LABORATORY MANUAL

ELECTRICAL MACHINE LAB-I LAB

B.Tech. (Electrical Engineering), 3rd Semester

Department of Electrical Engineering
Veer Surendra Sai University of Technology,
BURLA

Vision

To be recognized as a center of excellence in education and research in the field of Electrical Engineering by producing innovative, creative and ethical Electrical Engineering professionals for socio-economic development of society in order to meet the global challenges.

Mission

Electrical Engineering Department of VSSUT Burla strives to impart quality education to the students with enhancement of their skills to make them globally competitive through:

M1. Maintaining state of the art research facilities to provide enabling environment to create, analyze, apply and disseminate knowledge.

M2. Fortifying collaboration with world class R& D organizations, educational institutions, industry and alumni for excellence in teaching, research and consultancy practices to fulfil 'Make in India' policy of the Government.

M3. Providing the students with academic environment of excellence, leadership, ethical guidelines and lifelong learning needed for a long productive career.

Program Educational Objectives

The program educational objectives of B.Tech. in Electrical Engineering program of VSSUT Burla are to prepare its graduates:

1. To have basic and advanced knowledge in Electrical Engineering with specialized knowledge in design and commissioning of electrical systems/renewable energy systems comprising of generation, transmission and distribution to become eminent, excellent and skilful engineers.
2. To succeed in getting engineering position with electrical design, manufacturing industries or in software and hardware industries, in private or government sectors, at Indian and in Multinational organizations.
3. To have a well-rounded education that includes excellent communication skills, working effectively on team-based projects, ethical and social responsibility.
4. To have the ability to pursue study in specific area of interest and be able to become successful entrepreneur.
5. To have broad knowledge serving as foundation for lifelong learning in multidisciplinary areas to enable career and professional growth in top academic, industrial and government/corporate organizations.

LIST OF EXPERIMENTS

1. Open circuit and short circuit on single phase transformer.
2. Parallel operation of two single phase transformer and load sharing.
3. Back –to-back test of Single phase transformer.
4. Load characteristics of DC shunt/compound generator.
5. Load characteristics of DC series Motor.
6. Swinburne test and brake test of DC shunt machine.

COURSE OUTCOMES

Upon completion of this course, students will demonstrate the ability to:

CO1. Perform parallel connection of single phase transformers.

CO2. Evaluate performance of DC series and shunt motors.

CO3. Compute the efficiency of transformer by different experimental tests.

CO4. Perform tests to evaluate performance of DC machine and transformers.

CO5. Estimate load performance of DC series motor.

Experiment 1

AIM OF THE EXPERIMENT:

To perform the open circuit and short circuit tests on a single phase transformer.

OBJECTIVE:

To find the magnetising components, regulation and efficiency of single phase transformer at different power factor.

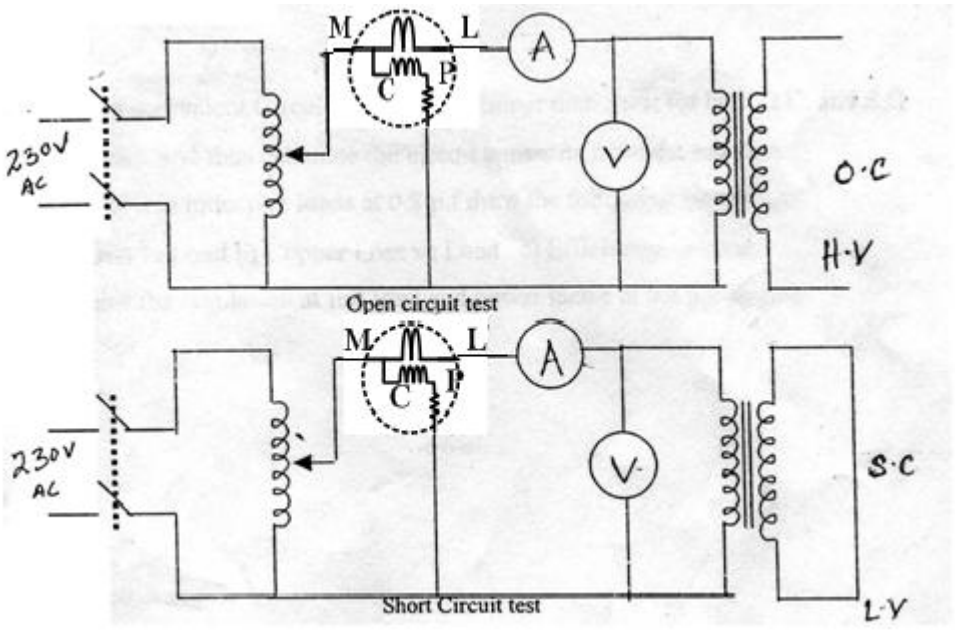
APPARATUS REQUIRED:

