University of Global Village (UGV), Barishal

Electrical Machine I Sessional

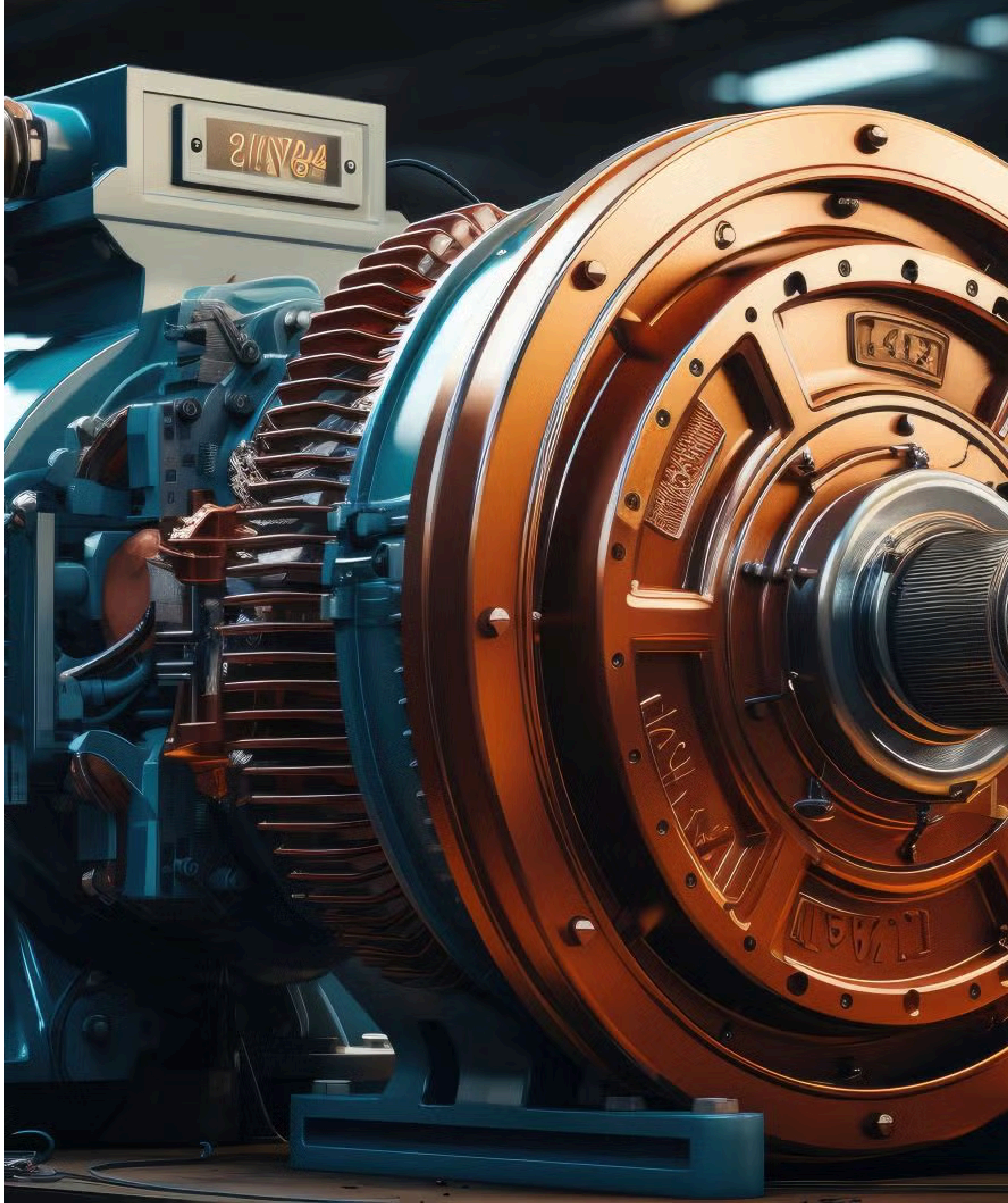
Prepared by:
Md. Mutassim Fuad
Lecturer, Dept. of EEE
University of Global Village (UGV), Barishal

Basic Course Information

Course Title	Electrical Machine I Sessional
Course Code	EEE 0713-2102
Credits	01
Marks	50
Course Type	Sessional Course
Level	3rd Semester
Academic Session	Winter 2025

Course Rationale

This course is developed for students of electrical engineering. Students taking this course will be exposed to introductory theoretical as well as practical concepts of Electrical Machines.

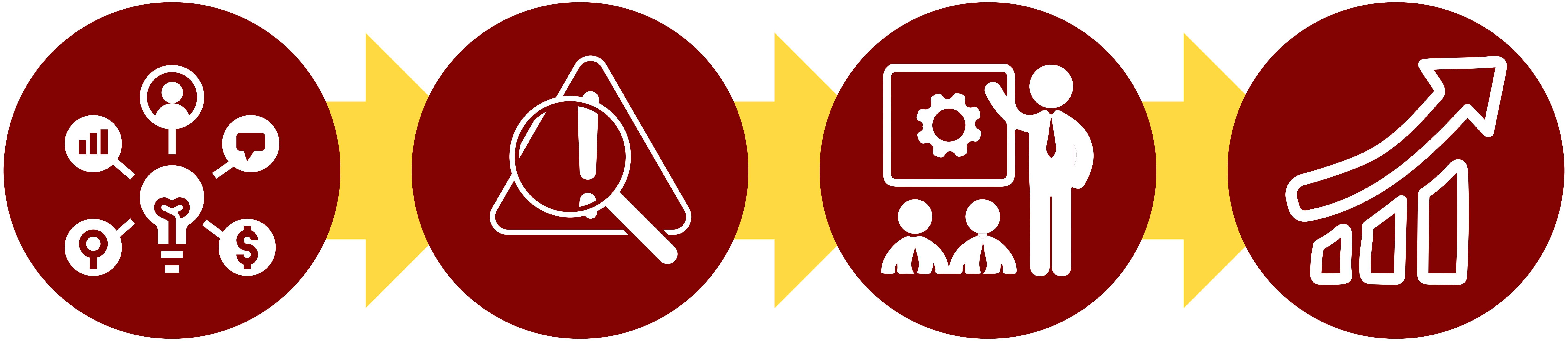


Course Objectives

This course has been designed for the students.

1. Understanding of the basic concepts of electrical machines.
2. Apply their knowledge of power systems.
3. Design, analyze and troubleshoot electrical circuits.

Course Learning Outcomes (CLOs):



CLO 1

Analyze different machines with respect to theoretical knowledge.

CLO 2

Identify the performance of different machines experimentally.

CLO 3

Apply practical knowledge for designing Electrical machines.

CLO 4

Analyze the properties of DC machines, Generator and Transformer machines practically.

Course Plan Mapped with CLO

Week No.	Experiment Name	Learning Outcomes	Theory Time (Hours)	Practical Time (Hours)	Alignment to CLO
1 - 2.	Determine Equivalent Circuit Parameters of Single-Phase Transformer by Performing Open Circuit Test.	To perform the O.C. test of a single-phase transformer with the help of an ammeter, voltmeter and a wattmeter and to find out the core loss of the transformer, different parameter at no load condition .	04	06	CLO 1 CLO 2
3 - 4.	Determination of equivalent circuit parameters of single phase transformer by performing short circuit test.	1. Understanding Copper loss at any load 2. Understanding Different parameters of the transformer with respect to high voltage side & low voltage side	04	06	CLO 2 CLO 3
5.	The transformation ratio of a 1 -φ transformer.	1. Identify HT and LT side of transformer. 2. Gain practical knowledge about transformation ratio of a transformer.	02	03	CLO 1 CLO 2

Course Plan Mapped with CLO

Week No.	Experiment Name	Learning Outcomes	Theory Time (Hours)	Practical Time (Hours)	Alignment to CLO
6 - 7.	Determine the regulation & efficiency of single phase transformer by direct loading method.	1. Regulation of single phase transformer by direct loading method . 2. Efficiency of single phase transformer by direct loading method	04	06	CLO 2 CLO 3
8 - 9.	Polarity Test for Operation of Two Single Phase Transformers in Parallel.	Gain a clear understanding of the significance of polarity in transformers and its role in determining the phase relationship between the primary and secondary windings.	04	06	CLO 3 CLO 4
10.	Parallel Operation of Two Single Phase Transformers to Determine the Sharing of Load Current, Apparent and Real Power.	Understanding the operation two single-phase transformers in parallel and determine how they share load current, apparent power, and real power under different load conditions.	02	03	CLO 3 CLO 4

Course Plan Mapped with CLO

Week No.	Experiment Name	Learning Outcomes	Theory Time (Hours)	Practical Time (Hours)	Alignment to CLO
11 - 12.	Brake Test on DC Shunt Motor	Understand the working principles of a DC shunt motor and its performance under load conditions. Analyze the relationship between torque, speed, and efficiency of the motor through experimental data.	04	06	CLO 2 CLO 3
13 .	Speed Control of DC Shunt Motor	After completing this experiment, students will be able to analyze and implement speed control techniques of a DC shunt motor using methods such as field flux control and armature voltage control.	02	03	CLO 2 CLO 3
14-15.	Load Test on DC Series Motor	Gain practical knowledge of measuring input power, output power, and efficiency to evaluate motor behavior in real-world applications.	04	06	CLO 3 CLO 4

Course Plan Mapped with CLO

Week No.	Experiment Name	Learning Outcomes	Theory Time (Hours)	Practical Time (Hours)	Alignment to CLO
16 - 17.	Field’s Test on DC Shunt Motor	Understand the efficiency and performance characteristics of a DC shunt motor through practical testing under various load conditions. Gain hands-on experience in conducting Field's Test to evaluate the motor's losses and analyze its energy efficiency.	04	06	CLO 4

SAFETY RULES

SAFETY FIRST

1. Do not touch any terminals (or) Switch without ensuring that it is dead.
2. Wearing shoes with rubber sole is desirable.
3. Use a fuse wire of proper rating.
4. Use sufficient long connecting leads rather than joining two or there small ones, because in case any joint is open it could be dangerous.
5. Make sure that all the electrical connections are correct before switching on any circuit. Wrong connections may cause large amount of current which results damage of equipment.
6. The circuit should be de-energized while changing any connection.
7. In case of emergency or fire switch-off the master switch on the main panel board.
8. Keep away from all the moving parts as for as possible.
9. Do not renew a blown fuse until you are satisfied to the cause and rectified problem.
10. Do not touch an electric circuit when your hands are wet or bleeding from a cut.

WARNING

WEEK 1-2

PAGES 12-15

Experiment No. 1: Determine Equivalent Circuit Parameters of Single-Phase Transformer by Performing Open Circuit Test.

Objective: To perform the O.C. test of a single- phase transformer with the help of an ammeter, voltmeter and a wattmeter and to find out the core loss of the transformer, different parameter at no load condition and to predetermine the performance of the transformer represented by its equivalent circuit.

Theory: Transformer is a static AC machine. In this test normally the high voltage winding is left opened and all the meters are placed on the low voltage winding side (depending upon the availability of supply voltage in the lab). At no load, the current taken by the ammeter gives no load current whose value is very small w.r.t. full load current. The wattmeter gives the reading of the core loss of the transformer, which is constant at any load. The voltmeter indicated the rated voltage of the transformer at which side of the winding of the transformer, the meters are connected

Experimental Setup for Open Circuit Test on a 1-φ Transformer:

Core loss depends upon the applied voltage. Since normal voltage is applied to low voltage side, so normal flux will be setup on the core, and the normal iron loss (core loss) will be occurred which are recorded by the wattmeter. Hence the wattmeter reading represents practically no load core loss, which is constant at any load.

Let, W_0 = Wattmeter reading which gives iron loss or core loss
I_0 = No load current
V_0 = Rated voltage at no load on the low voltage side
$Cos\theta_0$ = No load power factor
θ_0 = Angular distance between I_0 & V_0

So, Wattmeter reading, $W_0 = V_0 I_0 Cos\theta_0$ or $Cos\theta_0 = \frac{W_0}{V_0 I_0}$

By knowing the 'Cosθ0', we can find our $sin\theta_0$

Now, iron loss or working component of the current $I_w = I_0\ Cos\theta_0$

The magnetizing component of the current $I_\mu = I_0\ sin\theta_0$

There the no load resistance,

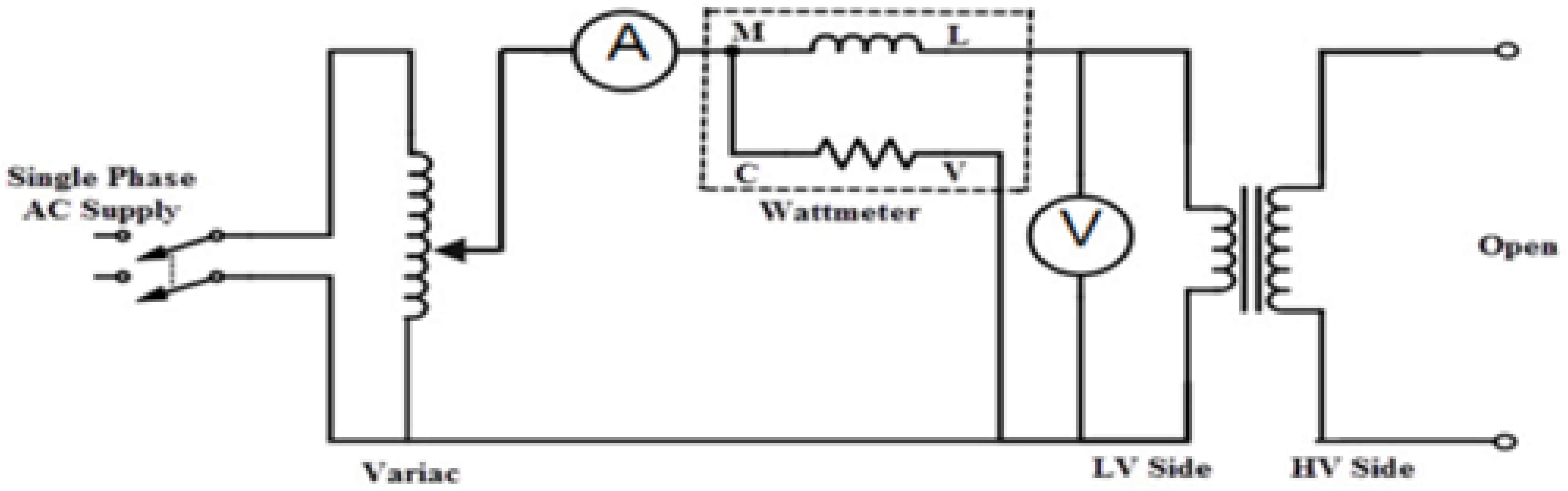
$$R_0 = \frac{V_0}{I_w}$$

And the leakage reactance,

$$X_0 = \frac{V_0}{I_\mu}$$

The open circuit test is done on the low voltage side and the high voltage side is kept open because it is safe and it requires low range meters which gives low cost for performing this test.

