

**STATE BOARD OF TECHNICAL EDUCATION & TRAINING
ANDHRA PRADESH :: VIJAYAWADA**



**DIPLOMA IN ELECTRICAL & ELECTRONICS ENGINEERING
III SEMESTER
ELECTRICAL MACHINES – II LABORATORY (EE-409A)
MANUAL (AS PER C-20 CURRICULUM)**

S no	Experiment Title	Date of Experiment	Page Number
1	Load test on 1- Φ Transformer		
2	O.C and S.C Tests on 1- Φ Transformer		
3	Sumpner's Test		
4	Scott Connection		
5	Parallel Operation of two identical Transformers		
6	Testing of Transformer oil dielectric strength		
7	Direct load on Alternator		
8	Regulation of an alternator by using Synchronous impedancemethod		
9	Synchronization of Alternator with supply mains using brightlamp method		

INTRODUCTION

1.0 INTRODUCTION

The Curriculum of Technical Education should invariably provide for knowledge, attitudes and skills required by the technicians /technologists in the country. In this context the laboratory courses form a vital portion in the entire curriculum of technician education. The laboratory courses shall therefore be so designed and delivered that they help the students acquire attitudes and motor skills that are essential to function effectively as technicians/technologists.

The planning, organization and implementation of lab courses need a detailed description of tasks to be performed by the students. Well thought out instructional objectives to a large extent give these descriptions. The analysis of tasks (by identifying the activities the students are expected to do) help prepare the objectives meticulously. In other words the objectives would be clearer, when the task analysis is done to spell out the sub tasks for each objective.

A survey of the practices currently followed in the technical/technician education shows an urgent need to plug in gaps in instructional procedures. The reasons for these gaps are ambiguity in the minds of the teachers regarding tasks to be performed, levels of competency to be achieved by the students and the weightage to be allocated for each task. This aids in scientific design of instructional plan (optimizing the resources, budgeting the time & content).

The task analysis, teaching points and the structured scheme of evaluation are very important in focusing the instruction on specific skill of desired outcome and in evaluating the same. The Instruction and evaluation in Laboratory courses are different from that of cognitive lessons in the sense that adequate importance and hence weightage needs to be given for all three domains of learning viz. cognitive, psychomotor and affective. Since both training and evaluation of traits of affective domain are practically difficult, a few traits (called values) most relevant and essential to occupations/professions after the Course may be identified for the purpose. It is imperative to integrate these values during instruction and evaluation and also overtly notify the same to the students.

A technician, in addition to performing a skill needs to prepare a report of testing that includes the description of procedure, details of measurements made, reasoning based inferences and so on.,. The current practice of record writing has failed to achieve this purpose as most of the time students end up with making copies of available material.

Therefore, for sensitizing the need for the changes in laboratory instruction, the present hand book has been prepared to meet the above requirements. As such the hand book comprises four parts that intend to :

- Present task analysis, teaching points which can be used for effective design of instruction
- provide a scheme of evaluation with rationally allocated weightage to each significant skill component
- offer a set of questions designed at different levels of competencies for assessment enabling the teacher to set the question paper with balanced levels of competencies

- present pre set worksheets that cultivate the habit of systematic recording of observations and writing the technical report.
- Provide all important data related to particular laboratory activity at one point in the form of an annexure

1.1. STRUCTURE OF THE BOOK

The hand book is presented in four parts viz., Laboratory sheets, Worksheet, Experimental Methodology and Annexure. The description of each part is given in the following sections

Part I. Laboratory Sheet

The information provided in this part is useful for the teacher for designing the instruction, planning & organization of the experiment and for scientific evaluation of the students. The major features of the Laboratory sheet are further explained below.

1. Objective

It indicates the **Task** to be performed and completed by the student during the specified duration of time.

2. Task Analysis

It is the process of identifying the component activities (sub tasks) to be carried out by the student in order to achieve the stipulated objective. As the task analysis aim at fitting the instructional objectives into various classes of behaviour, it would help the teacher to determine any particular type of behaviour the student has learnt / failed to perform.

The task analysis would help the teacher in identifying the specific activities to be performed by the students. This could also be used as some kind of check list to compare with activities planned for the laboratory. Further it would give clue to the teacher to make students think originally & act independently. It includes both psychomotor learning and the related cognitive information and hence the task analysis is presented as Knowledge and skill parts.

A. Knowledge Part: That includes the cognitive aspects of the task.

B. Skill Part: That includes Psychomotor & Affective aspects of the task.

3. Teaching Points:

This includes the points based on the SKILL identified with suggested duration for each point and total duration which helps the teacher for the time and content budgeting during instruction.

4. Need and Scope:

The purpose, application and scope of the task to be performed are normally included in this sub section.

5. Planning and Organisation:

It lists actions to be taken to perform various activities and hence useful in planning the instruction and organizing the resources and equipment

6. Scheme of Valuation:

The information provided in this section helps the teacher to devise a tool for rational measurement assessment of the competencies accomplished by the student.

Part II. Work Sheet

It is designed for the student, where in the student enters his personal data of identification, details of the experiment, stepwise procedure, observations made during experiment, a sample calculation, free hand typical graph, graph from experimental data and inference with discussion.

Part III. Experimental Methodology

This section furnishes information with regard to standard procedure to conduct the experiment along with the description of equipment/apparatus and the basic theory/concept involved in the conduct of the experiment. Thus this section is very useful for both teacher and student as well to conduct the experiment systematically. Thus this section is presented in four sub section as described below:

➤ **Description**

It gives the detailed description of apparatus / tools / equipment / materials to be used for the task.

➤ **Theory / Concept**

It gives the concept of the task to be performed with formulae and units.

➤ **Procedure**

It provides the idea of step wise procedure to perform the task.

➤ **Observation and Calculation**

It includes sample observation, sample graph, sample calculation for reference

Part IV. Annexure

All important and useful information that may help in accomplishment of tasks like conversion tables for units, technical & scientific data like material properties, standard trend or characteristic curves (graphs) etc are compiled and presented at one place in this section.

1.2. WHO IS TO USE AND HOW TO USE

The hand book is so designed that it can be beneficially used by different sections of the technical education viz., the teacher, the student, the examiner and the administrator convenient to individual's requirements. A few uses of this hand book each stakeholder could make is outlined in the following sections.

1. Teacher

A. The **laboratory sheet** is designed keeping the teacher in mind for the teacher has key responsibility of imparting the skills to the student and hence the information given in the labsheets may be useful for planning & organizing the experimental set up and designing an effective instruction. Thus the teacher may

Plan and organize as per *section 4*,

Instruct the students as per *section 2*,

Demonstrate each sub task as per
section 1.B and

Evaluate the students as per *section 5*, according to the level of competency.

Values: The values in a person are an important personality trait that needs to be nurtured in the learning environment. Further it is also a driving component in any individual to deliver the best and hence this component is also included in the evaluation. However only five key dimensions, that are important in the teaching-learning environment, are taken into consideration for nurturing and evaluation. A little information about these five dimensions is given below as a guideline for the teacher while assessing students.

1. Co-operation: It is the voluntary arrangement in which two or more students engage in a mutually beneficial exchange, instead of competition. Cooperation can happen where resources adequate for both students exist or are created by their interaction.

2. Co-ordination: It is the unification, integration, synchronization of the effect of group members so as provide unity of action in the pursuit of common goals. It is an integral element and required in each & every function and at each & every stage & therefore it cannot be separated.

3. Communication; Communication skill is the set of skills that enables a student to convey information so that it is received and understood.

4. Sharing: A part or portion belonging to, distributed to, contributed by, owed by a person or a group **Or** To participate in, use, enjoy or experience jointly or in turns.

5. Leadership: Students with the following leadership qualities are almost always the ones that rise above the crowd.

1. Trustworthiness: This refers to integrity.

2. Inspiration: Guides, leads and inspiring others to want to participate in the process of moving towards the vision.
3. Self awareness: It is the individual awareness of him or her self – their abilities and the impact that they have on others.
4. Acceptance of responsibility: True leaders are accepting responsibility for all that comes their way and taking ownership and responsibilities for getting things back on track. Blaming, justifying and excuse making just is not in their responsibility.

B. The Experimental methodology is designed for both teacher and student. The teacher can refer the experimental methodology for the details of equipment/apparatus/ materials/tools, procedure to be followed, observations to be made, graphs to be drawn and calculations to be done for the task to be performed

2. Student

The Worksheet is designed keeping in view the needs, deficiencies and the adolescent characteristics of the student for student.

The students submit the filled in work sheet given by the teacher on the day of experiment after referring to experimental methodology and listening to instructions of teacher. The design of the worksheet is made user friendly and the contents are so logically sequenced that the student finds it easy to understand and develop the skill of recording and report writing skill. It also helps the student to actively participate in skill learning. More importantly the student gets immediate meaningful feedback of his performance since the competency wise assessment is done and that too on the sameday.

3. Examiner

The examiner may find this hand book very useful as Laboratory sheets and Scheme of evaluation provides information with regard to various competencies (skills) the students is expected to acquire during the course of study and the relative weightages of each competency. This information helps him to design a well balance question paper/measurement tool for assessment.

LAB SHEET

LOAD TEST ON A SINGLE PHASE TRANSFORMER

OBJECTIVE: To conduct load test on single phase transformer and to find

- (i) Efficiency and (ii) Regulation at different loads.

APPARATUS: Single phase transformer (2KVA,230/115 V,50HZ), Single phase Auto transformer,
Ammeter (MI) 0-10 A , Ammeter (MI) 0-20A, Voltmeter(MI)0-300 V, Voltmeter(MI)0-150V
Single phase wattmeter (10A,300 V,UPF), single phase transformer, Resistive load and
connecting wires.

TASK ANALYSIS

A. KNOWLEDGE

1. Transformer working Principle
2. Need for Auto transformer
3. Identify L.V and H.V. windings
4. Applying of load on transformer.
5. Removing of load on transformer
6. Rated current of a transformer.
7. Efficiency of a transformer.
8. Regulation of a transformer.

B. SKILL

Handling of Apparatus	<ul style="list-style-type: none">• Drawing the circuit diagram• Identifying L.V and H.V windings.• Using correct range Voltmeter, Ammeter, watt meter.• Setting the Auto transformer to zero position.• Proper handling of the resistive load .
Manipulation of apparatus	<ul style="list-style-type: none">• Making the connections.• Checking the connections• Switching on the supply.• Handling the Auto transformer.• Observing the readings in the Ammeter , Voltmeter, wattmeter.
Precise operations/Activities	<ul style="list-style-type: none">• Adjusting the Auto transformer to minimum position & adjust the voltage using auto transformer.• Applying the load on single phase transformer.• Recording the readings on voltmeters, Ammeters, wattmeter.• Finding the output power of transformer by multiplying secondary voltage and load current.• Calculating the efficiency of the transformer by calculating input and output of the transformer at various loads, calculate regulation & Drawing the graph of output VS efficiency.

2. TEACHING POINTS

Sl No	Teaching Point	Suggested Time-15 min
1.	Types of Tests conducted on single phase transformer.	2
2.	Purpose of conducting load test.	1
3.	Auto transformer.- kept in minimum position.	2
4.	Resistive load arrangement	2
5.	Calculating %efficiency	1
6.	Calculating % regulation	1
7.	Drawing of output VS efficiency graph	2
8.	Applications of single phase transformer	1
9.	Interpreting Rated current on a transformer.	2
10.	Precautions	1

A. Procedural precautions

- Disconnect all the equipment from mains before making connections
- Ensure the correct range of meters
- Ensure that the meters and auto transformer are properly set
- Connect the circuit as per the circuit diagram .
- Get the connections checked by the concerned staff member
- Ensure that there are no loose connections

B. Safety precautions:

1. Make sure that the windings of the transformer are in working Condition (Continuity & Insulation Resistance).
2. Loads must be applied on LV side in order to have an accurate meter readings even from small load currents.
3. Make sure that all the wiring connections are in tight condition.
4. Note the readings without any parallax error.

3. NEED AND SCOPE OF EXPERIMENT

This experiment is essential to determine the efficiency and regulation under various loading conditions .

4. PLANNING AND ORGANISATION

ACTION	ACTIVITY
Check for	<ul style="list-style-type: none"> • The Meters & Auto transformer • Resistive load Arrangement • The students entry behavior • First aid kit • Wires of Standard colours and Gauges
For Design of Instruction	<ul style="list-style-type: none"> • Read teaching points carefully.

5. SCHEME OF EVALUATION

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
1. Handling of apparatus	A. Drawing circuit diagram B. Identifying L.V and H.V windings. C. Using correct range Voltmeter, Ammeter, watt meter D. Setting the auto transformer to zero position E. Proper handling of resistive load	<table border="1" style="margin: auto;"> <tr> <td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>T</td> </tr> <tr> <td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>10</td> </tr> </table>	A	B	C	D	E	T	2	2	2	2	2	10	
A	B	C	D	E	T										
2	2	2	2	2	10										
2. Manipulation of apparatus	A. Making the connections. B. Checking the connections. C. Switching on the supply. D. Handling the auto transformer E. Observing the readings in ammeter, voltmeter, wattmeter.	<table border="1" style="margin: auto;"> <tr> <td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>T</td> </tr> <tr> <td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>10</td> </tr> </table>	A	B	C	D	E	T	2	2	2	2	2	10	
A	B	C	D	E	T										
2	2	2	2	2	10										
3. Precise operations/Activities	A. Adjusting the voltage using auto transformer. B. Applying the load on the single phase transformer. C. Recording the readings on single phase transformer. D. Finding output power of transformer. E. Calculate efficiency & regulation.	<table border="1" style="margin: auto;"> <tr> <td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>T</td> </tr> <tr> <td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>25</td> </tr> </table>	A	B	C	D	E	T	5	5	5	5	5	25	
A	B	C	D	E	T										
5	5	5	5	5	25										
4. Values	A. Co Operation B. Co-Ordination C. Communication D. Sharing E. Leadership	<table border="1" style="margin: auto;"> <tr> <td style="height: 20px;"></td> </tr> <tr> <td style="text-align: center;">5</td> </tr> </table>		5											
5															
Total		50													

6. ASSESSMENT / VIVA QUESTIONS:

1. What is a transformer?
2. How does a transformer work?
3. What are the necessary tests to determine the efficiency, voltage regulation, and temperature rise of Winding & insulation of transformer.
4. What is auto transformer?
5. What are the factors affecting voltage regulation?
6. Why is the range of efficiency in transformer higher than those of other electrical machines?
7. What is the condition for maximum efficiency of transformer?
8. What are the typical uses of auto transformer?
9. Define efficiency of transformer.
10. What is meant by regulation of a transformer.

7. EXERCISE QUESTIONS :

Level-A

1. Draw the circuit diagram of Load test on single phase transformer.
2. Identify L.V &H.V windings in a transformer.
3. Mention the correct range and type of equipment used in load test on single phase transformer.

Level-B

1. Reading given circuit diagram and make the connections.
2. Handling auto transformer and observe the readings in ammeter and voltmeter for different load.
3. Conduct load test on a given single phase transformer

Level-C

1. Recording the reading of load test on single phase transformer for given load conditions.
2. Calculate the efficiency and regulation for various loads.
3. Draw the graph for single phase transformer for the given table of recordings .
4. Find the efficiency of a given Single Phase Transformer.

Lab sheet

OC & SC TEST ON SINGLE PHASE TRANSFORMER

OBJECTIVE: To conduct OC and SC tests on a single phase transformer and to obtain

1. The equivalent circuit constants
2. Regulation and efficiency at different loads and power factors.
3. Load at which the maximum efficiency occurs.
4. All –day efficiency for the given load cycle of 24 hours.

APPARATUS:

Name	Type	Specifications/ Range	No
Auto Transformer	1- ϕ	230/0-270 V	1
Transformer	1- ϕ	1 KVA, 50 Hz, 230/110 V	1
Ammeter	MI	0-2.5 A	1
Voltmeter	MI	0-150 V	1
1- ϕ Wattmeter	Dynamometer	2.5 A, 150V, LPF	1
Ammeter	MI	0-10 A	1
Voltmeter	MI	0-50 V	1
Wattmeter	Dynamometer	10 A, 50V, UPF	1

TASK ANALYSIS

A. KNOWLEDGE

- Transformer Definition.
- Need for Auto Transformer
- Terminals of Transformer.
- Ratings of Transformer
- Losses in Transformer
- Equivalent Circuit parameters
- Drawing Equivalent Circuit
- Power factor.
- Efficiency of Transformer.
- Regulation of Transformer.
- Load Cycle
- All-day Efficiency definition
- Precautions

B. SKILL

Handling of Apparatus	<ul style="list-style-type: none">✓ Drawing the circuit diagram✓ Identification of windings on Transformer.✓ Identification of meters.✓ Identification wattmeter terminal connections.✓ Setting the auto transformer to minimum position.
Manipulation of apparatus	<ul style="list-style-type: none">✓ Making Circuit Connections.✓ Checking the connections.✓ Switching on supply.✓ Increasing the voltage to rated value.✓ Observing the readings with multiplication factor in the meters.
Precise operations/Activities	<ul style="list-style-type: none">✓ Varying the Voltage and Current to rated Value✓ Noting down the readings with multiplication factor.✓ Calculating the equivalent circuit parameters from above readings.✓ Drawing the equivalent Circuit.✓ Calculating the Efficiency using formula.✓ Calculating percentage regulation.✓ Drawing the graph and showing salient points.✓ Calculating All-Day Efficiency.

2. TEACHING POINTS

Sl .No	Teaching Point	Suggested Time-20 min
1.	Transformer definition and its Windings	2 min
2.	Identification of transformer windings	3 min
3.	OC and SC Test	3 min
4.	Equivalent Circuit Constants calculations	4 min
5.	Drawing equivalent Circuit	2 min
6.	Calculating Efficiency	2 min
7.	Calculating Power factor	1 min
8.	Calculating Percentage Regulation	1 min
9.	Calculating All-day Efficiency	1 min
10.	Precautions	1 min

A. Procedural precautions

- Disconnect all the equipment from mains before making connections
- Ensure the correct range of meters
- Ensure that the meters and auto transformer is properly set
- Connect the circuit as per the circuit diagram and check for polarity
- Get the connections checked by the concerned staff member
- Use the proper fuse
- Ensure that there are no loose connections

B. Safety Precautions

1. Auto Transformer must be varied slowly.
2. Readings must be taken without any parallax error.
3. In case of OC Test the meters must be connected on LV side and the Open circuit is made on HV side.
4. In case of SC Test the meters must be connected on HV side and the Short circuit is made on LV side
5. Make sure that all the wiring connections are in tight condition.

3. NEED AND SCOPE OF EXPERIMENT

1. This experiment is essential to understand the basic working principle of a transformer and to obtain equivalent circuit parameters from OC and SC tests and also to estimate efficiency & regulation at various loads.
2. The power required for OC and SC test on transformer is equal to the power loss occurring in the transformer hence iron and copper losses can be determined from this experiment and from these losses All-Day Efficiency can be calculated.

4. PLANNING AND ORGANISATION

ACTION	ACTIVITY
Check for	<ul style="list-style-type: none">• The Auto transformer• Correct range of meters.• The students entry behavior• First aid kit• Wires of Standard colours and Gauges
For Design of Instruction	<ul style="list-style-type: none">• Read teaching points carefully.

5. SCHEME OF VALUATION

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded																		
1.Handling of apparatus	A. Identification of transformer windings and meters. C. Identification wattmeter terminal connections. D. Setting the auto transformer to minimum position.	<table border="1"> <tr> <td>A</td> <td>B</td> <td>c</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>3</td> </tr> </table>	A	B	c	T	1	1	1	3											
A	B	c	T																		
1	1	1	3																		
2. Manipulation of apparatus	A. Making Circuit Connections. B. Checking the connections. C. Switching on supply. D. Increasing the voltage to rated value. E. Observing the readings with multiplication factor in the meters.	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>T</td> </tr> <tr> <td>3</td> <td>2</td> <td>1</td> <td>1</td> <td>3</td> <td>10</td> </tr> </table>	A	B	C	D	E	T	3	2	1	1	3	10							
A	B	C	D	E	T																
3	2	1	1	3	10																
3. Precise operations/Activities	A. Varying the Voltage and Current to rated Value B. Noting down the readings with multiplication factor. C. Calculating the equivalent circuit parameters from above readings. D. Drawing the equivalent Circuit. E. Calculating the Efficiency using formula. F. Calculating percentage regulation. G. Drawing the graph and showing salient points. H. Calculating All-Day Efficiency.	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>F</td> <td>G</td> <td>H</td> <td>T</td> </tr> <tr> <td>2</td> <td>3</td> <td>6</td> <td>7</td> <td>3</td> <td>3</td> <td>3</td> <td>3</td> <td>30</td> </tr> </table>	A	B	C	D	E	F	G	H	T	2	3	6	7	3	3	3	3	30	
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4.Values	A. Co operation B. Co ordination C. Communication D. Sharing E. Leadership	<table border="1"> <tr> <td>T</td> </tr> <tr> <td>5</td> </tr> </table>	T	5																	
T																					
5																					
	Total	50																			

6. VIVA QUESTIONS :

1. Which winding (LV or HV) should be kept open while conducting OC Test. Justify the answer.
2. Assume that the given transformer has the following name plate ratings 40 KVA , 440 V/11KV, 50 Hz. What do these numbers imply.
3. Can regulation be negative ? what does it signify ?
4. Why transformers are rated in KVA.
5. Why core losses remain almost constant at any load .
6. What is regulation and efficiency of a transformer?
7. Justify OC test gives core losses while short Circuit gives copper losses.
8. Discuss the effect of output power on efficiency and regulation.
9. Why SC test is generally performed with LV side short circuited
10. Why OC test is generally performed on LV side.

7 Assessment Questions :

- i. Draw the circuit diagram of OC and SC test on Transformer.
- ii. Conduct OC and SC test on given Single Phase Transformer.
- iii. Draw the Equivalent Circuit from the OC and Test readings of the Transformer referred to LV side..
- iv. Draw the Equivalent Circuit from the OC and Test readings of the Transformer referred to HV side.
- v. Find the Iron and Copper losses from the given Test readings.
- vi. Find the efficiency of Transformer at Full load rated current from the given test readings.
- vii. Find the efficiency of Transformer at Half Full load rated current from the given test readings.

LAB SHEET
SUMPNERS TEST OF TRANSFORMERS

1 OBJECTIVE: To determine

- i) The efficiency and regulation at different power factors of transformer by conducting sumpners test and
- ii) To draw its performance curves (Efficiency Vs Output, at different power factor.

2 APPARATUS: transformers; Ammeter: 0-5A and 0-10A (MI. Type); Voltmeter: 0- 600V ,0-150V and 0-75V (MI Type); 1- ϕ wattmeter 5A,150V,LPF and 10A,75V,UPF (DM type), auto transformer, booster transformer and connecting wires.

3 TASK ANALYSIS

A. KNOWLEDGE

1. Transformer Principle
2. Open circuit test
3. Short circuit test
4. . Efficiency of a transformer
5. Regulation of a transformer
6. Precautions

B. SKILL

CATEGORY OF SKILL	SUB TASK
1. Handling of apparatus	A. Identification of windings on Transformer. B. Identification of meters. C. Identification wattmeter terminal connections. D. Setting the auto transformer to minimum position.
2. Manipulation of apparatus	A. Making Circuit Connections. B. Checking the Polarities. C. Switching on supply. D. Noting down the voltage zero in the voltmeter otherwise checking the polarity E. Increasing the voltage to rated value. F. Observing the readings with multiplication factor in the meters. G. Injected the voltage to the secondary winding.
3. Precise operations/Activities	A. Varying the Voltage and Current to rated Value B. Noting down the readings with multiplication factor. C. Calculating the copper losses fraction of full load. D. Calculating the input power. E. Calculating the Efficiency using formula. F. Calculating percentage regulation. G. Drawing the graph and showing salient points.

4. TEACHING POINTS

Sl No	Teaching Point	Suggested Time-15 min
1.	Types of Tests conducted on transformer.	2
2.	Purpose of conducting sumpners test.	1
3.	multiplication factor	2
4.	Various Terminals on wattmeter and usage	2
5.	Open circuit test	1
6.	Short circuit test	1
7.	Polarities of a transformer	2
8.	Injected the voltage to the secondary winding	1
9.	Interpreting Name plate Details	2
10.	Precautions	1

A. Procedural precautions

- Disconnect all the equipment from mains before making connections
- Ensure the correct range of meters
- Ensure that the meters are properly set
- Connect the circuit as per the circuit diagram and check for polarity
- Get the connections checked by the concerned staff member
- Ensure that there are no loose connections

B. Safety precautions: Refer Annexure

5.NEED AND SCOPE OF EXPERIMENT

This experiment is essential to understand the performance of transformer at different power factors. This test also gives an insight in to Standard testing procedures adopted in the industry.

6.PLANNING AND ORGANISATION

ACTION	ACTIVITY
Check for	<ul style="list-style-type: none">• The Meters & auto transformer and booster transformer• Polarities of transformer.• The students entry behavior• First aid kit• Wires of Standard colors and Gauges
For Design of Instruction	<ul style="list-style-type: none">• Read teaching points carefully.

