G.PULLA REDDY ENGINEERING COLLEGE (AUTONOMOUS): KURNOOL
DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING
B.TECH EEE IV SEMESTER
ELECTRICAL MACHINES-I (EMC-I(P)) LABORATORY

TITLE: **LIST OF EXPERIMENTS**	GPRECD/EEE/EXPT-EMCI(P)
SCHEME-13	DATE: 01-07-2016

1. **Open Circuit Characteristic (OCC) of DC shunt generator**
2. **Load test on DC Shunt Generator**
3. **Brake test on DC Compound Motor**
4. **Swinburne's test on DC machine**
5. **Brake test on DC Shunt Motor.**
6. **Hopkinson's test.**
7. **Field's test.**
8. **Speed Control of DC Shunt Motor.**
9. **Separation of losses of DC shunt motor.**
10. **Load test on DC Compound Generator.**

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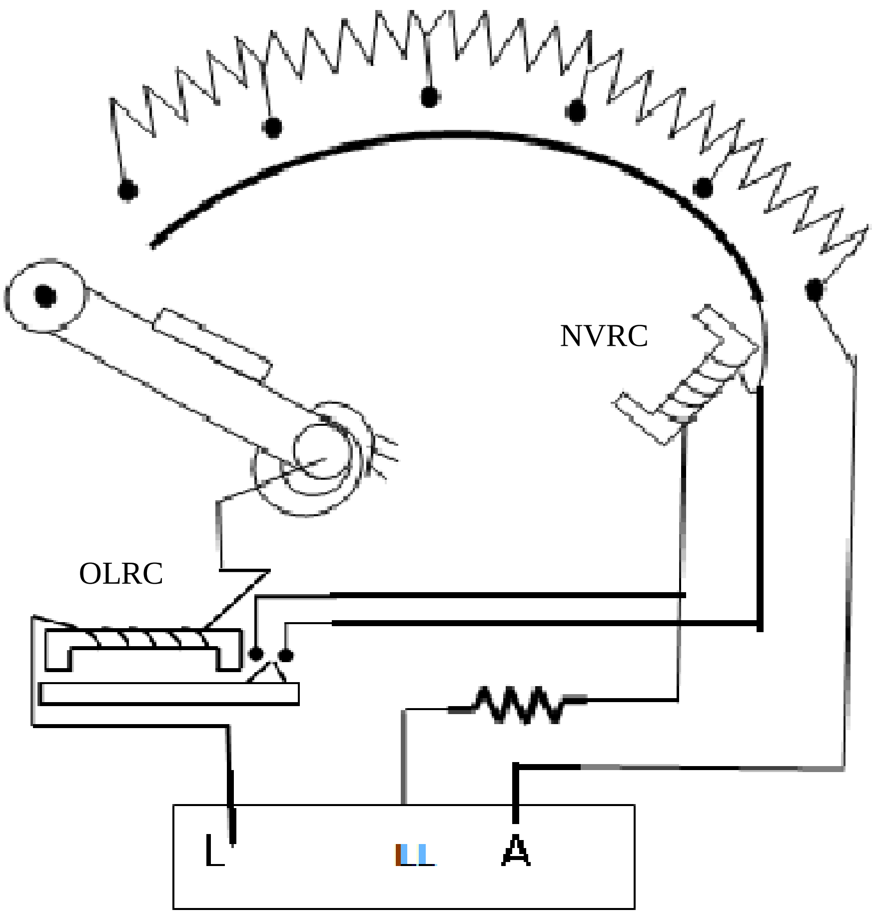
TITLE : **3-POINT STARTER**	GPRECD/EEE/EXPT-EMC-I(P)
SCHEME-13	DATE: 01-07-2016

3 POINT STARTER:



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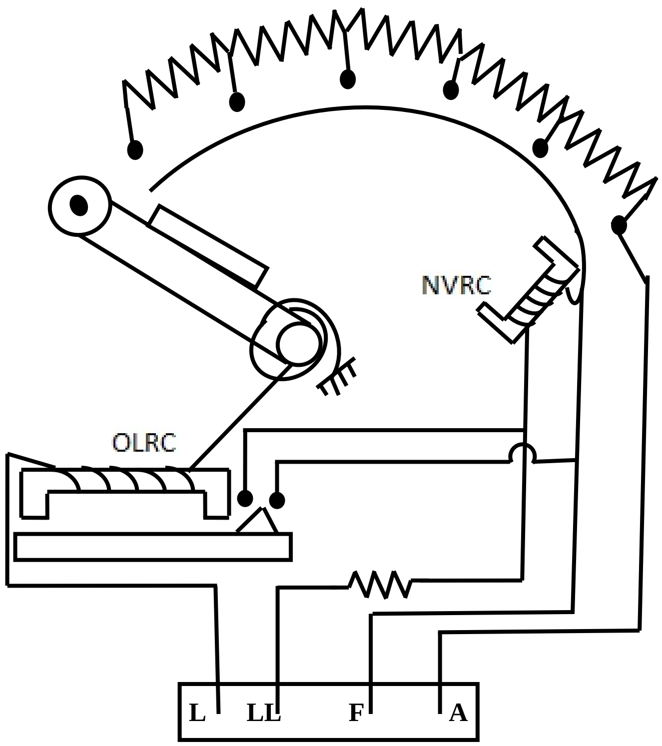
Revision No : 1

TITLE: **4-POINT STARTER**	GPRECD/EEE/EXPT-EMC-I(P)
SCHEME-13	DATE: 01-07-2016

4-Point Starter



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TITLE: **OCC OF DC SHUNT GENERATOR**	GPRECD/EEE/EXPT-EMC-I(P)-1
SCHEME-13	DATE: 01-07-2016

Objective:

To obtain the open circuit characteristics of the given DC shunt generator at its rated speed and determine the Critical resistance and Critical speed.

Apparatus:

DC Motor Generator Set, Rheostat, Voltmeters, Ammeters, Tachometer, Required number of connecting wires

Name plate details:

Fuse ratings:

Theory:

The O.C.C is a curve showing the relationship between the no load emf generated and the shunt field current (Eo and If). Even when the field current is zero there is some residual magnetism present in the poles. Hence there is a small voltage generated even at zero field current, which is called the residual voltage. As the field current is increased, Eo also increases and the curve traced is almost a straight line. As If is further increased the poles start getting saturated, the straight line relation no longer holds good and the curve bends and becomes almost horizontal.

In a D.C. generator, for any given speed, the induced emf in the armature is directly proportional to the flux per pole.

$E_g = (\Phi ZNP)/60A$ Volts

Where Φ is the flux per pole in webers,

Z is the no. of conductors in the armature,

N is the speed of the shaft in rpm,

P is the no. of poles and

A is the no. of parallel paths.

A = 2 (wave)

A = P (lap)

Critical resistance:

It is that value of resistance in the field circuit at which the generator will just excite(or voltage build up begins). If the resistance is higher, the machine will fail to build up voltage. It is given by the slope of the tangent drawn to the linear portion of the magnetization curve from the origin.

Conditions for voltage build up in a d.c shunt generator

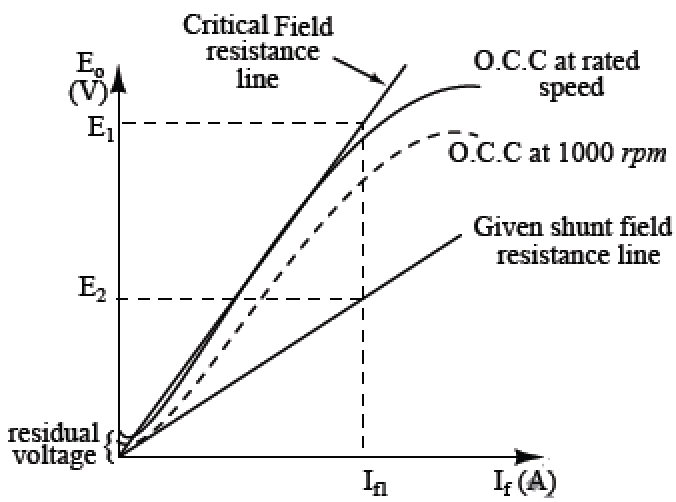
1. There should be some residual magnetism in the poles.
2. For the given direction of rotation, the shunt field coils should be properly connected. That is, The coils should be so connected that the flux generated by the field current aids the residual flux.
3. When excited at no load, the shunt field circuit resistance should be less than the critical resistance.

Critical speed:

It is that value of speed at which the given shunt field resistance represents the critical resistance. It is determined as follows. For the same value of I_f determine E_1 and E_2 from the field resistance lines. Then

$E_1/E_2 = N_1/N_c$; $N_c = (E_2/E_1)N_1$

Where, N_c is the Critical speed



Critical resistance at rated speed, $R_c = E_1 / I_{f1} =$

Critical speed of the Machine, $N_c = (E_2 / E_1)\ N_1 =$

TITLE: **OCC OF DC SHUNT GENERATOR**	GPRECD/EEE/EXPT-EMC-I(P)-1
SCHEME-13	DATE: 01-07-2016

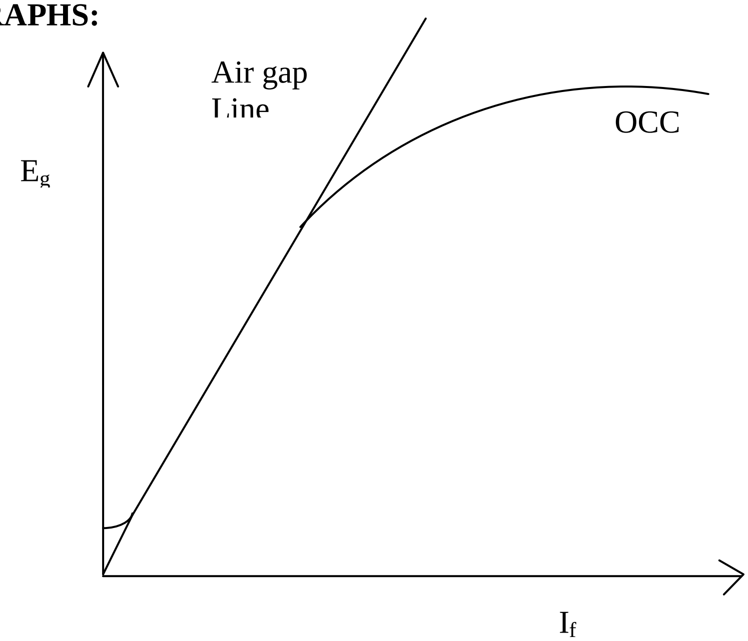
Procedure:

1. Connections are made as per the circuit diagram.
2. Motor field rheostat is kept in minimum position.
3. Generator field rheostat is kept in maximum position.
4. D.C. Generator is driven at its rated speed with the help of prime mover (DC shunt motor).
5. Gradually the field rheostat of generator is varied in steps to get field current in steps and armature terminal voltage is measured in each step.
6. Step 5 is repeated till 120% of rated voltage is obtained.
7. Then, the field current of generator is decreased and the armature terminal voltage is noted in each step.
8. The O.C.C curve is plotted

Observations:

I_f (A)			V_f (V)			E_g(V)		
Forward	Reverse	Average	Forward	Reverse	Average	Forward	Reverse	Average

GRAPHS:

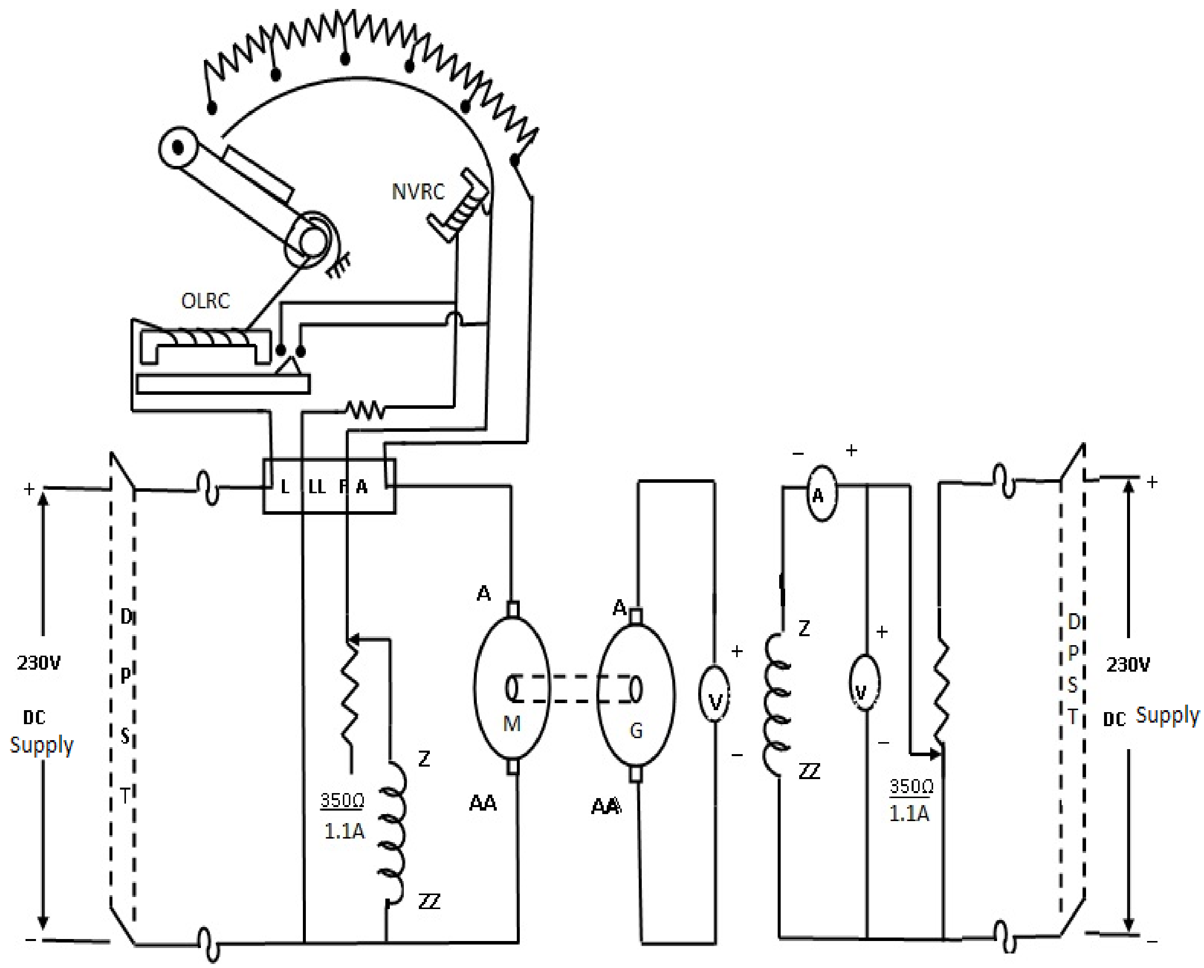


RESULT:

REMARKS IF ANY:

TITLE: **OCC OF DC SHUNT GENERATOR**	GPRECD/EEE/EXPT-EMC-I(P)-1
SCHEME-13	DATE: 01-07-2016

Circuit Diagram:



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Viva Questions:

1. What is the need for starter in a d.c motor?
2. How does a 3-point starter function?
3. Why is Rheostat of dc motor kept in minimum position at starting?
4. Why is Rheostat of generator kept in maximum position at start up?
5. What is residual voltage? How is it measured?
6. What is critical resistance? How can it be determined?
7. What are the conditions necessary for voltage build up in a d.c shunt generator?
8. What is critical speed?
9. Explain the shape of OCC.

TITLE:**LOAD TEST ON DC SHUNT GENERATOR**	GPRECD/EEE/EXPT-EMC-I(P)-2 SCHEME-13 DATE: 01-07-2016

Objective:

To conduct load test on DC shunt generator and to draw the external and internal characteristics of DC shunt generator.

Apparatus:

DC Motor-Generator Set, Voltmeters, Ammeters, Tachometer, Rheostat, Required number of connecting wires

Name plate details:

Fuse ratings:

Theory:

Load characteristics of the machine can be broadly classified into:-
1) External characteristics
2) Internal Characteristics

External Characteristics(V vs IL)

It is a curve showing the variation in terminal voltage of the generator as the load on the generator is increased. The characteristics are as shown in the figure. At no load, the terminal voltage of the generator is at its rated value. As the load current is increased the terminal voltage drops. The drop in terminal voltage is due to the following reasons:-

1. For a generator $V = E_g - I_aR_a$, as the load current increases, I_a increases, I_aR_a drop increases, thus decreasing the terminal voltage V.
2. As the load current increases, I_a increases, armature reaction effect also increases. Due to demagnetizing effect of armature reaction, the induced emf E_g decreases, thereby decreasing V.
3. Due to reasons (1) and (2), the terminal voltage decreases, which in turn reduces the field current I_{sh}, thereby decreasing E_g causing further decrease in V.

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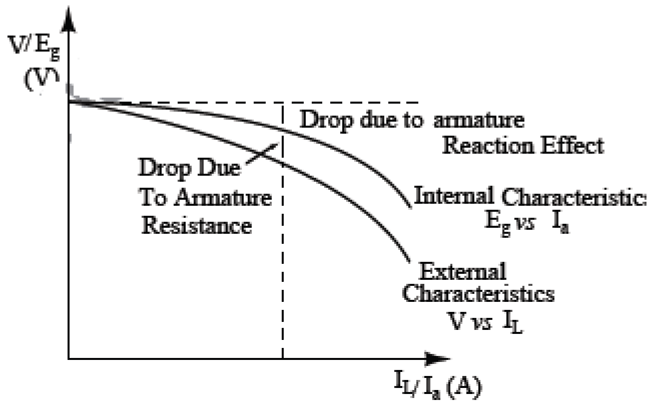


Internal Characteristics [E_g vs I_a]
It is a plot of the internally generated emf (E_g) and armature current (I_a). It is a curve similar to the external characteristics and lies above it.

Formulae used:
$E_g = V + I_aR_a$
& $I_a = I_L + I_{sh}$

Procedure:

1. Circuit is connected as shown in the circuit diagram.
2. After connecting the circuit, the motor field rheostat is kept at minimum position and generator field rheostat is kept at maximum position.
3. The generator is driven at its rated speed with the help of prime mover (DC motor).
4. The generator field excitation is adjusted to get the rated no-load voltage on open circuit.
5. A resistive load is connected as shown in figure.
6. The generator is loaded gradually upto full load.
7. The field current of the generator is kept constant by adjusting the generator rheostat.
8. The speed of the motor is checked for different loads and it is kept constant by adjusting the motor rheostat.
9. The terminal voltage, load current and shunt field current are noted for various loads.

TITLE: **LOAD TEST ON DC SHUNT GENERATOR**	GPRECD/EEE/EXPT-EMC-I(P)-2 SCHEME-13 DATE: 01-07-2016

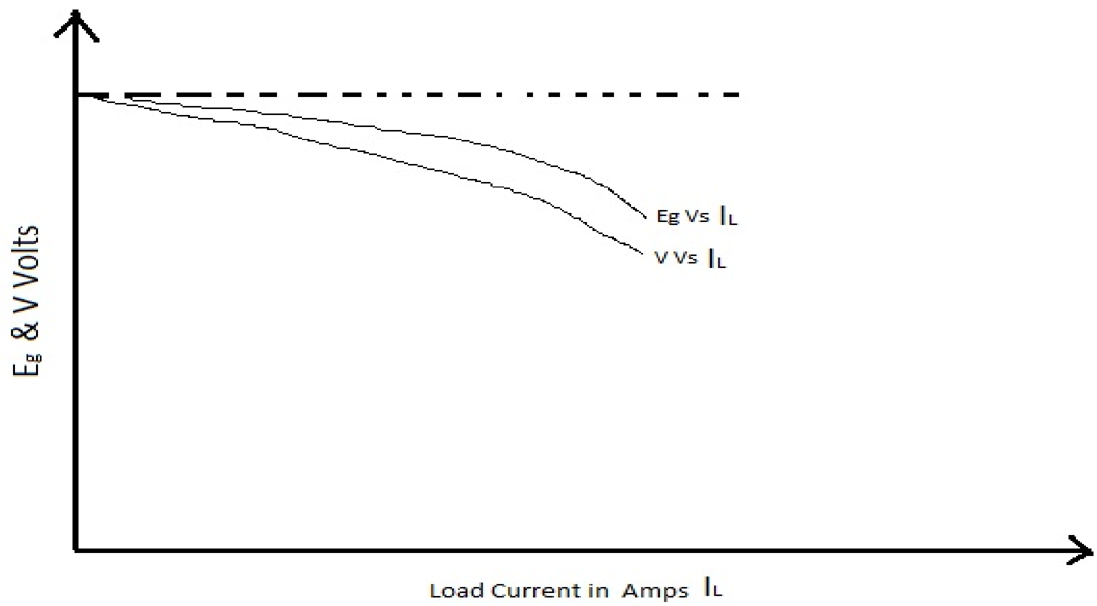
Observations:

I_f (A)	I_L (A)	I_a (A)= I_L+ I_f	V (v)	Eg= V +I_a (R_a+R_{se})

Sample Calculations:

Terminal Voltage (V) = ... V
Load Current (I_L) = ...A
Shunt Field Current (I_{sh}) = ...A
Armature Current (I_a) = I_L + I_{sh} = ...A
Generated emf (E_g) = V + I_a(R_a+R_{se}) = ...

Graphs:



Result:

Remarks if any:

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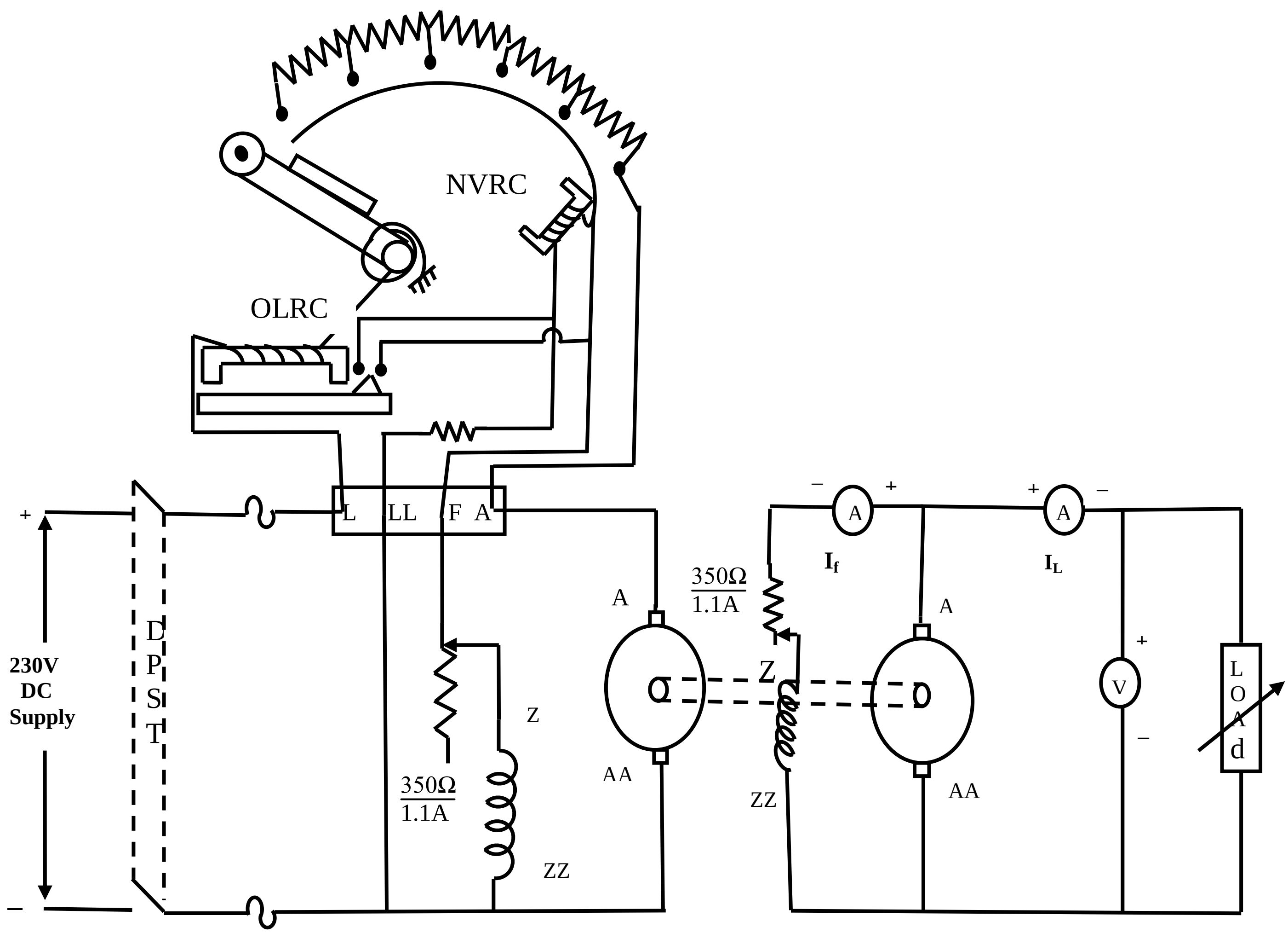
Circuit diagram:



Viva Questions:

1. What is the need for starter with a d.c motor?
2. How does a 3-point starter function?
3. Why is Rh1 kept in minimum position at starting?
4. Why is Rh2 kept in maximum position at starting?
5. Why does the terminal voltage of a generator decrease with increase in load?
6. How are the meter ratings selected for this experiment?
7. What are the different losses in a d.c generator?
8. What is the condition for maximum efficiency in a d.c machine?
9. What is armature reaction? How does it effect the functioning of the machine?

TITLE: **BRAKE TEST ON DC COMPOUND MOTOR**	GPRECD/EEE/EXPT-EMC-I(P)-3
SCHEME-13	DATE: 01-07-2016

Objective:

To conduct brake test on DC compound motor for long shunt cumulative & differential connections and to draw the performance characteristics.

Apparatus:

DC Compound Motor, Voltmeter, Ammeter, Tachometer, Required number of connecting wires

Name plate details:

Fuse ratings:

Theory:

This is a direct method of testing a dc compound motor as a cumulative and as a Differential compound motor. In this method, a rope is wound round the pulley and its two ends attached to two spring balances S1 and S2.The tensions on the rope T1 and T2 can be adjusted with the help of swivels. The force acting tangentially on the pulley is equal to the difference between the readings of the two spring balances. Power developed in the motor at the shaft = Pout = T ×ω watts where ω= (2πN)/ 60
(N is speed in r.p.m) ; T_{shaft} = F× r Newton-metre= (T_1~T_2) Kg × 9.8× r =
Motor output Pout = T_{shaft}× ω = (2ΠNTshaft)/ 60
(R is radius of the pulley in meter and 1kg wt = 9.8 Newton)
Total power input to the motor Pin=Power input to the field
Pin = $V_f I_f + V_a I_a$
% Efficiency = (P_{out} / P_{in})*x 100*
In a separately excited cumulatively compound motor Φ_{sh} is constant. Hence, Φ_{se} increases with increase in the load or armature current. Thus, the speed drops at a faster rate in a cumulative compound motor than in a shunt motor.

T_a=KΦI_a.
Where $\Phi = \Phi_{sh} + \Phi_{se}$; Φ_{sh} is constant. Φ_{se} increases with increase in I_a. Hence T_a increases.

If Φ_{sh} is stronger than Φ_{se}, the $T_a \sim I_a$ characteristic and Speed~Torque characteristic approaches to the shunt motor characteristics. If Φ_{se} is stronger than Φ_{sh}, above characteristics approaches to the series motor characteristics.

In a Differential Compound motor, the series flux opposes the shunt flux. With increase in I_a, the net flux in the air gap deceases. Thus, the motor speed increases slightly with load.

Hence, it can be designed to give a constant speed under all load conditions**.**

Formulae used:

Procedure:

1) Circuit is connected as per the circuit diagram.
2) The field rheostat of motor is kept at minimum position.
3) Machine is started at no load initially, speed is adjusted with the help of its rheostat at the rated speed and meter readings are noted.
4) By increasing load on the brake drum and by tightening the belt the corresponding meter readings are noted.
5) The same procedure is followed for differential compound motor also.

Observations:

Cumulative Compound Motor:

Voltage(V)	I_L (A)	Speed (N) (RPM)	Balance		Torque $T=(T_1 - T_2)rg$	O/p= $\frac{2\pi NT}{60}$	I/P= $V I_L$	η= o/p / i/p
			T_1	T_2				

TITLE: **BRAKE TEST ON DC COMPOUND MOTOR**	GPRECD/EEE/EXPT-EMC-I(P)-3
SCHEME-13	DATE: 01-07-2016

Differential Compound Motor:

Voltage(V)	I_L (A)	Speed (N) (RPM)	Balance		Torque $T=(T_1-T_2)rg$	O/p= $\frac{2\pi NT}{60}$	I/P= $V I_L$	η= o/p / i/p
			T_1	T_2				

Sample Calculations:

Cumulative compounding:

Input Voltage (V)= V
Input current = I_L= A
N= rpm
T_1 = kg; T_2 = kg.
T=(T1-T2)rg = Nm
Output = O/p= (2πNT)/60
Input = VI_L=
Efficiency = η=(O/p) / (I/p)

Differential Compounding:

Input Voltage (V)= V
Input current = I_L= A
N= rpm
T_1 = kg; T_2 = kg.
T=(T1-T2)rg = Nm
Output = O/p= (2πNT)/60
Input = VI_L=
Efficiency = η=(O/p) / (I/p)

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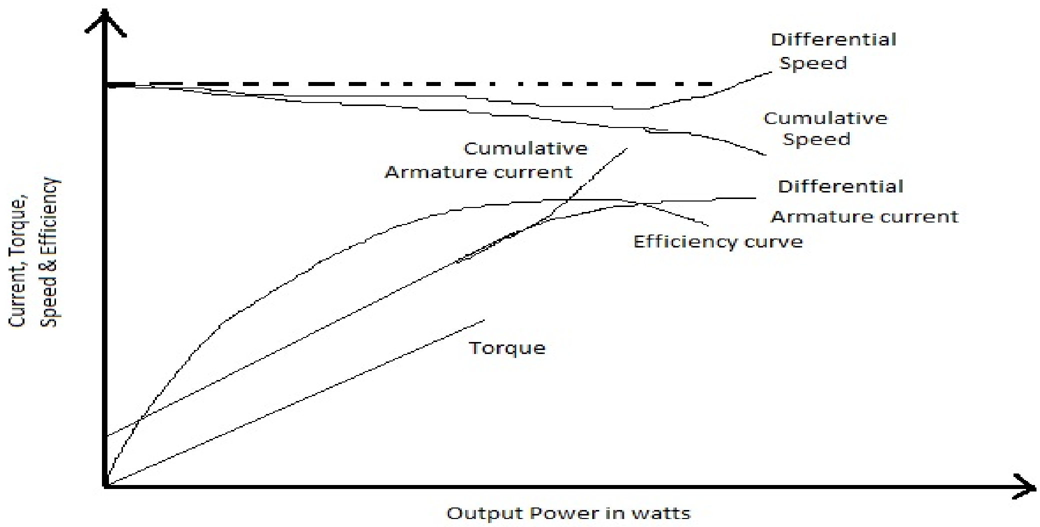
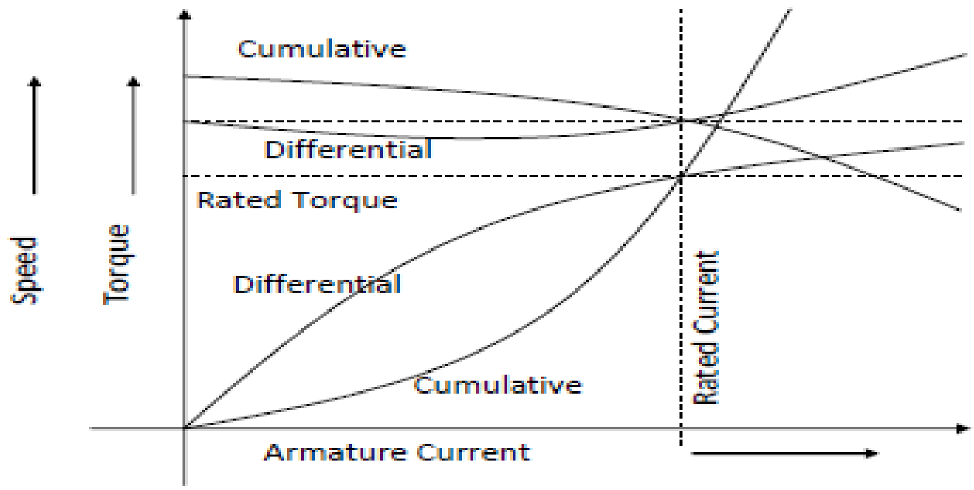
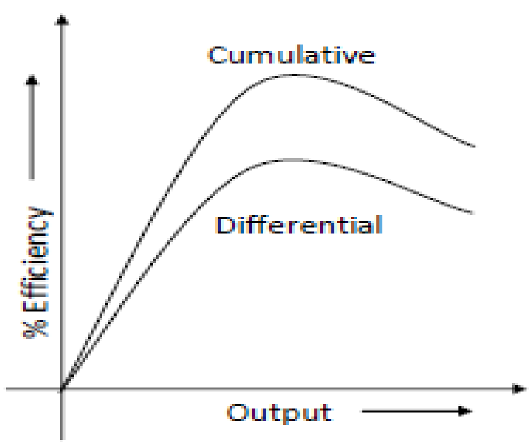
TITLE: **BRAKE TEST ON DC COMPOUND MOTOR**	GPRECD/EEE/EXPT-EMC-I(P)-3
SCHEME-13	DATE: 01-07-2016

Graphs:

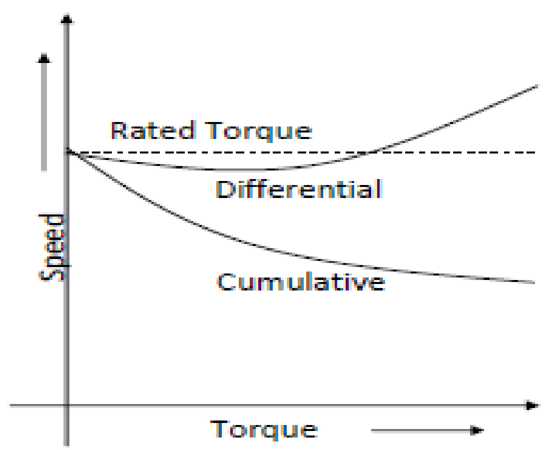




Speed, Torque Vs Armature Current Characteristics



% Efficiency Vs Output Characteristics



Speed Vs Torque Characteristics

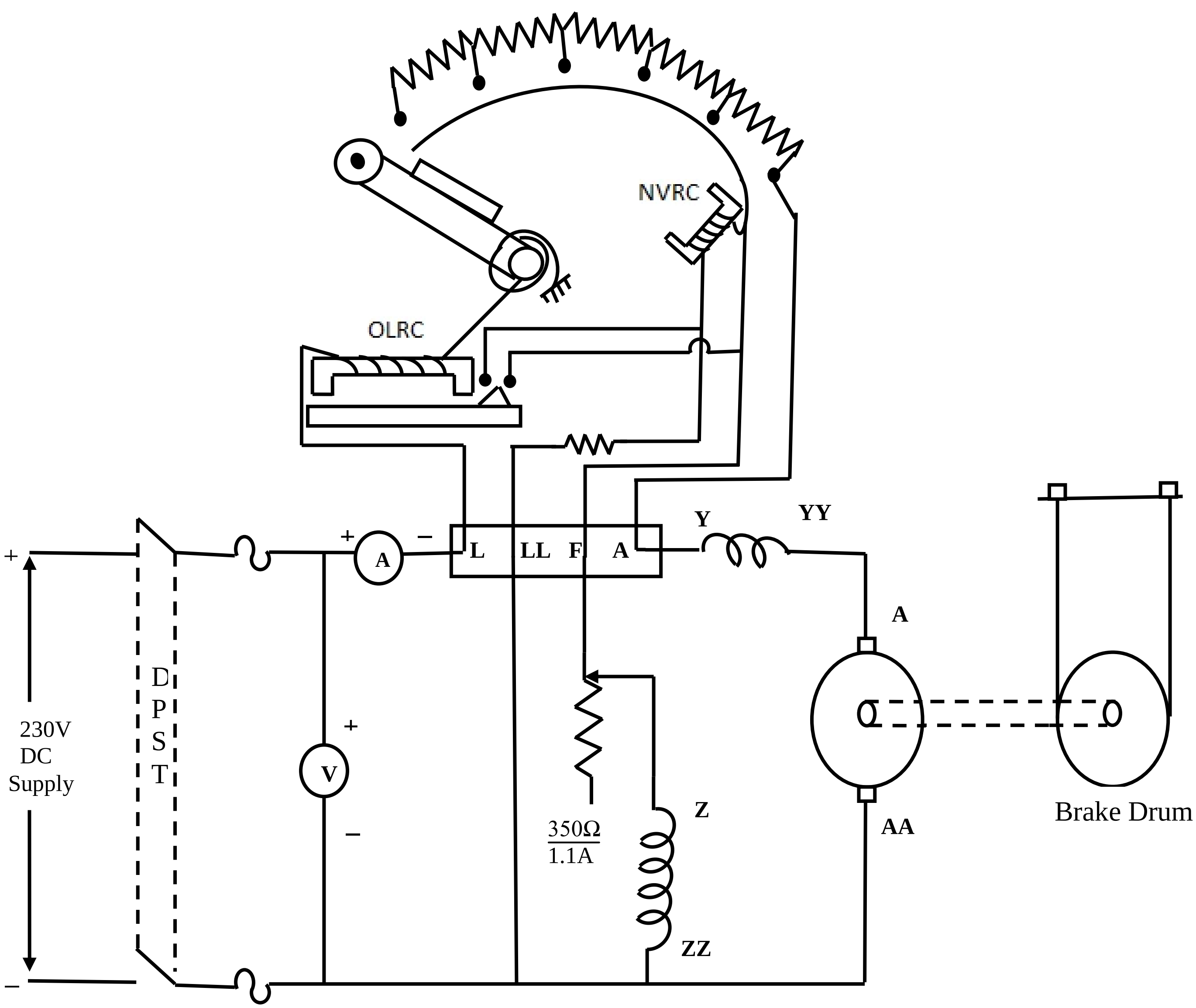
Result:

Remarks if any:

TITLE: **BRAKE TEST ON DC COMPOUND MOTOR**	GPRECD/EEE/EXPT-EMC-I(P)-3
SCHEME-13	DATE: 01-07-2016

Circuit Diagram:

Cumulative Compound Motor:



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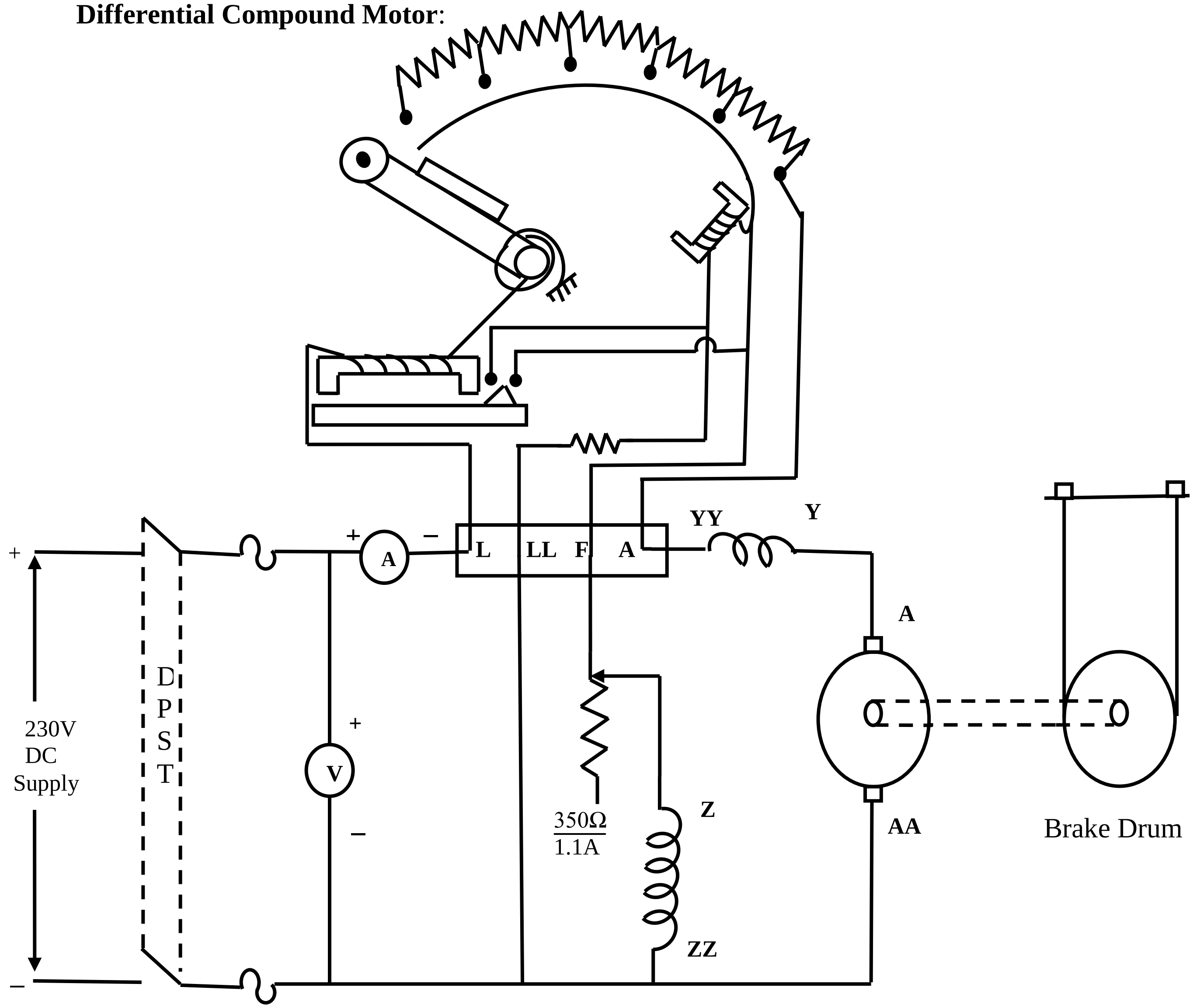
TITLE: **BRAKE TEST ON DC COMPOUND MOTOR**	GPRECD/EEE/EXPT-EMC-I(P)-3
SCHEME-13	DATE: 01-07-2016

Differential Compound Motor:



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Viva Questions:

1. On what principle does DC motor operates?
2. What are the applications of DC Compound motors?
3. What is the typical brush drop in DC motors?
4. Draw different characteristic curves of DC compound motors?
5. Explain cumulative compound machine.
6. Write the corresponding equations of Short shunt and long shunt compound Motors.

TITLE : SWINBURNE'S TEST	GPRECD/EEE/EXPT- EMC-I(P)-4
SCHEME-13	DATE: 01-07-2016

Objective:
To conduct Swinburne's test on DC shunt machine and to predetermine its efficiency both as a Generator and Motor.

