UNIT - 1

A Decimal no. such as 7392 represents a quantity equal to 7 thousand plus 3 hundreds, plus 9 tens plus 2 units. The thousands, hundreds, etc are powers of 10 implied by the position of the coefficients. To be more exact, 7392 should be written as -

$$7 \times 10^3 + 3 \times 10^2 + 9 \times 10^1 + 2 \times 10^0$$

There are numbers with different bases -

i) Decimal (base 10)

ii) Binary (base 2)

iii) Octal (base 8)

iv) Hexadecimal (base 16)

TABLE - No. with different bases

DECIMAL (BASE 10)	BINARY (BASE 2)	OCTAL (BASE 8)	HEXADECIMAL BASE
00	0000	00	0
01	0001	01	1
02	0010	02	2
03	0011	03	3
04	0100	04	4
05	0101	05	5
06	0110	06	6
07	0111	07	7
08	1000	10	8
09	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

Q. Convert $(24.25)_{10}$ In base 2, 4, 8, 16.

$(24.25)_{10}$

i) $(24.25)_2 =$

$$\begin{array}{r|ll} 2 & 24 & \\ 2 & 12 & 0 \\ 2 & 6 & 0 \\ 2 & 3 & 0 \\ 2 & 1 & 1 \\ & & 1 \end{array} \uparrow$$

$0.25 \times 2 = 0.50$

$0.50 \times 2 = 1.00 \downarrow$

$(24.25)_2 = (11000.01)_2$

ii) $(24.25)_4 =$

$$\begin{array}{r|ll} 4 & 24 & \\ 4 & 6 & 0 \\ 4 & 1 & 2 \\ & & 1 \end{array} \uparrow$$

$0.25 \times 4 = 1.00 \downarrow$

$(24.25)_4 = (120.1)_4$

iii) $(24.25)_8 =$

$$\begin{array}{r|ll} 8 & 24 & \\ 8 & 3 & 0 \\ & & 3 \end{array} \uparrow$$

$0.25 \times 8 = 2.0 \downarrow$ $= (30.2)_8$

iv) $(24.25)_{16} = $

$$\begin{array}{r|l} 16 & 24 \\ \hline 16 & 1 \quad 8 \\ \hline & \quad\ \ 1 \end{array} \uparrow$$

$0.25 \times 16 = 4.00 \downarrow$

$= (18.4)_{16}$

The given no. may be a combination of Integer and fractional part. In this case we divide the integer by the given base in which we have to convert the no. and we multiply the fractional part of no. with the base.

$$(N)_{10} = (\ )_r$$

$$\downarrow$$

$$(n) + (m)$$

$$\downarrow \qquad \downarrow$$

Int Frac.

Ex- $(63.24)_{10} = (\ )_5$

$(63.24)_5 =$

$$\begin{array}{r|l} 5 & 63 \\ \hline 5 & 12 \quad 3 \\ \hline 5 & 2 \quad 2 \\ & \quad\ \ 2 \end{array} \uparrow$$

LESS SIGNIFICANT BITS

MOST SIGNIFICANT BITS

$0.24 \times 5 = 1.20$

$0.20 \times 5 = 1.00 \downarrow$

$= (223.11)_5$

Ex-

$$(1101.100)_2 = (?)_{10}$$

$$(321.21)_4 = (?)_{10}$$

$$(625.25)_8 = (?)_{10}$$

$$(A4)_{16} = (?)_{10}$$

Conversion of Binary Numbers Into decimals

$(1101.100)_2$

$1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 0 \times 2^{-2}$
$+ 0 \times 2^{-3}$

$8 + 4 + 0 + 1 + 0.5 + 0 + 0$

$13 + 0.5$

$(13.5)_{10}$

$(321.21)_4$

$3 \times 4^2 + 2 \times 4^1 + 1 \times 4^0 + 2 \times 4^{-1} + 1 \times 4^{-2}$

$48 + 8 + 1 + 0.5 + 0.625$

$57 + 0.6 + 0.5$

$(58.125)_{10}$

$(625.25)_8$

$6 \times 8^2 + 2 \times 8^1 + 5 \times 8^0 + 2 \times 8^{-1} + 5 \times 8^{-2}$

$384 + 16 + 5 + 0.25 + 0.007$

$(405.32)_{10}$

$(A.4)_{16}$

$A \times 16^{1} + 4 \times 16^{-1}$

$160 + 0.25$

$(160.25)_{10}$

OCTAL & HEXADECIMAL NUMBERS -

$(3212.212)_4 = (?)_2$

$= (11100110.100110)_2$

$(756.45)_8 = (111101110.100101)_2$

$(A2C)_{16} = (1010\ 0010\ 1101)_2$

$(10212)_{16} =$

$(\underbrace{01}_{1}\underbrace{01}_{1}\underbrace{01}_{1}\underbrace{11}_{3}.\underbrace{10}_{2}\underbrace{11}_{3})_2 = (1113.23)_4$

$(\underbrace{001}_{1}\underbrace{010}_{2}\underbrace{111}_{7}.\underbrace{101}_{5}\underbrace{100}_{4})_2 = (127.54)_8$

$(\underbrace{0101}_{5}\ \underbrace{0111}_{7}.\underbrace{1011}_{B}) = (57.B)_{16}$

COMPLIMENTS -

r's compliment $= (r^n)_{10} - (N)_r$

$(r-1)$'s compliment $= (r^n)_{10} - (r^{-m})_{10} - (N)_r$

$(N)_r$

$n + m$

For ex - $(65.84)_{10}$

$r = 10$

$n = 2$

$m = 2$

10's compliment $= (10^2)_{10} - (65.84)_{10}$

$= (100)_{10} - (65.84)_{10}$

$= (34.16)_{10}$

9's compliment $= (10^2)_{10} - (10^{-2})_{10} - (65.84)_{10}$

$= (100)_{10} - \left(\frac{1}{100}\right)_{10} - (65.84)_{10}$

$= (100)_{10} - (0.01)_{10} - (65.84)_{10}$

$= (34.15)_{10}$

$(65.34)_8$ $\quad r = 8$

$n = 2$

$m = -2$

8's compliment $= (8^2)_{10} - (65.34)_8$

$= (64)_{10} - (65.34)_8$

$= (100)_8 - (65.34)_8$

$= (12.44)_8$

Here the bases were not same so we converted the base which was not given in the problem. as -

$$\begin{array}{r|l} 8 & 64 \\ \hline 8 & 8 \quad 0 \\ \hline 8 & 1 \quad 0 \\ \hline & \quad 1 \end{array} \uparrow$$

7's compliment $= (8^2)_{10} - (8^{-2})_{10} - (65.34)_8$

$= (64)_{10} - \left(\frac{1}{64}\right)_{10} - (65.34)_8$

$= (100)_8 - \left(\frac{1}{100}\right)_8 - (65.34)_8$

$= (100)_8 - (0.01)_8 - (65.34)_8$

$= (12.43)_8$

$(671)_9$

$(9-1)^s$ compliment $= (9^3)_{10} - (1)_{10} - (671)_9$

$= (729)_{10} - (1)_{10} - (671)_9$

$= (1000)_9 - (1)_9 - (671)_9$

$= (217)_9$

$(1010)_2 \quad = (2)^4_{10} - (1010)_2$

$= (16)_{10} - (1010)_2$

$= (10000)_2 - (1010)_2$

$= (0110)_2$

ADDITION & SUBTRACTION & MULTIPLICATION

$(234)_5$ — Augend

$+ \ (444)_5$ — Addend

$(1233)_5$ — Sum

$(845)_{11}$

$+ \ (764)_{11}$

$14A9$

$(765)_9$ - Minuend

$- \ (388)_9$ - Subtrahend

$(366)_9$

$(4B69)_{13}$

$+ \ (38C4)_{13}$

$(8760)_{13}$

$$\begin{array}{r} (45)_7 \\ \times\ (56)_7 \\ \hline 402 \\ 324\times \\ \hline 3642 \end{array}$$

- Multiplicand
- Multiplier

$$\begin{array}{r} (683)_9 \\ \times\ (786)_9 \\ \hline 4550 \\ 6136\times \\ 5343\times\times \\ \hline 611320 \end{array}$$

SUBTRACTION USING r's compliment –

If the given expression is of the form –

$$\begin{array}{rl} M & - \text{Minuend} \\ -\ N & - \text{Subtrahend} \end{array}$$

Then First we find the 2's compliment of Subtrahend, after it we add it to the minuend and if we get the sum in more bits than in the problem then we discard the extra bits from the left. If carry is not generated then again we find the 2's compliment and write it with negative sign.

Carry will generate only when $M \geq N$ i.e when $M < N$ happen than no carry will generate.

Ex -

$$\begin{array}{r} M = 10101 \\ - \quad N = 10001 \\ \hline \end{array}$$

2's compliment of 10001 =

$$\begin{array}{r} 10001 \\ 01110 \\ + \quad 1 \\ \hline 01111 \end{array}$$

Now

$$\begin{array}{r} 10101 \\ + \quad 01111 \\ \hline 1\,00100 \end{array}$$

Discard ← 1

Result is 00100

Again If M = 10001

N = 10101

2's compliment of 10101 = 01011

Now

$$\begin{array}{r} 10001 \\ + \quad 01011 \\ \hline 11100 \end{array}$$

carry not generated, Then

2's compliment of 11100 =

$$\begin{array}{r} 11100 \\ 00011 \\ 1 \\ \hline 00100 \end{array}$$

The result is - 00100.

Ex –

$$\begin{array}{rl} M = & 1010 \\ - \quad N = & 0111 \\ \hline \end{array}$$

2's compliment of 0111 =

$$\begin{array}{rr} & 0111 \\ & 1000 \\ + & 1 \\ \hline & 1001 \end{array}$$

Then

$$\begin{array}{rr} & 1010 \\ + & 1001 \\ \hline & 10011 \end{array}$$

Discard ← 1

The result is 0011

$M = (9876)_{10}$

$N = (0384)_{10}$

10s compliment $= (10^4)_{10} - (0384)_{10}$

$= 10000 - 0384$

$= 9616$

Then

$$\begin{array}{rr} & 9876 \\ + & 9616 \\ \hline & 9492 \\ \hline \end{array}$$

Ans

Gray Code -

w	x	y	z
0	0	0	0
0	0	0	1
0	0	1	1
0	0	1	0
0	1	1	0
0	1	1	1
0	1	0	1
0	1	0	0
1	0	0	0
1	0	0	1
1	0	1	1
1	0	1	0
1	1	1	0
1	1	1	1
1	1	0	1
1	1	0	0

Binary to Gray code -

Right → left

101
111 → Gray code
100

Same - zero
different = one

$1 \rightarrow 0 \rightarrow 1 \rightarrow 0 \rightarrow 1$

$\downarrow$

$1 \leftrightarrow 1 \leftrightarrow 1 \leftrightarrow 1 \leftrightarrow 1$

$\downarrow$

$1 \quad 0 \quad 0 \quad 0 \quad 0$

Gray code to Binary Code -

Gray	1 0 0	0 1 0
Binary	1 1 1	0 1 1

Boolean Functions -

$+ = x + y$

$\cdot = x \cdot y$

$- = x' \cdot y'$

OR	AND	NOT
$0+0=0$	$0 \cdot 0 = 0$	$1 = 0$
$0+1=1$	$0 \cdot 1 = 0$	$0 = 1$
$1+0=1$	$1 \cdot 0 = 0$	
$1+1=1$	$1 \cdot 1 = 1$	

$x + y = y + x$

$0 + 0 = 0 + 0$

$0 + 1 = 1 + 0$

$1 + 0 = 0 + 1$

$1 + 1 = 1 + 1$

$x' = x'$

$1 + x' = 1$

$x + 1 = 1$

$0 + 1 = 1$

$1 + 1 = 1$

$x \cdot 1 = x$

$0 \cdot 1 = 0$

$1 \cdot 1 = 1$

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

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

x y z	yz	x+yz	x+y	x+z	(x+y)(x+z)
0 0 0	0	0	0	0	0
0 0 1	0	0	0	1	0
0 1 0	0	0	1	0	0
0 1 1	1	1	1	1	1
1 0 0	0	1	1	1	1
1 0 1	0	1	1	1	1
1 1 0	0	1	1	1	1
1 1 1	1	1	1	1	1

$$\left.\begin{aligned} x + x' &= 1 \\ 0 + 1 &= 1 \\ 1 + 0 &= 1 \end{aligned}\right\} \quad \begin{aligned} x &= 0 \\ x &= 1 \end{aligned}$$

$x \cdot x' = 0$

$0 \cdot 0 = 0$

or

$1 \cdot 0 = 0$

$x + x = x$

$x \cdot x = x$

$x + xy = 0$

$x(1+y) = x$

$$x(x+y) = x \cdot x + x \cdot y = x + xy = x(1+y)$$
$$= x$$

Duality - i) $x + xy = x$

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

ii) $x + (y + z)$

$x \cdot (y \cdot z)$

iii) $x + 1 = x \cdot 0$

AND → OR   0 → 1   Replaces

OR → AND   1 → 0

De - Morgan's law -

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

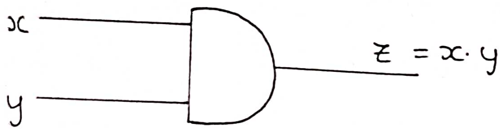
ii) $\overline{xy} = \bar{x} + \bar{y}$

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

GATES

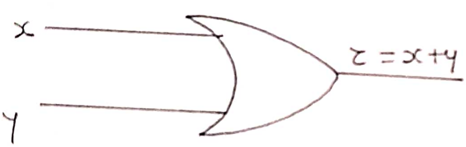
Basic Gates -

i) AND - $z = x \cdot y$



TRUTH - TABLE		
INPUT		OP
x	y	$z = x \cdot y$
0	0	0
0	1	0
1	0	0
1	1	1

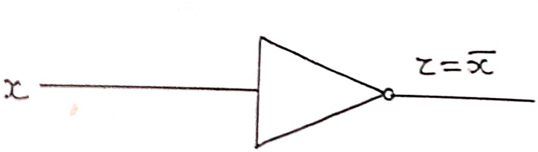
ii) OR - $z = x + y$



TRUTH - TABLE

INP		OP
x	y	$z = x + y$
0	0	0
0	1	1
1	0	1
1	1	1

iii) NOT - $z = \bar{x}$

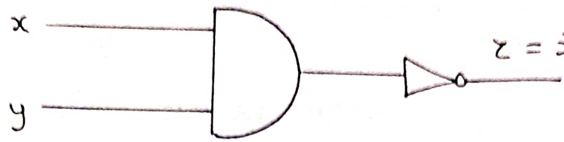


TRUTH - TABLE

I/P	O/P
x	$z = \bar{x}$
0	1
1	0

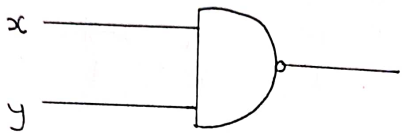
Universal Gates -

i) NAND -



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

⇓

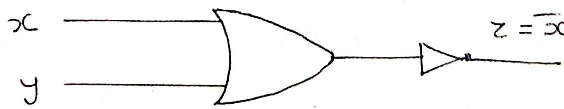


$z = \overline{x \cdot y} = \bar{x} + \bar{y}$

TRUTH TABLE

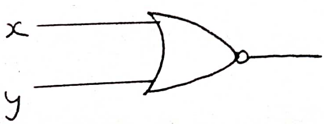
I/P		O/P
x	y	$z = \overline{xy}$
0	0	1
0	1	1
1	0	1
1	1	0

