

Unit - 01

Number System and Codes

- 1.1 → Comparison of Digital and analog system.
- 1.2 → Number system : Binary, Decimal and octal and Hexadecimal and their conversions.
- 1.3 → Binary Addition, Subtraction, Multiplication and Division.
- 1.4 → 1's and 2's Complement of a number, Basic arithmetic operation using Complement method.
- 1.5 → Different types of codes : 8421 BCD, Excess - 3, Gray Codes, ASCII.

Q1: write down atleast four different between analog and Digital system?

Q2: write down application gray codes and excess-3 code?

Q3: Solve the following

$$\begin{aligned} (11110)_2 &= ()_{10} \\ (24)_{10} &= ()_2 \\ (36)_{10} &= ()_2 \\ (324)_{10} &= ()_{BCD} \\ (4F)_{16} &= ()_2 \end{aligned}$$

Q4: Subtract using 2's Complement

$$\begin{aligned} ① \quad 10110 &- 11010 \\ ② \quad 11010 &- 10101 \\ ③ \quad 100100 &- 010110 \end{aligned}$$

Q5: Define 8421, BCD Code and excess-3 code?

Q6: Using 1's Complement Subtract

$$10110 - 11101$$

Analog and Digital system:-

* Analog system :- Analog system is system in which signal is continuous and change slowly.

For example :- Temperature, Pressure, Sound.

* Digital system :- Digital system is system in which signal is discrete and change abruptly. Data (0 or 1) Time is change continuously and communication is use digital.

* Different between Analog and Digital system:-

Analog system	Digital system
① Data and signal continues like a line.	① Data and signal are discrete form like a line.
② Signal is represent with high accuracy like a line.	② Signal is represent with low accuracy like a line.
③ Analog data can store more data like a line.	③ Digital data can store less data like a line.

4) The signal noise is Disturbance in signal and noise is noise sensitive

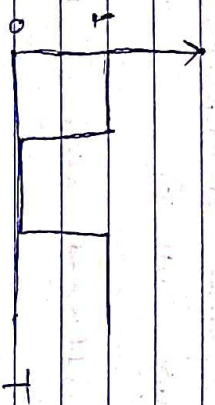
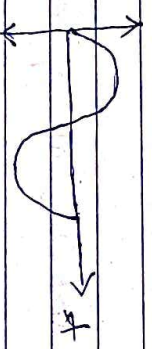
The signal noise is effect on the signal and noise sensitive effect is

5) Generally the Application is on cost matter is

The Application is High Initial (3000000) cost is efficient matter is

6) Example Temperature, Pressure, Sound

Example: Electronic Device



7) Analog System or a/c simple system is

Digital System or a/c Computer system is

Number System :-

The system in number is represent and for use they are the number system are addition, subtraction, multiplication and division are done is

Types of Number System :-

Number System Base Radix Number Example

- 1) Binary 2 0, 1 (10)₂
- 2) Octal 8 0, 1, 2, 3, 4, 5, 6, 7 (67)₈
- 3) Decimal 10 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 (98)₁₀
- 4) Hexadecimal 16 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F (5A)₁₆

Decimal Number System :- The number system

are 0 to 9 are the number are 10 is the decimal number system are

Example: 950, 316, 1248

Decimal Number system position value system
 होता है जिसमें Rightmost Digit का value सबसे अधिक होता है। यह सबसे ज्यादा use कर लिए गए। Right number system है।

Binary Number system :- यह number system जिसका Base 2 होता है और इसमें Right से Number 0 और 1 होते हैं इस Binary number system को हमें है। इसका use Computer में Electronic Device के में किया जाता है। यह एक position value system है। जिसमें Rightmost Digit का value सबसे अधिक होती है।

Binary Number system के Digits को Bits कहते हैं।

Example :- 10110 (यह 5 Bit Binary है)

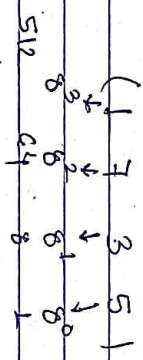


$$(1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (0 \times 2^0) \\
= (1 \times 16) + (0 \times 8) + (1 \times 4) + (1 \times 2) + (0 \times 1)$$

16 + 0 + 4 + 2 + 0 $\Rightarrow$ 22
 यह है Binary से Decimal Conversion

Octal Number system :- यह number system जिसका Base 8 होता है और जिसमें 0 से लेकर 7 तक Number होते हैं। इस Octal Number system को हमें है। यह एक position value system है जिसमें Right most Digit सबसे अधिक होता है। इसका use Electronic Device में होता है।

Example :-



$$(5 \times 8^2) + (1 \times 8^1) + (2 \times 8^0) + (3 \times 8^1) + (5 \times 8^0) \\
\Rightarrow (5 \times 64) + (1 \times 8) + (2 \times 1) + (3 \times 8) + (5 \times 1) \\
\Rightarrow 512 + 8 + 2 + 24 + 5$$

That is decimal number.

Hexadecimal Number System :- Real Number System

इस Hexadecimal Number System में 16 Base 16 होता है इस System में 0 से लेकर F तक Unique Number (चौदह) हैं जो कि 16 Position values System में लिखी श्रृंखला में प्रत्येक की value बताते हैं।

Example :- (1A2C)₁₆ या H

Number System Conversion :-

① Binary To Decimal Number Conversion :-

Example :-

$$(101101)_2$$

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

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

$$= 16 \times 1 + 8 \times 0 + 4 \times 1 + 2 \times 1 + 1 \times 0$$

$$= 16 + 0 + 4 + 2 + 0$$

$$= (22)_{10}$$

$$(1101011)_2$$

$$2^6 \times 2^5 \times 2^4 \times 2^3 \times 2^2 \times 2^1 \times 2^0$$

$$= 64 \times 1 + 32 \times 1 + 16 \times 0 + 8 \times 1 + 4 \times 0 + 2 \times 1 + 1 \times 1$$

$$= 64 + 32 + 0 + 8 + 0 + 2 + 1$$

$$= 107$$

$$(1011)_2 \rightarrow (11)_{10}$$

$$(100101001)_2 \rightarrow (216)_{10}$$

② Octal to Decimal Number Conversion:

$$(173)_8 \rightarrow ()_{10}$$

$$1 \times 8^2 + 7 \times 8^1 + 3 \times 8^0$$

$$= 64 \times 1 + 56 + 3$$

$$= (123)_{10}$$

$$(1056)_8 \rightarrow ()_{10}$$

$$1 \times 8^3 + 0 \times 8^2 + 5 \times 8^1 + 6 \times 8^0$$

$$= 512 \times 1 + 0 + 40 + 6$$

$$= (558)_{10}$$

$$(5712)_8 \rightarrow ()_{10}$$

$$5 \times 8^3 + 7 \times 8^2 + 1 \times 8^1 + 2 \times 8^0$$

$$= 4096 \times 5 + 512 \times 7 + 64 \times 1 + 8 \times 2$$

$$= 20480 + 3584 + 256 + 16$$

$$= (24336)_{10}$$

③ Hexadecimal To Decimal Number Conversion:

$$(ABC)_{16} \rightarrow ()_{10}$$

$$A \times 16^2 + B \times 16^1 + C \times 16^0$$

$$= 10^2 \times A + 16 \times B + 16^0 \times C$$

$$= 256 \times 10 + 16 \times 11 + 1 \times 12 = 2560 + 176 + 12$$

$$= (2748)_{10}$$

$$(4FA)_{16} \rightarrow ()_{10}$$

$$4 \times 16^2 + F \times 16^1 + A \times 16^0$$

$$= 256 \times 4 + 16 \times 15 + 1 \times 10$$

$$= 1024 + 240 + 10$$

$$= (1274)_{10}$$

$$(34B3E)_{16} \rightarrow ()_{10}$$

$$3 \times 16^4 + 4 \times 16^3 + B \times 16^2 + 3 \times 16^1 + E \times 16^0$$

$$= 65536 \times 3 + 4096 \times 4 + 256 \times 11 + 16 \times 3 + 1 \times 14$$

$$= 458752 + 16384 + 2816 + 48 + 14$$

$$= (478014)_{10}$$

(4) Decimal To Binary Number Conversion:-

$(22)_{10} \rightarrow ()_2$

2	22	
2	11	0
2	5	1
2	2	1
2	1	0

$\Rightarrow (10110)_2$

$(24)_{10} \rightarrow ()_2$

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

$(11000)_2$

(2105) $\rightarrow ()_2$

2	210	
2	105	0
2	52	1
2	26	0
2	13	0
2	6	1
2	3	0
2	1	1

$\Rightarrow (11010010)_2$

$(364)_{10} \rightarrow ()_2$

2	364	
2	182	0
2	91	0
2	45	1
2	22	1
2	11	0
2	5	1
2	2	1
2	1	0

$\Rightarrow (101101100)_2$

$(101101101111)_2$

③ Decimal To Octal Number Conversion

$$(243)_{10} \rightarrow (2)_8$$

$$(246)_{10} \rightarrow (3)_8$$

8	243		8	246	
8	35	7	8	305	6
	4	3	8	183	1
			8	10	5

$$\Rightarrow (437)_8$$

$$(1516)_8$$

$$(3531)_{10} \rightarrow (2)_8$$

8	3531		8	3531	
8	441	3	8	441	3
8	1187	45	8	1187	45
8	19	5	8	19	5
	1	6		1	6

$$\Rightarrow (16553)_8$$

④ Decimal To Hexadecimal Number Conversion

$$(350)_{10} \rightarrow (2)_8$$

$$(3624)_{10} \rightarrow (3)_8$$

16	350		16	3624	
16	21	14	16	439	0
	5		16	27	07
			16	11	0B

⑤ Octal To Binary Number Conversion :-

0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

जहाँ जो octal no. को binary में दर्शाते हैं और
और bit को वाक्यकार में है

$$(361)_8 \rightarrow (2)_2$$

$$(123)_8 \rightarrow (2)_2$$

$$111 \ 110 \ 001$$

$$001 \ 010 \ 011$$

$$= (11111001)_2 = (001010011)_2$$

⑥ Binary To Octal Number Conversion :-

$$\Rightarrow (10011)_2 \rightarrow (4)_8$$

$$\Rightarrow (101110)_2 \rightarrow (14)_8$$

$$(010011)_2 = (23)_8$$

$$(56)_8$$

$$\Rightarrow (1011001)_2 = 001011001 = (131)_8$$

Task 1 Binary number को ह्रित Bit Octal number में convert करने के लिए ह्रित Bit Binary number को group बायाँ जाता है।

⑨ Binary To Hexadecimal number Conversion:
 Task 1 ह्रित Bit Hexadecimal number को Represent करने के लिए 4 Bit Binary number को बायाँ

0	=	0 0 0 0	1
1	=	0 0 0 1	
2	=	0 0 1 0	
3	=	0 0 1 1	
4	=	0 1 0 0	
5	=	0 1 0 1	
6	=	0 1 1 0	
7	=	0 1 1 1	
8	=	1 0 0 0	
9	=	1 0 0 1	
A	=	1 0 1 0	
B	=	1 0 1 1	
C	=	1 1 0 0	
D	=	1 1 0 1	
E	=	1 1 1 0	
F	=	1 1 1 1	

⇒ (30)₁₆ ⇒ (22)₂ ⇒ (4F4)₁₆ ⇒ ()₂

3 0 = 4 F 4
 0011 0000 = (0100 1111 1010)₂

(00110000)₂ = (01001111010)₂

⇒ (4BAC)₁₆ = (88)₂

0100 1011 1010 1100 ⇒ (010010110101100)₂

⑩ Binary To Hexadecimal number Conversion:

(10110110101101)₂ ⇒ (22)₁₆

= 0001 0110 1110 1101 1101
 1 6 14 13 13 = (16EDD)₁₆

= (1001011)₂ ⇒ (22)₁₆

= 0100 1011 = (4B)₁₆

⑪ Hexadecimal to Octal Number Conversion:

$$(42FD)_{16} \rightarrow (31)_8$$

$$16 = 2^4$$

$$8 = 2^3$$

$$(0100\ 0010\ 1111\ 1101)_2 = (000\ 100\ 001\ 011\ 111\ 101)_2$$

$$(041375)_8$$

24bit uske hexadecimal number ko 4 bit binary number me convert krte hai aur 4 bit binary number ko 3 bit octal number me convert krte hai

$$(B9A)_{16} \rightarrow (2)_8$$

$$(1011\ 1001\ 1010)_2 = (101110011010)_2$$

$$= (5632)_8$$

Step ① :- Hexadecimal Digit ko 4 bit binary number me represent krte hai

$$B = 11 = 1\ 0\ 1\ 1$$

$$9 = 1\ 0\ 0\ 1$$

$$A = 10 = 1\ 0\ 1\ 0$$

$$(B9A)_{16} \rightarrow (1011\ 1001\ 1010)_2$$

Step ② :- Binary ko Octal me convert krte hai aur group krte hai

$$(101\ 110\ 011\ 010)_2$$

$$101 \rightarrow 5$$

$$110 \rightarrow 6$$

$$011 \rightarrow 3$$

$$010 \rightarrow 2$$

⑫ Octal to Hexadecimal Number Conversion:

$$(041375)_8 \rightarrow (2)_{16}$$

$$(000\ 100\ 1\ 001\ 111\ 101)_2$$

$$\Rightarrow (0000\ 0100\ 1001\ 1111\ 1101)_2 \Rightarrow (042FD)_{16}$$

$$(672)_{10} \rightarrow (2)_{16}$$

$$\Rightarrow (100110111010)_2 \Rightarrow (1BA)_{16}$$

$$\# (10101)_2 \rightarrow (13)_{10}$$
$$\frac{0010}{1101} \rightarrow (29)_{16}$$
$$\# \cdot (1110)_2 \rightarrow (2)_6$$
$$\frac{2011.1100}{12} \Rightarrow (3.6)_{12}$$
$$\# \quad (T_{g,1})_g \quad \Rightarrow \quad (?)$$
$$(111 \ 110 \ 001)_2 \rightarrow (\overline{0001} \ \overline{1111} \ \overline{0001})_2$$

(LLEP)₁₆

(3E.2)

$$\# \quad (T.A.C)_{16} \rightarrow (2)_8$$
$$2(101101100) \rightarrow 2(101101100) \rightarrow 2(101101100)$$

~~96578~~ = (172.80)

$$\#(296)_{10} \rightarrow (2)_2$$

2	298	2	9	0
---	-----	---	---	---

2	T.T.		2	0
2	L	N	2	0

$\frac{1}{2}$	$\frac{9}{18}$	$\frac{7}{2}$
---------------	----------------	---------------

