ElCoM
ELECTRICAL COMPUTER MECHATRONICS

تقدم لجنة ElCoM الاكاديمية

دفتر لمادة:

منطق رقمي

من شرح:

د. محمد عبابنة

جزيل الشكر للطالب:

حمزة اسماعيل

** Digital logic and Digital Electronics :-

* Number Systems :-

* Number Systems :-

1- Decimal System .
base (10) , element (0-9).

2- Binary System :-
base (2.B) , element (0.1) .

3- Octal System :
base (8.O) , element (0-7).

4- Hexadecimal system :-
base (16.H) , element (0-9 , A-F).

* Ex :-

1. $(\overset{3}{2}\overset{2}{3}\overset{1}{4}\overset{0}{5})_{10} = 2*10^{3} + 3*10^{2} + 4*10^{1} + 5*10^{0}$

$= 2000 + 300 + 40 + 5 .$

$= (2345)_{10}$

2. $(0.\overset{-1}{1}\overset{-2}{3}\overset{-3}{5}\overset{-4}{7})_{10} = 1*10^{-1} + 3*10^{-2} + 5*10^{-3} + 7*10^{-4} .$

$= 0.1 + 0.03 + 0.005 + 0.0007 .$

$= (0.1357)_{10}$

* Number System :-

* Octal conversion to Decimal :-

1. $\overset{2}{2}\overset{1}{3}\overset{0}{7}_{(8)} = 2*8^{2} + 3*8^{1} + 7*8^{0}$.

$= 2*64 + 24 + 7 = 159_{(12)}$

2. $0.\overset{-1}{2}\overset{-2}{6}_{(8)} = 2*8^{-1} + 6*8^{-2}$

$= 2*\frac{1}{8} + \overset{3}{\cancel{6}}*\frac{1}{4\cancel{8}*8} = \frac{11}{32}{}_{(10)}$

3. $\overset{1}{5}\overset{0}{1}.\overset{-1}{2}\overset{-2}{4}_{(8)} = 5*8^{1} + 1*8^{0} + 2*8^{-1} + 4*8^{-2}$.

$= 40 + 1 + \frac{1}{4} + \frac{4}{2\cancel{8}*8}. = \left(41\ \frac{5}{16}\right)_{(10)}$

* Hexadecimal conversion to Decimal :-

1. $\overset{0}{A}\overset{2}{B}\overset{1}{E}\overset{0}{D}_{(16)} = A*16^{0} + B*16^{2} + E*16^{1} + D*16^{0}$

$= 10*16^{3} + 11*16^{2} + 14*16^{1} + 13*16^{0}$.

$= 40960 + 2816 + 224 + 13 = 44013_{(10)}$

2. $0.\overset{-1}{3}\overset{-2}{C}_{(16)} = 3*16^{-1} + C*16^{-2}$

$= 3*\frac{1}{16} + \overset{3}{\cancel{12}}*\frac{1}{4\cancel{16}*16}. = \frac{15}{64}{}_{(10)}$

3. $\overset{1}{2}\overset{0}{8}.\overset{-1}{8}\overset{-2}{2}_{(16)} = 2*16^{1} + 8*16^{0} + 8*16^{-1} + 2*16^{-2}$

$= 32 + 8 + \frac{1}{2} + \frac{1}{128} = \left(40\ \frac{65}{128}\right)_{(10)}$

4. $\overset{1}{A}\overset{0}{0}_{16} = A*16^{1} + 0*16^{0} = 160_{(10)}$

$\boxed{2}$

* Number Systems :-

* Conversion from Decimal to Binary :-

1. $6_{(10)} = 110_{(2)}$

6		
3	0	→ LSB
1	1	↑
0	1	→ MSB

2. $11_{(10)} = 1011_{(2)}$

11		
5	1	→ LSB
2	1	↑
1	0	
0	1	→ MSB

3. $100_{(10)} = 1100100_{(2)}$

100		
50	0	→ LSB.
25	0	↑
12	1	
6	0	
3	0	
1	1	
0	1	→ MSB

4. $151_{(10)} = 10010111_{(2)}$

151		
75	1	→ LSB
37	1	↑
18	1	
9	0	
4	1	
2	0	
1	0	
0	1	→ MSB

5. $0.\overset{-1}{C}\overset{-2}{4}_{(16)} = C \times 16^{-1} + 4 \times 16^{-2}$

$= \overset{3}{\cancel{12}} \times \frac{1}{\underset{4}{\cancel{16}}} + \cancel{4} \times \frac{1}{\underset{4}{\cancel{16}} \times 16}.$

$= \left(\frac{49}{64}\right)_{(10)}$

* Number Systems:-

* Conversion from dceimal to Binary:-

1- $0.125_{(10)} = 0.001_{(2)}$

0.125 |
0.25 | 0 → MSB
0.5 | 0 ↑
0 | 1 → LSB..

2 $0.1_{(10)} \simeq 0.0001$

0.1 |
0.2 | 0
0.4 | 0
0.8 | 0
0.6 | 1
0.2 | 1
0.4 | 0
0.8 | 0.
⋮ ⋮

3- $9.25_{(10)} = 1001.01_{(2)}$

9 |
4 | 1 → LSB
2 | 0 ↑
1 | 0
0 | 1 → MSB

0.25 |
0.5 | 0 → MSB
0 | 1 → LSB

* Conversion from dceimal to Octal :-

1- $44_{(10)} = 54_{(8)}$

44 |
5 | 4 → LSB
0 | 5 → MSB

2. $812_{(10)} = 1454_{(8)}$

812 |
101 | 4 → LSB
12 | 5 ↑
1 | 4
0 | 1 → MSB

* Number Systems :-

* Conversion from decimal to Octal :

1. $0.0625_{(10)} = 0.04_{(8)}$

0.0625	
0.5	0 → MSD ↑
0	4 → LSD

2. $17.1_{(10)} = 21.063_{(8)}$

17	
2	1 → LSB
0	2 → MSB

0.1	
0.8	0
0.4	6
0.2	3
0.6	1

* Conversion from decimal to Hexadecimal :-

1. $171_{(10)} = AB_{(16)}$

171	
10	11 = B → LSD ↑
0	10 = A → MSD

2. $0.03125_{(10)} = 0.08_{(16)}$

0.03125	
0.5	0 → MSD
0	8 → LSD

3- $1.1_{(10)} \cong 1.199_{(16)}$

1	
0	1

0.1	
0.6	1 → MSD
0.6	9 ↓
0.6	9 → LSD.

* Bit = 0 or 1
Nibble = 4 Bits
Byte = 8 bits
Word = 8 bits.

* Number Systems :-

* Conversion from Binary to Octal :-

böp

Binary	octal
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

1. $\underbrace{101}_{421}\underbrace{110}_{421}{}_{(2)} = (56)_8$

2. $37_{(8)} = 011\,111_{(2)}$
   $2+1 \quad 1+2+4$

3. $63_{(8)} = 110\,011_{(2)}$
   $4+2 \quad 2+1$

4. $1.1_{(8)} = 001.001_{(2)}$

5. $1.4_{(8)} = 001.100_{(2)}$

* Conversion from Hexadecimal to Binary and Vica Version:-

Binary	Hexadicemal	Binary	Hexadicemal	Binary	Hex
0000	0	0110	6	1100	C
0001	1	0111	7	1101	D
0010	2	1000	8	1110	E
0011	3	1001	9	1111	F
0100	4	1010	A		
0101	5	1011	B		

* Number System :-

* Conversion from Hexadicemal to Binary and Vica Versa :-

1. $CAB.BEE_{(16)} = 110010101011 . 1011\ 1110\ 1110_{(2)}$.

2. $1.1_{(H)} = 2001 . 0001_{(2)}$.

3. $1.4_{(16)} = 0001 . 0100_{(2)} = 1.01_{(2)}$.

* Conversion from Hexadicemal to Octal and Vica Versa :-

1. $ABED_{(16)} = \underbrace{001}_{421}\underbrace{010}_{421}\ \underbrace{101}_{421}\underbrace{1\ 11}_{421}\underbrace{10\ 1}_{421}\underbrace{101}_{421}{}_{(2)} = 125755_{(8)}$

2. $273_{(8)} = 010\ 111\ 011_{(2)} = BB_{(16)}$

$2 \quad 4+2+1 \quad 2+1$; 8421

3. $(B.A)_{(16)} = \underbrace{1}_{421}\underbrace{011}_{421} . \underbrace{101}_{421}0_{(2)} = 13.5_{(8)}$

$11 \quad 10$

* Number System :-

* Binary Coded Decimal (BCD) :-

1. $29_{(10)} = \underbrace{0010}\ \underbrace{1001}_{(BCD)}$.
BCD Digit.

2. $49_{(10)} = \underbrace{0100}\ \underbrace{1001}_{(BCD)}$
BCD Digit.

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

* Gray Code :-

Gray Code	Decimal
0000	0
0001	1
0011	2
0010	3
0110	4
0111	5
0101	6
0100	7.

* Convert

1. $\underbrace{0010}\ \underbrace{0111}_{(Gray)} = 35_{(10)}$

* Implement $42_{(10)}$ in Gray Code :-

$42_{(10)} = \underbrace{0110}\ \underbrace{0011}_{(Gray)}$.
Gray digit.

* Number Systems :-

* Complement :-

1. One's complement (1's comp) :-

بدل: $\boxed{0 \rightarrow 1}$, $\boxed{1 \rightarrow 0}$

Ex:- $0110_{(2)} \xrightarrow{1's\ comp} 1001_{(2)}$

2. Two's complement (2's comp) :-

$\boxed{2's\ comp = 1's\ comp + 1}$

Ex:- $001101_{(2)} \longrightarrow 2's\ comp.$

$001101_{(2)} \xrightarrow{1's\ comp} 110010_{(2)}$

$001101_{(2)} \xrightarrow{2's\ comp} 110010_{(2)} + 1$

$001101_{(2)} \xrightarrow{2's\ comp} 110011_{(2)}$

Ex: $0011000_{(2)} \longrightarrow 2's\ comp$

$0011000_{(2)} \xrightarrow{1's\ comp} 1100111_{(2)}$

$0011000_{(2)} \xrightarrow{2's\ comp} 1100111_{(2)} + 1$

$0011000_{(2)} \longrightarrow 1101000_{(2)}$

طريقة أخرى :- $0011\underset{\uparrow}{}000_{(2)} \longrightarrow 1101000_{(2)}$

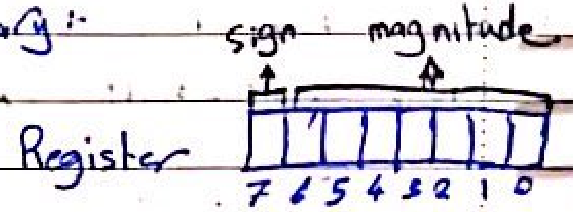
Ex: $1111 \xrightarrow{1's\ comp} 0000 \xrightarrow{2's} 0001$

$1000 \xrightarrow{1's} 0111 \xrightarrow{2's} 1000$

$00110 \xrightarrow{1's} 11001 \xrightarrow{2's} 11010.$

*Number Systems:-

*Representation of number in binary:-



1- Sign-magnitude representation:-

*Ex:- express the following number in 4 bit-register :

+2	0010
-2	1010
+3	0011
-3	1011

and in 8 bit register

+2	00000010
-2	10000010
+3	00000011

max / min number = $\boxed{\pm(2^{n-1}-1)}$
n → of bits

$n = 4$ bits ⇒ max/min $= \mp(2^3-1) = \mp 7$.

$n = 8$ bits ⇒ max/min $= \mp(2^7-1) = \mp 127$.

*Sign:-
Positive ⇒ 0
negative ⇒ 1.

2- One's Complement representation:-

Positive numbers stay the same.
negative numbers you need 1's complement.

Ex: express the following numbers in 4 bit and 8 bits representation

+2	0010	00000010
-2	1101	11111101
+3	0011	00000011

1's comp.

*Number Systems :-

* Representation of number in binary :-

3. Two's Complement representation :

Positive number $\xrightarrow{2's}$ no complement.

Negative number $\xrightarrow{2's}$ with complement.

*Ex :- Represent the following numbers in 2's complement representation for 4-bit data and 8 bit data.

+2 $\boxed{0|0|1|0}$ ⤵ 2's comp. +2 $\boxed{0|0|0|0|0|0|1|0}$ ⤵ 2's comp.

-2 $\boxed{1|1|1|0}$ -2 $\boxed{1|1|1|1|1|1|1|0}$

+3 $\boxed{0|0|1|1}$ ⤵ 2's comp. +3 $\boxed{0|0|0|0|0|0|1|1}$ ⤵ 2's comp.

-3 $\boxed{1|1|0|1}$ -3 $\boxed{1|1|1|1|1|1|0|1}$

4- Floating Point representation :- . مهم جدا

هو تمثيل للارقام الكبيرة والصغيرة جدا .

Ex :- $0.6 * 10^{21}$. $0.53202 * 10^{-18}$

(Decimal) . (Decimal)

* Ranges :-

1. Sign - magnuitude representation ⇒ Positive / negative ⇒ ± $(2^{n-1}-1)$
2. One's Complement representation ⇒ Positive / negative ⇒ ± $(2^{n-1}-1)$
3. Two's complement representation → Positive ⇒ ± $(2^{n-1}-1)$
   ↳ negative ⇒ $(-2^{n-1} \rightarrow 2^{n-1}-1)$

*Number Systems :-

*Why we use 2's complement instead of 1's comp.

① $+0 : 0000$

$\underbrace{-0 : 1111}$

1's comp.

→ Two representation for the same number

$+0 : 0000$

$\underbrace{-0 : 0000}$

2's comp.

→ One representation for the same number ✓✓

② One's comp repre..

$3_{(10)} - 2_{(10)} = 3_{(10)} + -2_{(10)}$

$= 0011 + 1101$ → 1's comp.

$$\begin{array}{r} 0011 \\ +\ 1101 \\ \hline ①\ 0000 \\ +\ \ \ \ 1 \\ \hline 0001 \end{array} \leftarrow$$

خطوة تانية

عملنا خطوتين لنوصل للجواب بال 1's comp

*Two's comp repr

$3_{(10)} - 2_{(10)} = 3_{(10)} + -2_{(10)}$

$= 0011 + 1110$

$$\begin{array}{r} 0011 \\ +\ 1110 \\ \hline ①\ 0001 \end{array} \leftarrow$$

خطوة وحدة. وصلنا للجواب بال 2's comp.

*Ex :-

1. $2_{(10)} - 3_{(10)} = 2_{(10)} + -3_{(10)}$

$= 0010_{(2)} + 1101_{(2)}$

$$\begin{array}{r} 0010 \\ +\ 1101 \\ \hline 1111 \end{array} \rightarrow \text{2's comp}$$

$2_{(10)} - 3_{(10)} = -1_{(10)}$

2. $33_{(10)} - 49_{(10)}$

$$\begin{array}{r} 00100001 \\ +\ 11001111 \\ \hline 11110000 \end{array} \rightarrow \text{2's comp.}$$

$33_{(10)} - 49_{(10)} = -16_{(10)}$

* Number Systems:-

*Ex:-

2. $33_{(10)} - 49_{(10)}$

33	
16	1 → LSB.
8	0
4	0
2	0
1	0
0	1 → MSB

49	
24	1 → LSB.
12	0
6	0
3	0
1	1
0	1 → MSB.

$33_{(10)} = 100001_{(2)} \overset{2's}{\Rightarrow} 00100001_{(2)}$

$\ominus 49_{(10)} = 110001_{(2)} \overset{2's}{\Rightarrow} 11001111_{(2)}$

$33_{(10)} + -49_{(10)}$

1 1 1 1

$$\begin{array}{r} 00100001 \\ + \; 11001111 \\ \hline 11110000 \end{array}$$

→ 2's Comp.

3. $4_{(10)} - 6_{(10)}$

$4_{(10)} = 0100_{(2)} \overset{2's}{\Rightarrow} 0100_{(2)}$

$6_{(10)} = 0110_{(2)} \overset{2's}{\Rightarrow} 1010_{(2)}$

$$\begin{array}{r} 0100 \\ + \; 1010 \\ \hline 1110 \end{array}$$

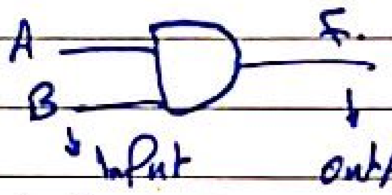
→ 2's Comp.

$4_{(10)} - 6_{(10)} = -2_{(10)}$

* logic Gates :-

* logic Gates:-

1- AND Gates :-



Symbols

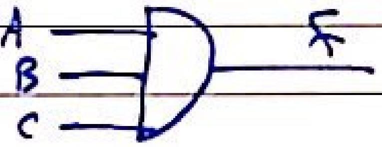
A.B = F.

AND operater

* Truth tables :-

A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

* Three input AND Gates :-

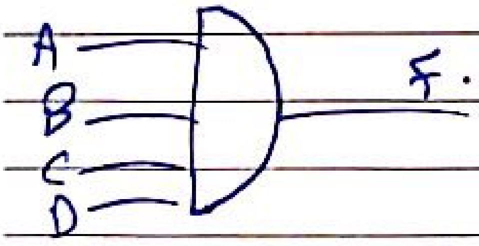


F = A.B.C

* Truth tables :-

A	B	C	F
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

* Four input AND

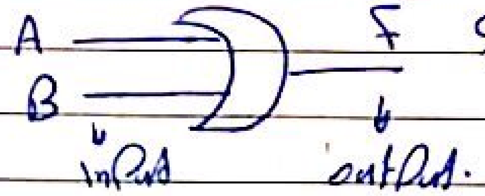


F = A.B.C.D.

* Logic Gates :-

* logic gates :-

2. OR Gate :-



Symbolic.

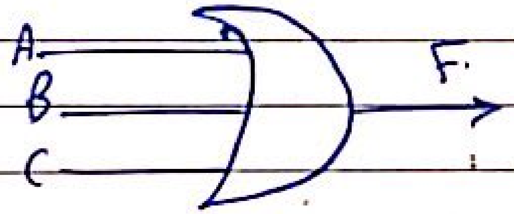
$A + B = F$.

OR operater.

* Truth tables :-

A	B	F.
0	0	0
0	1	1
1	0	1
1	1	1

* Three Input OR Gates :-

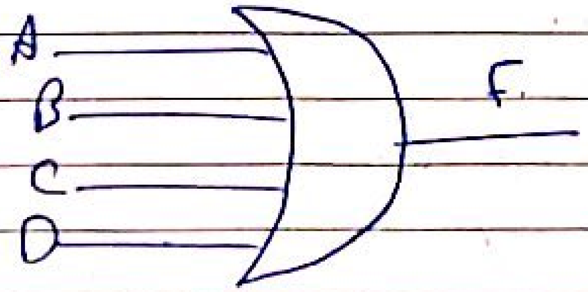


$F = A \oplus B \oplus C$

* Truth tables :-

A	B	C	F.
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	C	1
1	0	1	1
1	1	0	1
1	1	1	1

* Four Input OR Gates :-

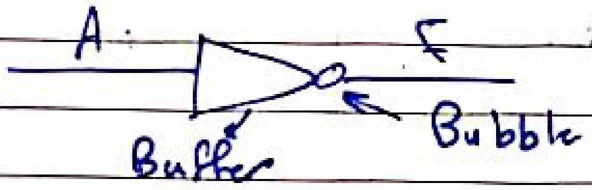


$F = A \oplus B \oplus C \oplus D$

* logic Gates :-

* logic Gates :-

3- Inverter (NOt) Gates.

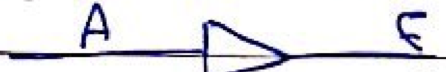


$F = A'$ ⤳ A complement

* Truth tables :-

A	F
0	1
1	0

4- Buffer Gates :-



$F = A$. موجود زي ما هو

* Truth tables.

A	F
0	0
1	1

* Boolean Theorems and Properties :-

1- closure with respect to "+" operator.
Closure with respect to "." operator.

2- $X + 0 = 0 + X = X.$ $\longrightarrow$ $\boxed{X + 1 = 1}$
$X \cdot 1 = 1 . X = X.$ $\longrightarrow$ $\boxed{X . 0 = 0}$

3- Commutative $X + Y = Y + X.$
$X \cdot Y = Y \cdot X.$

4- Distributive $X \cdot (Y + Z) = X.Y + X.Z$
$X + (Y . Z) = X Y + Y Z.$

5- $X + \bar{X} = 1$ $X . \bar{X} = 0.$
$Y + \bar{Y} = 1$ $Y + \bar{Y} = 0$

* logic Gates:-

* Demorgan Theorem :-

1. $(X+y)' = \overline{(X+y)} = \bar{X} . \bar{y}$
2. $(X . y)' = \overline{(X . y)} = \bar{X} + \bar{y}$.

* Ex :- $\overline{(Xy + \bar{X}\bar{y})}$

$$\overline{XY + \bar{X}\bar{Y}} = (\overline{X \cdot Y}) \cdot (\overline{\bar{X}\bar{Y}})$$
$$= (\bar{X} + \bar{y}) \cdot (\bar{\bar{X}} + \bar{\bar{y}}) .$$
$$= (\bar{X} + \bar{y}) \cdot (X + y) .$$
$$= \cancel{\bar{X}X}^{0} + \bar{X}y + X\bar{y} + \cancel{y\bar{y}}^{0}$$
$$= \bar{X}y + X\bar{y} \quad \#$$

* Absorption Theorem :-

1. $X + Xy = X$
2. $X(X+y) = X$

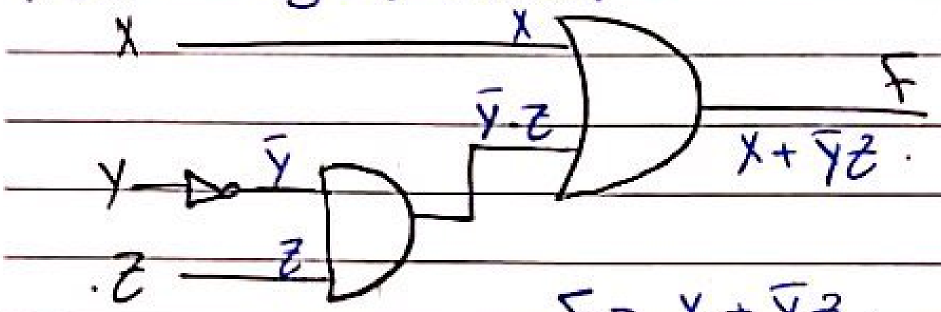
Proof :-

- $X + Xy = X(1+y)$
$= X(1) = X$ #

- $X(X+y) = X + Xy$
$X(1+y) = X(1) = X$. #

*logic Gates :-

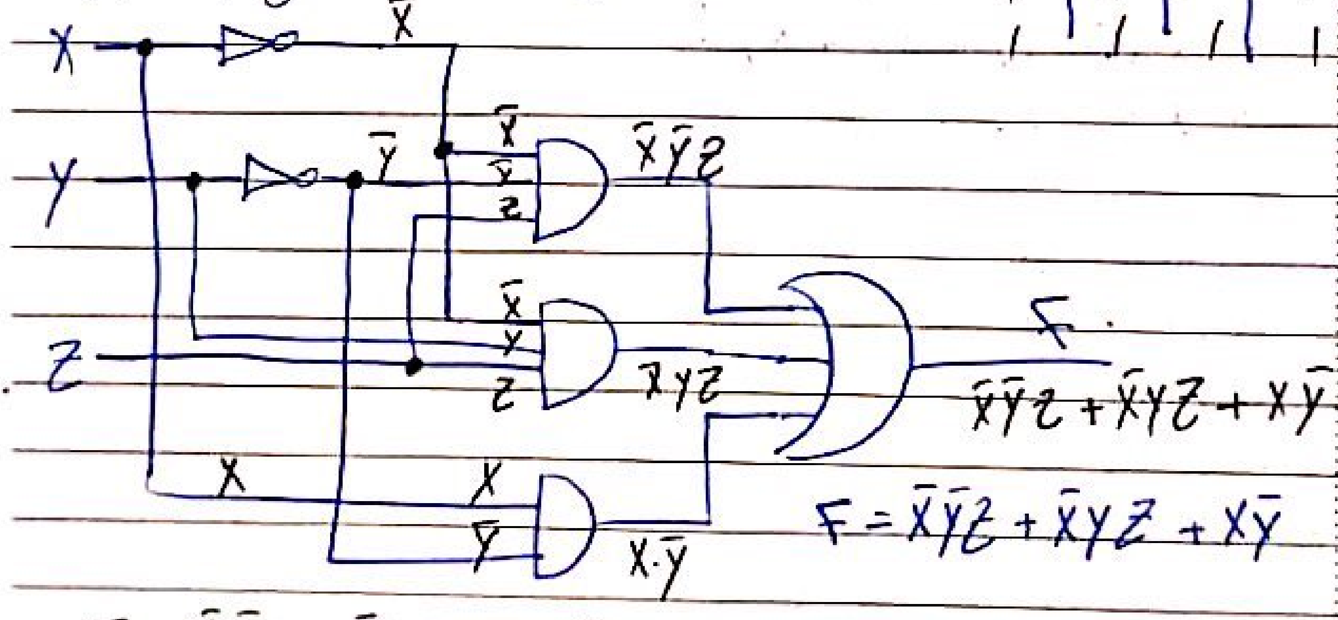
*Ex :- Digital Circuit :-



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	1
1	1	0	1
1	1	1	1

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

*Ex : Digital Circuit :-

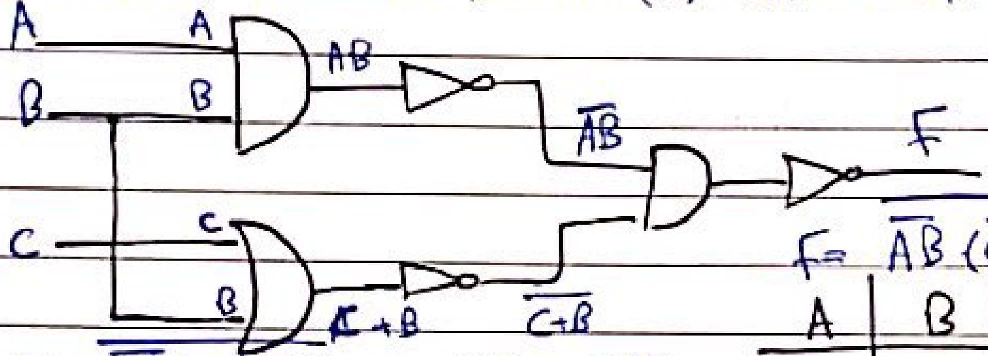


$F = \bar{x}\bar{y}z + \bar{x}yz + x\bar{y}$

$$F = \bar{x}\bar{y}z + \bar{x}yz + x\bar{y}$$
$$\bar{x}(\underbrace{\bar{y}+y}) z + x\bar{y}$$
$$\bar{x}(1) z + x\bar{y} \quad = \bar{x}z + x\bar{y} \; \#$$

*Logic Gates :-

*Ex:- Write down the function(F) and truth table :-

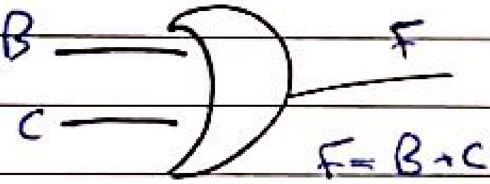


$F = \overline{\overline{AB}\,(\overline{C+B})}$

$F = \overline{(\overline{AB})\cdot(\overline{C+B})} = AB + C + B$

$= B(A+1) + C = B + C$

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



* Use demorgan theorem to simplify :-

1. $A+B+\overline{ABC}$

$= \bar{A}.\bar{B}.ABC = 0.$

2. $\overline{A+B+\bar{A}BC}$

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

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

*logic Gates :-

* Use demorgan theorem to simplify :-

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

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

2- $A(\bar{A}+AB)$

$= \cancel{A\bar{A}} + AAB = AB.$

3- $A(A+\bar{A}B)$ $\boxed{X+\bar{X}Y = X+Y}$

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

4- $A(A+AB) = A.A = A.$

5- $A+ABC+AB+ABCD+ABCDE = A.$

6- $\overline{\overline{ABC}EF + AB\overline{CE}FG + \overline{AF}}$

$= \overline{\overline{ABC}EF} \cdot \overline{AB\overline{CE}FG} \cdot \overline{\overline{AF}}$

$= (ABC+\overline{EF}) \cdot (\overline{ABFG}+CE)(AF).$

$= (ABC+\bar{E}+\bar{F})(\bar{A}+\bar{B}+\bar{F}+\bar{G}+CE)(AF)$

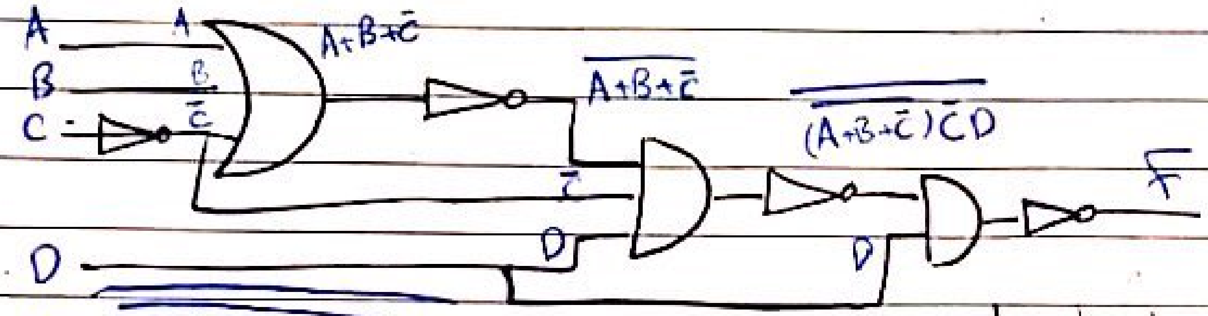
$= ABF\bar{G} + ABCEF + A\bar{B}\bar{C}F + A\bar{C}F\bar{G}$

$+ A\bar{B}\bar{E}F + A\bar{E}\bar{G}F.$

$\boxed{20}$

* logic Gates :-

*Ex: Write down the function F and truth table :-

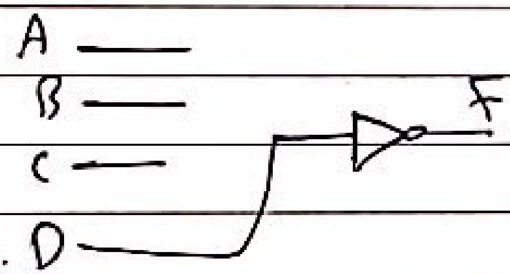


$F = \overline{\overline{(\overline{A+B+\bar{C}})\bar{C}D}\,D}$

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

$F = \bar{D}$

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



$F = \bar{D}$

* logic Gates :-

5- NAND Gates :-

NAND = AND Not Gates .

A	B	F
0	0	1
0	1	1
1	0	1
1	1	0

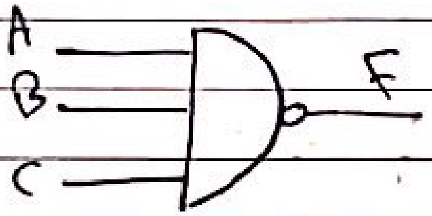
$F = \overline{AB}$

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

*logic Gates :-

*logic Gates :-

5- NAND Gates :-

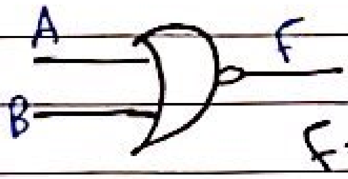


A	B	C	F
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

$$F = \overline{ABC} = \bar{A}+\bar{B}+\bar{C}$$

6- NoR Gates :-

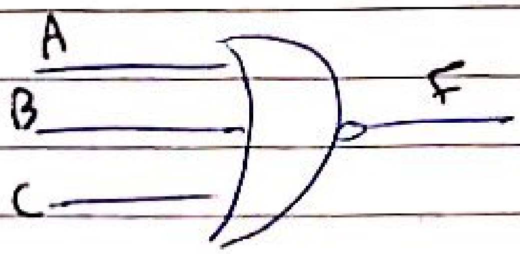
NoR = OR Not Gates.