ii) NOR -



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

⇓



$z = \overline{x + y}$

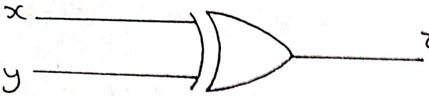
TRUTH - TABLE

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

Some other Gates -

$\oplus$ - Exclusive

i) XOR -

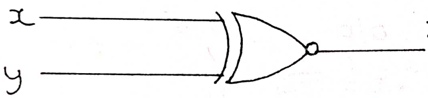


$z = x \oplus y = x\bar{y} + \bar{x}y$

TRUTH - TABLE

x	y	$z = x \oplus y$
0	0	0
0	1	1
1	0	1
1	1	0

ii) XNOR -

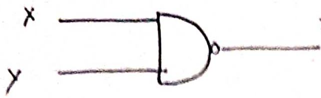


$z = \overline{x \odot y} = \bar{x}\bar{y} + xy = x \odot y$

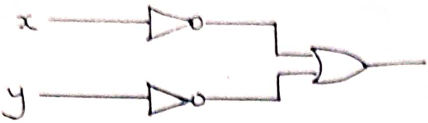
TRUTH TABLE

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

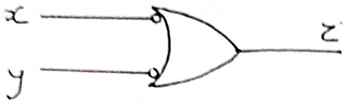
NAND GATE -



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



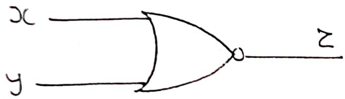
$z = \bar{x} + \bar{y}$



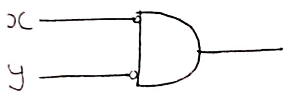
$z = \bar{x} + \bar{y} = \overline{xy}$ (Bubbled OR)

∴ Bubbled OR ~ NAND

NOR GATE -



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

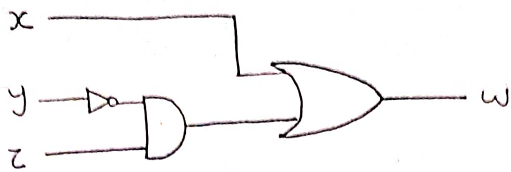


$z = \bar{x} \cdot \bar{y} = \overline{x + y}$ (Bubbled AND)

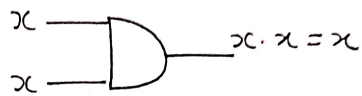
Bubbled AND ~ NOR

Bubbled OR ~ NAND

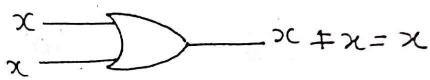
Q. $w = x + y'z$

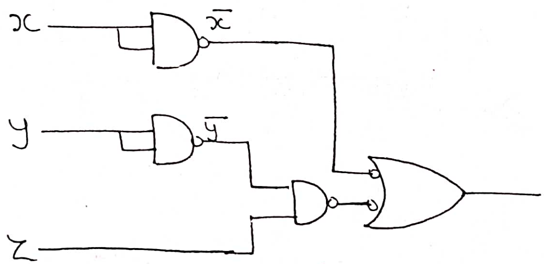


$x \cdot x = x$

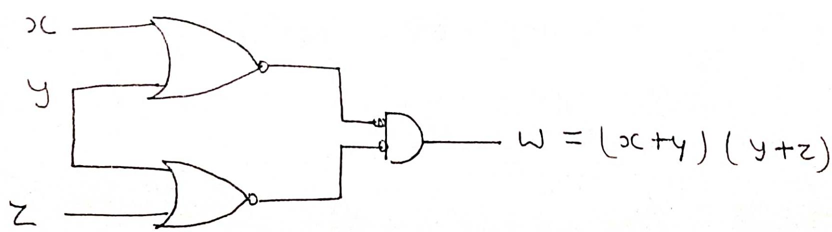


$x + x = x$





Q. $w = (x+y)(y+z)$



Some Important Points -

$x + 0 = x$ $\quad\quad$ $x \cdot 1 = x$

$x + x' = 1$ $\quad\quad$ $x \cdot x' = 0$

$x + x = x$ $\quad\quad$ $x \cdot x = x$

$x + 1 = 1$ $\quad\quad$ $x \cdot 0 = 0$

$(x')' = x$ $\quad\quad$ $(x')' = x$

$x + y = y + x$ $\quad\quad$ $x \cdot y = y \cdot x$

$x + (y + z) = (x + y) + z$ $\quad\quad$ $x \cdot (yz) = (x \cdot y) \cdot z$

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

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

$\overline{xy} = \overline{x} + \overline{y}$ $\quad\quad$ $\overline{x + y} = \overline{x} \cdot \overline{y}$

$x + xy = x$ $\quad\quad$ $x \cdot (x + y) = x$

x	y	xy	$x + xy$
0	0	0	0
0	1	0	0
1	0	0	1
1	1	1	1

$$x + xy = x(1+y)$$

$$= x \cdot 1$$

$$x + xy = x$$

$x + 0 = x$ duality $x \cdot 1 = x$

$$x + yz$$

$$\Downarrow$$

$$xz + xyz$$

$$\Downarrow$$

$$x'z' + xyz$$

Literals = simple & Complement

Q. Simplify the following Expressions –

i) $x + x'y$ ii) $x(x'+y)$ iii) $xy + x'z + yz$

Solⁿ i) $x + x'y = (x+x')(x+y)$

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

$$= (x+y)$$

ii) $x(x'+y) = xx' + xy$

$$= 0 + xy$$

$$= xy$$

iii) $xy + x'z + yz$

$xy + x'z + (x + x')(yz)$ $\{x + x' = 1\}$

$xy + x'z + xyz + x'yz$

$xy(1 + z) + x'z(1 + y)$

$xy + x'z$

Q. Find the Dual & complement of each Literals

$F_1' = x'yz' + x'y'z$

Dual - $F_1 = (x' + y + z')(x' + y' + z)$

Then complement of each literals

$F_1 = (x + y' + z)(x + y + z')$

Minterm = Sum of Product, Maxterm = Product of sum.

Max term ⇒ 0 - Normal, 1 - complement

Miniterm ⇒ 1 - Normal, 0 - Complement

x	y	z	Miniterm Term	Miniterm Designation	Maxtem Term	Maxtem Designation
0	0	0	$x'y'z'$	m_0	$(x + y + z)$	M_0
0	0	1	$x'y'z$	m_1	$(x + y + z')$	M_1
0	1	0	$x'yz'$	m_2	$(x + y' + z)$	M_2
0	1	1	$x'yz$	m_3	$(x + y' + z')$	M_3
1	0	0	$xy'z'$	m_4	$(x' + y + z)$	M_4
1	0	1	$xy'z$	m_5	$(x' + y + z')$	M_5
1	1	0	xyz'	m_6	$(x' + y' + z)$	M_6

Q. Express the Boolean function $F = A + BC$ in a sum of Miniterm.

Solⁿ

$F = A + BC$

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

$= AB(C+C') + AB'(C+C')$

$= ABC + ABC' + AB'C + AB'C'$

Term = Total no. of variables are must

$BC = (A+A')BC$

$= ABC + A'BC$

Now,

$F = ABC + ABC' + AB'C + AB'C' + ABC + A'BC$

$= ABC + ABC' + AB'C + AB'C' + A'BC$

$= M_7 + M_6 + M_5 + M_4 + M_3$

If an term occurs more than one time, then we count that term as one.

$= \Sigma(7, 6, 5, 4, 3) = \Sigma(3, 4, 5, 6, 7)$

Q. $xy + x'z$ in the form of product of maxterm.

Solⁿ-

$xy + x'z$ Let $A = xy$

$A + x'z$

$$= (A + x')(A + z)$$

$$= (xy + x')(xy + z)$$

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

$$1 \cdot (x' + y)(x + z)(y + z)$$

$$= (x' + y + zz')(x + z + yy')(y + z + xx')$$

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

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

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

$$= M_4 \cdot M_5 \cdot M_0 \cdot M_2$$

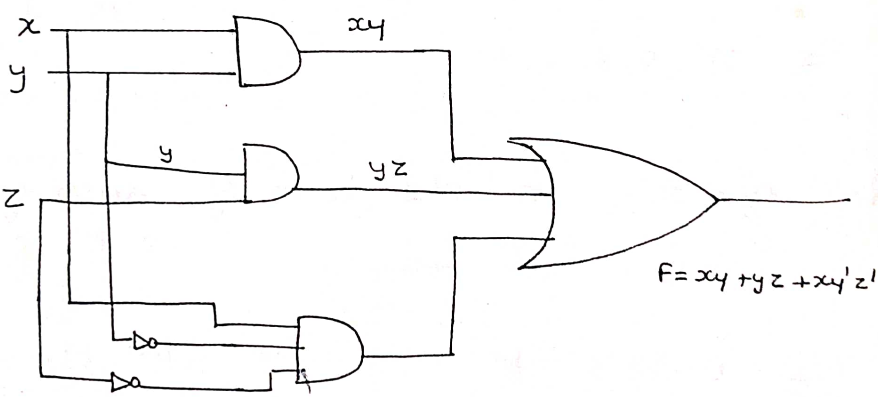
$$= \Pi(0, 2, 4, 5)$$

Q. $xy + x'z$ in the form of sum of miniterm

Q. $F = xy + yz + xy'z'$

Solution -

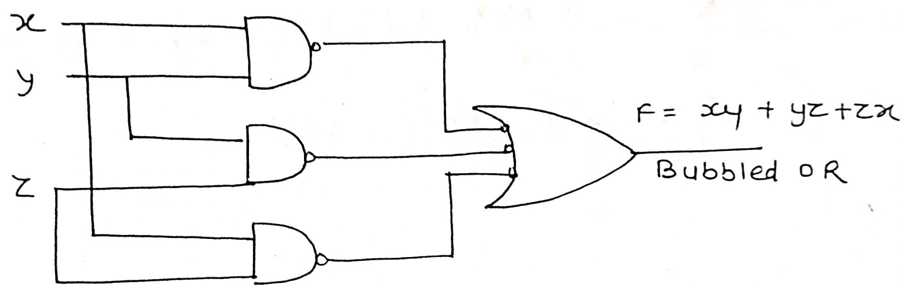
Inputs								
x	y	z	xy	yz	y'	z'	$xy'z'$	F
0	0	0	0	0	1	1	0	0
0	0	1	0	0	1	0	0	0
0	1	0	0	0	0	1	0	0
0	1	1	0	1	0	0	0	1
1	0	0	0	0	1	1	1	1
1	0	1	0	0	1	0	0	0
1	1	0	1	0	0	1	0	1
1	1	1	1	1	0	0	0	1



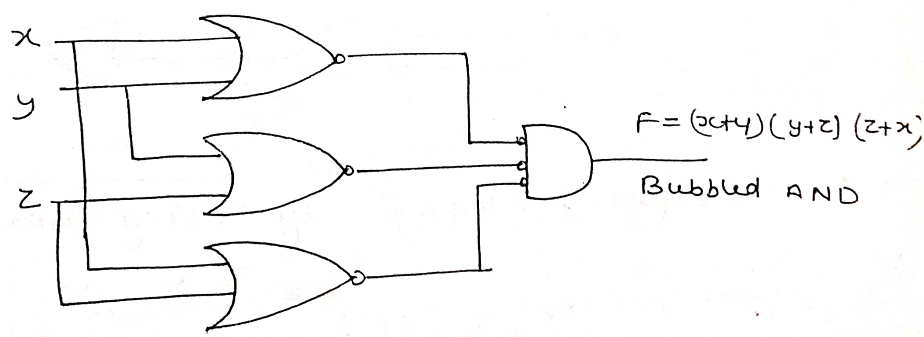
Q. i) If F= $xy + yz + zx$ is given then it is solved generally with NAND GATE because it is given in the form of sum of product.

If ii) F = $(x+y)(y+z)(z+x)$ then it is solved by using NOR gate because of Product of sum.

i) F = $xy + yz + zx$ by using NAND gates

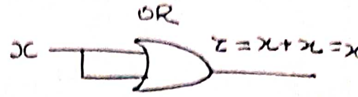


ii) F = $(x+y)(y+z)(z+x)$ by using NOR Gates

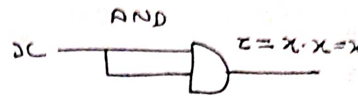


Q. Design $F = xy + yz$ by using NOR Gate.

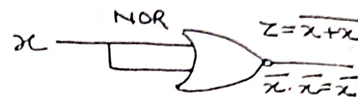
$$F = \overline{\overline{xy + yz}}$$



$$F = \overline{(\overline{xy}) . (\overline{yz})}$$

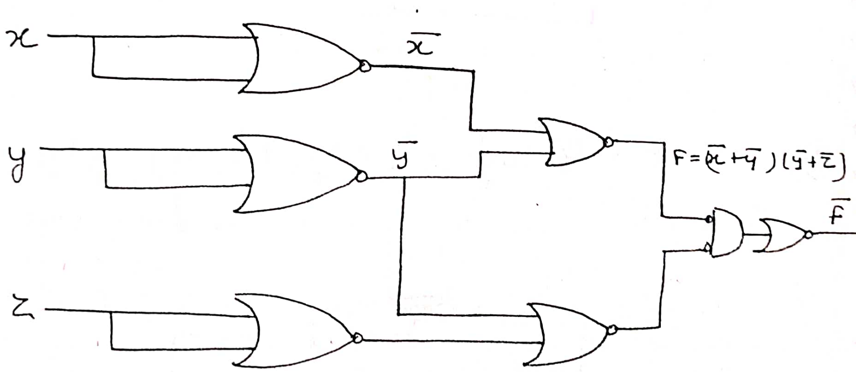


$$F = \overline{(\bar{x} + \bar{y}) . (\bar{y} + \bar{z})}$$



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

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



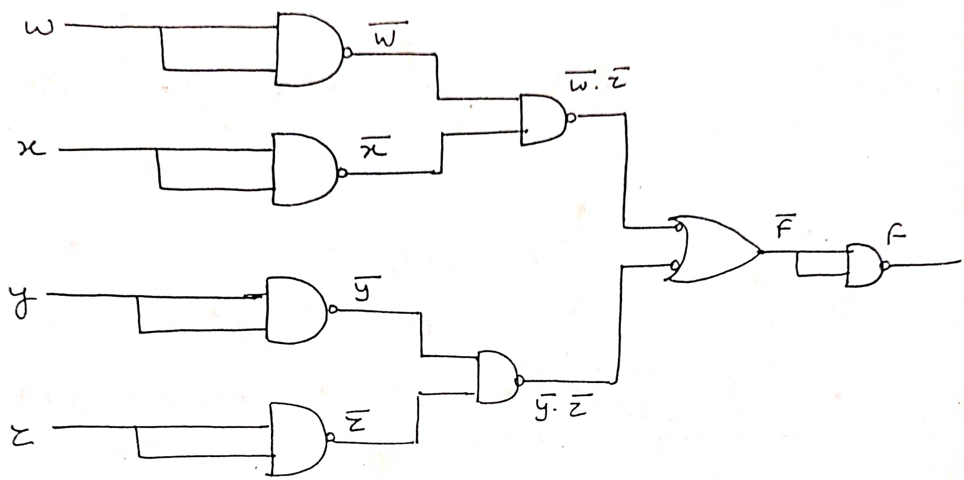
Q. $F = (w + x)(y + z)$ by using NAND gates.

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

$$F = \overline{\overline{(w + x)(y + z)}}$$

$$= \overline{\overline{(w+x)} + \overline{(y+z)}}$$

$$f = \overline{\bar{w} \cdot \bar{x} + \bar{y} \cdot \bar{z}}$$

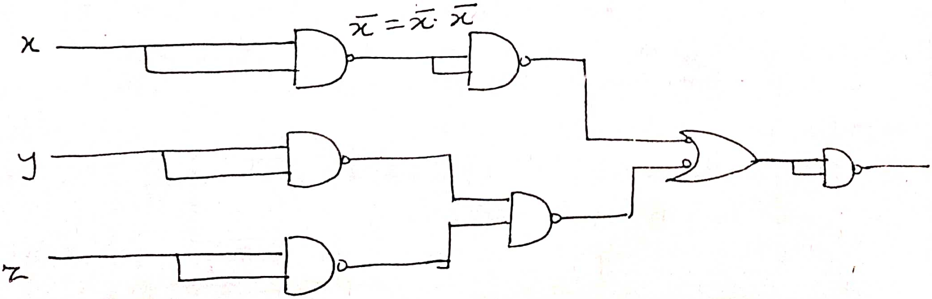


Q. $F = x(y+z)$ using NAND Gates.

$$F = \overline{\overline{x(y+z)}}$$

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

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



K – MAP (KARNAUGH MAP) –

$2^2 = 4$ (Two variables)

y - column

x (row) \ y	$\bar{y} = 0$	$y = 1$
$\bar{x} = 0$	00 $\bar{x}\bar{y}$	01 $\bar{x}y$
$x = 1$	10 $x\bar{y}$	11 xy

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

1- quad.

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

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

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

$$f = 1$$

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

2 - pairs

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

$= \bar{x}\cdot 1$ $\qquad$ $\bar{y}\cdot 1$

$f = \bar{x}$ $\qquad$ $\bar{y}$

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

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

$$= \overline{x \oplus y}$$

Q. $f = \bar{x}\bar{y} + \bar{x}y + xy$ using K-MAP.

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

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

$f = \bar{x} \cdot 1 + 1 \cdot y$

$f = \bar{x} + y$

Some cases – (Three variables) $2^3 = 8$

i)

$x \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{x}$	1	1	1	1
x	1	1	1	1

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

$f = \bar{x} \cdot 1$

$f = \bar{x}$

$f = x$ (2nd row)

ii)

1	1	1	1
1	1	1	1

Q. $F(x, y, z) = \Sigma(2, 3, 4, 5)$

$x \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{x}$			1	1
x	1	1		

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

Q. $F(x, y, z) = \Sigma(3, 4, 6, 7)$

$x \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{x}$			1	
x	1		1	1

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

Q. $F(x, y, z) = \Sigma(0, 2, 4, 5, 6)$

$x \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{x}$	1		$\cancel{1}$	1
x	1	1		1

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

Q. $F(x, y, z) = \Sigma(1, 2, 3, 5, 7)$

$x \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{x}$		1	1	1
x		1	1	

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

K-MAP using ~~Three~~ four variables – $(wxyz)$, $2^4 = 16$

SOP

$wx \backslash yz$	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{w}\bar{x}$ 00	$\bar{w}\bar{x}\bar{y}\bar{z}$ 0000 0	$\bar{w}\bar{x}\bar{y}z$ 0001 1	$\bar{w}\bar{x}yz$ 0011 3	$\bar{w}\bar{x}y\bar{z}$ 0010 2
$\bar{w}x$ 01	$\bar{w}x\bar{y}\bar{z}$ 0100 4	$\bar{w}x\bar{y}z$ 0101 5	$\bar{w}xyz$ 0111 7	$\bar{w}xy\bar{z}$ 0110 6
wx 11	$wx\bar{y}\bar{z}$ 1100 12	$wx\bar{y}z$ 1101 13	$wxyz$ 1111 15	$\bar{w}xy\bar{z}$ 1110 14
$w\bar{x}$ 10	$w\bar{x}\bar{y}\bar{z}$ 1000 8	$w\bar{x}\bar{y}z$ 1001 9	$w\bar{x}yz$ 1011 11	$w\bar{x}y\bar{z}$ 1010 10

Q.

$wx \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	1	1	1	1
$\bar{w}x$	1	1	1	1
wx	1	1	1	1
$w\bar{x}$	1	1	1	1

$F = 1$

Q. Simplify the function $F(w,x,y,z) = \sum(0,1,2,4,5,6,8,9,12,13,14)$

<u>Soln</u>

$wx \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	1	1		1
$\bar{w}x$	1	1		1
wx	1	1		1
$w\bar{x}$	1	1		

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

Q. $F(w,x,y,z) = \sum(0,1,2,6,8,9,10)$

$wx \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	1	1		1
$\bar{w}x$				1
wx				
$w\bar{x}$	1	1		1

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

Q. Simplify the following function

$$F = A'B'C' + B'CD' + A'BCD' + AB'C'$$

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

$$F = B'C' + B'C' + A'CD'$$ (Sum of Product)

K- MAP (By Product of Sum) or (Product of Maxterm)

	$y+z$	$y+\bar{z}$	$\bar{y}+\bar{z}$	$\bar{y}+z$
$w+x$	0000	0001	0011	0010
$w+\bar{x}$	0100	0101	0111	0110
$\bar{w}+\bar{x}$	1100	1101	1111	1110
$\bar{w}+x$	1000	1001	1011	1010

Q. Simplify the following by using i) SOP ii) POS

$$F(w,x,y,z) = \Sigma(0,1,2,4,8,9,10)$$

wx \ yz	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$	
$\bar{w}\bar{x}$	1	1	0	1	$w+x$
$\bar{w}x$	1	0	0	0	$w+\bar{x}$
wx	0	0	0	0	$\bar{w}+\bar{x}$
$w\bar{x}$	1	1	0	1	$\bar{w}+x$

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

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

Q. $F(A, B, C, D) = \Sigma(0, 1, 2, 5, 8, 9, 10)$

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

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

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

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

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

$SOP = \bar{B}\bar{D} + \bar{A}BD + \bar{A}BC$

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

DON'T CARE CONDITION -

$wx \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$	
$\bar{w}\bar{x}$	X	1	1	X	$w+x$
$\bar{w}x$	0	0	1	1	$w+\bar{x}$
wx	X	0	0	0	$\bar{w}+\bar{x}$
$w\bar{x}$	1	0	X	1	$\bar{w}+x$
	$y+z$	$y+\bar{z}$	$\bar{y}+\bar{z}$	$\bar{y}+z$	

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

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

Q. $F(w,x,y,z) = \Sigma(1,3,7,11,15)$

$d(w,x,y,z) = \Sigma(0,2,5)$

$wx \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$	
$\bar{w}\bar{x}$	X	1	1	X	$w+x$
$\bar{w}x$	0	X	1	0	$w+\bar{x}$
wx	0	0	1	0	$\bar{w}+\bar{x}$
$w\bar{x}$	0	0	1	0	$\bar{w}+x$
	$y+z$	$y+\bar{z}$	$\bar{y}+\bar{z}$	$\bar{y}+z$	

Q. $F(A,B,C,D) = \Sigma(5, 6, 7, 12, 14, 15)$

$d(A,B,C,D) = \Sigma(3, 9, 11)$

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

$SOP = CB + D\bar{A}B + AB\bar{D}$

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

22.08.16

UNIT-2

COMBINATIONAL & SEQUENTIAL CIRCUITS

Combinational- Output depends upon input.

Sequential- Output depends upon input as well as memory element.

INP		C	S
0+0	=	0	0
0+1	=	0	1
1+0	=	0	1
1+1	=	1	0

INP		B	D
0-0	=	0	0
φ-0	=	0	1
0-1	=	1	1
1-1	=	0	0

Half Adder- This circuit needs two binary inputs and two binary outputs.

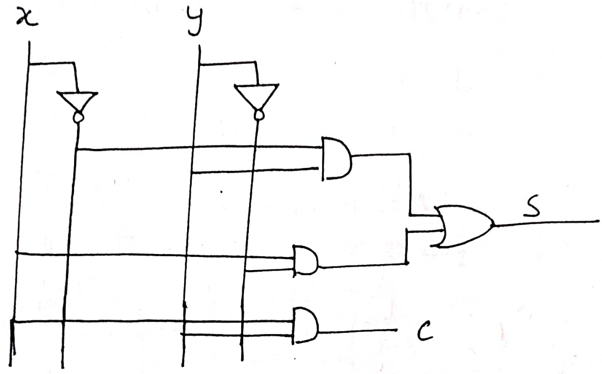
INPUTS		OUTPUT	
X	Y	C	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

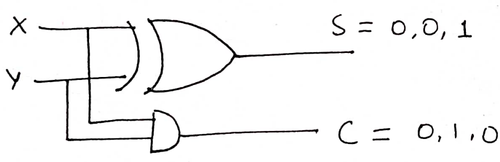
$S = \bar{x}y + x\bar{y}$ (Sum of Miniterms)

$S = x \oplus y$

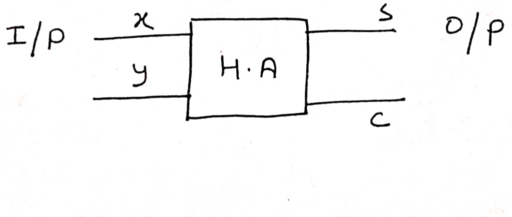
$C = xy$

Logic Diagram -





Symbolic Diagram -



Full Adder - A full Adder is a combinational circuit that forms the arithmatic sum of three bits. It consist of three inputs and two outputs.

INPUT			OUTPUT	
x	y	z	c	s
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

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

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

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

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

$$S = x \oplus t$$

$$S = x \oplus (y \oplus z)$$

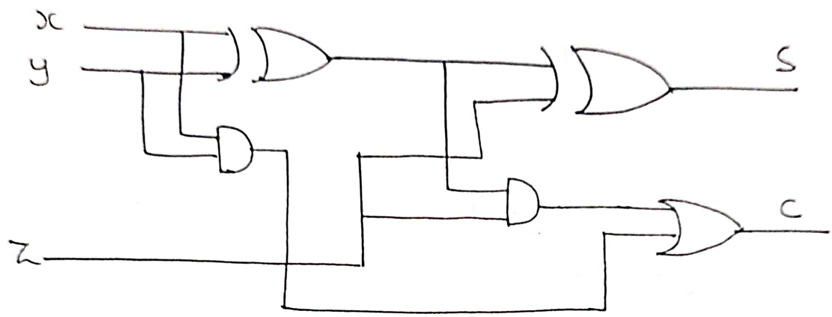
$$S = x \oplus y \oplus$$

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

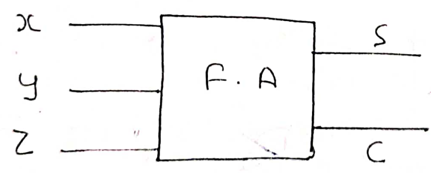
$$C = z(\bar{x}y + x\bar{y}) + xy(\bar{z}+z)$$

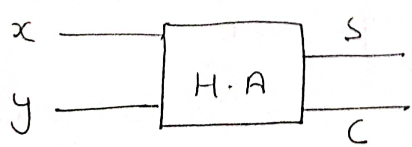
$$C = (x \oplus y)z + xy$$

logic Diagram -



Symbolic Diagram -





Half Subtractor-

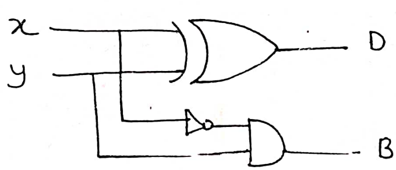
INPUT		OUTPUT	
x	y	B	D
0	0	0	0
0	1	1	1
1	0	0	1
1	1	0	0

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

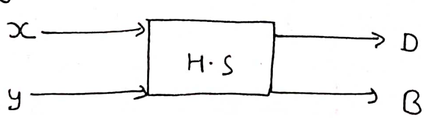
$$D = x \oplus y$$

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

Logic Diagram -



Symbolic Diagram -



Full - Subtractor-

INPUT			OUTPUT	
X	Y	Z	B	D
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	1	0
1	0	0	0	1
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

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

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

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

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

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

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

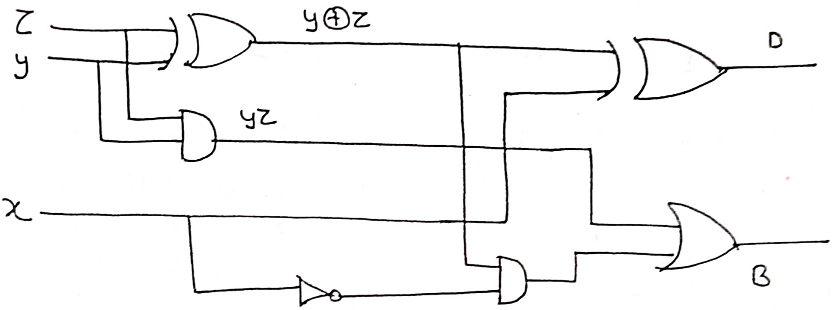
$$= \bar{x}(y \oplus z) + yz$$

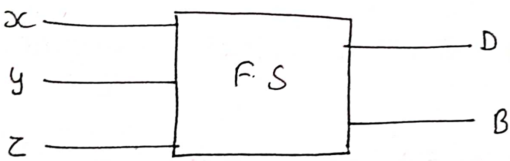
OR

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

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

Logic Diagram –

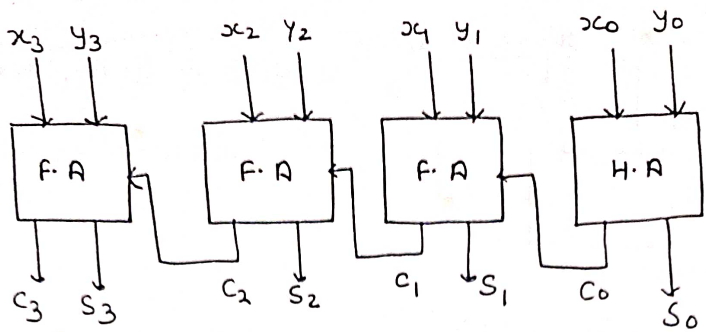




Binary Adder– Binary Adder consists one half Adder and (n) Full Adder.

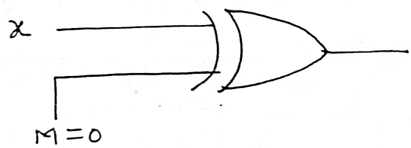
		C_2	C_1	C_0	
X	=	X_3	X_2	X_1	X_0
Y	=	Y_3	Y_2	Y_1	Y_0
C_3		S_3	S_2	S_1	S_0
		F.A	F.A	F.A	H.A

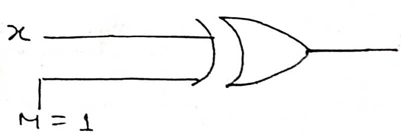
Symbolic Diagram -



✡ when we take '0' It gives the output as same as the input.

✡ when we take '1' It gives the opposite of the input. i.e compliment

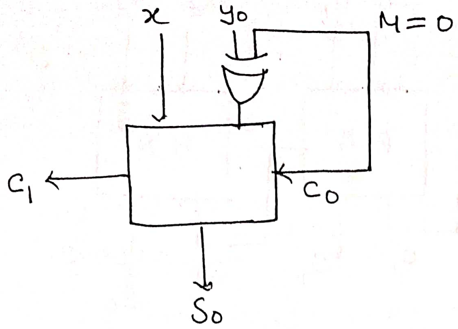




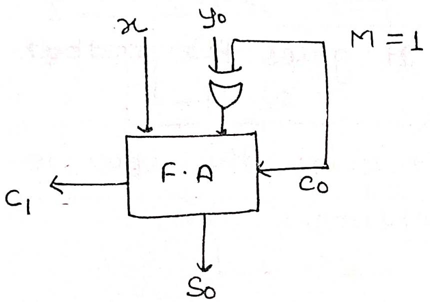
$$F = x\bar{y} + \bar{x}y$$
$$= x\cdot\bar{M} + \bar{x}\cdot M$$
$$= x\cdot 0 + \bar{x}\cdot 0$$
$$= x\cdot 1$$
$$F = x$$

$$F = x\cdot\bar{M} + \bar{x}M$$
$$= x\cdot\bar{1} + \bar{x}\cdot 1$$
$$= x\cdot 0 + \bar{x}$$
$$= 0 + \bar{x}$$
$$= \bar{x}$$

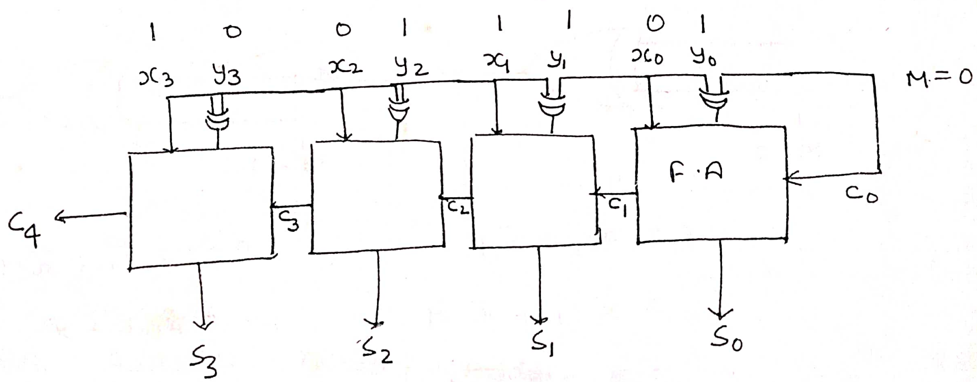
Symbolic Diagram -



$x + y$



$x + \bar{y} + 1 = x - y$



$x = 1010$

$y = 0111$

10001

M = 0 (Addition)

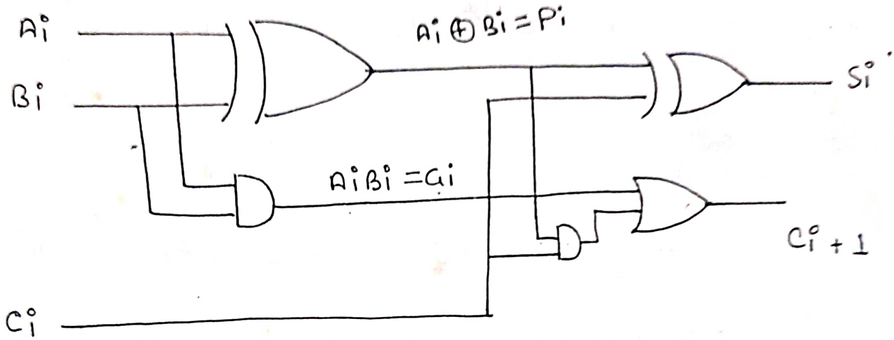
M = 1 (Subtraction)

23.08.16

CARRY PROPOGATION -

$S = A \oplus B \oplus C$

$C = (A \oplus B) C + AB$



$S_i = A_i \oplus B_i \oplus C_i = P_i \oplus C_i$

$C_{i+1} = (A_i \oplus B_i) C_i + A_i B_i = P_i C_i + G_i$

$i = 0$

$C_1 = P_0 C_0 + G_0$

$i = 1$

$C_2 = P_1 C_1 + G_1$

$= P_1 (P_0 C_0 + G_0) + G_1$

$$= \underbrace{\underbrace{P_1 P_0 C_0}_{\text{AND}} + \underbrace{P_1 G_0}_{\text{AND}}}_{\text{OR}} + G_1$$

$i = 2$

$$C_3 = P_2 C_2 + G_2$$

$$= P_2 (P_1 P_0 C_0 + P_1 G_0 + G_1) + G_2$$

$$= \underbrace{\underbrace{P_2 P_1 P_0 C_0}_{\text{AND}} + \underbrace{P_2 P_1 G_0}_{\text{AND}} + \underbrace{P_2 G_1}_{\text{AND}} + G_2}_{\text{OR}}$$

$i = 3$

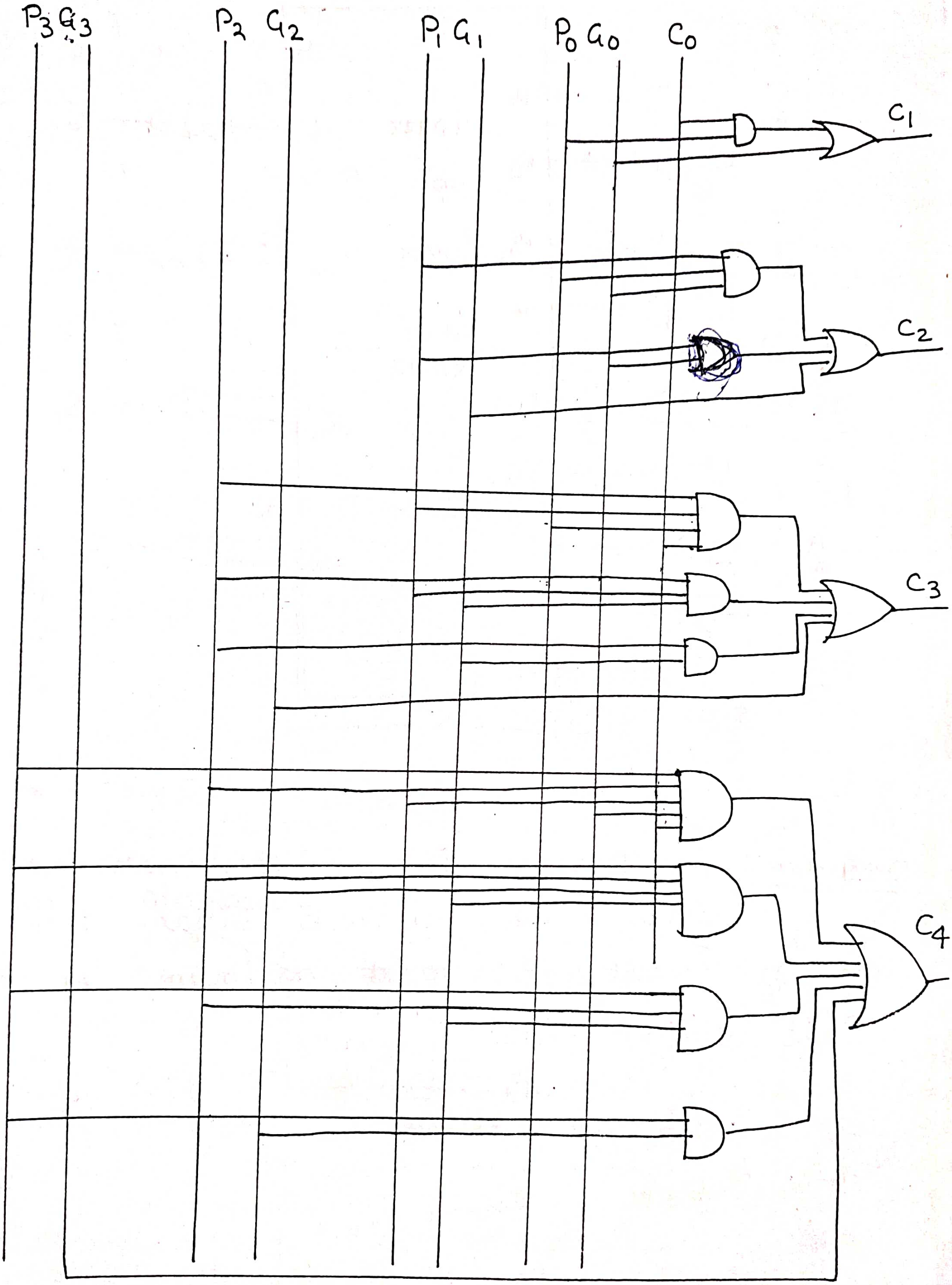
$$C_4 = P_3 C_3 + G_3$$

$$= P_3 (P_2 P_1 P_0 C_0 + P_2 P_1 G_0 + P_2 G_1 + G_2) + G_3$$

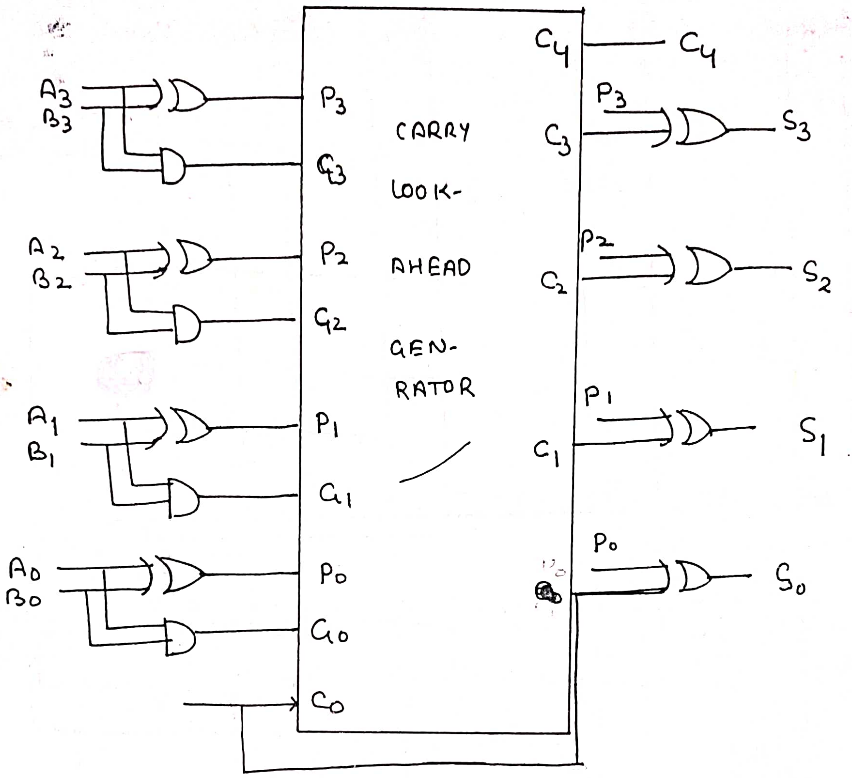
$$= \underbrace{\underbrace{P_3 P_2 P_1 P_0 C_0}_{\text{AND}} + \underbrace{P_3 P_2 P_1 G_0}_{\text{AND}} + \underbrace{P_3 P_2 G_1}_{\text{AND}} + \underbrace{P_3 G_2}_{\text{AND}} + G_3}_{\text{OR}}$$

✡ Carry Propogation solution increases complixity of circuit and decreases the time delay.

Design 4 bit carry lookahead Generator (fast adde



CARRY LOOK AHEAD GENERATOR (ADDER) 4-Bit



<u>Decoder</u>- A Decoder is a combinational circuit that converts binary Info. from n- Input lines to a maximum of 2^n unique output lines.

Truth Table -

29/08/16

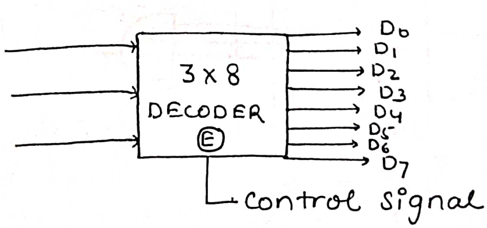
x	y	z	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1

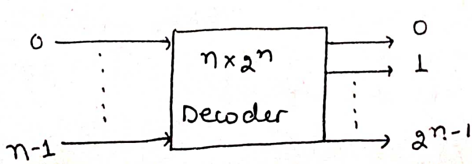
$D_0 = \bar{x}\bar{y}\bar{z}$ $\quad D_1 = \bar{x}\bar{y}z$ $\quad D_2 = \bar{x}y\bar{z}$

$D_3 = \bar{x}yz$ $\quad D_4 = x\bar{y}\bar{z}$ $\quad D_5 = x\bar{y}z$

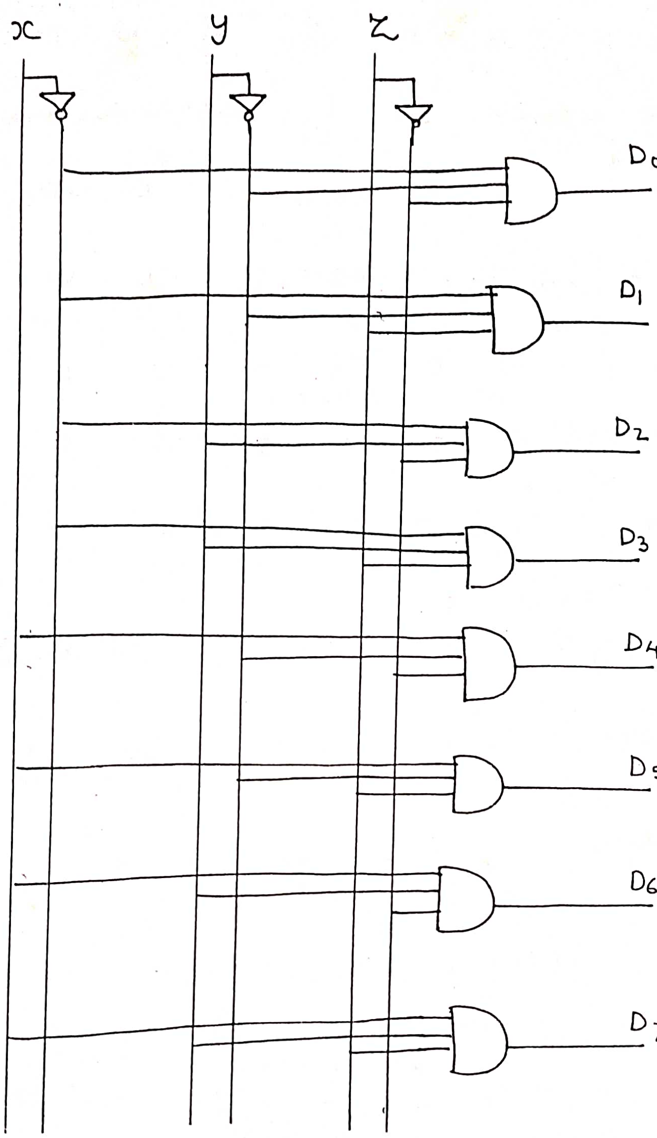
$D_6 = xy\bar{z}$ $\quad D_7 = xyz$

Symbolic Diagram -





LOGIC DIAGRAMS –



Design BCD Decoder with unused combinations

Binary → Decimal

Input				Output									
w	x	y	z	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9
0	0	0	0	ϕ	0	0	0	0	0	0	0	0	0
0	0	0	1	0	1	0	0	0	0	0	0	0	0
0	0	1	0	0	0	1	0	0	0	0	0	0	0
0	0	1	1	0	0	0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0	1	0	0	0	0	0
0	1	0	1	0	0	0	0	0	1	0	0	0	0
0	1	1	0	0	0	0	0	0	0	1	0	0	0
0	1	1	1	0	0	0	0	0	0	0	1	0	0
1	0	0	0	0	0	0	0	0	0	0	0	1	0
1	0	0	1	0	0	0	0	0	0	0	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	×	×	×	×	×	×	×	×	×	×

→ UNUSED OR USED AS DON'T CARE

K-MAP for D_0 -

$wx \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	1	0	0	0
$\bar{w}x$	0	0	0	0
wx	x	x	x	x
$w\bar{x}$	0	0	x	x

$$D_0 = \bar{w}\bar{x}\bar{y}\bar{z}$$

K-MAP for D_1 -

$wx \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	0	1	0	0
$\bar{w}x$	0	0	0	0
wx	x	x	x	x
$w\bar{x}$	0	0	x	x

$$D_1 = \bar{w}\bar{x}\bar{y}z$$

K-MAP for D_3 -

$wx \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	0	0	1	0
$\bar{w}x$	0	0	0	0
wx	x	x	x	x
$w\bar{x}$	0	0	x	x

$$D_3 = \bar{x}yz$$

K-MAP for D_2 -

$wx \backslash yz$	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	0	0	0	1
$\bar{w}x$	0	0	0	0
wx	x	x	x	x
$w\bar{x}$	0	0	x	x

$$D_2 = \bar{x}y\bar{z}$$

K-MAP for D4 -

wx \ yz	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	0	0	0	0
$\bar{w}x$	$\boxed{1}$	0	0	0
wx	$\boxed{x}$	x	x	x
$w\bar{x}$	0	0	x	x

$D_4 = x\bar{y}\bar{z}$

K-MAP for D5 -

wx \ yz	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	0	0	0	0
$\bar{w}x$	0	$\boxed{1}$	0	0
wx	x	$\boxed{x}$	x	x
$w\bar{x}$	0	0	x	x

$D_5 = x\bar{y}z$

K-MAP for - D6

wx \ yz	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	0	0	0	0
$\bar{w}x$	0	0	0	$\boxed{1}$
wx	x	x	x	
$w\bar{x}$	0	0	x	x

$D_6 = xy\bar{z}$
1 1 0

K-MAP for D7

wx \ yz	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	0	0	0	0
$\bar{w}x$	0	0	$\boxed{1}$	0
wx	x	x	$\boxed{x}$	x
$w\bar{x}$	0	0	x	x

$D_7 = xyz$

K-Map for D8

wx \ yz	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	0	0	0	0
$\bar{w}x$	0	0	0	0
wx	x	x	x	x
$w\bar{x}$	1	0	x	x

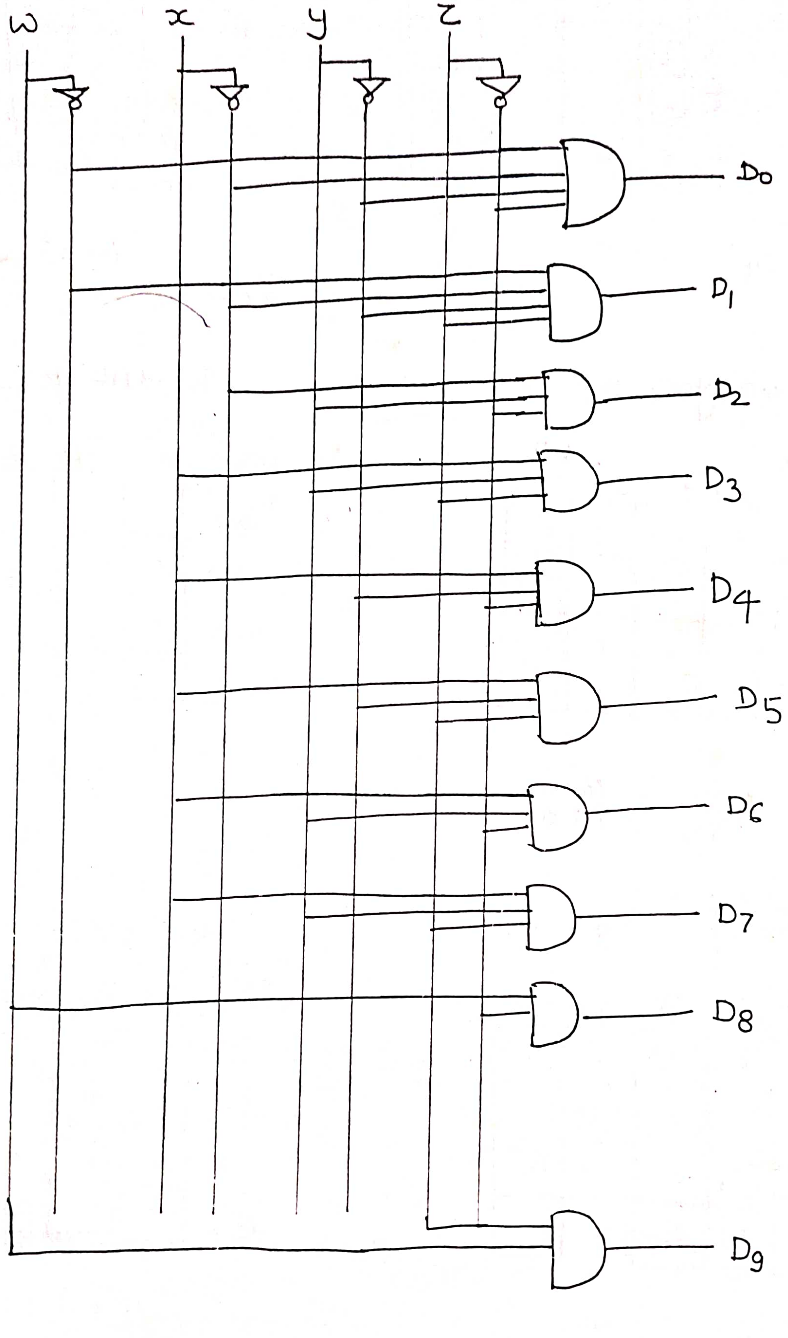
$D_8 = w\bar{z}$

K-Map for D9

wx \ yz	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	0	0	0	0
$\bar{w}x$	0	0	0	0
wx	x	x	x	x
$w\bar{x}$	0	1	x	x

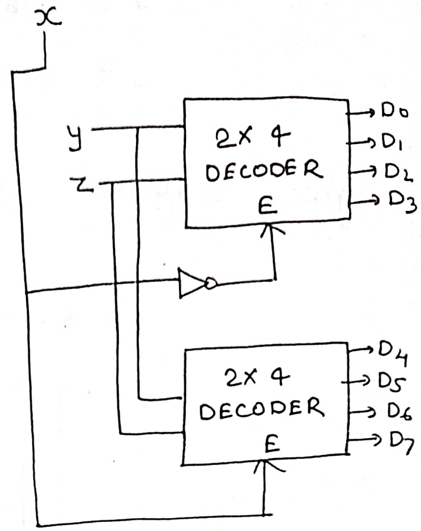
$D_9 = wz$

Design BCD Decoder using don't care -



Design 3×8 by using 2×4 Decoder

x	y	z	
0	0	0	$\rightarrow D_0$
0	0	1	$\rightarrow D_1$
0	1	0	$\rightarrow D_2$
0	1	1	$\rightarrow D_3$
1	0	0	$\rightarrow D_4$
1	0	1	$\rightarrow D_5$
1	1	0	$\rightarrow D_6$
1	1	1	$\rightarrow D_7$



30/08/16

Encoder – 2^n input & n output

Decoder – n-input & 2^n output

Encoders – An Encoder is a digital circuit that performs the inverse operation of a Decoder.

TRUTH-TABLE

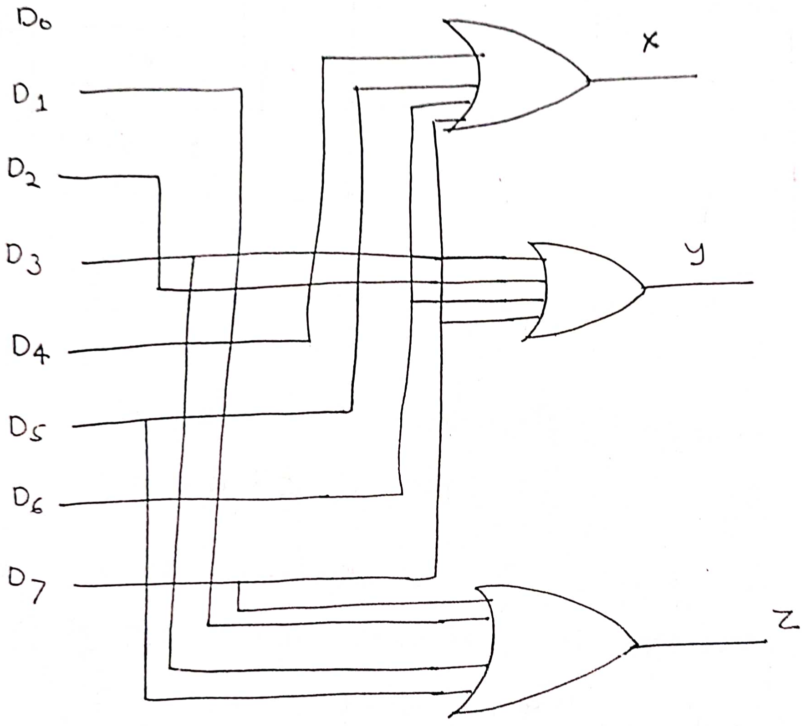
D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	x	y	z
1	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	0	1	0	1	1	0
0	0	0	0	0	0	0	1	1	1	1

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

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

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

Logic Diagram for Encoders -



Priority Encoder - A Priority Encoder is an encoder circuit that includes the priority function. The operation of the priority encoder is such that if two or more inputs are equal to 1 at the same time. The input having the highest priority will take precedence.

$D_0 \rightarrow$ Lowest $\qquad D_3 \rightarrow$ Highest $\qquad$ Low $\xrightarrow{D_0 D_1 D_2 D_3}$ High Priori

Input				Output		
D_0	D_1	D_2	D_3	A	B	V
0	0	0	0	x	x	0
1	0	0	0	0	0	1
x	1	0	0	0	1	1
x	x	1	0	1	0	1
x	x	x	1	1	1	1

K-Map for A -

D_0D_1 \ D_2D_3	00	01	11	10
00	x	1	1	1
01		1	1	1
11		1	1	1
10		1	1	1

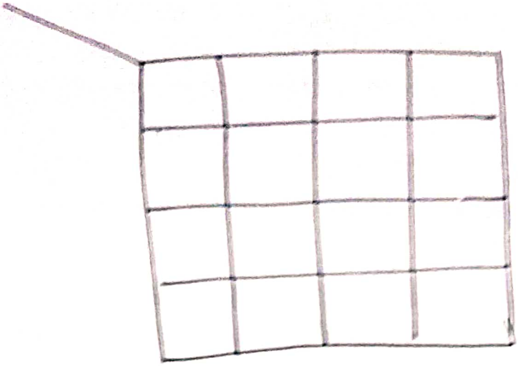
$A = D_2 + D_3$

K-MAP for B -

D_0D_1 \ D_2D_3	00	01	11	10
00	x	1	1	
01	1	1	1	
11	1	1	1	
10		1	1	

$B = D_3 + D_1\overline{D_2}$

K- MAP for V -



31/08/16

Q. Design 4-bit priority Encoder. $D_0 \rightarrow$ High
$D_3 \rightarrow$ Low

Sol^n

D_3	D_2	D_1	D_0	x	y	V
0	0	0	0	x	x	0
1	0	0	0	1	1	1
x	1	0	0	1	0	1
x	x	1	0	0	1	1
x	x	x	1	0	0	1

K- MAP for x -

D_2D_3 \ D_0D_1	$\overline{D_0}\,\overline{D_1}$	$\overline{D_0}D_1$	D_0D_1	$D_0\overline{D_1}$
$\overline{D_2}\,\overline{D_3}$	X			
$\overline{D_2}D_3$	1			
D_2D_3	1			
$D_2\overline{D_3}$	1			

$$X = \overline{D_0}\,\overline{D_1}$$

K-MAP for Y –

D_2D_3 \ D_0D_1	$\overline{D_0}\,\overline{D_1}$	$\overline{D_0}D_1$	D_0D_1	$D_0\overline{D_1}$
$\overline{D_2}\,\overline{D_3}$	X			1
$\overline{D_2}D_3$				1
D_2D_3				1
$D_2\overline{D_3}$	1			1

$$Y = D_0\overline{D_1} + \overline{D_1}\,\overline{D_3}$$

K-MAP for V –

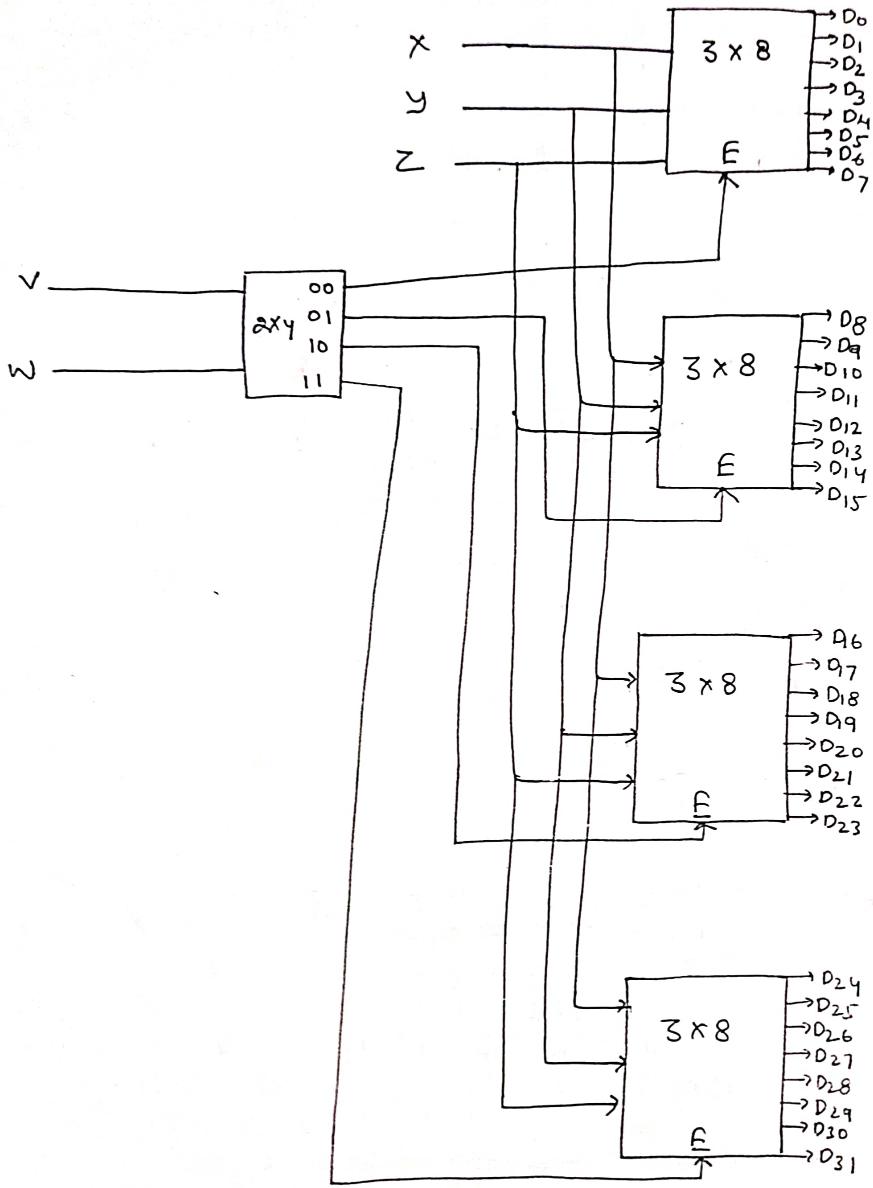
D_2D_3 \ D_0D_1	$\overline{D_0}\,\overline{D_1}$	$\overline{D_0}D_1$	D_0D_1	$D_0\overline{D_1}$
$\overline{D_2}\,\overline{D_3}$		1	1	1
$\overline{D_2}D_3$	1	1	1	1
D_2D_3	1	1	1	1
$D_2\overline{D_3}$	1	1	1	1

$$V = D_0 + D_1\overline{D_3} + D_3 + D_2$$

Imp.

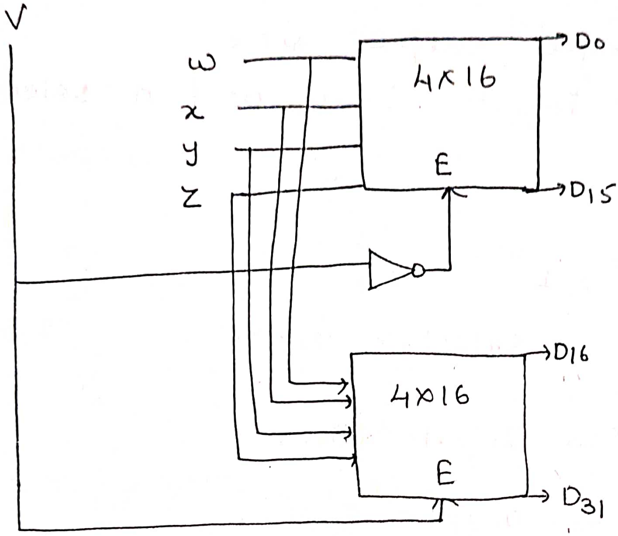
Q. Construct 5 × 32 decoder with enable and 4 3×8 and one 2×4 Decoder.

Solⁿ



Q. Construct 5 × 32 decoder with enable and 4 × 16 (two).

Sol^n^-



v	w	x	y	z	
0	0	0	0	0	→ 0
0	0	0	0	1	→ 1
⋮	⋮	⋮	⋮	⋮	
0	0	1	1	1	→ 7
0	1	0	0	0	
0	1	0	0	1	
0	1	0	1	0	
0	1	0	1	1	
⋮					
0	1	1	1	1	
1	0	0	0	1	
1	0	0	0	1	

1	1	0	0	0
1	1	0	0	1
⋮	⋮	⋮	⋮	⋮
1	1	1	1	1

05-09-16

MUX - A Multiplexer is a combinational circuit that selects binary information from one of many input lines and directs it to a single output line.

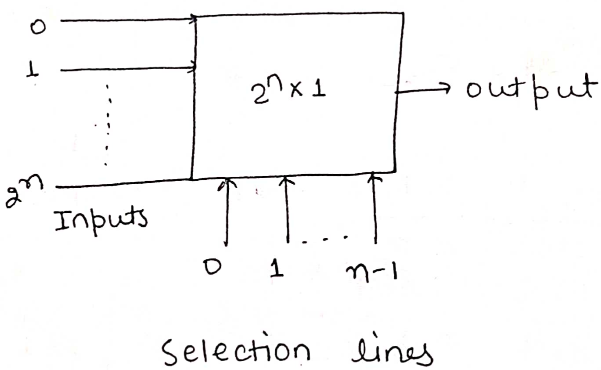
There are 2^n input lines and n-selection lines.

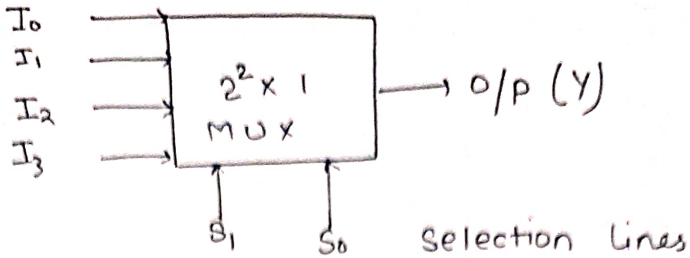
$2^n \times 1$

$n \rightarrow$ Selection lines

$2^n \rightarrow$ Input lines

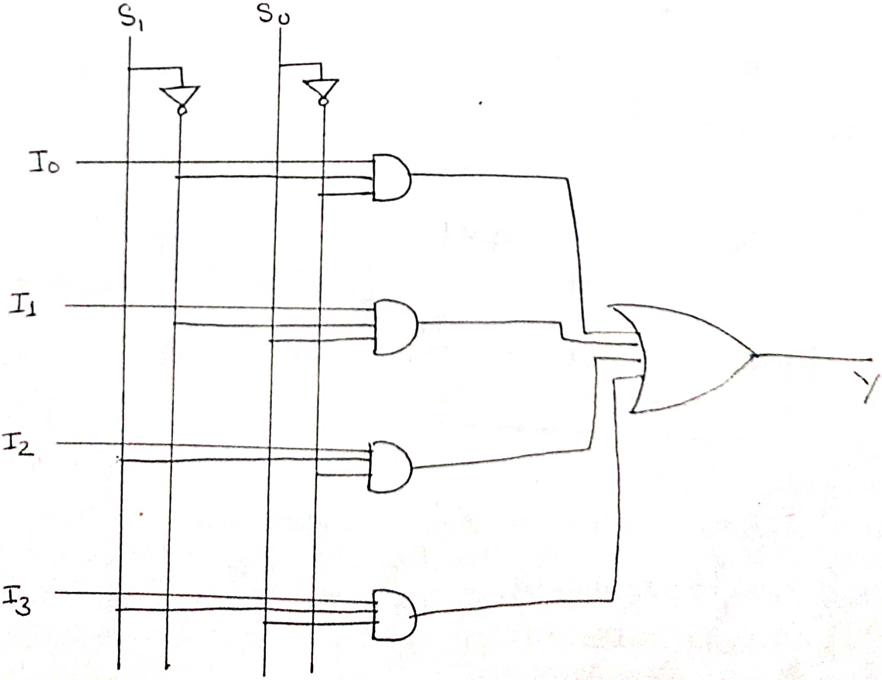
$1 \rightarrow$ Output lines



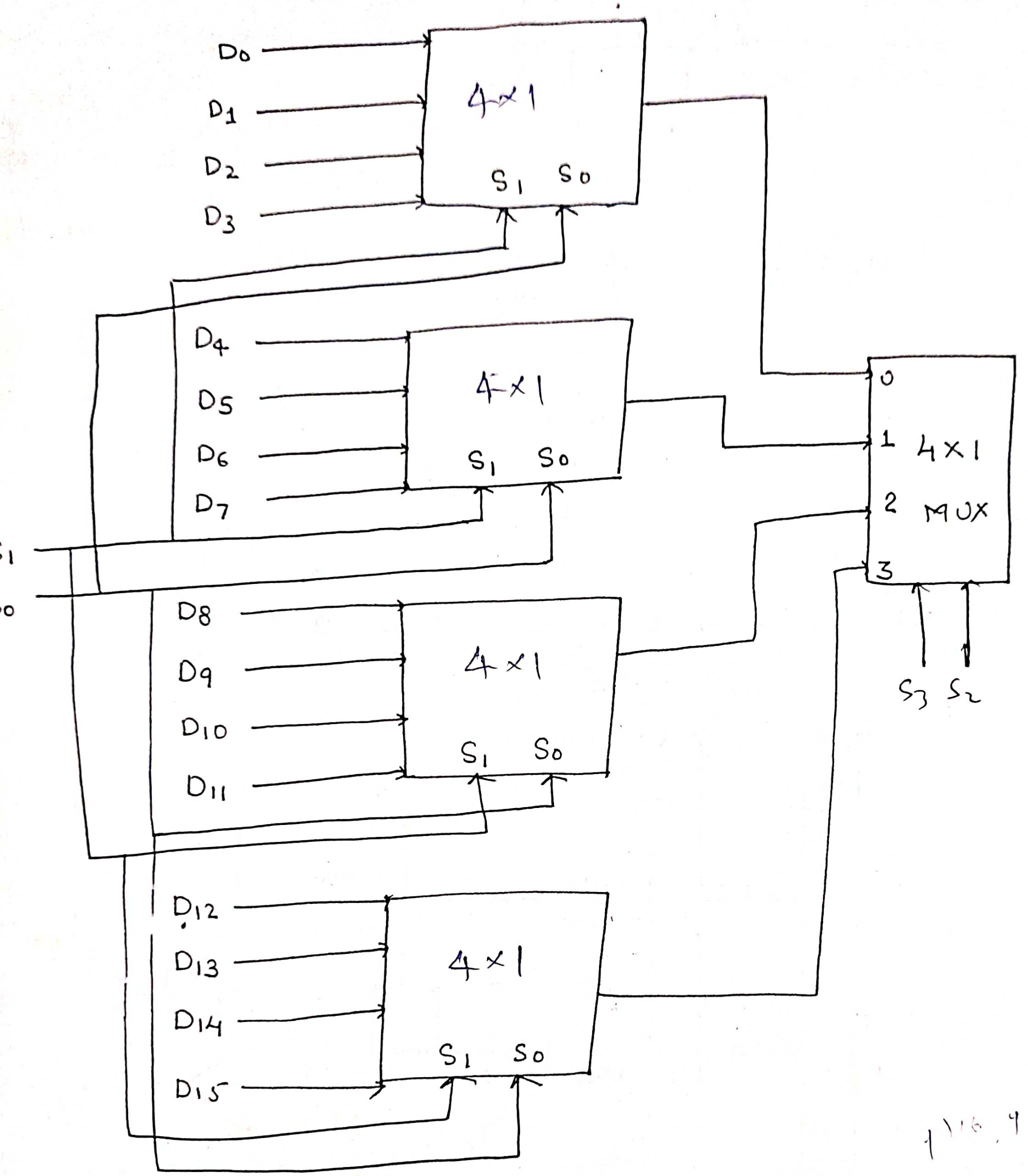


Inputs (I)	Selection (S_1, S_0)	O/P
I_0	0 0	I_0
I_1	0 1	I_1
I_2	1 0	I_2
I_3	1 1	I_3

$$Y = I_0 \overline{S_1}\,\overline{S_0} + I_1 \overline{S_1} S_0 + I_2 S_1 \overline{S_0} + I_3 S_1 S_0$$



Q. Design 16 x 1 mux using 4x1 Inputs.

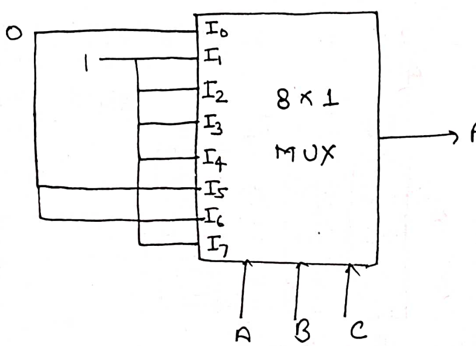


S1	S0	Y			
0	0	D0	D4	D8	D12
0	1	D1	D5	D9	D13
1	0	D2	D6	D10	D14
1	1	[illegible]	[illegible]	[illegible]	[illegible]

Q. Design $F(A, B, C) = \Sigma(1, 2, 3, 4, 7)$ using 8×1.

✡ change last digit in decimal in absence of inputs and count the bits. The no. of bits are inputs.

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



$$F = 1\cdot\bar{A}\bar{B}C + 1\cdot\bar{A}\cdot B\cdot\bar{C} + 1.\ \bar{A}\cdot B\cdot C + 1.\ A\bar{B}\bar{C} + 1.AB$$

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

Q. Design $F(A, B, C) = \Sigma(1, 2, 3, 4, 7)$ using two $2^2 \times 1$ MUX.

A B C

C → as input $2^0 = 1$ parallel digits use

B → as input $2^1 = 2$ parallel digits use

A → as input $2^2 = 4$ parallel digits use.

Implementation Table for A, B, C –

For C –

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

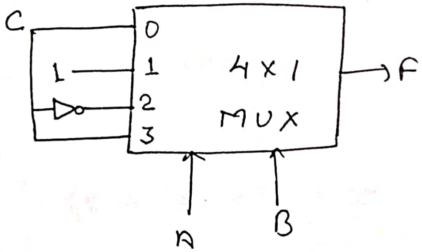
For B –

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

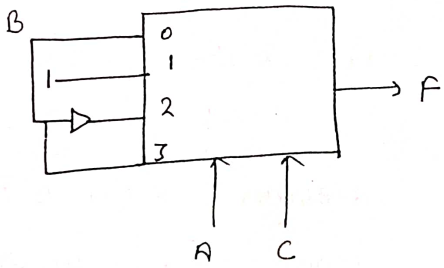
For A –

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

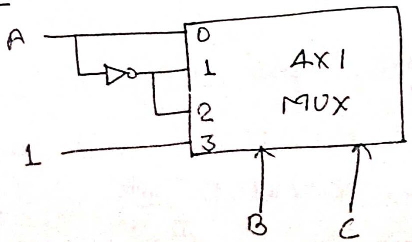
For C -



For B -



For A –



For C - $F = \bar{A}\bar{B}C + \bar{A}B \cdot 1 + A\bar{B}\bar{C} + ABC$

For B - $F = \bar{A}\bar{C}B + \bar{A}C \cdot 1 + A\bar{C}\bar{B} \quad ACB$

For A - $F = \bar{B}\bar{C}A + \bar{B}C\bar{A} + B\bar{C}\bar{A} + B \cdot 1$

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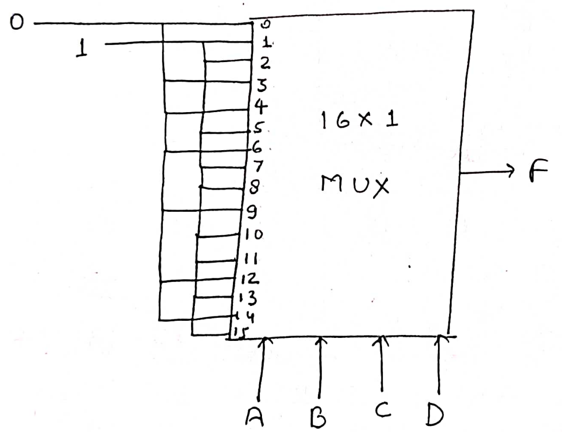
Q. $F(A, B, C, D) = \Sigma(1, 2, 5, 7, 8, 10, 11,$ [illegible]$)$

Design with 16x1 MUX.



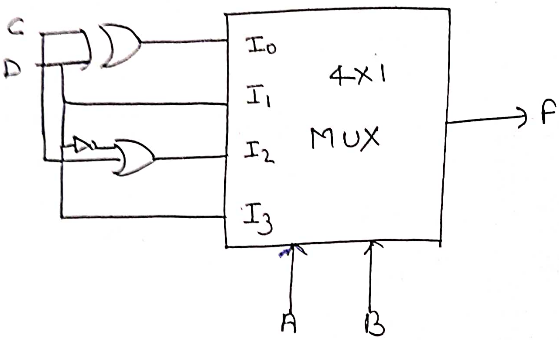
$$\overbrace{}^{1}$$
$$\underbrace{AB}_{2}\ \underbrace{CD}_{0}$$

CD - As an Input

$2^0 = 1$ parallel digits

Implementation Table for CD -

	I_0	I_1	I_2	I_3
$\bar{C}\bar{D}$	0	4	8	12
$\bar{C}D$	1	5	9	13
$C\bar{D}$	2	6	10	14
CD	3	7	11	15
	$\bar{C}D+C\bar{D}$ $\Downarrow$ $C \oplus D$	D	$\bar{C}\bar{D}+\bar{C}D+CD$ $\Downarrow$ $\bar{D}+C$	D

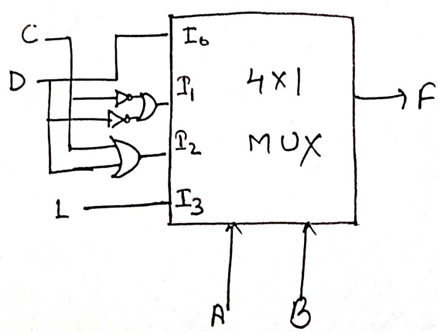


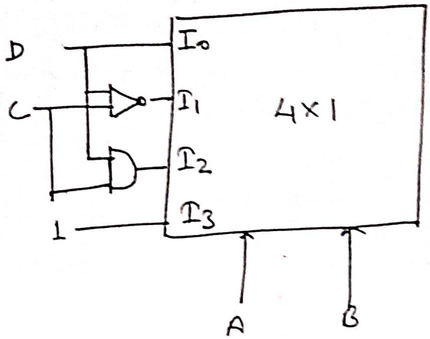
$$F(A, B, C, D) = \Sigma(1, 3, 4, 11, 12, 13, 14, 15)$$

CD - as input

$2^0 = 1$ parallel line

	I_0	I_1	I_2	I_3
$\bar{C}\bar{D}$	0	4	8	12
$\bar{C}D$	1	5	9	13
$C\bar{D}$	2	6	10	14
CD	3	7	11	15
	D	$\bar{C}\bar{D}$	CD	1

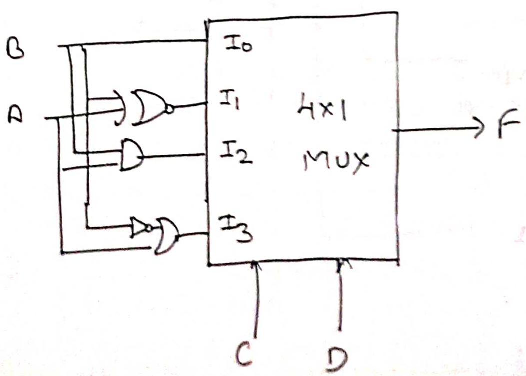




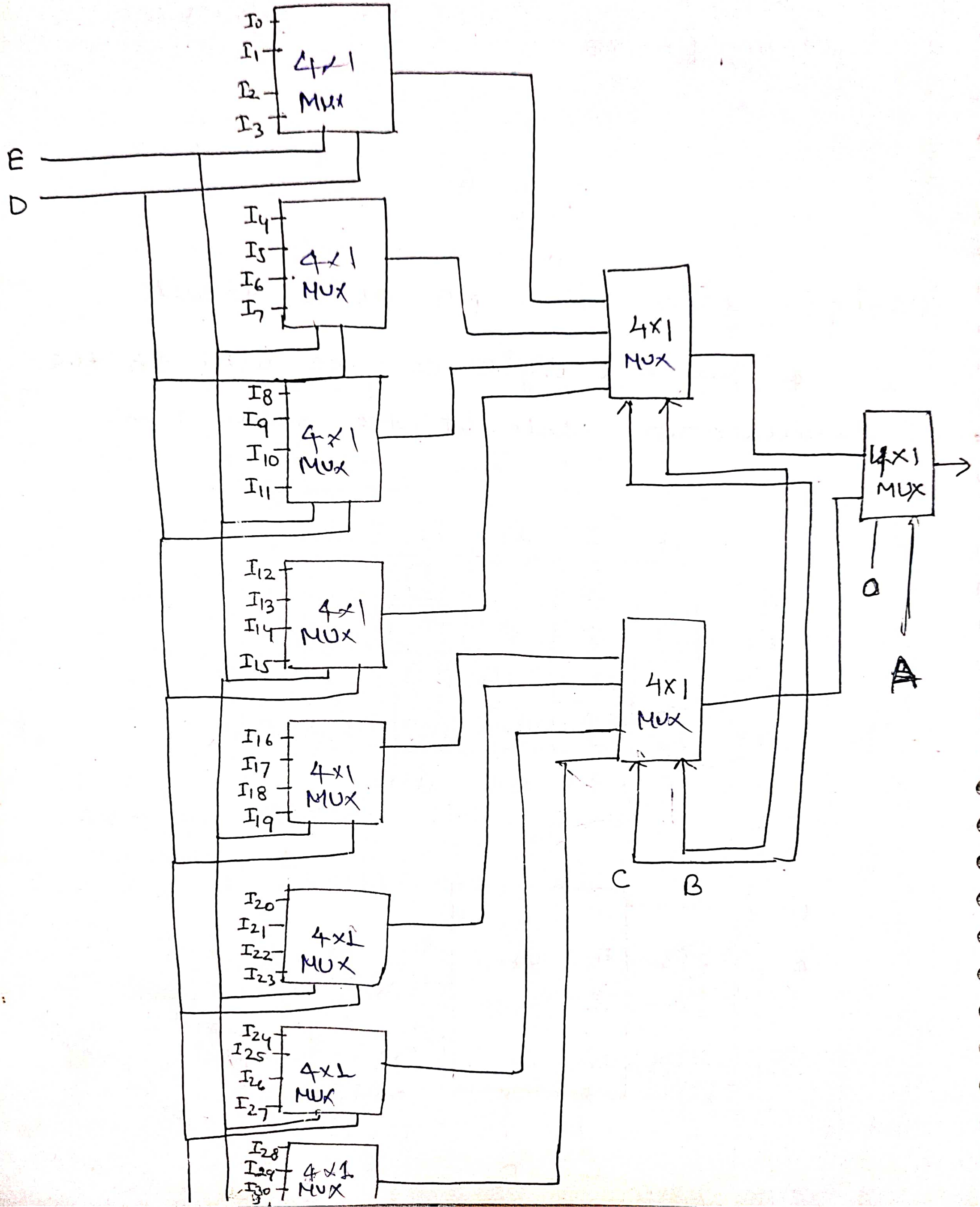
Design again with AB as a input

$2^2 = 4$ parallel digits can be used in the implementation table at the same time.

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



Q. Design 32x1 MUX using four 4x1 MUX.



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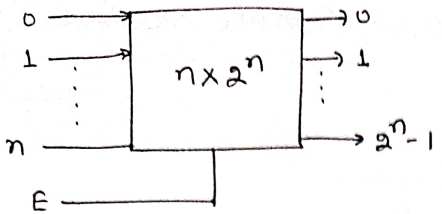
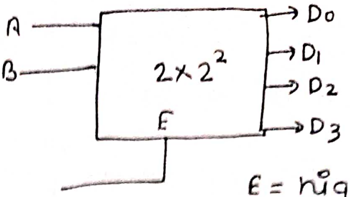
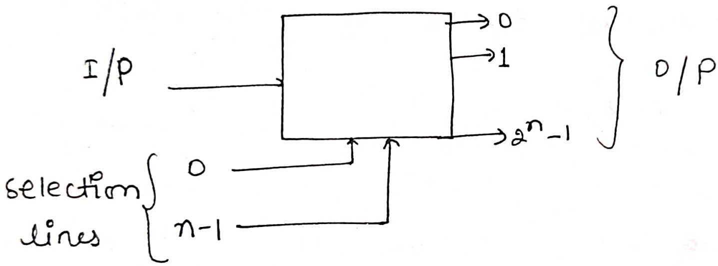




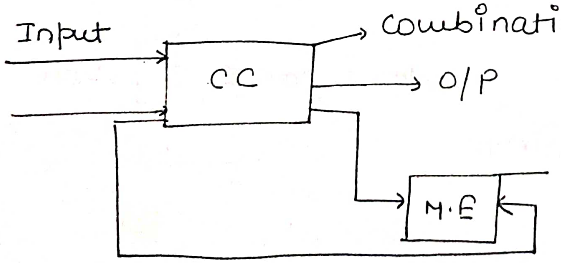
E = high 1
low 0

Decoder – Demux – output – Selection lines

enable – input

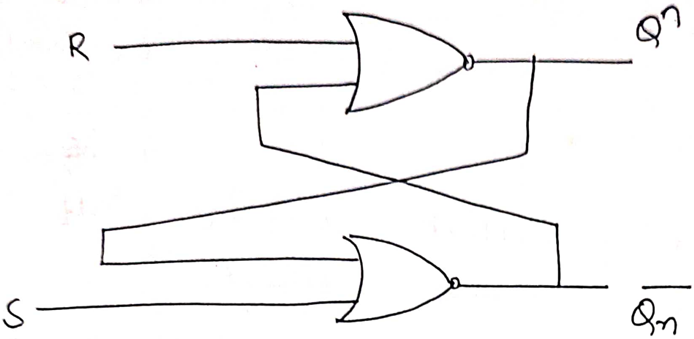


Sequential circuits –



Previous states of memory element

Flip- Flop - Flip flop is a memory element used for storing single bit either 0 or 1. Flip- Flop is a bistable device.



There are following types of flip- flops -

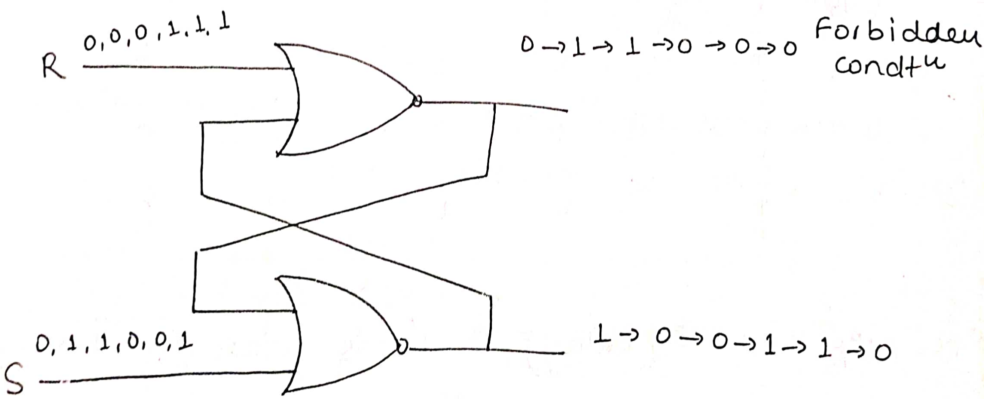
1. Set Reset (SR)
2. D
3. JK
4. T
5. Master slave

★ If we give input - 1 and 0 then one will operate first.

1. SET RESET (SR) -

Truth- Table for SR-

S	R	Present State Q_n	Next State Q_{n+1}	
0	0	0	0	-- Always zero
1	0	0	1	
1	0	1	1	-- Always one In case of 1,0
0	1	1	0	
0	1	0	0	Next state will always [illegible]
1	1	0	0	Forbidden [illegible] condition



✡ If we consider 0 or 1 as a previous state then next state will be 0 or 1.

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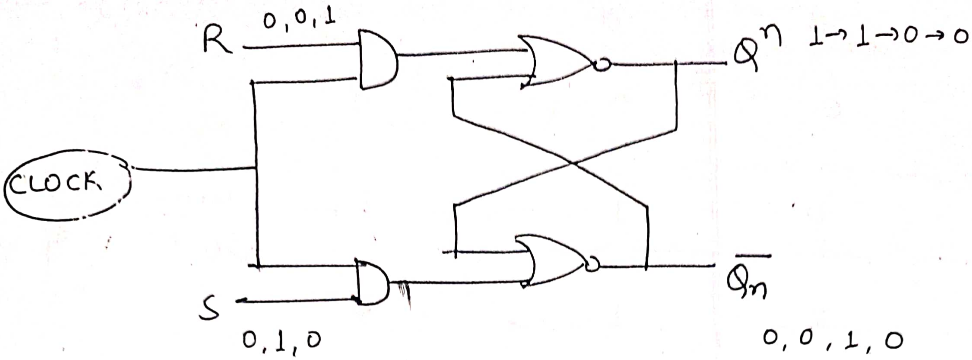
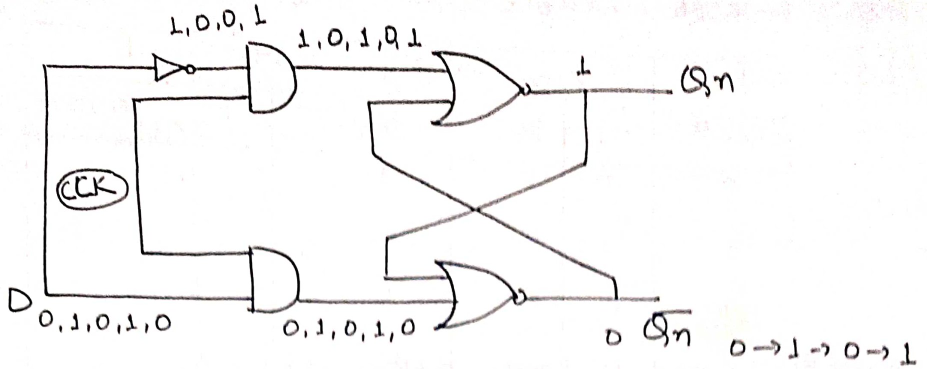
Flip- Flop with clock -



Truth Table -

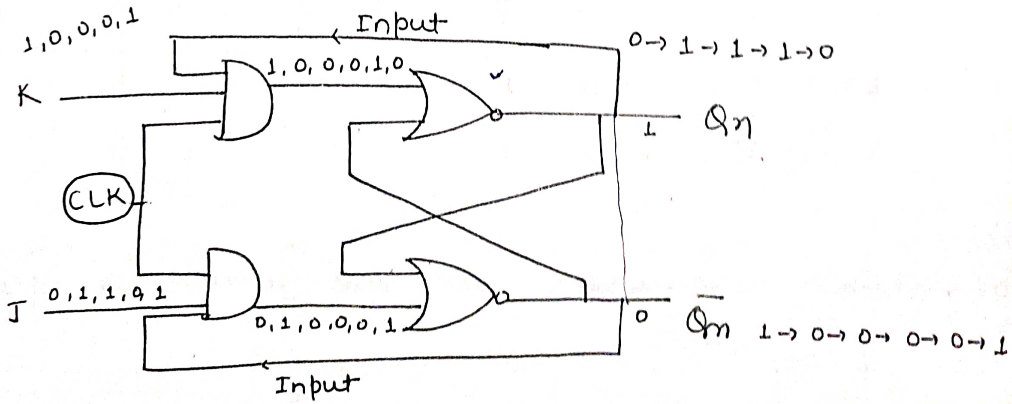
CLK	S	R	Q_n	Q_{n+1}
(High) ↑	0	0	1	1
↑	0	1	1	1
↑	1	0	1	0
↑	1	1	0	?

D- Flip Flop - (Delay) - It is used for transfering the data from one to another. It can be used for one clock delay.



Input	P.S	N.S
D	Qn	Qn+1
1	1	1
0	1	0
1	0	1
0	1	0

J. K Flip-Flop - JK Flip flop has two inputs and performs all three actions.



Toggling - output changes in same clock pulse.

Truth - Table for JK -

	I/P		P.S	N.S
CLK	J	K	Q_n	Q_{n+1}
↑	0	1	1	0
↑	1	0	0	1
↑	1	0	1	1
↑	0	0	1	1
↑	1	1	1	1 → 0 → 1 → 0

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Excitation Table -

P.S	N.S	F/F					
Q_n	Q_{n+1}	S	R	J	K	D	T
0 →	0	0	X	0	X	0	0
0 →	1	1	0	1	X	1	1
1 →	0	0	1	X	1	0	1
1 →	1	X	0	X	0	1	0

Registers - Registers are the group of flip-flops.

Counter- A Register that goes through a prescribed sequence of states upon the application of input pulses is called a counter.

(*) unused state goes to the initial state.

Design a counter with mod 7 by D-flip flop.

Initial state - $S_5 \rightarrow S_4 \rightarrow S_2 \rightarrow S_0 \rightarrow S_3$ final state

		Q_2	Q_1	Q_0	D_0	D_1	D_2
0	1	0	0	0	1	1	0
1	2	0	0	1	1	0	1
2	3	0	1	0	0	0	0
3	4	0	1	1	1	0	1
4	5	1	0	0	0	1	0
5	6	1	0	1	0	0	1
6	7	1	1	0	1	0	1
7	8	1	1	1	1	0	1

$S_5 - S_4$

	P.S	N.S	D_0
Q_0	1	$\rightarrow$ 0	0
Q_1	0	$\rightarrow$ 0	0
	1	$\rightarrow$ 1	1
	0	$\rightarrow$ 1	1

K-MAP for D_0 -

$Q_2 \backslash Q_1Q_0$	$\overline{Q}_1\overline{Q}_0$	$\overline{Q}_1Q_0$	Q_1Q_0	$Q_1\overline{Q}_0$
$\overline{Q}_2$	1	1	1	
Q_2			1	1

$D_0 = \overline{Q}_2\overline{Q}_1 + \overline{Q}_2Q_0 + Q_2Q_1$

K-MAP for D_1 -

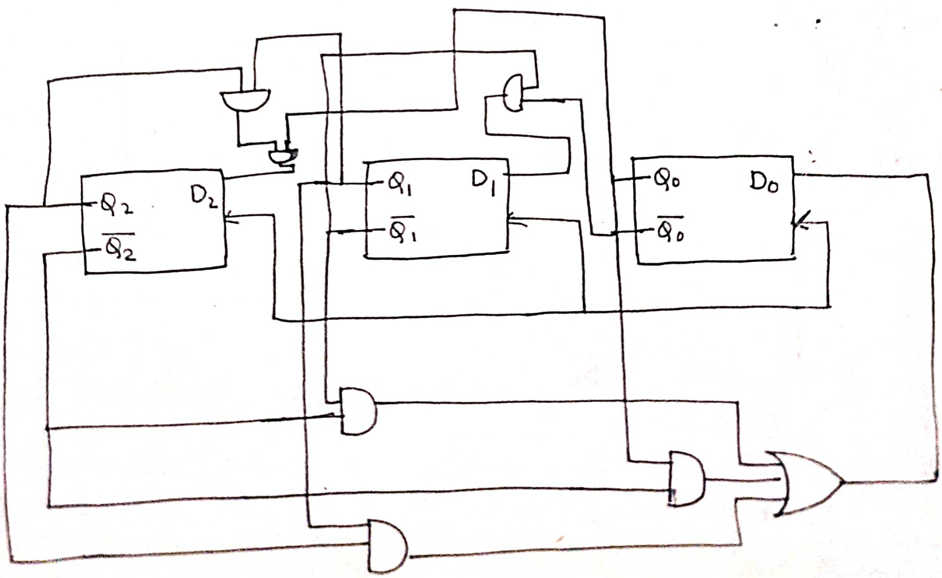
$Q_2 \backslash Q_1Q_0$	$\overline{Q}_1\overline{Q}_0$	$\overline{Q}_1Q_0$	Q_1Q_0	$Q_1\overline{Q}_0$
$\overline{Q}_2$	1			
Q_2	1			

$D_1 = \overline{Q}_1\overline{Q}_0$

K-MAP for D_2 -

$Q_2 \backslash Q_1Q_0$	$\overline{Q}_1\overline{Q}_0$	$\overline{Q}_1Q_0$	Q_1Q_0	$Q_1\overline{Q}_0$
$\overline{Q}_2$		1	1	
Q_0		1	1	1

$D_2 = Q_0 + Q_2Q_1$



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Q. Design counter with mod 6.

Q_2	Q_1	Q_0	J_0	K_0	J_1	K_1	J_2	2
0	0	0	1	X	0	X	0	X
0	0	1	X	1	1	X	0	X
0	1	0	1	X	X	0	0	X
0	1	1	X	1	X	1	1	X
1	0	0	1	X	0	X	X	0
1	0	1	X	1	0	X	X	1
1	1	0	0	X	X	1	X	1
1	1	1	X	1	X	1	X	1

K-MAP for - J_0

$Q_2 \backslash Q_1 Q_0$	$\bar{Q}_1 \bar{Q}_0$	$\bar{Q}_1 Q_0$	$Q_1 Q_0$	$Q_1 \bar{Q}_0$
$\bar{Q}_2$	1	X	X	1
Q_2	1	X	X	0

$J_0 = \bar{Q}_2 + \bar{Q}_1$

K-MAP for - K_0

	$\bar{Q}_1 \bar{Q}_0$	$\bar{Q}_1 Q_0$	$Q_1 Q_0$	$Q_1 \bar{Q}_0$
$\bar{Q}_2$	X	1	1	X
Q_2	X	1	1	X

$K_0 = 1$

K-MAP for J_1 -

	$\bar{Q}_1 \bar{Q}_0$	$\bar{Q}_1 Q_0$	$Q_1 Q_0$	$Q_1 \bar{Q}_0$
$\bar{Q}_2$		1	X	X
Q_2			X	X

$J_1 = \bar{Q}_2 Q_0$

K-MAP for K_1 -

	$\bar{Q}_1 \bar{Q}_0$	$\bar{Q}_1 Q_0$	$Q_1 Q_0$	$Q_1 \bar{Q}_0$
$\bar{Q}_2$	X	X	1	
Q_2	X	X	1	1

$K_1 = Q_0 + Q_2$

K-MAP for J_2 -

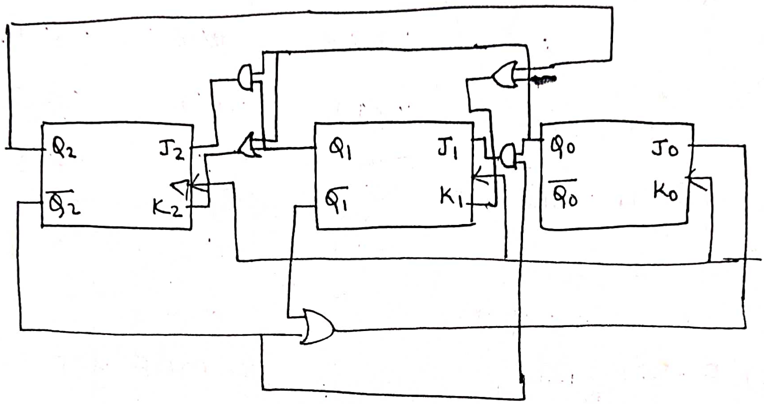
	$\overline{Q_1}\,\overline{Q_0}$	$\overline{Q_1}Q_0$	Q_1Q_0	$Q_1\overline{Q_0}$
$\overline{Q_2}$			1	
Q_2	X	X	X	X

$J_2 = Q_1Q_0$

K-MAP for K_2 -

	$\overline{Q_1}\,\overline{Q_0}$	$\overline{Q_1}Q_0$	Q_1Q_0	$Q_1\overline{Q_0}$
$\overline{Q_2}$	X	X	X	X
Q_2	0	1	1	1

$K_2 = Q_0 + Q_1$



Design the same with D- Flip-Flop -

	Q_2	Q_1	Q_0	D_0	D_1	D_2
0	0	0	0	1	0	0
1	0	0	1	0	1	0
2	0	1	0	1	1	0
3	0	1	1	0	0	1
4	1	0	0	1	0	1
5	1	0	1	0	0	0
6	1	1	0	0	0	0
7	1	1	1	0	0	0

K-MAP for D0 -

	$\overline{Q_1}\,\overline{Q_0}$	$\overline{Q_1}Q_0$	Q_1Q_0	$Q_1\overline{Q_0}$
$\overline{Q_2}$	1			1
Q_2	1			

$$D_0 = \overline{Q_1}\,\overline{Q_0} + \overline{Q_2}\,\overline{Q_0}$$

K-MAP for - D1

	$\overline{Q_1}\,\overline{Q_0}$	$\overline{Q_1}Q_0$	Q_1Q_0	$Q_1\overline{Q_0}$
$\overline{Q_2}$		1		1
Q_2				

$$D_1 = \overline{Q_2}\,\overline{Q_1}Q_0 + \overline{Q_2}Q_1\overline{Q_0}$$
$$= \overline{Q_2}\left(\overline{Q_1}Q_0 + Q_1\overline{Q_0}\right)$$
$$= \overline{Q_2}\left(Q_1 \oplus Q_0\right)$$

K- MAP for D3 -

	$\overline{Q_1}\,\overline{Q_0}$	$\overline{Q_1}Q_0$	Q_1Q_0	$Q_1\overline{Q_0}$
$\overline{Q_2}$			1	
Q_2	1			

$$D_2 = \overline{Q_2}Q_1Q_0 + Q_2\overline{Q_1}\,\overline{Q_0}$$