



LABORATORY MANUAL

B.Tech. Semester- I / II

BASICS OF ELECTRICAL ENGINEERING LAB

Subject code: EEE-103P

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**DEPARTMENT OF APPLIED SCIENCE & HUMANITIES
DRONACHARYA COLLEGE OF ENGINEERING
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Vision and Mission of the Institute

Vision:

Empowering human values and advanced technical education to navigate and address global challenges with excellence.

Mission:

- **M1** - Seamlessly integrate human values with advanced technical education.
 - **M2** - Supporting the cultivation of a new generation of innovators who are not only skilled but also ethically responsible.
 - **M3** - Inspire global citizens who are equipped to create positive and sustainable impact, driving progress towards a more inclusive and harmonious world.
-

Vision and Mission of the Department

Vision

- To establish a strong foundation for first-year engineering students, aiming to equip them with the skills to innovate and devise engineering solutions.

Mission

- **M1:** To develop a solid foundation of knowledge and hands on experience in budding technocrats, empowering them to apply scientific principles to address complex engineering challenges.
- **M2:** To provide education that fosters comprehension and collaboration between engineering and other core field of Applied Sciences.
- **M3:** To inculcate values and ethics in students and make them responsible citizens of India.

Programme Educational Objectives (PEOs)

- **PEO1:** PEO1: To instill the basic principles of Applied Sciences to enable students learn technical subjects effectively.
- **PEO2:** To equip students with innovative skills that improve their practical understanding enabling them to solve real-world challenges effectively.
- **PEO3:** To enhance students' team-building skills and leadership qualities continuously through social, cultural, and environmental activities.

Programme Outcomes (POs)

Engineering Graduates will be able to:

- 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 software tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- PO6: The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- PO7: Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- PO8: Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- PO9: Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- PO10: Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, 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.

University Syllabus

1. Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. (Resistors capacitors and inductors).
2. Verification of Ohm’s Law, Kirchhoff current and voltage laws.
3. To measure the power in three phase circuits using two wattmeter method.
4. To verify Thevenin and Norton theorems.
5. To verify Maximum power transfer and superposition theorems.
6. To perform direct load test of a transformer and plot efficiency vs load characteristics.
7. To perform O.C. and S.C. tests of a transformer.
8. Measurement of power in a 3-phase system by two wattmeter method.
9. Measurement of power by 3 voltmeter/3 ammeter method.
10. To verify the resonance in R-L-C circuits.
11. Demonstration of cut-out sections of machines: dc machines (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winding – slip ring arrangement) and single-phase induction machine.
12. Torque speed characteristics of shunt dc motor.

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Course Outcomes (COs)

Upon successful completion of the course, the students will be able to:

C103.1: To study multimeter and oscilloscope.

C103.2: To study all network theorems & laws.

C103.3: To observe waveforms and calculations of AC circuits.

C103.4: To study input and output characteristics of a Transformer.

C103.5: To study the characteristics of DC machines.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C103.1		3			3			2	2	2	2	2
C103.2			2		3			2	2	2	2	2
C103.3				2	3			2	2	2	2	2
C103.4				2	3			2	2	2	2	2
C103.5				2	3			2	2	2	2	2
C103		3	2	2	3			2	2	2	2	2

CO-PSO Mapping

	PSO1	PSO2	PSO3
C103.1	2	2	
C103.2		2	
C103.3		2	
C103.4		2	
C103.5		2	
C103	2	2	

Course Overview

This laboratory provides students with hands-on experience on the basic electrical system. This laboratory has played a role in on-going development of the circuit's & machines curriculum at institute. This laboratory is to provide students with experience on various electrical system & machine operating and planning functions, a set of experiments have been designed and are under design for use with breadboard and basic circuits.

List of Experiments mapped with COs

Sl No	List of Experiments	Course Outcome	Page no.
1.	Introduction of Electrical Elements, sources, measuring devices.	C103.1	1-7
2.	To measure DC voltage and current, AC voltage and current with multi-meter	C103.1	8-11
3.	To observe waveforms on oscilloscope, measure basic parameters amplitude and frequency of sine wave and square wave.	C103.1	12-17
4.	A. Verification of Ohm's Law	C103.2	18-24
	B. Verification of Kirchhoff voltage and current laws.	C103.2	
	C. Verification of Kirchhoff voltage and current laws.	C103.2	
5.	A. To verify Thevenin theorems.	C103.2	25-29
	B. To verify Norton theorems.	C103.2	
6.	To verify the resonance in R-L-C circuits.	C103.3	30-32
7.	To perform O.C. and S.C. tests of a transformer	C103.4	33-38
8.	To perform direct load test of a transformer and plot efficiency vs load characteristics.	C103.4	39-41
9.	Demonstration of cut-out sections of machines: dc machines (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winding – slip ring arrangement) and single-phase induction machine.	C103.5	42-47
10	Torque speed characteristics of shunt dc motor.	C103.5	48-50

DOs and DON'Ts

DOs

1. Enter the lab on time and leave at proper time.
2. Keep the bags outside in the racks.
3. Utilize lab hours in the corresponding experiment.
4. Make the Supply off the Kits/Equipments after completion of Experiments.
5. Maintain the decorum of the lab.

DON'Ts

1. Don't bring any external material in the lab.
2. Don't make noise in the lab.
3. Don't bring the mobile in the lab.
4. Don't enter in Faculty room without permission.
5. Don't litter in the lab.
6. Don't carry any lab equipments outside the lab

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 fire wood 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 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.
4. Immediately call medical emergency and security. Remember! Time is critical; be best.

Precautions (In case of Fire)

1. Turn the equipment off. If 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.
4. Call security and emergency department immediately:

Emergency : Reception
Security : Main Gate

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.

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Lab Assessment Criteria

An estimated 10 lab classes are conducted in a semester for each lab course. These lab classes are assessed continuously. Each lab experiment is evaluated based on 5 assessment criteria as shown in following table. Assessed performance in each experiment is used to compute CO attainment as well as internal marks in the lab course.

Grading Criteria	Exemplary (4)	Competent (3)	Needs Improvement (2)	Poor (1)
AC1: Pre-Lab written work (this may be assessed through viva)	Complete procedure with underlined concept is properly written	Underlined concept is written but procedure is incomplete	Not able to write concept and procedure	Underlined concept is not clearly understood
AC2: Program Writing/ Modeling	Assigned problem is properly analyzed, correct solution designed, appropriate language constructs/ tools are applied, Program/solution written is readable	Assigned problem is properly analyzed, correct solution designed, appropriate language constructs/ tools are applied	Assigned problem is properly analyzed & correct solution designed	Assigned problem is properly analyzed
AC3: Identification & Removal of errors/ bugs	Able to identify errors/ bugs and remove them	Able to identify errors/ bugs and remove them with little bit of guidance	Is dependent totally on someone for identification of errors/ bugs and their removal	Unable to understand the reason for errors/ bugs even after they are explicitly pointed out
AC4: Execution & Demonstration	All variants of input /output are tested, Solution is well demonstrated and implemented concept is clearly explained	All variants of input /output are not tested, However, solution is well demonstrated and implemented concept is clearly explained	Only few variants of input /output are tested, Solution is well demonstrated but implemented concept is not clearly explained	Solution is not well demonstrated and implemented concept is not clearly explained
AC5: Lab Record Assessment	All assigned problems are well recorded with objective, design constructs and solution along with Performance analysis using all variants of input and output	More than 70 % of the assigned problems are well recorded with objective, design constructs and solution along with Performance analysis is done with all variants of input and output	Less than 70 % of the assigned problems are well recorded with objective, design constructs and solution along with Performance analysis is done with all variants of input and output	

LAB EXPERIMENTS

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LAB EXPERIMENT 1

AIM: Introduction of Electrical Elements, sources, measuring devices.

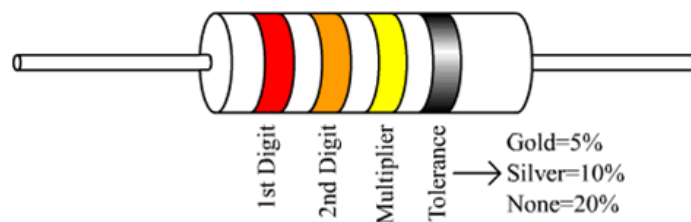
APPARATUS REQUIRED: Electrical elements, sources, measuring devices

THEORY:

Resistor:

Resistor is an electronic component whose function is to limit the flow of current in an electric circuit. It is measured in units called ohms. The symbol for ohm is Ω (omega).

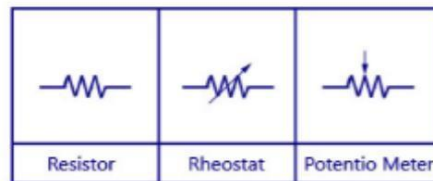
They are available in different values, shapes and sizes. Every material has some resistance. Some materials such as Rubber, Glass and air have very high opposition to current to flow These materials are called insulators. Other materials such as Copper, Silver and Aluminum etc, has very low resistance, they are called Conductors.



Color	Digit	Multiplier	Tolerance (%)
Black	0	10^0 (1)	
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	0.5
Blue	6	10^6	0.25
Violet	7	10^7	0.1
Grey	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

Resistor symbols:

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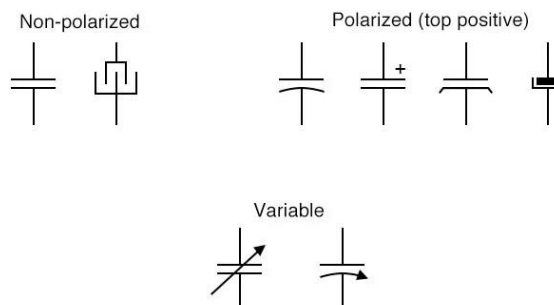


Different types of resistors

Capacitor:

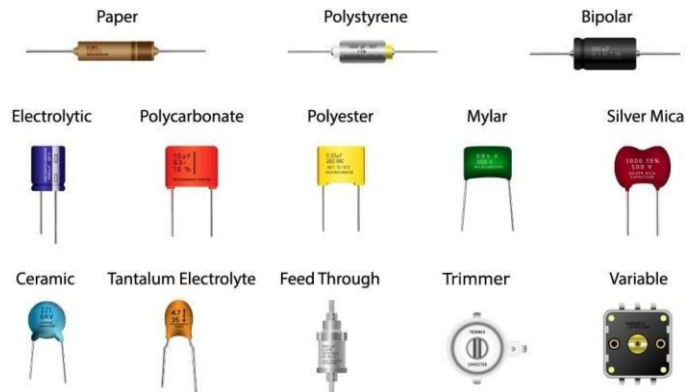
A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electrostatically in an electric field. By contrast, batteries store energy via chemical reactions. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator); for example, one common construction consists of metal foils separated by a thin layer of insulating film. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Capacitors are also very commonly used. A lot have their values printed on them, some are marked with 3-digit codes, and a few are color coded. The same resources listed above for resistors can also help you identify capacitor values. They are typically marked with an “C” on a circuit board.

Capacitor Symbol



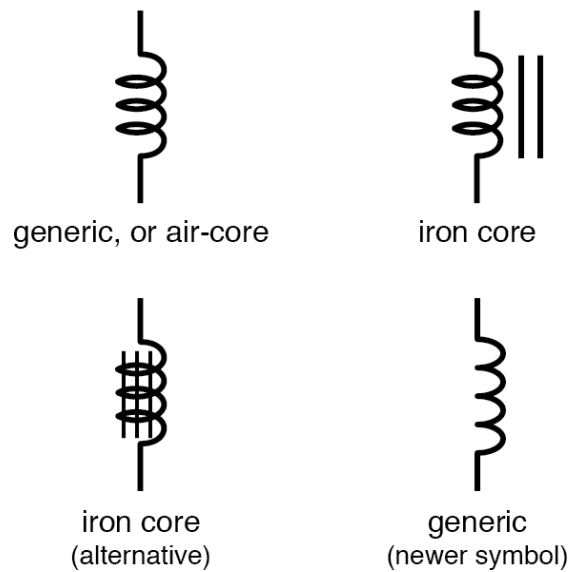
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Types of Capacitors



Inductor:

An inductor, also two-terminal electrical conductor such as a wire, current flows through it, in the coil. When the inductor change, the time voltage in the conductor, electromagnetic opposes the change in also called coils, can be a If they are color coded, can help, otherwise a inductance will be



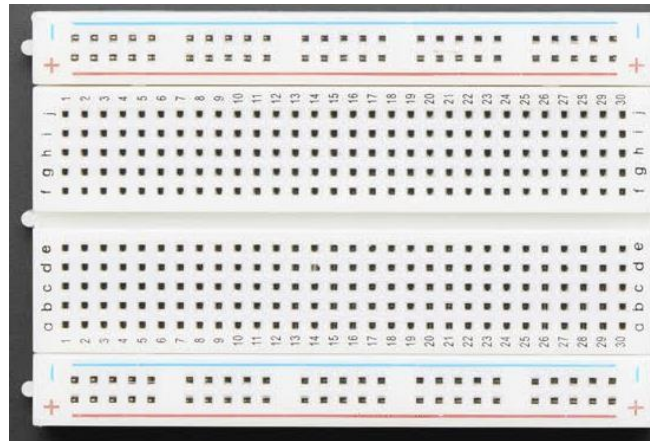
called a coil or reactor, is a passive component which resists changes passing through it. It consists of a usually wound into a coil. When a energy is stored in a magnetic field current flowing through an varying magnetic field induces a according to Faraday's law of induction, which by Lenz's law current that created it. Inductors, bit harder to figure out their values. the resources listed for resistors good meter that can measure needed.