$F = \overline{A+B}$

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

A	B	F
0	0	1
0	1	0
1	0	0
1	1	0



A	B	C	F
0	0	0	1
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	0

* Logic Gates :-

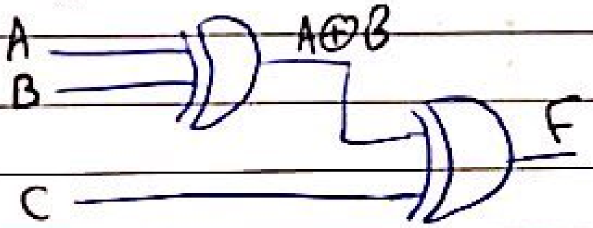
* logic Gates:

7- Eclusive OR (XOR) :-

A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

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

No Three or more input for (XOR) Gates
Only two input.



$F = (A \oplus B) \oplus C$

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

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

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

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

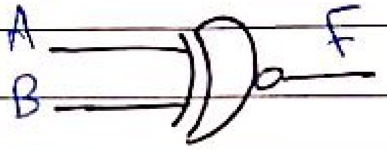
$F = A\bar{B}\bar{C} + \bar{A}B\bar{C} + ((\bar{A} + B)(A + \bar{B}))C.$

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

* logic Gates:-

* logic Gates:-

8- Exclusive NOR (XNOR)



$\boxed{F = A \odot B} \Rightarrow \bar{A}\bar{B} + AB$

OR

الأول

الثاني

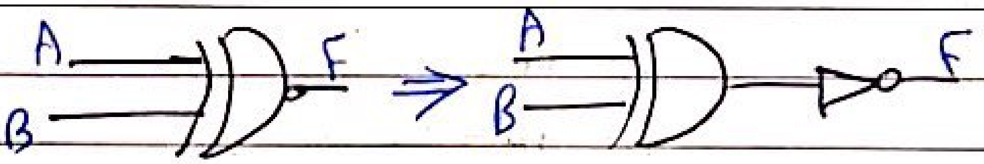
الأول comp.

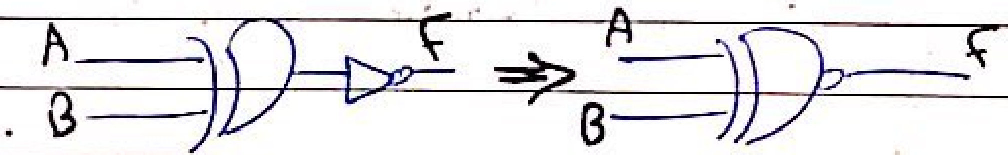
الثاني comp.

$F = \overline{A \oplus B} = \overline{A\bar{B} + \bar{A}B}$

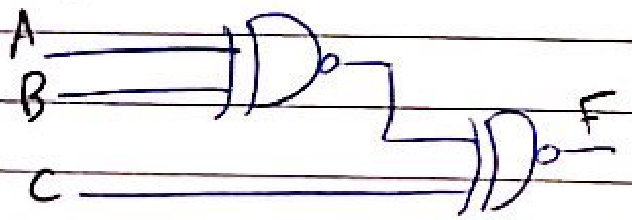
$F = (\overline{A\bar{B}}) \cdot (\overline{\bar{A}B}) = (\bar{A}+B)(A+\bar{B})$

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





Only Two input



$F = \underline{(A \odot B) \odot C}$

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

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

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

$F = (A \odot B) \odot C$

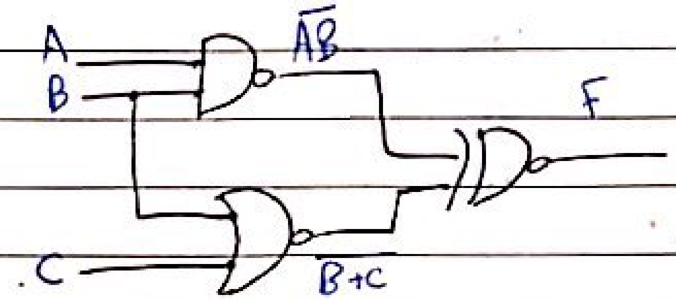
$= \underline{(\bar{A}\bar{B} + AB) \odot C}$ OR

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

comp الأول comp الثاني الأول الثاني

* Logic Gates :-

* Ex :- Find the function and the truth table :-



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

$F = \overline{\overline{AB}}\,(\overline{\overline{B+C}}) + \overline{AB}\,(\overline{B+C})$

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

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

$F = AB(1+C) + \bar{B}\bar{C}(\bar{A}+1)$

$F = AB + \bar{B}\bar{C}$ #.

K- maP :-

Number	X	Y	Z	Minterms Term Designation		Maxterms Term Designation	
0	0	0	0	$\bar{X}\bar{Y}\bar{Z}$ ⓪	m_0	$X+Y+Z$ ⓪	M_0
1	0	0	1	$\bar{X}\bar{Y}Z$ ①	m_1	$X+Y+\bar{Z}$ ①	M_1
2	0	1	0	$\bar{X}Y\bar{Z}$ (10)	m_2	$X+\bar{Y}+Z$ (10)	M_2
3	0	1	1	$\bar{X}YZ$ (11)	m_3	$X+\bar{Y}+\bar{Z}$ (10)	M_3
4	1	0	0	$X\bar{Y}\bar{Z}$ (100)	m_4	$\bar{X}+Y+Z$ (100)	M_4
5	1	0	1	$X\bar{Y}Z$ (101)	m_5	$\bar{X}+Y+\bar{Z}$ (101)	M_5
6	1	1	0	$XY\bar{Z}$ (110)	m_6	$\bar{X}+\bar{Y}+Z$ (110)	M_6
7	1	1	1	XYZ (111)	m_7	$\bar{X}+\bar{Y}+\bar{Z}$ (111)	M_7

Product of Sum (POS)

Sum of Product (SOP) ← $X, Y, Z \rightarrow 1$

$\bar{X}.\bar{Y}.\bar{Z} \rightarrow 0$

$\bar{X}.\bar{Y}.\bar{Z} \rightarrow 1$

$X.Y.Z \rightarrow 0$

*Logic Gates :-

sop pos sop

*Ex :- $F(x,y) = (\bar{x}+y) \cdot (\bar{x}+\bar{y})$

$= M_2 \cdot M_3 = \prod(2,3)$

$= \prod(2,3)$

مضروب

	X	Y	F
m_0	0	0	1
m_1	0	1	1
m_2	1	0	0
m_3	1	1	0

pos sop pos

*Ex: $F(A,B) = AB + \bar{A}\bar{B}$

$= m_3 + m_0$

$= \sum(0,3)$

مجموع

	A	B	F
m_0	0	0	1
m_1	0	1	0
m_2	1	0	0
m_3	1	1	1

K-map :-

number	A	B	minterms	maxterms
0	0	0	$\bar{A}\bar{B}$ m_0	$A+B$ M_0
1	0	1	$\bar{A}B$ m_1	$A+\bar{B}$ M_1
2	1	0	$A\bar{B}$ m_2	$\bar{A}+B$ M_2
3	1	1	AB m_3	$\bar{A}+\bar{B}$ M_3

$\bar{A}, \bar{B} \rightarrow 0$. $A, B \rightarrow 0$

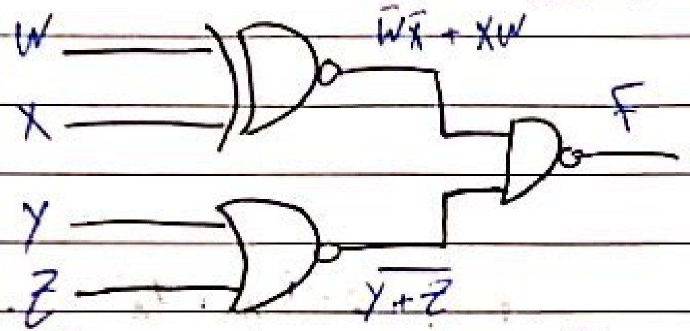
$A, B \rightarrow 1$ $\bar{A}, \bar{B} \rightarrow 1$

$\sum_{i=1}^{3} X_i$

$= X_1 + X_2 + X_3$

*logic Gates :-

*Ex:- Represent the following system in all posible representation:-



$F = \overline{(\overline{Y+Z})(\bar{W}\bar{X} + WX)}$

$F = (Y+Z) + \overline{(\bar{W}\bar{Y} + WX)}$

$F = (Y+Z) + (\bar{W}X + W\bar{X})$

$F(XW, X, Y, Z) = Y + Z + \bar{W}X + W\bar{X}$

SOP ↗

$F(W, X, Y, Z) = Y + Z + \bar{W}X + W\bar{X}$.

$F = (W+\bar{W})(X+\bar{X})Y(Z+\bar{Z}) + (W+\bar{W})(X+\bar{X})(Y+\bar{Y})Z$ → standard form.

$+ \bar{W}X(Y+\bar{Y})(Z+\bar{Z}) + W\bar{X}(Y+\bar{Y})(Z+\bar{Z})$.

$\boxed{Y}$

W	X	Y	Z	
0 1	0 1	1	0 1	
0	0	1	0	2
0	0	1	1	3
0	1	1	0	6
0	1	1	1	7
1	0	1	0	10
1	0	1	1	11
1	1	1	0	14
1	1	1	1	15

$\boxed{Z}$

W	X	Y	Z	
0 1	0 1	0 1	1	
0	0	0	1	1
0	0	1	1	3
0	1	0	1	5
0	1	1	1	7
1	0	0	1	9
1	0	1	1	11
1	1	0	1	13
1	1	1	1	15

$\boxed{\bar{W}X}$

$\bar{W}$	X	Y	Z	
0	1	0 1	0 1	
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7

$W\bar{X}$

W	$\bar{X}$	Y	Z	
1	0	0 1	0 1	
1	0	0	0	8
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11

$F = \Sigma(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15)$

$F = \Pi(0, 12) = M_0 \cdot M_{12}$

$F = (W + X + Y + Z) \cdot (\bar{W} + \bar{X} + \bar{Y} + Z)$

POS.

*logic Gates :-

*Ex :- Truth table :-

$F = Y + Z + \bar{W}X + W\bar{X}$

W	X	Y	Z	F	$\bar{F}$
0	0	0	0	0	1
0	0	0	1	1	0
0	0	1	0	1	0
0	0	1	1	1	0
0	1	0	0	1	0
0	1	0	1	1	0
0	1	1	0	1	0
0	1	1	1	1	0
1	0	0	0	1	0
1	0	0	1	1	0
1	0	1	0	1	0
1	0	1	1	1	0
1	1	0	0	0	1
1	1	0	1	1	0
1	1	1	0	1	0
1	1	1	1	1	0

$F = Y + Z + \bar{W}X + W\bar{X}$

$F = \Sigma(1,2,3,4,5,6,7,8,$
$9,10,11,13,14,15).$

$F = m_1 + m_2 + m_3 + \dots m_{15}$

$F = \Pi(0.12) \cdot$
$- M_0 \cdot M_{12}$

$F = \Sigma(1,2,3,4 \dots 11,13,14,15].$

$F = \bar{W}\bar{X}\bar{Y}Z + \bar{W}\bar{X}YZ \dots\dots$

$F = \Pi(0,12) \cdot - M_0 \cdot M_{12}$

$F = (W + X + Y + Z) \cdot (\bar{W} + \bar{X} + \bar{Y} + Z)$

*logic Gates :-

*Ex :-

$F(A.B.C) = AB + BC'.(A+C).$

$F = AB + BC'A + B\cancel{C'C}.$

$F = AB + ABC'$

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

$F = ABC + ABC' + ABC'$

$F = ABC + AB\bar{C}$

$F = m_7 + m_6.$

$F = \Sigma(6.7).$

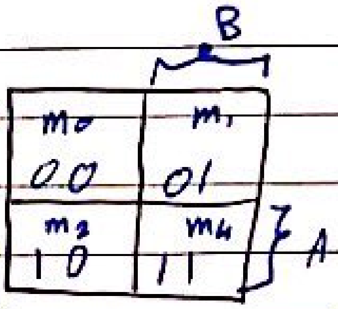
$F = \Pi(0.1.2.3.4.5).$

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

* Karnagh map (K-map) :-

1- Two Varicble (K-map) :-

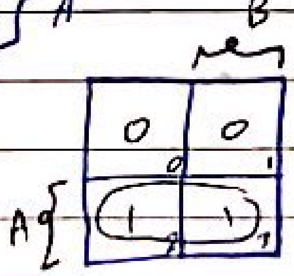
A	B	
0	0	m_0
0	1	m_1
1	0	m_2
1	1	m_3



$F(A.B) = \overset{10}{A\bar{B}} + \overset{11}{AB}$

$F(A.B) = m_2 + m_3.$

$F(A.B) = \Sigma(2.3)$



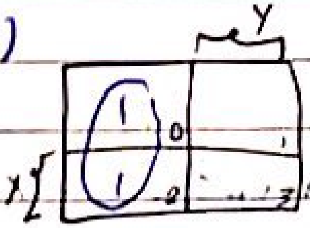
$F(A.B) = A.$

*logic Gates:-

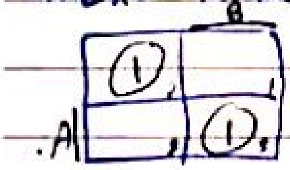
*Ex:- Simplify F(x,y) = Σ(0,2)

F(x,y) = Σ(0,2)

F(x,y) = $\bar{Y}$



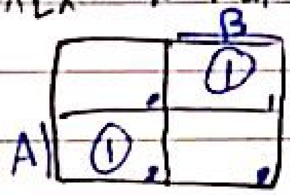
*Ex:- K-map.



F(A,B) = $\bar{A}\bar{B} + AB$ → XNOR

F(A,B) = A⊙B

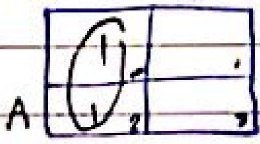
*Ex:- K-map:-



F(A,B) = $A\bar{B} + \bar{A}B$ → XOR

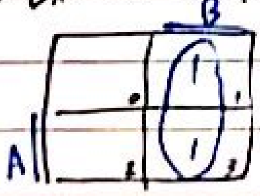
F(A,B) = A⊕B

*Ex:- K-map:-



F(A,B) = $\bar{B}$

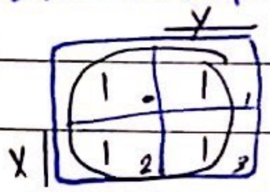
*Ex:- K-map:-



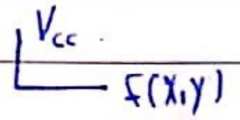
F(A,B) = B

*logic Gates :-

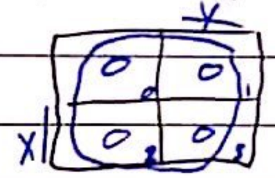
*Ex:- K-map :-



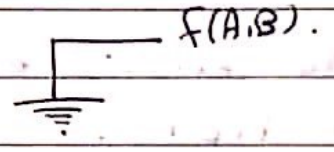
$F(x,y) = 1$



*Ex:- K-map :-



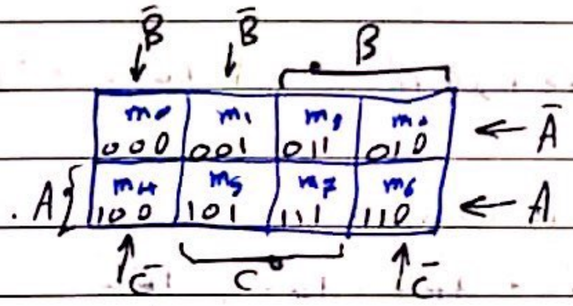
$F(x,y) = 0$



* K-map :-

2- Three Variable K-map :-

A	B	C	
0	0	0	m_0
0	0	1	m_1
0	1	0	m_2
0	1	1	m_3
1	0	0	m_4
1	0	1	m_5
1	1	0	m_6
1	1	1	m_7



*Three Variable K-map

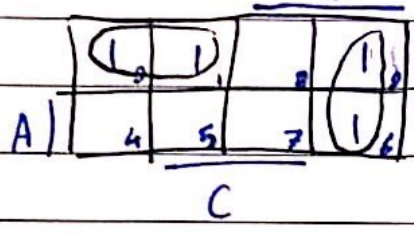
K-map ⇒ Cylinder

ال K-map عبارة عن اسطوانة

ال (Three Variable K-map).

