MUFFAKHAM JAH COLLEGE OF ENGINEERING & TECHNOLOGY

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DEPARTMENT OF ELECTRICAL ENGINEERING

LABORATORY MANUALS

POWER SYSTEMS LAB

For

B.E,VIIth SEM, EEE

2020-21

LIST OF EXPERIMENTS IN POWER SYSTEM LAB

B E ,VIIth Sem, EEE

CYCLE – I

1. Measurement of Capacitance of 3-core Cables.
2. IDMT characteristics of over-current relay & Study of Buchholz relay.
3. Determination of positive, negative and zero-sequence reactance of 3-phase transformers using sequence current excitation fault calculation.
4. Sequence impedance of 3-phase Alternators.
5. Characteristics of static relays.

CYCLE - II

6. Determination of dielectric strength of oils and study of Megger.
7. Determination of A,B,C,D constants of short, medium and long lines.
8. Simulation of string of insulators for determination of voltage distribution and string efficiency.
9. Parallel operation of Alternators.
10. Differential protection of Transformer.

POWER SYSTEM LAB MANUALS

EXPERIMENT NO: 01

MEASUREMENT OF CAPACITANCE OF 3- CORE CABLE

AIM : To measure the core capacitance, core to earth capacitance and charging current in three core underground cable.

APPARATUS: 1. THREE CORE CABLE -2.92 meter.

2. LCR meter.

THEORY: The capacitance of a cable system is much more important than that of overhead line because in cable conductors are nearer to each other and to the earthed sheath and they are separated by a dielectric of permittivity much greater than of air.

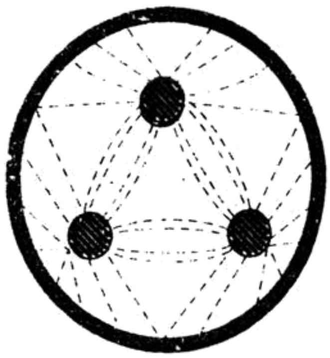


Fig (1)

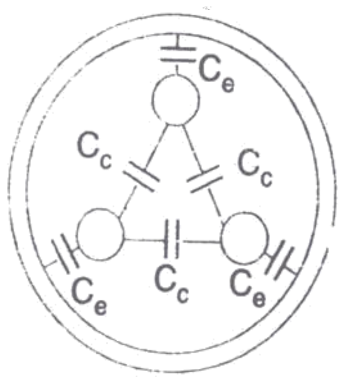


Fig (2)

Fig (1) shows a system of capacitances in a 3core belted cable used for 3 phase system. since potential difference exists between pair of conductors and between each conductor and the sheath, electrostatic fields are set up in the cable these electrostatic fields give rise to core – core capacitance Cc and conductor earth capacitance CE as shown in fig (2).the three Cc are Delta connected where as three CE as shown in fig (2).the three CC are delta connected where as the three CE are star connected. The sheath forming the star point as shown in fig (3) fig (3) can be reduced to fig (4)

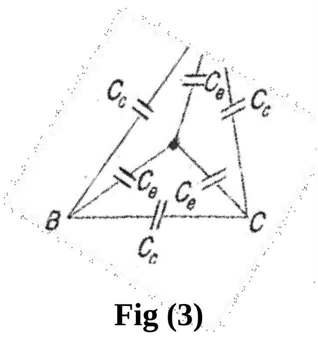


Fig (3)

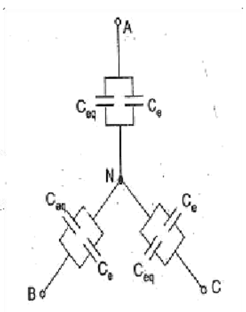


Fig (4)

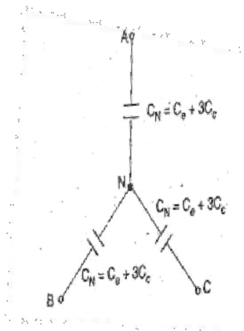


Fig (5)

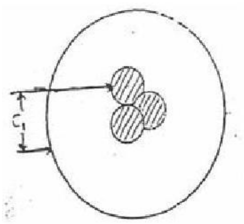
Where C_{eq} =3Cc.

Therefore, C_N as shown in fig (5).
Where $C_N = Ce + 3\ Cc$

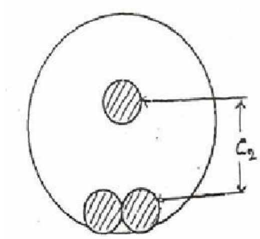
If V ph is the phase voltage, then charging current.

$$I_c = [V\ ph / \text{capacitive reactance per phase}] = 2\Pi\ f\ Vph\ C_N$$

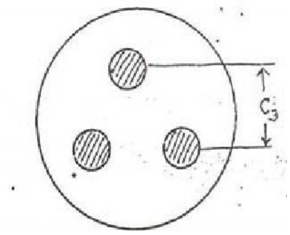
FUNTIONAL DIAGRAM:



Measurement of Ce



Measurement of Cc



Measurement of C_N

PROCEDURE:

(1) MEASURENT OF CE :

Three core are bunched together and capacitance C1 is measured between the bu8nched core and the sheath, the bunching eliminates all the three capacitance Cc leaving the three capacitors Ce in parallel,

CE = C1/ 3

(2) MEASURMENT OF Cc:

The two cores are bunched with sheath and capacitance C2 is measured between them and third core

Cc = (C2 – Ce)/2

(3) MEASURMENT OF C_N:

Measurement of capacitance C3 between two cores with the third core left free
$C_N = 2\ C3$

CALCULATIONS:

1 CE / km = CE (measured) into 1000/2.92
2 Cc / km = Cc (measured) into 1000/2.92
3 C_N / km = C_N (measured) into 1000/2.92
4 $Ic = 2\Pi f\ Vph\ C_N$
Where f= 50 HZ and Vph =440/ $\sqrt{3}$

Discussion of Result :

EXPERIMENT NO : 02 Part-A

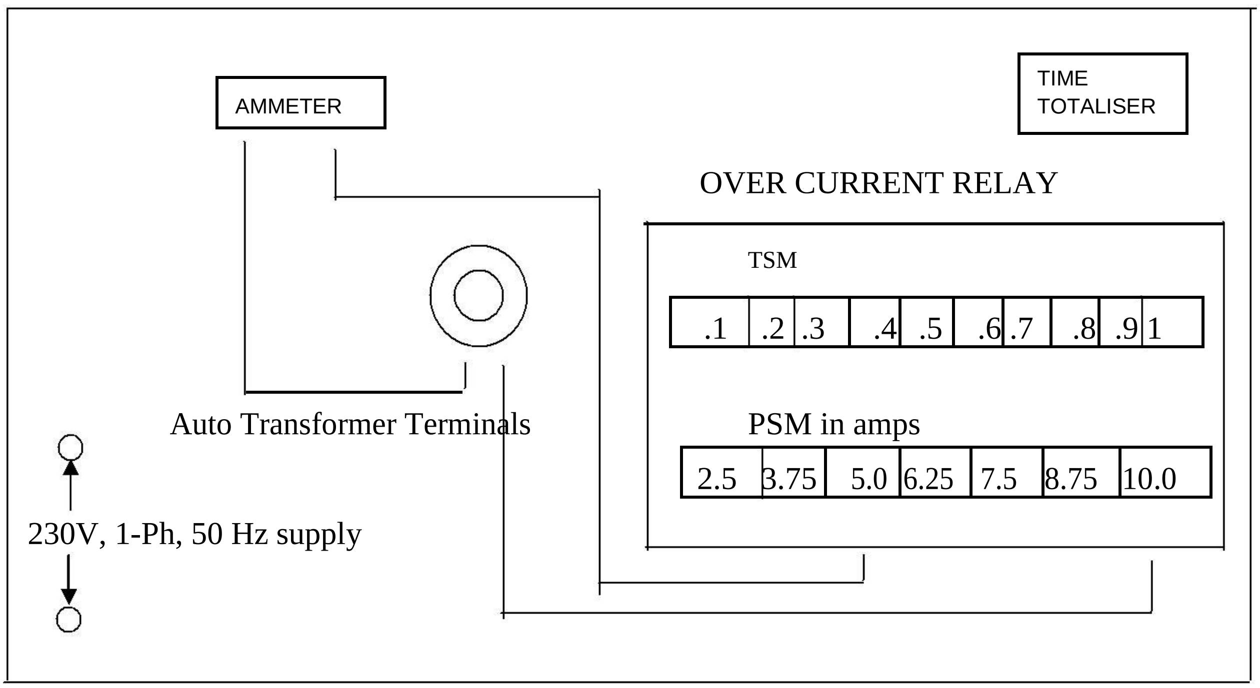
IDMT characteristics of over-current relay & Study of Buchholz relay.

AIM: To study the over current relay and determine its IDMT characteristics & study of Buchholz relay.

APPARATUS: Over current relay setup, connecting wires.

THEORY: This type of relay works on the induction principle and initiates corrective measures when the current in the circuit exceeds the predetermined value. The actuating source is a current in the supplied to the relay from a current transformer. It consist of a metallic (aluminum) disc, which is free to rotate in-between the poles of two electromagnets. The upper electromagnet has a primary and secondary of a C T. in the line to be protected and is tapped at intervals. The tapping are connected to a plug operating coil can be varied, thereby giving the desired current settings. The secondary winding is energized by induction from primary and is connected in series with the winding on the lower magnet. The control torque is provided by spiral spring.

PANEL DIAGRAM CT Secondary = 5 Amps

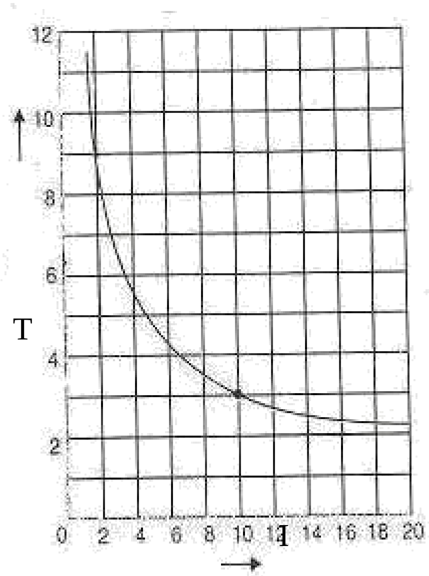


TABULAR COLUMN:

TSM=1.0	P.S.M=2.5		P.S.M=3.75		P.S.M=5.0		P.S.M=8.5	
S.NO	I(amps)	T(sec)	I(amps)	T(sec)	I(amps)	T(sec)	I(amps)	T(sec)

TSM=0.8	P.S.M=2.5		P.S.M=3.75		P.S.M=5.0		P.S.M=8.5	
S.NO	I(amps)	T(sec)	I(amps)	T(sec)	I(amps)	T(sec)	I(amps)	T(sec)

Expected Graph:



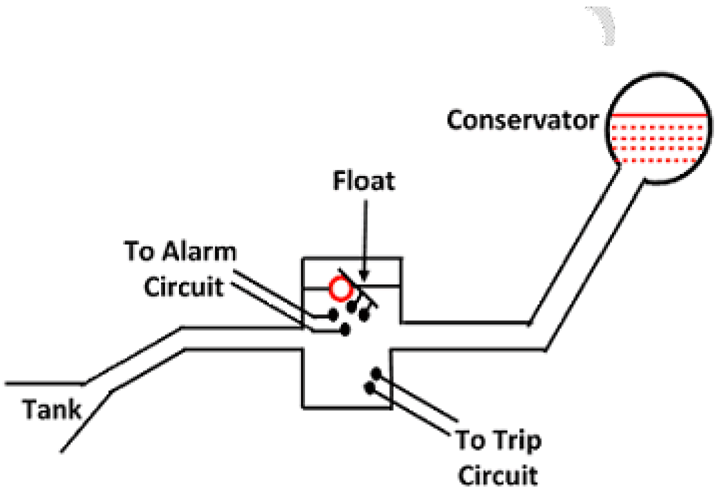
EXPERIMENT NO: 02 Part-B

STUDY OF BUCHHOLZ RELAY

AIM: To study working of Buchholz relay.