Sl. No.	Item	Range	Nos.

MACHINE SPECIFICATION:

Transformer: 3KVA, 230/230 V(1:1), 13 A, 50Hz.

CIRCUIT DIAGRAM:



THEORY:

The two tests open circuit test and short circuit test help to determine the parameter of a transformer, the voltage regulation and efficiency.

In open circuit test the instruments are connected on L.V. side and H.V. side is kept open.

Let Wo, Vo & Io are the readings we got.

$$\text{Calculate no load power factor } \cos\theta_0 = \frac{W_0}{V_0 I_0}$$

Hence θ_0 is known, calculate $\sin\theta_0$

$$\text{Calculate magnetizing current } I_m = I_0 \sin\theta_0$$

$$\text{Calculate core loss component of current } I_{cl} = I_0 \cos\theta_0$$

$$\text{Magnetising branch reactance } X_{m(LV)} = \frac{V_0}{I_m}$$

$$\text{Resistance representing core loss } R_{cl(LV)} = \frac{V_0}{I_{cl}}$$

We can also calculate $X_{m(HV)}$ and $R_{cl(HV)}$ as follows:

$$X_{m(HV)} = \frac{X_{m(LV)}}{a^2}$$

$$R_{cl(HV)} = \frac{R_{cl(LV)}}{a^2}$$

$$\text{Where, } a = \frac{N_{LV}}{N_{HV}} \text{ the turns ratio}$$

Where, Vo = Applied rated voltage in volt

Io = Exciting current in Amp. (2 – 6% of rated current)

Wo = Core loss in Watt.

Suppose the readings are Vsc, Isc and Wsc. It should be noted that voltage required to be applied for rated short circuit current is quite small (typically about 5%).

Therefore from the test data series equivalent impedance namely re(HV) and xe(HV) can easily be computed as follows:

$$\text{Equivalent resistance ref. to HV side } r_{e(HV)} = \frac{W_{sc}}{I_{sc}^2}$$

$$\text{Equivalent impedance ref. to HV side } z_{e(HV)} = \frac{V_{sc}}{I_{sc}}$$

$$\text{Equivalent leakage reactance ref. to HV side } x_{e(HV)} = \sqrt{z_{e(HV)}^2 - r_{e(HV)}^2}$$

We can also calculate $r_{e(LV)}$ and $x_{e(LV)}$ as follows:

$$r_{e(LV)} = a^2 r_{e(HV)}$$

$$x_{e(LV)} = a^2 x_{e(HV)}$$

$$\text{where, } a = \frac{N_{LV}}{N_{HV}} \text{ the turns ratio}$$

Where W_{sc} = Copper loss in watt

Vsc = Voltage reading in volt.

Isc = Current in Amp.

PROCEDURE:

OC TEST

1. The circuit connections were made according to the diagram.
2. The H.V. side was kept open.
3. Rated voltage and frequency were applied at L.V. side by auto transformer.
4. The wattmeter and ammeter readings were taken.

SC TEST

1. The instruments were connected on the H.V. side while L.V. side was shorted.
2. Using the auto transformer, rated current was made to flow through the H.V. side.
3. The readings of voltmeter and ammeter were noted down.

TABULTAION

Sl. No.	Tests	Primary Voltage	Primary Current	Wattmeter Reading	Supply Frequency	Power factor
1	O.C Test					
2	S.C Test					

CALCULATION:

Give sample calculation

REPORT:

1. Draw the equivalent Circuit for the transformer under test for both O.C. and S.C Conditions, and thus calculate the circuit constants from the test data.
2. For variable inductive loads at 0.8 p.f draw the following curves.
   a. Core loss Vs. Load
   b. Copper Loss Vs. Load
   c. Efficiency Vs. Load
3. Determine the regulation at full load and power factor at 0.8 p.f lagging.