*logic Gates :-

*Ex:- Simplify $F(A,B,C) = \Sigma(0,1,2,6)$.



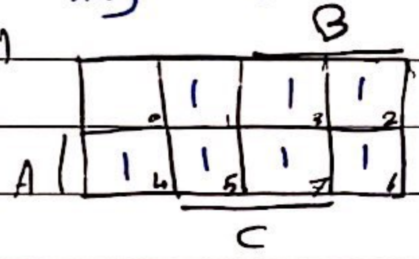
$F(A,B,C) = \bar{A}\bar{B} + B\bar{C}$.

*Ex:- Find the standered form for :-

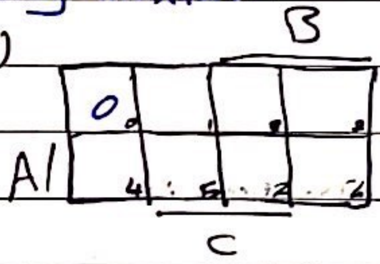
$F(A,B,C) = A+B+C$.

a) Using minterm. b) using maxterm.

a)



b)



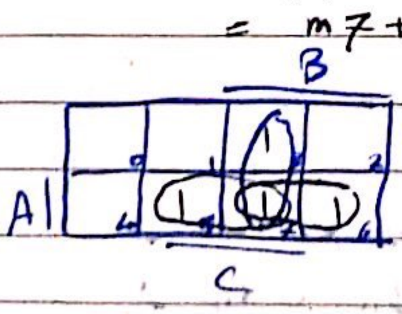
$F(A,B,C) = \Sigma(1,2,3,4,5,6,7)$ $F(A,B,C) = \Pi(0)$.

*Ex: Simplify using K-map :-

$F(A,B,C) = \underset{111}{ABC} + \underset{101}{A\bar{B}C} + \underset{011}{\bar{A}BC} + \underset{110}{AB\bar{C}}$.

$= m_7 + m_5 + m_3 + m_6 = \Sigma(3,5,6,7)$.

$F(A,B,C) = AC + AB + BC$.

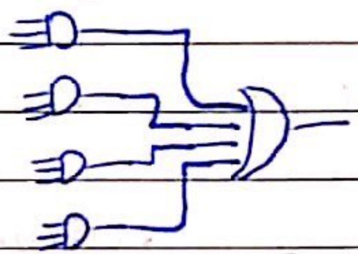


*logic Gaties :-

*Ex:- تابع

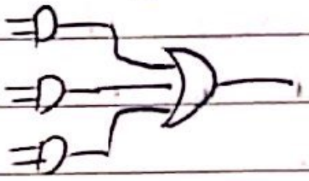
$F(A.B.C) = ABC + A\bar{B}C + \bar{A}BC + AB\bar{C}$

as logic Gaties



$F(A.B.C) = AC + BC + AB.$

as logic Gaties



* Rules for K-map simplification using minterms :-

1- Cover all ones and non of Zeros.
2- Minimize the number of circles (term).
3- Maximize ~~the~~ size for every circles (Variables).
4- Every circle should be inclued 1.2.4.8.16 ones.

* four Variable K-map :-

C

	m_0 0000	m_1 0001	m_3 0011	m_2 0010
	m_4 0100	m_5 0101	m_7 0111	m_6 0110
A	m_{12} 1100	m_{13} 1101	m_{15} 1111	m_{14} 1110
A	m_8 1000	m_9 1001	m_{11} 1011	m_{10} 1010

B

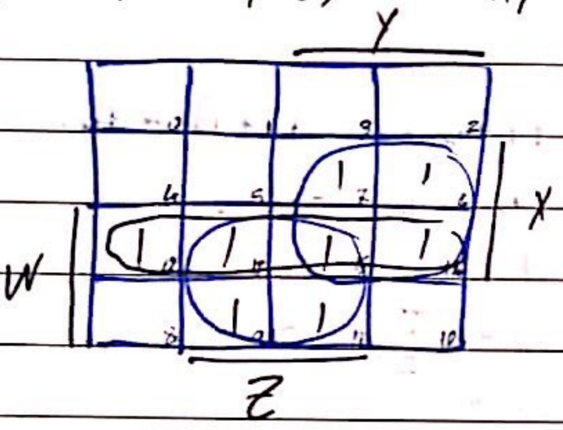
D

* four Variable K-map
K-map ⇒ sphere
ال K-map عبارة عن كرة
(four Validble K-map) ال.

$F(\underset{W}{\underset{\downarrow}{A}},\underset{X}{\underset{\downarrow}{B}},\underset{Y}{\underset{\downarrow}{C}},\underset{Z}{\underset{\downarrow}{D}})$

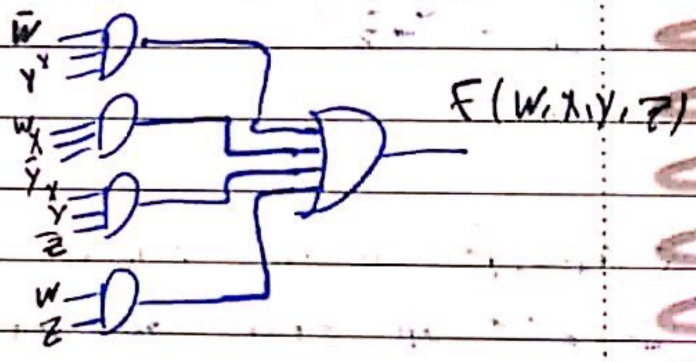
* Logic Gates :-

*Ex:- $F(W,X,Y,Z) = \bar{W}XY + WX\bar{Y} + XY\bar{Z} + WZ.$

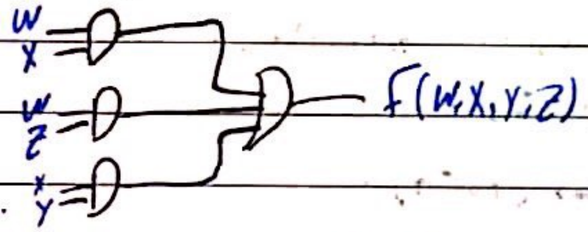


$F(W,X,Y,Z) = WX + WZ + XY.$

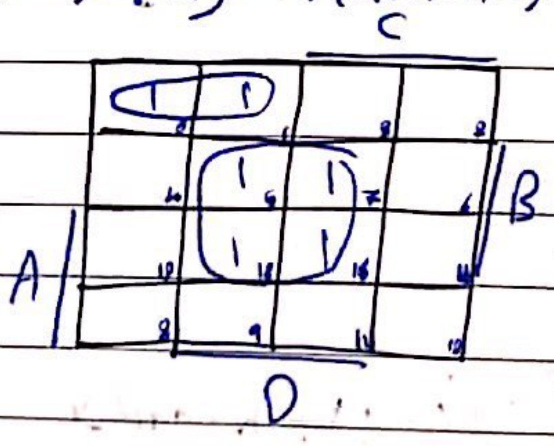
$F(W,X,Y,Z) = \bar{W}XY + WX\bar{Y} + XY\bar{Z} + WZ.$



$F(W,X,Y,Z) = Wx + WZ + XY.$



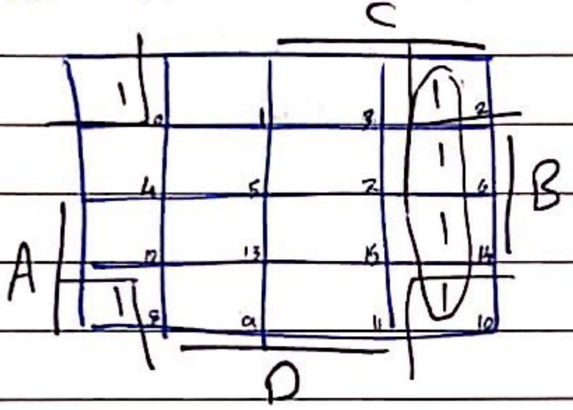
*Ex: Simplify $F(A,B,C,D) = \Sigma(0,1,5,7,13,15)$



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

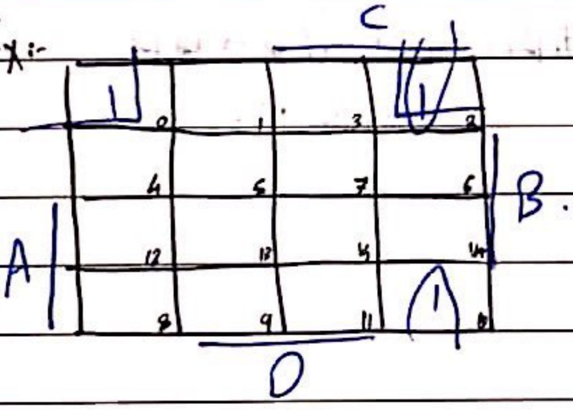
*logic Gates :-

*Ex :- Find the function :-



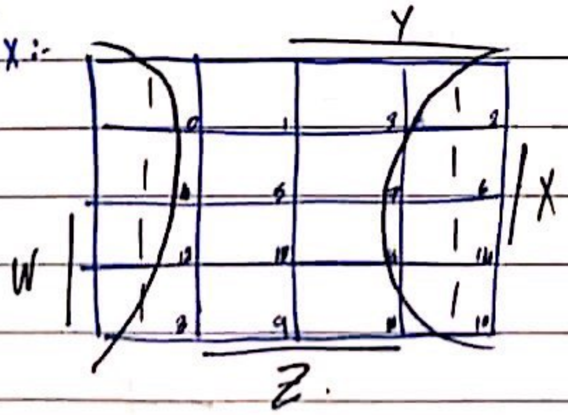
$F(A,B,C,D) = C\bar{D} + \bar{B}\bar{D}$

*Ex:-



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

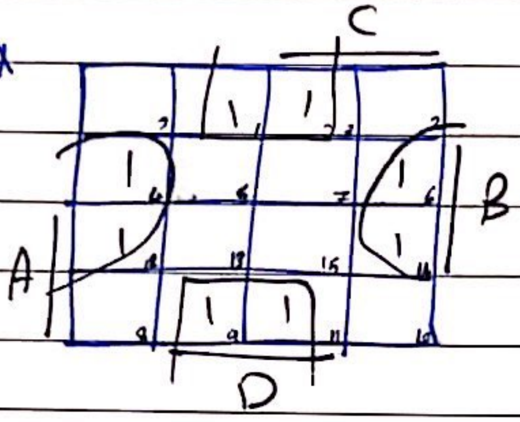
*Ex:-



$F(W,X,Y,Z) = \bar{Z}$.

*logic Gates:-

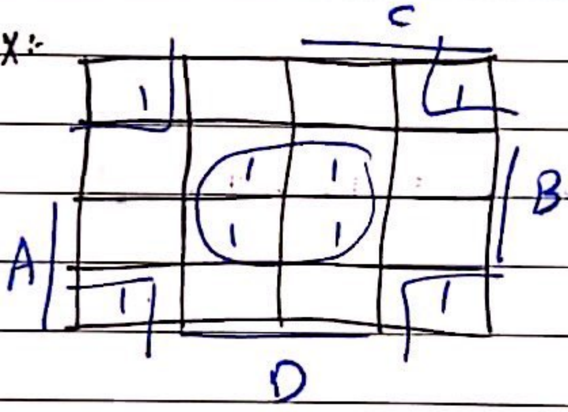
*Ex



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

$= B \oplus D.$

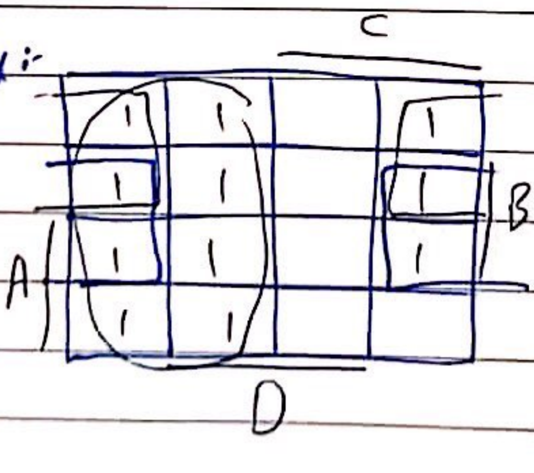
*Ex:-



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

$= B \odot D.$

*Ex:-



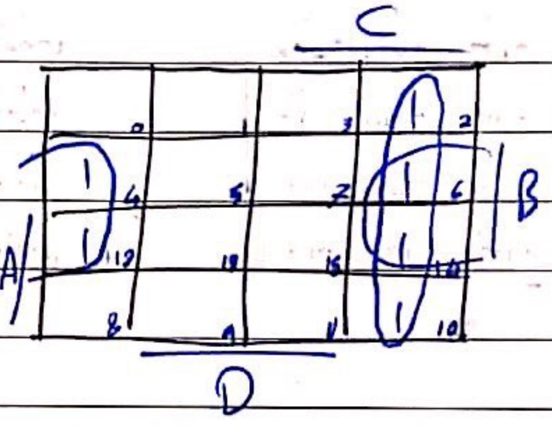
$F(A,B,C,D) =$

Subject Date No.

*logic Gates :-

*Ex :- F(A,B,C,D) Simplify.

