Transmission and Distribution Laboratory

(PCC- EE-212G**)**

IVSEMESTER

Prepared By.

Sh.Sandeep Kumar (A.P.)

B. Tech. (EEE), M. Tech. (EEE)

Department Of Electrical Engineering

BRCM College of Engineering & Technology

Bahal

Transmission and Distribution Laboratory

Class Work: 25
Exam : 25
Total : 50

Course Code	**PCC-EE-212G**		
Category	**Engineering Science Course**		
Course title	**Transmission and Distribution** (Laboratory)		
Scheme	**L**	**T**	**P**
	-	**-**	**2**

Notes:

At least 10 experiments are to be performed by students in the semester.

At least 7 experiments should be performed from the list, remaining three experiments may either be performed from the above list or designed and set by the concerned institution as per the scope of the syllabus

LIST OF EXPERIMENTS:

1. To study the Power System blocks in MATLAB.
2. To design short and long transmission line using MATLAB.
3. To study and calculate the transmission line parameters.
4. To study the corona loss in power distribution system.
5. To study the proximity and skin effect.
6. To find ABCD parameters of a model of transmission line.
7. To study performance of a transmission line under no load condition & under load at Different power factors.
8. To observe the Ferranti effect in a model of transmission line.
9. To study performance characteristics of typical DC distribution system in radial & ring main configuration.
10. To study mechanical design of transmission line.
11. IDMT CHARACTERISTICS OF OVER CURRENT RELAY

Experiment No. 1

IDMT CHARACTERISTICS OF OVER CURRENT RELAY

Aim: To study the Operation of a Non- Directional electromechanical type over current (I D M T relay) and plot the inverse time current characteristics**.**

Apparatus required:

S.No	Apparatus	Type	Quantity
1	IDMT Over current relay	Electro- mechanical	1No
2	Timer	Digital	1No
3	Fault creation Panel	Digital	1No
4	Ammeter	30A MI	1No
5	Current Transformer-40/2A	Core type	1No

Theory: A non-directional heavily damped induction disc relay which has an adjustable inverse time/current characteristic with a definite minimum time. The relay has a high torque movement combined with low burden and low overshoot. The relay disc is so shaped that as it rotates the driving torque increases and offsets the changing restraining torque of the control spring. This feature combined with the high torque of the relay ensures good contact pressure even at currents near pick-up. Damping of the disc movement is by a removable high retentivity permanent magnet. The unique method of winding the operating coil ensures that the time/current characteristics are identical on each of the seven current taps. Selection of the required current setting is by means of a plug setting bridge which has a single insulated plug. The maximum current tap is automatically connected when the plug is withdrawn from the bridge, allowing the setting to be changed under load without risk of open circuiting the current transformers. The IDMT relay has an auxiliary unit which is powered by a secondary winding on the electromagnet through a rectifier and as such a separate auxiliary supply is not required. The disc unit operates and closes its contacts, the auxiliary element connected across the secondary winding on the electromagnet operates, and one normally open contact of the auxiliary element reinforces the disc contact.

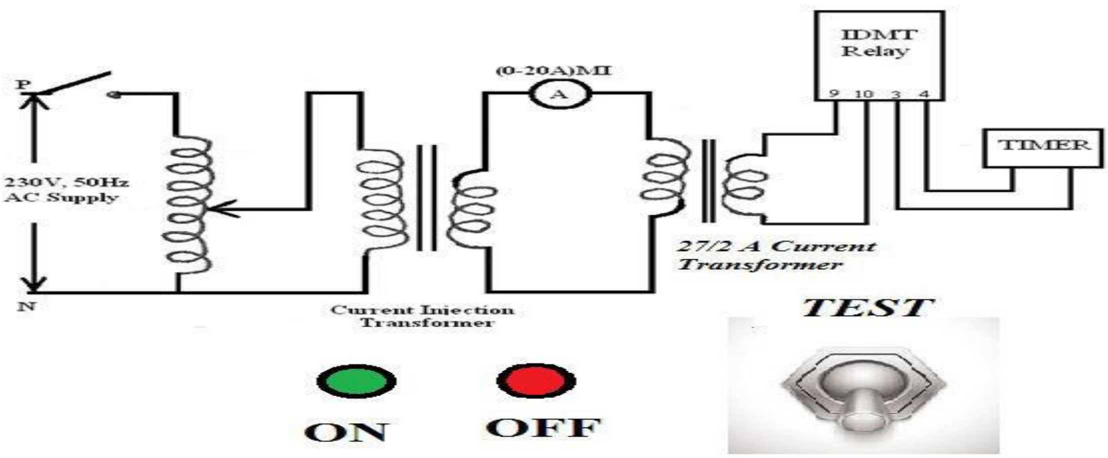
Pick Up Current of Relay:

In all electrical relays, the moving contacts are not free to move. All the contacts remain in their respective normal position by some force applied on them continuously. This force is called controlling force of the relay. This controlling force may be gravitational force, may be spring force, and may be magnetic force. The force applied on the relay’s moving parts for changing the normal position of the contacts, is called deflecting force. This deflecting force is always in opposition of controlling force and presents always in the relay. Although the deflecting force always presents in the relay directly connected to live line, but as the magnitude of this force is less than controlling force in normal condition, the relay does not operate. If the actuating current in the relay coil increases gradually, the deflecting force in electro mechanical relay is also increased. Once, the deflecting force crosses the controlling force, the moving parts of the relay initiate to move to change the position of the contacts in the relay. The current for which the relay initiates it operation is called pick up current of relay.

Current Setting of Relay:

The minimum pick up value of the deflecting force of an electrical relay is constant. Again the deflecting force of the coil is proportional to its number of turns and current flowing through the coil.Now, if we can

change the number of active turns of any coil, the required currentto reach at minimum pick value of the deflecting force, in the coil also changes. That means if active turns of the relay coil is reduced, then proportionately more current is required to produce desired relay actuating force.
Similarly if active turns of the relay coil are increased, then proportionately reduced current is required to produce same desired deflecting force.
Practically same model relays may be used in different systems. As per these systems requirement the pick-up current of relay is adjusted. This is known as current setting of relay. This is achieved by providing required number of tapping in the coil. These taps are brought out to a plug bridge. The number of active turns in the coil can be changed by inserting plug in different points in the bridge.
The current setting of relay is expressed in percentage ratio of relay pick up current to rated secondary current of CT.
For example, an over current relay should operate when the system current just crosses 125% of rated current. If the relay is rated with 1 A, the normal pick up current of the relay is 1 A and it should be equal to secondary rated current of current transformer connected to the relay.
Then, the relay will be operated when the current of CT secondary becomes more than or equal 1.25 A. As per definition,
The current setting is sometimes referred as current plug setting. The current setting of over current relay is generally ranged from 50% to 200%, in steps of 25%. For earth fault relay it is from 10% to 70% in steps of 10%.
Hence, pick up current of the relay is, 1 × 150 % = 1.5 A. Now, suppose fault current in the CT primary is 1000 A. Hence, fault current in the CT secondary i.e. in the relay coil is, 1000 × 1/200 = 5 A. Therefore PSM of the relay is, 5 / 1.5 =3.33
In order to adjust the relay operating time, both of the factors are to be adjusted. The adjustment of travelling distance of an electromechanical relay is commonly known as time setting. This adjustment is commonly known as **time setting multiplier of relay**. The time setting dial is calibrated from 0 to 1 in steps 0.05 sec. But by adjusting only time setting multiplier, we cannot set the actual time of operation of an electrical relay. As the time of operation also depends upon the speed of operation. The speed of moving parts of relay depends upon the force due to current in the relay coil. Hence it is clear that, speed of operation of an electrical relay depends upon the level of fault current. In time setting multiplier, this total travelling distance is divided and calibrated from 0 to 1 in steps of 0.05. So when time setting is 0.1, the moving part of the relay has to travel only 0.1 times of the total travelling distance, to close the contact of the relay.
IDMT relay is inverse definite minimum time relay. It is one in which Time of operation is inversely proportional to magnitude of fault current near pickup value and becomes substantially constant slightly above the pickup value of the Relay. This is achieved by using a core of the Electro Magnet which gets saturated for currents slightly greater than the pickup current. Fault current and measure relay operation
CIRCUIT DIAGRAM:



time is used to conduct the experiment. Values recorded for various TSMs and PSMs. Characteristics studied with the help of a graph and correlated with theory. This relay consists of Induction disc unit with an operation indicator and in some cases an instantaneous high set unit all assembled are in standard frame. Type disc shaft carried silver rod moving contacts which complete the auxiliary unit circuit through the fixed contract. Permanent magnet is used to control the disc speed. The setting is adjusted by the movement of the back stop which is controlled by the rotating a KNUR LED molded disc at the base of graduated time multiplier.

Procedure:

1. Connect the circuit as per the circuit diagram.

2. Select the P.S.M setting on the relay.

3. Make sure that the 1-phase dimmer stat is in minimum position, test switch is in ON position, and T.S.M settings of the relay are set to 0.5.

4. Increase the current in the circuit to the value calculated similar to step 2 depending on the PSM setting by varying the 1-phase variac.

5. Observe the relay tripping condition. The circuit will be in OFF position after relay tripping.

6. OFF the test switch, reset the timer and relay and push ON button. Make sure the rotating electromagnetic disc of relay is at initial position before switching ON.

7. Note down the value of tripping time and current.

8. Repeat the steps 3,4,5,6, 7to observe the operating time of the relay by increasing the fault current above calculated value of fault current in step 2 and tabulate the readings.

9. Repeat the same procedure for various T.S.M = 0.7

10. Plot the graph between time taken for relay to operate vs fault current for various T.S.M / P.S.M.

Precautions:-

- Disc must be stationary before applying fault current.
- TSM setting must be changed with due care.

SAMPLE OBSERVATIONS:

Rated Current : 0 to 25 Amps. CT Ratio: 40/2 Amps = 20.

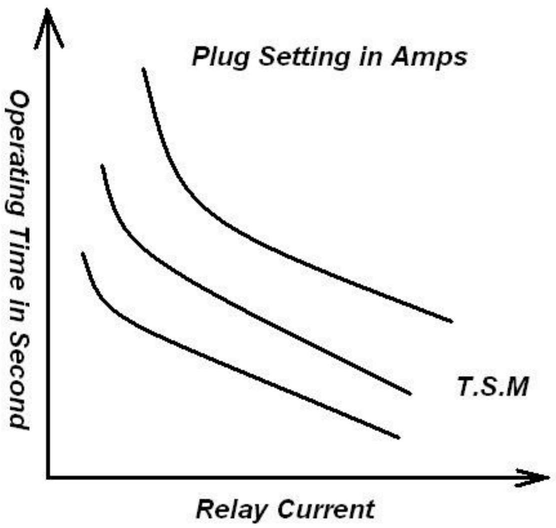
Pick-Up Current Setting = Plug setting Value X C.T ratio TSM = 0.1 to 0.6

PSM	Pick-Up Current
0.5	10
0.75	15
1.0	20
1.25	25

Readings and Tabular forms:-

PSM =		TSM =	
SNO.	Fault Current (A)	Time of operation TSM = 0.6(sec)	Time of operation TSM = 0.5(sec)

Expected graphs:


Plug Setting in Amps
Operating Time in Second
T.S.M
Relay Current

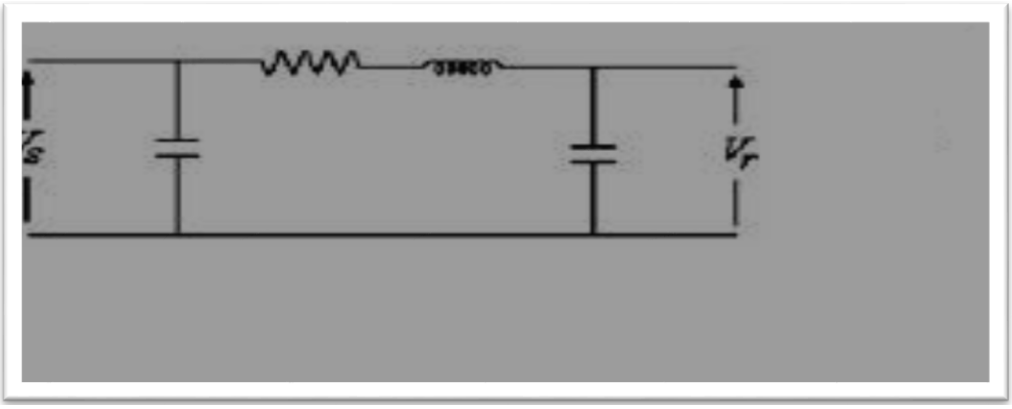
Experiment No. 2

Aim: To study Ferranti effect and voltage distribution in H.V. long transmission line using transmission line model.

Apparatus Used:

Transmission line model is consisting of four actions of transmission on line opera table at 220V with current rating at 2A connected in pi network. A continues variable power supply with two Digital voltmeter and two digital ammeter mounted on front panel with Resistive, Inductive, Capacitive load fitted in m.s. sheet complete with patch chords for interconnection. Additionally one LPF Wattmeter is required if A.B.C.D. parameter with phase angle is to be calculated, for which the calculation are given in our manual.

Theory: Transmission line model consists of four sections and each section represents 50 km long 400 KV transmission line. Parameters of 50 km long 400 KV Transmission line are taken as :- Series Inductance = 80 mH Series Resistance = 2 ohm (In addition to resistance of inductance coil) Shunt Capacitance = 0.47 microF Leakage resistance or Shunt Conductance = 470 kohm For actual 400 KV transmission lines range of parameter is :- l = Series Inductance = 1.0 to 2.0 mH/Km r = Series Resistance = 0.5 to 1.5 ohm /Km c = Shunt Capacitance = 0.008 to 0.010 microF/Km g = Leakage resistance (Shunt Conductance) = 3 x 10–8 to 5 x 10–8 mho/Km A long transmission line draws a substantial quantity of charging current. If such a line is open circuited for a very lightly loaded at the receiving end, the voltage at the receiving end may become higher then the voltage at the sending end. This is known as 'FERRANTI EFFECT' and is due to the voltage drop across the line inductance (due to the charging current) being in phase the sending end voltage. The both capacitance and inductance are necessary to produce this phenomenon. The capacitance and charging current is negligible in short line but significant in medium length lines and appreciable in long lines. Therefore, phenomenon occures in medium and long lines. In the phaser diagram, Ferranti effect is illustrated. The line may be represented by a nominal pi circuit so that half of the total line capacitance is assumed to be concentrated at the receiving end. OM represents the receiving end voltage. OC represents the current drawn by the capacitance assumed to be consetrated at the receiving end. MN is the resistance drop and NP is inductive reactance drop. OP is the sending end voltage under no load condition and is less than receiving end voltage.

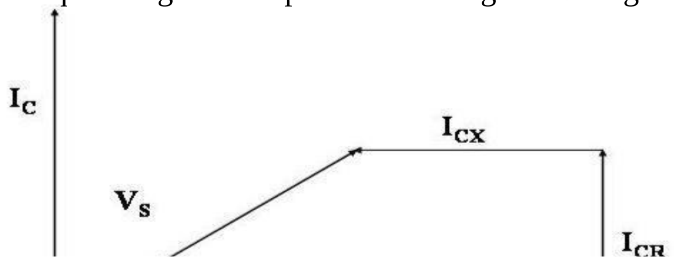


Procedure:

(i) Apply the voltage (200 V max.) to the sending end and connect power factor meter. Also connect 1 ammeter and voltmeter to each end (receiving and sending).

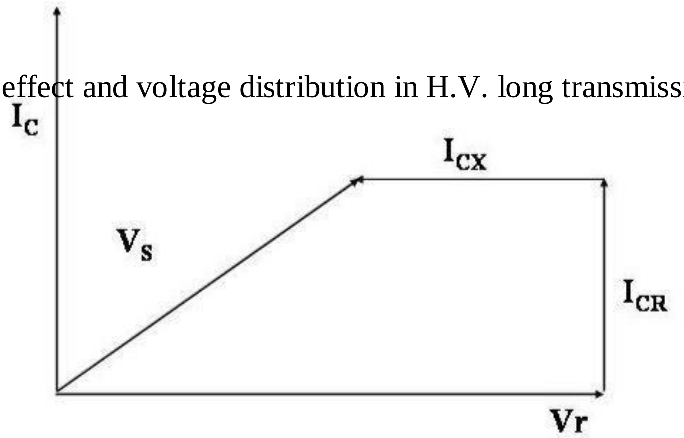
(ii) Connect the load comprising of R, L and C at the receiving end and note down the value of receiving end voltage.

Now remove the load from the receiving end and note down the voltage on receiving end. This voltage at the receiving end is quite large as compared to sending end voltage



LOAD	V_S (V)	I_S (A)	V_R (V)	I_R (A)
For Inductive	208			
For Capacitive	208			
For Resistive	208			
At No Load	208			

Result: We have performed Ferranti effect and voltage distribution in H.V. long transmission line using transmission line model.

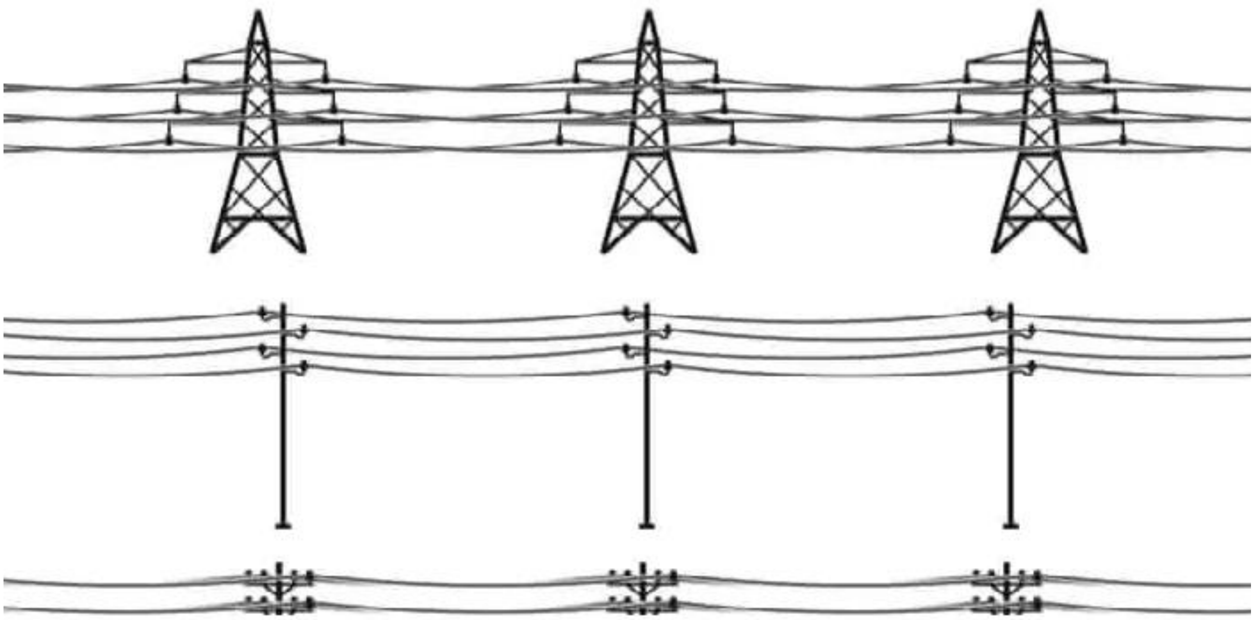


Experiment -3

To study the proximity and skin effect

Key Takeaways

- An increase in apparent resistance in a conductor causes a voltage drop and power loss. This phenomenon is called the proximity effect.
- A conductor's material, diameter, and structure all influence the intensity of the proximity effect.
- It is possible to reduce the proximity effect by reducing the size of the conductor and the frequency and by increasing the voltage and space between conductors.



The proximity effect is present in transmission lines when conductors are too close together

Delta-connected ac transmission lines transmit three-phase ac power between substations. When conductors are too close to each other in a delta arrangement, the proximity effect is present in transmission lines. The proximity effect could be avoided by keeping conductors spaced equally. However, extending the distance between transmission lines inflates the expense of the support structures, directly affecting the efficiency of the ac power transmission. In this article, we will discuss how to reduce the influence of the proximity effect in transmission lines.

The Proximity Effect in Transmission Lines

Conductors carrying alternating current will produce alternating flux in adjacent conductors. This alternating flux will cause a circulating current to start flowing in the conductor, creating a non-uniform current distribution in the transmission line, increasing the conductor's apparent resistance. The increased resistance along the transmission line causes a voltage drop and power loss. This phenomenon is called the proximity effect.

How Does the Proximity Effect Impact Transmission Lines?

The concentration of current through adjacent conductors varies with the alternating magnetic field and its associated eddy currents. When conductors carry current in the same direction, the currents flowing through them get concentrated at the conductors' farthest side. In contrast, when currents flowing through adjacent conductors flow in opposite directions, the currents get concentrated in the nearest side of both conductors.

As the alternating current frequency increases, the proximity effect becomes more intense. Conductors carrying 50Hz current endure less of the proximity effect than conductors carrying 60Hz current. The effective resistance and power loss is higher in 60Hz transmission lines than in 50Hz transmission lines. Most countries worldwide use 50Hz ac frequency, but the United States is not one of them. The 60Hz frequency in the transmission line causes more of the proximity effect than the 50Hz supply.

The proximity effect is due to varying magnetic fields, making it an impossible phenomenon in dc transmission. As dc frequency is zero, it fails to produce an alternating magnetic field in adjacent conductors. The current concentration remains uniform in dc transmission lines, apart from the influence of the skin effect.

Factors Influencing the Proximity Effect

Both transmission lines and nearby conductors carrying alternating currents experience the proximity effect. In ac transformers and inductors, the windings are close enough that the proximity effect is more predominant than the skin effect. If the conductors are stranded, both the internal proximity effect and external proximity effect exist. Several factors influence the proximity effect in transmission lines, including:

1. The conductor’s material - High ferromagnetic materials experience more proximity effects than non-ferromagnetic materials.
2. The conductor’s diameter - As the conductor’s diameter increases, the proximity effect also increases. The conductor’s diameter is dependent on current, and when the system current is high, the proximity effect becomes stronger.
3. Frequency - As the frequency increases, the proximity effect becomes more intense.
4. The conductor’s structure - The proximity effect is higher in solid conductors than in stranded conductors. The decreased surface area of stranded conductors causes the

proximity effect to be less than in solid conductors, which have more surface area. However, the internal proximity effect and external proximity effect exist in stranded conductors such as ACSR.

How to Reduce the Proximity Effect

Knowing the factors that create the proximity effect in transmission lines, it is possible to implement some changes. Several fixes can reduce the influence of the proximity effect, which include:

1. Reducing the size of the conductor - The proximity effect is directly proportional to the surface area of the conductor. Therefore, as the surface area increases, the proximity effect becomes stronger. Replacing solid conductors with stranded conductors helps reduce the conductor's surface area, decreasing the proximity effect.
2. Increasing the space between conductors - Dummy conductors can help increase the space between conductors. However, this will come at an added cost in support structures.
3. Increasing voltage and reducing frequency - Transferring power constantly through transmission lines increases voltage and decreases current—the reduced size of conductors decreases the proximity effect. Although not as practical, reducing the transmission voltage and current frequency is another means of reducing the proximity effect.

The proximity effect in transmission lines is a limitation in electrical ac power transmission.

The proximity effect is present not only in high voltage systems, but also in medium and low voltage systems. Cadence's software can help reduce the proximity effect in micro strips or strip lines in circuit boards.

Subscribe to our newsletter for the latest updates. If you're looking to learn more about how Cadence has the solution for you, talk to us and our team of experts

Experiment -4

Aim: - To find ABCD Parameter of a Model of Transmission Line

Apparatus:- Transmission Line model is consisting of four sections of transmission Kit.
Voltmeter-1, Ammeter-1, Power Supply-220V, Connected Wire (As per Requirement)
Theory:- ABCD Parameter are widely used in analysis of power transmission engineering where they will be turned as "Generalized circuit parameter" ABCD parameters are also called as Transmission parameter. It is conventional to designate the input port as sending end and the output port as receiving end while representing ABCD parameter

$V_s = AV_r + B I_r$

$I_s = CV_r + DI_r$

$[V_s/I_s] = [A\ B/C\ D]\ [V_r / I_r]$

Assuming the receiving end open Circuit i.e.

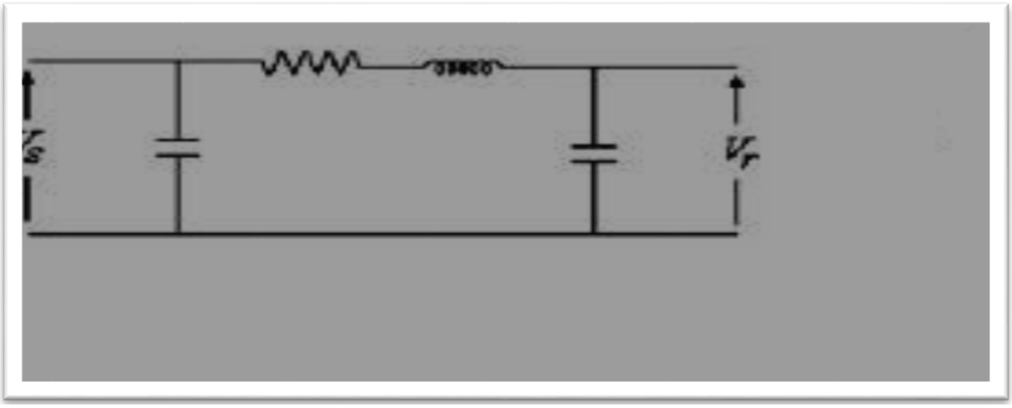
$A = V_s / V_r$ Where $I_r = 0$

$B = V_s / I_r$ Where $V_r = 0$

$C = I_s / V_r$ Where $I_r = 0$

$D = I_s / I_r$ Where $V_r = 0$

Diagram Circuit:-

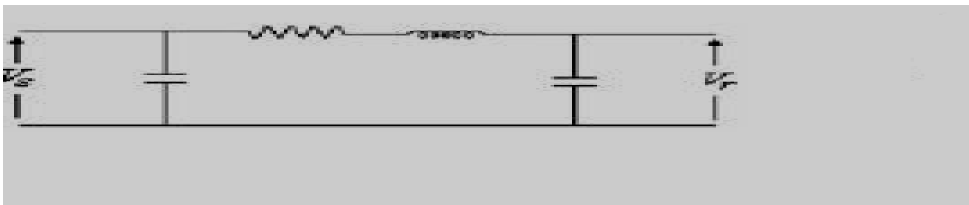


In transmission line if impedance at the sending end with Z_{12} at receiving end be Z_{11} and simulations the impedance looking back from receiving end with Z_{11} at input part is Z_{12} then Z_{11} and Z_{12} termed as the image impendence of the network

$Z_{11} = \frac{\sqrt{AB}}{CD}$ and $Z_{12} = \frac{\sqrt{BD}}{AC}$

$\alpha = \tanh^{-1} = \frac{\sqrt{BD}}{AC}$

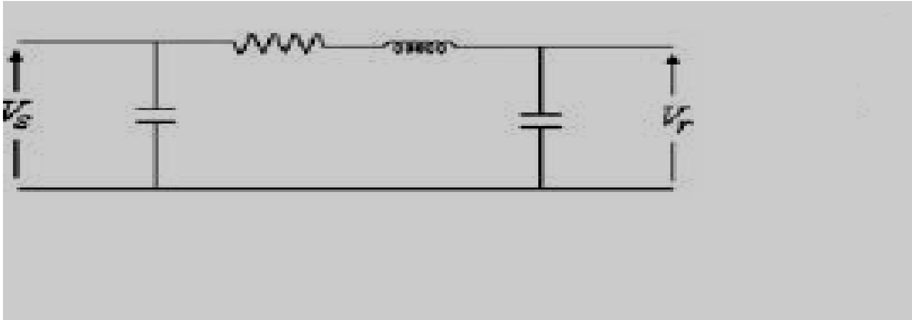
Open Circuit:-



Calculation & Observation:-

S. No	Vs	Is	Vr	A= V1 / V2	C = I1 / V2

Short Circuit:-



S. No	Vs	Is	Ir	B= Vs / Ir	D = Is / Ir

Procedure:-

1. To find out A and C parameters connect voltage supply of 220V to sending end and open circuit receiving end.
2. Observe the voltage of Vs,Is and Vr with the help of voltmeter and ammeters in the experimental kit.
3. To find out B and D receiving end is short circuited and supply of 220V is given to sending end.
4. Observe the voltage of Vs , Is and Ir

Result: - The Calculated A, B, C, D Parameters are

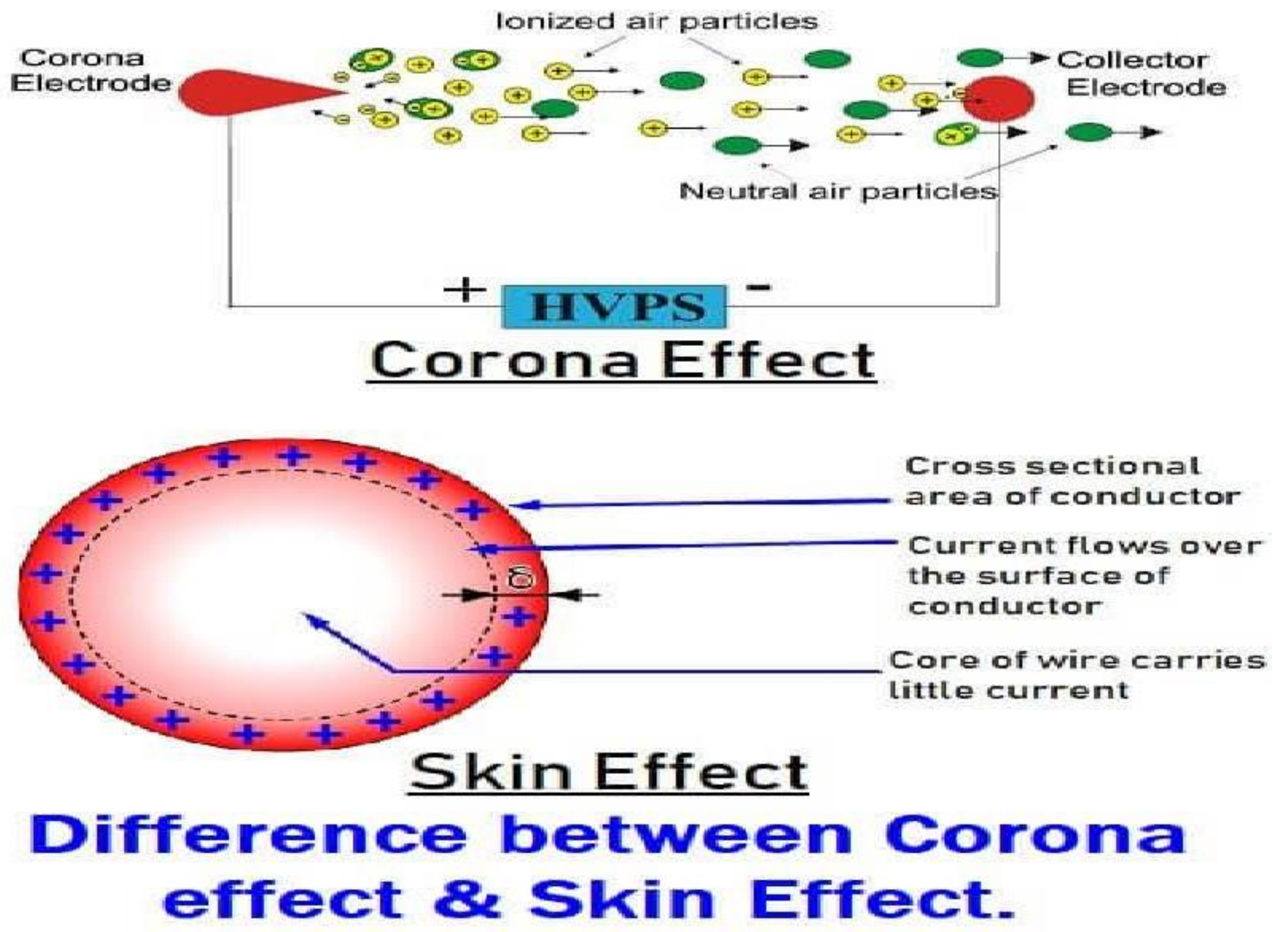
A=
B=
C=
D=

EXP-5

Aim:- To study the corona loss in power distribution system.

Theory:-

Corona Loss. **Corona loss** is the other major type of **power loss** in transmission lines. Essentially, **corona loss** is caused by the ionization of air molecules near the transmission line conductors. These coronas do not spark across lines, but rather carry current (hence the **loss**) in the air along the wire.



Corona loss in transmission line

Corona appears in the transmission line when the surface voltage gradient at the line conductor reaches the breakdown stress. Due to corona, heat and bluish light produce. There is a loss of power and energy dissipation. This loss is known as the **corona loss**.

The efficiency of the transmission line decreased due to corona loss.

There is also a minor effect on the voltage regulation of the transmission line. But this is always negligible.

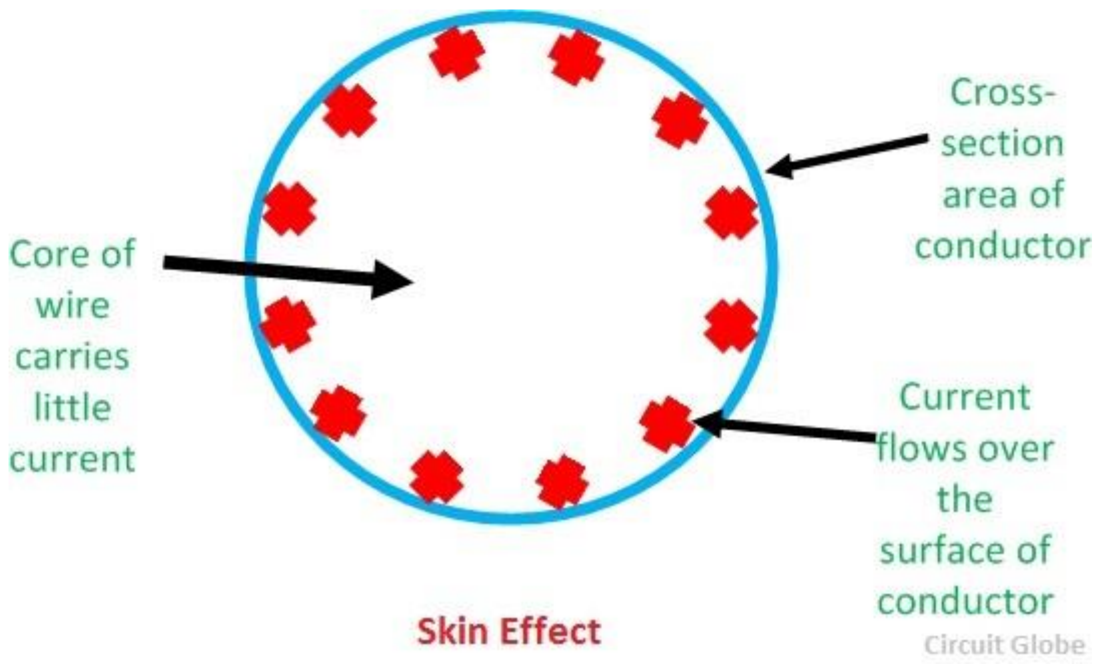
In normal and fair atmospheric conditions, the corona loss can vary between few kW/km lengths of the conductor in Extra high voltage transmission line.

Particularly in a thunderstorm, the corona loss is very high. It can be hundreds of kW/km in bad weather conditions.

Factors affecting corona loss

1) Atmospheric condition

The corona loss occurs due to the ionization of air between the conductors. In stormy weather conditions, the rainy condition number of ions in the air between the conductors will be more. Hence, chances of corona occurrence will increase.



2) The physical condition of the conductor

- **Line voltage:** If the line voltage is more, the electric field between the conductor is more. Hence the chance of corona occurrence is more. In a low voltage transmission line, there is less chance of corona.
- **Ratio D/r:** 'D' is the distance between the conductors and 'r' is the radius of the conductor. If the distance between the conductor is more compared to the radius, the possibility of the corona is reduced. The strength of the electrostatic field reduced because of the large spacing between the conductors.
- **Nature of conductor surface:** The rough and irregular surface of the conductor gives rise to more corona. Stranded conductors give rise to more corona compare to the circular conductor.
- **The roughness of conductor:** Surface causes field distortion and high voltage gradient developed in the local area of the conductor. Thus, the chance of the occurrence of the corona is more.

3) Effect of the frequency

Corona is directly proportional to the supply frequency.

4) Effect of density of air

Corona is intentionally proportional to the density of air. Density is lower in the hilly area. Hence, in this area more chance of the corona.

5) Effect of air conductivity

Higher conductivity leads to higher corona.

Methods to reduce the corona effect

- The corona effect can be reduced by increasing the radius of the conductor or by increasing the distance between the conductors. The spacing between the conductor cannot increase beyond a certain level. Therefore, increase the radius of the conductor to reduce the corona effect.
- The open parts like a clamp, support, etc. are designed with a smooth surface.
- Operating the line at lower voltage reduces the corona loss.

Experiment -6

An **electric power distribution** system can be classified according to its **feeder connection schemes or topologies** as follows -

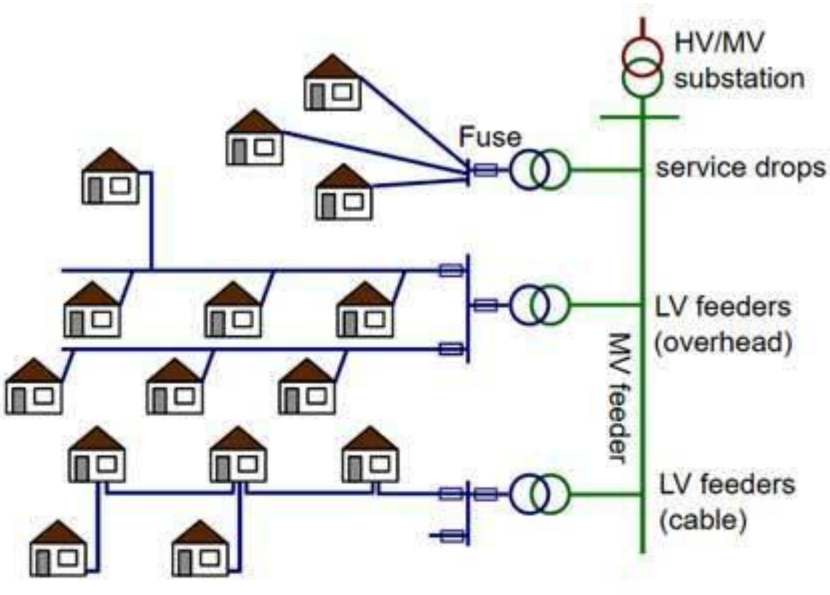
- Radial distribution system
- Parallel feeders distribution
- Ring main distribution system
- Interconnected distribution

There are few other **variations of distribution feeder systems**, but we'll stick to these four basic and commonly used systems.

[Also read: Classification of distribution systems according to number of phases and wires involved.]

Radial Distribution System

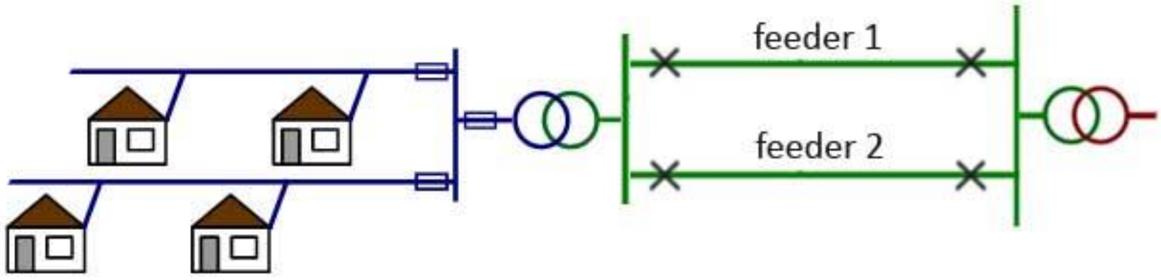
This system is used only when substation or generating station is located at the center of the consumers. In this system, different feeders radiate from a substation or a generating station and feed the distributors at one end. Thus, the main **characteristic of a radial distribution system** is that the power flow is in only one direction. Single line diagram of a typical radial distribution system is as shown in the figure below. It is the simplest system and has the lowest initial cost.



Although this system is simplest and least expensive, it is not highly reliable. A major **drawback of a radial distribution system** is, a fault in the feeder will result in supply failure to associated consumers as there won't be any alternative feeder to feed distributors.

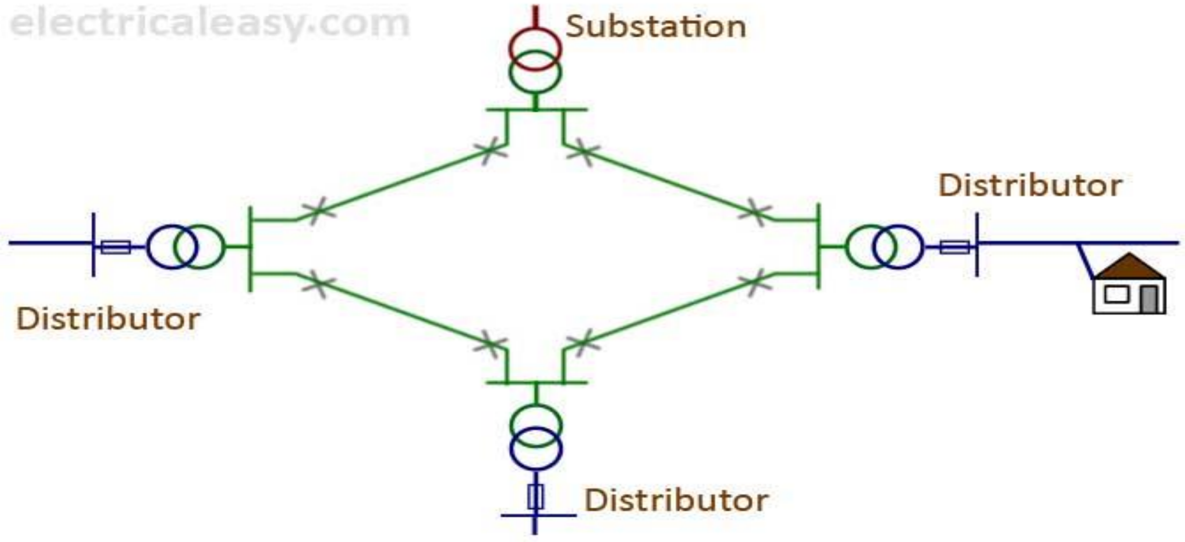
Parallel Feeders Distribution System

The above-mentioned disadvantage of a radial system can be minimized by introducing parallel feeders. The initial cost of this system is much more as the number of feeders is doubled. Such system may be used where reliability of the supply is important or for load sharing where the load is higher. (Reference: EEP - Distribution Feeder Systems)



Ring Main Distribution System

A similar level of system reliability to that of the parallel feeders can be achieved by using **ring distribution system**. Here, each distribution transformer is fed with two feeders but in different paths. The feeders in this system form a loop which starts from the substation bus-bars, runs through the load area feeding distribution transformers and returns to the substation bus-bars. The following figure shows a typical single line diagram of a ring main distribution system.



Ring main distribution system is the most preferred due to its following advantages.

Advantages Of Ring Main Distribution System

- There are fewer voltage fluctuations at consumer's terminal.
- The system is very reliable as each distribution transformer is fed with two feeders. That means, in the event of a fault in any section of the feeder, the continuity of the supply is ensured from the alternative path.

Interconnected Distribution System

When a ring main feeder is energized by two or more substations or generating stations, it is called as an interconnected distribution system. This system ensures reliability in an event of transmission failure. Also, any area fed from one generating stations during peak load hours can be fed from the other generating station or substation for meeting power requirements from increased load.

Experiment -7

AIM COMPUTATION OF PARAMETERS AND MODELLING OF TRANSMISSION LINES

(i) To determine the positive sequence line parameters L and C per phase per kilometer of a three phase single and double circuit transmission lines for different conductor arrangements.

(ii)To understand modeling and performance of medium lines.

SOFTWARE REQUIRED: MATLAB 7.6

THEORY

Transmission line has four parameters namely resistance, inductance, capacitance and conductance. The inductance and capacitance are due to the effect of magnetic and electric fields around the conductor. The resistance of the conductor is best determined from the manufactures data, the inductances and capacitances can be evaluated using the formula.

Inductance The general

formula L = 0.2 ln (Dm / Ds)

Where,

Dm = geometric mean distance (GMD)

Ds = geometric mean radius (GMR)

I. **Single phase 2 wire system**
II. **GMD = D**
III. **GMR = re-1/4 = r′**
IV. **Where, r = radius of conductor**

II. Three phase – symmetrical spacing

GMD = D

GMR = re-1/4 = r′

Where, r = radius of conductor

III. Three phase – Asymmetrical Transposed

GMD = geometric mean of the three distance of the symmetrically placed conductors

= 3√$D^{AB}D^{BC}D^{CA}$

GMR = re-1/4 = r′

Where, r = radius of conductors

Composite conductor lines

The inductance of composite conductor X, is given by

Lx = 0.2 ln (GMD/GMR)

where,

GMD = mn√ ($D^{aa'}$ $D^{ab'}$)…….($D^{na'}$ …….$D^{nm'}$)

where,

r′ a = ra e (-1/ 4)

Bundle Conductors

The GMR of bundled conductor is normally calculated

GMR for two sub conductor, c = (Ds * d)1/2

GMR for three sub conductor, Ds b =(Ds * d 2) 1/3

GMR for four sub conductor, Ds b = 1.09 (Ds * d 3) 1/4 where, Ds is the GMR of each subconductor d is bundle spacing

EXPERIMENT-8

OBJECT: Make a three phase model of power system using simulation & study – L-G fault on phase A

THEORY:

Short circuits occur in power system due to various reasons like, equipment failure, lightning strikes, falling of branches or trees on the transmission lines, switching surges, insulation failures and other electrical or mechanical causes. All these are collectively called faults in power systems.

A fault usually results in high current flowing through the lines and if adequate protection is not taken, may result in damages in the power apparatus.

SYMETRICAL FAULT:

In power engineering, specifically three-phase power a symmetric, symmetrical or balanced fault is a electrical fault which affects each of the three-phases equally. In transmission line faults, roughly 5% are symmetric. This is in contrast to an asymmetric fault, where the three phases are not affected equally. In practice, most faults in power systems are unbalanced. With this in mind, symmetric faults can be viewed as somewhat of an abstraction; however, as asymmetric faults are difficult to analyze, analysis of asymmetric faults is built up from a thorough understanding of symmetric faults.

ASYMETRICAL FAULT:

In power engineering, specifically three phase power, an **asymmetric** or **unbalanced fault** is a fault which does not affect each of the three phases equally. This is in contrast to asymmetric fault, where each of the phases is affected equally. In practice, most faults in power systems are unbalanced; however, as asymmetric faults are difficult to analyze, analysis of asymmetric faults is built up from a thorough understanding of symmetric faults.

Common types of asymmetric faults, and their causes:

- **Line-to-line** - a short circuit between lines, caused by ionization of air, or when lines come into physical contact, for example due to a broken insulator.

- **Line-to-ground** - a short circuit between one line and ground, very often caused byphysical contact, for example due to lightning or other storm damage
- **Double line-to-ground** - two lines come into contact with the ground (and each other),also commonly due to storm damage.

SINGLE-LINE-TO-GROUND FAULT

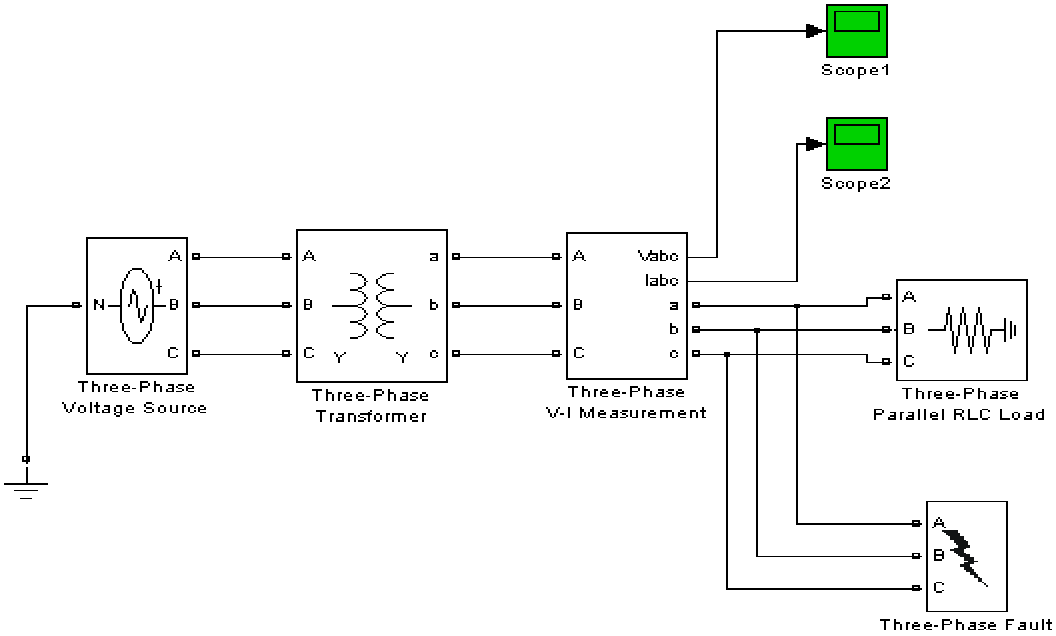


Fig: 2.1(a)-Three phase fault Analysis

Faulted Phase	: Phase A to Ground
Transition state	1 0 1
Transition Time	: 0 0.05 0.1 0.2
Nominal ϕ to ϕ voltage	: 220 V
Active Power	: 100 W
Nominal Frequency	: 50 Hz

Let a LG fault has occurred at node *k* of a network. The faulted segment is then as shown in Fig. 2.2(a) where it is assumed that phase-a has touched the ground through an impedance Z_f . Since the system is unloaded before the occurrence of the fault we have

$$I_{fb} = I_{fc} = 0 \quad \text{..............................2.1}$$

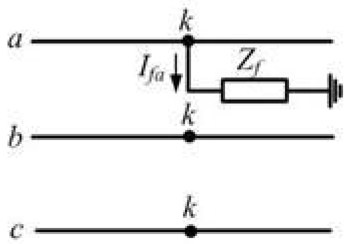


Fig. 2.2(a) Representation of L (A)-G fault.

Also the phase-a voltage at the fault point is given by

$$V_{ka} = Z_f I_{fa} \quad \text{..2.2}$$

From (2.1) we can write

$$I_{fa012} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix}\begin{bmatrix} I_{fa} \\ 0 \\ 0 \end{bmatrix} \quad \text{...........................2.3}$$

Solving (2.3) we get

$$I_{fa0} = I_{fa1} = I_{fa2} = \frac{I_{fa}}{3} \quad \text{..............................2.4}$$

This implies that the three sequence currents are in series for the LG fault. Let us denote the zero, positive and negative sequence Thevenin impedance at the faulted point as Z_{kk0} , Z_{kk1} and Z_{kk2} respectively. Also since the Thevenin voltage at the faulted phase is V_f we get three sequence circuits.We can then write

$$V_{ka0} = -Z_{kk0} I_{fa0}$$
$$V_{ka1} = V_f - Z_{kk1} I_{fa1}$$
$$V_{ka2} = -Z_{kk2} I_{fa2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.5$$

Then from (2.4) and (2.5) we can write

$$V_{ka} = V_{ka0} + V_{ka1} + V_{ka2}$$
$$= V_f - (Z_{kk0} + Z_{kk1} + Z_{kk2}) I_{fa0} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.6$$

Again since

$$V_{ka} = Z_f I_{fa} = Z_f (I_{fa0} + I_{fa1} + I_{fa2}) = 3 Z_f I_{fa0}$$

We get from (2.6)

$$I_{fa0} = \frac{V_f}{Z_{kk0} + Z_{kk1} + Z_{kk2} + 3Z_f}$$

……………………………………………………….2.7

The Thevenin equivalent of the sequence network is shown in Fig. 2.3(a)

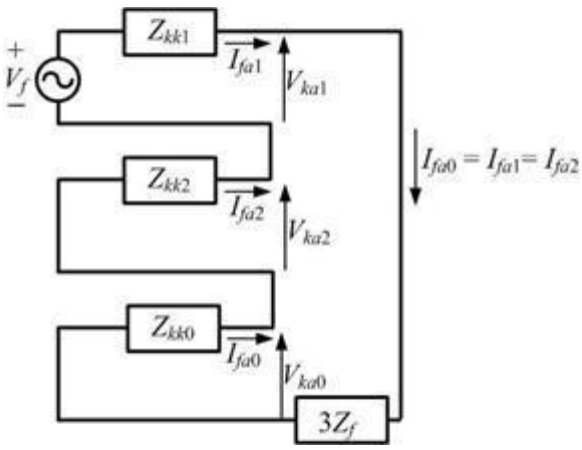


Fig. 2.3(a) Thevenin equivalent of a L (A) G fault.

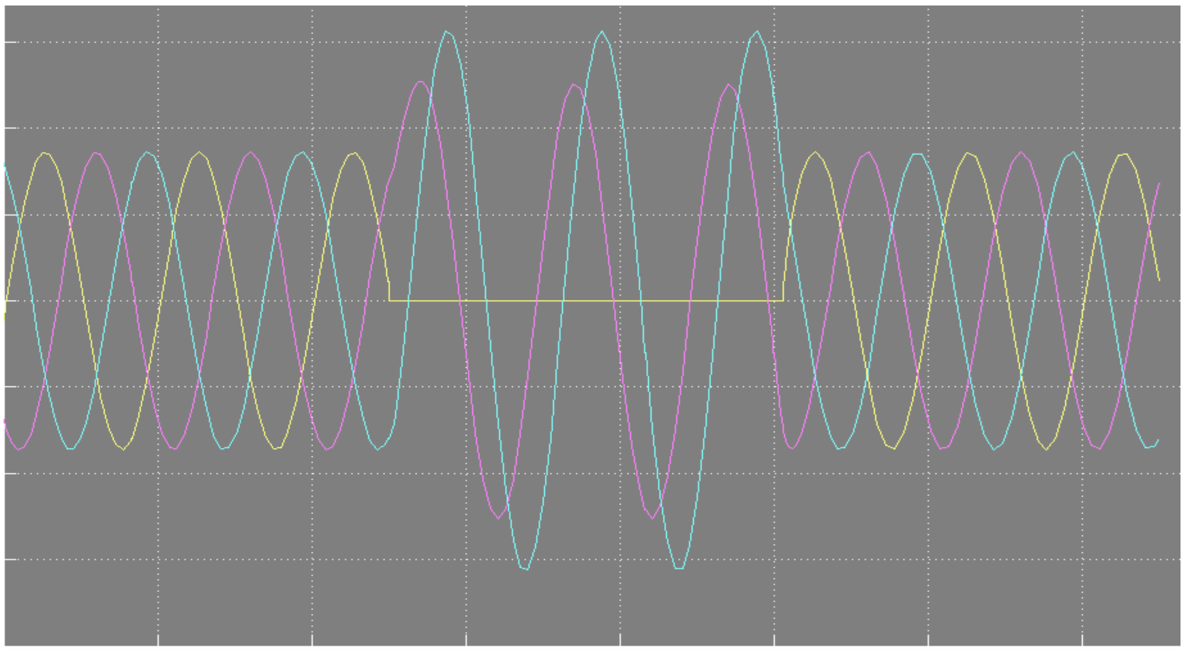
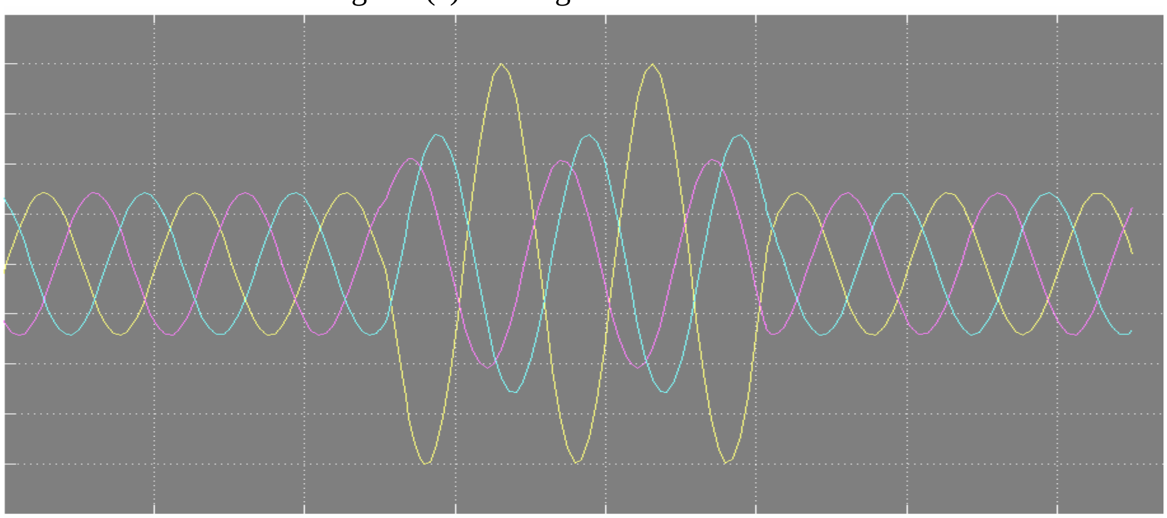


Fig: 2.4(a) –Voltage Waveform



of Line (A) - Ground Fault

Fig: 2.5(a) –Current Waveform of Line (A) - Ground Fault

Result: We have successfully studied the three phase fault on Line (A)-Ground fault andobtain the voltage and current waveforms

Experiment -9

AIM: Transmission line loading with load side shunt capacitive compensation to improvethe voltage profile

Theory:

The transmission line loading depends on the quantum and power factor of the load, which directly impacts the system voltages. At surge impedance loading of the line, the receiving end voltage is equal to the sending end voltage for a loss less line. For the higher loadings, the receiving end voltage will be much less compared to the sending end voltage. The voltage drop in the EHV transmission line is negligible at unity power factor as the line resistance of the line is much less compared to series reactance value of the line. When the transmission line is loaded with reactive power or when the line is loaded beyond the surge impedance loading, the receiving end voltage drops. The receiving end voltage can be improved by shunt capacitive compensation at the load point which reduces the reactive power loading on the line and there by reduces the reactive drop.

Procedure

1) Set up the TLS as explained in Ground Work 1.
2) Ensure that the load end contactor is off.
3) Switch on the main supply.
4) Switch on the line input supply.
5) Slowly increase and adjust the sending end voltage to measure 110V, line to line.
6) Switch on the load side contactor.
7) Connect the resistive load.
8) Connect the inductive load.
9) Vary the load side dimmer to maintain load side power factor at 0.90
10) Take the reading at different loading values.
11) Switch on the shunt capacitor bank to bring back the receiving voltage to above 0.95 pu.
12) At each step, adjust the sending end voltage to be 110 V

Calculations:

1. Using the steps given in ground work 2, the calculated parameters of each pi-section is asfollows

 Resistance: 3.27 Ω

 Inductance:
 50 mH
 Capacitanc
 e(C/2):
 12.14 µF

2. Compute the sending end or receiving end voltage/currents

The relation between the sending end and receiving end voltage and currents is given in equation1 and 2.

Vs = A*Vr + B*Ir .... (1)

Is = C*Vr + D*Ir..(2)

From the given input, Z and Y/2 can be calculated: Ztotal

= 3.27+j15.7079 Ω

Y/2 total =
j7.62776e-3 ℧
HenceABCD
parameters are:

A = D = 1 + (YZ/2) = 0.94009+j0.01247 B = Z

= 3.27145+j15.70796 ohm

C = Y [1+ (YZ/4)] = 0+j0.0076277 mho

Results:

Readings can be taken up for various loadings as per the procedure and verified using given calculation steps.The readings can be noted down as

Case no	**loading**		**Vr**	**Ir**	**Compensation**	**Vs**		**Is**		**Loss**	
	Amp	**pf**	**(V)**	**(A)**	**(Var)**	**TLS**	**hand cal**	**TLS**	**hand cal**	**TLS**	**hand cal**
1											
2											

For verifying the results with hand calculation, the receiving end data from TLS is used to compute the expected sending end data. The loading current is the load current which is held constant during a particular case. The receiving end current (Ir) is the current at the receiving end of the line which comprises of effect of load current and current due to shunt compensation.

B) To determine the various electrical parameters at sending and receiving end for a loaded line

THEORY

When a transmission line is loaded, it either generates or absorbs reactive power based on the level of loading. A line which is loaded above its SIL will experience a drop is voltage atits receiving end. The sending end power factor depends on the load power factor and also the line parameters and loading level. Further owing to certain resistance present in the line, the sending end real power is a summation of the line losses and the load power. The aim of this experiment is to observe the changes in various electrical parameters at the two ends during various loading condition.

PROCEDURE

i. Set up the TLS as explained in Ground Work 1.
ii. Ensure that the load end contactor is off.
iii. Switch on the main supply.
iv. Switch on the line input supply.
v. Slowly increase and adjust the sending voltage to measure 110V, line to line.
vi. Switch on the load side contactor.
vii. Connect the resistive load.
viii. Connect the inductive load.
ix. Vary the load side dimmer to maintain load side to adjust the loading to therequired power factor.
x. Record the various electrical parameters at the two ends.
xi. Take the reading at different loading values.

Calculations

1. Using the steps given in ground work 2, the calculated parameters

   of each pi-section is asfollows

   Resistance: 3.27 Ω
   Inductance: 50 mH
   Capacitance (C/2): 12.14 µF

2. Compute the sending end or receiving end voltage/currents

The relation between the sending end and receiving end voltage and currents isgiven by:

Vs = A*Vr + B*Ir Is =C*Vr + D*Ir
A = D 1 + (YZ/2) = 0.94009+j0.01247
B = Z =

C = Y [1+ (YZ/4)] = 0+j0.0076277 mho

The above equation is used to compute the voltage and currents at any one end, having thedata of the other end.

%Vol drop = (Vs-Vr)*100/Vs

Results:

The results are tabulated as follows.

Results of experiment on transmission line loading

Case no	loading		Vr	Ir	Vs (V)		Is (A)		%	
	Amp	pf	(V)	(A)	TLS	hand cal	TLS	hand cal	TLS	Hand Cal
1	0	0	118.95	0	110.52	111.8338	0.46	0.5082	-7.6276	-6.3632
2	0.3	0.999	111.84	0.3	109.24	107.6207	0.5	0.5456	-2.3801	-3.9205
3	0.6	0.999	107.6	0.6	108.61	106.7244	0.69	0.7141	0.9299	-0.8204
4	0.9	0.999	102.51	0.9	106.46	105.6839	0.93	0.9379	3.7103	3.0032
5	0.3	0.96	109.31	0.3	108.34	107.0348	0.45	0.4750	-0.8953	-2.1257

Results of experiment on transmission line loading

Case no	loading		Ps (W)		Pr (W)		loss (W)		Qs (Var)		Qr (Var)	
	Amp	pf	TLS	hand cal	TLS	hand cal	TLS	hand cal	TLS	hand cal	TLS	hand cal
1	0	0	0.42	0.6733	0	0	0.42	0	-85.35	-98.4295	0	0
2	0.3	0.999	60.63	59.4693	58.68	58.0557	1.95	1.4137	-69.39	-82.4919	6.06	2.5983
3	0.6	0.999	115.77	115.6687	111.39	111.7094	4.38	3.9593	51.54	-63.5862	6.09	4.9995
4	0.9	0.999	167.85	167.9089	159.9	159.6375	7.95	8.2714	-24.24	-35.8151	5.85	7.1446
5	0.3	0.96	59.64	55.5822	55.86	54.5272	3.78	1.0550	-59.91	-68.2949	16.53	15.9038
6	0.6	0.95	105.99	104.4773	101.91	101.2740	4.08	3.2032	-24.57	-34.2651	33.78	33.2872
7	0.88	0.95	145.86	145.8339	139.08	138.9351	6.78	6.8988	15.39	1.7643	47.97	45.6657