They are typically marked with an "L" on a circuit board

Inductor Symbol:

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Types of inductors:



Bread Boards:

This is the platform (or chassis) on which any circuit can be ringed up to provide inter connections between electronics components and devices. The advantage of bread board is, the components can be connected (or) disconnected easily. It has holes both horizontally and vertically as shown in the figure. The horizontal holes at the top and bottom are having internal shorts where as in the remaining part vertical holes are shorted internally.



Air-Core Inductor



Iron-Core Inductor



Ferrite-Core Inductor



Bobbin Based Inductor



Variable Inductor



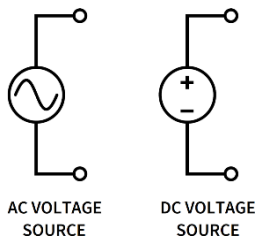
Multilayer Ceramic Inductor

Voltage Source:

A Voltage two-terminal device at any instant of time is independent of the from it.

Source is a whose voltage is constant and current drawn

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Variable Power supply available in lab:-

Current Source:

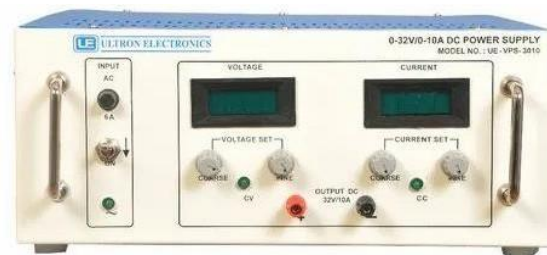
A current source is a two-terminal circuit element which supplies the same current to any load resistance connected across its terminals.

Voltmeter:

Voltmeter is parallelly connected with the electric circuit in order to measure the potential.

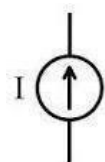
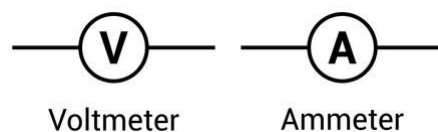
Ammeter:

The ammeter is used for measuring a small amount of current and the result is displayed in milliamperes when it is kept in series with the circuit to be measured so that the entire current in the circuit is passing through it.



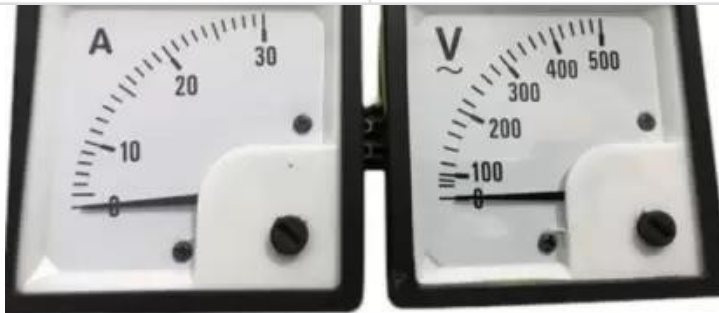
amount
circuit
circuit

Voltmeter and ammeter symbol:



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Difference Between Ammeter and Voltmeter	
Ammeter	Voltmeter
It is used to measure current.	It is used to measure the voltage across two points.
Resistance is low.	Resistance is high.
It is connected in series with the circuit and its accuracy is more.	It is connected in parallel with the circuit and its accuracy is less.
Changing the range is not possible.	Changing the range is possible.
For ideal ammeter, the value of resistance is 0.	For an ideal voltmeter, the value of resistance is approximately infinity.
It is denoted by a symbol A.	It is denoted by a symbol V.



RESULT: Study of

Electrical Elements, sources,

measuring devices is

done.

VIVA QUESTIONS:

1. What are the fundamental components of electrical circuits?

Ans: In general, a circuit has the following components:

- A cell or battery: source of electricity
- Connecting wires: Act as conductor to flow electric current
- Key or switch to control the circuit
- Bulb or electric device act as a load to the circuit

Metal wires are used in electric circuits because the metals are good conductors of electricity and allow current to pass through them

2. What are insulators?

Ans: Insulators are those substances through which electricity cannot flow are called insulators. Some

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common insulators are glass, plastic, rubber, and wood.

3. What are conductors?

Ans: Conductors are those substances through which electricity can flow are called conductors. Some common conductors are copper, aluminum, gold, and silver.

4. What is AC and DC?

Ans: Electric current flows in two ways as an alternating current (AC) or direct current (DC). The main difference between AC and DC lies in the direction in which the electrons flow. In DC, the electrons flow steadily in a single direction, while electrons keep switching directions, going forward and then backwards in AC.

5. What is active and passive elements?

Ans: An electric circuit element which can supply electric power to the circuit or power gain in the circuit, is known as an active element. The circuit element which can only absorb electrical energy and dissipates it in the form of heat or stores in either magnetic field or electric field is known as passive elements.

6. Explain R L and C.

Ans: R is a resistive component; L is Inductive and C is Capacitive.

In a R component, the current and Voltage vectors are in phase with each other i.e. the phase angle between the two is ZERO

In a L component, the phase angle between the current and Voltage vector is -90 deg i.e. the current vector lags the voltage vector by 90 deg

and in a C component, the phase angle between the current and voltage vectors is $+90$ deg i.e. the current vector leads the voltage vector by 90 deg.

LAB EXPERIMENT 2

AIM: To measure DC voltage and current, AC voltage and current with multi-meter

APPARATUS REQUIRED: Breadboard, Voltage source, Multimeter, Resistor, Ammeter, Voltmeter, Connecting wires

THEORY:

The DMM is an instrument which can be used to measure DC (non-time-varying) voltages and currents, AC (time-varying) voltages and currents, and resistance values. The signal is input to the DMM through two leads (wires), and the value measured is displayed. The DMM uses an A/D (analog-to-digital) converter, which converts DC voltages to a digital code. Therefore, internally the meter can read only DC voltages. Thus, to measure current or resistance, the signal must be converted into a voltage value. For current, this is easily done by placing a (very small) precision resistor in the circuit and measuring the voltage across the resistor, which will be linearly proportional to the current (remember Ohm's Law: $V=IR$).



Resistance measurements require more circuitry because a resistor is a passive element, thus a source must be provided in the DMM. In the DMM there is a current source to force a current through the resistor and the voltage is then measured. From this information the resistance value may be determined by Ohm's Law:

$$R = V/I$$

Additional circuitry is necessary to allow variable ranges. For voltage and resistance measurements this consists of various voltage-divider networks which are switched in. For current measurements it consists of different resistors to be switched in. Also, an RMS (root mean square) circuit is used to convert the AC

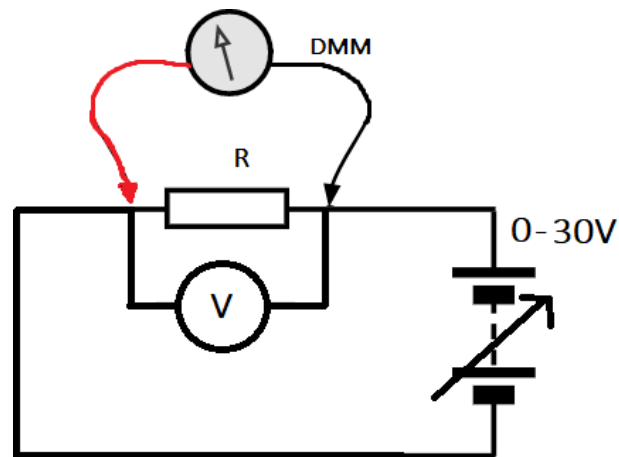
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voltages to DC voltages. The DC voltage given is the square root of the average value of the input voltage squared.

The DC voltage is converted into a digital code by the A/D converter. This digital code is decoded using the range of information and displayed. Since a voltmeter measures the voltage across itself, it should be connected in parallel with the device to guarantee that the voltage across the device under test (DUT) is the same as the voltage across the voltmeter. An ammeter measures the current through itself, so it should be connected in series with the DUT in order to ensure that the current through the ammeter is the same as the current through the DUT. An ohmmeter sends out a current and measures the voltage produced across the DUT. Because the ohmmeter is ultimately measuring a voltage, it should be connected in parallel with the DUT. When measuring a resistance, one end of the resistor should be disconnected from the circuit so that all of the current from the DMM's current source is passing through the resistor to be measured. Otherwise, one is not measuring the resistance value of the resistor because the current going through the resistor is unknown.

A. To measure voltage using DMM

Circuit Diagram:



measure voltage using DMM

OBSERVATION TABLE:

S. No.	Applied Voltage	Voltmeter Reading	DMM Reading	Error
1.				
2.				
3.				
4.				
5.				

B. To measure current using DMM

Circuit Diagram:

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OBSERVATION TABLE:

S. No.	Applied Voltage	Ammeter Reading	DMM Reading	Error
1.				
2.				
3.				
4.				
5.				

RESULT: DC voltage and current with multi-meter is measured.

PRECAUTIONS:

1. All the connection should be tight.
2. Ammeter is always connected in series in the circuit while voltmeter is parallel to the conductor.
3. The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.
4. Maximum reading of voltmeter should be greater than the electromotive force of the cell.
5. It should be care that the values of the components of the circuit is does not exceed to their ratings (maximum value).
6. Before the circuit connection it should be check out working condition of all the components.

VIVA QUESTIONS:

1. What are applications of multimeter?

Ans: The applications of a multimeter are mentioned as follows below:

- It is used to measure AC and DC voltage and current.
- It is also used to measure resistance.
- It is also used to check the diodes.
- It is also used to measure the frequency as well as the capacitance of an electronic device.
- It is also used to test batteries, switches, light bulbs, and outlets.
- It is also used to determine any faults present in the electric circuit.
- It is used to measure the time and frequency of the electronic device.
- It is also used to check the temperature of the electronic device.

2. What quantities are measured using multimeter?

Ans: A typical multimeter can measure voltage, resistance, and current.

3. What are different types of probes used in multimeter?

Ans: A multimeter can use many different test probes to connect to the circuit or device under test. Crocodile clips, retractable hook clips, and pointed probes are the three most common types. Tweezer probes are used for closely spaced test points, as for instance surface-mount devices.

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4. Current is converted to voltage _____.

Ans: through a low shunt resistance.

5. For resistance measurement, meter contains _____.

Ans: a precision low current source applied across an unknown resistance which gives a d.c. voltage.

6. Output of a digital multimeter is _____.

Ans: the digital display by which it shows results and the beeper

LAB EXPERIMENT 3

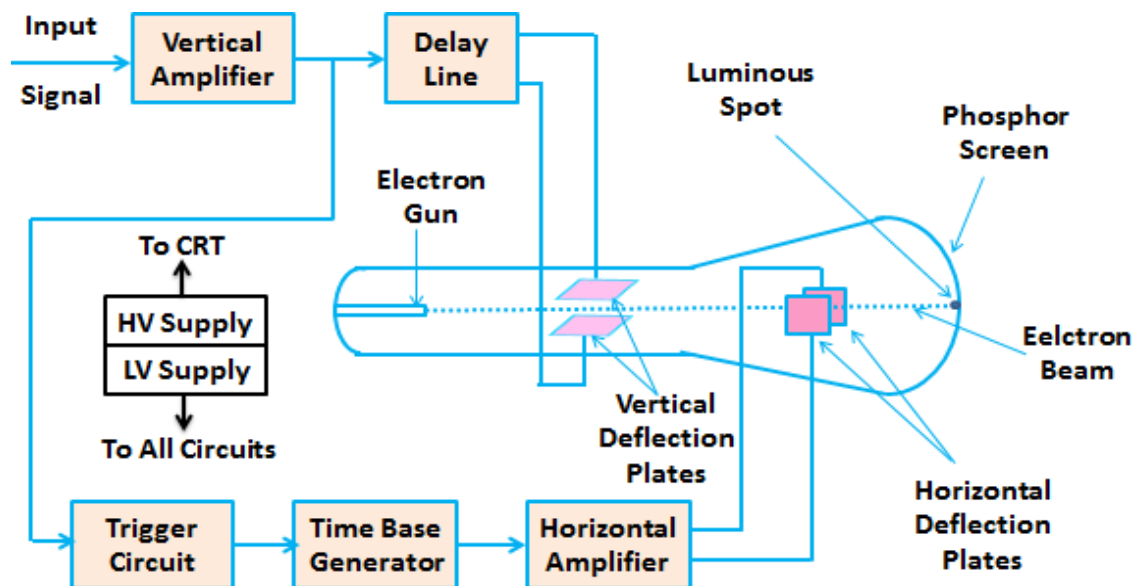
AIM: To observe waveforms on oscilloscope, measure basic parameters amplitude and frequency of sine wave and square wave.