Circuit Diagram:



Procedure of the Experiment:

1. Connect as shown in the circuit diagram
2. Set the variac to zero output, and switch on the supply
3. Set the variac to a suitable voltage output
4. Watch the wattmeter, ammeter and voltmeter. Increase the variac output voltage gradually till the rated voltage is reached. With rate voltage applied to the primary side, take the reading of the wattmeter, ammeter and voltmeter
5. Calculate R_0 & X_0 from these readings

Data Sheet:

Ammeter reading is Amp (I_0)	Voltmeter reading is volt (V_0)	Wattmeter reading is watt (W_0)	No load power factor ($Cos\theta_0$)	$I_w = I_0 Cos\theta_0$	$I_\mu = I_0 sin\theta_0$	$R_0 = \frac{V_0}{I_w}$	$X_0 = \frac{V_0}{I_\mu}$

Apparatus Used:

Sl. NO.	Name of the Apparatus	Specification	Quantity
01	Transformer	Single Phase. 230/115Volt,5 Amp.	1
02	Variac	230V/0-250 volt	1
03	Digital Multi-meter as Ammeter	0-750 V AC,0-1000 V DC,0-10A	1
04	Voltmeter	Digital	1
05	Wattmeter	Digital	1
06	Control Panel	230 V,50 Hz	1

Remarks: The measuring instruments are to be connected in low voltage side and high voltage side should be opened for open circuit test.

WEEK 3-4

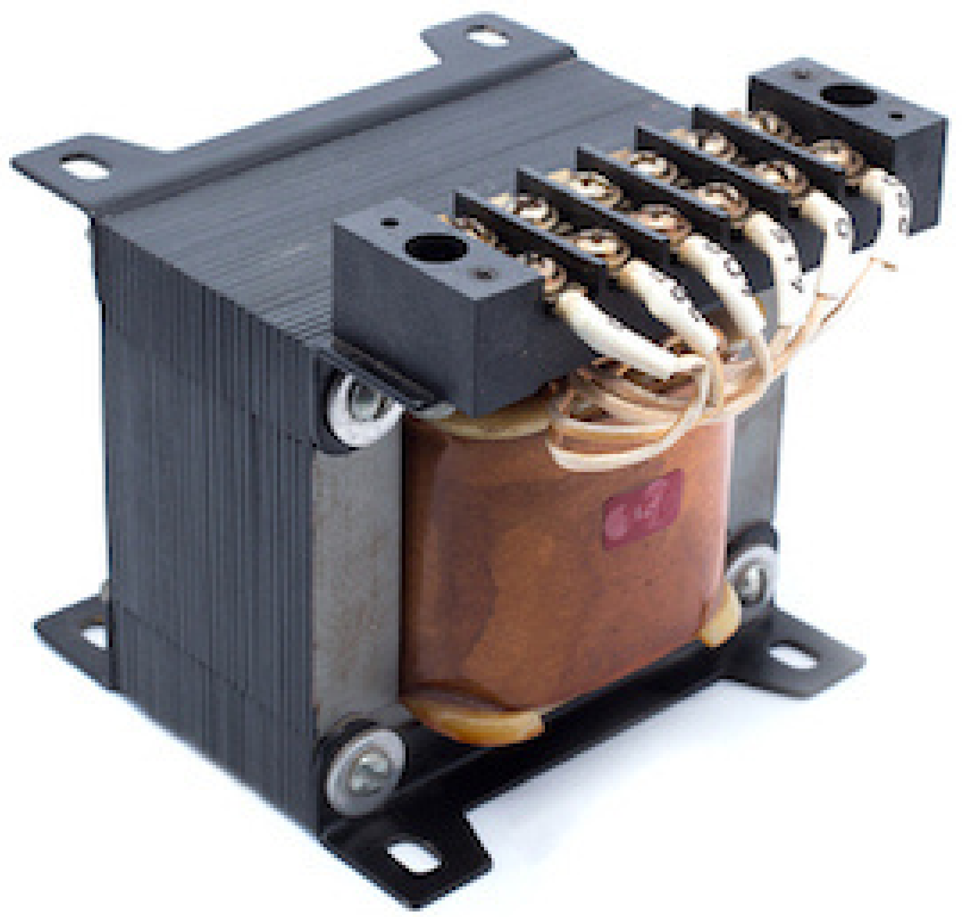
PAGES 17-23

Experiment No. 2: Determine Equivalent Circuit Parameters of Single-Phase Transformer by Performing Short Circuit Test.

Objective:

The objective of the experiment is to find out

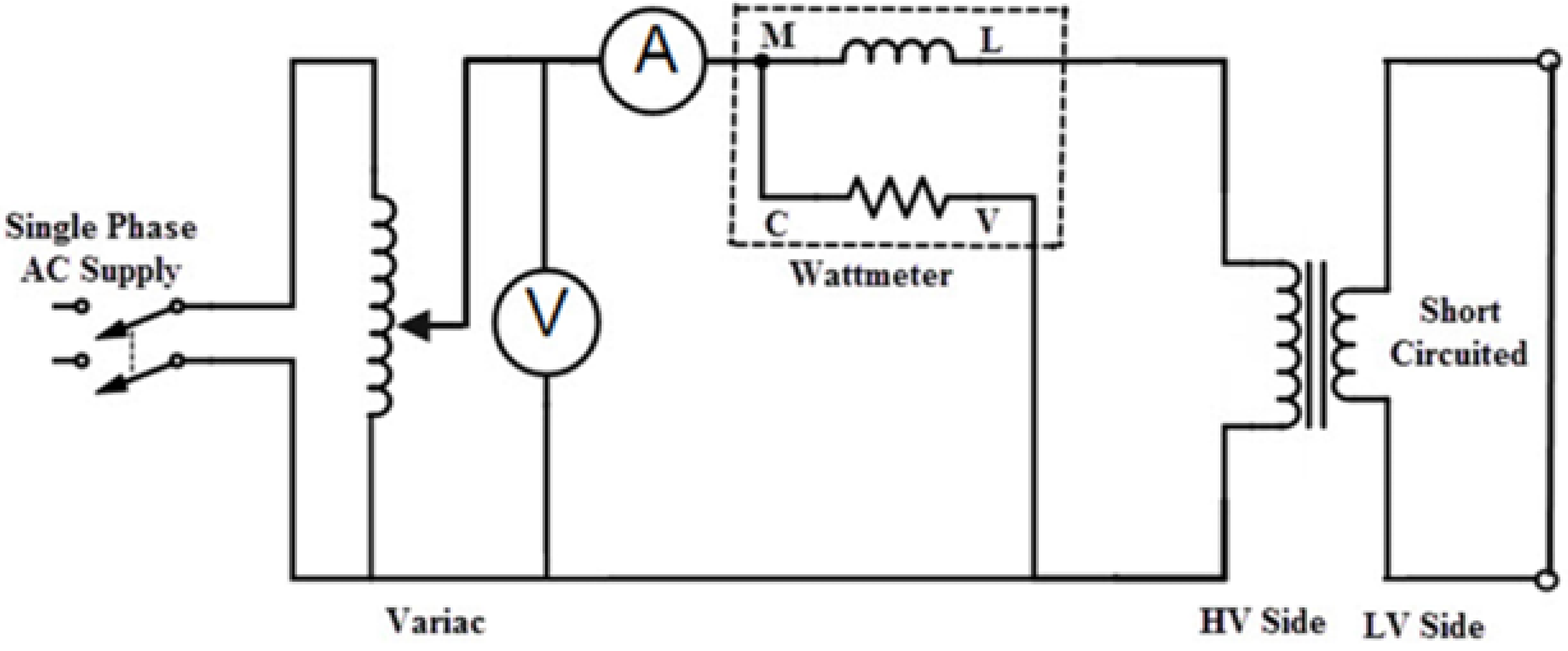
1. Copper loss at any load
2. Different parameters of the transformer with respect to high voltage side & low voltage side (i.e. equivalent resistance. equivalent impedance etc.) with the help of ammeter, voltmeter, wattmeter and dimmer stat.



Theory:

Transformer is a static AC machine. It has two winding, one is low voltage side and other is high voltage side. With the help of auto-transformer the supply voltage is gradually increased on the high voltage side of the transformer by 5% to 10% of the normal rated voltage on high voltage side, which gives the full load current on high voltage side. As the voltage is small, so the mutual flux is also smaller and hence the core loss is very small. The magnitude of the voltage needed to circulate the full load current will be very small. The reading of the wattmeter when the short circuit is performed at rated full load current will be approximately equal to full load copper loss. From short circuit test data, the equivalent resistance, reactance and impedance of the transformer can be found out with respect to high voltage side as well as the low voltage side.

Circuit Diagram:



Experimental Setup for the Short Circuit Test on a 1-ϕ Transformer:

When the transformer secondary terminals are short circuited, the secondary current is large, because only the transformer winding impedance limits it. Referring to the figure below, and neglecting the magnetizing current, the short circuit current (= current with the secondary short circuited) is given by:

Short circuit current= Voltage/Transformer leakage impedance

This current is large, since the transformer leakage impedance (=R+jX) is usually small. To keep this within limits, the only way is to apply a low voltage to the transformer primary. Since the voltage applied is low. the magnetizing current through the no load branch in its equivalent circuit is low and hence it can be ignored. The equivalent circuit then become as shown in figure above. This is obtained by using the equivalent circuit (phasor diagram) of the transformer with purely resistive load and putting $Z_L' = 0$. Measuring power input (W_{SC}) the short circuit currents (I_{SC}) and voltage applied (V_{SC}) the parameters ($R_1 + R_2'$ and $X_1 + X_2'$) are related as below:

Are related as below:

$$W_{SC} = I_{SC}^2 (R_1 + R_2')$$

Or, $$(R_1 + R_2') = \frac{W_{SC}}{I_{SC}^2}$$

& $$V_{SC} = I_{SC}(\sqrt{(R_1 + R_2')^2 + X_1 + X_2')^2}$$

$$\frac{V_{SC}}{I_{SC}} = \sqrt{(R_1 + R_2')^2 + X_1 + X_2')^2} = Z_{SC}$$

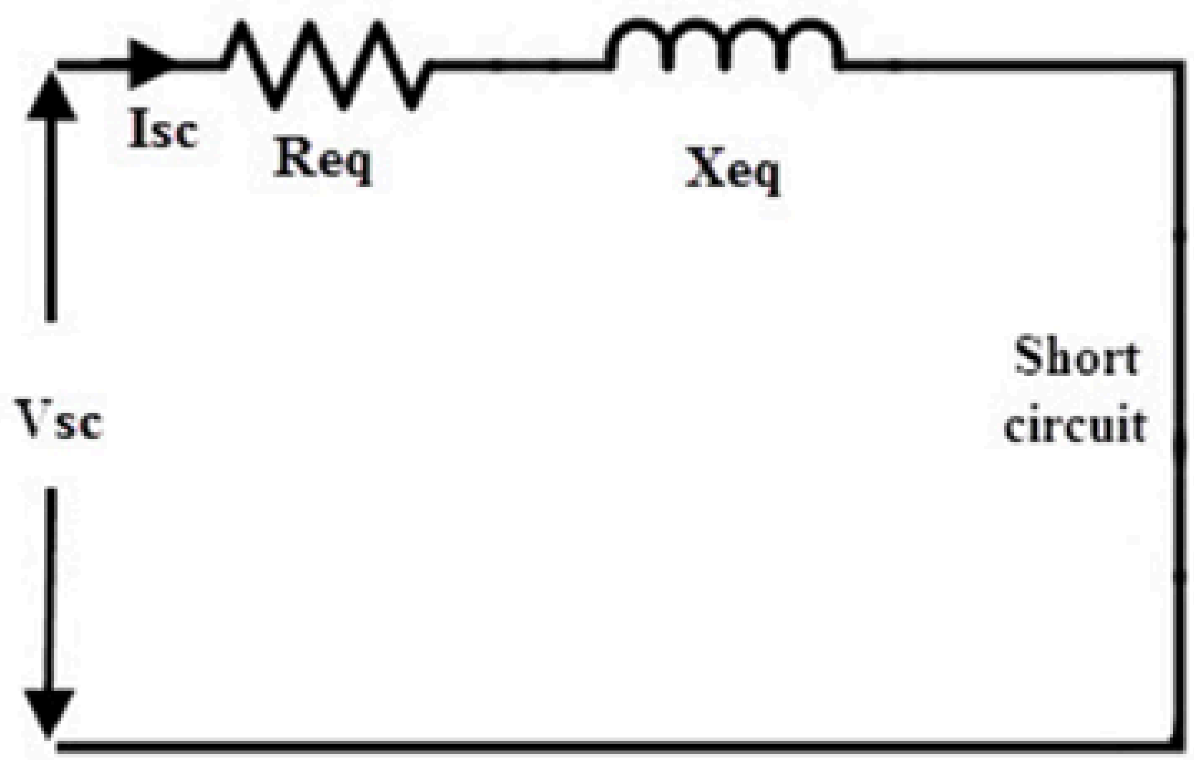
Therefore, $X_1 + X_2' = \sqrt{Z_{SC}^2 - (R_1 + R_2')^2}$