7. SCHEME OF EVALUTION

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded																														
1.Handling of apparatus	A. Identification of windings on Transformer. B. Identification of meters. C. Identification wattmeter terminal connections. D. Setting the auto transformer to minimum position.	<table border="1"> <tr> <td>A</td><td>B</td><td>C</td><td>D</td><td>T</td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>1</td><td>1</td><td>2</td><td>1</td><td>5</td><td></td><td></td><td></td><td></td><td></td> </tr> </table>	A	B	C	D	T						1	1	2	1	5																
A	B	C	D	T																													
1	1	2	1	5																													
2. Manipulation of apparatus	A. Making Circuit Connections. B. Checking the Polarities. C. Switching on supply. D. Noting down the voltage zero in the voltmeter otherwise checking the polarity E. Increasing the voltage to rated value. F. Observing the readings with multiplication factor in the meters. G. Injected the voltage to the secondary winding.	<table border="1"> <tr> <td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td><td>T</td><td></td><td></td> </tr> <tr> <td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>3</td><td>15</td><td></td><td></td> </tr> </table>											A	B	C	D	E	F	G	T			2	2	2	2	2	2	3	15			
A	B	C	D	E	F	G	T																										
2	2	2	2	2	2	3	15																										
3. Precise operations/Activities	A. Varying the Voltage and Current to rated Value B. Noting down the readings with multiplication factor. C. Calculating the copper losses fraction of full load. D. Calculating the input power. E. Calculating the Efficiency using formula. F. Calculating percentage regulation. G. Drawing the graph and showing salient points.	<table border="1"> <tr> <td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td><td>T</td><td></td><td></td> </tr> <tr> <td>3</td><td>3</td><td>3</td><td>4</td><td>4</td><td>4</td><td>4</td><td>25</td><td></td><td></td> </tr> </table>	A	B	C	D	E	F	G	T			3	3	3	4	4	4	4	25													
A	B	C	D	E	F	G	T																										
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4.Values	A. Co operation B. Co ordination C. Communication D. Sharing E. Leadership	<table border="1"> <tr> <td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>T</td><td></td><td></td><td></td><td></td> </tr> <tr> <td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>5</td><td></td><td></td><td></td><td></td> </tr> </table>											A	B	C	D	E	T					1	1	1	1	1	5					
A	B	C	D	E	T																												
1	1	1	1	1	5																												
	Total	50																															
Signature of Staff		Signature of student																															

8 Viva Questions :

1. Which test is also called as back to back test?
2. While conducting the sumpner's test, the primaries of the two identical transformers are connected in parallel across the supply. The secondary's are connected in-----
3. In sumpner's test, the net voltage in the local circuit of secondary's is -----
4. While performing sumpner's test on transformer, if the secondary's are not in series opposition then the meter will read-----
5. If W_1 is the input power measured by the wattmeter connected across the primaries and W_2 is the measurement of wattmeter connected in secondary's while performing sumpner's test then iron losses and copper losses is equal to-----
6. What is the basic condition to be fulfilled to conduct this test.

9. Assessment Questions :

1. Draw the circuit diagram to conduct Sumpners test on Transformers.
2. Conduct Sumpners Test on Transformers.
3. Calculate the efficiency of transformers from the readings of sumpners test.

LAB SHEET
Scott – Connection on single Phase Transformers

OBJECTIVE:

To get a two – phase supply from a three phase supply using Scott connection of transformers and verify the current relations for balanced loads

APPARATUS

Two identical single phase transformers; Ammeters: 0-10A (M.I. Type); Voltmetesr: 0-300V (M.I.Type); Single phase resistive load,and connecting wires.

TASK ANALYSIS

A. KNOWLEDGE

1. Transformer Principle
2. Need of Autotransformer
- 3.definition of scott connection
4. Various types of Transformers
- 5.purpose of scott connection
- 6.Applications of scott connections
- 8.Precautions

B. SKILL

Handling of Apparatus	<ul style="list-style-type: none">• Drawing the circuit diagram• Identifying various terminals• Identifying HV and LV terminals of transformers• Using correct range Voltmeter, Ammeters.• Setting the 3 phase auto transformer at minimum position.• Proper handling of single phase resistive load .
Manipulation of apparatus	<ul style="list-style-type: none">• Reading the Circuit Diagram.• Making the connections.• Checking the connections• Switching on the supply.• Handling the auto transformer.• Observing the readings in the Ammeter and Voltmeter.
Precise operations/Activities	<ul style="list-style-type: none">• Adjusting the primary of teaser transformer to its rated voltage By using auto transformer• Applying balanced load on the secondaries of teaser and main transformers• Recording the readings on voltmeter, Ammeters.• Observing the resultant primary line currents• Drawing the Phasor diagram and interpreting

2. TEACHING POINTS

Sl No	Teaching Point	Suggested Time-15 min
1.	Types of Tests conducted on transformers	2
2.	Purpose of conducting Scott connection	1
3.	Identifying the Tapings on the transformer	2
4.	Identifying the HV and LV terminals of the transformers	2
5.	Two transformers connections	1
6.	Calculating transformation ratio of the transformer	1
7.	Balancing the loads on secondaries of main and teaser transformer	2
8.	Applications of scott connection	1
9.	Interpreting Name plate Details	2
10.	Precautions	1

A. Procedural precautions

- Disconnect all the equipment from mains before making connections
- Ensure the correct range of meters
- Ensure that the meters and autotransformer are properly set
- Connect the circuit as per the circuit diagram and check for polarity
- Get the connections checked by the concerned staff member
- Use the proper fuse
- Ensure that there are no loose connections

B. Safety precautions:

1. Make sure that the windings of the transformer are in working Condition (Continuity & Insulation Resistance).
- .2. Care must be taken while applying the rated Voltage on HV Side of Teasure Transformer
3. Make sure that all the wiring connections are in tight condition.
4. Note the readings without any parallex error.

3. NEED AND SCOPE OF EXPERIMENT

4. PLANNING AND ORGANISATION

ACTION	ACTIVITY
Check for	<ul style="list-style-type: none">• The Meters & autotransformer• Loading Arrangement• The students entry behavior• First aid kit• Wires of Standard colours and Gauges
For Design of Instruction	<ul style="list-style-type: none">• Read teaching points carefully.

5. SCHEME OF EVALUATION

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
1. Handling of apparatus	<p>A. Drawing circuit diagram and Identifying various terminals</p> <p>B. Using correct range Voltmeter, Ammeter</p> <p>C. Adjusting the auto transformer at minimum positions during the stating of experiment</p>	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>3</td> <td>2</td> <td>10</td> </tr> </tbody> </table>	A	B	C	T	5	3	2	10					
A	B	C	T												
5	3	2	10												
2. Manipulation of apparatus	<p>A. Handling the single phase restive loads</p> <p>B. Varying the three phase auto transformer.</p>	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>5</td> <td>10</td> </tr> </tbody> </table>	A	B	T	5	5	10							
A	B	T													
5	5	10													
3. Precise operations/Activities	<p>A. Applyin rated voltage on primary side of teaser transformer</p> <p>B. Increasing the Loads on secondaries of two transformers uniformly</p> <p>C. Recording the readings in the Ammeter ,Voltmeter</p> <p>DDrawing the phasor</p> <p>EFinding primaray line currents</p>	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>5</td> <td>5</td> <td>5</td> <td>5</td> <td>25</td> </tr> </tbody> </table>	A	B	C	D	E	T	5	5	5	5	5	25	
A	B	C	D	E	T										
5	5	5	5	5	25										
4. Values	<p>A. Co Operation</p> <p>B. Co-Ordination</p> <p>C. Communication</p> <p>D. Sharing</p> <p>E. Leadership</p>	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>5</td> </tr> </tbody> </table>	A	B	C	D	E	T	1	1	1	1	1	5	
A	B	C	D	E	T										
1	1	1	1	1	5										
Total		for	50												

6. Viva Questions ::

1. Why teaser transformer is tapped at 86.6% and Main transformer is tapped at 50%?
2. How do you justify the primary line currents from the secondary currents of Teaser and Main transformers?
3. What is the need of Booster Transformer?
4. What are the applications of Scott connection?
5. Why the secondaries of both Main and Teaser Transformers loaded uniformly?
6. Can we perform the Scott connection on any type of single phase Transformers

7. Assessment Questions :

1. Draw the circuit diagram of Scott Connection.
2. Verify the 3-Phase to 2-Phase relationship of currents using the Scott Connection.

LAB SHEET

Parallel operation of 1 ϕ Transformers

OBJECTIVE: To operate two 1 ϕ transformer in parallel and to observe the load sharing between them

APPARATUS: 1 ϕ transformer 2kVA, 230/110V, 1 ϕ Auto transformer :230/(0-270)V 10A, Ammeter:0-10A (M.I. Type); Voltmeter:0-50V (M.I. type); Voltmeter:0-150V (M.I. Type); Voltmeter:0-500V (M.I.Type); Wattmeter: 10A 50V UPF (DM Type); SPST switch; Resistive load: 1 ϕ , 230V, 10A; Connecting wires:

TASK ANALYSIS

A. KNOWLEDGE

1. Transformer Principle.
2. Need of polarity test.
3. Conditions for parallel operation.
4. Connecting the secondaries in proper way
5. Calculating multiplication factor of wattmeter.
6. Observing the rated voltage of transformer in primary side.
7. Calculating the rated current of transformer in secondary side.
8. Making the short circuit on LV side.
9. Calculating the short circuit impedance.

B. SKILL

Handling of Apparatus	<ul style="list-style-type: none">• Drawing the circuit diagram• Identifying various terminals• Using correct range Voltmeter, Ammeters, Wattmeter.• Setting the Auto transformer in zero voltage position.• Proper handling of the 1ϕ Resistiveload .• Proper Handling of the SPST Switch.
Manipulation of apparatus	<ul style="list-style-type: none">• Reading the Circuit Diagram.• Making the connections.• Checking the connections• Switching on the supply.• Handling the 1ϕ Autotransformer.• Observing the readings in the Ammeter, Voltmeter and wattmeter.
Precise operations/Activities	<ul style="list-style-type: none">• Adjusting the Auto transformer to zero voltage position• Adjusting therated voltage of transformer primary side with the help of autotransformer.• Conducting the polarity test on secondary side.• After Polarity test, the SPST switch should be closed.• Recording the readings on voltmeter, Ammeter, wattmeter by varying the load.• Measure the short circuit voltage, short circuit current, power and calculating the short circuit impedance.• Calculating the secondary current of each transformer with the help of their impedances.• Comparing the calculated currents with the currents measured from ammeters.

2. TEACHING POINTS

Sl No	Teaching Point	Suggested Time-15 min
1.	Types of Tests conducted on 1 ϕ transformer.	2
2.	Purpose of operating two 1 ϕ transformer in parallel.	2
3.	Purpose of operating autotransformer on primary side	1
4.	Purpose of conducting polarity test	2
5.	Resistive load arrangement	1
6.	Multiplication factor of wattmeter	1
7.	Purpose of using SPST switch	2
8.	Uses of operating two transformers in parallel	1
9.	Interpreting Name plate Details	2
10.	Precautions	1

A. Procedural precautions

- Disconnect all the equipment from mains before making connections
- Ensure the correct range of meters
- Ensure that the meters and auto transformer are properly set
- Connect the circuit as per the circuit diagram and check for polarity
- Get the connections checked by the concerned staff member
- Use the proper fuse
- Ensure that there are no loose connections

B. Safety precautions:

1. Make sure that the windings of the transformer are in working Condition (Continuity & Insulation Resistance).
2. Ensure that the secondary Voltmeter reads ZERO else the connections on the secondary side of one transformer must be interchanged.
3. Make sure that all the wiring connections are in tight condition.
4. Note the readings without any parallax error.

3. NEED AND SCOPE OF EXPERIMENT

This experiment is essential to operate two 1ϕ transformers in parallel and load sharing between them. This parallel operation adopted in transmission and distribution of electrical power.

4. PLANNING AND ORGANISATION

ACTION	ACTIVITY
Check for	<ul style="list-style-type: none">• The Meters & autotransformer• Conducting polarity test• The students entry behavior• First aid kit• Wires of Standard colours and Gauges
For Design of Instruction	<ul style="list-style-type: none">• Read teaching points carefully.

5. SCHEME OF EVALUATION

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded												
1. Handling of apparatus	A. Identification of Correct Components B. Identification of meters C. Setting the auto transformer in zero voltage positions	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>2</td> <td>2</td> <td>5</td> </tr> </tbody> </table>	A	B	C	T	1	2	2	5					
A	B	C	T												
1	2	2	5												
2. Manipulation of apparatus	A. Making Circuit connections B. Checking the polarity test C. Adding the resistive load in step by step	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>4</td> <td>8</td> <td>8</td> <td>20</td> </tr> </tbody> </table>	A	B	C	T	4	8	8	20					
A	B	C	T												
4	8	8	20												
3. Precise operations /Activities	A. Recording the readings in the Ammeters, Voltmeter and wattmeter. B. Measuring the V_{sc} , I_{sc} & W_{sc} calculating the synchronous impedance. C. Calculating the currents in each transformer. D. Drawing the graph and showing the	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>7</td> <td>8</td> <td>20</td> </tr> </tbody> </table>	A	B	C	T	5	7	8	20					
A	B	C	T												
5	7	8	20												
4. Values	A. Co Operation B. Co-Ordination C. Communication D. Sharing E. Leadership	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table>	A	B	C	D	E	T	1	1	1	1	1	1	
A	B	C	D	E	T										
1	1	1	1	1	1										
Total			50												
Signature of the Staff		Signature of the Student													

6. ASSESSMENT / VIVA QUESTIONS

1. State the need of parallel operation?
2. What are the conditions of parallel operation of 1ϕ transformer?
3. How to conduct polarity test of a 1ϕ transformer?
4. What will happen if two transformers are connected in wrong polarity?
5. How do you parallel two single phase transformer?
6. How can two transformer share the load connected combine to them?
7. What is the role of impedance in load sharing?
8. What happens, if the secondary voltages of the transformers in parallel operation mismatched?

7. Exercise Questions :

1. Draw the circuit diagram for conducting Parallel Operation of Single Phase Transformers.
2. Conduct Parallel operation Test on Two given Transformers.
3. Test the conditions to be satisfied to conduct Parallel operation on a given two Transformers.

LAB SHEET

6. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Objective: To determine the dielectric strength of transformer Oil.

Equipment:

1. Transformer oil Testing Kit	-1No.
2. Sample Oil (to be tested)	-1No

Task Analysis

(a) Knowledge

1. Should have the knowledge regarding various parts of Oil Testing Kit
2. Working of Oil Testing Kit.
3. Instructions for operation of Oil Test Kit.(Enclosed in the Kit itself)
4. Applications of Transformer Oil

(b) Skill

Category of Skill	Sub Task	
Handling of Apparatus	A	Drawing circuit diagram and identifying various terminals.
	B	Connecting the sample test box as per the instructions in the kit
	C	Proper Handling of SPST Switch
Manipulation of Apparatus	A	Verifying the apparatus as per the Circuit Diagram
	B	Making the connections
	C	Operation of Transformer Oil kit
Precise Operations / Activities	A	Carefully preparing the Oil sample in the Test cell/Box.
	B	Carefully raise the voltage by keen observing the breakdown takes place
	C	Changing the breakdown voltage in precise steps.
	D	Suitable gauge is used to adjust the gap between the spheres

LAB SHEET

6. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Teaching Points:

S.no	Teaching Points	Suggested Time (15 Mins)
1	Different kinds of Transformer Oil Testing	2
2	Purpose of Conducting dielectric strength of Transformer Oil	3
3	Sample Test Cell /Box Arrangement	4
4	Applications of transformer Oil	2
5	Various parts of The Testing Kit	2
6	Precautions	2

Precautions:

1. Transformer Oil should be free from moisture content.
2. Nobody should go near the H.T bushing when the test being conducted.
3. Ignore the first one or two readings, as the air between the electrodes may not ionize.
4. The equipment must be grounded firmly.
5. The electrodes must be cleaned properly before and after the use.
6. Don't touch the equipment without grounding it with the grounding rod.
7. Before starting the experiment, make sure the electrodes are properly aligned and zero reading is adjusted.

LAB SHEET

6. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Need and Scope of Experiment :

This experiment is essential to understand the performance of dielectric strength of the transformer Oil by varying the voltage .Suitability of Oil for various applications can be assessed.

Planning and Organization

Action	Activity
Check for	Functioning of meters.
	Test cell / Box arrangement
	The students' entry behaviour.
	The first aid kit.
	The wires of standard colours and gauges.
For the design of instruction	Read the teaching points carefully.

LAB SHEET

6. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Scheme of Evaluation

Category of Skill	Sub Task		Individual Competency Level Weight age	Marks Awarded
Handling of Apparatus	A	Connecting the sample test box as per the instructions in the kit	5	
	B	Identifying various terminals	3	
	C	Proper Handling of SPST Switch	2	
Manipulation of Apparatus	A	Verifying the apparatus as per the Circuit Diagram	4	
	B	Making the connections	3	
	C	Operation of Transformer Oil kit	3	
Precise Operations / Activities	A	Carefully preparing the Oil sample in the Test cell/Box.	10	
	B	Carefully raise the voltage by keen observing the breakdown takes place	5	
	C	Changing the breakdown voltage in precise steps.	5	
	D	Suitable gauge is used to adjust the gap between the spheres	5	
Values	A	Co-Operation	1	
	B	Co-Ordination	1	
	C	Communication	1	
	D	Sharing	1	
	E	Leadership	1	
Total Marks			50	

LAB SHEET

6. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Viva Questions

1. Why Oil testing is necessary?
2. How does air bubble and moisture would affect the insulation strength?
3. Why earthing of the oil testing set is a mandatory requirement?
4. What does BDV mean and it unit?
5. Why Oil is used in transformer?
6. What is dielectric strength?
7. What is the **IS** recommendation of the dielectric strength of oil?
8. What type of oil you have tested?
9. Is it possible to test the dielectric strength of other liquid samples?

Assessment Questions

1. What is the dielectric strength of SUNFLOWER oil?
2. What happens when Oil is reheated?
3. What are the causes of reduction in dielectric strength of transformer oil?
4. What are the other properties of the oil? State their acceptable limiting value.

LAB SHEET

LOAD TEST ON 3-PHASE ALTERNATOR

1.OBJECTIVE: To determine

1. The voltage regulation of a 3-phase alternator by conducting load test at different loads.
2. To draw the graph between regulation verses load current for resistive, inductive and capacitive loads.

2.APPARATUS:

Note : Prepare a list of apparatus based on the specifications of the machines.				
S.No.	Name of Apparatus	Type	Range	Quantity
1.	Voltmeter	MI	0-600 V	1 No
2.	Ammeter	MI	0-5 A	1 No
3.	Ammeter	MC	0-2 A	1 No
4.	Rheostat	Wire wound	350 Ω , 1.7 A	2 No's
5.	Load	3 ϕ		1 No
6.	Tachometer	Digital		1 No
7.	Connecting wires	-	-	Required No

3.TASK ANALYSIS:

A.KNOWLEDGE:

1. Alternator working principle
2. Need of DC motor and exciter
3. Definition of voltage regulation
4. Different types of loads regarding power factors
A.Resistive load b.Inductive load c.Capacitive load
5. Equation of voltage regulation
6. Use of load test on alternator
7. Precautions

B. SKILL

Handling of Apparatus	<ul style="list-style-type: none">• Drawing the circuit diagram• Identifying various terminals• Using correct range Voltmeter, Ammeters.• Proper connecting of connecting wires without loose connections• Setting the Rheostats to correct positions.• Proper Handling of the DPST Switch• Proper handling of the field rheostat of alternator and DC motor• Proper handling of resistive, inductive and capacitive loads.
Manipulation of apparatus	<ul style="list-style-type: none">• Reading the Circuit Diagram.• Making the connections.• Checking the connections• Switching on the supply.• Handling the 3- point Starter.• Observing the readings in the Ammeter and Voltmeter
Precise operations/Activities	<ul style="list-style-type: none">• Adjusting the motor field rheostat to minimum position• Adjusting the alternator field to maximum position• Adjust the speed of the DC motor to its rated value by using its Field Rheostat.• Adjusting the excitation field current to such a value which gives rated terminal voltage using alternator.• Adjusting the resistive, inductive and capacitive loads of alternator in step wise up to rated value of current and keep the speed constant at each load• Recording the readings on voltmeter, Ammeter.• Calculating the voltage regulation at different loads• Drawing the graph and interpreting

4. TEACHING POINTS

Sl No	Teaching Point	Suggested Time-15 min
1.	Load test on alternator and voltage regulation	2
2.	Purpose of conducting load test	2
3.	Relation between voltage regulation on different loads and power factor	3
4.	3 - point starter.- Different terminals and Coils	2
5.	Various Terminals on Rheostats and usage	2
6.	Resistive, inductive and capacitive loads arrangement	1
7.	Interpreting Name plate Details	2
8.	Precautions	1

5. Procedural precautions

- Disconnect all the equipment from mains before making connections
- Ensure the correct range of meters
- Ensure that the meters and rheostat are properly set
- Connect the circuit as per the circuit diagram and check for polarity
- Keep the load in minimum position before the alternator started
- Get the connections checked by the concerned staff member
- Use the proper fuse
- Ensure that there are no loose connections and wrong connections

6. Safety precautions:

1. Wear shoes
2. Wear apron
3. Carry tool kit

7. NEED AND SCOPE OF EXPERIMENT

This experiment is essential to determine the voltage regulation of 3-phase alternator at different types of load conditions. By conducting this experiment terminal voltage can be maintained on par with grid voltage thereby minimizing the voltage fluctuations in the grid

8. PLANNING AND ORGANISATION

ACTION	ACTIVITY
Check for	<ul style="list-style-type: none">• The Meters & Rheostats• Different loads Arrangement• The students entry behavior• First aid kit• Wires of Standard colours and Gauges
For Design of Instruction	<ul style="list-style-type: none">• Read teaching points carefully.

9.SCHEME OF EVALUATION

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
1. Handling of apparatus	A. Drawing circuit diagram and Identifying various terminals B. Using correct range Voltmeter, Ammeter C. Setting the rheostats to correct positions.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>3</td> <td>2</td> <td>10</td> </tr> </tbody> </table>	A	B	C	T	5	3	2	10					
A	B	C	T												
5	3	2	10												
2. Manipulation of apparatus	A. Handling the 3- point Starter. B. Decreasing and increasing the value of resistance in the Rheostat C. Adjusting the resistive inductive and capacitive loads	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>3</td> <td>4</td> <td>3</td> <td>10</td> </tr> </tbody> </table>	A	B	C	T	3	4	3	10					
A	B	C	T												
3	4	3	10												
3.Precise operations/Activities	A. Increasing the resistive inductive and capacitive Loads B. Recording the readings in the Ammeter, Voltmeter. C. Calculation of voltage regulation for different loads D. Drawing the Graph and marking of suitable load on graph	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>5</td> <td>5</td> <td>5</td> <td>5</td> <td>25</td> </tr> </tbody> </table>	A	B	C	D	E	T	5	5	5	5	5	25	
A	B	C	D	E	T										
5	5	5	5	5	25										
4.Values	A. Co Operation B. Co-Ordination C. Communication D. Sharing E. Leadership	<table border="1"> <tbody> <tr> <td style="text-align: center;">5</td> </tr> </tbody> </table>	5												
5															
Total		50													

10. VIVA QUESTIONS :

1. What are the reasons of variation in terminal voltage when the alternator is loaded?
2. Define voltage regulation of an alternator?
3. What is the basic principle of alternator
4. What is the need for starter?
5. What are the various methods to determine the voltage regulation of alternator?
6. Explain why alternator output voltage increases with capacitive loads

11. ASSESSMENT QUESTIONS:

1. Draw the circuit diagram for conducting the Load Test On an alternator.
2. Find the Regulation of an alternator by conducting the suitable Test.

LAB SHEET

REGULATION OF 3- ϕ ALTERNATOR BY SYNCHRONOUS IMPEDENCE METHOD

1. OBJECTIVE:

1. To conduct O.C, S.C and armature resistance tests on the 3- ϕ alternator and
2. To determine regulation of alternator by using synchronous impedance method.

2. SPECIFICATIONS OF MACHINES:

3 ϕ Alternator (3.5 kVA, 415 V, 5 A, 1500 rpm)	DC Shunt Motor (5 HP, 230 V, 17 A, 1500 rpm)
KVA :	HP :
Voltage :	Voltage :
Current	Current :
Speed :	Speed :

3. APPARATUS REQUIRED:

Note : Prepare a list of apparatus based on the specifications of the machines.				
S.No.	Name of Apparatus	Type	Range	Quantity
1.	Voltmeter	MI	0-300 V	1 No
2.	Voltmeter	MC	0-30 V	1 No
3.	Ammeter	MC	0-2 A	1 No
4.	Ammeter	MI	0-5 A	1 No
5.	Rheostat	Wire wound	350 Ω , 1.7 A	2 No's
6.	Tachometer	Digital	-	1 No
7.	Connecting wires	-	-	Required No

4. TASK ANALYSIS:

A. KNOWLEDGE

- 1) Alternator working principle.
- 2) Need of dc motor and excitation
- 3) Definition of regulation and equation
- 4) List different methods of finding regulation of alternator.
- 5) Synchronous impedance method of alternator
- 6) OC and SC characteristics
- 7) Parameters Z_s , R_a and X_s of alternator
- 8) Equation of no-load voltage E_o in terms of parameters Z_s , R_a and X_s
- 9) Precautions

B. SKILL

Handling of Apparatus	<ul style="list-style-type: none">• Drawing the circuit diagram.• Identifying various terminals.• Using correct range Voltmeter, Ammeters.• Proper connecting of connecting wires without loose connections• Setting the Rheostats to appropriate positions.• Proper Handling of the DPST Switch.• Proper handling of the field rheostats of alternators and DC motor.
Manipulation of apparatus	<ul style="list-style-type: none">• Reading the Circuit Diagram.• Making the connections.• Checking the connections• Switching on the supply.• Handling the 3- point Starter.• Observing the readings in the Ammeter and Voltmeter.

**Precise
operations/Activities**

1. OC TEST:

- Adjusting the field rheostat of DC motor to minimum position.
- Adjusting the field rheostat of Alternator to maximum position.
- Making open circuit at load terminals of alternator
- Adjust the speed of the DC motor to alternator rated value by using its Field Rheostat.
- Varying the various values of phase voltage by changing the field excitation of alternator
- Recording the readings on voltmeter and Ammeter at every step.
- Switching OFF supply after bringing the rheostat to initial state
- Drawing the graphs and interpreting.

2. SC TEST:

- Adjusting the field rheostat of DC motor to minimum position.
- Adjusting the field rheostat of Alternator to maximum position.
- Making short circuit at load terminals of alternator
- Adjust the speed of the DC motor to alternator rated value by using its Field Rheostat.
- Varying to rated load current of alternator by changing the field excitation of alternator
- Recording the readings on voltmeter and Ammeter at every step.
- Switching OFF supply after bringing the rheostat to initial state
- Drawing the graphs and interpreting.

3. ARMATURE RESISTANCE TEST:

- Adjusting the rheostat in maximum position.
- Varying the current values in ammeter up to rated current of alternator by changing rheostat.
- Recording the readings of voltmeter and ammeter at every step
- Switching OFF supply after bringing the rheostat to initial state
- Calculating effective ac resistance value of armature winding of alternator

- 4.** calculating Z_s from graph and calculating no load terminal voltage and regulation of alternator

5.TEACHINGPOINTS:

Sl.No.	TEACHING POINT	SUGGESTED TIME 15 mins
1.	Definition of regulation and formula of no load voltage in terms of Parameters Z_s , R_a and X_s of alternator	3
2.	Methods of finding regulation of alternator.	1
3.	Purpose of conducting OC test and SC test for synchronous impedance method.	3
4.	OC and SC characteristics	2
5.	Calculation of Z_s from graph	2
6.	Type and Rating of fuse.	1
7.	3- point starter and Different terminals and Coils	1
8.	Interpreting Name plate Details	1
9.	Precautions	1

6.PRECAUTIONS:

A. Procedural precautions

- Initially all switches are in open position.
- Ensure the correct range of meters
- Ensure that the meters and rheostat are properly set
- Connect the circuit as per the circuit diagram
- Check for polarity, continuity of winding connections of machines and working condition of meters and starters.
- Get the connections checked by the concerned staff member
- Use the proper fuse
- Ensure that there are no loose connections and wrong connections.
- Take reading without parallax error

B. Safety precautions:

- Wear shoes and apron
- Carry tool kit

7. NEED AND SCOPE OF EXPERIMENT:

This experiment is essential to understand the synchronous impedance method for finding regulation of alternator. This test also gives an insight in accuracy of regulation when compared to other methods.

8. PLANNING AND ORGANISATION:

ACTION	ACTIVITY
Check for	<ul style="list-style-type: none">• The Meters & Rheostats• Switch positions• Continuity of windings of machines• Wrong and loose connections• The students entry behavior• First aid kit• Wires of Standard colors and Gauges
For Design of Instruction	<ul style="list-style-type: none">• Read teaching points carefully.

9.SCHEME OF EVALUATION:

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)																
HANDLING OF APPARATUS	a. Drawing the circuit diagram and identifying various terminals. b. Proper connecting of connecting wires without loose connections and Proper Handling of the DPST Switch. c. Setting the Rheostats to appropriate positions and Proper handling of the field rheostats of alternators and dc motor d. Using correct range Voltmeter, Ammeters.	<table border="1" data-bbox="1003 495 1333 575"> <tr> <td>a</td> <td>b</td> <td>c</td> <td>d</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>2</td> <td>5</td> </tr> </table>	a	b	c	d	T	1	1	1	2	5							
a	b	c	d	T															
1	1	1	2	5															
MANIPULATION OF APPARATUS	a. Reading the Circuit Diagram and Making the connections. b. Switching on the supply and Handling the 3- point Starter. c. Observing the readings in the Ammeter and Voltmeter.	<table border="1" data-bbox="1003 947 1333 1026"> <tr> <td>a</td> <td>b</td> <td>c</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>3</td> <td>5</td> </tr> </table>	a	b	c	T	1	1	3	5									
a	b	c	T																
1	1	3	5																
PRECISE OPERATIONS /ACTIVITIES	a. Conducting OC ,SC and armature resistance tests b. Recording the readings on voltmeter andAmmeter at every step. c. Drawing the graphs and interpreting. d. Calculating effective ac resistance value of armature winding of alternator. e. Calculating Z_s from graph. f. Calculating no load terminal voltage g. Calculating regulation of alternator	<table border="1" data-bbox="1003 1526 1393 1688"> <tr> <td>a</td> <td>b</td> <td>c</td> <td>d</td> </tr> <tr> <td>5</td> <td>5</td> <td>5</td> <td>5</td> </tr> <tr> <td>e</td> <td>f</td> <td>g</td> <td>T</td> </tr> <tr> <td>5</td> <td>5</td> <td>5</td> <td>35</td> </tr> </table>	a	b	c	d	5	5	5	5	e	f	g	T	5	5	5	35	
a	b	c	d																
5	5	5	5																
e	f	g	T																
5	5	5	35																

VALUES	A. Co Operation	5	
	B. Co-Ordination		
	C. Communication		
	D. Sharing		
	E. Leadership		
Total		50	

10. VA QUESTIONS :

1. Define regulation?
2. List different types of methods to find regulation for alternator.
3. Write formula for no load voltage
4. Synchronous impedance method is called optimistic method. Why?
5. How many inputs are need to run alternator .what are they?
6. Importance of regulation
7. Draw circuit of alternator
8. For full load excitation ,open circuit voltage will be _____
9. Types of alternators
10. Applications of alternator.

11. ASSESSMENT QUESTIONS :

1. Draw the circuit diagram of an alternator to find its synchronous impedance .
2. Conduct test on an alternator to find its synchronous impedance.

LAB SHEET

SYNCHRONIZATION OF AN ALTERNATOR

OBJECTIVE: To synchronize the alternator with supply mains by using bright lamp method.

APPARATUS: 3 ϕ alternator coupled to DC motor; Ammeter: 0-2A (M.C. Type); Ammeter: 0-5A (M.I. Type); Voltmeter: 0- 600V (M.I.Type); Rheostats: 350ohms/1.7A ; Tachometer(Digital): 0-5000rpm; Incandescent lamps; 3-Point Starter; 220 V D.C.Supply ; DPST Switch ; TPST Switches; Fuse-20A; Fuse-2A and connecting wires.

TASK ANALYSIS

A. KNOWLEDGE

1. Alternator Principle
2. Meaning of Synchronization
3. Need for synchronization
4. Conditions for Synchronization
5. Effects of wrong Synchronization
6. Methods of Synchronization
7. Advantages and disadvantages of methods of synchronization
8. Precautions.

B. SKILL

Handling of Apparatus	<ul style="list-style-type: none">• Drawing the circuit diagram• Identifying various terminals• Using correct range Voltmeter, Ammeters and Rheostats.• Proper Handling of the DPST Switch.
Manipulation of Apparatus	<ul style="list-style-type: none">• Reading the Circuit Diagram.• Making the connections.• Checking the connections• Setting the Rheostats to correct positions before switching ON.• Switching on the supply.• Handling the 3- point Starter.• Observing the readings in the Ammeter and Voltmeter.
Precise operations/Activities	<ul style="list-style-type: none">• Adjust the speed of the alternator to rated speed by varying Field Rheostat of DC motor.• Adjust the field current of alternator till voltmeter reads busbar voltage by varying rotor field rheostat.• Close the switch S_1.• Adjust the speed of the alternator slowly by varying field rheostat of DC motor so that Lamp L_1 is dark and Lamps L_2 and L_3 are equally bright.• Close the switch S_2 in the middle of that period.

2. TEACHING POINTS

Sl No	Teaching Point	Suggested Time-15 min
1.	Need for Synchronization	2
2.	Conditions for Synchronization	3
3.	Methods of Synchronization	3
4.	Various Terminals on Rheostats and usage	2
5.	Interpreting name plate Details	2
6.	Observing the lamps for synchronization	2
7.	Precautions	1

A. Procedural precautions

1. Ensure that all switches are in open position.
2. Check for the polarity and continuity of winding connections of the machine.
3. Check for the correct range of meters.
4. Check the working condition of meters and starters.
5. Check the connections as per the circuit diagram and avoid any loose connections.
6. Check for the correct positions of rheostats.
7. Observe readings without any parallax error.
8. Close the synchronizing switch S_2 at correct instant by observing lamps.
9. After experiment is done, open the synchronizing switch S_2 , switch off the 3 phase supply (S_1) and bring rheostats to starting position and switch off the dc supply.

B. Safety precautions: Refer Annexure

3.NEED AND SCOPE OF EXPERIMENT

This experiment is essential to understand how to synchronize the alternators which gives insight in to procedures adopted in power systems. This method is used only for low voltage alternators and doesn't tell how fast or slow the machine is running which is overcome by the synchroscope method.

4.PLANNING AND ORGANISATION

ACTION	ACTIVITY
Check for	<ul style="list-style-type: none"> • The Meters & Rheostats • Condition of Switches • The students entry behavior • First aid kit • Wires of Standard colours and Gauges
For Design of Instruction	<ul style="list-style-type: none"> • Read teaching points carefully.

5.SCHEME OF EVALUATION

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
1. Handling of apparatus	A. Drawing circuit diagram and Identifying various terminals. B. Using correct range Voltmeter, Ammeters and Rheostats. C. Handling the DPST switch.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">5</td> <td style="text-align: center;">4</td> <td style="text-align: center;">1</td> <td style="text-align: center;">10</td> </tr> </tbody> </table>	A	B	C	T	5	4	1	10					
A	B	C	T												
5	4	1	10												
2. Manipulation of apparatus	A. Making the connections. B. Setting the Rheostats to correct positions before switching ON. C. Handling the 3- point Starter. D. Observing the readings in ammeter and voltmeter.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>T</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">5</td> <td style="text-align: center;">2</td> <td style="text-align: center;">2</td> <td style="text-align: center;">1</td> <td style="text-align: center;">10</td> </tr> </tbody> </table>	A	B	C	D	T	5	2	2	1	10			
A	B	C	D	T											
5	2	2	1	10											
3.Precise operations/Activities	A. Varying the rheostat for rated speed B. Varying the rheostat for busbar voltage in voltmeter C. Closing of switch S_1 . D. Adjusting the speed of alternator slowly for one dark and two bright lamp condition. E. Closing the switch S_2 for synchronization.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>T</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">4</td> <td style="text-align: center;">4</td> <td style="text-align: center;">2</td> <td style="text-align: center;">10</td> <td style="text-align: center;">5</td> <td style="text-align: center;">25</td> </tr> </tbody> </table>	A	B	C	D	E	T	4	4	2	10	5	25	
A	B	C	D	E	T										
4	4	2	10	5	25										
4.Values	A. Co Operation B. Co-Ordination C. Communication D. Sharing E. Leadership	<table border="1"> <tbody> <tr> <td style="text-align: center;">T</td> </tr> <tr> <td style="text-align: center;">5</td> </tr> </tbody> </table>	T	5											
T															
5															
Total		50													

6. VIVA QUESTIONS :

- 1) What is meant by Synchronization?
- 2) What is the need for Synchronization?
- 2) What are the conditions of synchronization of alternators?
- 3) What are the possible effects of wrong synchronization?
- 4) What are the different methods for synchronization?
- 5) What are the advantages and disadvantages of this method of synchronization?
- 6) Why a lamp pair is required in this experiment?
- 7) Where Synchronization of alternators is used?

7. Assessment Question.

1. Draw the circuit diagram for synchronization of an alternator.
2. Conduct the synchronization test on an Alternator using Dark Lamp/ Bright Lamp method.

WORK SHEET

Name of the student :		Date of experiment:
PIN :	Branch:	
Institution:		Experiment No.

1. Title of the Experiment : _____

2. Objective of the Experiment : _____

3. Equipment Required :

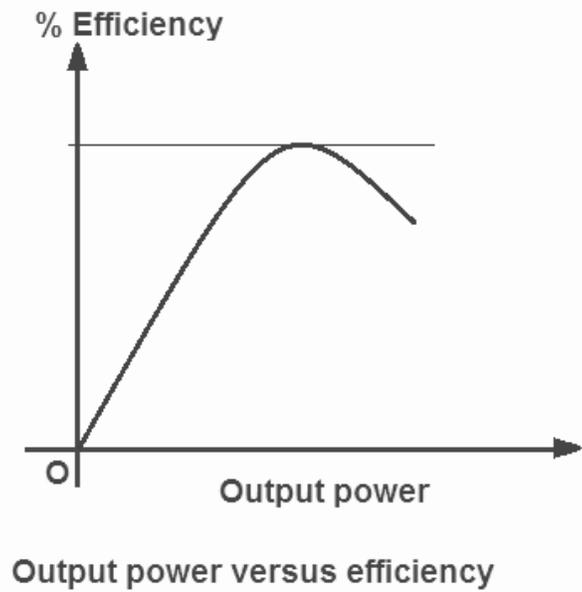
4. Circuit Diagram:

5. Procedure:

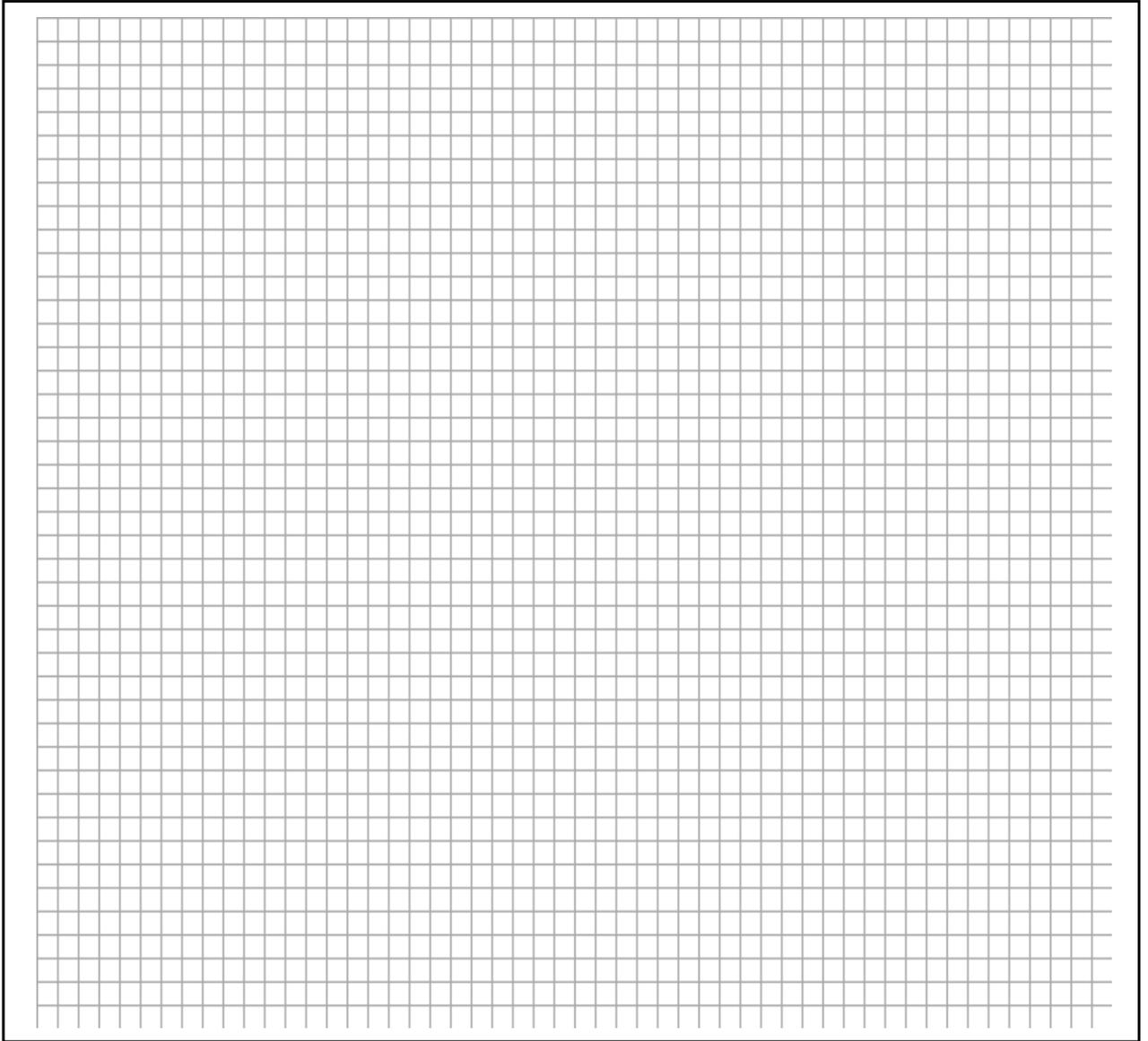
6. Readings :

S.No.	Primary side			Secondary side			% Efficiency $= \frac{\text{Output}}{\text{Input}} \times 100$	% Regulation $= \frac{E_2}{E_2} \times 100$
	Voltmeter Reading V_1 (Volts)	Ammeter Reading I_1 (amps)	Wattmeter Reading =input (watts)	Voltmeter Reading V_2 (volts)	Ammeter Reading I_2 (Amps)	Output = $V_2 I_2$ (watts)		
1.								
2.								
3.								
4.								
5.								

7. Model Graph:



8. Graph :



Observed Waveforms

9. Inference & Interpretation:-

10. Scheme of Evaluation:-

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded		
1. Handling of apparatus	A. Drawing circuit diagram B. Identifying L.V and H.V windings. C. Using correct range Voltmeter, Ammeter, watt meter D. Setting the auto transformer to zero position E. Proper handling of resistive load	<table border="1" style="margin: auto;"> <tr><td> </td></tr> <tr><td>10</td></tr> </table>		10	
10					
2. Manipulation of apparatus	A. Making the connections. B. Checking the connections. C. Switching on the supply. D. Handling the auto transformer E. Observing the readings in ammeter, voltmeter, wattmeter.	<table border="1" style="margin: auto;"> <tr><td> </td></tr> <tr><td>10</td></tr> </table>		10	
10					
3. Precise operations /Activities	A. Adjusting the voltage using auto transformer. B. Applying the load on the single phase transformer. C. Recording the readings on single phase transformer. D. Finding output power of transformer. E. Calculate efficiency & regulation.	<table border="1" style="margin: auto;"> <tr><td> </td></tr> <tr><td>25</td></tr> </table>		25	
25					
4. Values	A. Co Operation B. Co-Ordination C. Communication D. Sharing E. Leadership	<table border="1" style="margin: auto;"> <tr><td> </td></tr> <tr><td>5</td></tr> </table>		5	
5					
Total			50		
Signature of the Staff		Signature of the Student			

WORK SHEET

Name of the student		Date of experiment
Pin No	Branch	
Institution		Experiment No

1. **Title of the experiment:**

2. **Objective of the experiment:**

3. **Equipment required**

Name	Type	Specifications/ Range	No	Purpose

SPECIFICATIONS :

1-ϕ Transformer (1 KVA, 230/110 v, 50 Hz)	1-ϕ AutoTransformer
KVA :	Input :
Pri. Voltage and circuit :	Output:
Sec Voltage and Circuit :	
Frequency :	

4. Circuit diagram

O.C. Test

S.C Test

5. Procedure

O.C Test

S..C Test

6. Readings

O.C Test

S.NO	Voltmeter Reading V_1 (volts)	Ammeter Reading I_0 (Amps)	Wattmeter Reading w_0 (Watt)

S.C Test

S.NO	Voltmeter Reading V_{sc} volts)	Ammeter Reading I_{sc} (Amps)	Wattmeter Reading w_{sc} (Watt)

7. Calculations :

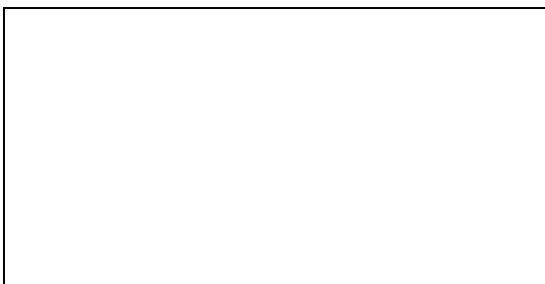
1. Equivalent Circuit Constants :

From O.C Test :

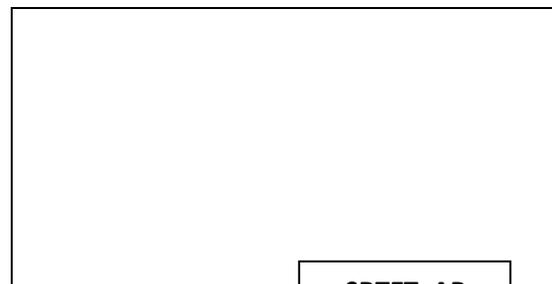
From S.C Test :

Equivalent Circuits :

a) On NO-Load



b) On S.C. Test



C) Equivalent Circuit referred to LV and HV Side.

2. Calculation of Efficiency :

S.NO	P.F of load $\cos\phi$	Fraction of load FL ,x	Output	Copper Loss	Total loss	Input = output+(losses)	% Efficiency = (output/input) * 100
1.	Unity	1					
		$\frac{3}{4}$					
		$\frac{1}{2}$					
		$\frac{1}{4}$					
2.	0.8	1					
		$\frac{3}{4}$					
		$\frac{1}{2}$					
		$\frac{1}{4}$					

3. Load for Maximum Efficiency:

4. Calculation of Regulation :

% Regulation =

S.NO	LOAD PF ,COS ϕ	% Regulation

Power factor for maximum regulation =

Power factor for Zero Regulation =

5. Calculation of All – day Efficiency :

Daily Load Cycle of Transformer :

S.NO	No. Of Hours	Load	Power factor

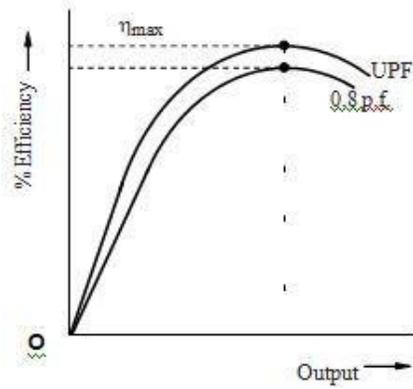
From the Load Cycle _____

S.No	Load in KW	P.F	Load in KVA	Time in Hours	Output in KWh	Copper Loss in KW at different Loads	Copper Loss in Kwh

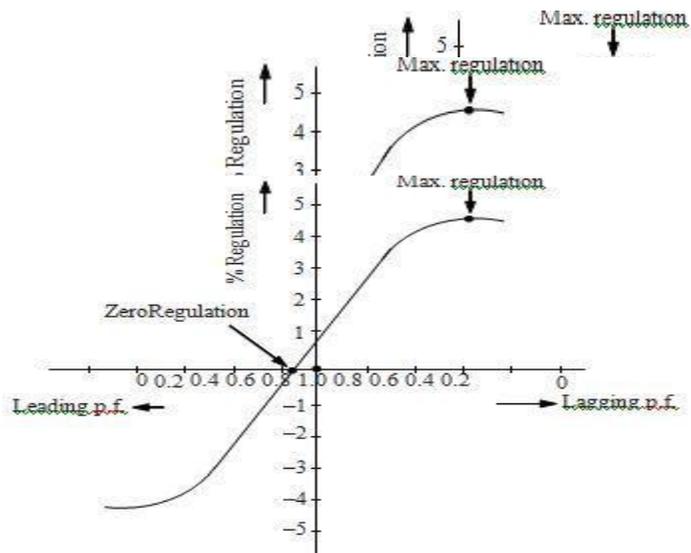
Total:

8. Model graphs :

a) Efficiency Vs Output.



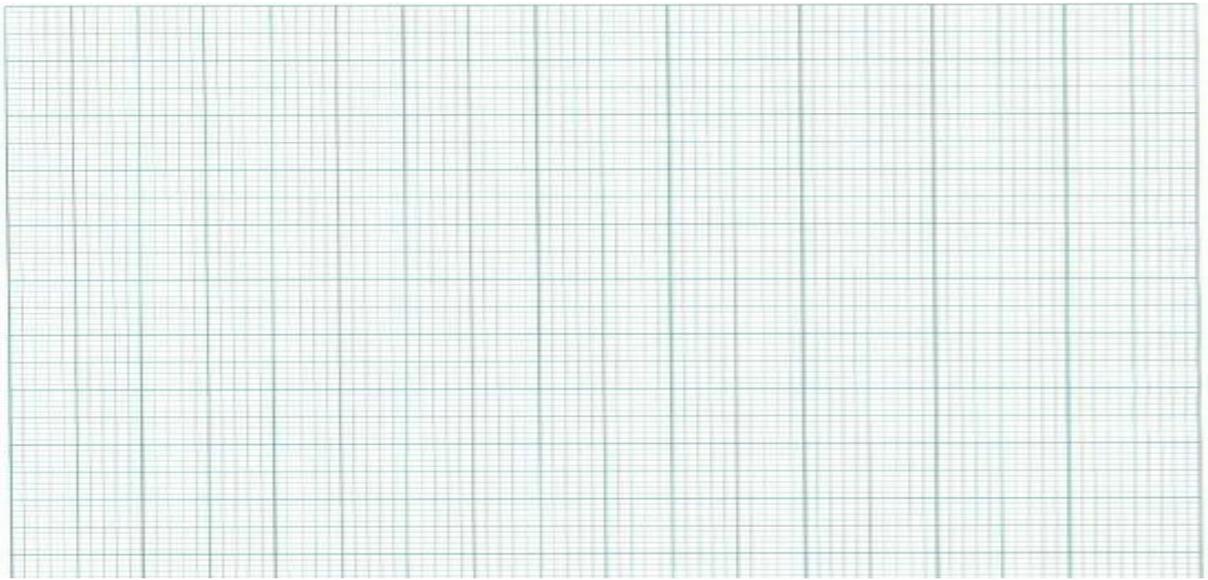
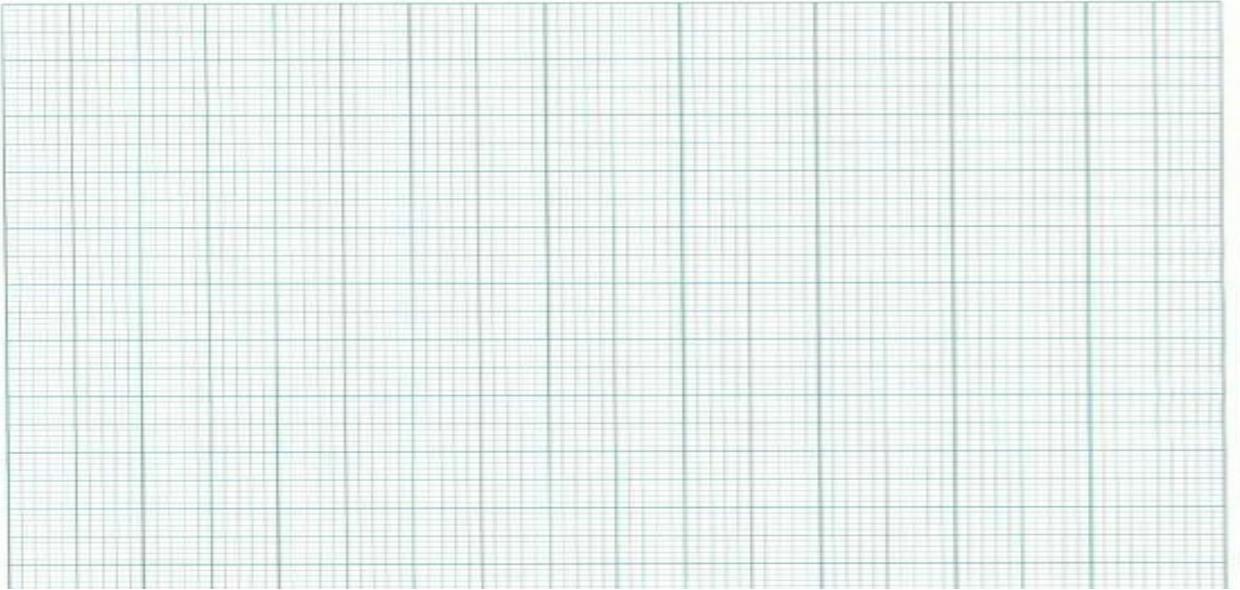
b) Regulation Vs Power Factor.



9. Precautions:

10. Inference and interpretation :

11. Observed Waveforms



12. Scheme of Evaluation

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded
1.Handling of apparatus	A. Identification of windings on Transformer. B .Identification of meters. C. Identification wattmeter terminal connections. D. Setting the auto transformer to minimum position.	T 3	
2. Manipulation of apparatus	A. Making Circuit Connections. B. Checking the connections. C. Switching on supply. D. Increasing the voltage to rated value. E. Observing the readings with multiplication factor in the meters.	T 12	
3. Precise operations/Activities	A. Varying the Voltage and Current to rated Value B. Noting down the readings with multiplication factor. C. Calculating the equivalent circuit parameters from above readings. D. Drawing the equivalent Circuit. E. Calculating the Efficiency using formula. F. Calculating percentage regulation. G. Drawing the graph and showing salient points. H.Calculating All-Day Efficiency.	T 30	
4.Values	A. Co operation B. Co ordination C. Communication D. Sharing E. Leadership	T 5	
	Total	50	
Signature of Staff		Signature of student	

WORK SHEET

Name of the student :		Date of experiment:
PIN :	Branch:	
Institution:		Experiment No.

1. Title of the Experiment: _____

2. Objective of the Experiment: _____

3. Equipment Required:

S. No	Name	Specifications/ Range	No	Purpose

4. Circuit Diagram

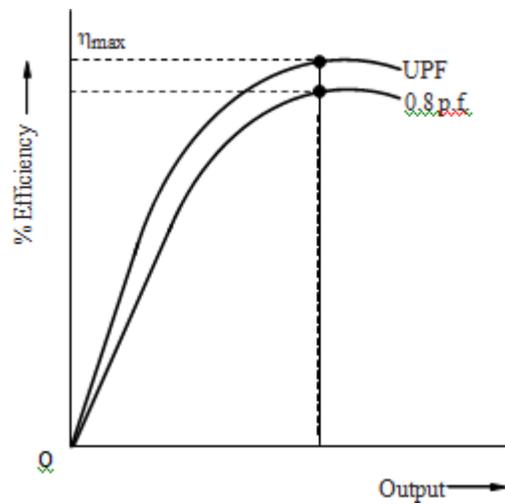
5 PROCEDURE:

6 OBSERVATIONS

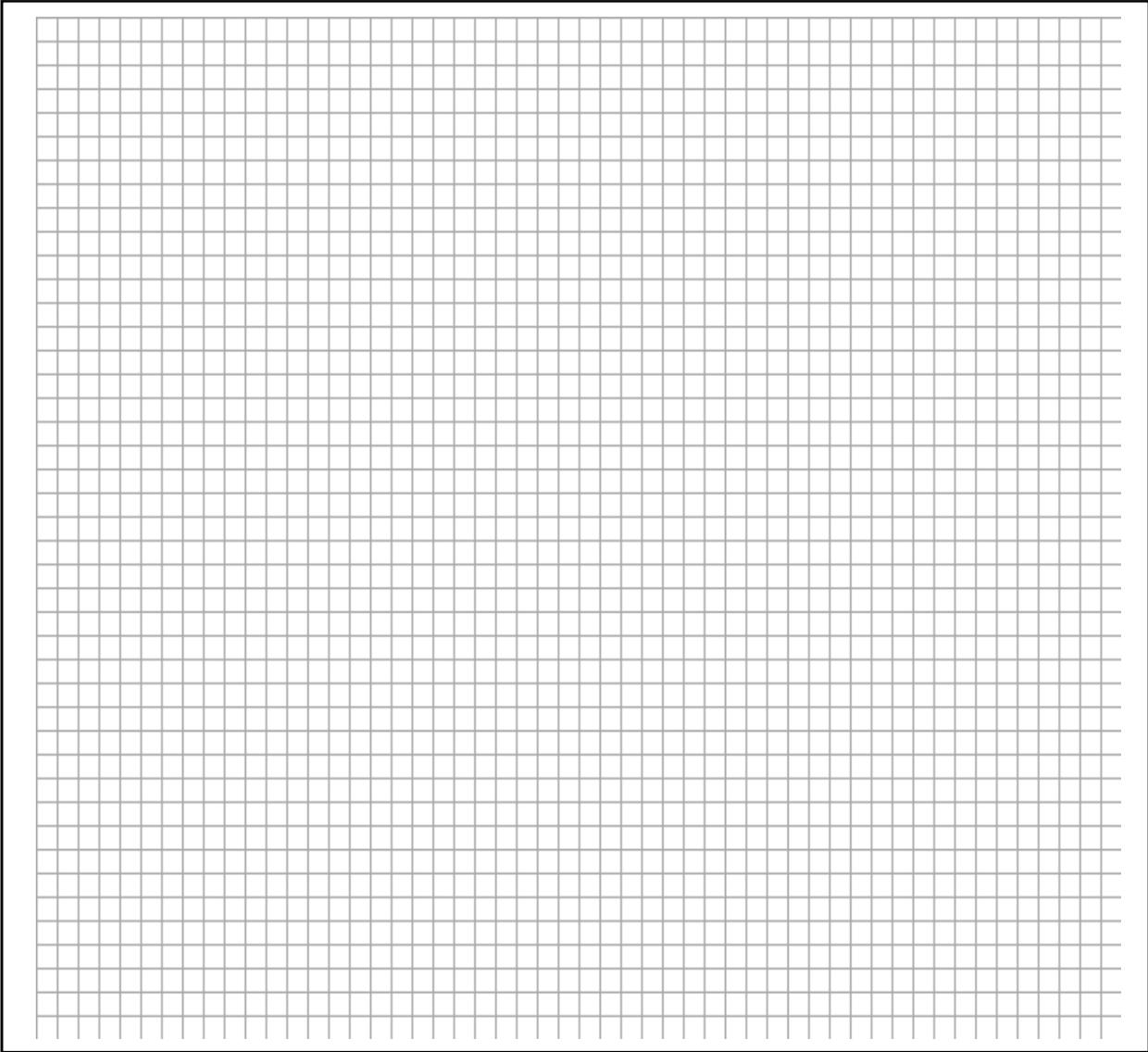
	Primary side			Secondary side		
S.NO	Reading of Voltmeter= v_1 (volts)	Reading of Ammeter A1 $=2I_o$ (Amps)	Reading of wattmeter $w_1 = p_o$ (watt)	Reading of voltmeter $v_2 =$ $2v_{sc}$ (volts)	Reading of Ammeter A2 $= I_{SC}$ (amps)	Reading of Wattmeter $w_2 = P_{SC}$ (watts)
1.						

7 MODEL GRAPH:

A graph is drawn with output on X-axis and % efficiency on Y-axis for various power factors.



8 GRAPH



9 CALCULATIONS:

S.No.	p.f of the load, $\cos\phi$	Fraction of the F.L. x	Output = $x\text{scos}\phi$ (watts)	Copper loss = $x^2\text{WC}$ (watts)	Total loss = $W_i + x^2 \text{WC}$ (watts)	Input = Output + losses(watts)	% Efficiency $\frac{\text{output}}{\text{input}} * 100$
1.	Unity	1					
		3/4					
		1/2					
		1/4					
2.	0.8	1					
		3/4					
		1/2					
		1/4					

S.No.	Load p.f, $\cos\phi$	% Regulation
1.	Unity	
2.	0.8 lagging	
3.	0.8 leading	

10 INFERANCE INTER PRETECTION

11. Assessment:

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded		
1.Handling of apparatus	A. Identification of windings on Transformer. B. Identification of meters. C. Identification wattmeter terminal connections. D. Setting the auto transformer to minimum position.	<table border="1"> <tr><td>T</td></tr> <tr><td>5</td></tr> </table>	T	5	
T					
5					
2. Manipulation of apparatus	A. Making Circuit Connections. B. Checking the Polarities. C. Switching on supply. D. Noting down the voltage zero in the voltmeter otherwise checking the polarity E. Increasing the voltage to rated value. F. Observing the readings with multiplication factor in the meters. G. Injected the voltage to the secondary winding.	<table border="1"> <tr><td>T</td></tr> <tr><td>15</td></tr> </table>	T	15	
T					
15					
3. Precise operations/Activities	A. Varying the Voltage and Current to rated Value B. Noting down the readings with multiplication factor. C. Calculating the copper losses fraction of full load. D. Calculating the input power. E. Calculating the Efficiency using formula. F. Calculating percentage regulation. G. Drawing the graph and showing salient points.	<table border="1"> <tr><td>T</td></tr> <tr><td>25</td></tr> </table>	T	25	
T					
25					
4.Values	A. Co operation B. Co ordination C. Communication D. Sharing E. Leadership	<table border="1"> <tr><td>T</td></tr> <tr><td>5</td></tr> </table>	T	5	
T					
5					
	Total	50			
Signature of Staff		Signature of student			

WORK SHEET

SCOTT CONNECTION ON TRANSFORMERS

Name of the student :		Date of experiment:
PIN :	Branch:	
Institution:		Experiment No.

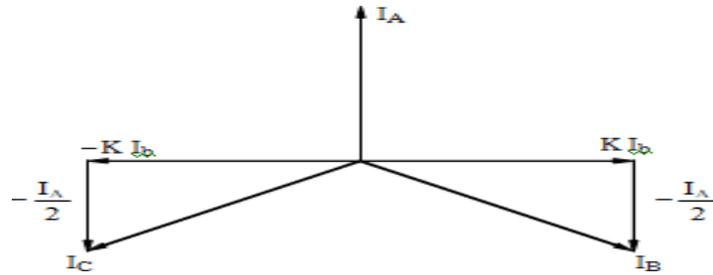
1. Title of the Experiment : _____

2. Objective of the Experiment : _____

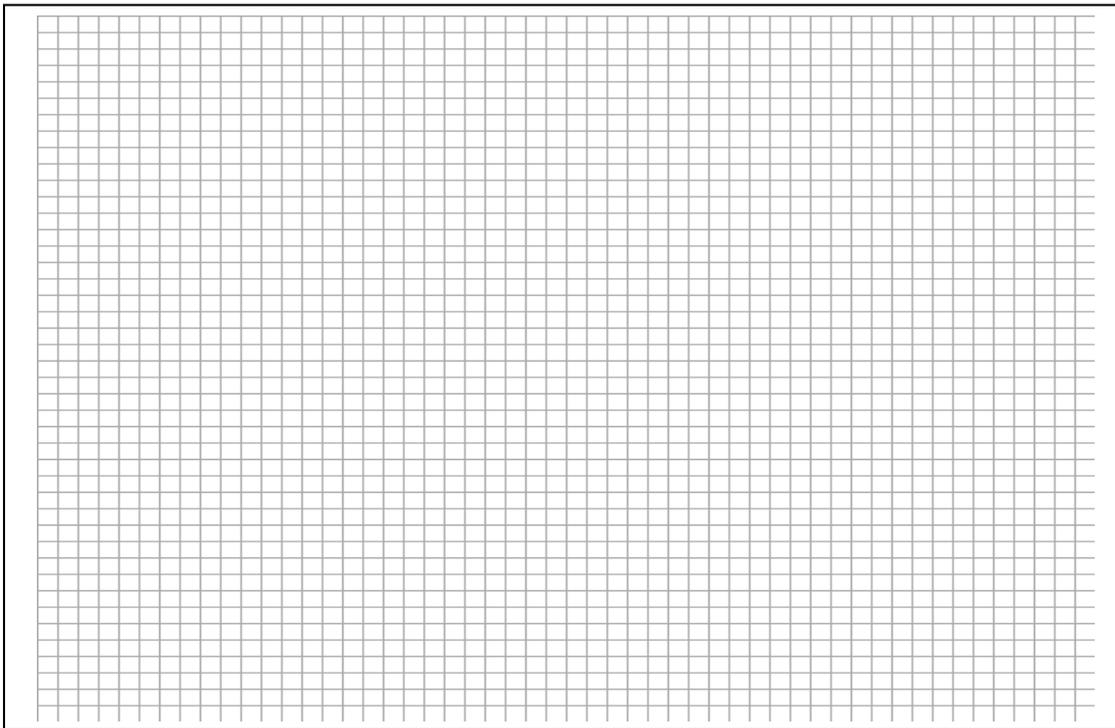
3. Equipment Required : _____

4. Circuit Diagram:

Model graph:



8. Graph :



Observed Waveforms

9. Inference and Interpretation:

10. Evaluation :

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded
1. Handling of apparatus	A. Identification of Correct Components B. Identification of meters C. Setting the auto transformer in minimum positions	<input type="text"/> 5	
2. Manipulation of apparatus	A. Making Circuit connections B. Checking the polarity test C. Adding the resistive load in step by step	<input type="text"/> 20	
3. Precise operations /Activities	A. Recording the readings in the Ammeters, Voltmeter . B. Measuring the currents of three phases and on secondaries of two transformers. C. Balancing the loads in secondaries of two transformer. D. Drawing the phasor Diagram	<input type="text"/> 20	
4. Values	A. Co Operation B. Co-Ordination C. Communication D. Sharing E. Leadership	<input type="text"/> 5	
Total			50
Signature of the Staff		Signature of the Student	

WORK SHEET

Name of the student :		Date of experiment:
PIN :	Branch:	Experiment No.
Institution:		

1. Title of the Experiment: _____

2. Objective of the Experiment: _____

3. Equipment Required: _____

4. Circuit Diagram:

From S.C Test :Metering is on HV (primary)side

On First Transformer :

S.No.	V_{SC} (Volts)	I_{SC} (Amps)	W_{SC} (Watts)	$Z_{01} = \frac{V_{SC}}{I_{SC}}$ (ohms)
1.				

On Second Transformer :

S.No.	V_{SC} (Volts)	I_{SC} (Amps)	W_{SC} (Watts)	$Z_{01} = \frac{V_{SC}}{I_{SC}}$ (ohms)
1.				

7. Scheme of Evaluation:

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded		
1. Handling of apparatus	A. Identification of Correct Components B. Identification of meters C. Setting the auto transformer in zero voltage positions	<table border="1" style="margin: auto;"> <tr><td> </td></tr> <tr><td>5</td></tr> </table>		5	
5					
2. Manipulation of apparatus	A. Making Circuit connections B. Checking the polarity test C. Adding the resistive load in step by step	<table border="1" style="margin: auto;"> <tr><td> </td></tr> <tr><td>20</td></tr> </table>		20	
20					
3. Precise operations /Activities	A. Recording the readings in the Ammeters, Voltmeter and wattmeter. B. Calculating the currents in each transformer.	<table border="1" style="margin: auto;"> <tr><td> </td></tr> <tr><td>20</td></tr> </table>		20	
20					
4. Values	A. Co Operation B. Co-Ordination C. Communication D. Sharing E. Leadership	<table border="1" style="margin: auto;"> <tr><td> </td></tr> <tr><td>5</td></tr> </table>		5	
5					
Total			50		
Signature of the Staff		Signature of the Student			

WORKSHEET

6. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Name of the student :	Date of the experiment
PIN :	
Institution :	

Objective of the experiment :

Apparatus Required :

Sno	Apparatus Name	Specifications	Quantity
1			
2			
3			
4			
5			
6			

Circuit Diagram :

WORKSHEET

6. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Readings :

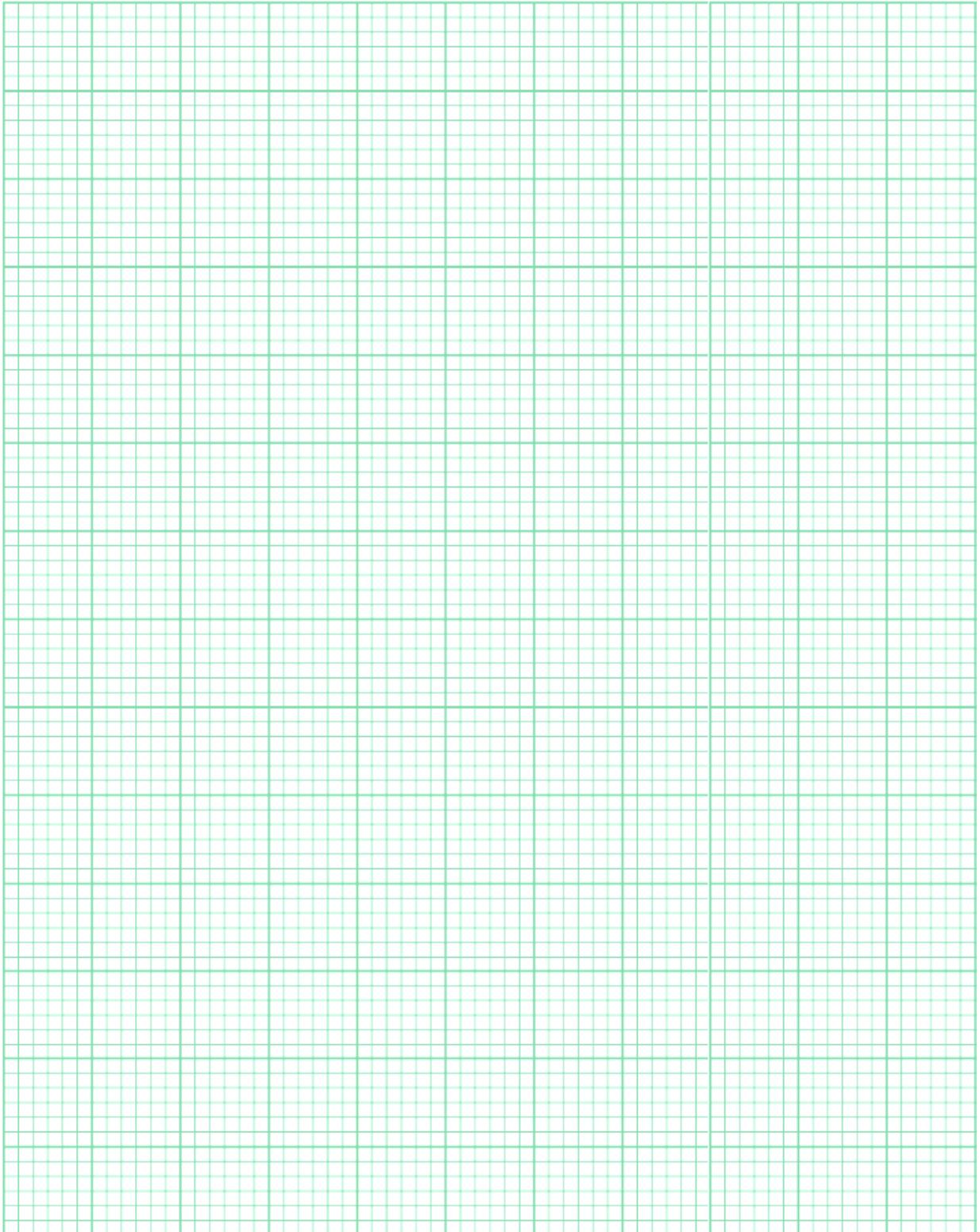
Gap length = mm

No.of observations	Breakdown Voltage

WORKSHEET

6. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Graph :



WORKSHEET

6. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Inference and Interpretation :

WORKSHEET

6. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Scheme of Evaluation

Category of Skill	Sub Task		Individual Competency Level Weight age	Marks Awarde
Handling of Apparatus	A	Connecting the sample test box as per the instructions in the kit	5	
	B	Identifying various terminals	3	
	C	Proper Handling of SPST Switch	2	
Manipulation of Apparatus	A	Verifying the apparatus as per the Circuit Diagram	4	
	B	Making the connections	3	
	C	Operation of Transformer Oil kit	3	
Precise Operations / Activities	A	Carefully preparing the Oil sample in the Test cell/Box.	10	
	B	Carefully raise the voltage by keen observing the breakdown takes place	5	
	C	Changing the breakdown voltage in precise steps.	5	
	D	Suitable gauge is used to adjust the gap between the spheres	5	
Values	A	Co-Operation	1	
	B	Co-Ordination	1	
	C	Communication	1	
	D	Sharing	1	
	E	Leadership	1	
Total Marks			50	

WORK SHEET

LOAD TEST ON 3-PHASE ALTERNATOR

Name of the student :		Date of experiment:
PIN :	Branch:	
Institution:		Experiment No.

1. Title of the Experiment:

2. Objective of the Experiment:

3. Equipment Required:

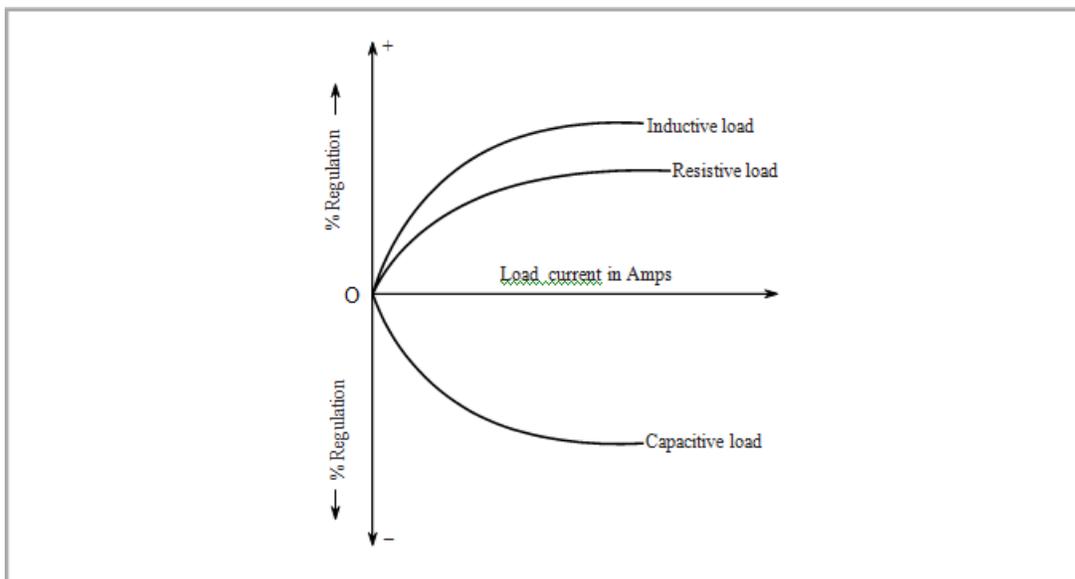
SPECIFICATIONS OF ALTERNATOR AND DC MOTOR:

4. Circuit Diagram:

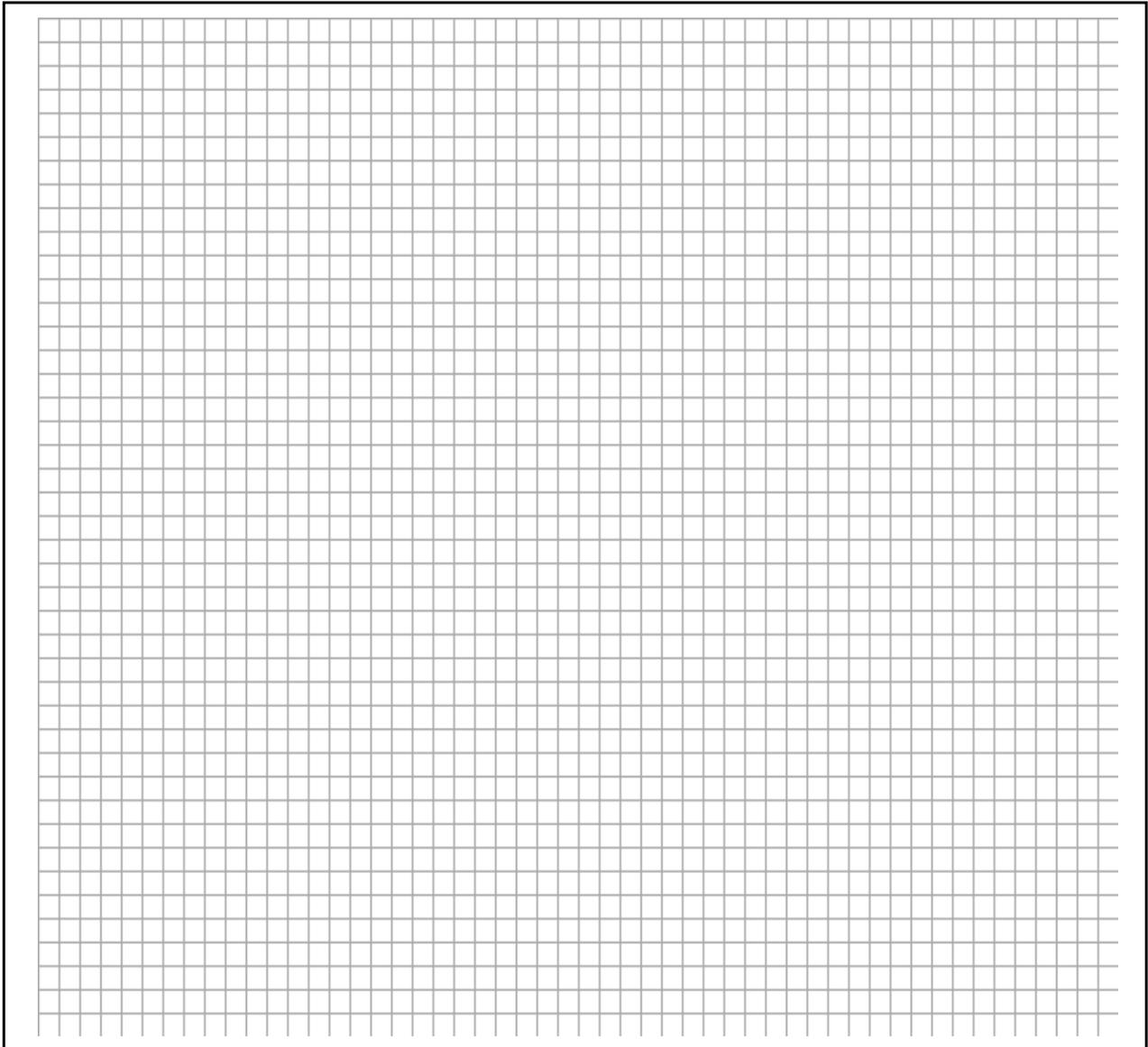
6. Readings:

S.No	Resistive (unity p.f.) load			Inductive (lagging p.f.) load			Capacitive (leading p.f.) load		
	Load Current I_L (Amps)	Load Voltage V (Volts)	%Regulation $E_0 - V$ $= \frac{V}{V} \times 100$	Load Current I_L (Amps)	Load Voltage V (Volts)	%Regulation $E_0 - V$ $= \frac{V}{V} \times 100$	Load Current I_L (Amps)	Load Voltage V (Volts)	%Regulation $E_0 - V$ $= \frac{V}{V} \times 100$
1.									
2.									
3.									
4.									
5.									
6.									

7. Model graph:



8. Graph :



Observed Waveforms

9. Inference and Interpretation:

10. Specimen caluclations:

10. SCHEME OF EVALUATION:

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded		
1.Handling of apparatus	A. Identification of Correct Components B. Identification of meters C. Setting the rheostats to correct positions	<table border="1" style="width: 100px; height: 40px;"> <tr><td style="height: 20px;"></td></tr> <tr><td style="text-align: center;">5</td></tr> </table>		5	
5					
2. Manipulation of apparatus	A. Handling the 3- point Starter. B. Decreasing and increasing the value of resistance in the Rheostat C. Adjusting the resistive inductive and capacitive loads	<table border="1" style="width: 100px; height: 40px;"> <tr><td style="height: 20px;"></td></tr> <tr><td style="text-align: center;">20</td></tr> </table>		20	
20					
3.Precise operations /Activities	A. Increasing the resistive inductive and capacitive Loads B. Recording the readings in the Ammeter, Voltmeter. C. Calculation of voltage regulation for different loads D. Drawing the Graph and marking of suitable load on graph	<table border="1" style="width: 100px; height: 40px;"> <tr><td style="height: 20px;"></td></tr> <tr><td style="text-align: center;">20</td></tr> </table>		20	
20					
4. Values	A. Co Operation B. Co-Ordination C. Communication D. Sharing E. Leadership	<table border="1" style="width: 100px; height: 40px;"> <tr><td style="height: 20px;"></td></tr> <tr><td style="text-align: center;">5</td></tr> </table>		5	
5					
Total			50		
Signature of the Staff		Signature of the Student			

WORK SHEET

REGULATION OF 3-ph ALTERNATOR BY SYNCHRONOUS IMPEDANCE METHOD

Name of the student :		Date of experiment:
PIN :	Branch:	
Institution:		Experiment No.

1. Title of the Experiment: _____

2. Objective of the Experiment: _____

3. Equipment Required: _____

Specifications of DC motor and alternator

DC motor

Alternator

4. Circuit Diagram:

OC TEST

SC TEST

ARMATURE RESISTANCE TEST

SC TEST

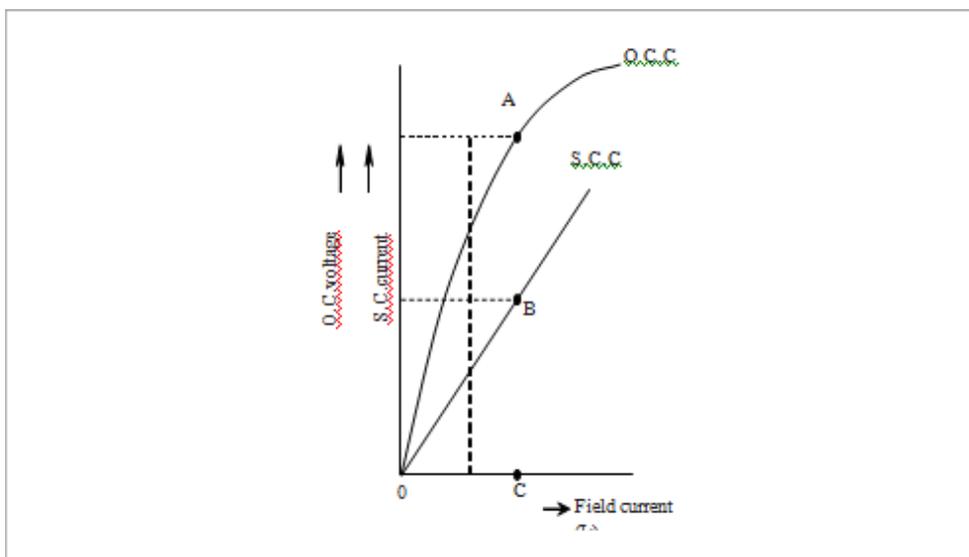
S.No	Field Current I_f (Amps)	O.C. Voltage (or) induced emf/phase E_{ph} (Volts)
1.		

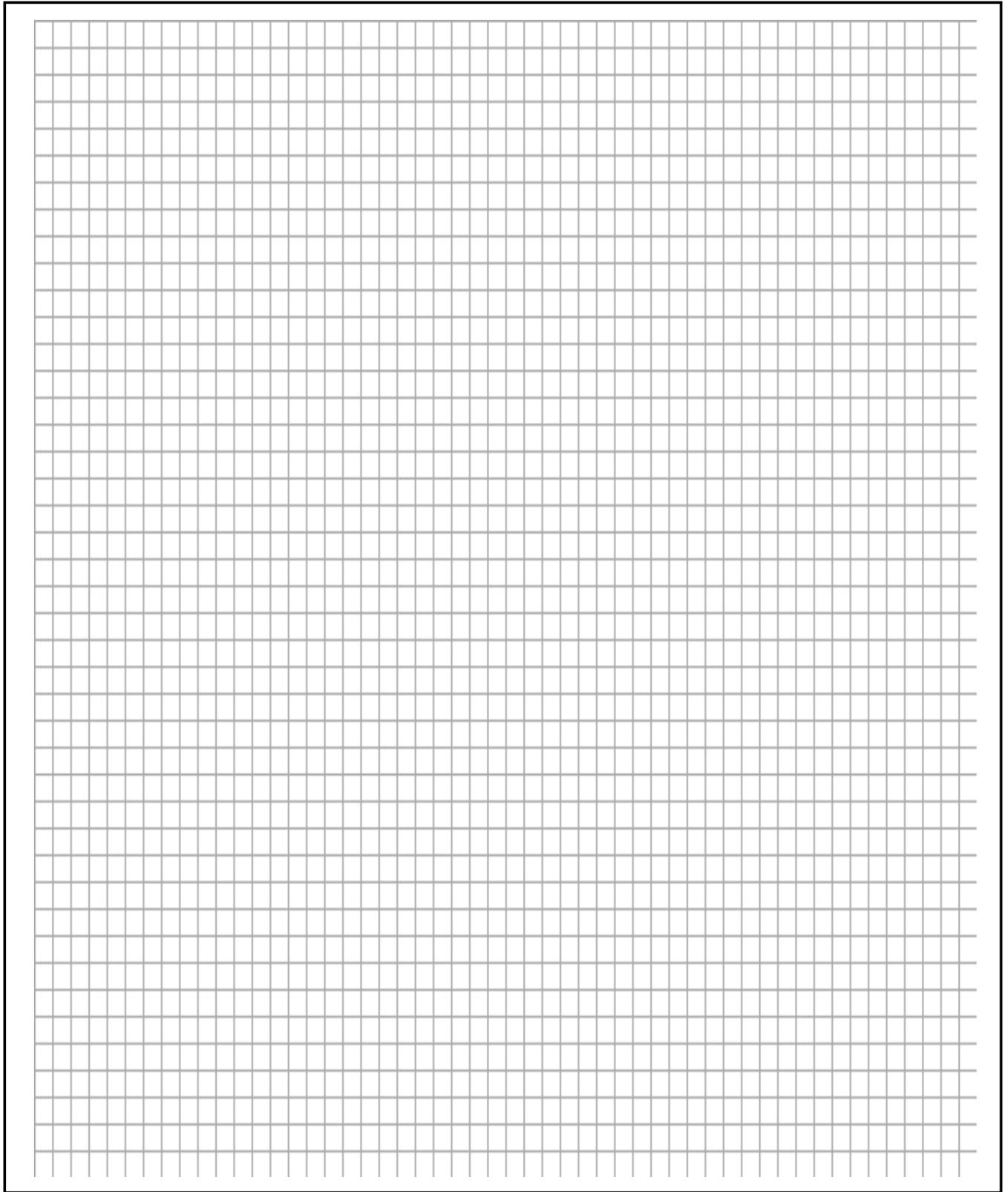
ARMATURE RESISTANCE TEST

S.No	Voltage Reading V_{dc} (Volts)	Ammeter Reading I_{dc} (Amps)	Armature Resistance $R_{dc} = \frac{V_{dc}}{I_{dc}}$ (ohms)
1.			
2.			
3.			
4.			
		Average value	$R_{dc} = \text{_____} \Omega$

The effective ac resistance, $R_a = 1.6 R_{dc} = \text{_____} \Omega$

7. Graph:





Observed Waveforms

SBTET, AP

8. Inference and Interpretation :

9. Specimen caluculations :

10. Scheme of Evaluation:

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded																								
<p>Handling of apparatus</p>	<p>a. Drawing the circuit diagram and identifying various terminals. b. Proper connecting of connecting wires without loose connections and Proper Handling of the DPST Switch. c. Setting the Rheostats to appropriate positions and Proper handling of the field rheostats of alternators and dc motor d. Using correct range Voltmeter, Ammeters.</p>	<table border="1"> <tr> <td>a</td> <td>b</td> <td>c</td> <td>d</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>2</td> <td>5</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>	a	b	c	d	T	1	1	1	2	5															
a	b	c	d	T																							
1	1	1	2	5																							
<p>Manipulation of apparatus</p>	<p>a. Reading the Circuit Diagram and Making the connections. b. Switching on the supply and Handling the 3- point Starter. c. Observing the readings in the Ammeter and Voltmeter.</p>	<table border="1"> <tr> <td>a</td> <td>b</td> <td>c</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>3</td> <td>5</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> </tr> </table>	a	b	c	T	1	1	3	5																	
a	b	c	T																								
1	1	3	5																								
<p>Precise operations /Activities</p>	<p>a. Conducting OC ,SC and armature resistance tests b. Recording the readings on voltmeter and Ammeter at every step. c. Drawing the graphs and interpreting. d. Calculating effective ac resistance value of armature winding of alternator. e. Calculating Z_s from graph. f. Calculating no load terminal voltage g. Calculating regulation of alternator</p>	<table border="1"> <tr> <td>a</td> <td>b</td> <td>c</td> <td>d</td> </tr> <tr> <td>5</td> <td>5</td> <td>5</td> <td>5</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>e</td> <td>f</td> <td>g</td> <td>T</td> </tr> <tr> <td>5</td> <td>5</td> <td>5</td> <td>35</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> </tr> </table>	a	b	c	d	5	5	5	5					e	f	g	T	5	5	5	35					
a	b	c	d																								
5	5	5	5																								
e	f	g	T																								
5	5	5	35																								
<p>Values</p>	<p>a. Co ordination b. Cooperation c. Communication d. Sharing e. leadership</p>	<p style="text-align: center;">5</p>																									
		<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> </tr> </table>					<p style="text-align: right;">Total</p>																				
		<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> </tr> </table>					<p style="text-align: right;">50</p>																				
<p>Signature of the Staff</p>	<p>Signature of the Student</p>																										

WORK SHEET
SYNCHRONISATION OF AN ALTERNATOR

Name of the student :		Date of experiment:
PIN :	Branch:	
Institution:		Experiment No.

1. Title of the Experiment : _____

2. Objective of the Experiment : _____

3. Equipment Required : _____

4. Circuit Diagram:

5. Procedure:

6. Inference and interpretation:

7. Scheme of Evaluation:

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded
1. Handling of apparatus	A. Drawing circuit diagram and Identifying various terminals. B. Using correct range Voltmeter, Ammeters and Rheostats. C. Handling DPST switch.	<div style="border: 1px solid black; padding: 2px; width: 60px; margin: 0 auto;">10</div>	
2. Manipulation of apparatus	A. Making the connections. B. Setting the Rheostats to correct positions before switching ON. C. Handling the 3- point Starter. D. Observing the readings in ammeter and voltmeter.	<div style="border: 1px solid black; padding: 2px; width: 60px; margin: 0 auto;">10</div>	
3. Precise operations/ Activities	A. Varying the rheostat for rated speed B. Varying the rheostat for busbar voltage in voltmeter C. Closing of switch S_1 . D. Adjusting the speed of alternator for one dark and two bright lamp condition. E. Closing the switch S_2 .	<div style="border: 1px solid black; padding: 2px; width: 60px; margin: 0 auto;">25</div>	
4.Values	A. Co Operation B. Co-Ordination C. Communication D. Sharing E. Leadership	<div style="border: 1px solid black; padding: 2px; width: 60px; margin: 0 auto;">5</div>	
Total			50
Signature of the Staff		Signature of the Student	

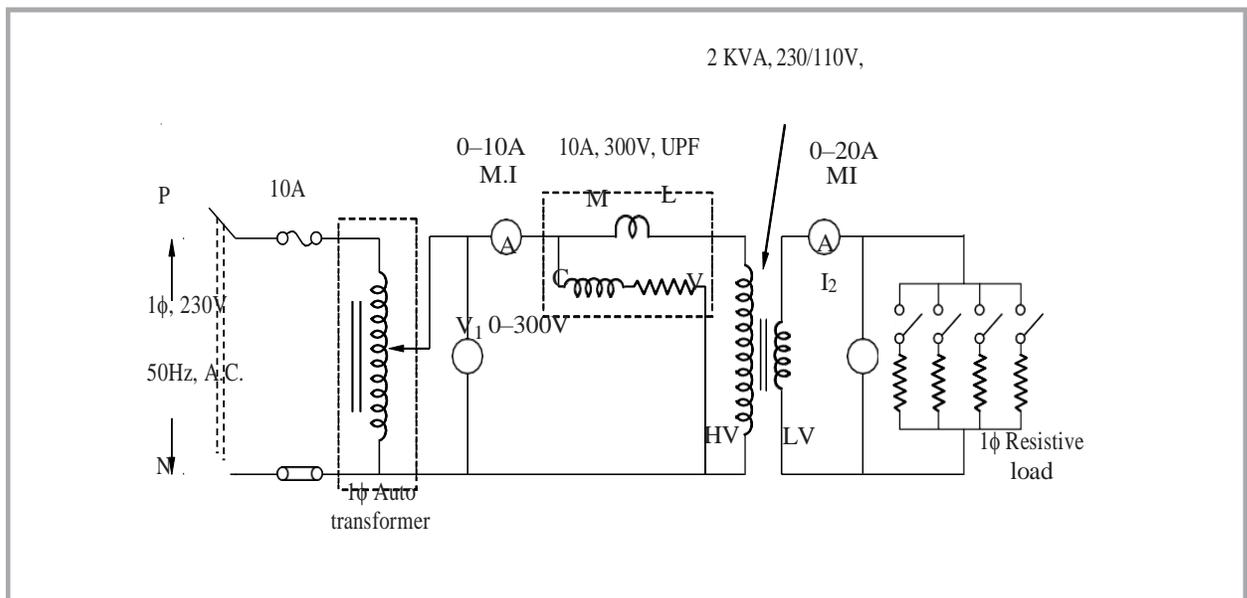
LOAD TEST ON SINGLE PHASE TRANSFORMER

1. Description

The setup for this experiment requires the following equipment

Name	Specifications/ Range	No	Purpose
Ammeter (MI)	(0-10)A	1	To measure primary current.
Ammeter(MI)	(0-20)A	1	To observe Load current I_L
Voltmeter(MI)	(0-300)V	1	To primary voltage
Voltmeter(MI)	(0-150)V	1	To measure secondary voltage.
Wattmeter(Dynamometer type)	10A,300V,UPF	1	To measure input power
Single phase transformer	2KVA,230/110V,50HZ	1	To conduct load test on single phase transformer
Auto transformer(single phase)	230/0-270V	1	To adjust the rated voltage across primary winding
Resistive Load	230V,10A	1	To vary the load in steps
Connecting wires	-	Required no	To connect the circuit.

2. Circuit Diagram



3. Theory

The load is connected to the secondary side of the transformer. The voltage applied across the primary winding remains practically constant or should be kept constant throughout the test. As the secondary winding is electromagnetically linked with the primary winding, the current in the loaded secondary winding will automatically change the current in the primary winding. The efficiency of a transformer defined as the ratio of output in watts to input in watts.

4. Procedure:-

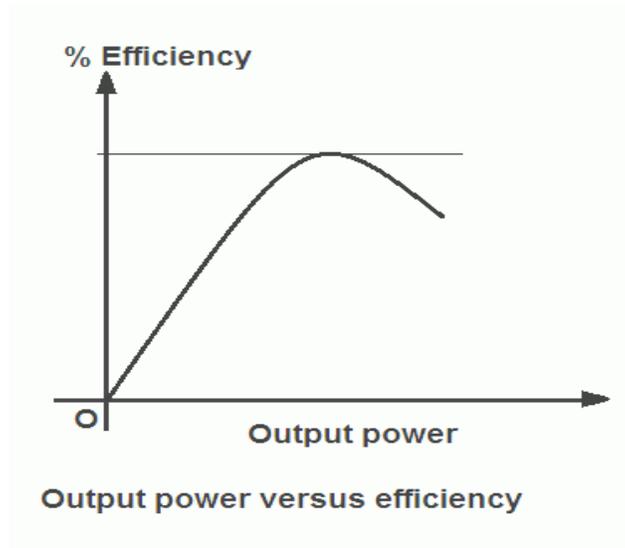
1. Connections are made as per the circuit diagram.
2. Keep the autotransformer in the minimum position and switch 'ON' the single phase AC supply.
3. Adjust the Autotransformer (variac) so that rated voltage is impressed across the primary winding. (here 230V).
4. At first, take the readings of primary voltage, primary current input, power and secondary voltage at no load.
5. Then by varying the load in steps, the readings of Ammeter and voltmeter are noted and tabulated.
6. Remove the load and switch 'OFF' the supply after bringing the autotransformer to the initial state.

5. Observations:-

S.No.	Primary side			Secondary side			Efficiency = $\frac{\text{Output}}{\text{Input}} \times 100$	Regulation = $\frac{E_2 - V_2}{E_2} \times 100$
	Voltmeter Reading V ₁ (Volts)	Ammeter Reading I ₁ (amps)	Wattmeter Reading =input (watts)	Voltmeter Reading V ₂ (volts)	Ammeter Reading I ₂ (Amps)	Output =V ₂ I ₂ (watts)		
1.								
2.								
3.								
4.								
5.								

6. Graph - Plot the following graphs

1. Output verses Efficiency.



7. Calculations

No load secondary voltage, $E_2 = \underline{\hspace{2cm}}$ V

Primary side:

Volt meter reading, $V_1 = \underline{\hspace{2cm}}$ V

Ammeter reading, $I_1 = \underline{\hspace{2cm}}$ A

Wattmeter reading, input = $\underline{\hspace{2cm}}$ W

Secondary side:

Volt meter reading, $V_2 = \underline{\hspace{2cm}}$ V

Ammeter reading, $I_2 = \underline{\hspace{2cm}}$ A

Output = $\underline{\hspace{2cm}}$ W

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

$$\% \text{ Regulation} = \frac{E_2 - V_2}{E_2} \times 100$$

Precautions:

- 1) Avoid loose connections.
- 2) Readings must be taken without parallax error.
- 3) Check the continuity of the L.V & H.V windings of the transformer.
- 4) Applying load on the transformer must be within the limits of rated value on L.V side.
- 5) Applying voltage on primary side should not exceed rated voltage of the transformer on H.V. side.
- 6) Set the auto transformer in minimum position.

Exercise questions

Level-A

1. Draw the circuit diagram of Load test on single phase transformer.
2. Identify L.V & H.V windings in a transformer.
3. Mention the correct range and type of equipment used in load test on single phase transformer.

Level-B

1. Reading given circuit diagram and make the connections.
2. Handling auto transformer and observe the readings in ammeter and voltmeter for different load

Level-C

1. Recording the reading of load test on single phase transformer for given load conditions.
2. Calculate the efficiency and regulation for various loads.
3. Draw the graph for single phase transformer for the given table of recordings .

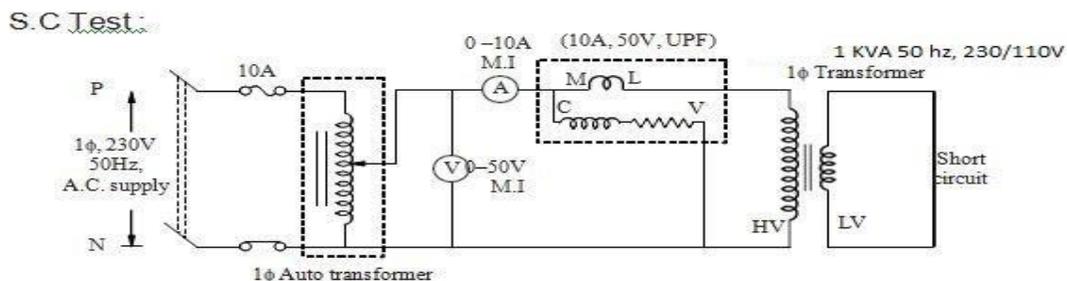
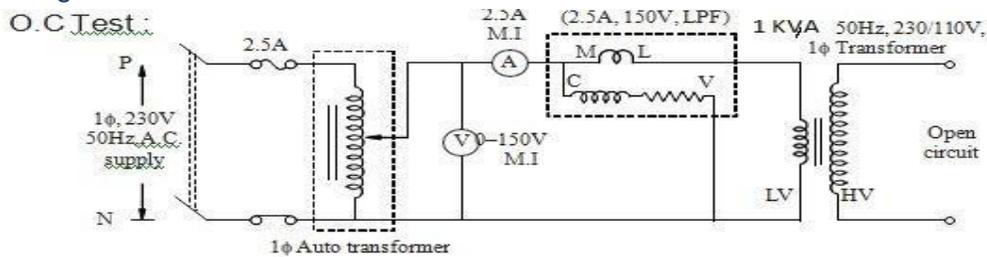
OC & SC TEST ON SINGLE PHASE TRANSFORMER

Description

The setup for this experiment requires the following equipment

Name	Type	Specifications/ Range	No	Purpose
Auto Transformer	1- ϕ	230/0-270 V	1	To vary the voltage to rated value
Transformer	1- ϕ	1 KVA, 50 Hz, 230/110 V	1	To connect LV or HV as per circuit diagram
Ammeter	MI	0-2.5 A	1	To measure Open Circuit Current
Voltmeter	MI	0-150 V	1	To measure Open Circuit Voltage
1- ϕ Wattmeter	Dynamometer	2.5 A, 150V, LPF	1	To measure Open Circuit Power
Ammeter	MI	0-10 A	1	To measure Short Circuit Current
Voltmeter	MI	0-50 V	1	To measure Short Circuit Voltage
Wattmeter	Dynamometer	10 A, 50V, UPF	1	To measure Short Circuit Power
Connecting Wires	-----	Red , Green, Blue , Yellow and Black 3/20 gauge , suitable lengths	As per the need	To make connections and interconnections to the equipment

2. Circuit Diagram



3. Theory :

Open-Circuit (O.C) or No-Load Test:

The purpose of this test is to determine iron loss and to find R_0 and X_0 . In this test one winding of the transformer usually H.V.winding is left open and the other is connected to its supply of normal voltage and frequency. The current drawn is very low about 3to 5% of F.L current. So copper losses are negligible with normal voltage applied to the primary (LV), normal flux will be setup in the core. Hence normal iron losses will occur which are recorded by the wattmeter.

Short Circuit (S.C.) Test:

The purpose of this test is to determine copper loss at full load and equivalent impedance, leakage reactance and total resistance of the transformer. In this test one winding usually LV winding is short circuited by thick conductor. A reduced voltage (5 to 10% of normal voltage) is applied to the primary (HV) until full load current flows in either winding. Because of small percentage of voltage applied the iron loss will be negligible. The wattmeter reading represents F.L copper loss.

4. Procedure :O.C. Test :

1. Connect the circuit as shown in circuit diagram.
2. Switch on the supply after checking connection by concerned teacher.
3. Increase the input voltage to the transformer winding up to the rated value (110V in this case) slowly using 1- ϕ auto transformer.
4. Measure the primary voltage, primary current, primary circuit power.
5. Reduce the voltage slowly using variac.
6. Switch off the supply and remove connections.

S.C .Test :

- 1) Connect the circuit as shown in circuit diagram.
- 2) Switch on the supply after checking connection by concerned teacher.
- 3) Increase the input voltage very carefully and slowly so that the current in the secondary winding reaches rated value (8.6A in this case) using 1- ϕ auto transformer.
- 4) Measure the primary voltage, primary current, primary circuit power and secondary current of transformer.
- 5) Reduce the voltage slowly using variac.
- 6) Switch off the supply and remove connections.

5. Observations:

a) SPECIFICATIONS :

1- ϕ Transformer (1 KVA, 230/110 v, 50 Hz)	1- ϕ AutoTransformer
KVA :	Input :
Pri. Voltage and circuit :	Output:
Sec Voltage and Circuit :	
Frequency :	

b) O.C.Test

S.No.	Voltmeter Reading V_1 (Volts)	Ammeter Reading I_0 (Amps)	Wattmeter Reading W_0 (watts)

c) S.C.Test

S.No.	Voltmeter Reading V_{SC} (Volts)	Ammeter Reading I_{SC} (Amps)	Wattmeter Reading W_{SC} (watts)

CALCULATIONS :

1. Equivalent Circuit (Constants): 1 KVA , 230/110 V, 50Hz, 1- ϕ Transformer.

From O.C Test : Metering is on LV (Secondary) side.

Voltmeter reading , $V_1 =$ _____ V.

Ammeter reading, $I_0 =$ _____ A.

Wattmeter reading = No load input Power , $W_0 =$ _____ W.

No Load power factor , $\cos \phi_0 = \frac{W_0}{V_1 I_0} =$ _____

Working Component of no load current , $I_w = I_0 \cos\phi_0 =$ _____

Magnetising component of no load current , $I_\mu = I_0 \sin\phi_0 =$ _____

Equivalent Circuit parameters :

$$R_0 = \frac{V_1}{I_w} \Omega$$

$$X_0 = \frac{V_1}{I_\mu} \Omega$$

REFERRED TO PRIMARY (HV SIDE) :

Transformation Ratio , $K = \frac{V_2}{V_1}$

$$R_0^1 = R_0 / K^2 = \text{_____} \Omega$$

$$X_0^1 = X_0 / K^2 = \text{_____} \Omega$$

From S.C Test : Metering is on HV (primary Side)

Voltmeter Reading , $V_{sc} =$ _____ V.

Ammeter reading , $I_{sc} =$ _____ A.

Wattmeter reading $W_{sc} =$ _____ W.

Total Resistance , impedance and reactance referred to primary are $R = W$

$$R_{01} = \frac{W_{sc}}{(I_{sc})^2} = \text{_____} \Omega$$

$$Z_{01} = V_{sc} / I_{sc} = \text{_____} \Omega$$

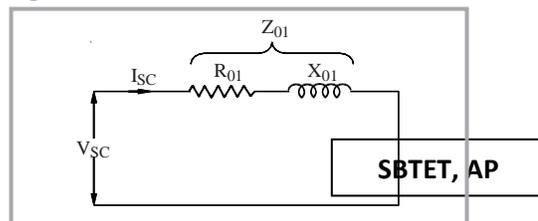
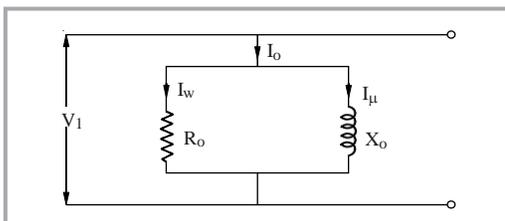
$$X_{01} = \sqrt{(Z_{01})^2 - (R_{01})^2}$$

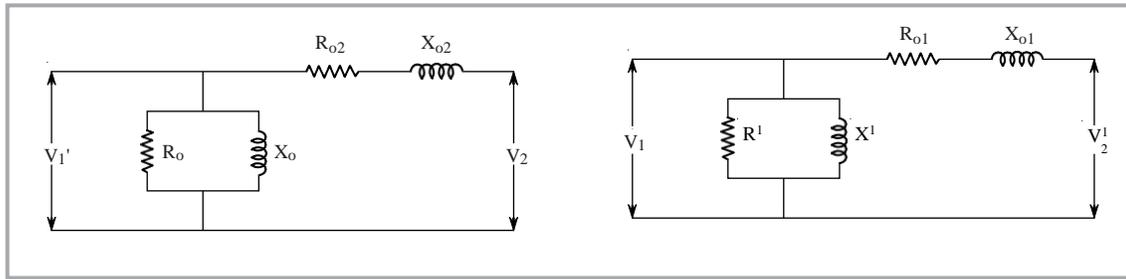
Referred to Secondary Side (LV) :

$$R_{02} = K^2 R_{01} = \text{_____} \Omega$$

$$X_{02} = K^2 X_{01} = \text{_____} \Omega$$

The equivalent circuit referred to LV and HV are shown in the figure below.





2. Efficiency :

Rating of the transformer , $S = \text{_____ KVA} = \text{_____ VA}$.

From OC Test :

Wattmeter reading , $W_0 = \text{iron loss} , W_i = \text{_____ W}$ (When rated voltage is

applied)From SC test :

Rated i.e; FL primary current $I_1 = I_{FL}$

$I_{FL} = (KVA * 10^3) / \text{Rated Voltage } V_1 \text{ (here 230 V)} = \text{_____ A}$

F.L copper loss $W_c = (I_{FL} / I_{sc})^2 w_{sc} = \text{_____ w}$

S.NO	P.F of load $\cos\phi$	Fraction of load FL ,x	Output	Copper Loss	Total loss	Input = output+(losses)	% Efficiency = (output/input) * 100
1.	Unity	1					
		3/4					
		1/2					
		1/4					
2.	0.8	1					
		3/4					
		1/2					
		1/4					

3. Load for Maximum Efficiency:

FL KVA = rating of the Transformer in KVA = _____ KVA

Load KVA corresponding to maximum efficiency = $\sqrt{\frac{W_i}{W_c}}$ * FL KVA

4. Regulation

% Regulation = (I₁R₀₁COSφ ± X₀₁ I₁Sinφ) / V₁ *100

(Or)

(I₂R₀₂COSφ ± X₀₂ I₂Sinφ) / E₂ *100

('+' sign for lagging pf and '-' sign for leading pf)

Power factor for maximum regulation = _____ lagging

Power factor Zero regulation = _____ leading.

S.NO	LOAD PF ,COSφ	% Regulation
1	Unity	
2	0.8 lagging	
3	0.8 leading	

5. All- day Efficiency:

F.L. KVA of the transformer = _____ KVA

From OC test : Iron loss W_i = _____ W

From SC test : F.L copper loss = W_c= _____ W

Iron loss remains constant and copper loss proportional to (KVA)²

Copper loss at 'x' KVA = ('x'/FL KVA)² * FL copper loss. KVA load = KW/pf.

Daily load cycle of transformer is as follows.

S.No.	No of Hours	Load	p.f
1.			
2.			
3.			
4.			

From the Load Cycle , output in KWh and copper loss in KWh are calculated as follows.

S.No	Load in KW	P.F	Load in KVA	Time in Hours	Output in KWh	Copper Loss in KW at different Loads	Copper Loss in Kwh

Total:

Total output in Kwh for 24 hours = _____(Note from

Table)Copper loss for 24 hours = _____KWh (Note from Table)

Iron loss for 24 hours = iron loss in KW *24 = _____KWh

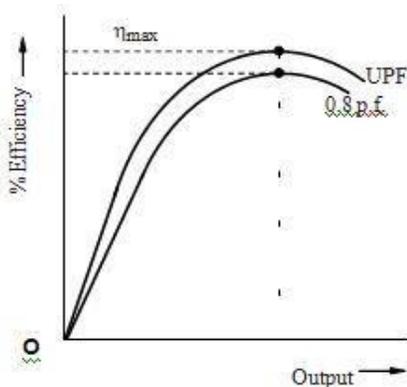
Total losses for 24 hours = iron loss in kWh + copper loss in KWh = _____KWh

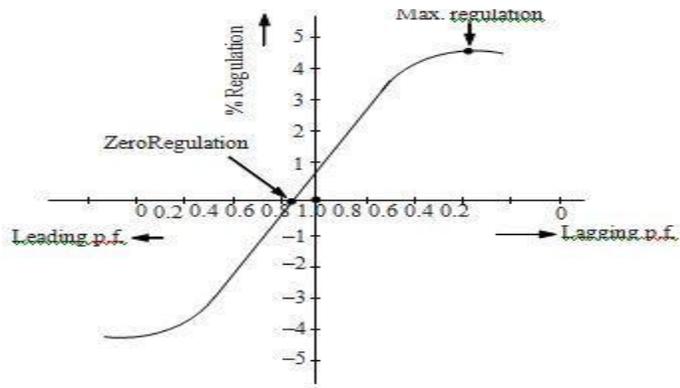
All Day Efficiency = (Output in Kwh)/(Output in KWh + losses in kwh) for 24 hours = _____%

6. GRAPH :

The following graphs can be drawn

1. Efficiency verses Output
2. Regulation Verses Power factor.





7. Precautions :

1. Make sure that all the wiring connections are in tight condition
2. Auto Transformer must be varied slowly.
3. Readings must be taken without any parallax error.
4. In case of OC Test the meters must be connected on LV side and the Open circuit is made on HV side.
5. In case of SC Test the meters must be connected on HV side and the Short circuit is made on LV side.

8. Assessment Questions :

- i. Draw the circuit diagram of OC and SC test on Transformer.
- ii. Conduct OC and SC test on given Single Phase Transformer.
- iii. Draw the Equivalent Circuit from the OC and Test readings of the Transformer referred to LV side..
- iv. Draw the Equivalent Circuit from the OC and Test readings of the Transformer referred to HV side.
- v. Find the Iron and Copper losses from the given Test readings.
- vi. Find the efficiency of Transformer at Full load rated current from the given test readings.
- vii. Find the efficiency of Transformer at Half Full load rated current from the given test readings.

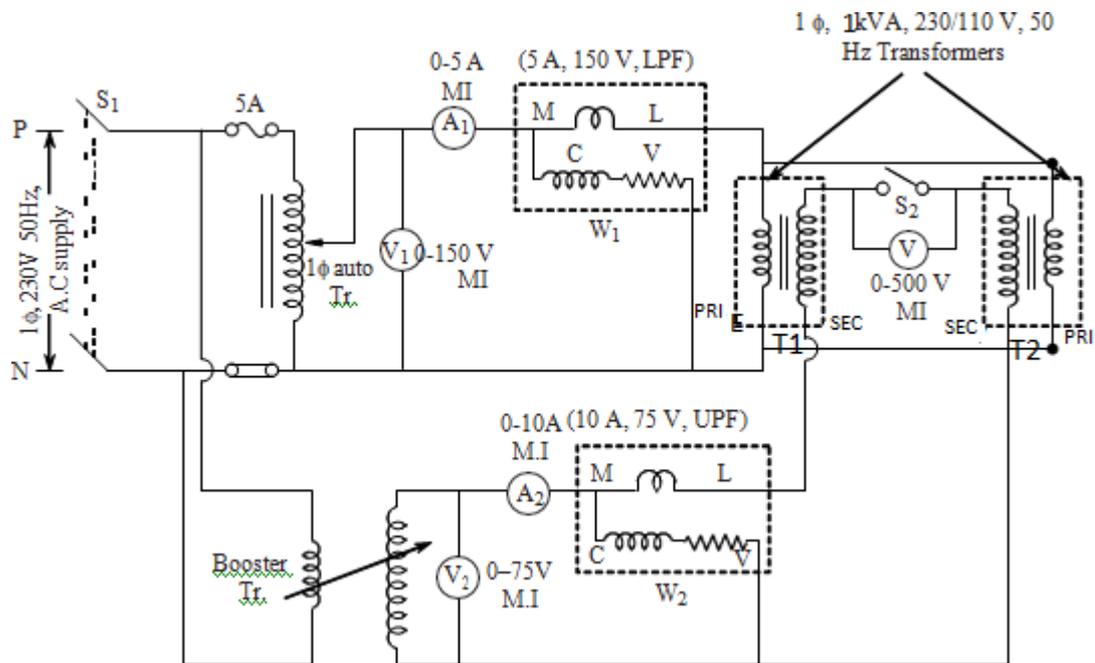
SUMPNERS TEST ON TRANSFORMERS

1. Description

The setup for this experiment requires the following equipment

Name	Specifications/ Range	No	Purpose
Ammeter (MI)	(0-5)A	1	To observe the open circuit current
Voltmeter (MI)	(0-150)V	1	To observe the open circuit voltage
Ammeter (MI)	(0-10)A		To observe the short circuit current
Voltmeter (MI)	(0-75)V	1	To observe the short circuit voltage
Voltmeter(MC)	(0-600)V	1	To observe the voltage across two transformers .
1- ϕ Wattmeter (DM type)	5A,150V,LPF	1	To Observe the iron loss of the transformers
1- ϕ Wattmeter (DM type)	10A,75V,UPF	1	To Observe the Copper loss of the transformers
1- ϕ Auto transformer	230/(0-270)V_	1	To varies the voltage up to rated value
1- ϕ Auto transformer	230/(0-270)V_	1	To varies the voltage up to rated value
1- ϕ transformers	1KVA,230/110V,50HZ	2	Sumner's test on the transformer
SPST Switch	-	1	Check the polarities
1- ϕ booster transformer	230/(0-270)V_	1	Voltage can be injected into the secondary
Connecting Wires	Red , Green, Blue , Yellow and Black 3/20 gauge , suitable lengths	As per the need	To make connections and interconnections to equipment

2. Circuit Diagram



3. Theory

Sumner's test (also known as **Sumner's test**, **back-to-back test** or **load test**)

Principle of the test

The test requires two identical transformers (see **T1** and **T2** in the diagram). The primary winding of each of the transformer is connected to the main supply under nominal operating conditions. They are therefore connected in parallel.

With the secondary windings open-circuited (switch **S** open), the wattmeter **W1** measures the sum of no-load loss of both transformers. Under such conditions the copper loss is very low so the wattmeter measures essentially the iron loss.

The secondary windings are connected in series, but with opposing polarity. The secondary voltages cancel each other so there is no current flowing after the switch **S** is closed. For this reason the transformers must be identical. Otherwise complete voltage cancellation cannot be achieved, and this creates problems with injecting the current into secondary windings for simulation of copper loss.

The variable supply is connected in series with the secondary windings. This can be achieved either by using a variable-amplitude voltage source with a booster transformer.

The variable supply is then used to drive current into the secondary windings. Because the polarities are in opposition, a relatively low voltage is required to achieve nominal value of currents (as dictated by the nominal rating of the transformers under test). The secondary current is transformed to the primary side, but due to the parallel connection the current circulates in the primary windings, without flowing to the main supply and affecting the indication of the wattmeter **W1**. Therefore, the wattmeter **W2** shows only the sum of copper loss for both transformers.

During the operation the transformers do not deliver any significant power, so the energy use is relatively low. However, full-load losses for both copper and iron are achieved, which allows performing full-load-like thermal tests.

4 PROCEDURE:

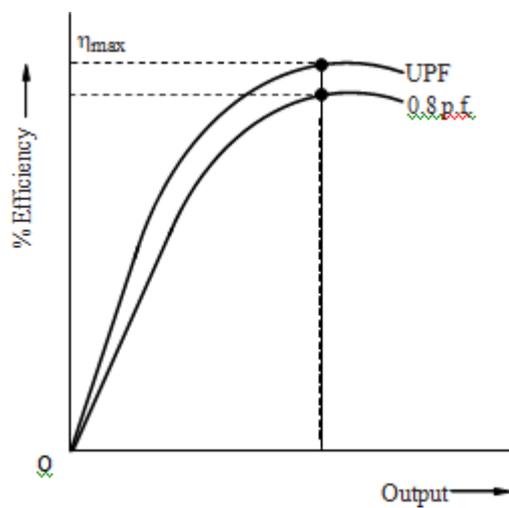
1. Connections are made as per the circuit diagram.
2. Check the polarity of secondaries.
3. Close the secondary circuit when the polarity voltmeter reads zero. (Reverse and check double the voltage as a precaution against a faulty meter and connect again the correct polarity).
4. Adjust the primary voltage to the rated value (here 110V).
5. With the help of booster transformer a voltage can be injected into the secondary such that Ammeter 'A2' reads the *F.L* sec current of any one of the transformer.
6. Note down the Ammeter, voltmeter and wattmeter readings.
7. The wattmeter *W1* connected in the main circuit reads twice their iron loss of a single transformer and wattmeter *w2* connected in booster circuit reads twice the copper loss of a single transformer.

5 OBSERVATIONS

	Primary side			Secondary side		
S.NO .	Reading of Voltmeter= v_1 (volts)	Reading of Ammeter A1 $=2I_o$ (Amps)	Reading of wattmeter $w_1 = p_o$ (watt)	Reading of voltmeter $v_2 =$ $2v_{sc}$ (volts)	Reading of Ammeter A 2 $= I_{SC}$ (amps)	Reading of Wattmeter $w_2 = P_{SC}$ (watts)
1.						

6 MODEL GRAPH:

A graph is drawn with output on X-axis and % efficiency on Y-axis for various power factors.



7 CALCULATIONS:

1 KVA, 230/110 V, 50 Hz, 1 ϕ transformers

$$W_1 = V_1 (2I_o) \cos\phi = 2 W_i$$

Iron loss of each transformer,

$$W_i = \frac{W_1}{2} = \text{_____} W$$

$$W_2 = (2 V_{SC}) I_{SC} \cos\phi = 2 W_{SC}$$

Copper loss of each transformer,

$$W_{SC} = \frac{W_2}{2} = \text{_____} W$$

Total resistance, impedance and reactance referred to primary (HV side) are

$$R_{01} = W_{SC} / I_{SC}^2 = \text{-----} \Omega$$

$$Z_{01} = V_{SC} / I_{SC} = \text{-----} \Omega \quad \text{And}$$

$$X_{01} = \sqrt{(Z_{01})^2 - (R_{01})^2} = \text{-----} \Omega$$

(i) Efficiency

Rating of the transformer, $S = \text{_____} \text{KVA} = \text{_____} \text{VA}$.

Iron loss, $W_i = \text{_____} W$ (when rated voltage is applied)

S.No.	p.f of the load, $\cos\phi$	Fraction of the F.L. x	Output = $x\cos\phi$ (watts)	Copper loss = x^2W_C (watts)	Total loss = $W_i + x^2 W_C$ (watts)	Input = Output + losses(watts)	% Efficiency $\frac{\text{output}}{\text{input}} * 100$
1.	Unity	1					
		3/4					
		1/2					
		1/4					
2.	0.8	1					
		3/4					
		1/2					
		1/4					

(i) Regulation

$$\% \text{ Regulation} = \frac{I_1 R_{01} \cos\phi + I_1 X_{01} \sin\phi}{V_1} \times 100 \quad (\text{or})$$

$$\frac{I_2 R_{02} \cos\phi + I_2 X_{02} \sin\phi}{E_2} \times 100$$

(‘+’ Sign for lagging p.f and ‘-’ sign for leading p.f)

S.No.	Load p.f, $\cos\phi$	% Regulation
1.	Unity	
2.	0.8 lagging	
3.	0.8 leading	

8 Scheme of Evaluation

CATEGORY OF SKILL	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	Marks Awarded																		
1.Handling of apparatus	A. Identification of windings on Transformer. B. Identification of meters. C. Identification wattmeter terminal connections. D. Setting the auto transformer to minimum position.	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>T</td> <td></td> </tr> <tr> <td>1</td> <td>1</td> <td>2</td> <td>1</td> <td>5</td> <td></td> </tr> </table>	A	B	C	D	T		1	1	2	1	5								
A	B	C	D	T																	
1	1	2	1	5																	
2. Manipulation of apparatus	A. Making Circuit Connections. B. Checking the Polarities. C. Switching on supply. D. Noting down the voltage zero in the voltmeter otherwise checking the polarity E. Increasing the voltage to rated value. F. Observing the readings with multiplication factor in the meters. G. Injected the voltage to the secondary winding.	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>F</td> <td>G</td> <td>T</td> <td></td> </tr> <tr> <td>2</td> <td>2</td> <td>2</td> <td>2</td> <td>2</td> <td>2</td> <td>3</td> <td>15</td> <td></td> </tr> </table>	A	B	C	D	E	F	G	T		2	2	2	2	2	2	3	15		
A	B	C	D	E	F	G	T														
2	2	2	2	2	2	3	15														
3. Precise operations/Activities	A. Varying the Voltage and Current to rated Value B. Noting down the readings with multiplication factor. C. Calculating the copper losses fraction of full load. D. Calculating the input power. E. Calculating the Efficiency using formula. F. Calculating percentage regulation. G. Drawing the graph and showing salient points.	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>F</td> <td>G</td> <td>T</td> <td></td> </tr> <tr> <td>3</td> <td>3</td> <td>3</td> <td>4</td> <td>4</td> <td>4</td> <td>4</td> <td>25</td> <td></td> </tr> </table>	A	B	C	D	E	F	G	T		3	3	3	4	4	4	4	25		
A	B	C	D	E	F	G	T														
3	3	3	4	4	4	4	25														
4.Values	A. Co operation B. Co ordination C. Communication D. Sharing E. Leadership	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>5</td> </tr> </table>	A	B	C	D	E	T	1	1	1	1	1	5							
A	B	C	D	E	T																
1	1	1	1	1	5																
	Total	50																			
Signature of Staff		Signature of student																			

9 PRECAUTIONS:

- 1 AVOID LOOSE CONNECTIONS.
- 2 Auto transformers and booster transformer are must be varied slowly.
- 3 Reading must be taken without any parallax error.
- 4 Connect correct polarity of secondary winding of transformers.
- 5 Close the switch (S_2) when the polarity voltmeter reads zero.

10 Assessment Questions :

Experimental Methodology Sheet

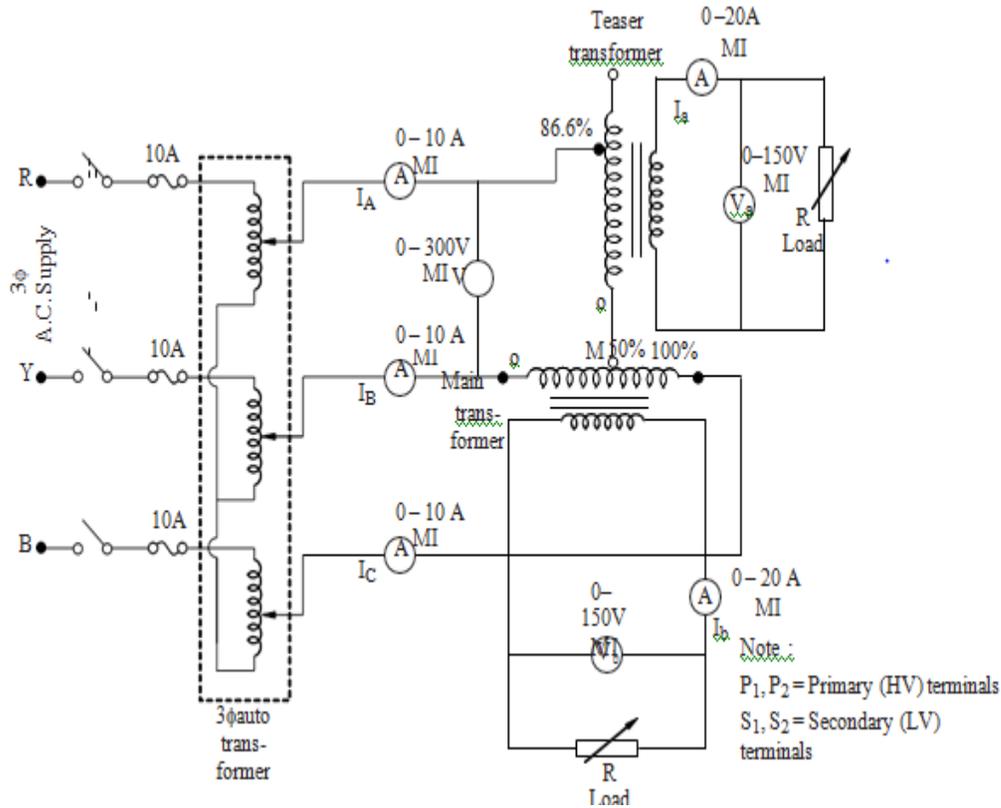
SCOTT CONNECTION ON TRANSFORMERS

1. Description

The setup for this experiment requires the following equipment

Name	Specifications/ Range	No	Purpose
Single phase transformers	1 KVA	02	To obtain 2phase supply from 3phase supply
Ammeter (MI)	(0-10)A	03	To observe the Line current I
Voltmeter(MI)	(0-300)V	03	To observe the voltage across lines and across the secondaries of the teaser and main transformers
Autotransformer	(0-600)V	1	To obtain the rated voltage across the hv side of Teaser transformer
Resistive load	Single phase	02	To apply the load on secondaries of both teaser and Main transformers
Connecting Wires	Red,Green,Blue, Yellow and Black,3/20 gauge , suitable lengths	As per the need	To make connections and interconnections to equipment

2. Circuit Diagram



Theory:

Principle of a transformer:

Transformer is a static device which converts electrical power from one circuit to another without changing its frequency. it Step up (or Step down) the level of AC Voltage and Current. Working principle: it works on the principle of mutual induction of two coils or Faraday Law's Of Electromagnetic induction

Scott connection:

The Scott-T Connection is the method of connecting two single phase transformer to perform the 3-phase to 2-phase conversion and vice-versa. The two transformers are connected electrically but not magnetically. One of the transformers is called the main transformer, and the other is called the auxiliary or teaser transformer.

The teaser transformer has the primary voltage rating that is $\sqrt{3}/2$ or 0.866 of the voltage ratings of the main transformer. Rated Voltage is applied to the primary of the teaser transformer and therefore the secondary of the voltage V_{2t} of the teaser transformer will lead the secondary terminal voltage V_{2m} of the main transformer by 90°

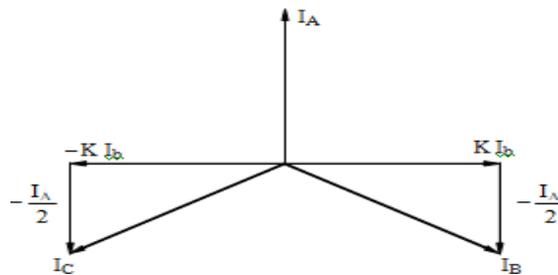
Procedure:

1. Connections are made as per the circuit diagram.
2. Keep the auto transformer in the minimum position and switch 'ON' the 3 phase A.C supply.
3. Rated voltage is applied at the HV side of teaser transformer varying the 3 phase auto transformer gradually.
4. Apply the load uniformly on the secondaries of both the main and teaser transformers and note down the readings of all the meters.
5. Remove the load and switch 'OFF' the supply after bringing the auto transformer to the initial state.

OBSERVATIONS:

Load	Primary line currents			Primary line voltage V (Volt)	Secondary voltages		Secondary currents	
	I_A (Amps)	I_B Amps	I_C (Amps)		V_a (volt)	V_b (volt)	I_a (Amps)	I_b (AMPS)
Balanced load at upf							2	2
							4	4

6. Graph – Draw the following phasor



7. **Calculations** . Use the following formulae for calculations

Let load is balanced and at unity pf

$I_a = I_b$, the sec currents be

balanced the phasor of the
primary currents,

$$I_A = 2/\sqrt{3} K I_a = 1.15 * k * I_a$$

$$I_B = k * I_b * (I_A/2)$$

$$I_C = -k * I_b * (I_A/2)$$

Magnitude of Primary
currents

$$I_A = 2/\sqrt{3} K I_a$$

$$I_B = \sqrt{(K I_b)^2 + (1/\sqrt{3} K I_a)^2}$$

$$I_B = I_C$$

Where N_2/N_1 = Transformation
ratio of the main Transformer

8. Precautions:

1. Make sure that the windings of the transformer are in working Condition (Continuity& Insulation Resistance).
2. Care must be taken while applying the rated Voltage on HV Side of Teasure Transformer
3. Make sure that all the wiring connections are in tight condition.
4. Note the readings without any parallex error.
5. Identical transformers having 86% tapping and 505 tapping are to be selected.

9. Viva Questions :

1. What is Scott connection?
2. What are the applications of scott connection?
3. What is the purpose of scott connection?
4. Why in scott connection of transformers, main transformer is tapped at 50% and teaser transformer at 86.6% ?
5. What is a Teaser transformer?
6. How many transformers are used in Scott connection?

10. Exercise/ Assessment questions:

1. Draw the circuit diagram of Scott Connection test.
2. Verify the 3-Phase to 2-Phase relationship of currents using the Scott Connection.

Experimental Methodology Sheet

Parallel Operation of 1 ϕ

Transformer

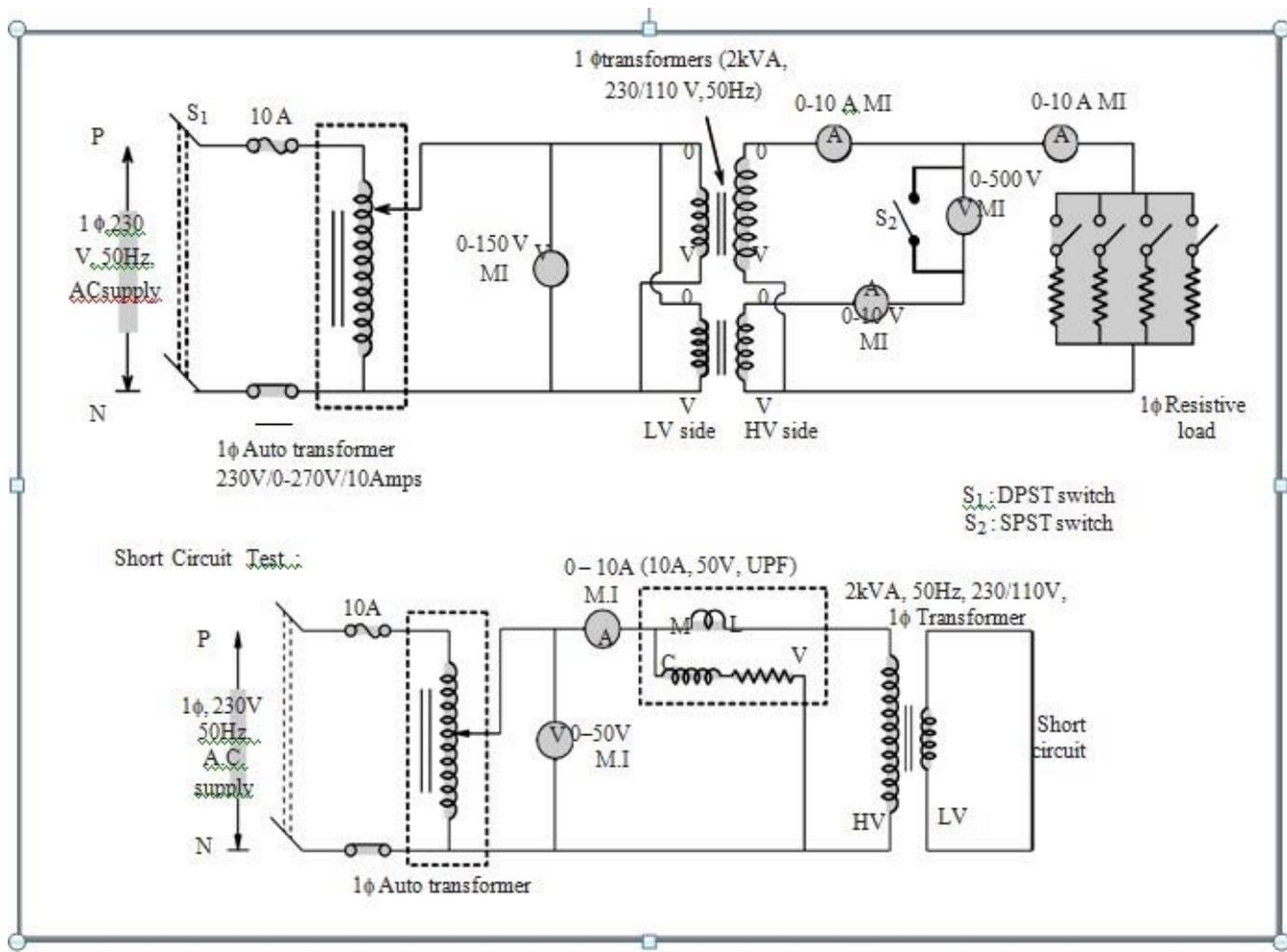
1. Description

The setup for this experiment requires the following equipment

S.No.	Name	Specifications/ Range	No	Purpose
1	1 ϕ Transformer	2kVA, 230/110V	2	To observe to the Load sharing
2	1 ϕ AutoTransformer	230/(0-270)V 10A	1	To vary the voltage on primary side
4	Voltmeter	(0-150)V MI	1	To apply the rated voltage on primary side
5	Voltmeter	(0-500)V MI	1	To check the polarities of secondaries
6	Ammeter	(0-10A) MI	3	To measure the currents in transformers
7	1 ϕ wattmeter	10A,50V,UPF DM type	1	To measure the power during short circuit test
8	SPST switch	-	1	To make on similar polarities
9	Voltmeter	(0-50)V MI	1	To obtain short circuit voltage for calculating impedance
10	Ammeter	0-10A MI	1	To obtain short circuit current for calculating impedance
11	Connecting wires	Red and Black of 3/16 gauge	Sufficient lengths	To complete the circuit connections

2. CIRCUIT DIAGRAM:

Parallel operation of 1 ϕ transformer



THEORY.

Parallel operation of transformer is used for load sharing. The transformers are connected in parallel on both primary and secondary side.

The following conditions to be satisfied during the parallel operation of transformer, namely

1. Same polarities should be connected.
2. The two transformers should have same voltage ratio.
3. The percentage impedance should be same.

4. The ratio of resistance to reactance should be same.

Formulae used :

Load current shared by transformers,

$$I_A = I \frac{Z_B}{Z_A + Z_B}$$

$$I_B = I \frac{Z_A}{Z_A + Z_B}$$

Where I: Load current

Z_A : Impedence of transformer A

Z_B : Impedence of transformer B

4. PROCEDURE:

1. Make the Connections as per the circuit diagram.
2. Rated voltage (110V) is applied across the primaries of both the transformers.
3. Ensure that the voltmeter across the switch 'S₂' shows 'Zero' else the connection on the Secondary side of the one transformer must be interchanged.
4. Close the switch 'S₂' and vary the load current by adding load on these secondary sides of the transformers.
5. The maximum load current should not exceed the sum of full load secondary side currents.
6. By varying the load, note down the corresponding meter readings.
7. Now short circuit test is conducted individually on each transformer.
8. From SC test, the impedance offered by each transformer and power factor are recalculated.
9. Thus the observed and calculated values of load currents of each transformer are verified

5. OBSERVATIONS :

S.No.	Applied Voltage V (Volts)	Load Current I (Amps)	Current Flowing in 1 st Transformer I _A (Amps)	Current Flowing in 2 nd Transformer I _B (Amps)	Calculated Values	
					I _A	I _B
1.						
2.						
3.						
4.						
5.						

From S.C Test: Metering is on HV (primary) side

On First Transformer:

S.No.	V _{SC} (Volts)	I _{SC} (Amps)	W _{SC} (Watts)	$Z_{01} = \frac{V_{SC}}{I_{SC}}$ (ohms)
1.				

On Second Transformer :

S.No.	V _{SC} (Volts)	I _{SC} (Amps)	W _{SC} (Watts)	$Z_{01} = \frac{V_{SC}}{I_{SC}}$ (ohms)
1.				

6. CALCULATIONS:

Formulae used :

Load current shared by transformers,

$$I_A = I \frac{Z_B}{Z_A + Z_B}$$

$$I_B = I \frac{Z_A}{Z_A + Z_B}$$

Where I: Load current

Z_A : Impedence of transformer

Z_B : Impedence of transformer B

7. PRECAUTIONS:

- (1). Make sure that all the wiring connections are in tight condition.
- (2). Check the continuity of the LV and HV of the windings.
- (3). Connecting LV and HV windings of two transformer's on one side respectively.
- (4). Applied voltage on primary side should not exceed the rated LV voltage of the transformer.
- (5). Make sure that the load currents on secondary side should not exceed rated HV current of the transformer.
- (6). Note the readings without any parallax error.
- (7). Ensure that the secondary Voltmeter reads ZERO else the connections on the secondary side of one transformer must be interchanged.

8. Viva Questions :

1. State the need of parallel operation?
2. What are the conditions of parallel operation of 1ϕ transformer?
3. How to conduct polarity test of a 1ϕ transformer?
4. What will happen if two transformers are connected in wrong polarity?
5. How do you parallel two single phase transformer?
6. How can two transformer share the load connected combine to them?
7. What is the role of impedance in load sharing?
8. What happens, if the secondary voltages of the transformers in parallel operation mismatched?

9. Assessment Questions :

1. Draw the circuit diagram for conducting Parallel Operation of Single Phase Transformers.
2. Conduct Parallel operation Test on Two given Transformers.
3. Test the conditions to be satisfied to conduct Parallel operation on a given two Transformers.

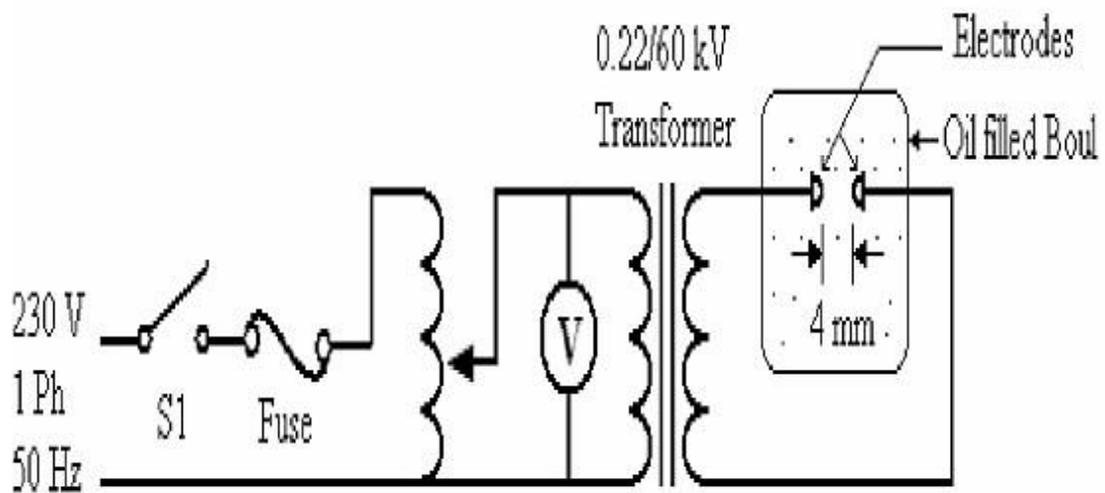
EXPERIMENTAL METHODOLOGY

1. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Objective of the experiment : To determine the dielectric strength of transformer Oil.

Sno	Apparatus Name	Specifications	Quantity
1	Transformer oil Testing Kit		1
2	Sample Oil (to be tested)		300ml

Circuit Diagram :



EXPERIMENTAL METHODOLOGY

1. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Theory :

- Oil Test Set is ideal for speedy and accurate testing of break down/withstand test of transformer and circuit breaker oil.
- Dielectric strength, also known as dielectric breakdown strength (DBS), is **the maximum electrical potential that a material can resist before the electrical current breaks through the material** and the material is no longer an insulator.
- DBS is measured in kV/mm or V/mil.
- Dielectric breakdown voltage of pure transformer oil is **about 10 kV** with a gap distance of 1 mm between electrodes.

Procedure :

1. The sample should be poured down into the test cell, slowly in order to avoid air forming (for example by means of a clean, dry glass rod). The operation should be carried out in a dry place free from dust.
2. Place the cell across the electrode. Close the door.
3. Ensure that the test set is properly earthed. This is most important.
4. Connect the chord to supply. Switch on the test set. Green lamp will glow. It not, checks the connection, fuses on the front panel.
5. Bring the variac pointer gently at zero position. A clicking sound of the variac zero position interlock pressure switch will confirm the zero position of the variac.
6. Press the green push button (ON). The Red lamp will glow. This indicates that the H.V. Circuit is energized. Increase the voltage by rotating the variac (Clockwise) uniformly, at the rate. 2KV/Sec, starting from zero to the value producing break down.
7. After each break down the cell is gently stirred so as to keep away the carbon particles between the electrodes, avoiding as far as possible the production of air bubbles.
8. The test shall be carried out six times on the same cell filling.

EXPERIMENTAL METHODOLOGY

1. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Observations :

No. Of Observation	Break down Voltage in KV

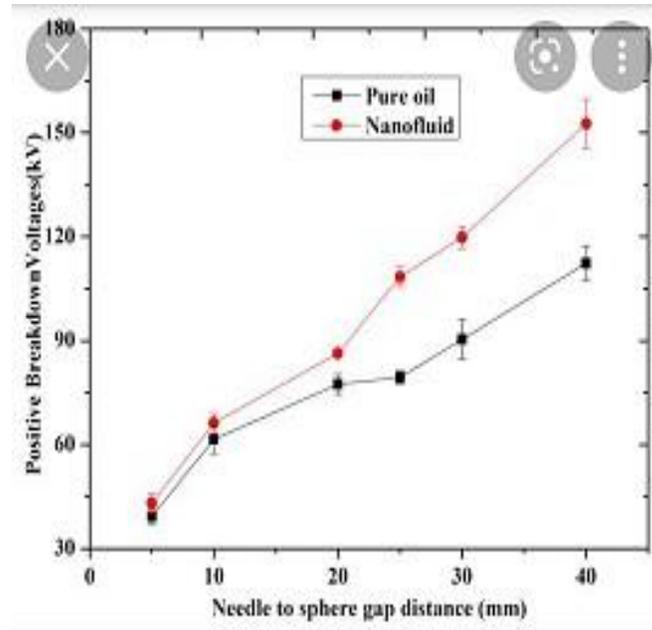
Specimen Calculations :

$$\text{Breakdown Voltage} = V_{\text{max}}/d$$

EXPERIMENTAL METHODOLOGY

1. DIELECTRIC STRENGTH OF TRANSFORMER OIL

Model Graphs :



Precautions :

1. Transformer Oil should be free from moisture content.
2. Nobody should go near the H.T bushing when the test being conducted.
3. Ignore the first one or two readings, as the air between the electrodes may not ionize.
4. The equipment must be grounded firmly.
5. The electrodes must be cleaned properly before and after the use.
6. Don't touch the equipment without grounding it with the grounding rod.

Experimental Methodology sheet

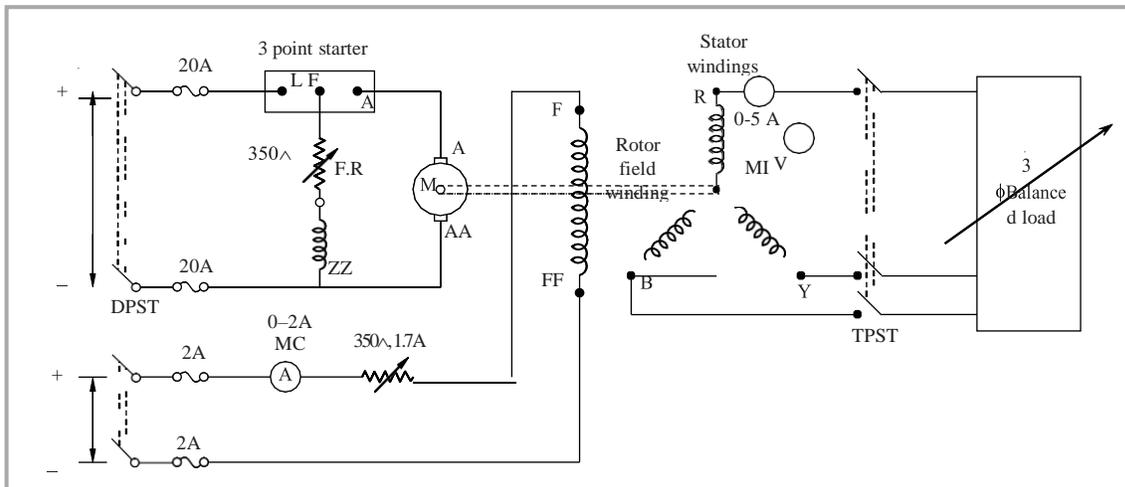
Load Test on Three Phase alternator

1. Description

The setup for this experiment requires the following equipment

Name	Specifications/ Range	No	Purpose
Voltmeter	0-600 V	1 no	To observe the voltage across stator line voltage
Ammeter	0-5 A	1 No	To observe the load current
Ammeter	0-2 A	1 No	To observe the alternator field current
Rheostat	350Ω,1.7 A	2 No	To adjust the motor speed and load voltage
Load	3-phase	1 No	To vary the load on the Alternator
Tacho meter		1 No	To measure the motor speed
Connecting wires		Required number	To make the connections and interconnection to equipment

2.CIRCUIT DIAGRAM:



3. THEORY:

When alternator is loaded its terminal voltage changes. The change in terminal voltage depends on load current and power factor of the load. In resistive and inductive loads terminal voltage decreases but in capacitive load, terminal voltage increases. The factors which affect the terminal voltage are:

- Armature resistance
- Leakage reactance and
- Armature reaction.

Formulae:

$$\% \text{voltage regulation} = \frac{E_0 - V}{V} \times 100$$

E_0 = No load terminal voltage

V = Load voltage

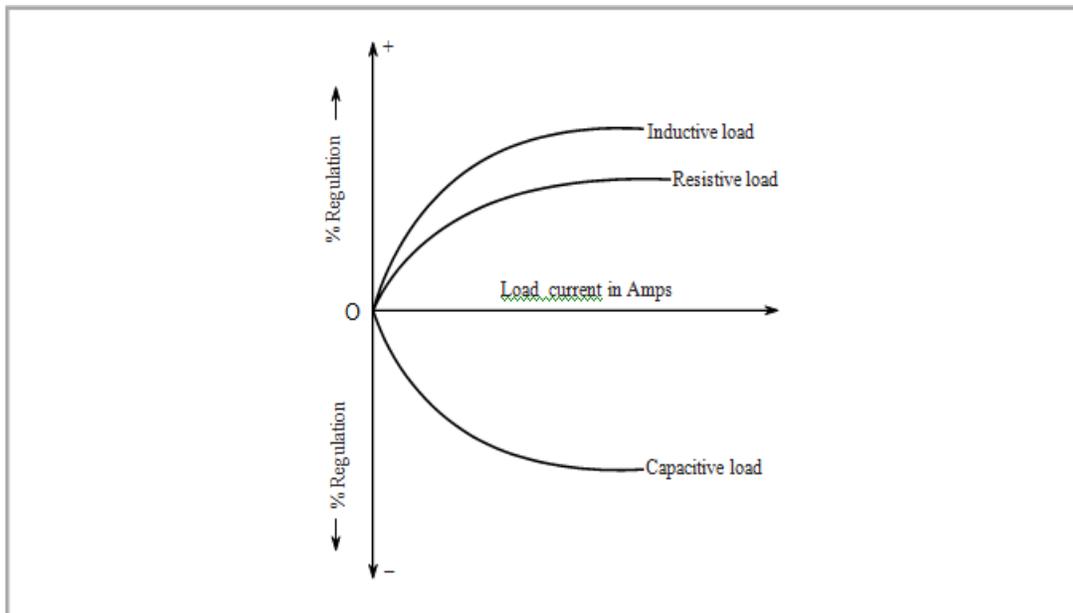
4. Procedure:

1. Connections are made as per the circuit diagram.
2. Start the D.C motor by means of its starter.
3. Adjust the speed of the motor equal to the rated speed with the help of motor field regulator.
4. Close the switch of the excitation circuit of the alternator.
5. Adjust the excitation field current to such a value which gives rated terminal voltage. Note this no load voltage.
6. Load the alternator in steps up to rated value keep the speed of the set constant at each load.
7. Note the corresponding meter readings at each load condition.
8. Repeat step No 4 to 7 for different loads such as inductive (lagging p.f) and capacitive (leading p.f) loads.

5.OBSERVATIONS:

S.No	Resistive (unity p.f.) load			Inductive (lagging p.f.) load			Capacitive (leading p.f.) load		
	Load Current I_L (Amps)	Load Voltage V (Volts)	%Regulation $E_o - V$ $= \frac{V}{V} \times 100$	Load Current I_L (Amps)	Load Voltage V (Volts)	%Regulation $E_o - V$ $= \frac{V}{V} \times 100$	Load Current I_L (Amps)	Load Voltage V (Volts)	%Regulation $E_o - V$ $= \frac{V}{V} \times 100$
1.									
2.									
3.									
4.									
5.									
6.									

6.GRAPHS:



7.CALCULATIONS:

No load voltage $E_0 =$ _____ V

Load current $I_L =$ _____ A

Load voltage, $V =$ _____ V

%voltage regulation = $\frac{E_0 - V}{V} \times 100 =$ _____ %

8.PRECAUTIONS:

1. Ensure working conditions of windings of machines, preferred meters and connected starters.
2. Check the connections as per the circuit diagram without any loose connections.
3. Check the minimum and maximum positions of rheostat whether placed in correct position or not
4. Initially all load switches are open position
5. The DC motor field regulator should be in minimum position at starting condition.
6. Apply the load in stepwise within the rated current of machine
7. Take the reading without parallax errors.

9.ASSESSMENT QUESTIONS :

1. Draw the circuit diagram for conducting the Load Test On an alternator.
2. Find the Regulation of an alternator by conducting the suitable Test.

METHODOLOGY

REGULATION OF 3- ϕ ALTERNATOR BY SYNCHRONOUS IMPEDENCE METHOD

1. DESCRIPTION

The setup for this experiment requires the following equipment as per specifications of machines
3 ϕ alternator coupled to a D.C motor

3 ϕ Alternator (3.5 kVA, 415 V, 5 A, 1500 rpm)
KVA :
Voltage :
Current
Speed :

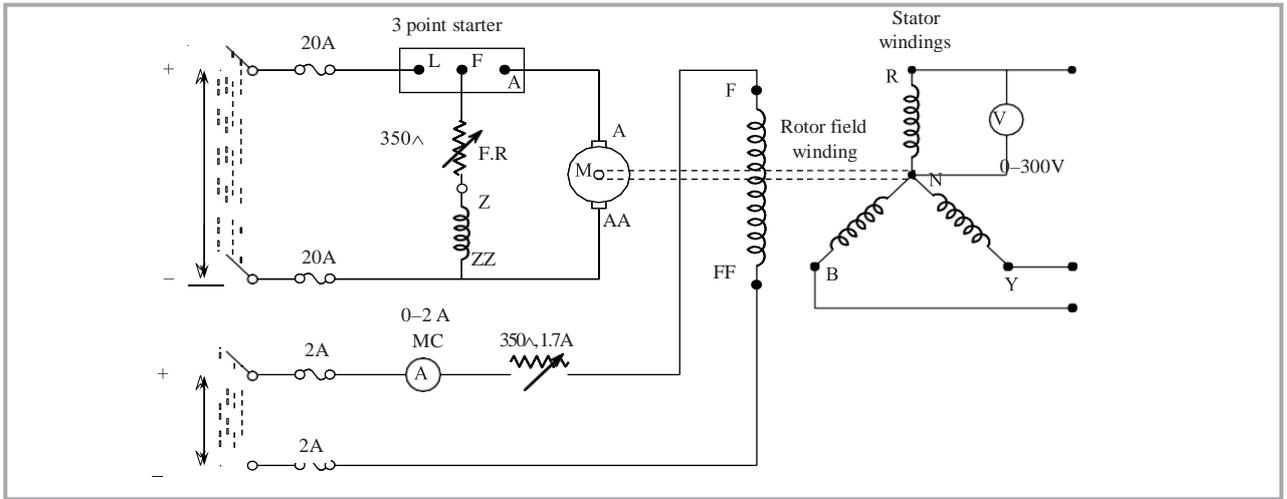
DC Shunt Motor (5 HP, 230 V, 17 A, 1500 rpm)
HP :
Voltage :
Current :
Speed :

2. APPARATUS REQUIRED

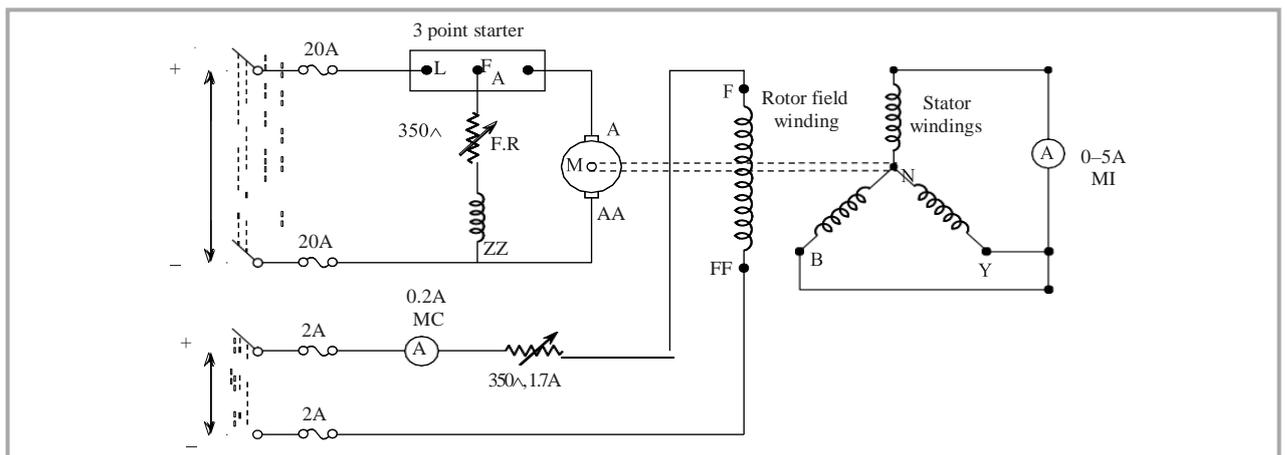
Sl.no.	Name	Specifications/ Range	quantity	Purpose
1.	Voltmeter	0-300 V , MI	1 No	To observe open circuit phase voltage V_{oc} .
2.	Voltmeter	0-30 V , MC	1 No	To observe voltage at winding terminals
3.	Ammeter	0-2 A , MC	1 No	To observe excitation current I_f
4.	Ammeter	0-5 A , MI	1 No	To observe short circuit current I_{sc} and to observe current in armature resistance test
5.	Rheostat	350 Ω , 1.7 A Wire wound	2 No's	To regulate speed and excitation
6.	Tachometer	Digital	1 No	To measure speed of machine
7.	Connecting wires	-	Required No	To make connections

3. CIRCUIT DIAGRAM

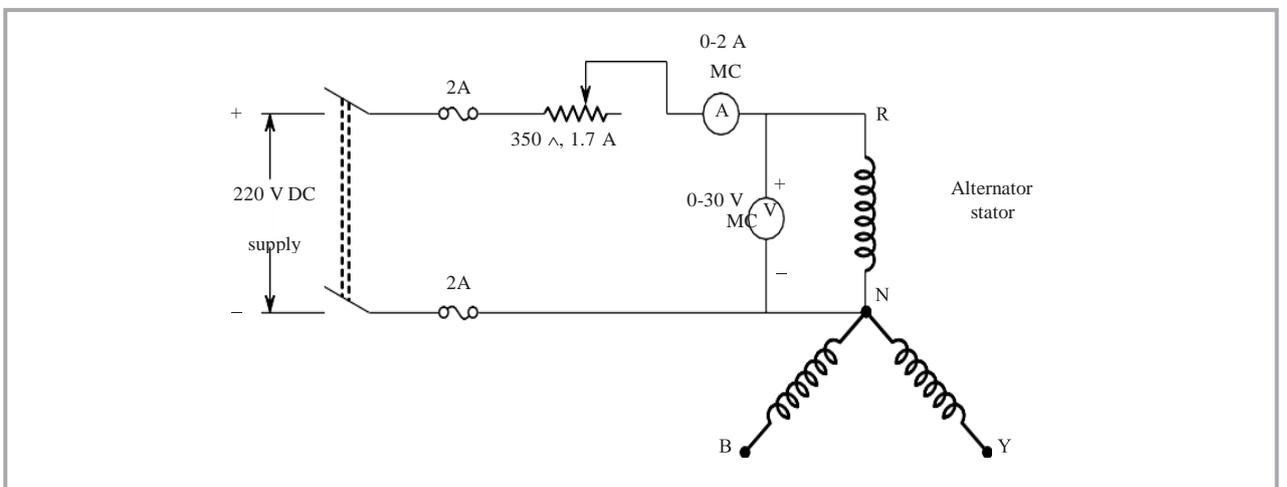
a. OC TEST



b. SC TEST



c. ARMATURE RESISTANCE TEST



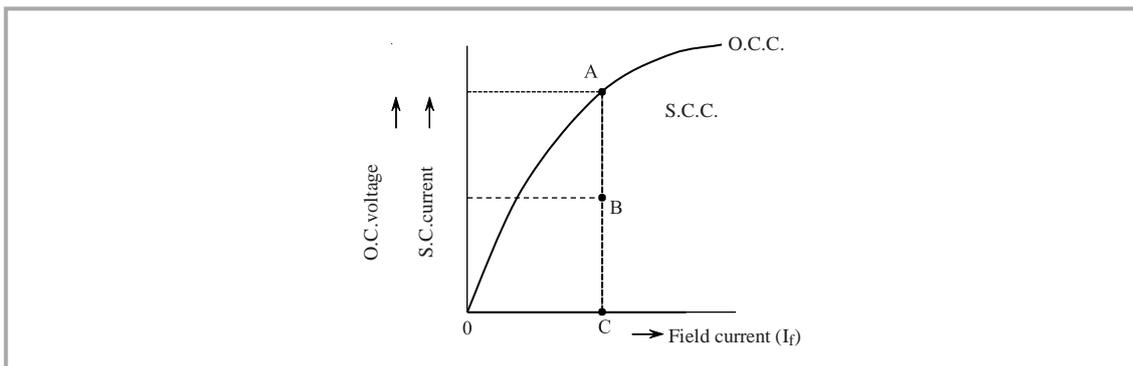
4. THEORY

Voltage Regulation by Synchronous Impedance Method:

The method is also called as EMF method. This method requires:

- (i) Opencircuitcharacteristics(O.C.voltageVsFieldcurrent)
- (ii) Shortcircuitcharacteristics(S.C.currentVsFieldcurrent)
- (iii) The armature resistance per phase(R_a)

The synchronous impedance of an alternator can be determined using the open circuit and short circuit characteristics of the alternator shown in Fig., below.



1. Consider OC is the normal field current, then BC gives S.C. current I_{SC} corresponding to this current on the S.C.C.
2. And 'AC' gives the open circuit voltage per phase on the O.C. for the same excitation.
3. Then the synchronous impedance, Z_S can be calculated as:

$$Z_S = \frac{\text{O.C Voltage}}{\text{S.C Current}} \quad \text{for same excitation}$$

$$Z_S = \frac{AC \text{ (in volts)}}{BC \text{ (in amps)}}$$

$$\text{And synchronous reactance, } X_S = \sqrt{Z_S^2 - R_a^2}$$

Where R_a is the effective armature resistance per phase
No load induced emf,

$$E_o = \sqrt{(V \cos \phi + IR_a)^2 + (V \sin \phi \pm IX_s)^2}$$

+ ve sign for lagging p.f and

- ve sign for leading p.f

$$\% \text{ Regulation} = \frac{E_o - V}{V} \times 100$$

V

4. PROCEDURE

OC TEST:

1. Connections are made as per the circuit diagram.
2. Start the DC motor by means of its Starter.
3. Adjust the speed of the motor equal to the rated speed with the help of motor field regulator.
4. Close the switch of the excitation circuit of the alternator.
5. Then by varying the excitation current in steps, the readings of field ammeter and voltmeter (O.C. voltage) are noted and tabulated.

SC TEST:

1. Connections are made as per the circuit diagram.
2. Start the DC motor by means of its Starter.
3. Adjust the speed of the motor equal to the rated speed with the help of motor field regulator.
4. After closing the switch in the excitation circuit, slowly change excitation current so that the full load armature current flows.
5. Readings of the field ammeter (excitation current) and armature current are noted and tabulated.

ARMATURE RESISTANCE TEST:

1. Connections are made as per the circuit diagram.
2. Keep the Rheostat in the maximum position and switch 'ON' the supply.
3. Note down the ammeter and voltmeter readings.
4. Vary the Rheostat slowly in steps up to rated value, note down corresponding meter readings at every step.
5. Switch 'OFF' the supply after bringing the Rheostat to the initial state.

5. OBSERVATION

:

OC TEST

S.No.	Field Current I_f (Amps)	O.C. Voltage (or) induced emf/phase E_{ph} (Volts)
1.		
2.		
3.		
4.		
5.		
6.		

SC TEST

S.No	Field Current I_f (Amps)	O.C. Voltage (or) induced emf/phase E_{ph} (Volts)
1.		

ARMATURE RESISTANCE TEST

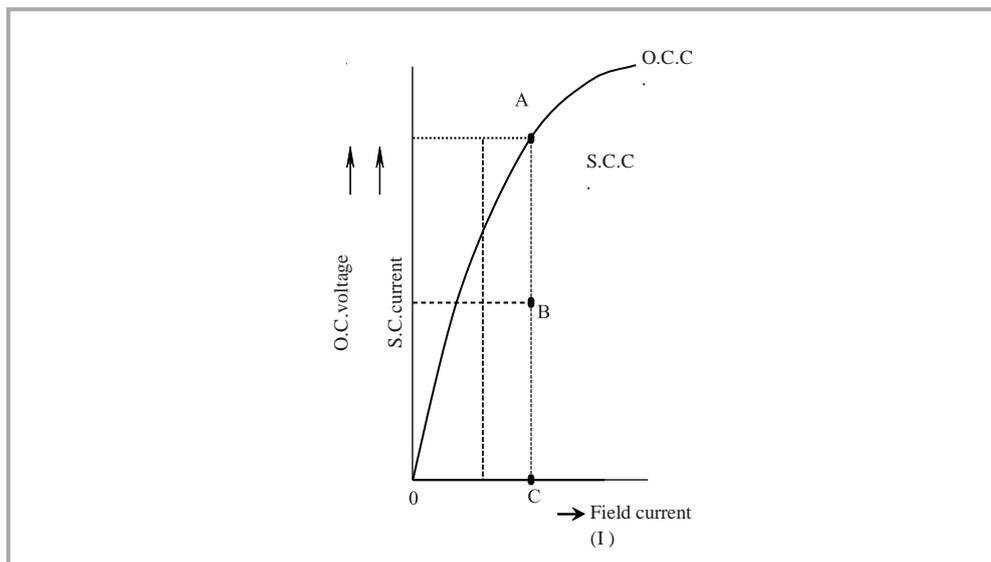
S.No	Voltage Reading V_{dc} (Volts)	Ammeter Reading I_{dc} (Amps)	Armature Resistance $R_{dc} = \frac{V_{dc}}{I_{dc}}$ (ohms)
1.			
2.			
3.			
4.			
		Average value	$R_{dc} = \text{_____} \Omega$

The effective ac resistance, $R_a = 1.6 R_{dc} = \text{_____} \Omega$

6. GRAPH:

The following graphs can be drawn:

- (i) Open circuit characteristics (O.C.C) - Field current, I_f Vs O.C Voltage/Phase, E_{ph} .
- (ii) Short circuit characteristics (S.C.C) -Field current, I_f Vs S.C Current, I_{SC} .



7. CALCULATION

1. The effective ac resistance, $R_a = \underline{\hspace{2cm}} \Omega$
2. From graph

Synchronous impedance $Z_s = \frac{OC \text{ voltage, } V_o}{SC \text{ current, } I_c}$ *at same field current*

$$Z_s = \underline{\hspace{2cm}} \Omega$$

3. synchronous reactance $X_s = \sqrt{Z_s^2 - R_a^2}$

=

4. Voltage/Phase, $V = \underline{\hspace{2cm}} V$

F.L. Current, $I = \underline{\hspace{2cm}} A$

No. Load terminal voltage,

$$E_o = \sqrt{(V \cos \phi + IR_a)^2 + (V \sin \phi \pm I X_s)^2}$$

('+' Sign for lagging and '-' sign for leading p.f.

=

5. % Regulation = $\frac{E_o - V}{V} \times 100 =$

8. PRECAUTIONS

1. Ensure working condition of windings of machines , preferred meters and connected starters.
2. Do not start and stop the alternator with load.
3. Operate the 3 point starter slowly.
4. Do not exceed the rated current.
5. The DC motor field regulator should be in the minimum position at starting condition.
6. Initially all switches are in open position.
7. Avoid loose connections and wrong connections.
8. Take readings without parallax errors.

9. EXERCISE QUESTIONS

Level-A

1. Draw the circuit diagram of OC test of alternator.
2. Draw the circuit diagram of SC test of alternator.
3. Draw the circuit diagram of armature resistance test of alternator.
4. Identify various terminals in synchronous impedance method of alternator.
5. Mention the correct range and type of equipment used in synchronous impedance method of alternator.
6. Handle the DPST switch, rheostats in synchronous impedance method of alternator.

Level-B

1. Read given circuit diagram and make the connections.
2. Handle 4-point starter and observe the readings in ammeter and voltmeter for different tests.

Level-C

1. Record the reading of OC test, SC test.
2. Find the armature resistance of alternator.
3. Draw OCC and SCC and find Z_s .
4. Calculate no load voltage and regulation.

Experimental Methodology Sheet

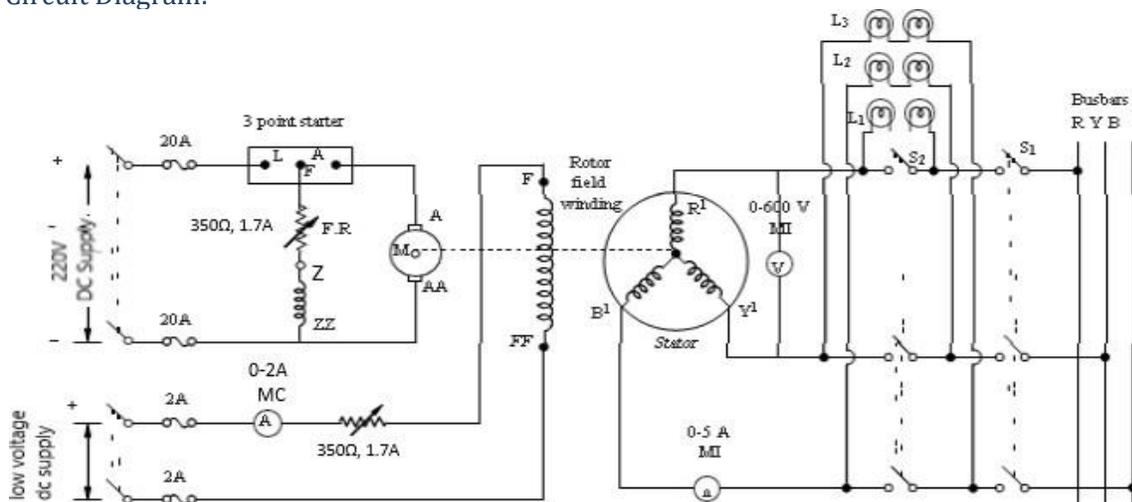
SYNCHRONIZATION OF ALTERNATORS

1. Description

The setup for this experiment requires the following equipment

Name		Specifications/ Range	No	Purpose
3 ϕ alternator coupled to a DC motor	3 ϕ alternator	3.5 KVA, 415 V, 5A, 1500 rpm	1	To conduct experiment
	DC shunt motor (prime mover)	5 HP, 230 V, 17 A, 1500 rpm		
Voltmeter (MI)		(0-600)V	1	To observe line voltage across alternator
Ammeter (MI)		(0-5)A	1	To observe Line current
Ammeter (MC)		(0-2)A	1	To observe field current of alternator
Rheostat (Wire wound)		350 Ω , 1.7A	2	To adjust motor speed to rated value and to adjust field current of alternator
Tachometer (Digital)		0 to 5000 RPM	1	To measure the motor speed
Incandescent lamps			6	To observe the condition of synchronization
Connecting Wires		Red, Green, Blue, Yellow and Black 3/20 gauge, suitable lengths	As per the need	To make connections and interconnections to equipment

2. Circuit Diagram:



3. Theory

The process of connecting an alternator in parallel with another alternator or with the common busbars is called synchronizing.

The following are the conditions for synchronization of alternators:

1. The terminal voltage of the incoming alternator must be equal to the busbar voltage.
2. The frequency of the alternator must be equal to the busbar frequency.
3. The phase of the incoming machine voltage must be same as the phase of the busbar relative to the load.
4. For a 3 phase alternator, the phase sequence of the incoming machine is the same as that of the busbars.

The synchronizing of an alternator with the busbar is accomplished by the following methods :

- (i) Three dark lamp method.
- (ii) Two bright lamps and one dark lamp method.

4. Procedure

1. Connections are made as per circuit diagram. Three lamps L₁, L₂, L₃ are connected between RR', YB' and BY'.
2. Prime mover of the alternator is brought up to its rated speed.
3. The field current of the alternator is varied till the voltmeter reads the busbar voltage.
4. Close the switch S₁ to observe the frequency difference between incoming alternator and busbars.
5. Adjust the speed of the alternator slowly so that the lamp L₁ is dark and cross connected Lamps L₂ and L₃ are equally bright.
6. At the middle of the period when lamp L₁ is dark and lamps L₂ and L₃ are bright, close the synchronizing switch S₂ to synchronize busbar with alternator.

Note :

- (i) The alternators are generally rated for high voltage and the lamps available are of low voltage so more than one lamp are used in series.
- (ii) If incoming alternator is running fast, the lamp L₁ starts glowing, lamp L₂ will be less bright than lamp L₃ and if incoming alternator is too slow, lamp L₂ will be more bright than lamp L₃.
- (iii) When the lamps connected across two different phases i.e., RY', YB', and BR'. In that case switch 'ON' the synchronising switch at the time all three lamps are fully bright.

5. Precautions:

1. Ensure that all switches are in open position.
2. Check for the polarity and continuity of winding connections of the machine.
3. Check for the correct range of meters
4. Check the working condition of meters and starters.
5. The motor field rheostat should be in minimum position at start.
6. The rotor field rheostat of alternator should be in maximum position at start.
7. Observe readings without any parallax error.
8. Close the synchronizing switch S_2 at correct instant by observing lamps.
9. After experiment is done, open the synchronizing switch S_2 , switch off the 3 phase supply (S_1) and bring rheostats to starting position and switch off the dc supply.

6. VIVA QUESTIONS :

- 1) What is meant by Synchronization?
- 2) What is the need for Synchronization?
- 2) What are the conditions of synchronization of alternators?
- 3) What are the possible effects of wrong synchronization?
- 4) What are the different methods for synchronization?
- 5) What are the advantages and disadvantages of this method of synchronization?
- 6) Why a lamp pair is required in this experiment?
- 7) Where Synchronization of alternators is used?

7. Exercise questions:

Level-A

1. Draw the circuit diagram for synchronization of Alternators.
2. Identify various terminals in synchronization of Alternators.
3. Mention the correct range and type of equipment used in Synchronization of Alternators.
4. Handle the DPST switch and TPST switches.

Level-B

1. Read the given circuit diagram and make the connections.
2. Handle 3-point starter .
3. Set the correct positions of rheostats before starting experiment.
4. Observe the readings in ammeter and voltmeter.

Level-C

1. Adjust the field rheostat of dc motor to rated speed.
2. Adjust the rotor field rheostat till voltmeter reads busbar voltage.
3. Adjust the speed of alternator for bright lamp condition for synchronization.

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DIPLOMA EXAMINATIONS – PRACTICALS

C20 – EE-409A – ELECTRICAL MACHINES - II LABORATORY

Duration: 11/2 hours

Formative Assessment – 1

Maximum Marks: 60

Instructions:

- I. Any one question is allotted by the lottery system.
- II. Each question carries three sub questions: a, b and c of total 54 marks.
- III. Viva carries 06 marks.
- IV. Perform the test with standard safety procedures by the use of right tools.

1	(a) Draw the circuit diagram to operate the two single phase Transformers in parallel.	10 M	CO1
	(b) Make the electrical wiring circuit to find the efficiency of a 1- Φ transformer at the given load currents.	20 M	CO1
	(c) Perform and find the losses of a given 1- Φ transformer from the given wiring circuit.	24 M	CO1
2	(a) Draw the circuit diagrams of open circuit and short circuit for a given 1- Φ transformer.	10 M	CO1
	(b) Make the electrical wiring circuit to conduct two transformers in parallel.	20 M	CO3
	(c) Perform and plot the efficiency curve for a given electrical 1- Φ transformer wiring circuit.	24 M	CO1
3	(a) Draw the circuit diagram to find the efficiency at HALF-LOAD for a given 1- Φ transformer.	10 M	CO1
	(b) Make the electrical wiring circuit to find the equivalent circuit values for a given 1- Φ transformer.	20 M	CO1
	(c) Perform to find the regulation of a given electrical 1- Φ transformer wiring circuit at different loads.	24 M	CO2
4	(a) Draw the circuit diagram to find the efficiency of two identical transformers at a time.	10 M	CO2
	(b) Make the electrical wiring circuit to find iron and copper losses for a given 1- Φ transformer.	20 M	CO1
	(c) Perform and plot the efficiency curve for a given electrical 1- Φ transformer wiring circuit.	24 M	CO1
5	(a) Draw the circuit diagram to obtain two single phase currents from the given 3- Φ supply. (SCOTT Connection)	10 M	CO2
	(b) Make the electrical wiring circuit to find the regulation of a given electrical 1- Φ transformer.	20 M	CO1
	(c) Perform and plot the efficiency curve for a given electrical 1- Φ transformer wiring circuit connection.	24 M	CO1

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DIPLOMA EXAMINATIONS – PRACTICALS

C20 – EE-409A – ELECTRICAL MACHINES - II LABORATORY

Duration: 1 1/2 hours

Formative Assessment – 1

Maximum Marks: 60

- | | | | | |
|-----|-----|--|------|-----|
| 6 . | (a) | Draw the circuit diagram to find the regulation of a given 1- Φ transformer. | 10 M | CO1 |
| | (b) | Make the electrical wiring connections to operate two 1- Φ transformers in parallel. | 20 M | CO3 |
| | (c) | Perform and find the losses of a given 1- Φ transformers from the given wiring circuit. | 24 M | CO2 |

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DIPLOMA EXAMINATIONS – PRACTICALS

C20 – EE-409A – ELECTRICAL MACHINES - II LABORATORY

Duration: 1 1/2 hours

Formative Assessment – 2

Maximum Marks: 60

Instructions:

- I. Any one question is allotted by the lottery system.
- II. Each question carries three sub questions: a, b and c of total 54 marks.
- III. Viva carries 06 marks.
- IV. Perform the test with standard safety procedures by the use of right tools.

- | | | | | |
|---|-----|---|------|-----|
| 1 | (a) | Draw the circuit diagram to operate the two given transformers in parallel. | 10 M | CO3 |
| | (b) | Make the wiring circuit to conduct load Test on a given Alternator. | 20 M | CO4 |
| | (c) | Perform the operation of synchronization of an Alternator using Bright lamp Method. | 24 M | CO4 |
| 2 | (a) | Draw the circuit diagram to conduct load test on an Alternator to find its regulation. | 10 M | CO4 |
| | (b) | Make the wiring connections to operate the two given 1- Φ transformers in parallel. | 20 M | CO3 |
| | (c) | Perform and find the regulation of an Alternator using Synchronous Impedance method from the given wiring connection. | 24 M | CO4 |
| 3 | (a) | Draw the circuit diagram to synchronize an Alternator the given supply. | 10M | CO4 |
| | (b) | Make the wiring circuit to conduct load test on a given Alternator. | 20 M | CO4 |
| | (c) | Perform the polarity test on a given electrical wiring circuit. | 24 M | CO3 |

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DIPLOMA EXAMINATIONS – PRACTICALS

C20 – EE-409A – ELECTRICAL MACHINES - II LABORATORY

Duration: 11/2 hours

Formative Assessment – 2

Maximum Marks: 60

- | | | | | |
|---|-----|--|------|-----|
| 4 | (a) | Draw the circuit diagram to find the dielectric strength. Of a given Transformer oil. | 10 M | CO3 |
| | (b) | Make the connections to operate the two given 1- Φ Transformers in parallel. | 20 M | CO3 |
| | (c) | Perform and find the regulation of an Alternator from the given Wiring Connections. | 24 M | CO4 |
| 5 | (a) | Draw the circuit diagram to find the regulation of an alternator. | 10 M | CO4 |
| | (b) | Make the connections to synchronize an alternator using Dark lamp method. | 20 M | CO4 |
| | (c) | Find the dielectric strength. Of a given Transformer oil by conducting Suitable Test and suggest your recommendations for improvement of dielectric strength of Oil. | 24 M | CO3 |
| 6 | (a) | Draw the circuit diagram operate the given transformers in parallel. | 10 M | CO3 |
| | (b) | Make the connections to synchronize the given Alternator using bright lamp method. | 20 M | CO4 |
| | (c) | Find the regulation of alternator by using EMF method or Pessimistic method. | 24 M | CO4 |

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DIPLOMA EXAMINATIONS – PRACTICALS

C20 – EE-310 – ELECTRICAL CIRCUITS AND MEASURING INSTRUMENTS LAB

Duration: 11/2 hours

Summative Assessment

Maximum Marks: 60

Instructions:

- I. Any one question is allotted by the lottery system.
- II. Each question carries three sub questions: a, b and c of total 54 marks.
- III. Viva carries 06 marks.
- IV. Perform the test with standard safety procedures by the use of right tools.

1	(a)	Draw the circuit diagrams of open circuit and short circuit for a given 1- Φ transformer.	10 M	CO1
	(b)	Make the wiring connections to operate the two given 1- Φ transformers in parallel.	20 M	CO3
	(c)	Perform to find the regulation of a given electrical 1- Φ transformer wiring circuit at different loads.	24 M	CO1
2	(a)	Draw the circuit diagram to synchronize an Alternator to the given supply.	10 M	CO4
	(b)	Make the electrical wiring circuit to conduct two transformers in parallel.	20 M	CO3
	(c)	Find the regulation of alternator by using EMF method or Pessimistic method.	24 M	CO4
3	(a)	Draw the circuit diagram to obtain two single phase currents from the given 3- Φ supply. (SCOTT Connection)	10 M	CO2
	(b)	Make the connections to synchronize an alternator using Dark lamp method.	20 M	CO4
	(c)	Find the dielectric strength. Of a given Transformer oil by conducting Suitable Test.	24 M	CO3
4	(a)	Draw the circuit diagram to find the efficiency of two identical transformers at a time.	10 M	CO2
	(b)	Make the electrical wiring circuit to find iron and copper losses for a given 1- Φ transformer.	20 M	CO1
	(c)	Make the electrical wiring circuit to find iron and copper losses for a given 1- Φ transformer.	24 M	CO1

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DIPLOMA EXAMINATIONS – PRACTICALS

C20 – EE-310 – ELECTRICAL CIRCUITS AND MEASURING INSTRUMENTS LAB

Duration: 11/2 hours

Summative Assessment

Maximum Marks: 60

- | | | | | |
|---|-----|---|------|-----|
| 5 | (a) | Draw the circuit diagram to find the efficiency at HALF-LOAD for a given 1- Φ transformer. | 10 M | CO1 |
| | (b) | Make the connections to synchronize the given Alternator using bright lamp method. | 20 M | CO4 |
| | (c) | Perform and plot the efficiency curve for a given electrical 1- Φ transformer wiring circuit. | 24 M | CO1 |
| 6 | (a) | Draw the circuit diagram to obtain two single phase currents from the given 3- Φ supply.(SCOTT Connection) | 10 M | CO3 |
| | (b) | Make the connections to operate the two given 1- Φ Transformers in parallel. | 20 M | CO2 |
| | (c) | Perform the polarity test on a given electrical wiring circuit. | 24 M | CO3 |