DAV UNIVERSITY

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Department of Electrical Engineering

LABORATORY MANUAL

Electrical Machine Lab
(ELE----)

DAV UNIVERSITY

Department of Electrical Engineering

VISION

The Department aims to serve as a platform for the growth and transfer of technical competence to endeavor academics, entrepreneurship, and strategic judgments in local and global spheres in order to satisfy the altering demands of society.

MISSION

1. To create technocrat in the fields of Electrical Engineering to develop them into qualified, ambitious professionals with expertise.
2. Working to develop aspiring minds into more competitive, motivated professionals with concrete theoretical and practical skills.
3. To encourage Bi- lateral influences (industry-institute and institute-institute connections) for the long-term growth in educational, research, training, and employment opportunities.
4. To teach students how to formulate, analyze and solve problems in real life by using their computational and analytical skills.
5. To create excellence in strategic areas to foster an innovative and creative mindset among stakeholder.

Programme Educational Objectives (PEOs)

1. **To have a solid understanding of the fundamental principles of Electrical Engineering in order to pursue higher education, a successful career as an entrepreneur or both.**
2. **To foster an ethically responsible, logical approach towards rapidly changing technologies.** Harvest the knowledge by analyzing complicated, real-world issues that are sustainable from a technological, economic, and social perspective.
3. **To develop technologically commercially savvy abilities for cutting-edge approaches in Electrical Engineering (or similar fields).** Show leadership and teamwork while collaborating with various interdisciplinary and multidisciplinary groups.
4. **To engage in ongoing learning in the appropriate field in order to fulfil societal issues on a global scale.**
5. **Through instruction, group activities, and self-study, demonstrate persistent learning and adaptation to recent technology engineering tools, techniques, and practices. Be ethically responsible and devoted to the objectives for welfare of Human kind.**

PROGRAM OUTCOMES

Engineering Graduates will be able to:

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

2 **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3 **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4 **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.

5 **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6 **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7 **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.

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

9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10 **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.

11 **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.

12 **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 (PSO)

1. To comprehend power systems, electrical energy usage, and energy conservation, and to identify the best solution.

2. Making use of latest pedagogical tools and techniques to create original solutions in order to meet the challenges in electrical engineering and related fields.

COURSE OUTCOMES

After successfully studying this course, students will:

1. Explain the concept of circuit laws and network theorems and apply them to laboratory measurements.
2. Be able to systematically obtain the equations that characterize the performance of an electric circuit as well as solving both DC Machines and single phase transformer.
3. Acknowledge the principles of operation and the main features of electric machines and their applications.
4. Acquire skills in using electrical measuring devices.

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INSTRUCTIONS TO STUDENTS

- Before entering the lab the student should carry the following things.
    - Identity card issued by the University.
    - Class notes
    - Lab Manual.
- Come to the laboratory in time. Students, who are late more than 15 min., will not be allowed to attend the lab.
- Students need to maintain 100% attendance in lab if not a strict action will be taken.
- All students must follow a Dress Code while in the laboratory
- Foods, drinks are NOT allowed.
- All bags must be left at the indicated place.
- The objective of the laboratory is learning. The experiments are designed to illustrate phenomena in different areas of Physics and to expose you to measuring instruments, conduct the experiments with interest and an attitude of learning
- You need to come well prepared for the experiment.
- Work quietly and carefully.
- Be honest in recording and representing your data.
- If a particular reading appears wrong repeat the measurement carefully, to get a better fit for a graph
- All presentations of data, tables and graphs calculations should be neatly and carefully done
- Graphs should be neatly drawn with pencil. Always label graphs and the axes and display units.
- If you finish early, spend the remaining time to complete the calculations and drawing graphs. Come equipped with calculator, scales, pencils etc.
- Do not fiddle with apparatus. Handle instruments with care. Report any breakage to the Instructor. Return all the equipment you have signed out for the purpose of your experiment.

SPECIFIC SAFETY RULES FOR DC MACHINE LABORATORY

- You must not damage or tamper with the equipment or leads.
- You should inspect laboratory equipment for visible damage before using it. If there is a problem with a piece of equipment, report it to the technician or lecturer. DONOT return equipment to a storage area
- You should not work on circuits where the supply voltage exceeds 40 volts without very specific approval from your lab supervisor. If you need to work on such circuits, you should contact your supervisor for approval and instruction on how to do this safely before commencing the work.
- Always use an appropriate stand for holding your soldering iron.
- Turn off your soldering iron if it is unlikely to be used for more than 10 minutes.
- Never leave a hot soldering iron unattended.
- Never touch a soldering iron element or bit unless the iron has been disconnected from the mains and has had adequate time to cool down.
- Never strip insulation from a wire with your teeth or a knife, always use an appropriate wire stripping tool.
- Shield wire with your hands when cutting it with a pliers to prevent bits of wire flying about the bench.

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CONTENTS

Experiment-01

AIM: - To Perform Open Circuit and Short Circuit on A Single Phase Transformer.

APPARATUS REQUIRED: -

S. No.	Apparatus Required	Specifications	Quantity
1.	Transformer	115/230V	1
2.	Variac	230V, 1-phase, 50Hz	1
3.	Wattmeter	0-440V, 0-2.5A.(for OC) 0-150V,0-20A(for SC)	1
4.	Voltmeter	300V	1
5.	Ammeter	15A	1

THEORY: -

1. Open Circuit (OC) or No-Load Test

The purpose of this test is to determine the shunt branch parameters of the equivalent circuit of the transformer. One of the windings is connected to supply at rated voltage, while the other winding is kept open - circuited. From the point of view of convenience and availability of supply the test is usually performed from the LV side, while the HV side is kept open circuited.

V_O= Rated Voltage applied.

I_O= No load current (it is usually 2-6% of the rated current)

P_O= Power input (No load

losses) Then the relation is

$$P_o = V_o \times I_o \times Cos(\emptyset_o)$$

$(\emptyset_o)$- No load power factor.

$$Cos(\emptyset_o) = \frac{P_o}{V_o \times I_o}$$

Therefore, magnetizing current,

$$I_m = I_o Sin(\emptyset_o)$$

Energy component of current

$$I_w = I_o Cos(\emptyset_o)$$

R_0 and X_0 are also small, that V_o can be regarded as = E_1 by neglecting the series impedance. This means that for all practical purposes the power input on no-load equals the core (iron) loss i.e.

$$Z = \frac{V_o}{I_o}$$

I

$$R = \frac{V_o}{I_W}$$

$$X_o = \sqrt{Z_o^2 - R_o^2}$$

2. Short Circuit (SC) Test

This test serves the purpose of determining the series parameters of a transformer. For convenience of supply arrangement and voltage and current to be handled, the test is usually conducted from the HV side of the transformer while the LV side is short-circuited. Since the transformer resistance and leakage reactance are very small, the voltage Vsc needed to circulate the full load current under short circuit is as low as 5-8% of the rated voltage. The exciting current under these conditions is only about 0.1to 0.5% of the full load current Thus the shunt branch of the equivalent circuit can be altogether neglected. While conducting the SC test, the supply voltage is gradually raised from zero till the transformer draws full load current. The meter readings under these conditions are: Since the transformer is excited at very low voltage, the iron loss is negligible (that is why shunt branch is left out), the power input corresponds only to the copper loss, i.e

V_{SC}= Voltage applied.

I_{SC}= Rated load current

P_{SC}= Power input (Copper loss) Then

the relation is $P_{sc} = V_{sc} \times I_{sc} \times Co(\emptyset)$

$Cos\ (\emptyset)$ - full power factor.

$$Cos(\emptyset) = \frac{P_{sc}}{V_{SC} \times I_{SC}}$$

Equivalent resistance, $R_{eq} = P_{sc} / (I_{sc})^2$

reactance, $X_{eq} = \sqrt{(Z_{eq}^2 - R_{eq}^2)}$

CIRCUIT DIAGRAM: -

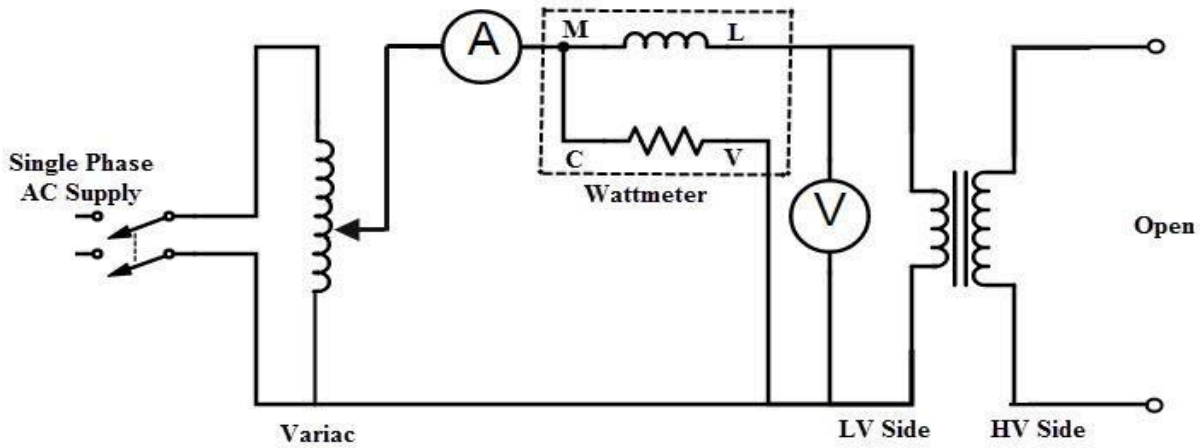

Fig1. Circuit Diagram for Open Circuit Test.

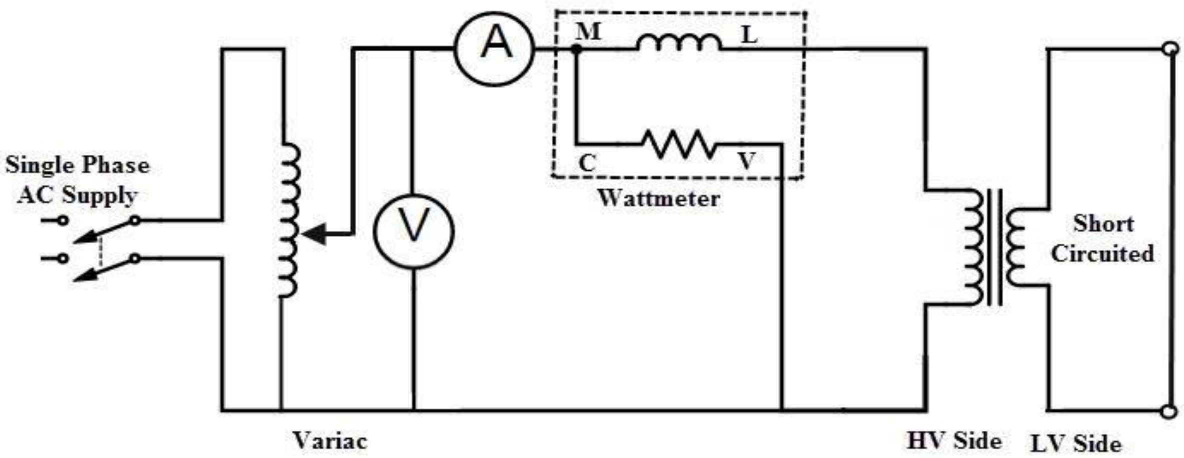

Fig2. Circuit Diagram for Short Circuit Test.

Procedure: -

OC Test:

1. Make the connections as per the circuit diagram in fig. 1.
2. By using 1- phase variac apply rated voltage.
3. Measure voltage, current & power input from voltmeter, ammeter and wattmeter resp.
4. Evaluate no load power factor, Iw , Im , $R0$ and $X0$
5. Verify the results

SC Test:

1. Make the connections as per the circuit diagram in fig. 2.
2. By using 1-phase variac apply voltage and increase till the rated current starts flowing.
3. Measure voltage, current & power input from voltmeter, ammeter and wattmeter resp.
4. Evaluate no load power factor, Zeq ,Req and Xeq
5. Verify the results

Observations and calculations:

OC Test:

S. No.	V_o(Volts)	I_o(Amps)	W_o(Watts)
1.			
2.			
3.			

SC Test:

S. No.	V_{sc}(Volts)	I_{sc}(Amps)	W_{sc}(Watts)
1.			
2.			
3.			

Evaluate the no load and full load parameters.

Precautions:

1. Open circuit test is performed on LV side i.e. meter are connected LV and HV side will be open circuited.
2. For short circuit test is connect meters on HV side and LV side will be short circuited.
3. Rated voltage and rated current must be maintained in OC test and SC test respectively.
4. All the connections should be tight.

Viva Questions:

1. What are the advantages of OC and SC test?
2. Why the SC test is normally done on HV side?
3. Why the OC test is normally done on the LV side?
4. What are the components of iron loss?

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Experiment-02

AIM: - To conduct load test on single phase transformer and to find efficiency and Percentage regulation.

APPARATUS REQUIRED: -

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-10)A (0-5) A	MI MI	1 1
2	Voltmeter	(0-150)V (0-300) V	MI MI	1 1
3	Wattmeter	(300V, 5A) (150V, 5A)	Upf Upf	1 1
4	Auto Transformer	1�, (0-260)V	-	1
5	Resistive Load	5KW, 230V	-	1
6	Connecting Wires	2.5sq.mm	Copper	Few

FORMULAE:

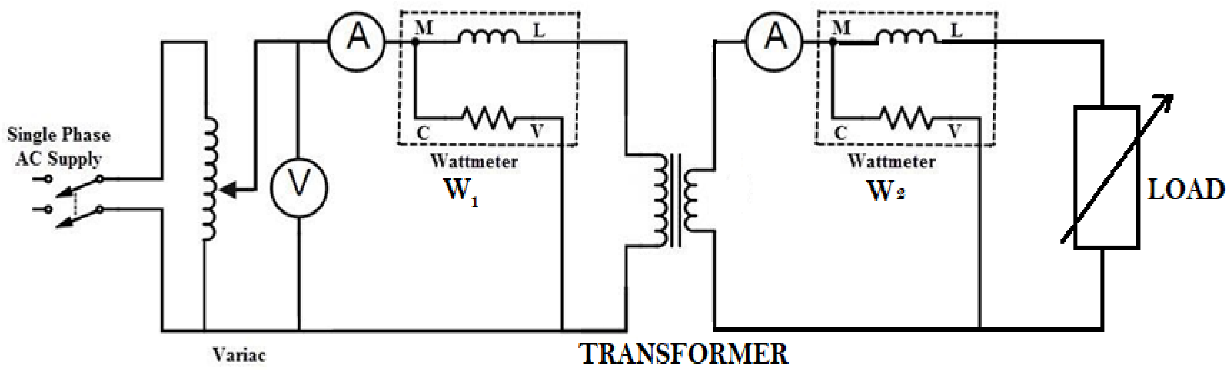
Output Power = W_2 x Multiplication factor

Input Power = W_1 x Multiplication factor

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

$$\text{Regulation R } \% = \frac{V_{NL} - V_{FL} \text{ (Secondary)}}{V_{NL}} \times 100\%$$

CIRCUIT DIAGRAM: -



PROCEDURE: -

1. Connections are made as per the circuit diagram.
2. After checking the no load condition, minimum position of auto transformer and DPST switch is closed.
3. Ammeter, Voltmeter and Wattmeter readings on both primary side and secondary side are noted.
4. The load is increased and for each load, Voltmeter, Ammeter and Wattmeter readings on both primary and secondary sides are noted.
5. Again no load condition is obtained and DPST switch is opened.

TABULAR COLUMN: -

S. No.	Load	Primary			Secondary			Input Power W_1 x MF	Output Power W_2 x MF	Efficiency %	% Regulation
		V_1 (Volts)	I_1 (Amp)	W_1 (Watt)	V_2 (Volt)	I_2 (Amp)	W_2 (Watt)				
1.											
2.											
3.											
4.											

PRECAUTIONS:

1. Auto Transformer should be in minimum position.
2. The AC supply is given and removed from the transformer under no load condition.

RESULT:

Thus the load test on single phase transformer is conducted.

Viva Questions:

1. What is the function of a transformer?
2. What is a load?
3. Why do we perform load test when the efficiency can be determined by O.C. and S.C. tests?
4. Mention the types of transformer.
5. Explain the operating principle of a transformer.
6. List out general applications of transformer.
7. What are core type transformers?
8. What are shell type transformers?
9. Distinguish between power and distribution transformer.
10. Define voltage regulation of a transformer.

Experiment-03

AIM: - To Study the Parallel Operation of Two Single Phase Transformers.

APPARATUS: -

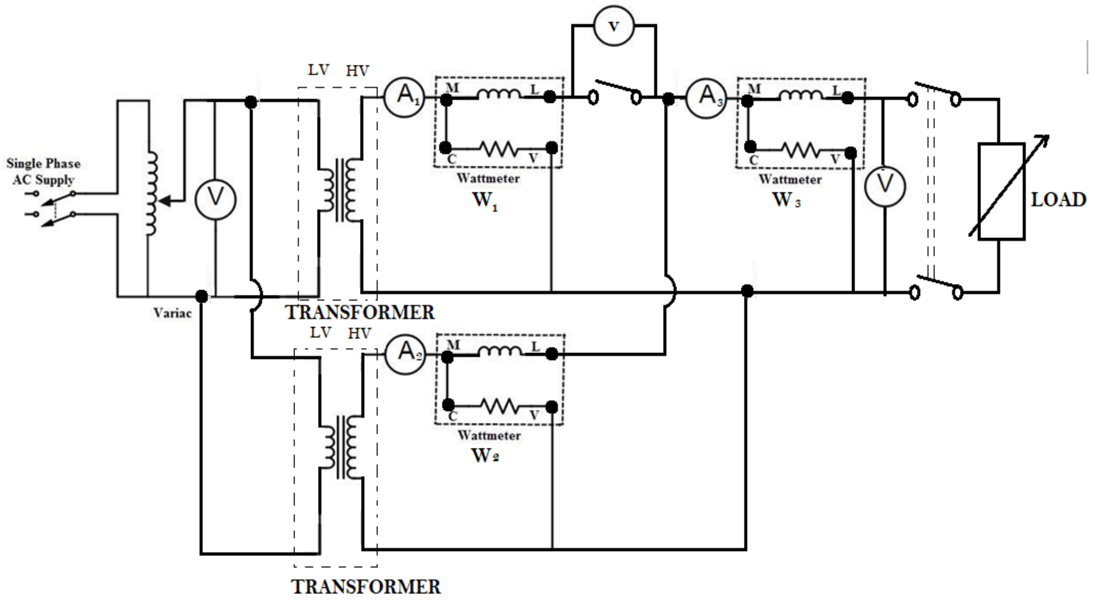
S.No.	Apparatus	Range	Quantity
1	Transformers	2KVA,230/115V	2
2	Wattmeter	300V,10A	3
4	Autotransformer	0-270V	1
5	Single phase load	2KW,1.5A step	1
6	Voltmeter	0-300V	3
7	Ammeter	0-10A 0-20A	2 1

THEORY: -

Parallel operation of transformers is used for load sharing. The transformers are connected in parallel on both primary and secondary side. Following conditions to be satisfied during the parallel operation of transformers

- Same polarities should be connected.
- The two transformers should have same voltage ratio.
- The percentage impedance should be same.
- There should be no circulating current.

CIRCUIT DIAGRAM: -



PROCEDURE: -

1. Connect the circuit as shown in the diagram.
2. Note down the readings of all wattmeters, ammeters and voltmeters for given load.
3. Repeat the above test for different values of load
4. Take at least three readings.

OBSERVATIOBN TABLE: -

S.NO.	I_1 (AMPS)	W_1(WATTS)	I_2(AMPS)	W_2(WATTS)	$I_L=I_1+I_2$ (AMPS)	$W_L=W_1+W_2$ (WATTS)
1.						

RESULT: -

The two transformers connected in parallel share the load equally.

DISCUSSION: -

The total load current is distributed on two transformers accordingly.

I1+I2=IL

The total wattmeter readings are distributed on two wattmeter accordingly.

W1+W2=WL

PRECAUTIONS: -

1. Transformers should be connected in such a way that they have same polarity.
2. All connections should be neat and tight.
3. Connecting leads should be perfectly insulated.

QUIZ: -

Q.1 What is the minimum no. of transformers needed to conduct this exp.? A1 Two

Q.2 What is the effect of circulating current in the circuit having two transformers in parallel? A2 produces additional copper losses

Q.3 when does the circulating current flow in a circuit of two transformers connected in parallel? A3 If the two transformers have different voltage ratios

Q.4 How much circulating current can be tolerated for parallel operation of transformers? A4 10% of rated value

Q.5 why the transformer are needed to be operated in parallel. A5 If the load is more than rated load

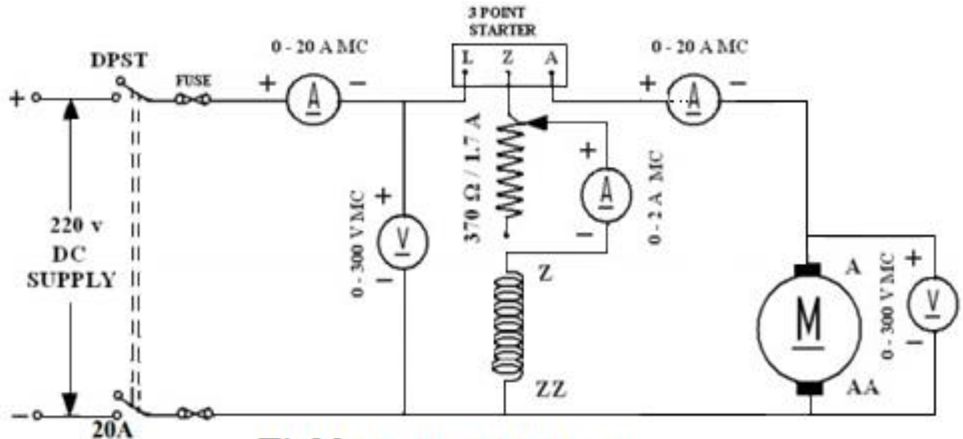
Experiment-04

AIM: - To Perform Speed Control of a DC Motor using Field Control and Armature Control Method.

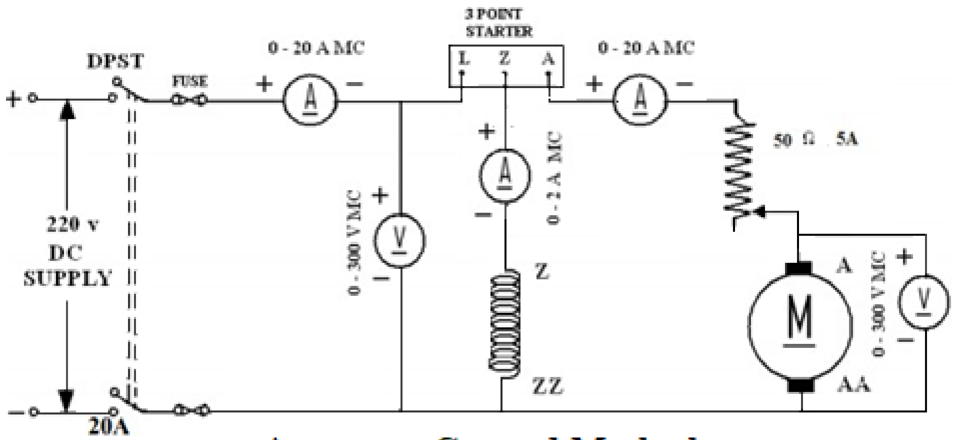
APPARATUS REQUIRED: -

S.No	Meter	Range	Qty
1	DC machine	3HP,230V16A,1500RPM	1
2	Ammeter	(0-2A)	1
3	voltmeter	(0-300V)	1
4	Tachometer	0-10000 RPM	1
5	Rheostat	110Ω, 3A	1

CIRCUIT DIAGRAM: -



Field Control Method



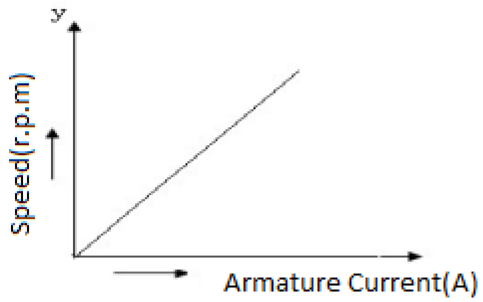
Armature Control Method

Speed of Dc shunt motor is given by the relation

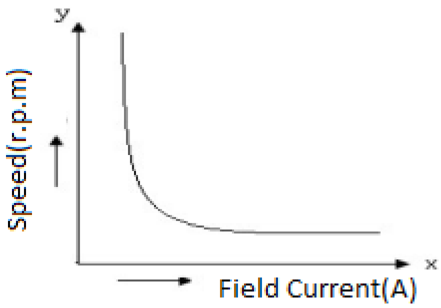
$$N = \frac{V - I_a R_a}{\varnothing Z}$$

1. For armature control operation Ø is constant and the speed is function of armature current
2. For field current control method the armature current is kept constant and the speed is function of magnetic flux which in turn field current

Armature Control



Field Control



PROCEDURE: -

1. Make the connections as per the circuit diagram.
2. Keep the field rheostat in the minimum resistance position and the armature resistance in the maximum resistance position.
3. Start the motor by moving the handle of the starter slowly.

FIELD CONTROL: -

1. Vary the Armature rheostat resistance until voltmeter across the armature reads 200 Volts.
2. Increase the Field resistance in steps.
3. Note down the values of Ish, the shunt field current, speed.

ARMATURE CONTROL: -

1. Keep the field rheostat at a selected field current value at the rated field current such that it shows Base speed
2. Decrease the armature resistance from the maximum position in steps keeping the field current at the set value.
3. Note down the speed for each value of armature voltage and armature current.

OBSERVATIOBN TABLE: -

Flux control:

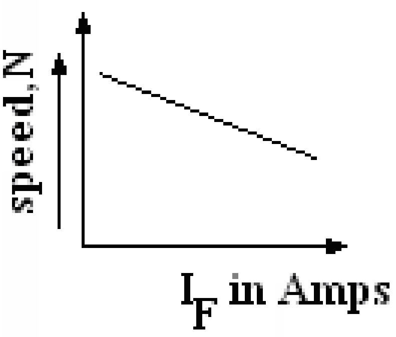
S.NO	Field current I_f (A)	Speed N (rpm)

Armature control:

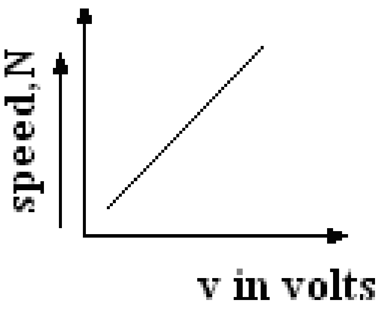
S.NO	Voltage V (V)	Speed N (rpm)

Model Graph:

1. Plot I_F Vs speed **N**



2. plot **voltage Va** speed **N**



RESULT: -

PRECAUTION: -

1. Take care while using the starter.
2. Keep the armature and field rheostats at proper positions.
3. The speed should be adjusted to rated speed.
4. There should be no loose connections.

Experiment-05

AIM: - To obtain open circuit characteristics of DC shunt generator and to find its critical resistance.

APPARATUS REQUIRED: -

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-1)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	1250Ω, 0.8A	Wire Wound	2
4	SPST Switch	-	-	1
5	Tachometer	(0-1500)rpm	Digital	1
6	Connecting Wires	2.5sq.mm.	Copper	Few

THEORY: -

The emf generated by the DC generator is given by the relation

$$E_o = \frac{\varnothing ZNP}{60A}$$

Ø , Z, N,P and A are the magnetic flux per pole, number of conductors, speed in rpm, number of poles and number of parallel paths respectively.

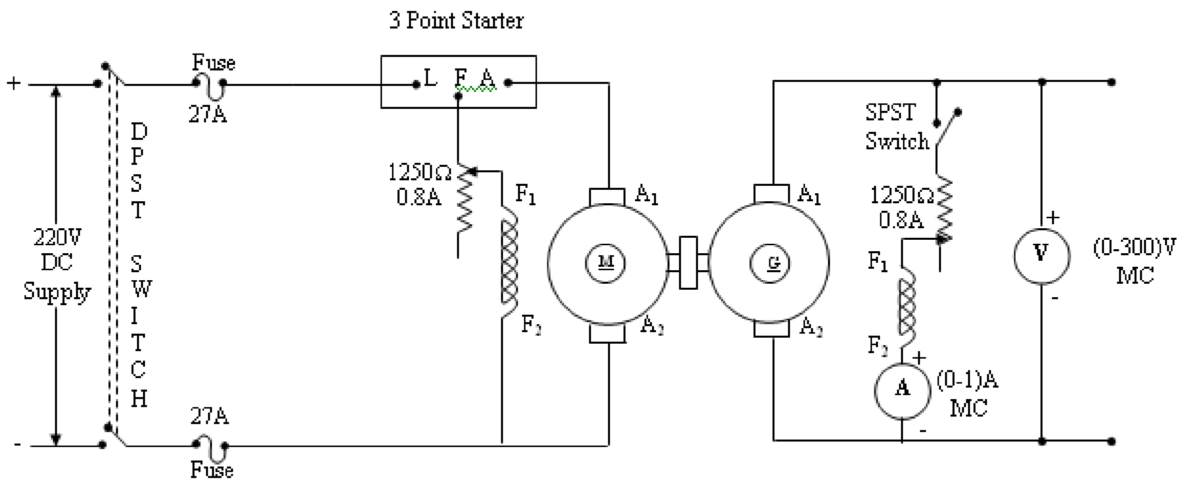
In case of DC shunt generator as the field winding is connected in parallel to the armature winding, the magnetic flux will be the function of field current. So, the magnetization

Characteristics is plot of induced emf with field current as shown in the figure. The nature of OCC is due to the following points

1. When the field current is zero, there is some generated e.m.f which is due to residual magnetism in the field poles
2. Over a fairly wide range of field current (in the initial portion) the curve is linear. It is because in this range reluctance of iron is negligible as compared with that of air gap. The air gap reluctance is constant and hence linear relationship.

3. After that the reluctance of iron also comes into picture. Consequently, the curve deviates from linear relationship.
4. Finally the magnetic saturation of poles begins and E_0 tends to level off.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :	220V	220V
Rated Current :	21A	21A
Rated Power :	3.5KW	7.5KW
Rated Speed :	1500 RPM	1500 RPM

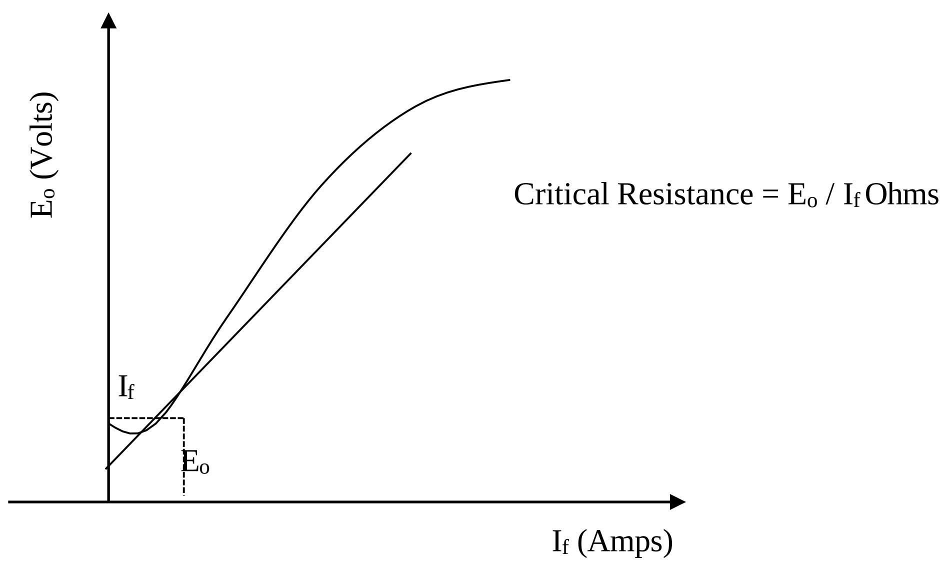
PROCEDURE: -

1. Connections are made as per the circuit diagram.
2. After checking minimum position of motor field rheostat, maximum position of generator field rheostat, DPST switch is closed and starting resistance is gradually removed.
3. By adjusting the field rheostat, the motor is brought to rated speed.
4. Voltmeter and ammeter readings are taken when the SPST switch is kept open.
5. After closing the SPST switch, by varying the generator field rheostat, voltmeter and ammeter readings are taken.
6. After bringing the generator rheostat to maximum position, field rheostat of motor to minimum position, SPST switch is opened and DPST switch is opened.

