MLRS
MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY AND MANAGEMENT
(AN AUTONOMOUS INSTITUTION)
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Electrical Engineering Laboratory Manual

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Class: I B. Tech (common to ECE & EEE)–II Semester

Prepared by

Mr. S. Rajkumar
Assistant Professor

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

CERTIFICATE

This is to certify that this manual is a Bonafide record of practical work in **Electrical Engineering Laboratory in II Semester of I year B. Tech (EEE & ECE) Programme** during the academic year **2024-25.** This manual is prepared by **Mr. S. RAJKUMAR, Assistant Professor,** Department of Electrical and Electronics Engineering.

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PREFACE

The **Electrical Engineering Laboratory** is designed to provide students with hands-on experience in fundamental electrical circuit principles. This laboratory serves as a bridge between theoretical concepts and real-world applications, ensuring a deeper understanding of electrical laws, circuit behavior, and measurement techniques.

The experiments included in this laboratory manual cover essential electrical engineering principles such as Ohm's Law, Kirchhoff's Laws, network theorems, resonance, impedance analysis, and waveform characteristics. Each experiment is carefully structured to reinforce theoretical knowledge and develop practical skills in circuit analysis and troubleshooting.

By this laboratory experiments, students will gain valuable experience in circuit design, analysis, and validation of fundamental electrical engineering concepts. The practical exposure provided by this laboratory will not only enhance their academic understanding but also prepare them for industrial and research applications.

We hope this manual will serve as a useful guide in exploring the principles of electrical engineering and help students develop the necessary technical skills for their future endeavors.

By

Mr. S. RAJKUMAR,
Assistant Professor, EEE

ACKNOWLEDGEMENT

It was really a good experience dealing with The Electrical Simulation Tools Laboratory. First, I would like to thank **Dr. A. Vinod**, Professor & Head of the Department of Electrical and Electronics Engineering, Marri Laxman Reddy Institute of Technology & Management for his concern and giving the technical support in preparing the document.

I gratefully acknowledge the constant support and valuable patronage of **Dr. P. Sridhar**, Director, Marri Laxman Reddy Institute of Technology & Management for giving me this wonderful opportunity for preparing the Measurements and Instrumentation laboratory manual.

I express my heartful thanks to **Dr. R. Murali Prasad**, Principal, Marri Laxman Reddy Institute of Technology & Management, for timely corrections and scholarly guidance.

At last, but not the least I would like to thanks all the EEE Department faculty members those who guided and helped me in preparing this manual.

By

Mr. S. RAJKUMAR,
Assistant Professor, EEE

GENERAL INSTRUCTIONS

1. Students are instructed to come to Electrical Engineering Laboratory on time. Late comers are not entertained in the lab.
2. Students should be punctual to the lab. If not, the conducted experiments will not be repeated.
3. Students are expected to come prepared at home with the experiments which are going to be performed.
4. Students are instructed to display their identity cards before entering into the lab.
5. Students are instructed not to bring mobile phones to the lab.
6. Any damage/loss of system parts like Meters, Components during the lab session, it is student's responsibility and penalty or fine will be collected from the student.
7. Students should update the records and lab observation books session wise. Before leaving the lab, the student should get his lab observation book signed by the faculty.
8. Students should submit the lab records by the next lab to the concerned faculty members in the staffroom for their correction and return.
9. Students should not move around the lab during the lab session.
10. If any emergency arises, the student should take the permission from faculty member concerned in written format.
11. The faculty members may suspend any student from the lab session on disciplinary grounds.
12. Never copy the output from other students. Write down your own outputs.

Instructions to the students to conduct an experiment:

1. Students are supposed to come to the lab with preparation, proper dress code and the set of tools required.
2. Dress code:

   Boys: Shoe & Tuck.

   Girls: Apron & Cut shoe.
3. Don't switch on the power supply without getting your circuit connections verified.
4. Disciplinary action can be taken in the event of mishandling the equipment or switching on the power supply without faculty presence.
5. All the apparatus taken should be returned to the Lab Assistant concerned, before leaving the lab.
6. You have to get both your Observation book and your Record for a particular experiment corrected well before coming to the next experiment.

GUIDELINES TO WRITE YOUR OBSERVATION BOOK

1. Experiment title, Aim, Apparatus, Procedure should be right side.
2. Circuit diagrams, Model graphs, Observations table, Calculations table should be left side.
3. Theoretical and model calculations can be any side as per convenience.
4. Result should always be at the end (i.e. there should be nothing written related to an experiment after its result).
5. You have to write the information for all the experiments in your observation book.
6. You are advised to leave sufficient no. of pages between successive experiments in your observation book for the purpose of theoretical and model calculations.

SAFETY PRECAUTIONS

General Guidelines

1. Conduct yourself in a responsible manner at all times in the laboratory.
2. Be ***familiar with your lab experiment before you come to the lab***. Follow all written and verbal instructions carefully. If you do not understand a direction or part of a procedure, ask the lecturer/instructor/technician before proceeding.
3. No student may work in the laboratory alone. The lab instructor/lecturer grant exceptions on a case-by-case basis.
4. When first entering a laboratory, do not touch any equipment, wires or other materials in the laboratory area until you are instructed to do so.
5. ***Do not eat, drink beverages or chew gum in the laboratory***. Do not use laboratory glassware as containers for food or beverages.
6. ***Smoking is strictly not allowed*** in any indoor area.
7. No music allowed in the laboratory. Radio (including walk-man) and other entertainment devices are not permitted.
8. No cellular phone is allowed in this laboratory.
9. Perform only those experiments authorized by the lecturer/instructor/technician. Never do anything in the laboratory that is not called for the laboratory procedures or by your lecture/instructor/technician. Carefully follow all instructions, both written and oral. Unauthorized experiments are prohibited.
10. Observe good housekeeping practices. ***Work areas should be kept clean and tidy at all times***.
11. Horseplay, practical jokes, and pranks are dangerous and prohibited.
12. Bring only your laboratory manual, worksheets and report to the work area. Other materials (books, purses, backpacks etc.) should be stored in the cabinet.
13. Know the locations and operation procedures of all safety equipment including the first aid kit, eyewash station, safety shower, spill kit and fire extinguisher.
14. Be alert and proceed with caution at all times in the laboratory. Notify the lecturer/instructor immediately of any unsafe condition you observe.
15. Label and equipment instructions must be read carefully before use. Set up and use the prescribed apparatus as directed in the laboratory instructions provided by your lecturer/instructor.
16. Experiments must be personally monitored at all times. You will be assigned a laboratory station at which to work. Do not wander around the room, distract other students or interfere with laboratory experiments or others
17. Defeating safety devices or using equipment in a manner other than that which is intended will be grounds for dismissal from the lab.

INSTITUTION VISION AND MISSION

VISION

To be as an ideal academic institution by graduating talented engineers to be ethically strong, competent with quality research and technologies.

MISSION

To fulfill the promised vision through the following strategic characteristics and aspirations:

- Utilize rigorous educational experiences to produce talented Engineers
- Create an atmosphere that facilitates the success of students
- Programs that integrate global awareness, communication skills and Leadership qualities
- Education and Research partnership with institutions and industries to prepare the students for interdisciplinary research.

VISION AND MISSION OF THE DEPARTMENT

Vision of the Department

To produce comprehensively trained, socially responsible, innovative electrical engineers and researchers of high quality who can contribute to the nation and global development.

Mission of the Department

- To provide an academic environment with a strong theoretical foundation and practical engineering skills.
- To experience interpersonal communication and teamwork along with emphasis on ethics, professional conduct, and critical thinking.
- The graduates will be trained to have successful engagement in research and development and entrepreneurship.

PROGRAMME EDUCATIONAL OBJECTIVES AND SPECIFIC OUTCOMES

PROGRAMME EDUCATIONAL OBJECTIVES

The Programme Educational Objectives (PEOs) that are formulated for the Electrical Engineering programme are listed below:

PEO 1 Success in Electrical Engineering

PEO 2 Industrial awareness and research

PEO 3 Successful employment and professional ethics

PEO 4 Being a leader professional and societal environment

PROGRAM SPECIFIC OUTCOMES

PSO1 Design, develop, fabricate and commission the electrical systems involved in power generation, transmission, distribution and utilization.

PSO2 Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development.

PSO3 Gain the hands-on competency skills and other computing tools necessary for entry level position to meet the requirements of the employer.

PROGRAMME OUT COMES

The Program Outcomes (POs) of the department are defined in a way that the Graduate Attributes are included, which can be seen in the Program Outcomes (POs) defined. The Program Outcomes (POs) of the department are as stated below:

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

PO 2: Problem analysis: Identify, formulate, research literature, and analyze engineering problems to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Engineering 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.

PO 6: The engineer and The world: 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.

PO 7: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 8: Individual and Collaborative team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

PO 9: Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.

PO 10: Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one’s own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

PO 11: 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.

ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Exp. No	Name of the Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1	Verification of Ohm's Law	PO 1, PO 2	PSO 1
2	Verification of Kirchhoff's laws	PO 1, PO 2, PO 4	PSO 1
3	Calculations and verification of Impedance and current of series RL & RC	PO 1, PO 2, PO 3, PO 4	PSO 1, PSO 2
4	Determination of Resonant frequency and band width of Series Resonance circuit	PO 1, PO 2, PO 3, PO 4, PO 5	PSO 1, PSO 2
5	Calculations and verification of Impedance and current of series RLC	PO 1, PO 2, PO 3, PO 4	PSO 1, PSO 2
6	Verification of Thevenin's and Norton's Theorem	PO 1, PO 2, PO 4	PSO 1
7	Verification of Superposition Theorem	PO 1, PO 2, PO 4	PSO 1
8	Verification of Reciprocity Theorem	PO 1, PO 2, PO 4	PSO 1
9	Verification of Maximum Power Transfer Theorem	PO 1, PO 2, PO 3, PO 4, PO 5	PSO 1, PSO 2
10	Determination of self and mutual inductance of two inductive coils	PO 1, PO 2, PO 3, PO 4, PO 5	PSO 1, PSO 2
11	Determination of form factor for non-sinusoidal waveform	PO 1, PO 2, PO 3, PO 4, PO 5	PSO 1, PSO 2

COURSE STRUCTURE, OBJECTIVES & OUTCOMES

COURSE STRUCTURE:

The Electrical Engineering Laboratory will have a continuous evaluation during 2nd semester for 40 sessional marks and 60 End semester examination marks.

Out of the 40 marks for internal evaluation, day-to-day in the laboratory shall be evaluated for 15 marks and internal practical examination shall be evaluated for 25 marks conducted by the concerned Laboratory Teacher.

The End semester examination shall be conducted with an external examiner and internal examiner. The external examiner shall be appointed by the Principal / Chief Controller of Examinations.

COURSE OBJECTIVES: The students will try to learn

- The gap between theoretical knowledge and practical applications by exposing students to a wide range of electrical components and circuit configurations.
- The essential skills in circuit design, measurement, testing, and analysis using laboratory equipment such as multimeters, and power supplies.
- The basic laws, network reduction techniques and theorems for different circuits.

COURSE OUTCOMES: After successful completion of the course, students should be able to

- Solve the source resistance, currents, voltage and power using various laws associated with electrical circuits.
- Perform the superposition principle, reciprocity and maximum power transfer condition
- for the Electrical network with DC excitation.
- Demonstrate Thevenin's and Norton's theorem to reduce complex networks into simple
- equivalent networks with DC excitation.
- Apply Faraday's laws of electromagnetic induction for calculating the various performance parameters in magnetic circuits.
- Understand the waveforms of different inputs and determine the form factor of electrical circuits.

Department of Electrical & Electronics Engineering

2420276: ELECTRICAL ENGINEERING LABORATORY

COURSE CONTENT:

EXERCISES FOR ELECTRICAL ENGINEERING LABORATORY

Perform Any Ten Experiments from Below

1. Verification of Ohm's Law
2. Verification of Kirchhoff's laws
3. Calculations and verification of Impedance and current of series RL & RC
4. Determination of Resonant frequency and band width of Series Resonance circuit
5. Calculations and verification of Impedance and current of series RLC
6. Verification of Thevenin's and Norton's Theorem
7. Verification of Superposition Theorem
8. Verification of Reciprocity Theorem
9. Verification of Maximum Power Transfer Theorem
10. Determination of self and mutual inductance of two inductive coils
11. Determination of form factor for non-sinusoidal waveform

TEXT BOOKS:

1. A Chakrabarti, "Circuit Theory", Dhanpat Rai Publications, 8th Edition, 2021.
2. William Hayt, Jack E Kemmerly S.M. Durbin, "Engineering Circuit Analysis", Tata McGraw Hill, 9th Edition, 2020.

REFERENCE BOOKS:

1. CL Wadhwa, Electrical Circuit Analysis including passive network synthesis, International, 2nd Edition, 2009.

2. David A Bell, Electrical Circuits, Oxford University Press, 7th Edition, 2009.

Ex No :

Date :

1. VERIFICATION OF OHM'S LAW

AIM: To verify Ohm's law (V=IR) where current through a resistor is proportionalto the voltage across it.

APPARATUS REQUIRED:

S.No	Name of the Equipment	Range	Type	Quantity
1	Voltmeter	(0-20) V	Digital	1
2	Ammeter	(0-200) mA	Digital	1
3	Regulated power supply	(0-15) V	Dual	1
4	Multimeter	---------	Digital	1
5	Bread Board	---------	---------	1
6	Resistors	1kΩ,1.5kΩ, 6.8kΩ	Fixed	Each one
7	Connecting wires	As required		

THEORY:

The most fundamental law in electricity is ohm's law or V=IR. Where V is voltage, which means the potential difference between two terminals. Electrical resistance, measured in ohms, is the measure of the amount of current repulsion in a circuit. According to the Ohm's law, "The current flowing through a conductor is directly proportional to the potential difference across its ends provided the physical conditions (temperature, dimensions, pressure) of the conductor remains the same." If I be the current flowing through a conductor and V be the potential difference across its ends, then according to Ohm's Law,

$$I \alpha V$$

$$V \alpha I \text{ or } V=IR$$

Where, R is the constant of proportionality. It is known as resistance of the conductor. R depends upon the material, temperature and dimensions of the conductor. In S.I. units, the potential difference V is measured in volt and the current I in ampere,
the resistance R is measured in ohm.

How do we establish the current-voltage relationship?

Ans: To establish the current-voltage relationship, it is to be shown that the ratio V / I remains constant for a given resistance, therefore a graph between the potential difference(V) and the current (I) must be a straight line.

For a wire of uniform cross-section, the resistance depends on the length l and the area of cross-section A. It also depends on the temperature of the conductor. At a given temperature the resistance,

$$R = \rho \frac{l}{A}$$

Where ρ is the specific resistance or resistivity and is characteristic of the material of wire.

Hence, the specific resistance or resistivity of the material of the wire,

$$\rho = \frac{RA}{l}$$

If 'r' is the radius of the wire, then the cross-sectional area, A = πr^2. Then the specific resistance or resistivity of the material of the wire is,

$$\rho = \frac{\pi r^2 R}{l}$$

CIRCUIT DIAGRAM:

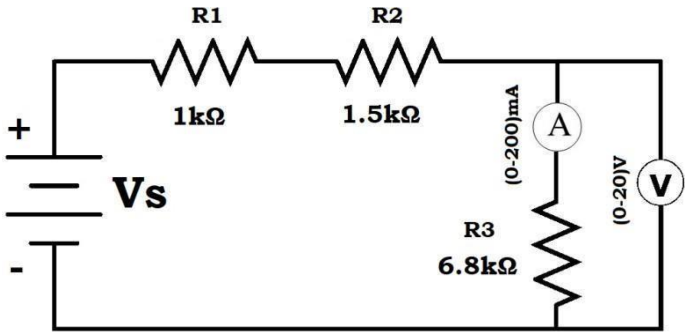


Fig.1

PROCEDURE:

1. Connect the circuit shown in above *Fig.1*
2. Measure the actual value of each resistor and record in *Table 1.*
3. Beginning at 0 V, increase the power supply so that the voltage across R_3in steps of 1V until 6 V. Measure and record the resulting current in *Table 1*for each increment of voltage.
4. Plot the graphs of I verses V for results in *Table 1*(Assign I to the vertical axis and V to the horizontal axis).

5. Construct a right-angle triangle on the graph and from this, re-determinethe slope and hence evaluate the conductance, G.

6. From this information, evaluate the resistance, R. Record G and R for the graph in the appropriate column in *Table 2*.

7. Compare these experimentally obtained values with those measured values recorded in the respective tables

THEORETICAL CALCULATIONS:

Voltage across a resistor = I x R

OBSERVATION TABLE: Table-1

<table>
<tr><td>R = 6.8kΩ</td><td colspan="8">Measured Resistance, R =</td></tr>
<tr><td>R = 1 kΩ</td><td colspan="8">Measured Resistance, R =</td></tr>
<tr><td>R = 1.5 kΩ</td><td colspan="8">Measured Resistance, R =</td></tr>
<tr><td>Voltage Across R_3</td><td>(V)</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>Current
(Measured values)</td><td>(mA)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Current
(Theoreticalvalues)</td><td>(mA)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table-2

	Slope (G)	**R (1/G)**
Measured Values		
Theoretical Values		

PRECAUTIONS:

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

RESULT:

APPLICATIONS:

1. A resistor is used to control the rate of current flowing through these components.
2. The **Ohm's law** is used to calculate the rating of current which should be used in the typical circuit.

VIVA QUESTIONS:

1. Has Ohm’s law been verified?
2. What are the facts supporting this decision?
3. State the factors affecting resistance of a material with a uniform cross-sectional area?
4. What are the common types of fixed and variable resistors? State usage ofeach type.
5. If the resistor from the experiment above is changed to 10 kΩ, deduce whatwill happen to the slope of I-V graph. What effect on the conductance G?
6. Define electric current.
7. What is meant by the term electric potential difference?
8. Give example of a good non-metallic conductor.
9. What is SI unit of resistance? Define it.

10. What is an ohmic resistance?
11. What is the shape of V v/s I graph for an ohmic conductor?
12. How is the resistance of a conductor affected by rise in temperature?
13. Can a voltmeter measure e.m.f.?
14. What is the resistance of an ideal voltmeter?
15. Define electric current?
16. What is SI unit of electric current?
17. What is meant by the term electric potential difference?
18. What is a conductor?
19. Give example of a good non-metallic conductor.
20. State Ohm's law.
21. What is meant by the term electric resistance?
22. State the factors on which the resistance of a conductor depends.
23. Define the term resistivity. Give its SI unit.
24. What is an ohmic resistance?
25. What is a non-linear device? Give an example.
26. Give example of a material whose resistance decreases with rise in temperature.
27. How is ammeter connected in a circuit?
28. How is a voltmeter connected in a circuit?
29. What do you mean by e.m.f. of a cell?
30. What do you mean by terminal voltage?

Ex No :

Date :

2. VERIFICATION OF KIRCHHOFF'S LAWS

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

APPARATUS:

S.No.	Name of the Equipment	Range	Type	Quantity
1	Voltmeter	(0-20) V	Digital	4
2	Ammeter	(0-200) mA	Digital	3
3	Regulated power supply	(0-15) V	Dual	1
4	Multimeter	---------	Digital	1
5	Kit Board	---------	---------	1
6	Resistors	1Kω	Fixed	3
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.

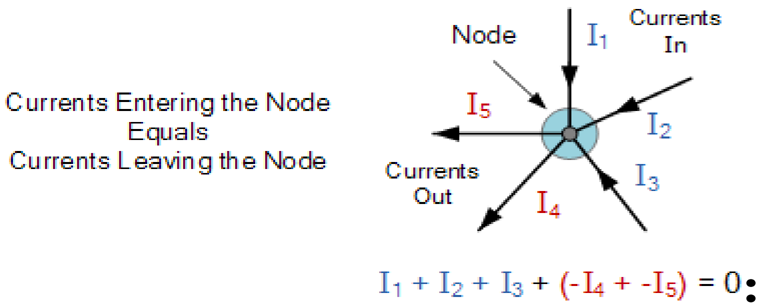
In 1845, a German physicist, Gustav Kirchhoff developed a pair or set of rules or laws which deal with the conservation of current and energy within electrical circuits. These two rules are commonly known as: Kirchhoff's Circuit Laws with one of Kirchhoff's laws dealing with the current flowing around 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)

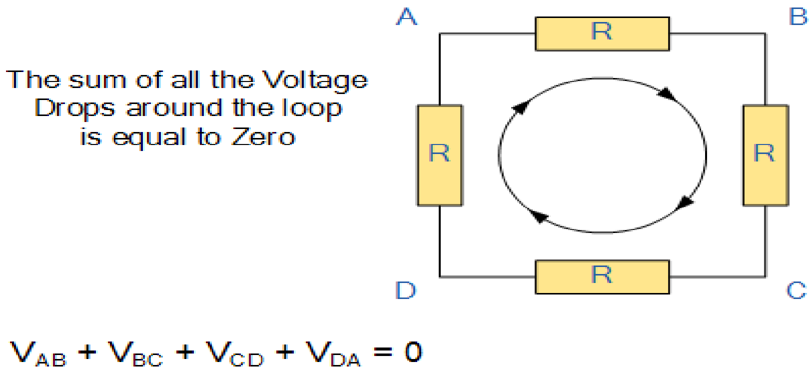
Kirchhoff's Current Law or KCL, states that the "total current or charge enteringa junction or node is exactly equal to the charge leaving the node as it has no other place to go except to leave, as no charge is lost within the node". In other words the algebraic sum of ALL the currents entering and 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**.

Kirchhoff's Current Law

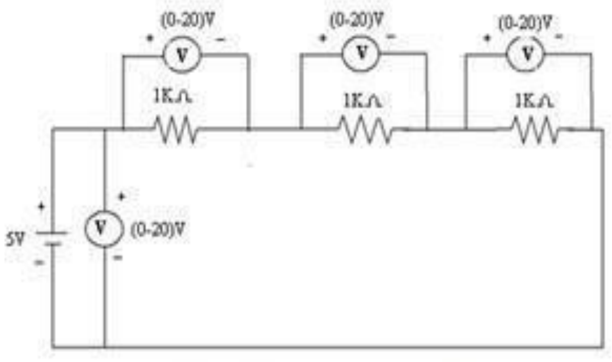


2. Kirchhoff's Second Law – The Voltage Law, (KVL)

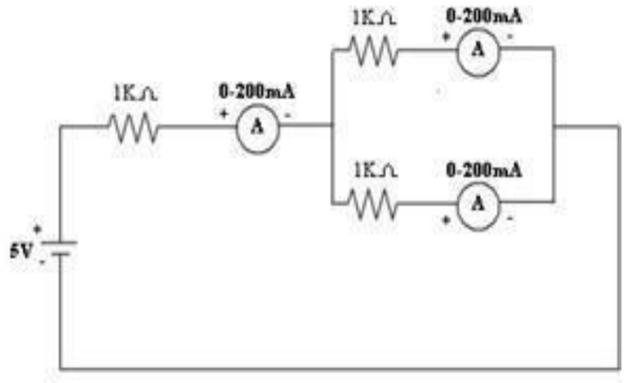
Kirchhoff's Voltage Law or KVL, states that "in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop" which is also equal to zero. In other words, the algebraic sum of all voltages within the loop must be equal to zero. This idea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



CIRCUIT DIAGRAM:



(a) Circuit diagram for KVL



(b) Circuit diagram for KCL

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 $V_S=V_1+V_2+V_3$ (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).

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)
Theoretical Values									
Practical Values									

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?
6. Please Define Ohm’s Law for A.C (Alternating Current)?
7. What is Voltage Divider Rule?
8. What is Current Divider Rule (CDR)?
9. Differentiate between Kirchhoff’s First law and Kirchhoff’s Second law?
10. What is the function of Capacitor in Electrical Circuits?
11. Why Inductors are installed in electrical Circuits?

12. Briefly explain the purpose of Inductor in an electric circuit?

13. What do you mean by dependent and independent voltage sources?

14. Differentiate between ideal and non-ideal voltage sources?

15. What does the term “Voltage Regulation” means?

16. What is DC Current source? Differentiate between ideal and non ideal current sources?

17. What is the difference between power and energy?

18. Define steady state?

19. Initial conditions of capacitors?

20. Explain how an inductor and capacitors behaves when AC&DC are given?

21. Initial conditions of inductance?

22. What is the difference between Voltage Divider Rule and current divider rule?

23. What is the function of an inductor in electrical circuits?

24. What is dependent voltage source?

25. What is independent voltage source?

26. On what bases KCL is based on?

27. Kirchhoff’s current law is applied at?

28. Kirchhoff’s voltage law is based on?

29. Which law can be best suited for the analysis of circuit with more number of loops?

30. Mathematically KVL can written as?

Exp No :
Date :

3. CALCULATIONS AND VERIFICATION OF IMPEDANCE AND CURRENT OF SERIES RL & RC

AIM: To calculate and verify the Impedance and Current of series RL circuits.

APPARATUS:

S.No	Name of the Equipment	Range	Type	Quantity
1	Function Generator	(0-100) MHz	Digital	1
2	Decade Resistance Box	---------	---------	1
3	Decade Inductance Box	---------	---------	1
4	Decade Capacitance Box	---------	---------	1
5	CRO	(0-20) MHz	Dual	1
6	Voltmeter	(0-20) V	Digital	1
7	Ammeter	(0-10) A	Digital	1
8	CRO Probes	---------	---------	1
9	Connecting wires	As required		

THEORY:

SERIES RL CIRCUIT:

Consider a simple RL circuit in which resistor, R and inductor, L are connected in series with a voltage supply of V volts. Let us think the current flowing in the circuit is I (amp) and current through resistor and inductor is I_R and I_L respectively. Since both resistance and inductor are connected in series, so the current in both the elements and the circuit remains the same. i.e $I_R = I_L = I$. Let V_R and V_l be the voltage drop across resistor and inductor.

The impedance of series RL circuit opposes the flow of alternating current. The impedance of series RL Circuit is nothing but the combine effect of resistance (R) and inductive reactance (X_L) of the circuit as a whole. The impedance Z in ohms is given by, $Z = (R^2 + X_L{}^2)^{0.5}$ and from right angle triangle, phase angle $\theta = \tan^{-1}(X_L/R)$.

In series RL circuit, the values of frequency f, voltage V, resistance R and Inductance L are known and there is no instrument for directly measuring the value of inductive reactance and impedance; so, for complete analysis of series RL circuit, follow these simple steps:

Step 1. Since the value of frequency and inductor are known, so firstly calculate the value of inductive reactance X_L: $X_L = 2\pi fL$ ohms.

Step 2. From the value of X_L and R, calculate the total impedance of the circuit which is given

by $$Z = \sqrt{R^2 + X_L^2}$$

Step 3. Calculate the total phase angle for the circuit $\theta = \tan^{-1}(X_L/R)$.

RC SERIES CIRCUIT:

The following steps are used to draw the phasor diagram of RC Series circuit.

1. Take the current I (r.m.s value) as a reference vector.
2. Voltage drops in resistance V_R = IR is taken in phase with the current vector
3. Voltage drops in capacitive reactance $V_C = IX_C$ is drawn 90 degrees behind the current vector, as current leads voltage by 90 degrees in pure capacitive circuit)
4. The vector sum of the two voltage drops is equal to the applied voltage V (r.m.s value).

Now, $V_R = I_R$ and $V_C = IX_C$ Where, $X_C = I/2\pi fC$

$$Z = \sqrt{\left(R^2 + X_C^2\right)}$$

R-L-C SERIES CIRCUIT: $Z = \sqrt{\left(R^2 + (X_L - X_C)^2\right)}$

CIRCUIT DIAGRAM:

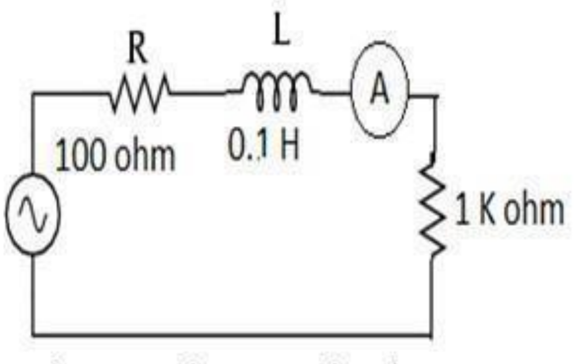


Fig.(a) Series R-L Circuit

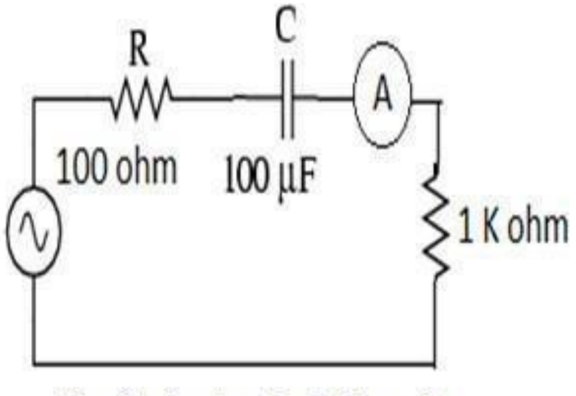


Fig.(b) Series R-C Circuit

PROCEDURE:

1. Give the connections as per the circuit diagram.
2. Connect the CRO probe at point A to get voltage waveform and at B to get the current waveform.
3. Adjust vertical deflection of each channel such that the waveform fills the whole screen.
4. Adjust the sweep rate and the horizontal position control until one half cycle ofthe waveform spans 9 divisions on the scope's scale.
5. Since one half cycle covers 9 divisions, it means each major division on the scope represents 200.
6. Since each major division consists of 5 smaller divisions, each smaller division represents 20/5 = 40.
7. Phase difference between two waveforms is determined by simply counting the number of small divisions between corresponding points on the 2 waveforms.
8. Phase Angle φ= (no. of divisions) * (degree / divisions).
9. Power Factor is given by Cosφ.

SERIES R-L CIRCUIT:

1. Connections are made as shown in the fig-(a).
2. Input voltage (Square wave) is set to a particular value.
3. The waveform of voltage across inductor is observed on CRO and the waveform is drawn on a graph sheet.

The time constant is found from the graph and verified with the theoretical value.

OBSERVATION TABLE:

	Series R-L Circuit	
	Theoretical	Practical
Impedance		

PRECAUTIONS:

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

RESULT:

APPLICATIONS:

1. The two fundamental applications/operations of RC circuits are as: filter circuits, in the frequency domain; as timing circuits, in the time domain.
2. Whenever current flows through the coil, lines of magnetic flux are generated around it. This magnetic flux opposes changes in the current due to induced emf. that component is inductor.