When the primary side resistance R_1 is measured, the secondary side resistance R_2' can be separated from the total resistance.

$$R_2' = (R_1 + R_2') - R_1$$

The leakage reactance's are generally assumed to be equal and hence

$$X_1 \equiv X_2' \approx \frac{(X_1 + X_2')}{2}$$



Experimental Procedure:

1. Connect as shown in the circuit diagram

2. Set the variac output to zero and switch on the supply

3. Apply a low voltage, setting the variac output suitably and watch the ammeters

4. Apply such a voltage, which circulates the rated current

5. Note the reading of the wattmeter, voltmeter and the two ammeters

6. Calculate the total resistance $(R_1 + R_2')$ and the reactance $X_1 + X_2'$ from these readings.

7. Measure the resistance of primary winding using a battery, (or a low voltage DC source) and an ammeter.

Data Sheet:

SL. No.	Observations				calculation		
	Primary			Secondary			
	Voltmeter reading	Ammeter reading	Wattmeter reading	Ammeter reading	$R_{01} = (R_1 + R_2') = \frac{W_{SC}}{I_{SC}^2}$	$Z_{SC} = \frac{V_{SC}}{I_{SC}}$	$R_{01} = X_1 + X_2' = \sqrt{Z_{SC}^2 - (R_1 + R_2')^2}$
	V_{SC}	I_{SC}	W_{SC}	I_{SC}			
	Volt	Amp	Watt	Amp	Ohm	Ohm	Ohm
01							

Apparatus Used:

Sl. NO.	Name of the Apparatus	Specification	Quantity
01	Transformer	Single Phase. 230/115Volt,5 Amp.	1
02	Variac	230V/0-250 volt	1
03	Digital Multi-meter as Ammeter	0-750 V AC,0-1000 V DC,0-10A	1
04	Voltmeter	Digital	1
05	Wattmeter	Digital	1
06	Control Panel	230 V,50 Hz	1

Remarks:

The experimental results obtained from the short circuit tests were not evaluated. It would be possible to test the maximum efficiency of the transformer is operating at maximum effiency. The actual efficiency of the transformer could be found by dividing the power out by the power. The procedure used to find the parameter values of the non-ideal transformer equivalent circuit model allows the engineer to more efficiency design transformer circuits. Modelling and simulation are more accurate when the no-ideal parameters are used. This means that designs can be optimized prior to implementation.

WEEK 5

PAGES 25-27

Experiment No.3: The transformation ratio of a 1 -φ transformer

Objective:

1. Identify HT and LT side of transformer.
2. Gain practical knowledge about transformation ratio of a transformer.

Theory: The induced voltage and current on both sides of the transformer maintains a certain ratio with the number of turns in a coil. It is known as Turn ratio or transformation ratio. This ratio is denoted by "a".

The turn ratio of a single phase transformer is defined as the ratio of number of turns in the primary winding to the number of turns in the secondary winding, i.e.

ie $\frac{Ep}{Es} = \frac{Np}{Ns} = a$ where, a = transformation ratio

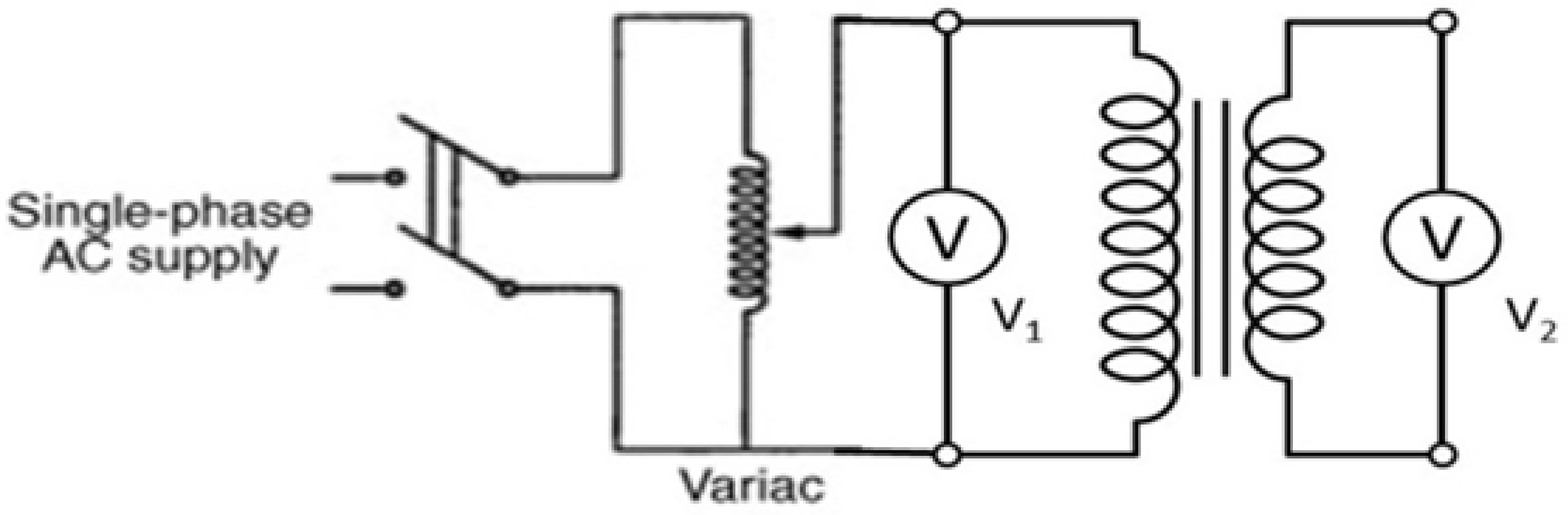
The ratio of the number of turns in the primary and secondary of the transformer is equal to the ratio of the voltage across them and from this we know how much the voltage of the secondary is increased or decreased compared to the primary.

The voltage on the primary side of the transformer is $E_p = 4.44N_pf\varphi_m$ volt
The voltage on the secondary side of the transformer is $E_s = 4.44N_sf\varphi_m$ volt

Required Instruments & Materials:

1	Single phase Transformer 240,220,200/120,110,100 volt	1nos
2	Variac AC 0-250V, 5Amp	1nos
3	Digital Multi-meter (With AC Amp)	2nos
4	Load (100W/220V lamp)	4nos
5	Crocodile clip	As required

Circuit Diagram:



Data Sheet:

<table>
<tr><th>OBS No.</th><th>Primary Voltage E_p</th><th>Secondary Voltage E_s</th><th>Ratio</th><th>Remarks</th></tr>
<tr><td>1</td><td></td><td></td><td></td><td rowspan="2">Step-down</td></tr>
<tr><td>2</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td><td rowspan="2">Step-up</td></tr>
<tr><td>4</td><td></td><td></td><td></td></tr>
</table>

Work steps: 1. Collect the necessary equipment and materials. 2. Identify the primary and secondary sides of the transformer. 3. Connect according to the circuit diagram. 4. Connect the meters according to the circuit. 5. Check again whether the circuit is correct or wrong. 6. Take the reading with power supply and record it in the data sheet. 7. Complete the data sheet using necessary calculations.

Precaution: 1. The primary and secondary sides of the transformer must be correctly identified. 2. Meters should be connected according to range. 3. Connection should be tight and clean. 6. Meter readings should be taken proper way.

WEEK 6-7

PAGES 29-32

Experiment No.4 : Determine the regulation & efficiency of single-phase transformer by direct loading method.

Objective:

To determine
1. Regulation of single-phase transformer by direct loading method
2. Efficiency of single-phase transformer by direct loading method

Theory:

Although two chief difficulties which do not warrant the testing of large transformer by direct load test are:
1. Large amount of energy has to be wasted in such a test.
2. It is stupendous (impossible for large transformer) task to arrange a load large enough for direct loading. Yet this test can be performed to find out the efficiency & voltage regulation of small rating transformers.

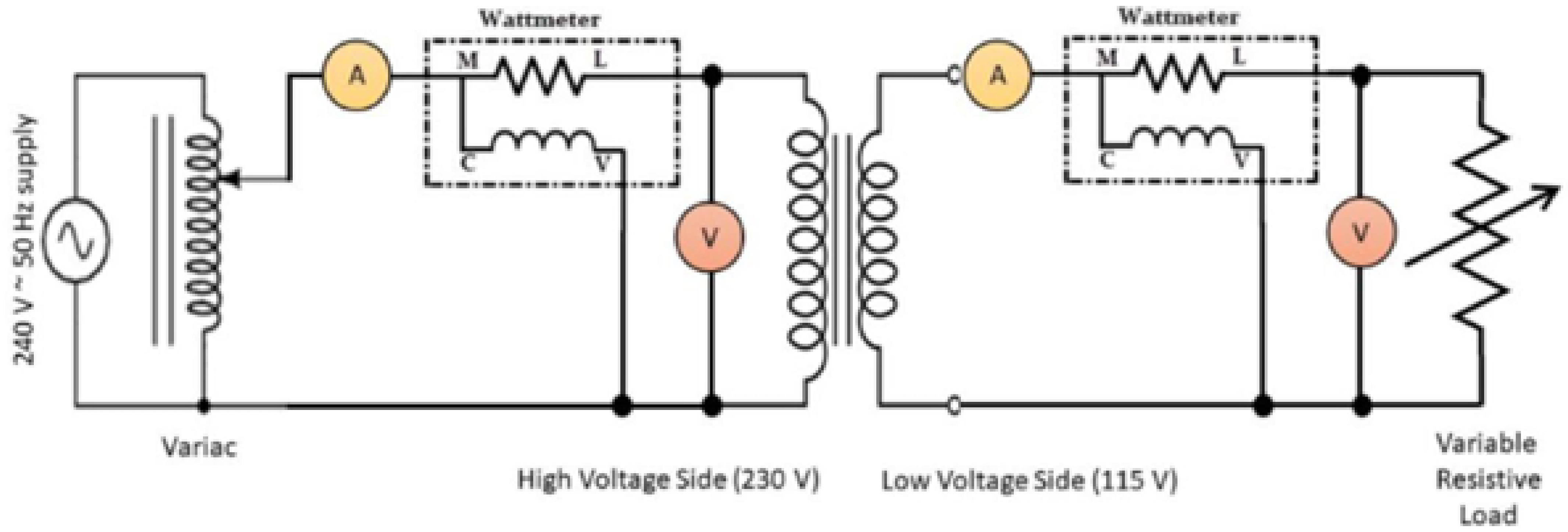
Efficiency, η = Output Power/Input Power

$\% \eta = ((P_2)/(P_1)) \times 100$

% Voltage regulation up = ((No load voltage – Full load voltage)/ Full load voltage) x 100

% Voltage regulation down = ((No load voltage – Full load voltage) /NO load voltage) x100

Circuit Diagram:



Data Sheet:

At No load Condition

Primary Voltage, V_1	Primary Current, I_1	Primary Power, P_1	Secondary No Load Voltage, V_0	Secondary Load Current, I_2	Secondary Power, P_2

At Loaded Condition

Primary Voltage, V_1	Primary Current, I_1	Primary Power, P_1	Secondary Load Voltage, V_2	Secondary Load Current, I_2	Secondary Power, P_2

Calculation:

$$Efficiency = \frac{Output(Secondary)Power}{Input(Primary)Power} \times 100$$

$$= \frac{P_2}{P_1} \times 100$$

$$\text{Voltage Regulation Up} = \frac{V_0 - V_2}{V_2} \times 100\%$$

$$\text{Voltage Regulation Down} = \frac{V_0 - V_2}{V_0} \times 100\%$$

Apparatus Used:

Sl. NO.	Name of the Apparatus	Specification	Quantity
01	Transformer	Single Phase. 230/115Volt,5 Amp.	1
02	Variac	230V/0-250 volt	1
03	Digital Multi-meter as Ammeter	0-750 V AC,0-1000 V DC,0-10A	1
04	Voltmeter	Digital	1
05	Wattmeter	Digital	1
06	Control Panel	230 V,50 Hz	1
07	Rheostat	0-100W,1kw	1

Remarks: This method is not applicable for large rated transformer as a large amount of energy has to be wasted in such test. During this test we should cautious about the heat radiated by the resistive load.

WEEK 8-9

PAGES 34-38

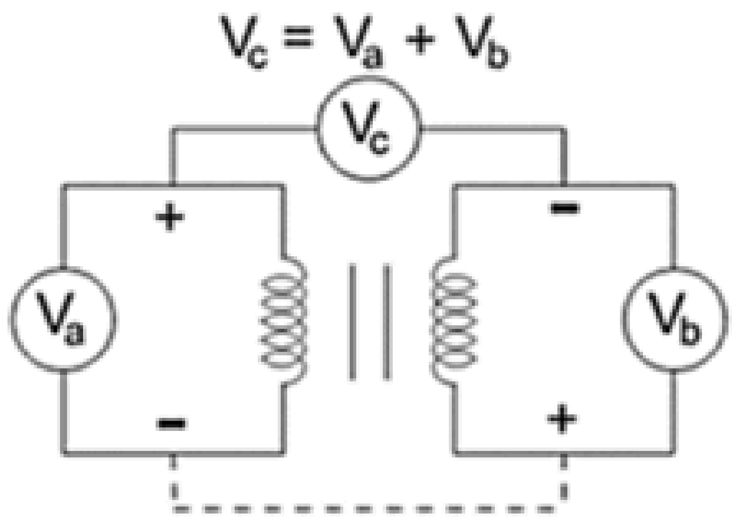
Experiment No. 5: Polarity Test for Operation of Two Single Phase Transformers in Parallel.

Objective:
To test polarity of two single phase transformers

Theory:
We do polarity test on parallel transformers to ensure that we connect the same polarity windings and not the opposite ones. If we accidentally connect the opposite polarities of the windings, it will result in a short-circuit and eventually damage the machine. We can categories the polarity of the transformer to two type.

1. Additive Polarity
2. Subtractive Polarity

Additive Polarity:
In additive polarity, the voltage (V_c) between the primary side (V_a) and the secondary side (V_b) will be the sum of both high voltage and the low voltage, i.e. We will get $V_c = V_a + V_b$

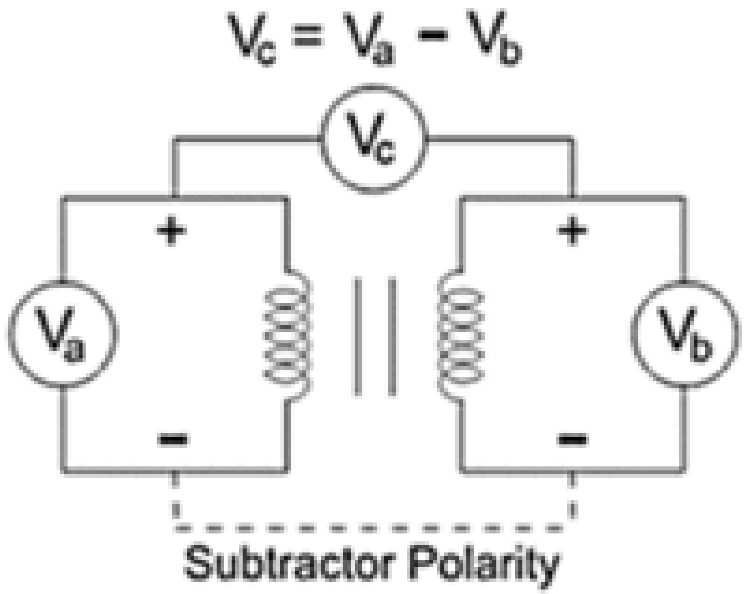


Additive Polarity

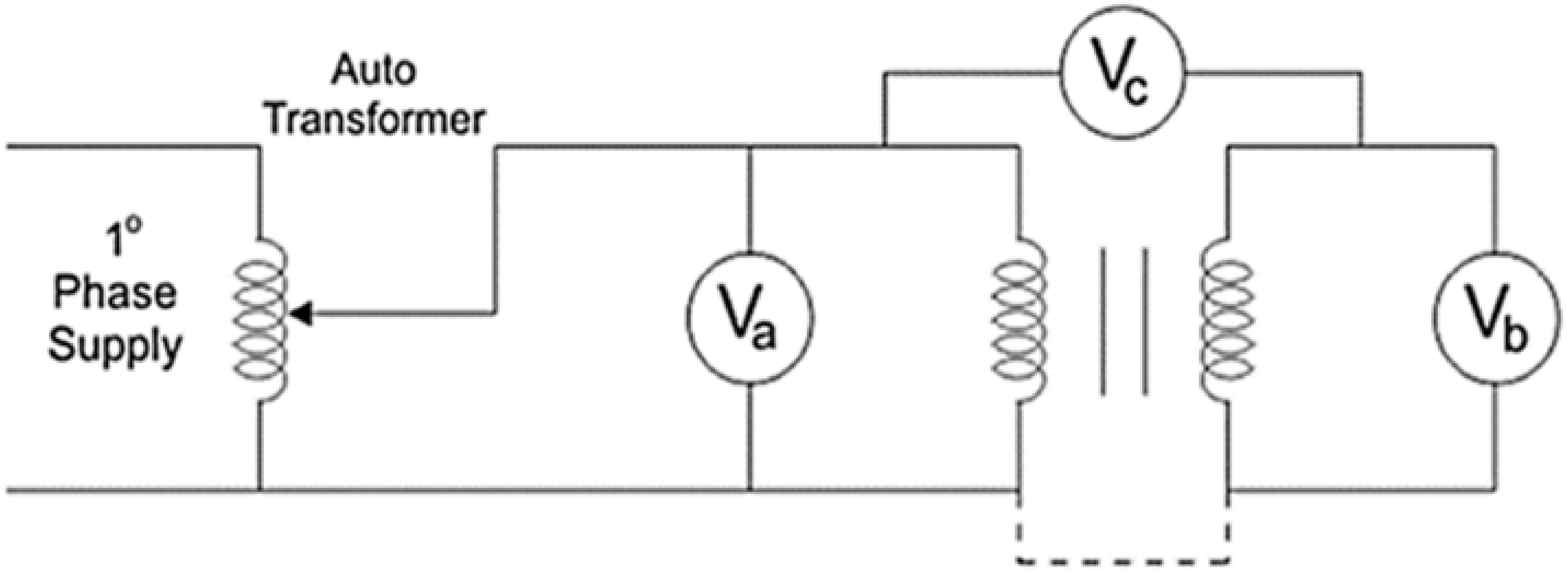
Subtractive Polarity:

In subtractive polarity, the voltage (V_c) between the primary side (V_a) and the secondary side (V_b) will be the difference of both high voltage and the low voltage, i.e. we will get $V_c = V_a - V_b$

In subtractive polarity, if $V_c = V_a - V_b$, it is a step-down transformer and if $V_c = V_b - V_a$, it is step-up transformer. We use additive polarity for small-scale distribution transformers and subtractive polarity for large-scale transformers.



Circuit Diagram:



Transformer Circuit Diagram for Test

Procedure:

1. Connect the circuit as shown above with a voltmeter (Va) across primary winding and another voltmeter (Vb) across the secondary winding. 2. If available, take down the ratings of the transformer and the turn ratio. 3. We connect a voltmeter (Vc) Between primary and secondary windings. 4. We apply some voltage to the primary side. 5. By checking the value in the voltmeter (Vc) we can find whether it is additive or subtractive polarity. 6. Mark the terminals with 'dot' sign to indicate the polarity.

If additive polarity – V_c should be showing the sum of V_a and V_b.
If subtractive polarity – V_c should be showing the difference between V_a and V_b.

Observation Table:

Sl. No.	Votage across Primary Side (V_a)	Voltage across Secondary Side (V_b)	Voltage Between Primary & Secondary Side (V_c)	Result
Transformer 1				$V_c = V_a + V_b$ Additive polarity
Transformer 2				$V_c = V_a + V_b$ Additive polarity

Apparatus Used:

Sl. NO.	Name of the Apparatus	Specification	Quantity
01	Transformer	Single Phase. 230/115Volt,5 Amp.	2
02	Variac	230V/0-250 volt	1
03	Digital Multi-meter as Voltmeter	0-750 V AC,0-1000 V DC,0-10A	1
04	Control Panel	230 V,50 Hz	1

Caution: Be careful that the maximum measuring the voltage of voltmeter V_c should be greater than the sum of V_a (Primary winding) and (Secondary winding) otherwise during the additive polarity, the sum of V_a and V_b comes across it.

Remarks: If we require additive polarity, but we have subtractive polarity, we can simply change it by keeping any of the primary or secondary winding in the same fashion and reversing the other one. Similarly, if we require subtractive polarity but have additive polarity, we could do the same procedure as above.

WEEK 10

PAGES 40-44

Experiment No. 6: Parallel Operation of Two Single Phase Transformers to Determine the Sharing of Load Current, Apparent and Real Power.

Objective

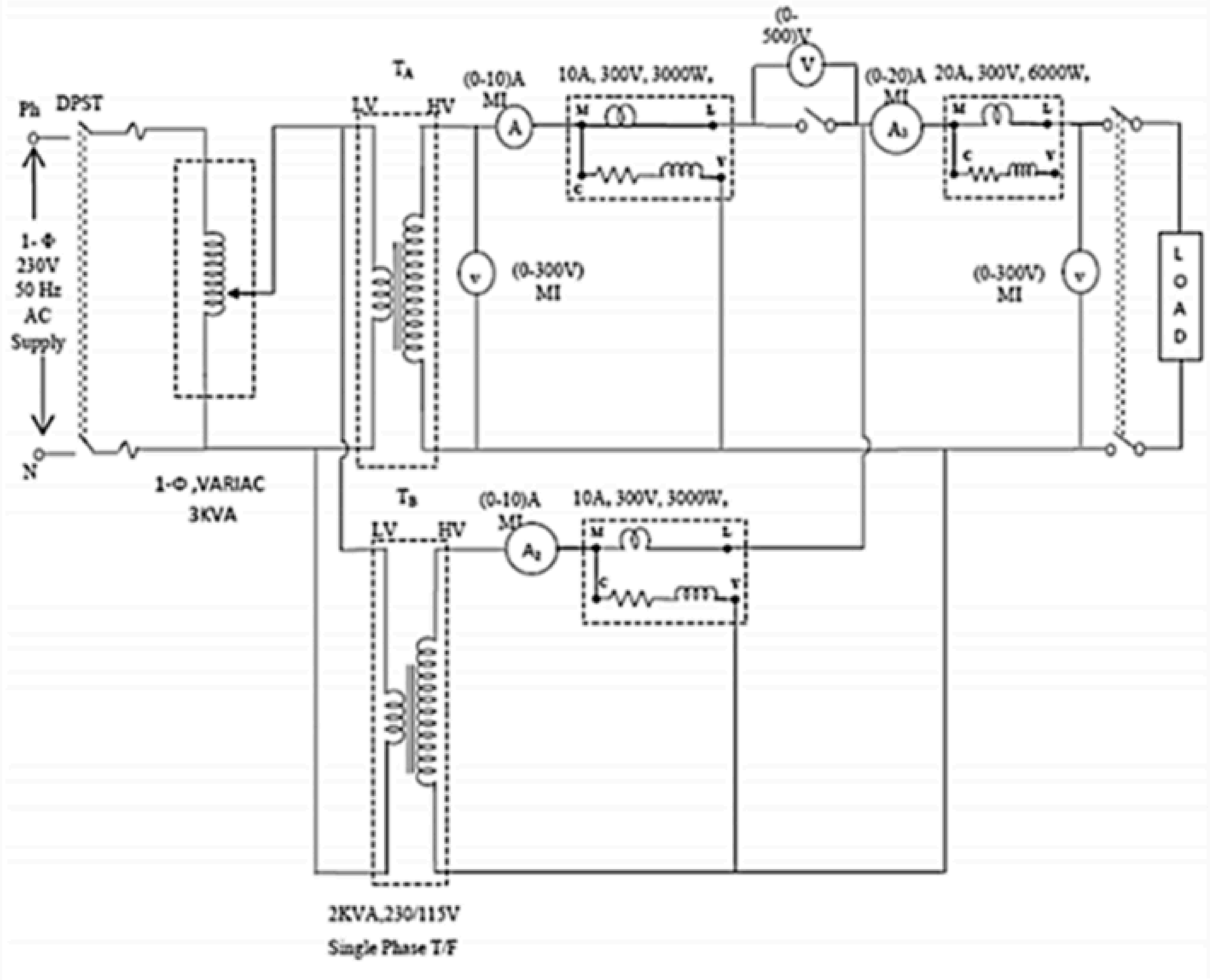
The objective of this experiment is to operate two single-phase transformers in parallel and determine how they share load current, apparent power, and real power under different load conditions.

Theory

When two transformers are operated in parallel, they share the load based on their impedance characteristics and ratings. The conditions for successful parallel operation include:

1. Identical voltage ratios
2. Same polarity
3. Similar percentage impedance
4. Phase sequence and phase angle should be identical

Circuit Diagram:



Procedure:

1. Connect the circuit as shown in diagram
2. Note down the reading of all wattmeters, ammeters and voltmeters for given load
3. Repeat the above test for different vales of load

Observation Table:

Sl. No.	Transformer 1			Transformer 2			Transformer 1 and Transformer 2 parallel connected		
	I_1(A)	W_1(W)	V_1(V)	I_2(A)	W_2(W)	2_1(V)	I_L(A)	W_L(W)	V_L(V)

Calculation:

Total load shared by both of the transformer (as per wattmeter reading) =……. W

Total load shared by both of the transformer (calculated) = …..+…… =……… W

The difference is due to instrumental error.

Load shared by Transformer 1 (real power) = … W, % load shared = (…/…) x 100 = …%

Load shared by Transformer 2 (real power) = … W, % Load shared = (…/…) x 100 =… %

Total Real Power = (…+…) =… W

Load shared by Transformer 1 (apparent power) = … x … VA = …VA,% Load shared =(…/…) x 100= … %

Load shared by Transformer 2 (apparent power) = … x … VA = …VA,% Load shared =(…/…) x 100= … %

Total Apparent Power = (… + …) = …VA

Apparatus Used:

Sl. NO.	Name of the Apparatus	Specification	Quantity
01	Transformer	Single Phase. 230/115Volt,5 Amp.	2
02	Variac	230V/0-250 volt	1
03	Digital Multi-meter as Ammeter, Voltmeter and Wattmeter	0-750 V AC,0-1000 V DC,0-10A	2
04	Control Panel	230 V,50 Hz	1
05	Rheostat	1kw, Resistive wire wound	

Precaution:

1. Ensure that all connections are secure and insulated.
2. Do not exceed the rated capacity of the transformers.
3. Handle all electrical equipment with care and follow standard electrical safety procedures.

WEEK 11-12

PAGES 46-49

Experiment No.7: BRAKE TEST ON DC SHUNT MOTOR

Aim:-

To conduct Brake test on dc shunt motor and to draw the performance curves of the motor.