TABULAR COLOUMN: -

S.No.	Field Current I_f (Amps)	Armature Voltage E_o (Volts)
1.		
2.		
3.		
4.		

MODEL GRAPH: -



RESULT: -

Thus open circuit characteristics of DC shunt generator are obtained and its critical resistance is determined

Precautions: -

1. The field rheostat of motor should be in minimum resistance position at the time of starting to start the machine from minimum speed.
2. The field rheostat of generator should be in maximum resistance position at the time of starting and stopping the machine.
3. Residual voltage should be taken under no field current.
4. The characteristics should be drawn at constant rated speed by adjusting the drive unit or motor filed resistance as required.

Viva Questions: -

1. What is the principle of generator?
2. What is meant by residual magnetism?
3. What is critical field resistance?
4. What is meant by saturation?
5. What is the difference between a separately excited dc generator and shunt generator?

Experiment-06

AIM: - To Draw the Load Characteristics of DC Shunt Generator.

APPARATUS REQUIRED: -

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-2)A (0-20) A	MC MC	1 1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	1200Ω, 0.8A	Wire Wound	2
4	Loading Rheostat	5KW, 230V	-	1
5	Tachometer	(0-1500)rpm	Digital	1
6	Connecting Wires	2.5sq.mm.	Copper	Few

FORMULAE: -

$E_g = V + I_a R_a$ (Volts)

$I_a = I_L + I_f$ (Amps)

E_g = Generated emf in Volts

I_a = Armature Current in Amps

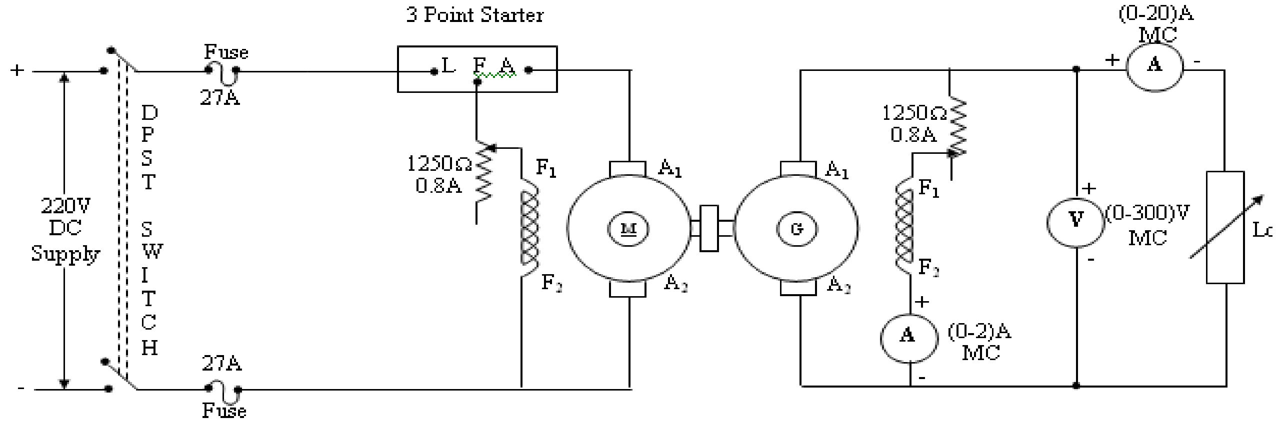
I_f = Field Current in Amps

V = Terminal Voltage in Volts

I_L = Line Current in Amps

R_a = Armature Resistance in Ohms

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :	220V	220V
Rated Current :	21A	21A
Rated Power :	3.5KW	7.5KW
Rated Speed :	1500 RPM	1500 RPM

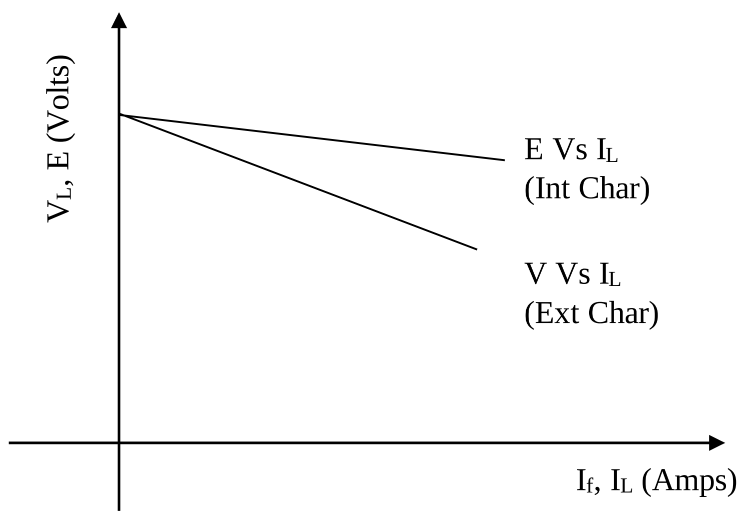
PROCEDURE: -

1. Connections are made as per the circuit diagram.
2. After checking minimum position of DC shunt motor field rheostat and maximum position of DC shunt generator field rheostat, DPST switch is closed and starting resistance is gradually removed.
3. Under no load condition, Ammeter and Voltmeter readings are noted, after bringing the voltage to rated voltage by adjusting the field rheostat of generator.
4. Load is varied gradually and for each load, voltmeter and ammeter readings are noted.
5. Then the generator is unloaded and the field rheostat of DC shunt generator is brought to maximum position and the field rheostat of DC shunt motor to minimum position, DPST switch is opened.

TABULAR COLUMN: -

S.No.	Field Current I_f (Amps)	Load Current I_L (Amps)	Terminal Voltage (V) Volts	$I_a = I_L + I_f$ (Amps)	$E_g = V + I_a R_a$ (Volts)
1.					
2.					
3.					
4.					
5.					
6.					

MODEL GRAPH: -



PRECAUTIONS: -

1. The field rheostat of motor should be at minimum position.
2. The field rheostat of generator should be at maximum position.
3. No load should be connected to generator at the time of starting and stopping.

RESULT: -

Thus the load characteristics of DC shunt generator is obtained.

Viva Questions: -

1. What is the principle of DC generator?
2. Mention the application of DC generator.
3. Give the advantages and disadvantages of DC generators.
4. What will be the value of current in open circuit condition?
5. What is the purpose of starter?
6. On what occasions DC generators may not have residual flux?
7. Define the term critical resistance referred to DC shunt generator.
8. Define the term critical speed in DC shunt generator.
9. The efficiency of generator rises to a maximum value and then decreases. Why?
10. What do you mean by residual magnetism in DC shunt generators?

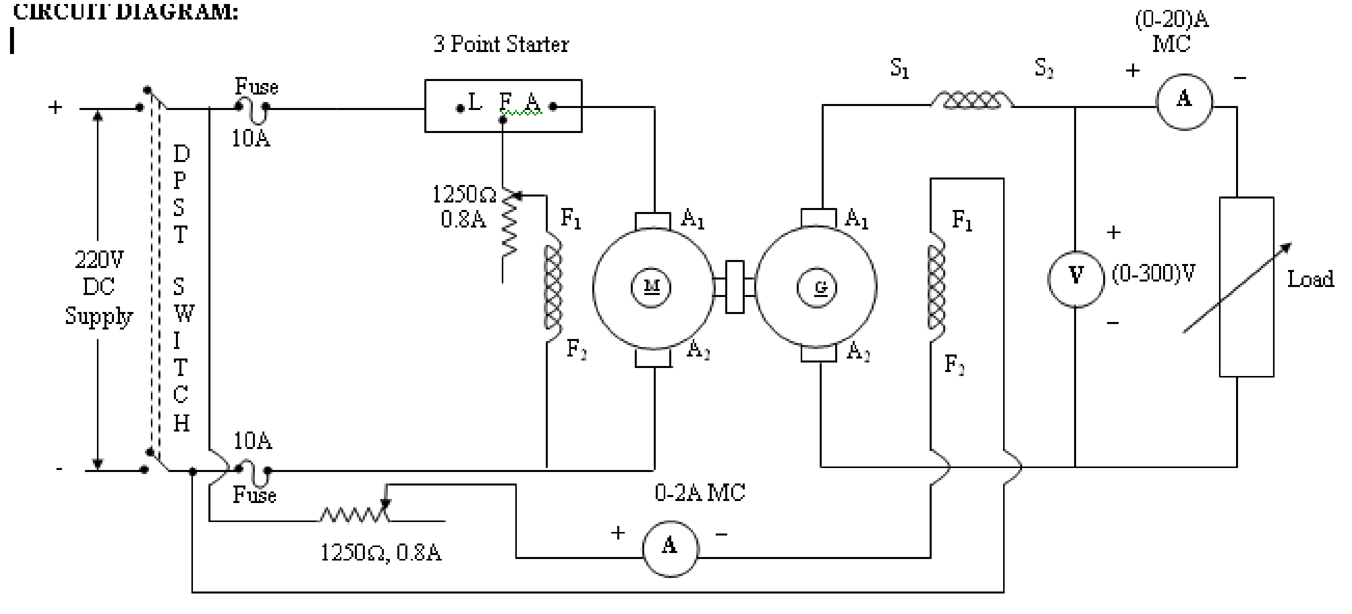
Experiment-07

AIM: - To obtain the load characteristics of DC Compound generator under cumulative and differential mode condition.

APPARATUS REQUIRED: -

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-2)A (0-20) A	MC MC	1 1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	1200Ω, 0.8A	Wire Wound	2
4	Loading Rheostat	5KW, 230V	-	1
5	Tachometer	(0-1500)rpm	Digital	1
6	Connecting Wires	2.5sq.mm.	Copper	Few

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :	220V	220V
Rated Current :	21A	21A
Rated Power :	3.5KW	7.5KW
Rated Speed :	1500 RPM	1500 RPM

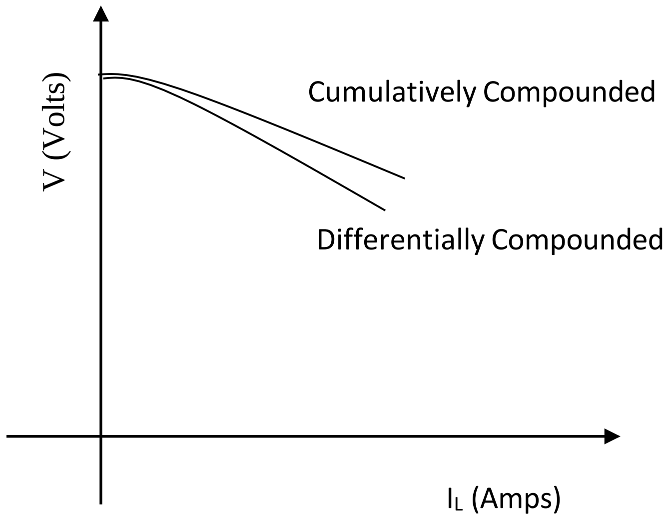
PROCEDURE: -

1. Connections are made as per the circuit diagram.
2. After checking minimum position of DC shunt motor field rheostat and maximum position of DC shunt generator field rheostat, DPST switch is closed and starting resistance is gradually removed.
3. Under no load condition, Ammeter and Voltmeter readings are noted, after bringing the voltage to rated voltage by adjusting the field rheostat of generator.
4. Load is varied gradually and for each load, voltmeter and ammeter readings are noted.
5. Then the generator is unloaded and the field rheostat of DC shunt generator is brought to maximum position and the field rheostat of DC shunt motor to minimum position, DPST switch is opened.
6. The connections of series field windings are reversed the above steps are repeated.
7. The values of voltage for the particular currents are compared and then the differential and cumulative compounded DC generator is concluded accordingly.

TABULAR COLUMN: -

S.No.	Cumulatively Compounded		Differentially Compounded	
	V (Volts)	I_L (Amps)	V (Volts)	I_L (Amps)
1.				
2.				
3.				
4.				
5.				
6.				

MODEL GRAPH: -



RESULT: -

Thus load characteristics of DC compound generator under cumulative and differential mode condition are obtained

PRECAUTIONS: -

1. The field rheostat of motor should be at minimum position.
2. The field rheostat of generator should be at maximum position.
3. No load should be connected to generator at the time of starting and stopping

Viva Questions: -

1. What is the standard direction of rotation of the DC generator and DC motor?
2. How should a generator be started?
3. What are the indications and causes of an overloaded generator?
4. Generator operates in the principle of Fleming's ________________________.

5. Whether compound generators can be used as shunt and series generators? How?
6. An electrical machine can be loaded up to---------------------------- % of rated current.
7. Why series generators are not used for power generation at the power house?
8. How do we conclude that connections between field coils and armature are correct?
9. How will you differentiate cumulative compound and differential compound generators?
10. Define commutation.

Experiment-08

AIM: - To conduct load test on DC shunt motor and to find efficiency.

APPARATUS REQUIRED: -

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostat	1250Ω, 0.8A	Wire Wound	1
4	Tachometer	(0-1500) rpm	Digital	1
5	Connecting Wires	2.5sq.mm.	Copper	Few

FORMULAE: -

$$\mathbf{R} = \frac{\text{Circumference}}{100 \times 2\pi} \text{ m}$$

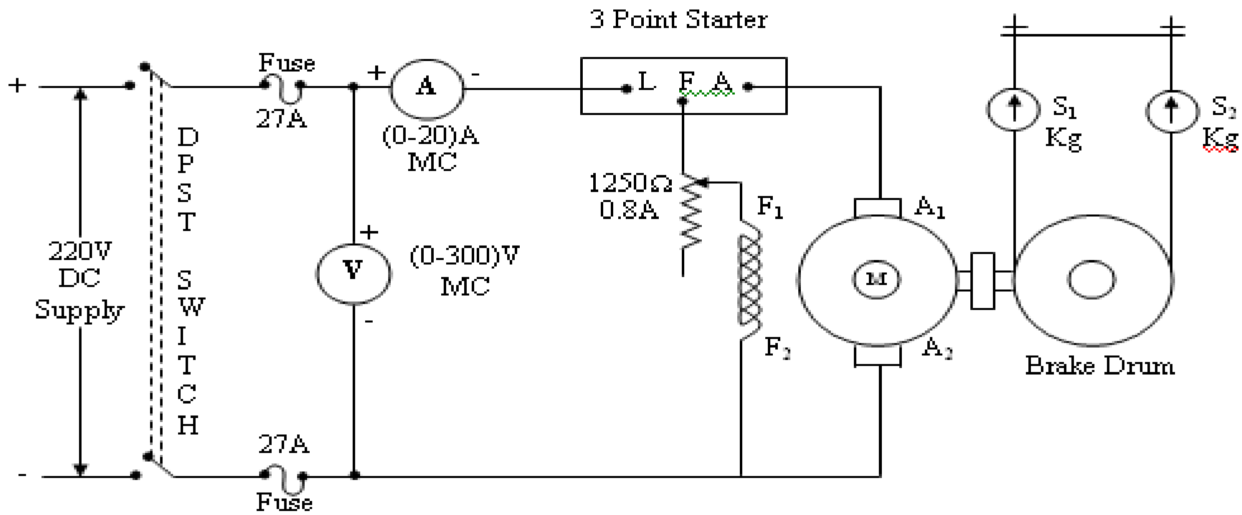
Torque T $= (S_1 \sim S_2) \times R \times 9.81$ Nm

Input Power P_i = VI Watts

Output Power P_m $= \dfrac{2\pi NT}{60}$ Watts

Efficiency η % $= \dfrac{\text{Output Power}}{\text{Input Power}} \times 100\%$

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

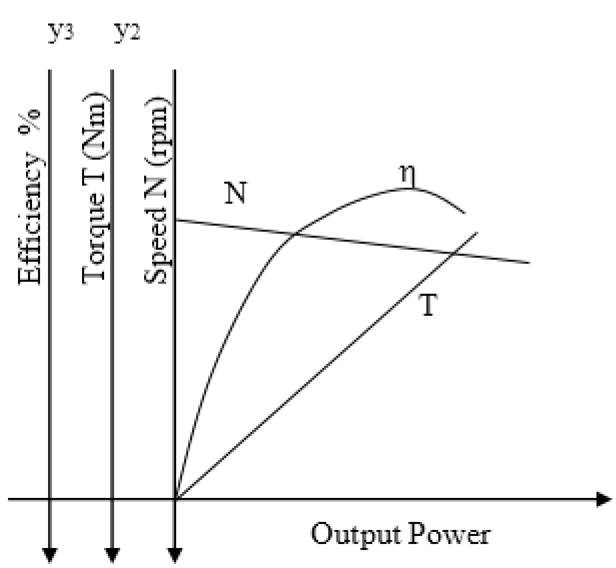
Rated Voltage : 220V
Rated Current : 21A
Rated Power : 3.5KW
Rated Speed : 1500 RPM

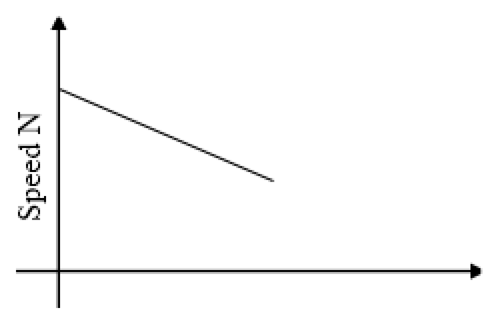
PROCEDURE: -

1. Connections are made as per the circuit diagram.
2. After checking the no load condition, and minimum field rheostat position, DPST switch is closed and starter resistance is gradually removed.
3. The motor is brought to its rated speed by adjusting the field rheostat.
4. Ammeter, Voltmeter readings, speed and spring balance readings are noted under no load condition.
5. The load is then added to the motor gradually and for each load, voltmeter, ammeter, spring balance readings and speed of the motor are noted.
6. The motor is then brought to no load condition and field rheostat to minimum position, then DPST switch is opened.

S.No.	Voltage V (Volts)	Current I (Amps)	Spring Balance Reading		(S_1~ S_2)Kg	Speed N (rpm)	Torque T (Nm)	Output Power Pm (Watts)	Input Power P_i (Watts)	Efficiency η%
			S_1 (Kg)	S_2 (Kg)						
1.										
2.										
3.										
4.										
5.										
6.										

MODEL GRAPHS: -





PRECAUTIONS: -

1. DC shunt motor should be started and stopped under no load condition.

2. Field rheostat should be kept in the minimum position.
3. Brake drum should be cooled with water when it is under load.

RESULT: -

Thus load test on DC shunt motor is conducted and its efficiency is determined.

Viva Questions: -

1. State the principle of DC motor.
2. How may the direction of DC motor be able to be reversed?
3. Why the field rheostat of DC motor is kept at minimum position while starting?
4. What will happen if the field of the DC motor is opened?
5. What will happen if both the field current and armature current are reversed?
6. What will happen if the shunt motor is directly connected across the supply line?
7. Mention the applications of DC compound motor.
8. The differentially compounded motor has a tendency to start in the opposite direction, why?
9. What are the advantages of a compound motor?
10. Differentiate between cumulative compound and differential compound motors.

Experiment-09

AIM: - To conduct load test on DC compound motor and to find its efficiency.

APPARATUS REQUIRED: -

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostat	1250Ω, 0.8A	Wire Wound	1
4	Tachometer	(0-1500) rpm	Digital	1
5	Connecting Wires	2.5sq.mm.	Copper	Few

FORMULAE: -

$$\mathbf{R} = \frac{\text{Circumference}}{100 \times 2\pi} \text{ m}$$

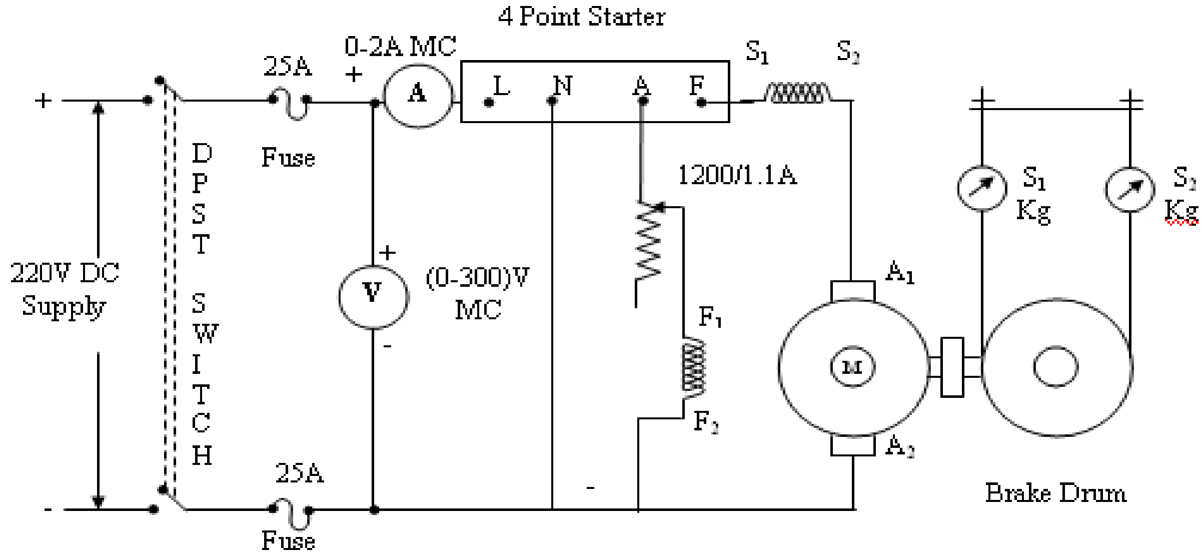
Torque T $= (S_1 \sim S_2) \times R \times 9.81$ Nm

Input Power $\mathbf{P_i} = VI$ Watts

Output Power $\mathbf{P_m} = \dfrac{2\pi NT}{60}$ Watts

Efficiency $\boldsymbol{\eta}$ **%** $= \dfrac{\text{Output Power}}{\text{Input Power}} \times 100\%$

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 18.6}{100} = 23.25A$$

NAME PLATE DETAILS:

Rated Voltage :	220V
Rated Current :	18.6A
Rated Power :	3.5KW
Rated Speed :	1500 rpm.

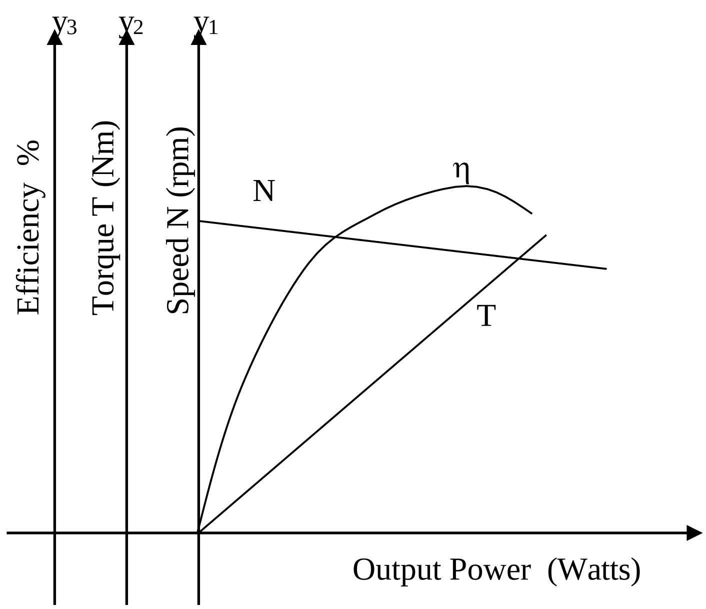
PROCEDURE: -

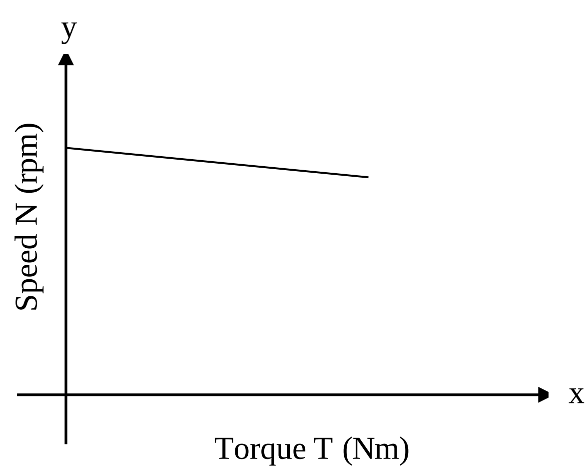
1. Connections are made as per the circuit diagram.
2. After checking the no load condition, and minimum field rheostat position, DPST switch is closed and starter resistance is gradually removed.
3. The motor is brought to its rated speed by adjusting the field rheostat.
4. Ammeter, Voltmeter readings, speed and spring balance readings are noted under no load condition.
5. The load is then added to the motor gradually and for each load, voltmeter, ammeter, spring balance readings and speed of the motor are noted.
6. The motor is then brought to no load condition and field rheostat to minimum position, then DPST switch is opened.

TABULAR COLOUMN:

S.No	Voltage V (Volts)	Current I (Amps)	Spring Balance Reading		$(S_1 \sim S_2)$ Kg	Speed N (rpm)	Torque T (Nm)	Output Power Pm (Watts)	Input Power P_i (Watts)	Efficiency $\eta\%$
			S_1 (Kg)	S_2 (Kg)						
1.										
2.										
3.										
4.										
5.										
6.										

MODEL GRAPHS: -





RECAUTIONS: -

1. DC compound motor should be started and stopped under no load condition.
2. Field rheostat should be kept in the minimum position.
3. Brake drum should be cooled with water when it is under load.

RESULT: -

Thus load test on DC compound motor is conducted and its efficiency is determined.

Viva Questions: -

1. State the principle of DC motor.
2. How may the direction of DC motor be able to be reversed?
3. Why the field rheostat of DC motor is kept at minimum position while starting?
4. What will happen if the field of the DC motor is opened?
5. What will happen if both the field current and armature current are reversed?
6. What will happen if the shunt motor is directly connected across the supply line?
7. Mention the applications of DC compound motor.
8. The differentially compounded motor has a tendency to start in the opposite direction, why?
9. What are the advantages of a compound motor?
10. Differentiate between cumulative compound and differential compound motors.

Experiment-10

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

APPARATUS REQUIRED: -

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

FORMULAE:

$$R = \frac{\text{Circumference}}{100 \times 2\pi} \text{ m}$$

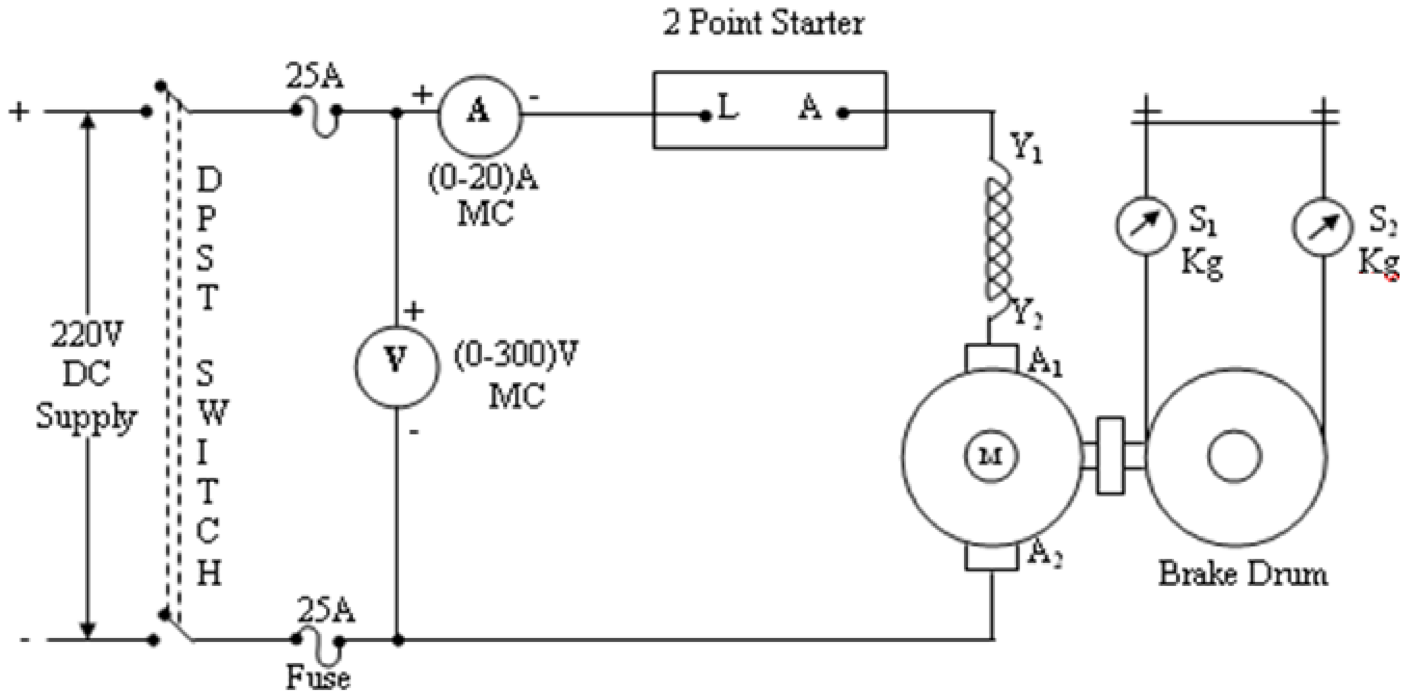
Torque T = $(S_1 \sim S_2) \times R \times 9.81$ Nm

Input Power P_i = VI Watts

$$\textbf{Output Power } P_m = \frac{2\pi NT}{60} \text{ Watts}$$

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

CIRCUIT DIAGRAM: -



FUSE RATING:

125% of rated current

$$\frac{125 \times 20}{100} = 25A$$

NAME PLATE DETAILS:

Rated Voltage : 220V
Rated Current : 20A
Rated Power : 3KW
Rated Speed : 1500 RPM

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.

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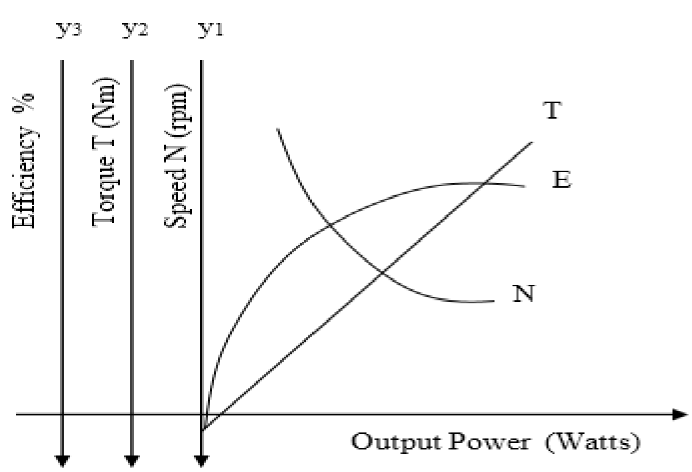
TABULAR COLOUMN: -

S.No	Voltage V (Volts)	Current I (Amps)	Spring Balance Reading		$(S_1 \sim S_2)$ Kg	Speed N (rpm)	Torque T (Nm)	Output Power Pm (Watts)	Input Power P_i (Watts)	Efficiency η%
			S_1 (Kg)	S_2 (Kg)						
1.										
2.										
3.										
4.										
5.										

MODEL GRAPH: -



PRECAUTIONS: -

1. The motor should be started and stopped with load
2. Brake drum should be cooled with water when it is under load.

RESULT: -

Thus load test on DC series motor is conducted and its efficiency is determined.

Viva Questions: -

1. What are the applications of DC series motors?
2. What are the special features of a DC series motors?
3. Which type of starter is used for DC series motors?
4. How will you control the speed of DC series motor?
5. What will happen to the speed of series motor when the supply voltage is reduced?
6. What is the importance of no-load current of the motor?
7. Why we use starters to start DC motors?
8. DC series motors should never be started on no-load. Why?
9. Why the DC series motors have high starting torque?
10. What is meant by speed losses in DC machines?

Experiment-11

AIM: - To conduct Swinburne's test on DC machine to Pre-determine the efficiency when working as generator and motor without actually loading the machine.

APPARATUS REQUIRED: -

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20) A	MC	1
2	Voltmeter	(0-300) V	MC	1
3	Rheostats	1250Ω, 0.8A	Wire Wound	1
4	Tachometer	(0-3000) rpm	Digital	1
5	Resistive Load	5KW,230V	-	1
6	Connecting Wires	2.5sq.mm.	Copper	Few

FORMULAE: -

Hot Resistance R_a = 1.2 X R Ω Constant

losses = $VI_o - I_{ao}^2 R_a$ watts Where

I_{ao} = $(I_o - I_f)$ Amps

As MOTOR: -

Load Current I_L = ______Amps

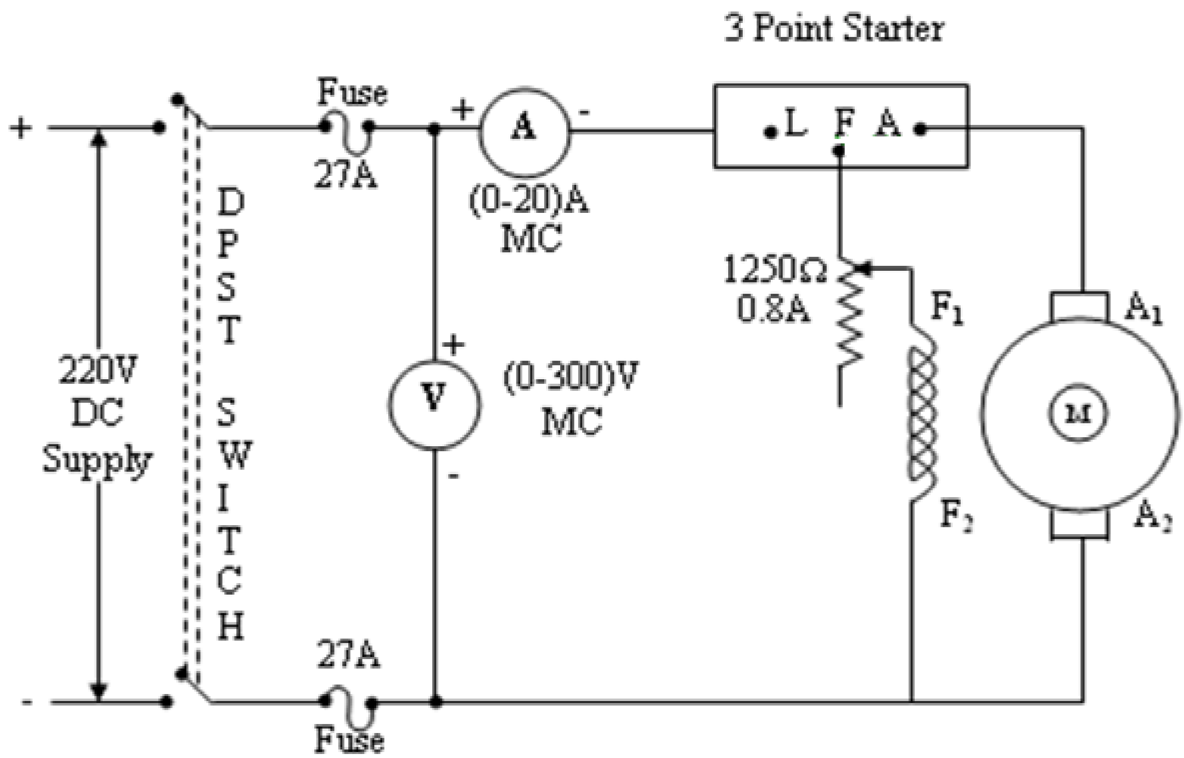
Armature current Ia = $I_L - I_f$ Amps

Copper loss = $I_a^2 R_a$ watts

Total losses = Copper loss + Constant losses

Input Power = VI_L watts

CIRCUIT DIAGRAM: -



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

Rated Voltage : 220V
Rated Current : 21A
Rated Power : 3KW
Rated Speed : 1500 RPM

PROCEDURE: -

1. Connections are made as per the circuit diagram.
2. After checking the minimum position of field rheostat, DPST switch is closed and starting resistance is gradually removed.
3. By adjusting the field rheostat, the machine is brought to its rated speed.
4. The armature current, field current and voltage readings are noted.
5. The field rheostat is then brought to minimum position DPST switch is opened.

TABULAR COLOUMN: -

AS MOTOR: I_f = ____________A

S. No.	V (Volts)	I_L (Amps)	I_a (Amps)	Ia^2Ra (Watts)	Total Losses W (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%
1.								
2.								
3.								
4.								
5.								
6.								

AS GENERATOR:

I_f = ____________A

S. No.	V (Volts)	I_1 (Amps)	I_a (Amps)	Ia^2Ra (Watts)	Total Losses (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%
1.								
2.								
3.								
4.								
5.								
6.								

Output Power = Input Power – Total losses

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

AS GENERATOR: -

Load Current I_L = ______Amps

Armature current Ia = $I_L + I_f$ Amps

Copper loss $= I_a^{2} R_a$ watts

Total losses = Copper loss + Constant losses

Output Power = VI_L watts

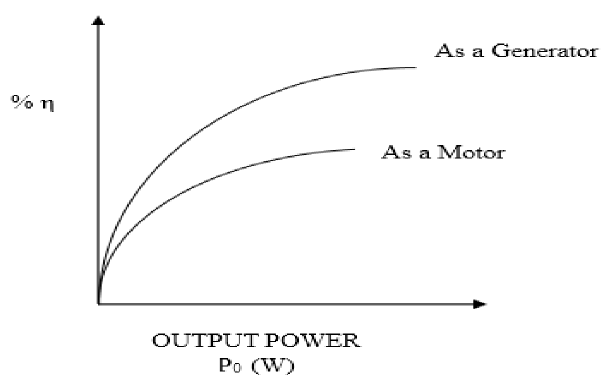
Input Power = Output Power +Total losses

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

PRECAUTIONS: -

The field rheostat should be in the minimum position at the time of starting and stopping the motor

MODEL GRAPH: -



RESULT: - Thus the efficiency of the D.C machine is predetermined by Swinburne’s test.

Experiment-12

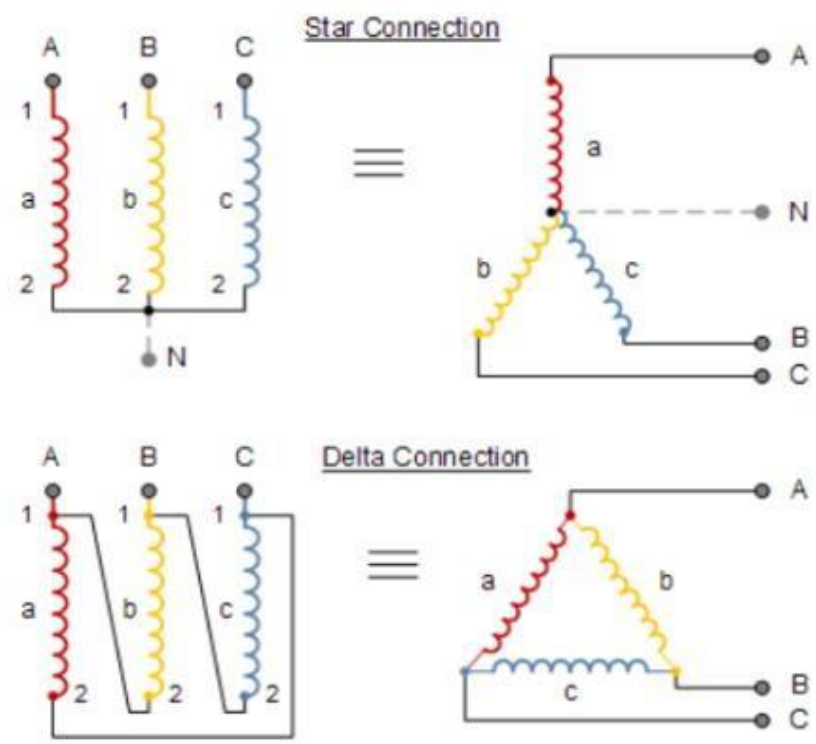
Aim: - To Study the Various Connections of Three Phase Transformer.

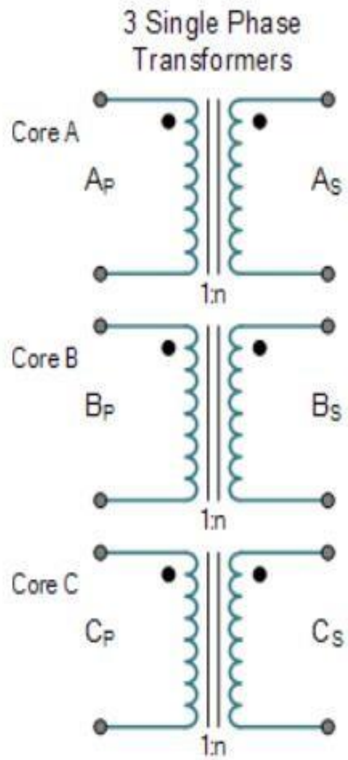
Theory: -

Three Phase Transformer Configuration.

A *three phase transformer* or 3ϕ transformer can be constructed either by connecting together three single-phase transformers, thereby forming a so-called three phase transformer bank, or by using one pre-assembled and balanced three phase transformer which consists of three pairs of single phase windings mounted onto one single laminated core.

The advantages of building a single three phase transformer is that for the same kVA rating it will be smaller, cheaper and lighter than three individual single phase transformers connected together because the copper and iron core are used more effectively. The methods of connecting the primary and secondary windings are the same, whether using just one **Three Phase Transformer** or three separate *Single Phase Transformers.* Consider the circuit below:





Primary Configuration	Secondary Configuration
Delta (Mesh)	Delta (Mesh)
Delta (Mesh)	Star (Wye)
Star (Wye)	Delta (Mesh)
Star (Wye)	Star (Wye)
Interconnected Star	Delta (Mesh)
Interconnected Star	Star (Wye)

The primary and secondary windings of a transformer can be connected in different configuration as shown to meet practically any requirement. In the case of three phase

Transformer windings, three forms of connection are possible: “star” (wye), “delta” (mesh) and “interconnected-star” (zig-zag)

The combinations of the three windings may be with the primary delta-connected and the secondary star-connected, or star-delta, star-star or delta-delta, depending on the transformers use. When transformers are used to provide three or more phases they are generally referred to as a Polyphase Transformer.

Three Phase Transformer Star and Delta Configurations

But what do we mean by “star” (also known as Wye) and “delta” (also known as Mesh) when dealing with three-phase transformer connections. A three phase transformer has three sets of primary and secondary windings. Depending upon how these sets of windings are interconnected, determines whether the connection is a star or delta configuration. The three

Available voltages, which themselves are each displaced from the other by 120 electrical degrees, not only decided on the type of the electrical connections used on both the primary and secondary sides, but determine the flow of the transformers currents. With three single-phase transformers connected together, the magnetic flux's in the three transformers differ in phase by 120 time-degrees. With a single the three-phase transformer there are three magnetic flux's in the core differing in time-phase by 120 degrees.

The standard method for marking three phase transformer windings is to label the three primary windings with capital (upper case) letters A, B and C, used to represent the three individual phases of RED, YELLOW and BLUE. The secondary windings are labeled with small (lower case) letters a, b and c. Each winding has two ends normally labeled 1 and 2 so that, for example, the second winding of the primary has ends which will be labeled B1 and B2, while the third winding of the secondary will be labeled c1 and c2 as shown.

Transformer Star and Delta Configurations: -

Symbols are generally used on a three phase transformer to indicate the type or types of connections used with upper case Y for star connected, D for delta connected and Z for interconnected star primary windings, with lower case y, d and z for their respective secondaries.

Then, Star-Star would be labeled Yy, Delta-Delta would be labeled Dd and interconnected star to interconnected star would be Zz for the same types of connected transformers.

Transformer Winding Identification

Connection	Primary Winding	Secondary Winding
Delta	D	d
Star	Y	y
Interconnected	Z	z

We now know that there are four different ways in which three single-phase transformers may be connected together between their primary and secondary three-phase circuits. These four standard configurations are given as: Delta-Delta (Dd), Star-Star (Yy), Star-Delta (Yd), and Delta-Star (Dy).

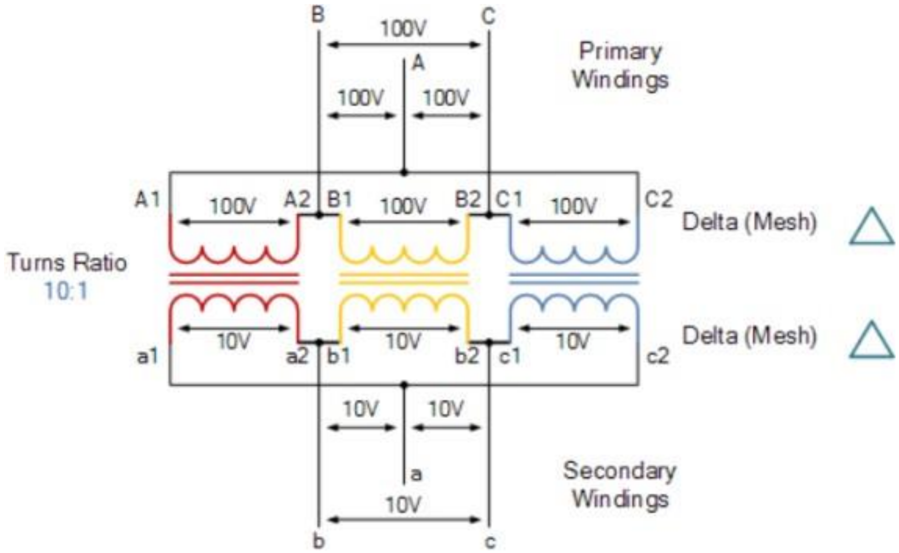
Transformers for high voltage operation with the star connections has the advantage of reducing the voltage on an individual transformer, reducing the number of turns required and an increase in the size of the conductors, making the coil windings easier and cheaper to insulate than delta transformers.

The delta-delta connection nevertheless has one big advantage over the star-delta configuration, in that if one transformer of a group of three should become faulty or disabled, the two remaining ones will continue to deliver three-phase power with a capacity equal to approximately two thirds of the original output from the transformer unit.

Transformer Delta and Delta Connections

In a delta connected (Dd) group of transformers, the line voltage, V_L is equal to the supply voltage, $V_L = V_S$. But the current in each phase winding is given as: $1/\sqrt{3} \times I_L$ of the line current, where I_L is the line current.

One disadvantage of delta connected three phase transformers is that each transformer must be wound for the full-line voltage, (in our example above 100V) and for 57.7 per cent, line current. The greater number of turns in the winding, together with the insulation between turns, necessitate a larger and more expensive coil than the star connection. Another disadvantage with delta connected three phase transformers is that there is no “neutral” or common connection.



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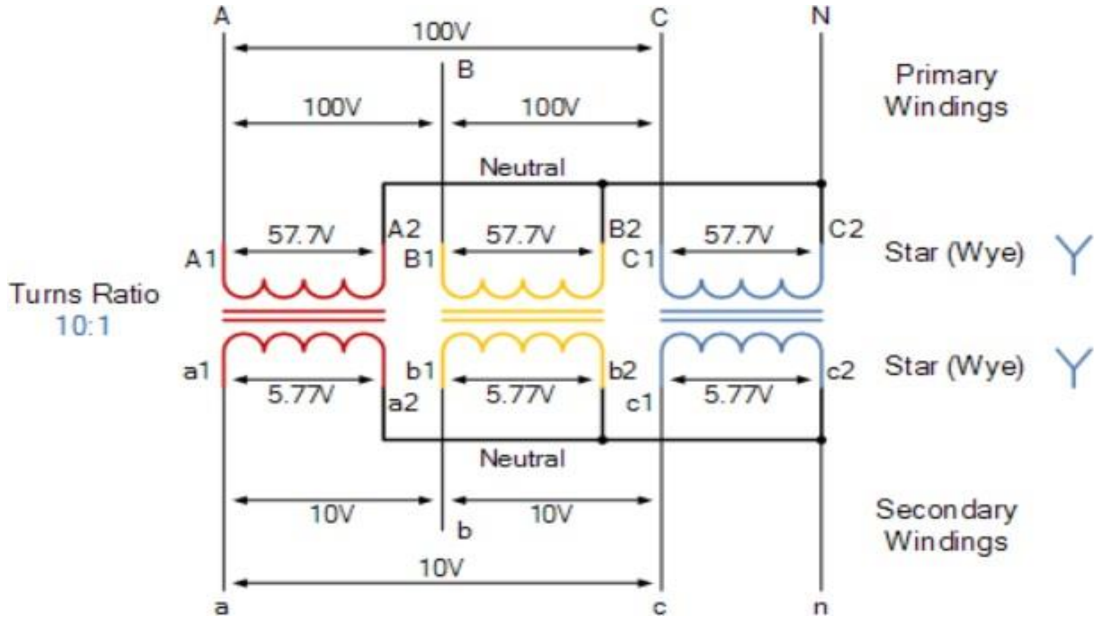
In the star-star arrangement (Yy), (wye-wye), each transformer has one terminal connected to a common junction, or neutral point with the three remaining ends of the primary windings connected to the three-phase mains supply. The number of turns in a transformer winding for star connection is 57.7 per cent, of that required for delta connection.

The star connection requires the use of three transformers, and if any one transformer becomes fault or disabled, the whole group might become disabled. Nevertheless, the star connected three phase transformer is especially convenient and economical in electrical power distributing systems, in that a fourth wire may be connected as a neutral point, (n) of the three star connected secondary's as shown.

Transformer Star and Star Connections

The voltage between any line of the three-phase transformer is called the "line voltage", V_L, while the voltage between any line and the neutral point of a star connected transformer is called the "phase voltage", V_P. This phase voltage between the neutral point and any one of the line



Connections is 1/√3 × V_L of the line voltage. Then above, the primary side phase voltage, V_P is given as.

$$V_p = \frac{\mathbf{1}}{\sqrt{3}} \times V_L = \frac{1}{\sqrt{3}} \times 100 = 57.7\ volts$$

Connection	Phase Voltage	Line Voltage	Phase Current	Line Current
Star	$V_P = V_L \div \sqrt{3}$	$V_L = \sqrt{3} \times V_P$	$I_P = I_L$	$I_L = I_P$
Delta	$V_P = V_L$	$V_L = V_P$	$I_P = I_L \div \sqrt{3}$	$I_L = \sqrt{3} \times I_P$

The secondary current in each phase of a star-connected group of transformers is the same as that for the line current of the supply, then $I_L = I_S$.

Then the relationship between line and phase voltages and currents in a three-phase system can be summarized as:

Three-phase Voltage and Current: -

Where again, V_L is the line-to-line voltage, and V_P is the phase-to-neutral voltage on either the primary or the secondary side.

Other possible connections for three phase transformers are star-delta Yd, where the primary winding is star-connected and the secondary is delta-connected or delta-star Dy with a delta-connected primary and a star-connected secondary.

Delta-star connected transformers are widely used in low power distribution with the primary windings providing a three-wire balanced load to the utility company while the secondary windings provide the required 4th-wire neutral or earth connection.

When the primary and secondary have different types of winding connections, star or delta, the overall turns ratio of the transformer becomes more complicated. If a three-phase transformer is connected as delta-delta (Dd) or star-star (Yy) then the transformer could potentially have a 1:1 turns ratio. That is the input and output voltages for the windings are the same.

However, if the 3-phase transformer is connected in star–delta, (Yd) each star-connected primary winding will receive the phase voltage, V_P of the supply, which is equal to $1/\sqrt{3} \times V_L$.

Then each corresponding secondary winding will then have this same voltage induced in it, and since these windings are delta-connected, the voltage $1/\sqrt{3} \times V_L$ will become the secondary line voltage. Then with a 1:1 turn's ratio, a star–delta connected transformer will provide a √3:1 step-down line-voltage ratio.

Star-Delta Turns Ratio:

$$TR = \frac{N_P}{N_S} = \frac{V_P}{\sqrt{3}V_S}$$

Likewise, for a delta–star (Dy) connected transformer, with a 1:1 turns ratio, the transformer will provide a 1:√3 step-up line-voltage ratio.

Delta-Star Turns Ratio:

$$TR = \frac{N_P}{N_S} = \frac{\sqrt{3}V_P}{V_S}$$

Then for the four basic configurations of a three-phase transformer, we can list the transformers secondary voltages and currents with respect to the primary line voltage, V_L and its primary line current I_L as shown in the following table.

Three-phase Transformer Line Voltage and Current:

Primary-Secondary Configuration	Line Voltage Primary or Secondary	Line Current Primary or Secondary
Delta – Delta	$V_L \Rightarrow nV_L$	$I_L \Rightarrow \frac{I_L}{n}$
Delta – Star	$V_L \Rightarrow \sqrt{3}.nV_L$	$I_L \Rightarrow \frac{I_L}{\sqrt{3}.n}$
Star – Delta	$V_L \Rightarrow \frac{nV_L}{\sqrt{3}}$	$I_L \Rightarrow \sqrt{3}.\frac{I_L}{n}$
Star – Star	$V_L \Rightarrow nV_L$	$I_L \Rightarrow \frac{I_L}{n}$