METHODIST

Estd:2008

COLLEGE OF ENGINEERING AND TECHNOLOGY

(Affiliated to Osmania University&Approved by AICTE, New Delhi)

LABORATORY MANUAL

ELECTRICAL MACHINES -I LABORATORY

BE, IV Semester (AICTE): 2021-22

NAME: ____

ROLL NO:____________________________________

BRANCH:____________________________________

SEM:________________________________

DEPARTMENT OF ELECTRICAL AND ELECTRONCS ENGINEERING

Empower youth- Architects of Future World

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COLLEGE OF ENGINEERING AND TECHNOLOGY

VISION

To produce ethical, socially conscious and innovative professionals who would contribute to sustainable technological development of the society.

MISSION

To impart quality engineering education with latest technological developments and interdisciplinary skills to make students succeed in professional practice.

To encourage research culture among faculty and students by establishing state of art laboratories and exposing them to modern industrial and organizational practices.

To inculcate humane qualities like environmental consciousness, leadership, social values, professional ethics and engage in independent and lifelong learning for sustainable contribution to the society.

DEPARTMENT
OF
ELECTRICAL AND ELECTRONICS ENGINEERING

LABORATORY MANUAL

ELECTRICAL MACHINES –I LABORATORY

Prepared
By

Mr. E. Saidulu,

Assistant Professor

Estd:2008

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION

To become a reputed centre for imparting quality education in Electrical and Electronics Engineering with human values, ethics and social responsibility.

MISSION

- To impart fundamental knowledge of Electrical, Electronics and Computational Technology.
- To develop professional skills through hands-on experience aligned to industry needs.
- To undertake research in sunrise areas of Electrical and Electronics Engineering.
- To motivate and facilitate individual and team activities to enhance personality skills.

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PROGRAM EDUCATIONAL OBJECTIVES

BE-Electrical Engineering graduates shall be able to:

- **PEO1**. Utilize domain knowledge required for analyzing and resolving practical Electrical Engineering problems.

- **PEO2**.Willing to undertake inter-disciplinary projects, demonstrate the professional skills and flair for investigation.
- **PEO3**. Imbibe the state of the art technologies in the ever transforming technical scenario.

- **PEO4**. Exhibit social and professional ethics for sustainable development of the society.

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PROGRAM OUTCOMES

Engineering Graduates will have ability to:

- **PO1. Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of electrical and electronics engineering problems.
- **PO2. Problem analysis:** Identify, formulate, review research literature, and analyze complex electrical and electronics engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **PO3. Design/development of solutions:** Design solutions for complex electrical and electronics engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- **PO4. Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **PO5. Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex electrical and electronics engineering activities with an understanding of the limitations.
- **PO6. The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional electrical and electronics engineering practice.
- **PO7. Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **PO.8 Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the electrical and electronics engineering practice.
- **PO9. Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- **PO10. Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- **PO11. Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **PO12. Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

At the end of BE program Electrical and Electronics Engineering graduates will be able to:

- **PSO1.**Provide effective solutions in the fields of Power Electronics, Power Systems and Electrical Machines using MATLAB/MULTISIM.
- **PSO2.** Design and Develop various Electrical and Electronics Systems, particularly Renewable Energy Systems.
- **PSO3.** Demonstrate the overall knowledge and contribute for the betterment of the society.

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I. PREREQUISITE(S):

Level	Credits	Semester	Prerequisites
UG	1	1	Electrical machines-1

II. SCHEME OF INSTRUCTIONS

Lectures	Tutorials	Practicals	Credits
0	0	2	1

III. SCHEME OF EVALUATION & GRADING

S. No	Component	Duration	Maximum Marks
	Continuous Internal Evaluation (CIE)		
1.	Internal Examination – I and II	1 hour each	25
	CIE (Total)		**25**
2.	**Semester End Examination** (University Examination)	3 hours	**50**
		TOTAL	**75**

%Marks Range	>=90	80 to < 90	70 to < 80	60 to < 70	50 to < 60	40 to < 50	< 40	Absent
Grade	S	A	B	C	D	E	F	Ab
Grade Point	10	9	8	7	6	5	0	-

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COURSE OUTCOMES

After completing this course the student will be able to:

CO. No	Course Outcomes	Taxonomy Level
C455.1	Apply and Conclude the principles of Electrical Machines through laboratory experimental work.	**Evaluate**
C455.2	Construct the circuit to perform experiments, measure, analyze the observed data & come to a conclusion.	**Apply**
C455.3	Organize reports based on performed experiments with effective demonstration of diagrams and characteristics /graph	**Apply**
C455.4	Demonstrate the starting & speed control of various DC motors	**Understand**
C455.5	Determine efficiency & voltage regulation of electrical machines by various test.	**Evaluate**
C455.6	Compare the performance characteristics of different electrical machines.	**Analyze**

MAPPING OF COs WITH POs & PSOs

Correlation Level: High – 3; Medium – 2; Low – 1

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS0 1	PSO 2	PSO3
C455.1	3	3	2	-	-	-	-	3	3	3	-	-	2	2	3
C455.2	3	2	-	-	-	-	-	3	3	3	-	-	2	2	3
C455.3	3	2	-	-	-	-	-	3	3	3	-	-	2	2	3
C455.4	2	1	-	-	-	-	-	3	3	3	-	-	2	2	3
C455.5	3	3	2	-	-	-	-	3	3	3	-	-	2	2	3
C455.6	3	3	1	2	-	-	-	3	3	3	-	-	2	2	3
C455	2.8	2.3	1.5	1.7	-	-	-	3	3	3	-	-	2	2	3

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LABORATORY CODE OF CONDUCT

1. Students should report to the labs concerned as per the scheduled time table.
2. Students, who report late to the labs will not be permitted to perform the experiment scheduled for the day.
3. Students to bring a 100 pages note book to enter the readings /observations while performing the experiment.
4. After completion of the experiment, certification of the staff in-charge concerned, in the observation book is necessary.
5. Staff member in-charge shall evaluate for 25 marks, each experiment, based on continuous evaluation which will be entered in the continuous internal evaluation sheet.
6. The record of observations, along with the detailed procedure of the experiment performed in the immediate previous session should be submitted for certification by the staff member in-charge.
7. Not more than three students in a group would be permitted to perform the experiment on the equipment-based lab set up. However only one student is permitted per computer system for computer-based labs.
8. The group-wise division made at the start of the semester should be adhered to, and no mix up with any other group would be allowed.
9. The components required, pertaining to the experiment should be collected from the stores in-charge, after duly filling in the requisition form / log register.
10. After the completion of the experiment, students should disconnect the setup made by them, and return all the components / instruments taken for the purpose, in order.
11. Any damage of the equipment or burn-out of components will be charged at cost as a penalty or the total group of students would be dismissed from the lab for the semester/year.
12. Students should be present in the lab for the total time duration, as scheduled.
13. Students are required to prepare thoroughly, before coming to Laboratory to perform the experiment.
14. Procedure sheets / data sheets provided to the students, if any, should be maintained neatly and returned after the completion of the experiment.

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DOS AND DON'TS IN THE LABORATORY

Dos

- All bags most be left at the indicated place.
- Shoes and apron must be worn at all times.
- Be as neat as possible. Keep the work area and workbench clear of items not used in the experiment.
- Always check to see that the power switch is OFF before plugging into the outlet. Also, turn instrument or equipment OFF before unplugging from the outlet.
- The lab timetable must be followed strictly.
- Be PUNCTUAL for your laboratory session.
- Experiment must be completed within the given time.
- Noise must be kept to a minimum.
- Handle all apparatus with care.

Don'ts

- No ungrounded electrical or electronic apparatus is to be used in the laboratory unless it is double insulated or battery operated.
- When unplugging a power cord, pull on the plug, not on the cable.
- Students are strictly PROHIBITED from taking out any items from the laboratory.

Before Leaving Lab:

- Place the stools under the lab bench.
- Turn off the power to all instruments.
- Return all the equipment to lab assistant.
- Turn off the main power switch to the lab bench.
- Please check the laboratory notice board regularly for updates.

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CONTENTS

Expt. No.1.MAGNETISATION CHARACTERISTICS OF SEPARATELY EXCITED DC GENERATOR

Aim: To obtain the open circuit magnetization characteristics (OCC) of a separately excited D.C generator and to find the following

a) Maximum Voltage built up

b) Critical field resistance

c) Critical speed

Apparatus:

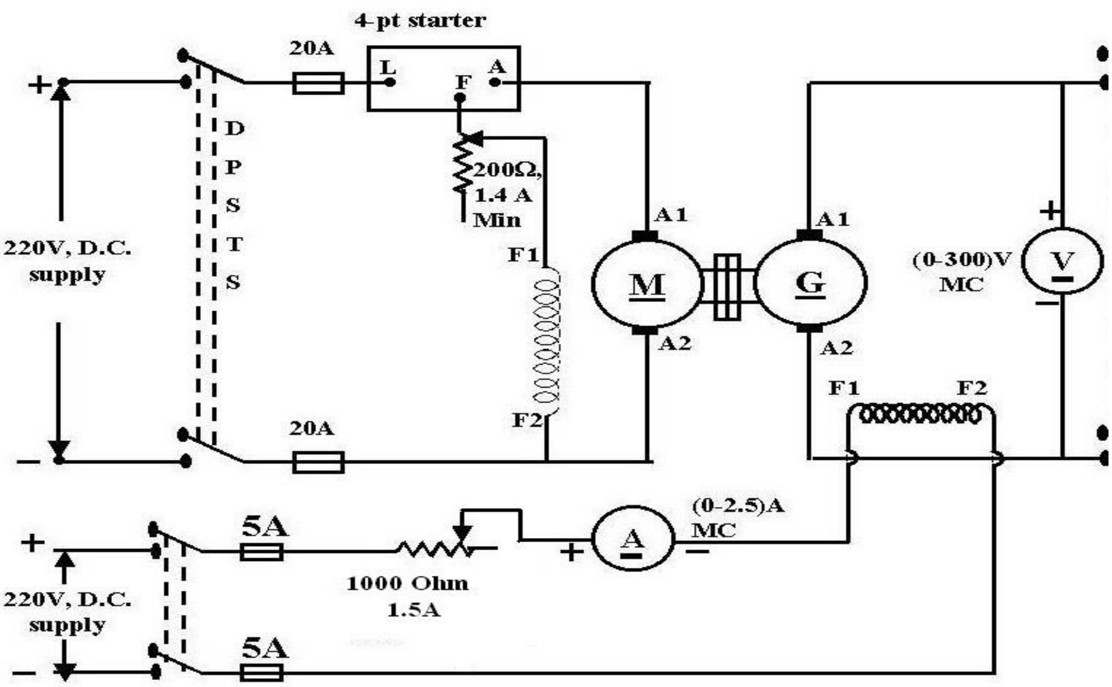
S. No	Apparatus	Range	Type	Qty
1	Voltmeter	0 – 300V	MC	1 No
2	Ammeter	0 – 2A (MC)	MC	1 No
3	Rheostat	600Ω/1.7A	Wire Wound	1 No
4	Tachometer	-	Digital	1 No

Theory:

This characteristic is also called as no load characteristic through which the generator performance parameters can be determined. This characteristic gives the value of maximum voltage the generator can give and to avoid the failure of excitation, the field winding resistance value which is called as critical field resistance can be determined. Also, the above parameters at various speeds can be determined. The basic set up for determining the above parameters is that the generator is run on separately excited condition. The basic requirement is that the prime mover ,the motor, is run at its rated speed and by varying the generator excitation in steps, the generator voltage is noted and the procedure is repeated in forward as well as reverse direction so that an observation can be made such the both the induced values will not be same. I_f is increased by suitable steps and the corresponding values of E_g are measured on plotting the relation between I_f& E_g, a curve of the form is shown in fig.

Due to residual magnetism in the poles, some emf is generated even when I_f =0. Hence the curve starts a little way up. The slight curve at the lower and is due to magnetic inertia. At low flux densities, reluctance of iron path being negligible the first part of the curve is practically straight. OCC for higher speed lie above the shown curve & low speed lie below it

Circuit Diagram:



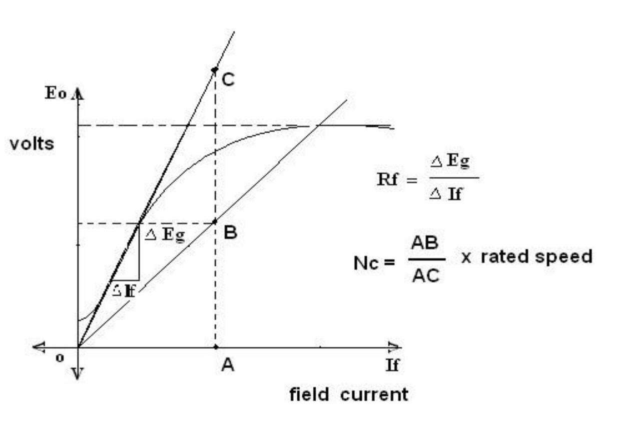
Procedure:

1. Choose the proper ranges of meters after noting the name plate details of the given machine and make the connections as per the circuit diagram.
2. Keep the motor field rheostat (R_f) in the minimum resistance position.
3. Keep the generator field rheostat (R_f) in the maximum resistance position.
4. The motor is started using the 3-point starter by slowly and carefully moving the starter handle from it's OFF to ON position.
5. Observe the speed of the generator using a tachometer and adjust to the rated value by varying the motor field rheostat.
6. Keep the same speed throughout the experiment.
7. Note down the terminal voltage of the generator. This is the e.m.f. due to residual magnetism.
8. Increase the generator field current I_f(ammeter) by gradually moving the rheostat for every value and note down the corresponding voltmeter reading. Increase the field current till induced e.m.f is about120%ofratedvalue.
9. Draw the characteristics of generated emf (E_g) versus field current (I_f).
10. Draw a tangent to the initial portion of O.C.C from the origin. The slope of this straight line gives the critical field resistance and also calculates critical speed.

Tabular Form:

Sl.No	Field Current (Amps)	Generated Voltage (Volts)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Expected waveforms:



Precautions:

1. Field rheostat of motor should be at minimum position.
2. Don’t switch on the supply without any load.
3. Take care while using the starter.
4. The speed should be adjusted to rated speed.
5. There should be no loose connections.
6. Avoid parallax errors and loose connections

Result:

Viva Questions:

1. Under what conditions does the DC shunt generator fail to self-excite?
2. OCC is also known as magnetization characteristic, why?
3. How do you check the continuity of field winding and armature winding?
4. How do you make out that the generator is DC generator without observing the nameplate?
5. Does the OCC change with speed?

Expt. No.2.LOAD CHARACTERISTICS OF DC SHUNT AND COMPOUND GENERATOR

Aim:

To obtain the internal and external characteristics of a DC shunt and compound generator

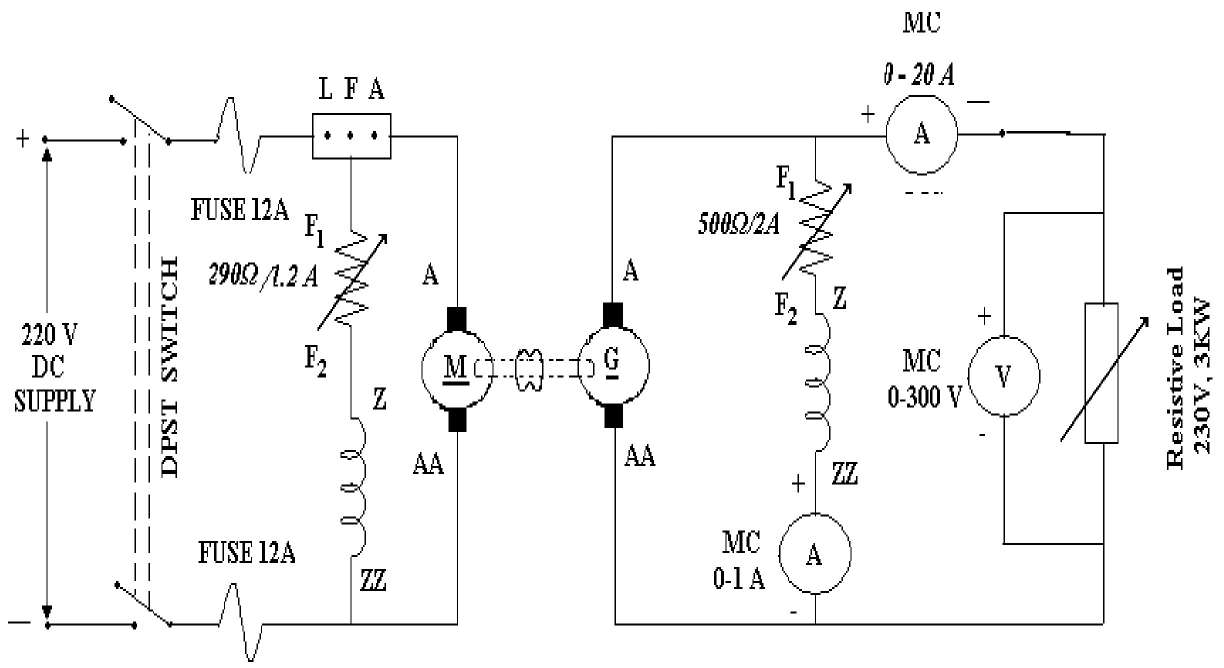
Apparatus:

S. No	Apparatus	Range	Type	Qty
1.	Rheostat	290Ω/1.2A	Wire Wound	1 No
2.	Rheostat	500Ω/2A	Wire Wound	1 No
3	Ammeter	0 – 1A	MC	1 No
4	Ammeter	0 – 20A	MC	1 No
5	Voltmeter	0 - 300V	MC	1 No
6.	Resistive load	3KW		1 No

Theory:

When the generator is loaded, the terminal voltage drops as the load current increases. This characteristic is called external characteristic. The graph is between the terminal voltage (V) and the load current (I_L). Ideally the characteristic should be horizontal line and the drop in terminal voltage is not desirable and should remain constant and should be independent of load. This situation is impossible unless the field current is automatically adjusted by an voltage regulator. The reasons for the drop in terminal of voltage are due to a) armature resistance b) armature reaction. The other characteristic is the graph between the induced emf (E) and the armature current (I_a).These characteristics give the performance indication of the shunt generator used. Also the characteristics give voltage regulation.

Circuit Diagram:



LOAD TEST ON SHUNT GENERATOR CIRCUIT DIAGRAM

Procedure:

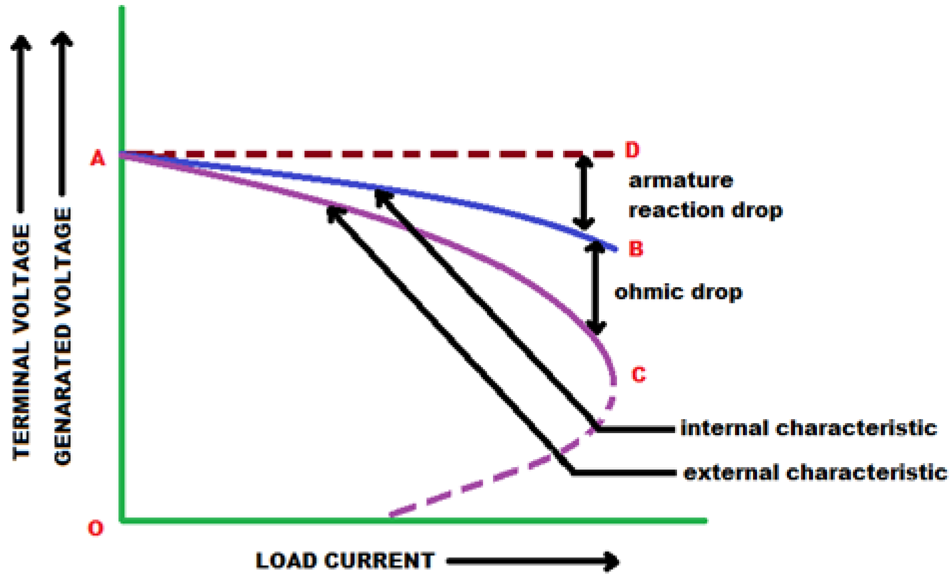
1. Note down the nameplate readings and give the connections as per the circuit diagram.
2. Keep the field resistance of the motor minimum and generator maximum.
3. Start the DC motor and run the generator at the rated speed and keep it constant throughout the experiment.
4. Keep the load switch in open condition adjusts the voltage of the generator to rated voltage by adjusting the field regulator of the generator.
5. Switch on the loads one by one and note down the corresponding readings**.**
6. Measure the Armature Resistance.
7. Plot the graph between load voltage & load current to get external characteristics and between generated emf 'E_g' & armature current to get internal characteristics.

Tabular Form:

R_A = ------------------ ohm

S.NO	VOLTAGE (V)	LOAD CURRENT (I_L)	FIELD CURRENT (I_F)	ARMATURE CURRENT(I_A) $I_A = I_L + I_F$	$Eg = V + (I_A * R_A)$

Model Graphs:



Precautions:

1. Field rheostat of motor should be at minimum position.
2. Don’t switch on the supply without any load.
3. Take care while using the starter.
4. The speed should be adjusted to rated speed.
5. There should be no loose connections.
6. Avoid parallax errors and loose connections.

Result:

Viva Questions:

- What is the inference of we get from the internal and external characteristics
- Compare the external characteristics of shunt, series and compound generators.
- What is the effect of armature reaction in a DC machine?
- Why is the generated e.m.f. not constant even though the field circuit resistance is kept unaltered?
- Differentiate between D. C. Shunt Motor and D. C. shunt Generator?
- State the conditions required to put the D.C shunt generator on load.
- Why the terminal voltage decreases when load is increased on the generator?
- What happens if shunt field connections is reversed in the generator?

Expt. No.3.CHARACTERISTICS OF A SERIES MOTOR

Aim:

To conduct load test on DC Series Motor and to find efficiency.

Apparatus:

S. No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Tachometer	(0-3000) rpm	Digital	1
4	Connecting Wires	2.5sq.mm.	Copper	Few

Theory:

The precondition to be set for the load test on DC series motor is to run the motor at the rated voltage and the rated speed. For Small motors the efficiency can be found directly by a brake test. The loading arrangement done to the motor is that a brake drum is attached to the shaft of the motor and spring balances are connected through which the brake drum is tightened so that the shaft is loaded. This set is said to be called as applied mechanical load. The torque can be determined and speed is measured from which the power output can be calculated. The input to the motor is found by knowing the applied voltage and load current. Hence the efficiency can be known.

Let S1 and S2 are the spring balance readings.

The pull on the brake drum = 9.81 (S1-S2) Newton.

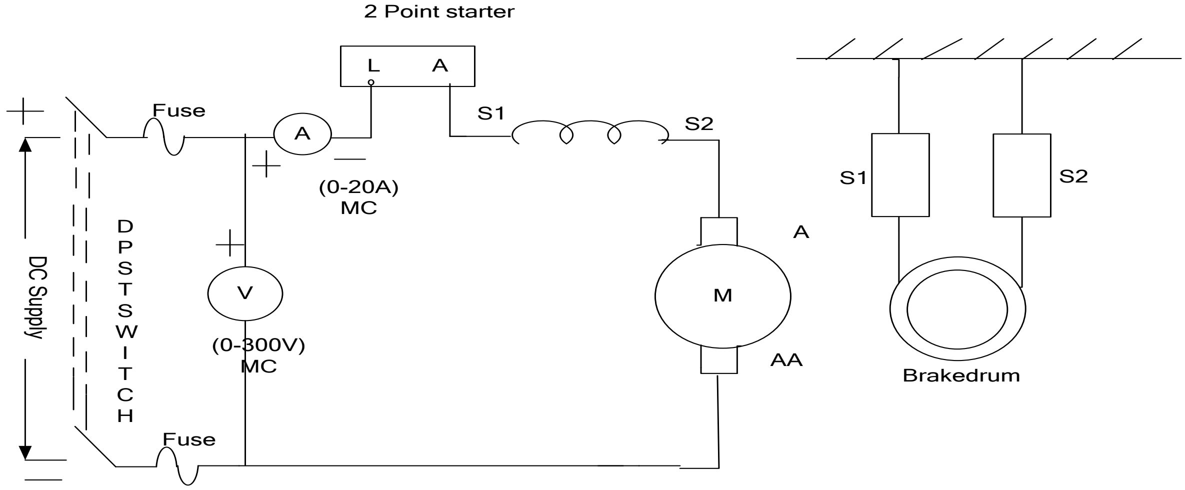
Torque on the drum T_{sh} = 9.81 (S1-S2) r N-m where r is the radius of the drum.

Motor power output $P_{sh} = T_{sh}\, 2\pi N/60$ watts; where N is the rpm of the motor.

Let input voltage and current be V and I, the power input to the motor is V*I

The efficiency = η = output/ input

Circuit Diagram:



Procedure:

1. Connections are made as per the circuit diagram.
2. After checking the load condition, DPST switch is closed and starter resistance is gradually removed.
3. For various loads, Voltmeter, Ammeter readings, speed and spring balance readings are noted.
4. After bringing the load to initial position, DPST switch is opened.

Tabular Form:

S. No	V (V)	I_L (A)	N (rpm)	S1 (Kg)	S2 (Kg)	W=(S1-S2) (Kg)	T= 9.81 W* r (Nm)	Output= 2πNT/60 (watts)	Input= VI_L (Watts)	η = Output / Input (%)
1										
2										
3										
4										
5										
6										
7										

Formulae:

R= Circumference/ 100 x2π m

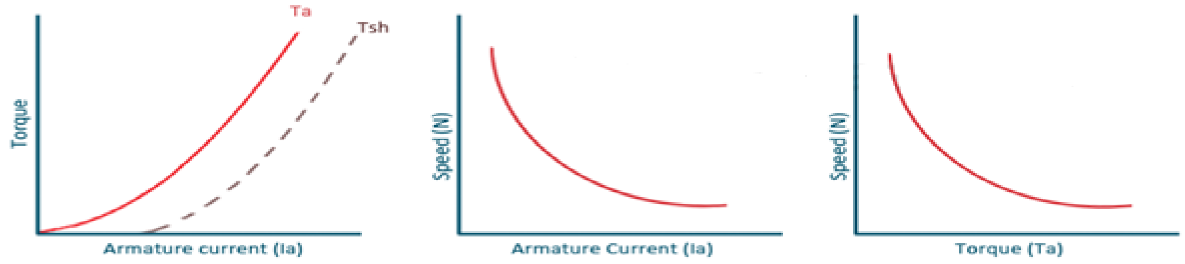
Torque T = (S1 ~ S2) x R x 9.81 Nm

Input Power Pi = VI Watts

Output Power Pm = 2πNT/ 60 Watts

Efficiency η % = Output Power/ Input Power x 100%

Model Graphs:



Characteristics of DC series motor

Precautions:

1. Field rheostat of motor should be at minimum position.
2. Don't switch on the supply without any load.
3. Take care while using the starter.
4. The speed should be adjusted to rated speed.
5. There should be no loose connections.
6. Avoid parallax errors and loose connections.

Result:

Viva Questions:

1. What are the methods for finding the efficiency?
2. What are the basic requirements to conduct the load test?
3. Compare the load characteristics for different types of DC motors.
4. If two motors are required to drive a common load, how will they share the total load?
5. What are the functions of a DC motor Starter?
6. If starter is not available, how can you start a D.C motor?
7. What is the efficiency range of a D.C motor?
8. Where can you use the D.C shunt motor?
9. Why is it considered as a constant speed motor?

Expt. No.4.SEPARATION OF NO LOAD LOSSES IN DC MACHINE

Aim:

To separate the no load losses in a DC Machine as iron losses and mechanical losses.

Apparatus:

S. NO	APPARATUS	RANGE	TYPE	QTY
1.	Voltmeter	0 – 300 V	MC	1
2	Ammeter	0 – 5/10 A	MC	1
3.	Ammeter	0 – 1/2 A	MC	1
4.	Voltmeter	0 – 5 V	MC	1
5.	Rheostat	1200 Ohms, 0.8 A	Wire Wound	1
6.	Rheostat	250 Ohms, 1.5 A	Wire Wound	1
7.	Tachometer	--	Digital	1

Theory:

In a DC motor, the no load input power supplies for the following losses:

1. Constant loss consisting of the iron losses or core loss and the mechanical loss due to friction and windage.
2. Armature copper loss and field copper loss (usually negligible) in this experiment, the no load test is conducted on a DC motor in order to obtain the constant losses. The mechanical loss is separated from the constant losses and hence the iron losses are determined. In this test various losses in a dc machine can be separated in to their parts

The dc machine is running at no load by varying the speed and keeping excitation constant.

If 'N' is the speed of the shunt motor at any given time,

Then mechanical losses

Frictional losses α N

Windage losses α N^2

Mechanical losses, $W_m = AN+BN^2$

Where A and B are constants

The iron losses consist of Hysteresis and eddy current losses

Hysteresis losses α $B_m^{1.6} f v$

Eddy current losses α $B_m^2 f^2 t^2$

Where B_m is the maximum flux density

F is the frequency of current induced

T is the thickness of lamination

f - Cycles / sec =

Where the flux density B_m is held constant,

Iron losses, $W_i = CN+DN^2$

Hence the total losses (W) = $AN+BN^2 + CN+DN^2$

$$= (A+C)\ N + (B+D)\ N^2$$

Dividing both the sides by N, we get

$$W/N= (A+C) + (B+ D)\ N$$

If a graph is drawn showing W/N as y-axis and N as x-axis, we get a straight line relationship (PQ) as shown in fig.

$W/N= (A+C)\ N + (B+ D)\ N^2$

And the slope of the line PQ,

$\tan \Phi_1 = B+ D$

If a motor is run at a constant excitation, B max remains the same and the constants C and D will remain constant. Now the motor is run at different excitations, then C and D will change to C^1 and D^1 . Thus the equation (4) can be written as

$$W/N= (A+C^1) + (B+ D^1)\ N$$

If this relationship, is plotted on the same graph, as straight line, SR

Then $OR = A+C^1$

$\tan \Phi_2 = B+ D^1$

Subtracting (8) from (5)

$C- C^1 = OP-OR$

Then substituting (9) from (6)

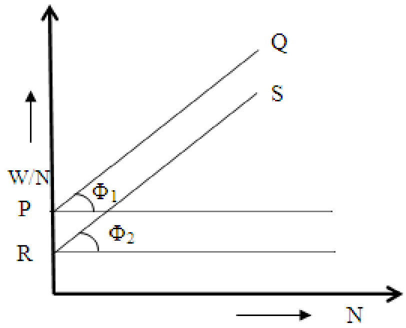
$D-D^1 = \tan \Phi_1 - \tan \Phi_2$

= m1-m2 .... (11)

If B_{max1} and B_{max2} are the flux densities at two excitations then,

$$C / C^1 = (B_{max1} / B_{max2})^{1.6} = (Eb_1/Eb_2)^{1.6}$$

Where Eb1 and Eb2 are the back emfs developed in the motor at the two excitations at any given speed. Then



The constant losses are calculated as follows:-

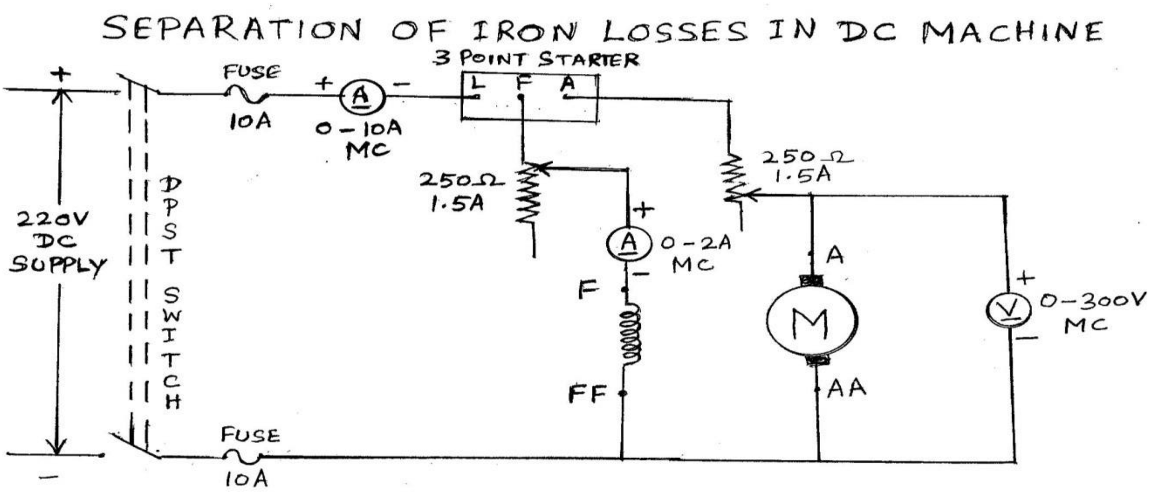
Constant losses = No load input – Armature Cu loss (Ia^2Ra)

i.e. $Wc = VaIa – Ia^2\ Ra$

The mechanical loss Wm is found from the graph

Hence the core losses or iron losses Wi = Wc – Wm

Circuit Diagram:



Procedure:

1. Connections are made as per the circuit diagram.
2. The DC supply is switched ON and the motor is started using 3-point starter.
3. The armature rheostat is adjusted from maximum position to obtain the rated voltage.
4. The field rheostat is adjusted to obtain the rated speed.
5. The readings of the voltmeter and ammeter are noted.
6. By varying the armature rheostat the voltage is gradually reduced till the current becomes almost constant. The readings of the voltmeter and the ammeter are noted in the tabular column.
7. The armature resistance (Ra) is determined by voltmeter – ammeter method by giving low voltage DC supply.
8. The armature copper loss is calculated and hence the constant losses are obtained.
9. A graph is drawn with constant losses along Y-axis and no load voltage along the X- axis.
10. The mechanical loss is found from the graph hence the iron losses are determined.

Tabular Form:

Mechanical Loss Wm = ______Watts

S. No.	**No Load Voltage (Vo) Volts**	**No load current (Io) Amps**	**No load Input Power W_o = Vo * Io Watts**	**Field Current I_f Amps**	**Armature Current Ia Amps**	**Armature Cu Loss Ia^2Ra Watts**	**Constant loss Wc = Wo – Ia^2Ra Watts**	**Iron loss Wi = Wc – Wm Watts**
1								
2								

Calculations:

(From the graph)

Formulae Used:

No load input power $W_o = V_oI_o$ Watts

Armature current $I_a = I_o – I_f$ Amps

Armature Copper loss = $I_a^2R_a$ Watts

Constant losses $W_c = V_aI_a – I_a^2R_a$ Watts

Mechanical loss = W_m (from graph) Watts

(Friction and windage)

Core losses or Iron losses $W_i = W_c – W_m$ Watts

Constant losses VS No load voltage

SEPARATION OF IRON LOSSES IN DC MACHINE

Tabular Columns

To find Armature Resistance Ra

SL.NO.	Armature Current I_a (Amps)	Armature Voltage V_a (Volts)	Armature Resistance R_a = Va/Ia (Ohms)
1			
2			
3			
4			
Average R_a			

Precautions:

1. Fieldrheostatofmotorshouldbeatminimumposition.
2. Don’t switch on thesupplywithout anyload.
3. Takecarewhileusing thestarter.
4. Thespeed should be adjusted to rated speed.
5. Thereshould beno loose connections.
6. Avoidparallaxerrorsandlooseconnections.

Result:

Viva Questions:

- What are the losses in a DC machine?
- Why is the field copper loss negligible at no load?
- Why does the armature resistance increase when the motor is running?
- How can the mechanical losses be reduced?
- How can the core losses be minimized?

Expt. No.5.SPEED CONTROL OF DC SHUNT MOTOR

Aim:

To control the speed of a DC shunt motor by armature control method and field control method.

Apparatus:

S. No	Apparatus	Type	Range	Qty
1.	Voltmeter	MC	0 – 300V	1 No
2.	Voltmeter	MC	0 -15V	1 No
3.	Ammeter	MC	0 – 2A	1 No
4.	Ammeter	MC	0 – 20A	1 No
5.	Rheostat	Wire Wound	50 Ω /5A	1 No
6.	Rheostat	Wire Wound	290Ω/ 1.2A	1 No

Theory:

Any D.C. motor can be made to have smooth and effective control of speed over a wide range. The shunt motor runs at a speed defined by the expressions.

$$E_b = \frac{\phi P N Z}{60 A} \text{ volts}$$

Since $I_a R_a$ drop is negligible $N \alpha V$ and $N \alpha 1/\phi$ or $N \alpha 1/I_f$

Where, N is the speed,

V is applied voltage,

I_a is the armature current

R_a is the armature resistance

Φ is the field flux.

Speed Control Methods of a Shunt Motor:

1. Armature rheostat control
2. Field flux control

Armature Rheostat Control:

Speed control is achieved by adding an external resistance in the armature circuit. This method is used where a fixed voltage is available. In this method, a high current rating rheostat is required.

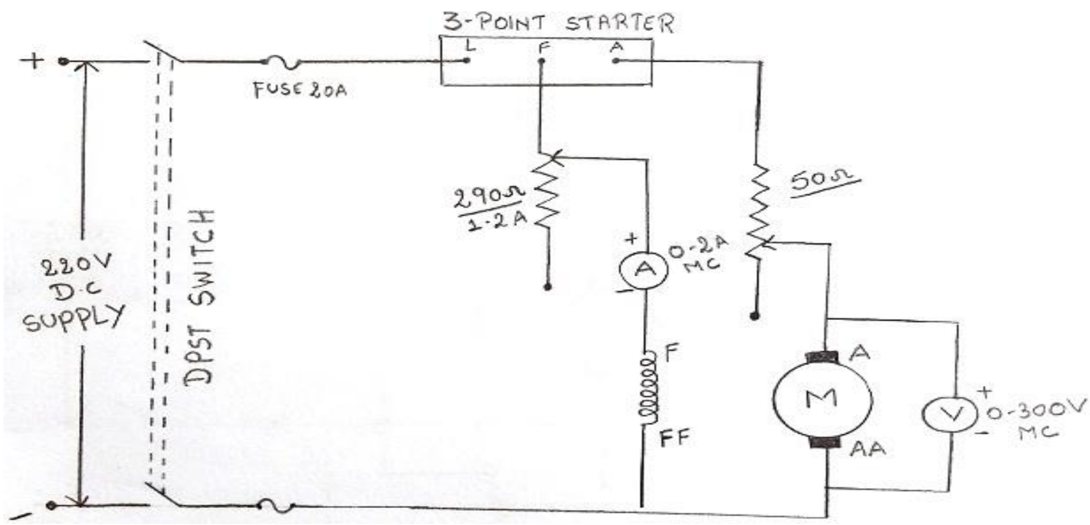
Disadvantages:

1. Large amount of power is lost as heat in the rheostat. Hence, the efficiency is low.
2. Speed above the rated speed is not possible. The motor can be run from its rated speed to low speeds.

Field Flux Control:

Speed control by adjusting the air gap flux is achieved by means of adjusting the field current i.e. by adding an external resistance in the field circuit. The disadvantage of this method is that a low field flux, the armature current will be high for the same load. This method is used to run the motor above its rated speed only.

Circuit Diagram:



Procedure:

Armature Voltage control Method

1. Connections are made as per circuit diagram.
2. The minimum position of field rheostat and maximum position of armature resistance is verified before going to switch on to the D.C supply.
3. The motor is started by slowly varying the 3-point starter until its final position.
4. By varying the field resistance, the motor is brought down to its rated speed.
5. The readings of ammeter, voltmeter, field current and speed of motor are note down without any Parallax errors.
6. The corresponding voltmeter, ammeter field current and speed of the motor up to 6-7 reading is taken by increasing the armature resistance.
7. Slowly the field rheostat is brought to its initial position and the supply is switched off.
8. A graph is plotted between speed of the motor (N) and armature voltage (V_a).

Field Control or Flux Control Method:

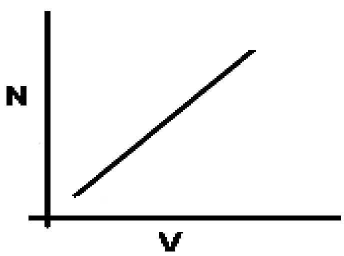
1. Connections are made as per circuit diagram.
2. The field rheostat in minimum position and armature resistance in maximum position is verified before going to switch on DC supply.
3. Adjust the armature rheostat so that voltmeter reads rated voltage.
4. The motor is started by slowly varying the 3-pt starter until its final position.
5. By varying the field resistance, the motor is brought down to its rated speed.
6. The readings of ammeter, voltmeter, field current and speed of motor are note down without any parallax errors.
7. The corresponding voltmeter, ammeter field current and speed are noted down by increasing the field resistance.
8. Slowly the field rheostat is brought to its initial position and the supply is switched off.
9. A graph is plotted between speed of the motor (N) and field current (I_f).

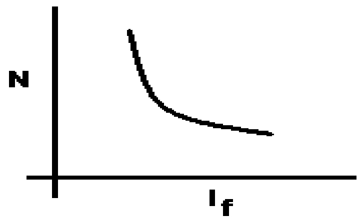
Tabular Form:

Armature Voltage control Method			Field Control or Flux Control Method		
S. No.	V_g (Volts)	N (Speed)	S. No.	I_f (Amps)	N (Speed)
1.			1.		
2.			2.		
3.			3.		
4.			4.		
5.			5.		

Expected waveforms:

Armature control MethodField Control Method





(a) Speed Vs armature voltage (b) Speed Vs Field current

Precautions:

1. Fieldrheostatofmotorshouldbeatminimumposition.
2. Don’t switch on thesupplywithout anyload.
3. Takecarewhileusing thestarter.
4. Thespeed should be adjusted to rated speed.
5. Thereshould beno loose connections.
6. Avoidparallaxerrorsandlooseconnections.

Result:

Viva Questions:

- Why is it not possible to get higher speeds with armature voltage method?
- Can lower speeds be obtained by using field control method?
- What are the disadvantages of armature and field control methods?
- Explain why the graph of armature speed control of motor is linear?
- What is the shape of the curve of field control of method motor speed? Explain why it is so?
- What are the disadvantages of using armature control of speed no load?
- How do you change the direction of rotation of a D.C. motor?
- What are the limitations of shunt field control?
- What is meant by speed control?

Expt. No.6.SEPERATION OF CORE LOSSES IN A SINGLE PHASE TRANSFORMER

Aim:

To Separate the Eddy current loss and Hysteresis loss from the iron loss of 1-Φ transformer.

Apparatus:

Sl.No.	Equipment	Type	Range	Quantity
1.	Voltmeter	MI	(0-3000)V	1
2.	Ammeter	MI	(0-2)A	1
3.	Wattmeter	MI	300V/5A, LPF	1
4.	Rheostat	Wire wound	290Ω/1.2A	1
5.	Rheostat	Wire Wound	50Ω/2A	1
6.	Tachometer	Digital	-	1

Theory:

Hysteresis loss and eddy current loss both depend upon magnetic properties of the materials used to construct the core of transformer and its design. So these **losses in transformer** are fixed and do not depend upon the load current. So **core losses in transformer** which is alternatively known as **iron loss in transformer** can be considered as constant for all range of load.

Hysteresis loss in transformer is denoted as,

$$W_h = K_h f (B_m)^{1.6} \quad watts$$

Eddy current **loss in transformer** is denoted as,

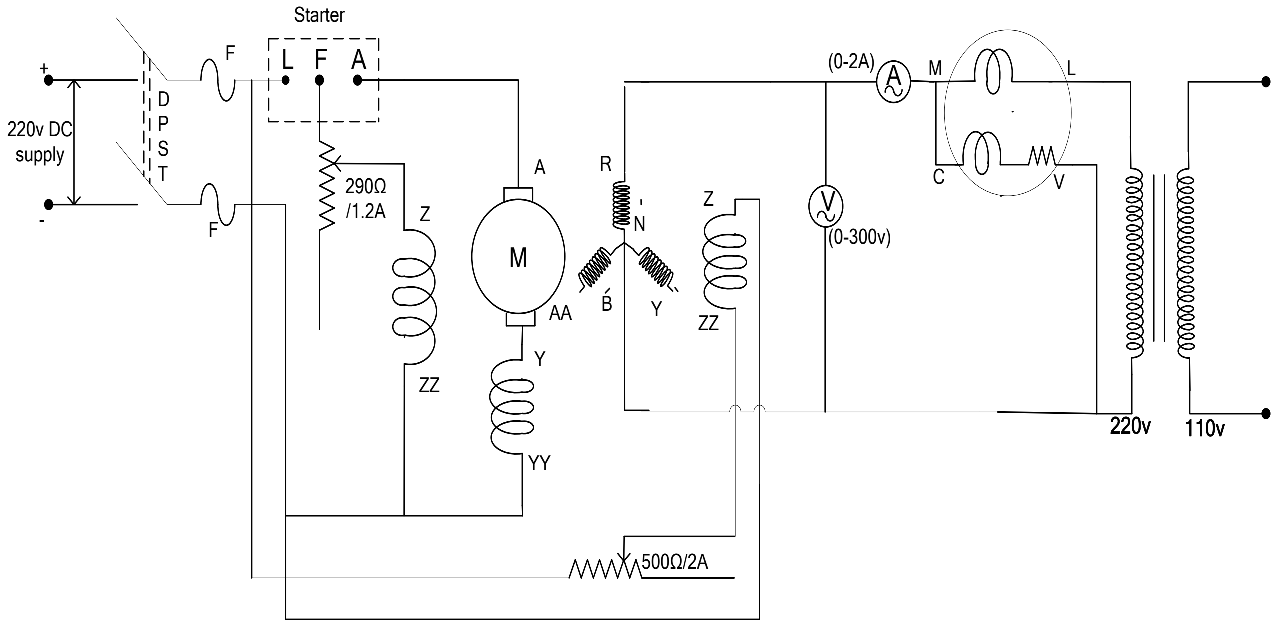
$$W_e = K_e f^2 K_f^2 B_m^2 \, watts$$

Where, K_h = Hysteresis constant. K_e = Eddy current constant. K_f = form constant. Copper loss can simply be denoted as,

$I_L^2 R_2'$ + Stray loss

Where, $I_L = I_2$ = load of transformer, and R_2' is the resistance of transformer referred to secondary.

Circuit Diagram:



Procedure:

1. Make the circuit connections as per the circuit diagram.
2. The prime mover is started with the help of 3-point starter and it is made to run at rated speed.
3. By varying alternators field rheostat gradually, the rated primary voltage is applied to transformer
4. By adjusting the speed of prime mover the required frequency, is obtained and corresponding reading are noted
5. The experiment is repeated for different frequency and corresponding readings are tabulated.
6. The prime mover is switched off using the DPIC switch after bringing all the rheostats to initial position
7. From the tabulated readings the iron loss is separated from eddy current loss and hysteresis loss by using respective formulae.

Tabular Form:

S. No.	Speed N (RPM)	Frequency f (Hz)	Voltage V (V)	Wattmeter reading (Watts)	Iron loss Wi (Watts)	Wi / f

Calculations:

1. Frequency (f) =PNs/120

Where P-number of poles; Ns-Synchronous speed in rpm

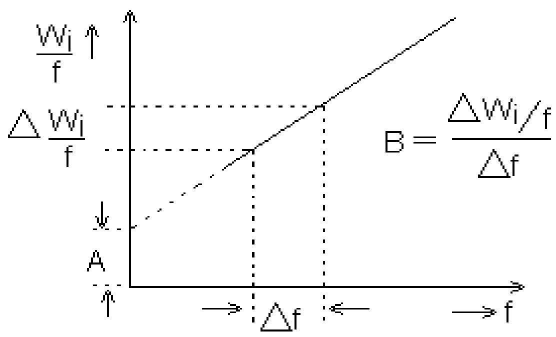
2. Hysteresis loss (Wh)=Af

3. Eddy current loss (We) =Bf

4. Iron loss or core loss (Wi) = We +Wh

Modal graph:

The graph drawn as frequency Vs (Wi/f)



Precautions:

1. Fieldrheostatofmotorshouldbeatminimumposition.
2. Don't switch on thesupplywithout anyload.
3. Takecarewhileusing thestarter.
4. Thespeed should be adjusted to rated speed.
5. Thereshould beno loose connections.
6. Avoidparallaxerrorsandlooseconnections.

Result:

Viva Questions:

- What are core losses in a transformer? Why they occur? On what factors do they depend? What are the usual methods that are being employed in reducing them?
- How does change in frequency affect the operation of a given transformer?
- A transformer is designed for 50C/S operation. It is worked at double and half the designed frequency what changes does you except in the performance? Discuss?
- Whether you can excite a transformer from a DC supply of rated voltage Justify your answer.

Expt. No.7.OPEN CIRCUIT AND SHORT CIRCUIT TESTS ON A 1-Ø TRANSFORMER

Aim:

To predetermine the efficiency of a single phase transformer, equivalent circuit of the transformer and regulation of the transformer.

Apparatus:

S. No	Apparatus	Type	Range	Qty
1	Voltmeter	MI	0 – 150 V	2 No
2	Ammeter	MI	0 – 1A	1 No
3	Ammeter	MI	0 – 10A	1 No
4	Wattmeter	LPF	150V/5A	1 No
5	Wattmeter	UPF	150V/10A	1 No
6	Transformer	Single phase	220/110V, 1.8KVA	1 No

Theory:

Open Circuit (or No-Load) Test: -

This test is conducted to determine the iron losses (core losses) and parameters R_0 and X_0 of the transformer. In this test, the rated voltage applied to the primary (usually low voltage side) while the secondary is left open circuited. The applied primary voltage V_1 is measured by the voltmeter, the no load current I_0 by ammeter and no- load input power W_0 by wattmeter.

As the normal rated voltage is applied to the primary, therefore, normal Iron losses will occur in the transformer core. Hence wattmeter will record the Iron losses.

Let V_1 = applied rated voltage on L.t side,

I_0 = exciting current (or no-load current)

W_0 = core loss

Then $W_0 = V_1 I_0 \cos\theta_0$

⇨ No Load p.f. $= \cos\theta_0 = W_0 / V_1 I_0$.

$I_w = I_0 \cos\theta_0$ and $I_m = I_0 \sin\theta_0$

$R_0 = V_1 / I_w$ and $X_0 = V_1 / I_m$

Short-Circuit Test: -

This test conducted to determine R_{01} (or R_{02}), X_{01}(or X_{02}) and full load copper losses of the transformer. In this test, the secondary (usually Lv winding) is short circuited and variable low voltage is applied to the primary. The low input voltage is gradually raised till at voltage V_{sc}, full load current I_1 flows in the primary. Then I_2 in the secondary also has full load value since I1/ I_2= N_2/ N_1 under such conditions copper loss in the windings is the same as that on full load. There is no output from the transformer under short circuit conditions. Therefore, input power is all loss and this loss is entirely copper loss. Hence the wattmeter practically registers the full load copper losses in the tarnsformer windings.

Full load copper loss = W_c

Applied voltage= V_{sc}

Full load primary current = I_1

$W_c= I_1^2 R_{01}$

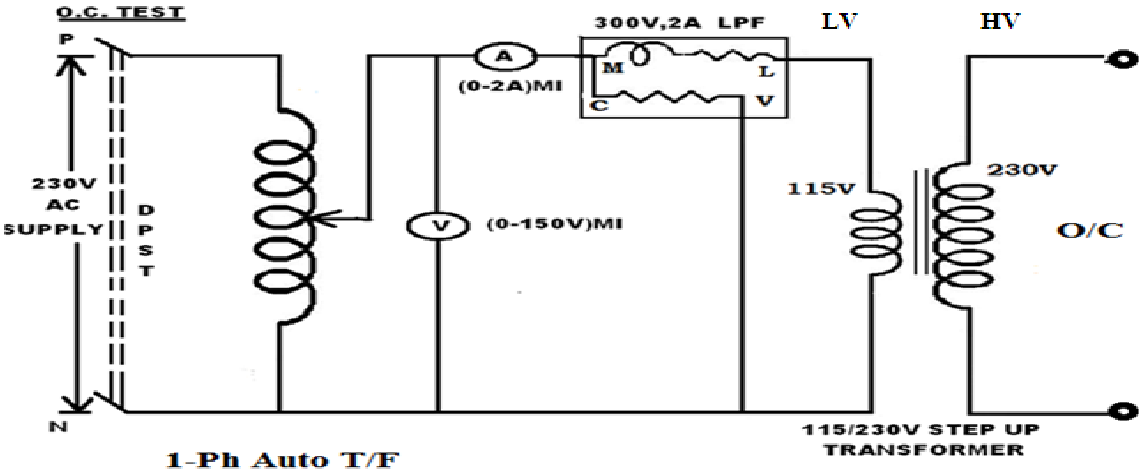
$R_{01}= W_c / I_1^2$, where R_{01} is the total resistance of transformer referred to primary.

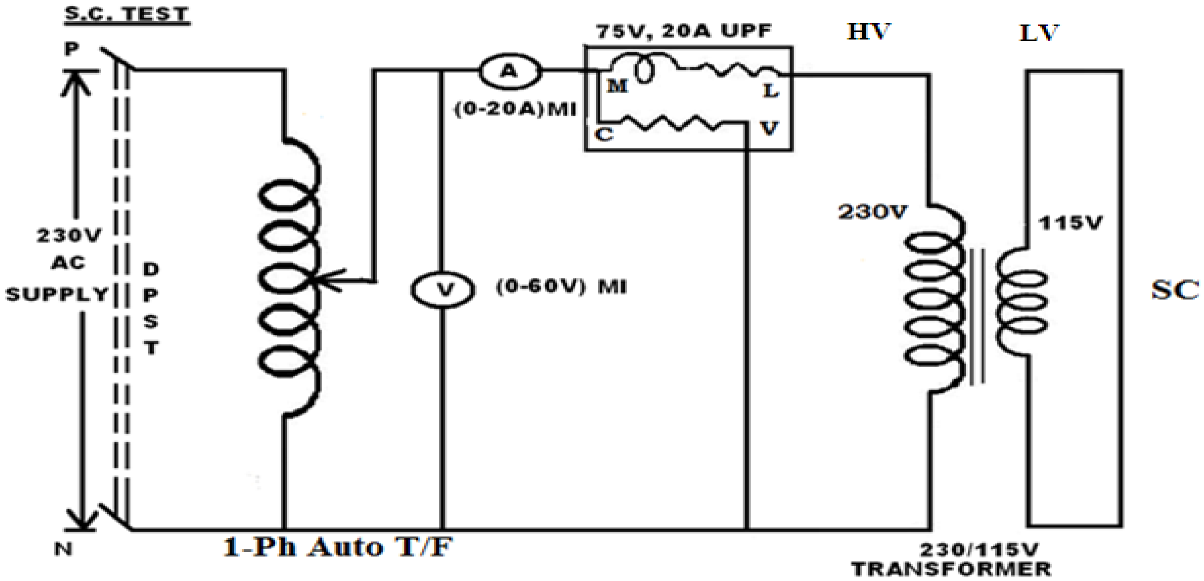
Total impedance referred to primary $Z_{01}= V_{sc} / I_1$

Total leakage reactance referred to primary $X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$

Thus short circuit test gives full load copper loss, R_{01} and X_{01}

Circuit Diagram:





Procedure:

(A).OPEN CIRCUIT TEST (O.C.TEST)

1. Make the connections as per the circuit diagram, the 220V winding of the transformer is kept open
2. Apply the rated voltage, i.e.110V through the auto transformer.
3. Note down the voltmeter V_{oc}, ammeter I_{oc} and wattmeter W_{oc} readings and tabulate
4. Now reduce the voltage given to the transformer to Zero and Switch off the supply.
5. Calculate the values of R_0 and X_0.
6. The wattmeter used in the OC test should be low power factor wattmeter, since it must be able to measure power at low power factor at which the transformer works on no load.

(B).SHORT CIRCUIT TEST (S.C TEST)

1. Make the connections as per the circuit diagram and keep the 110V winding of the transformer short circuited.
2. Apply the low voltage to the 220V side through the auto transformer and increase the voltage gradually till the full load current (8A) flows in the 220V winding.
3. Note down the voltmeter, ammeter and wattmeter readings and tabulate as
4. Reduce the voltage given to the transformer to zero and switch off the supply
5. Calculate values of R_{01} or R_{02} and X_{01} or X_{02}.
6. Draw the equivalent circuit diagram of the 1-Φ transformer.

Tabular Form:

OC Test:

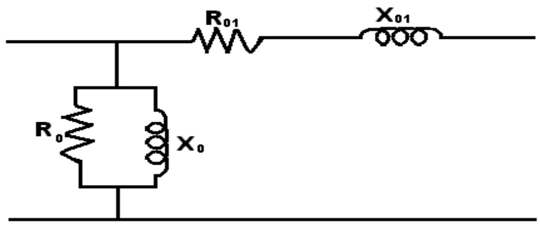
$V_{o.c}$(volts)	I_o (amps)	P_o (watts)

SC Test:

$V_{s.c}$ (Volts)	$I_{s.c}$ (amps)	$P_{s.c}$ (watts)

Calculations:

To draw Equivalent circuit:



- P_0 = Iron Loss = $I_0 V_0 \cos Ø_0$
- $\cos Ø_0 = P_0/(V_0 X I_0)$, $Ø_0 = \cos^{-1} P_0/(V_0 X I_0)$
- $R_0 = V_0/(I_0 \cos Ø_0) = V_0 / I_w$
- $X_0 = V_0/(I_0 \sin Ø_0) = V_0 / I\mu$
- P_{sc} = Copper Loss = $I^2_{sc} X R_{01}$
- $R_{01} = Psc/ I^2_{sc}$
- $Z_{01} = Vsc/Isc$
- $X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$
- Copper losses $= X^2 * W_{cu\ at\ FL}$ (Where 'X' Fraction of load)

Load at which max efficiency occurs is the same whatever the power factor, However numerical value of "η" decreases with decrease in P.F

<u>TO CALCULATE THE EFFICIENCY AT U.P.F/0.8 PF/0.6 PF</u>

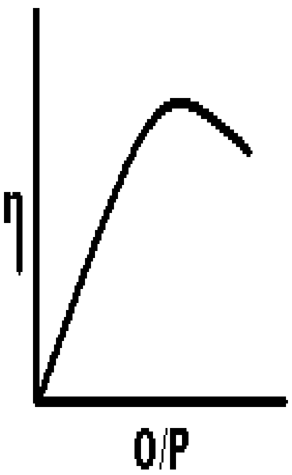
S. No	Load	Load Current I_L (Amps)	Iron Loss P_0 (Watts)	Copper Loss P_{sc} (Watts)	Total Loss $P_0 + P_{sc}$ (Watts)	Output KVA * P.f	Input = Output +Losses	η= Output/Input
At U.P.F								
1	Full Load							
2	½ Load							
3	¼ Load							
4	¾ Load							

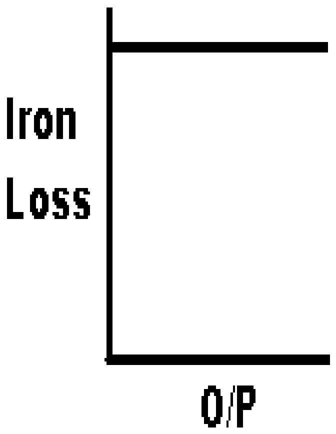
At 0.8 P.F								
1	Full Load							
2	½ Load							
3	¼ Load							
4	¾ Load							
At 0.6 P.F								
1	Full Load							
2	½ Load							
3	¼ Load							
4	¾ Load							

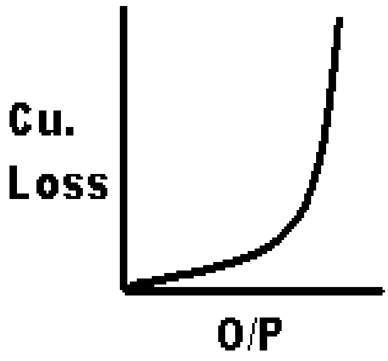
Expected waveforms:

1) Efficiency
2) Iron Loss
3) Cu Loss

And from the graph find the condition for efficiency to be maximum







To calculate the percentage regulation at UPF/0.8 lag/0.8 lead

$$\% \text{ Regulation} = \frac{I_1(R_{01}Cos\phi \pm X_{01}\sin\phi)}{V_1}$$

(or)

$$\frac{I_2 (R_{02} Cos\phi \pm X_{02} \sin\phi)}{V_2}$$

Where V_1 = Primary Rated voltage

I_1 = Rated Primary Current

Positive sign for Lagging Power factor

Negative sign for Leading Power Factor

Result:

Viva Questions:

- Explain why the wattmeter reading in O.C Test is taken as Iron Loss?
- Explain why the wattmeter reading in S.C Test is taken as Copper Loss?
- What re the uses of transformers, explain with example?
- Why the efficiency of the transformer is high as compared to the electrical motor?
- What are the materials used for making the core and winding of the transformer?
- Explain why those materials are used?
- What do you understand by an Auto-transformer?
- Why transformer rating is in KVA not KW.
- What is the all-day efficiency of a transformer?

Expt. No.8. SUMPNER'S TEST ON TWO IDENTICAL TRANSFORMERS

Aim:

a) Perform Sumpner's (Back to Back) test on two identical transformers.
b) Determine the efficiency at 1/4, 1/2, 3/4, full load and 1.25 times the full load and at 0.85 p.f. lagging.
c) Plot efficiency Vs output characteristic.

Apparatus:

Sl. No.	Name	Type	Range	Quantity
1.	Ammeter	MI	2.5/5 A	1
2.	Ammeter	MI	15/30 A	1
3.	Voltmeter	MI	0 - 300 V	1
4.	Voltmeter	MI	0 - 600 V	1
5.	Voltmeter	MI	0- 30 V	1
6.	Wattmeter	Dynamometer	2.5 A, 200 V	1
7.	Wattmeter	Dynamometer	15 A, 75 V	1
8.	Single phase Variac	Fully Variable	230/0-270 V, 15 A	1

Theory:

This test needs two identical transformers. The primary windings of these transformers are connected in parallel and supplied at rated voltage and frequency, while the two secondary are connected in phase opposition. Thus the voltage across the two secondary is zero, when the primary windings are energized. As such, this test is also called back to back test. In this test, iron losses occur in the cores and full load copper losses occur in the windings of the two transformer. Current flowing in the two secondary is rated full load current of the transformer. Thus, heat run test can be conducted on the transformer can be estimated. The current drawn by the primaries is twice the no load current of each transformer. The wattmeter W_1 connected in the circuit of the primaries measures the total core losses of both the transformers.

Thus, iron losses of each transformer = (1/2) * W_0

Where, W_0 is the reading of wattmeter, W_1, when rated voltage is applied to the primaries of the transformers.

Similarly, wattmeter W_2 connected in the secondary circuit measures the total full load copper losses of the two transformers.

Hence, full load copper losses of each transformer = (1/2) * W_c

Where, W_c is the reading wattmeter W_2, when full load current is flowing in the secondary circuit. A low voltage, hardly 8 to 10 percent of the rated value is applied across the secondary for full load current to flow.

(a) Efficiency at full load:

Let the output in KVA of each transformer be P_0

Total losses of each transformer under full load operation = $(1/2 * W_0) + (1/2 * W_c)$

$P_0 * 1000 * \cos \varphi$

Percentage efficiency at full load, η_f = ------------ *100

$P_0 * 1000 * \cos \varphi + (1/2 * W_0 + 1/2 * W_c)$

(b) Efficiency at half full load:

Power output of each transformer at half full load = $1/2\ P_0$

Iron losses at half the full load = $1/2\ W_0$ (constant)

Copper losses at half the full load = $(1/2)^2\ [1/2\ W_{C]} = 1/8\ W_c$

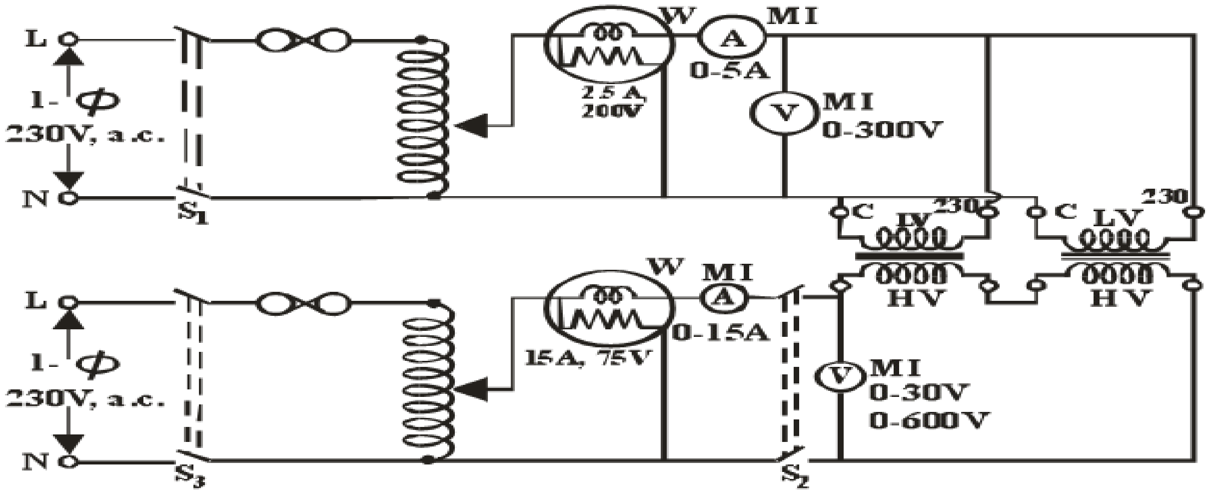
$(1/2\ P_0) * 1000 * \cos \varphi$

Thus, efficiency at half full load, $\eta_{1/2f}$ = ------------- * 100

$(1/2\ P_0) * 1000 * \cos \varphi + (1/2 * W_0 + 1/8 * Wc)$

The below Fig.shows the complete circuit diagram for performing Sumpner’s test on two identical single phase transformers. Primaries of the two transformers are connected in parallel. Ammeter and wattmeter have been connected in the primary circuit to record the total no load current and no load power of both the transformers. Secondary of the two transformers have been connected in phase opposition. A voltmeter of higher range i.e. 600 V has been connected across the two terminals of the secondary to verify the phase opposition. It should be remembered that the voltage would be much higher, in case the two secondary are in phase addition. The voltage applied to the secondary circuit is quite low, as such a voltmeter of 30 V range has been connected in place of the voltmeter of 600 Volts after verifying the phase opposition of the two secondary. Single phase Variac has been used in the secondary circuit to obtain a low voltage. Ammeter and wattmeter has been included in the secondary circuit to measure full load current flowing in the circuit and the corresponding power drawn by the secondary respectively.

Circuit Diagram:



Sumpner's test on transformer

Procedure:

1. Connect the circuit as per circuit diagram.
2. Ensure that switches S_2 and S_3 are open.
3. Energize the primaries by closing the switch S_1.
4. Observe the reading of voltmeter V_1, which should be zero for correct connection of the secondary. In case, the voltmeter reads twice the rated voltage of each transformer, open the switch S_1 and interchange the connections at the secondary terminals of one of the transformer. Close the switch S_1 again and verify that the voltmeter V_1 now reads zero. Important caution : Even if the voltmeter V_1 reads zero at the first instance, it is advisable to check the reading of Voltmeter V_1 by interchanging the connections at the secondary terminals of one of the transformer
5. Adjust the setting of the variac, to give nearly zero output voltage.
6. Replace the voltmeter V_1, by a low range voltmeter.
7. Close the switch S_3 and then S_2.
8. Adjust the output voltage of the variac, so that the current flowing in the secondary is full load secondary current of each transformer.
9. Record the readings of all the instruments connected in the primary and secondary circuit. Only one set of reading is sufficient to calculate the efficiency at different loads.
10. Switch off the supply to primary and secondary circuits.

Tabular Form:

S. No.	Primary side			Secondary side		
	V_0	I_0	W_0	V_{sc}	I_{sc}	W_{sc}

Result:

Viva Questions:

- Why two transformers, and that too identical, are needed in this test?
- Discuss various losses occurring in a transformer along with their variation with respect to loading condition and the parts in which these occur.
- If the iron losses and copper losses at full load single phase, 30 KVA, 1100/250 V, 50 Hz transformer are 300 watts and 400 watts respectively. Find out these losses at 3/4 of the full load.

Expt. No.9.ESTIMATION OF EFFICIENCY OF DC MACHINE BY HOPKINSON TEST

Aim:

To perform Hopkinson's test on the given motor generator set and determine the efficiency of both motor and generator.

Apparatus:

S. No	Apparatus	Range	Type	Qty
1.	Rheostat	290Ω/1.2A	Wire Wound	1 No
2.	Rheostat	500Ω/2A	Wire Wound	1 No
3	Ammeter	0 – 2A	MC	2 No
4	Ammeter	0 – 20A	MC	3 No
5	Voltmeter	0 - 300V 0 - 600V	MC MC	1 No 1 No

Theory:

Regenerative or Back-to-Back Method:

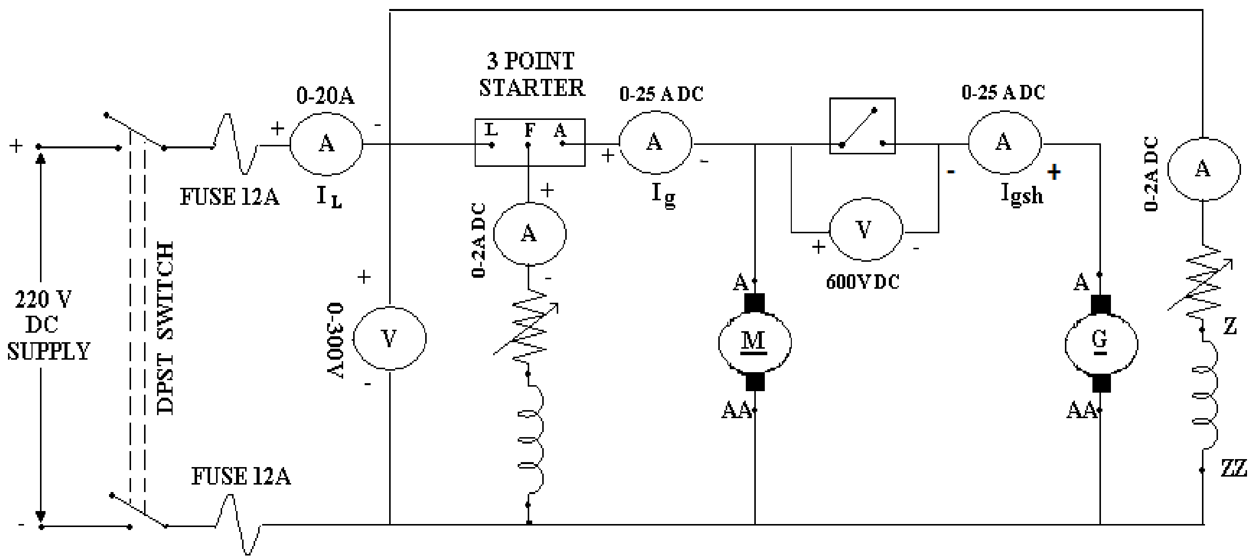
This method requires two identical machines. One of the machines is used as a motor to drive the other as a generator. The output of the generator is only fed back to the supply mains. The total power drawn from the supply is only for supplying the internal losses of the two machines. Thus very large motors can be tested with less amount of wastage of energy. The difference between the input to the motor generator set and the output to the generator gives the sum total of the losses occurring in both the machines. By subtracting the copper losses, the stray losses are obtained. The stray loss is assumed to be equal to the rated current. The effect of armature reaction and communication are truly reflected.

The two-shunt machines are connected back-to-back, i.e., the armatures are connected in series opposition in the local circuit formed by the armatures. Since the machines are mechanically coupled, their speed is the same. So, by suitably adjusting the excitation, one of the machines can be made to act as a generator and carry a current almost equal to its rated current.

If the Power supplied by each machine is adequate to overcome the losses in the other machine, then there is no necessity of an external power source. Hence theoretically at least, when the two machines are running as a motor generator set, if the power supply from outside is cut off, the two machines must continue to run as a motor generator set for all time. But in practice, it is seen that, if the DC supply for the set is cut off by opening the supply switch, the machines come to a position of stand still. This clearly implies that additional power is needed to overcome the internal losses in the two machines. Hence, power supplied to the M-G set by the external DC source is equal to the sum of all internal losses in the two machines. **(Total internal losses for each machine = Armature copper loss + Field copper loss + Rotational losses (Iron loss + Mechanical loss)).**

From the data obtained during the test, the armature copper loss and field copper loss of each of the two machines can be determined. Stray losses can then be calculated.

Circuit Diagram:



HOPKINSON'S TEST CIRCUIT DIAGRAM

Procedure:

1. Make the connections as per the circuit diagram.
2. The filed regulator in the motor circuit is initially kept in minimum position (zero initial external resistance in the field circuit) so that the starting speed of the motor is minimum. The generator field regulator is kept in maximum position.
3. Close the DPST switch in the motor circuit and start the motor with the help of three-point starter, by moving the starter handle to the right in a single stretch.
4. The speed of the motor is adjusted to its rated value by 'cutting-in' the resistance in the motor field circuit i.e., by gradually increasing the external field resistance of the motor till the motor runs at its rated speed. Since the

generator is mechanically coupled to the motor, it also runs as its rated speed (which is the same as that of the motor).

5. Excite the generator by decreasing the generator field resistance. This is done till the paralleling voltmeter reads zero, whereupon it's voltage is the same, both in polarity and magnitude, as that of the main supply. The paralleling switch S is then closed.
6. By adjusting the respective field regulators, any load can now be thrown on to the machines. Generator current can be adjusted to desired value by increasing the excitation of the generator or by reducing the excitation of the motor. Note down the readings in the ammeters and voltmeters for a particular loading condition.

Tabular Form:

Sl. No.	N	V	I_L	I_g	I_{shm}	I_{shg}
1.						
2.						
3.						
4.						

Calculations:

Efficiency calculations are done as explained in the theory.

Motor armature current, I_{am} =

Generator armature current, I_{ag} =

Armature copper loss in motor =

Armature copper loss in generator=

Shunt field copper loss in motor=

Shunt field copper loss in generator=

Total copper losses in the motor generator set=

Power drawn from the supply mains=

Stray power losses of both machines, P_s =

Motor Intake (input)=

Total losses in motor=

Motor output=

Motor efficiency=

Generator output=

Total losses in generator=

Generator input=

Generator efficiency =

Calculations: -

Current drawn from the supply means, I_L

Motor intake current = I_m (I_L+I_g)

Motor Shunt field current = I_{shm}

Motor armature current I_{am} = I_m - I_{shm}

Generator output current = I_g

Generator shunt field current = I_{shg}

Generator armature current, I_{ag} = I_g + I_{shg}.

Bus bar Voltage = V

Power drawn from the supply mains = VI_L = Total losses of both the machines.

Armature copper loss in motor = $I^2_{am} R_{am}$

Armature copper loss in generator = $I^2_{ag}R_{ag}$

Shunt field copper loss in motor = VI_{shm}

Shunt field copper loss in generator= VI_{shg}

Total copper losses = $I^2_{am}R_{am} + I^2_{ag}R_{ag} + VI_{shm} + VI_{shg}$.

But, power drawn from the supply= Total losses of both the machines. Therefore,

VI_L = Total copper losses + Total Stray losses (i.e of both the machines)

➔ Stay power losses of both machines, P_s = VI_L + Total copper losses.

➔Stray losses of each machine = P_s / 2

Efficiency of Motor:

Motor Intake (input) = VI_m

Total losses in motor = Armature Cu loss + Field Cu loss + Stray loss

$= I^2_{am}R_{am} + VI_{shm} + P_s / 2$

Motor output = Motor input – total losses in motor

$= VI_m-(I^2_{am}R_{am} + VI_{shm} + P_s/2)$

Motor efficiency= (output/input) x 100.

Efficiency of generator:

Generator output = VI_g

Total losses in generator = Armature Cu loss + Filed Cu loss +Stray loss

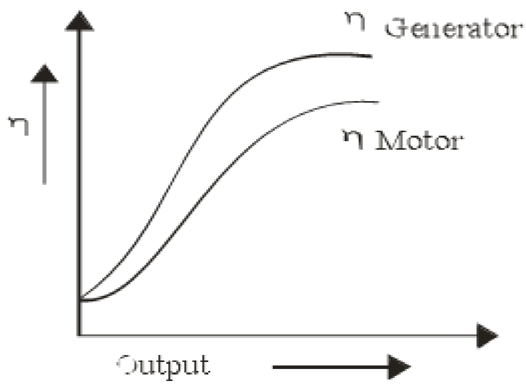
$= I^2_{ag}R_{ag} + VI_{shg} + P_s / 2$

Generator input = output + losses

$= VI_g + I^2_{ag}R_{ag} + VI_{shg} + P_s / 2$

Generator efficiency = (output / input) x 100.

Model graphs:



Characteristics

Precautions:

1. Fieldrheostatofmotorshouldbeatminimumposition.
2. Don't switch on thesupplywithout anyload.
3. Takecarewhileusing thestarter.
4. Thespeed should be adjusted to rated speed.
5. Thereshould beno loose connections.
6. Avoidparallaxerrorsandlooseconnections.

Result:

Viva Questions:

- What are the advantages of the test?
- Can this test be applied to compound machines?
- Explain when two dc machine s are paralleled as is done in this test, which machine acts as generator and which machine acts as motor?
- What are the disadvantages of this test?
- What are heat run tests?
- Hopkinson's test is a ………..test.
- Hopkinson's test on DC Machines is conducted at ….load.
- The armature voltage control of dc motor provides …… drive

Expt. No.10.SWINBURNE'S TEST

Aim:

To Pre - determines the efficiency of a DC shunt machine by using Swinburne's test.

Apparatus:

S. No.	Meter	Range	Type	Quantity
1.	Voltmeter	0-300V	MC	1
2.	Ammeter	0-2A	MC	1
3.	Ammeter	0-1A	MC	1
4.	Tachometer	--	Digital	1

Theory:

It is a simple method in which losses are measured separately and from their knowledge, efficiency at any desired load can be predetermined in advance. The only running test needed is no-load test. However, this test is applicable to those machines in which flux is practically constant i.e., shunt and compound –wound machines. The machine is run as a motor on no-load at its rated voltage i.e., voltage stamped on the nameplate. The speed is adjusted with the help of shunt regulation as shown in fig.

The no-load current I_0 is measured by the armature A_1 where shunt field current I_{sh} is given by ammeter A_2. The no-load armature current is $(I_o – I_{sh})$ or I_{ao}.

Let, supply voltage = V   no-load input = VI_o watt

$\therefore$ Power input to armature = $V (I_o – I_{sh})$;   Power input to shunt = VI_{sh}

No-load power input to armature supplies the following:-

(i) Iron losses in core

(ii) Friction loss

(iii) Winding loss and

(iv) Armature Cu loss = $(I_o – I_{sh})^2 R_a$ or $I_{ao}^2 R_a$

If we subtract from the total input the no-load armature Cu loss, then we get constant losses.

$$\therefore \text{Constant losses } W_c = VI_o – (I_o – I_{sh})^2 R_a$$

Knowing the constant losses of the machine, its efficiency at any other load can be determined as given below. Let I= load current at which efficiency is required.

Then, armature current is $I_a = \begin{cases} I - I_{sh}, & \text{...if machine is motoring} \\ I + I_{sh} & \text{...if machine is generating} \end{cases}$

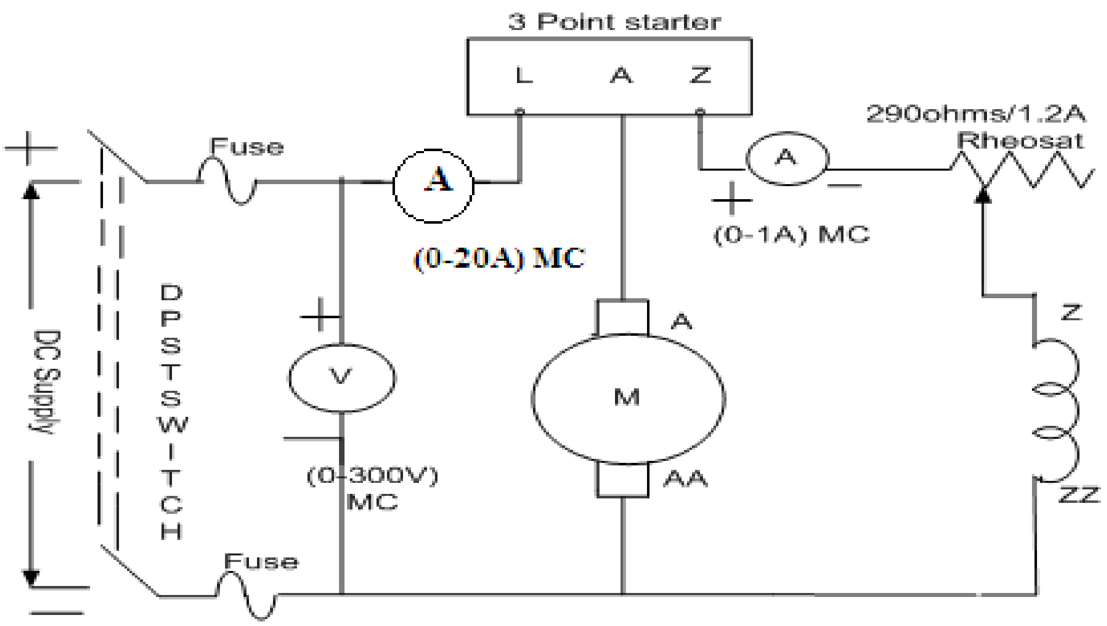
Advantages: -

1. Since constant losses are known, the efficiency can be estimated at any load.
2. The method is convenient and economical as less power is required.
3. The motor is not required to be loaded.

Disadvantages: -

1. In this method, the iron losses are assumed to be constant which is not true as they change from no load to full load.
2. It is difficult to know whether there will be satisfactory commutation at full load as the test is no load test.
3. As it is no load test it cannot be performed on series motor.

Circuit Diagram:



Procedure:

1. Connect the circuit as per the circuit diagram.
2. Start the motor using 3-point starter.
3. The speed is adjusted to the rated speed with the help of field regulator.
4. The motor is run on no load current at its rated voltage.
5. Note down the readings of no load current, field current & voltage.
6. Measure the resistance of armature of the machine.
7. Calculate the constant loss from the readings.
8. Calculate the efficiency of the machine at different loads when acting as both motor & generator.

Tabular Form:

Supply voltage V_L (V)	**Field Current I_{sh} (A)**	**No load Current I_O (A) =(I – I_{sh})**	**Armature Resistance R_a (Ω)**	**Speed N (RPM)**

Calculations:

Efficiency when running as a motor:

Input = VI

Armature Cu loss = $I_a^2 R_a = (I - I_{sh})^2 R_a$

Constant losses = $W_c = VI_o - (I_o - I_{sh})^2 R_a$

Total losses = $(I - I_{sh})^2 R_a + W_c$; $\eta_m = \dfrac{input - loss}{input} = \dfrac{VI - (I - I_{sh})^2 R_a - W_e}{VI} =$

Efficiency when running as a generator:

Output = VI

Armature Cu loss = $(I + I_{sh})^2 R_a$ =

Constant loss = $W_c = VI_o - (I_o - I_{sh})^2 R_a$

$\therefore$ Total losses = $(I + I_{sh})^2 R_a + W_c$

$$\eta_g = \frac{output}{output + losses} = \frac{VI}{VI + (I + I_{sh})^2 R_a + W_c}$$

No load input = Total losses = V_L I_O =

No load copper losses = $I_u^2 .R_u$ =

Constant losses = Total losses – copper losses =

Machine when running as a Motor

(i) At Full load: I_L =

Total Input = V_L I_L =

Copper losses = I_a^2 R_a =

Total losses=

Efficiency η = (input – losses) X 100 / (input).

(ii) At Half load: I_L =

Total Input = V_L I_L =

Copper losses = I_a^2 R_a =

Total losses=

Efficiency η = (input – losses) X 100 / (input).

Machine when running as a generator

(i) At Full load: I_L =

Total Input = V_L I_L =

Copper losses = I_a^2 R_a =

Total losses=

Efficiency (η) = (input – losses) X 100 / (input).

(ii) 9At Half load: I_L =

Total Input = V_L I_L =

Copper losses = I_a^2 R_a =

Total losses=

Efficiency (η) = (input – losses) X 100 / (input).

Precautions:

1. Field rheostat of motor should be at minimum position.
2. Don’t switch on the supply without any load.
3. Take care while using the starter.
4. Thespeed should be adjusted to rated speed.
5. There should be no loose connections.
6. Avoid parallax errors and loose connections.

Result:

Viva Questions:

- What are the advantages of the test?
- What are the Losses in dc machines?
- Define motor?
- What is the difference between resistor and rheostat?
- Why we are using 3 point starter in this test?

Expt. No.11.PARALLEL OPERATION OF A SINGLE PHASE TRANSFORMERS

Aim:

To conduct the two single phase transformers in parallel and to study the load sharing of each transformer.

Apparatus:

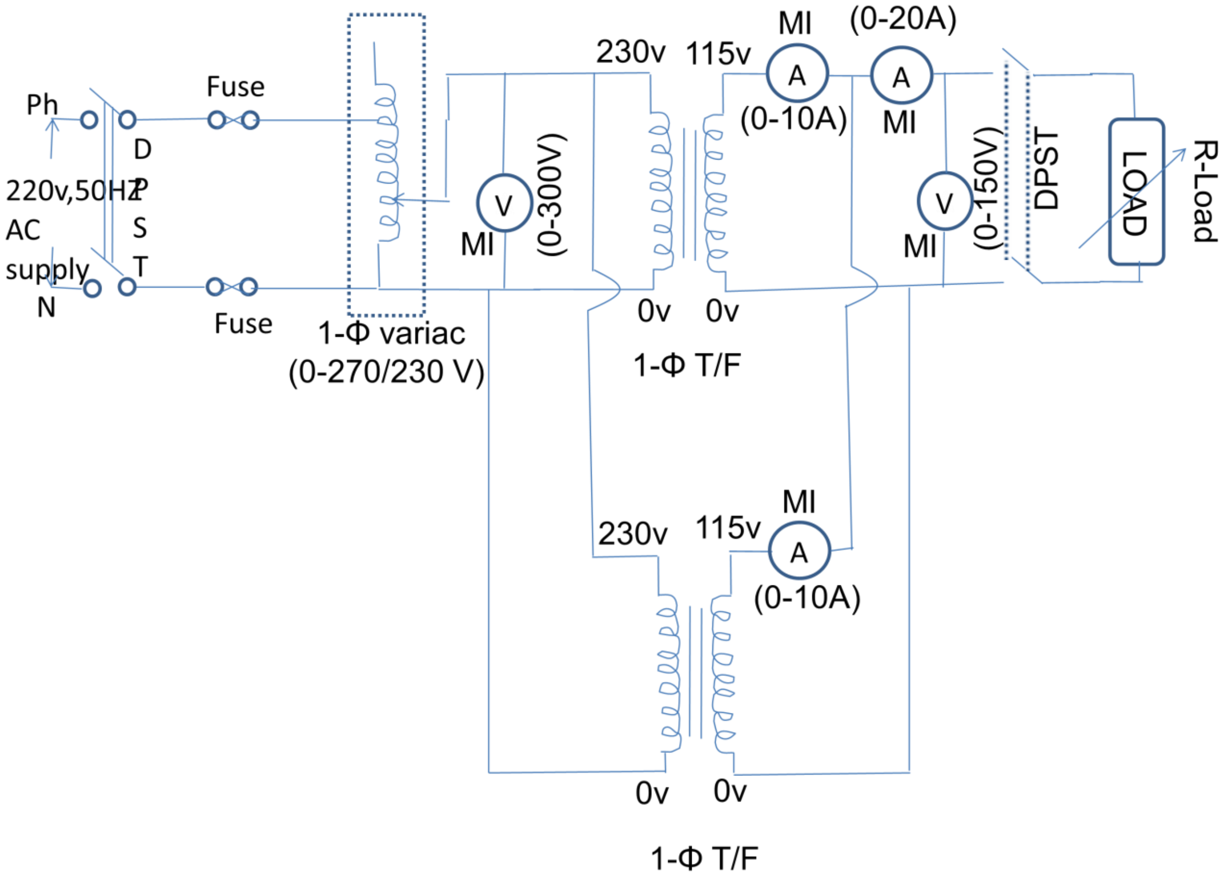
S.No	Apparatus	Type	Range	Qty
1	1-Φ Auto transformer	Fully Variable	(0-230)v	1 No
2	Voltmeter	M.I	(0-300)V	1 No
3	Voltmeter	M.I	(0-150)V	1 No
4	Ammeter	M.I	(0-10)A	2 No
5	Ammeter	M.I	(0-20)A	1 No
6	Wattmeter	UPF	75V/10A	1 NO

Theory:

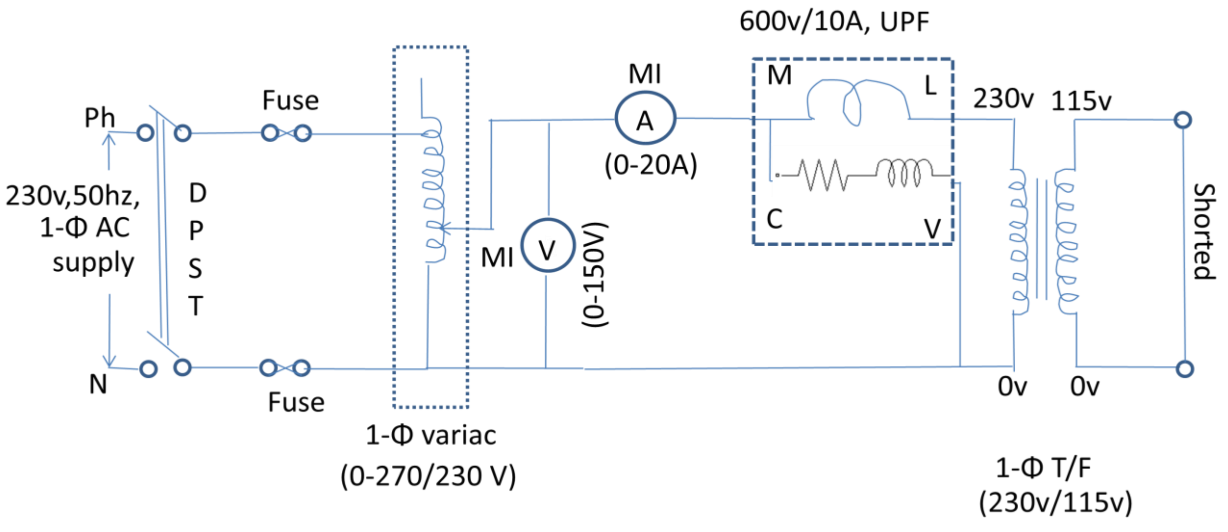
When the load out grows the capacity of an exciting transformer, it may be economical to install another one in parallel with if rather than replacing with a single large unit. Also, sometimes in a new installation two units In parallel, through more expensive, may be preferred over a single unit for reasons of reliability-half the load can be supplied with one unit out further, the cost of maintaining a spare is less with two units in parallel. However, when spare units are maintained at a central location to serve transformer installations in a certain reason, single unit installations would be preferred. It is therefore seen that parallel operation of the transformer is quite important and desirable under certain circumstances.

Circuit diagram:

LOAD TEST:



Impedance Test:



Procedure:

Parallel Operation:

1. The connections are made as per the circuit diagram.
2. Consider that the dimmer starter at zero position. The load switch is in OFF position the supply (DPST) is closed.
3. The dimmer starter output is gradually adjusted such that voltmeter reads rated voltage of primary winding.
4. The load on the transformers is applied in steps. Load switch and all the meter readings are noted in tabular form.
5. The step number 4 is repeated until the transformer reaches the rated current.
6. Remove the load in steps and switch off the load switch & bring back the auto- transformer to zero position.
7. Switch OFF the power supply.

Impedance Test:

1. The connections are made as per the circuit diagram.
2. Consider that the dimmer starter at zero position. The supply(DPST) is closed.
3. The dimmer starter output is gradually adjusted such that ammeter reads rated current of primary winding. Note down all the meter readings in tabular column.
4. Bring back the dimmer starter to zero position and switch OFF the power supply.

Tabular Forms:

Parallel Operation (Load Test):

		Practical Values			Theoritical Values	
S.NO	Load	I_1(A)	I_2(A)	I_3(A)	I_A(A)	I_B(A)

Impedance Test:

T/F	V_{sc}(V)	I_{sc}(A)	W_{sc}(W)	Cos Φ_{sc}	Z_{SC}(Ω)	R_{SC}(Ω)	X_{SC} (Ω)
T/F (A)							
T/F (B)							

Calculations:

$$\cos\Phi_{SC} = W_{SC} / (V_{SC} \times I_{SC})$$

$$Z_{SC}=V_{SC}/I_{SC}$$

$$X_{SC}=\sqrt{\boldsymbol{Z}_{SC}^2-R_{SC}^2}$$

$$R_{sc}=W_{sc}/I_{sc}^2$$

The current sharing by each transformer

$$I_A=I_T*Z_B/Z_A+Z_B$$

$$I_B =I_T.Z_A/Z_A+Z_B$$

Precautions:

1. Check if the connections are tight.
2. Do the connections properly with proper grounded terminals.
3. Avoid the loose connections.
4. Before switching on the supply check whether 1-Φ auto transformer is in minimum position or not.

Result:

Viva Questions:

1. What is the necessity of the parallel operation?
2. What are the conditions required for the parallel operation of transformer?
3. What are the applications of transformer?
4. What is the need of polarity test?

Expt. No.12.POLARITY AND TURNS RATIO TEST ON A 1-PHASE TRANSFORMER

Aim:

To conduct polarity test, and determine turn`s ratio, transformation ratio, and magnetizing component of No Load current of single phase transformer. (115/ 220 V, 2 KVA).

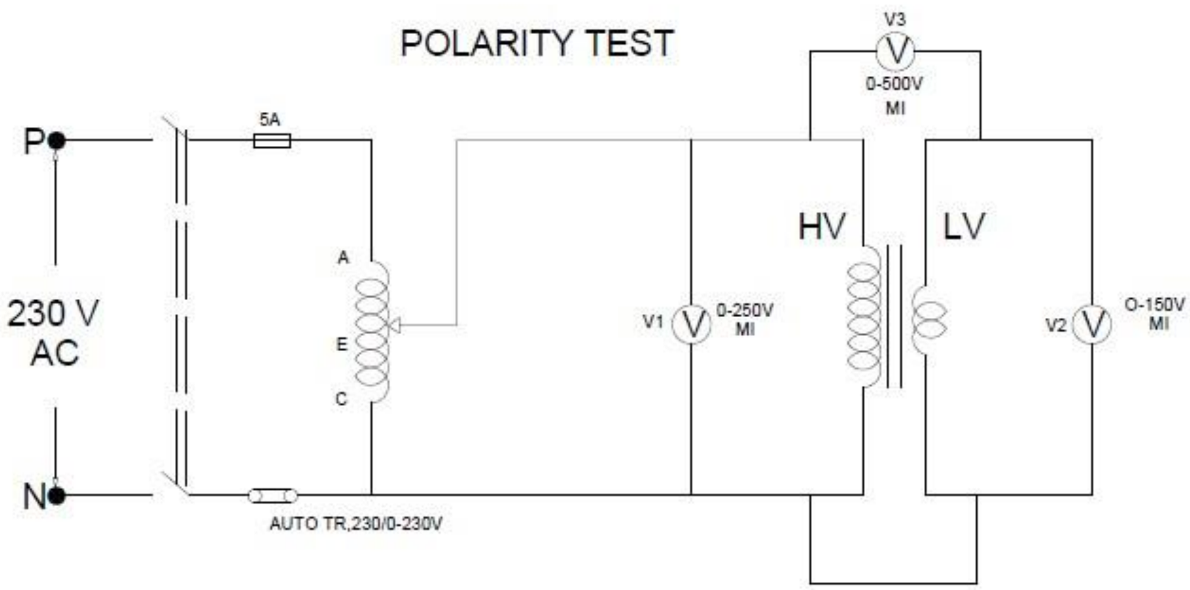
Apparatus:

Sl.NO	Name	Range	Type	Quantity
1.	Voltmeter	(0 – 30)V	MC	01
2.	Voltmeter	(0 – 30)V	MI	01
3.	Ammeter	(0 – 10)A	MI	01
4.	1-Phase Transformer	2KVA, 115/230V	--	01
5.	Connecting wires	--	--	Required

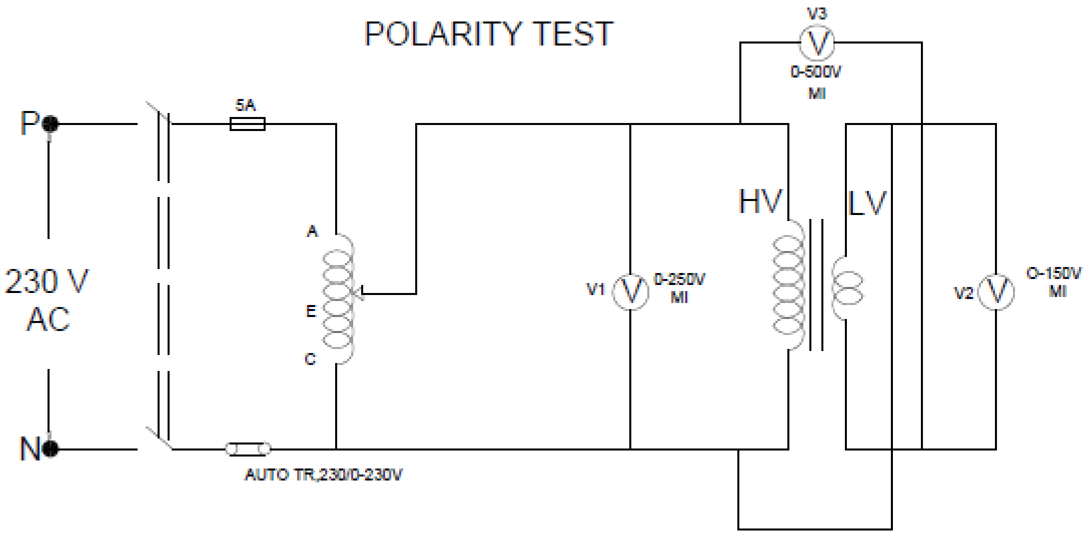
Theory:

Turns ratio of a transformer = No of turns of primary/No of turns of secondary.
Transformation ratio K = Secondary induced EMF/ Primary induced EMF= E2/E1
E1 = 4.444 φm.f.N1 Volts. And E2 = 4.444 φm.f.N2Volts ... K= E2/E1
K =4.444 φm.f.N2/4.444 φm.f.N1, =N2/N1
Turns ratio, N1/N2=E1/E2.
No load input power, W0= V0 I0 Cosφ0, Cosφ0= W0/ V0 I0, φ0 =Cos-1(W0/ V0 I0).
Magnetizing component of no load current Iμ = I0 Sinφ0.

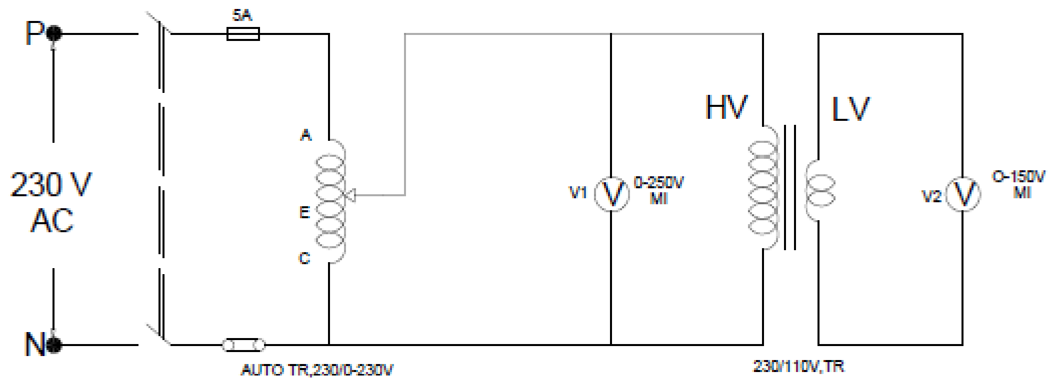
Circuit Diagrams:


POLARITY TEST
V3
0-500V
MI
P
N
230 V
AC
5A
A
E
C
AUTO TR,230/0-230V
V1
0-250V
MI
HV
LV
V2
O-150V
MI

POLARITY TEST



TURNS RATIO TEST



Procedure:

Polarity test:

1. Connections are made as shown in figure.

2. Checked the connections and given a specified voltage to primary.

3. Noted the volt meter reading and verified the polarity of the transformer.ie If the voltmeter reading in the inter connected voltmeter is greater than the input voltage, and then the polarity is additive, So Opposite polarity on the other adjacent terminal on secondary.

4. Interchanged the connections to confirm first determined polarity.

Turn`s ration and transformation ratio:

1. Connections are made as in figure (2)
2. Checked the connections and given the supply gradually from minimum voltage to rated voltage of primary using autotransformer.
3. Noted the V/m readings on primary and secondary and the A/m and W/m reading when applying the rated primary voltage.
4. Completed the experiment neatly and correctly.

Result: Checked the polarity and determined the turn's ratio transformation ratio, and magnetizing component of no load current of 115/220V 2 KVA transformer.

Turns ratio= Transformation ratio=

Magnetizing component of no load current $I\mu$ =

Determined the polarity of the transformer also.

Sl. No	Prim. V/m reading E_1	Sec. V/m reading E_2	Watt meter reading W_0	A/m. reading I_0	Turns ratio	Transf. ratio =K