A	B	C	D	F	
0	0	0	0	0	m_0
0	0	0	1	0	m_1
0	0	1	0	1	m_2
0	0	1	1	0	m_3
0	1	0	0	1	m_4
0	1	0	1	0	m_5
0	1	1	0	1	m_6
0	1	1	1	0	m_7
1	0	0	0	0	m_8
1	0	0	1	0	m_9
1	0	1	0	1	m_{10}
1	0	1	1	0	m_{11}
1	1	0	0	1	m_{12}
1	1	0	1	0	m_{13}
1	1	1	0	1	m_{14}
1	1	1	1	0	m_{15}



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

*logic Gates :-

* Five - Variables K-map :-

D

m_0 00000	m_1 00001	m_3 00011	m_2 00010
m_4 00100	m_5 00101	m_7 00111	m_6 00110
m_{12} 01100	m_{13} 01101	m_{15} 01111	m_{14} 01110
m_8 01000	m_9 01001	m_{11} 01011	m_{10} 01010

C

B

E

A

D

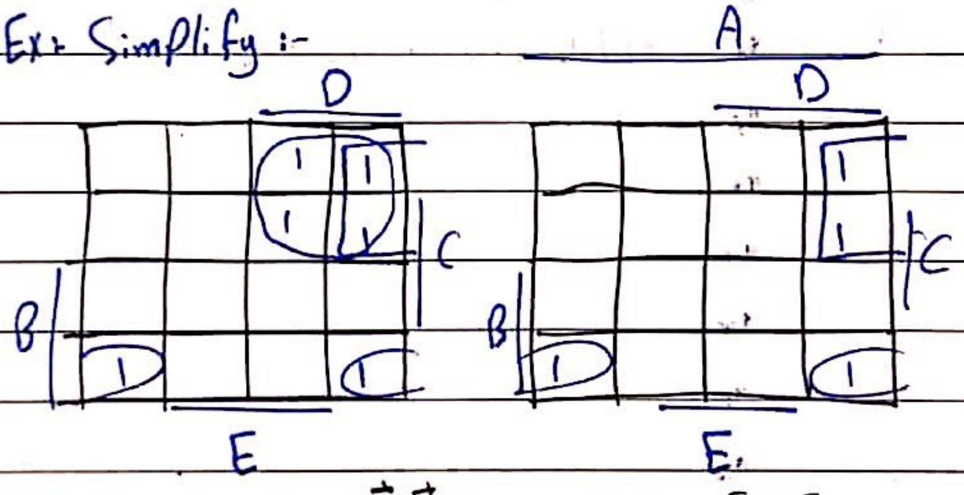
m_{16} 10000	m_{17} 10001	m_{19} 10011	m_{18} 10010
m_{20} 10100	m_{21} 10101	m_{23} 10111	m_{22} 10110
m_{28} 11100	m_{29} 11101	m_{31} 11111	m_{30} 11110
m_{24} 11000	m_{25} 11001	m_{27} 11011	m_{26} 11010

C

B

E

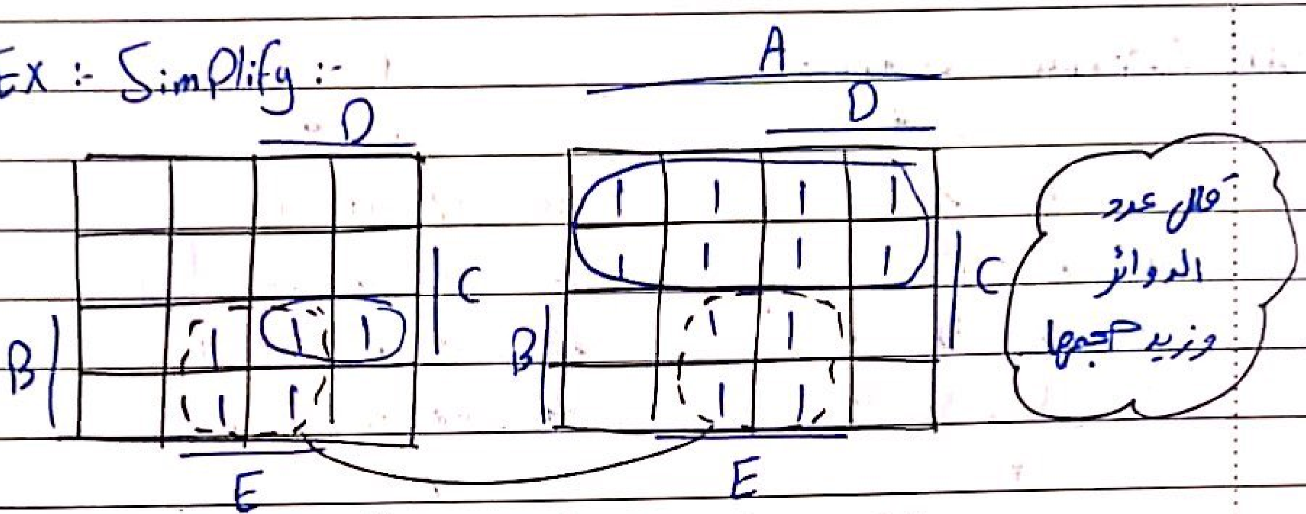
*Ex: Simplify :-



$$F(A,B,C,D,E) = \vec{A}\vec{B}D + B\bar{C}\bar{E} + \bar{B}DE$$

* logic Gates :-

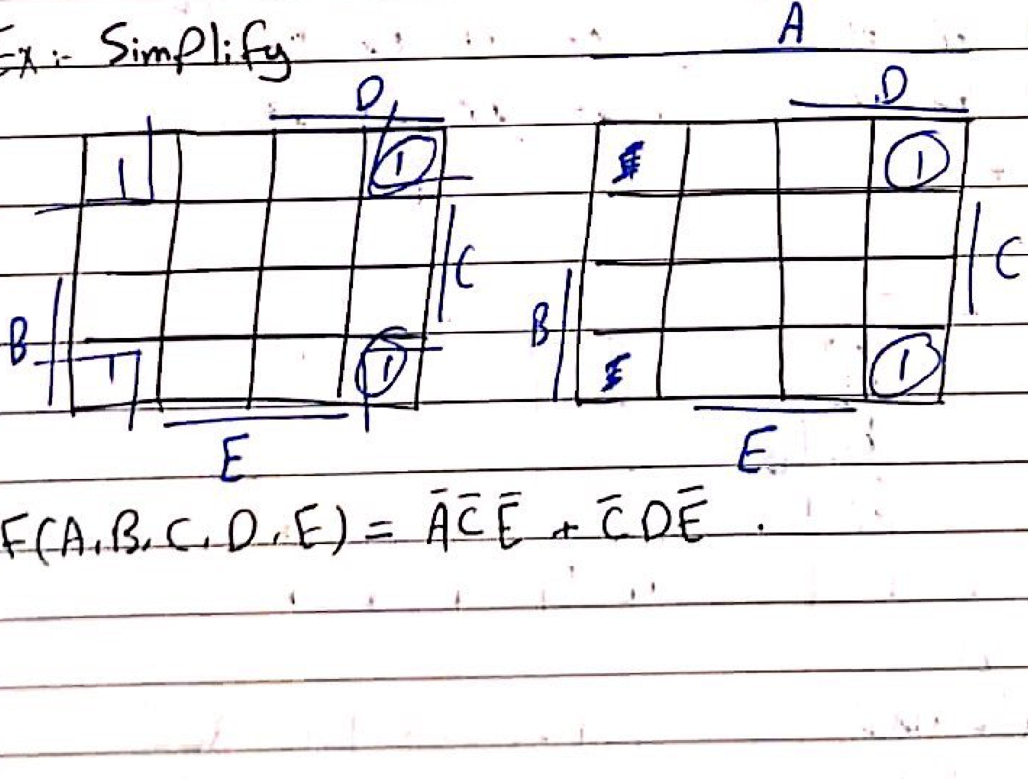
* Ex :- Simplify :-



$F(A,B,C,D,E) = \bar{A}BCD + ABE + \bar{A}BE + A\bar{B}$

$\Rightarrow F(A,B,C,D,E) = BE + \bar{A}BCD + A\bar{B}$

* Ex :- Simplify



$F(A,B,C,D,E) = \bar{A}\bar{C}\bar{E} + \bar{C}D\bar{E}$.

*logic Gates :-

*Six Variable K-map :-

A

E

0	1	3	2
4	5	7	6
12	13	15	14
8	9	11	10

C D F

E

16	17	19	18
20	21	23	22
28	29	31	30
24	25	27	26

C D F

B

E

32	33	35	34
36	37	39	38
44	45	47	46
40	41	43	42

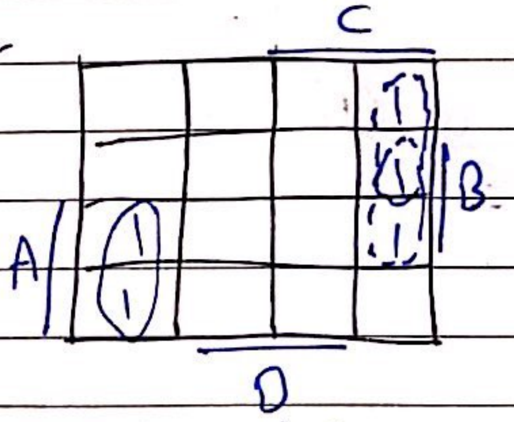
C D F

E

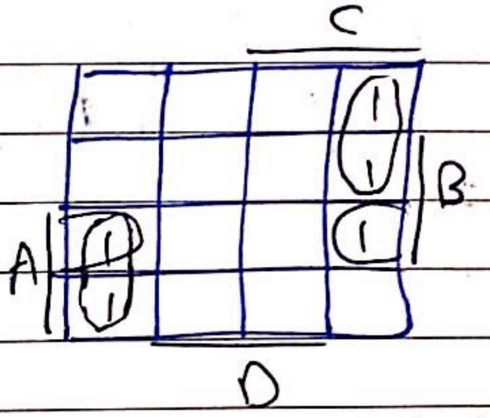
48	49	51	50
52	53	55	54
60	61	63	62
56	57	59	58

C D F

*Ex :-



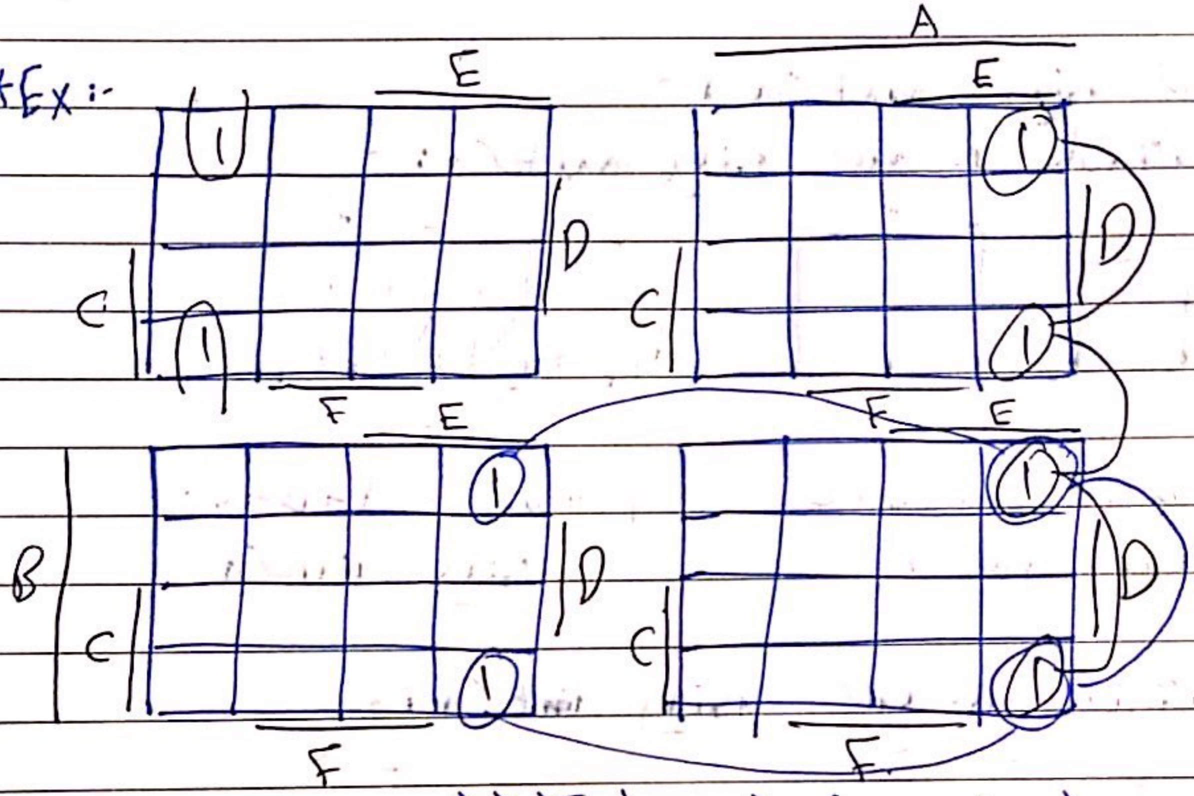
$F(A,B,C,D) = AC'D' + BCD$
$+ A'CD'$



$F(A,B,C,D) = AC'D' + ABD'$
$+ A'CD'$

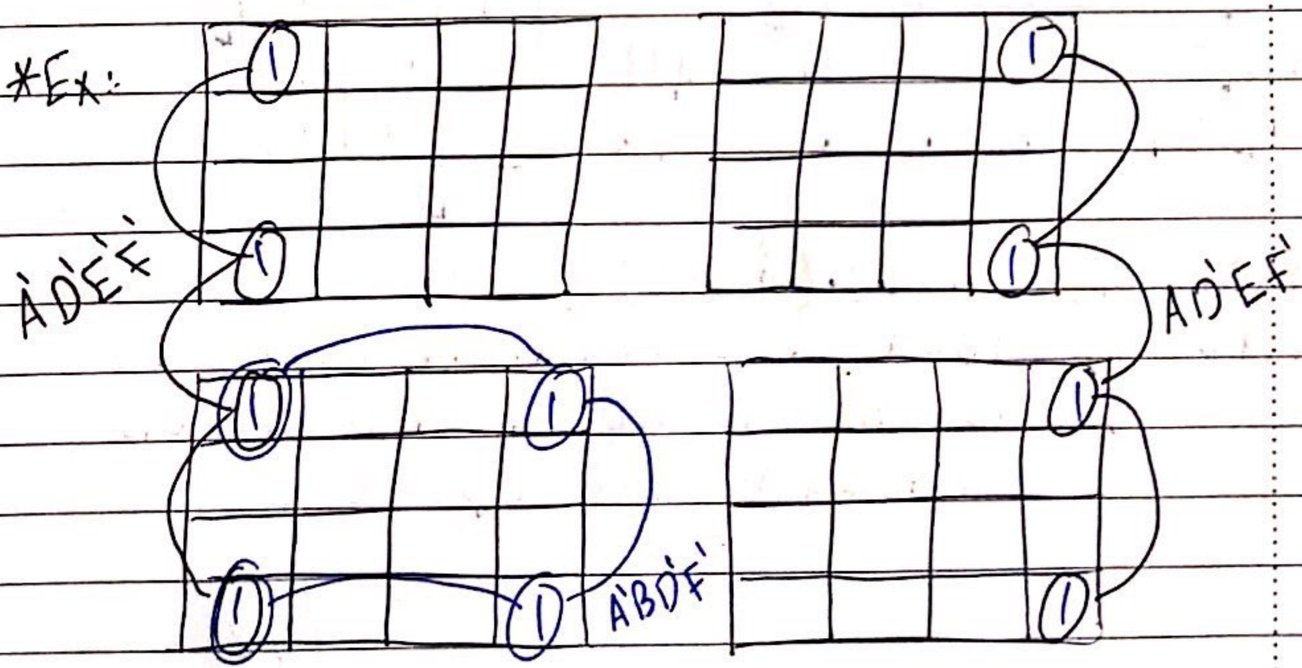
*logic Gates :-

*Ex:-



$F(A,B,C,D,E,F) = A'B'D'EF' + BD'EF' + AD'EF'$.

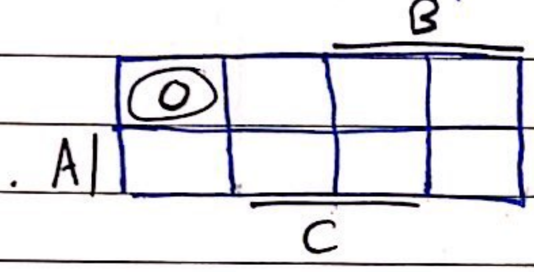
*Ex:

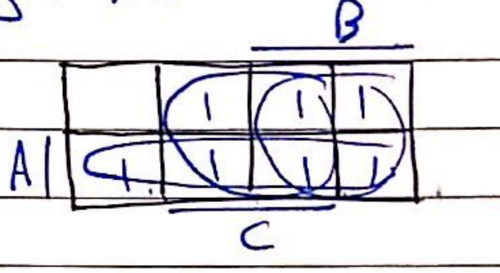


* logic Gates :-

* K-map using maxterm :-

* 3 Variable K-map using maxterm :-

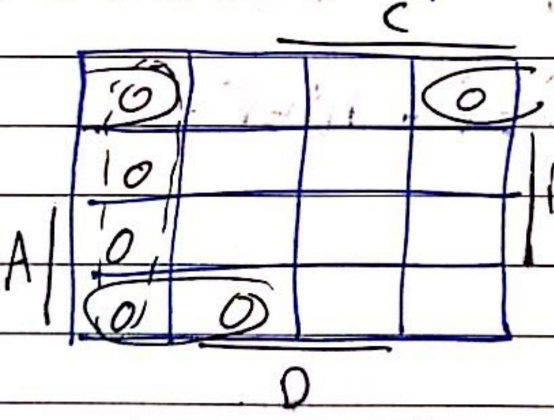




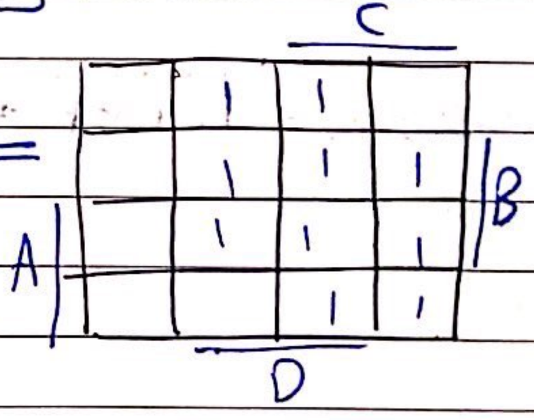
$F(A,B,C) = A+B+C$ using maxterm

$F(A,B,C) = A+B+C$. Using minterm

* 4 Variable K-map using maxterm :-



=



$F(A,B,C,D) = (A'+B'+D)\cdot(A'+B+C)\cdot(C+D)$

$F(A,B,C,D) = (AB+AC+A'B+B+BC+A'D+BD+DC)\cdot(C+D)$

$= ABC+ABD+AC+ACD+AB'C+AB'D+BC+BD$

$+A'DC+A'D+BCD+BD+DC+DC$.

