

**MALLA REDDY ENGINEERING COLLEGE &
MANAGEMENT SCIENCES**

**(Approved by the AICTE, New Delhi and affiliated to JNTU, Hyderabad)
Kistapur Hamlet of Medchal, Hyderabad, Medchal .Dist. - 501401**

Department of Electrical and Electronics Engineering

Power Systems Lab

Student Lab Manual

III B. Tech: II – SEM

Lab code: EE605PC



Department of Electrical & Electronics Engineering
MALLREDDY ENGINEERING COLLEGE AND MANAGEMENT SCIENCES
(Approved by AICTE New Delhi & Affiliated to JNTU Hyderabad)
Kistapur, Medchal, Medchal – 501401



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(Approved by AICTE New Delhi & Affiliated to JNTU Hyderabad)
Kistapur Village, Medchal, Medchal District-501401

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

Vision of the Institute:

The aspiration is to emerge as a premier institution in technical education to produce competent engineers and management professionals contributing to Industry and Society.

Mission of the Institute (MI):

The aspirations are fulfilled and continue to be fulfilled:

MI-1: By providing the student supporting systems:

To impart updated pedagogical techniques with supportive learning environment and state-of-the-art facilities.

MI-2: By training the students as per the industry needs:

To cultivate a culture of interdisciplinary approach, problem solving, innovative ecosystem, and entrepreneurship by facilitating critical thinking, teamwork, and research-driven activities with hands-on learning.

MI-3: By educating the students about society's needs:

To instill ethical, social, and environmental values through community engagement resulting in sustainable development of society.

Vision of the EEE-Department:

The aspiration is to produce competent Electrical and Electronics Engineering Graduates capable of making valuable contributions in the field of Electrical and Electronics Engineering.

Mission of the Department:

MD-1: Student Support Systems:

To equip students with advanced learning skills in Electrical and Electronics Engineering, while providing them with the necessary professional competencies to overcome future challenges.

MD-2: Training the students as per the industry needs:

To facilitate the students to acquire interdisciplinary skills in renewable energy, electric vehicles, and power electronics applications through practical knowledge and innovative techniques to meet evolving global challenges.

MD-3: Educating the students, the needs of society:

To develop professional ethics, self-confidence, and leadership qualities among students.

Program Educational Objectives (PEO'S)

PEO 1: MREM B.Tech EEE graduates shall be able to apply technical knowledge in Electrical and Electronics Engineering, empowering them to pursue higher studies or succeed in their professional careers **in the electrical Power Industry.**

PEO 2: MREM B.Tech EEE graduates shall be able to design and implement complex electrical systems, **meeting the electrical and electronics industry demands.**

PEO 3: MREM B.Tech EEE graduates shall be able to handle societal and environmental problems with ethical values **as demanded by society.**

Program Specific Outcomes (PSOs)

PSO1: Provide efficient problem-solving techniques in the areas of Power Electronics, Power Systems, Control systems, and Electrical Machines using MATLAB/MULTISIM.

PSO2: Design and develop a wide range of Electrical and Electronics Systems, specifically emphasizing Electric Drives, Conventional Renewable Energy, and Automation to demonstrate overall knowledge and contribute to the betterment of society.

PROGRAM OUTCOMES (POs)

PO1: ENGINEERING KNOWLEDGE:

Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: PROBLEM ANALYSIS:

Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: DESIGN/DEVELOPMENT OF SOLUTIONS:

Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: CONDUCT INVESTIGATIONS OF COMPLEX PROBLEMS:

Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: MODERN TOOL USAGE:

Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: THE ENGINEER AND SOCIETY:

Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: ENVIRONMENT AND SUSTAINABILITY:

Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: ETHICS:

Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: INDIVIDUAL AND TEAM WORK:

Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: COMMUNICATION:

Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, give and receive clear instructions.

PO11 PROJECT MANAGEMENT AND FINANCE:

Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 LIFE-LONG LEARNING:

Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

MALLA REDDY ENGINEERING COLLEGE & MANAGEMENT SCIENCES*DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING***GENERAL LABORATORY INSTRUCTIONS**

1. There must be at least two (2) people in the laboratory while working on live circuits or chemical processing
2. Shoes and apron must be worn at all times.
3. Remove all loose conductive jewelry and trinkets, including rings, which may come in contact with exposed circuits. (Do not wear long loose ties, scarves, or other loose clothing around machines.)
4. Consider all circuits to be "hot" unless proven otherwise.
5. When making measurements, form the habit of using only one hand at a time. No part of a live circuit should be touched by the bare hand.
6. Keep the body, or any part of it, out of the circuit. Where interconnecting wires and cables are involved, they should be arranged so people will not trip over them.
7. Be as neat as possible. Keep the work area and workbench clear of items not used in the experiment.
8. Always check to see that the power switch is OFF before plugging into the outlet. Also, turn instrument or equipment OFF before unplugging from the outlet.
9. When unplugging a power cord, pull on the plug, not on the cable.
10. When disassembling a circuit, first remove the source of power.
11. No ungrounded electrical or electronic apparatus is to be used in the laboratory unless it is double insulated or battery operated.
12. Keep fluids, chemicals, and heat away from instruments and circuits.
13. Report any damages to equipment, hazards, and potential hazards to the laboratory instructor.
14. If in doubt about electrical safety, see the laboratory instructor. Regarding specific equipment, consult the instruction manual provided by the manufacturer of the equipment. Information regarding safe use and possible hazards should be studied carefully.

Power Systems Lab

Part - A

1. Characteristics of IDMT Over-Current Relay.
2. Differential protection of 1- Φ transformer.
3. Characteristics of Micro Processor based Over Voltage/Under Voltage relay.
4. A,B,C,D constants of a Long Transmission line
5. Finding the sequence impedances of 3- Φ synchronous machine.
6. Finding the sequence impedances of 3- Φ Transformer.

Part - B

1. Formation of YBUS.
2. Load Flow Analysis using Gauss Seidal (GS) Method.
3. Load Flow Analysis using Fast Decoupled (FD) Method.
4. Formation of ZBUS.
5. Simulation of Compensated Line

Beyond The Syllabus Experiments

1. Time constant calculation of RL circuit
2. Time constant calculation of RLC circuit

S. No	Name of the Experiment	Page No
1	Characteristics of IDMT over Current Relay	3-6
2	Differential protection of 1-phase transformer.	7-9
3	Characteristics of Micro Processor based Over Voltage/Under Voltage relay	10-14
4	Finding the sequence impedances of 3phase Transformer	15-17
5	Finding the sequence impedances of 3phase synchronous machine	18-22
6	(a) Performance and Testing of Transmission line Model.	23-32
	(b) ABCD constants of a long transmission line.	
7	Formation of Y-BUS.	37-39
8	Load Flow Analysis using Gauss Seidal (GS) Method.	40-48
9	Load Flow Analysis using Fast Decoupled Method.	49-56
10.	Formation of Z-BUS.	57-59
Beyond The Syllabus Experiments		
1.	Time constant calculation of RL circuit	60-65
2.	Time constant calculation of RLC circuit	66-68

Power System Lab

Course Outcome	Course Outcome Statement	Bloom's Taxonomy level
C325.1	Plot the characteristics of Over Current, Under Voltage and overvoltage relay.	Apply
C325.2	Analyze the operation of differential relay	Analyze
C325.3	Determine the transmission line parameters of a given long transmission line model	Apply
C325.4	Determine the sequence impedance of three phase synchronous machine and three phase transformer	Apply
C325.5	Develop the bus impedance and admittance model	Create
C325.6	Develop GS and NR method to analyze the loadflow analysis	Create

Power Systems Lab

Name : Power Systems Lab
Course Code : EE605PC
Class : III - II

CO-PO MAPPING

	P O1	P O2	P O3	P O4	P O5	P O6	P O7	P O8	P O9	P O 10	P O 11	P O 12	PSO1	PSO2
C325.1	1		3		2								2	2
C325.2	1	2	3										2	2
C325.3	1		3		2								2	2
C325.4	1	2	3										2	2
C325.5	1		3		2								2	3
C325.6	1		3		2								2	2
Avg	1	2	3		2								2	2

**MALLA REDDY ENGINEERING COLLEGE & MANAGEMENT SCIENCES
EEE DEPARTMENT****Power System Lab**

S. No	Name of the Experiment	CO Mapping	PO/PSO Mapping
1	Characteristics of IDMT Over-Current Relay.	C325.1	PO 1, PO3, PO5
2	Differential protection of 1- Φ transformer.	C325.2	PO1, PO2, PO3 & PSO3
3	Characteristics of Micro Processor based Over Voltage/Under Voltage relay.	C325.1	PO 1, PO3, PO5
4	A, B, C, D constants of a Long Transmission line	C325.3	PO 1, PO3, PO5 & PSO3
5	Finding the sequence impedances of 3- Φ synchronous machine.	C325.4	PO1, PO2, PO3
6	Finding the sequence impedances of 3- Φ Transformer.	C325.3	PO 1, PO3, PO5 & PSO3
7	Formation of YBUS.	C325.5	PO 1, PO3, PO5 & PSO3
8	Load Flow Analysis using Gauss Seidal (GS) Method.	C325.6	PO 1, PO3, PO5
9	Load Flow Analysis using Fast Decoupled (FD) Method.	C325.6	PO 1, PO3, PO5
10	Formation of ZBUS.	C325.5	PO 1, PO3, PO5 & PSO3

1.IDMT Characteristics of Over Current Relay

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

Apparatus:

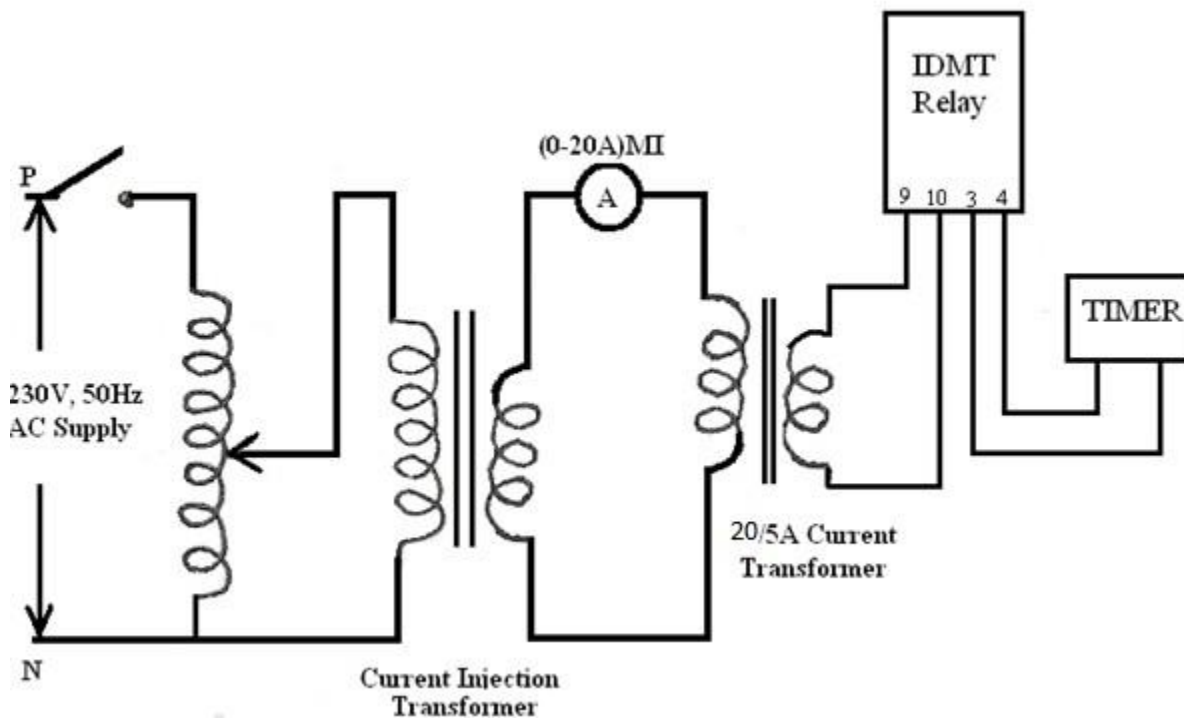
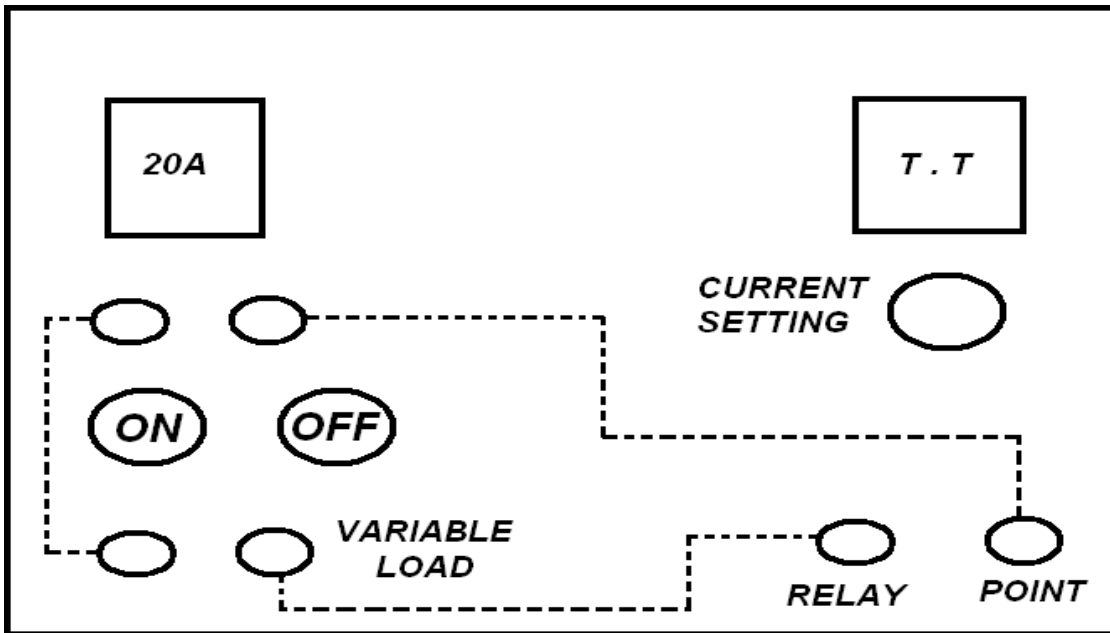
S.No	Name Of The Equipment	Quantity
1	Non-Directional Over current relay	1
2	Time Totalizer	1
3	Fault creation Panel	1
4	Digital Ammeter	1

Theory:

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 time is used to conduct the experiment. Values recorded for various TSMsand 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 stopwhich is controlled by the rotating a KNUR LED molded disc at the base of graduated time multiplier.

Circuit Diagram:



Procedure:-

1. Switch ON the MCB.
2. Initially rotor switch should be in OFF position.
3. Now set the described fault current by using the current source. For that switch ON the rotor switch and move the current till the described fault current is indicated in the ammeter.
4. Now move the rotor switch is OFF position and press the green button. Note down the time in seconds after relay operated.
5. Repeat the same procedure for various T.S.M and P.S.M
6. Plot the graph between time take for relay to operate Vs P.S.M for various T.S.M.

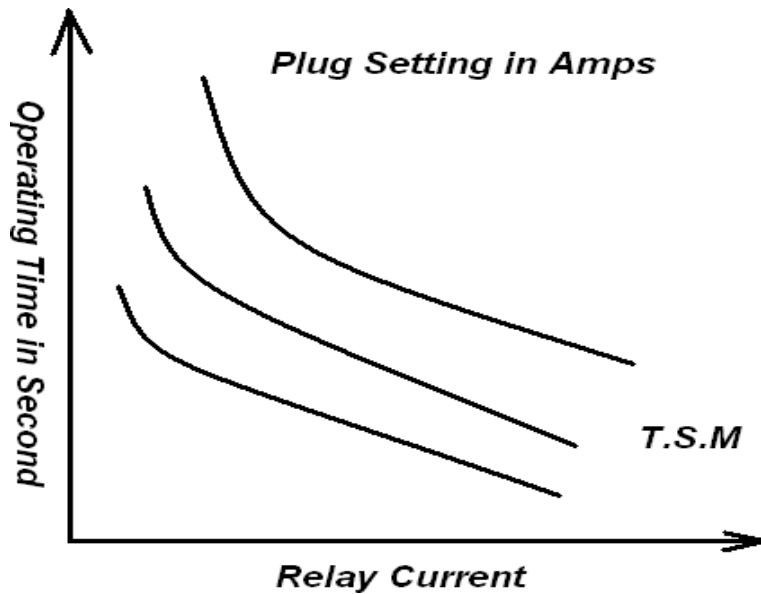
Precautions:-

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

Readings and Tabular forms:-

PSM = TSM =

SNO.	Fault Current	Time of operation

Expected graphs:Result:**Discussion questions:**

1. Why CT is required in this experiment?
2. Can we design the experiment without Current Injection Unit?
3. What is TSM & PSM and why different TSM & PSM?
4. Identify different terminals of the relay and explain their use. Write them in your record.

2. Differential Protection on Single Phase Transformer.

Aim: To study the differential protection scheme for a single phase transformer with unequal turn's ratio

Apparatus:

S.No	Name Of The Equipment	Quantity
1	Single phase transformer	1
2	Current transformer	1
3	Single phase variac	1
4	Suitable ammeters	1
5	over current relay	1

Theory:

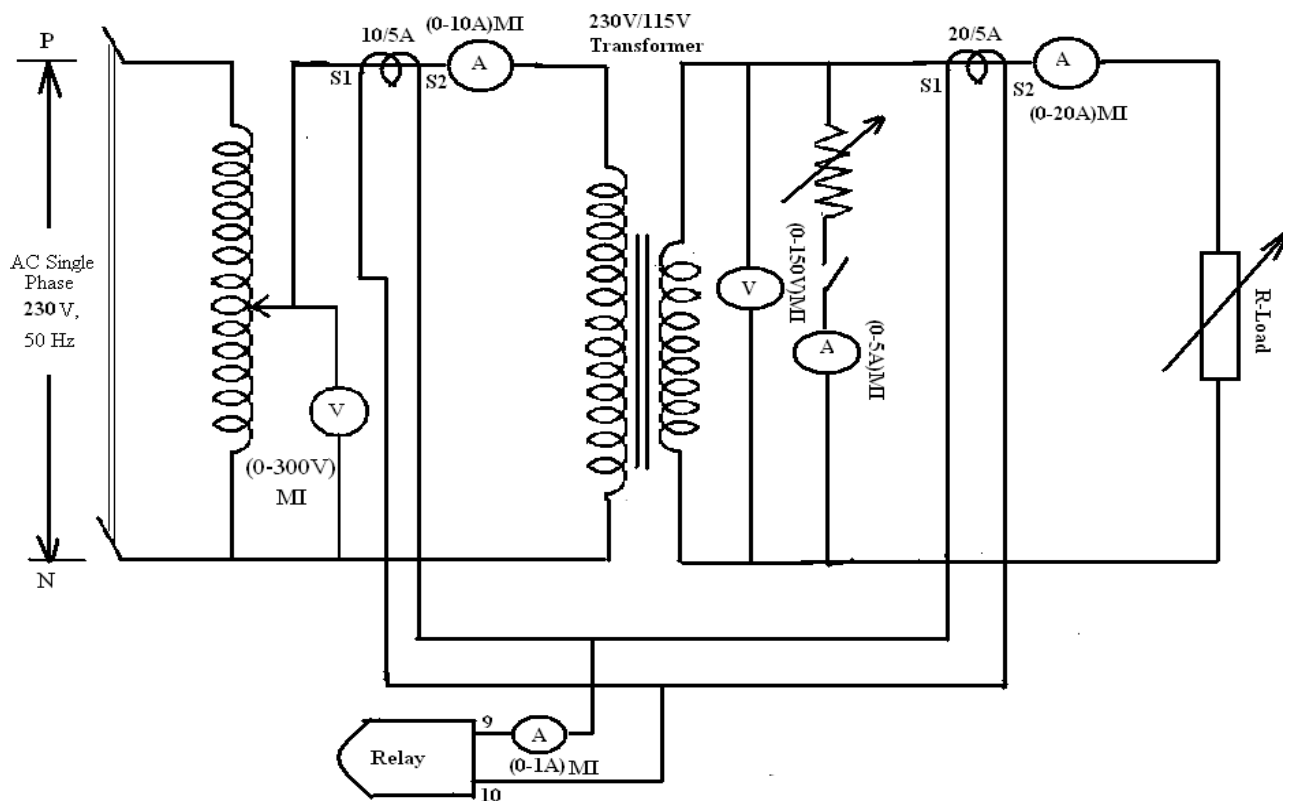
A Differential relay responds to vector difference between two or more similar electrical quantities. From this definition the Differential relay has at least two actuating quantities say 1-1 and 2-1.

The two or more actuating quantities should be same.

Ex: Current/Current.

The Relay responds to vector difference between 1-1 & 2-1 which includes magnitude and /or phase angle difference. Differential protection is generally unit protection. The protection zone is exactly determined by location of CTs. The vector difference is actuated by suitable connection of CTs or PTs secondaries. Most differential relays are current differential relays in which vector difference between current entering the winding & current leaving the winding is used for relay operation. Differential protection is used for protection of Generators, Transformers etc. Internal fault is created using switch and relay operation observed for various TSMs. Relay operations for external faults can also be studied.

Circuit Diagram:



Procedure:

1. Make the connections as shown in fig.1
2. Select the transformation ratio 2:1 and the C.T. ratios of 2:1 and 4:1 Set PSM of the relay equal to 0.5.
3. Apply rated voltage 230V to primary by varying the variac.
4. Without applying fault, note down different meter readings.
5. By applying load observe whether the relay is operating or not .
6. Now close the switch so as to create an internal fault.
7. Note the various ammeter readings when relay operates.
8. Create internal fault at different loads and note the various meter readings.
9. Now create an external fault and observe whether the relay operates or not, note the various meter readings.

Readings and Tabular form:

Observation:- For Internal Fault

S.No	I _{Primary}	I _{Secondary}	I _{relay}	I _{fault}	Relay operates/doesn't operate

For External Fault

S.No	I _{Primary}	I _{Secondary}	I _{relay}	I _{fault}	Relay operates/doesn't operate

Result:

Discussion Questions:

1. Why identical CTs are required in this scheme.
2. How would you take into account CT imbalances?
3. What do you understand by internal fault?

3. Characteristics of Static Relay UV/OV relay

Aim:

To study the operation of Microprocessor Based type under voltage relay and hence to obtain inverse time/voltage characteristics.

Apparatus Required:

S.No	Name Of The Equipment	Quantity
1	Microprocessor Based Under voltage relay	1
2	Auto Transformer	1
3	Voltmeter (0-600V)MI	1
4	Timer	1
5	Connecting Wires	Required

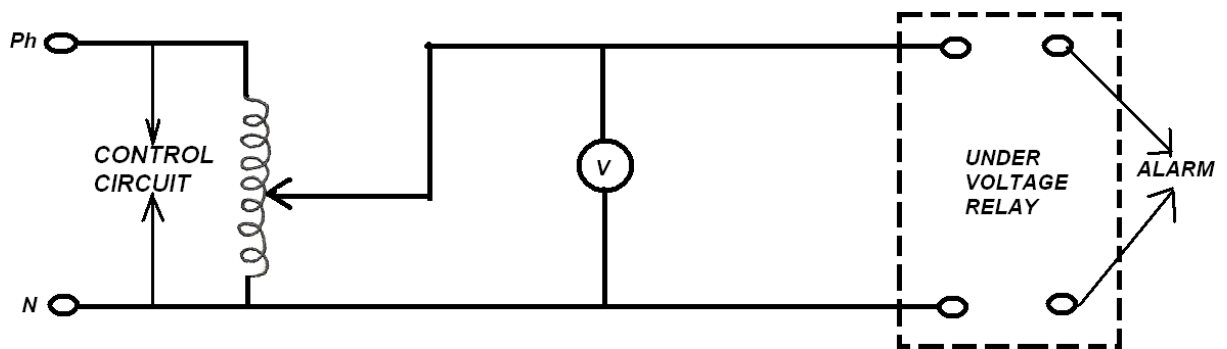
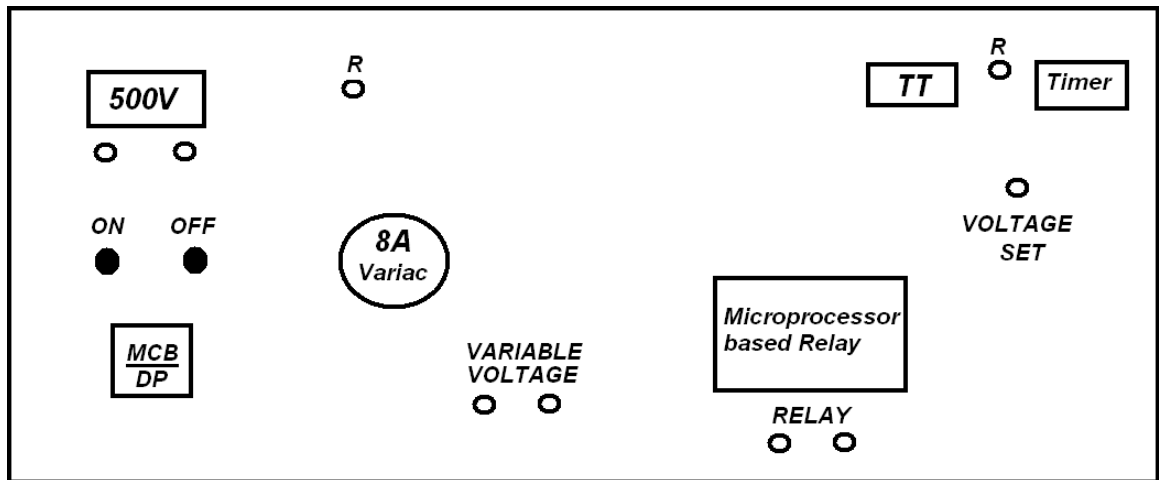
Theory:

Over Voltage/Under Voltage Relay is an electronic microcontroller based single-phase voltage relay. It is suitable for over voltage/under voltage protection schemes in LV, MV and HV power distribution systems. It is also suitable for over voltage protection of AC circuits, capacitors, machines such as generators, synchronous motor and under voltage protection of AC circuits, Induction motors, automatic change over schemes etc.

The microcontroller-based design offers a wide range of Trip-Time characteristics, under voltage or over voltage mode and PT rating (110V, 240V, 415V), which can all be selected in the field at the time of commissioning. It accepts very wide auxiliary supply range.

Relay is designed for flush mounting. It is very compact in size, which results in saving of panel space. Its draw-out construction makes installation and maintenance very easy.

Circuit Diagram:



Procedure:

1. Switch on the MCB
2. Initially Rotary switch should be in OFF position
3. Now to set the desired fault voltage we will be using voltage source. For that switch ON the Rotary switch marked as voltage set and move the voltage source till the desired fault voltage is indicated on the voltmeter, it is quit possible that while adjusting the fault voltage the Relay might trip for that you have to RESET the RELAY by pressing the red button provided on the relay denoted by (RELAY RESET) for resetting the relay the Rotary switch must be brought in OFF position.
4. Now the desire Fault voltage is SET and Relay RESET. Now move the Toggle Switch on OFF position 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.
(1) Now for various T.M.S (Time Multiplier Setting) and Voltage setting the time taken by the relay to operate at various fault voltage may be note down.

Tabular Column

S.No.	T.M.S	Voltage Setting	Applied Voltage	Operating Time

Graph

Plot the graph operating time Vs applied voltage.

Setting of Fault voltage Level: $V_s =$

$$1 - (0.05 + \sum a) V_n,$$

Where,

$V_s =$ Pick up setting in volts V_n

$=$ PT rating 110V

$a =$ weight of the switch in ON position

Note: In Under voltage mode, continuing with above example, the pick up setting becomes $V_s = (1 - 0.30) = 70\%$ of V_n . For 110 volts V_n , the pick up voltage becomes 77 volts. If $V_n = 415$, then pick up voltage becomes 290.5 volts. Where voltages below this set value, relay picks up and trips according to selected trip time characteristics.

The trip time will depend upon:

- a) Trip time characteristic selected and magnitude of fault in case of Inverse Trip Time Characteristics.
- b) Define Time in case of Definite Time Characteristics.

Time Multiplier Setting:

This feature offers various operations of Trip Time for a selected Trip Time Characteristic. The Time Multiplication Factor can be set from 0.1 to 1.6 in steps of 0.1 using the last block of four DIP switches shown in Diagram. This means in case of Inverse Trip Time Characteristics. Relay offers 16 parallel curves corresponding to each Time Multiplier Setting as shown in Figure and in case of Definite Trip Time mode, the trip time can be set 100msec to 160 secs.

The method of setting this switch is similar to one explained in previous pages.

Trip time T is given by formula

$$T = K (0.1 + \sum t) \text{ where } T$$

$=$ Trip time in seconds.

K = Constant depending on Trip Time Characteristic selected

Normal Inverse (3.5 secs) in OV mode when fault is 2Vs Normal

Inverse (5.7 secs) in UV mode when fault is 0.5Vs.

1.0 Definite Time (1.0 sec)

10.0 Definite Time (10 sec)

100.0 Definite Time (100 sec)

t=weight of the switches in ON position

Result:

4.Determination of Positive, Negative and zero sequence reactance of 3 ph Transformers.

Aim: -

To determine the Positive, Negative and Zero sequence (sequence impedance) of the given three phase transformer

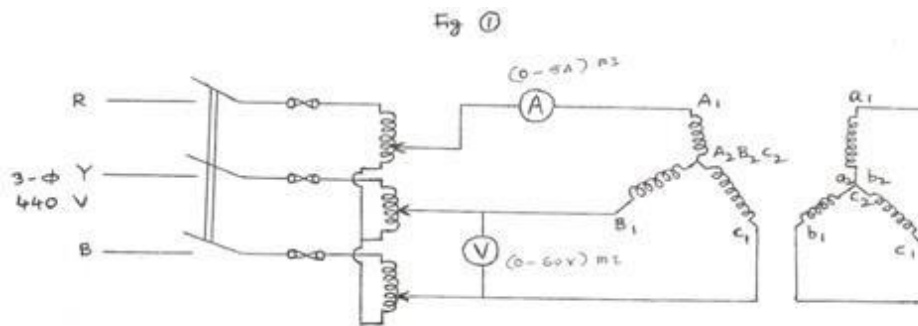
Apparatus: -

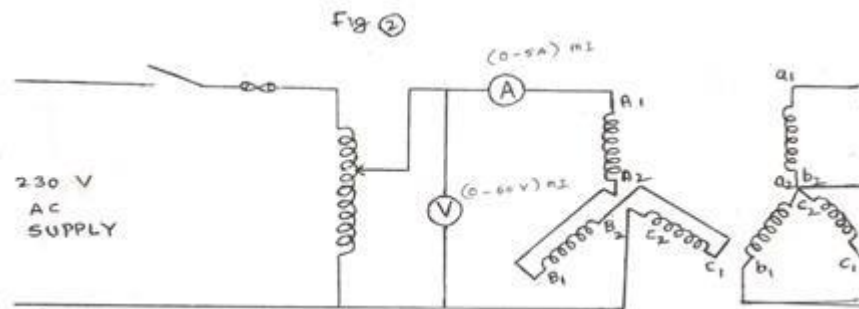
S.No	Name Of The Equipment	Quantity
1	Ammeter --(0 – 5) A	1
2	Voltmeter ---(0 – 600)V	1
3	Connecting Wires	Required

Theory:

Since Transformers have the same impedance with reversed phase rotation, their +ve and –ve sequence impedances are equal. This value being equal to the impedance of the Transformer. However, Zero sequence impedance depends upon the Earth connection. If there is a through Circuit for the earth current, zero sequence impedance will be equal to the +ve sequence impedance otherwise it will be infinite. Lab experiment is planned to find out sequence impedances by creation of faults at secondary suitably and measure impedances. Proper care is taken to ensure readings would not damage the equipment.

1. Circuit Diagram:





Procedure: -

- Connect the given three phase transformer as shown in the circuitDiagram 1
- After short-circuiting the low voltage side adjust the voltage on high voltage side with the help of the autotransformer such that the rated current flows in the windings.
- Note down the voltage and current.
- From these readings determine the transformer positive sequence Impedance which is also equal to negative sequence impedance.
- Determine the zero sequence impedance of the transformer by making connections as shown in the 4. Circuit Diagram 2.
- Note down the voltage and current.

$$Z_1 = \frac{V}{\sqrt{3}I}$$

$$Z_2 = Z_1$$

$$Z_0 = \frac{V}{3I}$$

Readings and Tabular form:

S.No	Z ₁		Z ₂		Z ₀	
	V	I	V	I	V	I

Result:

Discussion Questions:

2. Define Sequence Impedances.
3. Explain symmetrical components method.
4. Why +ve, -ve sequence impedances same for a transformer?

5.Determination of sequence impedances of a cylindrical rotor Synchronous Machine.

Aim: To determine the Positive, Negative and Zero sequence of impedances or sequence impedances of the given three phase alternator.

Apparatus:-

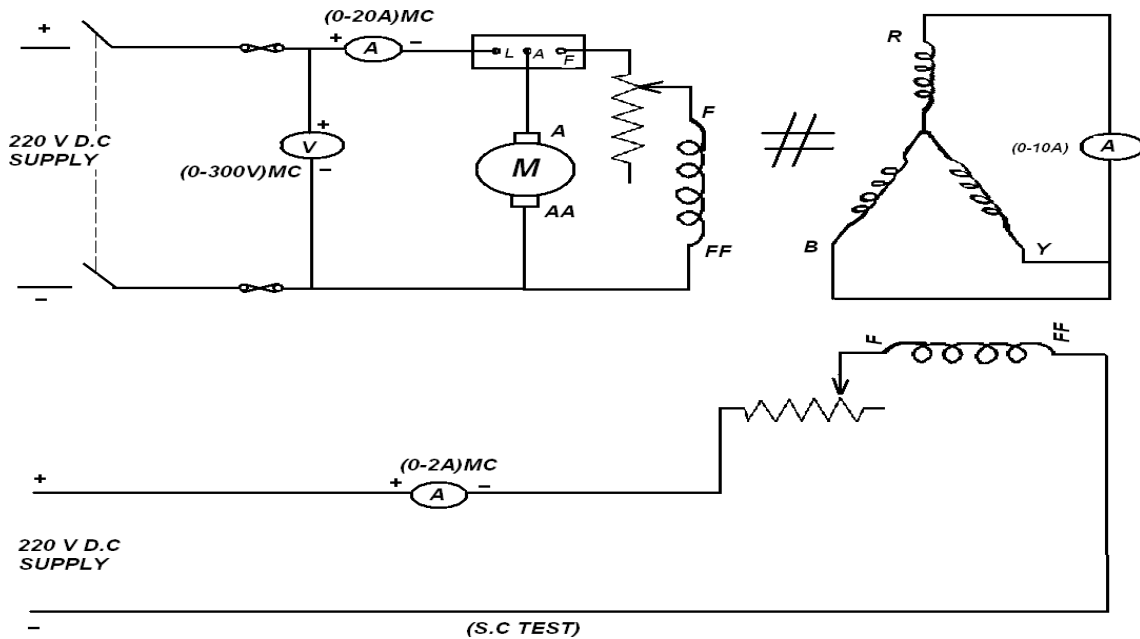
S.No	Name Of The Equipment	Quantity
1	Three phase alternator DC motor set	1
2	Ammeter (0 –2 A) MC	1
3	Voltmeter (0-300) MC	1
4	Ammeter (0-5)A MI	1
5	Voltmeter (0-600)V MI	
6	Auto-Transformer (0—230V)	
7	Connecting Wires	Required

Theory:

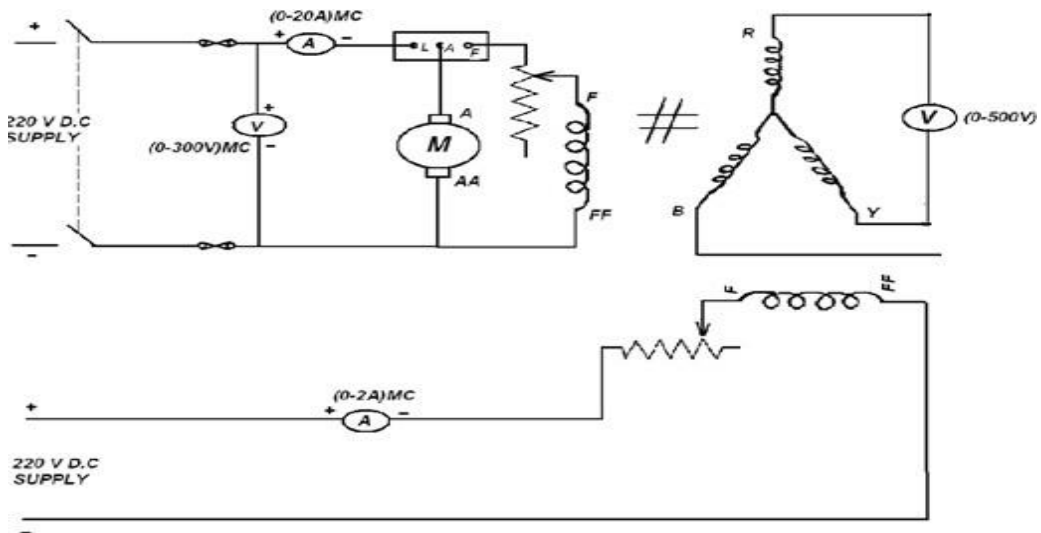
The positive, Negative and Zero sequence impedances of rotating machines are generally different. The +ve sequence impedance of Synchronous generator is equal to the Synchronous impedance of the machine. Experimental set up to conduct OCC and SCC is made available. With the help of observations Synchronous impedance can be calculated. The –ve sequence impedance is much less than +ve Sequence impedance. The zero sequence impedance is a variable item and if its value is not given, it may be assumed to be equal to the +ve sequence impedance. For Zero sequence impedance a separate model is used to conduct of experiment.

CIRCUIT DIAGRAM

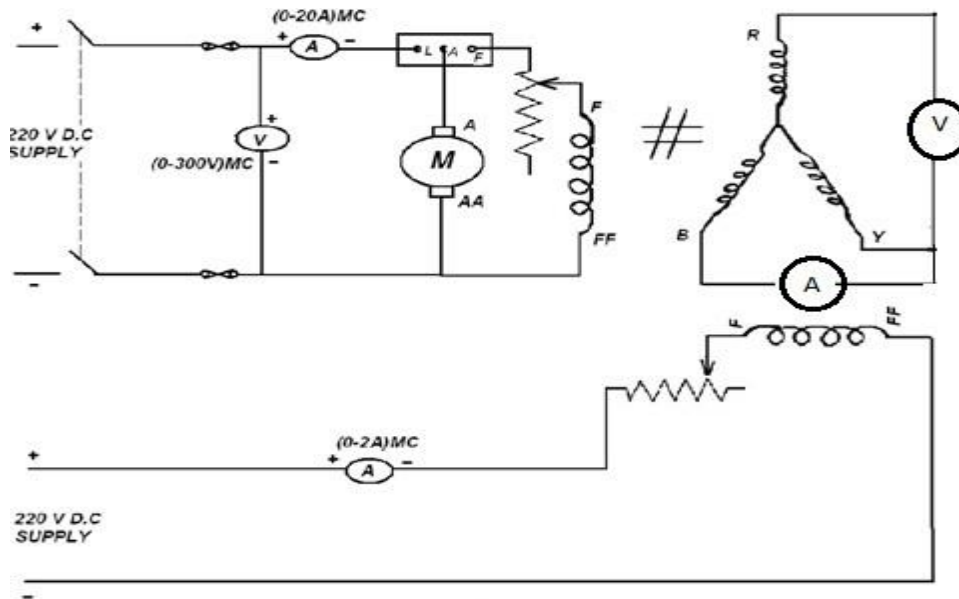
(A) POSITIVE SEQUENCE IMPEDANCE



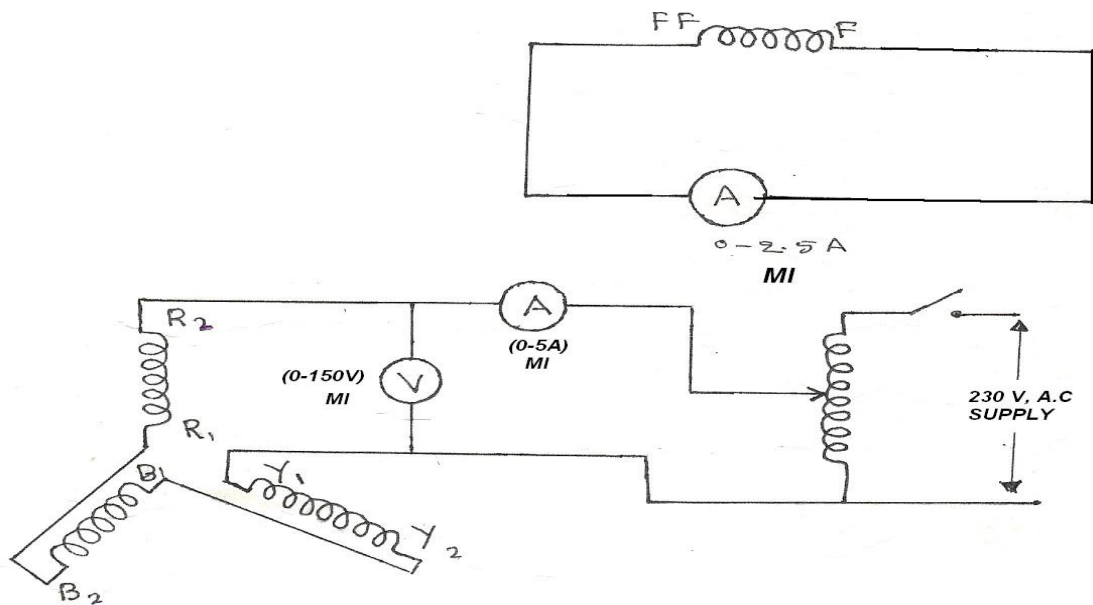
OC test



2) Negative sequence impedance



3) ZERO-SEQUENCE IMPEDANCE:



Procedure:-

I. POSITIVE SEQUENCE IMPEDANCE

1. Obtain the O.C.C of the Alternator by connecting the Alternator As in fig .1.
2. Obtain the S.C.C of the Alternator by connecting the Alternator as in fig .2.
3. Determine the stator resistance / phase by connecting as shown in fig.3. $Z_s = \frac{O.C}{\text{voltage} / \text{S.C current (at a same value of field current)}}$

II NEGATIVE SEQUENCE IMPEDANCE

1. Connect the Circuit as shown in the fig.4.
2. Run the machine at rated speed with low excitation to the field of the Alternator.
3. The lines B and C shorted and the meters are connected as Shown $\cos \phi = \frac{W}{VI}$

(VI)

$$Z_2 = \frac{V}{\sqrt{3} I}$$

III ZERO SEQUENCY IMPEDANCE

1. Connect the circuit as shown in the fig. 5.
2. Three phase winding are connected in series.

Apply low voltage to the Armature, so that rated full load current flow in the series fieldwinding.

$$Z_0 = \frac{V_{ao}}{I_{ao}} = \frac{3E}{I}$$

Readings and Tabular forms:

S.No.	E	I	P	Zo	Xo

Result:

Discussion Questions:

1. Define +ve, -ve, Zero sequence impedances.
2. Why are they different for Alternators?
3. Can we analyze an unbalanced system otherwise?
4. What is the effect on the value of zero sequence reactance if the synchronous machine is rotated at synchronous speed during the above experiment?
5. Out of all the reactance of synchronous machine which one is lowest?
6. What is the typical value of zero sequence reactance in per unit per large ratingsalient pole alternator?

6.(a)Performance and Testing of Transmission line Model.

Aim:-

- To determine Efficiency and Regulation of 3 phase Transmission model With Resistive load .
- To observe Ferranti effect.
- Open conductor operation and measurement of Voltages and Currents.

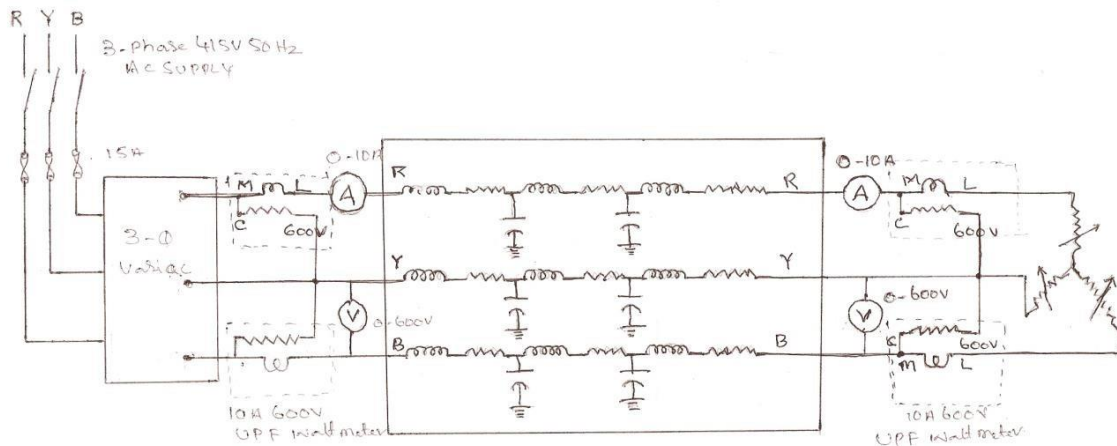
Apparatus:-

S.No	Name Of The Equipment	Quantity
1	Voltmeter (0 - 600v) MI	2
2	Ammeter (0 - 10 A) MI	2
3	Watt meter (UPF, 5A, 600V)	2
4	Connecting Wires	Required

Theory:

The transmission line constants are uniformly distributed over the entire length for a short line and these constants are called lumped constants. If the length of the transmission line is more than 200 km serious errors are introduced in the performance calculations. Hence an equivalent T or pi network is determined to represent the line accurately by assuming suitable values of lumped constants.

Circuit Diagram:

3 Φ TRANSMISSION LINE MODEL

Procedure: - (For finding Efficiency and Regulation)

1. Make the connection as per the 4. Circuit Diagram.
2. Switch ON supply and adjust rated voltage, note down voltage, Current and power at sending end and receiving end at no load.
3. Repeat step 2 at different loads of (A) Resistive load (B) inductive load

Readings and Tabular forms :

FOR RESISTIVE LOAD

	Vs		W s	V r	Ir	Wr	Regulation	Efficiency

Sample calculations:

$$\% \text{ Efficiency} = \frac{\text{W receiving}}{\text{W sending}} * 100$$

$$\% \text{ Regulation} = \frac{V_{N0} - V_L}{V_{N0}} * 100$$

Where V_{N0} = Voltage at receiving end at no load.

V_L = Voltage at receiving end at particular load.

Precaution: -

Keep the voltage at sending end constant through out the experiment.

Results:**Discussion questions:**

- 1. Can we simulate Nominal – π and Nominal T- Models and measure Regulation and Efficiency?**
- 2. What are the reasons for Ferranti Effect?**
- 3. How faults are classified?**

6.(b) DETERMINATION A, B, C, D CONSTANTS OF MEDIUM LINE AND CIRCLE DIAGRAM

Aim: To determine ABCD constants of 3 phase transmission line with

- a) Distributed Connection**
- b) Nominal – T connection**

Apparatus:

a) For Open Circuit Test:

- i) p.f. meter – 10A, 150/300/600V (0.5-1-0.5)**
- ii) Voltmeter - (0-300V) MI**
- iii) Ammeter - (0-1A) MI**

b) For Short Circuit Test

- i) Wattmeter - 10A, 75V, UPF**
- ii) Voltmeter - (0-30V) MI**
- iii) Ammeter - (0-10A) MI**

Theory: If a transmission line is erected, the constants are measured by conducting the OC & SC tests at the two ends of the line.

Using equations

$$V_s = AV_r + BI_r$$

$$I_s = CV_r +$$

$$DI_r$$

Impedance measurement on the SE side: SE impedance with RE open circuit is

$$Z_{so} = \frac{V_s}{I_s} = \frac{A}{C} \quad (I_r=0)$$

SE impedance with RE short circuited,

$$Z_{ss} = \frac{V_s}{I_s} = \frac{B}{D} \quad (V_r=0)$$

Measurement of impedance on RE side

Using equations

$$V_r = DV_s - BI_s$$

$$I_r = -CV_s + AI_s$$

While performing test, the current leaves the Network I_s :-

$$-I_s, I_r = -I_r$$

$$V_r = DV_s - BI_s$$

$$-I_r = -CV_s - AI_s$$

$$I_r = CV_s + AI_s$$

RE impedance with SE open circuited, $Z_{ro} V_r$

$$Z_{ro} = \frac{V_r}{I_r} = \frac{D}{C} \quad (I_s=0)$$

RE impedance with SE short circuited, Z_{rs}

$$Z_{rs} = \frac{V_r}{I_r} = \frac{B}{A} \quad (V_s=0)$$

$$Z_{ro} - Z_{rs} = \frac{D}{C} - \frac{B}{A} = \frac{1}{AC}$$

$$\frac{Z_{so}}{\dots} = A^2$$

$$Z_{ro} - Z_{rs}$$

$$A = \sqrt{\frac{Z_{so}}{(Z_{ro} - Z_{rs})}}$$

$$Z_{rs} = \frac{B}{A}$$

$$B = Z_{rs} \cdot A$$

$$Z_{so}$$

$$B = Z_{rs} \sqrt{\frac{Z_{so}}{Z_{ro} - Z_{rs}}}$$

$$Z_{so} = \frac{A}{C} \quad \overline{\times} \quad C = \frac{A}{Z_{so}} = \frac{1}{Z_{so}} \sqrt{\frac{Z_{so}}{Z_{ro} - Z_{rs}}}$$

$$D$$

$$Z_{ro} = \frac{D}{C}$$

$$C$$

$$D = C \cdot Z_{ro}$$

$$= \frac{Z_{ro}}{Z_{so}} \sqrt{\frac{Z_{so}}{Z_{ro} - Z_{rs}}} \quad (Z_{ro} = Z_{so})$$

$$D = A$$

Procedure:

O.C. & S.C. tests on SE side:

2. Connect the circuit as per fig.(1) for O.C. test on SE.
3. Set 230V on Voltmeter using variac and note V_s , I_s and p.f. meter reading.
4. Connect the circuit as per fig (2) for S.C. test on SE.
5. Set 8A on Ammeter and note V_s , I_s and wattmeter readings.

O.C. & SC tests of RE side

1. Connect the circuit as per fig (3) for O.C test on RE.
2. Set 230V in Voltmeter & note V_r , I_r & p.f meter reading.
3. Connect the circuit as per fig (4) for SC test on RE.
4. Set 8A in Ammeter & note V_r , I_r & Wattmeter reading.

Readings and Tabular forms

O.C. & S.C. tests on SE side:

Test	V_s	I_s	p.f / Wattmeter reading
O.C ($I_r=0$)	230		
S.C ($V_r=0$)		8A	

O.C. & SC tests of RE side

Test	V_r	I_r	p.f / Wattmeter reading
O.C ($I_s=0$)	230		
S.C ($V_s=0$)		8A	

Calculations:

$$V_s$$

$$Z_{s0} = \frac{V_s}{I_s} \quad (I_r = 0)$$

$$I_s$$

$$V_s$$

$$Z_{ss} = \frac{V_s}{I_s} \quad (V_r = 0)$$

$$I_s$$

$$V_r$$

$$Z_{r0} = \frac{V_r}{I_r} \quad (I_s = 0)$$

$$I_r$$

$$V_r$$

$$Z_{rs} = \frac{V_r}{I_r} \quad (V_s = 0)$$

$$I_r$$

$$Z_{s0}$$

$$A = \sqrt{\frac{Z_{r0} - Z_{rs}}{Z_{s0}}}$$

$$(Z_{r0} - Z_{rs})$$

$$Z_{s0}$$

$$B = Z_{rs} \sqrt{\frac{Z_{r0} - Z_{rs}}{Z_{s0}}}$$

$$(Z_{r0} - Z_{rs})$$

$$1 \quad Z_{s0}$$

$$C = \frac{1}{Z_{s0}} \sqrt{\frac{Z_{r0} - Z_{rs}}{Z_{s0}}}$$

$$Z_{s0} \quad (Z_{r0} - Z_{rs})$$

$$D = A$$

Note: Same 5. Procedure is repeated for Nominal – T Connection. Result:

Discussion questions:

1. What are A,B,C,D constants?
2. Prove $AD-BC = 1$

Power transmission line :

Electric-power transmission is the bulk transfer of electrical energy, from generating power plants to electrical substations located near demand centers. This is distinct from the local wiring between high-voltage substations and customers, which is typically referred to as electric power distribution.

Most transmission lines use high-voltage three-phase alternating current (AC), although single phase AC is sometimes used in railway electrification systems. High-voltage direct-current (HVDC) technology is used for greater efficiency in very long distances (typically hundreds of miles (kilometres), or in submarine power cables (typically longer than 30 miles (50 km). HVDC links are also used to stabilize against control problems in large power distribution networks where sudden new loads or blackouts in one part of a network can otherwise result in synchronization problems and cascading failures.

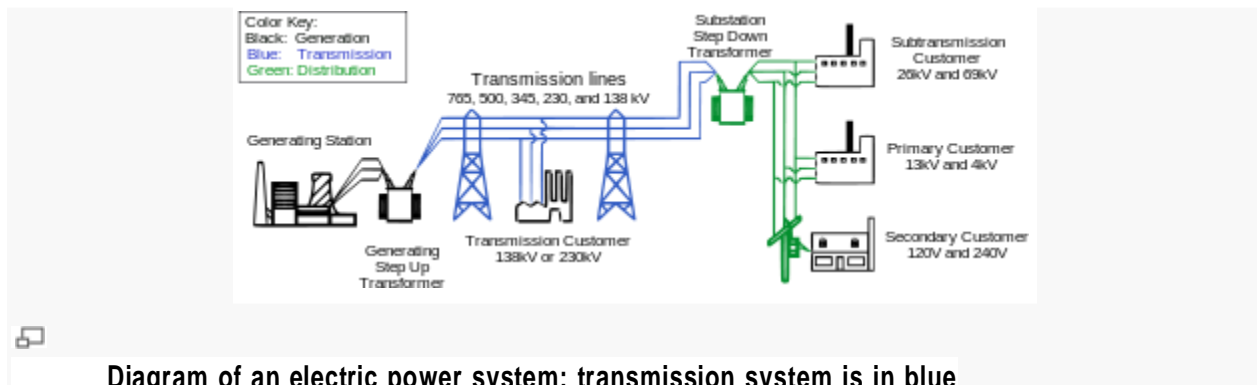


Diagram of an electric power system; transmission system is in blue

Electricity is transmitted at high voltages (110 kV or above) to reduce the energy lost in long-distance transmission. Power is usually transmitted through overhead power lines.

Underground power transmission has a significantly higher cost and greater operational limitations but is sometimes used in urban areas or sensitive locations.

A key limitation in the distribution of electric power is that, with minor exceptions, electrical energy cannot be stored, and therefore must be generated as needed. A sophisticated control system is required to ensure electric generation very closely matches the demand. If the demand

for power exceeds the supply, generation plants and transmission equipment can shut down which, in the worst cases, can lead to a major regional blackout, such as occurred in the India Northeast blackouts of 1965, 1977, 2003, and other regional blackouts in 1996 and 2011. To reduce the risk of such failures, electric transmission networks are interconnected into regional, national or continental wide networks thereby providing multiple redundant alternative routes for power to flow should (weather or equipment) failures occur. Much analysis is done by transmission companies to determine the maximum reliable capacity of each line (ordinarily less than its physical or thermal limit) to ensure spare capacity is available should there be any such failure in another part of the network.

High-voltage overhead conductors are not covered by insulation. The conductor material is nearly always an aluminium alloy, made into several strands and possibly reinforced with steel strands. Copper was sometimes used for overhead transmission but aluminium is lighter, yields only marginally reduced performance, and costs much less. Overhead conductors are a commodity supplied by several companies worldwide. Improved conductor material and shapes are regularly used to allow increased capacity and modernize transmission circuits. Conductor sizes range from 12 mm² (#6 to 750 mm² (1,590,000 circular mils area), with varying resistance and current-carrying capacity. Thicker wires would lead to a relatively small increase in capacity due to the skin effect, that causes most of the current to flow close to the surface of the wire. Because of this current limitation, multiple parallel cables (called bundle conductors) are used when higher capacity is needed. Bundle conductors are also used at high voltages to reduce energy loss caused by corona discharge.

Today, transmission-level voltages are usually considered to be 110 kV and above. Lower voltages such as 66 kV and 33 kV are usually considered sub transmission voltages but are occasionally used on long lines with light loads. Voltages less than 33 kV are usually used for distribution. Voltages above 230 kV are considered extra high voltage and require different designs compared to equipment used at lower voltages.

Since overhead transmission wires depend on air for insulation, design of these lines requires minimum clearances to be observed to maintain safety. Adverse weather conditions of high wind and low temperatures can lead to power outages. Wind speeds as low as 23 knots (43 km/h) can permit conductors to encroach operating clearances, resulting in a flashover and loss of supply.^[2] Oscillatory motion of the physical line can be termed gallop or flutter depending on the frequency and amplitude of oscillation Grid input

At the power stations the energy is produced at a relatively low voltage between about 2.3 kV and 30 kV, depending on the size of the unit. The generator terminal voltage is then stepped

up by the power station transformer to a higher voltage (115 kV to 765 kV AC, varying by the transmission system and by country) for transmission over long distances.

Losses

Transmitting electricity at high voltage reduces the fraction of energy lost to resistance, which averages around 7%.^[8] For a given amount of power, a higher voltage reduces the current and thus the resistive losses in the conductor. For example, raising the voltage by a factor of 10 reduces the current by a corresponding factor of 10 and therefore the I^2R losses by a factor of 100, provided the same sized conductors are used in both cases. Even if the conductor size (cross-sectional area) is reduced 10-fold to match the lower current the I^2R losses are still reduced 10-fold. Long distance transmission is typically done with overhead lines at voltages of 115 to 1,200 kV. At extremely high voltages, more than 2,000 kV between conductor and ground, corona discharge losses are so large that they can offset the lower resistive losses in the line conductors. Measures to reduce corona losses include conductors having large diameter; often hollow to save weight,^[9] or bundles of two or more conductors.

Transmission and distribution losses in the USA were estimated at 6.6% in 1997^[10] and 6.5% in 2007.^[10] In general, losses are estimated from the discrepancy between energy produced (as reported by power plants) and energy sold to end customers; the difference between what is produced and what is consumed constitute transmission and distribution losses, assuming no theft of utility occurs.

As of 1980, the longest cost-effective distance for DC electricity was determined to be 7,000 km (4,300 mi). For AC it was 4,000 km (2,500 mi), though all transmission lines in use today are substantially shorter.^[7]

In an alternating current circuit, the inductance and capacitance of the phase conductors can be significant. The currents that flow in these components of the circuit impedance constitute reactive power, which transmits no energy to the load. Reactive current causes extra losses in the transmission circuit. The ratio of real power (transmitted to the load) to apparent power is the power factor. As reactive current increases, the reactive power increases and the power factor decreases. For systems with low power factors, losses are higher than for systems with high power factors. Utilities add capacitor banks and other components (such as phase-shifting transformers; static VAR compensators; physical transposition of the phase conductors; and flexible AC transmission systems, FACTS) throughout the system to control reactive power flow for reduction of losses and stabilization of system voltage.

Subtransmission

Subtransmission is part of an electric power transmission system that runs at relatively lower voltages. It is uneconomical to connect all distribution substations to the high main transmission voltage, because the equipment is larger and more expensive. Typically, only larger substations connect with this high voltage. It is stepped down and sent to smaller substations in towns and neighborhoods. Subtransmission circuits are usually arranged in loops so that a single line failure does not cut off service to a large number of customers for more than a short time. While subtransmission circuits are usually carried on overhead lines, in urban areas buried cable may be used.

There is no fixed cutoff between subtransmission and transmission, or subtransmission and distribution. The voltage ranges overlap somewhat. Voltages of 69 kV, 115 kV and 138 kV are often used for subtransmission in North America. As power systems evolved, voltages formerly used for transmission were used for subtransmission, and subtransmission voltages became distribution voltages. Like transmission, subtransmission moves relatively large amounts of power, and like distribution, subtransmission covers an area instead of just point to point.^[1]

Transmission grid exit

At the substations, transformers reduce the voltage to a lower level for distribution to commercial and residential users. This distribution is accomplished with a combination of sub-transmission (33 kV to 132 kV) and distribution (3.3 to 25 kV). Finally, at the point of use, the energy is transformed to low voltage (varying by country and customer requirements—).

EXPERIMENT-7

Formation of Y_{BUS} .

AIM: To Develop MATLAB program for YBUS formation.

SOFTWARE-REQUIRED:

MATLAB:7.8

THEORY:

Bus admittance is often used in power system studies. In most of the power system studies it is required to form y- bus matrix of the system by considering certain power system parameters depending upon the type of analysis. Y-bus may be formed by inspection method only if there is no mutual coupling between the lines. Every transmission line should be represented by p- equivalent. Shunt impedances are added to diagonal element corresponding to the buses at which these are connected. The off diagonal elements are unaffected. The equivalent circuit of Tap changing transformers is included while forming Y-bus matrix.

FORMATION OF Y-BUS MATRIX:

Generalized Y-bus = y_{ii} y_{id}
 y_{di} y_{dd}

where, Y_{ii} = Self admittance

Y_{di} = Transfer admittance

PROCEDURE:

1. Enter the command window of the MATLAB.
2. Create a new M – file by selecting File - New – M – File
3. Type and save the program in the editor window.
4. Execute the program by either pressing tools – Run.
5. View the results.

PROGRAM:

```

% loine data
%      bus  bus      R      X      1/2B      Tap
%      nl   nr      pu      pu      pu
linedata=[1    2      0.02   0.04   0          1
          1    3      0.01   0.03   0          1
          2    3      0.0125 0.025  0          1];

% This program obtains the Bus Admittance Matrix for
power flow solution

j=sqrt(-1); i = sqrt(-1);
nl = linedata(:,1); nr = linedata(:,2); R = linedata(:,3);
X = linedata(:,4); Bc = j*linedata(:,5); a = linedata(:, 6);
nbr=length(linedata(:,1)); nbus = max(max(nl), max(nr));
Z = R + j*X; y= ones(nbr,1)./Z;          %branch admittance
for n = 1:nbr
if a(n) <= 0 a(n) = 1; else end
Ybus=zeros(nbus,nbus);      % initialize Ybus to zero
          % formation of the off diagonal elements
for k=1:nbr;
    Ybus(nl(k),nr(k))=Ybus(nl(k),nr(k))-y(k)/a(k);
    Ybus(nr(k),nl(k))=Ybus(nl(k),nr(k));
end
end
          % formation of the diagonal elements
for n=1:nbus
    for k=1:nbr

```

```
if nl(k)==n
    Ybus(n,n) = Ybus(n,n)+y(k)/(a(k)^2) + Bc(k);
elseif nr(k)==n
    Ybus(n,n) = Ybus(n,n)+y(k) +Bc(k);
else, end
end
end
disp(Ybus);
clear Pgg
```

RESULTS

```
Ybus=[20.0000 -50.0000i -10.0000 +20.0000i -10.0000 +30.0000i
        -10.0000 +20.0000i 26.0000 -52.0000i -16.0000 +32.0000i
        -10.0000 +30.0000i -16.0000 +32.0000i 26.0000 -62.0000i]
```

EXPERIMENT-8**Load Flow Analysis using Gauss Seidal (GS) Method.**

AIM : To Develop MATLAB program for G-S Load Flow Analysis.

SOFTWARE REQUIRED:

MATLAB -7.8

THEORY:

The GAUSS – SEIDEL method is an iterative algorithm for solving a set of non-linear load flow equations.

PROCEDURE:

1. Enter the command window of the MATLAB.
2. Create a new M – file by selecting File - New – M – File
3. Type and save the program in the editor Window
4. Execute the program by either pressing tool – Run.
5. View the results.

PROGRAM:

```
%PF studies for the Gauss Siedel Method

clc;

clear all;

basemva=100;

accuracy=0.001;

maxiter=100;

%bus data

%      Bus      Bus      Vmag      Angle      -Load-      -Gen-      Qmin  Qmax  Inj
%      No      Code
busdata=[1      1      1.05      0      0      0      0      0      0      0      0
         2      0      1.00      0      400  250      0      0      0      0      0
         3      2      1.04      0      0      0      200  0      -100  200 0];
```



```

% line data
%      bus  bus      R      X      1/2B      Tap
%      nl   nr      pu      pu      pu
linedata=[1   2      0.02   0.04   0          1
          1   3      0.01   0.03   0          1
          2   3      0.0125 0.025  0          1];

Lfybus;
Lfgauss;
Busout;
Lineflow;

```

MATLAB PROGRAM FOR GUASS SEIDAL METHOD

```

% Power flow solution by Gauss-Seidel method

Vm=0; delta=0; yload=0; deltad =0;

nbus = length(busdata(:,1));

for k=1:nbus

n=busdata(k,1);

kb(n)=busdata(k,2); Vm(n)=busdata(k,3); delta(n)=busdata(k, 4);

Pd(n)=busdata(k,5); Qd(n)=busdata(k,6); Pg(n)=busdata(k,7); Qg(n) =
busdata(k,8);

Qmin(n)=busdata(k, 9); Qmax(n)=busdata(k, 10);

Qsh(n)=busdata(k, 11);

    if Vm(n) <= 0  Vm(n) = 1.0; V(n) = 1 + j*0;

    else delta(n) = pi/180*delta(n);

        V(n) = Vm(n)*(cos(delta(n)) + j*sin(delta(n)));

        P(n)=(Pg(n)-Pd(n))/basemva;

        Q(n)=(Qg(n)-Qd(n)+ Qsh(n))/basemva;

        S(n) = P(n) + j*Q(n);

end

```

```
DV(n)=0;

end

num = 0; AcurBus = 0; converge = 1;

Vc = zeros(nbus,1)+j*zeros(nbus,1); Sc = zeros(nbus,1)+j*zeros(nbus,1);

    while exist('accel')~=1

        accel = 1.3;

    end

while exist('accuracy')~=1

    accuracy = 0.001;

end

while exist('basemva')~=1

    basemva= 100;

end

while exist('maxiter')~=1

    maxiter = 100;

end

iter=0;

maxerror=10;

while maxerror >= accuracy & iter <= maxiter

iter=iter+1;

    for n = 1:nbus;

        YV = 0+j*0;

        for L = 1:nbr;

            if nl(L) == n, k=nr(L);

                YV = YV + Ybus(n,k)*V(k);

            elseif nr(L) == n, k=nl(L);

                YV = YV + Ybus(n,k)*V(k);

            end

        end

    end

end
```

```

end

Sc = conj(V(n))*(Ybus(n,n)*V(n) + YV) ;

Sc = conj(Sc);

DP(n) = P(n) - real(Sc);

DQ(n) = Q(n) - imag(Sc);

if kb(n) == 1

S(n) =Sc; P(n) = real(Sc); Q(n) = imag(Sc); DP(n) =0; DQ(n)=0;

Vc(n) = V(n);

elseif kb(n) == 2

Q(n) = imag(Sc); S(n) = P(n) + j*Q(n);

if Qmax(n) ~= 0

Qgc = Q(n)*basemva + Qd(n) - Qsh(n);

if abs(DQ(n)) <= .005 & iter >= 10 % After 10 iterations

if DV(n) <= 0.045 % the Mvar of generator buses
are
limits Vm(n)
0.005 pu
bring
the

if Qgc < Qmin(n), % tested. If not within

Vm(n) = Vm(n) + 0.005; % is changed in steps of

DV(n) = DV(n)+.005; % up to .05 pu in order to

elseif Qgc > Qmax(n), % the generator Mvar within

Vm(n) = Vm(n) - 0.005; % specified limits.

DV(n)=DV(n)+.005; end

else, end

else,end

else,end

end

```

```

    if kb(n) ~= 1

Vc(n) = (conj(S(n))/conj(V(n)) - YV )/ Ybus(n,n);

    else, end

        if kb(n) == 0

V(n) = V(n) + accel*(Vc(n)-V(n));

        elseif kb(n) == 2

VcI = imag(Vc(n));

VcR = sqrt(Vm(n)^2 - VcI^2);

Vc(n) = VcR + j*VcI;

        V(n) = V(n) + accel*(Vc(n) -V(n));

        end

    end

maxerror=max( max(abs(real(DP))), max(abs(imag(DQ))) );

    if iter == maxiter & maxerror > accuracy

fprintf('\nWARNING: Iterative solution did not converged after ')

fprintf('%g', iter), fprintf(' iterations.\n\n')

fprintf('Press Enter to terminate the iterations and print the results
\n')

    converge = 0; pause, else, end

    end

if converge ~= 1

    tech= ('                ITERATIVE SOLUTION DID NOT CONVERGE'); else,

    tech=('                Power Flow Solution by Gauss-Seidel Method');

end

k=0;

for n = 1:nbus

    Vm(n) = abs(V(n)); deltad(n) = angle(V(n))*180/pi;

        if kb(n) == 1

            S(n)=P(n)+j*Q(n);

```

```
Pg(n) = P(n)*basemva + Pd(n);  
Qg(n) = Q(n)*basemva + Qd(n) - Qsh(n);  
k=k+1;  
Pgg(k)=Pg(n);  
elseif kb(n) ==2  
k=k+1;  
Pgg(k)=Pg(n);  
S(n)=P(n)+j*Q(n);  
Qg(n) = Q(n)*basemva + Qd(n) - Qsh(n);  
end  
yload(n) = (Pd(n) - j*Qd(n) + j*Qsh(n)) / (basemva*Vm(n)^2);  
end  
Pgt = sum(Pg); Qgt = sum(Qg); Pdt = sum(Pd); Qdt = sum(Qd); Qsht = sum(Qsh);  
busdata(:,3)=Vm'; busdata(:,4)=deltad';  
clear AcurBus DP DQ DV L Sc Vc VcI VcR YV converge delta
```

RESULTS

Ybus= 20.0000 -50.0000i -10.0000 +20.0000i -10.0000 +30.0000i
 -10.0000 +20.0000i 26.0000 -52.0000i -16.0000 +32.0000i
 -10.0000 +30.0000i -16.0000 +32.0000i 26.0000 -62.0000i

Power Flow Solution by Gauss-Seidel Method

Maximum Power Mismatch = 7.88577e-005

No. of Iterations = 6

Bus Injected	Voltage		-----Load-----		---Generation---	
	No.	Mag.	MW	Mvar	MW	Mvar
1	1.050	0.000	0.000	0.000	218.436	140.871
2	0.972	-2.697	400.000	250.000	0.000	0.000
3	1.040	-0.499	0.000	0.000	200.000	146.171
Total			400.000	250.000	418.436	287.042

Line Flow and Losses

--Line--		Power at bus & line flow			--Line loss--		Transformer
from	to	MW	Mvar	MVA	MW	Mvar	tap
1		218.436	140.871	259.921			
	2	179.366	118.726	215.100	8.393	16.787	
	3	39.064	22.117	44.890	0.183	0.548	
2		-400.000	-250.000	471.699			
	1	-170.972	-101.940	199.056	8.393	16.787	
	3	-229.035	-148.043	272.715	9.846	19.693	
3		200.000	146.171	247.722			
	1	-38.881	-21.568	44.463	0.183	0.548	
	2	238.881	167.736	291.890	9.846	19.693	
Total loss					18.423	37.028	

EXAMPLE**%PF studies for the Gauss Siedel Method 5-bus system**

```

clear all

clc

basemva=100;

accuracy = .0001;

maxiter = 10;

% IEEE 5-bus system

      % bus bus  vaolt  angle ----load----- generator--  injected
      % no  code  mag    degree MW MVAR   MW MVAR Qmin Qmax  MVAR
busdata=[1   1   1.06   0   0   0   0   0   10  50   0
          2   2   1.045  0   20  10  40  30  10  50   0
          3   2   1.03   0   20  15  30  10  10  40   0
          4   0   1       0   50  30  0   0   0   0   0
          5   0   1       0   60  40  0   0   0   0   0];

      %line dadta

      %      busnl busnr R X 1/2B tapset ing
linedata=[ 1   2   0.02   0.06   0.03   1
           1   3   0.08   0.24   0.025  1
           2   3   0.06   0.18   0.020  1
           2   4   0.06   0.018  0.023  1
           2   5   0.04   0.12   0.015  1
           3   4   0.01   0.03   0.010  1
           4   5   0.08   0.24   0.025  1];

Lfybus;

Decouple;

Busout;

Lineflow;

```


EXPERIMENT-9

Load Flow Analysis using Fast Decoupled (FD) Method.

AIM: To Develop MATLAB program for FDLF Load Flow Analysis.

SOFTWARE REQUIRED:

MATLAB -7.8

THEORY:

The GAUSS – SEIDEL method is an iterative algorithm for solving a set of non-linear load flow equations.

PROCEDURE:

1. Enter the command window of the MATLAB.
2. Create a new M – file by selecting File - New – M – File
3. Type and save the program in the editor Window
4. Execute the program by either pressing tool – Run.
5. View the results.

PROGRAM:

```
%PF studies for the fast decouple load flow
Method

clc;

clear all;

basemva=100;

accuracy=0.001;

maxiter=100;

%bus data

%      Bus  Bus  Volt   Angle  -Load-  -----Gen-----  ----Inj---
%      No   Code mag    deg    MW  MVar  MW   MVar  Qmin Qmax  MVar
busdata=[1   1   1.05  0     0   0     0   0     0   0   0
         2   0   1.00  0    400 250   0   0     0   0   0
         3   2   1.04  0     0   0    200 0    -100 200 0];
```

```

% loine data
%      bus   bus      R      X      1/2B      Tap
%      nl    nr      pu      pu      pu
linedata=[1    2      0.02   0.04   0          1
          1    3      0.01   0.03   0          1
          2    3      0.0125 0.025  0          1];

Lfybus;
decouple;
Busout;
Lineflow;

```

MATLAB PROGRAM FOR Fast Decoupled METHOD

```

% Fast Decoupled Power Flow Solution

ns=0; Vm=0; delta=0; yload=0; deltad=0;

nbus = length(busdata(:,1));

for k=1:nbus
n=busdata(k,1);

kb(n)=busdata(k,2); Vm(n)=busdata(k,3); delta(n)=busdata(k, 4);

Pd(n)=busdata(k,5); Qd(n)=busdata(k,6); Pg(n)=busdata(k,7); Qg(n) =
busdata(k,8);

Qmin(n)=busdata(k, 9); Qmax(n)=busdata(k, 10);

Qsh(n)=busdata(k, 11);

    if Vm(n) <= 0  Vm(n) = 1.0; V(n) = 1 + j*0;
    else delta(n) = pi/180*delta(n);

        V(n) = Vm(n)*(cos(delta(n)) + j*sin(delta(n)));
        P(n)=(Pg(n)-Pd(n))/basemva;
        Q(n)=(Qg(n)-Qd(n)+ Qsh(n))/basemva;
        S(n) = P(n) + j*Q(n);

end

```

```
if kb(n) == 1, ns = ns+1; else, end

nss(n) = ns;

end

Ym = abs(Ybus); t = angle(Ybus);

ii=0;

for ib=1:nbus

    if kb(ib) == 0 | kb(ib) == 2

        ii = ii+1;

        jj=0;

        for jb=1:nbus

            if kb(jb) == 0 | kb(jb) == 2

                jj = jj+1;

                B1(ii,jj)=imag(Ybus(ib,jb));

            else,end

        end

    else, end

end

ii=0;

for ib=1:nbus

    if kb(ib) == 0

        ii = ii+1;

        jj=0;

        for jb=1:nbus

            if kb(jb) == 0

                jj = jj+1;

                B2(ii,jj)=imag(Ybus(ib,jb));

            else,end

        end

    end

end
```

```

    else, end
end

B1inv=inv(B1); B2inv = inv(B2);

maxerror = 1; converge = 1;

iter = 0;

% Start of iterations
while maxerror >= accuracy & iter <= maxiter % Test for max. power mismatch
iter = iter+1;
id=0; iv=0;
for n=1:nbus
nn=n-nss(n);
J11=0; J33=0;
    for i=1:nbr
        if nl(i) == n | nr(i) == n
            if nl(i) == n, l = nr(i); end
            if nr(i) == n, l = nl(i); end
            J11=J11+ Vm(n)*Vm(l)*Ym(n,l)*sin(t(n,l) - delta(n) + delta(l));
            J33=J33+ Vm(n)*Vm(l)*Ym(n,l)*cos(t(n,l) - delta(n) + delta(l));
        else , end
    end
Pk = Vm(n)^2*Ym(n,n)*cos(t(n,n))+J33;
Qk = -Vm(n)^2*Ym(n,n)*sin(t(n,n))-J11;
if kb(n) == 1 P(n)=Pk; Q(n) = Qk; end % Swing bus P
    if kb(n) == 2 Q(n)=Qk;
        Qgc = Q(n)*basemva + Qd(n) - Qsh(n);
        if Qmax(n) ~= 0
            if iter <= 20 % Between the 1th & 6th iterations

```

```

        if iter >= 10                % the Mvar of generator buses are
            if Qgc < Qmin(n),        % tested. If not within limits Vm(n)
                Vm(n) = Vm(n) + 0.005; % is changed in steps of 0.05 pu to
            elseif Qgc > Qmax(n),    % bring the generator Mvar within
                Vm(n) = Vm(n) - 0.005;end % the specified limits.
            else, end
        else,end
    else,end
end

if kb(n) ~= 1
    id = id+1;
    DP(id) = P(n)-Pk;
    DPV(id) = (P(n)-Pk)/Vm(n);
end

if kb(n) == 0
    iv=iv+1;
    DQ(iv) = Q(n)-Qk;
    DQV(iv) = (Q(n)-Qk)/Vm(n);
end

end

Dd=-B1\DPV';
DV=-B2\DQV';
id=0;iv=0;

for n=1:nbus
    if kb(n) ~= 1
        id = id+1;
        delta(n) = delta(n)+Dd(id); end
    if kb(n) == 0

```

```
    iv = iv+1;

    Vm(n)=Vm(n)+DV(iv); end

end

    maxerror=max(max(abs(DP)),max(abs(DQ)));

    if iter == maxiter & maxerror > accuracy

        fprintf('\nWARNING: Iterative solution did not converged after ')

        fprintf('%g', iter), fprintf(' iterations.\n\n')

        fprintf('Press Enter to terminate the iterations and print the results\n\n')

        converge = 0; pause, else, end

    end

if converge ~= 1

    tech= ('                ITERATIVE SOLUTION DID NOT CONVERGE'); else,

    tech=('                Power Flow Solution by Fast Decoupled Method');

end

k=0;

V = Vm.*cos(delta)+j*Vm.*sin(delta);

deltad=180/pi*delta;

clear A; clear DC; clear DX

i=sqrt(-1);

for n = 1:nbus

    if kb(n) == 1

        S(n)=P(n)+j*Q(n);

        Pg(n) = P(n)*basemva + Pd(n);

        Qg(n) = Q(n)*basemva + Qd(n) - Qsh(n);

        k=k+1;

        Pgg(k)=Pg(n);

    elseif kb(n) ==2

        S(n)=P(n)+j*Q(n);
```

```
Qg(n) = Q(n)*basemva + Qd(n) - Qsh(n);  
k=k+1;  
Pgg(k)=Pg(n);  
end  
yload(n) = (Pd(n) - j*Qd(n) + j*Qsh(n)) / (basemva*Vm(n)^2);  
end  
busdata(:,3)=Vm'; busdata(:,4)=deltad';  
Pgt = sum(Pg); Qgt = sum(Qg); Pdt = sum(Pd); Qdt = sum(Qd); Qsht = sum(Qsh);  
clear Pk Qk DP DQ J11 J33 B1 B1inv B2 B2inv DPV DQV Dd delta ib id ii iv jb  
jj
```

RESULTS

Ybus= 20.0000 -50.0000i -10.0000 +20.0000i -10.0000 +30.0000i
 -10.0000 +20.0000i 26.0000 -52.0000i -16.0000 +32.0000i
 -10.0000 +30.0000i -16.0000 +32.0000i 26.0000 -62.0000i

Power Flow Solution by Fast Decoupled Method

Maximum Power Mismatch = 0.00045882

No. of Iterations = 13

Bus No.	Voltage Mag.	Angle Degree	Load MW	Load Mvar	Generation MW	Generation Mvar	Injected Mvar
1	1.050	0.000	0.000	0.000	218.408	140.854	0.000
2	0.972	-2.697	400.000	250.000	0.000	0.000	0.000
3	1.040	-0.499	0.000	0.000	200.000	146.185	0.000
Total			400.000	250.000	418.408	287.039	0.000

Line Flow and Losses

--Line-- Power at bus & line flow --Line loss-- Transformer

from to MW Mvar MVA MW Mvar tap

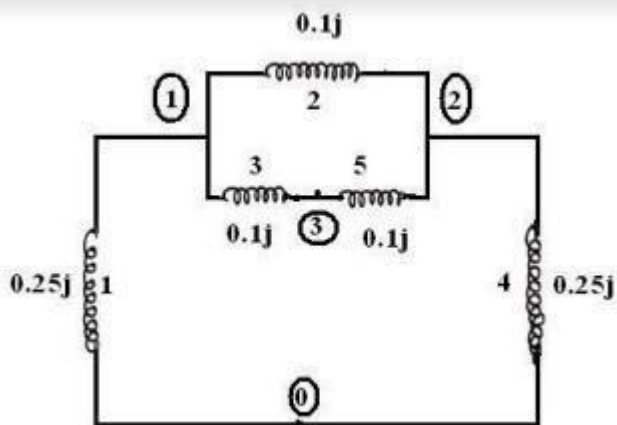
1	218.408	140.854	259.888				
2	179.359	118.723	215.093	8.393	16.785		
3	39.061	22.117	44.888	0.183	0.548		
2	-400.000	-250.000	471.699				
1	-170.967	-101.937	199.050	8.393	16.785		
3	-229.028	-148.037	272.707	9.846	19.692		
3	200.000	146.185	247.730				
1	-38.879	-21.569	44.461	0.183	0.548		
2	238.874	167.729	291.880	9.846	19.692	Total loss	18.421 37.025

EXPERIMENT-10**FORMATION OF Z-BUS MATRIX****Aim:**

Forming ZBus by building algorithm

Problem statement:

Form the ZBus by building algorithm for the following network shown.



Appartus required: Matlab software

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on matlab icon in the desktop.
- Type edit and press enter to get the Editor window.
- Type the program.
- Save and run the program.
- Enter the inputs in the command window and see the output response.
- Note down the simulated results.

PROGRAM:

```
%Zbus building algorithm
clear;
clc;
% en fb tb self imp
Zprimary=[1 1 0 0.25
2 2 1 0.1
3 3 1 0.1
4 2 0 0.25
5 2 3 0.1];
[elements columns]=size(Zprimary);
Zbus=[];
currentbusno=0;
for i=1:elements,
[rows columns]=size(Zbus);
from=Zprimary(i,2);
to=Zprimary(i,3);
value=Zprimary(i,4);
newbus=max(from,to);
ref=min(from,to);
if newbus>currentbusno & ref==0
Zbus=[Zbus zeros(rows,1);
zeros(1,columns) value]
currentbusno=newbus;
continue
end
if newbus>currentbusno & ref~=0
Zbus=[Zbus Zbus(:,ref);
Zbus(ref,:) value+Zbus(ref,ref)]
currentbusno=newbus;
continue
end
if newbus<=currentbusno & ref==0
Zbus=Zbus-1/(Zbus(newbus,newbus)+value)*Zbus(:,newbus)*Zbus(newbus,:);
```

```
end
if newbus<=currentbusno & ref~=0
Zbus=Zbus-1/(value+Zbus(from,from)+Zbus(to,to)-2*Zbus(from,to))*(Zbus(:,from)-
Zbus(:,to))*(Zbus(from,:)-Zbus(to,:));
continue
end
end
fprintf('\n Thus Zbus by building algorithm is \n');
disp(Zbus);
```

OUTPUT RESPONSE:

```
Zbus =
0.2500
Zbus =
0.2500 0.2500
0.2500 0.3500
```

```
Zbus =
0.2500 0.2500 0.2500
0.2500 0.3500 0.2500
0.2500 0.2500 0.3500
```

```
Thus Zbus by building algorithm is
0.1397 0.1103 0.1250
0.1103 0.1397 0.1250
0.1250 0.1250 0.1750
```

RESULT:

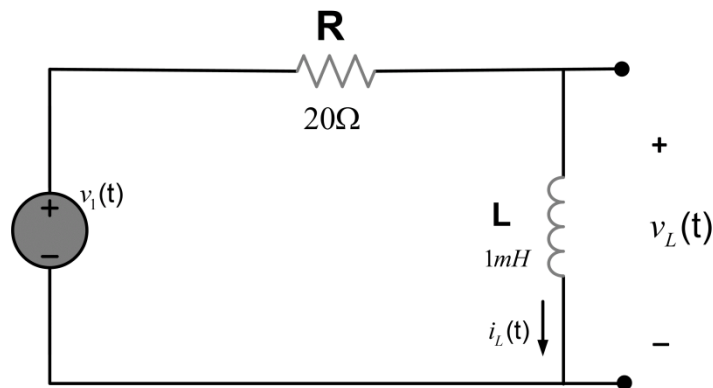
EXPERIMENT - 11
TIME CONSTANT CALCULATION OF RL CIRCUIT

AIM:

To calculate time constant of RL circuit and plot its response..

APPARATUS REQUIRED:

Desktop with pre installed MATLAB

CIRCUIT DIAGRAM:

Circuit Diagram

THEORY:**RL Circuit:**

Let switch K be at position 1. When it is switched to 2 then the equation becomes

$$L \frac{di}{dt} + Ri = 0$$

$$\frac{di}{i} = -R/L dt$$

Integrating & then taking log on both sides

$$\log i = -Rt/L + \log c \quad \text{where } c \text{ is constant}$$

$$\text{or, } \log i = -Rt/L + \log c$$

$$\text{or, } i = c e^{-Rt/L} \quad \text{-----(1)}$$

This is the general solution of RL circuit if the value of C2 is calculated then the result is known as particular solution.

Just before switching at $t = 0$,

$$i(0) = V / R$$

∴ Putting in equation (1)

$$I(0) = C_2 e^{V/R}, \quad C_2 = V / R$$

∴ Particular solution is

$$i = V / R e^{-Rt/L}$$

PROCEDURE:

1. Open MATLAB Software
2. Open editor window
3. Write the Program in the editor window
4. Run the program
5. Observe the result in the plot window

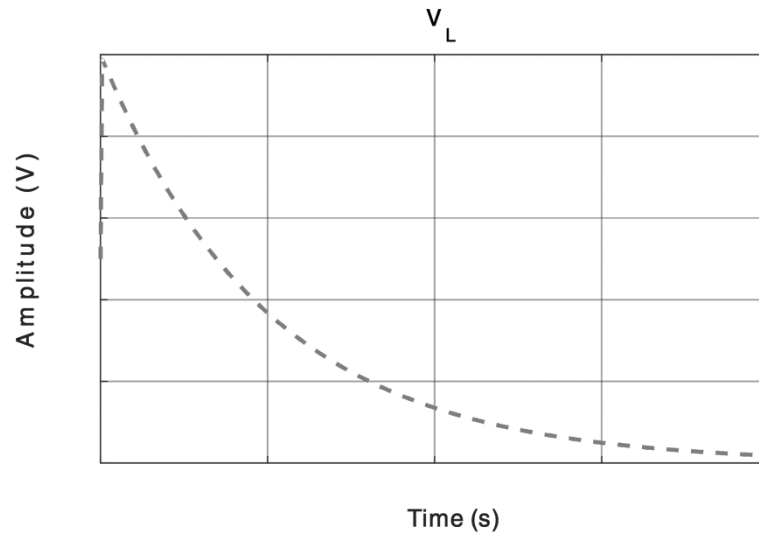
MATLAB PROGRAM:

```
%RL Circuit Analysis
clear all;
close all;
clc
%%Circuit Parameters
R= 20; % Resistance (20 Ohm)
L= 1e-3; % Inductance (1mH)
tau= L/R; % RL Circuit Time Constant
Vs= 1; % Source Voltage (1V)
Time= 0:
tau/100:3*tau; % Sampling Time
VL= Vs.*exp(-Time./tau).*heaviside(Time);
plot(Time,VL)
xlabel('Time (s)')
ylabel('Amplitude (V)')
title('VL')
```

OBSERVATION TABLE:

S. No.	Time constant (Theoretical)	Time constant (Simulation)

MODEL GRAPH:



RESULT:

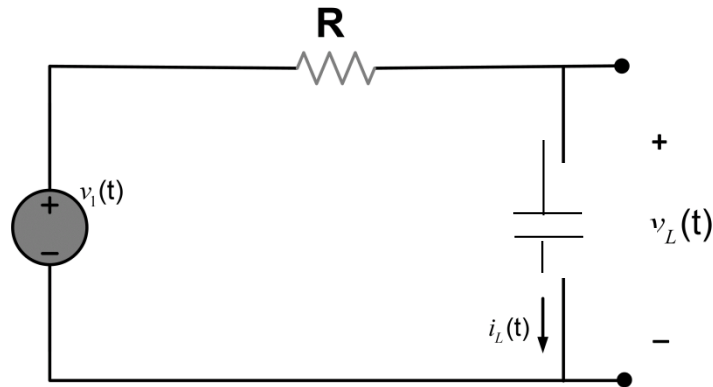
EXPERIMENT - 12
TIME CONSTANT CALCULATION OF RC CIRCUIT

AIM:

To calculate time constant of RC circuit and plot its response..

APPARATUS REQUIRED:

Desktop with pre installed MATLAB

CIRCUIT DIAGRAM:

Circuit Diagram

THEORY:**RC Circuit:**

Let initially the K is at 1, if it is moved to position 2, then apply KVL,

$$1/C \int i dt + Ri = V$$

Differentiating w.r.t 't'

$$1/C i + R di/dt = 0$$

$$R di/dt = -1/C i$$

$$di/i = -1/RC dt$$

Integrating w.r.t 'i' & then taking log on both sides

$$\text{Log } i = -1/RC t + C_2$$

$$i = C_2 e^{-t/RC} \quad \text{-----(1)}$$

On putting $I = V/R$ in equation (1)

$$V/R = C_2 e^{-t/RC}$$

$$\text{At } t = 0, C_2 = V/R$$

$$i = \frac{V}{R} e^{-t/RC}$$

PROCEDURE:

1. Open MATLAB Software

2. Open editor window
3. Write the Program in the editor window
4. Run the program
5. Observe the result in the plot window

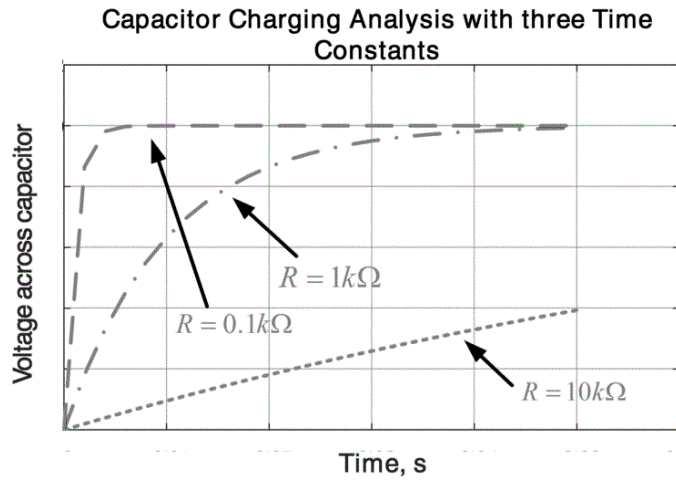
MATLAB PROGRAM:

```
clc;clearall;close all;
%% RC circuit Charging Analysis
%
C = 10e-6; % Capacitance
R_1 = 1e3; % Resistance 1
Tau_1 = C*R_1; % Time Constant 1 (tau=RC)
t = 0:0.002:0.05; % Time Sampling
V_1 = 10*(1-exp(-t/Tau_1)); % Voltage Calculation 1 (formula
from text)
R_2 = 10e3; % Resistance 2
Tau_2 = C*R_2; % Time Constant 2 (tau=RC)
V_2 = 10*(1-exp(-t/Tau_2)); % Voltage Calculation 2
R_3 = .1e3; % Resistance 3
Tau3 = C*R_3; % Time Constant 3 (tau=RC)
V_3 = 10*(1-exp(-t/Tau3)); % Voltage Calculation 3
%% Plotting the Results
plot(t,V_1,'r',t,V_2,'g', t,V_3,'b')
axis([0 0.06 0 12])
title('Capacitor Charging Analysis with three Time Constants')
xlabel('Time, s')
ylabel('Voltage across capacitor')
```

OBSERVATION TABLE:

S. No.	Time constant (Theoretical)	Time constant (Simulation)

MODEL GRAPH:



RESULT:

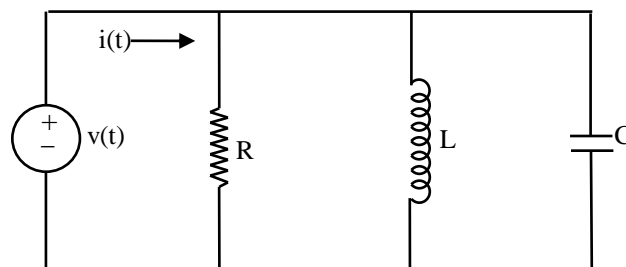
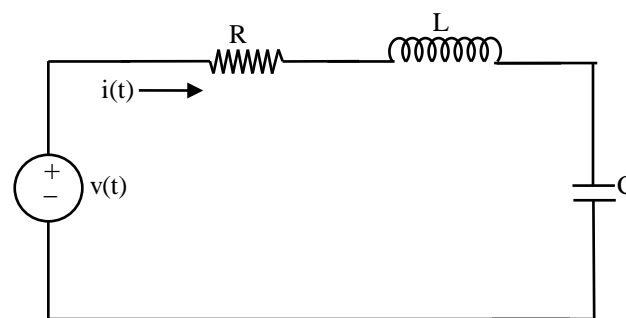
EXPERIMENT - 13
TIME CONSTANT CALCULATION OF RLC CIRCUIT

AIM:

To calculate time constant of RLC circuit

APPARATUS REQUIRED:

Desktop with pre installed MATLAB

CIRCUIT DIAGRAM:**PROCEDURE:**

1. Open MATLAB Software
2. Open editor window
3. Write the Program in the editor window
4. Run the program
5. Observe the result in the plot window

MATLAB PROGRAM:

```
clc;
clear all;
close all;
%% Series RLC circuit
C=input('C value'); % Capacitance
R=input('R value'); % Resistance
L=input('L value');
TC1=2*L/R
%% parallel RLC circuit
TC2=2*R*C
```

OBSERVATION TABLE:

S. No.	Time constant (Theoretical)	Time constant (Simulation)

CALCULATIONS:

RESULT: