Number system :

- A number system defines how a number can be represented using distinct digits or symbols.
- A number can be represented differently in different number system. for example the two number $(2A)_{16}$ and $(52)_8$ both refers to the same quantity $(42)_{10}$, but their representation are different.
- Number system include decimal, binary, octal and hexadecimal.

Number System	Base	Symbol
Binary	2	B
Octal	8	O
Decimal	10	D
Hexadecimal	16	H

- **Decimal number system :** It uses digit 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. Total digits are 10. so base or radix is 10

Ex : $(812.43)_{10}$ ← Base

MSD (most significant digit)   LSD (least significant digit)

- **Binary number system :** It uses two digit 0 and 1. so base is 2.

Ex : $(1011.110)_2$ ← base or radix

MSB (most significant bit)   LSB (least significant bit)

A combination of 8 bit is called byte.

A combination of 4 bit is called nibble.

- **Octal number system :** It uses digit 0, 1, 2, 3, 4, 5, 6, 7. So base is 8

Ex : $(4321.20)_8$ ← base or radix

MSD   LSD

- **Hexadecimal number system :** It uses digits 0–9 and A, B, C, D, E, F. So ~~total~~ digits are 16. So base is 16.

A → 10, B → 11, C – 12, D → 13, E – 14, F → 15

Ex : $(A4D.6F)_{16}$ ← Base or radix

MSB   LSD

Conversion of number system :

1) From any base to decimal :

- write the positional weight of each digit.

$$(\overset{3}{3}\,\overset{2}{7}\,\overset{1}{2}\,\overset{0}{1}\,.\,\overset{-1}{4}\,\overset{-2}{6}\,\overset{-3}{1})_8$$

- Now raise the positional weight on given base

$$(\overset{8^3}{3}\ \overset{8^2}{7}\ \overset{8^1}{2}\ \overset{8^0}{1} \cdot \overset{8^{-1}}{4}\ \overset{8^{-2}}{6}\ \overset{8^{-3}}{1})_8$$

- Now multiply each new wieght with corresponding digit and sum up all terms. Answer will be in decimal.

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

Example ÷ 1 $(1011.001)_2 = (\ ?\ )_{10}$

Soln ÷

$$(\overset{2^3}{1}\ \overset{2^2}{0}\ \overset{2^1}{1}\ \overset{2^0}{1} \cdot \overset{2^{-1}}{0}\ \overset{2^{-2}}{0}\ \overset{2^{-3}}{1})_2$$

$$= 1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0 + 0\times2^{-1} + 0\times2^{-2} + 1\times2^{-3}$$

$$= 8 + 0 + 2 + 1 + 0 + 0 + 0.125$$

$$= (11.125)_{10}$$

Example ÷ 2 $(437)_8 = (\ ?\ )_{10}$

Soln ÷

$$\overset{8^2}{4}\ \overset{8^1}{3}\ \overset{8^0}{7}$$

$$= 4\times8^2 + 3\times8^1 + 7\times8^0$$

$$= 256 + 24 + 7$$

$$= (287)_{10}$$

Example 3: Convert $(6FB.67)_{16}$ into decimal.

Soln ÷

$$\overset{16^2}{6}\ \underset{(15)}{\overset{16^1}{F}}\ \underset{(11)}{\overset{16^0}{B}} \cdot \overset{16^{-1}}{6}\ \overset{16^{-2}}{7}$$

$$= 6\times16^2 + 15\times16^1 + 11\times16^0 + 6\times16^{-1} + 7\times16^{-2}$$

$$= 1536 + 240 + 11 + .375 + .0273$$

$$= (1787.4023)_{10}$$

2) Decimal to any Base ÷

- For integer part ÷ Divide the decimal number to be converted, by value of new base and record the remainder.

Ex-1 ÷ $(73.12)_{10} = (\ ?\ )_2$

		Remainder
2	73	
2	36	1 ↑ LSB
2	18	0
2	9	0
2	4	1
2	2	0
	1	0
MSB		

$(73)_{10} = (1001001)_2$

- For fractional part ÷ multiply the fractional part by new base and record the carry

		Carry	
.13 × 2	=	0 (MSB)	.26
.26 × 2	=	0	.52
.52 × 2	=	1	.04
.04 × 2	=	0 (LSB)	.08

$(.13)_{10} = (.0010)_2$

So final answer

$$(73.12)_{10} = (1001001.0010)_2$$

- Now raise the positional weight on given base

$$(\overset{8^3}{3}\ \overset{8^2}{7}\ \overset{8^1}{2}\ \overset{8^0}{1} \cdot \overset{8^{-1}}{4}\ \overset{8^{-2}}{6}\ \overset{8^{-3}}{1})_8$$

- Now multiply each new wieght with corresponding digit and sum up all terms. Answer will be in decimal.

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

Example : 1 $(1011.001)_2 = (?)_{10}$

Solⁿ :

$$(\overset{2^3}{1}\overset{2^2}{0}\overset{2^1}{1}\overset{2^0}{1} \cdot \overset{2^{-1}}{0}\overset{2^{-2}}{0}\overset{2^{-3}}{1})_2$$

$$= 1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0 + 0\times2^{-1} + 0\times2^{-2} + 1\times2^{-3}$$

$$= 8 + 0 + 2 + 1 + 0 + 0 + 0.125$$

$$= (11.125)_{10}$$

Example : 2 $(437)_8 = (?)_{10}$

Solⁿ :

$$\overset{8^2}{4}\ \overset{8^1}{3}\ \overset{8^0}{7}$$

$$= 4\times8^2 + 3\times8^1 + 7\times8^0$$

$$= 256 + 24 + 7$$

$$= (207)_{10}$$

Example : 3 : Convert $(6FB.67)_{16}$ into decimal.

Solⁿ :

$$\overset{16^2}{6}\ \overset{16^1}{\underset{(15)}{F}}\ \overset{16^0}{\underset{(11)}{B}} \cdot \overset{16^{-1}}{6}\ \overset{16^{-2}}{7}$$

$$= 6\times16^2 + 15\times16^1 + 11\times16^0 + 6\times16^{-1} + 7\times16^{-2}$$

$$= 1536 + 240 + 11 + .375 + .0273$$

$$= (1787.4023)_{10}$$

2) Decimal to any Base :

- For integer part : Divide the decimal n… to be converted, by value of new base … record the remainder

Ex-1 : $(73.12)_{10} = (?)_2$

		Remainder
2	73	
2	36	1 (LSB)
2	18	0
2	9	0
2	4	1
2	2	0
	1 (MSB)	0

$(73)_{10} = (1001001)_2$

- For fractional part : multiply the fractio… part by new base and record the carry

		Carry	
.13 × 2	=	0 (MSB)	.26
.26 × 2	=	0	.52
.52 × 2	=	1	.04
.04 × 2	=	0 (LSB)	.08

$(.13)_{10} = (.0010)_2$

So final answer

$$(73.12)_{10} = (1001001.0010)_2$$

Binary

Each octal digit is represent by 3 bit in binary ($2^3 = 8$). So make group of 3 bit starting from LSB.

