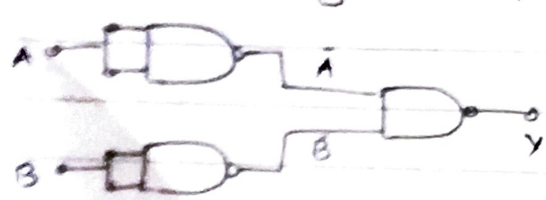
→ AND Gate Using NAND Gate :

AB

Truth Table

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

→ OR Gate Using NAN Gate :



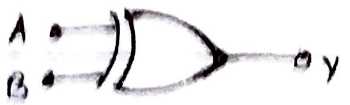
$Y = \overline{\bar{A} \cdot \bar{B}} = A + B$

Truth Table :

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

→ NOT Gate using NAND Gate :

XOR Gate (exclusive OR gate)



Min 2 inputs.

Y = A Ex-OR B

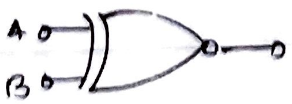
$Y = A \oplus B$

Truth Table

A	B	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

Only 1 must be 1 (True)
(or odd nos of 1)

X NOR Gate (exclusive NOR gate)



Y = A Ex-NOR B

$Y = \overline{A \text{ Ex-OR } B}$

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

$Y = A \odot B$

Truth Table :

A	B	$Y = A \odot B$
0	0	1
0	1	0
1	0	0
1	1	1

Evaluate 10101 = $(?)_{10}$

1 0 1 0 1

$2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$

$= (1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2)$

$+ (0 \times 2^1) + (1 \times 2^0)$

$= 16 + 0 + 4 + 0 + 1$

$= 21$ Ans

Evaluate $(312.4)_5 = (?)_{10}$

312.4

$5^2 \quad 5^1 \quad 5^0 \quad 5^{-1}$

$(3 \times 5^2) + (1 \times 5^1) + (2 \times 5^0) + (4 \times 5^{-1})$

$75 + 5 + 2 + (4 \times 0.2)$

$= 82.8$ Ans

Binary to Decimal (Integer)

101

$2^2 \quad 2^1 \quad 2^0$

$= 4 + 1 = 5$ Ans

10101 = 21 (1st question same page).

01010110

0 1 0 1 0 1 1 0

$2^7 \quad 2^6 \quad 2^5 \quad 2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$

$= 1 \times 2^6 + 1 \times 2^4 + 1 \times 2^2 + 1 \times 2^1$

$64 + 16 + 4 + 2$

$= 86$ Ans

	128	64	32	16	8	4	2	1	0.5	0.25	0.125
.625									1	0	1
.375									0	1	1

* Repeated division method :

2	10	
2	5	0
2	2	1
2	1	0
	0	1

= 1010

Ques: Convert decimal no. to binary.

i) 19

2	19	
2	9	1
2	4	1
2	2	0
2	1	0
	0	1

= 10011

49

2	49	
2	24	1
2	12	0
2	6	0
2	3	0
2	1	1
	0	1

$\Rightarrow$ 110001

Ques Convert decimal fraction to binary

i) $(0.3125)_{10} \longrightarrow (?)$

0.3125 × 2 = 0.625 with carry 0

0.625 × 2 = 1.25 = 0.25 with carry 1

0.25 × 2 = 0.5 with carry 0

0.5 × 2 = 0 with carry 1

b) 11 - 10

$$\begin{array}{r} 1\ 1 \\ 1\ 0 \\ \hline 0\ 0 \end{array}$$

(c)

$$\begin{array}{r} 1\ 0\ 0 \\ -\ 1\ 1\ 1 \\ \hline 0\ 0\ 1 \end{array}$$

X

(d)

$$\begin{array}{r} 1\ 0\ 1\ 1 \\ -\ 0\ 1\ 1\ 0 \\ \hline 0\ 1\ 0\ 1 \end{array} \qquad \begin{array}{r} 11 \\ -\ 6 \\ \hline 5 \end{array}$$

✓

(e)

$$\begin{array}{r} \cancel{0\ 1\ 1} \\ 1\ 0\ 1 \\ -\ 0\ 1\ 1 \\ \hline 0\ 1\ 0 \end{array} \qquad \begin{array}{r} 5 \\ -\ 3 \\ \hline 2 \end{array}$$

Qus Sub. the following nos. also show the equivalent decimal substraction.

(a) 10 from 11 → 01
2 from 3 → 1

$$\begin{array}{r} 1\ 1 \\ -\ 1\ 0 \\ \hline 0\ 1 \end{array} \qquad \begin{array}{r} 3 \\ 2 \\ \hline 1 \end{array}$$

(b)

$$\begin{array}{r} 1\ 1\ 0\ 1\ 1 \\ -\ 0\ 1\ 0\ 1\ 1 \\ \hline 1\ 0\ 0\ 0\ 0 \end{array} \qquad \begin{array}{r} 27 \\ -\ 11 \\ \hline 16 \end{array}$$

★

→ Covert Bi-ve to 1's complement method

Eg 5 - 6 = -1
5 - 101 ← +
6 - 110 → 1s' 001

$$\begin{array}{r} 1\ 0\ 1 \\ +\ 0\ 0\ 1 \\ \hline 1\ 1\ 0 \end{array}$$

1 ⇒ -ve

1s' comp

⇒ Ans -ve (001)

If ans is -ve

Research Needed

→ Binary Multiplication

→ Rules :

0 × 0 = 0

1 × 0 = 0

0 × 1 = 0

1 × 1 = 1

Que Carry out following multiplicⁿ and show equi decimal multiplicⁿ

1)

			1	1	1
		×	1	0	1
			1	0	1

7
5
35

			1	1	1
			1	0	1
			1	1	1
		0	0	0	×
	1	1	1	×	×
1	0	0	0	1	1
↓				↓	↓
32				2	1

= 35

2)

			1	0	1	1
			1	0	0	1
			1	0	1	1
		0	0	0	0	×
	0	0	0	0	×	×
1	0	1	1	×	×	×
1	1	0	0	0	1	1
64	32				2	1

= 99

11
× 9
99

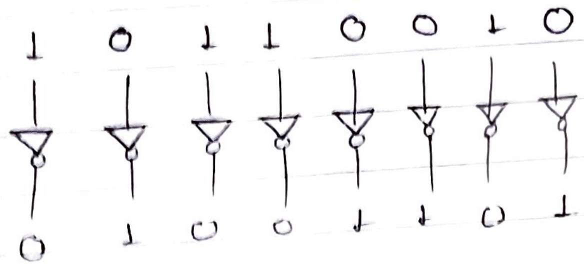
* 1's Complement

No 1 0 1 1 0 0 1 0
Com 0 1 0 0 1 1 0 1

Que Find 1st Complement of binary nos.

(a) 1 0 1 → 0 1 0
(b) 1 1 0 1 → 0 0 1 0
(c) 1 1 1 0 0 → 0 0 0 1 1

Que How will you obtain 1's comp of nos. with digital circuits.



* 2's Complement

Method 1 : find 1's complement
Add 1 to LSB.

(i) B No : 1 0 1 1 0 0 1 0
1's C : 0 1 0 0 1 1 0 1.
Add 1 : + 1

0 1 0 0 1 1 1 0 → 2's complement

Method 2 : B.No 1 0 1 1 1 0 0 0

0 1 0 0 ___

1's complement

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* Arithmatic Substraction using 2's C. Method.

(a)

$$\begin{array}{r} +7 \\ -\;+5 \\ \hline +2 \end{array}$$

7 → 00111

5 → 00101

1's C of 5 → 11010

+1 → 1

11011

= 00111

11011

100010

Discard Ans is +ve

(b)

$$\begin{array}{r} -5 \\ -\;+7 \\ \hline -12 \end{array}$$

-5

-7 = 00111

1'SC 11000

+1 +1

2'SC 11001

11011

\- 11001

110100

Ques

84 = 12

00001100

\- 11110111

11

→ $-2^7 + 2^6 + 2^5 + 2^4 + 2^2 + 2^1 + 2^0$

$-128 + 16 + 32 + 16 + 4 + 2 + 1$

⇒ -9 Ans

12 - -9 = 12 + 9 = 21

Qus 11100111 - 00010011 → 19

-128+64+32+4+2+1

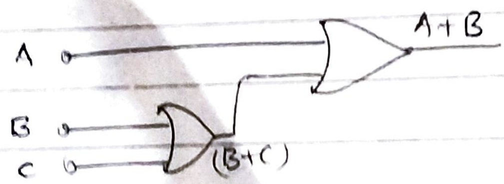
= -25

(-25) + (-19) = -44 (Expected).

* Basic Theorams and Properties

→ Commutative Law. $A + B = B + A$

→ Associative Law $A + (B + C) = (A + B) + C$.

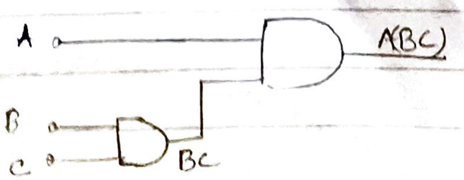


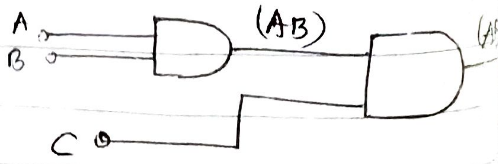
|||ly draw.

Draw Truth Table and prove.

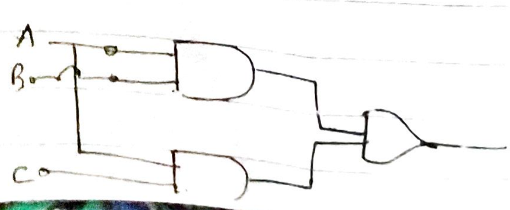
Multiplⁿ

$A(BC) = (AB)C$.





→ Distributive Laws $A(B+C) = AB + AC$



Properties / Rules.

i) $A + 0 = A$

ii) $A + 1 = 1 \longrightarrow$ ★

iii) $A0 = 0$

iv) $A \cdot 1 = A$

v) $A + A = A$

vi) $A + \bar{A} = 1 \longrightarrow$ ★ $\quad\quad A + AB = A$

vii) $A \cdot A = A$

viii) $A \cdot \bar{A} = 0 \longrightarrow$ ★

ix) $\bar{\bar{A}} = A$

x) $A + AB = A$

$LHS = A + AB$

$= A(1 + B)$

$= A(1)$

$= A = RHS \quad HP$

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

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

Apply rule 10

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

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

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

$A + B(1)$

$= A + B = RHS$

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

$= AA + BA + AC + BC$

$= A + BA + AC + BC \quad\quad (\because AA = A)$

$= A + A(B C) + BC \quad\quad$ (Take A common)

$= A + BC(A + 1) = A + BC(1) = A + BC = RHS$

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Ques Simplify :-

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

= Take $A\bar{B}$ common

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

$= A\bar{B}$ Ans

(b) $X = ACD + \bar{A}BCD$

Take CD common

$= CD(A + \bar{A}B)$ (Rule xi)

$= CD(A + B)$

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

Expand

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

$0 + BA + B$

$= B(A + 1)$

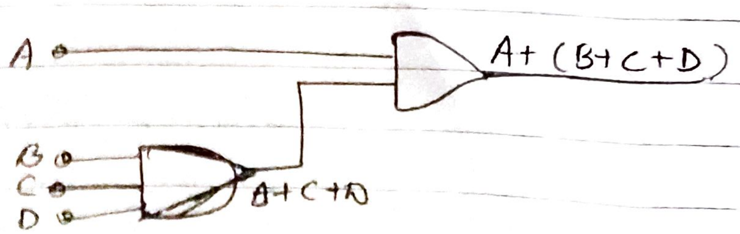
$= B$ Ans

Ques: Apply associative law of addⁿ to expression $A + (B + C + D)$

$A + (B + C + D) = (A + B) + (C + D)$ ✗

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

LHS =

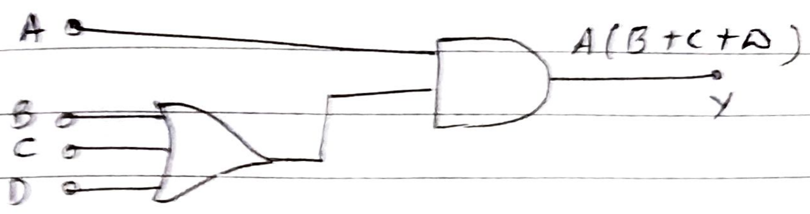


Apply distributive law to expression

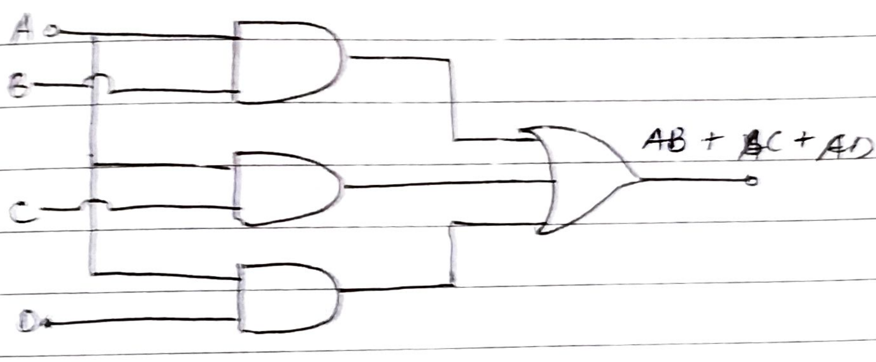
$A(B+C+D)$

$= AB + AC + AD$

LHS



RHS =



1st De Morgan's Law :-

$\overline{XY} = \bar{X} + \bar{Y}$

Complement of product of variables = Sum of complement of variables.

2nd De Morgan's Law :-

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

Ques: Apply DML to $\overline{XYZ} = \bar{X} + \bar{Y} + \bar{Z}$ (1st DML)

Ques: Apply DML to $\overline{X+Y+Z} = \bar{X}.\bar{Y}.\bar{Z}$ (2nd DML)

Ques: Apply DML $\overline{\bar{X}+\bar{Y}+\bar{Z}}$

$= \bar{\bar{X}}.\bar{\bar{Y}}.\bar{\bar{Z}}$ (2nd DMT)

$= X.Y.Z$ (Rule no ix).

Ques: Apply DMT to $\overline{\bar{W}\bar{X}\bar{Y}\bar{Z}}$

$= \bar{\bar{W}} + \bar{\bar{X}} + \bar{\bar{Y}} + \bar{\bar{Z}}$ (1st DMT).

$= W + X + Y + Z$ (Rule no. ix)

Ques A DMT to $\overline{(AB+C)(A+BC)}$

$= \overline{(AB+C)} + \overline{(A+BC)}$ (1st DMT)

$= (\overline{AB}.\bar{C}) + (\bar{A}.\overline{BC})$ (2nd DMT)

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

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

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

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

ii) $\overline{\overline{A+B\bar{C}} + D(\overline{E+\bar{F}})}$

$= \overline{\overline{A+B\bar{C}}} . \overline{D(\overline{E+\bar{F}})}$ (2nd DMT)

$= (A+B\bar{C}).(\bar{D} + \overline{\overline{E+\bar{F}}})$ (1st DMT & $\bar{\bar{A}} = A$) ix
to 2nd term of exp.

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

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

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

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

(X)

i) $\overline{ABC + DEF}$

$= \overline{ABC} \cdot \overline{DEF}$

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

ii) $\overline{A\bar{B} + \bar{C}D + EF}$

$= \overline{A\bar{B}} \cdot \overline{\bar{C}D} \cdot \overline{EF}$

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

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

iii) $\overline{\overline{ABC} + \overline{D+E}}$

$= \overline{\overline{ABC}} \cdot \bar{D} \cdot \bar{E}$ $= (ABC) \cdot \bar{D} \cdot \bar{E}$ ✓