APPARATUS :

1. Buchholz relay fitted on stand with pipeline valves and conservator.
2. Air compressor to produce air pressure
3. control panel



Arrangement of Buchholz Relay

Circuit Globe

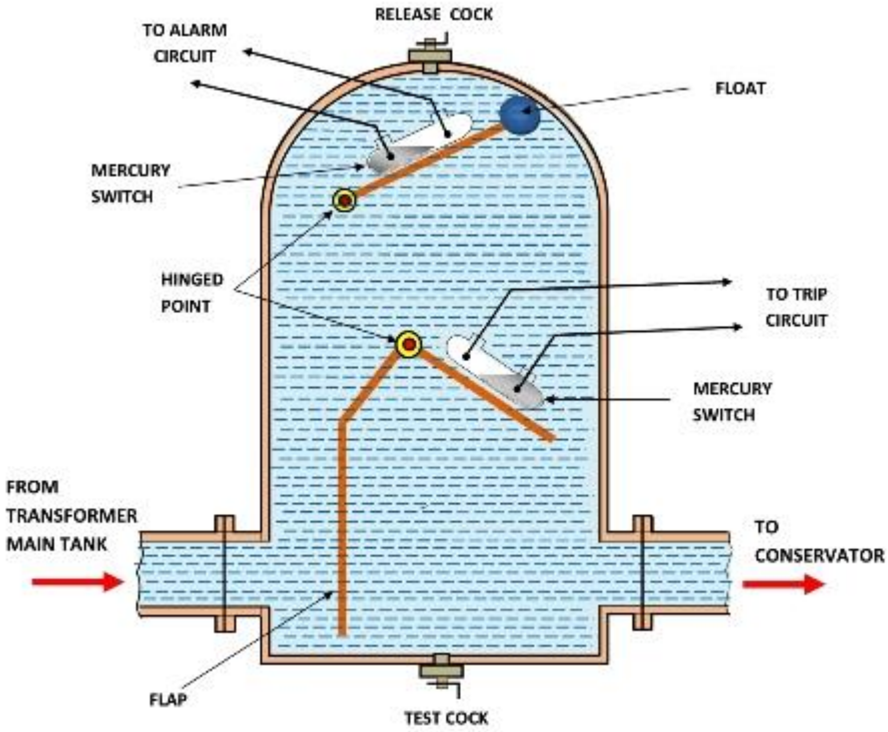


Fig of BUCHHOLZ RELAY

THEORY:
Power transformers are considered to be a highly reliable type of equipment yet in order to ensure the continuity of service that modern condition demand protective. Devices are required the purpose of such devices is to disconnect faulty apparatus before large scale damage is caused by fault to the faulty apparatus or to other connected apparatus Such devices generally respond to a change in the current or pressure arising from the faults and are used for either signaling or tripping the circuit. Protective devices in the ideal cause must be sensitive to all faults simple in operation, robust for service and economically feasible. Considering liquid immersed transformers, a near ideal protective device is available in the gas and oil relay described here .it is sensitive simple in construction and operation robust and inexpensive. The relay operates on the well known facts that almost every type of electric fault in liquid immersed transformers gives rise to gas. This gas is collected in the body of the relay and is used in some way or another to cause the alarm or the tripping circuit to operate. It was proved that the relay is very sensitive and capable of bringing to light incipient fault there by preventing further spreading of the fault and extensive damage, and thus saving expensive and protected repairs.

So successful is the principle of this relay, that despite the continued search for better protective devices so successful in other electrical field, the gas and oil relay is still on its own in providing protection against a variety of faults. Not only does this relay provide protection against a number of internal faults, but it also is able to indicate, in several causes, the type of fault. This is possible because the gas collecting in the relay, Can form its color, odor and composition, indicates where the fault may be and what its nature is.

DESCRIPTION OF THE RELAY SETUP:- The relay comprises an oil tight case cover. It is provided with two hinged floats which separate mercury switches connected to customers protective alarm, or tripping circuits. It is connected in the pipe connection between the transformer and the expansion vessel so that normally it is completely filled with oil.

OPERATION: Gas produced by abnormal conditions in the transformer collects in the relay, which lowers the oil level so that the top float gradually comes down and ultimately operates the mercury switch when it reaches a certain level this switch is usually connected to an external alarm circuit.

Faults which cause operation of this type are:

1. Low oil level in the transformer due to any reason.
2. Accumulation of air.
3. fault in the core laminations
4. breakdown of core bolts insulation
5. local overheating in the windings
6. Bad connections
7. Bad switch contacts.

Abnormal conditions associated with major faults cause a surge in the oil which moves towards the expansion vessel. This surge displaces the lower float operating the switch associated with it is customary to connect this switch in the trip circuit to ensure that the transformer is disconnected on the operation of this switch and thus prevents further damage

Faults which may cause operation of this switch are:

1. Internal short-circuit between the turns.
2. Short circuit between phase and earth.
3. phase to phase short circuit
4. insulation breakdown

PROCEDURE:-

1. Connect the phase & neutral in to side strip
2. Connect output to the motor.
3. Connect alarm point to the alarm point of relay
4. Connect trip point to the trip point of relay
5. Switch on the MCB
6. Push the green button, now motor will start.
7. By opening the valve slowly, oil in the chamber decreases and relay operates.

Discussion of Result:

EXPERIMENT NO: 03

Determination of positive, negative and zero-sequence reactance of 3-phase transformers using sequence current excitation fault calculation.

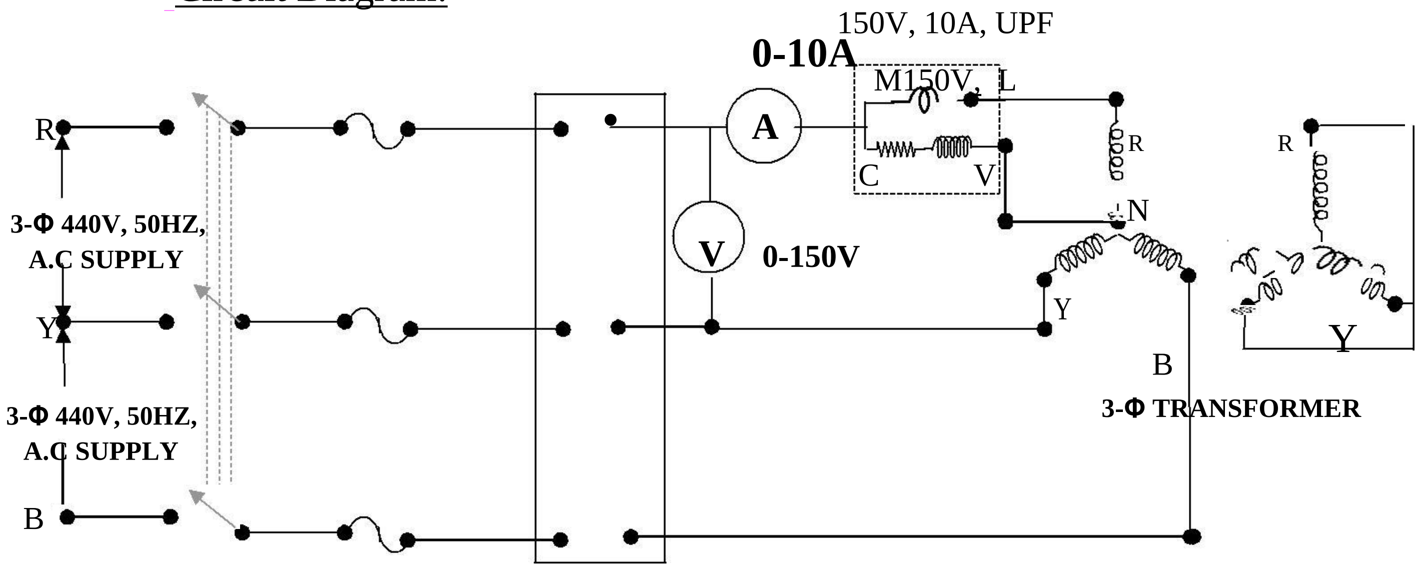
AIM: To determine the positive, negative and zero sequence reactance of a 3 phase Transformer.

APPARATUS:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1.	Voltmeter	MI	0-150V	1 No.
2.	Ammeter	MI	0-10A	1 No.
3.	Wattmeter		150V,10A.UPF	1 No.
4.	3 phase variac		10A	1 No.
5.	Single phase variac		10A	1 No.
6.	Connecting Wires		3/20,10/20	20Pieces

(A) Measurement of Positive and Negative sequence reactance:

Circuit Diagram:



PROCEDURE:

1. Connect the circuit as shown in the circuit diagram.
2. Using the 2-phase variac apply the rated current of the primary and note down the voltage, current and Power.

OBSERVATION:

V(In volts)	I(In amps)	Wm(Watts)

CALCULATIONS:

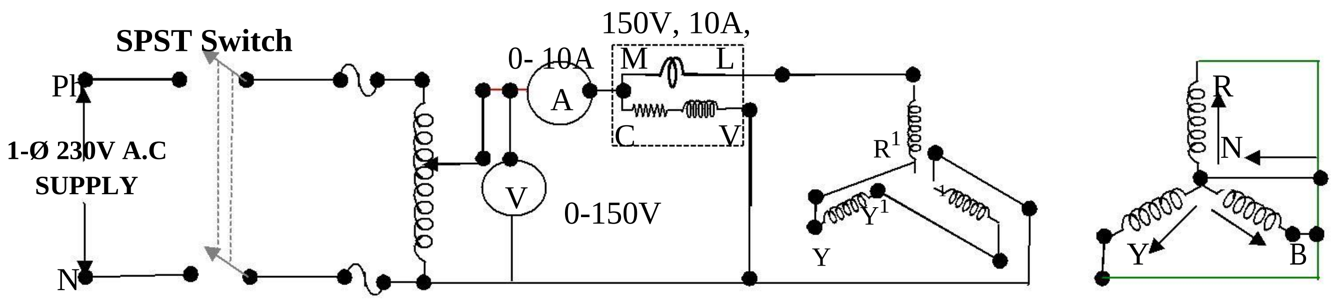
$$Z_1 = Z_2 = \frac{V}{\sqrt{3}I}$$

$$R_1 = \frac{W}{I^2}$$

$$X_1 = X_2 = \sqrt{Z_1^2 - R_1^2}$$

(B) **Measurement if Zero Sequence reactance :**

Circuit Diagram:



PROCEDURE:

1. Connect the circuit as shown in the circuit diagram.
2. Apply the rated current to the primary of the transformer and note down voltage, current and power.

