QMP 7.1 D/F



Channabasaveshwara Institute of Technology

(An ISO 9001:2008 Certified Institution)

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.



Department of Electrical & Electronics Engineering

DC MACHINES AND SYNCHRONOUS MACHINES LAB

10EEL67

B.E. - VI Semester

Lab Manual 2016-17

Name : _____

USN : _____

Batch : _____ Section : _____

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Department of Electrical & Electronics Engineering

DC MACHINES & SYNCHRONOUS MACHINES LAB

Version 1.0

August 2015

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Channabasaveshwara Institute of Technology

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OUR VISION

To create centers of excellence in education and to serve the society by enhancing the quality of life through value based professional leadership.

OUR MISSION

- To provide high quality technical and professionally relevant education in a diverse learning environment.
- To provide the values that prepare students to lead their lives with personal integrity, professional ethics and civic responsibility in a global society.
- To prepare the next generation of skilled professionals to successfully compete in the diverse global market.
- To promote a campus environment that welcomes and honors women and men of all races, creeds and cultures, values and intellectual curiosity, pursuit of knowledge and academic integrity and freedom.
- To offer a wide variety of off-campus education and training programmes to individuals and groups.
- To stimulate collaborative efforts with industry, universities, government and professional societies.
- To facilitate public understanding of technical issues and achieve excellence in the operations of the institute.

QUALITY POLICY

Our organization delights customers (students, parents and society) by providing value added quality education to meet the national and international requirements. We also provide necessary steps to train the students for placement and continue to improve our methods of education to the students through effective quality management system, quality policy and quality objectives.

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION:

To be a department of excellence in electrical and electronics Engineering education and Research, thereby to provide technically competent and ethical professionals to serve the society.

MISSION:

- To provide high quality technical and professionally relevant education in the field of electrical engineering.
- To prepare the next generation of electrically skilled professionals to successfully compete in the diverse global market.
- To nurture their creative ideas through research activities.
- To promote research and development in electrical technology and management for the benefit of the society.
- To provide right ambience and opportunities for the students to develop into creative, talented and globally competent professionals in electrical sector.

Caution

- *Do not play with electricity.*
- *Carelessness not only destroys the valuable equipment in the lab but also costs your life.*
- *Mere conductivity of the experiment without a clear knowledge of the theory is of no value.*
- *Before you close the switch, think of the consequences.*
- *Do not close the switch until the faculty-in-charge checks the circuit.*

Instructions to the Candidates

- ✓ Students should come in leather shoes and thoroughly prepared for the experiment to be conducted.
- ✓ Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
- ✓ Name plate details including the serial number of the machine used for the experiment should be invariably recorded.
- ✓ Experiment should be started only after the staff-in-charge has checked the circuit diagram.
- ✓ All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.
- ✓ Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.
- ✓ Practical record note book should be maintained neatly.
- ✓ Students should obtain the signature of the staff-in-charge in the observation / Manual book after completing each experiment.
- ✓ Theory regarding each experiment should be written in the practical record before procedure in your own words.

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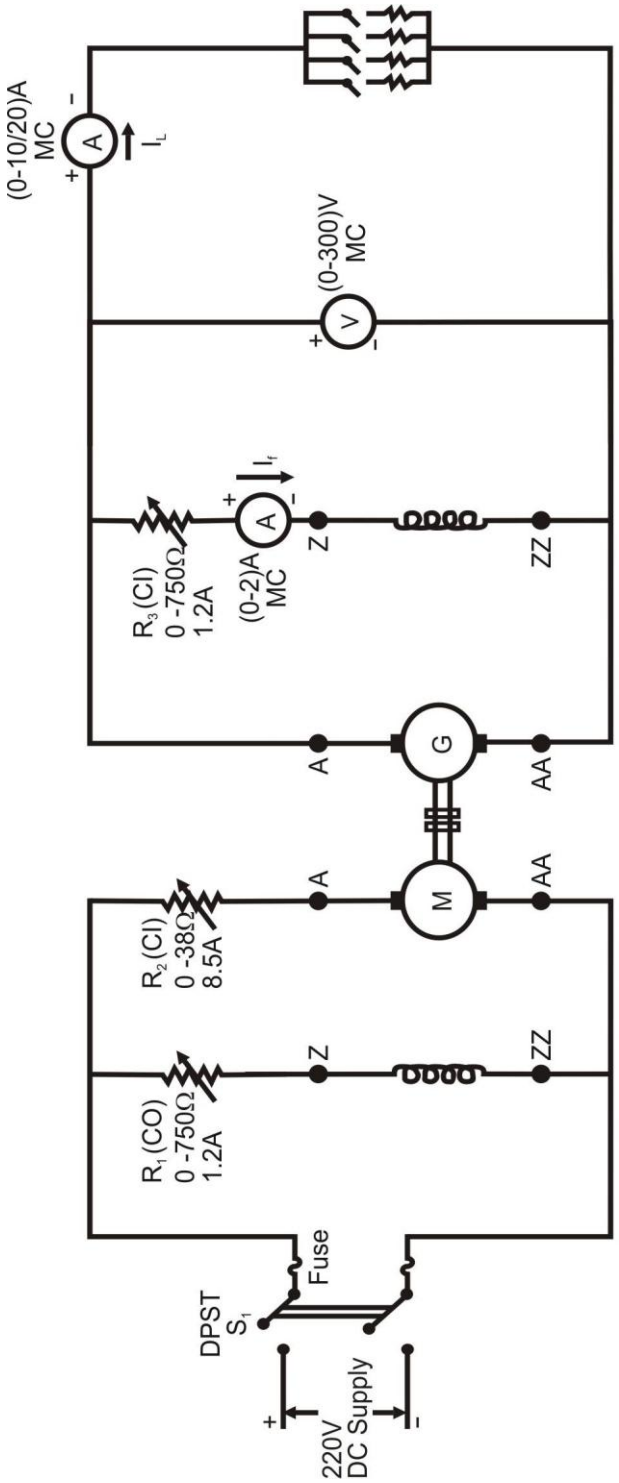
Syllabus

Dc machines and Synchronous Machines Lab

Sub Code: 10EEL67	**IA Marks: 25**
No. of Practical Hrs/ Week: 03	**Exam Hours: 03**
Total Hrs. 42	**Exam Marks: 50**

1. Load characteristics of a D.C. shunt and compound generator - i) Short shunt-Cumulative and Differential (ii) Long shunt-Cumulative and Differential.
2. Load test on a DC motor- determination of speed-torque and HP-efficiency characteristics.
3. Swinburne's Test.
4. Hopkinson's Test.
5. Field's test on series motors.
6. Retardation test- electrical braking method.
7. Speed control of DC motor by armature voltage control and flux control.
8. Ward Leonard Method of speed control of D.C. Motor.
9. Voltage regulation of an alternator by EMF and MMF method.
10. Voltage regulation of an alternator by ZPF method.
11. Slip test and determination of regulation.
12. Performance of synchronous generator connected to infinite bus, under constant power and variable excitation & vice - versa.
13. V and Inverted V curves of a synchronous motor.
14. Measurement of X_1, X_2 and X_0 of a Synchronous generator and calculation of currents for an LG,LL or LLG fault.

Resistive Load



Circuit Diagram (1.a)

LOAD CHARACTERISTICS OF DC SHUNT GENERATOR

Name Plate Details

	Motor	Generator
Kw		
Volt		
Amp		
rpm		

EXPERIMENT NO. 1 **Date: ___/___/_____**

LOAD CHARACTERISTICS OF A DC-SHUNT GENERATOR

Aim

To draw the external and internal characteristics of the given D.C Shunt Generator.

Apparatus Required

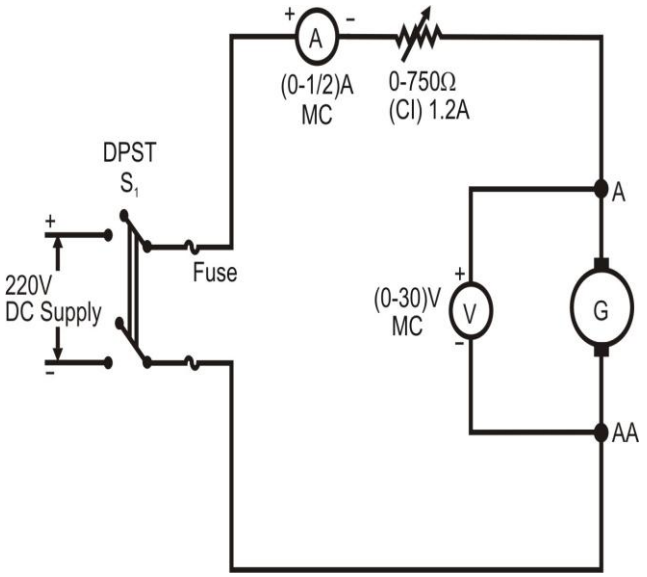
Sl. No.	Particulars	Range	Type	Quantity
01	Voltmeters	0-300V 0-30V	MC MC	01 01
02	Ammeters	0-10/20 A 0-1/2A	MC MC	01 01
03	Rheostats	0-750Ω,1.2A 0-38Ω, 8.5A	- -	02 01
04	Tachometer	-	-	01

Procedure

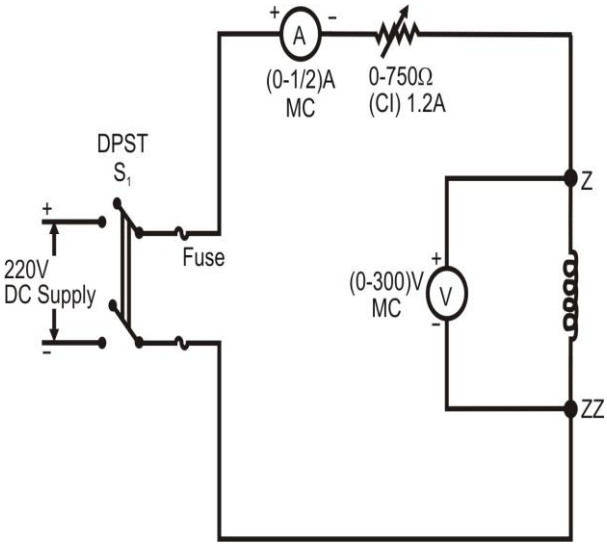
1. Connections are made as shown in the circuit diagram (1.a).
2. Keeping the rheostat R_1 in the field circuit of the motor in cut-out position, the rheostat R_2 in the armature circuit of the motor and the rheostat R_3 in the field circuit of the generator in cut-in positions, and all load switches in off condition, the supply switch (S_1) is closed, the motors starts rotating.
3. The motor is brought to its rated speed by gradually cutting out rheostat R_2 completely and cutting in the rheostat R_1, if necessary.
4. The generator voltage is built up to its rated value by gradually cutting-out rheostat R_3.
5. The generator is loaded in steps by gradually applying the loads. At each step the corresponding values of the terminal voltage (V_L), the load current (I_L) and the field current (I_f) are noted, after the motor is brought to its rated speed by operating the rheostat R_1.
   Note: (Motor or Generator should not be loaded beyond its rated value)
6. The load on the generator is completely removed; all the rheostats are brought back to their respective initial positions, then the supply switch (S_1) is opened.

Determination of Armature Resistance (R_a) by V- I method.

a. Connections are made as shown in the circuit diagram (1.b)
b. Keeping the rheostat in cut-in position, the supply switch (S_1) is closed, Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and voltmeter are noted down.
c. The supply switch (S_1) is opened.

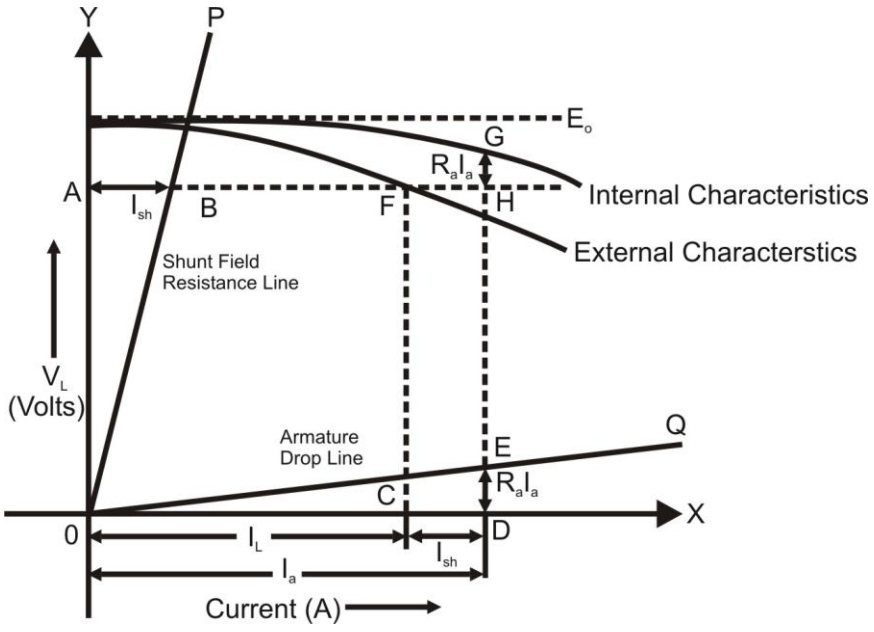


Circuit Diagram (1.b)
Determination of Armature Resistance (Ra)



Circuit Diagram (1.c)
Determination of Shunt Field Resistance (Rsh)

Model Graph



Determination of Shunt field Resistance (R_{sh}) by V- I method.

a. Connections are made as shown in the circuit diagram (1.C)
b. Keeping the rheostat in cut-in position, the supply switch (S_1) is closed , Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and voltmeter are noted down.
c. The supply switch (S_1) is opened.

Characteristics Curves

a. External Characteristics

A graph of V_L v/s I_L is drawn, which represents the 'External Characteristics curve'

b. Internal Characteristics

I. Graphical method

1. To Draw Q: Consider any reading I_a vs I_aR_a, Draw a Straight line from origin
2. To Draw P: Consider any reading I_f vs V_L. Draw a Straight line from origin
3. Shunt field resistance line OP and armature line OQ are drawn as shown in the External characteristics curve.
4. A point F is selected on the external characteristics curve.
5. From point F, horizontal line FA and vertical line FC are drawn which are intersecting Y and X axes respectively.
6. A point D on X-axis is selected so that CD=AB, representing the shunt field Current.
7. From point D a vertical line DE is drawn and it is produced to intersect to the Produced line AF at point H.
8. Point G is selected on the produced line DH so that HG=DE, which represents the Armature drop.
9. Terminal Voltage : V = OA= DH
10. Armature Voltage Drop : $I_a R_a$ = DE
11. Therefore EMF generated : $E_g = V + I_a R_a$ volt
    =DH+DE
    =DH+HG (where HG=DE)
    =DG
12. Similarly some more points are located on the external characteristics curve and corresponding points are determined.
13. A curve is drawn passing through these points, which represents 'Internal Characteristics Curve'.

Tabular Column

Sl. No	V_L (Volt)	I_L (Ampere)	I_f (Ampere)	$I_a = I_L + I_f$ (Ampere)	$E_g = V + I_a R_a$ (Volts)	Speed (rpm)

Determination of Armature Resistance (R_a)

Sl. No	V (Volts)	I (Ampere)	Resistance $R_a = V/I\ \Omega$

Determination of Shunt Resistance (R_{sh})

Sl. No	V (Volts)	I (Ampere)	Resistance $R_{sh} = V/I\ \Omega$

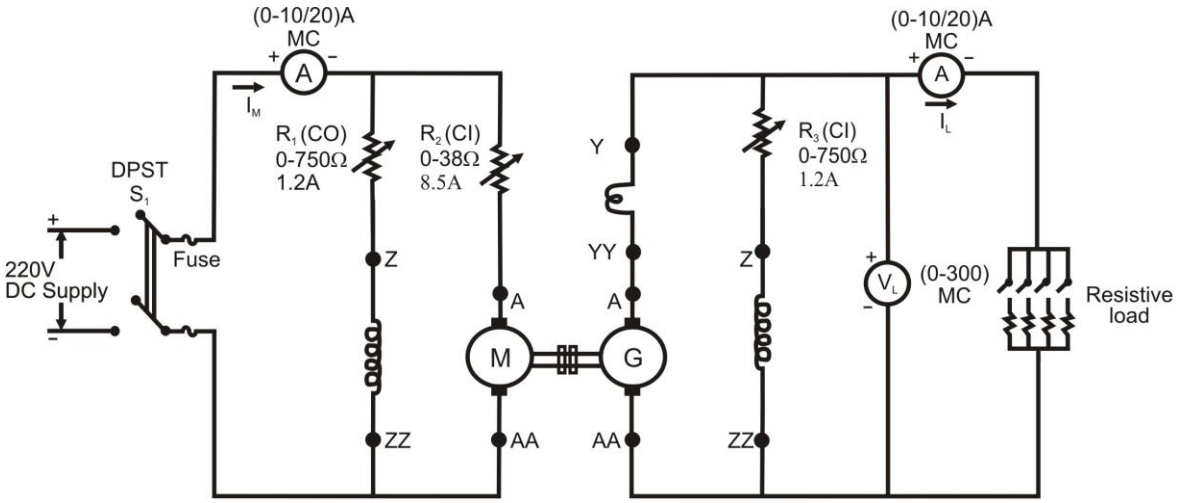
Calculation…

II. Analytical Method

Armature Current: $I_a = I_L + I_{sh}$ Amps

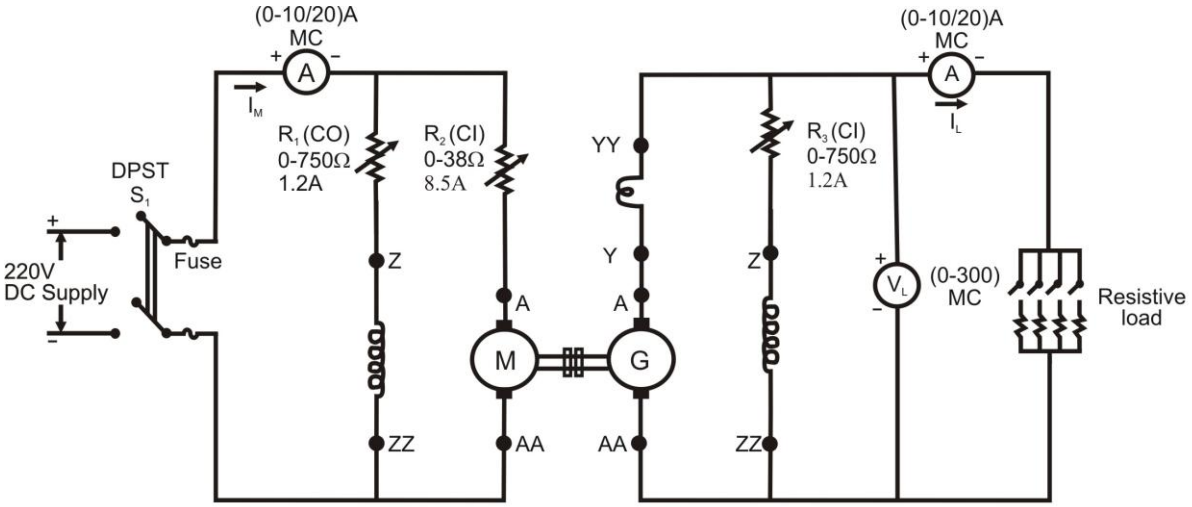
EMF Generated : $E_g = V + I_a R_a$ Volts

A graph of E_g v/s I_a is drawn, which represents 'Internal characteristics'**.**



Circuit Diagram (2.a)

LOAD CHARACTERISTICS OF DC COMPOUND GENERATOR (LONG SHUNT- DIFFERENTIAL)



Circuit Diagram (2.b)

LOAD CHARACTERISTICS OF DC COMPOUND GENERATOR (LONG SHUNT-CUMULATIVE)

Name Plate Details

	Motor	Generator
Kw		
Volt		
Amp		
rpm		

EXPERIMENT NO. 2 **Date: ___/___/_____**

LOAD CHARACTERISTICS OF D.C. COMPOUND GENERATOR

Aim

To draw the external characteristics of the given D.C Compound Generator.

Apparatus Required

Sl. No.	Particulars	Range	Type	Quantity
01	Voltmeter	0-300V	MC	01
02	Ammeters	0-10/20 A	MC	02
03	Rheostats	0-750Ω,1.2A 0-38Ω, 8.5A	- -	02 01
04	Tachometer	-	-	01

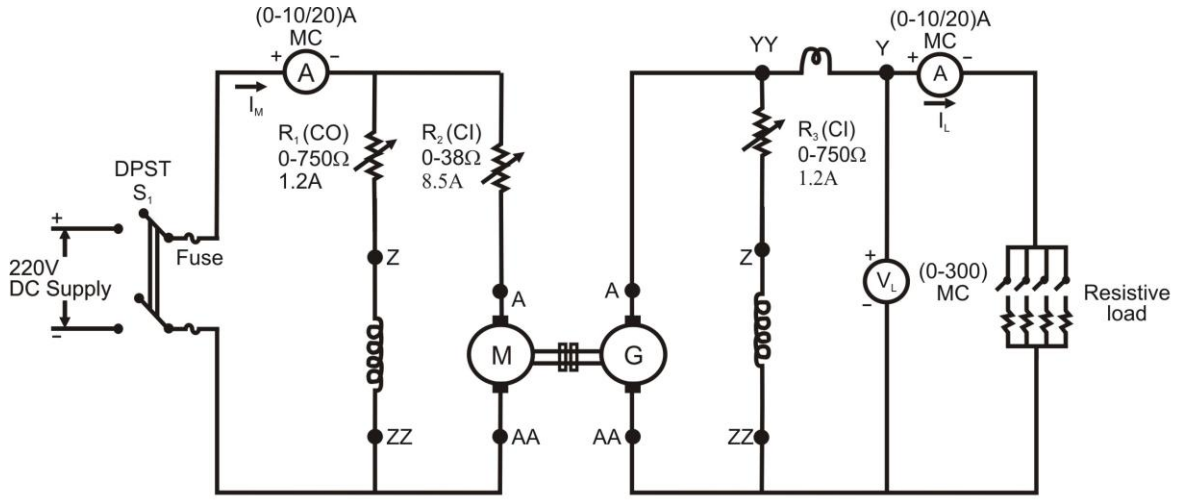
Procedure

1. Connections are made as shown in the circuit diagram (2.a).
2. Keeping the rheostat **R_1** in the field circuit of the motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor and the rheostat **R_3** in the field circuit of the generator in **cut-in** positions, and all load switches in off condition, the supply switch **(S_1)** is closed.
3. The motor is brought to its rated speed by gradually cutting out rheostat R_2 and cutting in the rheostat R_1, if necessary.
4. The generator voltage is built up to its rated value by gradually cutting-out rheostat R_3.
5. The generator is loaded in steps by gradually applying the loads. At each step the corresponding values of the terminal voltage (V_L) and load current (I_L) are noted, after the motor is brought to its rated speed by operating the rheostat R_1.
   Note: (Motor or Generator should not be loaded beyond its rated value)
6. The load on the generator is completely removed; all the rheostats are brought back to their respective initial positions and the supply switch (S_1) is opened.
7. The experiment is repeated for circuit diagrams (2.b), (2.c) and (2.d).