VIVA QUESTIONS:

1. What is impedance in an AC circuit?
2. How is impedance calculated in a series RL circuit?
3. How is impedance calculated in a series RC circuit?
4. What is the phase relationship between voltage and current in an RL circuit?
5. What is the phase relationship between voltage and current in an RC circuit?
6. How does resistance affect the total impedance in an RL or RC circuit?
7. How does inductive reactance (XL) depend on frequency?
8. How does capacitive reactance (XC) depend on frequency?
9. What happens to the impedance of an RL circuit if frequency increases?
10. What happens to the impedance of an RC circuit if frequency increases?
11. How do you calculate the current in a series RL or RC circuit?
12. What is the power factor in an RL circuit, and how is it determined?
13. What is the power factor in an RC circuit, and how is it determined?
14. What is the significance of the phase angle in an AC circuit?
15. How does an inductor behave in a DC circuit compared to an AC circuit?
16. How does a capacitor behave in a DC circuit compared to an AC circuit?
17. Why is the impedance in an RL or RC circuit not purely resistive?
18. How can you experimentally verify the impedance in an RL or RC circuit?
19. What instruments are used to measure voltage, current, and impedance in the experiment?
20. What are some practical applications of RL and RC circuits in electrical engineering?

Exp No :

Date :

4. DETERMINATION OF RESONANT FREQUENCY AND BAND WIDTH OF SERIES RESONANCE CIRCUIT

AIM:

To Determine the Resonant frequency and band width of Series Resonance circuit.

APPARATUS:

S.No.	Name of the Equipment	Range	Type	Quantity
1	CRO	(0-20) MHz	Dual	1
2	Series Resonance Kit	---------	---------	1
3	Connecting wires	As required		

THEORY:

The voltage across the inductor is $V_L = I X_L$ The voltage across the capacitor is $V_C = IX_C$ The voltage across the resistor is $V_R = IR$

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.

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

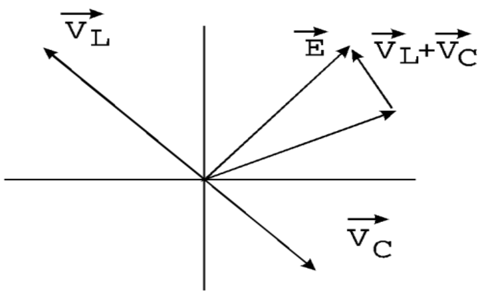


Figure 1

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

$$\mathbf{E/I = Z = R^2 + (X_L - X_C)^2}$$

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 $\omega = 1/\sqrt{LC} = \omega_0 = 2\pi f_0$

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 $V_{max}/\sqrt{LC} = 0.707\ V_{max}$

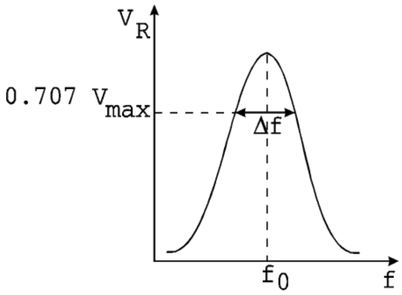
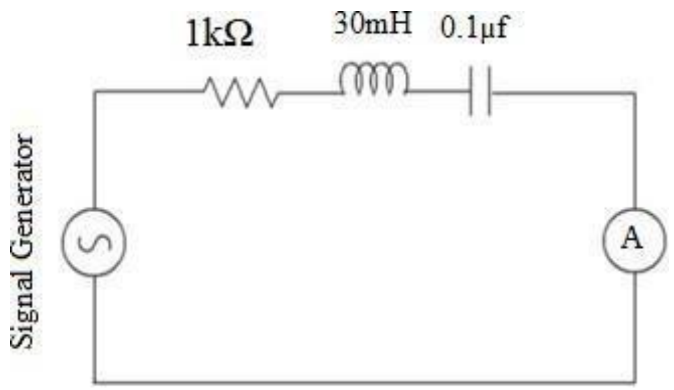


Figure 2

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 isdissipated in the circuit if the AC voltage source across the series circuit was removed.

CIRCUIT DIAGRAM:



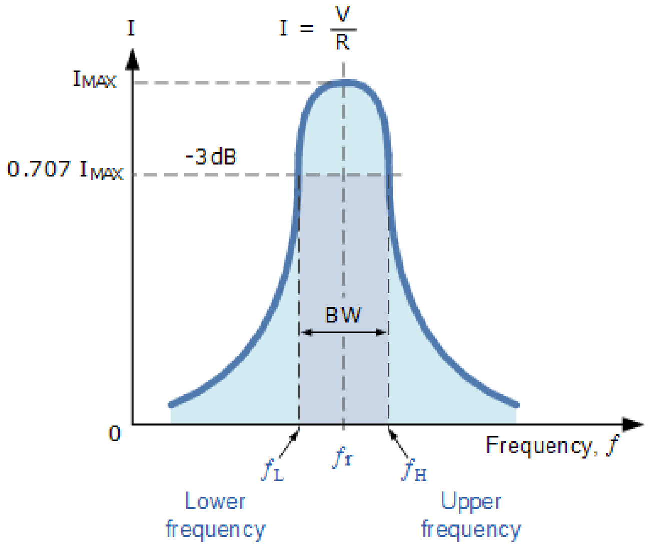
FORMULAE REQUIRED:

Resonant frequency, $f_o = \dfrac{1}{2\pi\sqrt{LC}}$

Quality factor, $Q = X_L / R = 2\pi f_o L/R$

Bandwidth, $BW = f_o / Q$

MODEL GRAPH:



PROCEDURE:

1. Circuit is connected as shown in the fig.
2. A fixed voltage is applied to the circuit through function generator.
3. The frequency is varied in steps and the corresponding ammeter reading isnoted down as I_s.
4. A graph is drawn between frequency f and current Is. Resonant frequency (f_o)and half power frequencies (f_1, f_2) are marked on the graph.
5. Bandwidth = (f_2-f_1.) & Quality factor are found from the graph.
6. Practical values of resonant frequency, Q-factor and bandwidth are comparedwith theoretical values.

OBSERVATION TABLE:

S.No.	Frequency	Current(Is)	S.No.	Frequency	Current(Ip)

RESULT TABLE:

	Series Resonance	
	Theoretical	Practical
Resonant frequency(f_0) Hz		
Bandwidth (BW)		
Quality factor(Q)		

PRECAUTIONS:

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

RESULT:

APPLICATIONS:

All mains operated appliances have switches that are connected to the live wire (the wire that carries current into the appliance). When a switch is in series witha device, it controls the device, allowing us to switch it on and off.

For example, often lawnmowers have two switches in series with each other so that both switches need to be pressed before the mower will turn on lighting circuits.

In the lighting circuit all the lamps are connected in parallel.

VIVA QUESTIONS:

1. Define resonance?
2. Difference between series & parallel resonance?
3. Define band width?
4. Define quality factor?
5. What is the relation between bandwidth & quality factor?
6. What is the lower &upper cutoff frequency?
7. What is the formula for RC series network using laplace transform?
8. Explain initial conditions of capacitance?
9. Explain types of elements?
10. Which capacitor is preferred for high voltage and frequency?
11. What are the materials used for resistor?
12. What happens to voltage when current through the inductor is constant?
13. How will you define capacitance?
14. When we use 3 terminal resistors?
15. What are the materials used for inductance coil?
16. Define Resonance and 3dB points?
17. What is phase difference between voltage and current in inductor andcapacitor?
18. Define Selectivity, Bandwidth and Q-factor?
19. For RLC circuit what is the power factor at the lowest frequency?
20. What are the expressions for admittance, conductance and suceptance andalso write its units?

20. What is meant by resonance?

21. What do you mean by sharpness of resonance?

22. What is resonance frequency?

23. What are forced vibrations?

24. What is bandwidth of series circuit?

25. Define quality factor of a series circuit.

27.Why should maximum value of current be divided by √2 for finding bandwidth?

26. Why is the series circuit called as acceptor circuit

27. Why parallel resonance circuit is called a rejecter circuit?

28. What is the importance of series resonance circuits?

Exp No :

Date :

5 . CALCULATIONS AND VERIFICATION OF IMPEDANCE AND CURRENT OF SERIES RLC

AIM:

To calculate and verify the Impedance and Current of series RLC circuits.

APPARATUS:

S.No	Name of the Equipment	Range	Type	Quantity
1	Function Generator	(0-100) MHz	Digital	1
2	Decade Resistance Box	---------	---------	1
3	Decade Inductance Box	---------	---------	1
4	Decade Capacitance Box	---------	---------	1
5	CRO	(0-20) MHz	Dual	1
6	Voltmeter	(0-20) V	Digital	1
7	Ammeter	(0-10) A	Digital	1
8	CRO Probes	---------	---------	1
9	Connecting wires	As required		

THEORY:

An RLC circuit is an electrical circuit consisting of a **Resistor (R)**, **Inductor (L)**, and **Capacitor (C)** connected in series or parallel. In a **series RLC circuit**, all components are connected end-to-end, forming a single path for current flow. The total opposition to the flow of alternating current (AC) is known as **impedance (Z)**, which is a combination of resistance (R), inductive reactance (XL), and capacitive reactance (XC).

Impedance in a Series RLC Circuit

The total impedance Z of a series RLC circuit is given by:

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

where:

- R = Resistance in ohms (Ω)
- $X_L = \omega L = 2\pi f L$ (Inductive Reactance, Ω)
- $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$ (Capacitive Reactance, Ω)
- f = Frequency in Hz
- L = Inductance in Henry (H)
- C = Capacitance in Farads (F)

Current in a Series RLC Circuit

The current III in the circuit is given by Ohm's Law:

$$I = \frac{V}{Z}$$

where:

- V = Applied voltage (V)
- Z = Total impedance (Ω)

Phase Angle (θ) and Power Factor

The phase angle **θ** between the applied voltage and current is determined by:

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

The power factor (PF) is given by:

$$PF = \cos(\theta) = \frac{R}{Z}$$

- If $X_L > X_C$, the circuit is **inductive** and the current lags the voltage.
- If $X_C > X_L$, the circuit is **capacitive** and the current leads the voltage.
- If $X_L = X_C$, the circuit is in **resonance**, and the impedance is minimum (Z = R).

Resonance Condition

Resonance in an RLC circuit occurs when:

$$X_L = X_C \quad \Rightarrow \quad 2\pi f L = \frac{1}{2\pi f C}$$

Solving for resonance frequency:

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

where fr is the **resonant frequency** at which impedance is purely resistive (Z=R).

CIRCUIT DIAGRAM:

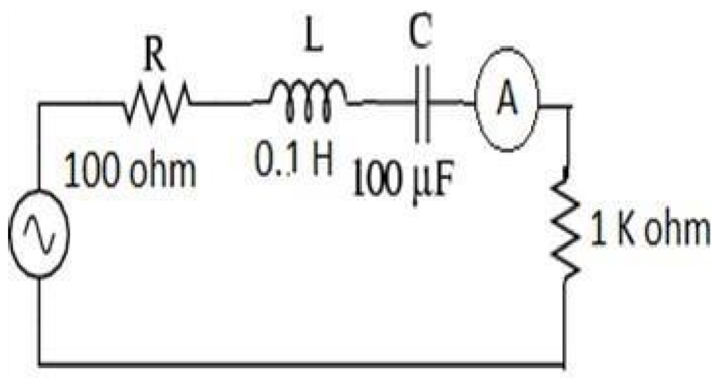


Fig.(c) Series R-L-C Ciruit

PROCEDURE:

10. Give the connections as per the circuit diagram.
11. Connect the CRO probe at point A to get voltage waveform and at B to get the current waveform.
12. Adjust vertical deflection of each channel such that the waveform fills the whole screen.
13. Adjust the sweep rate and the horizontal position control until one half cycle ofthe waveform spans 9 divisions on the scope's scale.
14. Since one half cycle covers 9 divisions, it means each major division on the scope represents 200.
15. Since each major division consists of 5 smaller divisions, each smaller division represents 20/5 = 40.
16. Phase difference between two waveforms is determined by simply counting the number of small divisions between corresponding points on the 2 waveforms.
17. Phase Angle φ= (no. of divisions) * (degree / divisions).
18. Power Factor is given by Cosφ.

OBSERVATION TABLE:

	Series R-L Circuit	
	Theoretical	Practical
Impedance		

PRECAUTIONS:

3. Loose connections are to be avoided.
4. Readings should be taken carefully without parallax error.

RESULT:

APPLICATIONS:

1. Used in **tuned circuits** (radio, TV, filters).
2. Power factor correction in **AC power systems**.
3. Used in **oscillators and signal processing**.
4. Important in **resonant converters and wireless charging systems**.

VIVA QUESTIONS:

1. What is an RLC circuit?
2. How do you define impedance in a series RLC circuit?
3. What is inductive reactance (XLX_LXL) and how is it calculated?
4. What is capacitive reactance (XCX_CXC) and how is it calculated?
5. How is the total impedance (ZZZ) of a series RLC circuit determined?
6. What is the phase angle (θ\thetaθ) in an RLC circuit, and how do you calculate it?
7. What is the power factor of an AC circuit, and how is it related to impedance?
8. What happens to the impedance when the circuit is at resonance?
9. How does frequency affect the impedance of an RLC circuit?
10. What are the conditions for resonance in a series RLC circuit?
11. What is the objective of this experiment?
12. What instruments are used to measure voltage, current, and impedance in the experiment?
13. How do you calculate the theoretical impedance before conducting the experiment?
14. How can you experimentally verify the impedance of the circuit?
15. Why do we use an AC source instead of DC for this experiment?
16. What happens to the current when the circuit reaches resonance?
17. How does resistance (RRR) affect the behavior of the RLC circuit?
18. How can you determine whether a circuit is inductive or capacitive?
19. What precautions should be taken while performing the experiment?
20. What are some practical applications of series RLC circuits?

Ex No :

Date :

6. VERIFICATION OF THEVENIN'S AND NORTON'S THEOREM

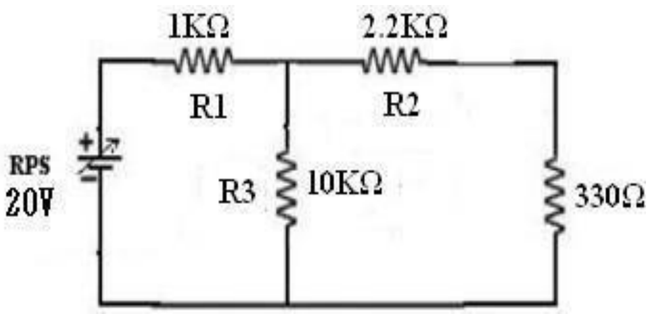
AIM: To verify Thevenin's theorem for the given circuit.

APPARATUS REQUIRED:

S. No	Name of the Equipment	Range	Type	Quantity
1	Voltmeter	(0-20) V	Digital	1 NO
2	Ammeter	(0-20) mA	Digital	1 NO
3	RPS	0-30V	Digital	1 NO
4	Resistors	10K Ω,1K Ω		1 NO
		2.2Ω		1 NO
		330 Ω		1 NO
5	Breadboard	-	-	1 NO
6	DMM	-	Digital	1 NO
7	Connecting wires			Required number

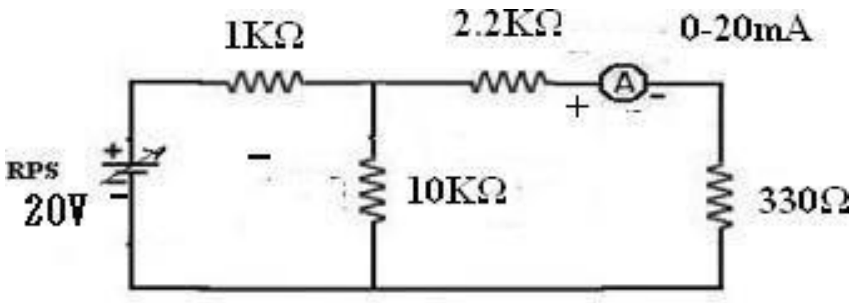
CIRCUIT DIAGRAM:

GIVEN CIRCUIT:



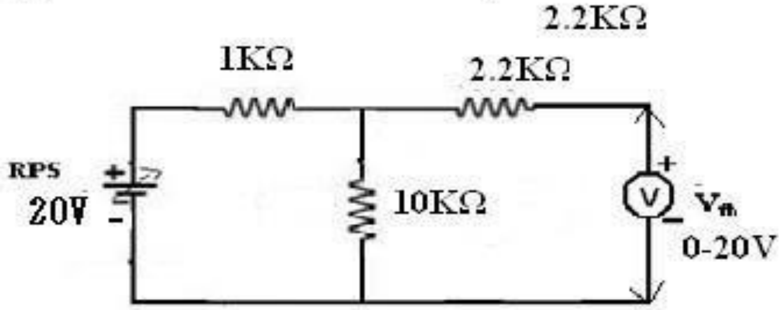
PRACTICAL CIRCUIT DIAGRAMS:

TO FIND IL:



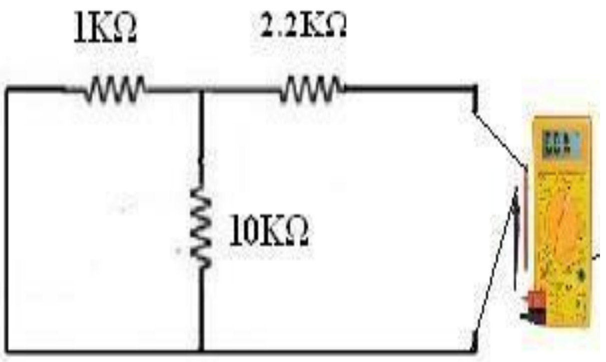
FIG(1)

TO FIND V_{TH}:



FIG(2)

TO FIND R_{th}:



fig(3)

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"

PROCEDURE:

1. Connect the circuit as per fig (1)

2. Adjust the output voltage of the regulated power supply to an appropriate value (Say 20V).

3. Note down the response (current, IL) 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. Disconnect the circuit and connect as per the fig (2).

6. Adjust the output voltage of the regulated power supply to 20V.

7. Note down the voltage across the load terminals AB (Voltmeter reading) that gives Vth.

8. Reduce the output voltage of the regulated power supply to 0V and switch-off the supply.

9. Disconnect the circuit and connect as per the fig (3).

10. Connect the digital multimeter (DMM) across AB terminals and it should be kept inresistance mode to measure Thevenin's resistance (R_{Th}).

THEORITICAL VALUES:

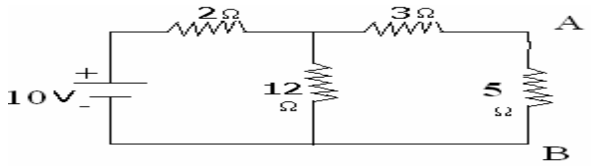
Tabulation for Thevenin's Theorem:

THEORITICAL VALUES	PRACTICAL VALUES
V_{th}= R_{th}= I_L=	V_{th}= R_{th}= I_L=

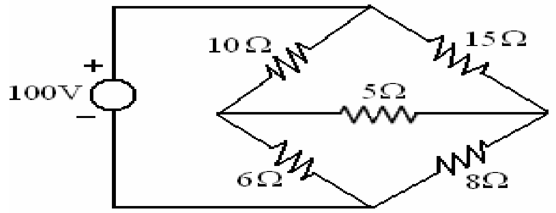
RESULT:

EXERCISE QUESTIONS:

1. Determine current through current 5 ohms resistor using Norton's theorem.



2. Determine the current flowing through the 5 ohm resistor using Thevenin's theorem



VIVA QUESTIONS:

1. The internal resistance of a source is 2 Ohms and is connected with an External Load Of 10 Ohms Resistance. What is Rth ?
2. In the above question if the voltage is 10 volts and the load is of 50 ohmsWhat is the load current and Vth? Verify I_L?
3. If the internal resistance of a source is 5 ohms and is connected with an External Load Of 25 Ohms Resistance. What is Rth?
4. 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 ?

VERIFICATION OF NORTON'S THEOREM

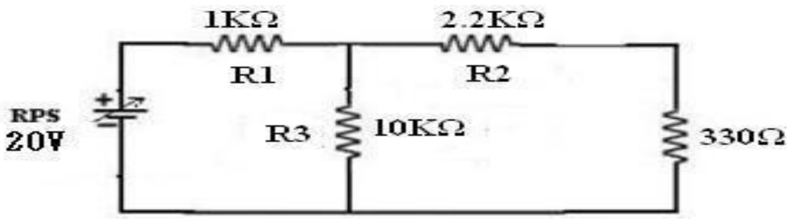
AIM: To verify Norton's theorem for the given circuit.

APPARATUS REQUIRED:

S. No	Name of the Equipment	Range	Type	Quantity
1	Voltmeter	(0-20) V	Digital	1 NO
2	Ammeter	(0-20) mA	Digital	1 NO
3	RPS	0-30V	Digital	1 NO
4	Resistors	10K Ω,1K Ω		1 NO
		2.2Ω		1 NO
		330 Ω		1 NO
5	Breadboard	-	-	1 NO
6	DMM	-	Digital	1 NO
7	Connecting wires			Required number

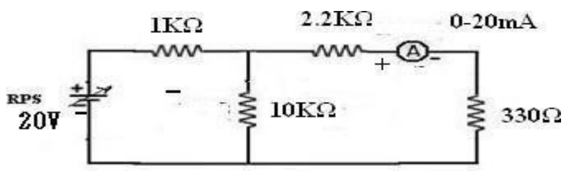
CIRCUIT DIAGRAM:

GIVEN CIRCUIT:



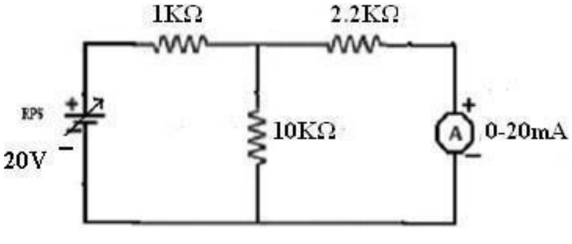
PRACTICAL CIRCUIT DIAGRAMS:

TO FIND IL:



FIG(1)

TO FIND IN:

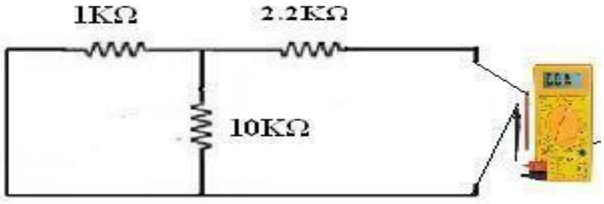


THEORY:

NORTON’S THEOREM:

Norton’s theorem states that in a lumped, linear network the equivalent circuit across any branch is

TO FIND R_N:



fig(3)

replaced with a current source in parallel a resistance. Where the current is the Norton’s current which is the short circuit current though that branch and the resistance is the Norton’s resistance which is the equivalent resistance across that branch by replacing all the sources sources with their internal resistances

for source current,

$$I = \frac{V}{R^{I}} = \frac{V(R_2 + R_3)}{R_1R_2 + R_1R_3 + R_2R_3}$$

FOR NORTON’s CURRENT

$$I_N = I \times \frac{R_3}{R_3 + R_2} = \frac{VR_3}{R_1R_2 + R_1R_3 + R_2R_3}$$

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

PROCEDURE:

1. Connect the circuit as per fig (1)

2. Adjust the output voltage of the regulated power supply to an appropriate value (Say 20V).

3. Note down the response (current, IL) 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. Disconnect the circuit and connect as per the fig (2).

6. Adjust the output voltage of the regulated power supply to 20V.

7. Note down the response (current, I_N) through the branch AB (ammeter reading).

8. Reduce the output voltage of the regulated power supply to 0V and switch-off the supply.

9. Disconnect the circuit and connect as per the fig (3).

10. Connect the digital multimeter (DMM) across AB terminals and it should be kept

in resistance mode to measure Norton’s resistance (R_N).

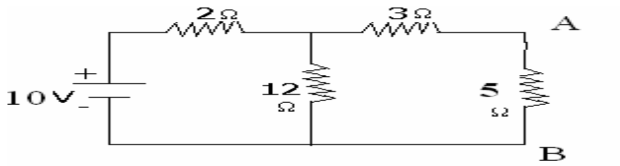
TABULATION FOR NORTON'S THEOREM:

THEORITICAL VALUES	PRACTICAL VALUES
I_N= R_N= I_L=	I_N= R_N= I_L=

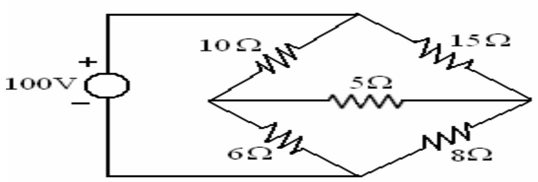
RESULT:

EXERCISE QUESTIONS:

1. Determine current through current 5 ohms resistor using Norton's theorem.



2. Determine the current flowing through the 5-ohm resistor using Thevenin's theorem



VIVA QUESTIONS:

1. The internal resistance of a source is 2 Ohms and is connected with an External Load Of10 Ohms Resistance. What is Rth?
2. In the above question if the voltage is 10 volts and the load is of 50 ohms. What is the load current and Vth? Verify I_L?
3. If the internal resistance of a source is 5 ohms and is connected with an External Load of 25 Ohms Resistance. What is Rth?
4. 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?

Ex No :

Date :

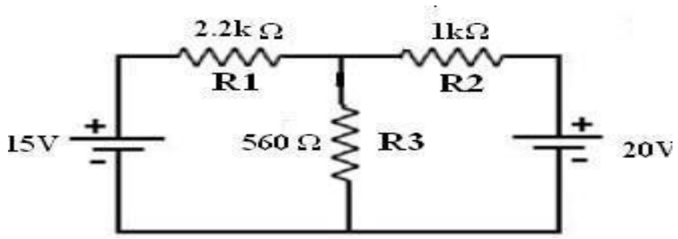
7. VERIFICATION OF SUPERPOSITION THEOREM

AIM: To verify the superposition theorem for the given circuit.

APPARATUS REQUIRED:

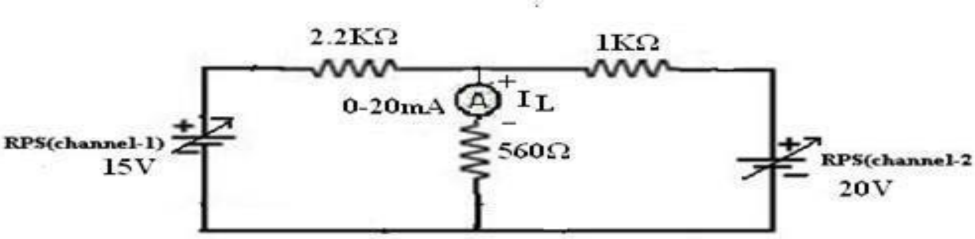
S. No	Name of the Equipment	Range	Type	Quantity
1	Bread board	-	-	1 NO
2	Ammeter	(0-20) mA	Digital	1 NO
3	RPS	0-30V	Digital	1 NO
4	Resistors	2.2k Ω		1 NO
		1k Ω		1 NO
		560 Ω		1 NO
5	Connecting Wires	-	-	As required

CIRCUIT DIAGRAM:



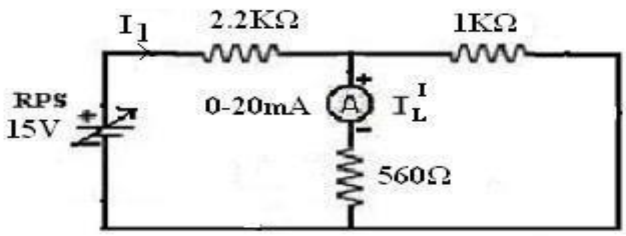
PRACTICAL CIRCUITS:

WhenV_1&V_2 source acting(To find I_L):-



Fig(1)

When V_1 Source Acting (To Find I^{I})



WhenV2 source acting (To find I_L^{II}):

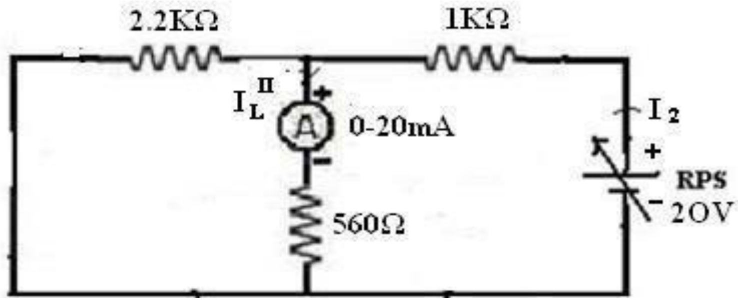


Fig (3)

THEORY:

SUPERPOSITION THEOREM:

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:

1. Connect the circuit as per the fig (1).
2. Adjust the output voltage of sources X and Y to appropriate values (Say 15V and20V respectively).
3. Note down the current (I_L) through the 560 0hm resistor by using the ammeter.
4. Connect the circuit as per fig (2) and set the source Y (20V) to 0V.
5. Note down the current$_L$(I $^{l)}$ through 560ohm resistor by using ammeter.
6. Connect the circuit as per fig(3) and set the source X (15V) to 0V and source Y to 20V.
7. Note down the current$_L$ (I ^{ll}) through the 560-ohm resistor branch by using ammeter.
8. Reduce the output voltage of the sources X and Y to 0V and switch off the supply. Disconnect the circuit.

THEORITICAL CALCULATIONS

From Fig(2)

$$I_1 = V_1/(R_1+(R_2//R_3))$$

$$I_L^{1} = I_1 * R_2/(R_2+R_3)$$

From Fig(3)

$$I_2 = V_2/(R_2+(R_1//R_3))$$

$$I_L^{11} = I_2 * R_1/(R_1+R_3)$$

$$I_L = I_L^{1} + I_L^{11}$$

TABULAR COLUMNS:

From Fig(1)

S. No	Applied voltage (V_1) Volt	Applied voltage (V_2) Volt	Current I_L (mA)

From Fig(2)

S. No	Applied voltage (V_1) Volt	Current I_L^{I} (mA)

From Fig(3)

S. No	Applied voltage (V_2) Volt	Current I_L^{II} (mA)

S.No	Load current	Theoretical Values	Practical Values
1	When Both sources are acting, I_L		
2	When only source X is acting, I_L^{1}		
3	When only source Y is acting, I_L^{11}		

PRECAUTIONS:

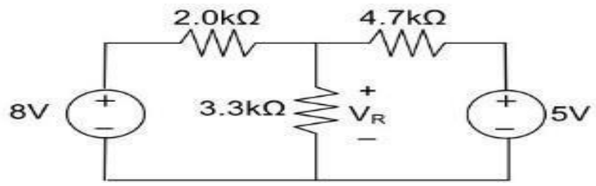
1. Initially keep the RPS output voltage knob in zero volt position.
2. Set the ammeter pointer at zero position.
3. Take the readings without parallax error.
4. Avoid loose connections.

Avoid short circuit of RPS output terminals

RESULT:

EXERCISE QUESTIONS:

1. Using the superposition theorem, determine the voltage drop and current across the resistor 3.3K as shown in figure below.



VIVA QUESTIONS:

1. What do you mean by Unilateral and Bilateral network?
2. Give the limitations of Superposition Theorem?
3. What are the equivalent internal impedances for an ideal voltage source and for a

   Current source?
4. Transform a physical voltage source into its equivalent current source. If all the 3 star connected

   impedance are identical and equal to ZA, then what is the Delta connected resistors

Exp No :
Date :

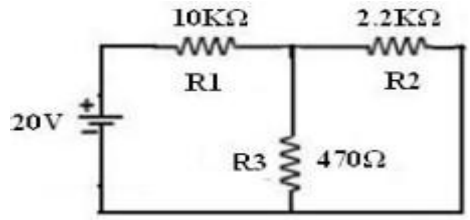
8. RECIPROCITY THEOREM

AIM: To verify reciprocity theorem for the given circuit.

APPARATUS REQUIRED:

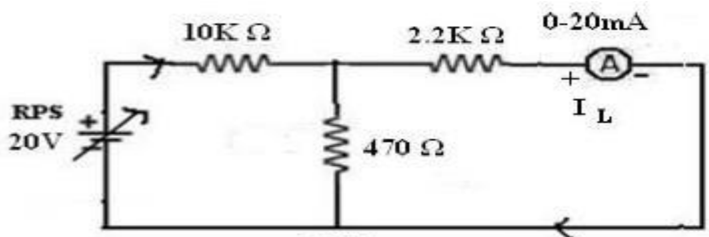
S.No	Name Of The Equipment	Range	Type	Quantity
1	Bread board	-	-	1 NO
2	Ammeter	(0-20)mA	Digital	1 NO
3	RPS	0-30V	Digital	1 NO
4	Resistors	2.2k Ω		1 NO
		10k Ω		1 NO
		470 Ω		1 NO

CIRCUIT DIAGRAM:



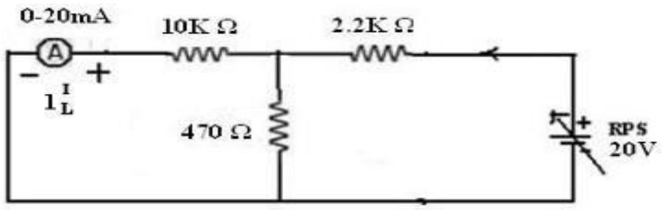
PRACTICAL CIRCUITS:

CIRCUIT-1



fig(1)

CIRCUIT-2:



fig(2)

THEORY:

STATEMENT:

In any linear, bilateral, single source network, the ratio of response to the excitation is same even though the positions of excitation and response are interchanged. This theorem permits in to transfer source from one position in the circuit to another and may be stated as under. In any linear bilateral network, if an e.m.facting in a branch causes a current 'I' inbranch 'Y' then the same e.m.f (E) located in branch 'Y' will cause a current I in branch. However, currents in other branches will not change.

PROCEDURE:

1. Connect the circuit as per the fig (1).

2. Adjust the output voltage of the regulated power supply to an appropriate value (Say20V).

3. Note down the current through 2.2K Ω by using ammeter.

4. Reduce the output voltage of the RPS to 0V and switch-off the supply.

5. Disconnect the circuit and connect the circuit as per the fig (2).

6. Adjust the output voltage of the regulated power supply to an appropriate value (Say20V).

7. Note down the current through 10K Ω resistor from ammeter.

8. Reduce the output voltage of the RPS to 0V and switch-off the supply.

9. Disconnect the circuit.

THEORITICAL CALCULATIONS :

From Fig(1)

$$I_1 = V/(R_1 + (R_2 // R_3))$$

$$I_L = I_1 * R_3/(R_2 + R_3)$$

From Fig(2)

$$I_2 = V/(R_2 + (R_1 // R_3))$$

$$I_L^1 = I_2 * R_3/(R_1 + R_3)$$

TABULAR COLUMNS:

From fig 1

S. No	Applied voltage (V1) Volt	Current I_L (mA)

From fig 2

S. No	Applied voltage (V2) Volt	Current I_L^1 (mA)

OBSERVATION TABLE:

S.No	Parameter	Theoretical Value	Practical Value
1	I_L /v1		
2	I_L^1/v2		

PRECAUTIONS:

1. Initially keep the RPS output voltage knob in zero-volt position.
2. Set the ammeter pointer at zero position.
3. Take the readings without parallax error.
4. Avoid loose connections.
5. Avoid short circuit of RPS output terminals.
6. If voltmeter gives negative reading, then interchange the terminals connections of a voltmeter

RESULT:

VIVA QUESTIONS:

1) What is reciprocity theorem?

2) Why it is not applicable for unilateral circuit?

3) What are the necessary conditions for the Reciprocity Theorem to hold?

4) In which type of circuits is the Reciprocity Theorem applicable?

5) Can the Reciprocity Theorem be applied to nonlinear circuits? Why or why not?

6) Does the Reciprocity Theorem hold for AC circuits? Explain.

Exp No :

Date :

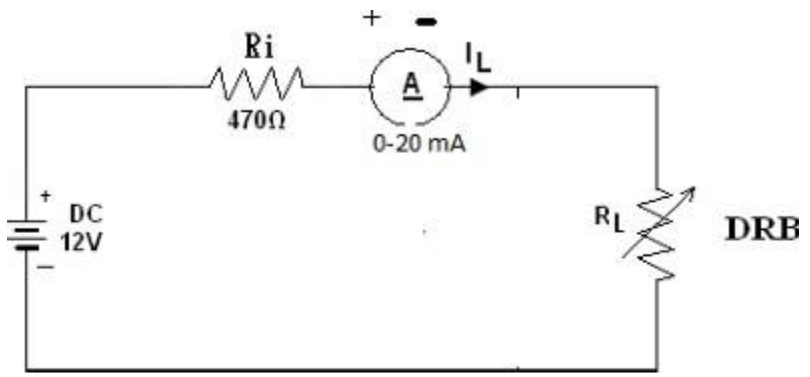
9. MAXIMUM POWER TRANSFER THEOREM

AIM: To Verify the Maximum Power Transfer Theorem for The Given Circuit.

APPARTUS REQUIRED:

Sl. No	Equipment	Range	Qty
1	Bread board	-	1
2	DC Voltage source.	0-30V	1
3	Resistors	470 Ω	1
4	Decade resistance box	0-10k Ω	1
5	Ammeter	0-20mA	1
6	Connecting wires	1.0.Sq.mm	As required

CIRCUIT DIAGRAM:



THEORY:

STATEMENT:

It states that the maximum power is transferred from the source to load when the load resistance is equal to the internal resistance of the source. (or) The maximum transformer states that "A load will receive maximum power from a linear bilateral network when its load resistance is exactly equal to the Thevenin's resistance of network, measured looking back into the terminals of network.

Consider a voltage source of V of internal resistance R_i delivering power to a load **Resistance R_L**

Circuit current = $\frac{V}{R_L + R_i}$

Power delivered $P = I^2 R_L$

$$= \left|\frac{V}{R_L + R_i}\right|^2 R_L$$

for maximum poewer $\frac{d(p)}{dt} = 0$

RL+Ri cannot be zero,

Ri – RL = 0

$$\boxed{R_L == Ri}$$

$$\textbf{Pmax} = \frac{V^2}{4R_L} \textbf{ watts}$$

PROCEDURE:

1. Connect the circuit as shown in the above figure.

2. Apply the voltage 12V from RPS.

3. Now vary the load resistance (RL) in steps and note down the corresponding Ammeter Reading (IL) in milli amps and Load Voltage (VL) volts

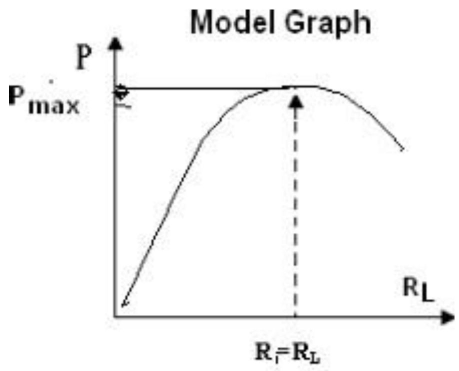
4. Tabulate the readings and find the power for different load resistance values.

5. Draw the graph between Power and Load Resistance.

6. After plotting the graph, the Power will be Maximum, when the Load Resistance will be equal to source Resistance

TABULAR COLUMN:

S.No	R_L	I_L(mA)	Power(P max)=I_L^2*R_L(mW)
1			
2			
3			
4			
5			
6			



Theoretical Calculations:-

$R = (R_i + R_L) = \ldots\Omega$

$I_L = V / R \quad = \ldots mA$

Power = $(I_L^2)\ R_L = \ldots mW$

RESULT:

VIVA QUESTIONS:

1) What is maximum power transfer theorem?

2) What is the application of this theorem?

3) What are the conditions for maximum power transfer?

4) Does the theorem apply to AC as well as DC circuits?

5) What is the mathematical expression for maximum power transfer?

6) In DC circuits, what should be the relationship between load resistance and source resistance for maximum power transfer?

7) How is the theorem different in AC circuits compared to DC circuits?

Exp No :

Date :

10. DETERMINATION OF SELF, MUTUAL INDUCTANCE OF TWO INDUCTIVE COILS

AIM: To determine the self-inductance, mutual inductance of two inductive coils.

APPARATUS:

S. No	Name of the apparatus	Range	Type	Quantity
1	Single phase transformer	230V / 115V, 2KVA	-	1No
2	1-ϕ auto transformer	230V / 0-270V,10A, 2.7 KVA	-	1No
3	Ammeter	(0-2) A	MI	1 No
4	Voltmeter	(0-600) / (0-300) V	MI	1No
5	Wattmeter	0-150 / 300 / 600V 2.5 / 5A, LPF	DM	1No
6	3-ϕ auto transformer	415 /0-470V, 10A, 4.7 KVA	-	1No
7	Connecting wires	-	-	Required number

THEORY:

The **determination of self and mutual inductance** of two inductive coils involves measuring how effectively they store and transfer magnetic energy. **Self-inductance** (L) is the property of a coil to oppose changes in current by inducing a voltage in itself, depending on the number of turns and core material. **Mutual inductance** (M) occurs when a changing current in one coil induces a voltage in another nearby coil, depending on their orientation and coupling coefficient. These inductances can be determined experimentally using methods like the **LCR meter, Maxwell's Bridge, or by measuring induced EMF**. The study of inductance is crucial in designing transformers, wireless power transfer systems, and electrical machines.

Self-Inductance (L)

The self-inductance of a coil is given by:

$$L = \frac{N\phi}{I}$$

where:

- L = Self-inductance (H)
- N = Number of turns
- ϕ = Magnetic flux (Weber)
- I = Current (A)

Mutual Inductance (M)

The mutual inductance between two coils is:

$$M = k\sqrt{L_1 L_2}$$

where:

- M = Mutual inductance (H)
- k = Coefficient of coupling ($0 \leq k \leq 1$)
- L_1 = Self-inductance of the first coil (H)
- L_2 = Self-inductance of the second coil (H)

PRECAUTIONS:

1. Ensure the minimum position of autotransformer during power on and off.

2. Set the ammeter pointer at zero position.

3. Take the readings without parallax error.

4. Avoid loose connections.

PROCEDURE:

1. Connect the circuit as per the fig (9.1).
2. Apply 230V across the primary winding by varying the knob of autotransformer slowly.
3. Note down the corresponding voltmeter, ammeter, and wattmeter readings.
4. Calculate the self-inductance, L1 of the primary coil with the help of above readings.
5. Disconnect the circuit and connect the circuit as per the fig (9.2).
6. Apply 115V across the secondary winding by varying the knob of autotransformer
7. Note down the corresponding voltmeter, ammeter, and wattmeter readings.
8. Calculate the self-inductance, L2 of the secondary coil with the help of above readings.
9. Disconnect the circuit and connect the circuit as per the fig (9.3).
10. Apply 345V across the cumulatively coupled windings by varying the knob of 3-phase autotransformer slowly.
11. Note down the corresponding voltmeter, ammeter, and wattmeter readings.
12. Calculate the equivalent inductance, LA of the windings with the help of above readings.
13. Disconnect the circuit and connect the circuit as per the fig (9.4).
14. Apply 115V across the differentially coupled windings by varying the knob of 1-phase autotransformer slowly.
15. Note down the corresponding voltmeter, ammeter, and wattmeter readings and disconnect the circuit.
16. Calculate the equivalent inductance, LB of the windings with the help of above readings.
17. Calculate Mutual inductance M, and coefficient of coupling K, using the values of L1, L2, LA, LB.

CIRCUIT DIAGRAMS:

a) To determine the self-inductance of coil 1:

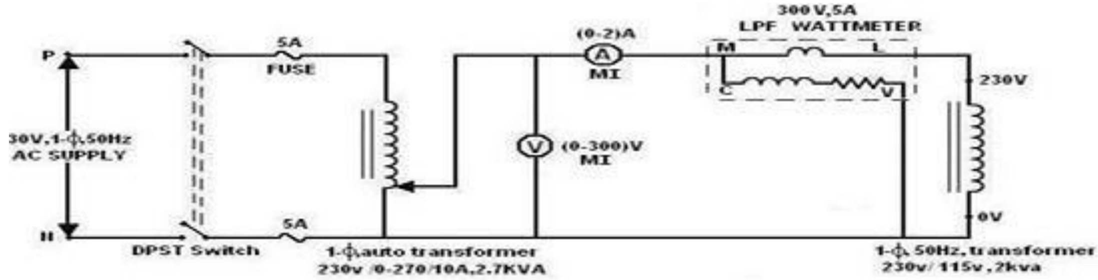


Fig.9.1

Tabular column:

S.No	V_1 (Volts)	I_1 (amp)	W_1 (Watt)	$Z_1 = \frac{V_1}{I_1}\Omega$	$R_1 = \frac{W_1}{I_1^2}\Omega$	$X_{L_1} = \sqrt{Z_1^2 - R_1^2}\Omega$	$L_1 = \frac{X_{L_1}}{2\pi f} H$

b) To determine the self-inductance of coil 2:

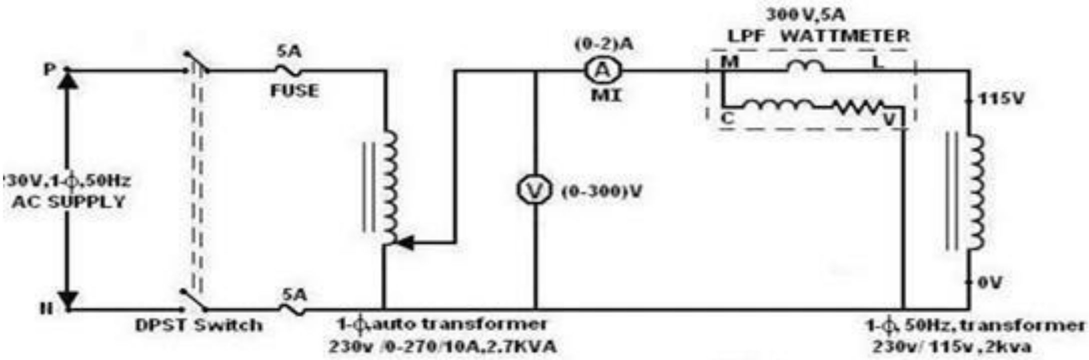


Fig.9.2

Tabular column:

S.No	V_2 (Volts)	I_2 (amp)	W_2 (Watt)	$Z2 = \frac{V_2}{I_2}\ \Omega$	$R2 = \frac{W2}{I_2^2}\ \Omega$	$X_{L2} = \sqrt{Z_2^2 - R_2^2}\ \Omega$	$L2 = \frac{X_{L2}}{2\pi f}\ H$

RESULT:

VIVA QUESTIONS:

1. What is inductance?
2. Define self-inductance and mutual inductance.
3. What is the SI unit of inductance?
4. State the formula for self-inductance of a coil.
5. State the formula for mutual inductance between two coils.
6. What is the significance of the coefficient of coupling k?
7. What is the maximum and minimum value of k, and what do they indicate?
8. What factors affect the self-inductance of a coil?
9. How does the number of turns in a coil affect inductance?
10. What is the difference between mutual and self-inductance?
11. How does the distance between two coils affect their mutual inductance?
12. What is the physical significance of mutual inductance in transformers?
13. How does the presence of a magnetic core affect inductance?
14. What is meant by flux linkage?
15. Can mutual inductance be negative? Why or why not?

Exp No :

Date :

11.DETERMINATION OF FORM FACTOR FOR NON-SINUSOIDAL WAVEFORM

AIM: To determine the form factor of a given non-sinusoidal waveform using an oscilloscope and a digital multimeter.

APPARATUS:

S. No	Name of the Equipment	Range	Type	Quantity
1	Function Generator	-	Digital	1 NO
2	Digital Storage Oscilloscope (DSO)	-	Digital	1 NO
3	Multimeter	-	Digital	1 NO
4	Resistors	10K Ω,1K Ω		1 NO
		2.2Ω		1 NO
		330 Ω		1 NO
5	Connecting wires			Required number

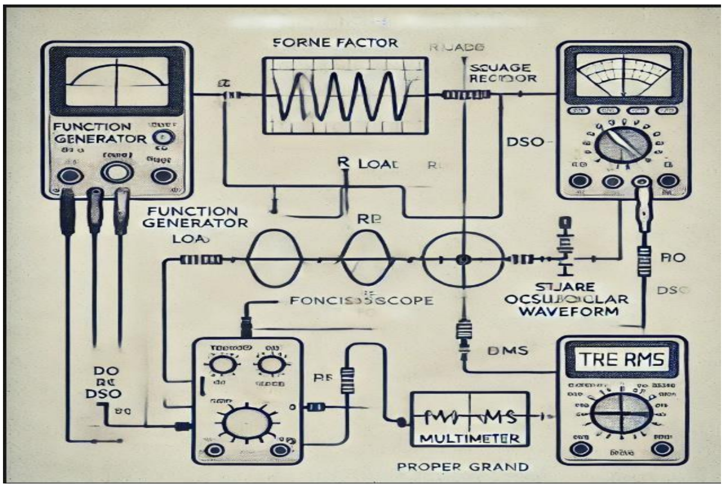
Theory:

The **Form Factor (FF)** is defined as the ratio of the **RMS (Root Mean Square) value** to the **Average (Mean) value** of the waveform. It is given by:

$$\text{Form Factor} = \frac{V_{\text{RMS}}}{V_{\text{avg}}}$$

For a pure sinusoidal waveform, the form factor is **1.11** (i.e., **FF = 1.11**). However, for non-sinusoidal waveforms, the form factor varies depending on the waveform shape.

CIRCUIT DIAGRAM:



PROCEDURE:

1. **Setup the Circuit:**
   - Connect the function generator to generate a non-sinusoidal waveform (e.g., square, triangular, or rectangular wave).
   - Connect the output of the function generator to the oscilloscope and a load resistor.
2. **Observation on Oscilloscope:**
   - Set the function generator to generate a desired frequency (e.g., 1 kHz).
   - Observe and analyze the waveform on the oscilloscope.
3. **Measure RMS Value:**
   - Use the Digital Storage Oscilloscope (DSO) to measure the **RMS voltage** (VRMS) directly.
   - Alternatively, use a **True RMS multimeter** to measure VRMS.
4. **Measure Average Value:**
   - The **average value** (Vavg) of the waveform can be determined from the oscilloscope or calculated using:

$$V_{\text{avg}} = \frac{1}{T}\int_0^T v(t)dt$$

where T is the time period of the waveform.

- Some oscilloscopes also provide a direct reading of Vavg.

5. **Calculate the Form Factor:**

   - Use the formula:

$$\text{Form Factor} = \frac{V_{\text{RMS}}}{V_{\text{avg}}}$$

6. **Compare Results:**

   - Compare the obtained form factor with the theoretical values for the waveform.
   - Example:
     - For a **square wave**, FF=1
     - For a **triangular wave**, FF≈1.15

RESULT:

PRECAUTIONS:

- Ensure proper grounding of the oscilloscope and function generator.
- Use a True RMS meter for accurate measurements.
- Carefully observe the waveform on the oscilloscope to avoid measurement errors.

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