OBSERVATION:

V(In volts)	I(In amps)	Wm(Watts)

Calculation:

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

$$R_0 = \frac{W}{3I^2}$$

$$X_0 = Z_0^2 - R_0^2$$

Discussion of Results:

EXPERIMENT NO: 04

Sequence impedance of 3-phase Alternators

AIM: To determine experimentally positive, negative and zero sequence impedances of 3-phase Alternators.

APPARATUS:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1.	Voltmeter	MI	0-300V	1 No.
2.	Voltmeter	MI	0-30V	1 No.
3.	Ammeter	MI	0-10A/20A	1 No.
4.	Ammeter	MC	0-2A	1 No.
5.	Rheostat	-	1000 ohm,1A	1 No.
6.	Rheostat	-	350ohm,1.7A	1 No.

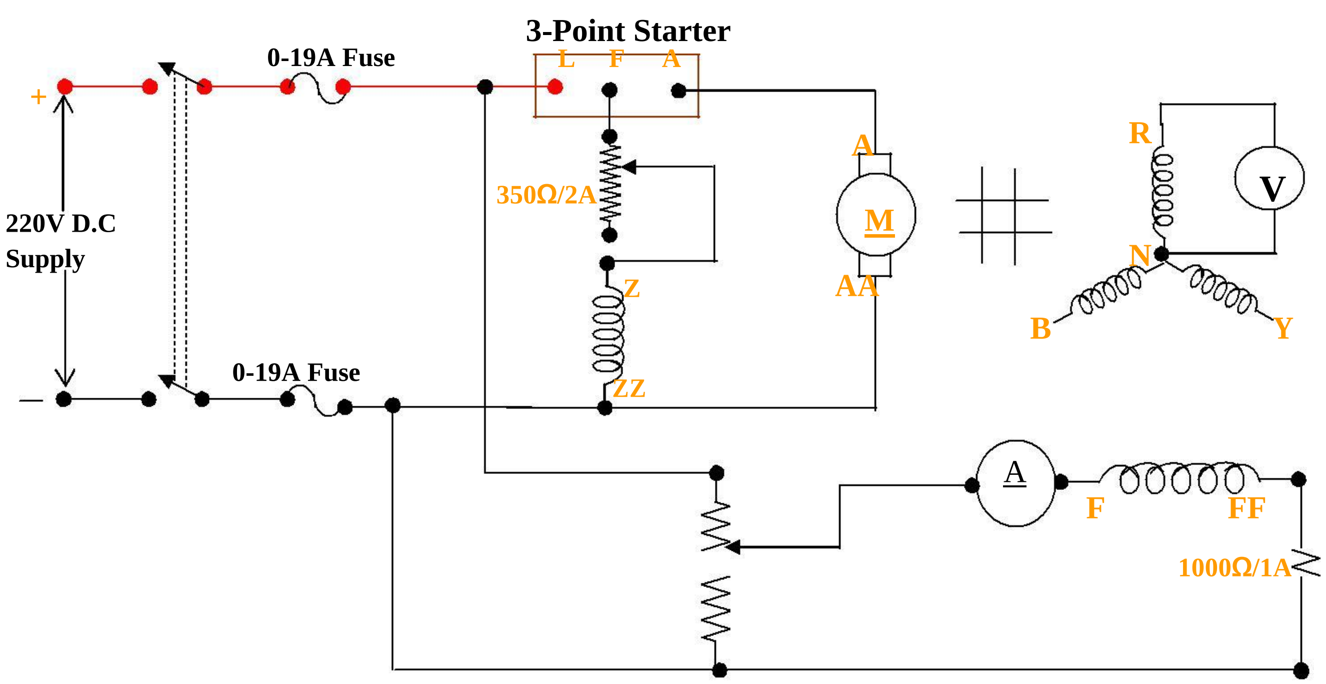
(A) Determination of Positive Sequence Impendence (Z_1):

Conduct open circuit and short circuit tests on the given synchronous machine and evaluate the synchronous impendence at rated excitation. This is positive sequence impendence.

$$Z_1 = \frac{E_0\,(PerPhase)}{I_{SC}}$$

OPEN CIRCUIT(O.C) TEST:

Circuit diagram:



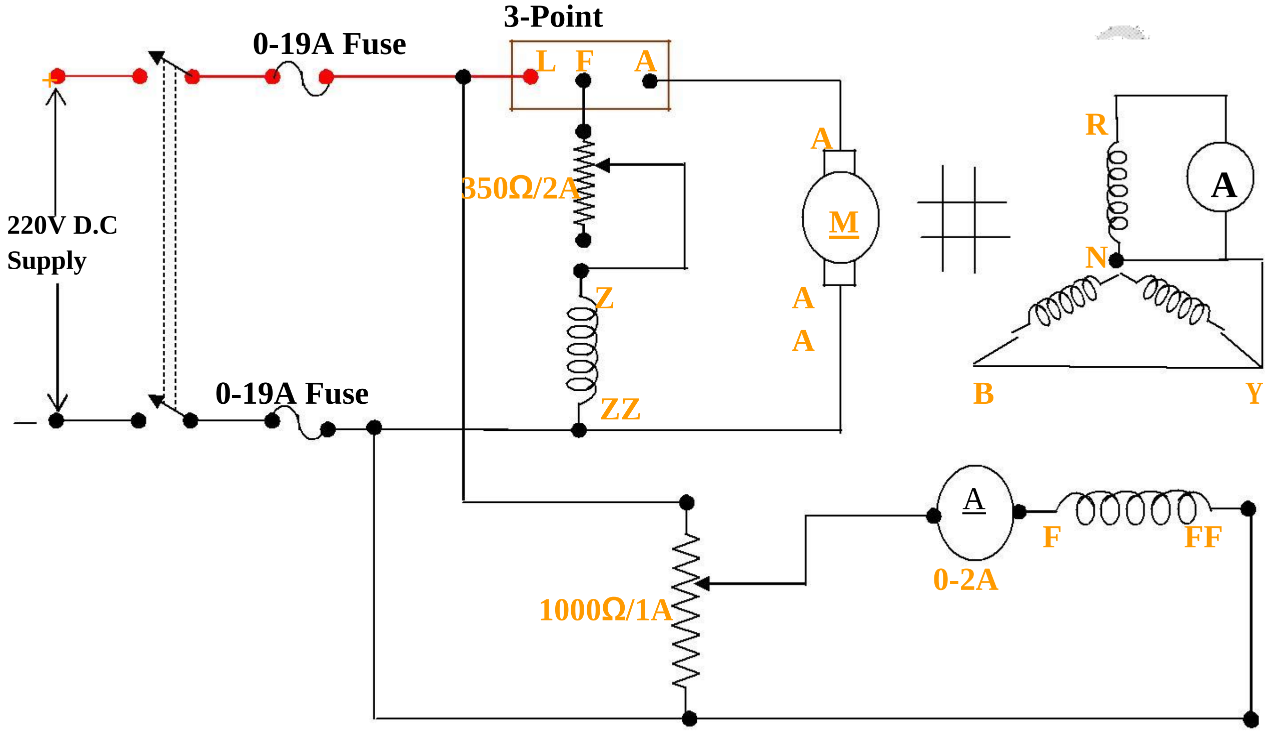
PROCEDURE:

1. Connect the alternator set as shown in the circuit diagram and start the motor and adjust the speed to the rated value.
2. Switch on the DC supply to the field of the alternator.

3. By increasing the excitation gradually note he field current If and generated voltage of the alternator.
4. Record the readings and plot the OCC characteristics as shown in the model graph.

2. **SHORT CIRCUIT(S.C) TEST**:

Circuit diagram:



PROCEDURE:

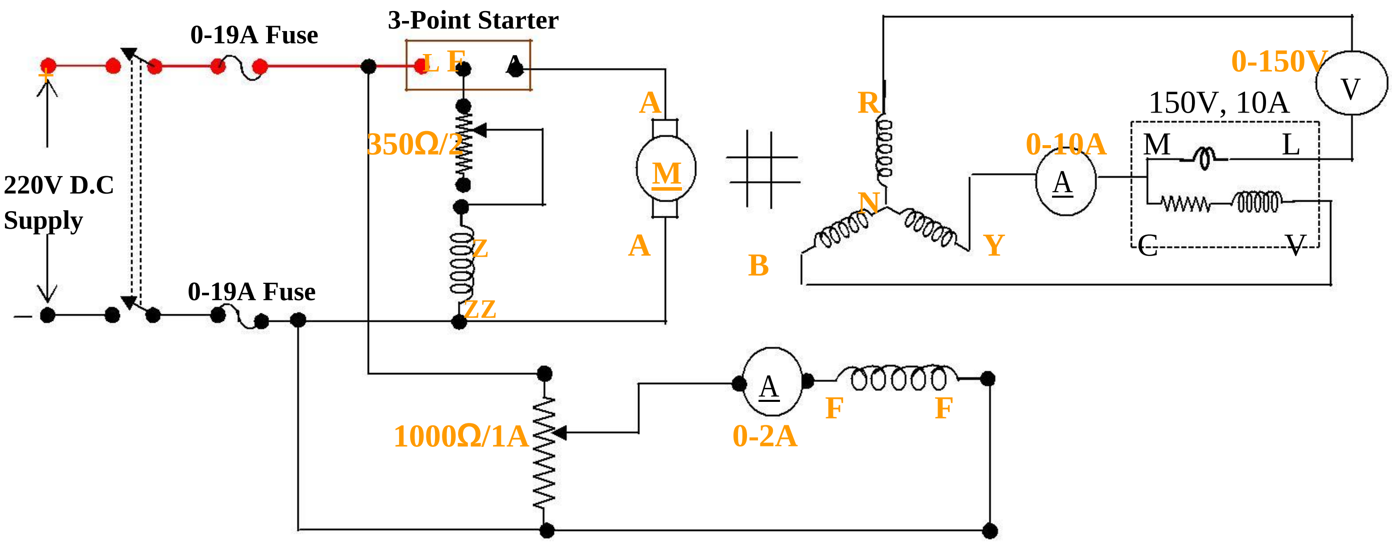
1. Keeping the previous connections unchanged replace voltmeter by ammeter and short the other two phases with neutral as shown in the circuit diagram.
2. Run the alternator set at rated speed and note down the excitation current w.r.t. Short circuit current.
3. Plot the curve field current Vs S.C. current on the same graph drawn for O.C. test.
4. Find the Synchronous impendence graphically from the above characteristics.

OBSERVATION:

O.C.TEST			S.C.TEST		
S.NO	I_F	E	S.NO	I_F	I_{SC}
1.			1.		
2.			2.		
3.			3.		
4.			4.		
5.			5.		
6.					
7.					
8.					
9.					
10.					

MODEL GRAPH:

(B) Determination of negative sequence impedance (Z2)
CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the machine as shown in the circuit diagram.
2. Run the machine at rated speed.
3. Gradually increase the excitation such that the short circuit does not exceed full load value.
4. Take readings of voltage, current and power.

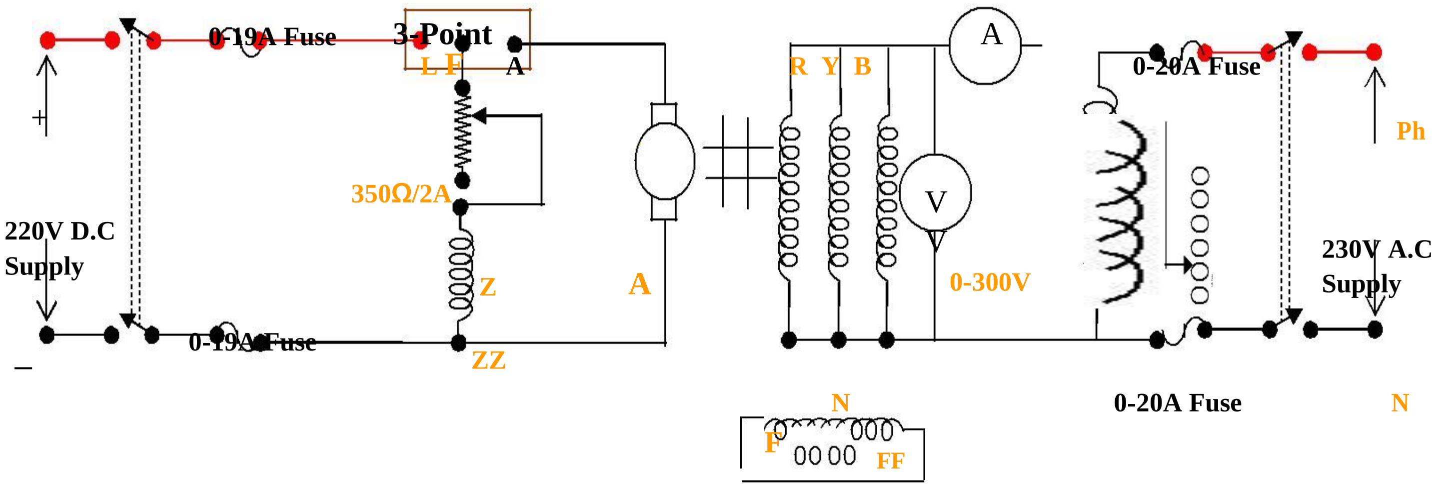
OBSERVATIONS:

S.No	Voltage(v)	Current(A)	Power(W)
1.			

Negative sequence impedance, Z2=V/√3I
Sin = Wm/VI and Negative Sequence reactance, X2
X2=Z2sin∅ =Z2*Wm/VI

(C) Determination of Zero sequence impendence, (Zo):

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the armature windings in parallel as shown in the circuit diagram.
2. Short circuit the alternator field winding.
3. Run the machine at rated speed.
4. Apply rated current to each phase winding which are connected in parallel through a single phase variac.
5. Take readings of voltage and current.

OBSERVATIONS:

S.No	Voltage(v)	Current(A)

EXPERIMENT NO: 05

MICRO CONTROLLER BASED OVER CURRENT RELAY

AIM: To determine the characteristics of given microcontroller based over current relay

APPARATUS:

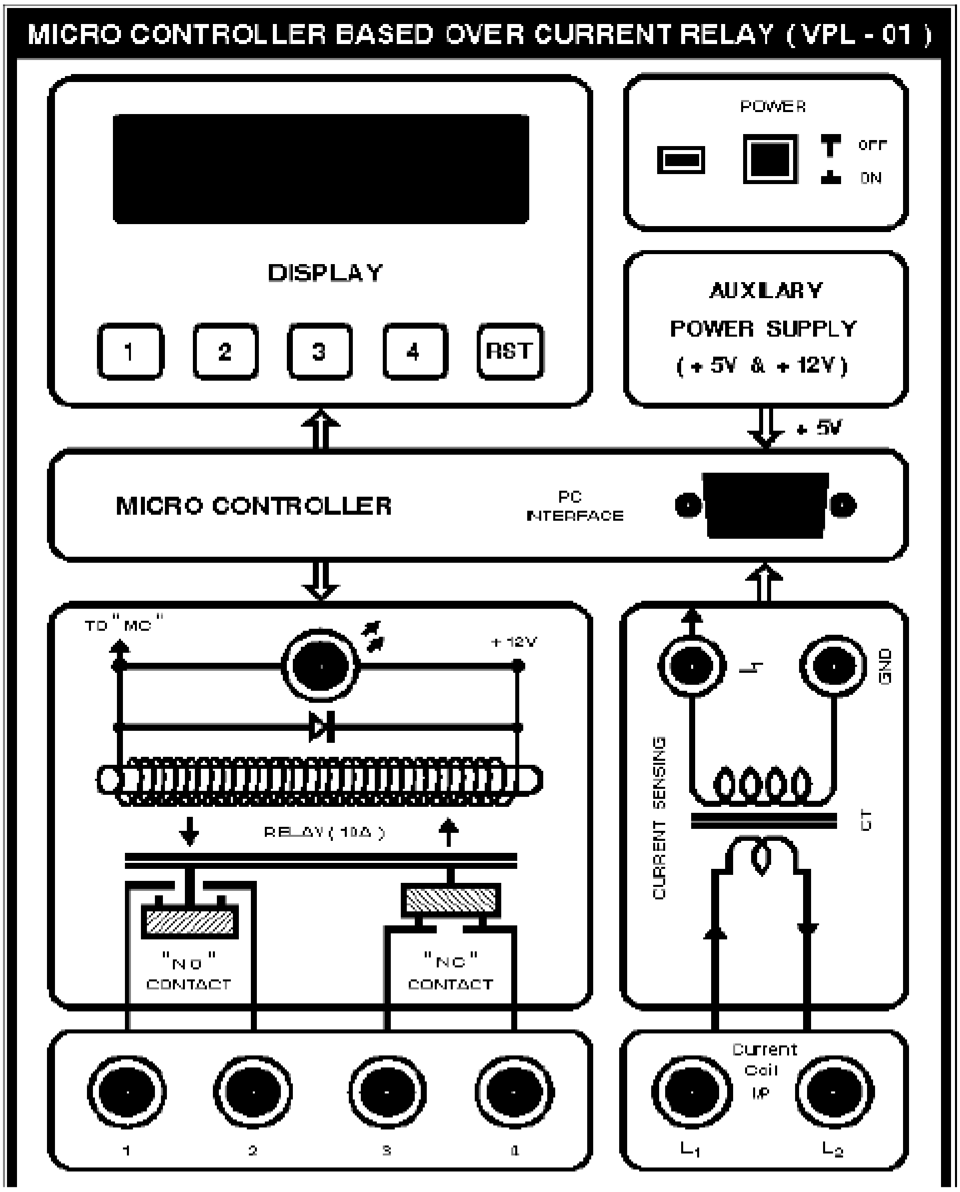
1) Microcontroller based over current relay set up
2) Connecting wires

Theory:

The over current relays are used to sense the fault currents and over-load currents and trips off the system. Micro controller is used for the control operation. The programming is done in such a way that when the fault current value is above the set value the relay is

closed/opened (depends on connection) and it trips the circuit. The tripping of the relay is indicated by the LED. The LCD displays the set time, set current, fault current and

tripping time.



FRONT PANEL VIEW DIAGRAM Of

Microcontroller Based Over Current Relay

Procedure:

1. Current source is connected to across the banana connector L1 & L2 of VPL - 01 module.

2. Power ON the VPL - 01 module (Micro controller based Over Current relay). The LCD display shows the following with a delay of few seconds between each display.

VI MICROSYSTEMS

OVER CURRENT RELAY

SELECT ANY ONE....

1.DMT

2. IDMT

The selection between type of relay should be made by pressing the appropriate buttons in the display. The details of buttons in the display.

1 - Selecting and Incrementing

2 - Selecting and Decrementing

3 - Cursor movement

4 – Enter

RST - Reset the relay system.

The type of operation to be carried out is displayed and is selected by the buttons 1 or 2.

Select buttons :

1. DMT (Definite Minimum Time)

2. IDMT (Inverse Definite Minimum Time)

i. SELECT IDMT

1. IDMT is selected by pressing 2. Then the **set Current (Is)** of the Relay unit is to be Entered. The LCD displays,

Enter Current :00.1A ….(0.1 – 15A)….

Set the Relay reset time by using 1,2 & 3 buttons

Enter TMS = 0.1s (0.1 - 1 Sec)

2. The button 4 is pressed. (All the set values are sent to the processor).

Now the displays shows.

Set current = 00.00A Act current = 00.00A

3. Set the current value by using 1, 2 & 3 buttons

Set current = 00.10A Act current = 00.00A

The Time Multiplier Setting (TMS) value is to be entered. The range of TMS is 0.1 to 2s. This value is entered by pressing 4.

NOTE:

If the fault Current < set Current the LCD displays the Current values by default as

Set current = 00.10A Act current = 00.01A

Now press the RST button. Again set the same values and set the fault Current is above the set Current.

4. If the fault Current > set Current then the LCD displays

Time : 0.1S

The calculate time for relay tripping is obtained from the formula.

$$t = TMS \times \left[\frac{K}{\left(\frac{I}{I_S}\right)^{\alpha} - 1} \right] + C$$

The IDMT used is of normal inverse type. So the values of k, α,C are constant

and are K = 0.14, α = 0.02 and C = 0. I is the fault Current and Is is the set Current of the relay unit.

4. The time starts to increase from 0.1S to until end of the calculated time in sec, then the relay coil is energized and trips the relay contacts. At the same time LED glows. After shows the LCD display.

Relay Tripped...   Due to Over Current

6. Now LCD displays the following message one by one continuously until the relay system is reset and LED is glow.

S.T = 0.10 SC = 00.30   CT = 00.65 TC = 00.80

7. Press the RST button, Reset the processor and Relay tripping action.

ii. SELECT DMT

1. The DMT operation can be selected by pressing 1. The LCD displays the following.

Enter Current :00.1A   …[0.1 – 15 A] …

Set the Relay reset time by using 1,2 & 3 buttons

Enter time = 000S   ….(0 - 300 Sec)….

3. The button 4 is pressed. (All the set values are sent to the processor).

Now the displays shows.

Set curr = 00.00A Act curr = 00.00A

Set the current value by using 1,2 & 3 buttons

Set curr = 00.10A Act curr = 00.00A

3. Press the button 4.

4. The time starts to increase from 00.01S to until the calculated time. After 007S the relay coil is energized and trips the relay contacts. At the same time LED glows. After relay is tripped the LCD displays it as.

Time = 00.01

After the tripping of relay, the following messages are displayed one by one continuously until the system is reset.

Set time = 00.105 SC = 00.60 TC = 1.07

The relay system is reset by pressing RST button.

TABULAR COLUMN:

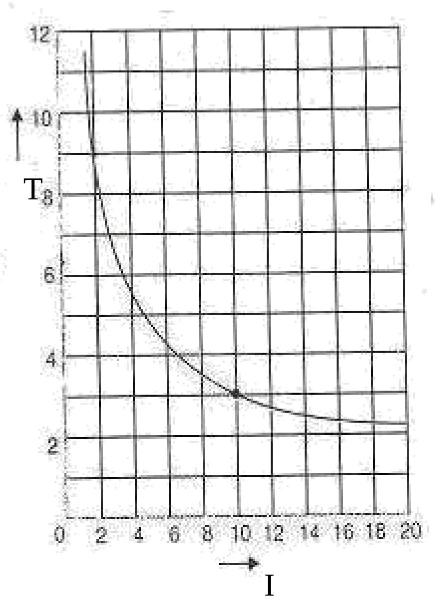
IDMT

S NO	Set Current (A)	Fault Current (A) Trip Current	Time Multiplier Setting(sec) (or)Set Time	Calculated Relay Tripping Time (Sec)	Actual Relay Tripping Time (Sec)

DMT:

S NO	Set Current (A)	Fault Current (A)	Set Time (Sec)	Actual Relay Tripping Time (Sec)

Expected Graph: IDMT



Discussion of Result:

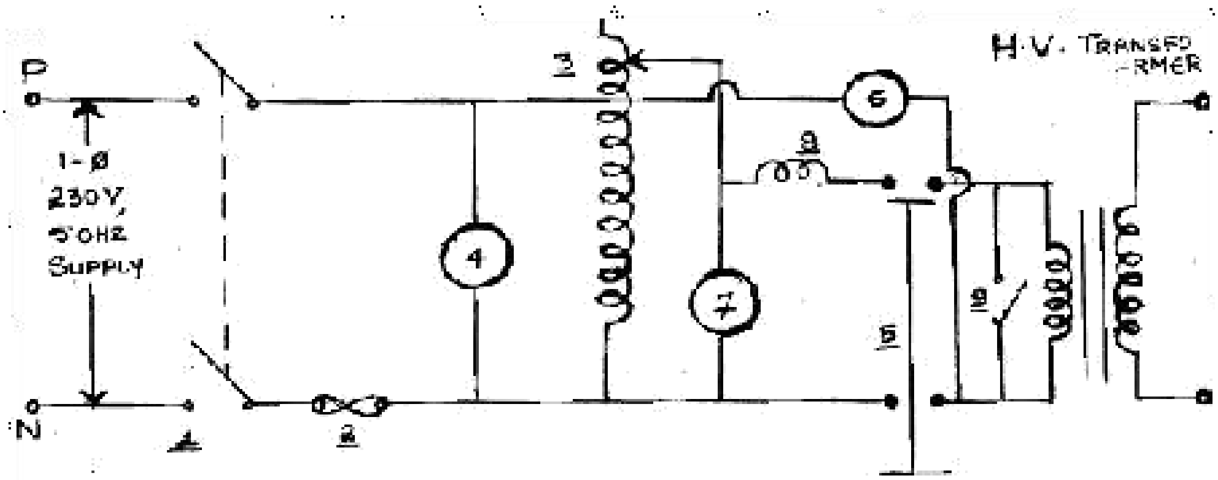
EXPERIMENT NO: 06

Determination of dielectric strength of oils and study of Megger.

AIM: To test the breakdown strength of Transformer oil.

APPARATUS: 1.Transformer oil test kit. 2.
Transformer oil.

CIRCUIT DIAGRAM:



1. Main Switch.
2. Fuse.
3. Voltage Regulator.
4. Mains Indicator.
5. over Load Switch.
6. Trip voltage indicator.
7. Voltmeter.
8. Trip coil.
9. Interlock Switch.

PROCEDURE

When testing oils, the set is operated according to a particular method i.e., with a fixed spark gap and variable testing voltages. The voltage should be increased gradually under continuous observation of the measuring instrument until the break down occurs To test oil of high quality the distance between electrodes should be adjusted to 2.5mm for testing oils of medium quality or inferior quality the gap adjusted to 4mm by means of distance gauge. The oil testing cup is equipped normally with two electrodes of 36mm dia radius of each in 285mm. The oil-testing cup is kept as small as possible to do with minimum quality of oil 400ml suitable safety contacts are provided to put the setout 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 oil tests are possible as long as the lid of the rear of the cabinet is open, the test must be carried out six times on the same cell filing.

The first application of the voltage is made as quickly as possible after cell has been filled, provided there are no longer 'AIR BUBBLES' in the oil and at the latest ten minutes after filling.Aftereach breakdown the oil is gently stirred between the electrodes by means of a clean dry glass rod avoiding as far as possible the production of air bubbles. For the subsequent five tests, the voltage is reapplied one minute after the disappearance of air bubbles is not possible it is necessary to wait five minutes before a new breakdown tests is started. The electric strength shall be the arithmetic mean of the six results, which have been obtained.

OBSERVATIONS

S.NO	*BREAKDOWN VOLTAGE*
1.	
2.	
3.	
4.	
5.	
6.	
	AVERAGE B.V=

RESULTS:

Record in kilovolts the break down voltages obtained during all the six tests have been carried out and the average of such results

Distance between electrodes =2.5mm

Break down voltage for 2.5mm=

Break down voltage for 1cm=

Di-electrical strength of Transformer oil = Avg breakdown voltage/distance between electrodes.

Discussion of Result:

STUDY OF MEGGER

EXPERIMENT NO: 06

Aim : To Test the insulation resistance.

Apparatus : 1) Megger kit

2) Connecting wires..

The Megger test is a method of testing making use of an insulation resistance meter that will help to verify the condition of electrical insulation The test does have a limit of between 500 and 1000 volts, so it may not always be able to detect some insulation punctures It will usually show he amount of moisture,the leakage current the moist or dirty areas of the insulation, and winding faults and deterioration..

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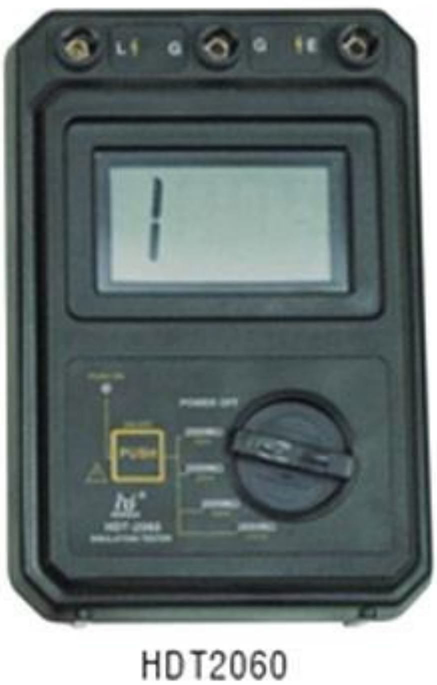

Fig of HDT 2060 (Megger Electronic)

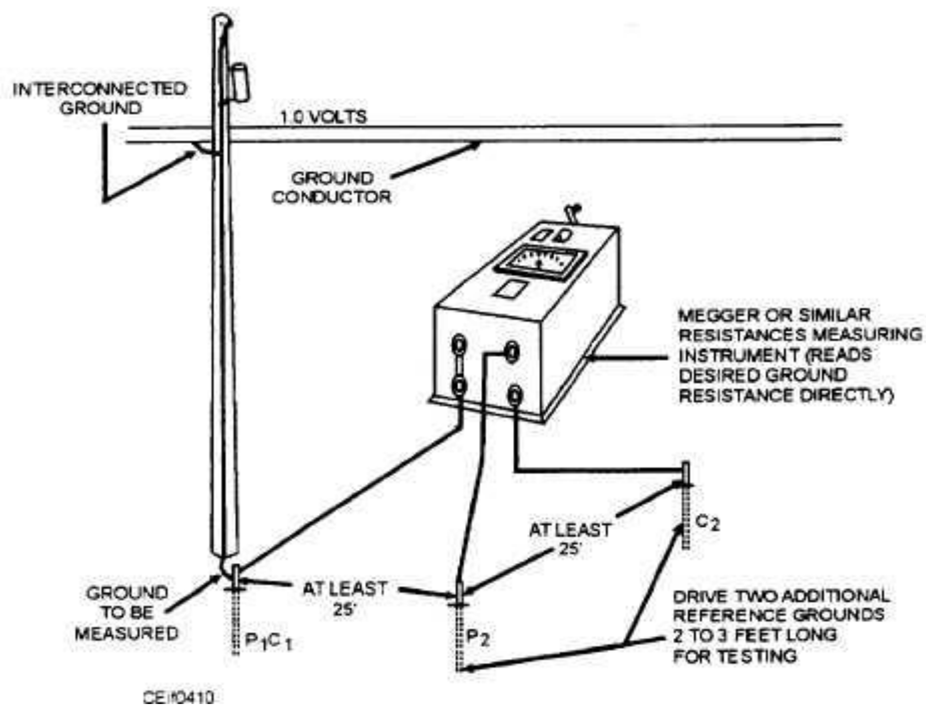

Fig of Megger

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Uses of Megger :

The device enable us to measure electrical leakage in wire, results are very reliable as we shall be passing electric current through device while we are testing. The equipment basically use for verifying the electrical insulation level of any device such as motor, cable, generator winding, etc. This is a very poplar test being carried out since very long back. Not necessary it shows us exact area of electrical puncture but shows the amount of leakage electric current & level of moisture within electrical equipment/winding/system.

The main purpose behind the Megger test is so that you will be able to test for electrical leakage in wires. They are helpful in detecting issues and leakage that other devices, such as the ohm detector, might not. This is because you will actually be running current through the device while you are testing it.

PROCEDURE

1.Firstly ensure that the equipment to be tested and the work area is safe, e.g. equipment is de-energised and disconnected, all the relevant work permits have been approved and all locks / tags in place.

2.Next, discharge capacitances on the equipment (especially for HV equipment) with static discharge sticks or an IR tester with automatic discharging capabilities.

3.The leads on the IR tester can then be connected to the conductive parts of the equipment. For example, for a three-core and earth cable, the IR test would be applied between cores (Core 1 to Core 2, Core 1 to Core 3 and Core 2 to Core 3) and between each core and earth.

4.Similarly for three-phase motors, circuit breakers, switch-disconnectors, etc the IR test can be applied at the equipment terminals (and earth connection).

5.Note that when applying an IR test to earth, it is good practice to connect the positive pole of the IR tester to earth in order to avoid any polarisation effects on the earth.

6.Once connected, the IR tester is energised for a typical test duration of 1 minute. The IR test measurements are recorded after 1 minute.

7.When the IR test is finished, discharge capacitances again for a period of 4-5 times the test duration.

Result:

EXPERIMENT NO: 07

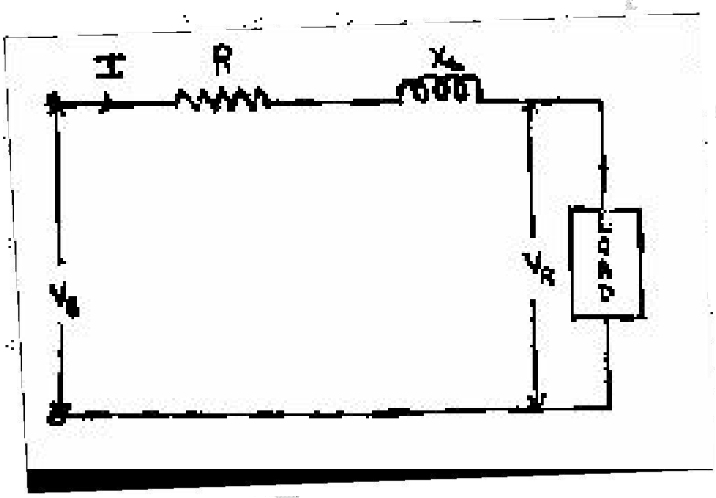
Determination of A,B,C,D constants of short, medium and long lines.

AIM: To determine A,B,C,D constants of transmission lines for R=4 OHMS, L=80mH, C=0.47 MICRO FARAD..

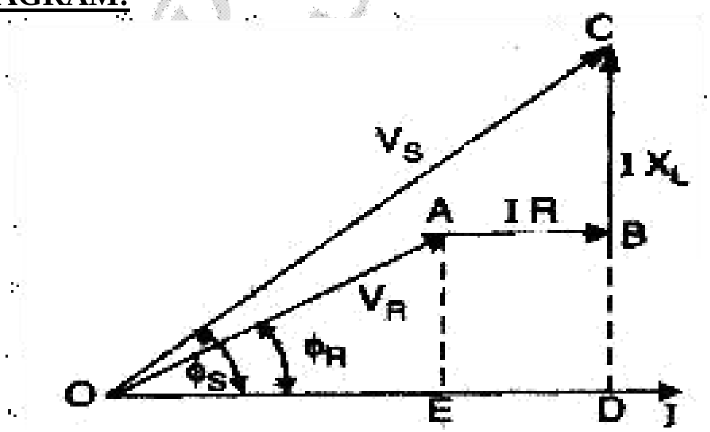
APPARATUS REQUIRED:

1. AC transmission line simulator kit VPST-101A, VPST-101B, VPST-101C, VPST-101D
2. Connector

CIRCUIT DIAGRAM: 1. SHORT TRANSMISSION LINE



PHASOR DIAGRAM:



PROCEDURE:

DETERMINATION OF CONSTANT A.C.

1. Make connections as per circuit diagram.
2. Switch ON all the trainers.
3. Set the input voltage as 30 volts.
4. Microcontroller LCD1 displays V_S, V_R and either I_S or I_R and LCD 2 displays constant A.C.

OBSERVATION TABLE:

S.NO	V_S	V_R	Phase Angle of V_S/V_R	A	C

DETERMINATION OF CONSTANT B, D:

1. Set the input voltage as 5 V and follow the same procedure given for A & C and tabulate the readings.

OBSERVATION TABLE:

S. NO	V_S	I_S	I_R	Phase Angle of V_S/V_R		B	D
				V_S/I_R	V_S/I_S		

THEORITICAL CALCULATIONS:

$A = V_S/V_R \mid I_R=0$

$B = V_S/I_R \mid V_R=0$

$C = I_S/V_R \mid I_R=0$

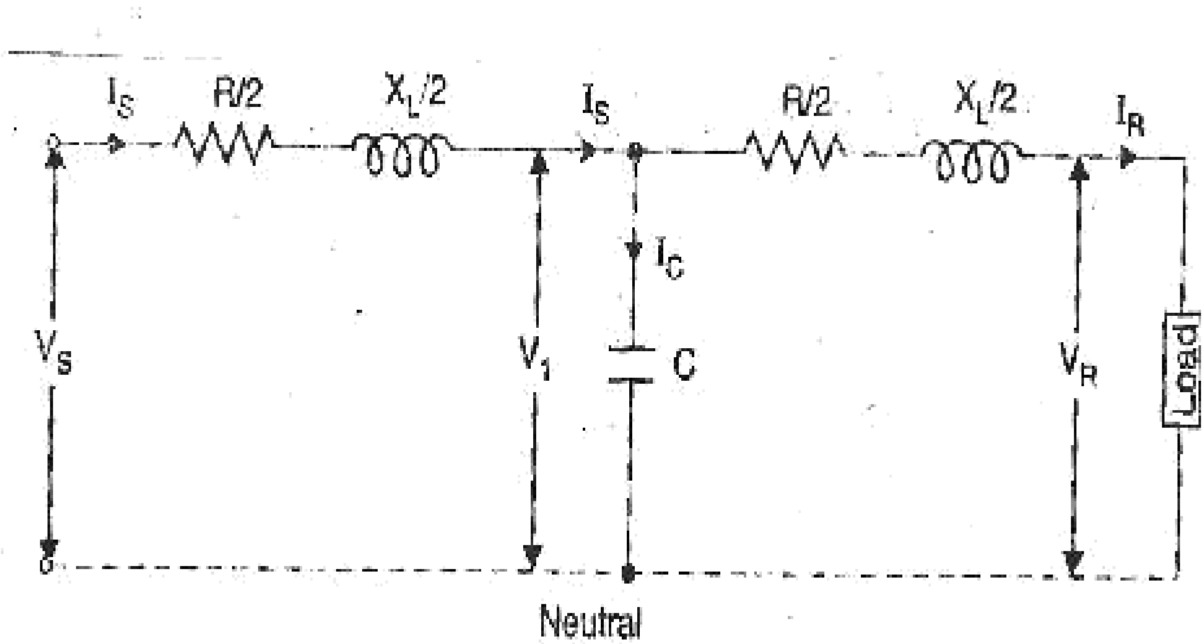
$D = I_S/I_R \mid V_R=0$

1**. SHORT TRANSMISSION LINE:**

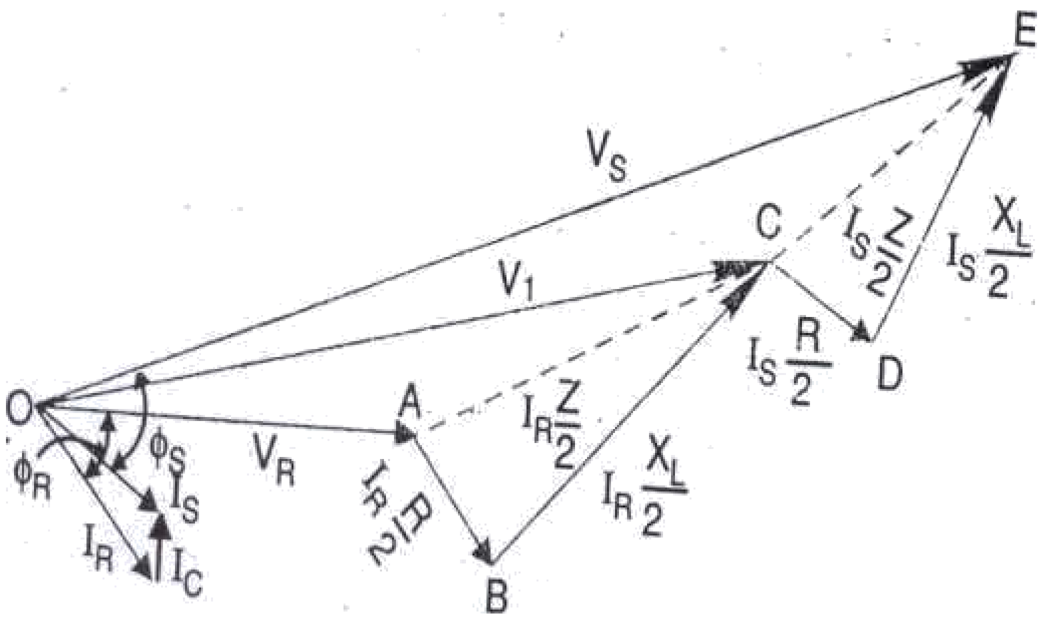
A=1
B=Z
C=0
D=1

CIRCUIT DIAGRAM: 2. **MEDIUM TRANSMISSION LINE**

a) **T – NETWORK:**



PHASOR DIAGRAM



PROCEDURE:

DETERMINATION OF CONSTANTS A & C:

1. Set the input voltage as 40 V and follow the same procedure given for short

S. NO	V_S	I_S	I_R	Phase Angle of V_S/V_R		B	D
				V_S/I_R	V_S/I_S		

2. transmission line and tabulate the readings.

OBSERVATION TABLE:

S. NO	V_S	I_S	I_R	Phase Angle of V_S/V_R		A	C
				V_S/I_R	V_S/I_S		

DETERMINATION OF CONSTANT B,D :

1. Follow the same procedure given for short transmission line and tabulate the readings.

THEORITICAL CALCULATIONS:

A= V_S/V_R | I_R=0

B= V_S/I_R| V_R =0

C= I_S/V_R | I_R=0

D= I_S/I_R | V_R=0

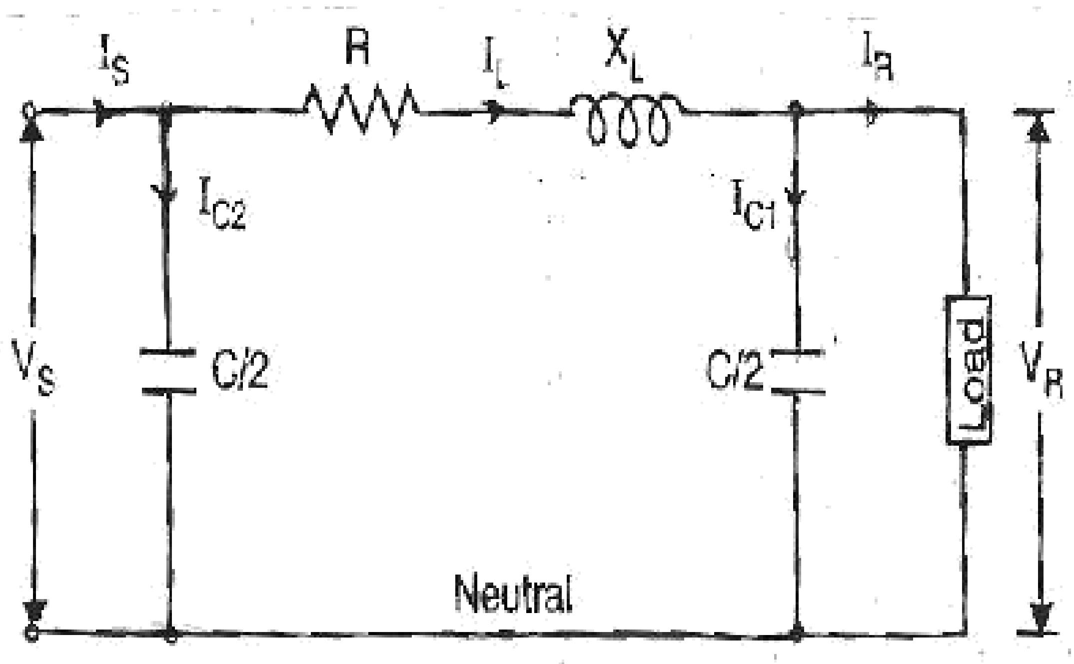
2. **MEDIUM TRANSMISSION LINE:**

a) T – NETWORK:

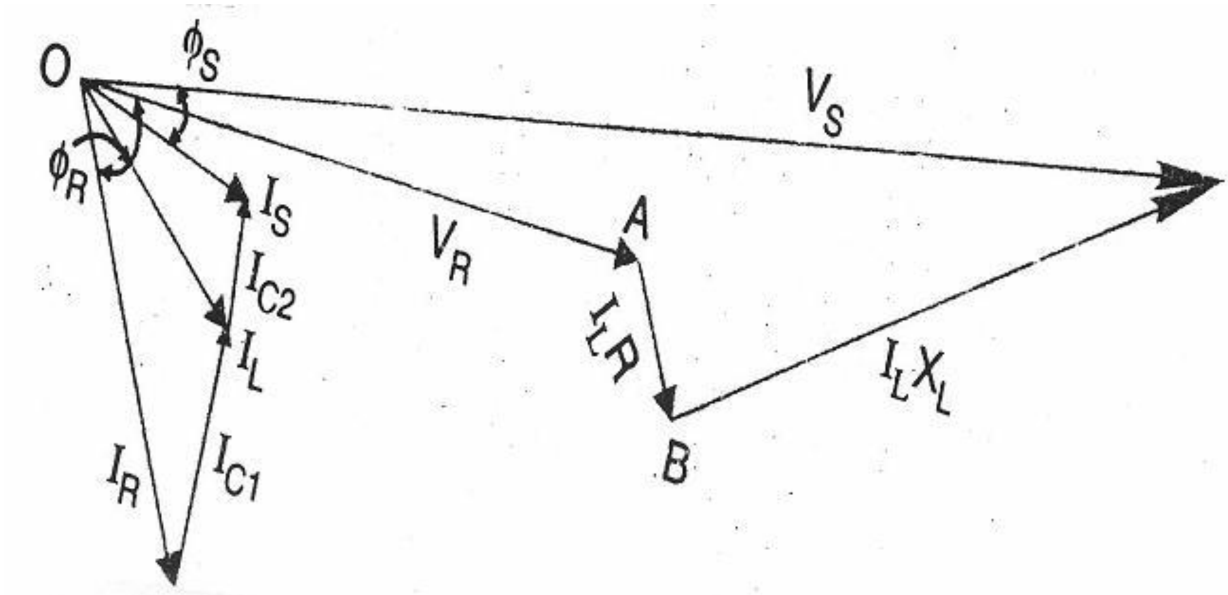
A=1+YZ/2
B=Z (1+YZ/4)
C=Y
D=1+YZ/2

CIRCUIT DIAGRAM: 2. **MEDIUM TRANSMISSION LINE**

b) **– NETWORK**



PHASOR DIAGRAM:



PROCEDURE:

DETERMINATION OF CONSTANTS A & C:

1. Set the input voltage as 40 V and follow the same procedure given for short transmission line and tabulate the readings.

OBSERVATION TABLE:

S. NO	V_S	I_S	I_R	Phase Angle of V_S/V_R		A	C
				V_S/I_R	V_S/I_S		

DETERMINATION OF CONSTANT B,D:

1. Follow the same procedure given for short transmission line and tabulate the readings.

S. NO	V_S	I_S	I_R	Phase Angle of V_S/V_R		B	D
				V_S/I_R	V_S/I_S		

THEORITICAL CALCULATIONS:

$A = V_S/V_R \mid I_R=0$

$B = V_S/I_R \mid V_R = 0$

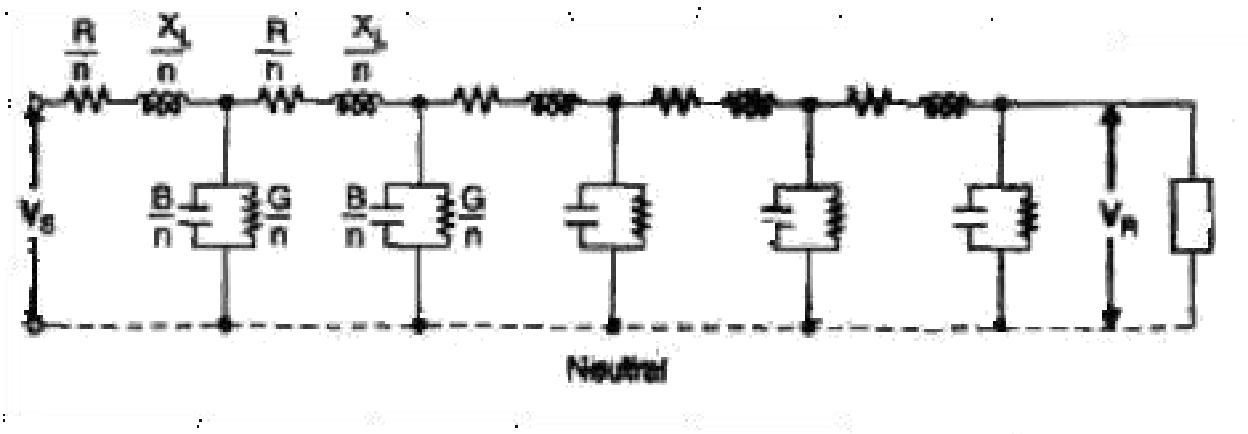
$C = I_S/V_R \mid I_R=0$

$D = I_S/I_R \mid V_R=0$

b) Π – NETWORK:

$A=1+YZ/2$
$B=Z$
$C=Y(1+YZ/4)$
$D=1+YZ/2$

CIRCUIT DIAGRAM: 3**. LONG TRANSMISSION LINE**



PROCEDURE:

DETERMINATION OF CONSTANTS A & C:

OBSERVATION TABLE:

S. NO	V_S	I_S	I_R	Phase Angle of V_S/V_R		A	C
				V_S/I_R	V_S/I_S		

DETERMINATION OF CONSTANT B,D:

S.NO	V_S	I_S	I_R	Phase Angle of V_S/V_R		B	D
				V_S/I_R	V_S/I_S		

THEORITICAL CALCULATIONS:

$A = V_S/V_R \mid I_R=0$

$B = V_S/I_R \mid V_R=0$

$C = I_S/V_R \mid I_R=0$

$D = I_S/I_R \mid V_R=0$

3**. LONG TRANSMISSION LINE:**

$A = \cosh\sqrt{YZ}$

$B = \sqrt{Z/Y}\,\sinh\sqrt{YZ}$

$C = \sqrt{Y/Z}\,\sinh\sqrt{YZ}$

$D = \cosh\sqrt{YZ}$

Result:

Discussion of Results: Students will find line constants for short,medium &long lines &determine whether the lines are symmetrical &unsymmetrical.

EXPERIMENT NO: 08

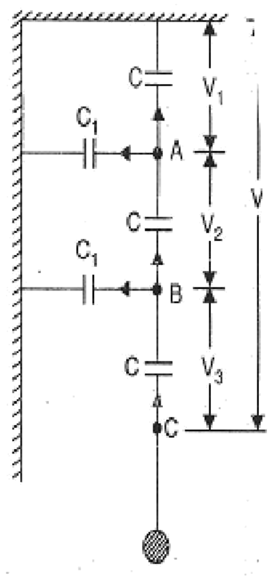
SIMULATION OF STRING INSULATORS FOR DETERMINATION OF VOLTAGE DISTRIBUTION AND STRING EFFICIENCY

AIM: To determine voltage distribution and the string efficiency of suspension insulator with and without guard ring.

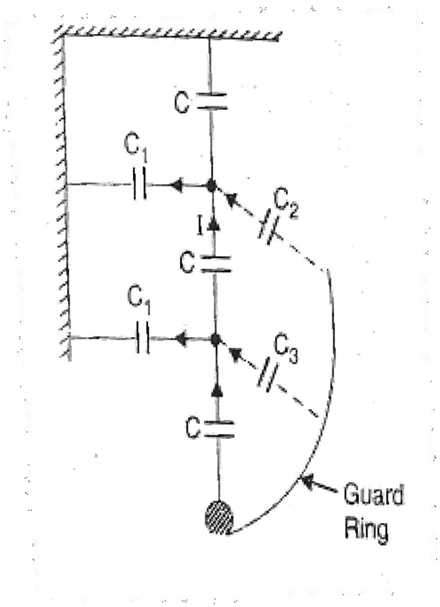
APPRATUS: Experiment board, variac, multimeter.
Capacitors - 0.1μf - 2 no
0.22μf- 2 no
1μf -3 no
Connecting wires

CIRCUIT DIAGRAM:

WITH OUT GUARDRING:



WITH GUARD RING



THEORTICAL CALUCTIONS:

WITH OUT GUARD RING

$V_1 = V / (1+k)(3+k)$; $V_2 = V1(1+K)$; $V_3 = V1\ (1+3K+K^2)$ where k C_1/C

WITH GUARD RING

$V_3 = 12.2V_1 - 11V_2$
$V_3 = 0.22/1.1V_1 + 1.22/1.1V_2$

FROM EQUATION NO (1) & (2). FIND V_2 &V_3 in terms of V_1

String efficiency = $V/3*V_3$

TABULAR COLUMN:

WITH OUT GUARD RING

V	V_1	V_2	V_3	V_4	V_5

WITH GUARD RING

V	V_1	V_2	V_3	V_4	V_5	V_6	V_7

Formulae used: string efficiency = voltage across the string n *voltage across unit near the power conductor
Where n = number of units in a series string.

THEORY:

PROCEDURE:

1. connect the circuit as shown in the diagram
2. Apply voltage less than 100v across the series string
3. measure the voltage cross each string
4. calculate the string efficiency with out guard ring
5. repeat the procedure 1 to 4 with guard ring
6. verify the result theoretically

RESULT:

	Practical Efficiency	Theoretical Efficiency
String efficiency with guard ring		
String efficiency without guard ring		

Discussion of Result: Students will analyze how the voltage distribution is equalized across each string by guard ring & means of which string efficiency is improved.

EXPERIMENT NO: 09

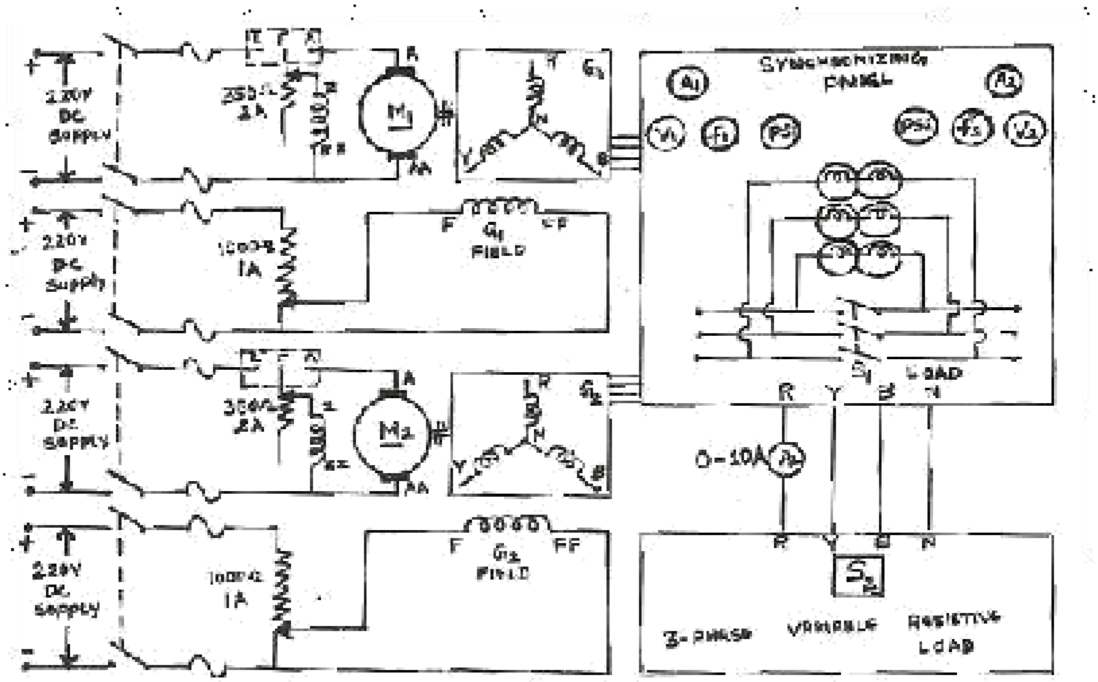
PARALLEL OPERATION OF ALTERNATORS

AIM: To Operate two alternators in parallel and determine load sharing.

APPARATUS:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1.	Voltmeter	MI	0-600V	1 No.
2.	Ammeter	MI	0-10A	1 No.
3.	Rheostats		350 Ω,2A	2 No.
4.	Rheostats		350 Ω,2A	2 No.
5.	Tacho meter		0-5000 rpm	1 No.
6.	Connecting Wires		3/20,10/20	20Pieces

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the circuit as shown in circuit diagram. Ensure that all the switches are open at the time of starting .Keep motor field rheostats at minimum resistance position and generators field rheostats at maximum resistance position or minimum potential position.
2. Run the prime mover of the machine G_1 and bring it up to the generator rated speed.
3. Energize the field circuit of G_1 and adjust the field current to such a value that rated voltage is obtained across its terminals.

4. Run the prime mover of the machine G_2 which is to be synchronized with G1.Adjust the motor speed equal to the rated speed of G_2.
5. Energize the field circuit of G_2 and adjust the field current to obtained rated voltage across its armature terminals.
6. Set the phase sequence of the running and incoming machines, if these are not same, change the phase sequence of the incoming machine G_2
7. Check and adjust the frequency of the incoming machine G2 to be very nearly equal to that of the G_1, by adjusting speed of G_2.
8. If steps 6, 7 have been carried out properly, the lamps will become dark and bright in a cyclic manner. If the lamps flicker at a fast rate readjust the frequency of the incoming machine.
9. At the exact instant of synchronism i.e. all lamps completely dark, close switch S_1.G_2 now will run in parallel with G_1.
10. Close the switch S_2; increase the three phase resistive load in gradual steps and at the same time note down the readings of I_1, I_2& I_L

SWITCH OFF PROCEDURE

1. Reduce the load, switch off S_2.
2. Switch off S_1.
3. Reduce the excitations of G_1 and G_2.
4. Switch off DC motors.

TABULAR COLUMN:

SI.No	I_1	I_2	I_L^*
1.			
2.			
3.			
4.			
5.			

.

$*I_L=I_1+I_2$

Result:

Discussion of Result: Students can explain how the load sharing will be done between two Alternators(Isolated)

EXPERIMENT NO: 10

Differential protection of Transformer

AIM: To study the differential protection of a two winding Transformer.

Apparatus required :

1) Differential Relay - Type MIB202

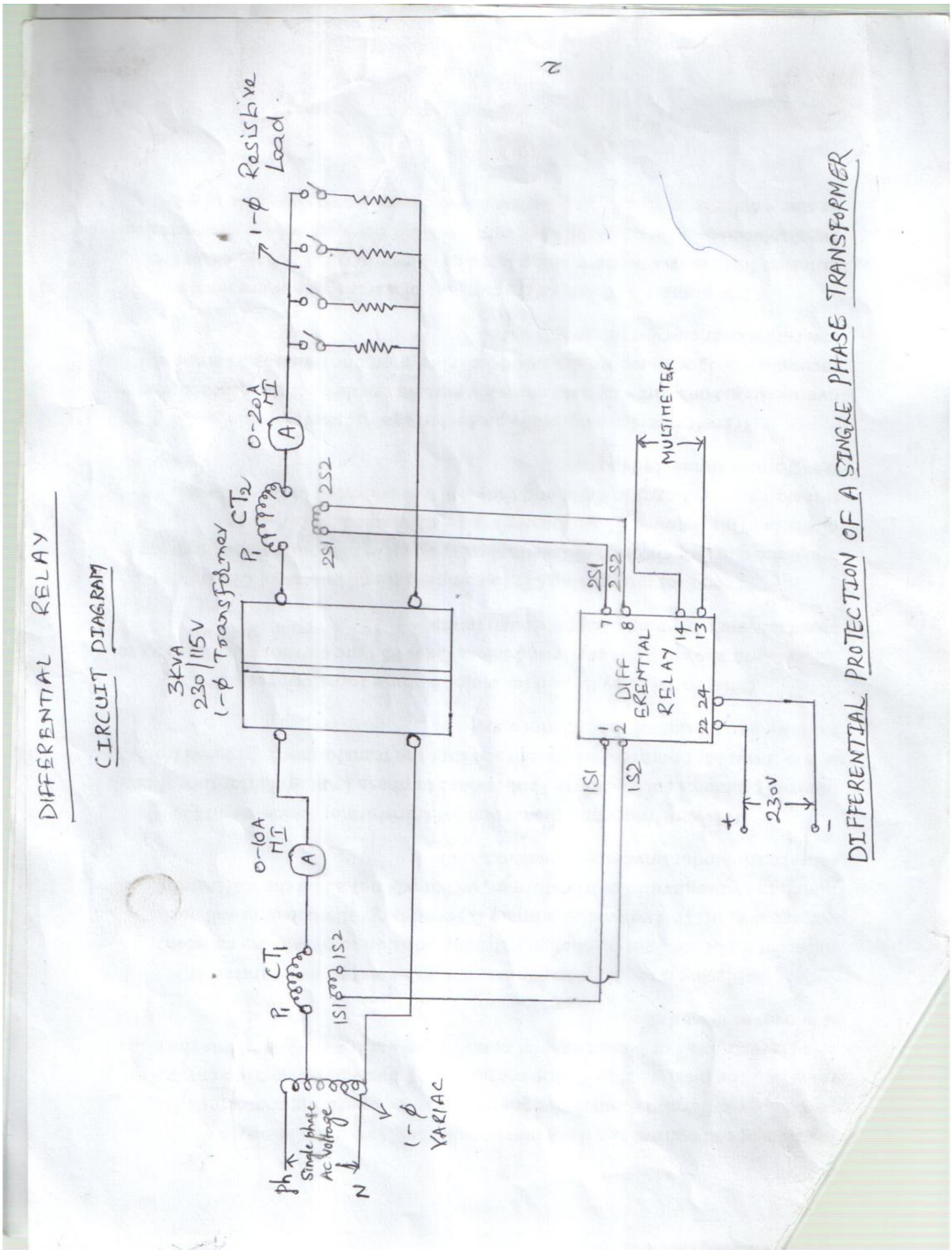
2) Single phase transformer

3) Single phase Variac

4) Ammeters 0 – 10A, 0 – 20A

5) Current Transformers 10/5 – 2Nos

6) Connecting wires.



Circuit Diagram:

THEORY: The differential relay is one that operates when the vector difference of two or more similar electrical quantities exceed a pre – determined value. This means for a differential relay it should have two or more similar electrical quantities and these quantities should have phase displacement for the operating of the relay. The name is not due to particular construction of the relay but is due to the way in which the relay is connected in the circuit.

The percentage differential protection relay consists of an Operating coil and a Restraining coil. The operating coil is connected to the midpoint of the restraining coil. Normally

no current flows through the operating coil under normal conditions. The operating coil under through fault condition, but to the dissimilarities in C-T's. The differential current through the operating coil is (I1-I2) and equivalent developed by the operating coil is proportional to the ampere turns. i.e., TO (I1-i2) NR where NR is number of turns in the restraining coil at balance, (I1-I2) No=1/2(I1-I2) NR

From the above characteristics it is clear that expect of control spring at low currents, the ratio of the differential operating coil current to the average restraining coil current is a fixed percentage that is why it is known as percentage differential, since the relay has a using operating characteristics relay i.e., The pickup value T's the magnitude of through current increases. The relay is restrained or biased against operating in accurately due to this the relay is known as biased relay.

Biasing is required to allow the transformer to be operated at different input voltages by changing the tap position to obtain the constant voltage output. This will make primary & secondary ratio currents will not match the voltage ratio of transformer, which will not allow the differential relay to trip under unwanted condition.

It is very important protection for transformer which identifies internal problems such as Earth Fault, phase to phase fault and inter turn short. When this relay operates; we should see that the transformer is isolated from both HV and LV side of the transformer.

Differential relay is used for major 3 phase transformers such as 10MVA and above as it is costly and needs Class PS type current transformers to avoid nuisance tripping due to through faults.

It requires interposing CTs to compensate mismatch of CTs and to make the currents through differential relay equal in magnitude and opposite in direction. This requires CT secondary's to be connected in star when transformer winding is in delta and they will be connected in Delta for the transformer connected in star.

Transformers are normally protected against short – circuits and overheating. For short – circuits normally percentage differential protection is recommended for transformers rated for more than one mega volts amps, for low rating over current relaying is used.

The primary and secondary currents of a transformer are normally different from each other are and related by their turn's ratio. These currents are displaced by in phase from each other by 30 if the winding are connected in as star – delta connection. The current transformers on the star side of the power transformer are connected in delta, and as delta side. They are connected in star as the current of the star – delta power transformer will be displaced in phase by 30 it is required that this phase displacement must be nullified by connecting the current transformer in that fashion.

In this experiment, the MIB202 is micro-controller based Numerical Biased Differential Protection Relay within build Current Amplitude and Vector Group Compensation features and also with Instantaneous Differential High set Element for two winding Power Transformer and Auto Transformers.

MIB202 relay, which can be used to operate for internal faults, like phase to phase, phase to earth and inter turn faults in the Transformers. The same relay, we can use for 1A or 5A CT input on both LV & HV side. The relay has supervisory components and self – monitoring features give high confidence of serviceability.

Procedure:

1) Connect the circuit as per the circuit diagram.
2) Apply the rated voltage of 230 V using variac to primary transformer.
3) Note down the readings & then switch 'ON ' the load at various steps until the relay "Trips" & then note down the readings of Transformer Currents & CT Currents.
4) Repeat the same procedure for same biasing & change the CT terminals.

Tabular Column :

V=220 V Biasing 10%

CT—15 CT—10

I_1	I_2	CT_1	CT_2

Repeat the tabular column for various values of CT terminals.

Result:

Discussion of Result: