INSTITUTE OF AERONAUTICAL ENGINEERING
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Lab Manual:

BASIC ELECTRICAL ENGINEERING LABORATORY(AEEC04)

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Contents

INTRODUCTION

Introduction

This course is intended to enhance the learning experience of the student in topics encountered in Basic Electrical Engineering Course AEEC01.In this lab, students are expected to develop the practical skills required to do the experiments and gain experience in using the basic measuring devices used in Electrical Engineering. Students also learn to interpret the experimental results in terms of the concepts introduced in the Basic Electrical Engineering course.How the student performs in the lab depends on his/her preparation and participation. Each student must participate in all aspects of the lab to ensure a thorough understanding of the equipment and concepts. The student, Faculty teaching the lab course, Laboratory In-charge and faculty coordinator all have certain responsibilities towards successful completion of the lab's goals and objectives.

Student Responsibilities

The student is expected tocome prepared for each lab.Lab preparation includes understanding the labexperiment from the lab manual and reading the related textbook material.

Students have to write the allotted experiment for that particular week in the work sheets given and carry them to the Lab. In case of any questions or problems with the preparation, students can contact the Faculty Teaching the Lab course, but in a timely manner.

Students have to be in formal dress code, wear shoes and lab coat for the Laboratory Class.

After the demonstration of experiment by the faculty, student has to perform the experiment individually. They have to note down the observations in the observation Tables drawn in work sheets, do the calculations and analyze the results.

Active participation by each student in lab activities is expected. The student is expected to ask the Faculty any questions they may have related to the experiment.

The student should remain alert and use commonsense while performing the lab experiment.They are also responsible for keeping a professional and accurate record of the labexperiments in the files provided.

Responsibilities of Faculty Teaching the Lab Course

The Faculty shall be completely familiar with each labprior to the laboratory. He/She shall provide the students with details regarding the syllabus and safety review during the first week.Lab experiments should be checked in advance to make sure that everything is in working order.The Faculty should demonstrate and explain the experiment and answer any questions posed by the students.Faculty have to supervise the students while they perform the lab experiments. The Faculty is expected to evaluate the lab worksheets and grade them based on their practical skills and understanding of the experiment by taking Viva Voce. Evaluation of work sheets has to be done in a fair and timely manner to enable the students, for uploading them online through their CMS login within the stipulated time.

Laboratory In-charge Responsibilities

The Laboratory In-charge should ensure that the laboratory is properly equipped, i.e., the Faculty teaching the lab receive any equipment/components necessary to perform the experiments.He/She is responsible for ensuring that all the necessary equipment for the lab is available and in working condition. The Laboratory In-charge is responsible for resolving any problems that are identified by the teaching Faculty or the students.

Course Coordinator Responsibilities

The course coordinator is responsible fo rmaking any necessary corrections in Course Description and lab manual. He/She has to ensure that it is continually updated and available to the students in the CMS learning Portal.

Lab Policy and Grading

The student should understand the following policy:

ATTENDANCE: Attendance is mandatory as per the academic regulations.

LAB RECORD's: The student must:

1. Write the work sheets for the allotted experiment and keep them ready before the beginning of eachlab.
2. Keep all work in preparation of and obtained during lab.
3. Perform the experiment and record the observations in the worksheets.
4. Analyze the resultsand get the work sheets evaluated by the Faculty.
5. Upload the evaluated reports online from CMS LOGIN within the stipulated time.

Grading Policy:

The final grade of this course is awarded using the criterion detailed in the academic regulations. A large portion of the student's grade is determined in the comprehensive final exam of the Laboratory course (SEE PRACTICALS),resulting in a requirement of understanding the concepts and procedure of each lab experiment for successful completion of the lab course.

Pre-Requistes and Co-Requisties:

The lab course is to be taken during the same semester as AEEC04, but receives a separate grade. Students are required to have completed both AEEC01 and AEEC04 with minimum passing grade or better grade in each.

Course Goals and Objectives

The BEE Laboratory course is designed as a foundation course to provide the student with the knowledge to understand the basic concepts in electrical Engineering which have lot of applications in the field of Engineering.

The experiments are designed to complement the concepts introduced in AEEC01. In addition, the student should learn how to record experimental results effectively and present these results in a written report.

More explicitly, the class objectives are:

1. To gain proficiency in the use of common measuring instruments.
2. To enhance understanding of theoretical concepts including:
   - Verify circuit concepts for DC circuits
   - Measure the impedance of series RL, RC and RLC circuits
   - The various theorems used to reduce the complexity of electrical network
   - The operation and characteristics of DC machines
   - The operation and characteristics of AC machines
3. To develop communication skills through:
   - Verbal interchanges with the Faculty and other students.
   - Preparation of succinct but complete laboratory reports.
   - Maintenance of laboratory worksheets aspermanent, written descriptions of procedures, analysis and results.
4. To compare theoretical predictions with experimental results and to determine the source of any apparent errors.

Use of Laboratory Instruments

One of the major goals of this lab is to familiarize the student with the proper equipment and techniques for making DC machines operation. Some understanding of the lab instruments is necessary to avoid personal or equipment damage. By understanding the device's purpose and following a few simple rules, costly mistakes can be avoided..

The following rules provide a guideline for instrument protection.

Instrument Protection Rules

Set instrument scales to the highest range before turning on the power/source.

Be sure instrument grounds are connected properly. Avoid accidental grounding of "hot" leads, i.e., those that are above ground potential.

Check polarity markings and connections of instruments carefully before connecting power.

Never connect an ammeter across a voltage source. Only connect ammeters in series with loads.

Do not exceed the voltage and current ratings of instruments or other circuit elements. This particularly applies to wattmeters since the current or voltage rating may be exceeded with the needle still on the scale.

Be sure the fuse and circuit breakers are of suitable value. When connecting electrical elements to make up a network in the laboratory, it is easy to lose track of various points in the network and accidentally connect a wire to the wrong place. A procedure to follow that helps to avoid this is to connect the main series part of the network first, then go back and add the elements in parallel. As an element is added, place a small check by it on your circuit diagram. Then go back and verify all connections before turning on the power. One day someone's life may depend upon your making sure that all has been done correctly.

Data Recording and Reports

The Laboratory Worksheets

Students must record their experimental values in the provided tables in this laboratory manual and reproduce them in the lab worksheets. Worksheets are integral to recording the methodology and results of an experiment. In engineering practice, the laboratory notebook serves as an invaluable reference to the technique used in the lab and is essential when trying to duplicate a result or write a report. Therefore, it is important to learn to keep accurate data. Make plots of data and sketches when these are appropriate in the recording and analysis of observations. Note that the data collected will be an accurate and permanent record of the data obtained during the experiment and the analysis of the results. You will need this record when you are ready to prepare a lab report i.e worksheets.

The Laboratory Files/Reports

Worksheets are the primary means of communicating your experience and conclusions to other professionals. In this course you will use the lab worksheets to inform your faculty coordinator about what you did and what you have learned from the experience. Engineering results are meaningless unless they can be communicated to others. You will be directed by your faculty coordinator to prepare a lab report on a few selected lab experiments during the semester.

Your laboratory report should be clear and concise. The lab report shall be student hand written on a work sheets provided by the college. As a guide, use the format on the next page. Use tables, diagrams, sketches, and plots, as necessary to show what you did, what was observed, and what conclusions you can draw from this by using pencil and scale. Free hand diagrams and tables will reduce your marks. Even though you will work with one or more lab partners, your report will be the result of your individual effort in order to provide you with practice in technical communication.

LAB-1 ORIENTATION

1.1 Introduction

In the first experiment period, the students should become familiar with the location of equipment and components in the lab, the course requirements, and the teaching instructor.

1.2 Objective

To familiarize the students with the lab facilities, equipment, standard operating procedures, lab safety, and the course requirements.

1.3 Prelab Preparation:

Read the introduction and procedure of the experiment of respective experiments which are given this manual.

1.4 Equipment needed

Lab manual

1.5 Procedure

1. During the first laboratory period, the faculty coordinator will provide the students with a general idea of what is expected from them in this course. Each student will receive a copy of the syllabus, stating the faculty coordinator's contact information. In addition, the faculty coordinator will review the safety concepts of the course.

2. During this period, the faculty coordinator will briefly review the equipment which will be used throughout the semester. The location of instruments, equipment, and components will be indicated. The guidelines for instrument use will be reviewed.

1.6 Further Probing Experiments

Questions pertaining to this lab must be answered at the end of laboratory report.

LAB-2 OHM'S LAW, KCL AND KVL

2.1 Introduction

This experiment focuses on the ohms law KVL and KCL analysis. Ohms law, specifically its usage in verify the relation between current and voltage. Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL) , specifically its usage in verify voltage and current relation in a Passive Resistive Network.

2.2 Objective

By the end of this experiment, the student should be able to verify ohm's law, KVL, KCL using hardware and digital simulation.

2.3 Prelab Preparation:

Read the material in the textbook that describes ohms law and Kirchhoffs Voltage Law. Prior to coming to the lab, complete Part 1, Part 2, Part 3 and Part 4 of the procedure.

2.4 Equipment needed

R.P.S, Breadboard, Connecting Wires Digital Ammeter, Digital Voltmeter and Digital Multimeter Resistors: 1000W, 47W, 220 W, 150W, 470W, 100W.

2.5 Background

. Ohms Law states that, at constant temperature in an electrical circuit the current (I) flowing through a conductor is directly proportional to potential difference (V) applied. I V or V I or V=IR Limitations of Ohm's Law It is applicable only for metallic conductor such as copper, silver etc. It is not applicable for all electrical circuit such semiconductor devices, transistors ect. In 1845, German physicist Gustav Kirchhoff was described relationship of two quantities in Current and potential difference (Voltage) inside a circuit. This relationship or rule is called as Kirchhoff's circuit Law. Kirchhoff's Circuit Law consist two laws, Kirchhoff's First law - which is related with current flowing, inside a closed circuit and called as Kirchhoff's current law (KCL) and the other one is Kirchhoff's Second law which is to deal with the voltage sources of the circuit, known as Kirchhoff's voltage law (KVL). Kirchhoffs First Law – The Current Law, (KCL) Kirchhoffs Current Law states that the "the algebraic sum of all the currents entering and leaving a node must be equal to zero. Or Total current entering a junction or node is exactly equal to total current leaving the node. This idea by Kirchhoff is commonly known as the Conservation of Charge. Kirchhoffs Second Law – The Voltage Law, (KVL) Kirchhoffs Voltage Law, 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. Or 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.

2.6 Procedure

1. Part (1) Determine the theoretical currents then set up of ohms law for Figure 2.1 , and record all the currents in Table 2.1.
2. Part (2) Determine the theoretical voltages then set up of KVL for Figure 2.2 , and record all the voltages in Table 2.2.
3. Part (3) Determine the theoretical current then set up of KCL for Figure 2.3 , and record all the currents in Table 2.3.

2.7 Results and Discussion

1. Part (1) Set up the circuit as shown in Figure 2.1. Apply a DC power supply of 0 to 10V and measure the currents (I) in the circuit (i.e. connect the ammeters as shown in Figure 2.1) and complete table 2.1. Compare the values obtained from part 1 above and part 1 here.
2. Part (2) Set up the circuit as shown in Figure 2.2. Apply a DC power supply of 15V and measure the voltages (V1, V2, V3) in the circuit (i.e. connect the voltmeters across these elements as shown in Figure 2.2) and complete table 2.2. Compare the values obtained from part 1 and part 2.
3. Part (3) Set up the circuit as shown in Figure 2.3. Apply a DC power supply of 15V and measure the currents (I, I1, I2) in the circuit (i.e. connect the voltmeters across these elements as shown in Figure 2.3) and complete table 2.3. Compare the values obtained from part 2 and part 3.
4. Part (4) Design the MATLAB model the circuit as shown in Figure 2.4. and Figure 2.5. Apply a DC power supply of 15V and measure the voltages (V1, V2, V3) and currents (I, I1, I2) in the circuits and complete table 2.4.and table 2.5.Compare the values obtained from part 2 and part 3.

