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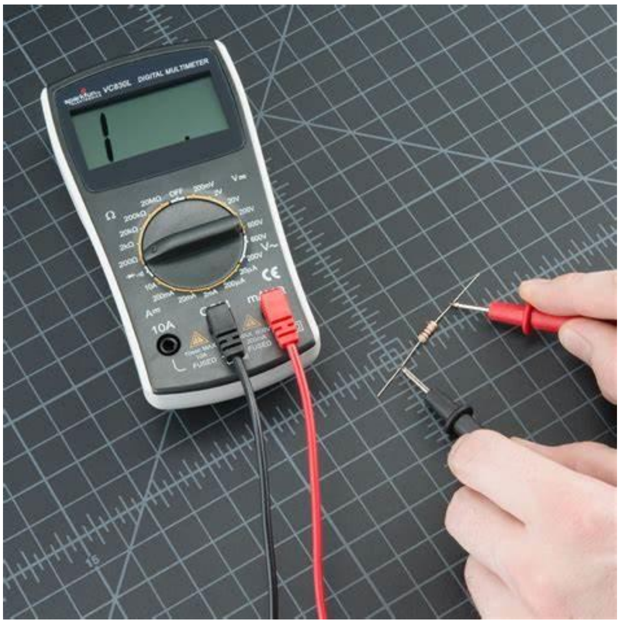
Department of Electrical Engineering

LABORATORY MANUAL



Basic Electrical & Electronics Engineering Lab (ELE----)

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Department of Electrical Engineering

VISION

The Department aims to serve as a platform for the growth and transfer of technical competence to endeavor academics, entrepreneurship, and strategic judgments in local and global spheres in order to satisfy the altering demands of society.

MISSION

1. To create technocrat in the fields of Electrical Engineering to develop them into qualified, ambitious professionals with expertise.
2. Working to develop aspiring minds into more competitive, motivated professionals with concrete theoretical and practical skills.
3. To encourage Bi- lateral influences (industry-institute and institute-institute connections) for the long-term growth in educational, research, training, and employment opportunities.
4. To teach students how to formulate, analyze and solve problems in real life by using their computational and analytical skills.
5. To create excellence in strategic areas to foster an innovative and creative mindset among stakeholder.

Programme Educational Objectives (PEOs)

1. To have a solid understanding of the fundamental principles of Electrical Engineering in order to pursue higher education, a successful career as an entrepreneur or both.
2. To foster an ethically responsible, logical approach towards rapidly changing technologies. Harvest the knowledge by analyzing complicated, real-world issues that are sustainable from a technological, economic, and social perspective.
3. To develop technologically commercially savvy abilities for cutting-edge approaches in Electrical Engineering (or similar fields). Show leadership and teamwork while collaborating with various interdisciplinary and multidisciplinary groups.
4. To engage in ongoing learning in the appropriate field in order to fulfil societal issues on a global scale.
5. Through instruction, group activities, and self-study, demonstrate persistent learning and adaptation to recent technology engineering tools, techniques, and practices. Be ethically responsible and devoted to the objectives for welfare of Human kind.

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PROGRAM OUTCOMES

Engineering Graduates will be able to:

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

2 **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.

3 **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.

4 **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.

5 **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.

6 **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.

7 **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.

8 **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10 **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.

11 **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.

12 **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.

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PROGRAM SPECIFIC OUTCOMES (PSO)

1. To comprehend power systems, electrical energy usage, and energy conservation, and to identify the best solution.

2. Making use of latest pedagogical tools and techniques to create original solutions in order to meet the challenges in electrical engineering and related fields.

COURSE OUTCOMES

After successfully studying this course, students will:

1. Explain the concept of circuit laws and network theorems and apply them to laboratory measurements.
2. Be able to systematically obtain the equations that characterize the performance of an electric circuit as well as solving both DC Machines and single phase transformer.
3. Acknowledge the principles of operation and the main features of electric machines and their applications.
4. Acquire skills in using electrical measuring devices.

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DAV UNIVERSITY, JALANDHAR

I Year B.Tech

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INSTRUCTIONS TO STUDENTS

- Before entering the lab the student should carry the following things.
    - Identity card issued by the University.
    - Class notes
    - Lab Manual.
- Come to the laboratory in time. Students, who are late more than 15 min., will not be allowed to attend the lab.
- Students need to maintain 100% attendance in lab if not a strict action will be taken.
- All students must follow a Dress Code while in the laboratory
- Foods, drinks are NOT allowed.
- All bags must be left at the indicated place.
- The objective of the laboratory is learning. The experiments are designed to illustrate phenomena in different areas of Physics and to expose you to measuring instruments, conduct the experiments with interest and an attitude of learning
- You need to come well prepared for the experiment.
- Work quietly and carefully.
- Be honest in recording and representing your data.
- If a particular reading appears wrong repeat the measurement carefully, to get a better fit for a graph
- All presentations of data, tables and graphs calculations should be neatly and carefully done
- Graphs should be neatly drawn with pencil. Always label graphs and the axes and display units.
- If you finish early, spend the remaining time to complete the calculations and drawing graphs. Come equipped with calculator, scales, pencils etc.
- Do not fiddle with apparatus. Handle instruments with care. Report any breakage to the Instructor. Return all the equipment you have signed out for the purpose of your experiment.

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SPECIFIC SAFETY RULES FOR BEE LABORATORY

- You must not damage or tamper with the equipment or leads.

- You should inspect laboratory equipment for visible damage before using it. If there is a problem with a piece of equipment, report it to the technician or lecturer. DONOT return equipment to a storage area
- You should not work on circuits where the supply voltage exceeds 40 volts without very specific approval from your lab supervisor. If you need to work on such circuits, you should contact your supervisor for approval and instruction on how to do this safely before commencing the work.
- Always use an appropriate stand for holding your soldering iron.
- Turn off your soldering iron if it is unlikely to be used for more than 10 minutes.
- Never leave a hot soldering iron unattended.
- Never touch a soldering iron element or bit unless the iron has been disconnected from the mains and has had adequate time to cool down.
- Never strip insulation from a wire with your teeth or a knife, always use an appropriate wire stripping tool.
- Shield wire with your hands when cutting it with a pliers to prevent bits of wire flying about the bench.

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CONTENTS

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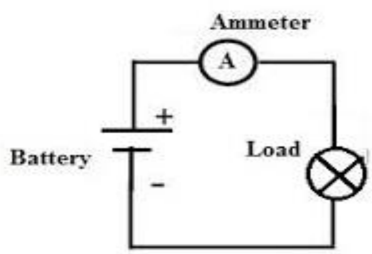
Experiment No. - 1

AIM : - Basic safety precautions. Introduction and use of measuring instruments -Ammeter, Voltmeter, Wattmeter, Multimeter.

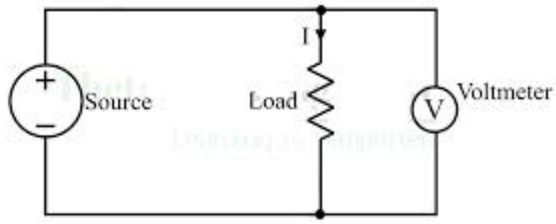
APPARATUS REQUIRED: - Ammeter, Voltmeter, Wattmeter and Multimeter.

THEORY:-

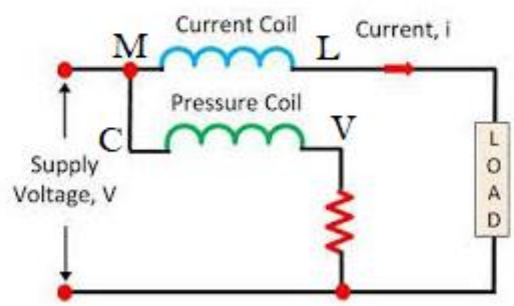
AMMETER: - An ammeter is a measuring instrument used to measure the electric current in a circuit. Electric currents are measured in amperes (A), hence the name. Smaller values of current can be measured using a milliammeter or a microammeter. Early ammeters were laboratory instruments only which relied on the Earth's magnetic field for operation. By the late 19th century, improved instruments were designed which could be mounted in any position and allowed accurate measurements in electric power systems.



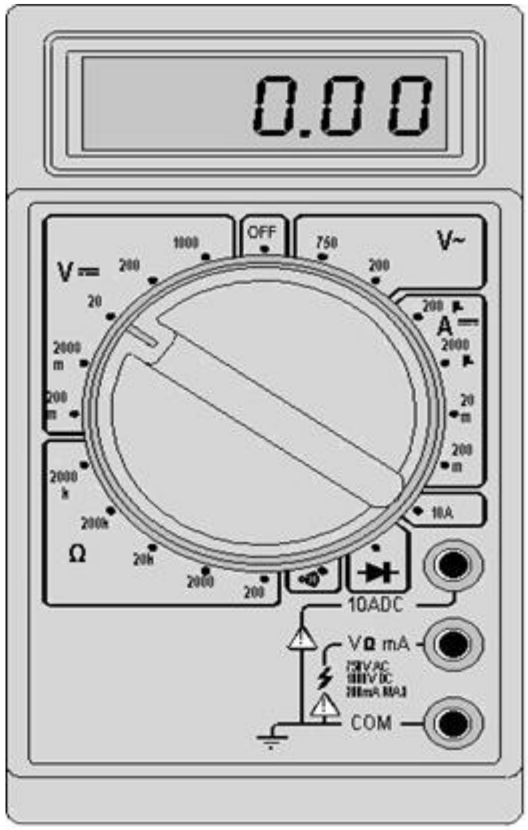
Voltmeter: - A voltmeter is an instrument used for measuring the electrical potential difference between two points in an electric circuit. Analog voltmeters move a pointer across a scale in proportion to the voltage of the circuit; digital voltmeters give a numerical display of voltage by use of an analog to digital converter. Voltmeters are made in a wide range of styles. Instruments permanently mounted in a panel are used to monitor generators or other fixed apparatus. Portable instruments, usually equipped to also measure current and resistance in the form of a multimeter, are standard test instruments used in electrical and electronics work. Any measurement that can be converted to a voltage can be displayed on a meter that is suitably calibrated; for example, pressure, temperature, flow or level in a chemical process plant. General purpose analog voltmeters may have an accuracy of a few per cent of full scale, and are used with voltages from a fraction of a volt to several thousand volts. Digital meters can be made with high accuracy, typically better than 1%. Specially calibrated test instruments have higher accuracies, with laboratory instruments capable of measuring to accuracies of a few parts per million. Meters using amplifiers can Measure tiny voltages of micro volts or less. Part of the problem of making an accurate voltmeter is that of calibration to check its accuracy. In laboratories, the Weston Cell is used as a standard voltage for precision work. Precision voltage references are available based on electronic circuits.

Wattmeter: - The wattmeter is an instrument for measuring the electric power (or the supply rate of electrical energy) in watts of any given circuit. An instrument which measures electrical energy in watt hours (electricity meter or energy analyzer) is essentially a wattmeter which accumulates or averages readings; many such instruments measure and can display many parameters and can be used where a wattmeter is needed: volts, current, in amperes, apparent instantaneous power, actual power, power factor, energy in KWh over a period of time, and cost of electricity consumed.

Multimeter: - A multimeter or a multitester, also known as a VOM (Volt-Ohm meter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter may include features such as the ability to measure voltage, current and resistance. Multimeters may use analog or digital circuits—analog multimeters (AMM) and digital multimeters (often abbreviated DMM or DVOM.) Analog instruments are usually based on a microammeter whose pointer moves over a scale calibrated for all the different measurements that can be made; digital instruments usually display digits, but may display a bar of a length proportional to the quantity being measured. A multimeter can be a hand-held device useful for basic fault finding and field service work or a bench instrument which can measure to a very high degree of accuracy. They can be used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment, motor controls, domestic appliances, power supplies, and wiring systems.



PROCEDURE: - 1. We use always voltmeter, ammeter, wattmeter and multimeter the purpose of various experiment.

PRECAUTION: - Always use all meters carefully.

RESULT: - We have study various types of meters

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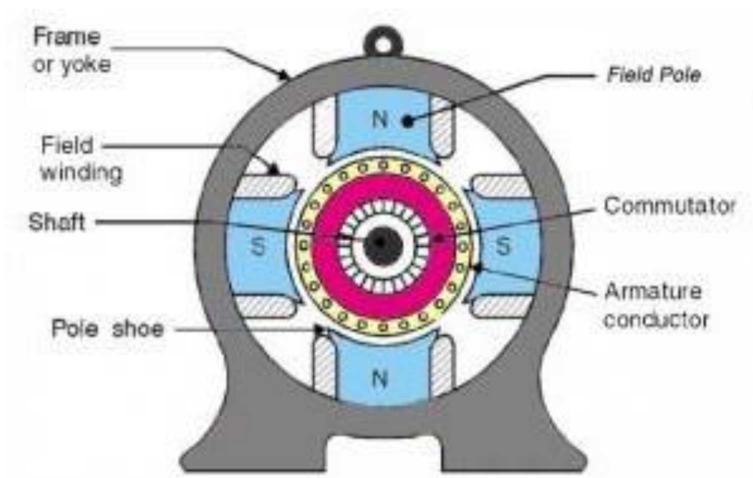
Experiment No. - 2

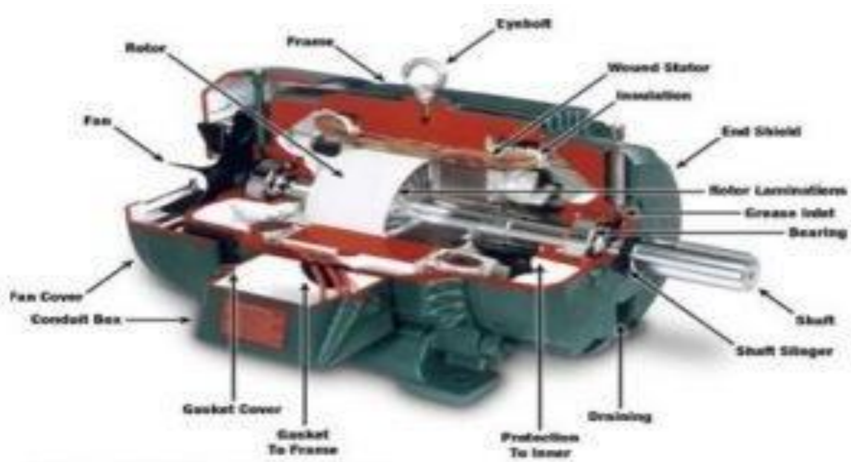
AIM:- To study the constructional details of direct current (DC) machine.

APPARATUS REQUIRED: -

S.No.	Apparatus Required	Specifications	Quantity
1.	DC Machine	Four pole section	1

Diagram:





Constructional Detail:

Yoke

Another name of a yoke is the frame. The main function of the yoke in the machine is to offer mechanical support intended for poles and protects the entire machine from moisture, dust, etc. The materials used in the yoke are designed with cast iron, cast steel otherwise rolled steel.

Pole and Pole Core

The pole of the DC machine is an electromagnet and the field winding is winding among pole. Whenever field winding is energized then the pole gives magnetic flux. The materials used for this are cast steel, cast iron otherwise pole core. It can be built with the annealed steel laminations for reducing the power drop because of the eddy currents.

Pol Shoes

Pole shoe in the DC machine is an extensive part as well as to enlarge the region of the pole. Because of this region, flux can be spread out within the air-gap as well as extra flux can be passed through the air space toward armature. The materials used to build pole shoe is cast iron otherwise cast steed, and also used annealed steel lamination to reduce the loss of power because of eddy currents.

Field Windings

In this, the windings are wounded in the region of pole core & named as field coil. Whenever current is supplied through field winding than it electromagnetics the poles which generate required flux. The material used for field windings is copper.

Armature Core

Armature core includes a huge number of slots within its edge. The armature conductor is located in these slots. It provides the low-reluctance path toward the flux generated with field winding. The materials used in this core are permeability low-reluctance materials like iron otherwise cast. The lamination is used to decrease the loss because of the eddy current.

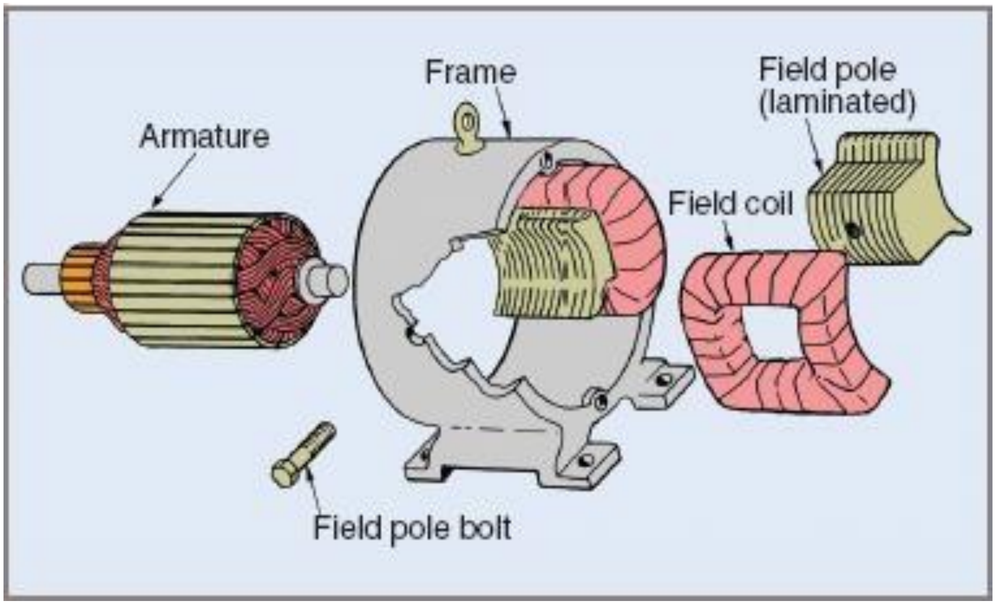
Armature Winding

The armature winding can be formed by interconnecting the armature conductor. Whenever an armature winding is turned with the help of prime mover then the voltage, as well as

Magnetic flux, gets induced within it. This winding is allied to an exterior circuit. The materials used for this winding are conducting material like copper.

Commutator

The main function of the commutator in the DC machine is to collect the current from the armature conductor as well as supplies the current to the load using brushes. And also provides unidirectional torque for DC-motor. The commutator can be built with a huge number of segments in the edge form of hard drawn copper. The Segments in the commutator are protected from the thin mica layer.



Parts of DC Machine

Brushes

Brushes in the DC machine gather the current from the commutator and supply it to the exterior load. Brushes wear with time to inspect frequently. Graphite or carbon brushes, sometimes mixed with copper dust, are used to provide a low resistance electrical connection between the armature windings and the external circuit. The brush makes a sliding contact with the commutator

The brush is usually connected to the brush holder with a flexible lead called a 'pigtail' and held down by a spring. The same connection terminal is used to connect to the external circuit.

The brushes must maintain contact with the commutator at a constant loading. By adjusting the spring tension, correct brush pressure can be obtained. Some brushes are tensioned by a spiral spring that provides a more constant pressure, thereby avoiding the need for adjustment.

The brush gear must be suitably insulated from the frame and in many cases the position of the brush around the commutator must also be adjustable.

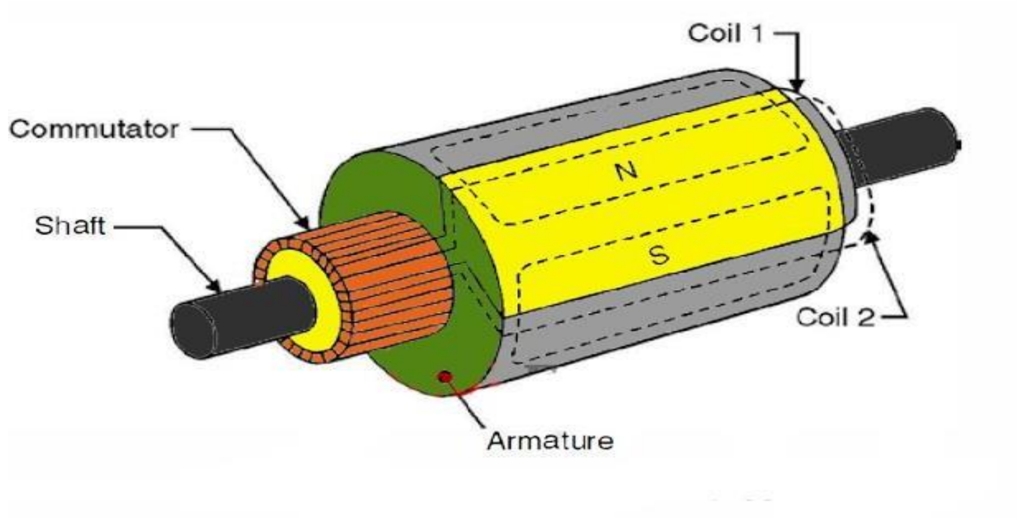
Types of DC Machines

The excitation of the DC machine is classified into two types namely separate excitation, as well as self-excitation. In a separate excitation type of dc machine, the field coils are activated with a separate DC source. In the self-excitation type of dc machine, the flow of current throughout the field-winding is supplied with the machine. The principal kinds of DC machines are classified into four types which include the following.

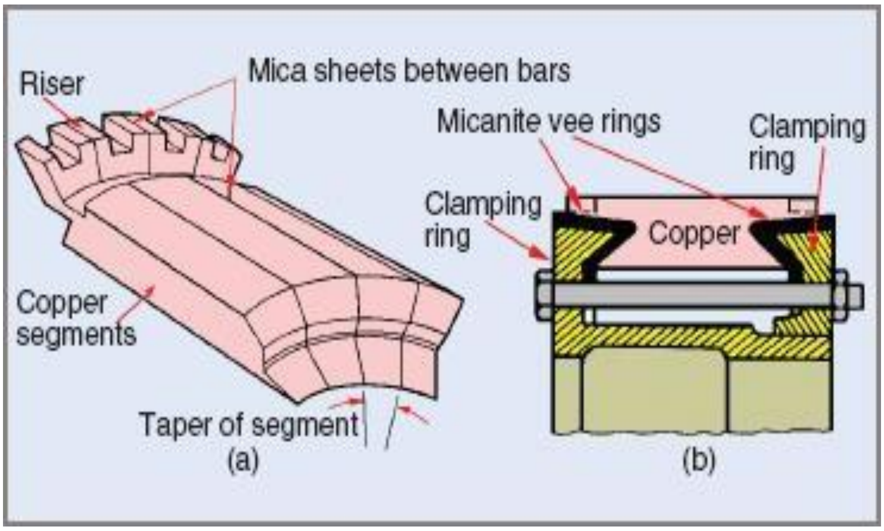
1. Separately excited DC machine
2. Shunt-wound/shunt machine.
3. Series wound/series machine.
4. Compound wound / compound machine.

Separately Excited

In Separately Excited DC Machine, a separate DC source is utilized for activating the field winding.



Armature Assembly



Commutator Segments

Brush Assembly

Shunt Wound

In Shunt wound DC Machines, the field coils are allied in parallel through **the armature**. As the shunt field gets the complete o/p voltage of a generator otherwise a motor supply voltage, it is normally made of a huge number of twists of fine wire with a small field current carrying.

Series Wound

In series-wound D.C. Machines, the field coils are allied in series through the armature. As series field winding gets the armature current, as well as the armature current is huge, due to this the series field winding includes few twists of wire of big cross-sectional region.

Compound Wound

A compound machine includes both the series as well as shunt fields. The two windings are carried-out with every machine pole. The series winding of the machine includes few twists of a huge cross-sectional region, as well as the shunt windings, include several fine wire twists.

The connection of the compound machine can be done in two ways. If the shunt-field is allied in parallel by the armature only, then the machine can be named as the 'short shunt compound machine' & if the shunt-field is allied in parallel by both the armature as well as series field, then the machine is named as the 'long shunt compound machine.

Viva Questions:

1. What is the principle of operation of a DC Motor?
2. What is back E.m.f or counter E.m.f?
3. When DC Generator fails to build up the voltage, what are the reasons?
4. What is field flashing?
5. Why do we use starter for dc machine?

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Experiment No. - 3

AIM: - To verify Kirchhoff's Voltage Law and Kirchhoff's Current Law theoretically and practically.

APPARATUS REQUIRED: -

S.No.	Name of the Equipment	Range	Type	Quantity
1	Voltmeter			
2	Ammeter			
3	Regulated power supply			
4	Multimeter			
5	Kit Board			
6	Resistors			
7	Connecting wires	As required		

THEORY: -

We saw in the Resistors tutorial that a single equivalent resistance, (R_T) can be found when two or more resistors are connected together in either series or parallel or combinations of both, and that these circuits obey Ohm's Law.

However, sometimes in complex circuits such as bridge or T networks, we cannot simply use Ohm's Law alone to find the voltages or currents circulating within the circuit. For these types of calculations we need certain rules which allow us to obtain the circuit equations and for this we can use Kirchhoff's Circuit Law.

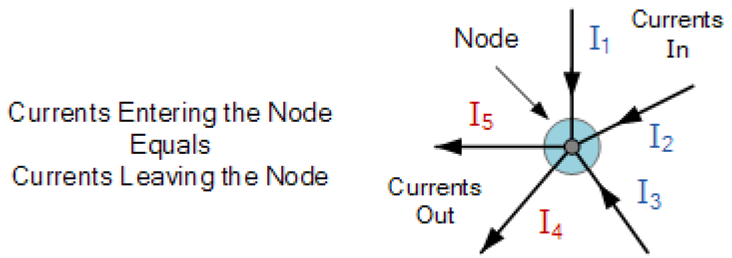
In 1845, a German physicist, Gustav Kirchhoff developed a pair or set of rules or laws which deal with the conservation of current and energy within electrical circuits. These two rules are commonly known as: Kirchhoff's Circuit Laws with one of Kirchhoff's laws dealing with the current flowing around a closed circuit, Kirchhoff's Current Law, (KCL) while the other law deals with the voltage sources present in a closed circuit, Kirchhoff's Voltage Law, (KVL).

This law is also called Kirchhoff's point rule, Kirchhoff's junction rule (or nodal rule), and Kirchhoff's first rule. It states that, "In any network of conductors, the algebraic sum of currents meeting at a point (or junction) is zero".

1. Kirchhoff's First Law – The Current Law, (KCL)

Kirchhoff's Current Law or KCL, states that the "total current or charge entering a junction or node is exactly equal to the charge leaving the node as it has no other place to go

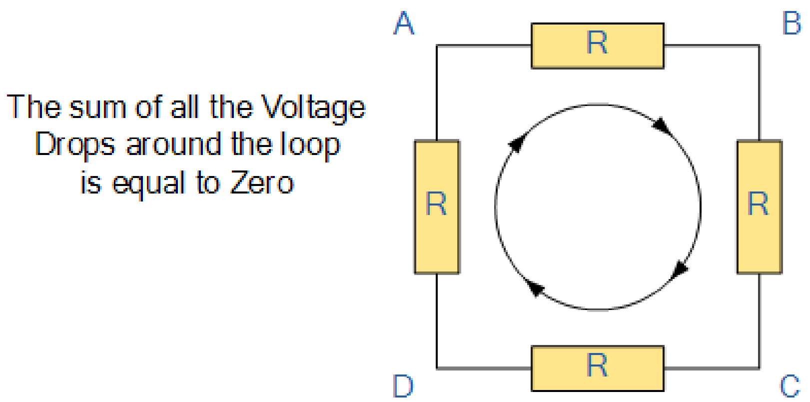
Except to leave, as no charge is lost within the node“. In other words the algebraic sum of ALL the currents entering and leaving a node must be equal to zero, I(exiting) + I(entering) = 0. This idea by Kirchhoff is commonly known as the **Conservation of Charge**.



$$I_1 + I_2 + I_3 + (-I_4 + -I_5) = 0$$

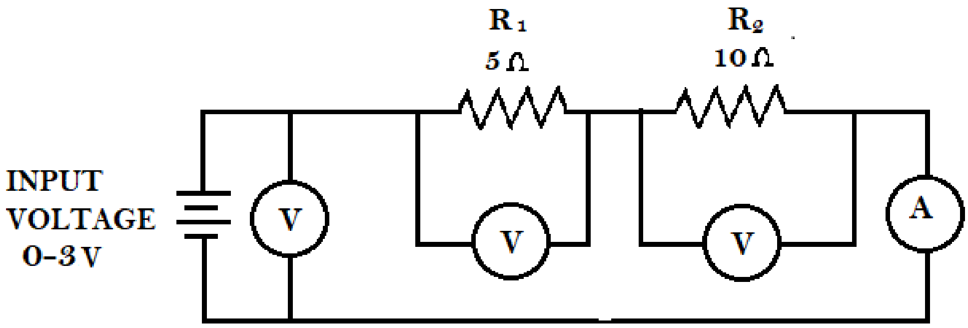
2. Kirchhoff’s Second Law – The Voltage Law, (KVL)

Kirchhoff’s Voltage Law or KVL, states that “in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop” which is also equal to zero. In other words the algebraic sum of all voltages within the loop must be equal to zero. This idea by Kirchhoff is known as the **Conservation of Energy**.

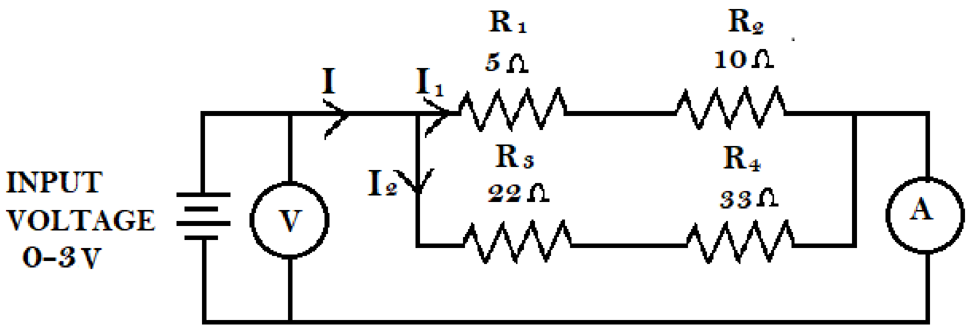


$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$

CIRCUIT DIAGRAM: -



(a) Circuit Diagrame for KVL



(b) Circuit Diagrame for KCL

$I_1 + I_2 = I$

PROCEDURE: -

1) To verify KVL, Connections are made as shown in the Fig-(a)
2) Supply is given to the circuit and the readings of the voltmeters are noted down.
3) Kirchhoff's Voltage law can be verified by $V_s = V_1 + V_2$ (v).
4) To verify KCL, Connections are made as shown in the Fig-(b)
5) Supply is given to the circuit and the readings of the Ammeters are noted down.
6) Kirchhoff's Current law can be verified by $I = I_1 + I_2$ (A).

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OBSERVATION TABLE: -

Kirchhoff's Voltage Law						Kirchhoff's Current law			
	V_s(V)	V_1(V)	V_2(V)	V_3(V)	$V_1+V_2+V_3$(V)	I(A)	I_1(A)	I_2(A)	I_1+I_2(A)
1.									
2.									
3.									
4.									

PRECAUTIONS: -

1. Loose connections are to be avoided.
2. Readings should be taken carefully without parallax error.

RESULT: -

APPLICATIONS: -

1. Kirchhoff's Laws are applications of two fundamental conservation laws: the Law of Conservation of Energy, and the Law of Conservation of Charge.
2. The current distribution in various branches of a circuit can easily be found out by applying Kirchhoff Current law at different nodes or junction points in the circuit.
3. After that Kirchhoff Voltage law is applied, each possible loop in the circuit generates algebraic equation for every loop.

VIVA QUESTIONS:

1. What is the statement of KVL?
2. What is the statement of KCL?
3. What is the statement of Ohm's law?
4. Give the limitations of Kirchhoff's laws?
5. What is the Condition of Ohm's law?

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Experiment No. - 4

AIM :- To verify Thevenin's theorem

APPARATUS REQUIRED: -

S.No	Name Of The Equipment	Range	Type	Quantity
1	Voltmeter			
2	Ammeter			
3	RPS			
4	Resistors			
5	Breadboard			
6	DMM			
7	Connecting wires			

THEORY: THEVENIN'S THEOREM: -

It states that in any lumped, linear network having more number of sources and elements the equivalent circuit across any branch can be replaced by an equivalent circuit consisting of Theremin's equivalent voltage source Vth in series with Theremin's equivalent resistance Rth. Where Vth is the open circuit voltage across (branch) the two terminals and Rth is the resistance seen from the same two terminals by replacing all other sources with internal resistances.

Thevenin's theorem:

The values of VTh and RTh are determined as mentioned in thevenin's theorem. Once the thevenin equivalent circuit is obtained, then current through any load resistance RL connected across AB is given by, $I = \frac{V_{TH}}{R_{TH}+R_L}$

Thevenin's theorem is applied to d.c. circuits as stated below.

Any network having terminals A and B can be replaced by a single source of e.m.f. V_{Th} in series with a source resistance R_{Th}

(i) The e.m.f the voltage obtained across the terminals A and B with load, if any removed i.e., it is open circuited voltage between terminals A and B.

(ii) The resistance R_{Th} is the resistance of the network measured between the terminals A and B with load removed and sources of e.m.f replaced by their internal resistances. Ideal voltage sources are replaced with short circuits and ideal current sources are replaced with open circuits.

To find V_{Th}, the load resistor 'RL' is disconnected, then $VTh = \frac{V}{R_1+R_2} X R3$

To find R_{Th},

$$R_{Th} = R2 + \frac{R_1 R_3}{R_1 + R_3}$$

Thevenin's theorem is also called as "Helmoltz theorem"

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PROCEDURE:-

NOTE: Result is in 10% Tolerance

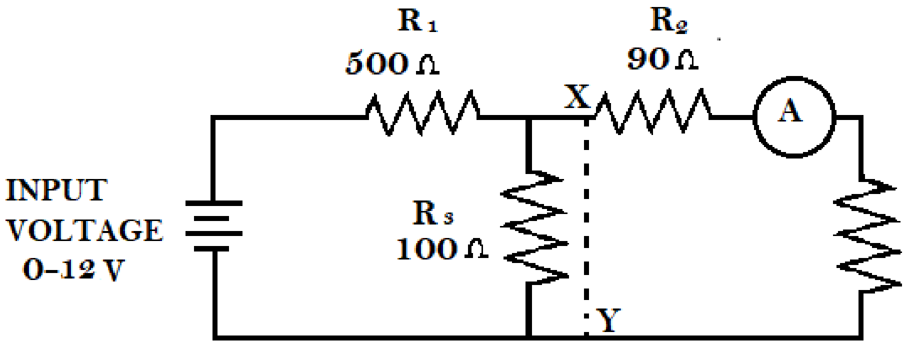
$R_1 = 500\ \Omega$

$R_2 = 100\ \Omega$

$R_3 = 90\ \Omega$

$V = 12\ V$

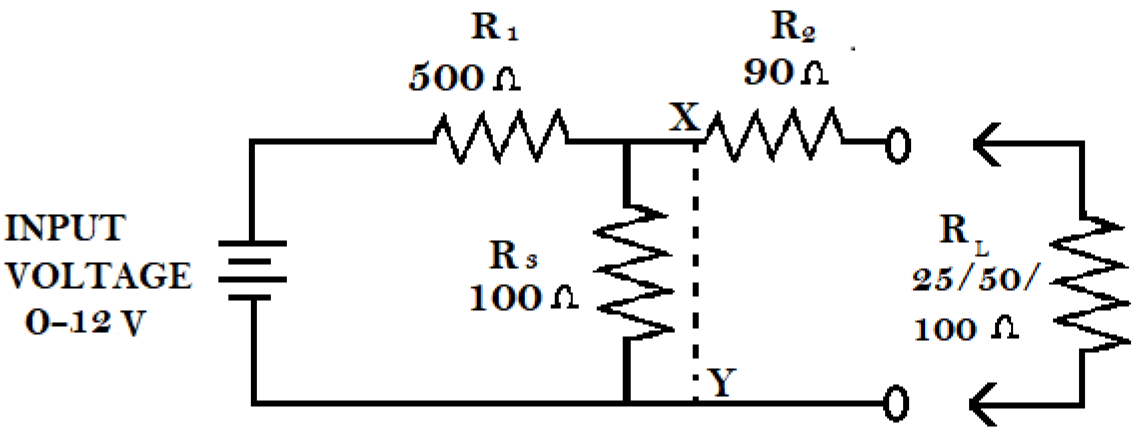
$R_L = 25/50/100\ \Omega$



Step 1:-

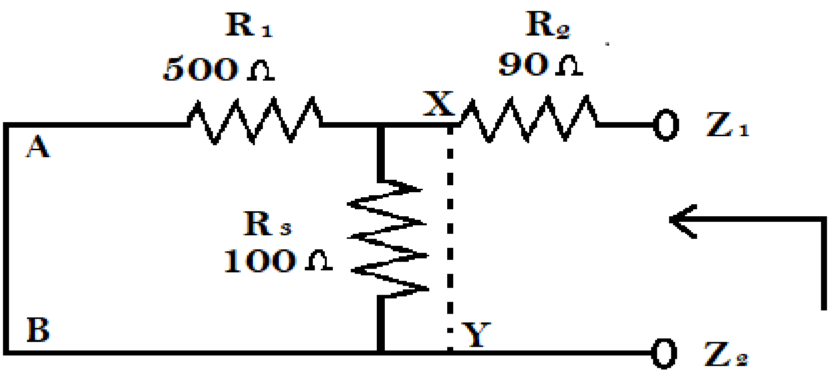
Open load and measure Voltage across Z1-Z2 . Open circuit voltage which will appear across 100 ohm resistance.

Vth = 100x12/600 = 2V



Step 2: -

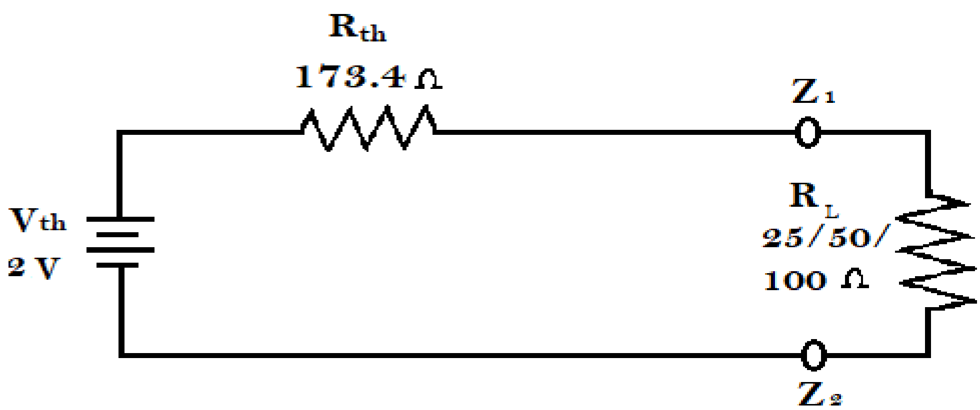
Know disconnect voltage source and short the A and B point as shown in fig (with RL open circuit)



Now measure the resistance at Z-Z

Rth = (500x100/500+100)+ 90 = 173.4

Now the circuit may be replace as



Vth = 2V Rth = 173.4 ohm

For RL = 25 ohm

IL = 2/173.4+25 = 10 mA

For RL = 50 ohm

IL = 2/173.4+50 = 8.9 mA

For RL = 100 ohm

IL = 2/173.4+100 = 7.3 mA

Compare the calculated values with observed value

Result:

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Experiment No. - 5

AIM: - Verification of Superposition theorem.

APPARATUS REQUIRED: -

S.No	Name Of The Equipment	Range	Type	Quantity
1				
2				
3				
4				

THEORY: -

Superposition theorem states that in a lumped ,linear, bilateral network consisting more number of sources each branch current(voltage) is the algebraic sum all currents (branch voltages), each of which is determined by considering one source at a time and removing all other sources. In removing the sources, voltage and current sources are replaced by internal resistances.

PROCEDURE: -

Fined the current I_1, I_2 and I_3 as shown in fig. no. 1 using superposition theorems.

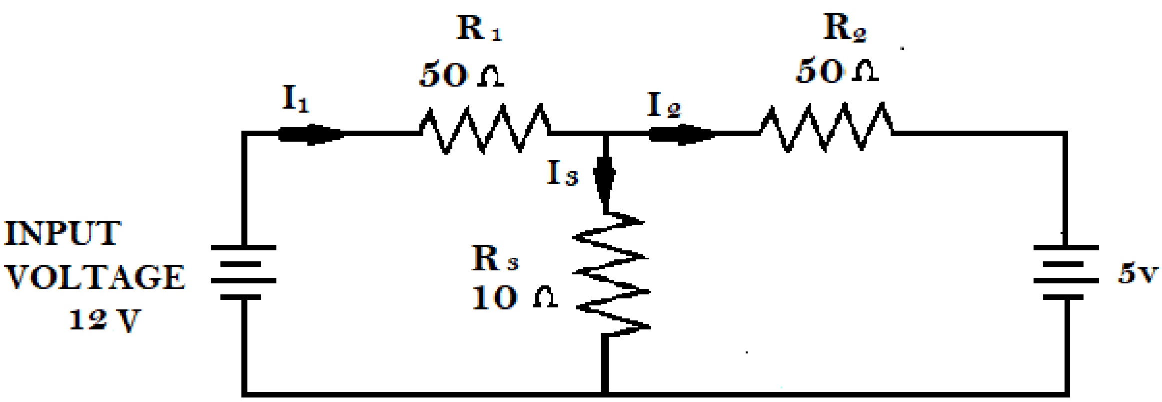

FIG. 1

1. Connect the circuit as shown in fig (2). Consider only one voltage source at a time first 12V.

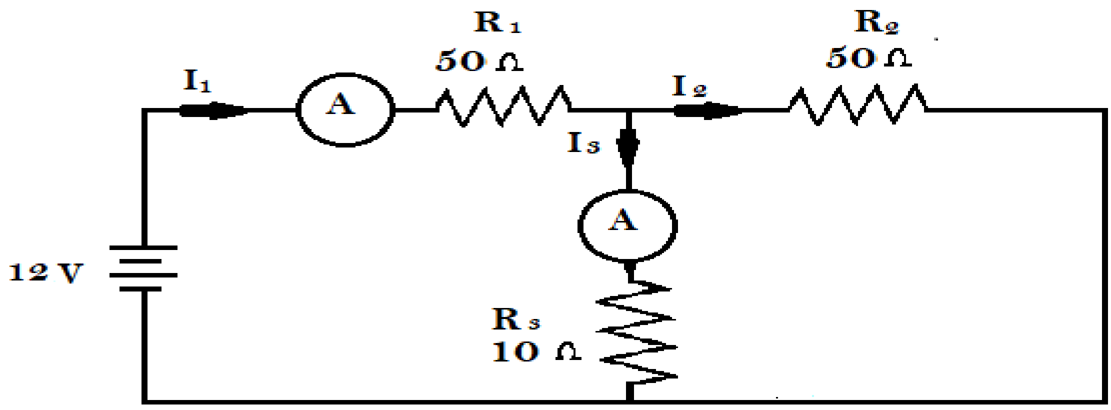

FIG. 2

2. Switch on the instrument using ON/OFF.
3. Note down the current I1, I2 and I3 one by one by connecting ammeter of 250mA range in series of resistance R1,R2 and R3.
4. Compare the observed current reading to calculated current.
   Formula used to calculate the circuit:

RT = 50ohm || 10 ohm + 50 ohm **(Where || represent parallel sing)**

RT = 50ohm **+** 8.33 ohm = 58.33 ohm

Therefore current

I1 = IT (IT = Total current)

IT = V/R

IT = 12V/58.33 ohm = 205.7 mA

I1 = 205.7 mA

I3 = 205.7 x 10/60 = 34.2 mA

Therefore for fig. (2)

I1 = 205.7 mA

I2 = 171.4 mA

I3 = 34.2 mA

5. Now connect the circuit as shown in fig. (3) Consider only one voltage source at a time, second 5V.

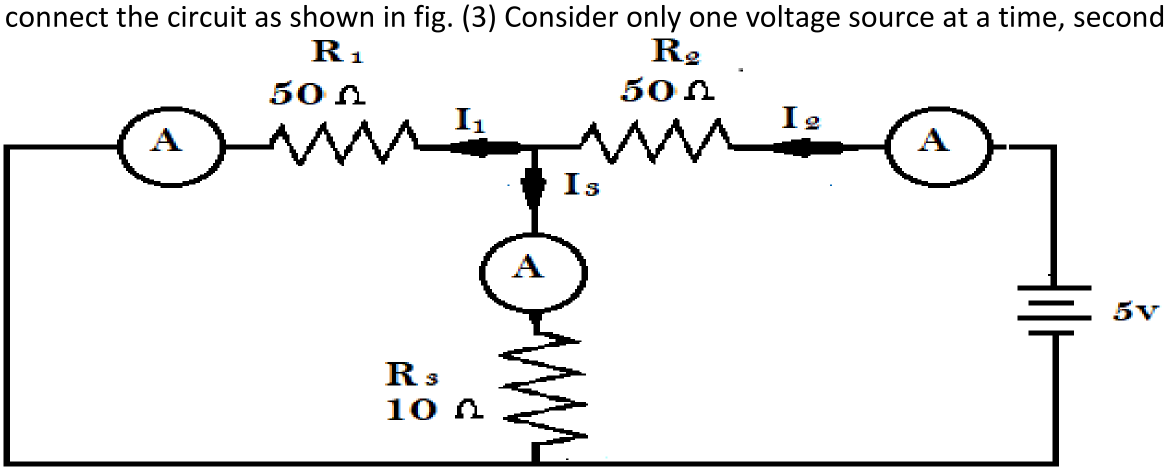

FIG. 3

6. Switch on the instrument using ON/OFF.
7. Note down the current I_1, I_2 and I_3 one by one by connecting ammeter of 250mA range in series of resistance R1, R2 and R3.
8. Compare the observed current reading to calculated current.

Formula used to calculate the circuit:

RT = 50ohm || 10 ohm + 50 ohm **(Where || represent parallel sing)**

RT = 50ohm + 8.33 ohm = 58.33 ohm

Therefore current

I'_3 = I_T (I_T = Total current)

I'_T = V/RT

I'_3 = 5V/58.33 ohm = 85.7 mA

I'_3 = 85.7 mA

I'_2 = 85.7 x 50/50 + 10 = 71.4 mA

I'_1 = 85.7 – 71.4 = 14.3 mA

Therefore for fig. (2)

I_1 = 14.3 mA

I_2 = 71.4 mA

I_3 = 85.7 mA

9. Connect the circuit as shown in fig (1). To measure net algebraic sum of current when both the voltage sources (12v & 5v) connected simultaneously.
10. Note down the current I_1, I_2 and I_3 one by one by connecting ammeter of 250mA range in series of resistance R1, R2 and R3.
11. Compare the observed current reading to calculated current.

Formula used to calculate the circuit I_1, I_2 and I_3

Current through resistance R1 = I_1 = I_1 - I'_1 = 205.7 – 14.3 = 191.4 mA

Current through resistance R2 = I_2 = I_2 - I'_2 = 171.4 + 71.4 = 242.8 mA

12. We can aslo observe the voltage drop across each resistance by connecting voltmeter across each resistance.

Formula used to calculate the voltage drop across each resistance.

When source voltage is 12v only:

Voltage drop across R1:

VR1 = I_1 x R1 = 205.7 x 50 = 10.28V

Voltage drop across R2:

VR2 = I_2 x R2 = 171.4 x 10 = 1.71V

Voltage drop across R2:

VR3 = I_3 x R3 = 34.2 x 50 = 1.71V

When source voltage is 5V only:

Voltage drop across R1:

VR1 = I1 x R1 = 14.3 x 50 = 0.71 V

Voltage drop across R2:

VR2 = I2 x R2 = 71.4 x10x= 0.71V

Voltage drop across R3:

VR3 = I3 x R3 = 85.7 x 50 = 4.2 V

When both source connected simultaneous:

Voltage drop across R1:

VR1 = I1 x R1 = 191.4 x 50 = 9.5 V

Voltage drop across R2:

VR2 = I2 x R2 = 242.8 x10x= 10.28V

Voltage drop across R3:

VR3 = I3 x R3 = 51.5 x 50 = 2.5 V

At low voltage Analog voltmeter may show error in reading because of their low impedance , so it is good to use a digital multimeter (DMM) to note down lower voltage reading.

PRECAUTIONS: -

1. Always switch off the instrument when you are connecting the circuit.
2. Connect ammeter in series and voltmeter in parallal with circuit.
3. Never touch with nacked wire
4. Joint should be tight.

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Experiment No. - 6

AIM: - To study frequency response of a series R-L-C circuit and determine resonant frequency and Q-factor for various values of R, L and C.

APPARATUS REQUIRED: -

S.No.	Name of the Equipment	Range	Type	Quantity
1	Multimeter			
2	Series Resonance Kit			
3	Connecting wires	As required		

THEORY: -

The voltage across the inductor is VL = I XL The voltage across the capacitor is VC = IXC The voltage across the resistor is VR = IR

Phase relations among these voltages are shown in Figure 1. The voltage across the resistor is in phase with the current. The voltage across the inductor leads the current by 90 degrees. The voltage across the capacitor lags the current by 90 degrees.

The total voltage across the resistor, inductor and capacitor should be equal to the emf supplied by the generator.

$$\vec{E} = \vec{V}_R + \vec{V}_C + \vec{V}_L$$

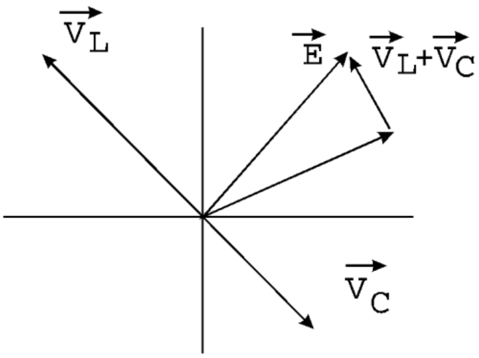

Figure 1

From Figure 2 we can see that $$E = \sqrt{V_R^2 + (V_L - V_C)^2}$$

If we divide both sides of this equation by current, we will get

$$E/I = Z = R^2 + (X_L - X_C)^2$$

Where $(X_L - X_C)$ is called the total reactance and Z is called the impedance of the circuit.

We know that the capacitive reactance $X_C = 1/\omega C$, and the inductive reactance $X_L = \omega L$ depend on frequency. The value of frequency when $X_L = X_C$, $\omega L = 1/\omega C$, or $\omega = 1/\sqrt{LC} = \omega_0 = 2\ f_0\pi$

The frequency f_0 is called the resonance frequency of the circuit. At this frequency, the impedance is smallest and the maximum value of the current (and the voltage across the resistor V_R) can be obtained. At this frequency, the circuit is said to be at resonance. At resonance, the current is in phase with the generator voltage.

If we measure voltage across the resistor, depending on frequency, we will obtain a resonance curve of the circuit as shown in Figure2. A resonance curve can be characterized by the resonance width Δf, the frequency difference between the two points on the curve where the power is half its maximum value or voltage is $V_{max}/\sqrt{LC} = 0.707\ V_{max}$

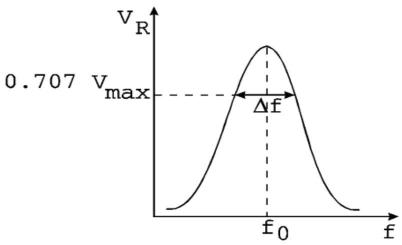

Figure 2

When the width is small compared with the resonance frequency, the resonance is sharp; that is, the resonance curve is narrow. The circuit can be characterized by the quality factor $Q = f_0/\Delta f$.

If resistance is small and resonance is sharp, the quality factor is large. When the resistor is large, the quality is small. Q is a measure of the rate at which energy is dissipated in the circuit if the AC voltage source across the series circuit was removed.

Circuit diagram:

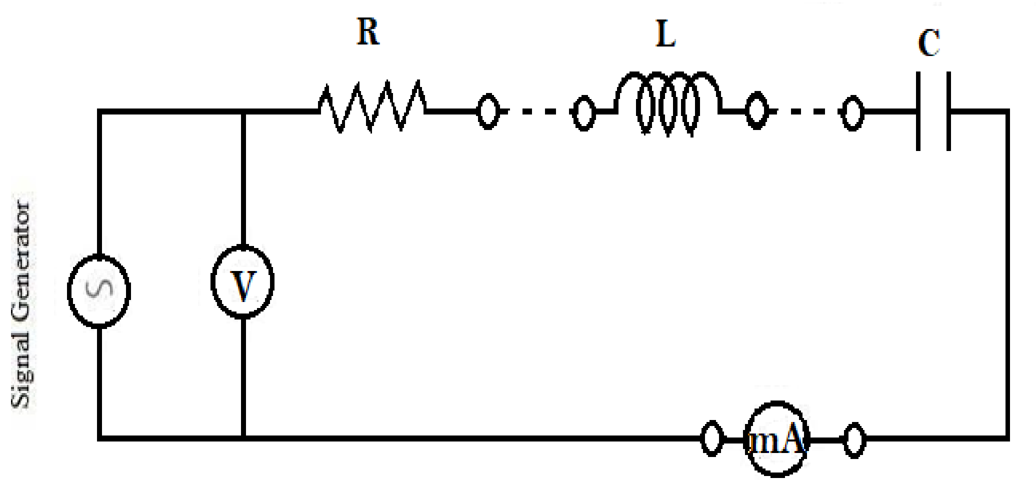

FIG. (1) SERIES RESONANCE

$R = 50\Omega$, $L = 10mH$, $C = 0.1\mu f$

Procedure:

1. Connect the circuit as shown in fig (1).
2. Adjust the Sine Wave signal of oscillator at 4V r.m.s., 1 kHz.
3. Increase the frequency of signal upto 10 kHz and note down the corresponding value of frequency and current Record the observations in table no. 1. The frequency where current start decreasing is known as resonance frequency. Formula used to calculate resonance frequency is:

$$f = 1/2\pi(L/C)$$

And formula used to calculate quality factor is:

$$\text{Quality fector}Q = (L/C)^{1/2}/R$$

4. Repeat step 1-3 for different values of R & C.
5. Plot a graph between Frequency v/s Current as shown in fig. 2.

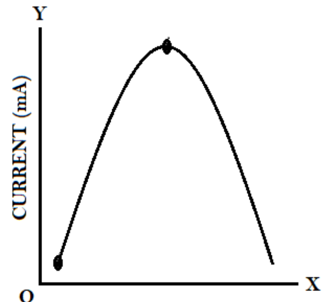

FIG. (2)

SERIES RESONANCE CURVE

OBSERVATION TABLE: -

S.NO.	FREQUENCY	CURRENT	VOLTAGE

PRECAUTIONS: -

1. Loose connections are to be avoided.
2. Readings should be taken carefully without parallax error.

RESULT: -

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Experiment No. - 7

AIM: - To conduct load test on single phase transformer and to find efficiency and Percentage regulation.

APPARATUS REQUIRED: -

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-10)A (0-5) A	MI MI	1 1
2	Voltmeter	(0-150)V (0-300) V	MI MI	1 1
3	Wattmeter	(300V, 5A) (150V, 5A)	Upf Upf	1 1
4	Auto Transformer	1ϕ, (0-260)V	-	1
5	Resistive Load	5KW, 230V	-	1
6	Connecting Wires	2.5sq.mm	Copper	Few

FORMULAE:

Output Power = W_2 x Multiplication factor

Input Power = W_1 x Multiplication factor

Efficiency

$$\eta\% = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

$$\text{Regulation R \%} = \frac{V_{NL} - V_{FL}\text{ (Secondary)}}{V_{NL}} \times 100\%$$

TABULAR COLUMN: -

S. No.	Load	Primary			Secondary			Input Power W_1 x MF	Output Power W_2 x MF	Efficiency %	% Regulationn
		V_1 (Volts)	I_1 (Amp)	W_1 (Watt)	V_2 (Volt)	I_2 (Amp)	W_2 (Watt)				
1.											
2.											
3.											
4.											
5.											

PRECAUTIONS:

1. Auto Transformer should be in minimum position.
2. The AC supply is given and removed from the transformer under no load condition.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. After checking the no load condition, minimum position of auto transformer and DPST switch is closed.
3. Ammeter, Voltmeter and Wattmeter readings on both primary side and secondary side are noted.
4. The load is increased and for each load, Voltmeter, Ammeter and Wattmeter readings on both primary and secondary sides are noted.
5. Again no load condition is obtained and DPST switch is opened.

RESULT:

Thus the load test on single phase transformer is conducted.

Viva Questions:

1. What is the function of a transformer?
2. What is a load?
3. Why do we perform load test when the efficiency can be determined by O.C. and S.C. tests?
4. Mention the types of transformer.
5. Explain the operating principle of a transformer.
6. List out general applications of transformer.
7. What are core type transformers?
8. What are shell type transformers?
9. Distinguish between power and distribution transformer.
10. Define voltage regulation of a transformer.

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Experiment No. - 8

AIM: - To Perform Open Circuit Test on A Single Phase Transformer.

APPARATUS REQUIRED: -

S. No.	Apparatus Required	Specifications	Quantity
1.	Transformer	115/230V	1
2.	Variac	230V, 1-phase, 50Hz	1
3.	Wattmeter	0-440V, 0-2.5A.(for OC) 0-150V,0-20A(for SC)	1
4.	Voltmeter	300V	1
5.	Ammeter	15A	1

CIRCUIT DIAGRAM: -

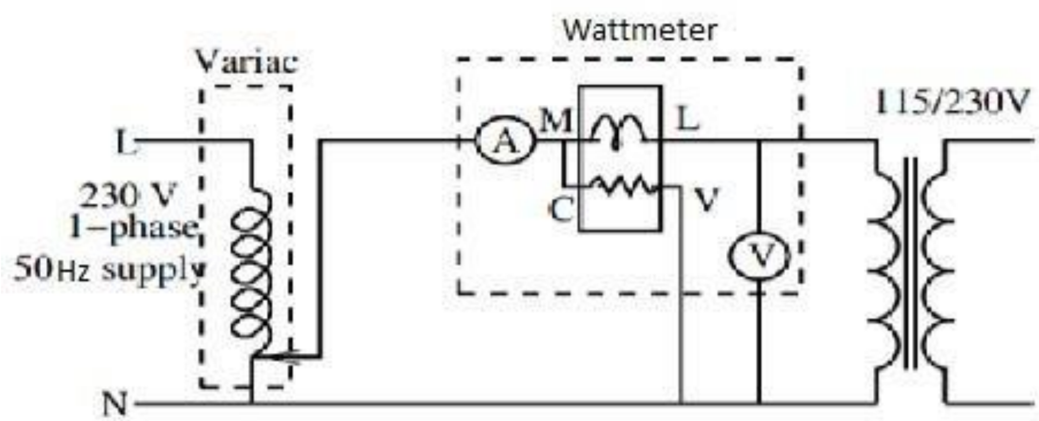

Fig1. Circuit Diagram for Open Circuit Test.

THEORY: -

1. **Open Circuit (OC) or No-Load Test**

The purpose of this test is to determine the shunt branch parameters of the equivalent circuit of the transformer. One of the windings is connected to supply at rated voltage, while the other winding is kept open - circuited. From the point of view of convenience and availability of supply the test is usually performed from the LV side, while the HV side is kept open circuited.

V_o= Rated Voltage applied.

I_o= No load current (it is usually 2-6% of the rated current)

P_o= Power input (No load losses)

Then the relation is

$$P_o = V_o \times I_o \times Cos(\emptyset_o)$$

($\emptyset_o$)- No load power factor.

$$Cos(\emptyset_o) = \frac{P_o}{V_o \times I_o}$$

Therefore, magnetizing current,

$$I_m = I_o Sin(\emptyset_o)$$

Energy component of current

$$I_w = I_o Cos(\emptyset_o)$$

R_0 and X_0 are also small, that V_o can be regarded as = E_1 by neglecting the series impedance. This means that for all practical purposes the power input on no-load equals the core (iron) loss i.e.

$$Z_o = \frac{V_o}{I_o}$$

$$R_o = \frac{V_o}{I_w}$$

$$X_o = \sqrt{Zo^2 - Ro^2}$$

$$X_o = \sqrt{Zo^2 - Ro^2}$$

Procedure:

1. Make the connections as per the circuit diagram in fig. 1.
2. By using 1-⍰ variac apply rated voltage.
3. Measure voltage , current & power input from voltmeter, ammeter and wattmeter resp.
4. Evaluate no load power factor, I_w , I_m , R_0 and X_0
5. Verify the results

Observations and calculations:

S. No.	V_o(Volts)	I_o(Amps)	W_o(Watts)
1.			
2.			
3.			

Evaluate the no load and full load parameters.

Precautions:

1. Open circuit test is performed on LV side i.e. meter are connected LV and HV side will be open circuited.
2. Rated voltage and rated current must be maintained in OC test.
3. All the connections should be tight.

Viva Questions:

1. What are the advantages of OC and SC test?
2. Why the OC test is normally done on the LV side?
3. What are the components of iron loss?

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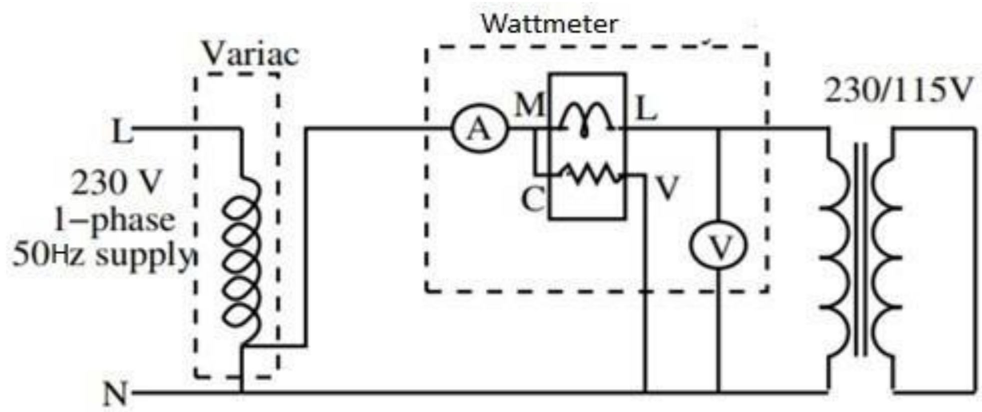
Experiment No. - 9

Aim: To Perform Short Circuit Test on A Single Phase Transformer.

APPARATUS REQUIRED: -

S. No.	Apparatus Required	Specifications	Quantity
1.	Transformer	115/230V	1
2.	Variac	230V, 1-phase, 50Hz	1
3.	Wattmeter	0-440V, 0-2.5A.(for OC) 0-150V,0-20A(for SC)	1
4.	Voltmeter	300V	1
5.	Ammeter	15A	1

Circuit Diagram:



THEORY:

Short Circuit (SC) Test:

This test serves the purpose of determining the series parameters of a transformer. For convenience of supply arrangement and voltage and current to be handled, the test is usually conducted from the HV side of the transformer while the LV side is short-circuited. Since the transformer resistance and leakage reactance are very small, the voltage Vsc needed to circulate the full load current under short circuit is as low as 5-8% of the rated voltage. The exciting current under these conditions is only about 0.1to 0.5% of the full load current Thus the shunt branch of the equivalent circuit can be altogether neglected. While conducting the SC test, the supply voltage is gradually raised from zero till the transformer draws full load current. The meter readings under these conditions are: Since the transformer is excited at very low voltage, the iron loss is negligible (that is why shunt branch is left out), the power input corresponds only to the copper loss, i.e

V_{sc}= Voltage applied.

I_{sc}= Rated load current

P_{sc}= Power input (Copper loss)

Then the relation is

$$P_{sc} = V_{sc} \times I_{sc} \times Cos(\emptyset)$$

(∅)- full power factor.

$$Cos(\emptyset) = \frac{P_{sc}}{V_{sc} \times I_{sc}}$$

Equivalent resistance, $R_{eq} = P_{sc} / (I_{sc})^2$

Equivalent reactance, $X_{eq} = \sqrt{(Z^2_{eq} - R^2_{eq})}$

Procedure:

1. Make the connections as per the circuit diagram in fig. 2.
2. By using 1-φ variac apply voltage and increase till the rated current starts flowing.
3. Measure voltage, current & power input from voltmeter, ammeter and wattmeter resp.
4. Evaluate no load power factor, Z_{eq} ,R_{eq} and X_{eq}
5. Verify the results

Observations and calculations:

SC Test:

S. No.	V_{sc}(Volts)	I_{sc}(Amps)	W_{sc}(Watts)
1.			
2.			
3.			

Evaluate the no load and full load parameters.

Precautions:

1 .For short circuit test is connect meters on HV side and LV side will be short circuited.
2. Rated voltage and rated current must be maintained in SC test respectively.
3. All the connections should be tight.

Viva Questions:

1. What are the advantages of SC test?
2. Why the SC test is normally done on HV side?
3. What are the components of iron loss?

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Experiment No. - 10

AIM: - Measurement of Power in a Three Phase System by two wattmeter method.

APPARATUS REQUIRED: -

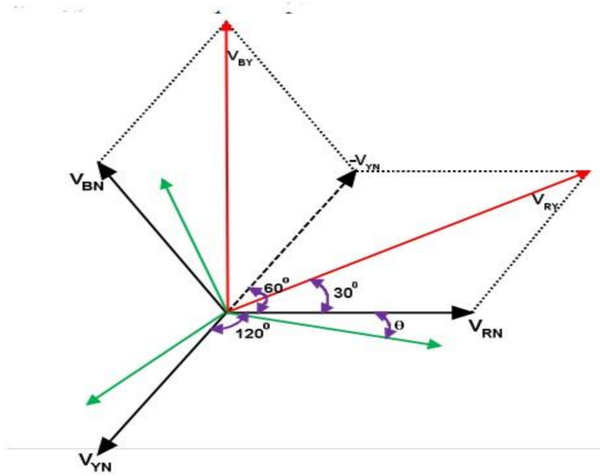
No.	Name	Specification	Quantity
1	Wattmeter	(0-1500)W, 5A/10A, UPF	2 Nos.
2	Voltmeter	(0-250)V, MI	1 Nos.
3	Ammeter	(0-5)A, MI	3 Nos.
4	Connecting Wires	PVC Insulated Copper	As per requirement
5	Three-phase Variac	(0-500)V, (5A/10A),	1 Nos.
6	Rheostat	(0-80)Ω, 5A	3 Nos.

THEORY: -

A watt meter is an instrument for measuring active power directly in a circuit. It has two coils i.e. current coil & pressure coil. Current coil measures the current through the circuit &pressure coil measures the voltage. Current coil is connected in series & pressure coil in parallel in the circuit. Two wattmeter can be used to measure power in a three phase 3-wire circuit, by making the connections as shown in circuit diagram. The load may be balanced or unbalanced. The current coils are connected in series with two phases and the pressure coils is connected between both phase and the third phase. The total power consumed by the two wattmeter = W1+W2 (algebraic sum).

Here current through the current coil of $W_1=I_R$ and $W_2=I_B$

While potential difference across pressure coil of $W_1=V_{RY}$ and $W_2=V_{BY}$



According to the phasor diagram

$$W_1 = V_{RY} I_R \cos(30+\theta)$$

$$W_2 = V_{BY} I_B \cos(30-\theta)$$

Total Power drawn by three phase load is

$$W_1 + W_2$$

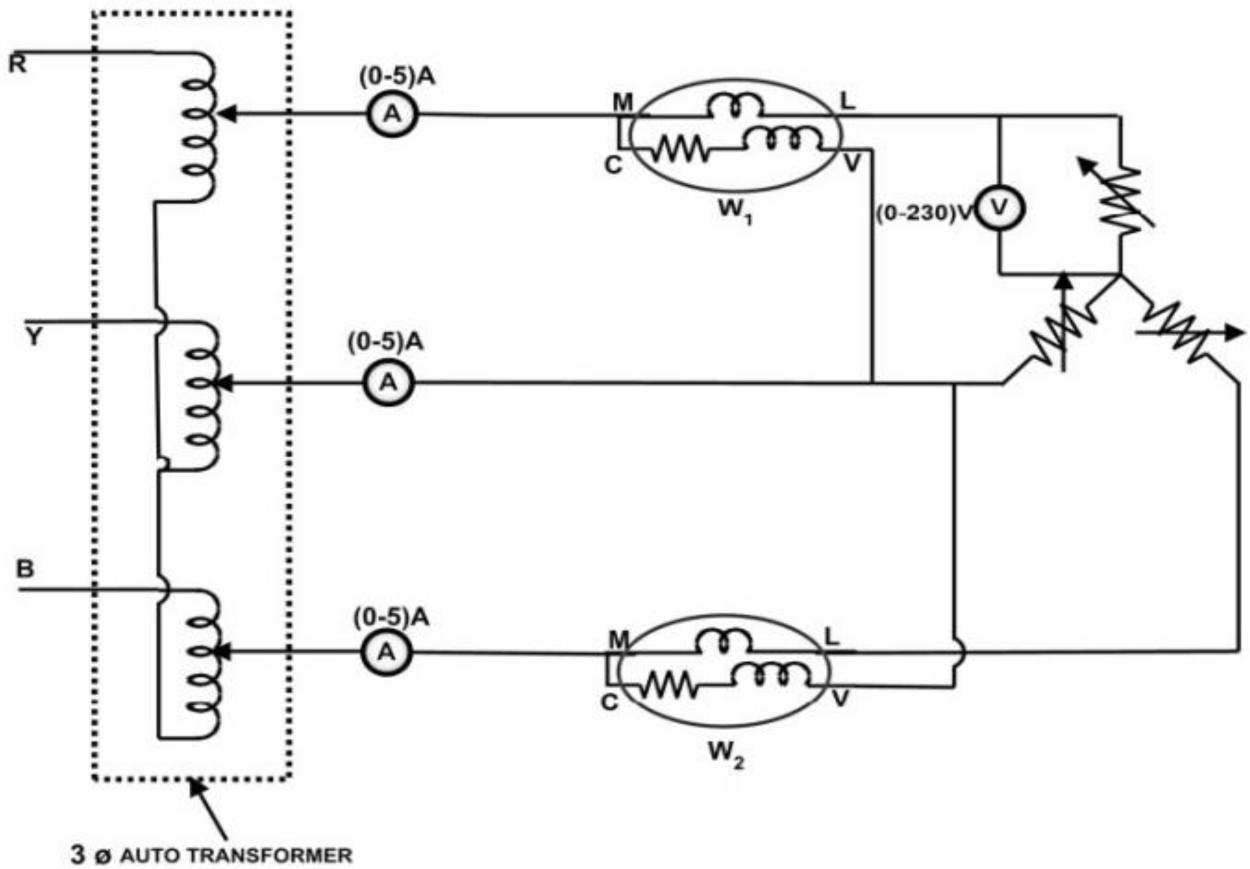
$$= V_{RY} I_R \cos(30+\theta) + V_{BY} I_B \cos(30-\theta)$$

Here $Y_{RY} = V_{BY} = V_L$

then

$$W_1 + W_2 = \sqrt{3} V_L I \cos\theta$$

Circuit Diagram:



Procedures: -

(i) Connect all the instruments as per circuit diagram.

(ii) Make sure i. e all instruments are showing zero error.

(iii) After connection, keep the rheostat in maximum position and slowly increase the output voltage of the Variac so that current in each phase is about 1A.

(iv) Then vary the resistance of the rheostats so the load is deliberately unbalanced, i.e. the current in each phase becomes different.

(v) Calculate the Three-phase power.

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Observation Table: for Balance Load

Sl. No.	Power in Watts (W_1)	Power in Watts (W_2)	Line Voltage in Volts. ($V_L=V_{RY}$)	Phase Current in Amp. (I_R)	Phase Current in Amp. (I_Y)	Phase Current in Amp. (I_B)	Total Power in watts. $P=W_1+W_2$
1							
2							
3							
4							
5							
6							
7							

Precautions:

1. Don't switch on power supply without concerning respective teachers.
2. Three phase auto transformer must be kept at minimum potential point before starting.
3. Resistant value of all rheostats should be kept at maximum position at starting