Module - III Digital Electronics

Number System

1. Positional Number System
2. Non positional Number system.

There are various types of positional number system. but generally 4 types of number system are used in digital computer system.

1. Decimal
2. Binary
3. Octal
4. Hexadecimal

Base or Radix of a number system.

The base or Radix of a number system is defined as the no. of different symbols (digits or characters) used in that number system.

(1) Decimal Number System

The base or Radix of this system is 10.

i.e. 0, 1, 2, ... 9.

$$Ex:- (756.8)_{10} = 7\times10^{2} + 5\times10^{1} + 6\times10^{0} + 8\times10^{-1}$$

$$[\ldots 10^{2}\ 10^{1}\ 10^{0}.\ 10^{-1}\ 10^{-2} \ldots]$$

(2) Binary Number System

Base or Radix is 2

i.e. 0 and 1.

EX:- $(1001101)_2$

The representation is

$$[\ldots 2^3\, 2^2\, 2^1\, 2^0 \,.\, 2^{-1}\, 2^{-2} \ldots]$$

$$(1001.10)_2 = 1\times2^0 + 0\times2^1 + 0\times2^2 + 1\times2^3 + 1\times2^{-1} + 0\times2^{-2}$$

$$= (1+8) + 2^{-1}$$

$$= (9.5)_{10}$$

(3) Octal Number System

Base or Radix is 8.

i.e. 0, 1, 2, 3, 4, 5, 6, 7

It is represented as

$$[\ldots 8^2\, 8^1\, 8^0 \,.\, 8^{-1}\, 8^{-2}\, 8^{-3} \ldots]$$

(4) Hexadecimal number system

Here Base or Radix is 16.

i.e. 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (A), 11 (B), 12 (C), 13 (D), 14 (E), 15 (F)

EX:- 35H

It is represented as

$$[\ldots 16^2\, 16^1\, 16^0 \,.\, 16^{-1}\, 16^{-2}\, 16^{-3} \ldots]$$

→ It is also known as alpha numeric number system.

Relationship between different Number System.

Decimal	Binary	Octal	Hexadecimal
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Number System Conversion

Decimal to Binary

$(52.75)_{10}$

```
2 | 52
2 | 26 — 0
2 | 13 — 0
2 | 6  — 1
2 | 3  — 0
2 | 1  — 1
    0  — 1
```

$(52)_{10} = (110100)_2$

$0.75 \times 2 = 1.50$
$0.50 \times 2 = 1.00$

$(0.75)_{10} = (0.11)_2$

$(52.75)_{10} = (110100.11)_2$

Decimal to octal

$(496.45)_{10} = (\quad)_8$

8 | 496
8 | 62 — 0
8 | 7 — 6
0 — 7

$(496)_{10} = (760)_8$

$0.45 \times 8 = 3.60$
$0.60 \times 8 = 4.80$
$0.80 \times 8 = 6.40$
$0.40 \times 8 = 3.20$

$(0.45)_{10} = (0.346)_8$

$(496.45)_{10} = (760.346)_8$

Decimal to Hexadecimal

$(496.45)_{10} = (\quad)_{16}$

16 | 496
16 | 31 — 0
16 | 1 — 15 (F)
0 — 1

$0.45 \times 16 = 7.20$
$0.20 \times 16 = 3.20$
$0.20 \times 16 = 3.20$

$(496.45)_{10} = (1F0.733)_{16}$

Binary to decimal

$$(110100.11)_2 = 0\times2^0 + 0\times2^1 + 1\times2^2 + 0\times2^3 + 1\times2^4 + 1\times2^5 + 1\times2^{-1} + 1\times2^{-2}$$

$$= 4 + 16 + 32 + \frac{1}{2} + \frac{1}{4}$$

$$= (52.75)_{10}$$

Octal to decimal

$$(760.346)_8 = 0\times8^0 + 6\times8^1 + 7\times8^2 + 3\times8^{-1} + 4\times8^{-2} + 6\times8^{-3}$$

$$= 48 + 448 + \frac{3}{8} + \frac{4}{64} + \frac{6}{512}$$

$$= 496 + 0.375 + 0.062 + 0.011$$

$$= (496.45)_{10}$$

Hexadecimal to decimal

$$(1F0.733)_{16} = 0\times16^0 + 15\times16^1 + 1\times16^2 + 7\times16^{-1} + 3\times16^{-2} + 3\times16^{-3}$$

$$= 0 + 240 + 256 + 0.43 + 0.011 + 0.0007$$

$$= (496.45)_{10}$$

Binary to octal

$$(\underbrace{110}_{6}\,\underbrace{100}_{4}.\underbrace{110}_{6})_2 = (64.6)_8$$

Octal to Binary

$$(67.73)_8 = (\quad)_2$$

$$= (110111.111011)_2$$

Scanned with CamScanner

Binary to Hexadecimal

$$(\underbrace{1011}_{B}\ \underbrace{1010}_{A}\ .\ \underbrace{0011}_{3})_2 = (BA.3)_{16}$$

Hexadecimal to Binary

$$(BA.3)_{16} = (\quad)_2$$

$$(1011\,1010.0011)_2$$

Hexadecimal to octal

The hexadecimal number is $(2A.B)_{16} = (\quad)_8$

2 10 11

$$(\underline{000}\,\underline{010}\,\underline{101}\,\underline{010}.\underline{101}\,\underline{100})_2$$

$$= (0\ 5\ 2.54)_8$$

Octal to Hexadecimal

$$(37.62)_8 = (\quad)_{16}$$

$$\underline{0001}\,\underline{1111}.\underline{1100}\,\underline{1000}$$

$$(1F.C8)_{16}$$

Binary Arithmetic

4 types of binary arithmatics are present

1. Addition
2. Substraction
3. Multiplication.
4. Division

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(1) Addition

$0+0=0$

$0+1=1$

$1+0=1$

$1+1=10$

$\swarrow$ carry $\searrow$ sum

$$\begin{array}{r} 10 \\ +\ 1 \\ \hline 11 \end{array} \qquad \begin{array}{r} 11 \\ +\ 1 \\ \hline 100 \end{array}$$

