DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

MANUAL FOR ME 228
ELECTRICAL MACHINES LABORATORY

(2/4 ME, II-Semester)

SIR C.R.REDDY COLLEGE OF ENGINEERING

ELURU - 534 007 (A.P)

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ME228 ELECTRICAL MACHINES LABORATORY

(2/4 ME, II- SEMESTER)

Experiment Name

1. Energy meter calibration

2. Measurement of armature and field resistance

3. Verification of Kirchoff's Laws

4. Parameters of a choke coil

5. OC and SC test on 1-Φ Transformer

6. Load test on DC shunt motor

7. O.C.C of a separately excited DC generator.

8. Swinburne's test.

9. Load test on 3-Φ induction motor.

10. Regulation of alternator by synchronous impedance method

11. DC shunt generator characteristics

12. Measurement of power in 3-Φ circuit

13. Speed control of D.C Shunt Motor

Exp. No :1

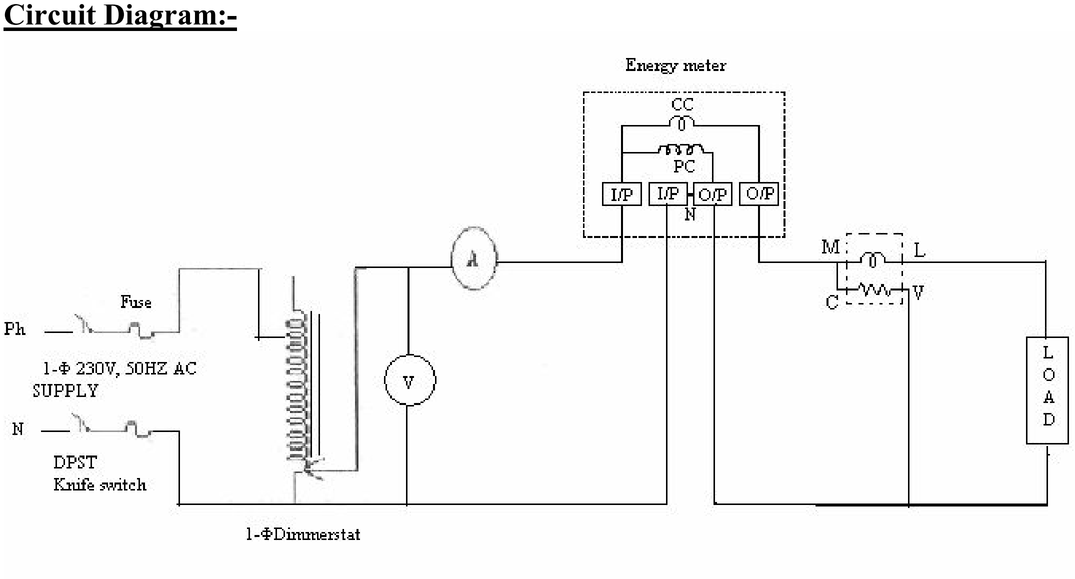
ENERGY METER CALIBRATION

Aim:- To calibrate the given single phase energy meter

Apparatus:-

S.no	Name	Type	Range	Qty
1	Voltmeter	M.I	0-250V	1
2	Ammeter	M.I	O-lOA	1
3	Single phase energy meter	Induction	250V/10A	1
4	Wattmeter U.P.F	Dynamometer	300V/10A	1
5	Stopwatch			1

Circuit Diagram:-



Procedure:-

1. Connect the circuit as shown in the circuit diagram.
2. Apply the rated voltage of230 V.
3. Vary the load such that Y4 of it's rated current flows in the ammeter.
4. Notedown the readings of Voltmeter, Ammeter and Wattmeter.
5. Notedown the time required for 5 revolutions in the Energy meter.
6. Vary the load to 'is, 2/3, full load current.
7. For every load noted own the Voltmeter, Ammeter and Wattmeter readings; and notedown time required for 5 revolutions.

Tabular column:-

S.no	Load	Voltage	Current	Power	CosΦ=W/ VI	Time in sec for 5 revolutions(t)

Specimen calculations:-

Meter constant = 1200 rev/1Kwh

No.of units consumed for 5 rev.Er= $\frac{1}{1200}x5$ kwh

No.of units consumed actually for 5 rev. E_a= $\frac{W}{1000}x\frac{time(t)}{60x60}$

% error = $\frac{E_r - E}{E_a}x100$

Viva Questions:

1. Why is generally the accuracy of a sub-standard and standard meters used for such an experiment?
2. Which type of instrument is most accurate for dc measurements and why?

Precautions:

1. Don't touch bare conductors when supply is ON
2. Don't Switch on the supply unless the circuit is approved by any Staffmember. 3. Wear shoes in laboratory to avoid Electric shocks
4. Switch off the all the measuring devices when NOT in USE.
5. Check for proper polarity of meters.
6. Ensure that there is no short circuit across the supply or any device, before switching on the supply.

Exp. No :2

MEASUREMENT OF ARMATURE AND FIELD WINDING RESISTANCE

Aim:- To measure the resistance of armature winding and field winding

Apparatus:-

S.No	Name	Type	Range	Quantity
1	Ammeter	M.C	0-10 A	1
2	Voltmeter	M.C	0-30 V	1
3	Voltmeter	M.C	0-300 V	1
4	Rheostat	Wire wound	38 Ω, 8.5 A 500Ω, 1.2 A	1 1
5	Resistive Load		230 V, *lOA*	1

Theory:-

As per ohms law, the resistance *of* winding *of* an electrical machine is defined as the ratio *of* the voltage applied across the winding to the current flowing in it i.e.

Resistance *of* the winding, R = V/I

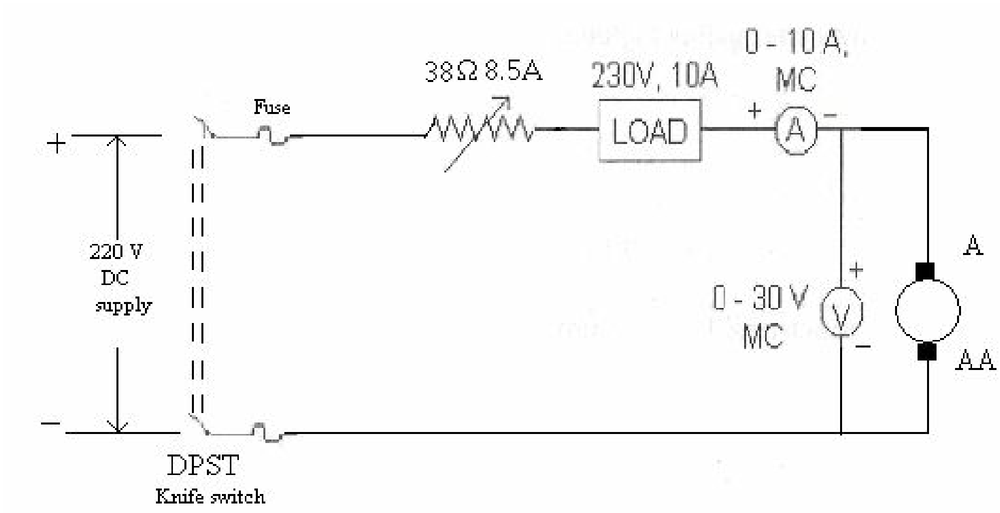
This concept is used for the measurement *of* resistance *of* armature and field winding
of a dc machine.

The armature winding *of* a dc machine is the main winding, which generates an emf in case *of* the generator and develops the desired torque in case *of* motor under normal operating conditions. This winding carries comparatively higher currents depending upon the loading conditions. In order to reduce the voltage drop in this winding during the full
load operating conditions, it is designed for low value *of* resistance. The resistance *of* armature winding *of* low rating dc machines commonly used for laboratory purpose, is *of*
the order *of* O.5 to 1.0 ohm. The resistance *of* the armature winding at room temperature is comparatively lesser. The value *of* resistance increases with increase in temperature *of* the winding.

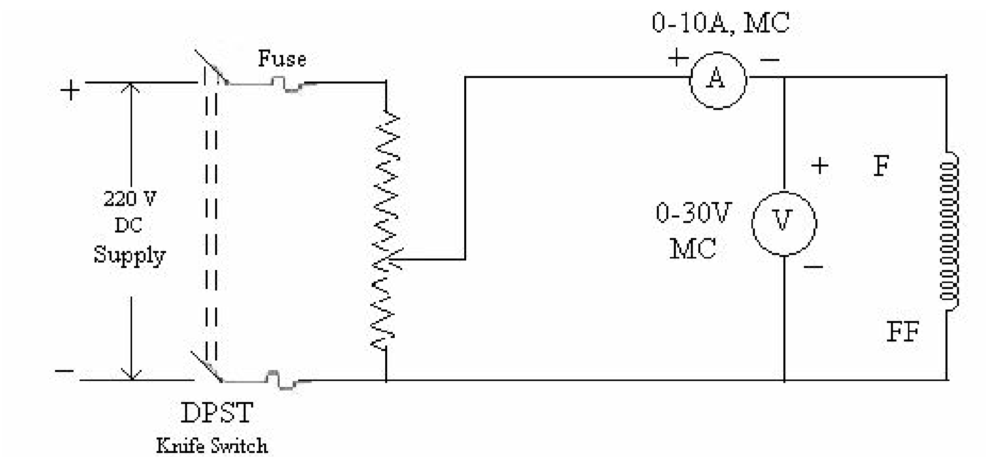
The field winding *of* a dc machine is connected in parallel with armature winding. The main function *of* this winding is to produce the desired flux for the proper operating *of* the dc machine. The field current needed to produce the desired the desired flux is mush lesser
compared to the armature current. For low rating dc machines, the field current may be *of*
the order *of* 0.8 to 1.2 A. As such the resistance *of* the shunt field winding is very quite high, *of* the order *of* 150 to 250 ohm for low rating machines. Thus winding is normally connected across the rated voltage *of* the machine, as such its resistance should be measured corresponding to rated voltage.

Circuit Diagram:-

A) For measurement of armature resistance



B) For measurement of field resistance



PROCEDURE:

A) For measurement of Armature winding resistance

1) Connect the circuit as shown in circuit diagram.
2) Ensure that all the switches of the load are in off position.
3) Switch on the main supply.
4) Now apply load in steps of 0.25 Kw.
5) For each step, note down the meter readings and calculate resistance.
6) Remove the'load and switch off the main supply.

For measurement of field winding resistance

1) Connect the circuit as shown in circuit diagram.
2) Set the potential divider to zero output voltage
3) Switch on the main supply.
4) Vary the potential divider gradually in seeps and note down the meter readings..
5) Bring back the potential divider to zero output voltage and switch off the main supply.

TABULAR COLUMN:

A) For measurement of Armature winding resistance

S.No	Voltage (in volts)	Current (in amps)	Resistance (in ohms)

B) For measurement of field winding resistance

S.No	Voltage (in volts)	Current (in amps)	Resistance (in ohms)

SPECIMEN CALCULATION:

R=V/I in ohms

Result: -The atmature winding and field winding resistances are measured.

Exp. No : 3

KIRCHHOFF'S LAWS

Aim:- To verify Kirchhoff's voltage law and current law

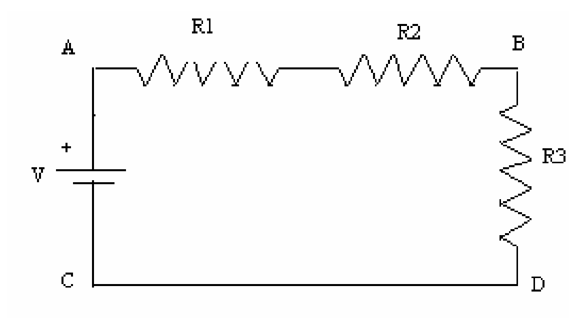
Apparatus:-

S.No	Description	Type	Rating	Qty
1	1-Φ Dimmerstat	Core type	230/0-270V,8A	1
2	Incandescent lamp	Filament	25W 40W 60W	1 1 1
3	Ammeter	MI	(0-1A) (0-3A)	3 1
4	Voltmeter	MI	(0-150/300)V	4
5	Connecting Board		----	1
6	Connecting wires	PVC insulated	----	-

Theory:-

a) Kirchhoffs Voltage Law:

According to this law, in any closed circuit or mesh, the algebraic sum of emfs acting in that circuit or mesh is equal to the voltage drops of each element of the circuit.