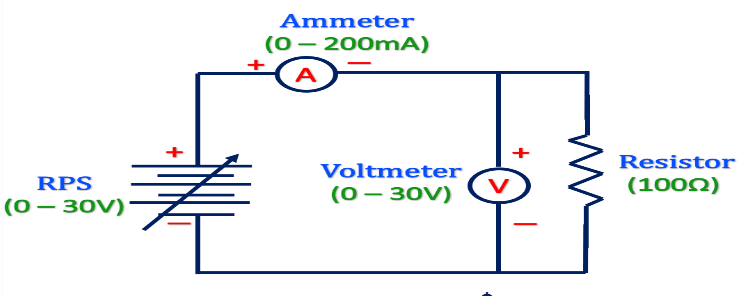


Figure 2.1.ohm's law

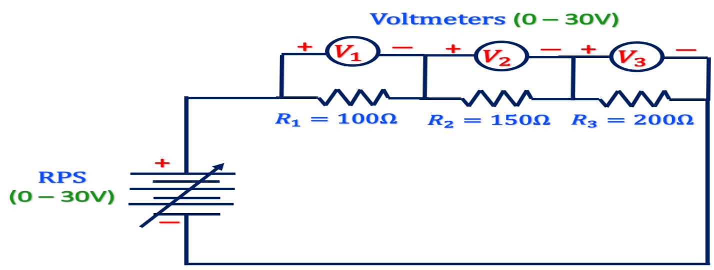


Figure 2.2. The Voltage Law, (KVL)

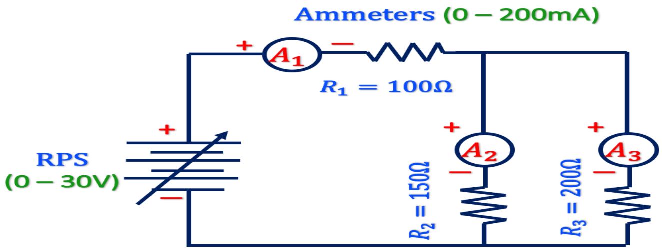


Figure 2.3. The Current Law, (KCL)

S. No.	Theoretical Voltage (V)	Practical Voltage (V)	Theoretical Current (A)	Practical Current (A)
1	5	5		
2	10	10		
3	15	15		
4	20	20		

Table 2.1. ohm's law

S. No.	Resistor (Ω)	Theoretical Voltage (V) = 10v	Practical Voltage (V) = 10v
1	100		
2	150		
3	200		

Table 2.2. The Voltage Law, (KVL)

S. No.	Resistor (Ω)	Theoretical Current (A) = 0.2A	Practical Current (A) = 0.2A
1	150		
2	200		

Table 2.3. The Current Law, (KCL)

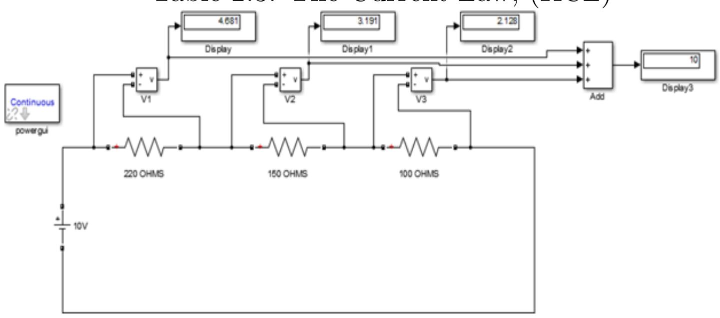


Figure 2.4. The Voltage Law, (KVL) simulation circuit

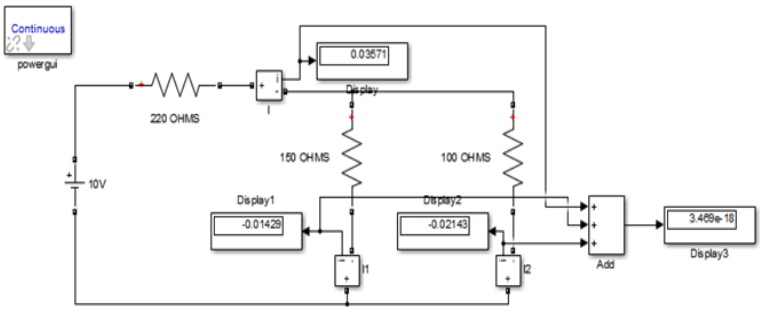


Figure 2.5. The Current Law, (KCL) simulation circuit

S. No.	Resistor (Ω)	Theoretical Voltage (V) = 10v	Practical Voltage (V) = 10v
1	100		
2	150		
3	200		

Table 2.2. The Voltage Law, (KVL) simulation result

S. No.	Resistor (Ω)	Theoretical Current (A) = 0.2A	Practical Current (A) = 0.2A
1	150		
2	200		

Table 2.3. The Current Law, (KCL) simulation result

2.8 Viva Questions

1. What do you mean by junction?
2. Derive current division rule.
3. Explain the sign conventions.
4. Explain the colour coding of resistors.

2.9 Further Probing Experiments

Q1. Use MATLAB/Simulink to determine the Mesh analysis for the circuit in Part 1. First, enter the circuit shown in Figure 1.1 using down node as the reference or "ground" node. To measure the short-circuit currents in parallel elements, place the ammeters in series with these elements and compare to your experimentally obtained values in Part 2. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.
Q2. Use MATLAB/Simulink to determine the Nodal analysis for the circuit in Part 3 First, enter the circuit shown in Figure 1.2 using down node as the reference or "ground" node. The voltage at upper node is then the open circuit voltage. Measure the voltages (V1, V2, V3) in the circuit as per Figure 1.2 and compare to your experimentally obtained values in Part 4. Record your

MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

LAB-3 MESH ANALYSIS

3.1 Introduction

This experiment focuses on the Mesh analysis. Mesh analysis , specifically its usage in multi-source DC circuits. Its application is finding circuit currents and voltages will be investigated.

3.2 Objective

By the end of this experiment, the student should be able to verify Mesh analysis .

3.3 Prelab Preparation:

Read the material in the textbook that describes Mesh analysis. Prior to coming to the lab, complete Part 1 of the procedure.

3.4 Equipment needed

R.P.S, Breadboard, Connecting Wires
Digital Ammeter, Digital Voltmeter and Digital Multimeter
Resistors: 1000Ω, 47Ω, 220 Ω, 150Ω, 470Ω, 100Ω.

3.5 Background

Mesh Analysis: Any closed electrical path is called loop. Mesh is defined as a loop which does not contain any other loops within it. If a network has a larger number of voltage sources, it is better to use mesh analysis, which mainly depends on KVL. The steps to follow in mesh analysis is given below:

- Identify all the meshes in network and select Loop/Mesh currents.
- Sign conventions for the IR drops and source/ battery emfs are the same as for KVL.
- Apply KVL around the mesh and use ohm's law to express the branch voltages in terms of unknown mesh currents and the resistance.
- Solve the simultaneous equations for unknown mesh currents.

3.6 Procedure

Part (1) Determine the theoretical currents then set up of mesh analysis for Figure 1.1 , and record all the currents in Table 1.1.

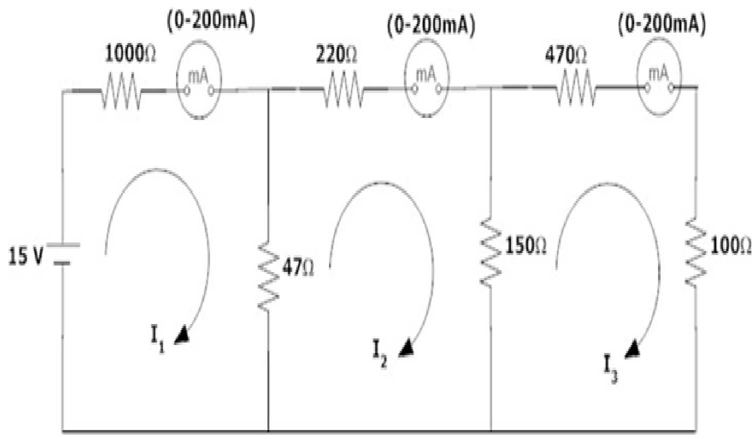


Figure 3.1: Mesh Analaysis Circuit

Applied Voltage V(volts)	Loop current(I_1)		Loop current (I_2)		Loop current(I_3)	
	Theoretical	Practical	Theoretical	Practical	Theoretical	Practical

Figure 3.2: Table 1.1:Calculated and Measured values using Mesh Analysis of Figure 1.1

3.7 Results and Discussion

Part (1) Set up the circuit as shown in Figure 1.1. Apply a DC power supply of 15V and measure the mesh currents (I1, I2, I3) in the circuit (i.e. connect the ammeters as shown in Figure 1.1) and complete table 1.1. Compare the values obtained from part 1 above and part 1 here.

3.8 Viva Questions

1. Explain mesh analysis?
2. Mention the application of super mesh analysis?
3. What is the equation for determining the number of independent loop equations in mesh current method?
4. How do we calculate branch currents from loop currents?

3.9 Further Probing Experiments

Q1. Use MATLAB/Simulink to determine the Mesh analysis for the circuit in Part 1. First, enter the circuit shown in Figure 1.1 using down node as the reference or "ground" node. To measure the short-circuit currents in parallel elements, place the ammeters in series with these elements and compare to your experimentally obtained values in Part 2. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

LAB-4 NODAL ANALYSIS

4.1 Introduction

This experiment focuses on the Nodal analysis. Nodal analysis, specifically its usage in multi-source DC circuits. Its application in finding circuit node voltages will be investigated.

4.2 Objective

By the end of this experiment, the student should be able to verify Nodal analysis.

4.3 Prelab Preparation:

Read the material in the textbook that describes Nodal analysis. Prior to coming to the lab, complete Part 1 of the procedure.

4.4 Equipment needed

R.P.S, Breadboard, Connecting Wires
Digital Ammeter, Digital Voltmeter and Digital Multimeter
Resistors: 1000Ω, 47Ω, 220 Ω, 150Ω, 470Ω, 100Ω.

4.5 Background

Nodal Analysis: A node is a point in a network common to more than two circuit elements. A node voltage is the voltage of given node with respective to one particulate node, called the reference node, which we assume at zero potential. If the network has more number of current sources, then the nodal analysis is useful method, mainly depends on KCL. An 'N' node circuit will be require (N-1) unknown voltages and (n-1) equations.The steps to follow in nodal analysis is given below:

- Identify all the nodes in network and select node voltages.
- One of these nodes is taken as reference node, which is at zero potential.
- Node voltages are measured with respective to the reference node.
- Apply KCL at each node and use ohm's law to express branch currents in terms of unknown node voltages and branch resistances.
- Solve the simultaneous equations for unknown node voltages.

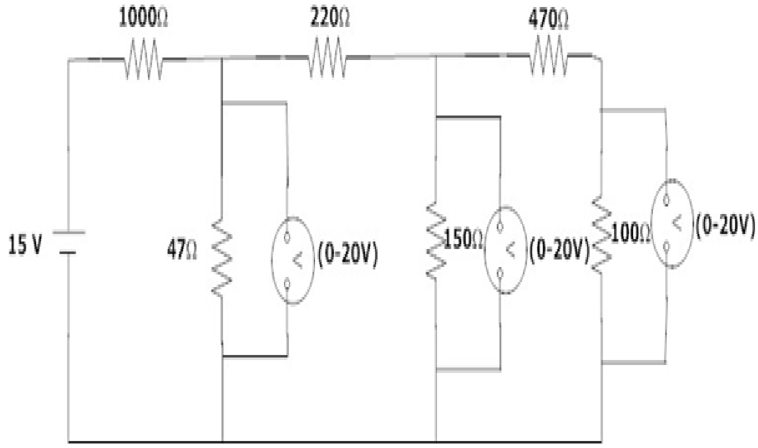


Figure 4.1: Nodal Analaysis Circuit

Applied Voltage V (volts)	Node voltage(V_1)		Node voltage(V_2)		Node voltage(V_3)	
	Theoretical	Practical	Theoretical	Practical	Theoretical	Practical

Figure 4.2: Table 1.2:Calculated and Measured values using Nodal Analysis of Figure 1.2

4.6 Procedure

Part (1) Determine the theoretical voltages then set up of nodal analysis for Figure 1.2 , and record all the voltages in Table 1.2.

4.7 Results and Discussion

Part (1) Set up the circuit as shown in Figure 1.2. Apply a DC power supply of 15V and measure the node voltages (V1, V2, V3) in the circuit (i.e. connect the voltmeters across these elements as shown in Figure 1.2) and complete table 1.2. Compare the values obtained from part 1 and part 2.

4.8 Viva Questions

1. Name the laws on which nodal analysis based?
2. Explain nodal analysis?
3. Give the necessary conditions for applying the super node analysis?

4. Define node.
5. Is nodal analysis is applicable to both DC and AC supply?
6. How to calculate branch currents from nodal voltages?
7. How to calculate branch voltages from nodal voltages?

4.9 Further Probing Experiments

Q1. Use MATLAB/Simulink to determine the Nodal analysis for the circuit in Part 3. First, enter the circuit shown in Figure 1.2 using down node as the reference or "ground" node. The voltage at upper node is then the open circuit voltage. Measure the voltages (V1, V2, V3) in the circuit as per Figure 1.2 and compare to your experimentally obtained values in Part 4. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.

LAB-5 SINGLE PHASE AC CIRCUITS

5.1 Introduction

This experiment focuses on the Characteristics of sinusoidal wave.

5.2 Objective

By the end of this experiment, the student should be able to determine the average value, RMS value, form factor, peak factor of sinusoidal wave.

5.3 Prelab Preparation:

Read the material in the textbook that describes periodic waveforms. Prior to coming to the lab, complete Part 1 of the procedure.

5.4 Equipment needed

Function Generator, Breadboard, Connecting Wires
Digital Ammeter, Digital Voltmeter and Digital Multimeter
Resistors: 1000Ω, Inductor: 1 mH.

5.5 Background

In alternating current (AC, also ac) the movement (or flow) of electric charge periodically reverses direction. An electric charge would for instance move forward, then backward, then forward, then backward, over and over again. In direct current (DC), the movement (or flow) of electric charge is only in one direction. Average value: Average value of an alternating quantity is expressed as the ratio of area covered by wave form to distance of the wave form.
Root Mean Square (RMS) Value: The RMS value of an alternating current is expressed by that steady DC current which when flowing through a given circuit for given time produces same heat as produced by that AC through the sane circuit for the same time period. In the common case of alternating current when I(t) is a sinusoidal current, as is approximately true for mains power, the RMS value is easy to calculate from the continuous case equation above. If we define Ip to be the peak current, then in general form
The factor is called the crest factor, which varies for different waveforms. For a triangle wave form centered about zero. For a square wave form centered about zero

5.6 Procedure

Part (1) Connect the circuit as shown in the circuit diagram of fig. 4.1., Set the value of frequency say 100 Hz in the function generator and Adjust the ground of channel 1 and 2 of

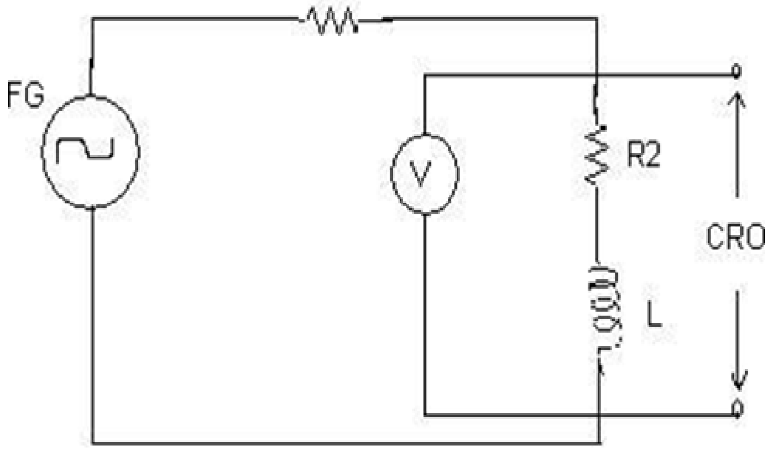


Figure 5.1: Basic Circuit

Peak Value(V)	RMS Value(V)	AverageValue(V)

Figure 5.2: Cathode Ray Oscilloscope results

Cathode Ray Oscilloscope and then set it into DC mode and Connect CRO across the load in DC mode and observe the waveform and Adjust the DC offset of function generator and Note down the amplitude and frequency.

5.7 Results and Discussion

Part (1) Set up the circuit as shown in Figure 4.1. 6. Set the multimeter into AC mode and measure input voltage and voltage across point AB. This value gives RMS value of sinusoidal AC and Measure the RMS and Average value of DC signal also where instead of function generator you can use DC supply and complete table 5.1. Compare the values obtained from part 1.

5.8 Viva Questions

1. Check for proper connections before switching ON the supply
2. Make sure of proper color coding of resistors
3. The terminal of the resistance should be properly connected

LAB-6 IMPEDANCE OF SERIES RL,RC AND RLC CIRCUITS

6.1 Introduction

This experiment focuses on the impedance of series RL, RC and RLC circuits.

6.2 Objective

By the end of this experiment, the student should be able to Find the impedance of series RL, RC and RLC circuits using hardware and digital simulation.

6.3 Prelab Preparation:

Read the material in the textbook that describes periodic waveforms. Prior to coming to the lab, complete Part 1 of the procedure.

6.4 Equipment needed

Function Generator, Breadboard, Connecting Wires
Digital Ammeter, Digital Voltmeter and Digital Multimeter
Resistors: 1000Ω, Inductor: 1 mH and Capacitor: 0.01F.

6.5 Background

The impedance is defined as the ratio of sinusoidal voltage to the sinusoidal current. It is also defined as the total opposition offered to the flow of sinusoidal current. Hence the impedance is measured in OHMS. The real part of the impedance is resistance and the imaginary part is reactance.
Impedance for series Resistive and Inductive : Impedance for series Resistive and Capacitive :
Impedance for series Resistive, Inductive and Capacitive :

6.6 Procedure

Part (1) Connect the circuit as shown in the circuit diagram of fig. 4.1., Set the value of frequency say 100 Hz in the function generator and Adjust the ground of channel 1 and 2 of Cathode Ray Oscilloscope and then set it into DC mode and Connect CRO across the load in DC mode and observe the waveform and Adjust the DC offset of function generator and Note down the amplitude and frequency.

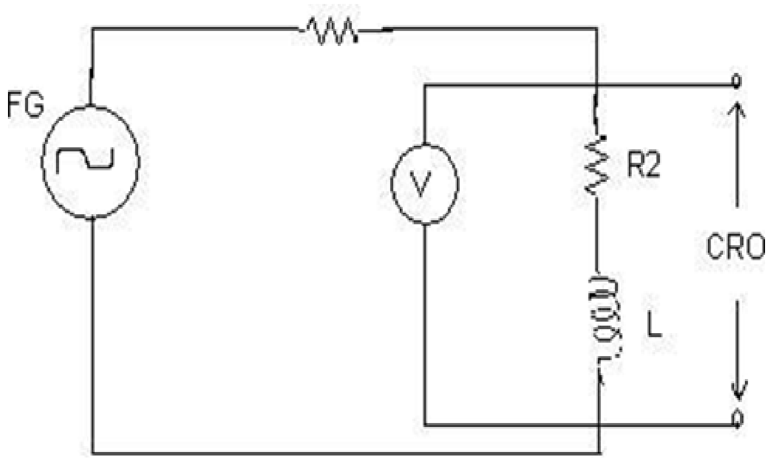


Figure 6.1: Basic Circuit

Peak Value(V)	RMS Value(V)	AverageValue(V)

Figure 6.2: Cathode Ray Oscilloscope results

6.7 Results and Discussion

Part (1) Set up the circuit as shown in Figure 4.1. 6. Set the multimeter into AC mode and measure input voltage and voltage across point AB. This value gives RMS value of sinusoidal AC and Measure the RMS and Average value of DC signal also where instead of function generator you can use DC supply and complete table 5.1. Compare the values obtained from part 1.

6.8 Viva Questions

1. Check for proper connections before switching ON the supply
2. Make sure of proper color coding of resistors
3. The terminal of the resistance should be properly connected

LAB-7 THEVENIN'S AND NORTON'S THEOREMS

7.1 Introduction

This experiment focuses on the Thevenin's and Norton's theorems. Complex circuits are often replaced with their Thevenin and Norton equivalent to simplify analysis. For example, in the analysis of large industrial power systems the Thevenin equivalent is used in short circuit studies.

7.2 Objective

By the end of this experiment, the student should be able to verify Thevenin's and Norton's equivalence theorem.

7.3 Prelab Preparation:

Read the material in the textbook that describes Thevenin's and Norton's equivalence theorem. Prior to coming to the lab, complete Part 1 and Part 2 of the Procedure.

7.4 Equipment needed

R.P.S, Breadboard, Connecting Wires
Digital Ammeter, Digital Voltmeter and Digital Multimeter
Resistors: 82Ω, 47Ω, 150Ω, 100Ω, and resistance substitution box.

7.5 Background

Thevenin's Theorem (Statement): It states that 'Any linear bilateral network (AC or DC) containing several voltage, current sources and resistances can be replaced by one voltage source (Vth) with a series single resistance (Rth).' Steps to apply Thevenin's theorem is given below:

- Find the Thevenin's resistance Rth:
- Replace all sources by their internal resistance (voltage sources are replaced by short circuit and current sources are replaced by open circuit)
- Find the equivalent resistance Rth across the open circuited load terminals
- Find the open circuit voltage Voc (or) Thevenin's voltage Vth:
- Remove the load resistance
- Find the thevenin's voltage Vth across the load terminals

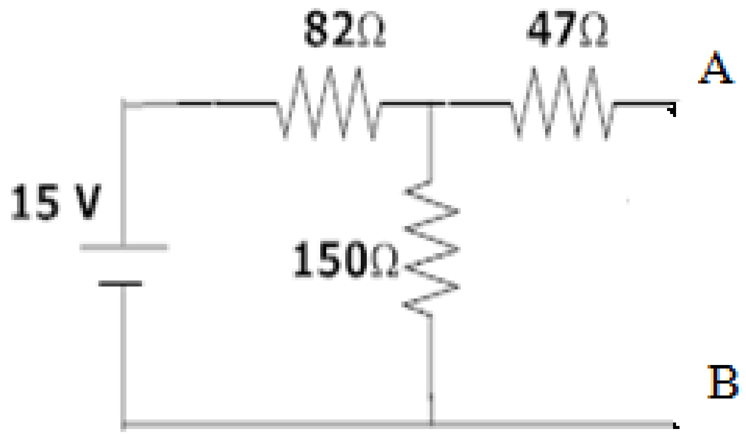


Figure 7.1: Determining the Thevenin Equivalent Circuit

Norton's Theorem (Statement): It states that 'Any linear bilateral network (AC or DC) containing several voltages, currents and resistances can be replaced by just one current source 'IN' with a parallel resistance 'RN'.

- Find the Norton's resistance RN (same as thevenin's resistance):
- Replace all sources by their internal resistance (voltage sources are replaced by short circuit and current sources are replaced by open circuit)
- Find the equivalent resistance Rth across the open circuited load resistance
- Find the short circuit current Isc (or) Norton's current IN:
- Replace the load resistance with a short circuit
- Find the Norton's current IN through the short circuit

7.6 Procedure

Part (1) Determine the theoretical values then set up for Thevenin equivalent circuit of Figure 4.1 from nodes A and B, and record all parameters in Table 4.1.

Part (1) Determine the theoretical values then set up for Norton's Equivalent Circuit of Fig. 4.1 from nodes A and B, and record all parameters in Table 4.4.

7.7 Results and Discussion

Part (1) Set up the circuit as shown in Figure 4.1. Adjust the output of the DC power supply to 15V and verify with the digital multimeter. Measure the open circuit voltage (Vth) between nodes A and B (i.e. connect the voltmeter between nodes A and B). Measure the short circuit current (Isc) between nodes A and B (i.e. connect the ammeter between nodes A and B). Using these measurements, determine the Rth by using ohm's law (V = I x R) and complete Table 4.2.