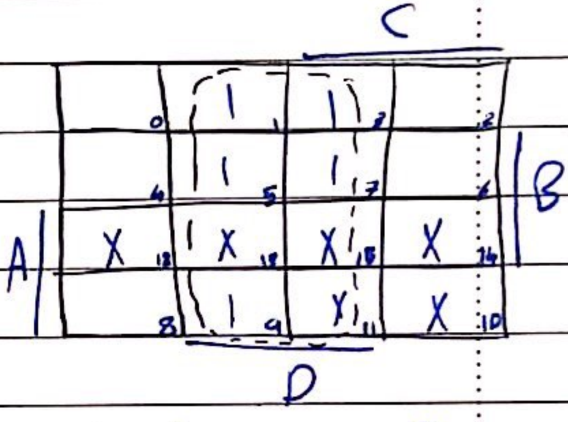
*logic Gates :-

* K-map using BCD :-

for BCD we have :- 0 or 1 or X

where X : not used.

W	X	Y	Z	Decimal	F
0	0	0	0	0	0
0	0	0	1	1	1
0	0	1	0	2	0
0	0	1	1	3	1
0	1	0	0	4	0
0	1	0	1	5	1
0	1	1	0	6	0
0	1	1	1	7	1
1	0	0	0	8	0
1	0	0	1	9	1
1	0	1	0	X	X
1	0	1	1	X	X
1	1	0	0	X	X
1	1	0	1	X	X
1	1	1	0	X	X
1	1	1	1	X	X



 0	1 1	1 3	 2
 4	1 5	1 7	 6
X 12	X 13	X 15	X 14
 8	1 9	X 11	X 10

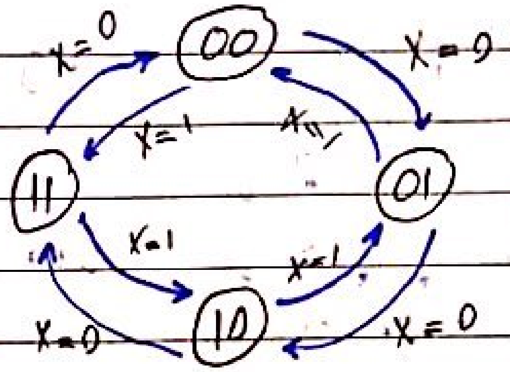
$F(A,B,C,D) = D.$

الـ not used بنقدر نتوسع
ع حسابها (بنجبرها تصير 1)
اذا بنقدر نوسع الدائرة .

* Digital logic and Digital Electronics :-

* Design a 2-bit up/Down Counter :-

A	B	X	F_1	F_2
0	0	0	0	1
0	0	1	1	1
0	1	0	1	0
0	1	1	0	0
1	0	0	1	1
1	0	1	0	1
1	1	0	0	0
1	1	1	1	0



$(A \oplus B) \oplus X.$

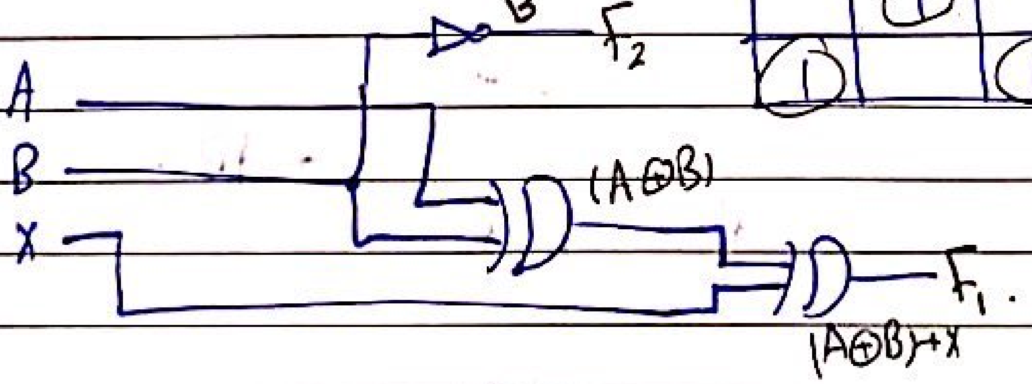
$(A \oplus B)\bar{X} + (\overline{A \oplus B})X$

$(A\bar{B} + \bar{A}B)\bar{X} + (A \odot B)X$

$F_2 = B'$

$A\bar{B}\bar{X} + \bar{A}B\bar{X} + \bar{A}\bar{B}X + ABX.$

	1		1
1		1	



*Design a 2-bit up / down Counter :-

*Adder :-

C_2 C_1

0 1 0 ← Carry (C)

0 0 . 1 1 ← A_0

0 0 1 0 + B_0

0 1 0 1 ← S_0 Sum (S)

S_2 S_1

* Half Adder :- (addition Two bits)

Design a half Adder that add two bits

A	B	S	C	
0	0	0	0	m_0
0	1	1	0	m_1
1	0	1	0	m_2
1	1	0	1	m_3

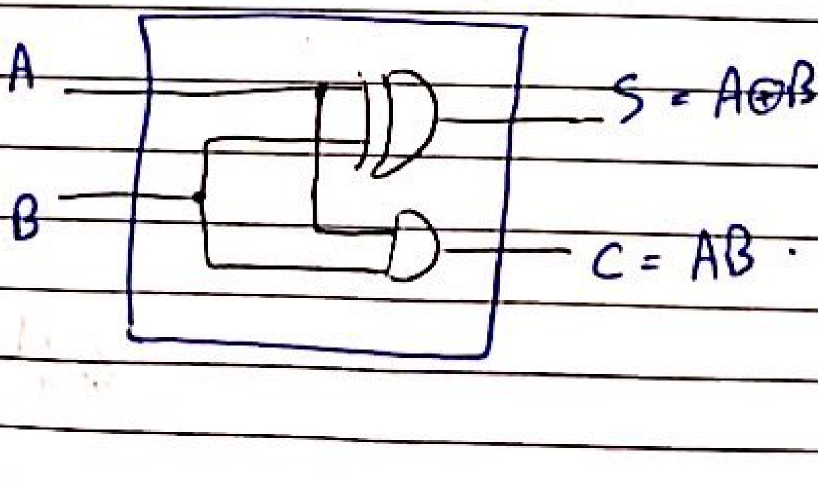
		$\overline{B}$
		1
A	1	

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

$S = A \oplus B$.

		$\overline{B}$
A		①

$C = AB$.

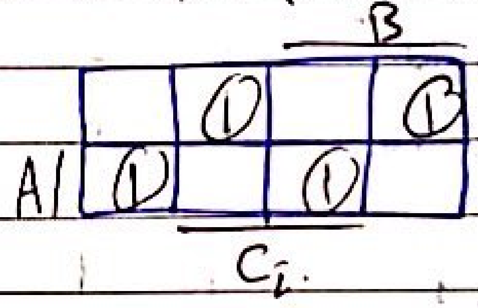


* Design a 2-bit up/down Counter :-

* Full-adder :-

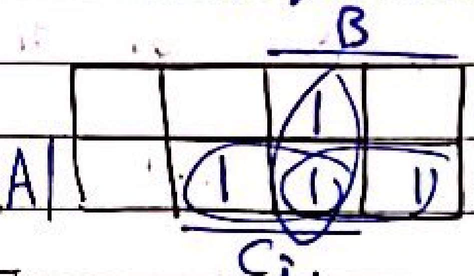
Design a full adder that accepts 3-input (A,B,C) .

A	B	C_i	S	C_o	
0	0	0	0	0	m_0
0	0	1	1	0	m_1
0	1	0	1	0	m_2
0	1	1	0	1	m_3
1	0	0	1	0	m_4
1	0	1	0	1	m_5
1	1	0	0	1	m_6
1	1	1	1	1	m_7

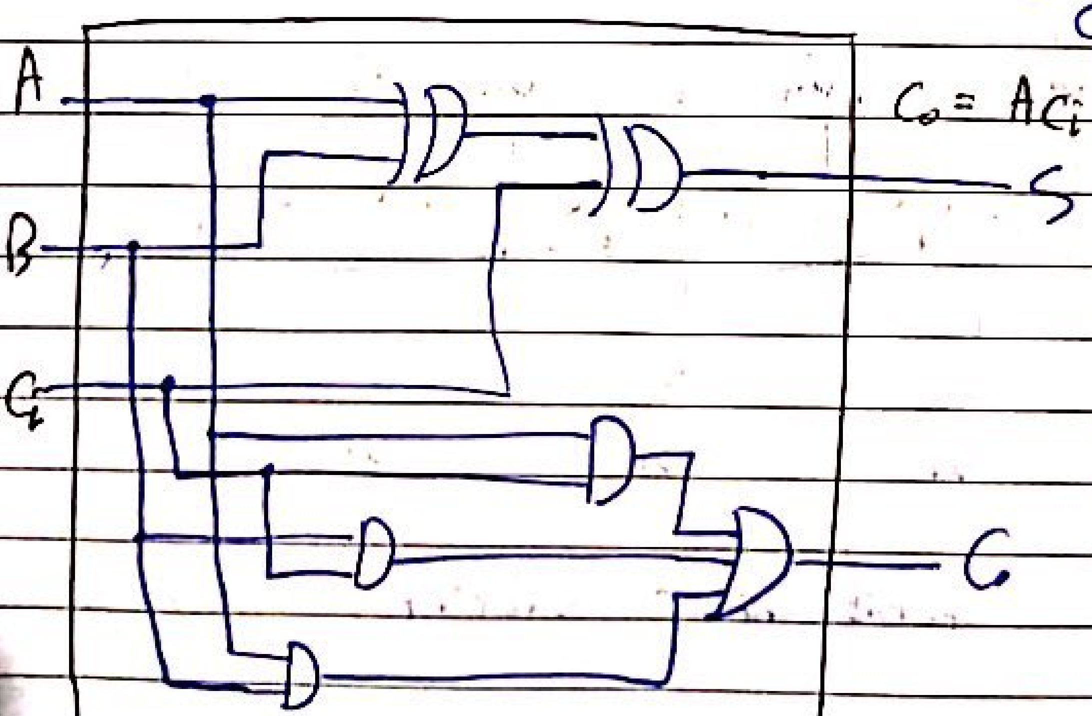


$S = A \oplus B \oplus C_i$.

$S = A\bar{B}\bar{C}_i + ABC_i + \bar{A}\bar{B}C_i + \bar{A}B\bar{C}_i$.

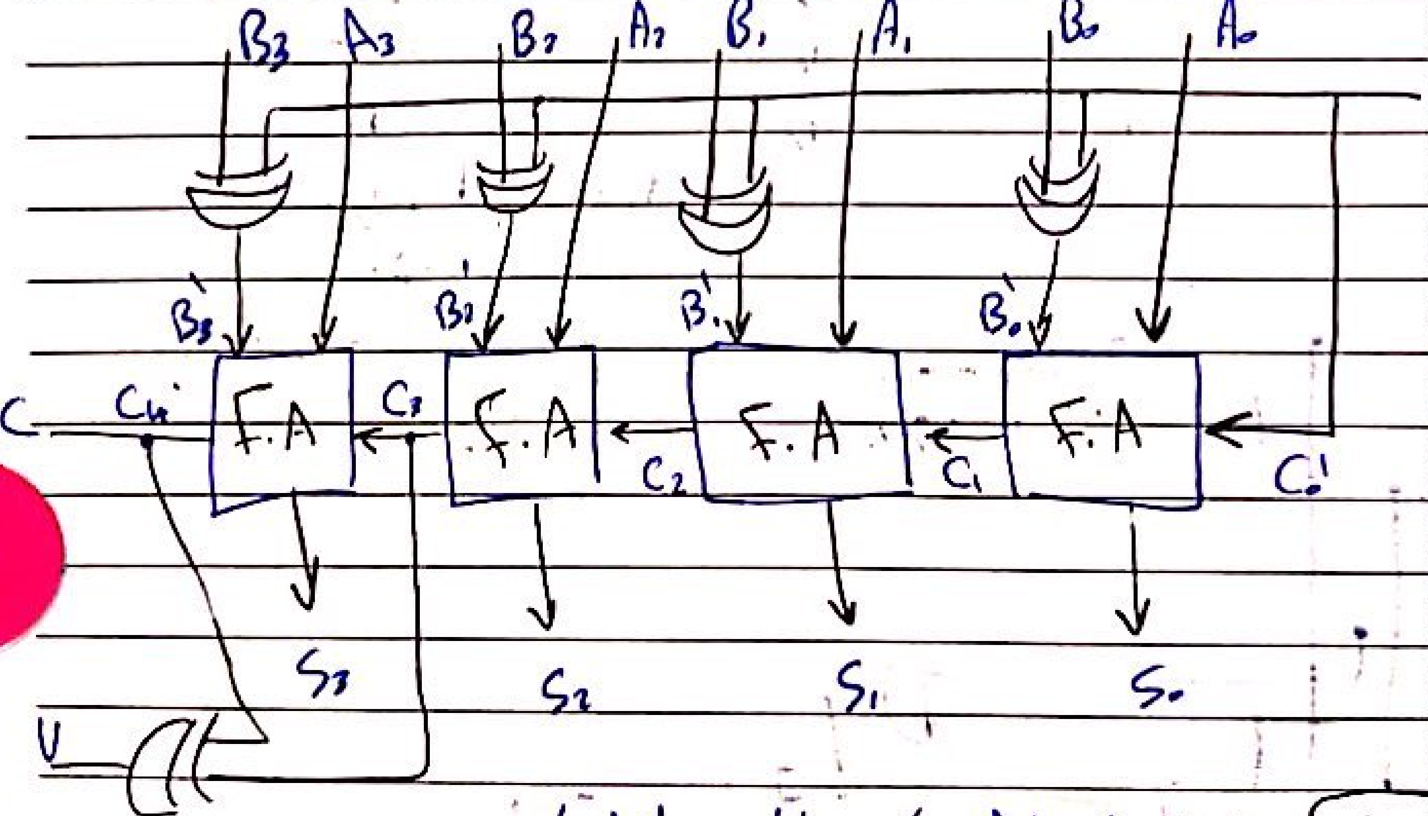


$C_o = AC_i + BC_i + AB$.