Apparatus:

DC Shunt Motor, Voltmeter, Ammeters, SPST Switch, Tachometer, Required number of connecting wires

Name plate details:

Fuse rating:

Formulae used: No Load armature current = I_{ao}
No Load input = VI_{ao} Watts
No Load armature Cu loss (Pcu)= $I_{ao}^2 R_a$

Constant losses of machine, $P_i = VI_{ao} - I_{ao}^2 R_a - VI_f$

Where I_a = Armature current (at any load) R_a = Armature resistance

As Motor:

Load current = I_L amps
Field current = I_f amps
Armature cu loss=Pcu= $I_a^2 R_a$ watts
$I_a = I_L - I_f$, Io= No load current

Constant losses of motor $P_i = VI_o - I_a^2 R_a$
$= VI_o - (I_o - I_f)^2 R_a$

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Total losses, $P_L=P_i+$ armature 'cu' loss(Pcu)
Input power = V I_L watts,
Output power = input-total losses=VI_L-P_L Watts

Efficiency = (output/input) * 100 = (VI_L-P_L / VI_L)*100

As Generator:

Load current =I_L amps,
Field current =I_f amps
$I_a = I_L + I_f$
Armature cu loss=Pcu= $I_a^2 R_a$ watts
Total losses, $P_L=P_i+$ Armature 'cu' loss (Pcu)
Output power =V I_L watts
Input power=Output + total losses=VI_L+P_L Watts

Efficiency = (output/input) * 100 = (VI_L/ VI_L+P_L)*100

Theory:

Testing of D.C. machines can be divided into three methods: (a) direct, (b) regenerative, and (c) indirect. Swinburne's Test is an indirect method of testing a D.C. machine. In this method, the constant losses of the D.C. machine are calculated at no-load. Hence, its efficiency either as a motor or as a generator can be pre-determined. In this method, the power requirement is very small. Hence, this method can be used to pre-determine the efficiency of higher capacity D.C. machines as a motor and as a generator.

Disadvantages:

(1) Efficiency at actual load is not accurately known.
(2) Temperature rise on load is not known.
(3) Sparking at commutator on load is not known.

Power input at No-load = Constant losses + Armature copper losses
Power input = Vf If+Va Ia

Losses in a D.C. Machine:

The losses in a D.C. machine can be divided as 1) Constant losses, 2) Variable losses, which changes with the load.

Constant losses:

Mechanical Losses: Friction and Windage losses are called mechanical losses. They depend upon the speed. A D.C. shunt machine is basically a constant speed machine both as a generator and as a motor. Thus, the mechanical losses are constant.

Iron Losses: For a D.C. shunt machine, the field current is constant and hence the flux. Hence, hysteresis and eddy current losses that depends on field flux (which are also called as iron losses) remain constant.

Field Copper Losses: Under normal operating conditions of a D.C. shunt machine, the field current remains constant. Thus, power received by the field circuit (which is consumed as field copper losses) is constant.

Constant losses in a D.C. shunt machine = Mechanical losses + IronLosses + Field copper losses

Variable Losses:

The power lost in the armature circuit of s D.C. machine increases with the increase in load. Thus, the armature copper losses are called as variable losses.

Procedure:

1. Connections are made as per the circuit diagram.
2. Motor field rheostat is kept in minimum position.
3. The SPST switch is kept in closed position on no load.
4. Supply is given & motor is started with the help of four-point starter.
5. The field rheostat is adjusted till the rated speed is achieved.
6. Switch was opened and currents I_L, I_F & Voltmeter reading are noted.

Observations:

Motor: No load current =Io= I_L initially, $P_i = VI_o - (I_o - I_f)^2 R_a$; $P_{cu} = I^2{}_a R_a$

V Volts	I_L (A)	I_F(A)	$I_a = I_L - I_f$ Watts	$P_L = P_i + P_{cu}$ Watts	Input (VI_L) Watts	Output ($VI_L - P_L$) Watts	Efficiency (Output/input)

Generator: $P_i = VI_o - (I_L + I_f)^2 R_a$; $P_{cu} = I^2{}_a R_a$

V Volts	I_L (A)	I_F (A)	$I_a = I_L + I_f$ A	$P_L = P_i + P_{cu}$ Watts	Output (VI_L) Watts	Input ($VI_L + P_L$) Watts	Efficiency (Output/input)

Sample Calculations:

Armature copper loss = Pcu= $I^2{}_a R_a$ watts

Total constant losses = Pi= $VI_o - (I_L - I_f)^2 R_a$ = watts

Efficiency as a motor:

Input to the motor = VI_L = watts

Total losses = constant losses + armature copper losses = Pi+Pcu watts

Output = Input – total losses = watts

Efficiency, η_m = output/input = %

Efficiency as a generator:

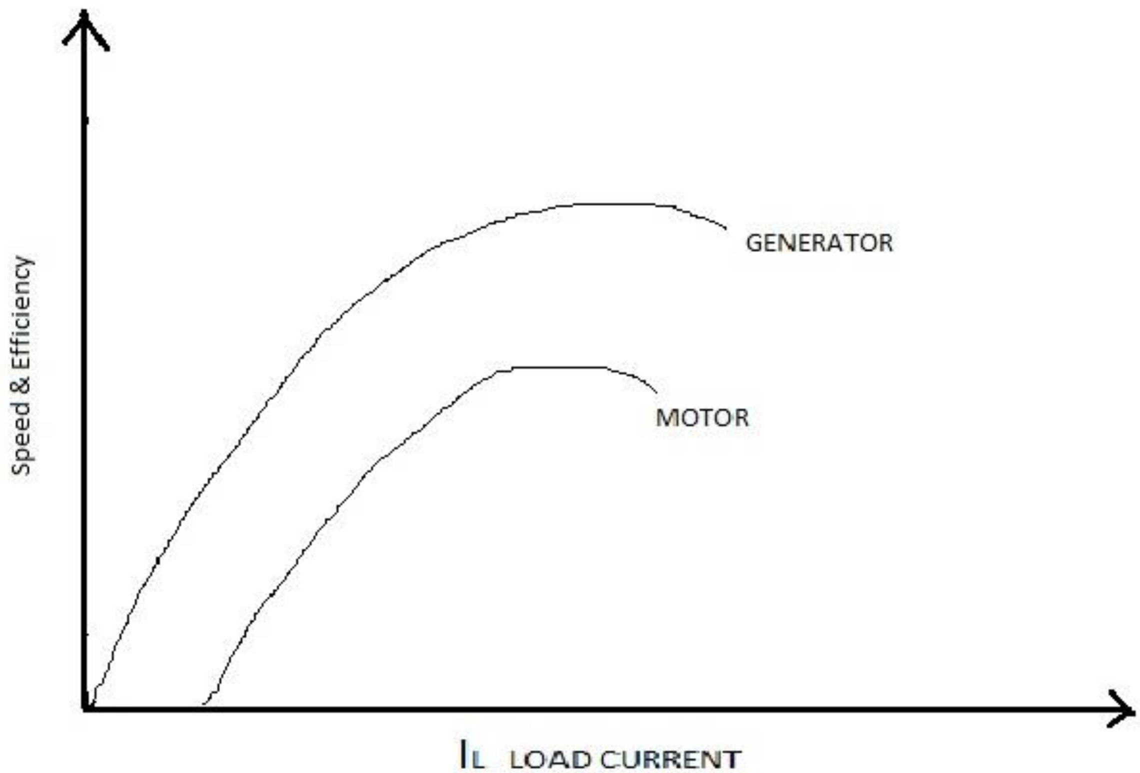
Output = VI_L = watts

Total losses = constant losses + armature copper losses = watts

Input = Output+ Total losses= Watts

Efficiency, η_g = output/input = %

Graphs:

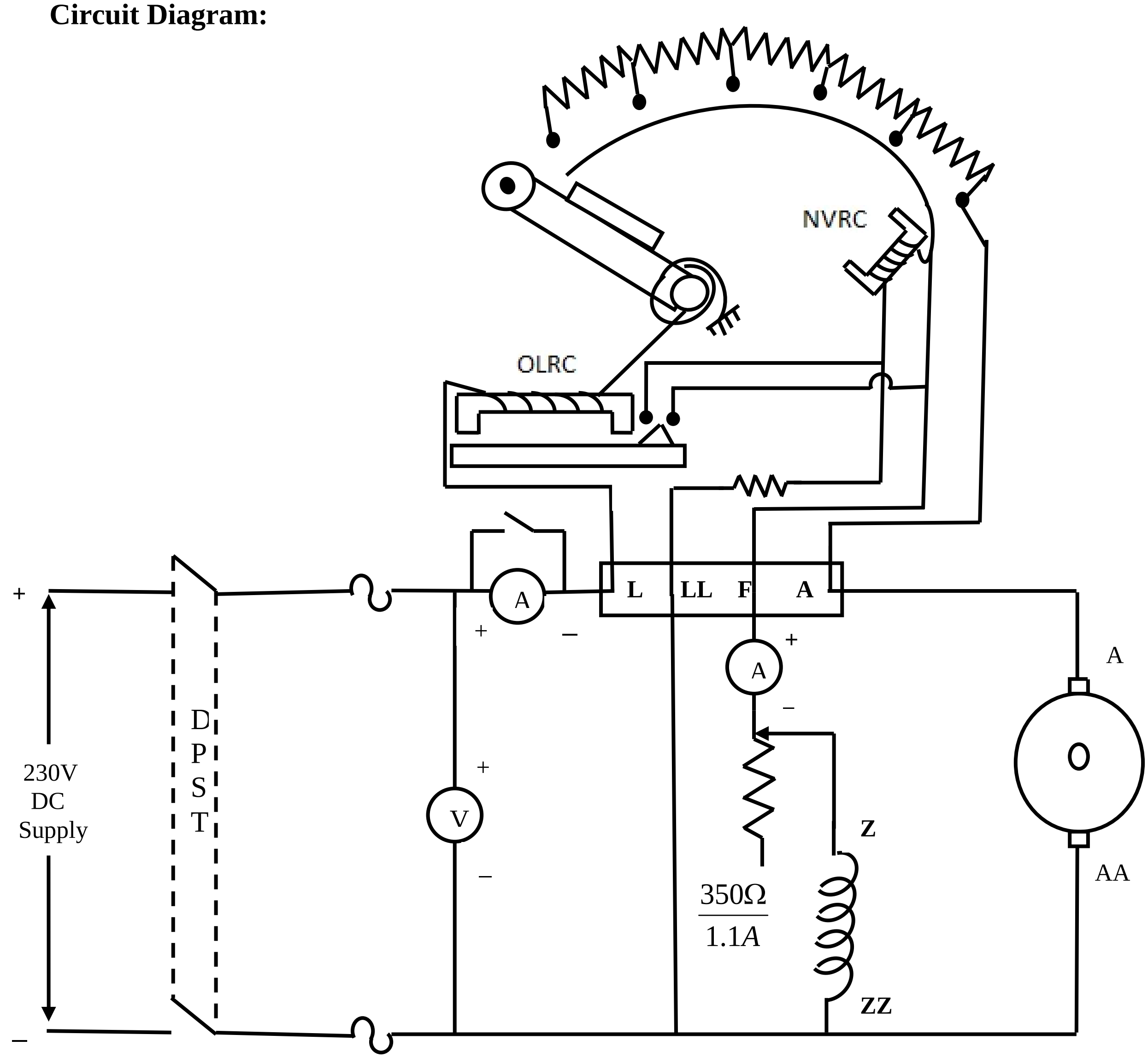


Result:

Remarks if any:

TITLE : SWINBURNE'S TEST	GPRECD/EEE/EXPT- EMC-I(P)-4
SCHEME-13	DATE: 01-07-2016

Circuit Diagram:



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Viva Questions:

1.What is the purpose of Swinburne's test?

2. What are the constant losses in a DC machine?

3.What are the assumptions made in Swinburne's test?

4. Why is the indirect method preferred to the direct loading test?

5. The efficiency of DC machine is generally higher when it works as a generator than when it works as a motor. Is this statement true or false? Justify your answer with proper reasons.

TITLE: **BRAKE TEST ON DC SHUNT MOTOR**	GPRECD/EEE/EXPT-EMC-I(P)- 5
SCHEME-13	DATE: 01-07-2016

Objective:
To conduct brake test on D.C.Shunt Motor and to draw the performance characteristics.

Apparatus:

DC Shunt Motor, Voltmeter, Ammeter, Tachometer, Required number of connecting wires

Name plate details:

Fuse ratings:

Theory:
This is a direct method of testing a dc machine. It is a simple method of measuring motor output, speed and efficiency etc., at different load conditions. A rope is wound round the pulley and its two ends are attached to two spring balances S_1 and S_2.The tensions provided by the spring balances S_1 and S_2 are T_1 and T_2. The tension of the rope can be adjusted with the help of swivels. The force acting tangentially on the pulley is equal to the difference between the readings of the two spring balances in Kg - force.
A dc shunt motor rotates due to the torque developed in the armature when the armature and field terminals are connected to the dc supply. The direction of rotation can be explained with help of Fleming's left hand rule. A counter emf or back emf (E_b) is induced in the armature conductors while the armature (rotor) rotating in the magnetic field. The direction of the induced emf can be explained with the help of Fleming's right hand rule and Lenz's law. The direction this induced emf is such that it opposes the applied voltage (V). This induced emf is also called as back emf E_b.
The torque developed in the motor is opposed by the torques due to
(a) Friction and windage
(b) Eddy currents and hysteresis and
(c) Mechanical load connected at the shaft.
The motor runs at a stable speed when the developed torque and resisting torques balance each other.
Let a small load be increased, and then the resisting torque increases and motor speed falls. The back emf reduces due to the fall in the speed. Hence, the armature current

increases. ($I_a = (V - E_b)/R_a$. If Φ is assumed constant, (i.e., neglecting the armature reaction) the torque developed by the motor increases and a new stable speed is reached at which the developed torque equals the resisting torque.

Armature current ~ Speed characteristics:

The armature current I_a increases with increase in the load at the shaft. Hence I_aR_a drop increases and counter emf (E_b) decreases.

$E_b = V - I_aR_a$,

Where R_a is armature resistance and $E_b \alpha \Phi N$.

If Φ is constant in the shunt motor, by neglecting the armature reaction; the speed falls as E_b falls. In a dc motor R_a is very small, hence I_aR_a is a small value and fall in E_b with increase in load is small. Thus, the speed falls slightly as I_a increases.

Armature current ~ Torque characteristics:

If Φ is constant, developed torque increases with increase in I_a. $T = K\Phi I_a$ In actual condition, Φ slightly falls with increase in I_a due to the effect of armature reaction.

Armature current ~ induced emf (back emf):

Induced emf (back emf E_b) falls slightly with increase in I_a as per the equation

$E_b = V - I_aR_a$

Torque ~ Speed:

With increase in load, I_a and T_a increase since the shunt field Φ is constant. The fall in speed is very small as the I_aR_a drop is very small compared to V. In a dc shunt motor

$N \alpha E_b/\Phi$

Output ~ Efficiency:

The graph between Output ~ Efficiency indicates that max torque occurs when armature copper losses is equal to the constant losses. (Sum of field copper losses, mechanical losses and Iron losses).

TITLE: **BRAKE TEST ON DC SHUNT MOTOR**	GPRECD/EEE/EXPT-EMC-I(P)- 5
SCHEME-13	DATE: 01-07-2016

Procedure:

1) Circuit is connected as per the circuit diagram.
2) The motor Rheostat is kept at minimum position.
3) Ensure that initially there is no load on the motor.
4) Machine is started using the four-point starter and the speed of the motor is adjusted to rated value by varying the field rheostat.
5) Load the motor by tightening the belt on the pulley and record the readings of all the meters, speed and the readings of both the spring balances.
6) Repeat step 5 by increasing the load on the motor in steps, till the rated current of the motor is obtained.
7) Remove the load gradually and then stop the motor by switching off the supply.

Observations:

Voltage (V)	I_L (A)	Speed (N) (RPM)	Balance		Torque	O/p=$\frac{2\pi NT}{60}$	I/P= V I_L	η= (o/p) / (i/p)
			T_1	T_2	$T=(T_1-T_2)$ rg			

r = radius of brake drum g = acceleration due to gravity

Sample Calculations:

Input Voltage (V)= V
Input current = $I_{L=}$ A
N= rpm
T_1 = kg; T_2 = kg.
T=(T1-T2)rg = Nm
Output = O/p= (2πNT)/60
Input = VI_L=
Efficiency = η=(O/p) / (I/p)

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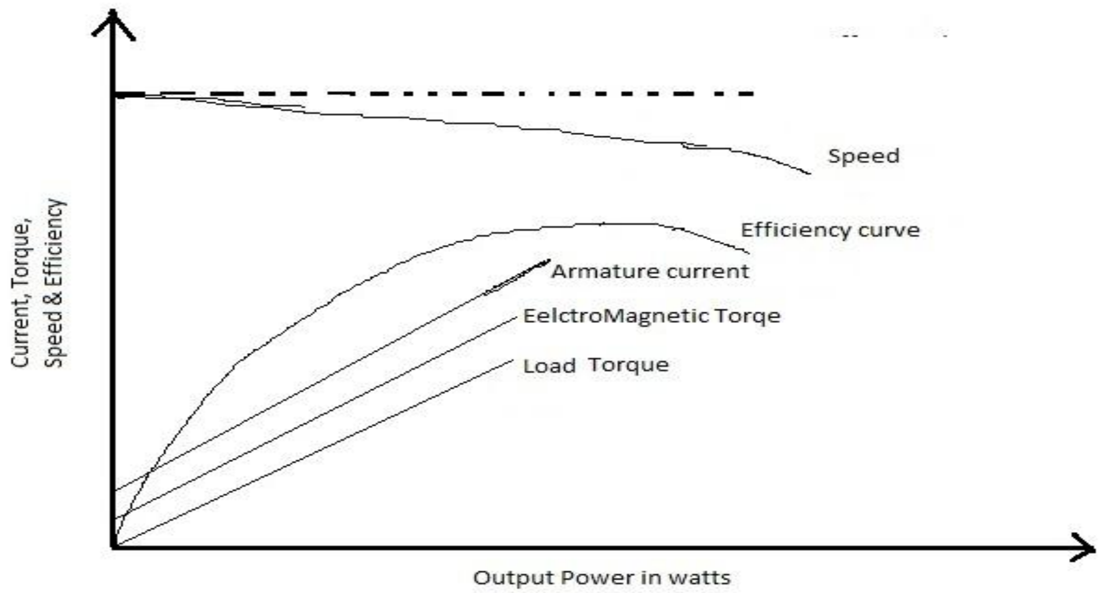
Graphs:

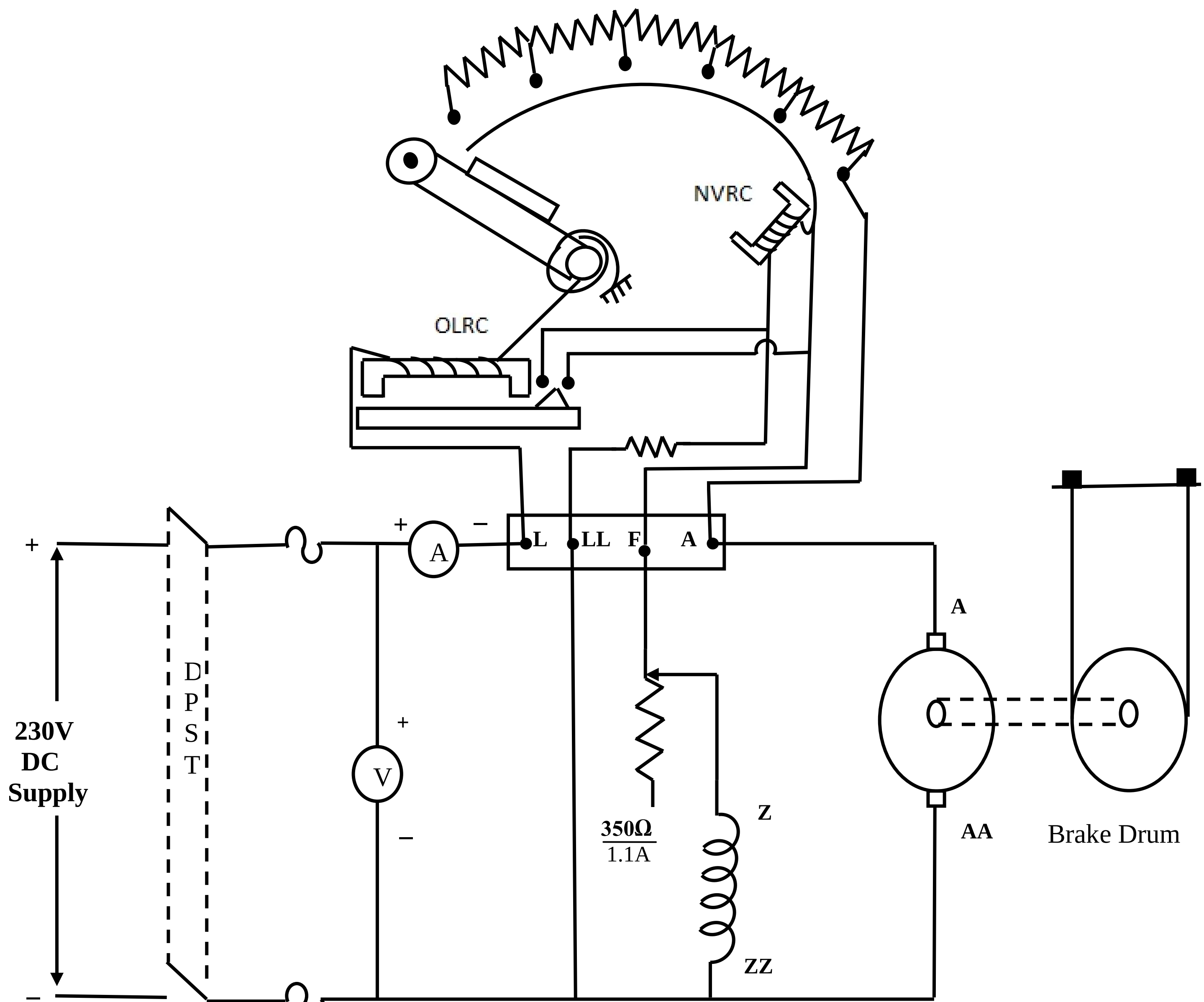


Result:

Remarks if any:

TITLE: **BRAKE TEST ON DC SHUNT MOTOR**	GPRECD/EEE/EXPT-EMC-I(P)- 5
SCHEME-13	DATE: 01-07-2016

Circuit Diagram:



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Viva Questions:

1.Why should the field rheostat be kept in the position of minimum resistance?

2.What is the loading arrangement used in a dc motor?

3.How can the direction of rotation of a DC shunt motor be reversed?

4.What are the mechanical and electrical characteristics of a DC shunt motor?

5.What are the applications of a DC shunt motor?

TITLE: **HOPKINSON'S TEST**	GPRECD/EEE/EXPT-EMC-I(P)-6
SCHEME-13	DATE: 01-07-2016

Objective:

To conduct Hopkinson's test on two identical DC machines and determine efficiencies of two machines.

Apparatus:

Name plate details:

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. Circuit is connected as shown in the circuit diagram.
2. The motor field rheostat is kept at minimum position and generator field rheostat is kept at maximum position.
3. Motor is started with the help of starter at no load.

4. The motor is to be made to run at rated speed by adjusting the motor field rheostat value.
5. The generator field resistance is varied so that voltmeter reads zero volts across the SPST switch, at that moment SPST switch is closed.
6. The generator field resistance is varied in steps and corresponding readings are noted.

Observations:

V	I_{fm}	I_{fg}	I_{am}	I_{ag}	$I_{ag} + I_{fg}$	$I_{am}+I_{ag}$	$(I_{ag} + I_{fg})^2R_{ag}$	$(I_{am}+ I_{ag})^2R_{am}$	P_0	η_m	η_g

Sample Calculations:

Calculation of Efficiencies:
$I_1 = (I_{am} + I_{fm})$ = Current drawn from the mains.
$I_2 = I_{ag}$ = Current supplied by the generator to the motor.
I_{fm} = Field current of motor.
I_{fg} = Field current of generator.
$I = I_1 + I_{ag}$ = Input to the motor.
V = Supply voltage.
V_f = Voltage across the field.
The electrical output of the generator plus the small power taken from the supply, equal to the power drawn by the motor as a mechanical power after supplying the motor losses.
$I = I_1 + I_2$
Motor input = $V(I_1 + I_2)$
Generator output = VI_{ag}
R_a = armature resistance of each machine
Armature copper losses in a generator = $I^2_{ag} * R_{a2}$
Armature copper losses in a motor = $(I_1 + I_2)^2 * R_{a1}$
Shunt copper losses in a generator = $V_f * I_{f2}$
Shunt copper losses in a motor = $V_f * I_{f1}$
Motor and Generator losses are equal to the power supplies by the mains.
Power drawn from supply = VI_1

Stray losses of both the machines = $W_{TS} = VI_1 - [I_2^2 R_{a2} + (I_1 + I_2) R_{a1}] =$ Watts
Therefore, total stray losses for the set $W_{Ts} =$ Watts
The stray losses are approximately equal in two machines.
Stray losses per machine = $W_s = W_{TS} / 2$

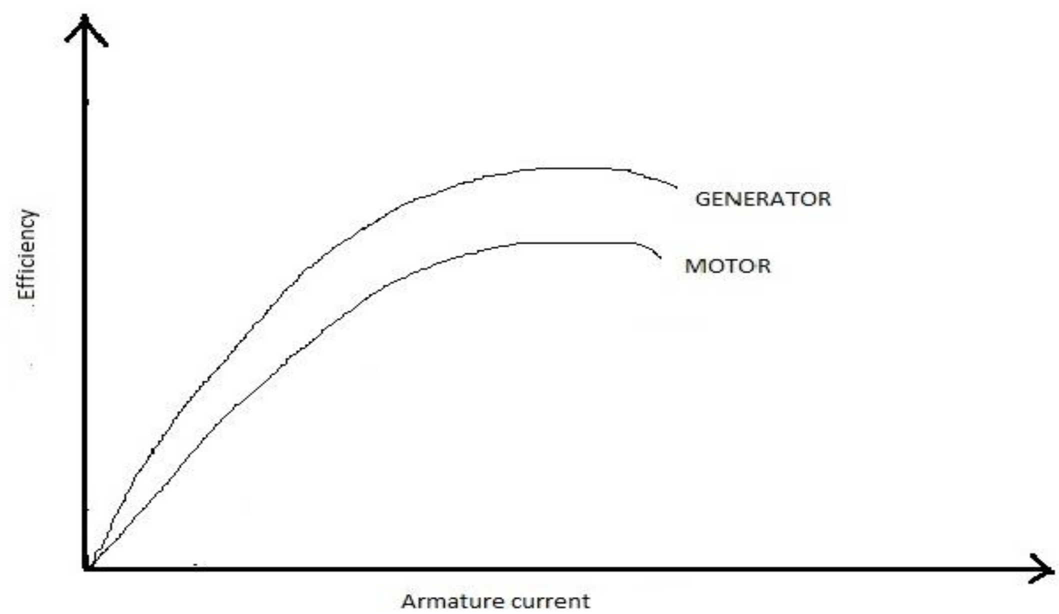
For Generator:

Total losses $W_g = I_2^2 R_{a2} + I_{f2} V_f + W_s$
Output = VI_2
Therefore % efficiency $N_g (\eta) = (VI_2 / (VI_2 + W_g))*100$.

For Motor:

Total losses = $W_m = (I_1 + I_2)^2 R_{a1} + V_f I_{f1}$
Input $P_{in} = V(I_1 + I_2) + V_f I_{f1}$
Output $P_o = P_{in} - W_m$
Therefore % efficiency $N_m(\eta) = (P_o / P_{in})*100$

Graphs:

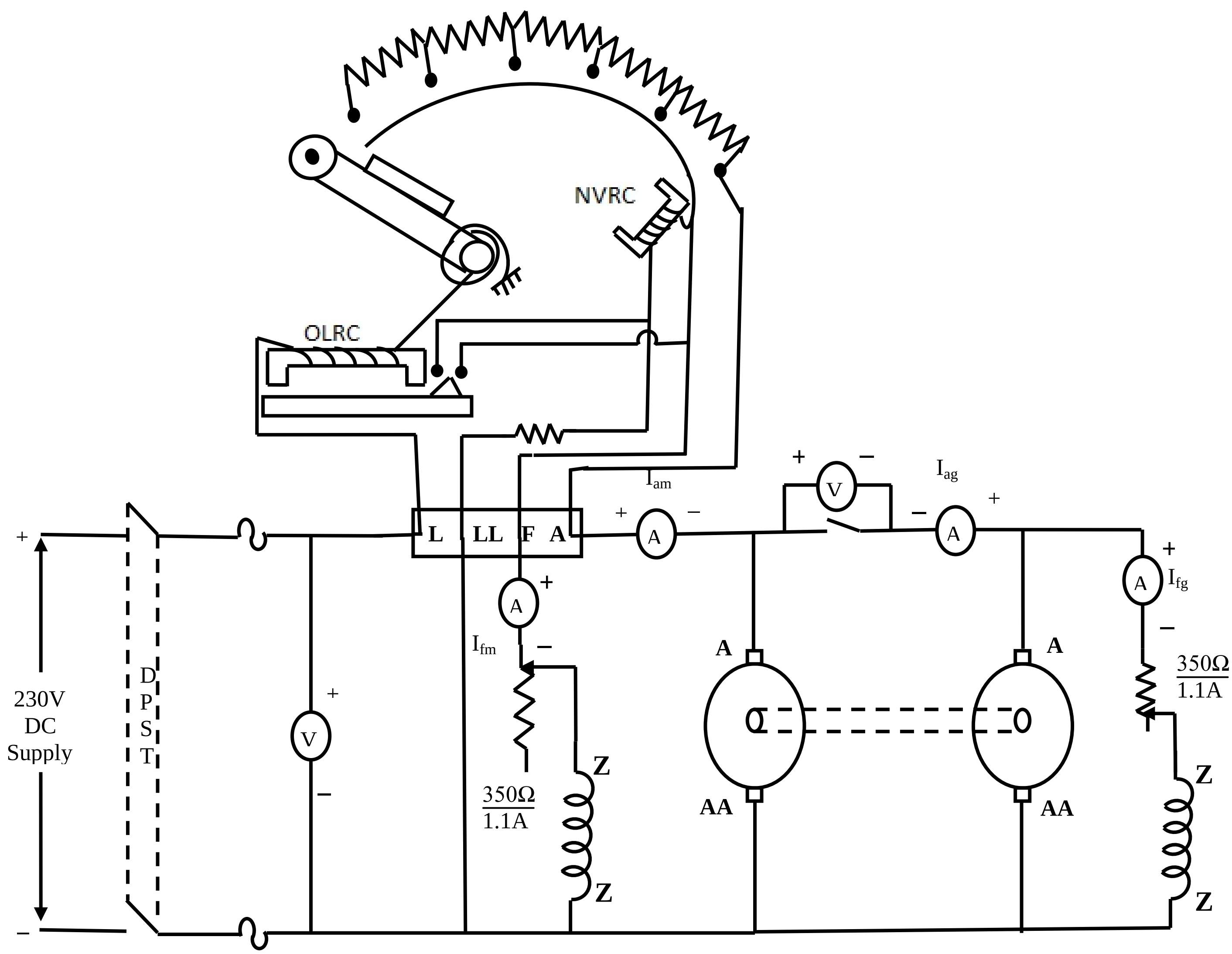


Result:

Remarks if any:

TITLE: **HOPKINSON'S TEST**	GPRECD/EEE/EXPT-EMC-I(P)-6
SCHEME-13	DATE: 01-07-2016

Circuit Diagram:



Viva Questions:

1. What is the need of conducting Hopkinson's test?
2. Why this test is known as regenerative test?
3. What is the purpose of voltmeter connection across the SPST switch?
4. The efficiency is more for dc machine as a generator when compared to that of a motor operation. Explain why?
5. What is the significance of Back emf in Dc motors?

TITLE: **FIELD'S TEST ON TWO IDENTICAL DC SERIES MACHINES**	GPRECD/EEE/EXPT-EMC-I(P)-7
SCHEME-13	DATE: 01-07-2016

Objective:

To conduct Field's test on two identical DC series machines and to calculate the efficiency of a given DC series machine.

Apparatus:

DC series Motor-Generator Set, Voltmeters, Ammeters, Tachometer, Resistive Load, Required number of connecting wires

Name plate details:

Theory:

In a series motor, the field winding is connected in series with the armature winding. Thus the same current flows through the field and armature windings.

Electrical characteristics(T vs Ia) :-

It shows the variation of torque with the armature current. We have T α ΦIa where Φ is the flux/pole α IaIa (as Φα Ia up to the point of magnetic saturation)

Thus $T \alpha I^2_a$

However after magnetic saturation Φ remains almost constant, Hence T αIa. Thus the curve is a parabola up to magnetic saturation and shows a linear variation after the point.

Mechanical Characteristics: (N1 vs T):- It shows the variation of speed with torque.

We have Nα E_b/ Φ as Eb is almost constant where Eb is back emf

In a series motor Φ α Ia and therefore N α 1/ Ia

That is, as Ia increases, Speed decreases.

The same pattern is followed in the N-T characteristics. The curve traced is a rectangular hyperbola.

A series motor should never be started at no load. At no load, Ia is very small, hence the speed of the motor becomes dangerously high(as N α1/ Ia).

Formulae used:

Total input = VI_1

Total output = V_4I_2

Total Losses = input – output

Armature copper losses = $(R_{am}+R_{sem}+R_{seg})I_1^2 +I_2^2 R_{ag}$

Stray losses of each machine=(Total losses-Armature copper losses)/2

Motor efficiency = $[V_1I_1-I_1^2 (R_a+R_{se})$-Stray losses] / V_1I_1

Generator efficiency = V_4I_2 / [$V_4I_2 + I_2^2R_a$+ stray losses]

R_{am} = Motor Armature resistance
R_{sem} = Motor series field winding resistance
R_{seg} = Generator series field winding resistance
R_{ag} = Generator Armature resistance

Procedure:

1. The mechanical coupled machines are connected as shown in the circuit diagram.
2. Before switching on the supply, sufficient load on generator is ensured.
3. Supply is given and the machine set is started gradually using a 3 –point starter.
4. The supply voltage is adjusted such that load on generator is maximum for which the speed of set is with in permissible limit and voltage across motor terminals is its rated value.
5. Ammeter and voltmeter readings are taken and efficiency is calculated.

TITLE: **FIELD'S TEST ON TWO IDENTICAL DC SERIES MACHINES** SCHEME-13	GPRECD/EEE/EXPT-EMC-I(P)-7 DATE: 01-07-2016

Observations:

V (V)	V_1 (V)	V_2 (V)	V_3 (V)	V_4 (V) Output voltage Vo	I_1 (A)	I_2 (A)	Speed (rpm)

Sample Calculations:

Total input = VI_1 Watts

Total output = V_oI_2 Watts

Total Losses = input – output Watts

Armature copper losses = $(R_{am}+R_{sem}+R_{seg})I_1^2 + I_2^2 R_{ag}$ Watts

Stray losses of each machine=(Total losses-Armature copper losses)/2 Watts

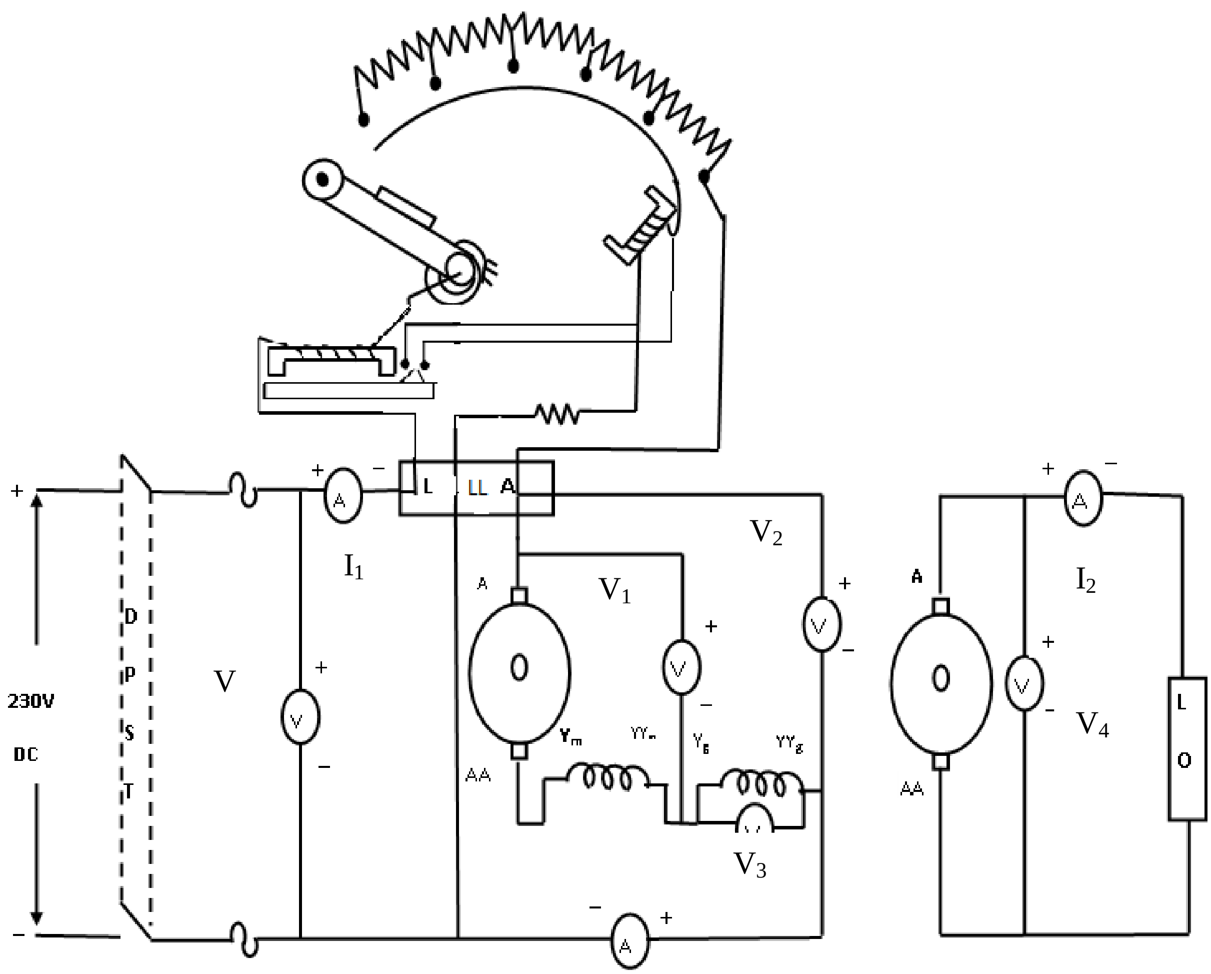
Motor efficiency = $([V_1I_1-I_1^2 (R_a+R_{se})\text{-Stray losses}] / V_1I_1)\text{x } 100$ =

Generator efficiency = $(V_oI_2 / [V_4I_2 + I_2^2R_a\text{+ stray losses}])\text{x } 100$ =

Result:

Remarks if any:

Circuit Diagram:



Viva Questions:

1. Why a DC series motor/generator should never be stared without load?
2. Why a DC series motor has a high starting torque?
3. Compare the resistances of the field windings of DC shunt and series motor?
4. What are the applications of DC series motor and generators?
5. Comment on the Speed – Torque characteristics of a DC series motor.
6. How does the torque vary with the armature current in a DC series motor?
7. What is the precaution to be taken when working with a d.c series motor?
8. What is the need for starter with a d.c motor?
9. How does a 2-point starter function?
10. Explain the shape of the electrical and mechanical characteristics.
11. What is the condition for maximum efficiency in a d.c motor?
12. What are the different losses occurring in a d.c machine?
13. How are the meter ratings selected for this experiment?

TITLE: **SPEED CONTROL OF DC SHUNT MOTOR**	GPRECD/EEE/EXPT-EMC-I(P) - 8
SCHEME-13	DATE: 01-07-2016

Objective:

To conduct an experiment on DC shunt motor for its speed control using (i) Flux control method (ii) Armature control method.

Apparatus:

DC Shunt Motor, Voltmeters, Ammeters, Tachometer, Required number of connecting wires

Name plate details:

Fuse ratings:

Theory:

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

$$Eb = \frac{\Phi ZNP}{60A} \quad \text{and} \quad Eb = V - IaRa$$

$$\text{i.e., } N = \frac{V - I_a R_a}{K\Phi} \quad \text{where} \quad K = \frac{ZP}{60A}$$

Since IaRa drop is negligible N α V and $N \alpha \frac{1}{\Phi}$ or $N \alpha \frac{1}{I_f}$

Where N is the speed, V is applied voltage, Ia is the armature current, and Ra is the armature resistance and Φ is the field flux.

Speed control methods of shunt motor:

1. Applied voltage control.
2. Armature rheostat control.
3. Field flux control.

Applied voltage control:

In the past, Ward-Leonard method is used for Voltage control method. At present,

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variable voltage is achieved by SCR controlled AC to DC converter unit is used to control the speed of a motor. In this method, speed control is possible from rated speed to low speeds.

Armature rheostat control:

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

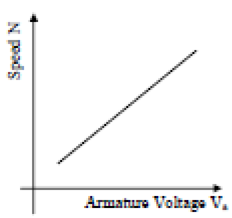
Disadvantages:

(a) Large amount of power is lost as heat in the rheostat. Hence, the efficiency is low.

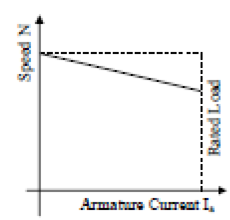
(b) Speed above the rated speed is not possible. The motor can be run from its rated speed to low speeds.

Field flux control:

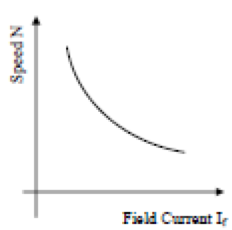
Speed control by adjusting the air gap flux is achieved by means of adjusting the field current i.e., by adding an external resistance in the field circuit. The disadvantage of this method is that at low field flux, the armature current will be high for the same load. This method is used to run the motor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



Armature Voltage Control method



Armature Rheostatic Control method



Flux Control method

TITLE: **SPEED CONTROL OF DC SHUNT MOTOR** SCHEME-13	GPRECD/EEE/EXPT-EMC-I(P) - 8 DATE: 01-07-2016

Procedure:

1. Connections are made as per the circuit diagram.
2. Motor field rheostat is kept in minimum position.
3. Armature rheostat is kept in maximum position.
4. The DC supply is switched on and the motor is started with the help of starter.
5. The speed of the motor is measured with the help of the tachometer and the voltage across the armature and the field current is noted.
6. The speed is changed by varying the rheostat in the armature circuit. During this period, the field current is constant.
7. The above process is repeated for different field currents.
8. The voltage across the armature, the field current and the speed are noted down.
9. The field current is varied and correspondingly the speed is noticed keeping the armature voltage constant.
10. The above step is repeated for different armature voltages.

Observations:

Flux control method:

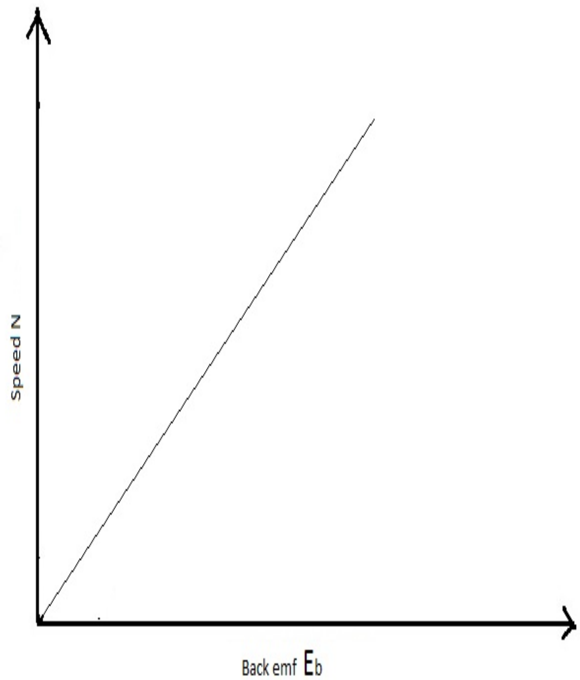
Sno	Back emf(E_b) = V= Volts	Field current (I_f) A	Speed (N)

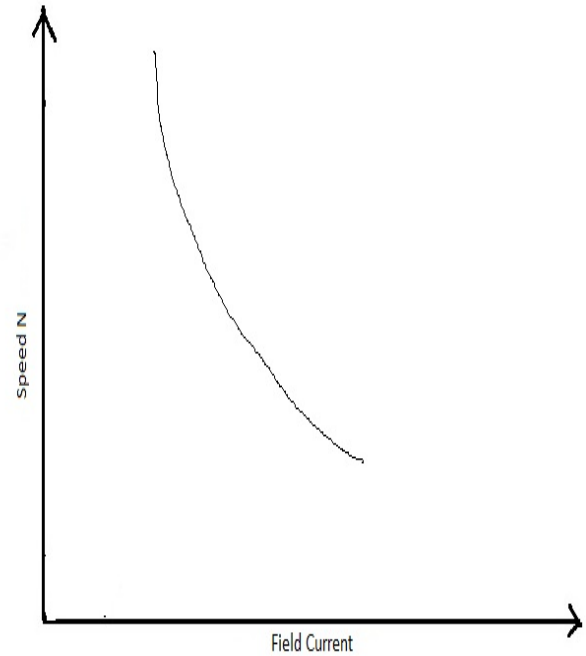
Armature control method:

Sno	V volts	Armature current (I_a) A	Field current (I_f) A	E_b=V- $I_a R_a$ Volts	Speed (N)

TITLE: **SPEED CONTROL OF DC SHUNT MOTOR** SCHEME-13	GPRECD/EEE/EXPT-EMC-I(P) - 8 DATE: 01-07-2016

Graphs:



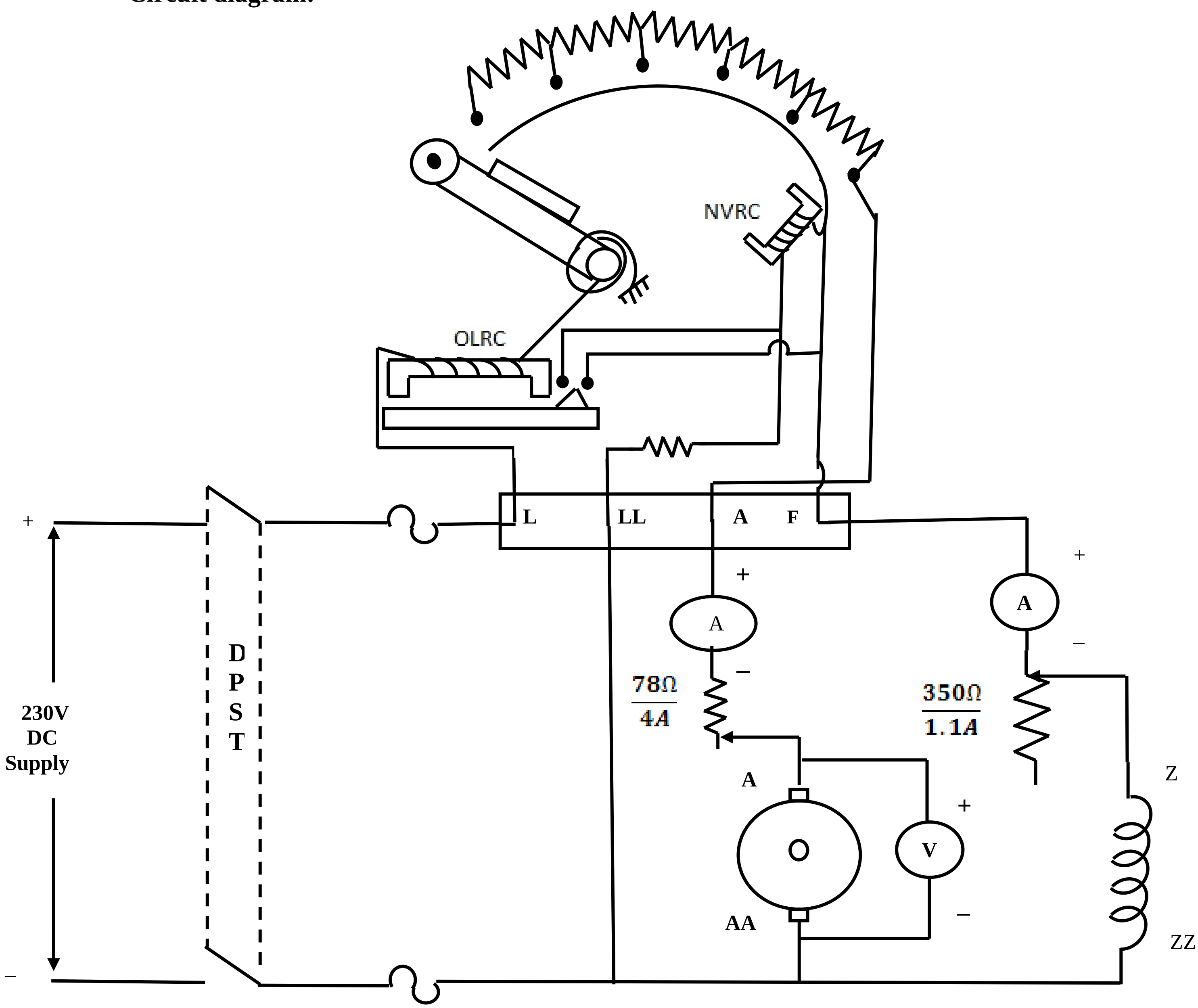


Result:

Remarks if any:

TITLE: **SPEED CONTROL OF DC SHUNT MOTOR**	GPRECD/EEE/EXPT-EMC-I(P) - 8
SCHEME-13	DATE: 01-07-2016

Circuit diagram:



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Viva Questions:

1.How does the speed of a DC shunt motor vary with armature voltage and field current?

2. Compare the resistance of the armature and field winding.

3.What is the importance of speed control of DC motor in industrial applications?

4.Which is of the two methods of speed control is better and why?

5.Why is the speed of DC shunt motor practically constant under normal load condition?

6. What are the factors affecting the speed of a DC shunt motor?

TITLE: **SEPARATION OF LOSSES OF DC MACHINE**	GPRECD/EEE/EXPT-EMC-I(P) -9
SCHEME-13	DATE: 01-07-2016

Objective:

To separate the constant losses of a DC machine into eddy current, hysteresis losses, windage and Frictional Losses

Apparatus:

DC Shunt Motor, Voltmeter, Ammeters, Tachometer, Required number of connecting wires

Name plate details:

Theory:

At a given excitation, friction losses and hysterisis are proportional to speed. Windage losses and eddy current losses on the other hand are both proportional to square of speed. Hence, for a given excitation (field current) we have,
Friction losses = AN Watts, Windage losses = BN^2 Watts
Hysterisis losses = CN Watts, Eddy current losses = DN^2 Watts; Where N = speed.
For a motor on no load, power input to the armature is the sum of the armature copper losses and the above losses.
In the circuit diagram, power input to the armature = V.Ia watts.
Armature copper losses = $Ia^2.Ra$ watts
$V.Ia – Ia^2.Ra = (A + C)N + (B + D)N^2$
$W/N = (A+C) + (B+D)N.$
The graph between W/N & N is a straight line, from which (A+C) and (B+D) can be found. In order to find A, B, C and D separately, let the field current be changed to a reduced value I_{f1}, and kept constant at that value.

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TITLE: **SEPARATION OF LOSSES OF DC MACHINE**	GPRECD/EEE/EXPT-EMC-I(P) -9
SCHEME-13	DATE: 01-07-2016

If, voltage is applied to the armature as before, we now have $W/N = (A+C^{I})\,N + (B+D^{'})\,N^{2}$ (at the reduced excitation, function and windage losses are still are AN and BN^{2}, but hysterisis losses become $C^{I}N$ and eddy current losses become $D^{I}\,N^{2}$). We can now obtain $(A+C^{'})$ and $(B+D^{'})$ as before.
Now, $C/C^{'}$ = (flux at normal excitation/flux at reduced excitation), and
$D/D^{'}$= (flux at normal excitation/flux at reduced excitation)
So, if we determine the ratio (flux at normal excitation/flux at reduced excitation) we can find A, B, C, D, C_{I}, & D_{I}.

Procedure:

1. The circuit is connected as shown in the figure.
2. The armature circuit rheostat is kept in maximum position before switching on the supply.
3. Motor is started with the help of a starter by keeping field rheostat in minimum position.
4. Field Rheostat is adjusted to get the field current I_f to its normal value or values at which losses are desired.
5. By varying armature rheostat, values of current, speed and voltage are noted.
6. Field current is kept constant while varying the armature rheostat.
7. Field rheostat is gradually decreased and is adjusted to another constant value of field current and above steps are repeated.
8. Graphs are plotted and losses are calculated.

Observations:

I_f (A)	I_L (A)	I_A (A)= I_L- I_f	V (v)	P=V I_L	Speed(N) (rpm)	P/N

Sample calculations:
From Graph A+C =
$A+C^{'}$ =
B+ D =

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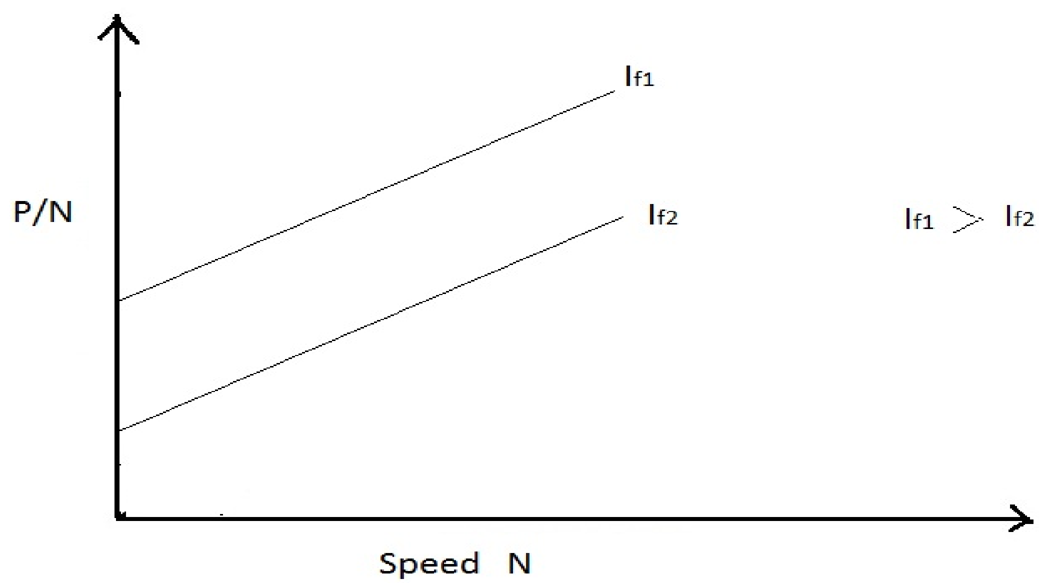
$C/C' = (I_{f1}/I_{f2})^{1.6} =$
$D/D' = (I_{f1}/I_{f2})^{2} =$
$D- D' =$
$C-C' =$
Once if C, C', D, D' are known then A and B can be found
Therefore A= and Pf= Friction losses= AN watts
B= Then Windage Losses $=P_w= BN^2$ watts

Hysterisis Losses = Ph = CN watts
Eddy current losses = Pe= DN^2 watts
Total Losses = Pf+Pw+Ph+Pe watts

Graphs:

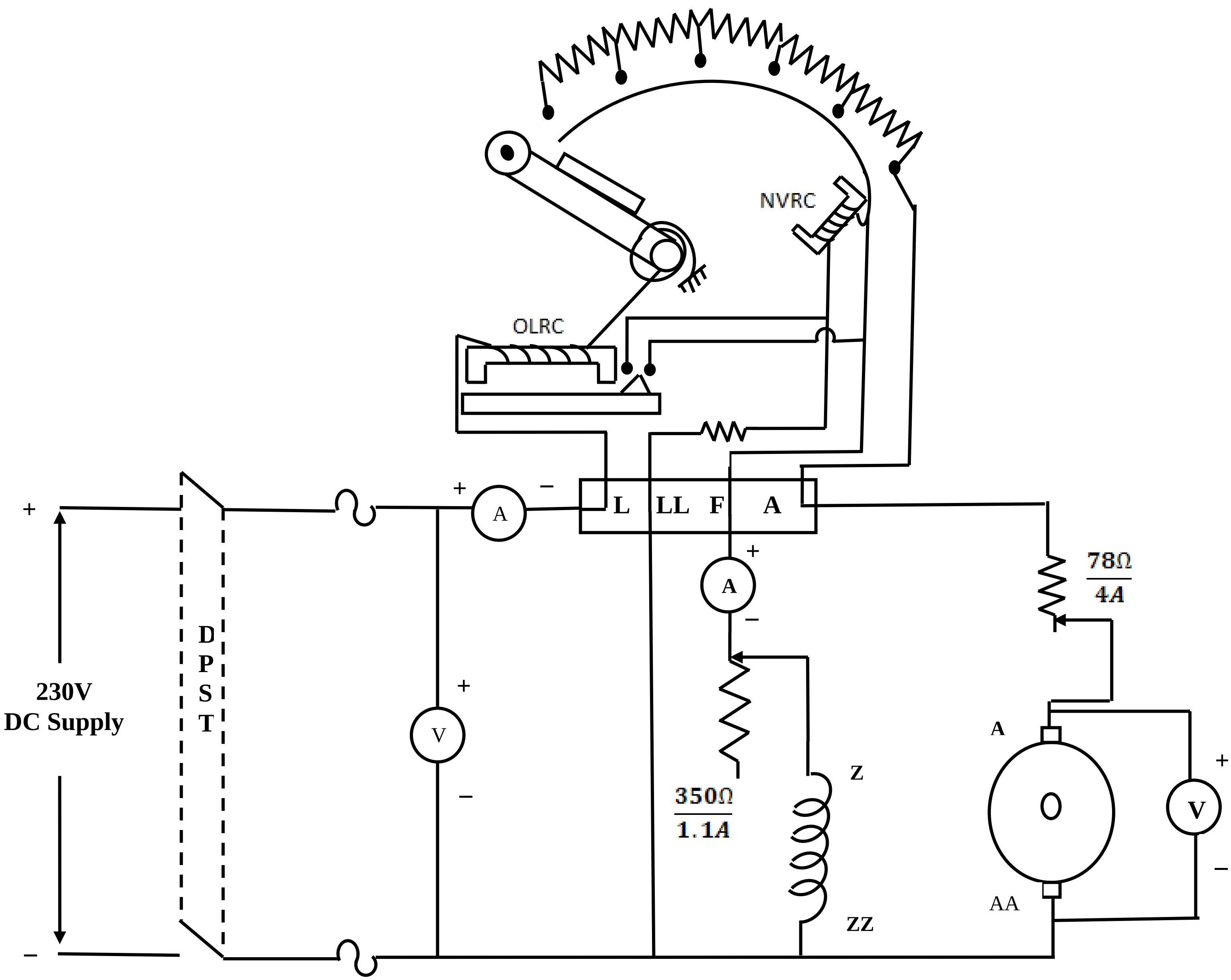


Result:

Remarks if any:

TITLE: **SEPARATION OF LOSSES OF DC MACHINE**	GPRECD/EEE/EXPT-EMC-I(P) -9
SCHEME-13	DATE: 01-07-2016

CIRCUIT DIAGRAM:



Viva Questions:

1. What do you mean by core loss in dc machine?
2. What are the parameters that influence the core losses of a dc machine?
3. Why do we call core loss as constant losses?
4. Explain why copper losses are called as variable losses?
5. What is the condition for maximum efficiency in dc machines?

TITLE: **LOAD TEST ON DC COMPOUND GENERATOR**	GPRECD/EEE/EXPT-EMC-I(P)-10
SCHEME-13	DATE: 01-07-2016

Objective:

To conduct load test on DC compound generator and to draw the external and internal characteristics of DC compound generator.

Apparatus:

DC Compound Motor-Generator Set, Voltmeters, Ammeters, Tachometer, Resistive Load, Required number of connecting wires

Name plate details:

Fuse ratings:

Theory:

A Compound generator consists of a series field winding and a shunt Field winding. It is further categorized into (a) cumulatively compound generator (b) Differentially Compounded generator.

Cumulatively Compound generator: In this generator, the flux produced by both field Windings adds up together. Hence, the net flux will be increased as the load on the Generator increases. The emf generated and hence, the terminal voltage increases with load till the series field is saturated. The terminal voltage decreases further Increase in the load current due to the armature reaction. Thus, the cumulatively Compounded Generator is categorized as (a) Flat- Compounded (b) Over Compounded and (c) Under Compounded based on the emf generated from No load to rated-load.

Differentially Compounded Generator: In this generator, the flux produced by both Field windings opposes each other. Hence, the net flux in the air gap decreases and the generated emf decreases with the increase in the load.

The graph between V_L and I_L is the External characteristic of the motor.

The graph between E and I_a is the Internal characteristic of the motor.

Prepared by: Sri C. Harinatha Reddy
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TITLE: **LOAD TEST ON DC COMPOUND GENERATOR**	GPRECD/EEE/EXPT-EMC-I(P)-10
SCHEME-13	DATE: 01-07-2016

Procedure:

1. Connections are made as per the circuit diagram.
2. After connecting the circuit, the motor field rheostat is kept at minimum position and generator field rheostat is kept at maximum position.
3. The generator is driven at its rated speed with the help of prime mover (DC motor).
4. The generator field excitation is adjusted to get the rated terminal voltage on open circuit.
5. A resistive load is connected as shown in figure through a 2-pole switch fuse and the generator is loaded gradually upto full load.
6. The field current of the generator is kept constant by adjusting the generator rheostat.
7. The speed of the motor is checked for different loads and it is kept constant by adjusting the motor rheostat.
8. The terminal voltage and shunt field current are noted for various loads.

Observations:

Cumulative Compound Generator:

I_f(A)	I_L(A)	$I_a = I_L + I_f$	V_t (v)	$Eg = V_t + I_a (R_a + R_{se})$

Differential Compound Generator:

I_f (A)	I_L (A)	$I_a = I_L + I_f$	V_t (v)	$Eg = V_t + I_a (R_a + R_{se})$

Sample Calculations:

For Cumulative Compound:

Armature Resistance (R_a) = Ω
Series field Resistance (R_{se}) = Ω
Field Current (I_f) = A
Load current (I_L) = A
Armature current (I_a) = $I_L + I_f$ A
Terminal Voltage (V_t)= V
Generated Voltage (Eg) = $V_t + I_a (R_a + R_{se})$V

For Differential Compound:

Armature Resistance (R_a) = Ω
Series field Resistance (R_{se}) = Ω
Field Current (I_f) = A
Load current (I_L) = A
Armature current (I_a) = $I_L + I_f$ A
Terminal Voltage (V_t)= V
Generated Voltage (Eg) = $V_t + I_a (R_a + R_{se})$V

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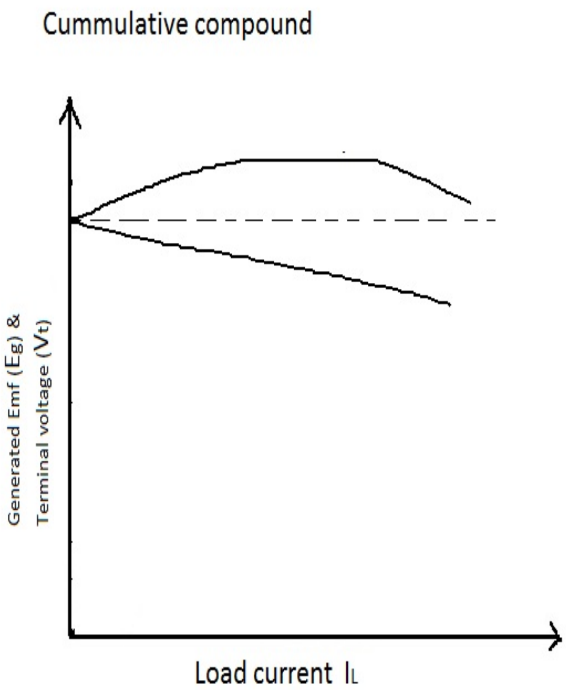
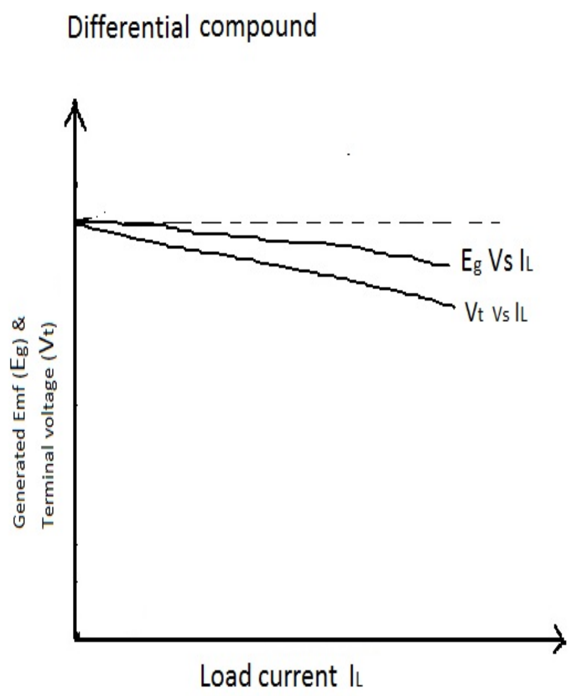
Graphs:





Result:

Remarks if any:

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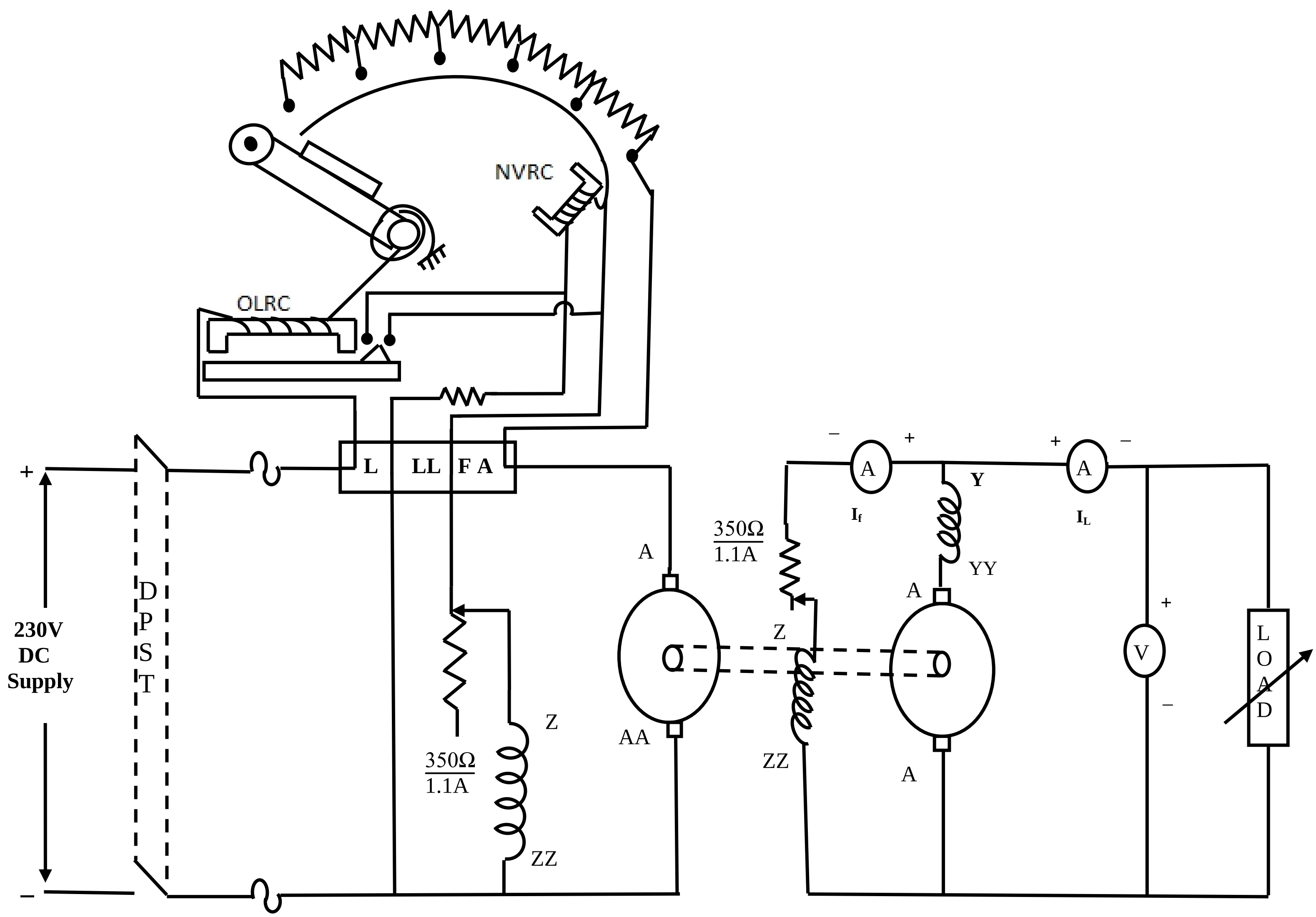
CIRCUIT DIAGRAM:

DC Cumulative Compound Generator



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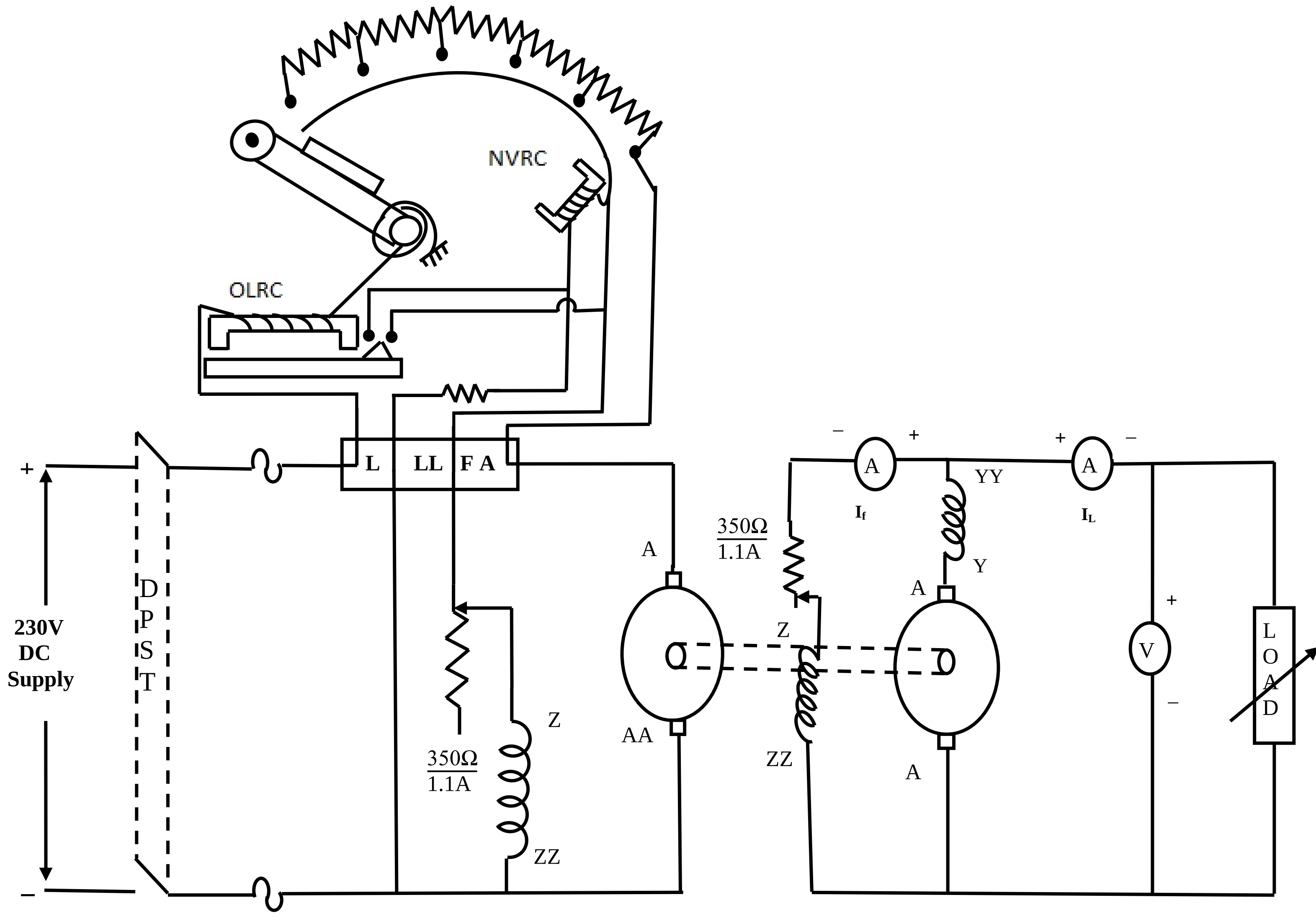
DC Differential Compound Generator



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Viva Questions:

1. What happens to induced emf when the compound machine is operated as cumulative compounding when the load is increased?
2. Which winding in compound generator is having large area of cross section of the copper and Why?
3. Explain why the commutator is used in dc machines?
4. What is the difference between the 3-point and 4-point starter?
5. What is armature reaction in dc machines?
6. How do you compensate the armature reaction in dc machines?
7. Why do we take the field rheostat in minimum position in the case of motor operation and it is in maximum position in the case of generator action?