PPT ON DC MACHINES

BY

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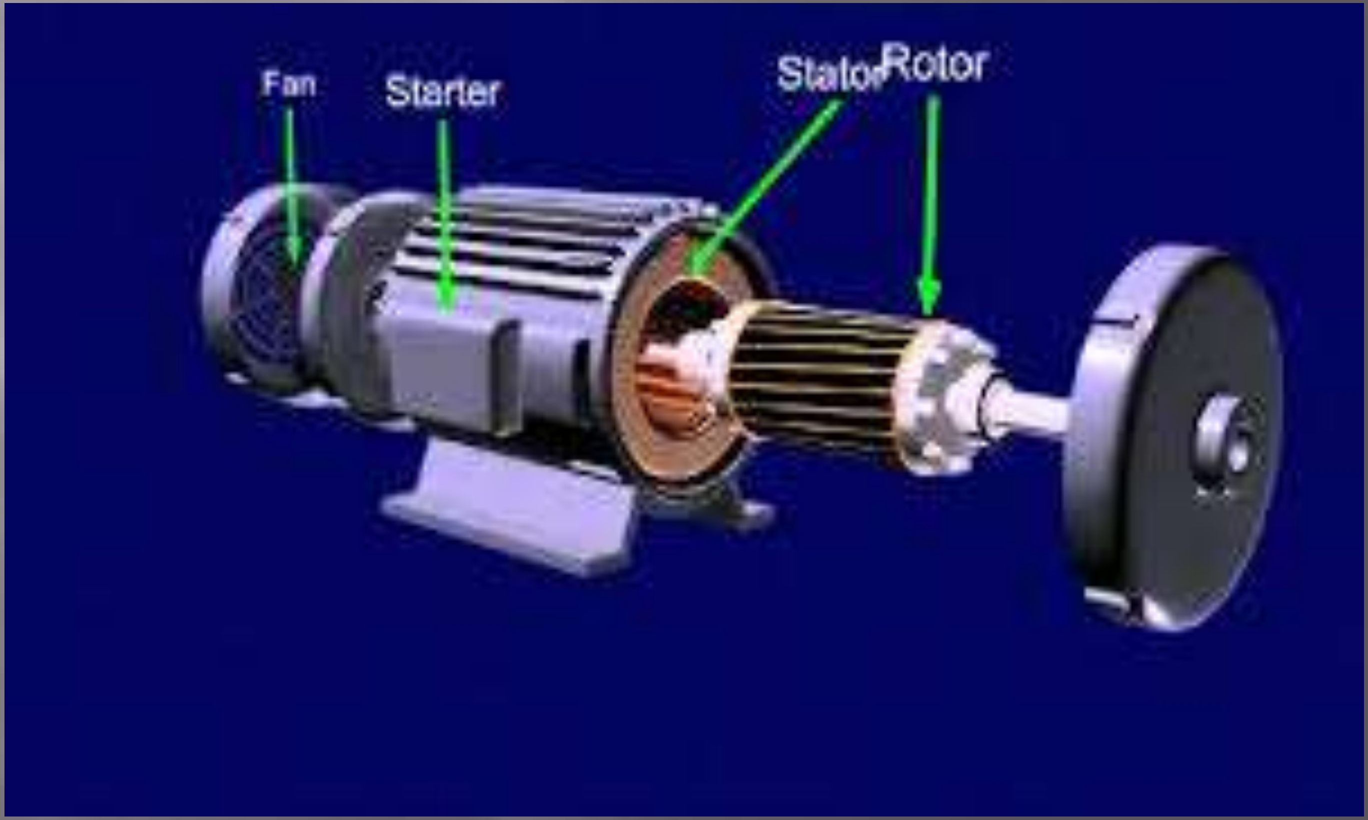
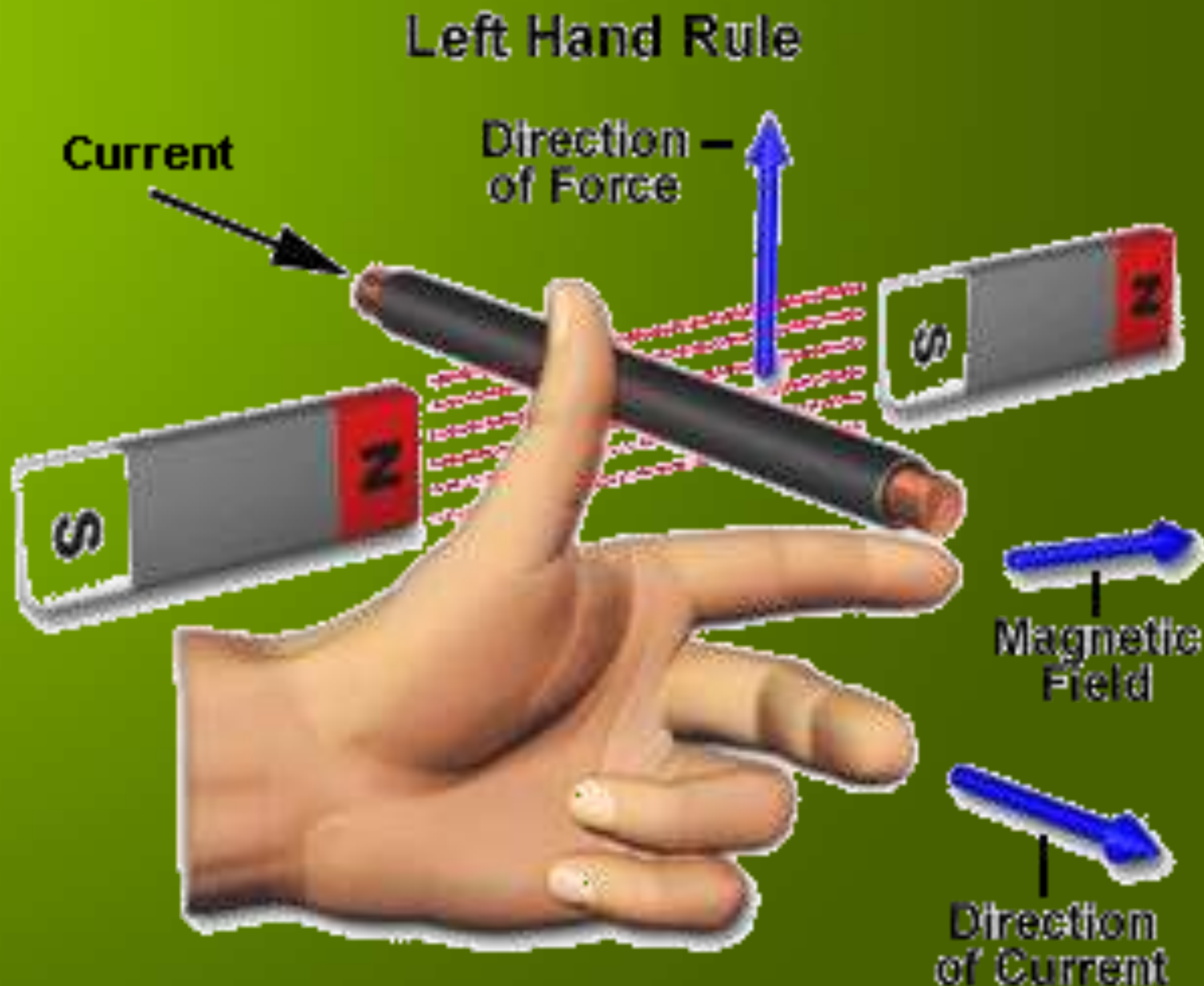
- NOTE-THE VIDEO CONTENT ETC. IF ANY HAS BEEN TAKEN FROM YOU TUBE FOR REFERENCE PURSPOSE.

A VIEW OF DC MACHINE



Fleming’s left hand rule

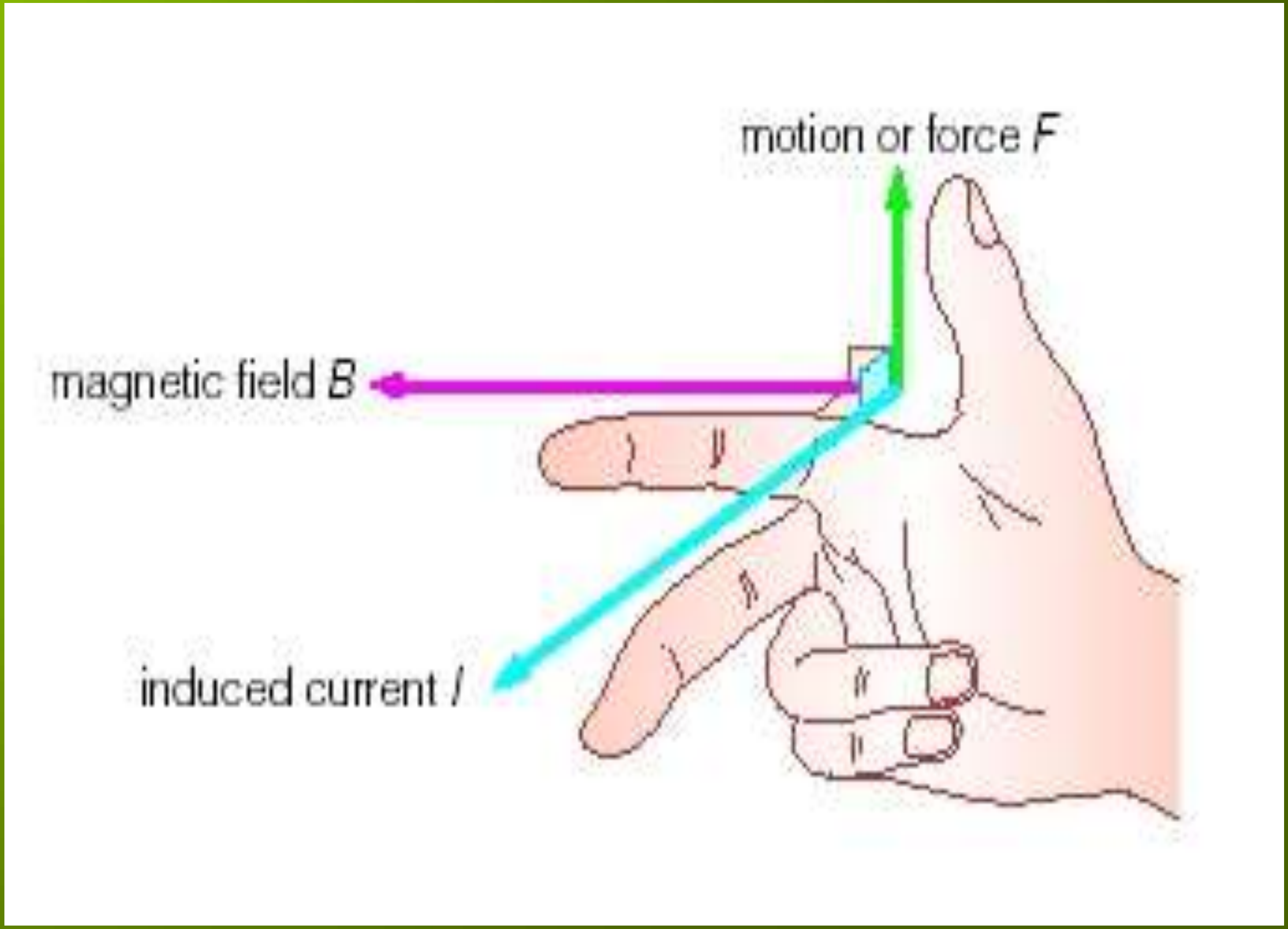


Fleming's left hand rule

- Used to determine the direction of force acting on a current carrying conductor placed in a magnetic field .
- The middle finger , the fore finger and thumb of the left hand are kept at right angles to one another .
  - The middle finger represent the direction of current
  - The fore finger represent the direction of magnetic field
  - The thumb will indicate the direction of force acting on the conductor .

This rule is used in motors.

Fleming’s Right hand rule



Fleming’s Right hand rule

- Used to determine the direction of emf induced in a conductor
- The middle finger , the fore finger and thumb of the left hand are kept at right angles to one another.
    - The fore finger represent the direction of magnetic field
    - The thumb represent the direction of motion of the conductor
    - The middle finger will indicate the direction of the inducted emf .

This rule is used in DC Generators

Len’s Law

The direction of induced emf is given by Lenz’s law .

According to this law, the induced emf will be acting in such a way so as to oppose the very cause of production of it .

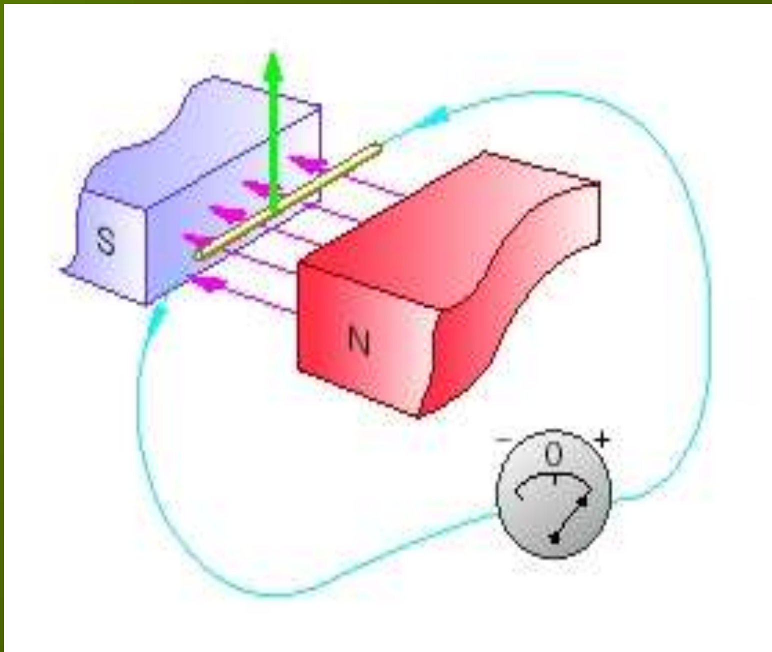
- $e = -N\,(d\text{Ø}/dt)$ volts

DC Generator

Mechanical energy is converted to electric energy

Three requirements are essential

1. Conductors
2. Magnetic field
3. Mechanical energy



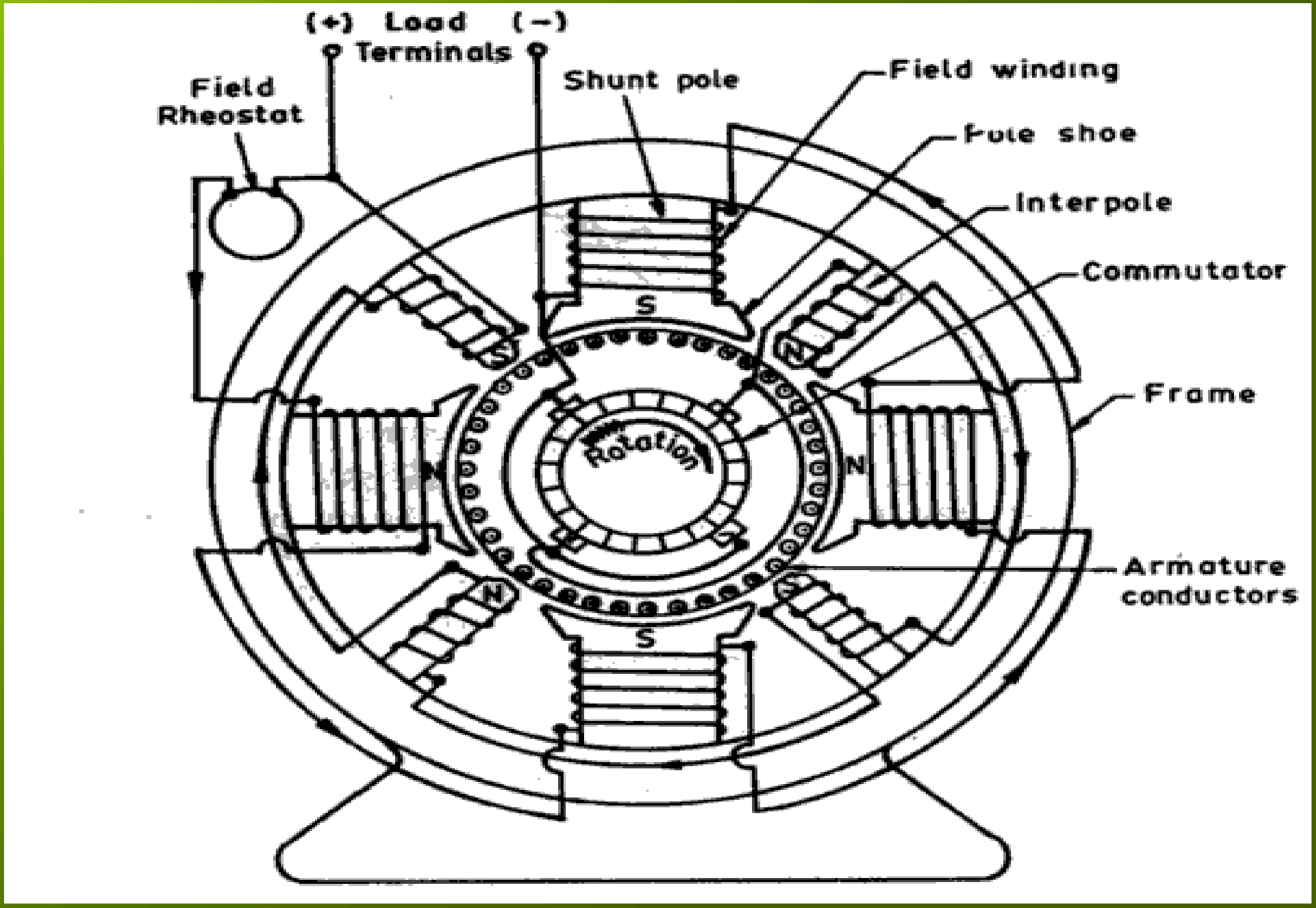
Working principle

- A generator works on the principles of Faraday’s law of electromagnetic induction

- Whenever a conductor is moved in the magnetic field , an emf is induced and the magnitude of the induced emf is directly proportional to the rate of change of flux linkage.

- This emf causes a current flow if the conductor circuit is closed .

Sectional view of a DC machine



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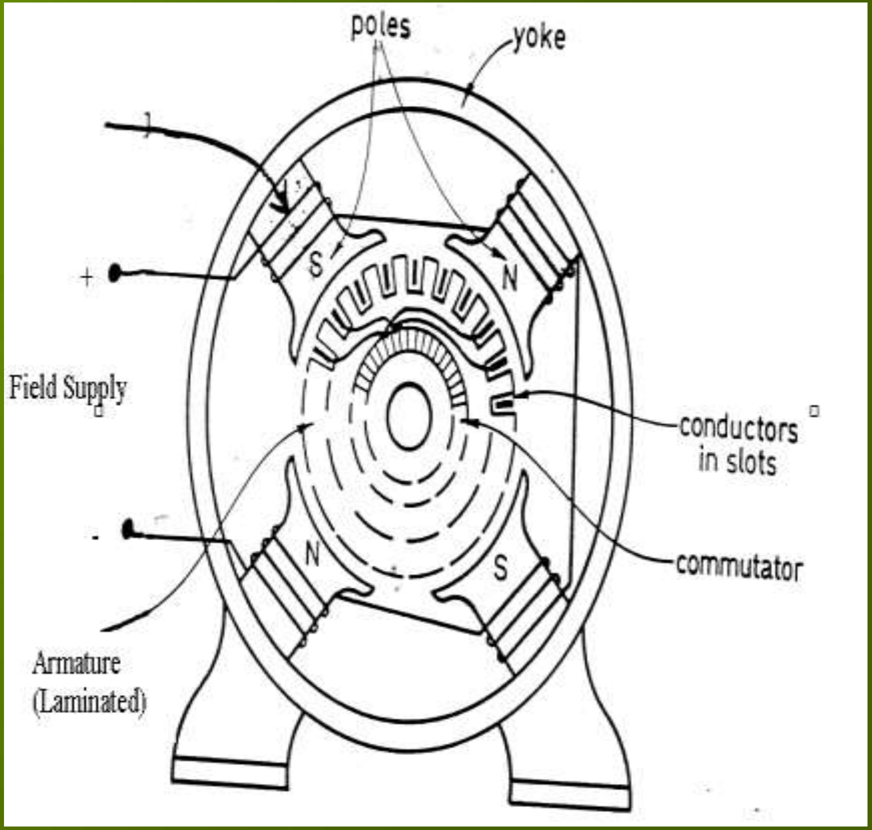
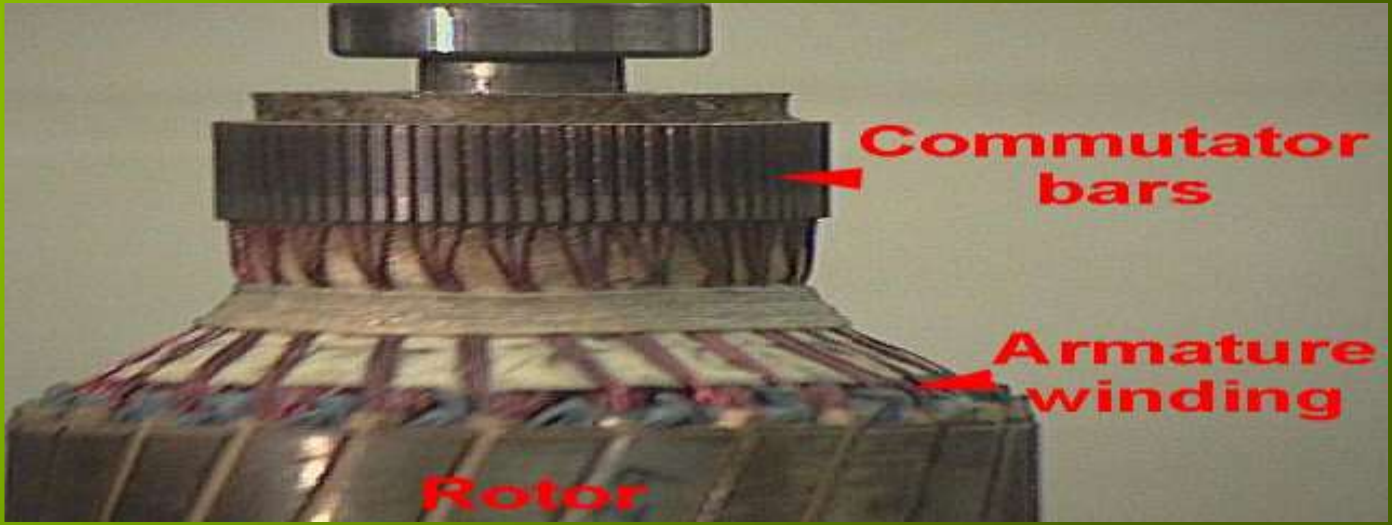
Construction of DC Generator

- Field system
- Armature core
- Armature winding
- Commutator
- Brushes

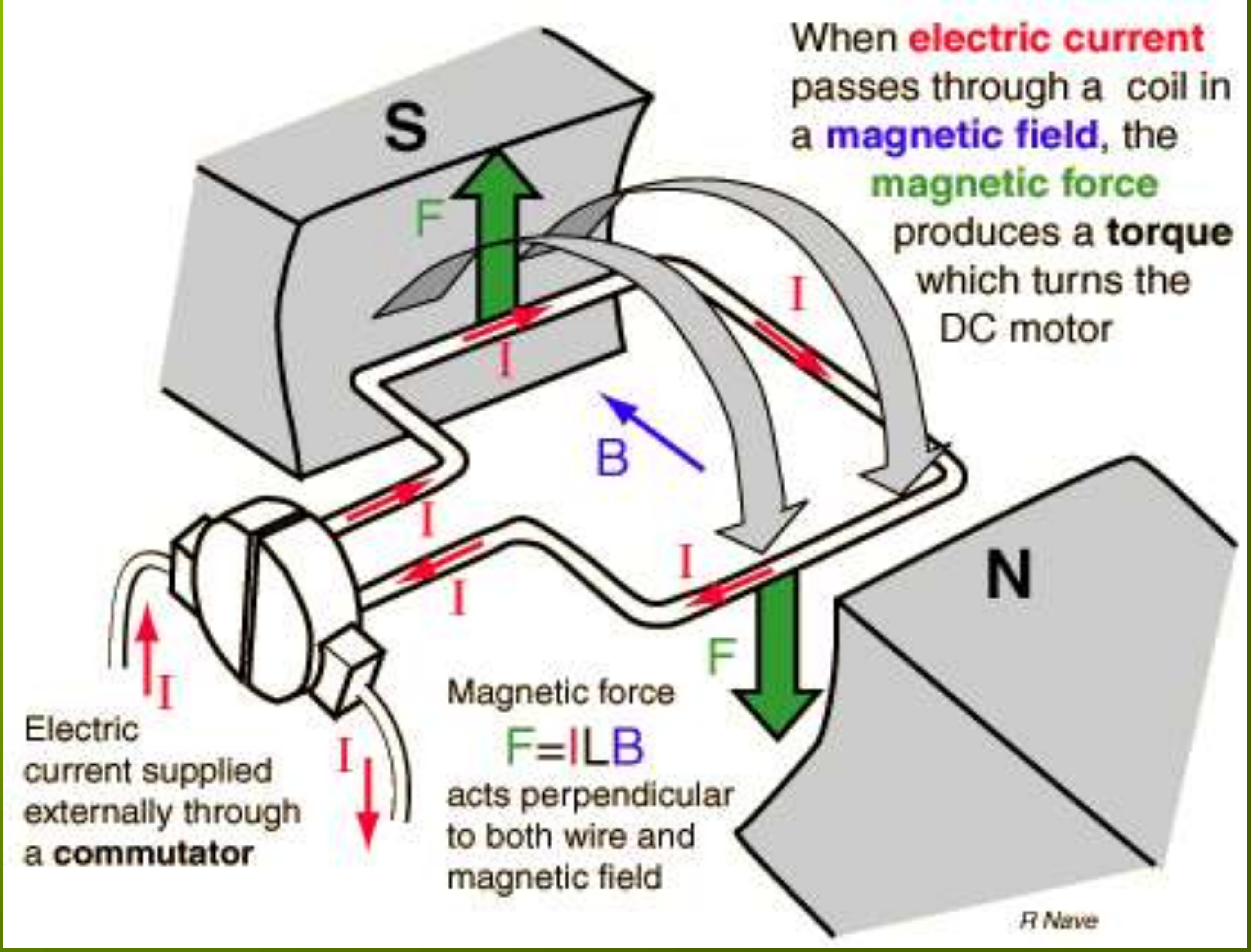


Field winding

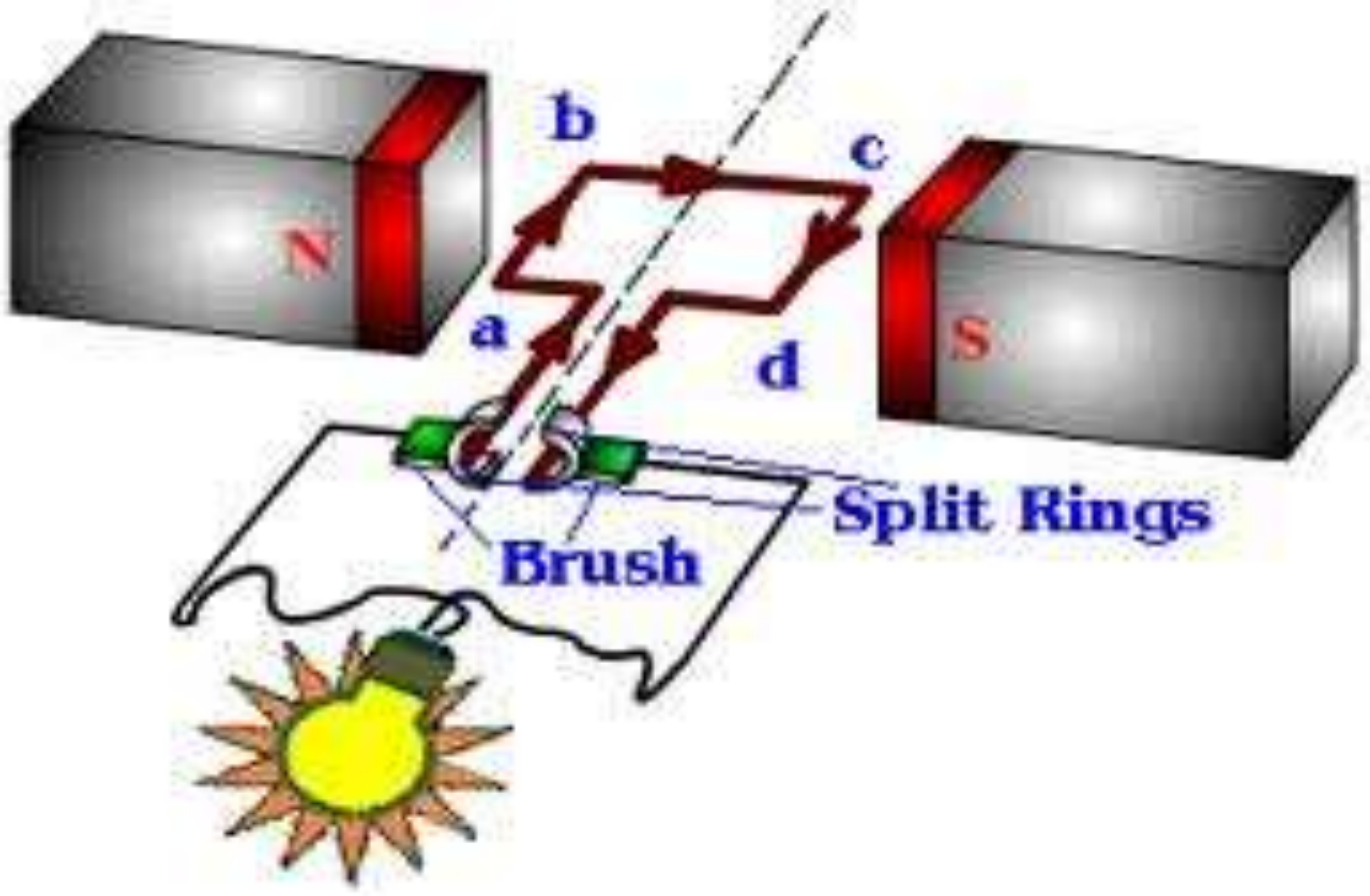
Rotor and rotor winding



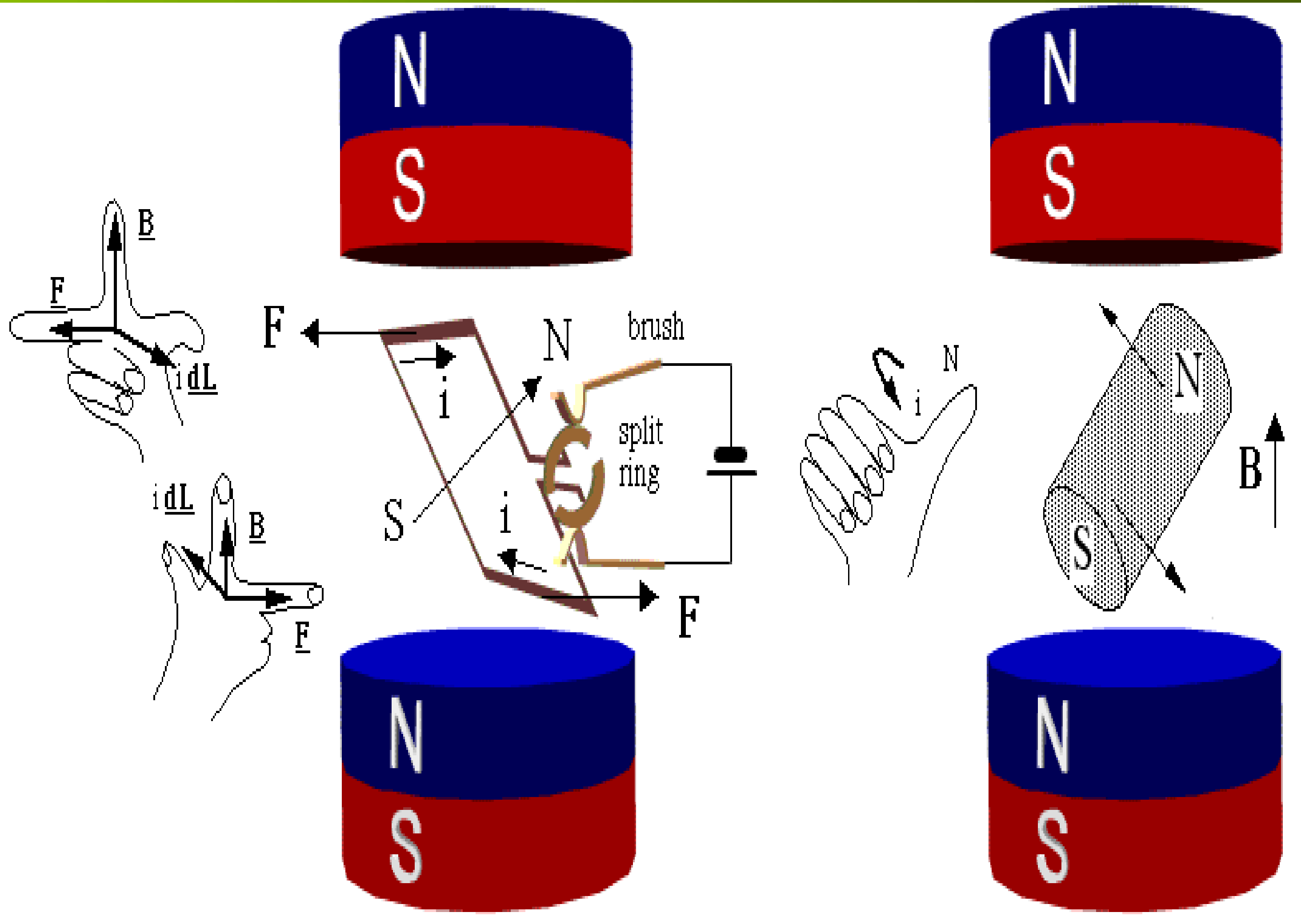
Working principle of DC motor



Working principle of DC motor



Force in DC motor



Armature winding

There are 2 types of winding

Lap and Wave winding

Lap winding

- **A = P**

- The armature windings are divided into no. of sections equal to the no of poles

Wave winding

- **A = 2**

- It is used in low current output and high voltage.

- 2 brushes

Field system

- It is for uniform magnetic field within which the armature rotates.
- Electromagnets are preferred in comparison with permanent magnets
- They are cheap , smaller in size , produce greater magnetic effect and
- Field strength can be varied

Field system consists of the following parts

- Yoke
- Pole cores
- Pole shoes
- Field coils

Armature core

- The armature core is cylindrical
- High permeability silicon steel stampings
- Impregnated
- Lamination is to reduce the eddy current loss

Commutator

- Connect with external circuit
- Converts ac into unidirectional current
- Cylindrical in shape
- Made of wedge shaped copper segments
- Segments are insulated from each other
- Each commutator segment is connected to armature conductors by means of a cu strip called riser.
- No of segments equal to no of coils

Carbon brush

- Carbon brushes are used in DC machines because they are soft materials
- It does not generate spikes when they contact commutator
- To deliver the current thro armature
- Carbon is used for brushes because it has negative temperature coefficient of resistance
- Self lubricating , takes its shape , improving area of contact

Brush rock and holder

Carbon brush

- Brush leads (pig tails)
- Brush rocker (brush gear)
- Front end cover
- Rear end cover
- Cooling fan
- Bearing
- Terminal box

EMF equation

Let,

- Ø= flux per pole in weber
- Z = Total number of conductor
- P = Number of poles
- A = Number of parallel paths
- N =armature speed in rpm
- Eg = emf generated in any on of the parallel path

EMF equation

Flux cut by 1 conductor in 1 revolution $= P * \phi$

Flux cut by 1 conductor in 60 sec $= P \phi N / 60$

Avg emf generated in 1 conductor $= P\phi N/60$

Number of conductors in each parallel path $= Z / A$

Eg $= P\phi NZ/60A$

Types of DC Generator

DC generators are generally classified according to their method of excitation .

- Separately excited DC generator
- Self excited D C generator

Further classification of DC Generator

- Series wound generator
- Shunt wound generator
- Compound wound generator
  - Short shunt & Long shunt
  - Cumulatively compound

    &

    Differentially compound

Characteristics

- No load saturation characteristic (E_o/I_f)
- Internal or Total characteristic (E/ I_a)
- External characteristic (V/I)

Critical field resistance

For appreciable generation of emf, <u>the field resistance must be always less certain resistance</u>, that resistance is called as the critical resistance of the machine .

General terms used in Armature reaction

Magnetic neutral axis :

It is perpendicular to the lines of force between the two opposite adjacent poles.

Leading pole Tip (LPT) :

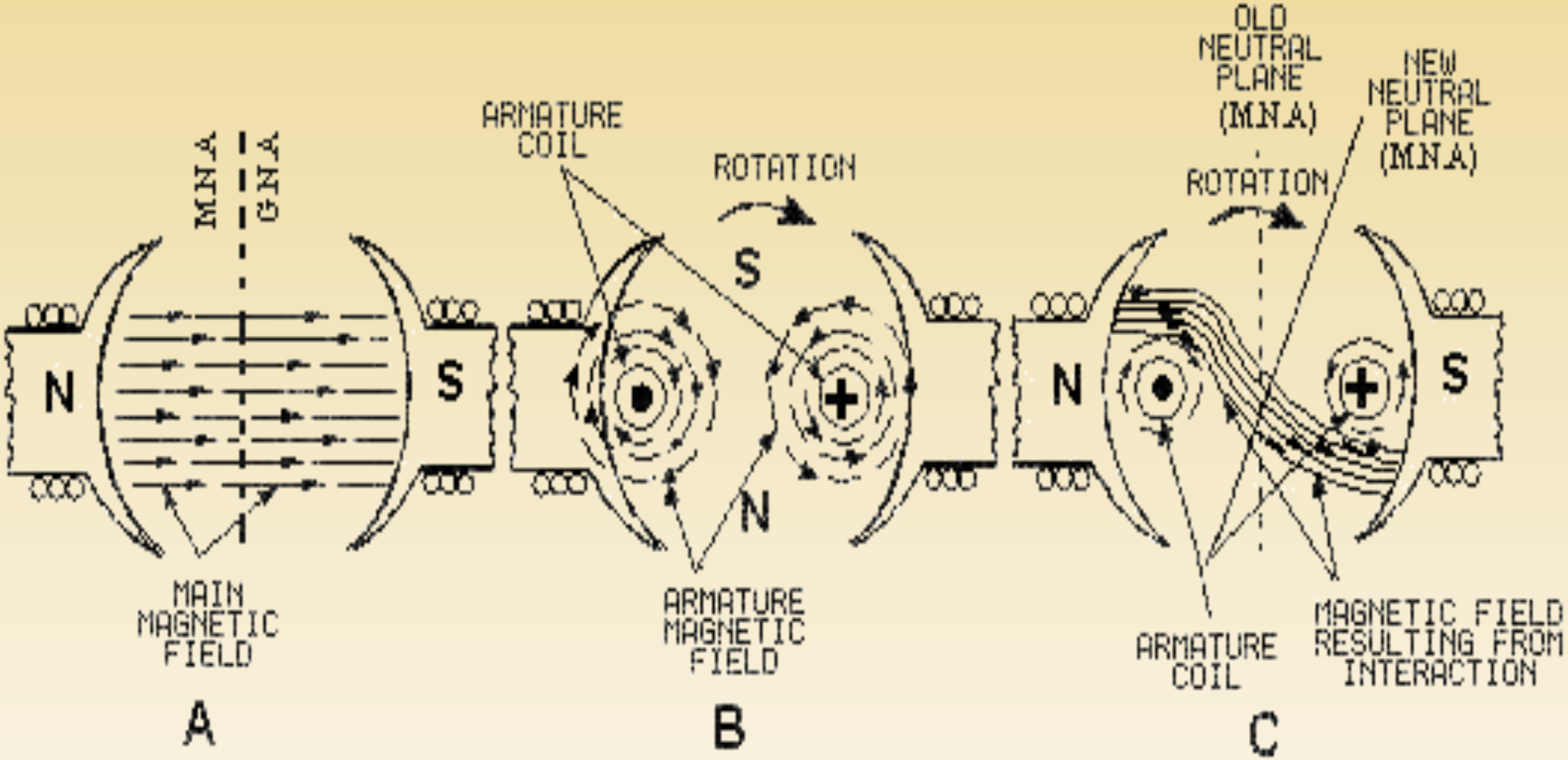
It is the end of the pole which first comes in contact with the armature.

Trailing pole tip :

It is the end of the pole which comes in contact later with the armature.

Armature Reaction

Interaction of Main field flux with Armature field flux



Effects of Armature Reaction

- It decreases the efficiency of the machine
- It produces sparking at the brushes
- It produces a demagnetising effect on the main poles
- It reduces the emf induced
- Self excited generators some times fail to build up emf

Armature reaction remedies

1. Brushes must be shifted to the new position of the MNA
2. Extra turns in the field winding
3. Slots are made on the tips to increase the reluctance
4. The laminated cores of the shoe are staggered
5. In big machines the compensating winding at pole shoes produces a flux which just opposes the armature mmf flux automatically.

Commutation

The change in direction of current takes place when the conductors are along the brush axis .

During this reverse process brushes short circuit that coil and undergone commutation

Due to this sparking is produced and the brushes will be damaged and also causes voltage dropping.

Losses in DC Generators

1. Copper losses or variable losses
2. Stray losses or constant losses

Stray losses : consist of (a) iron losses or core losses and (b) windage and friction losses .

Iron losses : occurs in the core of the machine due to change of magnetic flux in the core . Consist of hysteresis loss and eddy current loss.

Hysteresis loss depends upon the frequency , Flux density , volume and type of the core .

Losses

Hysteresis loss depends upon the frequency , Flux density , volume and type of the core .

Eddy current losses : directly proportional to the flux density , frequency , thickness of the lamination .

Windage and friction losses are constant due to the opposition of wind and friction .

Applications

<u>Shunt Generators:</u>

a. in electro plating

b. for battery recharging

c. as exciters for AC generators.

<u>Series Generators :</u>

A. As boosters

B. As lighting arc lamps

DC Motors

- Converts Electrical energy into Mechanical energy
- Construction : Same for Generator and motor
- Working principle : Whenever a current carrying conductor is placed in the magnetic field , a force is set up on the conductor.

Back emf

The induced emf in the rotating armature conductors always acts in the opposite direction of the supply voltage .

According to the Lenz's law, the direction of the induced emf is always so as to oppose the cause producing it .

In a DC motor , the supply voltage is the cause and hence this induced emf opposes the supply voltage.

Classification of DC motors

DC motors are mainly classified into three types as listed below:

- Shunt motor
- Series motor
- Compound motor
  - Differential compound
  - Cumulative compound

Torque

The turning or twisting force about an axis is called torque .

- $P = T * 2\pi N/60$
- $Eb\ Ia = Ta * 2\pi N/60$
- $T \propto \phi\ I\ a$
- $Ta \propto I2a$

Characteristic of DC motors

- T/ Ia characteristic
- N/ I a characteristic
- N/T characteristic

Speed control of DC motors

According to the speed equation of a dc motor

$$N \propto Eb/\phi$$

$$\propto V- Ia\ Ra/ \phi$$

Thus speed can be controlled by-

<u>Flux control method:</u> By Changing the flux by controlling the current through the field winding.

<u>Armature control method:</u> By Changing the armature resistance which in turn changes the voltage applied across the armature

Flux control

<u>Advantages of flux control:</u>

- It provides relatively smooth and easy control
- Speed control above rated speed is possible
- As the field winding resistance is high the field current is small. Power loss in the external resistance is small . Hence this method is economical

<u>Disadvantages:</u>

- Flux can be increased only upto its rated value
- High speed affects the commutation, motor operation becomes unstable

Armature voltage control method

- The speed is directly proportional to the voltage applied across the armature .
- Voltage across armature can be controlled by adding a variable resistance in series with the armature

Potential divider control :

If the speed control from zero to the rated speed is required , by rheostatic method then the voltage across the armature can be varied by connecting rheostat in a potential divider arrangement .

Starters for DC motors

Needed to limit the starting current .

1. Two point starter
2. Three point starter
3. Four point starter

Testing of DC machines

To determine the efficiency of as DC motor , the output and input should be known.

There are two methods.

- The load test or The direct method
- The indirect method

Direct method: In this method , the efficiency is determined by knowing the input and output power of the motor.

Indirect method: Swinburne's test is an indirect method of testing DC shunt machines to predetermine the effficency , as a motor and as a Generator. In this method, efficiency is calculated by determining the losses .

Applications:

<u>Shunt Motor</u>:

- Blowers and fans
- Centrifugal and reciprocating pumps
- Lathe machines
- Machine tools
- Milling machines
- Drilling machines

Applications:

<u>Series Motor:</u>

- Cranes
- Hoists , Elevators
- Trolleys
- Conveyors
- Electric locomotives

Applications:

Cumulative compound Motor:

- Rolling mills
- Punches
- Shears
- Heavy planers
- Elevators

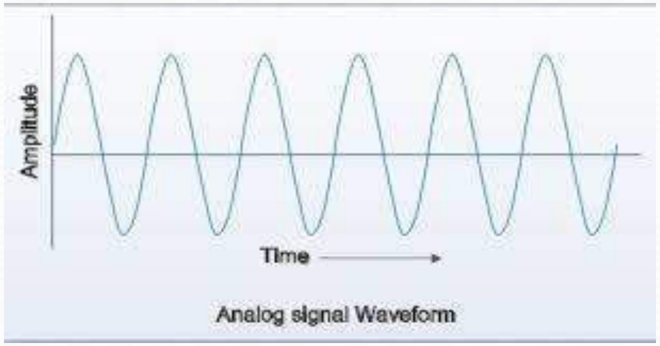
THANK YOU

INTRODUCTION

CHAPTER-1

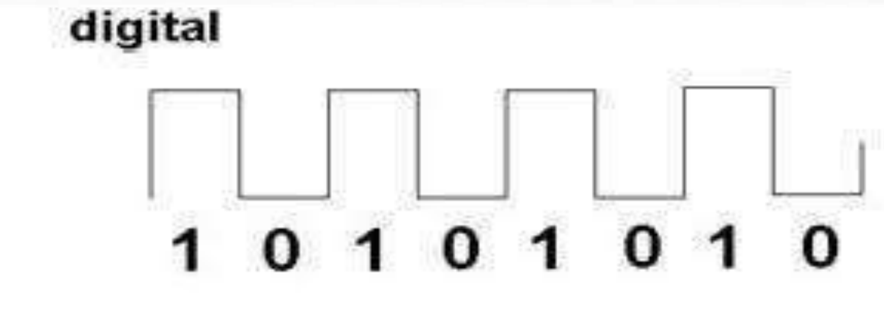
ANALOG SIGNAL

- An **analog signal** is any continuous signal for which the time-varying feature (variable) of the signal is a representation of some other time varying quantity, i.e., *analogous* to another time varying signal.
- For example, in an analog audio signal, the instantaneous voltage of the signal varies continuously with the pressure of the sound waves.



DIGITAL SIGNAL

- A **digital signal** is a signal that is being used to represent data as a sequence of discrete values; at any given time it can only take on one of a finite number of values in most digital circuits.
- The signal can have two possible values(0,1); this is called a binary signal or **logic signal**.[4

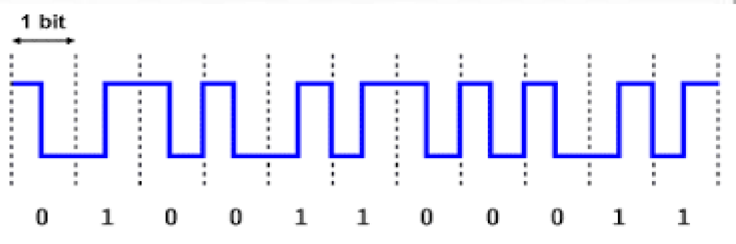


Difference Between Analog And Digital Signal

Factors	Analog	Digital
Waves	Denoted by Sine waves	Denoted by Square waves
Signal	Continuous signal representing physical measurements	Discrete signal representing discrete time signals generated by digital modulation
Data Transmission	Subject to deterioration by noise	Noise-immune without deterioration
Bandwidth	Consumes less bandwidth	Consumes more bandwidth
Memory	Stored in the form of wave signal	Stored in the form of binary bit
Power	Draws large power	Draws negligible power
Impedance	Low impedance	High order of 100 megaohm
Errors	Analog instruments have considerable observational errors	Digital instruments are free from observational errors

Advantages Of Digital Signal

- Easier To Design.
- Digital System Have Got Fast Response Time.
- Information Can Be Stored And Retrived Very Easily.
- More Accurate And Have Great Percision.
- Less Effected By Noise.
- Easier To Use Because Direct Display Of Data Is Convenient To Read.
- Digital Ckt. Can Be Fabricated On IC Chips.



Advantages of Analog Signal

- Best suited for the transmission of audio and video.
- Consume less bandwidth than digital signals to carry the same information.
- Analog signal is less susceptible to noise.

Applications Of Digital Signal

- Data Base Management System(DBMS) Used In Banks, Offices, Institutes, Shops etc. Using Computers.
- Process Monitoring And Control System In Industries Using Computers, PLC's, Robots.
- Digital Signal Processing And Digital Communication.
- Entertainment Appliances Like CD/DVD Player LED TVs, Digital Cameras.

- Medical Instruments Like Digital X-ray Machin[e] Ultra Sound Machines etc.

- Combustion Control In Modern Vechicles.

Applications Of Analog signal

→Thermometer.
→photocopiers
→old land-line telephone
→audio tapes
→VCRs (same as TV)

NUMBER SYSTEM

CHAPTER -2

Number system & its types

- Code using symbols that refers to a set of items.
- **Types of Number system**

    Binary number system

    Decimal number system

    Octal number system

    Hexa -decimal number system

Binary Number System

- A number system which have two values 0 and 1 is called binary number system.
- The base or radix is 2.

Decimal Number system

- The decimal number system contains ten distinct symbols (0 to 9).
- The base or radix is 10.

Decimal to Binary conversion

- Technique
  - Divide by two, keep track of the remainder
  - First remainder is bit 0 (LSB, least-significant bit)
  - Second remainder is bit 1
  - Etc.

Example

$125_{10} = ?_2$

2	125	
2	62	1
2	31	0
2	15	1
2	7	1
2	3	1
2	1	1
	0	1

$125_{10} = 1111101_2$

Binary to Decimal Conversion

- Technique
  - Multiply each bit by 2^n, where n is the “weight” of the bit
  - The weight is the position of the bit, starting from 0 on the right
  - Add the results

Example

101011_2 =>

$$
\begin{aligned}
1 \times 2^0 &= 1 \\
1 \times 2^1 &= 2 \\
0 \times 2^2 &= 0 \\
1 \times 2^3 &= 8 \\
0 \times 2^4 &= 0 \\
1 \times 2^5 &= 32
\end{aligned}
$$

43_{10}

Octal Number system

- In this system, there are eight distinct symbols that represent octal numbers(0 to 7).
- The base or radix is 8.

Hexa-decimal Number system

- This system uses 16 distinct symbols (o to 9, A toF).
- The base or radix is 16.

Octal to Binary conversion

- Technique
  - Convert each octal digit to a 3-bit equivalent binary representation

Example

$705_8 = ?_2$

$$\begin{array}{ccc} 7 & 0 & 5 \\ \downarrow & \downarrow & \downarrow \\ 111 & 000 & 101 \end{array}$$

$705_8 = 111000101_2$

Binary to Octal

- Technique
  - Group bits in threes, starting on right
  - Convert to octal digits

Example

$1011010111_2 = ?_8$

1 011 010 111

1 3 2 7

$1011010111_2 = 1327_8$

Octal to Decimal

- Technique
  - Multiply each bit by 8^n, where *n* is the "weight" of the bit
  - The weight is the position of the bit, starting from 0 on the right
  - Add the results

Example

724_8 =>

$4 \times 8^0 = 4$
$2 \times 8^1 = 16$
$7 \times 8^2 = 448$

468_{10}

Decimal to Octal

- Technique
  - Divide by 8
  - Keep track of the remainder

Example

$1234_{10} = ?_8$

Divisor	Quotient	Remainder
8	1234	
8	154	2
8	19	2
8	2	3
	0	2

$1234_{10} = 2322_8$

Decimal to Hexadecimal

- Technique
  - Divide by 16
  - Keep track of the remainder

Example

$1234_{10} = ?_{16}$

16	1234	
16	77	2
16	4	13 = D
	0	4

$1234_{10} = 4D2_{16}$

Binary to Hexadecimal

- Technique
  - Group bits in fours, starting on right
  - Convert to hexadecimal digits

Example

$1010111011_2 = ?_{16}$

10 1011 1011

2 B B

$1010111011_2 = 2BB_{16}$

Hexadecimal to Binary

- Technique
  - Convert each hexadecimal digit to a 4-bit equivalent binary representation

Example

$10AF_{16} = ?_2$

1	0	A	F
↓	↓	↓	↓
0001	0000	1010	1111

$10AF_{16} = 0001000010101111_2$

Hexadecimal to Decimal

- Technique
  - Multiply each bit by 16^n, where n is the “weight” of the bit
  - The weight is the position of the bit, starting from 0 on the right
  - Add the results

Example

$ABC_{16} \Rightarrow$

$$
\begin{aligned}
C \times 16^0 &= 12 \times 1 = 12 \\
B \times 16^1 &= 11 \times 16 = 176 \\
A \times 16^2 &= 10 \times 256 = 2560
\end{aligned}
$$

2748_{10}

Binary Addition

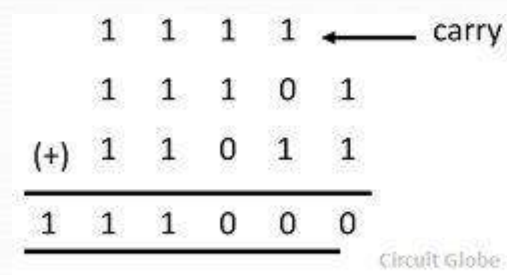
- The binary number system uses only two digits 0 and 1. So , there are four basic operations.

0+0=0

0+1=1

1+0 = 1

1+1 = 10



Binary Subtraction

The subtraction of binary digit depends on four basic operation.

0-0 = 0

1-0 = 1

1 − 1 = 0

10 − 1 = 1

- 1011011 − 10010 = 1001001:

$$\begin{array}{cccccccc} & 1 & 0 & 1 & 1 & 0 & 1 & 1 \\ - & & & 1 & 0 & 0 & 1 & 0 \\ \hline & 1 & 0 & 0 & 1 & 0 & 0 & 1 \end{array}$$

- 100010110 − 1111010 = 10011100:

$$\begin{array}{cccccccccc} & 0 & 1 & 1 & 1 & {}^{1}0 & & & & \\ & \cancel{1} & {}^{1}\cancel{0} & {}^{1}\cancel{0} & {}^{1}\cancel{0} & \cancel{1} & {}^{1}0 & 1 & 1 & 0 \\ - & & & 1 & 1 & 1 & 1 & 0 & 1 & 0 \\ \hline & & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 0 \end{array}$$

Binary Multiplication

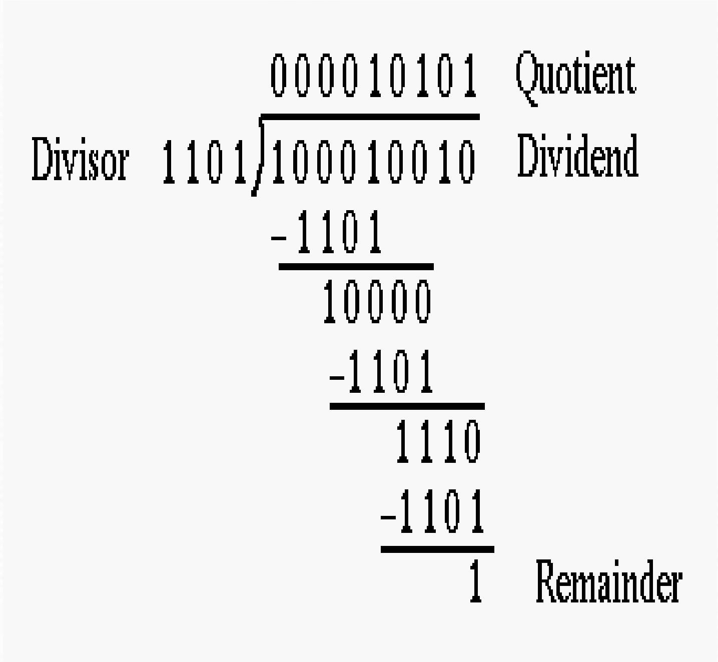
- The rules for binary multiplication are:
- 0 x 0 = 0
- 0 x 1 = 0
- 1 x 0 = 0
- 1 x 1 = 1

$1100 \times 11 = 10100$

$$
\begin{array}{r}
1100 \\
\times 11 \\
\hline
1100 \\
1100\times \\
\hline
10100
\end{array}
$$

Binary Division

- The rules binary division are:
- 0 ÷ 1 =0
- 1 ÷ 1 = 1



Codes and Parity

CHAPTER- 3

Binary Codes

- Binary codes are used in computers and digital communication. These binary codes can be classified as:
- Weighted codes
- Non- weighted codes

Binary Codes

- Electronic digital systems use signals that have two distinct values and circuit elements that have two stable states.
- Digital systems represent and manipulate not only binary numbers, but also many other discrete elements of information.
- Any discrete element of information distinct among a group of quantities can be represented by a binary code.
- Binary codes merely change the symbols, not the meaning of the elements of information that they represent.

Weighted codes

- A weighted code is one in which each digit position has a specific weight or value.
- Examples of weighted codes are 8421(BCD),2421,5211etc.

Binary –Coded Decimal

- Binary-Coded Decimal is a weighted code because each decimal digit can be obtained from its code word by assigning a fixed weight to each code-word bit.
- The weights for the BCD bits are 8, 4, 2, and 1, and for this reason the code is sometimes called the 8421 code.

Non – Weighted Codes

- In non-weighted codes, each digit of the code do not have any position weight.
- Example of non –weighted codes are: ASCII CODE, Excess -3 code, Gray code.

Gray Code

Table 2-10
A comparison of 3-bit binary code and Gray code.

Decimal Number	Binary Code	Gray Code
0	000	000
1	001	001
2	010	011
3	011	010
4	100	110
5	101	111
6	110	101
7	111	100

Excess -3 code

- The code word for each decimal digit is the corresponding BCD code word plus 0011_2.
  - 0010 = 2 in BCD
  - + 0011_2
  - = 0101 = 2 in excess-3

Gray Code

- Gray code is a code where only one bit changes at a time while traversing from 0 to any decimal number in sequence.
- This is a useful property when converting analog values into digital values, since it eliminates the problem of misinterpreting asynchronous changes to bits between valid values.

Parity and its types

- In computers, **parity** is a technique that checks whether data has been lost or written over when it is moved from one place in storage to another or when it is transmitted between computers.

- **TYPES OF PARITY**
- Even parity
- Odd parity

EVEN PARITY

- In this method , one extra bit known as parity bit is added to the binary information.
- The parity is added in such a way that the total number of one’s becomes even.

ODD PARITY

- It is similar to even parity method but the total number of one's should be odd.
- Example of Even and Odd parity

Original Data	Even Parity	Odd Parity
0 0 0 0 0 0 0 0	0	1
0 1 0 1 1 0 1 1	1	0
0 1 0 1 0 1 0 1	0	1
1 1 1 1 1 1 1 1	0	1
1 0 0 0 0 0 0 0	1	0
0 1 0 0 1 0 0 1	1	0

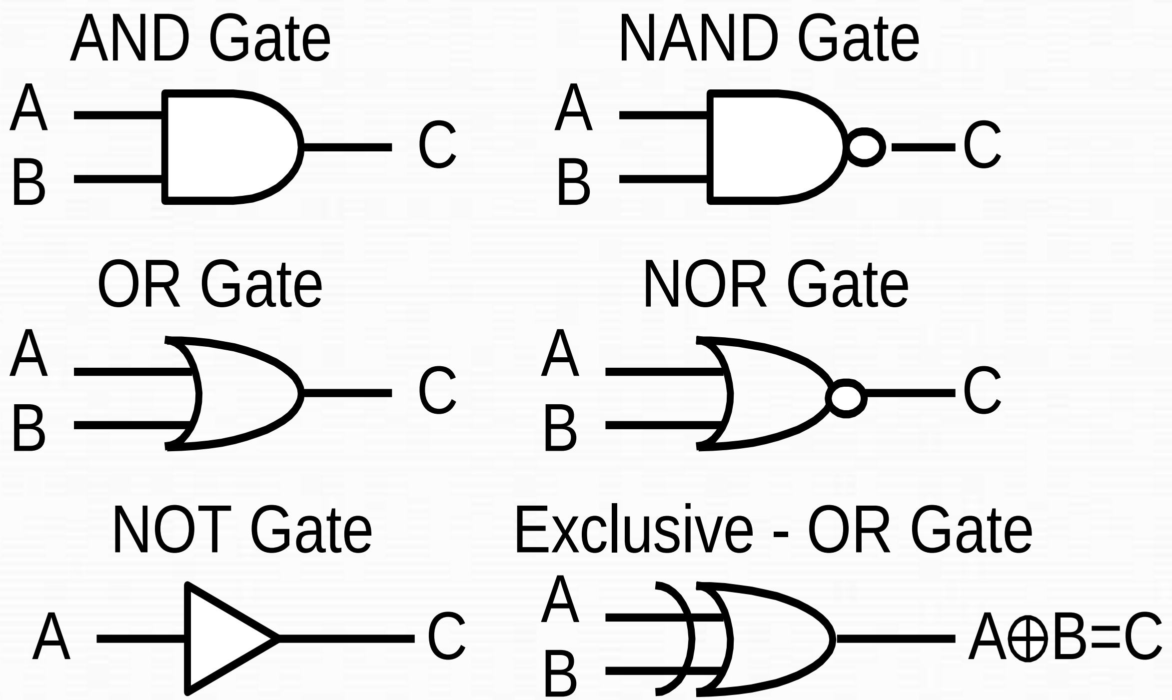
LOGIC GATES AND FAMILIES

CHAPTER- 4

Logic Gates

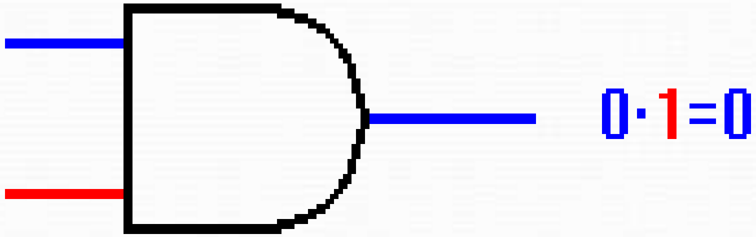
Logic gates are electronic digital circuit perform logic functions. Commonly expected logic functions are already having the corresponding logic circuits in Integrated Circuit (I.C.) form.

Types of Logic Gates



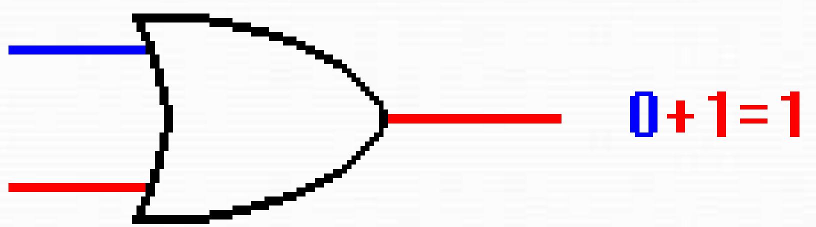
AND Gate

- The AND gate implements the Boolean AND function where the output only is logical 1 when all inputs are logical 1.
- The standard symbol and the truth tabel for a two input AND gate is:



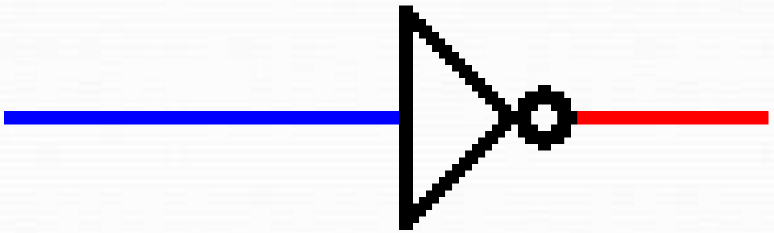
OR Gate

- The OR gate implements the Boolean OR function where the output is logical 1 when just input is logical 1.
- The standard symbol and the truth table for a two input OR gate is:



NOT Gate

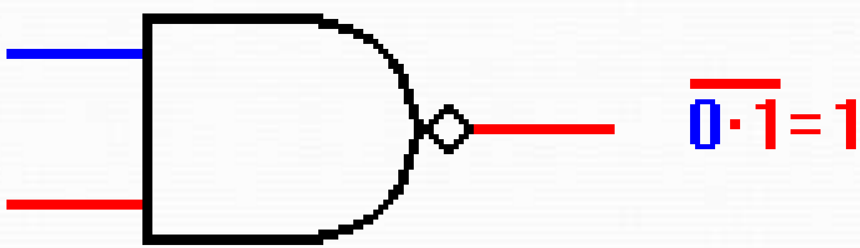
- The NOT gate implements the Boolean NOT function where the output is the inverse of the input.
- The standard symbol and the truth table for the NOT gate is:



$\bar{0} = 1$

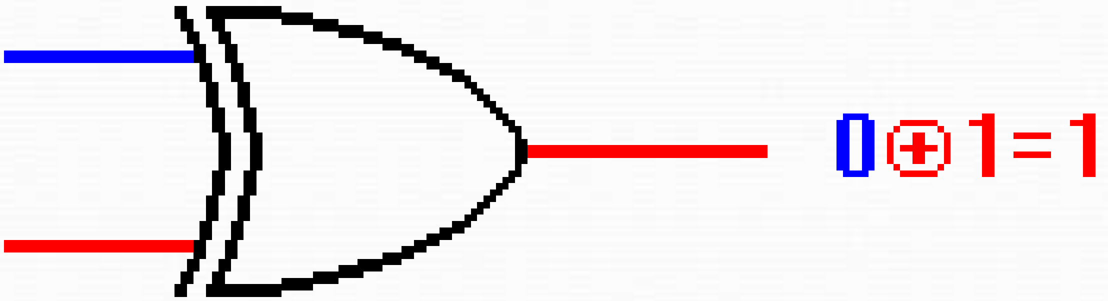
NAND Gate

- The NAND gate is an AND gate followed by a NOT gate. The output is logical 1 when one of the inputs are logical 0
- The standard symbol and the truth table for the NAND gate is:



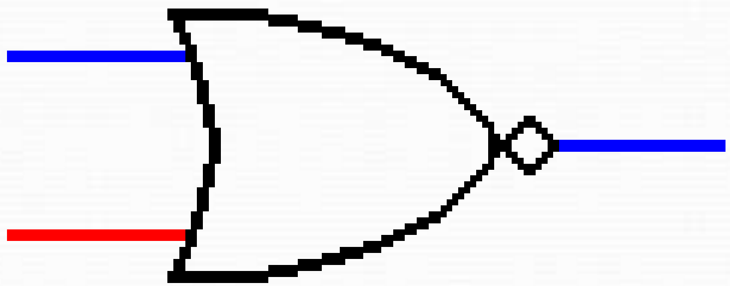
XOR Gate

- The XOR gate produces a logic 1 output only if its two inputs are *different*. If the inputs are the same, the output is a logic 0
- The XOR symbol is a variation on the standard OR symbol. It consists of a plus (+) sign with a circle around it. The logic symbol, as shown here, is a variation on the standard OR symbol.



NOR Gate

- The NOR is a combination of an OR followed by a NOT gate. The output is logical 1 when non of the inputs are logical 0
- The standard symbol and the truth table for the NOR gate is:



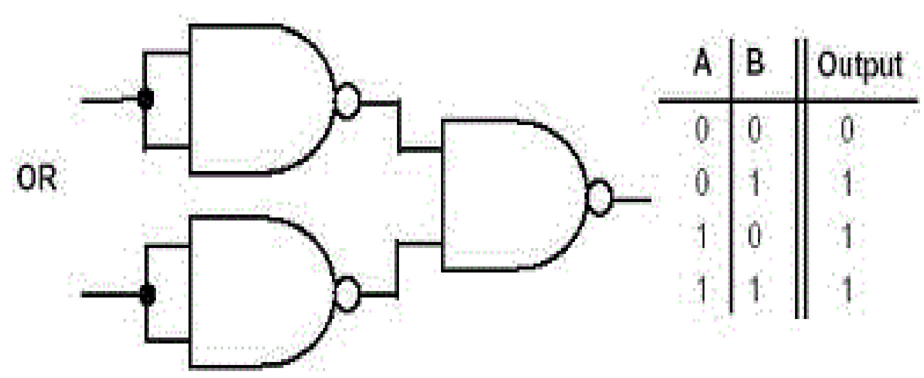
$\overline{0+1}=0$

UNIVERSAL GATES

- A universal gate is actually **NAND and NOR gate**. It is simply because they can be used to construct other gates. To build big and complex digital system, we only use NAND and NOR gate.

NAND GATE AS UNIVERSAL GATE

- NAND gate is used to make OR gate , NOT gate. These gate help us in making al the gates for eg: NAND gate as NC



NOR GATE AS UNIVERSAL GATE

- NOR gate is used for make OR gate , NOT gate . with the help of these gate we can make any gate for ex : NOR gate as OR gate.

Introduction to TTL logic family

- The full form of TTL is Transistor Transistor logic . The digital ICs in the TTL family used only transistor to perform the basic logic operations . TTL families are used as more complex devices in digital system .

TTL CHARACTERISTICS

- **Transistor-transistor logic (TTL)**
  - based on bipolar transistors
  - one of the most widely used families for small- and medium-scale devices – rarely used for VLSI
  - typically operated from 5V supply
  - typical noise immunity about 1 – 1.6 V
  - many forms, some optimised for speed, power, etc.
  - high speed versions comparable to CMOS (~ 1.5 ns)
  - low-power versions down to about 1 mW/gate

Introduction to CMOS logic family

- CMOS stands for Complementary Metal Oxide Semiconductor. A complementary pair uses both p or n channel MOSFETs.

CMOS CHARACTERISTICS

- **Complementary metal oxide semiconductor (CMOS)**
  - most widely used family for large-scale devices
  - combines high speed with low power consumption
  - usually operates from a single supply of 5 – 15 V
  - excellent noise immunity of about 30% of supply voltage
  - can be connected to a large number of gates (about 50)
  - many forms – some with t_{PD} down to 1 ns
  - power consumption depends on speed (perhaps 1 mW

LOGIC SIMPLIFICATION

CHAPTER- 5

INTRODUCTION

- ALL the digital circuit operation depend upon only two values that is either 1 or 0 . Where the value of 1 and 0 denoted the predefined voltage level . So , Boolean algebra can used for the analysis , simplification design of digital circuit .
- There are three operation in Boolean Algebra :
- Logical addition
- Logical multiplication
- Logical inversion

Postulates OF Boolean Algebra

- A statement that is not proved but assumed to be true is called the postulates .
- The basic postulates of Boolean Algebra are:
- Commutative laws
- Associative laws
- Distributed laws
- Identity rule
- Complement rule

DEMORGAN'S THEOREMS

- A great mathematician named demorgan gives two theorems of Boolean Algebra . These theorem are very useful and powerful identities used in Boolean Algebra.

DeMorgan's Theorem #1

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

A	B	A • B	A • B		A	B	A + B
0	0	0	1		1	1	1
0	1	0	1		1	0	1
1	0	0	1		0	1	1
1	1	1	0		0	0	0

EQUAL

DeMorgan’s Theorem #2

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

A	B	A + B	A + B		A	B	A x B
0	0	0	1		1	1	1
0	1	1	0		1	0	0
1	0	1	0		0	1	0
1	1	1	0		0	0	0

EQUAL

KARNAUGH MAPS (K-MAP)

- An n-variable k-map has two cell with each cell corresponding to an n-variable truth table value .
- K-Map cell are labeled with the corresponding truth table row .
- K-Map cells are arranged such that adjacent cells correspond to truth rows that differ in only one bit position (logical adjacency) .

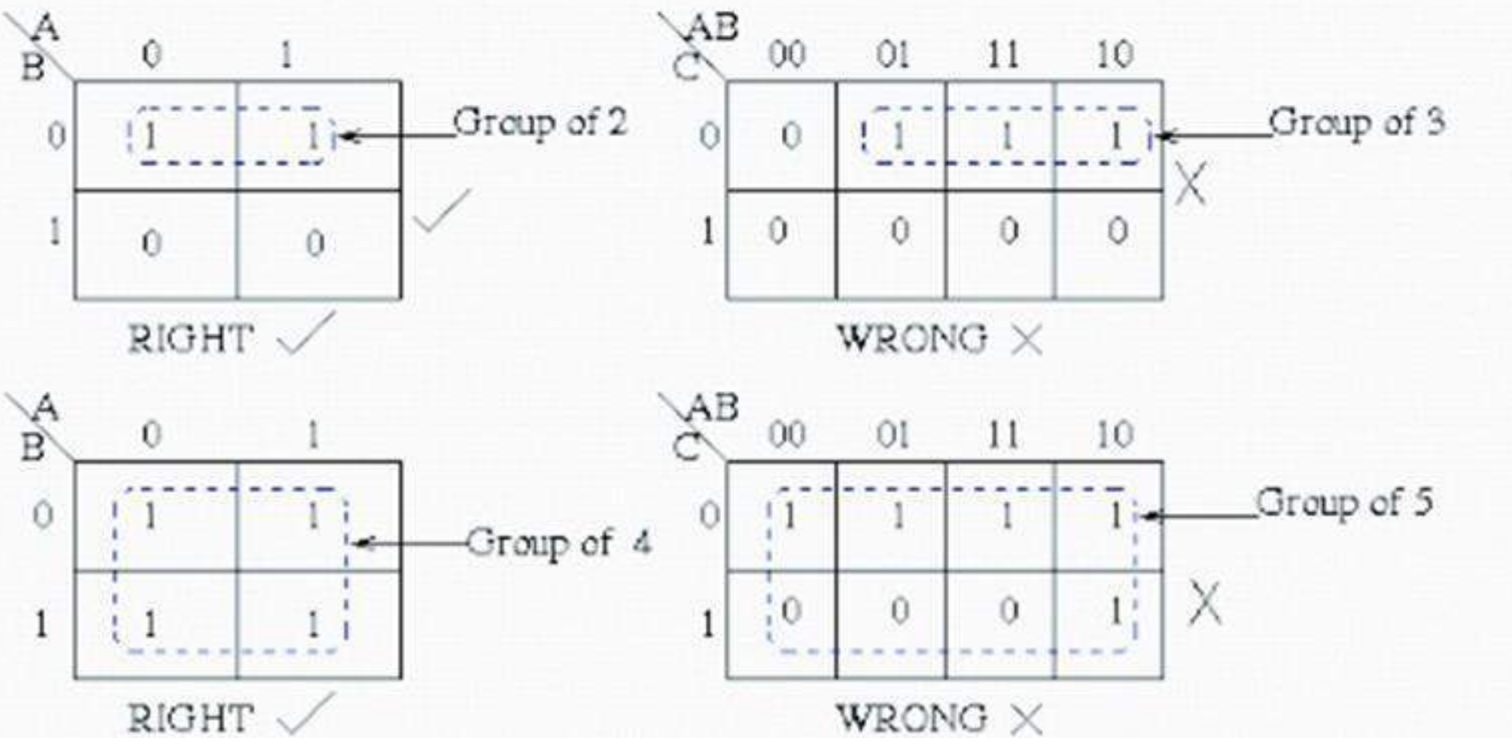
KARNAUGH MAPS (K-MAPS)

- K-Map – A tool for representing Boolean function up to six variables .
- K-Map are tables of row and columns with entries represent 1's or 0's of SOP and POS representation .

3. Groups must contain 1, 2, 4, 8, or in general 2^n cells.

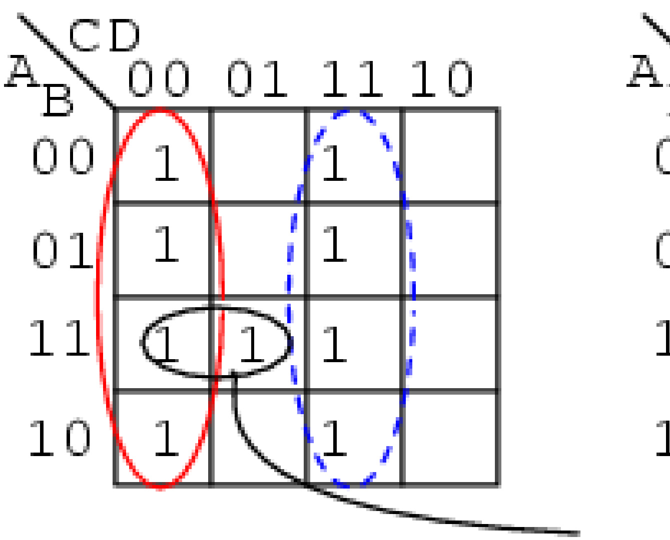
That is if $n = 1$, a group will contain two 1's since $2^1 = 2$.

If $n = 2$, a group will contain four 1's since $2^2 = 4$.

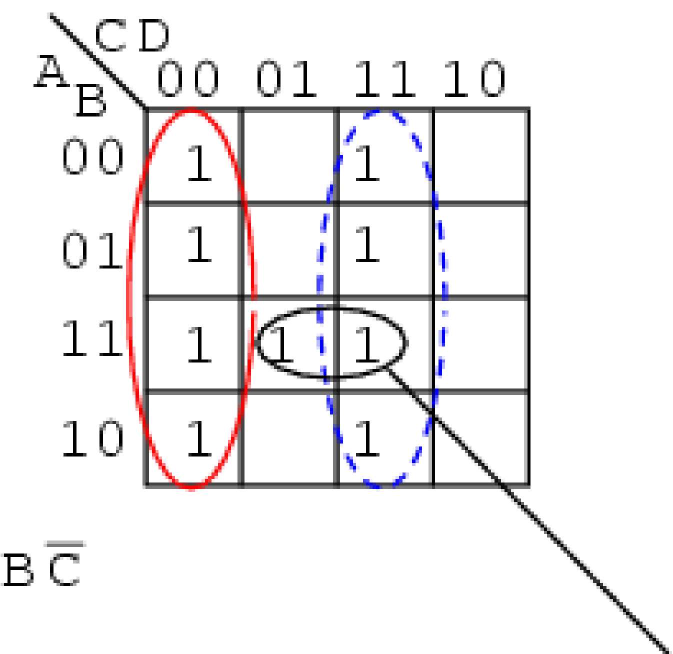


Example – 4 variable K-Map

$$Out = \overline{A}\,\overline{B}\,\overline{C}\,\overline{D} + \overline{A}\,\overline{B}CD + \overline{A}B\overline{C}\,\overline{D} + \overline{A}BCD + AB\overline{C}\,\overline{D} + AB\overline{C}D + ABCD + A\overline{B}\,\overline{C}\,\overline{D} + A\overline{B}CD$$



$$Out = \overline{C}\,\overline{D} + CD + AB\overline{C}$$



$$Out = \overline{C}\,\overline{D} + CD + ABD$$

Advantages and Disadvantages of K-Map

Advantages :

1. Minimizes boolean expressions without the need using various boolean theorems & computations.
2. Minimizes number of Logical gates used.

Disadvantages :

1. Become tedious for 5 variables.
2. It is not suitable for computer reduction.

ARITHMETIC CIRCUITS

CHAPTER- 6

Combinational Arithmetic Circuits

- Addition:
  - **Half Adder (HA).**
  - **Full Adder (FA).**
- Subtraction:
  - **Half Subtractor.**
  - **Full Subtractor.**
- 4 bit adder/subtracter
- Adder and Subtractor IC (7484)

HALF ADDER

Adding two single-bit binary values, X, Y produces a sum S bit and a carry out C-out bit. This operation is called half addition and the circuit to realize it is called a half adder.

Half Adder Truth Table

Inputs		Outputs	
X	Y	S	C-out
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

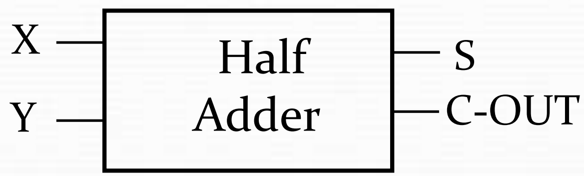
$S(X,Y) = \Sigma\ (1,2)$

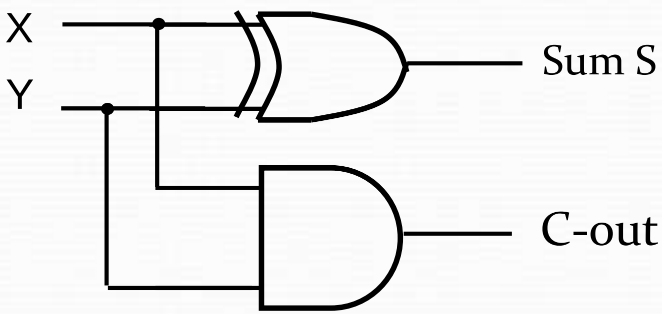
$S = X'Y + XY'$

$S = X \oplus Y$

$C\text{-out}(x, y, C\text{-in}) = \Sigma\ (3)$

$C\text{-out} = XY$





FULL ADDER

Adding two single-bit binary values, X, Y with a carry input bit C-in produces a sum bit S and a carry out C-out bit.

Full Adder

Full Adder Truth Table

Inputs			Outputs	
X	Y	C-in	S	C-out
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

$S(X,Y, C\text{-in}) = \Sigma\,(1,2,4,7)$

$C\text{-out}(x, y, C\text{-in}) = \Sigma\,(3,5,6,7)$

Sum S

C-in \ XY	00	01	11	10
0	0	2: 1	6	4: 1
1	1: 1	3	7: 1	5

X = columns 11, 10; Y = columns 01, 11; C-in = row 1

S = X'Y'(C-in) + XY'(C-in)' + XY'(C-in)' + XY(C-in)

$S = X \oplus Y \oplus (C\text{-in})$

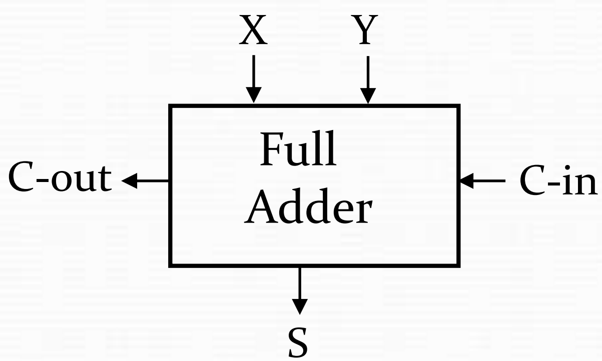
Carry C-out

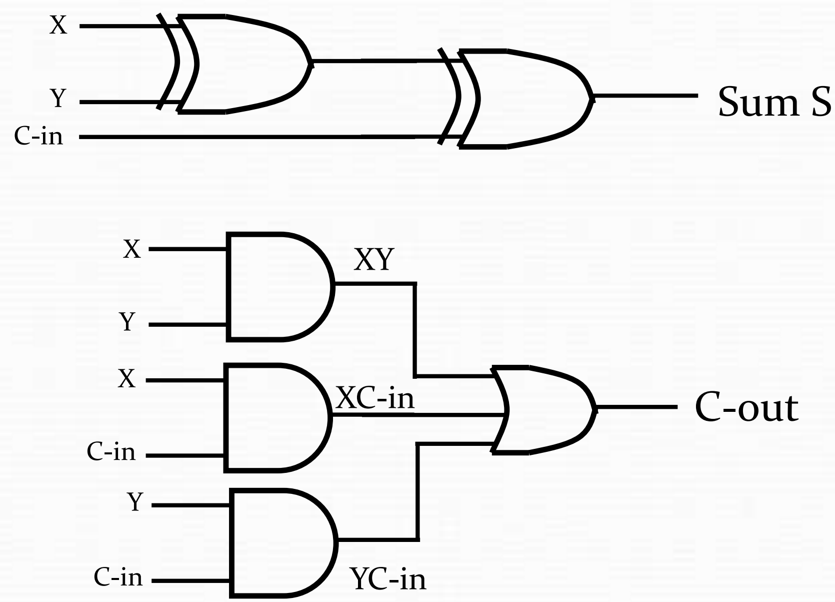
C-in \ XY	00	01	11	10
0	0	2	6: 1	4
1	1	3: 1	7: 1	5: 1

X = columns 11, 10; Y = columns 01, 11; C-in = row 1

C-out = XY + X(C-in) + Y(C-in)

Full Adder Circuit Using XOR





HALF SUBTRACTOR

- Subtracting a single-bit binary value Y from anther X (I.e. X -Y) produces a difference bit D and a borrow out bit B-out.
- This operation is called half subtraction and the circuit to realize it is called a half subtractor.

Half Subtractor

Half Subtractor Truth Table

Inputs		Outputs	
X	Y	D	B-out
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

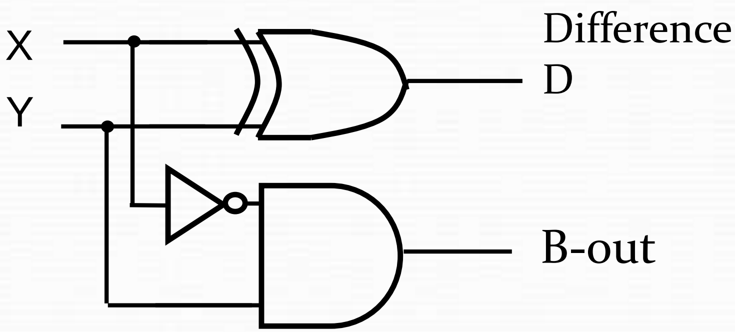
$D(X,Y) = \Sigma\,(1,2)$

$D = X'Y + XY'$

$D = X \oplus Y$

$B\text{-}out(x, y, C\text{-}in) = \Sigma\,(1)$

$B\text{-}out = X'Y$



FULL SUBTRACTOR

- Subtracting two single-bit binary values, Y, B-in from a single-bit value X produces a difference bit D and a borrow out B-out bit. This is called full subtraction.

Full Subtractor

Full Subtractor Truth Table

Inputs			Outputs	
X	Y	B-in	D	B-out
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

S(X,Y, C-in) = Σ (1,2,4,7)
C-out(x, y, C-in) = Σ (1,2,3,7)

Difference D

B-in \ XY	00	01	11	10
0	0	2 1	6	4 1
1	1 1	3	7 1	5

X: columns 11, 10; Y: columns 01, 11; B-in: row 1

S = X'Y'(B-in) + XY'(B-in)' + XY'(B-in)' + XY(B-in)
S = X ⊕ Y ⊕ (C-in)

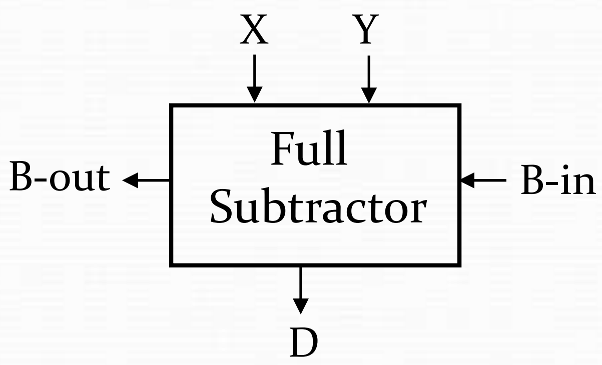
Borrow B-out

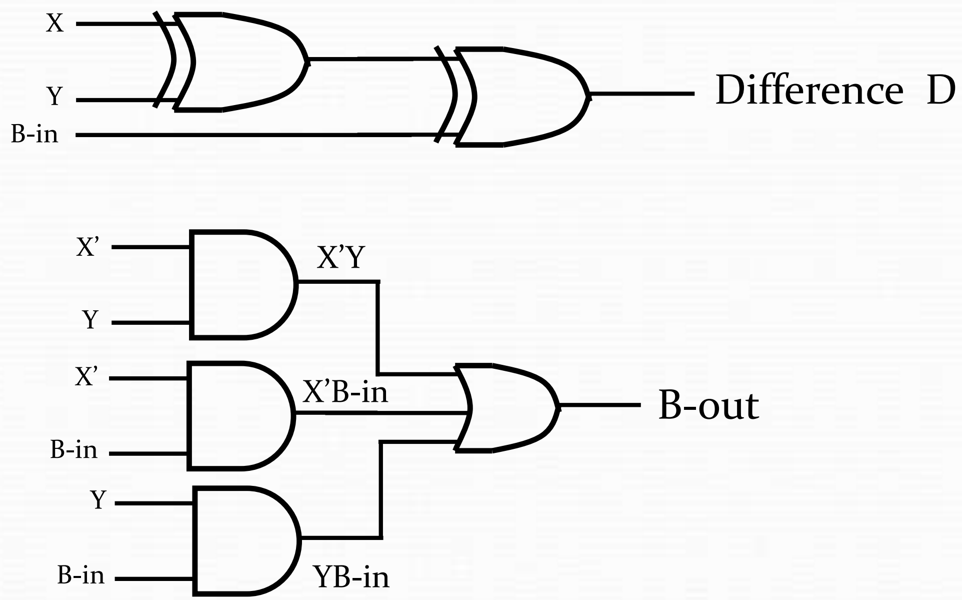
B-in \ XY	00	01	11	10
0	0	2 1	6	4
1	1 1	3 1	7 1	5

X: columns 11, 10; Y: columns 01, 11; B-in: row 1

B-out = X'Y + X'(B-in) + Y(B-in)

Full Subtractor Circuit Using XOR

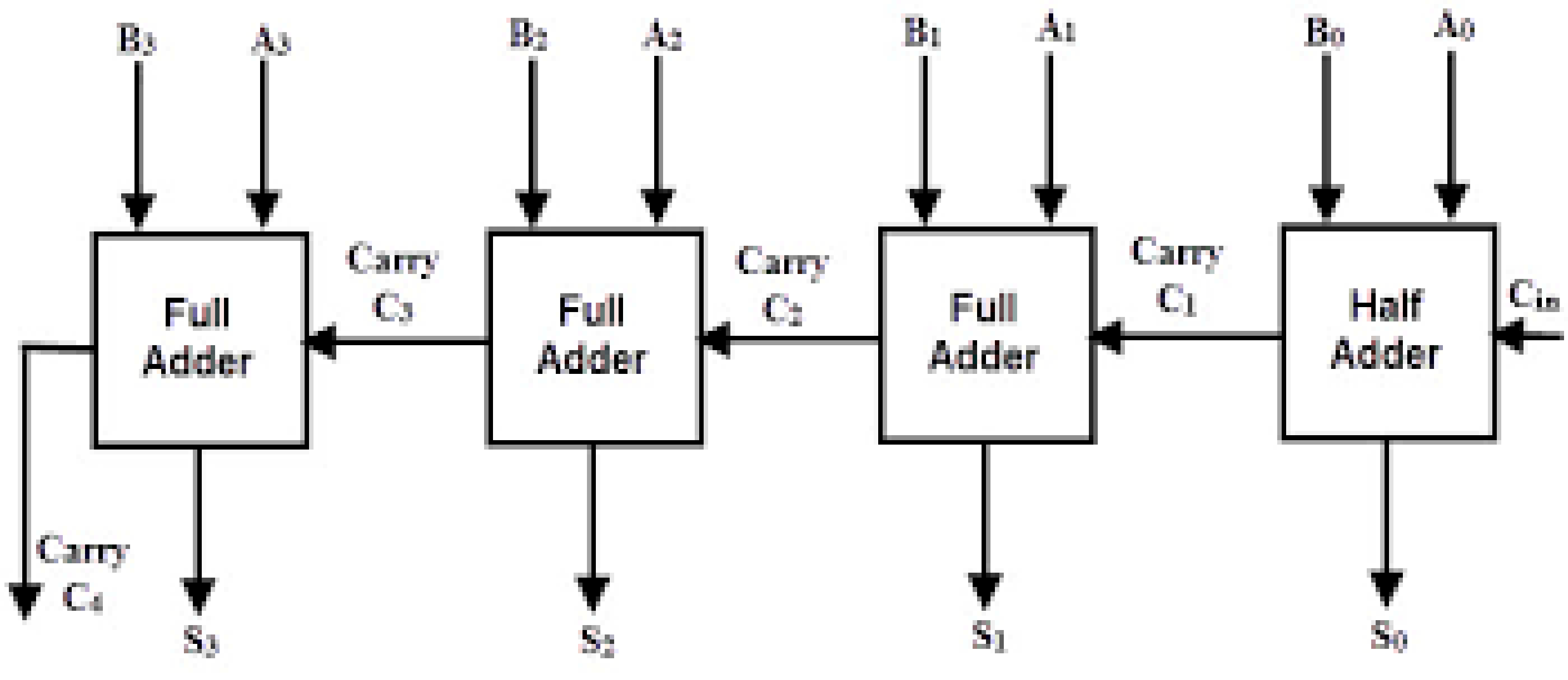




PARALLEL BINARY ADDER

- These adders are constructed by connecting two or more full adders.
- A single full adder is used for adding two one-bit binary numbers and an input carry.
- For the addition of binary numbers having more than one bit, additional full adders must be used.

Block diagram of 4- bit binary Parallel Adder



4-bit Parallel Adder

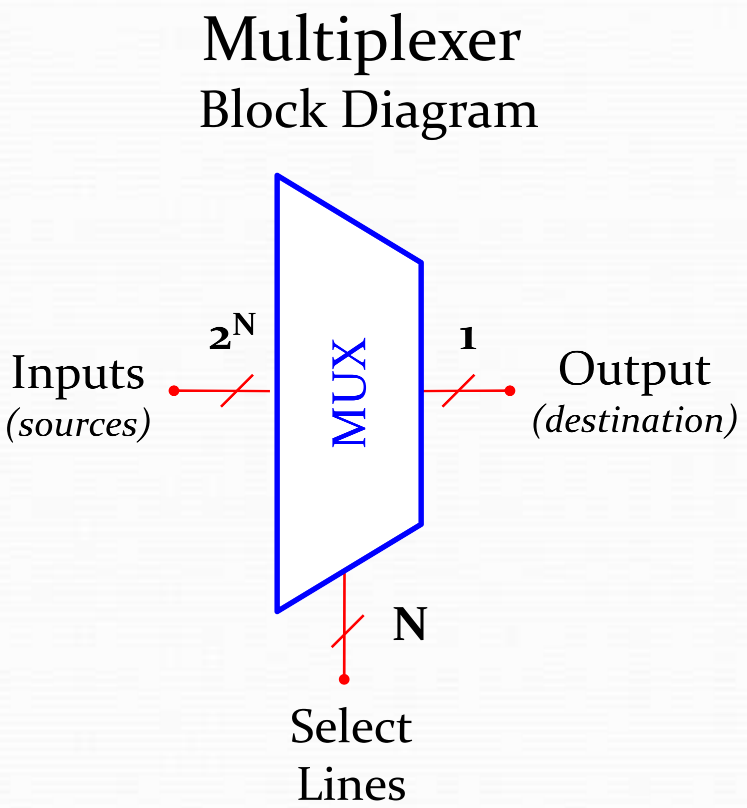
- For 4-bit binary full adder, we require four full adders(or three full adders and one half adder).
- The carry output of the rightmost full adder becomes the carry input of the second full adder.
- Let the two four bit binary numbers are $A_3\ A_2\ A_1\ A_0$ and $B_3\ B_2\ B_1\ B_0$ and five sum bits $S_3\ S_2\ S_1\ S_0$.
- The carry output of the leftmost full adder becomes the MSB in the sum which is represented by S_4.

Decoders, Multiplexers, De-Multiplexers and Encoder

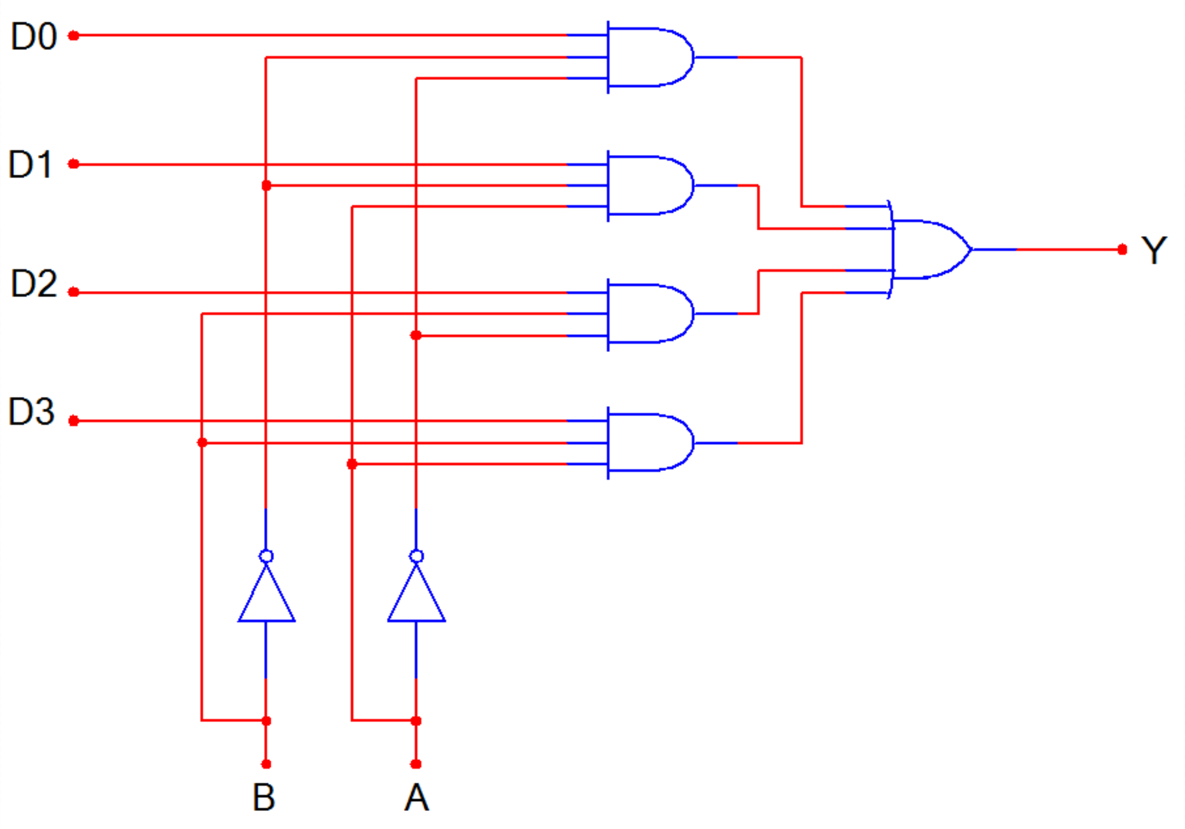
CHAPTER- 7

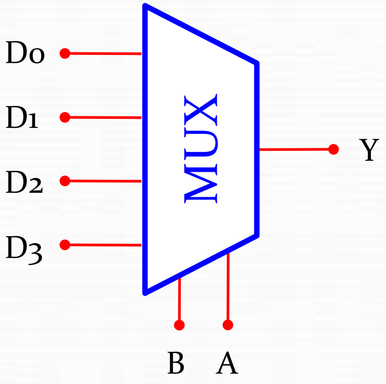
What is a Multiplexer (MUX)?

- A MUX is a digital switch that has multiple inputs (sources) and a single output (destination).
- The select lines determine which input is connected to the output.
- MUX Types
  - → 2-to-1 (1 select line)
  - → 4-to-1 (2 select lines)
  - → 8-to-1 (3 select lines)
  - → 16-to-1 (4 select lines)



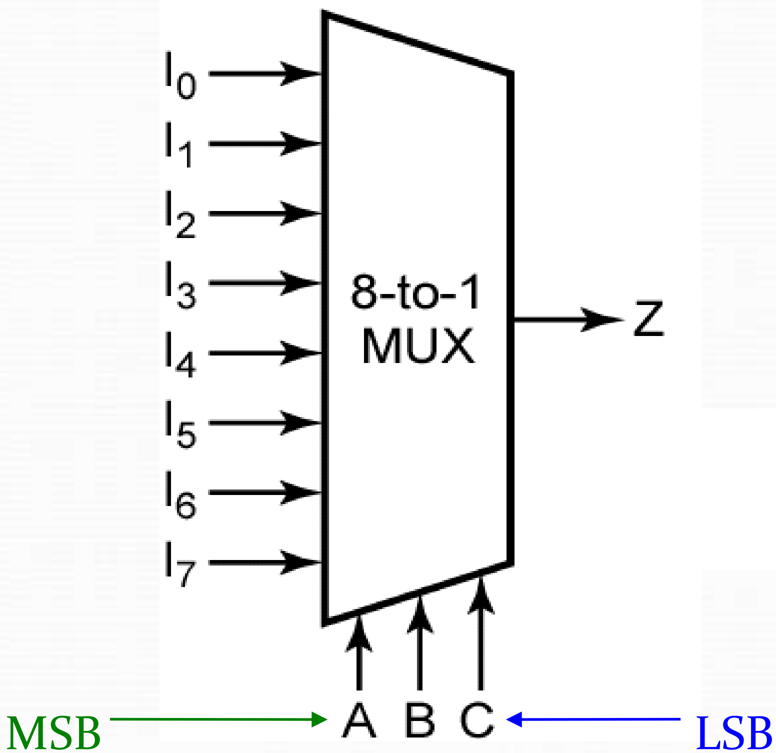
4-to-1 Multiplexer (MUX)





B	A	Y
0	0	D0
0	1	D1
1	0	D2
1	1	D3

Multiplexers



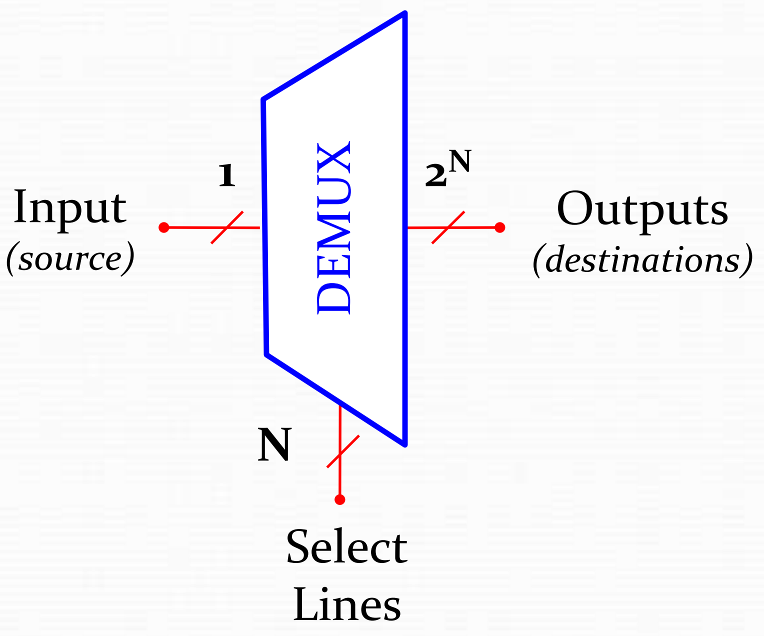
A	B	C	**F**
0	0	0	I_0
0	0	1	I_1
0	1	0	I_2
0	1	1	I_3
1	0	0	I_4
1	0	1	I_5
1	1	0	I_6
1	1	1	I_7

$$\mathbf{Z = A'.B'.C'.I_0 + A'.B'.C.I_1 + A'.B.C'.I_2 + A'.B.C.I_3 + A.B'.C'.I_0 + A.B'.C.I_1 + A'.B.C'.I_2 + A.B.C.I_3}$$

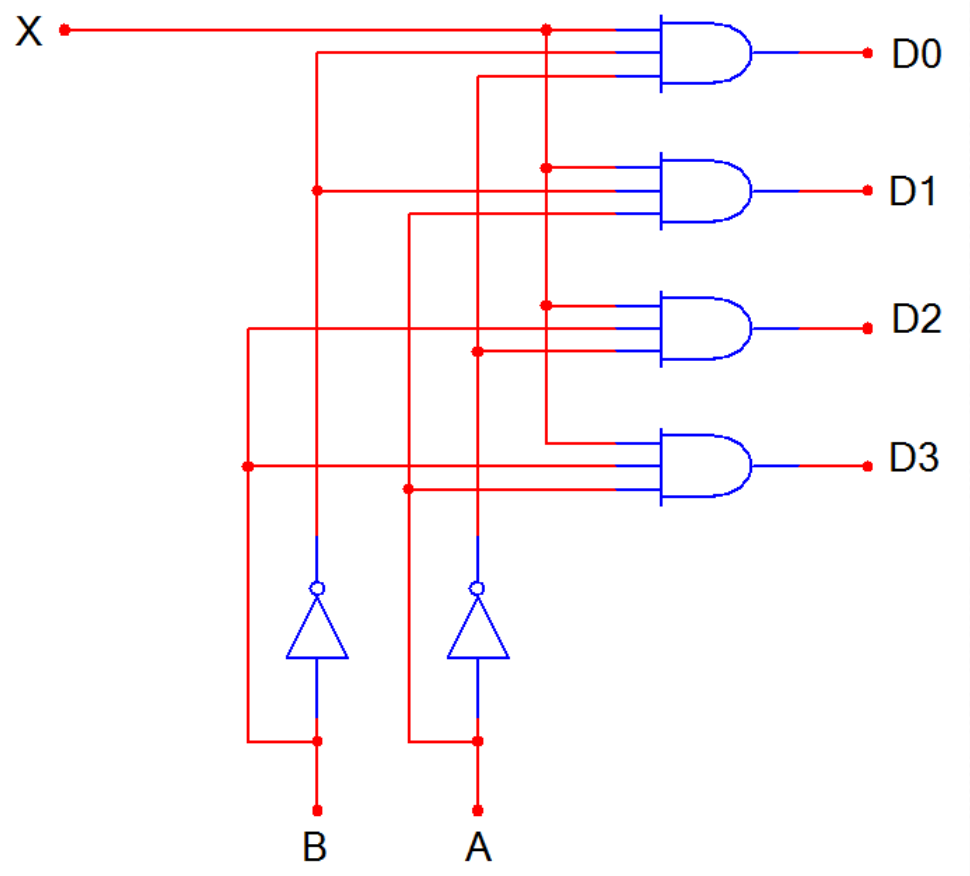
What is a Demultiplexer (DEMUX)?

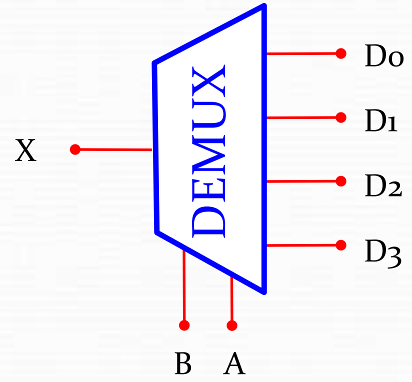
- A DEMUX is a digital switch with a single input (source) and a multiple outputs (destinations).
- The select lines determine which output the input is connected to.
- DEMUX Types
  - → 1-to-2 (1 select line)
  - → 1-to-4 (2 select lines)
  - → 1-to-8 (3 select lines)
  - → 1-to-16 (4 select lines)

Demultiplexer
Block Diagram



1-to-4 De-Multiplexer (DEMUX)





B	A	D0	D1	D2	D3
0	0	X	0	0	0
0	1	0	X	0	0
1	0	0	0	X	0
1	1	0	0	0	X

Decoders

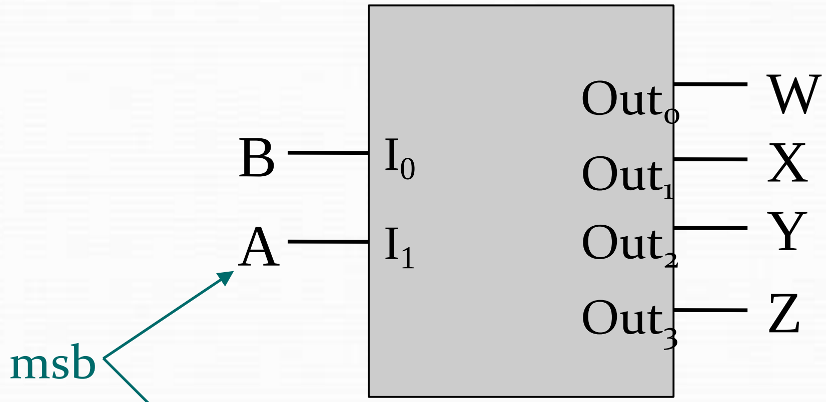
A decoder has

- N inputs
- 2^N outputs

A decoder selects one of 2^N outputs by decoding the binary value on the N inputs.

The decoder generates all of the minterms of the N input variables.

Decoders



W = A'.B'

X = A.B'

Y = A'.B

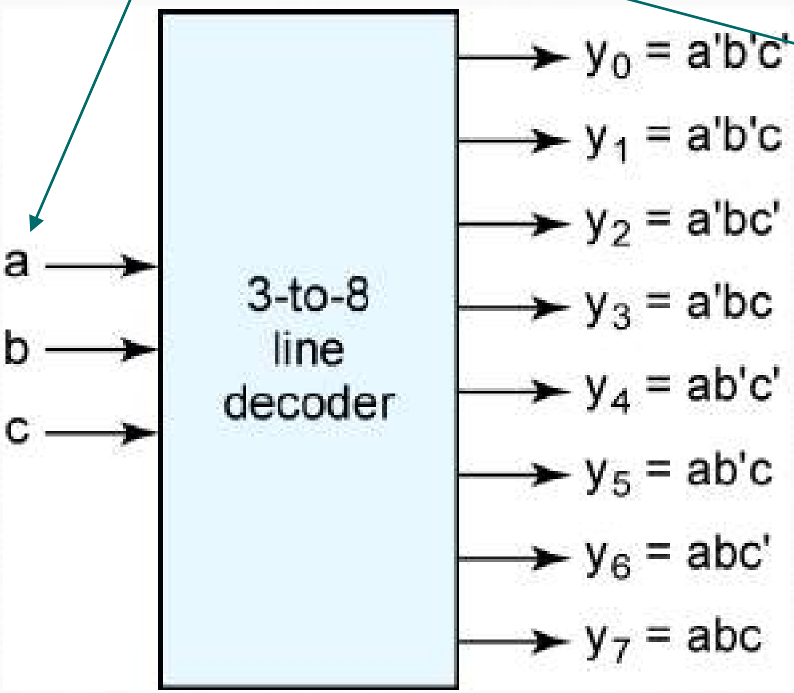
Z = A.B

Active-high outputs

A	B	**W**	**X**	**Y**	**Z**
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

Decoders

msb



a	b	c	y_0	y_1	y_2	y_3	y_4	y_5	y_6	y_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

Encoders

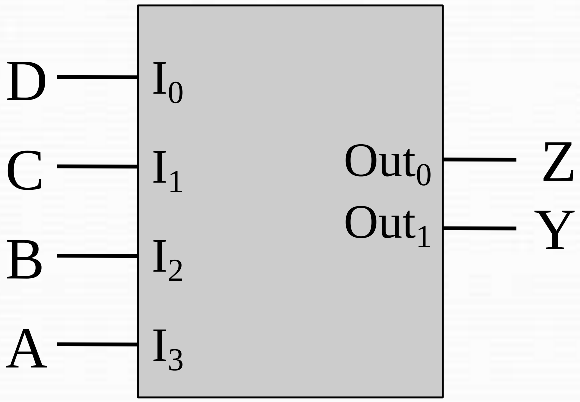
An encoder has

- 2^N inputs
- N outputs

An encoder outputs the binary value of the selected (or active) input.

An encoder performs the inverse operation of a decoder.

Encoders

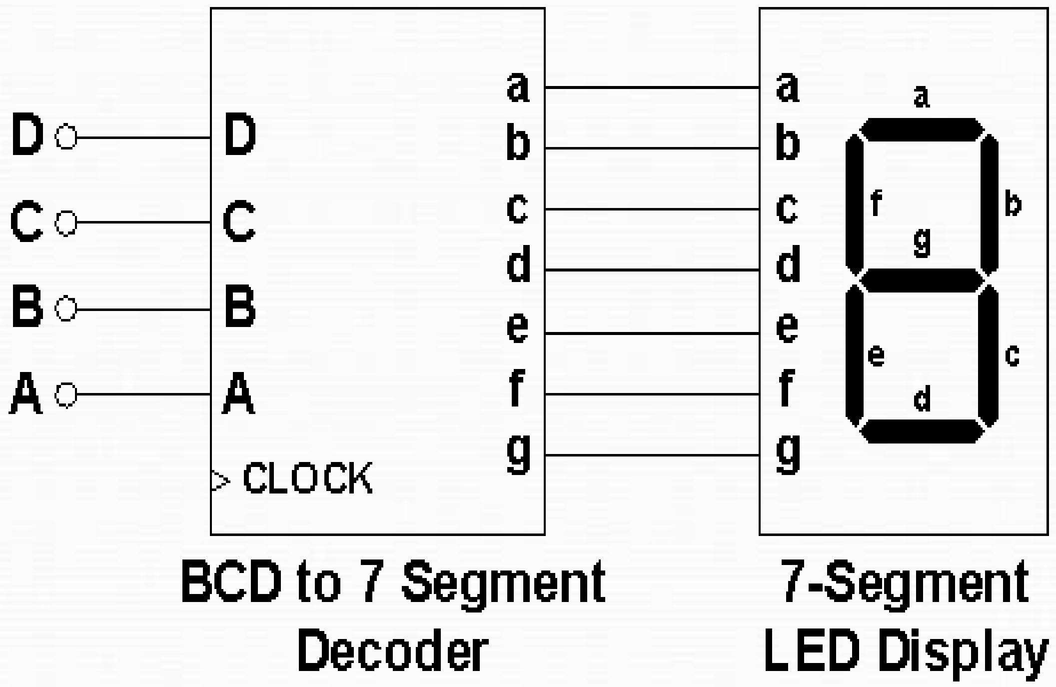


A	B	C	D	**Y**	**Z**
0	0	0	1	0	0
0	0	1	0	0	1
0	1	0	0	1	0
1	0	0	0	1	1

BCD TO SEVEN SEGMENT DECODER

- In this display device, the data which is in the BCD format has to be changed suitably.
- For this purpose, we require a BCD to 7- segment decoder.
- The circuit has four input lines for receiving the BCD inputs & seven output lines i.e. a,b,c,d,e,f,g to drive a 7-segment display.

BLOCK DIAGRAM OF BCD TO 7-SEGMENT DECODER



TRUTH TABLE OF BCD TO 7 SEVEN SEGMENT DECODER

Binary Inputs				Decoder Outputs							7-Segment Display Outputs
D	C	B	A	a	b	c	d	e	f	g	
0	0	0	**0**	1	1	1	1	1	1	0	0
0	0	0	**1**	0	1	1	0	0	0	0	**1**
0	0	**1**	0	1	1	0	1	1	0	1	**2**
0	0	1	1	1	1	1	1	0	0	1	3
0	**1**	0	0	0	1	1	0	0	1	1	**4**
0	1	0	1	1	0	1	1	0	1	1	5
0	1	1	0	1	0	1	1	1	1	1	6
0	1	1	1	1	1	1	0	0	0	0	7
1	0	0	0	1	1	1	1	1	1	1	**8**
1	0	0	1	1	1	1	1	0	1	1	9

LATCHES AND FLIP - FLOPS

CHAPTER -8

What is latch ?

- A flip-flop or **latch** is a circuit that has two stable states and can be used to store state information.
- It is a sequential circuit.
- It is a temporary storage device.

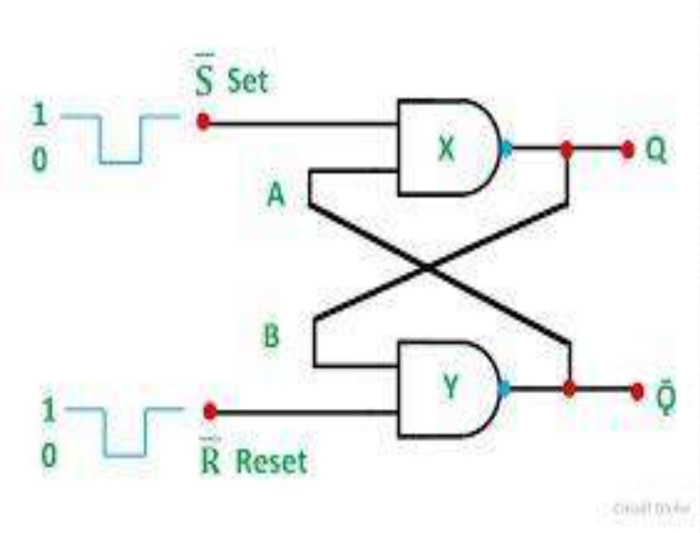
FLIP FLOP

- A flip-flop is a bistable multivibrator. The circuit can be made to change state by signals applied to one or more control inputs and will have one or two outputs.
- Flip Flops are sequential circuits.
- It also stores memory.

TYPES OF FLIP-FLOP

- SR flip-flop
- T flip-flop
- D flip-flop
- JK flip-flop

SR- LATCH



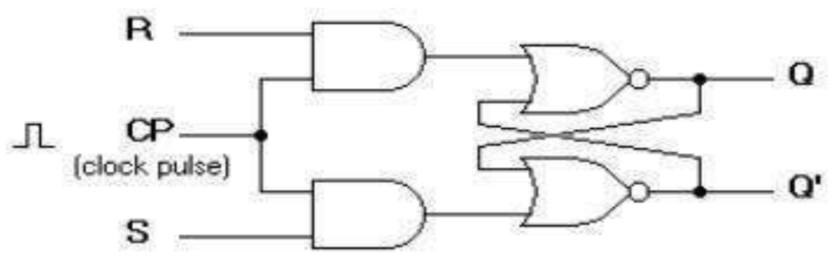
TRUTH TABLE OF SR-LATCH

Sno	S	R	Q	Q'	State
1	1	0	1	0	Q is set to 1
2	1	1	1	0	No change
3	0	1	0	1	Q' is set to 1
4	1	1	0	1	No change
5	0	0	1	1	Invalid

SR FLIP FLOP

- **SR Flip Flop** is an arrangement of logic gates that maintains a stable output even after the inputs are turned off.
- This simple **flip flop** circuit has a set input (S) and a reset input (R).

SR FLIP FLOP



(a) Logic diagram

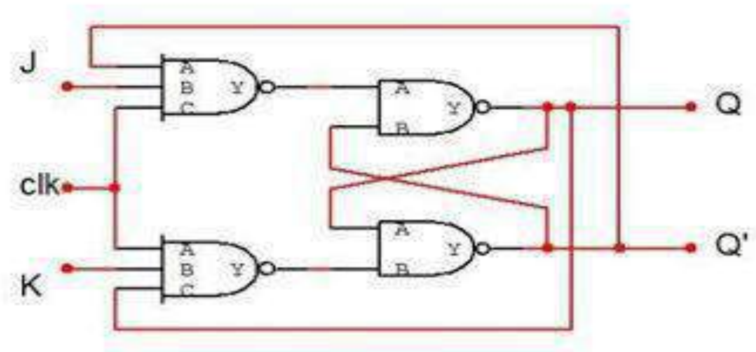
Q	S	R	Q(t+1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	indeterminate
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	indeterminate

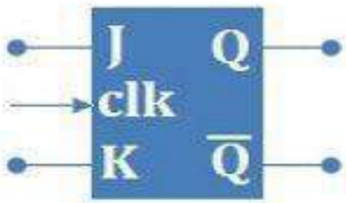
(b) Truth table

Clocked SR flip-flop

JK FLIP FLOP

- The **JK flip flop** is basically a gated SR **flip-flop** with the addition of a clock input circuitry that prevents the illegal or invalid output condition that can occur when both inputs S and R are equal to logic level "1".
- There is no such thing as a J-K latch, only J-K **flip-flops**.
- Without the edge-triggering of the clock input, the circuit would continuously **toggle** between its two output states when both J and K were held high (1), making it an astable device instead of a bistable device in that circumstance.





J	K	clk	Q
0	0	1	Önceki konum
0	1	1	0
1	0	1	1
1	1	1	toggle

Q	J	K	Q(t+1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

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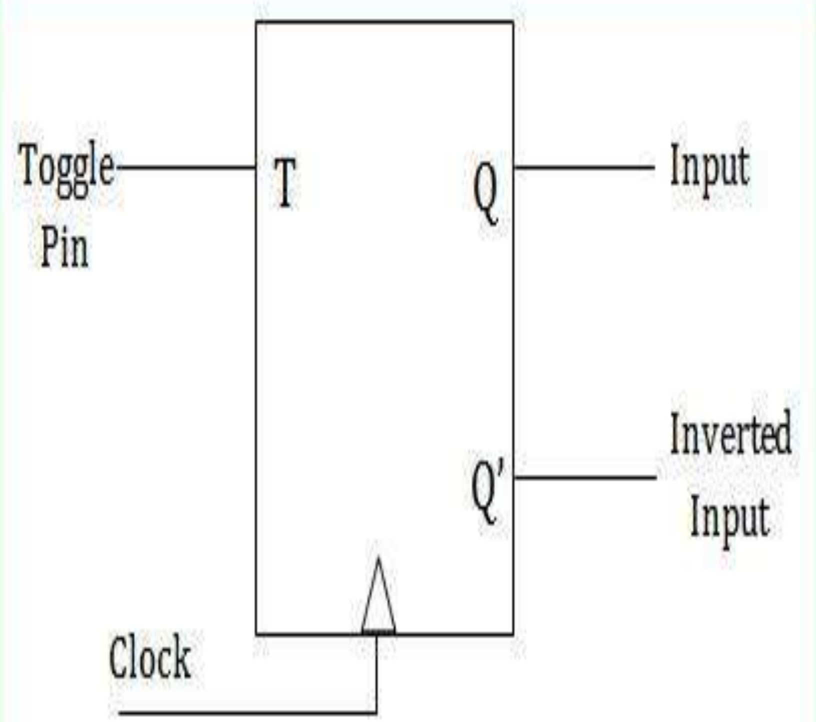
T or Toggle flip -flop

- The **T or "toggle" flip-flop** changes its output on each clock edge, giving an output which is half the frequency of the signal **to** the **T** input.
- It is useful for constructing binary counters, frequency dividers, and general binary addition devices.
- It can be made from a J-K **flip-flop** by tying both of its inputs high.

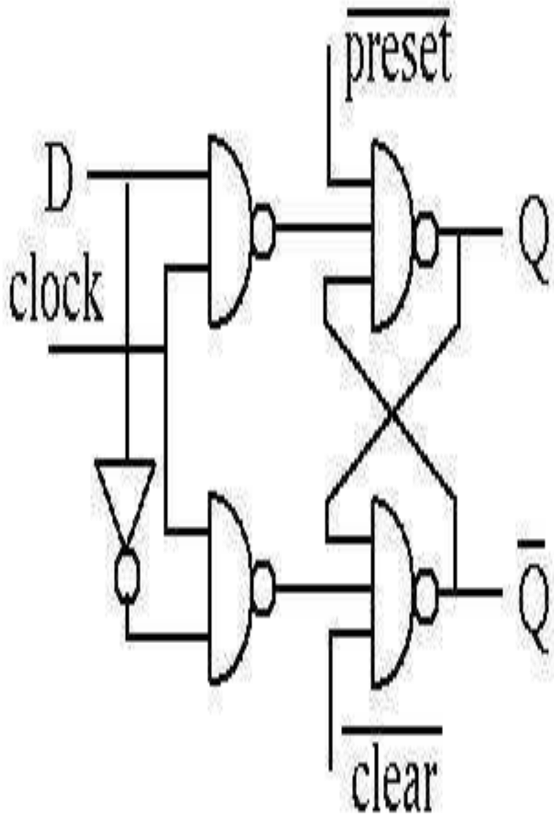


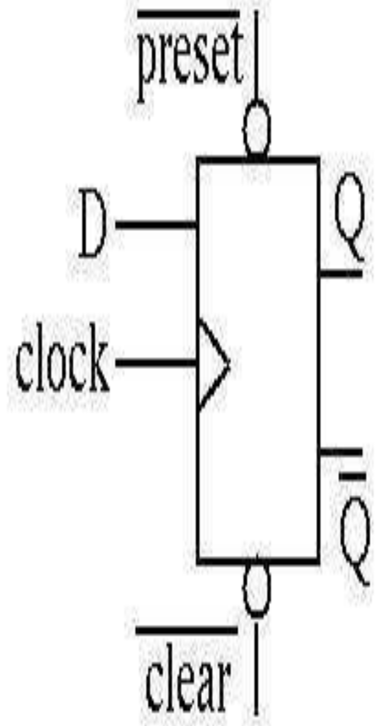
Symbol: T Flip-flop

T	Q_n	Q_{n+1}
0	0	0
0	1	1
1	0	1
1	1	0

D FLIP FLOP

- The **D flip-flop** tracks the input, making transitions with match those of the input **D**.
- The **D** stands for "data"; this **flip-flop** stores the value that is on the data line.
- It can be thought of as a basic memory cell. A D **flip-flop** can be made from a set/reset **flip-flop** by tying the set to the reset through an inverter.


$\overline{\text{preset}}$
D
clock
Q
$\overline{Q}$
$\overline{\text{clear}}$


$\overline{\text{preset}}$
D
clock
Q
$\overline{Q}$
$\overline{\text{clear}}$

D	Q_{t+1}
0	0
1	1

APPLICATIONS OF FLIP FLOP

- **flip flop** circuit mainly involves in bounce elimination switch.
- data storage, data transfer.
- latch, registers, counters.
- frequency division, memory, etc.

APPLICATIONS OF LATCHES

- Cascading of a positive latch and negative latch gives a negative edge-triggered flip-flop and cascading of negative and positve latch gives a positive edge-triggered flip-flop.
- A latch is used as a savior for scan hold timing closure in the form of lockup latch.
- Latch is used in pipelines.

DIFFERENCE

LATCH

- Gates are the building block of the latches.
- Latches does not have clock signal.
- It is a level triggered device.
- It is based on the enable function input.

FLIP FLOP

- Latches are the building block of Flip Flop.
- Flip Flop has clock signal.
- It is edge triggered.
- It works on the clock pulses.

COUNTERS

CHAPTER- 9

INTRODUCTION

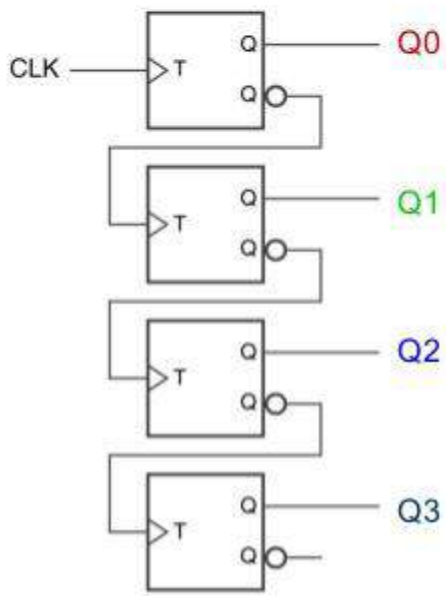
- Counter is the combination of flip-flop which is used to count the events of number of clock at input. Depending upon the manner by mean of which the flip-flop of counter triggered.
    - There is two types of counters:
        - Asynchronous Counter
        - Synchronous Counter

ASYNCHRONOUS COUNTER

- Asynchronous counters are **those whose output is free from the clock signal**. Because the flip flops in asynchronous counters are supplied with different clock signals, there may be delay in producing output. The required number of logic gates to design asynchronous counters is very less. So they are simple in design.

ASYNCHRONOUS RIPPLE COUNTER

Asynchronous Ripple Counter



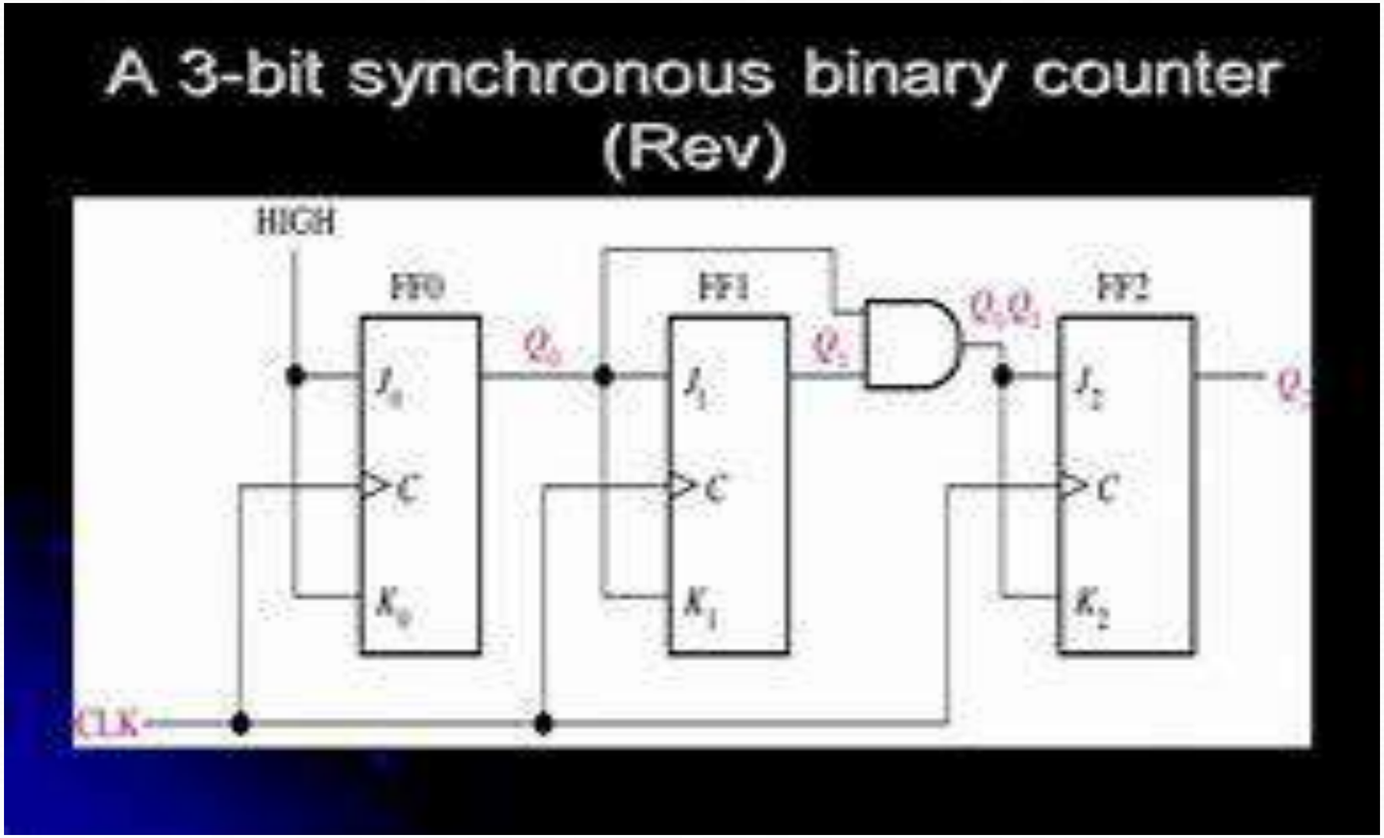
Q3	Q2	Q1	Q0
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0

⋮

SYNCHRONOUS COUNTER

- In synchronous counters, the **clock inputs of all the flip-flops** are connected together and are triggered by the input pulses. Thus, all the flip-flops change state simultaneously (in parallel).

3 BIT SYNCHRONOUS COUNTER

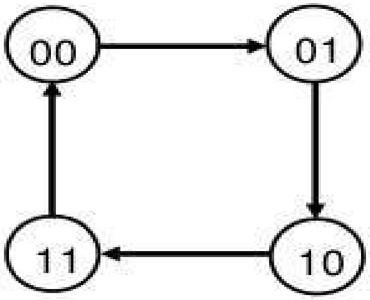


APPLICATION OF COUNTER

Counters

- Applications include:
  - system clock
  - timer, delays
  - watches, clocks, alarms
  - counting events
  - memory addressing
  - frequency division
  - sequence control
  - cycle control
  - protocols

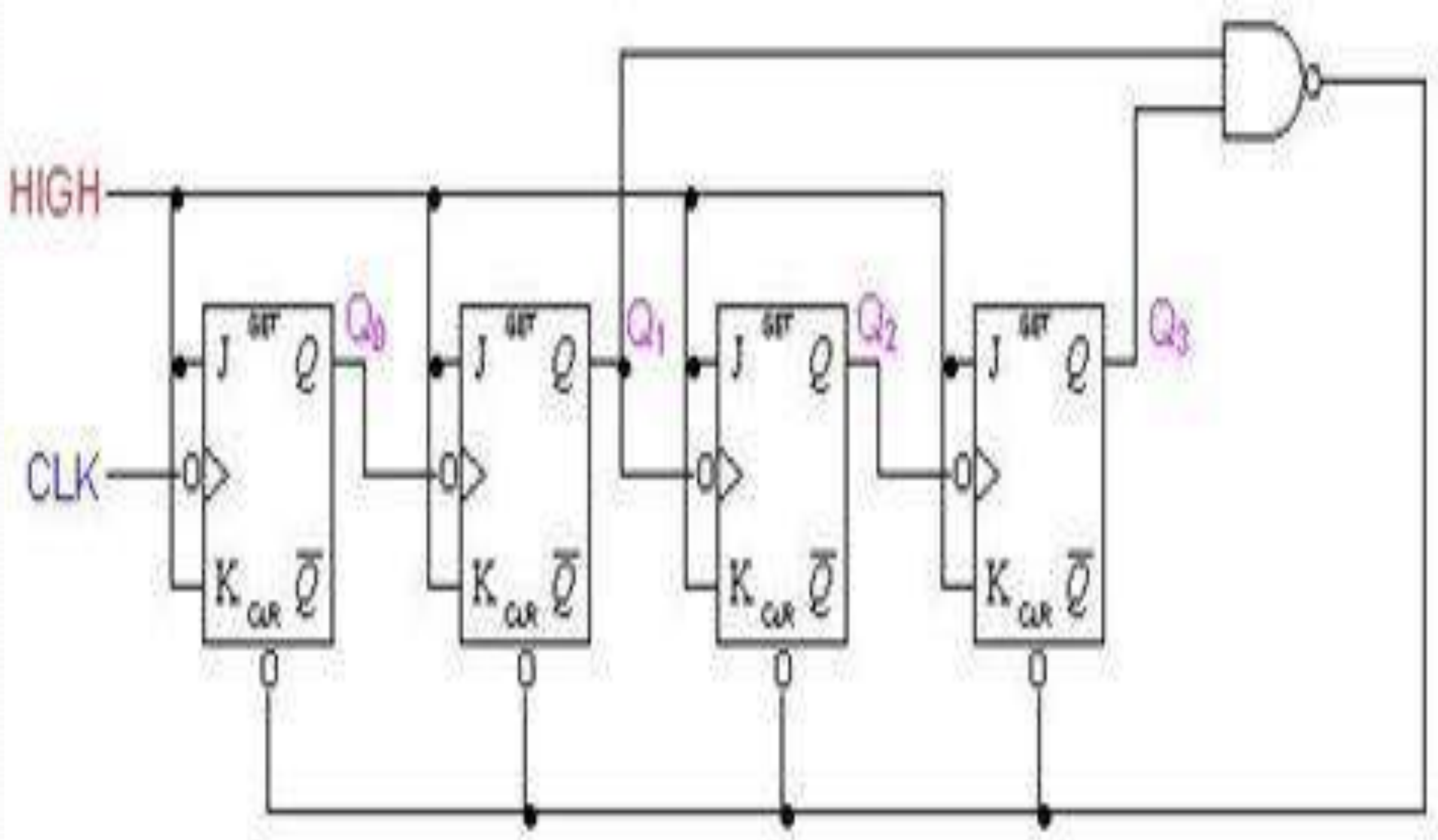
Present State		Next State	
A	B	A	B
0	0	0	1
0	1	1	0
1	0	1	1
1	1	0	0



DECADE COUNTER

- A decade counter is one that counts in decimal digits, rather than binary. It counts from **0 to 9** and then resets to **zero**. The counter output can be set to zero by pulsing the reset line low. The count then increments on each clock pulse until it reaches 1001 (decimal 9).

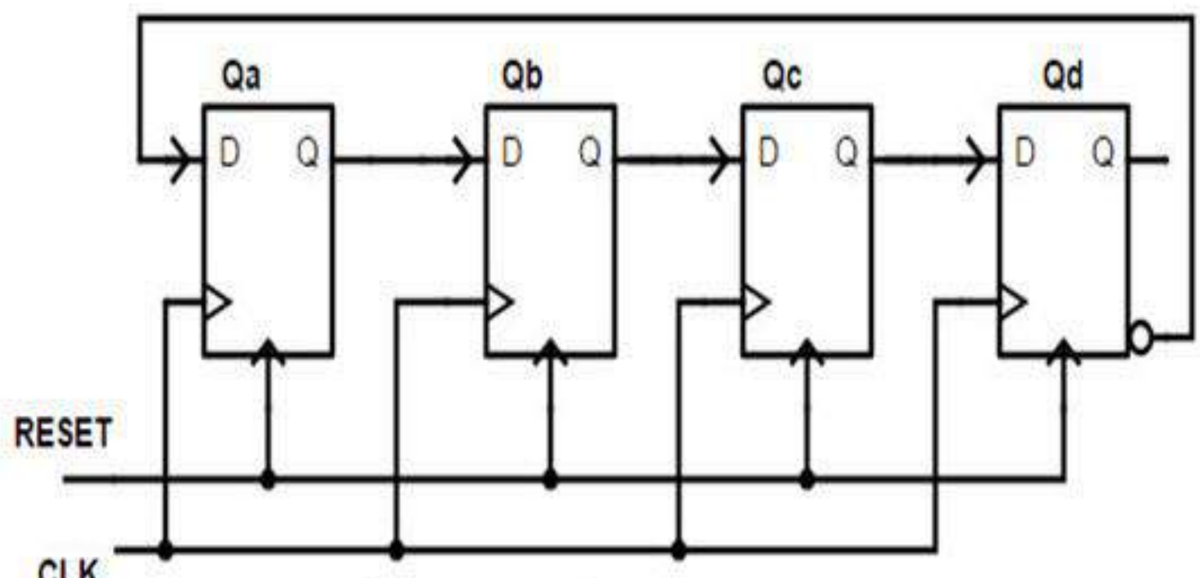
CIRCUIT DAIGRAM OF DECADE COUNTER



RING COUNTER

In a computer system, the standard ring counter form is a type of counter that is composed of a **shift register**, another type of counter that exists in the sequential logic form.

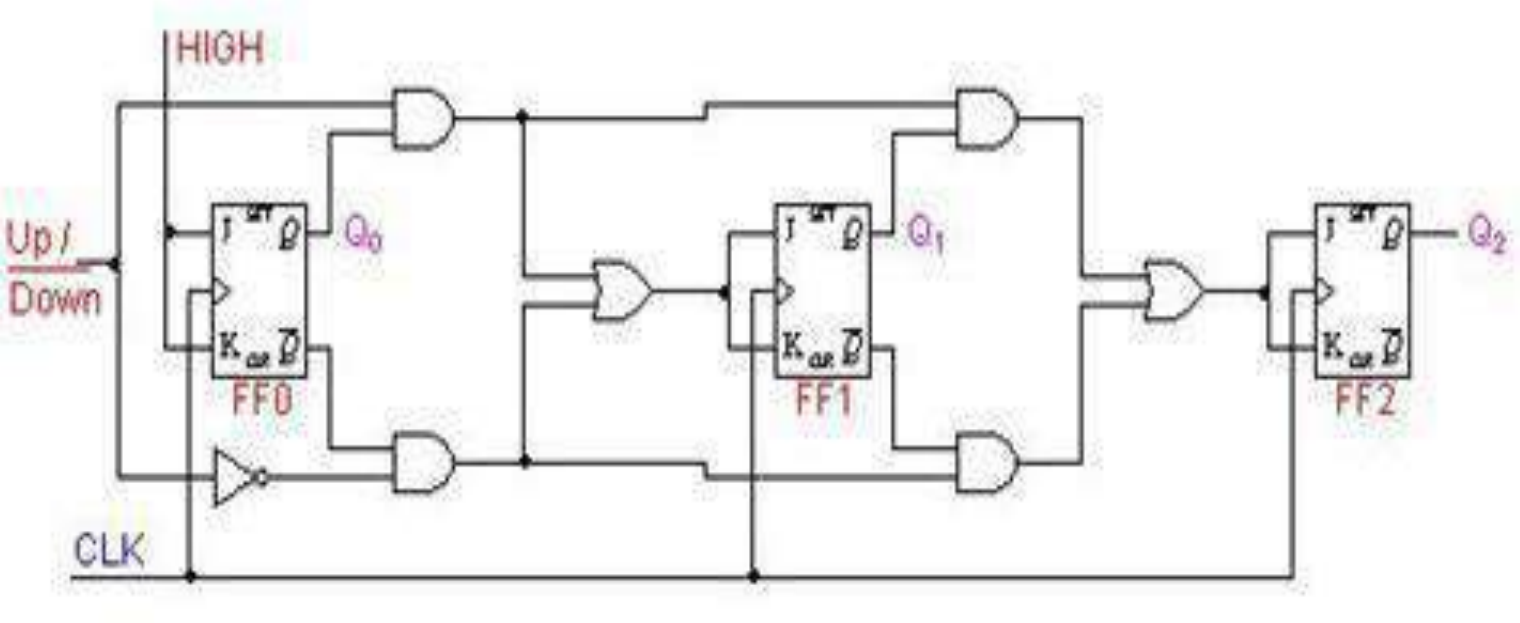
Q_A	Q_B	Q_C	Q_D
0	0	0	0
1	0	0	0
1	1	0	0
1	1	1	0
1	1	1	1
0	1	1	1
0	0	1	1
0	0	0	1
repeat			



Johnson counter

UP/DOWN COUNTER

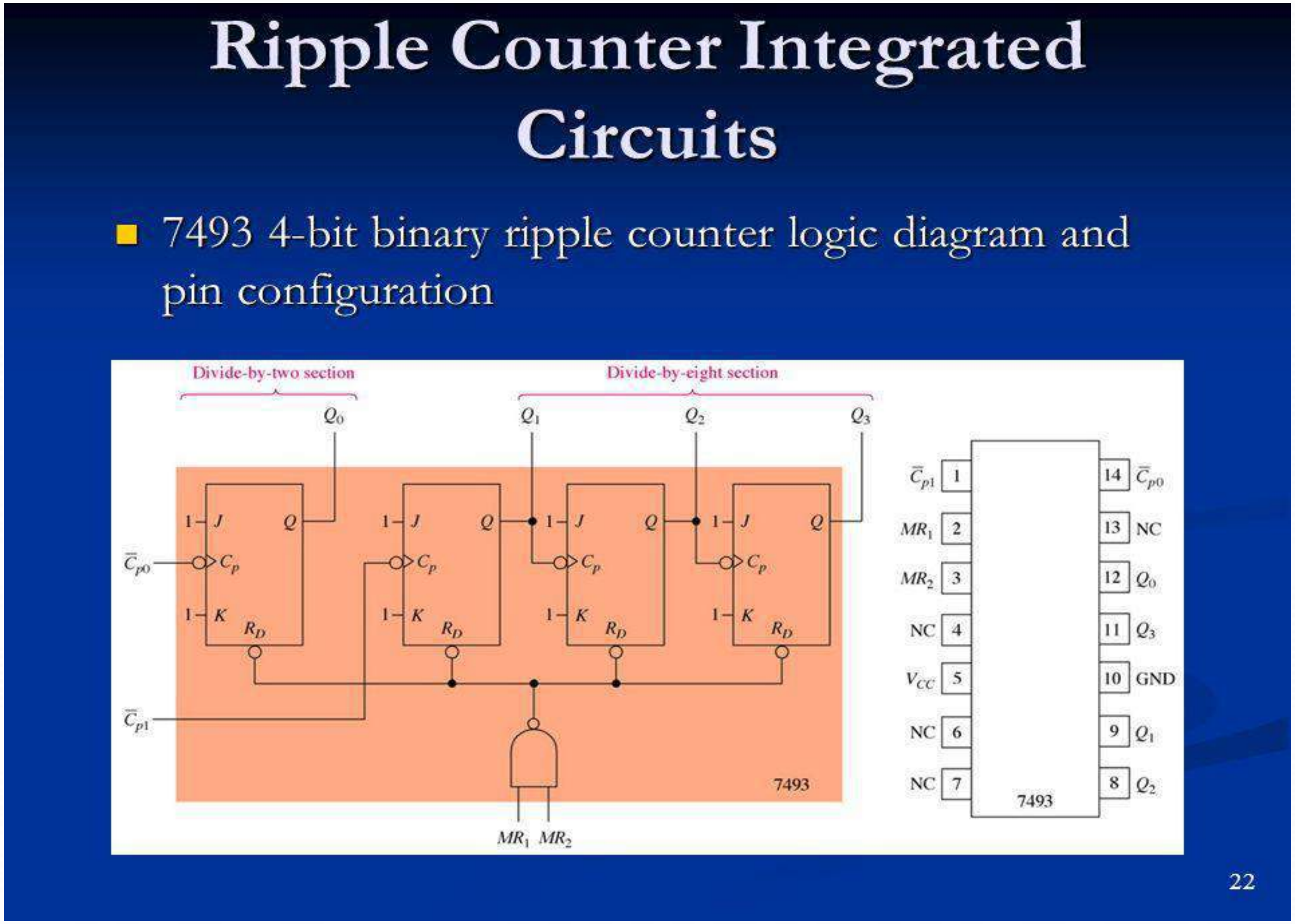
A circuit of a 3-bit synchronous up-**down counter** and a table of its sequence are shown below. Similar to an asynchronous up-**down counter**, a synchronous up-**down counter** also has an up-**down** control input. It is used to control the direction of the **counter** through a certain sequence



RIPPLE COUNTER

A **ripple counter** is an asynchronous **counter** where only the first flip-flop is clocked by an external clock. All subsequent flip-flops are clocked by the output of the preceding flip-flop. Asynchronous **counters** are also called **ripple-counters** because of the way the clock pulse ripples it way through the flip-flops.

CIRCUIT DAIGRAM OF RIPPLE COUNTER

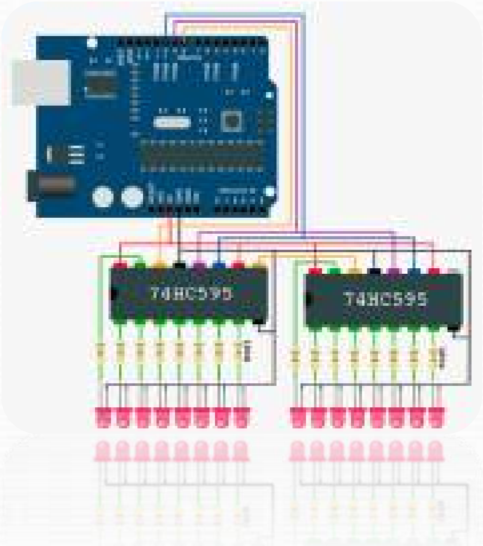


SHIFT REGISTER

CHAPTER-10

SHIFT REGISTER

- Introduction and basic concepts including shift left and shift right.
- (a) Serial in parallel out, serial in serial out, parallel in serial out, parallel in parallel out
- (b)Universal shift register
- (c)Buffer register, Tristate Register
- (d)IC 7495



DEFINATION

- A register is a digital circuit with two basic functions: Data Storage and Data Movement
  - A shift register provides the data movement function
  - A shift register "shifts" its output once every clock cycle

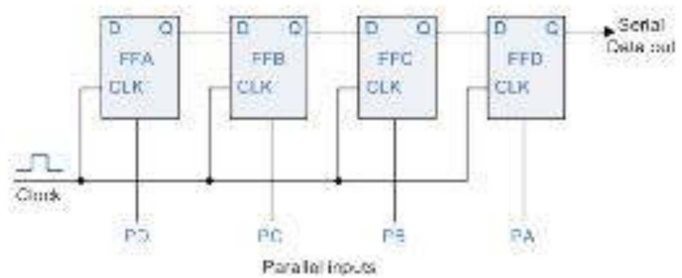
- A shift register is a group of flip-flops set up in a linear fashion with their inputs and outputs connected together in such a way that the data is shifted from one device to another when the circuit is active

TYPES OF SHIFT REGISTER

- SERIAL IN SERIAL OUT (SISO)
- SERIAL IN PARALLEL OUT (SIPO)
- PARALLEL IN SERIAL OUT (PISO)
- PARALLEL IN PARALLEL OUT (PIPO)

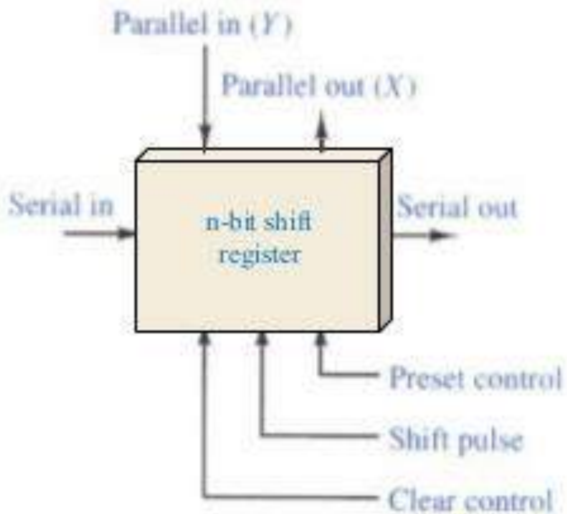
Shift Register Applications

- converting between serial data and parallel data
- temporary storage in a processor
  - scratch-pad memories
- some arithmetic operations
  - multiply, divide
- communications
  - UART
- some counter applications
  - ring counter
  - Johnson counter
  - Linear Feedback Shift Register (LFSR) counters
- time delay devices
- more …



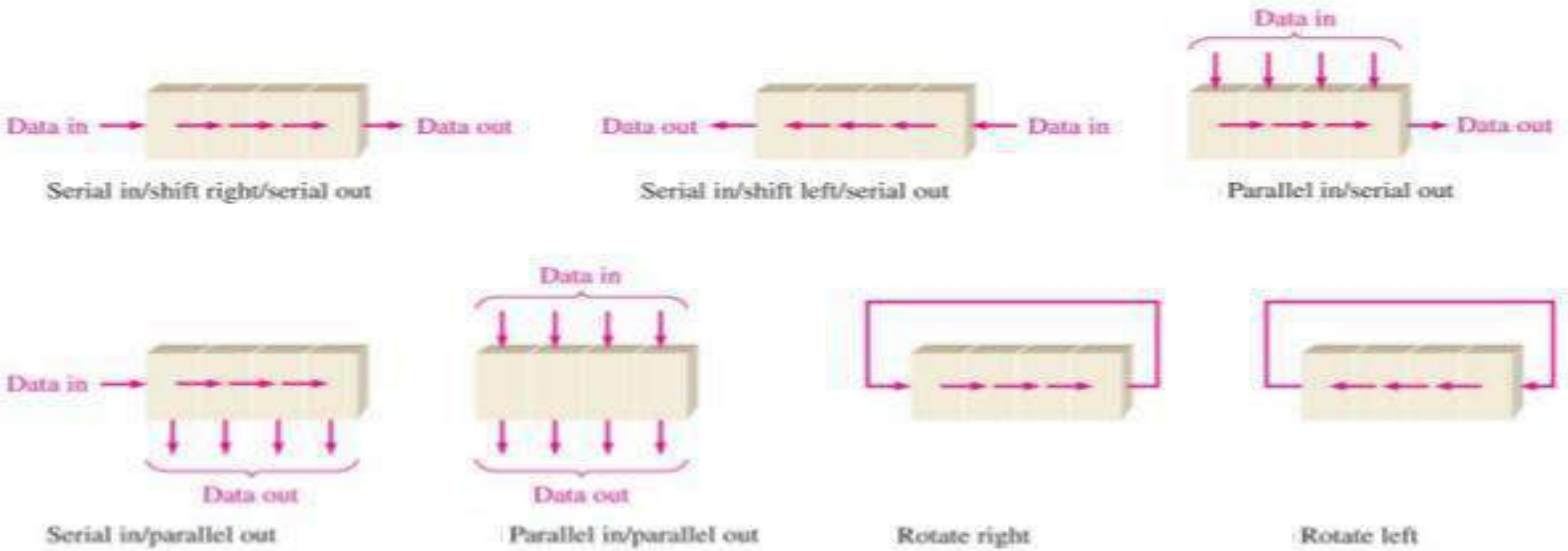
Shift Register Characteristics

- Types
  - Serial-in, Serial-out
  - Serial-in, Parallel-out
  - Parallel-in, Serial-out
  - Parallel-in, Parallel-out
  - Universal
- Direction
  - Left shift
  - Right shift
  - Rotate (right or left)
  - Bidirectional



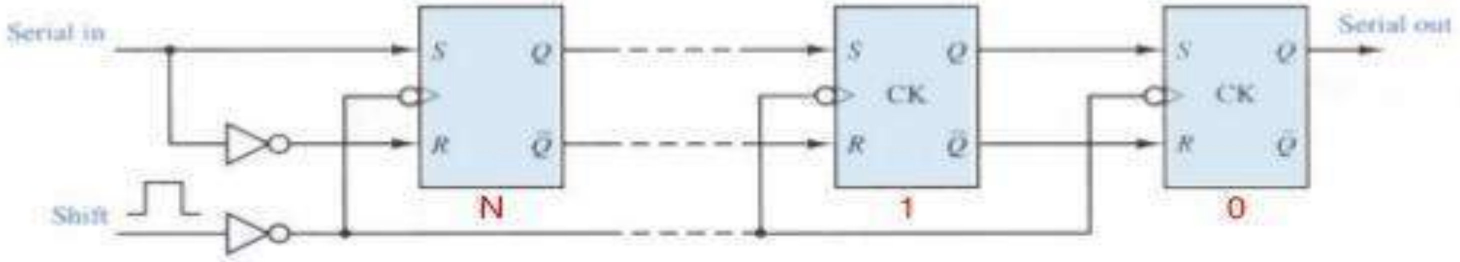
Data Movement

- The bits in a shift register can move in any of the following manners



Serial-In Serial-Out

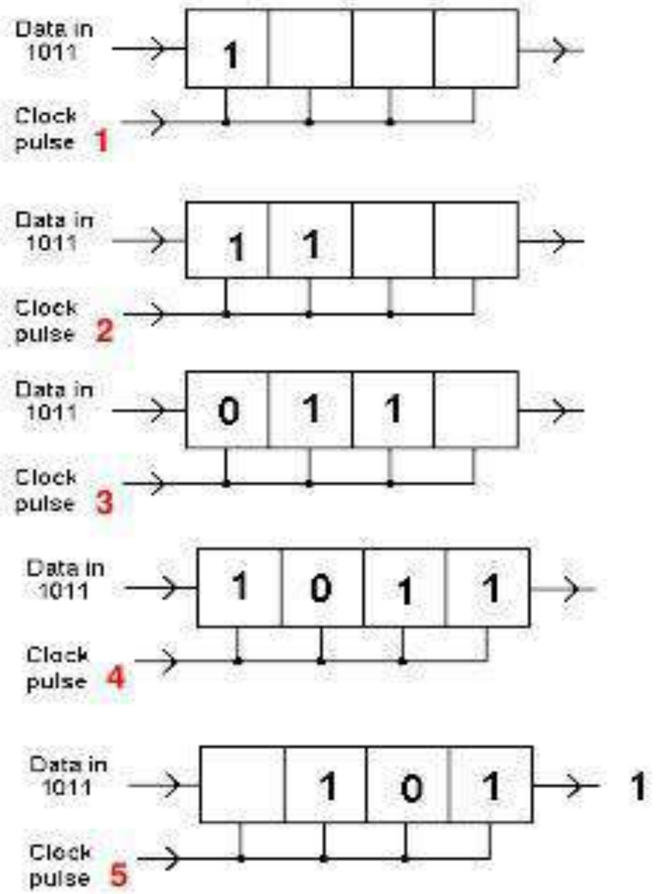
- The logic circuit diagram below shows a generalized serial-in serial-out shift register
  - SR Flip-Flops are shown
  - Connected to behave as D Flip-Flops
  - Input values moved to outputs of each Flip-Flop with the clock (shift) pulse



N-Bit Shift Register

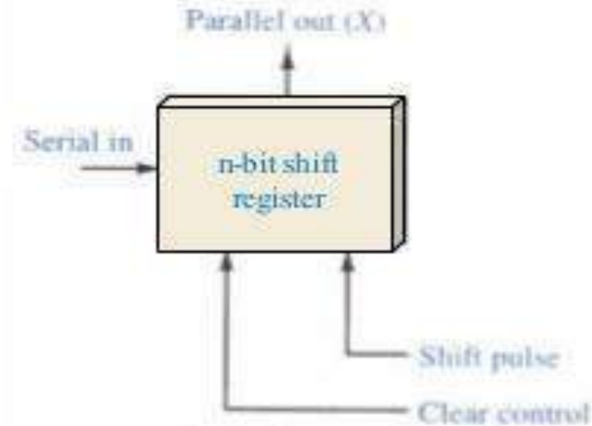
Serial-In Serial-Out

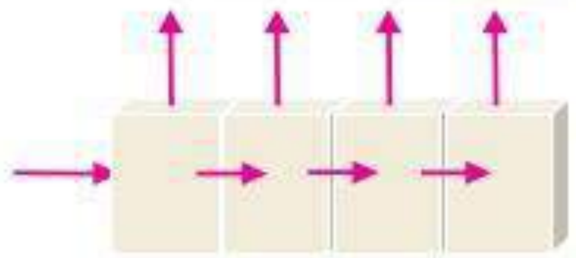
- A simple way of looking at the serial shifting operation, with a focus on the data bits, is illustrated at right
- The 4-bit data word "1011" is to be shifted into a 4-bit shift register
- One shift per clock pulse
- Data is shown entering at left and shifting right



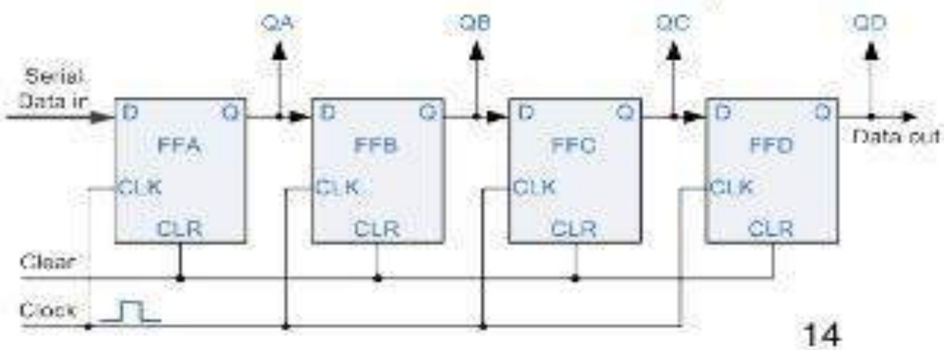
Serial-to-Parallel Conversion

- We often need to convert from serial to parallel
  - e.g., after receiving a series transmission
- The diagrams at the right illustrate a 4-bit serial-in parallel-out shift register
- Note that we could also use the Q of the right-most Flip-Flop as a serial-out output



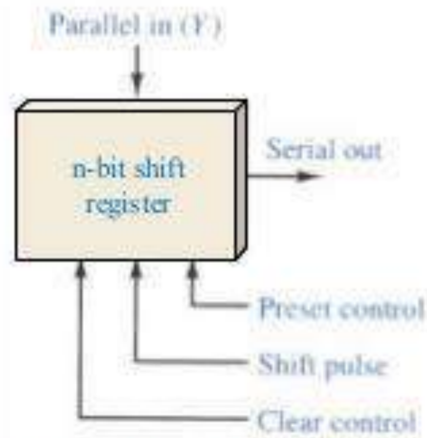


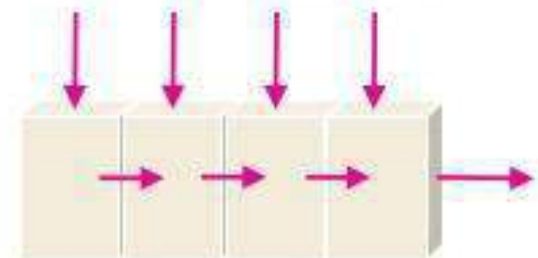
4-bit Wide Parallel Data Output

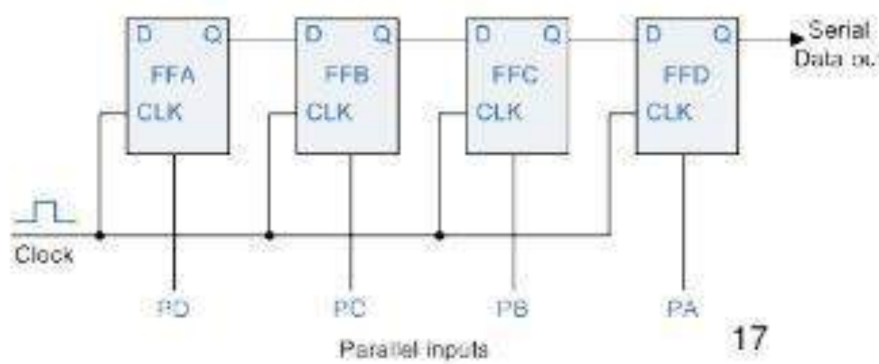


Parallel-to-Serial Conversion

- We use a Parallel-in Serial-out Shift Register
- The DATA is applied in parallel form to the parallel input pins PA to PD of the register
- It is then read out sequentially from the register one bit at a time from PA to PD on each clock cycle in a serial format
- One clock pulse to load
- Four pulses to unload

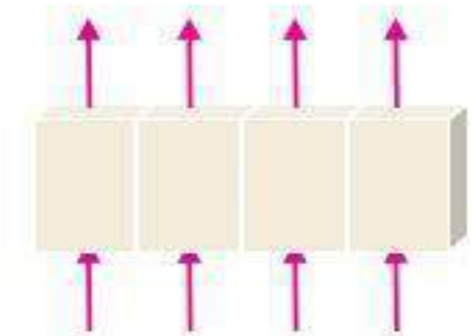


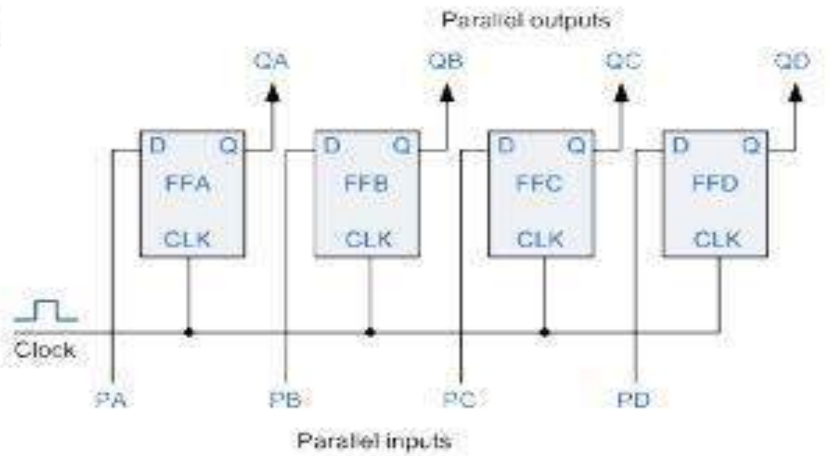




Parallel-In Parallel-Out

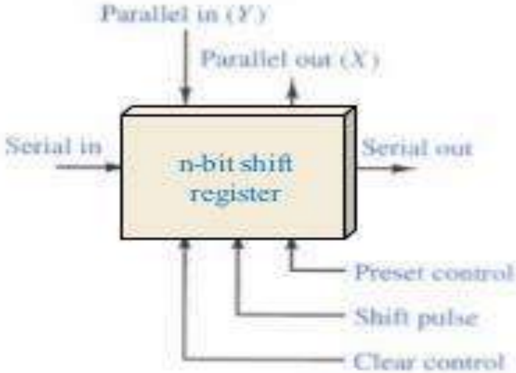
- Parallel-in Parallel-out Shift Registers can serve as a temporary storage device or as a time delay device
- The DATA is presented in a parallel format to the parallel input pins PA to PD and then shifted to the corresponding output pins QA to QD when the registers are clocked
- One clock pulse to load
- One pulse to unload

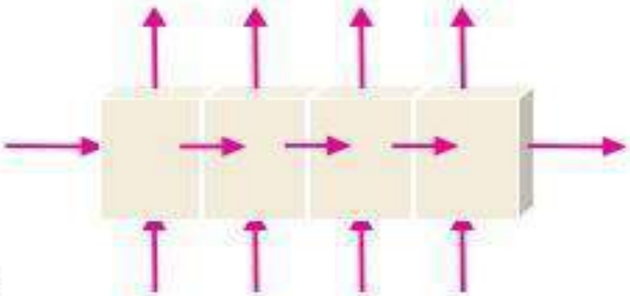


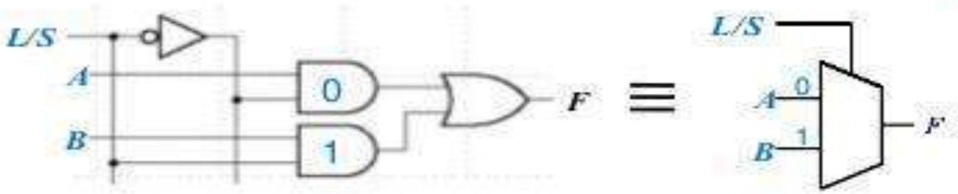


Universal Shift Register

- Universal shift register
- Can do any combination of parallel and serial input/output operations
- Requires additional inputs to specify desired function
- Uses a Mux-like input gating

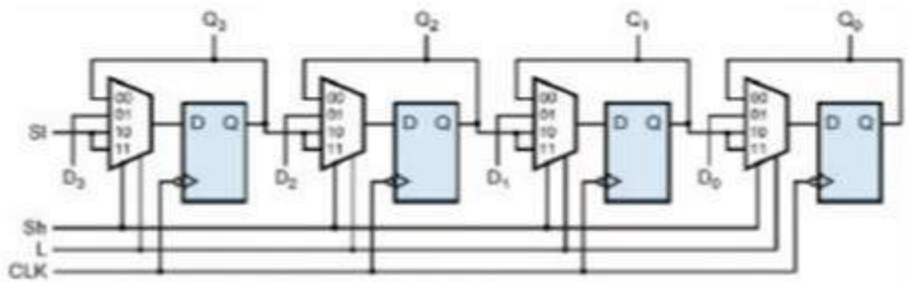




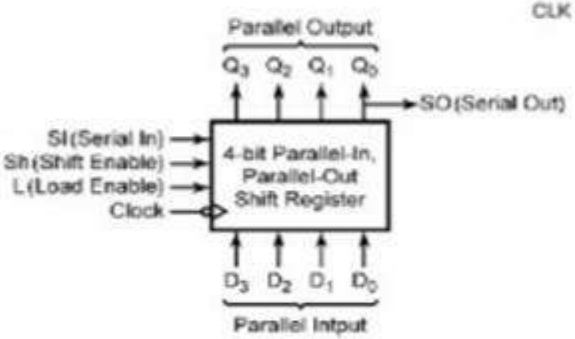


Universal Shift Register

- Parallel shift register (can serve as converting parallel-in to serial-out shifter):



Implementation using flip-flops and MUXes



Inputs		Next State				Action
Sh (Shift)	Ld (Load)	Q_3^+	Q_2^+	Q_1^+	Q_0^+	
0	0	Q_3	Q_2	Q_1	Q_0	no change
0	1	D_3	D_2	D_1	D_0	load
1	X	SI	Q_3	Q_2	Q_1	right shift

BUFFER REGISTER

Buffer registers are a type of registers used to store a binary word. These can be constructed using a series of flip-flops as each flip-flop can store a single bit.

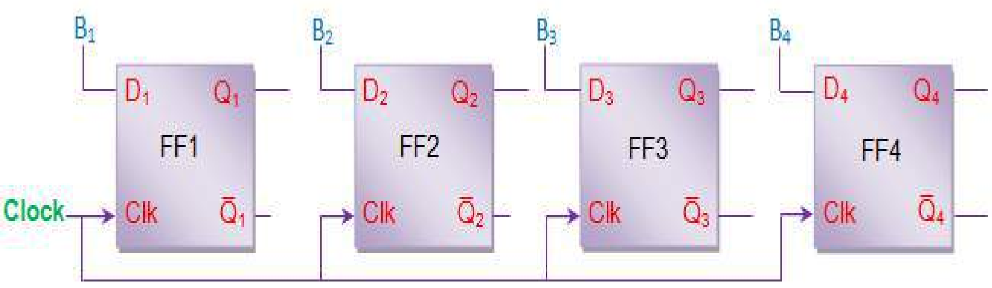


Figure 1 4-bit Buffer Register

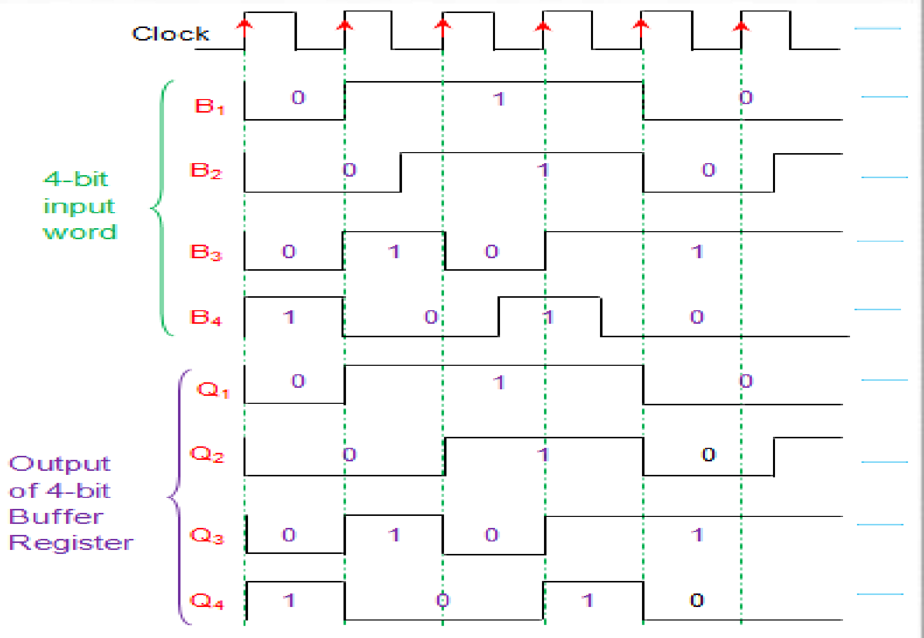


Figure 2 Input-Output Waveform for 4-bit

CONTROLLED BUFFEER REGISTER

Buffer registers offer no means of control over the inputs which in turn leads to uncontrolled outputs. In order to overcome this drawback one can resort to controlled buffer registers.

- Tri-state switches are used to control the operation of loading and/or retrieval of the data to/from the buffer register. Here one has to pull the $\overline{LD}$ or $\overline{WR}$ control line (blue line) low in order to store the data into the register, while $\overline{RD}$ control line (red line) should be made low to read the data.

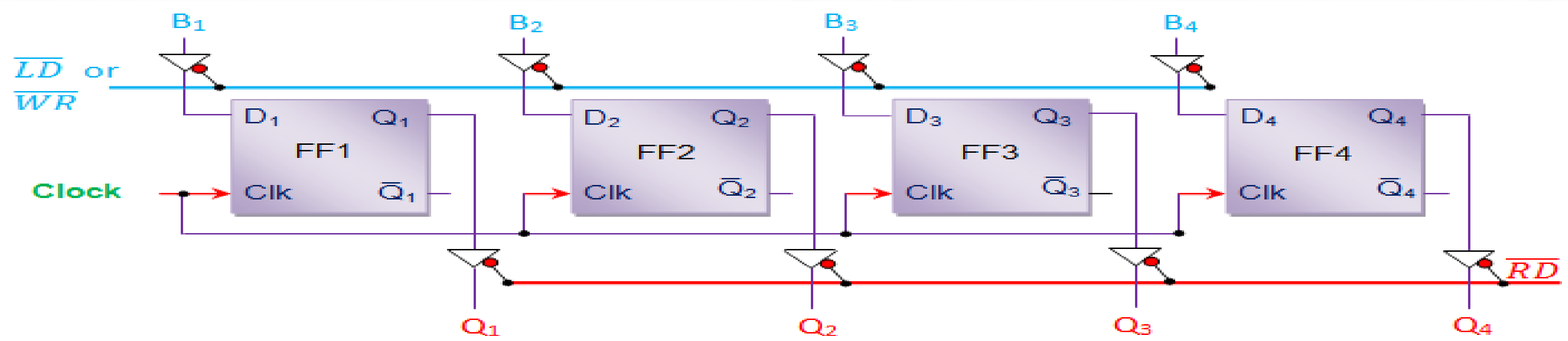


Figure 3 4-bit Controlled Buffer Register

BIDIRECTIONAL SHIFT REGISTER

Bidirectional shift registers are the storage devices which are capable of shifting the data either right or left depending on the mode selected.

n-bit bidirectional shift register with serial data loading and retrieval capacity. Initially all the flip-flops in the register are reset by driving their clear pins high. Next R/LÌ… control line is made either low or high in order to opt for either left-shift or right-shift of the data bits, respectively.

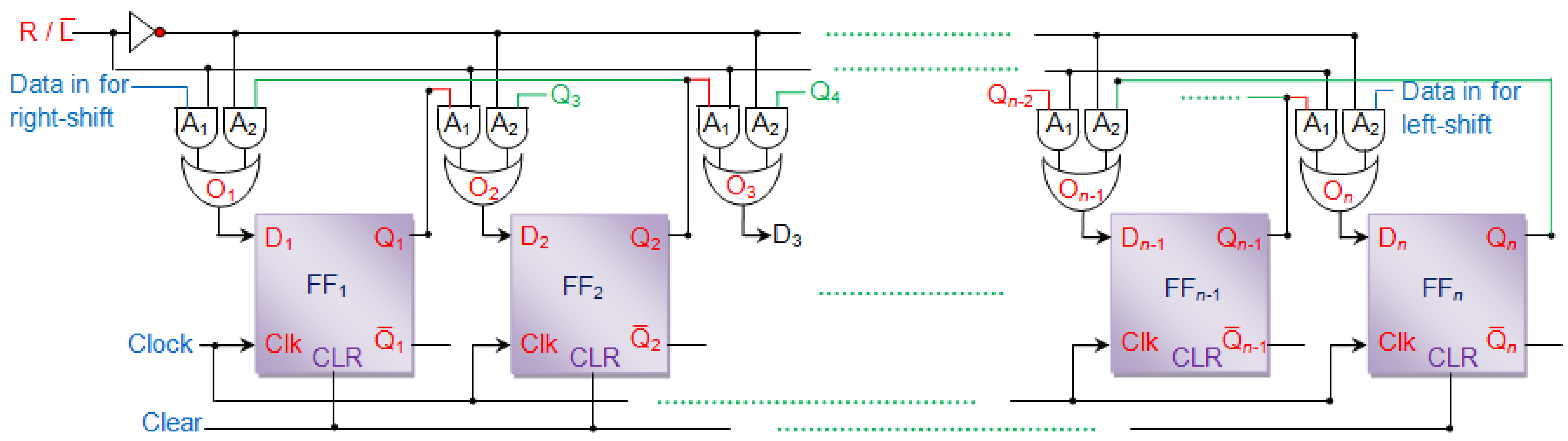
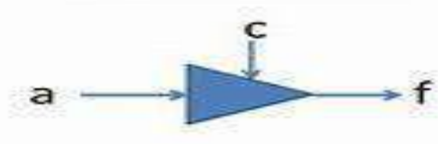


Figure 1 *n*-bit Bidirectional Shift Register

TRISTATE BUFFER

A tri-state buffer is similar to a buffer, but it adds an additional "enable" input that controls whether the primary input is passed to its output or not. If the "enable" inputs signal is true, the tri-state buffer behaves like a normal buffer. If the "enable" input signal is false, the tri-state buffer passes a *high impedance* (or hi-Z) signal, which effectively disconnects its output from the circuit

Tri-State Buffer



c	a	f
0	0	Z
0	1	Z
1	0	0
1	1	1

APPLICATIONS OF SHIFT REGISTER

- (A) TIME DELAY
- (B) SERIAL/PARALLEL DATA CONVERSION
- (C) RING COUNTERS
- (D)UNIVERSAL ASYNCHRONOUS RECEIVER TRANSMITTER

A/D AND D/A CONVERTERS

CHAPTER- 11

WHAT IS A/D CONVERTER?

- An electronic integrated circuit which transforms a signal from analog (continuous) to digital (discrete) form.
- Analog signals are directly measurable quantities.
- Digital signals only have two states. For digital computer, we refer to binary states, 0 and 1.

WHY A/D CONVERTER IS NEEDED

- Microprocessors can only perform complex processing on digitized signals.
- When signals are in digital form they are less susceptible to the deleterious effects of additive noise.
- ADC Provides a link between the analog world of transducers and the digital world of signal processing and data handling.

APPLICATION OF A/D CONVERTERS

- ADC are used virtually everywhere where an analog signal has to be processed, stored, or transported in digital form.
- Some examples of ADC usage are digital volt meters, cell phone, thermocouples, and digital oscilloscope.

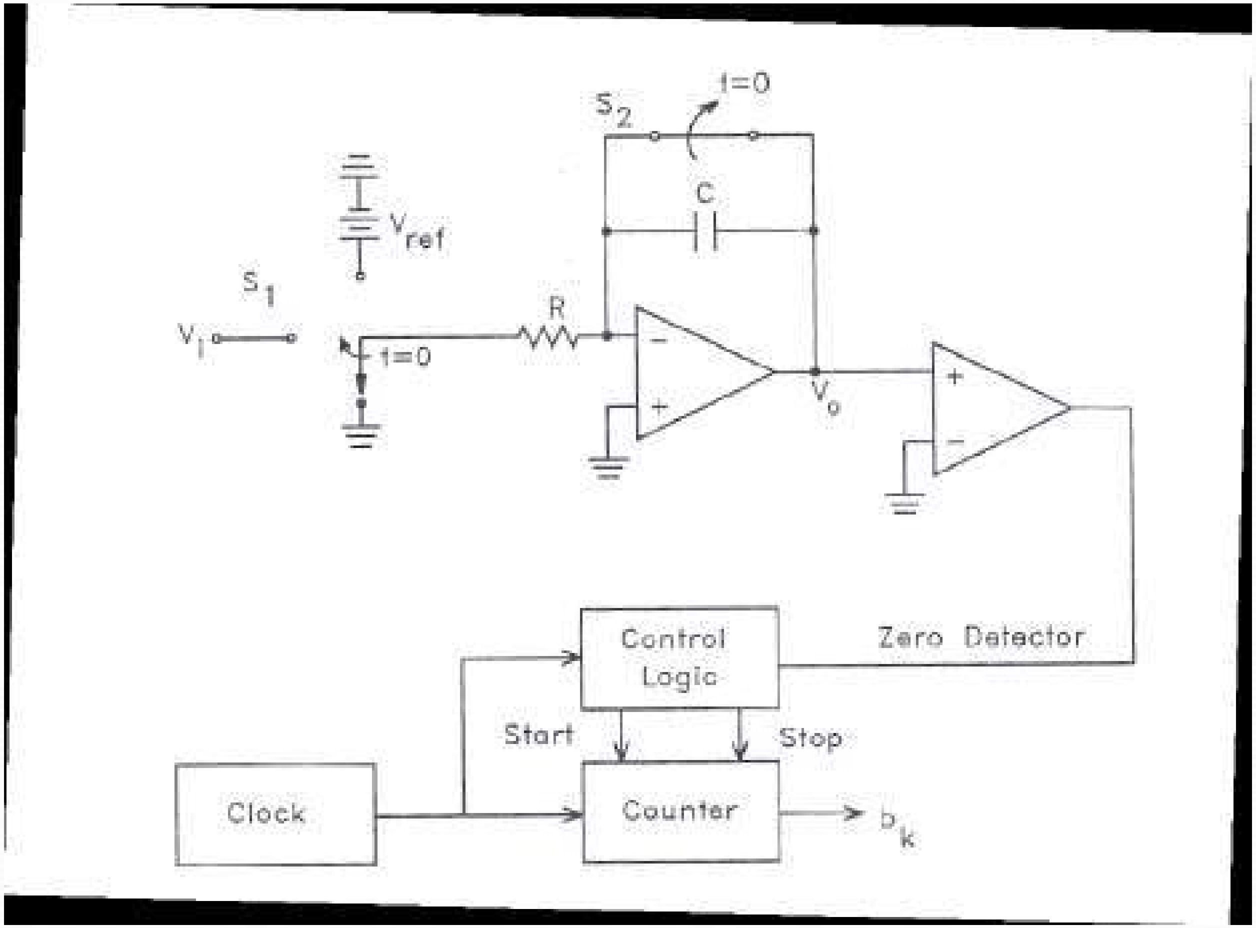
TYPES OF A/D CONVERTERS

- Dual Slope A/D Converter
- Successive Approximation A/D Converter
- Staircase ramp or Single Slope A/D Converter
- Parallel comparator A/D Converter

DUAL SLOPE A/D CONVERTER

- **Fundamental components**
- Integrator
- Electronically Controlled Switches
- Counter
- Clock
- Control Logic
- Comparator

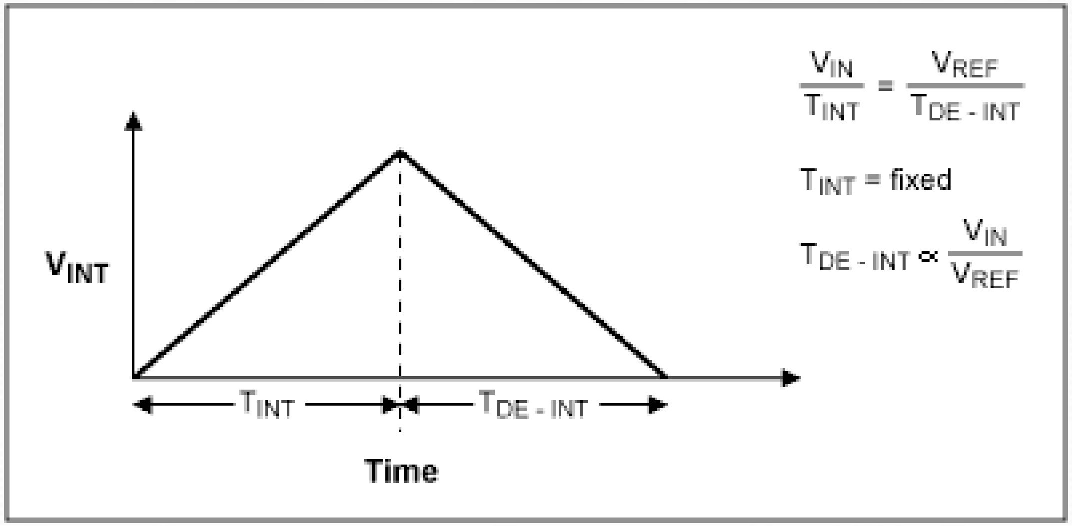
Block diagram of A/D Converter



How does it work

- A dual-slope A/D (DS-ADC) integrates an unknown input voltage (V_{IN}) for a fixed amount of time (T_{INT}), then "de-integrates" (T_{DEINT}) using a known reference voltage (V_{REF}) for a variable amount of time.
- The key advantage of this architecture over the single-slope is that the final conversion result is insensitive to errors in the component values. That is, any error introduced by a component value during the integrate cycle will be cancelled out during the de-integrate phase.

Waveform of DS-ADC



DS –ADC ADV. & DISADVANTAGES

- ADVANTAGES
  - Conversion result is insensitive to errors in the component values.
  - Fewer adverse affects from "noise"
  - High Accuracy
- DISADVANTAGES
  - Slow
  - Accuracy is dependent on the use of precision external components
  - Cost

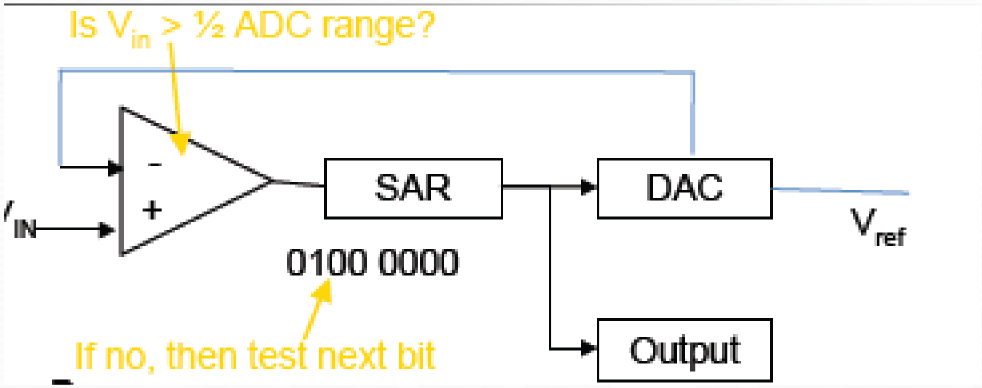
SUCCESSIVE APPROXIMATION A/D CONVERTER

- Uses a n-bit DAC to compare DAC and original analog results.
- Uses Successive Approximation Register (SAR) supplies an approximate digital code to DAC of Vin.
- Comparison changes digital output to bring it closer to the input value.
- Uses Closed-Loop Feedback Conversion.

PROCESS OF SA-ADC

- MSB initialized as 1
- Convert digital value to analog using DAC
- Compares guess to analog input
- Is $V_{in}>V_{DAC}$
    - Set bit 1
    - If no, bit is 0 and test next bit

BLOCK DIAGRAM OF SA-ADC



ADVANTAGES OF SA-ADC

Advantages

- Capable of high speed and reliable .
- Medium accuracy compared to other ADC types.
- Good tradeoff between speed and cost.
- Capable of outputting the binary number in serial.

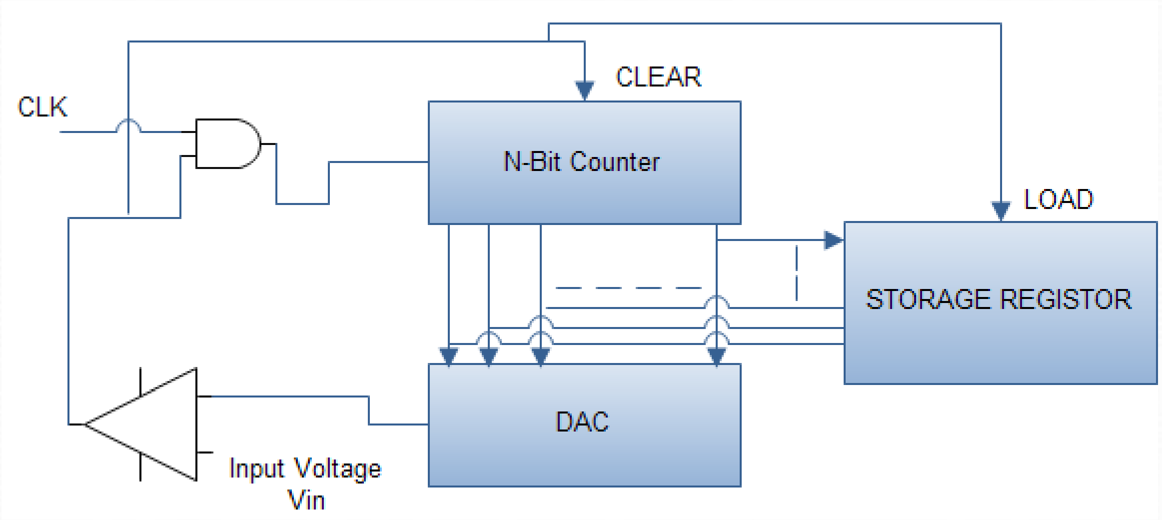
DISADVANTAGES OF SA-ADC

Disadvantages

- ADC's will be slower
- Speed limited to ~5Msps

COUNTER TYPE ADC

THE COUNTER TYPE ADC IS THE BASIC TYPE OF ADC WHICH IS ALSO CALLED AS DIGITAL RAMP TYPE ADC OR STAIR CASE APPROXIMATION ADC. THIS CIRCUIT CONSISTS OF N BIT COUNTER, DAC AND OP-AMP COMPARATOR AS SHOWN IN BELOW FIGURE.



ADVANTAGES & DISADVANTAGES OF COUNTER TYPE ADC

Advantages

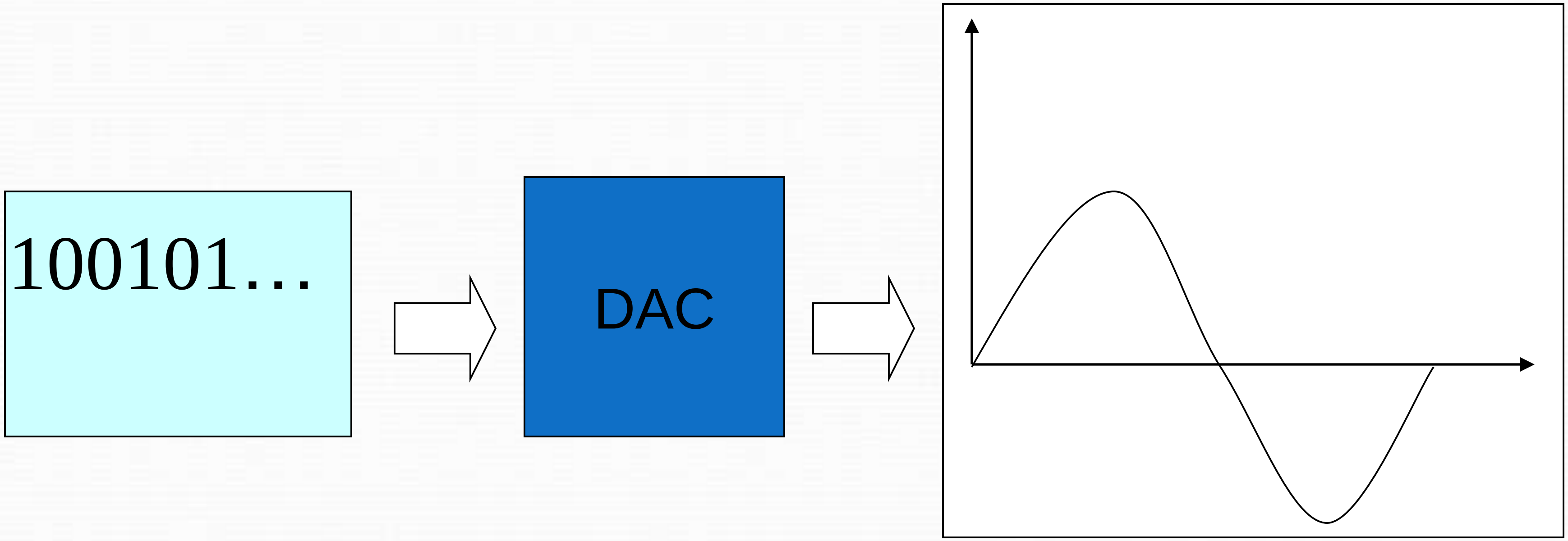
- Simple to understand and operate.
- Cost is less because of less complexity in design.

Disadvantages

- Speed is less because every time the counter has to start from ZERO.
- There may be clash or aliasing effect if the next input is sampled before completion of one operation ost is less because of less complexity in design.

What is a DAC?

- A digital to analog converter (DAC) converts a digital signal to an analog voltage or current output.



Types of DACs

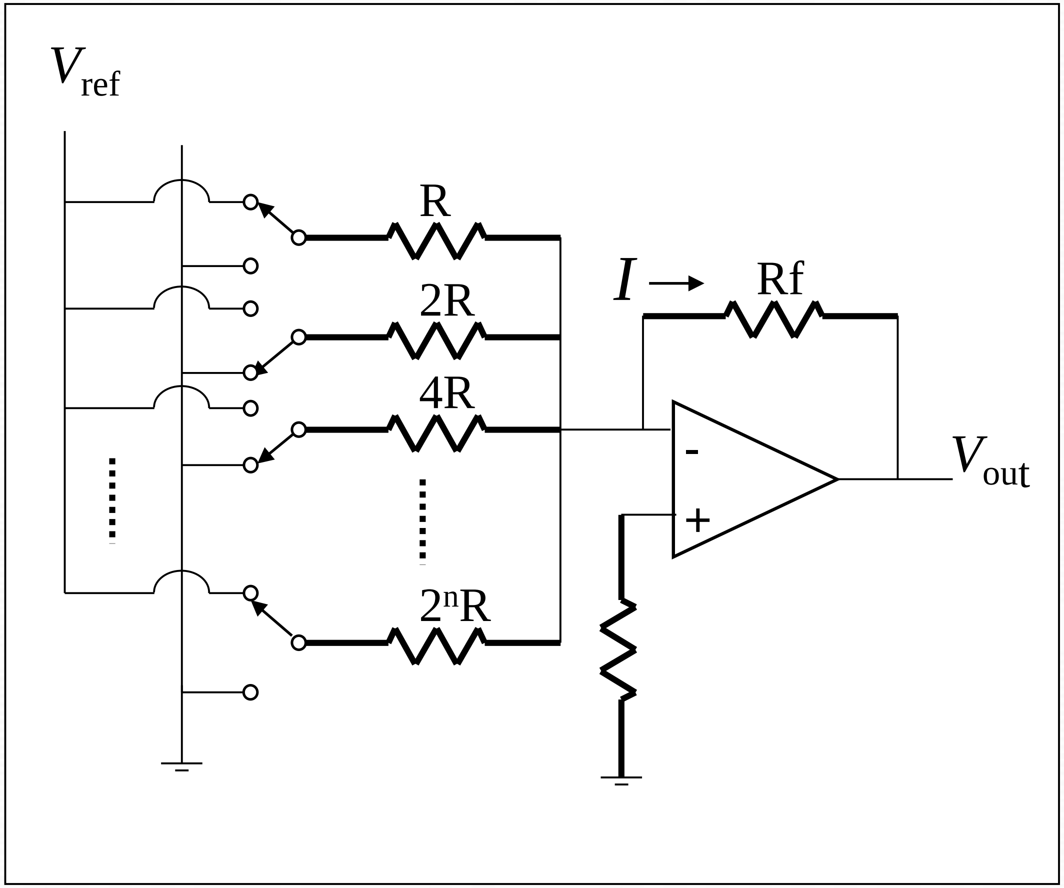
- Many types of DACs available.
- Usually switches, resistors, and op-amps used to implement conversion
- Two Types:
  - Binary Weighted Resistor
  - R-2R Ladder

Binary Weighted Resistor

- Utilizes a summing op-amp circuit
- Weighted resistors are used to distinguish each bit from the most significant to the least significant
- Transistors are used to switch between V_{ref} and ground (bit high or low)

Binary Weighted Resistor

- Assume IdealOp-amp
- No current int op-amp
- Virtual ground at inverting input
- $V_{out} = -IR_f$

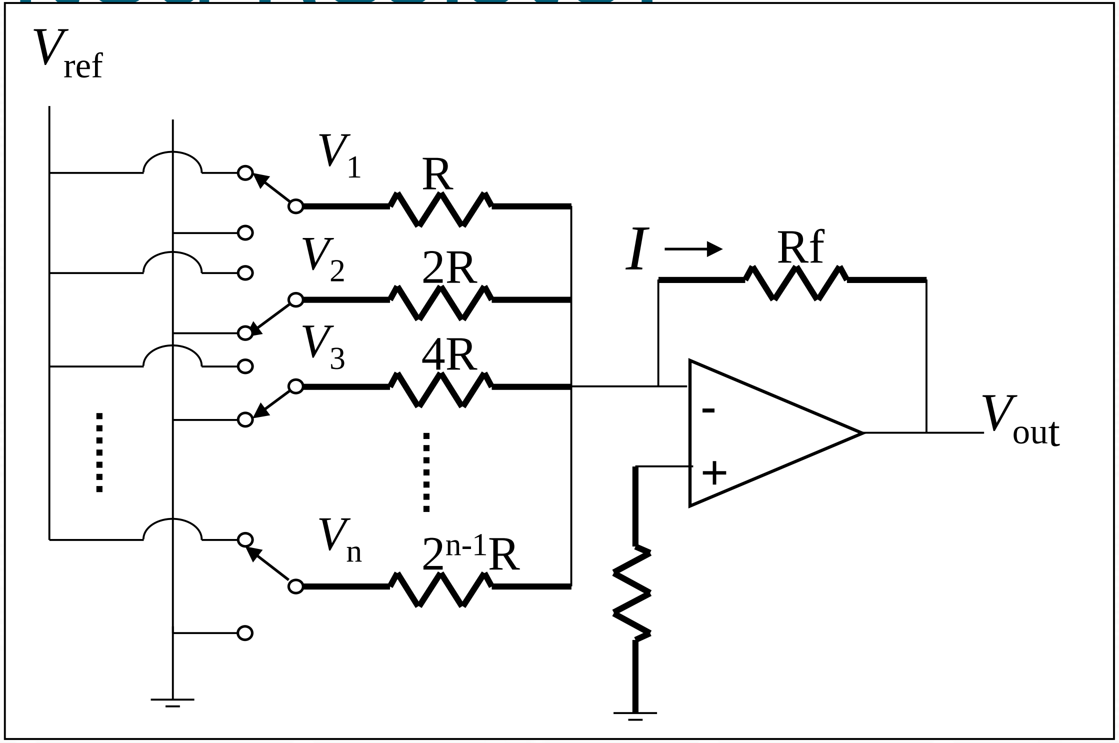


Binary Weighted Resistor

Voltages V_1 through V_n are either V_{ref} if corresponding bit is high or ground if corresponding bit is low

V_1 is most significant bit

V_n is least significant bit



MSB

LSB

$$V_{out} = -IR_f = -R_f\left(\frac{V_1}{R} + \frac{V_2}{2R} + \frac{V_3}{4R} + \cdots \frac{V_n}{2^{n-1}R}\right)$$

Binary Weighted Resistor

If $R_f = R/2$

$$V_{out} = -IR_f = -\left(\frac{V_1}{2} + \frac{V_2}{4} + \frac{V_3}{8} + \cdots \frac{V_n}{2^n}\right)$$

For example, a 4-Bit converter yields

$$V_{out} = -V_{ref}\left(b_3\frac{1}{2} + b_2\frac{1}{4} + b_1\frac{1}{8} + b_0\frac{1}{16}\right)$$

Where b_3 corresponds to Bit-3, b_2 to Bit-2, etc.

Binary Weighted Resistor

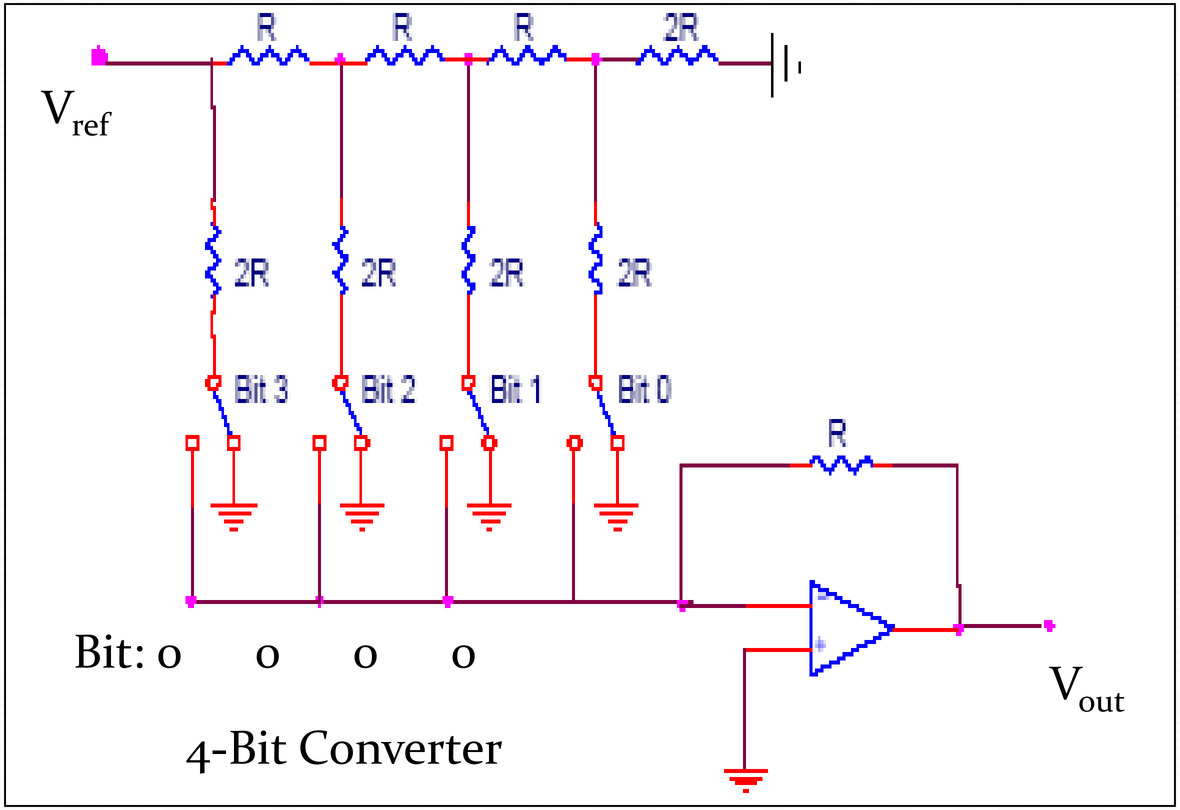
Advantages

- Simple Construction/Analysis
- Fast Conversion

Disadvantages

- Requires large range of resistors (2000:1 for 12-bit DAC) with necessary high precision for low resistors
- Requires low switch resistances in transistors
- Can be expensive. Therefore, usually limited to 8-bit resolution.

R-2R Ladder

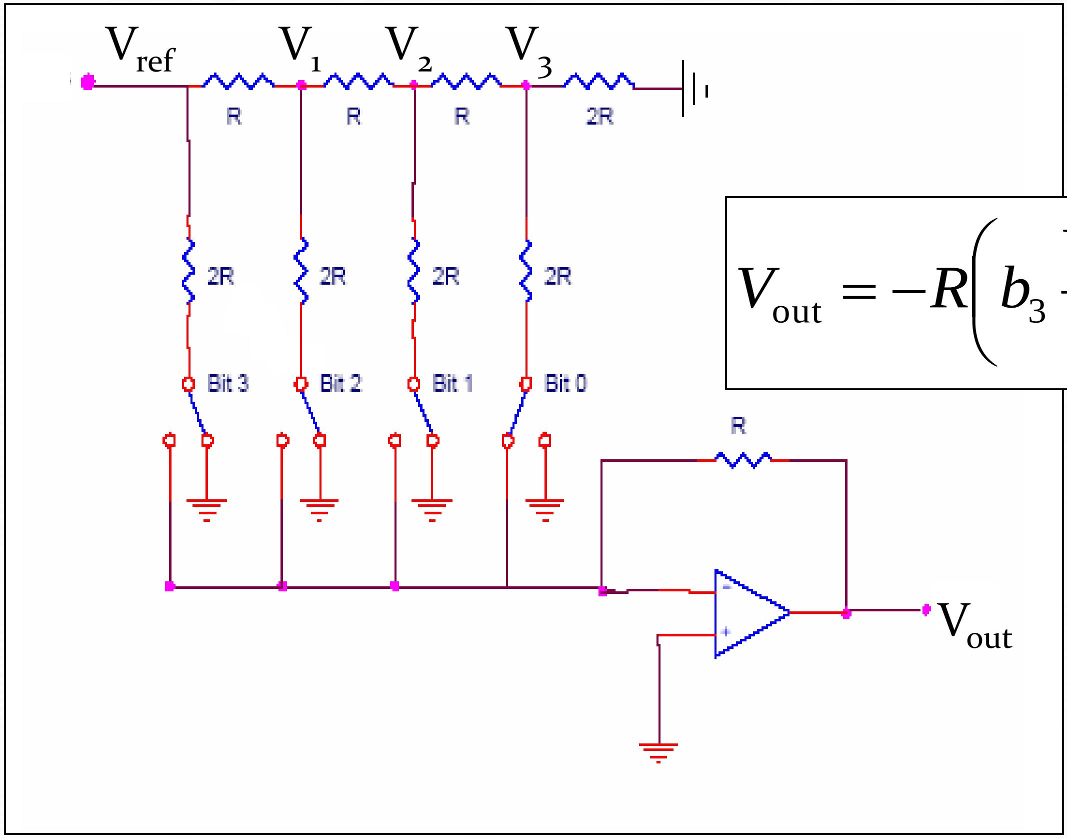


Each bit corresponds to a switch:

If the bit is high, the corresponding switch is connected to the inverting input of the op-amp.

If the bit is low, the corresponding switch is connected to ground.

R-2R Ladder



Results:

$$V_3 = \frac{1}{8}V_{ref}, \; V_2 = \frac{1}{4}V_{ref}, \; V_1 = \frac{1}{2}V_{ref}$$

$$\boxed{V_{out} = -R\left(b_3\frac{V_{ref}}{2R} + b_2\frac{V_{ref}}{4R} + b_1\frac{V_{ref}}{8R} + b_0\frac{V_{ref}}{16R}\right)}$$

Where b_3 corresponds to bit 3, b_2 to bit 2, etc.

If bit n is set, b_n=1

If bit n is clear, b_n=0

R-2R Ladder

For a 4-Bit R-2R Ladder

$$V_{out} = -V_{ref}\left(b_3\frac{1}{2} + b_2\frac{1}{4} + b_1\frac{1}{8} + b_0\frac{1}{16}\right)$$

For general n-Bit R-2R Ladder or Binary Weighted Resister DAC

$$\boxed{V_{out} = -V_{ref}\sum_{i=1}^{n} b_{n-i}\frac{1}{2^i}}$$

R-2R Ladder

Advantages

- Only two resistor values (R and 2R)
- Does not require high precision resistors

Disadvantage

- Lower conversion speed than binary weighted DAC

APPLICATIONS

- Digital Motor Control
- Computer Printers
- Sound Equipment (e.g. CD/MP3 Players, etc.)
- Electronic Cruise Control
- Digital Thermostat

SEMICONDUCTOR MEMORIES

CHAPTER-12

Memory Organization

- It provides spaces for storing instruction and data, space for intermediate results and spaces for final results.
- Memory is primarily of two types;
- (a) INTERNAL MEMORY: Primary/Main Memory And Cache Memory.
- (b) EXTERNAL MEMORY: Secondary Storage.

INTERNAL MEMORY

- PRIMARY

Primary memory is computer memory that a processor or computer accesses first or directly. It allows a processor to access running execution applications and services that are temporarily stored in a specific memory location. Primary memory is also known as primary storage or main memory

- CACHE MEMORY

Cache memory is a small-sized type of volatile computer **memory** that provides high-speed data access to a processor and stores frequently used computer programs, applications and data. It is the fastest **memory** in a computer

EXTERNAL MEMORY

- The storage capacity of the main memory or the primary memory of the computer is limited. Sometimes we have to store millions or billions bytes of data and primary memory of this computer is not able to store this data. Therefore, we require additional memory called auxiliary memory or secondary storage.

WHAT IS MEMORY?

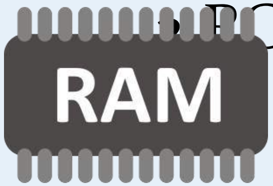
- The ability to store and retrive the digital information in a microcomputer system is called MEMORY.
- In past years, magnetic tape is used as memory element . But now days, with advancement in semi-conductor technology, semiconductor or memories of different types and sizes are used

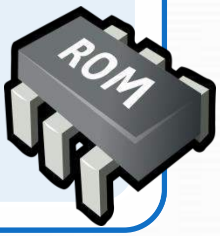
MEMORY

SEMICONDUCTOR MEMORY

MAGNETIC MEMORY

1.RAM
2.ROM

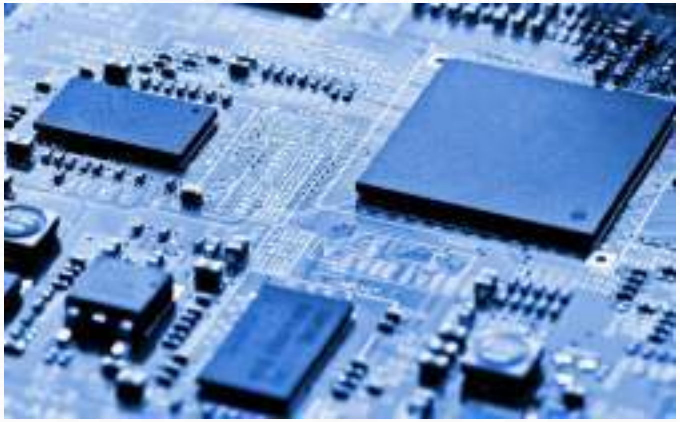




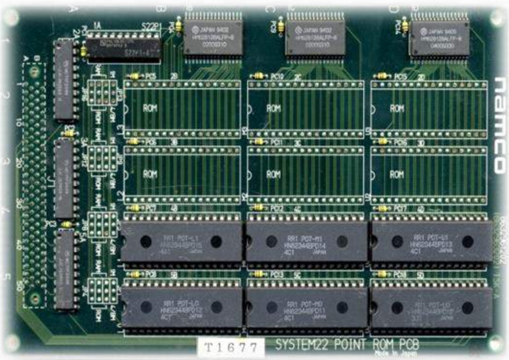
1.MAGNETIC TAPE
2.FLOPPY DISK
3.HARD DISK
4.OPTICAL DISC
5.MAGNETIC BUBBLE MEMORY

SEMICONDUCTOR MEMORY

semiconductor memories are small in size, have low cost, high speed of operation, high reliability and memory size can be expanded according to their requirements.



ROM



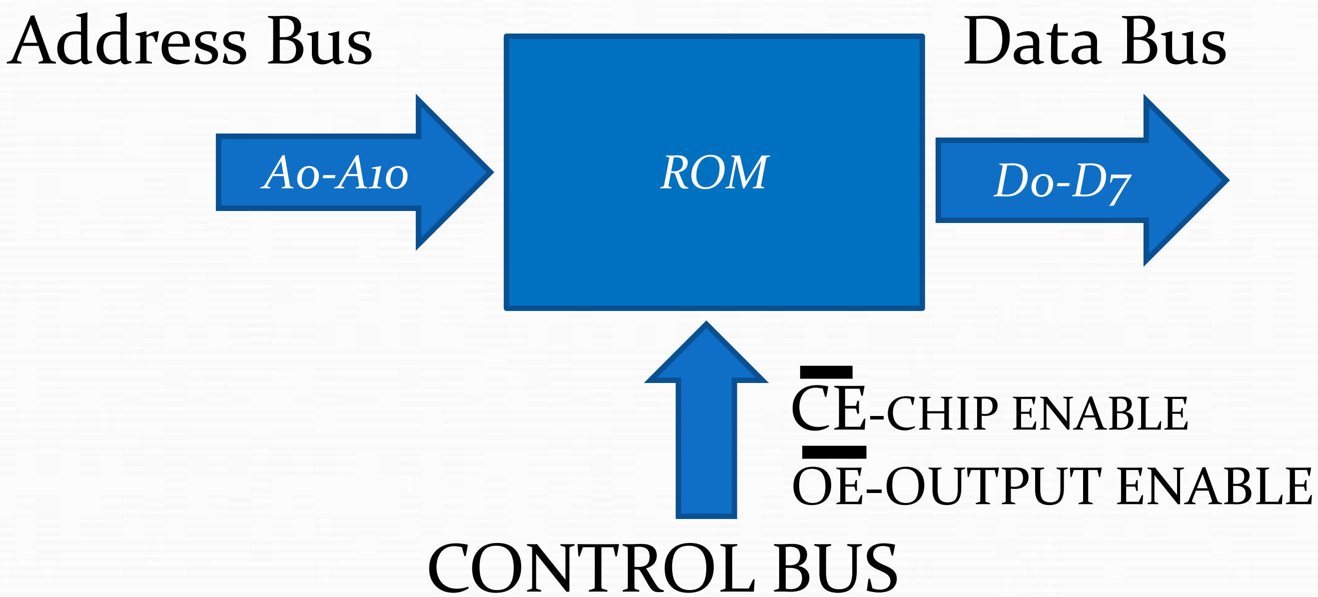
Bipolar Rom

MOS

WHAT IS ROM?

Read-only memory (**ROM**) is a type of storage medium that permanently stores data on personal computers (PCs) and other electronic devices. It contains the programming needed to start a PC, which is essential for boot-up; it performs major input/output tasks and holds programs or software instructions.

BLOCK DIAGRAM OF ROM



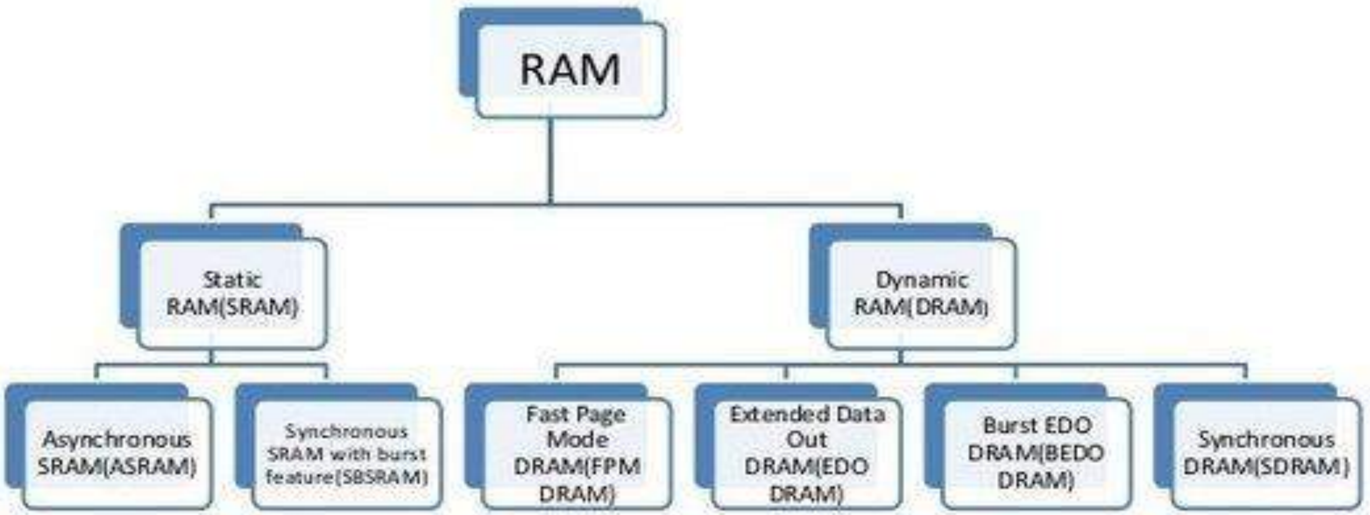
TYPES OF ROM:-

1. Programmable Read Only Memory[PROM]
2. Erasable Programmable Read Only Memory [EROM]
3. Electrical Erasable Programmable Memory [EEPROM]

WHAT IS RAM?

Random Access Memory (**RAM**) is the hardware in a computing device where the operating system (OS), application programs and data in current use are kept so they can be quickly reached by the device's processor. **RAM** is the main memory in a computer, and this type of memory is volatile and all information that was stored in **RAM** is lost when computer is turned off.

Types of Random-Access Memory(RAM)



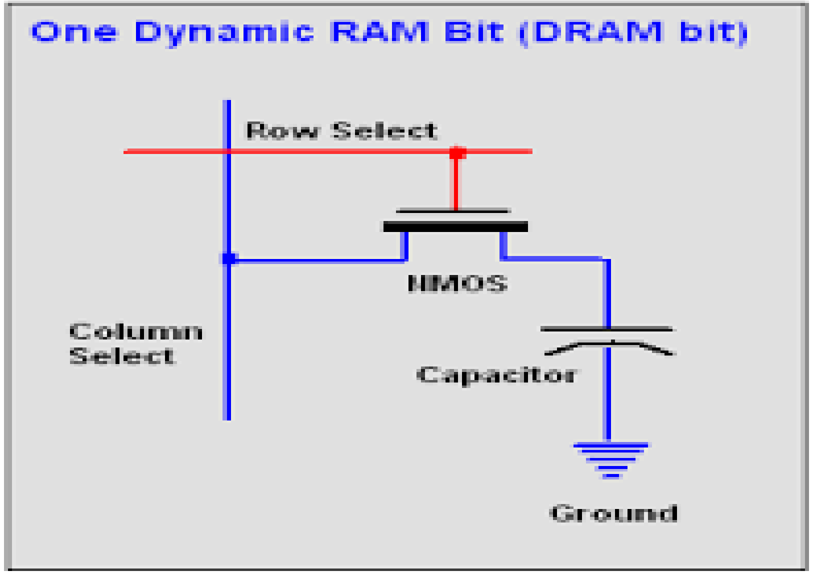
TYPES OF RAM

1.STATIC RAM

SRAM (**Static RAM**) is random access memory (**RAM**) that retains data bits in its memory as long as power is being supplied.

2.DYNAMIC RAM

Dynamic RAM (DRAM), which stores bits in cells consisting of a capacitor and a transistor



DIFFERENCE BETWEEN STATIC AND DYNAMIC RAM

Static RAM	Dynamic RAM
➢ SRAM uses transistor to store a single bit of data	➢ DRAM uses a separate capacitor to store each bit of data
➢ SRAM does not need periodic refreshment to maintain data	➢ DRAM needs periodic refreshment to maintain the charge in the capacitors for data
➢ SRAM's structure is complex than DRAM	➢ DRAM's structure is simplex than SRAM
➢ SRAM are expensive as compared to DRAM	➢ DRAM's are less expensive as compared to SRAM
➢ SRAM are faster than DRAM	➢ DRAM's are slower than SRAM
➢ SRAM are used in Cache memory	➢ DRAM are used in Main memory

"DIFFERENCE"

RAM	***ROM***
1. Temporary memory	1. Permanent memory
1. RAM enables data read & write to memory	1. Instructions written in ROM can only be read
1. Data can be changed or deleted	1. Data cannot be changed or deleted
1. Instructions are written into the RAM at the time of execution	1. Instructions are written into ROM at manufacturing time

Installation and Maintenance of Electrical Engineering

Semester-4th

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Nanakpur

INSTALLATION & MAINTENANCE

OF

Electrical Engg.

LEARNING OUTCOMES

After undergoing the subject, the students will be able to:

- Erect/install various electrical equipment as per IE Rules Act by adopting all safety measures.
- Prepare specifications for different items required for transmission lines.
- Design and excavation of cable trenches.
- Lay underground cables
- Test cables and their termination.
- Check HT/LT circuit breakers, transformers and related equipment in a substation
- Carry out earthing, make earth pits and measure earth resistance values.
- Find fault in a transmission/distribution system.
- Carry out preventive maintenance to minimize breakdowns.

DETAILED CONTENTS

1. Tools and Accessories (04 Periods)

Tools, accessories and instruments required for installation, maintenance and repair work. Knowledge of Indian Electricity rules, safety codes, causes and prevention of accidents, artificial respiration of an electrocuted person, workmen's safety devices

2. Installation (18 Periods)

2.1 Installation of transmission and Distribution Lines:

Erection of steel structures, connecting jumpers, tee-off points, joints and dead ends; crossing of roads, streets, power/telecommunication lines andrailway line crossings, clearances; earthing of transmission lines and guarding, spacing and configuration of conductors: Arrangement for suspension and strain insulators, bird guards, anti-climbing devices and danger plates; sizes of conductor, earthwire and guy wires.

Laying of service lines, earthing, provision of service fuses, installation of energy meters

2.2 Laying of Underground Cables:

Inspection, storage, transportation and handling of cables, cable handling equipment, cable laying depths and clearances from other services such as: water, sewerage, gas, heating and other mains, and also a series of power and telecommunication cables and coordination with these services, excavation of trenches, direct cable laying, including laying of cable from the drum, laying cable in the trench, taking all measurements and making drawings, back filling of trenches with earth or sand, laying protective layer of bricks etc,) laying of cables into pipes and conduits and within buildings.

2.3 Elementary idea regarding, inspection and handling of transformers; pole mounted substations, plinth mounted substations, grid substation, busbars, isolators, voltage and current transformers, lightning arrestors, control and relay panels, HT/LT circuit breakers, LT switches, installation of power/distribution transformers, dehydration. Earthing system, fencing of yard, equipment foundations and trenches etc..

2.4 Testing of various electrical equipment such as electrical motor, transformers, cables, and generators, motor control centres, medium voltage distribution panels, power control centres, motor control centres, lighting arrangement, storage, pre-installation checks, connecting and starting, pre-commissioning checks, drying out

3. Maintenance (42 Periods)

3.1 Types of maintenance, maintenance schedules, procedures

3.2 Maintenance of Transmission and Distribution System

Authorized persons, danger notice, caution notice, permit to work, arranging of shutdowns personally, temporary earthing, cancellation of permit and restoration of supply.

Patrolling and visual inspection of lines - points to be noted during patrolling from ground; special inspections and night inspections;Location of faults using Meggar, effect of open or loose neutral connections, provision of proper fuses on service lines and their effect on system, causes of dim and flickering lights.

3.3 Maintenance of Distribution Transformers

Transformer maintenance and points to be attended to in respect of various items of equipment

Checking of insulation resistance, transformer oil level and BDV test of oil, measurement of earth resistance

Chapter-1

Tools and Accessories

Chapter-1 (TOOLS AND ACCESSORIES)

INTRODUCTION:- Tools are required to carry out the installation and maintenance work. Without proper tool it is difficult to carry repair and maintenance work.

Various tools used in installation and maintenance and repairing:-

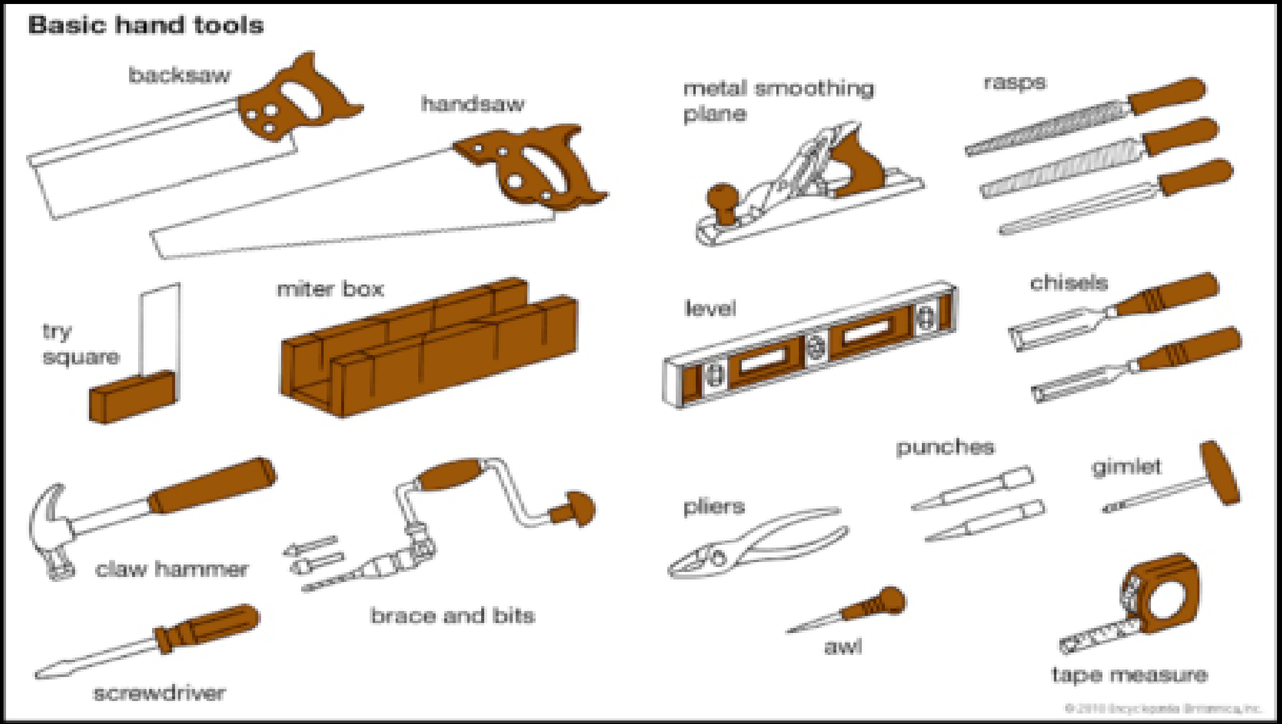
- Combination plier:- Side cutting plier

  Long nose plier
- Screw driver
- Hammer:- Ball peen hammer

  Cross pin hammer

  Claw hammer
- Cutter
- Saws
- Wood saw

- Hack saw
- Knife
- Chisel
- Hand drill
- Files
- Poker
- Gimlet
- Auger bit
- Plumb bob
- Bench vice
- Centre punch
- Spanner
- Standard wire gauge



TESTING AND MEASURING INSTRUMENTS

Earth tester:- Earth tester is used to measure the earth resistance. Earth resistance is special type of ohm meter which send A.c through earth and D.c through the measuring instruments as shown in fig. The value of earth resistance is indicated directly on the scale when handle is turned at uniform speed. The distance between earth electrode and current electrode should be 25m and between potential electrode amd earth electrode it shold be 12.5m.

Value of earth resistance of different systems

Large power station -0.5ohm

Major sub station -1 ohm

Small sub station. - 2 ohm

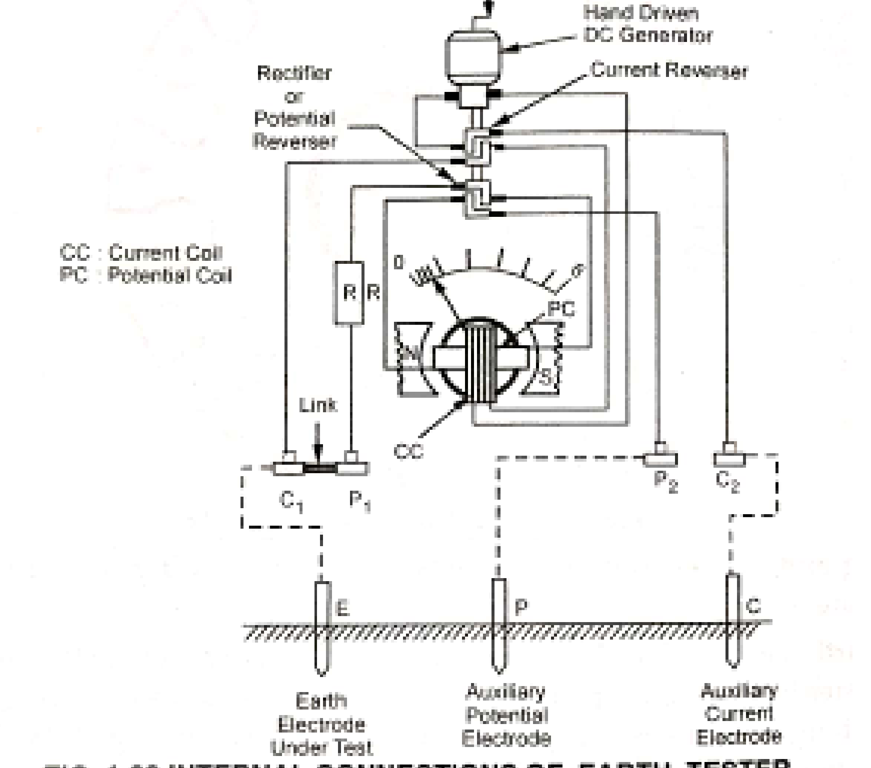


FIG. 1.23 INTERNAL CONNECTIONS OF EARTH TESTER

Meggar :- Meggar is high resistance meter and is used to measure insulation resistance of transformer, generator,motor etc. Available in different voltage that is 500v,1000v,2500v,5000v. A high value of resistance indicates good insulation.

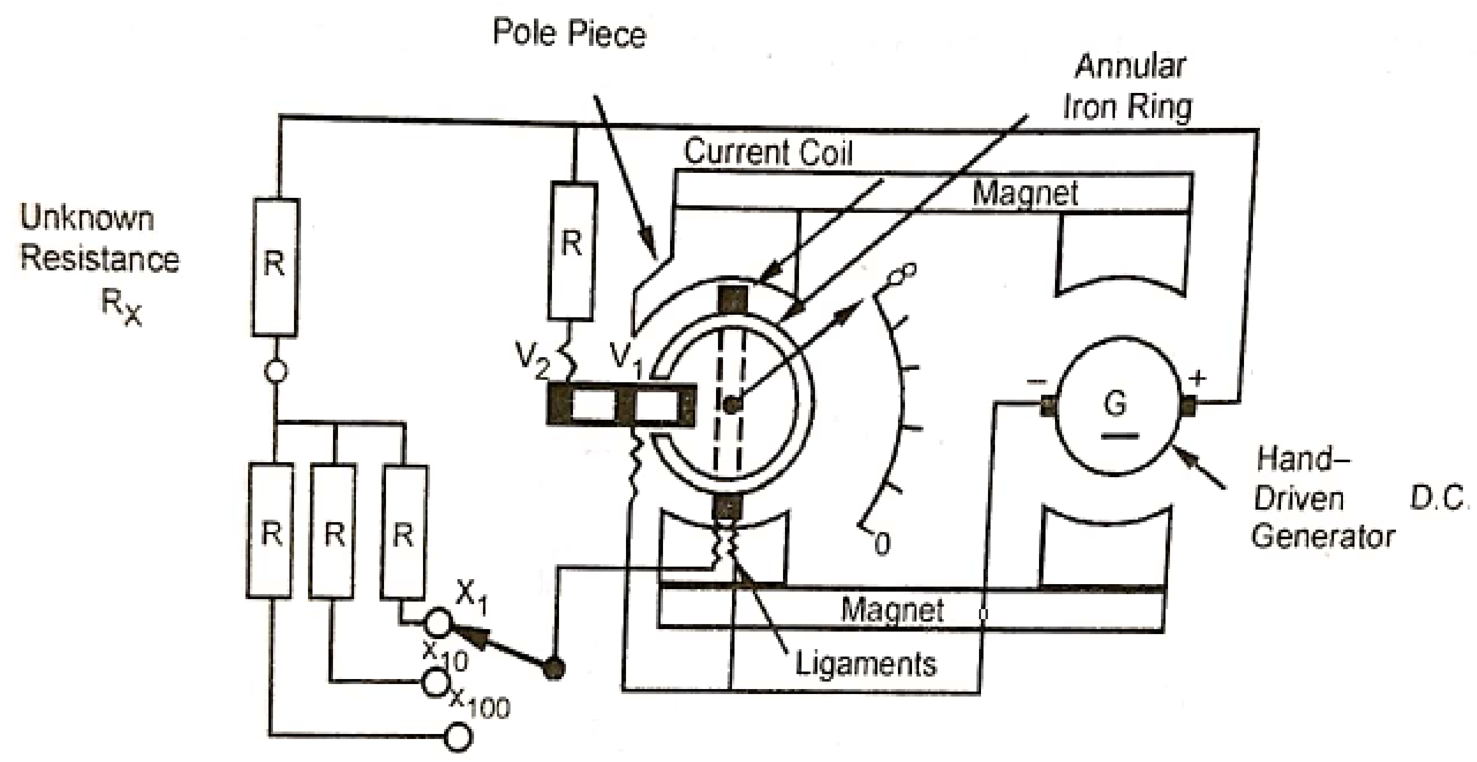


FIG. 1.25 INTERNAL CONNECTION DIAGRAM OF A MEGGER

Phase sequence indicator :- It consist of rotating disc with an arrow marked on it and three terminal RYB.

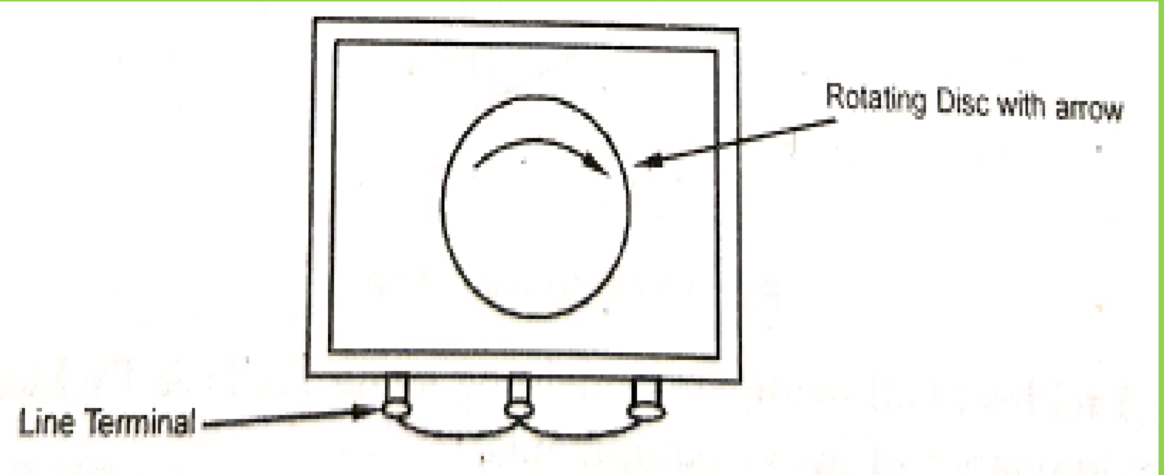


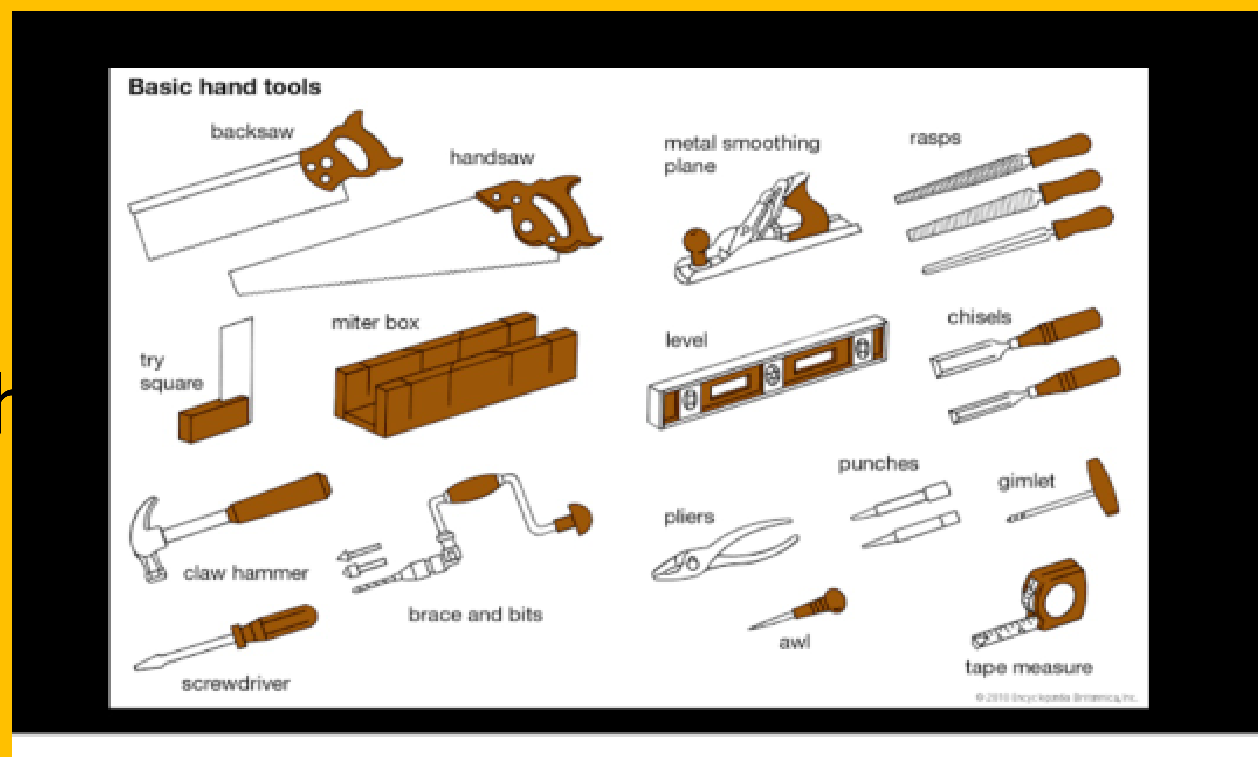
FIG. 1.26 PHASE SEQUENCE INDICATOR

Transformer oil test kit :- It is used to measure the dielectric strength or breakdown value of transformer oil. Details about the test will be discussed in subsequent chapter.

Multimeter :- It is also known as AVO meter that is ammeter, voltmeter and ohmmeter. It is also used to measure AC/DC current and resistance.

Tools and tackles :-

a. Chain pulley
b. Jacks
c. Crane
d. Hammer drill machine
e. Ladder
f. Rubber gloves
g. Helmets
h. Protective cloth
i. Crimping tools



Electric shock :- It is a sudden stimulation of nervous system of human body by flow of electric current through a part of a body.

Treatment for electric shock :-

1. Switch off the supply
2. Remove the person from direct contact of live wire with wood stick.
3. Remove from the fire
4. Treatment of burns

Artificial respiration

Accident :- It is an unexpected and unplanned event which may or may not injury.

Electrical accidents :- In every case where a person receive an electric shock and suffer injury directly or indirectly incommunication with generation, transmission,distribution and used for electrical energy should be electrical accidents.

Cause of Electrical Accidents :-

1. Working on line wires
2. Unsafe working
3. Lack of supervision
4. Lack of knowledge of electrical instruments
5. Not use proper insulation tools

Artificial respiration :- By following the above points if a person is still not breathing the artificial respiration should be applied immediately to restore the normal breathing and prevent death until the medical aid reaches.

Methods

- Schafer's prone method
- Silvester's method
- Mouth to mouth

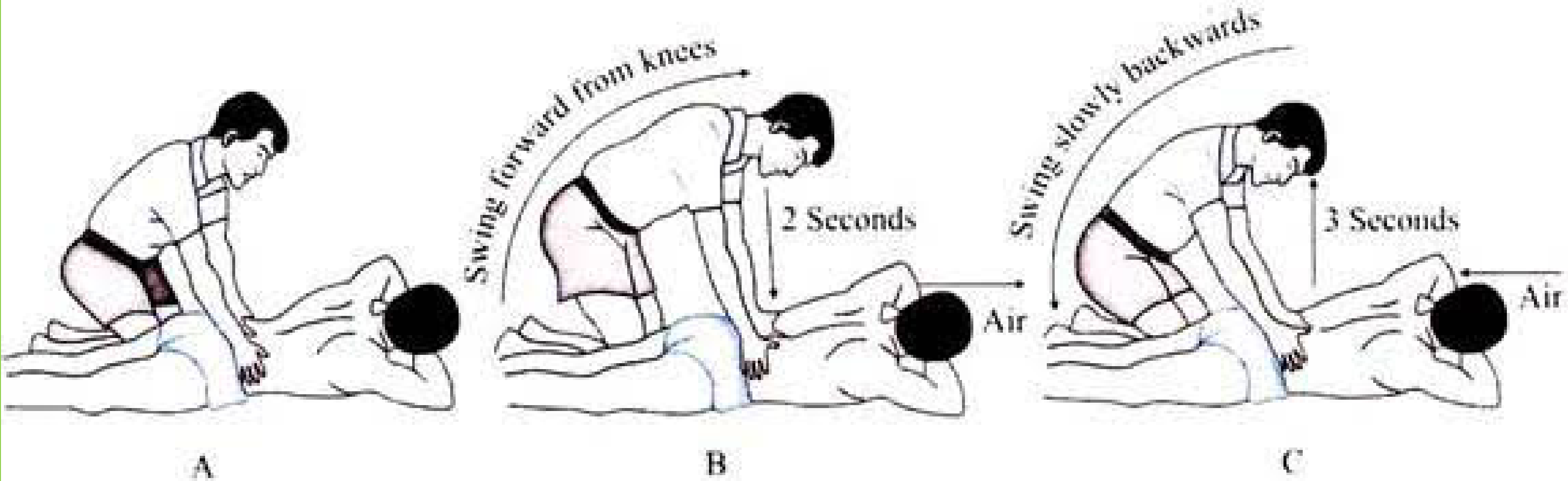


Fig. 8.43 Schafer's manual method for artificial respiration.

Electrical safety rules :-

Indian electricity rules 1956 :- knowledge of this is imporatant for all electrical engineer and supervisors etc.

- Do not use wire with poor insulation.
- Do not tough any electrical equipment with wet hands or bleeding from cut an abrasion.
- Do not work on online circuit without taking extra precautions such as use of rubber gloves, insulated tools like plier, screw driver etc.
- Do not use fire extinguisher on electrical equipment use sand or blanket instead.
- Do not throw water on electrical equipment in case of fire.
- Do not allow to touch the electrical appliance or motor to any unauthorized person or visitors.
- Do not allow to any people in danger zone of HV line
- Do not test the circuit with bare finger

Rule 29 :- Construction, installation, protection, operations and maintenance of electric supply and apparatus.

Rule 30 :- Service line and apparatus on consumer premises.

Rule 35:- Danger Notice

Rule 42:- Accidental charge

Rule 44:- Instructions for restoration of person suffering from electric shock.

Rule 45:- Precautions to be adopted by consumers owner occupies electric contractors electrical work man and suppliers

Rule 47:- Testing of consumer installation

Rule 50:- Supply and use of energy

Rule 51:- Provision applicable to medium high or extra high voltage installation

Rule 56:- sealing of meters and cut-outs

Rule 60:- test for resistance and insulation

Rule 77:- Clearance above ground of the lowest conductors.

Chapter-2

Installation

Chapter - 2 (INSTALLATION TRANSMISSION AND DISTRIBUTION LINE)

Transmission system:- An arrangement of substation transmission line and intermediate substation associated control, protection observe etc are known as transmission system.

Transmission line:- The transmission of electrical power or eneiis done through wire supported on towers are called transmission line.

Distribution system:- The system which which receives the bulk power from the transmission system at the receiving stations(66kv,132kv,220kv,400kv) and distribute it to various consumers at reduced voltage level i.e 440v 3- phase/230v single phase is known as distribution system.

Installation:- It is the process of installing the machinery/ eauipment/transmission line etc. On foundation at site along with accessories to make the equipment plant ready for testing and commissioning.

Testing:- After installing the equipment testing is carried on equipment and its sub-system to ensure safe and proper performance as per the the specification of the equipments.

Commissioning:- It is done after the testing of equipment is over.

Classification of Voltages:-

Low voltage - below 1000

medium voltage -between 1000v and 33kv

high voltage - above 33kv

Extra high voltage - above 220kv

Ultra high voltage - above 750kv

Classification of Lines:-

Short line -80 km

Medium line -80 km - 160km

Long line - above 160km

Planning in Route of lines:-

- The proposed route of the line should be shortest practicable distance and as straight as possible.
- If possible the lines should be run along the roadway or railway
- Bridges,industries,religious place,water logged areas, garden,tress should be avioded as far as practicable.
- The line should be away from bulk storage of oil tanks, oil or gas pipelines.
- Line should be away from telecommunication line.

Components of Transmission line

a. Conductors
b. Supports and cross arms
c. Insulators
d. Pole fitting
e. Stay wire
f. Miscellaneous items

Conductors:- The conductors are used for transmission and distribution of electrical power from generating station to sub station and from sub station to consumers premises.

Properties:-

- High Electrical conductivity
- High tensile strength
- Easily available
- Light in weight
- Low cost

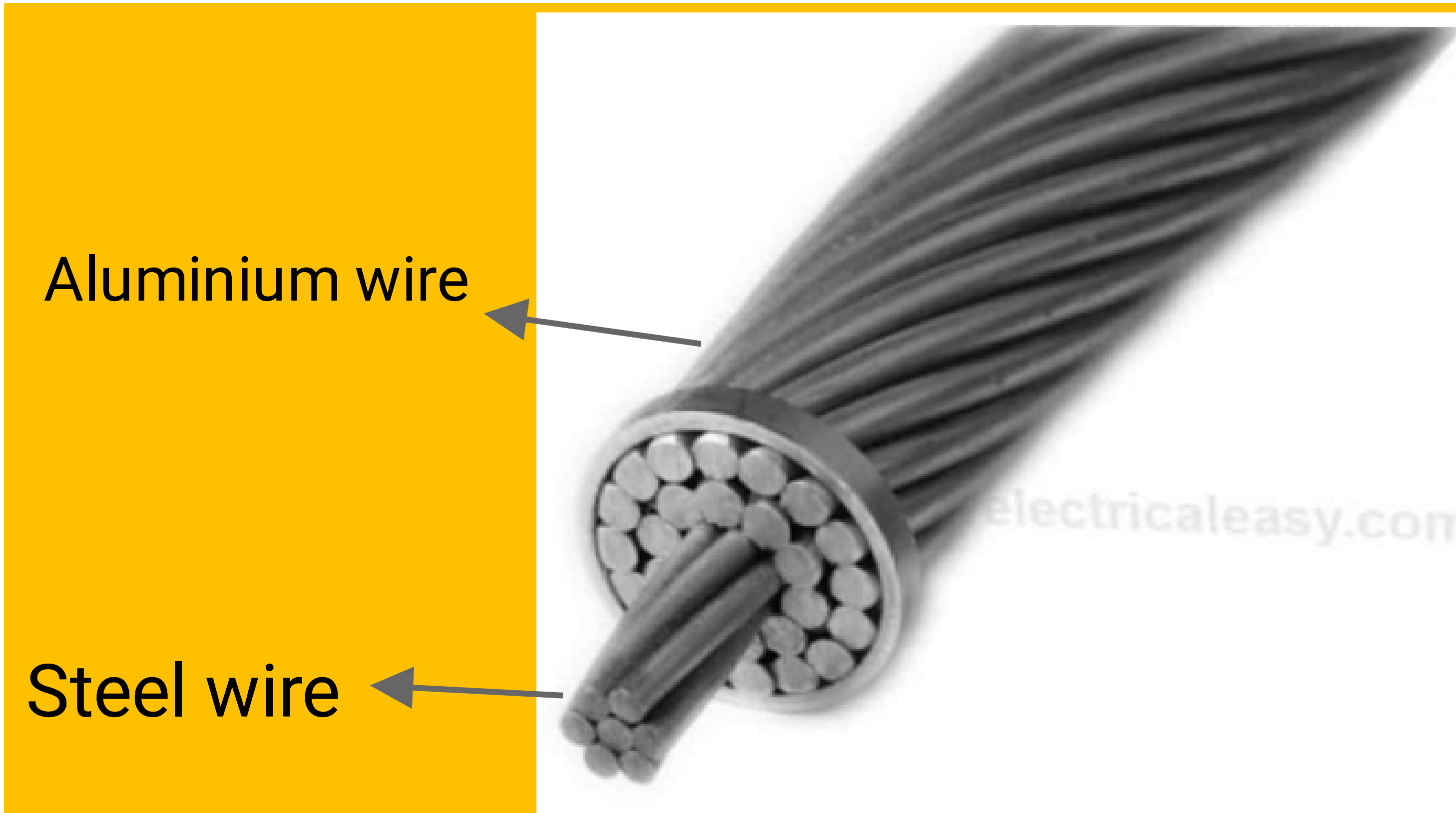
Types of conducors:-

a. Copper
b. Aluminium
c. A.C.S.R

Copper:-Copper has a high conductivity and greater tensile strength. So, copper in hard drawn stranded form is a great option for overhead lines.

Aluminium:- Aluminium has about 60% of the conductivity of copper; that means, for the same resistance.Also, tensile strength of aluminium is less than that of copper. Considering combined factors of cost, conductivity, tensile strength, weight etc., aluminium has an edge over copper. Therefore, aluminium is being widely used for overhead conductors. Cheap in cost.

A.C.S.R:- ACSR consists of a solid or stranded steel core with one or more layers of high purity aluminium (aluminium 1350) wires wrapped in spiral. The core wires may be zinc coated (galvanized) steel or aluminium coated (aluminized) steel. Galvanization or aluminization coatings are thin and are applied to protect the steel from corrosion. The central steel core provides additional mechanical strength and



hence, sag is significantly less than all other aluminium conductors.

Line support

The support for transmission and distribution lines are poles and towers.

Properties:-

- High mechanical strength
- Light in weight
- Longer life
- Cheap in cost
- Low maintenance cost
- Easily accessible for paint

Types of line supports

1. Wooden pole
2. Steel pole
3. R.C.C poles
4. Steel pole

Wooden poles:- It is one of the cheapest types of line supports and used for lines where spans are short, and tension is low. The wood poles have the limitations of height and diameter. It is two types A or H. Height is 10 to 12 mtr. These are embedded in ground depth of 1/6th of height of pole in case normal soil and 1/5th of poor case soil. Life of this pole is 25 yrs.

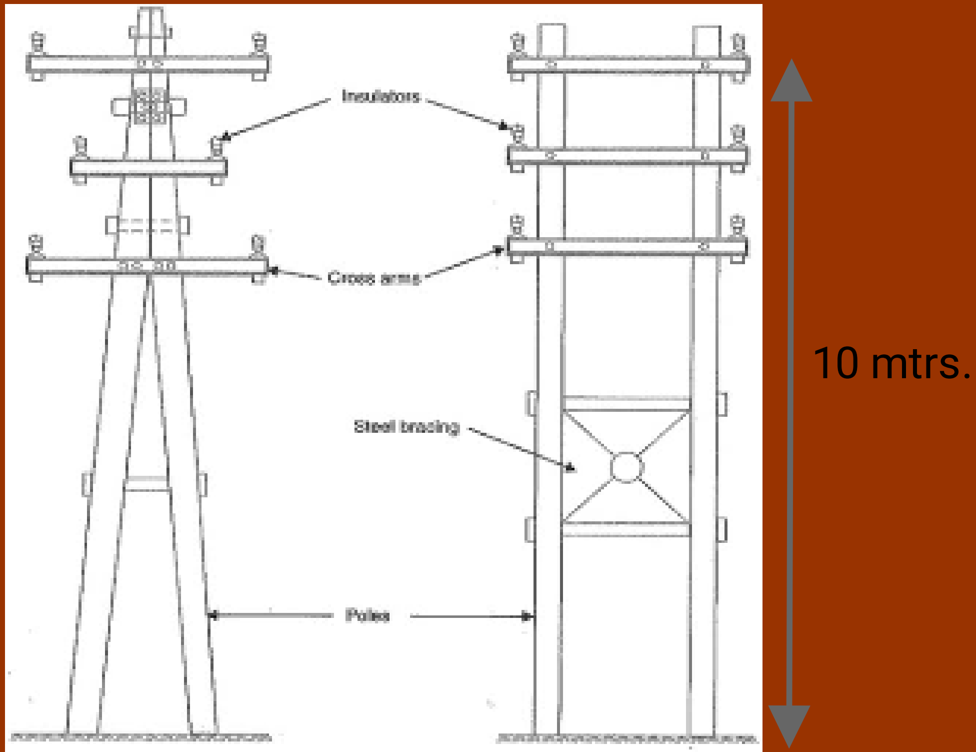
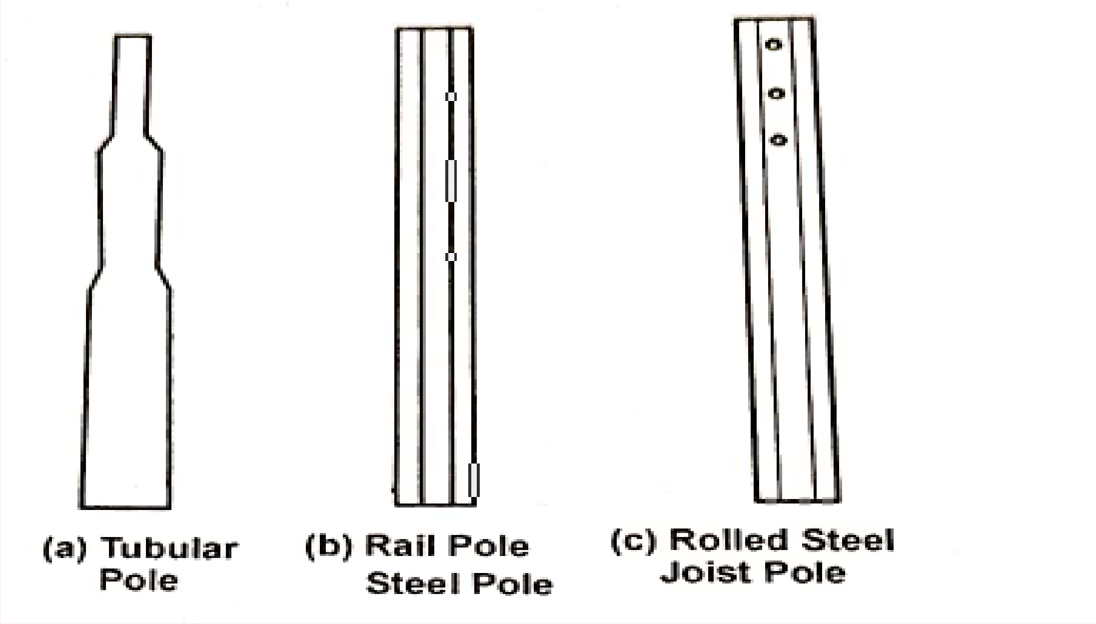


Fig. 8.2 Wooden poles

Steel pole:- These poles have more strength as compared to wooden poles.For low and medium voltage tubular steel poles or Grider steel supports are used. Longer spans are possible with steel poles. The poles need to be galvanised or painted periodically to prevent them from corrosion. Their maintenance expense is high.



Life of this pole 40 yrs.

R.C.C pole:- Reinforced cement concrete. These pole are used upto 33 kv line. They have replaced the wooden and steel pole due to its longer life free from insects and atmospheric effect. The life of this pole is very long.

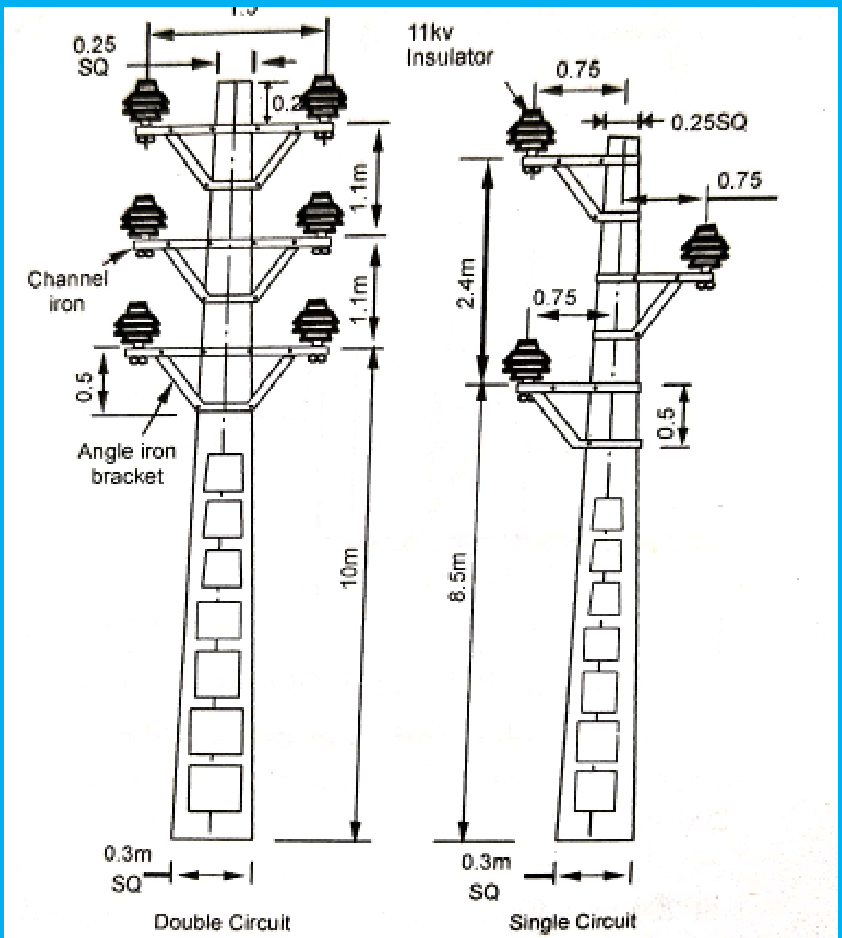


FIG. 4.5 11kV CONCRETE POLES

Steel tower:- These are used for long distance transmission line at higher voltage. These are most strong and rigid. The tower are filled in concrete base called concrete muffs.

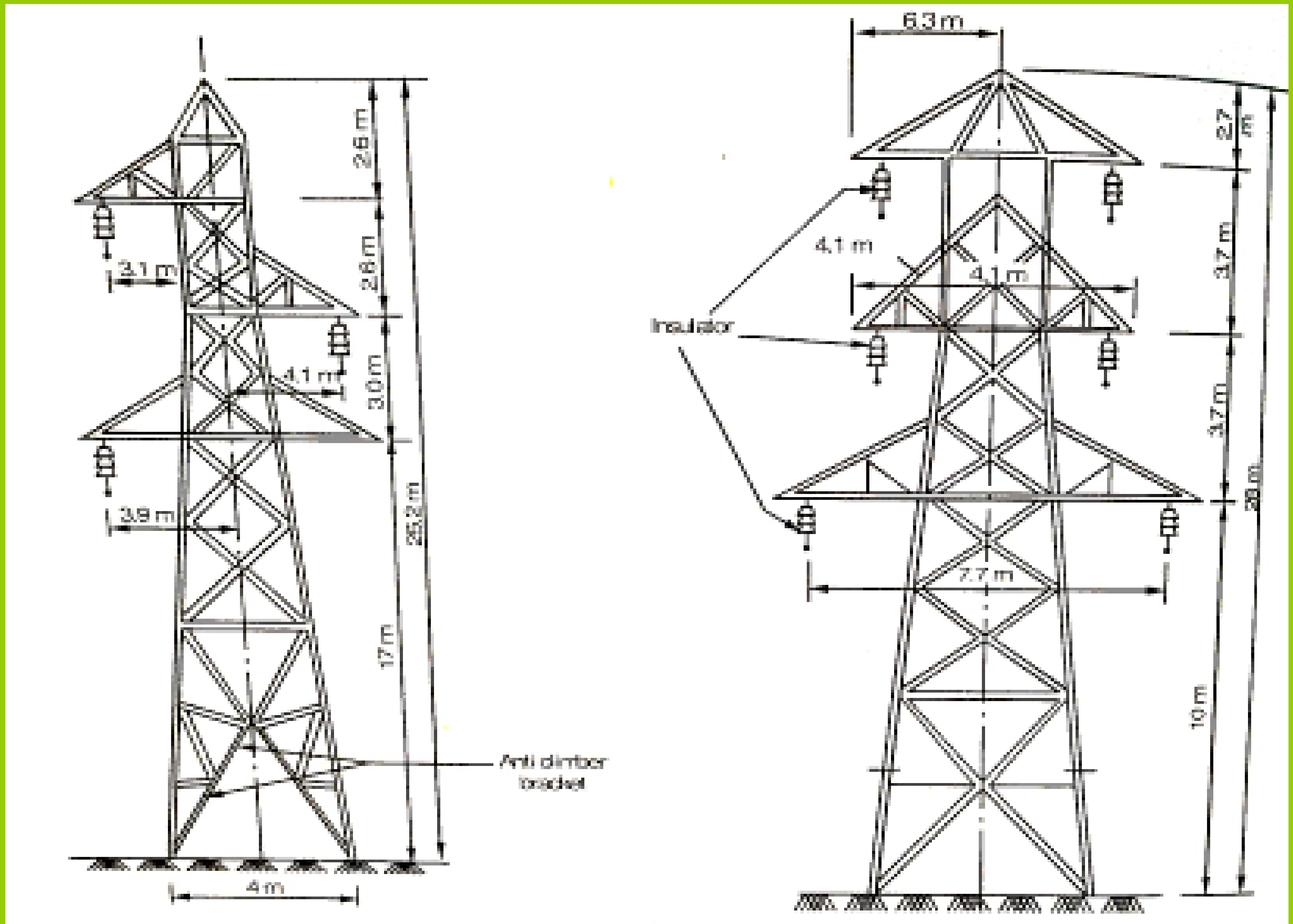


FIG. 4.6 STEEL TOWER

Spans for poles and tower:-

Wooden and steel pole:- 30m to 50m as a distribution poles in residential areas. Longer spans 50m to 80m are used in rural areas. R.C.C poles spans are 80m to 200m.

Steel tower:- The height of steel tower varies from 20m to 45m and span of 200m to 400m are used. For railway and river crossing long span upto 800m are employed.

Erection of pole and steel structures:-

Once the collection amd transportation of material about poles is completed the next- step is to start the pole foundation excavation work and then erect the pole.

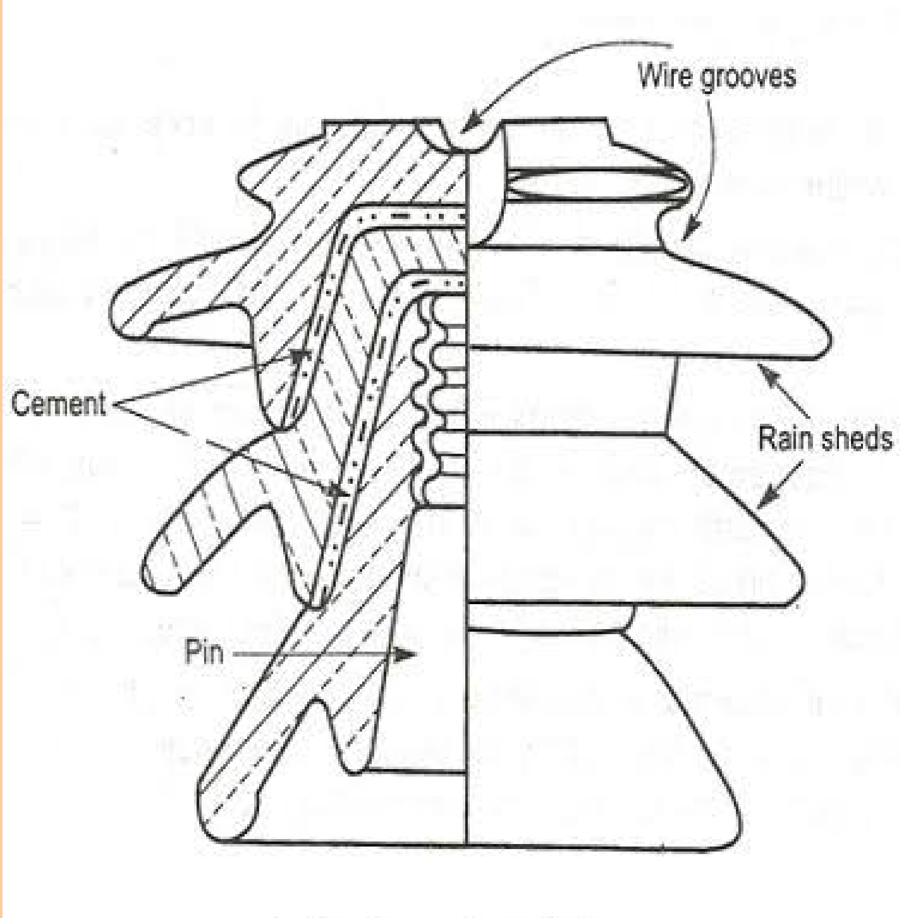
1. Dead man method
2. Derrick pole method

Insulator:- The overhead line conductors are supported by mean of insulating fixtures called the **insulators.** The insulator are made up of porcelain,glass or steatite.

Types:-

a. Pin type insulator
b. Shackle type insulator
c. Suspension type insulator
d. Egg type insulator

Pin type insulator:- used for 33kv line. These are economical simple and easy to install. These type of insulator carry the conductors at the top.



Pin-type insulator

Shackle type insulator:- used for low voltage distribution lines. These are used at the starting and last end poles or turning end poles.

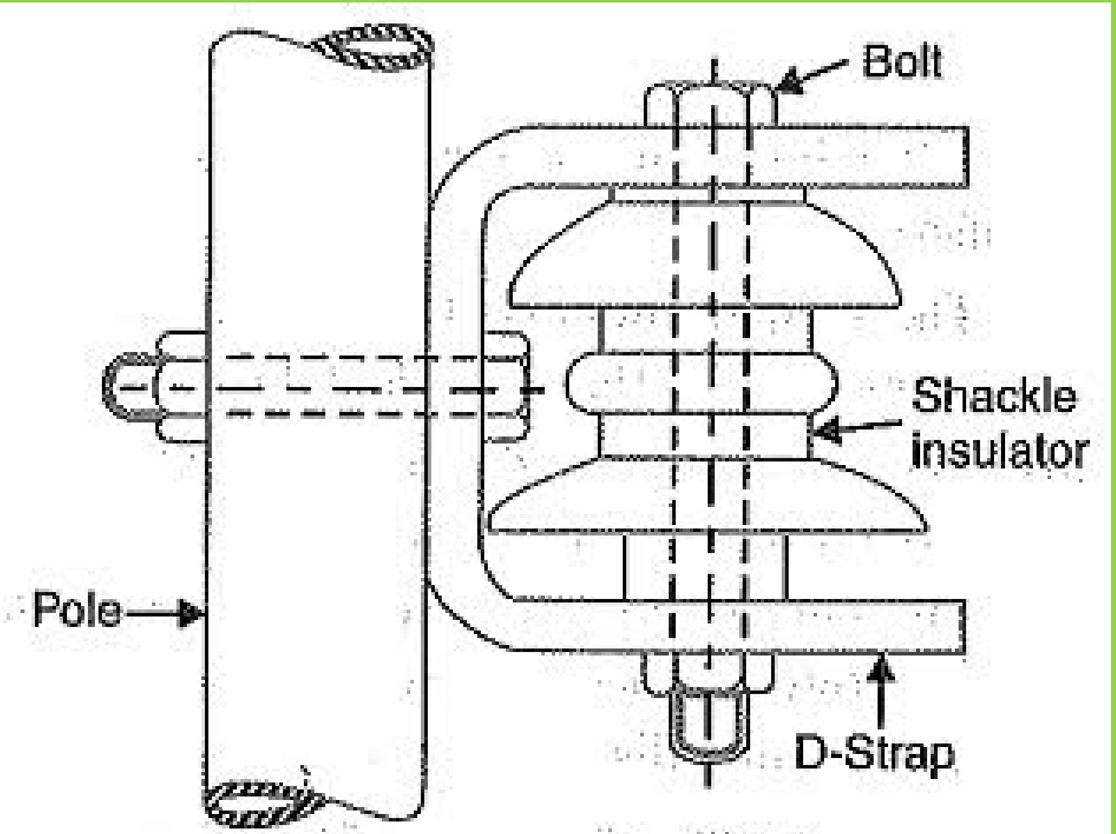
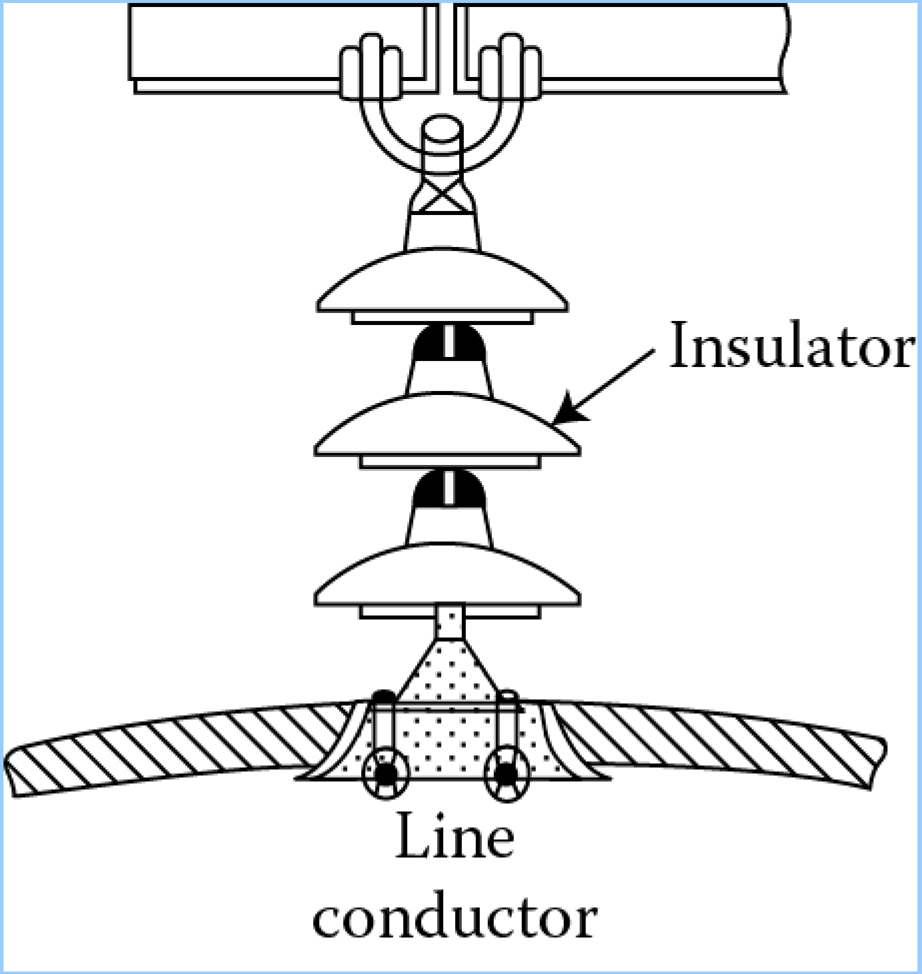


Fig. 8.9

Suspension type insulator:- It is used for high voltage transmission. This insulator consist a number of similar disc sus-pended from the tower amd hold the conductors at bottom.



Egg type insulator:- It is used for support the pole. These insulators provide the insulation between between pole and lower parrt of stay wire for the safety of people and animal on the ground. These provide at a height of about 3m from the ground level.

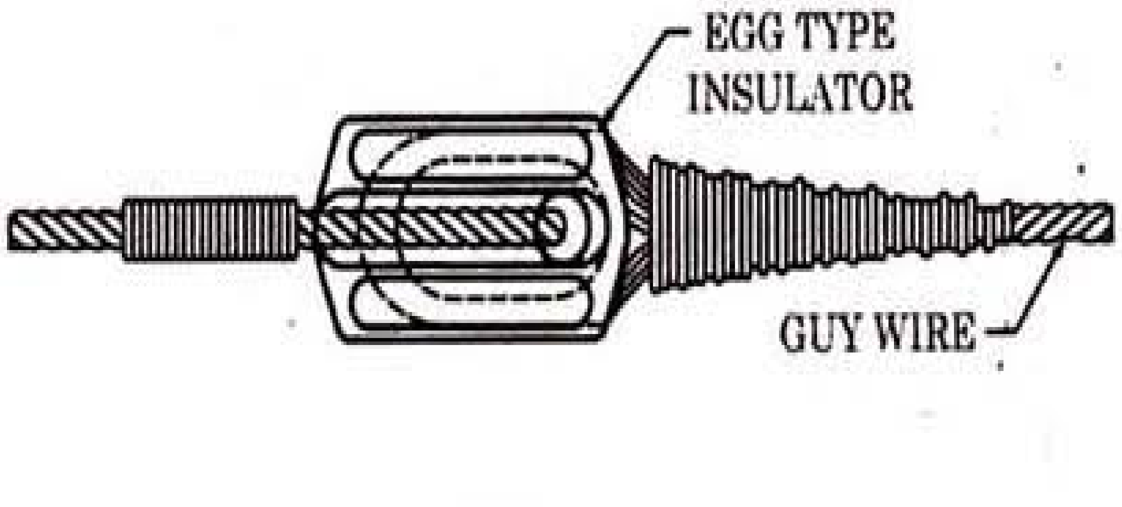
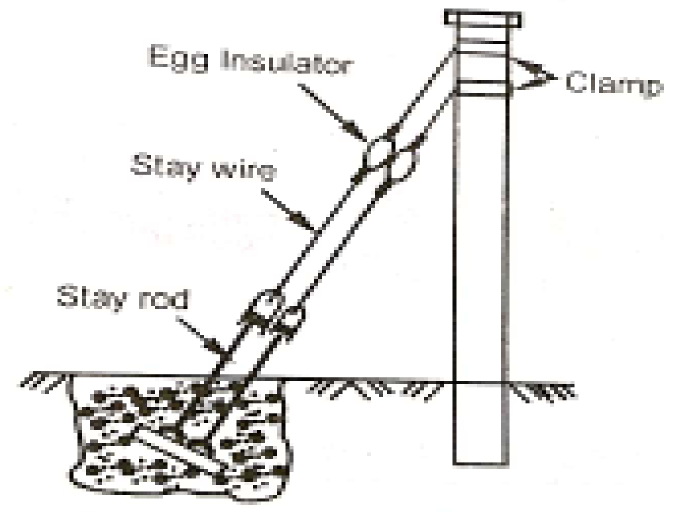


Fig. 9.14

Cross-arms:- Cross arm are used to support on the poles. These are made of eíther wóód or iron. These are fixed at the top portion of the pole.

Stay wire and guy wire:- It is necessary to support overhead line pole when conductor run at angles and terminal position so that the pull or tesnsion created by conductors is balanced stay wire is also known as guy wire.



Single Stay Arrangement with no Space Available For Laying Stay Rod

Miscellaneous items

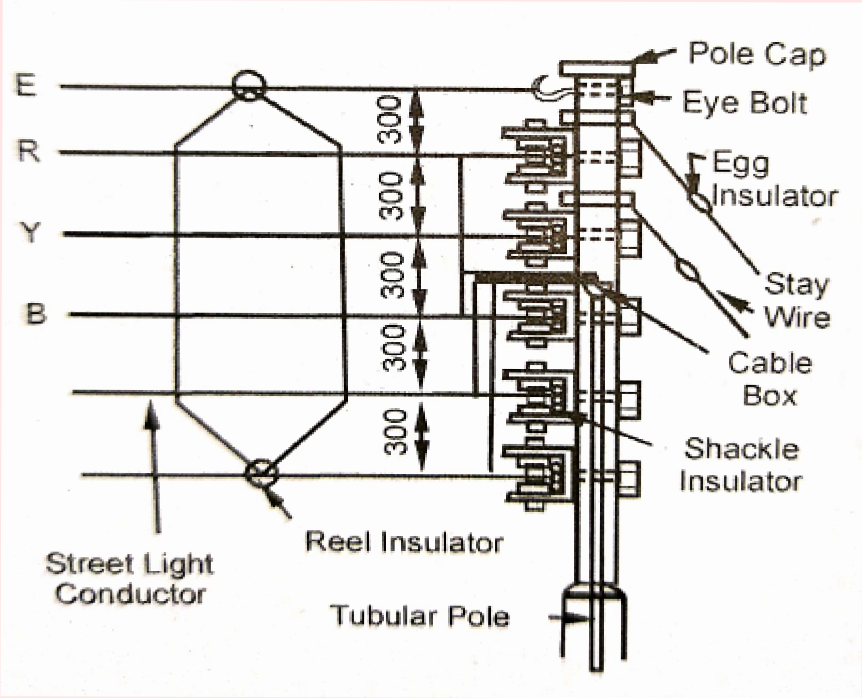
Lightning arrestors:- A lightning arrestors provide a path through air gap for electric current between electric circuit and the earth at the time of excessive voltage caused by lightning.

Guarding of over head lines:- I.E rules 87 and 88 provide important guidelines about guarding of overhead lines. Gurading is generally done to prevent the falling of live wire on the ground.

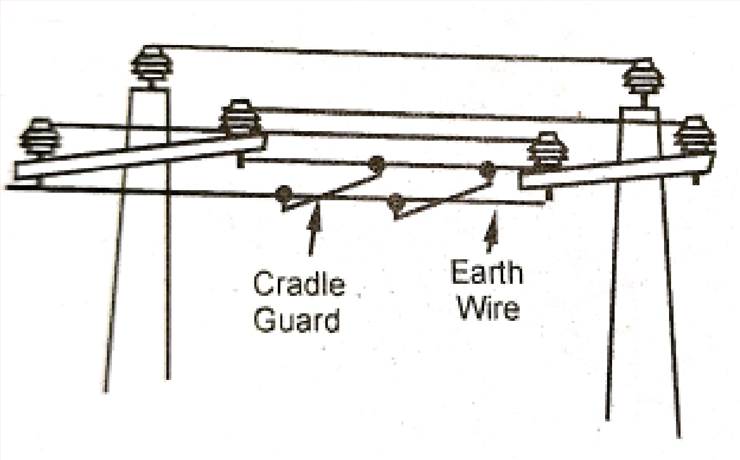
Types:-

1. Cage guarding
2. Cradle gurading
3. Bird guarding

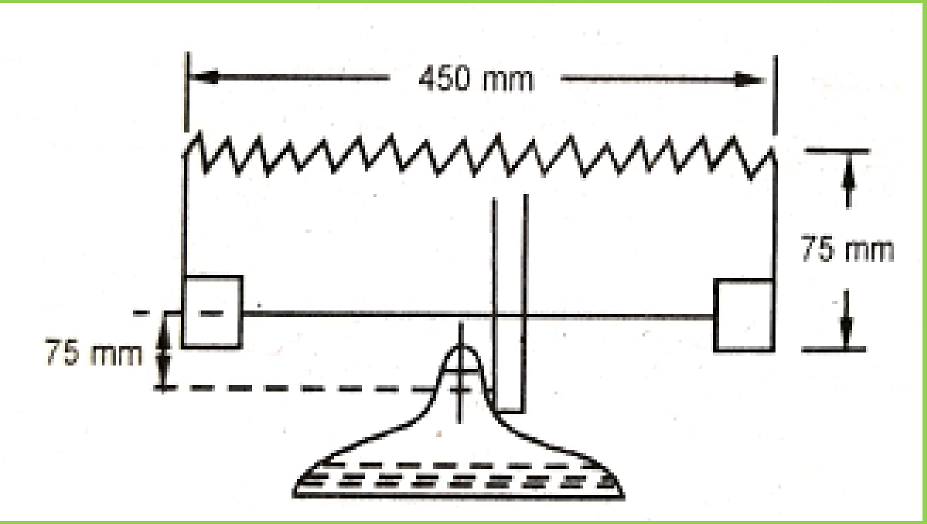
Cage gurading:- It provide on L.T lines when the conductors are in vertical configuration.



Cradle gurading:- it is provided when the conductors are in horizontal formation.

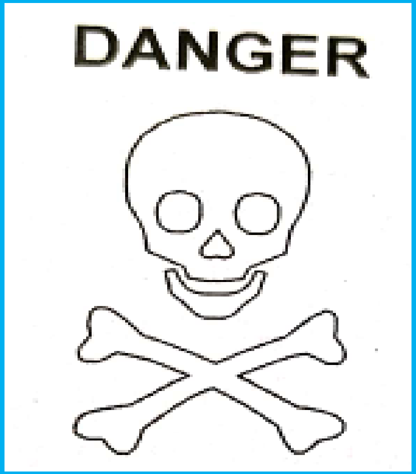


Bird guarding:- To prevent the fault condition caused due to the bird come in contact with the high tension line bird are fixed ovér the suspension isulator strings in the saw tooth form

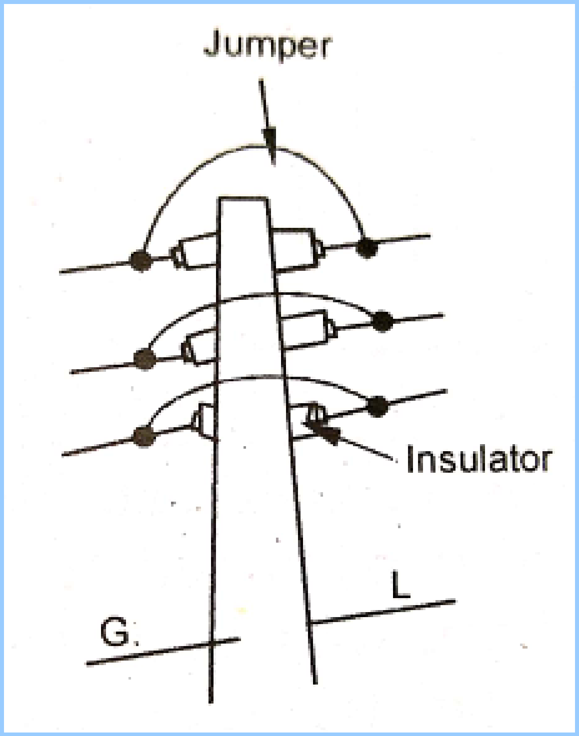


Anti-climbing device:- A wire which is wrapped on a pole at a height about 2.5m from the ground atleast 1m length is called barbed wire.

Danger plate:- Danger notice mean a notice attached ti live electrical apparatus calling attention to the danger of touching such apparatus.



Jumper:- A short length of conductor which is used to used to connect the line conductor on one side of the terminal pole to the line conductor on the other side of the pole is known as jumper. It is made of the same materialas of the same material as of the line conductor. A suitable clamp is needed to fire



the jumper to the line conductor.

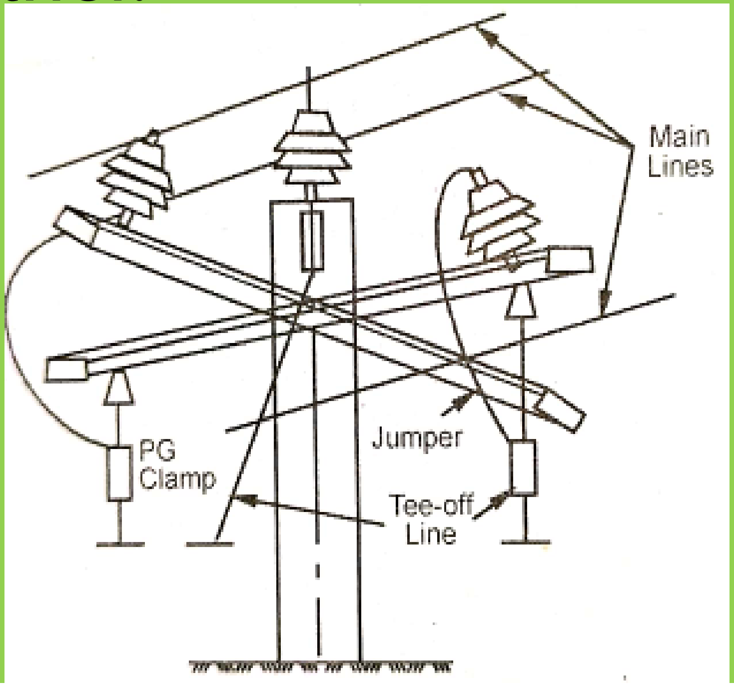
Tee-off:- Tee off should be taken from the pole not from the centre of the line. It should be done in same manner as in case of jumpers. Tee off for two different conducotrs that is one for main line and other for tee off line should not be done directly a special connector such as tee connectors.

Types of tee arrangement:-

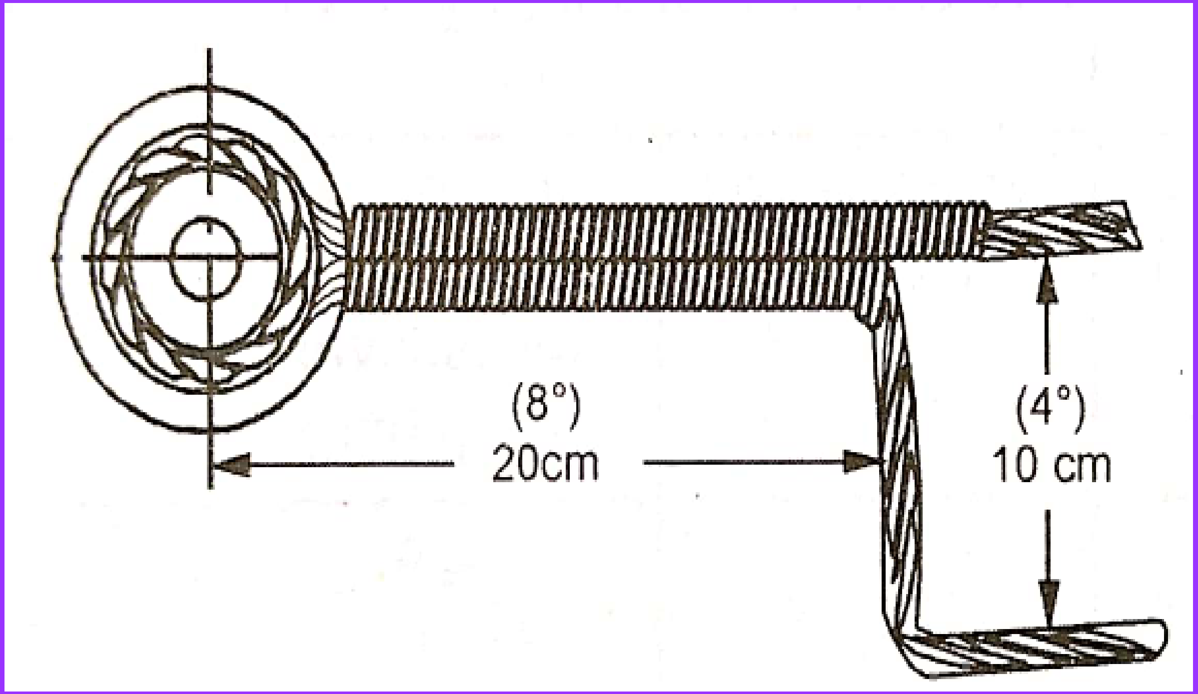
Single pole tee arrangement

H- pole tee arrangement

Parallel grove clamp:- A clamp or connectors which is used for the purpose of connecting of two or more conductors of similar material and whose axes are parallel of each other.



Dead end:- During distribution and transmission systemthe situation comes when conductors are required to he dead ended at several cases specially at places where line takes a turn and line conductor terminates.



Right of way

The land require for AC transmission line is called right of way.

Pole line

It require 7.5m to 15m in single ckt. In pole line

It require 9m to 22.5m in double ckt in pole line

Tower line

It requires 9m to 18m in single ckt in tower line

It requires 12m to 22.5m in double ckt in tower line

Size of conductors:-

The different material such as copper aluminium are used to carry the current from one place to to another place is called conductors.

Factor on conductor size depend:-

- Minimum size of conductors
- Current carrying capacity
- Voltage drop

Strength of material

Spacing and configuration:-

Conductors spacing:- spacing between the conductors should be reasonable.

Spacing should be neither be large and nor be less.

$$\text{Spacing} = \sqrt{S} + V/150 \text{ m}$$

S- sag in meter

V- line voltage in kv

Conductors configuration:-

The meaning of conductor configuration is an arrangement of the conductors on line suppport. It is based on nber of the conductors to supported. It os commonly used three types:-

a. Horizontal configuration
b. Vertical configuration
c. Triangular configuration

Clearance of conductor

Ground and lowest conductor rule 77 of I.E 78,79.

- **Repairing and jointing of sleeve**

Repairing:-

As we know that the ACSR are conductors are generally used for transmitting the electrical energy from generating station to substation due to passage of time or other atmospheric condition surface of these conductor may damage is causing aluminium strands broken or damaged badly. when damage of this conductors are less than repair sleeves may be employed for repairing of a ACSR conductor but when this damage is more than it is better to cut the conductor and join it with the help of jointing sleeve.

Jointing:-

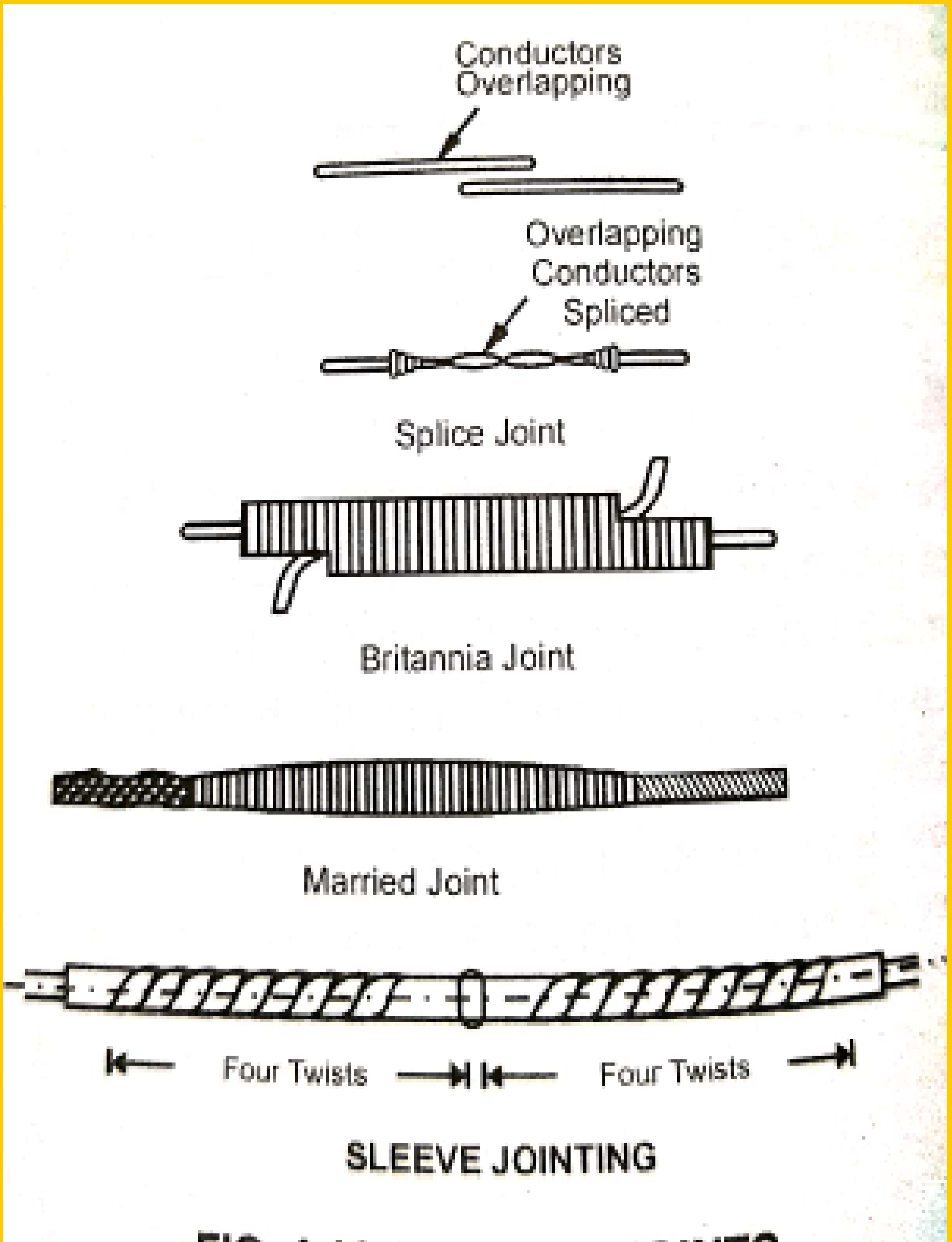
It is not possible to use single length of conductor for full length of transmission and distribution line therefore jointing of conductor essential.

A good joint should have the following qualities:-

- It should have some conductivity as as of conductor used
- Joint must be able to withstand maximum for current without failure
- Mechanical strength should not be less than 95% of breaking load of the conductor
- It should have a trouble-free long life it should be simple indesign

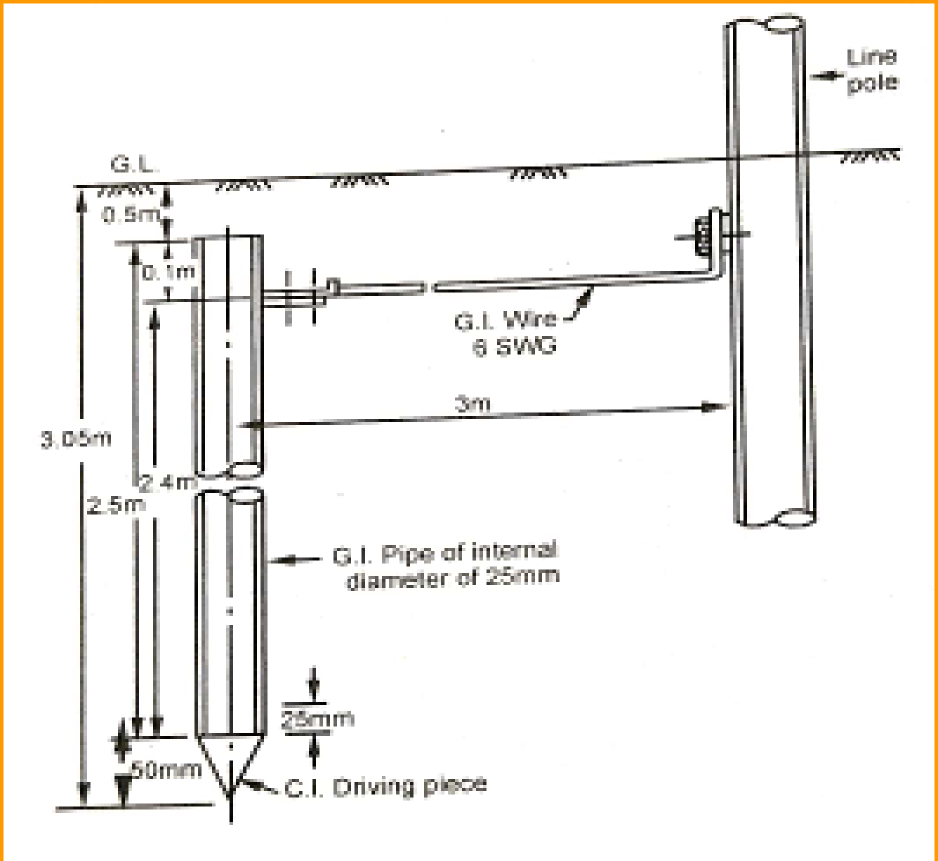
Types of joints:-

a. Splice joint
b. Britannia joints
c. Married joint
d. Sleeve joints
e. Compression joint



Earth wire:-

A wire made of galvanized steel used to connect the non current carrying metal parts used in transmission and distribution line to the general mass of earth is known as earth wire. The size of earth wire for distribution line is G.I no. 6 swg.



Service line or connection:-

The overhead line or cable connection taken from the nearest pole of the line to the consumer premises called service line. The voltage is step down from 11KV to 440 volt in service line by using transformer service line is the last line of transmission and distribution system of electrical power from generation to consumer premises.

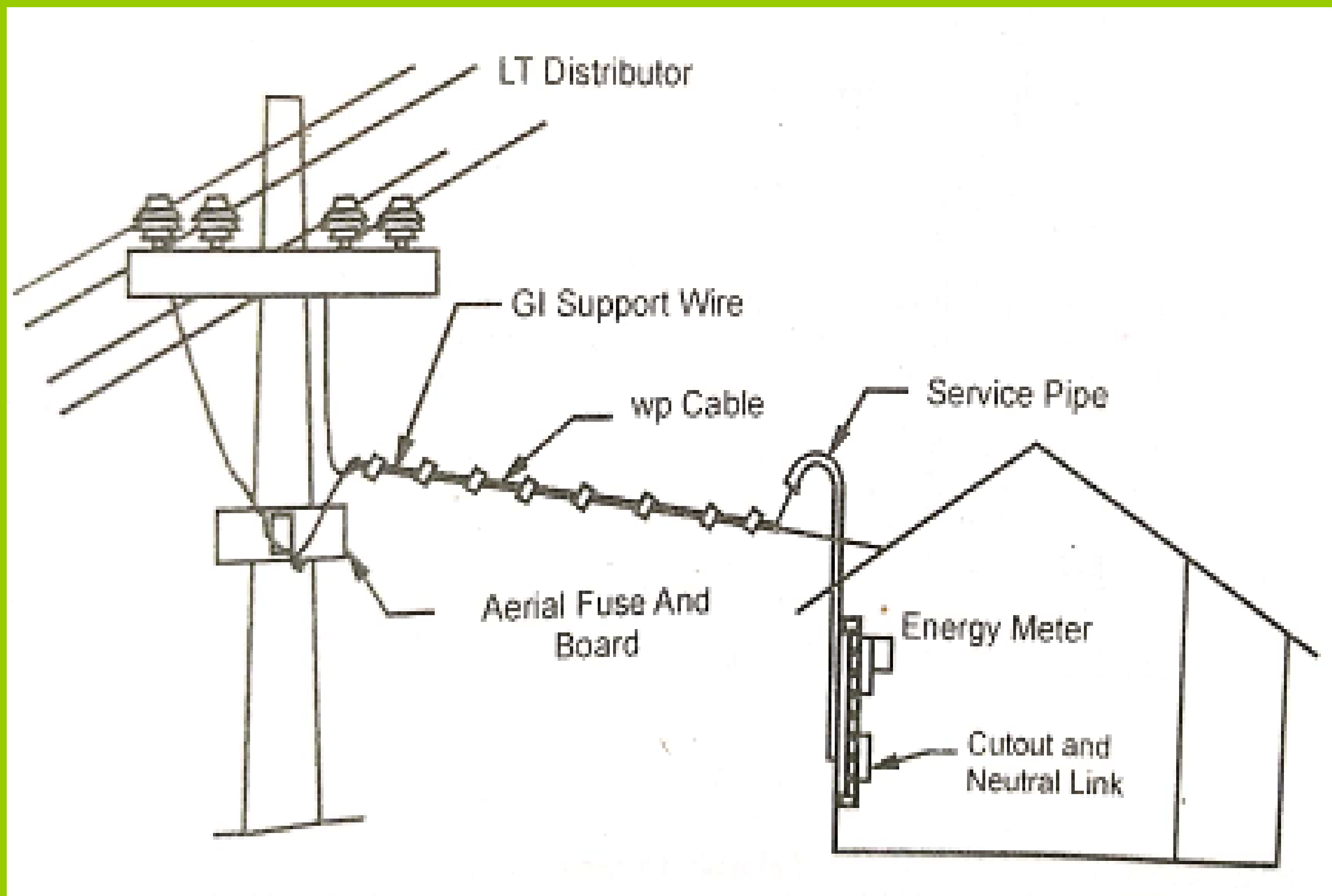
Service board:- The board on which cutout neutral link and energy metre are installed is called energy board of service board.

Types of laying service line:-

Overhead service connection

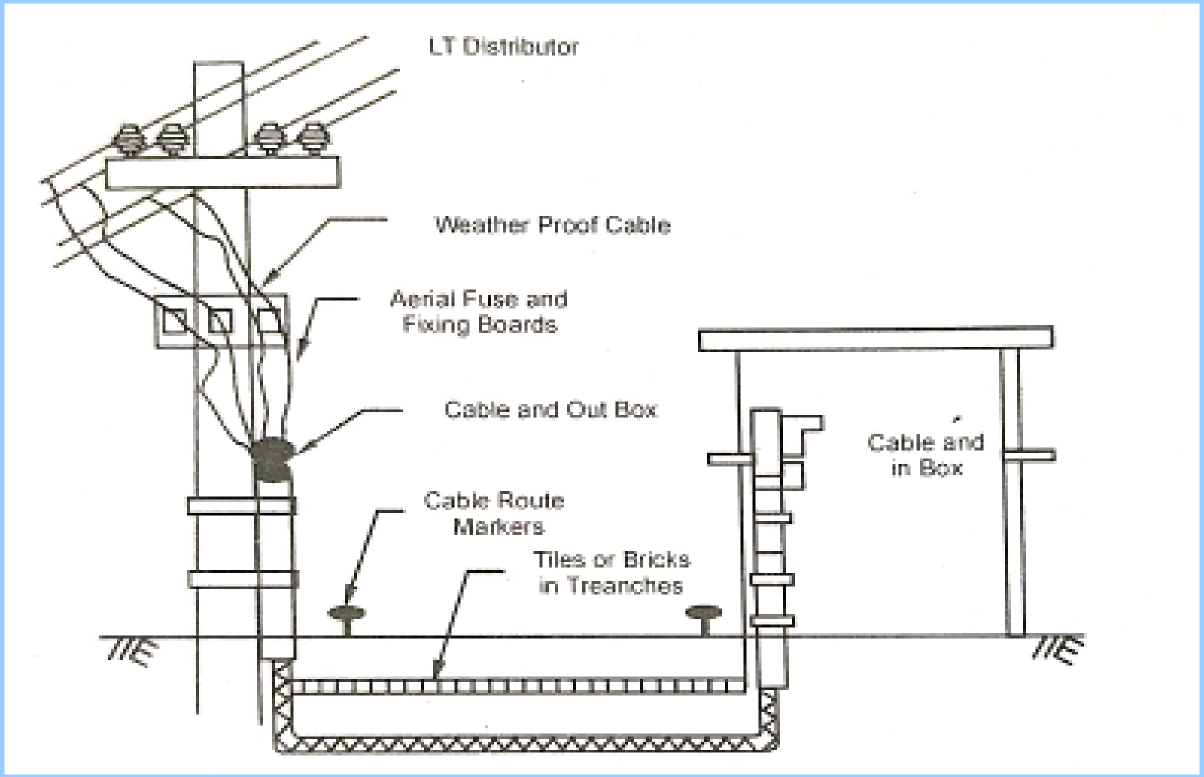
Underground service connection

Overhead service lines:- I.E rules number 58 77 and 79 must be regulated while laying of the overhead service connection.



Underground service connection:-

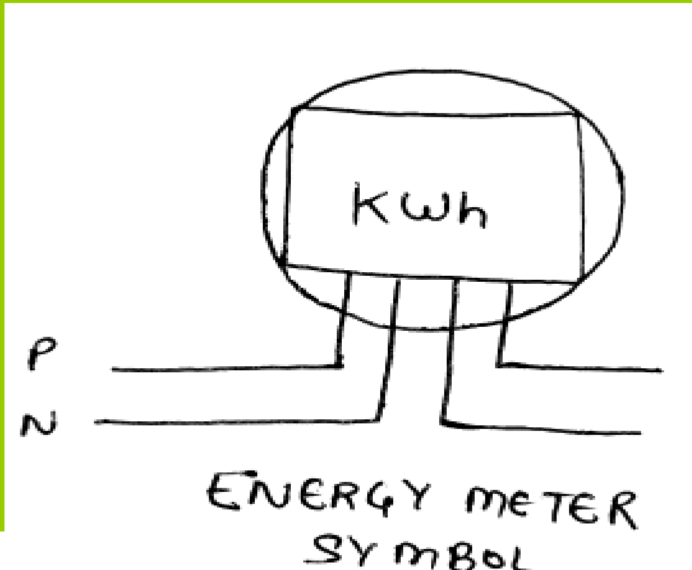
For background service connection cable box is fixed at the service pole by mild steel channel of size 16mm*25mm with bolts and nuts. 0this cable is carried from cable box of the cable box fitted on the service board.



Installation of energy meter:-

Energy:- It may be defined as work or dissipation of heat over an interval of time.

Energy meter:- Energy meter are the integrating instrument used for measurement of energy consumed in a circuit over a given interval of time. The energy metre is a selected as per load of the consumer etc. energy metre install on wooden board and these wooden boards are fixed on the wall at suitable height from the ground. Energy metre should be installed in the consumer premises and the next to the cutouts if used in service line.



Laying of underground cables:-

Cable:- A single conductor insulated through its full length is called cable.

Underground cable:- Two or more conductor is provided with its installation and laid up together under one out a protective covering is known as underground cable.

Core:- A single core cable has one conductor and three phase cable has three conductor core in a conductor.

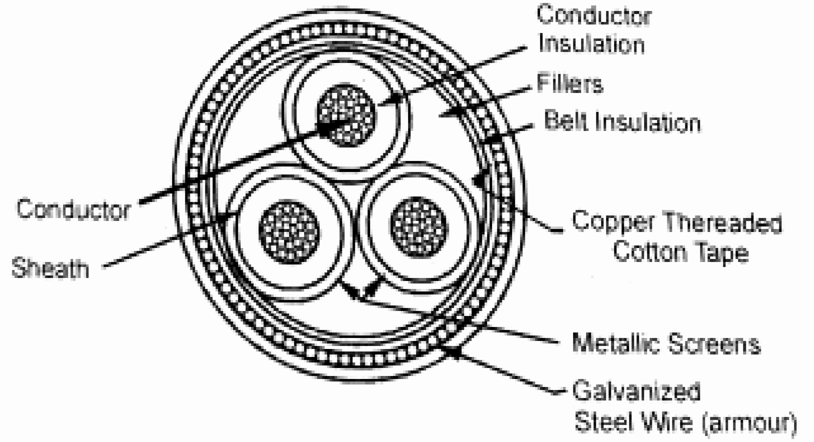


FIG. 4.22 THREE-CORE CABLE

Sheath:- Metallic aur non metallic protective covering over the conductor insulation and shield extra it is called as a jacket or covering.

Insulation:- Each conductor or core is covered by an insulation.

Armour:- Outer most protective layer for protection against soils,chemical,moisture and water extra.

Advantage of underground system:-

- It has a long life
- underground system installed in uninterrupted continuity of supply
- Require less maintenance
- 8 altimate hazards of electrocution due to breakage of overhead conductor
- Appearance in overhead system is not pleasant.

Classification of cables:-

Cables are classified on the basis of voltage:

Low tension cable - voltage upto 1000v

High tension cable - voltage rating 1000v to 11000v

Super tension cable - voltage upto 33kv

Extra high tension cable- voltage upto 66kv

Oil filled cables and gas filled
pressurized cables - voltage upto 132kv

Extra super tension cable - beyond voltage rating 132kv

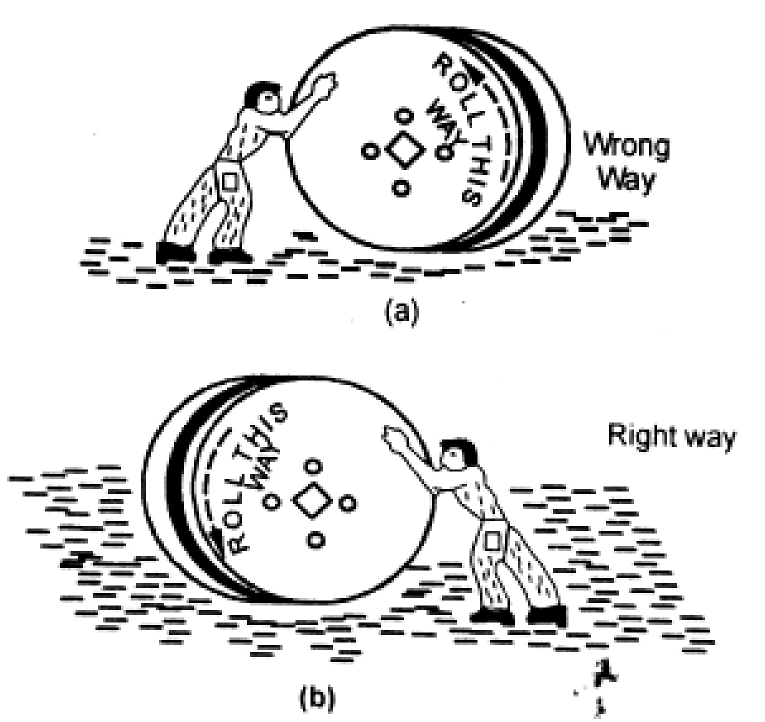
Control cable:- These conduct the low power of a few tens of a V.A. These cables are used for control measurement,monitoring,communication, protective, and electronic circuits.

According to types of insulation

- Paper insulated cable
- Poly vinyl chloride
- Polyethylene cable
- Poly tera ethylene cable
- Cross linked poly ethylene cable

Inspection of the cable:-

Before installation of the cables these should be inspected. Cables are generally available and solds in cable drums with several rounds of cable wound over it. The standard length of the cable are 250m, 500m,750m,1000m After receiving the cable drums at site cable packing should be checked for any damages to the drum.



Handling of cables:-

- Tools which are used for opening the cable drum must operate with at most care and ensure that tools does not damage the cables
- Check the arrow on cable drum for directions of rotation
- Check the continuity of the cable

Transportation of cable:-

Special truck are used to carrying the cable drums

Should be tied with the ropes ti avoid free falling during loading and unloading of cable drums.

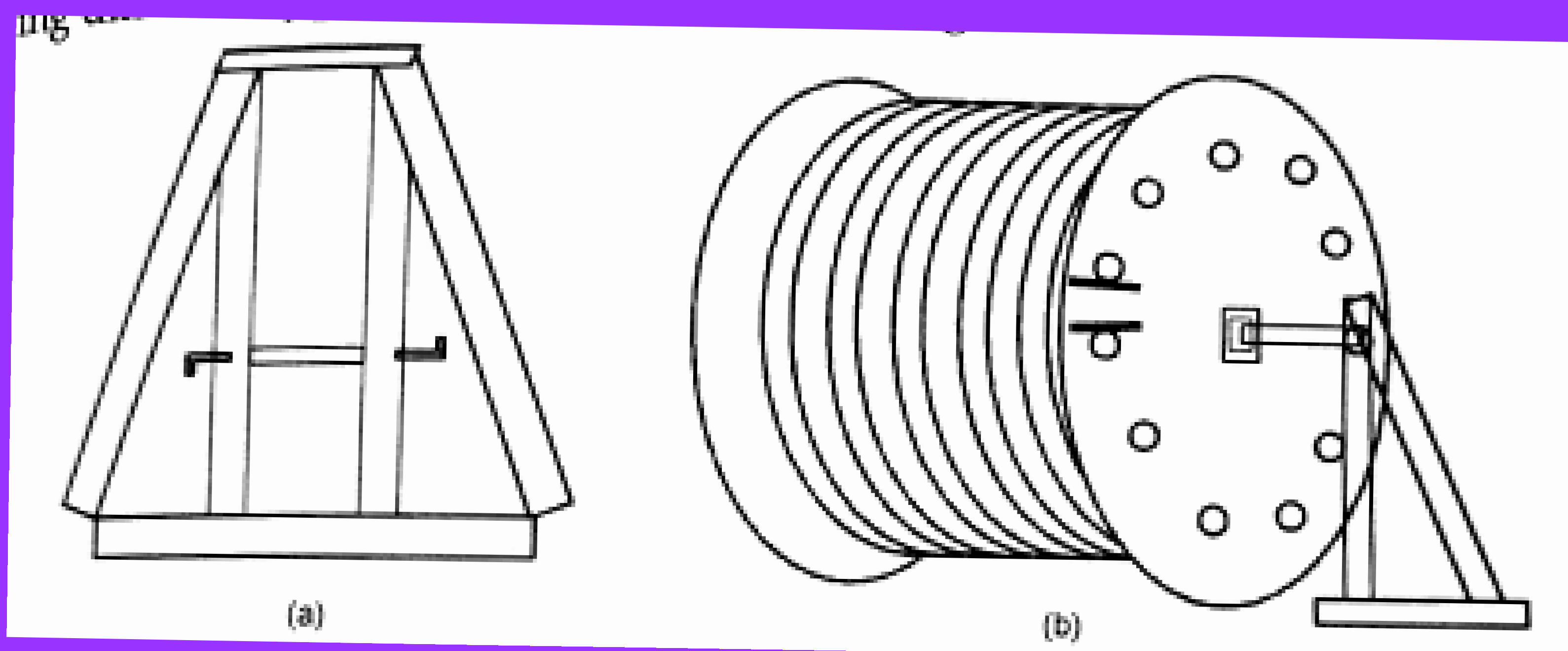
Storage of cable:- Cable drum should be stored at a place where free circulation of hair take place between them. Cable drum should be placed on smooth ground this will help in easily movement of cable drum. in damp situations it is a advisable to allow at least three inches gap between table drums for circulation of air.

Planning the route for cable laying:-

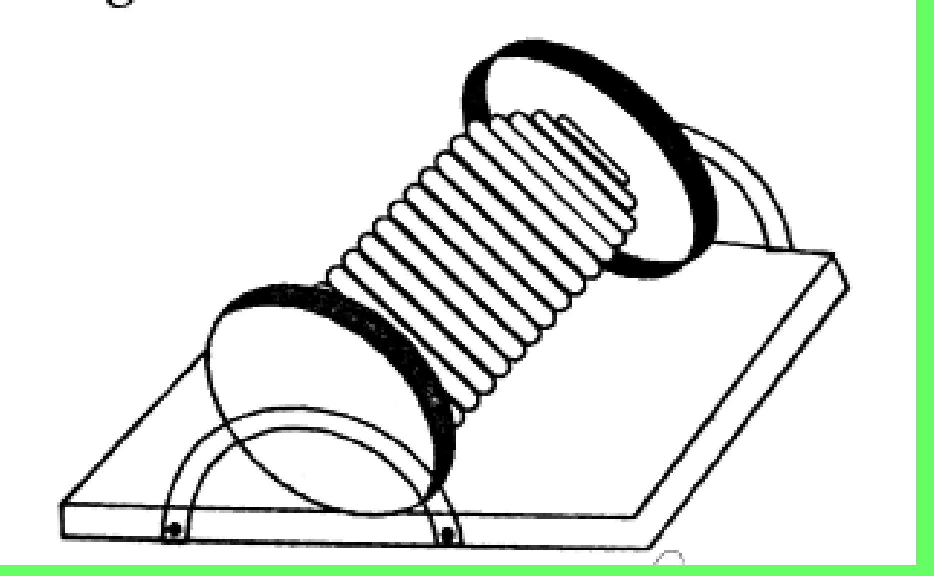
- Firstly survey of root of cable should be carried out
- The road should be shortest if applicable with minimum bends.
- While selecting the cable route corrosive soil and ground surrounding Sewer influent cell be avoided if it is not feasible then special precautions I'll be taken.
- Present and future condition shall be taken while deciding the future of cable such as cable route should not affect widening of roads etc.
- where cable cross is one another the higher voltage rating shall be placed at lower as compared to lower voltage cable.

Cable handling equipment:-

Jack:- jaikara used to lift the cable draw above the ground so that cable drum could be rotated easily. It will be help in unbounding the cable from cable drum. Following different types of jacks are shown in figure below.



Rollers:- As the name suggest there are used in pulling the cable on ground otherwise cable may be damaged. Hanging type rollers are used when cable to be installed at any height above ground level.



Winches:- These type of equipment help in loading and unloading of cable drum from truck extra

Cable laying depth and clearance:-

As per ISI specification of following depth from the ground level as under

Upto 11000v working voltage- 0.45+ radius of cable

3.3kv to 11kv voltage- 0.75+radius of cable

22kv to 33kv voltage- 1.0m+ radius of cable

Excavation of Trenches:-

The trenches are dug by any suitable means that is manual or mechanical along the the mark route. before starting the excarvation over the route should be properly check by other ground service department.

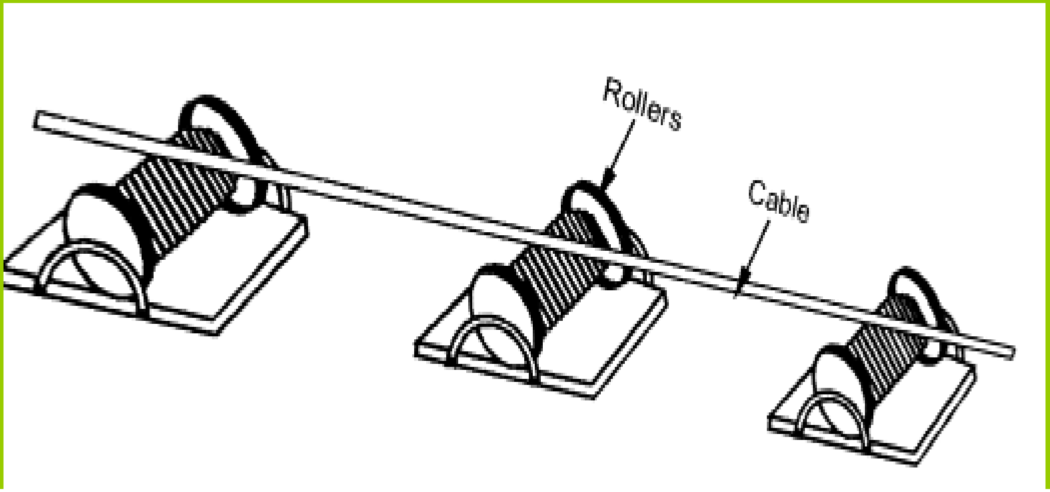
The bottom of trench is levelled. over the lavelled bottom of trenches a thickness of 8 centimetre of sand is prepared.

Method of laying of cable

There are two method of laying of cable

Direct cable laying method:-

There are various method of laying the table but direct laying method is more common. Material required such a cement bricks sand brought to the site. After this trenches are dug about 1.2 metre deep and 0.5 metre wide. A layer of sand is filled over the bottom of trench. The bottom of trenches should be leveled free from sharp objects stone and bricks bats extra. This method of laying the cable is simple clean and cheap point This provide better condition for heat dissipation point.



Back filling of Trenches:-

- The roller are removed from their position by lifting the cable to small height.
- In Trenches cable to be covered with dense layer of sand and then a layer of bricks. After this trench is filled with earth. to provide extra protection to cable brakes can be put on both side of cable.

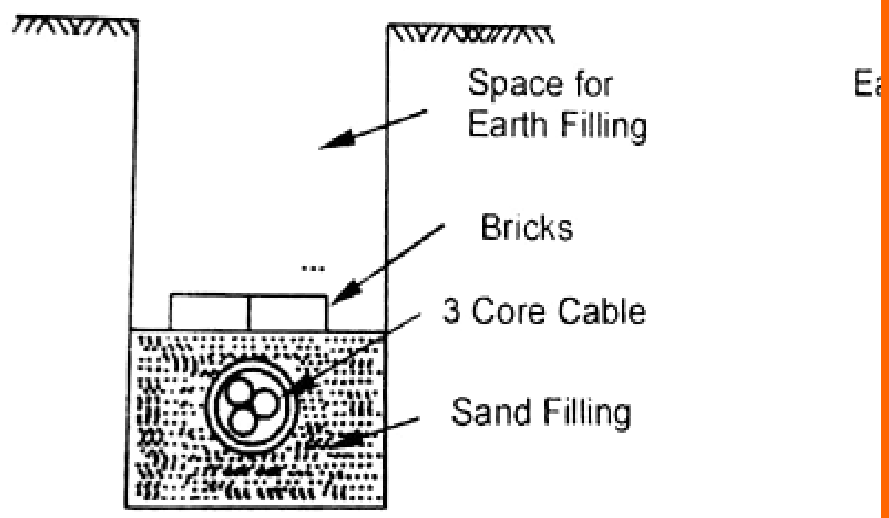


FIG. 4.27(a) BACK FILLING OF TRENCHES

Draw-in system:-

The system is employed where excavation is expensive and inconvenient. In this method of laying of underground cable line of conduit ducks made of iron or cement concrete ducks are laid in trenches side by side. the cables are pulled from manholes up to the duct by mean of strong ropes. The depth of trench should be such that top pipe remains at least 60 centimetre below ground level and width of trench depend upon number of pipe.

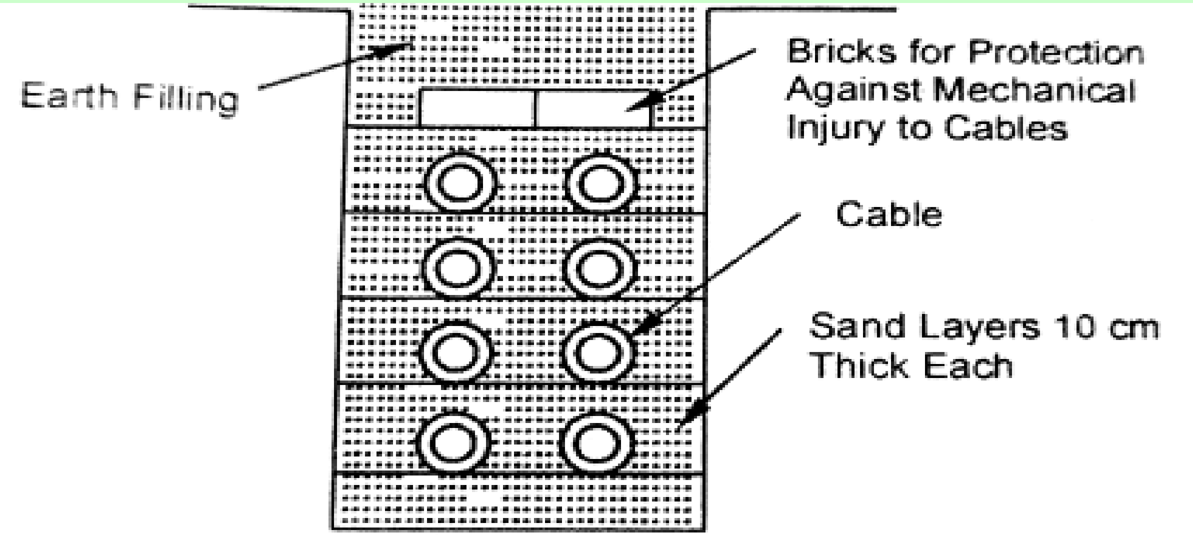
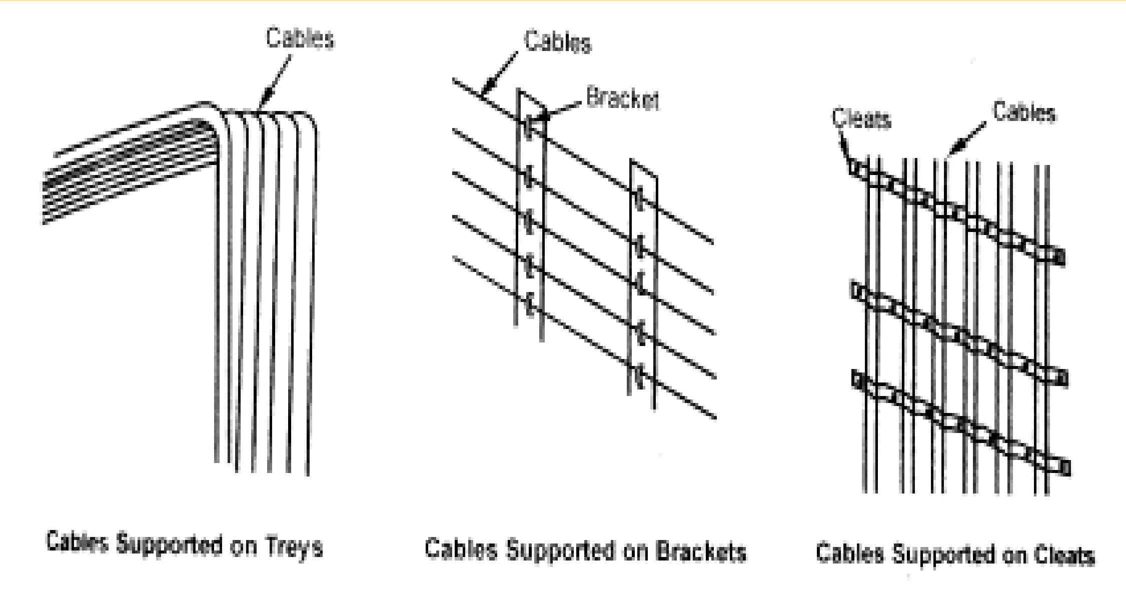


FIG. 4.27(b) DRAW-IN SYSTEM

Manhole:- It is the underground chamber where pipe and ducts terminate and which is employed for pulling in cable through the ducts and joining chamber for cable coming in and going out from it

Cable laying on surface:-

the cable may be laid on surface in switching /substation factories overhead busbar etc. The cable shall be laid in trough on bracket of fixed with mild steel clamp such as that there is no under say in the cable.



Cable jointing and terminations:-

Jointing:- The connection of two length of cable by suitable method which provide a continuous path for flow of current is called jointing.

Termination:- It is applied to the end of conductor in such a way that is suitable for connection to the terminal to which is to be connected by the mechanical means.

before jointing or terminations of the cable it is necessary to discuss the following terms:-

Cable glands:- The table and day matter in closed control boxes of cable through the cable glands. Glands are made of brass and stainless steel. types of cable glands that is single compression gland and double compression glands.

Cable sealing box:- It is used to seal the cabke ends at the terminating point where wires are taking out.

Classification of cable joints are cable box for cable termination:-

i. **Classification based on application:** termination jointing between straight length
ii. **Classification based on material:** epoxy junction box cast iron jointing box and lead jointing box
iii. **Classification based on:** straight T-shaped X-shaped

Method of cable jointing

Before jointing the conductor of cables in cable boxes conductor are dressed manually if their conductor cross section is less than 25 mm square. cable jointing is done by the following method

For copper conductor

1. **Soldering**
2. **Compression**

For aluminium conductors

1. **Soldering**
2. **Welding**
3. **Riveting**
4. **Bolding**
5. **Compression**

Precaution in cable jointing

- cable jointing work should be carried out immediately without wastage of time after cutting the cable
- Cable jointing work should not be undertaken in rainy season
- There should not be any services before the soldering
- correct grade of insulating material and box compound amended by manufacture of cable jointing system should be used
- after armouring properly clean the earth continuity conductor should be bolted at right place.

Cable filling compounds:-

The cable filling compound should have following properties:-

a. It should have a good adhesive property.
b. It should have high flash point that is 250 degree Celsius
c. Softening point should be high
d. It should not crack on cooling
e. It should have long travel free life

Testing and commissioning of cables

- Routine test
- Type test
- Special test

Routine test: These test are:-

- Conductor resistance test
- Insulation resistance test
- Power frequency (A.C.)high voltage test
- Partial discharge test
- Die electrical power factor

Types and special test

- Bending test
- Dielectric test
- Impulse withstand test
- Fire resistance test
- Insulation and sheath thickness test etc.

Commissioning:- after installation of cable at site 1 emission test are conducted on newly cables before energizing it.

a. Insulation resistance are major between conductor and earth. DC insulation resistance is measured by meggar

b. check that cable terminated inside a panel should have a cable glands.

Causes of failure of cables

- Mechanical failure
- Chemical causes
- Darkness aur moisture causes
- Overheating
- Insulation failure

Types of cable fault:-

Three types of cable fault:-

1. Ground fault
2. Earth fault
3. Open circuit fault
4. Short circuit fault

Ground fault:- when installation of cable breakdown then current start flowing from core to earth

Earth fault:- this type of fault taken place when conductor is broken of cable joint is open is known as open circuit fault

Short circuit fault:- when insulator between cores of the cable is damage then current flows from one pole to another pole.

Method of locating of fault:-

1. Ground or earth fault:- When installation of cable breakdown then current starts flowing from core to earth such for are called ground or earth fault.
2. Murray loop test:- this test is very common in this test a sound cable run along the faulty cable. wheatstone bridge principle are used for performing murray loop test. Short circuit and earth fault is used in this method.
3. Fall of potential test.

Precaution while working on cable and capacitor banks:-

1. A permit to work to be obtained before starting the work
2. Before any work on cable or capacitor is started it should be made that discharge and earth
3. After completion of work on cable is should be properly tag
4. In case star connected Bank of capacitor neutral point should be earth and before carrying out the work

Elementary idea regarding, inspection and handling of transformers

Sub-station:- It is an assembly of apparatus or equipment which transform the electrical energy from one voltage level to another voltage level substation are the most important part of power system.

Necessity of substation:-

- The generating station are for away from the load centres
- The generation of power from generating station must be discharged to the load centre
- The generation voltage is low it is step up and transmitted through lines to sub station located at load centre

Classification of substation

1. **Classification on the basis of nature of duties**

Step up substation or primary substation

Primary grid substation

Step down or distribution substation

2. **Classification on the basis of voltage**

High voltage substation i.e voltage between 11KV and 66kv

Extra high voltage substation i.e. voltage between 132 KV and 400 KV

Ultra high voltage i.e voltage above 400 KV.

3. Classification on the basis of importance

Grid substation

Town substation

4. Classification on the basis of design

Indoor type substation

Outdoor type substation:- outdoor type substation are further two types.

Pole mounted substation

Foundation mounted substation

Pole mounted substation

Pole mounted substation are erected for mounting distribution transformer of capacity upto 250 kilovolt ampere. Such substations are cheaper simple and smallest of sub station. All the equipments is of outdoor type and mounted on the supporting structure of high tension distribution line. Triple pole mechanically operated (TPMO) which is used for switching on and off high tension transmission line. HT fuse unit is installed for protection of high tension side. To control low tension side of ironclad low tension switch of suitable with fuse installed. Lightning arrester are installed over the high tension line to protect the transformer from the surges.

Diagram:-

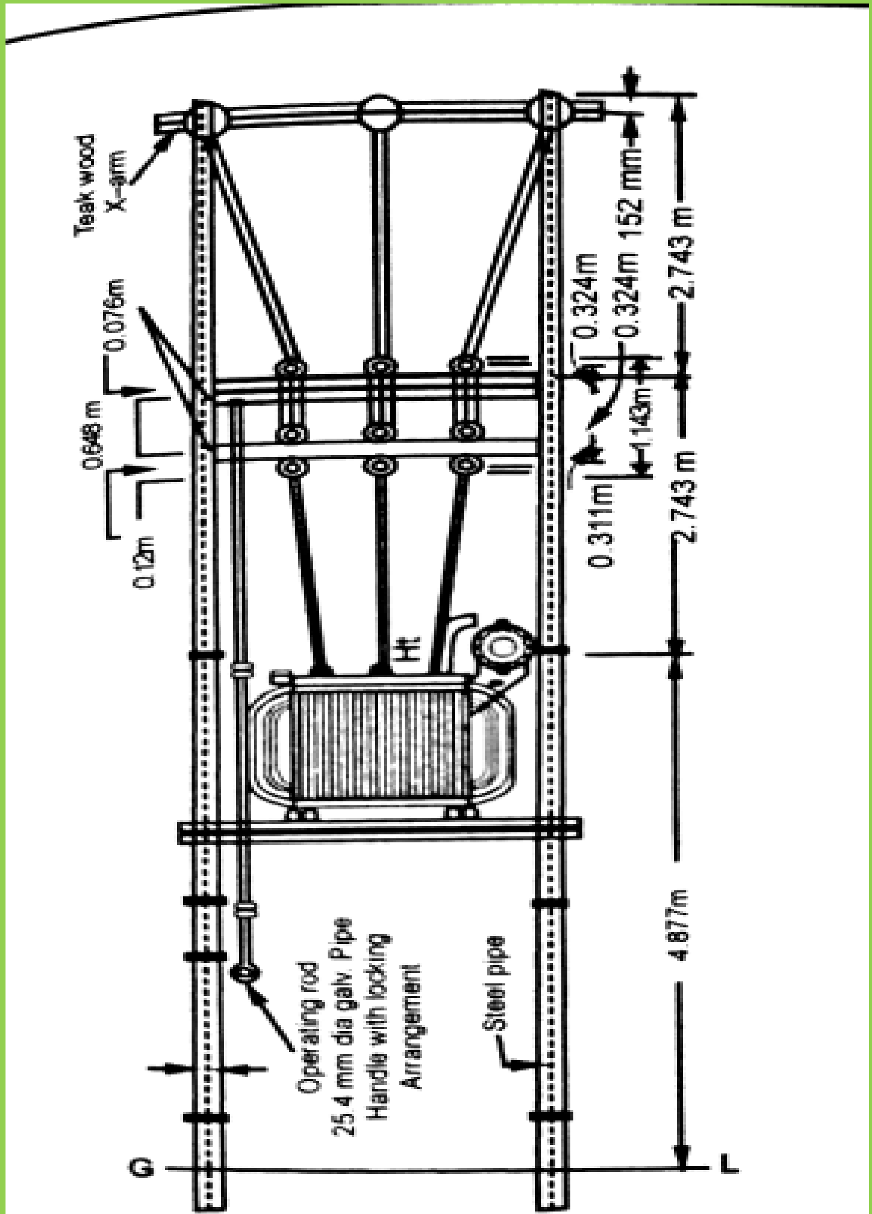


FIG. 4.33 (a) 200 kVA POLE-MOUNTED SUB-STATION

Land required for substation

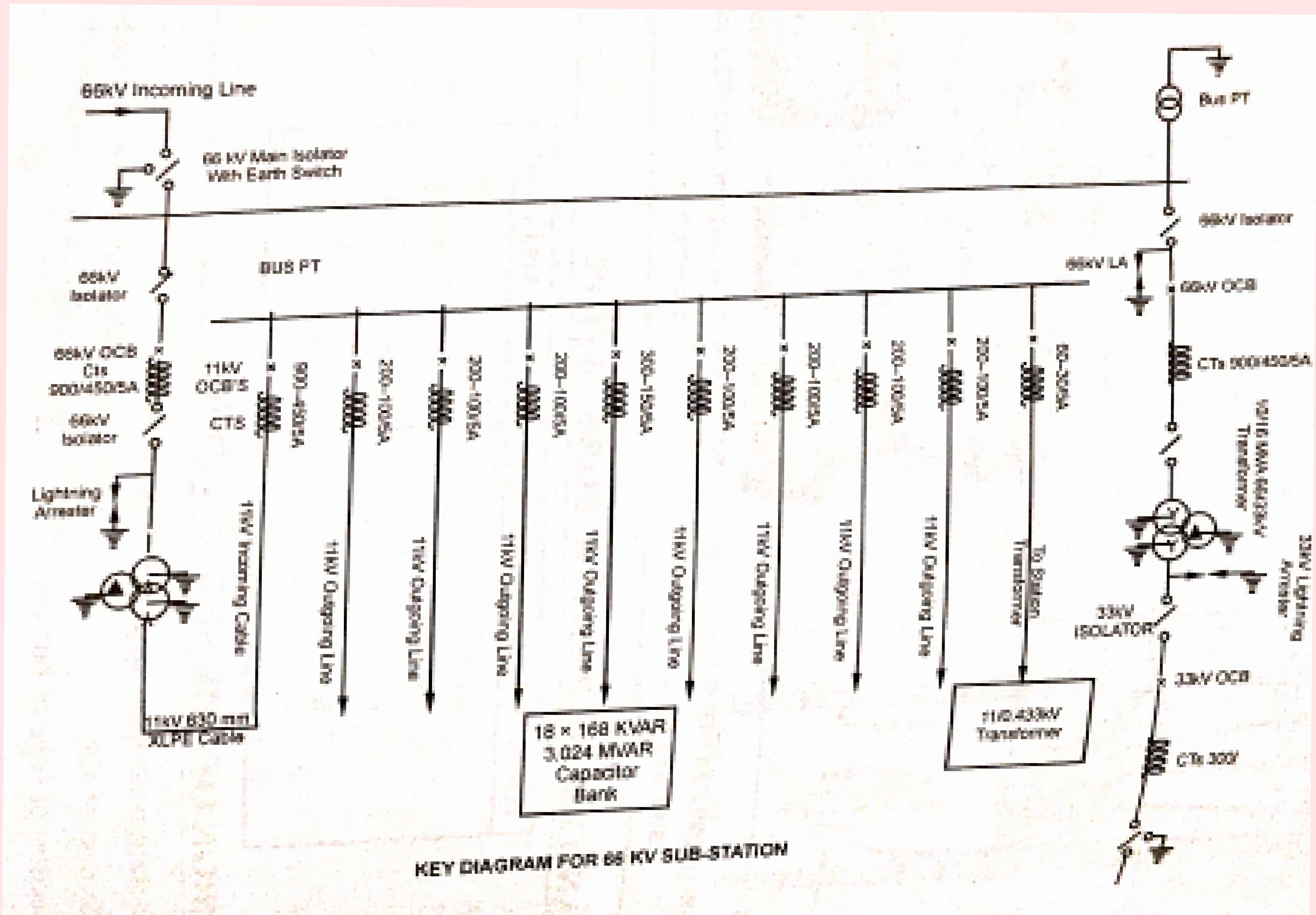
Type of sub-station(kv)	Area in acre
400kv	35-40
220kv	12-16
132kv	6-8
66kv	2-4
33kv	1-2

Design of the substation:-

I. Selection of site
II. Selection of switching scheme
III. Selection of type of busbar
IV. Design of bays width
V. clearance between phase to phase, phase 2toground, phase to earth for isolator.
VI. Design of earth mat
VII. Ground clearance
VIII. Main electrical equipment
IX. Design of layout
X. Auxiliary supplies
XI. Civil and electrical work

Key diagram:-

Key diagram of 66kv station

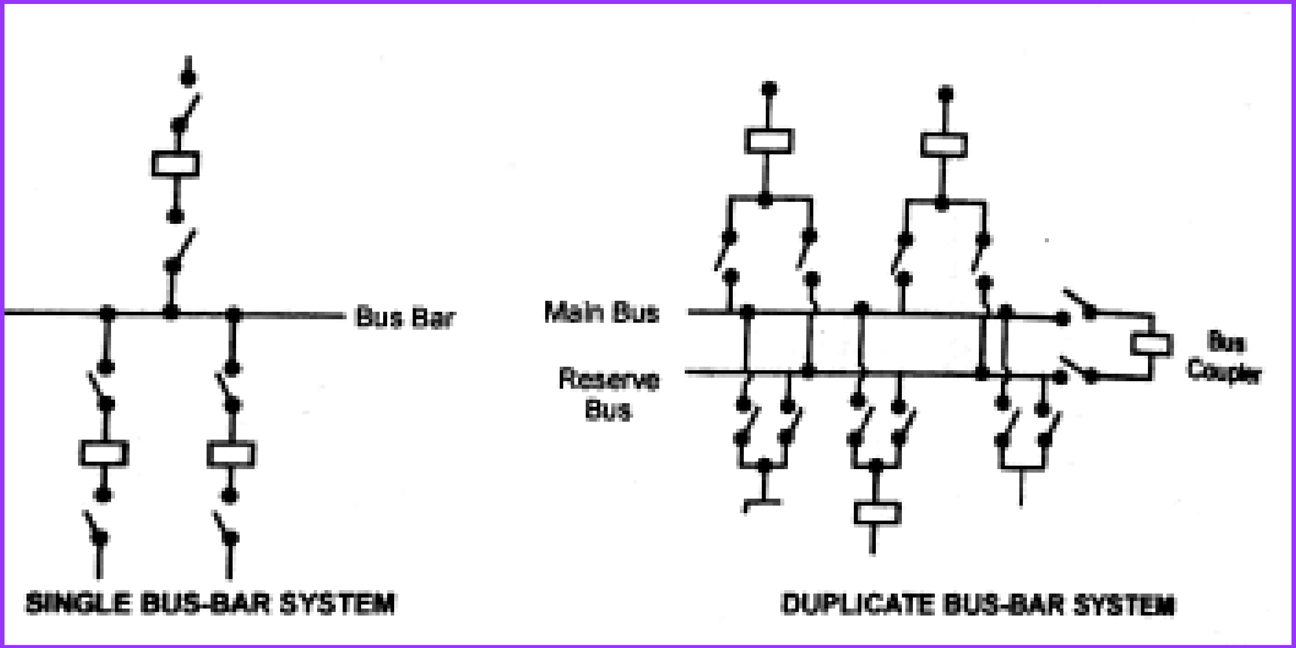


Grid substation:-

These are they substations from where bulk power is transmitted from one place to another place in the grid. These are important because any disturbance in the substation may result in failure of grid.

Bus-bars:- Copper aur aluminium conductor bar aur flats to which various incoming and outgoing circuit are connected known as busbar or simply a bus. bus bar receive power from incoming circuit and delivers power to outgoing circuits. the bus bar used in substation are generally rectangular in cross sections. the bus bar can be indoor or outdoor tubular type or a ACSR or AAC. These are rated in in ampere 200A,400A,600A,800A,1600A etc. All rigid type busbar mounted on support insulator are coated with enamel paint of red yellow and blue colour to indicate different phases. in case of DC system postive busbar claret colour and negative busbar are blue in colour.

Diagram of Bus-bars



Isolator:- The switch operate under no load condition are called isolating switch.it provide isolation of a circuit for the purpose of maintenance.isolator are known as disconnecting switch. Isolator are interlocked with circuit breaker to prevent operation on load i.e circuit breaker cannot be closed until the isolator is closed and isolated cannot be open unless the circuit breaker is opened

Current and potential Transformer:-

Current Transformer:- CTs are used for stepping down alternating current from higher value to lower value for measurement protection and control purpose

Typical secondary current is 5 ampere RMS.

It is used to measure high current.

Potential Transformer:- PTs or VTs are used for stepping down AC voltage from higher value to lower value for measurement protection and control purpose.

Typically scandal voltage is 110 voltage RMS

the difference between power Transformer and instrument Transformer are mainly due to their rating. Power transformer have high KVA rating(500kva,1000kva upto 1000mva). instrument Transformer have rating of few tens of V.A, 30 VA etc

It is used to measure high voltage or EMF

Potential Transformer are also two types:-

Electromagnetic

Capacitor voltage transformer

Lightning arrestors: It is used in substation for protection of power system against the higher voltage surges it is connected between line and earth at the substation near the Transformer it is also known as surge arrester or surge diverter.

lightning protection is done by lightning arrester gap and overhead ground wire. Transmission line is protected from direct stroke by running a conducted known as ground wire over the tower and earth at regular interval at tower/ pole. substations and power our house are protected from direct stroke by earthing screen. The ground wire and earthing screen does not give protection against high voltage. so for this different protective devices are employed.

Diagram of lightning arrester

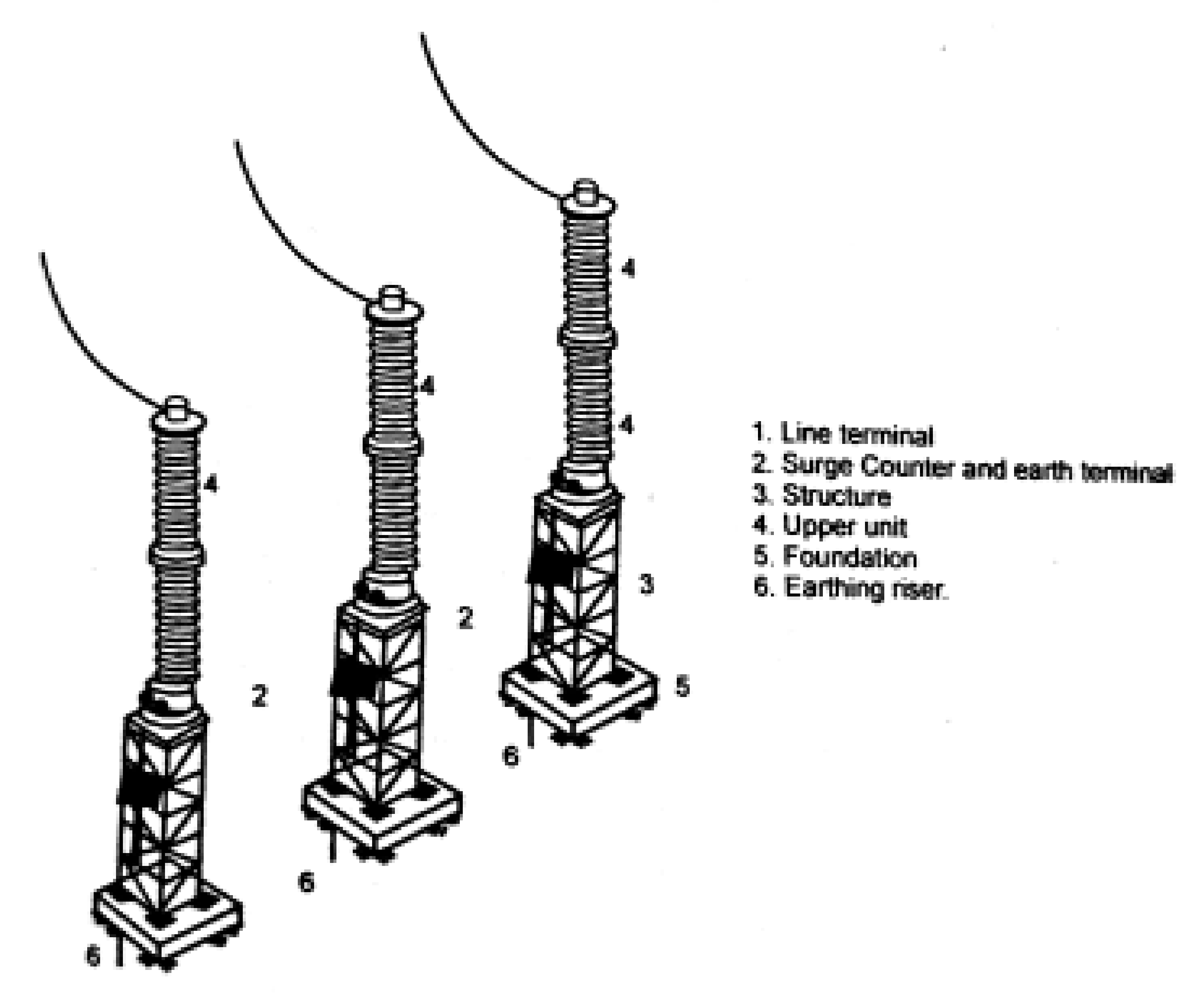


FIG. 4.38 INSTALLATION OF SURGE ARRESTERS

Control and relay panel:-

Protective relay is an electrical device interposed between the main circuit and the circuit breaker as shown in figure. the protective relay are automatic device which senses default and send signal to circuit breaker to open. All the delay have three elements sensing element, comparison element and control element

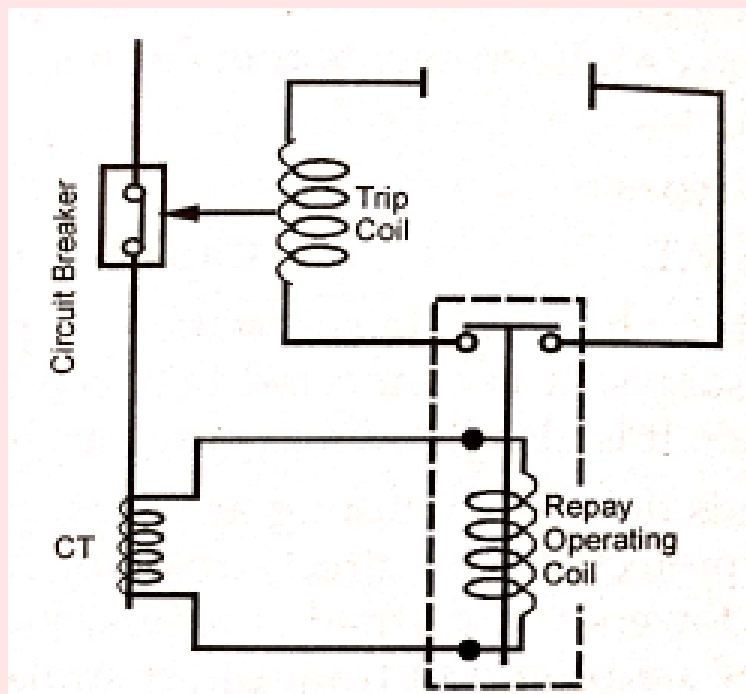


FIG. 4.39 TYPICAL RELAY CIRCUIT

HT and LT circuit breaker

H.T circuit breaker:- The circuit breaker about 1000v rating are called hightension circuit breaker.The circuit breaker cannot be used on DC unless specified by the manufacture. HT circuit breaker are classified as

BOCB:-Bulk oil circuit breaker

ABCB:- Air blast circuit breaker

SF6.CB etc.

L.T circuit breaker:- The circuit breaker disconnect d lighter kal circuit automatically from supply during abnormal condition such as overload short circuit power failure etc. LT circuit breaker are two types

LT OCB AND LT ACB.

LT switch:- Switch is used to connect or isolate an electrical circuit. L.T. switches are those in which fuses are also provided additionally to protect thr equipments against short circuit. LT switch are of air break type. The L.T switch are manually operated.

Installation of Distribution and power transformer:-

Power transformer:-

The transformer is static device except OLTC as no moving parts are involved. It transform energy from one voltage to another voltage level at same frequency. It is tge costilest equipments so regular supervision and maintenance is required to avoid its failure. Power transformer rating are between 5kva to 650 mva and very large transformer (250mva to 650mva) are installed in generating stations.

Distrubution Transformer:-

These are available in different size and generally installed in urban and rural distribution transformer. Their rating are 5 kva to 150 kva and upto 500 kva. They remain in operation for 24 hours a day irrespective of load. These transformer have good voltage regulation.

Dispatch of power transformer:-

the Transformer are dispatched by manufacture with main body filled with Transformer oil up to the coil and they ok. The oil level is reduced below the tank cover to provide the sufficient space in the tank for the oil expansion during transit on account of temperature variation. The Transformer are packed in a strong wooden packing for dispatch it over long distance. silica gel breather is fixed to the Transformer body to check the moisture free breathing due to ambient temperature variations. sometime the tank is without oil filled with dry nitrogen gas at pressure of 3PSI = 0.2kg percentage required at 35°c point in this situation all the opening in the tank and valves are closed so that nitrogen gas does not come out. All the other accessories are transported separately. As soon as Transformer reach the destination it should be exam in for case number agree with packing list and crates are not damaged.

Inspection and handling of transformers

After receipt of transformer at side gas pressure should be checked inside the transformer tank and recorded and to be intimated in writing to the manufacturer/supplier copy to higher officer also. if the pressure inside tank is zero report the matter immediately and fill the tank with dry nitrogen gas upto and internal pressure of 3 PSI at the earliest. Transformer received at site are always fitted with silica gel breather.

Handling:- Transformer should always be lifted by lungs designed to take the total weight of the unit. beside the lifting lungs transformer has subsidiary lifting points and take care must be taken to use right lifting point. normally in case of large transformer cranes are all used for lifting the transformers.

Storage of oil drums:-

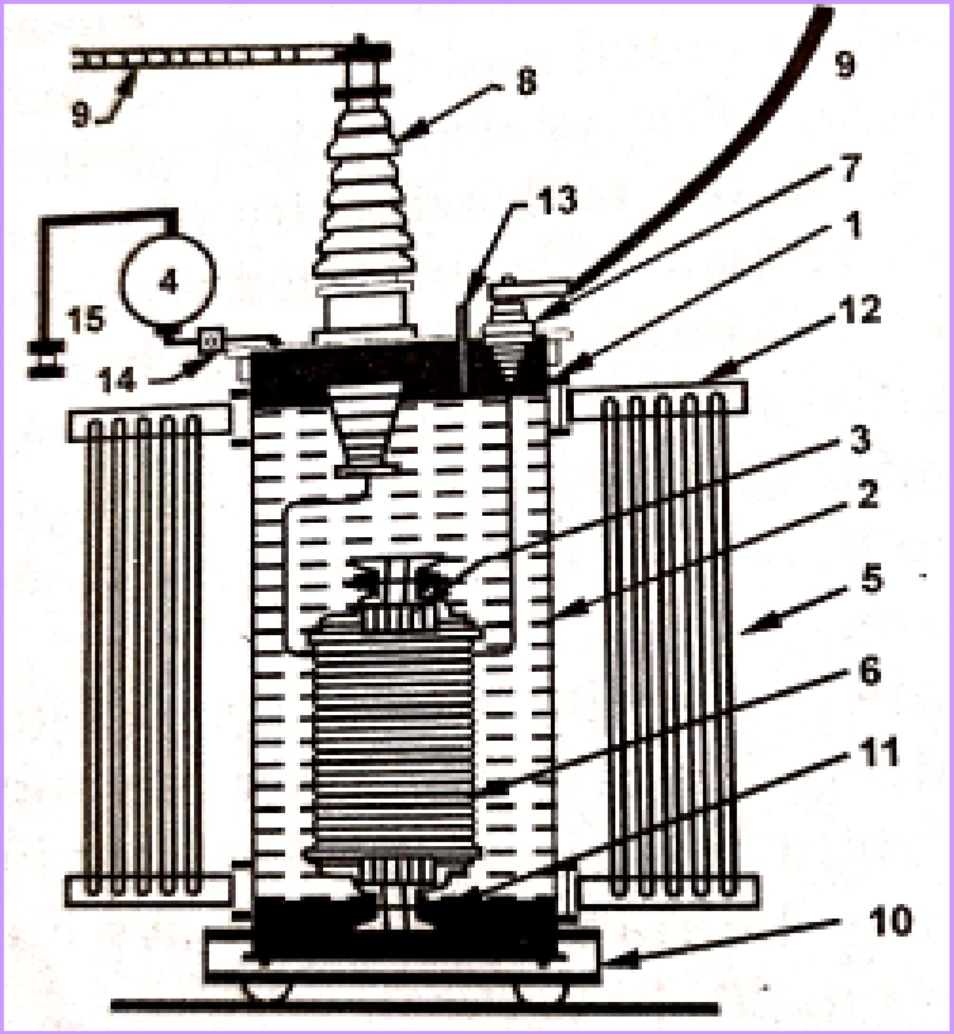
the oil drum should be stored at dry place in horizontal position with Bungs at 45° degree to horizontal in the downward direction. This will ensure that bungs are under the positive pressure. Drums should be away from fire hazards.

Site preparation for installation of transformer:-

The Transformer should be installed on level Foundation. The foundation should be strong enough to be the weight of Transformer and to prevent accumulation of water. Transformer Foundation should be provided drainage facility of oil during fire and emergency. Transformers should be installed in such a way that easy access is available all around and rating of diaphargram plate the metre valves oil level indicator can be easily read or reached. for the Transformer installed in the room must be ventilated so the air circulation can be done easily there. When roller are fitted, suitae rails all tracks should be used and grease the saft

Important fitting and accessories of transformers:-

1. Lifting lungs
2. Rollers
3. Bushing
4. Conservator
5. Diaphargram explosion vent
6. Radiators
7. Earthing terminal
8. Breather
9. Oil level indicator
10. Remote
11. Markshalling kiosk
12. Fans
13. Off circuit tap changing switch
14. Current Transformer



Filling Transformer with oil:-

before filling the oil tank it should be tested to meet the requirement laid down for oil. In case the oil does not meet the requirement filter and make it usable. When winding out of, oil filling will be done under vacuum only, before the oil filling all the accessories such as plunge and valve gears must be fitted of Transformer. All the air vents should be open. It should be filled with the help of metal hoses from oil filter tank point the oil should be filled only after testing and passing through filter

Testing of Transformer oil:- The property of Transformer oil are recommended as per IS 335- 1972 the fresh dielectric oil has a pale yellow colour. A dark cloudy colour indicate that deterioration as it contain moisture, dust particle etc.They lower down the dielectric strength of oil, so, the dielectric strength of soil should be tested by finding the breakdown voltage at which there is a visible arcing through oil across to electrode. This test is carried out in oil testing kit. A sample of soil is taken from bottom and top sampling valve. Oil should not be filled in sampling bottle completely, a space may be left for stopper on it.

Dehydration:-

The oil filtering equipments is used for filtering or dehrydration of transformer and switch gear oil. It is portable device. The oil is circulated in this decvice for several hours till the desired dielectric strength of oil is achieved.

OR The process in which moisture content or gases are removed from the transformer oil if any,is called dehydration of oil

Diagram of dehydration

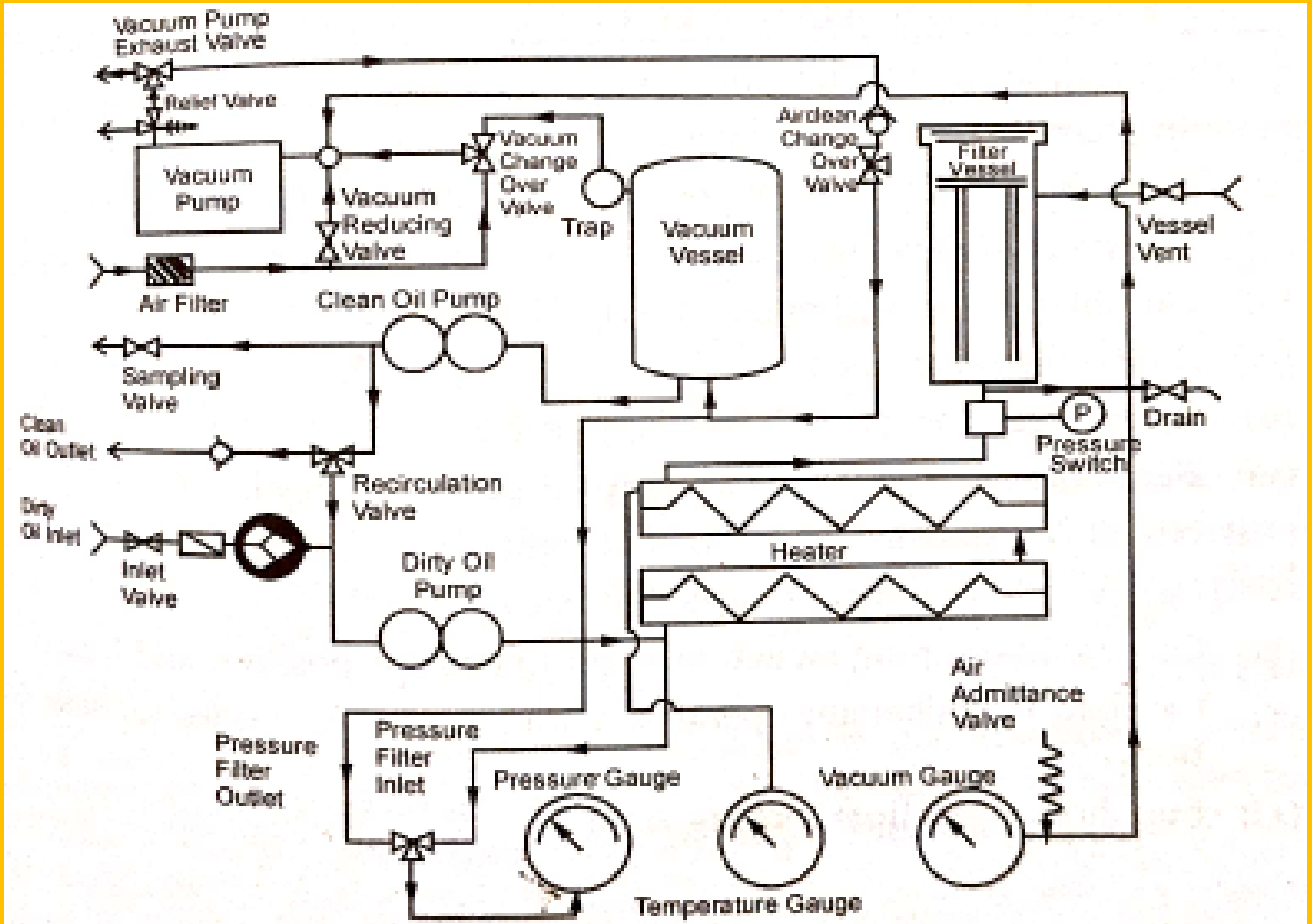


FIG. 4.42 PORATABLE OIL FILTERING EQUIPMENT

Earthing system:-

Earthing is done to provide a low resistance path to discharge current to the general mass of earth.

Earth mats and earth electrodes are placed below the ground level. These are connected to equipments structures and neutral points for the purpose of equipment and neutral point earth.

Fencing of yard:-

As per I.E rule 1956, 68(b) outdoor substation except pole mounted sub-station be efficiently protected by fencing not less than 2.4m in height or other means so as to prevent access to electric supply lines and apparatus there in by an

Unauthorized persons and animal etc.

Foundation and trenches:-

Foundation work are carried out by civil engg. Staff as per the maps or drawing of layout of substaions provided by manufacturer. All the switchyard equipment such as transformer, C.B,post,isolator, earthing mats require a good foundation.

Testing and Maintenance of Electrical Equipments

Electrical motor:-

Storage of a motor or machine:-

- The motor should be stored in dry and clean place.
- Temperature should be uniform otherwise it will cause differential expansion.
- Heaters should be provided to avoid dampness
- Motor should not be placed on mud or loose earth floor
- There must be No smoking sign in the store room

Testing of motors

- Insulation resistance measurement
- Rotor and stator resistance measurement
- Blocked rotor test
- Open circuit test
- No load test

Routine test

- IR measurement
- High voltage test
- No load test
- Locked rotor test

Special test

- Polarization index measurement
- Vibration test
- Sound level measurement
- Temperature rise test

Testing of Transformer:-

After installation work testing of transformer and its sub-system are carried out to check desired performance as per specification of the equipment.

Routine test:- These test are carried out in manufacture premises on every transformer.

- Ratio test
- Polarity test
- Insulation resistance test
- High voltage with stand test
- Breakdown value of oil
- No load test
- Test on load tap changer
- Resistance of winding
- Magnetising current test
- No load losses

Test of Transformer oil

a good oil should have combination properties of physical, chemical and electrical characteristics before discussing the test on Transformer oil the:-

property are discussed here properties of Transformer oil as

a. the oil should not contain suspended partical such as acid water sulphur etc.
b. the colour of oil should be clear pale yellow colour.
c. The Transformer oil have good resistance to electrical stress.
d. It should have low viscosity.
e. It should have thermal stability and excellent oxidation.

Various test

1. Physical test:- specific gravity, viscosity, pour point crackle test.
2. Chemical test:- neutralization number or acidity test, sapoxfication test, oxidation stability
3. Electrical test:- dielectric strength of oil, resistivity of oil, water content test, total acidity test, resistivity of oil

Testing of cable:-

A single conductor insulated through its full length is called a cable.

Testing:-

a. Routine test
b. Type test
c. Special test

Method of locating cable fault:-

- Ground fault of single cable
- Loop test
- Fall of potential test

Motor control centres:-

Motor control centre consists of switch fuse starter protection relays and conductor extra.

Starters:- Motor draw high current at starting this hai current mein damage the armature Hence motor. To avoid such situation we use starter. the starter are used for limiting the starting current to safe value.

For DC shunt and compound motor

3 point starter

4 point starter

For DC series motor

2 point starter

For AC motors

Direct online starter upto 5 HP

Star delta starter

Auto transformer starter

Protective relays

Release A device which sense of fault or short circuit and send a signal to the circuit breaker for tripping.

Voltage control relay

Current operated relay

Sensitive relay

Contactors:- Contactors electromechanical device used for making and breaking of an electric circuit under normal and overload condition. These are not operated under abnormal condition. like a circuit breaker contactor are extensively used in motor control circuit example motor starter and other control circuit using interlock.

Maintenance of motor control centre

- Maintenance of starter
- Maintenance of protective relays
- Maintenance of contactors

Power control centre

The apparatus used for switching controlling and protecting the electrical component in industry or substation are known as power control centre or simply switchgear.

Types:- switch

Circuit breaker

Maintenance of power control centre

- Check all the fuse for circuit continuity
- Remove dirt and dust from switchgear installation
- Clearing of all airbrake switches switches isolator and earth switch etc.
- Tight the nut and bolt
- Checking of earthing conductor system
- Check them for contact pressure

- **Lightning arrangement**

There must be proper and healthy lighting arrangement in a switchyard roads and control room building along with the standby arrangement. These are essential for operation maintenance and inspection purpose in substation.

Inspection of pre-installation checks

When the monetary received at site it should be properly checked as per the manual or instruction provided by the manufacture. If the packing is OK then it should be unpacked carefully. All the parts and accessories are properly examined as per the instruction provided. if there are any missing damaged item it should be brought to the notice of supplier or manufacturer immediately. after this instruction resistance of stator and motor windings are measured with the help of megger. If it is not satisfactory then the winding should be dried. Inspect the windings leads, brush, gear, bearing, commutator of slip ring, oil gauges etc. Check the router for easy rotation by moving it with the hand. If any type of dust seems on motor, remove the same by blowing.

Pre-Commissiong check

Mechanical and electrical checks are required before commissioning of motors are energised.

Mechanical checks

In mechanical checks correct alignment, air gap between stator and rotor, proper greasing of bearing, cheque clearance between rotor and stator check tightness of terminal connection should be carried out.

Electrical checks

Before connecting machine to the mains all connection should be checked with the wiring diagram. Rating of fuses should also be checked. Check the insulation resistance of the machine. Check the earth connections for tightness and measure earth resistance. Where relays are employed test should be performed for checking of relay stimulating loading conditions. Performance tests such as no load, full load, short-circuit, speed control tests are also carried out.

Drying out of motor

if the insulation resistance between the winding and earth major is less than 1 mega ohm then it mean that moisture awesome dust particles are prevent in the winding of the motor and the machine need to be cleared and dry out.

- Blocked rotor heating
- Heating by heaters or lamps
- By oven

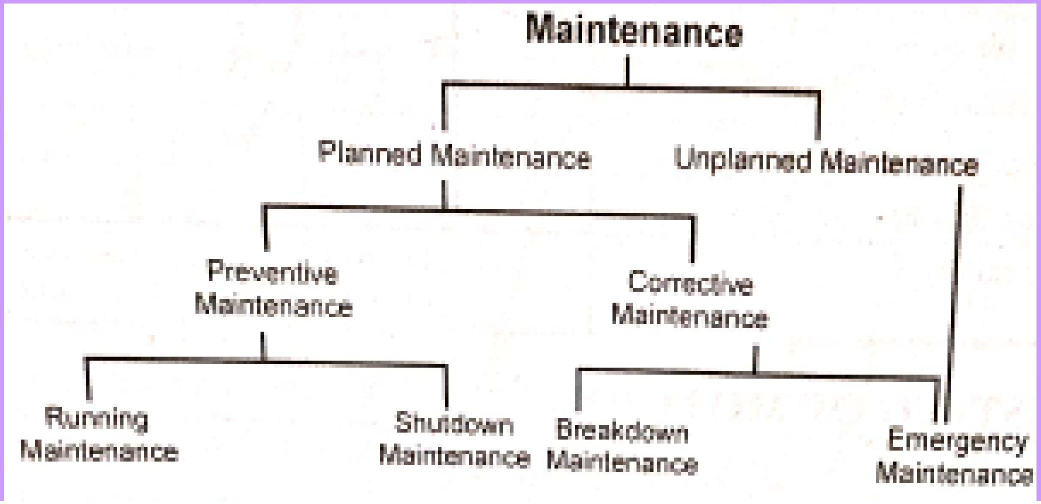
Chapter-3

Maintenance

Maintenance:- It is the process in which proper attention must be paid to protect the machine and its components a proper attention means lubrication cleaning and timely inspection it is important on a account of the following fact:-

- Machine breakdown cause a possible loss of production and their by sales
- Direct labour and part of indirect labour become idle
- Actual cost of repairing and machine is also involved

Types of maintenance:-



Planned maintenance:-

The terms in the maintenance work carried out in plant and orderly manner. It is two types.

1. Preventive maintenance
2. Corrective maintenance

Preventive maintenance:-

In this type of maintenance effort are made to prevent failure and to locate the faults.

Running maintenance

Shutdowm maintenance

Corrective maintenance:- This type of maintenance is carried out to restore the equipment to its original working condition.

Breakdown maintenance

Emergency maintenance

Maintenance schedule:-

There are different maintenance schedule for all electrical apparatus and component used in genration or Transmission system. These maintenance schedule helps in unkeeping the equipment in proper amd good working condition before discussing the maintenance, we will discuss some testing amd comissioning of transmission line.

Maintenance of transmission and distribution system:-

Maintenance of overhead:- overhead line, their structure and their components should be maintained to be in a safe operating condition.

A system of maintenance of overhead line, their structure and component consist of

- Inspection or testing programs
- Maintenance program
- replacement program for component approaching the end of their serviceable life
- Tree management program to ensure public safety
- Minimise lyrics of fire caused by contact between trees and overhead lines
- Reduce the number of introduction to supply caused by tree and
- protect the electricity distributors assets from damage

Authorised person:-

One who is properly authorised to perform specific duties under certain condition for who is carrying out order from competent authority and as defined under rule 3 of IE rule 1956.

Unauthorised person:-

One who is not permit to work on electrical apparatus except under the personal supervision of an authorised person.

Permit to work:-

permit to work means form of declaration signed by and given by an authorised person to another authorised person in charge of work to be carried out to any electrical apparatus main of service line means or service line are made dead and earth and safe for working.

- Perfoma of PTW(permit fo work)

PERFORMA

.... KV sub Station ....

PTW No. ....   Dates ....

Issued to Sh. ....

Name of Feeder ....

Purpose of Work ....

Operation done by operator ....

....

PTW Received

J.E./ A.F.M.   Time ....

This office is not in knowledge of any back feeding arrangement and will not be responsible for any back feeding due to this which may be noted.

Issued By ....Time ....

Certified that all men and material, temperature earth have been removed from the site and the line is clear for energisation.

Please Cancel   PTW No. ....   PTW Cancelled at :-

Time ....   Time ....

Date ....   Date ....

Signature J.E./A.F.M.   Signature J.E./G.S.O.

Danger notice:- Danger notice means a notice attached to live electrical apparatus line calling attention to the danger of touching such apparatus. It is provided at height of 3.0 m from the ground. Every line must have a danger plate as IE rule 35. A danger notice about the line is written in hindi or english and local language along with a sign skull and bones.

Caution notice:- caution notice means a notice attached to the dead electrical apparatus to convey a warning against such equipment being made live.

Arranging of shutdown personally or telephonically:-

when return permit cannot be given line clear should be given and taken over on the telephone. in such case substance there of shall be repeated by the person who receive the line clear message and shall be confirmed by the standard to ensure that both parties are quite clear as to its purpose. search instruction should be recorded only in permit books at both sending and receiving end. the issue of line clear over phone should be confirmed by some other department employee to this supervisor over phone and name of that person who confirm the issue of line clear permit to work should be recorded in the line clear permit book. Duplicate copy of line clear should be send by post as soon as possible for record at either end after cancelling the same.

Cancellation of permit and restoring of supply:-

PTW form issued to the supervisors shall be returned to permit issuing officer only after all the work are completed and earth remove so that apparatus main and O.H line are safe in all respect horse charging and after all the workmen are withdrawn from the working area and our suitably be warned that it is no longer safe to touch the apparatus within said area.

Special inspection and high inspection:-

The overhead line should be inspected regularly for maintenance purpose in order to detect the fault which may ultimate lead to breakdown of this line there by causing extensive damage to power supply.the cost of maintenance increased manifold is a major breakdown occur in addition to loss of electrical power supply to measure electrical installation leading to production shutdown and disruption in emergency electrical service.

Patrolling of overhead line:- all overhead line should be patrolled periodically at interval of 3 month. In case of heavy snowfall or thunderstorm it should be checked immediately for major breakdown. After patrolling the maintenance section should carry out of the necessary repair ever required.

Patrolling and visual inspection of lines

Visual Inspection:- visual inspection of electrical installation which is not considered is carried out Prior to any testing.starting the inspection cell include a check on the condition of electrical equipment and material and will take following factor into account

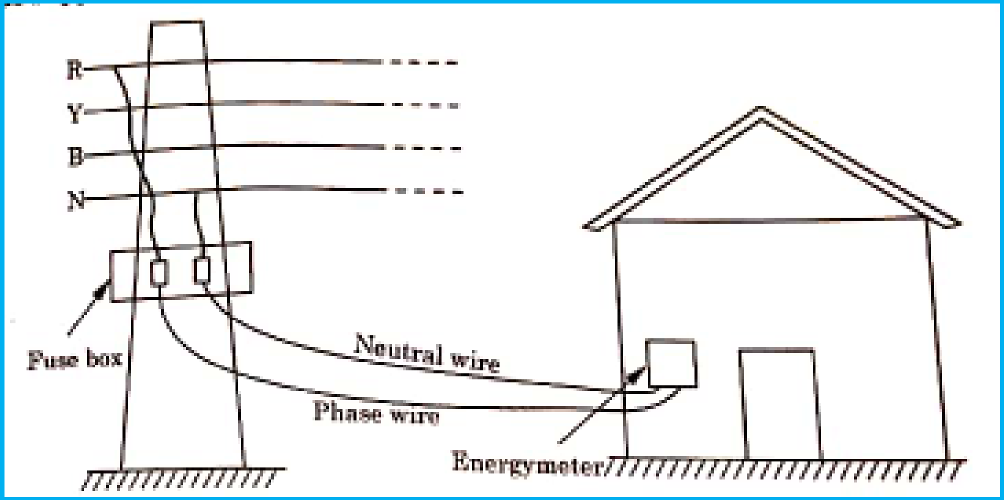
1. Safety
2. Wear and tear
3. Damage and corrosion
4. Overloading and overheating
5. External influences
6. the insulation and seat of each conductor at a sample of termination point shall be inspected to determine its condition and correct installation.

Effect effect of open or loose neutral connection:-

when the neutral is not connected or remain open or loose under such condition the neutral will assume a potential which will is determined by the load on each phase and in such a case neutral is called floating neutral. To explain this there may be three cases first case when balance load on 3 phase than voltage between neutral and each phase is same that is 230 volt if line voltage is 400 volt. If load are unequal in different phases. Voltage between all faces and neutrals will be different that is in some phase voltage will be low and in some phase voltage will be high. due to this several equipment may get damaged when lamp in 3 phase supply glow brighter than other of same voltage then it is an indication of something wrong with neutral connection.

Provision of proper fuses on service line and their effect on system:-

All the service line provided whether overhead or underground are provided proper fuse. A simple circuit diagram showing overhead service connection to domestic supply.



all the service connection are provided with proper fuse so that in case of fault within the zone between fuse box and energy meter the supply through the mainline being supplied remain infect by blowing of the fuse wire and electrical supply only to domestic installation get disconnected RMS provision of proper fuels affect the mainline from getting damage

Causing of Dim and flickering lights:-

the cause of dim or flickering light can be because of partially open connection providing varying resistance and therefore intermittent voltage drop.

This can be because of following reason:-

a. Bad terminal connection
b. Burned or broken wire
c. Bad or burned wires splice
d. Bad or burn light switch
e. Bad breaker etc.

even if there is nothing wiring is dry circuit and dim of flickering of light taking place it can be due to presence of large load on the same Francs circuit which may be causing this.

Temporary earthing:-

this is the most important phenomenon while carrying out the repair maintenance of electrical equipments. For temporary earthing stick or lose earth wire must be connected to earth first then to the phases. After completion of the work at sticker loose earth wire must be removed from the face first then from the earth.

Maintenance of Distribution Transformer:-

Transformer maintenance,checking of insulation resistance

The insulation resistance is measured with the help of megger insulation is completely dried up and all the moisture present is removed. The resistance of the installation depend upon the temperature at which the test is being performed for class eight insulation the insulation resistance get halves for every 10°c rise in temperature. The minimum value of insulation resistance 2Mohm for thousand volt operating voltage at 60°c temperature.the voltage generated by the generator during measurement of value should be steady.

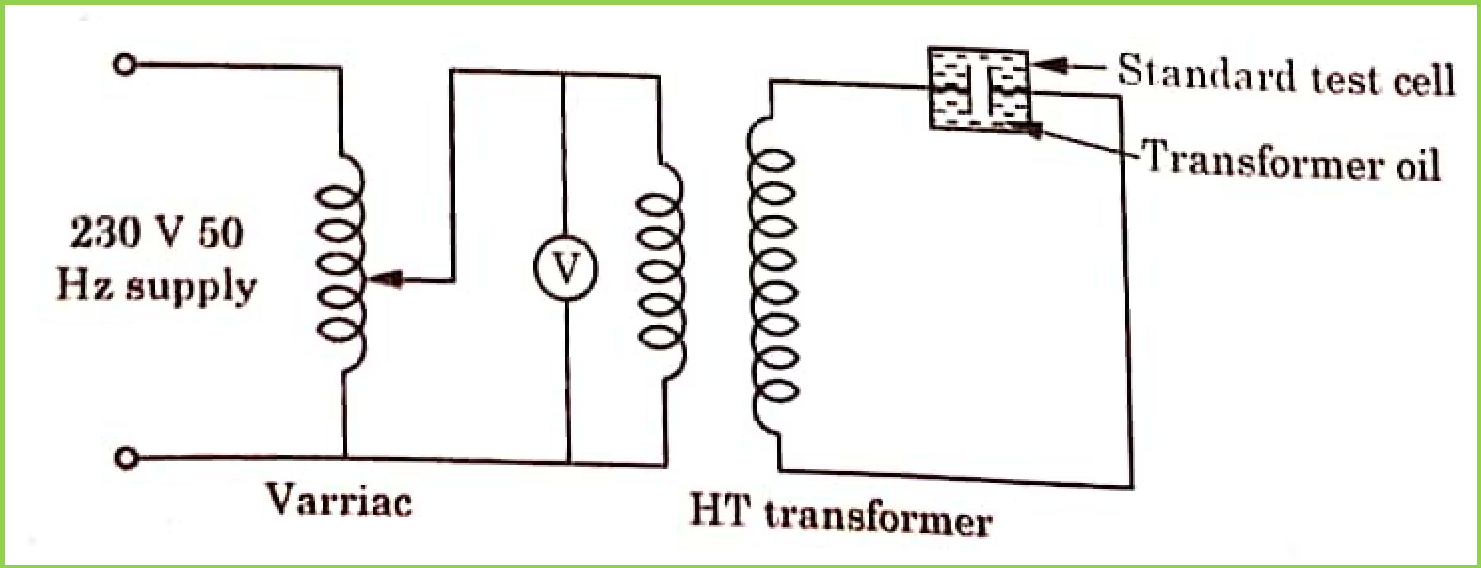
Checking of Transformer oil level:-

The oil level of the transformer is checked by looking at the level indicated in the printed fail on the glass installed at the conservator tank. the conservative tanks should be always be full of oil so that the oil which provide cooling effect to the temperature rise due to current carried by winding also provide insulation between the two winding of primary and secondary as well as between core and winding.

BDV test of oil:-

Breakdown voltage level test is conducted on the Transformer oil to measure its dielectric strength. The test is performed on a standard oil test set. This sample oil is taken and laced between two electrode of specified dimension as per relevant IS standard. The gap between these electrode is usually kept at 2.5 mm. The voltage applied across the electrode is gradually increased till a flashover take place.

the voltage level at which flashover take place is the dielectric strength of the oil. The arrangement of the test is shown in figure.



Measurement of earth resistance:-

Fall of potential method with the earth megger. the earth megger is used for measurement of her electrode for earthing system of small or medium extent such a single rod earthing electrode, strip earth electrode. The earth electrode the probe and auxiliary electrode should all lie in a straight line as for apart as possible. The distance of probe from the earth electrode test should be at least 2.5 times the maximum extension of this electrode but not less than 20 m.