APPARATUS REQUIRED: oscilloscope, cables and function generator

THEORY:

The oscilloscope is a valuable tool for both design and troubleshooting. Knowledge of the instrument's theory of operation aids in the correct application of the instrument in the laboratory. This knowledge will lead to correct measurements and the safe use of the instrument. The oscilloscope is a device for displaying repetitive events in terms of a voltage on the vertical axis and time on the horizontal axis. Any response that can be converted to a time varying electric signal can be displayed on the oscilloscope. The most common use of the instrument in electrical/electronic design is to display time varying waves.

Block Diagram of Typical Oscilloscope:

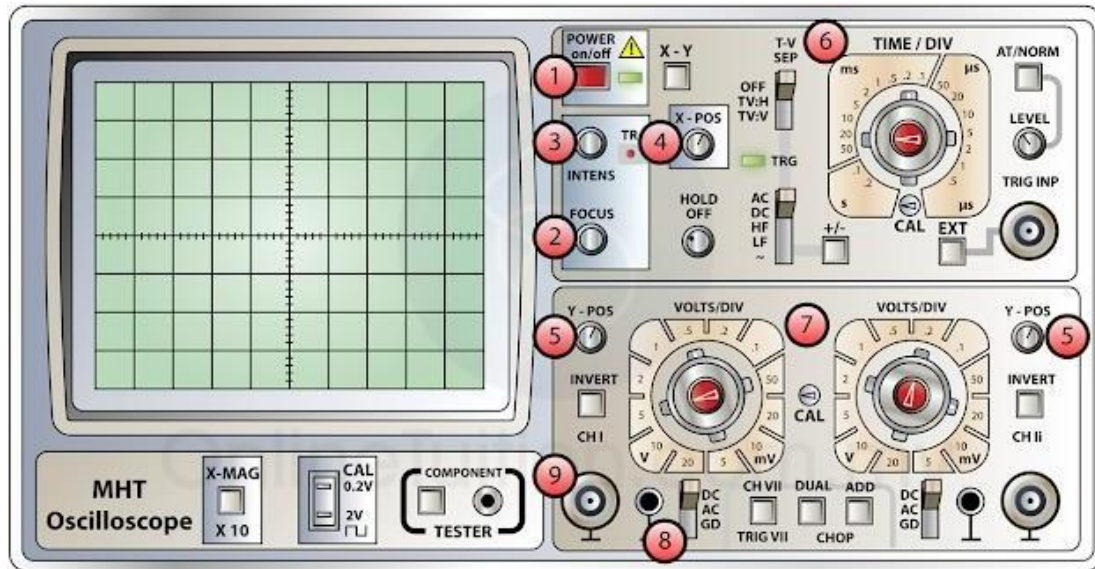


Signals enter the oscilloscope through the channel I and 2 inputs. The vertical preamplifiers are accurate, wide-band amplifiers connected to a voltage divider attenuator network. The incoming signals are routed through the input coupling switch to the preamplifier/attenuator. At this point, a portion of the signal is diverted to the Sweep Generator by the trigger circuits. The vertical signal is then sent on the delay line. The delay line provides a short time delay so the leading edge of the desired signal can be viewed. From the delay circuit, the vertical signal is routed to the vertical amplifier. The vertical amplifier provides a voltage to the plates inside the C.R.T. that direct the electron beam vertically onto the face of the scope. The heart of the horizontal deflection circuit is the sweep generator. The sweep generator produces a ramp wave that is synchronized to the input channels by the trigger circuit. The time base control determines the time required for the ramp wave to reach its maximum value, which controls the time it takes for the C.R.T. trace to traverse

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the scope face. The sweep generator drives the horizontal deflection amplifiers. These amplifiers connect to plates inside the C.R.T. that direct the electron beam horizontally onto the face of the scope.

The high voltage power supply supplies the potential that produces the electron beam in the C.R.T. The low voltage power supply powers all other sub-circuits in the instrument.



S. No.	Switch	Functions
1.	Power switch	To switch on and off of the oscilloscope
2.	Focus control	To control the focus of the spot on the screen.
3.	Intensity control	To control the brightness of the spot on the screen.
4.	X-offset	Y-offset moves the whole trace vertically up and down on the screen, while X-offset moves the whole trace from side to side on the screen.
5.	Y-offset	
6.	Time base control	Whenever we switch on the time-base, we are actually applying a sawtooth voltage to the X-plates * This makes the electron beam sweep across the screen at a constant speed. * By knowing the period of each cycle, T, we can then know how fast the beam is sweeping across the screen. The time-base is thus a measure of time for the oscilloscope.
7.	Y gain control	The “Volts/Div.” wheels amplify an input signal so that for a division a given voltage level is invalid. A “division” is a segment, a square on the screen of the oscilloscope. A setting of “.5” i.e., means, that the height of a single square equals a voltage of 0.5 V. An amplitude of 1 V would have a size of two divisions vertical to the abscissa.
8.	d.c./a.c. switch	d.c. – d.c. and a.c. voltage displayed. a.c. – only a.c. voltage displayed.
9.	X-input and Y-input	Electric input connects to the X-plate and Y-plate.

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APPLICATIONS

- The CRO's are used in huge applications like radio stations for observing the transmitting & receiving the properties of the signal.
- The CRO is used to measure the voltage, current, frequency, inductance, admittance, resistance, and power factor.
- This device is also used to check the AM and FM circuits characteristics
- This device is used to monitor the signal properties as well as characteristics and also controls the analog signals.
- The CRO is used through the resonance circuit to view the shape of the signal, bandwidth, etc.
- The shape of voltage and current waveform can be observed by CRO which helps to take the necessary decision in a radio station or communication station.
- It is used in laboratories for the purpose of research. Once researchers design a new circuit, then they use CRO to verify the waveforms of voltage and current of every element of the circuit.
- Used for comparing phase & frequency
- It is used in TV, Radar, and analysis of engine pressure
- To check the reactions of nervous and heartbeat.
- In the hysteresis loop, it is used to find BH curves
- Transistor curves can be traced.

Advantages

The advantages of CRO include the following.

- Cost and Timeline
- Training requirements
- Consistency & quality
- Time efficiency
- Hassle-free
- Expertise & experience
- Capacity for problem-solving
- Assurance for regulatory compliance
- Voltage measurement
- Current measurement
- Examination of waveform
- Measurement of phase and frequency

Disadvantages

The disadvantages of CRO include the following.

- These oscilloscopes are expensive as compared with other measuring devices like multimeters.
- They are complicated to repair once it gets damaged.
- These devices need complete isolation
- These are huge, heavy and uses more power
- A lot of control terminals

Use of CRO(Cathode Ray Oscilloscope)

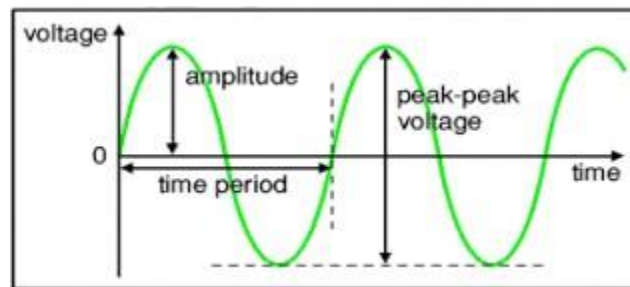
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Current Measurement: We can measure the value of current or magnitude and direction of current using CRO. By calculating the amplitude variation, horizontal and vertical cells in the CRO screen we can measure the current. We can measure both AC and DC in CRO.

Voltage Measurement: We can measure AC voltage as well as DC voltage in CRO. Here also the same procedure should be followed to measure the voltage that is calculating horizontal and vertical cells in the CRO screen.

Frequency Measurement: We not only measure voltage and current using CRO, but we can also measure the frequency of a signal by calculating the time period. Once we measure the time period of a signal then we can easily measure the frequency. The measurement of the time period using CRO also very easy.

Phase Difference Measurement: Most of the CROs has two channels. We can apply two different signals at a time on the CRO. And we can measure easily the phase difference between the two different signals. Lissajous figures in the CRO screen helps us to measure the phase difference between two signals. Using this method, we can also measure the frequency of two signals at a time.



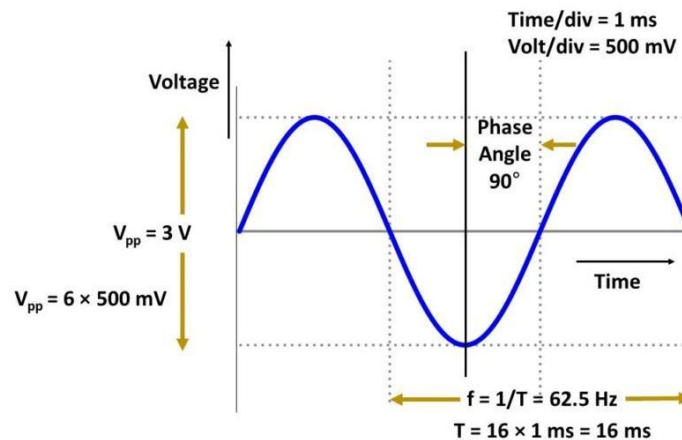
PROCEDURE:

1. Set the oscilloscope with the volt/cm control at 1, the time base control at 1 ms/cm and the AC-DC switch to AC.
2. Set the signal generator to 2 V, 50 Hz, sinusoidal output. Connect the high-impedance output terminals to the input of the CRO.
3. Show the effects of varying the output voltage of the signal generator (amplitude changes) and the frequency (period changes).
4. Switch between the different output waveforms (sinusoidal, square and triangular) to show these.

OBSERVATION TABLE:

S. No.	Observed waveform	Measured Voltage V_{pp}	Time Period T	Frequency f
1.				

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RESULT: Waveforms on oscilloscope, basic parameters amplitude and frequency of sine wave is observed and measured.

VIVA QUESTIONS:

1. How is CRO superior to ordinary measuring instruments?

Ans: CRO is an electronic device that gives graphical representation of alternating quantities under examination. The CRO gives very accurate measurements and is free from the errors introduced by the moving parts.

2. Name main components of a cathode ray tube (CRT).

Ans: The three main parts of a cathode ray tube are:

- Electron gun: It gives out a fine beam of electrons.
- Deflecting system: It deflects the electron beam.
- Fluorescent screen: It is the part of the cathode ray tube on which the visual pattern of electron beam is obtained.

3. Enlist the applications of CRO.

- radio stations for observing the transmitting & receiving the properties of the signal.
- measure the voltage, current, frequency, inductance, admittance, resistance, and power factor.
- This device is also used to check the AM and FM circuits characteristics
- monitor the signal properties as well as characteristics and also controls the analog signals.
- The CRO is used through the resonance circuit to view the shape of the signal, bandwidth, etc.
- The shape of voltage and current waveform can be observed by CRO which helps to take the necessary decision in a radio station or communication station.
- It is used in laboratories for the purpose of research.
- Used for comparing phase & frequency

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- It is used in TV, Radar, and analysis of engine pressure
- To check the reactions of nervous and heartbeat.
- In the hysteresis loop, it is used to find BH curves
- Transistor curves can be traced.

4. What is difference between analog storage oscilloscope and digital storage oscilloscope?

Ans: Digital storage allows you to store information in a way that is more efficient and compact than analog storage methods. The advantage of digital storage is that it can hold much more information, take up less space, and be created in a shorter amount of time than analog methods.

5. What electron gun assembly is provided in CRT?

Ans: The electron gun assembly of CRT consists of an indirectly heated cathode, a control grid surrounding the cathode, a focusing anode and an accelerating anode. The sole function of the electron gun assembly is to provide a focused electron beam which is accelerated towards the phosphor screen.

6. Deflection system of a CRT consists of _____

Ans: The cathode-ray-tube deflection system is made up of two pairs of parallel plates known as the vertical and horizontal deflection plates.

