Combination circuit → No memory

Sequencial circuit → has memory → output depends on present, previous

D.C. ⇒ 4 types

	Base
i) Binary	2
ii) decimal	10
iii) Octal	8
iv) Hexadecimal	16

← Memory address stored using this.

Q.1. $(1001.0101)_B = (?)_D$

$1\times 2^0 + \cancel{0} + 0 + 1\times 2^3 = 9 + \frac{1}{4} + \frac{1}{16} = 9.3125$

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

Q2. $(13)_D = (?)_B$

⇒ 1101

2	13	
	6	1
	3	0
	1	1

Q3. $(0.63625)_{10} = (?)_B$

$0.63625 \times 2 = 1.2725$

$0.2725 \times 2 = 0.545$

$0.545 \times 2 = 1.09$

$0.09 \times 2 = 0.18$

$0.18 \times 2 = 0.36$

∴ Ans: 0.10100

Q4. $(6327.4051)_8 = (?)_{10}$

$7\times8^0 + 2\times8^1 + 3\times8^2 + 6\times8^3 + 4\times8^{-1} + 0 + 5\times8^{-2} + 1\times8^{-3}$

$= 3287.51001$

Q5. $(3287.510048)_{10} = (?)_8$

8	3287	
	410	7
	51	2
	6	3

$0.510048\times8 = 4.080384$

$0.080384\times8 = 0.643072$

$0.643072\times8 = 5.144576$

$= 1.156608$

$\therefore$ Ans is 6327.4051

Q6. $(472)_8 = (?)_B$

$2\times8^0 + 7\times8^1 + 4\times8^2 = 314$ ← decimal.

$\Rightarrow 100111010$

314	
157	0
78	1
39	0
19	1
9	1
4	1
2	0
1	0

Q7. $(1010110.0101)_B = (?)_{oct}$

$2+4+16+64+\frac{1}{2}+\frac{1}{8} = 86.625$ decimal.

86	
10	6
1	2

$\boxed{126.500}$

$0.625\times8 = 5.00$

$0.00\times8 = 0$

[OR]

$\underbrace{001}\ \underbrace{010}\ \underbrace{110}\ .\ \underbrace{010}\ \underbrace{100}$

$\Rightarrow \boxed{126.24}$

Q8. $(3A.2F)_{16} = (?)_D$

$15\times16^{-2} + 2\times16^{-1} + 10\times16^{0} + 3\times16^{1}$

$= \underline{\underline{58.1835}}$

Q9. $(\underbrace{675}.625)_{10} = (?)_{Hexa}$

% 16

$0.625\times16 = 10.00$

675	
42	3
2	10

$\boxed{2A3.A}$

Q10. $(2F9A)_{16} = (?)_B$

$\Rightarrow (0010\ 1111\ 1001\ 1010)$

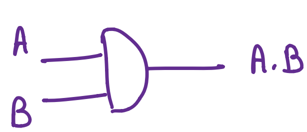
Q11. $(0010\ 1001\ 1010\ 1111)_B = (?)_H$

$\Rightarrow (29AF)$

28/07/25

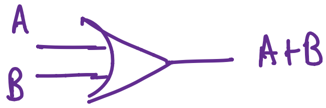
Logic gates:

AND :



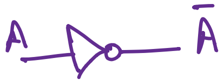
A	B	A.B
T	T	T
T	F	F
F	T	F
F	F	F

OR :



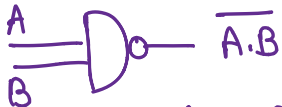
A	B	A + B
T	T	T
T	F	T
F	T	T
F	F	F

NOT :



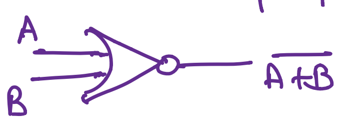
A	$\bar{A}$
T	F
F	T

NAND :



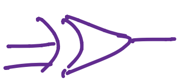
A	B	$\overline{A.B}$
T	T	F
T	F	T
F	T	T
F	F	T

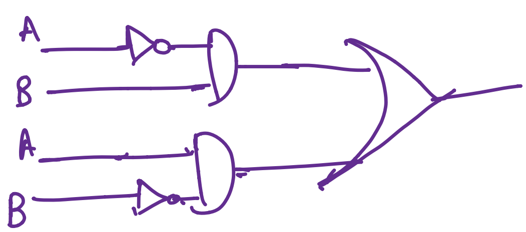
NOR :



A	B	$\overline{A+B}$
T	T	F
T	F	F
F	T	F
F	F	T

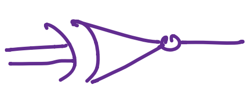
EXOR : output = $\bar{A}.B + A.\bar{B}$





A	B	output
T	T	F
T	F	T
F	T	T
F	F	F

EXNOR :

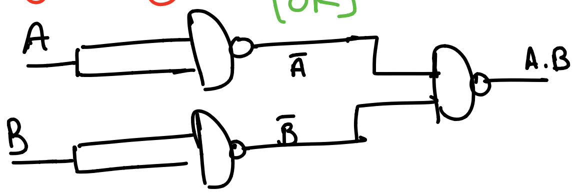


A	B	output
T	T	T
T	F	F
F	T	F
F	F	T

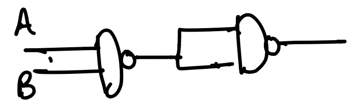
Prove NAND & NOR are universal gates:

using NAND gate

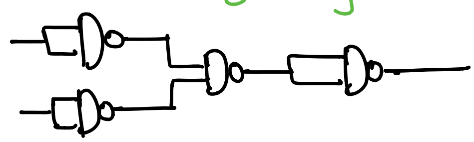
[OR]



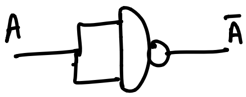
[AND]



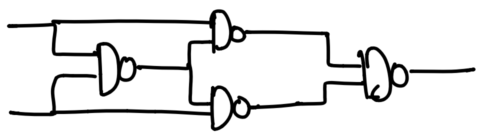
[NOR]



[NOT]

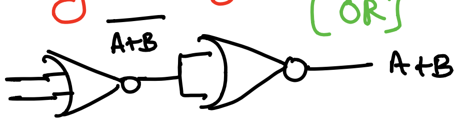


[EXOR]

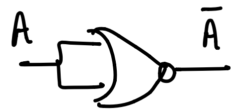


using NOR gate:-

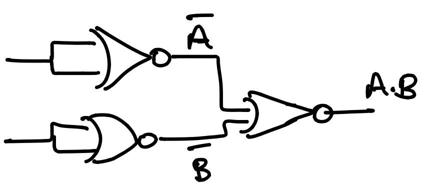
[OR]



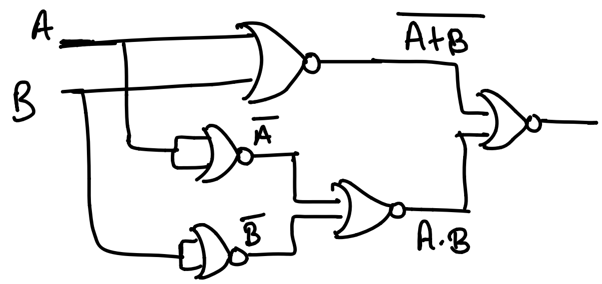
[NOT]



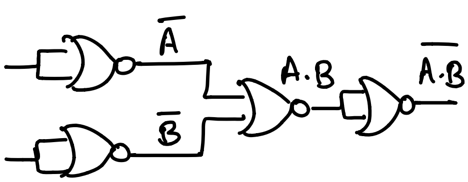
[AND]



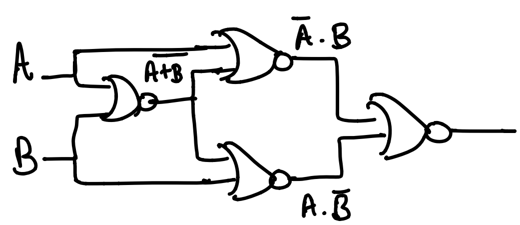
[EX-OR]



[NAND]



[EX-NOR]



EX NOR

EXOR

$A \oplus 1 = \bar{A}$

$A \odot 1 = A$

$A \oplus A = 0$

$A \oplus \bar{A} = 1$

$0 \cdot 0 = 0$

$0 \cdot 1 = 0$

$1 \cdot 0 = 0$

$1 \cdot 1 = 1$

$0 + 0 = 0$

$0 + 1 = 1$

$1 + 0 = 1$

$1 + 1 = 1$

$A + 0 = A$

$A + 1 = 1$

$A + A = A$

$A + \bar{A} = 1$

$A \cdot 0 = 0$

$A \cdot 1 = A$

$A \cdot A = A$

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

$A \odot 0 = \bar{A}$

$1 \oplus \bar{A} = A$

End Sem: Design EXOR using NAND, write VHDL/Verilog Code

* Reduce the expression.

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

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

$= A(1+BC) + BD + B\bar{C}D$

$= A + BD$

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

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

$= B \cdot [(B+C)](B+D)$

$= B(B+CD)$

$= B + BCD$

$= B$

iii) $f = A\left[B + \bar{C}\left(\overline{AB + A\bar{C}}\right)\right]$

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

$= A\left[B + \bar{C}\,(\bar{A})\,\bar{B}.C\right]$

$= AB$

iv] Show that $AB + A\bar{B}C + B\bar{C} = AC + B\bar{C}$

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

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

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

v] Show that $A\bar{B}C + B + B\bar{D} + AB\bar{D} + \bar{A}C = B + C$

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

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

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

$= C + B$

Q. Simplify the exp^n & implement using NAND gates only

a) $f = A\bar{B} + ABD + AB\bar{D} + \bar{A}\bar{C}\bar{D} + \bar{A}BC$?

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

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

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

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

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

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

Q. Prove ** $AB + \bar{A}C + BC = AB + \bar{A}C$ .. Consensus theorem

$= AB + \bar{A}C + 1.BC$

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

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

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

$= AB + \bar{A}C$

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

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

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

: $0 + ABC + AC + 0 + B\bar{A} + B\bar{A}C + BC + BC$

: $ABC + AC + B\bar{A} + BC$

: $AC + B\bar{A} + BC$

RHS: $A\bar{A} + B\bar{A} + AC + BC$

$0 + AC + B\bar{A} + BC$

LHS = RHS.

Q. $AB + \bar{A}C = (A+C)(\bar{A}+B)$ .. Transposition Theorem

RHS: $A\bar{A} + \bar{A}C + AB + BC$

$= 0 + \bar{A}C + AB + BC$

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

$= AB + \bar{A}C$

$\Rightarrow (A + AB) = A$ ... Absorption Theorem

Q. Implement using gates.

$f_1 = (A \oplus B).C + \bar{A}.B$

$f_2 = (A \odot B) + \bar{C} + \bar{A}\bar{B}$

$\Rightarrow$ Codes:-

Non-binary

Morse code

(—•—••—)

binary codes

- weighted
  - e.g. 8421 BCD
  - 2421
- Non-weighted
  - e.g. Excess 3
  - Gray Code

Alphanumaric

ASCII

ExoR

Binary $\downarrow$ conversion Gray

MSB $\rightarrow$ 1 $\oplus$ 1 $\oplus$ 0 $\oplus$ 1 $\oplus$ 1 $\leftarrow$ LSB

1 0 1 1 0

Gray $\downarrow$ Binary

0 1 1 0 1 1

$\oplus$ $\oplus$ $\oplus$ $\oplus$ $\oplus$

1 0 1 1 0 1

$B(0110110) = (\ ?\ )_g$

$\Rightarrow (0101101)_g$ is ans.

$(11101101)_g = (\ ?\ )_{Bi}$

$\Rightarrow (10110110)_{Bi}$ is ans.

* Binary Coded Decimal (BCD)

(4 bit code, 8421)

0	0000
1	0001
2	0010
3	0011
4	0200
5	0101
6	0110
7	0111
8	1000
9	1001

* Excess-3 :

$(48)_{10} \rightarrow (\ ?\ )_{Excess\text{-}3}$

$$\begin{array}{r} 4 \\ +3 \\ \hline 7 \end{array} \quad \text{and} \quad \begin{array}{r} 8 \\ +3 \\ \hline 11 \end{array}$$

$\therefore (48)_{10} \rightarrow (0111 \quad 1011)_{x-3}$

: Represent 6248 in 1) BCD 2) Excess-3

$\Rightarrow (0110 \quad 0010 \quad 0100 \quad 1000)_{BCD}$

$$\begin{array}{r} 6 \\ +3 \\ \hline 9 \end{array} \quad \begin{array}{r} 2 \\ +3 \\ \hline 5 \end{array} \quad \begin{array}{r} 4 \\ +3 \\ \hline 7 \end{array} \quad \begin{array}{r} 8 \\ +3 \\ \hline 11 \end{array}$$

$(1001 \quad 0101 \quad 0111 \quad 1011)_{x-3}$

	Binary	BCD	E-x 3	Gray
0	0000	0000	0011	0000
1	0001	0001	0100	0001
2	0010	0010	0101	0011
3	0011	0011	0110	0010
4	0100	0100	0111	0110
5	0101	0101	1000	0111
6	0110	0110	1001	0101
7	0111	0111	1010	0100
8	1000	1000	1011	1100
9	1001	1001	1100	1101
10	1010	X		
11	1011	X		
12	1100			
13	1101	X		
14	1110	X		
15	1111			

:
$$\begin{array}{r} 110110 \\ +\ 101101 \\ \hline \boxed{1}100011 \end{array}$$

for Octal no. :- add 567 & 243

$$\begin{array}{r} 567 \\ +\ 245 \\ \hline 1032 \end{array}$$

$$\begin{array}{r} 10 \\ -\ 8 \\ \hline \boxed{1}\ 2 \end{array} \qquad \begin{array}{r} 11 \\ -\ 8 \\ \hline \boxed{1}\ 3 \end{array} \qquad \begin{array}{r} 8 \\ -\ 8 \\ \hline \boxed{1}\ 0 \end{array}$$

, when sum is > 7 .

$$\begin{array}{r} 17 \\ +\ 7 \\ \hline 26 \end{array} \qquad \begin{array}{r} 24 \\ -\ 8 \\ \hline \boxed{1}\ 6 \end{array}$$

$$\begin{array}{r} 7 \\ +\ 2 \\ \hline 11 \end{array} \qquad \begin{array}{r} 9 \\ -\ 8 \\ \hline \boxed{1}\ 1 \end{array}$$

7
+48
+ 64×5
= 375

$$\begin{array}{r} 3 \\ +\ 32 \\ +\ 64\times 2 \\ \hline 163 \\ \hline 538 \end{array}$$

$$\begin{array}{c|c|c} 8 & 538 & \\ \hline & 67 & 2 \\ \hline & 8 & 3 \\ \hline & 1 & 0 \end{array}$$

Add Hexadecimal terms:-

ADD + DAD = ?

$$\begin{array}{r} 10\ \ 13\ \ 13 \\ +\ 13\ \ 10\ \ 13 \\ \hline 1\ \ 8\ \ 8\ \ A \end{array}$$

$$\begin{array}{r} 26 \\ -16 \\ \hline \boxed{1}\ 10 \end{array} \qquad \begin{array}{r} 24 \\ -16 \\ \hline \boxed{1}\ 8 \end{array} \qquad \begin{array}{r} 24 \\ -16 \\ \hline \boxed{1}\ 8 \end{array}$$

Q Convert decimal no.

$(76)_{10}$ & $(94)_{10}$ in BCD. & add.

:

$$\begin{array}{rcl} 76 & = & (0111\ \ 0110) \\ +\ 94 & = & (1001\ \ 0100) \\ \hline 170 & = & \boxed{1}0000\ 1010 \\ & & 0110\ \ 0110 \\ \hline & & \boxed{1}\ 0111\ 0000 \end{array}$$

> 9
∴ we have to add '6'

✓

:: Signed Magnitude Representation:- [To represent -ve no.]

4 bit representation:

MSB ⇒ $\boxed{0}$ for +ve no.

$\boxed{1}$ for -ve no.

+3 ⇒ $\boxed{0}$ 011

-3 ⇒ $\boxed{1}$ 011

:: Binary :- 1 0 1 1 0 1

1's complement = 0 1 0 0 1 0

2's comple. = 0 1 0 0 1 1

replace 1 by 0 & 0 by 1

add 1 to the LSB

Q. using 2's complement method:

46 − 17 = ?

$$\begin{array}{rl} 46 & = 00101110 \\ -\ 17 & = 00010001 \end{array}$$

∴ 8 bit representation

17 ⇒ 00010001

1's comple. ⇒ 11101110

2's comple. ⇒ 11101111 ⇐ −17

$$\begin{array}{r} 00101110 \\ 11101111 \\ \hline \boxed{1}00011101 \end{array}$$

∴ add ✓

Carry [ignore it]

Case 1: Carry is present. ∴ write ans. as it is.

Case 2: Carry is not there. ∴ Take 2's complement again for the ans.
MSB=1 ∴ −ve no.

Q Substract decimal no. 22 from 17 using 8 bit 2's complement.

$$\begin{array}{rl} 17 & = 00010001 \\ -\ 22 & = 00010110 \end{array}$$

22 = 00010110

1's comple. = 11101001 +1

2's comple. = 11101010

$$17 - 22 = \begin{array}{r} 00010001 \\ 11101010 \\ \hline 11111011 \end{array}$$

no carry.

$11111011 \xrightarrow{1's} 00000100$

2's ↓

00000101

Q2. add −25 & 14 using 8 bit 2's complement.

:

25 = 000 11 001

1's : 111 00 110 $\big\}$ +1

2's : 111 00 111

14		00001110
−25		11100111
	⇒	11110101

↳ no carry

$\xrightarrow{1's}$ 00001010

↓ 2's

00001011

Q5. add −45.75 using 12-bit 2's complement.
+ 87.50

0.75 × 2 = 1.50
0.50 × 2 = 1.00
0.00 × 2 = 0.0
"

45 = 00101101
87 = 01010111

0.50 × 2 = 1.00
0.00 × 2 = 0.0
"

45.75 = 00101101.1100
87.50 = 01010111.1000

−45.75 ⇒ $\xrightarrow{1's}$ 11010010.0011 $\big\}$ 2's
+1 ↓
11010010.0100

87.50   01010111.1000

−45.75   11010010.0100

$\boxed{1}$ 00101001.1100

carry present

Q4. add −31.5 , −93.125 using 12 bit 2's comple.

31.5 ⇒ 00011111.1000

93.125 ⇒ 01011101.0010

0.125 × 2 = 0.250
0.250 × 2 = 0.50
0.50 × 2 = 1.00
⋮   0.0

−31.5 ⇒ 1's 11100000.0111

↓+1

2's 11100000.1000

−93.125 ⇒ 10100010.1101 $\xrightarrow{2's}$ 10100010.1110

∴ −31.50 , −93.125 ⇒

11100000.1000
10100010.1110

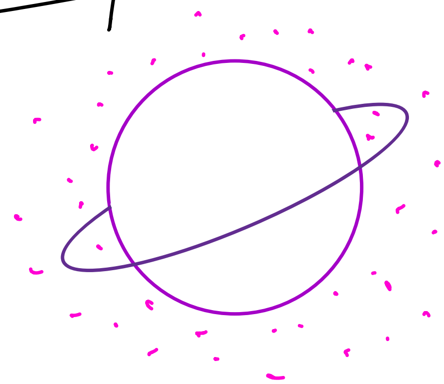
$\boxed{1}$ 10000011.0110

↓1's

01111100.1001

↓2's

01111100.1010 . ✓



Boolean Algebra:-

Idempotance law :- $A \cdot A = A$

$A + A = A$

Absorbtion law :- $A + AB = A(1+B) = A$

$A(A+B) = A$

Involutary law: $\bar{\bar{A}} = (A')' = A$

Demorgan's law :- $\overline{A \cdot B} = \bar{A} + \bar{B}$

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

Transposition theorem :- $(A \cdot B + \bar{A} C) = (A+C)(\bar{A} + B)$

RHS :- $AB + \bar{A} C (A + \bar{A})$

$\Rightarrow AB + \bar{A} C$ $\therefore$ RHS = LHS

Con sensus theorem:- $AB + \bar{A}C + BC = AB + \bar{A}C$

Q.1. $AB + B\bar{C} + AC = AC + B\bar{C}$. prove it.

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

$$ABC + AB\bar{C} + B\bar{C} + AC$$

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

$$= AC + B\bar{C}$$ hence proved

Q2. $(A+B)(\bar{B}+C)(C+A) = (A+B)(\bar{B}+C)$. prove it.

LHS

$: (A\bar{B} + AC + 0 + BC)(C+A)$

$: (A\bar{B}C + AC + BC) + (A\bar{B} + AC + ABC)$

$: A\bar{B}(1+C) + AC + BC(1+A)$

$: A\bar{B} + AC + BC$

RHS

$: A\bar{B} + AC + B\bar{B} + BC$

$: A\bar{B} + AC + BC$

LHS = RHS hence proved

(11) Duality theorem:-

expressing the boolean eq^n in dual or complementary form.

i. change OR operation $\longrightarrow$ AND & vice-versa
ii. complement 0 or 1.
iii. keep literals or variables as it is.

(12) Complementary theorem:-

i. —— " ——
ii. —— " ——
iii. Complement the literals & variables.

Q1. write complementary & dual form of given boolean f^n

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

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

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

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

Dual form $\Rightarrow (B+C) + (A+\bar{C})$

Complementary form $\Rightarrow (\bar{B}+\bar{C}) + (\bar{A}+\bar{\bar{C}})$

Boolean f^n representation

Canonical
(All variables either in complement or uncomplement form are present)

e.g. $f(A,B,C) = \bar{A}\cdot BC + A\bar{B}C + A\bar{B}\bar{C}$

Minimal
(Min. no. of variables)

e.g. $A + B\bar{C} + A\bar{C}$

§ Minterms :- product terms

Maxterms :- Sum terms

A	B	C	Minterms ($0 \to \bar{A}$, $1 \to A$)	Maxterms ($0 \to A$, $1 \to \bar{A}$)
0	0	0	$m_0 = \bar{A}\bar{B}\bar{C}$	$M_0 = A + B + C$
0	0	1	$m_1 = \bar{A}\bar{B}C$	$M_1 = A + B + \bar{C}$
0	1	0	$m_2 = \bar{A}B\bar{C}$	$M_2 = A + \bar{B} + C$
0	1	1	$m_3 = \bar{A}BC$	$M_3 = A + \bar{B} + \bar{C}$
1	0	0	$m_4 = A\bar{B}\bar{C}$	$M_4 = \bar{A} + B + C$
1	0	1	$m_5 = A\bar{B}C$	$M_5 = \bar{A} + B + \bar{C}$
1	1	0	$m_6 = AB\bar{C}$	$M_6 = \bar{A} + \bar{B} + C$
1	1	1	$m_7 = ABC$	$M_7 = \bar{A} + \bar{B} + \bar{C}$

* SOP :- sum of products
POS :- product of sums.

$f(A,B,C): (A\cdot\bar{B}C) + (B\bar{C}) + (A\cdot\bar{C})$ ← SOP

$f(A,B,C): (A+\bar{B}+C)(B+\bar{C})(A+\bar{C})$ ← POS

* standard SOP : all variables must present in each term.

e.g. $(A\bar{B}C) + (B\bar{C}) + (A\bar{C})$

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

std. POS : $(A+\bar{B}+C)(B+\bar{C})(A+\bar{C})$

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

A	B	C	Y (o/p)
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Express T.T. in SOP & POS term $f(A,B,C)$.

:- SOP:

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

POS:

$f(A,B,C):$

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

SOP : $f(A,B,C): \sum_m (3,5,6,7)$

POS : $f(A,B,C): \prod_M (0,1,2,4)$

⇒ K-map : Reducing the boolean f^n.
Q-method : Minimization.

Omkar

K-map :- A,B are two variables

A \ B	0	1
0	0	1
1	2	3

A	B	
0	0	0
0	1	1
1	0	2
1	1	3

B \ A	0	1
0	0	2
1	1	3

Grey Code Order

MSB

A \ BC	00	01	11	10
0	0	1	3	2
1	4	5	7	6

MSB

AB \ CD	00	10	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

MSB

BC \ A	0	1
00	0	4
01	1	5
11	3	7
10	2	6

Q Reduce the SOP expression :-

$$f(A,B) = \sum_m (0,2,3)$$

Ans: $m_0 + m_2 + m_3$

A	B	o/p
0	0	1
0	1	0
1	0	1
1	1	1

Step 1 :-

K-map :-

MSB A \ B	0	1
0	1 (0)	0 (1)
1	1 (2)	1 (3)

Step 2:

: Grouping or looping in k-map: (No diagonal grouping)

MSB A \ B	0	1
0	1 (0)	0 (1)
1	1 (2)	1 (3)

step 3: writing an expression for groups formed.

$f : \bar{B} + A$ is ans.

Q. Reduce the boolean expression in SOP form using k

: $f(A,B) = \sum(1,2)$

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

Step 1.

MSB A \ B	0	1
0	0 (0)	1 (1)
1	1 (2)	0 (3)

step 2.

MSB A \ B	0	1
0	0 (0)	1 (1)
1	1 (2)	0 (3)

step 3.

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

expressions:

A \ B	0	1
0	1	0
1	0	1

$f : \bar{A}\bar{B}$

A \ B	0	1
0	0	1
1	0	0

$f : \bar{A}B$

A \ B	0	1
0	0	0
1	1	0

$f : A\bar{B}$

A \ B	0	1
0	0	0
1	0	1

$f : AB$

Looking left side & upper side of that index

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Q1. Expand / find canonical form of

$$f = A + B\bar{C} + AB\bar{D} + ABCD$$

(Expand to min terms or max terms)

$$\therefore\ A(B+\bar{B})(C+\bar{C}).(D+\bar{D}) + (A+\bar{A})B\bar{C}(D+\bar{D}) + AB(C+\bar{C})\bar{D} + ABCD$$

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

$$+ ABC\bar{D} + AB\bar{C}\bar{D} + ABCD.$$

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

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

$$\therefore f = \Sigma m(15, 14, 13, 12, 11, 10, 9, 8, 5, 4)$$

$$\therefore f = \Pi M(0, 1, 2, 3, 6, 7)$$

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in SOP $A = 1$ $\bar{A} = 0$

$$f = A + B\bar{C} + AB\bar{D} + ABCD$$

Trick:-

A	x x x
1	0 0 0
1	0 0 1
1	0 1 0
1	0 1 1
1	1 0 0
1	1 0 1
1	1 1 0

x	B $\bar{C}$	x
0	1 0	0
0	1 0	1
1	1 0	0
1	1 0	1

A B	x	$\bar{D}$
1 1	0	0
1 1	1	0

1 | 1 1 1

Take common terms

Q. find canonical form of $f = A(\bar{A}+B)(\bar{A}+B+\bar{C})$

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

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

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

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

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

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

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

$\therefore f = \pi M(0,1,2,3,4,5)$

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

A	x	x
0	0	0
0	0	1
0	1	0
0	1	1

$\bar{A}$	B	x
1	0	0
1	0	1

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

✓

$\therefore f = \pi M(0,1,2,3,4,5)$

$2^3 = 8$
Total

$\therefore f = \Sigma m(6,7)$

Q. $f = A.(\bar{B}+A)B$

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

$: ((A+B)(A+\bar{B})+C\bar{C}).\left[(A+\bar{B}+C)(A+\bar{B}+\bar{C})\right]\left[(B+A)(B+\bar{A})+C\bar{C}\right]$

$: \left[(A+B+C\bar{C})(A+\bar{B}+C\bar{C})\right]\left[(A+\bar{B}+C)(A+\bar{B}+\bar{C})\right]\left[(A+B+C\bar{C})(\bar{A}+B+C\bar{C})\right]$

$: \left[(A+B+C)(A+B+\bar{C})(A+\bar{B}+C)(A+\bar{B}+\bar{C})\right]\left[(A+\bar{B}+C)(A+\bar{B}+\bar{C})\right]$

$\times \left[(A+B+C)(A+B+\bar{C})(\bar{A}+B+C)(\bar{A}+B+\bar{C})\right]$

$: \left[(A+B+C)(A+B+\bar{C})(A+\bar{B}+C)(A+\bar{B}+\bar{C})(\bar{A}+B+C)(\bar{A}+B+\bar{C})\right]$

$\therefore f = \pi M(0,1,2,3,4,5)$

$\therefore f = \Sigma m(6,7)$

Q. $f_{A,B} = \bar{A} + \bar{B}$

: SOP.

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

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

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

$\quad 0 \qquad 1 \qquad 2$

$\therefore f = \Sigma m(0,1,2)$

$\& \; f = \Pi M(3)$

$\bar{A}$	X
0	0
0	1

X	$\bar{B}$
0	0
1	0

00
01
10 ✓