$(798)_{10} \rightarrow (2)_8$

8	798	
8	99	6
8	12	3
1	4	

= $(1436)_8$

$(998)_{10} \rightarrow (2)_{16}$

16	998	
16	62	6
3	14	

= $(3E6)_{16}$

$(0.625)_{10} \rightarrow (2)_2$

fraction

(0.625) solve
fraction

2	0.625	
2	0.312	
2	0.156	
2	0.078	
2	0.039	
2	0.019	
2	0.009	
2	0.004	
2	0.002	
2	0.001	

0.625 $\times 2 = 1.250$ 1 | 0.250
 0.250 $\times 2 = 0.500$ 0 | 0.500
 0.500 $\times 2 = 1.000$ 1 | 0.000

$(0.625)_{10} \rightarrow (0.101)_2$

$(425.36)_{10} \rightarrow (2)_2$ $425.10.36$

2	425	2	13	0	
2	212	2	6	1	0.36 $\times 2 = 0.72$
2	106	0	3	0	0.72 $\times 2 = 1.44$
2	53	0	1	0	0.44 $\times 2 = 0.88$
2	26	1			0.88 $\times 2 = 1.76$

= $(100101001)_2$

= $(.0101)_2$

$\therefore (425.36)_{10} \rightarrow (100101001.0101)_2$

$(0.015625)_{10} \rightarrow (2)_8$

0.015625 $\times 8 = 0.125$ 0 | 0.125
 0.125 $\times 8 = 1.0$ 1 | 0.0

$(0.015625)_{10} \rightarrow (0.01)_8$

$(0.93)_{10} \rightarrow (2)_{16}$

16	0.93	
16	14	8
16	14	0
16	14	0
16	14	0
16	14	0
16	14	0
16	14	0
16	14	0
16	14	0

0.93 $\times 16 = 14.88$ 14 | 0.88
 0.88 $\times 16 = 14.08$ 14 | 0.08
 0.08 $\times 16 = 1.28$ 1 | 0.28
 0.28 $\times 16 = 4.48$ 4 | 0.48
 0.48 $\times 16 = 7.68$ 7 | 0.68

$(0.93)_{10} \rightarrow (0.FF147)_{16}$

$(113)_6 \Rightarrow (2)_2$

2	173	
2	86	1
2	43	0
2	21	1
2	10	1
2	5	0
2	2	1
2	1	0

$\Rightarrow (10101101)_2 \Rightarrow (173)_{10}$

$(672)_{10} \Rightarrow (2)_8$

8	672	
8	84	0
8	10	1
8	1	2

$\Rightarrow (1240)_8 \Rightarrow (672)_{10}$

$(999)_{10} \Rightarrow (2)_{16}$

16	999	
16	62	7
16	3	14

$(3FF)_{16} \Rightarrow (999)_{10}$

$(196.56)_{10} \Rightarrow (2)_2$

2	196		
2	98	0	0.56 x 2 = 1.12
2	49	0	0.12 x 2 = 0.24
2	24	1	0.24 x 2 = 0.48
2	12	0	0.48 x 2 = 0.96
2	6	0	0.96 x 2 = 1.92
2	3	0	
2	1	1	

$(0.56)_{10} \Rightarrow (10001)_2$

$(196)_{10} \Rightarrow (1100100)_2$

$(196.56)_{10} \Rightarrow (1100100.10001)_2$

$(2098.675)_{10} \Rightarrow (2)_2$

2	2098		
2	1049	0	$(.675 \times 2) = 1.35$
2	524	1	$0.35 \times 2 = 0.70$
2	262	0	$0.70 \times 2 = 1.40$
2	131	0	$0.40 \times 2 = 0.80$
2	65	1	$0.80 \times 2 = 1.6$
2	32	1	
2	16	0	
2	8	0	

$(2098)_{10} \Rightarrow (10000110010)_2$
 $(.675)_{10} \Rightarrow (10001)_2$

$(2098.675)_{10} \Rightarrow (10000110010.10001)_2$

2	4	0	
2	2	0	
2	1	0	

$(0.625)_{10} \rightarrow (2)_2$

integer fraction

$0.625 \times 2 = 1.25$

$0.25 \times 2 = 0.5$

$0.5 \times 2 = 1.0$

$(0.625)_{10} \rightarrow (0.101)_2$

$(0.101)_2 \rightarrow (2)_{10}$

$2^0 \quad 2^{-1} \quad 2^{-2} \quad 2^{-3}$

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

$1 \times \frac{1}{2} + 0 + \frac{1}{8} = \frac{4}{8} + \frac{1}{8} = \frac{5}{8}$

$\frac{1}{2} + 0 + \frac{1}{8} \Rightarrow 0.5 + 0.125 \Rightarrow (0.625)_{10}$

$(0.8650)_{10} \rightarrow (2)_{11}$

$0.8650 \times 16 = 13.84$

$0.86 \times 16 = 13.76$

$0.86 \times 16 = 13.76$

$(0.8650)_{10} \rightarrow (0.A66)_{16}$

$(1011)_2 \rightarrow (2)_{10}$

$(111)_2 \rightarrow (1011)_2$

$(106)_8 \rightarrow (2)_{10}$

$(106)_8 \rightarrow (70)_{10}$

$(13A)_{16} \rightarrow (2)_{10}$

$(1011.1101)_2 \rightarrow (2)_{10}$

$2^3 \quad 2^2 \quad 2^1 \quad 2^0 \quad 2^{-1} \quad 2^{-2} \quad 2^{-3} \quad 2^{-4}$

$6 \quad 4 \quad 2 \quad 1 \quad 0 \quad 1 \quad 1 \quad 1$

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

$\Rightarrow 8 \times 1 + 4 \times 0 + 2 \times 1 + 1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} \times 0 + \frac{1}{16} \times 1$

$11 + 0.5 + 0.25 + 0 + 0.0625$

$(11.8125)_{10}$

$(0.32)_8 \rightarrow (2)_{10}$

$8^{-1} \quad 8^{-2}$

$\frac{1}{8} \times 3 + \frac{1}{64} \times 2 =$

$0.5 \times 3 + 0.25 \times 2 = 1.5 + 0.5 = 2$

$0.125 \times 3 + 0.015625 \times 2$

$0.375 + 0.03125 = 0.40625$

$(10.135)_{10} \rightarrow (22)_{10}$

$$\begin{aligned} 16^1 \cdot 16^2 &= 16^1 \cdot 16^2 \\ 16^1 \cdot 16^2 &= 16^1 \cdot 16^2 \\ 16^1 \cdot 16^2 &= 16^1 \cdot 16^2 \end{aligned}$$

$(4057.06)_{10} \rightarrow (2)_{10}$

4	4057	0.6 x 8 = 4.8	4	0.8
8	507	0.5 x 8 = 4.0	6	0.4
8	63	0.4 x 8 = 3.2	3	0.2
8	7	0.2 x 8 = 1.6	1	0.6
8	7	0.6 x 8 = 4.8	4	0.8

$(4057)_{10} \rightarrow (3331)_{10}$ $(0.6)_{10} \rightarrow (46314)_{10}$

$(4057.06)_{10} \rightarrow (?)_{10}$

$512 \times 4 + 64 \times 0 + 8 \times 5 + 1 \times 7 + 0 \times 1 + 6 \times \frac{1}{2}$

$2048 + 0 + 40 + 7 + 0 + \frac{6}{8} + \frac{6}{8}$

$(2095.09)_{10}$

$(408F.EA)_{16} \rightarrow (2)_{10}$

$4096 \times 10 + 256 \times 0 + 16 \times 8 + 1 \times 15 + \frac{14}{16} + \frac{10}{256}$

$40960 + 128 + 15 + \frac{224}{256} + \frac{10}{256} = 41103.9$

$(41103.9)_{10}$

Binary Addition : 0.1

0 + 0 = 0

0 + 1 = 1

1 + 0 = 1

1 + 1 = 0

1000101.0001

Example :-

10011

100110

10001

15
105

Page No.	18
Date	02/25

$$\begin{array}{r} 11111010110 \\ 111111001001 \\ \hline 107.9375 \end{array}$$

$$\begin{array}{r} 1001011.1111 \\ 14321684210.50250.1250.645 \end{array}$$

$$\begin{array}{r} 100110 \\ 100110 \\ \hline 0001 \end{array}$$

Binary Operations :-

- Binary Addition
- Binary Subtraction
- Binary Multiplication
- Binary Division

* Binary Additions :-

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

⇒

$$\begin{array}{r} 10110 \\ 111101 \\ \hline 110011 = 51 \end{array}$$

$$\begin{array}{r} 101111011 \\ 110100111 \\ \hline 1100100010 \end{array}$$

* Binary Subtraction :-

Difference

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

$$\begin{array}{r} 110110 \\ 01110 \\ \hline 100000 \end{array}$$

$$\begin{array}{r} 1101101100 \\ 1001101111 \\ \hline 0101110001 \end{array}$$

125
0.25
0.125
0.0625
0.03125

Page No.	
Date	

23
20
3

* Binary Multiplication :-

- 0 x 0 = 0
- 0 x 1 = 0
- 1 x 0 = 0
- 1 x 1 = 1

$$\begin{array}{r}
 1011 \times 1001 \\
 \hline
 1011 \\
 0000 \times \\
 0000 \times \times \\
 + 1011 \times \times \times \\
 \hline
 110001
 \end{array}$$

$$\begin{array}{r}
 1011.1110 \times 1101.0110 \\
 \hline
 00000000 \\
 10111110 \times \\
 10111110 \times \times \\
 00000000 \times \times \times \\
 10111110 \times \times \times \times \\
 00000000 \times \times \times \times \times \\
 10111110 \times \times \times \times \times \times \\
 10111110 \times \times \times \times \times \times \times \\
 \hline
 101101111010100
 \end{array}$$

$$\begin{array}{r}
 1011 \times 1101 \\
 \hline
 1011 \\
 0000 \times \\
 1011 \times \times \\
 + 1011 \times \times \times \\
 \hline
 10001111
 \end{array}$$

$$\begin{array}{r}
 1110 \times 0110 \\
 \hline
 0000 \\
 1110 \times \\
 1110 \times \times \\
 + 0000 \times \times \times \\
 \hline
 1010100
 \end{array}$$

$$10011110.11010100$$

1's Complement and 2's Complement of Number :-

NOT GATE
 0 $\rightarrow$ 1
 1 $\rightarrow$ 0
 Complement $\rightarrow$ 1
 Complement $\rightarrow$ 0

फॉर्म में बिनरी नं. को 1's Complement फॉर्म में
 दो दिए गए बिनरी नं. के 3-3 bit को individually (एक-एक
 अलग) Complement फॉर्म में लिखा है 1 बाय 2 फॉर्म बिनरी
 नं. को NOT GATE के Input में दिया है और दो NOT
 GATE पर Output में बिनरी नं. को Complement फॉर्म में

Example :-
 Method - (1)

1 0 1 1
 1 1 1 1
 0 1 0 0 $\rightarrow$ 1's Complement

Method - (2)
 1 1 1 1
 0 0 1 1
 0 1 0 0 $\rightarrow$ 1's Complement

दो बिनरी नं. को 1's Complement फॉर्म में
 12 34 बिनरी नं. को 4-bit के अलग-अलग नं.
 दिए हैं देखिए नीचे

2's Complement :- फॉर्म बिनरी नं. को 2's

34 बिनरी नं. को 1's Complement फॉर्म में लिखा है और
 34 में 1 को 2 से घटाया है

1 0 1 1
 1 1 1 1
 0 1 0 0 $\rightarrow$ 1's Complement
 0 1 0 1 $\rightarrow$ 2's Complement

1's Complement and 2's Complement of Octal
 Number :-

(2431)₈ $\xrightarrow{1's \text{ Complement}}$ 5340

7337
 - 2437
 5340 $\xrightarrow{+1}$ 5341 $\rightarrow$ 2's Complement

9's Complement and 10's Complement of

Decimal Number

9432 $\xrightarrow{9's \text{ Complement}}$ 0567

9999
 - 9432
 0567
 10's Complement

1's Complement and 16's Complement of Hexadecimal number:-

$$\begin{array}{r} A2F9 \\ \text{com} \xrightarrow{15's} 5D06 \\ + 1 \\ \hline 5D07 \end{array} \quad \begin{array}{r} FFFF \\ - A2F9 \\ \hline 5D06 \end{array}$$

16's Complement

Subtraction using 1's Complement :-

Step ① - find 1's Complement of negative Binary no. (2nd no)

Step ② Add 1's Complement to 1st no. [positive Binary no.]

Step ③ ① Carry generated

③ No. carry generated

Result as 1's Complement $\rightarrow$ Res.

Example :-

(1101)₂ - (1010)₂ using 1's Complement

① 1st ② 2nd negative

$$1010 \xrightarrow{1's \text{ comple}} 0101$$

$$\begin{array}{r} 1101 \\ + 0101 \\ \hline 10010 \end{array} \quad \begin{array}{r} 0010 \\ + 1 \\ \hline 0011 \end{array}$$

Carry generated

Example :- No carry generated (1001)₂ - (1100)₂

$$\begin{array}{r} 1100 \\ \text{comple} \xrightarrow{1's} 0011 \end{array}$$

Step ② 1001

$$\begin{array}{r} 1001 \\ + 0011 \\ \hline 1100 \end{array}$$

Result

Step ③ No carry generated - Result $\xrightarrow{1's \text{ comple}} (-)$

$$1100 \xrightarrow{1's \text{ comple}} (-) 0011 \quad (9-12 = -3)$$

Subtraction using 2's Complement :-

Step ① :- Negative no. (2nd no) as 2's Complement (forget)

Step ② 2's Complement as positive Binary Number (1st no) as Add again

Step ③ → Carry generated is carry over 2's (discarded) and bit final Ans

→ No carry generated → Result 2's Complement

Example: (1101)₂ → (1010)₂

Step ① - 1010 $\xrightarrow{1's}$ 0101
 $\begin{array}{r} 1010 \\ + 0101 \\ \hline 0100 \end{array}$ → 2's Complement

Step ② 1101 Step ③ Discard carry generated
 $\begin{array}{r} 1101 \\ + 0110 \\ \hline 10011 \end{array}$ → 1001

Example ② (1001)₂ → (1100)₂

1100 $\xrightarrow{2's}$ 0011
 $\begin{array}{r} 1100 \\ + 0011 \\ \hline 0000 \end{array}$ → 2's Complement

Step ② 1001
 $\begin{array}{r} 1001 \\ + 0100 \\ \hline 1101 \end{array}$

Step ③ No carry generated in result
 $\begin{array}{r} 1101 \\ \xrightarrow{1's} 0010 \\ \hline 0011 \end{array}$ → 1001

8421 BCD Code :- Binary Coded decimal

BCD Code is 2's Decimal Digit or 4-bit binary no. of represent 10's until 9's 8421 BCD code 1st 4th 3rd 2nd 1st 4th 3rd 2nd 1st position of value 8421 end

Decimal no.	Binary no.
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111

valid BCD code

Invalid BCD code

Example :- $(156)_{10} \rightarrow (000101011101)_{BCD}$

$(16)_{10} \rightarrow (00011000)_{BCD}$

$(10100)_{BCD} \rightarrow (00010100) \rightarrow (14)_{10}$

BCD Code or use digital display
 Digital clock or calculator or display

Excess-3 code / X-3 code / X-3 code :-

X-3 code or 32 decimal digit or 3 bits
 or 32 bit binary equivalent

Decimal no	Binary no	X-3 code
0	0000	0011
1	0001	0100
2	0010	0101
3	0011	0110
4	0100	0111
5	0101	1000
6	0110	1001
7	0111	1010
8	1000	1011
9	1001	1100

Example :- $(319)_{10} \rightarrow (2)_{X-3}$

Step 1 $3+3 = 6 \rightarrow 0110$

$1+3 = 4 \rightarrow 0100$

$9+3 = 12 \rightarrow 1100$

$(319)_{10} \rightarrow (011001001100)_{X-3 \text{ code}}$

or use transmission line or Error Detection

GRAY CODE :-

Decimal no.	Binary no.	GRAY
0	0000	0000
1	0001	0001
2	0010	0010
3	0011	0011
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111

11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000

GRAY CODE consecutive number (15 bit) में 4th bit को change करें।
 Binary है। Analog Data को Digital Data में Convert करें और GRAY CODE को use करें।
 भाषा है।

Binary Code को GRAY CODE में बदलें।
 Convert फलाना है एक Switching को use करने का चक्र।

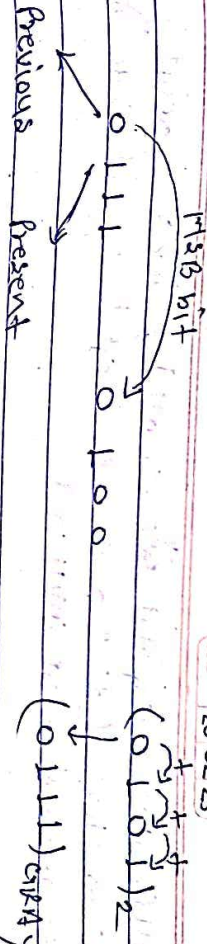
Binary To GRAY Conversion

Step 1 MSB bit वही का वही है रखा।

Step 2 Next bit के लिए present bit और previous bit को Add करेंगे। carry को Ignore करेंगे।
 यह sum को लिखेंगे।

MSB LSB
 0 0 0 0

Most Significant Least Significant
 bit bit



GRAY To Binary Conversion

(5) (0111)_{GRAY} → (1000)_{BINARY} → (1010)_{GRAY} → (1100)_{BINARY} → (1111)_{GRAY} → (1100)_{BINARY}

(96)₁₀ → (2)_{GRAY}

(1100000)₂ → (1010000)_{GRAY}

(32)₁₀ → (2)_{GRAY}

(00100100)_{BINARY}

ASCII Code: American Standard Code for Information Interchange.

यह 7 bit का एक binary code है जो 128 Unique (अधिक जगह कोई नहीं) Code होते हैं जिन्हें English में

Logic Gates and Boolean Algebra

2.1 → Boolean algebra : Laws of Boolean algebra and Demorgan's Theorem

2.2 → Type of logic gates : AND, OR and NOT, Universal Gates : NAND, NOR, EX-OR and EX-NOR. Truth table, Symbol, implementation of basic gate using Universal gate

2.3 → Max-term, min-term, Sum of product (SOP) and Product of Sum (POS) Expressions.

2.4 → Simplification of Boolean functions using laws and theorems.

2.5 → Simplification of Boolean functions using K-map method (up to 4 variable)

Law and Rules of Boolean Algebra :-

Binary number 0 और 1 को Represent करने के लिए Alphabets और Symbols का use किया जाता है। इसका use logical Expression को simplify (सरल कर्ना) करने के लिए किया जाता है।

① Complement Rules :-

NOT GATE :-

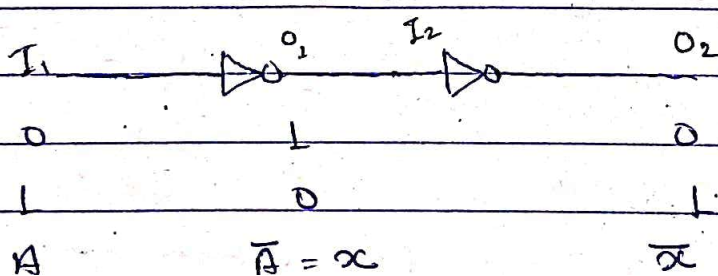


NOT GATE एक Basic logic gate है जो Input को Invert कर देता है। अगर NOT GATE का Input 1 है तो Output 0 होगा और अगर Input 0 होगा तो Output 1 होगा।

Truth Table सत्यता सारणी :-

Input	Output
0	1
1	0
A	$\bar{A}$

Truth Table दिए गए Input के लिए Output बता देगा इसका Information देता है।



नियम :-
 $\overline{\bar{A}} = A$
 A का double Complement A के बराबर होता है।

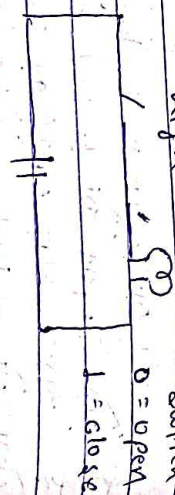
Conclusion :- # A or Complement = $\overline{\overline{A}}$ = A
A or Double Complement = $\overline{\overline{A}}$ = A

② AND Rule :- AND GATE



Truth Table

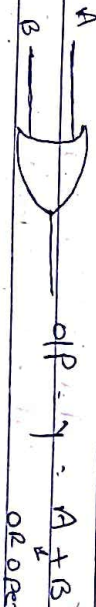
Input A	Input B	Output C
0	0	0
0	1	0
1	0	0
1	1	1



AND GATE ka basic logic chate hai ki jab jab tak jab jab input 0 (low) hai to output 0 hai aur jab jab input 1 (high) hai to output 1 hai.

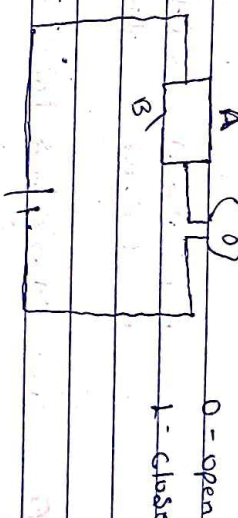
- ① $A \cdot 0 = 0$ $A \cdot 1 = A$
- ② $A \cdot A = A$ $A \cdot \overline{A} = 0$
- ③ $A \cdot \overline{A} = 0$

③ OR Rule :- OR GATE



Truth Table

A	B	Y = A + B
0	0	0
0	1	1
1	0	1
1	1	1



OR GATE ka basic logic chate hai ki jab jab input 1 (high) hai to output 1 hai aur jab input 0 (low) hai to output 0 hai.

- ① $A + 0 = A$
- ② $A + 1 = 1$
- ③ $A + A = A$
- ④ $A + \overline{A} = 1$

④ Distributive law :-

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

② $A + B \cdot C = (A + B) \cdot (A + C)$

(5) Commutative law :-

$$A+B = B+A$$

$$A \cdot B = B \cdot A$$

(6) Associative law :-

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

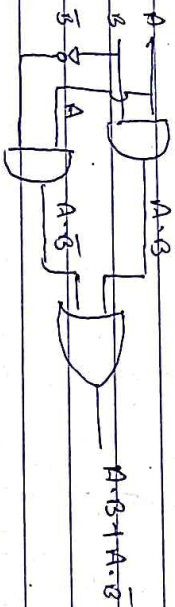
$$A \cdot (B \cdot C) = (A \cdot B) \cdot C$$

(7) De Morgan's law :-

① $\overline{A+B} = \bar{A} \cdot \bar{B}$ $\overline{A+B+C} = \bar{A} \cdot \bar{B} \cdot \bar{C}$

② $\overline{A \cdot B} = \bar{A} + \bar{B}$ $\overline{A \cdot B \cdot C} = \bar{A} + \bar{B} + \bar{C}$

③ $A \cdot B + A \cdot \bar{B} = A$



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

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

$$= A \cdot 1$$

$$= A$$

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

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

② $f = \overline{AB} + \bar{A} + AB$

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

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

$$= A \cdot B \cdot \bar{AB} \Rightarrow 1 \cdot 1 \cdot A \cdot B = m$$

$$m \cdot m \cdot m = 0 \quad (A \cdot A = 0)$$

③ $\overline{ABC} + \overline{A+B+C} + \bar{A} \bar{B} \bar{C} D = f$

$$= \overline{ABC} [C + \bar{C}D] + \overline{A+B+C}$$

$$= \bar{A} \bar{B} [C + \bar{C}D] + \overline{A+B+C}$$

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

$$= \bar{A} \cdot \bar{B} [C+D] + \overline{A+B+C}$$

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

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

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

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

211

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

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

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

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

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

$$(1) \quad \bar{A} B (C D + \bar{E} F) (\bar{A} B + \bar{C} D) = f$$

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

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

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

$$(2) \quad \bar{A} B \cdot (C D + \bar{E} F) \cdot (\bar{A} B + \bar{C} D) = f$$

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

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

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

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

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

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

$$= A B + \bar{C} D \cdot 1 + \bar{C} D \cdot \bar{E} F$$

$$(3) \quad F = x [y + z (\bar{x} y + x z)]$$

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

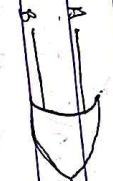
$$x y + x z (\bar{x} y + x z)$$

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

$$= x y + 0 + x y$$

$$= x y$$

For output terminal $\overline{A}$ and $\overline{B}$ are input 1
 Input 0 and output 1
 and output 0 and 1

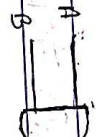
(B) OR Gate :- # Symbol  $Y = A + B$

Truth Table # Boolean Expression
 $Y = A + B$

A	B	Y = A + B
0	0	0
0	1	1
1	0	1
1	1	1

OR gate is the output of OR gate is 1
 OR gate is the output of OR gate is 1

output and 0 and 1 input 0 and 1

(C) AND Gate :- # Symbol  $Y = A \cdot B$

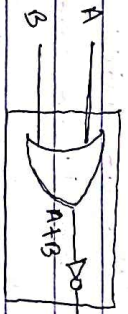
Truth Table # Boolean Expression
 $Y = A \cdot B$

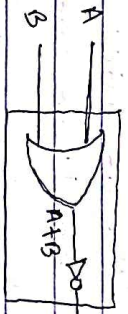
A	B	Y = A \cdot B
0	0	0
0	1	0
1	0	0
1	1	1

AND gate is the output of AND gate is 1
 AND gate is the output of AND gate is 1

and 1 input 1 and 1

(2) Universal Gate :- It is the logic gate which can perform all the logic operations
 use only NAND or NOR gate as a logic gate as a logic gate

(A) NOR Gate :- # Symbol 

NOR Gate + OR Gate  $Y = A + B$

Truth Table # Boolean Expression
 $Y = A + B$

A	B	Y = A + B
0	0	0
0	1	1
1	0	1
1	1	1

NOR gate is the output of NOR gate is 1
 NOR gate is the output of NOR gate is 1

and 1 input 0 and 1

(B) NAND Gate :- AND Gate + NOT Gate

Symbol 

NAND Gate 

Truth Table

A	B	Y = A \cdot B
0	0	1
0	1	1
1	0	1
1	1	0

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

NAND Gate में दो या दो से अधिक Input और केवल एक output होता है। NAND Gate को सबसे एक ही Input 0 होना से output 1 होता। NAND Gate को output चर 0 होना पर दो Input 1 होना।

③ Special Gate :- $\otimes$ OR Gate. Ex-OR Gate या Exclusive-OR Gate भी कहते हैं।

Symbol :-  $Y = A \oplus B$ या $A \oplus B = A\bar{B} + \bar{A}B$

Truth Table # Boolean Expression $Y = A \oplus B = A\bar{B} + \bar{A}B$

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

OR Gate में दो Input और केवल एक output होता है। Ex-OR Gate को output चर 0 होना पर दो Input Unequal होता।

Symbol  $Y = \overline{A \cdot B} = \overline{A \cdot B}$
 NOR Operator & NOR operator

④ X-NOR Gate, Ex-NOR Gate, Exclusive NOR Gate :-

Truth Table # Boolean Expression $Y = A \odot B = A \odot B$ या $\bar{A}B + A\bar{B}$

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

OR Gate में दो Input और केवल एक output होता है। Ex-OR Gate को output चर 1 होना पर दो Input 1 होना।

Implementation of Basic Gate using Universal Gate

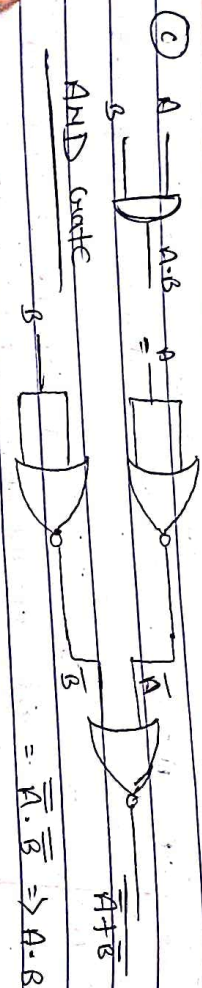
① NOR Gate :-

NOT Gate  $\bar{A} = A$ NOT using NOR Gate

NOT Gate Design करने के लिए सबसे एक NOR Gate को आवाजकाल होता है। इसे NOR Gate के दो Input को जोड़ दिया जाए तो output NOT Gate को करेगा। $(\bar{A})$

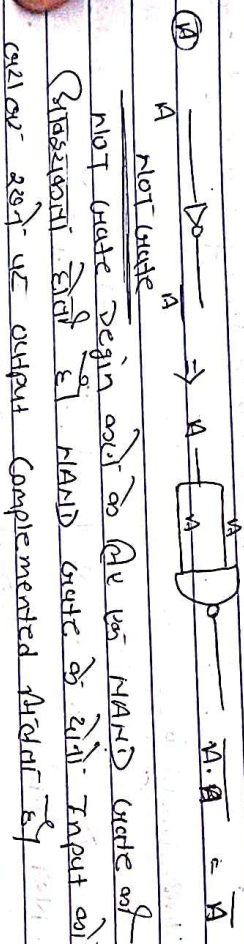
OR Gate  $A+B$ OR using NOR Gate $= A+B$

OR Gate Design करने के लिए दो NOR Gate को आवाजकाल होता है।

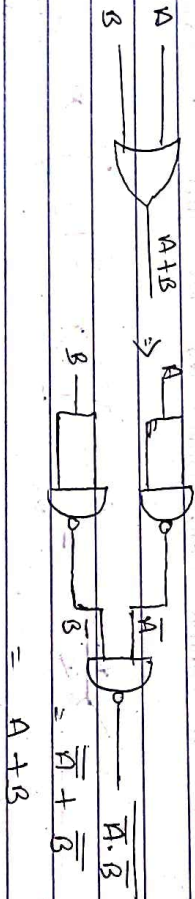


AND gate Design को लिए तीन NOR gate की आवश्यकता होती है।

② NAND gate :-

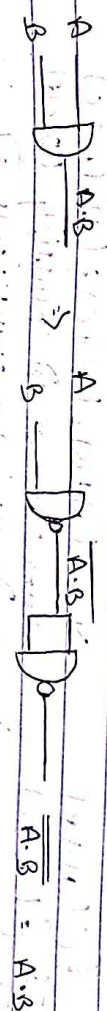


③ OR gate



OR gate को Design करने के लिए तीन NAND gate की आवश्यकता होती है।

④ AND gate



AND gate Design को लिए दो NAND gate की आवश्यकता होती है।

* SOP - POS Boolean function Representation :-

A	B	Logic circuit	output
0	0		0
0	1		0
1	0		0
1	1		1

उपर number of Inputs को Logic circuit को चार चरणों में दिखाते हैं। Output function को Represent करने के लिए SOP (Sum of product) और POS (Product of sum) का प्रयोग किया जाता है।

Sum of Product (SOP)

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

Product Terms को जोड़ने पर SOP प्राप्त होता है।

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

#1 Product of Sum (Pos)

$$Y = (A+B) \cdot (B+C) \cdot (A+B+C)$$

Sum Terms को Multiply (OR) करेंगे

अब हर Pos याद रखेंगे

MIN-TERMS :- Product terms को Add करेंगे

0 means $\rightarrow$ Complemented value

1 means $\rightarrow$ normal True value

2-Variable terms:-

Decimal	A	B	Min terms	
0	0	0	$\bar{A} \cdot \bar{B}$	$\rightarrow m_0$
1	0	1	$\bar{A} \cdot B$	$\rightarrow m_1$
2	1	0	$A \cdot \bar{B}$	$\rightarrow m_2$
3	1	1	$A \cdot B$	$\rightarrow m_3$

Min terms ko Product Terms में लिखेंगे और

Input Normal form या Complemented form में Present करेंगे

3-Variable terms:-

Decimal	A	B	C	Min terms
0	0	0	0	$\bar{A} \cdot \bar{B} \cdot \bar{C} \rightarrow m_0$
1	0	0	1	$\bar{A} \cdot \bar{B} \cdot C \rightarrow m_1$

2	0	1	0	$\bar{A} \cdot B \cdot \bar{C} \rightarrow m_2$
3	0	1	1	$\bar{A} \cdot B \cdot C \rightarrow m_3$
4	1	0	0	$A \cdot \bar{B} \cdot \bar{C} \rightarrow m_4$
5	1	0	1	$A \cdot \bar{B} \cdot C \rightarrow m_5$
6	1	1	0	$A \cdot B \cdot \bar{C} \rightarrow m_6$
7	1	1	1	$A \cdot B \cdot C \rightarrow m_7$

Min terms ko use sum of Product में लिखेंगे

$$f = 0 \ 1 \ 0 \ 0 \ 4 \ 1 \ 0 \ 1 \quad f = \bar{A} \bar{B} C + A \bar{B} \bar{C} + A \bar{B} C$$

$$f = m_1 + m_2 + m_3$$

$$f = \sum m(1, 2, 3)$$

$$f_2 = 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0 \quad f = \bar{A} \bar{B} \bar{C} + \bar{A} \bar{B} C + \bar{A} B \bar{C}$$

$$f = \sum m(0, 1, 2)$$

Min terms / Boolean form AND function में लिखेंगे

अब variable को Normal या Complemented form में Present करेंगे

Min terms को use SOP में लिखा जाता है

एक Min terms को Add करें दिया जाए तो SOP बन जाएगा

Max Terms - Sum Terms or 2501 or

0 means $\rightarrow$ Normal / True value

1 means $\rightarrow$ Complemented value

2. Variables terms :-

A	B	Max terms
0	0	$(A+B) \rightarrow M_0$
0	1	$(A+\bar{B}) \rightarrow M_1$
1	0	$(\bar{A}+B) \rightarrow M_2$
1	1	$(\bar{A}+\bar{B}) \rightarrow M_3$

3. Variable terms :-

A	B	C	Max terms
0	0	0	$(A+B+C) \rightarrow M_0$
0	0	1	$(A+B+\bar{C}) \rightarrow M_1$
0	1	0	$(A+\bar{B}+C) \rightarrow M_2$
0	1	1	$(A+\bar{B}+\bar{C}) \rightarrow M_3$
1	0	0	$(\bar{A}+B+C) \rightarrow M_4$
1	0	1	$(\bar{A}+B+\bar{C}) \rightarrow M_5$
1	1	0	$(\bar{A}+\bar{B}+C) \rightarrow M_6$
1	1	1	$(\bar{A}+\bar{B}+\bar{C}) \rightarrow M_7$

$f_1 = 00111110 \Rightarrow f = (A+B+C) \cdot (A+B+\bar{C}) \cdot (\bar{A}+\bar{B}+\bar{C})$

$f = M_0 \cdot M_1 \cdot M_7$
 $f = \pi M(0,1,7)$

$f_2 = 1011110101 \Rightarrow f = (\bar{A}+B+C) \cdot (\bar{A}+\bar{B}+C)$

$f = M_4 \cdot M_6$
 $f = \pi M(4,6)$

True form (Normal form) or Complemented form or
 Re Present: 2501 or 2502 use Product of sum or

Canonical form :-

Normal Canonical form

$f = \sum m(2,3,4,5,6)$

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

$f = m_2 + m_3 + m_4 + m_5 + m_6$

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

Sum Product Term or
 Input or output variable

Sum Product Term or
 Variable Normal or Complemented form or Present or

A	B	min term	Max term	f_1
0	0	$\bar{A} \cdot \bar{B} \rightarrow m_0$	$A+B \rightarrow M_0$	1
0	1	$\bar{A} \cdot B \rightarrow m_1$	$A+\bar{B} \rightarrow M_1$	1
1	0	$A \cdot \bar{B} \rightarrow m_2$	$\bar{A}+B \rightarrow M_2$	0
1	1	$A \cdot B \rightarrow m_3$	$\bar{A}+\bar{B} \rightarrow M_3$	0

$f_1 = m_0 + m_1$

$f_1 = M_2 \cdot M_3$

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

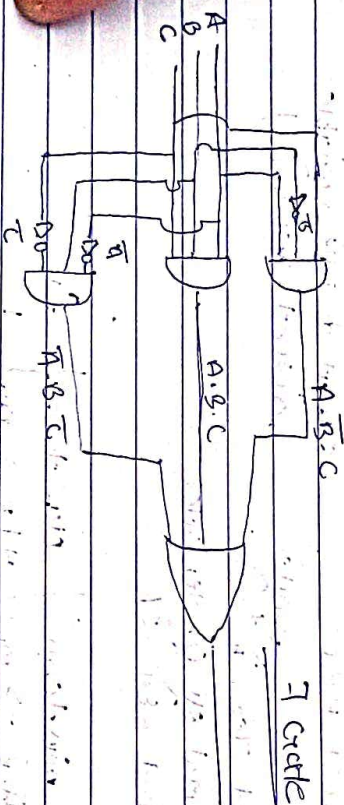
$$\Rightarrow \bar{A} [\bar{B} + B] \Rightarrow \bar{A} \cdot \bar{A} + \bar{A} \cdot B + \bar{A} \cdot \bar{B} + B \cdot \bar{A}$$

$$\Rightarrow \bar{A} \cdot 1 \Rightarrow \bar{A} + \bar{A} (B + \bar{B}) + 0$$

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

K-Map (Karnaugh Map) :-

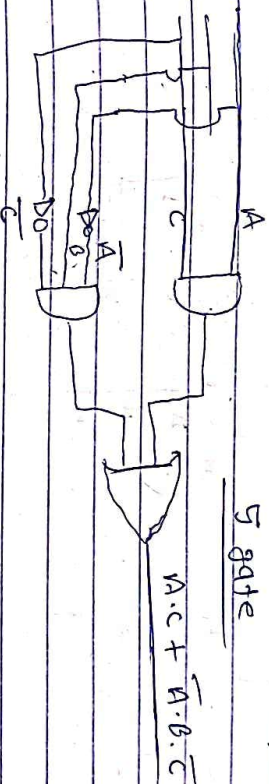
$$f(A, B, C) = A \cdot B \cdot C + \bar{A} \cdot B \cdot \bar{C} + A \cdot \bar{B} \cdot C$$



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

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

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



K-Map, Boolean function को simplify करने के लिए एक graphical methode है। और इसका use करने से function को perform करने के लिए छोटे चिपे logic gate को देखने में आसानी है।

Types of K-Map :-

- ① 2-variable K-Map (A, B)
- ② 3-variable K-Map (A, B, C)
- ③ 4-variable K-Map (A, B, C, D)

2-variable K-map :-

① Min-term

A	B	min term
0	0	$\bar{A} \cdot \bar{B} \rightarrow m_0$
0	1	$\bar{A} \cdot B \rightarrow m_1$
1	0	$A \cdot \bar{B} \rightarrow m_2$
1	1	$A \cdot B \rightarrow m_3$

3-variable K-Map

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

$\Rightarrow$

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

Eg $\Rightarrow f = \sum m(0,3)$

Eg $\Rightarrow f = \sum m(1,3)$

$f = m_0 + m_3$

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

$f = m_1 + m_3$

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

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

$f = B$

Eg $\Rightarrow f = \sum m(0,1,2,3)$

$f = m_0 + m_1 + m_2 + m_3$

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

$f = 1$

3-variable K-Map $\Rightarrow$

Eg $\Rightarrow f = \sum m(0,1,5,7)$

Eg $\Rightarrow f = \sum m(0,1,3,5)$

$f = \sum m(0,1,5,7)$

$\overline{A}\overline{B}\overline{C}$	0	1	0	0
$\overline{A}B\overline{C}$	0	1	0	0
$A\overline{B}\overline{C}$	0	0	1	0
$AB\overline{C}$	0	0	1	0
$\overline{A}\overline{B}C$	0	0	0	1
$\overline{A}BC$	0	0	0	1
$A\overline{B}C$	0	0	1	1
ABC	0	0	1	1

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

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

Eg $\Rightarrow f = \sum m(1,3,5,7)$

Eg $\Rightarrow f = \sum m(0,2)$

$f = \sum m(1,3,5,7)$

$\overline{A}\overline{B}\overline{C}$	0	1	0	0
$\overline{A}B\overline{C}$	0	1	0	0
$A\overline{B}\overline{C}$	0	0	1	0
$AB\overline{C}$	0	0	1	0
$\overline{A}\overline{B}C$	0	0	0	1
$\overline{A}BC$	0	0	0	1
$A\overline{B}C$	0	0	1	1
ABC	0	0	1	1

$f = \sum m(0,2)$

$\overline{A}\overline{B}\overline{C}$	1	0	0	0
$\overline{A}B\overline{C}$	0	1	0	0
$A\overline{B}\overline{C}$	0	0	1	0
$AB\overline{C}$	0	0	1	0
$\overline{A}\overline{B}C$	0	0	0	1
$\overline{A}BC$	0	0	0	1
$A\overline{B}C$	0	0	1	1
ABC	0	0	1	1

$f = C$

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

Eg $\Rightarrow f = \sum m(4,5)$

Eg $\Rightarrow f = \sum m(0,2,4,6)$

$f = \sum m(4,5)$

$\overline{A}\overline{B}\overline{C}$	0	0	0	0
$\overline{A}B\overline{C}$	0	0	0	0
$A\overline{B}\overline{C}$	0	0	1	1
$AB\overline{C}$	0	0	1	1
$\overline{A}\overline{B}C$	0	0	0	0
$\overline{A}BC$	0	0	0	0
$A\overline{B}C$	0	0	1	1
ABC	0	0	1	1

$f = \sum m(0,2,4,6)$

$\overline{A}\overline{B}\overline{C}$	1	0	0	0
$\overline{A}B\overline{C}$	0	1	0	0
$A\overline{B}\overline{C}$	0	0	1	0
$AB\overline{C}$	0	0	1	0
$\overline{A}\overline{B}C$	0	0	0	1
$\overline{A}BC$	0	0	0	1
$A\overline{B}C$	0	0	1	1
ABC	0	0	1	1

$f = A\overline{C}$

$f = \overline{C}$

Eg $\Rightarrow f = \sum m(0,1,2,3)$

$f = \overline{A}$

$f = \sum m(0,1,2,3)$

$\overline{A}\overline{B}\overline{C}$	1	1	1	1
$\overline{A}B\overline{C}$	1	1	1	1
$A\overline{B}\overline{C}$	0	0	0	0
$AB\overline{C}$	0	0	0	0
$\overline{A}\overline{B}C$	0	0	0	0
$\overline{A}BC$	0	0	0	0
$A\overline{B}C$	0	0	0	0
ABC	0	0	0	0

Eg $\Rightarrow f = \sum m(0, 1, 3, 4, 5, 7)$ Eg $\Rightarrow f = \sum m(0, 1, 2, 3, 4, 5, 6, 7)$

A	BC	00	01	11	10
$\overline{A}$	$\overline{B}\overline{C}$	1	1	1	1
A	$\overline{B}C$	1	1	1	1
A	$B\overline{C}$	1	1	1	1
A	BC	1	1	1	1

