DIGITAL AND COMMUNICATION ELECTRONICS

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UNIT:-1
NUMBER SYSTEMS

INTRODUCTION:-

Binary number systems and digital codes are very essential in computers and digital electronics

In this unit we will study different types of number systems such as binary,decimal,octal,hexadecimal,excess-3-code,BCD,GRAY code etc. Also we will study how to convert these numbers from one form of number system into another i.e. Interconversion of number system.

Also we will study 1's compliment representation and 2's compliment representation of numbers. Then we will study binary arithmetic i.e. addition, subtraction, multiplication and division of binary numbers. Having the knowledge of "Binary Arithmetic" we can basically understand the working of computers or other digital systems.

DECIMAL NUMBER SYSTEM:-

Decimal numbers are the numbers that we use in our daily life. This number system has digits used from 0,1,2,3,4,5,6,7,8 and 9 , therefore BASE or RADIX of decimal number system is **10**.

Ex:- $(534)_{10}$

In above example 534 is the number and 10 is the base of the number system used.

How to find Equivalent Weight of a Decimal Digit:-

Decimal number system is a "weighted number system" that means each digit or number of the decimal number system have a fixed weightage .Lets study how to find out the **Equivalent Weight of a Decimal Digit .**

The weightage of Decimal numbers starts from 10^0 , 10^1,10^2,10^3….. so on from right to left for whole numbers and for fractional numbers negative powers of 10 from left to right

i.e 10^{-1}, 10^{-2} ,10^{-3},10^{-4} ….so on

It can be shown as below

……10^3,10^2,10^1,10^0 **.** 10^{-1}, 10^{-2} ,10^{-3},10^{-4} ….

The point separating fractional and whole part of the numbers is the **Decimal Point**.

For example :-

In the number $(432)_{10}$,Right most digit 2 is called as the Least significant bit i.e. L.S.B. having the lowest weightage, and the digit 4 is called as the most significant bit i.e. M.S.B. having the highest weightage.

The Equivalent weight of the above decimal number can be determined as the follow,

4	3	2
↓	↓	↓
10^2	10^1	10^0
↓	↓	↓
100	10	1
↓	↓	↓
4x100=400	3x10=30	2x1=2

i.e. 400+30+2= 432 is the decimal number with its sum values of each digit.

Q. Calculate the weight of the digits of the following number.

1) $(65)_{10}$

Ans:-

6	5
↓	↓
10^1	10^0
↓	↓
10	1
↓	↓

6x10=60   5x1=5

i.e. Weight of digit 6 is 60 and weight of unit digit 5 is 5.Therefore the number formed is, 60 + 5= 65.

2) $(23.5)_{10}$

Ans:-

2	3	.5
↓	↓	↓
10^1	10^0	10^{-1}
↓	↓	↓
10	1	0.1
↓	↓	↓
2x10=20	**3x1=3**	**5x0.1=0.5**

i.e. 20+3+0.5= 23.5 is the number formed

Hence equivalent weight of the digit 2 is 20, digit 3 is 3 and digit 5 is 0.5

Binary Numbers System :-Computer only knows language of Binary Number system therefore, Binary numbers are very essential in computer and digital codes. All the programming of the computer is done in the form of binary number system.

In **Binary numbers** only **digits 0 and 1** are used. Hence **Base** or Radix of a binary number is **2**.

Largest Binary number which can be formed using given "n" number of binary digits is given by, **(2^n-1)**.

e.g. If **4 binary digits** are given then Largest binary number formed is , Here **n=4,**

2^4-1 = 16-1 = **15**.

Hence , by using **4 binary digits** a **largest binary number 15** can be formed.

e.g. **$(110001)_2$** is a binary number. Here 2 is the base of the given binary number.

In this given binary number **$(110001)_2$** the rightmost digit 1 is having the least weightage called as the least significant bit i.e. **L.S.B.** and the left most digit 1 is having the highest weightage and called as the most significant bit i.e. **M.S.B.**

Binary number system is also a weighted number system. i.e. Each digit of a binary number is having a fixed weightage. **Weightage** of the **binary number increases from right to left** for the whole number as,

..... $2^3 \leftarrow 2^2 \leftarrow 2^1 \leftarrow 2^0$

For the fractional part of binary number weightage decreases from left to right as,

. $2^{-1} \rightarrow 2^{-2} \rightarrow 2^{-3} \rightarrow 2^{-4}$.......

Equivalent Weight of a Binary Number :-

If a given binary number is **$(1101)_2$ then its equivalent weight is,**

1	**1**	**0**	**1**
↓	↓	↓	↓
2^3	**2^2**	**2^1**	**2^0**
↓	↓	↓	↓
8	4	2	1
↓	↓	↓	↓
1x8=8	1x4=4	0x2=0	1x1=1

Hence, the equivalent weight of right most digit i.e. LSB is $2^0 = 1$

And the equivalent weight of the left most digit i.e MSB is $2^3 = 8$

DECIMAL NUMBER	BINARY NUMBER
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

BINARY ARITHEMETIC :-

In the binary arithmetic we will study ,
(a) Addition of two Binary Numbers
(b) Subtraction Of Two Binary Numbers
(c) Multiplication Of Two Binary Numbers
(d) Division Of Two Binary Numbers

Now first we will study how to add two binary numbers ,

(a) Addition of two Binary Numbers

Rules Of Binary Addition :

				CARRY	SUM
0	+	**0**	=	**0**	**0**
0	+	**1**	=	**0**	**1**
1	+	**0**	=	**0**	**1**
1	+	**1**	=	**1**	**0**

Ex:- (1) -

```
   1 1   ⟶  CARRY
 1 0 0 1
   + 1 1
 -------
 1 1 0 0 ⟶  SUM
```

Ex:- (2) -

```
 1 0 0 0
   + 1 0
 -------
 1 0 1 0 ⟶  SUM
```

Ex:- (3) -

```
 1 1 0 0
   + 1 1
 -------
 1 1 1 1 ⟶  SUM
```

(b) Subtraction of two Binary Numbers

Rules Of Binary Subtraction:

			SUBTRACTION	BORROW
0	-	0 =	0	0
0	-	1 =	1	1
1	-	0 =	1	0
1	-	1 =	0	0

Ex:- (1) -

```
 1 0 1 1
   - 1 1
--------
 1 0 0 0  ⟶  SUBTRACTION
```

Ex:- (2) -

```
 1 1 1 1
  -1 0 0
--------
 1 0 1 1  ⟶  SUBTRACTION
```

Ex:- (3) - Subtract (**11**)$_2$ from (**110**)$_2$

```
    10  10 ⟶   BORROW
  1̸   1̸   0
     - 1   1
------------
       1   1 ⟶ SUBTRACTION
```

Ex:- (3) - Subtract (**100**)$_2$ from (**1000**)$_2$

```
    10        ⟶   BORROW
  1̸   0   0   0
     - 1   0   0
----------------
       1   0   0 ⟶ SUBTRACTION
```

(c) Multiplication of two Binary Numbers :-

Rules Of Binary Multiplication:

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

Ex (1):-

```
      1 1 0
    x   1 1
    -------
      1 1 0
  + 1 1 0 x
  ---------
  1 0 0 1 0
```

Ex (2):-

```
    1 1 1 0
    x   1 0
    -------
    0 0 0 0
 +1 1 1 0 x
 ----------
  1 1 1 0 0
```

Ex (3):-

```
      1 0 0
    x   1 0
    -------
      0 0 0
  + 1 0 0 x
  ---------
    1 0 0 0
```

(d) Division of two Binary Numbers :-

Ex. 1:- 1000 ÷ 10

Ans:-

```
              0  1  0  0      ──► Quotient
Diviser ◄── 10 ) 1  0  0  0   ──► Dividend
              -1  0
              ─────
               0  0  0
                -0  0
                ─────
                 0  0  0
               - 0  0
                 ─────
                 0  0         ──► Rimiander
```

Ex. 2:- 1100 ÷ 11

Ans:-

```
              0  1  0  0      ──► Quotient
Diviser ◄── 11 ) 1  1  0  0   ──► Dividend
              -1  1
              ─────
               0  0  0
                -0  0
                ─────
                 0  0  0
               - 0  0
                 ─────
                 0  0         ──► Rimiander
```

Ex. 3:- 1111 ÷ 11

Ans:-

```
              0  1  0  1      ──► Quotient
Diviser ◄── 11 ) 1  1  1  1   ──► Dividend
              -1  1
              ─────
               0  0  1
                -0  0
                ─────
                 0  1  1
                  -1  1
                  ─────
                   0  0       ──► Rimiander
```

Conversion Of Decimal Numbers to Binary numbers :-
There are two methods by which we can convert the given decimal number to its equivalent binary numbers,

1) Successive Division Method

2) Adding of Weights Method

We will first study how to convert a given decimal number to its equivalent binary number by Successive Division Method.

1)Conversion Of Decimal Numbers to Binary numbers by Successive Division Method :-

To convert a given decimal number to its equivalent binary number by successive division method following steps are to be followed,

STEP (1) :- Divide the given decimal number by 2

STEP (2) :-Then the first reminder generated is our first digit(L.S.B.) of a required binary number

STEP (3) :-Now divide the quotient by 2 and write down the reminder as the second digit of required binary number

STEP (4) :-Repeat above step no(3) until we get the **Quotient "0"** at last

STEP (5) :-Then the last reminder generated after getting the reminder zero is the last digit **(M.S.B.)** of our required binary number

STEP (6) :-Now write down all the reminders generated from right to left, starting from LSB To MSB

Ex: Convert the given Decimal number to its Binary equivalent

(1) $(23)_{10} \longrightarrow (\ ?\ )_2$

Number	Quotient	Reminder	Steps To be followed
$\frac{23}{2}$	11	8 (LSB)	Divide the number 23 by 2 and write reminder as LSB of a required Binary Number
$\frac{11}{2}$	5	1	Now divide the quotient 11 by 2, Reminder is 1
$\frac{5}{2}$	2	1	Divide the quotient 5 by 2, Reminder is 1
$\frac{2}{2}$	1	0	Divide the quotient 2 by 2, Reminder is 0
$\frac{1}{2}$	0	8 (MSB) no.	Divide the quotient 1 by 2, Reminder is 1 and this last reminder is our MSB of required binary

Write down the above reminders produced from top to bottom . First reminder is LSB and last reminder is MSB of required binary number,

i.e. $(1\quad 0\quad 1\quad 1\quad 1)_2$

MSB ↓ (first digit) LSB ↓ (last digit)

Ans:- $(23)_{10} = (10111)_2$

(2) $(17)_{10} \longrightarrow (\ ?\ )_2$

Number	Quotient	Reminder	Steps To be followed
$\frac{17}{2}$	8	8 (LSB)	Divide the number 17 by 2 and write reminder as LSB of a required Binary Number
$\frac{8}{2}$	4	0	Now divide the quotient 8 by 2, Reminder is 0
$\frac{4}{2}$	2	0	Divide the quotient 4 by 2, Reminder is 0
$\frac{2}{2}$	1	0	Divide the quotient 2 by 2, Reminder is 0
$\frac{1}{2}$	0	8 (MSB) no.	Divide the quotient 1 by 2, Reminder is 1 and this last reminder is our MSB of required binary

Write down the above reminders produced from top to bottom . First reminder is LSB and last reminder is MSB of required binary number,

i.e. (1 0 0 0 1 $)_2$

MSB (1) ↓ LSB (1) ↓

Ans:- **$(17)_{10} = (10001)_2$**

Method-2:- **Adding of Weights method**

To convert a given decimal number to its equivalent binary number , write down the given decimal number in the form of addition of numbers which are whole powers of 2 .

Then write down the position of that numbers as 1 if number is absent then write down 0 at the respective positions.

Ex.(1) $(15)_{10} = (?)_2$

Ans:-

Write down 15 in the form of whole powers of 2

15 = 8+4+2+1

$= 2^3 + 2^2 + 2^1 + 2^0$

2^0 is the unit place or LSB of the required binary number

2^1 is the 2^{nd} place the required binary number

2^2 is the 3^{rd} place the required binary number

2^3 is the 4^{th} place or the MSB of the required binary number

Hence the required binary equivalent of the given decimal number 15 is ,

1	1	1	1
MSB	3^{rd} place	2^{nd} place	LSB

$(15)_{10} = (1111)_2$

Ex:- 2) $(33)_{10} = (?)_2$

Ans:-

33 = 32 + 1

$= 2^5 + 2^0$

Hence Unit place or LSB and MSB positions are only present in the required binary number and write down "0" at the positions which are absent in above addition of weights

i.e. $(33)_{10} = (100001)_2$

Conversion Of Binary Numbers to Decimal numbers :-

To convert Binary Numbers to Decimal numbers just add the equivalent weights of all binary digits.

Ex.1- $(1010)_2 = (\ ?\ )_{10}$

Ans:

First write down the digits of the given binary numbers, then add their equivalent weights

1	**0**	**1**	**0**
↓	↓	↓	↓
2^3	**2^2**	**2^1**	**2^0**
↓	↓	↓	↓
8	4	2	1
↓	↓	↓	↓
1x8=8	0x4=0	1x2=2	0x1=0

Addition of equivalent weights = Required decimal numbers

= 8+0+2+0

= $(10)_{10}$

Ans: - $(1010)_2 = (\ 10\ )_{10}$

Ex.2- $(1110)_2 = (\ ?\ )_{10}$

Ans:

First write down the digits of the given binary numbers, then add their equivalent weights

1	**1**	**1**	**0**
↓	↓	↓	↓
2^3	**2^2**	**2^1**	**2^0**
↓	↓	↓	↓
8	4	2	1
↓	↓	↓	↓
1x8=8	1x4=4	1x2=2	0x1=0

Addition of equivalent weights = Required decimal numbers

= 8+4+2+0

= $(14)_{10}$

Ans: - $(1110)_2 = (14)_{10}$

Octal Number System:-

In Octal number system 8 digits are used from 0,1,2,3,4,5,6 and 7 ,hence the base of octal numbers is 8.

Each Octal digit is representing a group of three binary digits

Ex:- $(267)_8$

In above example 267 is the **octal number** and **8** is the base of the number system used.

DECIMAL NUMBER	BINARY NUMBER	OCTAL NUMBER
0	000	0
1	001	1
2	010	2
3	011	3
4	100	4
5	101	5
6	110	6
7	111	7
8	001 000	10
9	001 001	11
10	001 010	12
11	001 011	13
12	001 100	14
13	001 101	15
14	001 110	16
15	001 111	17

How to find Equivalent Weight of a Octal Digit:-

Octal number system is a "weighted number system" that means each digit or number of the Octal number system have a fixed weightage .Lets study how to find out the **Equivalent Weight of a Octal Digit .**

The weightage of Octal numbers starts from 8^0, 8^1,8^2,8^3….. so on from right to left for whole numbers and for fractional numbers negative powers of 8 from left to right

i.e 8^{-1}, 8^{-2} ,8^{-3},8^{-4} ….so on
It can be shown as below
……8^3,8^2,8^1,8^0 **.** 8^{-1}, 8^{-2} ,8^{-3},8^{-4} ….
The point separating fractional and whole part of the numbers is the **Octal Point**.

For example :-

In the **number** $\mathbf{(471)_8}$,

Right most digit **1** is called as the **Least significant bit i.e. L.S.B.** having the **lowest weightage,** and the digit 4 is called as the most significant bit i.e. M.S.B. having the highest weightage.

The Equivalent weight of the above Octal number can be determined as the follow,

4	7	1
↓	↓	↓
10^2	10^1	10^0
↓	↓	↓
100	10	1
↓	↓	↓
4x100=400	7x10=70	1x1=1

i.e. **400+70+1= 471** is the **Octal number** with its sum values of each digit.

Conversion Of Octal Numbers to Decimal numbers :-To convert a given Octal number to its decimal equivalent we have to add the equivalent weights of the each Octal digit

Ex.1) $\mathbf{(25)_8 = (?)_{10}}$

Ans:- 2 5

↓ ↓

8^1 8^0

↓ ↓

8 1

↓ ↓

2x8=16 5x1=5

i.e. Weight of digit 2 is 16 and weight of unit digit 5 is 5.

Therefore the number formed is , 16 + 5= $(21)_{10}$

Ans. $\mathbf{(25)_8 = (21)_{10}}$

Ex.2) $(364)_8 = (?)_{10}$

Ans:- 3 6 4

↓ ↓ ↓

8^2 8^1 8^0

↓ ↓ ↓

64 8 1

↓ ↓ ↓

3x64=192 6x8=48 4x1=4

i.e. 192+48+4= 244 is the required decimal number of given octal number

Ans. $\mathbf{(364)_8 = (244)_{10}}$

Conversion Of Octal Number to Binary Number :-

Each Octal digit is representing a group of three binary digits. So to convert a given octal number to its Binary equivalent, replace each Octal digit by its group of three binary digits

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

Ex.1) $(56)_8 = (?)_2$

Ans:- 5 → 101, 6 → 110

$(56)_8 = (101\ 110)_2$

Ex.2) $(123)_8 = (?)_2$

Ans:-

1 → 001, 2 → 010, 3 → 011

i.e. $(123)_8 = (001\ \ 010\ \ 011)_2$

Conversion Of Binary Number to Octal Number :-

A Group of three binary digits is representing an Octal Digit So to convert a given Binary number to its Octal equivalent, replace the group of three binary digits by its Octal Equivalent

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

Ex.1) $(101011)_2 = (?)_8$

Ans:-

Step 1 :- First write down the given binary digits

1 0 1 0 1 1

Step 2 :- Now make a group of three binary digits from right to left

1 0 1   0 1 1

←   ←

Step 3 :- Each group of these three binary digits is representing an Octal digit

1 0 1   0 1 1

5   3

Hence , the required octal number is $(53)_8$

Ans:- $(101011)_2 = (53)_8$

Ex.2) (01101001)$_2$ = (?)$_8$

Ans:-

<u>Step 1</u> :- First write down the given binary digits

0 1 1 0 1 0 0 1

<u>Step 2</u> :- Now make a group of three binary digits from right to left

0 0 1   1 0 1   0 0 1

← ← ←

<u>Step 3</u> :- Each group of these three binary digits is representing an Octal digit

0 0 1	1 0 1	0 0 1
1	**5**	**1**

Hence , the required octal number is (151)$_8$

Ans:- **(01101001)$_2$ = (151)$_8$**

Conversion Of Decimal Numbers to Octal numbers :-

Ex.(1) :- $(39)_{10} = (?)_8$

To convert a given decimal number into its octal equivalent following steps are to be followed,

Step 1 :-First convert a given decimal number into its binary equivalent number by successive division method.

Number	Quotient	Reminder	Steps To be followed
$\frac{39}{2}$	19	1 (LSB)	Divide the number 39 by 2 and write reminder as LSB of a required Binary Number
$\frac{19}{2}$	9	1	Now divide the quotient 19 by 2, Reminder is 1
$\frac{9}{2}$	4	1	Divide the quotient 9 by 2, Reminder is 1
$\frac{4}{2}$	2	0	Divide the quotient 4 by 2, Reminder is 0
$\frac{2}{2}$	1	0	Divide the quotient 2 by 2, Reminder is 0
$\frac{1}{2}$	0	1 (MSB) no.	Divide the quotient 1 by 2, Reminder is 1 and this last reminder is our MSB of required binary

$(39)_{10} = (100111)_2$

Step 2 :- Then write down the given binary digits

1 0 0 1 1 1

Step 3 :- Now make a group of three binary digits from right to left

1 0 0   1 1 1

Step 4 :- Each group of these three binary digits is representing an Octal digit

1 0 0   1 1 1

4   7

Ans:- $(39)_{10} = (47)_8$

Ex.(1) :- $(33)_{10} = (?)_8$

To convert a given decimal number into its octal equivalent following steps are to be followed,

Step 1 :-First convert a given decimal number into its binary equivalent number by successive division method.

Number	**Quotient**	**Reminder**	**Steps To be followed**
$\frac{33}{2}$	16	1 (LSB)	**Divide the number 33 by 2 and write reminder as LSB of a required Binary Number**
$\frac{16}{2}$	8	0	**Now divide the quotient 16 by 2, Reminder is 0**
$\frac{8}{2}$	4	0	**Divide the quotient 8 by 2, Reminder is 0**
$\frac{4}{2}$	2	0	**Divide the quotient 4 by 2, Reminder is 0**
$\frac{2}{2}$	1	0	**Divide the quotient 2 by 2, Reminder is 0**
$\frac{1}{2}$	0	1 (MSB) no.	**Divide the quotient 1 by 2, Reminder is 1 and this last reminder is our MSB of required binary**

$(33)_{10} = (100001)_2$

Step 2 :- Then write down the given binary digits

1 0 0 0 0 1

Step 3 :- Now make a group of three binary digits from right to left

1 0 0 ← **0 0 1** ←

Step 4 :- Each group of these three binary digits is representing an Octal digit

1 0 0 → **4** **0 0 1** → **1**

Ans:- $(33)_{10} = (41)_8$

Hexadecimal Number System :-

Hexadecimal number system is an **Alphanumeric** weighted number system.

In hexadecimal number system digits **0,1,2,3,4,5,6,7,8, 9** and alphabets **A,B,C,D,E** and **F** are used.

So in total **16** symbols are used to represent a **Hexadecimal** number. Hence the **base** or **radix** of the **Hexadecimal** number is **16**

DECIMAL NUMBER	BINARY NUMBER	HEXADECIMAL NUMBER
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

How to find Equivalent Weight of a Hexadecimal Digit:-

Hexadecimal number system is a "weighted number system" that means each digit or number of the Hexadecimal number system have a fixed weightage .Lets study how to find out the **Equivalent Weight of a Octal Digit .**

The weightage of Hexadecimal numbers starts from **16^0 , 16^1,16^2,16^3**….. so on from **right to left** for **whole numbers** and for **fractional** numbers **negative** powers of **16** from **left to right**

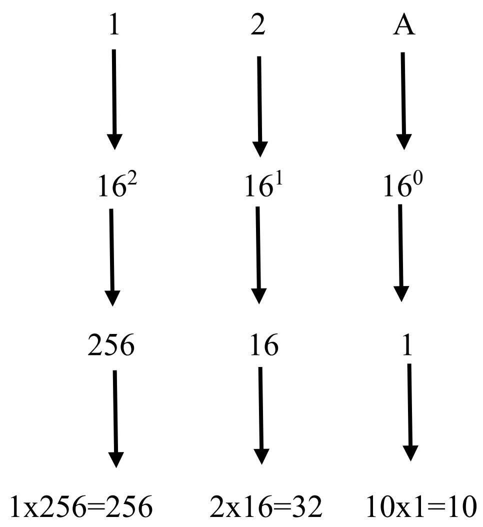
i.e **16^{-1}, 16^{-2} ,16^{-3},16^{-4}** ….so on
It can be shown as below
……**16^3,16^2,16^1,16^0 . 16^{-1}, 16^{-2} ,16^{-3},16^{-4}** ….
The **point** separating **fractional** and **whole** part of the numbers is the **Hex. Point**.

For example :-

In the number **(12A)$_{16}$**,

Right most 'A' is called as the **Least significant bit** i.e. **L.S.B.** having the **lowest weightage**, and the **digit 1** is called as the **most significant bit** i.e. **M.S.B.** having the **highest weightage**.

The **Equivalent weight** of the above **Hexadecimal number** can be determined as the follow,



i.e. **256+32+10 = 298 is the Hexadecimal number with its sum values of each digit.**

Conversion Of Hexadecimal Number System To Decimal Number System:-

To Convert a given Hexadecimal Number To Decimal Number we have to add the equivalent weights of the each Hexadecimal digit

Ex.1) $(11)_{16} = (?)_{10}$

Ans:-

1	1
↓	↓
16^1	16^0
↓	↓
16	1
↓	↓
1x16=16	1x1=1

Therefore the number formed is , 16 + 1= $(17)_{10}$

$(11)_{16} = (17)_{10}$

Ex.2) $(2A5)_{16} = (?)_{10}$

Ans:-

2	A	5
↓	↓	↓
16^2	16^1	16^0
↓	↓	↓
256	16	1
↓	↓	↓
2x256=512	10x16=160	5x1=5

Therefore the number formed is , 512 + 160+ 5 = $(677)_{10}$

Conversion Of Decimal Number System To Hexadecimal Number System:-

A **group** of **four binary digits** represents a **Hexadecimal digit**

BINARY NUMBER	HEXADECIMAL NUMBER
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Ex.1:- $(67)_{10} = (?)_{16}$

To convert a given decimal number into its Hexadecimal equivalent following steps are to be followed,

Step 1 :-First convert a given decimal number into its **binary equivalent** number by successive division method.

Number	Quotient	Reminder	Steps To be followed
$\frac{67}{2}$	33	1 (LSB)	Divide the number 67 by 2 and write reminder as LSB of a required Binary Number
$\frac{33}{2}$	16	1	Now divide the quotient 33 by 2, Reminder is 1
$\frac{16}{2}$	8	0	Divide the quotient 16 by 2, Reminder is 0
$\frac{8}{2}$	4	0	Divide the quotient 8 by 2, Reminder is 0
$\frac{4}{2}$	2	0	Divide the quotient 4 by 2, Reminder is 0
$\frac{2}{2}$	1	0	Divide the quotient 2 by 2, Reminder is 0
$\frac{1}{2}$	0	1 (MSB) no.	Divide the quotient 1 by 2, Reminder is 1 this last reminder is our MSB of required binary

$(67)_{10} = (1000011)_2$

Step 2 :- Then write down the given binary digits

1 0 0 0 0 1 1

Step 3 :- Now make a group of four binary digits from right to left

0 1 0 0   0 0 1 1

← ←

Step 4 :- Each group of these four binary digits is representing an Hexadecimal digit

0 1 0 0   0 0 1 1

4   3

Ans:- $(67)_{10} = (43)_{16}$

Ex.2:- **(88)$_{10}$ = (?)$_{16}$**

To convert a given decimal number into its Hexadecimal equivalent following steps are to be followed,

Step 1 :-First convert a given decimal number into its binary equivalent number by successive division method.

<u>Number</u>	Quotient	Reminder	Steps To be followed
$\frac{88}{2}$	44	0 (LSB)	Divide the number 88 by 2 and write reminder as LSB of a required Binary Number
$\frac{44}{2}$	22	0	Now divide the quotient 44 by 2, Reminder is 0
$\frac{22}{2}$	11	0	Divide the quotient 22 by 2, Reminder is 0
$\frac{11}{2}$	5	1	Divide the quotient 11 by 2, Reminder is 1
$\frac{5}{2}$	2	1	Divide the quotient 5 by 2, Reminder is 1
$\frac{2}{2}$	1	0	Divide the quotient 2 by 2, Reminder is 0
$\frac{1}{2}$	0	1 (MSB) no.	Divide the quotient 1 by 2, Reminder is 1 this last reminder is our MSB of required binary

(88)$_{10}$ = (1011000)$_2$

<u>**Step 2**</u> :- Then write down the given binary digits

1 0 1 1 0 0 0

<u>**Step 3**</u> **:-** Now make a group of four binary digits from right to left

0 1 0 1 ← **1 0 0 0 ←**

<u>**Step 4**</u> :- Each group of these four binary digits is representing a Hexadecimal digit

0 1 0 1 → **5**

1 0 0 0 → **8**

Ans:- **(88)$_{10}$ = (58)$_{16}$**

Conversion Of Hexadecimal Number System To Binary Number System:-

Each **hexadecimal digit** is representing a **group of four binary digits**. So to convert a given hexadecimal number to its equivalent binary number write down the corresponding binary group of each hexadecimal digit.

BINARY NUMBER	HEXADECIMAL NUMBER
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Ex .(1):- $(F275)_{16} = (?)_2$

Ans: F → 1111, 2 → 0010, 7 → 0111, 5 → 0101

F	2	7	5
↓	↓	↓	↓
1111	0010	0111	0101

Ans:- $(F275)_{16} = (1111001001110101)_2$

Ex .(2):- $(B26A)_{16} = (?)_2$

Ans:

B 2 6 A

↓ ↓ ↓ ↓

1011 0010 0101 1010

Ans:- $(F275)_{16} = (1011001001011010)_2$

<u>Conversion Of Binary Number System To Hexadecimal Number System:-</u>

A group of four binary digits represents a Hexadecimal digit. So to convert the Binary number to its equivalent Hexadecimal number, replace the Each group of four binary numbers to its equivalent Hexadecimal digit.

Ex.1:- $(101000100011)_2 = (?)_{16}$

Ans:

First write down the given Binary number and make a group of four binary digits from right to left

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

← ← ←

Now each group of four binary digits is representing a Hexadecimal digit

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

A   2   3

Ans:- $(101000100011)_2 = (A23)_{16}$

Conversion Of Hexadecimal Number System To Octal Number System:-

To convert a given Hexadecimal number to its equivalent Octal number first convert the given Hexadecimal number to its equivalent binary number.

Then convert that **Binary** number to **octal** number by making **group of three binary** digits from **right to left**.

DECIMAL NUMBER	BINARY NUMBER	OCTAL NUMBER	HEXADECIMAL NUMBER
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Ex:-1) $(77)_{16}$ = (?)$_8$

Ans: First convert the given Hexadecimal number to its equivalent binary number

7 → 0111, 7 → 0111

0111 0111

Write down above binary number and make a group of three binary numbers from right to left

001 110 111

1 6 7

Ans: $(77)_{16}$ = (167)$_8$

Ex:-2) $(C307)_{16}$ = (?)$_8$

Ans: First convert the given Hexadecimal number to its equivalent binary number.

C → 1100, 3 → 0011, 0 → 0000, 7 → 0111

1100 0011 0000 0111

Write down above binary number and make a group of three binary numbers from right to left

001 100 001 100 000 111

1 4 1 4 0 7

Ans: $(C307)_{16}$ = (141407)$_8$

Conversion Of Octal Number System To Hexadecimal Number System:-

Step-1: To convert the given **Octal** number to its equivalent **Hexadecimal** number, first convert the given **octal** number to its **binary** equivalent

Step-2: Then make a **group of four binary digits** from **right to left**.

Step-3: Now each group of four binary numbers represents a hexadecimal digit

Ex. (1):- $(564)_8 = (?)_{16}$

Ans :

First convert the given octal number to its binary equivalent

5	6	4
↓	↓	↓
101	110	100

Then make a group of four binary digits from right to left

0001	0111	0100
1	7	4

Ans:- **$(564)_8 = (174)_{16}$**

Ex. (2):- $(777)_8 = (?)_{16}$

Ans :

First convert the given octal number to its binary equivalent

7	7	7
↓	↓	↓
111	111	111

Then make a group of four binary digits from right to left

0001	1111	1111
1	F	F

Ans:- **$(777)_8 = (1FF)_{16}$**

BINARY CODED DECIMAL (BCD) NUMBER SYSTEM:-

In Binary Coded Decimal (BCD) number system each decimal digit is represented as the group of 4 bit binary number. In the group of 4 bit Binary digits **MSB** is having weight **8** ,then 3rd bit is having weight **4**, 2nd bit having weight **2** and LSB is having weight **1.**

Hence BCD code is also called as 8421 number system

DECIMAL NUMBER	BCD or 8421 Code
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	0001 0000
11	0001 0001
12	0001 0010
13	0001 0011
14	0001 0100
15	0001 0101

Ex.1) $(237)_{10}$ = (? $)_{BCD}$

Ans: In the conversion of **Decimal to BCD** number system **each decimal digit** is represented as the **4 bit binary number** as,

2	3	7
↓	↓	↓
0010	0011	0111

Ans:- **$(237)_{10}$ = (0010 0011 0111 $)_{BCD}$**

Ex.2) $(3468)_{10}$ = (? $)_{BCD}$

Ans: In the conversion of **Decimal to BCD** number system each **decimal digit** is represented as the **4 bit binary** number as,

3	4	6	8
↓	↓	↓	↓
0011	0100	0110	1000

Ans:- **(3468 $)_{10}$ = (0011 0100 0110 1000 $)_{BCD}$**

Excess-3-Code:

Excess-3-Code is a **Non weighted** number system . In which we **add three (0011)** to a given **decimal number** or in the number which we are asked to convert into **Ex-3 code**.

DECIMAL NUMBER	BCD or 8421 Code	Excess-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

Ex. (1) :- (45)$_{10}$ = (?)$_{Ex-3}$

Ans:- 4 5

↓ ↓

BCD:- 0100 0101

+ 0011 + 0011

Excess-3-code- 0111 1000

(45)$_{10}$ = (0111 1000)$_{Ex-3}$

Ex. (2) :- (384)$_{10}$ = (?)$_{Ex-3}$

Ans:- 3 8 4

↓ ↓ ↓

BCD:- 0110 1000 0100

Add 3:- + 0011 + 0011 +0011

Excess-3-code- 0110 1011 0111

(384)$_{10}$ = (0110 1011 0111)$_{Ex-3}$

<u>GRAY Code :-</u>

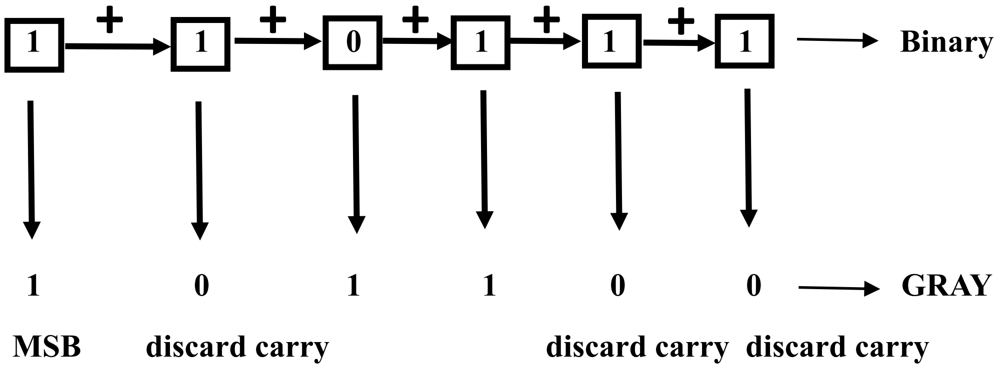
GRAY code is the non weighted number system.

In GRAY code , we change only one bit at a time

Conversion Of Binary to GRAY code :-

Ex:- 1) (110111)$_2$ = (?)$_{GRAY}$

Ans:-



Step 1:- First write down the digits of the given binary numbers separately

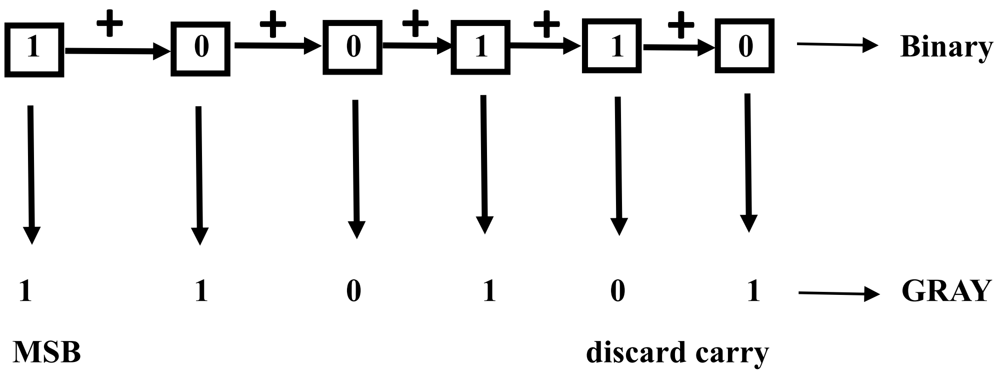
Step 2 :-Then write down MSB of the given binary number as it is

Step 3 :-Now add the pair of adjacent bits of the given binary numbers and discard the carry generated

Ans :- (110111)$_2$ = (101100)$_{GRAY}$

Ex:- 2) (100110)$_2$ = (?)$_{GRAY}$

Ans:-

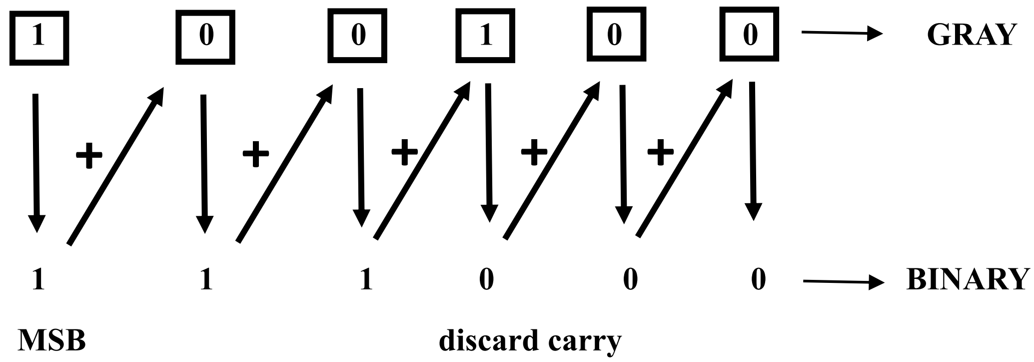


Ans :- (100110)$_2$ = (110101)$_{GRAY}$

Conversion Of GRAY to BINARY code :-

Ex:- 1) (100100)$_{GRAY}$ = (?)$_2$

Ans:-



Step 1:- First write down the digits of the given GRAY code separately

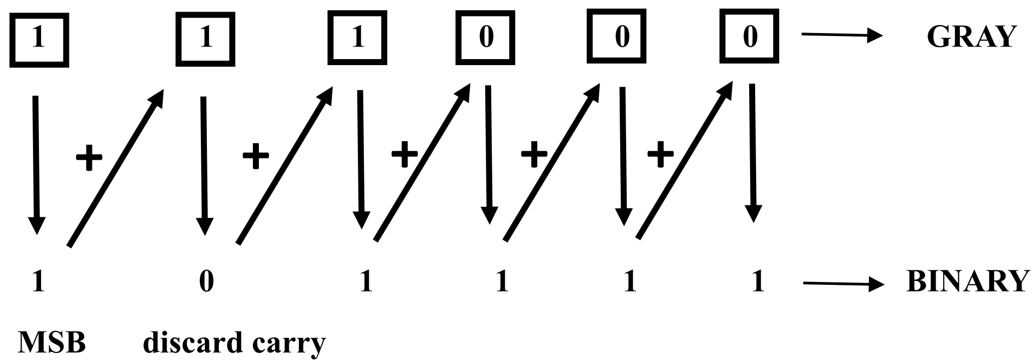
Step 2 :-Then write down MSB of the given GRAY Code as it is

Step 3 :-Now diagonally add the Binary digit generated to the adjacent bit of the given GRAY Code and discard the carry generated

Ans:- (100100)$_{GRAY}$ = (?)$_2$

Ex:- 2) (111000)$_{GRAY}$ = (?)$_2$

Ans:-



Step 1:- First write down the digits of the given GRAY code separately

Step 2 :-Then write down MSB of the given GRAY Code as it is

Step 3 :-Now diagonally add the Binary digit generated to the adjacent bit of the given GRAY Code and discard the carry generated

Ans:- (100100)$_{GRAY}$ = (101111)$_2$

1's Compliment Representation :-

To get **One's Compliment** of a given binary number, replace **'1'** of the given binary number by **'0'** and **'0'** of the given binary number by **'1'**

Ex.1:- Find the 1's Compliment of (1100011)$_2$

Ans:- Replace 1 by o and 0 by 1 of the given binary number to get the **1's Compliment complement**

1	**1**	**0**	**0**	**0**	**1**	**1**	→ **Binary No.**
↓	↓	↓	↓	↓	↓	↓	
0	**0**	**1**	**1**	**1**	**0**	**0**	→ **1's Comp.**

Ans:- 1's Compliment of (1100011)$_2$ is (0011100)

Ex.2:- Find the 1's Compliment of (1010101)$_2$

Ans:- Replace 1 by o and 0 by 1 of the given binary number to get the **1's Compliment complement**

1	**0**	**1**	**0**	**1**	**0**	**1**	→ **Binary No.**
↓	↓	↓	↓	↓	↓	↓	
0	**1**	**0**	**1**	**0**	**1**	**0**	→ **1's Comp.**

Ans:- 1's Compliment of (1010101)$_2$ is (0101010)

2's Compliment Representation :-

To get **Two's Compliment** of a given binary number, First find out **1's Compliment** of the given binary number then **add '1'** to the obtained **1's Compliment**

Ex.1:- Find the 2's Compliment of (1110001 $)_2$

Ans:- Replace 1 by o and 0 by 1 of the given binary number to get the **1's Compliment complement**

1	1	1	0	0	0	1	→ **Binary No.**
↓	↓	↓	↓	↓	↓	↓	
0	0	0	1	1	1	0	→ **1's Comp.**

1's Compliment of (1110001 $)_2$ is (0001110)

Now to get **2's Compliment** add **'1'** to the above **1's Compliment** obtained

```
  0  0  0  1  1  1  0   ——→  1's Compliment
                 +  1
  ————————————————————
  0  0  0  1  1  1  1   ——→  2's Compliment
```

Ans:- **2's Compliment of (1110001 $)_2$ is (0 0 0 1 1 1 1)**

Ex.2:- Find the 2's Compliment of (1000011 $)_2$

Ans:- Replace 1 by o and 0 by 1 of the given binary number to get the **1's Compliment complement**

1	0	0	0	0	1	1	→ **Binary No.**
↓	↓	↓	↓	↓	↓	↓	
0	1	1	1	1	0	0	→ **1's Comp.**

1's Compliment of (1000011 $)_2$ is (0111100)

Now to get **2's Compliment** add '1' to the above **1's Compliment** obtained

0	**1**	**1**	**1**	**1**	**0**	**0**	⟶	**1's Compliment**
					+	**1**		
0	**1**	**1**	**1**	**1**	**0**	**1**	⟶	**2's Compliment**

Ans:- **2's Compliment of (1000011)$_2$ is (0 1 1 1 1 0 1)**

Unit-2

LOGIC GATES

In this unit we will study ,

AND GATE

OR GATE

NOT GATE

NAND GATE

NOR GATE

EX-OR GATE

EX-NOR GATE

UNIVERSAL PROPERTIES OF NAND GATE AND NOR GATE

BOOLEAN OPERATIONS

LOGIC EXPRESSIONS FOR 2,3 AND 4 INPUTS

LAWS OF BOOLEAN ALGEBRA

DE'MORGEN'S THEOREMS

SOP FORM OF BOOLEAN EXPRESSIONS

SIMPLIFICATION OF BOOLEAN EXPRESSION USING K-MAPS(UP TO 4 VARIABLES)

HALF ADDER

FULL ADDER

First we will study the basic gates as **NOT , AND , OR** gates , their Logic Symbol , it's Logic Operation ,TRUTH Tables

BASIC GATES :-

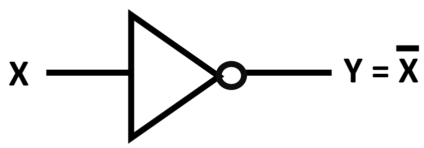
NOT , AND , OR are called as the **BASIC GATES**

1)NOT Gate :-

NOT Gate is also called as **INVERTER GATE ,** because whatever input given to the NOT gate it **Inverts** the given input.

NOT GATE has only **ONE INPUT** and **ONE OUTPUT**

Logical Symbol of the **NOT GATE** is shown here,



LOGIC SYMBOL OF NOT GATE

Operation Of NOT GATE :-

Operation Of NOT gate is given as, $Y = \overline{X}$

Where , **‘X’** is Input given to the **NOT** gate and **‘Y’** is **OUTPUT** provided by the **NOT** gate

i.e. If we provide **INPUT HIGH** or **‘1’** to the NOT gate then it gives **OUTPUT LOW** or **‘0’**

and If we provide **INPUT LOW** or **‘0’** to the NOT gate then it gives **OUTPUT HIGH** or **‘1’**

TRUTH Table of **NOT** GATE is given as,

INPUT	OUTPUT
0	1
1	0

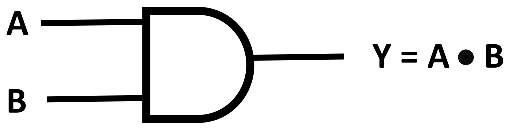
2)AND Gate :-

AND GATE is one of the basic gates

It is used for **MULTIPLICATION** operation which is shown by **dot (●)**

AND GATE have **TWO INPUTS** and **ONE OUTPUT**

Logical Symbol of the **AND GATE** is shown here,



LOGIC SYMBOL OF AND GATE

TRUTH Table Of 2 INPUT AND gate is given below :-

INPUTS		OUTPUT
A	B	Y = A● B
0	0	0
0	1	0
1	0	0
1	1	1

Operation Of AND GATE :-

If one of the **INPUTS** of the **AND** gate is **LOW** or **'0'** then **OUTPUT** of the **AND** gate is **LOW** or **'0'**

AND gate gives **HIGH** or **'1' OUTPUT** only when **BOTH** the **INPUTS** are **HIGH or '1'**

TRUTH Table Of 3 INPUT AND gate is given below :-

INPUTS			OUTPUT
A	B	C	Y =A• B•C
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

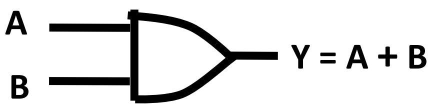
3) OR Gate :-

OR GATE is one of the basic gates

It is used for **ADDITION** operation which is shown by **(+)**

OR GATE have **TWO INPUTS** and **ONE OUTPUT**

Logical Symbol of the **OR GATE** is shown here,



LOGIC SYMBOL OF OR GATE

TRUTH Table of AND gate is given below :-

INPUTS		OUTPUT
A	B	Y = A + B
0	0	0
0	1	1
1	0	1
1	1	1

Operation Of AND GATE :-

If one of the **INPUTS** of the **OR** gate is **HIGH** or **'1'** then **OUTPUT** of the **OR** gate is **HIGH** or '1'

OR gate gives **LOW** or '**0**' **OUTPUT** only when **BOTH** the **INPUTS** are **LOW or '0'**

TRUTH Table Of 3 INPUT OR gate is given below :-

INPUTS			OUTPUT
A	B	C	Y=A+B+C
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

DERIVED GATES:-

In this chapter up to now we have studied all the BASIC GATES. Now we will study some DERIVED GATES such as NAND gate and NOR gates.

NAND and NOR gates are called as the DERIVED gates because they are made up of some basic gates.

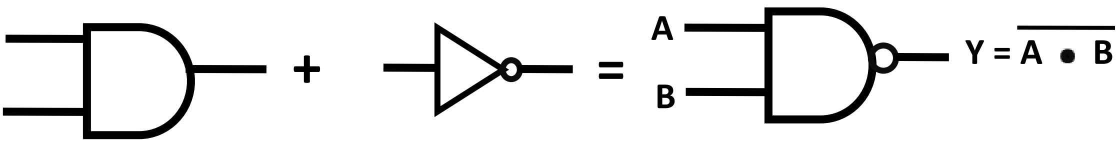
NAND GATE :-

NAND gate is one of the **DERIVED** gates **.**

NAND gate is the combination of **one AND** gate and one **NOT** gate**.**

NAND gate is also called as the **UNIVERSAL** gate**,** because all the **basic gates** can be formed by using **only NAND** gates**.**

Logical Symbol Of NAND gate :



LOGIC SYMBOL OF NAND GATE

TRUTH Table Of NAND gate :

INPUTS		OUTPUT
A	**B**	Y = $\overline{A \bullet B}$
0	**0**	**1**
0	**1**	**1**
1	**0**	**1**
1	**1**	**0**

Logical Operation Of NAND gate :

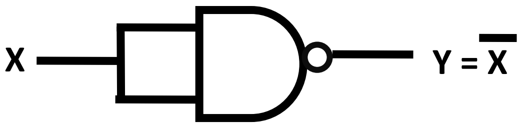
NAND gate gives **OUTPUT LOW** or ‘**0**’ only when **both the INPUTS** are **HIGH** or ‘**1**’ otherwise **NAND** gate gives **OUTPUT HIGH** or ‘**1**’

UNIVERSAL PROPERTIES OF NAND GATE :-

All the basic gates that is AND,OR,NOT can be constructed by using only NAND gates. Hence NAND gate is called as the UNIVERSAL gate

CONSRUCTION OF NOT GATE USING NAND GATES :-

NOT gate can be constructed by using only **ONE NAND** gate as follow,



TRUTH Table :-

INPUT	OUTPUT
0	1
1	0

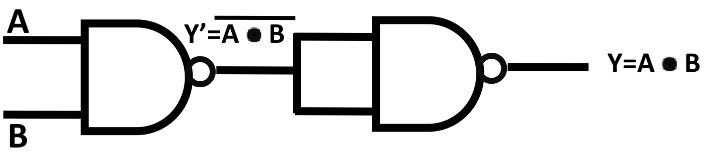
If we provide 0 as an INPUT to the above NAND gate then we gate 1

And if we provide 1 as an INPUT then we get 0 as an OUTPUT

Hence the above Construction of the NAND gate is working like the **NOT** GATE

CONSRUCTION OF AND GATE USING NAND GATES :-

AND gate can be constructed by using **TWO NAND gates** connected together as follows,



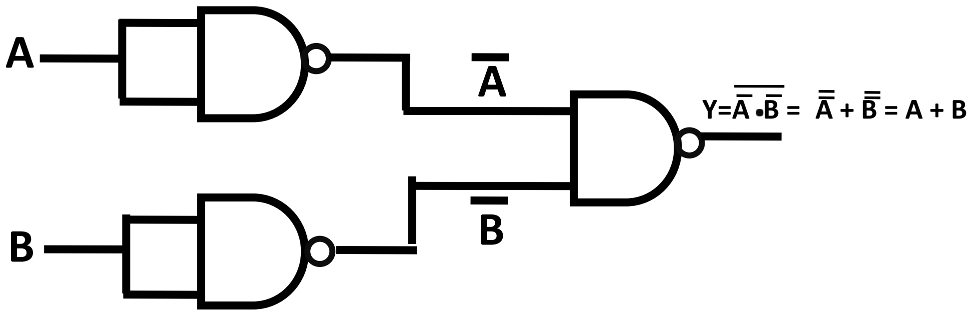
TRUTH TABLE :-

INPUTS		OUTPUT
A	B	$Y = A \bullet B$
0	0	0
0	1	0
1	0	0
1	1	1

The above combination of NAND gates gives output HIGH only when both the inputs are HIGH otherwise it gives LOW OUTPUT. Hence above combination of TWO NAND gates working like the AND gate

CONSRUCTION OF OR GATE USING NAND GATES :-

OR gate can be constructed by using **three NAND** gates as follows,



TRUTH TABLE :-

INPUTS		OUTPUT
A	B	$Y = A + B$
0	0	0
0	1	1
1	0	1
1	1	1

The above combination of NAND gates gives output LOW when both the inputs are LOW otherwise it gives HIGH OUTPUT . Hence above combination of three NAND gates working like the OR gate

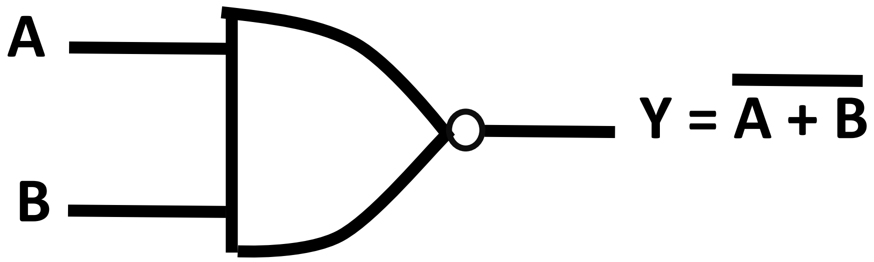
NOR GATE:-

NOR gate is also one of the **DERIVRED** gates .

NOR gate is the combination of **ONE OR** gate and **ONE NOT** gate

NOR gate is also called as the **UNIVERSAL** gate**,** because all the **basic gates** can be formed by using **only** **NOR** gates**.**

Logical Symbol Of NOR gate :-



TRUTH TABLE Of NOR gate :-

INPUTS		OUTPUT
A	B	$Y = \overline{A + B}$
0	0	1
0	1	0
1	0	0
1	1	0

Logical Operation Of NOR gate :

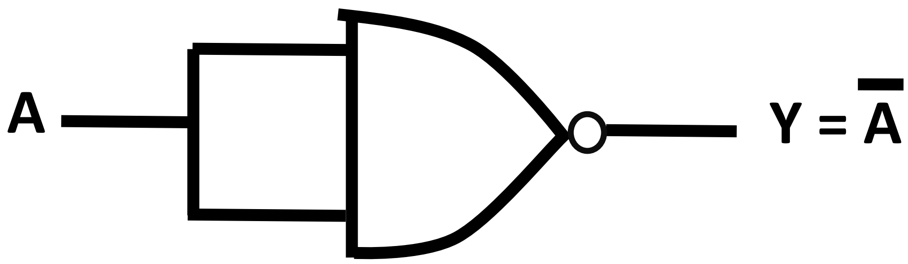
NOR gate gives **OUTPUT HIGH** or '**1**' only when **both the INPUTS** are **LOW** or '**0**' otherwise **NOR** gate gives **OUTPUT LOW** or '**0**'

UNIVERSAL PROPERTIES OF NAND GATE :-

All the basic gates that is AND,OR,NOT can be constructed by using only NAND gates .Hence NAND gate is called as the UNIVERSAL gate

CONSRUCTION OF NOT GATE USING NAND GATES :-

NOT gate can be constructed by using only **ONE NOR** gate as follow,



TRUTH Table :-

INPUT	OUTPUT
0	**1**
1	**0**

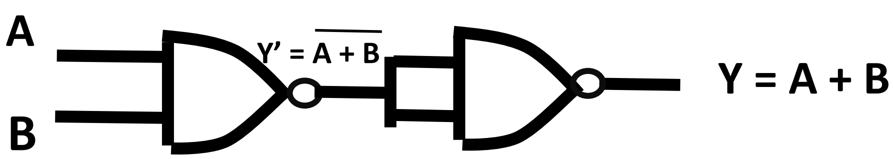
If we provide **0** as an **INPUT** to the above **NOR** gate then we gate **1**

And if we provide **1** as an **INPUT** then we get **0** as an **OUTPUT**

Hence the above Construction of the **NOR gate** is working like the **NOT** GATE

CONSRUCTION OF OR GATE USING NOR GATES :-

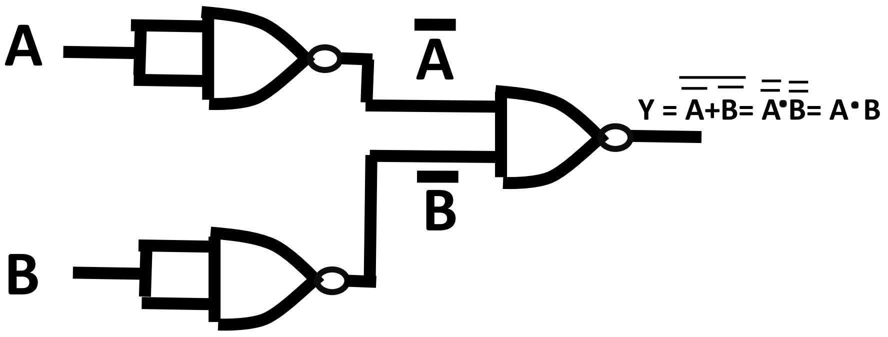
OR GATE can be constructed by using combination of **TWO NOR** gates



The above combination of **NOR** gates gives output **LOW** when both the inputs are **LOW** otherwise it gives **HIGH OUTPUT**. Hence above combination of **TWO NOR** gates working like the **OR gate**

CONSRUCTION OF AND GATES USING NOR GATES :-

AND GATE is Constructed by using **THREE NOR** gates as follows



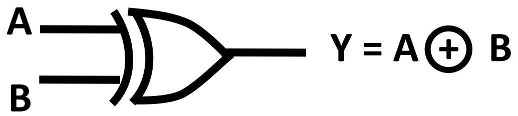
The above combination of **NOR** gates gives output HIGH only when both the inputs are **HIGH** otherwise it gives **LOW OUTPUT**. Hence above combination of **THREE NOR** gates working like the AND gate

TRUTH TABLE :-

INPUTS		OUTPUT
A	**B**	**Y = A + B**
0	**0**	**0**
0	**1**	**1**
1	**0**	**1**
1	**1**	**1**

EXCLUSIVE OR GATE (EX-OR gate) :-

LOGIC SYMBOL OF EX-OR GATE :-



LOGICAL OPERATION OF EX-OR GATE :-

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

TRUTH TABLE OF EX-OR GATE :-

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

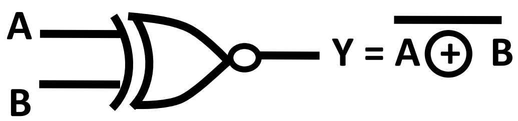
EXCLUSIVE OR GATE or **EX-OR** gate gives **OUTPUT LOW** or '**0**' when both the **INPUTS** provided are **SAME** i.e. both the **INPUTS** are '**0**' or both the **INPUTS** are '**1**'

And **EXCLUSIVE OR** GATE or **EX-OR** gate gives **HIGH OUTPUT** or '**1**' when both the **INPUTS** provided are **DIFFERENT i.e.** one of the **INPUT** is '**0**' and other is '**1**' or one of the **INPUT** is '**1**' and other is '**0**'

So here **EXCUSIVE OR GATE** is Different than the **OR gate** only in the **FOURTH ROW**

EXCLUSIVE NOR GATE (EX-NOR gate) :-

LOGIC SYMBOL OF EX-NOR GATE :-



LOGICAL OPERATION OF EX-NOR GATE :-

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

TRUTH TABLE OF EX-NOR GATE :-

INPUTS		OUTPUT
A	**B**	$Y = \overline{A \oplus B}$
0	**0**	**1**
0	**1**	**0**
1	**0**	**0**
1	**1**	**1**

EXCLUSIVE NOR GATE or **EX-NOR** gate gives **OUTPUT HIGH** or '**1**' when both the **INPUTS** provided are **SAME** i.e. both the **INPUTS** are '**0**' or both the **INPUTS** are '**1**'

And **EXCLUSIVE NOR** GATE or **EX-NOR** gate gives **LOW OUTPUT** or '**0**' when both the **INPUTS** provided are **DIFFERENT i.e.** one of the **INPUT** is '**0**' and other is '**1**' or one of the **INPUT** is '**1**' and other is '**0**'

BOOLEAN ALGEBRA

INTRODUCTION :-

To **study** and **analysis** of the logical circuits , **BOOLEAN ALGEBRA** is used as a **MATHEMATICAL TOOL** .

Terms used in BOOLEAN ALGEBRA are ,as follow,

VARIABLE :-

To represent values in LOGIC variables are used.

A variable can have value either ‘1’ or ‘0’

e.g. **A = 0** or **A = 1,** where **A** is the **VARIABLE** and ‘**0**’ and ‘**1**’ are the possible values of the VARIBLE ‘**A**’

COMPLIMENT :

‘’COMPLIMENT’’ is the **INVERSE** the value of the VARIABLE.

‘’COMPLIMENT’’ is represented as the BAR over the VARIABLE

e.g. If ‘**A**’ is any VARIABLE then its COMPLIMENT is represented as the $\bar{A}$

and if $A = 0$ then $\bar{A} = 1$

and if $A = 1$ then $\bar{A} = 0$

LITERAL :

‘’LITERAL” is either VARIABLE or COMPLIMENT of the VARIABLE

BOOLEAN OPERATIONS :-

BOOLEAN ADDITION :-

BOOLEAN ADDITION is similar to the **OR OPERATION**

BOOLEAN ADDITION is shown by the symbol “ + “

Rules of BOOLEAN ADDITION are ,

$$0 + 0 = 0$$

$$0 + 1 = 1$$

$$1 + 0 = 1$$

$$1 + 1 = 1$$

BOOLEAN MULTPLICATION :-

BOOLEAN MULTIPLICATION is similar to the **AND OPERATION**

BOOLEAN MULTIPLICATION is shown by the symbol " ● "

Rules Of **BOOLEAN MULTIPLICATION** are ,

$$0 \bullet 0 = 0$$

$$0 \bullet 1 = 1$$

$$1 \bullet 0 = 1$$

$$1 \bullet 1 = 1$$

LAWS OF BOOLEAN ALGEBRA :-

If A , B , C are any VARIABLES then ,

COMMUTATIVE LAWS :-

1) COMMUTATIVE LAW OF ADDITION :-

$$A + B = B + A$$

2) COMMUTATIVE LAW OF MULTIPLICATION :-

$$A \bullet B = B \bullet A$$

ASSOCIATIVE LAWS :-

1) ASSOCIATIVE LAW OF ADDITION

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

2) ASSOCIATIVE LAW OF MULTIPLICATION

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

DISTRIBUTIVE LAW :-

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

SOME RULES USED IN BOOLEAN ALGEBRA :-

$A + 0 = A$

$A + 1 = 1$

$A \bullet 0 = 0$

$A \bullet 1 = A$

$A + A = A$

$A + \overline{A} = 1$

$A \bullet A = A$

$A \bullet \overline{A} = 0$

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

$A + AB = A$

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

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

Ex. Simplify the following expression using Rules and Laws of Boolean Algebra
$AB + A(B + C) + B(B + C)$
Ans:-
First using Distributive law to 2^{nd} and 3^{rd} term of the given expression, we get

$AB + AB + AC + BB + BC$

Now $AB + AB = AB$ and $BB = B$
Therefore, above expression becomes,

$AB + AC + B + BC$

Here, $B + BC = B$

Hence, $AB + AC + B$

Again, $B + AB = B$

Therefore above expression becomes, **$B + AC$**

This is required simplified form of the given expression

De-Morgan's Theorems :-

De-morgan's 1st Theorem states that a **COMPLIMENT** of **ADDITION** of **TWO VARIABLES** is equal to the **PRODUCT** of **COMPLIMENTS** of the given **VARIABLES**

i.e. $\overline{(A + B)} = \overline{A} \bullet \overline{B}$

De-morgan's 2nd Theorem states that a **COMPLIMENT** of **PRODUCT** of **TWO VARIABLES** is equal to the **ADDITION** of **COMPLIMENTS** of the given **VARIABLES**

i.e. $\overline{(A \bullet B)} = \overline{A} + \overline{B}$

Ex.1) Apply De-morgan's Theorem to,

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

Ans:- Applying **De-Morgan's 1st Theorem** to the given expression we get,

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

Ex.2) Apply De-morgan's Theorem to,

$$\overline{A \bullet B \bullet C}$$

Ans:- Applying **De-Morgan's 2nd Theorem** to the given expression we get,

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

Ex.3) Apply De-morgan's Theorem to,

$$\overline{\overline{X} + \overline{Y} + \overline{Z}}$$

Ans:- Applying **De-Morgan's 1st Theorem** to the given expression we get,

$$\overline{\overline{X}} \bullet \overline{\overline{Y}} \bullet \overline{\overline{Z}}$$

Now we know that , $\overline{\overline{X}} = X$, $\overline{\overline{Y}} = Y$ **and** $\overline{\overline{Z}} = Z$

Hence ,

Answer is , $X \bullet Y \bullet Z$

SUM OF PRODUCTS FORM (SOP) :-

In SOP form of the Boolean Expression product terms are added by using Boolean Addition .

e.g. AB + CD

ABC + DEF

KARNAUGH MAP (K-MAP) :-

K-MAP is used for the simplification of the given Boolean expression.

K-MAP can be of many variables as 3,4 etc.

In this chapter we will study 3- Variables K-MAP and 4-Variables K-MAP

3-VARIABLES K-MAP :-

In 3-VARIABLES K-MAP 8 cells are arranged as shown below,

AB \ C	0	1
00	$\bar{A}\bar{B}\bar{C}$	$\bar{A}\bar{B}C$
01	$\bar{A}B\bar{C}$	$\bar{A}BC$
11	$AB\bar{C}$	ABC
10	$A\bar{B}\bar{C}$	$A\bar{B}C$

Ex:-Map the following expression into 3-variables K-MAP.

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

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

4-VARIABLES K-MAP :-

In **4-VARIABLES** K-MAP **16 cells** are arranged as shown below,

AB \ CD	00	01	11	10
00	$\bar{A}\bar{B}\bar{C}\bar{D}$	$\bar{A}\bar{B}\bar{C}D$	$\bar{A}\bar{B}CD$	$\bar{A}\bar{B}C\bar{D}$
01	$\bar{A}B\bar{C}\bar{D}$	$\bar{A}B\bar{C}D$	$\bar{A}BCD$	$\bar{A}BC\bar{D}$
11	$AB\bar{C}\bar{D}$	$AB\bar{C}D$	$ABCD$	$ABC\bar{D}$
10	$A\bar{B}\bar{C}\bar{D}$	$A\bar{B}\bar{C}D$	$A\bar{B}CD$	$A\bar{B}C\bar{D}$

Ex:-Map the following expression into 4-variables K-MAP.

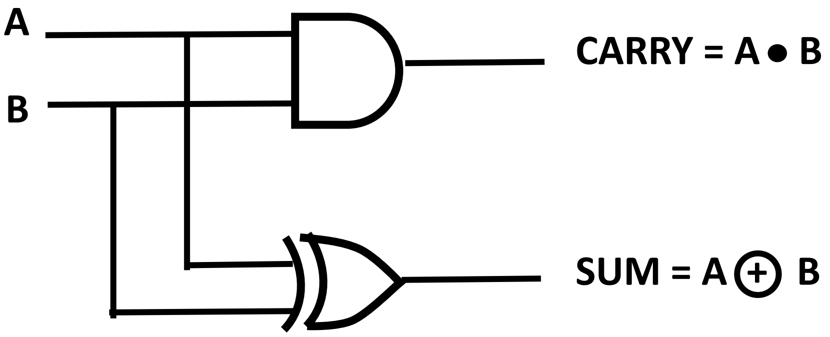
$A\bar{B}\bar{C}\bar{D} + \bar{A}BC\bar{D} + \bar{A}BCD + \bar{A}\bar{B}CD + A\bar{B}C\bar{D} + ABCD$

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

HALF ADDER :-

Half is used to for the addition of TWO Binary digits

Circuit Diagram of the Half Adder is as shown below,



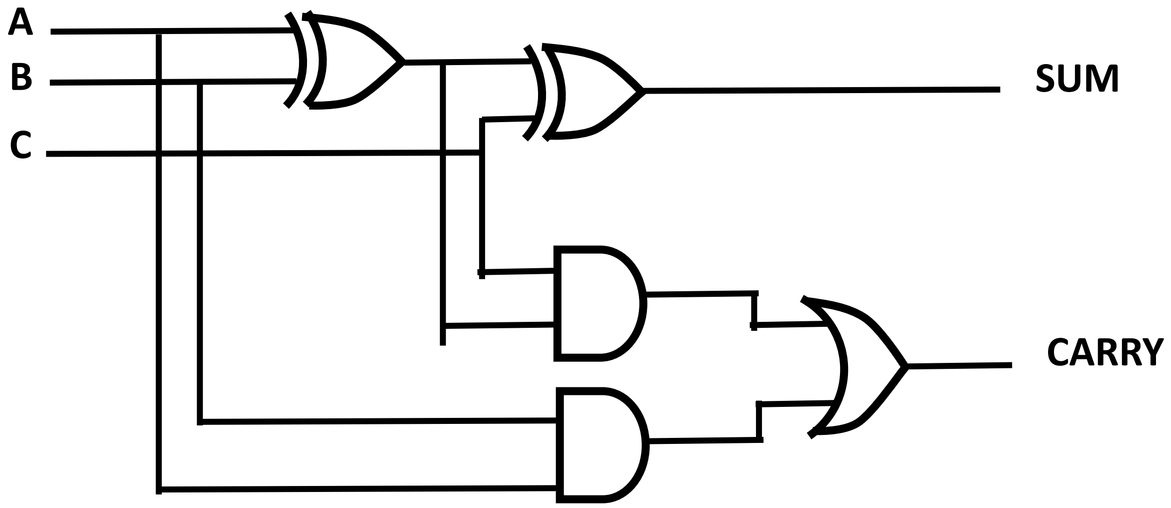
TRUTH TABLE OF HALF ADDER :-

INPUTS		OUTPUTS	
A	B	CARRY = A ● B	SUM = A ⊕ B
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

FULL ADDER :-

FULL ADDER is used to for the addition of **THREE Binary** digits

Circuit Diagram of the FULL Adder is as shown below,



TRUTH TABLE OF FULL ADDER :-

INPUTS			OUTPUTS	
A	B	C	CARRY	SUM
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

Unit – 3

MODULATION AND DEMODULATION

In this unit we will study,

INTRODUCTION

TYPES OF MODULATION

EXPRESSION FOR A.M.VOLTAGE

A.M.WAVES

FREQUENCY SPECTRUM OF A.M.WAVES

POWER OUTPUT IN AM

EXPRESSION FOR FREQUENCY MODULATED VOLTAGE

PRINCIPLE OF DEMODULATION

LINEAR DIODE AM DETECTOR OR DEMODULATER

INTRODUCTION :-

What is modulation ?

Weak signals can not be transmitted to a large distances by its own due to its lower energy.

So we have to provide an **EXTERNAL ENERGY** so that the signals can be sent to a large distances

This process of converting a weak signals to a higher frequency signals is called as the **MODULATION** .

The weak signals are also called as the **UNMODULATED** signals.

TYPES OF MODULATION :-

On the basis of which parameter of the unmodulated wave is changed there are THREE types of modulation as ;

1) **Amplitude Modulation (A.M.)**

2) **Frequency Modulation (F.M.)**

3) **Phase Modulation (P.M.)**

In **Amplitude Modulation** only **AMPLITUDE** of the Unmodulated signals is **changed** and other two parameters as **Frequency** and **Phase** are kept **constant**.

In **Frequency Modulation** only **Frequency** of the unmodulated wave is changed and other two parameters as **Amplitude** and **Phase** are kept constant

In **Phase Modulation** only **PHASE** of the Unmodulated signals is **changed** and other two parameters as **AMPLITUDE** and **FREQUENCY** are kept **constant**.

EXPRESSION FOR AMPLITUDE MODULATED VOLTAGE (A.M. VOLTAGE):-

In **Amplitude Modulation** only **AMPLITUDE** of the Unmodulated signals is **changed** and other two parameters as **Frequency** and **Phase** are kept **constant**.

Now the lower frequency modulating voltage is given as ,

$$e_m = E_m . Cos\omega_m t$$

where ,

ω_m is the Angular Frequency of the modulating voltage

E_m is the Amplitude of the modulating voltage

Now the equation of the higher frequency Carrier wave is given as,

$$e_c = E_c . Cos (\omega_c t + \theta)$$

Here, θ is the Phase Angle of the Higher Frequency Carrier wave

In Amplitude Modulation this Phase Angle θ can be neglected .

Hence above equation of the higher frequency Carrier wave can be written as ,

$$e_c = E_c . Cos (\omega_c t)$$

Now after Amplitude modulation equation of the modulated wave can be written as ,

$$e = (E_c + K_a E_m . Cos\omega_m t). Cos\omega_c t$$

Taking E_c common from above equation ,we get

$$e = E_c (1 + K . \frac{Em}{Ec} . Cos\omega_m t). Cos\omega_c t$$

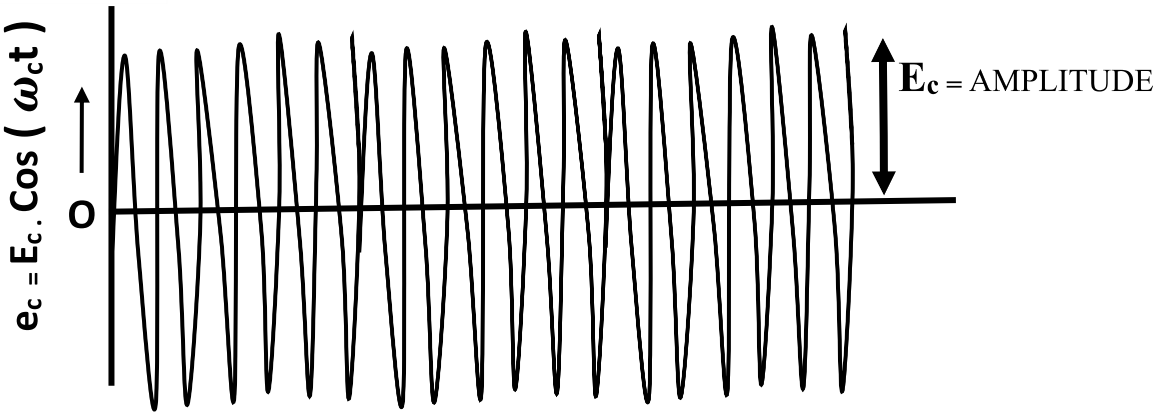
Now put , $K . \frac{Em}{Ec} = m_a$, We get ,

$$e = E_c (1 + m_a . Cos\omega_m t). Cos\omega_c t$$

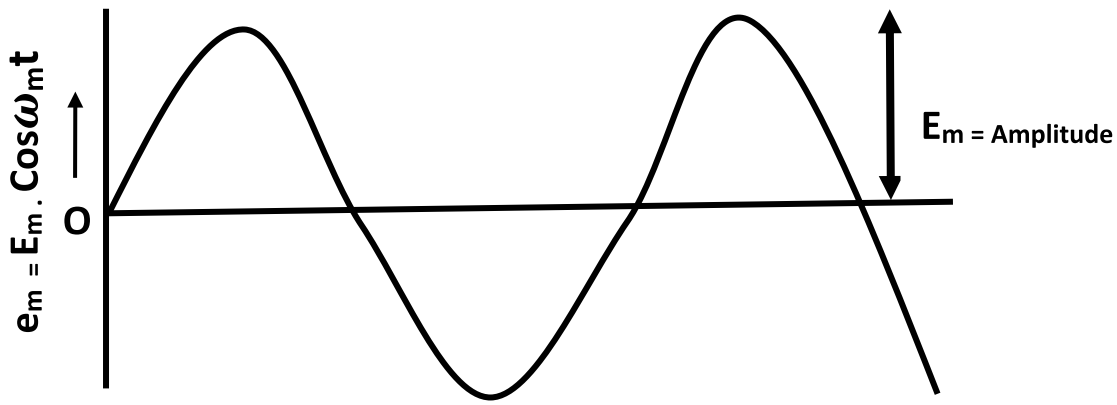
Where m_a is called as the modulation index

(100 X m_a) gives **percentage modulation**

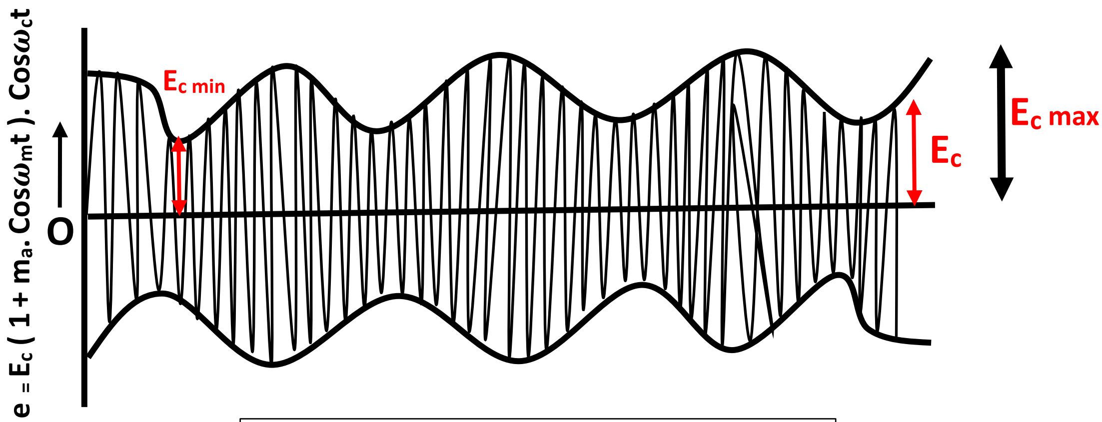
Waveform of Amplitude Modulated Voltage :-



HIGHER FREQUENCY CARRIER WAVE



LOWER FREQUENCY MODULATING WAVE



AMPLITUDE MODULATED WAVE

Now in terms of E_c **max** and E_c we can write Modulation Index m_a as ,

$m_a = \frac{Ec\ max - Ec}{Ec}$ --------(1)

Also in terms of E_c **min** and E_c we can write Modulation Index m_a as ,

$m_a = \frac{Ec - Ec\ min}{Ec}$ --------(2)

Now comparing above equations (1) and (2), we get,

$$Ec\ max - Ec = Ec - Ec\ min$$

Hence , $Ec\ max + Ec\ min = 2Ec$ ...... (3)

Now adding equations (1) and (2) , we get ,

$m_a = \frac{Ec\ max - Ec\ min}{2Ec}$ .... (4)

Now putting the value of equation (3) in equation (4), we get

$$m_a = \frac{Ec\ max - Ec\ min}{Ec\ max + Ec\ min}$$

from the above formula , we can determine the value of Modulation Index experimentally.

SIDEBANDS PRODUCED IN THE AMPLITUDE MODULATED WAVE :-

The modulated voltage is given by the formula ,

$$e = E_c\ (1 + m_a . Cos\omega_m t). Cos\omega_c t \quad .....(1)$$

Now we know that ,

$$2CosA. 2CosB = Cos(A + B) + Cos(A - B)$$

Now equation (1) can be simplified as ,

$$e = E_c.Cos\omega_c t + \frac{maEc}{2}. (2Cos\omega_c t. Cos\omega_m t)$$

$$e = E_c.Cos\omega_c t + \frac{maEc}{2}. \left[Cos(\omega_c + \omega_m)t + Cos(\omega_c - \omega_m)t\right]$$

$$e = E_c.Cos\omega_c t + \frac{maEc}{2}. \left[Cos(\omega_c + \omega_m)t + \frac{maEc}{2} Cos(\omega_c - \omega_m)t\right]$$

Now from the above equation, sidebands produced in the AM Wave are ,

ORIGINAL HIGHER FREQUENCY CARRIER WAVE :-

$$E_c.\cos\omega_c t$$

Here angular frequency of the ORIGINAL CARRIER WAVE is "ω_c"

UPPER SIDEBAND :-

$$\frac{maEc}{2}.\cos(\omega_c + \omega_m)t$$

Here angular frequency of the UPPER SIDEBAND is , $\omega_c + \omega_m$

LOWER SIDEBAND :-

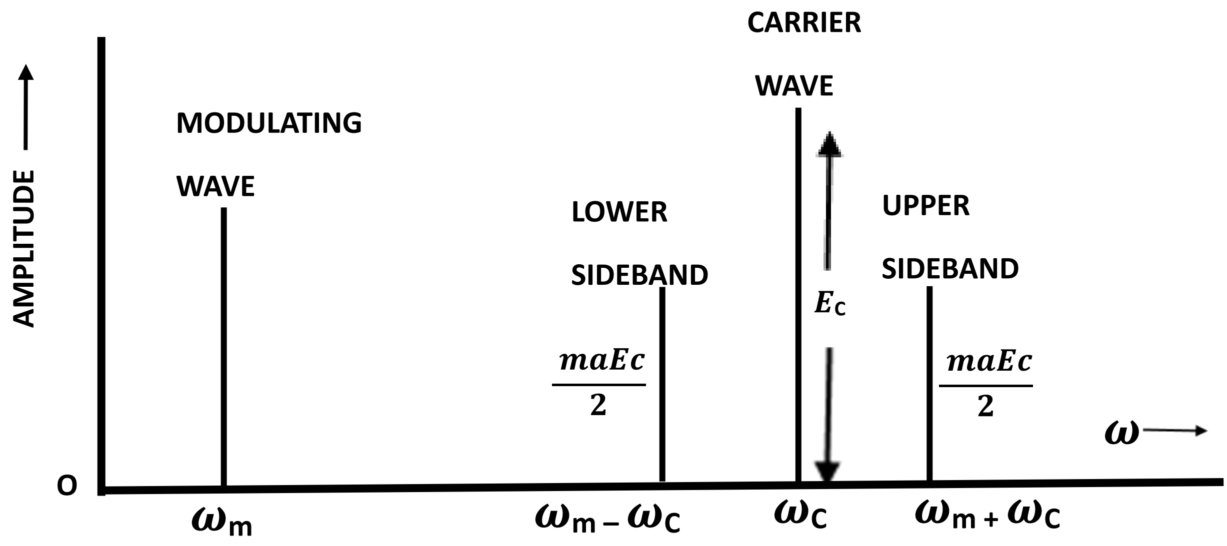
$$\frac{maEc}{2}.\cos(\omega_c - \omega_m)t$$

Here angular frequency of the LOWER SIDEBAND is , $\omega_c - \omega_m$

Location of the Upper and Lower Sidebands are on either sides of the CARRIER wave and the magnitude of the Upper and Lower side bands is Half of the Magnitude of the Carrier Wave

FREQUENCY SPECTRUM OF THE AMPLITUDE MODULATED VOLTAGE :-

Frequency spectrum of the AM Wave is as shown below,



POWER OUTPUT IN A.M.WAVE :-

In the A.M. wave Total power is the sum of energies of its upper and lower side bands.

Modulated wave has following components ,

ORIGINAL HIGHER FREQUENCY CARRIER WAVE :-

$$E_c.\cos\omega_c t$$

Here angular frequency of the ORIGINAL CARRIER WAVE is "ω_c"

UPPER SIDEBAND :-

$$\frac{maEc}{2}.\cos(\omega_c+\omega_m)t$$

Here angular frequency of the UPPER SIDEBAND is , $\omega_c+\omega_m$

LOWER SIDEBAND :-

$$\frac{maEc}{2}.\cos(\omega_c-\omega_m)t$$

Here angular frequency of the LOWER SIDEBAND is , $\omega_c-\omega_m$

Now the power output given by each component is directly proportional to the square of the amplitude of the AM wave.

Hence , power output from the original Higher frequency carrier wave is directly proportional to the Ec^2

i.e. Power output in Carrier Wave = $K.\ Ec^2$

where K is the proportionality constant.

Power in the **UPPER** sideband $\propto$ $\left(\frac{maEc}{2}\right)^2$

Hence , Power in the **UPPER** sideband = $K\,\frac{ma^2-Ec^2}{4}$

Power in the **LOWER** sideband $\propto$ $\left(\frac{maEc}{2}\right)^2$

Hence , Power in the **LOWER** sideband = $K\,\frac{ma^2-Ec^2}{4}$

Total power is the sum of energies of its upper and lower side bands, Total power output in AM wave is = $\mathbf{K}.\ \boldsymbol{Ec^2} + \mathbf{K}\ \frac{\boldsymbol{ma^2 - Ec^2}}{\mathbf{4}} + \mathbf{K}\ \frac{\boldsymbol{ma^2 - Ec^2}}{\mathbf{4}}$

$$= \mathbf{K}.\ \boldsymbol{Ec^2}\ (\ \mathbf{1} + \frac{\boldsymbol{ma^2}}{\mathbf{2}})$$

Here $\mathbf{K}.\ \boldsymbol{Ec^2}$ is the Power output from the Carrier Wave

Hence the above equation can be written as ,

Total Power = Carrier Power X $(\ \mathbf{1} + \frac{\boldsymbol{ma^2}}{\mathbf{2}})$

Now putting $\mathbf{m_a = 1}$ **,** we get

Total Power = Carrier Power **X** $(\ \mathbf{1} + \frac{\mathbf{1}}{\mathbf{2}})$

Total Power = $\frac{\mathbf{3}}{\mathbf{2}}$ **Carrier Power**

Carrier Power = $\frac{\mathbf{2}}{\mathbf{3}}$ **Total Power**

FREQUENCY MODULATIO (F.M.) :-

In **Frequency Modulation** only **FREQUENCY** of the Unmodulated signals is **changed** and other two parameters as **Amplitude** and **Phase** are kept **constant**.

Now the lower frequency modulating voltage is given as ,

$$e_m = E_m . \cos\omega_m t$$

where ,

ω_m is the Angular Frequency of the modulating voltage

E_m is the Amplitude of the modulating voltage

Now the higher frequency carrier voltage can be written as,

$$e_c = E_c . \sin(\omega_c t + \theta)$$

Here, θ is the Phase Angle of the Higher Frequency Carrier Wave

E_c is the Angular Frequency of the Carrier Wave

ω_c is the Amplitude of the Carrier Wave

Now put $\phi = \omega_c t + \theta$ in the above equation we get,

$$e_c = E_c . \sin\phi$$

Now , the Angular Frequency ω_c in terms of Phase Angle ϕ is given as,

$$\omega_c = \frac{d\Phi}{dt}$$

After Frequency Modulation , Carrier Frequency can be written as,

$$\omega = \omega_c + K_f . e_m$$

$$\omega = \omega_c + K_f . E_m . \cos\omega_m t$$

Where, K_f is the Proportionality Constant for Frequency Modulation

To obtain the value of Phase Angle ϕ we integrate the above equation, we get

$$\phi = \int \omega \, dt$$

$$\phi = \int (\omega c + Kf . Em . \cos\omega mt) \, dt$$

$$\phi = \omega_c.t + K_f.\, E_m . \frac{1}{\omega m} . \operatorname{Sin}\omega_m t \; + \theta_1$$

Now neglecting θ_1 , above equation of Frequency Modulation becomes ,

$$e = E_c . \operatorname{Sin} (\omega_c t + K_f.\, E_m . \frac{1}{\omega m} . \operatorname{Sin}\omega_m t \;)$$

Frequency of the FM Voltage is also given by ,

$$\boxed{f = \frac{\omega}{2\pi}}$$

$$f = \frac{\omega c}{2\pi} + \frac{Kf.Em}{2\pi} \operatorname{Cos}\omega_m t$$

To get the maximum value of the above higher frequency modulated wave putting $\operatorname{Cos}\omega_m t = +1$

To get the minimum value of the above higher frequency modulated wave putting $\operatorname{Cos}\omega_m t = -1$, above values of Modulated Frequency becomes ,

Hence ,

$$\boxed{f_{max} = f_c + K_f . \frac{Em}{2\pi}}$$

$$\boxed{f_{min} = f_c - K_f . \frac{Em}{2\pi}}$$

Now , maximum change or deviation in the Modulated Frequency f_d is given as ,

$$f_d = f_{max} - f_c$$

$$= \cancel{f_c} + K_f . \frac{Em}{2\pi} - \cancel{f_c}$$

$$\boxed{f_d = K_f . \frac{Em}{2\pi}}$$

$$f_d = f_c - f_{min}$$

$$= \cancel{f_c} - \cancel{f_c} + K_f . \frac{Em}{2\pi}$$

$$\boxed{f_d = K_f . \frac{Em}{2\pi}}$$

Modulation Index of Frequency Modulated Voltage :-

Modulation Index of Frequency Modulated Voltage is the ratio of the Deviation in Frequency f_d and the Frequency of the Carrier wave f_c ,

i.e. $mf = \frac{fd}{fc} = Kf \cdot \frac{Em}{2\pi} \times \frac{1}{fc}$

$$mf = Kf \cdot \frac{Em}{2\pi fc}$$

But,

$$\omega_c = 2\pi f_c$$

The value of the modulation index can be written as ,

$$m_f = Kf \cdot \frac{Em}{\omega c}$$

Deviation Ratio of Frequency Modulated Voltage :-

Deviation Ratio can be defined as the ratio of the deviation in frequency f_d and the modulation index of the frequency modulataion f_m

i.e. $\delta = \frac{fd}{fm}$

Now putting the value of deviation in frequency $f_d = K_f \cdot \frac{Em}{2\pi}$, above equation of frequency deviation ratio becomes ,

$$\delta = K_f \cdot \frac{Em}{2\pi fm}$$

But we know that , $\omega_m = 2\pi f_m$, equation becomes ,

$$\delta = K_f \cdot \frac{Em}{\omega m}$$

Now multiplying and dividing above equation by ω_c we get,

$$\delta = \left(K_f \cdot \frac{Em}{\omega c} \right) \times \frac{\omega c}{\omega m}$$

Putting $\left(K_f \cdot \frac{Em}{\omega c} \right) = m_f$, above equation of deviation ratio becomes ,

$$\delta = m_f \times \frac{\omega c}{\omega m}$$

Using above value of deviation ratio , frequency modulated voltage can be written as,

$$e = E_c . \text{Sin} (\omega_c t + (K_f . E_m . \frac{1}{\omega m}) . \text{Sin}\omega_m t \ )$$

$$e = E_c . \text{Sin} (\omega_c t + \delta \ . \text{Sin}\omega_m t \ )$$

PRINCIPLE OF DEMODULATION :-

Process of getting the lower frequency modulating wave from the higher frequency modulated carrier wave is called as the Demodulation or this process is also called as the Detection

TYPES OF DETECTORS :-

There are two types of dectors as follow ,

a) **Linear Detectors**

In Linear Detectors Output of the Amplitude is the linear function of the Input Amplitude

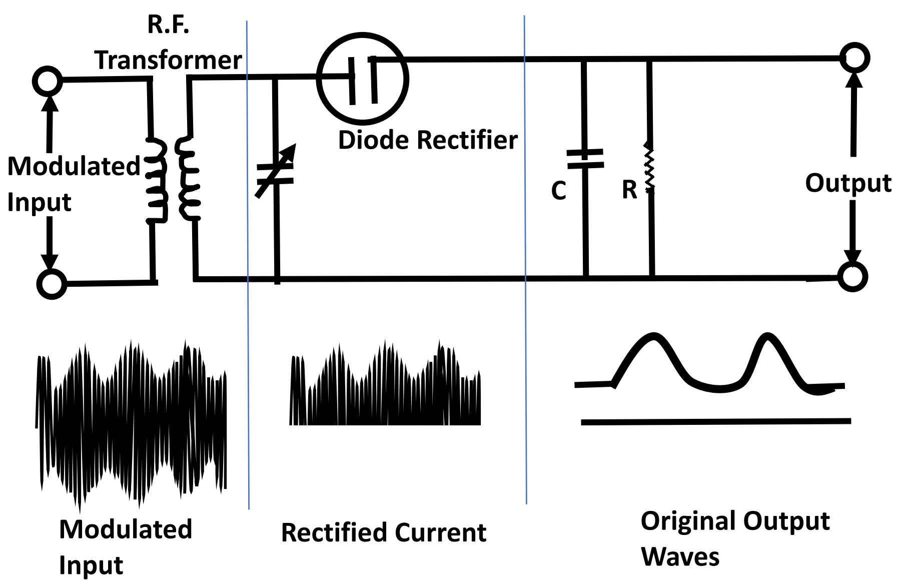
b) **Non Linear Detectors**

In Linear Detectors Output of the Amplitude is not the linear function of the Input Amplitude

LINEAR DIODE AM DETECTOR OR DEMODULATOR :-

In linear Diode AM detectors OUTPUT of the amplitude is linearly proportional to the INPUT.

Circuit Diagram of the Linear Diode AM detector is as shown below ,



WORKING OF LINEAR DIODE AM DETECTOR :-

Linear Diode AM detector works like a Half-Wave Rectifier.

The modulated waves are provided to the Transformer.

The current flows only during the positive half cycles , therefore we get rectified waves of positive half cycles.

These rectified waves are then provided to the RC filter to make them audible.

During these positive half cycles capacitor gets charged to its maximum value.

These changes can be converted into desired lower frequency original waves.

Unit-4

COMMUNICATION SYSTEM

In this chpter we will study about following topics ,

INTRODUCTION

BLOCK DIAGRAM OF BASIC COMMUNICATION SYSTEM

ESSENTIAL ELEMENTS OF A.M. TRANSMITTER

A.M. RECEIVER

TUNNED RADIO FREQUENCY (TRF) RECEIVER

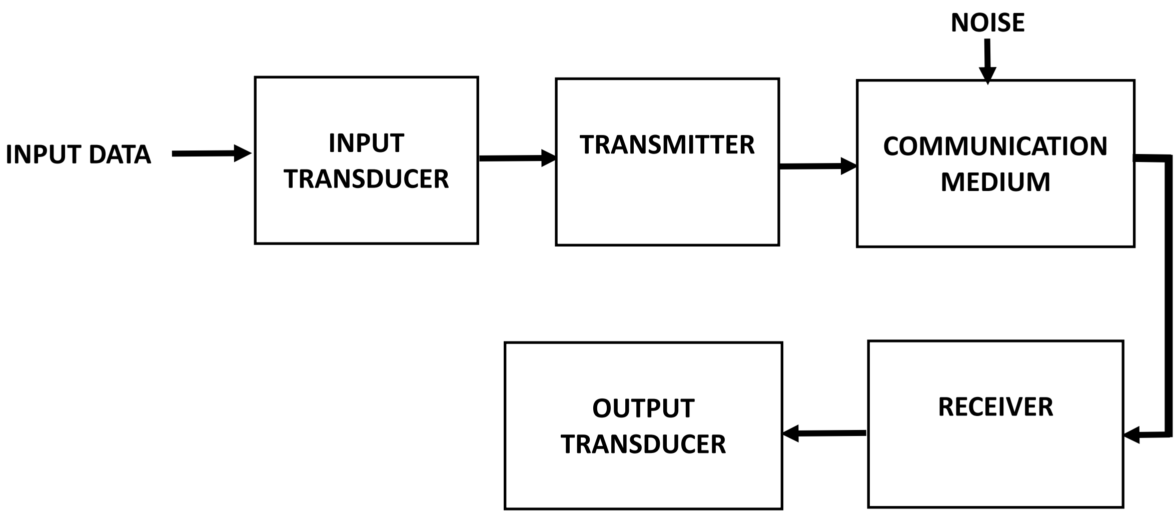
SUPER HETERODYNE RECEIVER

CHARCHTERISTICS OF RADIO RECEIVERS: SENSITIVITY, SELECTIVITY, FIDELITY AND THEIR MEASUREMENTS

Introduction :-

To transmit the data or information from one place to another we use a " Communication System "

BLOCK DIAGRAM OF BASIC COMMUNICATION SYSTEM :-



BLOCK DIAGRAM OF BASIC COMMUNICATION SYSTEM

A basic communication system have the following components as ,

a) Input Signal :-

Input signal is the Information or data that we want to transmit from one place to another.

b) Input Transducer :-

The input signals can not be transmitted from one place to another as it is . Therefore input signals are converted into electrical signals by using Input Transducers.

Examples of Input transducers used in the communication systems are , microphones , Video cameras etc.

c) Transmitter :-

The transmitter have following components ,

Amplifier

Mixer

Oscillator

Power Amplifier

The Input signals converted into the electrical signals by the Input transducer , are then converted into the desired form.

The transmitter is used to increase the power level of the Input signals , so that they can travel a large distance through the communication medium.

d) Communication medium :-

To transmit the Information or Input signals from one place to another we need Communication medium.

Examples of communication medum are ,

Free space , Optiacal Fibre , Wires etc.

Communication system can be divided into two types on the basis of which type of communication medium is used as follows ,

A) Radio Communication :-

If the communication medium used in the Communication system is " free space " then that type of communication is called as the " **Radio Communication** "

Radio Communication has a very long range as compared to the Wire Communication .

Therefore by using Radio Communication Input signals or Information can be sent to the large distances.

B) Wire Communication :-

In the Wire Communication , Optical Fibres or cable Wires are used as communication system.

Wire Communication has lower range as compared to the Radio Communication System.

e) NOISE :-

Noise are the unwanted signals that get added in the desired Input signals while transmitting from one place to the another place though communication medium.

f) RECEIVER :-

Receiver collects the data sent by the transmitter

g) OUTPUT TRANSDUCER :-

Output Transducer converts the data recevived from the receiver into the desired Input signals or data

WHAT ARE THE BASE BAND SIGNALS :-

The original signals or information or data as it is without any modulation , is called as th BASE BAND SIGNALS or Lower Frequency Modulating Waves

COMMUNICATION SYSTEMS USING MODULATION :-

The BASE BAND SIGNALS have very short range. So to transmit the BASE BAND SIGNALS to the large distances we Modulate the BASE BAND SIGNALS with the Higher Frequency Carrier Waves.

As we have already sudied in the last Chapter , there are three types of Modulation as,

Amplitude Modulation (A.M.)

Frequency Modulation (F.M.)

Phase Modulation (P.M.)

NEED OF MODULATION IN THE COMMUNICATION SYSTEMS :-

Modulation is useful in many ways in the Communication systems as ,

1) Modulation Reduces the Height of the Antenna :-

If $\boldsymbol{\lambda}$ is the wavelength of the signals then for thier transmission the Height of the antenna must be multiple of the $\frac{\boldsymbol{\lambda}}{\mathbf{4}}$.

Now we know that , $\boldsymbol{\lambda} = \frac{\boldsymbol{C}}{\boldsymbol{f}}$

Where , C is the velocity of the light and f is the frequency of the Input signals .

Now for an example , we are transmitting the Base Band Signals of **5 KHz** then,wavelength of the Input Signal would be ,

$$\lambda = \frac{C}{f} = \frac{3\ X\ 10^8\ m/s}{5\ \ X\ 10^3\ Hz}$$

$$\lambda = \ 60,000\ m$$

So the height of the Antenna would be ,

$\frac{\lambda}{4} = \frac{60{,}000}{4}$ **m = 15,000 m = 15 km**

So , it is impossible to Install the Antenna of Height 15 km

Now we use Modulated Signals having frequency **f = 10 MHz** then its wavelength is,

$$\lambda = \frac{C}{f} = \frac{3\ X\ 10^8\ m/s}{10\ \ X\ 10^6\ Hz}$$

$$\lambda = \ 30\ m$$

So the height of the Antenna would be ,

$\frac{\lambda}{4} = \frac{30}{4}$ **m = 7.5 m**

Antenna of this height can be easily installed . So in this way by using modulation height of the Antenna gets reduced .

2) By using modulation , many signals can be transmitted throuth the same communication medium.

3) Modulation also Increases the **RANGE** of the Communication , because modulated signals are the higher frequency signals that have very high energy so that they can be transmitted to the large distances

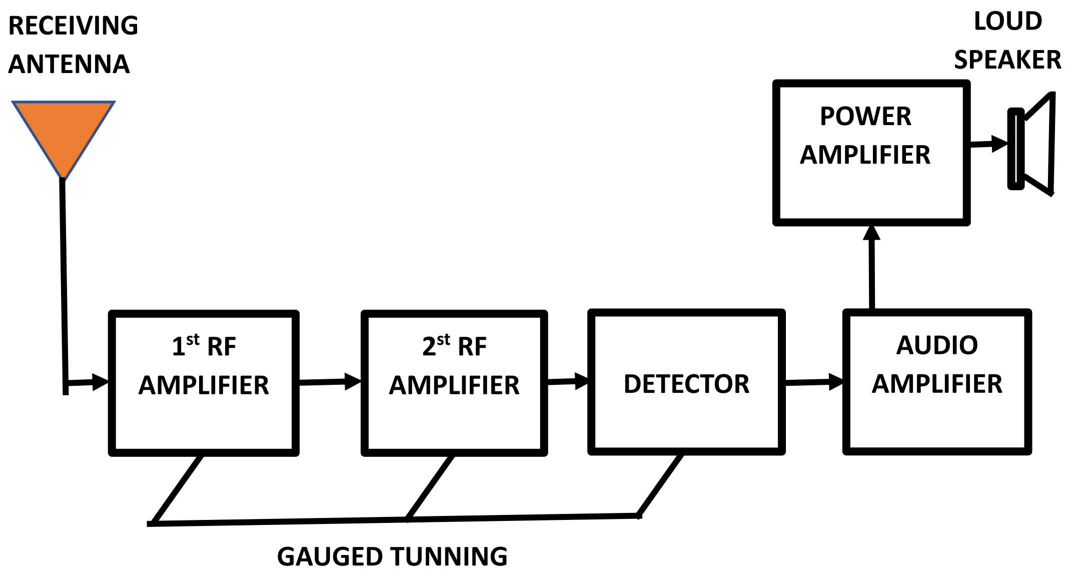
4) Noise gets reduced with modulation.

A.M. RADIO RECEIVER :-

Receivers first demodulate the given higher frequency modulated signals and then amplify that demodulated signals.

There are two types of receivers that we will study as ,

(1)Tunned Radio Frequency (TRF) Receivers :-



In TRF receiver the RF amplifiers are tunned to the disired frequency .

Detector,audio amplifier and power amplifiers are connected next to the RF amplifiers.

Different waves passing over the receiving Antenna induces different types of signals having different frequency range.Now RF amplifiers select only desired signal and then amplify it.

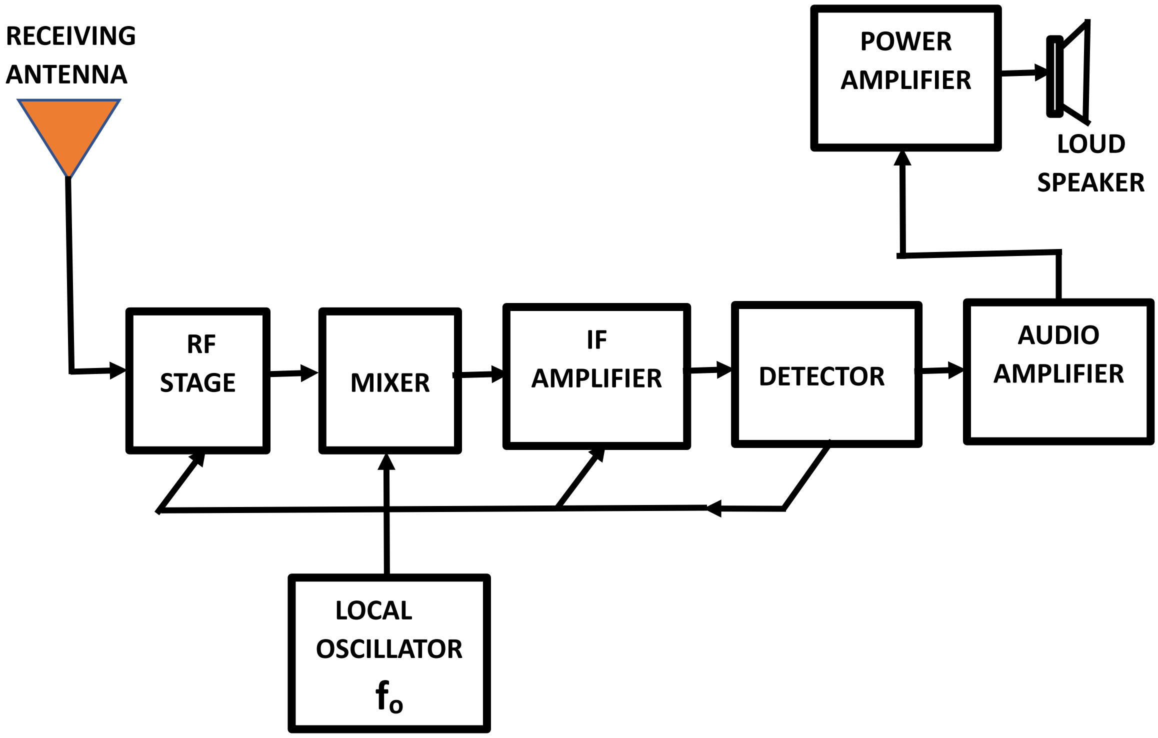
Amplified higher frequency signals are then demodulated by using Detector.

Finally this detected signal is amplified by using audio amplifier and power amplifier and provided to the loudspeaker.

SUPER HETERODYNE RECEIVER :-

Advantage of Super Heterodyne Receiver over TRF receiver is that RF signal is replaced with a fixed lower frequency known as constant Intermediate Frequency (IF) which is lower than the lowest RF signal and same for all RF signals.

This results in the stabilized signals with minimum oscillation. This Intermediate Frequency (IF) is then amplified and original Lower Frequency Modulating signal is obtained back from IF by using Detector .



BLOCK DIAGRAM OF SUPER HETRODYNE RECEIVER

The RF amplifier is used to select only desired signal. Hence Noise gets reduced.

At the output of RF amplifier we get frequency $\mathbf{f_s}$ **.**

Signals from RF local oscillator and RF amplifier are sent to Mixer.

A capacitor is used in Gauged tunning to maintain a constant difference between local oscillator and Input Frequency .

Advantage of Super Heterodyne Receiver is that the properties of the radio receiver like Sensitivity and Selectivity are not changing with change in the Incoming Frequency.

Characteristics Of Radio Receivers :-

To determine how well the Radio Receiver is working we take the help of certain parameters of the Radio Receivers as ,

SENSITIVITY

SELECTIVITY

FIDELITY

We will study these important characteristics of Radio receivers one by one as follows ,

SENSITIVITY :-

The ability of the Radio receiver to amplify the weak signals is called as the SENSITIVITY of radio receiver. Sensitivity is measured in volts or decibels.

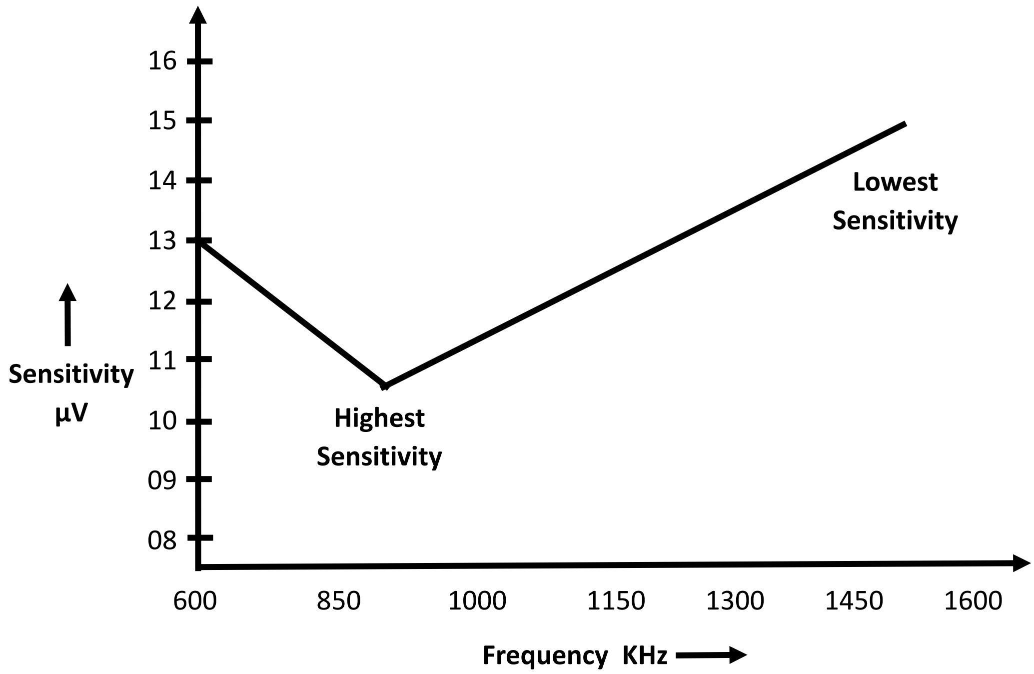


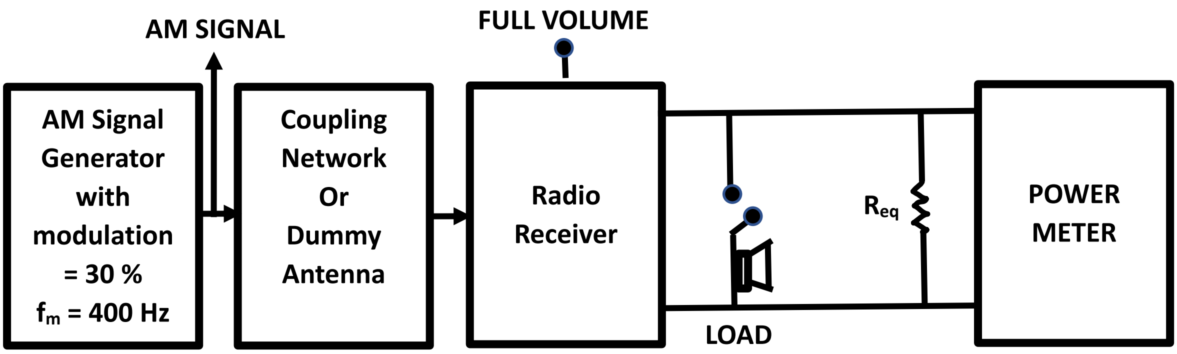
Fig. SENSITIVITY CURVE

Sensitivity of the receiver is determined by using Gain of RF and IF of the amplifiers.

Sensitivity of the Radio receiver is highest at **850 KHz.**

Measurement Of the Sensitivity :-

AM signals are provided to the receiver by using a coupling network. With the help of load resistance power output is measured.



A dummy antenna receives a signal of 400 Hz with 30 % modulation.

To achieve maximum sensitivity of the receiver 50 mW power is supplied.

Procedure Of Measurement of Sensitivity :-

A signal of 400 Hz with 30 % modulation is provided by the AM signal generator.

Carrier frequency of the AM generator is adjusted to 530 KHz with 50 mW output power .

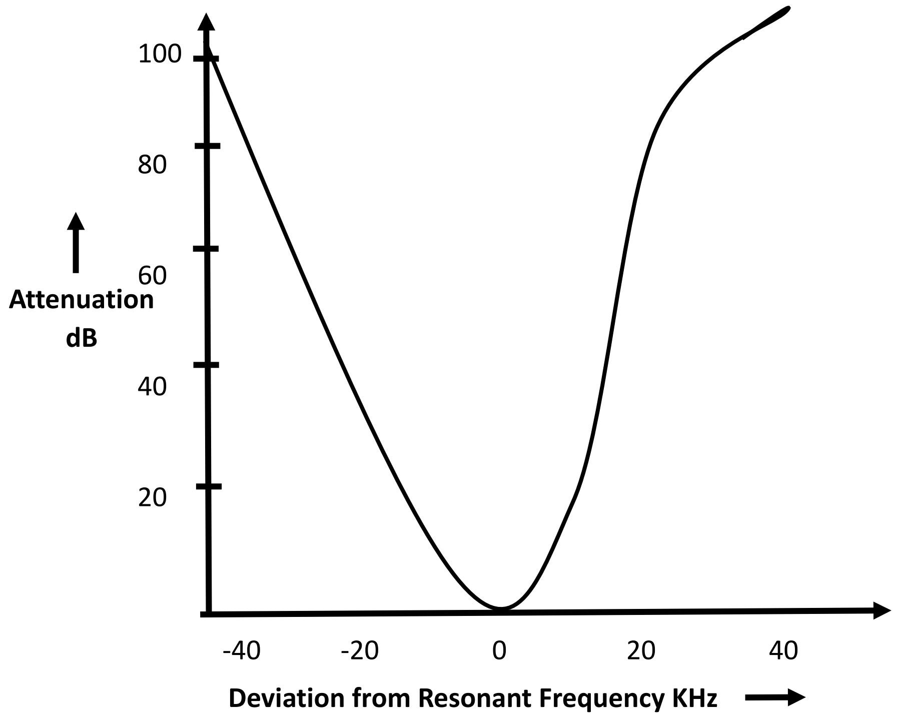
Now respective Input Voltage is measured.

Carrier Frequencies are varied from 530 KHz to 1650 KHz and the respective Input Voltages are measured.

Finally plot the graph of sensitivity curve with carrier frequency on X-axis and Receiver Input on Y-axis.

SELECTIVITY :-

Ability of the Radio receiver to select the desired signal and reject the unwanted signal is called as the " **Selectivity of the Radio Receiver** "

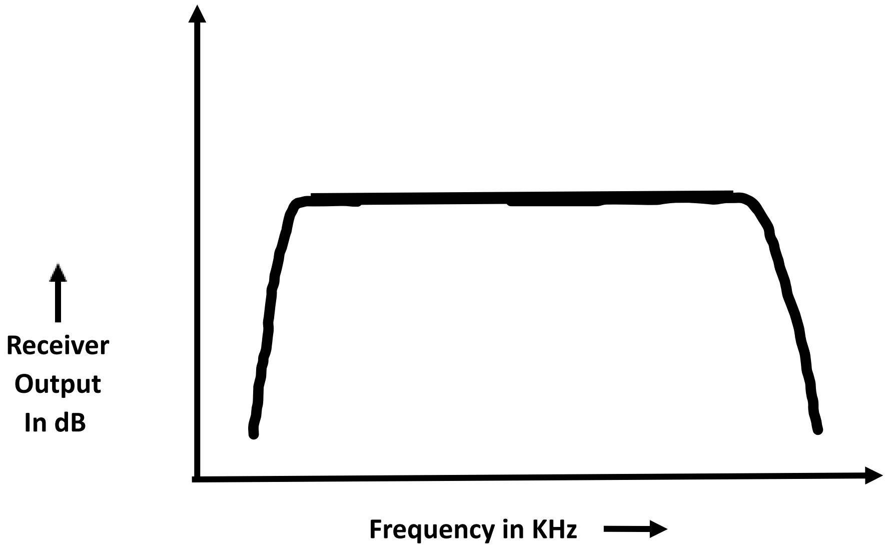


A frequency output of 950 KHz is obtained by tunning the receiver to 950 KHz

To get the receiver output of 50 mW generator output power is adjusted in steps.

A graph is plotted with Deviation from Resonant Frequency in KHz on X-axis and Attenuation on Y-axis.
The narrower is the selectivity curve , more is the selectivity of the receiver becomes.

FIDELITY OF THE RADIO RECEIVER :-



The ability of the Radio receiver to reproduce all the original lower frequency signals equally is called as the " FIDELITY " of the radio receiver .

AF amplifier decides the Fidelity of the given radio receiver .

To obtain a quality music High Fidelity is required i.e. Fidelity curve must be flat.

PROCEDURE OF MEASURING FIDELITY OF THE RADIO RECEIVER :-

A constant Carrier frequency of 1000 KHz with 30 % modulation is obtained to measure the fidelity of the radio receiver.

To get the maximum constant output , modulating frequency and output voltage are varied while keeping constant Input voltage.

Modulating Frequencies are varied from 10 Hz to 10 KHz and the respective Output Voltages are measured.

A graph is plotted with modulating Frequencies in KHz on X-axis and Output power on Y-axis.

For all the audio frequencies fidelity curve must be flat.

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