+B)(A+y)$

$y = A.A + B.y$

$y = A + B.[\bar{B}+C]$

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

$$\boxed{y = A+BC}$$

Ans

* Short Trick -

$(A+B)(A+C) = A+BC$

$\underset{1}{A} + \underset{2\cdot 3}{BC} = (A+B)(A+C)$

$(1+2.3) = (1+2)(1+3)$

Qus Find the minimise expression of the given eq^n.

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

Sol^n $y = \underset{1}{B} + \underset{2\cdot 3}{\bar{B}C}$

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

$y = B+C$ Ans

Ques Find the minimise equation of the given expression.

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

Sol^n

$$y = \bar{A}BC + A\bar{B}C + AB\bar{C} + ABC$$
$$= \bar{A}BC + A\bar{B}C + AB(\bar{C}+C)$$
$$= \bar{A}BC + A\bar{B}C + AB \qquad \{\because (C+\bar{C}) = 1\}$$
$$= \bar{A}BC + A[B+\bar{B}C]$$
$$= \bar{A}BC + A(B+\bar{B})(B+C)$$
$$= \bar{A}BC + A(B+C)$$
$$= \bar{A}BC + AB + AC$$
$$= B(\bar{A}C + A) + AC$$
$$= B(A + \bar{A}C) + AC$$
$$= B(\bar{A}+A)(A+C) + AC$$
$$= B(A+C) + AC$$
$$y = AB + BC + AC \qquad \text{Ans}$$

Ques Find the minimise expression of the given equation. $y = \bar{A}\bar{B}C + \bar{A}B\bar{C} + \bar{A}BC + ABC$

Sol^n:-

$$y = \bar{A}\bar{B}C + \bar{A}B\bar{C} + \bar{A}BC + ABC$$
$$= \bar{A}\bar{B}C + \bar{A}B\bar{C} + BC(\bar{A}+A)$$
$$= \bar{A}\bar{B}C + \bar{A}B\bar{C} + BC$$
$$= \bar{A}\bar{B}C + B[C + \bar{A}\bar{C}]$$
$$= \bar{A}\bar{B}C + B(C+\bar{A})(C+\bar{C})$$
$$= \bar{A}\bar{B}C + B(C+\bar{A})$$
$$= \bar{A}\bar{B}C + BC + \bar{A}B$$
$$= C(\bar{A}\bar{B} + B) + \bar{A}B$$
$$= C(B+\bar{A}) + \bar{A}B$$
$$\boxed{Y = \bar{A}C + BC + \bar{A}B} \qquad \text{Ans}$$

* Sum of Product (SOP) And Product of Sum (POS) :-

1. Sum of Product (SOP) :-

It is used variabl output of the digital circuit is 1. (high).

Example :- i/P → o/P

5 → 1

101 → 1

$(A\bar{B}C)$

9 → 1

1001 → 1

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

2. Product of Sum (POS) :-

It is used variable output of the digital circuit is zero.

e.g. :-

i/P → o/P

5 → 0

101 → 0

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

i/P → o/P

9 → 0

1001 → 0

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

Que. From the given table find the output minimise expression by using SOP.

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

Sol^n ∵ SOP is written for the high output.

So

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

$$Y_{SOP} = (\bar{A}.\bar{B}) + (A.\bar{B}) + (A.B)$$

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

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

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

$$\boxed{Y_{SOP} = A+\bar{B}} \text{ —— (I)}$$

for POS :-

Since POS written for the low output

So,

A	B	Y	
0	0	1	
0	1	0	$\rightarrow A+\bar{B}$
1	0	1	
1	1	1	

So,

$$\boxed{Y_{POS} = A+\bar{B}} \text{ —— (II)}$$

from equation (I) and (II)

$$\boxed{SOP_{exp.} = POS_{exp.}}$$

Ques From the given truth table find the minimise expression of output.

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

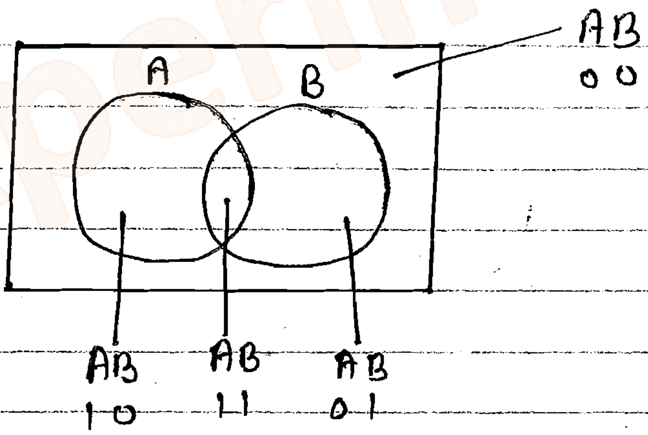
Sol^n

$$Y_{sop} = \bar{A}BC + AB\bar{C}$$

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

Ans

* Logical Venn Diagram :-



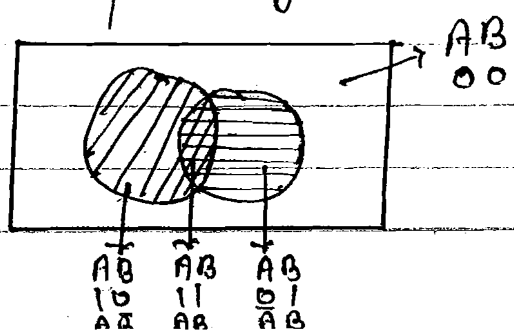
Ques From the given diagram find the minimise expression for the shaded region by using SOP.

Sol^n

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

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

$$= \underset{1}{A} + \underset{2 \cdot 3}{\bar{A}B}$$

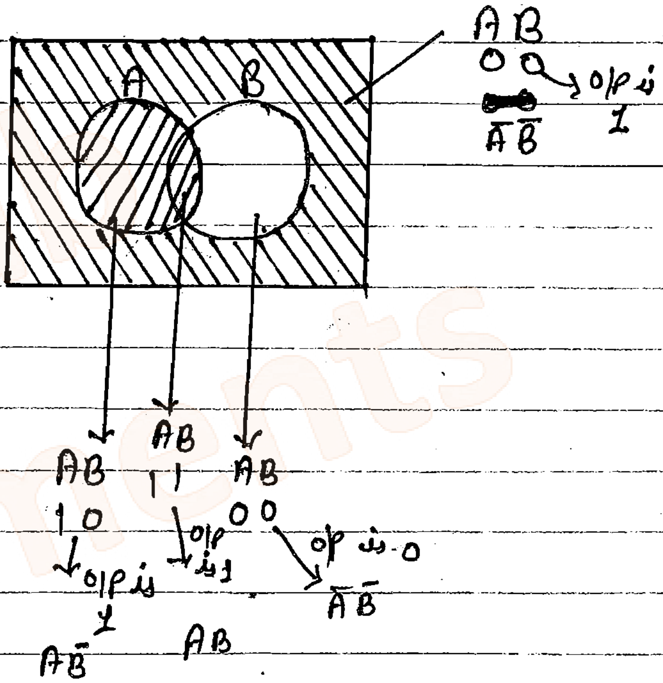


$$= (A+\bar{A})(A+B)$$

$$\boxed{Y_{SOP} = (A+B)}_{Ans} \quad \{\because (A+\bar{A}) = 1\}$$

Ques From the given diagram find the output minimise expression for the shaded region by using SOP.

Sol^n



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

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

$$= \underset{1}{A} \underset{+}{+} \underset{2\cdot 3}{\bar{A}\bar{B}}$$

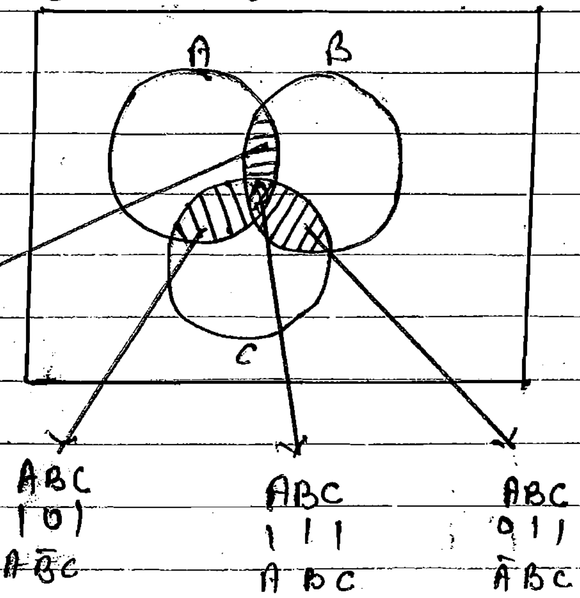
$$= (A+\bar{A})(A+\bar{B})$$

$$\boxed{Y_{SOP} = A+\bar{B}}_{Ans}$$

Ques For the given diagram find the minimise expression.

Sol^n:-

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



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

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

$$= AB\bar{C} + C(\underbrace{B + A\bar{B}}_{1+2.3})$$

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

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

$$= B(\underbrace{C + A\bar{C}}_{1+2.3}) + AC$$

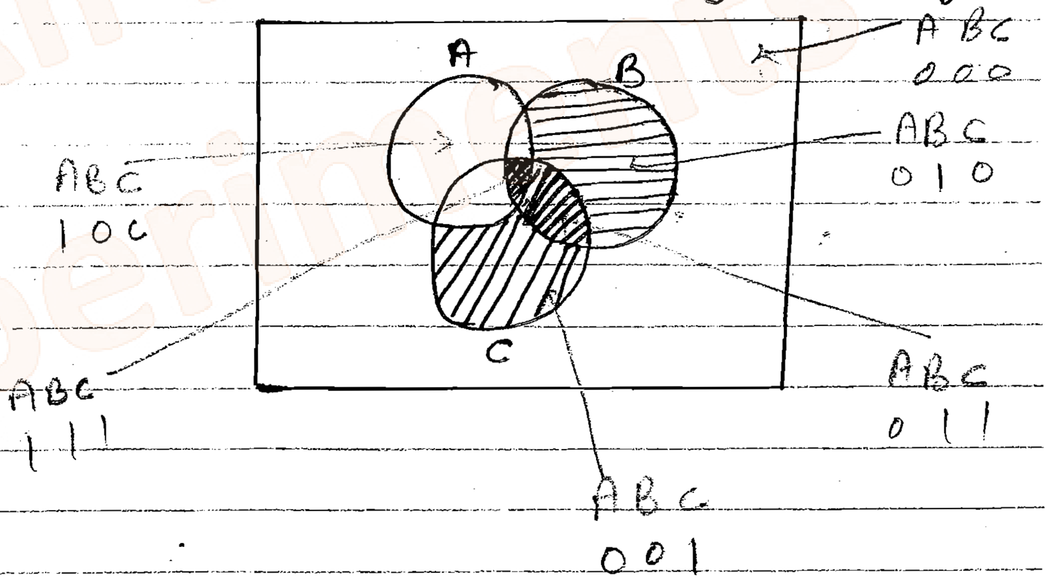
$$=$$

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

$$\boxed{Y_{sop} = BC + AB + AC}$$

Ans

Qus Find the minimise expression for the given diagram



Note :-

1. Each term taken from the truth table for implimentation of SOP expression is called Minterm.
   Minterm must include every variable.
   Minterm has dot (•) sign in between.
2. Each term taken from the truth table for the implimentation of POS expression it is called as Maxterm.
   Maxterm will have +ve sign in between and include every variable.

* Mathematical Representation of SOP and POS :-

For n variable the value assigned to the maximum number of 1's is given by $(2^n - 1)$.

SOP :-

Minterm = $\Sigma m(0, 2, 3)$

	A	B	Y
0 ←	0	0	1
1 ←	0	1	0 →
2 ←	1	0	1
3 ←	1	1	1

$(2^n - 1)$ where n is the no. of variable {here 2}

POS :-

Maxterm = $\Pi M(1)$

• SOP is always equal to POS.

Ques For the given function $f(A,B,C) = \Sigma m(0,2,3,6)$ find the ~~sof~~ equivalent ~~and~~ POS.

Sol^n

Here number of variable = 3

So

$$2^3 - 1 = 8 - 1 = 7$$

Equivalent POS is :-

$$= \Pi M(1,4,5,7)$$

Ans

Ques Find the equivalent POS of $f(A,B,C,D) = \Sigma m(0,2,3,6,7,11,13)$.

Sol^n Here number of variable = 4

So $2^4 - 1 = 15$

Equivalent POS :-

$$= \Pi M(1,4,5,8,9,10,12,14,15).$$

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Note :-

Representation of SOP or POS without reducing the number of variable is called Canonical form of representation.

Ques For the given expression $f(A,B,C) = A + \bar{B}C$ represents minterm of canonical form of SOP. And Identify no. of minterms presents.

Sol^n :-

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

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

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

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

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

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

Ans

There is 5 minterm.

IInd Method :-

A	B	C	O/P
0	0	0	
0	0	1	1
0	1	0	
0	1	1	
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

$$\boxed{f_{sop} = ABC + AB\bar{C} + A\bar{B}C + A\bar{B}\bar{C} + \bar{A}\bar{B}C}$$

Ques For the given function find the number of minterms

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

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

Soln:-

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

A	B	C	D
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0
1	0	0	1
1	0	1	0
1	0	1	1
1	1	0	0
1	1	0	1
1	1	1	0
1	1	1	1

So no. of minterm = 10

(i) $f(A,B,C,D) = A + \bar{C}D$ = 10 min term

(ii) $f(A,B,C,D) = B + C\bar{D}$ = 10 minterm

* Note :-

- For a single variable we have 4 types of truth tables so we have 4 types of Boolean expression.

e.g.

A	Y_1	Y_2	Y_3	Y_4
0	0	0	1	1
1	0	1	0	1

$2^{2^1} = 4.$

- So for n no. of variables no. of possible truth table or Boolean expression or switching expression is given by - $= 2^{2^n}$

Ans For 4-variable no. of possible boolean expression is given by -

Sol^n

$$2^{2^4} = 2^{16} = 2^{10} \times 2^6$$
$$= 1024 \times 64$$
$$= 65536 \text{ Ans}$$

* Positive Logic and Negative Logic :-

- If higher values are assigned to higher voltages and lower values are assigned to lower voltages such a logic is called +ve logic.

e.g:-

logic 0 ———— 0 V
logic 1 ———— +5 V

- If the values are reverse the resultant logic will be negative logic.

e.g. -

logic 0 ———— +5 V
logic 1 ———— 0 V

The process of conversion of +ve logic to negative logic or vice-versa is called as "duality."

e.g:- AND → +ve logic

A	B	Y (A·B)
0	0	0
0	1	0
1	0	0
1	1	1

OR → -ve logic

A	B	Y (A+B)
1	1	1
1	0	1
0	1	1
0	0	0

small → 10 ← big = 1

01 = 1 (big, small)

* Important Point for duality :-

(i) $0 \rightleftarrows 1$

(ii) $\cdot \rightleftarrows +$

(iii) Variable as it is.

Examples:-

$$A \cdot B \xrightarrow{\text{duality}} A+B$$

$$A+B \longrightarrow A \cdot B$$

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

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

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

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

$$= (\bar{A}\bar{B} + AB) \quad \left\{ \because A\bar{A} = 0, \; B\bar{B} = 0 \right\}$$

Ques Find the dual of $y = AB + CD$

Sol^n

$$\boxed{y_D = (A+B) \cdot (C+D)} \quad \text{Ans}$$

$$y_{DD} = AB + CD = y$$

Ques Find the dual of $y = AB + BC + AC$.

Sol^n

$$y_D = (A+B) \cdot (B+C) \cdot (A+C)$$

$$= (B \cdot B + A \cdot C) \cdot (A+C)$$

$$= (B + AC) \cdot (A+C)$$

$$= A \cdot B + B \cdot C + A \cdot AC + A \cdot CC$$

$$= A \cdot B + B \cdot C + A \cdot C + A \cdot C$$

$$\boxed{y_D = A \cdot B + B \cdot C + A \cdot C} \quad \text{Ans}$$

self dual.

- If single time dual results same expression then it is called self dual expression.

Ques Find the dual of given expression -
$Y = (A+B)(B+C)(A+C)$.

Sol^n

$$Y = (A+B).(B+C).(A+C)$$

$$\boxed{Y_D = AB + BC + AC} \quad \text{———} \quad (1)$$

Since eq^n (1) is self dual so

$Y = (A+B)(B+C)(A+C)$ is also self dual expression.

Ques Check wheather self dual or not?
$Y = \bar{A}\bar{B} + \bar{B}\bar{C} + \bar{A}\bar{C}$

Sol^n

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

Self dual expression.

Q. $Y = (\bar{A}+\bar{B}).(\bar{B}+\bar{C}).(\bar{A}+\bar{C})$ check duality.

Sol^n It's also a self dual.

Current prefers resistance less path.

Note :-

- Duality of single variable :-

$A \xrightarrow{D} A$ self dual

$\bar{A} \xrightarrow{D} \bar{A}$

$2^{2^{1-1}} = 2^{2^{0}} = 2^{1} = 2$ self dual expressions

- For n ~~nuber~~ number of variable number of possible self dual expression is given by

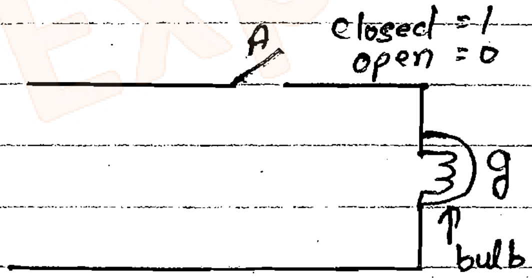
$= 2^{2^{n-1}}$.

{ SWITCHING CIRCUITS }

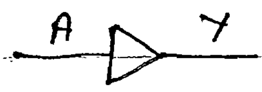
The circuit produces same input same output condition is called Buffer.

Common Collector configuration is also called Buffer.

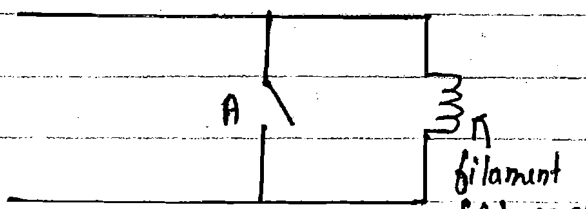
closed = 1
open = 0



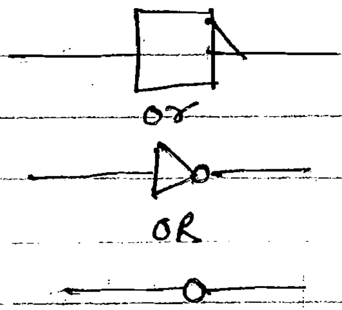
A	Y
0	0
1	1



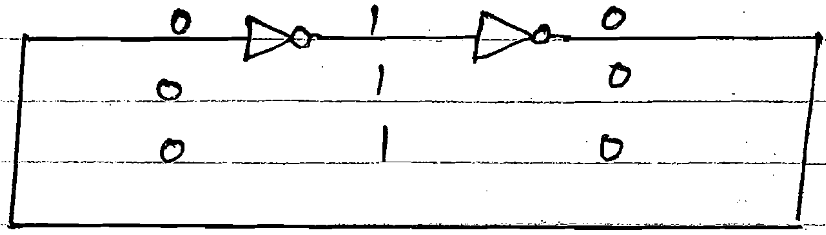
Buffer.



A	Y
0	1
1	0

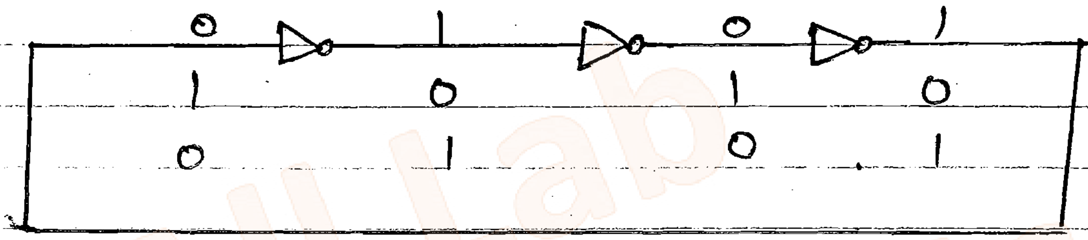


NOT Gate.

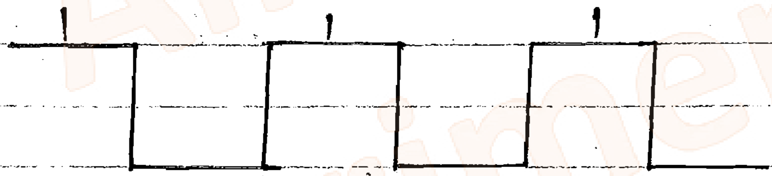


Bistable Multivibrator.

⇒ Even numbers of NOT gate with feedback is called as Bistable Multivibrator.

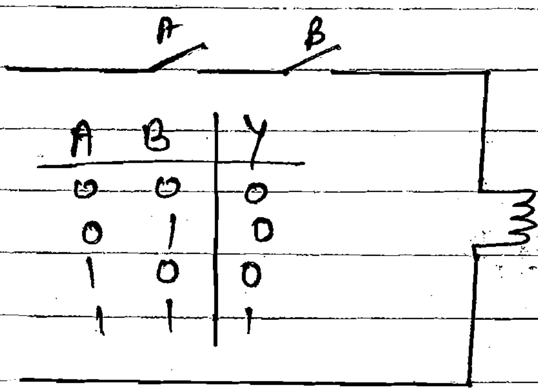


Astable Multivibrator. (Not stable



The output waveform of Astable multivibrator is square wave.

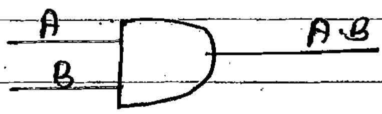
⇒ Odd numbers of NOT gate combination with feedback is called Astable Multivibrator.



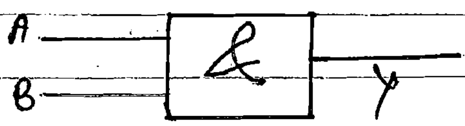
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

AND Gate.

Equivalent Symbols:-

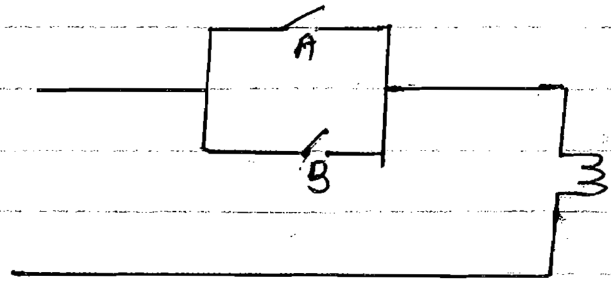


OR



Input Condition :- If any i/p = 0 then o/p = 0.

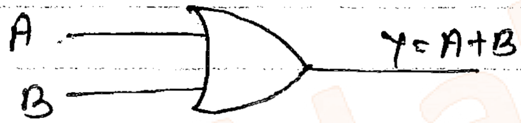
- In AND gate Switches are in series.



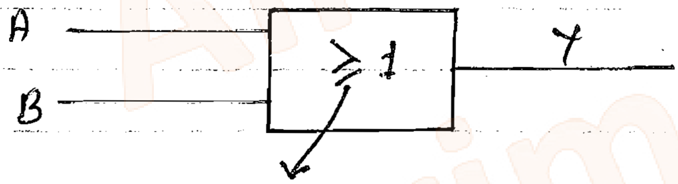
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

OR Gate

Equivalant Circuit Symbols:-



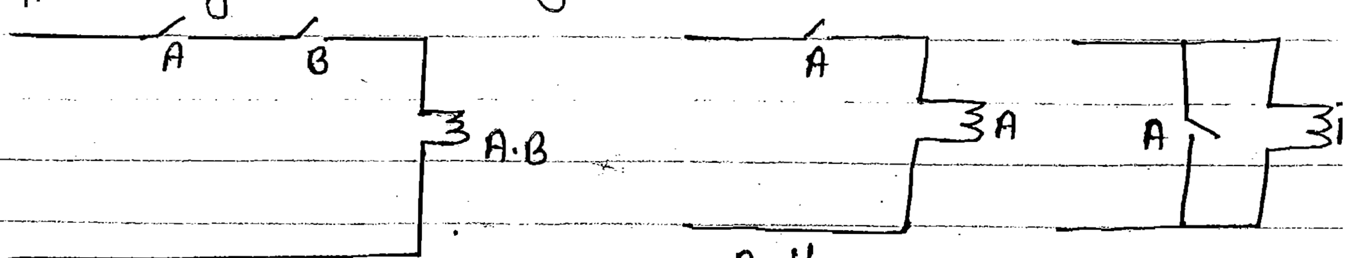
Rectangular form of representation:-



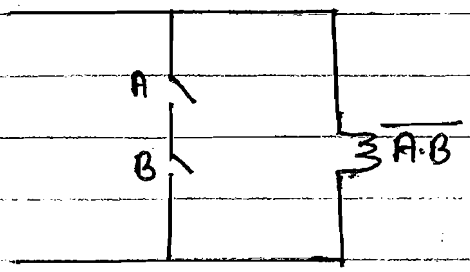
Means one or more than one input is 1 then output is 1.

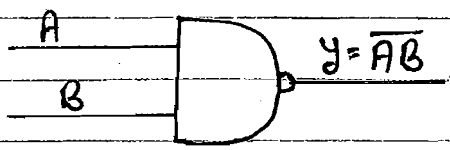
Universal Gates

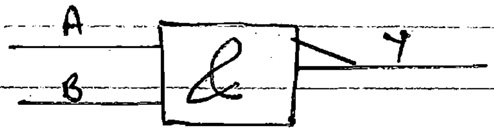
* NAND and NOR gates are universal because any digital circuit can be implimented by using these gates.



Buffer NOT





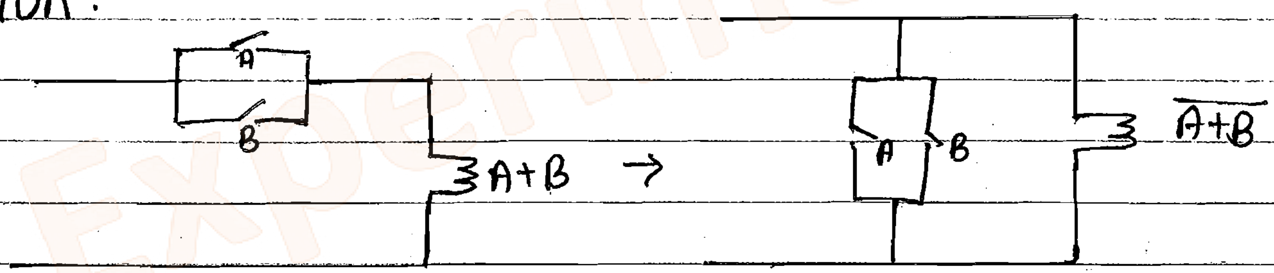


NAND Gate

A	B	$A \cdot B$	$\overline{A \cdot B}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

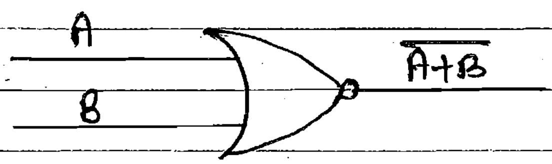
When any i/p is zero then o/p = 1.

* NOR :-

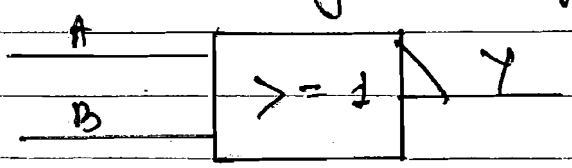


NOR

Equivalent Circuit Symbol:-



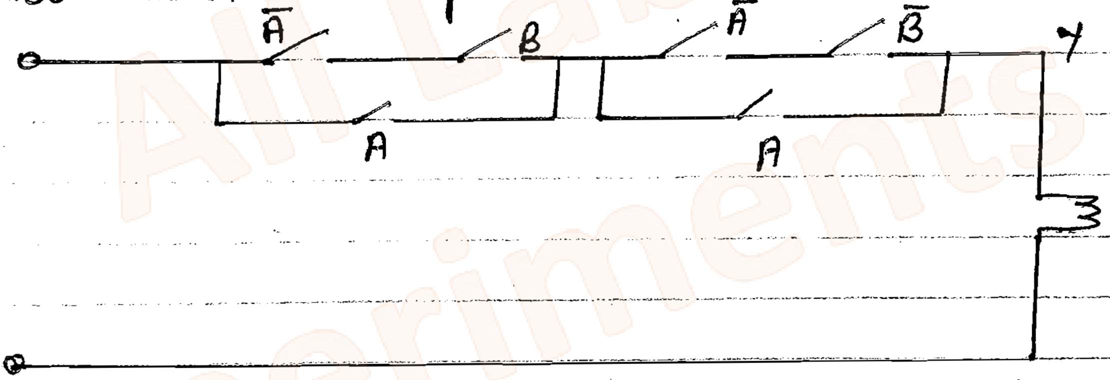
Equivalent recctangular representation:-



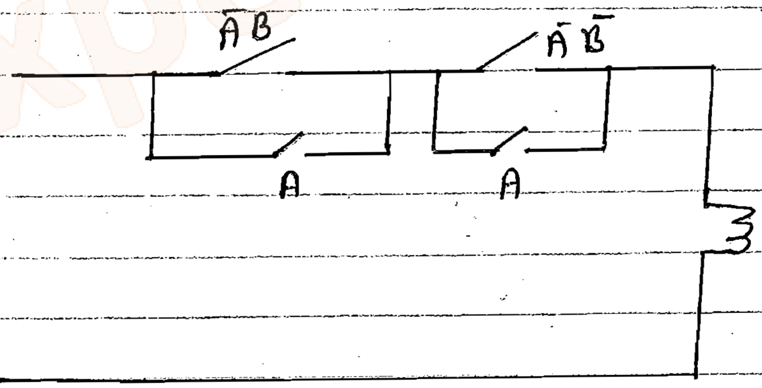
A	B	A + B	$\overline{A+B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

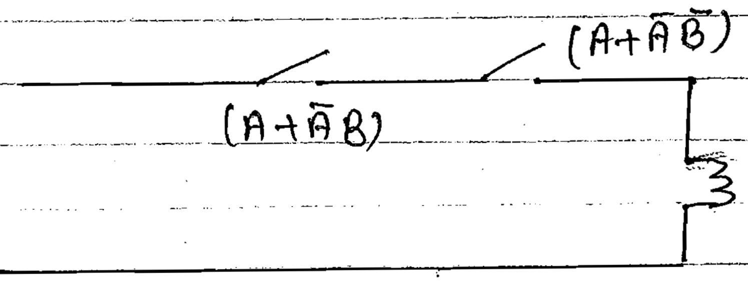
$\boxed{\text{If any i/p = 1 then o/p = 0}}$

Ques For the given switch diagram find the o/p minimise Boolean expression.



Sol^n:





$$y = \underbrace{(A+\bar{A}B)}_{1+2.3}\underbrace{(A+\bar{A}\bar{B})}_{1+2.3}$$

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

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

$$= A + 0$$

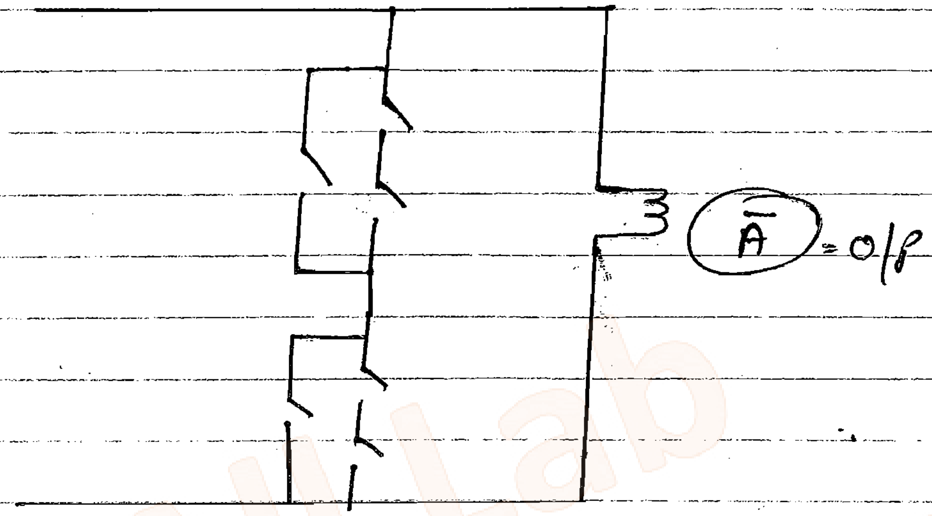
$$= A \quad \text{Ans}$$

O/p minimise expression.

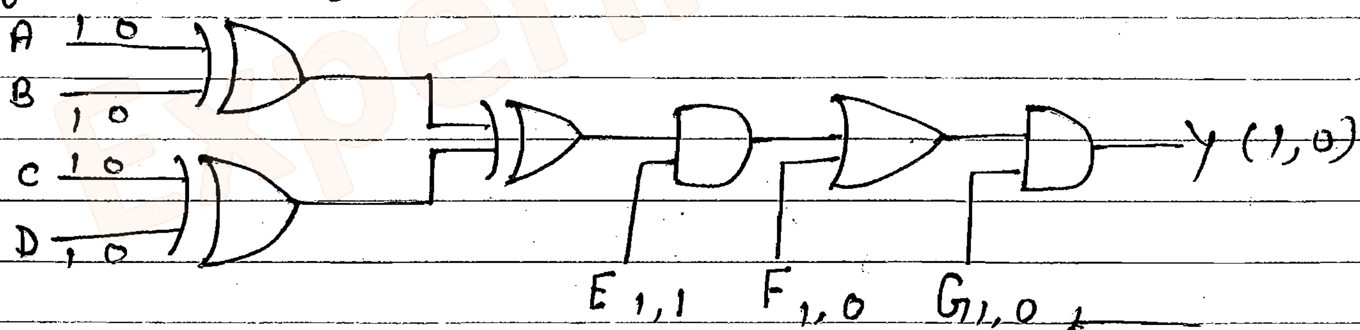
Contain Bar. But when swithches are in parallel with bulb then o/p contain Bar.

Ques For the given switch diagram find the o/p minimise expression.

Sol^n



Ques Calculate output Y for two different cases for which given circuit shown -



Sol^n Case I :-

$A = B = C = D = E = F = G = 1$

So o/p = 1

Case II :-

$A = B = C = D = 0, \; E = 1, \; F = G = 0$

So o/p = 0

* Arithmatic Circuit Gate :-

Ex-OR gate and Ex-NOR are arithmatic circuit gate because most of the arithmatic circuits utilises Ex-OR & Ex-NOR operations.

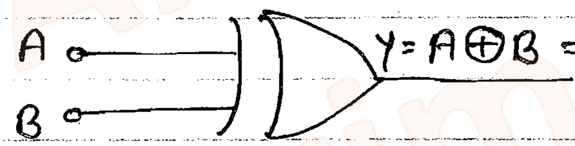
Ex-OR :-

Ex-OR = Exclusive OR = X-OR

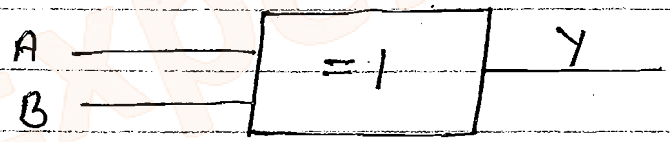
Symbol :-

$\oplus$

- Circuit Symbol :-



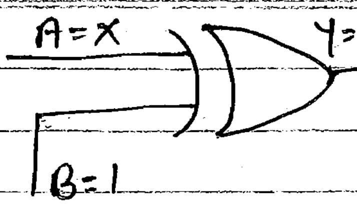
Equivalent circuit symbol of Rectangular ? :-



The disadvantage of X-OR gate is only two input X-OR operations are possible.

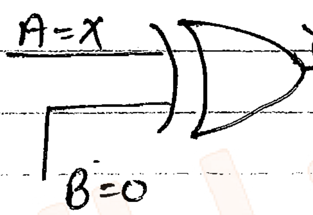
A	B	$Y = \bar{A}B + A\bar{B}$
0	0	0
0	1	1
1	0	1
1	1	0

for same input, output = 0, for different input output = 1.



$$Y = \bar{A}B + A\bar{B}$$
$$= \bar{X}\cdot 1 + X\cdot 0$$
$$= \bar{X} + 0$$
$$o/p = \bar{X}$$

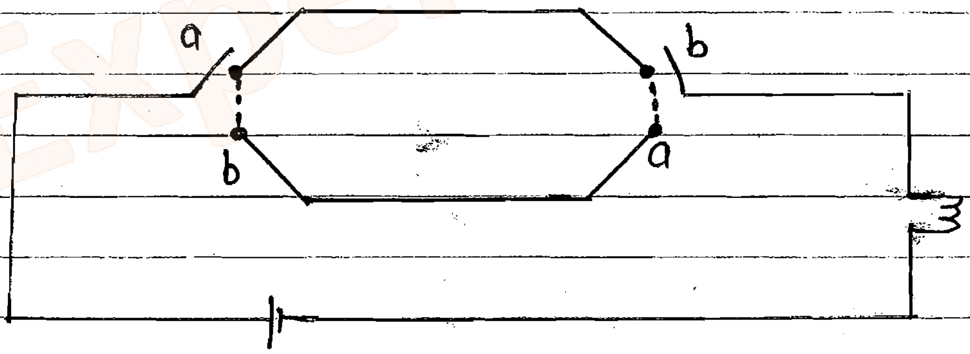
If one input of X-OR gate is 1 then output is complement of another input.



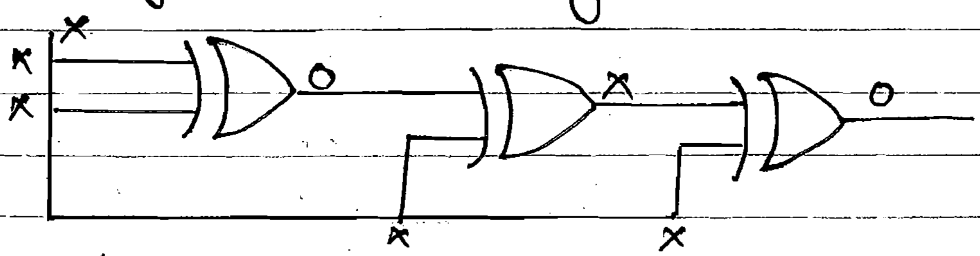
$$Y = \bar{A}B + A\bar{B} = 0 + X\cdot 1 = X$$

If any one input is zero then output is another input.

* Switching Diagram :-



Ques For the given circuit diagram determine the output Y.

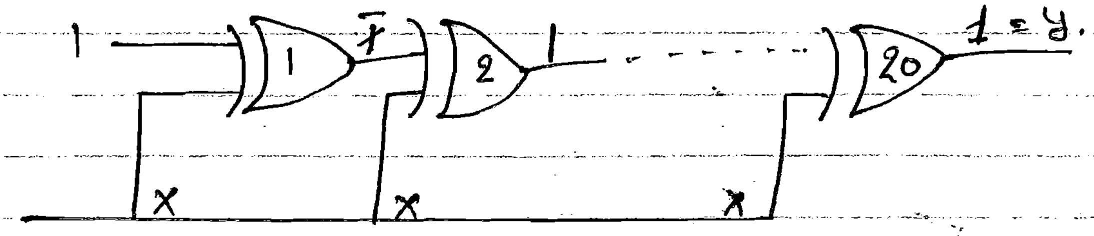


Ans So o/p $Y = 0$.

$\overline{A \cdot B} = \bar{A} + \bar{B}$
$\overline{A + B} = \bar{A} \cdot \bar{B}$ → Demorgan theorem.

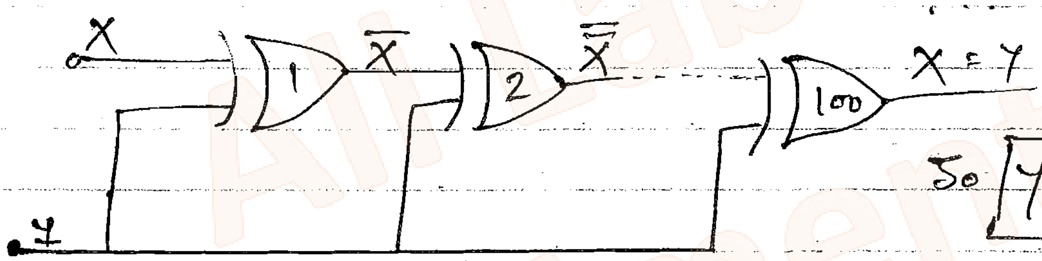
Qus For the given circuit diagram determine Y.

(a) x (b) $\bar{x}$ (c) 1 [✓] (d) 0



Qus For the given circuit diagram.

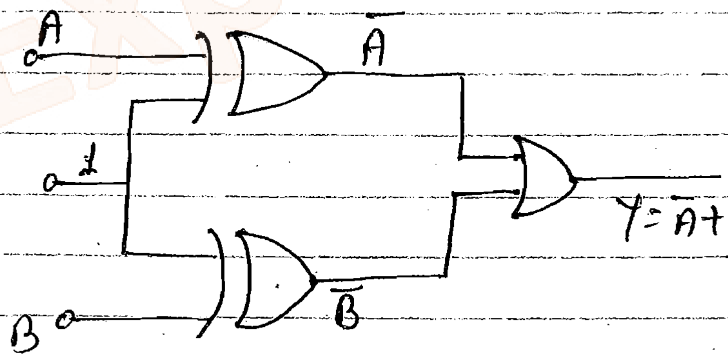
(a) x [✓] b = $\bar{x}$ (c) 1 (d) 0



So $\boxed{Y = X}$

Qus For the given circuit diagram calculate o/p Y.

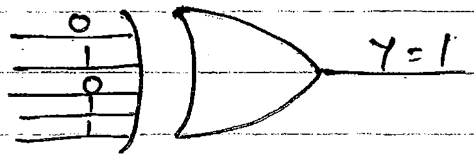
(a) $\overline{A+B}$ [✓] (b) $\overline{A \cdot B}$ [✓] (c) $\bar{A} \cdot \bar{B}$ (d) $\bar{A} \cdot B$



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

A	B	$\bar{A} + \bar{B}$	$\overline{A \cdot B}$
0	0	1	1
0	1	1	1
1	0	1	1
1	1	0	0

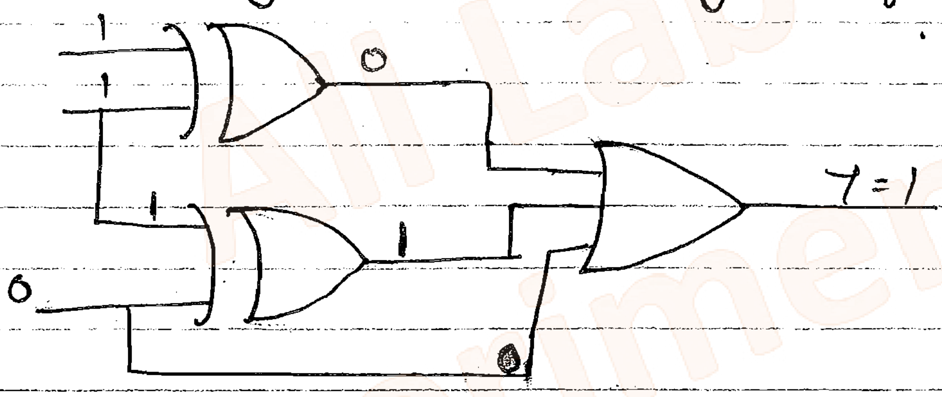
• Ex-OR is also called as odd function of 1. i.e. whenever odd numbers of i/ps are high then output = 1.



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

Ques For the given circuit diagram find Y = ?

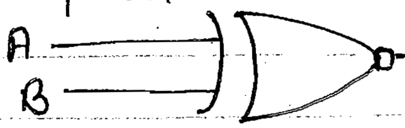
Ans



So o/p Y = 1 Ans

* Ex- NOR Gate :-

Circuit Symbol :-



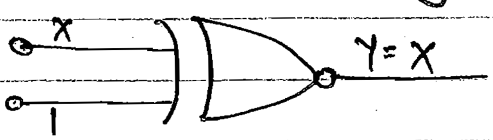
$Y = A \odot B$ or $\overline{A \oplus B}$

$$\overline{A \oplus B} = \overline{\bar{A} B + A \bar{B}}$$
$$= \overline{\bar{A} B} \cdot \overline{A \bar{B}}$$
$$= (\bar{\bar{A}} + \bar{B})(\bar{A} + \bar{\bar{B}})$$
$$= (A + \bar{B})(\bar{A} + B)$$
$$= \cancel{A\bar{A}} + AB + \bar{A}\bar{B} + \cancel{\bar{B}B}$$
$$= AB + \bar{A}\bar{B}$$
$$\boxed{\overline{A \oplus B} = A \odot B}$$

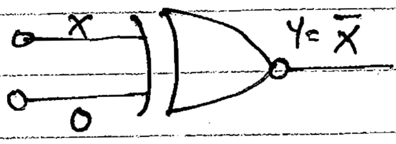
Truth Table :-

A	B	$A \oplus B$	$\overline{A \oplus B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	0	1

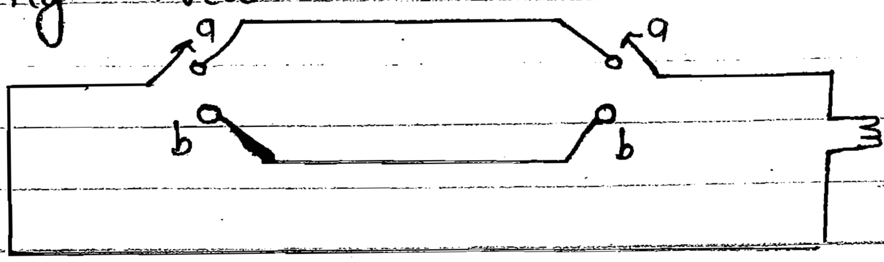
Ex-NOR is also called equality detector. It is also called as coinsidence circuit or coinsidence gate.

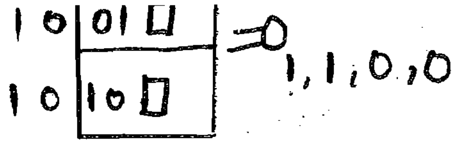


,



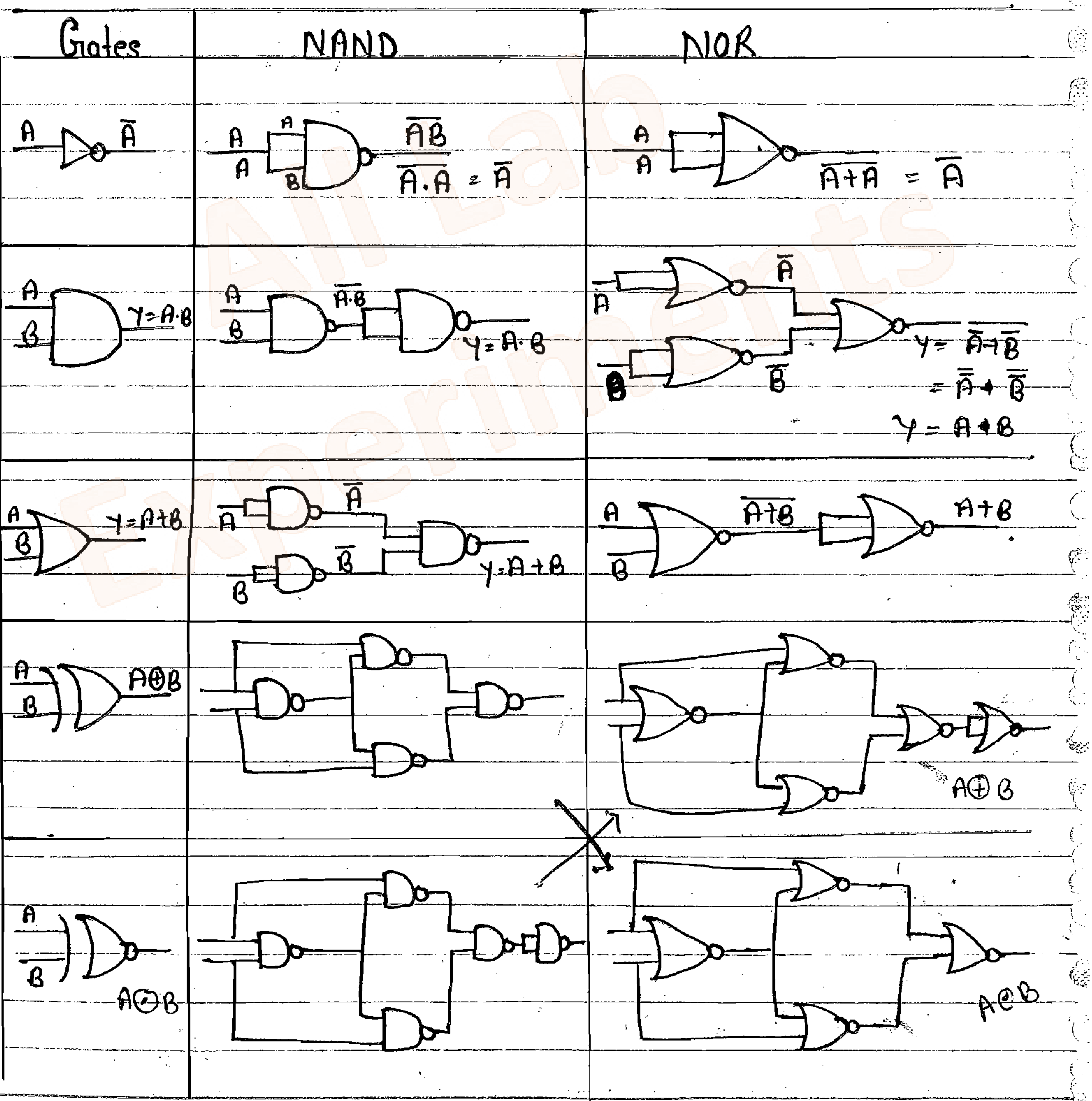
* Switching Circuit :-





* For the stairs case application the logic circuit is used for the control of bulb is X-OR (if X-OR is not available then X-NOR).

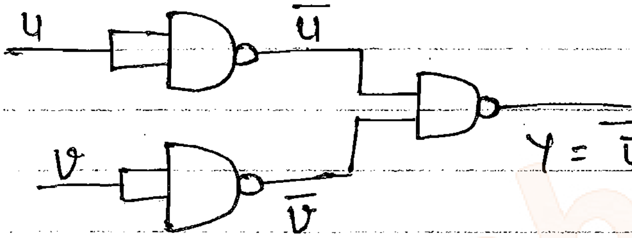
Universal Gates



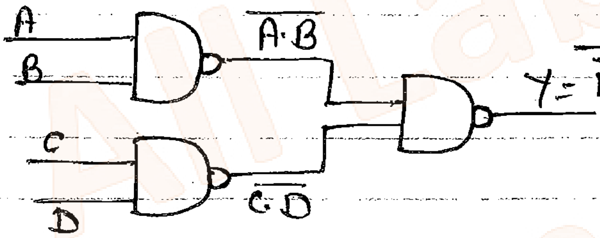
Qus Impliment $Y = AB + CD$ by using minimum number of two input NAND gate.

Soln

$$Y = \underbrace{AB}_{u} + \underbrace{CD}_{v}$$



$Y = \overline{\bar{u} \cdot \bar{v}} = \bar{\bar{u}} + \bar{\bar{v}} = u + v$

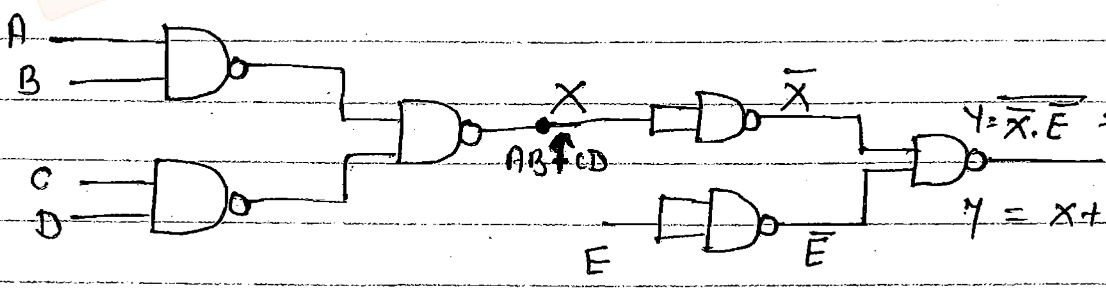


$Y = \overline{\overline{A \cdot B} \cdot \overline{C \cdot D}} = \overline{\overline{A \cdot B}} + \overline{\overline{C \cdot D}}$

$\boxed{Y = A \cdot B + C \cdot D}$

Qus Impliment $Y = AB + CD + E$

Soln $Y = \underbrace{AB + CD}_{X} + E$

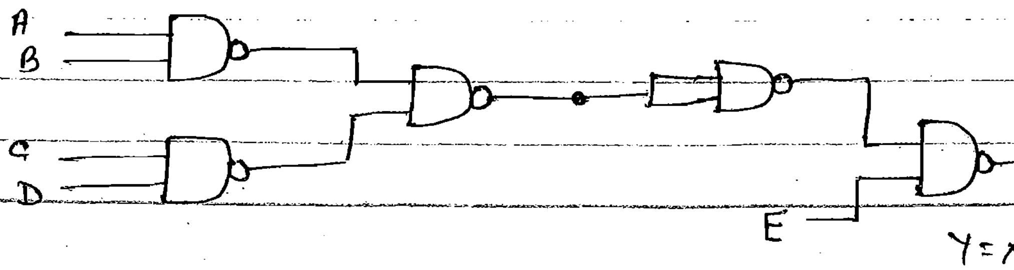


$Y = \overline{\bar{X} \cdot \bar{E}} = \bar{\bar{X}} + \bar{\bar{E}}$

$Y = X + E = AB + CD + E$

Ans

Qus Impliment $Y = AB + CD + \bar{E}$



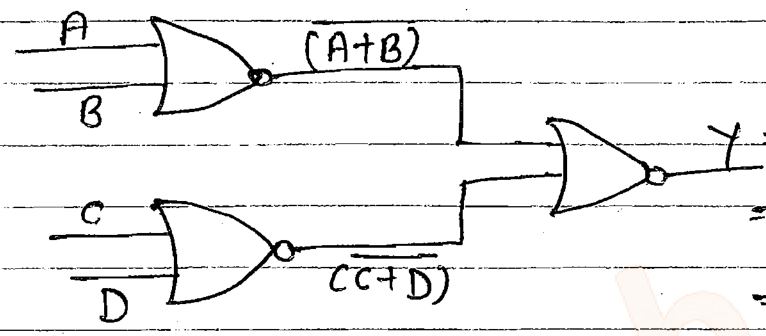
$Y = \overline{\bar{X} \cdot E} = \bar{\bar{X}} + \bar{E}$

$Y = X + \bar{E} = AB + CD + \bar{E}$

Ans

Ques For the given expression $Y = (A+B).(C+D)$ by using minimum number of two input NOR gates.

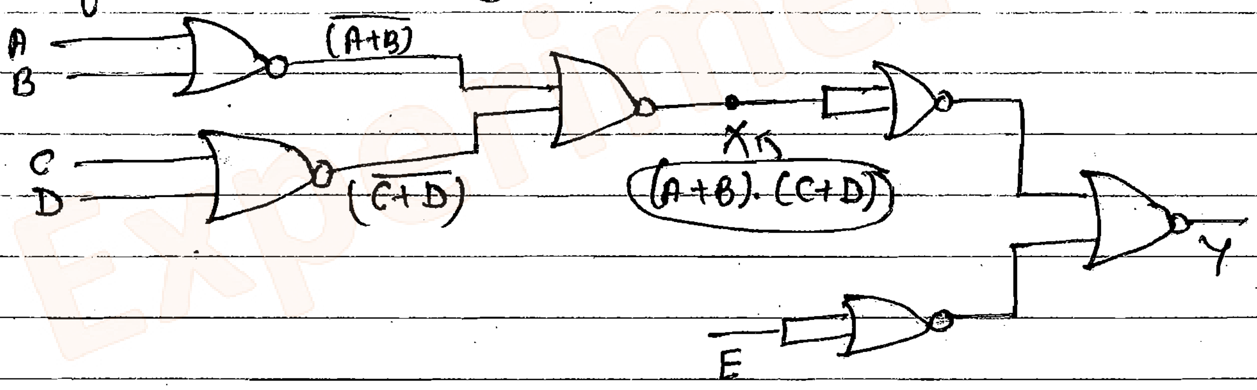
Solⁿ $Y = (A+B).(C+D)$



$$Y = \overline{\overline{(A+B)} + \overline{(C+D)}}$$
$$= \overline{\overline{(A+B)}} \cdot \overline{\overline{(C+D)}}$$
$$= (A+B).(C+D)$$ Ans

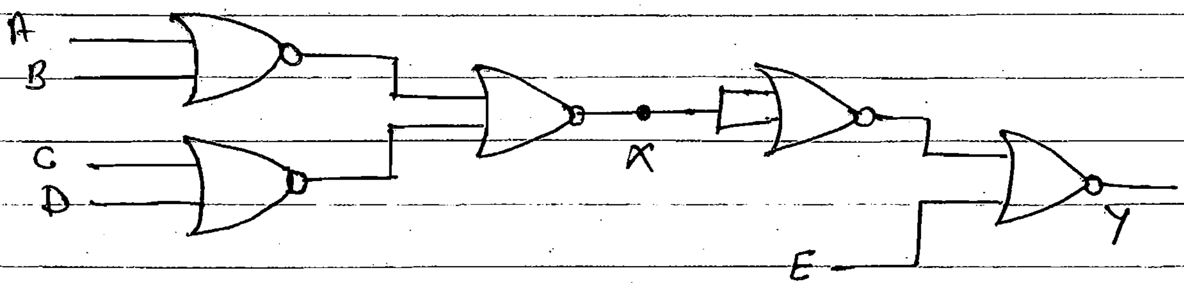
Ques For the given expression $Y = (A+B).(C+D).E$ by using minimum number of two input of NOR gates.

Ans:



So $Y = (A+B).(C+D).E$

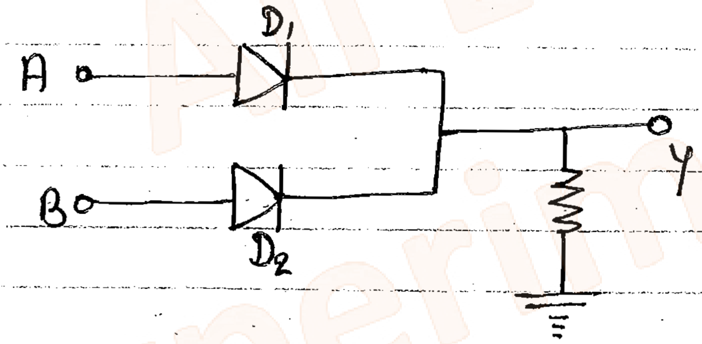
Ques Similarly impliment $Y = (A+B).(C+D).\bar{E}$.



$Y = (A+B).(C+D).E$

Gates	NAND	NOR
NOT	1	1
AND	2	3
OR	3	2
Ex-OR	4	5
Ex-NOR	5	4

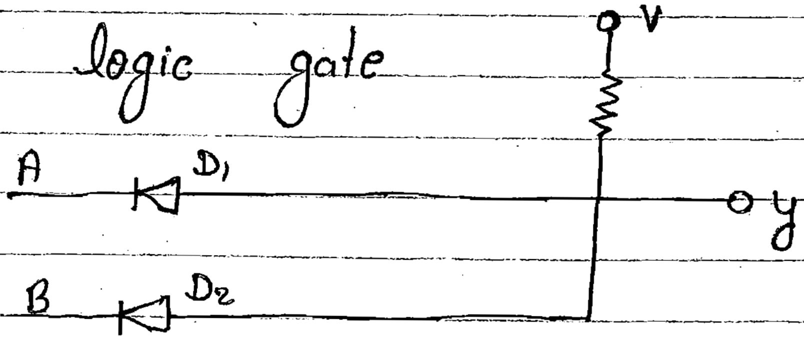
Gates by using diodes



A	B	D_1	D_2	Y
0	0	R.B	R.B	0
0	1	R.B	F.B	1
1	0	F.B	R.B	1
1	1	F.B	F.B	1

So Gate is OR Gate

Ques Identify the logic gate

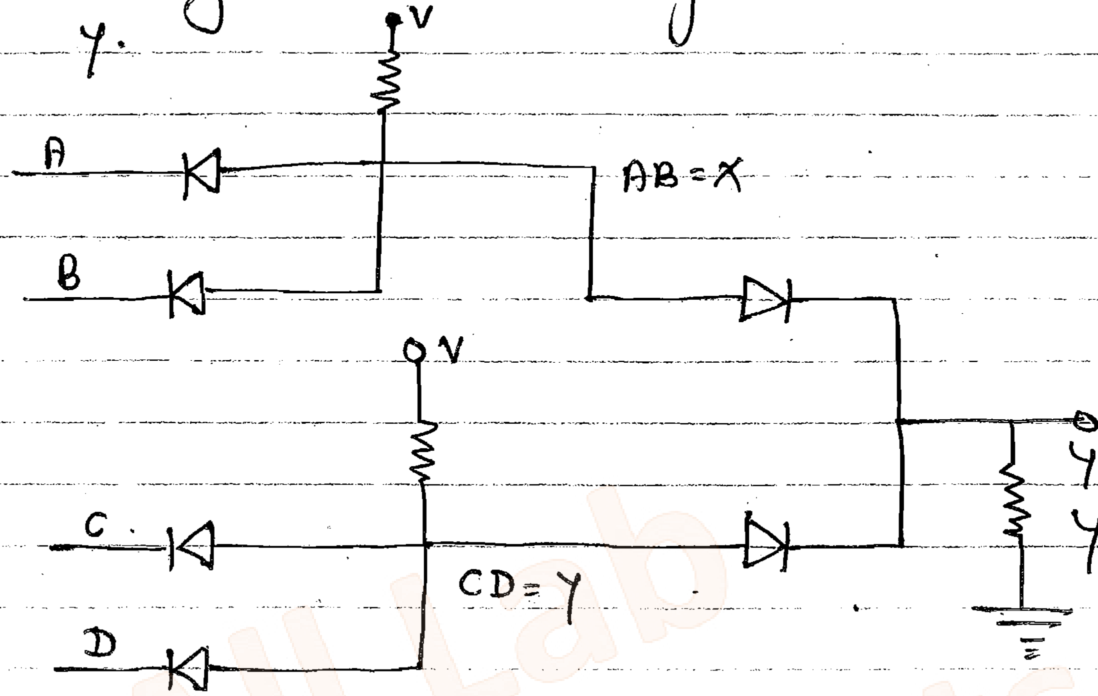


Sol^n

A	B	D_1	D_2	Y
0	0	F.B.	F.B.	0
0	1	F.B	R.B.	0
1	0	R.B.	F.B	0
1	1	R.B	R.B	1

So Gate is AND gate.

Ques For the given circuit diagram determine o/p Y.



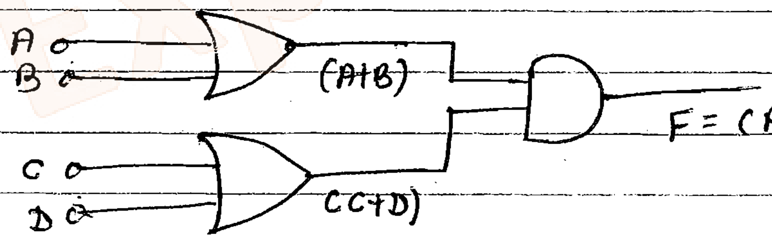
$Y = X + Y$

$Y = AB + CD$

Ans

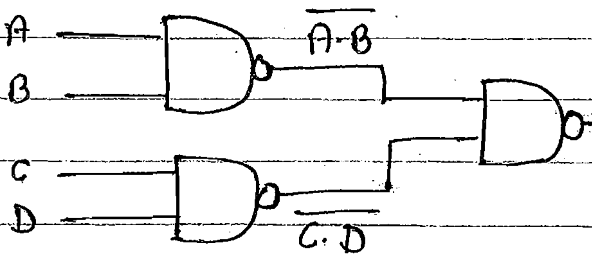
Ques For the given circuit diagram shown in figure output expression is F replace every logic gate by using NAND gate. the resultant expression will be ?

(a) F (b) F_D [✓] (c) $\overline{F_D}$ (d) $\overline{F}$



$F = (A+B).(C+D)$

Sol^n-



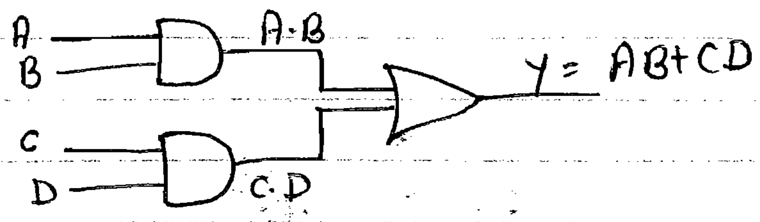
$Y = \overline{\overline{A \cdot B} \cdot \overline{C D}}$

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

$Y = A \cdot B + C \cdot D$

Self dual.

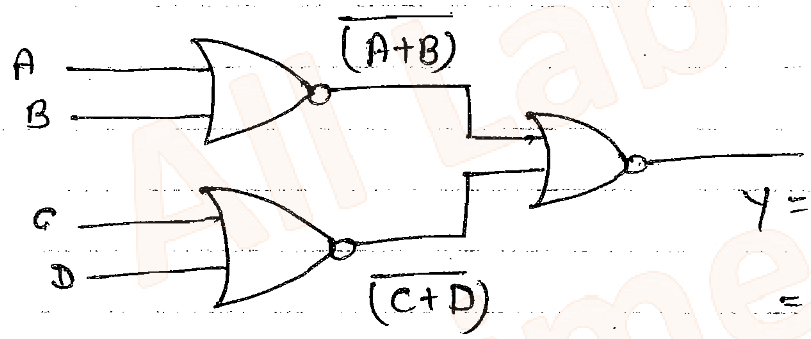
Qus For the given circuit diagram shown



Replace every gate by NOR gate the resultant expression will be -

(a) F (b) F_D [✓] (c) $\overline{F_D}$ (d) $\overline{F}$

Soln-



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

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

$$= (A+B)\cdot(C+D)$$

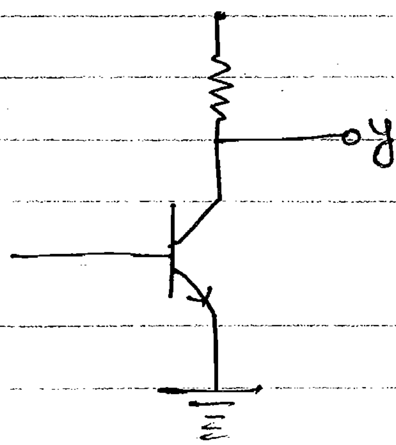
→ self dual.

Ans

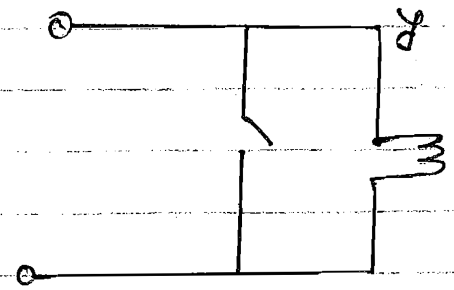
23/July/2014

Logic Gates by using Transistor

Qus For the given circuit diagram identify the logic gate

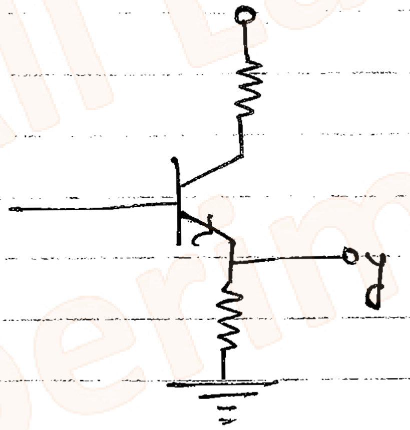


Ans Here the transistor is replaced by a switch we get -

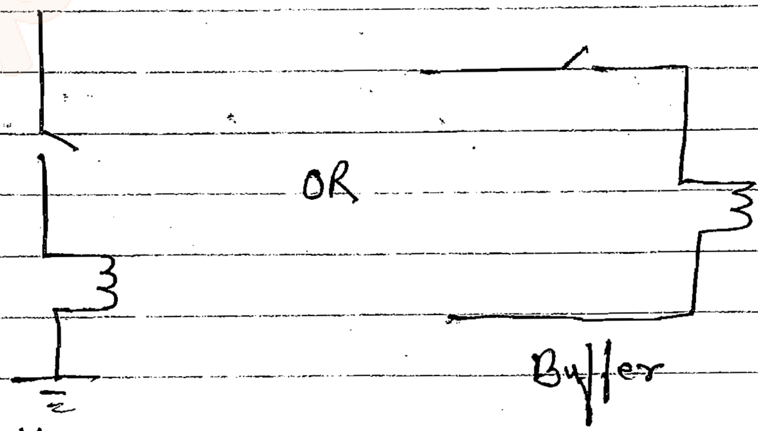


NOT Gate.

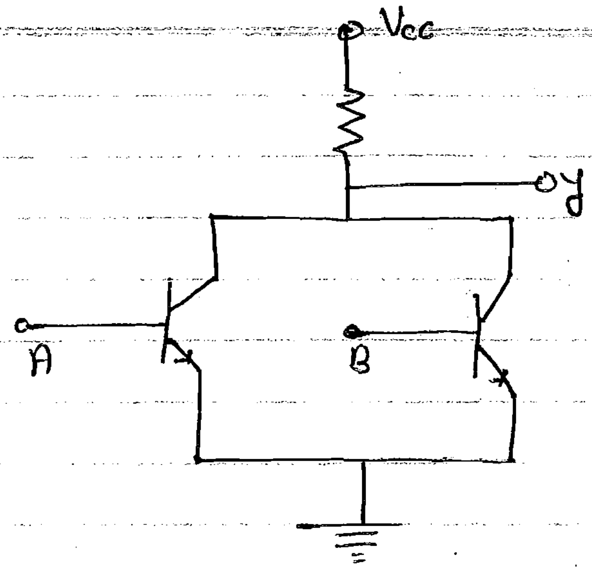
Ques For the given circuit diagram identify the logic gate



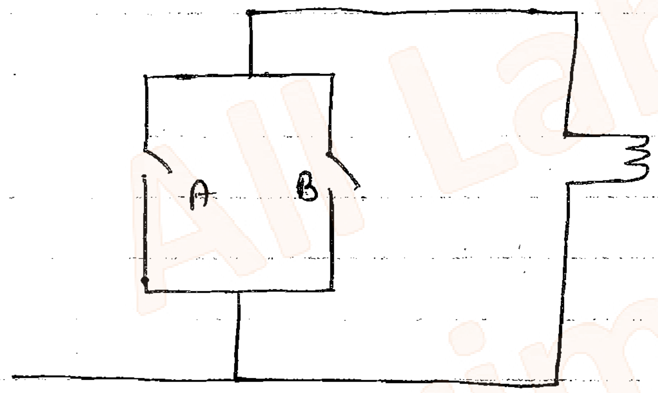
Sol^n



Ques For the given circuit diagram identify the gate.



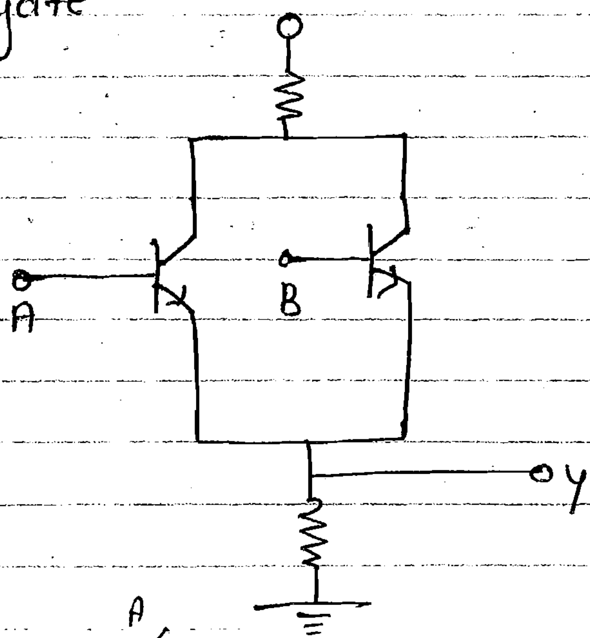
Sol^n



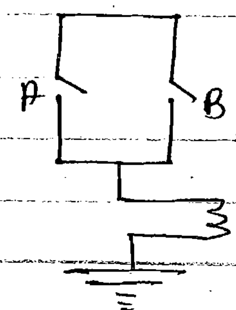
$\overline{A+B}$

So NOR Gate.

Qus Identify the gate

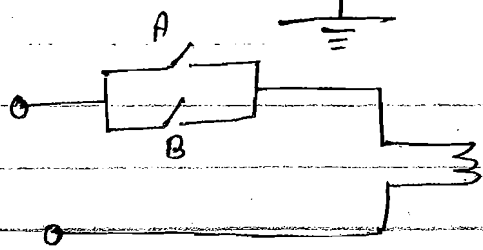


Sol^n



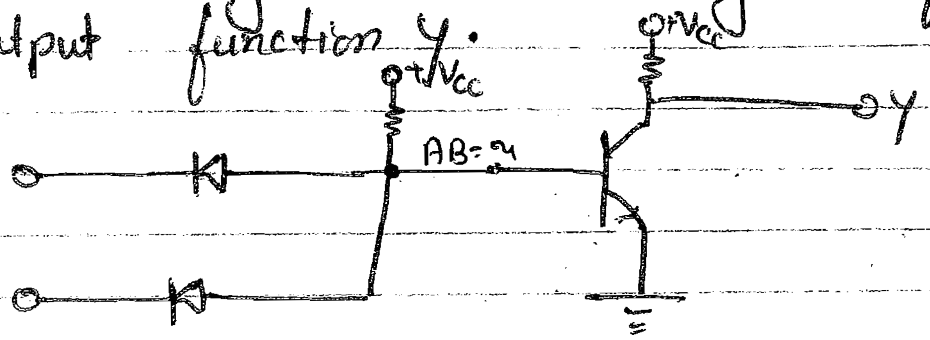
OR Gate

or

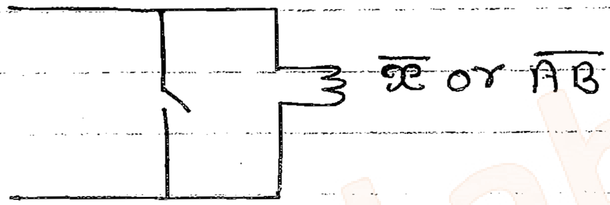


OR Gate.

Ques For the given circuit diagram find the output function Y.



Soln



Logic Circuits

Universal gates are used to impliment logic circuits, which are further clasified into -

1 Combinational Circuits
2. Sequencial Circuits.

1 Combinational Circuits :- In combinational circuits there is no feedback presents between output and input hence no memory like capacity develops.

e.g. Half Adder, Full Adder, Half Subtractor, Full Subtractor, Multiplexer, Demultiplexer, Comparator etc.

2. Sequencial Circuits :-

In sequential circuits feedback is present, hence memory capacity develops.

e.g. - Flip-Flop, Bistable Multivibrator, Register, Countor.

* Combinational Circuit :-

Steps for Combinational Circuits design.

(i) Identify the number of input and output lines.

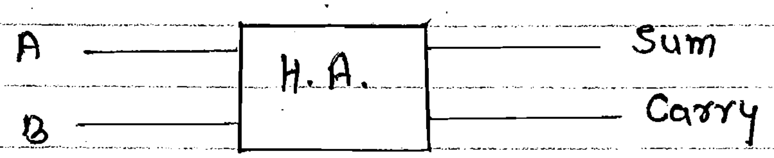
(ii) Develop the Truth table

(iii) Minimise the expression by using SOP & POS

(iv) Impliment the logic circuit by using universal gate.

* Half Adder :-

It is also called as 2-bit addition



A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

SOP expression of sum (y_1) -

$$y_{1(sum)} = \bar{A}B + A\bar{B}$$

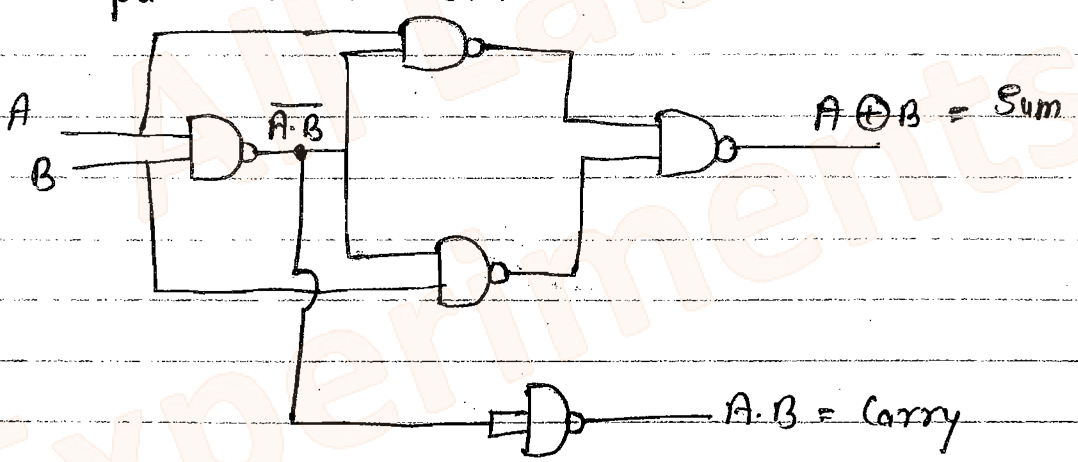
$$y_{1(sum)} = A \oplus B \quad \text{——} \; (I)$$

SOP expression of carry (y_2) -

$$y_{2(carry)} = A.B. \quad \text{——} \; (II)$$

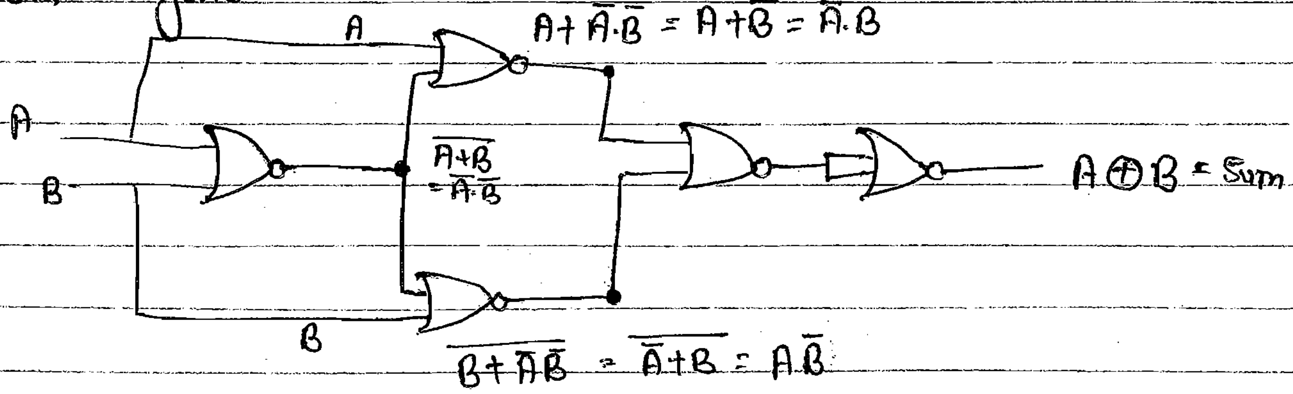
Ques Impliment H.A. by using minimum number of two input NAND Gate.

Sol^n



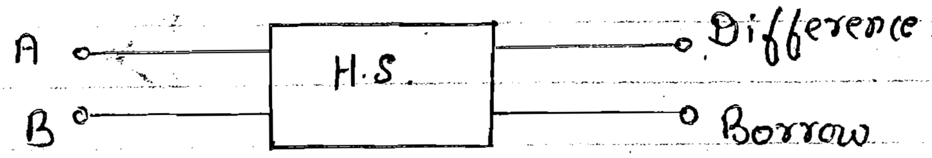
Ques Impliment H.A. by using minimum numbers of NOR gate.

Sol^n



* Half Subtractor :-

It is also called as two- bit subtraction.



Impliment Truth Table :-

A	B	Difference	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

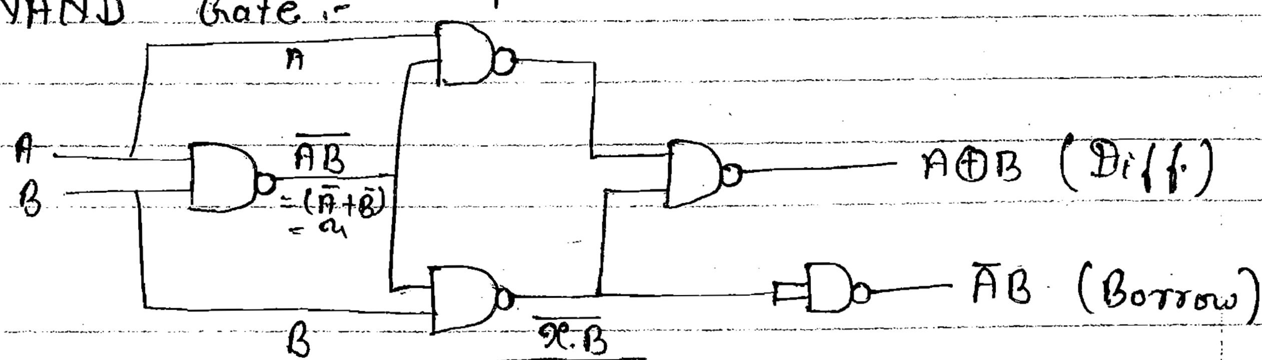
SOP for Difference :-

$$Y_{Diff.} = \bar{A}B + A\bar{B} = A \oplus B$$

SOP for Borrow :-

$$Y_{(Borrow)} = \bar{A}B$$

Impliment H.S. by using minimum number of NAND Gate :-



$\overline{x.B}$

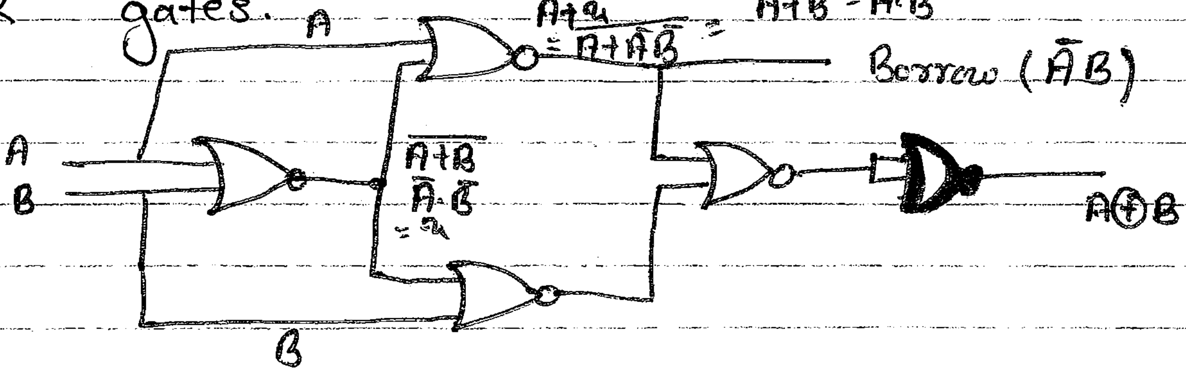
$\overline{\overline{(\bar{A}+\bar{B}).B}}$

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

$= \bar{A}B$

Ques Impliment H.S. by using minimum number of NOR gates.

Sol^n



- H.A./H.S. ⟶ NAND/NOR ⟶ 5

* Comparator {Single bit}:-

Impliment Truth Table :-

A	B	Y_1 A > B	Y_2 A = B	Y_3 A < B
0	0	0	1	0
0	1	0	0	1
1	0	1	0	0
1	1	0	1	0

SOP for A > B :-

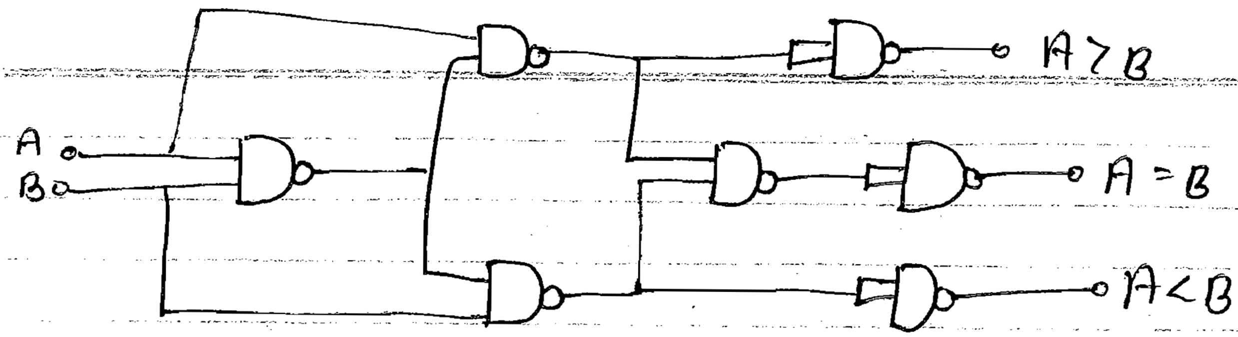
$$y_1 = A\bar{B} \quad \text{——— (I)}$$

SOP for A = B :-

$$y_2 = \bar{A}\bar{B} + AB = A \odot B \quad \text{——— (II)}$$

SOP for A < B :-

$$y_3 = \bar{A}B \quad \text{——— (III)}$$



Circuit Diagram of Comparator.

Ques Write the expression for 2-bit Comparator.

Sol^n

For A = B

$$\overbrace{A_2 \quad A_1}^{A}$$

$$\underbrace{B_2 \quad B_1}_{B}$$

like 1 9
1 9
Here 1 = 1 & 9 = 9

Analogus,

$(A_2 = B_2)$ & $(A_1 = B_1)$

$$= \boxed{(A_2 \odot B_2) \cdot (A_1 \odot B_1)}$$

For A > B :-

$$\overbrace{A_2 \quad A_1}^{A}$$

$$\underbrace{B_2 \quad B_1}_{B}$$

like 1 9 or 2 9
1 9 1 9

Analogus,

$(A_2 > B_2)$ or $(A_2 = B_2)$ & $(A_1 > B_1)$

$$= \boxed{(A_2 \cdot \overline{B_2}) + (A_2 \odot B_2) \cdot (A_1 \cdot \overline{B_1})}$$

For A < B :-

$$\overbrace{A_2 \quad A_1}^{A}$$

$$\underbrace{B_2 \quad B_1}_{B}$$

like 19 17
29 19

$= (A_2 < B_2)$ OR $(A_2 = B_2)$ & $(A_1 < B_1)$

$$= \boxed{\bar{A}_2 B_2 + (A_2 \odot B_2) \cdot \bar{A}_1 B_1}$$

Ques 80 1/3 Write the expression for 3-bit comparator.

For $A = B$:-

$$\overbrace{A_3\ A_2\ A_1}^{A}$$

$$\underbrace{B_3\ B_2\ B_1}_{B}$$

like 199
199

$$= (A_3 = B_3) \ \& \ (A_2 = B_2) \ \& \ (A_1 = B_1)$$

$$= \boxed{(A_3 \odot B_3) \cdot (A_2 \odot B_2) \cdot (A_1 \odot B_1)}$$

For $A > B$:-

$$\overbrace{A_3\ A_2\ A_1}^{A}$$

$$\underbrace{B_3\ B_2\ B_1}_{B}$$

like 200 or 119
199 117

or 197
107

$$= (A_3 > B_3) \text{ or } (A_3 = B_3) \ \& \ (A_2 > B_2) \text{ or } (A_3 = B_3) \ \& \ (A_2 = B_2) \ \& \ (A_1 > B_1)$$

$$= \boxed{A_3 \bar{B}_3 + (A_3 \odot B_3) \cdot (A_2 \bar{B}_2) + (A_3 \odot B_3) \cdot (A_2 \odot B_2) \cdot A_1 \bar{B}_1}$$

For $A < B$

$$\overbrace{A_3\ A_2\ A_1}^{A}$$

$$\underbrace{B_3\ B_2\ B_1}_{B}$$

* General Expression for n-bit :-

$$\overbrace{A_n \quad A_{n-1} \quad \cdots\cdots \quad A_1}^{A}$$

$$\underbrace{B_n \quad B_{n-1} \quad \cdots\cdots \quad B_1}_{B}$$

For $A = B$:-

$$(A_n \odot B_n) \cdot (A_{n-1} \odot B_{n-1}) \cdots\cdots (A_1 \odot B_1)$$

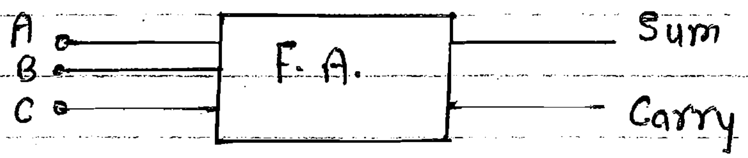
For $A > B$:-

$$\boxed{A_n \overline{B}_n + (A_n \odot B_n) \cdot (A_{n-1} \cdot \overline{B}_{n-1}) + \cdots (A_n \odot B_n) \cdot (A_{n-1} \odot B_{n-1}) \cdots\cdots A_1 \overline{B}_1}$$

For $A < B$:-

* Full Adder :-

Full Adder is called as 3-bit addition.



Truth Table :-

A	B	C	SUM	CARRY
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

SOP for Sum :-

$$Y_{sum} = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$$
$$= \bar{A}(\bar{B}C + B\bar{C}) + A(\bar{B}\bar{C} + BC)$$
$$= \bar{A}[B \oplus C] + A[\overline{B \oplus C}]$$

let $B \oplus C = X$

So $Y_{sum} = \bar{A}X + A\bar{X}$

$$= A \oplus X$$

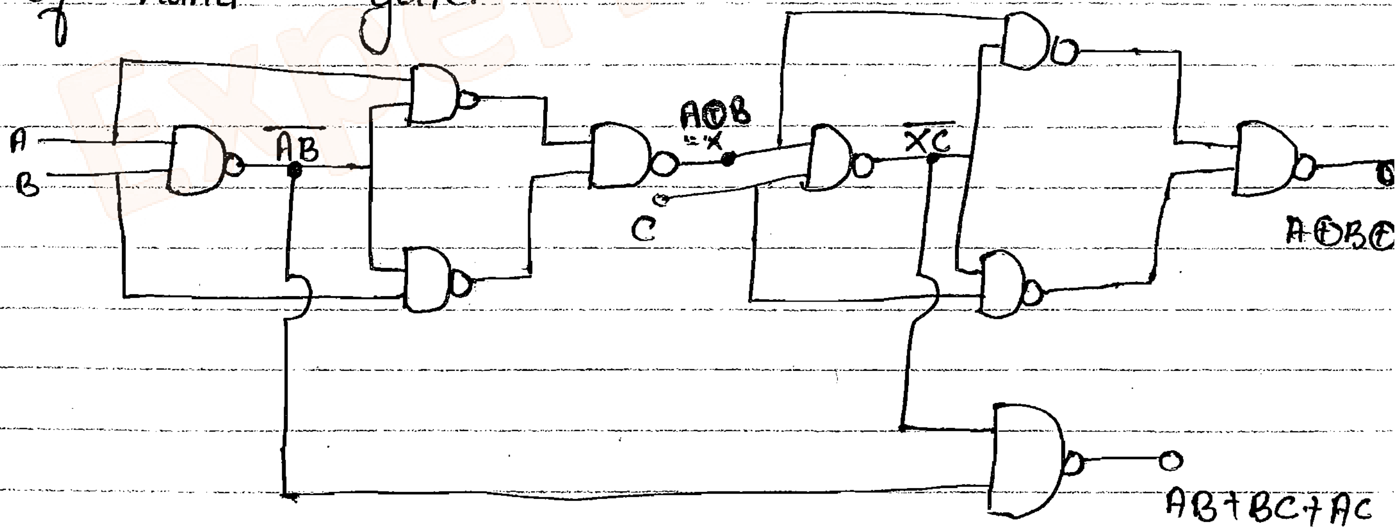
$$\boxed{Y_{sum} = A \oplus B \oplus C}$$

SOP for Carry :-

$$y_{carry} = \bar{A}BC + A\bar{B}C + AB\bar{C} + ABC$$
$$= \bar{A}BC + AB\bar{C} + AC(B+\bar{B})$$
$$= \bar{A}BC + A(B\bar{C} + C)$$
$$\quad 3.2 + 1$$
$$= \bar{A}BC + A[B+C]$$
$$= \bar{A}BC + AB + AC$$
$$= B(\bar{A}C + A) + AC$$
$$\quad 3.2 + 1$$
$$= B(A+C) + AC$$
$$\boxed{y_{carry} = AB + BC + AC}$$

Ques Impliment full adder by using minimum numbe[r] of nand gate.

Sol^n



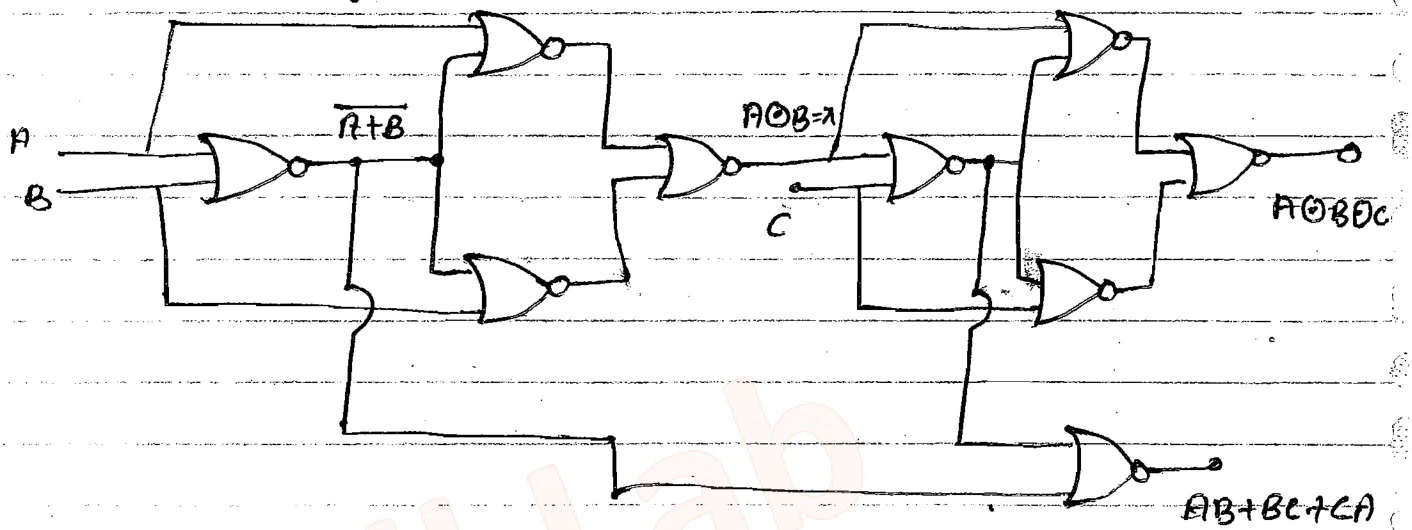
Sum = $A \oplus B \oplus C$

Carry = $AB + BC + AC$

$\overline{(A\oplus B).C}$ =

Ques Impliment Full Adder by using minimum number of NOR gate!

Sol^n



Note :-

for three input $A \oplus B \oplus C$ is equivalent to $A \odot B \odot C$ with respect to output.

Ques Find the output minimise expression for three input functions if majority number of inputs are high output is assumed high.

Sol^n

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	$\rightarrow ABC$

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

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

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

$\boxed{y_{sop} = AB+BC+AC}$ Ans

Ques For the previous ques. output is high when minority number of inputs are high.

Sol^n

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

$$Y_{sop} = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C}$$
$$= \bar{A}\bar{B}(\bar{C}+C) + \bar{A}B\bar{C} + A\bar{B}\bar{C}$$
$$= \bar{A}\bar{B} + \bar{A}B\bar{C} + A\bar{B}\bar{C}$$
$$= \bar{A}[\bar{B} + B\bar{C}] + A\bar{B}\bar{C}$$
$$= \bar{A}[\bar{B}+\bar{C}] + A\bar{B}\bar{C}$$
$$= \bar{A}\bar{B} + \bar{A}\bar{C} + A\bar{B}\bar{C}$$
$$= \bar{A}\bar{B} + \bar{C}[\bar{A} + A\bar{B}]$$
$$= \bar{A}\bar{B} + \bar{C}[\bar{A} + \bar{B}]$$
$$\boxed{Y_{sop} = \bar{A}\bar{B} + \bar{A}\bar{C} + \bar{B}\bar{C}}$$

Ans

Ques Find the o/p minimise expression for output is 1 if input is atleast 3 and maximum is 6.

Sol^n

	A	B	C	Y
0 ←	0	0	0	0
1 ←	0	0	1	0
2 ←	0	1	0	0

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

$$
\begin{aligned}
Y_{SOP} &= \bar{A}BC + A\bar{B}\bar{C} + A\bar{B}C + AB\bar{C} \\
&= \bar{A}BC + A\bar{B} + AB\bar{C} \\
&= \bar{A}BC + A[\bar{B} + B\bar{C}] \\
&= \bar{A}BC + A[\bar{B} + \bar{C}]
\end{aligned}
$$

$$\boxed{Y_{SOP} = \bar{A}BC + A\bar{B} + A\bar{C}}$$

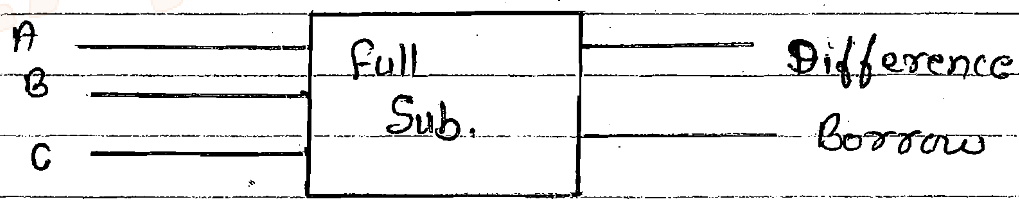
Ans

25/July/2014

* Full Subtractor :- {3-bit} :-

Full subtractor is called as 3-bit subtraction.

Symbol:-



Truth Table :-

	A	B	C	D	B	
	0	0	0	0	0	
$\bar{A}\bar{B}C$ ←	0	0	1	1	1	→ $\bar{A}\bar{B}C$
$\bar{A}B\bar{C}$ ←	0	1	0	1	1	→ $\bar{A}B\bar{C}$
	0	1	1	0	1	→ $\bar{A}BC$
$A\bar{B}\bar{C}$ ←	1	0	0	1	0	

	1 0 1	0	0
	1 1 0	0	0
$ABC \leftarrow$	1 1 1	1	1 $\rightarrow ABC$

SOP for ~~Sum~~ Difference :-

$$Y_{sum} = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$$
$$= \bar{A}(\bar{B}C + B\bar{C}) + A[\bar{B}\bar{C} + BC]$$
$$= \bar{A}(B \oplus C) + A(\overline{B \oplus C})$$

let $B + C = X$

So,

$$Y_{sum} = \bar{A}X + A\bar{X}$$
$$= A \oplus X$$
$$\boxed{Y_{sum} = A \oplus B \oplus C}$$

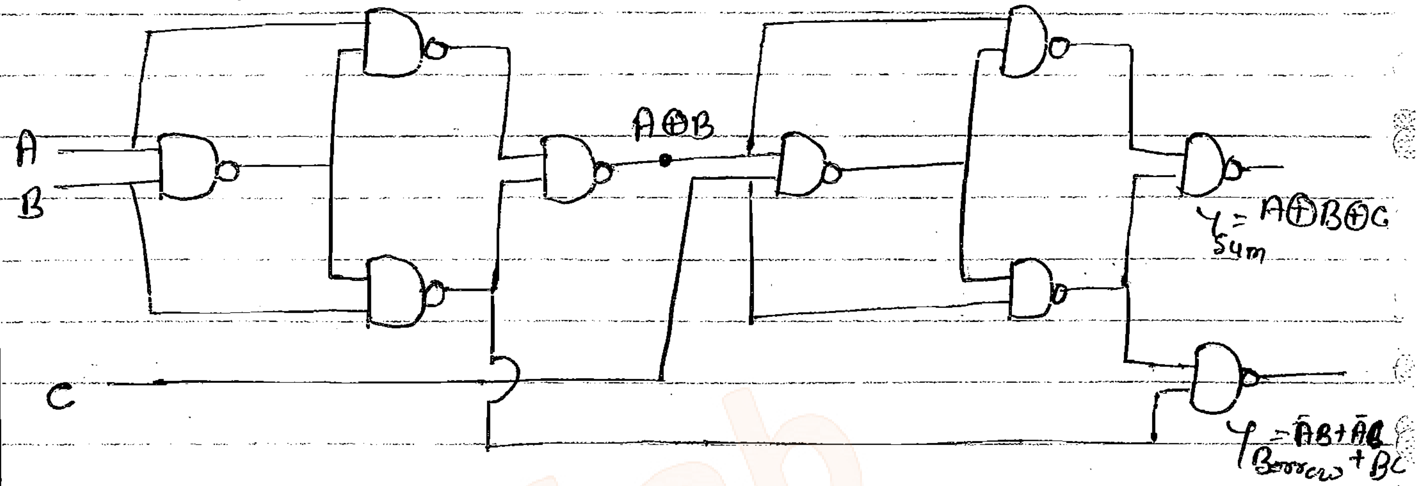
SOP for Borrow :-

$$Y_{Borrow} = \bar{A}\bar{B}.C + \bar{A}B\bar{C} + \bar{A}BC + ABC$$
$$= \bar{A}\bar{B}C + \bar{A}B\bar{C} + BC(A + \bar{A})$$
$$= \bar{A}\bar{B}C + B(C + \bar{A}\bar{C}) \qquad \{\because A + \bar{A} = 1$$
$$= \bar{A}\bar{B}C + B(C + \bar{A})(C + \bar{C}) \qquad \{\because C + \bar{C} = 1$$
$$= \bar{A}\bar{B}C + BC + \bar{A}B$$
$$= \bar{A}(B + \bar{B}C) + BC$$
$$= \bar{A}(B + \bar{B})(B + C) + BC$$
$$= \bar{A}(B + C) + BC \qquad \{\because B + \bar{B} = 1\}$$
$$\boxed{Y_{Borrow} = \bar{A}B + \bar{A}C + BC}$$

Ans

Q. Impliment full subtractor by using min^m no. of NAND Gates.-

Sol^n



Full Subtractor by using NAND Gate.

* Note :-

FA / FS ⟶ NAND / NOR ⟶ 9

Ques Impliment full subtractor by using min^m no. of NOR Gates.-

Sol^n