Part (2) Set up the newly determined Thevenin equivalent circuit as shown in Figure 4.2 (i.e. use the values from Part 2) and verify that this circuit has the same open circuit voltage and

	Calculated Value
V_{th} (V)	
R_{th} (Ω)	
I_{sc}(mA)	

Figure 7.2: Table 4.1: Calculated Thevenin Equivalent Parameters of Figure 4.1

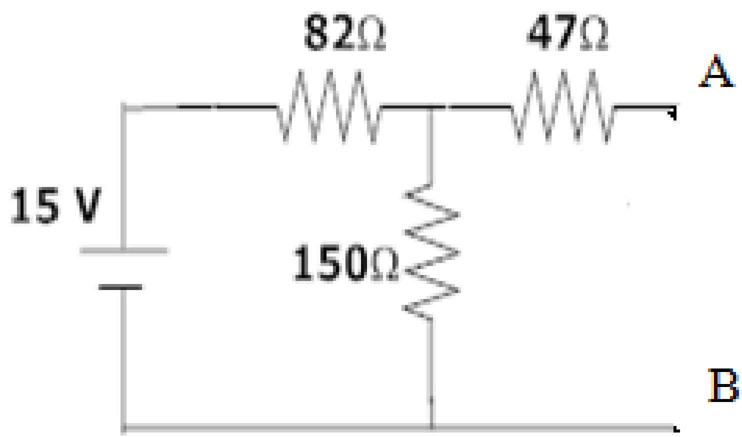


Figure 7.3: Determining the Norton Equivalent Circuit

	Calculated Value
I_{sc}(mA)	
R_{th} (Ω)	
V_{th} (V)	

Figure 7.4: Table 4.4: Calculated Norton Equivalent Parameters of Figure 4.1

	Calculated Value
V_{th} (V)	
R_{th} (Ω)	
I_{sc}(mA)	

Figure 7.5: Table 4.2: Measured Th´evenin Equivalent Parameters of Figure 4.1

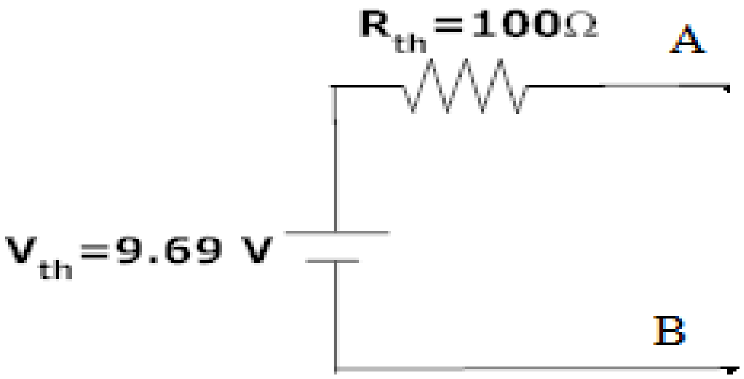


Figure 7.6: Thevenin Equivalent Circuit of Figure 4.1

short circuit current as the previous circuit by performing the same procedures as in Part 2. Record all your measurements in Table 4.3 and compare with the values obtained from Parts 2 and 3.

Part (3) Set up the circuit as shown in Figure 4.1. Apply a DC power supply of 15V and verify with the digital multimeter. Measure the short circuit current (Isc), also called Norton's current (IN) between nodes A and B (i.e. connect the ammeter between nodes A and B). Measure the open circuit voltage (Vth) or Voc between nodes A and B (i.e. connect the voltmeter between nodes A and B). Using these measurements, determine the Rth or RN by using ohm's law (V = I x R) and complete Table 4.5.

Part (4) Set up the newly determined Norton equivalent circuit as shown in Figure 4.3 (i.e. Use the values from Part 5) and verify that this circuit has the same short circuit current and open circuit voltage as the previous circuit by performing the same procedures as in Part 5. Record all your measurements in Table 4.6 and compare with the values obtained from Parts 4 and 5.

7.8 Viva Questions

1. What is load resistance?

	Newly Measured Value	Value from Part 2	Value from Part 1
V_{th} (V)			
I_{sc}(mA)			
R_{th} (Ω)			

Figure 7.7: Table 4.3: Measured Thevenin Equivalent Parameters of Figure 4.2

	Calculated Value
I_{sc}(mA)	
R_{th} (Ω)	
V_{th} (V)	

Figure 7.8: Table 4.5: Measured Norton's Equivalent Parameters of Figure 4.1

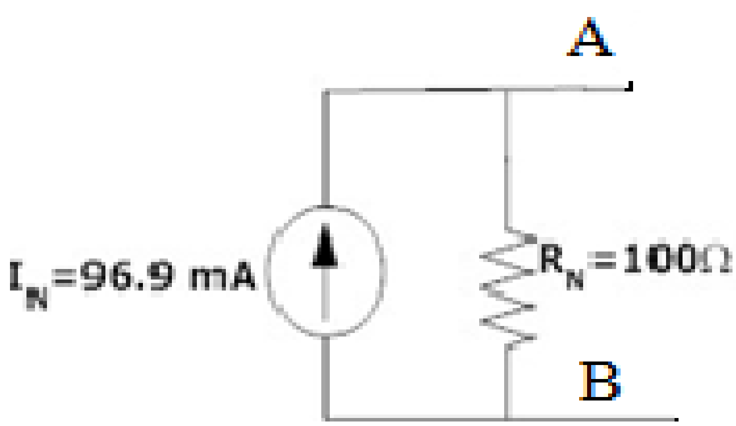


Figure 7.9: Norton Equivalent Circuit of Figure 4.1

	Newly Measured Value	Value from Part 5	Value from Part 4
I_{sc}(mA)			
V_{th}(V)			
R_{th} (Ω)			

Figure 7.10: Table 4.6: Measured Norton Equivalent Parameters of Figure 4.3

2. Define Thevenin's resistance RTH ?
3. What is Thevenin's voltage VTH?
4. How will you calculate load current IL?
5. Is Thevenin's theorem is applicable to both AC and DC supply?
6. State Thevenin's theorem.
7. State Norton's theorem.
8. Define Norton's resistance RN.
9. Explain the procedure for finding the Norton's current IN.
10. Convert Thevenin's equivalent into Norton's equivalent.
11. Is it possible to apply Norton's theorem ac as well as dc circuit?
12. What are the applications of Norton' s theorem?

7.9 Further Probing Experiments

Q1. Use MATLAB/Simulink to determine the Th´evenin equivalent for the circuit in Part 1. First, enter the circuit shown in Figure 4.1 using node B as the reference or "ground" node. The voltage at node A is then the open circuit voltage. To measure the short-circuit current between points A and B, place an ammeter between the points. Determine the Th´evenin equivalent and compare to your experimentally obtained equivalent circuit in Part 1. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts. Highlight the open-circuit voltage value and short-circuit current value obtained from the simulation.
Q2. Use MATLAB/Simulink to determine the Norton equivalent for the circuit in Part 4. First, enter the circuit shown in Figure 4.1 using node B as the reference or "ground" node. To measure the short-circuit current between points A and B, place an ammeter between the points. The voltage at node A is then the open circuit voltage. Determine the Norton equivalent and compare to your experimentally obtained equivalent circuit in Part 4. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the

printouts. Highlight the short-circuit current value and open-circuit voltage value obtained from the simulation.

LAB-8 SUPERPOSITION AND MAXIMUM POWER TRANSFER THEOREMS

8.1 Introduction

This experiment focuses on the superposition and maximum power transfer theorems. In complex circuits, Superposition theorem is used to find current or voltage in any element.

8.2 Objective

By the end of this experiment, the student should be able to verify superposition and maximum power transfer theorem.

8.3 Prelab Preparation:

Read the material in the textbook that describes superposition and maximum power transfer-theorem. Prior to coming to the lab, complete Part 1 and Part 2 of the procedure.

8.4 Equipment needed

R.P.S, Breadboard, Connecting Wires
Digital Ammeter, Digital Voltmeter and Digital Multimeter
Resistors: 82Ω, 47Ω, 150Ω, 100Ω, 220 Ω, 150 Ω, 10 Ω.

8.5 Background

Superposition Theorem: It states that in any linear network containing two or more sources, the response in any element is equal to the algebraic sum of the responses caused by individual sources acting alone, while other sources are non-operative; that is, while considering the effect of individual sources , other ideal voltage sources and ideal current sources in the network are replaced by short circuit and open circuit across their terminals. This theorem is valid only for linear system.
Maximum Power Transfer Theorem (Statement): It states that in any linear bilateral network a load will receive maximum power from the source when the load resistance is exactly equal to the thevenin's resistance of the network.Steps to appply maximum power transfer is below:

- Find the Thevenin's resistance Rth:
- Replace all sources by their internal resistance (voltage sources are replaced by short circuit and current sources are replaced by open circuit)
- Find the equivalent resistance Rth across the open circuited load terminals

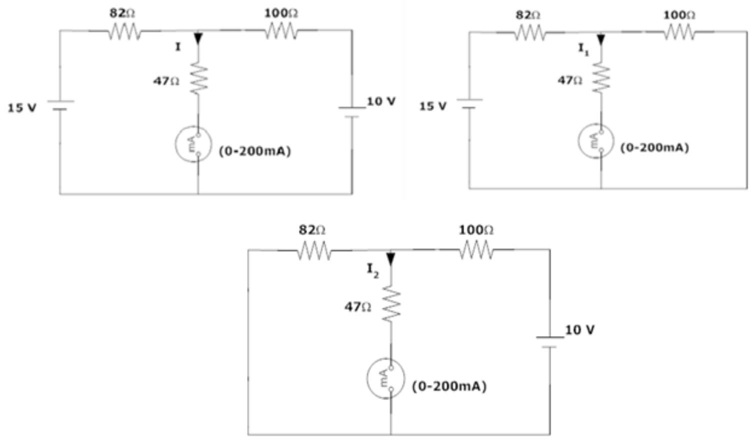


Figure 8.1: Determining the Currents using Superposition Theorem

	Calculated Value
I (mA)	
I_1 (mA)	
I_2 (mA)	

Figure 8.2: Table 2.1: Calculated Currents using Superposition Theorem of Figure 2.1

- Find the open circuit voltage Voc (or) Thevenin's voltage Vth:
- Remove the load resistance
- Find the thevenin's voltage Vth across the load terminals

8.6 Procedure

Part (1) Determine the theoretical current then set up of superposition theorem (to find current in middle element) for Figure 2.1, and record all parameters in Table 2.1.

Part (1) Determine the theoretical values then set up of Th´evenin's equivalent circuit for Figure 3.1 from nodes A and B, and record all parameters in Table 3.1.

8.7 Results and Discussion

Part (1) Set up the circuit as shown in Figure 2.1. Apply the first DC power supply of 15V and second supply of 10V. Measure the current (I) in middle element of Figure 2.1.1 (i.e. connect the ammeter as shown in Figure 2.1.1). Similarly measure the currents (I1 and I2) w.r.t Figure

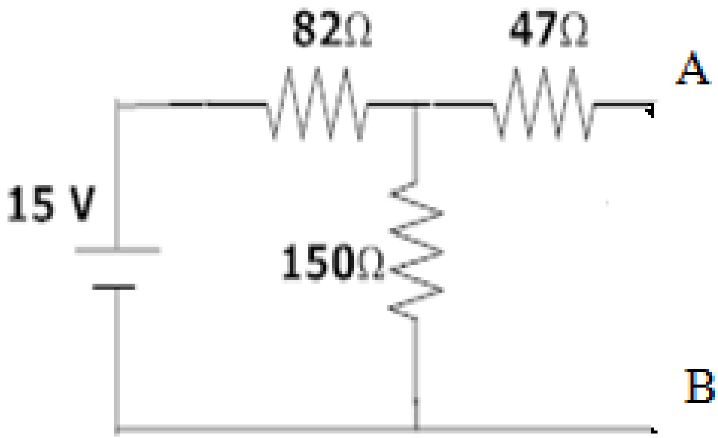


Figure 8.3: Determining the Thevenin Equivalent Circuit

	Calculated Value
V_{th} (V)	
R_{th} (Ω)	
I_{sc}(mA)	

Figure 8.4: Table 3.1: Calculated Th´evenin Equivalent Parameters of Figure 3.1

	Measured Value
I (mA)	
I_1 (mA)	
I_2 (mA)	

Figure 8.5: Table 2.2: Measured Currents using Superposition Theorem of Figure 2.1

	Calculated Value	Measured Value
I (mA)		
I_1 (mA)		
I_2 (mA)		

Figure 8.6: Tbale 2.3: Currents using Superposition Theorem of Figure 2.1

2.1.2 and Figure 2.1.3. and complete table 2.2. And compare the values obtained from part 1 of procedure with part 1 here.

Part (1) Set up the circuit as shown in Figure 3.1. Apply a DC power supply of 15V and verify with the digital multimeter. Measure the open circuit voltage (Vth) between nodes A and B (i.e. connect the voltmeter between nodes A and B). Measure the current (Isc) between nodes A and B (i.e. connect the ammeter between nodes A and B). Using these measurements, determine the Rth by using ohm's law (V = I x R) and complete Table 3.2.

Part (2) Set up the newly determined Th´evenin equivalent circuit as shown in Figure 3.2 (i.e. use the values from Part 1) and verify that this circuit has the same open circuit voltage and short circuit current as the previous circuit by performing the same procedures as in Part 1. Record all your measurements in Table 3.3 and compare with the values obtained from Parts 1 and 2.

Part (3) This part of the lab is to illustrate maximum power transfer. Use the Th´evenin equivalent circuit developed in Part 2. As shown in Figure 3.3, connect a resistance substitution box R between nodes A and B.

Measure the voltage across R-Box if R = 1Ω and calculate the power dissipated by this resistor (P=V2/R). Repeat with R = 50Ω, 100Ω, 145Ω, 180Ω, 220Ω, 250Ω, 300Ω, and 320Ω. Record all

	Calculated Value
V_{th} (V)	
R_{th} (Ω)	
I_{sc}(mA)	

Figure 8.7: Table 3.2: Measured Th´evenin Equivalent Parameters of Figure 3.1

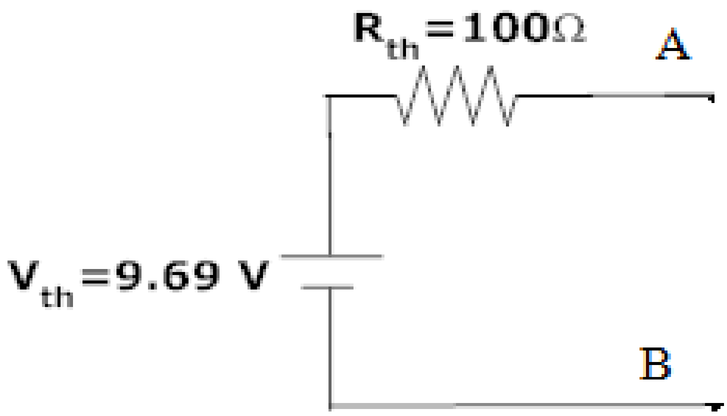


Figure 8.8: Thevenin Equivalent Circuit of Figure 3.1

	Newly Measured Value	Value from Part 2	Value from Part 1
V_{th} (V)			
I_{sc}(mA)			
R_{th} (Ω)			

Figure 8.9: Table 3.3: Measured Thevenin Equivalent Parameters of Figure 3.2

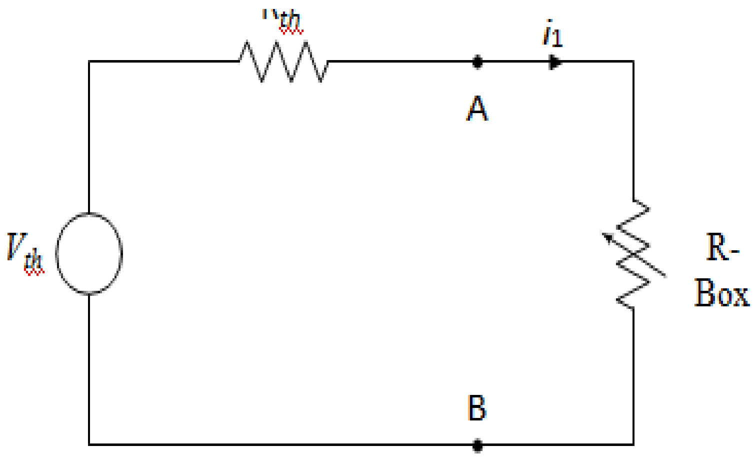


Figure 8.10: Circuit for Maximum Power Transfer

R-Box	V_{R-Box} (V)	P_{R-Box} (mW)
1Ω		
50Ω		
100Ω		
145Ω		
180Ω		
220Ω		
300Ω		
400Ω		
500Ω		

Figure 8.11: Table 3.4: Voltage and Power for Figure 3.3

your measurements in Table 3.4.
Part (4) Model graph of resistance Vs power is shown in Figure 3.4.

8.8 Viva Questions

1. State reciprocity theorem.
2. Is it possible to apply both theorems to ac as well as dc circuit?
3. Is Reciprocity is applicable for unilateral and bilateral networks?
4. Comment on the applicability of reciprocity theorem on the type of network.
5. Is reciprocity theorem is applicable to nonlinear circuits?
6. State maximum power transfer theorem.
7. Is it possible to apply maximum power transfer theorem to ac as well as dc circuit?
8. How to find power using maximum power transfer theorem?

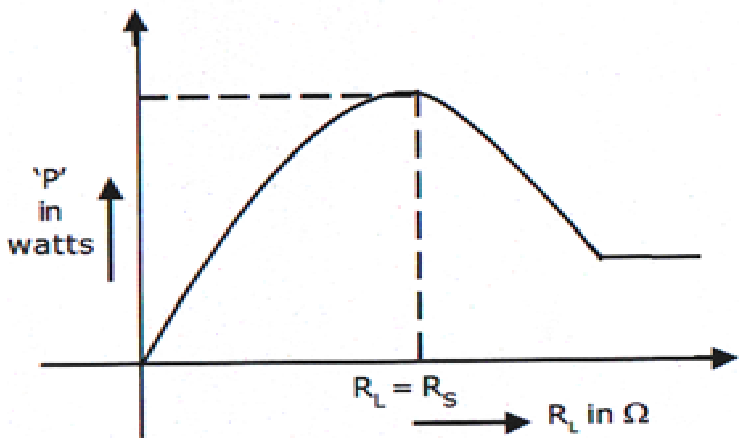


Figure 8.12: Output Graph of Maximum Power Transfer Theorem

9. What are conditions for maximum power transfer theorem?
10. Is it possible to apply maximum power transfer theorem to nonlinear circuit?

8.9 Further Probing Experiments

Q1. Use MATLAB/Simulink to verify the Superposition theorem for the circuit in Part 1. First, enter the circuit shown in Figure 2.1 using down node as the reference or "ground" node. To measure the short-circuit current in middle element, place an ammeter in series with that element. Determine the currents in middle element of Figure 2.1 and compare to your experimentally obtained currents in Part 2. Record your MATLAB/Simulink file and the data obtained from the simulation in your laboratory notebook by pasting in the printouts.
Q2. Use MATLAB/Simulink to simulate the circuit of Part 4. Start with the value of R = Rmaxpower that you determined experimentally to give maximum power transfer and find, from the MATLAB/Simulink simulation, the power delivered to this resistance. Then repeat with 20Ω increments through 100Ω, Compare the values of power obtained by simulation with those you obtained experimentally. Record your MATLAB/Simulink file and the data obtained from them in your laboratory notebook

LAB-9 MAGNETIZATION CHARACTERISTIC OF DC SHUNT GENERATOR

9.1 Introduction

The open circuit characteristics for a DC generator are determined as follows. The field winding of the DC generator (series or shunt) is disconnected from the machine and is separately excited from an external DC source. The generator is run at fixed speed (i.e. rated speed).

9.2 Objective

By the end of this lab, the student should learn the no load magnetization characteristics, the external characteristics of DC shunt generators.

9.3 Prelab Preparation:

Read the Introduction and procedure of the experiment of respective experiments which are given this manual.

9.4 Equipment needed

1. Three digital voltmeters (0-300v MC Type), three digital ammeters (0-20A MC Type), a set of sheathed banana cables and a power quality meter from the stockroom
2. One tachometer from the stockroom
3. HMRL Adjustable Load Cart
4. A bench mounted Motor-Generator s
5. A bench mounted Multi-Range DC Power Supply (PSW 250-4.5)
6. Connecting Wires.

9.5 Background

A DC generator, whose schematic is an electrical machine which converts the mechanical energy of a prime mover (e.g. DC motor, AC induction motor or a turbine) into direct electrical energy. The generator shown in figure 1 is self exciting. It uses the voltage Ea generated by the machine to establish the field current If , which in turn gives rise to the magnetic-field flux. When the armature winding rotates in this magnetic field so as to cut the flux, the voltage Ea is induced in the armature. This voltage is commonly referred to as the armature electromotive force or EMF. The induced EMF is proportional to the rate of cutting the flux and is given by.

The magnetic field necessary for generator action may be provided by (a) permanent magnets, (b) electromagnets receiving their exciting current from an external source, and (c) electromagnets being excited from the current obtained from the generator itself (like that shown in figure 1). The use of permanent magnets is confined to very small generators. The electromagnetic excitations listed in (b) and (c) above give rise to generators having somewhat different types of characteristics. In the case of a compound generator, the series and shunt fields may be connected so as to aid each other, i.e. the fluxes set up by each will add up. An increase in the total flux will generate a greater EMF. Such a connection is known as cumulative. If, however, the shunt and series winding are so connected that the flux set up by one opposes the other, then the induced EMF will be smaller. This type of connection is called differential

9.6 Procedure

Magnetization Characteristics 1. Choose the proper ranges of meters after noting the name plate details of the given machine and make the connections as per the circuit diagram.

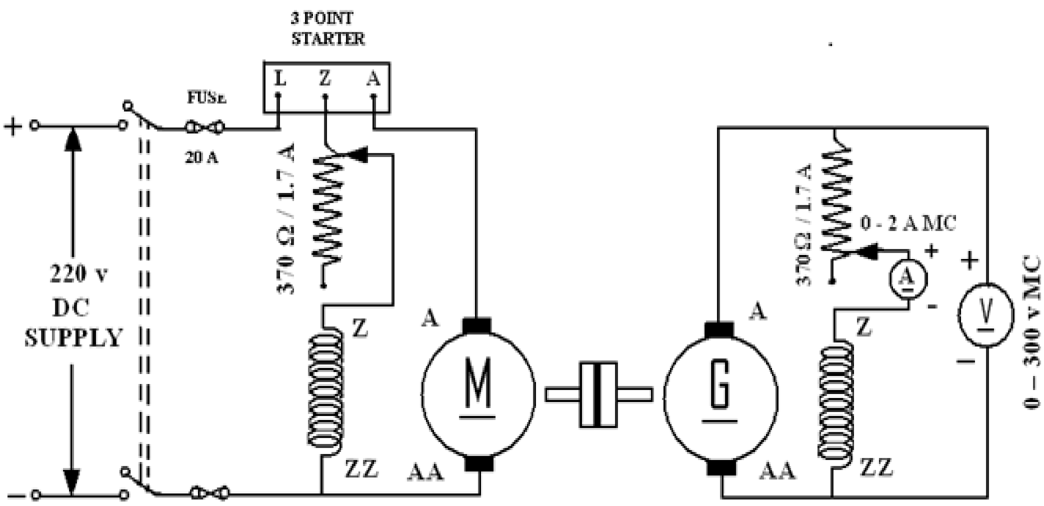


Figure 2.1 MAGNETIZATION CHARACTERISTIC

2. Keep the motor field rheostat (Rf) in the minimum resistance position.
3. Keep the generator field rheostat (Rf) in the maximum resistance position.
4.Observe the speed of the generator using a tachometer and adjust to the rated value by varying the motor field rheostat. Keep the same speed throughout the experiment 5.Note down the terminal voltage of the generator. This is the e.m.f. due to residual magnetism 6.Increase the generator field current If (ammeter) by gradually moving the rheostat for every value and note down the corresponding voltmeter reading. Increase the field current till induced e.m.f is about 120 percentage of rated value

S No	Field Current (Amp)	Generated Voltage (Volts)
1		
2		
3		
4		
5		

Table 2.1 Mgnetization Measured Values

9.7 Model graphs

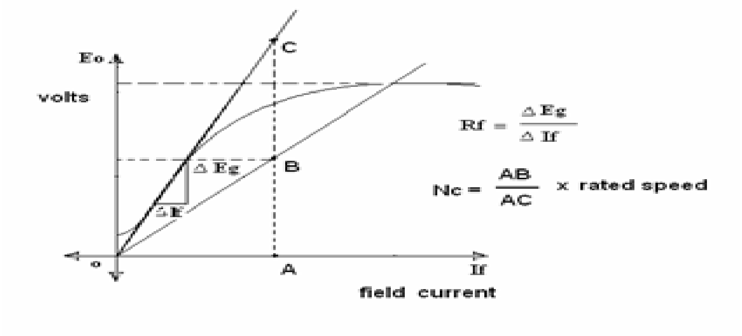


Figure 2.3: Field Current versus induced emf

9.8 Probing Further Experiments

Q1. Design the magnetizing characteristics of DC shunt generator by using the MAT Lab and Lab View and also find the critical resistance, critical speed.

Q2. Design the process of voltage build up in self excited DC generators and state the conditions for self excitation.

LAB-10 SPEED CONTROL OF DC SHUNT MOTOR

10.1 Introduction

Often we want to control the speed of a DC motor on demand. This intentional change of drive speed is known as speed control of a DC motor. Speed control of a DC motor is either done manually by the operator or by means of an automatic control device. This is different to speed regulation – where the speed is trying to be maintained (or 'regulated') against the natural change in speed due to a change in the load on the shaft.

10.2 Objective

To vary the speed of the given DC shunt motor by armature control and field control methods

10.3 Prelab Preparation:

Read the Introduction and procedure of the experiment of respective experiments which are given this manual.

10.4 Equipment needed

1. Three digital voltmeters (0-300v MC Type), three digital ammeters (0-20A MC Type), a set of sheathed banana cables and a power quality meter from the stockroom
2. One tachometer from the stockroom.
3. HMRL Adjustable Load Cart.
4. A bench mounted Motor-Generator set
5. A bench mounted Multi-Range DC Power Supply (PSW 250-4.5)
6. Connecting Wires.

10.5 Background

Terminal voltage and external resistance involve a change that affects the armature circuit, while flux involves a change in the magnetic field. Therefore speed control of DC motor can be classified into: 1. Armature Control Methods 2. Field Control Methods We will discuss how both of these methods control the speed of DC series motors and DC shunt motors. Speed Control of DC Series Motor Speed control methods for a DC series motor can be classified as: 1. Armature Control Methods 2. Field Control Methods Armature Controlled DC Series Motor Speed adjustment of a DC series motor by armature control may be done by: 1. Armature Resistance Control Method 2. Shunted Armature Control Method 3. Armature Terminal Voltage Control

10.6 Procedure

SPEED CONTROL Armature Control Method: (below rated speed) 1. Choose the proper ranges of meters after noting the name plate details of the given machine and make the connections as per the circuit diagram.

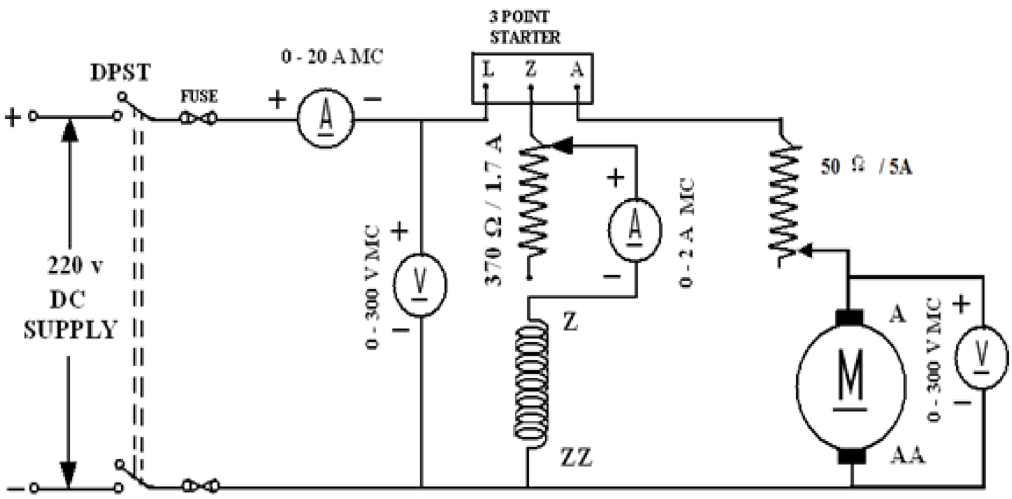


Figure 6.1 Speed control of DC motor

2.Keep the motor field rheostat (Rf) in the minimum position and the armature rheostat (Ras) in the maximum position, start the MG set.
3. Give supply and accelerate the motor using 3-point starter.
4.Decrease the armature rheostat value and note down speed and induced emf in motor winding.
5.Tabulate these readings and plot the graph Eb VS N

S.No.	E_b(Volt)	Speed (rmp)
1		
2		
3		
4		
5		
6		

Table 8.1 below rated Measured Values

Field Control Method: (above rated speed) 1.Maintain the armature rheostat in maximum position and vary the field current (If) by varying the field rheostat. Note down the speeds (N) at different values of field current. Take care that the speed doesn't exceed 2000 rpm. Note down the armature voltage also.

2.Tabulate these readings and plot the N Vs If describes the field control of motor speed on no load. .

S. No.	E_b(Volt)	Speed (rmp)
1		
2		
3		
4 5		
6		

Table 8.1 Above rated Measured Values

10.7 Model graphs

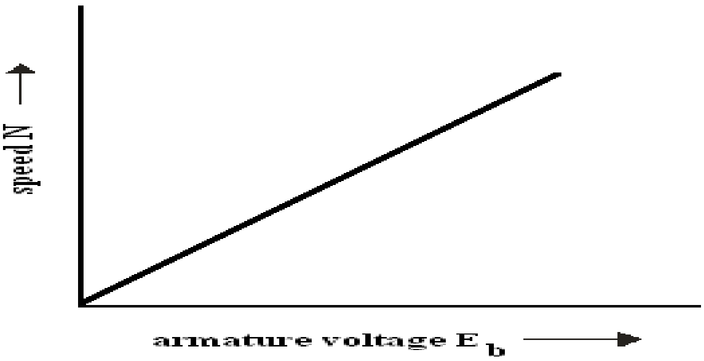


Figure 8.2:Armature Control

10.8 Model graphs

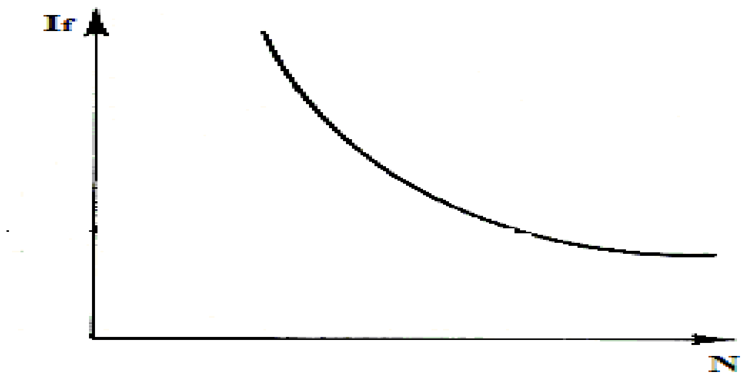


Figure 8.3:Field Control

10.9 Probing Further Experiments

Q1.Design of speed control of DC Shunt motor the using digital simulations.

Q2.Simulation and construction of a speed control for a DC series motor

LAB-11 SWINBURNE'S TEST ON DC SHUNT MOTOR

11.1 Introduction

Often we want to find efficiency of a DC machine on demand. This is calculated by using swinburne's test on a DC motor.

11.2 Objective

To find the efficiency of DC shunt generator and motor.

11.3 Prelab Preparation:

Read the Introduction and procedure of the experiment of respective experiments which are given this manual.

11.4 Equipment needed

1. Three digital voltmeters (0-300v MC Type), three digital ammeters (0-20A MC Type), a set of sheathed banana cables and a power quality meter from the stockroom
2. One tachometer from the stockroom.
3. HMRL Adjustable Load Cart.
4. A bench mounted Motor-Generator set
5. A bench mounted Multi-Range DC Power Supply (PSW 250-4.5)
6. Connecting Wires.

11.5 Background

Terminal voltage and external resistance involve a change that affects the armature circuit, while flux involves a change in the magnetic field. Therefore speed control of DC motor can be classified into: 1. Armature Control Methods 2. Field Control Methods We will discuss how both of these methods control the speed of DC series motors and DC shunt motors. Speed Control of DC Series Motor Speed control methods for a DC series motor can be classified as: 1. Armature Control Methods 2. Field Control Methods Armature Controlled DC Series Motor Speed adjustment of a DC series motor by armature control may be done by: 1. Armature Resistance Control Method 2. Shunted Armature Control Method 3. Armature Terminal Voltage Control

11.6 Procedure

SPEED CONTROL Armature Control Method: (below rated speed) 1. Choose the proper ranges of meters after noting the name plate details of the given machine and make the connections as per the circuit diagram.

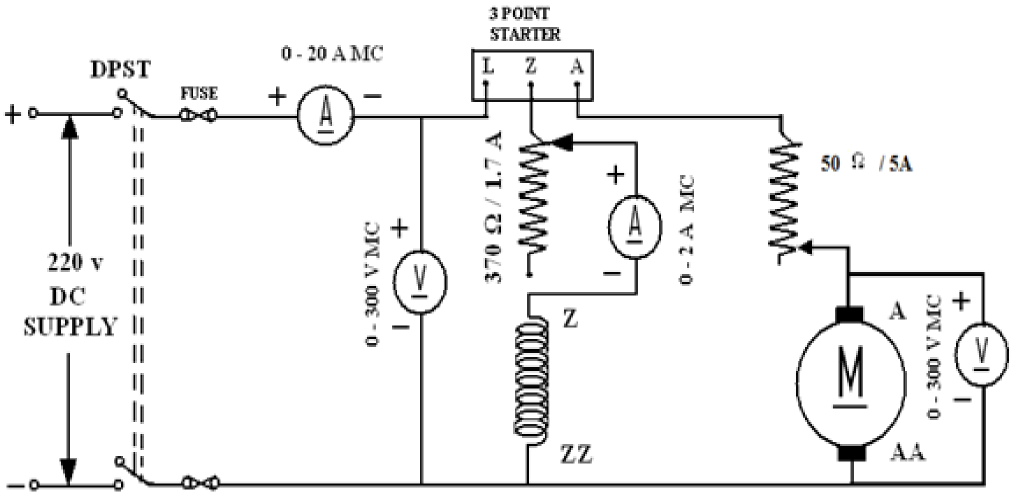


Figure 6.1 Speed control of DC motor

2.Keep the motor field rheostat (Rf) in the minimum position and the armature rheostat (Ras) in the maximum position, start the MG set.
3. Give supply and accelerate the motor using 3-point starter.
4.Decrease the armature rheostat value and note down speed and induced emf in motor winding.
5.Tabulate these readings and plot the graph Eb VS N

S.No.	E_b(Volt)	Speed (rmp)
1		
2		
3		
4		
5		
6		

Table 8.1 below rated Measured Values

Field Control Method: (above rated speed) 1.Maintain the armature rheostat in maximum position and vary the field current (If) by varying the field rheostat. Note down the speeds (N) at different values of field current. Take care that the speed doesn't exceed 2000 rpm. Note down the armature voltage also.

2.Tabulate these readings and plot the N Vs If describes the field control of motor speed on no load. .

S. No.	E_b(Volt)	Speed (rmp)
1		
2		
3		
4 5		
6		

Table 8.1 Above rated Measured Values

11.7 Model graphs

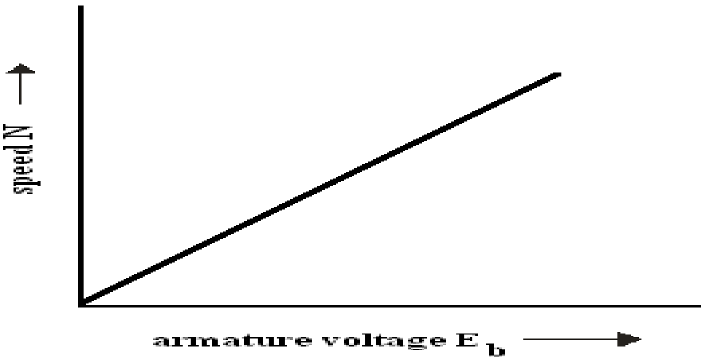


Figure 8.2:Armature Control

11.8 Model graphs

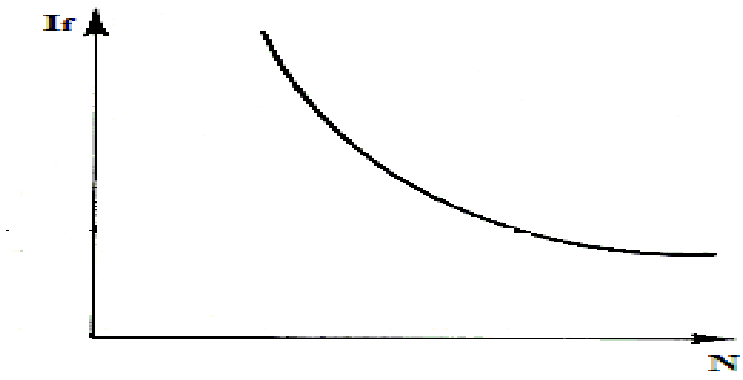


Figure 8.3:Field Control

11.9 Probing Further Experiments

Q1.Design of speed control of DC Shunt motor the using digital simulations.

Q2.Simulation and construction of a speed control for a DC series motor

LAB-12 BRAKE TEST ON A DC SHUNT MOTOR

12.1 Introduction

The Brake test can be conducted by using a belt brake or rope brake. For a constant applied voltage, the field current is constant for a D.C. Shunt motor. The flux will, therefore have its maximum value at no-load, and because of armature reaction will decrease slightly as the load increases

12.2 Objective

To determine the efficiency of DC shunt motor by conducting brake test

12.3 Prelab Preparation:

Read the Introduction and procedure of the experiment of respective experiments which are given this manual

12.4 Equipment needed

1. Three digital voltmeters (0-300v MC Type), three digital ammeters (0-20A MC Type), a set of sheathed banana cables and a power quality meter from the stockroom
2. One tachometer from the stockroom.
3. HMRL Adjustable Load Cart.
4. A bench mounted Motor-Generator set
5. A bench mounted Multi-Range DC Power Supply (PSW 250-4.5)
6. Connecting Wires.

12.5 Background

In this method, a brake is applied to a water-cooled pulley mounted on the motor shaft as shown in Fig.1. One end of the rope is fixed to the floor via a spring balance S and a known mass is suspended at the other end. If the spring balance reading is S kg-Wt and the suspended mass has a weight of W kg-Wt,then, Net pull on the rope = (W - S) kg-Wt = (W - S)9.81 newtons If r is the radius of the pulley in meters, then the shaft torque Tsh developed by the motor is Tsh = (W - S)9.81r N - m

12.6 Procedure

BRAKE TEST ON DC SHUNT MOTOR

1. Make the connections as shown in the circuit diagram.

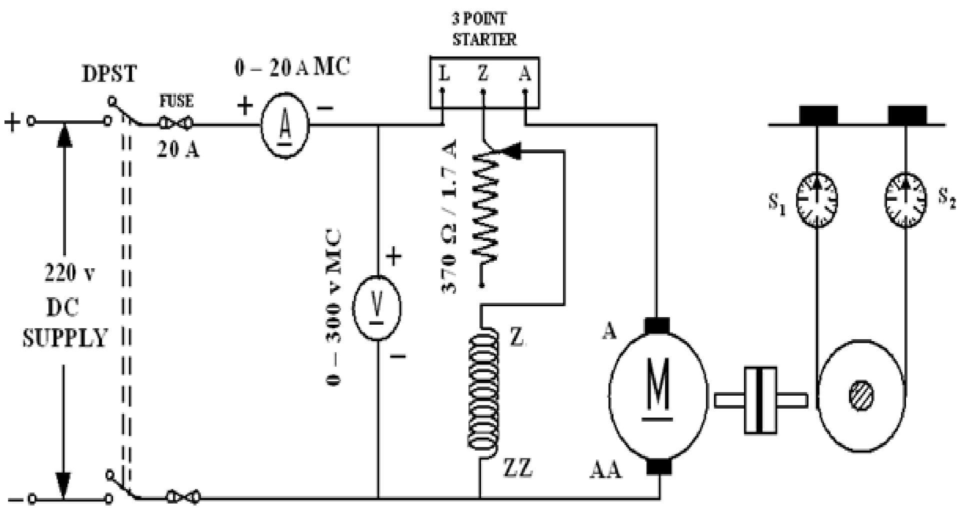


Figure 10.1 Brake test on DC shunt motor

2. Keeping the field rheostat (Rf) at the minimum position, switch on the supply and start the motor.
3.Adjust the speed of the motor on no load to its rated value by means of the field rheostat. Do not disturb the position of the rheostat throughout the test.
4.Put on the load by tightening the screws of the spring balances. Note down the spring tensions, the speed, the voltage and the currents at different loads until full load current is obtained.
5.Reduce the loads one by one till the motor speed does not exceed 1800rpm 6.Note down the readings of the instruments at different loads. Armature resistance of the motor Ra1 Series field resistance of the motor Rse1 Armature resistance of the generator Ra2 Series field resistance of the generator Rse2 7.Gradually, reduce the armature voltage of the prime mover and then switch off the Supply

S No	I_L (A)	V_L (V)	W_1 Kg	W_2 Kg	W (kg) = $W_1 - W_2$	N (RPM)	T = rgW (N-m)	P_0= 2ΠNT/60	P_I= $V_L I_L$	η = P_0/P_Ix 100
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Table 9.1 Measured Values

8. The load on the drum is removed and the motor is stopped. 9. The efficiency is calculated at different load conditions

12.7 Calculations

Brake Test on DC Shunt Motor 1. Measure the circumference of the brake drum and calculate its radius (r), in meters.
2. Calculate the torque, T = Wrg (N-m). Where W = W1 − W2 = spring balance reading (the difference between the spring tensions) and 'g' is acceleration due to gravity i.e.9.81. Calculate the power output of the motor given by P0= 2UNT/60
3. Calculate the input power, PI =VIL (IL is the line current = Ia+ If).
4. Calculate the percentage efficiency, efficiency = P0/PIx 100
5. Draw the following graphs:
a) Output Vs efficiency, T, Ia and N in one graph.
b) Speed Vs Torque.

12.8 Model graphs

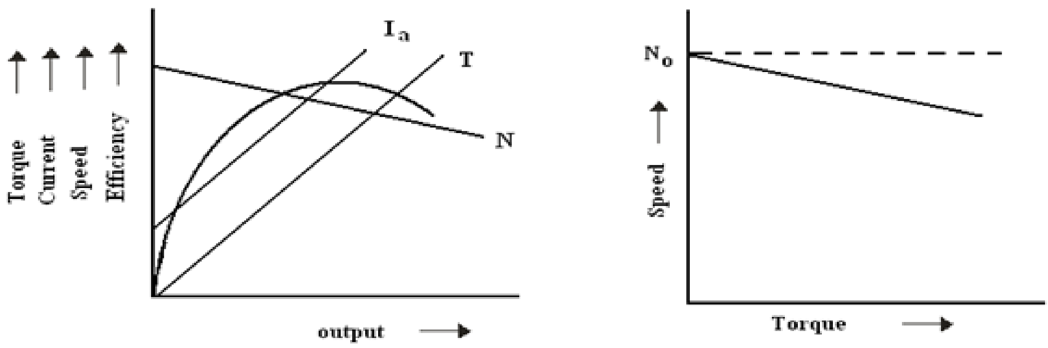


Figure 9.2:Performance Characteristics of DC Shunt Motor

12.9 Probing Further Experiments

Q1.Design the DC shunt motor the using digital simulations.

Q2. Design the break test on DC shunt motor by using labview to verify the different type of characteristics.

LAB-13 OPEN AND SHORT CIRCUIT TEST ON A SINGLE PHASE TRANSFORMER

13.1 Introduction

To predict the performance of a transformer at various loadings by knowing all the equivalent circuit parameters. These circuit parameters are supplied from Open Circuit (OC) and Short Circuit (SC) test data of a transformer without actually loading the transformer, these two assessed tests give the test results which are used to determine the equivalent circuit parameters.

13.2 Objective

By the end of this lab, the student should learn how to determine the equivalent circuit parameters, voltage regulation and efficiency of single phase transformer.

13.3 Prelab Preparation:

Read the material in the textbook that describes open circuit and short circuit test. Prior to coming to the lab. Prior to coming to lab class, have glance of the Procedure.

13.4 Equipment needed

1. Single phase transformer (2 KVA)
2. Single phase auto transformer
3. Ammeter (0-2 A) MI
4. Ammeter (0-20 A) MI
5. Voltmeter (0-60 V) MI
6. Voltmeter (0-150 V) MI
7. Watt meter (150/300 V, 1/2 A) LPF
8. Watt meter (150/300 V, 10/0 A) UPF
9. Connecting Wires.

13.5 Background

Open Circuit Test: The main purpose of this test is to find the iron loss and no-load current which are useful in calculating core loss resistance and magnetizing reactance of the transformer. In O.C. test primary winding is connected to AC supply, keeping secondary open. Sometimes a voltmeter may be connected across secondary as voltmeter resistance is very high and voltmeter current is negligibly small so that secondary is treated as open circuit. When primary voltage is adjusted to its rated value with the help of variac, readings of ammeter and wattmeter are to be recorded. Ammeter gives no load current. Transformer no load current is always very small, 2 to 5 percentage of its full load current. As secondary is open, I2 = 0, hence secondary copper losses are zero. And I1 = I0 is very low hence copper losses on primary are also very low. Thus, the total copper losses in O.C. test are negligibly small, hence neglected. Therefore, the wattmeter reading in O.C. test gives iron losses which remain constant for all the loads.

Short Circuit Test: The main purpose of this test is to find full load copper loss and winding parameters (R01, X01 or R02, X02) which are helpful for finding regulation of transformer. In this test, secondary is short circuited with the help of ammeter. As secondary is shorted, its resistance is very small and on rated voltage it may draw very large current. Such large current can cause overheating and burning of the transformer. To limit this short circuit current, primary is supplied with low/reduced voltage (5 – 15 percentage of the rated voltage) which is just enough to cause rated current to flow through primary which can be observed on an ammeter. The reduced voltage can be adjusted with the help of variac. The wattmeter reading as well as voltmeter, ammeter readings are recorded. As the voltage applied is low which is a small fraction of the rated voltage and iron losses are function of applied voltage, hence iron losses are negligibly small. Since the currents flowing through the windings are rated currents hence the total copper loss is full load copper loss. Hence the wattmeter reading is the power loss which is equal to full load copper losses.

13.6 Procedure

Open circuit test 1. Make the connections as per the circuit diagram.

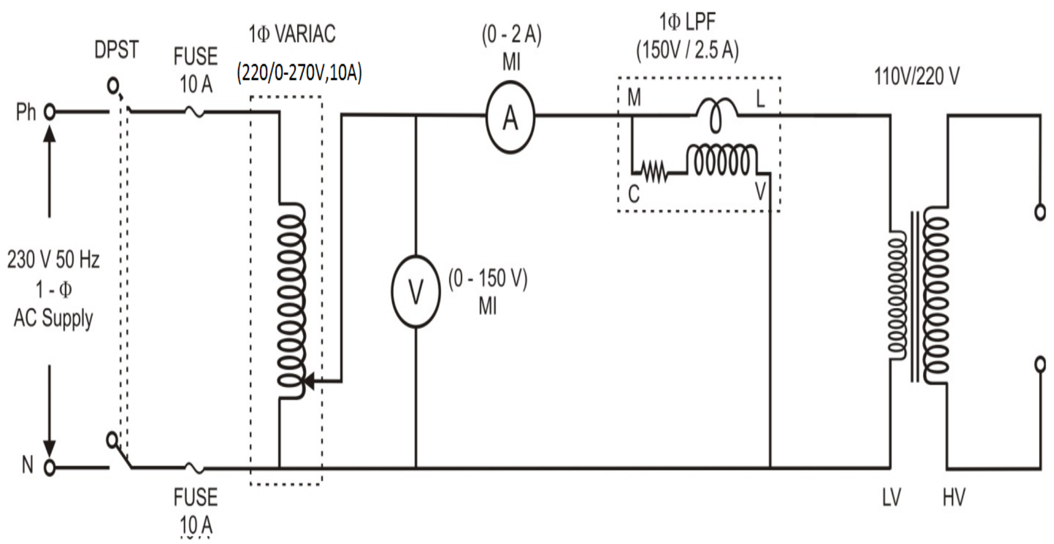


Figure 2.1 Open circuit test Circuit

2. Apply rated voltage with the help of autotransformer across LV winding, with the HV winding as open circuited.

3. Note down the readings of voltmeter (V), Ammeter (Io) and wattmeter (Po).

S. No	V_{oc}	I_0	W_0
1.			

Table 2.1 Open Circuit Measured Values

Short circuit test:

1. Make the connections as per the circuit diagram.

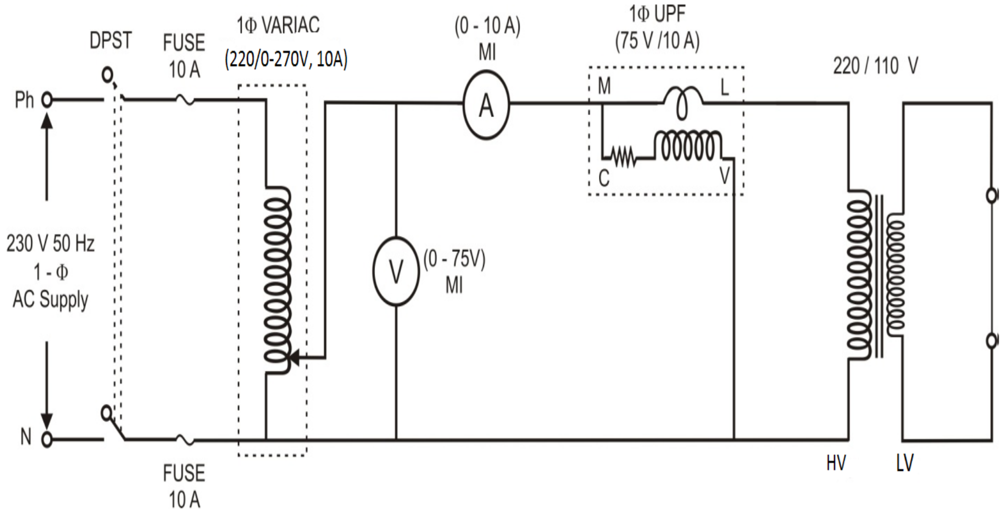


Figure 2.2 Short circuit test Circuit

2. Adjust supply voltage by single phase auto transformer such that the current through the transformer is the rated value and note down all meter readings.

S. No	V_{sc}	I_{sc}	W_{sc}
1.			

Table 2.2 Short Circuit Measured Values

13.7 Calculations

Open circuit test

Iron losses, $P_I = P_o$ watts.

No load P.f., $\cos\phi_o = \frac{P_o}{VI_o}$

Magnetizing current, $I_m = I_0 \sin\phi_o$

Loss component of no load current, $I_w = I_0 \cos\phi_o$

Magnetizing reactance, $X_0 = \frac{V}{I_m}$

Equivalent resistance of iron losses, $R_0 = \frac{V}{Iw}$

Short circuit test:

Full load copper losses $P_{Cu} = P_{SC}$ Watts.

Power factor on short circuit, $\cos\phi_{SC} = \frac{P_{sc}}{V_{sc} I_{sc}}$

Short circuit impedance $Z_{01} = \frac{V_{sc}}{I_{sc}}$ Ω.

Referred to primary:

HT equivalent resistance, $R_{01} = \frac{Psc}{I_{sc}^2}$.

HT equivalent reactance, $X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$

a) Efficiency: At X times full load and power factor cosϕ, output, P_0= X*S cos ϕ KW

Where S = KVA rating of the transformer.

Input = Output +Iron Loss+ x^2 *P_{Cu}

Efficiency (%η) = Output power / Input power *100

1. Calculate the efficiency of the transformer at Unity, 0.8 and 0.6 Power factors for 1/4, 1/2,3/4, full load and draw the output characteristics.
2. Calculate the maximum efficiency corresponding to the maximum load.

b) Regulation: Regulation is defined as percentage drop in voltage from no load to full load at any power factor due to voltage drops in resistance and leakage reactance of the transformer.

1. Calculate the percentage resistance voltage drop ($\%V_R$) = $I_1 R_1/V_1$ x 110
2. Calculate the percentage reactance voltage drop ($\%V_x$) = $I_1 X_1/V_1$ x 110.
3. Calculate the percent regulation, = $\%V_R$ Cos ϕ + $\%V_x$ Sinϕ at Unity,0.8,0.6 leading and lagging power factors

13.8 Tabular column

PART - I: Efficiency

S. No.	Fraction of load (X)	Po	Pi	η
1	0.25			
2	0.5			
3	0.75			
4	1			

Table 2.3 Calculated efficiency values

PART - II: Regulation

S. No.	Power Factor	Regulation
1.		
2		
3		

Table 2.4 Calculated regulation valuess

13.9 Model graphs

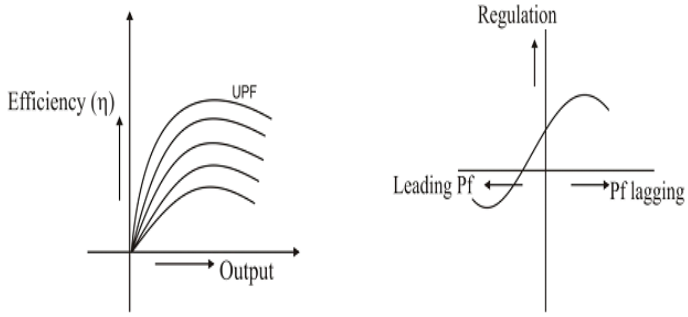


Figure 2.3: Efficiency and regulation curves under different power factor loading conditions

13.10 Probing Further Experiments

Q1. Plot efficiency curves of single phase transformer under different loading conditions using digital simulations.

Q2. Design open circuit and short circuit test on single phase transformer using LabVIEW

LAB-14 REGULATION OF THREE PHASE ALTERNATOR BY SYNCHRONOUS IMPEDANCE METHOD

14.1 Introduction

The voltage regulation of alternator by EMF method involves the EMF quantities of all the armature parameters (armature resistance, Armature leakage reactance, armature reaction). The drop due to armature reaction is not considered, because it does not occur due to any of the physical element but due to interaction of armature flux with main flux.

14.2 Objective

By the end of this lab, the student should learn how to determine the voltage regulation of alternator by synchronous impedance method

14.3 Prelab Preparation:

Read the material in the textbook that describes open circuit and short circuit test. Prior to coming to the lab. Prior to coming to lab class, have glance of the Procedure.

14.4 Equipment needed

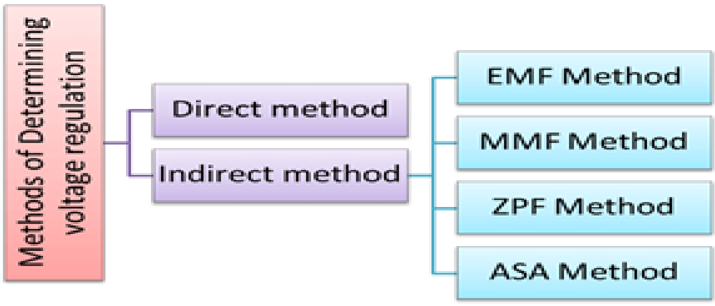
1. DC Shunt motor (5 HP)
2. Three phase alternator (3 KVA)
3. Two rheostats (0-370 Ω / 1.7 A)
4. Voltmeter (0-600 V) MI
5. Ammeter (0-2 A) MC
6. Ammeter (0-10 A) MI
7. Tachometer
8. Connecting Wires

14.5 Background

The voltage regulation of an alternator is defined as "the rise in voltage at the terminals, when the load is reduced from full load rated value to zero, speed and field current remaining constant". With the change in load, there is a change in terminal voltage of an alternator or synchronous generator. The magnitude of this change not only depends on the load but also on the load power factor. It is also defined as "the rise in voltage when full load is removed divided by the rated terminal voltage, when speed and field excitation remain the same." It is given by the formula,

$$\text{Percentage Voltage Regulation} = \frac{E_0 - V}{V} \times 100$$

Methods to determine voltage regulation:



Methods to determine Voltage Regulation: Direct method of determining the voltage regulation is employed for smaller machines.

In this direct method, a three phase load is connected to star connected alternator with the help of Triple Pole Single Throw switch. The field winding of alternator is excited using an external DC supply. A rheostat is connected in series with the field winding, to control the flux produced in the field winding.

Adjust the rheostat of the field winding so that, to produce the rated terminal voltage. Close the load switch, apply the full load and measure the voltage at full load V.

Then the entire load is thrown off while the speed and field excitation are kept constant. The open circuit or no load voltage is measured and now the regulation can be determined from the below equation.

$$\text{Percentage Voltage Regulation} = \frac{E_0 - V}{V} \times 100$$

But in the case of large machines, it becomes very difficult to determine the voltage regulation by direct loading method. So, it is very important to switch over to the indirect methods of determination.

14.6 Procedure

1. Make the connections as per the circuit diagram. Start the alternator with the help of prime mover (DC Shunt motor) and adjust speed to the synchronous speed. The speed of the alternator is to be kept constant throughout the experiment

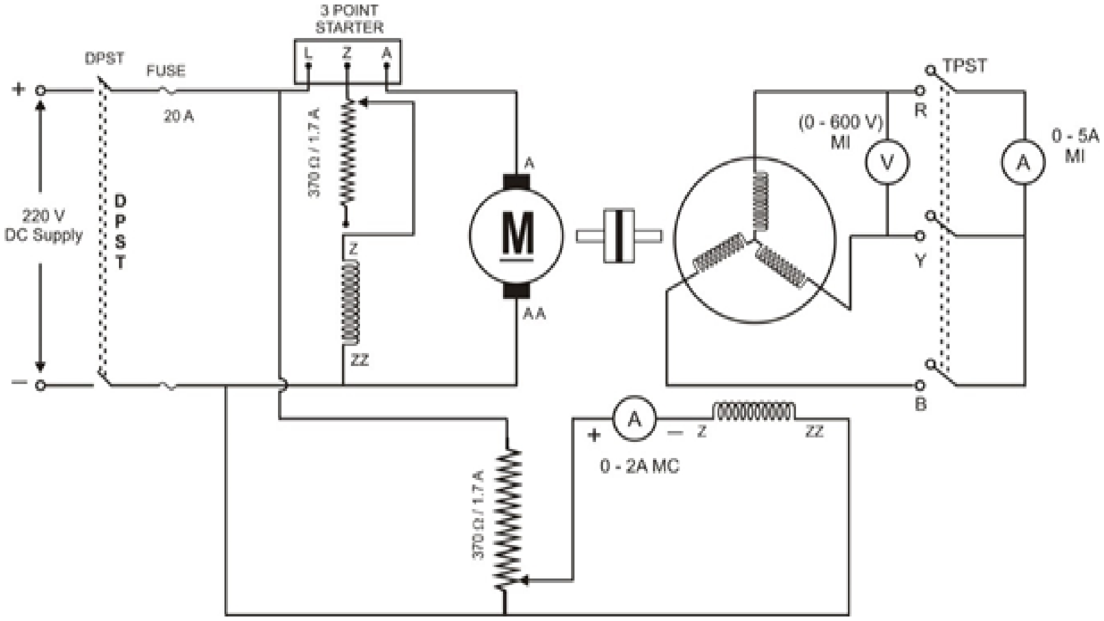


Figure 10.1: Regulations of three phase Alternator Synchronous Impedance Method

2. Excite the field winding alternator keeping armature open.
3. Note down the terminal voltage at different values of field currents.

S. No	I_f	E_g	I_f	I_{SC}
1				
2				
3				
4				

Table 10.1: Measured values

4. Draw the graph of armature voltage versus field current to get the open circuit characteristic (O.C.C) of the Alternator.
5. Close the TPST switch and excite the field winding of the alternator till the rated current flows through the armature.
6. Note down field current and short circuit current.
7. Draw the graph of the short circuit current versus field current to get the short circuit characteristic (SCC).

14.7 Model graph

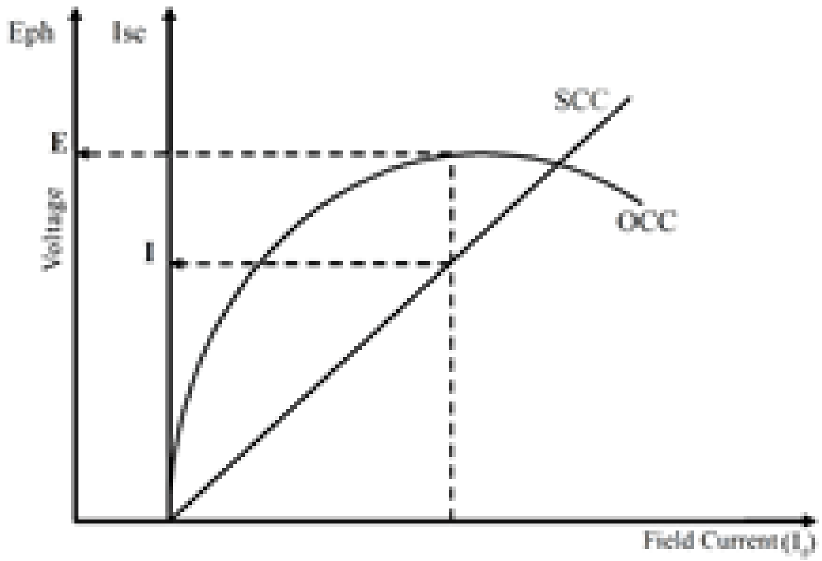


Figure 10.3: OC and SC Characteristics

8. Obtain the synchronous impedance corresponding to the rated voltage.

$$Z_s = \frac{V_{oc}}{I_{sc}}, I_f \text{ const}$$

9. Measure the armature resistance per phase by drop method. The a.c. resistance will be 20 percentage more than the D.C. Resistance: Ra = 1.2 Rdc
10. Calculate the synchronous reactance, Xs
11. Calculate the generated EMF with full load at a 0.8 lagging and leading power factor
E =[(V Cos¢ + I R a)2 (V Sin ¢ + I Xs)2]1/2
(+) sign for lagging power factor and (-) sign for leading power factors.
12. Calculate full load regulation at different power factors.
13. Draw the graph of regulation versus power factor

14.8 Probing Further Experiments

Q1. How the voltage regulation is affected by armature reaction?
Q2. State the condition for zero regulation