$(1011)_2 + (1110)_2 =$

$$\begin{array}{r} 1011 \\ 1110 \\ \hline (11001)_2 \end{array}$$

Carry

(2) Substraction

$0-0=0$

$1-0=1$

$1-1=0$

$0-1=1$ with borrow 1

$(11011.11)_2 - (10101.01)_2 = (00110.10)_2$

$$\begin{array}{r} 11011.11 \\ 10101.01 \\ \hline 00110.10 \end{array}$$

(3) Multiplication

$0\times0=0$

$0\times1=0$

$1\times0=0$

$1\times1=1$

$(111)_2 \times (101)_2 = (100011)_2$

$$
\begin{array}{r}
111 \\
101 \\
\hline
111 \\
000 \\
111 \\
\hline
(100011)_2
\end{array}
$$

(4) Division :-

$(101101)_2 \div (110)_2 =$

$$
\begin{array}{r|l}
110 & 101101 \;|\; 111.1 \\
 & 110 \\
\hline
 & 1010 \\
 & 110 \\
\hline
 & 1001 \\
 & 110 \\
\hline
 & 0110 \\
 & 110 \\
\hline
 & 0
\end{array}
$$

Compliment

Compliments are used in digital computer for simplifying the substraction operation and for logical manipulation.

1's compliment

1's compliment of (101) is 010

2's Compliment

2's compliment of 101 is 011

$$
\begin{array}{r}
010 \\
+\;\;1 \\
\hline
011
\end{array}
$$

2's compliment = 1's compliment +1

Substraction by compliments method

EX ~~Set~~ - I

$$\begin{array}{r} 0110 \\ -\ 0011 \\ \hline +(0011) \end{array}$$

EX ~~Set~~ - II

$$\begin{array}{r} 0011 \\ -\ 0110 \\ \hline -(0011) \end{array}$$

Step-1 First write the 1st number.

Step-2 Find the 1's compliment of 2nd number.

Step-3 Add both the numbers.

$$\begin{array}{r} 0110 \\ 1100 \\ \hline 1\,0010 \end{array}$$

Carry

Step-4 If carry is there, then the answer is +ve.

Step-5 Remove the carry from the left side & add ~~to~~ that to the result.

$$\begin{array}{r} 0010 \\ +\ \ \ 1 \\ \hline +(0011) \end{array}$$

EX ~~Set~~ - II

Follow the First 3 steps at discuss above.

$$\begin{array}{r} 0011 \\ 1001 \\ \hline 1100 \end{array}$$

Step-4 If carry is not there then answer is -ve.

Step-5 Find out 1's compliment of result and represent with -ve sign.

ans = - (0011)

2's compliment method of substraction.

EX-1

```
  0110
- 0011
------
```

Step-1 write the 1st number.

Step-2 Find the 2's compliment of 2nd number.

1100+1

Step-3 Add both the number.

```
  0110
+ 1101
------
 (1)0011
```

Carry

Step-4 If carry is there then remove the carry and represent by +ve sign.

ans :- + (0011)

EX-2

Step-1 0 0011

Step-2 1's of 2nd no.

```
     1001
      + 1
     ----
2's  1010
```

Step-3

$$\begin{array}{r} 0011 \\ 1010 \\ \hline 1101 \end{array}$$

Step-4 If carry is not there the result is -ve

Step-5 Find out 2's compliment of result & represent with -ve sign.

$$\begin{array}{lr} 1's & 0010 \\ & +1 \\ \hline 2's & -(0011) \end{array}$$

Sign magnitude

+ve → 0, 1100 (+12)

-ve → 1, 1100 (-12)

one extra bit is required for sign representation.

Logic gate and Boolean ~~Expression~~ Algebra

A logic gate is an electronic circuit which takes one or more inputs and give one output.

NOT, AND, OR → Basic logic gates.

NAND and NOR → Universal logic gates.

Exclusive-OR or EX-OR or XOR
Exclusive-NOR or XNOR
→ special gates.

NOT Gate / Inverter Gate

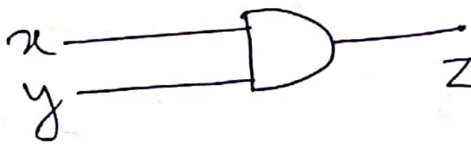
$\bar{x}$ or x'

Truth Table

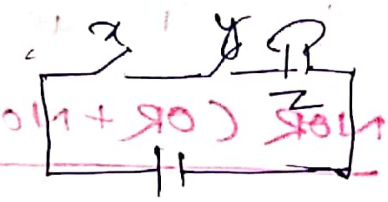
Input (x)	output ($\bar{x}$ or x')
0	1
1	0

$\bar{\bar{x}} = x$

AND Gate

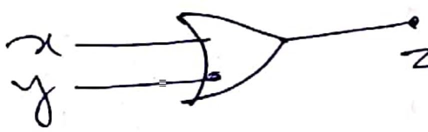


$Z = x \cdot y$

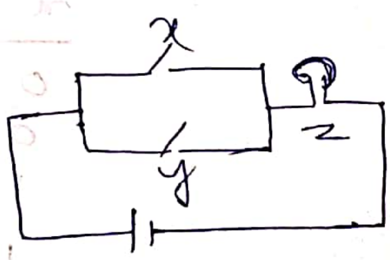


x	y	$Z = x \cdot y$
0	0	0
0	1	0
1	0	0
1	1	1

OR Gate



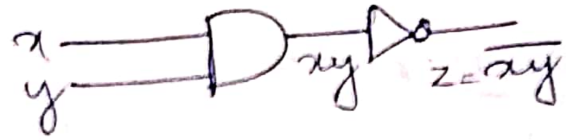
$Z = x + y$



x	y	$Z = x + y$
0	0	0
0	1	1
1	0	1
1	1	1

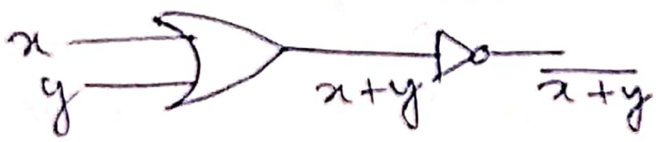
→ Binary arithmetic output depends upon the no. of input but binary logic output always one digit i.e. 0 or 1.

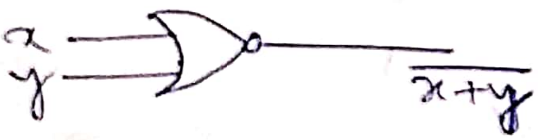
NAND Gate (AND + NOT)



x	y	$z = \overline{xy}$
0	0	1
0	1	1
1	0	1
1	1	0

NOR (OR + NOT)



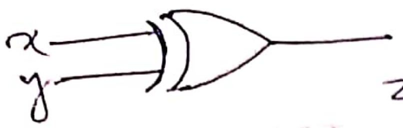


x	y	$z = \overline{x+y}$
0	0	1
0	1	0
1	0	0
1	1	0

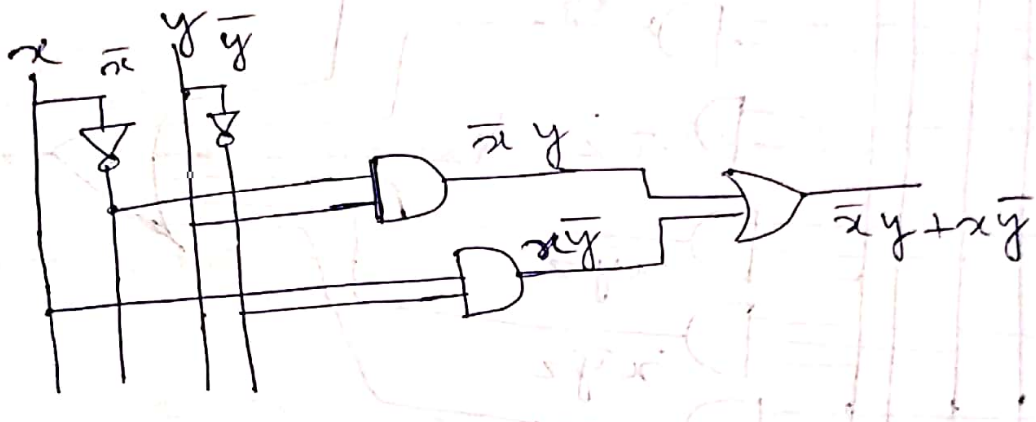
EX-OR Gate

$Z = \bar{x}y + x\bar{y}$

x	y	$Z = \bar{x}y + x\bar{y}$
0	0	0
0	1	1
1	0	1
1	1	0



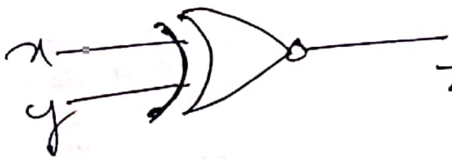
$Z = \bar{x}y + x\bar{y}$
$= x \oplus y$



EX-NOR

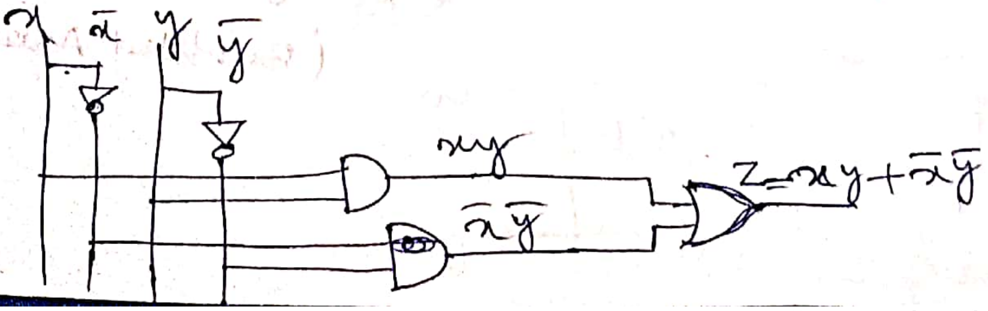
Complement of X-OR

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



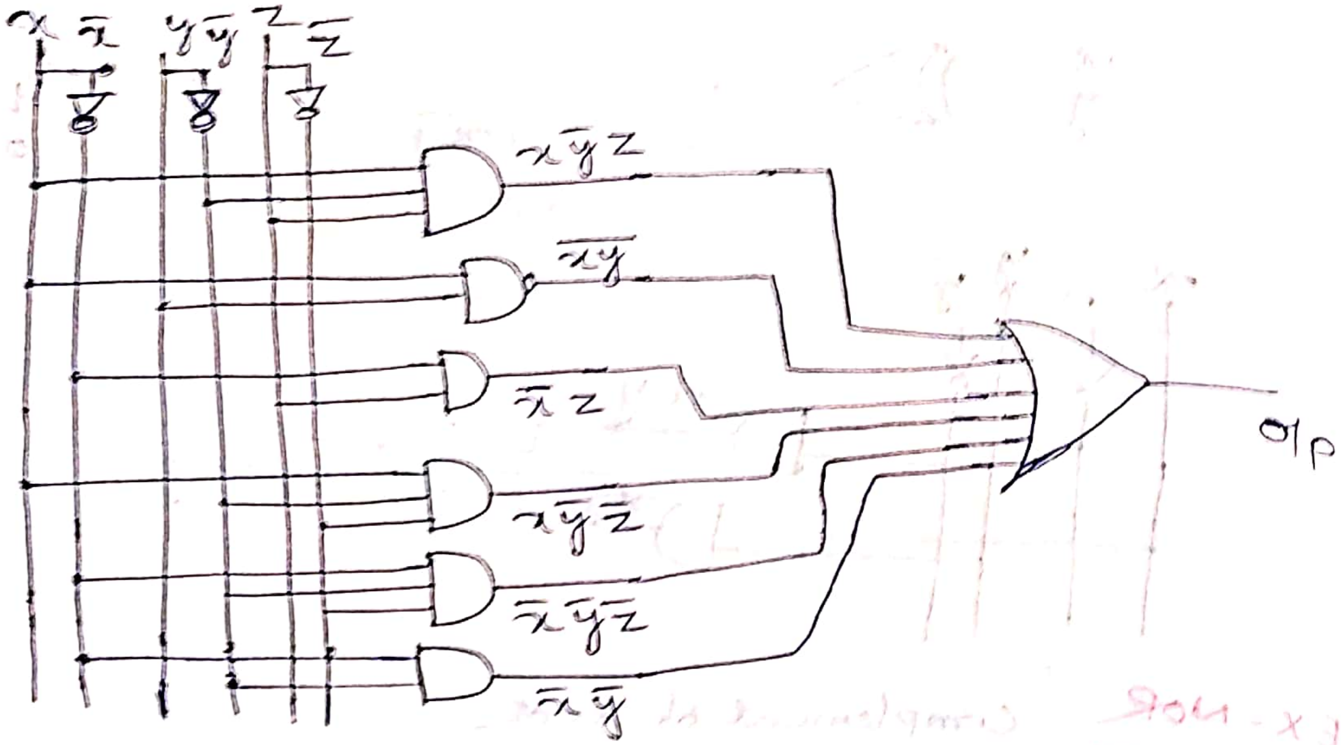
$Z = x \odot y$

x	y	$Z = xy + \bar{x}\bar{y}$
0	0	1
0	1	0
1	0	0
1	1	1



Q1 $f(x,y,z) = x\bar{y}z + \overline{xy} + \bar{x}z + x\bar{y}\bar{z} + \bar{x}\bar{y}\bar{z} + \bar{x}\bar{y}$

Implement the function by logic gates.



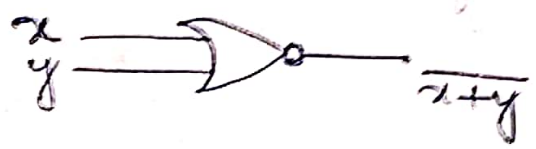
Demorgan's Law/theorem

two theorems are there

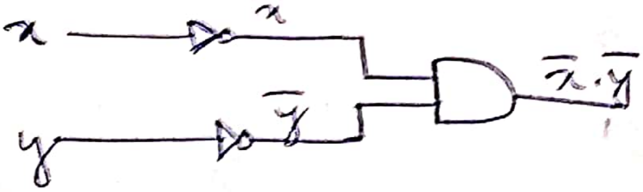
1) $\overline{x+y} = \bar{x}\cdot\bar{y}$

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

LHS



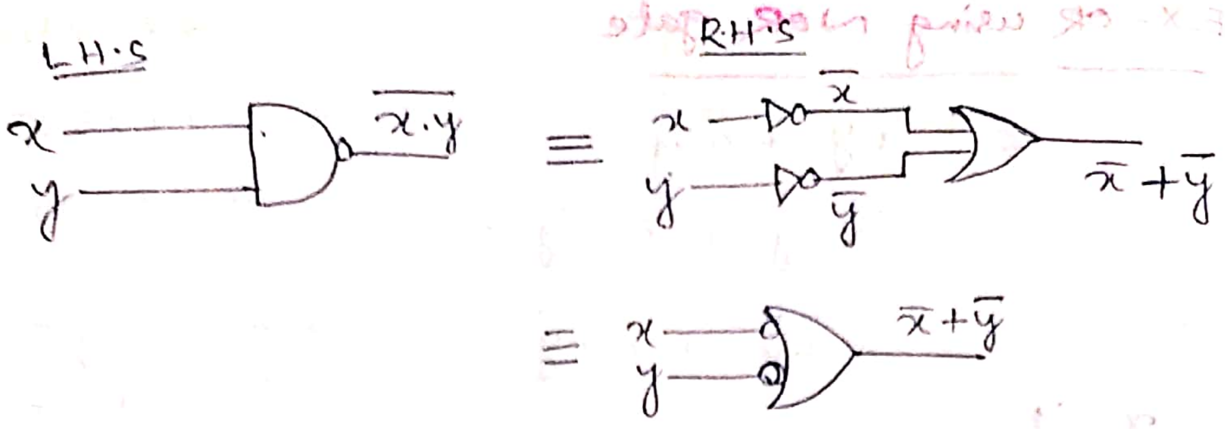
RHS



$\equiv$

(Bubbled AND Gate)

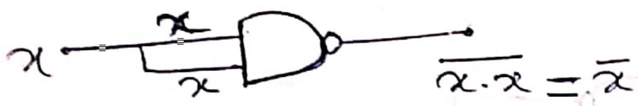
2)



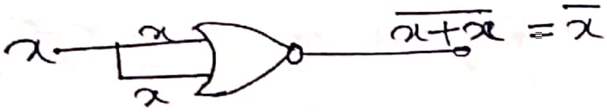
Universal gates

NAND & NOR Gates are called universal gates.

1) NAND as NOT :-



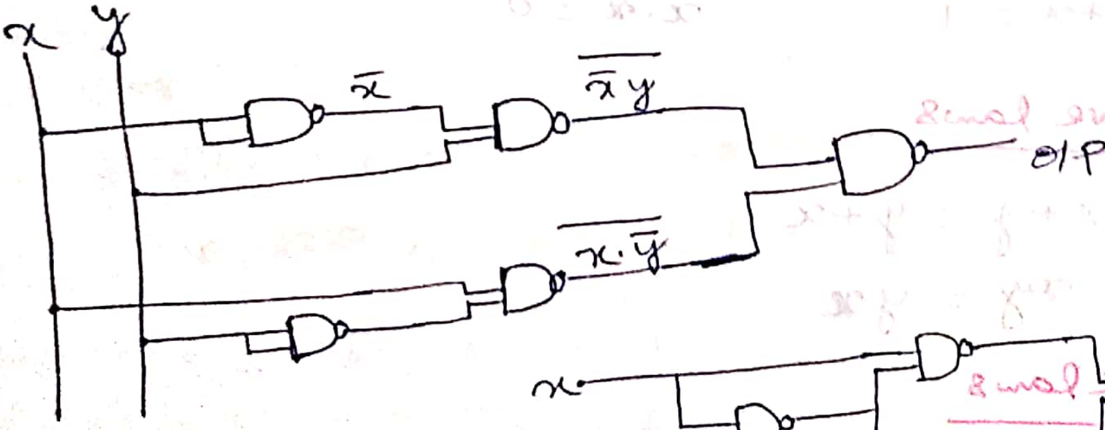
2) NOR as NOT :-

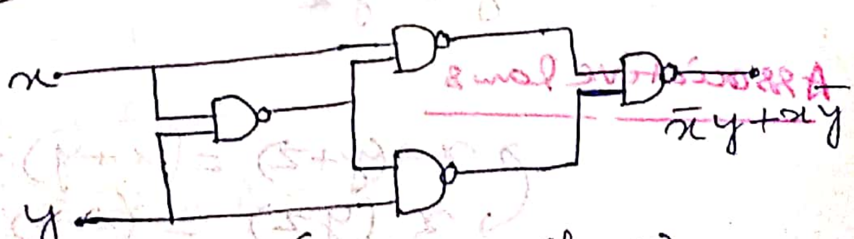


EX-OR using NAND

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

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





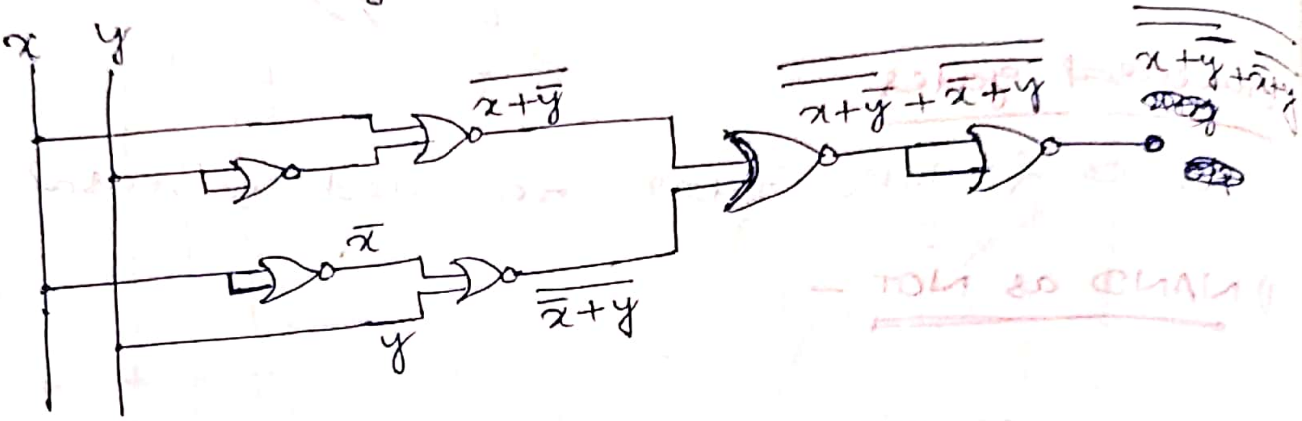
(Daimond Shape)

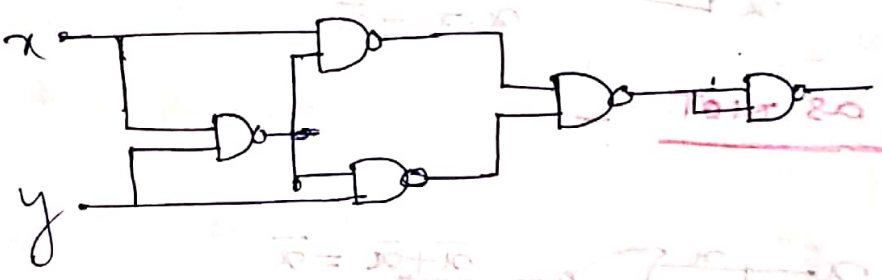
EX-OR using NOR gate

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

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

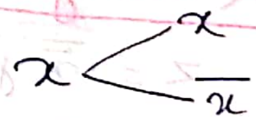
$$= \overline{\overline{\overline{x+\bar{y}} + \overline{\bar{x}+y}}}$$





Boolean Algebra

OR laws	AND laws
$x+0=x$	$x\cdot 0=0$
$x+1=1$	$x\cdot 1=x$
$x+x=x$	$x\cdot x=x$
$x+\bar{x}=1$	$x\cdot\bar{x}=0$



Commulative laws

$$x+y=y+x$$

$$xy=yx$$

Associative laws

$$x+(y+z)=(x+y)+z$$

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

Distributive law :-

$$x\cdot(y+z) = xy + xz$$

$$x + yz = (x+y)(x+z)$$

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

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

Demorgan's Rule/law

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

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

Q// $F = x\bar{y} + \bar{x}y + xy$

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

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

$$= x + y$$

Q// $F = xy\bar{z} + xyz + \bar{x}y + xy$

Ans :- $F = xy(\bar{z}+z) + y(\bar{x}+x)$

$$= xy + y$$

$$= y(x+1)$$

$$= y$$

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Q// Simplify the Boolean expression :

$$f = \cancel{ABB}\ \overline{AB+AC} + A\bar{B}C$$

ans :- $f = \overline{AB+AC} + A\bar{B}C$

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

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

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

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

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

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

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

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

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

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

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

Standard representation of Boolean Expression

1 → minterm
0 → maxterm

x	y	minterm 'm' (SOP)	maxterm "M" (POS)
0	0	$\overline{x}\cdot\overline{y} = m_1$	$x+y = M_1$
0	1	$\overline{x}\cdot y = m_2$	$x+\overline{y} = M_2$
1	0	$x\cdot\overline{y} = m_3$	$\overline{x}+y = M_3$
1	1	$x\cdot y = m_4$	$\overline{x}+\overline{y} = M_4$

→ No. of minterms = No. of maxterms $= 2^n$

→ minterms = Complement of Maxterms & viceversa

Ex:-

x	y	F
0	0	0
0	1	1
1	0	1
1	1	0

$$SOP = \bar{x}y + x\bar{y}$$
$$POS = (x+y)\cdot(\bar{x}+\bar{y})$$

Ex:-

x	y	z	F
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	
1	1	1	1

$$SSOP = \underset{0\,0\,1}{\bar{x}\bar{y}z} + \underset{0\,1\,0}{\bar{x}y\bar{z}} + \overset{1\,0\,1}{x\bar{y}z} + \overset{1\,1\,1}{xyz}$$

Standard form means all variables will be present in compliment or in the same form.

$$= m_1 + m_2 + m_5 + m_7$$

$$= \sum m(1,2,5,7)$$

POS

$$F(x,y,z) = \underset{0\;0\;0}{(x+y+z)}\cdot\overset{0\;1\;1}{(x+\bar{y}+\bar{z})}\cdot\overset{1\;0\;0}{(\bar{x}+y+z)}\cdot\underset{1\;1\;0}{(\bar{x}+\bar{y}+z)}.$$

$= M_0 \cdot M_3 \cdot M_4 \cdot M_6$

$= \Pi M(0,3,4,6)$

Q// $F(x,y,z) = \Sigma m(1,2,4,7)$. what is it's equivalent canonical form or $\Pi M = ?$

$\Pi M (0,3,5,6)$

Q// ~~what~~ $f(x,y,z) = \Sigma m(0,1,2,3,4,5,6,7)$ equivalent canonical form ?

ans :- does not exist.

Q// $F(x,y,z) = \Sigma m(0,1,2,3,4,5,6,7)$

$= 1$

Q// $F(x,y,z) = \Pi M(0,1,2,3,4,5,6,7)$

$= 0$

→ Sum of all the minterms of a given boolean equation is unity.

→ The product of all the maxterms of a given boolean equation is equal to zero.

SOP

$F(x,y,z) = xy + \bar{x}y\bar{z} + \bar{x}yz$

Convert into standard SOP.

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

$= xyz + xy\bar{z} + \bar{x}y\bar{z} + \bar{x}yz$

$\quad 111 \quad\; 110 \quad\; 010 \quad\; 011$

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

POS $F(x,y,z) = (x+y)\cdot(\bar{x}+\bar{y}+z)$

Convert into Standard POS.

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

$= (\underset{0}{x}+\underset{0}{y}+\underset{0}{z})(\underset{0}{x}+\underset{0}{y}+\underset{1}{\bar{z}})\cdot(\underset{1}{\bar{x}}+\underset{1}{\bar{y}}+\underset{0}{z})$

$= \pi M(0,1,6)$

$= \Sigma m(2,3,4,5,7)$

Q// $F = xy + yz + \bar{x}\bar{y}\bar{z}$. Implement the function in SOP.

Soln: $F = xy(z+\bar{z}) + yz(x+\bar{x}) + \bar{x}\bar{y}\bar{z}$

$= xyz + xy\bar{z} + xyz + \bar{x}yz + \bar{x}\bar{y}\bar{z}$

$= \underset{111}{xyz} + \underset{110}{xy\bar{z}} + \underset{011}{\bar{x}yz} + \underset{000}{\bar{x}\bar{y}\bar{z}}$

$= \Sigma m(0,3,6,7)$

Q// Implement the function in P.O.S.

$(x+y)(y+z)(z+x)$.

ans:- $(x+y+z\cdot\bar{z})\cdot(y+z+x\cdot\bar{x})\cdot(z+x+y\cdot\bar{y})$

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

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

Q// $F(x,y,z) = \Sigma m(0,1,6,7)$ simply using SOP concept.

$= 000 + 001 + 110 + 111$

$= \bar{x}\bar{y}\bar{z} + \bar{x}\bar{y}z + xy\bar{z} + xyz$

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

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

K-map (Karnaugh-map)

No. of cells $= 2^n$ ($n =$ no. of variable)

Two variable K-map

$x \backslash y$	0 $\bar{y}$	y 1
0 $\bar{x}$	0	1
1 x	2	3

① $F = \bar{x}y + x\bar{y}$

$= \Sigma m(1,2)$

$x \backslash y$	0	1
0	0	1
1	1	0

② $f(x,y) = \bar{x}y + x\bar{y} + \bar{x}\bar{y}$

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

$x \backslash y$	0 $\bar{y}$	1 y
0 $\bar{x}$	1	1
1 x	1	0

③ $f(x,y) = \bar{x}y + x\bar{y} + xy$

$= x + y$

$x \backslash y$	$\bar{y}$	y
$\bar{x}$ 0	0	1
x 1	1	1

3-Variable K-map

$x \backslash yz$	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	0	1	3	2
x 1	4	5	7	6

Q// $f(x,y,z) = \Sigma m(2,3,4,5)$

$x \backslash yz$	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	0	0	1	1
x 1	1	1	0	0

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

Q// $f(x,y,z) = \Sigma m(2,3,5,7)$

$x \backslash yz$	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	0	0	1	1
x 1	0	1	1	0

$= \bar{x}y + xz$.

Assignment

1. $F(x,y,z) = \Sigma m(1,2,3,4,5,7)$
2. $F(x,y,z) = \Sigma m(0,2,4,5,6,7)$

(1)

x \ yz	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	0	1	1	1
x 1	1	1	1	0

$= z + \bar{x}y + x\bar{y}$

(2)

x \ yz	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	1	0	0	1
x 1	1	1	1	1

$= x + \bar{z}$

→ one pair eliminates 1 variable.
one quad " 2 variables.
one octate " 3 variables-

Pair 2^{1} → eliminate
quad 2^{2}
octate 2^{3}

4-variables K-map

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	0	1	3	2
$\bar{A}B$ 01	4	5	7	6
AB 11	12	13	15	14
$A\bar{B}$ 10	8	9	11	10

Q1/ $F(A,B,C,D) = \sum m(0,2,4,5,6,8,9,10,11,12,13)$

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	1	0	0	1
$\bar{A}B$ 01	1	1	0	1
AB 11	1	1	0	0
$A\bar{B}$ 10	1	1	1	1

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

Q1/ $F(A,B,C,D) = \sum m(0,1,2,3,8,9,10,11,6,7,14,15)$

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	1	1	1	1
$\bar{A}B$ 01	0	0	1	1
AB 11	0	0	1	1
$A\bar{B}$ 10	1	1	1	1

$= \bar{B} + C$

Q1/ $f(A,B,C,D) = \prod M(1,3,5,6,11,13,15)$

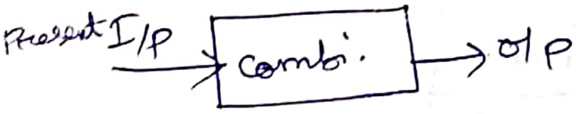
AB \ CD	00	01	11	10
00	1	0	0	1
01	1	0	1	0
11	1	0	0	1
10	1		0	1

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

Digital circuits

classified into 2 groups

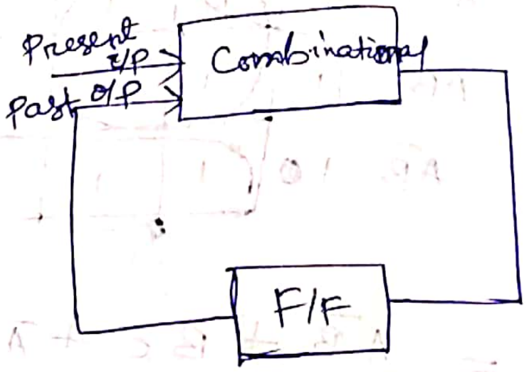
Combinational ckt



EX :- Half Adder, FA,
Half Substractor, FS,
Encoder, Decoder,
MUX, DEMUX, ROM

→ The ckt which consist of only logic gates is Combinational ckt.

Sequential ckt



EX :- Counter, Register,
R/W memory etc.

→ Consist of logic gates & memory elements.

Combinational ckt

① Half Adder

x	y	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

For Sum

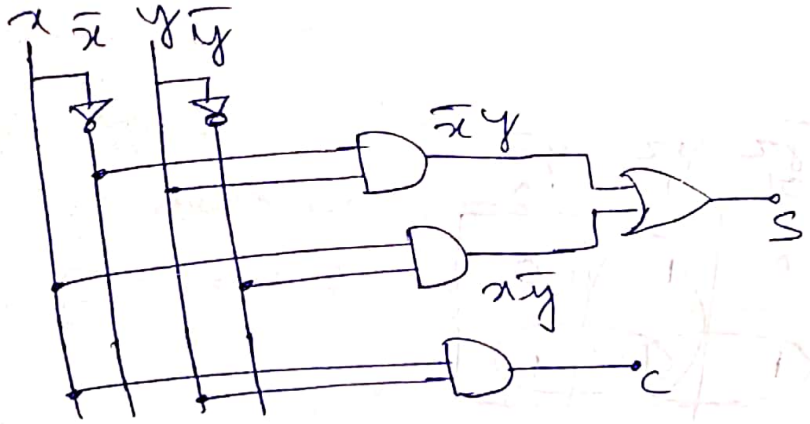
x \ y	0	1
0	0	1
1	1	0

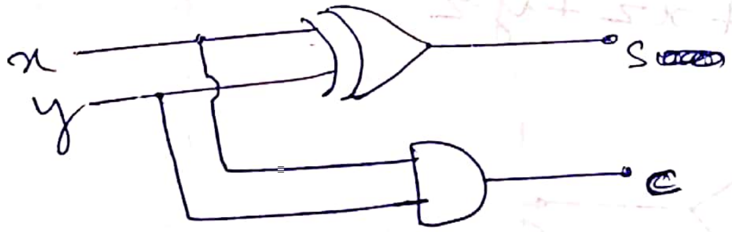
$S = \bar{x}y + x\bar{y}$

for carry

x \ y	0	1
0	0	0
1	0	1

$C = xy$





Full Adder

x	y	z	S	C
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

For Sum

x \ yz	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	0	1	0	1
x 1	1	0	1	0

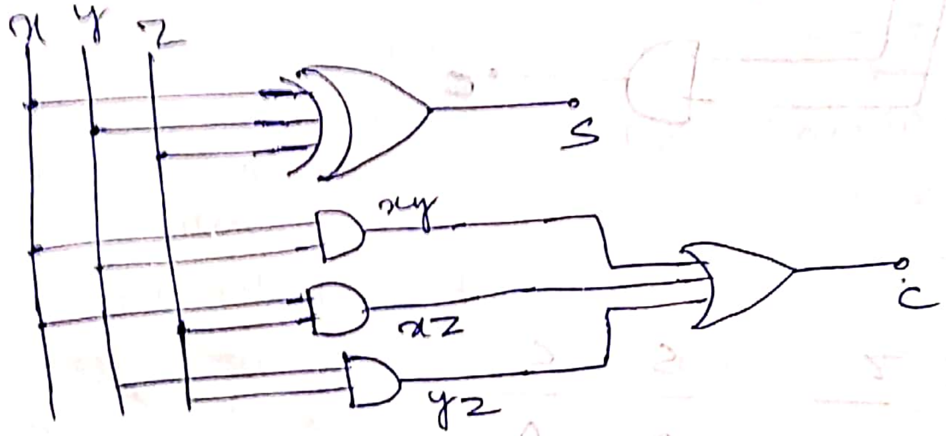
$$= \bar{x}\bar{y}z + \bar{x}y\bar{z} + x\bar{y}\bar{z} + xyz$$

$$= x \oplus y \oplus z$$

For carry

x \ yz	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	0	0	1	0
x 1	0	1	1	1

$$= xy + xz + yz$$



Four bit Binary Parallel Adder

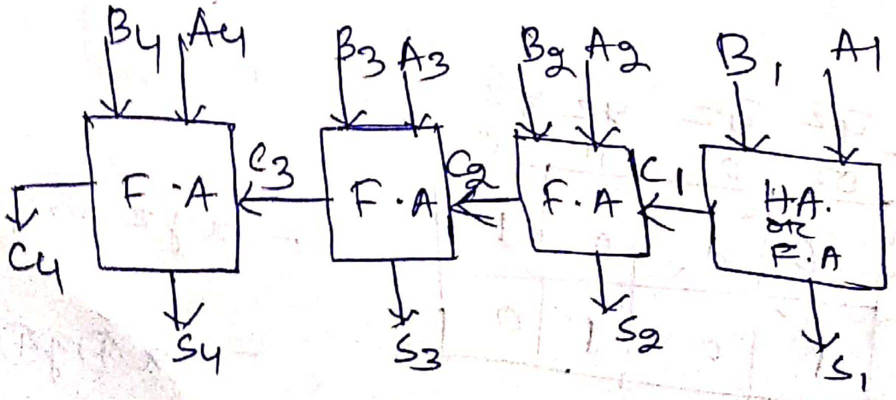
$$A = \overset{A_4 A_3 A_2 A_1}{1\,0\,1\,1}$$

$$B = \overset{B_4 B_3 B_2 B_1}{1\,1\,0\,1}$$

$$11000$$

$C_3(1)$ $C_2(1)$ $C_1(1)$

	A_4	A_3	A_2	A_1
	1	0	1	1
	B_4	B_3	B_2	B_1
	1	1	0	1
C_4 ← 1	1	0	0	0
	S_4	S_3	S_2	S_1



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Substractor

It is two types

1. Half Substractor
2. Full Substractor

① Half Substractor

x	y	D	B
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

For Difference

x \ y	0	1
0	0	1
1	1	0

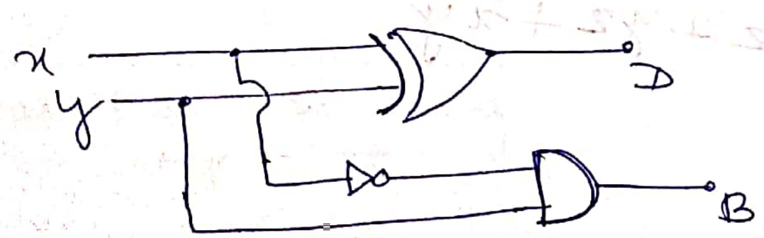
$= \bar{x}y + x\bar{y}$

$= x \oplus y$

For Borrow

x \ y	0	1
0	0	1
1	0	0

$B = \bar{x}y$



Full substractor :-

x	y	z	D	B
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

For Difference

$x \backslash yz$	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	0	1	0	1
x 1	1	0	1	0

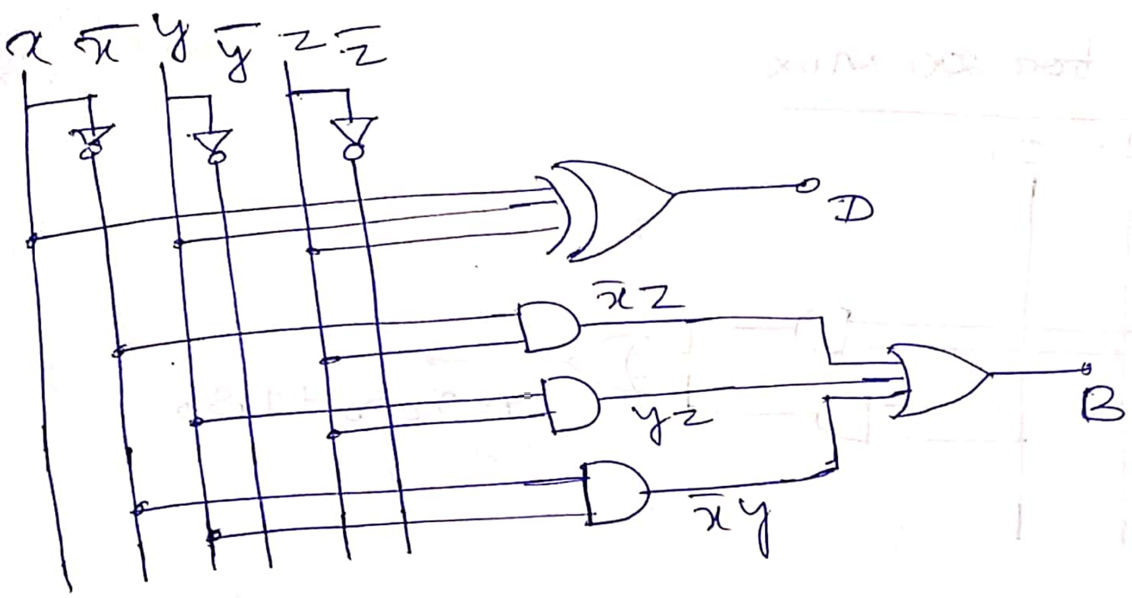
$$D = x \oplus y \oplus z$$

For Borrow

$x \backslash yz$	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
0	0	1	1	1
1	0	0	1	0

$$= \bar{x}z + yz + \bar{x}y$$

Scanned with CamScanner


x x̄ y ȳ z z̄
D
x̄z
yz
x̄y
B