* Design a 2-bit up/down Counter i-

Subscribt	3	2	1	0	
Input + Carry	0	1	1	0	C_i → Carry
Augend	1	0	1	1	A_i → number
Addend	0	0	1	1	B_i → number
Sum	1	1	1	0	S_i
	0	0	1	1	C_{i+1}



4.bit adder / subtractor

47

* BCD addition :-

1. $0011_{BCD} + 0100_{BCD} = 0111_{BCD}$

0011 +
0100
$0111 \rightarrow 7 \leq 9$
$8\,4\,2\,1$ ←

This way is right until the number 9 after that it won't be true

2. $0111_{BCD} + 0101_{BCD} = 0001\,0010.$

$1\,1\,1$
0111 +
0101
$1100 \rightarrow 12_{10} = 00010010.$
0110 +
$0001\,0010$

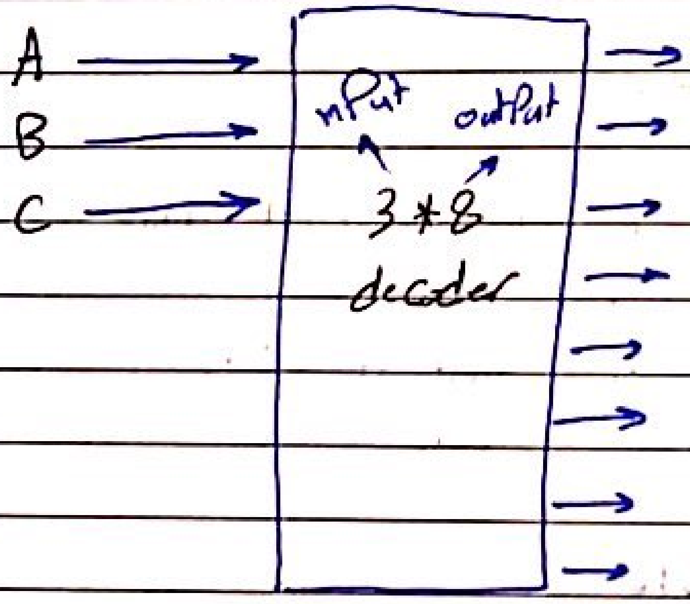
نضيف اشي اسمو Connection factor. بعد ال unsied bits

$\boxed{\text{منضيف } (6_{10}) = 0110}$

3. $0110\,1000_{BCD} + 0011\,0111_{BCD} = 0001\,0000\,0101_{BCD}.$

$1\,1$
$0110\,1000$
$0011\,0111$ +
10011111 → bigger than 15 we sum $6 = 0110$
0110 +
10100101 +
0110
$0001.0000.0101$

*Decoder :-



$m_0 = \bar{A}\bar{B}\bar{C}$

$m_1 = \bar{A}\bar{B}C$

$m_2 = \bar{A}B\bar{C}$

$m_3 = \bar{A}BC$

$m_4 = A\bar{B}\bar{C}$

$m_5 = A\bar{B}C$

$m_6 = AB\bar{C}$

$m_7 = ABC$.

n = 2 → output = 4
n = 3 → output = 8
n = 4 → output = 16
n = 5 → output = 32
⋮

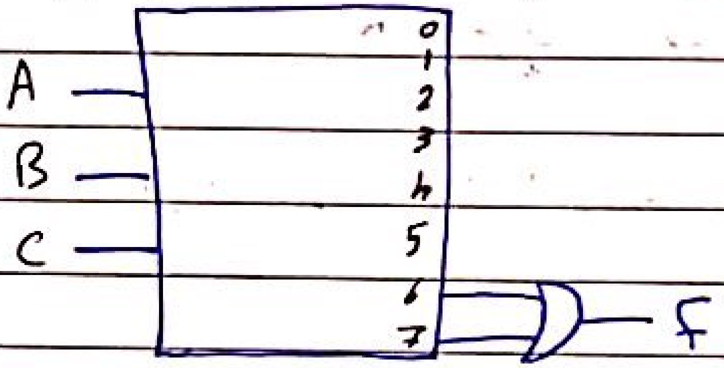
A	B	C		D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
0	0	0	m_0	1	0	0	0	0	0	0	0
0	0	1	m_1	0	1	0	0	0	0	0	0
0	1	0	m_2	0	0	1	0	0	0	0	0
0	1	1	m_3	0	0	0	1	0	0	0	0
1	0	0	m_4	0	0	0	0	1	0	0	0
1	0	1	m_5	0	0	0	0	0	1	0	0
1	1	0	m_6	0	0	0	0	0	0	1	0
1	1	1	m_7	0	0	0	0	0	0	0	1

*Decorder :-

*Ex : Design $F(A,B,C) = AB$ using decorder

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

$F(A,B,C) = m_6 + m_7 = \Sigma(6,7)$.

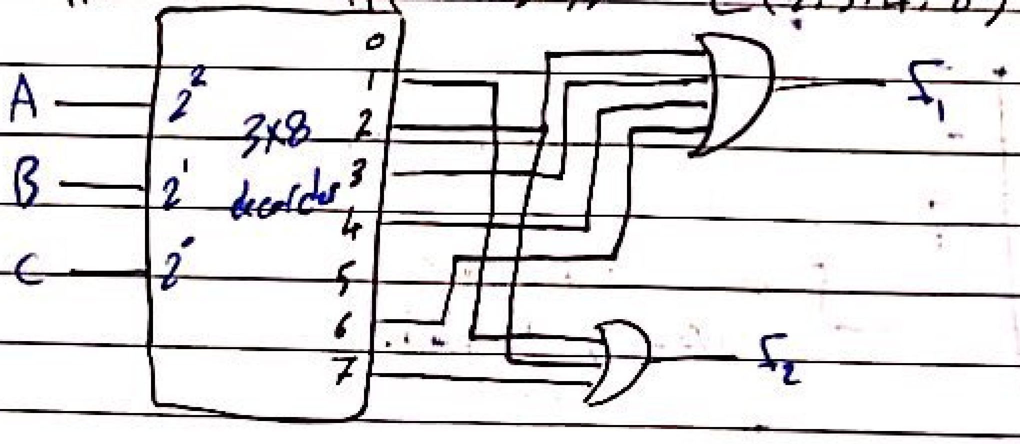


*Ex: Design the following two function using decoder

$F_1(A,B,C) = \underbrace{(\overset{0}{A}+\overset{0}{B}+\bar{C})}_{m_1}\underbrace{(\overset{1}{\bar{A}}+\overset{1}{\bar{B}}+\overset{1}{\bar{C}})}_{m_7}\underbrace{(\overset{1}{\bar{A}}+\overset{0}{B}+\overset{1}{\bar{C}})}_{m_5}\underbrace{(\overset{0}{A}+\overset{0}{B}+\overset{0}{C})}_{m_0}$

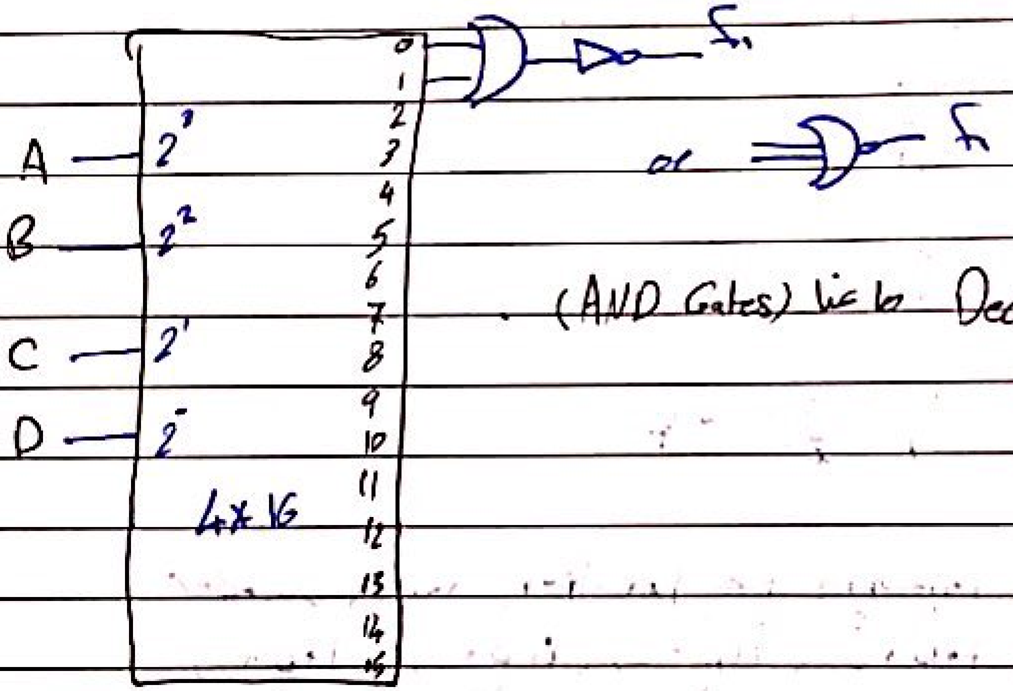
$F_2(A,B,C) = \Sigma(1,2,7)$

$F(A,B,C) = \Pi(0,1,5,7) = \Sigma(2,3,4,6)$.

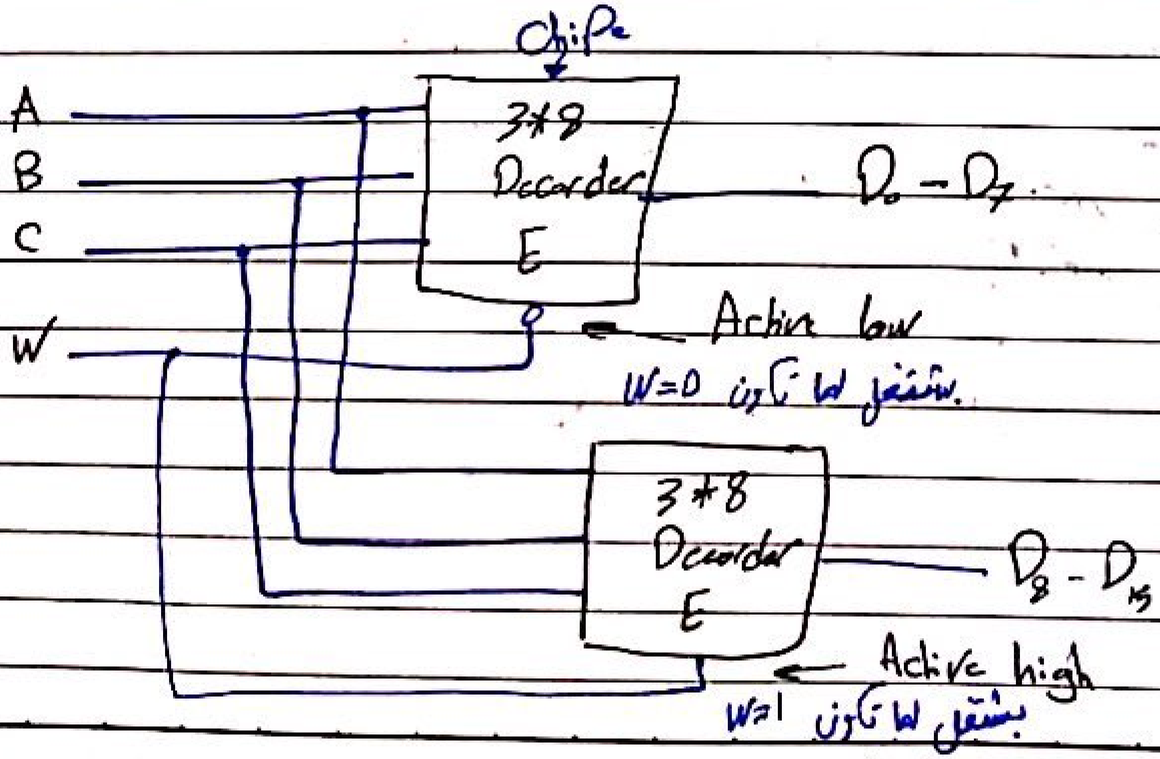


*Decorder :-

*Ex: Design $F_1(A.B.C.D) = \Sigma(2,3,4,5,6,7,8,9,10,11,12,13,14,15)$



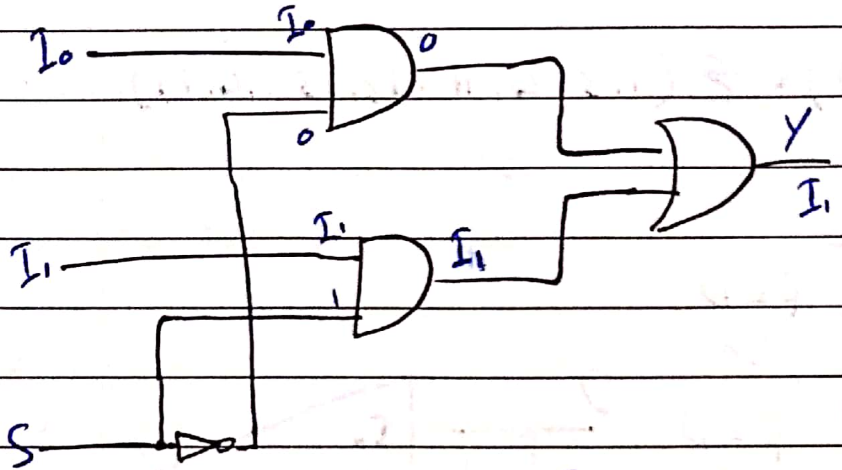
ال Decorder فيها (AND Gates).



W=0 بشتغل لما تكون.

W=1 بشتغل لما تكون

*Design with Multiplexer (MUX) :-

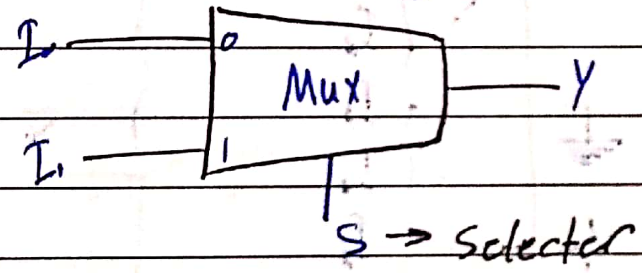


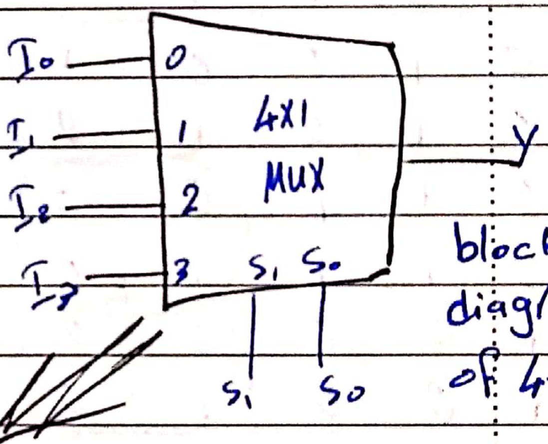
a) logic diagram (2x1) Mux.

S	Y
0	I_0
1	I_1

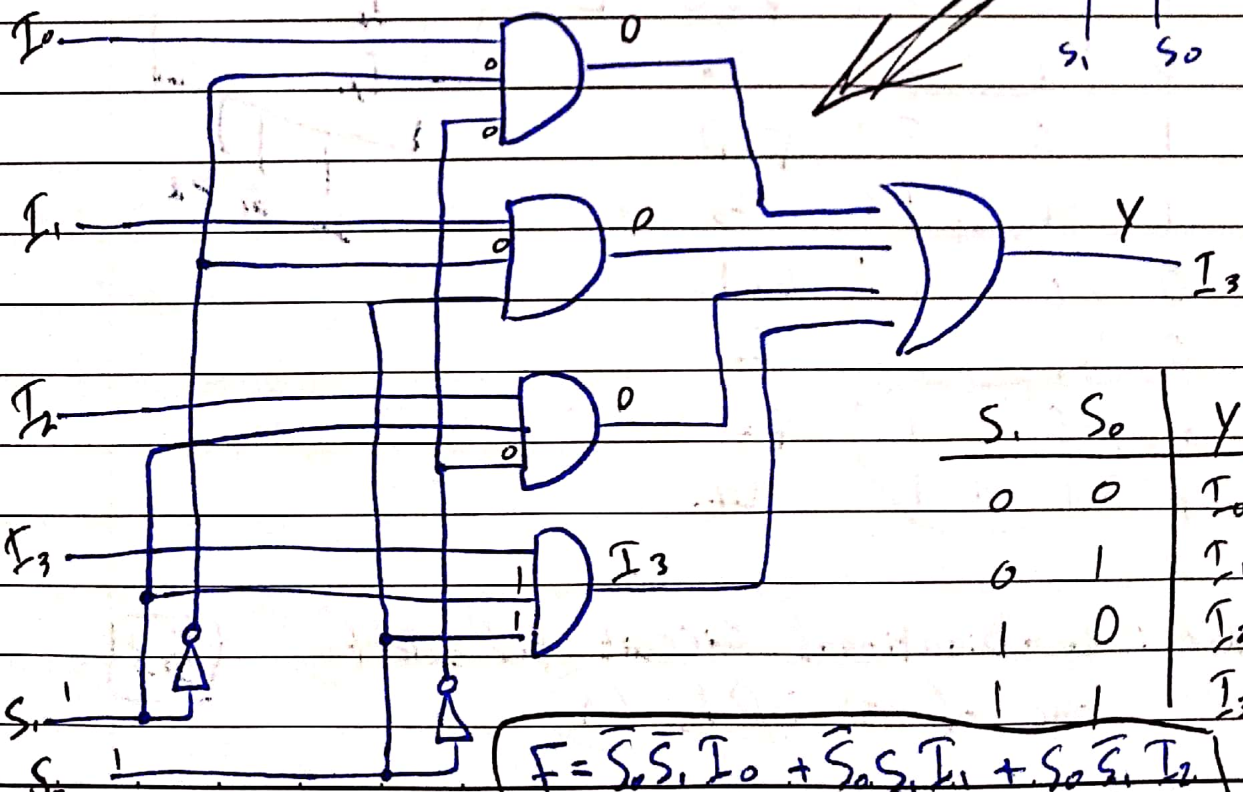
$$\boxed{Y = I_0 \cdot \bar{S} + I_1 \cdot S}$$

b) block diagram of 2-input





block diagram of 4-input



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

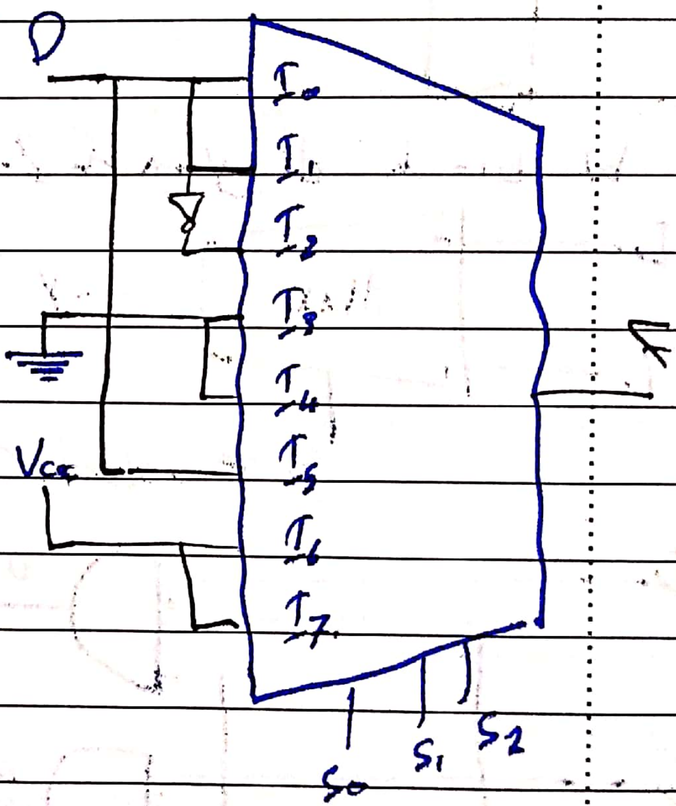
$$\boxed{F = \bar{S}_0 \bar{S}_1 I_0 + \bar{S}_0 S_1 I_1 + S_0 \bar{S}_1 I_2 + S_0 S_1 I_3}$$

*Design with MultiPlexer (MUX) :-

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

Using Mux selection

A	B	C	D	F	
0	0	0	0	0	F=D
0	0	0	1	1	I_0
0	0	1	0	0	F=D
0	0	1	1	1	I_1
0	1	0	0	1	F=D'
0	1	0	1	0	I_2
0	1	1	0	0	F=0
0	1	1	1	0	I_3
1	0	0	0	0	F=0
1	0	0	1	0	I_4
1	0	1	0	0	F=D
1	0	1	1	1	I_5
1	1	0	0	1	F=1
1	1	0	1	1	I_6
1	1	1	0	1	F=1
1	1	1	1	1	I_7.



Multiplexer :- Combinational circuit that select one of the inputs ☺.

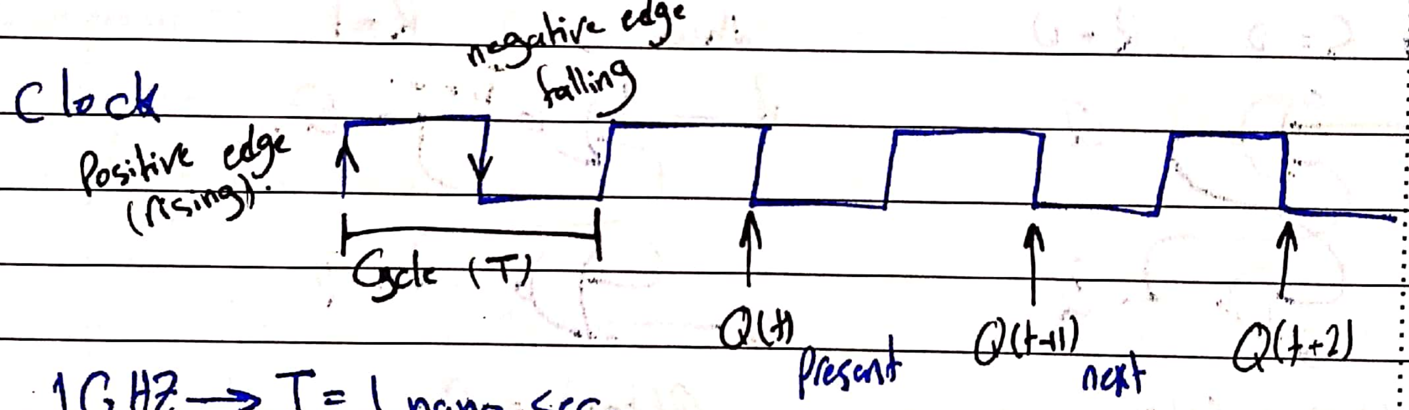
* Digital Circuits :-

* Digital Circuits :-

1- Combinational Circuits → (Mux).
2- Sequential Circuits. دوائر متتالية

* Sequential Circuits :-

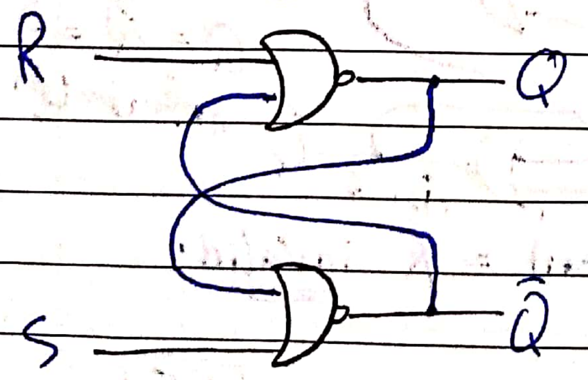
1- latch Circuits (Without Clock).
2- flip / flop Circuits (with Chock).

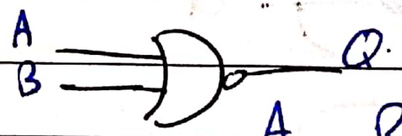


1GHZ → T = 1 nano sec.

* Set / Reset flip / flop :-

Set to high (1) ; Reset to low (0).

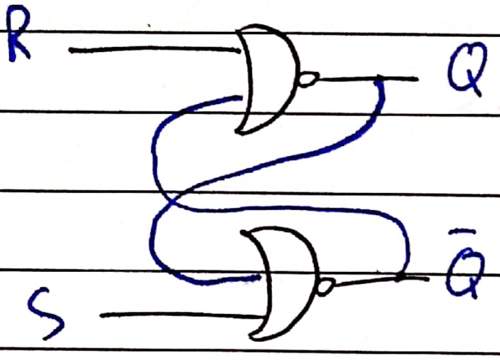




A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

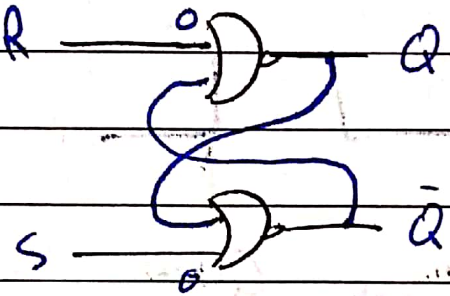
* Digital Circuits :-

* Set / Reset flip / flop circuits :-



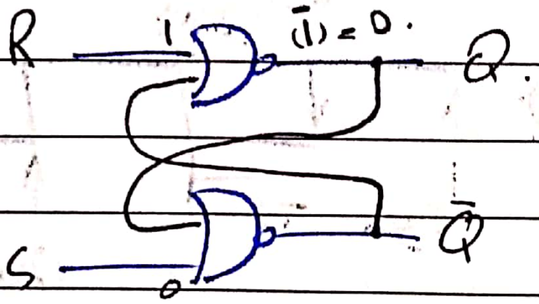
S	R	$Q(t+1) \rightarrow \boxed{Q^+}$	
0	0	$Q(t)$	No change state
0	1	0	Reset state.
1	0	1	set state.
1	1	X	invalid.

When S = 0 , R = 0.



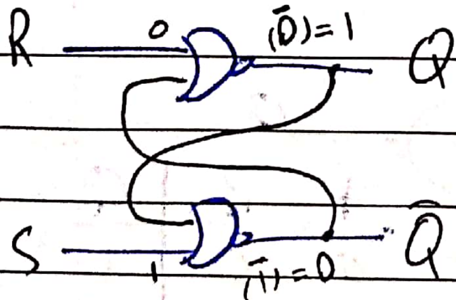
$Q(t+1) = Q(t)$

When S = 0 , R = 1



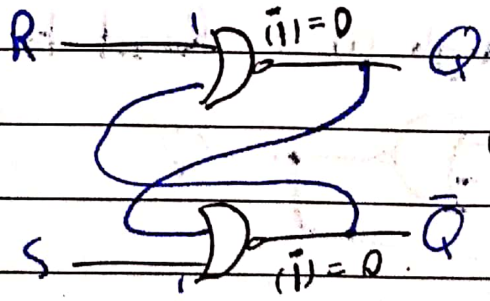
$Q(t+1) = 0.$

When S = 1 , R = 0.



$Q(t+1) = 1$

When S = 1 , R = 1.



$Q = \bar{Q} = 0.$

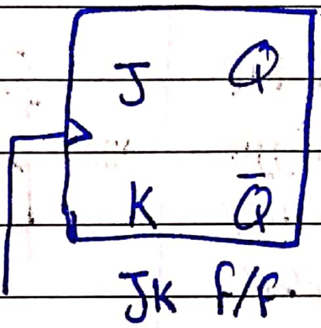
انّنا مش معقول

$Q(t+1) = X$ invalid.

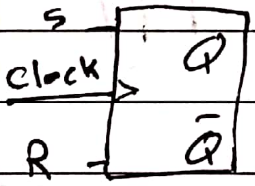
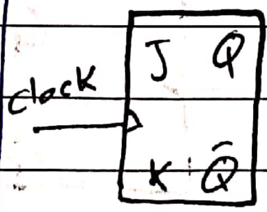
* Digital Circuits :-

* JK flip/flop Circuits (JK f/f) :-

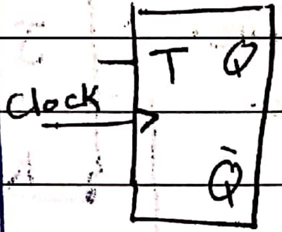
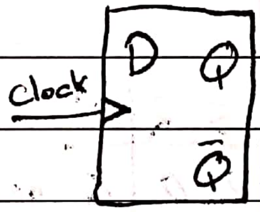
J K	$Q(t+1) \rightarrow \boxed{Q^+}$	
0 0	$Q(t)$	no change state.
0 1	0	Reset state.
1 0	1	set state.
1 1	$\bar{Q}(t)$	toggle state.



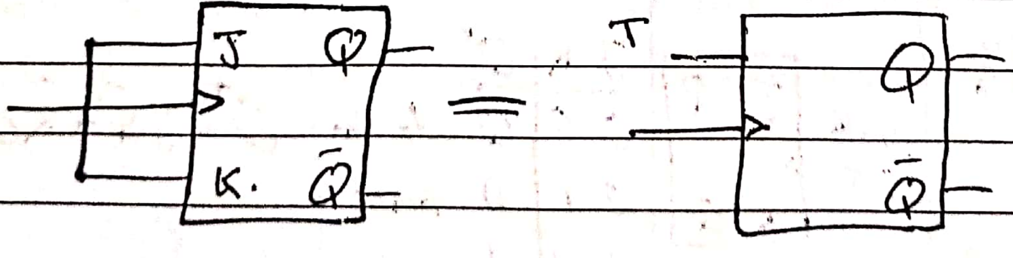
JK f/f.

* number	Name	Symbol	state table	Characteristic equ
1	SR f/f		S R | Q^+ 0 0 | Q no cha 0 1 | 0 Reset 1 0 | 1 set 1 1 | X invalid	X
2	JK f/f		J K | Q^+ 0 0 | Q No cha 0 1 | 0 Reset 1 0 | 1 set 1 1 | $\bar{Q}$ toggle	$Q^+ = J\bar{Q} + \bar{K}Q$.

*Digital Circuits :-

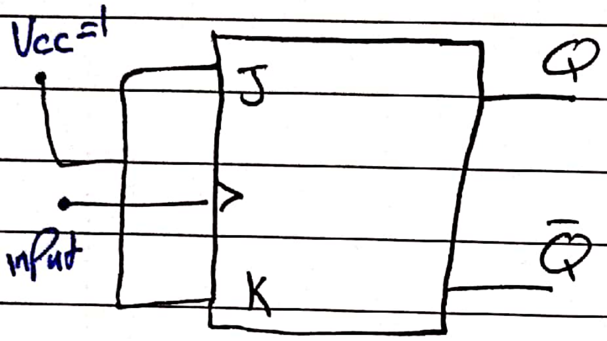
*Number	Name	Symbol	state table	characteristic equ
3	T f/f Toggle flip/ flop		T | Q^+ 0 | Q No cha 1 | $\bar{Q}$ Toggle	$Q^+ = T \oplus Q$ $= T\bar{Q} + \bar{T}Q$
4	D f/f Data flip/flop تستخدم لتخزين البيانات		D | Q^+ 0 | 0 1 | 1	$Q^+ = D$.

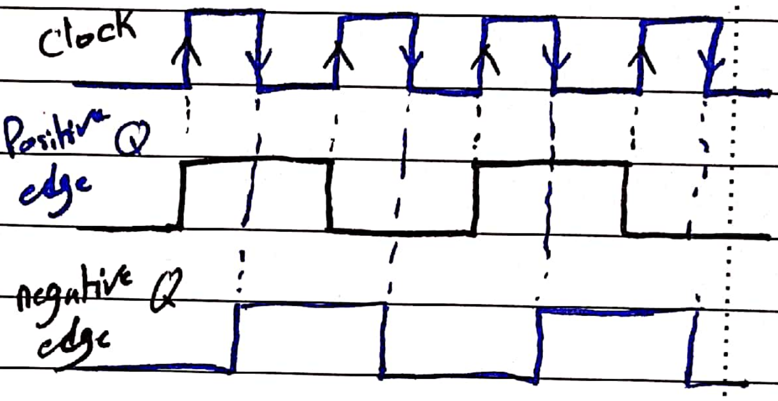
*Ex :- how do you make a T f/f out of JK f/f:



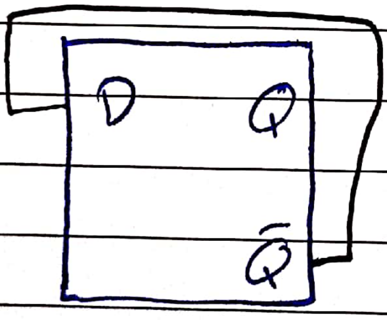
* Digital Circuits :-

* JK f/f :-





* D f/f :-



$Q^+ = D$.

$D = \bar{Q}$