BASICS OF ELECTRICAL ENGINEERING LAB (EEE-103P)

LAB EXPERIMENT 4(A)

AIM: Verification of Ohm's law

APPARATUS REQUIRED: Breadboard, Voltage source, Resistor, Ammeter, Voltmeter, Connecting wires

THEORY:

Ohm's Law states that "If the physical conditions such as temperature, pressure, etc., remain the same during the experiment, then the current (I) flowing is directly proportional to the potential difference (V) across the ends of the circuit"

$$V = I \times R \quad I = \frac{V}{R} \quad R = \frac{V}{I}$$

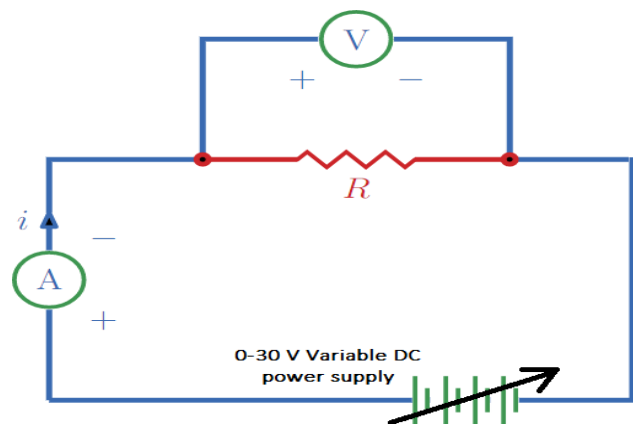
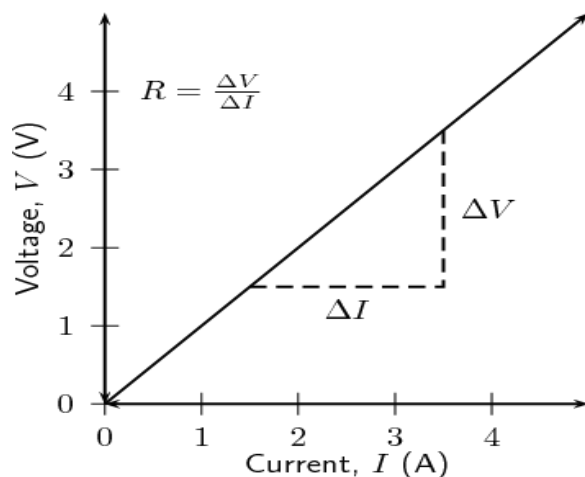
V = volts , I = current in amperes , R = resistance in ohms

Where,

1. The resistance(R) is the characteristic property of the conductor which resist the flow of electric current through it
2. The potential difference (V) is the is the potential difference across the ends of a conductor.
3. The electric current (I) is the amount of charge flowing through a particular area in a unit time.

Ohm's law only holds true if the provided temperature and the other physical factors remain constant. In certain components, increasing the current raises the temperature. An example of this is the filament of a light bulb, in which the temperature rises as the current is increased. In this case, Ohm's law cannot be applied. The lightbulb filament violates Ohm's Law.

If we plot a graph between the current (I) and the applied potential difference(V) between its ends, for an ideal resistance it will be a straight line as shown:



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PROCEDURE:

1. Connect the battery, ammeter and resistance in series.
2. The voltmeter is connected in parallel connection across the given coil. The circuit is closed.
3. Note down the ammeter reading I and the corresponding potential difference across the coil in the voltmeter as V.
4. Use the formula to calculate the resistance of the resistance.
5. The experiment is repeated for different values of current and the corresponding potential difference is noted.
6. These values will be found to be a constant. Thus, verifying Ohm's law.

OBSERVATION TABLE:

S. No.	Applied Voltage	Ammeter Reading	Voltmeter Reading	Resistance of coil $R = V/I$ (ohm)
1.				
2.				
3.				
4.				
5.				

The mean value of Resistance is calculated as:

$$R = \frac{R_1 + R_2 + R_3 + R_4 + R_5}{5}$$

For the V-I graph, The slope of Line AB

$$R = \frac{V_2 - V_1}{I_2 - I_1}$$

RESULT: Ohm's law is verified.

PRECAUTIONS:

1. All the connection should be tight.
 2. Ammeter is always connected in series in the circuit while voltmeter is parallel to the conductor.
 3. The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.
 4. Maximum reading of voltmeter should be greater than the electromotive force of the cell.
 5. It should be care that the values of the components of the circuit is does not exceed to their ratings (maximum value).
 6. Before the circuit connection it should be check out working condition of all the components
-

LAB EXPERIMENT 4(B)

AIM: Verification of KVL

APPARATUS REQUIRED: Breadboard, Voltage source, Resistor, Voltmeter, Connecting wires

THEORY:

Kirchhoff's Voltage Law (KVL):

Kirchhoff's Voltage Law (KVL) in a DC circuit states that, "the algebraic sum of the Voltage drop around any closed path is equal to the algebraic sum of the Voltage rises".

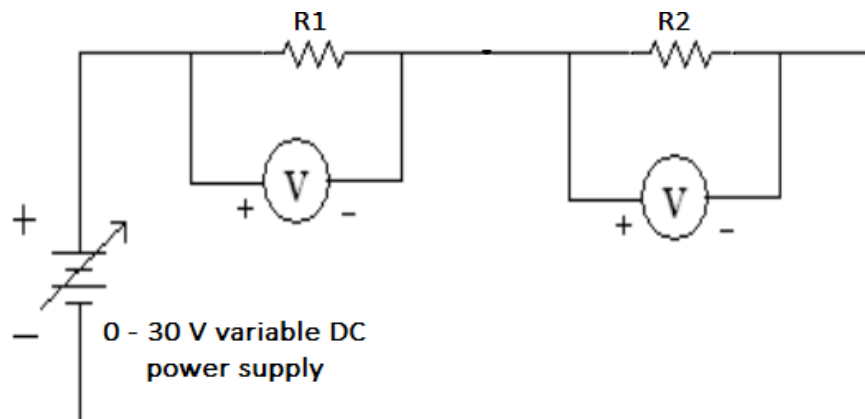
In other words, "the algebraic sum of the Voltage rises and drops around any closed path is equal to zero". A plus (+) sign is assigned for the potential rises (- to +) and minus sign (-) is assigned to a potential drop (+ to -). In symbolic form, Kirchhoff's Voltage Law (KVL) can be expressed as $\sum V=0$, Where C is used for closed loop and V is used for the potential rises and drops.

In any closed path / mesh, the algebraic sum of EMF and voltage drops is zero.

The sum of all the voltages around a loop is equal to zero i.e., $v_1 + v_2 + v_3 + v_4 = 0$.

Kirchhoff's Voltage Law (KVL) is Kirchhoff's second law that deals with the conservation of energy around a closed-circuit path.

CRICUT DIAGRAM:



PROCEDURE:

1. Connect the battery and resistance in series.
 2. The voltmeters are connected in parallel connection across the resistances. The circuit is closed.
 3. Note down the voltmeters reading.
 4. Use the formula to calculate the total voltage $V = V_1 + V_2$.
-

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5. The experiment is repeated for different values of supply voltage and the corresponding potential differences are noted.
6. Also find the errors between calculated and measured values.

OBSERVATION TABLE:

S. No.	Applied Voltage V	V ₁	V ₂	V _m = V ₁ + V ₂	Error V-V _m
1.					
2.					
3.					
4.					
5.					

RESULT: KVL is verified.

PRECAUTIONS:

1. All the connection should be tight.
2. Ammeter is always connected in series in the circuit while voltmeter is parallel to the conductor.
3. The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.
4. Maximum reading of voltmeter should be greater than the electromotive force of the cell.
5. It should be care that the values of the components of the circuit is does not exceed to their ratings (maximum value).
6. Before the circuit connection it should be check out working condition of all the components.

LAB EXPERIMENT 4(C)

AIM: Verification of KCL

APPARATUS REQUIRED: Breadboard, Voltage source, Resistor, Ammeter, Connecting wires

THEORY:

Kirchhoff's Current Law (KCL):

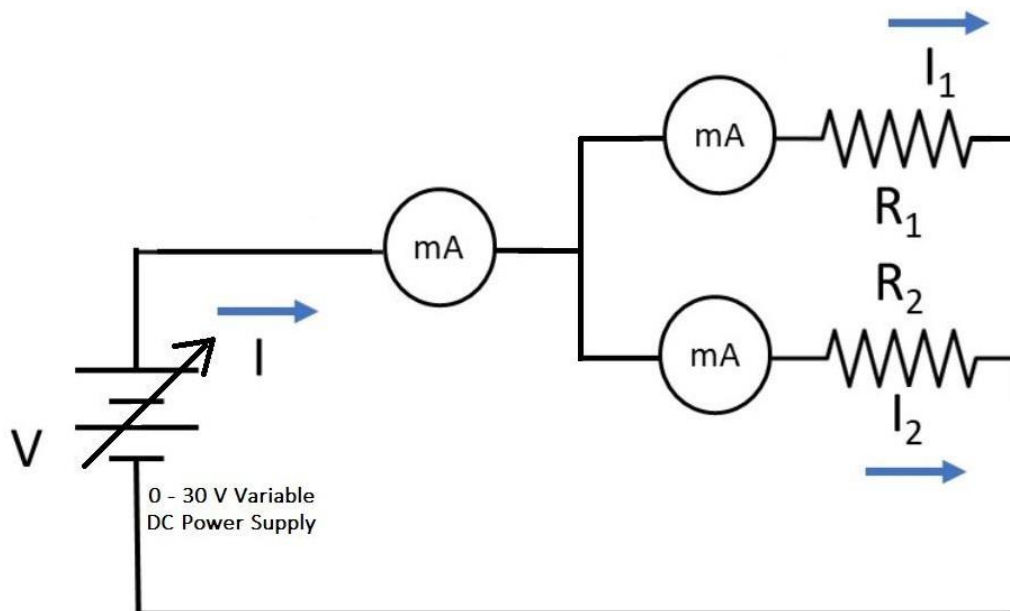
It States that the algebraic sum of currents meeting at a junction is zero. In other words, the sum of the currents flowing away from a junction is equal to the sum of current entering in to the junction.

For example-

There are six currents I_1, I_2, I_3, I_4, I_5 and I_6 meeting at a junction. Assuming that the currents entering into the junction, are positive and current leaving the junction, are negative.

According to KCL $I_1 + I_2 + I_3 + I_4 + I_5 + I_6 = 0$

CRICUT DIAGRAM:



PROCEDURE:

1. Connect the battery in series with a parallel combination of resistances.
2. The ammeters are connected in series of the resistances. The circuit is closed.
3. Note down the ammeters reading.
4. Use the formula to calculate the total current $I = I_1 + I_2$.

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- The experiment is repeated for different values of supply voltage and the corresponding current readings are noted.
- Also find the errors between calculated and measured values.

OBSERVATION TABLE:

S. No.	Applied Voltage V	I	I ₁	I ₂	I _m = I ₁ + I ₂	Error I-I _m
1.						
2.						
3.						
4.						
5.						

RESULT: KCL is verified.

PRECAUTIONS:

- All the connection should be tight.
- Ammeter is always connected in series in the circuit while voltmeter is parallel to the conductor.
- The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.
- Maximum reading of voltmeter should be greater than the electromotive force of the cell.
- It should be care that the values of the components of the circuit is does not exceed to their ratings (maximum value).
- Before the circuit connection it should be check out working condition of all the components.

VIVA QUESTIONS:

- Explain Ohm's Law.
Ans: Ohm's law states that the voltage across a conductor is directly proportional to the current flowing through it, provided all physical conditions and temperatures remain constant.
- What is another name for KCL & KVL?
Ans: Nodal Analysis and Mesh Analysis
- Define network and circuit?
Ans: An electrical circuit is a network consisting of a closed loop, giving a return path for the current. Thus, all circuits are networks, but not all networks are circuits (although networks without a closed loop are often imprecisely referred to as "circuits").
- What is the difference between mesh and loop?
Ans: Loop and mesh both are a part of a circuit. A loop is any closed path through a circuit where no

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node quite once is encountered. A mesh is a closed path during a circuit with no other paths inside it.

5. What is the difference between node and junction?

Ans: A node has at least two connecting elements, but a junction has at least 3 connecting elements.

LAB EXPERIMENT 5(A)

AIM: To verify Thevenin's Theorem

APPARATUS REQUIRED: Breadboard, Voltage source, Resistor, Voltmeter, Connecting wires

THEORY:

THEVENIN'S THEOREM:

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

The values of V_{Th} and R_{Th} are determined as mentioned in thevenin's theorem.

Once the thevenin equivalent circuit is obtained, then current through any load resistance R_L

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.

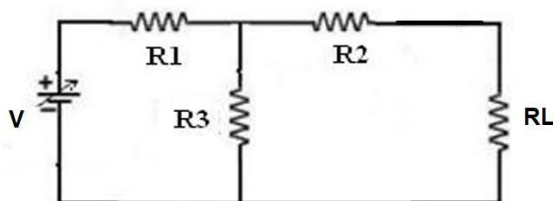
To find V_{Th} , the load resistor 'RL' is disconnected, then $V_{Th} = \frac{V}{R_1 + R_2} \times R_2$

To find R_{Th} ,

$$R_{Th} = R_2 + \frac{R_1 R_3}{R_1 + R_3}$$

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

CRICUT DIAGRAM:



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PROCEDURE:

1. Connect the circuit as per fig
2. Adjust the output voltage of the regulated power supply to an appropriate value, V .
3. Note down the response (current, I_L) through the branch of interest i.e., AB.
4. Reduce the output voltage of the regulated power supply to 0V and switch-off the supply.
5. Adjust the output voltage of the regulated power supply, V .
6. Note down the voltage across the load terminals AB (Voltmeter reading) that gives V_{th} .
7. Connect the digital multimeter (DMM) across AB terminals and it should be kept in resistance mode to measure Thevenin's resistance (R_{Th}) without power supply.

OBSERVATION TABLE:

Applied Voltage V	I_L	V_{TH}	R_{TH}	I_L (calculated)	V_{TH} (calculated)	R_{TH} (calculated)

RESULT: Thevenin Theorem is verified.

PRECAUTIONS:

1. All the connection should be tight.
2. Ammeter is always connected in series in the circuit while voltmeter is parallel to the conductor.
3. The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.
4. Maximum reading of voltmeter should be greater than the electromotive force of the cell.
5. It should be care that the values of the components of the circuit is does not exceed to their ratings (maximum value).
6. Before the circuit connection it should be check out working condition of all the components.

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LAB EXPERIMENT 5(B)

AIM: To Verify Norton's Theorem.

APPARATUS REQUIRED: Breadboard, Voltage source, Resistor, Ammeter, Connecting wires

THEORY:

NORTON'S THEOREM:

Norton's theorem states that in a lumped, linear network the equivalent circuit across any branch is replaced with a current source in parallel a resistance. Where the current is the Norton's current which is the short circuit current through that branch and the resistance is the Norton's resistance which is the equivalent resistance across that branch by replacing all the sources with their internal resistances

FOR SOURCE CURRENT

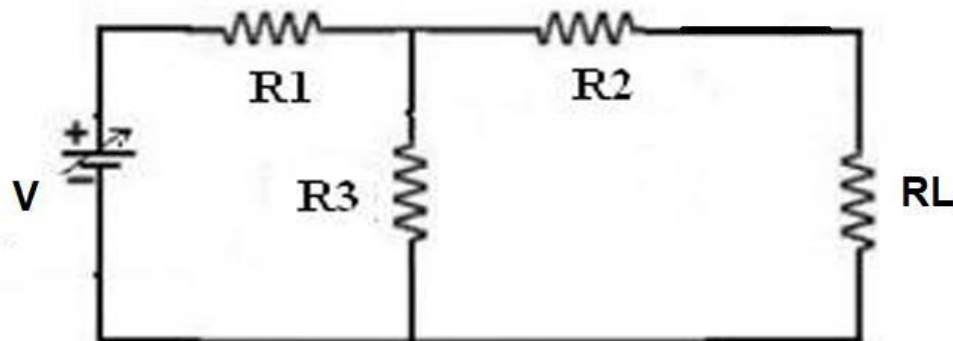
$$I = \frac{V}{R_1 + R_2 + R_3} = \frac{V(R_2 + R_3)}{R_1(R_2 + R_3) + R_2 R_3}$$

FOR NORTON'S CURRENT

$$I_N = I \times \frac{R_3}{R_2 + R_3} = \frac{V \times R_3}{R_1(R_2 + R_3) + R_2 R_3}$$

Load Current through Load Resistor $I_L = I_N \times [R_N / (R_N + R_L)]$

CRICUT DIAGRAM:



PROCEDURE:

1. Connect the circuit as per fig
2. Adjust the output voltage of the regulated power supply to an appropriate value.
3. Note down the response (current, I_L) through the branch of interest i.e., AB (ammeter reading).
4. Reduce the output voltage of the regulated power supply to 0V and switch-off the supply.
5. Note down the response (current, I_N) through the branch AB (ammeter reading).

6. Connect the Assignment File to the Assignment File (Distance mode to)

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measure Norton's resistance (R_N).

OBSERVATION TABLE:

Applied Voltage V	I_L	I_N	R_N	I_L (calculated)	I_N (calculated)	R_N (calculated)

RESULT: Norton's theorem is verified.

PRECAUTIONS:

1. All the connection should be tight.
2. Ammeter is always connected in series in the circuit while voltmeter is parallel to the conductor.
3. The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.
4. Maximum reading of voltmeter should be greater than the electromotive force of the cell.
5. It should be care that the values of the components of the circuit is does not exceed to their ratings (maximum value).
6. Before the circuit connection it should be check out working condition of all the components.

VIVA QUESTIONS:

1. State and explain Thevenin's theorem.
Ans: Thevenin's theorem states that an equivalent circuit can replace any linear circuit consisting of various resistances and voltages with a single source voltage and a series resistance connected across the load terminal.
2. State and explain Norton's theorem.
Ans: Norton's theorem states that any linear circuit can be simplified to an equivalent circuit consisting of a single current source and parallel resistance that is connected to a load.
3. The internal resistance of a source is 2 Ohms and is connected with an External Load of 10 Ohms Resistance. What is R_{th} ?
Ans: 2 ohms
4. In the above question if the voltage is 10 volts and the load is of 50 ohms. What is the load current and V_{th} ? Verify I_L ?
Ans: $I_L = 10/(50+2) = 0.19$ A, $R_{th} = 2$ ohms and $V_{th} = 10$ V, $I_L = 0.19$ A
5. If the internal resistance of a source is 5 ohms and is connected with an External Load Of 25 Ohms Resistance. What is R_{th} ?

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Ans: 5 ohms

6. In the above question if the voltage is 20V and the load is of 50 Ohms. What is the load current and I_N ?
Verify I_L ?

Ans: $I_L = 20/(50+5) = 0.364$ A, $R_N = 5$ ohms and $I_N = 4$ A, $I_L = 4*5/55 = 0.364$ A

LAB EXPERIMENT 6

AIM: To verify the resonance in R-L-C circuits.

APPARATUS REQUIRED: Resonance kit, Oscilloscope, Connecting leads and Power Supply.

THEORY:

Resonance in AC circuits implies a special frequency (called the resonant frequency) determined by the values of the circuit elements. This frequency is designated f_r in hertz and ω_r in radians/second, and is the frequency at which the series resonant circuit will exhibit minimum impedance and the parallel resonant circuit will exhibit a very large impedance. If capacitors and inductors were ideal (i.e., no series or parallel resistance) the definition of resonant frequency would be much simpler. In most applications the primary concern with capacitors is the parallel resistance which gives rise to a parallel leakage current. However, if the capacitor is properly chosen, this resistance will be 100 M Ω or more, and will cause little difficulty. In addition to inductance, inductors will have a series resistance and possibly a parallel capacitance of concern. The series resistance is simply the resistance of the wire used to wind the inductor and may significantly increase at frequencies in the MHz range as a result of the skin effect. The parallel capacitance is due to the distributed capacitance between the windings and is also of greater concern in higher frequency applications. For the purposes of this experiment, we will assume the capacitor and inductor are ideal.

In addition to the resonant frequency, resonant circuits also exhibit lower and upper half power frequencies or break frequencies designated as f_1 and f_2 , respectively. These are the frequencies below and above the resonant frequency at which the power absorbed by the network falls to 50% of its maximum value. At these frequencies, the magnitude of the current into a voltage-driven, series-resonant network and the magnitude of the voltage across a current-driven, parallel-resonant network are 0.707 of their maximum value.

This 0.707 value results from the fact that both current and voltage are proportional the square-root of power and the square-root of 0.5 is 0.707. Since 3dB is equivalent to half power, these frequencies are also referred to as the 3 dB frequencies. The difference between the upper and lower half-power frequencies is the bandwidth (BW).

Series Resonance

The resonance of a series RLC circuit occurs when the inductive and capacitive reactance are equal in magnitude but cancel each other because they are 180 degrees apart in phase. The impedance of an RLC series circuit at resonance is simply R

CIRCUIT DIAGRAM:

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$$|Z| = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\phi_z = \tan^{-1} \left(\frac{X_L - X_C}{R} \right)$$

$$\omega_r = \sqrt{1/LC} = \sqrt{\omega_{c1}\omega_{c2}}$$

$$B = \omega_{c2} - \omega_{c1} = R/L$$

$$Q = \frac{\omega_r}{B}$$

At Resonance

$$|Z| = R$$

$$|X_L| = |X_C|$$

$$\phi_z = 0$$

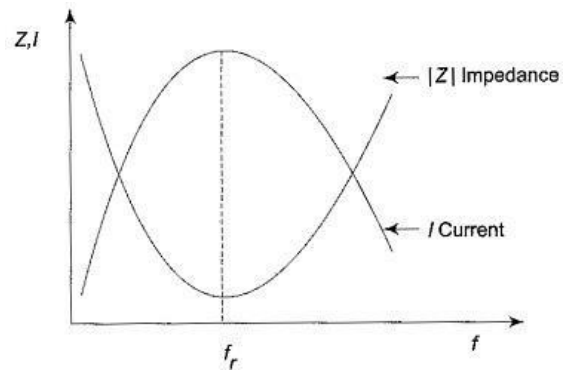
At resonance

$$* X_L = X_C$$

$$* f_r = \frac{1}{2\pi\sqrt{LC}}$$

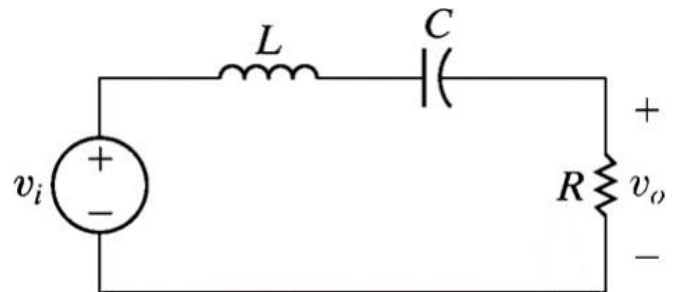
$$* Z_S = R \text{ (min.)}$$

$$* I = \frac{V}{R} \text{ (max.)}$$



PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Vary the frequency in the set region slowly.
3. Record I (which may not remain constant at the set value).
4. Read the frequency at the peak value of the current.



OBSERVATION TABLE:

R	L	C	f _r (calc.)	I _{peak}	f _r (measured)

RESULT: -The input and output characteristic of transistor in common base configuration has been plotted.

PRECAUTIONS:

1. All the connection should be tight.
2. Handle the equipment's with care.
3. The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.

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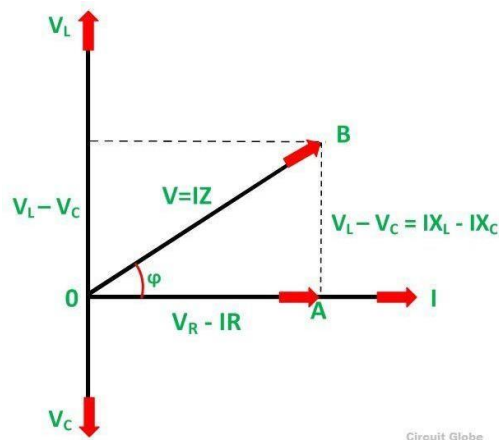
4. It should be care that the values of the components of the circuit is does not exceed to their ratings (maximum value).
5. Before the circuit connection it should be check out working condition of all the components.

VIVA QUESTIONS:

1. Define Q factor.

Ans: The Q, or quality, factor of a resonant circuit is a measure of the “goodness” or quality of a resonant circuit. A higher value for this figure of merit corresponds to a narrower bandwidth, which is desirable in many applications. More formally, Q is the ratio of power stored to power dissipated in the circuit reactance and resistance

2. Draw the phasor diagrams for series RLC circuit.



3. Define resonant frequency.

Ans: Resonant frequency is the natural frequency where a medium vibrates at the highest amplitude. Resonant frequency is usually denoted as f_0 . Resonance is witnessed in objects in equilibrium with acting forces and could keep vibrating for a long time under perfect conditions.

4. How the RLC series circuit behaves for the frequencies above and below the resonant frequencies?

Ans: Below resonant frequency, the circuit behaves as inductive circuit and above resonant frequency, the circuit behaves as capacitive circuit.

5. What is the condition for resonance for an RLC series circuit?

Ans: The resonance of a series RLC circuit occurs when the inductive and capacitive reactances are equal in magnitude but cancel each other because they are 180 degrees apart in phase.

6. Define Bandwidth.

Ans: The bandwidth (BW) of a resonant circuit is defined as the total number of cycles below and above the resonant frequency for which the current is equal to or greater than 70.7% of its resonant value. The two frequencies in the curve that are at 0.707 of the maximum current are called band, or half-power frequencies.

LAB EXPERIMENT 7

AIM: To perform O.C. and S.C. tests of a transformer

APPARATUS REQUIRED: Single Phase Transformer 1 KVA 230/230V with Tappings at 50% & 86.6% Naturally Air-Cooled Copper Double wound, Shell type. The transformer will be housed in MS sheet box enclosure with rubber footings. All the terminals of primary & secondary shall be brought over to bakelite sheet fitted on top of the box through insulated terminals.

THEORY:

Open Circuit Test:

In this test low voltage winding (primary) is connected to a supply of normal voltage and frequency (as per the rating of transformer) and the high voltage winding (secondary) is left open as shown in fig. The primary winding draws very low current hardly 3 to 5 percentage of full load current (may be upto 10% for very small rating transformer used for laboratory purpose) under this condition. As such copper losses in the primary winding will be negligible. Thus mainly iron losses occur in the transformer under no load or open circuit condition, which are indicated by the wattmeter connected in the circuit.

Hence, total iron losses = W_0 (Reading of Wattmeter)

From the observation of this test, the parameters R_0 and X_m of the parallel branch of the equivalent circuit can also be calculated, following the steps given below :

Power drawn, $W_0 = V_0 I_0 \cos \phi_0$

$$\text{Thus, no load power factor, } \cos \phi_0 = \frac{W_0}{V_0 I_0}$$

Core loss component of no load current, $I_w = I_0 \cos \phi_0$

And, magnetising component of no load current, $I_m = I_0 \sin \phi_0$

$$\text{Equivalent resistance representing the core loss, } R_0 = \frac{V}{I_w}$$

$$\text{Magnetising reactance representing the magnetising current, } X_0 = \frac{V}{I_m}$$

Short Circuit Test :

In this test, low voltage winding is short circuited and a low voltage hardly 5 to 8 percent of the rated voltage of the high voltage winding is applied to this winding. This test is performed at rated current flowing in both the windings. Iron losses occurring in the transformer under this condition is negligible, because of very low applied voltage. Hence the total losses occurring under short circuit are mainly the copper losses of both the

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winding, which are indicated by the wattmeter connected in the circuit as shown in fig. 'B'.

Thus total full load copper losses = W_{sc} (reading of wattmeter)

The equivalent resistance R_{eq} and reactance X_{eq} referred to a particular winding can also be calculated from the observation of this test, following the steps given below.

$$\text{Equivalent resistance referred to H.V. winding, } R_{eq} = \frac{W_{sc}}{I_{sc}^2}$$

$$\text{Also, equivalent impedance referred to H.V. winding, } Z_{eq} = \frac{V_{sc}}{I_{sc}}$$

$$\text{Thus the equivalent reactance referred to H.V. winding } X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2}$$

PERFORMANCE CALCULATIONS :

Complete performance of the transformer can be calculated based on the above observation of open-circuit and short-circuit test following the steps given by,

1. Efficiency at different loads :

(a) Efficiency at full load :

$$\text{Total losses at full load} = W_0 + W_{sc}$$

Let the full load output power of the transformer in KVA be P_0

$$\text{Then percentage efficiency at full load, } \eta_t = \frac{P_0 \times 1000 \times \cos \phi}{P_0 \times 1000 \times \cos \phi + W_0 + W_{sc}} \times 100$$

(b) Efficiency at half the full load :

$$\text{Iron losses at half the full load} = W_0 \text{ (constant)}$$

$$\text{Total copper losses at half the full load} = \left(\frac{1}{2}\right)^2 W_{sc} = \frac{1}{4} W_{sc}$$

$$\text{Output power at half full load} = \frac{1}{2} P_0 \text{ KVA}$$

Thus, percentage efficiency at half the full load,

$$\eta_{1/2f} = \frac{1/2 P_0 \times 1000 \times \cos \phi}{1/2 P_0 \times 1000 \times \cos \phi + W_0 + 1/4 W_0} \times 100$$

In a similar manner, efficiency at other loads can be found out and the efficiency Vs output power curve can be plotted.

2. Equivalent circuit:

All the parameters of the approximate equivalent circuit has been calculated above. Thus an approximate equivalent circuit of the transformer can be drawn with these value of parameters marked on it. The equivalent circuit can be solved easily for estimating the performance like terminal voltage across the secondary etc.

3. Regulation:

Regulation of the transformer can now be calculated based on the parameters of the equivalent circuit, using the approximate formula given below.

$$\text{Percentage Regulation} = \frac{I (R_{eq} \cos \phi \pm X_{eq} \sin \phi)}{V} \times 100$$

Where, I – rated current of the winding referred to which Req and Xeq have been calculated.

V – Voltage of that winding.

Cos ϕ – Power factor at which regulation is to be calculated.

CRICUT DIAGRAM:

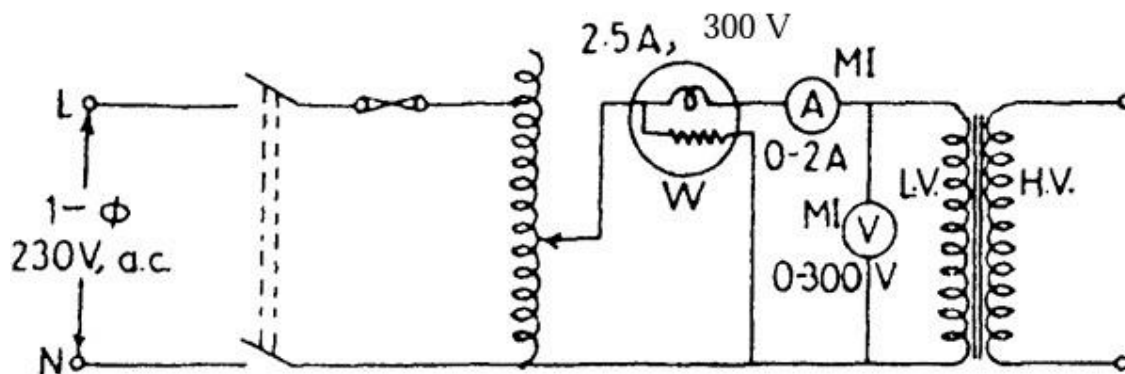


Fig 'A' – Open circuit test on transformer.

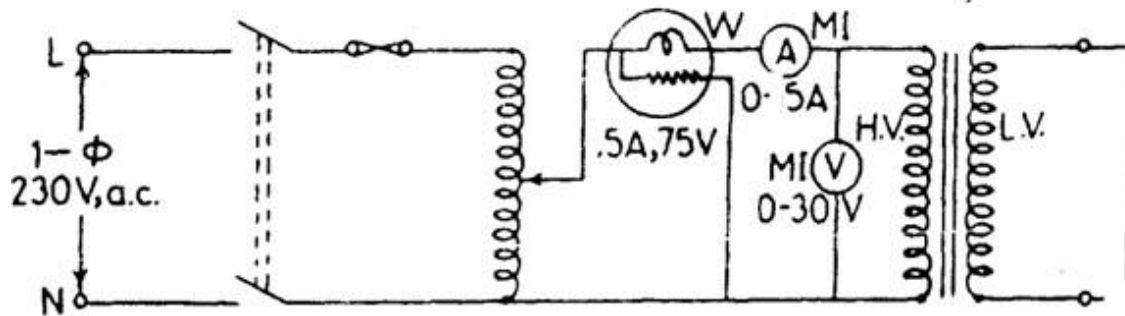


Fig 'B' – Short circuit test on transformer.

PROCEDURE:

Open Circuit Test:

1. Connect the circuit as per fig 'A'.
2. Ensure that the setting of the variac is at low output voltage.
3. Switch on the supply and adjust rated voltage across the transformer circuit.
4. Record no load current, voltage applied and no load power, corresponding to the rated voltage of the transformer winding.
5. Switch-off the AC supply. (b)

Short Circuit Test:

1. Connect the circuit as per fig 'B' for conducting short circuit test
2. Adjust the setting of the variac, so that the output voltage is zero.
3. Switch on the AC supply to the circuit.
4. Increase the voltage applied slowly, till the current in the windings of the transformer is full load rated value.
5. Record, short circuit current, corresponding applied voltage and power with full load current flowing under short circuit conditions.
6. Switch off the AC supply.

OBSERVATION TABLE:

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S. No.	No Load Test			Short Circuit Test		
	V_0	I_0	W_0	V_{sc}	I_{sc}	W_{sc}

CALCULATION - May be tabulated as follows.

S. No.	$\cos \phi_0$	I_0	W_0	R_0	X_m	R_{eq}	X_{eq}	Load	η	Regulation

RESULT: -OC and SC test on transformer has been performed.

PRECAUTIONS:

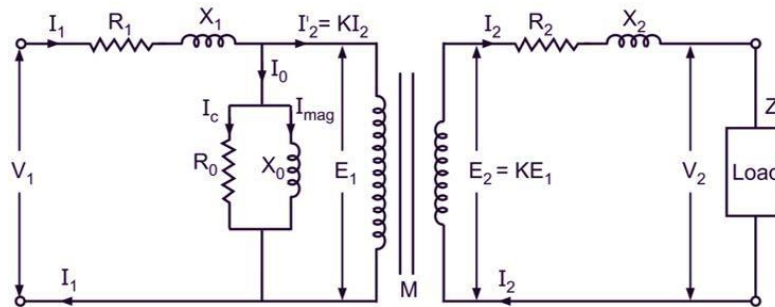
1. All the connection should be tight.
2. Handle the equipment's with care.
3. The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.
4. It should be care that the values of the components of the circuit is does not exceed to their ratings (maximum value).
5. Before the circuit connection it should be check out working condition of all the components.

VIVA QUESTIONS:

1. What is a transformer?
Ans: A transformer, device that transfers electric energy from one alternating-current circuit to one or more other circuits, either increasing (stepping up) or reducing (stepping down) the voltage.

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2. Draw the equivalent circuit of transformer?



3. What is the efficiency and regulation of transformer?

Ans: Good voltage regulation means minimum regulation i.e. less fluctuation in full load voltage compared to no-load voltage. Efficiency: Efficiency (η) of a transformer is the ratio of output to input. The transformer with fewer losses gives high efficiency.

4. When a transformer is energized what types of losses occur in the magnetic frame of the transformer?

Ans: copper losses, iron losses, Eddy current losses and hysteresis losses

5. What information can be obtained from open circuit test of a transformer?

Ans: The open-circuit test is conducted to determine the core or iron losses and the no-load circuit parameters R_0 and X_m of the transformer.

6. Why in open circuit test HV side is always kept open?

Ans: As rated current is less on HV side, it is convenient to conduct this test on HV side by short-circuiting the LV terminals. This ensures that the low range of meters can be used for conducting this test as the wattmeter is connected to the primary side (High voltage side).

LAB EXPERIMENT 8

AIM: To perform direct load test of a transformer and plot efficiency vs load characteristics.

APPARATUS REQUIRED: Single Phase Transformer 1 KVA 230/230V with Tappings at 50% & 86.6% Naturally Air-Cooled Copper Double wound, Shell type. The transformer will be housed in MS sheet box enclosure with rubber footings. All the terminals of primary & secondary shall be brought over to bakelite sheet fitted on top of the box through insulated terminals.

THEORY:

This test is direct test to find the efficiency of the DC shunt motor. In this test the motor directly loaded by connecting brakes which are with pulley and motor is subjected to rated load and entire power is wasted. belt around the water-cooled pulley has its ends attached to spring balances S1 and S2. The belt tightening hand wheels h1 and h2 help in adjusting the load on the pulley so that the load on the motor can be varied.

Output power of the motor = $(S1-S2) * Re * 9.81 * w$ (watts)

S1, S2 = weights on the pulley.

Re = Effective radius of the pulley.

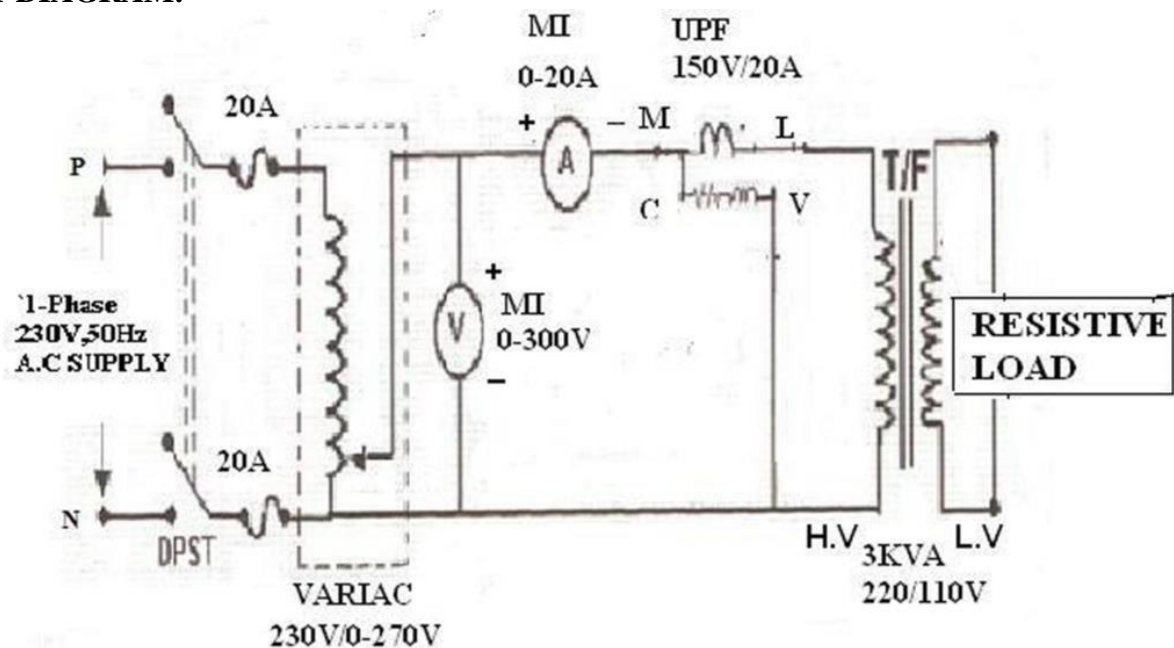
w = motor speed in rad/sec.

If V is the terminal voltage IL is the line current

Power in put = $V * IL$ watts.

Efficiency ($\% \eta$) = $(w (S1-S2) * Re * 9.81 / V * IL) * 100$

CRICUT DIAGRAM:



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PROCEDURE:

1. Connect the circuit as shown in above fig.
2. Switch on the input AC supply.
3. Slowly vary the auto transformer knob up to rated input voltage of main transformer.
4. Apply the load slowly up to rated current of the transformer.
5. Take down the voltmeter and ammeter readings.
6. Draw the graph between efficiency and output power

OBSERVATION TABLE:

S.No.	Voltage (V)	Load Current (A)	% of Load	%Efficiency η

RESULT: - The graph is drawn between Output in Watts Vs Efficiency ($\% \eta$). By taking output in Watts on X axis and Efficiency on Y- axis.

PRECAUTIONS:

1. All the connection should be tight.
2. Handle the equipment's with care.
3. The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.
4. It should be care that the values of the components of the circuit is does not exceed to their ratings (maximum value).
5. Before the circuit connection it should be check out working condition of all the components.

VIVA QUESTIONS:

1. What is the operating principle of a Transformer?
Ans: A transformer works on the principle of mutual induction. Mutual induction is the phenomenon by which when the amount of magnetic flux linked with a coil changes, an E.M.F. is induced in the neighboring coil.
 2. What is the transformation ratio of a transformer?
Ans: The transformation ratio is defined as the ratio of output voltage to the input voltage of the transformer.
 3. What is the power factor of a transformer under no load test situation?
Ans: The no-load power factor is 0.454 (lagging).
-

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4. What is the magnitude of no-load current as compared to full load current?

Ans: The no load current is about 2-5% of the full load current and it accounts for the losses in a transformer.

5. What is load test on transformer and what is the advantage of this test?

Ans: The purpose of load test is to determine the parallel operation and calculate the efficiency, thermal stability and dynamic stability of power transformer through measuring the short circuit loss and impedance voltage of power transformer.

6. What is other test to determine the efficiency and regulation of transformer?

Ans: Sumpner's test or back-to-back test on transformer is another method for determining transformer efficiency, voltage regulation and heating under loaded conditions.

LAB EXPERIMENT 9

AIM: Demonstration of cut-out sections of machines: dc machines (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winding – slip ring arrangement) and single-phase induction machine.

APPARATUS REQUIRED: cut-out sections of machines

THEORY:

Basic Construction and Working of A DC machine:

A dc generator is an electrical machine which converts mechanical energy into direct current electricity. This energy conversion is based on the principle of production of dynamically induced emf.

Construction of a DC Machine:

A DC machine consists of two basic parts; stator and rotor. Basic constructional parts of a DC machine are described below.

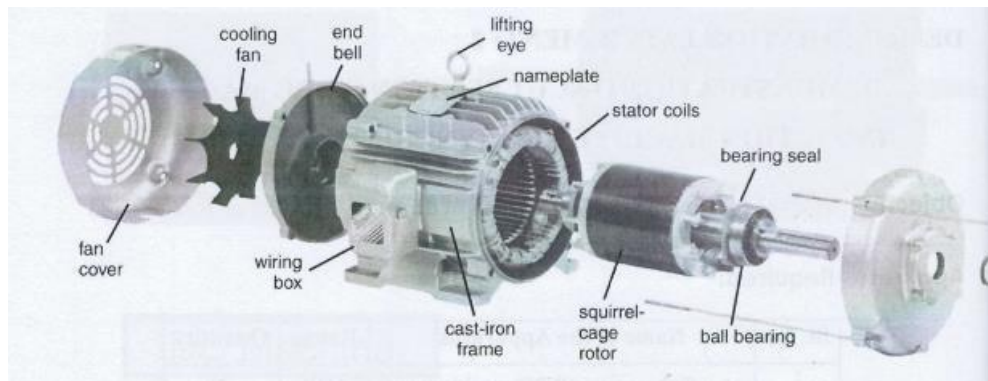
1. **Yoke:** The outer frame of a dc machine is called as yoke. It is made up of cast iron or steel. It not only provides mechanical strength to the whole assembly but also carries the magnetic flux produced by the field winding.
2. **Poles and pole shoes:** Poles are joined to the yoke with the help of bolts or welding. They carry field winding and pole shoes are fastened to them. Pole shoes serve two purposes;
 - (i) they support field coils and
 - (ii) spread out the flux in air gap uniformly.
3. **Field winding:** They are usually made of copper, Field coils are former wound and placed on each pole and are connected in series. They are wound in such a way that, when energized, they form alternate North and South poles.
4. **Armature core:** Armature core is the rotor of a dc machine. It is cylindrical in shape with slots to carry armature winding. The armature is built up of thin laminated circular steel disks for reducing eddy current losses. It may be provided with air ducts for the axial air flow for cooling purposes. Armature is keyed to the shaft.
5. **Armature winding:** It is usually a former wound copper coil which rests in armature slots. The armature conductors are insulated from each other and also from the armature core. Armature winding can be wound by one of the two methods; lap winding or wave winding.

6. **Commutator and brushes:** The function of a commutator, in a dc generator is to collect the current generated in armature conductors whereas, in case of a dc motor, commutator helps in providing current to the armature conductors. A commutator consists of a set of copper segments which are insulated from each other. The number of segments is equal to the number of armature coils. Brushes are usually made from carbon or graphite. They rest on commutator segments and slide on the segments when the commutator rotates keeping the physical contact to collect or supply the current.

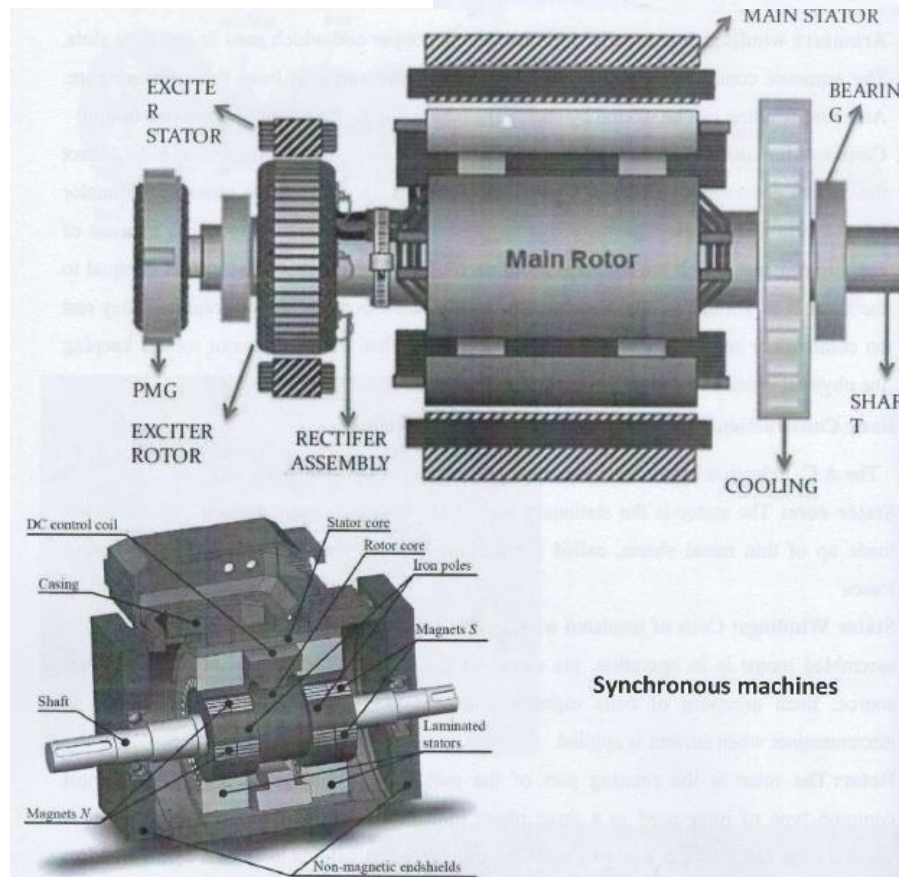
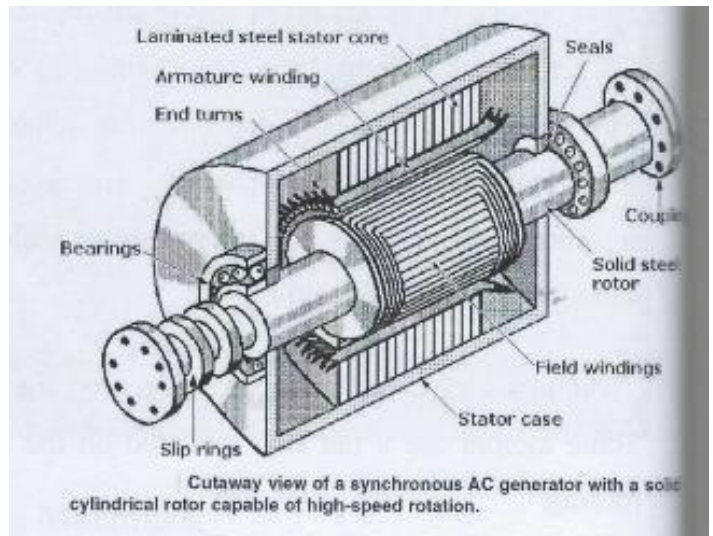
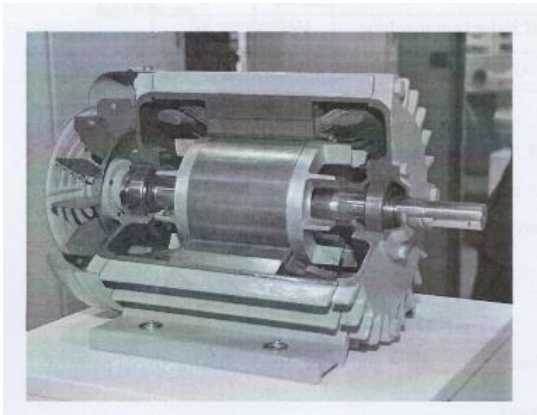
Basic Construction and Working of an Induction Machine

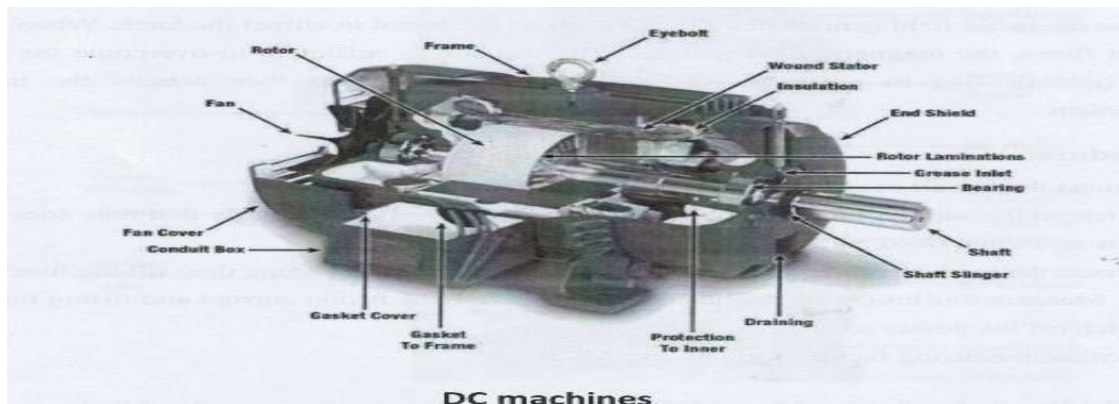
The A.C. Induction Motor has three main parts, rotor, stator and enclosure.

1. **Stator core:** The stator is the stationary part of the motor's electromagnetic circuit and is made up of thin metal sheets, called laminations. Laminations are used to reduce energy losses.
2. **Stator Windings:** Coils of insulated wire are inserted into slots of the stator core. When the assembled motor is in operation, the stator windings are connected directly to the power source. Each grouping of coils together with the steel core it surrounds becomes an electromagnet when current is applied.
3. **Rotor:** The rotor is the rotating part of the motor's electromagnetic circuit. The most common type of rotor used in a three-phase induction motor is a squirrel cage rotor. A squirrel cage rotor core is made by stacking thin steel laminations to form the conductor bars. After die casting, rotor conductor bars are mechanically and electrically connected with end rings.
4. **Enclosure:** The enclosure consists of a frame and two end bells (or bearing housings) the stator is mounted inside the frame. The rotor fits inside the stator with a slight air gap separating it from the stator. The enclosure protects the internal parts of the motor from water and other environmental elements.
5. **Bearings and fan:** Bearings mounted on the shaft, support the rotor and allow it to turn. Some motors use a fan also mounted on the rotor shaft to cool the motor when the shaft is rotating.



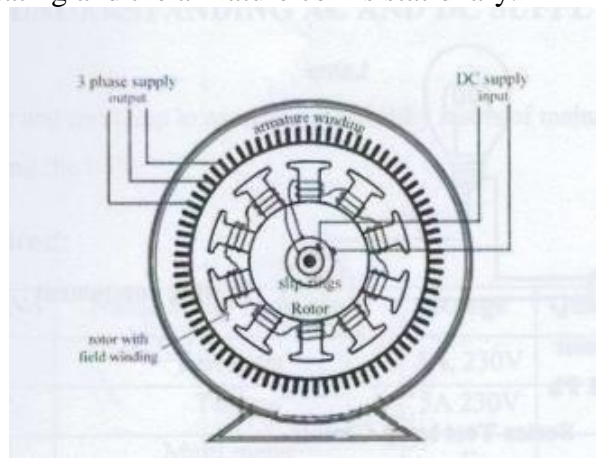
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Construction of a Synchronous Machine

Main parts of the alternator consist of stator and rotor. But, the unlike other machines, in most of the alternators, field excitors are rotating and the armature coil is stationary.



1. **Stator:** Unlike in DC machine stator of an alternator is not meant to serve path for magnetic flux. Instead, the stator is used for holding armature winding. The stator core is made up of lamination of steel alloys or magnetic iron, to minimize the eddy current losses.
2. **Rotor:** There are two types of rotors used in an AC generator / alternator:
 - (i) Salient and

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(ii) Cylindrical type

- (i) Salient pole type: Salient pole type rotor is used in low and medium speed alternators. Construction of AC generator of salient pole type rotor is shown in the figure above. This type of rotor consists of large number of projected poles (called salient poles), bolted on magnetic wheel. These poles are also laminated to minimize the eddy current losses. Alternators featuring this type of rotor are large in diameters and short in axial length.
- (ii) Cylindrical type: cylindrical type rotors are used in high-speed alternators, especially in turbo alternators. This type of rotor consists of a smooth and solid steel cylinder having slots along its outer periphery. Field windings are placed in these slots. The DC supply is given to the rotor winding through the slip rings and brushes arrangement.

RESULT: - Demonstration of cut-out sections of machines has been done.

VIVA QUESTIONS:

1. Explain what is meant by a 3-phase induction motor?

Ans: A 3-phase induction motor is an electromechanical energy conversion device which converts 3-phase input electrical power into output mechanical power. A 3-phase induction motor consists of a stator and a rotor.

2. Write the classification of 3-phase induction motor?

Ans: There are two types of three phase induction motors viz. squirrel cage motor and slip ring motor.

3. Give the different methods of speed control of I.M.

Ans: Induction Motor Speed Control From Stator Side

1. By Changing The Applied Voltage:
2. By Changing The Applied Frequency
3. Constant V/F Control Of Induction Motor
4. Changing The Number Of Stator Poles

Speed Control From Rotor Side:

1. Rotor Rheostat Control
2. Cascade Operation
3. By Injecting EMF In Rotor Circuit

4. How do you calculate slip speed?

Ans: The difference between the synchronous speed and the rotor speed is known as slip speed. It is given by, $\text{Slip speed} = N_s - N_r$. Slip is defined as the ratio of slip speed to the rotor speed.

5. Explain what is meant by a 3-phase synchronous generator?

Ans: The synchronous generator or alternator is an electrical machine that converts the mechanical

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power from a prime mover into an AC electrical power at a particular voltage and frequency. The synchronous motor always runs at a constant speed called synchronous speed.

6. Write the classification of 3-phase synchronous generator?

Ans: According to the shape of the field, synchronous machines may be classified as cylindrical-rotor (non-salient pole) machines and salient-pole machines

LAB EXPERIMENT 10

AIM: Torque speed characteristics of shunt dc motor.

APPARATUS REQUIRED: Shunt DC motor panel

THEORY:

This test is direct test to find the efficiency of the DC shunt motor. In this test the motor directly loaded by connecting brakes which are with pulley and motor is subjected to rated load and entire power is wasted. belt around the water-cooled pulley has its ends attached to spring balances S1 and S2. The belt tightening hand wheels h1 and h2 help in adjusting the load on the pulley so that the load on the motor can be varied.

Output power of the motor = $(S1-S2) * Re * 9.81 * w$ (watts)

S1, S2 = weights on the pulley.

Re= Effective radius of the pulley.

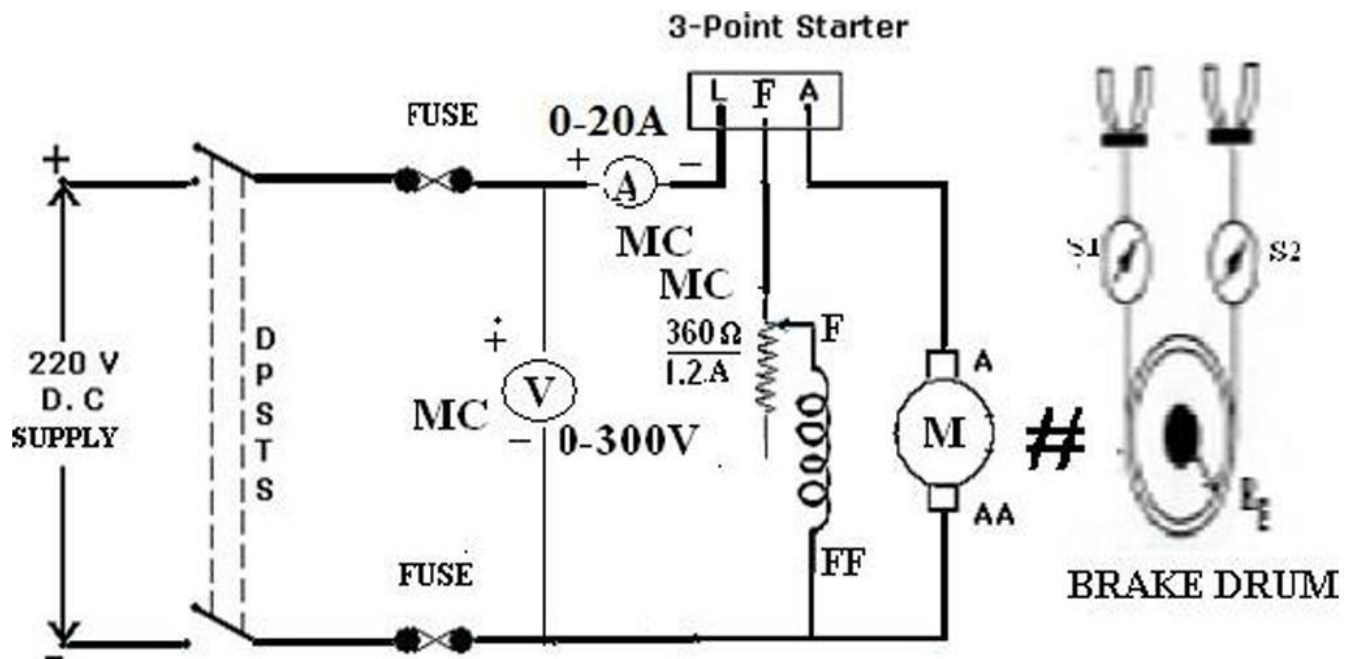
w= motor speed in rad/sec.

If V is the terminal voltage IL is the line current

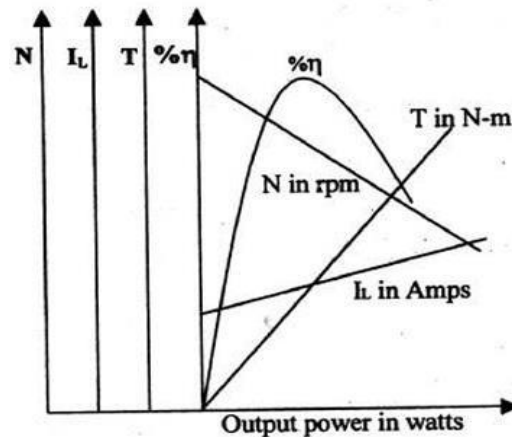
Power in put = $V * I_L$ watts.

Efficiency ($\% \eta$) = $(w (S1-S2) * Re * 9.81 / V * I_L) * 100$

CRICUT DIAGRAM:



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PROCEDURE:

1. All the connections are as per the circuit diagram.
2. 220V, DC supply is given to the motor by closing DPST switch.
3. Move the 3-point starter handle from 'OFF' to 'ON' position slowly and motor Starts running.
4. Vary the field rheostat until the motor reaches its rated Speed and take voltmeter and ammeter readings.
5. Apply the load by break drum pulley and for each application of load the Corresponding Voltmeter (V), Ammeter (I), spring forces S1 & S2 and Speed (N) Readings are noted.
6. Calculate output & efficiency for each reading.
7. Note down all the readings in the tabular form carefully.
8. Remove the load slowly and keep the rheostat as starting position and switch 'OFF' the supply by using DPST switch.

OBSERVATION TABLE:

S.No.	Voltage (V)	Current (A)	Input = VI watts	Forces in KG		Net force F = S1~S2 in kg	Torque(T) = F*Re*9.81 (N-M)	Speed in RPM (N)	O/p = $\frac{2\pi NT}{60}$ (Watts)	%Efficiency $\eta = \frac{\text{output}}{\text{input}} * 100$
				S1	S2					

RESULT: - The graph is drawn between Watts Vs Speed(N) in RPM, Watts Vs Torque (T) in N-m, Watts Vs Current (I) in A, Watts Vs Efficiency (%η). By taking output in Watts on X axis and speed, Torque, current, Efficiency on Y- axis.

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PRECAUTIONS:

1. All the connection should be tight.
2. Handle the equipment's with care.
3. The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.
4. It should be care that the values of the components of the circuit is does not exceed to their ratings (maximum value).
5. Before the circuit connection it should be check out working condition of all the components.

VIVA QUESTIONS:

1. Why a 3-point starter is used for starting a D.C shunt motor?
Ans: Initially back emf is zero, therefore starting armature current is high. To limit or minimize starting armature current, we use 3- point starter. A three-point starter helps in starting and running the shunt wound motor or compound wound DC motor.
2. If a 3-point starter is not available, how can a D.C motor be started?
Ans: rheostat connected in series field winding perfect rating
3. Explain the function of overload release coil in 3-point starter.
Ans: It is connected in series with the supply line to protect the motor against overload. When the motor is overload, overload release coil is magnetized and it lifts the armature to the upward and short circuit the No volt release coil.
4. Why the magnetic losses calculated by Swinburn's method are less than the actual value?
Ans: Disadvantages of Swinburne's Test
Change in iron loss is not considered at full load from no load. Due to armature reaction flux is distorted at full load and, as a result, the iron loss is increased.
As the Swinburne's test is performed at no load. Commutation on full load cannot be determined whether it is satisfactory or not and whether the temperature rise is within the specified limits or not.
5. Is Swinburn's method applied to D.C series machines?
Ans: In Swinburne's test machine under test is run on no load at rated speed and rated voltage.
This test is cannot be performed with DC SERIES MOTOR, since on no load series motor will attain such a high speed that it will get damaged and secondly this test is only applicable to those machines in which flux and speed remains constant.
6. Comment on the efficiency determined by Swinburn's method.
Ans: The Swinburne test is an indirect method for determining the efficiency of DC motors. It works by finding the no-load losses experimentally and then estimating additional losses from the rated motor data.

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This lab manual has been updated by

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Please spare some time to provide your valuable feedback.