In mesh ABCD, $V=I(R_1+R_2+R_3)$

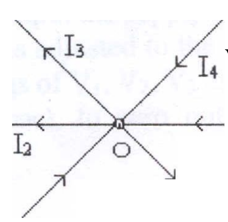
b) Kirchhoffs Current Law:

According-to this law, in any network of wires carrying currents, the algebraic sum of all the currents meeting at a node is zero or the sum of all the incoming currents is equal to the sum of outgoing currents away from that node.

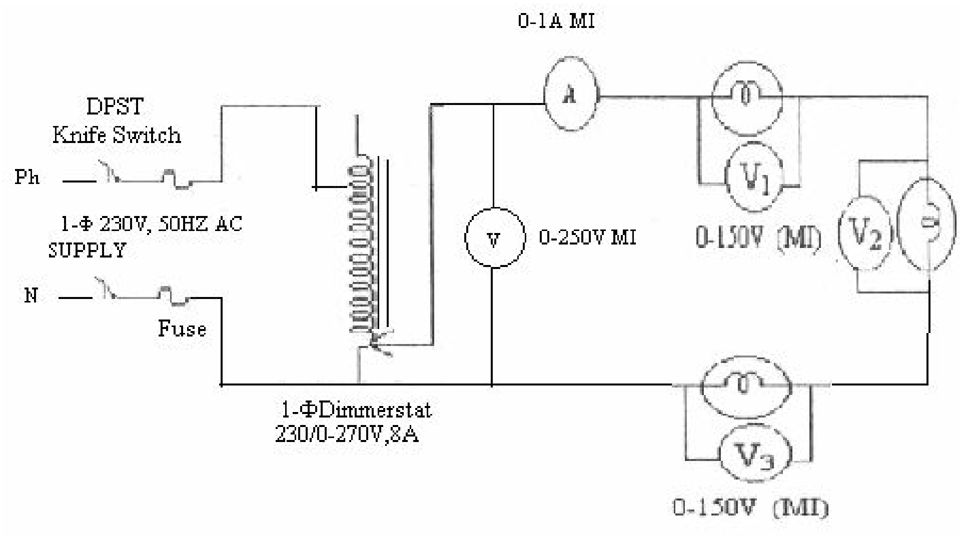
Let I_1, I_2, I_3, I_4, I_5 I_6 be the currents at node O. I_1, I_4, I_5 are the currents entering the node O and I_2, I_3, I_6 are the currents leaving the node O. Then according to Krichoff's law,

$I_1 - I_2 - I_3 + I_4 + I_5 - I_6 = 0$

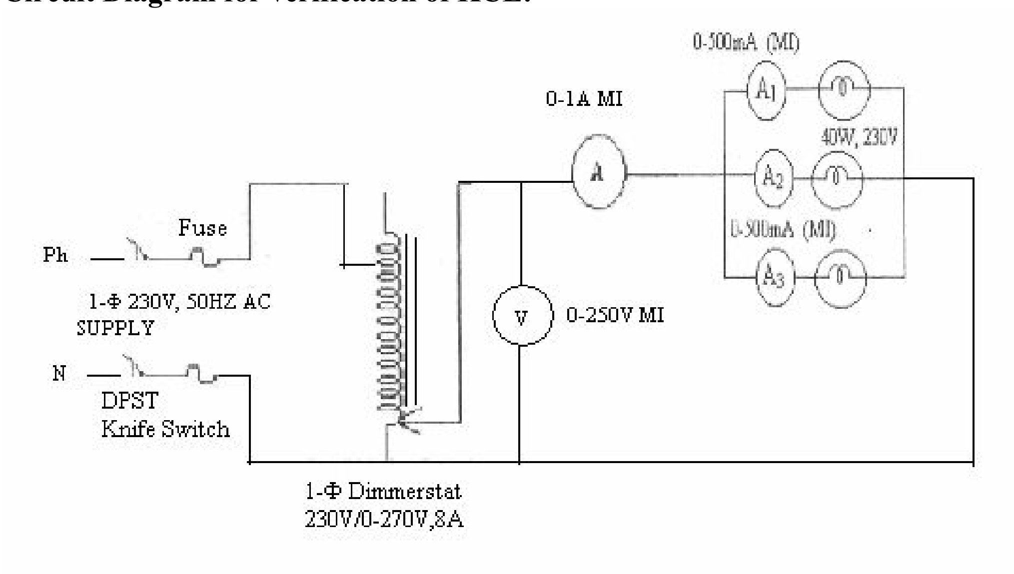
i.e $I_1+I_4+I_5=I_2+I_3+I_6$



Circuit diagram for Verification of KVL:



Circuit Diagram for verification of KCL:-



Procedure:-

a) <u>Kirchhoffs Voltage Law:</u>

1. The connections are made as shown in the circuit diagram.
2. With the dimmer stat at zero output the supply switch is closed.
3, The output of the dimmers tat is adjusted to the voltage in steps as given in the tabular column and the readings of V I, V 2, V 3 are noted for each step,
4. The dimmerstat is brought back to zero output and the supply switch is opened.

b) <u>Kirchhoff s Current Law:</u>

1. The connections are made as shown in the circuit diagram.
2. With the dtmmerstat at zero output the supply switch is closed.
3. The outpljtofthe dimmer stat is adjusted to the voltage in steps as given in the tabular column and all the ammeter readings are noted for each step.
4. The dimmerstat is brought back to zero output and the supply switch is opened

Tabular Column for Verification of KVL:

Sl.No	Applied voltage				
	V in volts	VI in volts	V2 in volts	V3 in volts	V = VI+V2+V3
1	50				
2	100				
3	150				
4	200				
5	230				

Tabular Column for Verification of KCL:

Sl.No	Applied voltage				
	V in volts	$I_i$in Amps	I_2in Amps	$I_{3\ i}$in Amps	$I=I_1+I_2+I_3$
1	50				
2	100				
3	150				
4	200				
5	230				

<u>Specimen calculations:-</u>

V = VI+V2+V3 (for KVL)
$I = I_1+I_2+I_3$ (for KCL)

Viva Questions:-
1) State KVL and KCL
2) Can these laws be applied in non~linear networks? 3) What are other names for these laws?

<u>Precautions:-</u>

1) Do not touch bare conductors when supply is ON
2) Switch off all the measuring devices when NOT in USE.
3) Ensure that dimmerstat is in minimum position before switching ON the supply and before switching OFF the supply.
4) Ensure that there is no short circuit across the supply or any device, before switching ON the supply.
5) Check for prager polarity of meters.

Exp. No : 4

PARAMETERS OF AN IRON CORE INDUCTOR

Aim : To determine the resistance and inductance of an iron-core inductor.

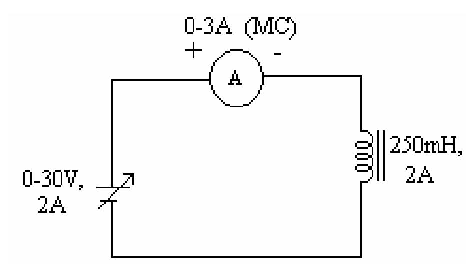
Apparatus :

Sl.No.	Description	Type	Rating	Qty.
1.	Iron core inductor		250 mH, 2A	1

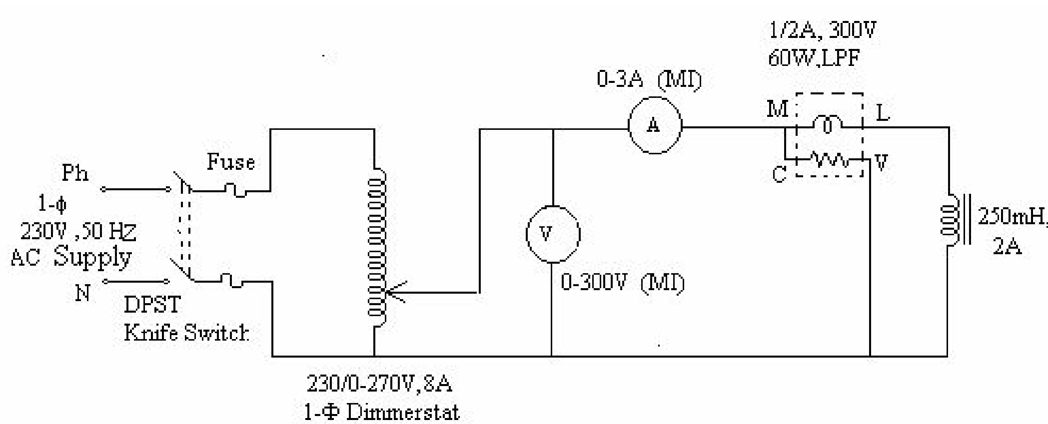
2.	1-ϕ Dimmerstat	Core type	230/0-270V, 4A	1
3.	D.C power supply		0-30V, 2A	1
4.	Ammeter	M.C M.II	0-3A 0-3A	1 1
5.	Voltmeter	M.I	0-250V	1
6.	Wattmeter	Dynamometer	1/2A, 300V, 60W, LPF	1
7.	Connecting wires	P.V.C Insulated	---	---

Circuit diagram :

a) <u>For calculating DC resistance</u>



b) <u>For calculating all the parameters of the Inductor</u>



Procedure :

a) <u>For calculating DC resistance</u>

1. The connections are made as shown in the circuit diagram - a.
2. With the voltage knobs of the D.C.Power supply at minimum positions the power supply is switched ON.
3. The voltage is varied in steps as given in the tabular column and the respective currents are noted.
4. The voltage knobs are brought back to their minimum positions and the power supply is switched OFF.

b) <u>For calculating all the parameters of the Inductor</u>

1. The connections are made as shown in the circuit diagram - b.
2. With the Dimmerstat at zero output the supply switch is closed.
3. The Dimmerstat is varied in steps such that the output voltage is adjusted to the values given in the tabular column and for each step the readings of all the meters are noted.
4. The Dimmerstat is brought back to zero output and the supply switch is opened.

Tabular column (1):

Sl.No.	V in Volts	I in Amps	R in Ohms
1.	2		
2.	4		
3.	6		
4.	8		

Specimen calculation :

$$R = \frac{V}{I}$$

Tabular column (2):

Sl.No.	V in Volts	I in Amps	W in Watts	Z in Ohms	R in Ohms	X_L in Ohms	L in Henry	p.f
1	50							
2	100							
3	150							
4	200							
5	230							

Specimen calculation :

$$Z = \frac{V}{I}; \quad R = \frac{W}{I^2}; \quad X_L = \sqrt{Z^2 - R^2}; \quad L = \frac{X_L}{2\pi f}; \quad \text{Cos}\phi = \frac{R}{Z};$$

Viva Questions :

1. What is meant by skin effect?
2. Can you perform the experiment without help of Wattmeter?
3. What is the behavior of inductor for dc supply?
4. In an inductive circuit current leads the voltage, Is the statement True or False?

Exp. No :5

OPEN CIRCUIT AND SHORT CIRCUIT TESTS ON 1-ϕ TRANSFORMER

Aim: -Conduct the open circuit and short circuit test on 1-ϕ transformer and determine the efficiency and regulation at different loads.

