Geethanjali College of Engineering and Technology

ELECTRICAL MACHINES - I LAB

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

LAB MANUAL (Ver. 1.03)

FOR II YEAR B.TECH EEE

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING
2015-2016
EVALUATION PATTERN

FOR ELECTRICAL MACHINES – I LABORATORY

The Electrical Machines – I lab evaluation can be broadly classified as per the contents

Internal Assessment: 25 Marks

1. Two internals will be conducted for laboratory assessment.
2. Day-to-day work in the laboratory shall be evaluated for 15 marks.
3. Internal examination for practical shall be evaluated for 10 marks conducted by the concerned laboratory teacher.

End Examination Assessment: 50 Marks

1. The end examination conducted for 50 marks with duration of 3 hours.
2. The end examination shall be conducted with external examiner and laboratory teacher.
3. The external examiner shall be appointed from the cluster of colleges as decided by the University examination branch.

LIST OF EXPERIMENTS

S.No	Name of the Experiment
1.	Magnetization characteristics DC shunt generator. Determination of critical field Resistance critical speed.
2.	Load test on DC shunt generator. Determination of characteristics.
3.	Brake test on DC shunt motor. Determination of performance curves.
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.	Load test on DC series generator. Determination of characteristics.
10.	Separation of losses in DC shunt motor.
11.	Retardation test on DC shunt motor. Determination of losses at rated speed.

Learning objectives:

The Significance of Electrical Machines-I is renowned in the various fields of Engineering. For an Electrical Engineer, it is obligatory to have the practical idea about the Electrical Machines-I.

A Course in Laboratory Experiments on Electrical Machines-I is offered to 2nd year B.Tech EEE Students keeping in view the following objectives.

(1) To provide experience in experimental methods.
(ii) To provide experience in selecting and using variety of electrical instruments & accessories.
(iii) To reinforce theoretical instructions with Related Practical's.
(iv) To give practice in Machine circuit Connections.
(v) To Provide Training the Technical report writing.

Learning Outcomes

The student will:

A. Explain principles of operation of DC motors.
B. Summarize National Electric Code (NEC) regulations governing the installation of
transformers and AC/DC motors.
C. Identify the various terms associated with /DC motors.
D. Describe basic motor and generator parts as to their specific use and application.
E. Discuss troubleshooting techniques for motors, generators, and transformers.
F. Calculate motor horsepower, speed, slip, efficiency, power factor, and torque for
electrical machines.
G Discuss motor losses at unloaded and loaded conditions
H. Understand the principles and construction of D.C. machines
I. Demonstrate an awareness of the sources of electrical energy and their sustainability;
J. Describe the construction and operation of simple electrical machines and use
nameplate data and equivalent circuits to determine electrical and mechanical
performance;

Safety Precautions:

1. Ensure appropriate attires: no slippers, sandals or open-toe footwear allowed.
2. Long hair should be properly tied.
3. Make sure hands are dry when conducting experiment. KEEP WATER BOTTLES AWAY FROM EXPERIMENT AREA.
4. Make sure all power supplies are switched off before commencing with connections.
5. Make circuit connections with test leads. Use only ONE hand when making connections to avoid closing circuit with your body.
6. Signal tutor or technician to check and verify your wire connections are correct.
7. Switch on power supply and proceed with data collection for experiment.
8. After each set of readings, switch off power supply before making any changes to wire connections.

When disconnecting test leads, remove the main power supply connections first, i.e. DC positive voltage output or AC voltage live output

MAGNETISATION CHARACTERISTICS OF DC SHUNT GENERATOR

Aim: To draw the Open Circuit Characteristics Curve of DC Shunt generator and to determine critical field resistance.

Apparatus Required:

Sl No	Equipment	Rating	Type	Quantity
1.	Volt meter	0 – 300V	MC	1 No
2.	Ammeter	0 – 2A	MC	1 No
3.	Tachometer	0 – 10k RPM	Digital	1 No

Name plate Details:

Motor
Generator

a) Rated Armature Voltage →
b) Rated full load Current →
c) Rated Speed →
d) Rated Power →
e) Type of excitation →

Fuse rating: For Open Circuit test 10% of rated full load current

Theory:

The open circuit characteristics for a DC generator are determined as follows. The field winding of the DC generator (series or shunt) is disconnected from the machine and is separately excited from an external DC source. The generator is run at fixed speed (i.e. rated speed). The field current (I_f) is increased from zero in steps and the corresponding values of generated e.m.f (E_0) read of an voltmeter connected across the armature terminals are tabulated. On plotting the relation between E_0 and I_f, we get the open circuit characteristics.

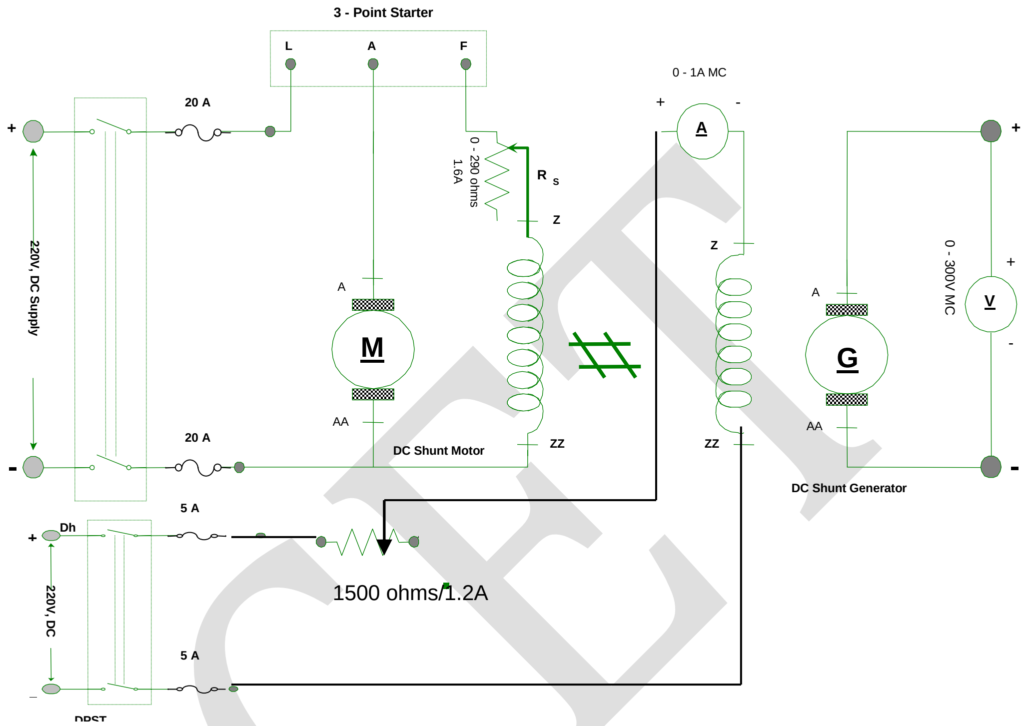
The following points may be noted from the OCC

(i) When the field current is zero, there is some generated e.m.f which is due to residual magnetism in the field poles
(ii) 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 relation ship.

(iii)After that the reluctance of iron also comes into picture. Consequently, the curve deviates from linear relation ship.

(iv) Finally the magnetic saturation of poles begins and E_0 tends to level off

Circuit Diagram:



1. Connections are given as per the circuit diagram.
2. Set the potential divider to zero output keeping motor field rheostat in minimum resistance position.
3. Switch on the supply and start the motor with the help of the starter. Adjust the Speed of the motor generator set to the rated speed of the generator by controlling the Motor field resistance the set speed is to be maintained constant through out the experiment. Note down the voltmeter reading at zero field current. Increase the field Current uniformly in steps, by moving the potential divider jockey, simultaneously noting down the field current and the terminal Voltage across the generator armature Terminals.
4. Continue the experiment till saturation of the field is reached.

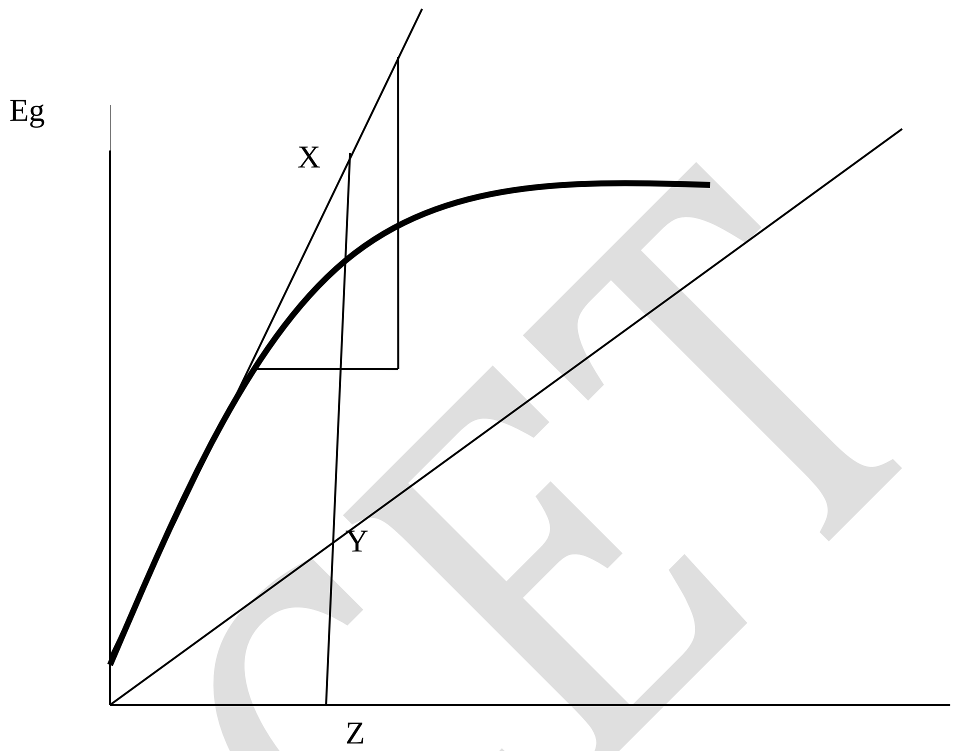
Tabular Column:

Rated Speed of the Generator = ………….

i) For Ascending Order of I_f:

Expected Graphs:

The graph is drawn in between Field Current (I_f) on X-Axis Vs Generated EMF E_G on y-Axis for both increasing and decreasing values of field current and the average curve is drawn.



Sl No:	Field Current I_f (A)	Generated EMF E_g (V)
1.		

Conclusion:

The open circuit characteristics of DC Shunt generator are drawn and the Critical field resistance is determined.

Viva Questions:

1. What is critical field resistance?
2. What are the conditions to build up e.m.f?
3. What is critical speed?
4. Does voltage will be developed at zero field current
5. What are the reasons for failure of building up e.m.f in a DC generator?
6. What are different types of DC generators?
7. What is meant by prime mover?

SWINBURNE'S TEST ON DC SHUNT MACHINE

Aim: *To Predetermine the efficiency of the given DC Shunt machine by Swinburne's test as a Motor operation and Generator operation.*

Apparatus Required:

Sl No	Equipment	Rating	Type	Quantity
1.	Volt meter	0-300V	MC	1 No
2.	Ammeter	0-1A	MC	1 No
		0-5A	MC	1 No
3.	Tubular Rheostat	0 - 270Ω / 2.8A	Wire Wound	1 No
		0 -100Ω / 5A	Wire Wound	1 No
4.	Tachometer	0 – 10K rpm	Digital	1 No

Motor Name Plate Details:

DC Shunt motor

1. Rated Voltage →
2. Arm Full Load Current →
3. Rated Speed →
4. Excitation →

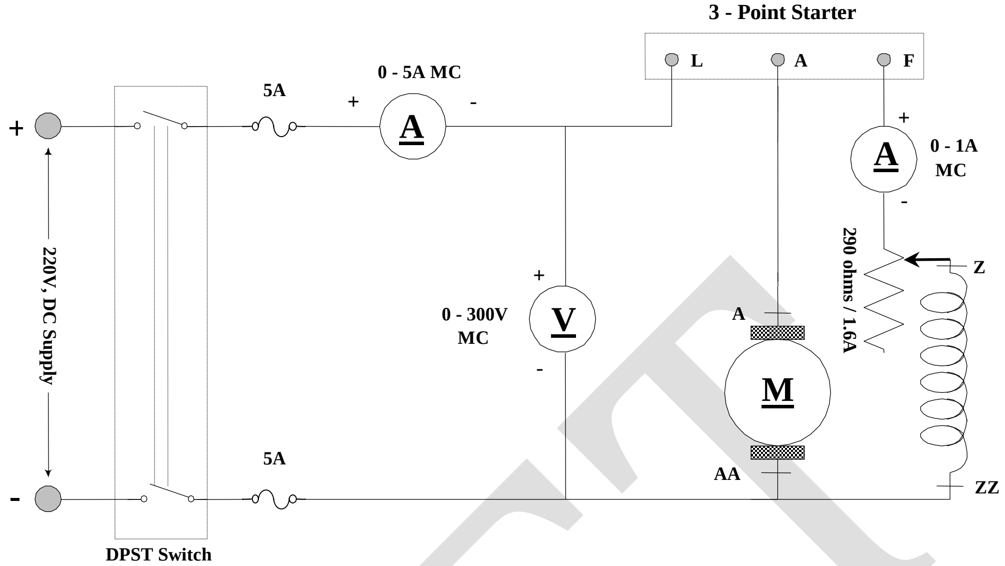
Fuse Rating: For No load 10% of rated full load current

Theory:

There are several tests that are conducted upon a DC machine (Motor or Generator) to judge its performance. One important test is performed measure the efficiency of the DC machine. Efficiency depends on its losses. The smaller the losses the greater its efficiency and vice versa. The consideration of losses in a DC machine is important because they determine the efficiency of the machine and appreciably influences its operating cost. And also they determine heating of the machine and hence the power output that may be obtained without undue deterioration of the insulation.

In Swinburne's method the DC machine is run as a motor at no load, and the losses of the machine are determined. Once the losses of the machine are known its efficiency at any desired load can be determined in advance. It may be noted that this method is applicable to those machines in which flux is practically constant (e.g. Shunt & Compound Machines).

Circuit diagram:



Part I:

Procedure:

1. Connect the circuit as shown in figure.
2. Insert the correct rating of fuse wires in the circuit.
3. Close the SPST switch and keep field rheostat in minimum resistance position.
4. Start the motor with the help of starter and by adjusting the field regulator of
   the Motor Such That it runs at its rated speed given on the nameplate.
5. Now open SPST switch and note down the values of supply voltage V,
   Line Current I_{Lo}, Field current I_f.
6. Calculate the efficiency of the machine as a Motor and as a Generator
   for Different Assured Values of load current I_L.

Observations:

(a) For Motor operation:

Rated voltage V =.............Volts
Line Current I_{LO} = ... Amps
Field Current I_f =............. Amps

Sl No	I_L (A)	Input = $V\ I_L$ watts	$I_a = I_L - I_f$ (A)	Copper losses = $I_a^2 R_a$	Output Power = $V\ I_L - W_T$	%Efficiency = (O.P / I.P) x 100.
	0 . . 15A					

(b) For Generator operation:

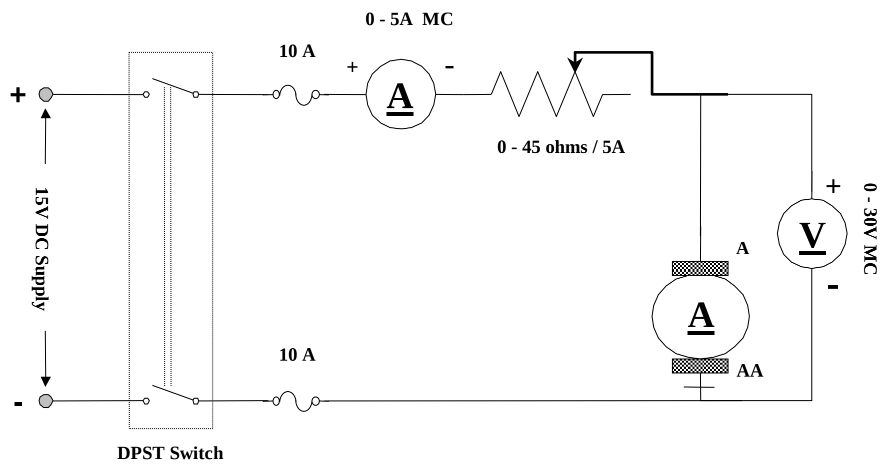
Rated voltage V =............ Volts
Line Current I_{LO} = ... Amps
Field Current I_f = ... Amps

Sl No	I_L (A)	Output = $V\ I_L$ Watts	$I_a = I_L + I_f$ (A)	Copper loss = $I_a^2 R_a$ in Watts	In put Power = $V\ I_L + W_T$	%Efficiency = (O.P / I.P) x 100.
	0 . . 15 Amp					

Part II:

Measurement of Armature circuit resistance of the machine:

Circuit diagram:



Procedure:

1. Make the connections as per circuit diagram.
2. Keep the Rheostat in maximum resistance positions
3. Switch on the LV DC supply
4. Adjust the resistance in steps, Note down the readings of Voltmeter and ammeter
5. Calculate the value of Armature resistance R_a = (V / I) Ω
6. Take the average value R_a to nullify the errors on the scale of Voltmeter and Ammeter

Tabular Column:

Sl No	V_a (V)	I_L (A)	$R_a = (V_a / I_L)$ Ω
1. 2. 3. 4.			

Avg R_a =…………… Ω

Sample Calculation's:

Armature current $I_{ao} = I_{Lo} - I_f$

No load input = $V I_{LO}$

Constant Power Losses $P_c = V I_{Lo} - I_{ao}^2$ Ra watts.

Armature Resistance R_a =

Predetermination of efficiency for motor:

Assume a line current I_L

Armature current $I_a = I_L - I_f$

Input Power = $V I_L$

Copper losses = $I_a^2 R_a$

Output = input – (Copper losses + Constant losses).

Efficiency = (Output / Input) x100.

Predetermination of Efficiency for Generator:

Output = V I_L

Armature current $I_a = I_L + I_f$

Copper losses = $I_a^2 R_a$

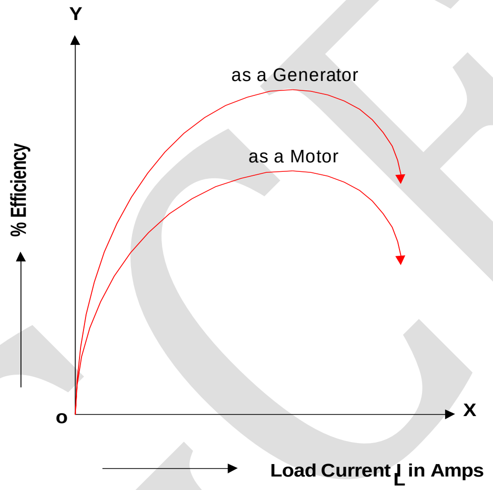
Total losses (W_T) = Cu loss + Constant loss

Input = Out put + (Cu loss + Const loss)

% Efficiency = (Output / Input) x 100.

Expected graphs:

The graph drawn between Load current Vs Efficiency



Conclusion:

The efficiency of the given DC shunt machine by Swinburne's test is determined for both Motor operation & Generator operation.

Viva Questions:

1. Give another name for Swinburne's test and give reason why it is called so?
2. What are different methods of calculating efficiency of dc shunt machine?
3. When a dc machine is run as motor and generator which I s having higher efficiency?
4. Which method is accurate for calculating efficiency?
5. Give the direct and indirect methods for calculation efficiency?
6. Swinburne's test can be done only on shunt machines why?

BRAKE TEST ON DC SHUNT MOTOR

Aim: *To perform the Brake test on the given DC Shunt motor and to obtain the performance characteristics of the motor.*

Apparatus Required:

Si.	Equipm	Rating	Type	Quantity
1	Ammeter	(0-25A)	MC	1No
2	Voltmete	(0-300V)	MC	1No
3	Tachome		Digita	1No

Nameplate details:

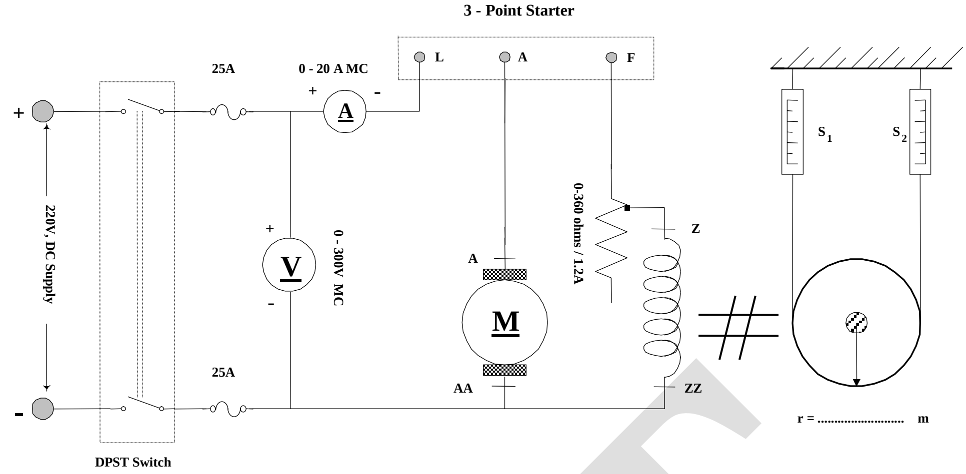
1. Rated Voltage →
2. Rated Current →
3. Speed →
4. Type of Excitation →
5. Power →

Theory:

There are several tests that are conducted upon a DC machine (Motor or Generator) to judge its performance. One important test is performed to measure the efficiency of the DC machine. Efficiency depends on its losses. The smaller the losses the greater its efficiency and vice versa. The consideration of losses in a DC machine is important because they determine the efficiency of the machine and appreciably influences its operating cost. And also they determine heating of the machine and hence the power output that may be obtained without undue deterioration of the insulation.

In this method a brake drum is connected in the shaft of the motor with spring balances to measure the load. The mechanical output of the motor is calculated with the help of spring balances readings and speed of the machine.

Circuit Diagram:



Fuse Rating: 125% fuse rating of Rated full load Current.

Procedure:

1. Make the connections as per circuit diagram.
2. Keep the field regulator of the Motor at minimum Resistance position.
3. At the time of starting check that the belt on the pulley is free, so that there is no load on the pulley.
4. Start the motor slowly by using stator
5. Adjust the field regulator so that motor runs at its rated speed.
6. Apply load on the pulley gradually in steps by adjusting of tension of spring Balance.
7. Take the readings of the Ammeter and Voltmeter and two spring balance readings and the speed for each step.
8. Cool the pulley through out the loading period by pouring water.
9. Continue the experiment till full load of the motor is reached.

Tabular Column:

SL No	V_L (V)	I_L (A)	F_1 (kg)	F_2 (kg)	Speed 'N' in RPM	Input Power (w)	Torque (T) in 'Newton meter's	Output Power in		%Efficiency
								Watts	BHP	
1										

Calculations:

Radius of the Brake drum r = …….. Mtrs

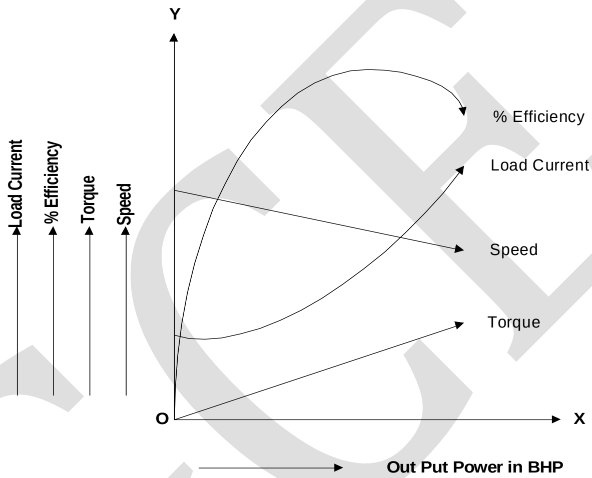
Torque (T) = $(F_1 - F_2)$ r.g N.mtr

Power Output = $(2\pi NT / 60)$ watts

%Efficiency = (Output / Input) X 100.

Expected Graphs:

i. % Efficiency Vs Output Power in BHP
ii. Speed Vs Output Power in BHP
iii. Torque Vs Output Power in BHP
iv. Load Current Vs BHP.



Conclusion:

Brake test on the given DC Shunt motor is performed to obtain performance characteristics

Viva Questions:

1. Give the disadvantages of brake test?
2. What are the precautions taken while preparing brake load test?
3. Which method is the most economical method for calculating efficiency of a D.C shunt machine?
4. Give any two advantages of brake load test?
5. Give direct and indirect method of testing a D.C shunt machine
6. What are the different methods of calculating efficiency of D. C shunt machine?

Load characteristics of DC shunt generator

Aim : To determine the load characteristics of DC shunt generator

Apparatus:

S.NO	Apparatus required	Type	Range	Quantity
1	Ammeter	MC	0-20A	1
2	Ammeter	MC	0-2A	1
3	Voltmeter	MC	0-300V	1
4	Tachometer	digital	0-9999rpm	1

Theory

Load characteristics are study of voltage when the load on a generator is increased from no load or decreased from full load.

There are two types of characteristics

(i) External characteristics
(ii) Internal characteristics

External characteristics

A plot of the terminal voltage V_T and load current I_L with preset values of field current and speed gives External characteristics curve. The drop in terminal voltage V_T is due to armature reaction and further reduction is due reduction in field current I_f, since the terminal voltage fallen because of the above two reasons.

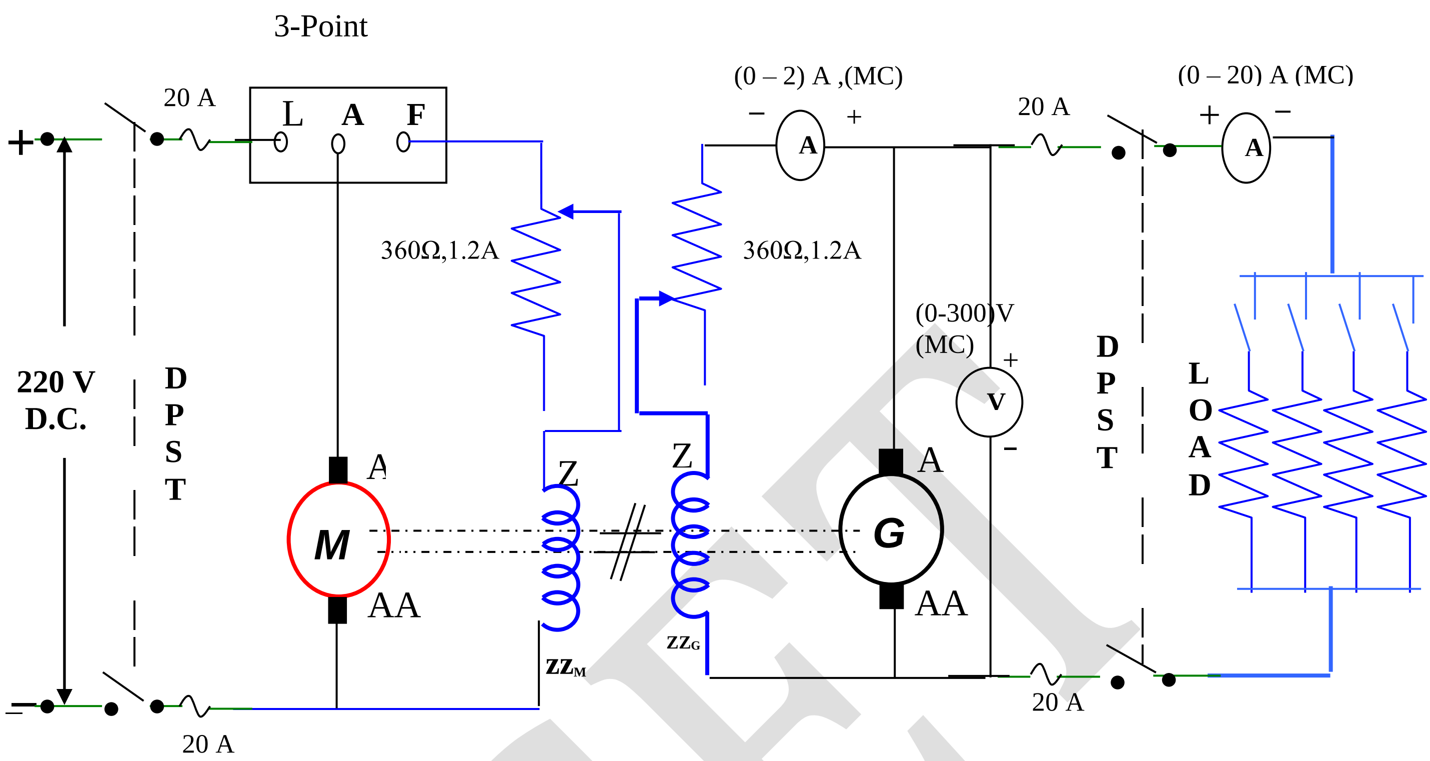
Internal characteristics

A plot of generated armature voltage Eg and armature current Ia with preset value of field current and speed gives internal characteristics. The drop in Eg is due to armature reaction and further reduction in field current is due to drop in terminal voltage and so on.

Procedure

1. Switch on the prime mover (i.e. DC motor)
2. Adjust the field of motor to run the generator with rated speed
3. by adjusting the field of generator keep the terminal voltage V_L around 220V
4. Load the generator by keeping the speed of generator constant and note the values of V_L, I_L and I_f.
5. Repeat step 4 till the rated load current is attained.
6. Reduce the load and w\switch off the supply
7. Plot the load characteristics as external and internal characteristics

CIRCUIT DIAGRAM: LOAD TEST ON DC SHUNT GENERATOR



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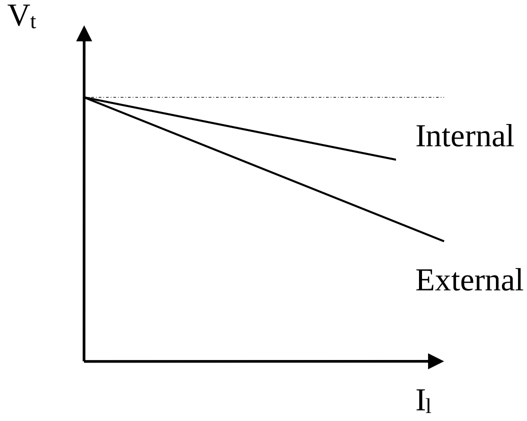
Modelgraph:



Tabular Form:

Sl.NO	V_L	I_L	I_F	$I_a = I_L + I_f$	$E = V - I_a R_a$

Result:

The load characteristics of the shunt generator are obtained.

Separation of losses in DC machine

Aim: To separate the losses in DC machine

Apparatus:

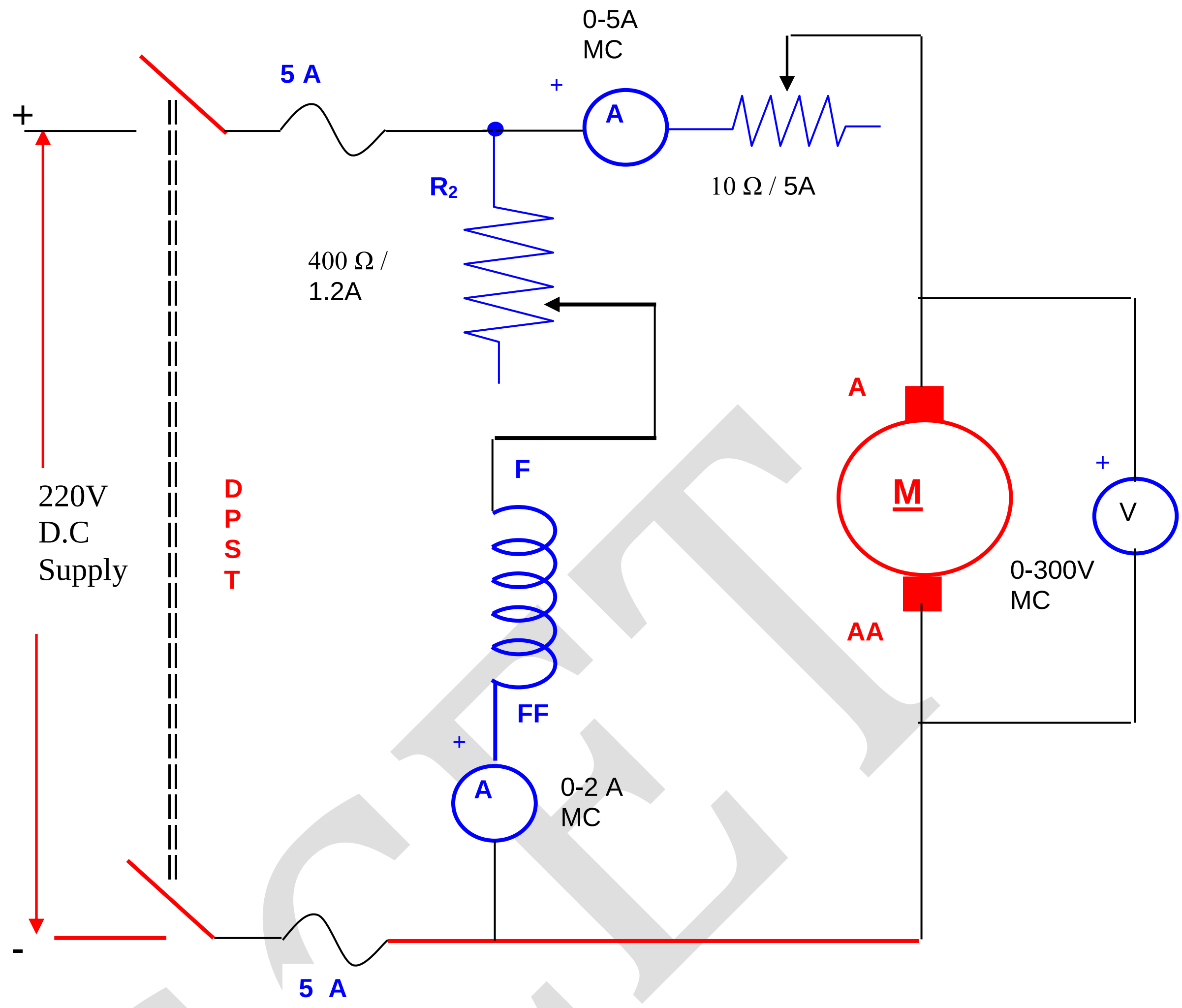
S.No	Apparatus	Type	Range	Quantity
1	Ammeter	MC	0-5A	1
2	Ammeter	MC	0-2A	1
3	Voltmeter	MC	0-300V	1
4	Rheostat	WW	100Ω/5A	1
5	Rheostat	WW	400Ω/1.2A	1
6	Tachometer	Digital	0-9999rpm	1

Theory

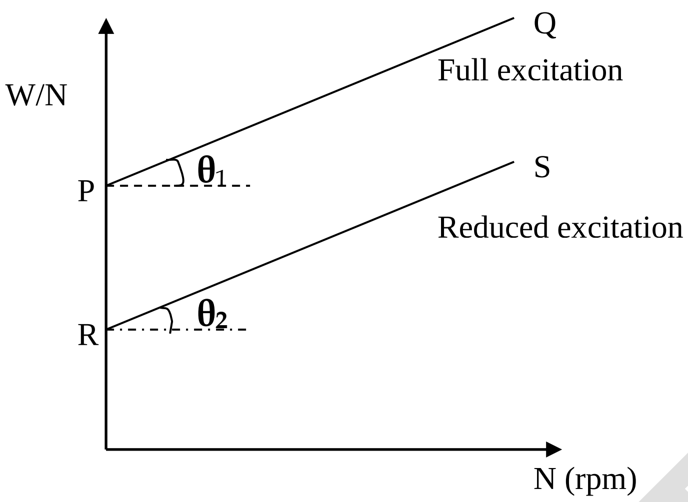
The various machine losses may be classified as
a) Electrical losses and (b) Mechanical losses
a) Electrical losses
Electrical losses consist of resistance losses and no load core losses and stay load losses. These no load core losses consists of hysteresis losses and eddy current losses.

(b) Mechanical losses
This loss consist of baring friction, brush friction and windage losses. The windage loss includes the power required to circulate air through the machine and ventilating ducts.

Procedure
1.Make the connections as shown in the figure
2.Ensure maximum resistance in armature circuit and minimum resistance in field circuit, switch on the main supply.
3. Apply rated voltage across armature of the motor and adjust the rated speed of motor
4. Apply rated excitation and note the readings of all meters
5. Keeping the excitation constant note down the speed and reading of ll meter by decreasing the voltage across armature step by step.
6. Repeat the steps from 3 to 5 with reduces excitations
7. Plot the curves W/N Vs N


0-5A
MC
5 A
+
A
10 Ω / 5A
R2
400 Ω / 1.2A
+
220V
D.C
Supply
D
P
S
T
F
A
M
AA
+
V
0-300V
MC
FF
+
A
0-2 A
MC
-
5 A

Model graph



Model calculations

Friction and windage losses = $AN + BN^2$
Where A and B are friction and windage loss corresponding constants
Hysterisys and eddy current losses = $CN + DN^2$
Where C and D are Hysteresis and eddy current loss corresponding constants

Total iron and mechanical losses (W) = $AN + BN^2 + CN + DN^2$

$W/N = (A + C) + (B + D)N$
From graph
OP = A+C ------------------(1)
Slope PQ =tan θ_1=B+D------(2)
At reduced excitation constants C and D varies to C' and D'
OR = A+C' -----------------(3)
Slope RS=Tan θ_2=B+D' ----(4)

Subtracting 3 from 1 and 4 from 2
OP-OR= C-C'
Tanθ_1-tanθ_2 =D-D'
C and C' are Hysteresis loss constant proportional to $Ø^{1.6}$
D and D' are eddy current loss constant proportional to $Ø^2$
Ø and Ø' are fluxes of full and reduced excitation proportional to E_b and E_b'

$$\frac{C'}{C} = \frac{Ø'^{1.6}}{Ø^{1.6}} = \frac{E_b'^{1.6}}{E_b^{1.6}}$$

$$\frac{b'}{b} = \frac{\text{Ø}'^2}{\text{Ø}^2} = \frac{E'^2_b}{E^2_b}$$

Tabular form:

S.No	Va	I_f	Ia	N(speed)	Ia^2Ra	Irom losses=VaIa-Ia^2Ra

Result:

Iron and mechanical losses are separated for the given D.C.Shunt machine.

Viva questions

1. What is meant by hysteresis losses
2. What is meant by eddy current losses
3. What are the different types of constant losses.
4. What is meant by stray load losses
5. Which losses are proportional to frequency of voltage

Brake test on compound motor

Aim: *To perform the Brake test on the given DC compound motor and to obtain the performance characteristics of the motor.*

Apparatus Required:

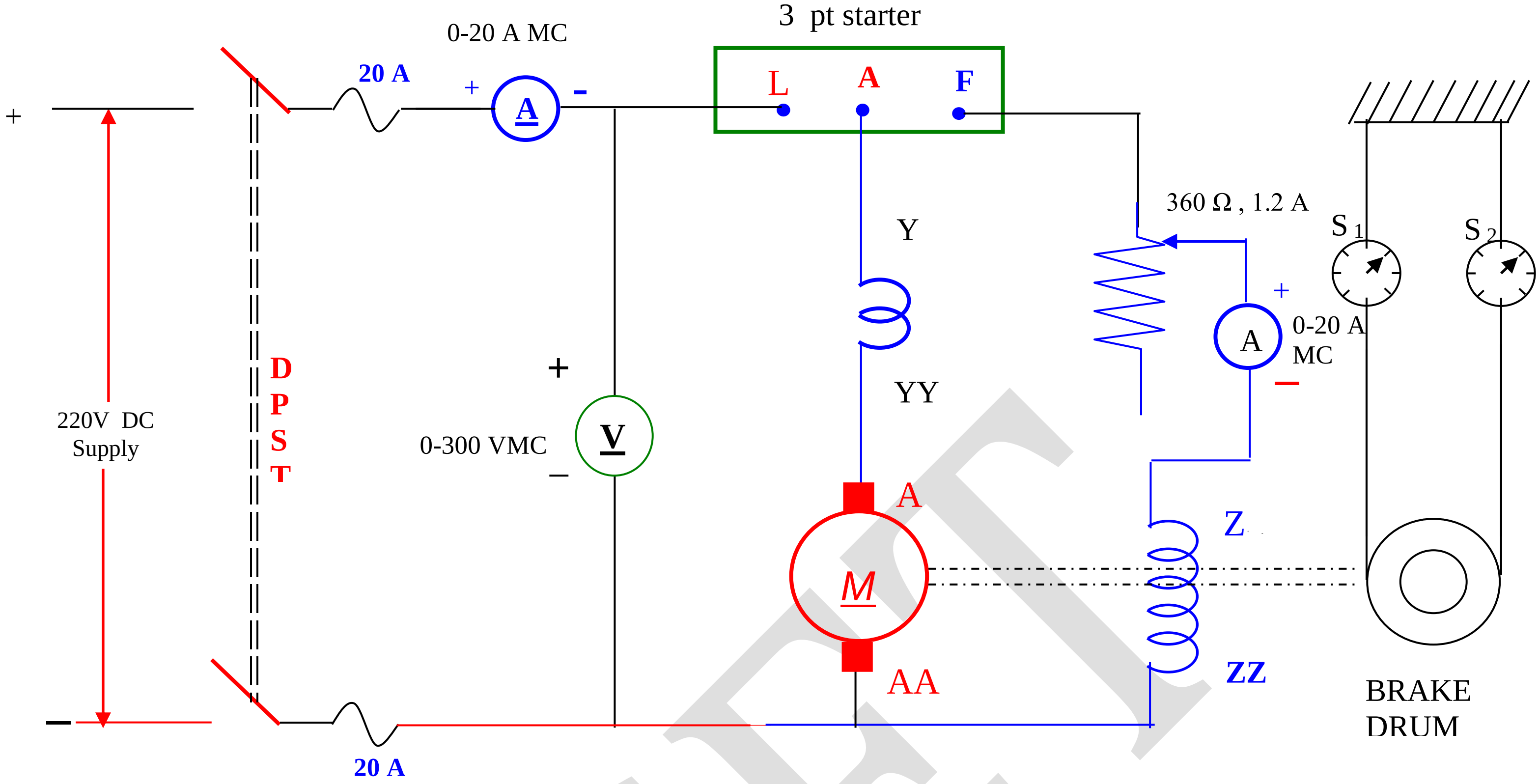
S.No	Equipment	Rating	Type	Quantity
1	Ammeter	(0-25A)	MC	1No
2	Voltmeter	(0-300V)	MC	1No
3	Tachometer	0-9999rpm	Digit	1No

Theory:

There are several tests that are conducted upon a DC machine (Motor or Generator) to judge its performance. One important test is performed to measure the efficiency of the DC machine. Efficiency depends on its losses. The smaller the losses the greater its efficiency and vice versa. The consideration of losses in a DC machine is important because they determine the efficiency of the machine and appreciably influences its operating cost. And also they determine heating of the machine and hence the power output that may be obtained without undue deterioration of the insulation.

In this method a brake drum is connected in the shaft of the motor with spring balances to measure the load. The mechanical output of the motor is calculated with the help of spring balances readings and speed of the machine.

CIRCUIT DIAGRAM: BRAKE TEST ON DC COMPOUND MOTOR



Procedure:

1. Make the connections as per circuit diagram.
2. Keep the field regulator of the Motor at minimum Resistance position.
3. At the time of starting check that the belt on the pulley is free, so that there is no load on the pulley.
4. Start the motor slowly by using stator
5. Adjust the field regulator so that motor runs at its rated speed.
6. Apply load on the pulley gradually in steps by adjusting of tension of spring Balance.
7. Take the readings of the Ammeter and Voltmeter and two spring balance readings and the speed for each step.
8. Cool the pulley through out the loading period by pouring water.
9. Continue the experiment till full load of the motor is reached.

Tabular Column:

SL No	V_L (V)	I_L (A)	S_1 (kg)	S_2 (kg)	Speed 'N' in RPM	Input Power (w)	Torque (T) in 'Newton meter's	Output Power in		%Efficiency
								Watts	BHP	
1										

Calculations:

Radius of the Brake drum r = …….. Mtrs

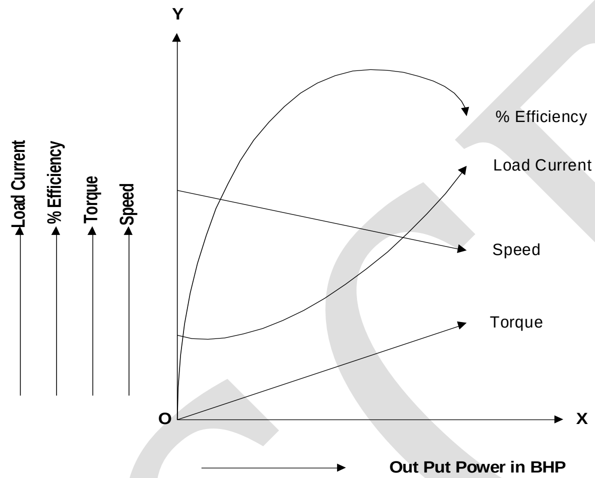
Torque (T) = $(F_1 - F_2)$ r.g N.mtr

Power Output = (2 **π** NT / 60) watts

%Efficiency = (Output / Input) X 100.

Expected Graphs:

v. % Efficiency Vs Output Power in BHP
vi. Speed Vs Output Power in BHP
vii. Torque Vs Output Power in BHP
viii. Load Current Vs BHP.



Conclusion:

Brake test on the given DC Shunt motor has been performed to obtain the its performance characteristics

Viva Questions:

1. Give the disadvantages of brake test?
2. What are the precautions taken while preparing brake load test?
3. Which method is the most economical method for calculating efficiency of a D.C shunt machine?
4. Give any two advantages of brake load test?
5. Give direct and indirect method of testing a D.C shunt machine

Hopkinson's Test

Aim : *To determine the efficiency of two identical shunt machines by back to back test*

Apparatus

Sl.No	Equipment	Rating	Type	Quantity
1	Ammeter	(0-20)	MC	3No
2	Ammeter	(0-1)	MC	2No
3	Voltmeter	(0-300V)	MC	3No
4	Rheostat	1500Ω,1.2	W W	1No
5	SPST		Knife	1No
6	Tachomet		Digital	1No

Theory:

In this method two identical dc machines ate coupled both mechanically and electrically and are tested simultaneously. One of the machine is made to run as a motor and it drives the other machine as a generator.

The advantages of this method are

(a). This method can be used for large size machines because the power drawn from the dc source has to furnish only the losses in the two machines

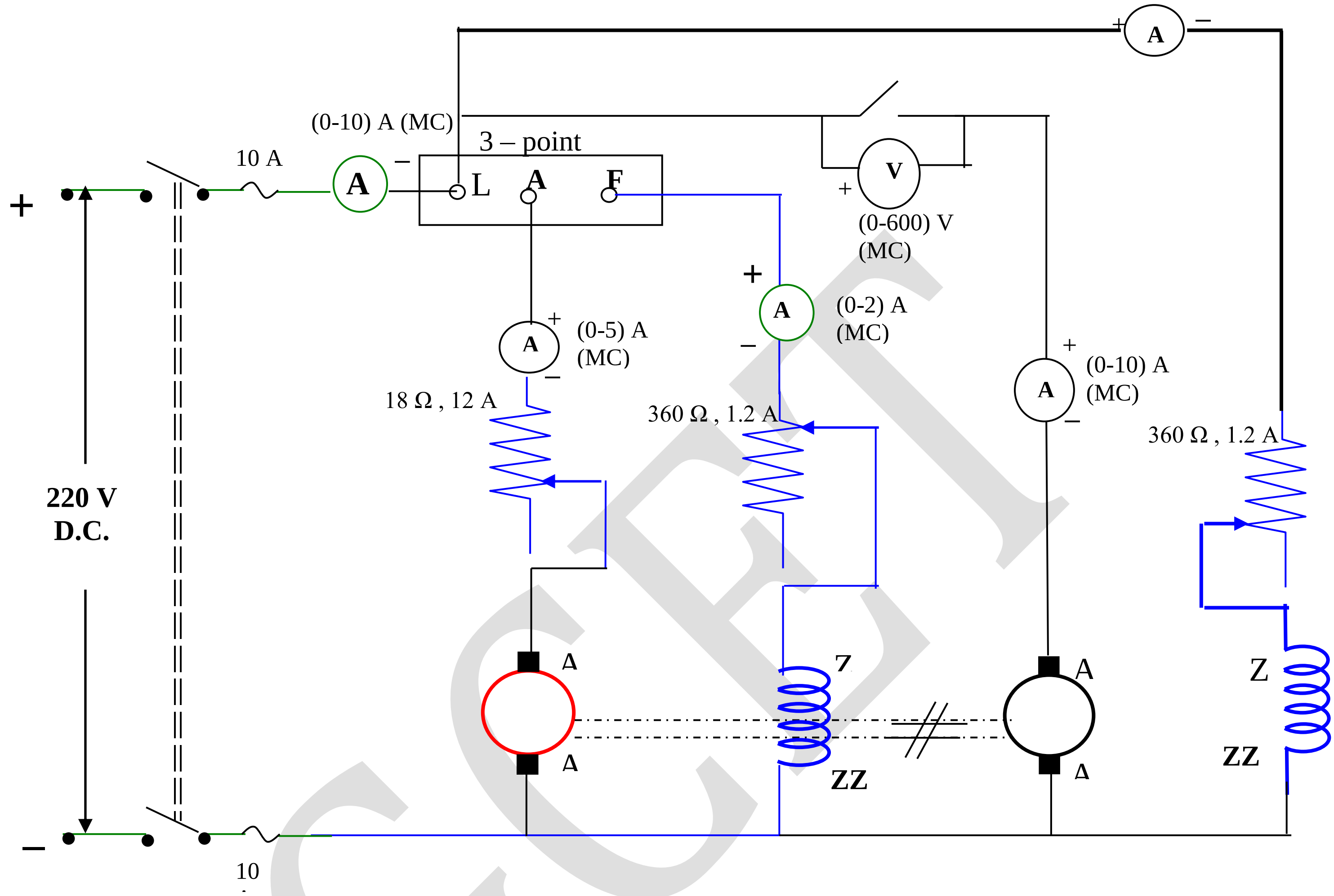
(b). The machines can be tested under rated load conditions and this the temperature rise and commutation process can be checked.

(c). The efficiency is being determined under rated load conditions, therefore the stray load losses are included

Disadvantages

The main disadvantage lies in the requirement of two identical machines

CIRCUIT DIAGRAM: HOPKINSON'S



Procedure

1. Make the connections as shown in figure
2. Ensure minimum resistance in motor field circuit and maximum resistance in generator field circuit, also ensure the switch is open condition, witch on the mains supply.
3. Pull the starter to ON-position and adjust the speed of the motor to its rated value.
4. Adjust the field of generator till rated or till voltage across switch is zero.
5. At this condition supply voltage opposes the generated voltage hence voltage across switch is zero.
6. Close the switch.
7. For generator voltage to supply motor, generator excitation to be increased in steps.
8. Note the readings of all meters at each step, till rated current of generator is reached.
9. Adjust the excitation for no load condition and switch off the main supply.
10. Measure the armature resistances and calculate the efficiencies and plot the same

Tabular form

I_{am}	I_{ag}	I_L	I_{fm}	I_{fg}	V_{1m}	V_{2g}

Model calculations:

R_{1m}: motor armature resistance
R_{2g}: generator armature resistance
Motor armature circuit copper loss = $I_1^2R_{1m}$
generator armature circuit copper loss = $I_2^2R_{2g}$
Total iron + friction losses for two machines = $VI - (I_1^2R_{1m} + I_2^2R_{2g})$
Total iron + friction losses for single machine (P_0)= $(VI - (I_1^2R_{1m} + I_2^2R_{2g}))/2$

Motor input(P_{mi}) = VI_1+IV_{f1}
Losses in motor(P_{mL})=$P_0+ I_1^2R_{1m}+VI_{f1}$
Motor output (P_{m0}) = P_{mi} - P_{mL}
Efficiency of the motor = P_{m0} / P_{mi}

Generator output $P_{g0}= V_2I_2$
Losses in generator $P_{gL}=P_0+I_2^2R_2+VI_{f2}$
Generator input $P_{gi} = P_{g0} + P_{gL}$
Generator efficiency = P_{g0} / P_{gi}

Result:

The efficiency of the given D.C Shunt machines are determined using back to back test.

VIVA

1. What is meant by regenerative test?
2. What are the merits and demerits of Hopkinsons test
3. What is the condition to perform Hopkinsons test
4. Can we perform Regenerative test on DC series machines.

LOAD TEST ON DC SERIES GENERATOR

AIM: *To conduct the load test on DC series Generator and obtain the characteristics.*

APPARATUS REQUIRED:

S. No	NAME	RANGE/RATING	TYPE	QUANTITY
1	Generator-motor set			1
2	Ammeter	0-20 V	MC	1
3	Voltmeter	0-300 V	MC	1
4	Variable load			1
5	Tachometer	0-2000 RPM		
6	Rheostat	6 Ω, 120 A		1
7	Connecting wires			

THEORY:

In the series generator, field windings are in series with the armature, they carry full armature current I_a. As I_a is increased flux and hence generated emf is also increased.

A series generator has rising voltage characteristics i.e. with increase in load, its voltage is also increased. At high loads the voltage the voltage starts decreasing due to excessive demagnetizing effects of armature reaction. But the terminal voltage starts decreasing as load current increased.

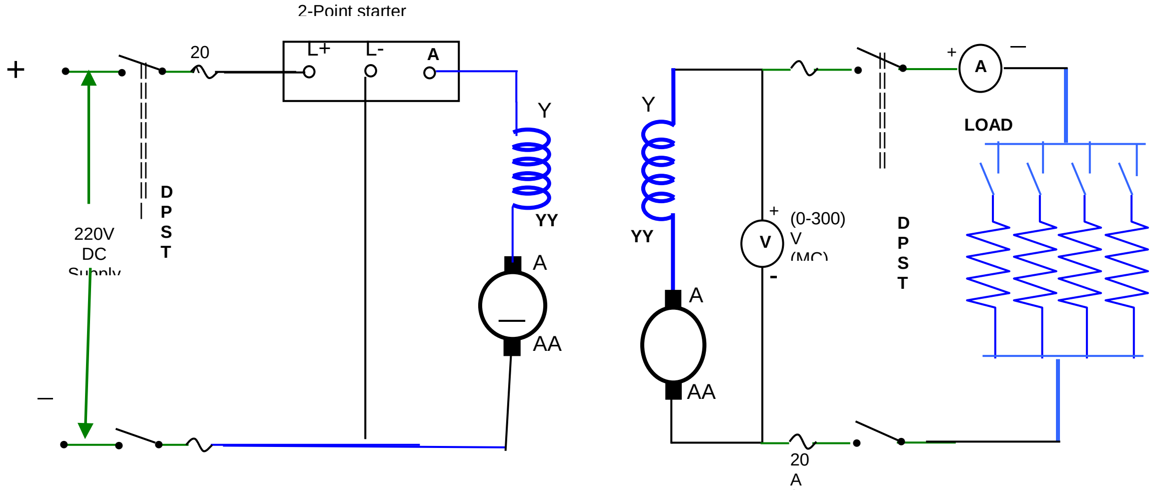
The load characteristics gives the relation of V_t (terminal voltage) such that V_t = F (I_f) with both I_a and N are constant. This characteristic is also called as load magnetization curve.

The voltage drop observed in the internal characteristics is due to emf lost due to armature reaction.

The drop of voltage due to armature and series field resistances is observed in external characteristics.

i.e. $E-V = I_a (R_a + R_{se})$

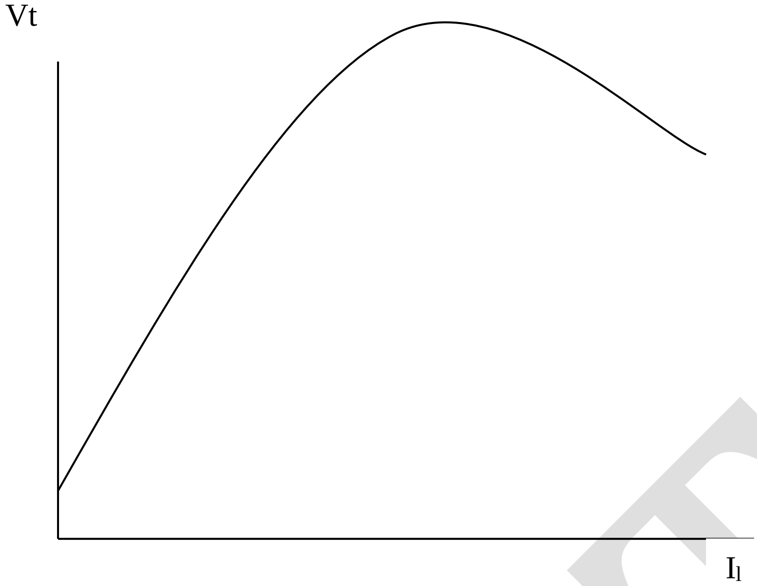
where R_{se} is resistance of series field.



PROCEDURE:

1. Connections are made as shown in fig-1.
2. Ensuring the field resistance of motor in minimum position and generator field resistance in maximum position. Motor is switched ON by dragging the starters handle slowly still it attains ON position.
3. The speed of the Generator is adjusted, seen that it induces rated voltage, by adjusting the motor to rated speed by varying the motor field resistance.
4. At rated speed of the Generator, the voltage across the terminals is noted.
5. At different loads on the Generator, the induced emf is noted and also armature current is noted.
6. After noting all the values the motor is switched OFF by bringing the field resistance of both motor and Generator to its initial position.
7. Armature resistance and series field resistance is calculated by armature-voltmeter method as shown in fig-2 and fig-3 respectively.
8. I_a (Ra + R_{se}) values are calculated and tabulated.
9. Graph for V_t versus I_f is plotted.

MODEL GRAPH:



RESULT: Load test von Dc series Generator is performed and load characteristics curves are plotted.

Viva Questions:

1. How the internal characteristics are derived from external characteristics?
2. How do you control the speed pf the series motor?
3. What is the critical load resistance?
4. What material is used for brushes
5. What are the reasons for failure of a D.C Series generator to build up voltage?

SPEED CONTROL OF D.C. SHUNT MOTOR

Aim: To determine the speed charrcteristics of D.C . shunt motor by
(i) field control and (ii) armature control

APPARATUS REQUIRED:

Sl No	Equipment	Rating	Type	Quantity
1	Volt meter	0-300V	MC	1 No
2	Ammeter	0-1A	MC	1 No
		0-5A	MC	1 No
3	Tubular Rheostat	0 - 270Ω / 2.8A	Wire Wound	1 No
		0 -100Ω / 5A	Wire Wound	1 No
4	Tachometer	0 – 10K rpm	Digital	1 No

Theory:

The speed of the D.C. motor is given by $N = V- Ia\ Ra\ /\Phi\ Z\ * 60/P$

$K \times V\text{-}Ia\ Ra\ /\Phi\ = K \times Eb\ /\Phi$

Where V is the applied voltage and Eb is the back emf

Field Control :

In a D.C. shunt motor applied voltage is constant and hence the exciting current is constant . The flux will have maximum value at no load and because of armature reactance it will decrease slightly as load increases. Neglecting this Φ can be regarded more or less as constant.

The speed – current characteristic $N \alpha\ I_1$ is thus slightly drooping. If now rheostat is placed in the shunt field so as to control I_{sh} the shunt field current as the back emf is proportional to the product of speed and flux.

$$Eb1\ \alpha\ \ \Phi 1\ N1$$

$$Eb2\ \alpha\ \ \Phi 2\ N2$$

$$\Phi 2 = \Phi 1\ \ Eb2/Eb1 * N1/N2$$

Thye speed is inversely proportional to the flux or field current. This method of speed control is generally adopted to obtain speeds greater than normal speed.

Armature control :

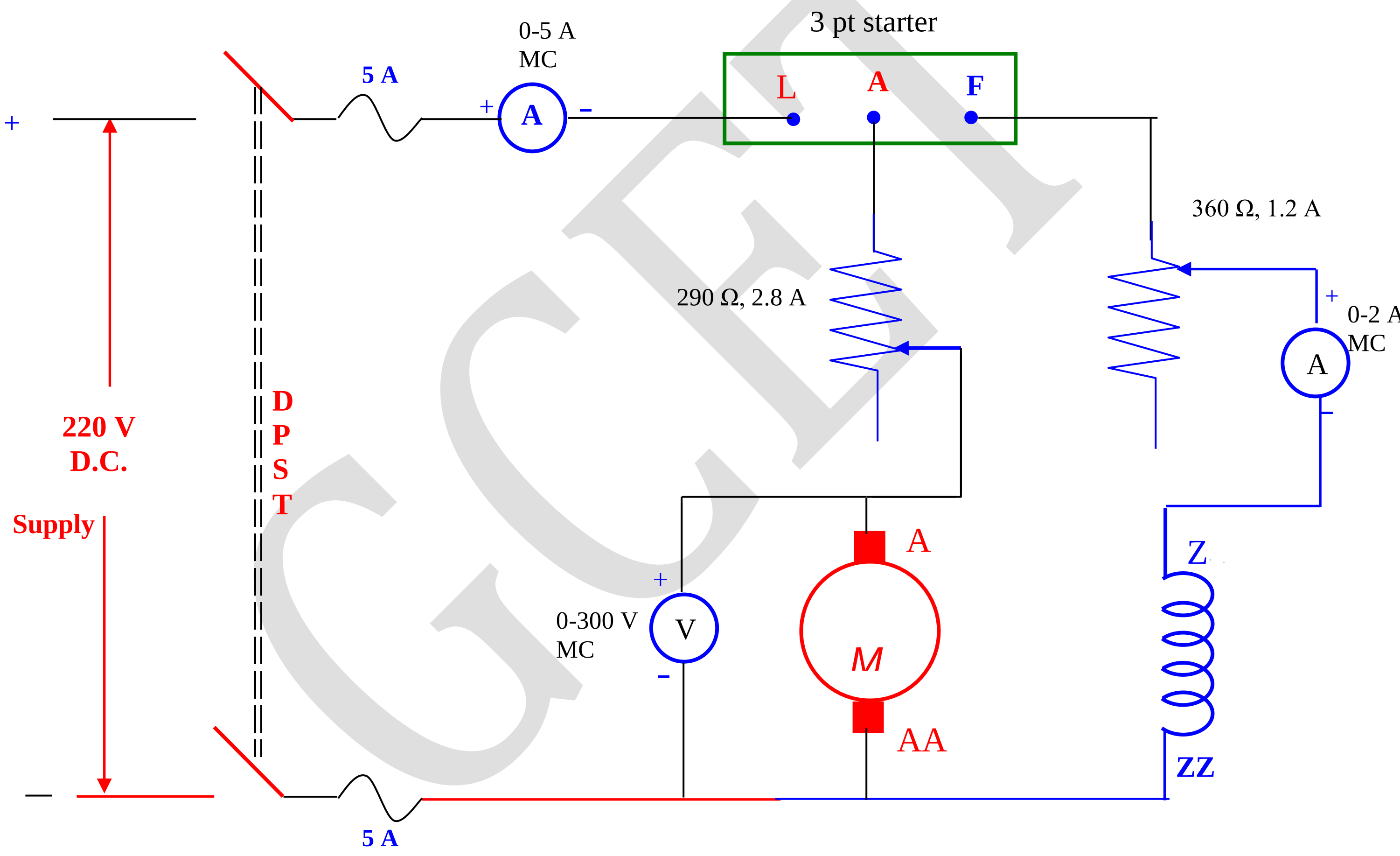
If an adjustable resistance R is placed in series with the armature resistance of Ra then the back emf Eb =V- Ia (Ra +R). Then at no load and any other load condition we have

$$N/No = V\text{-}Ia\ (R+Ra)/V$$

The speed is a linear function of armature voltage V-Ia (R+Ra) since V and No are constants.

Note that at V- Ia (R + Ra) the speed is zero. This method is used to obtain the speeds less than the rated speed.

CIRCUIT DIAGRAM: SPEED CONTROL OF DC MOTOR



NAME PLATE DETAILS:

Procedure:

Armature Voltage Control:

1.The connection made as shown in figure.
2.Ensuring maximum resistance in armature circuit and minimum resistance in field circuit switch o n the main supply and start the motor using starter.
3.Keep the field current constant and vary the resistance in armature circuit in steps.
4.Note the armature voltage and speed at each step.

Field Control:

1. Keep the armature voltage constant and vary the field current in steps.
2. Note the field current and speed at each step.
3. Plot Va vs N and If vs N.

Armature control Method				Field flux control method			
I_{f1}=		I_{f2}=		Va_1=		Va_2=	
Va	Speed	Va	Speed	I_f	Speed	I_f	Speed

Result:

The speed control of the given D.C.Shunt motor is obtained by armature voltage control and field control.

Viva Questions:

1. What will happens if the shunt field is open during running?
2. What is the purpose of no volt coil in a D.C. Motor?
3. How do you change the direction f rotation of a D.C. Shunt motor?
4. In which method of speed control above the base speed can be achieved, why?
5. What are the methods of speed control in a D.C Shunt motor?

LOAD CHARACTERISTICS OF A COMPOUND GENERATOR

Aim: To determine the load characteristics of a cumulative and differential compound generator for long and short shunt connections.

Apparatus Required :

S.No	Name of the apparatus	Type	Range	Quantity
1	Ammeter	MC	0 – 5 A 0 – 20 A	1 1
2	Rheostats	WW	270 ohm / 1.2 A 1500 ohm / 1.2 A	1 1
3	Voltmeter	MC	0 – 300 V	1

Theory :

Compound Generators are classified into two types. One is cumulative compounded generator and other is Differential compound generator. In a cumulative compound generator, with the increase of load current the series field flux aids the shunt field flux. Depending upon the number of series field turns the cumulative compound generator may be under compounded (terminal voltage falls with increase of load), Flat compounded (Terminal voltage remains practically constant with the increase of load) , Over compounded (Terminal voltage rises with increase in load). The following characteristics and observations may be made from external characteristics of a cumulative compounded generator.

In differential compound generator with increase of load series field flux subtracts the shunt field flux. So the terminal voltage drastically falls with increase of load.

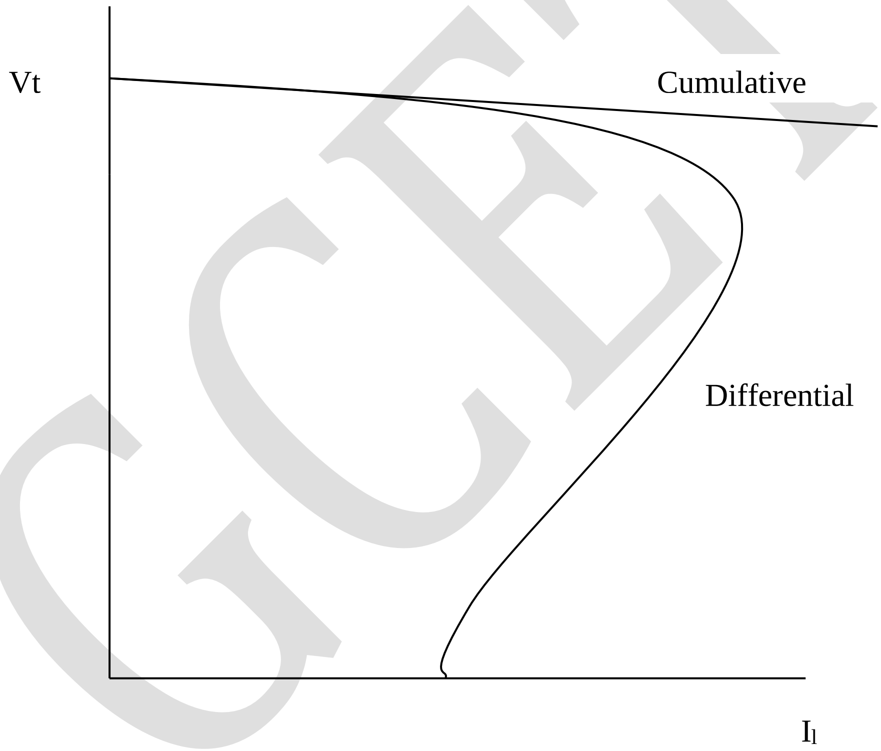
Procedure :

1. The connections are made as per the circuit diagram
2. Ensuring the motor starter handle in off position, and minimum resistance in motor field circuit the d.c main supply is switched on and the motor is started using starter.
3. The speed is adjusted to its rated voltage by varying the motor shunt field resistance.
4. Generator terminal voltage is adjusted to rated value using generator field rheostat.
5. Vary the load in steps and note down the terminal voltage and load current maintaining speed at rated value.
6. Draw the graph terminal; voltage Vs Load current.
7. Repeat the steps from (2) to (6) for circuits as shown in fig (2),fig(3) and fig(4)

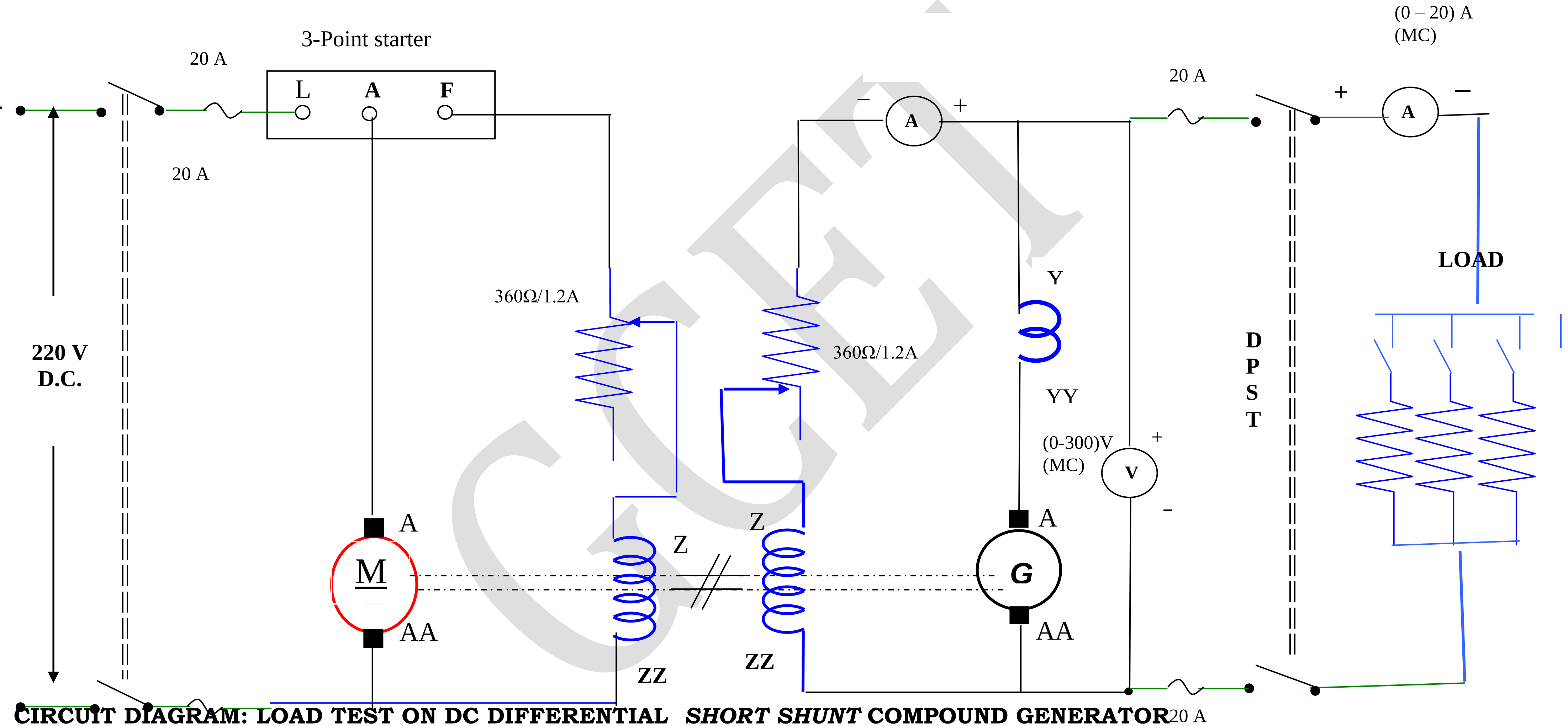
Tabular Form:

Si.No	Load current(A)	Terminal Voltage(V)

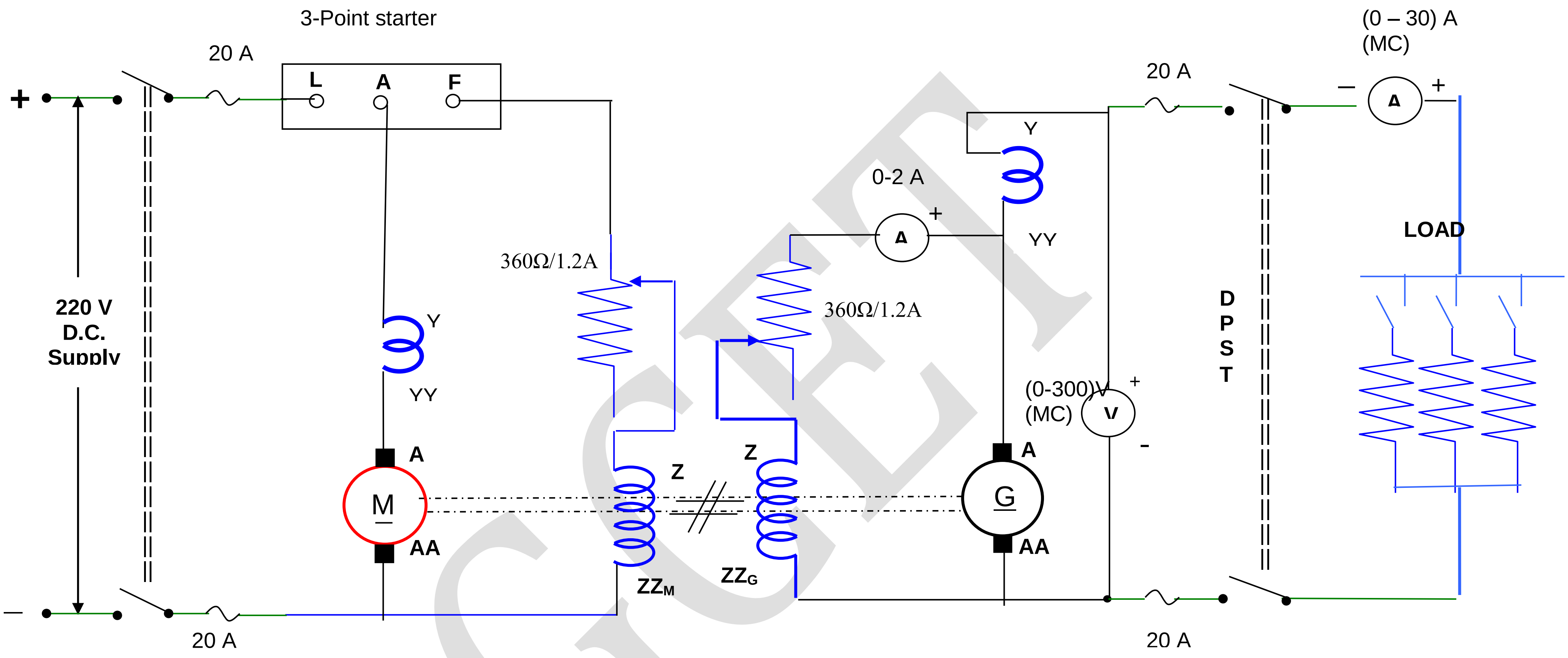
Model Graphs:



CIRCUIT DIAGRAM: LOAD TEST ON DC DIFFERENTIAL LONG SHUNT COMPOUND GENERATOR



CIRCUIT DIAGRAM: LOAD TEST ON DC DIFFERENTIAL *SHORT SHUNT* COMPOUND GENERATOR



CIRCUIT DIAGRAM: LOAD TEST ON DC CUMULATIVE SHORT SHUNT COMPOUND GENERATOR

Result:

Load characteristics of the given D.C.Compound generator are obtained for cumulative and differential modes.

Viva Questions:

1. What are the advantages of compound generator over Shunt generator?
2. What are the applications of the D.C.Differential compound generator?
3. What are the differences between cumulative and differential compound generator?
4. What are the different types in cumulative compound generator?
5. What arte the applications of cumulative compound generator?

FIELD'S TEST

Aim: To determine the efficiencies of two DC Series machines.

Apparatus:

.No	Apparatus	Type	Range	Quantity
1	Voltmeter	M.C.	0-300V	3nos
2	Ammeter	M.C.	0-20A	2nos
3	Rheostst		6Ω,20A	1No.
4	1-Φ load	Resistive	20amps,220V	1No.
5	Tachometer	Contact type		

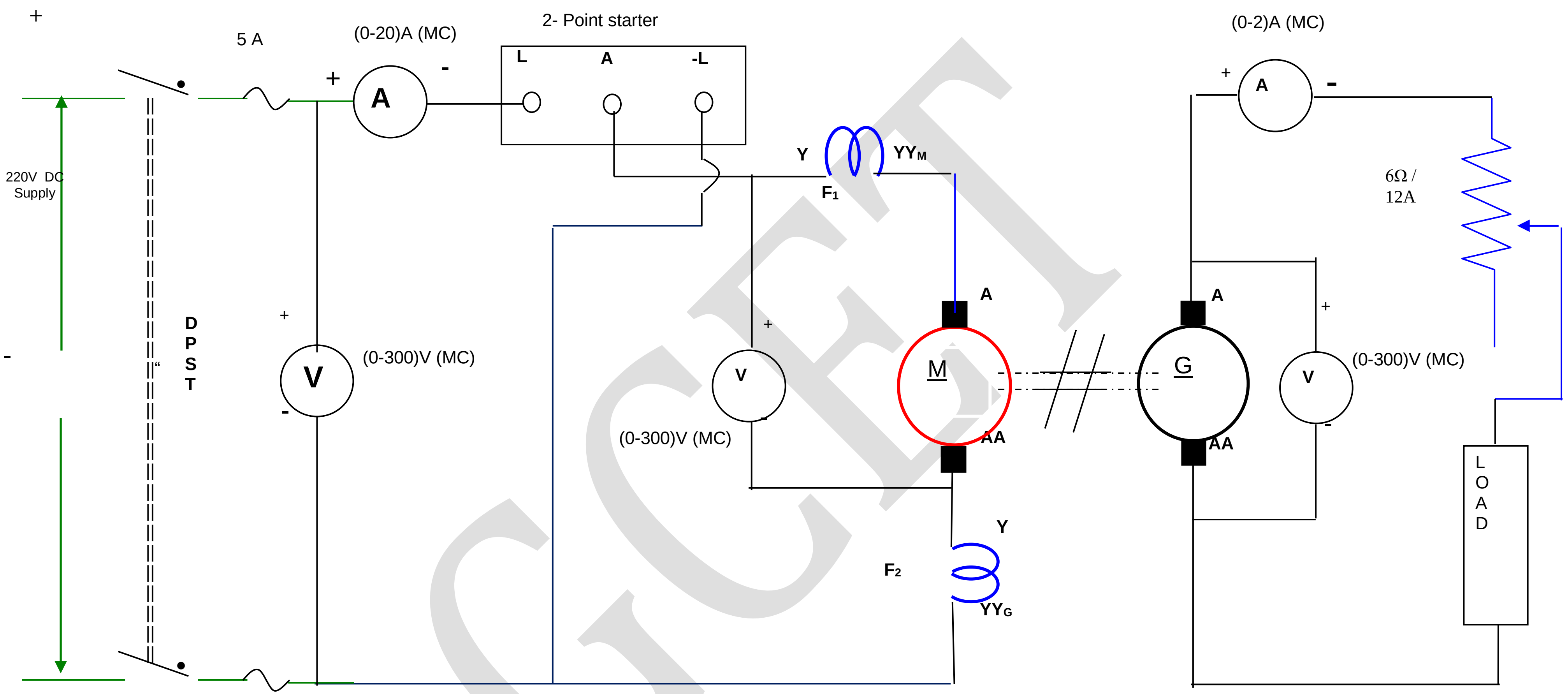
Theory:

In this method, two identical DC series machine, mechanically and electrically coupled are required. This test gives efficiencies of both the machines. Field's test is not a regeneration one because of the generator out put is wasted in resistances and not fed to motor.

Brake test on series is possible in case of small machines. Swin burne's method of testing is not possible, because series motor have the tendency of attaining dangerous speed at no- load. In view of this, the Field's test is quite suitable for DC series machine.

Procedure:

1. Make the connections as shown in the fig.
2. Ensure maximum resistance in load circuit, switch –on the main supply.
3. The speed of motor – generator set speed is beyond its normal value.
4. Note the meter readings under this condition.
5. Switch – on the load 6amp and take the meter readings


+
5 A
(0-20)A (MC)
2- Point starter
(0-2)A (MC)
L
A
-L
+
A
-
+
A
-
220V DC
Supply
Y
YYM
F1
6Ω /
12A
D
P
S
T
+
V
-
(0-300)V (MC)
+
V
(0-300)V (MC)
A
M
AA
A
G
AA
+
V
-
(0-300)V (MC)
L
O
A
D
Y
F2
YYG
-

Model calculations:

In put to M-G set = $V_1 I_1$
Out put of Generator =$V_2 I_2$
Total losses in M- G set, $W_t = V_1 I_1 - V_2 I_2$
Total copper losses, $W_c = (2R_{se} + R_{am}) I_1^2 + R_{ag} I_2^2$
(R_{se}=series fields, R_{am} = motor armature resistance)

No-load losses of M- G set,$W_o = W_t - W_c$
No-load losses of each M/G = $W_o/2$

Motor efficiency
Motor input = $V_3 I_1$
Total motor losses (W_{tm})= $(R_{am} + R_{se}) I_1^2 + W_o$
%Motor η= $(V_3 I_1 - W_{tm} / V_3 I_1) X100$

Generator efficiency
Total generator losses (W_{tg}) = $I_2^2(R_{ag}) + (R_{se}) I_1^2 + W_o$
% Generator η= $(V_2 I_2 / V_2 I_2 + W_{tg}) X100$

Tabular Form:

S.No.	V_G (volts)	Vm (volts)	V_L(volts)	I_L(amps)	Ig(amps)

Result:

Efficiency of the given D.C.Series machines are found using Field's test.

VIVA Questions:

1. Is it possible to conduct Swinburne's test on DC series motor?
2. Can we conduct regenerative test on DC series motors?
3. What are the applications of series motors?
4. What is the purpose of connecting the two fields of machines in series?