CONCLUSION:

Experiment 2

AIM OF THE EXPERIMENT:

Parallel operation of Two single phase transformers.

OBJECTIVE:

To study the load sharing of load by two similar single phase transformer.

APPARATUS REQUIRED:

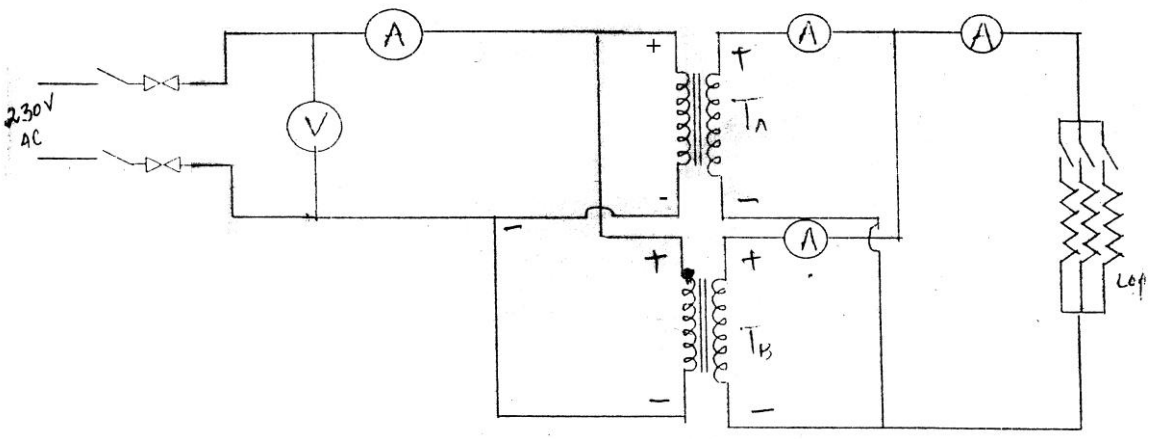
Sl. No.	Item	Range	Nos.

MACHINE SPECIFICATION:

Transformer cycle 50 Hz, power 3KVA, volt 250/230/119V current 13.1 Amp.

CIRCUIT DIAGRAM (FOR POLARITY TEST):

CIRCUIT DIAGRAM



THEORY:

$$I_A = I \cdot \left(\frac{Z_B}{Z_A + Z_B}\right), \qquad I_B = I \cdot \left(\frac{Z_A}{Z_A + Z_B}\right)$$

Where

I = Total Current in Amp.

Z_A = Impedance on Transformer B in Ω

Z_B = Impedance on Transformer A in Ω

Condition for the parallel operation:

1. Primary winding coil the transformers should be suitable for the supply system voltage and frequency.
2. The transformers should be properly connected with regard to polarity, otherwise it will result in dead short circuit.
3. The voltage rating of both primaries and secondary should be identical (should have same turn ratio). If not, there will be inequality in the induced emf & in secondary and even in no load, as the resistance of the transformer winding are very small, resuls in high current former winding are very small, results in high current flow through the windings which may damage the transformers.
4. The percentage impedances should be equal in magnitude and have the same λ/R ratio. If this is not satisfied i.e. impedance triangles are not identical in shape and size, then the power factors at which the two transformer operate will be different from the P.F. of the common load. So in this case, the two transformers will not share the load in proportion to their KVA ratings.
5. With transformers having different KVA ratings the equivalent impedances should be inversely proportional to the individual KVA ratings if circulating currents are to be avoided. If we will take two ideal transformers having the same voltage ratio and having impedance voltage triangle size and shape.

Late E be no load rating of secondary voltage of each transformer and V_2 be the terminal voltage. I_A and I_B the currents supplied by them and I, the total current, lagging behind V_2 by and angle ϕ.

$I = I_A + I_B$; $V_2 = E - I_A Z_A = E - I_B Z_B$

ALSO, $I_A Z_A = I_B Z_B$

Or $I_A + I_B = Z_B / Z_A$

$I_A = I[Z_B/(Z_A + Z_B)]$ and $IB = I[Z_A/ (Z_A + Z_B)]$

Value of Z_A& Z_B can be found mathematically from above equation.

PROCEDURE:

1. First the polarity test was done on each of the transformers.
2. Connect the two transformers as shown in the figure. Load the transformers by variable resistance in such a way that none of them carry more than its rated load. Take the readings of A_1, A_2 and A_3 and measure the supply voltage.

TABULTAION

No. of Obs.	Supply Volt and Frequency 50 Hz	Load current shared by transformer-I (A_1) in Amp.	Load Current of transformer-II (A_2) in Amp.	Total current taken by Load (A_3) in Amp.

CONCLUSION:

Experiment 3

AIM OF THE EXPERIMENT:

To perform Back-to-Back test on two similar single phase transformers.

OBJECTIVE:

To find the voltage regulation and efficiency

MACHINE SPECIFICATION:

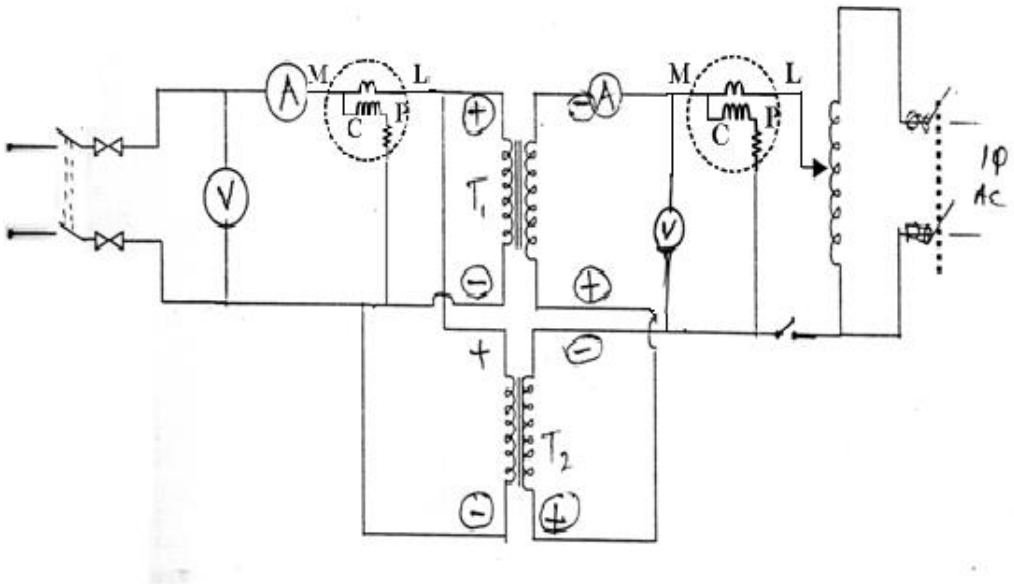
Auto Transformer: 0 - 270 volt, 30A

Transformer: 3KVA, 230/115 V (1:2), 13A, 50Hz

APPARATUS REQUIRED:

Sl. No.	Item	Range	Nos.

CIRCUIT DIAGRAM:



THEORY:

$$efficiency\ \eta = \frac{output}{input} = \frac{input - losses}{input} = 1 - \frac{losses}{input}$$

$$losses = core\ loss + copper\ loss$$

PROCEDURE:

1. Check the polarities of the transformers and connect them as shown in the circuit diagram.
2. Switch on the supply and adjust the auto-transformer so that rated secondary current circulates in the secondary of both the transformers.
3. Note the readings of the instruments.

TABULATION:

SL. No.	Primary side current (A)	Primary side voltage (V)	Primary side Power (Watt)	Secondary side current (A)	Secondary side voltage (V)	Secondary side power (Watt)

REPORT:

1. a. Find out the voltage regulation of each transformer at full load.
   b. Plot the efficiency of each transformer against the load. Give sample calculation in each case
2. Draw the equivalent circuit of each transformer and mention the values of the parameters.
3. Mention the advantages and the disadvantages of this method over other methods, for determining the efficiency and the regulation of a transformer.

CONCLUSION:

Experiment 4

AIM OF THE EXPERIMENT:

To study the load characteristics of a D.C. Cumulatively and differential Compound wound generator and to find out the relationship between the terminal voltage and load current at its rated speed.

OBJECTIVE:

a. To study the effects of load on the terminal voltage of DC cumulatively compound & differential wound generator.
b. To plot efficiency Vs. Output power characteristics.

APPARATUS REQUIRED:

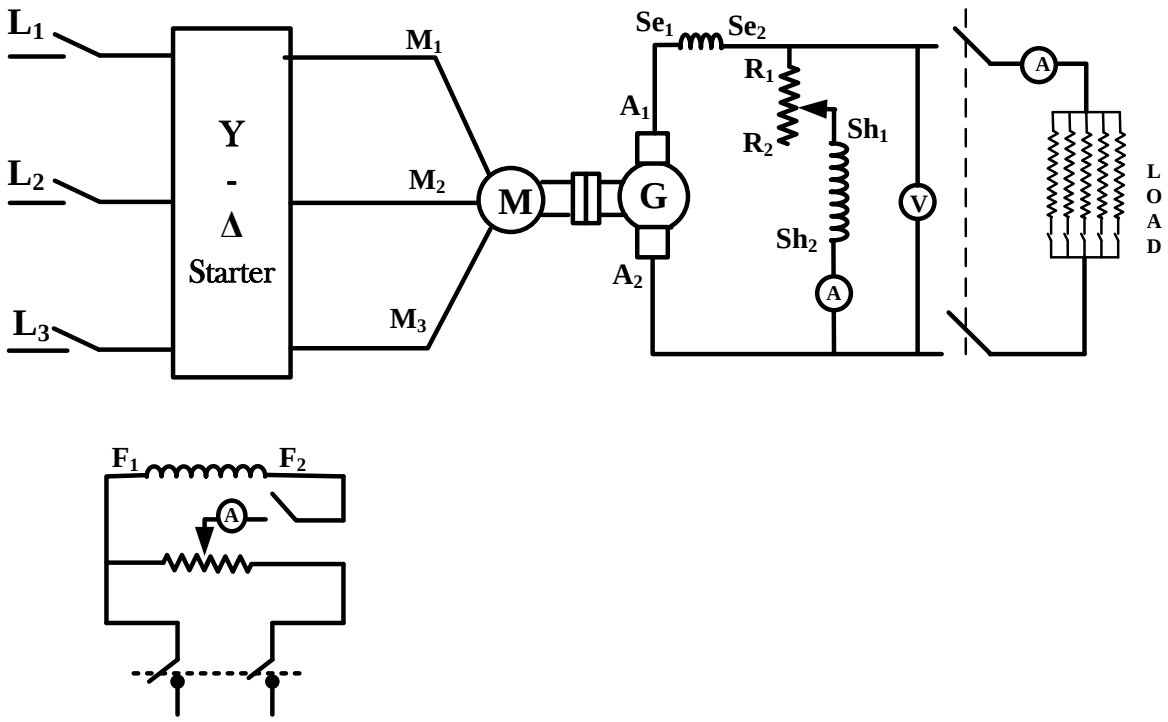
Sl. No.	Item	Range/Rating	Maker's Name	Maker's No.

MACHINE SPECIFICATION:

Synchronous Motor (AC): 7.5 KW, 400 V, 13.5 A, 1500 RPM; Rotor – 55 V, 4 A

DC Compound Generator: 5 KW, 230 V (DC), 21.7 A, 1500 RPM

CIRCUIT DIAGRAM:



THEORY:

PROCEDURE:

1. Connections are done as per the circuit diagram.
2. The machine is run at rated speed by adjusting the speed of the driving motor.
3. Before loading the generator, the field resistance is varied so that it gives rated voltage.
4. The load is varied gradually at its rated speed.
5. The terminal voltage is noted down for each value of load current.
6. The load is switch off.
7. The load is increased from starting at no load in steps until the machine is considerably overloaded. (say about 25% overload).
8. The field current, terminal voltage, load current and speed for each value of load current are recorded.
9. The above procedures are repeated for both cumulative and differential compound generator.

TABULTAION

Sl. No.	Load Current In A	Field Current In A	Terminal Voltage in Volt	Speed in rpm

REPORT:

1. Draw the graph of Terminal voltage Vs. Load current at constant speed.
2. Discuss different types of compounding methods and the differences in their characteristics.

CONCLUSION:

Experiment 5

AIM OF THE EXPERIMENT:

To determine the efficiency of a DC shunt machine by measurement of losses in Swinburne test and directly by applying load in brake test.

OBJECTIVE:

To find efficiency of DC shunt motor and DC shunt generator.

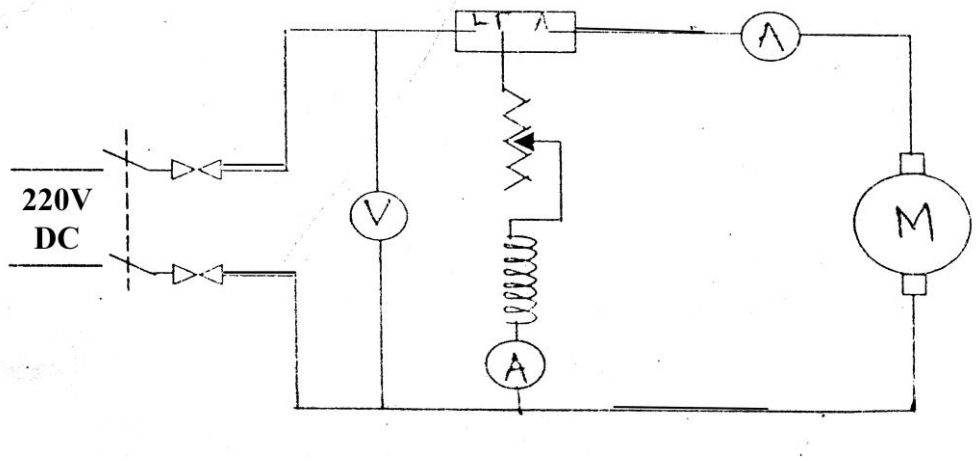
APPARATUS REQUIRED:

Sl. No.	Item	Range/Rating	Maker's Name	Maker's No.

MACHINE SPECIFICATION:

DC Shunt Motor: 7.5 KW, 230 V (DC), 30 A, 950 RPM

CIRCUIT DIAGRAM FOR SWINEBURNE'S TEST:



CIRCUIT DIAGRAM FOR BREAK TEST:

CIRCUIT DIAGRAM FOR MEASUREMENT OF RESISTANCE:

THEORY:

A. SWINBURNE TEST:

1. The machine runs at rated speed with rated excitation.
2. In this method, the losses are measured separately and from this efficiency at any desired load can be predetermined in advance.

At No load the input power to the motor = VI_0

Power input to the armature = $VI_{a0} = V(I_0 - I_{SH})$

Constant losses $W_C = VI_0$ – Armature cupper loss (I^2_{a0} x Ra)

To find efficiency load is given.

Armature current $I_a = I - I_{SH}$

For Generator $I_a = I + I_{SH}$

Where I = load current

Now Input Power = VI

Armature cupper loss = $I_a^2 Ra = (I - I_{SH})^2 Ra$

Total Losses = $(I - I_{SH})^2 Ra + Wc$

$$efficiency\ \eta = \frac{output}{input} = \frac{VI - (I - I_{SH})^2 R_a - Wc}{VI}$$

Where R_a is found by voltmeter and ammeter method.

B. BREAK TEST:- It is a direct method and consists of applying a brake to a water cooled pulley mounted on the shunt motor shaft. The efficiency is measured by directly measuring the power input & output.

$$\text{The output power} = \frac{2\pi N T_{SH}}{60} = \frac{2\pi N\ (W - S) \times 9.8r}{60}$$

Where T_{SH} = (W-S) x 9.8 r Nmt. (shaft torque)

W = Suspended weight in Kg.wt.

S = Spring balance weight in Kg.wt.

N = Speed in rpm

r = Radius of pully in meter

Input power = VI

Where

V = Supply voltage in volt.

I = Input Current to the motor.

$$\eta = \frac{output}{input}$$

PROCEDURE:

A. Swinburn's Test

1. Connections are done as per circuit diagram.
2. The machine is run at its rated speed without load.
3. The reading of voltmeter & ammeter is noted down.

B. Break Test

4. The voltmeter & ammeters reading corresponding to no load are noted down.
5. The load is given to the machine gradually by applying break with the help of pulley and the reading of current and its speed are taken.
6. The terminal voltage is noted down for each value of load current.
7. Armature cupper loss is found out.
8. Total Losses are taken.
9. The efficiency from Brake test is found out.

PRECUTION:

Cooling should be done by spraying water inside the groove of the pulley to avoid excessive heating of surface due to friction.

TABULTAION:

Table-1 (For Armature Resistance)

No. of Obs.	Ia in Amp	Va in Volt	Ra = V_a / $I_a$in Ohm	Mean

Table-2(Swinburne's Test)

Sl. No.	Supply Voltage V in Volt	Load Current I in A	Field Current I_{SH} in A	Armature Current $I_a = (I-I_{SH})$ in A

Table-3(Break Test)

Sl. No.	Supply Voltage V in Volt	Motor Current I in Amp.	Speed in rpm	W in Kg. Wt.	S in Kg. Wt.	Pulley Radius in m

SAMPLE CALCULATION

CONCLUSION:

Experiment 6

AIM OF THE EXPERIMENT:

Performance characteristics of a DC series Motor by direct loading and study of the drum controller.

OBJECTIVE:

1. To plot the performance characteristics of DC series motor
2. To plot T~I_a, N~I_a and N~T Characteristics of DC series, shunt and compound machine.

APPARATUS REQUIRED:

Sl. No.	Item	Range	Maker's No.

MACHINE SPECIFICATION:

DC Series Motor: 2.5 KW, 230 V, 10 A, 1500 RPM

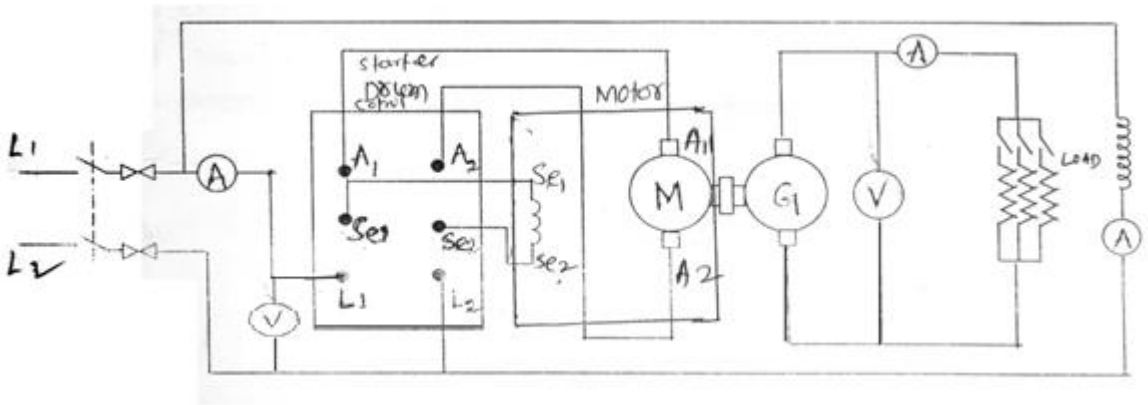
Generator: 230 V (DC), 10 A, 3 HP, 1440 RPM

THEORY:

A. Output torque of the motor = Motor output / (2 Π N), Where N = speed

B. N = (V-IR) x I / (2 Π T), where, T = Torque for current I.

CIRCUIT DIAGRAM:



PROCEDURE

1. Before starting the motor ensure that-
   a. The DC generator switch is closed and the load switches are kept in on position.
   b. The field circuit of the generator is closed and it carries normal current.
2. Start the motor and cut off all the starting resistances.
3. Load the motor until the current is about 110% of the rated current. Record the various instrument readings.
4. Reduce the load in suitable steps and note the instrument readings. The speed should not exceed beyond 120% of the rated speed.
5. Repeat the above procedures for reverse rotation of drum controller.

CALCULATION

A. Calculate torque, efficiency and output of the motor assuming the efficiency of the motor and generator to be equal at all loads.
B. Compute the speed torque characteristics.

GRAPHS:

Plot the following graphs

1. Speed Vs. Torque
2. Current, Speed, Efficiency and Torque Vs. Output.

CONCLUSION:

DISCUSSION: