National Institute of Technology Srinagar

Electrical Engineering Department

Course Title: Electrical Machines-1 Lab

Course Code: ELE-401-P

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CIRCUIT DIAGRAM:

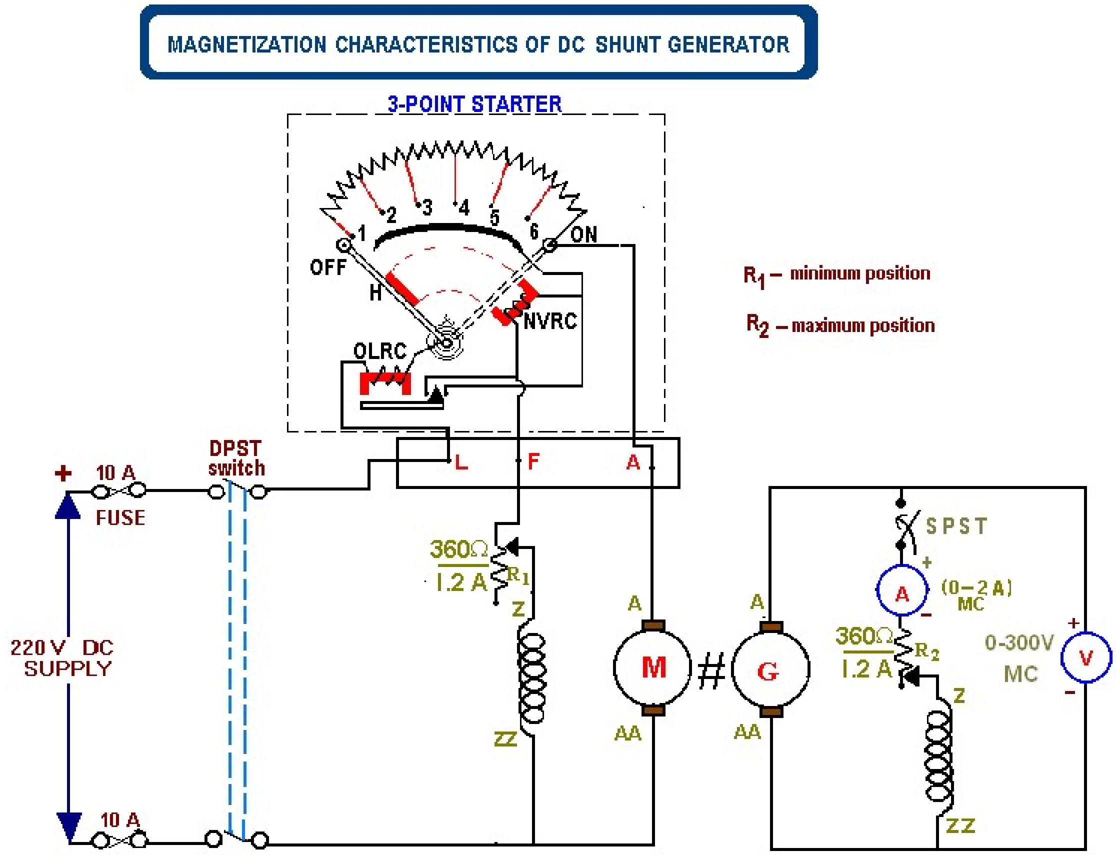


Fig 1.1

To find field resistance:

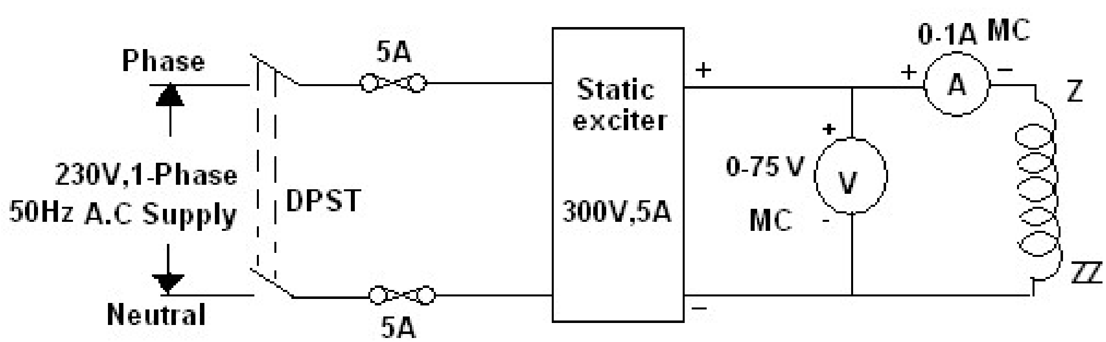


Fig 1.2

EXPT NO: 1

MAGTNETIZATION CHARACTERISTICS OF A DC SHUNT GENERATOR

AIM: To plot the magnetization characteristics of the given dc shunt generator and to determine its critical field resistance and critical speed.

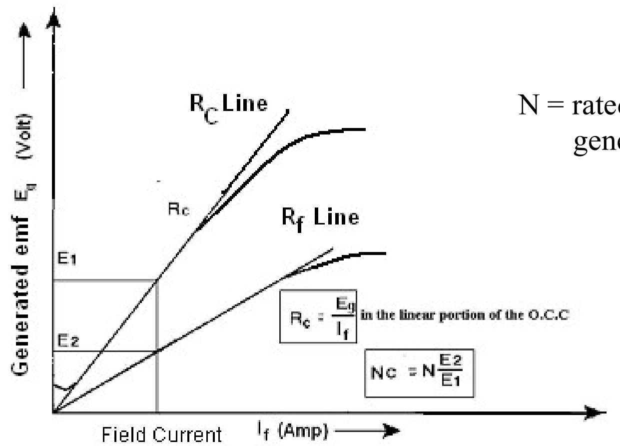
NAME PLATE DETAILS:

Specifications	Motor	Generator
Power	2.2 KW	2.2 KW
Voltage	220V	220V
Current	11.6A	10A
Speed	1500 rpm	1500 rpm
Excitation	0.6A,220V	0.6A,220V
Winding	Shunt	Shunt

APPARATUS:

S. No	Name of the apparatus	Range	Type	Quantity
1	Voltmeters	(0-300)V (0-75)V	MC MC	1 1
2	Ammeter	(0-1/2)A	MC	1
3	Rheostats	360Ω/1.2A	Wire Wound	2
4	SPST switch			1
5	Tachometer			1
6	Connecting probes			Required number

MODEL GRAPH:



N = rated speed of generator

TABULAR COLUMN:

S.No	Increasing Field current I_F	Generated emf (E_{g1})
1	0.1	40
2	0.2	76
3	0.3	110
4	0.4	114
5	0.5	162
6	0.55	176
7	0.6	182
8	0.7	200
9	0.8	214
10	0.9	228
11	0.95	232
12	1.0	238
13	1.2	246

S.No	Decreasing Field current I_F	Generated emf (E_{g2})	Average Generated emf (E_{g1} + E_{g2})/2
1	0.1	52	46
2	0.2	86	81
3	0.3	124	117
4	0.4	152	146
5	0.5	176	169
6	0.55	184	180
7	0.6	194	188
8	0.7	206	203
9	0.8	220	217
10	0.9	228	228
11	0.95	232	232
12	1.0	238	238
13	1.2	246	246

PRECAUTIONS:

1. Avoid loose connections.
2. Avoid parallax error while taking the readings.

PROCEDURE:

1. Make the connections as per circuit diagram (Fig.1.1).
2. Keep the SPST switch in open position; keep the motor field rheostat at minimum resistance position and the generator field rheostat at maximum resistance position.
3. Close the DPST switch and start the motor using 3-point starter.
4. Adjust the motor field rheostat till the rated speed of the generator is achieved.
5. Note down the residual voltage (voltmeter reading).
6. Close the SPST switch, decrease the resistance of generator field rheostat in steps till the generator builds up to 125% of its rated voltage and note down the corresponding values of generated e.m.f and the shunt field current.
7. Now increase the resistance of generator field rheostat in steps and note down the generated emf for the same field currents as taken in the step 6.
8. Calculate the average of the generated emf for corresponding field currents obtained in step 6 & 7.
9. Open the DPST switch and disconnect the circuit.

To calculate field resistance:

10. Make the connections as per the circuit diagram (Fig.1.2).
11. Keep the static exciter knob at zero voltage position and switch on the single-phase AC supply by closing the DPST switch.
12. Vary the static exciter in steps and note down the corresponding readings of voltage and current at each step.(Don't exceed the current rating of the static exciter i.e. 5A)
13. Reduce the static exciter output voltage to zero value and disconnect the circuit.
14. Calculate the field resistance in each step and take the average value of it.

To determine critical field resistance:

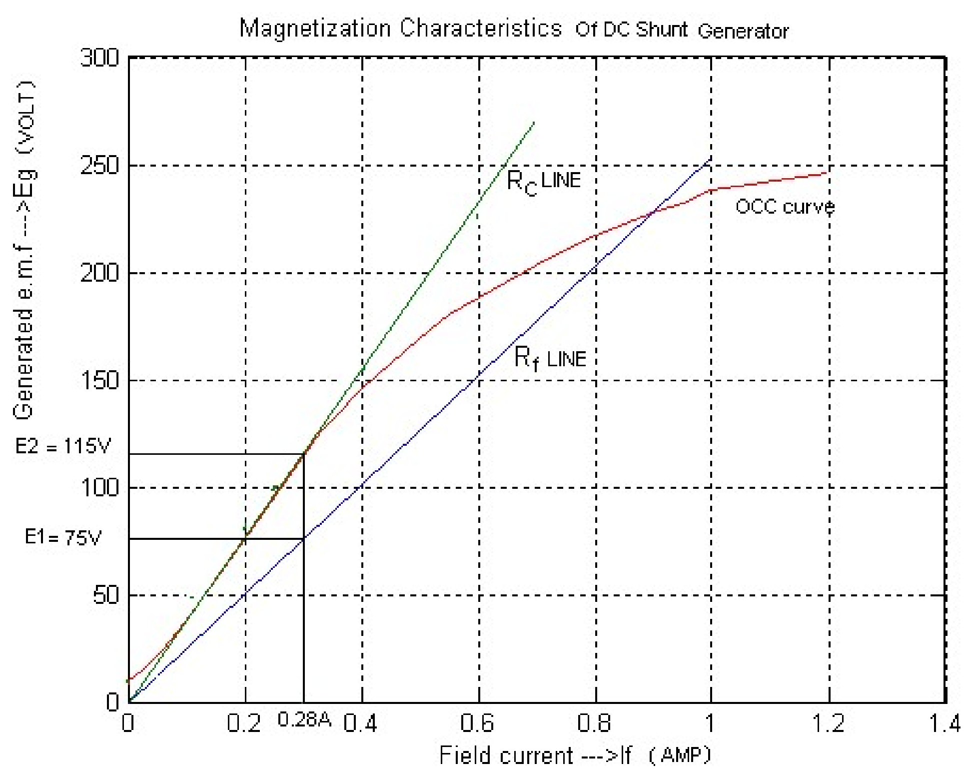
15. After plotting the magnetization characteristics draw a tangent line to its initial portion, which passes through the origin.
16. Calculate the slope of this tangent line, which gives the critical field resistance (R_c) at the rated speed of the generator.

To calculate field winding resistance:

S.No	Applied Voltage V(volt)	Current I (Amp)	Field winding resistance $R_f(cold) = \frac{V}{I}\ \Omega$
1	10	0.05	200
2	20	0.09	222.2
3	40	0.17	210.52
Average value of R_f(cold)=210.9			

$R_f(Hot) = 1.2 \text{ X } 210.9 = 253\Omega$

GRAPH:



To determine critical speed:

17. Draw the designed field resistance line (R_f)

18. Draw a line parallel to y-axis, which cuts the R_f line and R_c line with in the linear portion of the magnetization characteristics.

19. Take the generated emf values corresponding to points of intersection of the line.

20. Calculate the critical speed using the formula. $N_C = \frac{E_1}{E_2} \times N_{rated}$

SAMPLE CALCULATIONS:

From Graph

1) Critical field resistance, $R_c = \frac{E_2}{I_f} = \frac{115V}{0.28A} = 410.714\Omega$

2) Critical speed $N_c = N_{Rated} \frac{E_1}{E_2} = 1500 \times \frac{75}{115} = 978rpm$

RESULT:

The critical field resistance of the generator at its rated speed is found to be <u>410.74Ω</u> and the critical speed of the generator for the designed field winding resistance is found to be <u>978 rpm.</u>

CONCLUSIONS:

1. If the excitation is below its rated value the maximum part curve is linear and above the rated value of excitation the curve is non-linear i.e the further increase of field current will not have any effect on terminal voltage of the generator.

2. The total magnetization characteristics are non-linear in nature.

3. The point of intersection of field winding resistance line with magnetization characteristics gives the rated no-load terminal voltage of the given generator.

4. As the steepness of the curve will increases with increase in field resistance and the maximum value of generated emf at its terminals decreases.

CIRCUIT DIAGRAM:

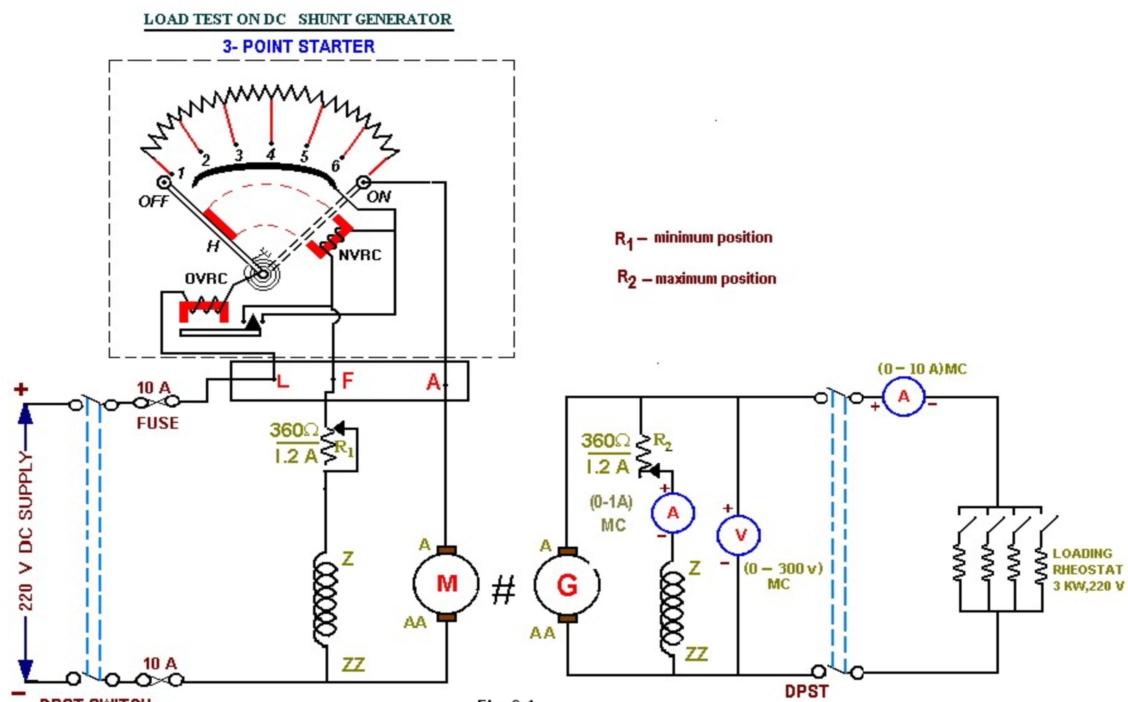


Fig 2.1

To find armature resistance (R_a):

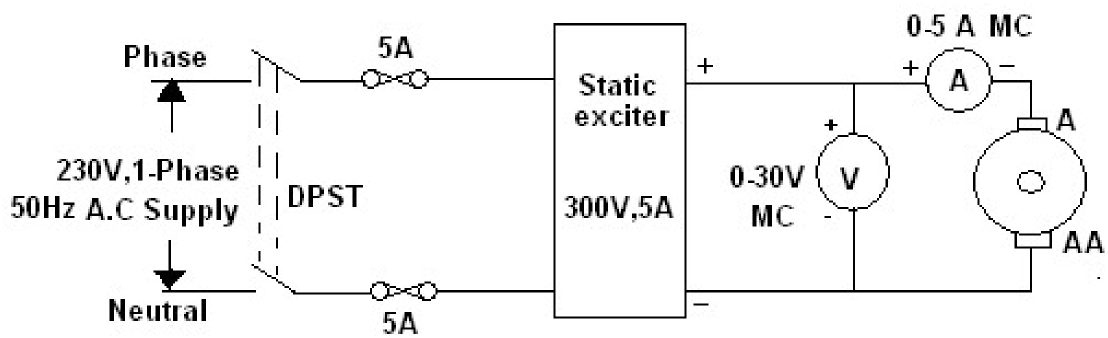


Fig 2.2

EXPT NO: 2

LOAD TEST ON DC SHUNT GENERATOR

AIM: To determine the internal and external characteristics of the given dc shunt generator by conducting load test.

NAME PLATE DETAILS:

Specifications	Motor	Generator
Power	2.2 KW	2.2 KW
Voltage	220 V	220V
Current	11.6 A	10A
Speed	1500 rpm	1500 rpm
Excitation	0.6A, 220V	0.6A, 220V
Winding	Shunt	Shunt

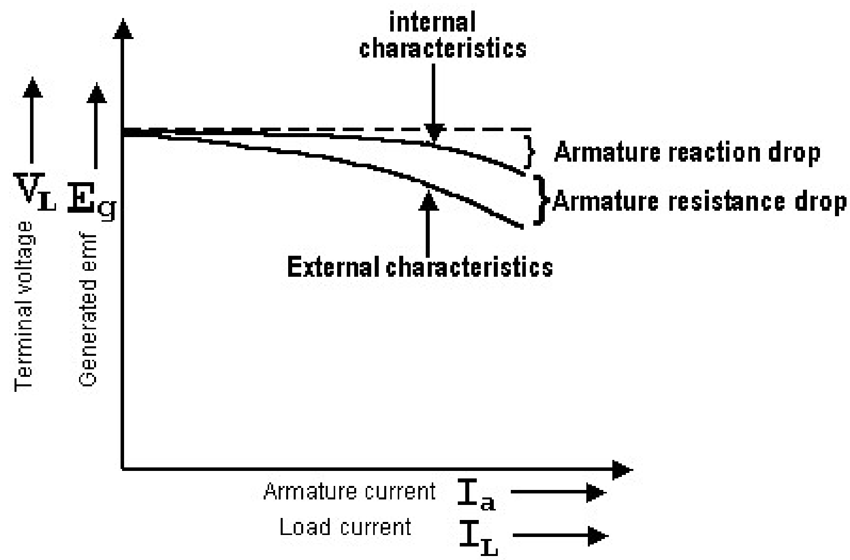
APPARATUS:

S. No	Name of the apparatus	Range	Type	Quantity
1	Voltmeters	(0-300) V (0-30) V	MC MC	1 1
2	Ammeters	(0-1) A (0-5/10) A	MC MC	1 1
3	Rheostats	360Ω/1.2A	Wire Wound	2
4	DPST switch			1
5	Tachometer			1
6	Loading rheostat	3 KW, 220 V		1
7	Connecting probes			Required number

PRECAUTIONS:

1. Avoid loose connections.
2. Avoid parallax error while taking the readings.
3. Don’t switch off the motor-generator set when the generator is on load.
4. Maintain speed of the motor constant through out the experiment.

MODEL GRAPH:



TABULAR COLUMN:

S.No	Load current (I_L) (Amp)	Voltage across the load (V_L) (Volt)	Field current (I_f) (Amp)	Armature current (I_a) (Amp)	Armature resistance drop ($I_a R_a$) (Volt)	Generated emf ($E_g=V_L+I_aR_a$) (Volt)
1	0.00	220	0.58	0.58	1.16	221.16
2	0.75	214	0.56	1.31	2.62	216.62
3	1.70	208	0.54	2.24	4.48	212.48
4	2.60	204	0.53	3.13	6.26	210.26
5	3.60	198	0.52	4.12	8.23	206.23
6	4.30	196	0.51	4.81	9.61	205.61
7	5.25	192	0.50	5.75	11.50	203.50
8	5.90	190	0.49	6.39	12.78	202.78
9	6.60	186	0.48	7.08	14.16	200.16
10	7.20	182	0.47	7.67	15.34	197.34
11	7.75	178	0.46	8.21	16.42	194.42
12	8.35	174	0.45	8.80	17.60	191.16
13	8.90	170	0.44	9.44	18.88	188.00
14	9.50	168	0.43	9.93	19.86	187.00

PROCEDURE:

1. Make the connections as per the circuit diagram.(Fig.2.1)
2. Initially keep the motor field rheostat (R_1) in minimum resistance position and generator field rheostat (R_2) in maximum resistance position. Keep the load DPST switch in open position.
3. Close the supply DPST switch and start the motor with the help of 3-point starter.
4. Adjust the speed of motor- generator set to the rated speed of the generator by varying motor field rheostat (R_1).
5. Vary the generator field rheostat till no load rated voltage is generated across the generator terminals.
6. Close the load DPST switch and vary the load to full load value in steps. Note down the corresponding values of field current (I_f), load current (I_L) and load voltage (V_L) in each step.
7. Gradually reduce the load to zero, open the DPST switch to disconnect the circuit.

To calculate armature resistance:

8. Make the connections as per the circuit diagram (Fig.2.2).
9. Keep the static exciter knob at zero voltage position and switch on the single-phase AC supply by closing the DPST switch.
10. Vary the static exciter in steps and note down the corresponding readings of voltage and current at each step. (Don't exceed the current rating of the static exciter i.e. 5A)
11. Reduce the static exciter output voltage to zero value and disconnect the circuit.
12. Calculate the armature/field resistance in each step and take the average value of it.

To calculate armature resistance of shunt generator:

S.No	Applied Voltage V(volt)	Armature current I_a (Amp)	Armature resistance $R_a(cold) = \frac{V}{I_a}\,\Omega$
1	1.0	0.6	1.66
2	1.8	1.0	1.80
3	2.2	1.3	1.70
4	3.3	2.0	1.65
5	4.6	2.9	1.58
Average value of R_a(cold)=1.67Ω			

$$R_a(Hot) = 1.67 \times 1.2 = 2\ \Omega$$

SAMPLE CALCULATIONS:

Load current (I_L) = 0.75 A

Voltage across the load terminals (V_L) = 214 V

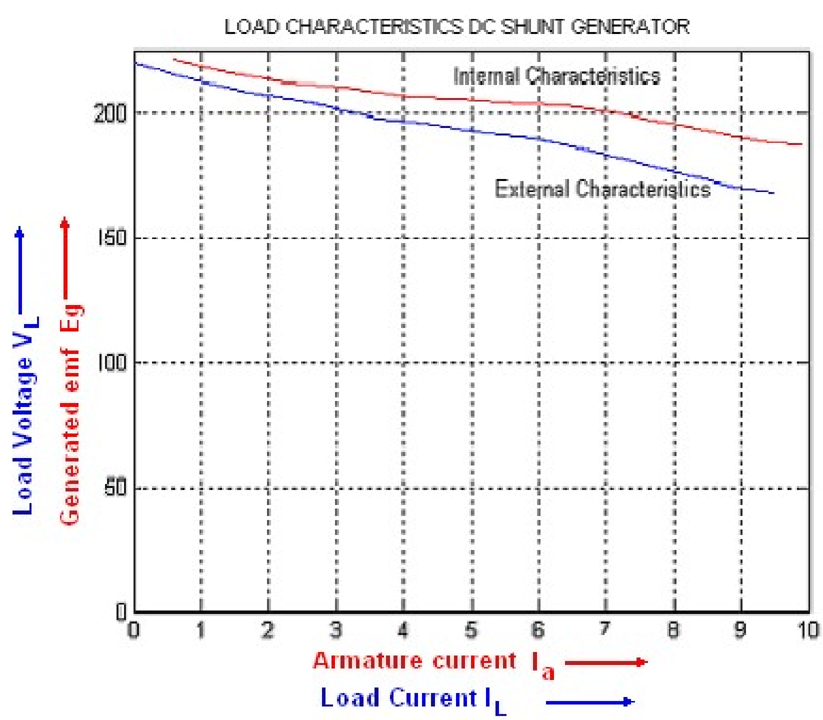
Field current (I_f) = 0.56 A

Armature current(I_a) = 1.31 A

Armature resistance drop ($I_a R_a$) = 1.31×2 = 2.62 V

Generated emf (E_g) = $V_L + I_a R_a$ = 214 + 2.62 =216.62 V

GRAPH:



RESULT:

Obtained and plotted the internal and external characteristics of the given dc shunt generator.

CONCLUSIONS:

1. The terminal voltage decreases with the increase in load current due to the cumulative effect of armature reaction and I_aR_a drop.(from external characteristics)
2. The internal characteristics represent the drop in generated emf due to armature reaction.
3. From the internal characteristics the effect of armature reaction on generated e.m.f is more predominant at high loads.
4. As the terminal voltage is almost constant from no load to full load, the dc generators can be used as constant voltage sources. (For charging the batteries…)

CIRCUIT DIAGRAMS:

LOAD TEST ON DC SERIES GENERATOR

CIRCUIT DIAGRAM:

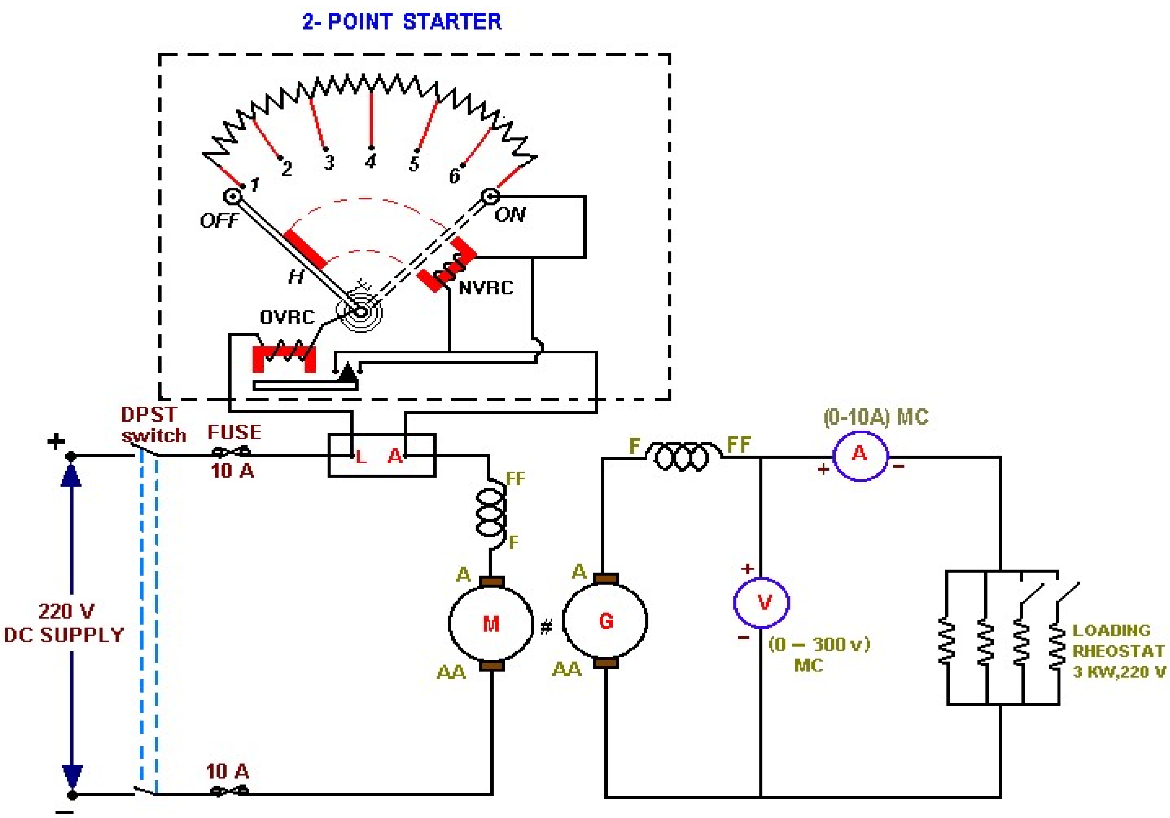


Fig 3.1

To find armature resistance R_a:

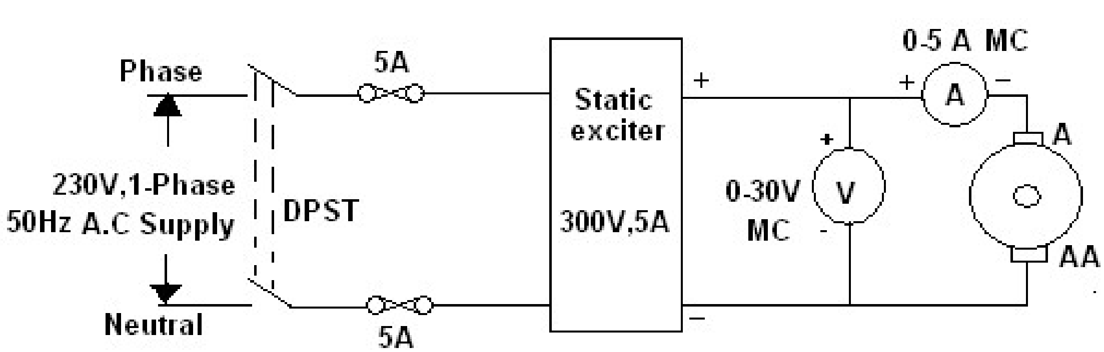


Fig 3.2

EXPT NO: 3

LOAD TEST ON DC SERIES GENERATOR

AIM: To determine the internal and external characteristics of the given dc series generator by conducting load test.

NAME PLATE DETAILS:

Specification	Motor	Generator
Power	2.2 KW	2.2 KW
Voltage	220V	22O V
Current	11.6 A	10 A
Speed	1500rpm	1500 rpm
Winding	Series	Series

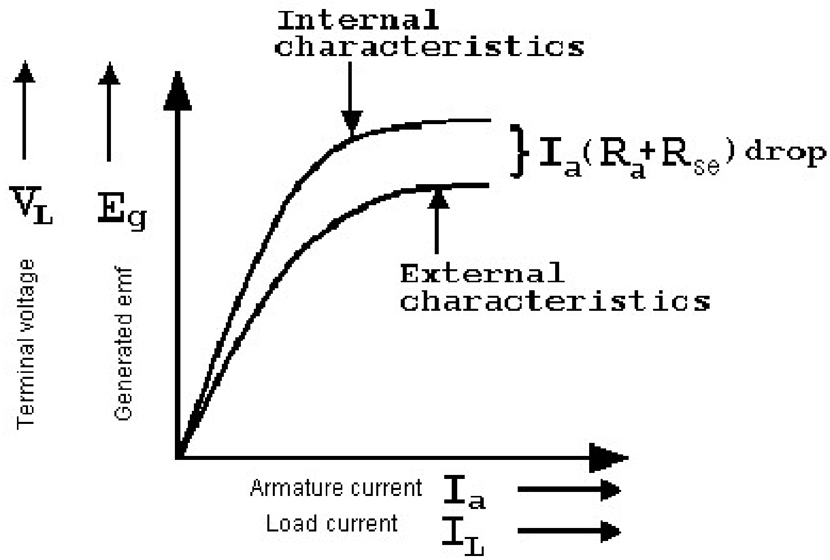
APPARATUS:

S.No	Name of the apparatus	Range	Type	Quantity
1	Voltmeters	(0- 300)V (0-30)V	MC MC	1 1
2	Ammeter	(0-5/10) A	MC	1
3	Loading rheostat	3 KW, 220 V		1
4	Connecting probes			Required number

PRECAUTIONS:

1. Avoid loose connections.
2. Avoid parallax error while taking the readings.
3. Don’t start the motor without loading the generator.
4. If generated voltage is found to be less than the residual voltage (approximately 10 V) stop the motor and reverse the field terminals of the generator.

GRAPH:



TABULAR COLUMN:

S. No	Voltage across the load V_L (volt)	Load current $I_L=I_a=I_f$ (Amp)	Generated emf $E_g=V_L+I_a(R_a+R_{se})$ (Volt)
1	178	5.5	186.99
2	182	6.4	192.47
3	182	7.1	193.61
4	182	7.8	194.76
5	180	8.5	193.91

To calculate armature resistance of series generator:

S.No	Applied Voltage V (Volt)	Armature current I (Amp)	Armature resistance R_a (cold)= $\frac{V}{I}\,\Omega$
1	0.9	1	0.9
2	1.7	2	0.85
3	2.4	3	0.8
4	3.2	4	0.8
Average value of R_a(cold) = 0.8375Ω			

$R_a(\text{Hot})=1.2\times 0.8375=1.005\Omega$

To find series field winding resistance R_{se}:

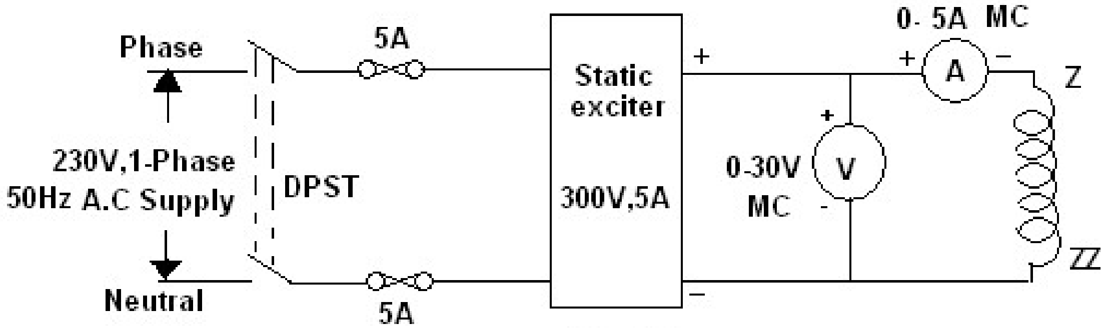


Fig 3.3

PROCEDURE:

1. Make the connections as per the circuit diagram (Fig.3.1).
2. Close the DPST switch and start the motor with the help of 2-point starter.
3. Increase the load on the generator in steps and tabulate the corresponding readings of terminal voltage (voltmeter) and load current (ammeter).
4. Reduce the load on generator to half full load in steps, open the DPST switch and disconnect the circuit.

To calculate armature / field winding resistance:

5. Make the connections as per the circuit diagram (Fig.6.2/Fig.6.3).
6. Keep the static exciter knob at zero voltage position and switch on the single-phase AC supply by closing the DPST switch.
7. Vary the static exciter in steps and note down the corresponding readings of voltage and current at each step.(Don’t exceed the current rating of the static exciter i.e. 5A)
8. Reduce the static exciter output voltage to zero value and disconnect the circuit.
9. Calculate the armature/field resistance in each step and take the average value of it .

To calculate field winding resistance of series generator:

S.No	Applied Voltage V(volt)	Series field current I (ampere)	Field winding resistance $R_f(cold) = \frac{V}{I}\,\Omega$
1	0.5	1	0.5
2	1.1	2	0.55
3	1.6	3	0.53
4	2.1	4	0.525
Average value of $R_f(cold) = 0.526\Omega$			

$R_{se}(Hot)=1.2 \times 0.526=0.631\Omega$.

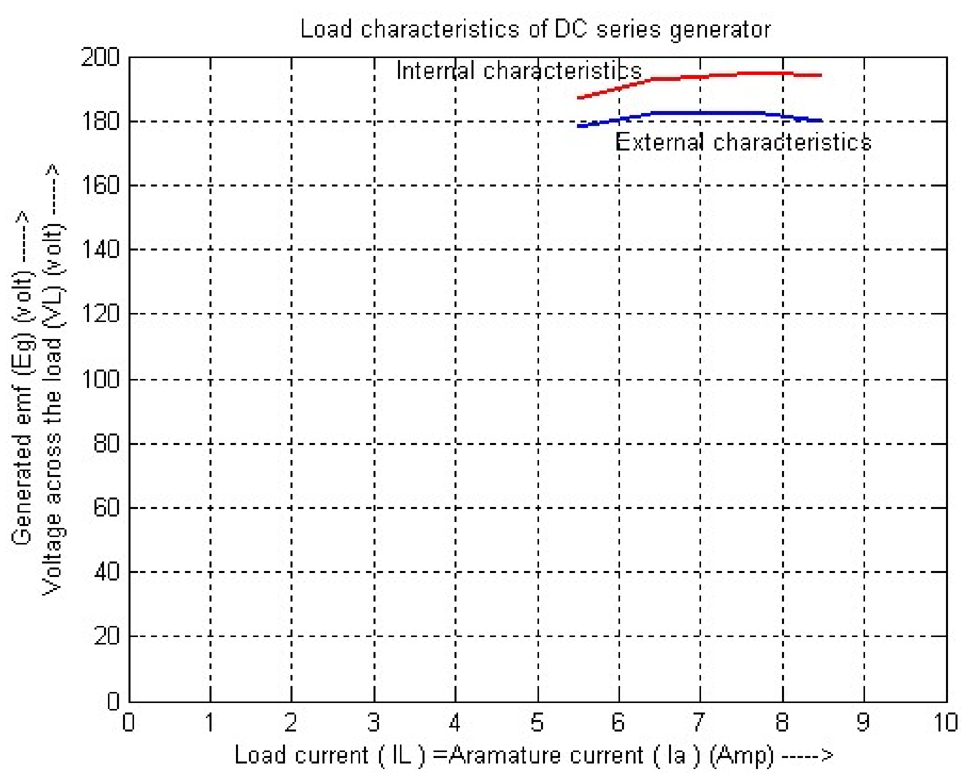
SAMPLE CALCULATIONS:

Voltage across the load V_L = 178 V

Load current $I_L=I_a=I_f$ = 5.5 A

Generated emf $E_g=V_L+ I_a(R_a+R_{se})=178 +5.5(1.005+0.631)$ =186.99V

GRAPH:



RESULT:

Obtained and drawn internal and external characteristics of the the given dc series generator.

CONCLUSIONS:

1. With the increase in the load current, the field current increases and therefore the generated voltage also increases, therefore series generator has raising voltage characteristics. Because of these raising characteristics D.C. Series generator can be used as a voltage booster.
2. The difference between internal and external characteristics is because of the drop due to armature and series field resistances.
3. From the effect of armature reaction on generated emf is more predominant at higher loads.
4. The terminal voltage decreases with the increase in load current due to the cumulative effect of armature reaction and armature resistance (I_aR_a) drop.

CIRCUIT DIAGRAM:

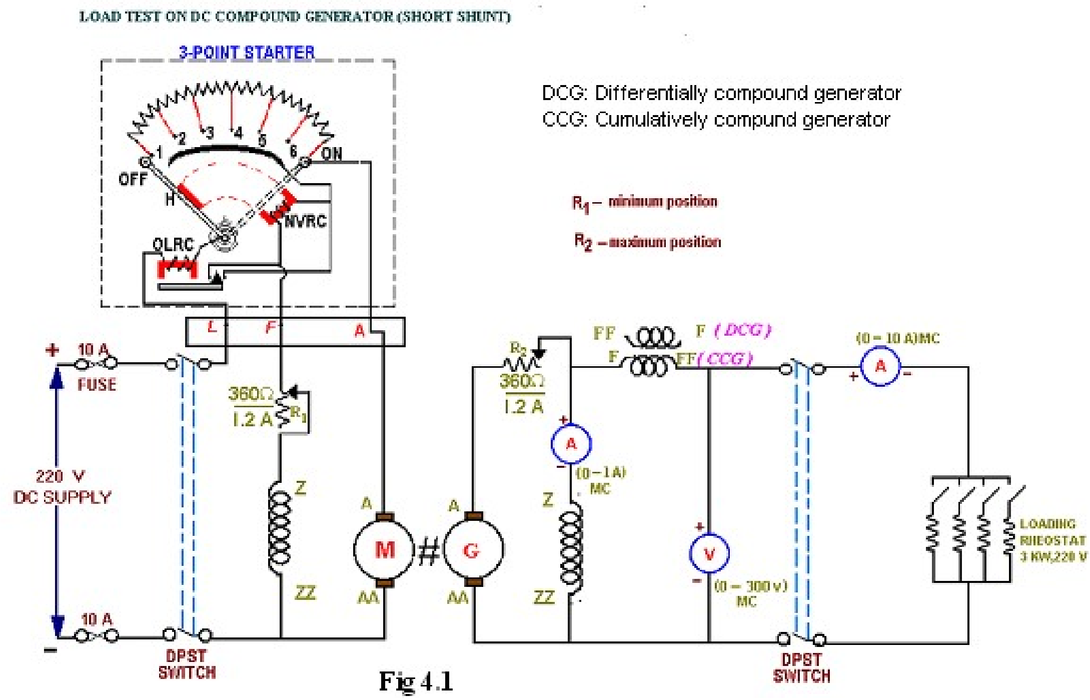


Fig 4.1

To find armature resistance R_a:

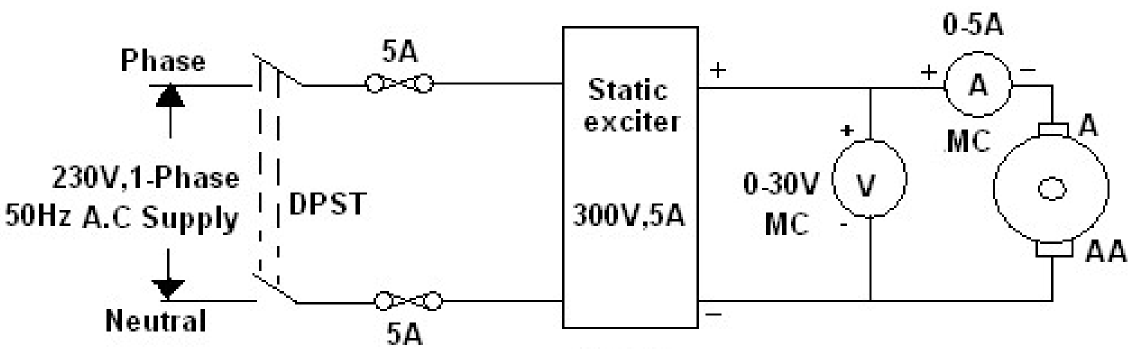


Fig 4.3

To find series field winding resistance:

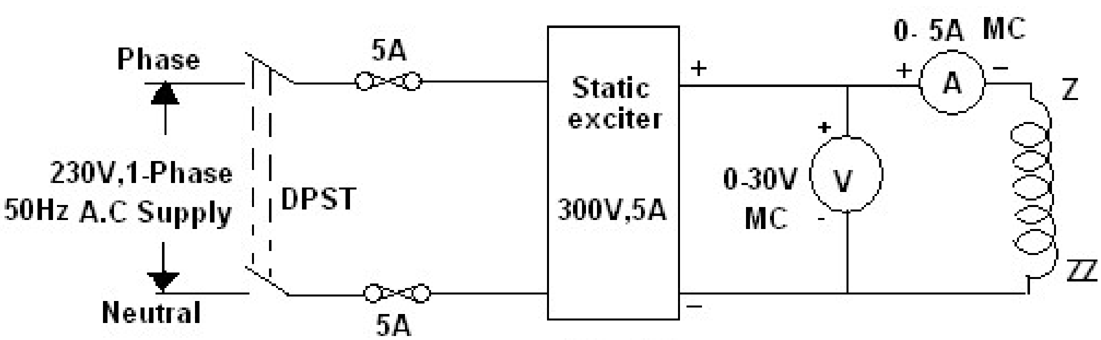


Fig 3.3

EXPT NO: 4

LOAD TEST ON D.C. COMPOUND GENERATOR

AIM: To determine the internal and external characteristics of the given dc short-shunt compound generator by conducting load test on it.

NAME PLATE DETAILS:

Specification	Motor	Generator
Power	2.2 KW	2.2 KW
Voltage	22O V	220V
Current	11.6 A	10A
Speed	1500 rpm	1500 rpm
Excitation	0.6A,220V	0.6A,220V
Winding	Shunt	Compound

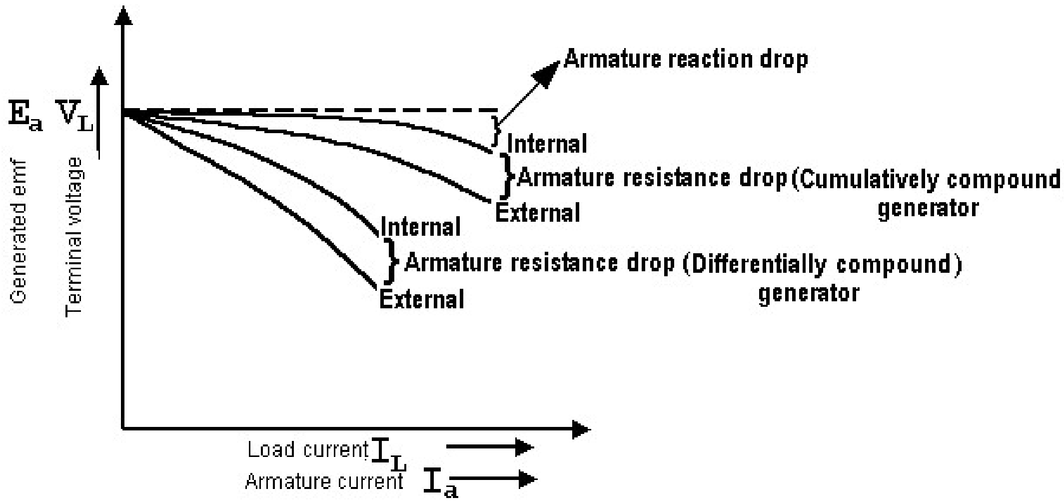
APPARATUS:

S. No	Name of the apparatus	Range	Type	Quantity
1	Voltmeters	(0-300)V (0-30)V	MC MC	1 1
2	Ammeters	(0-1) A (0-10) A	MC MC	1 1
3	Rheostats	360Ω/1.2A	Wire Wound	2
4	DPST switch			1
5	Tachometer			1
6	Loading rheostat	3 KW, 220 V		1
7	Connecting probes			Required number

PRECAUTIONS:

1. Avoid loose connections.
2. Avoid parallax error while taking the readings.
3. The motor-generator set should not be switched off when the generator is on load.

MODEL GRAPH:



TABULAR COLUMN:
Cumulatively compound generator

S. No	Voltage across the load (V_L) (Volt)	Load current (I_L) (Amp)	Field current (I_f) (Amp)	Armature current $I_a = I_L + I_f$ (Amp)	Voltage drop across R_a I_aR_a (Volt)	Generated emf $E_g=V_L+I_aR_a+I_LR_{se}$ (Volt)
1	219	0.45	0.640	1.09	1.962	220.96
2	218	0.85	0.640	1.49	2.682	220.68
3	214	1.70	0.630	2.33	4.194	218.19
4	210	2.60	0.620	3.22	5.796	215.79
5	208	3.40	0.610	4.01	7.218	215.21
6	204	4.20	0.600	4.80	8.640	212.64
7	200	5.00	0.585	5.58	10.04	210.04
8	196	5.75	0.580	6.33	11.39	207.39
9	192	6.55	0.565	7.11	12.79	204.79
10	190	7.25	0.550	7.80	14.04	204.04
11	184	8.75	0.54	9.29	16.72	200.72

NOTE: Voltage drop due to series field winding resistance is negligible since its resistance is very less.

PROCEDURE:

For cumulative mode of operation:

1. Make the connections as per the circuit diagram (Fig.4.1).
2. Initially keep the motor field rheostat (R_1) in minimum resistance position and generator field rheostat (R_2) in maximum resistance position. Keep the load DPST switch in open position.
3. Close the supply DPST switch and start the motor with the help of 3-point starter.
4. Adjust the speed of motor-generator set to rated speed of the generator, by varying the motor field rheostat (R_1).
5. Vary the generator field rheostat until the rated voltage is developed across the generator terminals.
6. Close the load DPST switch and increase the load up to the full load value of the generator and note down the corresponding values of field current (I_f), load current (I_L) and terminal voltage (V_L).
7. Reduce the load to zero, switch off the supply and disconnect the circuit.

For differential mode of operation:

8. Reverse the series field terminals of the generator and repeat the above steps from 1 to 7.

To calculate armature/Series field winding resistance of dc compound generator:

9. Make the connections as per the circuit diagram (Fig.4.2/Fig.4.3).
10. Keep the static exciter knob at zero voltage position and switch on the single-phase AC supply by closing the DPST switch.
11. Vary the static exciter in steps and note down the corresponding readings of voltage and current at each step.(Don’t exceed the current rating of the static exciter i.e. 5A)
12. Reduce the static exciter output voltage to zero value and disconnect the circuit.
13. Calculate the armature/field resistance in each step and take the average value of it

Differentially compounded generator:

S. No	Voltage across the load (V_L) (Volt)	Load current (I_L) (Amp)	Field current (I_f) (Amp)	Armature current $I_a = I_L + I_f$ (Amp)	Voltage drop across R_a I_aR_a (Volt)	Generated emf $E_g = V_L+I_aR_a+I_LR_{se}$ (Volt)
1	216	0.40	0.62	1.020	1.836	217.83
2	214	0.85	0.61	1.460	2.628	216.62
3	206	1.65	0.59	2.240	4.032	210.03
4	198	2.45	0.57	3.020	5.436	203.43
5	194	3.20	0.55	3.750	6.750	200.75
6	188	3.90	0.54	4.440	7.992	196.00
7	174	5.10	0.50	5.600	10.080	184.08
8	164	5.60	0.47	6.070	10.926	174.92
9	158	6.15	0.46	6.610	11.898	169.89
10	148	6.50	0.43	6.930	12.474	160.47
11	140	6.90	0.40	7.300	13.140	153.14
12	136	7.30	0.395	7.695	13.851	149.85

NOTE: Voltage drop due to series field winding resistance is negligible since its resistance is very less.

To calculate series field winding resistance of dc compound generator:

S.No	Applied Voltage V(volt)	Sereis field current I (Amp)	Series field resistance $R_{se}(cold)= \frac{V}{I}\ \Omega$
1	0.2	1.25	0.16
2	0.4	2.4	0.166
3	0.8	5	0.16
Average value of R_{se}(cold)=0.16Ω			

To calculate armature resistance of dc compound generator:

S.No	Applied Voltage V (Volt)	Armature current I (Amp)	Armature resistance $R_a\ (cold)= \frac{V}{I}\ \Omega$
1	3.2	2	1.6
2	4.0	2.5	1.6
3	4.4	3.0	1.46
4	4.8	3.5	1.37
Average value of R_a(cold)=1.5Ω			

R_a(hot)=1.2 x Ra(cold)=1.2 x 1.5 =1.8 Ω

SAMPLE CALCULATIONS:

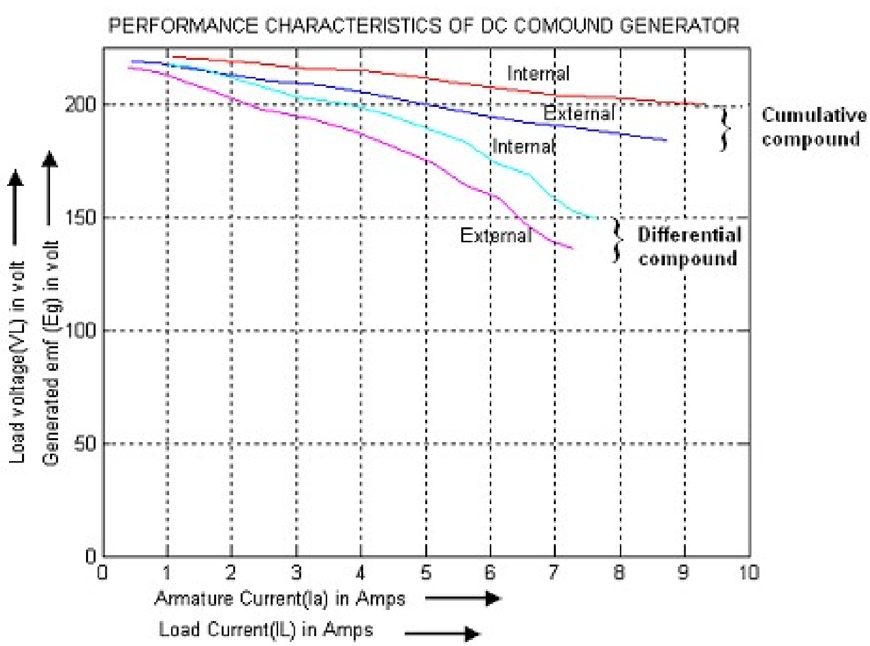
<u>For cumulatively compound generator</u>:

Voltage across the load(V_L)	=219 V
Load current (I_L)	=0.45 A
Field current (I_f)	=0.64A
Armature current $I_a = I_L + I_f$	=1.09 A
R_a(hot)	=1.8 Ω
Voltage drop across $R_a = I_aR_a$	=1.962 V
Gnerated emf $E_g=V_L+I_aR_a+I_LR_{se}$	=220.96V

<u>For differentially compound generator:</u>

Voltage across the load(V_L)	=216 V
Load current (I_L)	=0.40 A
Field current (I_f)	=0.62A
Armature current $I_a = I_L + I_f$	=1.02 A
R_a(hot)	=1.8 Ω
Voltage drop across $R_a= I_aR_a$	=1.836 V
Gnerated emf $E_g=V_L+I_aR_a+I_LR_{se}$	=217.83V

GRAPH:



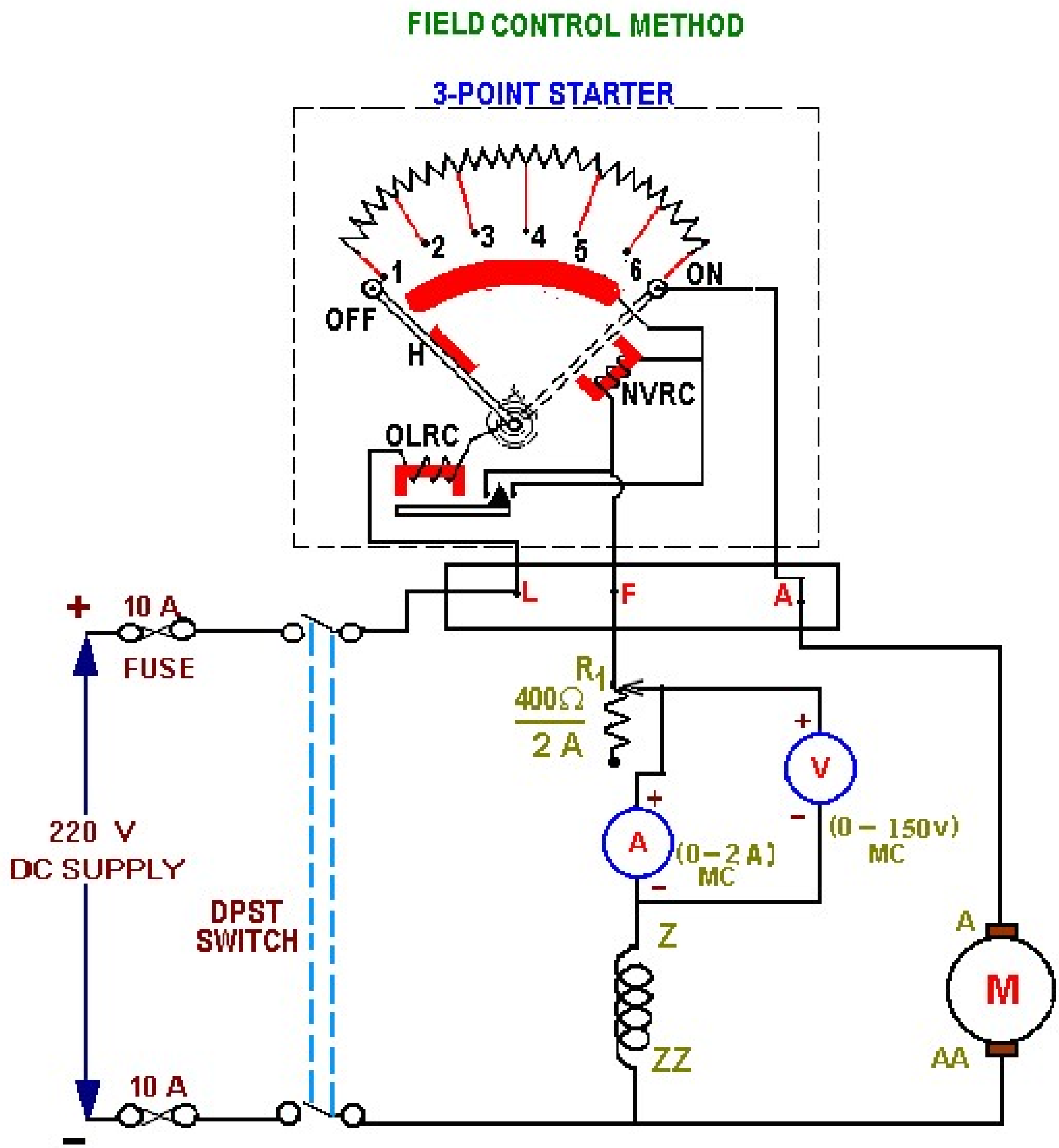
RESULT:

Obtained and plotted the internal and external characteristics of the given dc compound generator for both cumulative and differential compound modes.

CONCLUSIONS:

1. There is a reduction in generator terminal voltage from no load to full load, due to armature resistance drop and armature reaction drop, which increases with increase in load current.
2. In differential compound generators, the generator terminal voltage drops very rapidly with the increase of load. So these generators are best suited in applications like arc welding.
3. In cumulative compound generator, terminal voltage (v_L) is almost constant as compared with shunt generator. So these generators are best suited for constant voltage applications (the series winding provides compensation for drooping terminal voltage by aiding the shunt field).
4. From the Characteristics the effect of armature reaction and armature resistance drop (I_aR_a) on generated e.m.f is more predominant at high loads.

CIRCUIT DIAGRAM:



EXPT NO: 06

SPEED CONTROL OF DC SHUNT MOTOR

AIM: To study the speed variation of the given DC shunt motor by

a) Armature voltage control method and

b) Field control method.

NAME PLATE DETAILS:

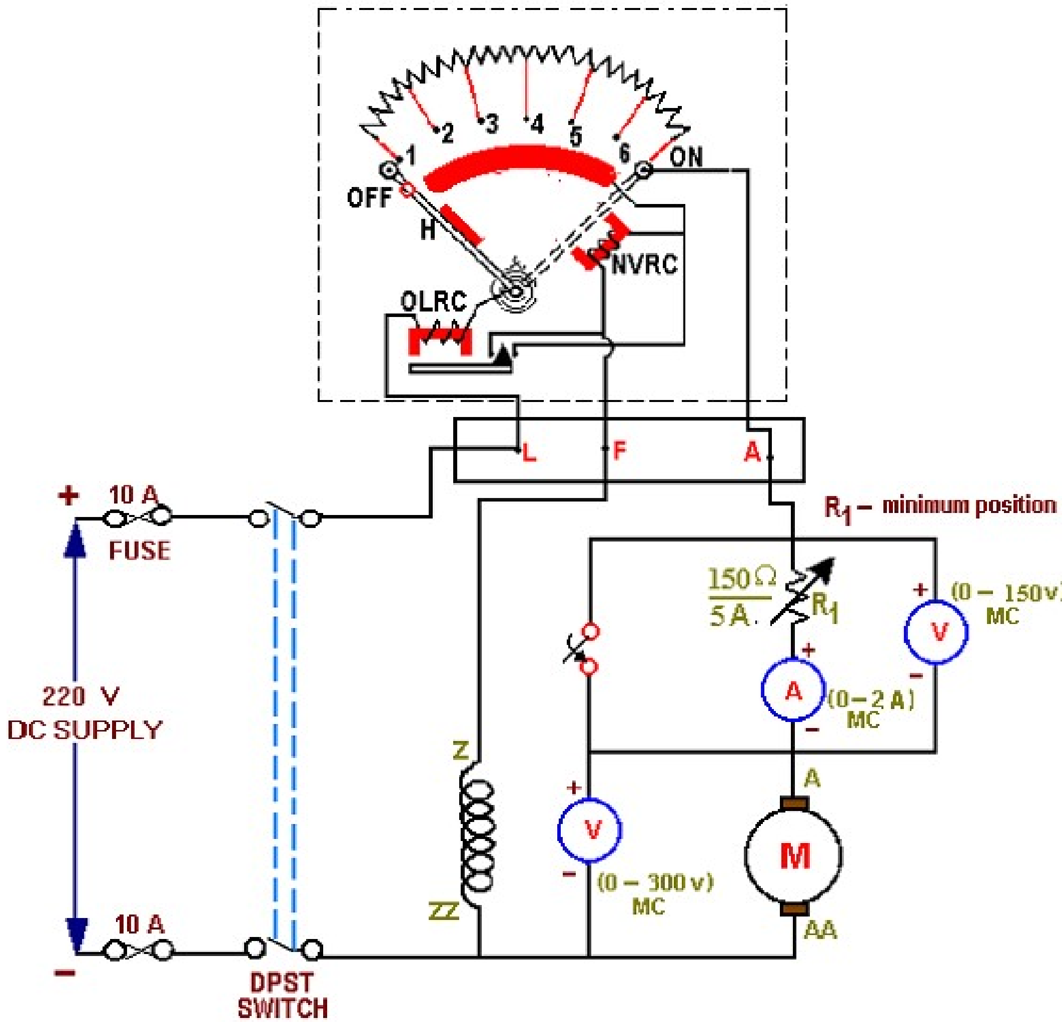
Specifications	Motor
Power	2.2 KW
Voltage	22O V
Current	11.6 A
Speed	1500
Excitation	0.6A
Winding	shunt

APPARATUS:

S. No	Name of the apparatus	Range	Type	Quantity
1	Voltmeter	(0-300)V	MC	1
2	Ammeter	(0-2) A	MC	1
3	Rheostat	150Ω/3A, 400Ω/2A	Wire Wound	1 1
4	SPST Switch			1
5	Tachometer			1

SPEED CONTROL OF DC SHUNT MOTOR

ARMATURE VOLTAGE CONTROL METHOD



PRECAUTIONS:

1. Avoid loose connections.
2. Avoid parallax error while taking the readings.
3. While using the field control method the speed of the machine can not exceed double the rated speed of the machine.

PROCEDURE:

Armature voltage control method:

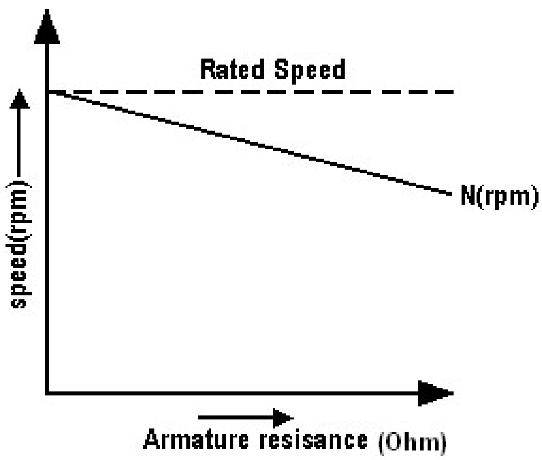
1. Make the connections as per the circuit diagram and keep the motor armature rheostat at minimum resistance position.
2. Close the DPST switch and start the motor by using the 3-point starter.
3. Increase the external resistance in the armature circuit with the help of armature rheostat note down voltage across the armature, across the rheostat, current through rheostat and speed of the motor at each step.
4. Calculate external resistance added in the armature circuit ($R_{external}=\frac{V_R}{I_R}$).
5. Open the DPST and disconnect the circuit.

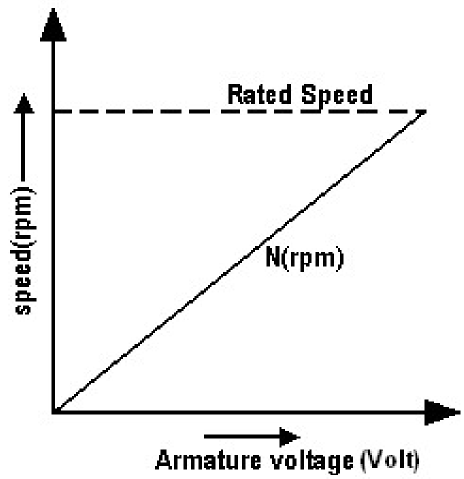
Field control method:

1. Make the connections as per the circuit diagram and keep the motor field rheostat at minimum resistance position.
2. Close the DPST switch and start the motor by using the 3-point starter.
3. Increase the external resistance in the field circuit with the help of field rheostat note down voltage across the rheostat ,field current through rheostat and speed of the motor at each step .
4. Calculate external resistance added in the field circuit ($R_{external}=\frac{V_R}{I_R}$).
5. Open the DPST and disconnect the circuit.

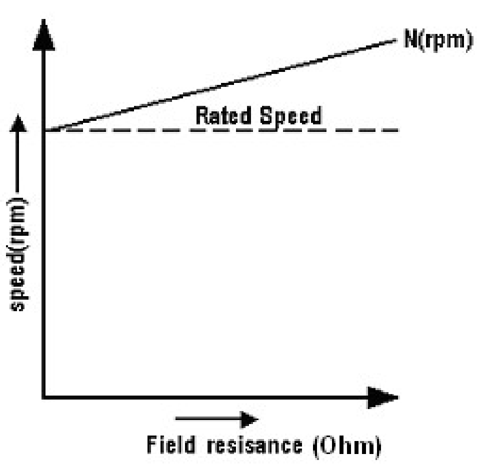
MODEL GRAPHS:

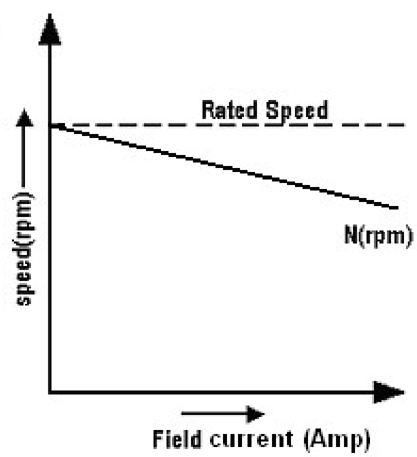
Armature voltage control method:





Field control method:





TABULAR COLUMN:

Armature voltage control method:

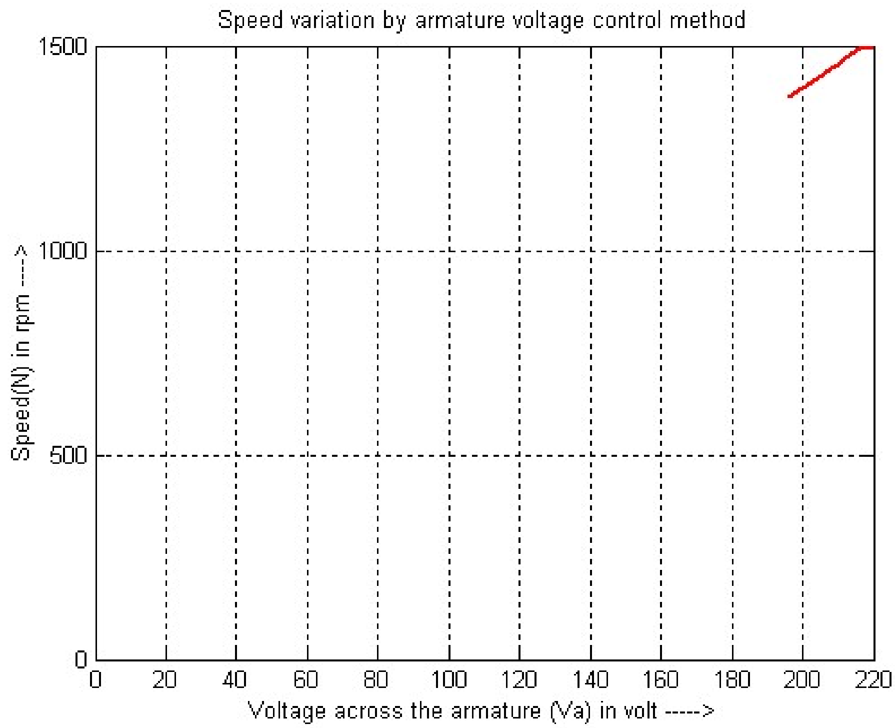
S.No	Voltage across armature V_a (Volt)	Speed N(rpm)	Voltage across rheostat V_{Ra} (Volt)	Armature current I_{Ra} (Amp)	$R_{ext.}$= V_{Ra}/I_{Ra} (Ohm)
1	220	1500	0	0.96	0
2	216	1492	12	0.96	12.5
3	212	1471	20	0.94	21.27
4	210	1453	26	0.94	27.67
5	209	1450	28	0.94	29.78
6	208	1445	30	0.93	32.25
7	204	1419	40	0.92	43.47
8	200	1397	46	0.92	50.00
9	196	1375	50	0.92	54.34

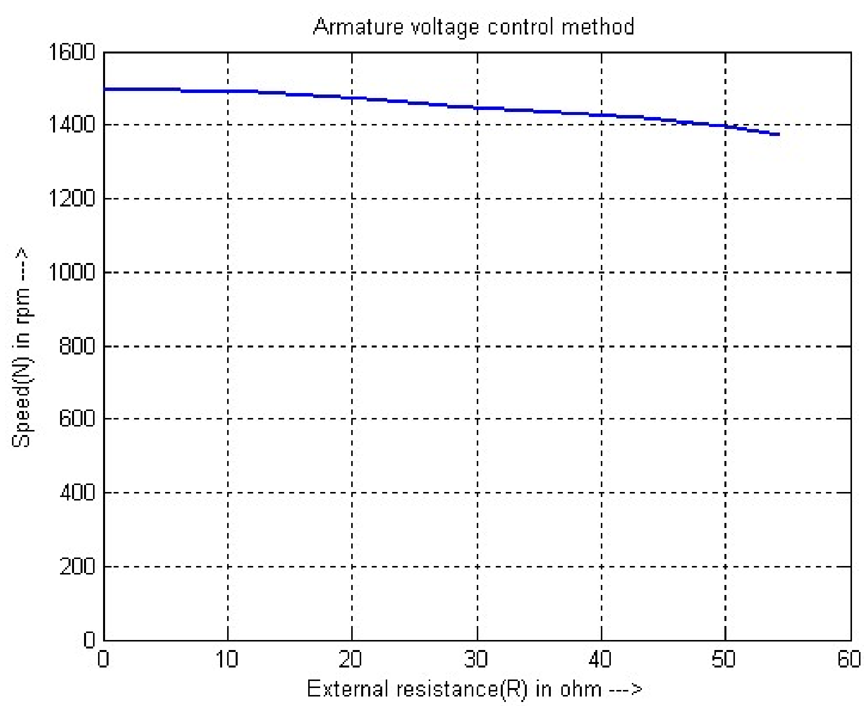
Field control method:

S.No	Field current I_f (Amp)	Speed N (rpm)	Voltage across rheostat V_{Rf} (Volt)	$R_{ext.}$= V_{Rf}/I_f (Ohm)
1	0.66	1500	0	0
2	0.64	1559	6	9.375
3	0.62	1571	10	16.12
4	0.61	1585	14	22.95
5	0.60	1591	16	26.66
6	0.59	1597	18	30.50
7	0.59	1601	20	33.89
8	0.58	1635	22	37.93
9	0.56	1642	30	53.57

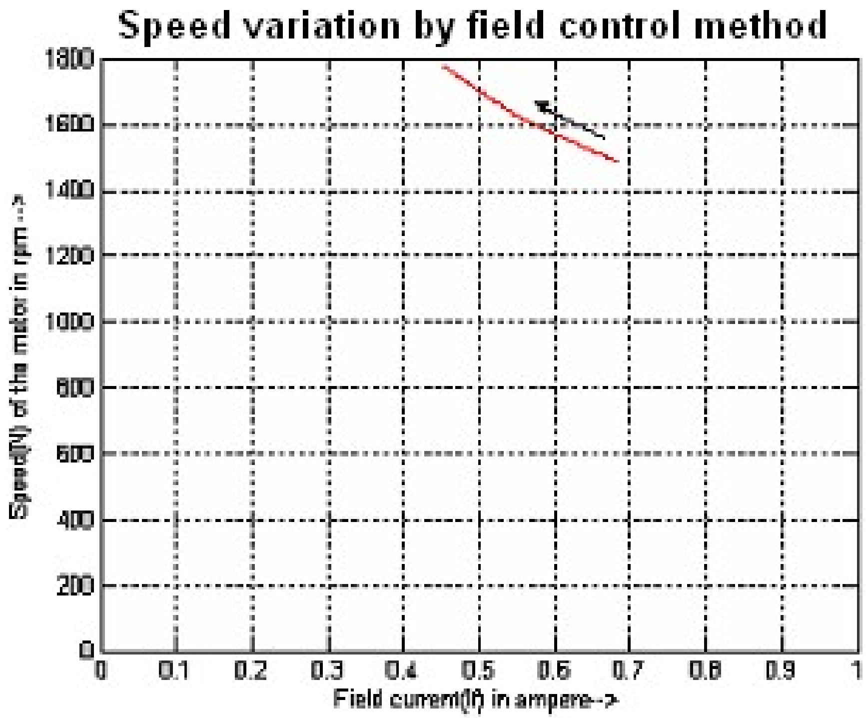
GRAPHS:

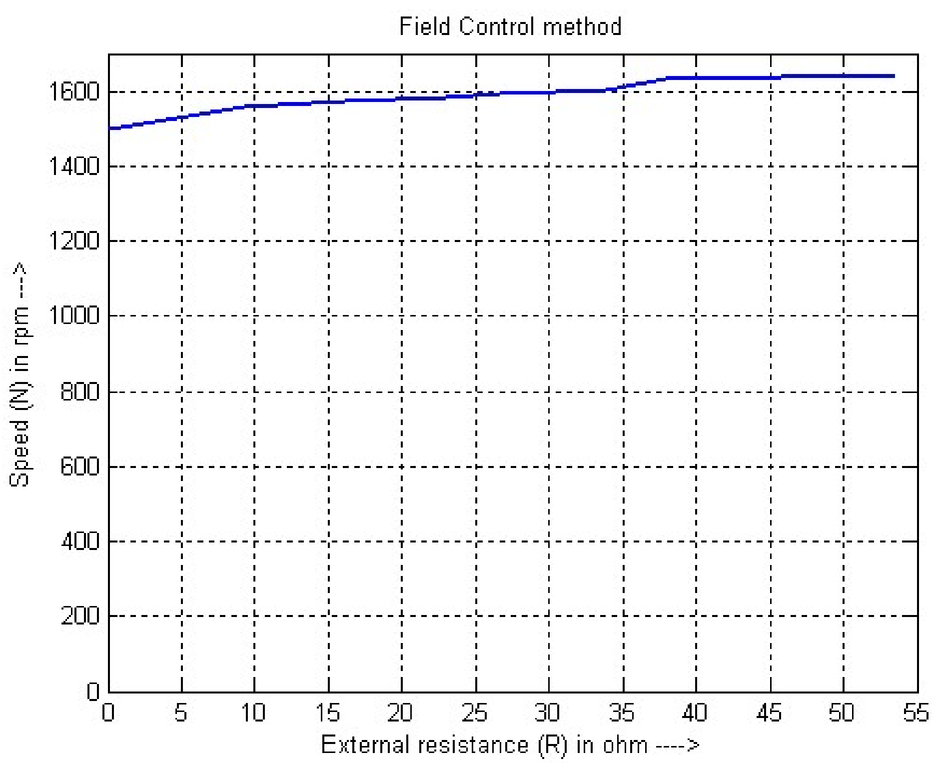
Armature voltage Control method:





Field control method:





RESULT:

The speed of the given DC shunt motor is varied above and below its rated speed by field control and armature control methods respectively.

CONCLUSIONS:

1. The addition of resistance in the armature path causes to decrease the voltage across the armature hence decrease in speed of the motor.

2. The addition resistance in the field path causes to decrease the field current hence increase in speed of the motor.

3. The fall in speed of the motor from 1500 rpm to 1375 rpm for addition of the resistance 54.34 ohm in the armature path.

4. The raise in speed of the motor from 1500 rpm to 1642 rpm for addition of the resistance 53.57 ohm in the field path.

OC AND SC TESTS ON SINGLE PHASE TRANSFORMER

AIM: To predetermine the %efficiency, %voltage regulation & equivalent circuit of a 1-ϕ transformer by conducting OC & SC tests on it.

NAME PLATE DETAILS:

Parameter	L.V.WINDING	H.V.WINDING
Rated voltage	115V	230V
Rated current	17.39 A	8.69A
Rated Power	2 KVA	2 KVA
Phase	Single phase	Single phase

APPARATUS:

S.No	Apparatus	Range	Type	Quantity
1	Ammeters	(0-1) A (0-10) A	MI MI	1 1
2	Voltmeters	(0-75) V (0-150)V	MI MI	1 1
3	Watt meters	150V,5A 75V,10A	L.P.F U.P.F	1 1
4	1-Φ autotransformer	230V/0-270V,10A		1
5	1-Φ Transformer	230V/115V, 2KVA,50Hz		1
6	Connecting wires			Required number

PROCEDURE:

O.C.Test:

1. Make the connections as per circuit diagram(1).
2. Keep the autotransformer in zero output voltage position and close the DPST switch
3. Vary the autotransformer variable knob and apply rated voltage across LV winding of the 1-Φ transformer.
4. Note the values of no load current, no load voltage and input power .
5. Bring back the auto transformer to zero output voltage position and open DPST to disconnect the circuit

s.C.Test:

1. Make the connections as per circuit diagram(2).
2. Keep the autotransformer in zero output voltage position and close the DPST switch
3. Vary the autotransformer variable knob and allow rated current throughHV winding of the 1-Φ transformer.
4. Note the values of short circuit current, voltage and input power .
5. Bring back the auto transformer to zero output voltage position and open DPST to disconnect the circuit

EXPT. NO:

SEPERATION OF IRON LOSSES OF A 1-Φ TRANSFORMER

AIM:- To separate core losses of a 1-Φ transformer into Hysterisis and Eddy current losses by performing suitable test

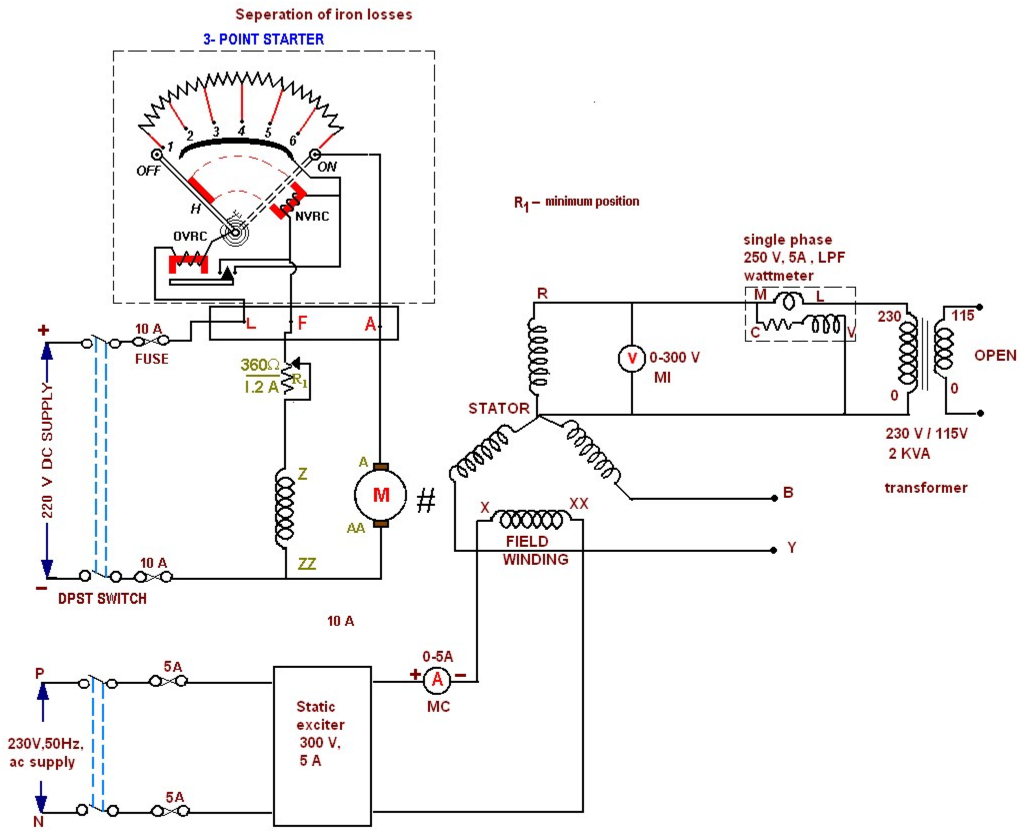
NAME PLATE DETAILS:-

Parameter	Alternator	DC Motor	Transformer	
			H.V. Side	L.V. Side
Rated Voltage	440V	220V	230V	115V
Rated Current	7A	11.6A	8.69	17.39
Rated Power	5KVA	2.2 KW	2KVA	2KVA
Frequency	50HZ		50HZ	50HZ

APPARATUS:-

Apparatus	Type	Range	Number
Ammeter	MC	0-5A	1
Voltmeter	MI	0-300V	1
Wattmeter	Dynamometer	300V,5A,L.P.F	1
1-Φ Tansformer		230V/115V ,2KVA ,50HZ	
Rheostat	Wire wound	360Ω/1.2A	1
Rheostat	Wire wound	50Ω/5A	1
Tachometer	Digital		1
Static exciter		300V,5A	1

CIRCUIT DIAGRAM:



PROCEDURE:-

1. Connect the circuit as per the circuit diagram.
2. Initially keep both the rheostats connected in series with the field winding and armature of D.C motor in minimum resistance position
3. Start the D.C motor with the help of starter.
4. Close the D.P.S.T Switch (S2).
5. adjust the variable knob of the static exciter until the generator generates the rated voltage of H.V. Winding of the transformer.
6. calculate V/f Ratio for the rated values of voltage and frequency.
7. change the speed (By field control or armature control) and generated voltage(By changing the excitation) such that V/f is kept constant.
8. Repeat the procedure for various values of frequencies (speeds)Tabulate all the values.

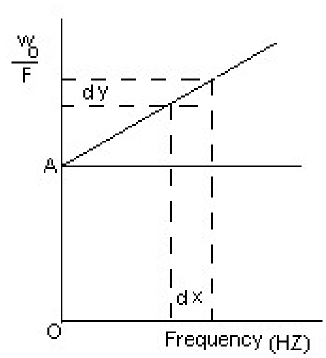
NOTE: V/f should kept constant at every step

TABULAR COLUMN:-

P=Number of poles in alternator, f=Frequency

S.No	Volt meter reading (Volts)	Speed N (RPM)	f=PN/120 HZ	V/F Ratio	Wattmeter reading Wo (watts)	Iron losses per cycle Wo/f

EXPECTED GRAPHS:-



From the graph
OA=K1, Slope of AB=K2 =dy/dx
Hysterisis loss at any frequency=K1*f
Eddy current loss at any frequency=$K2*f^2$

SAMPLE CALCULATIONS:-

- Compute the frequency at each step
- Plot the graph by taking frequency on X-Axis and Wo/f on Y-axis
- Draw a horizontal to X-axis starting from the point of intersection of Y-axis and Wo/f vs f plot.
- Complete triangle ABCas shown in the model graph

PRECAUTIONS:-

1 Avoid the loose connections.
2 .Avoid parallax error while taking the readings.
3 .Keep the field rheostat in the minimum resistance position
4 .Keep the static exciter in minimum voltage output position

RESULT:-The core losses of given single phase transformer are seperated into hysterisis &eddy current losses

CONCLUSIONS:- From the experiment we can conclude that eddy current losses per cycle are proportional to frequency and hysterisis losses per cycle are independent of Frequency.

EXP NO: **DATE:**

SCOTT CONNECTION OF TRANSFORMERS

Aim: To obtain balanced two phase supply from balanced three phase supply by connecting two 1-ϕ transformers in scott connection.

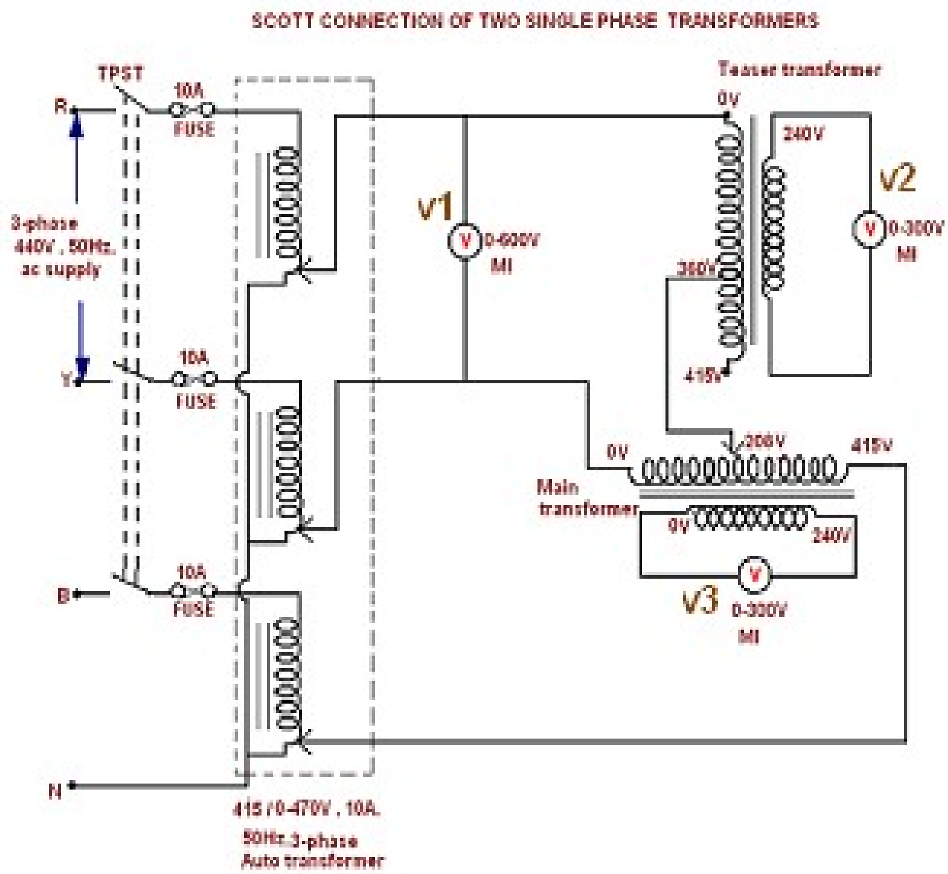
Name plate details:

Parameters	Main transformer		Teaser transformer	
	Primary	Secondary	Primary	Secondary
Voltage	415V	240V	415V	240V
Power	2KVA		2KVA	
Current	4.82A	8.33A	4.82A	8.33A
Phases	Single Phase		Single phase	

Apparatus:

S.No	Apparatus	Range	Type	Quantity
1.	Voltmeters	(0-600)V (0-300)V	MI MI	1NO 2NO
2.	Three phase auto transformer	415/ (0-470) 3-Phase, 10A ,50Hz auto transformer	-	1NO
3.	1-φ Transformers	0-208-360-415 v/240 v 2 KVA,50Hz		2 NO
4.	TPST switch	-	-	1NO
5.	Connecting wires	-	-	Required NO

CIRCUIT DIAGRAM:



PROCEDURE:

1. Polarity test is performed & the polarities of the terminals of both transformers are marked.
2. Make the connections as per circuit diagram.
3. TPST Switch is kept in open position & autotransformer is kept in zero out put voltage position.
4. TPST switch is closed.
5. Adjust the variable knob of 3-φ autotransformer in steps and increase the voltage applied. Note down secondary side voltmeter readings V2,V3 & primary voltmeter reading V1 in each step.
6. Applied voltage is increased until the secondary voltage (V3) of main transformer reaches its rated value.

7. Autotransformer is brought to minimum output voltage position & the TPST switch is opened.
8. Values are tabulated. $\sqrt{2}V_2$ & $\sqrt{2}V_3$ are calculated.

Tabular column:

S.No	**Primary line voltage V_1 (V)**	**Secondary voltage of main transformer V_3(V)**	**Secondary Voltage of Teaser transformer V_2 (V)**	**Resultant voltage $\sqrt{V_2^2 + V_3^2}$**	$\sqrt{2}V_2$	$\sqrt{2}V_3$
1.	30	28	30	41	42.43	39.59
2.	60	42	42	59.39	59.39	59.39
3.	90	60	60	84.85	84.85	84.85
4.	120	66	66	93.34	93.34	93.34
5.	140	81	81	114.55	114.55	114.55
6.	160	92	90	128.7	127.27	130
7.	180	103.	102	144.96	144.25	145.6
8.	200	118	115	164.76	162.6	166.89
9.	220	128	126	179.6	179.19	181
10.	240	139	137	195.2	193.7	196.57
11.	260	150	148	210.7	209.3	212.13
12.	280	162	160	227.69	226.2	229
13.	300	174	172	244.6	243.24	246.07
14.	320	184	183	259.5	258.8	260.2
15.	340	196	195	276.48	275.7	277.185
16.	360	208	207	293.45	292.7	294.1
17.	380	220	218	309.7	308.29	311.12
18.	416	240	238	338	336.5	339.4

Result:

Thus two-phase supply is obtained from three-phase supply by connecting two 1-ϕ transformers in Scott connection.

Conclusion:

Thus it can be concluded that the voltages are displaced by 90^0 in Scott connection. So by using Scott connection we get balanced two phase supply from three-phase supply & vice versa.

SUMPNER'S TEST (BACK TO BACK TEST)

AIM: To conduct sumpner's test on a pair of identical single-phase transformers and to determine efficiency and regulation at different loads, at different power factors.

NAME PLATE DETAILS:

Specifications	**LV side**	**HV side**
Rated power	2 KVA	2 KVA
Rated voltage	208V	240V
Rated current	9.66A	8.33A
Rated frequency	50Hz	50Hz

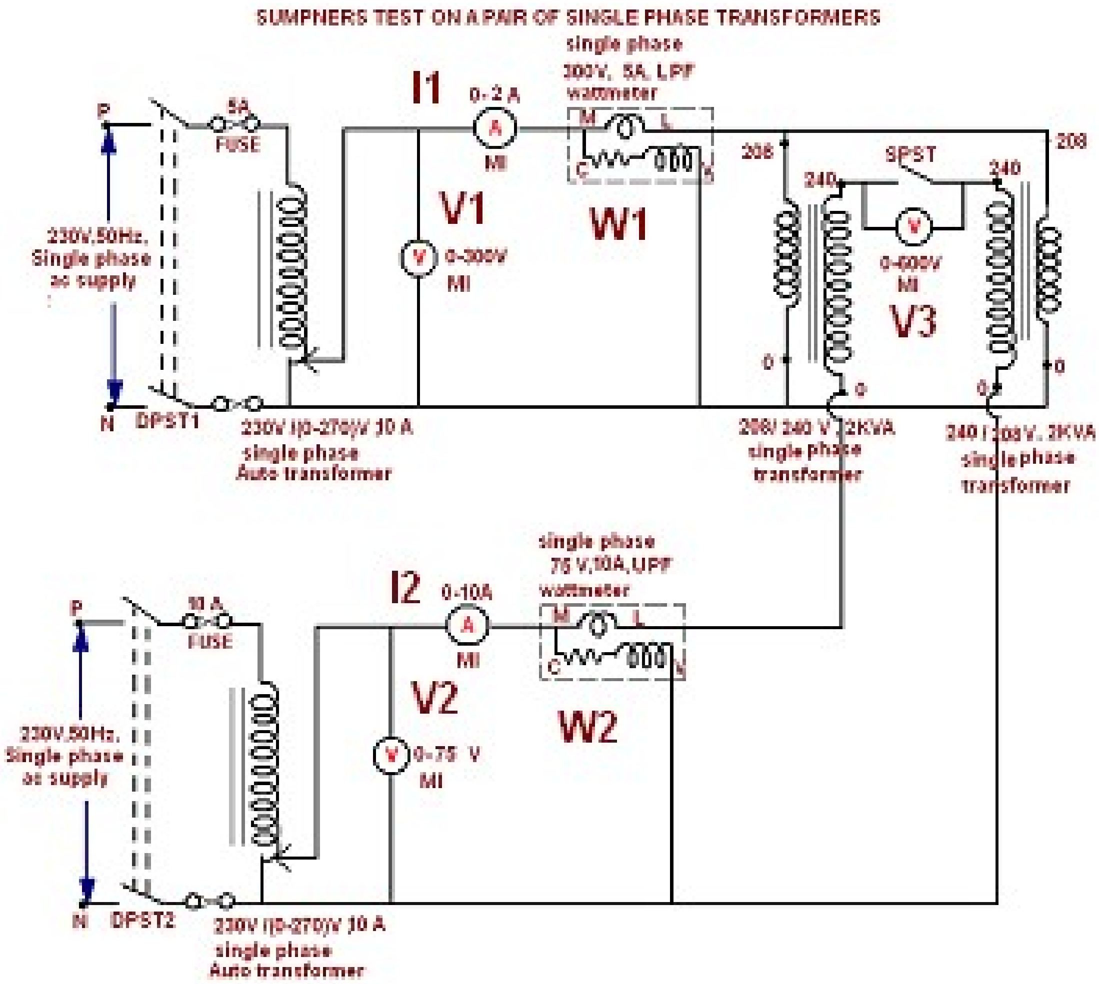
APPARATUS:

S. No	Apparatus	Range	Type	Quantity
1	Ammeters	(0-2)A (0-10)A	MI MI	2NO
2	Voltmeters	(0-75)V (0-300)V (0-600)V	MI MI MI	3 NO
3	Wattmeter's	300V, 5A, LPF 75V, 10A, UPF		1NO
4	Auto Transformer	230/ (0-270)V 10A, 1-ϕ		2NO
5	1-φ Transformer	208V/240V, 2KVA,50HZ		2NO
6	SPST Switch			1NO

PRECAUTIONS:

1. Initially autotransformer should be kept in zero output voltage position.
2. SPST should be closed only when voltmeter connected across it shows zero reading.

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connections are to be made as per the circuit diagram.
2. Supply is given by closing DPST1.
3. Apply the rated voltage to LV side by adjusting the auto-transformer variable knob.
4. If the voltmeter V3 reads some voltage then decrease the applied voltage to zero and the connections of secondary of one of the transformer is reversed and then apply the rated voltage by varying the auto-transformer.

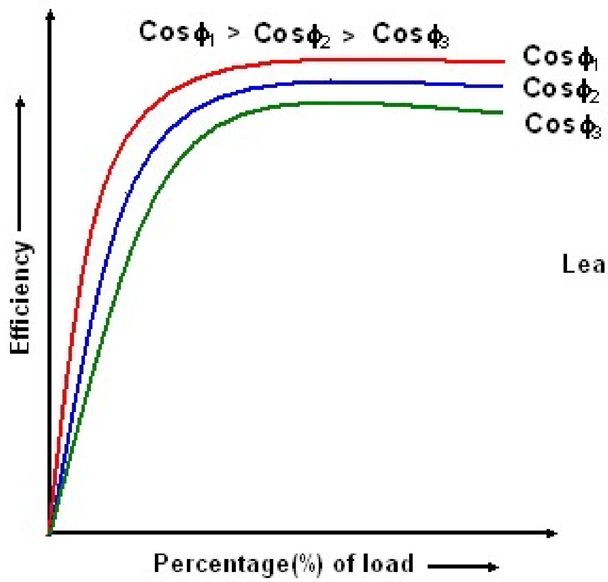
(or)

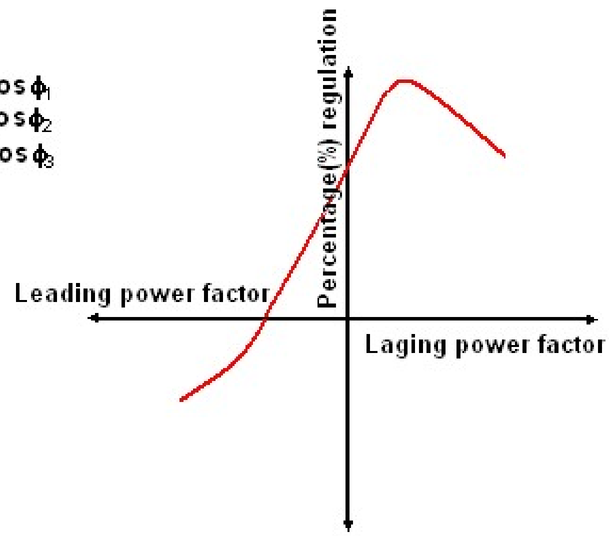
If V_3 shows 'zero' voltage then close the SPST switch connected across volt meter V_3.

5. Now Close the DPST2 and adjust the auto-transformer variable knob, until (0-10)A ammeter reads rated current of HV winding.

6. Note down the readings of all meters in the tabular column.

MODEL GRAPHS:





TABULAR COLUMNS:

OBSERVATION S:

Voltmeter reading V_1 (Volts)	Ammeter reading I_1 (amp)	Wattmeter reading W_1 (watts)	Voltmeter reading V_2 (Volts)	Ammeter reading I_2 (Amp)	Wattmeter reading W_2 (watts)
208	1.225	72	46.5	8.33	310

FOR REGULATION:

$R_{eh}=W_{sc} / I_{sc}^2$ (Where $W_{sc} = W_2 / 2$) and $Z_{eh}= V_{sc} / I_{sc}$ (Where $V_{sc}= V_2 / 2$ & $I_{sc}= I_2$)

$X_{eh}=\sqrt{Z_{eh}^2 - R_{eh}^2}$

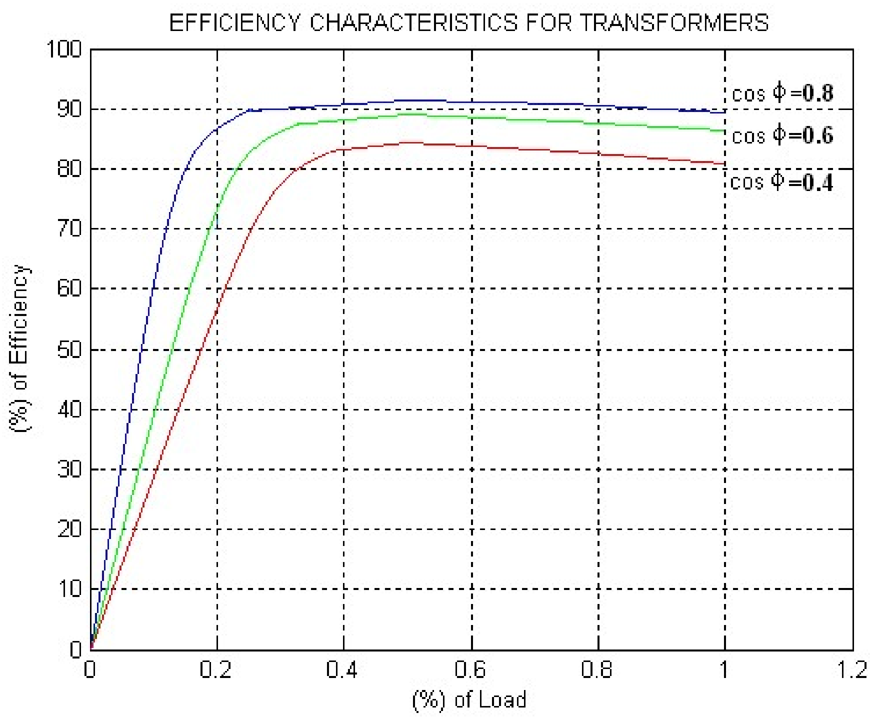
Power Factor	% reg = $\frac{I_{HV}[R_{eh}\cos\phi \pm X_{xh}\sin\phi]}{V_{HV}}$
0.2 lag	7.24%
0.4 lag	8.43%
0.6 lag	9.28%
0.8 lag	9.66 %
0.2 lead	-4.15%
0.4 lead	-2.2 %
0.6 lead	-0.0097%
0.8 lead	2.7%
unity	7.73%

FOR EFFICIENCY:

$W_{iron} = W_1/2$(watts) & $W_{cu} = W_2/2$.

Power Factor	Fraction 0f load (χ)	Output = χ P COS ϕ	W_{iron} (watts)	$\chi^2 W_{cu}$ (W)	Input = Output + Losses	$\eta = \frac{o/p}{i/p} \times 100$
0.4	¼	200	36	9.69	245.69	81.40
	½	400		38.75	474.75	84.25
	¾	600		87.18	723.18	82.96
	1	800		155	991.00	80.72
0.6	¼	300	36	9.69	345.69	86.78
	½	600		38.75	674.75	88.92
	¾	900		87.18	1023.18	87.96
	1	1200		155	1391.00	86.26
0.8	¼	400	36	9.69	445.69	89.74
	½	800		38.75	874.75	91.45
	¾	1200		87.18	1323.18	90.69
	1	1600		155	1791.00	89.33

GRAPH



Result:

Thus Sumpner's test is conducted on two transformers and the efficiency & regulation at various power factors & loads are determined.

CONCLUSION:

1. It can be concluded that in Sumpner's test, both O.C & S.C tests are conducted at a time & the temperature rise is considered.
2. By using this test more number of transformers can be tested in less time.