Digital Electronics

(Second Year B. Tech program in Computer Engineering)

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Unit-II Boolean Algebra and Logic Gates — 08 Hrs.

Theorems and Properties of Boolean Algebra, Boolean Functions, Boolean Function Reduction using Boolean Laws, Canonical Forms, Standard SOP and POS Form. Basic Digital Gates: NOT, AND, OR, NAND, NOR, EX-OR, EX-NOR, Positive and Negative Logic, K-Map Method: 2-variable, 3-variable, 4-variable, Don't-Care Conditions, Quine-McCluskey Method, NAND-NOR Realization.

Digital Circuit

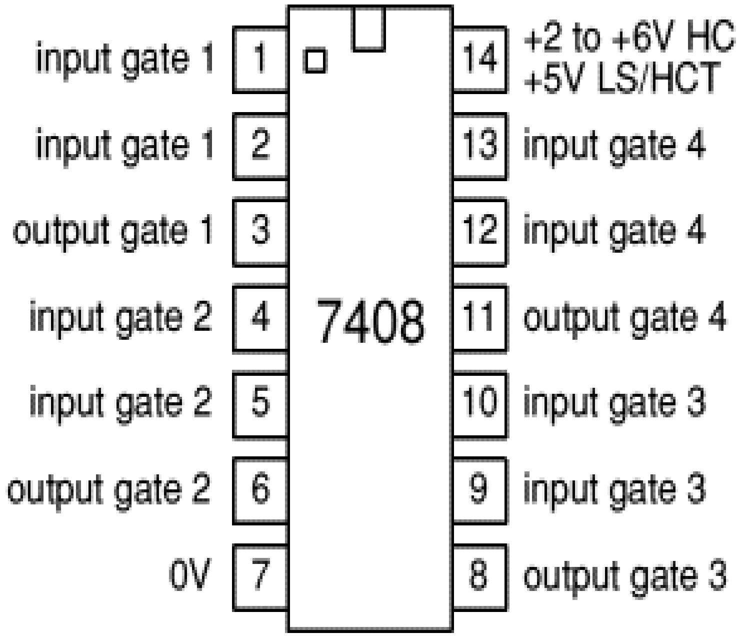
A digital circuit is a circuit where the signal must be one of two discrete levels. Each level is interpreted as one of two different states (for example, on/off, 0/1, true/false).

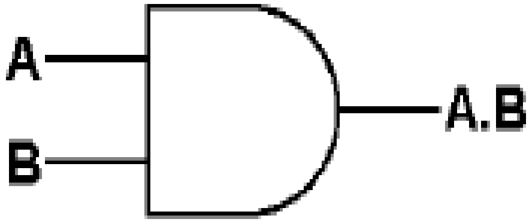
Digital circuits are less susceptible to noise or degradation in quality than analog circuits.

Logic Gates

- Basic Gates – AND, OR and NOT
- Universal Gates – NAND and NOR
- Special Gates – XOR and XNOR

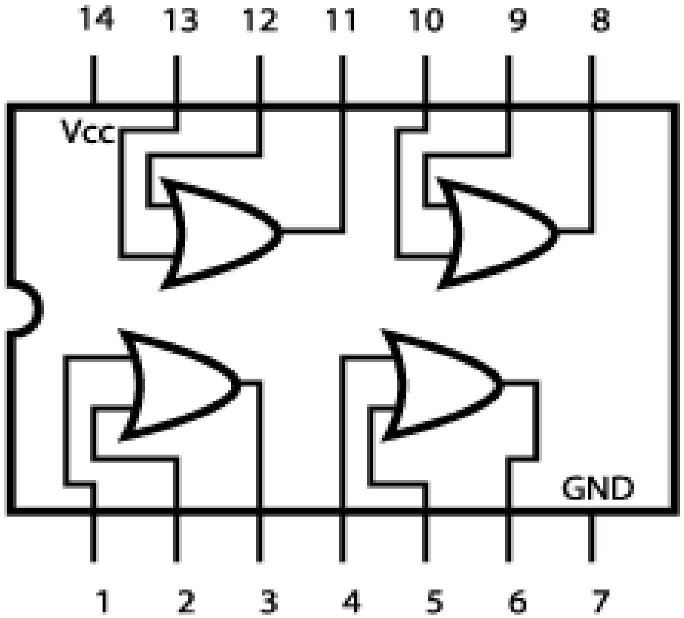
AND Gate IC -7408

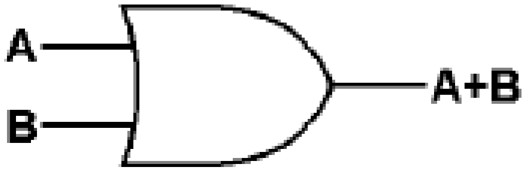




A	B	$A.B$
0	0	0
0	1	0
1	0	0
1	1	1

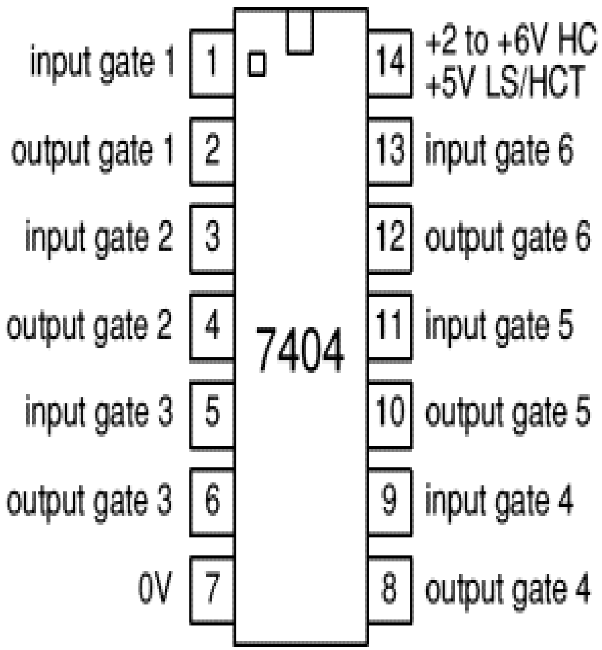
OR Gate IC -7432

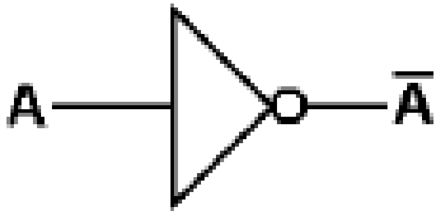




A	B	$A+B$
0	0	0
0	1	1
1	0	1
1	1	1

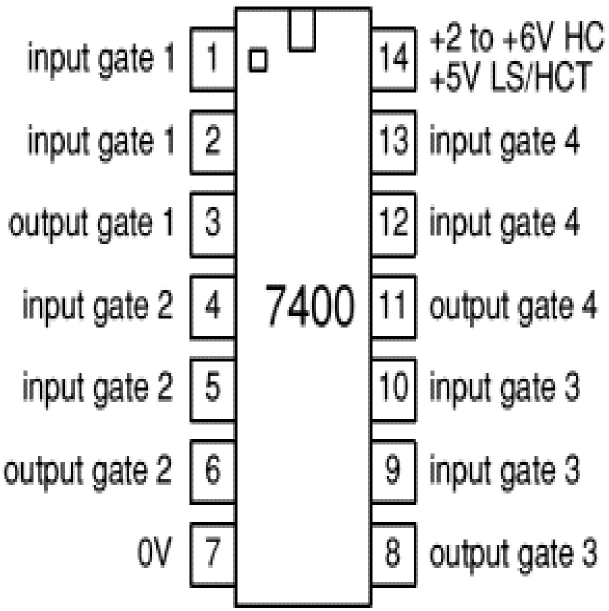
NOT Gate IC -7404

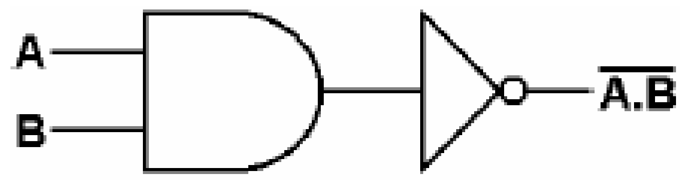


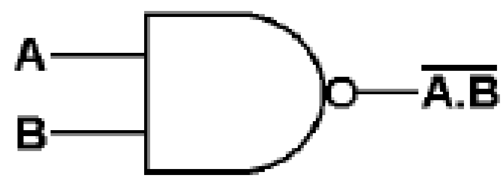


Input	Output
A	Y
0	1
1	0

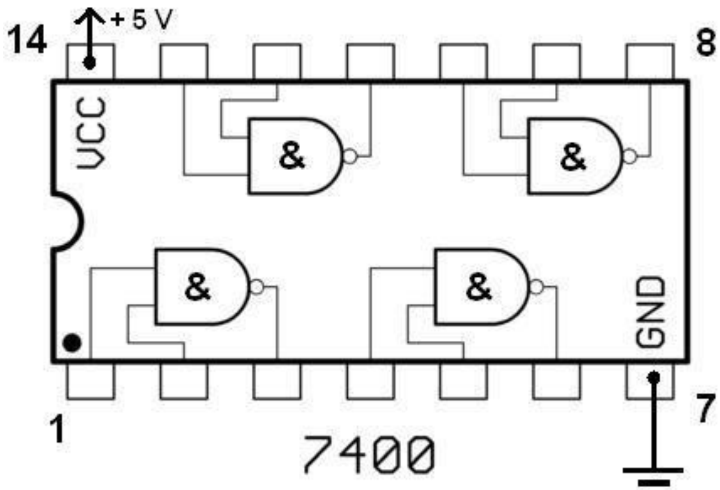
NAND Gate IC -7400



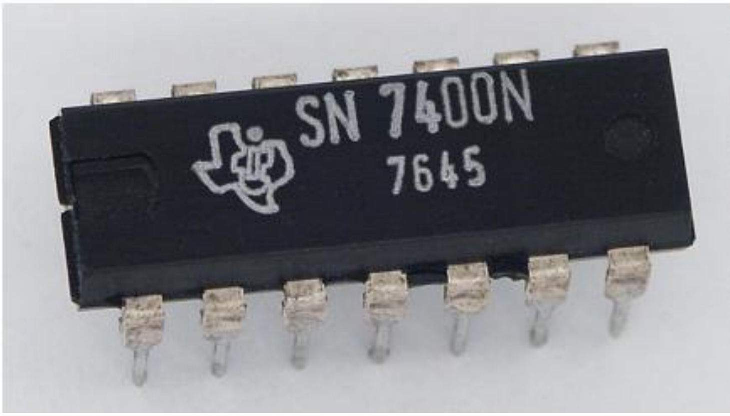




A	B	$\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

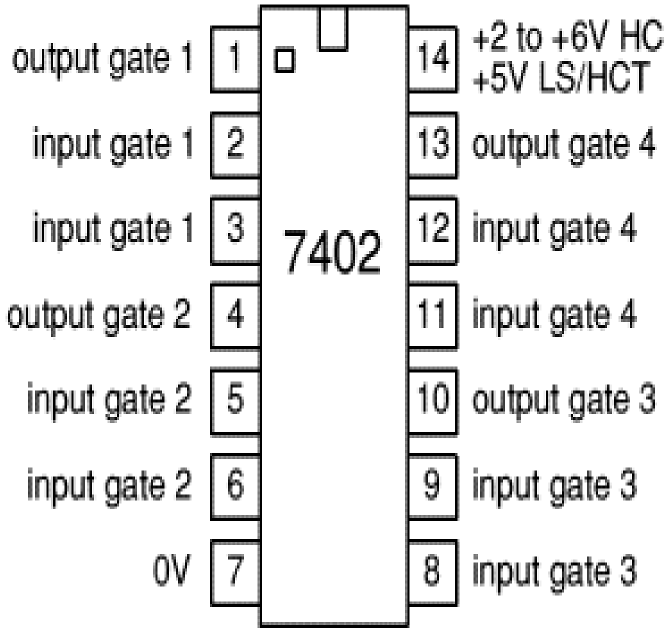


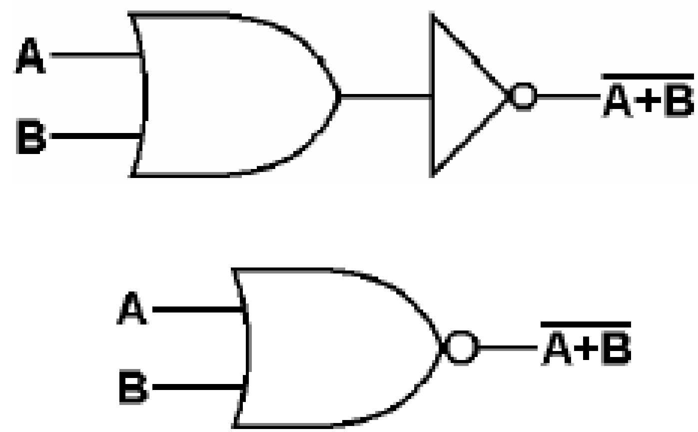
14
+ 5 V
8
VCC
&
&
&
&
GND
1
7
7400



SN 7400N
7645

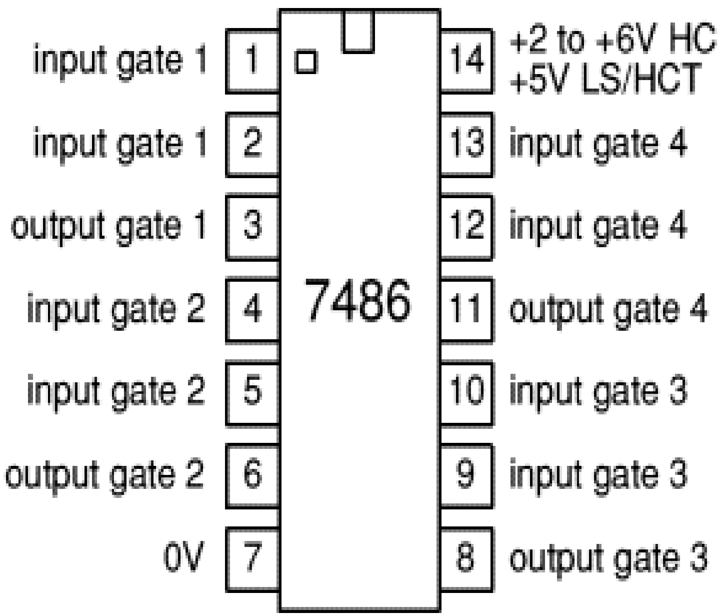
NOR Gate IC -7402

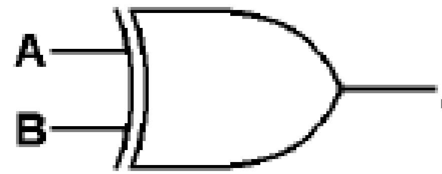




A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

XOR Gate IC -7486



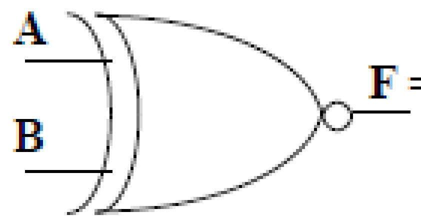


$$A \oplus B = A.\overline{B} + \overline{A}.B$$

A	B	$A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

XNOR

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



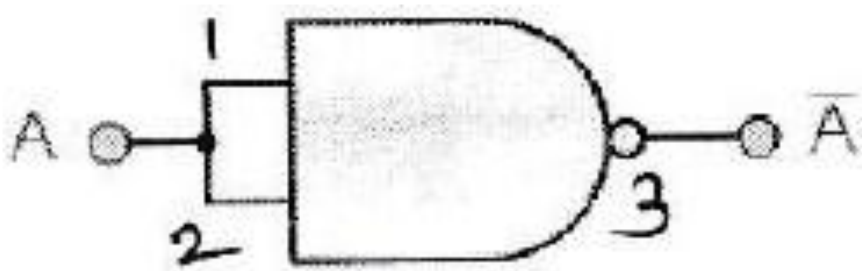
$F = \overline{A \oplus B}$

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

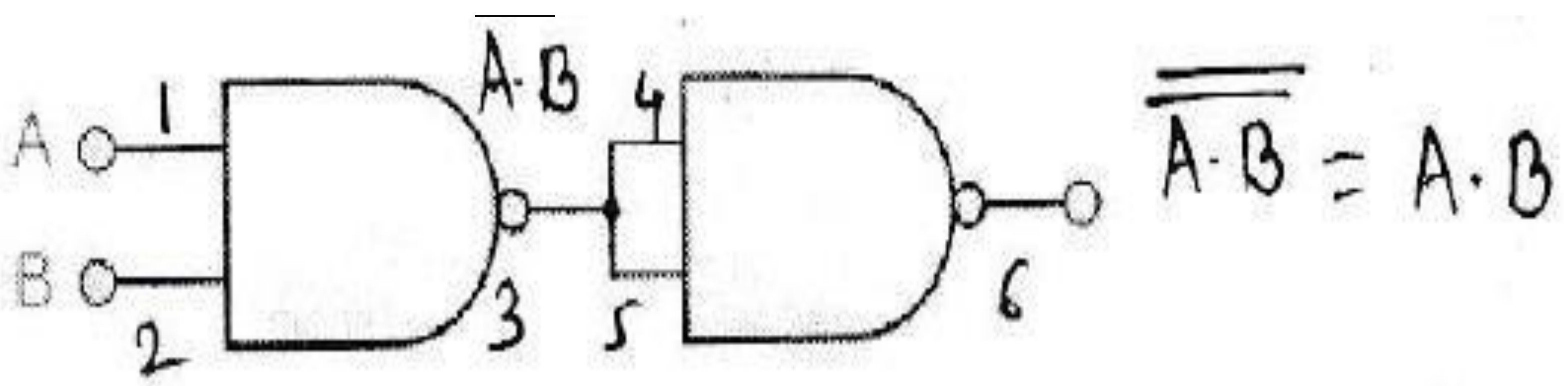
Implementation of Basic Gates using NAND Gate

1) NOT Using NAND

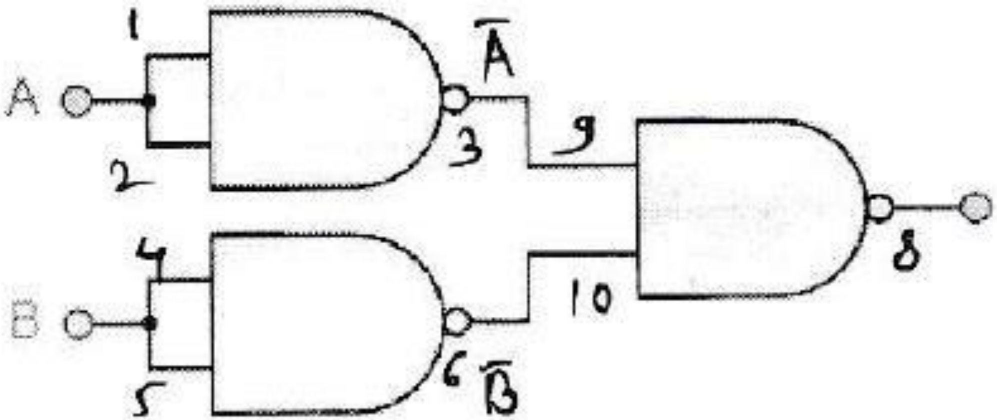
A	B	$\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0



2) AND Using NAND

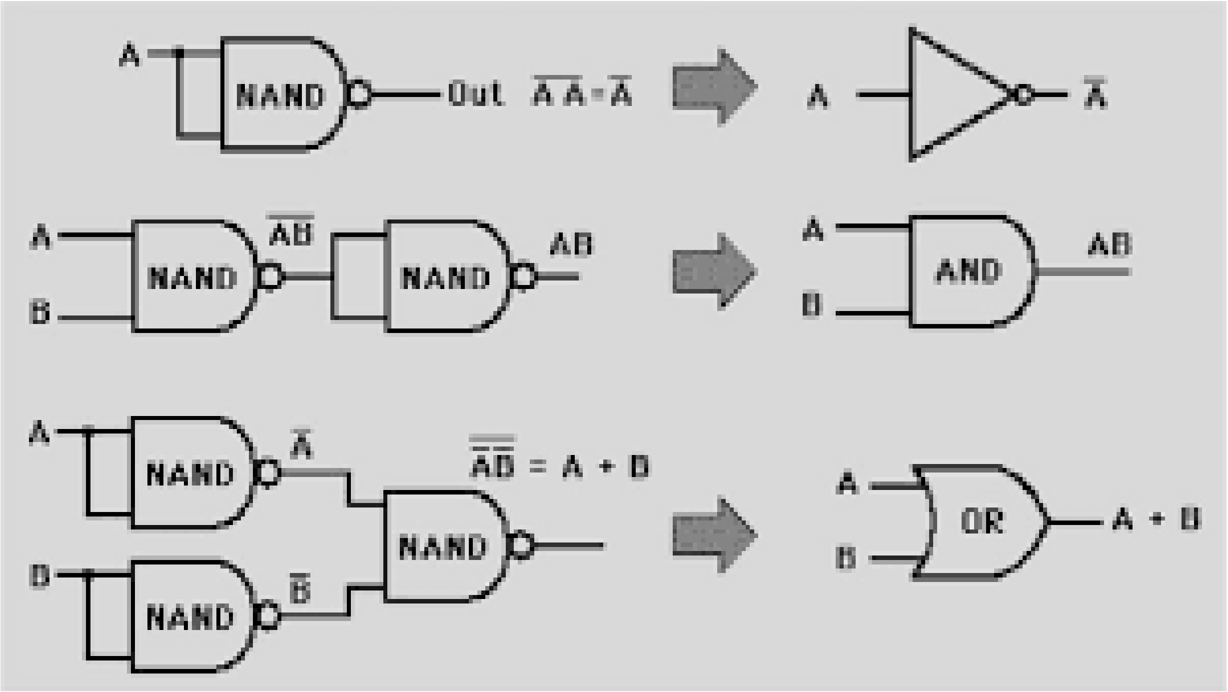


3) OR Using NAND



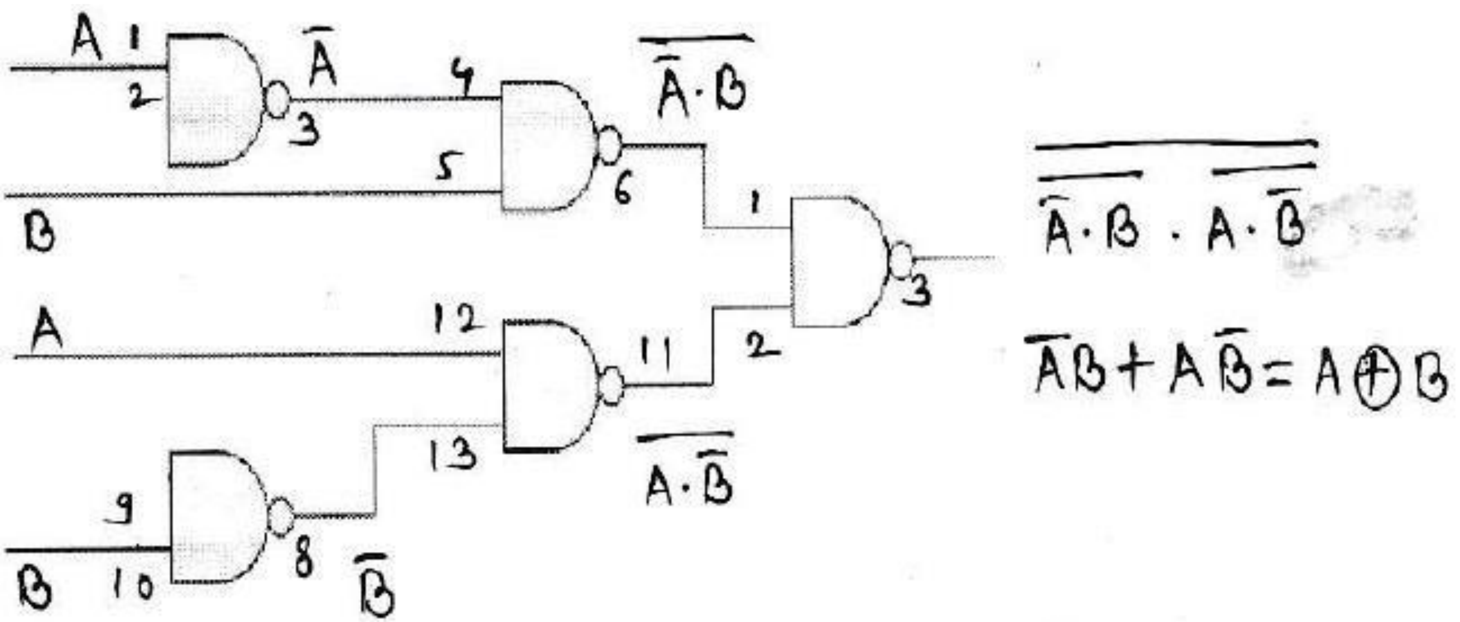
$$\overline{\bar{A}\cdot\bar{B}} = \bar{\bar{A}} + \bar{\bar{B}} = A + B$$

Implementation of Basic Gates using NAND Gate

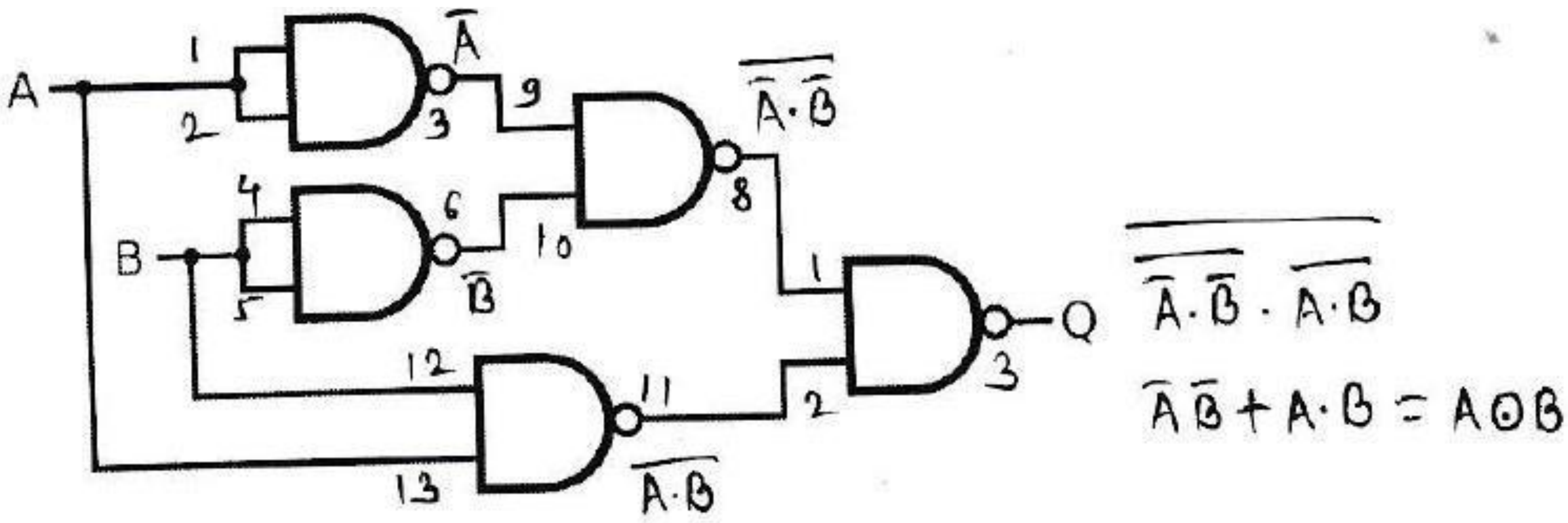


Is it possible to implement special gates using universal gates ?????

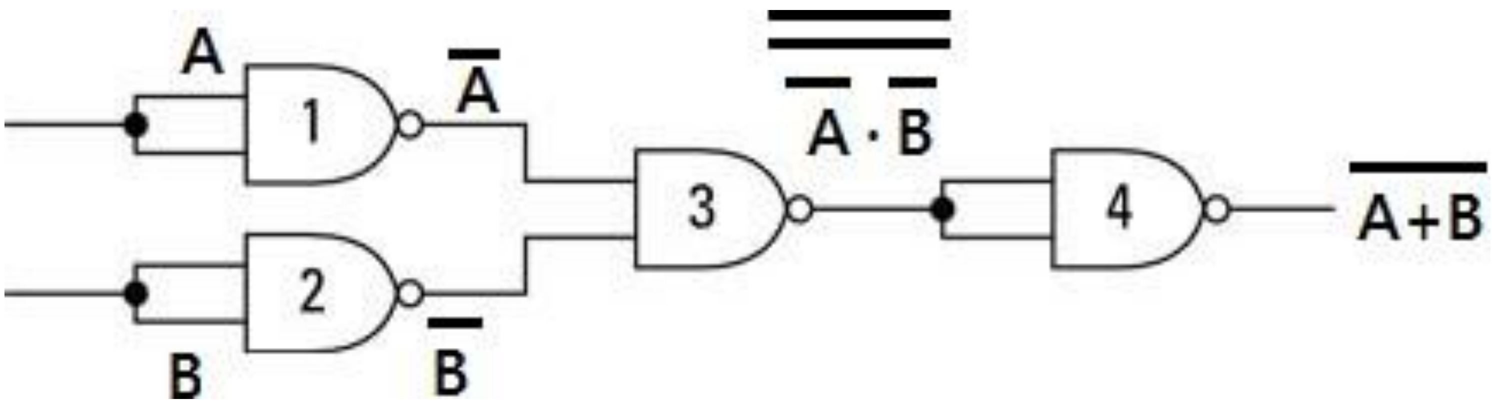
XOR Using NAND



XNOR Using NAND



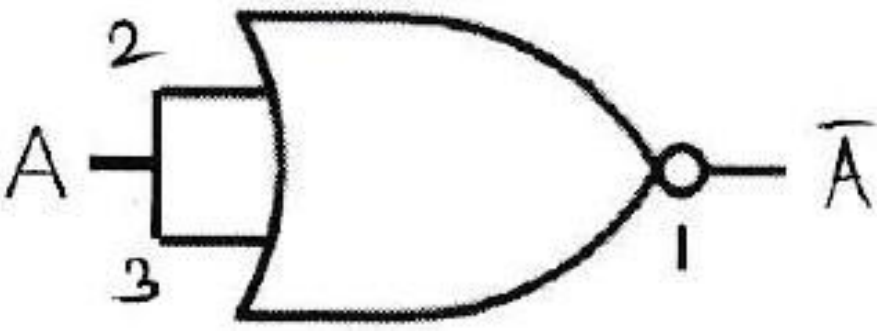
NOR Using NAND



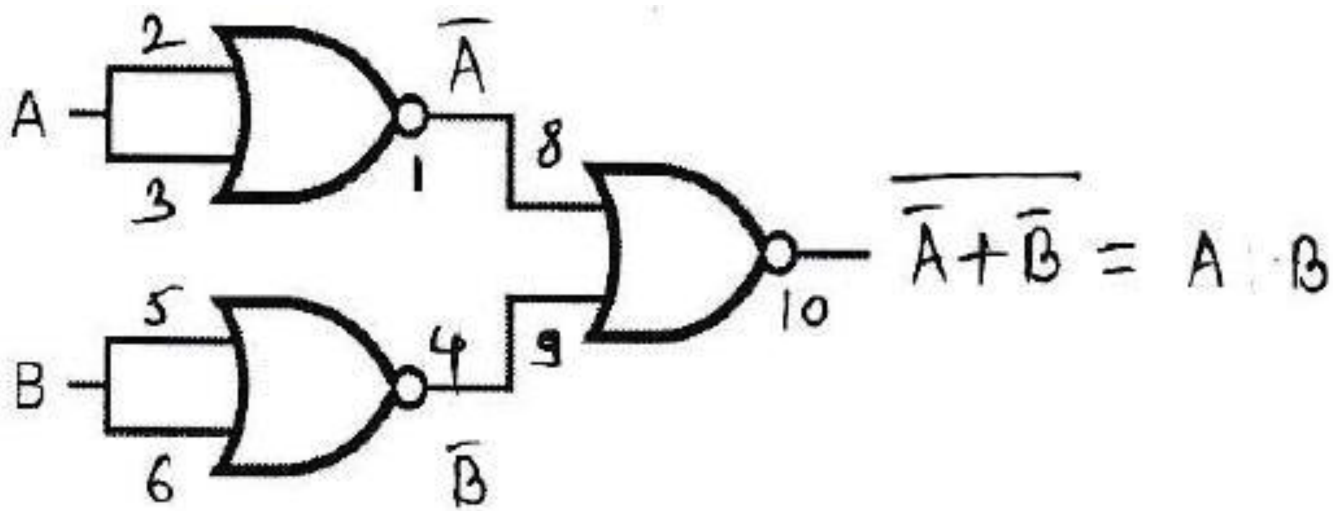
Implementation of Basic Gates using NOR Gate

1) NOT Using NOR

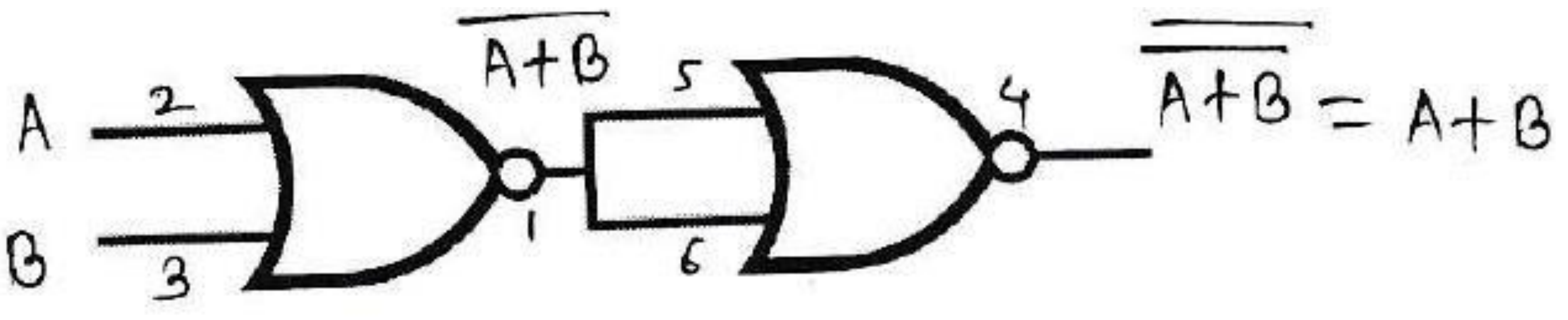
A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0



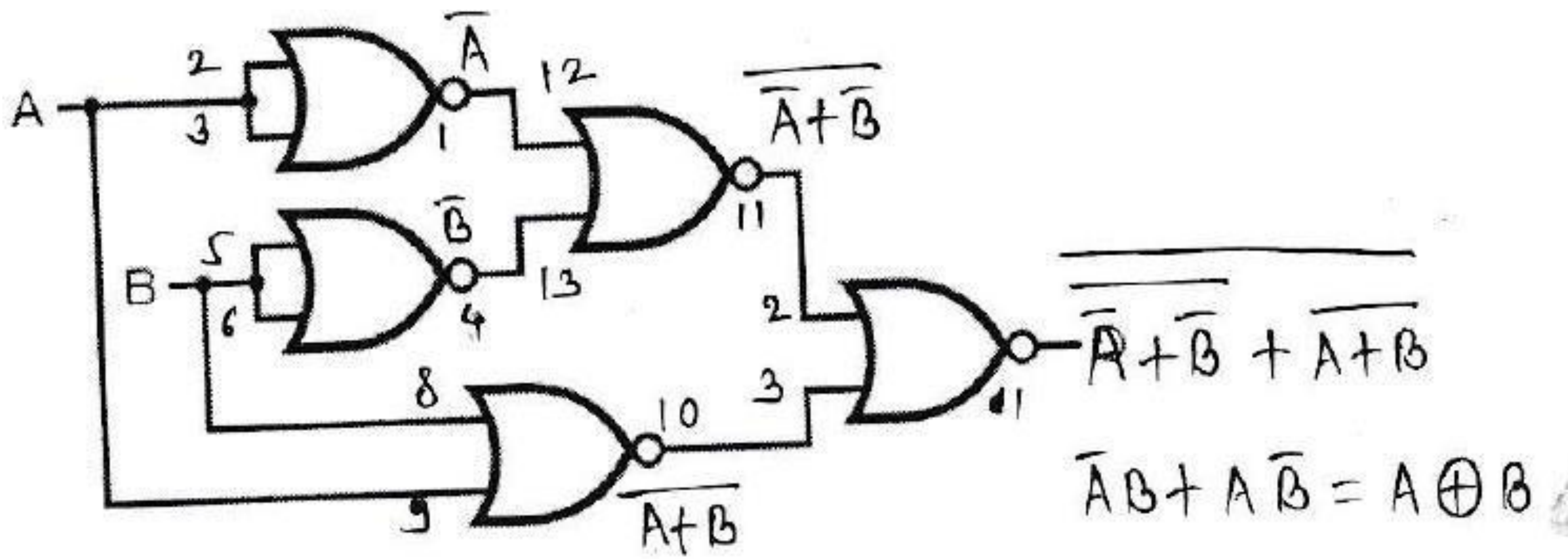
2) AND Using NOR



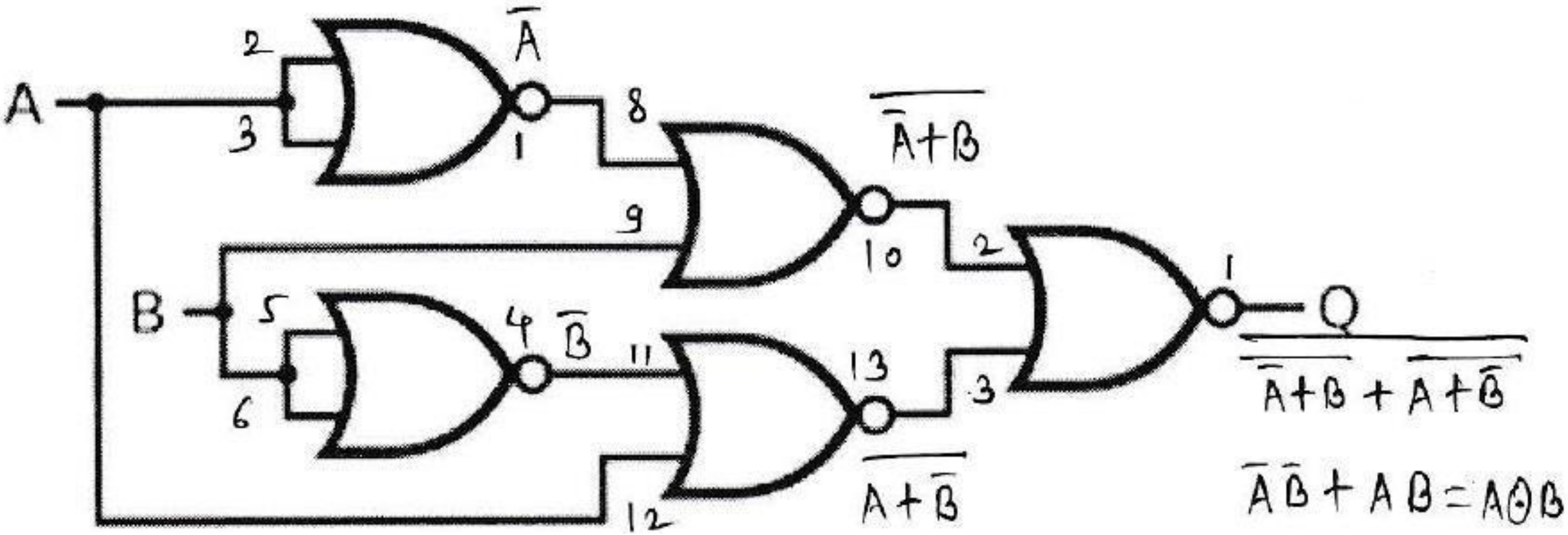
3) OR Using NOR



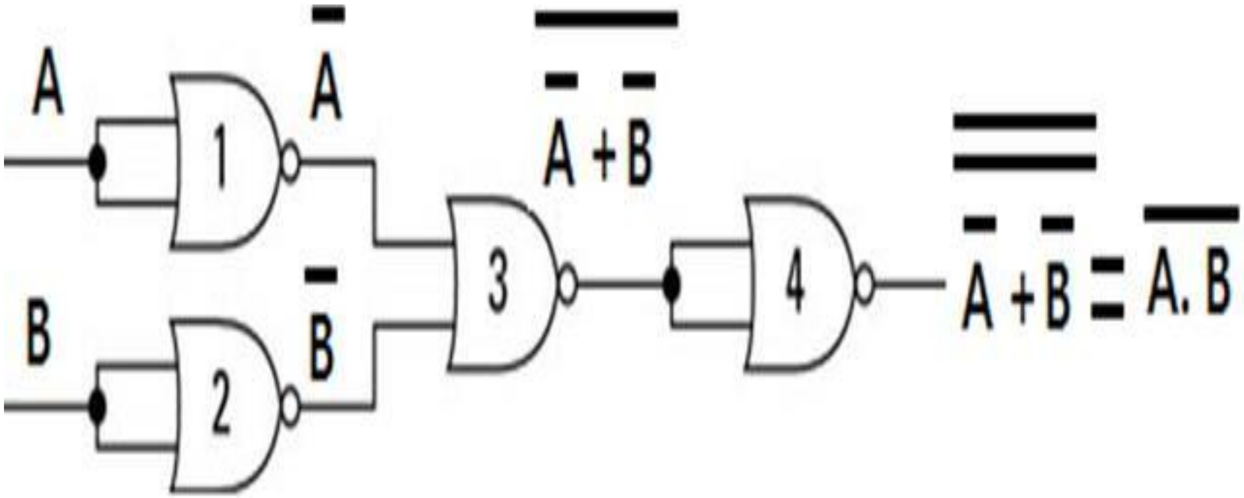
XOR Using NOR



XNOR Using NOR



NAND Using NOR



Breadboard Connection

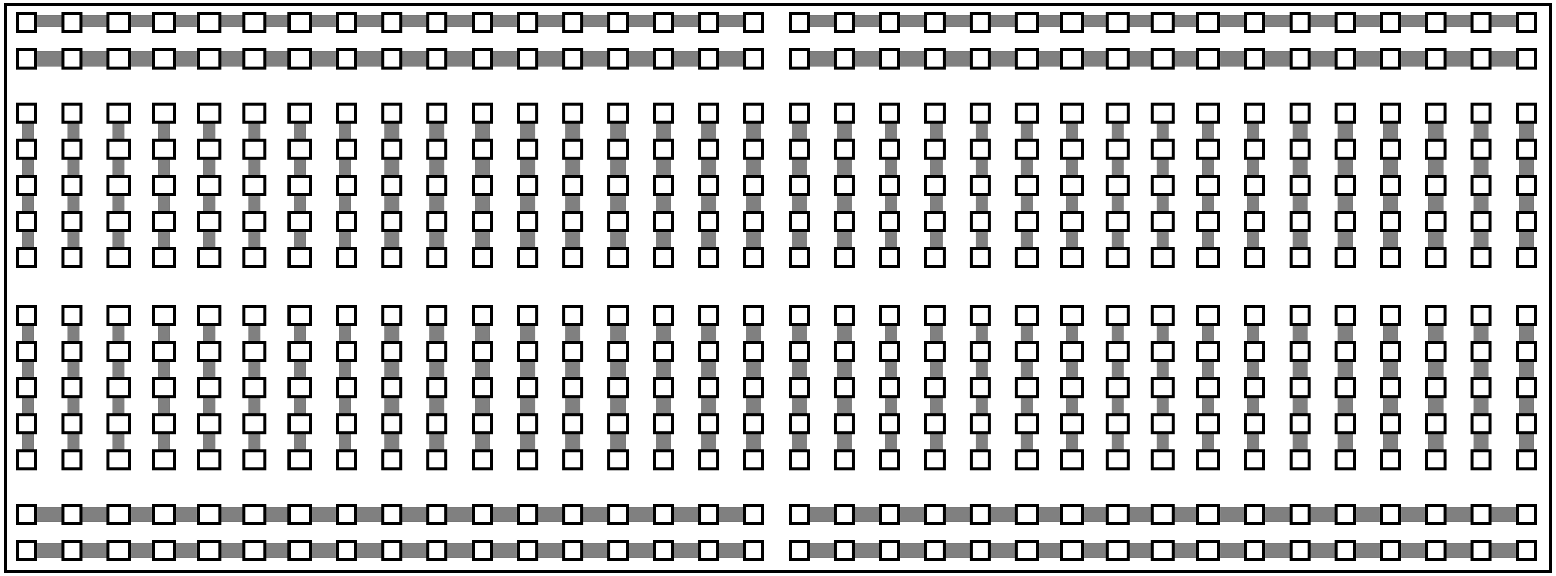
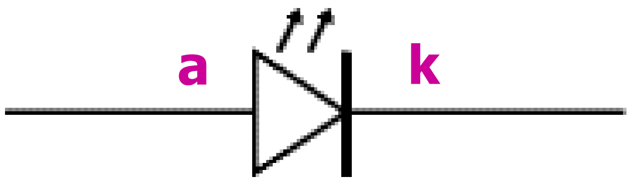
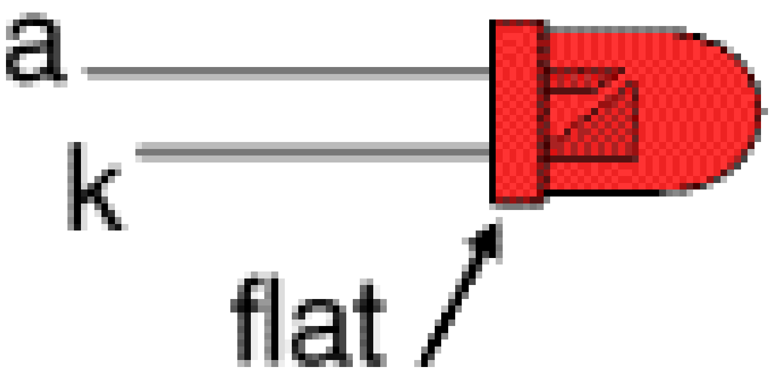


Figure 9: Connection pattern used in the breadboard

LED

Circuit symbol:

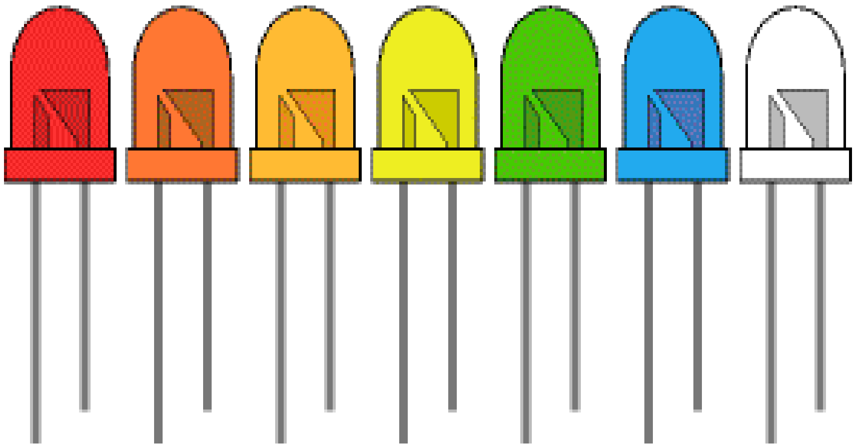




The cathode is the short lead and there may be a slight flat on the body of round LEDs

Colours of LEDs

LEDs are available in red, orange, amber, yellow, green, blue and white.
Blue and white LEDs are much more expensive than the other colours



The colour of an LED is determined by the semiconductor material, not by the colouring of the 'package' (the plastic body).

Boolean Laws & Theorems

1) AND Laws

$A.\overline{A}=0$

$A.A=A$

$A.1=A$

$A.0=0$

2) OR Laws

$A+A=A$

$A+\overline{A}=1$

$A+0=A$

$A+1=1$

3) Complement Laws

$$\overline{\overline{A}} = A$$

4) Idempotent Laws

A.A.A…..=A

A+A+A+…=A

5) Distributive Laws

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

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

6) Associative Laws

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

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

7) Commutative Laws

A+B=B+A

A.B=B.A

8) Other Laws

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

$\overline{A}+AB = \overline{A}+B$

$A+AB = A$

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

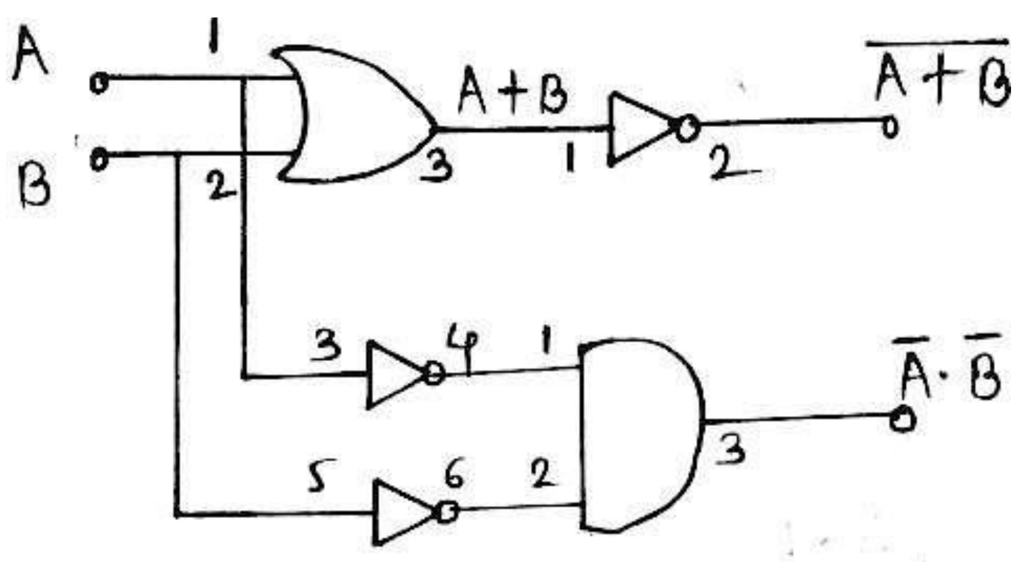
$\overline{A}+1=1$

9) Demorgan's Thm

A	B	A+B	$\overline{A+B}$	$\bar{A}$	$\bar{B}$	$\bar{A}.\bar{B}$
0	0	0	**1**	1	1	**1**
0	1	1	**0**	1	0	**0**
1	0	1	**0**	0	1	**0**
1	1	1	**0**	0	0	**0**

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

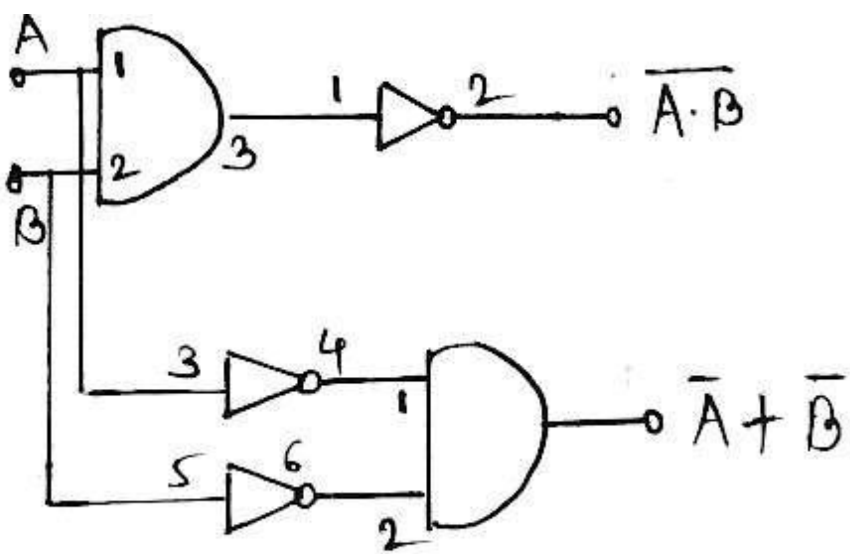
Complement of sum is equal to product of individual complements



A	B	A.B	$\overline{A.B}$	$\bar{A}$	$\bar{B}$	$\bar{A}+\bar{B}$
0	0	0	**1**	1	1	**1**
0	1	0	**1**	1	0	**1**
1	0	0	**1**	0	1	**1**
1	1	1	**0**	0	0	**0**

b) $\overline{A.B}$=A+B

Complement of product is equal to sum of individual complements



Standard Representation for Logical Functions:

1) Literal
2) Sum of Products (SOP)
3) Product of Sums (POS)
4) Standard (Canonical) SOP
5) Standard (Canonical) POS
6) Minterm
7) Maxterm

Literal

It is the variable. It may be in the complemented form or in uncompleted form

For Examples: A , B , $\overline{A}$, $\overline{B}$ etc

Sum of Products (SOP)

It is an OR (Sum) of AND (Product) terms.

For Example:

AB + BC+ AC

Product of Sum (POS)

It is an AND (Product) of OR (Sum) terms.

For Example:

$$(A+B).(B+C).(A+C)$$

Standard (Canonical) SOP

Conversion of SOP Form into Standard SOP Form

For Example:

AB + BC + AC

1. $A + 0 = A$	7. $A \cdot A = A$
2. $A + 1 = 1$	8. $A \cdot \overline{A} = 0$
3. $A \cdot 0 = 0$	9. $\overline{\overline{A}} = A$
4. $A \cdot 1 = A$	10. $A + AB = A$
5. $A + A = A$	11. $A + \overline{A}B = A + B$
6. $A + \overline{A} = 1$	12. $(A + B)(A + C) = A + BC$

A, B, or C can represent a single variable or a combination of variables.

Standard (Canonical) SOP

Conversion of SOP Form into Standard SOP Form

For Example:

$$AB + BC + AC$$
$$=AB(C+C')+BC(A+A')+AC(B+B')$$
$$=ABC+ABC'+ABC+A'BC+ABC+AB'C$$
$$=ABC+ABC'+A'BC+AB'C$$

Given,

$$\begin{aligned} F(A, B, C) &= A + B'C \\ &= A.(B + B')(C + C') + (B'C).(A + A') \\ &= A.(BC + BC' + B'C + B'C') + AB'C + A'B'C \\ &= ABC + ABC' + AB'C + AB'C' + AB'C + A'B'C \\ &= ABC + ABC' + AB'C + AB'C' + A'B'C \end{aligned}$$

SOP to Canonical SOP

$F = A\bar{C} + AB + BC$ $\qquad B + \bar{B} = 1$

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

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

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

Standard (Canonical) POS

Conversion of POS Form into Standard POS Form.

For Example 1:

$$(A+B).(B+C).(A+C)$$
$$=(A+B+CC').(AA'+B+C).(A+C+BB')$$
$$=(A+B+C).(A+B+C').(A+B+C).(A'+B+C).(A+C+B).(A+C+B')$$
$$=(A+B+C).(A+B+C').(A'+B+C).(A+C+B')$$

For Example 2:

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

Minterm

Each individual term in Standard SOP form is called as Minterm.

It is denoted by m or Σ

In case of Minterms, Complemented variable can be treated as 0's & Uncomplemented variable can be treated as 1's.

Maxterm

Each individual term in Standard POS form is called as Maxterm.

It is denoted by M or Π

In case of Maxterms, Complemented variable can be treated as 1's & Uncomplemented variable can be treated as 0's.

Minterms and Maxtems for Three Variables

Row No.	A B C	Minterms	Maxterms
0	0 0 0	$A'B'C' = m_0$	$A + B + C = M_0$
1	0 0 1	$A'B'C = m_1$	$A + B + C' = M_1$
2	0 1 0	$A'BC' = m_2$	$A + B' + C = M_2$
3	0 1 1	$A'BC = m_3$	$A + B' + C' = M_3$
4	1 0 0	$AB'C' = m_4$	$A' + B + C = M_4$
5	1 0 1	$AB'C = m_5$	$A' + B + C' = M_5$
6	1 1 0	$ABC' = m_6$	$A' + B' + C = M_6$
7	1 1 1	$ABC = m_7$	$A' + B' + C' = M_7$

Simplification of Logical Expression

- Algebraic Simplification.
  - Simplify symbolically using theorems/postulates.
- Karnaugh Maps.
  - Diagrammatic technique using 'Venn-like diagram'.

Karnaugh Map (K-Map)

- We have simplified the Boolean functions using Boolean postulates and theorems. It is a time consuming process and we have to re-write the simplified expressions after each step.

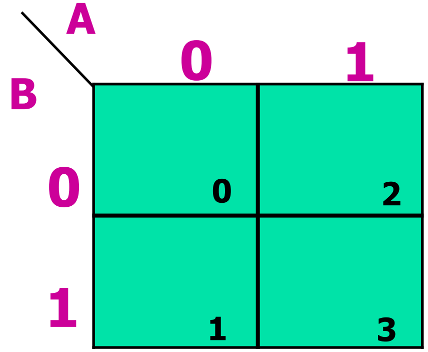
- To overcome this difficulty, Karnaugh introduced a method for simplification of Boolean functions in an easy way. This method is known as Karnaugh map method or K-map method.

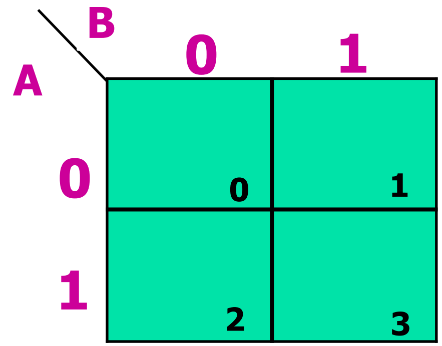
It is a graphical method, which consists of 2n cells for 'n' variables. The adjacent cells are differed only in single bit position.

Karnaugh Map (K-Map)

- K-Map for 2 Variable
- K-Map for 3 Variable
- K-Map for 4 Variable
- K-Map for 5 Variable
- K-Map for 6Variable

K-Map for 2 Variable





K-Map for 3 Variable

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

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

K-Map for 4 Variable

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

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

Binary to Gray Code Conversion

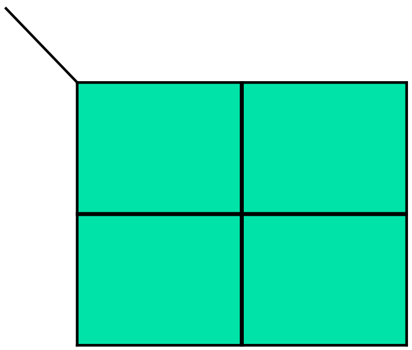
Dec No.	B_0	B_1	B_2	B_3	G_0	G_1	G_2	G_3	Dec No.
0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1	1
2	0	0	1	0	0	0	1	1	3
3	0	0	1	1	0	0	1	0	2
4	0	1	0	0	0	1	1	0	6
5	0	1	0	1	0	1	1	1	7
6	0	1	1	0	0	1	0	1	5
7	0	1	1	1	0	1	0	0	4
8	1	0	0	0	1	1	0	0	12
9	1	0	0	1	1	1	0	1	13
10	1	0	1	0	1	1	1	1	15
11	1	0	1	1	1	1	1	0	14
12	1	1	0	0	1	0	1	0	10
13	1	1	0	1	1	0	1	1	11
14	1	1	1	0	1	0	0	1	9
15	1	1	1	1	1	0	0	0	8

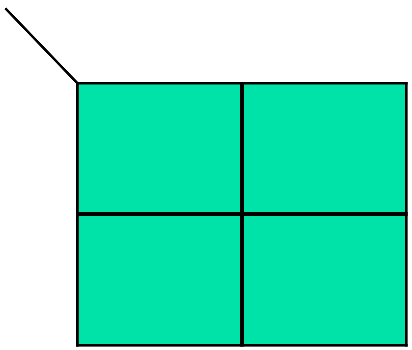
Binary Code 1 0 0 1

↓ ↓ ↓ ↓

Gray Code 1 1 0 1

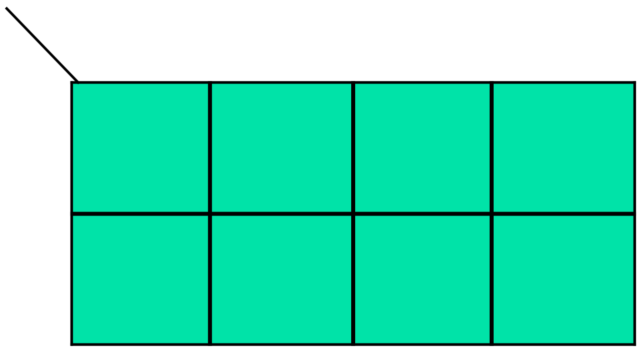
Grouping in 2 Variable K-map

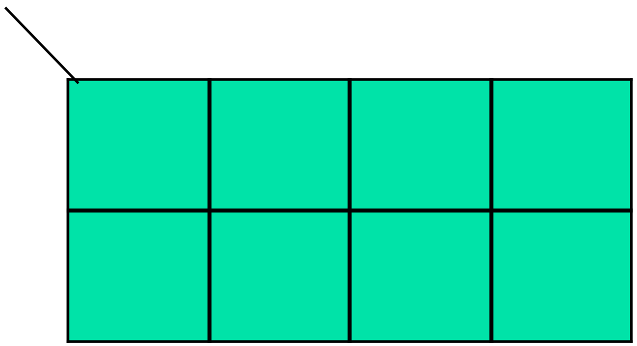




- **Quad**
- **Pair**
- **Pair with Fold back**
- **Single**

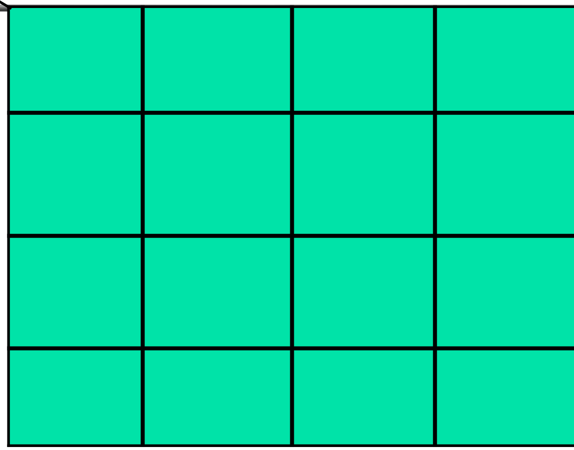
Grouping in 3 Variable K-map

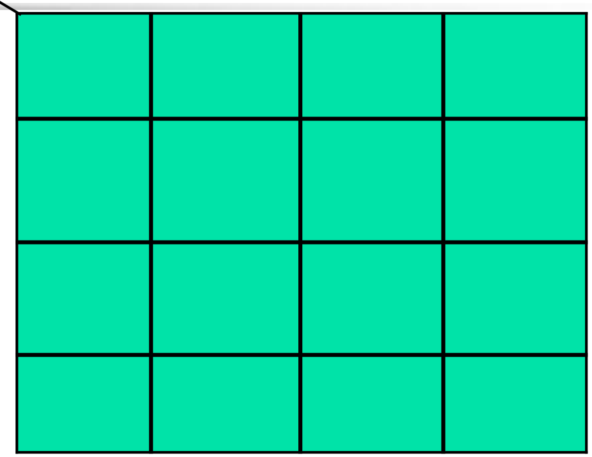




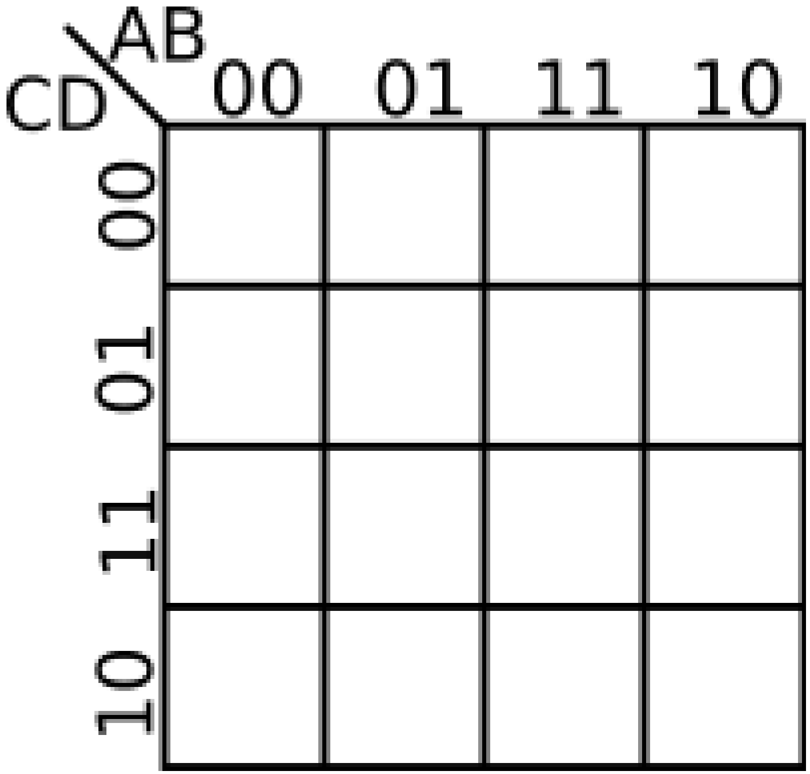
- Octet
- Quad
- Quad with Fold back
- Pair
- Pair with Fold back
- Single

Grouping in 4 Variable K-map





- Hexa
- Octet
- Octet with Fold back
- Quad
- Quad with Fold back
- Pair
- Pair with Fold back
- Single

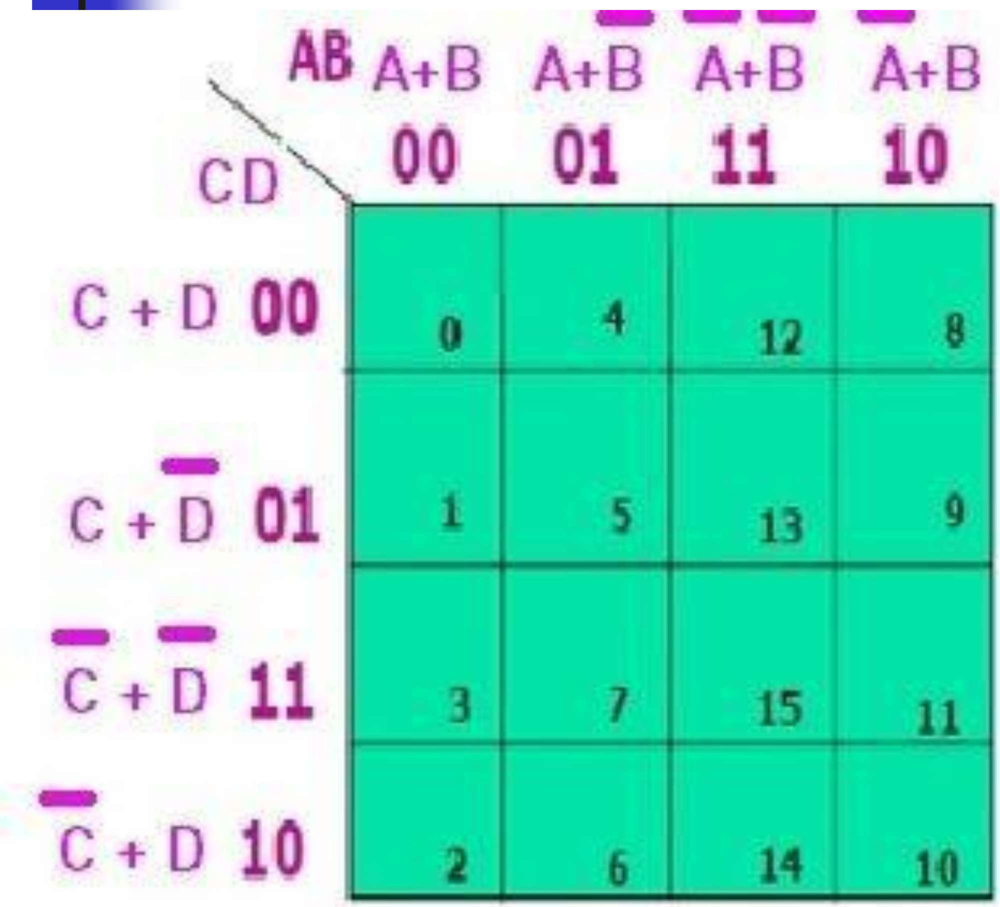

AB
CD
00
01
11
10
00
01
11
10

CD \ AB	$\overline{A}\,\overline{B}$ 00	$\overline{A}B$ 01	AB 11	$A\overline{B}$ 10
$\overline{C}\,\overline{D}$ 00	0	4	12	8
$\overline{C}D$ 01	1	5	13	9
CD 11	3	7	15	11
$C\overline{D}$ 10	2	6	14	10

SOP

A=1

A′=0



AB
CD
A+B A+B A+B A+B
00 01 11 10
C + D 00
C + D 01
C + D 11
C + D 10
0 4 12 8
1 5 13 9
3 7 15 11
2 6 14 10

<u>POS</u>

A=0

A′=1

K-map for 5 Variable

$A = 0$

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

$A = 1$

DE \ BC	00	01	11	10
00	16	20	28	24
01	17	21	29	25
11	19	23	31	27
10	18	22	30	26

Fig. 5.38 ***A Five-variable K-map***

K-map for 5 Variable

$\overline{A}$

DE \ BC		$\overline{B}\,\overline{C}$ 00	$\overline{B}C$ 01	BC 11	$B\overline{C}$ 10
$\overline{D}\,\overline{E}$	00	0	4	12	8
$\overline{D}E$	01	1	5	13	9
DE	11	3	7	15	11
$D\overline{E}$	10	2	6	14	10

A

DE \ BC		$\overline{B}\,\overline{C}$ 00	$\overline{B}C$ 01	BC 11	$B\overline{C}$ 10
$\overline{D}\,\overline{E}$	00	16	20	28	24
$\overline{D}E$	01	17	21	29	25
DE	11	19	23	31	27
$D\overline{E}$	10	18	22	30	26

K-map for 6 Variable

A = 0, B = 0

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

A = 1, B = 0

EF \ CD	00	01	11	10
00	32	36	44	40
01	33	37	45	41
11	35	39	47	43
10	34	38	46	42

A = 0, B = 1

EF \ CD	00	01	11	10
00	16	20	28	24
01	17	21	29	25
11	19	23	31	27
10	18	22	30	26

A = 1, B = 1

EF \ CD	00	01	11	10
00	48	52	60	56
01	49	53	61	57
11	51	55	63	59
10	50	54	62	58

Fig. 5.39 ***A Six-variable K-map***

K-map for 6 Variable

A' (A = 0), B' (B = 0):

EF \ CD	C'D' 00	C'D 01	CD 11	CD' 10
E'F' 00	0	4	12	8
E'F 01	1	5	13	9
EF 11	3	7	15	11
EF' 10	2	6	14	10

A (A = 1), B' (B = 0):

EF \ CD	C'D' 00	C'D 01	CD 11	CD' 10
00	32	36	44	40
01	33	37	45	41
11	35	39	47	43
10	34	38	46	42

A' (A = 0), B (B = 1):

EF \ CD	C'D' 00	C'D 01	CD 11	CD' 10
E'F' 00	16	20	28	24
E'F 01	17	21	29	25
EF 11	19	23	31	27
EF' 10	18	22	30	26

A (A = 1), B (B = 1):

EF \ CD	C'D' 00	C'D 01	CD 11	CD 10
00	48	52	60	56
01	49	53	61	57
11	51	55	63	59
10	50	54	62	58

A Six-variable K-map

Q. Minimize the function $F(A,B,C) = \Sigma m(0,1,5,6,7)$

$A \backslash BC$	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	1 (0)	1 (1)	(3)	(2)
A 1	(4)	1 (5)	1 (7)	1 (6)

8, 4, 2, 1

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

② $(\bar{B}C)(\cancel{\bar{A} + A})$ — $\bar{B}C$

③ $(BC + B\bar{C})(A) = (AB)$

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

$F(A,B,C) = ① + ② + ③$

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

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

$f(P,Q,R,S) = (0,2,5,7,8,10,13,15)$

Q. $f(A,B,C) = \Sigma m(1,3,6,7)$

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

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

$f(P,Q,R,S) = (0,2,5,7,8,10,13,15)$

PQ \ RS	00	01	11	10
00	1 (0)	(1)	(3)	1 (2)
01	(4)	1 (5)	1 (7)	(6)
11	(12)	1 (13)	1 (15)	(14)
10	1 (8)	(9)	(11)	1 (10)

$(\bar{R}\bar{S} + R\bar{S})$
$(\bar{P}\bar{Q} + P\bar{Q})$

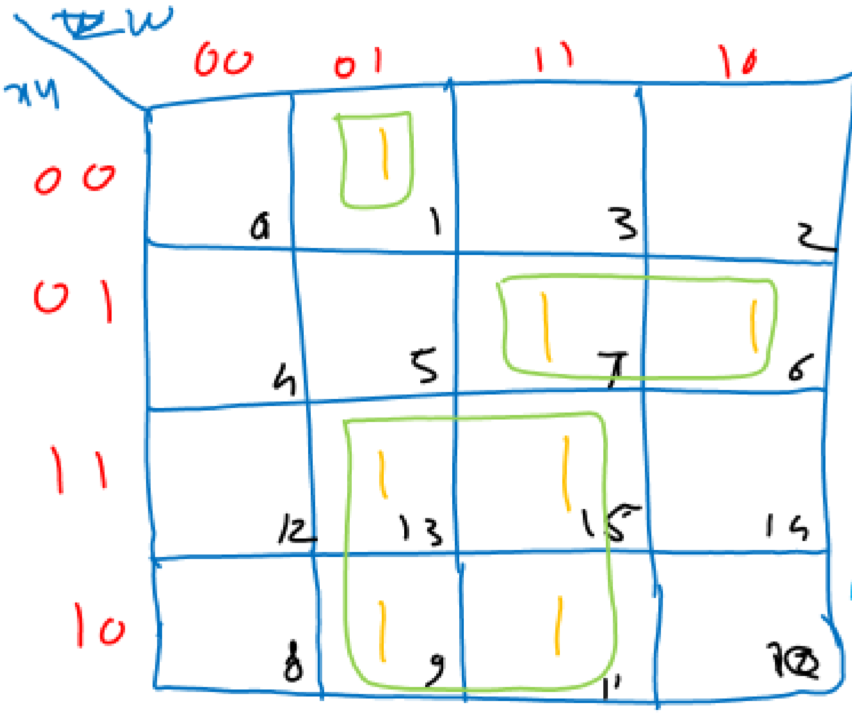
② $= \bar{S}\bar{Q}$

$(\bar{R}S + RS)(\bar{P}Q + PQ)$

① $= (SQ)$

$\therefore f(P,Q,R,S)$
$= QS + \bar{Q}\bar{S}$

Q. $F(x,y,z,w) = \Sigma m(1,6,7,9,11,13,15)$



group ① :- $\cancel{\bar{z}}w + \cancel{z}w \cdot xy + x\cancel{\bar{y}}$

wx

group ② :- $z\cancel{w} + z\cancel{\bar{w}} + \bar{x}y$

$z\bar{x}y$

group ③ :- $(\bar{z}w)(\bar{x}\bar{y})$

$\boxed{\text{Ans: } wx + z\bar{x}y + \bar{z}w\bar{x}\bar{y}}$

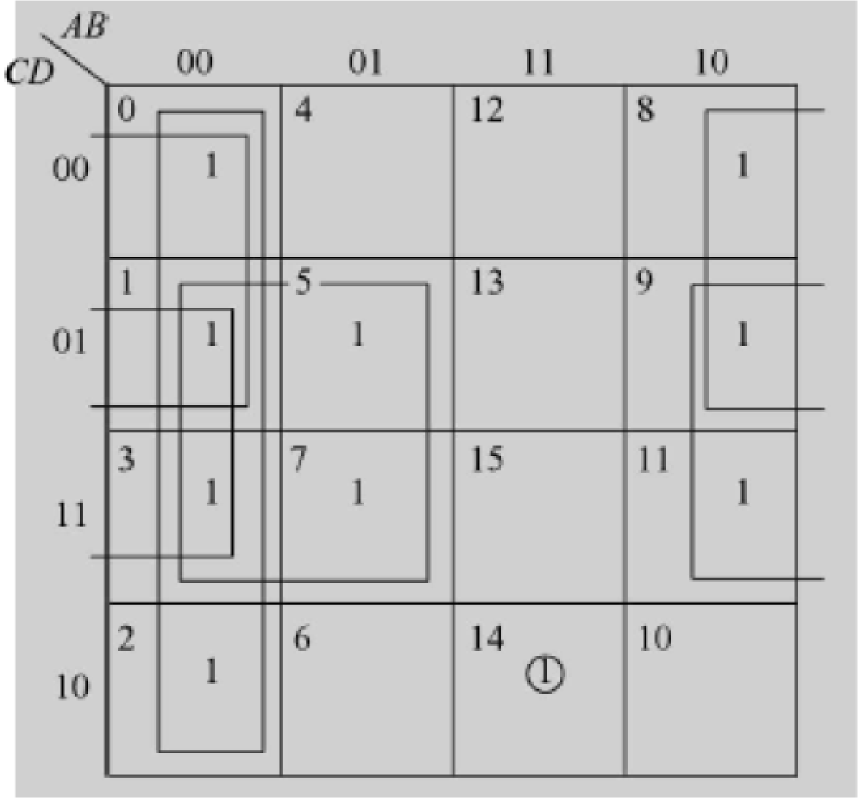
$$f = \Sigma(0, 1, 6, 7)$$

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

Minimise the four-variable logic function using K-map.

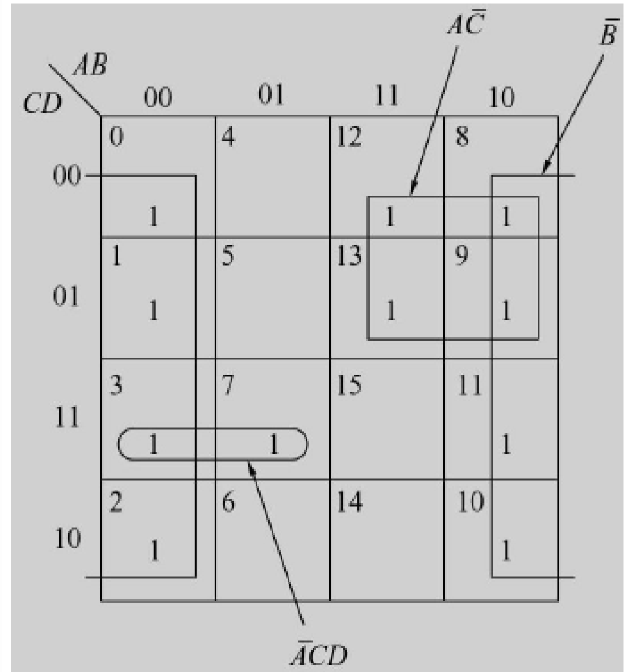
$$f(A, B, C, D) = \Sigma m(0, 1, 2, 3, 5, 7, 8, 9, 11, 14)$$

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



Determine the minimised expression in SOP form for the truth table given in Table 5.8.

Inputs				Output
A	*B*	*C*	*D*	*Y*
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0



$$Y = \bar{B} + A\bar{C} + \bar{A}CD$$

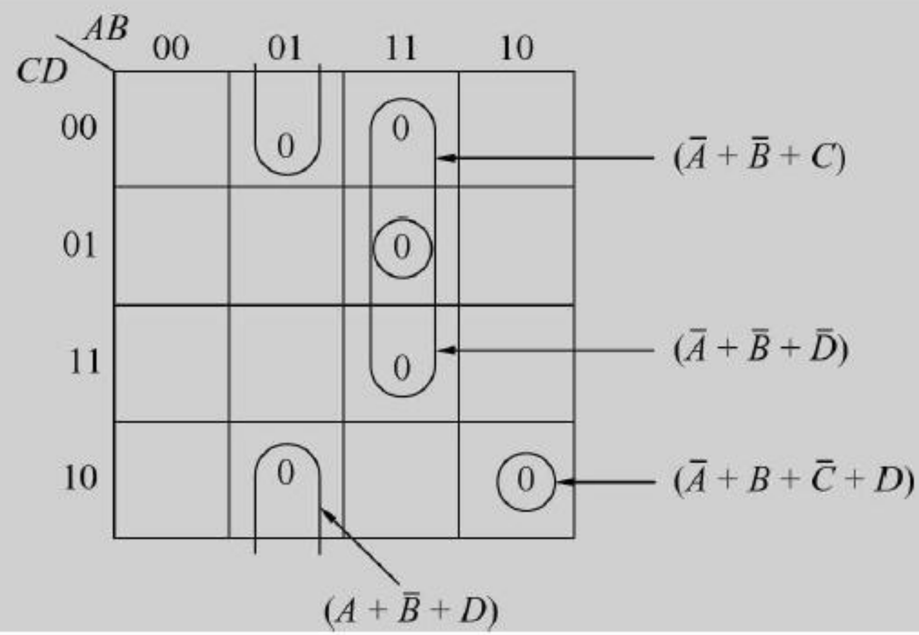
Minimise the logic function of Eq. (5.23) in POS form

$$f(A, B, C, D) = \Sigma m(0, 1, 2, 3, 5, 7, 8, 9, 11, 14) \tag{5.23}$$

Solution

Equation (5.23) can be expressed in canonical POS form as

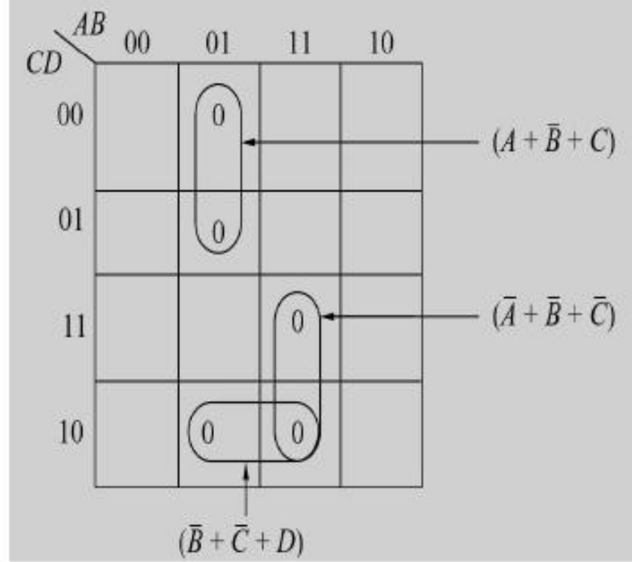
$$f(A, B, C, D) = \Pi M(4, 6, 10, 12, 13, 15)$$



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

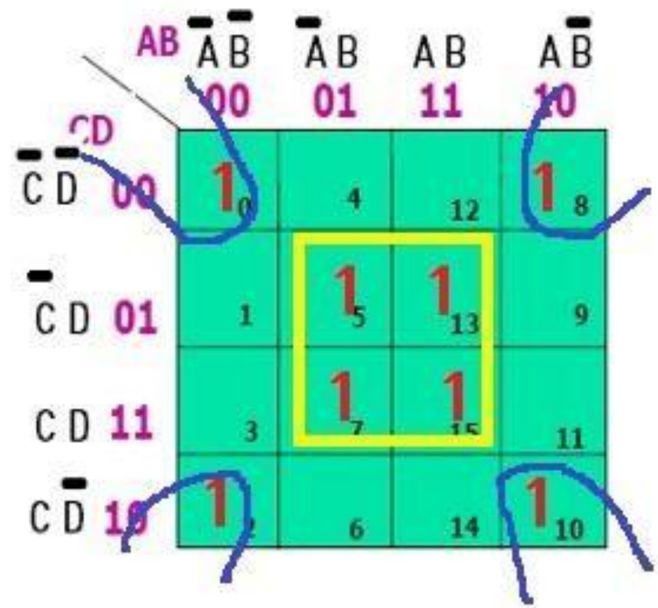
Minimise the truth table given in Table 5.8 using maxterms.

Inputs				Output
A	*B*	*C*	*D*	*Y*
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0



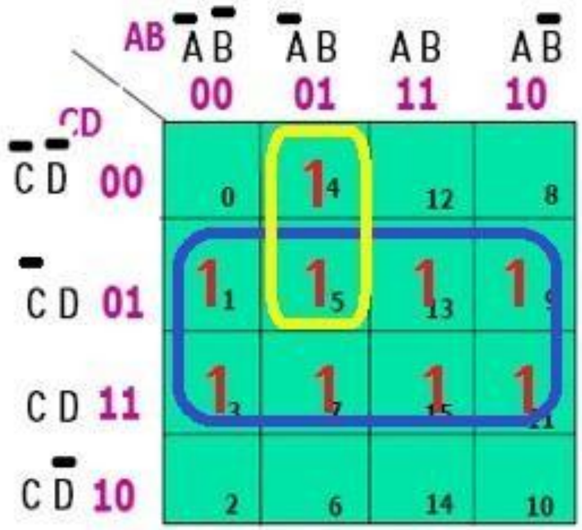
$$Y = (A+\bar{B}+C)(\bar{A}+\bar{B}+\bar{C})(\bar{B}+\bar{C}+D)$$

Solve using KMAP F= m (0,2,5,7,8,10,13,15)



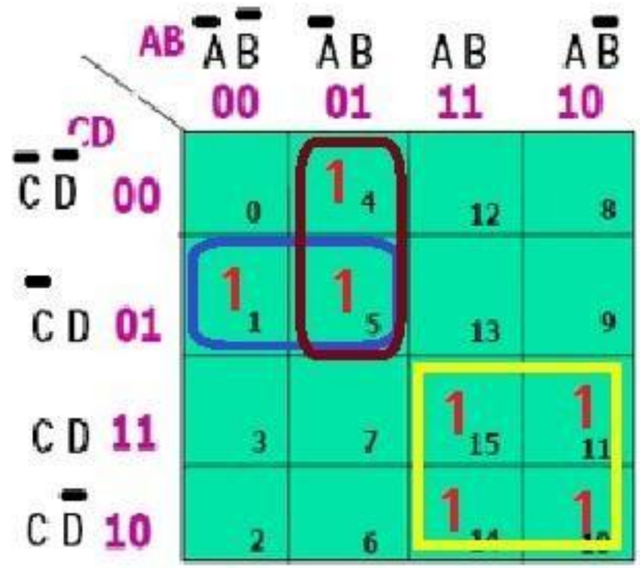
$F = B\,D + B'\,D'$

Solve using KMAP F= m (1,3,4,5,7,9,11,13,15,)



$$\boxed{F = D + A'BC'}$$

Solve using KMAP F= m(1,4,5,10,11,14,15)



$$F = AC + A'C'D + A'BC'$$

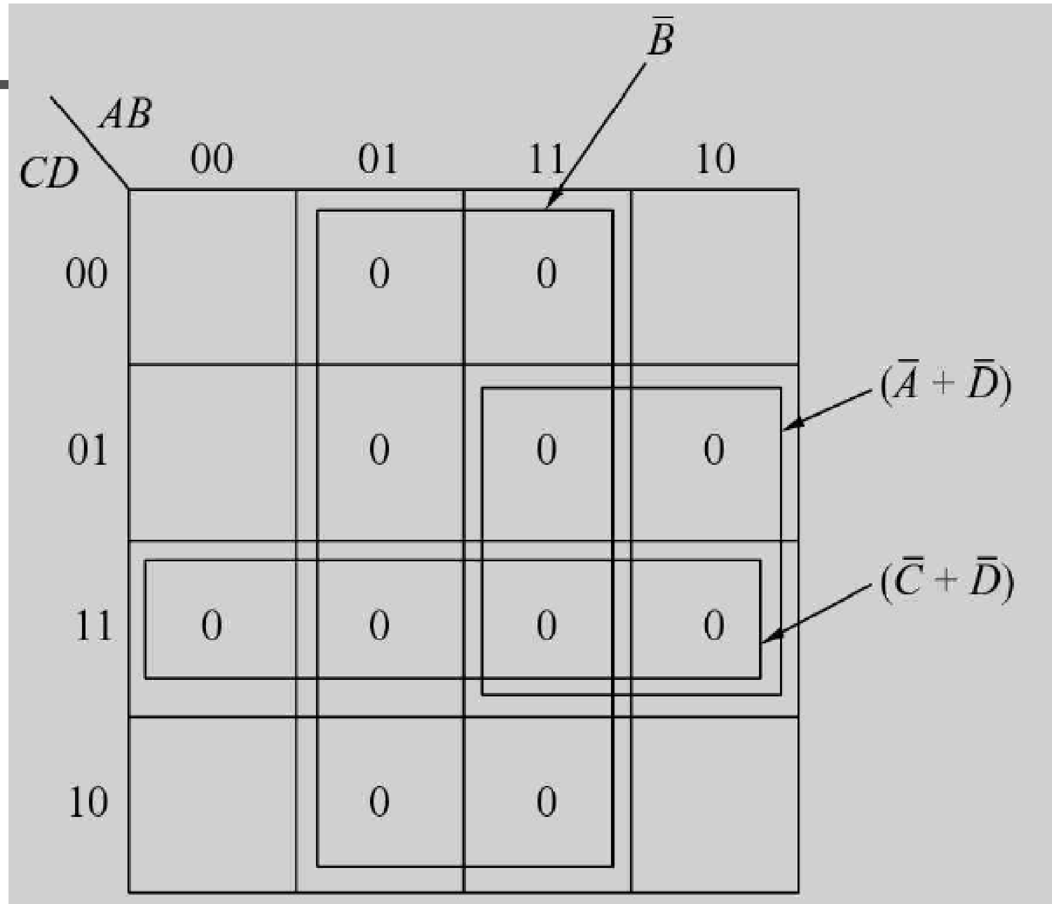
Minimise the four variable logic function

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

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

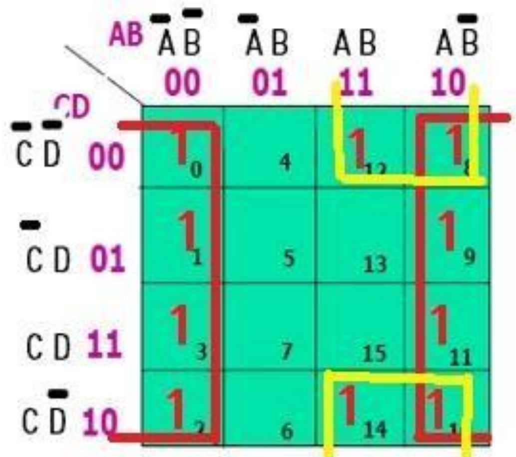
Minimise the four variable logic function

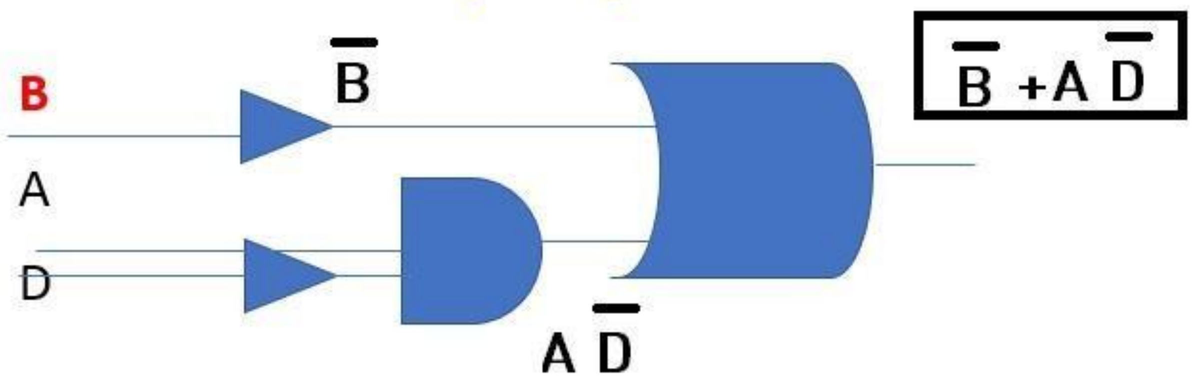
$$f(A, B, C, D) = (A + B + \bar{C} + \bar{D}) \cdot (\bar{A} + C + \bar{D}) \cdot (\bar{A} + B + \bar{C} + \bar{D}) \cdot (\bar{B} + C) \cdot (\bar{B} + \bar{C}) \cdot (A + \bar{B}) \cdot (\bar{B} + \bar{D})$$



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

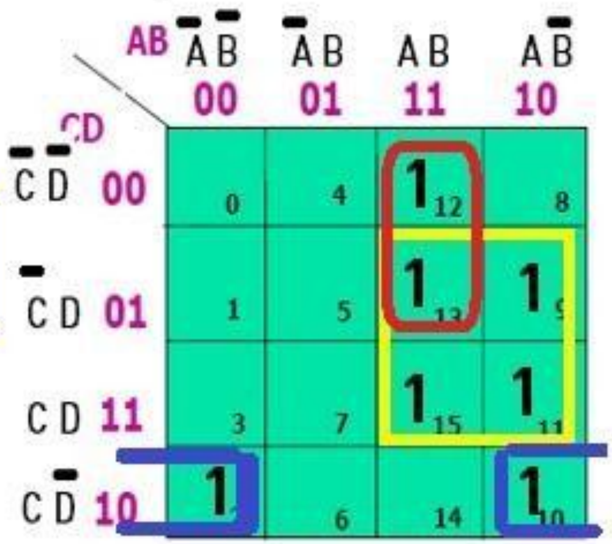
solve using kmap $F = A B C \overline{D} + \overline{B}\,\overline{C} + \overline{B} D + A B \overline{C}\,\overline{D} + \overline{B} C$



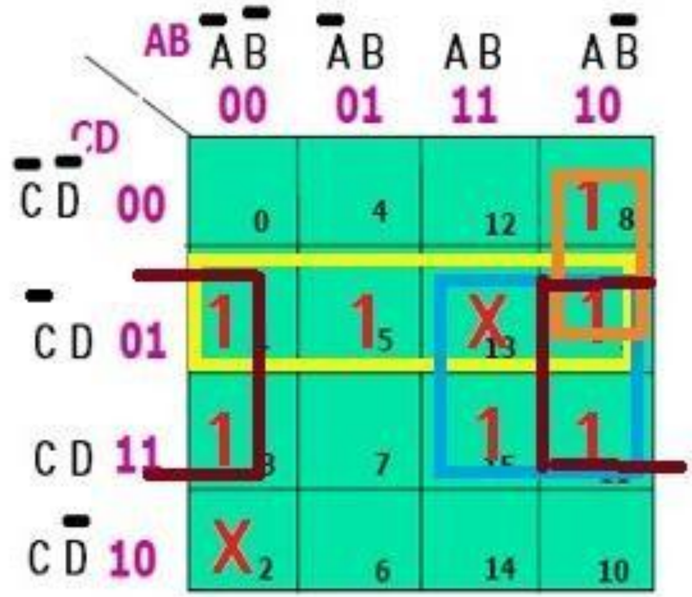


Solve using kmap $Y = A B \overline{C} + A \overline{B} C D + A D + \overline{B} C \overline{D}$

$$\boxed{A D + A B \overline{C} + \overline{B} C \overline{D}}$$

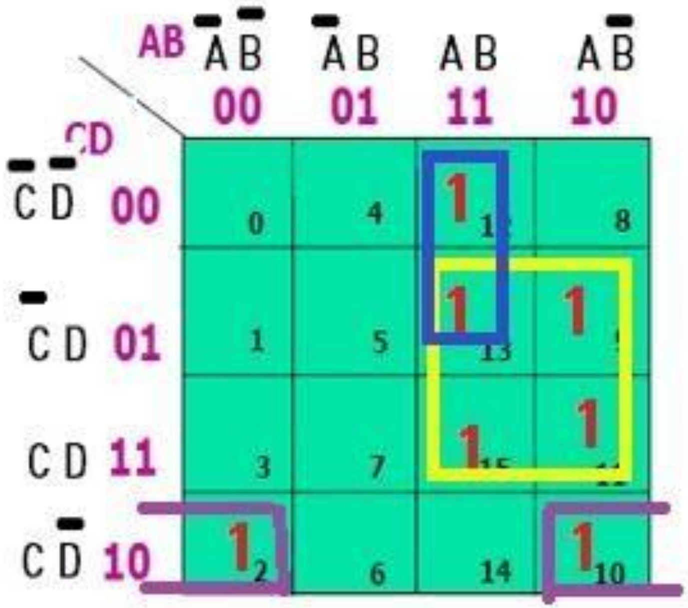


Solve using KMAP F= m[1,3,5,8,9,11,15]. d[2,13]



F= C'D + AD + B'D + AB'C'

Solve using kmap $Y = AB\overline{C} + A\overline{B}CD + AD + \overline{B}C\overline{D}$

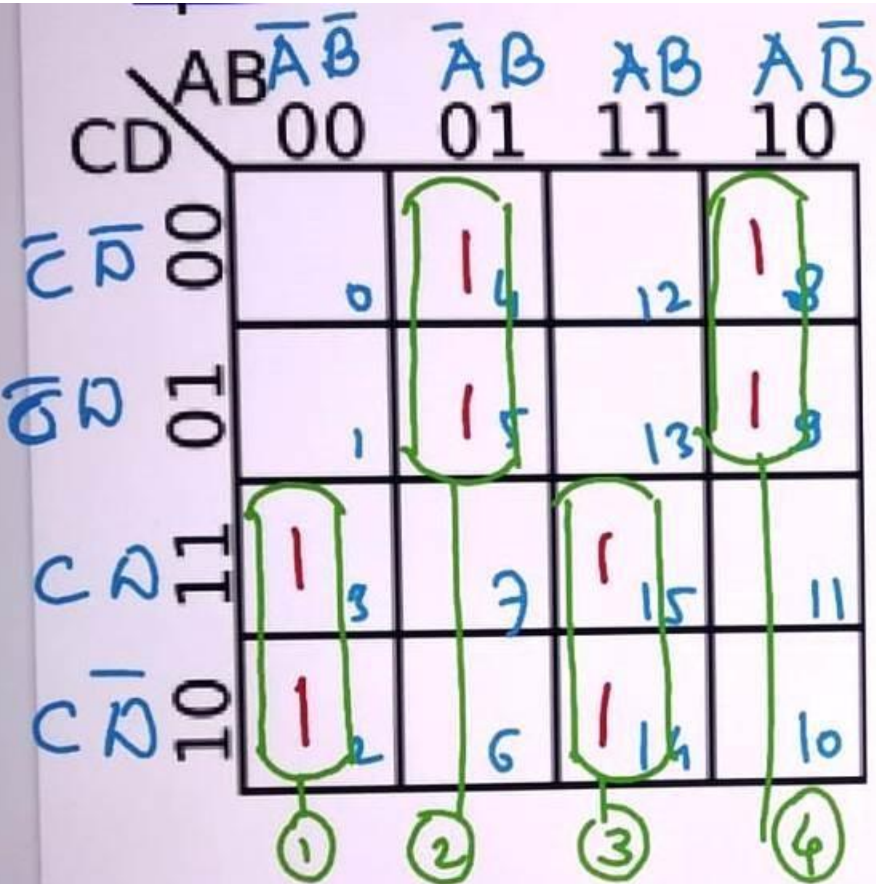


$$\boxed{F = AD + ABC' + B'CD'}$$

$CD \backslash AB$	$\bar{A}\bar{B}$ 00	$\bar{A}B$ 01	AB 11	$A\bar{B}$ 10
$\bar{C}\bar{D}$ 00	0	4	1 12	1 8
$\bar{C}D$ 01	1	5	1 13	1 9
CD 11	3	7	1 15	1 11
$C\bar{D}$ 10	2	6	1 14	1 10

$$F = \Sigma(8, 9, 10, 11, 12, 13, 14, 15)$$

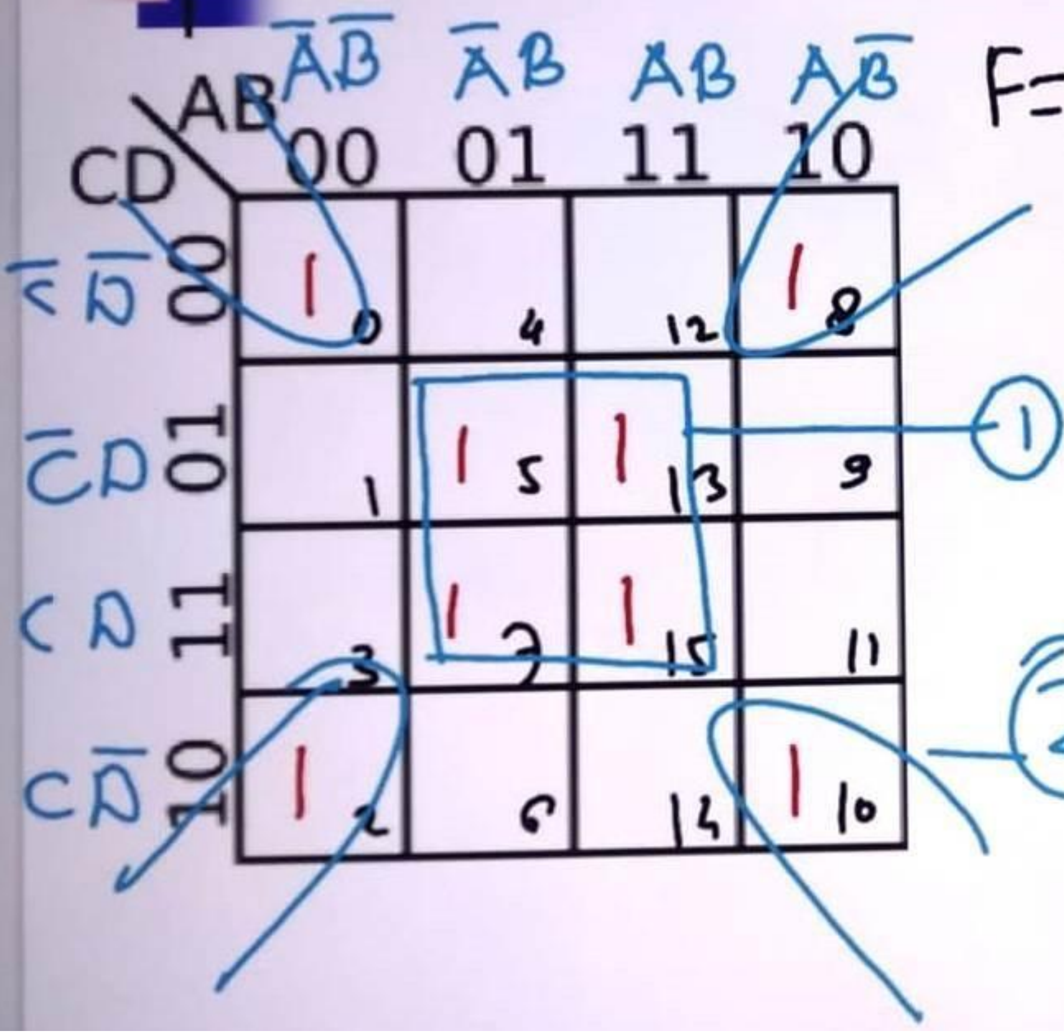
$$\boxed{F = A}$$



$F = \sum m(2,3,4,5,8,9,14,15)$

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

$\boxed{F = A \oplus B \oplus C}$



$F = \Sigma(0,2,8,10,5,7,13,15)$

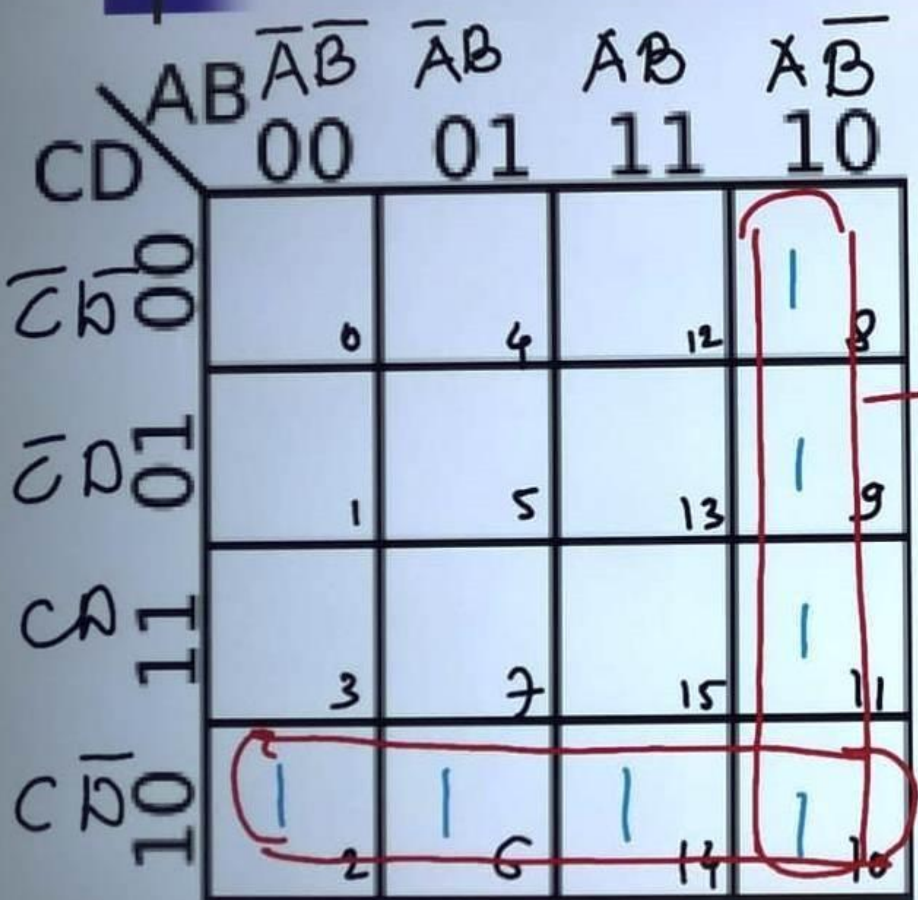
$$\boxed{F = BD + \bar{B}\bar{D}}$$

1 BD

2 $\bar{B}\bar{D}$

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

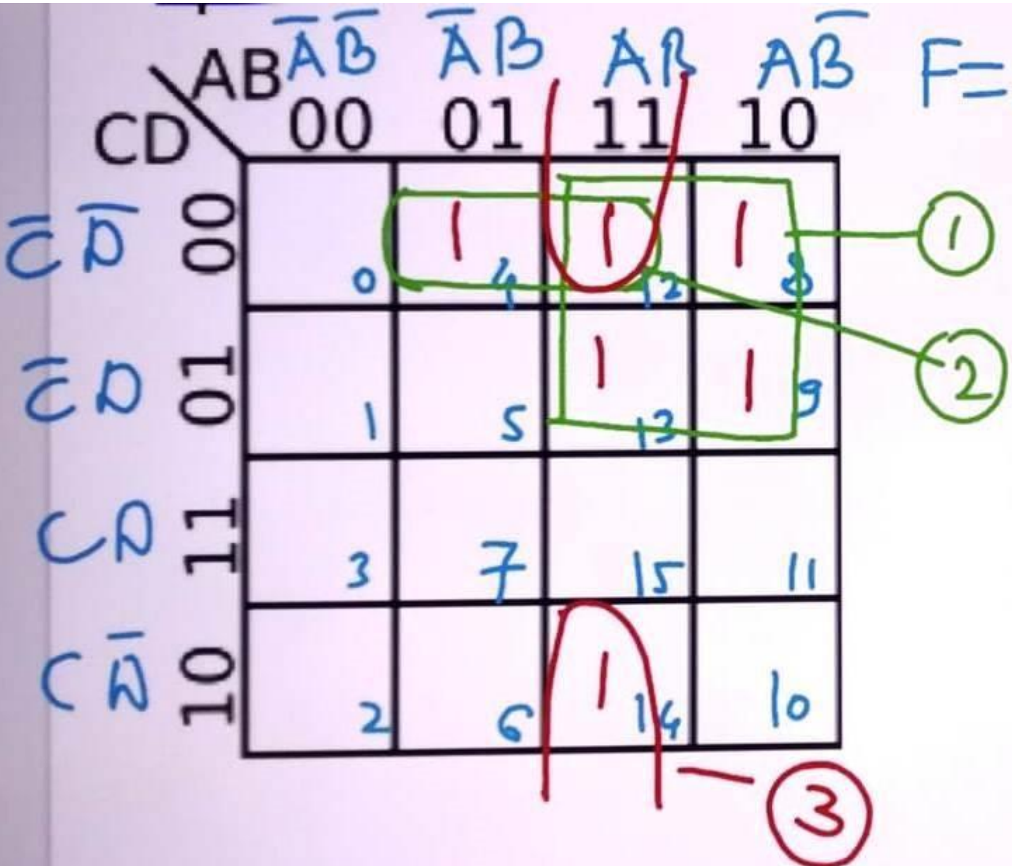
$$\boxed{F = A\bar{B} + C\bar{D}}$$



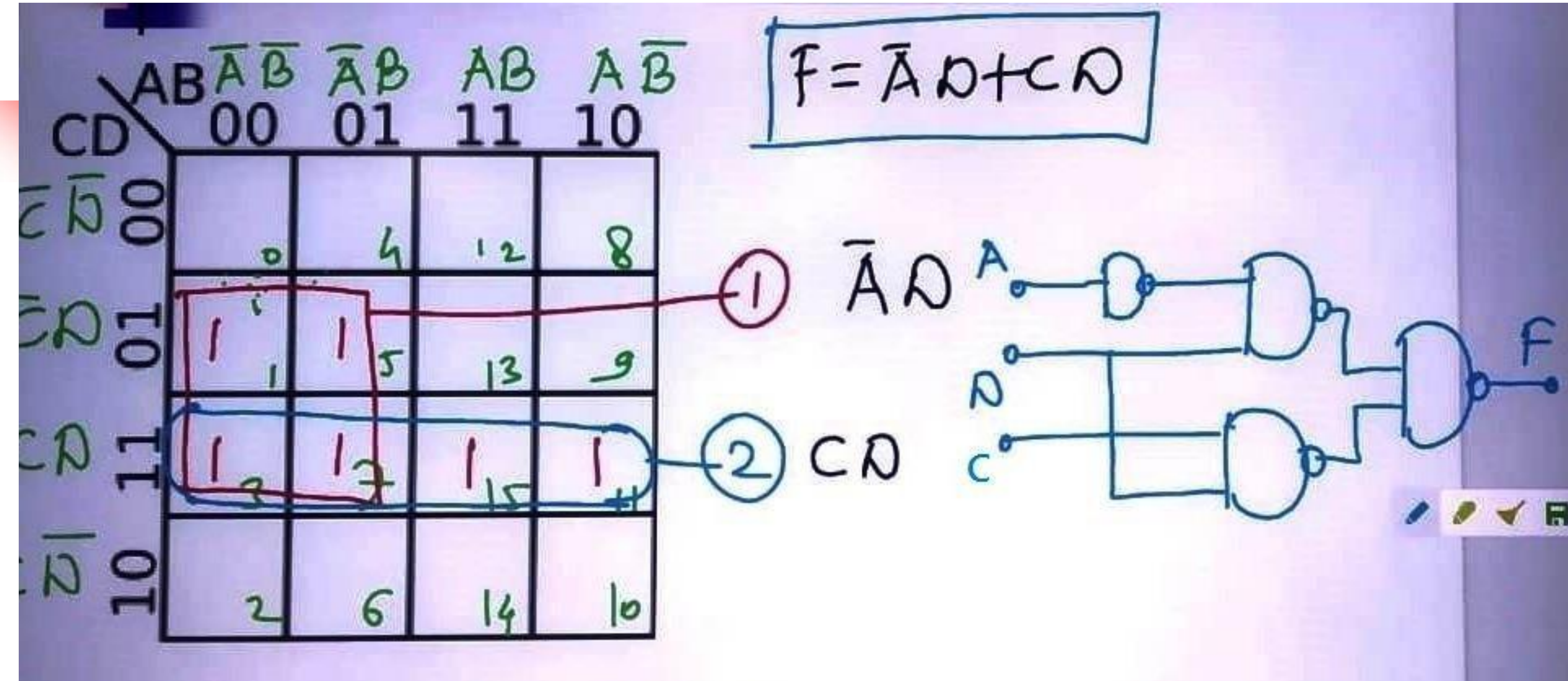
① $A\bar{B}$

② $C\bar{D}$

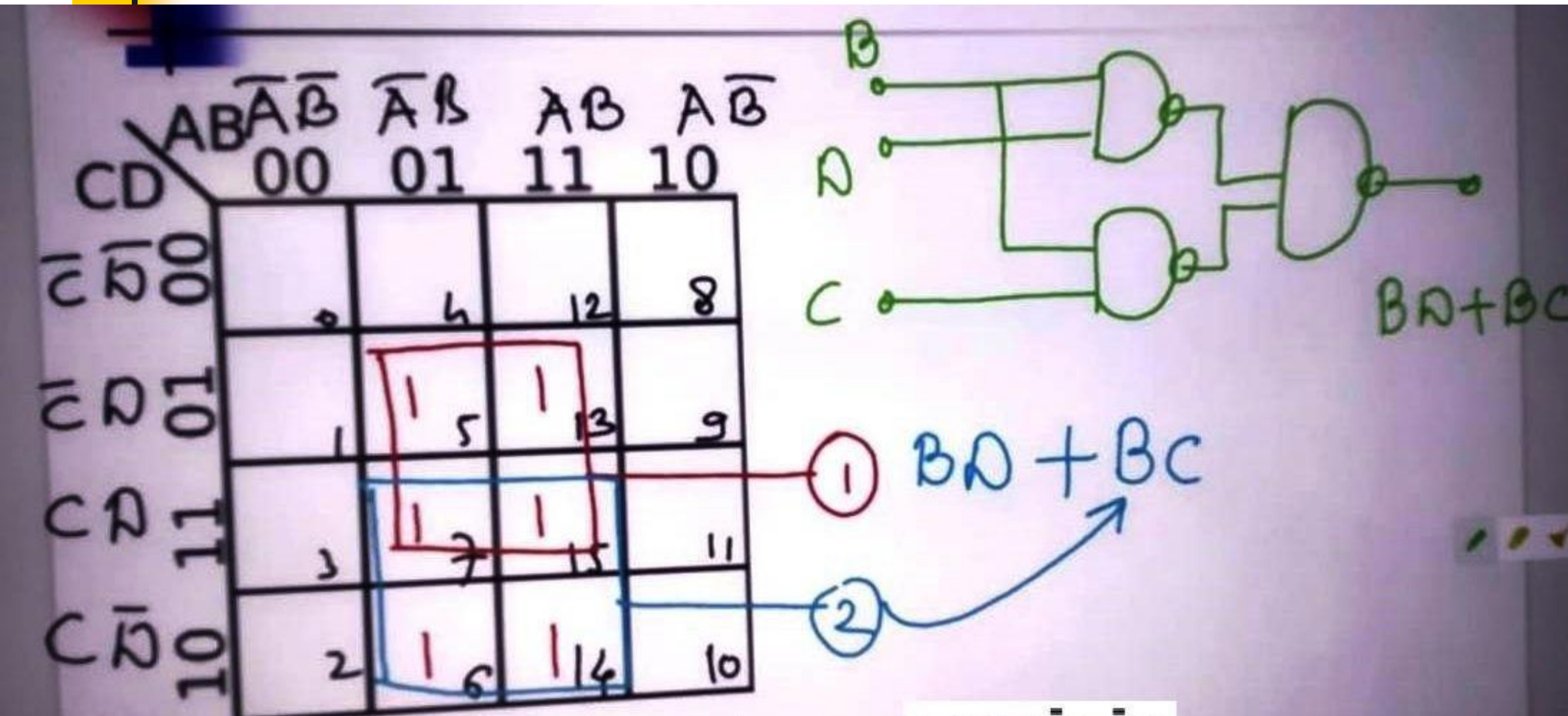
$F = \sum m(4, 8, 9, 12, 13, 14)$



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

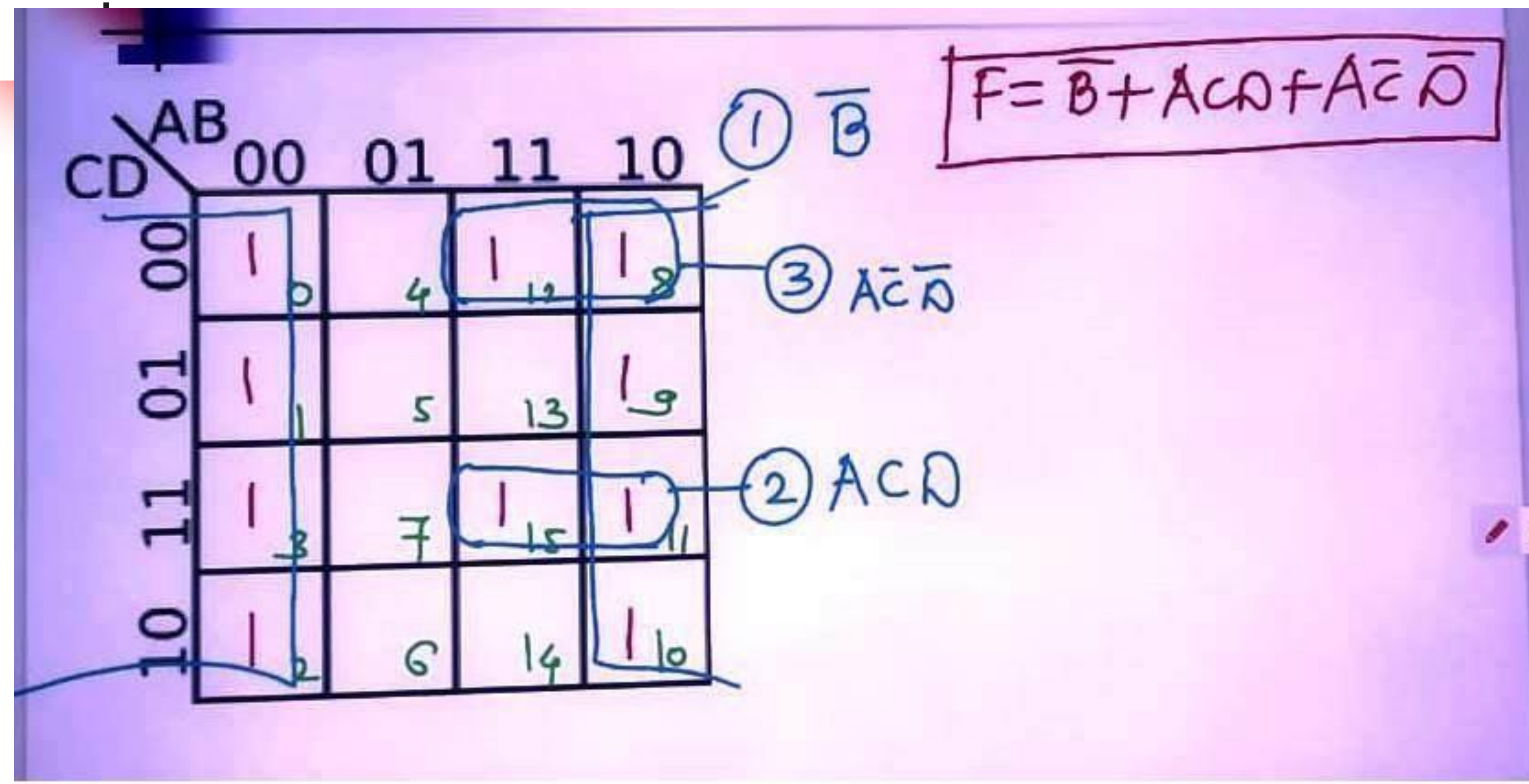


Solve using Kmap F = m(1,3,5,7,11,15)

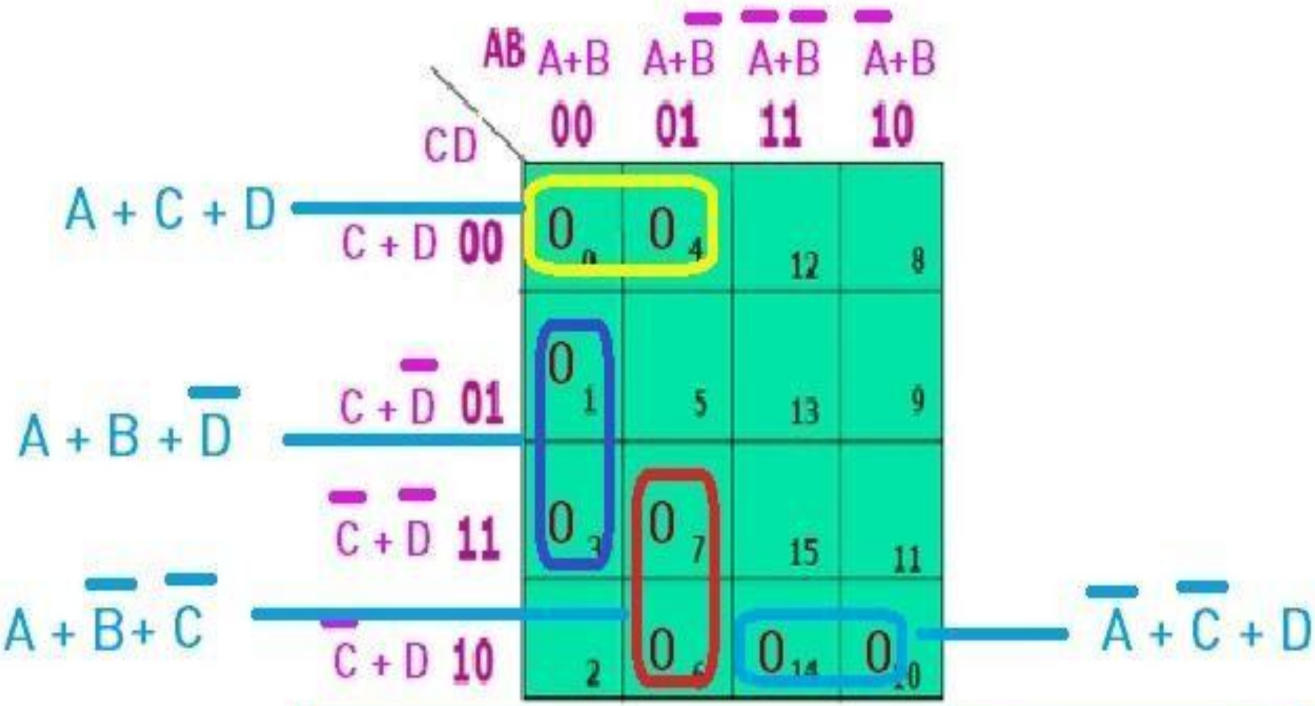


For given logic equation $F = ABC + B\bar{C}D + \bar{A}BC$

For given equation $F = ABC\bar{D} + \bar{B}\bar{C} + \bar{B}D + AB\bar{C}\bar{D} + \bar{B}C$ simplify using Kmap

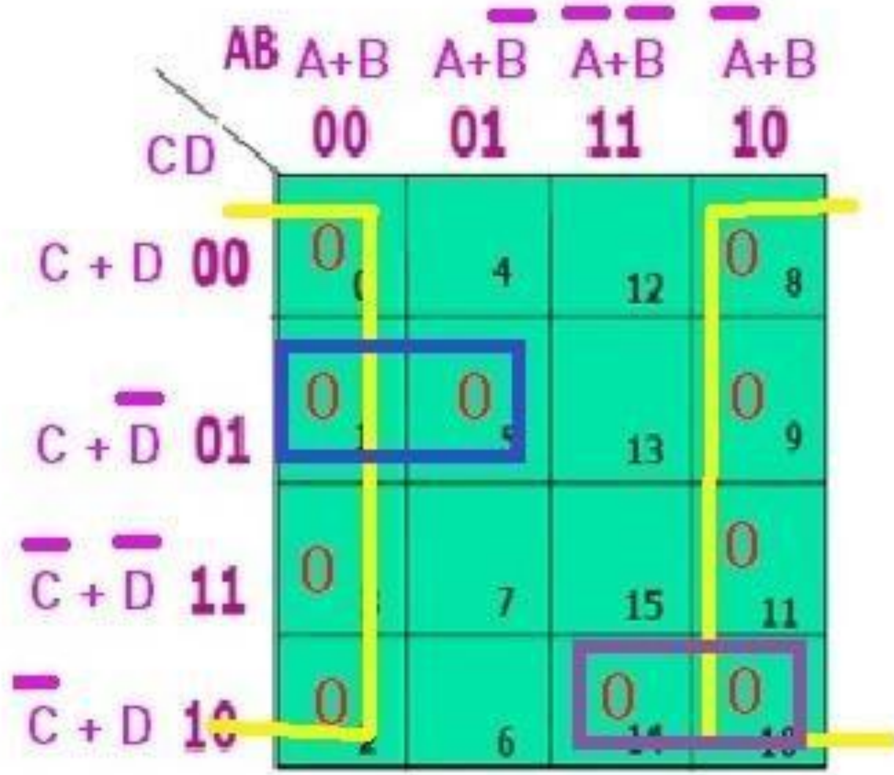


solve using kmap F = M (0,1,3,4,6,7,10,14)



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

solve using kmap F = M (0,1,2,3,5,8,9,10,11,14)



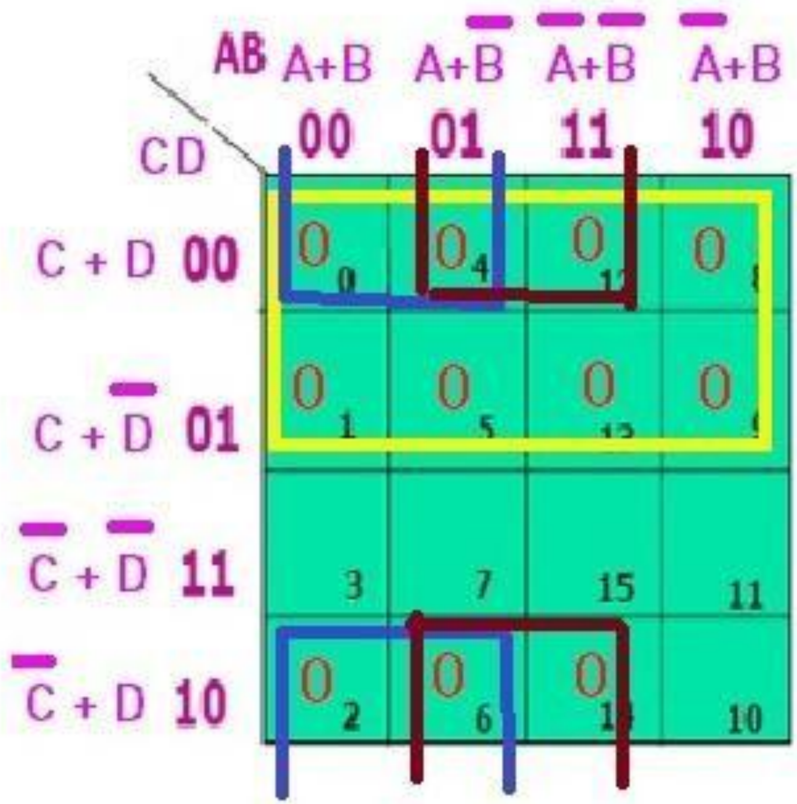
POS

A=0

A′=1

F= (B) (A+C+D')(A'+C'+D)

solve using kmap F = M (0,1,2,4,5,6,8,9,12,13,14)



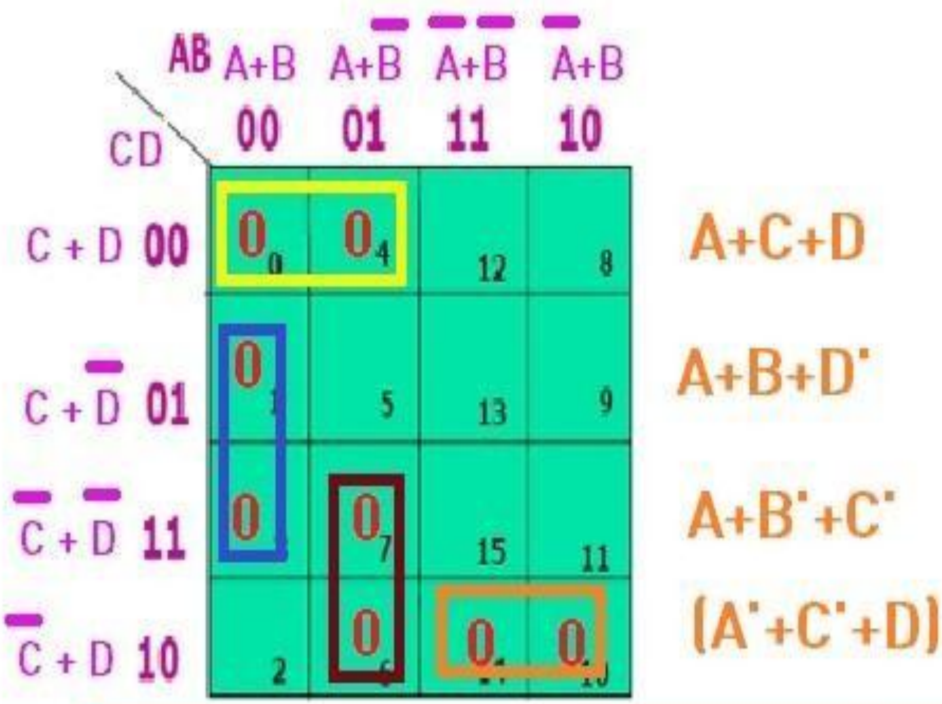
POS

A=0

A′=1

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

solve using kmap F = M (0,1,3,4,6,7,10,14)

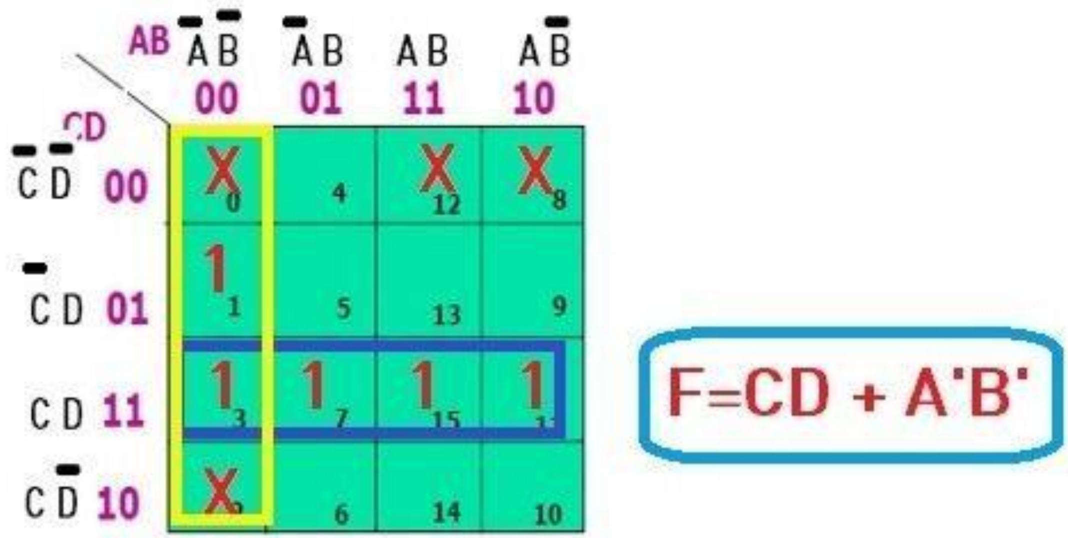


F=(A+C+D)(A+B+D')(A+B'+C')(A'+C'+D)

Don't Care condition in KMAP :

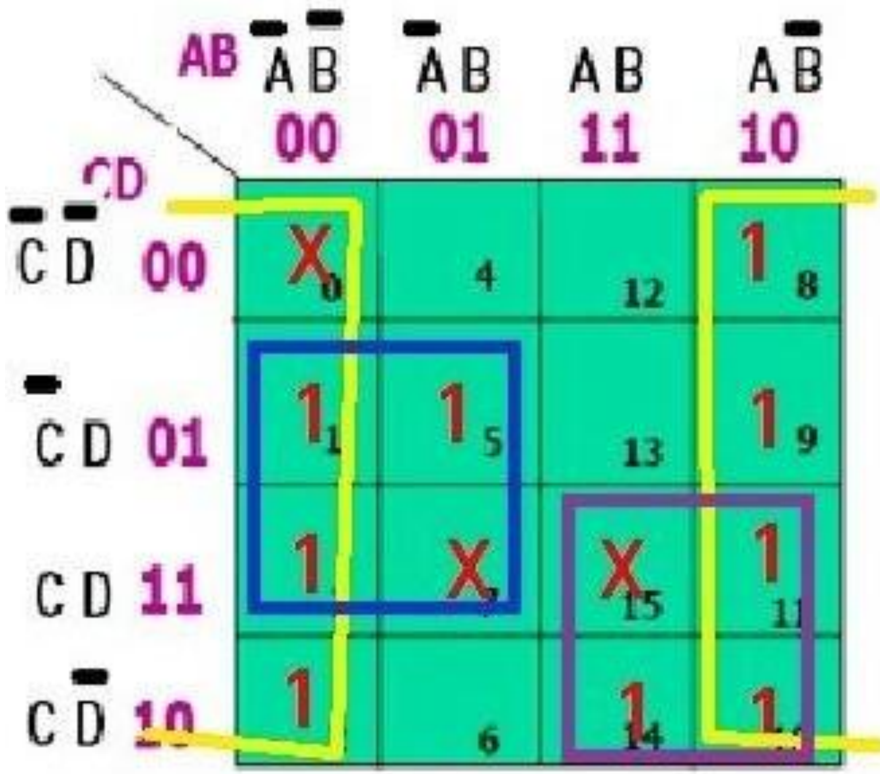
1. It is represented by symbol 'X' in kmap
2. It has the value either 0 or 1. We may have to assume the value of it either 0 or 1 as per our convenience

$$F = m(1,3,7,11,15).\ d(0,2,8,12)$$

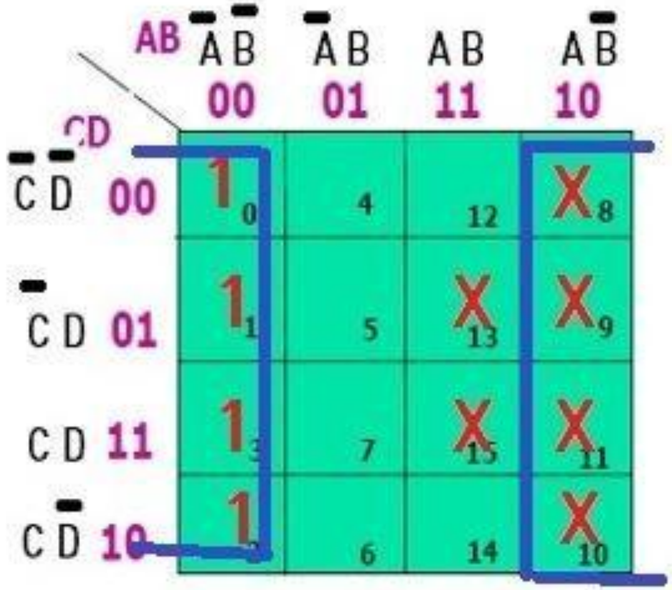


Solve the following using KMAP

F = m(1, 2,3,5,8,9,10,11,14). d(0,7,15)

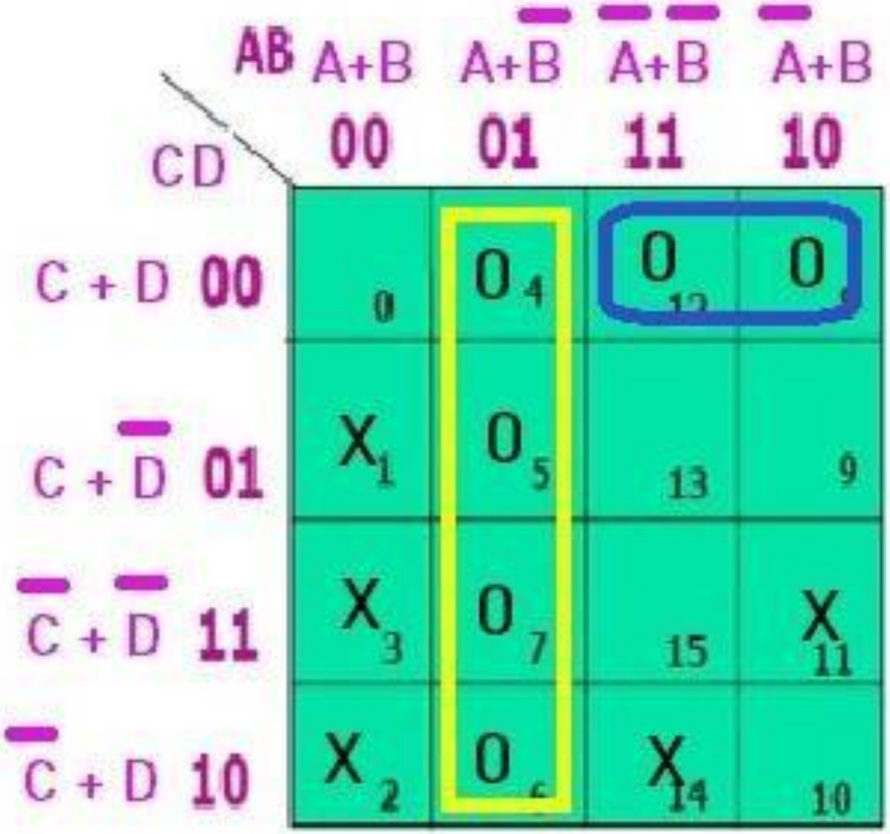


Solve using KMAP F= (0,1,2,3). d(8,9,10,11,13,15)



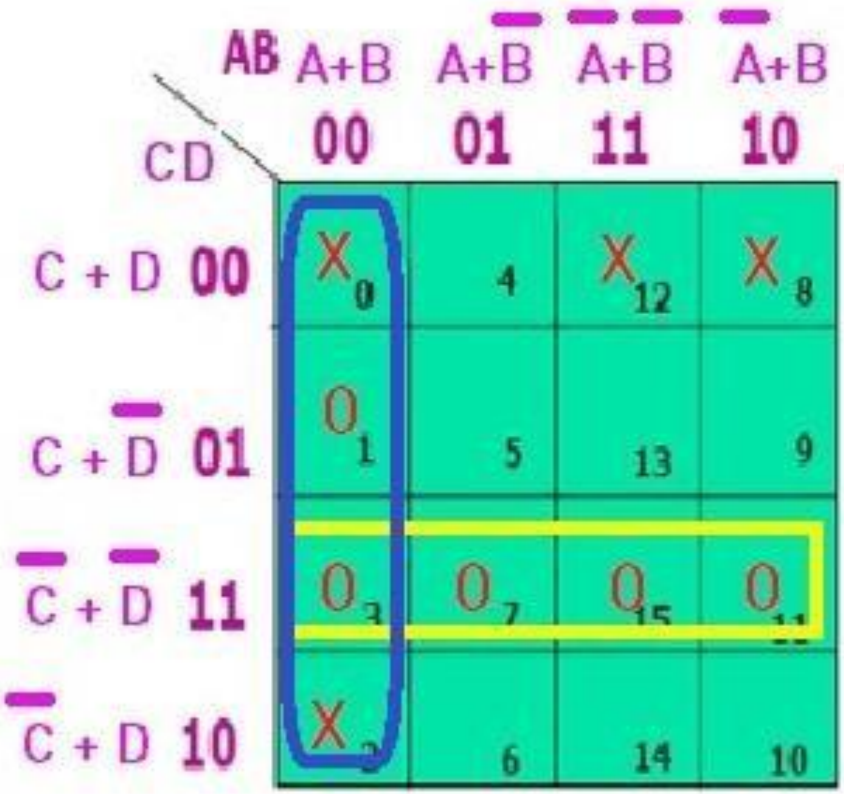
$\boxed{F = B'}$

Calculate F(A,B,C,D) = πM(4,5,6,7,8,12) . d(1,2,3,11,14).



$$\boxed{F = (A + B')(A' + C + D)}$$

solve using kmap F = M(1,3,7,11,15). D(0,2,8,12)



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

K-map for 5 Variable

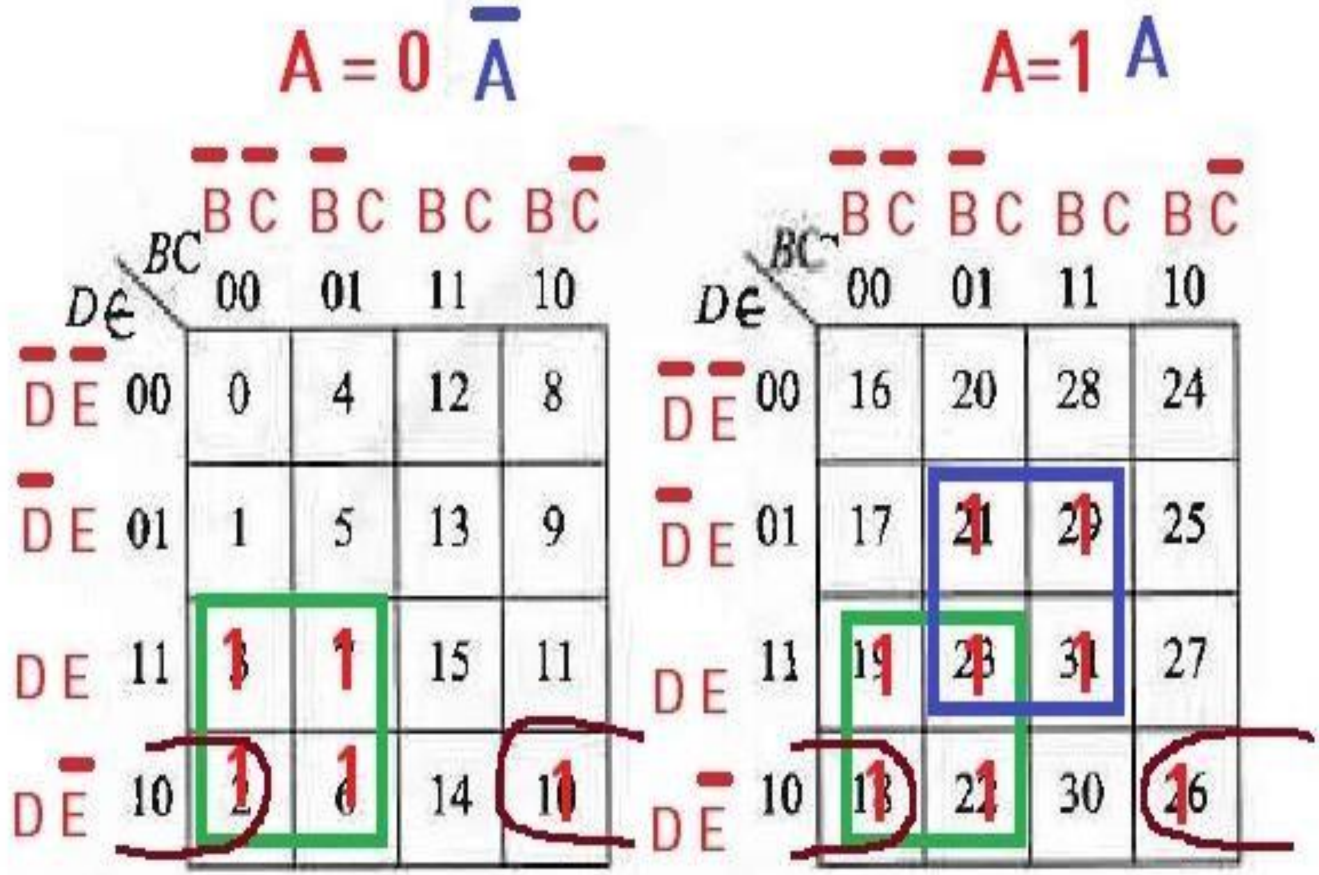
$\overline{A}$

DE \ BC	$\overline{B}\,\overline{C}$ 00	$\overline{B}C$ 01	BC 11	$B\overline{C}$ 10
$\overline{D}\,\overline{E}$ 00	0	4	12	8
$\overline{D}E$ 01	1	5	13	9
DE 11	3	7	15	11
$D\overline{E}$ 10	2	6	14	10

A

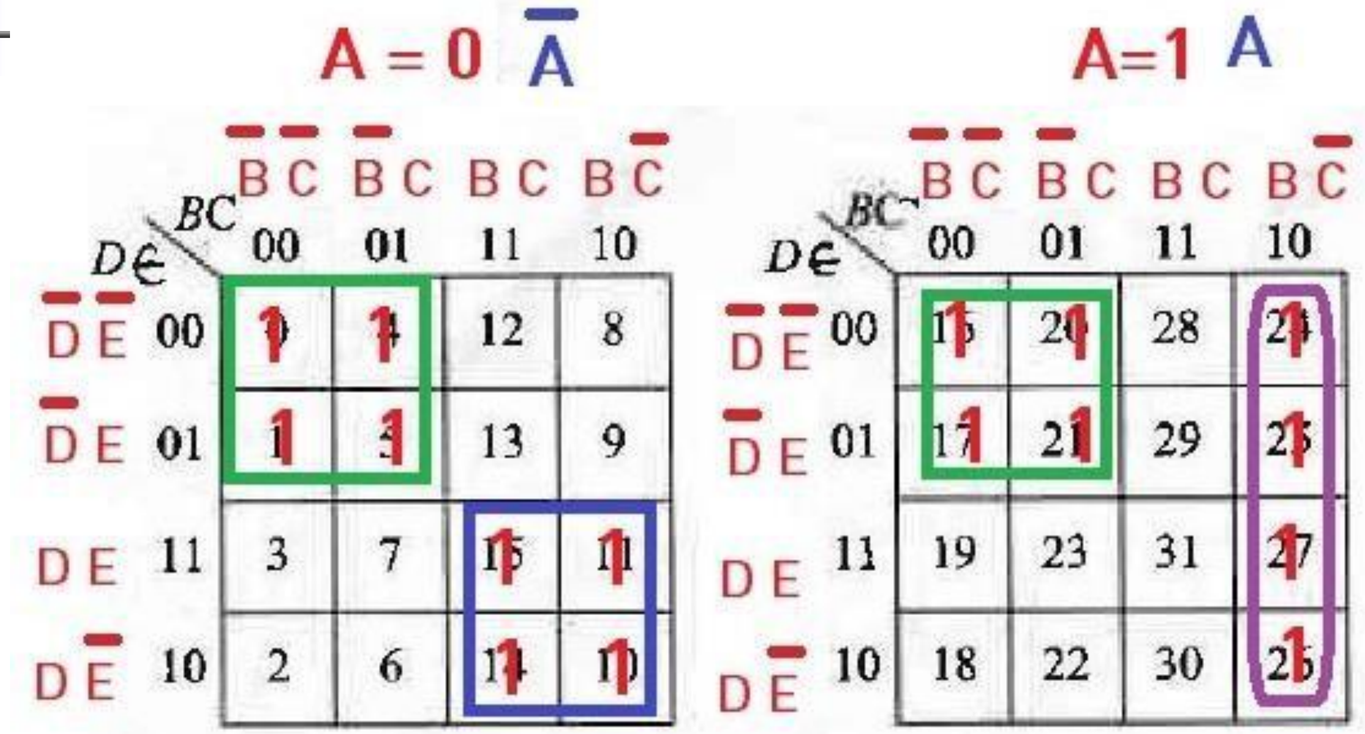
DE \ BC	$\overline{B}\,\overline{C}$ 00	$\overline{B}C$ 01	BC 11	$B\overline{C}$ 10
$\overline{D}\,\overline{E}$ 00	16	20	28	24
$\overline{D}E$ 01	17	21	29	25
DE 11	19	23	31	27
$D\overline{E}$ 10	18	22	30	26

Solve using KMAP F = m (2,3,6,7,10,18,19,21,22,23,26,29,31)



F= A ' B' D + A' C' D E' + A B' D + A C E + A C' D E'

Solve using Kmap F = 0,1,4,5,10,11,14,15,16,17,20,21,24,25,26,27)



F = A'B'D' + A'BD + AB'D' + A B C'

F= B'D' + A'BD + ABC'

$$F(PQRST) = \Sigma(0,2,4,7,8,10,12,16,18,20,23,24,25,26,27,28)$$

5-variable

$$F(PQRST) = \Sigma(0, 2, 4, 7, 8, 10, 12, 16, 18, 20, 23, 24, 25, 26, 27, 28)$$

5-variable

F = (S’T’) + (R’T’) + (Q’RST) + (PQR’)

Q. Solve using K-map,

$$F(A,B,C,D,E) = m(0,1,7,9,11,13,15,16,17,23,25,27)$$

Q. Solve using K-map,

$$F(A,B,C,D,E) = m(0,1,7,9,11,13,15,16,17,23,25,27)$$

Answer:

$$B'C'D' + B'CDE + BC'E + A'BE$$

$$=B'(C'D' + CDE) + BE(A'+C')$$

Q. Solve using K-map,

$$F(A,B,C,D,E) = m(0,2,5,7,13,15,18,20,21,23,28,29,31)$$

Q. Solve using K-map,

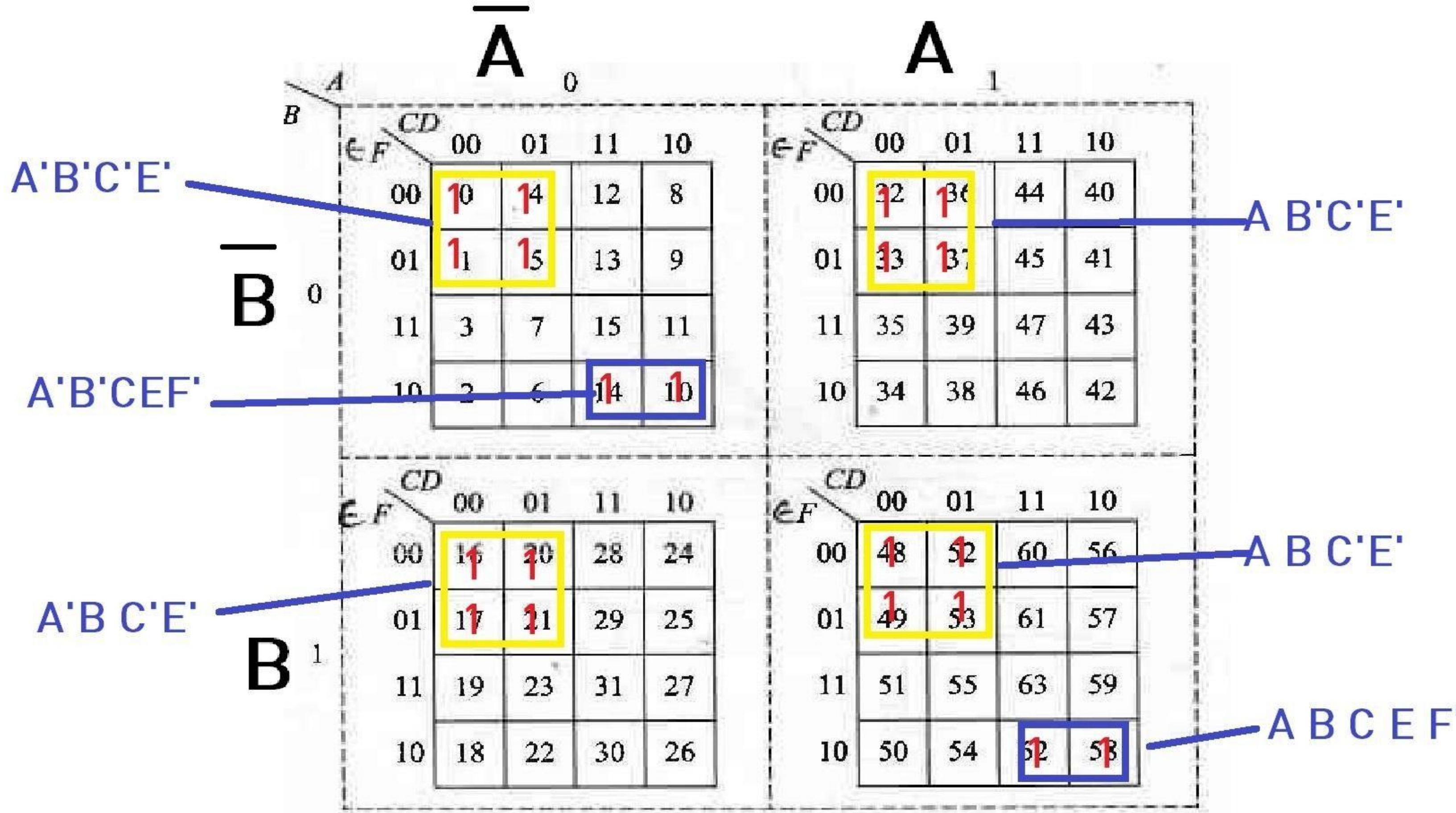
F(A,B,C,D,E) = m(0,2,5,7,13,15,18,20,21,23,28,29,31)

Answer:

A'B'C'E' + B'C'DE' + CE + ACD'

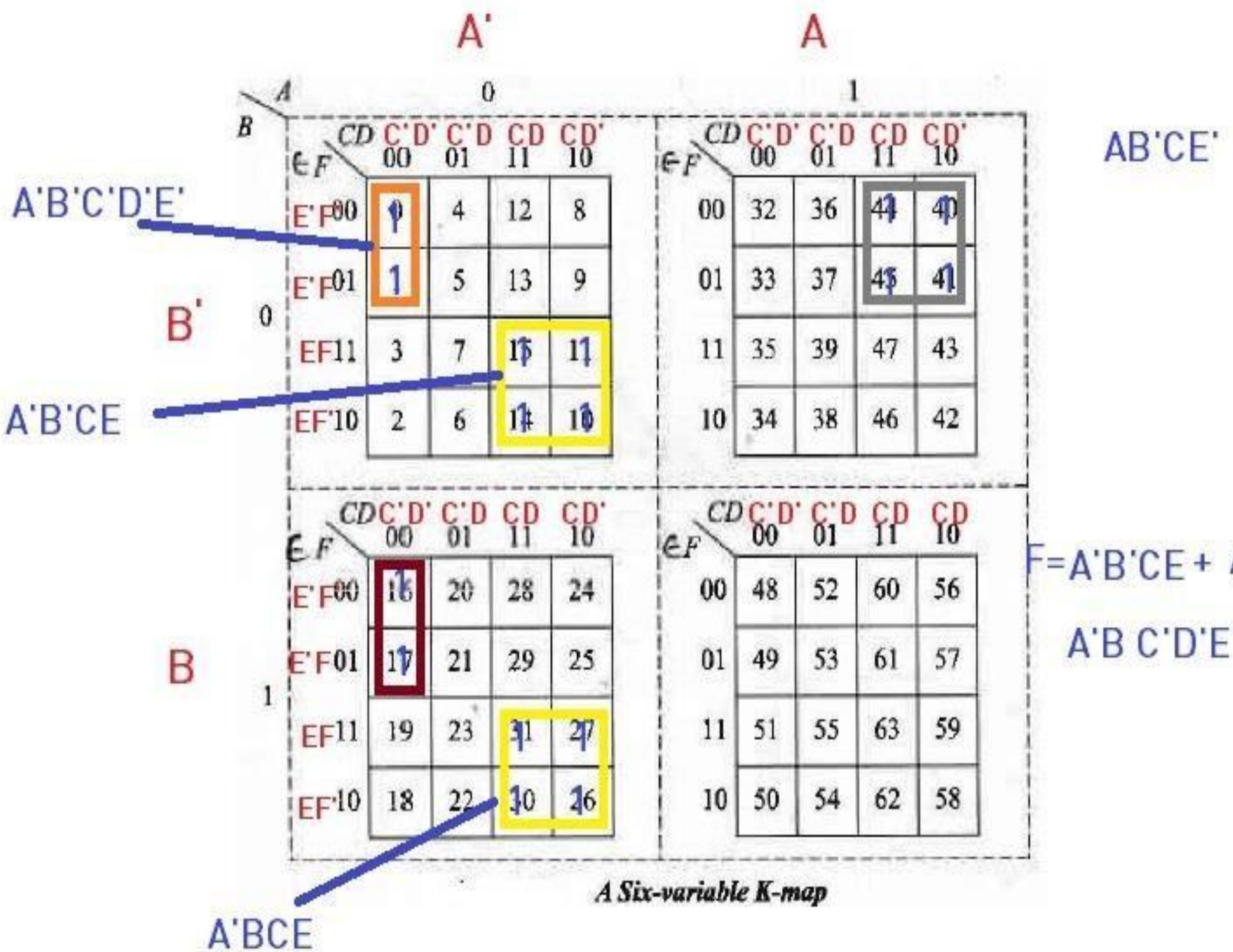
= B'C'E'(A'+D) + C (E+AD')

Solve using KMAP F = m(0,1,4,5,10,14,16,17,20,21,32,33,36,37,48,49,52,53,58,62)



F = C'E' + (A XNOR B)CEF

Solve the function using kmap F= m (0,1,10,11,14,15,16,17,26,27,30,31,40,41,44,45)



A Six-variable K-map

F=A'B'CE + A'B'C'D'E' + A'BCE +

A'B C'D'E' +AB'CE'

Q. Solve using Quine-McClusky Tabulation Method,
$F(A,B,C,D) = m(0,1,3,7,8,9,11,15)$

T-1.

Minterms	A	B	C	D
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-2.

Group	Minterms	A	B	C	D
0	0	0	0	0	0
1	1	0	0	0	1
	8	1	0	0	0
2	3	0	0	1	1
	9	1	0	0	1
3	7	0	1	1	1
	11	1	0	1	1
4	15	1	1	1	1

T-3

Group	Minterms	A	B	C	D
0	0, 1	0	0	0	–
	0, 8	–	0	0	0
1	1, 3	0	0	–	1
	1, 9	–	0	0	1
	8, 9	1	0	0	–
2	3, 7	0	–	1	1
	3, 11	–	0	1	1
	9, 11	1	0	–	1
3	7, 15	–	1	1	1
	11, 15	1	–	1	1

T-4.

Group	Minterms	A	B	C	D
0	0, 1, 8, 9	–	0	0	–
	0, 8, 1, 9	–	0	0	–
1	1, 3, 9, 11	–	0	–	1
	1, 9, 3, 11	–	0	–	1
2	3, 7, 11, 15	–	–	1	1
	3, 11, 7, 15	–	–	1	1

Prime-Implicants

P.I.	Decimal	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

$Y = \bar{B}\bar{C} + CD$

MC-CLUSKEY METHOD (TABULAR FORM)

$f = (a, b, c, d) = \Sigma (0, 5, 8, 9. 10, 11, 14, 15)$

0 = 0000
5 = 0101
8 = 1000
9 = 1001
10=1010
11=1011
14=1110
15=1111

STEP = 1

Group	minterm	A	B	C	D
0	0	0	0	0	0
1	8	1	0	0	0
2	5	0	1	0	1
	9	1	0	0	1
	10	1	0	1	0
3	11	1	0	1	1
	14	1	1	1	0
4	15	1	1	1	1

STEP = 2

Group	matched pair	A	B	C	D
0	0 , 8	-	0	0	0
1	8 , 9	1	0	0	-
	8 , 10	1	0	-	0
2	9 , 11	1	0	-	1
	10 , 11	1	0	1	-
	10 , 14	1	-	1	0
3	11 , 15	1	-	1	1
	14 , 15	1	1	1	-

STEP = 3

Group	matched pair	A	B	C	D
0	8 , 9 ,10 ,11	1	0	-	-
A B'	8 ,10 ,9 , 11	1	0	-	-
1	10 ,11 ,14 ,15	1	-	1	-
A C	10 ,14 ,11 ,15	1	-	1	-
	0 , 8	-	0	0	0
	5	0	1	0	1

STEP = 4

P . I	0	5	8	9	10	11	14	15
8,9,10,11			X	X	X	X		
10,11,14,15					X	X	X	X
0 , 8	X		X					
5		X						

= A B' + A C + B' C'D' + A'B C'D

1) $F(ABCD) = \Pi M(0, 2, 3, 6, 7, 8, 9, 12, 13)$

2) $F(ABCD) = \Pi M(0, 2, 4, 5, 7, 8, 9, 10, 13, 14, 15)$

3) $F(ABCDE) = \Pi M(2, 3, 5, 8, 9, 10, 11, 17, 18, 19, 21, 24, 25, 26, 27, 29)$

4) $F(ABCD) = \Pi M(0, 5, 7, 8, 9, 10, 11, 13)$

5) $F(ACD) = \Pi M(1, 2, 4, 5, 7, 8, 10, 11, 13, 14)$

6) $F(ABCD) = \pi m(4, 6, 8, 9, 10, 12, 13, 14) + d(0, 2, 5)$

7) Find expression in POS form for given function

$F(ABCD) = \Sigma m(0, 2, 3, 4, 7, 9, 10, 12, 14, 15)$

8) $F(ABCD) = \Sigma m(1,4,6,8,11,13,14)$
Find expression in POS form for above function.

9) $F(ABCD) = \Sigma m(0,4,6,7,10,12,14) + d(2,13)$
Find expression in POS form.

10) Solve using kmap
$Y = ABC\bar{D} + \bar{B}\bar{C} + \bar{B}D + AB\bar{C}\bar{D} + \bar{B}C$

11) obtain expression in SOP form
a) $F_1(ABCD) = \Pi M(2,7,8,9,10,12)$
b) $F_2(WXYZ) = \Sigma m(1,3,7,11,15) + d(0,2,5)$

12) $F(ABCD) = \Sigma m(2,3,4,8,10,11) + d(0,13,15)$

13) Simplify using kmap & implement using NAND gate only.
$F = ABC + B\bar{C}D + \bar{A}BC$

14) $F = \Sigma m(0,2,8,9,10,12,13,14)$

15) $F = \Pi M(1,2,3,5,8,9,10,11,14) \cdot d(0,7,15)$