MALLA REDDY ENGINEERING COLLEGE
(Autonomous)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

LAB MANUAL
DC MACHINES AND TRANSFORMERS LAB

Prepared by
Mr. K.S.S. NAGA TEJA
Assistant Professor

Approved by
Dr.N.Rajeswaran
Prof. & HOD/EEE

CLASS	:	**II YEAR EEE**
SEMESTER	:	**II SEM**
SUBJECT CODE	:	**80211**
REGULATION	:	**MR18**
SUBJECT	:	**DC Machines and Transformers Lab**

SYLLABUS

2018-19 Onwards (MR-18) | **B.Tech. IV Semester**
Code: 80211 | **Credits: 1.5**
L/T/P
DC MACHINES AND TRANSFORMERS LAB **- / - / 3**

Course Objectives:
To provide students with a strong back ground in different types of electrical machines. To train the students with well practical knowledge of different DC machines.

List of Experiments:

1. Magnetization characteristics of DC shunt generator. Determination of critical field resistance and critical speed.
2. Load test on DC shunt generator. Determination of characteristics.
3. Load test on DC series generator. Determination of characteristics.
4. Load test on DC compound generator. Determination of characteristics.
5. Hopkinson's test on DC shunt machines. Predetermination of efficiency.
6. Fields test on DC series machines. Determination of efficiency.
7. Swinburne's test and speed control of DC shunt motor. Predetermination of efficiencies.
8. Brake test on DC compound motor. Determination of performance curves.
9. Brake test on DC shunt motor. Determination of performance curves.
10. Retardation test on DC shunt motor. Determination of losses at rated speed
11. Separation of losses in DC Shunt motor.
12. Brake test on DC Series motor. Determination of performance curves

Course Outcomes:

At the end of the course, students will be able to

1. Assess the performance of DC shunt, series and compound motors.
2. Determine the efficiency of DC shunt, series and compound motors.
3. Perform the speed control methods of DC shunt motor.
4. Predetermine the efficiency of DC shunt motor.
5. Determine the performance characteristics of DC machines.

CYCLE I:

1. Magnetization characteristics of DC shunt generator. Determination of critical field resistance and critical speed.
2. Load test on DC shunt generator. Determination of characteristics.
3. Load test on DC series generator. Determination of characteristics.
4. Load test on DC compound generator. Determination of characteristics.
5. Brake test on DC compound motor. Determination of performance curves.
6. Brake test on DC shunt motor. Determination of performance curves.
7. Brake test on DC Series motor. Determination of performance curves

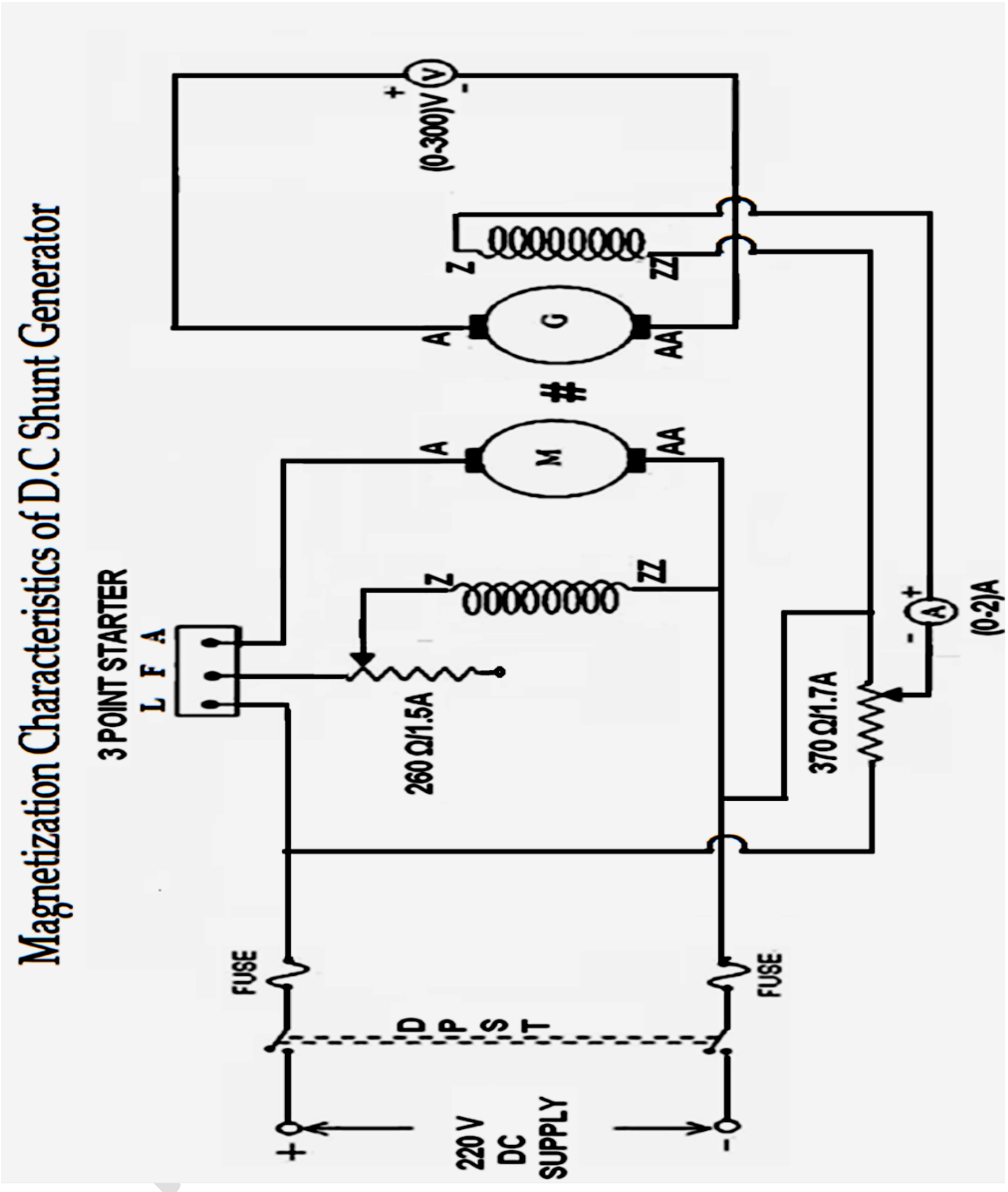
CYCLE II:

1. Hopkinson's test on DC shunt machines. Predetermination of efficiency.
2. Fields test on DC series machines. Determination of efficiency.
3. Swinburne's test and speed control of DC shunt motor. Predetermination of efficiencies.
4. Retardation test on DC shunt motor. Determination of losses at rated speed
5. Separation of losses in DC Shunt motor.

1

MAGNETIZATION CHARACTERISTICS OF DC SHUNT GENERATOR

Circuit Diagram:



Exp.No.1

MAGNETIZATION CHARACTERISTICS OF DC SHUNT GENERATOR

AIM: To obtain magnetization characteristics of self excited DC shunt generator and to find its critical resistance and critical speed.

NAME PLATE DETAILS:

Capacity	Motor	Generator
Type	**Shunt**	**Shunt**
Rated Power(KW/HP)		
Rated Voltage(Volts)		
Field Current(Amps)		
Armature current (Amps)		
Rated Speed (RPM)		

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostats			
4	SPST Switch			
5	Tachometer			
6	Connecting Wires			

THEORY:

Critical field resistance:

It is that value of the field resistance at which the D.C. shunt generator will fail to excite.

Critical Speed:

It is that speed for which the given shunt field resistance becomes the critical field resistance. Critical field resistance is obtained by plotting the OCC as in fig.1 and determining the slope of the tangent to the linear position of the curve from the origin. While drawing the tangent, the initial position of the O.C.C is neglected.Due to residual magnetism in the poles some EMF is generated even when If = 0. Hence the curve starts a little way up. The slight curvature at the lower end is due to magnetic inertia. It is seen that in the first part of the curve is practically straight. Hence the flux and the consequently the generated EMF is directly proportional to the exciting current. However at the higher flux densities where it is small iron path reluctance becomes appreciable and straight. Field windings are connected parallel to the armature and it is called dc shunt generator. Due to residual magnetism some initial emf and hence some current will be generated. This current while passing into the field coils will strengthen the magnetism of poles. This will increase pole flux which will further increase the generated emf. Increased emf and flux proceeds till equilibrium reached. This reinforcement of emf and flux proceeds till equilibrium reached at some point.

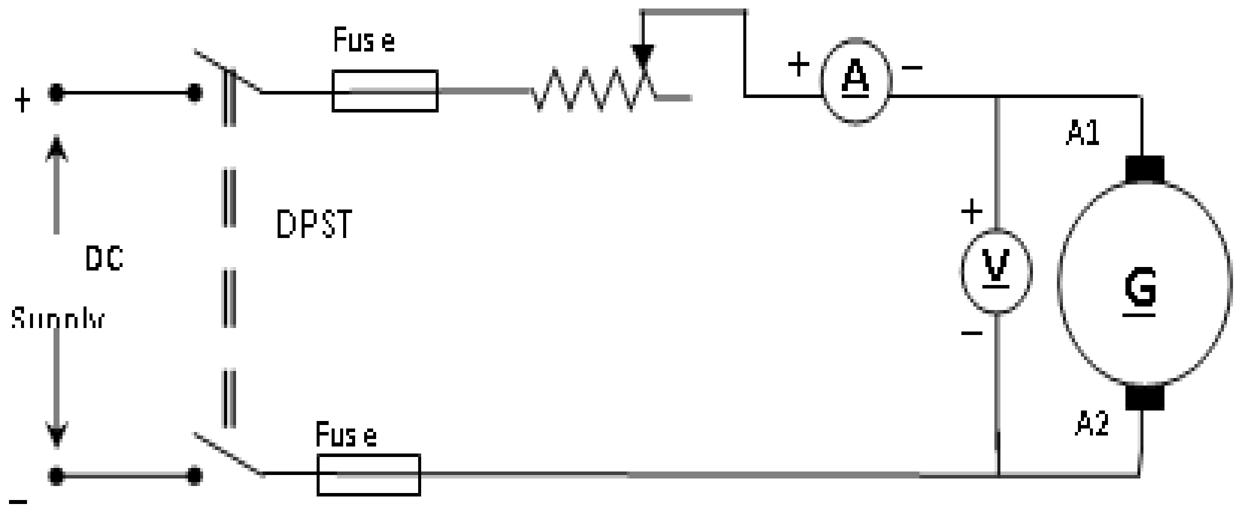
PROCEDURE:

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.

PROCEDURE FOR FIND ARMATURE RESISTANCE R_a:

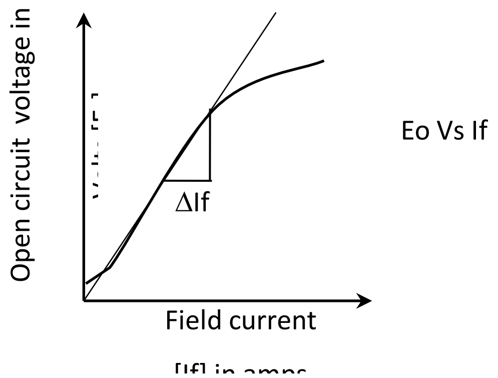
1. Connections are given as per circuit diagram
2. Check loading rheostat must be at maximum resistance position.
3. Close the DPST switch and vary the loading rheostat for various values in steps and noted the corresponding voltmeter and ammeter reading.
4. Open the DPST switch after loading rheostat begins its initial position.

CIRCUIT DIAGRAM FOR FIND THE GENERATOR ARMATURE RESISTANCE [Ra]:



Open circuit characteristics

Fig 1: Magnetization characteristics or OCC



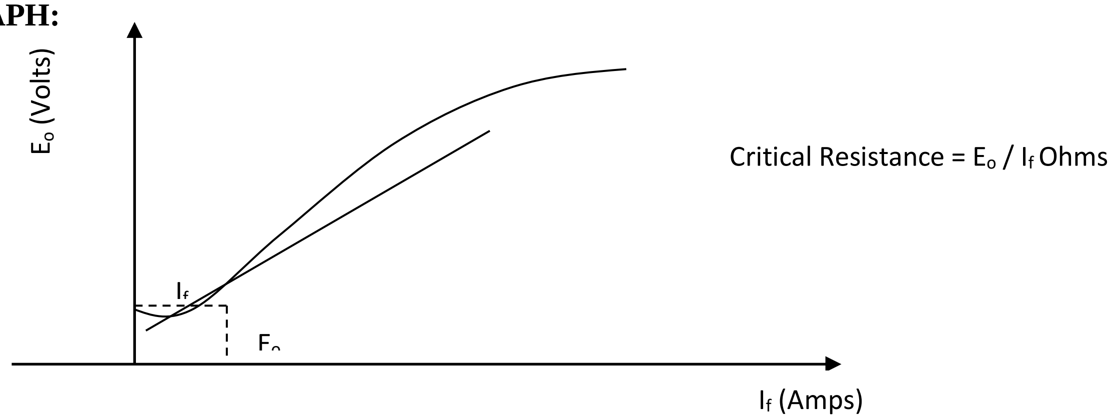
TABULAR COLUMN:

Decreasing		
S.No	Field current in Amps [I_f]	Open circuit voltage in Volts [E_g]
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

Increasing		
S.No	Field current in Amps [I_f]	Open circuit voltage in Volts [E_g]
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

Note: Zero Excitation (Residual Voltage = 10Volts, armature DC Current = 0.08A)

MODEL GRAPH:



FORMULA USED:

(Generated voltage) $E_g = V_L + I_a R_a$

From the Graph:

(Critical Speed) $N_c = (BC/AC)*1500$

(Critical Resistance) $R_c = E_g/I_f$

PRECAUTIONS:

1. The field rheostat of motor should be in minimum resistance position at the time of starting and stopping the machine.
2. The field rheostat of generator should be in maximum resistance position at the time of starting and stopping the machine.
3. SPST switch is kept open during starting and stopping.