Characteristic Curves

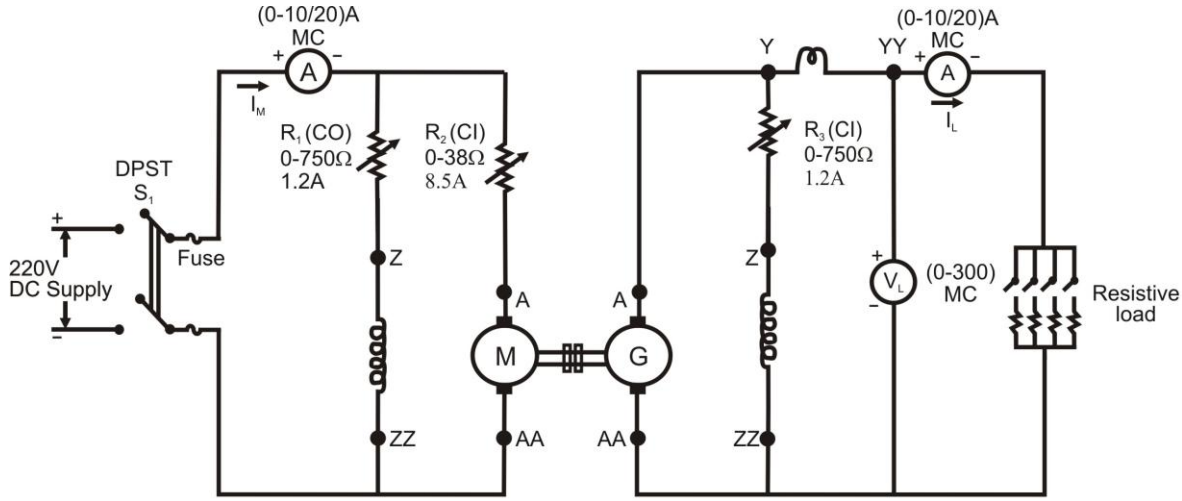
External Characteristics

A graph of V_L v/s I_L is drawn as shown in model graph), which represents the 'External Characteristics curve'



Circuit Diagram (2.c)

LOAD CHARACTERISTICS OF DC COMPOUND GENERATOR (SHORT SHUNT- DIFFERENTIAL)



Circuit Diagram (2.d)

LOAD CHARACTERISTICS OF DC COMPOUND GENERATOR (SHORT SHUNT- CUMULATIVE)

Tabular Column

1. LONG SHUNT DIFFERENTIAL

Sl. No	V_L (Volt)	I_L (Ampere)	Speed (r.p.m)

2. LONG SHUNT CUMULATIVE

Sl. No	V_L (Volt)	I_L (Ampere)	Speed (r.p.m)

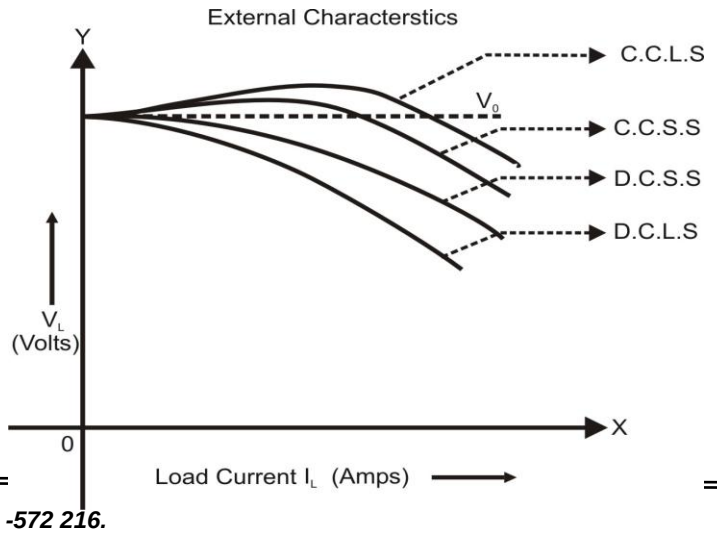
3. SHORT SHUNT DIFFERENTIAL

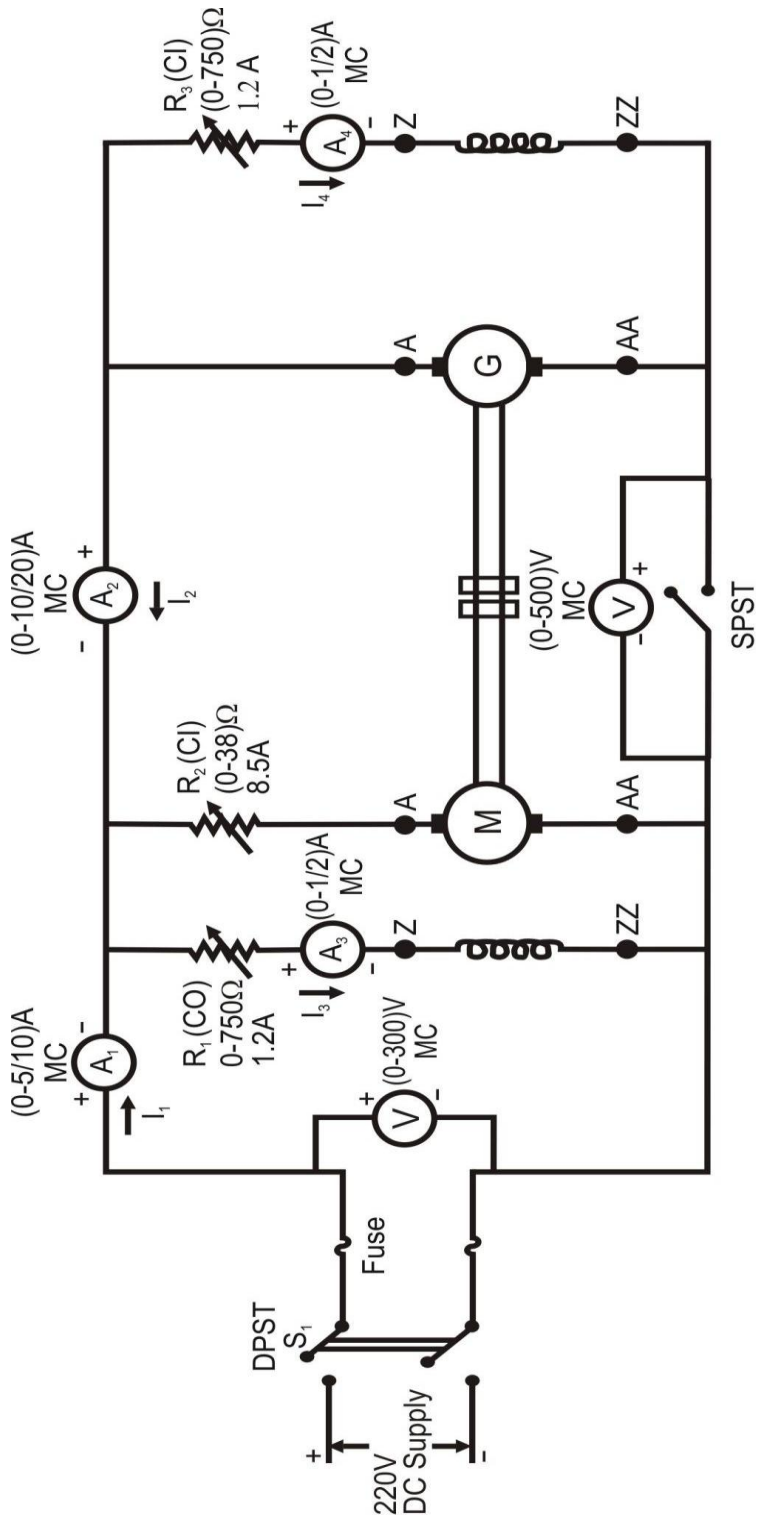
Sl. No	V_L (Volt)	I_L (Ampere)	Speed (r.p.m)

4. SHORT SHUNT CUMULATIVE

Sl. No	V_L (Volt)	I_L (Ampere)	Speed (r.p.m)

Model Graph





Circuit Diagram (3.a)
HOPKINSON'S TEST

Name Plate Details

	Motor	Generator
Kw		
Volt		
Amp		
rpm		

EXPERIMENT NO. 3 **Date: ___/___/_____**

HOPKINSON'S TEST

Aim

To determine the stray loss and hence to find the efficiency of the given two Identical D.C Machines.

Apparatus Required

Sl.No.	Particulars	Range	Type	Quantity
01	Voltmeters	0-500V 0-300V	MC MC	01 01
02	Ammeters	0-10/20A 0-1/2A 0-5/10 A	MC MC MC	01 02 01
03	Rheostats	0-750Ω,1.2A 0-38,8.5A	- -	02 01
04	Tachometer	-	-	01

Procedure

1. Connections are made as shown in the circuit diagram (3.a)
2. Keeping the rheostat **R_1** in the field circuit of motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor and the rheostat **R_3** in the field circuit of the generator in **cut-in** positions and the **SPST** switch in open position, the supply switch **(S_1)** is closed.
3. The motor is brought to its rated speed by cutting out the rheostat R_2 and then by cutting in the rheostat R_1, if necessary.
4. The excitation of the generator is increased gradually by cutting out the rheostat R_3, until the voltmeter connected across the SPST switch reads zero.
5. The SPST switch is closed. Now the generator is connected in parallel with the motor.
6. The generator is overexcited or the motor is under excited by varying their field rheostats. At I_2=rated current, the readings of all the meters are noted down.
7. The rheostat R_3 (if the motor is under excited vary the rheostat R_1) is brought to its initial position, then the SPST switch is opened, all other rheostats are brought back to their respective initial positions, and supply switch (S_1) is opened.

Determination of Armature Resistance (R_a) by V-I Method

a. Connections are made as shown in the circuit diagram (3.b)

b. Keeping the rheostat in cut-in position, the supply switch (S_1) is closed, Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and Voltmeter are noted down.

c. The supply switch (S_1) is opened.

Tabular column					Stray Loss of Each M/C	MOTOR				GENERATOR			
V Volt	I_1 amp	I_2 Amp	I_3 Amp	I_4 Amp		I/P Watt	Total Loss Watt	O/P Watt	% Efficiency	I/P Watt	Total Loss Watt	O/P Watt	% efficiency

Determination of Armature Resistance:

	V Volt	I Amp	R = (V/I) ohm
Motor			R am =
Generator			R ag =

Circuit Diagram (4.b)
DETERMINATION OF ARMATURE RESISTANCE Ra

Calculations

I. To find stray losses of each machine

Armature copper loss of motor = $(I_1 + I_2 - I_3)^2 \times R_{am}$ Watt ----------(1)

Field copper loss of motor = $V \times I_3$ Watt ---------- (2)

Armature copper loss of generator = $(I_2 + I_4)^2 \times R_{ag}$ Watt ----------(3)

Field copper loss of generator = $V \times I_4$ Watt ---------- (4)

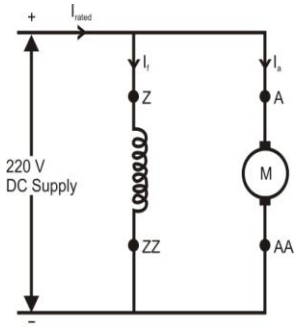
Total copper losses = (1) + (2) + (3) + (4)

Total I/P to the M-G set = $V \times I_1$ Watts

Stray losses for both machines = $W_s = [(V \times I_1)$ - Total copper losses] Watt

Therefore Stray loss for each M/C = $W_s / 2$ Watt

II. Efficiency when working as a motor



I/P to the motor = V (x. I_{rated}) Watt

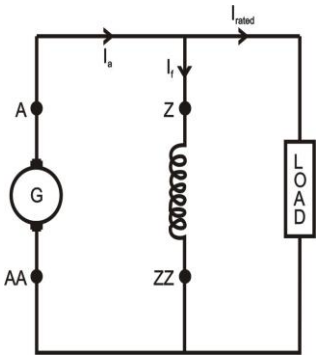
Where x = (1, 3/4, 1/2, 1/4)

Total losses = $(x.I_{rated} - I_3)^2 \times R_{am} + (V \times I_3) + (W_s / 2)$ **Watt**

O/P of motor = (I/P of motor – Total loss) Watt

$\%\eta_m$ = (output/ input) ×100

III. Efficiency when working as a generator



O/P of the generator = V (x. I_{rated})Watt

Where x = (1, 3/4, 1/2, 1/4)

Total losses = $(x. I_{rated} + I_4)^2 \times R_{ag} + (V \times I_4) + (W_s / 2)$**Watt**

I/P to the generator = (O/P of the generator +

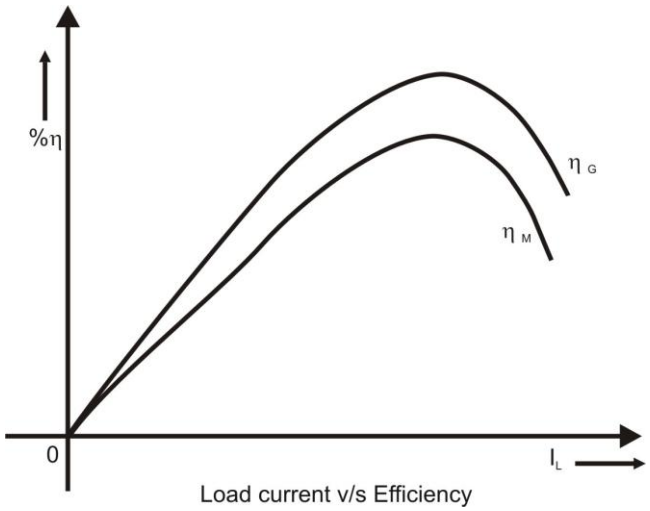
Total losses) Watt

$\%\ \eta_g$ = (output / input) ×100

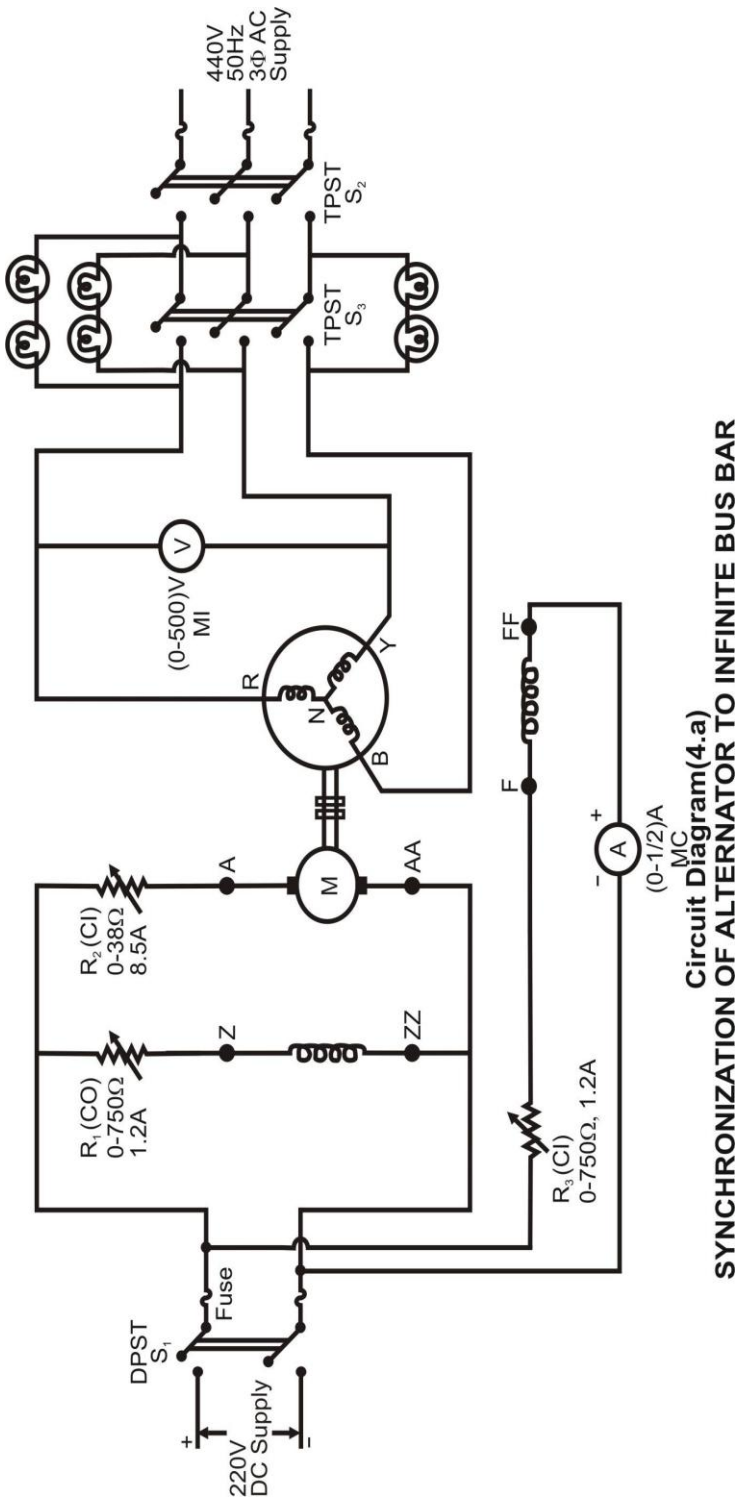
Tabular Column

Sl.No	% η_g	% η_m

Model Graph



Load current v/s Efficiency



Circuit Diagram(4.a)
SYNCHRONIZATION OF ALTERNATOR TO INFINITE BUS BAR

NAME PLATE DETAILS

D.C. Shunt motor	
Kw	
Volt	
Amp	
Rpm	

Alternator	
KVA	
Phase	
Hz	
Volt	
Amp	
Rpm	

EXPERIMENT NO. 4 **Date: ___/___/_____**

SYNCHRONIZATION OF ALTERNATOR TO INFINITE BUS AND DETERMINATION OF PERFORMANCE UNDER CONSTANT POWER AND VARIABLE EXCITATION & VICE-VERSA.

Aim

To operate the Alternator on

- Infinite Bus.
- Constant Power and Variable Excitation.
- Variable Excitation and Constant Power.

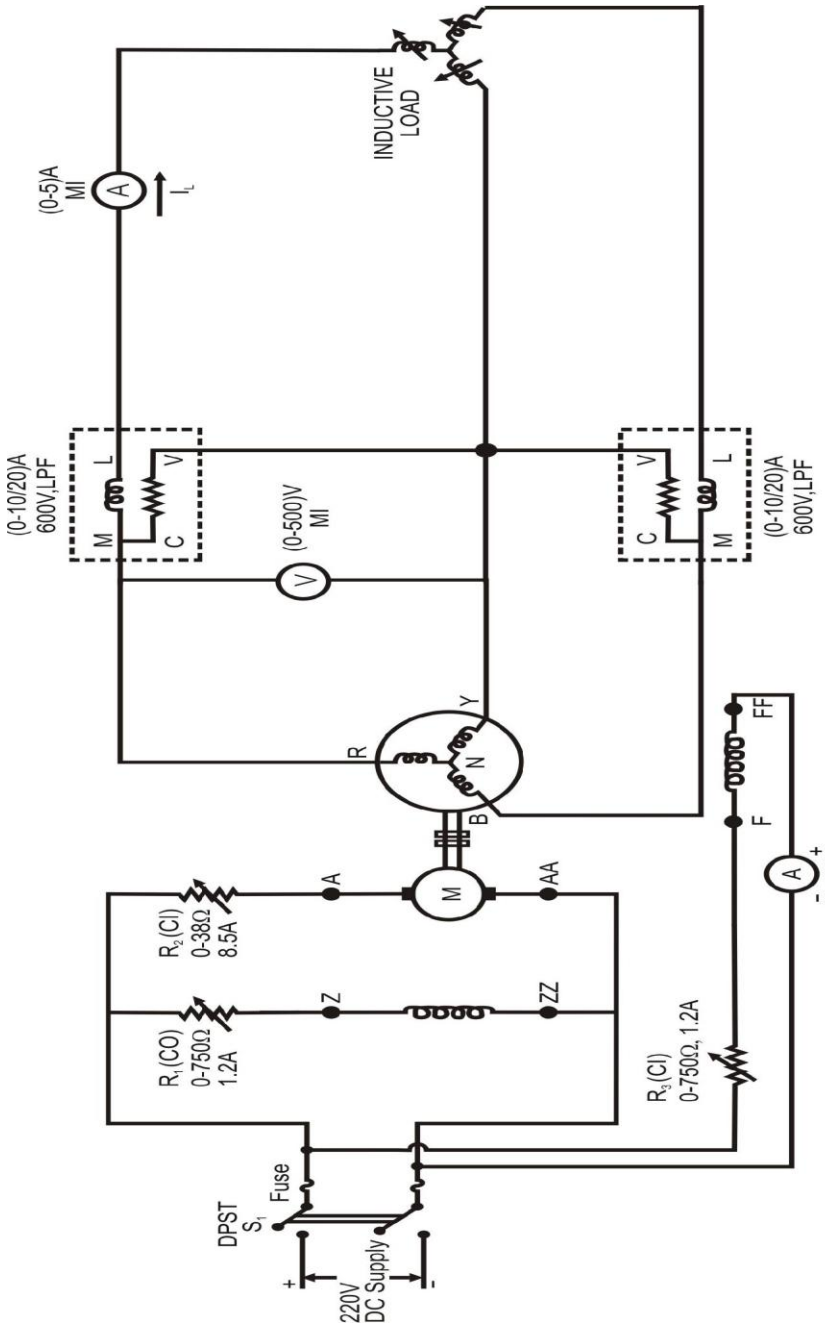
Apparatus Required

Sl.No.	Particulars	Range	Type	Quantity
01	Voltmeter	0 – 500 V	MI	01
02	Ammeters	0-1/2A 0-5/10A	MC MI	01 01
03	Rheostats	0-750Ω,1.2A 0-38Ω,8.5A	- -	02 01
04	Watt meters	10/20A, 0 – 600 V	LPF	02
05	Tachometer	-	-	01

Procedure

a. Operation on Infinite Bus Bar

1. Connections are made as shown in the circuit diagram (4.a)
2. Keeping the rheostat **R_1** in the field circuit of motor in **cut-out** position, the rheostat **R_2** in the armature circuit of motor and the rheostat **R_3** in the field circuit of alternator in **cut-in** positions, the bus bar switch **(S_2)** and synchronizing switch (**S_3**) in **open** positions, the supply switch **(S_1)** is closed.
3. The motor is brought to the synchronous speed of the alternator by gradually cutting out the rheostat R_2 and cutting in the rheostat R_1, if necessary.
4. By gradually cutting out the rheostat R_3, the alternator voltage is built-up to the bus bar voltage.
5. Now, bus bar switch (S_2) is closed, and the phase sequence is verified. For correct phase sequence, all the lamps will flicker simultaneously. Otherwise, they flicker alternately. If they flicker alternatively the switch S_2 is opened and alternator voltage is minimized by varying R_3, then minimize the motor speed by varying R_1 and R_2 and open supply switch (S_1). The connections of any two terminals of switch S_3 are interchanged to get the correct phase sequence.
6. Repeat step number 2, 3 and 4.
7. By varying the rheostats R_1, R_2 and R_3 the dark period of the lamps are obtained.
8. When all the lamps are in dark condition, the synchronization switch S_3 is closed and now the alternator is connected in parallel with the bus bar.
9. Switches (S_3) and (S_2) are opened; all the rheostats are brought back to their respective initial positions, and supply switch (S_1) is opened.



CIRCUIT DIAGRAM (4.b)
CONSTANT POWER - VARIABLE EXCITATION & VICE-VERSA

b. Constant Power - Variable Excitation Operation

1. Connections are made as shown in the circuit diagram (4.b)
2. Follow the procedure steps 2, 3.
3. By gradually cutting out the rheostat R_3, the alternator voltage is built-up to its rated voltage.
4. Apply load gradually.
5. Vary generator excitation (R3) to keep wattmeter readings constant (Total Power).
6. Tabulate the readings.
7. Bring back the load to zero, reduce the excitation to a normal value and all rheostats are brought back to respective initial positions & supply switch (S_1) is opened.

c. Constant Excitation - Variable Power Operation

1. Connections are made as shown in the circuit diagram (4.b)
2. Follow the procedure steps 2, 3.
3. By gradually cutting out the rheostat R_3, the alternator voltage is built-up to its rated voltage.
4. Apply load in steps & note down all meter readings (Excitation should be constant by adjusting the speed of the Motor).
5. Bring back the load to zero, reduce the excitation to a normal value and all rheostats are brought back to respective initial positions & supply switch (S_1) is opened.

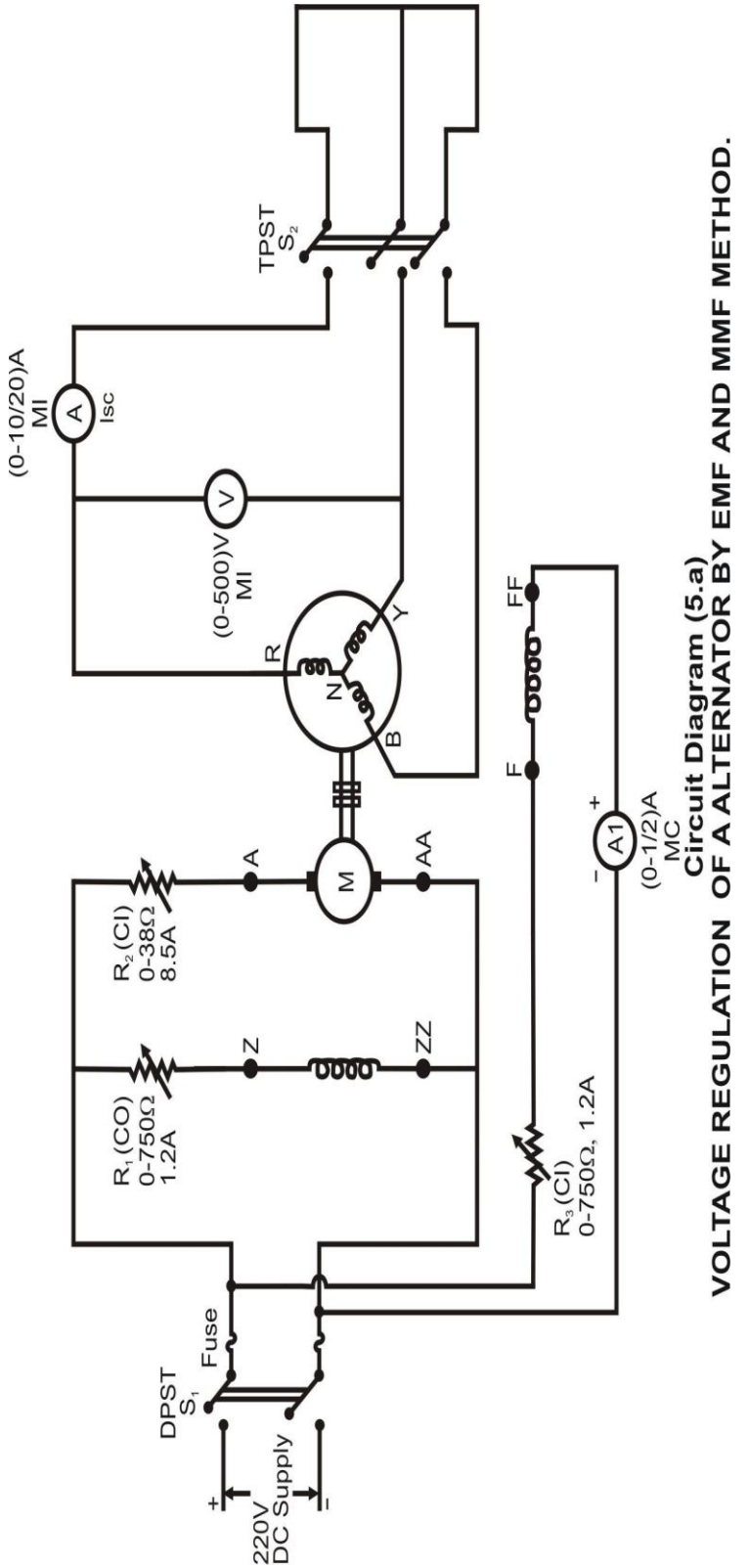
Tabular Column

1. Constant Power - Variable Excitation Operation

Sl. No.	I_f (A)	Power (W1+W2)	Speed (RPM)	Voltage (V)	I_L (A)

2. Constant Excitation - Variable Power Operation

Sl. No.	I_f (A)	Power (W1+W2)	Speed (RPM)	Voltage (V)	I_L (A)



Circuit Diagram (5.a)

VOLTAGE REGULATION OF A ALTERNATOR BY EMF AND MMF METHOD.

NAME PLATE DETAILS

D.C. Shunt motor	
Kw	
Volt	
Amp	
Rpm	

Alternator	
KVA	
Phase	
Hz	
Volt	
Amp	
Rpm	

EXPERIMENT NO. 5 **Date: ___/___/_____**

REGULATION OF ALTERNATOR BY EMF AND MMF METHOD

Aim

To determine the percentage regulation of the given three phase alternator by Open circuit and short circuit tests.

- By EMF method
- By MMF method

Apparatus Required

Sl.No	Particulars	Range	Type	Quantity
01	Voltmeters	0-30V 0-500V	MC MI	01 01
02	Ammeters	0-10/20A 0-1/2A	MI MC	01 01
03	Rheostats	0-750Ω,1.2A 0-38Ω,8.5A	-	02 01
04	Tachometer	-	-	01

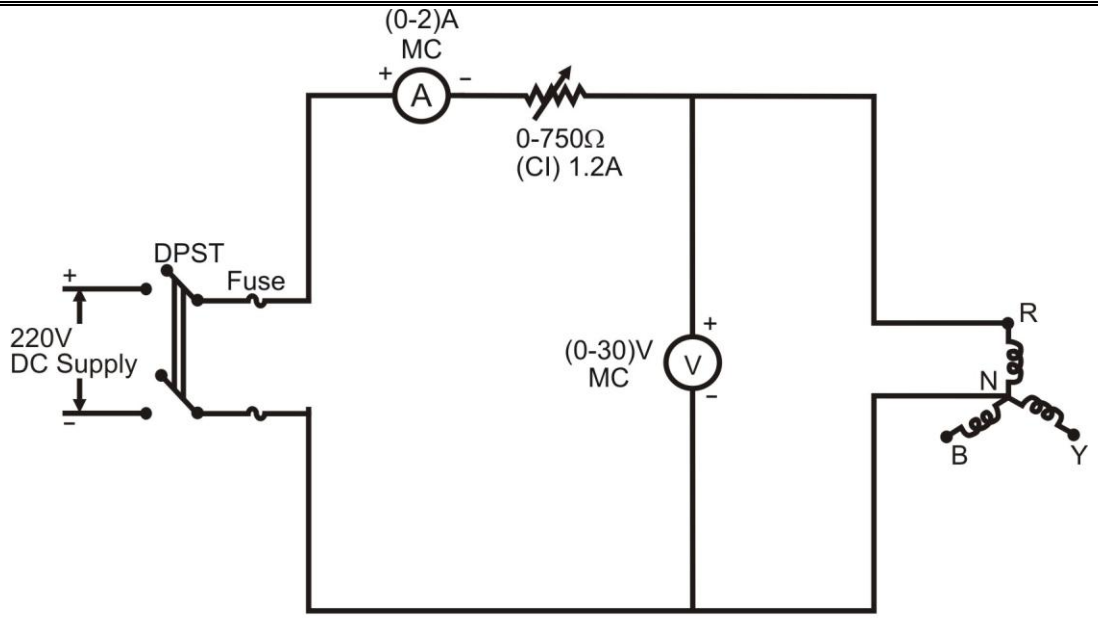
Procedure

a. Open Circuit Test

1. Connections are made as shown in the circuit diagram (5.a)
2. Keeping the rheostat **R_1** in the field circuit of motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor and the rheostat **R_3** in field circuit of the alternator in **cut-in** positions and **TPST (S_2)** in open position, the supply switch **(S_1)** is closed.
3. The motor is brought to synchronous speed by cutting out the rheostat R_2 and then by cutting in the rheostat R_1, if necessary.
4. By gradually cutting out the rheostat R_3, the readings of ammeter (A_1, 0-2A) and voltmeter (V) are noted down.
5. The above step is continued until voltmeter reads about 1.25 times the rated voltage of the alternator.

b. Short Circuit Test

1. The rheostat R_3 is brought to its initial position (cut-in) and TPST (S_2) is closed.
2. By gradually cutting out the rheostat R_3, reading of the ammeter (A_2, 0-10/20A) is adjusted to the rated current of the alternator and the corresponding field current (A_1) is noted down.
3. All the rheostats are brought back to their respective initial positions, TPST switch (S_2) and supply switch (S_1) are opened.



Circuit Diagram (5.b)
DETERMINATION OF ARMATURE RESISTANCE.

Tabular Column

1. Open Circuit Test

Sl.No	I_1 Amps	V_0 Volts	
		V_L	V_{ph}

2. Short Circuit Test

Sl.No	I_f Amps	I_{sc} Amps

Determination of Armature Resistance (R_a) by V-I Method

1. Connections are made as shown in the circuit diagram (5.b)
2. Keeping the rheostat in cut-in position, the supply switch (S_1) is closed, Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and voltmeter are noted down.
3. The supply switch (S_1) is opened.

Calculation

I. EMF Method

i. Draw OCC and SCC for suitable scales as shown in model graph no (1).

ii. Mark a point A on the OCC corresponding to the rated voltage and draw a Perpendicular so that it cuts SCC line at a point B and X-axis at point C.

iii. Corresponding to point A, E_1 is the open circuit voltage per phase, and BC is the Short circuit current.

Therefore Synchronous impedance per phase $Zs = E_1/I_1 \Omega$ (I_f Constant)

Synchronous reactance per phase $X_s = \sqrt{Z_s^2 - R_a^2}\ \Omega$

iv. Determination of % Regulation:

V = Rated voltage per phase, Volt.

I = Rated Current, Ampere.

Φ = Phase angle

(a) Regulation for lagging power factor:

From the vector diagram, as shown in fig.(2)

$OB = \sqrt{OA^2 + AB^2}$

i.e. $E = \sqrt{((V\cos\Phi + IR_a)^2 + (V\sin\Phi + IX_s)^{2)}}$ Volt.

Therefore %R= $\left[\frac{E-V}{V}\right]*100$

(b) Regulation for leading power factor:

From the vector diagram, as shown in fig.(3)

$OB = \sqrt{OA^2 + AB^2}$

i.e. $E = \sqrt{((V\cos\Phi + IR_a)^2 + (V\sin\Phi - IX_s)^2)}$ Volt.

Therefore %R= $\left[\frac{E-V}{V}\right]*100$.

(c) Regulation for Unity power factor:

From the vector diagram, as shown in fig.(1)

$E = \sqrt{((V + IR_a)^2 + IX_s^2)}$ Volt.

Therefore %R= $\left[\frac{E-V}{V}\right]*100$

Determination of Stator Resistance of Alternator (R_a)

Sl.No	V (Volts)	I (Ampere)	Resistance R_{DC} = V/I Ω	Resistance R_{AC} =1.5*R_{DC}

% Regulation Tabular Column

PF	0.2	0.4	0.6	0.8	1.0	REMARKS
LEAD						FOR E.M.F METHOD
LAG						
LEAD						FOR M.M.F METHOD
LAG						

II. MMF Method

i. Draw the OCC and SCC for suitable scales as shown in model graph no. (2)

ii. Mark the point F on the OCC corresponding to the rated voltage.

iii. Draw a perpendicular and let it cuts X-axis at point A.

iv. Mark the point G on SCC corresponding to the rated current, $I_{sc,}$ now, OA = Field current required to produce rated voltage under open circuit condition and OC = Field current required to produce full load current under short circuit condition.

a. Regulation for lagging power factor: model graph no. (2)

At point A, take the vector at an angle = (90+Φ); Where Φ is the lagging power factor angle and take AB = OC.

Therefore OB = Total field current (Vector sum) in Ampere.

(with 'O' as center and radius equal to OB, an arc is drawn cutting X-axis at point 'D'. projection of 'D' on OCC gives the no-load voltage E_t)

Therefore %R= $\left[\frac{E-V}{V}\right]*100$

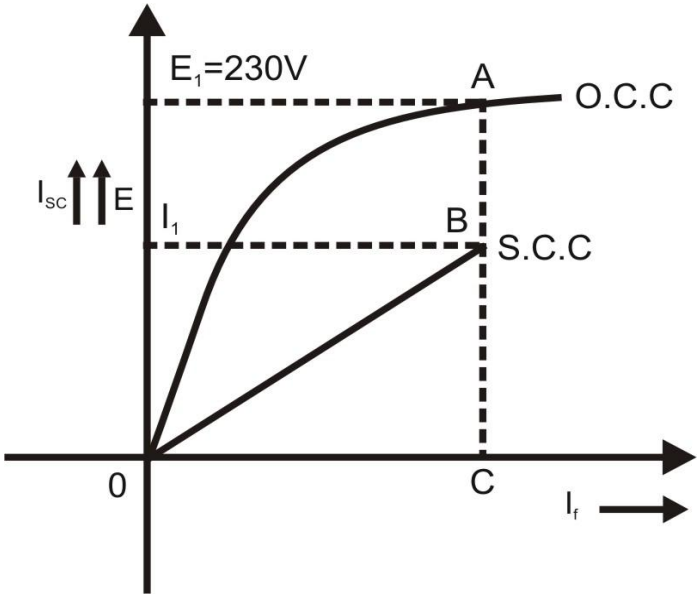
b. Regulation for leading power factor: model graph no. (3)

At point A, take the vector at an angle = (90-Φ); Where Φ is the leading power factor angle and take AB = OC.

(Same procedure is followed to determine the Regulation.)

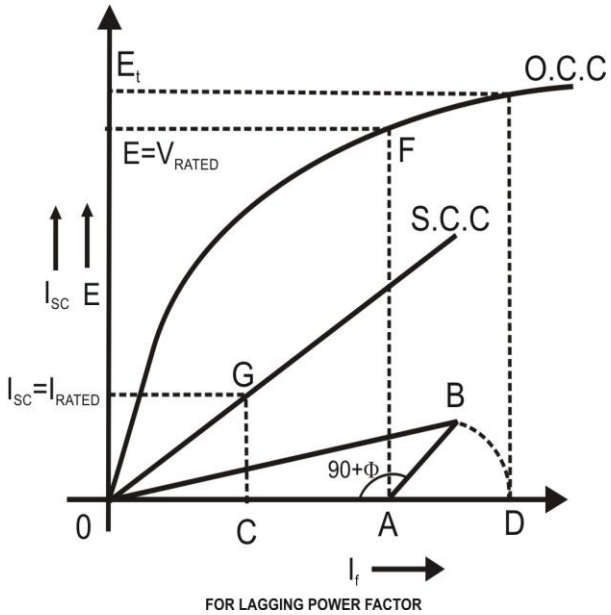
Model Graphs

1. EMF Method

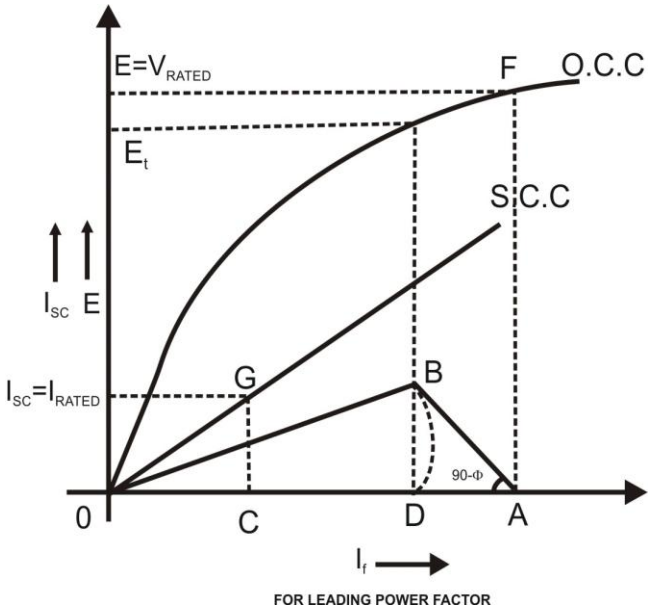


Graph No. 1

2. MMF Method



Graph No. 2

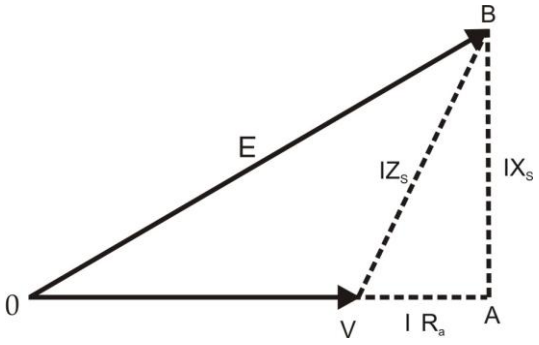


Graph No. 3

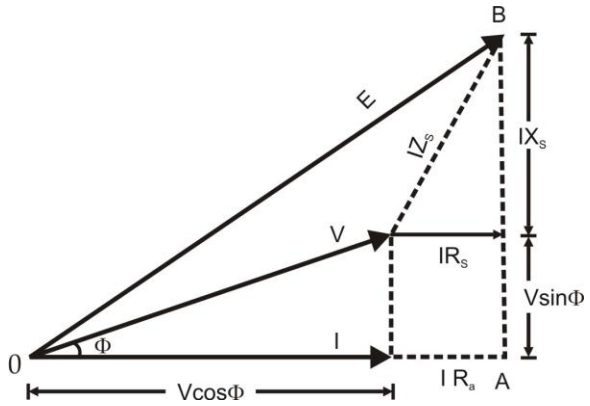
Vector Diagrams

I. EMF METHOD

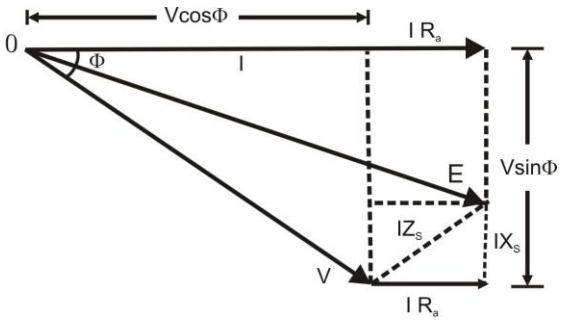
1. UNITY POWER FACTOR



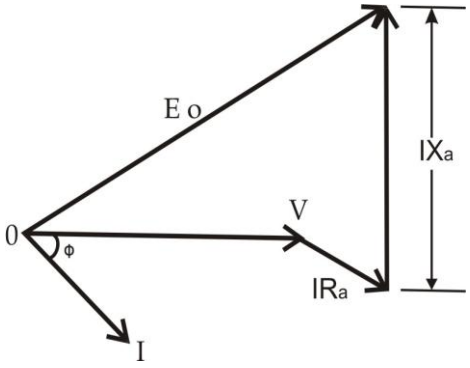
2. LAGGING POWER FACTOR



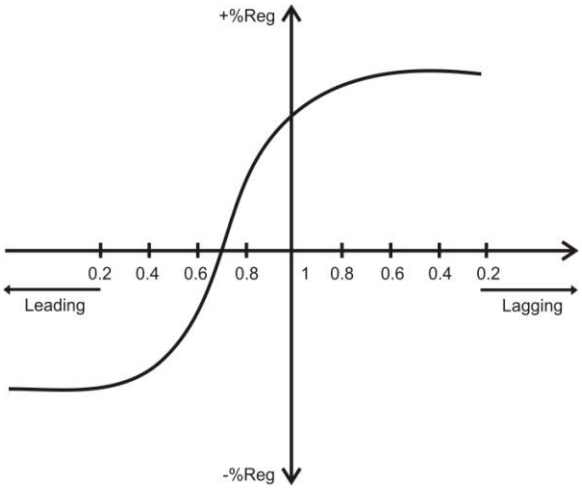
3. LEADING POWER FACTOR

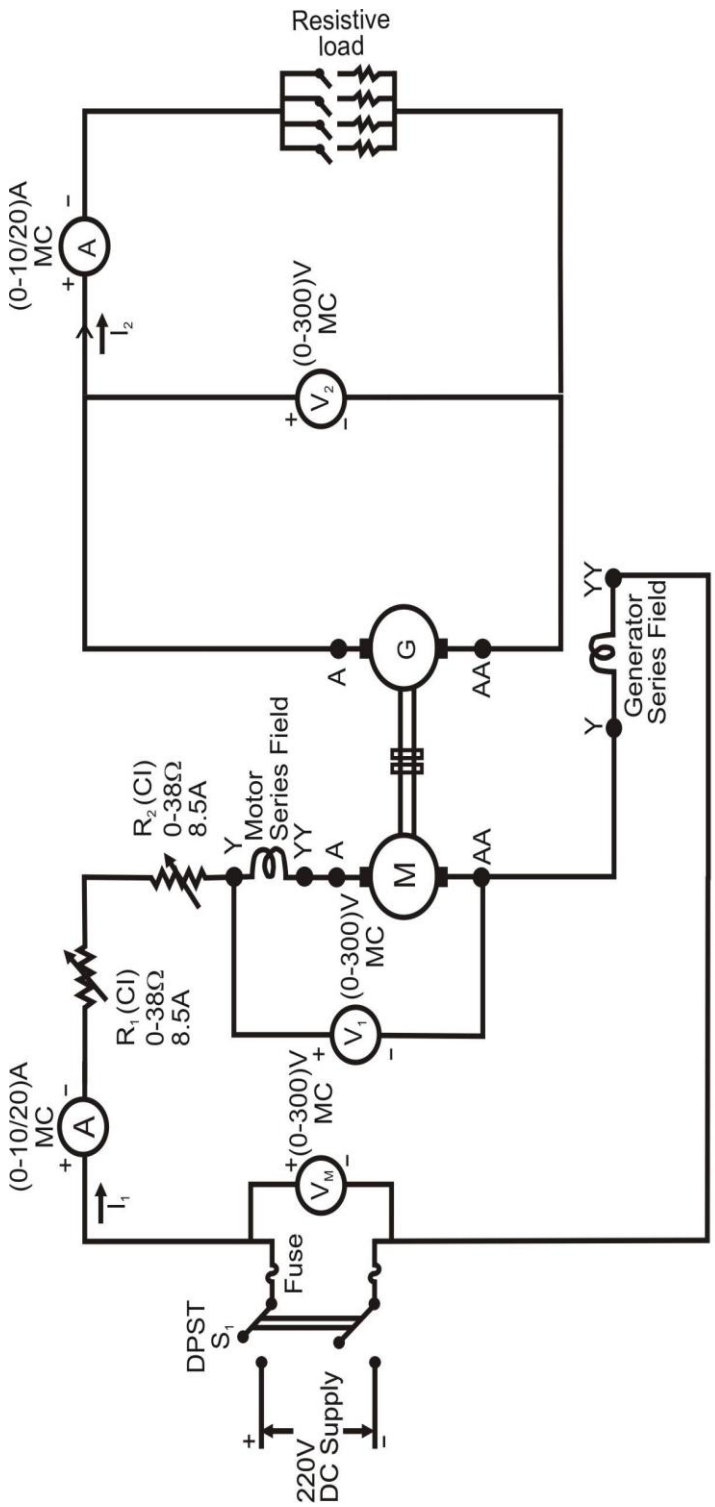


II. MMF METHOD



Regulation Curve





CIRCUIT DIAGRAM (6.a)

FIELD TEST ON DC SERIES MOTOR

Name Plate Details

	Motor	Generator
Kw		
Volt		
Amp		
rpm		

EXPERIMENT NO. 6 **Date: ___/___/_____**

FIELD TEST ON DC SERIES MOTOR

Aim

To determine the stray loss and hence to find the efficiency of the given two identical D.C series machines.

Apparatus Required

Sl.No.	Particulars	Range	Type	Quantity
01	Voltmeters	0-300V 0-30V	MC MC	02 01
02	Ammeters	0-10/20 A 0-1/2 A	MC MC	02 02
03	Rheostats	0-38Ω,8.5A	-	02
04	Tachometer	-	-	01
05	Multi meter	-	-	01

Procedure

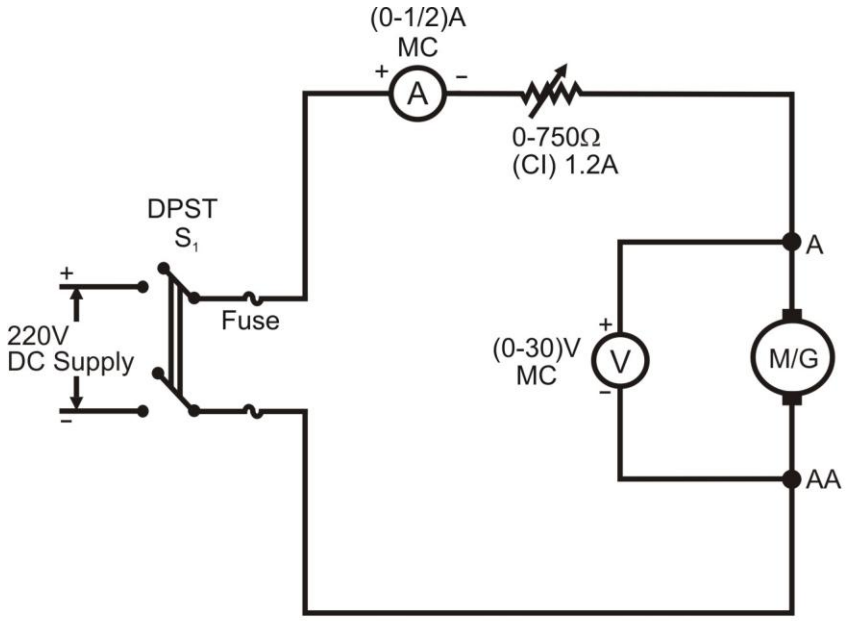
1. Connections are made as shown in the circuit diagram (6.a)
2. Keeping all the load switches in **ON** condition and the load switch (S_2) in **closed** position, the supply switch **(S_1)** is closed.
3. The rheostat **R_1& R_2** are completely cut-out by simultaneously **decreasing** the load, till the machine acquires the rated current.
4. Measure the Voltage across Generator and Motor series field windings using Multi meter
5. The rheostat R_1& R_2 are brought back to their initial positions. (By keeping (S_2) in closed position i.e. loads are applied if necessary) and the supply Switch (S_1) is opened

Determination of Armature Resistance (R_a) and Series Field Resistance (R_{se}) of Both Motor and Generator by V-I method.

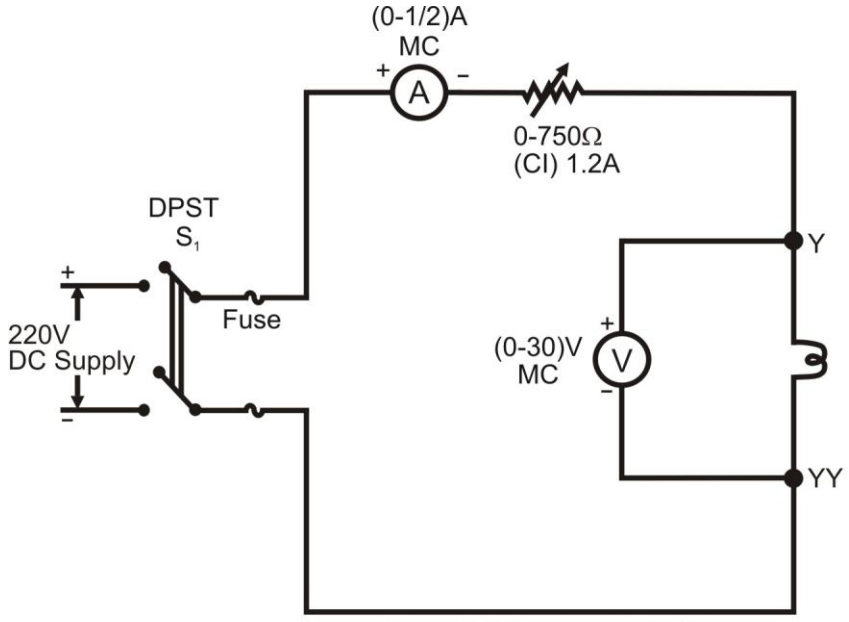
a. Connections are made as shown in the circuit diagram (6.b)and (6.c)

b. Keeping the rheostat in cut-in position, the supply switch (S_1) is closed, Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and voltmeter are noted down.

c. The supply switch (S_1) is opened



Circuit Diagram (6.b)
DETERMINATION OF ARMATURE RESISTANCE(Ra)



Circuit Diagram (6.c)
DETERMINATION OF SERIES FIELD RESISTANCE(R_{se})

Calculation

1. To find the stray loss

Input to the whole set = $V_M I_1$ Watt

Output of the Generator = $V_2 I_2$ Watt

Total Losses of the set; P_T = Input – Output

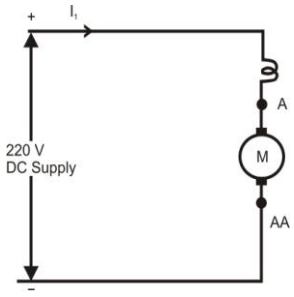
Series field and Armature Copper losses of Motor = $I_1^2 (R_a + R_{se})$ Watt -----(1)

Series field and Armature Copper losses of Generator = $I_1^2 R_{se} + I_2^2 R_a$ ------ (2)

Total Copper Losses of the Set; P_c = (1) + (2) Watt

Stray Loss of the Set; $W_s = P_T - P_C$ Watt

Stray Loss of each Machine = $W_s / 2$ Watt



2. Determination of Motor efficiency

Motor Input = ($x.V_1 I_1$) Watt → I_1= **rated current**

Where x= (1, ¾ , ½, ¼)

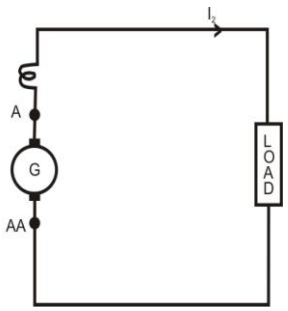
Motor Losses = ($x.I_1^2 (R_a + R_{se}) + W_s / 2$)Watt

Motor Output = ($x.V_1 I_1 – (x.I_1^2 (R_a + R_{se})) - W_s / 2$) Watt

$\%\eta_m$ = O/P / I/P ×100.

.

3. Determination of Generator efficiency



Generator Output = $xV_r I_r$ Watt → I_r= **rated current**

Where x= (1, ¾ , ½, ¼)

Generator Losses = $x.I_2^2 R_a + I_1^2 R_{se} + (W_s / 2)$ Watt

Generator Input = $(xV_2 I_2 + (x.I_1^2 R_{se}) + I_2^2 R_a + W_s / 2)$ Watt

$\%\eta_g = \frac{\text{output}}{\text{Input}} \times 100$

Calculation……..

Tabular Column

Sl.No.	V_M (Volts)	V_1 (Volts)	V_2 (Volts)	I_1 (Amps)	I_2 (Amps)

Determination of Armature Resistance (R_a)

Remarks	V (Volts)	I (Amps)	Ra =V/I Ω
Genetator			
Motor			

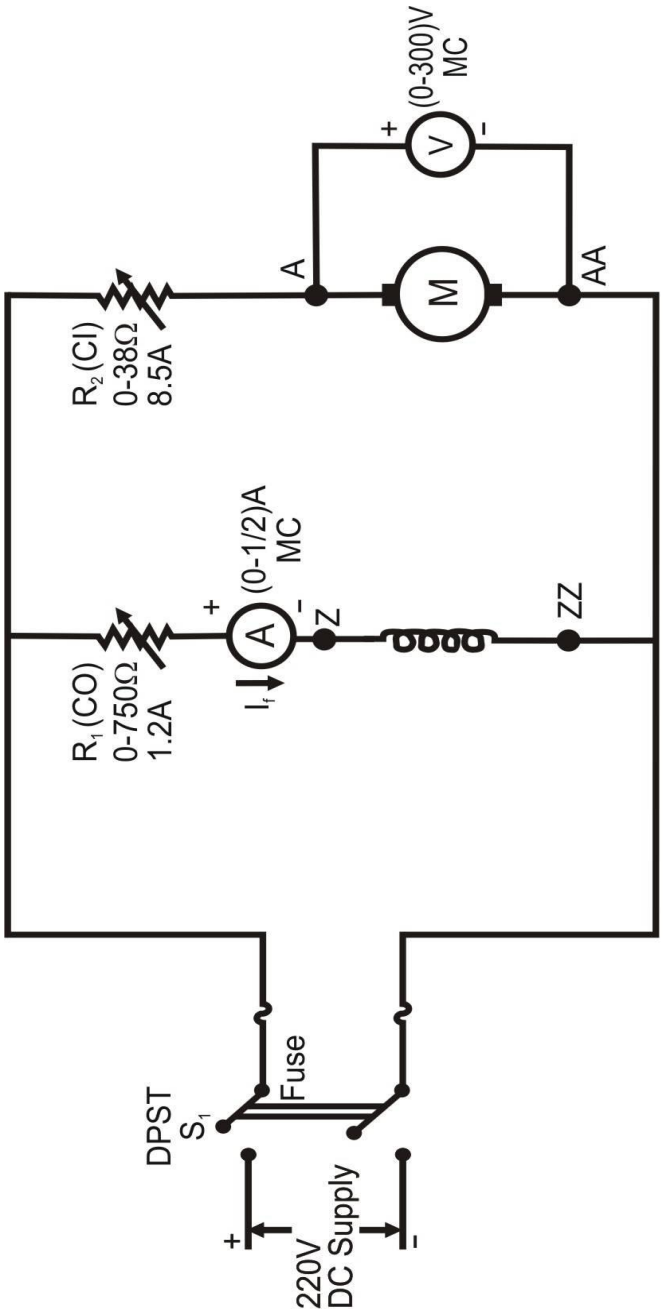
Determination of Series Field Resistance (R_{se})

Remarks	V (Volts)	I (Amps)	Rse =V/I Ω
Genetator			
Motor			

Tabulation of Results

Motor				Generator			
I/P (Watt)	Total Loss (Watt)	O/P (Watt)	%η	I/P (Watt)	Total Loss (Watt)	O/P (Watt)	%η

Calculations



CIRCUIT DIAGRAM (7.a)

SPEED CONTROL OF DC SHUNT MOTOR

Name Plate Details	Motor
Kw	
V olt	
Amp	
rpm	

EXPERIMENT NO. 7 **Date: ___/___/_____**

SPEED CONTROL OF D.C. SHUNT MOTOR

Aim

To control the speed of D.C. Shunt motor by- (1) Armature control method
(2) Field Flux control method

Apparatus Required

Sl.No.	Particulars	Range	Type	Quantity
01	Voltmeter	0-300V	MC	01
02	Ammeter	0-1/2A	MC	01
03	Rheostats	0-38 Ω,8.5A 0-750Ω,1.2A	-	01 01
04	Tachometer	-	-	01

Procedure

I. Armature Control Method

1. Connections are made as shown in the circuit diagram (7.a)
2. Keeping the rheostat **R_1** in the field circuit of motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor in **cut-in** positions the supply switch **(S_1)** is closed.
3. Field current (I_f) is adjusted to a constant value by adjusting the rheostat R_1 and the rheostat R_2 is gradually cut-out in steps and at each step the readings of voltmeter and the speed are noted down.
4. The above procedure is repeated for another value of field currents.
5. All rheostats are brought back to their respective initial Positions and the supply switch (S_1) is opened

II. Field Flux Control Method

1. Keeping the rheostat **R_1** in the field circuit of the motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor in **cut-in** position, the supply switch **(S_1)** is closed.
2. The rheostat R_2 is adjusted to get the required voltage across the armature
3. The rheostat R_1 is gradually brought to cut-in in steps and at each step the readings of ammeter and speed are noted down.
   [**Note:** The rheostat $R_1$is cut-in till the speed is little above the rated speed of Motor]
4. The experiment is repeated for another value of armature voltage.
5. All rheostats are brought back to their respective initial Positions and the supply switch (S_1) is opened.
6. The graphs are plotted as shown in model graphs (1 and 2).

Tabular Column

1. Armature Control Method

I_f = ---------- Ampere (Constant)

Sl. No	V_a Volts	Speed rpm

I_f= ---------- Ampere (Constant)

Sl. No	V_a Volts	Speed rpm

2. Field Flux Control Method

Armature Voltage = ---------- Volt (Constant)

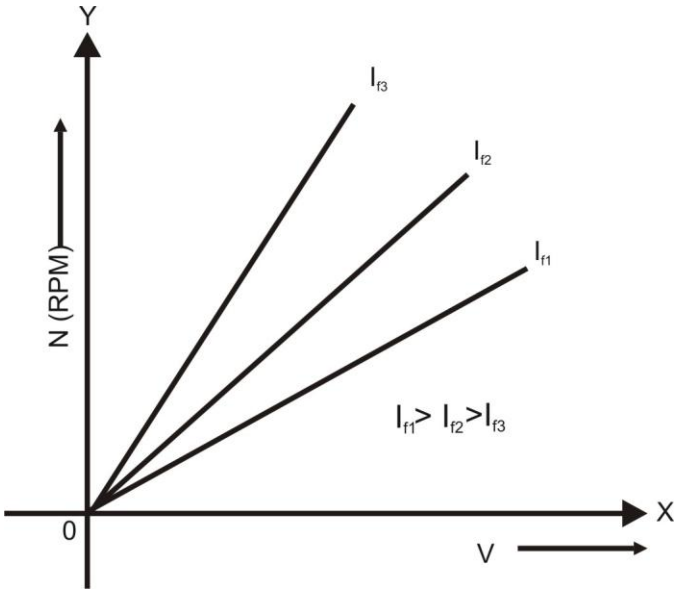
Sl. No	I_f Ampere	Speed rpm

Armature Voltage = --------- Volt (Constant)

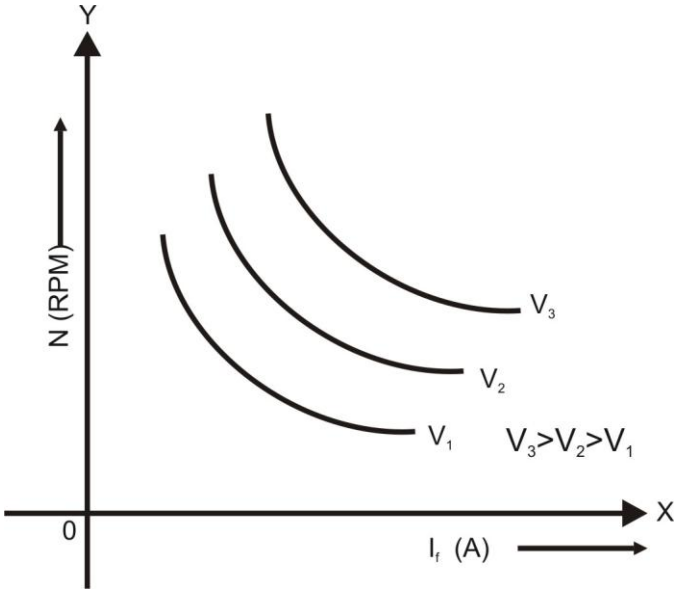
Sl. No	I_f Ampere	Speed rpm

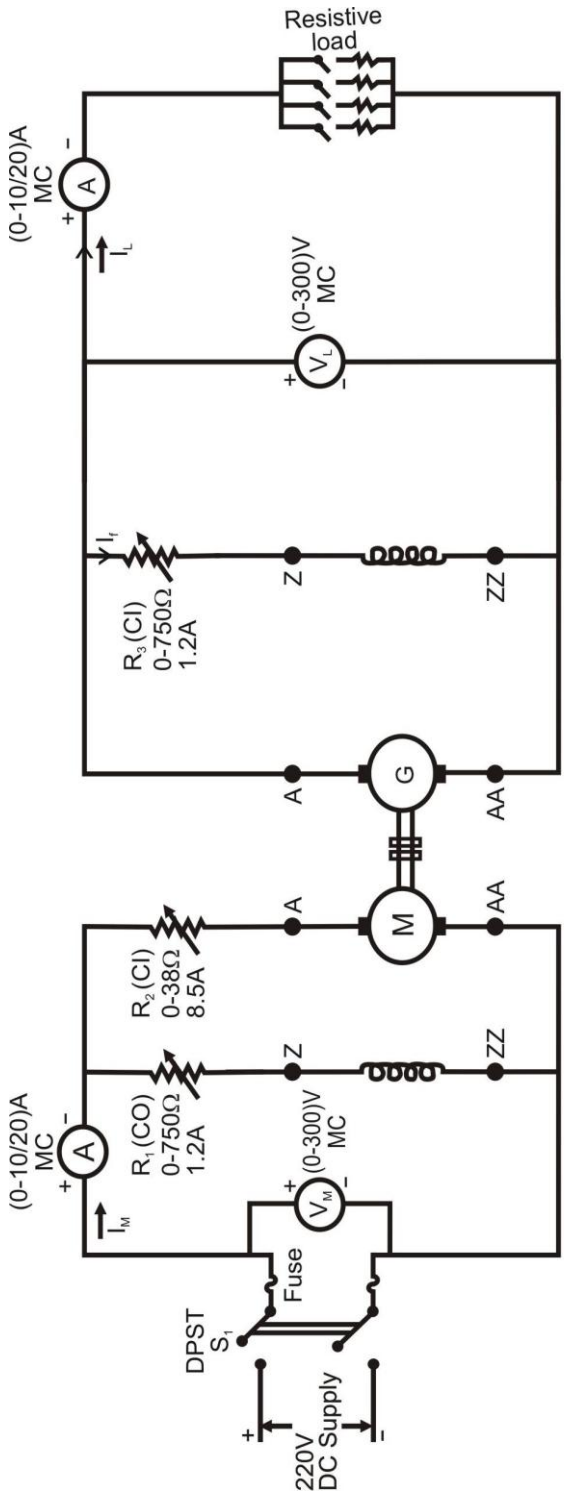
Model Graphs

1. Armature Control Method



2. Flux Control Method





Circuit Diagram (8.a)

LOAD TEST ON DC SHUNT MOTOR

Name Plate Details

	Motor	Generator
Kw		
Volt		
Amp		
rpm		

EXPERIMENT NO. 8 **Date: ___/___/_____**

LOAD TEST ON A D.C. SHUNT MOTOR

Aim

To conduct the load test on the given DC shunt motor and to plot the Following Characteristic curves - (1) Speed v/s BHP
(2) %η v/s BHP and
(3) Speed v/s Torque
(4) BHP v/s Torque

Apparatus Required

Sl. No	Particulars	Range	Type	Quantity
01	Voltmeters	0-300V	MC	02
02	Ammeters	0-10/20 A	MC	02
03	Rheostats	0-750Ω, 1.2A 0-38 Ω,8.5A	- -	02 01
04	Tachometer	-	-	01

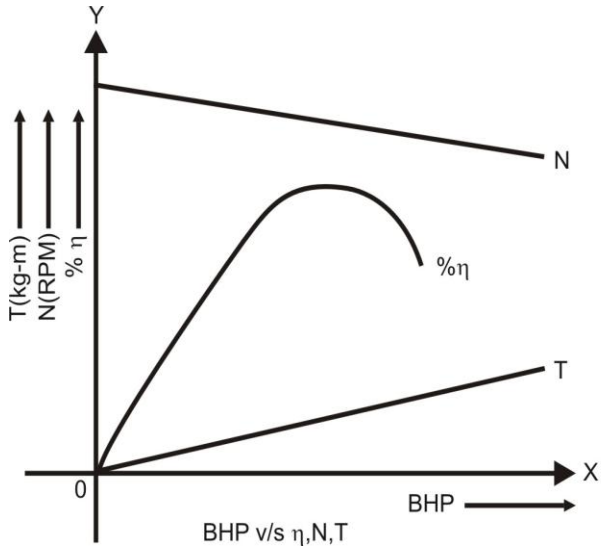
Procedure

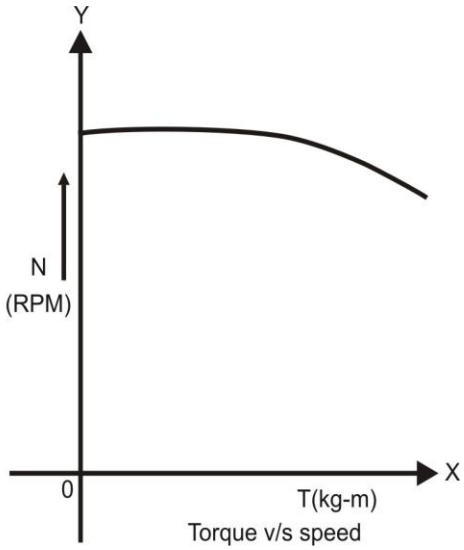
1. Connections are made as shown in the circuit diagram (8.a).
2. Keeping the rheostat $\mathbf{R_1}$ in the field circuit of motor in **cut-out** position, the rheostat $\mathbf{R_2}$ in the armature circuit of the motor and the rheostat $\mathbf{R_3}$ in the field circuit of the generator in **cut-in** positions and all load switches in off condition, the supply switch **(S_1)** is closed.
3. The motor is brought to its rated speed by cutting out the rheostat R_2 and then by cutting in the rheostat R_1, if necessary.
4. The generator voltage is built up to its rated value by gradually cutting out the rheostat R_3.
5. No load readings of all meters and speed are noted down.
6. The generator is loaded by gradually applying the loads. At each load, readings of all the meters and the speed are noted down.
7. The load on the generator is completely removed; all the rheostats are brought back to their respective initial positions and the supply switch (S_1) is opened.

Tabular Column

Sl. No	V_m (Volt)	I_m (Ampere)	V_L (Volt)	I_L (Ampere)	N (rpm)	Motor O/P (Watt)	BHP	%η	Torque (Kg-m)

Model Graphs





Calculations

Motor Input = $V_m \times I_m$ Watt

Motor Output = Generator Input Watt

Generator Output = $V_L \times I_L$ Watt

Assuming generator η as 0.85

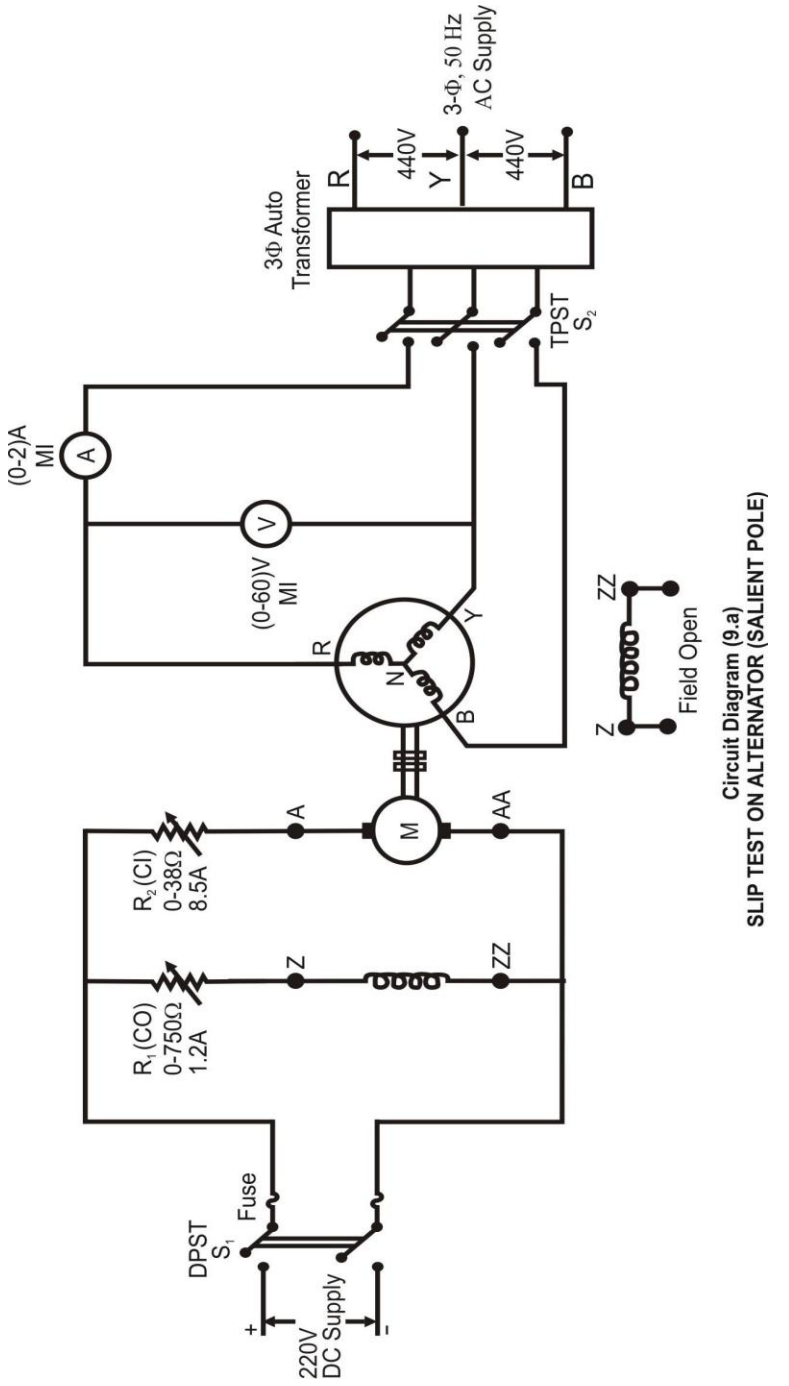
Motor output = $(V_L \times I_L)/ 0.85$ Watt

% η_{motor} = (Motor output in watt / motor input in watt) × 100

B.H.P = Motor output in watt / 735.5

Torque = (B.H.P × 4500) / 2 π N Kg-m

Calculation…



Circuit Diagram (9.a)
SLIP TEST ON ALTERNATOR (SALIENT POLE)

NAME PLATE DETAILS

	D.C. Shunt motor
Kw	
Volt	
Amp	
Rpm	

	Alternator
KVA	
Phase	
Hz	
Volt	
Amp	
Rpm	

EXPERIMENT NO. 9 Date: ___/___/_____

SLIP TEST ON ALTERNATOR

Aim

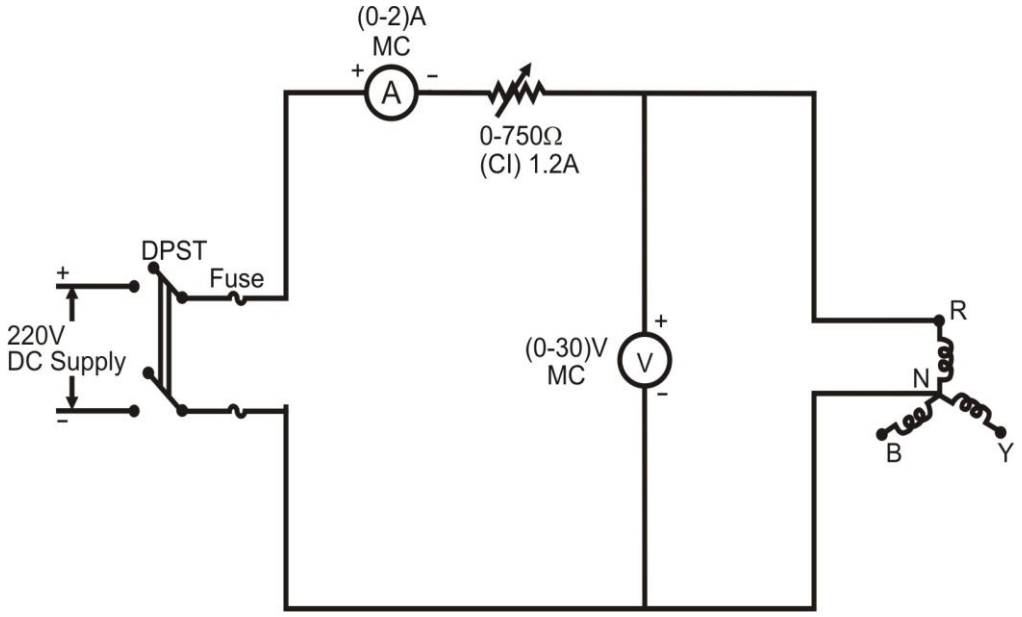
To determine X_d and X_q of a salient pole alternator by conducting slip test and to Predetermine its regulation.

Apparatus Required

Sl.No	Particulars	Range	Type	Quantity
01	Voltmeters	0 – 60 V 0 – 30V	MI MC	01 01
02	Ammeters	0-1/2A 0-2A	MC MI	01 01
03	Rheostats	0-750Ω,1.2 A 0-38Ω,8.5A	-	01 01
04	3 phase Auto-transformer	-	-	01
05	Tachometer	-	-	01

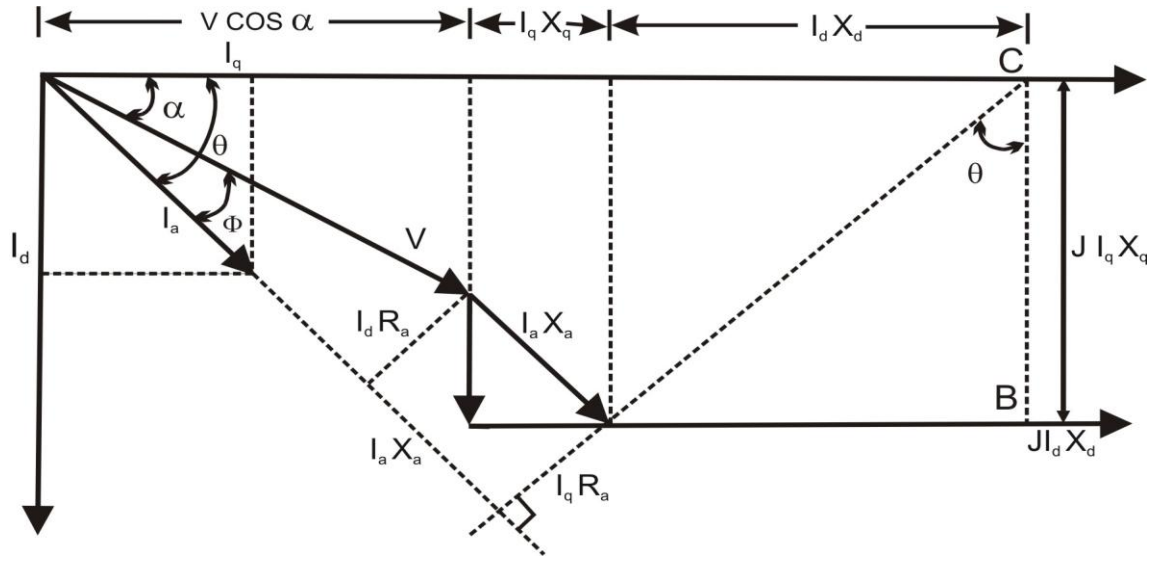
Procedure

1. Connections are made as shown in the circuit diagram (9.a)
2. Keeping the rheostat **R_1** in the field circuit of motor in **cut-out** position, the rheostat **R_2** in the armature circuit of motor in **cut-in** positions, the switch **S_2** in open position And 3-phase auto-transformer at zero output position, supply switch **(S_1)** is closed.
3. The motor is brought to a speed slightly less than the synchronous speed of Alternator by gradually cutting out the rheostat R_2 and cutting in the rheostat R_1, if Necessary.
4. A low voltage (say 30-50 V) is applied across the rotor terminals of the alternator by varying the three phase auto transformer.
5. The following readings are noted down.
   - Maximum value of voltage ----------V_{max}, Volt
   - Minimum value of voltage----------V_{min}, Volt
   - Maximum value of current ----------I_{max}, Ampere
   - Minimum value of current----------I_{min}, Ampere
7. Step 5 is repeated for different values of applied voltage.
8. The three phase auto transformer is brought to its zero output position, all the rheostats are brought back to their respective initial positions and the supply switch (S_1) is opened.



Circuit Diagram (9.b)
DETERMINATION OF ARMATURE RESISTANCE.

Vector Diagram



Determination of Stator Resistance (R_a)

a. Connections are made as shown in the circuit diagram (9.b).
b. By keeping rheostat in cut-in position the supply switch (S_1) is closed. Rheostat is adjusted to any value of current (say 1A)
c. All the meter readings are noted down.
d. The supply switch (S_1) is opened.

NOTE: Field of the alternator is kept opened.

Calculation

V = Rated phase Voltage, Volt
I = Rated current, Ampere.

X_d = Vmax / Imin =…… Ω

X_q = Vmin / Imax =…… Ω

For 0.8 p.f lagging

CosΦ = 0.8
SinΦ = 0.6
Therefore Φ = 36.86

$\tan\Theta = (V \sin \Phi \pm I X_q) / (V \cos \Phi + I R_a)$ (Note: + → lag , - → lead)

$\Theta = \tan^{-1} ((V \sin \Phi \pm I X_q) / (V \cos \Phi + I R_a))$

Therefore $\alpha = \Theta - \Phi$

Therefore
E_o/phase = $(V \cos \alpha \pm I_d . X_d + I_q . R_a)$ Volt

Where $I_q = I \cos \Theta$
$I_d = I \sin \Theta$

Therefore

Regulation %R= $\left[\frac{Eo - V}{V}\right] * 100$

Tabular Column

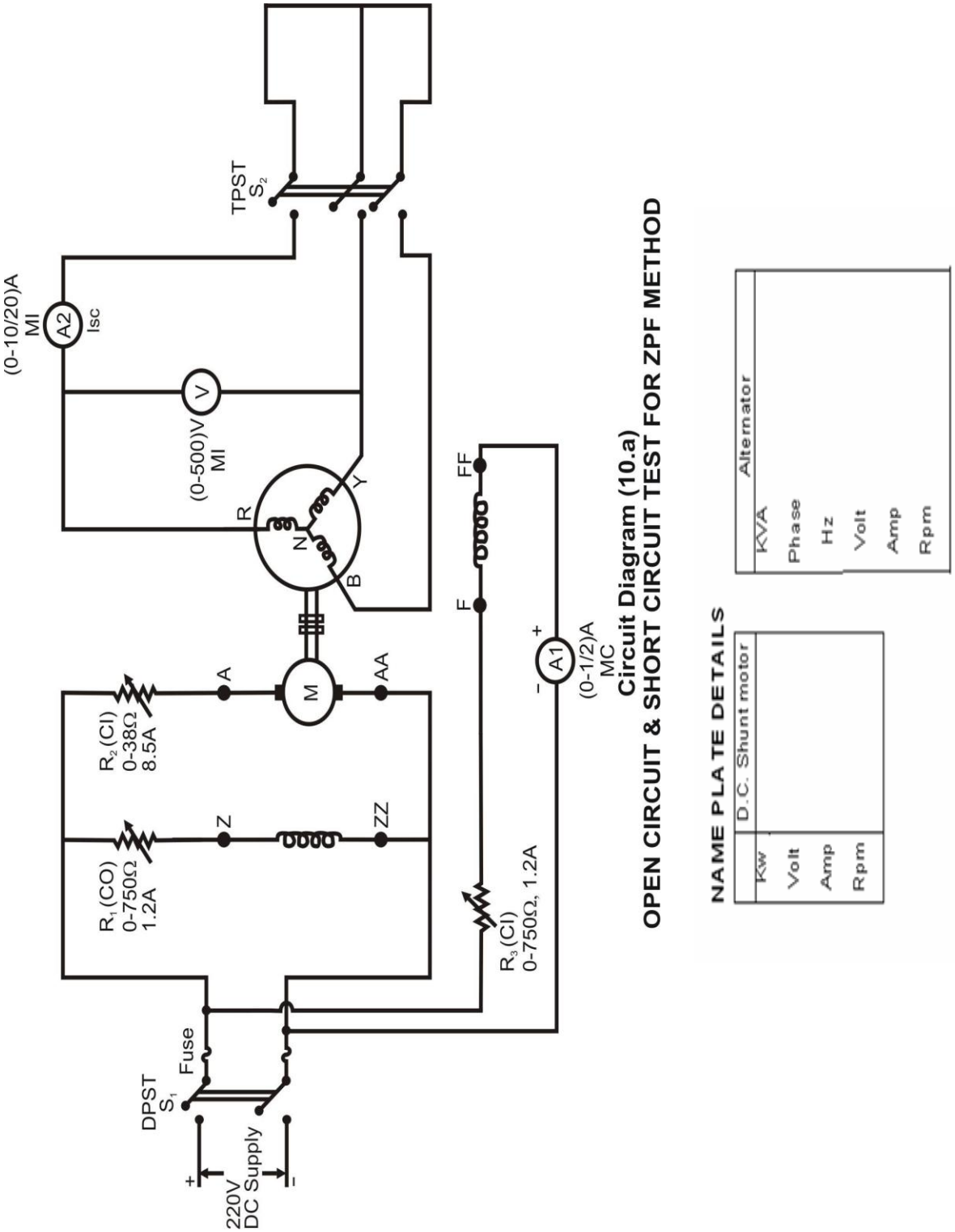
Sl. No	V_{max} (V)	V_{min} (V)	I_{max} (A)	I_{min} (A)	X_d (Ω)	X_q (Ω)	%Regulation	
							0.8 lag	0.8 lead

Determination of Stator Resistance of Alternator (R_a)

Sl. No	V (Volts)	I (Ampere)	Resistance R_{DC} = V/I Ω	Resistance R_{AC} =1.5*R_{DC}

Calculation…….

Date:……. **Signature of the Faculty**


TPST
S_2
(0-10/20)A
MI
A2
Isc
(0-500)V
MI
V
R
Y
B
N
FF
F
A
AA
M
R_2(Cl)
0-38Ω
8.5A
Z
ZZ
R_1(CO)
0-750Ω
1.2A
A1
(0-1/2)A
MC
R_3(Cl)
0-750Ω, 1.2A
DPST
S_1
Fuse
220V
DC Supply
Circuit Diagram (10.a)
OPEN CIRCUIT & SHORT CIRCUIT TEST FOR ZPF METHOD
NAME PLATE DETAILS
D.C. Shunt motor
Kw
Volt
Amp
Rpm
Alternator
KVA
Phase
Hz
Volt
Amp
Rpm

EXPERIMENT NO. 10 **Date: ___/___/_____**

REGULATION OF ALTERNATOR BY ZPF METHOD

Aim

To determine the percentage regulation of an alternator by ZPF method or Potier Triangle Method.

Apparatus Required

Sl.No	Particulars	Range	Type	Quantity
01.	Voltmeter	0 – 500 V	MI	01
02.	Ammeters	0-10/20A 0-1/2A	MI MC	01 01
03.	Rheostats	0-750Ω,1.2A 0-38Ω,8.5A	-	02 01
04.	Watt meters	0 – 10/20 A, 0 – 600 V	LPF	02
05.	Tachometer	-	-	01
06.	3-phase Inductive Load	-	-	01

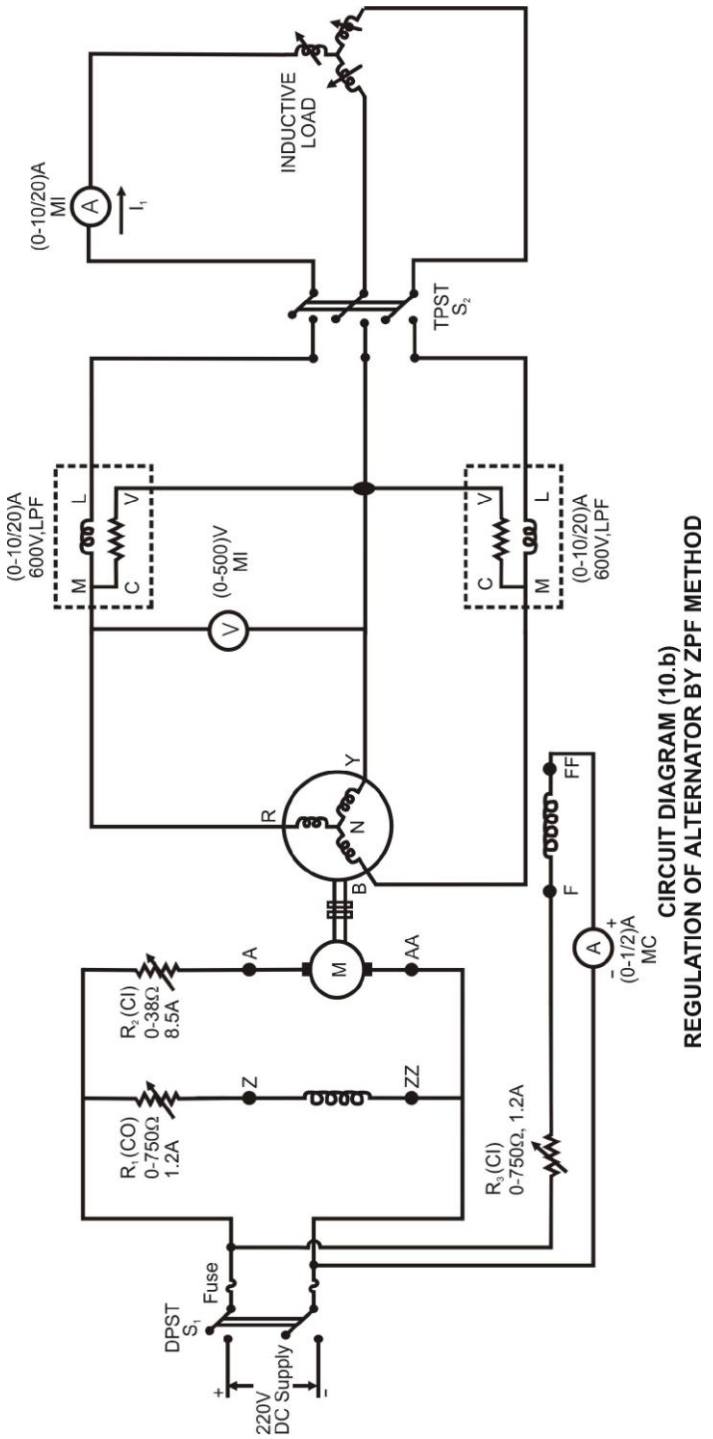
Procedure

a. Open Circuit Test

1. Connections are made as shown in the circuit diagram (10.a)
2. Keeping the rheostat **R_1** in the field circuit of motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor and the rheostat **R_3** in field circuit of the alternator in **cut-in** positions, and **TPST (S_2)** in open position, the supply switch **(S_1)** is closed.
3. The motor is brought to synchronous speed by cutting out the rheostat R_2 and then by cutting in the rheostat R_1, if necessary.
4. By gradually cutting out the rheostat R_3, the readings of ammeter (A_1, 0-2A) and voltmeter (V) are noted down.
5. The above step is continued until voltmeter reads about 1.25 times the rated voltage of the alternator.

b. Short Circuit Test

1. The rheostat R_3 is brought to its initial position (cut-in) and TPST **(S_2)** is closed.
2. By gradually cutting out the rheostat R_3, reading of the ammeter (A_2,0-10/20A) is adjusted to the rated current of the alternator and the corresponding field current (A_1, 0-1/2A) is noted down.
3. All the rheostats are brought back to their respective initial positions, TPST switch (S_2) and supply switch (S_1) are opened.



CIRCUIT DIAGRAM (10.b)
REGULATION OF ALTERNATOR BY ZPF METHOD

c. ZPF Test

1. Connections are made as shown in the circuit diagram (10.b)
2. Keeping the rheostat **R_1** in the field circuit of the motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor and the rheostat **R_3** in the field circuit of the generator in **cut-in** position, the supply switch **(S_1)** is closed.
3. The motor is brought to its rated speed by cutting out the rheostat R_2 and Cutting in the rheostat R_1, if necessary.
4. The alternator voltage is built up to its rated value by gradually cutting out the rheostat R_3.
5. The TPST (S_2) is closed and vary the inductive load up to the rated current of the Alternator. The readings of all the meters are noted down.
6. The load is gradually removed, the TPST switch (S_2) is opened and all Rheostats are brought back to their respective initial positions then the supply switch **(S_1)** is opened.

d. Construction of Potier Triangle

1. Draw OCC and SCC for suitable scales.
2. A tangent drawn to OCC curve represents the air gap line.
3. Point B is obtained from ZPF test, which indicates the full load current for a particular field current I_f value when power consumed by load is zero.
4. Point A is marked on X-axis such that OA represents the field current required to drive full load current at short circuit condition. It is equal and opposite to the demagnetizing armature reaction and balancing leakage reactance drop at full load.
5. Points A and B are joined to get ZPF curve which is parallel to OCC curve.
6. From point B a point H is marked such that BH=OA.
7. From point H a line HD is drawn parallel to the tangent such that it cuts OCC curve at point D.
8. Join DB. Now triangle BHD is known as 'Potier Triangle'.
9. A perpendicular line DF is drawn, which represents the armature voltage drop (IX_L) due to armature leakage reactance.

Tabular Column

1. Open Circuit Test

Sl. No.	I_f Ampere	V_o Volts

2. Short Circuit Test

I_f Ampere	I_{SC} Ampere

3. ZPF Test

Sl. No	I_1 Ampere	I_f Ampere	W_1 Watt	W_2 Watt	V Volt

e. Determination of No-Load EMF (E_o)

1. From point D, perpendicular line is drawn to X-axis and horizontal line to Y-axis to locate point G and E respectively. DG is measured on Y-axis, which represents E and field current corresponding to E is OG.
2. A line NA is drawn such that NA=BF, which represents the field current required to overcome armature reaction.
3. NA is added to OG as in case of MMF method. GM is marked such that GM=NA at an angle (90+ Φ) from point G. Now points O & M are joined, which represents the resultant excitation required to generate no-load EMF E_o.
4. With O as center, OM as radius an arc is drawn which cuts X-axis at point P.
5. From point P a vertical line is drawn to X-axis such that it cuts OCC at a point Q. It is extended to Y-axis, measures E_o volts,

Therefore

Regulation %R= $\left[\frac{Eo-V}{V}\right]*100$ where V = voltage / phase, volt

f. Determination of Resultant Field Current (I_{fr})

1. BF is measured, which gives field current I_{f1}, ampere.
2. DF is measured, which gives Reactive drop $IX_{L,}$ volt.
3. Considering lagging power factor,

   $E = \sqrt{((V\cos\Phi)^2 + (V\sin\Phi + IX_L)^2)}$ Volt

   Where V= voltage/ phase, volt.

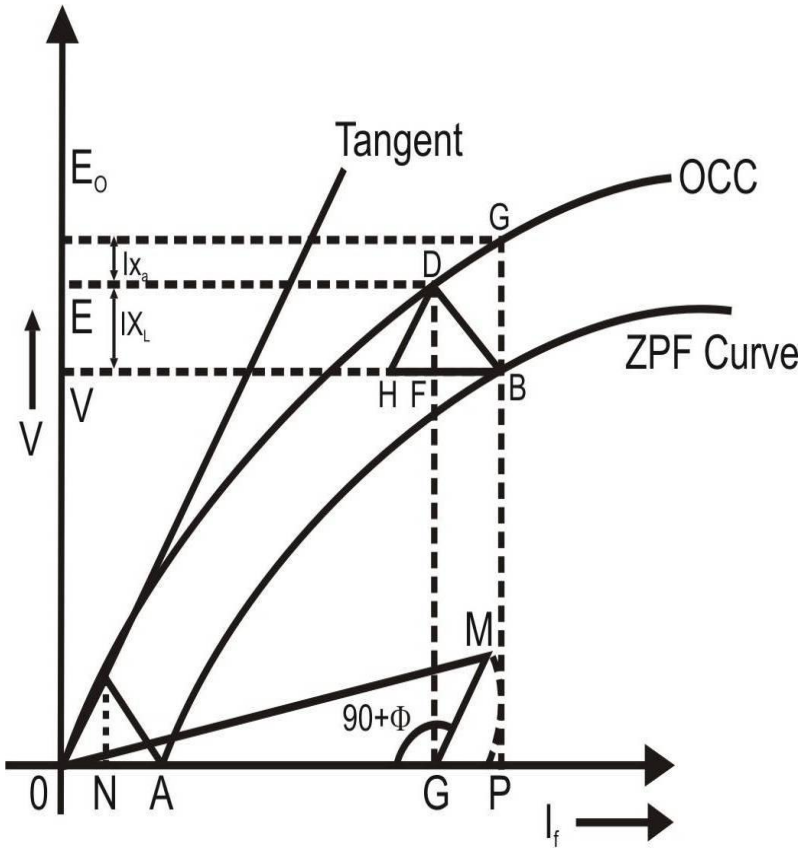
   a. I= rated current, ampere.

   This value is measured on Y-axis.
4. A line from point E is extended to OCC such that OR is located which gives I_{f2}.

Therefore resultant field current is given by

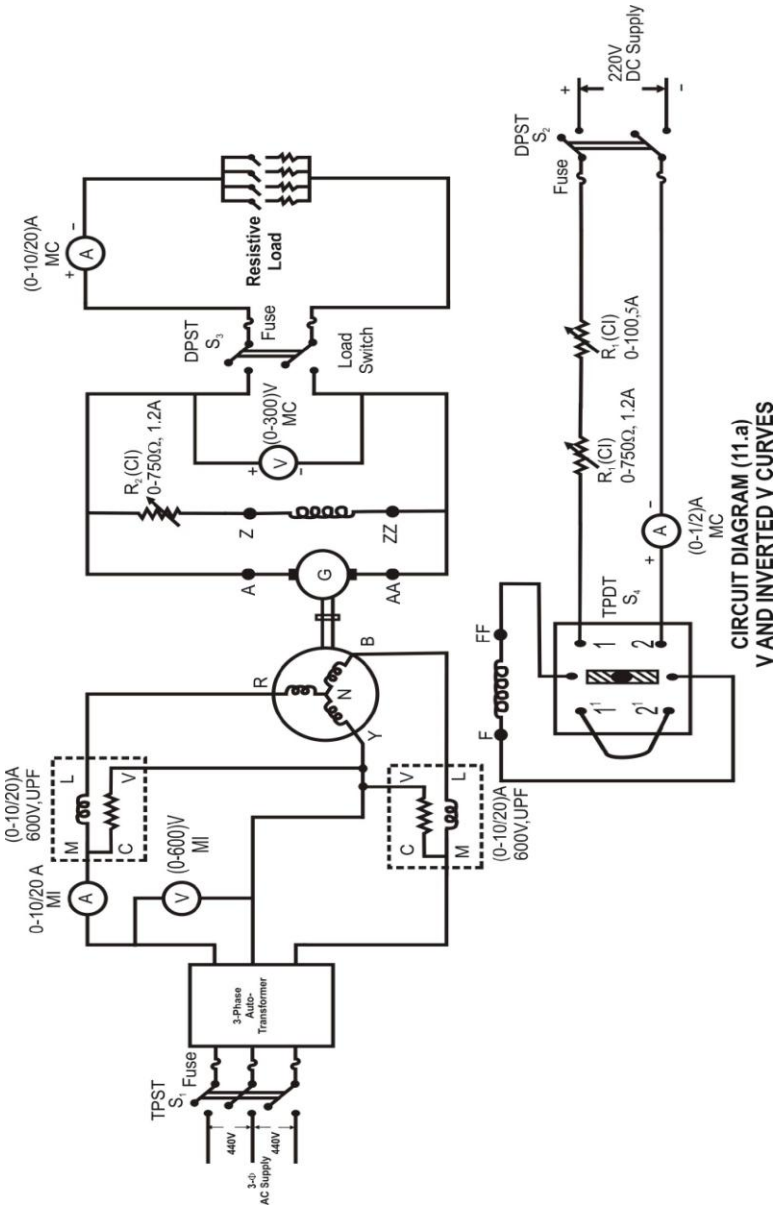
$I_{fr} = \sqrt{(I_{f2}^2 + I_{f1}^2 + 2\, I_{f1}\, I_{f2}\cos\Theta)}$ Ampere.

Model Graph



DETERMINATION OF NO LOAD EMF (E_0)

calculations



CIRCUIT DIAGRAM (11.a)
V AND INVERTED V CURVES

Name Plate Details

D.C. Shunt Generator	
Kw	
Volt	
Amp	
rpm	

Synchronous Motor	
HP	
Phase	
Hz	
Volt	
amp	

EXPERIMENT NO. 11 **Date: ___/___/_____**

V AND Λ CURVES OF SYNCHRONOUS MOTOR

Aim

To obtain V and Λ curves of synchronous motor.

Apparatus Required

Sl. No.	Particulars	Range	Type	Quantity
01	Voltmeter	0 –300 V	MC	01
02	Ammeters	0-10/20A 0-10/20A 0- 1/2 A	MC MI MC	01 02 01
03	Rheostats	0-750Ω,1.2A	-	02
04	Watt meters	0-600V, 10/20A	UPF	02

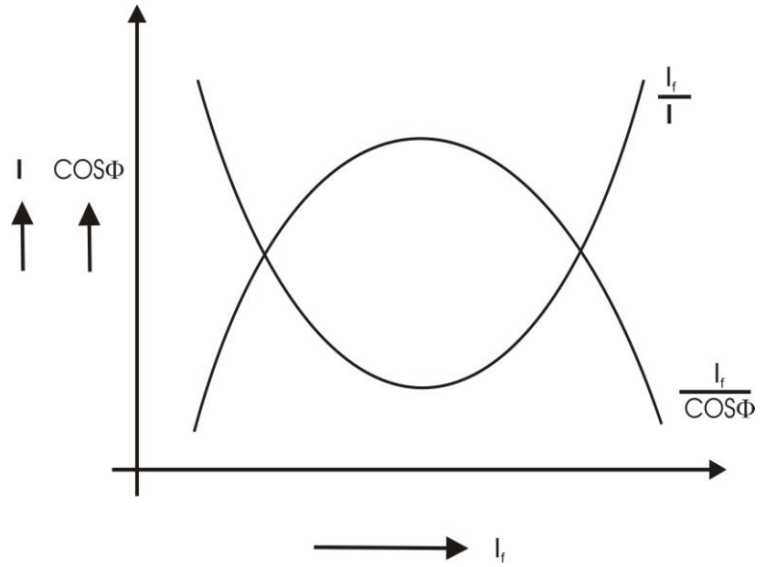
Procedure

1. Connections are made as shown in the circuit diagram (11.a)
2. The TPDT switch (S_4) in 1' & 2' position. (The field of the synchronous motor (F and FF) is temporarily shorted).
3. Keeping load switch **(S_3)** open, the both rheostats **R_1** in the field circuit of synchronous motor in **cut-in** position and rheostat **R_2** in the field circuit of generator in **cut-in** positions, the exciter switch DPST **(S_2)** and supply switch TPST **(S_1)** are closed.
4. The output of the three phase Auto transformer is increased slightly, and the direction of rotation of the motor is observed. If the motor runs in opposite direction of the marked position then bring back the Auto Transformer to Zero position and change any two phases of the supply Terminals.
5. The out-put of the three phase auto-transformer is again increased till the synchronous motor attains 50% of its rated speed, immediately the TPDT (S_4) is switch over to 1 & 2 position. And then increase to rated voltage.
6. The excitation of synchronous motor is varied in steps by cutting-out the rheostats R_1, at no-load, the readings of all the meters are noted down.
7. The rheostat R_1 is brought back to cut-in position and generator voltage is built up to its rated value by gradually cutting out the rheostat R_2.
8. The load switch (S_3) is closed and the load on the generator is adjusted to any convenient value (Say ¼, ½ or ¾ of the rated load current) and the excitation of synchronous motor is varied in steps by cutting-out the rheostat R_1. At each step readings of all the meters are noted down.
   (**NOTE:** The selected load current is kept constant throughout the experiment)
9. The load on generator is gradually removed, the load switch (S_3) is opened, all the rheostats are brought back to their respective initial positions, and the TPDT (S_4) is opened.

Tabular Column

Sl. No	I Amps	I_f Amps	I_L Amps	W_1 Watt	W_2 Watt	CosΦ	Remarks
							No Load Condition
							Loaded Condition

Model Graph



Graph No (1)

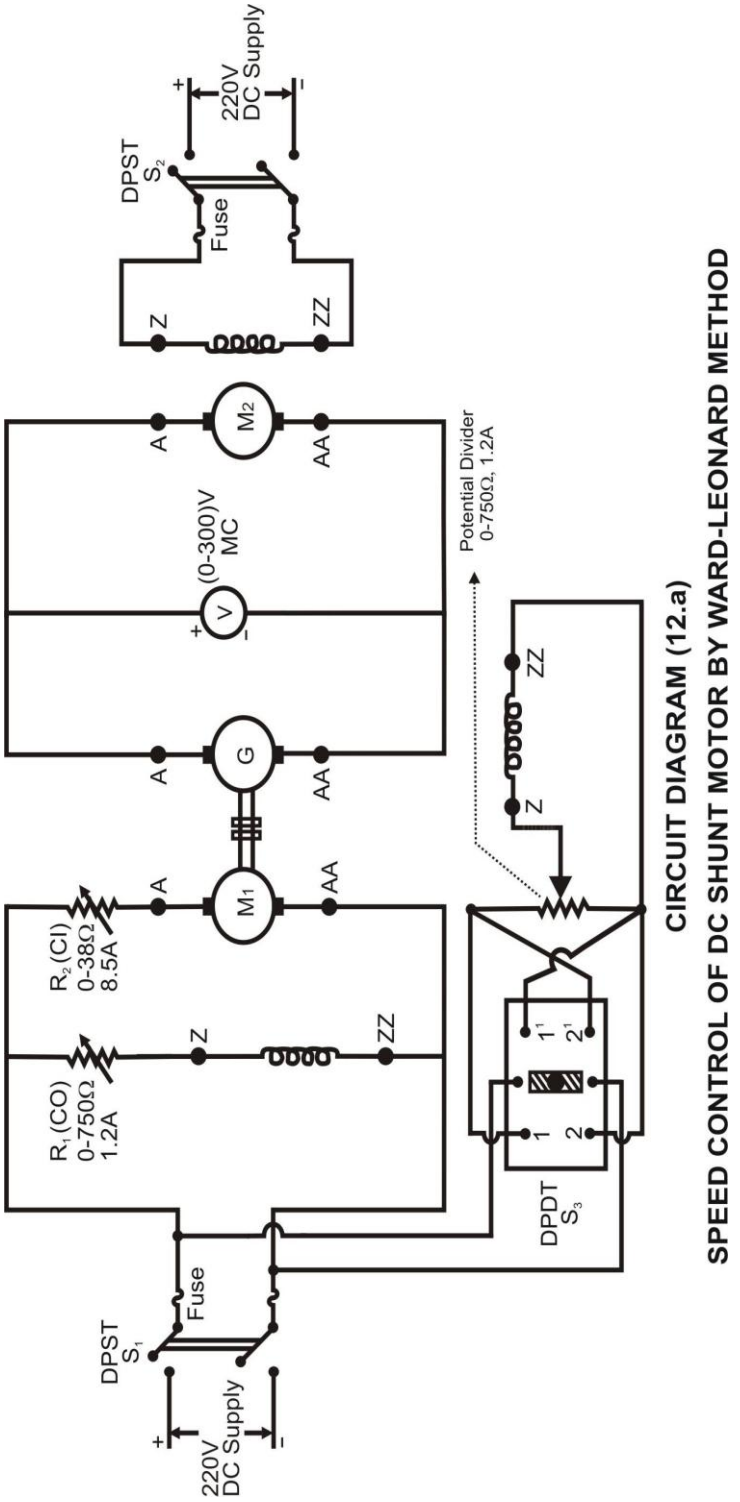
10. The out-put of the 3-phase auto-transformer is brought zero out-put position, then the supply switch (S_1) and the exciter switch (S_2) is opened.
11. Following graphs are plotted as shown in model graph no (1)
    i. Supply current v/s Field current → V curve and
    ii. Power factor v/s Field current. → Λ curve.

Calculation

Power factor is given by

$$Cos\Phi = Cos[\tan^{-1}\sqrt{3}\{ (W1-W2)/(W1+W2)\}]$$

Calculation……



CIRCUIT DIAGRAM (12.a)

SPEED CONTROL OF DC SHUNT MOTOR BY WARD-LEONARD METHOD

Name Plate Details

	Motor	Generator
Kw		
Volt		
Amp		
rpm		

EXPERIMENT NO. 12 **Date: ___/___/_____**

SPEED CONTROL OF D.C. SHUNT MOTOR BY WARD LEONARD METHOD

Aim

To control the speed of a D.C. shunt motor by Ward-Leonard method.

Apparatus Required

Sl.No.	Particulars	Range	Type	Quantity
01	Voltmeter	0-300V	MC	01
02	Rheostats	0-750Ω,1.2A 0-38Ω,8.5A	-	02 01
03	DPDT Switch	-	-	01
04	Tachometer	-	-	01

Procedure

1. Connections are made as shown in the circuit diagram (12.a)
2. Keeping the rheostat **R_1** in the field circuit of motor **M_1** in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor **M_1** in **cut-in** position, potential divider **R_3** in **minimum output** position, and by keeping DPDT switch **(S_3**) in open position, the supply switches **(S_1)** and **(S_2)** are closed.
3. The motor M_1 is brought to its rated speed by cutting out the rheostat R_2 and cutting in the rheostat R_1, if necessary.
4. The DPDT Switch (S_3) is closed to 1-2 position and by varying the potential divider, the voltage across the field circuit of the generator is gradually increased in steps up to the rated speed of the motor M_2. At each step the readings of voltmeter and speed of motor M_2 are noted down.
5. Potential divider is brought to its original position and DPDT switch (S_3) is opened. (**NOTE**: Ensure that the motor M_2 is in stand-still position.)
6. By keeping the Potential divider in minimum position the direction of rotation of the motor M_2 is changed by throwing DPDT switch (S_2) to the positions $1'$-$2'$. The voltage across the field circuit of the generator is gradually increased in steps up to the rated speed of the motor M_2. At each step the readings of voltmeter and speed of motor M_2 are noted down
7. The potential divider and all rheostats are brought back to their respective initial positions; switches (S_3), (S_2) and (S_1) are opened.
8. Graph of speed of motor M_2 (N) v/s voltage (V) is plotted as shown in model graph.

Tabular Column

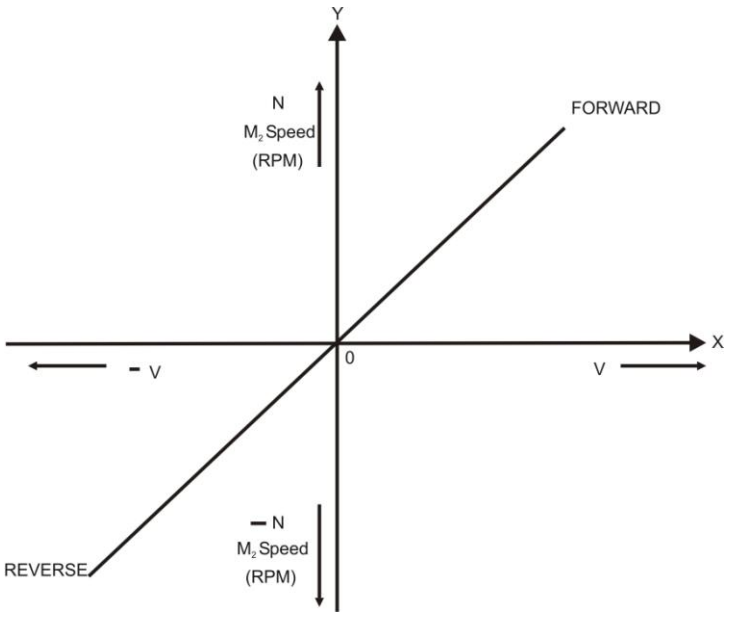
1. Forward Rotation

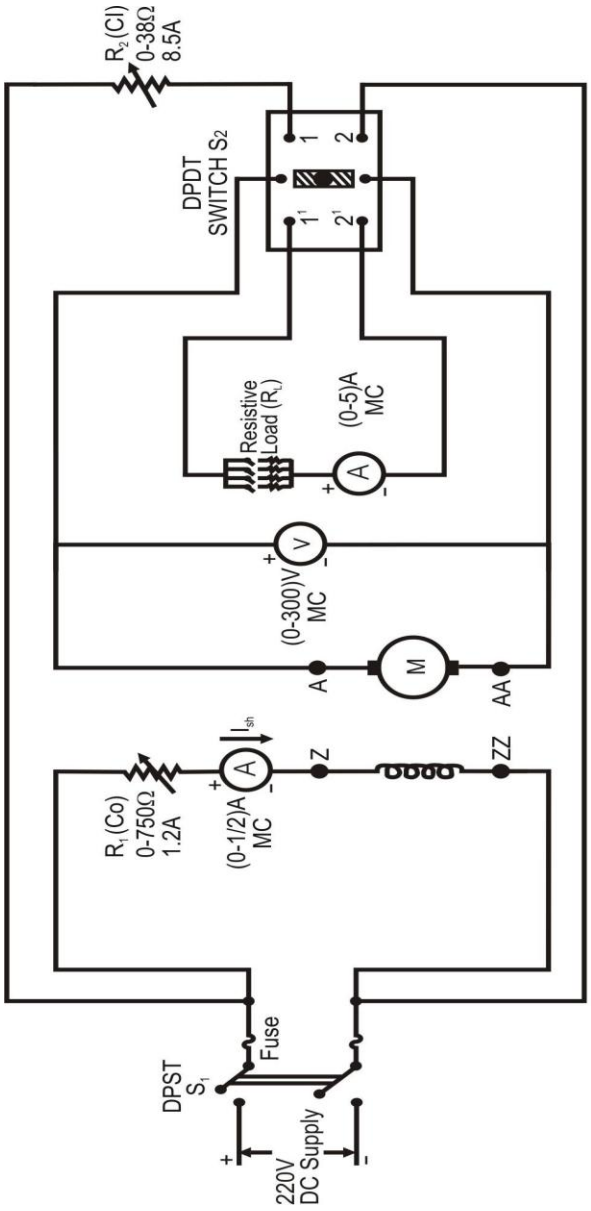
Sl. No	Voltage Volt	Speed of M_2 rpm

2. Reverse Rotation

Sl. No	Voltage Volt	Speed of M_2 rpm

Model Graph

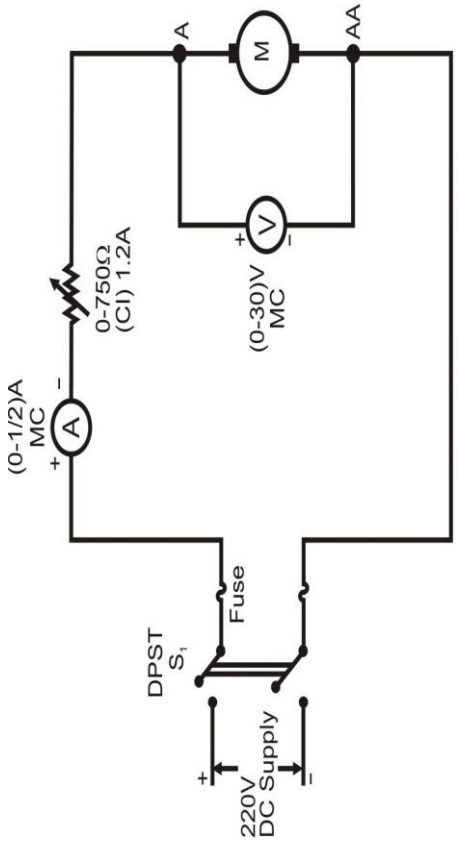




CIRCUIT DIAGRAM (13.a)

RETARDATION TEST

Name Plate Details	Motor
Kw	
V olt	
Amp	
rpm	



Circuit Diagram (13.b)

DETERMINATION OF ARMATURE RESISTANCE (Ra)

EXPERIMENT NO. 13 **Date: ___/___/_____**

RETARDATION TEST

Aim

To determine the stray loss and hence to find the efficiency of the given D.C. shunt motor and Shunt generator.

Apparatus Required

Sl.No	Particulars	Range	Type	Quantity
01.	Voltmeters	0-30V 0-300V	MC MC	01 01
02.	Ammeters	0-5A 0-1/2A	MC MC	01 01
03.	Rheostats	0-750Ω,1.2A 0-38Ω,8.5A	-	01 01
04.	Tachometer	-	-	01
05.	Stopwatch	-	-	01

Procedure

1. Connections are made as shown in the circuit diagram (13.a)
2. Keeping the rheostat **R_1** in the field circuit of motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor in **cut-in** position, the load rheostat **R_L** in the armature circuit of motor in fixed position and the **DPDT** switch **(S_2)** in1-2 position, the supply switch **(S_1)** is closed.
3. The motor is brought to its rated speed by cutting out the rheostat R_2 and then by cutting in the rheostat R_1, if necessary.
4. Readings of Voltmeter (V_1) and Ammeter A_1 (I_{sh}) are noted down.
5. DPDT switch (S_2) is opened, time taken by the motor to reach zero speed is noted down (t_1 second) and the corresponding reading of voltmeter is (V_2).
6. Again the motor is brought to the rated speed as explained in step no.2 and 3.
7. DPDT switch (S_2) is opened and immediately thrown on to the position 1'-2' and at this instant; the reading of ammeter A (I_{L1}) is noted down.
8. Time taken by the motor to reach zero speed is noted down (t_2 second) and the corresponding reading of Ammeter is (I_{L2}).
9. All other rheostats are brought back to their respective initial positions, the DPDT switch (S_2) and supply switch (S_1) are opened.

Determination of Armature Resistance (R_a) by V-I Method

a. Connections are made as shown in the circuit diagram (13.b)
b. Keeping the rheostat in cut-in position, the supply switch is closed, Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and voltmeter are noted down.
c. The supply switch (S_1) is opened.

Tabular Column

Sl. No	I_{sh} Amps	V_1 Volts	V_2 Volts	$V=(V_1+V_2)/2$ Volts	I_{L1} Amps	I_{L2} Amps	$I_L=(I_1+I_2)/2$ Amps	t_1 Sec	t_2 Sec

Determination of Armature Resistance (R_a)

Sl.No	V (Volts)	I (Ampere)	Resistance Ra = V/I Ω

Calculation

V_1 = Rated Voltage, Volt.

V_2 = Voltage after opening the DPDT switch and at the instant, of 5% reduction in speed, Volt.

Average Voltage across the load = V = $(V_1 + V_2) / 2$ Volt

I_{L1} = Load current at the instant when DPDT switch is along 1'-2', Ampere

I_{L2} = Load current at the instant of 5% reduction in speed, Ampere

$I_L = (I_1 + I_2) / 2$ Ampere

Total Input = $V_r I_r$ Watt

Power absorbed by the load resistance = $W_1 = VI_L$ Watt---------- (1)

Stray loss = $W_S = W_1 * [t_2 / (t_1 – t_2)]$ Watt

- **Efficiency When Working as a Motor**

Aramature current $I_a = I_r - I_{sh}$ ----------(1)

Armature copper loss = $I_a^2 R_a$ Watt ----------(2)

Shunt field Copper loss = $V I_{sh}$ Watt ----------(3)

Total Losses = (1) + (2) + (3) Watt

Motor Output =Motor Input - Total Losses Watt

Motor efficiency = η_m = Motor Output / Motor Input *100

- **Efficiency When Working as a Generator**

Generator Output = $V_r I_r$ Watt ----------(1)

Armature copper loss = $I_a^2 R_a$ Watt ----------(2)

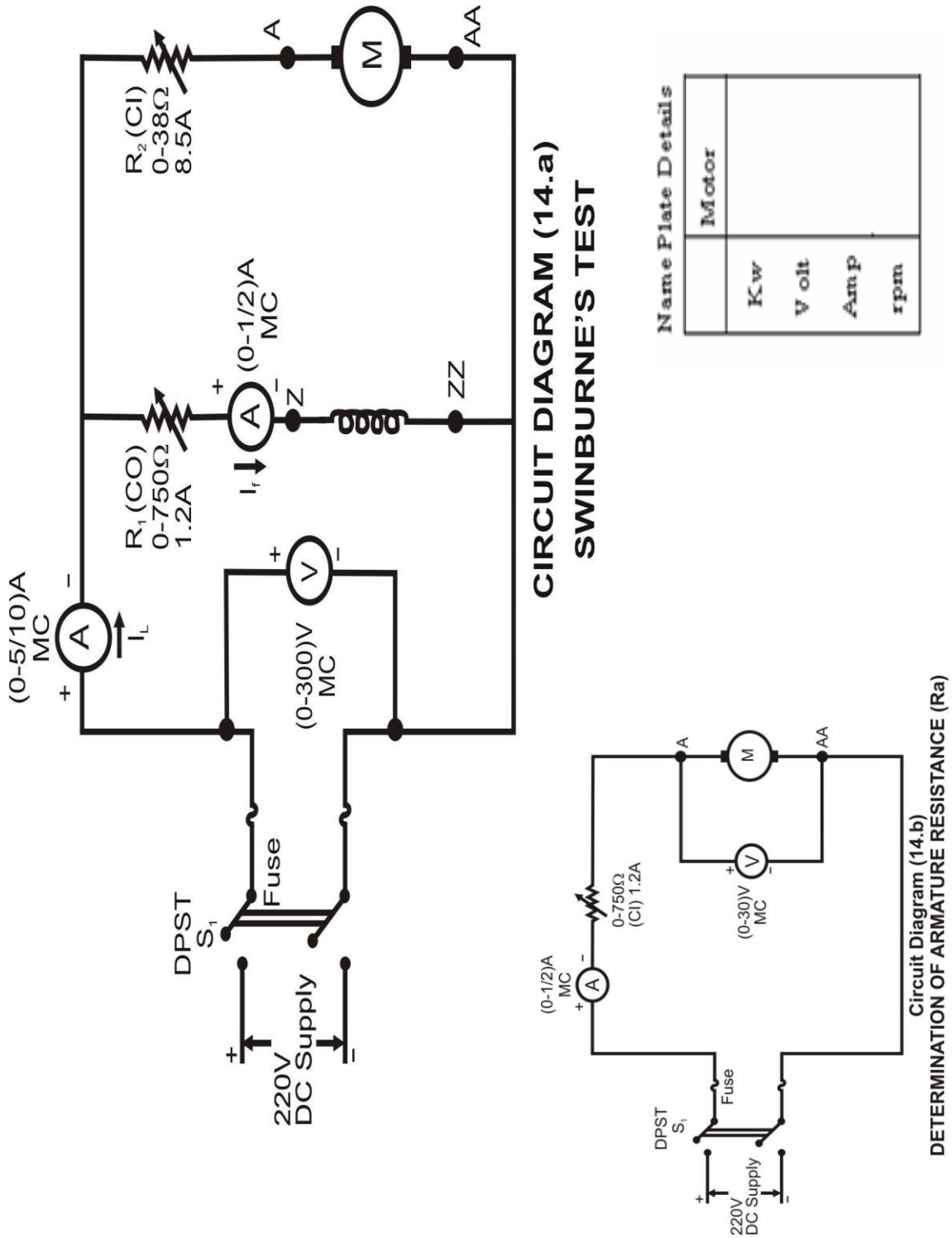
Shunt field Copper loss = $V I_{sh}$ Watt ----------(3)

Total Losses = (1) + (2) + (3) Watt

Generator Input = Generator Output-+Total Losses Watt

Generator efficiency = η_m = Generator Output / Generator Input *100

Calculation……..


CIRCUIT DIAGRAM (14.a)
SWINBURNE'S TEST
A
M
AA
R2 (Cl) 0-38Ω 8.5A
(0-1/2)A MC
Z
ZZ
R1 (CO) 0-750Ω 1.2A
If
(0-5/10)A MC
IL
(0-300)V MC
DPST S1
Fuse
220V DC Supply
Name Plate Details
Motor
Kw
V olt
Amp
rpm
Circuit Diagram (14.b)
DETERMINATION OF ARMATURE RESISTANCE (Ra)
0-750Ω (Cl) 1.2A
(0-30)V MC

EXPERIMENT NO. 14 **Date: ___/___/_____**

SWINBURNE'S TEST

Aim

To determine the constant losses and hence to find the efficiency of a given D.C.Machine at any desired load.

Apparatus Required

Sl.No.	Particulars	Range	Type	Quantity
01	Voltmeters	0-300V 0-30V	MC MC	01 01
02	Ammeters	0-5A 0-1/2A	MC MC	01 01
03	Rheostats	0-750Ω,1.2A 0-38Ω,8.5A	-	01 01
04	Tachometer	-	-	01

Procedure

1. Connections are made as shown in the circuit diagram (13.a).
2. Keeping the rheostat **R_1** in the field circuit of motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor in **cut-in** positions the supply switch**(S_1)** is closed.
3. The motor is brought to its rated speed by cutting out the rheostat R_2 and cutting in the rheostat R_1 if necessary.
4. Readings of all the meters and speed are noted down.
5. All the rheostats are brought back to their respective initial positions and the supply switch (S_1) is opened.
6. The graph of Efficiency v/s Load current is plotted as shown in Model Graph.

Determination of Armature Resistance (R_a) by V-I method

a. Connections are made as shown in the circuit diagram(13.b)

b. Keeping the rheostat in cut-in position, the supply switch (S_1) is closed, Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and voltmeter are noted down.

c. The supply switch (S_1) is opened.

Tabular Column

Sl. No	V_L Volt	I_L Amp	I_f Amp

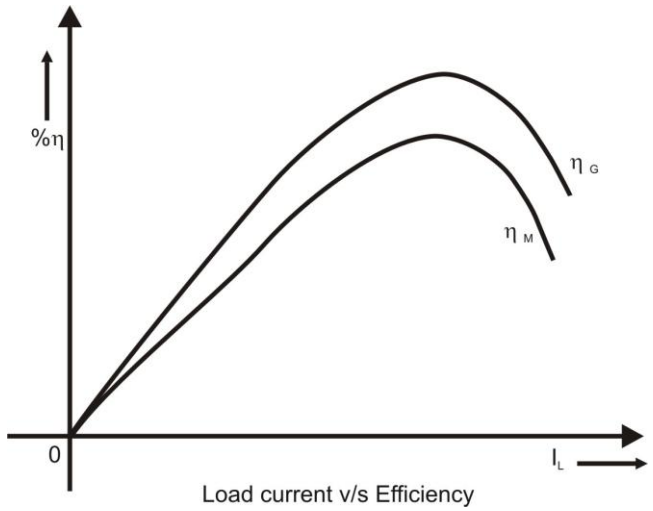
Tabulation of Results

Sl. No.	Load (X)	% η_m	% η_g
1.	Full Load		
2.	¾ of F.L		
3.	½ of F.L		
4.	¼ of F.L		

Determination of Armature Resistance (R_a)

Sl.No	V (Volts)	I (Ampere)	Resistance Ra = V/I Ω

Model Graph



Load current v/s Efficiency

Calculation

I_L = No-load motor current, Ampere

I_f = Field current, Ampere

V_L= No-load motor terminal voltage, Volt

i. No-load input power = $V_L \times I_L$ Watts

ii. Armature copper loss = $(I_L - I_f)^2 \times Ra$ Watts

iii. Constant losses, Wc = No load input power – armature Cu loss

I. Efficiency when working as a motor

a. $I_a = (x.I_{FL} - I_f)$ Ampere
   Where x= (1, ¾, ½, ¼)

b. Armature copper loss = $(I_a)^2 \times R_a$ Watts = $(x.I_{FL} - I_f)^2 \times Ra$ Watts

c. Total losses = (Wc + armature copper loss) Watts

d. Input to the motor = $V_1 (x.I_{FL})$ Watts
   (V_1 is the rated voltage of the Motor)

e. Output of the motor = (Input - Total losses) Watts

f. %η = (Output / Input) × 100

II. Efficiency when working as a generator

a. $I_{ag} = (x.I_{FL} + I_f)$ Ampere
   Where x= (1, ¾, ½, ¼)

b. Armature copper loss = $(I_{ag})^2 \times R_a$ Watt = $(x.I_{FL} + I_f)^2 \times Ra$ Watts

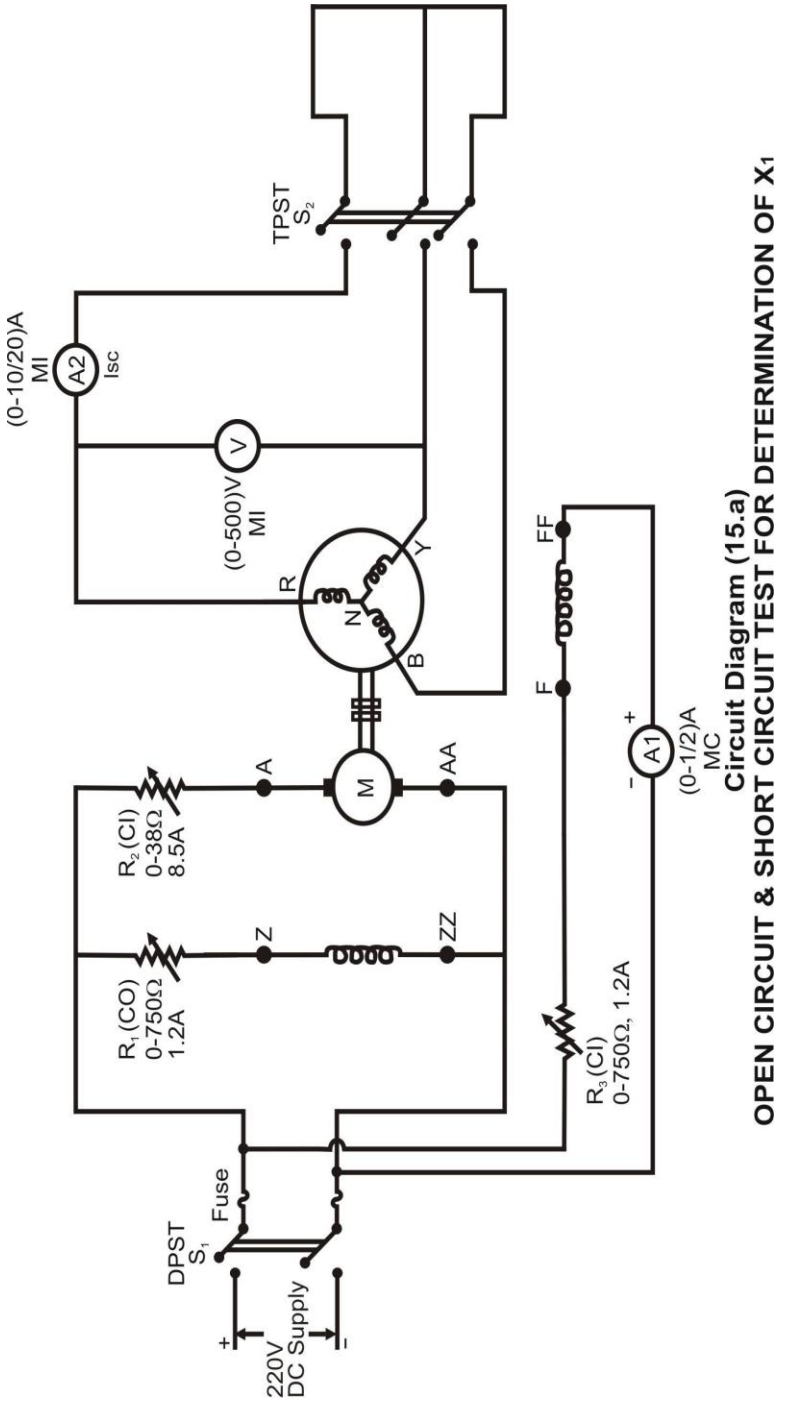
c. Total losses = (Wc + armature copper loss) Watts

d. Output of generator = $V_1(x.I_{FL})$ Watts
   (V_1 is the rated voltage of the Generator)

e. Input to the generator = (Output + Total losses) Watts

f. $\%\eta_g$ = (Output / Input) × 100

Calculation…….



Circuit Diagram (15.a)

OPEN CIRCUIT & SHORT CIRCUIT TEST FOR DETERMINATION OF X_1

NAME PLATE DETAILS

D.C. Shunt motor	
Kw	
Volt	
Amp	
Rpm	

Alternator	
KVA	
Phase	
Hz	
Volt	
Amp	
Rpm	

EXPERIMENT NO. 15 **Date: ___/___/_____**

MEASUREMENT OF X_1, X_2 AND X_O OF A SYNCHRONOUS GENERATOR AND CALCULATION OF CURRENTS FOR AN LG, LL AND LLG FAULT.

Aim: To determine X_1, X_2 AND X_O of a synchronous generator and calculation of currents foran LG,LL or LLG fault.

Apparatus Required

Sl.No	Particulars	Range	Type	Quantity
01	Voltmeters	0-30V 0-500V	MC MI	01 01
02	Ammeters	0-10/20A 0-1/2A	MI MC	01 01
03	Rheostats	0-750Ω,1.2A 0-38Ω,8.5A	-	02 01
04	Tachometer	-	-	01

Procedure

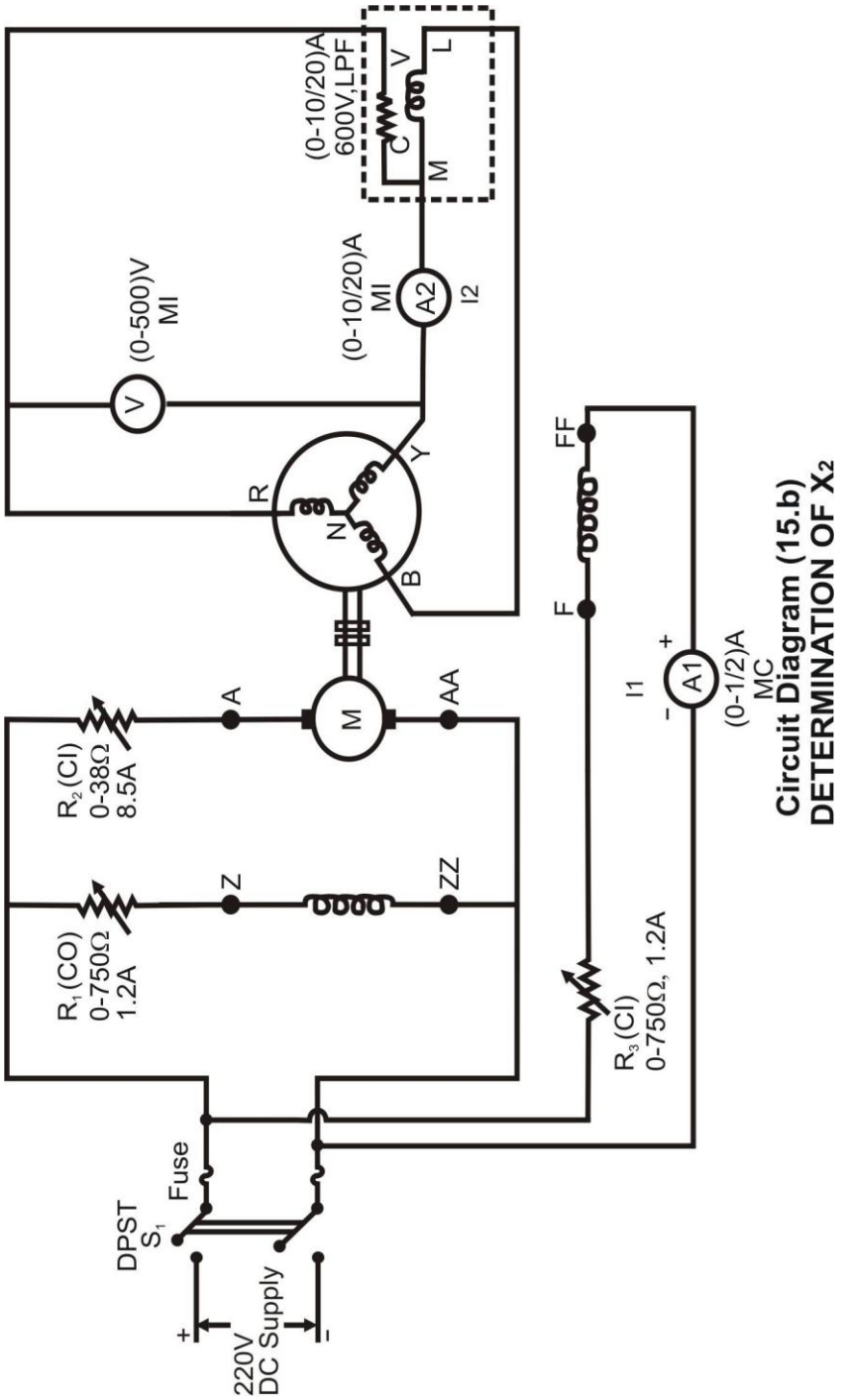
A. Determination of Positive Sequence reactance (X_1)

a. Open Circuit Test

1. Connections are made as shown in the circuit diagram (15.a)
2. Keeping the rheostat **R_1** in the field circuit of motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor and the rheostat **R_3** in field circuit of the alternator in **cut-in** positions and **TPST (S_2)** in open position, the supply switch **(S_1)** is closed.
3. The motor is brought to synchronous speed by cutting out the rheostat R_2 and then by cutting in the rheostat R_1, if necessary.
4. By gradually cutting out the rheostat R_3, the readings of ammeter (A_1, 0-2A) and voltmeter (V) are noted down.
5. The above step is continued until voltmeter reads about 1.25 times the rated voltage of the alternator.

b. Short Circuit Test

1. The rheostat R_3 is brought to its initial position (cut-in) and TPST (S_2) is closed.
2. By gradually cutting out the rheostat R_3, reading of the ammeter (A_2, 0-10/20A) is adjusted to the rated current of the alternator and the corresponding field current (A_1) is noted down.
3. All the rheostats are brought back to their respective initial positions, TPST switch (S_2) and supply switch (S_1) are opened.



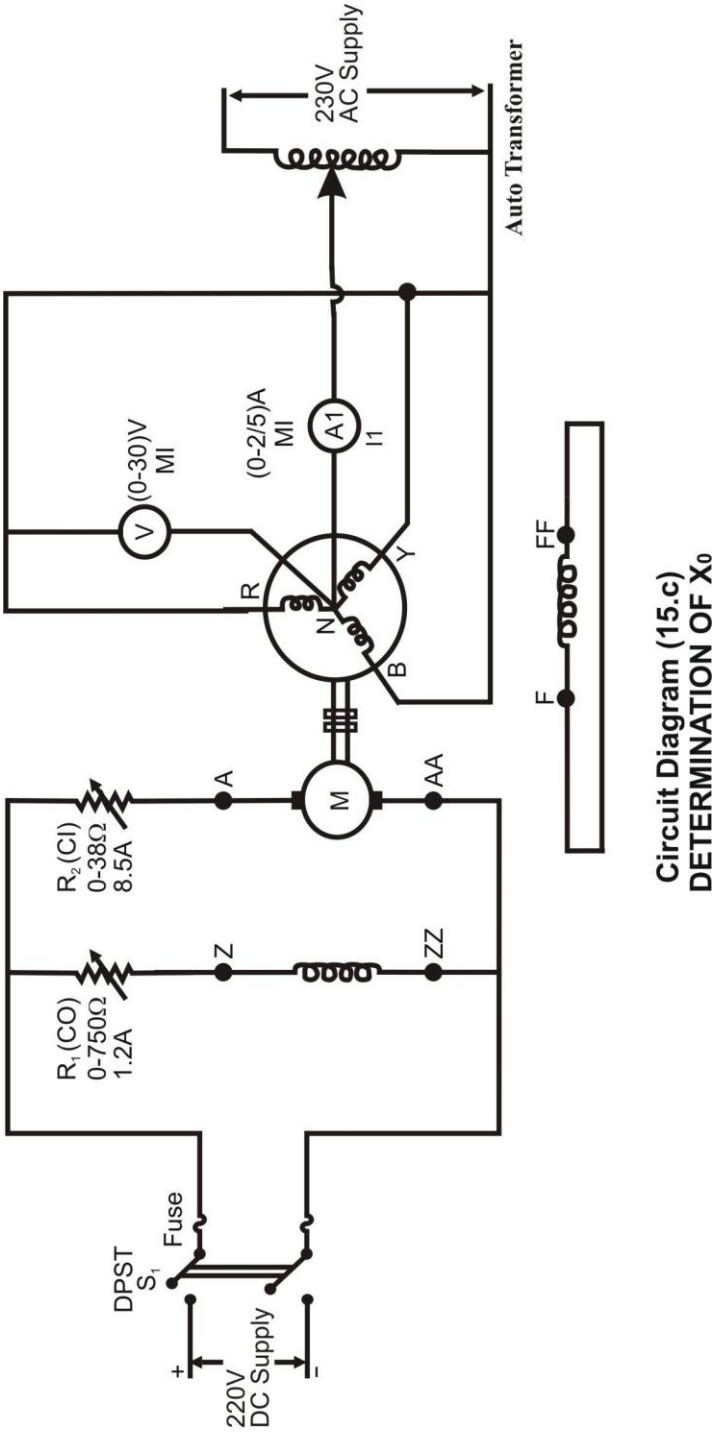
Circuit Diagram (15.b)
DETERMINATION OF X_2

B. Determination of negative Sequence reactance (X_2)

1. Connections are made as shown in the circuit diagram (15.b)
2. Keeping the rheostat **R_1** in the field circuit of motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor and the rheostat **R_3** in field circuit of the alternator in **cut-in** positions.
3. The motor is brought to rated speed by cutting out the rheostat R_2 and then by cutting in the rheostat R_1, if necessary.
4. Gradually increase the excitation such that the short circuit current does not exceed its rated value. Note the reading of voltage, current and Power.
5. All the rheostats are brought back to their respective initial positions then the supply switch S_1 is opened

C. Determination of Zero Sequence reactance (X_0)

1. Connections are made as shown in the circuit diagram (15.c)
2. Keeping the rheostat **R_1** in the field circuit of motor in **cut-out** position, the rheostat **R_2** in the armature circuit of the motor and in **cut-in** positions, switch S_2 in open condition and close switch S_1.
3. The motor is brought to rated speed by cutting out the rheostat R_2 and then by cutting in the rheostat R_1, if necessary.
4. Apply low voltage using single phase auto transformer and measure both voltage and current taken by the armature windings.
5. Open switch S_2, all the rheostats are brought back to their respective initial positions and supply switch S_1 is opened



Circuit Diagram (15.c)
DETERMINATION OF X_0

Calculations:

A. Calculation of Positive Sequence reactance (X_1)

Z_1 (actual) = $\frac{v/\sqrt{3}}{Isc}$, where V and I_{sc} is obtained from the graph

$Z_1 = R_1 + j X_1$, for finding R_1 refer page no. 27

$X_{1\,(actual)} = \sqrt{z_1^2 - R_1^2}$

$X_1(p.u) = \frac{X_1(actual)}{Z\,(base)}$, Where $Z_{(base)} = \frac{(KV)^2}{MVA}$

B. Calculation of Negative Sequence reactance (X_2)

$|Z_2| = \frac{1}{\sqrt{3}}\frac{V}{I}$, $Z_2 = |Z_2|\,(\sin\Theta + j\cos\Theta)$, Where $\Theta = \cos^{-1}\left(\frac{P}{V.I}\right)$

$Z_2 = R_2 + JX_2$

Therefore X_2(actual)= imaginary part of Z_2

$X_2(p.u) = \frac{X_2\,(actual)}{Z(base)}$, where $Z_{base} = \frac{(KV)^2}{MVA}$

C. Calculation of Zero Sequence reactance (X_0)

X_0 (actual)= $\frac{3V}{I_1}$

$X_0(p.u) = \frac{X_0\,(actual)}{Z(base)}$, where $Z_{base} = \frac{(KV)^2}{MVA}$

D. Calculation of Current for LG fault

$I_f = 3I_{a0}$ Where $I_{a1} = I_{a2} = I_{ao}$

$\boxed{I_f = 3\left(\frac{Ea}{X1+X2+X0}\right)}$ where E_a = 1p.u

E. Calculation of Current for LL fault

$I_f = \sqrt{3}\,I_{a1}$

$\boxed{I_f = \sqrt{3}\left(\frac{Ea}{X1+X2}\right)}$

F. Calculation of Current for LLG fault

$I_f = 3I_{a0}$ $I_f = -3Ia1\left(\frac{X2}{X2+X0}\right)$, Where $I_{a1} = \frac{Ea}{X1+\left(\frac{X2X0}{X2+X0}\right)}$

$\boxed{I_f = \frac{-3EaX2}{X1X2+X1X0+X2X0}}$, where E_a = 1p.u

Tabular Column

i. Determination of X_1

1. Open Circuit Test

Sl.No	I_1 Amps	V Volts

2. Short Circuit Test

Sl.No	I_f Amps	I_{sc} Amps

ii. Determination of X_2

Sl.No	I_1 Amps	I_2 Amps	V Volts	W watts	Z_2	X_2

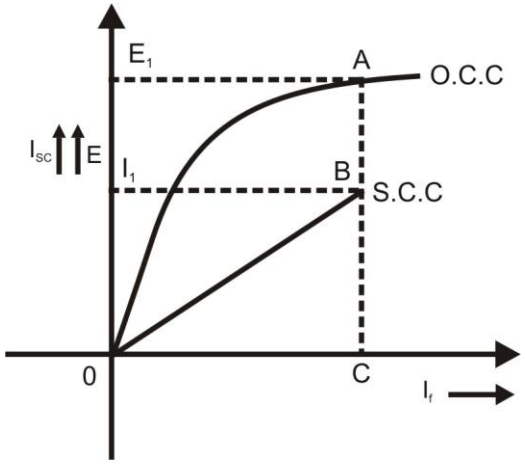
iii. Determination of X_0

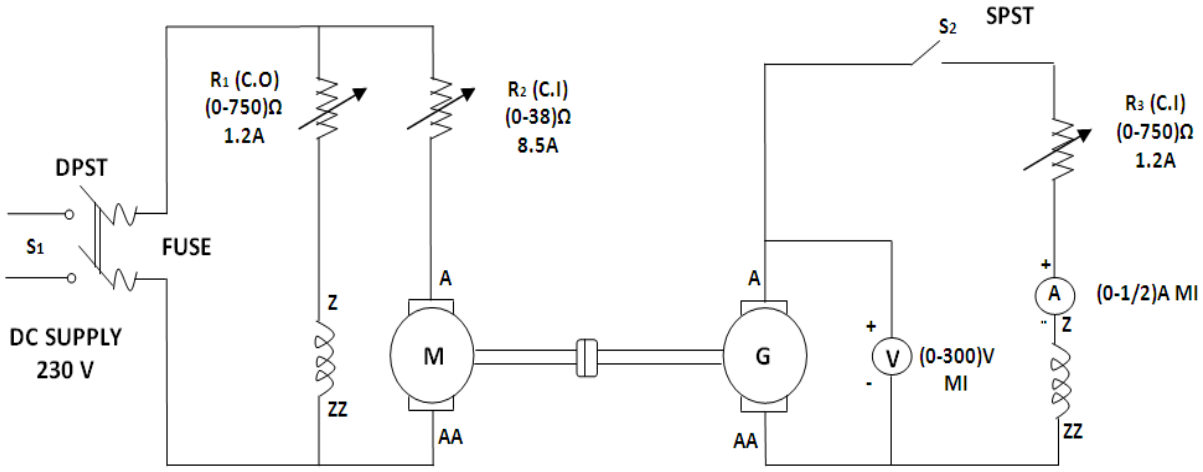
Sl.No	I_1 Amps	V Volts	X_0

To draw graph for Open circuit test and Short circuit test

i. Draw OCC and SCC for suitable scales as shown in model graph.
ii. Mark a point AB on the SCC corresponding to the rated current and draw a Perpendicular so that it cuts OCC line at a point A and X-axis at point C.
iii. Corresponding to point A, E_1 is the open circuit voltage per phase, and BC is the Short circuit current.

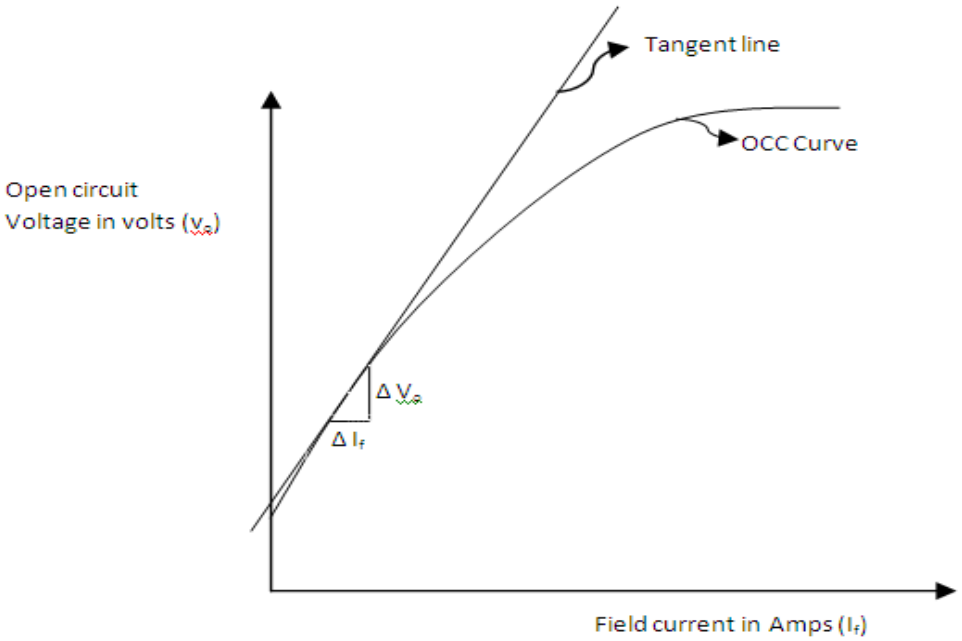
Model Graph:





Circuit Diagram (16.A)
Determination of critical field resistance of DC shunt motor

Model Graph:



EXPERIMENT NO. 16 **Date: ___/___/_____**

MEASUREMENT OF CRITICAL RESISTANCE OF DC SHUNT GENERATOR.

Aim

To determine Critical Field Resistance($R_{critical}$) a DC shunt generator.

Apparatus Required

Sl.No	Particulars	Range	Type	Quantity
01	Voltmeters	0-300V	MC	01
02	Ammeters	0-1/2A	MC	01
03	Rheostats	0-750Ω,1.2A 0-38Ω,8.5A	-	02 01
04	Tachometer	-	-	01

Procedure

1. Connections are made as shown in the circuit diagram (16.a).
2. Keeping the rheostat R_1 in the field circuit of the motor in cut-out position, the rheostat R_2 in the armature circuit of the motor and the rheostat R_3 in the field circuit of the generator in cut-in positions, and switch (S_2) in open condition, the supply switch (S_1) is closed.
3. The motor is brought to its rated speed by gradually cutting out rheostat R_2 and cutting in the rheostat R_1, if necessary.
4. Using voltmeter measure the value of residual voltage which is present in the armature of DC shunt motor.
5. Close switch S_2 gradually bring the rheostat R_3 from cut-in to cut-out position at each step note down ammeter and voltmeter readings.
6. All the rheostats are brought back to their respective initial positions, then the supply switch (S_2) and switch (S_1) are opened.

Tabular Column

Open Circuit Test

Sl.No	I_f in Amps	V_0 in Volts

To draw graph for Open circuit characteristics

i. Draw OCC for suitable scales as shown in model graph.

ii. Draw tangent line for the OCC curve.

iii. Take slope to calculate critical resistance of the given DC shunt generator.

$$\textbf{i.e. } R_{(critical)} = \frac{\Delta V_o}{\Delta I_f}$$

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6. **"Design of Electrical Machines"** – by V.N.Mittle**,** Published 2006: Standard Publishers and Distributers

7. **Principles of Electrical Machines ,** Mehta.V.K **,**Published 2007

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?
6. What is meant by armature reaction?
7. How should a generator be started?
8. How should a Shunt or compound generator be started?
9. When a generator loses its residual flux due to short circuit, how can it be made to build up?
10. What causes heating of armature?
11. What will happen if both the currents are reversed?
12. What will happen if the field of a d.c shunt motor is opened?
13. What happens if the direction of current at the terminals of series motor is reversed?
14. Explain what happens when a d.c motor is connected across an a.c supply?
15. Why does a d.c motor sometimes spark on light load?
16. A d.c motor fails to start when switched on. What could be the possible reasons and remedies?
17. What is meant by back e.m.f?
18. Discuss different methods of speed control of a d.c motor.
19. Why a d.c series motor should not be started at No load?
20. What are the losses that occur in d.c machines?
21. State some present day uses of d.c machines.
22. Write down the equation for frequency of emf induced in an Alternator.
23. Name the types of Alternator based on their rotor construction.
24. Which type of Synchronous generators are used in Hydro-electric plants and why?
25. What are the advantages of salient pole type construction used for Synchronous machines?
26. Why is the stator core of Alternator laminated?
27. What are the causes of changes in voltage in Alternators when loaded?
28. Define the term voltage regulation
29. State the condition to be satisfied before connecting two alternators in parallel
30. What is meant by infinite bus-bars?
31. How do the synchronizing lamps indicate the correctness of phase sequence between existing and incoming Alternators?
32. Why are Alternators rated in kVA and not in kW?

33. Why a DC series motor should never be stared without load?
34. Why a DC series motor has a high starting torque?
35. Compare the resistances of the field windings of DC shunt and series motor?
36. What are the applications of DC series motor?
37. Comment on the Speed – Torque characteristics of a DC series motor.
38. How does the torque vary with the armature current in a DC series motor?
39. How does the speed of a DC shunt motor vary with armature voltage and field current?
40. Compare the resistance of the armature and field winding.
41. What is the importance of speed control of DC motor in industrial applications?
42. Which is of the two methods of speed control is better and why?
43. Why is the speed of DC shunt motor practically constant under normal load condition?
44. What are the factors affecting the speed of a DC shunt motor?
45. What is meant by residual magnetism?
46. What is critical field resistance?
47. What is meant by saturation?
48. What is the difference between external and internal characteristics?
49. What is the purpose of Swinburne's test?
50. What are the constant losses in a DC machine?
51. What are the assumptions made in Swinburne's test?
52. Why is the indirect method preferred to the direct loading test?
53. The efficiency of DC machine is generally higher when it works as a generator than motor. Is this statement true or false? Justify your answer with proper reasons
54. What is the purpose of Hopkinson's test?
55. What are the precautions to be observed in this test?
56. What are the advantages of Hopkinson's test?
57. What are the conditions for conducting the test?
58. Why the adjustments are done in the field rheostat of generator and motor?
59. If the voltmeter across the SPST switch reads zero what does it indicate? If it does not read zero value what does it indicate?
60. What are the other names for Hopkinson's test?
61. Why is armature resistance less than field resistance of dc shunt machine?
62. Why is armature resistance more than field resistance of dc series machine?
63. Write the emf equation of DC and AC machine.
64. Write the torque equation of DC motor.
65. Which is the most common type of fault occurring in a power system?
66. What are unsymmetrical faults?

MODEL QUESTIONS

1. Obtain the following performance characteristics of the given DC Shunt Generator by conducting suitable experiment. Determine the induced emf at _____ load. (Graphically/ Analytically) a. Internal Characteristics

2. Obtain the following performance characteristics of the given DC Shunt Generator by conducting suitable experiment. a. External Characteristics b. Internal Characteristics and determine the induced emf at _____ load.

3. By conducting suitable experiment, Pre determine the efficiency of the given DC machine when running as motor for a Load of _____% by conducting suitable experiment

4. By conducting suitable experiment, Pre determine the efficiency of the given DC machine when running as Generator for a load of _____ % by conducting suitable experiment

5. Draw the Armature Voltage vs Speed and Field current vs Speed characteristics of a given DC shunt motor by conducting a necessary Tests.

6. By conducting suitable experiment, Pre determine the regulation of the given three phase Alternator by EMF method at full load p.f _____ (lag/lead)

7. By conducting suitable experiment, Pre determine the Regulation of the given three phase Alternator by MMF method at full load p.f _____ (lag/lead)

8. By conducting suitable experiments on the given three phase alternator to find its Synchronous reactance.

9. By conducting suitable experiments on the given three phase alternator, find the Potier reactance.

10. By conducting suitable experiment to Pre determine the regulation of the given three phase Alternator by Potier Triangle method at full load p.f _____ (lag/lead).

11. By conducting suitable experiment on the given salient pole alternator, pre-determine the regulation at full load p.f _____ (lag/lead).

12. By conducting suitable experiment demonstrate that Speed can be controlled in both forward and reverse directions for a DC shunt motor.

13. Draw the following Curves for a given DC shunt motor by conducting load test.
    (a) % Efficiency Vs BHP (c) T Vs BHP
    (b) N Vs T (d) N Vs BHP

14. Conduct a suitable test on a given DC shunt motor and obtain the following parameters at _____ % load.
    (a) % efficiency (d) N
    (b) BHP (e) Motor power input
    (c) T Vs BHP

15. After making necessary adjustments synchronize a 3phase Alternator to Infinite Bus-bar.

16. Conduct a suitable experiment to operate the given three Phase alternator on Constant power and variable excitation.

17. Conduct a suitable experiment to operate the given three phase alternator on Constant excitation and variable power.

18. Conduct the regenerative test on two similar DC machines and pre-determine efficiency of a motor at _____ % load.

19. Conduct the regenerative test on two similar DC machines and pre-determine efficiency of a generator at _____ % load.

20. Conduct the Back to Back test to pre-determine the efficiency of a motor at _____ load and efficiency of a generator at _____load.

21. Conduct Retardation Test and predetermine the efficiency as a generator at _____ Load.

22. Conduct Retardation Test and predetermine the efficiency as a Motor at _____ Load.

23. Conduct Retardation Test and predetermine the efficiency as a generator and as a Motor at _____ Load.

24. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'V' curve at no Load.

25. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'V' curve at 3A Load.

26. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'Λ' curve at no Load.

27. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'Λ' curve at 2A Load.

28. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'V' and 'Λ' curve at No Load.

29. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'V' and 'Λ' curve at 4A Load.

30. Conduct necessary test on a compound Generator to draw its external Characteristics (For Cumulative Compound Long-Shunt).

31. Conduct necessary test on a compound Generator to draw its external Characteristics (For Cumulative Compound Short-Shunt).

32. Conduct necessary test on a compound Generator to draw its external Characteristics (For Differentially Compound Long-Shunt).

33. Conduct necessary test on a compound Generator to draw its external Characteristics (For Differentially Compound Short-Shunt).

34. Conduct necessary test on a compound Generator to draw its external Characteristics (For both Differentially Compound Short-Shunt and Differentially Compound Long-Shunt).

35. Conduct necessary test on a compound Generator to draw its external Characteristics. (For Cumulative Compound Short-Shunt and Cumulative Compound Long-Shunt).

36. Conduct Field test on a D.C Series Machines and calculate Its Efficiency as a Motor at _____Load.

37. Conduct Field test on a D.C. Series Machines and calculate Its efficiency, as a Generator at _____ load.

38. Conduct Field test on a D.C. Series Machines and calculate Its efficiency, as a Generator and as a Motor at _____ load.

39. Conduct Field test on a D.C. Series Machines, to draw the % efficiency vs Load curve.

40. Conduct suitable experiment on a given three phase Alternator and determine its regulation at full load _____ p.f by ZPF method.

41. Conduct suitable experiments on synchronous generator to Calculate current for LG fault.

42. Conduct suitable experiments on synchronous generator to Calculate current for LL fault.

43. Conduct suitable experiments on synchronous generator to Calculate current for LLG fault.