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

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

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

$= (A+B) \cdot C$

v) $\overline{(\bar{A}+B)+CD}$

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

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

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

vi) $\overline{(A+B)\bar{C}D + E + \bar{F}}$

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

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

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

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

$= \overline{AB(C+D)} \cdot \bar{E}$

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

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

Take $\bar{A}\bar{B}$

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

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

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

Convert to Standard SOP.

i> $W\bar{X}Y + \bar{X}Y\bar{Z} + WX\bar{Y}$

Take $W\bar{X}Y$

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

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

Take $\bar{X}Y\bar{Z}$

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

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

Take $WX\bar{Y}$

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

$= WX\bar{Y}Z + WX\bar{Y}\bar{Z}$

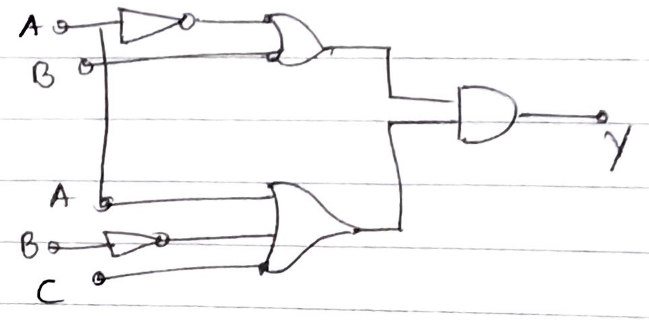
POS :- Product of Sum.

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

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

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

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



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

All variable should be present in each term

Use $A \cdot \bar{A} = 0$ and $A+BC = (A+B)(A+C)$

Standard POS.

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

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

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

Take $\bar{B}+C+\bar{D}$

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

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

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

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

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

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

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

ATTE SPOS E

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

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

Determine SPOS & SSOP expression from T.T. given below

A	B	C	O/P	
0	0	0	0	$\rightarrow A+B+C$
0	0	1	0	$\rightarrow A+B+\bar{C}$
0	1	0	0	$\rightarrow A+\bar{B}+C$
0	1	1	1	$\rightarrow \bar{A}BC$
1	0	0	1	$\rightarrow A\bar{B}\bar{C}$
1	0	1	0	$\rightarrow \bar{A}+B+\bar{C}$
1	1	0	1	$\rightarrow AB\bar{C}$
1	1	1	1	$\rightarrow ABC$

SPOS expression

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

SSOP expression

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

Canonical SOP form from the K. Map.

C \ AB	00	01	11	10
0	0	2 1	6	4
1	1	3	7	5

AB \ C	0	1
00	0	1
01	2	3
11	6	7
10	4	5

Grouping : 1 cell , 2 cells
4 cells , 8 cells.
3 cells , 6 cells

→ having cell adjacency.

Σm (0, 1, 2, 3, 4, 6)

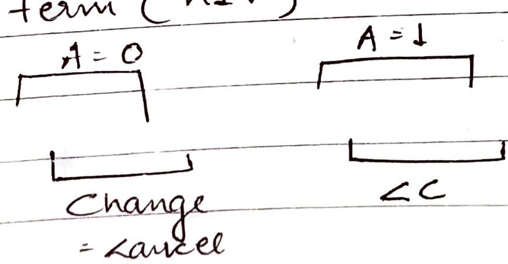
ry

→ Maximise size of cells.
→ Cancel variable which is changing.

* In 3 variable Map :

→ If

1 grouph cell = term (having 3 variables)
2 group cells = term (having 2 variables) $= \bar{A}\bar{C}$
4 cells = term (h1V)



8 cells = No term.

0 1
4

* In 4 variable Map :

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

1 cell → 4 variables

2 cells → 3 variables

4 cells → 2 variables
= BD

8 cells → 1 variable.

Ques Determine product term in K Map and find resulting SOP form in minimized form.

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

→ Can't make gp of 3 cells.

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

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

AB \ C	0	1
00	1	
01		1
10	1	1
10		

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

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

$= \bar{A} + B.$

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

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

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

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

Map : Only standard SOP
If not ; make it ; then map.

* 3 variable MSOP

* 1 missing

$\bar{A}$ $\bar{B}$ C → Missing

0	0	0
0	0	1

1 missing
→ 2 combn.

* 2 missing

$\bar{A}$ B C → Missing

0	0	0
0	0	~~0~~1
0	1	0
0	1	1

2 m
→ 4C

Not change.

A B C → Missing

0	1	0
0	1	1
1	1	0
1	1	1

* 4 variable MSOP.

* 1 missing

A B C D → Missing.

1	1	1	0
1	1	1	1.

→ 2 combn

* 2 missing

Missing

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

Missing

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

Missing

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

Missing

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

Qus Use K. Map to minimize expression.

i) $\bar{B}\bar{C}\bar{D} + \bar{A}B\bar{C}\bar{D} + AB\bar{C}\bar{D} + \bar{A}\bar{B}CD + A\bar{B}CD + \bar{A}\bar{B}C\bar{D}$
$+ \bar{A}BC\bar{D} + ABC\bar{D} + A\bar{B}C\bar{D}$

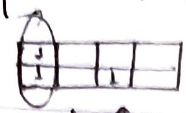
A	$\bar{B}$	$\bar{C}$	D
0	0	0	D
1	0	0	D

] 2 + = 10 terms

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

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

Prime Implicant ⇒ Group of minterms which can be combined with other minterms or groups.



can't combine.

Ques Minimize using K. Map.

i) $\bar{A}\bar{B}C + \bar{A}BC + \bar{A}\bar{B}\bar{C} + A\bar{B}\bar{C} + A\bar{B}C$

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

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

* Quine McCluskey Thm. :

5–10 Marks

$\Sigma m(0, 1, 3, 5, 7)$

↳ Find no. of variable (3 or 4 or ...)

0	0 0 0
1	0 0 1
3	0 1 1
5	1 0 1
7	1 1 1

Group	Minterm	Binary rep A B C
0	m_0	0 0 0
1	m_1	0 0 1
2	m_3	0 1 1
	m_5	1 0 1
3	m_7	1 1 1

Group	Matched pair	BR of A B C
0	0, 1 or $m_0 - m_1$	0 0 –
1	$m_1 - m_3$	0 – 1
	$m_3 - m_5$	– 0 1
2	$m_3 - m_7$	– 1 1

Can't compare

PI	Minterms	0	1	3	7	9
AB	m_0 m_1	x	x			
A	m_1 m_3		x	x		
BC	m_1 m_9		x			x
BC	m_3 m_7			x		x
AC	m_3 m_7				x	x

Simplify logic funcⁿ using QMC minimization tech

$f(A, B, C, D) = \Sigma m(0, 1, 3, 7, 8, 9, 11, 15)$

		Group	Minterm	A	B	C	D
0	0 0 0 0	0	m_0	0	0	0	0
1	0 0 0 1	1	m_1	0	0	0	1
3	0 0 1 1		m_8	1	0	0	0
7	0 1 1 1	2	m_3	0	0	1	1
8	1 0 0 0		m_9	1	0	0	1
9	1 0 0 1	3	m_7	0	1	1	1
11	1 0 1 1		m_{11}	1	0	1	1
15	1 1 1 1	4	m_{15}	1	1	1	1

Group	MT	A	B	C	D
0	m_0 m_1	0	0	0	-
	m_0 m_8	-	0	0	0
1	m_1 m_3	0	0	-	1
	m_1 m_9	-	0	0	1
	m_8 m_9	1	0	0	-
2	$m_8 - m_9$				
	m_3 m_7	0	-	1	1
	m_3 m_{11}	-	0	1	1
	m_9 m_{11}	1	0	-	1
3	m_7 m_{15}	-	1	1	1
	m_{11} m_{15}	1	-	1	1

ABC

→ Repeat

1 to 2

Essential PI : PI having atleast one unique minterm.

PI	Minterm	0	1	3	5	7
$\bar{A}\bar{B}$	$m_0 - m_1$	x	x			
$\bar{A}C$	$m_1 - m_3$		x	x		
$\bar{B}C$	$m_1 - m_5$		x		x	
BC	$m_3 - m_7$			x		x
AC	$m_5 - m_7$				x	x

$x + y + \cdots$ = Min. eqn.

Simplify Logic func^n using QMcC minimization teq.

$f(A, B, C, D) = \Sigma m\,(0, 1, 3, 7, 8, 9, 11, 15)$

0	0 0 0 0						
1	0 0 0 1						
3	0 0 1 1						
7	0 1 1 1						
8	1 0 0 0						
9	1 0 0 1						
11	1 0 1 1						
15	1 1 1 1						

T: 1

Group	Minterm	A	B	C	D
0	m_0	0	0	0	0
1	m_1	0	0	0	1
	m_8	1	0	0	0
2	m_3	0	0	1	1
	m_9	1	0	0	1
3	m_7	0	1	1	1
	m_{11}	1	0	1	1
4	m_{15}	1	1	1	1

Group	MP	A	B	C	D	
0	$m_0 - m_1$	0	0	0	–	$\bar{A}\bar{B}\bar{C}$
	$m_0 - m_8$	–	0	0	0	
1	$m_1 - m_3$	0	0	–	1	$\Rightarrow$ Repeat
	$m_1 - m_9$	–	0	0	1	
	$m_8 - m_9$	1	0	0	–	1 - to 2 -
2	~~$m_3 - m_9$~~					
	$m_3 - m_7$	0	–	1	1	
	$m_3 - m_{11}$	–	0	1	1	
	$m_9 - m_{11}$	1	0	–	1	
3	$m_7 - m_{15}$	–	1	1	1	
	$m_{11} - m_{15}$	1	–	1	1	

Table :

Group	MP	A	B	C	D	
0	$(m_0-m_1)-(m_8-m_9)$	-	0	0	-	$\bar{B}\bar{C}$
	$(m_0-m_8)-(m_1-m_9)$	-	0	0	-	$\bar{B}\bar{C}$
1	$(m_1-m_3)-(m_9-m_{11})$	-	0	-	1	$\bar{B}D$
	$(m_1-m_9)-(m_3-m_{11})$	-	0	-	1	$\bar{B}D$
2	$(m_3-m_7)-(m_{11}-m_{15})$	-	-	1	1	CD
	$(m_3-m_{11})-(m_7-m_{11})$	-	-	1	1	CD

Table 4

PI	Minterm	0	1	3	7	8	9	11	15
$\bar{B}\bar{C}$	0, 1, 8, 9	x	x			x	x		
$\bar{B}D$	1, 3, 9, 11		x	x			x	x	
CD	3, 7, 11, 15			x	x			x	x

EPI.

Simplified SOP = $\bar{B}\bar{C} + \bar{B}D + CD$
or minimized.

EPI = $\bar{B}\bar{C}$ & CD

ii) $f(A, B, C, D) = \Sigma m\,(0, 1, 2, 3, 5, 7, 8, 9, 11, 14)$

0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
5	0 1 0 1
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
11	1 0 1 1
14	1 1 1 0

Table - 1

Group	Minterm	A	B	C	D
0	m_0	0	0	0	0
1	m_1	0	0	0	1
	m_2	0	0	1	0
	m_8	1	0	0	0
2	m_3	0	0	1	1
	m_5	0	1	0	1
	m_9	1	0	0	1
3	m_7	0	1	1	1
	m_{11}	1	0	1	1
	m_{14}	1	1	1	0

2

Group	Matching Pair	A	B	C	D
0	$m_0 - m_1$	0	0	0	-
	$m_0 - m_2$	0	0	-	0
	$m_0 - m_8$	-	0	0	0
1	$m_1 - m_3$	0	0	-	1
	$m_1 - m_9$	0	-	0	1
	$m_2 - m_3$	0	0	1	-
	$m_8 - m_9$	1	0	0	-
2	~~$m_3 - m_8$~~				
	$m_3 - m_7$	0	-	1	1
	$m_3 - m_{11}$	-	0	1	1
	$m_5 - m_7$	0	1	-	1
	$m_9 - m_{11}$	1	0	-	1

3 m_{14} to next table as it is

m_{14}	1	1	1	0