RESULT:

CONCLUSION:

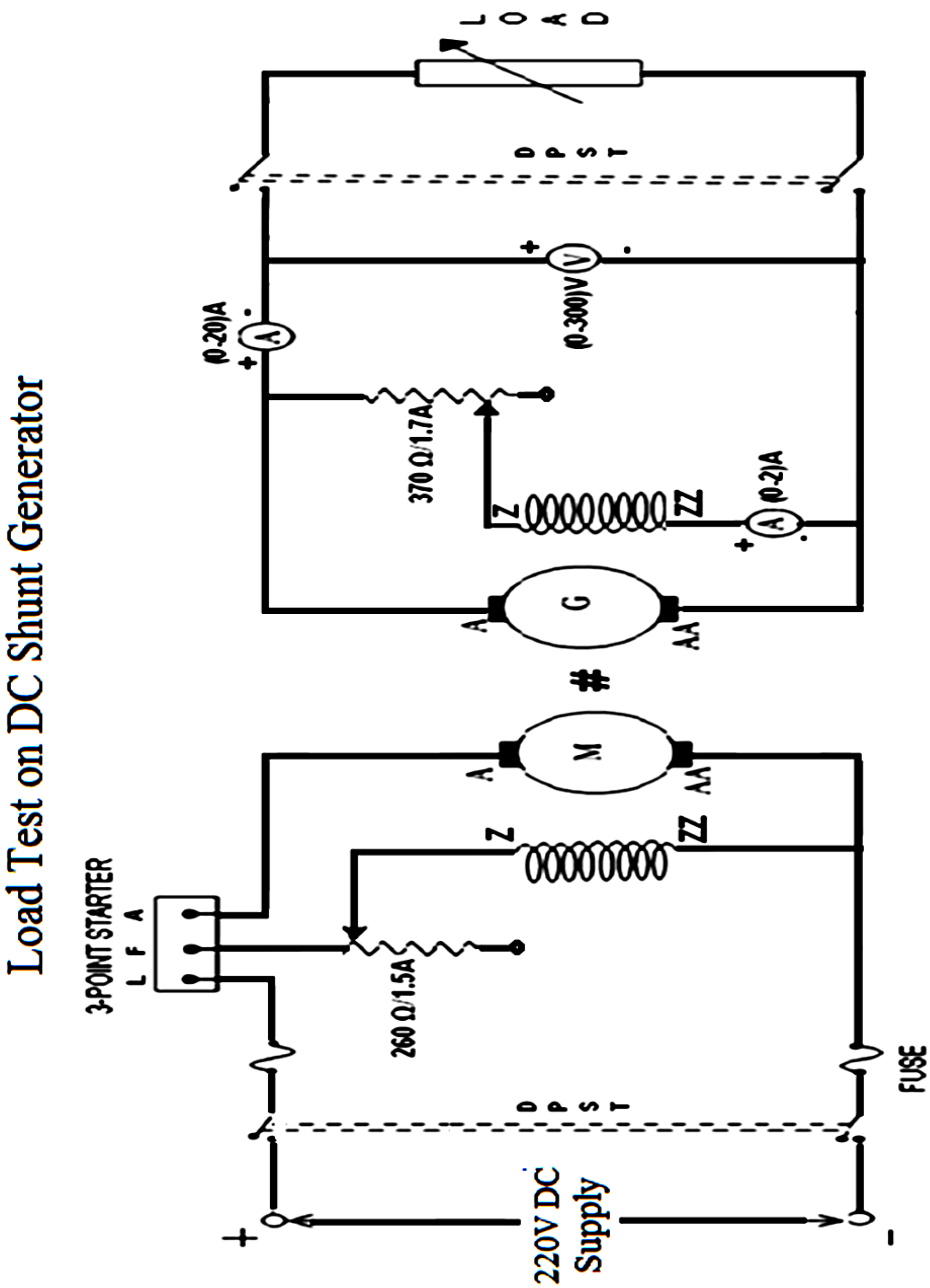
VIVA QUESTIONS:

1. What is an DC machine Principle of operation?
2. What are types of DC motors and Generator?
3. Why OCC is also called magnetization characteristic?
4. What is critical resistance and speed?
5. Why should the field rheostat be kept in the position of minimum resistance?

2

LOAD TEST ON DC SHUNT GENERATOR

Circuit Diagram:



Exp.No.2

LOAD CHARACTERISTICS OF DC SHUNT GENERATOR

AIM: To obtain internal and external characteristics of DC shunt generator.

NAME PLATE DETAILS:

Capacity	**Motor**	**Generator**
Type	**Shunt**	**Shunt**
Rated Power(KW/HP)		
Rated Voltage(Volts)		
Field Current(Amps)		
Armature current (Amps)		
Rated Speed		

APPARATUS REQUIRED:

S.No.	**Apparatus**	**Range**	**Type**	**Quantity**
1	Ammeter			
2	Voltmeter			
3	Rheostats			
4	Loading Rheostat			
5	Tachometer			
6	Connecting Wires			

THEORY:

Due to residual magnetism in the poles some EMF is generated even when If = 0. Hence the curve starts a little way up. The slight curvature at the lower end is due to magnetic inertia. It is seen that in the first part of the curve is practically straight. Hence the flux and the consequently the generated EMF is directly proportional to the exciting current. However at the higher flux densities where it is small iron path reluctance becomes appreciable and straight. Field windings are connected parallel to the armature and it is called dc shunt generator. Due to residual magnetism some initial emf and hence some current will be generated. This current while passing into the field coils will strengthen the magnetism of poles. This will increase pole flux which will further increase the generated emf. Increased emf and flux proceeds till equilibrium reached. This reinforcement of emf and flux proceeds till equilibrium reached at some point.

FUSE RATING:

125% of rated current125*17/100=21.25≈ 20 A

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 start the motor by using starter, so 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.

FORMULAE:

$$E_g = V + I_a R_a \text{ (Volts)}$$

$$I_a = I_L + I_f \text{ (Amps)}$$

Where

E_g: Generated emf in Volts

V : Terminal Voltage in Volts

I_a : Armature Current in Amps

I_L : Line Current in Amps

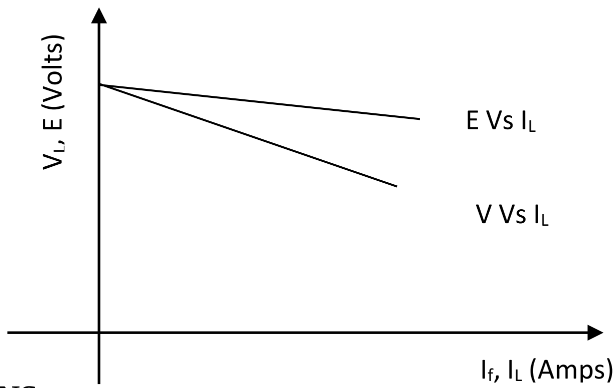
I_f : Field Current in Amps

R_a : Armature Resistance in Ohms

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)

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:

CONCLUSIONS:

VIVA QUESTIONS:

1. If the shunt generator fails to build-up the voltage what could be the reason for it? Explain how this can be overcome.
2. what is meant by armature reaction?
3. Why are the characteristics of the shunt generator drooping?
4. Why DC generators are normally designed for maximum efficiency around the load?
5. Define commercial and electrical efficiencies for DC generators?
6. Which losses in a DC generator vary significantly with the load current?

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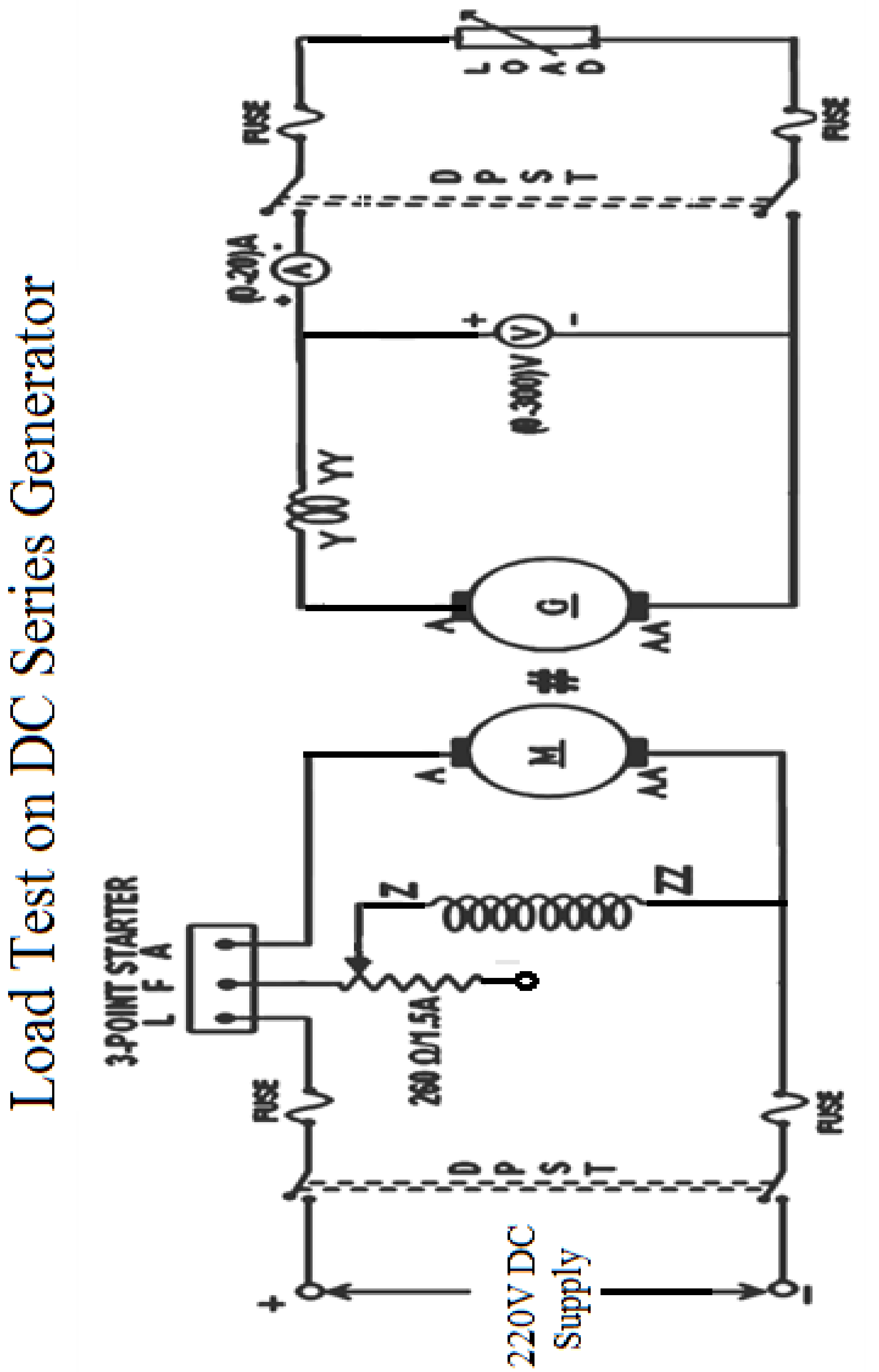
LOAD TEST ON DC SERIES GENERATAOR

Circuit Diagram:



Exp.No. 3

LOAD TEST ON DC SERIES GENERATAOR

AIM: To perform load test on a D.C. series generator and to draw the internal and external characteristics.

NAME PLATE DETAILS:

Capacity	Motor	Generator
Type	**Series**	**Series**
Rated Power(KW/HP)		
Rated Voltage(Volts)		
Field Current(Amps)		
Armature current (Amps)		
Rated Speed (RPM)		

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostats			
4	Tachometer			
5	Resistive Load			
6	Connecting Wires			

THEORY:

In a D.C. series generator the field winding is connected in series with the armature winding. In this case the armature current flows through the field winding as well as the load. Since the armature winding and the field winding are in series the armature current is the same as the field current. The field winding has less number of turns of thick wire and hence its resistance is low.

$$Ia = Ise = I_L$$

The load characteristics of a D.C. series generator are plotted with the load current (I_L) on the X-axis and the Voltage (V) on the Y-axis. As in the case of the D.C. shunt generator there are two types of load characteristics:

1. Internal characteristics – Induced emf E vs Load current I_L. Here the drop is due to armature reaction.
2. External characteristics – Terminal Voltage V vs Load current I_L. Here the drop is due to armature and series field resistance.

The Voltage equation of a D.C. series generator is given by

$$V = E - Ia(Ra + Rse)$$

The load characteristics are shown in the model graph.
It will be noticed that a series generator has rising voltage characteristic i.e. with increase in load, its voltage is also increased, but it is seen that at high loads, the voltage starts decreasing due to excessive demagnetizing effects of armature reaction. In fact, terminal voltage starts decreasing as load current is increased as shown by the dotted curve and for a particular high value of load current the terminal voltage is reduced to zero.

Procedure:

1. Connections are made as per the circuit diagram.
2. DPST switch is closed; Start the motor by using starter with some load, so starting resistance is gradually removed.
3. Load is varied gradually and for each load, voltmeter and ammeter readings are noted.
4. After loading the generator up to the rated value, gradually reduce the loads in steps and DPST switch is opened.

FORMULAE:

$$V = E_g - I_a (Ra + R_{se})$$

Where

V = Terminal voltage

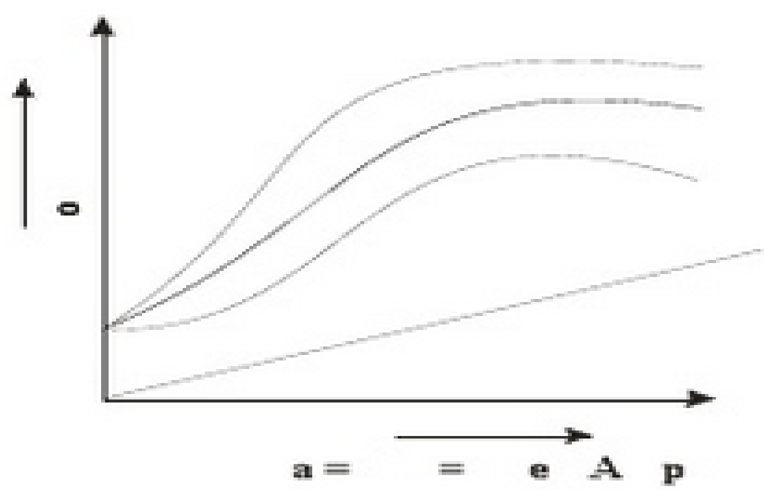
E_g = Emf generated in the armature (Volts)

L_a = Armature current (A) = I_se = I_L

R_a = Armature resistance (Ω)

R_{se} = Series field resistance (Ω)

MODEL GRAPH:



TABULAR COLUMN:

S.No	I_L(Amps)	V(Volts)	Ia(Amps)	Eg(volts)

PRECAUTIONS:

1). Loose connections are to be avoided.

2). Remove the load gradually in steps and switch OFF the motor

RESULT:

CONCLUSIONS:

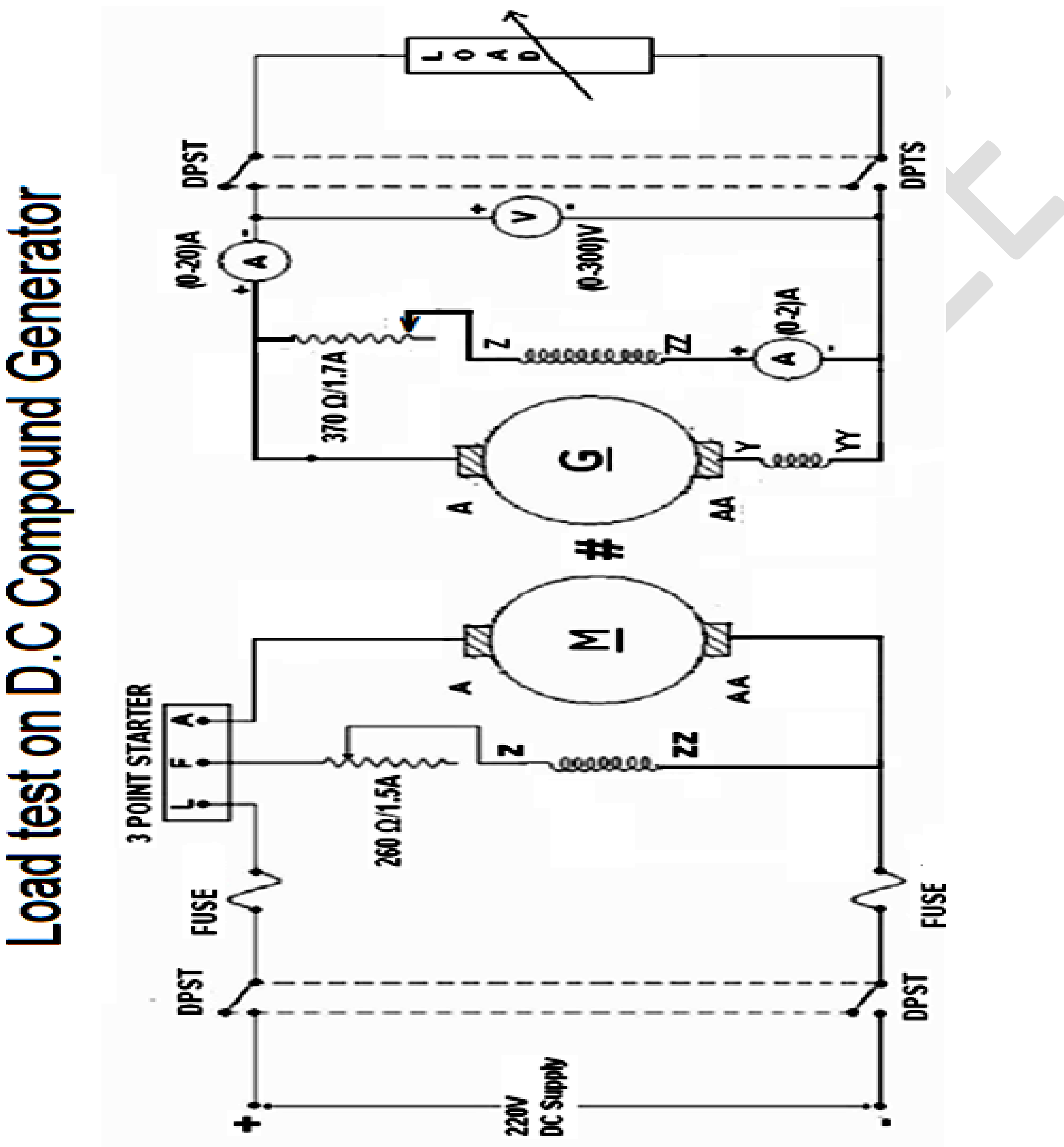
VIVA QUESTIONS:

1. How the internal characteristics are derived from the external characteristics?
2. What are the reasons for the failure of a DC series generator to build-up voltage?
3. What is meant by critical resistance of a DC series generator?
4. What is the necessity of starter in DC motors?
5. What material used for brushes. Why?
6. Why external characteristics are lies below the internal chrematistics in DC shunt generator?
7. What is the critical load resistance?
8. How do you control the speed of DC motor?

4

LOAD TEST ON DC COMPOUND GENERATOR

Circuit Diagram:



Exp.No.4

LOAD TEST ON DC COMPOUND GENERATOR

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

NAME PLATE DETAILS:

Capacity	Motor	Generator
Type	**Shunt**	**Compound**
Rated Power(KW/HP)		
Rated Voltage(Volts)		
Field Current(Amps)		
Armature current (Amps)		
Rated Speed (RPM)		

APPARATUS REQUIRED:

S.no.	Apparatus	Range	Type	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostats			
4	Loading Rheostat			
5	Tachometer			
6	Connecting Wires			

THEORY:

D.C. Compound generator consists of both series and shunt field windings. The shunt and series fields can be connected in two ways.

1. Short shunt.
2. Long shunt.

When the MMF of series field opposes the MMF of shunt field, the generator is different ially compound. The terminal voltage decreases sharply with increasing load current. Evident ly this connection is not used.

In cumulative compound the connections of the two fields are such that their MMF's add and help each other. If the series field is very strong, the terminal voltage may increase as the load current increases and it is called over compounding. When terminal voltage on full load and no load are equal, it is known as flat compounded generator. If the series field is not strong, the terminal voltage will decreases with increase in load current (under compound).

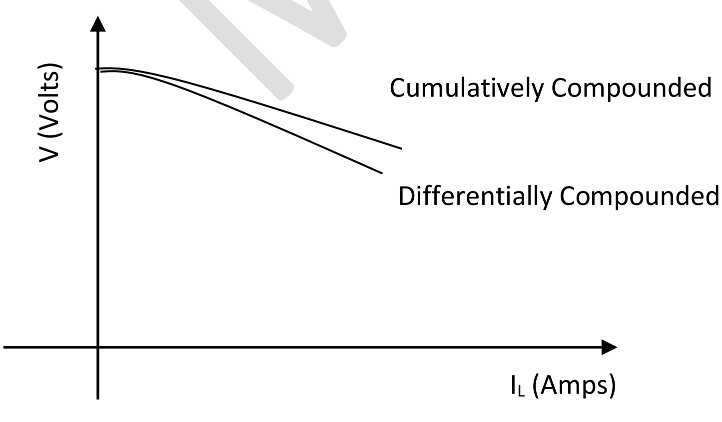
PROCEDURE:

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 start the motor by using starter. so 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)

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:

CONCLUSION:

VIVA QUESTIONS:

1. How many field windings are there in a compound generator? What are they?
2. What does compounding mean?
3. In a compound wound generator which of the two fields dominates?
4. What is meant by commutation?
5. What are the different methods of obtaining spark less or good commutation?
6. Why do you perform load test?
7. Differentiate cumulative and differential compound generators?
8. Give at least three applications of DC compound generators?

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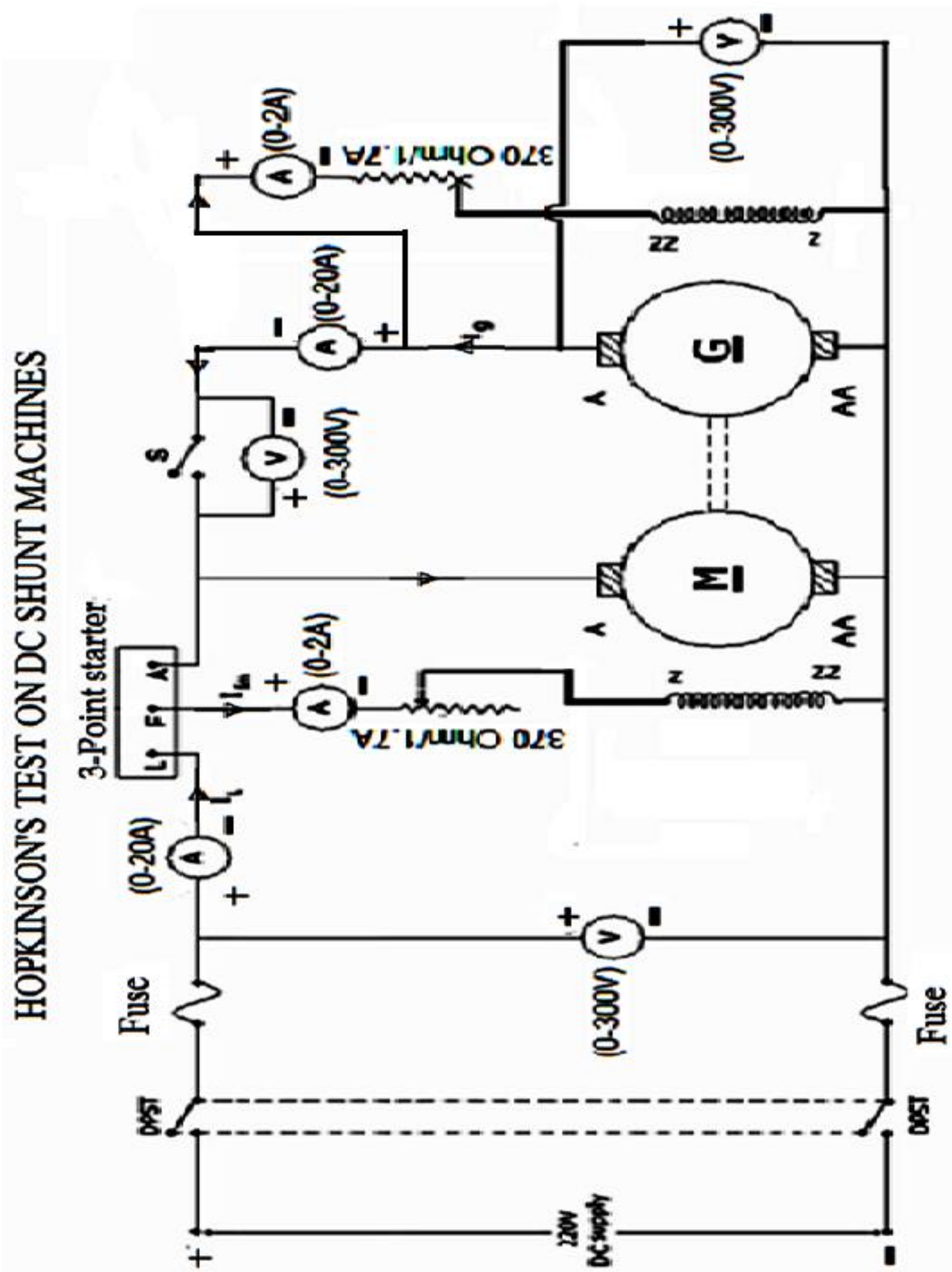
HOPKINSON’S TEST

Circuit Diagram:



Exp.No. 5

HOPKINSON'S TEST

AIM: To conduct Hopkinson's test on a pair of identical DC machines to pre-determine the efficiency of the machine as generator and as motor.

NAME PLATE DETAILS:

Capacity	Motor	Generator
Type	**Shunt**	**Shunt**
Rated Power(KW/HP)		
Rated Voltage(Volts)		
Field Current(Amps)		
Armature current (Amps)		
Rated Speed (RPM)		

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostats			
4	Tachometer			
5	Resistive Load			
6	Connecting Wires			

THEORY:

To find efficiency of a dc shunt machine, the best method is to directly load it and measure its output and input. For large rating machines the direct load test method is difficult to conduct due to a) It is costly to obtain a suitable load and b) The amount of energy to be spent for testing is too large. For, these reasons, electrical engineers use indirect methods like Swinburne's test, Separation of losses, and the Retardation test etc, are used to determine the efficiency. These tests are simple to carry out but they offer no information about how the machine performs under actual load conditions. Also, because of assumptions the results obtained are not so accurate.

Hopkinson's test (also called Regenerative or Back-to-Back test) offers the advantages of load test without its disadvantages. By this method, full-load test can be carried out on two identical shunt machines without wasting theirs outputs. The two machines are mechanically coupled and are so adjusted that one of them runs as a motor and the other as a generator. The mechanical output of the motor drives the generator. The generator emf value is brought to the bus bar voltage and then paralleled it to bus bars. The electrical output of the generator is used in supplying the greater part of input to the motor. If there were no losses in the machines, then they would have run without any external power supply. But due to losses, generator output is not sufficient to drive the motor and vice versa. Thus, these losses in the machines are supplied electrically from the supply mains.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. After checking the minimum position of field rheostat of motor, maximum position of field rheostat of generator, opening of SPST switch, DPST switch is closed and starting resistance is gradually removed.
3. The motor is brought to its rated speed by adjusting the field rheostat of the motor.
4. The voltmeter V_1 is made to read zero by adjusting field rheostat of generator and SPST switch is closed.
5. By adjusting field rheostats of motor and generator, various Ammeter readings, voltmeter readings are noted.
6. The rheostats and SPST switch are brought to their original positions and DPST switch is opened.

FORMULAE:

Input Power = VI_1 watts

Motor armature cu loss = $(I_1 + I_2)^2$ Ra watts

Generator armature cu loss = I_2^2 Ra watts

Total Stray losses W = $V I_1 - \left[(I_1+I_2)^2 Ra + I_2^2 Ra\right]$ watts.

Stray loss per machine = W/2 watts.

AS MOTOR:

Input Power = Armature input + Shunt field input
= $(I_1 + I_2) V + I_3V = (I_1+I_2+I_3) V$

Total Losses = Armature Cu loss + Field loss + stray loss
= $(I_1 + I_2)^2$ Ra + VI_3 + W/2 watts

$$\text{Efficiency } \eta\% = \frac{\text{Input power} - \text{Total Losses}}{\text{Input Power}} \times 100\%$$

AS GENERATOR:

Output Power = VI_2 watt

Total Losses = Armature Cu loss+ Field Loss + Stray loss
= I_2^2 Ra + VI_4 + W/2 watts

$$\text{Efficiency } \eta\% = \frac{\text{Output power}}{\text{Output Power} + \text{Total Losses}} \times 100\%$$

TABULAR COLUMN:

S. No.	Supply Voltage V(Volts)	I_1 (A)	I_2 (A)	I_3 (A)	I_4 (A)	$I_1 + I_2$ (A)	Motor Armature Cu Loss W (watts)	Generator Armature Cu Loss W(watts)	Total Stray losses W (watts)	Stray Loss Per M/c w/2 (watts)

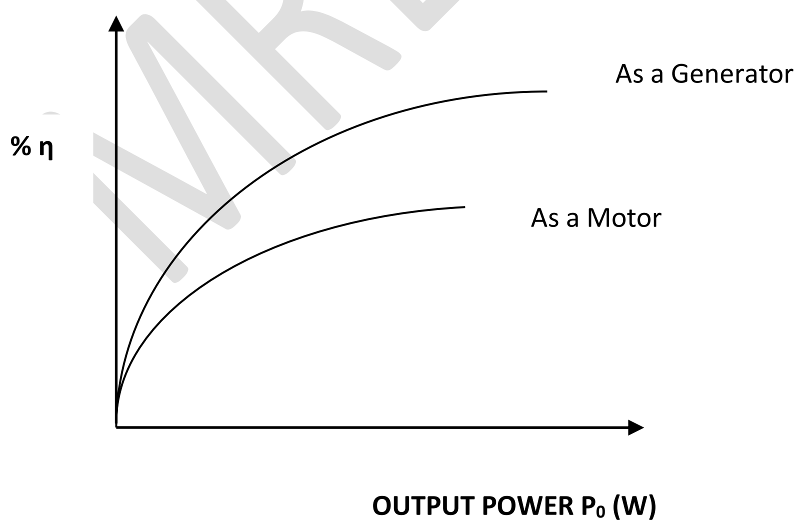
AS MOTOR:

S.No.	V (V)	I_1 (A)	I_2 (A)	I_3 (A)	Motor Armature Cu Loss W (Watts)	Field Loss (Watts)	stray losses/2 (Watts)	Total Losses W (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%

AS GENERATOR:

S.No	V (V)	I_1 (A)	I_2 (A)	Motor Armature Cu Loss W (Watts)	Field Loss (Watts)	Stray losses /2(Watts)	Total Losses W (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%

MODEL GRAPH:



PRECATUIONS:

1. The field rheostat of the motor should be in the minimum position at the time of starting and stopping the machine.
2. The field rheostat of the generator should be in the maximum position at the time of starting and stopping the machine.
3. SPST switch should be kept open at the time of starting and stopping the machine.

RESULT:

CONCLUSIONS:

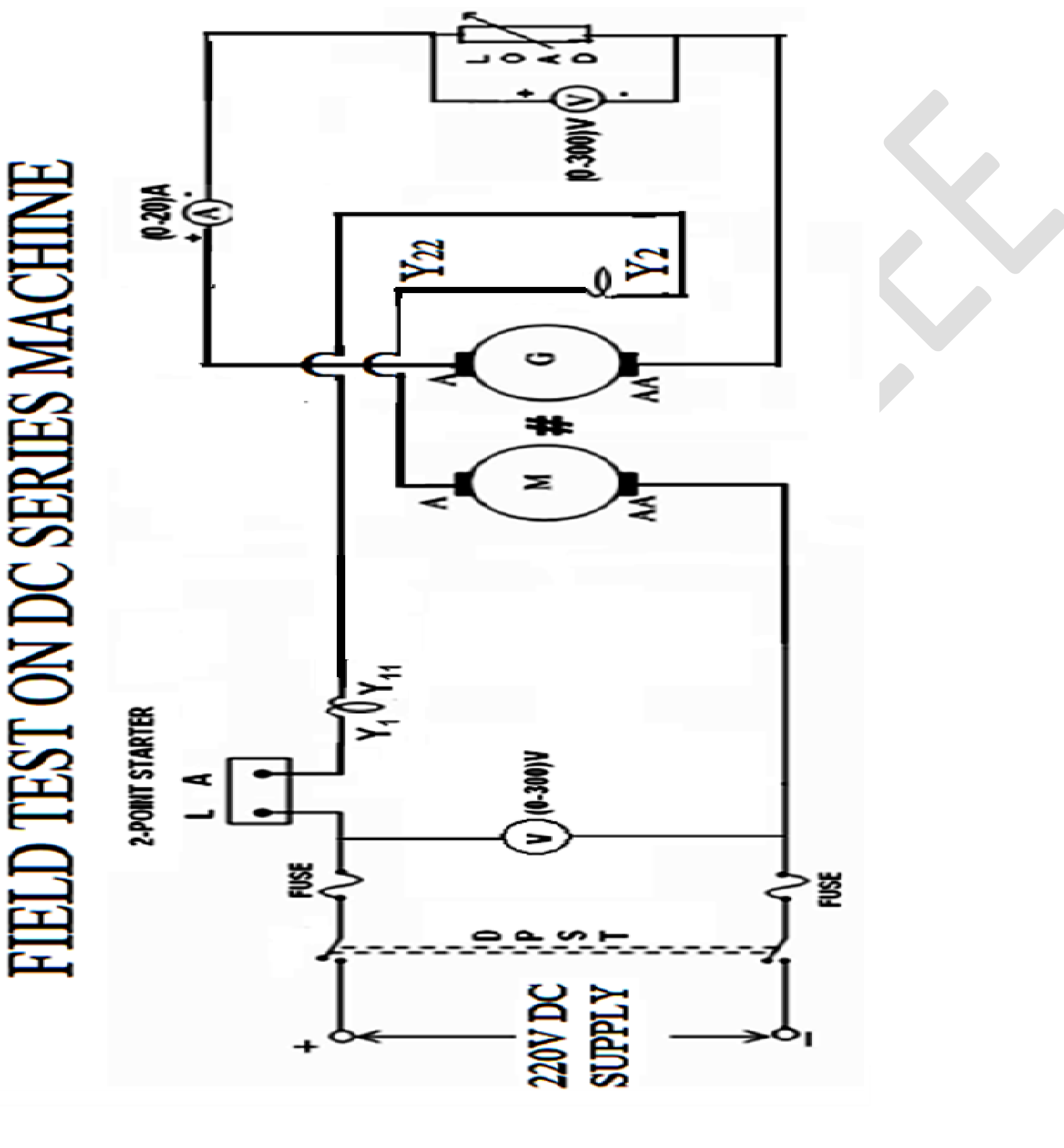
VIVA QUESTIONS:

1. When two DC machines are paralled as is done in this test, which machine acts as a generator and which machine acts as a motor?
2. What are the disadvantages of this test
3. What are heat run tests?
4. What is the other name for this test?
5. Hopkinsons test on DC machines is conducted at what load?

6

FIELD TEST ON DC SERIES MACHINES

Circuit Diagram:



Exp.No. 6

FIELD TEST ON DC SERIES MACHINES

AIM: To conduct Field's test of two similar machines and draw efficiency curves.

NAME PLATE DETAILS:

Capacity	Motor	Generator
Type	**Series**	**Series**
Rated Power(KW/HP)		
Rated Voltage(Volts)		
Field Current(Amps)		
Armature current (Amps)		
Rated Speed (RPM)		

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostats			
4	Tachometer			
5	Resistive Load			
6	Connecting Wires			

Theory:

Testing of series motors in the laboratory is rather more difficult compared to testing of shunt motors. This is because:

(a) The field current varies over a wide range during normal working conditions of a series motor. Therefore, tests made at a constant excitation are no value.

(b) On no- load, the series motor attains dangerously high speed. So no – load test is not possible.

Field's Test is conducted on series machines to obtain its efficiency.

In this test,

- Two similar rating series machines are mechanically coupled.
- One series machine runs as a motor and drives another series machine, which runs as a generator.
- The series field winding of the generator is connected in series with the motor series field winding as shown in the figure.
- This test is not a regenerative test.

Procedure:

1. Connect the circuit as shown in the circuit diagram.
2. Note down the ratings of the dc series motor and dc series generator.
3. Put a minimum load of 400W on the generator
4. Start the motor by using Starter and gradually increase the armature voltage and simultaneously add the loads till the armature current I_a or I_f reaches the rated value.
5. Note down the readings at different loads.
6. Reduce the loads one by one till the motor speed does not exceed 1800rpm
7. Keep a minimum load of 400W and then switch off the supply.

.

FORMULAE:

V_t = ______ I_M =________ V_M =_________ V_G =_________ I_G =________

R_{aG} =_______ R_{seG} =_______ R_{seM} =________ R_{aM} =________

Total Input = $V_M I_M$ =___________ W

Total Output = $V_G I_G$ = ___________ W

Losses of two machines = I/P - O/P = ___________ W

$$W_C = \frac{(\text{Total losses} - I_m^2 R_{SEM} - I_M^2 R_{AM} - I_G^2 R_{SEG} - I_G^2 R_{AG})}{2}$$

W_C = ___________ W

Motor Input = $V_M I_M$ =_________

Motor losses = $W_C + I_M^2 R_{seM} + I_M^2 Ra_M$ =__________W

Motor Output = Input - losses =__________W

$\eta_M = \frac{O/p}{I/P} \times 100$ =_________

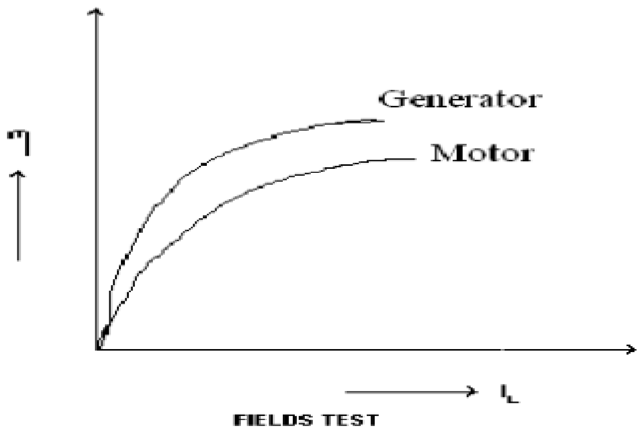
Generator output = Vg Ig = __________W

Generator losses = $W_C + Ig^2 Rag + Ig^2 Rseg$ =_________ W

Generator Input = output + losses = ___________W

$\eta g = \frac{output}{Input} \times 100$ = ___________

Model Graph :



TABULAR FORM :

S.NO	Vt	Vm	Vg	Im	Ig	Wcm	Wo	Wcg	Wc	Motor efficiency	Generator efficiency

Precautions:-

1. The motor should must be started with any load.
2. Motor rheostat should be kept in maximum resistance position.
3. Both motor and generator should be coupled before starting the system.
4. Readings should be taken with out parallax error.

RESULT:

CONCLUSIONS:

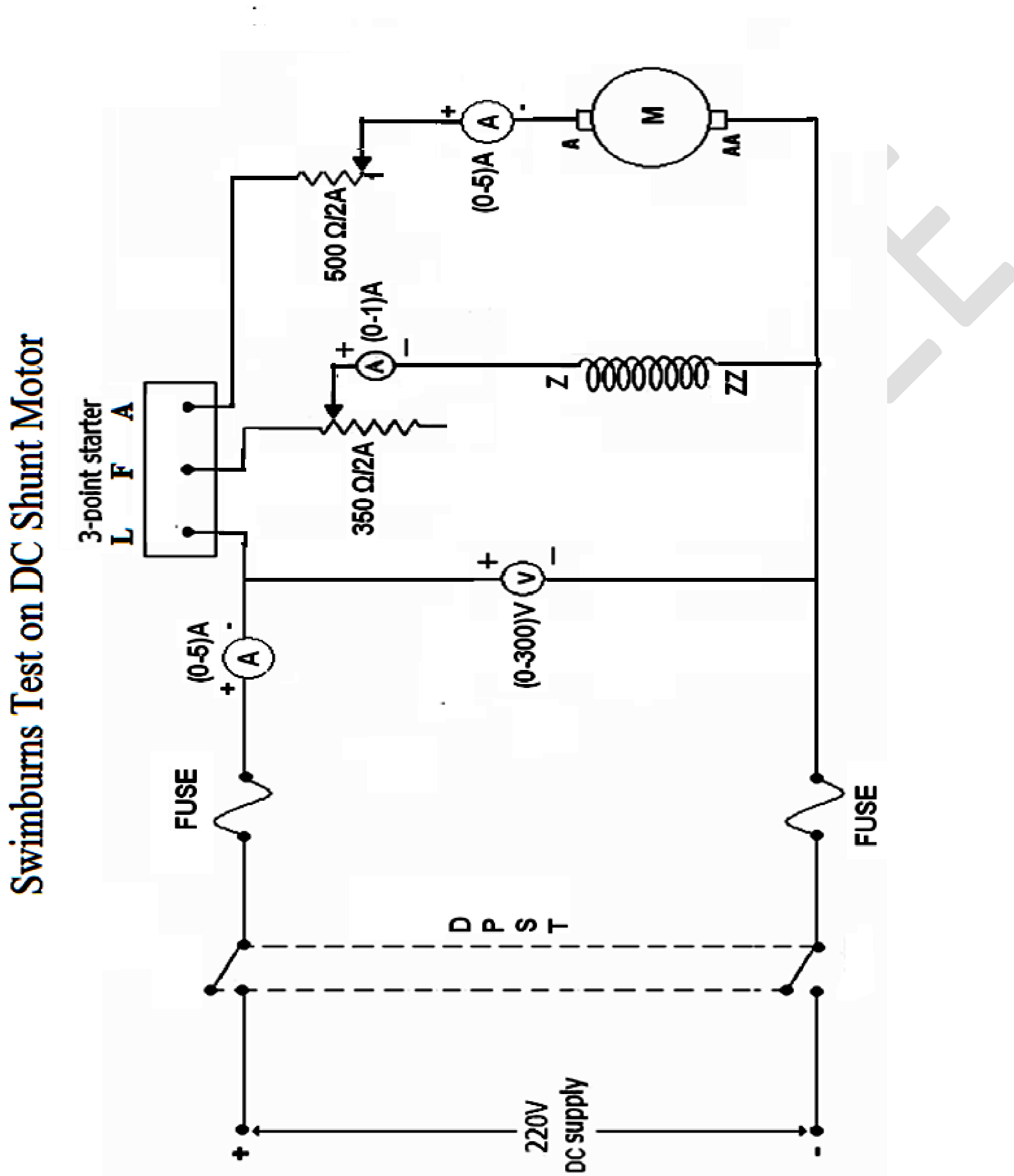
VIVA QUESTIONS:

1. What is the application of series motor?
2. Why the motor should started on load?
3. Which efficiency is greater when compared to motor and generator?

7

SWINBURNE'S TEST
AND
SPEED CONTROL OF DC SHUNT MOTOR

Circuit Diagram:



Exp. No. 7

SWINBURNE’S TEST

AIM: To conduct Swinburne’s test on DC machine to determine efficiency when working as Generator and motor without actually loading the machine.

NAME PLATE DETAILS:

Capacity	Motor
Type	**Shunt**
Rated Power(HP)	
Rated Voltage(Volts)	
Field Current(Amps)	
Armature current (Amps)	
Rated Speed (RPM)	

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostats			
4	Tachometer			
5	Resistive Load			
6	Connecting Wires			

THEORY:

Loss summation method in DC shunt machines: Swinburne‟s test is the most commonly used method for testing of D.C machines. It is an indirect method of testing D.C machines. In this method, the no load losses of the machine are determined experimentally and the additional losses on load are estimated from the known data of the machine, and with the help of the losses and input power the efficiency at any desired load is predetermined. For a D.C. shunt motor change of speed from no load to full load is quite small. Therefore, mechanical loss can be assumed to remain same from no load to full load. Also if field current is held constant during loading, the core loss too can be assumed to remain same. In this test, the motor is run at rated speed under no load condition at rated voltage.

Losses:

We are using the term machine in the discussion of power losses owing to the fact that no distinction need be made between the losses in the D.C generator and the motor. The law of conservation of energy dictates that the input power must always be equal to the output power plus the losses in the machine. There are three major categories of losses:

1) Mechanical losses

2) Iron losses

3) Copper losses   Mechanical losses

Mechanical losses are the result of:

(a) The friction between the bearings and the shaft,

(b) The friction between the brushes and the commutator, and

(c) The drag on the armature caused by air enveloping the armature (winding loss).

The bearing-friction loss depends upon the diameter of the shaft at the bearing, the shaft′s peripheral speed, and the coefficient of friction between the shaft and the bearing. To reduce the coefficient of friction, the bearing is usually lubricated. The brush-friction loss depends upon the peripheral speed of the commutator, the brush pressure, and the coefficient of friction between the brush and the commutator. The graphite is the brush helps provide lubrication to lessen the coefficient of friction. The winding loss depends upon the peripheral speed of the armature, the number of slots on its periphery, and its length. Mechanical losses due to friction and winding Pfw can be determined by rotating

the armature of an unexcited machine at its rated speed by coupling it to a calibrated motor. Because there is no power output, the power supplied to the armature is the mechanical loss.

Stray-load loss:

A machine always has some losses that cannot be easily accounted for; they are termed as stray-load losses. It is suspected that the stray-load losses in the D.C. machine s are the result of :

(a) the distorted flux due to armature reaction and

(b) Short-circuit currents in the coils undergoing commutation.

As a rule of thumb, the stray-load loss is assumed to be 1% of the power output in large machines (above 100 horse power) and can be neglected in small machines.

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 COLUMNS:

S.No.	I_f (Amps)	I_o (Amps)	V (Volts)
1			

AS MOTOR:

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

5								

AS GENERATOR:

S. No.	**V (Volts)**	**I_1 (Amps)**	**I_a (Amps)**	**Ia^2Ra (Watts)**	**Total Losses (Watts)**	**Output Power (Watts)**	**Input Power (Watts)**	**Efficiency η%**

CALCULATIONS:

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 (Assume 15%, 25%, 50%, 75% of rated current)

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

Output Power = Input Power – Total losses

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

AS GENERATOR:

Load Current I_L = _____ Amps (Assume 15%, 25%, 50%, 75% of rated current)

Armature current Ia = $I_L + I_f$ Amps

Copper loss = $I_a^2 R_a$ watts

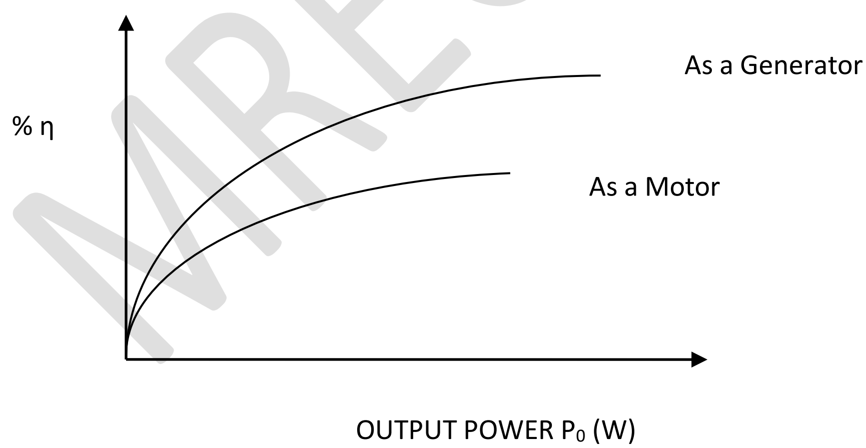
Total losses = Copper loss + Constant losses

Output Power = VI_L watts

Input Power = Input Power +Total losses

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

MODEL GRAPH:



RECAUTIONS:

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

2. Loose connections are avoid

3. While running there should be no load

RESULT:

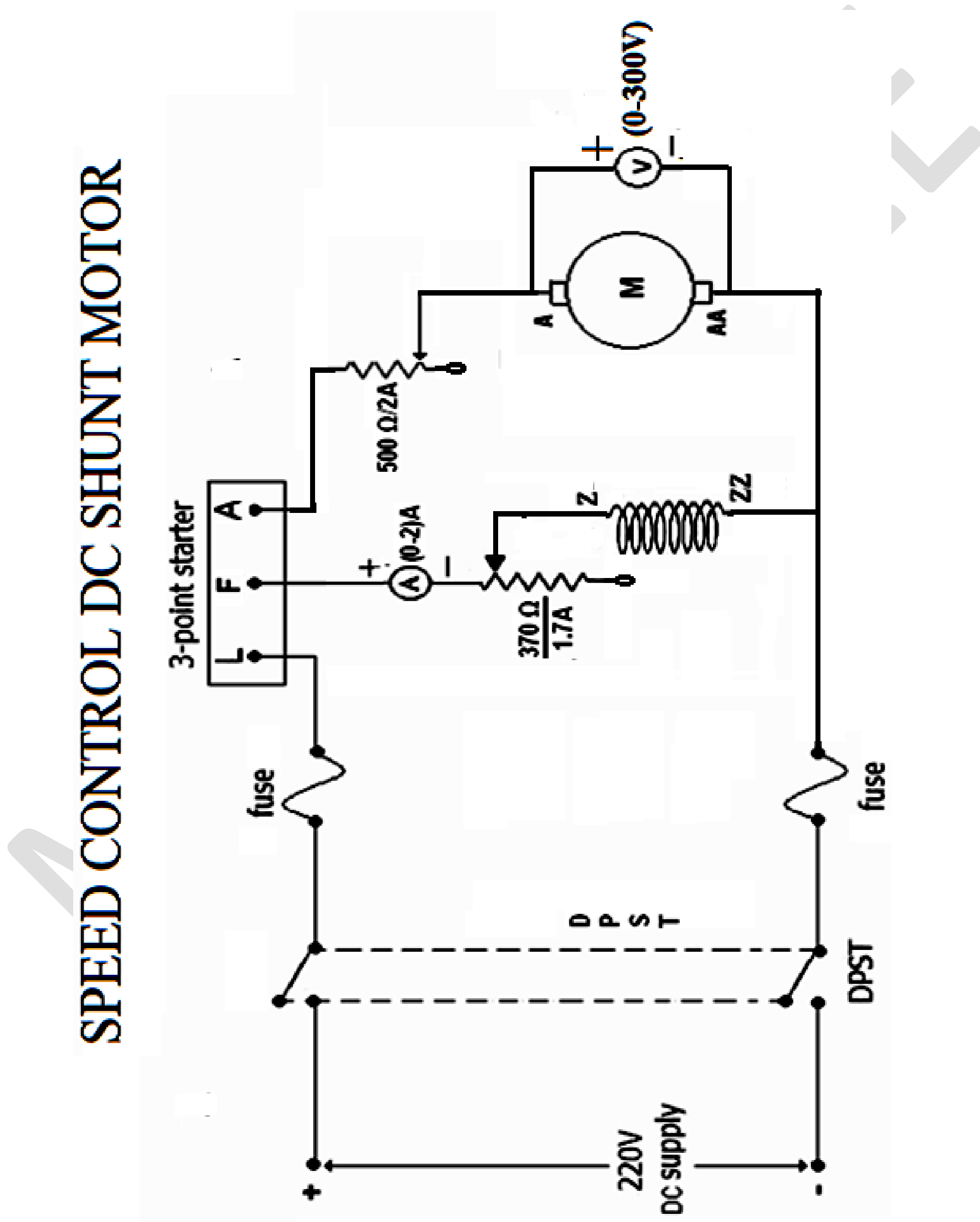
CONCLUSIONS:

VIVA QUESTIONS:

1. What are the advantages of Swinburne test?
2. Why Swinburns test cannot be performed on series machines? Explain.
3. How do you obtain accurate measurements in this experiment?
4. How do you reverse the direct ion of motor?
5. In a Dc machine, winding losses varies with speed in the proportion of ______?
6. Why do we pour water in the break drum during break test?

SPEED CONTROL OF DC SHUNT MOTOR

CIRCUIT DIAGRAM:



APPARATUS REQUIRED:

S.No.	Item	Type	Range	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostat			
4	Tachometer			
5	Connecting wires			

PROCEDURE

Part - A

Armature Control Method: (below rated speed)

1. Choose the proper ranges of meters after noting the name plate details of the given machine and make the connections as per the circuit diagram.
2. Keep the motor field rheostat (R_f) in the minimum position and the armature rheostat (R_{as}) in the maximum position, start the MG set.
3. Give supply and accelerate the motor using 3-point starter.
4. Decrease the armature rheostat value and note down speed and induced emf in motor winding.
5. Tabulate these readings and plot the graph Eb V_S N.

Part - B

Field Control Method: (above rated speed)

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

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

TABULAR COLUMN:

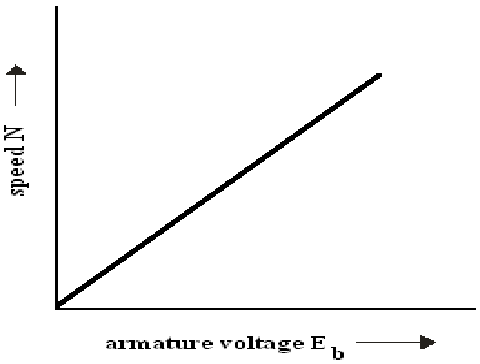
ARMATURE CONTROL METHOD

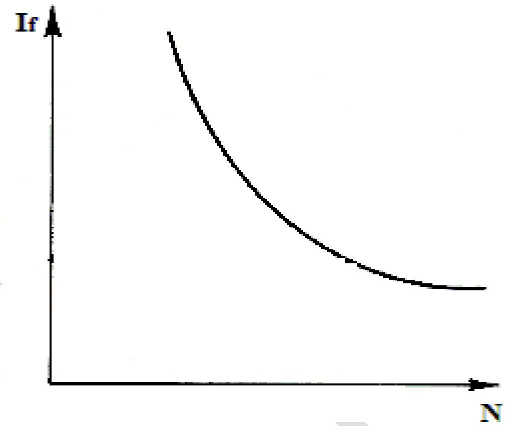
S. No.	E_b(Volt)	Speed (rmp)
1		
2		
3		
4		
5		
6		

FIELD CONTROL METHOD

S. No.	I_f (Amp)	Speed (rpm)
1		
2		
3		
4		
5		
6		

MODEL GRAPH:





Armature control **Field Control**

PRECAUTIONS:

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

RESULT:

CONCLUSION:

VIVA QUESTIONS:

1. How do you change the direction of rotation of a D.C. motor?
2. What is the disadvantage of using armature control of speed on load?
3. What are the limitations of shunt field control?
4. Can we conduct continuity test on ac supply?
5. While running if the field winding gets disconnected, what will happen?
6. What is the shape of the curve of field control of method motor speed? Explain why is it so?

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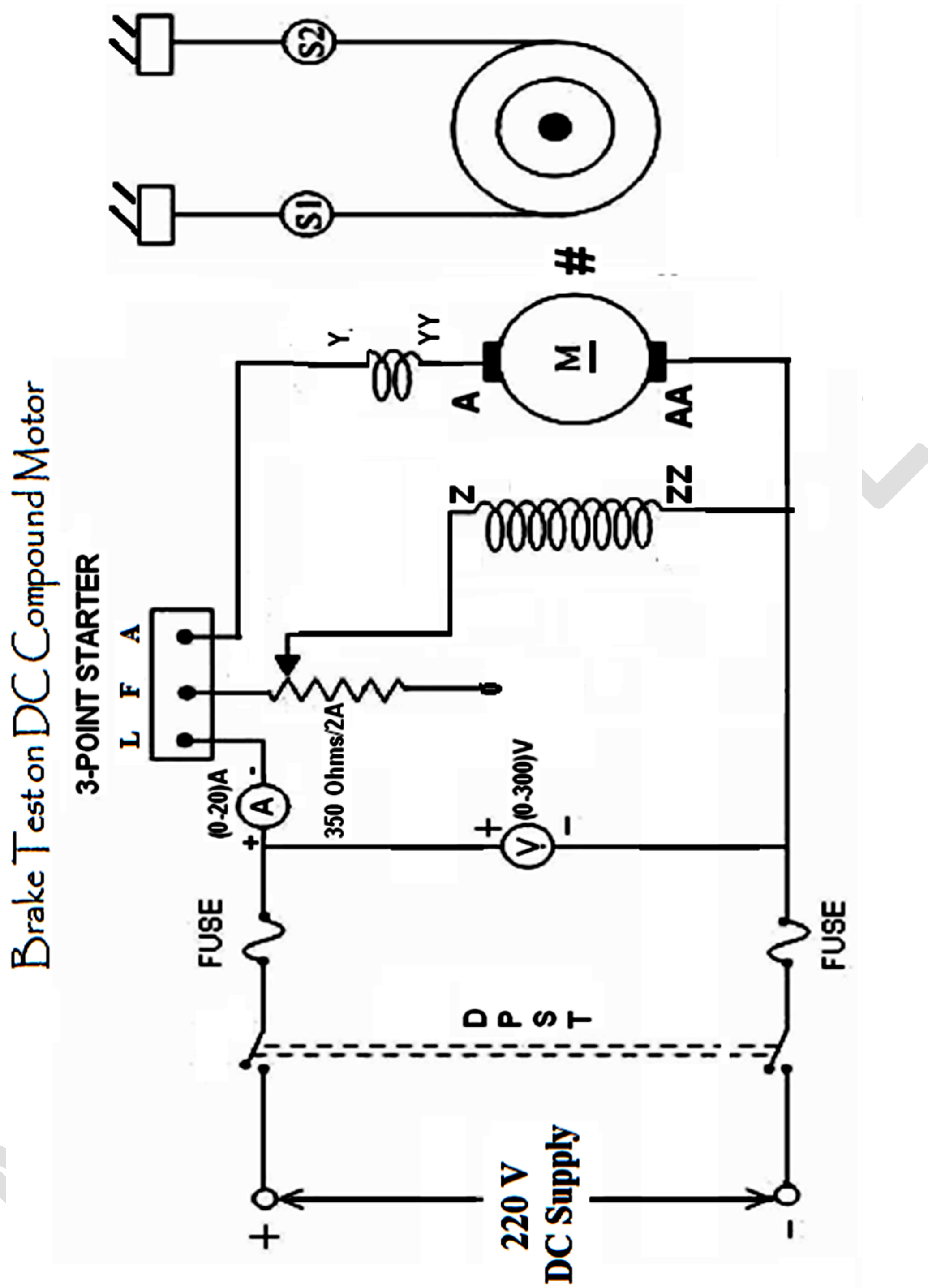
8

BRAKE TEST ON DC COMPOUND MOTOR

Circuit diagram:



Exp.No.8

BRAKE TEST ON DC COMPOUND MOTOR

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

NAME PLATE DETAILS:

Capacity	Motor
Type	**compound**
Rated Power(HP)	
Rated Voltage(Volts)	
Armature current(Amps)	
Field Current(Amps)	
Rated Speed(RPM)	

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostat			
4	Tachometer			
5	Connecting Wires			

THEORY:

It is a direct method in which a braking force is applied to a pulley mounted on the motor shaft. A belt is wound round the pulley and it s two ends are attached to the frame through two spring balances S1 and S2. The tension of the belt can be adjusted with the help of tightening wheels. The tangential force acting on the pulley is equal to the difference between the readings of the two spring balances.

Spring balance readings are S1 and S2 in Kg. Radius of the shaft is R meters.

Speed of the motor is N rpm. Input voltage across the motor is V volts

Input current is I amps

Torque(T) = (S1 – S2) R x 9.81 N-m.

Motor output = 2ΠNT / 60 watts

Motor input = VI watts

Efficiency = output/ input

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.

FORMULAE:

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

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

Input Power $P_i = VI$ Watts

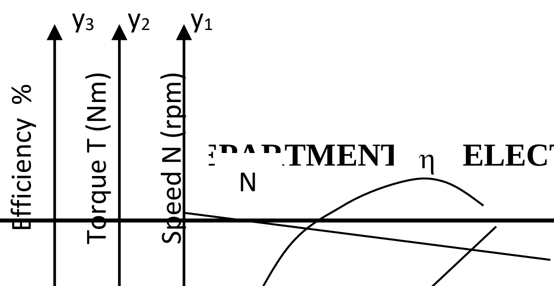
$$\text{Output Power } P_m = \frac{2\pi NT}{60} \text{ Watts}$$

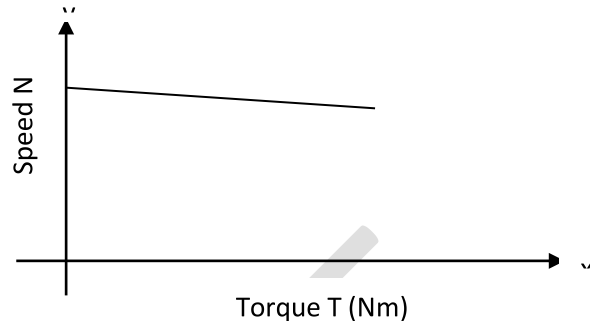
$$\text{Efficiency } \eta\ \% = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

TABULAR COLUMN:

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)						

MODEL GRAPHS:





PRECAUTIONS:

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:

CONCLUSION:

VIVA QUESTIONS:

1. Explain the difference between long shunt and short shunt compounding?

2. What are the uses of different types of compound motors?
3. How do you reverse the direct ion of motor?
4. Draw the speed- torque curve for differential compound motor?
5. What is flat compounding?
6. What is the effect on speed of DC compound motor if the series field winding is shorted?
7. How do you minimize iron losses in a DC machine?

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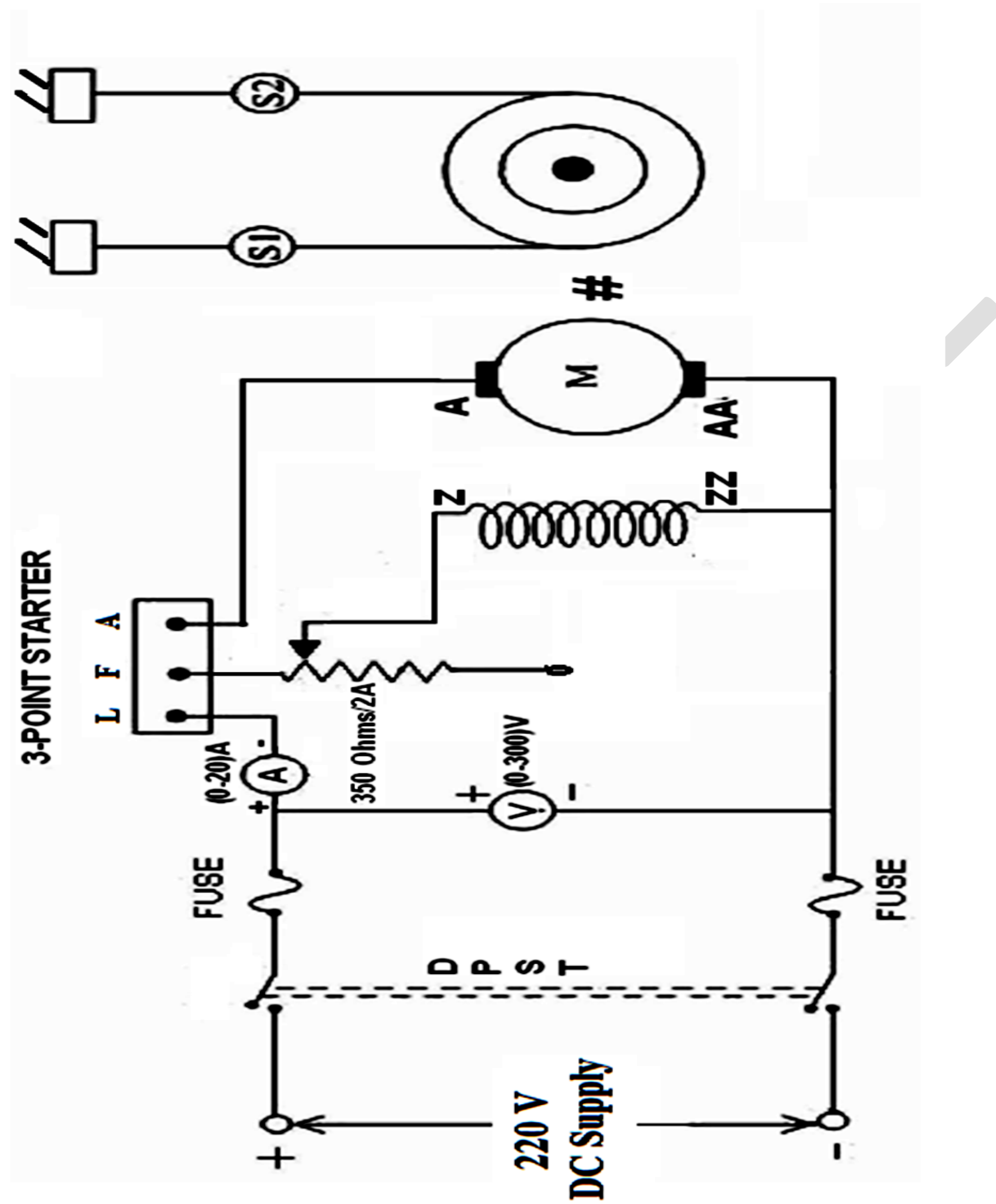
BRAKE TEST ON DC SHUNT MOTOR

Circuit Diagram:

Brake Test on DC Shunt Motor



Exp.No.9

BRAKE TEST ON DC SHUNT MOTOR

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

NAME PLATE DETAILS:

Capacity	Motor
Type	**Shunt**
Rated Power(HP)	
Rated Voltage(Volts)	
Field Current(Amps)	
Armature current (Amps)	
Rated Speed (RPM)	

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostat			
4	Tachometer			
5	Connecting Wires			

THEORY:

It is a direct method and consists of applying a brake to a water – cooled pulley mounted on the motor shaft. The brake band is fixed with the help of wooden blocks gripping the pulley.

The sample brake test described above can be used for small motors only. Because in the case of large motors. It is difficult to dissipate the large amount of heat generated at the brake.The load test can be conducted by using a belt brake or rope brake. For a constant applied voltage, the field current is constant for a D.C. Shunt motor. The flux will, therefore have its maximum value at no-load, and because of armature reaction will decrease slightly as the load increases. For most purpose this decrease can be neglected, and the flux per pole 'ϕ' can be regarded as constant.

The speed N is proportional to $\frac{V - I_a R_a}{\phi}$. The speed of shunt motor from no load to any other load is proportional to the armature drop at that load. The fall in speed will not be quite so great. Since the full load drop in the armature is small compared with applied voltage, the speed curve of a D.C. Shunt motor is a slightly drooping curves. Torque (T) is proportional to ϕ I_a, since ϕ is approximately constant,. The torque is proportional to (I_a) the armature current. Hence the torque characteristic is a straight line through the origin.

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 up to rated load current
6. The motor is then brought to no load condition and field rheostat to minimum position, then DPST switch is opened.

FORMULAE:

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

(Circumference of the Brake drum = 150 cm (or) 0.15 mtr)

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

Input Power (P_i) = VI Watts

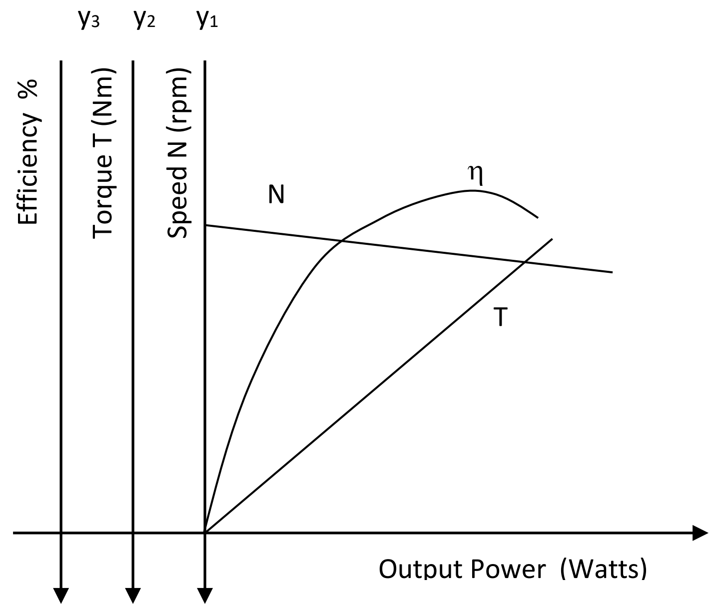
$$\text{Output Power } P_m = \frac{2\pi NT}{60} \text{ Watts}$$

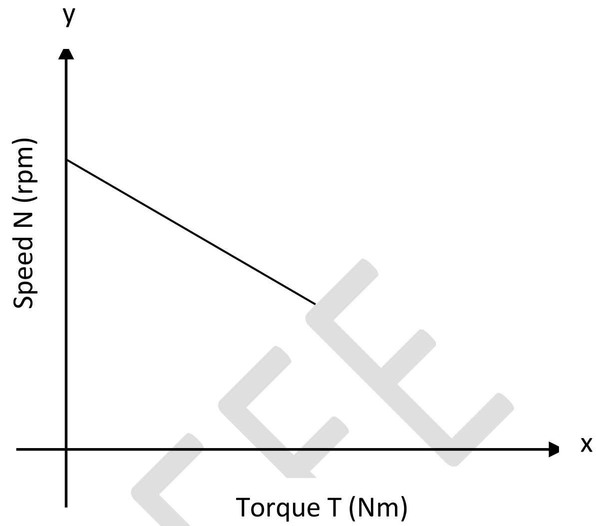
$$\text{Efficiency } \eta \% = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

TABULAR COLUMN:

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)						

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:

CONCLUSION:

VIVAQUESTIONS:

1. What is the back emf of the motor?
2. Why the speed falls as load increases for a DC shunt motor?
3. What are the applications of Dc shunt motor?
4. When is the efficiency of the motor maximum?
5. Define commutation?
6. How do you minimize reactance voltage for sparkles commutation?
7. What should be the position of rheostat in the field circuit while starting?
8. What is the nature of load connected across DC motor?
9. What will happen when Dc shunt motor is started with load?
10. What is the effect on speed if part of the field winding is shorted?

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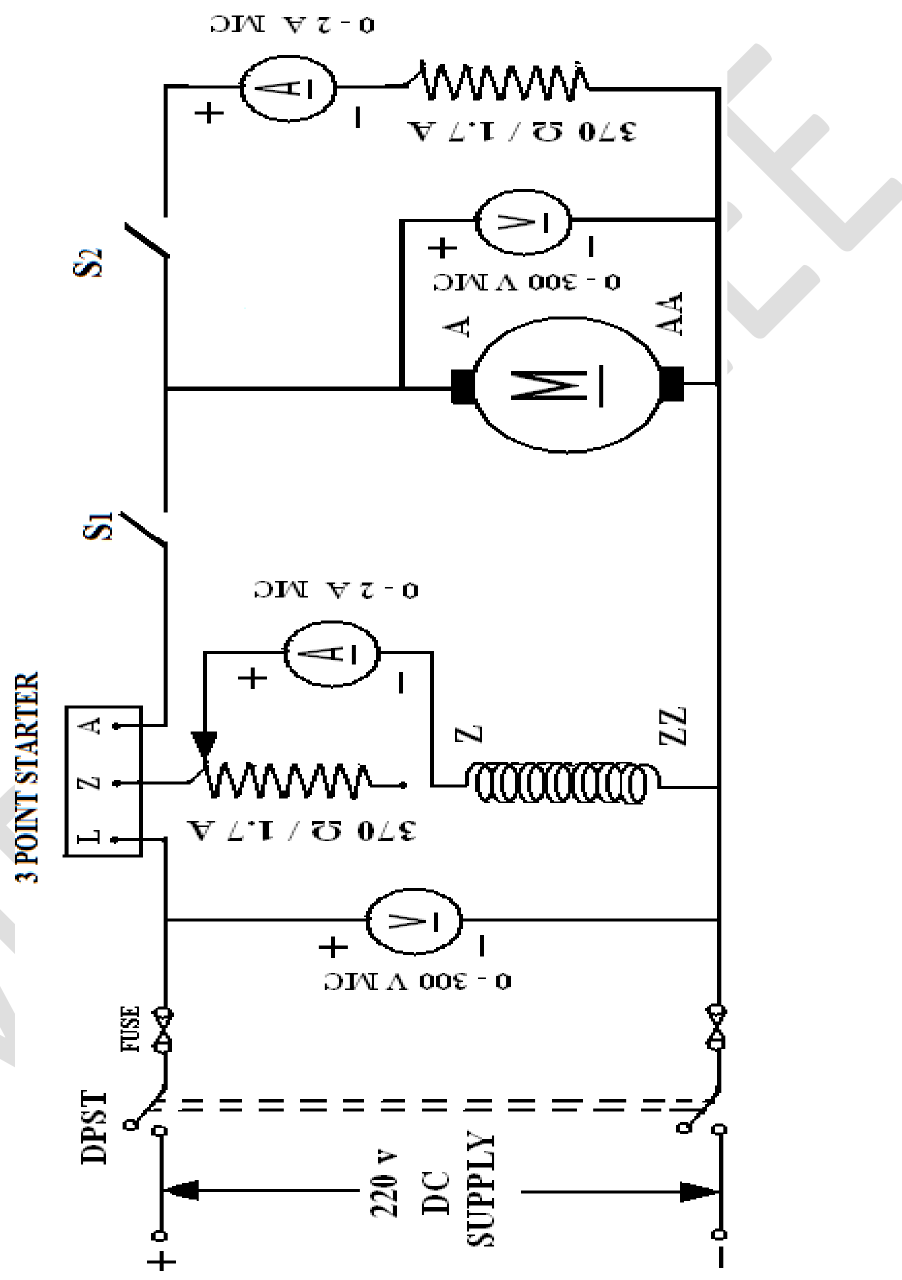
10

RETARDATION TEST ON DC SHUNT MOTOR

CIRCUIT DIAGRAM:



Exp. No. 10

RETARDATION TEST ON DC SHUNT MOTOR

AIM: To determine the stray losses and efficiency of DC shunt machine by conducting retardation test.

NAME PLATE DETAILS:

MOTOR

Voltage	
Current	
Output	
Speed	

APPARATUS REQUIRED:

S.No	Meter	Type	Range	Quantity
1	Ammeter			
2	Ammeter			
3	Voltmeter			
4	Rheostat			
5	Tachometer			

THEORY:

This is the best and simplest method to find the **efficiency of a constant-speed dc machine** (e.g. shunt generator and motor). In this method, we find the mechanical (friction and windage) and iron losses of the machine. Then knowing the armature and shunt Cu losses at any load, the efficiency of the machine can be calculated at that load.

Retardation test Working Principle:

Consider a dc shunt motor running at no-load.

(i) If the supply to the armature is cut off but the field remains normally excited, the motor slows down gradually and finally stops. The kinetic energy of the armature is used up to overcome friction, windage and iron.

losses.

(ii) If the supply to the armature as well as field excitation is cut off, the motor again slows down and finally stops. Now the kinetic energy of the armature is used up to overcome only the friction and windage losses. This is expected because, in the absence of flux, there will be no iron losses.

By carrying out the first test, we can find out the friction, windage and iron losses and hence the efficiency of the machine. However, if we perform the second test also, we can separate friction and windage losses from the iron losses.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Initially the switch S_2 is open and S_1 is closed then the motor is started with the help of three point starter.
3. The speed is adjusted to just above the rated speed by adjusting the field rheostat.
4. The voltage is noted then switch S_1 is opened and also note down the time taken to reach the armature voltage to a voltage of 25% less than the initial value.
5. Again S_1 is closed immediately before the motor reaches to zero speed and rheostats are adjusted until the motor reaches its rated speed.
6. Then S_1 is opened and at a time S_2 is closed at this instant record the readings of ammeter and also note down the time taken to reach the armature voltage to a voltage of 25% less than the initial voltage.

TABULAR COLUMN:

S_1 close and S_2 open

S No	Vs (Volts)	I_f (A)	Time (t1)

S_1 open at a time S_2 close

S No	Va (Volts)	I_a(A)	Time (t2)

CALCULATIONS:

Rotational losses or stray losses PS=P 1(t /t -t)

P 1 = V I

S avg * Lavg

Input power = V IL

IL = full load current of the motor Armature cu losses = Ia2 Ra

Ia = IL-If

Total losses = Armature cu losses + Stray losses Output power=Input -Total losses

Motor efficiency ή = output/input.

PRECAUTIONS:

1. Take care while using the starter.
2. The speed should be adjusted to rated speed.
3. There should be no loose connections.

RESULT:

CONCLUSION:

VIVAQUESTIONS:

1. Explain the principle of operation of a DC motor?
2. What are various DC starters?
3. Write the condition for maximum powr developed by a dc motor?
4. Write the voltage equation of dc shunt motor?
5. How can we reverse the direction of dc shunt motor?

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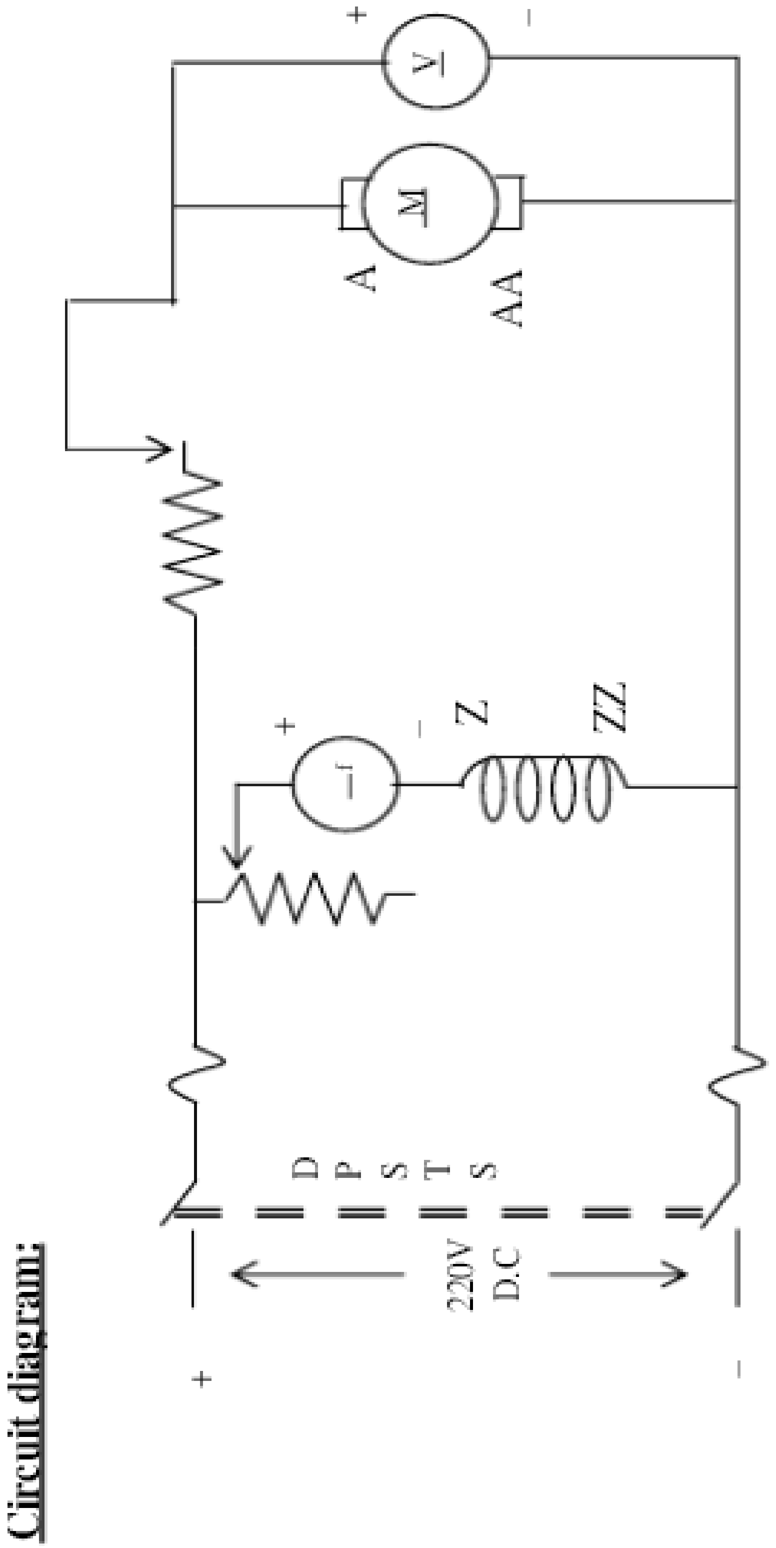
11

SEPARATION OF LOSSES IN A DC SHUNT MOTOR

Circuit Diagram:



Exp. No. 11

SEPARATION OF LOSSES IN A DC SHUNT MOTOR

AIM: To determine the losses in a DC shunt motor.

NAME PLATE DETAILS:

Capacity	Motor
Type	**Shunt**
Rated Power(HP)	
Rated Voltage(Volts)	
Field Current(Amps)	
Armature current (Amps)	
Rated Speed (RPM)	

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter			
2	Voltmeter			
3	Rheostats			
4	Tachometer			
5	Resistive Load			
6	Connecting Wires			

THEORY:

D.C. machine consist the following losses.

1. Copper losses

2. Rotational losses

Copper loss consists of armature copper loss and field copper loss. Rotational losses consist of iron losses, mechanical losses and stray load losses. Iron loss again subdivided into hysteresis loss and eddy current loss. By performing no- load test on D.C. Shunt machine at different fixed field currents all the above losses can be separated.

PROCEDURE:

1) make the connection as per the circuit diagram
2) Ensure maximum resistance in armature circuit and minimum resistance in the field circuit, then switch on the main supply
3) Apply the rated voltage across the armature of the motor and adjust the rated speed of the motor. This excitation is known as the full excitation and Note the readings in all the meters such as ammeter and voltmeter
4) And repeat the step 3 for reduced armature voltage at full excitation and note the readings
5) Then decrease the voltage across the armature, for this excitation note down all the readings from the meters.
6) And repeat the step 5 of reducing armature voltage for another readings
7) Plot the curve as shown from the model graph to calculate $Tan\theta_1$ and $Tan\theta_2$ and to observe OP and OR

TABULAR COLUMN:

S.no	Vm(volts)	Ia(Amps)	I_f(Amps)	Speed(N-rpm)	$W=VI_a$	W/N

TABULAR COLUMN:

S.no	Vm(volts)	Ia(Amps)	I_f(Amps)	Speed(N-rpm)	$W=VI_a$	W/N

PRECAUTIONS:

1. Take care while using the starter.
2. The speed should be adjusted to rated speed.
3. There should be no loose connections.

RESULT:

CONCLUSION:

VIVAQUESTIONS:

1. Explain the principle of operation of a DC motor?
2. What are various DC starters?
3. Write the condition for maximum powr developed by a dc motor?
4. Write the voltage equation of dc shunt motor?
5. How can we reverse the direction of dc shunt motor?

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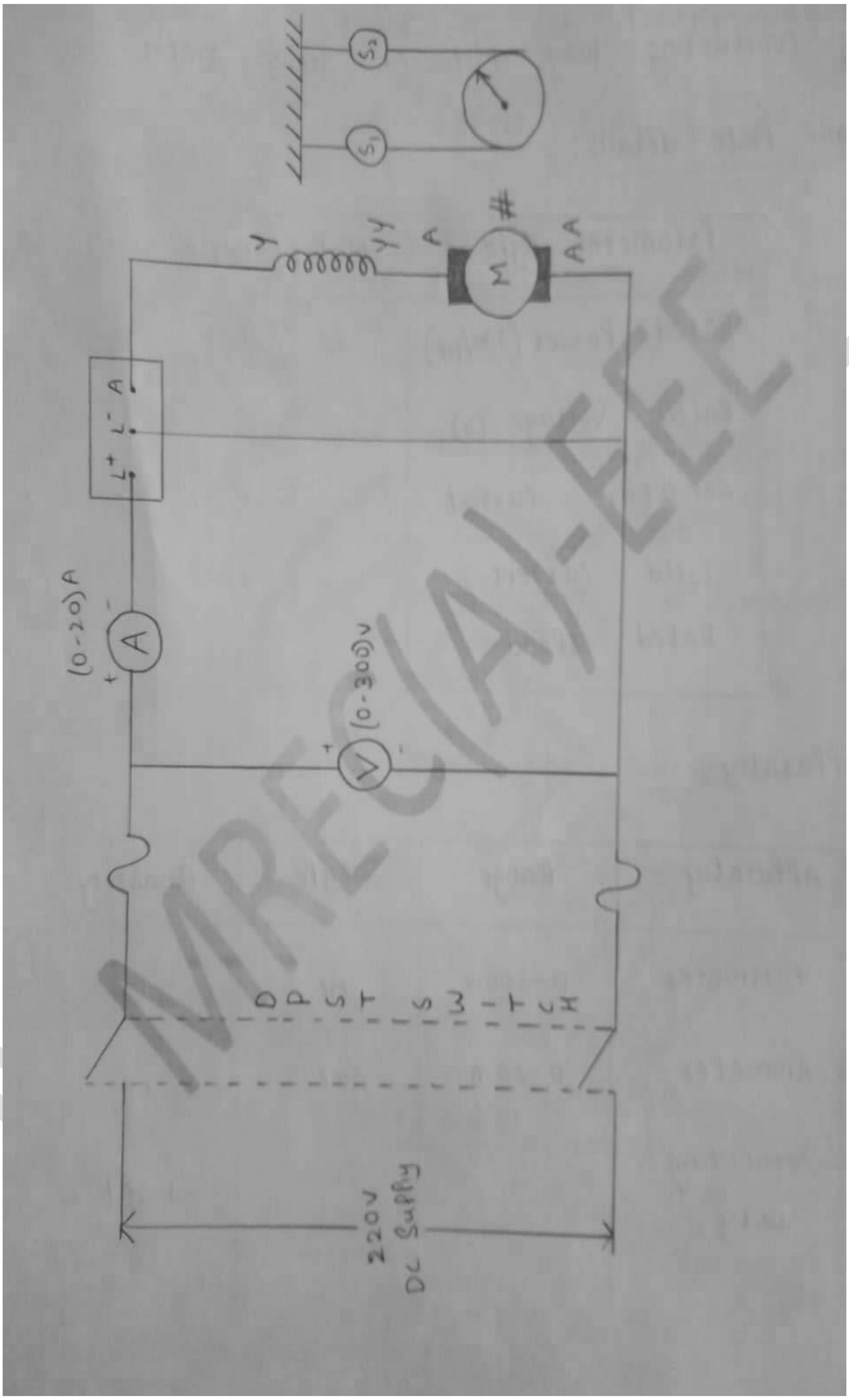
BRAKE TEST ON DC SERIES MOTOR

CIRCUIT DIAGRAM



Exp. No. 12

BRAKE TEST ON DC SERIES MOTOR

AIM: To determine the effiicency of a DC series motor.

NAME PLATE DETAILS:

Capacity	Motor
Type	**Series**
Rated Power(HP)	
Rated Voltage(Volts)	
Armature current (Amps)	
Rated Speed (RPM)	

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter			
2	Voltmeter			
3	Tachometer			
4	Connecting Wires			

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. DPST switch is closed; Start the motor by using starter with some load, so starting resistance is gradually removed.
3. Load is varied gradually and for each load, voltmeter and ammeter readings are noted.
4. Note down the speed of the motor for each load and spring balances.
5. Remove the load gradually and switch off the supply.

FORMULAE:

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

(Circumference of the Brake drum = 150 cm (or) 0.15 mtr)

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

Input Power (P_i) = VI Watts

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

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

TABULAR COLUMN:

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)						

RESULT: