2 Conditions for orthogonal

↳ Neutural

↳ Mutal exclusive terms

* K-MAP (konaugh Map) L-20

- **Boolean variable** → symbol which can take value 0 or 1

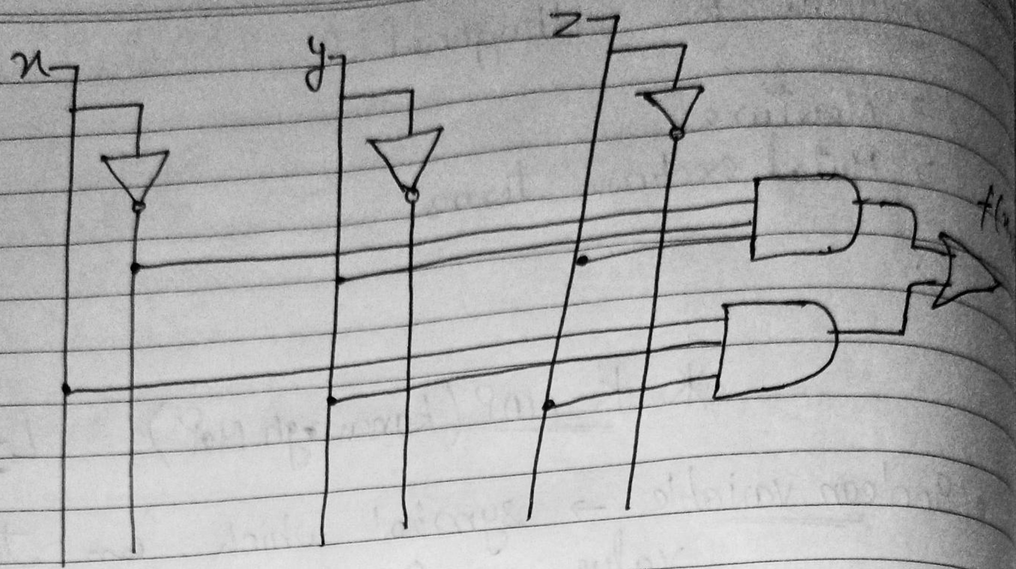
  Ex $x \begin{cases} \to 0 \\ \to 1 \end{cases}$

- **Literal** → use of variable or its complement in an expression

$$\underbrace{f(x, y)}_{\text{2 variables}} = \underbrace{\bar{x}y + x\bar{y}}_{\text{4 Literals}}$$

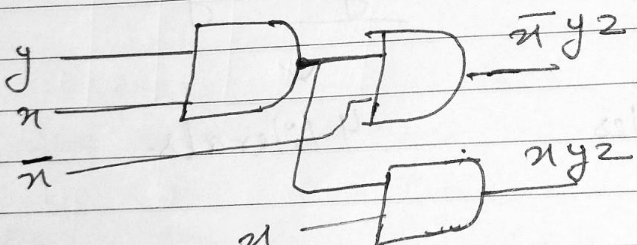
* Implement the following function

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



2 AND gate (3 I/P)
1 OR gate
1 Not gate

Another way to implement:-



- Minimization

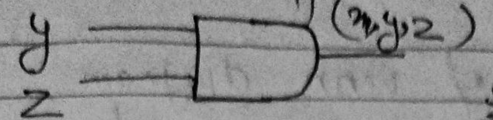
$f(x, y, z) = \bar{x}yz + xyz$

$yz(x + \bar{x})$

$\downarrow$ Complement law

$yz(1)$

yz



Ans

There are two way to minimize an expression

1) Boolean laws   2) ~~kara~~ Karnaugh Map

Summary :-

→ before implementing the function by logic gates we must first minimize it

→ for minimization we can apply boolean laws on identities. But some time its difficult to minimize expression by laws like:

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

$\downarrow 1 \cdot BC$ (crucial step) identity law

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

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

$AB + \bar{A}C$

Hence better option is Karnaugh Map.

K-Map

→ Application of venn diagram
→ based on gray code
→ Minimum possible k map is for 1 var & max for n variable
→ for "n" var boolean f^n we've to make 2^n minterms & for each minterm we have cell in K-Map

Hence total no. of cells = 2^n (for n variable)

Q 4 var k map has no. of cells ⇒ $2^4 = 16$

Q $f(A,B,C,D) = \Sigma m(0, 1, 13, 15)$

CD \ AB	00	01	11	10
00	m0	m4	m12	m8
01	m1	m5	m13	m9
11	m3	m7	m15	m11
10	m2	m6	m14	m10

AB \ CD	00	01	11	10
00	m0	m1	m3	m2
01	m4	m5	m7	m6
11	m12	m13	m15	m14
10	m8	m9	m11	m10

2 way to make ~~ma~~ K-Map

Size of rectangle
1
2
4
8
16
32

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

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

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

$2^n \times 2^m = 1 \times 2$

$n = 0, \ m = 1$

Q $f(A, B, C, D) = \Sigma m(0, 7, 8, 15)$

CD \ AB	00	01	11	10
00	1_0	4	12	1_8
01	1	5	13	9
11	2	1_7	1_{15}	11
10	3	6	14	10

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

Q $f(A, B, C, D) = \Sigma m(0, 2, 12, 14)$

CD \ AB	00	01	11	10
00	1_0	4	1_{12}	8
01	1	5	13	9
11	3	7	15	11
10	1_2	6	1_{14}	10

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

Q $f(A, B, C, D) = \Sigma m(3, 5, 6, 15)$

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

$\bar{A}BCD + ABCD + \bar{A}BC\bar{D} + \bar{A}\bar{B}CD$

Q $f(A, B, C, D) = \Sigma m(0, 1, 2, 3)$

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

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

Size of rectang → literal

1 → 4

2 → 3

4 → 2

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Q $f(A,B,C,D) = \Sigma m(5,7,13,15)$

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

BD

Ans

Q $f(A,B,C,D) = \Sigma m(0,1,2,3,4,5)$

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

Q $f(A,B,C,D) = \Sigma m(5,7,13,15)$

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

BD

Ans

Q $f(A,B,C,D) = \Sigma m(0,1,2,3,4,5)$

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

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

Ans

Q $f(A,B,C,D) = \Sigma m(0,1,2,3,10,11)$

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

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

Ans

Q $f(A,B,C,D) = \Sigma m(0,2,4,6,8,10,12,14)$

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

$\bar{D}$

Ans

Que $f(A, B, C, D) = \Sigma m(0, 2, 5, 7, 13, 15, 8, 10)$

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

$BD + \overline{B}\,\overline{D}$

Ans

Que $f(A, B, C, D) = \Sigma m(0, 1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 14)$

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

$\overline{D} + \overline{B}$

Ans

Que $f(A, B, C, D) = \Sigma m(0, 1, 2, 3, 4, 5, 10, 11)$

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

$\cancel{\overline{A}\,\overline{B} + \overline{A}\,\overline{C} + \overline{C}\,\overline{B}}$ X

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

Ans

Que $f(A,B,C,D) = \Sigma m(1,4,6,9,11,15)$

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

$\bar{B}\bar{C}D + ACD + \bar{A}B\bar{D}$ Ans

Que $f(A,B,C,D) = \Sigma m(0,1,2,3 \ldots 15)$

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 Ans

if every cell is present then ans will always be "1" and literal count is "zero"

Proof :
Make 2 boxes of 8 – 8 cells

$\bar{A} + A$

↓

"1" Ans

Size of box	→	literal Count
1	→	4
2	→	3
4	→	2
8	→	1
16	→	0

"n" Variable K-MAP

Rectangle		Literal Count
1	—	n
2	—	$n-1$
4	—	$n-2$
8	—	$n-3$
16	—	$n-4$
32	—	$n-5$
2^x	—	$n-x$

* Cover

Consider 2 sets f & g we say f covers g if $g \subseteq f$

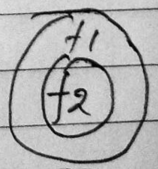
Q

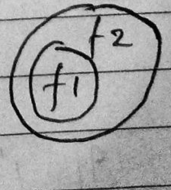
A	B	f1	f2
0	0	0	0
0	1	1	1
1	0	1	1
1	1	0	1

$f1 = \Sigma m(1, 2)$
$f2 = \Sigma m(1, 2, 3)$

Since the element in f_1 is also present in $f2$, means $f2$ covers $f1$

Q
a f_1 covers $f2$
b $f2$ covers f_1 ✓
c both
d none

f_1 cover $f2$ →


$f2$ cover f_1 →


- In logic/B.A we say f covers g ~~ments~~ means $g \Rightarrow f$ is a tautology
  g implies in f

A	B	f_1	f_2	$f_1 \to f_2$
0	0	0	0	1
0	1	1	1	1
1	0	1	1	1
1	1	0	1	1

implies Truth table

P	Q	$P \to Q$
0	0	1
0	1	1
1	0	0
1	1	1

f_2 covers f_1 $\therefore$ $f_1 \to f_2$ is tautology

* Implicant:
given 2 functions f_1 & f_2 s.t $f_1 \subseteq f_2$ then f_1 is called implicant of f_2 i.e $f_1 \to f_2$ is tautology

Simply we can say that every subset of boolean f^n is an implicant

Ex $f(A,B) = \Sigma(1,2)$

$f_1(A,B) = \phi$
$f_2(A,B) = \Sigma(1)$
$f_3(A,B) = \Sigma(2)$
$f_4(A,B) = \Sigma(1,2)$

All function from f_1 to f_4 are implicant of $f(A,B) = \Sigma m(1,2)$

If f^n 'f' has n minterms then how many implicant ?
2^n Ans

Q If f^n 'y' of n var has 'x' minterms then how many ~~implicants~~ functions can cover f?

$n \rightarrow 2^n$ = minterms

$2^n - x = 2^{(2^n - x)}$

Q $f(A,B,C) = AB + BC \rightarrow$ SOP

How many functions can cover f?

$f(A,B,C) = \Sigma m(6,7,3)$

$8 - 3 = 5 = 2^5 \rightarrow 32$ Ans

"3" are always present rest 5 having "2" possibilite they can be or can be present

for (6, 7, 3, 0) and so on...