POWER SYSTEM-II LABORATORY MANUAL

SUBJECT CODE: BEE 651

B.TECH.(EEE) SEMESTER -VI

Academic Session: 2024-25, Even Semester

Student Name:	
Roll. No.:	
Branch/Section:	

Dronacharya Group of Institutions

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Vision and Mission of the Institute

Vision:

"Dronacharya Group of Institutions, Greater Noida aims to instill core human values and facilitating competence to address global challenges by providing Quality Technical Education."

Mission:

M1: Enhancing technical expertise through innovative research and education, fostering creativity and excellence in problem-solving.

M2: Cultivating a culture of ethical innovation and user-focused design, ensuring technological progress enhances the well-being of society.

M3: Equipping individuals with the technical skills and ethical values to lead and innovate responsibly in an ever-evolving digital landscape.

Vision and Mission of the Department

Vision

To be a Centre of Excellence in Globalizing Education and Research in the field of Electrical and Electronics Engineering.

Mission

M1: To empower technocrats with state-of-art knowledge to excel as eminent electrical engineers with multi-disciplinary skills.

M2: To emphasize social values and leadership qualities to meet the industrial needs, societal problems and global challenges.

M3: To enable the technocrats to accomplish impactful research and innovations.

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, review 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 engineering practice.

PO 9: Individual and teamwork: 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, and 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.

Program Educational Objectives (PEOs)

PEO 1. To foster strong knowledge in basic sciences and electrical engineering that enable technocrats to have successful careers.

PEO 2. Imbibed with the state of art knowledge to adapt ever transforming technical scenario.

PEO 3. Inspire engineers to provide innovative solutions to real-world challenging problems by applying electrical and electronics engineering principles.

Program Specific Outcomes (PSOs)

PSO1: Graduates will be capable to gain knowledge in diverse areas of electrical and electronics engineering and apply that to a successful career, entrepreneurship and higher education.

PSO2: Enhance the competence of graduates to design and analyze systems used in advanced power applications, renewable energy, electrical drives in allied technical fields.

PSO3: Graduate will use advance tools to analyze, design and develop electrical and electronic systems for feasible operation and meet the industry requirements.

University Syllabus

(A) Hardware Based:

1. To determine direct axis reactance (xd) and quadrature axis reactance (xq) of a salient Pole alternator.
2. To determine negative and zero sequence reactances of an alternator.
3. To determine sub transient direct axis reactance (xd) and sub transient quadrature axis reactance (xq) of an alternator.
4. To determine fault current for L-G, L-L, L-L-G and L-L-L faults at the terminals of an alternator at very low excitation .
5. To study the IDMT over current relay and determine the time current characteristics
6. To study percentage differential relay.
7. To study Impedance, MHO and Reactance type distance relays.
8. To determine location of fault in a cable using cable fault locator.
9. To study ferranty effect and voltage distribution in H.V. long transmission line using transmission line model.
10. To study operation of oil testing set.

(B) **Simulation Based Experiments (using MATLAB or any other software)**

11. To determine transmission line performance.
12. To obtain steady state, transient and sub-transient short circuit currents in an alternator
13. To obtain formation of Y-bus and perform load flow analysis
14. To perform symmetrical fault analysis in a power system.

Course Outcome

CO 1	Test various relays for different characteristics and compare with the performance characteristics provided by manufacturers.	
CO 2	Select the power system data for load-flow and fault studies and to develop a program to solve power flow problem using NR and GS methods	
CO 3	Analyze various types of short circuit faults	
CO 4	Demonstrate different numerical integration methods and factors influencing transient stability	
CO 5	Determine the effect of load in long transmission line	

Course Overview

The course deals with exploring the ways and means to perform advanced power system analysis in normal operation and under symmetrical and unsymmetrical faults. Models of generators, transformers and transmission lines essential for such analyses are assembled. Additionally, principles for the formulation, solution, and application of optimal power flow are established. Computer-aided analysis of the performance of large-scale power systems is one of the central learning objectives. After completing this course the student will be able to: - conduct the analysis of large-scale power systems using advanced methods and algorithms - model generators, transformers, lines and cables in the positive, negative and zero sequence systems as basis for the analysis of symmetrical and unsymmetrical faults - perform analysis of power systems subjected to symmetrical and unsymmetrical faults - define, establish and solve equations for regular (AC) power flow, DC power flow, and optimal power flow - use simulation tools to perform comprehensive short circuit studies, load flow studies, and optimal power flow studies - use instruments and equipment in the laboratory - think independently and critically - supplement their learning through appropriate literature study - reflect upon results from assignments - demonstrate integrity and accountability in their learning .

List of Experiments mapped with COs

S. No	Aim of the	COs
1	To determine direct axis reactance (xd) and quadrature axis reactance (xq) of a salientPole alternator	**CO1**
2	To determine negative and zero sequence reactances of an alternator	**CO4**
3	To determine sub transient direct axis reactance (xd) and sub transient quadrature axis reactance (xq) of an alternator.	**CO1**
4	To determine fault current for L-G, L-L, L-L-G and L-L-L faults at the terminals of an alternator at very low excitation .	**CO2**
5	To study the IDMT over current relay and determine the time current characteristics	**CO3**
6	To study percentage differential relay.	**CO3**
7	To study Impedance, MHO and Reactance type distance relays	**CO4**
8	To determine location of fault in a cable using cable fault locator.	**CO5**
9	To obtain formation of Y-bus and perform load flow analysis	**CO2**
10	To perform symmetrical fault analysis in a power system.	**CO2**

DOs and DON'Ts

DOs

1. Treat every electrical device like it is energized, even if it does not look like it is plugged in or operational.
2. Unplug appliances before performing any service or repairs on them.
3. When working on electrical devices, only use tools that have official *"non-conducting"* handles.
4. Try to limit the use of electrical equipment in rooms that are very cold or have a lot of condensation.
5. When handling electrical equipment, make sure your hands are dry.
6. If you spill any kind of liquid on electrical equipment, *first* immediately shut off power to the equipment via the main switch or circuit breaker *and then* unplug the equipment itself.
7. Keep all electrical circuit contact points enclosed.

DON'Ts

1. First and foremost – don't touch active electrical circuits.
2. Never touch electrical equipment when any part of your body is wet, (that includes fair amounts of perspiration).
3. Do not store liquids of any sort near electrical equipment.
4. If a person comes into contact with an energized electrical conductor, do not touch the equipment, its cords, or the person affected because the charge may pass to you. Instead, shut down the main power source via the circuit breaker and then unplug the equipment using a leather belt.
5. Do not wear metal of any sort if you are working on electrical equipment.
6. Also, do not try to poke, probe, or fix electrical equipment with objects like pencils or rulers because the metal in them can serve as a form of conductor.

General Safety Precautions

Precautions (In case of Injury or Electric Shock)

1. To break the victim with live electric source, use an insulator such as firewood or plastic to break the contact. Do not touch the victim with bare hands to avoid the risk of electrifying yourself.
2. Unplug the risk of faulty equipment. If the main circuit breaker is accessible, turn the circuit off.
3. If the victim is unconscious, start resuscitation immediately, use your hands to press the chest in and out to continue breathing function. Use mouth-to-mouth resuscitation if necessary.

Precautions (In case of Fire)

1. Turn the equipment off. If the power switch is not immediately accessible, take plug off.
2. If fire continues, try to curb the fire if possible, by using the fire extinguisher or by covering it with a heavy cloth if possible isolate the burning equipment from the other surrounding equipment.
3. Sound the fire alarm by activating the nearest alarm switch located in the hallway.

Guidelines to Students for Report Preparation

All students are required to maintain a record of the experiments conducted by them. Guidelines for its preparation are as follows:-

1) All files must contain a title page followed by an index page. ***The files will not be signed by the faculty without an entry in the index page.***

2) Student's Name, Roll number and date of conduction of experiment must be written on all pages.

3) For each experiment, the record must contain the following

(i) Aim/Objective of the experiment

(ii) Pre-experiment work (as given by the faculty)

(iii) Lab assignment questions and their solutions

(iv) Test Cases (if applicable to the course)

(v) Results/ output

Note:

1. Students must bring their lab record along with them whenever they come for the lab.

2. Students must ensure that their lab record is regularly evaluated.

EXPERIMENT No-1

OBJECTIVE: -To determine direct axis reactance (X_d) and quadrature axis reactance (X_q) of a salient pole alternator.

Apparatus required: -

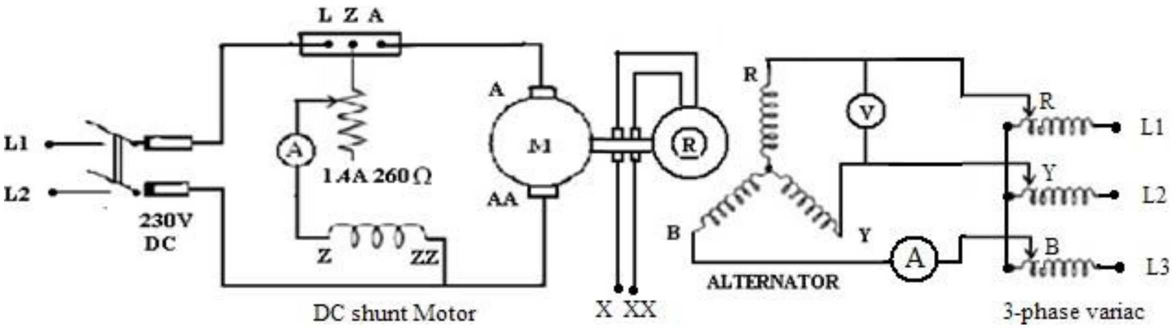
S.No.	Name of apparatus	Type	Range	Quantity
1.	Voltmeter	M.I.	(0 – 300/600V)	1 No.
2.	Voltmeter	M.I.	(0 – 75/150/300V)	1 No.
3.	Ammeter	M.I.	(0 – 5A)	1 No.
4.	Rheostat	Tubular	(1.4A- 260 Ω)	1. No.
5.	3 - Phase variac	-	(8A – 415V)	1 No.
6.	Connecting wire	Multi core	--------	L.S.

Apparatus required: - MG Set (DC motor + AC generator)

DC motor: - 3HP, 230V, 10Amp**,** 1500rpm.
AC generator: - 2 KVA, 3-phase, 415V, 50Hz, 2.8Amp, 1500rpm**.**

Theory: -The direct axis (Xd) and quardature axis (Xq) synchronous reactance of a salient pole synchronous machine can be determined from simple no load test known as the slip test.
In this test the alternator should be driven at a speed, slightly less than the synchronous speed with field circuit open, 3-phase small voltage at same frequency is applied to the armature (or stator) terminal of the synchronous machine, applied voltage to be adjust from 3-phase variac. So that current drawn by the stator winding is full load rated current. Under this condition of operation, variation of the current and voltage across the stator winding is maximum and minimum. Voltage will be maximum when the crest of the stator m.m.f wave conceded with the direct axis of the rotating field the induced e.m.f. in the open field is zero, the voltage across the stator terminals will be maximum and the current drawn by the stator winding is minimum. Thus the approximate value values of direct axis synchronous reactance .When the crest of stator m.m.f. wave conceded with the quadrature axis of the rotating field induced e.m.f. in the open circuit field is maximum, the voltage across the stator terminals will be minimum and current drawn by the stator winding is maximum. Hence approximate values of quardature axis synchronous reactance –

Circuit diagram: -



Procedure: -

1. Connect the circuit as per circuit diagram.
2. Insure that the resistance in the field circuit of DC motor is maximum.
3. Switch ON the DC supplies to the motor and start the DC motor with the help of 3- point starter.
4. Adjust the speed of the DC motor slightly less than the synchronous speed of the alternator by varying the resistance in the field circuit of the motor, slip should be extremely low, preferably less than 4%.
5. Insure that the setting of 3-phase variac it's at zero position.
6. Switch on 3- phase AC supply to the stator winding of alternator.
7. Adjust the voltage applied to the stator winding till the current in the stator Winding approximately full load rated current.
8. Under this conditions current in the stator winding, the applied voltage to the Stator winding and the induced voltage in the open field circuit will fluctuate from minimum to maximum values which may be recorded by the connected meters.
9. Reduced the applied voltage to the stator winding of alternator and switch OFF the 3-phase AC supply.
10. Decrease the speed of DC motor and switch OFF the DC supply

Observation table: -

S.No.	Armature voltage		Armature current	
	V_{min}(Volts)	V_{max}(Volts)	I_{min}(Amps)	I_{max}(Amps)

Calculation: -

Direct axis synchronous reactance (X_d) = $\frac{V_{max}}{I_{min}}$ = - - - - Ω

Direct axis synchronous reactance per phase = $\frac{X_d}{\sqrt{3}}$ = - - - - - - Ω

Quardature axis synchronous reactance (X_q) = $\frac{V_{min}}{I_{max}}$ = - - - - - Ω

Quardature axis synchronous reactance per phase = $\frac{X_q}{\sqrt{3}}$ = - - - - - Ω

Result: -

Precautions: -

EXPERIMENT No-2

OBJECTIVE :-Determination of negative sequence and zero sequence Impedance of asynchronous generator.

Apparatus required: -

S.No.	Name of apparatus	Type	Range	Quantity
1.	Ammeter	M.I.	(0 – 5A)	1
2.	Ammeter	M.C.	(0 – 2A)	1
3.	Voltmeter	M.I.	(0 – 300V)	1
4.	Voltmeter	M.I.	(0 – 75V)	1
5.	Wattmeter	Dynamo	(150V,5A)	1
6.	1 - Phase variac	-	(8A – 230V)	1
7.	Connecting wire	Multi core	--------	L.S.
8.	Tachometer	Digital		1

Apparatus required: - MG Set (DC motor + AC generator)
DC motor: - 2HP, 230V, 1500rpm.

AC generator: - 1 KVA, 3-phase, 415V, 50Hz, .8-P.FLagging, 1500rpm**.**

Theory: -When a synchronous generator is carrying an unbalanced load its operation may be analyzed by symmetrical components. In a synchronous machine the sequence current produce an armature reaction which is stationary with respect to reactance and is stationary with respect to field poles. The component currents therefore encounter exactly same as that by a balanced load as discussed. The negative sequence is produced and armature reaction which rotates around armature at synchronous speed in direction to that of field poles and therefore rotates part the field poles at synchronous speed. Inducing current in the field damper winding and rotor iron. The impendence encountered by the negative sequence is called the – ve sequence impedance of the generator. The zero sequence current produce flux in each phase but their combined armature reaction at the air gap is zero. The impedance encountered by their currents is therefore different from that encountered by + ve and –ve sequence components and is called zero sequence impedance of generator.

Negative sequence: The –ve sequence impedance may be found by applying balanced – ve sequence voltage to the armature terminals. While the machine is drive by the prime mover at its rated synchronous speed with the field winding short circuited. The ratio of E/ph and Ia/ph gives –ve sequence Z/ph. The reading of the wattmeter gives I^2 R losses. This loss /ph divided by I_{ph} required gives the –ve sequence R/ph from the impedanceand–reactance/ph. –ve sequence can be calculated. Another method of measuring –ve sequence reactance is found to be connect the arm terminals. The machine is driven at synchronous speed and field current adjusted until rated current flows in the phases shorted through armature and current coil of wattmeter respectively

Negative Sequence Impedance, $Z_2 = \frac{E}{\sqrt{3}I} = \frac{E}{\sqrt{3}I}$

Negative Sequence reactance, $X_2 = Z_2 \frac{P}{EI}$

Zero sequence: The sequence impedance may be determined by the connecting the armature windings of the three phases in series and then connecting them to the single phase source of power. If the machine is driven at synchronous speed with field winding shorted, however the magnitude of zero sequence reactance is not much affected by the rotation of the machine. Zero sequence can be then found out by recording current, applied voltage, input power and proceeding as per the following.

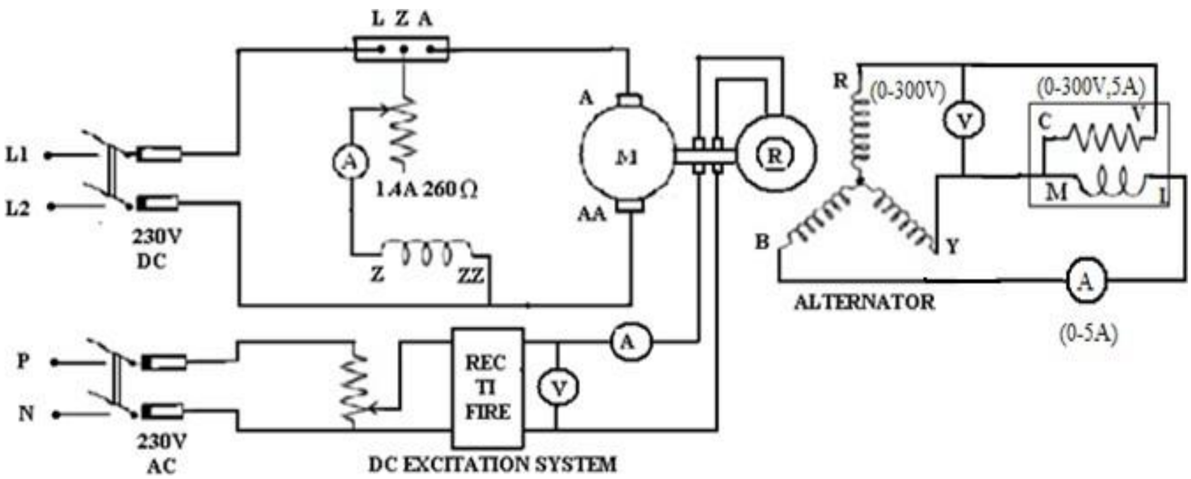
Zero sequence impedance, $Z_0 = \frac{E}{3I}$

And Zero sequence reactance $X_0 = Z_0 \{1 - (\frac{}{EI})^2\}^{\frac{1}{2}}$

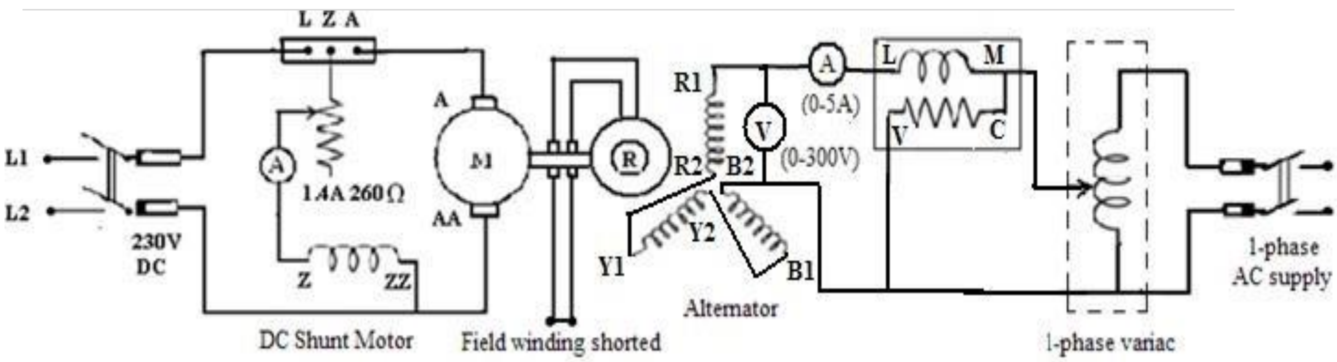
Practically the same results will be obtained with rotor stationary. If windings are connected in parallel, then

$Z_0 = \frac{\text{Voltage applied to phase}}{\text{Current through each phase}} = \frac{E}{I/3} = \frac{3E}{I}$

Circuit diagram: -



Negative Sequence



Zero Sequence

Procedure: -

A. For Negative Sequence

(1) Make connection as shown in circuit diagram.

(2) Run DC motor with synchronous speed.

(3) Keeping the speed constant, vary the excitation and measure the voltmeter, ammeter and wattmeter reading.

(4) Take 3-4 readings for different excitation.

(5) The excitation should not be increased beyond the rated capacity of synchronous machine.

(6) Switch of the DC supply both of the field circuit alternator and of DCmotor.

B. For Zero Sequence

(1) Make connection as shown in circuit diagram.

(2) Set the dimmer stat output to zero volts and switch on the supply.

(3) Gradually increase dimmer stat output and note the ammeter reading for Suitable voltage applied.

(4) Repeat reading for suitable voltage applied.

(5) It should be kept in mind that the ammeter reading should not exceed the rated current Capacity of the machine i.e.

(6) Switch off the AC supply.

Observation table: -

A. For Negative SequenceReactance

S.No.	**E (Volts)**	**I (Amps)**	**P (Watts)**	**Z_2**	**X_2**	**Avg X_2(Ω)**

B. For Zero SequenceReactance

S.No.	**E (Volts)**	**I (Amps)**	**P (Watts)**	**Z_2**	**X_0**	**Avg X_2(Ω)**

Result: -The negative sequence reactance and zero sequence reactance of an alternator were determined.

Precautions:-

EXPERIMENT No-3

OBJECTIVE: To study the IDMT over current relay and determine the time current characteristics.

Apparatus required:

1. Voltmeter (0-300 V) Digital
2. Ammeter (0-10 A) Digital
3. Loading C.T.
4. Auto Transformer 0-270V
5. Indicating Light
6. I.D.M.T. Relay Type CDG
7. Timer with Start & Stop facility
8. Push Button for Timer START & STOP
9. Rotary Switch
10. DP Switch
11. Insulating terminals

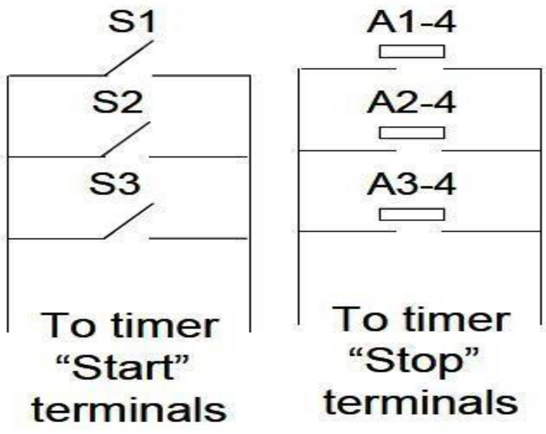
Theory

There are several over current protection such as fuse, thermal relay & IDMT Relay. IDMT (Inverse Definite Minimum Time) Relay is a high accuracy over current relay. If we does not want to flow the current in lines more than 1 Amp, we will set the tripping current in our relay 1 Amp. As the current will become 1.10 or 1.20, the relay disc will start forward and trip the breaker after certain time. It is widely used to prevent over current on transmission lines, power transformers etc, because the error & tripping time of the relay is tolerable by the lines and transformer.

As the requirement of system is that the faulted line should be open instantaneously. If the faulted line breaker fails to open the faulted line, the next supply breakers have to be open to for making dead the faulty line. The next breaker may be at higher voltage lineor the same voltage. The next breaker should open only after the first breaker failure. So we will allow approx 0.4 sec time to operate first breaker.

If first breaker does not become open within 0.4 sec than it will be assume failure and thenext breaker will become functional. These time and current distinguish is made by IDMT relay.

Circuit diagram:



Procedure:

1. Study the operating current & de-operating current of disc.

1) Keep the current source at minimum.

2) The amp adj / relay test rotary switch is kept at AMP ADJ.

3) Switch ON the test set.

4) Increase the current source slowly and pay attention at disc of relay.

5) At certain current, it just moves in forward direction, this current is operatingCurrent and note the current.

6) Now decrease the current through current source and pay hard attention at disc.

7) The disc will stop at certain current and moves in reverse direction just after

Reducing the current. This current is de-operating current and notes its value.

Observation table:

S NO.	PLUG SETTING	OPERATING CURRENT	DE-OPERATING CURRENT
1.	1 A	1.06 A	0.90 A
2.			
3.			
4.			
5.			
6.			
7.			

(1) Study the time current characteristics at various multiples of plug setting current .We have to study the graph between PSM and time at TMS-1 etc.Keep the current source at minimum.

(2) The amp adj / relay test rotary switch is kept at AMP ADJ.

(3) Switch ON the MCB/Isolator.

(4) Increase the fault current upto required PSM (refer table). It is quite 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 andThe marked shaft move UPWARD.

(5) Now the desire Fault Current is SET and relay FLAG RESET – Only when the diskHas move fully anti clockwise. Now move the Toggle 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.

(6) 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.

(7) Now plot the graph between time take for the relay to operate Vs Plug

(8) Setting Multiplierat various T.M.S.

Observation table:

S NO.	PLUG SETTING (PS)	PSM	FAULT CURRENT = PS x PSM	TRIPPING TIME
1.	1 A	1.5	1.5	
2.		2.0	2.0	
3.		2.5	2.5	
4.		3.0	3.0	
5.		3.5	3.5	
6.		4.0	4.0	
7.		4.5	4.5	
8.		5.0	5.0	

Result: We have drawn the characteristics of IDMT relay after performing the test.

Precautions

(1) The relay should be used very carefully and fast, beyond its rating.

(2) Suppose the 1 amp relay can withstand up to 1 amp continuously and if more than 1 Amp the relay should trip the system within few seconds.

EXPERIMENT No-4

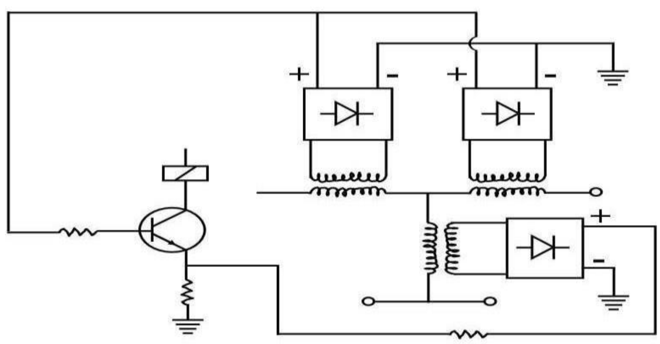
OBJECTIVE: To study percentage differential relay.

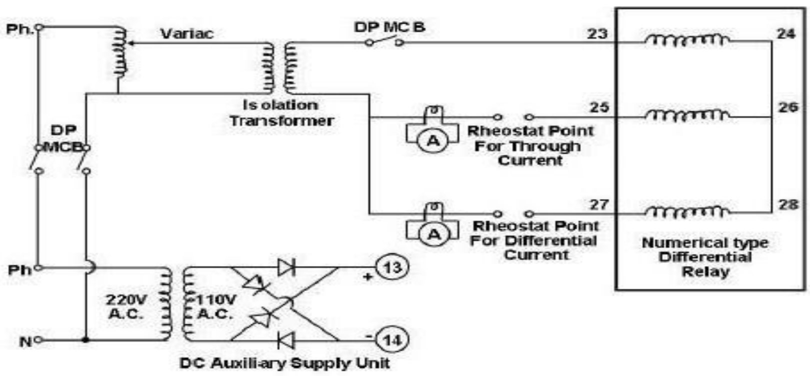
Apparatus required:

1. Relay Single Pole Version 1 A (Numerical Type) 'AREVA' make MBCH-12
2. Timer
3. Auto Transformer 0-270V, 10 A
4. Ammeter (10 A, AC) - 2 Nos.
5. Neon lamp 1A, AC, 230 V
6. Rheostat 5 A, 45 Ohms - 1 Nos.
7. Rheostat 10 A, 20 Ohms - 1 Nos.
8. Isolation Transformer
9. Auxiliary DC Supply Unit with Transformer

Theory: It is a very important protection of the transformer. It is based on the ratio of H.T.current and L.T. current should be constant. Consider the Fig No '1', here we considering the single pole of 132/33 KV Transformer. It's H.T. current and L.T. current ratio will be 1:4. If theCT of H.T. side is considered 100/1 Amp, so the CT of
L.T. side will be 400/1 Amp. The secondary current of L.T. side CT and H.T. side CT will always equal in normal condition. Both the secondary of CTs will enter in Numerical type % Differential Relay. The secondary of CT connection is make in sucha way that the CT current will flow only through coil circuit and no extra current is to flow from Differential coil. As soon as the fault occurs in transformer, the H.T. current will high. The ratio of H.T. current and L.T. current will change. The secondary of H.T.side CT current will become high with respect to secondary of L.T. side CT current. So the difference of current will flow through differential winding. The secondary of differential winding transformer will go to an electronic circuit that will operate a tripping relay to trip the breaker of main transformer. The through windings are used to restraining the differential relay. It will more clearly by drawing the curve between through current and differential current.

Circuit Diagram:





Procedure:

1. Turn the current source to minimum.
2. Connect the rheostat 5A, 45 Ohms to differential point.
3. Connect the rheostat 10A, 20 Ohms to through point.
4. Select the moving part of rheostat 5A, 45 Ohms at maximum Ohms.
5. Select the moving part of rheostat 10A, 20 Ohms at center.
6. Select the current by DP switch at the relay.
7. Switch ON the MCB then push green start button.
8. Increase the through current gradually as given in table by the current source.
9. Increase the differential current gradually up to the tripping of the relay and record inthe table.
10. Repeat the same process to gate the differential values at different through current.

Observation Table:

S No.	Restraining Current (A) (Through Current)	Operating Current (Differential Current)
1	0.50 Amp	
2	0.60 Amp	
3	0.70 Amp	
4	0.80 Amp	
5	0.90 Amp	
6	1.00 Amp	
7	1.10 Amp	
8	1.20 Amp	
9	1.30 Amp	
10	1.40 Amp	
11	1.50 Amp	

Result: we have performed the test on percentage differential relay.

Precautions:

1. The relay is design to handle 1 amp current. The study of relay more than1 amp is required fast operation.
2. Do not touch the any electronic parts with hand otherwise the relay may be damaged by static current

EXPERIMENT No-5

OBJECTIVE: To study Impedance, MHO and Reactance type distance relays.

Apparatus required:

1. Distance protection relay
2. Timer-2 Nos
3. Digital ammeter-1No
4. Digital Voltmeter-1No
5. Transformer 220/110V Instant rating – 1 No
6. Transformer having facilities to select the voltage by friction of 1 %
7. Current transformer 20/10 Amp.
8. Different values of resistance
9. Impedance

Theory: There_are several type of line protections uses in the transmission system. Every type of protection s has its own merit and de-merits. In line protection our moto isto isolate the fault zone without disturbing the healthy area. The distance Protection relay is one of the sensitive, fast and accurate relay. Here the tripping of relay divided into three zones i.e. Zone-1, Zone-2 and Zone-3.

Total line length is called principle section Zone -1is the 80% of principle section are total line.If the fault occurs within the 80% of line the relay will cover it Zone -1 and thetripping time in zone -1 should be in instant or minimum as possible.

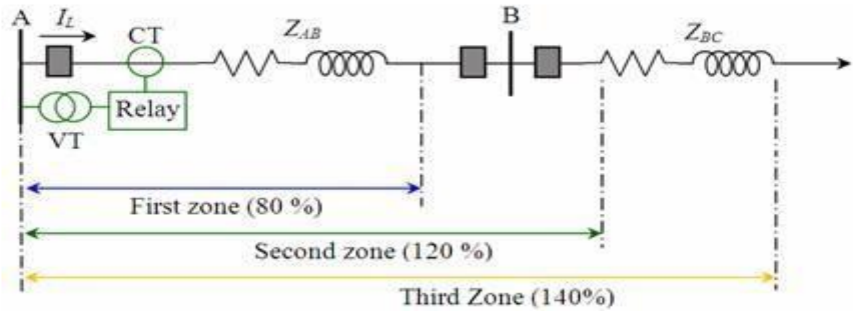
80 % to 120 % of principle section are total line length is covered in zone -2. We can delay in tripping of zone -2. Practically it is selected approximate 0.4 seconds. For testing or study purpose we can selected as our convenience.

120 % to 150 % of the principle section or total line length is covered in zone -3. We can delay in tripping of zone -3.Practically it is selected approximate 1.2 seconds. For testing or study purpose we can selected as our convenience.

When fault occurs in line, in zone -3 section of relay will operate. It is called the starter section. If the fault occurs in zone-1than also zone –3 Section will operate. The zone -3 sections will come into function at the fault condition 0 to 150 %but it will be trip the circuit breaker after the time set 1.2 seconds or may other.

When the fault occurs in line the zone -3 section or starter section senses and start the time of zone-2 and zone -3. If the fault is within 80 % of the principle section the zone - 1 section will trip the circuit breaker without any delay and if the faultis more than 80 %. The timer of zone -2 extended the reach of zone -1 relay 80 % to 120 %. Than after the time set for zone -2 the zone -1 section will measured the fault from 0 to 120 % and trip the circuit breaker accordingly. If the fault is more than 120 % the zone -3 section isalready in operative condition, after the time of 1.2 seconds or other set value the relay trip the circuit breaker.

A question arises, how it fast other relay? Its lower type of relay is IDMT. In distance protection is sharp line between less than 80 % or more than 80 %. Less than 80 % notime delay and more than 80 % a set delay. In IDMT to give than 80 % a set delay we can not avoid a less delay below 80 % a that few milli seconds may harm the line and disturb the GRID in big voltage transmission line are we can say 132 KV and higher.



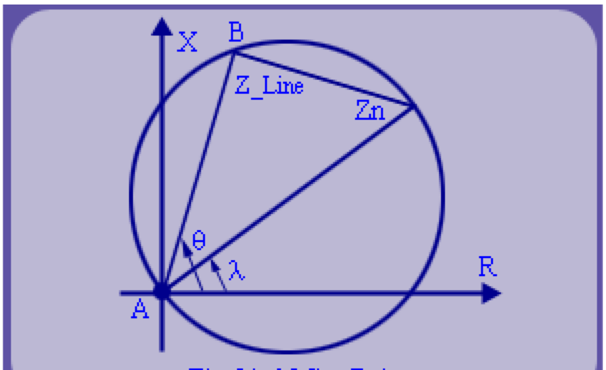


Fig 21.6 Mho Relay

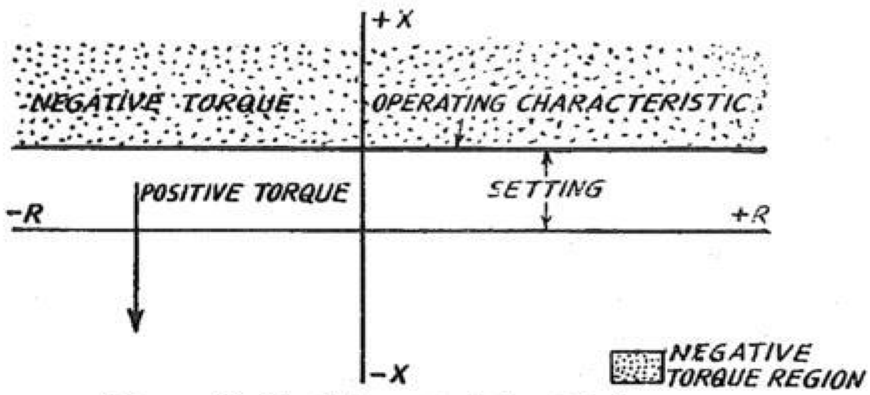


Fig. .13. Ideal characteristic of plain reactance type distance relays (simplified).

EXPERIMENT No-6

OBJECTIVE: - To determine location of fault in a cable using cable fault locator

Apparatus required:

1. Rheostat 1.1 A, 800 Ohms – 2 Nos.
2. Galvanometer – 1 No.
3. Measuring Tape (5M) – 1 No.
4. 3 Core Cable (25M) – 1 No.
5. DC Power Source – 1 No.
6. Digital Multimeter

Theory:

Most of the distribution and part transmission of electrical power is now-a-days carriedout through underground cables because of several advantages over the over head system. Many a times locating a fault becomes a difficult task because cable is buried under the ground and is not accessible. The faults which are most likely to occurare:-

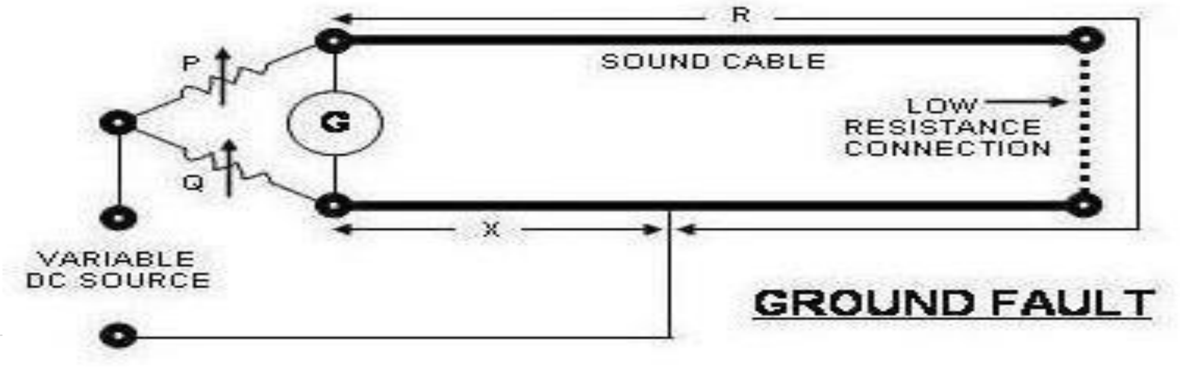
(a) Ground Fault: - A breakdown of the insulation of the cable which allows current to flow from core to earth or to cable sheath.

(b) Short Circuit: - A cross or short circuit between two cables or between two cores of a multicore cable.

Amongst various methods used for localizing cable faults. Murray Loop Test is very common and is described here.

This test is carried out for locating a ground or a short circuit fault, provided that a cable runs along with the grounded cable or with two cables (or with two cores of a multi-core cable) which are short circuited. The advantage of loop test is that the resistance of the fault does not affect the results obtained. Provided this resistance isnot very high. Otherwise it may adversely affect the sensitivity.

Circuit diagram:



$$\text{Then} \quad \frac{P}{Q} = \frac{R}{X}$$

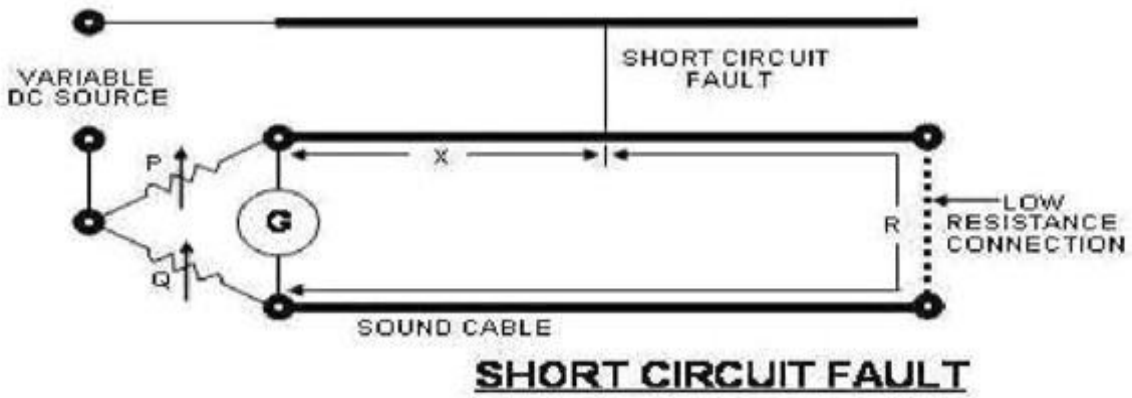
$$\text{Or} \quad \frac{P+Q}{Q} = \frac{R+X}{X}$$

$$\text{Or} \quad \frac{Q}{P+Q} = \frac{X}{R+X} = \frac{x\,(r)}{21\,(r)}$$

$$x = 21\left(\frac{Q}{P+Q}\right)$$

Connection diagram for locating ground fault by Murray Loop Test

(Here l is length of cable in meter and x is distance of fault in meter.)



Connection diagram for locating short circuit fault by Murray Loop Test

$$\text{Then} \quad \frac{Q}{P} = \frac{X}{R}$$

$$\text{Or} \quad \frac{P}{P+Q} = \frac{X}{R+X} = \frac{x\,(r)}{21\,(r)}$$

$$\text{Or} \quad x = 21\left(\frac{P}{P+Q}\right)$$

(Here l is length of cable in meter and x is distance of fault in meter.)

Procedure

(1) Take a multicore cable (say 3 core) of known length (say 25M).

(2) Measure the resistance of each core.

(3) Make connections as shown in Fig - ‘1’. Short circuit the two cores of the cable at the Other end. Adjust P and Q such that balance is obtained. Note P, Q and calculate Distance of fault x. Take three-four observations and take the mean of calculated value Of length of the fault from each set of readings. This length should be equal to the Distance of fault from the lower end of resistance Q.

(4) Note down the actual distance of fault by measuring the actual distance of fault and Calculate the % error.

(5) Make connections as shown in Fig -‘2’. Short circuit any two cores of cable to create Short circuit fault. Adjust P and Q such that balance is obtained. Note P and Q in the Observation table. Calculate x with.

(6) Take three-four observations and find average of x. calculate the distance of short circuit fault from the measuring end of the cable.

(7) Note down the actual distance of fault by measuring of actual fault distance and Calculate the %age error.

Observation

Total length of the cable = 25 Meterr = resistance per meters = 0.9/25 = 0.036

Localization of Earth Fault:-

S No.	P (Ohm)	Q (Ohm)	x = 2l [Q/(P+Q)]	Distance of fault from measuring end = x (m) (Average of x1, x2, x3…)	Actual location of fault	% Error
1.	699	172.7	9.91	9.82	10.00	1.8
2.	609	148.3	9.79			
3.	799	194	9.77			

Localization of Short Circuit Fault:-

S No.	P (Ohm)	Q (Ohm)	X = 2l [P/(P+Q)]	Distance of fault from measuring end = x (m) (Average of x1, x2, x3…)	Actual location of fault	% Error
1.	161	670	10.32	9.96	10.00	0.4
2.	185	761	9.78			
3.	165	678	9.77			

Result: We have performed the location of fault in a cable using cable fault locator.

EXPERIMENT No-7

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

Apparatus required:

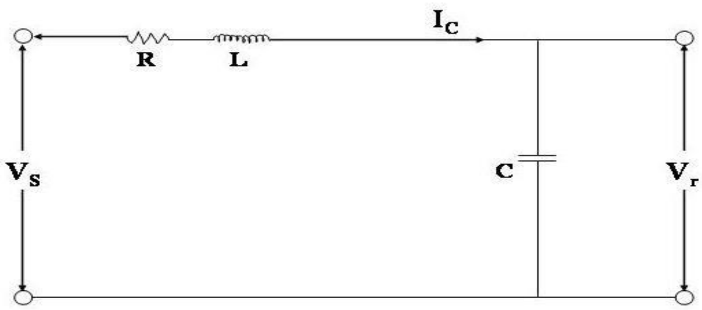
Transmission line model is consisting of four actions of transmission on line operatable at 220V with current rating at 2A connected in network. A continues variable power supply with two Digital voltmeter and two digital ammeter mounted on front panel with Resistive, Inductive, Capacitive load fitted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

Theory

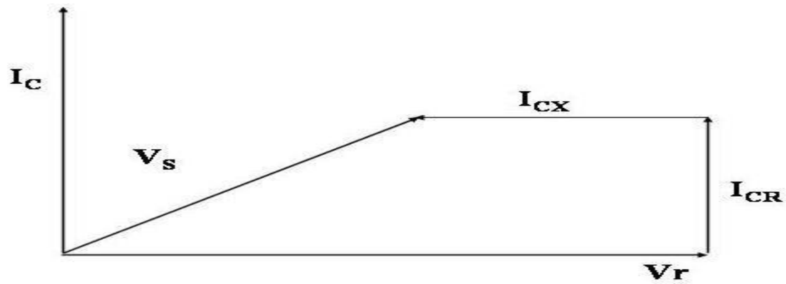
Transmission line model consists of four sections and each section represents 50 km long 400 KV transmission line. Parameters of 50 km long 400 KV Transmission line are taken as :-
Series Inductance = 80 mH Series
Resistance = 2
(In addition to resistance of inductance coil) Shunt
Capacitance = 0.47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

Circuit diagram:

A simple explanation of Ferranti Effect can be given by approximating the distributed parameters of the line by lumped impedance as shown in Fig –'1'and fig-2.



Line representation (Lumped) under No Load Condition



Phasor Diagram for Line representation (Lumped) under No LoadCondition

Procedure

(1) Apply the voltage (200 V max.) to the sending end and connect power factormeter.
also connect 1 ammeter and voltmeter to each end (receiving and sending).

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

(3) Now remove the load from the receiving end and note down the voltage on Receiving end. This voltage at the receiving end is quite large as compared to sendingend voltage.

Observation table:

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

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

EXPERIMENT No-8

OBJECTIVE: To study operation of oil testing set.

Apparatus required: Oil Testing Set

Theory: When a sample of oil is subjected to dielectric stress in a gap between two spheres the materials of higher conductivity and higher spheres capacity are drawn into the intense field between the spheres and causes a distortion of the field resulting in local high density and disruption begins at these points.

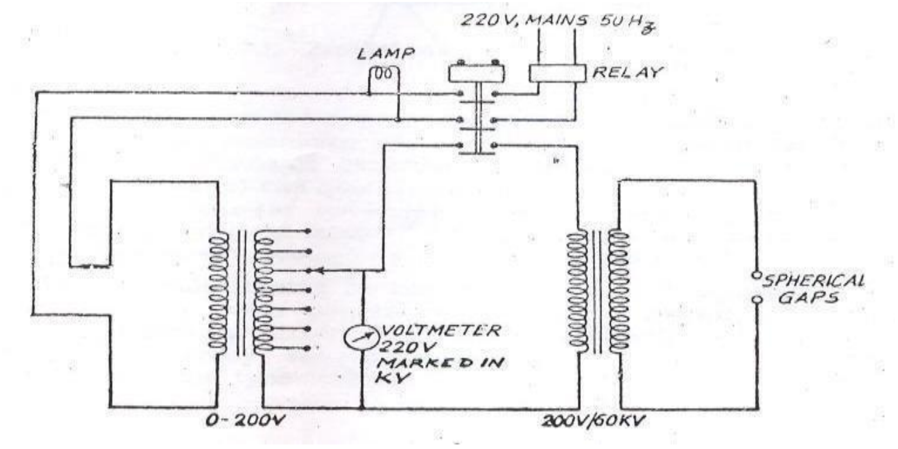
When testing transformer oil it is found often that one or more discharge occur across the gap at comparatively low voltages due to the presence of water particles but that the voltage can be raised to a very much higher value before complete rupture occurs.

If particles of higher dielectric constant than the oil are drawn into the intense field, they will cause excessive local stress which may result in dissociation or ionization of oil and the gases of ionization may bridge the gap and causes complete rupture.

In standard specifications for 'Insulating Oil' the method of applying the testing voltage (which must be alternating or approximately sine waveform of frequency between 25 and 100 Hz and with a peak factor of 2 +5% has been laid down. The test has to be carried out under standard conditions. The minimum dimensions of the test cell, diameter of the electrode and the distance between them are specified.

Procedure: When testing oils the set is operated according to a particular method (in compliance with the regulations) i.e. with a fixed spark gap and variable testing voltage. The voltage should be increased gradually under continues observation of the measuring until the breakdown occurs. To test oils of high quality the distance between electrodes should be adjusted to 2 mm. The equipment permits 310 KV/cm to be measured. For testing oils of medium quality or inferior quality the spark gap should be adjusted to 4 mm by means of a distance gauge. The insulating material oil testing cup is equipped normally with two calotte-shaped electrodes of 36 mm dia, radius of each sphere is 25 mm. The oil testing cup is kept as small as possible to do with minimum quantity of oil. Suitable safety contacts are provided to put the set out of operation as soon as the top lid is opened in order to insert or remove the test cup, thus eliminating HT danger. The set is disconnected automatically as soon as the puncture occurs. No oiltests are possible as long as the lid of the rear of the cabinet is open.

Circuit Diagram



Result: Distance between electrodes = _______________ Breakdown voltage = _

EXPERIMENT No-9

OBJECTIVE: To perform symmetrical fault analysis in a power system.

Apparatus required: MATLAB Software, Computer system etc.

Theory: In symmetrical faults all the three phases are short circuited to each other and often to earth also. Such faults are balanced and symmetrical in the sense that the system remains balanced even after the fault.

Fault Analysis: For a 3-bus power system the positive-sequence bus impedance matrix, zero-sequence bus impedance matrix are given by

```
zdata1 = [0    1    0    0.25
0              2    0    0.25
1              2    0    0.125
1              3    0    0.15
2              3    0    0.25];


zdata0 = [0    1    0    0.40
0              2    0    0.10
1              2    0    0.30
1              3    0    0.35
2              3    0    0.7125];
```

Where zdata1 represents positive sequence bus impedance matrix, zdata0represents zero sequence bus impedance matrix. The negative-sequence data is assumed to be the same as the positive-sequence data.

Perform the symmetrical fault analysis for this system.

MATLAB Programming:

Symmetrical three-phase fault

Enter Faulted Bus No. -> 1

Enter Fault Impedance Zf = R + j*X in complex form (for bolted fault enter 0). Zf= 1.1

Balanced three-phase fault at bus No. 1
Total fault current =0.9013 per unit

Bus Voltages during fault in per unit

Bus No.	Voltage Magnitude	Angle degrees
1	0.9914	-7.5093
2	0.9921	-5.4268
3	0.9915	-6.7281

Line currents for fault at bus No. 1

From Bus	To Bus	Current Magnitude	Angle degrees
G	1	0.5228	-7.5093
1	F	0.9013	-7.5093
G	2	0.3785	-7.5093
2	1	0.2884	-7.5093
2	3	0.0901	-7.5093
3	1	0.0901	-7.5093

Another fault location? Enter 'y' or 'n' within single quote -> 'n'

EXPERIMENT No-10

OBJECTIVE: To perform unsymmetrical fault analysis in a power system.

Apparatus required: MATLAB Software, Computer system etc.

Theory: Unsymmetrical faults involve only one or two phases. For unsymmetrical faults, voltages and currents become unbalanced and each phase is to be treated individually for calculation purpose.

Fault Analysis: For a 3-bus power system the positive-sequence bus impedance matrix, zero-sequence bus impedance matrix are given by

```
zdata1 = [0    1    0    0.25
0          2    0    0.25
1          2    0    0.125
1          3    0    0.15
2          3    0    0.25];


zdata0 = [0    1    0    0.40
0          2    0    0.10
1          2    0    0.30
1          3    0    0.35
2          3    0    0.7125];
```

Where zdata1 represents positive sequence bus impedance matrix,zdata0represents zero sequence bus impedance matrix. The negative-sequencedata is assumed to be the same as the positive-sequence data.

Perform the unsymmetrical fault analysis for this system.

MATLAB Programming:

(a) Line-to-ground fault analysis

Enter Faulted Bus No. -> 2

Enter Fault Impedance Zf = R + j*X in complex form (for bolted fault enter 0). Zf = 2.2 Single line to-ground fault at bus No. 2

Total fault current = 0.4538 per unit Bus Voltages during the fault in per unit

Bus -------Voltage Magnitude-------

No. Phase a Phase b Phase c

1	0.9985	0.9932	1.0064
2	0.9984	0.9921	1.0074
3	0.9984	0.9926	1.0070

Line currents for fault at bus No. 2 From To -----Line Current Magnitude----

Bus	Bus	Phase a	Phase b	Phase c
1	2	0.1129	0.0323	0.0323
1	3	0.0348	0.0106	0.0106
2	F	0.4538	0.0000	0.0000
3	2	0.0348	0.0106	0.0106

Another fault location? Enter 'y' or 'n' within single quote -> 'n'

(b) Line-to-line fault analysis

Enter Faulted Bus No. -> 3

Enter Fault Impedance Zf = R + j*X in complex form (for bolted fault enter 0). Zf = 3.3Line-to-line fault at bus No. 3

Total fault current =0.5203 per unit Bus Voltages during the fault in per unit

Bus -------Voltage Magnitude-------

No.	Phase a	Phase b	Phase c
1	1.0000	1.0277	0.9602
2	1.0000	1.0254	0.9632
3	1.0000	1.0490	0.9346

Line currents for fault at bus No. 3 From To -----Line Current Magnitude----

Bus	Bus	Phase a	Phase b	Phase c
1	3	0.0000	0.3122	0.3122

2	1	0.0000	0.0416	0.0416
2	3	0.0000	0.2081	0.2081
3	F	0.0000	0.5203	0.5203

Another fault location? Enter 'y' or 'n' within single quote -> 'n'

(c) Double line-to-ground fault analysis

Enter Faulted Bus No. -> 1

Enter Fault Impedance Zf = R + j*X in complex form (for bolted fault enter 0). Zf = 1.2

Double line-to-ground fault at bus No. 1

Total fault current =0.4156 per unit Bus Voltages during the fault in per unit

Bus -------Voltage Magnitude-------

No.	Phase a	Phase b	Phase c
1	1.0004	0.4988	0.4988
2	0.9995	0.5470	0.5597
3	1.0001	0.5018	0.5118

Line currents for fault at bus No. 1 From To -----Line Current Magnitude----

Bus Bus Phase a Phase b Phase c

1	F	0.0000	6.1799	5.7653
2	1	0.0145	1.9921	1.8304
2	3	0.0028	0.6208	0.5738
3	1	0.0028	0.6208	0.5738

Another fault location? Enter 'y' or 'n' within single quote -> 'n'

This lab manual has been updated by

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Crosschecked By HOD EEE

Verified By Director, DGI Greater Noida

Please spare some time to provide your valuable feedback.