$f = \overline{B} + C$ $f = 1$

Eg $\Rightarrow f = \sum m(0, 1, 2, 4, 5, 6)$

A	BC	00	01	11	10
$\overline{A}$	$\overline{B}\overline{C}$	1	1	1	1
A	$\overline{B}C$	1	1	1	1
A	$B\overline{C}$	1	1	1	1
A	BC	1	1	1	1

$f = \overline{B} + C$

3 - variable k-map methode :-

A	B	C	min terms
0	0	0	$\overline{A} \cdot \overline{B} \cdot \overline{C} \rightarrow m_0$
0	0	1	$\overline{A} \cdot \overline{B} \cdot C \rightarrow m_1$
0	1	0	$\overline{A} \cdot B \cdot \overline{C} \rightarrow m_2$
0	1	1	$\overline{A} \cdot B \cdot C \rightarrow m_3$
1	0	0	$A \cdot \overline{B} \cdot \overline{C} \rightarrow m_4$
1	0	1	$A \cdot \overline{B} \cdot C \rightarrow m_5$
1	1	0	$A \cdot B \cdot \overline{C} \rightarrow m_6$
1	1	1	$A \cdot B \cdot C \rightarrow m_7$

4 - variable k-map :-

A	BC	00	01	11	10
$\overline{A}$	$\overline{B}\overline{C}$	0	1	1	0
A	$\overline{B}C$	0	1	1	0
A	$B\overline{C}$	0	1	1	0
A	BC	0	1	1	0

A	B	C	D	min terms
0	0	0	0	$\overline{A} \cdot \overline{B} \cdot \overline{C} \cdot \overline{D} \rightarrow m_0$
0	0	0	1	$\overline{A} \cdot \overline{B} \cdot \overline{C} \cdot D \rightarrow m_1$
0	0	1	0	$\overline{A} \cdot \overline{B} \cdot C \cdot \overline{D} \rightarrow m_2$
0	0	1	1	$\overline{A} \cdot \overline{B} \cdot C \cdot D \rightarrow m_3$
0	1	0	0	$\overline{A} \cdot B \cdot \overline{C} \cdot \overline{D} \rightarrow m_4$
0	1	0	1	$\overline{A} \cdot B \cdot \overline{C} \cdot D \rightarrow m_5$
0	1	1	0	$\overline{A} \cdot B \cdot C \cdot \overline{D} \rightarrow m_6$
0	1	1	1	$\overline{A} \cdot B \cdot C \cdot D \rightarrow m_7$
1	0	0	0	$A \cdot \overline{B} \cdot \overline{C} \cdot \overline{D} \rightarrow m_8$
1	0	0	1	$A \cdot \overline{B} \cdot \overline{C} \cdot D \rightarrow m_9$
1	0	1	0	$A \cdot \overline{B} \cdot C \cdot \overline{D} \rightarrow m_{10}$
1	0	1	1	$A \cdot \overline{B} \cdot C \cdot D \rightarrow m_{11}$
1	1	0	0	$A \cdot B \cdot \overline{C} \cdot \overline{D} \rightarrow m_{12}$
1	1	0	1	$A \cdot B \cdot \overline{C} \cdot D \rightarrow m_{13}$
1	1	1	0	$A \cdot B \cdot C \cdot \overline{D} \rightarrow m_{14}$
1	1	1	1	$A \cdot B \cdot C \cdot D \rightarrow m_{15}$

$\overline{A}B$	$\overline{A}B$	CD	CD	CD
00	01	11	10	
0000	0001	0011	0010	
$\overline{A}B\overline{C}\overline{D}$	$\overline{A}B\overline{C}D$	$\overline{A}B\overline{C}D$	$\overline{A}B\overline{C}\overline{D}$	
0100	0101	0111	0110	
$\overline{A}B$	$\overline{A}B\overline{C}\overline{D}$	$\overline{A}B\overline{C}D$	$\overline{A}B\overline{C}\overline{D}$	
1100	1101	1111	1110	
$\overline{A}B\overline{C}\overline{D}$	$\overline{A}B\overline{C}D$	$\overline{A}B\overline{C}D$	$\overline{A}B\overline{C}\overline{D}$	
1000	1001	1011	1010	
$\overline{A}B\overline{C}\overline{D}$	$\overline{A}B\overline{C}D$	$\overline{A}B\overline{C}D$	$\overline{A}B\overline{C}\overline{D}$	

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

$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	CD
1	3	2		
1	3	2		
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	

$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	CD
1	3	2		
1	3	2		
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	

$f = \sum m(0, 1, 2, 3, 6, 9, 10, 11)$

$f = \sum m(0, 4, 8, 9, 10, 11, 12)$

$f = \overline{B}$

$f = \overline{C}\overline{D} + A\overline{B}$

$f = \sum m(4, 5, 6, 7, 9, 13)$

$f = \sum m(0, 1, 5, 6, 7, 8, 9)$

$(14, 15)$

$(13, 15)$

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

$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	CD
1	3	2		
1	3	2		
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	

$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	CD
1	3	2		
1	3	2		
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	

$f = \overline{A} \cdot B + B \cdot C + A \cdot \overline{C} \cdot D$

$f = B \cdot D + \overline{A} \cdot B \cdot C + \overline{C} \cdot D + \overline{A} \cdot \overline{B} \cdot C$

$f = \sum m(0, 1, 4, 5, 7, 8, 9)$

$(11, 12, 13, 15)$

$f = \sum m(0, 2, 8, 10)$

$f = \sum m(0, 2, 4, 6, 8, 10, 12, 14)$

$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	CD
1	3	2		
1	3	2		
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	

$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	CD
1	3	2		
1	3	2		
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	

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

$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	CD
1	3	2		
1	3	2		
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	
0	1	3	2	
$\overline{A}B$	$\overline{C}\overline{D}$	$\overline{C}D$	CD	

$f = \overline{C} + B\overline{D} + A\overline{D}$

Ex: $f = \sum m(5, 7, 8, 10, 11, 12, 13, 14, 15)$

	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	0	1	3	4
$\bar{A}B$	5	7	1	6
AB	13	15	11	14

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

यसको 1st Q. Boolean function को 1st map and 2nd map को बारेमा :-

$f(A, B, C) = \sum m(1, 3, 6, 7)$

	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	0	1	0	3
A	6	0	7	5

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

यसको $f(A, B, C, D) = \sum m(0, 2, 3, 7, 8, 9, 10, 11, 15)$

	$(C+D)$	$(A\bar{B})$	$(\bar{C}+D)$	$(\bar{C}+D)$
$\bar{A}\bar{B}$	0	1	3	4
$\bar{A}B$	5	7	1	6
AB	13	15	11	14

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

यसको 1st Q. Boolean function को 1st map and 2nd map को बारेमा :-

$f(A, B, C, D) = \sum m(1, 5, 6, 12, 13, 14, 15)$

$d \rightarrow$ don't care $x \rightarrow 0, 1$

	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	0	1	0	X
$\bar{A}B$	5	7	0	6
AB	13	15	0	14

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

Unit - 03

Combinational Circuit

3.1 → Half Adder, Full Adder, Half Subtractor, Full Subtractor, Parallel adder and Subtractor, BCD Adder

3.2 → Magnitude Comparator (2 and 3 bit), IC 7485 (Pin diagram and truth table)

3.3 → Encoder: 4-Input and 2-output encoder, Octal to binary and binary to BCD Encoder, BCD to binary encoder, Multiplexer: 2×1 , 4×1 and 8×1 multiplexer (IC 74151)

3.4 → Decoders: 3-line to 8-line Decoder, 4-4-2-1 BCD to Decimal Decoder, De-multiplexer: 1×2 , 1×4 and 1×8 demultiplexer

Combinational circuit

ये एक Digital circuit है जो $\bar{A}$ output, Input के Combinational Depend करता है।

Combinational Ckt में memory present नहीं है।
 यह output gate present Input के Depend करता है।

Half Adder :-

A	Half Adder	Sum
B	adder	Carry

Half Adder एक Combinational Ckt है जो दो single bit binary no. को जोड़ने के लिए use करता है।

Half Adder में दो Input (A, B) और दो output (Sum और carry) present हैं।

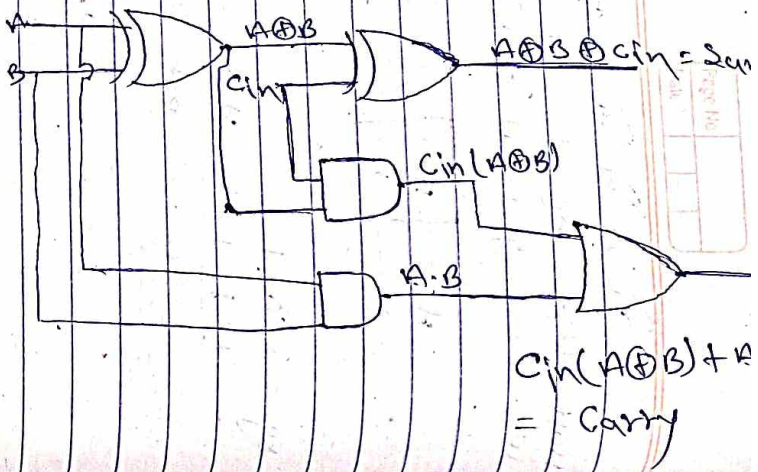
Truth table :-

A	B	Sum	Carry	min. term
0	0	0	0	m_0
1	0	1	0	m_1
2	1	0	1	m_2
3	1	1	1	m_3

Truth Table:

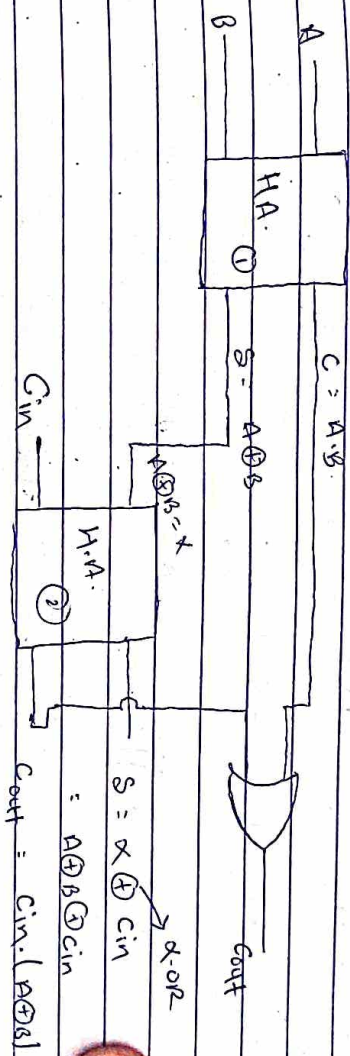
Input	Output
A B cin	S Cout
0 0 0	0 → m ₀
0 0 1	0 → m ₁
0 1 0	1 → m ₂
0 1 1	1 → m ₃
1 0 0	1 → m ₄
1 0 1	0 → m ₅
1 1 0	0 → m ₆
1 1 1	1 → m ₇

Circuit Diagram:



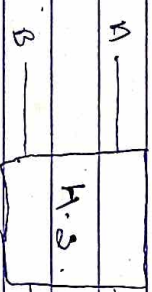
Full Adder using Half Adder

Half Adder can't use only Full Adder Design can't



Half Subtractor :-

Half Subtractor is combination ckt of two Half Adders. Single bit binary numbers ko subtract kr ke use krna hoga. Single bit Input aur (A, B) ke output Difference, Borrow.



Difference		Borrow	
A	B	Diff	Borrow
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Truth Table:

$$S = \bar{A}[\bar{B}cin + A\bar{B}cin + ABcin + A\bar{B}cin]$$

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

$$S = \bar{A}[\bar{B}cin + A\bar{B}cin + ABcin + A\bar{B}cin]$$

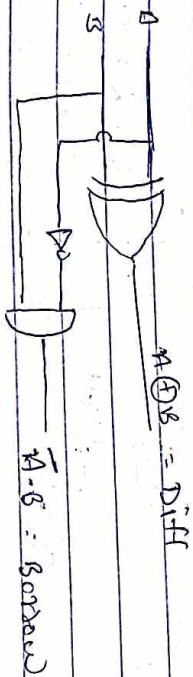
$$Cout = cin(\bar{A}B + AB) + AB$$

$$\text{Difference} = \bar{A} \cdot B + A \cdot \bar{B}$$

$$= A \oplus B$$

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

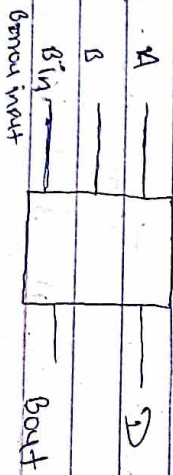
Ckt Diagram:-



Disadvantage of Half sub.

2nd bit ke liye ye borrow generate karega
 2nd bit ke liye borrow binary no. ke liye ke liye Half Sub. ko
 use krke phara kr sakenge!

Full Subtractor :-



Truth Table

A	B	Bin	Bout	Diff
0	0	0	0	0
0	0	1	1	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	0	0
1	1	1	1	1

Truth Table

Input			Output	
A	B	Bin	Bout	Diff
0	0	0	0	0
0	0	1	1	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	0	0
1	1	1	1	1

Diff :-

$$\bar{A} \cdot \bar{B} \cdot \text{Bin} + \bar{A} \cdot B \cdot \bar{\text{Bin}} + A \cdot \bar{B} \cdot \text{Bin} + A \cdot B \cdot \bar{\text{Bin}}$$

$$= \bar{A} [\bar{B} \cdot \text{Bin} + B \cdot \bar{\text{Bin}}] + A [B \cdot \text{Bin} + \bar{B} \cdot \bar{\text{Bin}}]$$

$$\text{let } = B \oplus \text{Bin} = X$$

$$\bar{A} \cdot X + A \cdot \bar{X}$$

$$= A \oplus X = A \oplus (B \oplus \text{Bin}) = \text{Diff}$$

Borrow :-

$$\bar{A} \cdot \bar{B} \cdot \text{Bin} + \bar{A} \cdot B \cdot \bar{\text{Bin}} + \bar{A} \cdot B \cdot \text{Bin} + A \cdot \bar{B} \cdot \text{Bin}$$

$$= \bar{A} [\bar{B} \cdot \text{Bin} + B \cdot \bar{\text{Bin}}] + A [B \cdot \text{Bin} + \bar{B} \cdot \text{Bin}]$$

$$= \bar{A} [B \oplus \text{Bin}] + A \cdot \text{Bin} = \text{Bout}$$

3:21 AT

$$\begin{aligned} B_{out} &= \bar{A} \cdot \bar{B} \cdot B_{in} + \bar{A} \cdot \bar{B} \cdot \bar{B}_{in} + \bar{A} \cdot B \cdot B_{in} + A \cdot B \cdot B_{in} \\ &= \bar{A} \cdot \bar{B} \cdot B_{in} + \bar{A} \cdot B \cdot (B_{in} + \bar{B}_{in}) + A \cdot B \cdot B_{in} \\ &= \bar{A} \cdot \bar{B} \cdot B_{in} + \bar{A} \cdot B + A \cdot B \cdot B_{in} \\ &= B_{in} (A \oplus B) + \bar{A} \cdot B \\ B_{out} &= \bar{A} \cdot B + B_{in} (A \oplus B) \end{aligned}$$

HA

$$S = A \oplus B$$

$$C = A \cdot B$$

FA

$$S = A \oplus B \oplus C_{in}$$

$$C = A \cdot B + C_{in} (A \oplus B)$$

HA

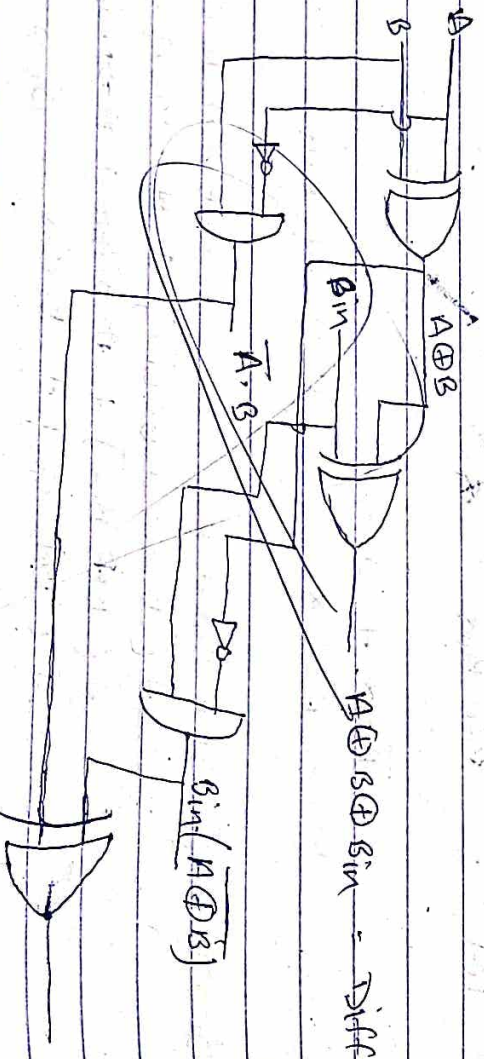
$$S = A \oplus B$$

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

FS

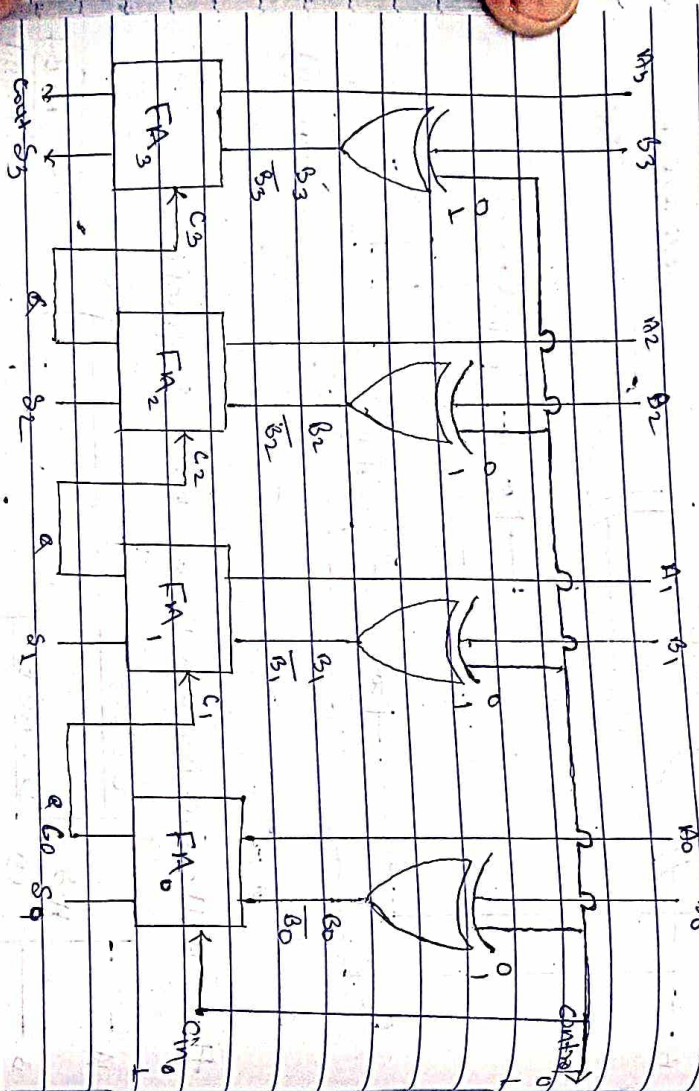
$$S = A \oplus B \oplus B_{in}$$

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



A.B

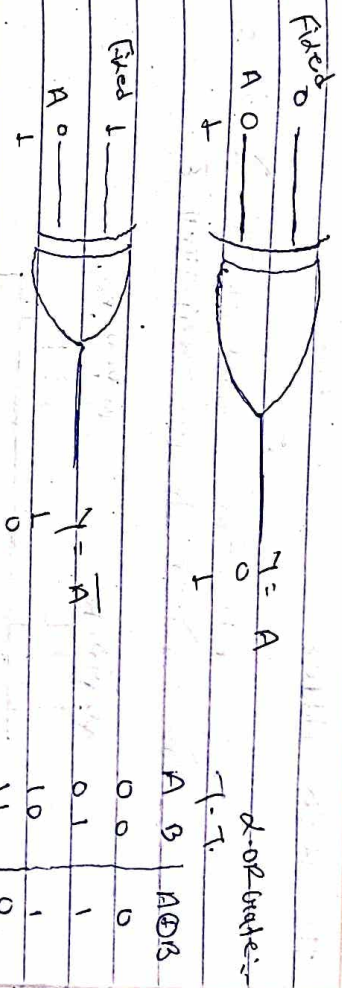
41 Parallel Adder and Subtractor :-



Parallel adder and Sub. is Digital Ckt is
function use only binary no. or just give value in
decimal is

इसमें एक Control Input होता है जिसकी मदद से
यह एक जोड़ने की या घटाने की (Add or Subtract) कर सकेगा
है। Binary Control Input की value 0 होनी चाहिए जो

X-OR Gate :-



Conclusion :- Binary X-OR Gate का एक Input 0 और दूसरा
Input 1 को Output 1 मिलेगा।

यदि X-OR Gate का एक Input 1 और दूसरा
Input 1 को Output 0 मिलेगा।

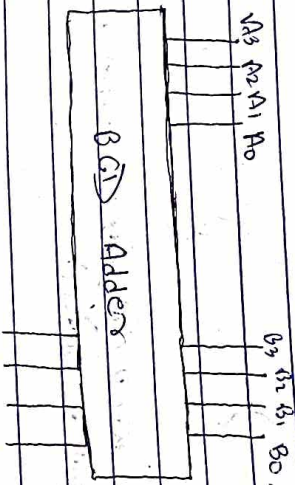
Circuit Adder की तरह काम करेगा क्योंकि यह Binary Control
Input की value 1 होनी चाहिए जो एक Subtractor को तब
करेगा

Advantage :-

इसका Design Simple होता है और
इसमें no. of logic gate की संख्या कम होती है।

BCD Adder :-

BCD Adder एक Digital circuit है जो दो BCD numbers को जोड़ने के लिए use किया जाता है



Decimal	BCD	Function	13	14	15
0	0000	0	01101	1	
1	0001	0	1110	1	
2	0010	0	1111	1	
3	0011	0			
4	0100	0			
5	0101	0			
6	0110	0			
7	0111	0			
8	1000	0			
9	1001	0			
10	1010	1			
11	1011	1			
12	1100	1			

Invalid BCD

Step For BCD Addition :-

1. दो 4-bit BCD number को Add करके इसके से 4-bit का sum प्राप्त होगा।
2. Check करें कि sum valid है कि नहीं अगर sum 9 से बड़े का होगा तो answer valid BCD होगा।
3. अगर sum 9 से अधिक होगा तो answer invalid होगा। इस case में invalid answer प्राप्त करने के लिए 6 (0110) Add कर दिया जाएगा।

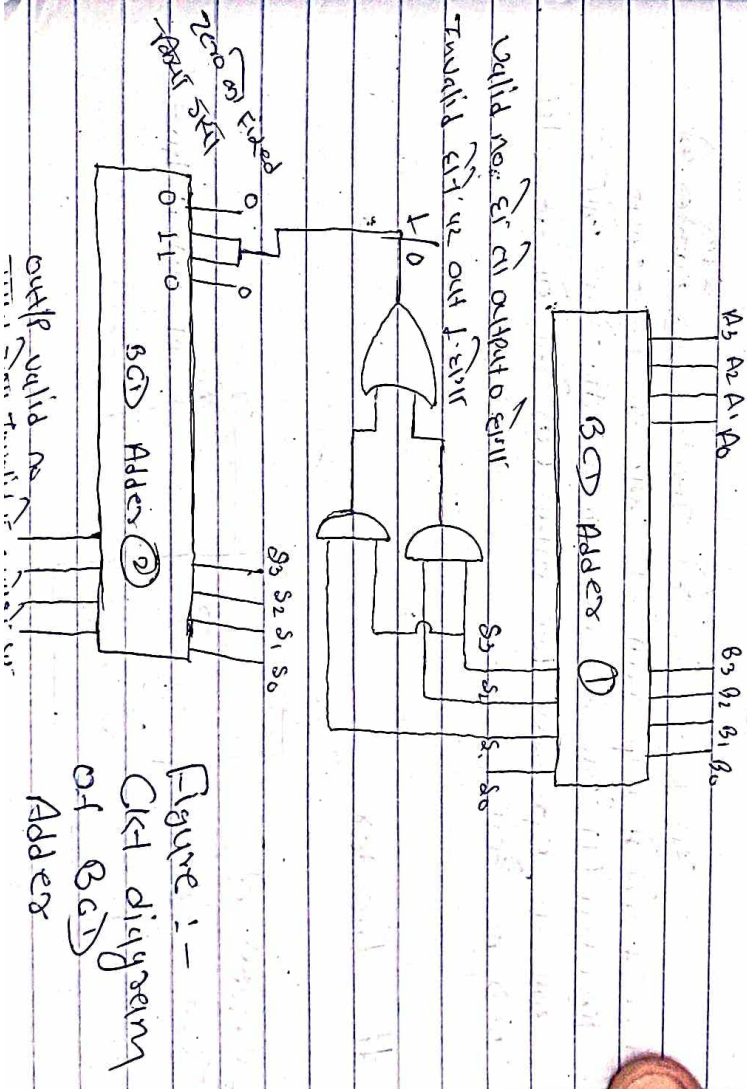


Figure :-
Ckt diagram of BCD Adder

2180
8552

	0	1	2	3
0	0	0	0	0
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0

$$f = S_3S_2 + S_3S_1$$

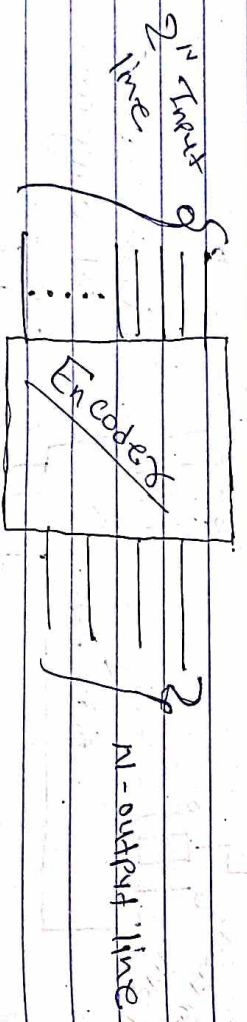
2nd Expression है Invalid BCD ~~अपवैध~~ ^{अवैध}

Detect करें में Help करता है 3012 2nd Expression

High output (1) है 011 की BCD no. Invalid-है 011 और

3012 2nd Expression low output (0) है 011 की 2nd valid BCD no. है 011

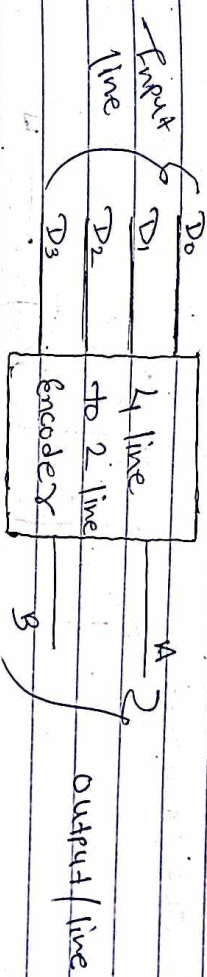
Encoder :-



Encoder का Combination circuit है ^{2nd Input} lines ^{4th Input} है 3rd N output line ^{4th Input} है

Encoder Information को Code में Convert करता है

Generally Encoder Information को Compare करता है



Input Table :-

Input	D ₀	D ₁	D ₂	D ₃	Output	A	B
0	0	0	0	0	0	0	0
1	0	1	0	0	0	1	1
2	0	0	1	0	1	1	0
3	0	0	0	1	1	1	1

4. line to 2 line encoder में 4-bit binary Information को 2-bit में Information में Convert करती है

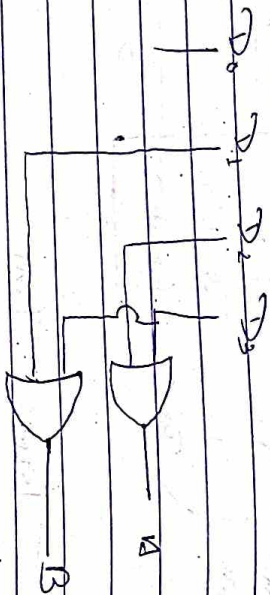
Encoder :- 4 inputs to 2 outputs
 line 01: Single 3-bit line
 single 7-bit line (b)

Equation output line

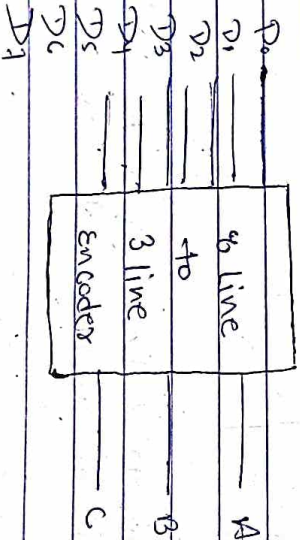
$$A = D_2 + D_3$$

$$B = D_1 + D_3$$

Ckt diagram :-



8-line to 3-line Encoder :-
 or octal to binary Encoder :-



Truth Table :-
 Input

D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	A	B	C
1	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	1	0
0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	0	1	0	1	1	0
0	0	0	0	0	0	0	1	1	1	1

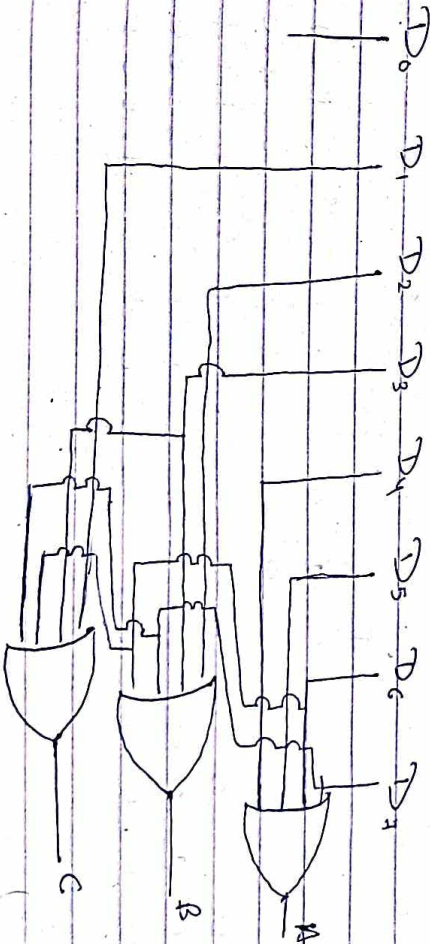
Output line equation

$$A = D_4 + D_5 + D_6 + D_7$$

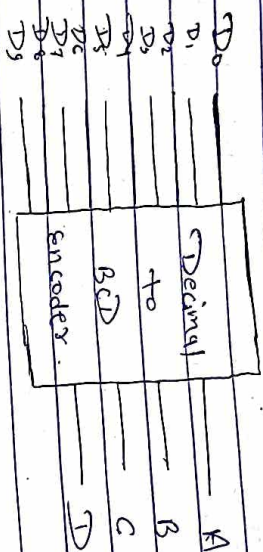
$$B = D_2 + D_3 + D_6 + D_7$$

$$C = D_1 + D_3 + D_5 + D_7$$

Ckt diagram :-



Decimal to BCD encoder :



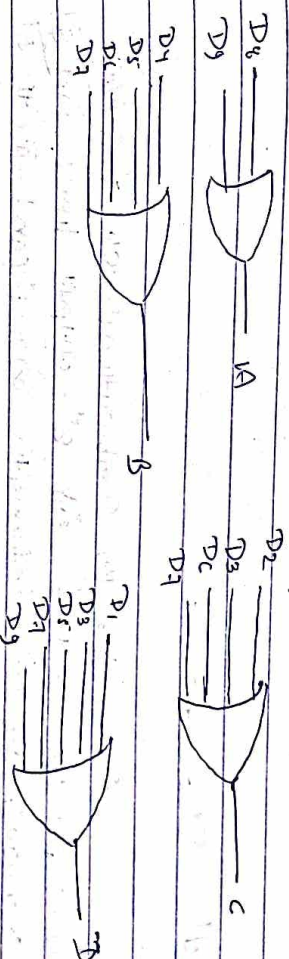
840 Input H 10 line 312 output H 4 line
 840 2

Fairy Tale

	Input										Output			
	D ₀	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇	D ₈	D ₉	N	B	C	D
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	1	0	0	0	0	0	0	0	0	0	1	1
0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	1	0	0	0	0	0	0	1	0	1
0	0	0	0	0	0	1	0	0	0	0	0	1	1	0
0	0	0	0	0	0	0	1	0	0	0	0	1	1	1
0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	1	0	1	0	0	1

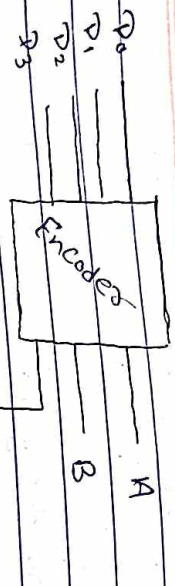
Output line Equation :-

$$A = D_8 + D_9 \quad B = D_4 + D_5 + D_6 + D_7$$



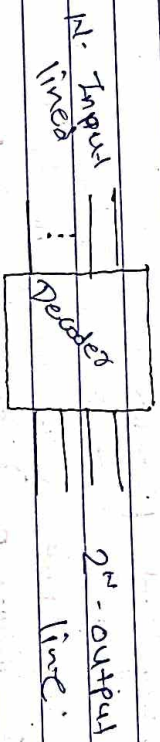
* Disadvantage of Encoder :

- ① - कोई भी Encoder 1 के बिना भी Input में signal नहीं दिया जाएगा जो output line invalid binary no. देता।
ये Invalid binary no. से show करेगा कि Input line DO में signal दिया गया है।
- ② DO की Condition से output के लिए output में एक Extra line (Design को जाता है) और $V = 0$ होगा इसका मतलब Input line में कोई signal नहीं दिया गया है और $DO = 1$ है तो इसका मतलब Input line में signal दिया गया है।
- ③ फिर दो-दो के पार्श्व Input line में एक साथ signal दिया जाएगा जो Encoder अपना Result Show करेगा और Encoder अभी भी work नहीं करेगा।



Decoder :-

Decoder is a combinational circuit which takes n input lines and gives 2^n output lines. Generally, decoders information given. Expand circuit is



2-line to 4-line Decoder :-
or 2-Input and 4-output Decoder :-



2-Input Decoder - 4 Output line (A, B) - 2² = 4 output line (D0, D1, D2, D3) - 2² = 4

Truth Table :-

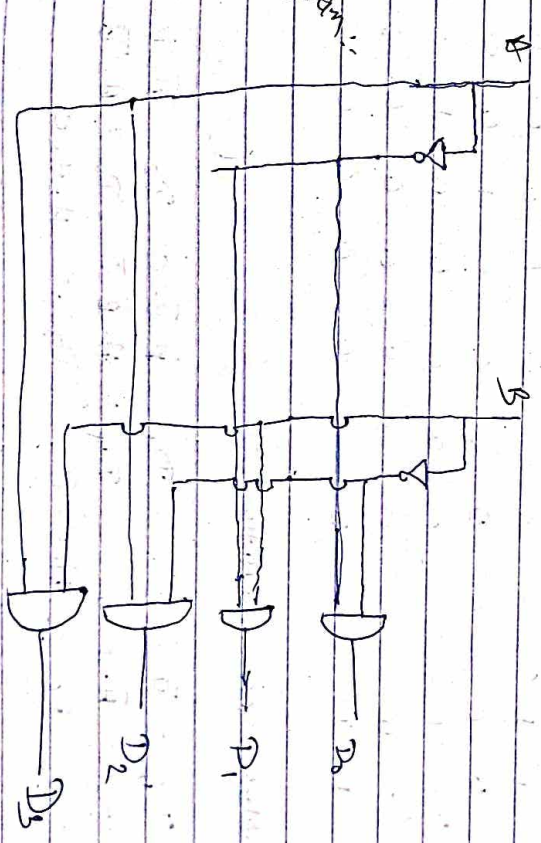
Input		Output			
A	B	D ₀	D ₁	D ₂	D ₃
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

Output Expression Equation :-

$$D_0 = \bar{A} \cdot \bar{B} \quad D_1 = \bar{A} \cdot B$$

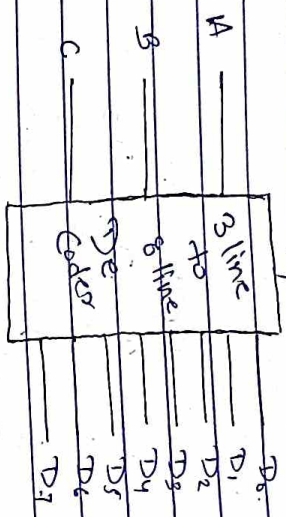
$$D_2 = A \cdot \bar{B} \quad D_3 = A \cdot B$$

Circuit Diagram :-



H. 3 line to 8 line Decoder

Binary to Octal Converter

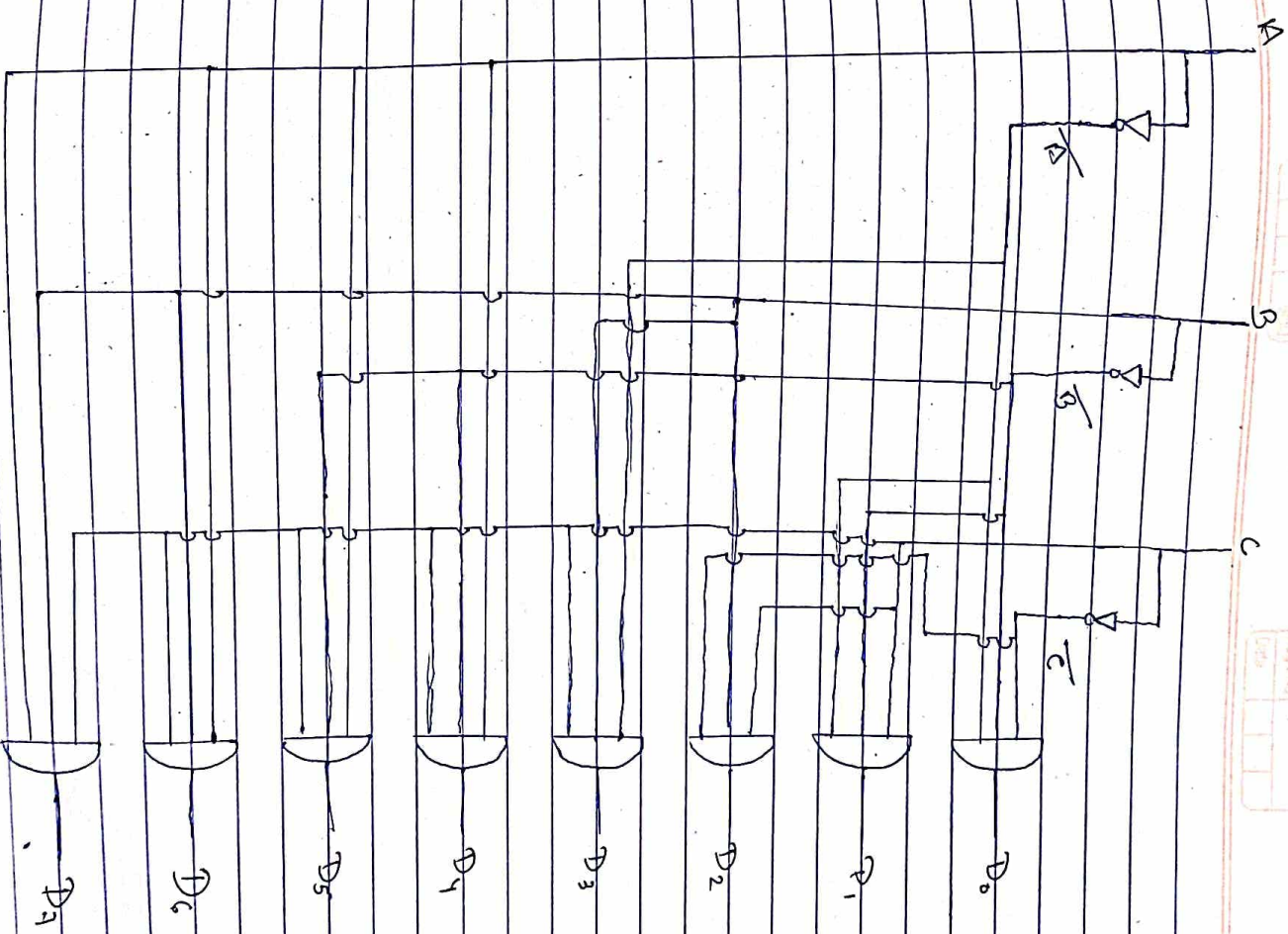


Truth Table :-

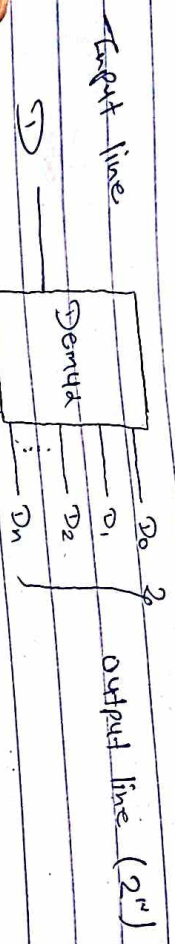
Input			Output							
A	B	C	D ₀	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1

Output line Equation :-

$D_0 = \bar{A} \cdot \bar{B} \cdot \bar{C}$ $D_1 = \bar{A} \cdot \bar{B} \cdot C$ $D_2 = \bar{A} \cdot B \cdot \bar{C}$
 $D_3 = \bar{A} \cdot B \cdot C$ $D_4 = A \cdot \bar{B} \cdot \bar{C}$ $D_5 = A \cdot \bar{B} \cdot C$
 $D_6 = A \cdot B \cdot \bar{C}$ $D_7 = A \cdot B \cdot C$

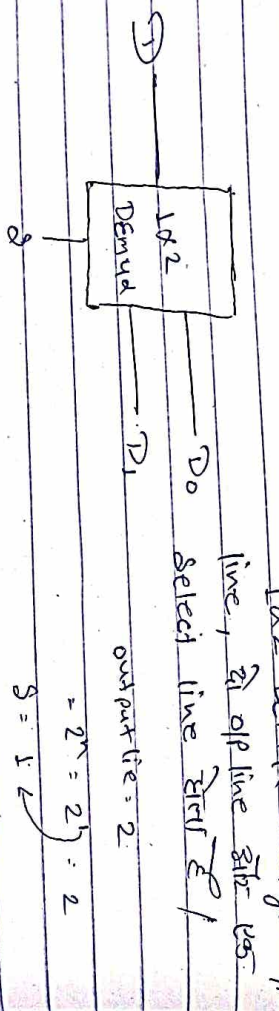


Demultiplexer (Demux) :-



Select line
Demultiplexer is combination circuit which is given single input line, multiple output line (or) single select line and multiple output or input or connect with it.

1 x 2 Demultiplexer :-



Truth table

Input	S	D ₀	D ₁
0	0	0	0
1	1	0	1

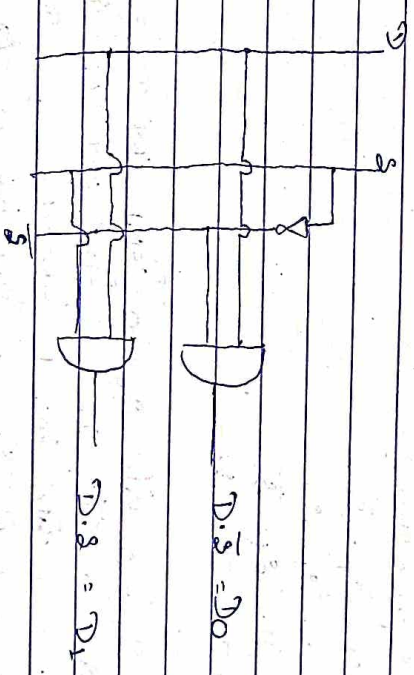
When select line of value $S = 0$ then the output line D_0 input to output connect with it. $D_0 = D$ (input)

When $S = 1$ then the output line D_1 input to output connect with it. $D_1 = D$ (input)

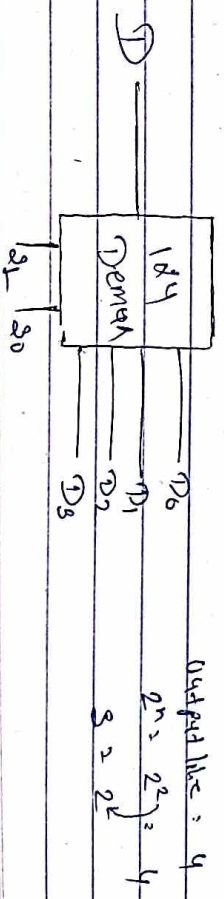
Output expression :-

$D_0 = D \cdot \bar{S}$
 $D_1 = D \cdot S$

Circuit Diagram :-



1 x 4 Demultiplexer :-



1x4 Decoder to combination circuit
 2 select line S_1, S_0
 4 output line D_0, D_1, D_2, D_3

Truth Table

Input	Select line	Output
	S_1 S_0	D_0 D_1 D_2 D_3
0	0 0	1 0 0 0
1	0 1	0 1 0 0
2	1 0	0 0 1 0
3	1 1	0 0 0 1

output expression :-

$$D_0 = \overline{S_1} \cdot \overline{S_0}$$

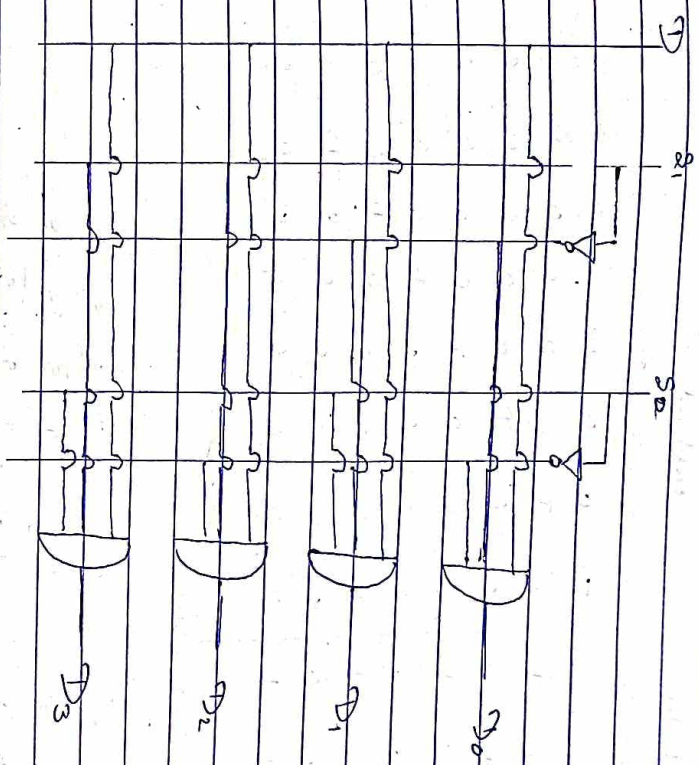
$$D_1 = \overline{S_1} \cdot S_0$$

$$D_2 = S_1 \cdot \overline{S_0}$$

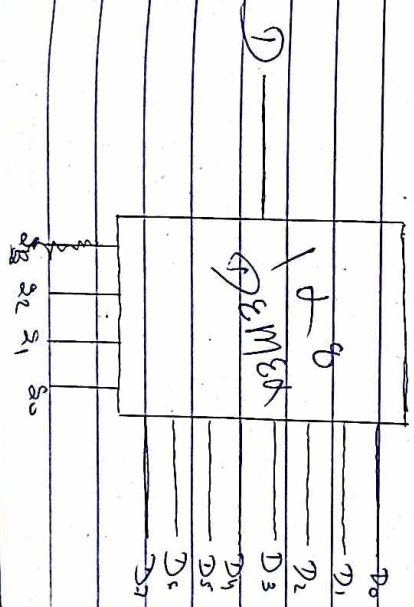
$$D_3 = S_1 \cdot S_0$$

when $S_1 = 0, S_0 = 0$ then $D_0 = 1$ and $D_1 = 0$
 when $S_1 = 0, S_0 = 1$ then $D_1 = 1$ and $D_0 = 0$
 when $S_1 = 1, S_0 = 0$ then $D_2 = 1$ and $D_3 = 0$
 when $S_1 = 1, S_0 = 1$ then $D_3 = 1$ and $D_2 = 0$

Circuit Diagram:-



1x4 Demultiplexer:-



Truth Table :-

Input	Select line	Output															
	S_2	S_1	S_0	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7						
0	0	0	0	0	0	0	0	0	0	0	0						
1	0	0	1	0	0	0	0	0	0	0	0						
2	0	1	0	0	0	0	0	0	0	0	0						
3	0	1	1	0	0	0	0	0	0	0	0						
4	1	0	0	0	0	0	0	0	0	0	0						
5	1	0	1	0	0	0	0	0	0	0	0						
6	1	1	0	0	0	0	0	0	0	0	0						
7	1	1	1	0	0	0	0	0	0	0	0						

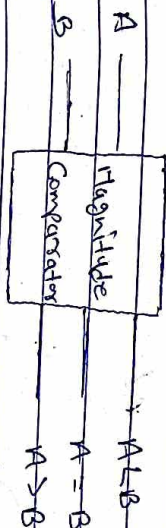
Output expression :-

$$\begin{aligned}
 D_0 &= D_0 \cdot \overline{S_2} \cdot \overline{S_1} \cdot \overline{S_0} & D_1 &= D_0 \cdot \overline{S_2} \cdot \overline{S_1} \cdot S_0 \\
 D_2 &= D_0 \cdot \overline{S_2} \cdot S_1 \cdot \overline{S_0} & D_3 &= D_0 \cdot \overline{S_2} \cdot S_1 \cdot S_0 \\
 D_4 &= D_0 \cdot S_2 \cdot \overline{S_1} \cdot \overline{S_0} & D_5 &= D_0 \cdot S_2 \cdot \overline{S_1} \cdot S_0 \\
 D_6 &= D_0 \cdot S_2 \cdot S_1 \cdot \overline{S_0} & D_7 &= D_0 \cdot S_2 \cdot S_1 \cdot S_0
 \end{aligned}$$

Circuit Diagram :-

Magnitude Comparator :-

ये एक Combination Ckt है जो 2 binary no. को Compare करके जो रिजल्ट देता है उसे Magnitude Comparator कहते हैं।



1-bit Comparator :-

1-bit Comparator को use करके single bit binary no. को Compare करने के लिए use किया जाता है।

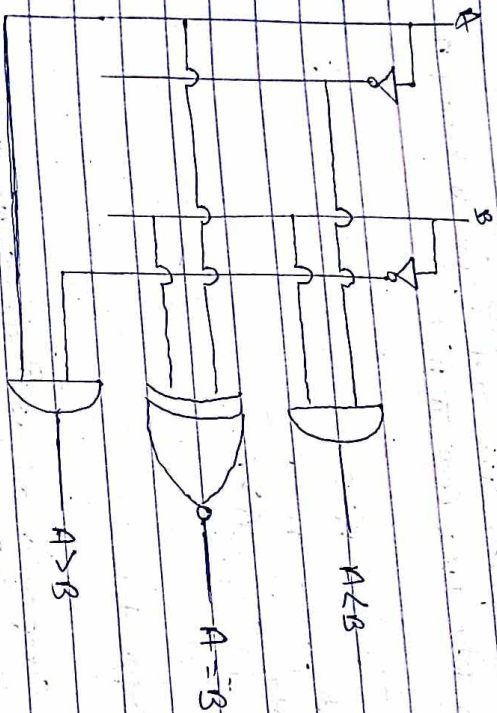
Truth Table :-

A	B	$A < B$	$A = B$	$A > B$
0	0	0	1	0
0	1	1	0	0
1	0	0	0	1
1	1	0	1	0

Output Expression :-

$$\begin{aligned}
 Y(A < B) &= \overline{A} \cdot B \\
 Y(A = B) &= \overline{A} \cdot \overline{B} + A \cdot B = A \odot B \text{ (XNOR gate)} \\
 Y(A > B) &= A \cdot \overline{B}
 \end{aligned}$$

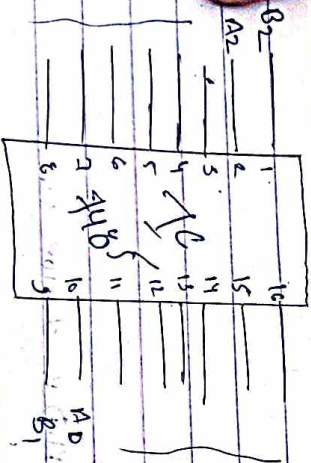
Ckt Diagram :-



IC 7485 :- IC Integrated Ckt

IC 7485, चार bit binary no. को Compare करे के लिए use किया जाता है। इसे Total 16 pin होते हैं।

binary no. A = A₃ A₂ A₁ A₀
और binary no. B = B₃ B₂ B₁ B₀



IC 7485 को Supply देने के लिए +Vcc में signal दिया जाता है।

Pin Diagram

Pin Configuration

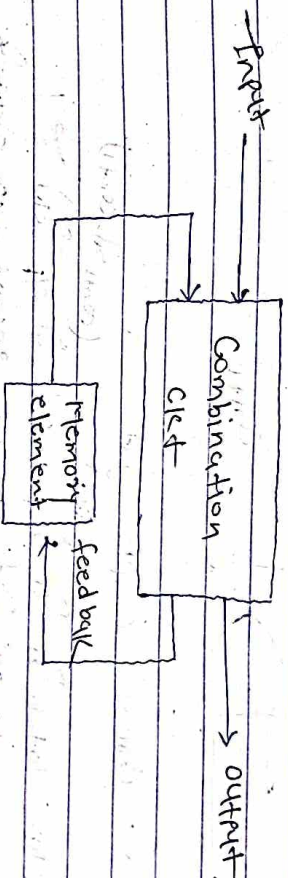
B ₃	=	1	V _{cc}	=	16
A ₂	=	2	A ₃	=	15
(A = B) out	=	3	B ₃	=	14
(A > B) in	=	4	(A > B) out	=	13
(A < B) in	=	5	(A < B) out	=	12
(A = B) in	=	6	B ₀	=	11
A ₁	=	7	A ₀	=	10
Ground	=	8	B ₁	=	9

A < B, A = B और A > B में एक साथ में दोनो पिन पर 1 signal प्राप्त होता है। चार bit को Compare करने के लिए सबसे महत्वपूर्ण (most significant bit) को Compare किया जाता है।

Sequential Circuit

Sequential ckt :-

Combination ckt in output depends on present input & dependent on the past sequential ckt in output depends on present input & past output & it is dependent on the past.



- Sequential ckt in memory element present in the memory element we use information to store data in the past output.
- Latch & flip flop are use memory element of the circuit.

- # Latch :- Latch Design is the universal gate with the help of the NAND gate we use the latch.
- Latch Cross-coupled gate circuit.

NOR latch :-

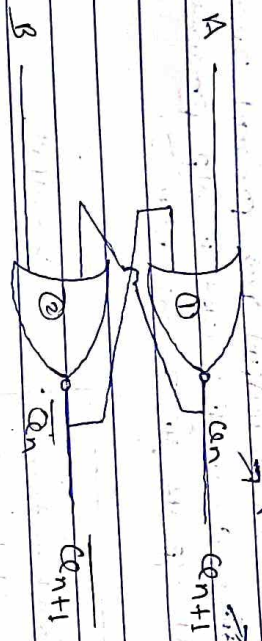


Figure :- Cross-Coupled gate

NOR latch में दो input और दो output हैं।
 First NOR-Gate को जोड़ें उस TIP second NOR-Gate के output से connect करें। और second NOR-Gate को जोड़ें उस TIP first NOR-Gate के output से connect करें।
 जोड़ें हैं उसीलिए इसे Cross-Coupled gate कहते हैं।

A, B → present TIP of latch

Q_{nt1} → Normal output / main output / Present output

Q_{nt1} → Complemented output

Q_n → Past output

$\overline{Q_n}$ → Complemented Past output

State of latch and Flip Flop :-

① HOLD State - $Q_{nt1} = Q_n$

② SET State HOLD State में present output of value Past output से compare करेंगे

Example :- यदि $Q_n = 0$ और $Q_{nt1} = 0$
 $Q_{nt1} = 1$ और $Q_{nt1} = 1$

② SET State - $Q_{nt1} = 1$

यदि present output of value 1 प्राप्त होगा तो latch SET State में होगा।

③ RESET State - $Q_{nt1} = 0$

यदि present output of value 0 होगा तो latch RESET State में होगा।

④ Invalid State - $Q_{nt1} = \overline{Q_{nt1}}$

यदि Normal output और Complemented output of value equal होगा तो latch Invalid State में होगा।

⑤ Toggle state $a_{n+1} = \bar{a}_n$

જો present o/p, past o/p નો complement એ
equal હોય તો latch Toggle state માં હોય/

Example - જો $a_n = 0$ તો $a_{n+1} = \bar{a}_n = 1$
 $a_n = 1$ તો $a_{n+1} = 0$