Virtual Lab Manual

List of Experiments

Cycle – 1:

1. Study and verification of Thevenin's theorem.
2. Calculation of current, voltage, power and power factor in a series R-L-C circuit excited by 1-Φ AC supply.
3. Draw the B-H curve of a magnetic Specimen.
4. Study of Fluorescent lamp and improvement of power factor using Capacitor.
5. Connection and testing of Single-Phase Energy meter using Unity power factor load.

Cycle – 2:

6. To perform the polarity test of a single-phase transformer.
7. Measurement of power consumed and power factor by a three-phase resistive load by Two-Wattmeter method.
8. Study and measurement of armature & field resistance of a D.C. machine.
9. To start a single-phase permanent capacitor induction run motors.
10. To determine the efficiency & voltage regulation of a single-phase (1-ϕ) transformer by Direct loading.

EXPERIMENT NO:-6

AIM OF THE EXPERIMENT:- To perform the polarity test of a single-phase transformer.

1. Theory
2. Procedure
3. Video clips
4. Assignment
5. Reference
6. Feedback

OBJECTIVE OF THE EXPERIMENT:-

1. To study the basic operation of a single-phase transformer.
2. To find the correct polarity of the transformer windings.

EQUIPMENTS REQUIRED:

Sl.No	Instrument/Equipment	Specification	Quantity
1	Single phase Variac	(0-270) Volts,15 Amps	1
2	Single phase Transformer	3 kVA, 230/110 V	1
3	Voltmeter	(0-300) V, MI	2
		(0-600) V, MI	1
4	Connecting wires	1.5mm^2,cu wire	As Required

THEORY:-

Polarity means the direction of the induced voltages in the primary and the secondary winding of the transformer. If the two transformers are connected in parallel, then the polarity should be known for the proper connection of the transformer. There are two types of polarity one is **Additive,** and another is **Subtractive.** Each of the terminals of the primary as well as the secondary winding of a transformer is alternatively positive and negative with respect to each other as shown in the figure below. Let P_1 and P_2 be the positive and negative terminal respectively of the transformer primary and S_1, $S_2$are the positive and negative terminal of the secondary side of the transformer .In situations where the secondary winding identification is not available or when a transformer has been rewound, it may be necessary to determine the transformer polarity by test. The following procedure can be used. The P_1 (left-hand) primary winding and the left hand secondary winding S_1 are temporarily jumpered together and a test voltage is applied to the transformer primary. The resultant voltage is measured between the right-hand windings.

If the measured voltage is greater than the applied voltage, the transformer is Additive Polarity because the polarity is such that the secondary voltage is being added to the applied primary voltage. If, however, the measured voltage across the right-hand windings is less than the applied primary voltage, the transformer is Subtractive Polarity. For example applying a test voltage of 120 volts to the primary will result in a secondary voltage of 30 volts (120 / 4 = 30). If transformer is subtractive polarity, the voltmeter will read 90 volts (120 - 30 = 90). If the voltmeter reads 150 volts, the transformer is additive polarity (120 +30 = 150).

