INSTITUTE OF AERONAUTICAL ENGINEERING
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Lab Manual:

Electrical Power Systems Laboratory(AEEB29)

Prepared by

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Contents

INTRODUCTION

Introduction

This course is intended to enhance the learning experience of the student in topics encountered in Power System Protection Laboratory, AEE112.In this lab, students are expected to develop the practical skills required to do the experiments and gain experience in using the basic measuring devices used in Computer Science Engineering. Students also learn to interpret the experimental results in terms of the concepts introduced in the Engineering Physics course.How the student performs in the lab depends on his/her preparation and participation. Each student must participate in all aspectsof the lab to ensure a thorough understanding of the equipment and concepts. The student, Faculty teachingthe lab course, Laboratory In-charge and faculty coordinator all have certain responsibilities towards successful completion of the lab's goals and objectives.

Student Responsibilities

The student is expected tocome prepared for each lab.Lab preparation includes understanding the lab experiment from the lab manual and reading the related textbook material.

Students have to write the allotted experiment for that particular week in the work sheets given and carry them to the Lab. In case of any questions or problems with the preparation, students can contact the Faculty Teaching the Lab course, but in a timely manner.

Students have to be in formal dress code, wear shoes and lab coat for the Laboratory Class.

After the demonstration of experiment by the faculty, student has to perform the experiment individually. They have to note down the observations in the observation Tables drawn in work sheets, do the calculations and analyze the results.

Active participation by each student in lab activities is expected. The student is expected to ask the Faculty any questions they may have related to the experiment.

The student should remain alert and use commonsense while performing the lab experiment.They are also responsible for keeping a professional and accurate record of the labexperiments in the files provided.

Responsibilities of Faculty Teaching the Lab Course

The Faculty shall be completely familiar with each labprior to the laboratory. He/She shall provide the students with details regarding the syllabus and safety review during the first week.Lab experiments should be checked in advance to make sure that everything is in working order.The Faculty should demonstrate and explain the experiment and answer any questions posed by the students.Faculty have to supervise the students while they perform the lab experiments. The Faculty is expected to evaluate the lab worksheets and grade them based on their practical skills and understanding of the experiment by taking Viva Voce. Evaluation of work sheets has to be done in a fair and timely manner to enable the students, for uploading them online through their CMS login within the stipulated time.

Laboratory In-charge Responsibilities

The Laboratory In-charge should ensure that the laboratory is properly equipped, i.e., the Faculty teaching the lab receive any equipment/components necessary to perform the experiments.He/She is responsible for ensuring that all the necessary equipment for the lab is available and in working condition. The Laboratory In-charge is responsible for resolving any problems that are identified by the teaching Faculty or the students.

Course Coordinator Responsibilities

The course coordinator is responsible fo rmaking any necessary corrections in Course Description and lab manual. He/She has to ensure that it is continually updated and available to the students in the CMS learning Portal.

Lab Policy and Grading

The student should understand the following policy:

ATTENDANCE: Attendance is mandatory as per the academic regulations.

LAB RECORD's: The student must:

1. Write the work sheets for the allotted experiment and keep them ready before the beginning of eachlab.
2. Keep all work in preparation of and obtained during lab.
3. Perform the experiment and record the observations in the worksheets.
4. Analyze the resultsand get the work sheets evaluated by the Faculty.
5. Upload the evaluated reports online from CMS LOGIN within the stipulated time.

Grading Policy:

The final grade of this course is awarded using the criterion detailed in the academic regulations. A large portion of the student's grade is determined in the comprehensive final exam of the Laboratory course (SEE PRACTICALS),resulting in a requirement of understanding the concepts and procedure of each lab experiment for successful completion of the lab course.

Pre-Requistes and Co-Requisties:

The lab course is to be taken during the samesemester as AEE112, but receives a separate grade. Students are required to have completed both AEE007 with minimum passing grade or better grade in each.

Course Goals and Objectives

The Power System Protection Laboratory is designed to give hands-on experience on virtual instrumentation through digital simulation techniques. These techniques enable the students to design and validate Students are able to analyze domestic and industrial power networks during normal as well as abnormal conditions. More explicitly, the class objectives are:

More explicitly, the class objectives are:

1. Examine the functioning of miniature circuit breaker(MCB) and Fuse.
2. Calculate surge impedance loading (SIL) of a transmission line.
    - Explain the concept of shunt compensation to counteract the voltage rise on no load and zero-regulation at different loads in a transmission line.
    - Calculate positive, negative and zero sequence impedances of synchronous machine by using direct method and fault analysis method.
    - Understand the modeling of transmission circuits MATLAB/SIMULINK. Develop single transmission line model using MATLAB

Use of Laboratory Instruments

One of the major goals of this lab is to familiarize the student with the proper equipment and techniques for making electrical measurements. Some understanding of the lab instruments is necessary to avoid personal or equipment damage. By understanding the device's purpose and following a few simple rules, costly mistakes can be avoided.

The following rules provide a guideline for instrument protection.

Instrument Protection Rules

3. Set instrument scales to the highest range before turning on the power/source.
4. Be sure instrument grounds are connected properly. Avoid accidental grounding of "hot" leads, i.e., those that are above ground potential.
    - Check polarity markings and connections of instruments carefully before connecting power.
    - Never connect an ammeter across a voltage source. Only connect ammeters in series with loads.
    - Do not exceed the voltage and current ratings of instruments or other circuit elements. This particularly applies to power analyzers since the current or voltage rating may be exceeded with the needle still on the scale.
    - Be sure the fuse and circuit breakers are of suitable value. When connecting electrical elements to make up a circuits in the laboratory, it is easy to lose track of various points in the network and accidentally connect a wire to the wrong place. A procedure to follow that helps to avoid this is to connect the main series part of the network first, then go back and add the elements in parallel. As an element is added, place a small check by it on your circuit diagram. Then go back and verify all connections before turning on the power. One day someone's life may depend upon your making sure that all has been done correctly.

Data Recording and Reports

Students must record their experimental values in the provided tables in this laboratory manual and reproduce them in the lab worksheets. Worksheets are integral to recording the methodology and results of an experiment. In engineering practice, the laboratory notebook serves as an invaluable reference to the technique used in the lab and is essential when trying to duplicate a result or write a report. Therefore, it is important to learn to keep accurate data. Make plots of data and sketches when these are appropriate in the recording and analysis of observations.

Note that the data collected will be an accurate and permanent record of the data obtained during the experiment and the analysis of the results. You will need this record when you are ready to prepare a lab report i.e worksheets.

The Laboratory Worksheets

Worksheets are the primary means of communicating your experience and conclusions to other professionals. In this course you will use the lab worksheets to inform your faculty coordinator about what you did and what you have learned from the experience. Engineering results are meaningless unless they can be communicated to others. You will be directed by your faculty coordinator to prepare a lab report on a few selected lab experiments during the semester.

The Laboratory Files/Reports

Your laboratory report should be clear and concise. The lab report shall be student hand written on a work sheets provided by the college. As a guide, use the format on the next page. Use tables, diagrams, sketches, and plots, as necessary to show what you did, what was observed, and what conclusions you can draw from this by using pencil and scale. Free hand diagrams and tables will reduce your marks. Even though you will work with one or more lab partners, your report will be the result of your individual effort in order to provide you with practice in technical communication.

LAB-1 ORIENTATION

1.1 Introduction

In the first lab period, the students should become familiar with the location of equipment and components in the lab, the course requirements, and the teaching instructor. Students should also makesurethattheyhaveallofthecο-requisitesandpre-requisitesforthecourseatthistime.

1.2 Objective

To familiarize the students with the lab facilities, equipment, standard operating procedures, labsafety , and the course requirements.

1.3 Prelab Preparation:

Read the Introduction and AppendixA, of this manual. Download and install the“WaveForms” and “Power Analyzers “ software on your personal computer, available here.

1.4 Equipment needed

AEE112 labmanual.

1.5 Procedure

1. During the first laboratory period, the faculty will provide the students with a general idea of what is expected from them in this course. Each student will receive a copy of the syllabus, stating the instructor’s contact information. In addition, the instructor will review the safety concepts of the course.

2. During this period, the faculty will briefly review the equipment which will be used throughout the semester. The location of instruments, equipment, and components (e.g. resistors, capacitors, connecting wiring) will be indicated. The guidelines for instrument use will be reviewed.

LAB-2 CHARACTERISTICS OF AN MCB

2.1 Introduction

This lab focuses on the Characteristics of an MCB.MCB is most widely used protective device in domestic and industrial applications. This device are made to break the circuit in case of overload or Short circuit. The working of MCB by applying full load current is investigated. The time-current characteristics are plotted.Time-current curves are used to show the amount of time required for a circuit breaker to trip at a given overcurrent level.

2.2 Objective

Bytheendofthislab,thestudentshouldbeabletocalculate the trip time for any given overcurrent value.

2.3 Prelab Preparation:

Readthematerialinthetextbookthatdescribesworking and construction of miniature circuit breaker.Priortocoming

2.4 Equipment needed

16A circuit breaker Ammeter, voltmeter Variable Resistive load, connecting wires

2.5 Background

MCB is high fault capacity, thermal /magnetic current limiting trip free automatic switching device with fast magnetic tripping. Thermal operation with inverse time current characteristics for overload protection. Hammer trip assisted magnetic operation for short circuit protection. Thermal operation is achieved with a bimetallic strip which deflected when heated by any over current flowing through it. In doing so releases the later mechanism and causes the contact to open. Inverse time current characteristic result greater the overload current short the time required to operate the MCB. When short circuit Fault occurs the rising current energizes the solenoid opening the plunger to strike the trip level causing immediate release of the latch mechanism. Rapidity of the magnetic solenoid operation causes instantaneous opening of contacts. MCB or Miniature Circuit Breaker is an electromechanical device which protects an electric circuit from an overcurrent. The overcurrent in an electrical circuit may result from short circuit, overload or faulty design. In short, MCB is a device for overload and short circuit protection. They are used in residential and commercial areas. Just like we spend the time to make a thorough check before buying appliances like washing machines or refrigerators, we must also research about MCBs. An MCB is a better alternative to a Fuse since it does not require replacement once an overload is detected. Unlike a fuse, an MCB can be easily operated and thus offers improved operational safety and greater convenience without incurring a large operating cost. They are used to protect lower current circuits and have the following specifications

- Current rating – Amperes
- Short Circuit Rating – Kilo Amperes (kA)
- Operating Characteristics – B, C or D Curves

Miniature Circuit Breakers are switchgear which is usually available in the range of 0.5A to 100A. Their Short circuit rating is given in Kiloamps (kA), and this indicates the level of its ability to work. For example, a domestic MCB would normally have a 6kA fault level, whereas one used in an industrial application may need a unit with a 10kA fault capability.

2.6 Procedure

1. Make the connections as shown in circuitdiagram shown in Fig.2.1

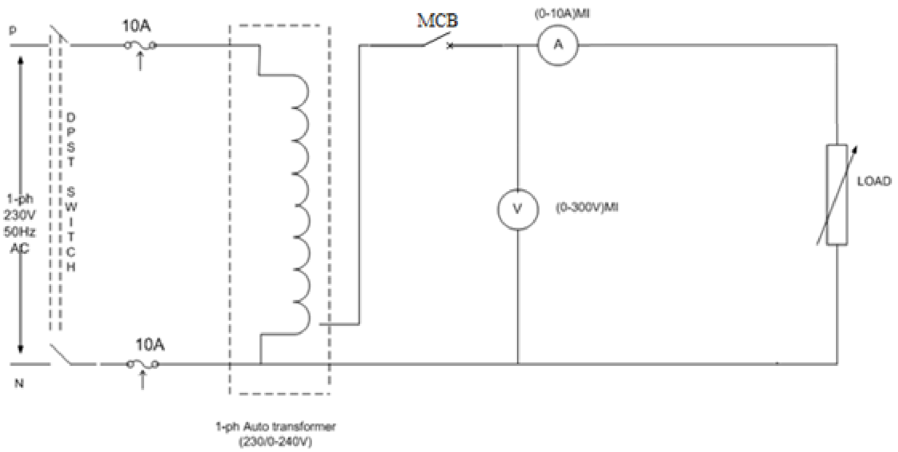

Figure 2.1: Circuit Diagram For Plotting Charecteristics of Mianiature Circuit Breaker

2. Now vary the load gradually till the rated current of MCB flows in the circuit. Therating of ammeter and voltmeter and note the time at which MCBblows
3. Now increase the load in small steps. Record the reading of voltmeter and ammeter
4. Plot the graph between time and current.

2.7 Further Probing Experiments

Q1: Use MATLAB/Simulink to plot voltage and current of an electromechanical circuit breaker. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

Table 2.1: Voltage-Current

S.No.	Voltage	Current	Time (In Sec.)

Q2:Use MATLAB/Simulink tostudy the performance of circuit breaker is connected in series with a series RL circuit on a 60Hz voltage source. The switching times of the Breaker block are controlled by a Simulink signal. The breaker device is initially closed and an opening order is given at t = 1.5 cycles, when current reaches a maximum. The current stops at the next zero crossing then the breaker is reclosed at a zero crossing of voltage at t = 3 cycles.RecordyourMATLAB/Simulink fileandthedataobtainedfromthesimulationinyour laboratory notebook by pasting in the printouts.

LAB-3 CHARACTERISTICS OF FUSE AND THERMAL OVER-LOAD PROTECTION

3.1 Introduction

This lab focuses on the characteristics of Fuse. Fuse characteristics is useful to determinethe fusing factor and cut-off current value.These factors are useful to study the performance of fuse element

3.2 Objective

By the end of this lab, the student should be able to analyze performance of HRC Fuse under thermal overload protection

3.3 Prelab Preparation:

Read the material in the textbook that describes Fuse and its time-current characteristics Prior to coming to the lab, complete Part1 and Part 3oftheProcedure.

3.4 Equipment needed

Fuse element and HRC Fuse, Ammeter, voltmeter Variable Resistive load, connecting wires

3.5 Background

A current limiting protective device cuts off a short circuit in less than one half cycle and that too before it reaches its total prospective highly destructive value fuses are current limiting time. By maintaining a minimum ratio of fuse – ampere rating between upstream and downstream fuse selective coordination is assured which prevents the power failure caused over current conditions.

3.6 Procedure

1. Make the connections as shown in circuit diagram
2. Now vary the load gradually till the rated current of FUSE flows in the circuit. Therating of ammeter and voltmeter and note the time at which MCB blows
3. Now increase the load in small steps. Record the reading of voltmeter and ammeter
4. Plot the graph between time and current.

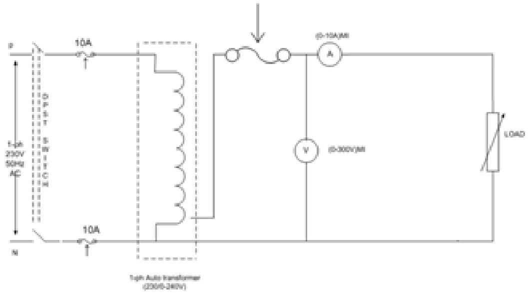

Figure 3.1: Circuit Diagram For Plotting Charecteristics of Fuse

3.7 Further Probing Experiments

Q1. Use MATLAB/Simulink toplot time-current characteristics of fuse. To measure the short-circuit current in last element, place an ammeter in series with that element.Determinethe change in current for that element and compare to your experimentally obtained currents in Part Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.
Q2. Use MATLAB/Simulink tocalculate fusing factor and arcing factor of High rupturing fuse-and compare them with experimentally obtained currents in Part 4.RecordyourMATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

Table 3.1: Charecteristics of FUSE

S.No.	Voltage	Current	Time (In Sec.)

LAB-4 ABCD PARAMETERS OF TRANSMISSION LINE

4.1 Introduction

This lab focuses on the generalized circuit parameters or transmission line parameters.Transmission line parameters are used for analysis of electrical circuits and Voltage and Current relationship of input and output of the Two-port network.

4.2 Objective

By the end of this lab, the student should be able to study the performance of single phase transmission line

4.3 Prelab

Read the material in the textbook that describes Transmission line parameters of two port network prior to coming to the lab, complete Part0 of the Procedure.

4.4 Equipment needed

Transmission line model,
Power Analyzer,
Ammeter, and
voltmeter
1-Phase Variac,
Connecting wires

4.5 Procedure

1. To find out A and C parameters connect voltage supply of 220V to sending end and open circuit receiving end. 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.We know that

2. Observe the voltage of Vs, Is and Vr with the help of voltmeter and ammeters in the experimental kit.

3. Observe the voltage of Vs, Is and Vr with the help of voltmeter and ammeters in the experimental kit. To find out B and D receiving end is short circuited and supply of 220V is given to sending end.

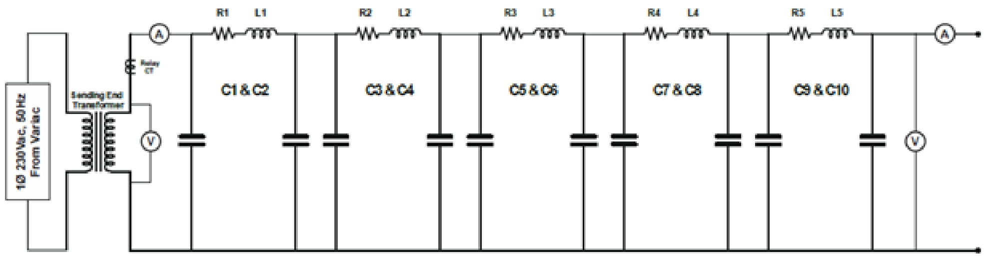

Figure 4.1: Circuit for open circuit test for calculating A and C values

4. Observe the voltage of Vs, Is and Ir,The Calculated A, B, C, D Parameters are
   A=
   B=
   C=
   D=

Table 4.1: Open Circuit Test:

S.No	VS	IS	VR	A=VS/ VR	C=IS/ VR

4.6 Further Probing Experiments

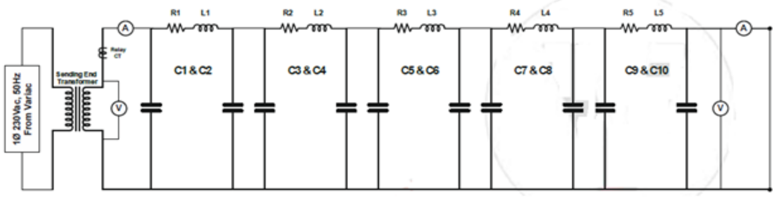

Figure 4.2: Circuit for open circuit test for calculating B and D values

Table 4.2: Short Circuit Test:

S.No	VS	IS	VR	B=VS/ IR	D=IS/ IR

LAB-5 FERRANTI EFFECT IN A TRANSMISSION LINE

5.1 Introduction

This lab focuses on the observation of Ferranti effect of transmission line.

5.2 Objective

By the end of this lab, the student should be able to observe ferrenti effect in a single phase transmission line

5.2.1 Educational

5.2.2 Experimental

Write the text here

5.3 Prelab Preparation:

Read the material in the textbook that describes rise in voltage on receiving end to that of sending end completePart0oftheProcedure.

5.4 Equipment needed

Transmission line model,
Power Analyzer,
Ammeter, and
voltmeter
1-Phase Variac,
Connecting wires

5.5 Background

A long transmission line/cables draws a substantial quantity of charging current. If such a line/cable is open circuited or very lightly loaded at the receiving end, the voltage at receiving end may become greater than voltage at sending end due to capacitive reactance. This is known as Ferranti Effect. Both capacitance and inductance is responsible to produce this effect. The capacitance (which is responsible for charging current) is negligible in short line but significant in medium line and appreciable in long line. Hence, this phenomenon occurs in medium and long lines.

The Line capacitance is assumed to be concentrated at the receiving end.

In the phasor diagram shown above
OM = receiving end voltage Vr
OC = Charging current drawn by capacitance = Ic
MN = Resistive drop
NP = Inductive reactance drop

Therefore; OP = Sending end voltage at no load and is less than receiving end voltage (Vr) Since, resistance is small compared to reactance; resistance can be neglected in calculating Ferranti effect. From Pi-model, Sending end voltageis equal to Difference of Receiving end voltage and Impedance drop Under open circuit condition is equal to 0, receiving end voltage is greater than sending end voltage and this effect is called Ferranti Effect. It is valid for open circuit condition of long line. When load current is increased of R-L loads the resultant current is not remains leading, because of the inductive drop. Hence, receiving end voltage (Vr) is lesser than sending end voltage (Vs) under full load conditions.

5.6 Procedure

1. Connect mains cable to 230VAC, Single phase supply with proper earth connection.Keep MAINS MCB in OFF position and the variac in Zero position. Make the connection as per circuit diagram shown in fig (3). Now the connection is for receiving end open condition.
2. Switch on MAINS PLUS CONTROL MCB. All the meters will glow.Select the values of line inductance and capacitance as required.

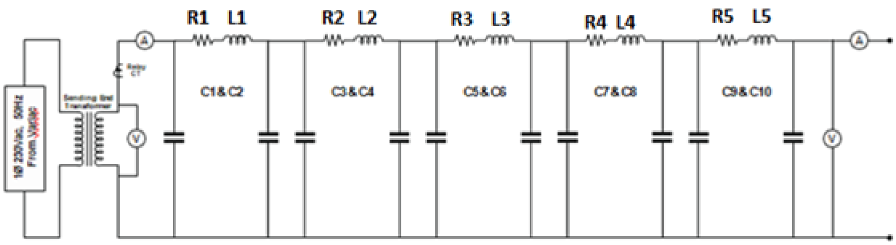

Figure 5.1: Circuit Diagram for Ferrenti Effect

3. Set the voltage of sending end to required level by varying the variac-1. Note down the reading for all parameters i.e., sending end voltage and receiving end voltage.

4. You can observe that the receiving end voltage will be higher than sending end voltage.

5. Note down the value for different sending end voltage readings With Varying loads. The receiving end voltage will be higher than sending end.

Table 5.1: Without Load:

S. No.	Sending End Voltage, Vs (V)		Receiving End Voltage Vr (V)	
1.				
2.				
3.				

Table 5.2: With Load

S. No.	Load			Sending End Voltage, Vs (V)		Receiving End Voltage Vr (V)	
	R(Ω)	L(H)	C(F)				
1.							
2.							
3.							
4.							
5.							

5.7 Further Probing Experiments

Q1:Use MATLAB/The MATLAB program that gives the locus of sending end voltage with line length which shows that receiving end voltage is greater than sending end voltage. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.
Q2:Use MATLAB/Simulink to study the Ferranti effect in transmission line and the fault simulation by MATLAB software Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

LAB-6 SURGE IMPEDANCE LOADING

6.1 Introduction

This lab focuses on the surge impedance loading (SIL). SIL gives maximum loading capacity on the transmission line. Which helps in optimum operation on transmission line.

6.2 Objective

By the end of this lab, the student should be able to study the performance of single phase transmission line.

6.3 Prelab Preparation:

Read the material in the textbook that describes surge impedance loading on transmission line Priortocomingtothelab,completePart0 oftheProcedure.

6.4 Equipment needed

Transmission line model,
Power Analyzer, Ammeter, and voltmeter
1-Phase Variac,
Connecting wires

6.5 Background

Capacitance and reactance are the main parameters of the transmission line. It is distributed uniformly along the line. These parameters are also called distributed parameters. When the voltage drops occur in transmission line due to inductance, it is compensated by the capacitance of the transmission line.

The transmission line generates capacitive reactive volt-amperes in its shunt capacitance and absorbing reactive volt-amperes in its series inductance.The load at which the inductive and capacitive reactive volt-amperes are equal and opposite, such load is called surge impedance load.

It is also called natural load of the transmission line because power is not dissipated in transmission. In surge impedance loading, the voltage and current are in the same phase at all the point of the line. When the surge impedance of the line has terminated the power delivered by it is called surge impedance loading.

Surge impedance loading depends on the voltage of the transmission line. Practically surge impedance loading always less than the maximum loading capacity of the line.

If the load is less than the SIL, reactive volt-amperes are generated, and the voltage at the receiving end is greater than the sending end voltage. On the other hand, if the SIL is greater than the load, the voltage at receiving end is smaller because the line absorbs reactive power.

If the shunt conductance and resistance are neglected and SIL is equal to the load than the voltage at both the ends will be equal.

6.6 Procedure

1. 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.

2. Make the connections as shown in circuitdiagram shown in fig.

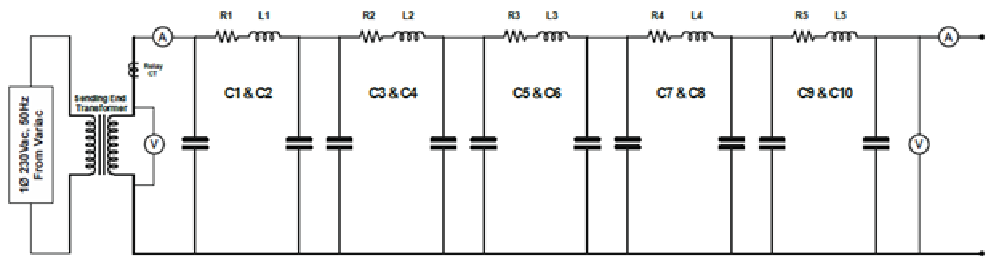

Figure 6.1: Circuit for open circuit test for calculating A and C values

3. Part(2)To find SIL, keep the receiving side open and note down sending end voltage (VOC) and current (ISC). Now, short the receiving end and note down sending end voltage (VOC) and current (ISC).Find impedance in open circuit and short circuitcondition.

4. Part(3)Find core or natural impedence,

6.7 Further Probing Experiments

Q1.Use MATLAB/Simulink to calculate surge impedance loading on a Short Transmission Line .Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

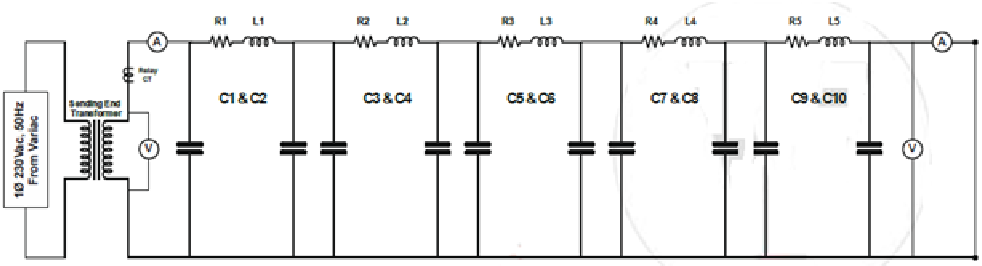

Figure 6.2: Circuit for open circuit test for calculating B and D values

Table 6.1: Open Circuit Test:

S.No	VS	IS	VR	A=VS/ VR	C=IS/ VR

Use MATLAB/Simulink to calculate surge impedance loading on a Medium and Long Transmission Line .Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

Table 6.2: Short Circuit Test:

S.No	VS	IS	VR	B=VS/ IR	D=IS/ IR

LAB-7 EFFECT OF SHUNT COMPENSATION

7.1 Introduction

This lab focuses on the to counteract Ferranti effect in transmission line. Observation on increasing the load and reducing the Ferranti effect by shunt compensation technique.

7.2 Objective

By the end of this lab, the student should be able to analyze shunt compensation technique

7.3 Prelab Preparation:

Read the material in the textbook that describes method of shunt compensation and various techniques

7.4 Equipment needed

Transmission line model,
Power Analyzer, Ammeter, and voltmeter
1-Phase Variac,
Connecting wires

7.5 Background

In shunt compensation, FACTS are connected in parallel with the power system transmission line. It works as a controllable current source. A reactive current is injected into the line to maintain constant voltage magnitude by varying shunt impedance. Therefore, the transmittable active power is increased but at the expense of increasing the reactive power demand. There are two methods of shunt compensations:
Shunt capacitive compensation: This method is used improve the power factor. Whenever an inductive load is connected to the transmission line, power factor lags because of lagging load current. To compensate it, a shunt capacitor is connected, which draws current leading to the source voltage. The net result is improvement in power factor.
Shunt inductive compensation: This method is used either when charging the transmission line or when there is very low load at the receiving end. Due to very low or no load, a very low current flows through the transmission line. Shunt capacitance in the transmission line causes voltage amplification (Ferranti effect). The receiving end voltage (Vr) may become double the sending end voltage (Vs) (generally in case of very long transmission lines). To compensate it, shunt inductors are connected across the transmission line.

7.6 Procedure

1. Connect mains cable to 230VAC, Single phase supply with proper earth connection.
2. Keep MAINS MCB in OFF position and the variac in Zero position.
3. Make the connection as per circuit diagram shown in fig (6.1). Now the connection is for receiving end open condition.
4. Switch on MAINS+CONTROL MCB. All the meters will glow.
5. Put both the relays to UNHEALTHY state.
6. Select the values of line inductance and capacitance as required.

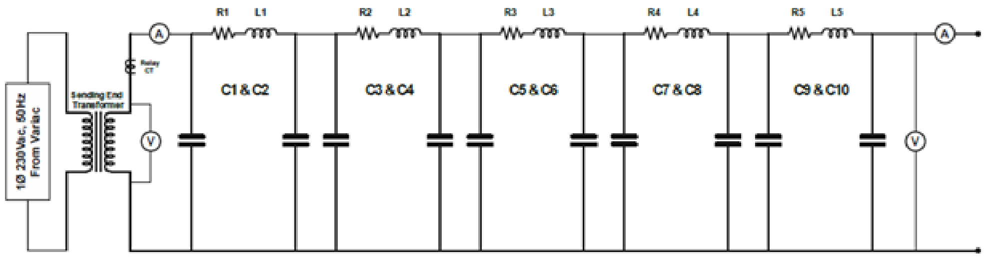

Figure 7.1: Circuit for open circuit test

7. Press CB-1 ON push button. Set the voltage of sending end to required level by varying the variac-1.
8. Note down the reading of sending end voltage and receiving end voltage.
9. You can observe that the receiving end voltage will be higher than sending end voltage.
10. Press CB-1 OFF and introduce the compensation unit. (Here RLC Unit-1 or 2 can be used). Connect as in fig

7.7 Further Probing Experiments

Q1. Use MATLAB/SIMULINK SIMPOWER SYSTEM for modeling of single phase power system with shunt capacitive network. Record your MATLAB/Simulink file and the data obtained

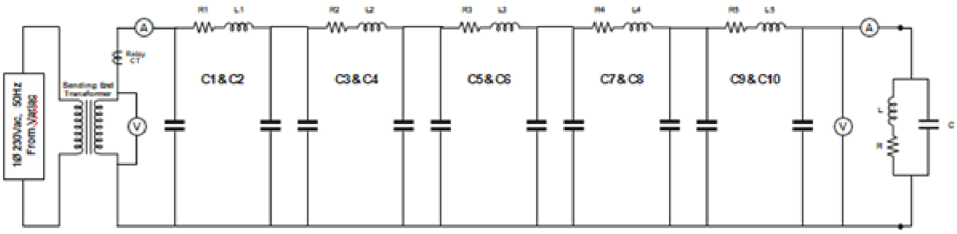

Figure 7.2: Circuit Diagram with RLC Load

Table 7.1: Without Compensation:

S. No.	Load		Sending End Voltage, Vs (V)		Receiving End Voltage Vr (V)	
	R(Ω)	L(H)				
1.						
2.						
3.						
4.						
5.						

from the simulation in your laboratory notebook by pasting in the printouts.
Q2. Use MATLAB/SIMULINK SIMPOWER SYSTEM for modeling of single phase power system with shunt inductive network. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

Table 7.2: With Compensation:

S. No.	Load			Sending End Voltage, Vs (V)		Receiving End Voltage Vr (V)	
	R(Ω)	L(H)	C(F)				
1.							
2.							
3.							
4.							
5.							

LAB-8 VOLTAGE PROFILE IMPROVEMENT USING TAP CHANGING TRANSFORMER

8.1 Introduction

This lab focuses on the Voltage profile improvement of single phase transmission line. Using tap-changing transformer.

8.2 Objective

By the end of this lab, the student should be able to study voltage profile improvement using tap-changing transformer

8.3 Prelab Preparation:

Read the material in the textbook that describes voltage profile improvement and working of tap-chaniging transformer.

8.4 Equipment needed

Transmission line model,
Power Analyzer, Ammeter, and voltmeter
1-Phase Variac,
Connecting wires

8.5 Background

Tap changing in Transformers is a normal fact that increases in load lead to decrease in the supply voltage. Hence the voltage supplied by the transformer to the load must be maintained within the prescribed limits. This can be done by changing the transformer turns ratio.The taps are leads or connections provided at various points on the winding. The turns ratio differ from one tap to another and hence different voltages can be obtained at each tap. Need for system voltage control
• System voltage control is essential for:
• Adjusting the terminal voltage of consumer within the prescribed limits
• Adjustment of voltage based on change in load.
• In order to control the real and reactive power.
• For varying the secondary voltage based on the requirement.
Types of taps
Taps may be principal, positive or negative. Principal tap is one at which rated secondary

voltage can be obtained for the rated primary voltage. As the name states positive and negative taps are those at which secondary voltage is more or less than the principle tap.

8.6 Procedure

1. Connect mains cable to 230VAC, Single phase supply with proper earth connection.

2. Keep MAINS MCB in OFF position and the variac in Zero position.Make the connection as per circuit diagram shown in fig (9). Recevind is connected through the meter to tap changing transformer and to the load. (if required use variac 2 to have control over input to the tap changing transformer)

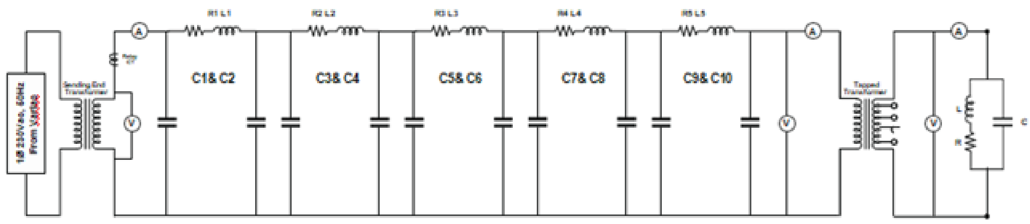

Figure 8.1: Circuit with load

3. Switch on MAINS plus CONTROL MCB. All the meters will glow.

4. Put both the relays to UNHEALTHY state.

5. Select the values of line inductance and capacitance as required. Press CB-1 ON push button.

6. Set the voltage of sending end such that the receiving end voltage is 220V. Press CB-2 ON and CB-3 ON push button.

7. Observe the voltage at the load end. If V¡220V increase it by changing the position of tap or V¿220V then decrease it by reduce the value of tapped output.

Table 8.1: Tap Setting:

S. No.	Tap Setting	Sending End Voltage, Vs (V)		Receiving End Voltage Vr (V)
1.				
2.				
3.				
4.				
5.				

8.7 Further Probing Experiments

Q1: Use MATLAB/SIMULINK Voltage Unbalance Improvement Using SFCL in matlab simulation Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.
Q2: Use MATLAB/SIMULINK Voltage regulation in transformer Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

LAB-9 EFFICIENCY AND REGULATION OF A TRANSMISSION LINE

9.1 Introduction

This lab focuses on the calculation of efficiency and regulation of transmission line. To analyze the performance of transmission line.

9.2 Objective

By the end of this lab, the student should be able to calculate efficiency and regulation of tap changing transformer.

9.3 Prelab Preparation:

Read the material in the textbook that describes efficiency and regulation of transmission line.

9.4 Equipment needed

Transmission line model,
Power Analyzer, Ammeter, and voltmeter
1-Phase Variac,
Connecting wires

9.5 Background

The performance of a power system is mainly dependent on the performance of the transmission lines in the system. It is necessary to calculate the voltage, current and power at any point on a transmission line provided the values at one point are known. The transmission line performance is governed by its four parameters - series resistance and inductance, shunt capacitance and conductance. All these parameters are distributed over the length of the line. The insulation of a line is seldom perfect and leakage currents flow over the surface of insulators especially during bad weather. This leakage is simulated by shunt conductance. The shunt conductance is in parallel with the system capacitance. Generally the leakage currents are small and the shunt conductance is ignored in calculations. Performance of transmission lines is meant the determination of efficiency and regulation of lines.

9.6 Procedure

1. Connect mains cable to 230VAC, Single phase supply with proper earth connection.

2. Keep MAINS MCB in OFF position and the variac in Zero position.
3. Make the connection as per circuit diagram shown in fig. Switch on MAINS CONTROL MCB. All the meters will glow.

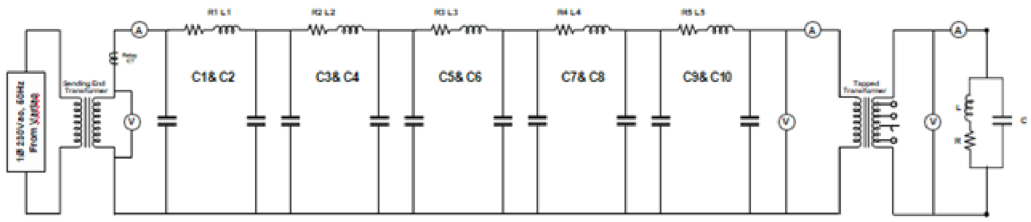

Figure 9.1: Circuit with load

4. Put both the relays to UNHEALTHY state. Select the values of line inductance and capacitance as required.
5. Initially keep all the loads to OFF state
6. Press CB-1 ON and CB-2 ON push button. Set the voltage of sending end to required level (say 220V) by varying variac-1.
7. Note down the reading of sending end and receiving end voltage, current, and power.
8. Apply loads gradually and note down the readings.
9. Tabulate the readings and calculate efficiency and regulation of the line.
10. Repeat the same for different values of line parameters.

Table 9.1: Efficiency and Regulation:

S. No.	Sending End			Receiving End			Efficiency	Regul
	Voltage (VS)	Current (IS)	Power(P)	Voltage (VR)	Current (IR)	Power		
1.								
2.								
3.								

9.7 Further Probing Experiments

Q1. Use MATLAB/SIMULINK SIMPOWER SYSTEM for modeling of single phase power system to calculate efficiency of transmission line. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.
Q2. Use MATLAB/SIMULINK SIMPOWER SYSTEM for modeling of single phase power system to calculation regulation of transmission line. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

LAB-10 PERFORMANCE OF IMPEDANCE RELAY

10.1 Introduction

This lab focuses on the working of Impedance Relay and effects during faults in transmission line

10.2 Objective

By the end of this lab, the student should be able understand working of impedance relay under abnormal conditions

10.3 Prelab Preparation:

Read the material in the textbook that describes working principle of impedance relay.

10.4 Equipment needed

Transmission line model,
Power Analyzer, Ammeter, and voltmeter
1-Phase Variac,
Connecting wires

10.5 Background

There is one type of relay which functions depending upon the distance of fault in the line. More specifically, the relay operates depending upon the impedance between the point of fault and the point where relay is installed. These relays are known as distance relay or impedance relay. The working principle of distance relay or impedance relay is very simple. There is one voltage element from potential transformer and a current element fed from current transformer of the system. The deflecting torque is produced by secondary current of CT and restoring torque is produced by voltage of potential transformer. In normal operating condition, restoring torque is more than deflecting torque. Hence relay will not operate. But in faulty condition, the current becomes quite large whereas voltage becomes less. Consequently, deflecting torque becomes more than restoring torque and dynamic parts of therelaystartsmovingwhichultimately-closetheNocontactofrelay.Henceclearlyoperation or working principle of distance relay, depends upon the ratio of system voltage and current. As the ratio of voltage to current is nothing but impedance a distance relay is also known as impedancerelay. The operation of such relay depends upon the predetermined value of voltage to current ratio. This ratio is nothing but impedance. The relay will only operate when this voltage to current ratio becomes less than its predetermined value. Hence, it can be said that the relay will only operate when the impedance of the line becomes less than predetermined impedance (voltage / current). As the impedance of a transmission line is directly proportional to its length, it can easily be concluded that a distance relay can only operateiffaultisoccurredwithinapredetermineddistanceorlengthofline.

10.6 Procedure

1. Connect mains cable to 230VAC, Single phase supply with proper earth connection.
2. Keep MAINS MCB in OFF position and the variac in Zero position. Make the connection as per circuit diagram shown in fig Now the connection is for receiving end open condition.

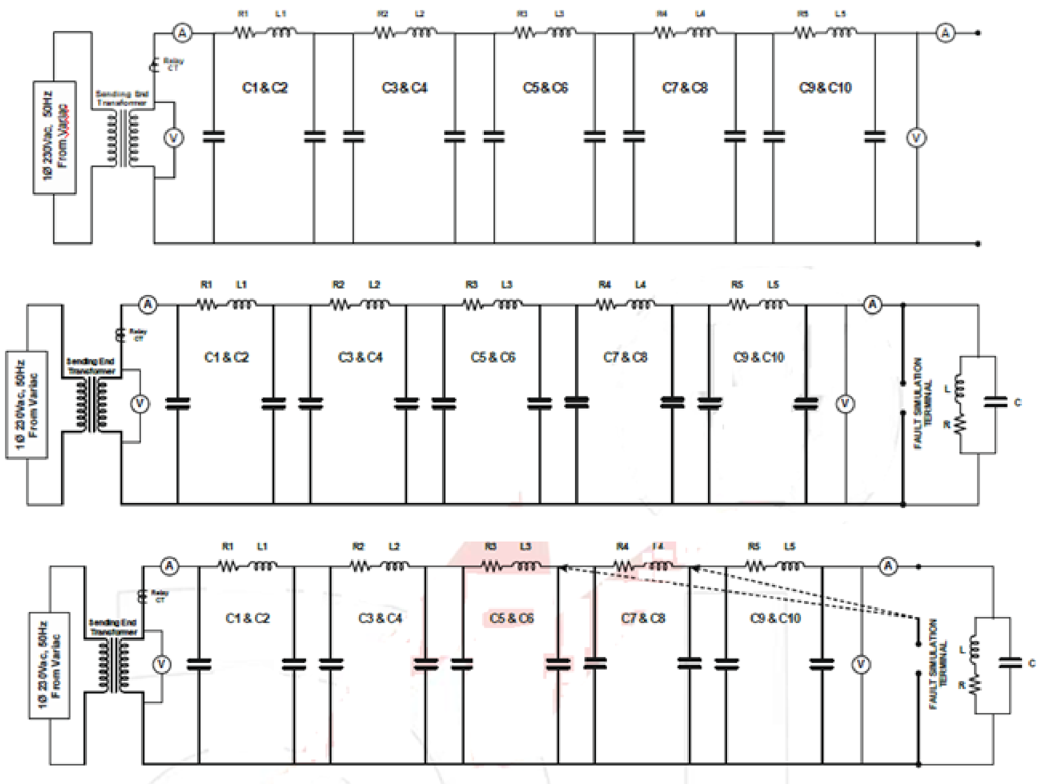

Figure 10.1: Circuit with load

3. Switch on MAINS plus CONTROL MCB. All the meters will glow
4. Put the impedance relay to HEALTHY state and Over current relay to UNHEALTHY state. Program the Impedance relay if required.
5. a. Press SET on the relay and select the percentage IMPEDANCE value using HIGH/LOWkey and press SET twice to confirm
   b. Now select the value of K=100 (Range: 10-100) and press SET twice toconfirm
   c. Set Impedance as 100
6. Apply a load of say 100W. Press CB-1 ON and CB-2 ON push button
7. Set the voltage of sending end to 220V by varying the variac-1. Press the ENTER key on impedance relay.
8. Put the Fault Simulation Switch to POSITION-2. Time Interval meter starts counting. The relay may not trip or may take a long time to trip.

9. Now switch off CB-1 and put the fault simulation switch to POSITION-1.
10. Change the connection to around 320kms that is after 4th position section as shown in fig(9.3)
11. Press CB-1 ON Push button and press ENTER key on the relay.
12. Put the Fault Simulation Switch to POSITION-2. Time Interval meter starts counting, the relay will be active and tripped after few seconds.
13. Display will show Impedance, voltage, current, trip time and distance of tripping. Note down the values.
14. Repeat the same at different distance of fault.

Table 10.1: Efficiency and Regulation

S.No	%Z	Trip time	Efficiency	Regulation
1.				
2.				
3.				

10.7 Further Probing Experiments

Q1. Use MATLAB/SIMULINK SIMPOWER SYSTEM for Modeling and Testing of a Digital Distance Relay. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.
Q2. Use MATLAB/SIMULINK SIMPOWER SYSTEM for Three Zone Protection By Using Distance Relays. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

LAB-11 PERFORMANCE OF OVER CURRENT RELAY

11.1 Introduction

This lab focuses on the working of Over Current Relay and effects during faults in transmission line

11.2 Objective

By the end of this lab, the student should be able understand working of Over Current Relay under abnormal conditions

11.3 Prelab Preparation:

Read the material in the textbook that describes working principle of Over Current Relay.

11.4 Equipment needed

Transmission line model,
Power Analyzer, Ammeter, and voltmeter
1-Phase Variac,
Connecting wires

11.5 Background

Lines are protected by overcurrent-, distance-, or pilot-relaying equipment, dependingon the requirements. Overcurrent relaying is the simplest and cheapest, the most difficult to apply, and the quickest to need readjustment or even replacement as a system changes. It is generally used for phase- and ground-fault protection on station-service and distribution circuits in electric utility and in industrial systems, and on some sub-transmission lines where the cost of distance relaying cannot be justified. It is used for primary ground-fault protection on most transmission lines where distance relays are used for phase faults, and for ground back-up protection on most lines having pilot relaying for primary protection. However, distance relaying for ground-fault primary and back-up protection of transmission lines is slowly replacing overcurrent relaying. Overcurrent relaying is used extensively also at power transformer locations for external-fault back-up protection, but here, also, there is a trend toward replacing overcurrent with distance relays. It is generally the practice to use a set of two or three overcurrent relays for protection against interphase faults and a separate overcurrent relay for single-phase-to ground faults. Separate ground relays are generally favoured because they can be adjusted to provide faster and more sensitive protection for single-phase-to-ground faults than the phase relays can provide. However, the phase relays alone are sometimes relied on for protection against all types of faults. On the other hand, the phase relays must sometimes be made to be inoperative on the zero-phase-sequence component of ground-fault current. Overcurrent relaying is well suited to distribution-system protection for several reasons. Not only is overcurrent relaying basically simple and inexpensive but also these advantages are realized in the greatest degree in many distribution circuits.

11.6 Procedure

1. Connect mains cable to 230VAC, Single phase supply with proper earth connection.
2. Keep MAINS MCB in OFF position and the variac in Zero position.
3. Make the connection as per circuit diagram shown in fig (10.2). Now the connection is for receiving end open condition.
4. Switch on MAINS plus CONTROL MCB. All the meters will glow.
5. Put the impedance relay to UNHEALTHY state and over current relay to HEALTHY state. Program the over current relay as required.

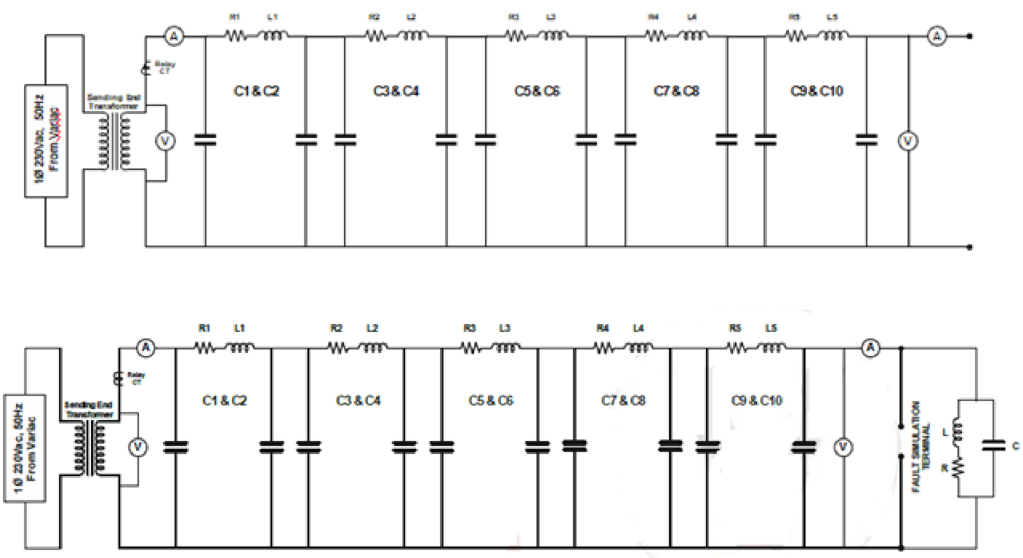

Figure 11.1: Circuit with load

6. Using DIP switches provided select the input current range and the type of characteristics required.
7. Select the required current limit for tripping. Also select the high-set feature if required.
8. Set the TMS value in range of 0.1 to 1.6. Select the values of line inductance and capacitance as required.
9. Keep the fault simulation switch in POSITION-2

10. Change the connection as shown in fig with connection RLC load
11. Press CB-1 ON and CB-2 ON push button
12. Set the voltage of sending end to 220V by varying the variac-1. Increase the load gradually, when the current exceeds the set limit in over current relay, the relay starts blinking and trips according to the TMS value and characteristics selected.
13. Note down the readings of current and trip time.

Table 11.1: Relay Setting

S.No	Relay set current	TMS	Fault current	PMS	Trip time
1.					
2.					
3.					

11.7 Further Probing Experiments

Q1. Use MATLAB/SIMULINK SIMPOWER SYSTEM for Modeling and Testing of a Over Current Relay. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.
Q2. Use MATLAB/SIMULINK SIMPOWER SYSTEM fo rover current protection using fault analysis on 11kv Transmission Line. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

LAB-12 EARTH FAULT PROTECTION

12.1 Introduction

This lab focuses on the working of Earth Fault Relay and effects during faults in transmission line

12.2 Objective

By the end of this lab, the student should be able understand working of Earth Fault Relay and protection schemes.

12.3 Prelab Preparation:

Read the material in the textbook that describes working principle of Earth Fault Relay.

12.4 Equipment needed

Transmission line model,
Power Analyzer, Ammeter, and voltmeter
1-Phase Variac,
Connecting wires

12.5 Background

In the electrical systems always exists the possibility of having shutdowns due to over currents or short circuits produced by operation mistakes, ambient conditions, lack of maintenance or atmospheric discharges. In the case of short circuit, this can be classified in the next types: 1.Bolted Faults. It occurs when the conductors (phase, neutral or ground) are solidly connected, having an impedance equal to cero on this connection and because this, a maximum current condition is present. 2. Ground Fault It occurs when one of the system phases get on direct contact to ground or to any metallic part that is grounded. 3. Arcing Fault It happens between two close conductors but are not in direct contact. Any of these faults is really dangerous for both equipment and personnel. In this document we will discuss more in detail the ground fault.

Why protect against Ground Fault:

The ground fault has its origin on different ways but the more common are reduced insulation, physical damages to insulation system or excessive transient or steady-state voltage stresses on insulation. These problems can be produced due to moisture, atmospheric contamination, insulation deterioration, mechanical stresses, etc. Although the situations mentioned before can be avoided following a good maintenance Schedule, always exists the latent risk of a fault, commonly during the installation or major maintenance to equipment.

Grounding Methods

Nowadays the interest on the using of ground fault Protection systems has been increasing due to this Protection is required for in some equipment and feeders, besides the interest of improving safety for personnel. The intention of grounding systems is to control the voltage with respect to ground and provide a current path that allows us to detect the unwanted connection between line and phase conductors and then be able to send a signal to trip the protection devices to remove the voltage on these conductors. There are several devices for Ground Fault protection on the market and they have their use depending on the grounding method used in our system. Whenever working on the design of an electrical system the question of how to ground the system came up. Grounding electrical systems is generally recommended, however there are exceptions.There are several methods and criteria for grounding systems and each has its own purpose.

Listed below are some of the existing methods and which are their advantages and disadvantages: -

Ungrounded System This system is defined as one who does not have an intentional connection to ground. However, there is always a capacitive coupling between the line conductors and ground. This system is also known as grounded by capacitance.

Fig 11.1 When the system is operating normally, capacitive currents and phase to ground voltages are equal and displaced 120 ° C of each other so that a vector system is fully balanced. If any of the phases is in contact with ground, the current flow through this phase to ground will stop because there will be no potential difference between conductors. At the same time in the remaining phases the current flow is increased by root 3 and will be moved only 60°C each other. Therefore, the vector sum of these currents is increased by 3 times the current Ico. Each time that a fault is presented in this configuration, it generates an over-voltage that can be many times greater in magnitude than the nominal (6 to 8 times) which is a result of resonance between the inductive reactance of the system and the distributed capacitance to ground. These over voltages can cause failure of the insulation system.

Resistance Grounding

A system grounded through resistance is defined as one in which the neutral of a transformer or generator is grounded through a resistor.

The reasons for limiting the current using a resistor are:

1. To reduce damage during a fault of electrical equipment such as panels, transformers, motors, cable, etc.
2. To reduce mechanical stresses in circuits and devices leading fault currents.
3. To reduce the risk of electrocution to personnel.
4. To reduce the risk of arc flash to personnel that could accidentally cause a failure or that is near to the fault location.
5. To reduce momentary voltage drop that occurs when a fault is present.
6. To secure control of transient voltages while at the same time avoiding shutdown of a faulted on the occurrence of the first ground fault (High Resistance Grounding) Grounding through resistance can be 2 types High Resistance or Low Resistance which are distinguished by the amount of current permitted to flow.

High Resistance Grounding High resistance grounding employs a neutral resistor of high ohmic value. The Resistor is used to limit the ground fault current (Ig) and typically is limited to 10A or less. When you have a system like this, does not require an immediate release of the fault as the current is limited to a very low level. Protective devices associated with a High Resistance system allows the system to continue working with the presence of a ground fault and send an alarm instead of tripping and open the associated protection. A typical scheme for detecting a ground fault in a high resistance grounding system is shown in the figure below, where under normal operation the neutral point of transformer is at zero potential, but when a line to ground fault occurs, phase voltage at the neutral is raised to almost the value of the line-to-neutral voltage which is detected by a relay. This relay activates a visual and / or sound alarm to notify to maintenance personnel and then attend, locate and repair the fault.

The advantages of using system could be listed as follows:

1. Service continuity. The first ground fault does not require equipment to be shutdown.
2. Transient over voltages due to re-striking are reduced.
3. A pulse system can help to locate the fault.
4. The need of coordinated ground fault relaying is eliminated. Typically this system can be used in low voltage systems where single-phase loads are not present, in MV where continuity of service is required and the capacitive current is not very high, and in retrofits where they had previously ungrounded system.

Low Resistance Grounding This system limits the ground fault current to a value between 100A and 1000A, being the most common value 400A. The value of this resistance is calculated as R = Vln / Ig, where Vln is the line to neutral voltage of the system and fault current Ig is the ground fault current desired. This system has the advantage of facilitating the immediate release and selectively to ground fault. The method used to detect this fault is to use an overcurrent relay 51G. At the moment of a fault the neutral voltage rises almost to the line to neutral voltage and a current begins to flow through the resistance.

Once the relay detects this current sends the signal to open the associated low-voltage switch. Grounding through a low resistance is used in medium voltage systems of 15KV and lower, particularly where large rotating machines are used and where is wanted to reduce ground fault to hundreds rather than thousands of amperes

Solid grounding

Solid grounding refers to the connection of the neutral conductor directly to ground.

This configuration can be suitably protected against voltage surges and ground faults. This system allows flexibility and allows the connection of line to neutral loads. When using this configuration in systems of 600V or higher, will have to use residual or zero sequence protective relays. The circuit breakers are normally provided with current transformers that provide the signal from each of the phases for over current relay and ground fault relay takes the signal from the star that forms from the current transformers to increase the sensitivity of ground faults. The methods of detection as zero-sequence and residual will be discussed later. One disadvantage of the solidly grounded system is that the ground fault magnitudes reached may be so large that they could completely destroy the equipment. However, if these faults are quickly released the damage to equipment would be within "acceptable" levels.

Reactance Grounded System

Reactance Grounded System In this configuration a reactor between the neutral and earth is installed. The levels of ground fault current when grounding through a reactor are considerably higher than desirable levels in systems grounded through resistance, because this grounding through a reactor is not commonly used as an alternative of grounding by low resistance.

Ground Fault Detection Methods: The ground fault current can be monitored in different ways, could be monitored either as it flows out of the fault or returning to the neutral point of the source transformer or a generator. When monitoring the current coming out from the fault all the conductors of the system are monitored individually and when monitoring the return to neutral point only neutral is monitored. To perform this monitoring power transformers are used either in all the line conductors or in the neutral depending on the method being used. Protection devices that receive signals from the current transformers must have the ability to adjust the values of pick-up and the ability to adjust the time delays.

Residual Ground Fault Protection

Residual protection is commonly used in medium voltage systems. This system consists of the use of 3 interconnected current transformers which send a signal proportional to the flow of ground fault current to the protection relay or device to trip. This system is not often used in low voltage equipment, but there are available low-voltage systems with 3 current transformers connected on a residual basis.

In 3-phase 3-wires systems the resulting from the vector sum of phase currents is zero even if a fault is present between phases. When one of the phases get in contact to ground short circuit current flows through the earth and not anymore by the line faulted line producing an imbalance in the circuit generating a residual current that is detected by the protective device. When you have systems of 3 phase 4 wire where they feed single phase loads, you should add a fourth current transformer to monitor the current consumed by such loads as well as single-phase zero sequence harmonic currents produced by nonlinear loads such as fluorescent lighting. If this fourth sensor is not used the protection device would see the imbalance between phases as a ground fault and will open the circuit. The selectivity of the residual protection scheme depends on the ratio of the CTs which should be sufficient capacity for normal loads of the circuit. In this system instantaneous trip is not used because when starting some loads such as motors can generate a "normal" imbalance between phases which could generate a protective device tripping. If more selectivity is required, the Balanced Core scheme must be used.

Core Balance (Zero sequence sensor): The core balance method is based on the flux summation. This method uses only one current transformer which monitors the three phases of the system (and neutral if exists) at the same time. Unlike the method residual current transformer is less amperage capacity and only monitors a possible imbalance and no load current of each line, it helps to have a better selectivity. In normal operating conditions (balanced, unbalanced, single phase loads or short circuits between phases) the flux summation of the currents flowing through the CT is zero. When a ground fault current flows through the ground wire it creates an imbalance in the CT output which generates the operation of the protection.

Ground Return

Ground Return Placing a current transformer on the grounded neutral and using a related protection relay, provides a ground fault detection method of low cost. Because only will monitor the ground fault current, adjustments can be set at very low current values.

In low-resistance grounded systems at 5 and 15KV this method is often used where ground fault currents are relatively low. It is also used in solidly grounded 480V, 3 phase 3 wire or 3 phase 4 wire. To provide adequate protection, the relay must be wired to trip the main circuit breaker at secondary side of the transformer and set a time delay to allow the circuit breaker to trip and if once the circuit breaker is tripped the fault is still sensed the relay must send a signal to that protection on the primary side to operate.

12.6 Procedure

1. Switch ON the MCB, the Voltmeter will show the line voltage.

2. Initially Rotary Switch should be in Amp Adjust Position.

3. Now to set the desired fault current we will be using current source. For that switch ON the Rotary switch and move the current source till the desired fault current is indicated on the Ammeter, it is quit possible that while adjusting the fault current the FLAG of the Relay might trip for that you have to RESET the FLAG by moving the marked shaft UPWARD denoted by (RELAY FLAG RESET) for resetting the FLAG the Toggle switch must be brought in OFF position and the marked shaft move UPWARD.

4. Now the desire Fault Current is SET and relay FLAG RESET – Only when the disk has move fully anti clockwise. Now move the Rotary Switch in Relay Test and press the green push button and timer counting will START and counting will STOP once the relay is operated. Note down the time in seconds.

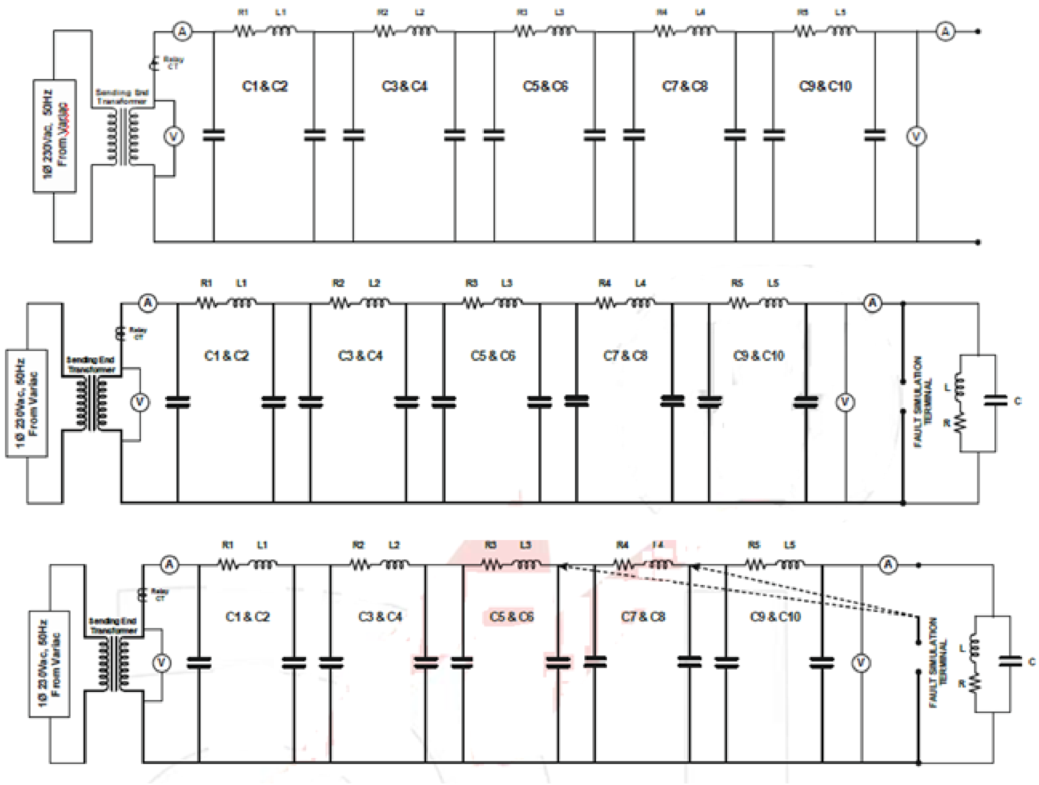

Figure 12.1: Circuit with load

Table 12.1: Relay Setting

S.No	Current(Amps)	Time(Secs)	PSM	Trip time

5. Now for various T.M.S. (Time Multiplier Setting) and P.S.M. (Plug Setting Multiplier), the time taken by the relay to operate at various fault current may be noted down.

6. Now plot the graph between time take for the relay to operate Vs Plug Setting Multiplier at various T.M.S.

12.7 Further Probing Experiments

Q1. Use MATLAB/SIMULINK SIMPOWER SYSTEM for Modeling and Testing of a Earth Fault Relay. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.
Q2. Use MATLAB/SIMULINK SIMPOWER SYSTEM for over current protection using fault analysis on 11kv Transmission Line. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

LAB-13 FEEDER PROTECTION

13.1 Introduction

To study the various protection schemes in radial feeder under various fault conditions.

13.2 Objective

By the end of this lab, the student should be able understand working of feeder and protection schemes.

13.3 Prelab Preparation:

Read the material in the textbook that describes working of protection schemes in feeder.

13.4 Equipment needed

Alternator coupled to Motor
Motor Drive
Power Analyzer
RPM meter
Variac(1-ph)
Rheostat(150Ω/3A)
Patch Cords

13.5 Background

The word feeder here means the connecting link between two circuits. The feeder could be in the form of a transmission line, short, medium of long, or this could be a distribution circuit. The various methods of protecting the feeders are:
over current protection.
Distance protection.
Pilot relaying protection.

Of these, over current protection is the simplest and cheapest form of protection. It is most difficult to apply and needs readjustment, should a change in the circuit occur. This may even have to be replaced depending upon the circuit conditions.Over current relaying for distribution circuits besides being simple and cheap provides the following advantages:

1. Very often the relays need not be directional and hence no A.C. voltage source is required.

2. Two phase and one earth fault relay or three element, earth fault relay can be used.
   The over current protection is normally used as back up protection where the primary protection is provided with distance schemes. The discrimination using over current protection is achieved in the following ways.

3. Time graded system.

4. Current graded system.

5. Time – current graded system.

TIME GRADED SYSTEM The selectivity is achieved based on the time of operation of the relays. Consider a radial feeder in fig.1 the feeder is being fed form one source and has four substations indicated by vertical lines. The crosses represent the location of the relays. The relays used are simple over current protection relays. The time of operation the relays at various locations is so adjusted that the relay farthest from the source will have minimum time of operation and as it is approached towards the source the operating time increases. This is the main drawback of grading the relays in this way because it is required that the more severs a fault is lesser should be the operating time of the relays whereas in this scheme of operating time increases. The main application of such a grading is done on systems where the fault current does not vary much with the location of the fault and hence the inverse characteristic is not used.

CURRENT GRADED SYSTEM This type of grading is done on a system where the fault current varies appreciably with the location of the fault. This means as we go towards the source the fault current increases. With this if the relays are set to pick at progressively higher current towards the source, then the disadvantages of the long-time delay that occurs in cars of time graded systems can be partially overcome. This is known as current grading. Since it is difficult to determine the magnitude of the current accurately and also the accuracy of the relays under transient conditions is likely to suffer, current grading alone cannot be used. Usually a combination of the two grading i.e., current time grading is used.

TIME – CURRENT GRADING. This type of grading is achieved with the help of inverse time over current relays and the most widely used is the IDMT relay. The other inverse characteristics. E.g. Very inverse or extremely inverse are also employed depending upon the system requirements. If the IDMT relays are slow at low values of overloads, extremely inverse relays are used and if the fault current reduces substantially as the fault location moves away from the source, very inverse type of relays are used.

13.6 Procedure

1. For proper coordination between various relays on a radial feeder, the pickup of the relay should be such that it will operate for all short circuits in its own line and should provide backup protection for short circuits in immediately adjoining line.

2. A three phase fault under maximum generation gives the maximum fault current and line to line fault under minimum generation gives the minimum fault current.

3. The relay must respond between these two extreme limits. On a radial system the current setting of the relay farthest from the source should be minimum and it goes on increasing as we go towards the source. According to Indian Standard Specification the operating value should exceed 1.3 times the setting, i.e Min short circuit current 1.3 I setting

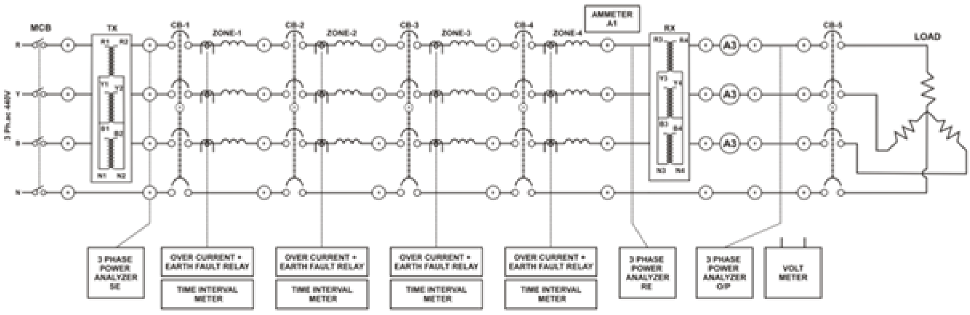

Figure 13.1: Circuit with load

Table 13.1: Feeder Protection

S.No	Voltage(VR)	Voltage(VY)	Voltage(VB)	Current(IR)	Current(IY)	Current(IB)

13.7 Further Probing Experiments

Q1. Use MATLAB/SIMULINK SIMPOWER SYSTEM for Modeling and Testing of a feeder protection Schemes. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.
Q2. Use MATLAB/SIMULINK SIMPOWER SYSTEM for over current protection using feeder protection Transmission Line. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

LAB-14 MEASUREMENT OF SEQUENCE IMPEDANCE OF SYNCHRONOUS MACHINE

14.1 Introduction

Measure the Sequence Impedance i.e., positive sequence, negative sequence and zero sequence of Synchronous Machine by direct method and fault protection devices.

14.2 Objective

By the end of this lab, the student should be able understand sequence components of alternator.

14.3 Prelab Preparation:

Read the material in the textbook that describes working of protection schemes in Sequence components.

14.4 Prelab Preparation:

Write the text here

14.5 Equipment needed

String insulators

14.6 Background

The sequence impedances of an alternator have differing values. This is because of the difference in the effect of the armature m.m.f on the DC field m.m.f for different sequences. They may be defined as:

1. Positive Sequence Impedance It is the ratio of the fundamental component of armature voltage, due to the fundamental positive sequence component of armature current, to this component of armature current at rated frequency. This is the usual impedance (either synchronous or transient or sub-transient) of alternator.
2. Negative Sequence Impedance It is the ratio of fundamental component of armature voltage, due to the fundamental negative sequence component of armature current, to this component of armature current at rated frequency

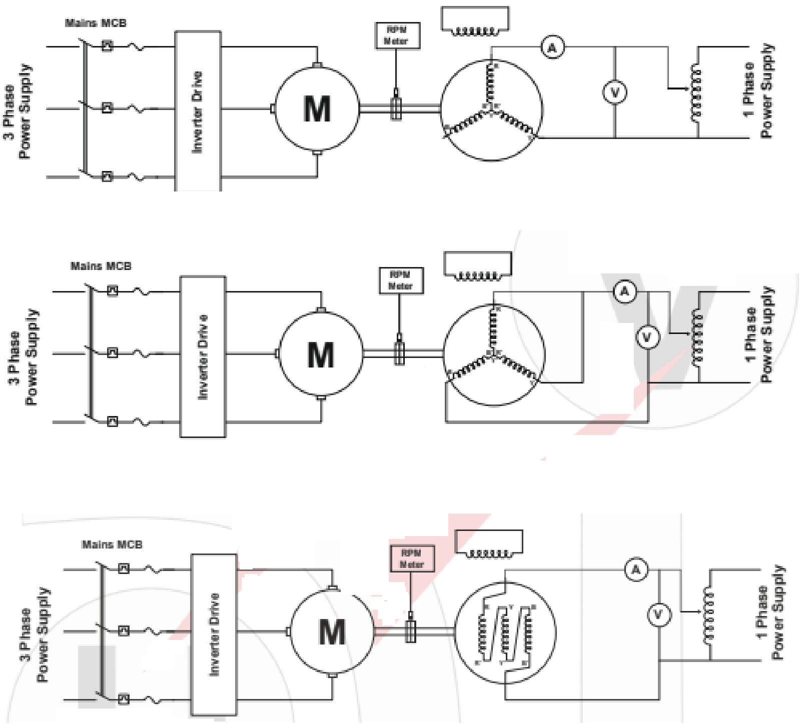

Figure 14.1: Circuit with load

3. Zero Sequence Impedance It is the ratio of fundamental component of armature voltage, due to the fundamental zero sequence component of armature current, to this component of armature current at rated frequency

14.7 Procedure

1. Positive Sequence Impedance
2. Connect as shown in figure.
3. Initially keep the variac at zero position.
4. Switch on the supply and run the Motor at synchronous speed using thespeed control knob provided in the panel.
5. Gradually apply single phase voltage using the variac across any twowinding(R-Y) of the alternator. (near rated current)
6. Note down the values of voltage and current.
7. Similarly do for Y-B and R-B and calculate the positive sequence impedance.
8. Negative Sequence Impedance
9. Connect as shown in figure.

10. Initially keep the variac at zero position.
11. Switch on the supply and run the Motor at synchronous speed using the speed control knob provided in the panel.
12. Short any two terminals of the alternator and connect single phase variac to the other terminal as shown.
13. Gradually apply single phase voltage using the variac across the two terminals (shorted and open end) of the alternator. (near rated current)
14. Note down the values of voltage and current.
15. Calculate the value of Negative Sequence Impedance.
16. Zero Sequence Impedance
17. Connect as shown in figure.
18. Initially keep the variac at zero position.
19. Switch on the supply and run the Motor at a speed close to the synchronousspeed using the speed control knob provided in the panel.

Table 14.1: Positive sequence Impedence

Phases	Voltage(V1)	Current(I1)	Z1	Current(IR)	Current(IY)	Current(IB)
R-Y						
Y-B						
B-R						

Table 14.2: Negative sequence Impedence

Phases	Voltage(V2)	Current(I2)	Z2	Current(IR)	Current(IY)	Current(IB)
R-Y						
Y-B						
B-R						

Table 14.3: Zero Sequence Impedence

Phases	Voltage(V0)	Current(I0)	Z0	Current(IR)	Current(IY)	Current(IB)
R-Y						
Y-B						
B-R						

14.8 Further Probing Experiments

Q1. Use MATLAB/SIMULINK SIMPOWER SYSTEM for Modeling and Testing of a sequence components. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

Q2. Use MATLAB/SIMULINK SIMPOWER SYSTEM for over current protection using sequence componets of alternator. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

LAB-15 STRING EFFICIENCY OF INSULATORS

15.1 Introduction

Determine string efficiency in a string of insulators.

15.2 Objective

By the end of this lab, the student should be able understand to calculate string efficiency of insulators.

15.3 Prelab Preparation:

Read the material in the textbook that describes string efficiency.

15.4 Equipment needed

String Insulators

15.5 Background

Power transmission by overhead lines ia the by means of transportation of electrical energy from source to load centers. This energy transfer requires higher system voltages in EHV/UHV ac and dc on order to reduce the line loss and increases the power handling capacity. As the system voltage increases, the design of external insulation for both line and station insulation depends on the pollution performance.

15.6 Procedure

1. Suspend the set of string insulator vertically and connect the top part of the string to the earth.
2. Connect the test jig across the last insulator.
3. Apply high voltage to the pin of the lowest insulator of the string.
4. Gradually increase the voltage until spark occurs.
5. Note down the breakdown voltage and the total voltage applied across the string.
6. Repeat the process for all the insulators in the string.
7. Tabulate the results and calculate efficiency.

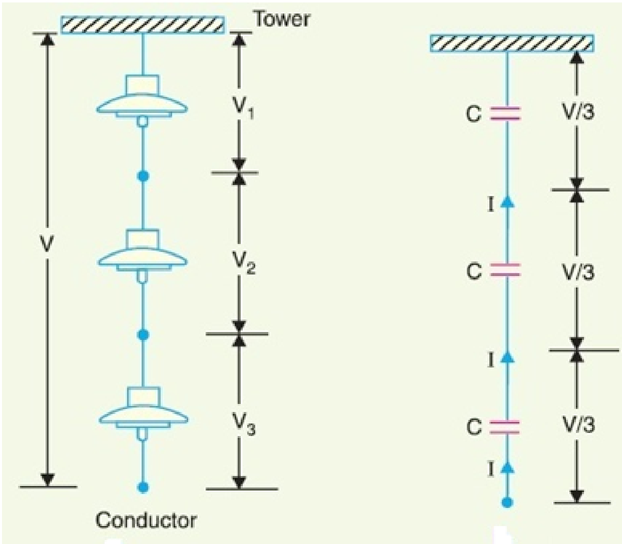

Figure 15.1: Circuit with load

Table 15.1: String Efficiency

S.No	Voltage across insulators	Breakdown Voltage	%Flash Voltage

15.7 Further Probing Experiments

Q1. Use MATLAB/SIMULINK SIMPOWER SYSTEM for Modeling and Testing of a string efficiency. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.
Q2. Use MATLAB/SIMULINK SIMPOWER SYSTEM for over current protection using string efficiency of insulators. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.