Apparatus: -

Sl.No	Apparatus	Type	Range	Qty
1.	Ammeter	(M.I)	0 - 3A	1
2.	Ammeter	(M.I)	0 – 10A	1
3.	Voltmeter	(M.I)	0 – 30V	1
4.	Voltmeter	(M.I)	0 – 115V	1
5.	Wattmeter L.P.F	Dynamometer	2.5A/150V	1
6.	Wattmeter U.P.F.	Dynamometer	10A/75V	1
7.	Variac	Core type	230V/0-270V, 8A	1
8.	1-ϕ Transformer	Core type	230V/115V 2kVA	1
9.	Connecting wires	P.V.C Insulated	-	-

Theory:-

By conducting O.C. and S.C. tests on a given transformers we can predict the efficiency, regulation and equivalent circuit without actually loading it. The purpose of this test is to determine no-load loss (or) core loss and no-load current, which is helpful in finding x_0 and R_0.

In O.C test one winding of the transformer usually high voltage winding is left open and the other is connected to its supply of normal voltage and frequency. A wattmeter w, voltmeter V, and an ammeter A are connected in L.V. winding, with the normal voltage is applied to the primary, normal flux will be setup in the core hence normal iron losses will occur which are recorded by the wattmeter. The no-load current is small so copper loss is negligibly small. Hence the wattmeter reading represents practically the core loss.

In S.C. test one winding, normally L.V. winding is short-circuited and meters are connected in H.V. side. Very low voltage is applied on H.V. side and it is increased slowly until full load current is flowing in the winding. Under these conditions wattmeter reading represents the full load copper loss. There is also a small amount of core loss, which is negligible compared to the copper loss.

Procedure:-

For O.C Test:-

1) The connections are made as shown in the circuit diagram .
2) With the dimmer stat at zero output, the supply switch (DPST) is closed.
3) The output of the dimmer stat is adjusted such that the voltmeter reads the rated voltage at the L.V winding of the transformer and all the meter readings are noted in the tabular column.
4) The dimmer stat is brought back to zero output and the supply switch (DPST) is opened

For S.C Test:-

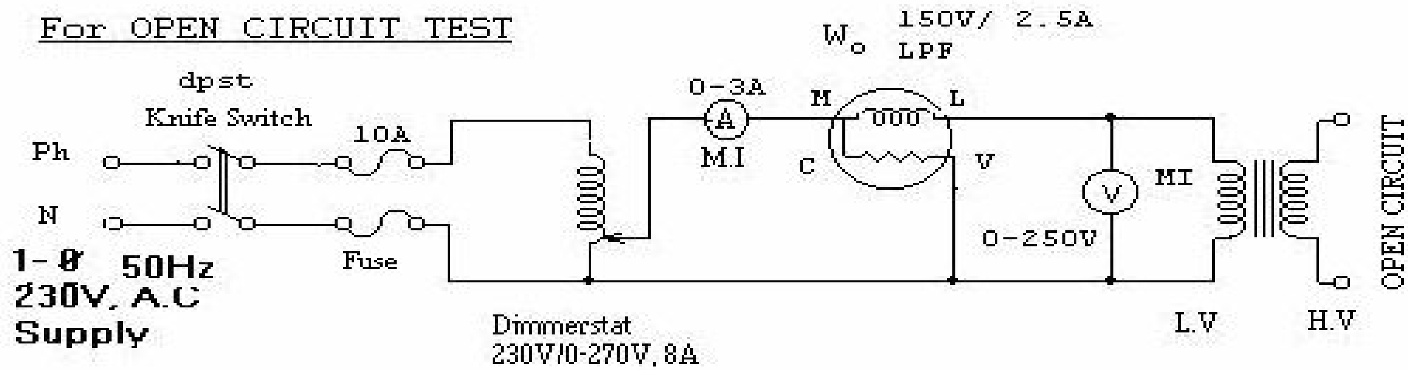
1) The connections are made as shown in the circuit diagram .
2) With the dimmer stat at zero output, the supply switch is closed.
3) The output of the dimmer stat is adjusted such that the ammeter reads the rated current at the H.V winding of the transformer and all the meter readings are noted in the tabular column.
4) The dimmer stat is brought back to zero output and the supply switch is opened

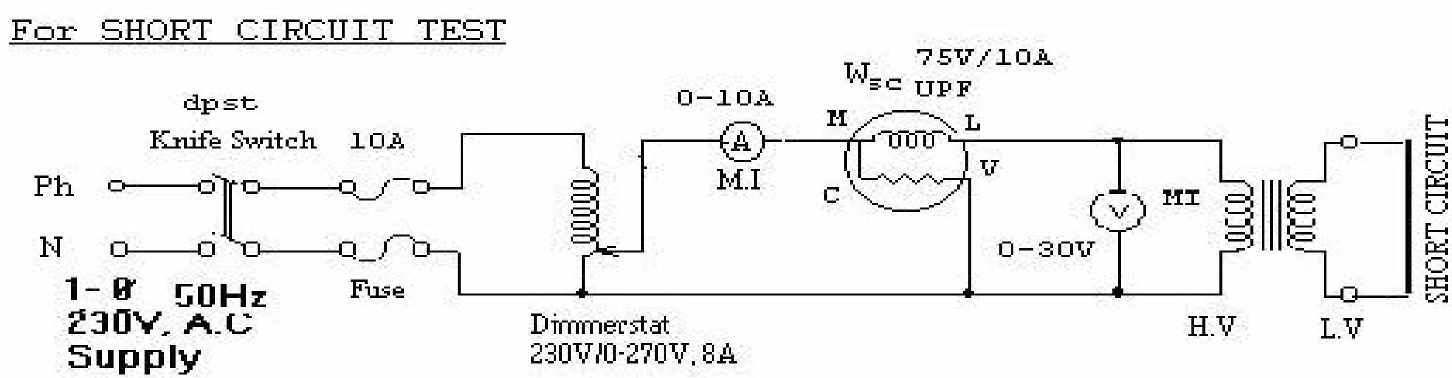
Tabular Column:-

	Open circuit test			Short circuit Test		
S.l No	V_o in volts	I_o in Amps	W_o in Watts	V_{SC} in volts	I_{SC} in Amps	W_{SC} In Watts

S.l No	COS ϕ_o	I_w in Amps	I_m in Amps	R_o in Ω	X_m in Ω	Cos ϕ_{sc}	R_{eq} in Ω	X_{eq} in Ω	W_{SC} In Watts

Circuit Diagram:-





Specimen calculations:-

Rated current of transformer $= \dfrac{\text{KVA rating of transformer}}{\text{Supply voltage}}$

Wattmeter Multiplication factor $= \dfrac{\text{Voltage Range X Current Range}}{\text{Maximum wattmeter scale reading}} \times \text{Power factor}$

Input Power = Wattmeter reading X Wattmeter Multiplication factor

1. $Cos\phi_0 = \dfrac{w_0}{v_0 i_0}$ 2. $I_W = I_0 \text{Cos}\phi_o$ 3. $I_m = I_0 \text{Sin}\phi_o$ 4. $R_o = \dfrac{V_o}{I_w}$

5. $X_m = \dfrac{V_o}{I_m}$ 6. $R_{eq} = \dfrac{W_{sc}}{I_{sc}^2}$ 7. $Z_{eq} = \dfrac{V_{sc}}{I_{sc}}$ 8. $X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2}$

% Efficiency at full load = $\dfrac{FullloadVA \times Cos\phi}{FullloadVA \times Cos\phi + W_o + W_{sc}} \times 100$

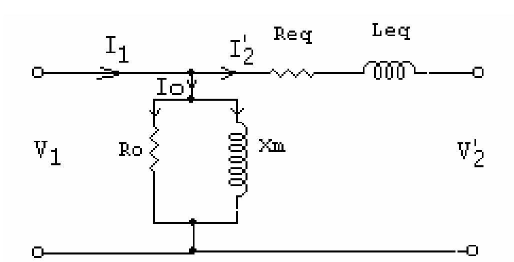
Efficiency at any load X*F.L, where X = ¼ or X= ½ or X = ¾

% Efficiency at X.* F.L = $\dfrac{X \cdot FullloadVA \times Cos\phi}{X \cdot FullloadVA \times Cos\phi + W_o + X^2 W_{sc}} \times 100$

% Regulation = $\dfrac{R_{eq} COS\phi \pm X_{eq} SIN\phi}{V_{rated}}$ X 100

where + is for Lagging P.F
\- is for Leading P.F

Equivalent Circuit:-



R_o, X_m – are refered to L.V Side

R_{eq}^1. X_{eq}^1– Refered to H.V Side

These values refered L.V Side are

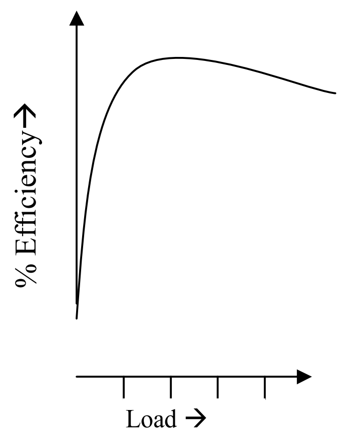
$$R_{eq} = \frac{R_{eq}^1}{k^2}$$

$$X_{eq} = \frac{X_{eq}^1}{k^2}$$

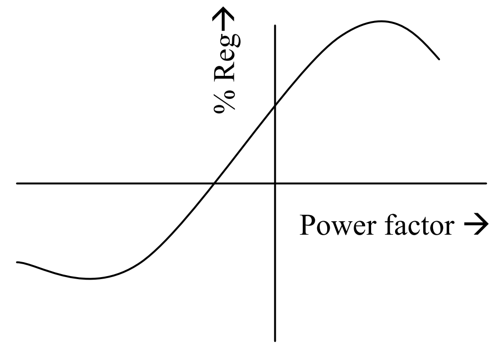
where k = $\dfrac{N_{21}}{N_1} = \dfrac{E_2}{E_1}$

Nature of graph:-

a) % Efficiency Vs Load



b) % Regulation Vs Power Factor



Viva questions :-

1 What is the purpose of OC & SC test?
2. Why are transformers rated in KVA?
3. Why is the OC test conducted on LV side
4. Why is the SC test conducted on HV side
5. Why is an L.P.F wattmeter is used in OC test?
6. Why is a UPF wattmeter is used in SC test
7. What are the advantages of transformer tests?
8. What is the applied voltage V_{Sc} under sc test?
9. Why iron loss are neglected in SC test
10 What is the value of primary current in OC test and why copper losses are neglected?
11 What are the readings of wattmeter obtain practically in OC & SC test
12. What is the output of transformer in SC test and what indicates the input power
13 What are the components of core loss?
14 What is the condition for maximum efficiency?
15 Types of transformers
16. Under what condition is DC supply applied to the primary of transformers?
17 Why are iron core transformers not used for high frequency applications?
18. What are the components of equivalent circuit of a transformer?

Exp. No : 6

LOAD TEST ON D.C. SHUNT MOTOR

Aim:- To conduct the brake load test on D.C. shunt motor and determine its performance characteristics.

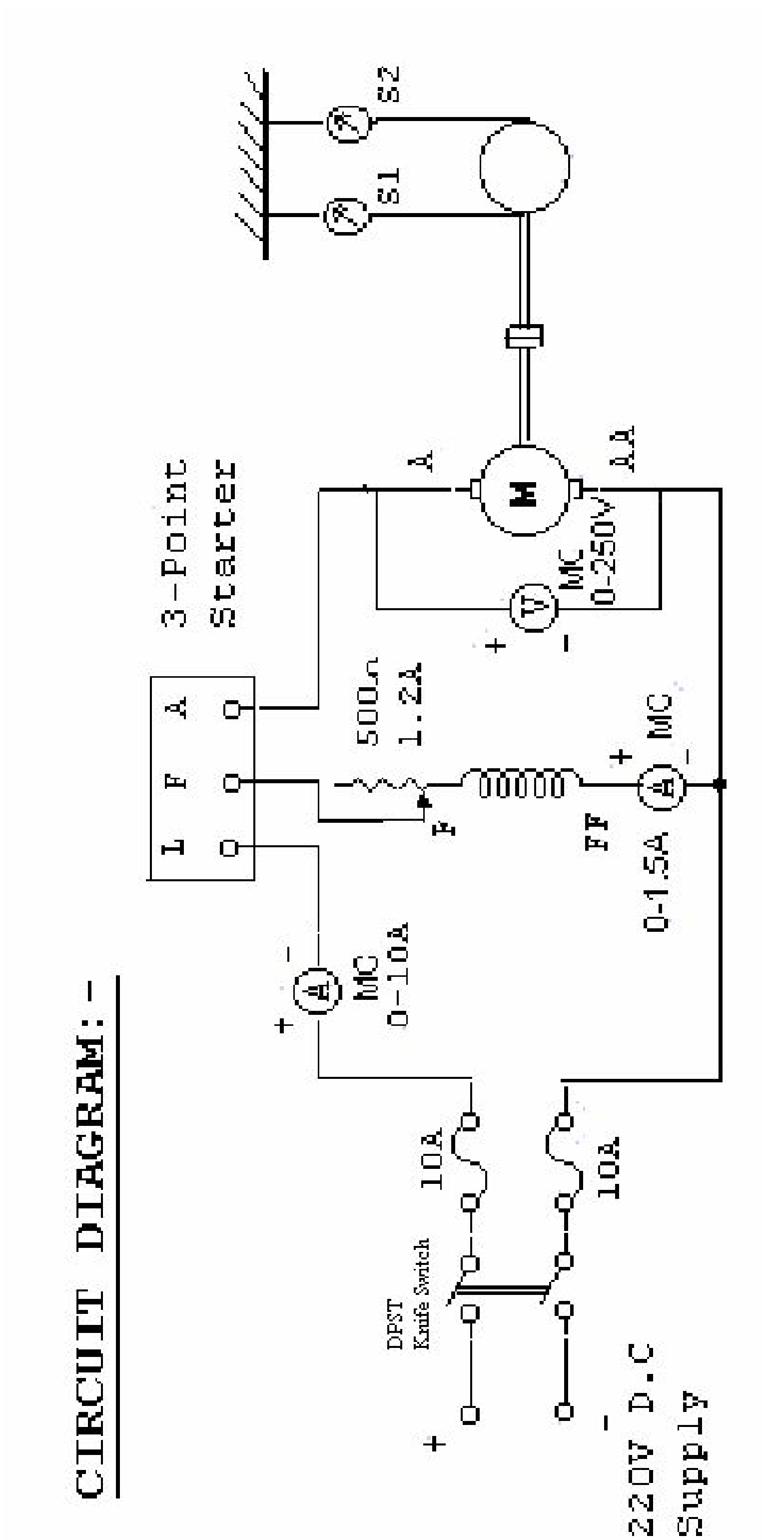
Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 10 A	1
2	Ammeter	(M.C)	0 – 1 A	1
3	Voltmeter	(M.C)	0 – 250 V	1
4	Rheostat	Wire Wound	500 Ω, 1.2 A	1
5	Tachometer	Digital	0-9999 rpm	1
6	D.C. shunt motor with loading arrangement		-	1
7	Connecting wires	P.V.C Insulated	-	-

Theory:- This is direct method of testing dc machine. This test is conducted on low H.P machines the machine is run as the motor and a brake frictional load is applied to the moving shaft. The moment of the brake drum is restricted with a braking arrangement. The braking arrangement consisting of a) Water cooled brake drum b) belt c)Spring balances to measure the tension on the brake belt and d) tension existing mechanism. The friction between brake drum and belt acts as a mechanical load. By adjusting the tension of the belt the load on the motor can be adjusted. Due to brake friction terrible heat is produced. To keep the brake drum with in the working temperature or to remove the heat due to friction the brake drum is filled with cooled water.

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in cutout position, the 3 point starter handle in initial position and ensuring that the belt over the brake drum is totally loosened, the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat and all the meter readings as well as speed are noted.
5. The load is applied in steps and for each step all the meter readings, spring balance readings as well as speed are noted.
6. Step no. 5 is repeated until the rated current of the motor is reached.
7. The load is removed in steps, the motor field rheostat is brought back to cut out position and the supply switch is opened.


CIRCUIT DIAGRAM: -
220V D.C
Supply
DPST
Knife Switch
10A
10A
MC
0-10A
L
F
A
3-Point
Starter
500Ω
1.2A
F
FF
MC
0-1.5A
MC
0-250V
A
AA
M
S1
S2

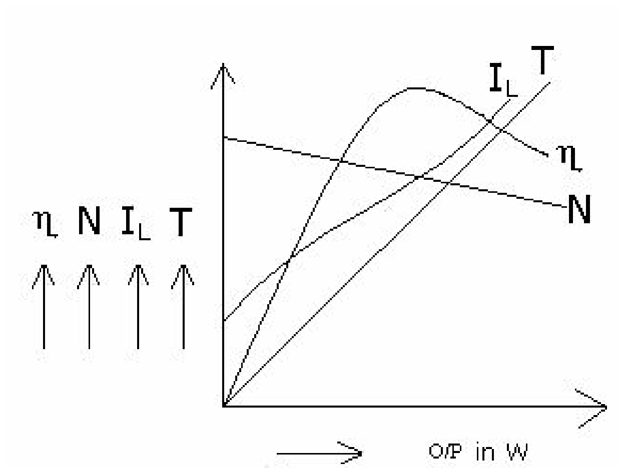
Tabular column:-

Sl. No	V In Volts	I_l In Amps	I_{sh} In Amps	S_1 In Kgs	S_2 In Kgs	T In N - m	N In rpm	I_a In Amps	Input In Watts	Output In watts	% Efficiency

Specimen calculations:-

1. Torque $T = (S_1 \sim S_2) \times r \times 9.81$ N – m
2. Armature current $I_a = I_L - I_{sh}$ amps
3. Motor input power $P_i = V \cdot I_L$ watts
4. Motor output power $P_o = \frac{2\pi NT}{60}$ watts
5. % efficiency $\eta = \frac{\text{output power}}{\text{input power}} \times 100$

Nature of the graph:-



Viva – Voce Questions:-

1. What is the condition for maximum output in a dc motor?
2. What happens if the field circuit of a dc motor is opened under running condition?
3. Write down the torque equation of a dc motor?
4. Draw the characteristics & performance curves of a dc shunt motor?
5. The lost torque in a dc motor is proportional to which loss?
6. What is meant by critical speed?
7. What are the usual ranges of field winding resistance armature resistance in case of a dc shunt motor?
8. Can we use 3-point starter for the speed control of dc motor using field rheostat method? Why?
9. What are the different speed control methods used for dc series motor?

Exp. No : 7

OPEN CIRCUIT CHARACTERISTICS OF A D.C. GENERATOR

Aim:- To plot the open circuit characteristics of a separately exited D.C. generator.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	1
2	Ammeter	(M.C)	0 – 1 A	1
3	Rheostat	Wire Wound	500 Ω, 1.2 A	2
4	Tachometer	Digital	0-9999 R.P.M	1
5	DC Motor coupled to D.C Generator		-	-
6	Connecting wires	PVC insulated	-	-

Theory:-The field current I_f is obtained from an external independent DC source. It can be varied from zero upwards by a potentiometer and its value is read by Ammeter connected in the field circuit.

Voltage equation of a DC generator is $E_g = \phi ZNP/60A$

Hence if speed is constant, the above relation becomes $E = K\phi$

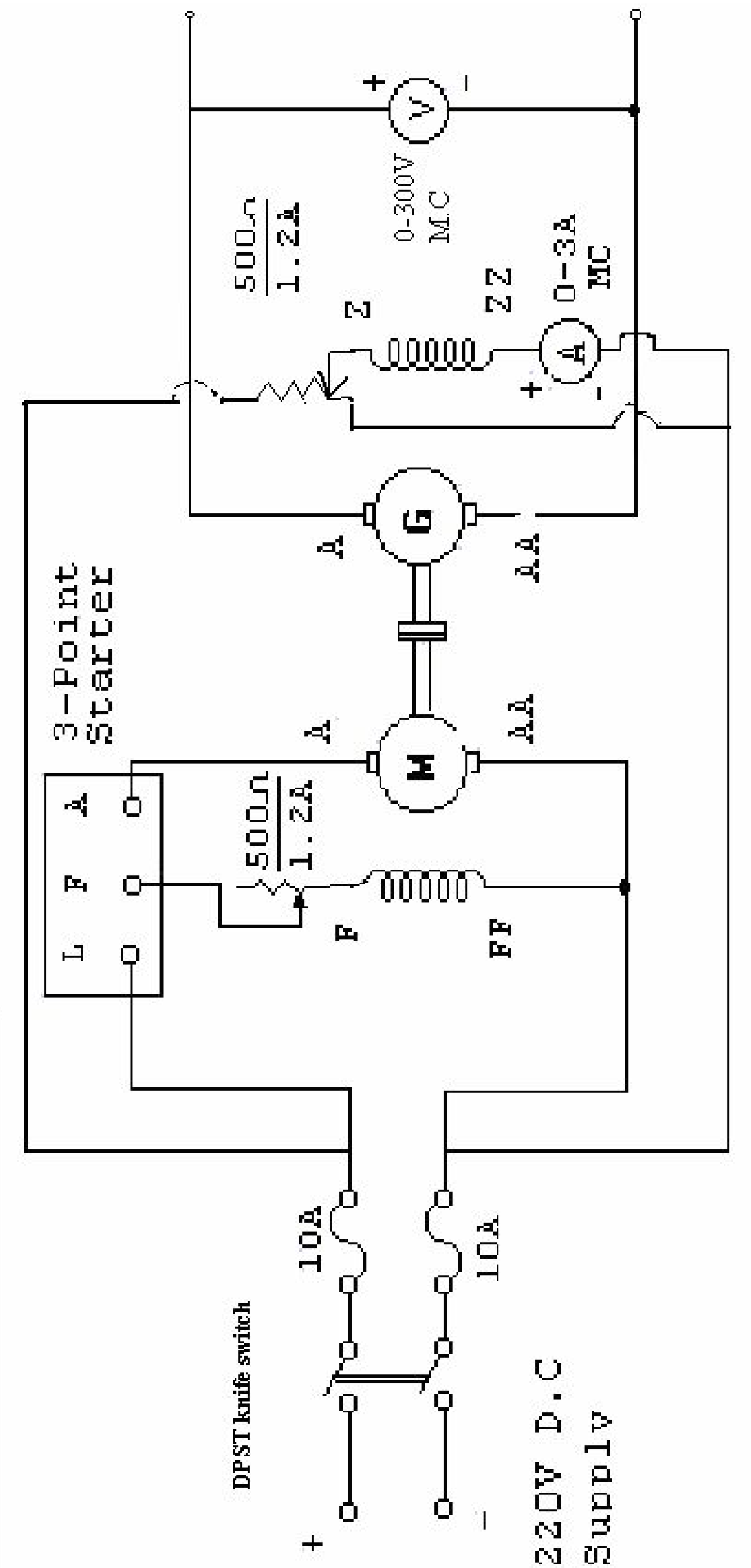
It is obvious that when I_f is increased from its initial small value, the flux ϕ and hence generated emf increases as current while the poles are unsaturated. But as the flux density increases, the poles become saturated so a generator in I_f is requires to produce a given increase in voltage than as the lower part of the curve.

The curve showing relation between the terminal voltage 'V' and field current I_f when the generator is on no-load

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in CUTOUT position, the generator field rheostat in CUTIN position and the motor 3-point starter handle at its initial position, the DC supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. The generator field is exited by gradually varying the resistance of the generator field rheostat in steps and for each step the corresponding field current and the no load voltage are noted.
6. Step no. 5 is repeated until the rated voltage of the generator is reached and all the meter readings are noted for each step.
7. The generator field rheostat is brought back to CUTIN position, the motor field rheostat to CUTOUT position and the supply switch is opened.

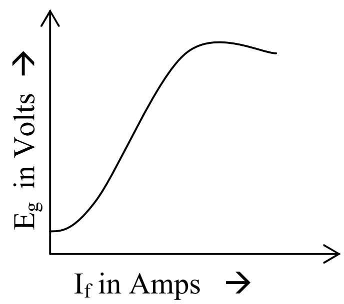
CIRCUIT DIAGRAM:-



Tabular column:-

Sl.No	I_f In Amps	E_g In volts

Nature of graph:-



Viva – Voce Questions:-

1. Identify the locations of field and armature windings for different machines.
2. What do you mean by rated values of a machine
3. What is to be done if the residual flux is not present in a dc generator?
4. Write down the EMF equation of a dc genertor?
5. To found OCC of a self excited shunt generator it has to be connected as a separately excited generator when it is (true or false).
6. Expand OCC what is the other name for it? Where does OCC of dc generator lies at speed N_1 with respect to that of OCC at N_2 if $N_1 < N_2$.
7. Commutator works as a ______________ in dc generator and as a ___________ in a dc motor.
8. Large dc generators will have __________ winding and high voltage, small generator will have _____________ windings.
9. Interpoles will be placed between ____________ in a dc generator.
10. A dc shunt motor can be started using 4 point starter (True or False) ?

Exp. No : 8

SWINBURNE'S TEST ON D.C. SHUNT MOTOR

Aim:-To conduct the no load test on the DC shunt machine and determine its efficiency at different loads when operates as a) Motor & b) Generator

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 3 A	1
2	Ammeter	(M.C)	0 – 1.5 A	1
3	Voltmeter	(M.C)	0 – 250 V	1
4	Rheostat	Wire Wound	500 Ω, 1.2 A	2
5	Tachometer	Digital	0-9999 R.P.M	1
6	DC shunt motor		-	1
7	Connecting wires	PVC insulated	-	-

Theory:- Swinburne's test is a simple indirect method to calculate the efficiency of a constant flux DC machines. In this method constant losses are calculated at no-load and from this efficiency at any desired load can be pre-determined in advance. In this method the machine is run as a motor at no-load. At its rated voltage & rated speed (adjusted by using shunt field Rh)

Limitations

- Applicable to constant flux machines i.e shunt & compound machines

Advantages:

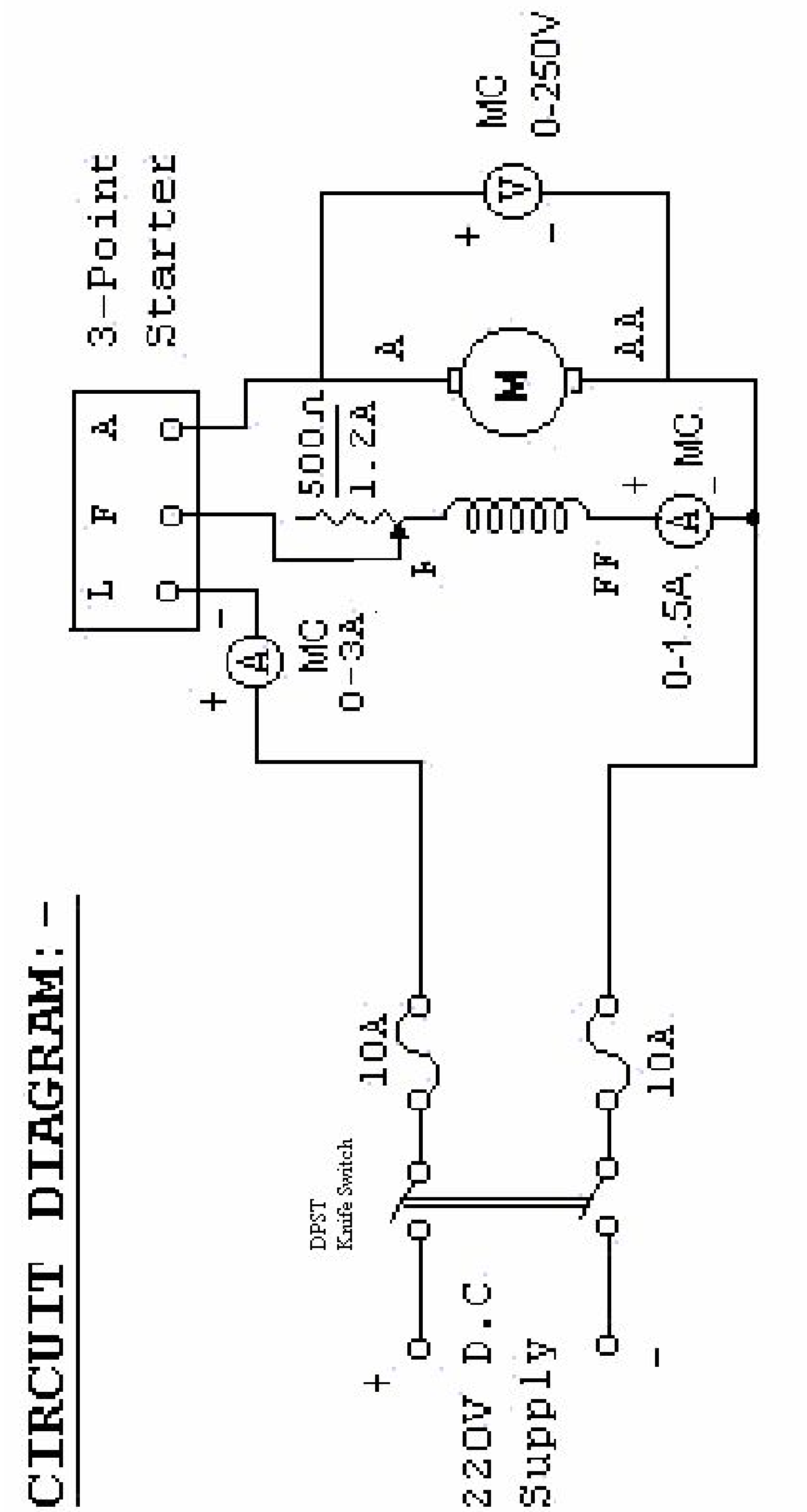
- It is economical because power required to test the machine is very small i.e no load input power.
- The efficiency can be pre-determined at any desired load.

Disadvantages:

- At full load due to armature reaction, flux is destroyed which increases the iron losses. No account is taken for this change in iron losses.
- As the test is on no-load, it is impossible to know whether commutation would be satisfactory at full load and whether the temp. rise would be within the specified limits.

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in CUTOUT position, 3-point starter handle at its initial position, the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. All the meter readings are noted into the tabular column.
6. The motor field rheostat is brought back to cut out position and the supply switch is opened.


CIRCUIT DIAGRAM:-
3-Point Starter
L
F
A
MC 0-250V
V
A
M
AA
500Ω
1.2A
F
FF
MC 0-1.5A
MC 0-3A
10A
10A
DPST Knife Switch
220V D.C Supply
+
-

Tabular column:-

Sl.No	I_0 In Amps	I_{sh} In Amps	V In volts

Specimen calculations:-

1. No load armature current $= I_{ao} = I_o - I_{sh}$ amps
   where I_o - is the no-load input current of the D.C motor
   I_{sh} – is the shunt field current
2. Armature copper loss $= I_{ao}^2$ Ra watts
   where R_a – is the armature resistance of the D.C.Machine
   it can be determined by Volt-Amp method.
3. Total input power $= P_i = V\,I_o$ watts
4. Constant power loss $= P_c = V\,I_o - I_{ao}^2$ Ra watts
5. Calculation of Efficiency

when running as motor : If I_L = Full Load current in amps

	At full Load	At Half Full Load
a. Armature current	$= I_a = I_L - I_{sh}$ amps	$I_a = \frac{I_L}{2} - I_{sh}$ amps
b. Armature cu. Loss	$= w_c = I_a^2$ Ra watts	$w_c = I_a^2 R_a$ watts
c. Motor input	$= P_i = V\,I_L$ watts	$P_o = ½\,VI_L$ watts
d. Constant losses	$= P_c$ watts	
e. Total losses	$= P_t = P_c + w_c$ watts	

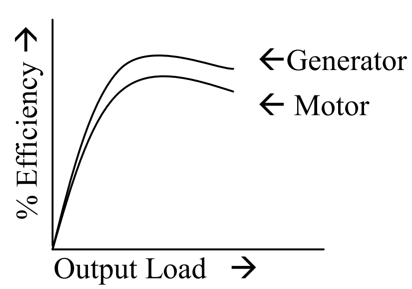
$$\therefore \text{ \% efficiency of motor} = \frac{p_i - p_t}{p_i} \times 100$$

when running as generator:

	At Full Load	At Half Full Load
a. Armature current	$= I_a = I_L + I_{sh}$ amps	$I_a = \frac{I_L}{2} + I_{sh}$ amps
b. Armature cu. Loss	$= w_c = I_a^2 R_a$ watts	$w_c = I_a^2 R_a$ watts
c. Generator output	$= P_o = V\,I_L$ watts	$P_o = ½\,VI_L$ watts
d. Constant losses	$= P_c$ watts	
e. Total losses	$= P_t = P_c + w_c$ watts	

$$\therefore \text{ \% efficiency of generator} = \frac{p_o}{p_o + p_t} \times 100$$

Nature of Graph :-



Viva – Voce Questions:

1. Do you require a startor for a dc motor under the running condition, why?
2. Can you use the dc motor as a dc generator? If so, what is to be done.
3. What are the losses taking place in a dc machine.?
4. What is the power o/p & efficievcy during swinburns test?
5. What is the fuse rating for conducting swinburns test on a dc machine of 18A?
6. What is the principle of operation of dc motor?
7. What happens to dc shunt motor if source polarity reversed?
8. A dc shunt motor refuses to start when switched on what could be the possible reasons and remedies?
9. What happens to motor if field circuit is suddenly opened?
10. What are the advantages and disadvantages of Swinburns test over the other tests?
11. When will you get the maximum efficiency for a dc machine?

Exp. No : 9

LOAD TEST ON THREE PHASE INDUCTION MOTOR

Aim:- To conduct load test on three phase squirrel cage Induction motor and obtain the performance Characteristics.

Apparatus:-

Sl.	Apparatus	Type	Range	Qty
1.	Ammeter	(M.I)	0 – 10A	1
2.	Voltmeter	(M.I)	0 – 600V	1
3.	Wattmeter U.P.F.	Dynamometer	10A/600V	1
4.	Tachometer	Digital	0-10,000 rpm	1
5.	3-ϕ Dimmer stat	Core type	415V/0-470V, 10A	
6.	3-ϕ Squirrel cage Induction motor with loading arrangements		Belt driven type Load	1
7.	Connecting wires	PVC insulated	-	-

Theory:-

The load test on induction motor is performed to compute its complete performance i.e. torque, slip, efficiency, power factor etc. during this test, the motor is operated at rated voltage and frequency and normally loaded mechanically by brake and pulley arrangement from the observed data, the performance can be calculated, following the steps given below.

Slip: The speed of the rotor, N_n droops slightly as load on the motor is increased.

Synchronous speed, $N_S = \frac{120f}{P}$ r.p.m. f → frequency

P → No. of poles

Then, slip $S = \frac{N_S - N_r}{N_S} \times 100\%$

Normally, the range of slip at full load is from 2 to 5 percent.

Torque: A brake drum is coupled to the shaft of the motor and the load is applied by tightening the belt, provided on the brake drum.

Net force exerted, $\omega = (S_1 - S_2)$ kg

Then, load torque, $T = \omega \times \frac{d}{2} \text{kg} - \text{m}$

$= \omega \times \frac{d}{2} \times 9.81\, \text{N}\omega - \text{m}$

Where, d is-effective diameter of the brake drum in meters.

Output power: The output power in watts developed by the motor is given by

Output power, $P_0 = \frac{2\pi NT}{60}$ watt

Where N is the speed of the motor in r.p.m

Power factor: If ϕ is the power factor angle, then

$$\cos\phi = \frac{\omega}{\sqrt{3}VI}$$

Where ω is the input power.

Efficiency: Percentage efficiency of the motor, $\eta = \frac{output\ power}{input\ power}$ X 100

Full load efficiency of 3-phase induction motor lies in the range of 82% (For small motor) to 92% (For very large motors)

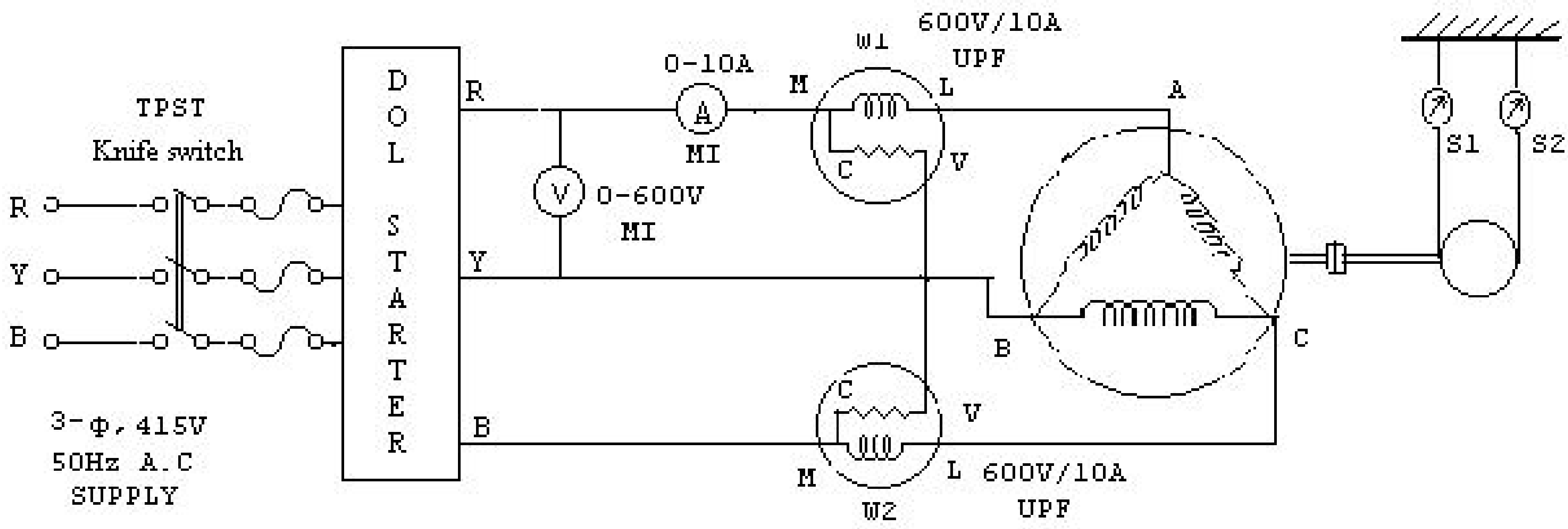
Procedure:-

1. The connections are made as shown in the circuit diagram.
2. Ensuring that the belt over the brake drum is totally loosened, the supply switch (TPST) is closed
3. The motor is started by pressing the 'On' push button on the three phase direct on line starter and al the meter readings as well as speed and spring balance readings are noted.
4. The load is applied in steps and for each step all the meter readings, spring balance readings as well as speed are noted.
5. Step no.4 is repeated until the rated current of the motor is reached.
6. The load is removed in steps, and the motor is stopped by pressing the 'OFF' push button on the direct online starter and the supply switch is opened.

Tabular column:-

S.l No	V_L in volts	I_L in Amps	W_1 in Watts	W_2 in Watts	S_1 In kgs	S_2 In kgs	W_T in Watts	Speed in rpm	Torque in N-m	Output In Watts	η in %	Power Factor cos ϕ	Slip in %

Circuit diagram:-

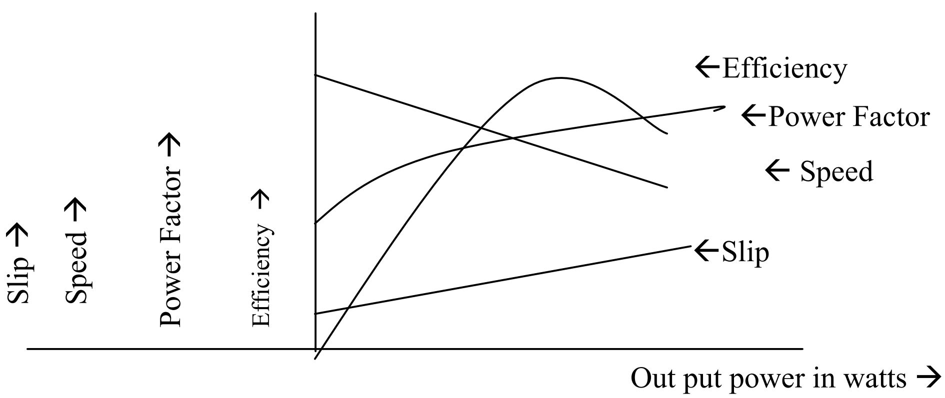


Specimen calculations: -

Wattmeter constant $= \dfrac{voltage\ range\ of\ W \times current\ range\ of\ W}{Maximumum\ Wattmeter\ scale\ reading}$

1. Input Power $= (W_1 \pm W_2)$ watts
2. Torque $= (S1 \sim S2) * R * 9.81$ N-m
3. Out put Power $= \dfrac{2 \prod NT}{60}$ watts
4. % Efficiency $= \dfrac{Output\ power}{Input\ power} \times 100$
5. Power Factor $= \text{COS}\ \phi = \text{COS} \left\{ Tan^{-1} \sqrt{3}\, \dfrac{(w_1 - w_2)}{(w_1 + w_2)} \right\}$
6. % Slip $= \dfrac{Ns - N}{Ns} \times 100$ where $Ns = \dfrac{120 f}{P}$ r.p.m

Nature of graph:-



Exp. No : 10

REGULATION OF AN ALTERNATOR BY SYNCHRONOUS IMPEDANCE METHOD.

Aim:- To conduct open circuit and short circuit test on a 3-ϕ alternator and determine the full load regulation curve by using synchronous impedance method.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 1.5 A	1
2	Ammeter	(M.I)	0 – 10 A	1
3	Voltmeter	(M.I)	0 – 300 V	1
5	Rheostat	Wire Wound	500 Ω / 1.2 A	2
8	Tachometer	(digital)	0.99999 rpm	1
9	Motor alternator set		-	1
10	Connecting wires	PVC insulated	-	-

Theory:-

The voltage regulation of an alternator is defined as the increase in the terminal voltage when the load is through off, produced that the field excitation and the speed are constant.

$$\%\ \text{regulation} = \frac{E - V}{V} \times 100$$

Where E – is the no-load voltage
V – is the load voltage

The variation is terminal voltage 'V' is due to the following reasons.

1. Voltage drop due to armature resistance Ra.
2. Voltage drop due to armature leakage reactance.
3. Voltage drop due to armature reaction.

Regulation of an alternator can be determined by measuring the voltage of the alternator, i.e. 'V' when loaded and 'E' when the load is taken off. In actual practice it will be difficult to load a big alternator in the testing laboratory as the laboratory may not have such heavy loads. More ever, during the testing period a considerable amount of electrical energy will be wasted as losses in the machine and in the load. This is why regulation of large alternators are not generally determined by direct loading method.

Regulation of an alternator can be determined from the results of the following two tests.

a. Open circuit test.
b. Short circuit test.

Open circuit test:-This test is carried out with the alternator running no-load and at rated speed. The field current and corresponding terminal voltage is recorded up to about 120% of rated terminal voltage. The characteristic shows the relationship between field current and terminal voltage on no-load is called the open circuit characteristic.

Short circuit test:-This test is performed when the alternator is running at rated speed. The armature terminals are short circuited with a very low excitation current and the field current corresponding to rated armature current is rated and a plot of field current versus armature current is called short circuited characteristic.

From these curves synchronous impedance can be calculated and then synchronous reaction can be separated as $X_S = \sqrt{Zs^2 - Ra^2}$

Procedure:-

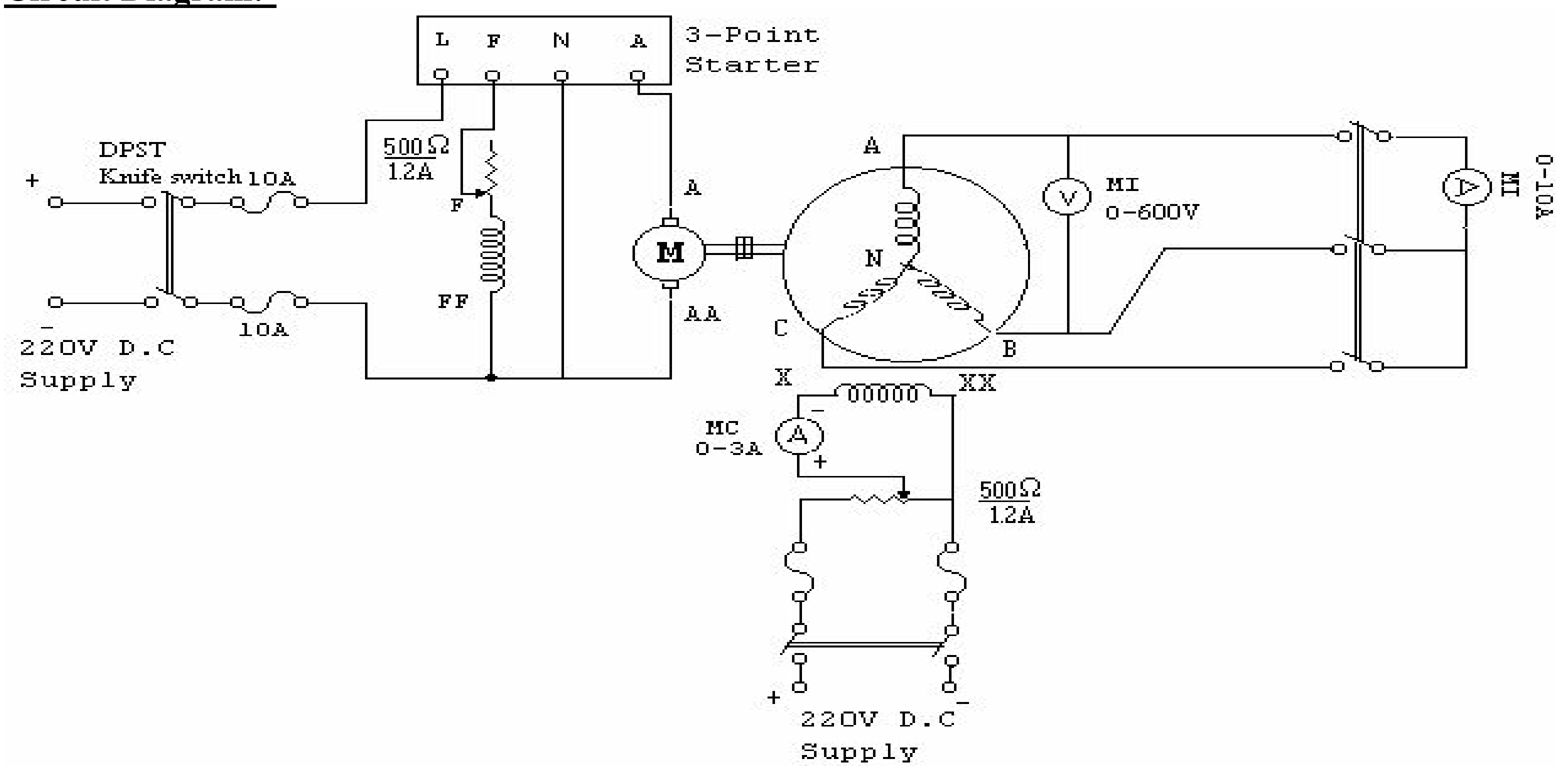
Open circuit characteristic Test

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in cut out position, the alternator field rheostat is cut in position, the 4-point starter handle is initial position and the TPST opened, the supply switch is closed.
3. The 4-point starter handle is moved slowly in the clockwise direction to cut out the resistance in the motor armature circuit so the motor starts.
4. The motor is brought to its rated speed, which is the rated speed of the alternator also by adjusting the motor field rheostat.
5. The dc supply switch of the alternator field is closed, the field current of the alternator is varied in steps and for each step the alternator voltage along with the field current are noted.
6. Stepno5 is repeated until the alternator voltage reaches about 120% of it rated value.
7. The alternator field rheostat is brought back to cutin position, the alternator field dc supply switch is opened, dc motor field rheostat is brought back to cutout position and the supply switch is opened.

Short circuit test:

1. Step no’s 1, 2, 3 and 4 of o.c.c. test are repeated.
2. The TPST switch is closed, so that the alternator terminals are short circuited.
3. The dc supply switch of the alternator field is closed and the alternator field rheostat is varied such that the ammeter reads the rated current of the alternator and the corresponding field current is noted.
4. The TPST switch is opened, the alternator field rheostat is brought back to cut in position, the alternator field dc supply switch is opened, the motor field rheostat is brought back cut out position and the dc supply switch is opened.

Circuit Diagram:-



Tabular column:-

O.C test:

Sl.No	I_f In Amps	E_0 In volts

S.C test:

Sl.No	I_f In amps	I_a In amps

Specimen calculations:-

D.C armature resistance per phase = R_{DC}

AC cumulative resistance per phase = 1.2 to 1.6 × R_{DC}

E.M.F. method (or) synchronous impedance method:

The synchronous impedance per phase $Z_s = \frac{E_0}{I_a}$ / at constant field current

$\therefore Z_S = \frac{\text{AC in volts}}{\text{AB in amps}}$ & Synchronous reactance

$$X_S = \sqrt{Zs^2 - Ra^2}$$

$$\% \text{ Regulation} = \frac{E_0 - V}{V} \times 100$$

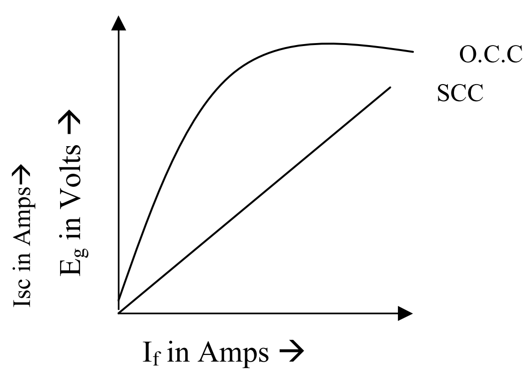
Where V – is the rated terminal voltage/phase

$$E_0 = \sqrt{(V \cos\phi + I_a R_a)^2 + (V \sin\phi \pm I_a X_s)^2}$$

(+) → for lagging power factor (-) → for leading power factor

for different power factors the regulation is calculated and tabulated corresponding to field current I_{fr} from o.c.c

Nature of graph:-



Exp. No : 11

DC SHUNT GENERATOR CHARACTERISTICS

Aim:- To conduct the no-load and load test on a D.C. shunt generator and draw its O.C.C, internal and external characteristics.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	1
2	Ammeter	(M.C)	0 – 10 A	1
3	Ammeter	(M.C)	0 – 2 A	1
4	Rheostat	Wire Wound	500 Ω, 1.2 A	2
5	Tachometer	Digital	0-9999RPM	1
6	Load box	Resistive	230 V/ 10 A	1
7	D.C. shunt generator coupled D.C. motor		-	-
8	Connecting wires	PVC insulated	-	-

Theory:-

External characteristic curve (ECC):- This is drawn under load condition.

It is the curve drawn between load current or line current and load voltage or terminal voltage taking current on X axis induced emf on Y axis.

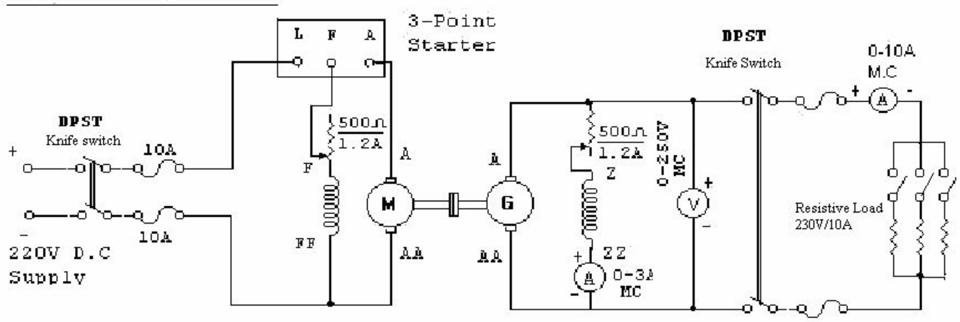
Internal characteristic curve (ICC). It is also called as total characteristic curve. It is drawn between armature current and generated voltage. Taking armature current on X axis, induced emf on Y axis

Relation between terminal voltage and induced emf:-The voltage given to the terminal is known as terminal voltage and induced in the generator is known as induced emf it is represented by E.

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. Ensuring that the motor field rheostat is in CUTOUT position, generator field rheostat is in CUTIN position, 3-point starter handle is in initial position and the load switch is in off position and the supply switch (DPST) is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance with motor armature circuit, so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. The generator field rheostat is varied in steps and the readings of field current and terminal voltage are noted.
6. Step No 5 is repeated until the generator voltage reaches to its rated value.
7. The load switch (DPST) is closed to connect the load to the generator and all the meter readings are noted in the tabular column.
8. The load is varied in steps and all the meter readings are noted in the tabular column.
9. Step no.8 is repeated until the rated current of the generator is reached.
10. The load is reduced in steps, the load switch is opened, the generator field rheostat is brought back to CUTIN position, the motor filed rheostat to CUTOUT position and the supply switch is opened.

CIRCUIT DIAGRAM:-



Tabular Column:-

Open circuit characteristic

Sl.no	I_f In Amps	E In Volts

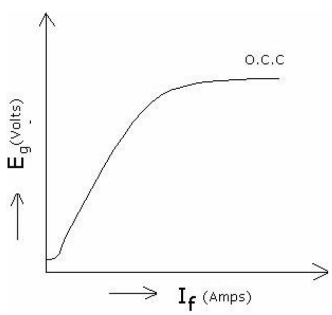
Internal and external characteristic

Sl.no	I_f In Amps	I_L In Amps	V In volts	I_a In Amps	$I_a R_a$ In Volts	E In volts

Specimen calculations:-

Induced voltage under load = $E = V + I_a R_a$

Nature of graph:-



Fig(a) : Open Circuit Characteristic

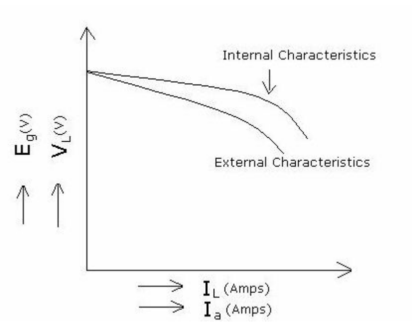


Fig (b) : Internal (E_g Vs I_a) and External (V_L Vs I_L)Characteristics

Viva – Voce Questions:-

1. What are the conditions to be fulfilled for the shunt generator to build up voltage?
2. What is meant by the term "critical field resistance" related to the dc shunt generator?
3. What is meant by the term "critical load resistance" in case of a dc shunt generator?
4. What is the type of voltage induced in the armature of a dc generator.
5. Can you measure the "Induced voltage" under load condition for a dc generator? Why?
6. Represent the armature reaction drop in the load characteristics of a dc shunt generator?
7. What is the purpose of the commutator in a dc machine?
8. What is meant by "critical speed N_0" in case of a dc shunt generator?
9. What is the principle of operation of dc generator?
10. List out the factors affecting the voltage fall in a dc shunt generator?
11. What will happen if you given ac supply to the field of a dc generator
12. A properly connected generator is showing a zero terminal voltage when it is run by a prime mover. What is the reason?

Exp. No : 12

POWER MEASUREMENT IN A 3-Φ BALANCED A.C CIRCUIT USING TWO WATT METER METHOD

AIM:

To measure the 3-Φ power using two watt meter method in a balanced A.C circuit.

APPARATUS REQUIRED:

S.no	Apparatus required	Type	Range	Quantity
1.	Ammeter	(M.I)	(0 – 10) A	1
2.	Volt meter	(M.I)	(0 – 600) V	1
3.	Wattmeter (UPF)	Dynamometer	600V/10A	2
4.	3-Φ load	Resistive	415V,20A	-
5.	Connecting wires	PVC insulated	-	-

THEORY:

The connections of the two current coils in series with the load in the two phases and the two pressure coils are connected between two phases and third phase respectively. I_f the current coil carrier I_R and I_B and the pressure coil are V_{YR} and V_{YB} .

In terms of instantaneous currents I_R, I_Y, I_B and instantaneous voltages V_R, V_Y, V_B.

The instantaneous total power is given by

$$P = V_R I_R + V_Y I_Y + V_B I_B \quad \text{——— (1)}$$

In case of y connected without neutral, we have

$$I_R + I_Y + I_B = 0$$

$$I_Y = -(I_R + I_B) \quad \text{——— (2)}$$

Substitute equation (2) in equation (1)

$$P = V_R I_R + V_Y(-I_R - I_B) + V_B I_B$$

$$= V_R I_R - V_Y I_R - V_Y I_B + V_B I_B$$

$$= I_R(V_R - V_Y) + I_B(V_B - V_Y)$$

$$P = V_{YR} I_R + V_{YB} I_B$$

NOTE: The watt meters read only the average power.

Wattmeter number 1: i.e.

W_1 ___ Current coil carries I_R

___ Pressure coil carries V_{YR}

Wattmeter number 2: i.e.

W_1 ___ Current coil carries I_B

___ Pressure coil carries V_{YB}

Therefore, $P = W_1 + W_2$

$$P = V_{YR}\, I_R \cos\Phi_1 + V_{YB}\, I_B \cos\Phi_2 \quad \text{\_\_\_\_\_\_\_\_} (3)$$

Thus, the total average power for a 3-Φ circuit is obtained by adding two reading of watt meter W_1 and W_2.

In equation (3) $\cos\Phi_1$ and $\cos\Phi_2$ are the phase angles between V_{YR} and I_R and between V_{YB} and I_B.

In terms of instantaneous currents I_R, I_Y, I_B and instantaneous voltages V_R, V_Y, V_B.

The instantaneous total power is given by

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Close the supply (TPST) switch.
3. The load is applied in steps and for each step meter readings are noted.
4. Repeat step 3 until the rated current of load is reached.
5. Load is removed in steps and switch is opened.
6. Calculate and verify the total power.

TABULAR COLUMN:

S.NO	V_1(Volts)	W_1(Watts)	W_2(Watts)	W_1+W_2	I_L(Amps)	$\sqrt{3}\, V_L I_L \cos\Phi$

MODEL CALCULATIONS:

Voltage across load (V_L) = V

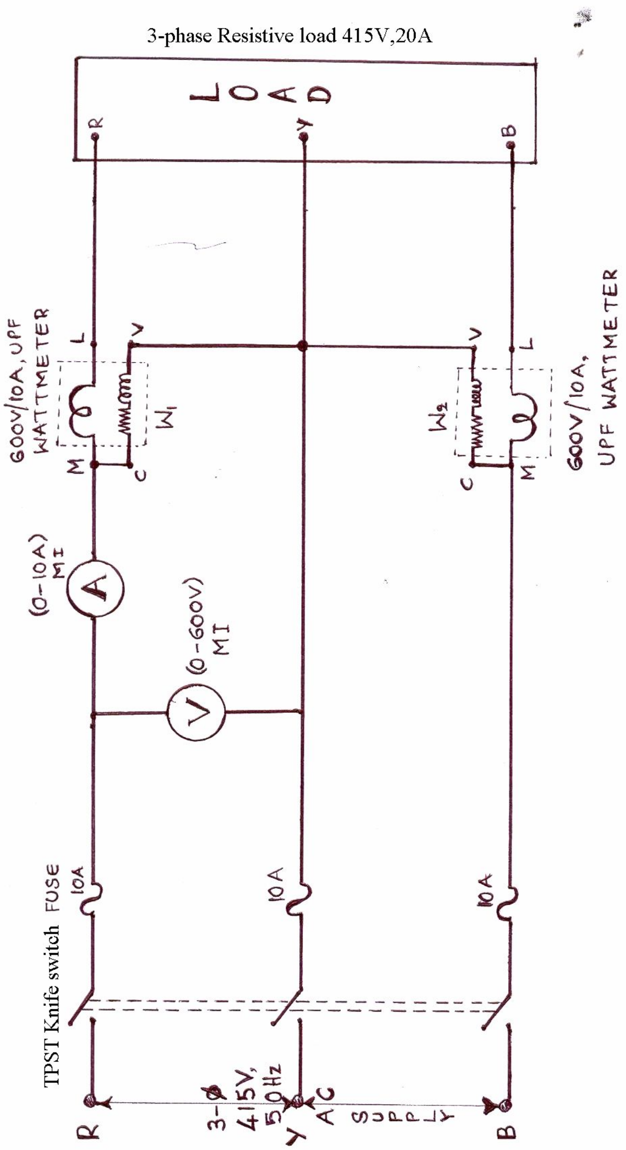
Load current (I_L) = A

Watt meter reading W_1 = Watts

$W_2 =$ Watts

$W_1 + W_2 =$ Watts

Total power = $\sqrt{3}\, V_L I_L \cos\Phi$ Watts


3-phase Resistive load 415V,20A
LOAD
600V/10A, UPF WATTMETER
W1
W2
600V/10A, UPF WATTMETER
(0-10A) MI
(0-600V) MI
TPST Knife switch
FUSE
10A
3-ϕ 415V, 50Hz AC SUPPLY
R
Y
B

Exp. No : 13

SPEED CONTROL OF DC SHUNT MOTOR

Aim:- To control the speed of a D.C. shunt motor by Armature control method and field control method.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 3 A	1
2	Voltmeter	(M.C)	0 – 250 V	1
3	Rheostat	Wire wound	500 Ω, 1.2 A	1
4	Rheostat	Wire Wound	38 Ω, 10 A	1
4	Tachometer	Digital	0 – 9999 rpm	1
6	D.C. shunt motor		3HP, 220 V, 12 A	1
7	Connecting wires	PVC insulated	-	-

Theory:-

The speed of a dc shunt motor can be controlled by varying

i) Flux/pole (Flux control method)
ii) Resistance of armature circuit (rheostat control method)
iii) Applied control (Voltage control method)

Speed of a motor is given by the relation:

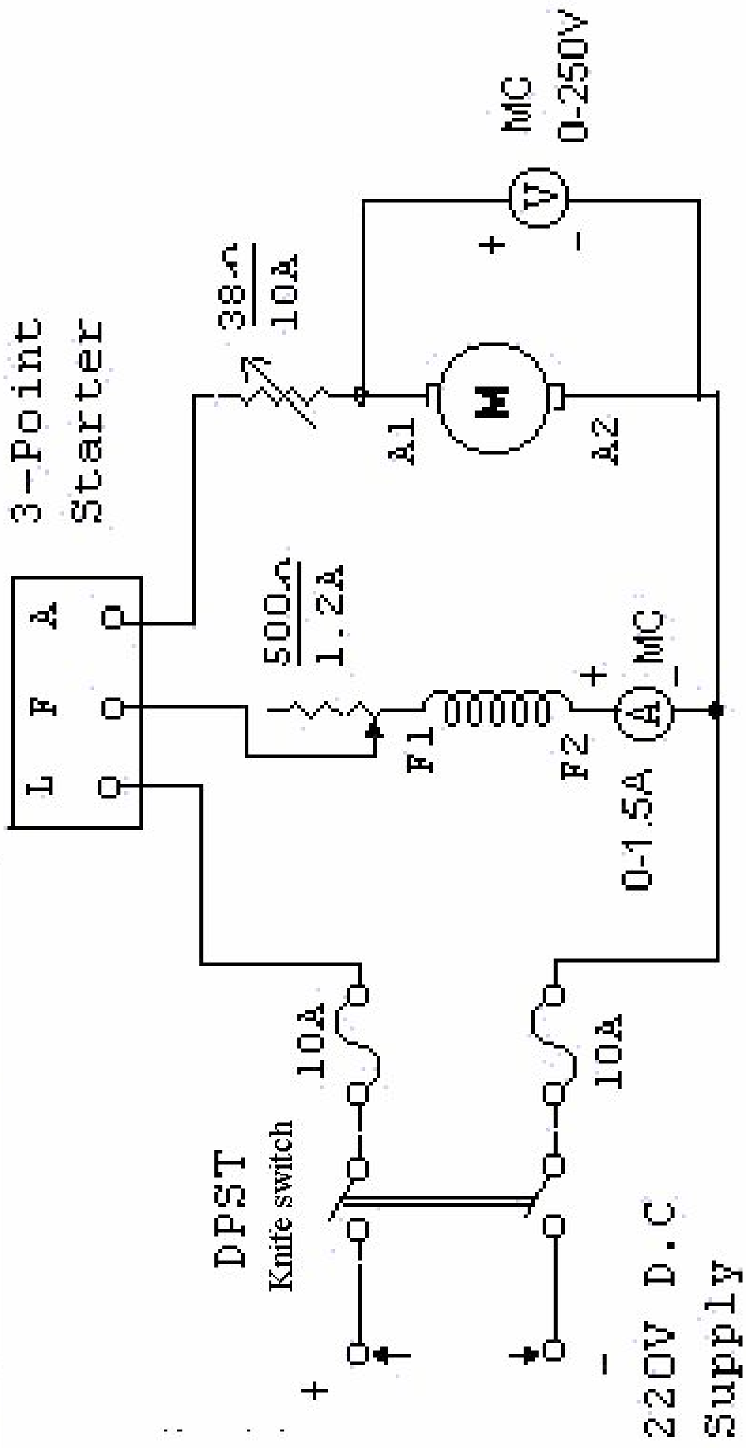
$$N \propto \frac{E_b}{\phi} \quad \text{-- (1)}$$

i) Flux control method:-This method is used when speeds above normal speeds are required. In the above equation (1) by decreasing the flux, the speed can be increased and vice versa. The flux of a dc motor can be changed by changing I_{sh} with the help of a shunt field rheostat. The current in shunt field rheostat is less. I^2R loss is small, so that rheostat is small in size.

ii) Armature or rheostat control method:- This method used when speeds below the no-load speeds are required. In this method the voltage across the armature is varied by increasing a variable rheostat in series with the armature circuit, as resistance is increased, potential difference across the armature & decreased, there by decreasing the armature speed. This method is expensive (Cu loss more) and unsuitable for rapidly changing loads because for a given value of R_t, the speed will change with load.

iii) Voltage control method:- This method is also used to control the speeds below the no-load speeds. Ij this method the shunt field of the motor is connected across the fixed supply and then by supplying different voltage to the armature different loads are obtained. The control voltage is obtained from potential deviders, solid state rectifier and ward-leonard system.

CIRCUIT DIAGRAM:-



Procedure:-

a) For Armature voltage control method:-

1. The connections are made as shown in the circuit diagram.
2. With the armature rheostat is CUTIN position, the field rheostat in CUTOUT position and the 3-point starter handle at its initial position, the D.C. supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the armature rheostat so that the motor starts and runs at some speed is adjusted to a certain value by varying the field rheostat.
4. The field current is adjusted to a certain value by varying the field rheostat such that the motor runs at neatly rated speed.
5. The armature rheostat is cutout gradually so that the armature voltage is varied in steps and the corresponding speeds are noted in the tabular column.
6. Step no. 5 is repeated until the armature rheostat is completely cutout.
7. The field rheostat is brought back to CUTOUT position, the armature rheostat to CUTIN position and the D.C. supply switch is opened.

b) For field control method:-

1. Step nos. 1, 2 & 3 of armature voltage control method are repeated.
2. The armature rheostat is varied such that the rated voltage is applied across the armature terminals.
3. The field resistance is gradually cut in steps so that the field current is varied in steps of 0.05A and the corresponding value of speeds are rated.
4. Step no. 3 is repeated until the field rheostat is completely CUT IN.
5. Step no. 3 and 4 are repeated for an armature voltage of 200V.
6. The field rheostat is brought back to CUT OUT, the armature rheostat to CUT IN position and the supply switch is opened.

Tabular column:-

a) Armature voltage control

Field current =

Sl.No	Armature voltage In Volts	Speed In rpm

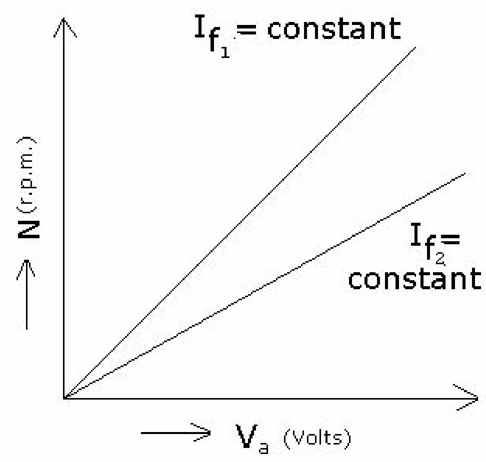
b) Field control method

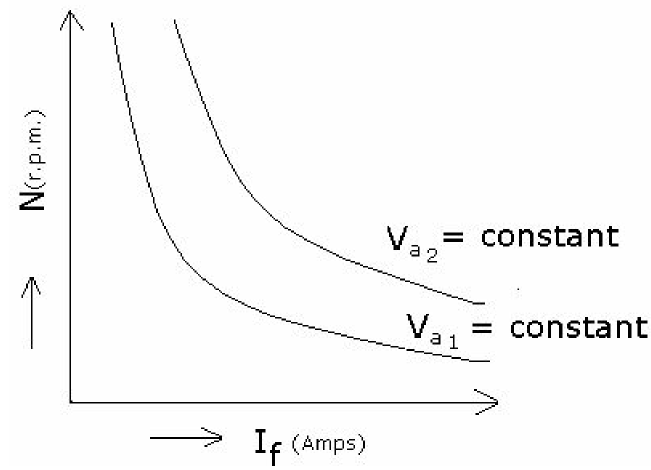
Armature voltage =

Sl.No	Field current In Volts	Speed In rpm

<u>Nature of graph:</u>

a) Armature Voltage Control **b) Field Control**





<u>Viva – Voce Questions:-</u>

1. Speed of a dc shunt motor is directly proportional to field current (true or false)?
2. A dc shunt motor rated speed as 1500 rpm. How do you get speed below and above 1500 rpm?
3. Give the equation of the back EMF induced in a dc motor. What is the other equation by which it can be calculated?
4. What is the difference between arm voltage control and arm series resistance control in case of dc shunt motor? Which one is preferable?
5. Define speed regulation of a dc motor? How much percent will it be usually for a shunt motor?