CIRCUIT DIAGRAM:-

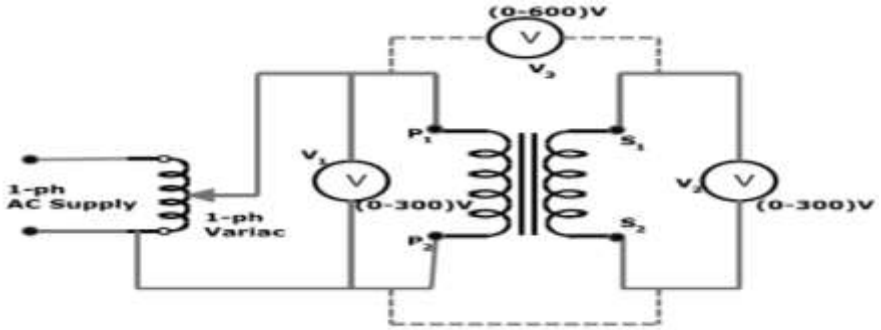


Fig1. Transformer connection for Subtractive polarity

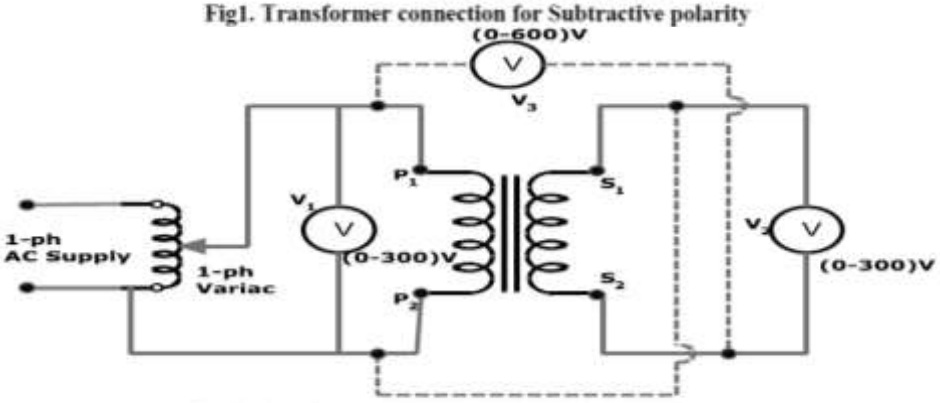


Fig2. Transformer connection for Additive polarity

The marking is correct if voltage V_3 is less than V_1, such a polarity is termed as subtractive polarity. The standard practice is to have subtractive polarity because it reduces the voltage stress between adjacent loads. In case $V_3 > V_1$, the EMF induced in primary and secondary have additive relation and transformer is said to have additive polarity.

PROCEDURE:-

For Polarity test:

1. Connect the circuit as shown in the diagram.
2. Switch on the single phase a.c. supply.
3. Take the voltage readings V_1, V_2 and V_3. In case $V_3 < V_1$ polarity is subtractive.
4. Repeat the step 3 after connecting terminals $P_1$and S_2 .In case $V_3 > V_1$ polarity is additive.
5. Switch off the a.c. supply.

PRECAUTION:-

1. All connections should be tight.
2. The circuit should be according to circuit diagram.
3. The power should be on when the circuit is checked completely.

OBSERVATIONS TABLE:-

For SUBTRACTIVE POLARITY

SL NO	V_1	V_2	$V_3=V_1-V_2$

For ADDITIVE POLARITY

SL NO	V_1	V_2	$V_3=V_1+V_2$

CONCLUSION:-

Videos of demonstration:-

ASSIGNMENT::-

1. What is a transformer?
2. What do you mean by turns ratio and transformation ratio of transformer?
3. What is the condition of additive polarity?
4. What is the condition for subtractive polarity?
5. What is the use of polarity test?
6. Why does transformer has an iron core?
7. What is one-to-one transformer? What is its application?
8. What is the difference between an ideal and practical transformer?
9. Why an iron-silicon alloy core used in a transformer?
10. Transformer are rated in kVA instead of kW. Why?

References:-

1. **Electrical Machines, P. K Mukherjee, S Chakravorti, Dhanpat Rai Publications, 2nd Edition, 1993, pp 411.**

2. **Principles of Electrical Machines , V K Mehta, Rohit Mehta, S Chand and Company ,3rd Edition, 2005, pp 292**

EXPERIMENT NO:-7

AIM OF THE EXPERIMENT:- Measurement of power consumed and power factor by a three-phase resistive load by **Two-Wattmeter** method.

1. Theory
2. Procedure
3. Video clips
4. Assignment
5. Reference
6. Feedback

OBJECTIVE OF THE EXPERIMENT:-

1. To measure the power consumed by the resistive load.
2. To calculate the power factor by the 3-phase resistive load.

EQUIPMENTS REQUIRED:-

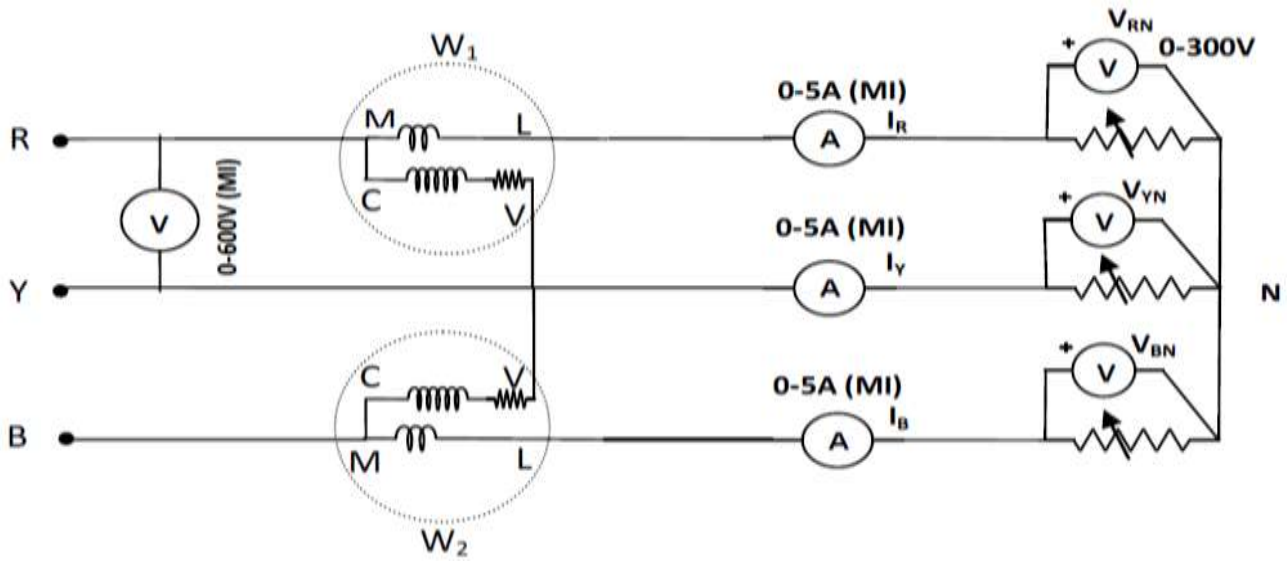
Sl.No	Instrument/Equipment	Specification	Quantity
1	Three phase Variac	15A,440V	01
2	M.I. Ammeter	(0-5)Amps	03
3	M.I Voltmeter	(0-600) Volts	01
4	Wattmeter	5A, 600V	2
5	Multimeter	digital	1
6	Rheostat	100Ω, 5Amps	03
7	Connecting wires	1.5mm^2,cu wire	As required

THEORY:-

A Wattmeter is an instrument for measuring power directly in a circuit. It has two coils which when connected in series shows the lower current range of the instrument and when connected in parallel shows double the range. The pressure circuit has a coil of high resistance. The current coil is connected in series with the circuit in which power is measured and the pressure coil across the circuit. Two-wattmeter can be used to measure power in a 3-phase, 3-wire circuit, whether the load is balanced or un-balanced one. The current coils are connected in series with two phases and the pressure coils is connected between line conductors as shown in the circuit diagram.

The total power consumed = $W_1 + W_2$ (algebraically sum).

CIRCUIT DIAGRAM:-



PROCEDURE:-

1. The circuit should be connected as shown in the diagram.
2. The 3-phase output of the variac should be connected to R, Y and B terminal.
3. The main supply should be switched ON.
4. The output voltage of the three-phase variac should be slowly increased.
5. The load should be connected in such a way that it forms a balanced condition.
6. The reading of W_1, W_2, I_R, I_Y, I_B, V_{RN}, V_{YN} and V_{BN} should be noted down.
7. Repeat the above step for the unbalanced connection.
8. The output voltage of the variac should be decreased.
9. The power supply should be switched OFF.

PRECAUTION:-

1. The connections should be proper as per the circuit diagram.
2. After verifying the circuit connection thoroughly, the supply should be switched ON.
3. Reading of the meter should be taken correctly.

OBSERVATIONS:-

Sl. No	W_1 (Watts)	W_2 (Watts)	$W = W_1 + W_2$ (Watts)	I_R (Amp.)	I_Y (Amp.)	I_B (Amp.)	V_{RN} (Volts)	V_{YN} (Volts)	V_{BN} (Volts)	Power factor	%Error

CALCULATION:-

Power consumed by R-phase of the load = $V_{RN} \times I_R$
Power consumed by Y-phase of the load = $V_{YN} \times I_Y$
Power consumed by B-phase of the load = $V_{BN} \times I_B$
Total power consumed by the three-phase load (P) = ($V_{RN} \times I_R + V_{YN} \times I_Y + V_{BN} \times I_B$) watt.

% Error = $\frac{P-W}{W} X\ 100$

$$\phi = \tan^{-1}\sqrt{3}\ \frac{(W1-W2)}{(W1+W2)}$$

CONCLUSION:-

Videos of demonstration:

ASSIGNMENT:-

1. How many coils are in a wattmeter and what are their names?
2. What do you mean by load in a 3 phase load ?
3. What is the relation between phase voltage and line voltage in a star connected system?
4. What is the value of neutral current in a balanced load system?
5. What is the minimum number of wattmeter required to measure power in a three phase system?
6. How to find out the P.F of a three phase balance load system if the two wattmeter readings are given?
7. If both wattmeter have same reading then what is the value of cos ϕ?
8. Explain how 3-phase power can be measured by using 2-wattmeter method with phasor diagram.
9. How the power factor of a balanced load can be measured by two wattmeter method?

References:-

1. **Electrical and Electronic Measurements and Instrumentation, R K Rajput, S Chand Publication, 2nd Edition, 2010, pp 410**

2. **Experiments in Basic Electrical Engineering, S K Bhattacharya, K M Rastogi, New Age International Publishers, 2nd Edition,1997.**

EXPERIMENT NO:-8

AIM OF THE EXPERIMENT:- Study and measurement of armature & field resistance of a D.C. machine.

1. Theory
2. Procedure
3. Video clips
4. Assignment
5. Reference
6. Feedback

OBJECTIVE OF THE EXPERIMENT:-

1. To measure the shunt and series field resistance.
2. To calculate the R_{AC} of above windings.

EQUIPMENTS REQUIRED:-

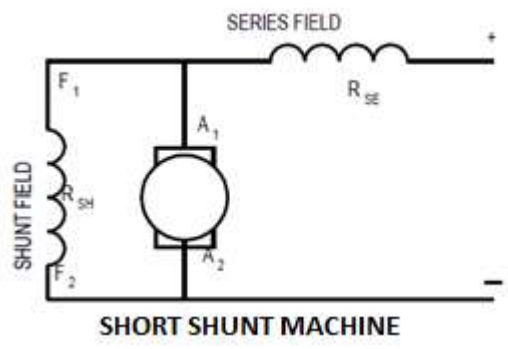
Sl.No	Instrument/Equipment	Specification	Quantity
1	Regulated power supply unit	15A	01
2	MC Ammeter	(0-1)A (0-10) A	01 01
3	M.I Voltmeter	(0-300)V (0-15)V	01 01
7	Connecting wire	1.5mm^2,cu wire	As required

MACHINE SPECIFICATION:-

Sl.No	Instrument/Equipment	Specification	Quantity
1.	D.C Compound Machine	2kW, 1500 RPM, 220 Volts, 9 Amps	1 No

THEORY:-

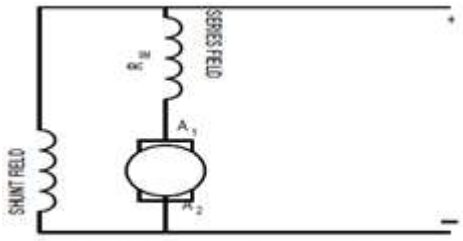
Although a far greater percentage of the electrical machine in service is A.C. machine, the D.C. Machines are of considerable industrial importance. A D.C. machine can be a D.C. generator or D.C. motor. In fact the machine can be used as generator as well as a motor.
Essentially a D.C. Machine consists of two main parts:
(ii) Armature
(iii) Field



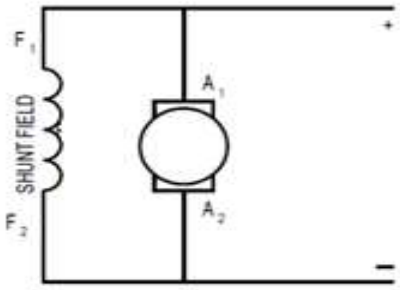
SHORT SHUNT MACHINE

Depending upon the field configuration D.C. machine can be classified as:
(i) D.C. series machine
(ii) D.C. shunt machine
(iii) D.C. compound machine
When field winding is connected in series with the armature, it is called series machine, when field winding is

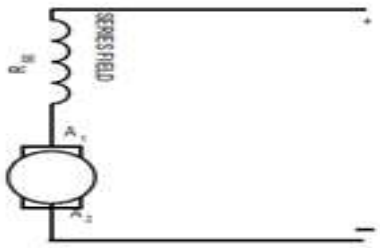
connected in parallel with the armature, it is called shunt machine. But when the machine carries both shunt winding and series winding it is called a compound machine. The schematic diagrams of D.C. machines are given below:



LONG SHUNT MACHINE

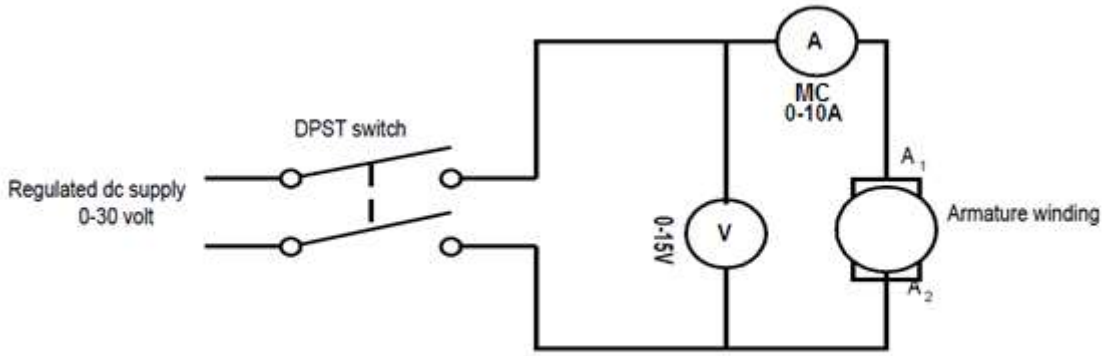


SHUNT MACHINE

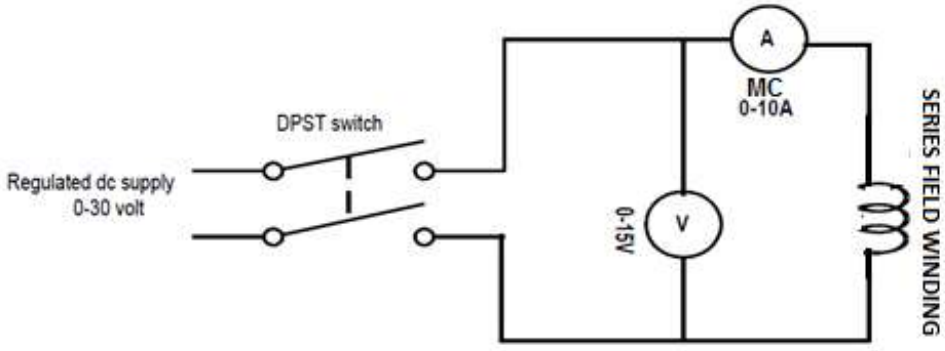


SERIES MACHINE

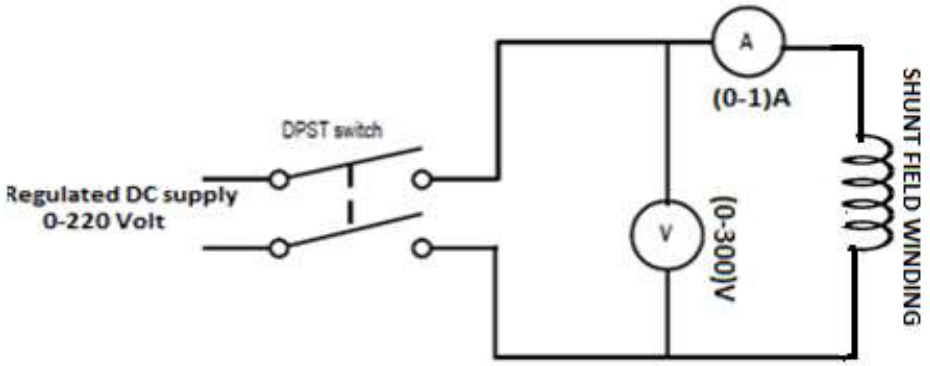
CIRCUIT DIAGRAM:-



(CIRCUIT DIAGRAM 1)



(CIRCUIT DIGRAM 2)



CIRCUIT DIAGRAM 3

PROCEDURE:-

1. Make connection as per the circuit diagram.
2. Switch ON the power supply.
3. Note down the readings Ammeter and Voltmeter correctly for different supply voltages.
4. Switch OFF the power supply.
5. Repeat the procedure for series and shunt field windings.

PRECAUTION:-

1. The connections should be proper as per the circuit diagram.
2. After verifying the circuit connection thoroughly, the supply should be switched ON.
3. Reading of the meter should be taken correctly.

OBSERVATIONS:-

Sl. No	Supply voltage in volts	Circuit current in Amps	Resistance in ohms	Effective Resistance in ohm
For Armature winding				
For series field winding				
For shunt field winding				

CALCULATION:-

Effective Resistance = 1.5 × (d.c resistance)

CONCLUSION:-

Videos of demonstration:-

ASSIGNMENT:-

1. Why the series field winding have less no of turns?
2. Why the shunt field winding have more resistance than the series field winding?
3. Why the effective resistance is more than the dc resistance?
4. If E_b is the back emf of d.c. motor and V is the terminal voltage, then what isthe condition for maximum power ?
5. For low reluctance path for the flux in armature, the permeability of the material should be……..
6. The armature reaction in d.c. machine causes distortion in the main field flux. This effect of armature reaction can be reduced by what?
7. The brush contact losses in a d.c. Machine is ……. proportional to the current.
8. When the motor runs on no load, then which quantity is almost equal to applied voltage?
9. If a shunt motor is started with its field winding open then what will happen to the speed of the motor?

References:-

1. **Electrical Machines, P. K Mukherjee, S Chakravorti, Dhanpat Rai Publications, 2nd Edition, 1993, pp 184-187.**

2. **Principles of Electrical Machines , V K Mehta, Rohit Mehta, S Chand and Company ,3rd Edition, 2005, pp 109-113**

3. **A text book of Electrical Technology, volume II by B.L. Thereja, A.K. Thereja , S. Chand & company, Edition 2009,pp 1015-1021**

EXPERIMENT NO-9

AIM OF THE EXPERIMENT:- To start a single phase permanent capacitor induction run motors.

1. Theory
2. Procedure
3. Video clips
4. Assignment
5. Reference
6. Feedback

OBJECTIVE OF THE EXPERIMENT:-

1. Find the starting current of the induction motor.
2. Identify the starting and running winding of the motor.

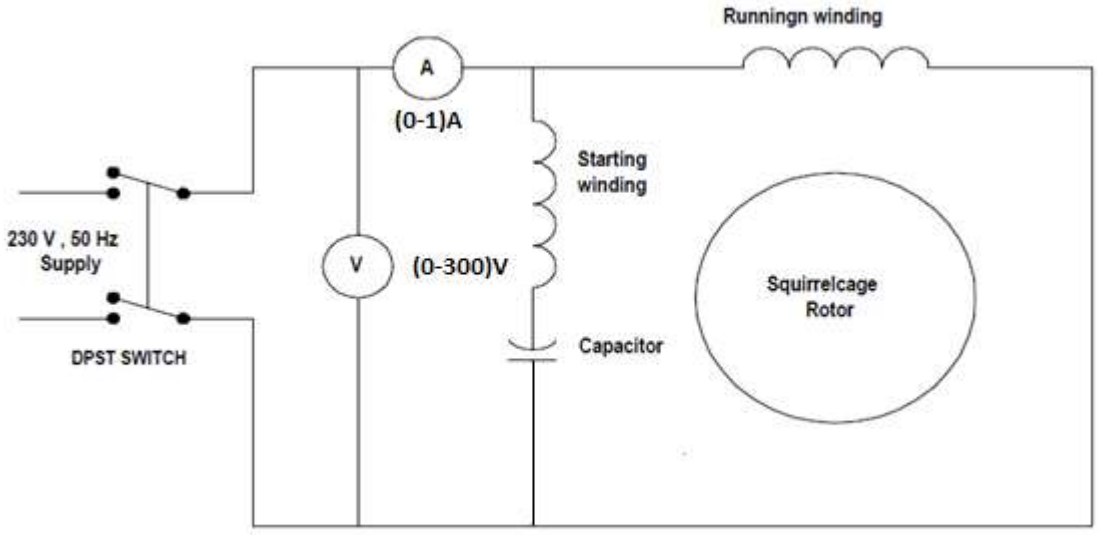
EQUIPMENTS REQUIRED:-

SI.NO	EQUIPMENT	SPECIFICATION	QUANTITY
1.	Voltmeter	MI type (0-300)V	01
2.	Ammeter	MI type (0-1)A	01
3.	Multimeter	Digital type	01
4.	Connecting wires	1.5 mm^2	As per required

THEORY:-

Single-phase motors are not self starting due to zero starting torque. So to make them self-starting an extra winding is wounded called starting winding (in parallel with running winding). To create a phase Difference between two winding current, a capacitor is connected in series with the starting winding. Approximately the angle between I_s (starting winding current) is 80^0. When single-phase supply in given, it produces a rotating magnetic field makes motor self start. When the motor achieves 75% to 80% of its normal speed the starting winding is disconnected from the supply by help of a centrifugal switch. Hence the motor runs by running winding only. In such type of motor, starting winding is more resistive and less inductive but running winding is just reversed. Direction of rotation can be changed by Reversing the connection of any one winding i.e. staring winding or running winding. Capacitor start type motors are used where high starting torque is required and starting period may be long. Power rating of such motor lies in-between 120 Watt to 7.5 Kilo Watt. The motors are used in large fans, Pumps, compressors etc.

CIRCUIT DIAGRAM:-



PROCEDURE:-

1. Identify the terminals of starting and running winding by series lamp test.
2. Test lamp is connected in series with each winding across the supply. (The test lamp glows brightly in running winding and glow dim in starting winding)
3. The starting winding connected in series with capacitor and running winding connected parallel as shown in circuit diagram.
4. Put "ON" the switch to start the motor.
5. Measure starting & running current, supply voltage and speed.

PRECAUTION:-

1. The connections should be proper as per the circuit diagram.
2. After verifying the circuit connection thoroughly, the supply should be switched ON.
3. Reading of the meter should be taken correctly.

OBSERVATIONS:-

Sl. No	Starting Current	Running Current	Supply Voltage

CONCLUSION:-

Videos of demonstration:-

ASSIGNMENT:-

1. Name the various type of single phase induction motor in a fractional KW rating.
2. Explain why a single phase induction motor should be provided with an auxiliary winding on the stator.
3. Explain the principle of split phasing used in single phase induction motor.
4. What is double-field revolving theory?
5. What is the condition necessary for production of a rotating magnetic field with the help of stationary winding?
6. What are the different types of single phase induction motors ?
7. What is the function of centrifugal switch in 1-ϕ Induction motor?
8. Why the starting torques of 1-ϕ capacitor start Induction motor high?
9. Why the 1-ϕ Induction motor is not self starting?
10. Write the application of 1-ϕ capacitor start Induction motor?

References:-

4. **Electrical Machines, P. K Mukherjee, S Chakravorti, Dhanpat Rai Publications, 2nd Edition, 1993, pp 919-920.**

5. **Principles of Electrical Machines , V K Mehta, Rohit Mehta, S Chand and Company ,3rd Edition, 2005, pp 386-387**

6. **A text book of Electrical Technology, volume II by B.L. Thereja, A.K. Thereja , S. Chand & company, Edition 2009,pp 1381-1383**

EXPERIMENT NO-10

AIM OF THE EXPERIMENT:- To determine the efficiency & voltage regulation of a single-phase (1-ϕ) transformer by Direct loading.

1. Theory
2. Procedure
3. Video clips
4. Assignment
5. Reference
6. Feedback

OBJECTIVE OF THE EXPERIMENT:-

1. Find the voltage regulation of the transformer.
2. Determine the efficiency and the losses of the transformer.

EQUIPMENTS REQUIRED:-

Sl. No	Instrument/Equipment	Specification	Quantity
1	1-ϕ transformer	3 KVA, 230 /230V	01
2	1-ϕ Variac	15 A, (0-270)V	01
4	M.I Ammeter	(0-10) A	02
5	M.I Voltmeter	(0-300) V	02
6	Wattmeter (UPF)	10/20 A, 300V	01
7	SPST Switch	250V,20A	
8	Connecting Wires	1.5mm^2, Cu wire	As required

THEORY:-

This method of calculation of efficiency and regulation of a transformer is entirely different from the determination of efficiency and regulation by OC and SC test on transformer. In this method secondary of transformer is connected to load. When secondary is loaded, the secondary current I_2 is set up. The magnitude and phase of I_2 with respect to terminal voltage V_2 depends on the type of load (If load is resistive then I2 will be in phase with V_2, for inductive load I_2 will lag behind V_2 and for capacitive load it will lead the voltage V_2).

Because of this secondary current I2, there is a drop in terminal voltage V_2. Drop in voltage depends on the impedance of load & PF For leading PF voltage drop may be negative and for lagging PF it is always positive. Since the flux passing through the core is same from no load to full load conditions, core losses remain same and since the copper losses depend on the square of the current, they vary with the current.

Regulation is defined as the ratio of change in terminal voltage from no load to full load to the no load voltage.

Voltage regulation=$\frac{V_{2(noload)}-V_{2\,(full\,load)}}{V_{2(full\,load)}}$

Regulation can be found out at any PF and at any load current. Efficiency is defined as the ratio of output power to the input power of the transformer. Efficiency of a transformer varies with power factor at different loads.

Efficiency= $\frac{\text{Output}}{\text{Input}}$

CIRCUIT DIAGRAM:-

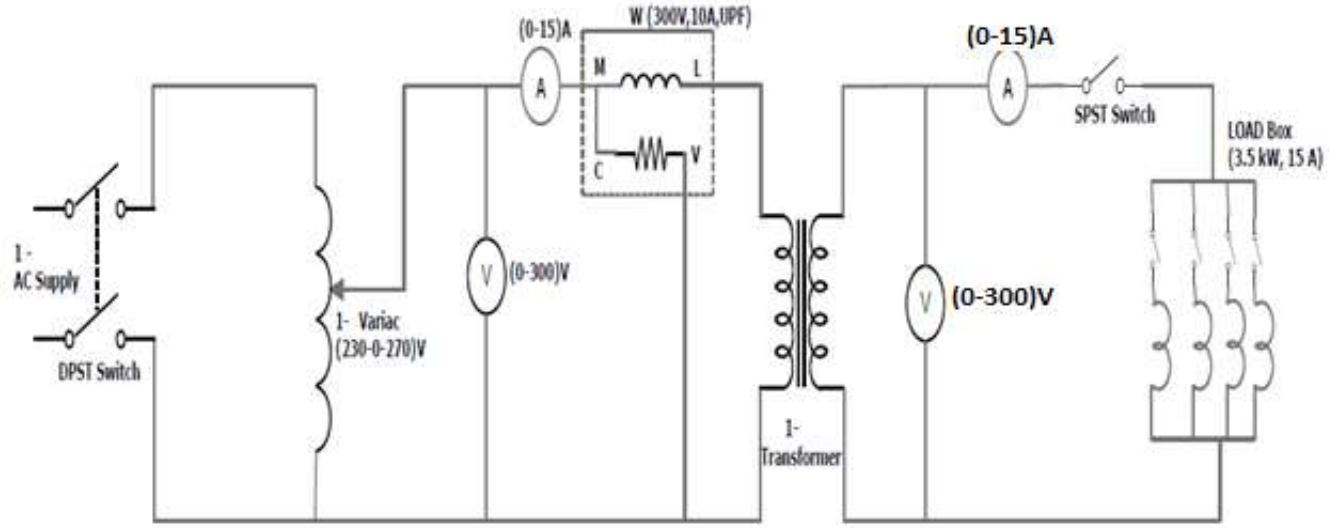


Fig.1 Direct Loading Test of 1 – Φ Transformer

PROCEDURE:-

1. Connect the circuit as per the circuit diagram.
2. Keep all the switches of loading rheostat in off position and variac at zero position.
3. Switch on the supply and Apply 220V to the primary winding of the transformer
4. Note down secondary voltage (V_{NL}) where V_{NL} is the No-load voltage.
5. Switch on the load and note down all meter readings correctly.
6. Go on increasing the load till the rated secondary current flows in the transformer.

PRECAUTION:-

1. The connections should be proper as per the circuit diagram.
2. After verifying the circuit connection thoroughly, the supply should be switched ON.
3. Reading of the meter should be taken correctly.

OBSERVATIONS:-

Sl. No	V_1 (in Volt)	I_1 (in Amp)	W_1 (in watt)	V_2 (in Volt)	I_2 (in Amp)	V_{2NL} (in Volt	W_2 (in watt)	$\%\,\eta=\frac{W_2}{W_1}\times 100$	%voltage regulation
1.									

CALCULATION:-

$$\%\ \text{Regulation} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

V_{FL} = Full -load Voltage, V_{NL} = No-load Voltage

$$\%\ \eta = \frac{W_2}{W_1} \times 100$$

W_1= Input Power

W_2 = Output Power = $V_2 I_2 \cos\phi$

CONCLUSION:-

Videos of demonstration:-

ASSIGNMENT:-

1. What is regulation and efficiency of a transformer?
2. Why core losses remain almost constant at any load?
3. How efficiency of transformer depends on the power factor of the load?
4. What is the condition for maximum efficiency? Derive it.
5. What is the effect of different types of load on the terminal voltage of transformer?
6. Discuss the effect of output power on efficiency and regulation.
7. Explain the principle of working of a transformer.
8. Give the constructional different between a core type and a shell type transformer.
9. State why the core of a transformer should be made of magnetic material.
10. A 100KVA ,1100/400 V ,50Hz single phase transformer has 100 no. Of turns on the secondary winding . find the no of winding on the primary side.

References:-

1. **Electrical Machines, P. K Mukherjee, S Chakravorti, Dhanpat Rai Publications, 2nd Edition, 1993, pp 390-392.**
2. **Principles of Electrical Machines , V K Mehta, Rohit Mehta, S Chand and Company ,3rd Edition, 2005, pp 244-247**
3. **A text book of Electrical Technology, volume II by B.L. Thereja, A.K. Thereja , S. Chand & company, Edition 2009,pp 1158-1163**