Now write decimal equivalent of each group using 421 coding.

Ex-1 : $(1\,1\,1\,0\,1\,1\,1 \cdot 1\,1\,0\,1\,1)_2 = (?)_8$

Soln : Extra zero to make group of 3

$$\underbrace{001}_{421}\,\underbrace{110}_{421}\,\underbrace{111}_{421} \cdot \underbrace{110}_{421}\,\underbrace{110}_{421} \leftarrow \text{Extra zero to make group of 3}$$

$$= (167 \cdot 66)_8$$

Ex-2 : $(1011 \cdot 101010)_2 = (?)_8$

Soln :

$$\underbrace{001}_{421}\,\underbrace{011}_{421} \cdot \underbrace{101}_{421}\,\underbrace{010}_{421}$$

$$= (13.52)_8$$

4) Binary to Hexadecimal :

- Each hexadecimal digit is represented by 4 bit in binary ($2^4 = 16$). So make group of 4 bit starting from LSB
- Now write decimal equivalent of each group using 8421 coding.

Ex-1 : $(1011 \cdot 10110)_2 = (?)_{16}$

Soln :

$$\underbrace{1011}_{8421} \cdot \underbrace{1011}_{8421}\,\underbrace{0000}_{8421}$$

$$= (B \cdot B0)_{16}$$

Ex-2 : $(101101 \cdot 110101)_2 = (?)_{16}$

Soln :

$$\underbrace{0010}_{8421}\,\underbrace{1101}_{8421} \cdot \underbrace{1101}_{8421}\,\underbrace{0100}_{8421}$$

$$= (2D \cdot D4)_{16}$$

5) Octal to Binary (opposite of binary to octal)

- Break each digit into a group of 3 by using 421 code.

Ex : $(743 \cdot 15)_8 = (?)_2$

Soln :

$$7\,4\,3 \cdot 1\,5$$

$$\underset{421}{111}\;\underset{421}{100}\;\underset{421}{011} \cdot \underset{421}{001}\;\underset{421}{101}$$

$$= (111100011 \cdot 001101)_2$$

6) Hexadecimal to binary (opposite of binary to hexadecimal) :

- Break each digit into a group of 4 bits using 8421 coding.

Ex :- $(9AC.1B)_{16} = (?)_2$

Soln :- $(9 \;\; A \;\; C \, . \, 1 \;\; B)_{16}$

$A = (10)$, $C = (12)$, $B = (11)$

9	A	C	.	1	B
8421	8421	8421		8421	8421
1001	1010	1100	.	0001	1011

$= (100110101100.00011011)_2$

7) octal to Hexadecimal :-

- first convert octal number into binary number then convert Binary number into Hexadecimal

$O \rightarrow B \rightarrow H$

Ex :- Convert $(312.67)_8 = (?)_{16}$

Soln :- • octal to binary

$(3 \; 1 \; 2 \, . \, 6 \; 7)_8$

3	1	2	.	6	7
421	421	421		421	421
011	001	010	.	110	111

$= (011001010.110111)_2$

Binary to hexadecimal :-

$\underbrace{0000}\,\underbrace{1100}\,\underbrace{1010}\,.\,\underbrace{1101}\,\underbrace{1100}$

$= (0CA.DC)_{16}$

8) Hexadecimal to octal :-

- first convert hexadecimal number into binary then convert binary number into octal.

Ex :- $(FB12)_{16} = (?)_{10}$

Soln. Hexadecimal to Binary :-

$F = (15)$, $B = (11)$

F	B	1	2
8421	8421	8421	8421
1111	1011	0001	0010

$= (1111101100010010)_2$

Binary to octal :-

$\underbrace{001}\,\underbrace{111}\,\underbrace{101}\,\underbrace{100}\,\underbrace{010}\,\underbrace{010}$

$= (175422)_8$

Ques-1 :- Convert the following as indicated (2020)

(i) $(110110.011)_2 = (?)_{16}$

(ii) $(231.36)_{10} = (?)_2$

(iii) $(11011.10)_2 = (?)_{10}$

(iv) $(534)_8 = (?)_{10}$

Solⁿ

(i) $0011\ 0110 \cdot 0110$

$8421\ 8421 \cdot 8421$

$= (36 \cdot 6)_{16}$

(ii) $(231 \cdot 36)_{10}$

Remainder

2	231	
2	115	1
2	57	1
2	28	1
2	14	0
2	7	0
2	3	1
	1	1

$(231)_{10} = (11100111)_2$

$\cdot 36 \times 2 = 0.72$

$\cdot 72 \times 2 = 1.44$

$\cdot 44 \times 2 = 0.88$

$\cdot 88 \times 2 = 1.76$

$(\cdot 36)_{10} = (\cdot 0101 \ldots)_2$

Final answer $(231 \cdot 36)_{10} = (11100111 \cdot 0101 \ldots)_2$

(iii) $(11011 \cdot 10)_2$

$= 1\times 2^4 + 1\times 2^3 + 0\times 2^2 + 1\times 2^1 + 1\times 2^0 + 1\times 2^{-1} + 0\times 2^{-2}$

$= (27 \cdot 5)_{10}$

(iv) $(534)_8$

$= 5\times 8^2 + 3\times 8^1 + 4\times 8^0$

$= (348)_{10}$

1's (Ones') Complement :

- To calculate the 1's complement of a binary number just 'flip' each bit of the origional binary number.

i.e. $0 \rightarrow 1$

$1 \rightarrow 0$

Ex: $0101010100 \xrightarrow[\text{complement}]{1's} 1010101011$

2's Complement :

- To calculate the 2's complement just calculate the 1's complement, then add 1.

Ex: $0101010100 \xrightarrow[\text{complement}]{1's} 1010101011$

$+1$

$1010101100 \leftarrow$ 2's Complement

Handy trick : Leave all the least significant 0's and first 1 unchanged, then flip the bits for all other digit.

Ex: $0101010100 \xrightarrow[\text{Complement}]{2's} 1010101100$

Ques. Find 1's and 2's complement of: 110100l (2020-21)

Solⁿ :

$1101001 \xrightarrow[\text{Complement}]{1's} 0010110$

$1101001 \xrightarrow{1's\ \text{complement}} 0010110$

$+1$

$0010111 \leftarrow$ 2's Complement

Boolean Algebra :

- called as binary algebra or logical algebra and invented by George Boole in 1854.
- used to analyze and simplify the digital (logic) circuit.
- Uses only the binary numbers i.e. 0 and 1.
- Common Boolean operators include AND, OR, and NOT.

Rules in Boolean Algebra :

- variable used can have only two value.
- Binary 1 = High and binary 0 = Low
- complement of a variable is represented by an overbar ($-$) ('). Thus if $B=0$, then $\bar{B}=1$ and if $B=1$ $\bar{B}$ or $B'=0$
- logical ORing of two variable is represented by a plus (+) sign between them. Ex- $A+B$
- Logical ANDing of the two or more variable is represented by a dot between them ie $A\cdot B\cdot C$ or ABC

Booleans Law : There are eight types of Boolean laws

1) Commutative law : Any binary operation which satisfy the following expression is referred to as commutative operation

a) $A\cdot B = B\cdot A$ b) $A+B = B+A$

Commutative law states that changing the sequence of the variable does not have any effect on the output of a logic circuit.

2) Associative law : This law states that the order in which the logic operations are performed is irrelevant as their effect is same.

a) $(A\cdot B)\cdot C = A(B\cdot C)$. b) $(A+B)+C = A+(B+C)$

3) Distributive law : Distributive law states the following condition.

$$A\cdot(B+C) = AB+AC$$

4) AND Law : This law uses the AND operation. So they are called as AND laws.

i) $A\cdot 0 = 0$ ii) $A\cdot 1 = A$

iii) $A\cdot A = A$ (iv) $A\cdot\bar{A} = 0$

5) OR Law : These law use the OR operation. So they are called as OR laws.

i) $A+0=A$ ii) $A+1=1$

iii) $A+A=A$ iv) $A+\bar{A}=1$

6. Inversion law : This law uses the NOT operation. The inversion law states that double inversion of a variable result in the original variable itself

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

7) Absorption law : This law enables a reduction in complicated expression to a simpler one by absorbing like terms.

i) $A(A+B) = A$

ii) $A + AB = A$

8) De morgan's Law :- There are two De morgan's laws (2013-14)

i) Two seperate terms NOR'ed together is the same as two term inverted (complement) and AND'ed ie.

$$(A+B)' = A' \cdot B'$$

ii) Two sperate terms NAND'ed together is same as the two terms inverted (complement) and OR'ed. ie.

$$(A \cdot B)' = A' + B'$$

Verification of Demorgan's law by truth table :-

A	B	A+B	(A+B)'	A'.B'
0	0	0	1	1
0	1	1	0	0
1	0	1	0	0
1	1	1	0	0

$(A+B)' = A' \cdot B'$

A	B	A'	B'	(AB)'	A'+B'
0	0	1	1	1	1
0	1	1	0	1	1
1	0	0	1	1	1
1	1	0	0	0	0

$(A \cdot B)' = A' + B'$

Ques1: Simplify the following boolean expression using booleans law :-

$$(A+C)(AD+A\bar{D}) + AC + C$$

Soln:- $(A+C)\ A(D+\bar{D}) + C[A+1]$.

$= (A+C) \cdot A(1) + C(\cdot 1)$

$= AA + AC + C$

$= A + C[A+1]$

$= A + C$

Ques2:- Simplify the following using booleans law :-

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

Soln:- $\{(AB)' + C\}' \cdot B$

$= \{(AB)'' \cdot C'\} \cdot B$

$= (ABC') \cdot B$

$= A B \cdot B C'$

$= ABC'$

Truth table formation:

- A truth table represents a table having all combination of inputs and their corresponding results.

Ex: $F(A,B,C) = A + BC$

The input combination for n variable is 2^n. Here $n = 3$ so $2^3 = 8$ possible input combination

Input			output
A	B	C	F
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

Digital Logic Gates:

- Boolean function may be practically implemented using electronic gates. Electronic gates requir a power supply.
- Gate inputs are driven by voltage having tw nominal values eg. 0V and 5V representing 0 and logic 1 respectivity.
- The output of a gate provide two nominals v of voltage 0V and 5V representing logic 0 and logic 1 respectivity.
- Types of Gates:

1) Basic gates: AND, OR, NOT are basic gates.

2) Universal gates: NAND and NOR are universal

3) Derived gates: Ex-OR and Ex-NOR are derived g

- NOT gate: The NOT gate produce an Inverted version of the input at it's output

It is also known as Inverter.

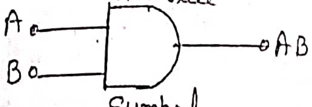
symbol

Truth table:

Input	output
A	$\overline{A}$
0	1
1	0

AND Gate :- The AND gate gives high output (1) only if all it's input are high (1). A dot (.) is used to show the AND operation i.e. A.B or AB

AND Gate



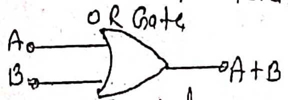
Symbol

Truth table :-

Input		output
A	B	AB
0	0	0
0	1	0
1	0	0
1	1	1

OR Gate :- OR gate gives a high output (1) if one or more of it's input are high (1). A plus (+) sign is used to show the OR operation.

OR Gate



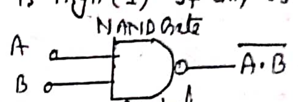
Symbol.

Truth table :-

Input		output
A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

• NAND Gate :- This is NOT-AND gate. The output of NAND gate is high (1) if any of the input is low.

NAND Gate



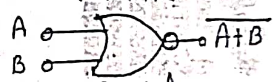
Symbol

Truth table :-

Input		output
A	B	$\overline{A\cdot B}$
0	0	1
0	1	1
1	0	1
1	1	0

• NOR Gate :- This is NOT-OR gate. The output of NOR gate is low if any one of the input is high.

NOR Gate



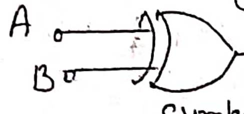
Symbol

Truth table :-

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

• Ex-OR (X-OR) Gate :- The exclusive-OR gate give high output if either, but not both, of it's input are high. It is odd gate. An encircled plus sign ($\oplus$) is used to show the Ex-OR operation

Ex-OR gate



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

symbol.

Truth table :

Input		output
A	B	$A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

- **Ex-NOR gate :** The Ex-NOR gate does the opposite of Ex-OR gate. It give two output If either, but not both, of two inputs are high. The symbol is Ex-OR gate with a small circle at the output. It is even gate.

Ex-NOR gate

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

Symbol.

Truth table :

Input		output
A	B	$A \odot B$
0	0	1
0	1	0
1	0	0
1	1	1

Ques 1 : What are universal gates? (2009-10, 2020-

Ans : • A universal gate is a gate which can implement any boolean function without need of any other gate.

- The NAND and NOR are called universal gate.
- This is advantageous since NAND and NOR gates are economical and easier to fabricate and are the basic gates used in all IC digital logic families.

Ques - 2 Draw all gates with the help of NAND only.

Ans :

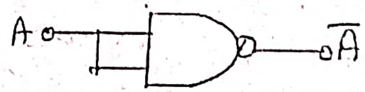
- NAND as NOT gate :

o/p of NAND gate $Y = \overline{A \cdot B}$

let $A = B$

$Y = \overline{A \cdot A}$

$Y = \bar{A}$

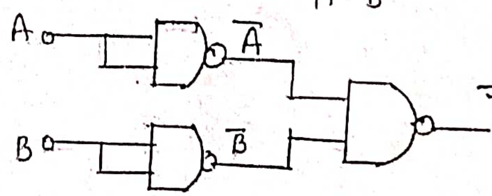


- NAND as OR Gate :

o/p of OR gate $= A + B$

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

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



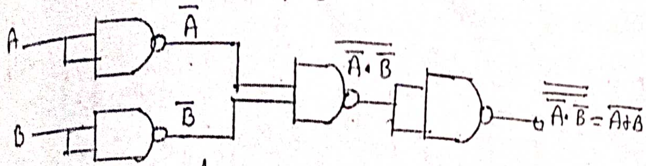
$\overline{\bar{A} \cdot \bar{B}} = A + B$

NAND

o/p of NOR gate $= \overline{A+B}$

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

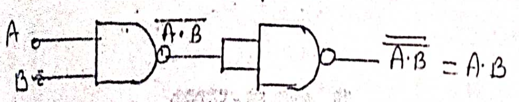
$= \overline{\overline{\bar{A}\cdot\bar{B}}}$



• NAND as AND gate :-

o/p of AND gate $Y = A\cdot B$

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



• NAND as EX-OR gate :- (2009-10, 2020-21, 2013-14)

o/p of EX-OR gate $= \bar{A}B + A\bar{B}$

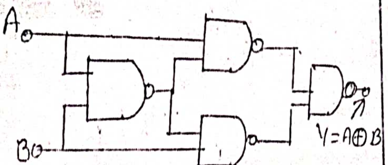
$= A\bar{A} + A\bar{B} + \bar{A}B + B\bar{B}$

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

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

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

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

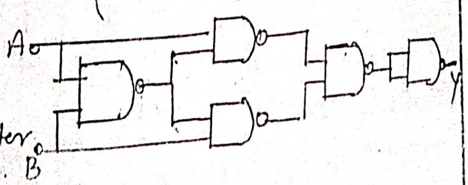


• NAND as EX-NOR gate

o/p of EX-NOR gate

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

It is opposite of EX-OR gate. So by adding one inverter gate we get the EX-NOR gate.



Ques:- 3. Draw all gates with the help of NOR gates only.

Ans :-

• NOR as NOT gate :-

o/p of NOR gate $Y = \overline{A+B}$

let $A = B$

$Y = \overline{A+A}$

$= \bar{A}$

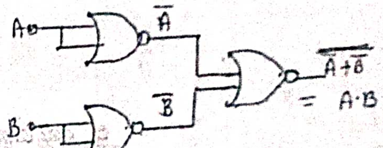
• NOR as AND gate :

o/p of AND gate

$Y = A\cdot B$

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

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



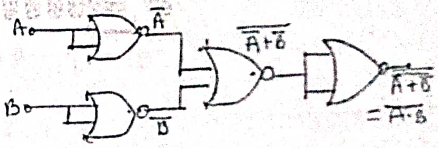
• NOR as NAND gate

o/p of NAND gate

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

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

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

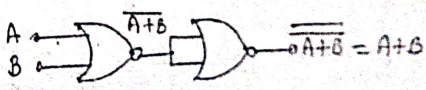


• NOR as OR gate :-

o/p of OR gate

$Y = A+B$

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



- NOR as Ex-OR gate : (2013-14, 2011-12)

O/P of Ex-OR gate

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

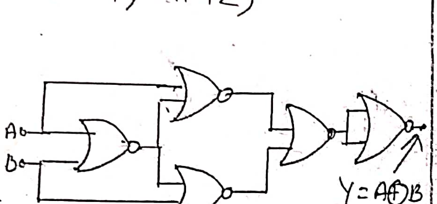
$= \bar{A}B + A\bar{B} + A\bar{A} + B\bar{B}$

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

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

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

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

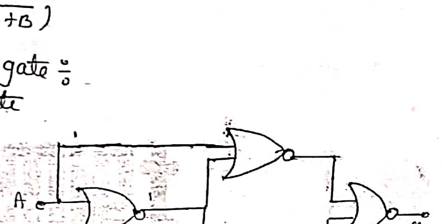


- NOR as Ex-NOR gate :

O/P of Ex-NOR gate

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

It is opposite of Ex-OR gate. So, by adding one inverter we get the Ex-NOR gate.



Ques 1 : What is SOP (sum of product)?

Ans : It is the logical expression in boolean algebra, where all the input terms are ANDed (product) first and then ORed (summed) toge

Ex :

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

Sum of

Product te

Ques 2 : What is standard or canonical SOP?

Ans : In standard SOP all the terms conta all variables either in complete form or in uncomplemented form. Each term in standard or canonical form is called min term.

Ex :

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

Ques 3 : What is POS (product of sum)?

Ans : It is the logical expression in boole algebra, where all the input terms ar ORed (sum first and then ANDed (product) together.

Ex

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

Produc

Sum

Ques 4 : What is standard or canonical POS?

Ans : In standard POS all the terms contain all variable either in complemented form or in uncomplemented form. Each term in standard or canonical POS is called max term.

• NOR as Ex-OR gate: (2013-14, 2011-12)

o/p of Ex-OR gate.

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

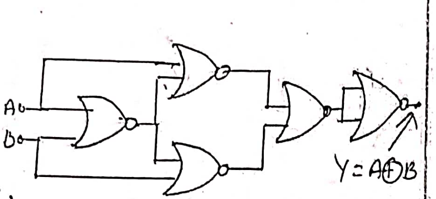
$= \bar{A}B + A\bar{B} + A\bar{A} + B\bar{B}$

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

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

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

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

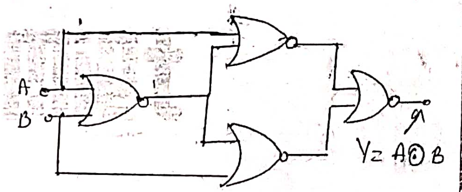


• NOR as Ex-NOR gate:

o/p of Ex-NOR gate

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

It is opposite of Ex-OR gate. So, by adding one inverter we get the Ex-NOR gate.



Ques1: what is SOP (sum of product)?

Ans: It is the logical expression in boolean algebra, where all the input terms are ANDed (product) first and then ORed (summed) together.

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

Sum of

Product term

Ques2: what is Standard or Canonical SOP?

Ans: In standard SOP all the terms contain all variables either in complemented form or in uncomplemented form. Each term in standard or canonical form is called min term.

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

Ques3: what is POS (product of sum)?

Ans: It is the logical expression in boolean algebra, where all the input terms are ORed (summed) first and then ANDed (product) together.

Ex: $Y = (A+B)\cdot(A+\bar{B}+C)\cdot(A+\bar{B})$

Product

Sum term

Ques4: what is standard or canonical POS?

Ans: In standard POS all the terms contain all variable either in complemented form or in uncomplemented form. Each term in standard or canonical POS is called max term.

Ex: $F(A,B,C) = (A+B+C)\cdot(\bar{A}+\bar{B}+C)\cdot(A+B+\bar{C})$

Ques 5 : What is minterm?

Ans : Each term in standard or canonical SOP is called min term. It is represented by m. Min term is opposite of max term.

In min-term uncomplemented variable is represented by 1 (ie. $A = 1$) and complemented variable is represented by 0 (ie $\bar{A} = 0$)

Ques 6 : What is max term?

Ans : Each term in standard or canonical POS is called max term. It is represented by M. Max term is opposite of minterm.

In max term uncomplemented variable is represented by 0 (ie $A = 0$) and complemented variable is represented by 1 (ie $\bar{A} = 1$)

Ques 7 : Convert the following boolean expression into standard SOP.

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

Ans :

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

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

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

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

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

Ques 8 : Convert the following boolean expression into canonical or standard POS.

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

Ans : $F(A,B,C) = A(\bar{B}+\bar{C})\cdot(A+\bar{B}+\bar{C})$

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

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

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

Ques 9 : Express the boolean function $F = A + \bar{B}C$ as standard sum of minterm.

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

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

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

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

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

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

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

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

$$= m_1 + m_4 + m_5 + m_6 + m_7$$

$$= \Sigma m(1,4,5,6,7)$$

Ques 10 : Express the boolean function $F = (A+\bar{B})(B+C)$ as a product of max-terms

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

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

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

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

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

$= M_2 \cdot M_3 \cdot M_0 \cdot M_4$

$= \Pi M(0,2,3,4)$

Ques 11: Express the Boolean function $F = xy + \bar{x}z$ as a product of max term.

Solⁿ: $F = xy + \bar{x}z$

$= (x+\bar{x})(y+\bar{x})(x+z)(y+z)$

$= (\bar{x}+y)(x+z)(y+z)$

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

$= (\bar{x}+y+z)(\bar{x}+y+\bar{z})$

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

$= (x+y+z)(x+\bar{y}+z)$

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

$= (x+y+z)(\bar{x}+y+z)$

$F = (x+y+z)(x+\bar{y}+z)(\bar{x}+y+z)\cdot(\bar{x}+y+\bar{z})$

$= M_0 \cdot M_2 \cdot M_4 \cdot M_5$

$= \Pi M(0,2,4,5)$

Ques-12 convert $F(A,B,C) = \Sigma m(1,4,5,6,7$ POS form.

Ans: missing terms of min term = terms of m

missing terms of max term = terms of

So missing terms in min term are = 0, 2, 3,

Therefore $F(A,B,C) = \Sigma m(1,4,5,6,7) = \Pi M(0,$

KARNAUGH MAP (K-MAP) :

- Simplification of logic expression using boolean algebra is awkward because:
  - It lacks specific rule to predict the most suitable step (next) in simplification process.
  - It is difficult to determine whether the simplest form has been achieved.
- A K-map is a graphical method used to obtained the most simplified form of an expression in SOP or POS.
- K map ensure that the simplified expression have minimum terms and each terms have minimum literals. So function will be implemented with minimum number of gates.
- In K-map gray code is used for levelling the cell.

Steps for Solving the Boolean expressions by K-maps

1) Select K map according to number of variables.
2) Identify minterm or maxterm as given in the problem.
3) For SOP put 1's in cell of kmap respective to the minterm.
4) For POS put 0's in cell of K-map respective to the max term
5) make rectangular groups containing total terms in power of two like, 2, 4, 8, 16 ---- (except 1) and try to cover as many element as you can in one group.

6) For SOP the group made in step 5, find the product terms and sum them up for SOP form.
7) For POS the group made in step 5, find the sum terms and multiply them.

- **Two Variable K map :**

Number of cells in K-map $= 2^n$

where $n \rightarrow$ no. of variable

Here $n = 2$

So Number of cells $= 2^2 = 4$

A \ B	$\bar{B}$ 0	B 1
$\bar{A}$ 0	m_0 $(\bar{A}\bar{B})$	m_1 $(\bar{A}B$
A 1	m_2 $(A\bar{B})$	m_3 (AB)

SOP representation

A \ B	B 0	$\bar{B}$ 1
A 0	m_0 $(A+B)$	m_1 $(A+\bar{B})$
$\bar{A}$ 1	m_2 $(\bar{A}+B)$	m_3 $(A+\bar{B})$

POS representation

Ex1: solve the folling using K-map

$F(A,B) = \Sigma m(0,1,3)$

Soln

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

$F = A + \bar{B}$

Ex-2 solve the following using kmap

$f(A,B) = \Sigma m(0,1,3,4)$

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

$F = 1$

Three variable K-map :-

In three variable K map number of cells = 2^3
= 8

$A \backslash BC$	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	m_0 $(\bar{A}\bar{B}\bar{C})$	m_1 $(\bar{A}\bar{B}C)$	m_3 $(\bar{A}BC)$	m_2 $(\bar{A}B\bar{C})$
A 1	m_4 $(A\bar{B}\bar{C})$	m_5 $(A\bar{B}C)$	m_7 (ABC)	m_6 $(AB\bar{C})$

For SOP form

$A \backslash BC$	$B+C$	$B+\bar{C}$	$\bar{B}+\bar{C}$	$\bar{B}+C$
A	m_0 $(A+B+C)$	m_1 $(A+B+\bar{C})$	m_3 $(A+\bar{B}+\bar{C})$	m_2 $(A+\bar{B}+C)$
$\bar{A}$	m_4 $(\bar{A}+B+C)$	m_5 $(\bar{A}+B+\bar{C})$	m_7 $(\bar{A}+\bar{B}+\bar{C})$	m_6 $(\bar{A}+\bar{B}+C)$

For POS form

Ex-1 Solve the following expression using K-map:

$f(A,B,C) = \Sigma m(1,3,4,5,6,7)$

Ans :-

$A \backslash BC$	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$		1	1	
A	1	1	1	1

→ C

→ A

$F = A + C$

Ex-2 Solve the following expression using K-map

$f(A,B,C) = \Pi m(1,2,3)$

Ans :-

$A \backslash BC$	$B+C$	$B+\bar{C}$	$\bar{B}+\bar{C}$	$\bar{B}+C$
A		0	0	0
$\bar{A}$				

$A+\bar{C}$

→ $A+\bar{B}$

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

You need Moti... You are under motivated! Truth

Four variable K-map :

In four variable K map number of cells = 2^4
= 16

$AB \backslash CD$	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	m_0 $(\bar{A}\bar{B}\bar{C}\bar{D})$	m_1 $(\bar{A}\bar{B}\bar{C}D)$	m_3 $(\bar{A}\bar{B}CD)$	m_2 $(\bar{A}\bar{B}C\bar{D})$
$\bar{A}B$	m_4 $(\bar{A}B\bar{C}\bar{D})$	m_5 $(\bar{A}B\bar{C}D)$	m_7 $(\bar{A}BCD)$	m_6 $(\bar{A}BC\bar{D})$
AB	m_{12} $(AB\bar{C}\bar{D})$	m_{13} $(AB\bar{C}D)$	m_{15} $(ABCD)$	m_{14} $(ABC\bar{D})$
$A\bar{B}$	m_8 $(A\bar{B}\bar{C}\bar{D})$	m_9 $(A\bar{B}\bar{C}D)$	m_{11} $(A\bar{B}CD)$	m_{10} $(A\bar{B}C\bar{D})$

SOP form

$AB \backslash CD$	$C+D$	$C+\bar{D}$	$\bar{C}+\bar{D}$	$\bar{C}+D$
$A+B$	m_0 $(A+B+C+D)$	m_1 $(A+B+C+\bar{D})$	m_3 $(A+B+\bar{C}+\bar{D})$	m_2 $(A+B+\bar{C}+D)$
$A+\bar{B}$	m_4 $(A+\bar{B}+C+D)$	m_5 $(A+\bar{B}+C+\bar{D})$	m_7 $(A+\bar{B}+\bar{C}+\bar{D})$	m_6 $(A+\bar{B}+\bar{C}+D)$
$\bar{A}+\bar{B}$	m_{12} $(\bar{A}+\bar{B}+C+D)$	m_{13} $(\bar{A}+\bar{B}+C+\bar{D})$	m_{15} $(\bar{A}+\bar{B}+\bar{C}+\bar{D})$	m_{14} $(\bar{A}+\bar{B}+\bar{C}+D)$
$\bar{A}+B$	m_8 $(\bar{A}+B+C+D)$	m_9 $(\bar{A}+B+C+\bar{D})$	m_{11} $(\bar{A}+B+\bar{C}+\bar{D})$	m_{10} $(\bar{A}+B+\bar{C}+D)$

POS form.

Ex-1 minimize the following function using K-

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

Ans:-

$AB \backslash CD$	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	1			1
$\bar{A}B$		1	1	
AB		1	1	
$A\bar{B}$	1			1

→ $\bar{B}\bar{D}$

→ BD

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

x-2:- minimize the following function using K-map

$F(W, X, Y, Z) = \pi m(0, 1, 4, 5, 6, 8, 9, 12, 13, 14)$

y.

WX \ YZ	Y+Z	Y+$\bar{Z}$	$\bar{Y}$+$\bar{Z}$	$\bar{Y}$+Z
W+X	0	0		
W+$\bar{X}$	0	0		0
$\bar{W}$+$\bar{X}$	0	0		0
$\bar{W}$+X	0	0		

→ Y

→ $(\bar{X}+Z)$

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

on't care condition:- (2009-10)

- Some times, not all values of a function are defined or some input condition will never occur
- We don't care what the output is for that input condition.
- In this code, we can choose the to be either 0 or 1, whichever simplifies the circuit.
- Generally don't care o/p in K map are expressed by d or X.

I/P			o/p
A	B	C	Y
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	X
1	1	0	X
1	1	1	X

} don't care condition

- 6 variable K map:-
- In 6 variable K map number of cell $= 2^6 = 64$
- A 6 variable K map is made from 4-variable 4 K-maps.

$\bar{A}\bar{B}$ (00)

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	E$\bar{F}$
$\bar{C}\bar{D}$	m_0	m_1	m_3	m_2
$\bar{C}D$	m_4	m_5	m_7	m_6
CD	m_{12}	m_{13}	m_{15}	m_{14}
C$\bar{D}$	m_8	m_9	m_{11}	m_{10}

$\bar{A}B$ (01)

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	E$\bar{F}$
$\bar{C}\bar{D}$	m_{16}	m_{17}	m_{19}	m_{18}
$\bar{C}D$	m_{20}	m_{21}	m_{23}	m_{22}
CD	m_{28}	m_{29}	m_{31}	m_{30}
C$\bar{D}$	m_{24}	m_{25}	m_{27}	m_{26}

$A\bar{B}$ (10)

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	E$\bar{F}$
$\bar{C}\bar{D}$	m_{32}	m_{33}	m_{35}	m_{34}
$\bar{C}D$	m_{36}	m_{37}	m_{39}	m_{38}
CD	m_{44}	m_{45}	m_{47}	m_{46}
C$\bar{D}$	m_{40}	m_{41}	m_{43}	m_{42}

AB (11)

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	E$\bar{F}$
$\bar{C}\bar{D}$	m_{40}	m_{49}	m_{51}	m_{50}
$\bar{C}D$	m_{52}	m_{53}	m_{55}	m_{54}
CD	m_{60}	m_{61}	m_{63}	m_{62}
C$\bar{D}$	m_{56}	m_{57}	m_{59}	m_{58}

Ex-4 minimize the following function using K-map

Ans: $F(A,B,C,D,E,F) = \Sigma m(0, 2, 8, 9, 10, 12, 13, 16, 18, 24, 25, 26, 29, 31, 32, 34, 35, 39, 40, 42, 43, 47, 48, 50, 56, 58, 61, 63)$

• 5 variable K map:

– In 5 variable K-map number of cell = 2^5 = 32

– A 5 variable K-map is made from 4-variable 2 K-maps.

$\bar{A}$

BC \ DE	$\bar{D}\bar{E}$	$\bar{D}E$	DE	$D\bar{E}$
$\bar{B}\bar{C}$	m_0	m_1	m_3	m_2
$\bar{B}C$	m_4	m_5	m_7	m_6
BC	m_{12}	m_{13}	m_{15}	m_{14}
$B\bar{C}$	m_8	m_9	m_{11}	m_{10}

A

BC \ DE	$\bar{D}\bar{E}$	$\bar{D}E$	DE	$D\bar{E}$
$\bar{B}\bar{C}$	m_{16}	m_{17}	m_{19}	m_{18}
$\bar{B}C$	m_{20}	m_{21}	m_{23}	m_{22}
BC	m_{28}	m_{29}	m_{31}	m_{30}
$B\bar{C}$	m_{24}	m_{25}	m_{27}	m_{26}

Ex: Simplify following function using K-map:

$F(A,B,C,D,E) = \Sigma m(0, 2, 5, 7, 8, 10, 16, 21, 23, 24, 27, 31)$

Sol^n

$\bar{A}$

BC \ DE	$\bar{D}\bar{E}$	$\bar{D}E$	DE	$D\bar{E}$
$\bar{B}\bar{C}$	1			1
$\bar{B}C$		1	1	
BC				
$B\bar{C}$	1			1

A

BC \ DE	$\bar{D}\bar{E}$	$\bar{D}E$	DE	$D\bar{E}$
$\bar{B}\bar{C}$	1			
$\bar{B}C$		1	1	
BC			1	
$B\bar{C}$	1		1	

$\bar{B}CE$ $ABDE$ $\bar{A}\bar{C}\bar{E}$ $\bar{C}\bar{D}\bar{E}$

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

Ans:

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

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	$E\bar{F}$
$\bar{C}\bar{D}$	1			1
$\bar{C}D$				
CD	1	1		
$C\bar{D}$	1	1		1

$\bar{A}B$

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	$E\bar{F}$
$\bar{C}\bar{D}$	1			1
$\bar{C}D$				
CD		1	1	
$C\bar{D}$	1	1		1

$A\bar{B}$

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	$E\bar{F}$
$\bar{C}\bar{D}$	1		1	1
$\bar{C}D$			1	
CD			1	
$C\bar{D}$	1		1	1

AB

CD \ EF	$\bar{E}\bar{F}$	$\bar{E}F$	EF	$E\bar{F}$
$\bar{C}\bar{D}$	1			1
$\bar{C}D$				
CD		1	1	
$C\bar{D}$	1			1

$\bar{D}\bar{F}$ $\bar{A}\bar{B}C\bar{E}$ $BCDF$ $\bar{A}C\bar{E}F$ $A\bar{B}EF$

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

Q. Simplify the function $F(A,B,C,D) = \Sigma m(0,2,5,6,7,13,14,15) + d(8,10)$ using K-map and implement the simplified function using NAND gates only.

Sol^n:-

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

$\rightarrow BD$

$\rightarrow C\bar{D}$

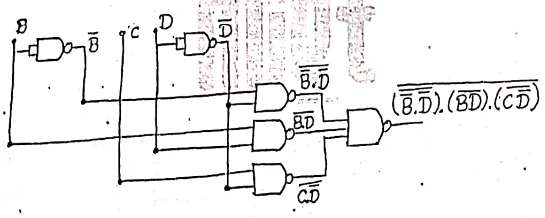
$\rightarrow \bar{B}\bar{D}$

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

Implementation with NAND Gate.

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

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



Q. Minimize using K-map. $F(A,B,C,D) = \Pi M(3,4,5,7,9,13,14,15) + d(0,2,8)$.

Sol^n:-

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

$\rightarrow A+C+D$

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

$\rightarrow \bar{B}+\bar{D}$

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

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

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

Ques-1 - Simplify the following using K-map:

$$F(A,B,C,D) = \Sigma m(3,5,9,11,15) + d(2,4,6,10)$$

(2011-12)

Sol^n.

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$			1	X
$\bar{A}B$	X	1		X
AB			1	
$A\bar{B}$		1	1	X

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

$\rightarrow ACD$

$\rightarrow \bar{B}C$

$A\bar{B}D$

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

Ques ÷ 2 minimize the following function using K map

$$F(A,B,C,D) = \Sigma m(1,3,4,6,8,9,11,13,15) + d(0,2,14)$$

(2010-11)

Sol^n:

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	X	1	1	X
$\bar{A}B$	1			1
AB		1	1	X
$A\bar{B}$	1	1	1	

$\bar{B}D$

$\rightarrow \bar{A}\bar{D}$

$\rightarrow AD$

$\bar{B}\bar{C}$

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

Ques 3 : minimize the following function using K map.

$F(A,B,C,D) = A\bar{B}\bar{C} + \bar{A}BC + \bar{A}\bar{B}CD + ABCD + d(1,5)$ (2011–12)

Ans : $F(A,B,C,D) = A\bar{B}\bar{C}(D+\bar{D}) + \bar{A}BC(D+\bar{D}) + \bar{A}\bar{B}CD + ABCD$

$= A\bar{B}\bar{C}D + A\bar{B}\bar{C}\bar{D} + \bar{A}BCD + \bar{A}BC\bar{D} + \bar{A}\bar{B}CD + ABCD + d(1,5)$

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$		X	1	
$\bar{A}B$		X	1	1
AB			1	
$A\bar{B}$	1	1		

$\rightarrow \bar{A}D$, $\rightarrow \bar{A}BC$, $\rightarrow BCD$, $A\bar{B}\bar{C}$

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

Ques 4 : simplify the following expression using K map and realize using NOR gates only. (2013–14)

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

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

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

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	1	1	1	1
$\bar{A}B$				
AB	1			1
$A\bar{B}$	1	1	1	1

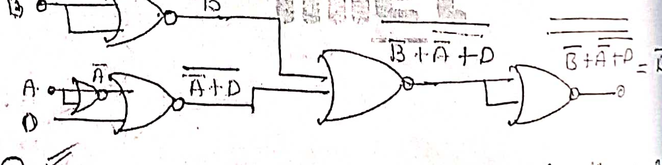
$\rightarrow A\bar{D}$, $\rightarrow \bar{B}$

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

NOR realization :

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

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



Ques 5 : Simplify the following function using K map $F(A,B,C,D) = \Sigma m(1,3,4,5,6,7,9,1$ Also implement with basic gates only (202

Ans : $F(A,B,C,D) = \Sigma m(1,3,4,5,6,7,9,11,13,$

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$		1	1	
$\bar{A}B$	1	1	1	1
AB		1	1	
$A\bar{B}$		1	1	

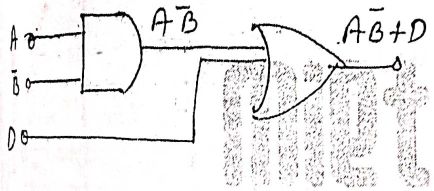
$\rightarrow \bar{A}B$

$\rightarrow D$

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

Basic gates realization:-

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



B. Tech I Year [Subject Name: F. of Electronics Engineering]

5 Years AKTU University Examination Questions		Unit-4	
S. No	Questions	Session	Lecture No
1	Convert FEDA(hex) into decimal 7650 octal into hex 11010110 binary into octal	2009-10(3)	28-34
2	Convert the following : $(2CCD)_{16} = (\quad)_8 = (\quad)_5$ $(784)_9 = (\quad)_{10} = (\quad)_4 = (\quad)_2$	2009-10(1)	28-34
3	Add and subtract without converting the following octal numbers 7461 and 3465.	2009-10(1)	28-34
4	Convert the following numbers as indicated $(62.7)_8 = (\quad)_{16}$ $(BC64)_{16} = (\quad)_{10}$ $(111011)_2 = (\quad)_5$	2009-10(1)	28-34
5	Represent the unsigned decimal number 965 and 672 in BCDand then show the steps necessary to form their sum.	2009-10(1)	28-34
6	$(CA95.12)_{16} - (9FE.A)_{16}$ = ____________ A'B'C' + A'B'C +A'BC' +ABC' = ____________	2010-11(1)	28-34
7	Convert decimal number 225 to binary, octal and hexadecimal. Add octal numbers 362 and 215.	2011-12(1)	28-34
8	Represent the unsigned numbers 84 and 56 in BCD and then show the steps necessary to form their sum.	2011-12(2)	28-34
9	Express (10110.0101_2) in decimal.	2011-12(2)	28-34
10	Convert the following $(389)_{10} = (\quad)_6$ $(FB27)_{16} = (\quad)_8$ $(11001101)_2 = (\quad)_{10}$	2011-12(3)	28-34
11	Subtract by using r's complement method where r is the base of the number: $(3762)_7$ and $(2664)_7$ $(11.0101)_2$ and $(11.100)_2$	2011-12(3)	28-34
12	Convert followings as directed: (i) 6089.25_{10} into Octal (ii) $A6B.F5_{10}$ into Binary (iii) 375.37_8 into Binary	2010-11(2)	28-34
13	Perform each of the following decimal addition in 8421 BCD code: 24+18, 48+58	2010-11(2)	28-34
14	Find 1's and 2's complement of : 1101001	2020-21	28-34
15	Evaluate: $(637)_9 = (?)_5$	2020-21	28-34
16	(i) Convert the 725.25_{10} to its equivalent in Base-2, Base-8 and base-16 (ii) Perform M-N and M+N if M=10101 and N=1111	2008-09	28-34
17	A.(A'+B)=	2009-10(1)	28-34
18	Three Boolean operators are: (i) NOT, OR, AND (ii) NOT, NAND, OR (iii) NOR,OR, NOT (iv) NOR, NAND, NOT	2009-10(1)	28-34
19	Express the Boolean function F=xy+z in a product of max term form.	2009-10(1)	28-34
20	Simplify the following function by using the Boolean algebra	2010-11(1)	28-34

	(ii) AB'C'D + A'B'D + BCD'+ A'B+BC'		
21	Simplify (A + B + C) (A +B'+C') (A + B+C') (A + B'+ C) using Boolean algebra.	2013-14	28-34
22	State DeMorgan's Theorem.	2013-14	28-34
23	What is meant by duality in Boolean algebra?	2011-12(1)	28-34
24	Write and explain the postulates of Boolean algebra.	2011-12(1)	28-34
25	Convert 120_{10} to equivalent hexadecimal.	2011-12(2)	28-34
26	Discuss the commutative and distributive postulates of Boolean algebra with example.	2011-12(2)	28-34

27	Simplify the following logic expression using Boolean Algebra (i) F= AB+ A(B+C) +B(B+C) (ii) F= AB'C'D +A'B'D+BCD'+A'B+BC'	2010-11(2)	28-34
28	Discuss the postulates of Boolean algebra. How it is different from ordinary algebra? What are universal gates? Implement the expression of XOR gate with the help of NAND gates only.	2008-09	28-34
29	Draw the circuit of a 2 input EX-OR gate using 2 input NAND gates	2009-10(3)	28-34
30	Realize the following expression using Ex-OR/Ex-NOR gates and basic gates if required F(A,B,C,D) = A'BC'+ A'B'C + AC'D + ACD'	2009-10(1)	28-34
31	What are universal gates? Justify your answer.	2009-10(1)	28-34
32	Given the Boolean function : F(A,B,C,D) = A'B'C' + AC'D' + AB' + ABCD' + A'B'C (i) Express it in sum of minterms. (ii) Find the minimal sum of products expression using K-map and implement the output using NAND gates only	2009-10(1)	28-34
33	What is the universal gate? Name the universal gate? Give the proof of universal gate at least for one type of gate.	2010-11(1)	28-34
34	Design a two input EX-OR gate using minimum number of (i) NAND gates only and (ii) NOR gates only.	2013-14	28-34
35	What are universal gates? Why are called so ?	2011-12(1)	28-34
36	Draw the logic diagram of Ex-OR gate using Universal gate (NAND and NOR).	2011-12(1)	28-34
37	Implement an OR gate using NAND gates.	2011-12(2)	28-34
38	Design a circuit using only NOR gates for Boolean expression Y=ABC'+ BCD'+CD	2011-12(3)	28-34
39	(i) What are universal gates? Why are they called so? (ii) Implement XOR gate using NAND gate	2020-21	28-34
40	Convert the given expression into canonical SOP form: f= A+ AB+ABC	2010-11(1)	28-34
41	Convert the given expression into canonical POS form:	2010-11(1)	28-34

	F= (A+B)(B+C)+(C+A)		
42	Convert F = X + YZ to canonical SOP.	2013-14	28-34
43	Simplify the given boolean function F together with don't care conditions in POS: F(w,x,y,z)= Sum(0,1,2,3,7,8,10) d(w,x,y,z)= π(5,6,11,15)	2011-12(1)	28-34
44	What do you mean by canonical form of a Boolean expression?	2011-12(2)	28-34
45	What are MAXTERM and MINTERM?	2011-12(3)	28-34
46	Convert the following into POS format: Y(A,B,C,D)= (A+B+C).(A+D)	2011-12(3)	28-34
47	By showing all the calculations, do as directed: (I) For a boolean function of 4 variables, ∑(3,7,11,14,15) = Π(?)	2020-21	28-34
48	Simplify the boolean function F in sum of products using don't care conditions d (using K-map) (i) F= Y' + X'Z' d= YZ +XY (ii) F= B'C'D' + BCD' + ABCD' d= B'CD' + A'BC'D	2008-09	28-34
49	Minimise the following K-Map : AB\CD: 00, 01, 11, 10 00: –, –, 1, – 01: 1, 1, 1, – 11: –, 1, 1, 1 10: –, 1, –, –	2009-10(3)	28-34
50	Minimize the given function using K-map and convert the minimized function into POS form F (A,B,C,D) = sum (1,3,5,7,9,10,12,13)	2009-10(1)	28-34
51	What do you understand by don't care conditions? Is it advantage or disadvantage to include them in a map ? Explain with reason.	2009-10(1)	28-34
52	Simplify the following function with the help of K map: F(A,B,C,D)= sum(3,5,9,11,15)+d(2,4,6,10)	2011-12(2)	28-34
53	Minimize the following using K-map technique: F(A,B,C,D)= AB'C' +A'BC + A'B'CD +ABCD + d(1,5)	2011-12(3)	28-34
54	Simplify the following function using k map: F(A,B,C,D)= sum(1,3,4,6,8,9,11,13,15)+ d(0,2,14)	2010-11(2)	28-34
55	Simplify the following expression using K-Map and realize using NOR gates only. F(A, B, C, D) = A' B' C' + AC'D' + AB'+ A B C D' + A'B'C	2013-14	28-34
56	Simplify the following function using K map F(A, B, C, D) = ∑(1, 3, 4, 5, 6, 7, 9, 11, 13, 15) Also implement the simplified function using basic gates only.	2020-21	28-34
57	(1010110100.110)2 = ( )16?	2021-22(O)	28-34
58	Simplify the Boolean function using Boolean Algebra theorems: A'B'C' + A'BC' + AB'C' + ABC'	2021-22(O)	28-34
59	i) Subtract using 10's complement: $(9754)_{10} - (364)_{10}$ ii) Subtract using 1's complement: $(10111)_2 - (110011)_2$	2021-22(O)	28-34

60	Minimize using K-map and realize using NOR gates only. F (A, B, C, D) = ΠM(3, 4, 5, 7, 9, 13, 14, 15). d(0, 2, 8).	2021-22(O)	28-34
61	F (A, B, C, D, E) = Σm (0,1,2,4,5,6,10,13,14,18,21,22,24,26,29,30). Simplify the function with help of K-map and realize the simplified function using basic logic gates.	2021-22(O)	28-34
62	Determine base of the following: (i) $(345)_{10}=(531)_x$ (ii) $(2374)_{16} = (9076)_x$	2021-22(E)	28-34
63	Write the truth table of two input X-OR gate and two input X-NOR gate.	2021-22(E)	28-34
64	Perform following operation as indicated. (i) Determine2's complement of (1010.110)2. (ii) Convert (25.125)10 into Hexadecimal number. (iii) Add binary number (1011)2 and (1111)2. (iv) State De Morgan's Law. (v) Define minterm and maxterm	2021-22(E)	28-34
65	Define universal logic Gates. Realize basic logic gates using NAND and NOR gates	2021-22(E)	28-34
66	Simplify the function F(A, B,C,D) = m(0,2,5,6,7,13,14,15) + d(8,10) using K-map and implement the simplified function using NAND gates only.	2021-22(E)	28-34