Apparatus Required:-

S.NO	NAME	RANGE	TYPE	QUANTITY
1	Voltmeter	(0-300)V	MC	1NO
2	Ammeter	(0-20)A	MC	1NO
3	Ammeter	(0-2)A	MC	1NO
4	Rheostat	400Ω, 1.7A	Wire wound	1NO
5	Tachometer	(0-10,000) RPM	Digital	1NO
6	Connecting wires	(0-20)A	-	Required

Nameplate details:-

Voltage - 220V

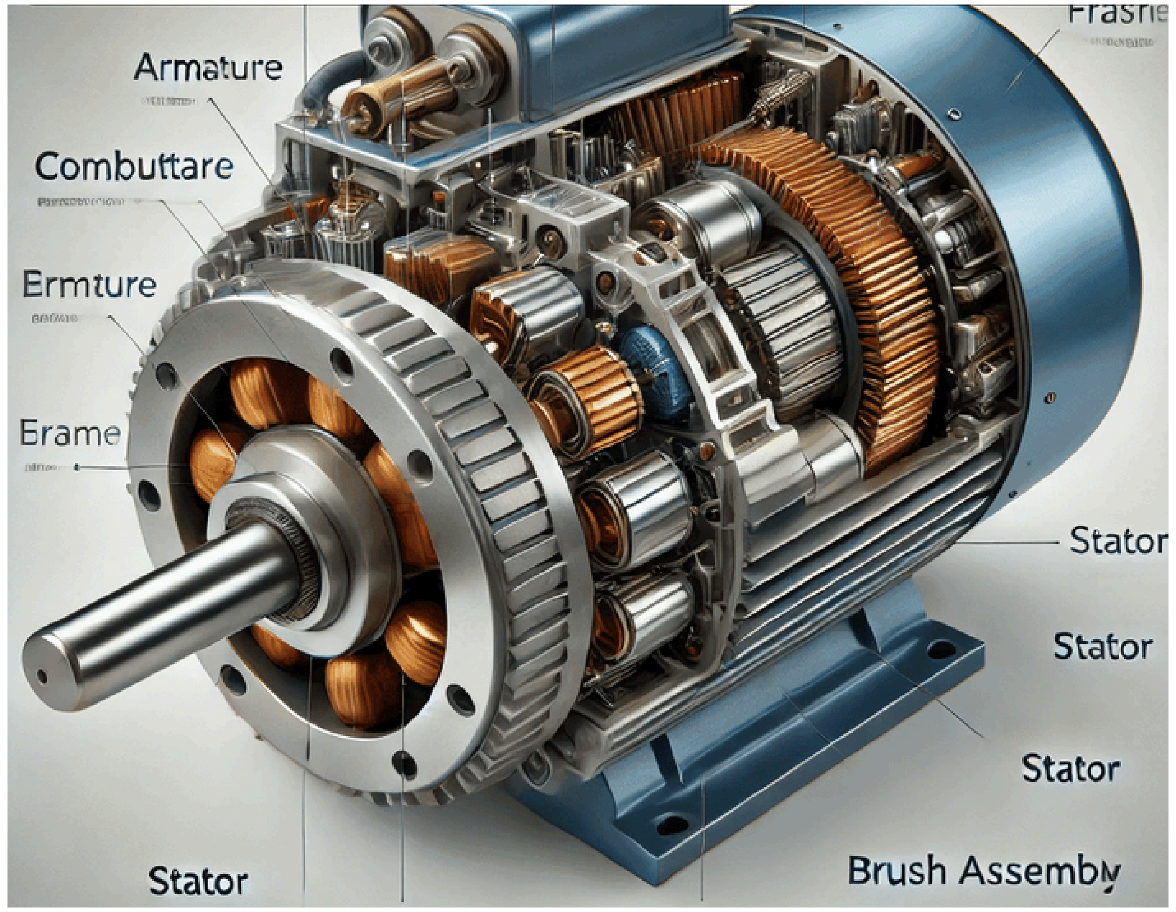
Current -12A

Speed - 1500 rpm

Excitation type –shunt

Procedure:-

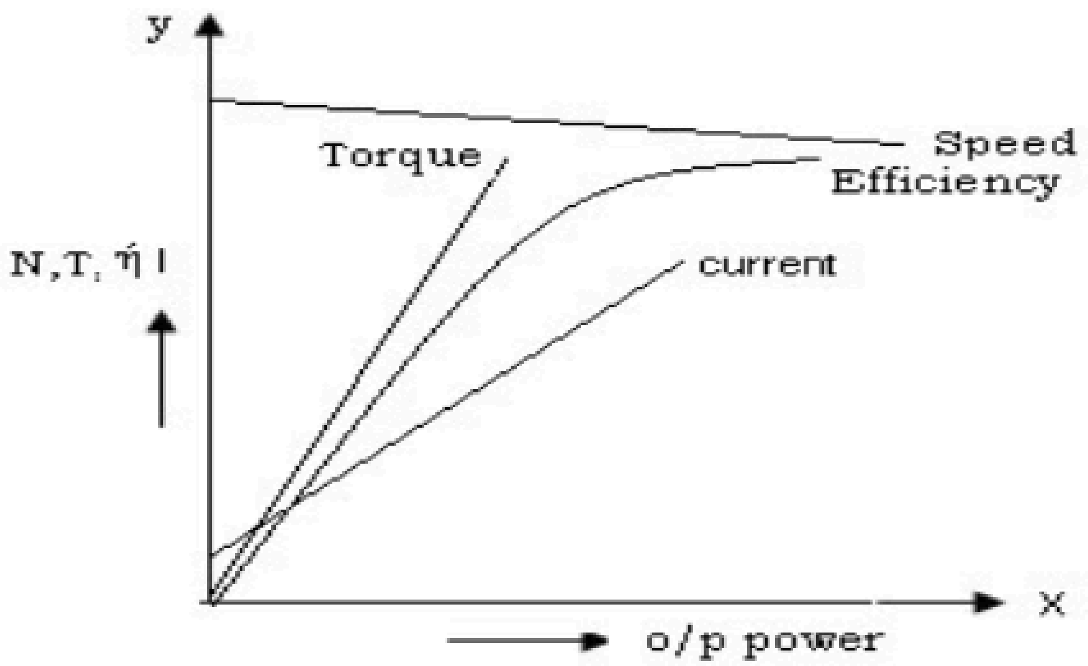
1. Make the connections as per the circuit diagram.
2. Initially keep the motor field rheostat in minimum resistance position.
3. Give the supply by closing DPST switch and start the motor with the help of 3- point starter.
4. Adjust the motor field rheostat till the rated speed is obtained.
5. Apply the load on brake drum in steps.
6. Note down the readings of speed, voltmeter, ammeter and spring balance.
7. Repeat step 5 and 6 until rated current is obtained.
8. Remove the load on the motor before switching off the supply.



Tabular columns:-

Voltage (volts)	Current (amp)	Speed (rpm)	i/p=VI (watts)	S_1 Kg	S_2 Kg	Torque= (S1≈S2)* r* 9.81 (N-m)	o/p = 2ΠNT/60 (watts)	%ή= output / input*100
220	1.7	1500	374	0	0	0	0	0
220	2.5	1496	550	0.5	0.5	0.98	153.6	27.9
220	3	1476	660	1	1	1.47	227.9	34.4
220	4	1466	880	1.5	4	2.45	376.5	42.7
220	4.5	1452	990	2	5	2.94	477.9	45.2

Model graph:- Draw the graph between output power on x-axis and speed , torque, efficiency & load current are on y-axis as shown below.



Result:-

Brake test is conducted on dc shunt motor and hence performance curves are plotted.

Viva voce:

1. Define Torque?
2. What is the need of starter?
3. What are the types of starters?
4. Can we conduct Brake test on series motor?

WEEK 13

PAGES 51-55

Experiment No. 8: SPEED CONTROL OF DC SHUNT MOTOR

Aim:-

To conduct the speed control of dc shunt motor by using following methods

(i) Armature control method.

(ii) Field control method.

Apparatus Required:-

S.NO	NAME	RANGE	TYPE	QUANTITY
1	Voltmeter	(0-300)V	MC	1NO
2	Ammeter	(0-20)A	MC	1NO
3	Ammeter	(0-2)A	MC	1NO
4	Rheostat	400Ω, 1.7A	Wire wound	1NO
5	Tachometer	(0-10,000) RPM	Digital	1NO
6	Connecting wires	(0-20)A	-	Required

Name plate details:-

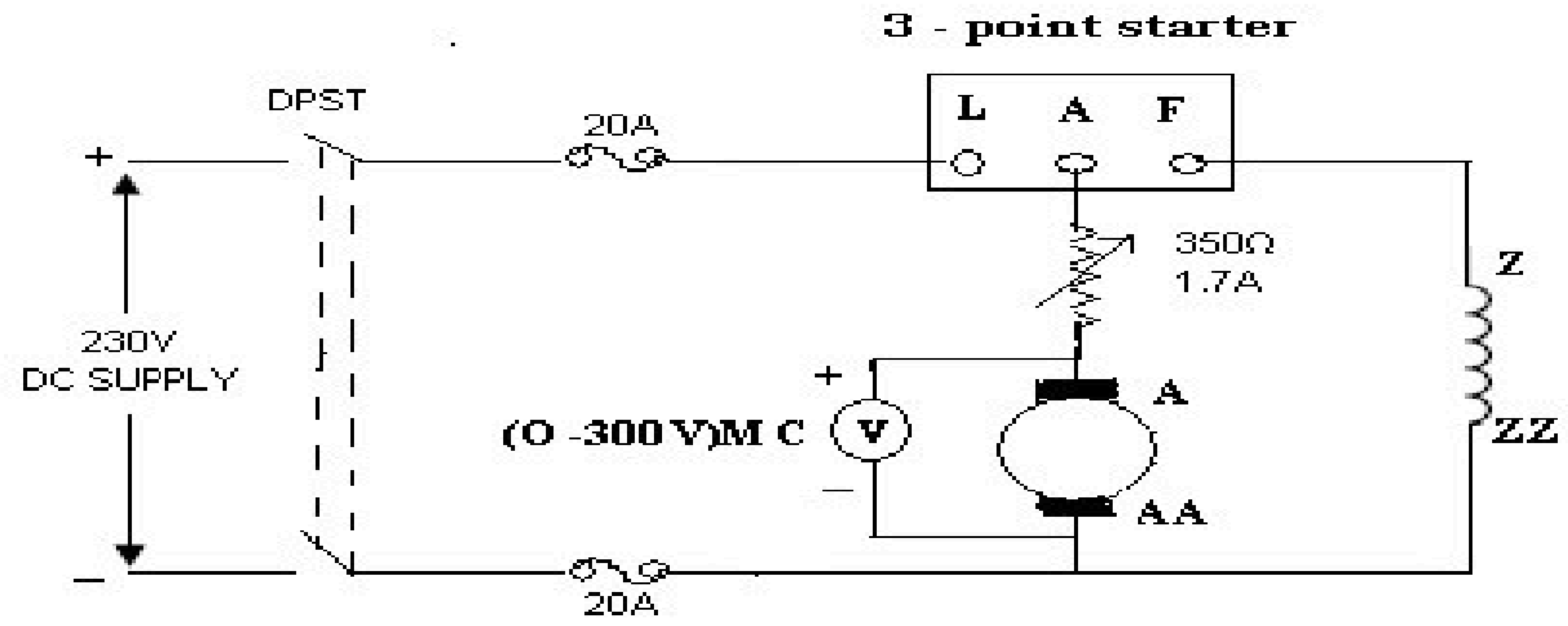
Volts	:	220 V
Current	:	12A
RPM	:	1500
H.P	:	3.0

Name plate details:-

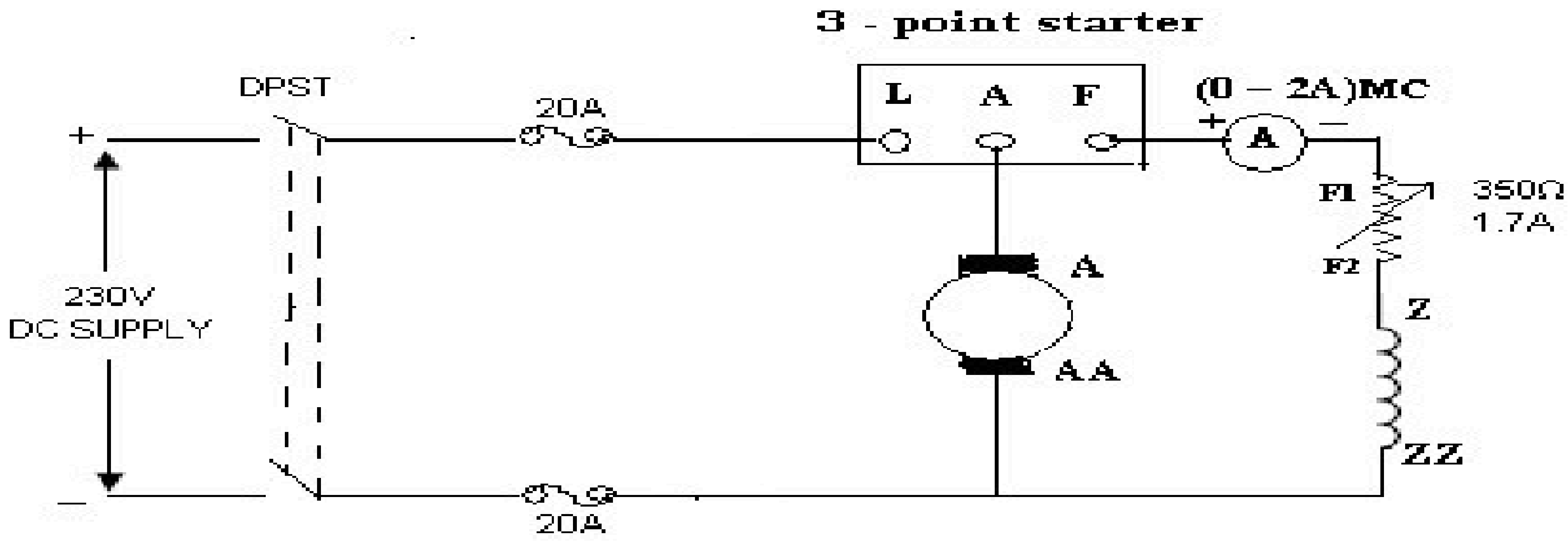
Volts	:	220 V
Current	:	12A
RPM	:	1500
H.P	:	3.0

Circuit diagram

A) Armature control method:-



B) Field control method:-



Procedure:-

Armature control method:

1. Connect the circuit as per the circuit diagram.
2. Ensure that the motor armature rheostat should be in maximum resistance position.
3. Give the dc supply to the machine by closing the DPST switch and start the motor with the help of three point starter.
4. By decreasing the resistance of rheostat, note down the readings of armature voltage and speed of the shunt motor.

5. Repeat the step no.4 till rated speed is obtained.
6. Switch off the dc supply by opening the DPST switch.

Field control method:-

1 .Connect the circuits as per the circuit diagram.
2. Ensure that the motor field rheostat should be in minimum resistance position.
3. Give the dc supply to the machine by closing the DPST switch and start the motor with the help of three point starter.
4. By increasing the resistance of field rheostat, note down the readings of field current and speed of the shunt motor.
5. Repeat the step no.4 till about 130% of rated speed is obtained.
6. Switch off the dc supply by opening the DPST switch..

Tabular columns:-

Armature control method:

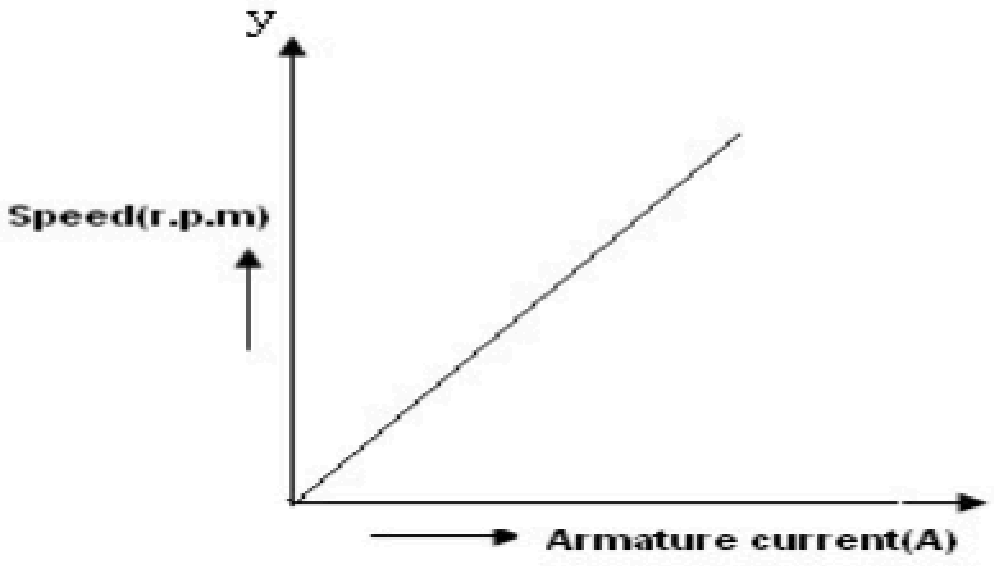
S.NO	Voltage across the armature(volts)	Speed(r.p.m)
1	100	1352
2	95	1316
3	93	1287
4	92	1273
5	90	1245

Field control method:-

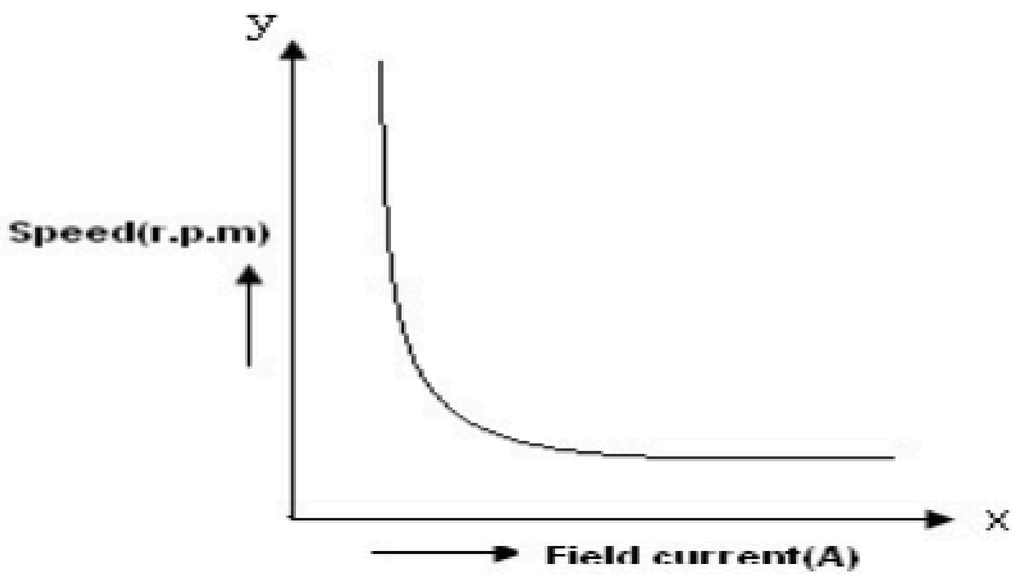
S.NO	Field current(A)	Speed(r.p.m)
1	0.58	1351
2	0.53	1376
3	0.48	1407
4	0.45	1448
5	0.39	1505

Model graphs:-

Armature control method :-



Field control method:-



WEEK 14-15

PAGES 57-62

Experiment No. 9: LOAD TEST ON DC SERIES GENERATOR

Aim:-

To conduct load test on dc series generator and obtain external characteristics and internal characteristics

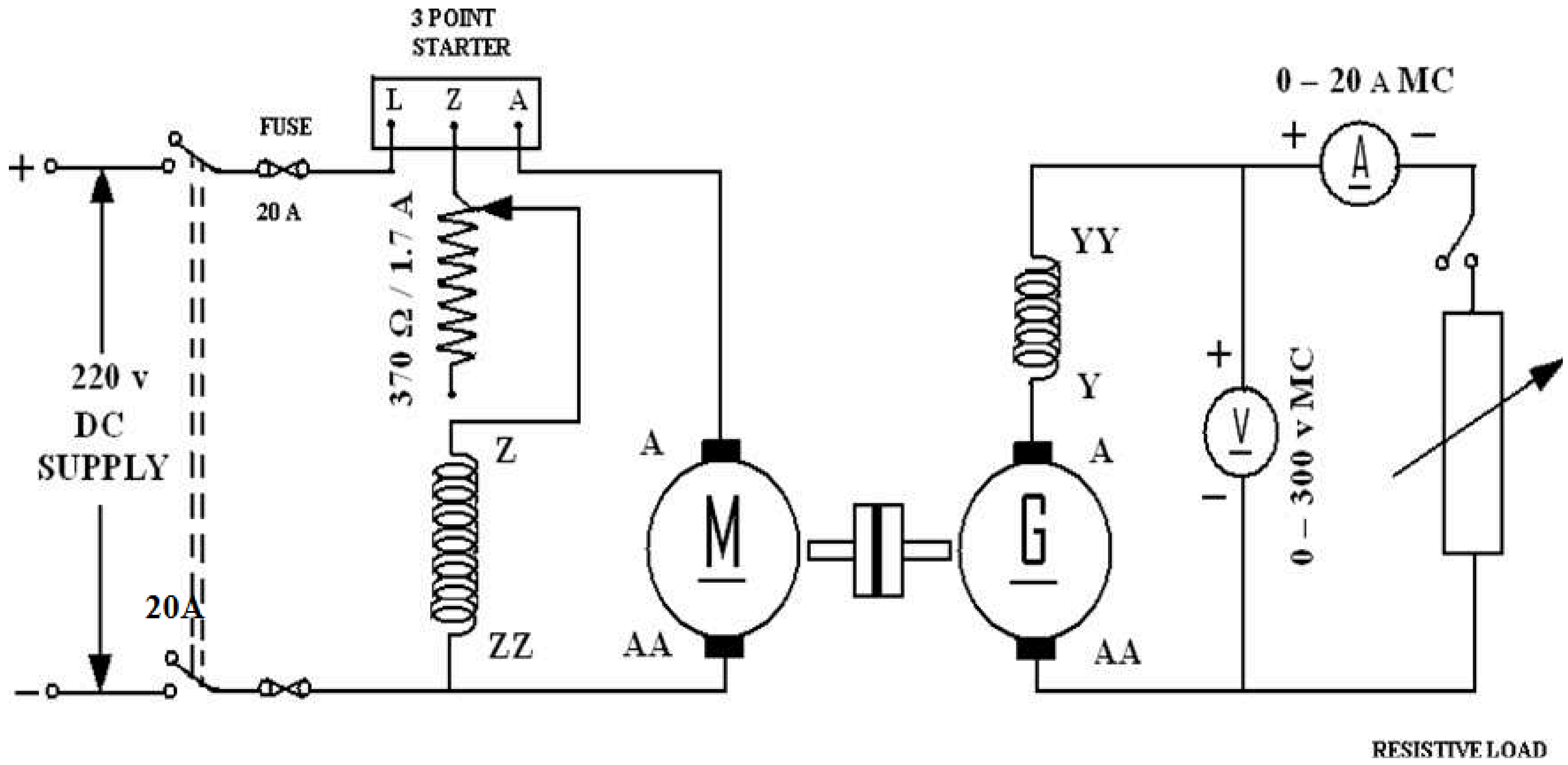
Apparatus Required:-

S.NO	NAME	RANGE	TYPE	QUANTITY
1	Voltmeter	(0-300)V	MC	2NO
2	Ammeter	(0-20)A	MC	1NO
3	Ammeter	(0-2)A	MC	1NO
4	Tachometer	(0-10,000) RPM	Digital	1NO
5	Rheostat	400Ω, 1.7A	Wire wound	1NO
6	Load box	230V,5KW/20A	Resistive	1NO
7	Connecting wires	(0-20)A	-	Required

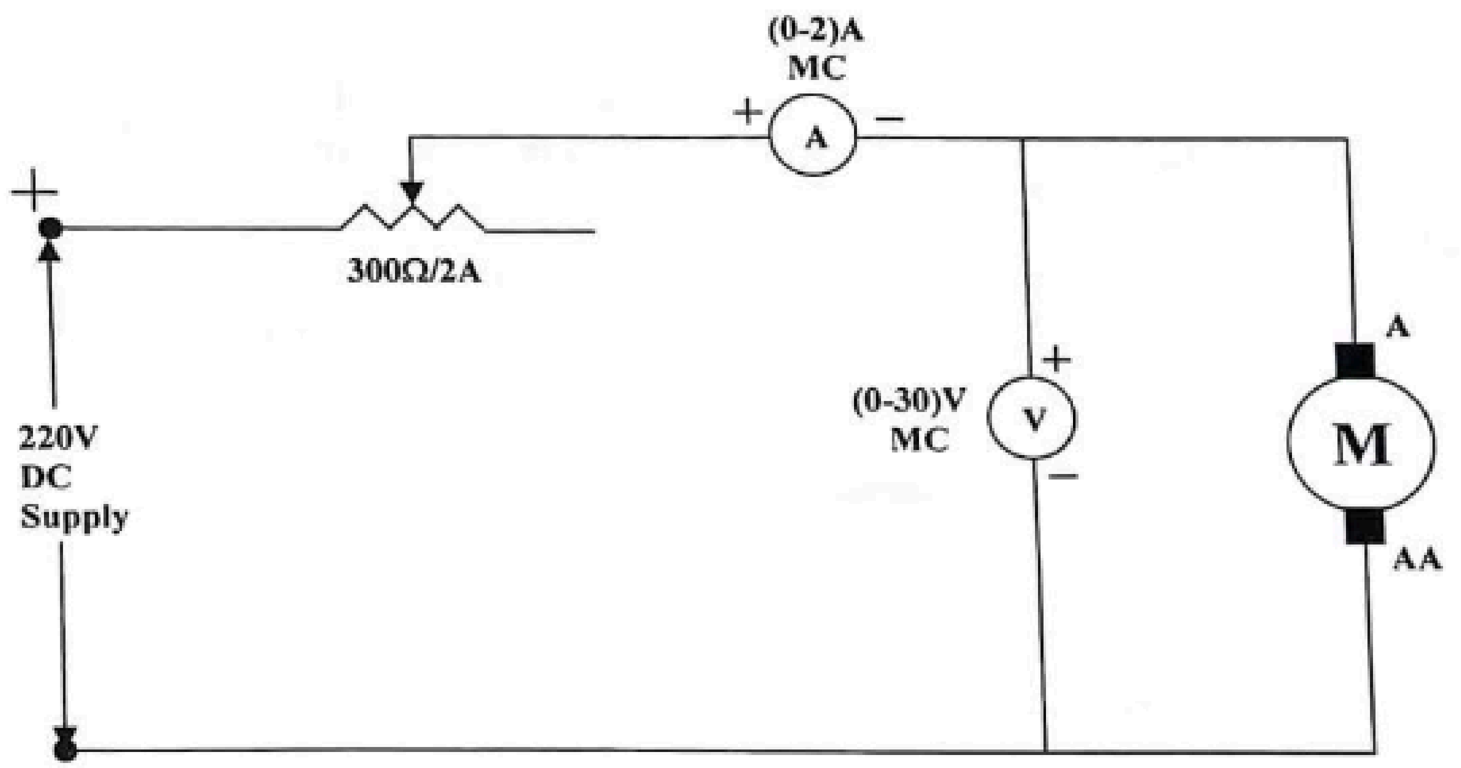
Nameplate details:-

Motor	Generator
Voltage - 220V	Voltage - 220V
Current -13.6A	Current -13.6A
Speed - 1500 rpm	Speed - 1300 rpm
Excitation type –series	Excitation type - series

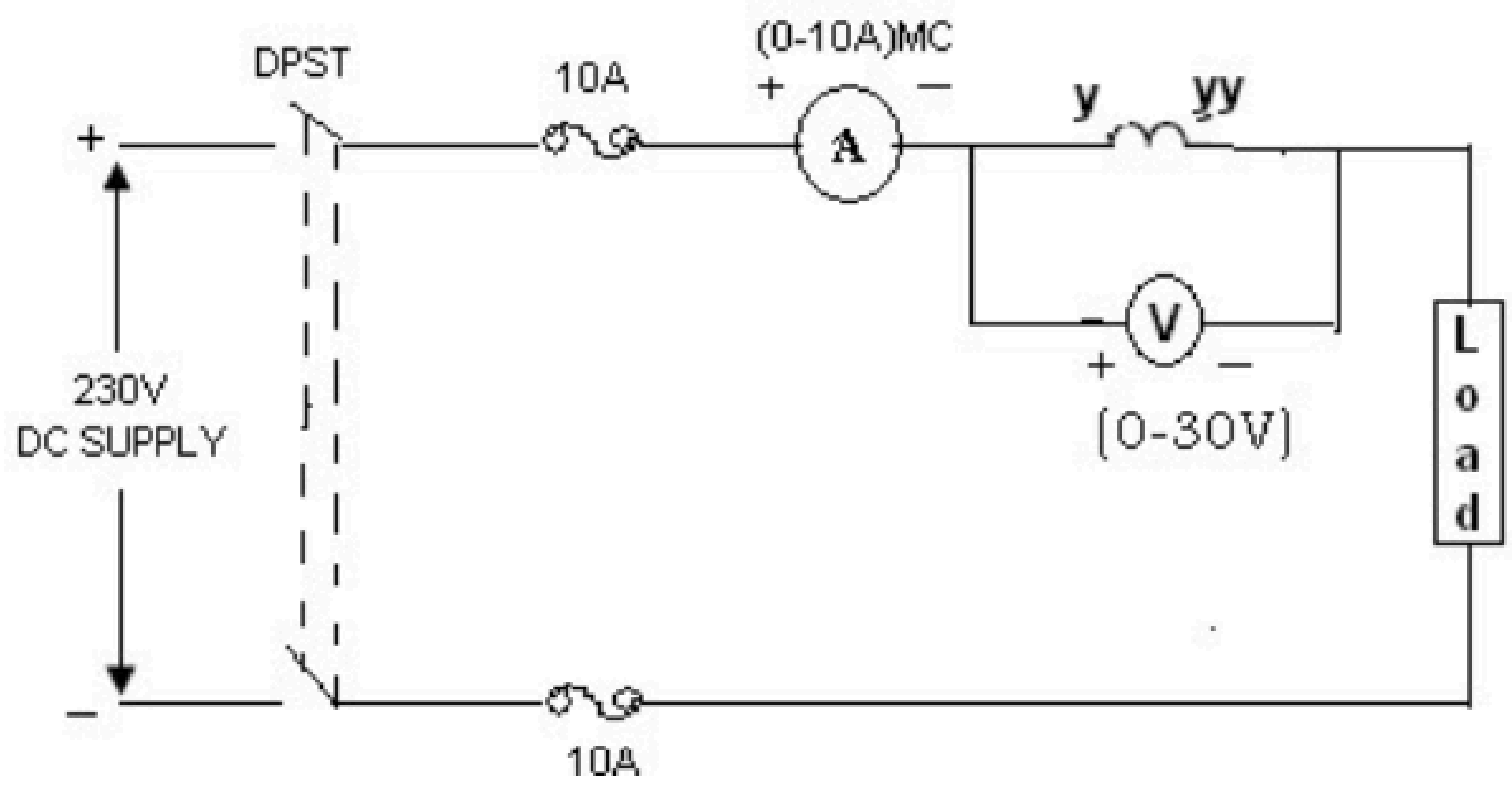
Circuit diagram:



To find armature resistance:-



To find series field resistance:-



Procedure:-

1. Make the connections as per the circuit diagram.
2. Ensure that series generator is electrically loaded to its rated capacity before giving supply and starting the machine.
3. Start the motor with the help of 2-point starter.
4. Decrease the resistive load in steps and note down the field current and terminal voltage.

To determine armature and field resistance:-

1. Connect the circuit as per the circuit diagram.

2 Switch on dc supply.

3. Increase the load and note down the voltage and current.

Tabular columns:-

Table1:

Field Current $I_f = I_L$ (amp)	Terminal Voltage (Volts)	$E_g = V + I_a(R_a + R_{se})$ (volts)
10	210	247
9	210	243.3
8	200	229.6
6	200	222.2
5	190	208.5

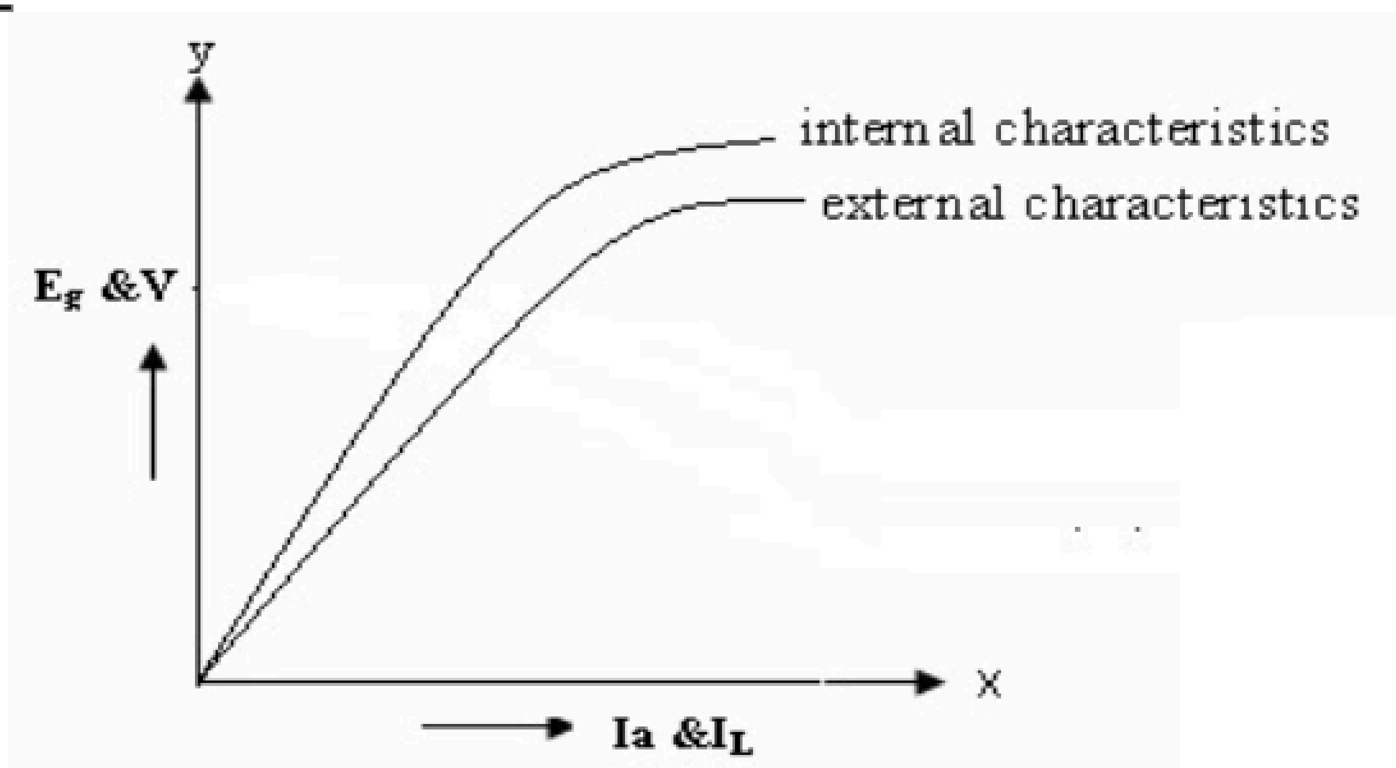
Table2: Armature Resistance

V(volts)	I(amp)	R_{se} =(V/I) (ohms)

Table3:Series field winding resistance

V(volts)	I(amp)	R_{se} =(V/I) (ohms)

Model graph:-



Result:-

Internal and external characteristics of dc series generator are drawn by conducting load test on it.

Viva voce

1. What are the different types D.C.motors?
2. What is the necessity of starter?
3. What is the basic principle of motor?
4. Why the series motor has rising characteristics?
5. What are the applications of series generators?

WEEK 16-17

PAGES 64-71

Experiment No. 10: FIELD'S TEST ON DC SERIES MACHINES

Aim:-

To conduct field's test on a given two identical dc series machines and to determine the efficiency.

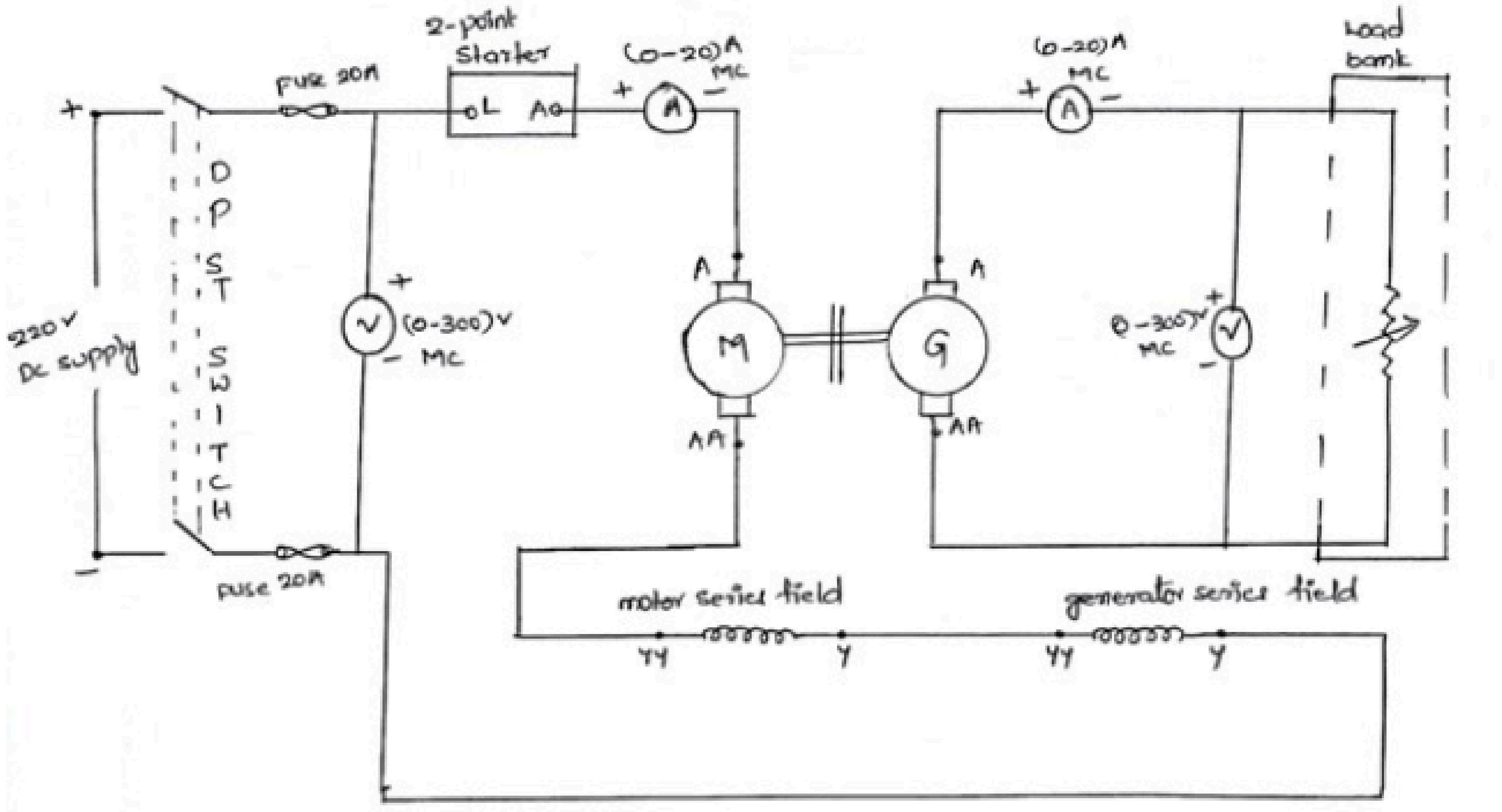
Apparatus:-

S.NO	NAME	RANGE	TYPE	QUANTITY
1	Voltmeter	(0-300)V	MC	2NO
2	Ammeter	(0-20)V	MC	1NO
3	Ammeter	(0-2)A	MC	1NO
4	Tachometer	(0-10,000) RPM	Digital	1NO
5	Rheostat	400Ω, 1.7A	Wire wound	1NO
6	Load box	230V,5KW/20A	Resistive	1NO
7	Connecting wires	(0-20)A	-	Required

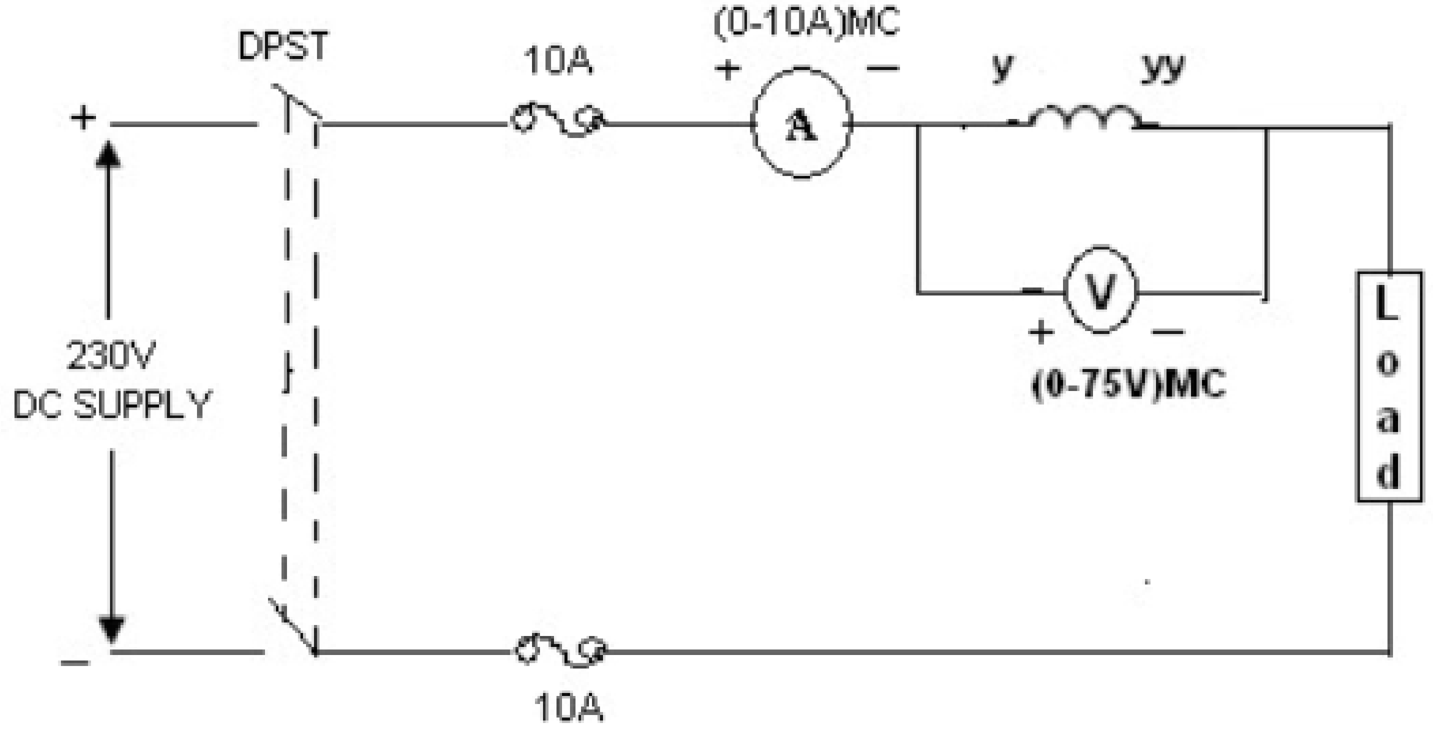
Nameplate details:-

Motor	Generator
Voltage - 220V	Voltage - 220V
Current -13.6A	Current -13.6A
Speed - 1500 rpm	Speed - 1300 rpm
Excitation type –series	Excitation type - series

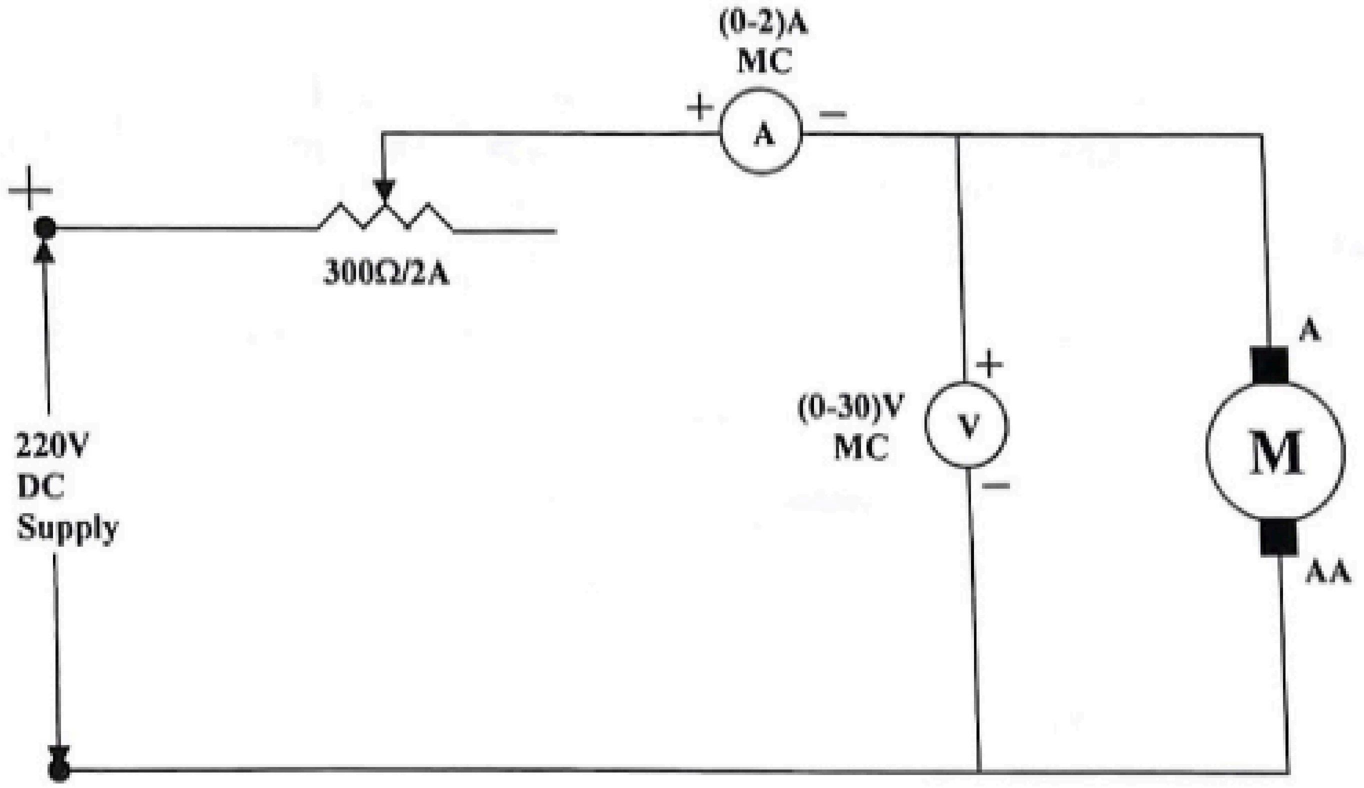
Circuit diagrams



To determine series field winding resistance:-



To determine armature resistance:-



Procedure:-

1. Connect the circuit as per the circuit diagram.
2. Ensure that dc series generator is electrically loaded to its rated current before starting.
3. Give the supply to the dc series motor by closing DPST switch and start the motor with the help of 2- point starter.
4. Note down the readings of voltage across armature and series field winding of dc series generator and terminal voltage across the load of dc series generator.
5. Repeat step no:4, by decreasing electrical load till 30% of rated current is obtained.
6. Switch off the supply by opening DPST switch.

To determine armature resistance:-

1. Connect the circuit as per the circuit diagram.

2. Switch on dc supply.

3. Increase the load and note down the voltage and current.

To determine series field winding resistance:-

1. Connect the circuit as per the circuit diagram.

2. Switch on dc supply.

3. Increase the load and note down the voltage and curren

Table:1

s.no	Input Voltage V (volts)	Armature current of motor I_1 (amps)	Armature current of generator I_2 (amps)	Motor voltage V_1(volts)	Generator voltage V_2 (volts)	Input power $W_i = V*I_1$ (watts)	Armature cu losses of motor $W_{cu,m} = (I_1)^2*R_a$ (watts)	Armature cu losses of generator $W_{cu,g} = (I_1)^2*R_a$ (watts)	Motor field cu losses $W_{se,m} = (I_1)^2*R_{se}$ (watts)
1	220	3.5	4	220	90	770	23.27	30.4	22.05
2	220	4	4.5	220	80	880	30.4	38.475	28.8
3	220	4	5	220	80	880	30.4	47.5	28.8
4	220	4.5	5.5	220	80	990	38.4	57.47	36.45
5	220	5	6	220	75	1100	47.5	68.4	45

Generator field cu losses $W_{se,g} = (I_1)^2 * R_{se}$ (watts)	Stray losses $Ws = W_i - \{ W_{cu,m} + W_{cu,g} + W_{se,g} + W_{se,m} \}$ (Watts)	Total losses of motor $W_m = W_{cu,m} + W_{se,m} + Ws/2$ (Watts)	Total losses of generator $W_g = W_{cu,g} + W_{se,g} + Ws/2$ (Watts)	% efficiency of motor $\%\eta_m = \frac{(V_1 I_1 - W_m)}{(V_1 I_1)} * 100$	% efficiency of generator $\%\eta_g = \frac{(V_2 I_2)}{(V_2 I_2 + W_g)} * 100$
22.05	672.225	381.44	388.56	50.46	46.09
28.8	753.2	435.96	444.04	50.45	44.8
28.8	744.5	431.45	448.55	50.97	47.14
36.45	821.5	504.5	504.5	49.04	46.6
45	894.1	521.97	560.45	52.55	44.53

Table:2

Armature Resistance

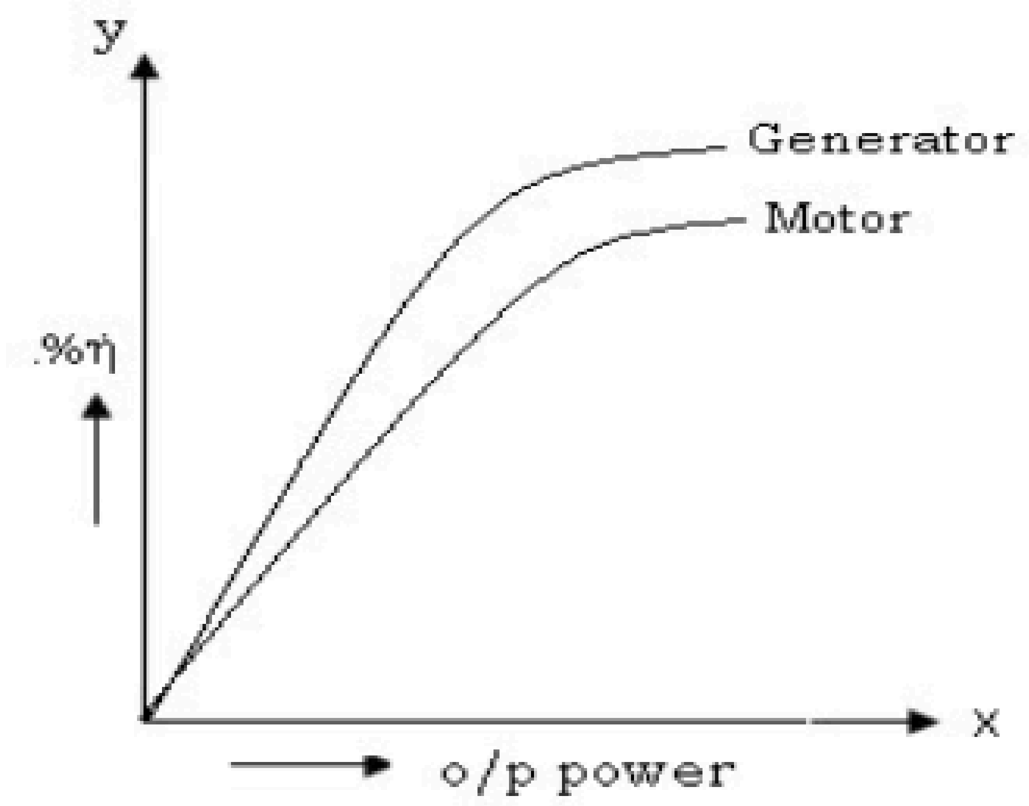
V	I	R_a =(V/I)

Table:3

Series field winding resistance

V	I	R_a =(V/I)

<u>MODEL GRAPH</u>:-



Calculations:-

Input voltage V=___ volts

Voltage across series field and armature winding V_1 =____ volts

Armature current of dc series motor, I_1 =____amps

Armature current of dc series generator I_2 =____amps

Terminal voltage of dc series generator V_2 =____ volts

Input power to the set $W_i = V * I_1$ watts

Armature copper losses of motor $W_{cu,m} = (I_2)^2 * R_a$ watts

$W_{cu,m}$ = ______ watts

Armature copper losses of generator $W_{cu,g} = (I_1)^2 * R_a$ watts

$W_{cu,g}$ =______watts

Generator field copper losses $W_{se,g} = (I_1)^2 * R_{se}$ watts

$W_{se,g}$ =______watts

Motor field copper losses $W_{se,m} = (I_1)^2 * R_{se}$ watts

$W_{se,m}$ =______watts

Stray losses $W_s = W_{i} - \{ W_{cu,m} + W_{cu,g} + W_{se,g} + W_{se,m} \}$ Watts

Total losses of motor $W_m = W_{cu.m} + W_{se.m} + W_s/2$ Watts

Total losses of generator $W_g = W_{cu,g} + W_{se,g} + W_s/2$ Watts

Percentage efficiency of motor $\%\eta_m = ((V_1 I_1 - W_m)/ V_1 I_1)*100$

Percentage efficiency of generator $\%\eta_g = ((V_2 I_2)/ (V_2 I_2 + W_g))*100$

Result:-

Field test is conducted on a given dc series machine and hence efficiency is calculated for motor and generator .

Viva voce

1. Why we are always start the series motor on load only?
2. Give me one application of the series motor?
3. What is the relation between torque and load current?
4. What is the necessity of doing fields test?

Thank You

FOR YOUR ATTENTION