MGM's
Jawaharlal Nehru Engineering College

Laboratory Manual

Electrical Power Transmission & Distribution

For

Second Year (EEP) Students

Manual made by

Prof. P.A. Gulbhile

FORWARD

It is my great pleasure to present this laboratory manual for second year EEP engineering students for the subject of Electrical Power Transmission & Distribution. Keeping in view the vast coverage required for visualization of concepts of Electrical Power Transmission with simple language.

As a student, many of you may be wondering with some of the questions in your mind regarding the subject and exactly what has been tried is to answer through this manual.

Faculty members are also advised that covering these aspects in initial stage itself, will greatly relieved the minfuture as much of the load will be taken care by the enthusiasm energies of the students once they are conceptually clear.

H.O.D.

LABORATORY MANNUAL CONTENTS

This manual is intended for the second year students of Electrical Electronics & Power engineering branch in the subject of Electrical Power Transmission & Distribution. This manual typically contains practical/Lab Sessions related layouts, sheets of different parts in electrical power transmission & distribution system as well as study of different models of transmission line, measurement of parameters of transmission line and various aspects related the subject to enhance understanding.

Although, as per the syllabus, only descriptive treatment is prescribed ,we have made the efforts to cover various aspects of electrical Power Transmission & Distribution subject covering types of different transmission lines , their circuit diagrams and phasor diagrams, electrical design of overhead transmission line , electrical design of overhead transmission line, elaborative understandable concepts and conceptual visualization.

Students are advised to thoroughly go through this manual rather than only topics mentioned in the syllabus as practical aspects are the key to understanding and conceptual visualization of theoretical aspects covered in the books.

Good Luck for your Enjoyable Laboratory Sessions

Prof. P. A. Gulbhile

SUBJECT INDEX

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2. Lab exercise:

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    3. To draw Layout of 400/132 KV transmission substation on A-1 size sheet.
    4. To sketch the types of over- head line insulators on A-1 size sheet.
    5. To sketch the types of over- head line supports on A-1 size sheet.
    6. To sketch the types of underground cables on A-1 size sheet.
    7. To Study of types of cable faults & its location.
    8. To Measure the ABCD parameters of transmission line.
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    11. To study ACSR conductor
    12. To study capacitance of 1-phase & 3-phase transmission line

DOs and DON'Ts in Laboratory:

1. Use various symbols while drawing the syllabus related sketches, layouts on A-1 size sheet
2. Prepare the analysis of transmission line.
3. Draw the phase diagrams where needed using different technical concepts & rules
4. Understand the panel board with its connections
5. Understand the equipment to be tested and apparatus to be used.
6. Do not touch the live terminals.
7. Use suitable wires (type and size).
8. All the connection should be tight.
9. Do not leave loose wires (i.e. wires not connected).
10. Get the connection checked before switching 'ON' the supply.
11. Never exceed the permissible values of current, voltage, and / or speed of any phase, wire, load, etc.
12. Switch ON or OFF the load gradually and not suddenly.
13. Strictly observe the instructions given by the teacher/Lab Instructor

Instruction for Laboratory Teachers:

1. Submission related to whatever lab work has been completed should be done during the next lab session. The immediate arrangements for print outs related to submission on the day of practical assignments.
2. Student should understand the power flow from generating station to load station with its respective voltage levels.
3. Student should able to understand the mechanical & electrical design of overhead lines.
4. Students should be taught for taking the observations/readings of different measuring instruments under the observation of lab teacher.
5. Students should be able to draw the subject related sheets under the observation of lab teacher.
6. The promptness of submission should been courage by way of marking and evaluation patterns that will benefit the sincere students.

Lab Exercises:

Exercise No1:(2Hours)-1Practical

Electric Supply System: Typical a.c. Power Supply Scheme

AIM: To study the Electric Supply System : Typical a.c. Power Supply Scheme

THEORY:

Electric Supply System

The conveyance of electric power from a power station to consumers' premises is known as **elec-tric supply system**

An electric supply system consists of three principal components *viz.*, the power station, the transmission lines and the distribution system. Electric power is produced at the power stations which are located at favorable places, generally quite away from the consumers. It is then transmit-ted over large distances to load centers with the help of conductors known as transmission lines. Finally, it is distributed to a large number of small and big consumers through a distribution network.

The electric supply system can be broadly classified into (*i*) d.c. or a.c. system (*ii*) overhead or underground system. Now-a-days, 3-phase, 3-wire a.c. system is universally adopted for gen-eration and transmission of electric power as an economical proposition. However, distribution of electric power is done by 3-phase, 4-wire a.c. system. The underground system is more expensive than the overhead system. Therefore, in our country, overhead system is *mostly adopted for transmission and distri-bution of electric power

Typical a.c. Power Supply Scheme

The large network of conductors between the power station and the consumers can be broadly divided into two parts *viz.,* transmission system and distribution system. Each part can be further sub-divided into two—primary transmission and second-ary transmission and primary distribution and secondary distri-bution. Fig. shows the layout of a typical a.c. power supply scheme by a single line diagram. It may be noted that it is not necessary that all power schemes include all the stages shown in the figure. For example, in a certain power scheme, there may be no secondary transmission and in another case, the scheme may be so small that there is only distribution and no transmis-sion.

(i) Generating station : In Fig , G.S. represents the generating station where electric power is produced by 3-phase alternators operating in parallel. The usual generation voltage is 11 kV. For economy in the transmission of electric power, the generation voltage (*i.e.*, 11 kV) is stepped upto 132 kV (or **more) at the generating station with the help of 3-phase trans-formers. The transmission of electric power at high voltages has several advantages including the saving of conductor material and high transmission efficiency. It may appear advisable to use the highest possible voltage for transmission of electric power to save conductor material and have other advantages. But there is a limit to which this voltage can be increased. It is because in-crease in transmission voltage introduces insulation problems as well as the cost of switchgear and transformer equipment is increased. Therefore, the choice of proper transmission voltage is essentially a question of economics. Generally the primary transmission is carried at 66 kV, 132 kV, 220 kV or 400 kV.

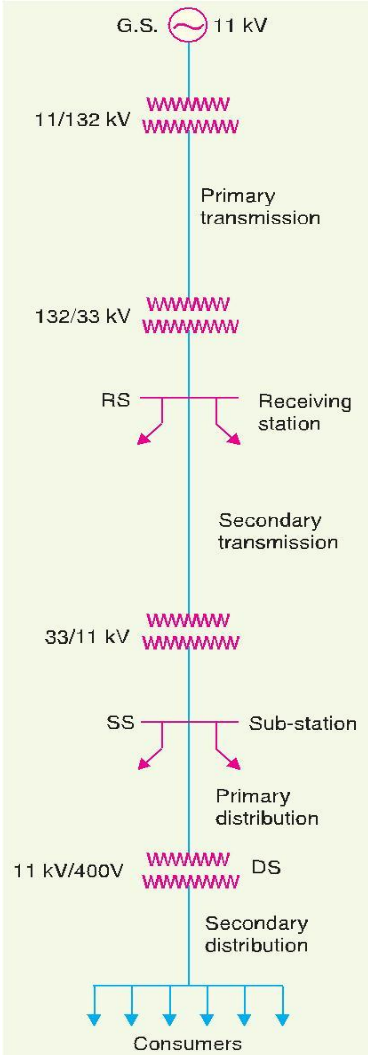


Fig. 7.1

(*ii*) *Primary transmission.* The electric power at 132 kV is transmitted by 3-phase, 3-wire overhead system to the out-skirts of the city. This forms the primary transmission.

(*iii*) *Secondary transmission.* The primary transmission line terminates at the receiving station (*RS*) which usually lies at the outskirts of the city. At the receiving station, the voltage is re-duced to 33kV by step-down transformers. From this station, electric power is transmitted at 33kV by 3-phase, 3-wire over-head system to various sub-stations (*SS*) located at the strategic points in the city. This forms the secondary transmission.

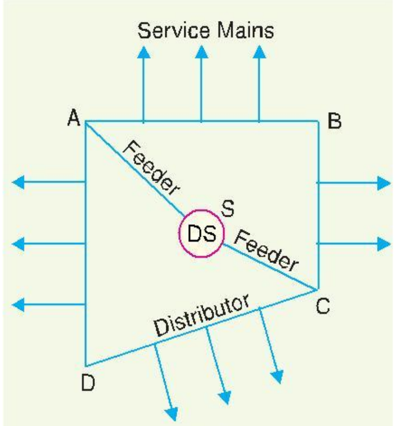


Fig. 7.2

(*iv*) *Primary distribution.* The secondary transmission line terminates at the sub-station (*SS*) where voltage is reduced from 33 kV to 11kV, 3-phase, 3-wire. The 11 kV lines run along the important road sides of the city. This forms the primary distribution. It may be noted that big con-sumers (having demand more than 50 kW) are generally supplied power at 11 kV for further handling with their own sub-stations.

(*v*) *Secondary distribution.* The electric power from primary distribution line (11 kV) is deliv-ered to distribution sub-stations (*DS*). These sub-stations are located near the consumers' localities and step down the voltage to 400 V, 3-phase, 4-wire for secondary distribution. The voltage between any two phases is 400 V and between any phase and neutral is 230 V. The single-phase residential lighting load is connected between any one phase and neutral, whereas 3-phase, 400 V motor load is connected across 3-phase lines directly.

It may be worthwhile to mention here that secondary distribution system consists of *feeders, distributors and service mains*. Fig. 7.2 shows the elements of low voltage distribution system. Feeders (*SC* or *SA*) radiating from the distribution sub-station (*DS*) supply power to the distributors (*AB*, *BC*, *CD* and *AD*). No consumer is given direct connection from the feeders. Instead, the consumers are connected to the distributors through their service mains.

Note. A practical power system has a large number of auxiliary equipments (*e.g.*, fuses, circuit breakers, voltage control devices etc.). However, such equipments are not shown in fig.

Conclusion: Hence we have studied Typical a.c. Power Supply Scheme & how the power flows from generating station to transmission station to distribution station to the load with respective voltages voltage

Lab Exercises:

Exercise No 2:(2Hours)–1Practical

Potential Distribution over Suspension Insulator String & string efficiency

AIM: To study Potential Distribution over Suspension Insulator String & find string efficiency

THEORY:

Potential Distribution over Suspension Insulator String

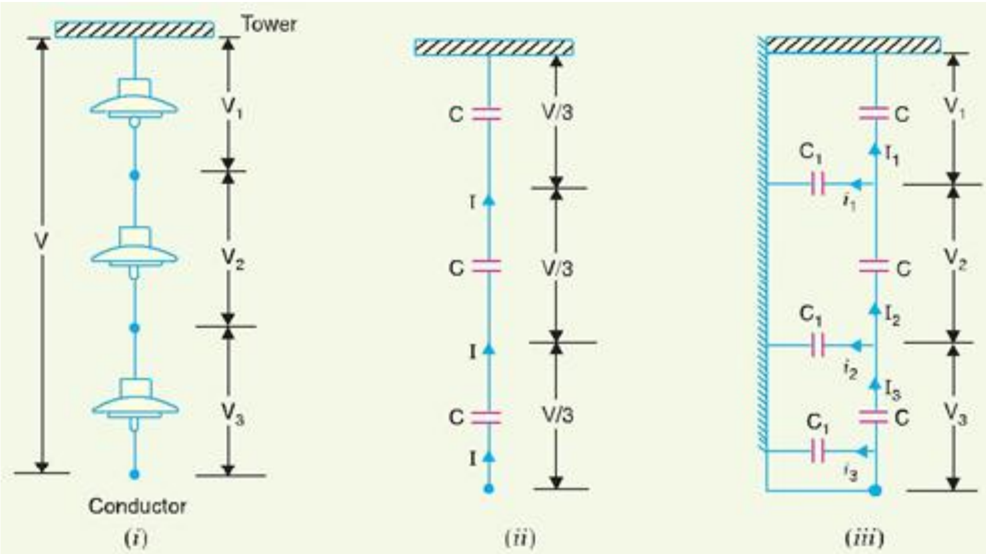


Fig.a.

A string of suspension insulators consists of a number of porcelain discs connected in series through metallic links. Fig. a. (*i*) shows 3-disc string of suspension insulators. The porcelain portion of each disc is inbetween two metal links. Therefore, each disc forms a capacitor *C* as shown in Fig. a. (*ii*). This is known as *mutual capacitance* or *self-capacitance*. If there were mutual capacitance alone, then charging current would have been the same through all the discs and consequently voltage across each unit would have been the same *i.e.,* $V/3$ as shown in Fig. a. (*ii*). However, in actual practice, capacitance also exists between metal fitting of each disc and tower or earth. This is known as *shunt capacitance* C_1. Due to shunt capacitance, charging current is not the same through all the discs of the string . Therefore, voltage across each disc will be different. Obvi-ously, the disc nearest to the line conductor will have the maximum* voltage. Thus referring to Fig. a. (*iii*), V_3 will be much more than V_2 or V_1.

The following points may be noted regarding the potential distribution over a string of suspen-sion insulators :

(*i*) The voltage impressed on a string of suspension insulators does not distribute itself uni-formly across the individual discs due to the presence of shunt capacitance.

(*ii*) The disc nearest to the conductor has maximum voltage across it. As we move towards the cross-arm, the voltage across each disc goes on decreasing.

(*iii*) The unit nearest to the conductor is under maximum electrical stress and is likely to be punctured. Therefore, means must be provided to equalise the potential across each unit. This is fully discussed in Art. 8.8.

(*iv*) If the voltage impressed across the string were d.c., then voltage across each unit would be the same. It is because insulator capacitances are ineffective for d.c.

8.7 String Efficiency

As stated above, the voltage applied across the string of suspension insulators is not uniformly dis-tributed across various units or discs. The disc nearest to the conductor has much higher potential than the other discs. This unequal potential distribution is undesirable and is usually expressed in terms of string efficiency.

The ratio of voltage across the whole string to the product of number of discs and the voltage across the disc nearest to the conductor is known as **string efficiency** *i.e.,*

$$\text{String efficiency} = \frac{\text{Voltage across the string}}{n \cdot \text{Voltage across disc nearest to conductor}}$$

where n = number of discs in the string.

String efficiency is an important consideration since it decides the potential distribution along the string. The greater the string efficiency, the more uniform is the voltage distribution. Thus 100% string efficiency is an ideal case for which the volatge across each disc will be exactly the same. Although it is impossible to achieve 100% string efficiency, yet efforts should be made to improve it as close to this value as possible.

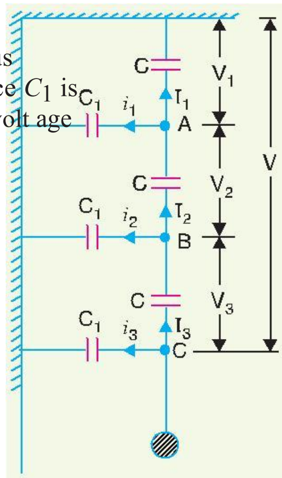


Fig. 8.11

Mathematical expression. Fig. 8.11 shows the equivalent circuit for a 3-disc string. Let us suppose that self capacitance of each disc is C. Let us further assume that shunt capacitance C_1 is some fraction K of self- capacitance *i.e.,* $C_1 = KC$. Starting from the cross-arm or tower, the volt age across each unit is V_1, V_2 and V_3 respectively as shown

Applying Kirchhoff's current law to node A, we get,

$$I_2 = I_1 + i_1$$

Or $\quad V_2 \omega C^* = V_1 \omega C + V_1 \omega C_1$

Or $\quad V_2 \omega C = V_1 \omega C + V_1 \omega K C$

$\therefore \quad V_2 = V_1 (1 + K) \quad \ldots(i)$

Applying Kirchhoff's current law to node B, we get,

$$I_3 = I_2 + i_2$$

Or $\quad V_3 \omega C = V_2 \omega C + (V_1 + V_2) \omega C_1 \dagger$

Or $\quad V_3 \omega C = V_2 \omega C + (V_1 + V_2) \omega K C$

Or $\quad V_3 = V_2 + (V_1 + V_2)K$

$$= KV_1 + V_2 (1 + K)$$

$$= KV_1 + V_1 (1 + K)^2 \quad [ŒV_2$$

$$= V_1 [K + (1 + K)^2]$$

$\therefore \quad V_3 = V_1 [1 + 3K + K^2]$

Voltage between conductor and earth (*i.e.,* tower) is

$$V = V_1 + V_2 + V_3$$

$$= V_1 + V_1(1 + K) + V_1(1 + 3K + K^2)$$

$$= V_1 (3 + 4K + K^2)$$

$\therefore \quad V = V_1(1 + K)(3 + K)$

From expressions (*i*), (*ii*) and (*iii*), we get,

$$\frac{V_1}{1} = \frac{V_2}{1+K} = \frac{V_3}{1+3K+K^2} = \frac{V}{(1+K)(3+K)} \quad ...(i$$

$$\therefore \text{ Voltage across top unit, } V_1 = \frac{V}{(1+K)(3+K)}$$

Voltage across second unit from top, $V_2 = V_1 (1+K)$

Voltage across third unit from top, $V_3 = V_1 (1+3K+K^2)$

$$\%\text{age String efficiency} = \frac{\text{Voltage across string}}{n \cdot \text{Voltage across disc nearest to conductor}}$$

$$= \frac{V}{3 \cdot V_3} \cdot 100$$

The following points may be noted from the above mathematical analysis :

If $K = 0{\cdot}2$ (Say), then from exp. (*iv*), we get, $V_2 = 1{\cdot}2\ V_1$ and $V_3 = 1{\cdot}64\ V_1$.

(*i*) This clearly shows that disc nearest to the conductor has maximum voltage across it; the voltage across other discs decreasing progressively as the cross-arm in approached.

(*ii*) The greater the value of $K (= C_1/C)$, the more non-uniform is the potential across the discs and lesser is the string efficiency.

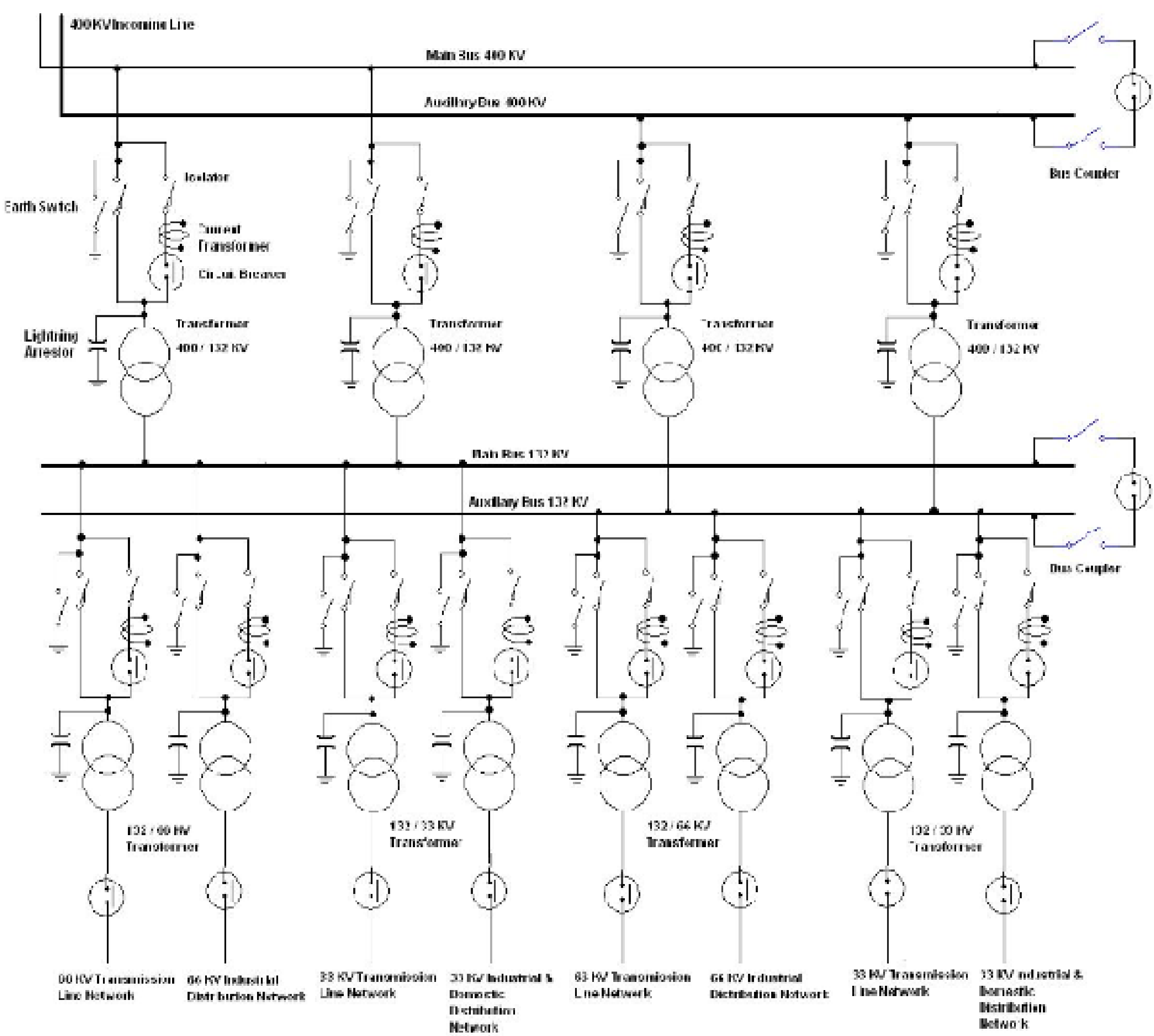
(*iii*) The inequality in voltage distribution increases with the increase of number of discs in the string. Therefore, shorter string has more efficiency than the larger one.

Conclusion: hence we have studied how line Potential is Distributed over the string of Suspension Insulator using the concepts of kirchoffs laws (KVL & KCL). Again we have studied how to find string efficiency .

Exercise No3:(2Hours)–1Practical

Layout of 400/132 KV transmission substation

AIM: To draw Layout of 400/132 KV transmission substation on A-1 size sheet.



400 / 132 /66 / 33 KV Outdoor Substation Layout

<u>Exercise No4:(2Hours)-1Practical</u>

Types of over- head line insulators

AIM: To sketch the types of over- head line insulators on A-1 size sheet.

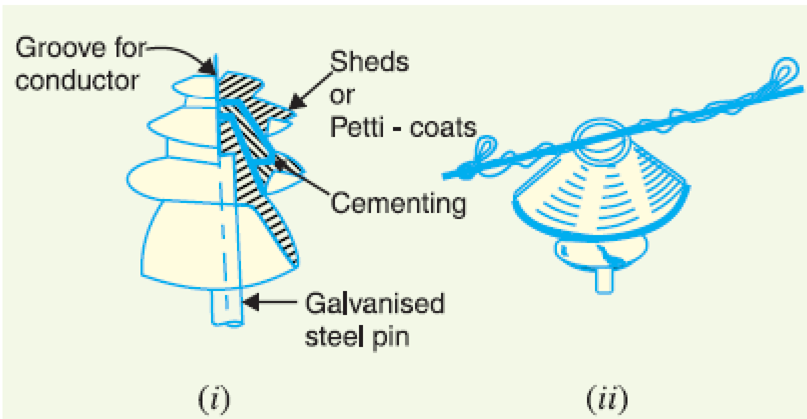


Fig. 8.5. Pin-type insulator

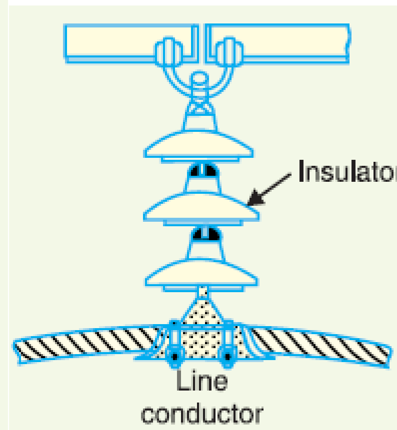


Fig: suspension insulator

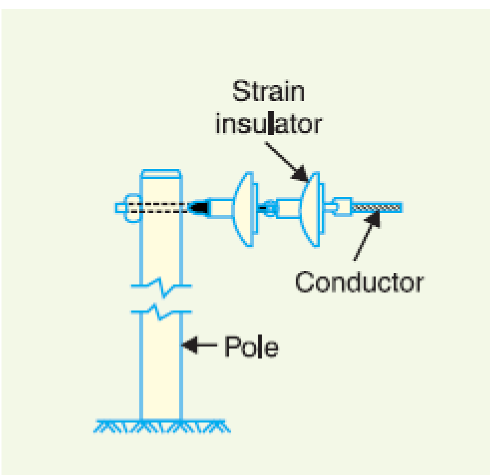


Fig. 8.8. Strain insulator.

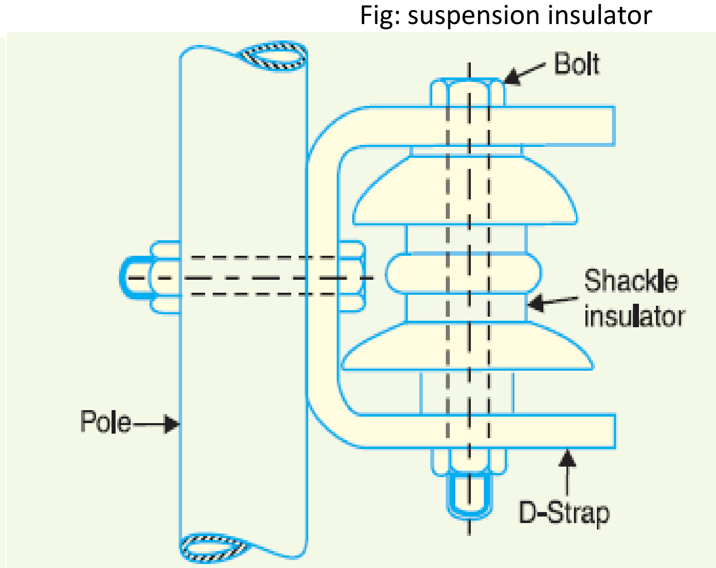


Fig: shackle insulator

Exercise No5:(2Hours)-1Practical

Types of over head line supports

AIM: To sketch the types of over- head line supports on A-1 size sheet

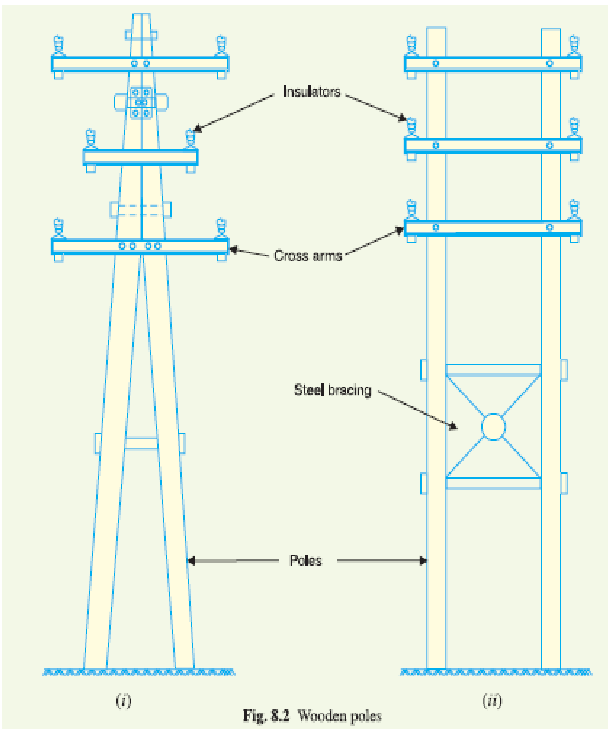


Fig: double pole structure(i-A-type, ii-H-type)

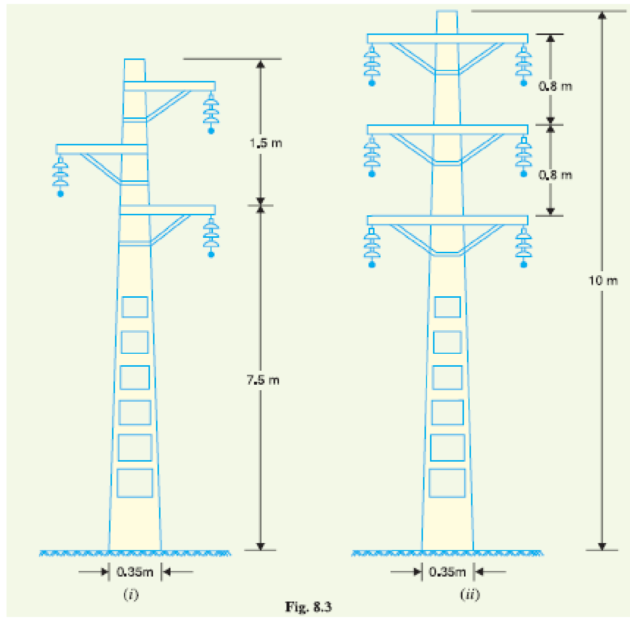


Fig: R.C.C tower (i- single circuit, ii- double circuit)

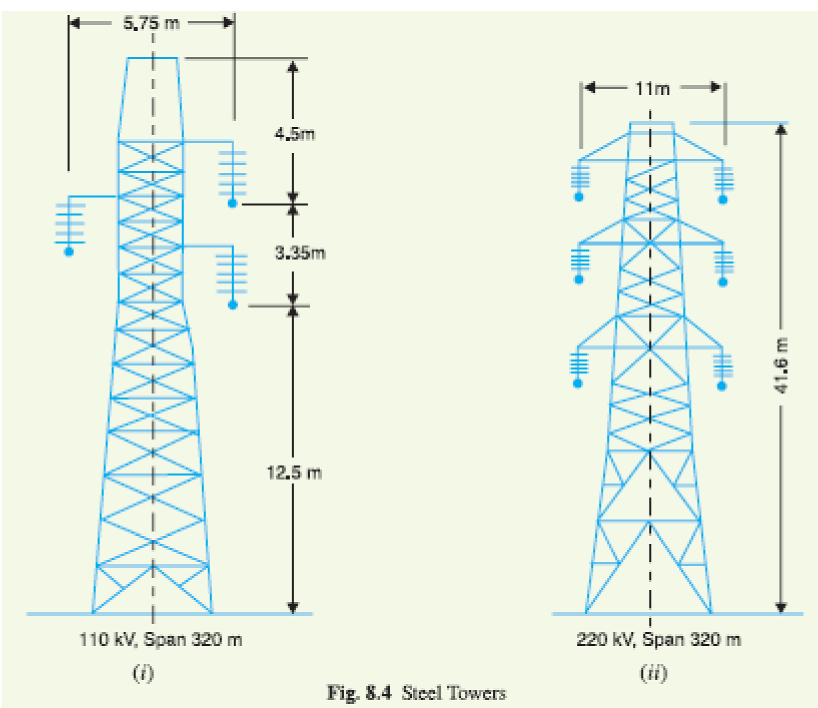


Fig: steel tower (i-single circuit, ii-double circuit)

Exercise No6:(2Hours)-1Practical

Types of underground cables

AIM: To sketch the types of underground cables on A-1 size sheet

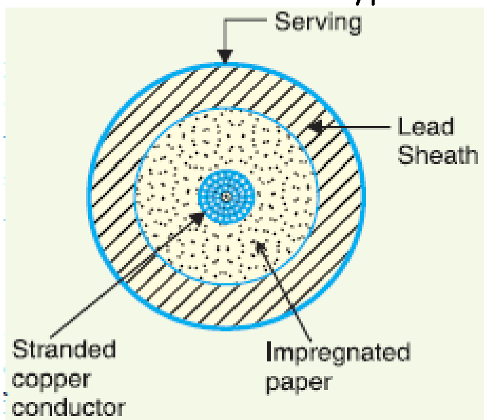


Fig: Single core low tension cable

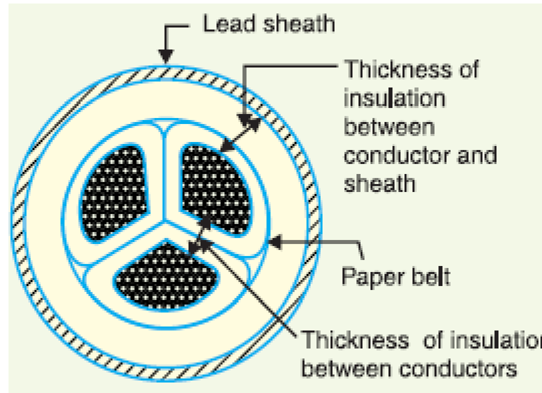


Fig: 3-core belted cable

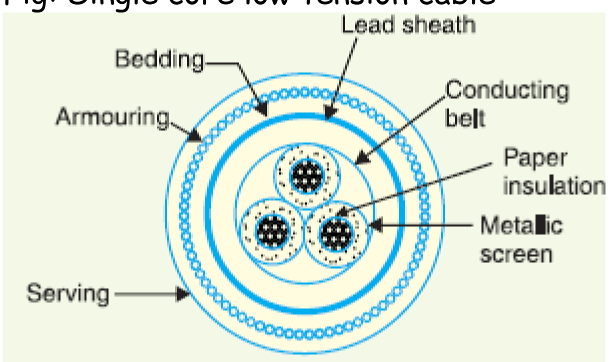


Fig: 3-core H-type cable

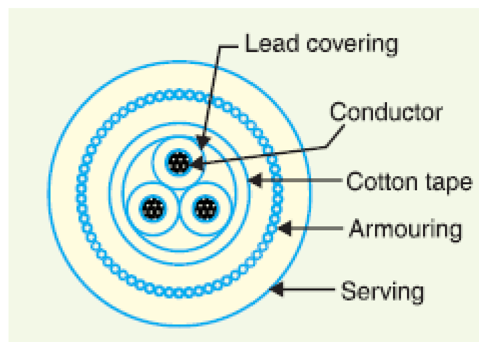


Fig: 3-core S.L. type cable

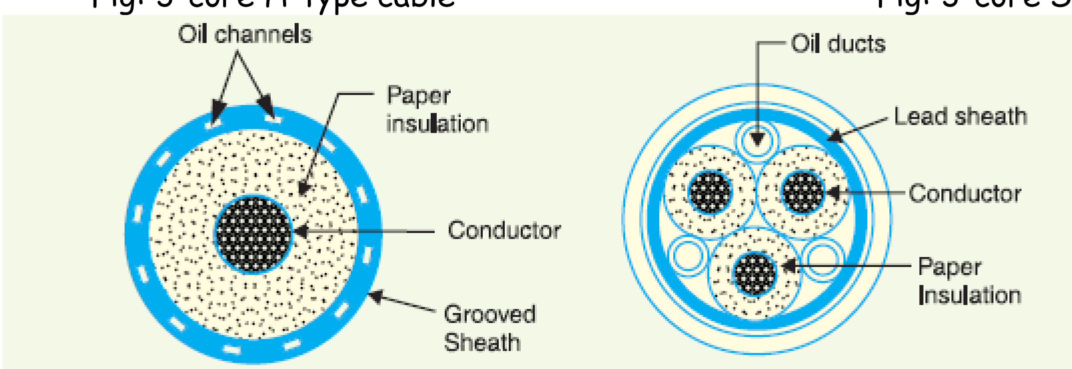


Fig: oil filled cable

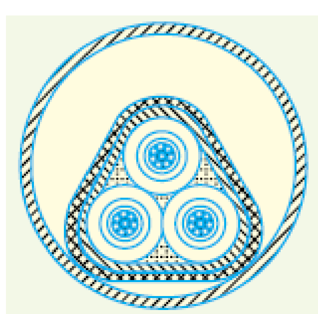


Fig: Gas pressure cable

Exercise No 7:(2Hours)-1Practical

Types of cable faults & its location.

AIM: To Study of types of cable faults & its location.

Theory:

Types of Cable Faults

Cables are generally laid directly in the ground or in ducts in the underground distribution system. For this reason, there are little chances of faults in underground cables. However, if a fault does occur, it is difficult to locate and repair the fault because conductors are not visible. Nevertheless, the following are the faults most likely to occur in underground cables :

(i) Open-circuit fault
(ii) Short-circuit fault
(iii) Earth fault.

(i) Open-circuit fault: When there is a break in the conductor of a cable, it is called open-circuit fault. The open-circuit fault can be checked by a megger. For this purpose, the three conductors of the 3-core cable at the far end are shorted and earthed. Then resistance between each conductor and earth is measured by a megger. The megger will indicate zero resistance in the circuit of the conductor that is not broken. However, if the conductor is broken, the megger will indicate infinite resistance in its circuit.

(ii) Short-circuit fault: When two conductors of a multi-core cable come in electrical contact with each other due to insulation failure, it is called a short-circuit fault. Again, we can seek the help of a megger to check this fault. For this purpose, the two terminals of the megger are connected to any two conductors. If the megger gives zero reading, it indicates short- circuit fault between these conductors. The same step is repeated for other conductors taking two at a time.

(iii) Earth fault: When the conductor of a cable comes in contact with earth, it is called earth fault or ground fault. To identify this fault, one terminal of the megger is connected to the conductor and the other terminal connected to earth. If the megger indicates zero reading, it means the conductor is earthed. The same procedure is repeated for other conductors of the cable.

Loop Tests For Location of Faults in Und erground Cables

There are several methods for locating the faults in underground cables. However, two popular methods known as loop tests are :

(i) Murray loop test
(ii) Varley loop test

These simple tests can be used to locate the earth fault or short-circuit fault in underground cables provided that a sound cable runs along the faulty cable. Both these tests employ the principle of Wheatstone bridge for fault location.

(i) Murray Loop Test

The Murray loop test is the most common and accurate method of locating earth fault or short-circuit fault in underground cables.

a. Earth fault :

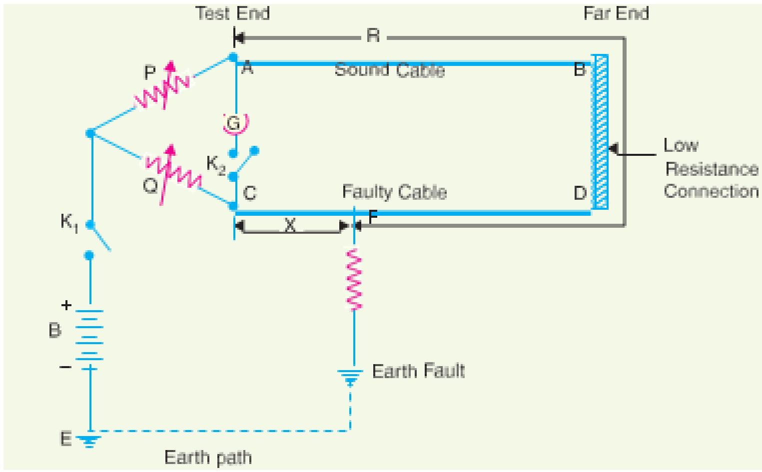


Fig a.

Fig. a. shows the circuit diagram for locating the earth fault by Murray loop test. Here AB is the sound cable and CD is the faulty cable; the earth fault occuring at point F. The far end D of the faulty cable is joined to the far end B of the sound cable through a low resistance link. Two variable resistances P and Q are joined to ends A and C (See Fig. a.) respectively and serve as the ratio arms of the Wheatstone bridge.

Let R = resistance of the conductor loop upto the fault from the test end

X = resistance of the other length of the loop

Note that P, Q, R and X are the four arms of the Wheatstone bridge. The resistances P and Q are varied till the galvanometer indicates zero deflection.

In the balanced position of the bridge, we have,

$$\frac{P}{Q} = \frac{R}{X}$$

or $$\frac{P}{Q} + 1 = \frac{R}{X} + 1$$

or $$\frac{P+Q}{Q} = \frac{R+X}{X}$$

If r is the resistance of each cable, then $R + X = 2r$.

$\therefore$ $$\frac{P+Q}{Q} = \frac{2r}{X}$$

or $$X = \frac{Q}{P+Q} \times 2r$$

If l is the length of each cable in metres, then resistance per metre length of cable $= \frac{r}{l}$

$\therefore$ Distance of fault point from test end is

$$d = \frac{X}{r/l} = \frac{Q}{P+Q} \times 2r \times \frac{l}{r} = \frac{Q}{P+Q} \times 2l$$

or $$d = \frac{Q}{P+Q} \times \text{(loop length)} \text{ *metres}$$

Thus the position of the fault is located. Note that resistance of the fault is in the battery circuit and not in the bridge circuit. Therefore, fault resistance does not affect the balancing of the bridge. However, if the fault resistance is high, the sensitivity of the bridge is reduced.

b. Short-circuit fault : Fig. 11.23 shows the circuit diagram for locating the short-circuit fault by Murray loop test. Again P, Q, R and X are the four arms of the bridge. Note that fault resistance is in the battery circuit and not in the bridge circuit. The bridge in balanced by adjusting the resistances P and Q. In the balanced position of the bridge :

$$\frac{P}{Q} = \frac{R}{X}$$

or $$\frac{P+Q}{Q} = \frac{R+X}{X} = \frac{2r}{X}$$

$\therefore$ $$X = \frac{Q}{P+Q} \times 2r$$

or $$X = \frac{Q}{P+Q} \times \text{(loop length) metres}$$

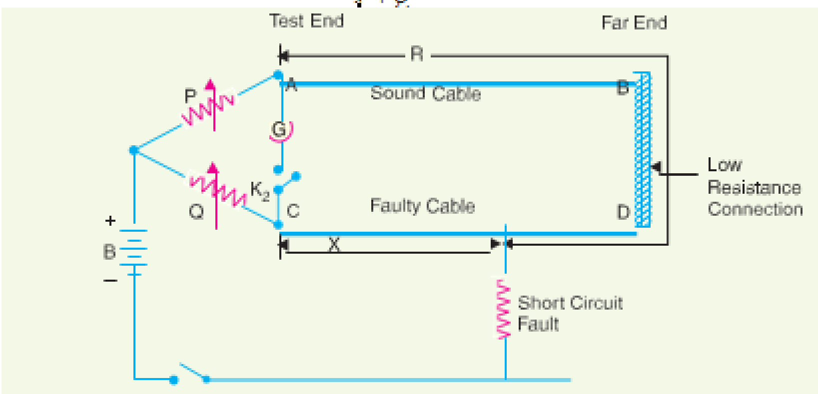


Fig. 11.23

Thus the position of the fault is located.

ii. Varley loop test:

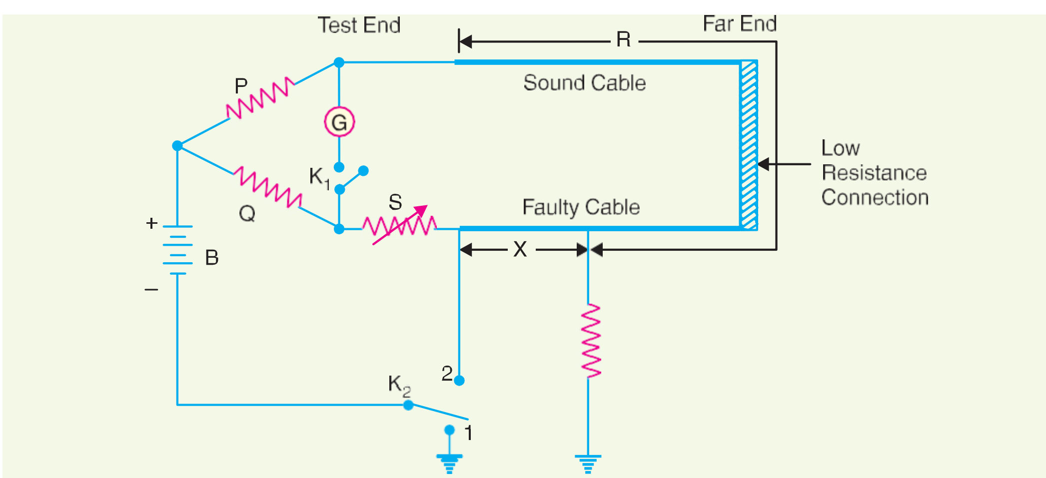


Fig. 11.24 Varley Loop Test (Earth Fault)

The Varley loop test is also used to locate earth fault or short-circuit fault in underground cables. This test also employs Wheatstone bridge principle. It differs from Murray loop test in that here the ratio arms *P* and *Q* are fixed resistances. Balance is obtained by adjusting the variable resistance *S* connected to the test end of the faulty cable. The connection diagrams for locating

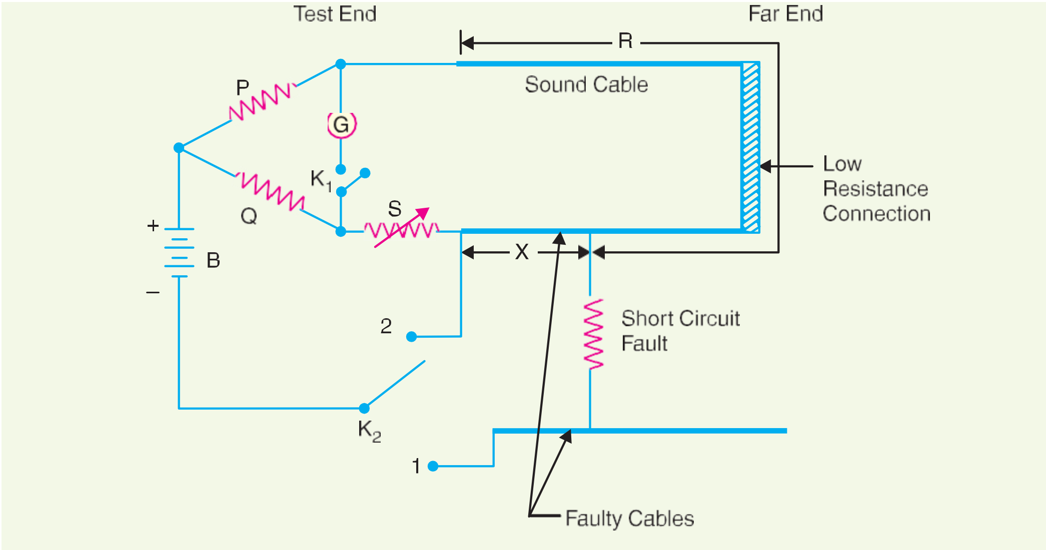


Fig. 11.25 Varley Loop Test (Short Circuit Test)

the earth fault and short-circuit fault by Varley loop test are shown in Figs. 11.24 and 11.25 respectively.

For earth fault or short-circuit fault, the key K_2 is first thrown to position 1. The variable resistance S is varied till the bridge is balanced for resistance value of S_1. Then,

$$\frac{P}{Q} = \frac{R}{X + S_1}$$

or $$\frac{P+Q}{Q} = \frac{R + X + S_1}{X + S_1}$$

or $$X = \frac{Q(R+X) - PS_1}{P+Q} \qquad ...(i)$$

Now key K_2 is thrown to position 2 (for earth fault or short-circuit fault) and bridge is balanced with new value of resistance S_2. Then,

$$\frac{P}{Q} = \frac{R+X}{S_2}$$

or $$(R+X)\,Q = PS_2 \qquad ...(ii)$$

From eqs. (i) and (ii), we get,

$$X = \frac{P(S_2 - S_1)}{P+Q}$$

Since the values of P, Q, S_1 and S_2 are known, the value of X can be determined.

Loop resistance $= R + X = \frac{P}{Q} S_2$

If r is the resistance of the cable per metre length, then,

Distance of fault from the test end is

$$d = \frac{X}{r} \text{ metres}$$

Conclusion: Hence we have studied types of faults & loop tests for location of faults in underground cables.

Exercise No 8:(2Hours)–1Practical

Measurement of ABCD parameters of transmission line.

AIM: To Measure the ABCD parameters of transmission line.

APPARATUS:

1) Input supply voltage=
phase,230V,50Hz.,ACsupply.
2) Current capacity= 1 amp.
3) Line voltage assumed as 220 KV.
4) Line length assumed as,
a)Short length=100Km
b)Medium length=200Km.
c)Long length=400Km

THEORY:

1)For open circuit test

$V_s=A.V_r+BI_r$

$A=V_s/V_r-B.I_r$

As $I_r=-0$

$A=V_s/V_r$

Now, $I_s=C.V_r+D.I_r$

$I_s=C.V_r$ (as $I_r=0$)

$C=I_s/V_r$

2)calculation for short circuit test

$V_s=A.V_r+B.I_r$

$B=(V_s-A.V_r)/I_r$

As, $V_r=0$ $B=V_s/I_r$

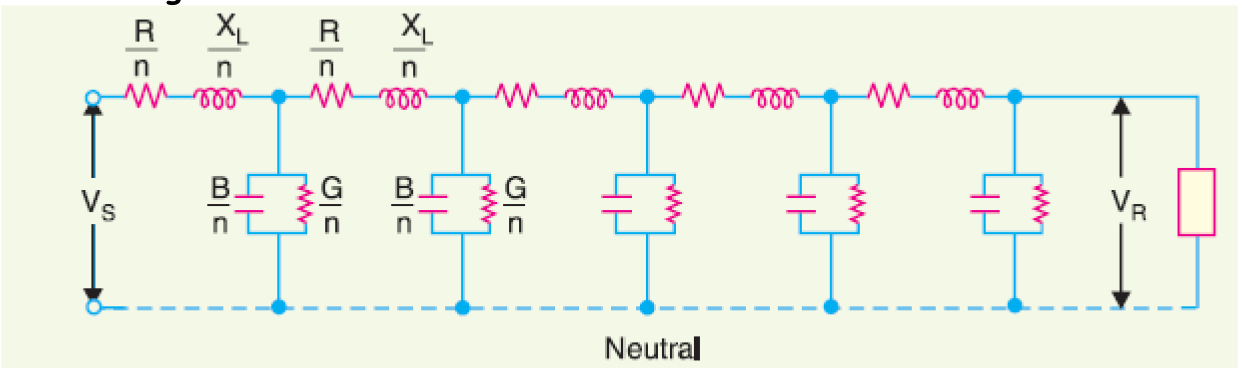
$I_s=C.V_r+DI_r$

$I_s=D.I_r$ ($V_r=0$)

$D=I_s/I_r$

Now, A.D-B.C=

Circuit Diagram:



PROCEDURE:

1. Connect input supply to the sending end of transmission line.
2. Adjust sending end voltage at 220V by autotransformer.

3. Now measure open circuit parameters of transmission line.
Vs (sending end voltage)
Is (sending end current)
Vr (receiving end voltage)
Ir receiving end current)
4. Now decrease sending end voltage to zero &short circuit the receiving end.
5) Now slowly increase sending end voltage &adjust sending end current to 1 amp.
6) Now, measure short circuit parameters.
Vs, Is, Vr & Ir

Observation table:

Sr. No.	Sending end vtg. (Vs)	Sending Current (Is)	Receiving end vtg (Vr)	Receiving current (Ir)
1.				
2.				
3.				

Calculation:

1) Long line open circuit
Vs=… Is=… Vr=… Ir=….

A=Vs/Vr=….

C=Is/Vr=…..

2)Short circuit
Vs=… Is=… Vr=… Ir=...

CONCLUSION:

From Graph, Voltage and Current ratio we conclude that transformation ratio K= slope of the graph as well as Voltage and Current ratio is constant for 1-Φ transformer.

Exercise No 9:(2Hours)–1Practical

Line parameters of 'pie' model of transmission line.

AIM: To Study line parameters of 'pie' model of transmission line.

Theory:

In this method, capacitance of ujj each conductor (*i.e.,*line to neutral) is divided into two halves ;one half being lumped at the sending end and the other half at the receiving end as shown in Fig. 10.16. It is obvious that capacitance at the sending end has no effect on the line drop. However, its charging current must be added to line current in order to obtain the total sending end current.

Let I_R = load current perphase

R = resistance perphase

X_L = inductive reactance perphase

C = capacitance perphase

$\cos\phi_R$ = receiving end power factor(*lagging*)

V_S = sending end voltage perphase

$$\vec{V_R} = V_R + j0$$

Load current, $\vec{I_R} = I_R(\cos\phi_R - j\sin\phi_R)$

Charging current at load end is

$$\vec{I_{C1}} = j\omega(C/2)\vec{V_R} = j\pi fC\vec{V_R}$$

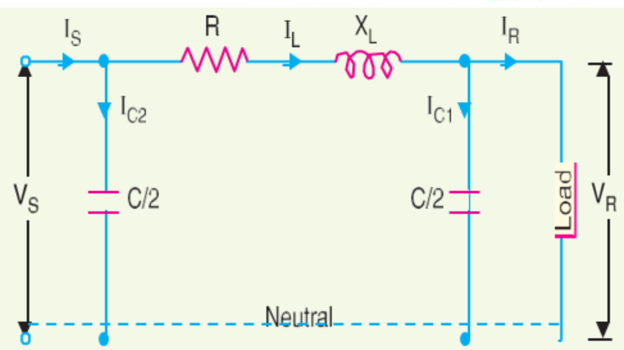


Fig. 10.16

The*phasordiagramforthecircuitisshowninFig.10.17.Takingtherec eivingendvoltageas the reference phasor, wehave,

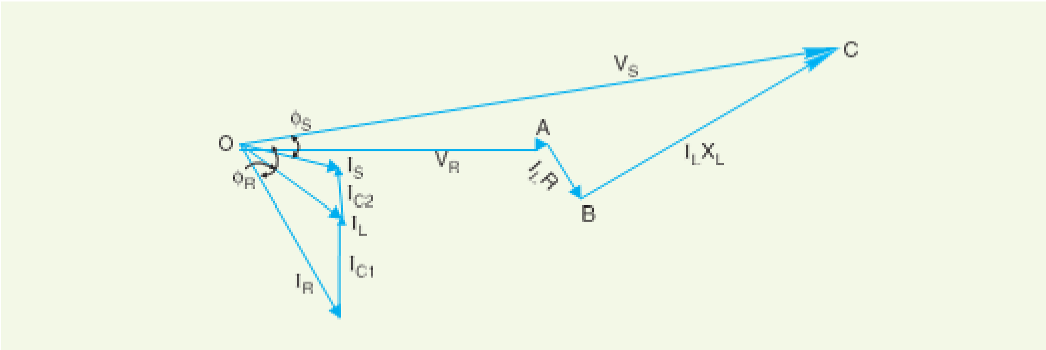


Fig. 10.17

Line current, $\overrightarrow{I_L} = \overrightarrow{I_R} + \overrightarrow{I_{C1}}$

Sending end voltage, $\overrightarrow{V_S} = \overrightarrow{V_R} + \overrightarrow{I_L}\,\overrightarrow{Z} = \overrightarrow{V_R} + \overrightarrow{I_L}\,(R + jX_L)$

Charging current at the sending endis

$$\overrightarrow{I_{C2}} = j\,\omega\,(C/2)\,\overrightarrow{V_S} = j\,\pi\,f\,C\,\overrightarrow{V_S}$$

$\therefore$ Sending end current, $\overrightarrow{I_S} = \overrightarrow{I_L} + \overrightarrow{I_{C2}}$

Conclusion : Hence we have studied parameters of 'pie' model of transmission line

Exercise No 10:(2Hours)-1Practical

Line parameters of 'T' model of transmission line.

AIM: To Study line parameters of 'T' model of transmission line.

Theory:

Nominal T Method

In this method, the whole line capacitance is assumed to be concentrated at the middle point of the line and half the line

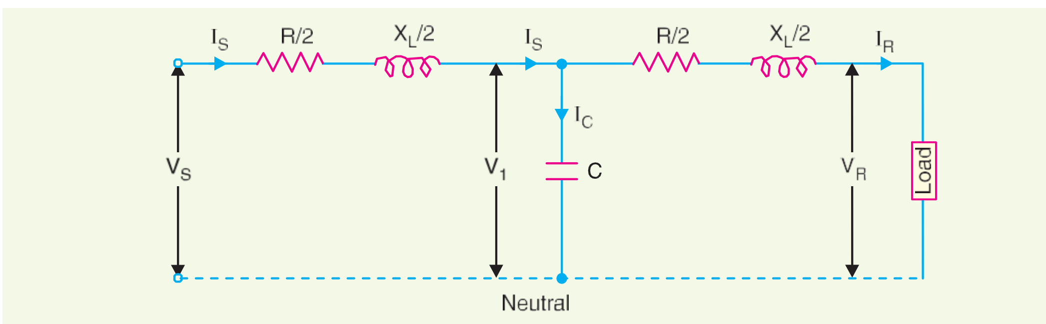


Fig. 10.11

resistance and reactance are lumped on its either side as shown in Fig.10.11.

There- fore, in this arrangement, full charging current flows over half the line. In Fig.10.11, one phase of3- phase transmission line is shown as it is advantageous to work in phase instead of line-to-line values.

Let I_R = load current per phase;

R = resistance per phase
X_L = inductive reactance per phase;
C = capacitance per phase
Cos ϕ_R = receiving end power factor(*lagging*);
V_S=sending end voltage/phase
V_1 = voltage across capacitor C
The*phasordiagramforthecircuitisshowninFig.10.12.Takingthereceivingendvoltage $\vec{V_R}$ as the reference phasor, we have,

Receiving end voltage, $\vec{V_R} = V_R + j\,0$

Load current, $\overline{I_R} = I_R(\cos\phi_R - j\sin\phi_R)$

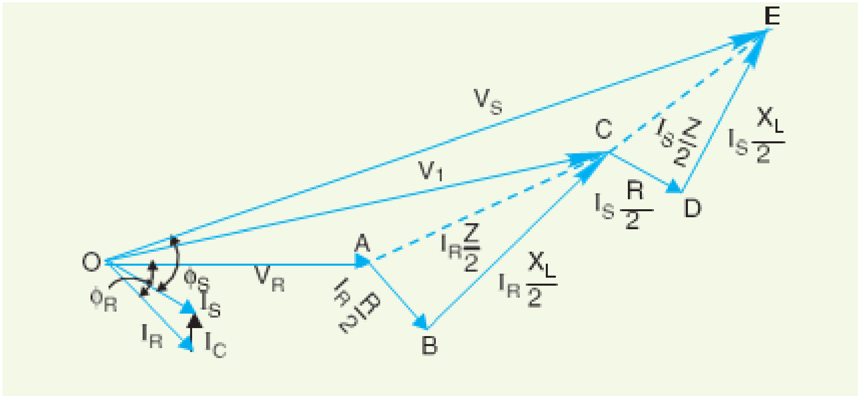


Fig. 10.12

Voltage across C, $\quad \vec{V_1} = \vec{V_R} + \vec{I_R}\,\vec{Z}/2$

$$= V_R + I_R(\cos\phi_R - j\sin\phi_R)\left(\frac{R}{2} + j\,\frac{X_L}{2}\right)$$

Capacitive current, $\quad \vec{I_C} = j\,\omega\,C\,\vec{V_1} = j\,2\pi f\,C\,\vec{V_1}$

Sending end current, $\quad \vec{I_S} = \vec{I_R} + \vec{I_C}$

Sending end voltage, $\quad \vec{V_S} = \vec{V_1} + \vec{I_S}\,\frac{\vec{Z}}{2} = \vec{V_1} + \vec{I_S}\left(\frac{R}{2} + j\,\frac{X_L}{2}\right)$

Conclusion : Hence we have studied parameters of 'T' model of transmission line