DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGG.

LABORATORY MANUAL

Name of the Lab: Electrical Machine Laboratory-I

Semester: III

Subject Code: 18EEL37

Staff Incharge: Prof P M Murari

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Vision of Institute

"To be a preferred institution in Engineering Education by achieving excellence in teaching and research and to remain as a source of pride for its commitment to holistic development of individual and society."

Mission of Institute

"To continuously strive for the overall development of students, educating them in a state-of-the-art-infrastructure, by retaining the best practices, people and inspire them to imbibe real time problem solving skills, leadership qualities, human values and societal commitments, so that they emerge as competent professionals."

Vision of Program

"To be the centre of excellence in teaching and learning to produce the competent & socially responsible professionals in the domain of Electrical & Electronics Engineering."

Mission of Program

"To educate students with core knowledge of Electrical and Electronics Engineering by developing problem solving skills, professional skills and social awareness to excel in their career."

Sl. NO	Experiments
1	Open Circuit and Short circuit tests on single phase step up or step down transformer and predetermination of (i) Efficiency and regulation (ii) Calculation of parameters of equivalent circuit.
2	Sumpner's test on similar transformers and determination of combined and individual transformer efficiency.
3	Parallel operation of two dissimilar single-phase transformers of different kVA and determination of load sharing and analytical verification given the Short circuit test data.
4	Polarity test and connection of 3 single-phase transformers in star – delta and determination of efficiency and regulation under balanced resistive load.
5	Comparison of performance of 3 single-phase transformers in delta – delta and V – V (open delta) connection under load.
6	Scott connection with balanced and unbalanced loads.
7	Separation of hysteresis and eddy current losses in single phase transformer.
8	Voltage regulation of an alternator by EMF and MMF methods.
9	Voltage regulation of an alternator by ZPF method.
10	Slip test – Measurement of direct and quadrature axis reactance and predetermination of regulation of salient pole synchronous machines.
11	Performance of synchronous generator connected to infinite bus, under constant power and variable excitation & vice - versa.
12	Power angle curve of synchronous generator

CIRCUIT DIAGRAM:(**Open Circuit test**)

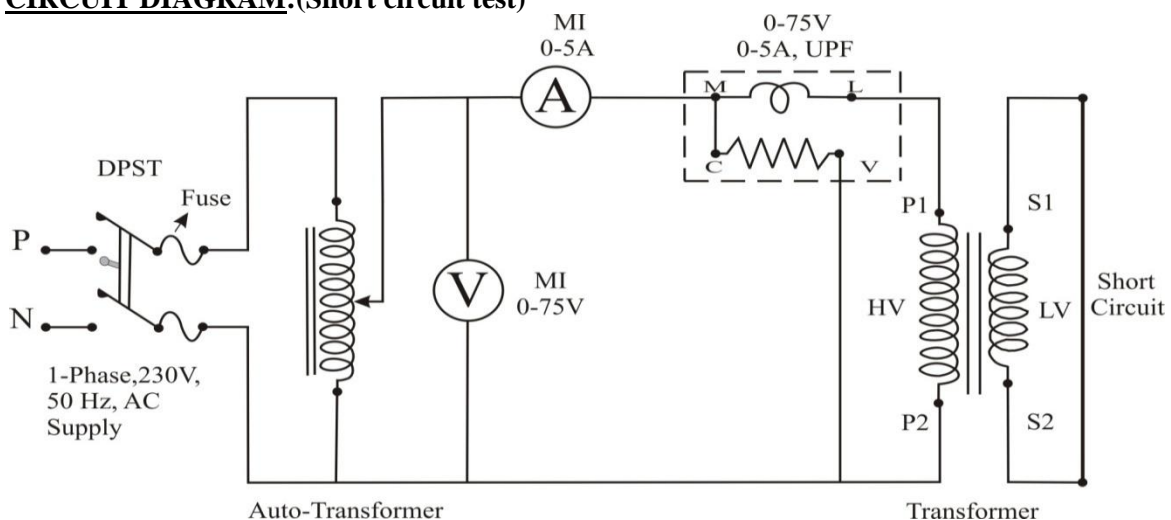Auto-Transformer   Transformer
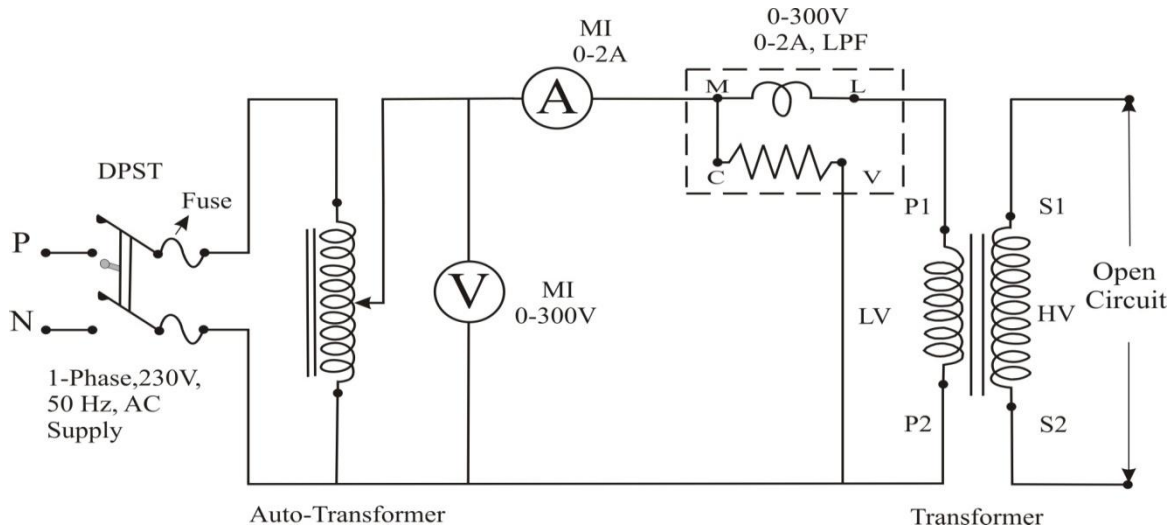
OBSERVATION:

1. KVA rating of transformer =__KVA
2. Primary voltage = _____V
3. Secondary voltage =_____V

$$\text{Wattmeter constant} = \frac{\text{Voltage range} \times \text{Current Range}}{\text{Full Scale Division of Wattmeter}}$$

TABULATION(OCC):

Sl.No	Open Circuit Voltage in Volts (V_0)	No Load Current in Amps (I_0)	No Load Power (W_0) In Watts
1			

CIRCUIT DIAGRAM:(**Short circuit test**)

Auto-Transformer   Transformer

TABULATION(SCC):

Sl.No	Short Circuit Voltage V_{SC} (in Volts)	No Load Current I_{SC}(in Amps)	No Load Power W_{SC} (In Watts)
1			

EXPT.NO.1   **DATE:**

OPEN CIRCUIT AND SHORT CIRCUIT TESTS ON SINGLE PHASE STEP UP OR STEP DOWN TRANSFORMER AND PREDETERMINATION OF

    (I)   **EFFICIENCY AND REGULATION**

    (II)   **CALCULATION OF PARAMETERS OF EQUIVALENT CIRCUIT.**

AIM: Predetermination of efficiency and regulation by open circuit and short circuit test on single phase transformer, also calculate equivalent circuit parameters from short circuit and open circuit test .

APPARATUS REQUIRED:

S.no	Particulars	Range	Quantity
1	Ammeter	MI 0-2A	1No
2	Ammeter	MI 0-5A	1No
3	Voltmeter	MI 0-300V	1 No
4	Voltmeter	MI 0-75V	1 No
5	Wattmeter	0-75V/0-5A UPF	1 No
6	Wattmeter	0-300V/0-2A LPF	1 No
7	Auto transformer	230V/0-260V 1-Phase,	1 No
8	Transformer	1KVA, 230V/115V,50Hz	1 No
9	Connecting wires	--	Few

THEORY:

        The OC and SC test are used to calculate the efficiency and regulation of a transformer. Also, we find equivalent circuit parameters of transformer.

Open Circuit Test (OC Test):

        The transformer primary is connected to AC supply through variac, ammeter and Wattmeter. The secondary of the transformer is kept open. Usually low voltage side is used as primary and high voltage side is used as secondary to conduct OC test.

The primary is excited by rated voltage which is adjusted precisely with the help of a variac. The Wattmeter measures input power. The ammeter measures input current. The voltmeter gives the value of rated primary voltage applied at rated frequency.

        Sometimes a voltmeter may be connected across the secondary to measure secondary voltage which is $V_2=E_2$. As the voltmeter resistance is very high secondary current is negligible.

Short circuit Test (SC Test):

        The secondary of the transformer is short circuited with the help of thick copper wire or solid links. As high voltage side is always low current side to supply and low current flows through meters.As the secondary is short circuited its resistance is very small and on rated voltage it will draw very large current such large current can cause overheating and burning of the transformer. To limit this short circuit current primary is supplied with low voltage which is enough to cause rated current to flow through primary. This can be observed on an ammeter. The low voltage can be adjusted with the help of variac. Hence this test is also called Low voltage Test or Reduced voltage Test.

PROCEDURE:a) Procedure for OC Test:

1. Connections are made as per the circuit diagram.
2. Ensure that the HV side of transformer winding is kept open and the knob of the auto transformer at its zero position.
3. Switch 'ON' the power supply.
4. Slowly, go on varying the auto transformer knob until the voltmeter shows the rated voltage of the transformer.
5. Note down the readings of the voltmeter, ammeter and wattmeter then bring the auto transformer to its zero position.
6. Switch 'OFF' the supply.

b) <u>Procedure for SC Test</u>:
1. Connections are made as per the circuit diagram.
2. Ensure that the LV side of transformer winding is kept short circuited by thick copper wire and the knob of the auto transformer at its zero position.
3. Switch 'ON' the power supply.
4. Slowly, go on varying the auto transformer knob until the ammeter connected on HV side shows the rated current of the transformer.
5. Note down the readings of the voltmeter, ammeter and wattmeter then bring the auto transformer to its zero position.
6. Switch 'OFF' the supply.

NATURE OF GRAPH:

I) Efficiency Vs Percentage loading (load current)

II) Regulation Vs Power factor
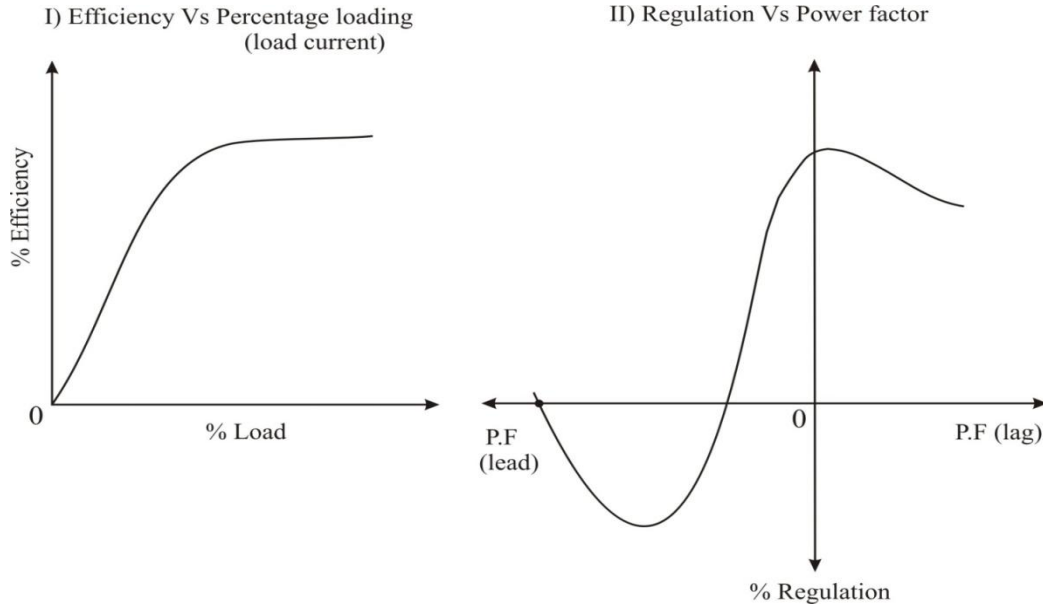
CALCULATIONS:

I) PREDETERMINATION OF EFFICIENCY AND REGULATION
From Open Circuit Test:

Core loss $W_0 = V_0 I_0 cos\emptyset_0$ Watts.

$\therefore$ No-load power factor $= cos\emptyset_0 = \dfrac{W_0}{V_0 I_0} = $ _____

$I_c = I_0 cos\emptyset_0 = $ _____

$I_m = I_0 sin\emptyset_0 = $ _____

Once I_c and I_m are known we can determine exciting circuit parameters as-

$R_0 = \dfrac{V_0}{I_c} = $ _____ Ω

$X_0 = \dfrac{V_0}{I_m} = $ _____ Ω

From Short Circuit Test:

Full load current of Transformer

$$= \frac{KVA \times 1000}{Rated\ primary\ Voltage} = \underline{\hspace{2cm}}\ \text{Amps}$$

$W_{sc} = V_{sc} I_{sc} cos\emptyset_{sc}$ Watts.

$\therefore cos\emptyset_{sc} = \frac{W_{sc}}{V_{sc} I_{sc}} = \underline{\hspace{2cm}}$

Also, $W_{sc} = I_{sc}^2 R_{1e}$

$\therefore R_{1e} = \frac{W_{sc}}{I_{sc}^2} = \underline{\hspace{2cm}}\quad \Omega$

$Z_{1e} = \frac{V_{sc}}{I_{sc}} = \sqrt{R_{1e}^2 + X_{1e}^2} = \underline{\hspace{2cm}}\quad \Omega$

$\therefore X_{1e} = \sqrt{Z_{1e}^2 - R_{1e}^2} = \underline{\hspace{2cm}}\quad \Omega$

Practically:

$$\%\eta = \frac{x \times KVA \times 10^3\ cos\phi}{x \times KVA \times 10^3 \times cos\phi + W_0 + x^2 W_{sc}} \times 100$$

Where, x= Load factor,

      x =3/4 for 3/4th of load,

      x = ½ for half load.

% Regulation = $\dfrac{I_1\ R_{1e}\ cos\varphi\ \pm\ I_1\ x_{1e}\ sin\varphi}{V_1} \times 100$ +ve sign for lagging power factor

 –ve sign for leading power factor.

EFFICIENCY TABULATION:

LOAD	100%(x=1)	75%(x=3/4)	50%(x=1/2)
P.F	0.7	0.7	0.7
%η			

REGULATION TABULATION:

Power factor	% R (Leading)	%R (Lagging)
0.1		
0.2		
0.3		
0.4		

CONCLUSION:

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CIRCUIT DIAGRAM:

Auto-Transformer   Transformer   Auto-Transformer
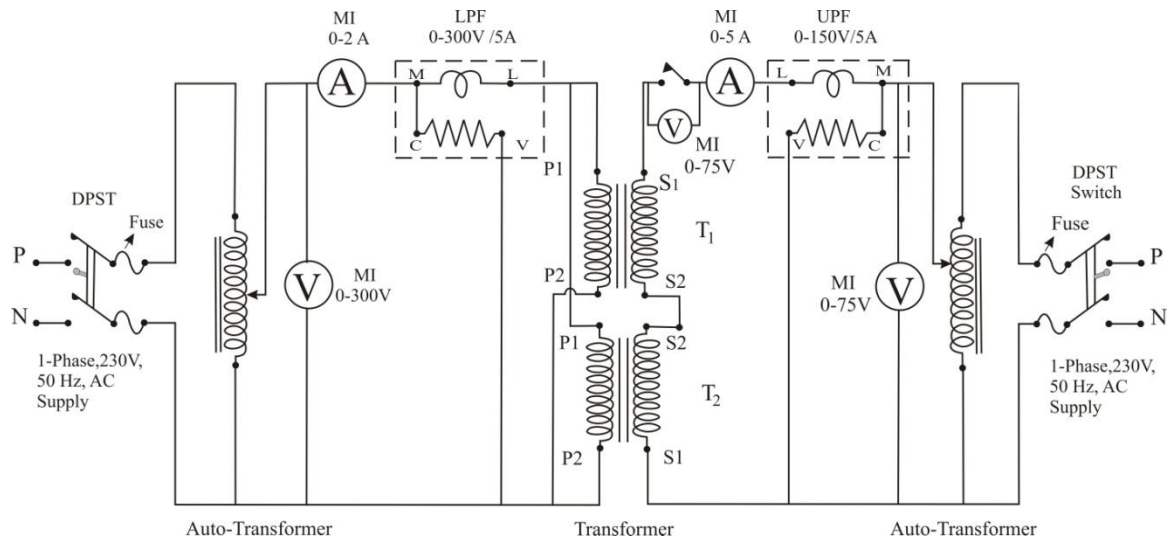
OBSERVATION:

1. KVA rating of transformer T_1=__KVA
2. Primary voltage = _____V
3. Secondary voltage =_____V
4. KVA rating of transformer T_2=   KVA
5. Primary voltage = _____V
6. Secondary voltage =____V
7. Full load current = _____Amps.

$$\text{Wattmeter constant} = \frac{\text{Voltage range} \times \text{Current Range}}{\text{Full Scale Division of Wattmeter}} \text{ for UPF Wattmeter}$$

NATURE OF GRAPH:

I) Efficiency Vs Percentage loading (load current)
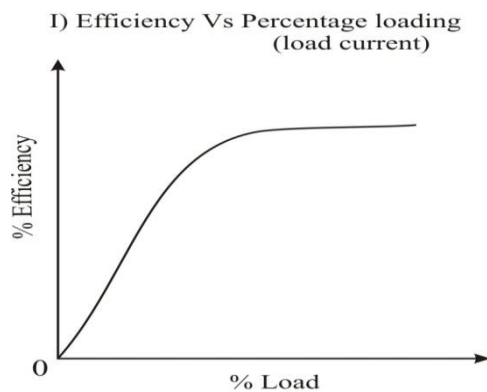
EXPT.NO.2   **DATE:**
SUMPNER'S TEST ON SIMILAR TRANSFORMERS AND DETERMINATION OF COMBINED AND INDIVIDUAL TRANSFORMER EFFICIENCY.

AIM: To conduct sumpner'-s test on similar transformers and determination of combined and individual transformer efficiency.

APPARATUS REQUIRED:

S.no	Particulars	Range	Quantity
1	Voltmeter	MI 0-300V	1 Nos
2	Voltmeter	MI 0-75V	2 Nos
3	Ammeter	MI 0-2A	1 No
4	Ammeter	MI 0-5A	1 No
5	Wattmeter	MI 300V / 5A LPF	1 No
6	Wattmeter	MI 75V/5A UPF	1 No
7	1-phase auto-transformer	230V/0-260V	2 Nos
8	Transformers	1KVA, 230V/115V Single phase, 50Hz	2 Nos
9	Connecting wires	--	Few

THEORY:

        The Sumpner's test is conducted simultaneously on two identical transformers and provides data for finding the efficiency, regulation and the effect of temperature rise.

Operation: The secondary's of the transformer are in phase opposition with switch S_1 closed and switch S_2 open, there will be no circulating current in the loop circuit. It is because the induced emf's in the secondaries are equal and in opposition. The reading of the wattmeter W_1 will be equal to the core losses of two transformers.

W1= core loss of two transformers.

        Now switch S_2 is also closed and output voltage of the regulating transformer is adjusted to fill full load current I_2 flows in the secondary circuit. The full load secondary current will cause full load current I1 in the primary circuit. Note that, full load current are flowing through the primary and secondary windings. The reading of wattmeter W_2 will be equal to the full load copper losses of the two transformers.

W_2= Full load copper losses of two transformer.

Advantages:
1. The power required to carry out the test is small.
2. The transformers are tested under full load conditions.
3. The iron losses and copper losses are measured simultaneously.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Ensure that the position of the auto transformer knob at its zero position.
3. Switch 'ON' the power supply.
4. Slowly, go on varying the auto-transformer knob until the voltmeter shows the rated voltage of the transformer. If the polarities are correct then voltmeter across SPST switch shows zero, otherwise change the polarity of any one of the transformer on secondary side.
5. When voltmeter across SPST switch shows zero reading.
6. Then note down the readings of wattmeter, Voltmeter, ammeter on the primary side of transformer.
7. Then close SPST switch, Then vary the auto transformer knob, connected in secondary side of transformer until ammeter shows its full load current.

8. Then note down the readings of wattmeter, Voltmeter and ammeter on secondary side of transformer.
9. Open the SPST switch and bring the auto transformer to its zero position.
10. Switch OFF the supply.

TABULATION:

S.no	I_0 In Amps	V_0 in Volts	W_0 In Watts	I_{SC} in Amps	V_{SC} in Volts	W_{SC} in Watts

Determination of combined and individual transformer efficiency.

Load	100%	80%	60%	40%	20%
P.F	0.8	0.8	0.8	0.8	0.8
Individual transformer% η					
Combined transformer % η					

CALCULATIONS:

i) Individual Transformer Efficiency:

Core loss of each transformer:

➤ $W_1 = \dfrac{W_0}{2} = $ \qquad\qquad Watts.

Copper loss of each transformer:

➤ $W_2 = \dfrac{W_{SC}}{2} = $ \qquad\qquad Watts.

Full Load Current of Transformer:

➤ $I_L = \dfrac{KVA}{230} \times 10^3 = $ \qquad\qquad Amps.

$$\% \, \eta = \frac{x \times KVA \times 10^3 \times \cos\varphi}{(x \times KVA \times 10^3 \times \cos\varphi) + W_1 + x^2 \, W_2} \times 100$$

Where x- Load factor

ii) **Combined Transformer Efficiency**:

Total core loss = $W_0 = W_1$ _____ Watts.

Total Copper Loss = $W_{sc} = W_2$ _____ Watts.

Full Load Current of Transformer:

- $I_L = \dfrac{KVA}{230} \times 10^3 = $ _____ Amps.

- $\% \eta = \dfrac{x \times KVA \times 10^3 \times \cos\varphi}{(x \times KVA \times 10^3 \times \cos\varphi) + W_1 + x^2 W_2} \times 100$
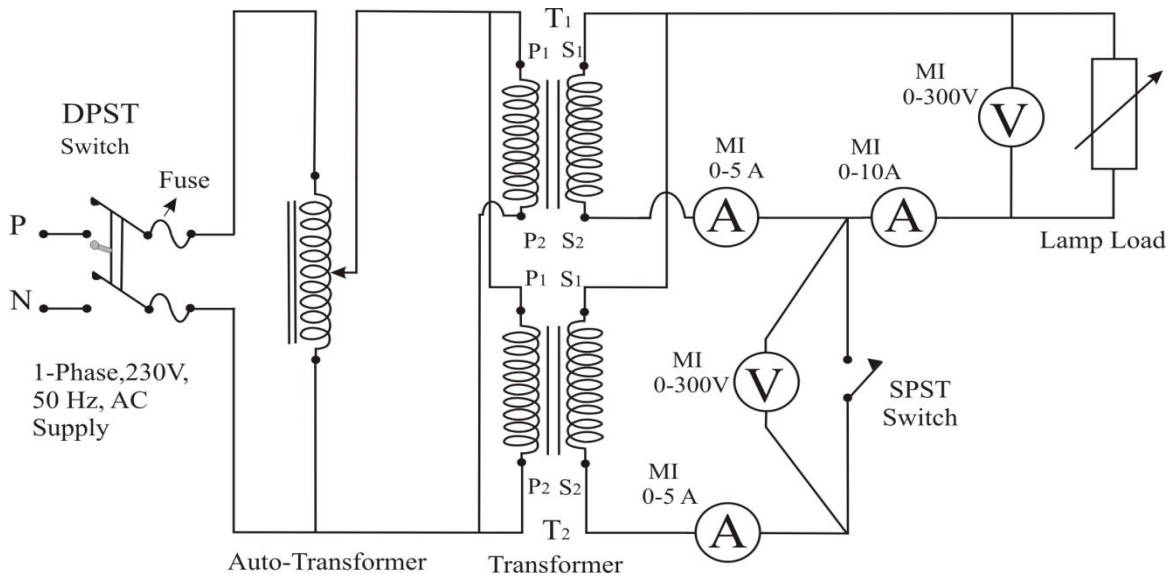
Where x- Load factor

CALCULATIONS:

CONCLUSION:

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CIRCUIT DIAGRAM:

OBSERVATION:

1. KVA rating of the Transformer T_1 = _____KVA
2. Primary voltage of Transformer T_1 = _____V
3. Secondary voltage of Transformer T_1=_____V
4. KVA rating of the Transformer T_2 =_____KVA
5. Primary voltage of Transformer T_2 = _____V
6. Secondary voltage of Transformer T_2 = _____V

TABULATION:

ANALYTICAL VERIFICATION GIVEN THE SHORT CIRCUIT TEST DATA.
Z_a= Impedance of transformer 1= $V_{sc}/I_{sc,}$_____Ω
Z_b= Impedance of transformer 2= V_{sc}/I_{sc}_____ Ω

DETERMINATION OF LOAD SHARING

S.No	I_1	I_2	$I_L=I_1+I_2$	$P=I_LV_L$	$I_1=I_L\dfrac{Z_b}{Z_a+Z_b}$	$I_2=I_L\dfrac{Z_a}{Z_a+Z_b}$	$P_1=P.\dfrac{Z_b}{Z_a+Z_b}$	$P_2=P.\dfrac{Z_a}{Z_a+Z_b}$
	Amps	Amps	Amps	Watts	Amps	Amps	Watts	Watts
1								
2								
3								
4								

EXPT.NO.3   **DATE:**

PARALLEL OPERATION OF TWO DISSIMILAR SINGLE-PHASE TRANSFORMERS OF DIFFERENT KVA AND DETERMINATION OF LOAD SHARING AND ANALYTICAL VERIFICATION GIVEN THE SHORT CIRCUIT TEST DATA.

AIM: Conduct an experiment to understand load sharing by two single phase transformer connected in parallel.

APPARATUS REQUIRED:

S.no	Particulars	Range	Quantity
1	Voltmeter	MI 0-300V	2No
2	Voltmeter	MI 0-600V	1 No
3	Ammeter	MI 0-5/10A	3 No
4	Auto transformer 1-ϕ	230V/0-260V	1 No
5	Transformer	1KVA, 230V/115V Single phase, 50Hz	1 No
6	Transformer	2KVA, 230V/115V Single phase, 50Hz	1 No
7	Connecting wires	--	Few

THEORY:

The secondary emf of the two transformers are equal because they have the same turns ratio and have their primary connected to the same supply.

The transformers are connected in parallel when the load on them is more than the rating of individual transformer, generally smaller units are operated in parallel which share a common load. The parallel operation is advantageous as they can be interchangeable in some conditions for satisfactory. Hence polarity should be carried out for proper operation. The voltage ratio of primary and secondary must be same. The % impedance should be same in magnitude and hence same transformer ratio in order to avoid the circulating current and operating at different power factor.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Ensure that the position of the auto transformer knob at its zero position, and SPST switch in open position.
3. Switch 'ON' the power supply.
4. Give a small voltage using auto transformer and check with some positive voltage. If the polarities are correct then voltmeter across SPST switch shows zero otherwise change the polarities of any one of the transformer on the secondary side.
5. When voltmeter across SPST switch shows zero reading then close SPST switch, apply rated voltage of the transformer.
6. Then go ON varying the load in the steps and at each step note down all meter readings.
7. Repeat this procedure until rated current of the transformer.
8. Bring load on the transformer to zero position, open the SPST switch and auto transformer to its zero position.
9. Switch OFF the supply.
10. Conduct the short circuit test on the two transformers used for the parallel operations & find transformer impedances (Z_a & Z_b).
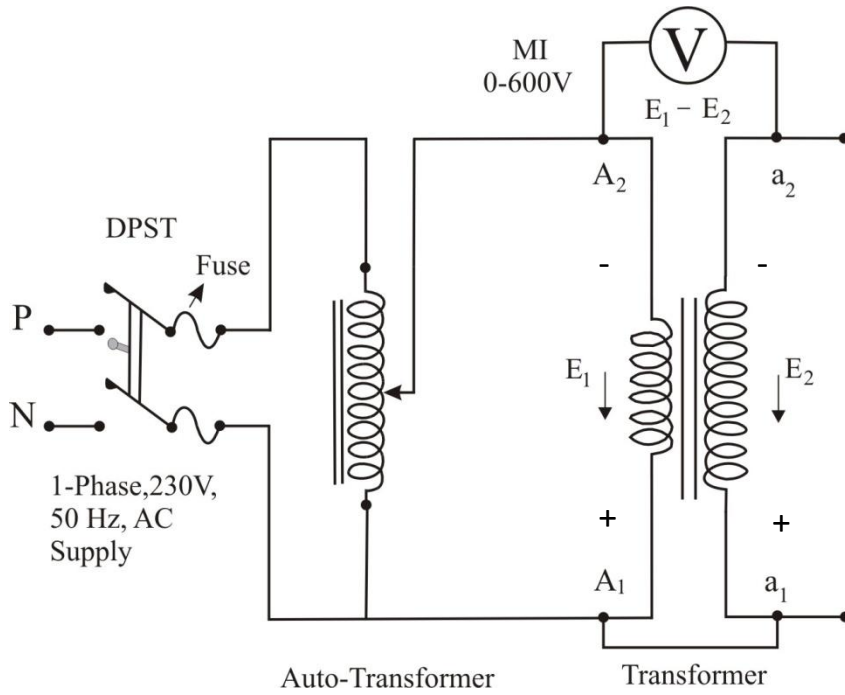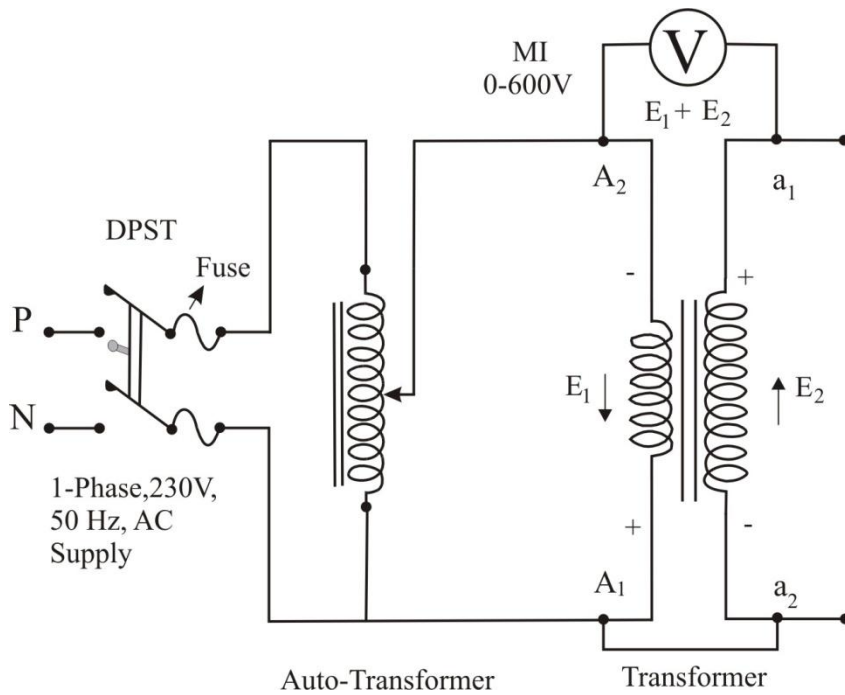
CALCULATIONS:

CONCLUSION:

CALCULATIONS:

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CIRCUIT DIAGRAM:

I. **POLARITY TEST**:

a) **SUBTRACTIVE**:

MI
0-600V

$E_1 - E_2$

A_2 a_2

−   −

DPST

Fuse

P

N

1-Phase,230V,
50 Hz, AC
Supply

$E_1 \downarrow$ $E_2 \downarrow$

+   +

A_1 a_1

Auto-Transformer   Transformer

b) **ADDITIVE**:

MI
0-600V

$E_1 + E_2$

A_2 a_1

−   +

DPST

Fuse

P

N

1-Phase,230V,
50 Hz, AC
Supply

$E_1 \downarrow$ $\uparrow E_2$

+   −

A_1 a_2

Auto-Transformer   Transformer

EXPT.NO.4   **DATE:**

POLARITY TEST AND CONNECTION OF 3 SINGLE-PHASE TRANSFORMERS IN STAR – DELTA AND DETERMINATION OF EFFICIENCY AND REGULATION UNDER BALANCED RESISTIVE LOAD.

AIM: Conduct polarity test on single phase transformer and connection of 3- single phase transformers in star-Delta and determination of efficiency and regulation under balanced resistive loads.

APPARATUS REQUIRED:

S.no	Particulars	Range	Quantity
1	Voltmeter	MI 0-600V	2Nos
2	Ammeter	MI 0-10A	2 Nos
3	3-φ Auto-transformer	415V/0-440V,50Hz	1 No
4	1-φ Auto-transformer	230V/0-260V, 50Hz	1 No
5	1- φ transformer	1KVA, 230V/230V, Single phase, 50Hz.	3 Nos
6	Connecting wires	--	Few

THEORY:

A Star-delta connection of transformer is mainly used in the substation and in transmission line. The main use connection is to step down the voltage. The neutral available on primary side is grounded. It can be seen that there is a phase difference of 30º between primary and secondary line voltages. In this type of connection, primary is connected in star fashion and the secondary is connected in delta fashion.

PROCEDURE:

I. Polarity Test:

1. Connections are made as per the circuit diagram.
2. With Auto-transformer knob at zero position, Switch ON the supply.
3. Slowly vary the Auto-transformer knob and apply rated voltage (230V) on primary side of the Transformer.
4. If Voltmeter reads E_1-E_2 , Then it is subtractive polarity or if voltmeter reads E_1+E_2 , then it is additive polarity.
5. Then mark the respective polarity as A_1, A_2, a_1, and a_2.
6. Bring the Auto-transformer knob to zero position and switch OFF the supply.

II.   Star-Delta Connection:

1. Connections are made as per the circuit diagram.
2. Ensure load on the transformer is in OFF position and position of the auto transformer knob at its zero position.
3. Then switch ON the supply.
4. Slowly go on varying the auto transformer knob until the voltmeter shows the rated voltage on the transformer.
5. Then gradually apply load on the transformer and at each step note down the readings.
6. Bring load on the transformers to zero position.
7. Switch OFF the supply.

STAR-DELTA CONNECTION:
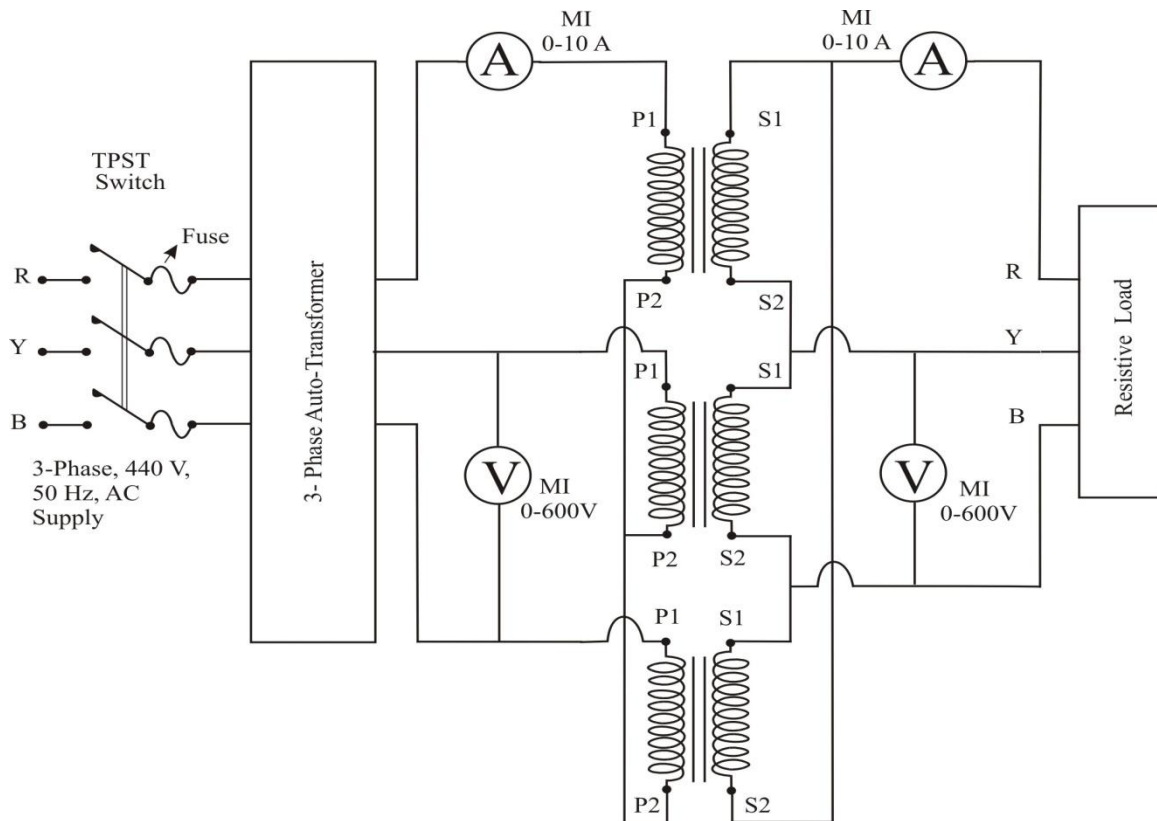
OBSERVATIONS:

1. KVA= _____KVA

2. Primary Voltage =_____V

3. Secondary Voltage =_____V

4. Current =_____ Amps.

5. Phases = __ Phase.

TABULATION:

S.no	Primary side		Secondary side		% η	% R
	V1 in volts	I1 in Amps	V2 in Volts	I2 in Amps		
1						
2						

CONCLUSION:

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EXPT 5   **DATE**
COMPARISON OF PERFORMANCE OF 3 SINGLE-PHASE TRANSFORMERS IN DELTA – DELTA AND V – V (OPEN DELTA) CONNECTION UNDER LOAD.

AIM: comparison of performance of 3 single-phase transformers in delta – delta and v – v (open delta) connection under load.

APPARATUS REQUIRED:

S.no	Particulars	Range	Quantity
1	Voltmeter	MI 0-600V	2Nos
2	Ammeter	MI 0-10A	2 Nos
3	3-φ Auto-transformer	415V/0-440V,50Hz	1 No
4	1-φ Auto-transformer	230V/0-260V, 50Hz	1 No
5	1- φ transformer	1KVA, 230V/230V, Single phase, 50Hz.	3 Nos
6	Connecting wires	--	Few

THEORY:
        As seen previously in connection of three single phase transformers that if one of the transformers is unable to operate then the supply to the load can be continued with the remaining tow transformers at the cost of reduced efficiency. The connection that obtained is called V-V connection or open delta connection.

If one of the transformers fails in Δ - Δ bank and if it is required to continue the supply eventhough at reduced capacity until the transformer which is removed from the bank is repaired or a new one is installed then this type of connection is most suitable.
        When it is anticipated that in future the load increase, then it requires closing of open delta. In such cases open delta connection is preferred.
Key point : It can be noted here that the removal of one of the transformers will not give the total load carried by V - V bank as tow third of the capacity of Δ - Δ bank.
        The load that can be carried by V - V bank is only 57.7% of it. it can be proved as follows.
  It can be seen from the Fig. 2(a)
        Δ - Δ capacity = $\sqrt{3} \, V_L I_L = \sqrt{3} \, V_L (\sqrt{3} \, I_{ph})$
        Δ - Δ capacity = $3 \, V_L I_{ph}$ ....(i)
    It can also be noted from the Fig. 2(b) that the secondary line current I_L is equal to the phase current I_{ph}.
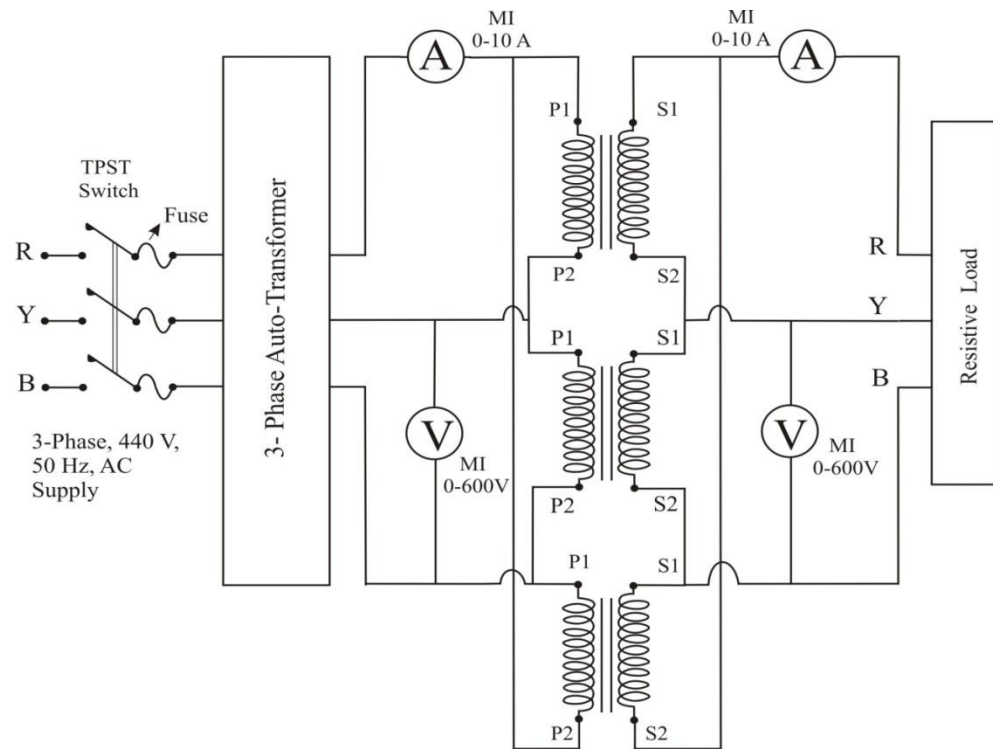   V- V capacity = $\sqrt{3} \, V_L I_L = \sqrt{3} \, V_L I_{ph}$ ....(ii)
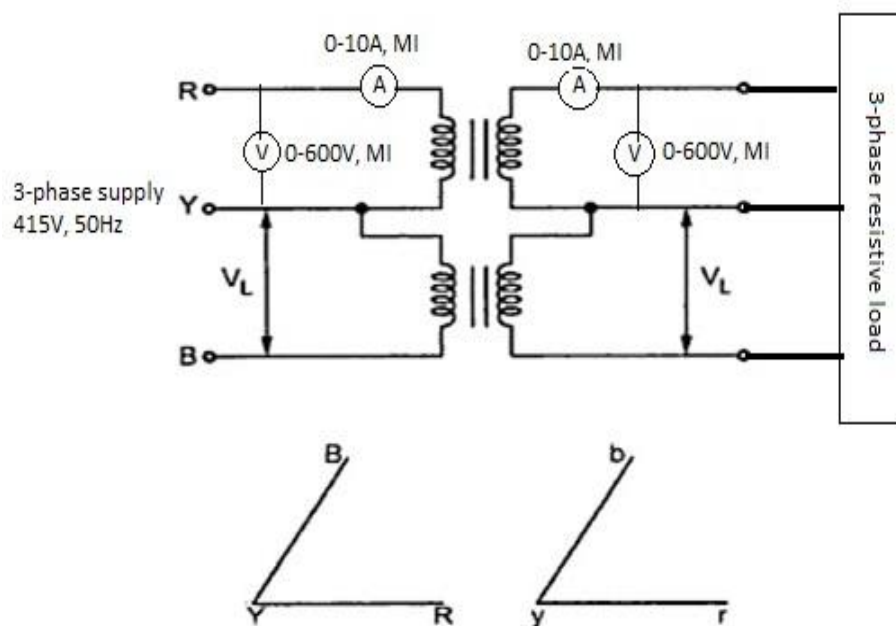   Dividing equation (ii) by equation (i)

$$\frac{V\text{-}V \text{ capacity}}{\Delta\text{-}\Delta \text{ capacity}} = \frac{\sqrt{3} \, V_L I_{ph}}{3 \, V_L I_{ph}} = \frac{1}{\sqrt{3}} = 0.557 \approx 58\% \qquad \dots \text{(iii)}$$

CIRCUIT DIAGRAM:

DELTA- DELTA CONNECTION:

OPEN- DELTA CONNECTION:

THEORY:
TABULATION:(DELTA –DELTA CONNECTION)

S.no	Primary side		Secondary side		% η	% R
	V_1 in volts	I_1 in Amps	V_2 in Volts	I_2 in Amps		
1						
2						

PROCEDURE:

I.   **Delta-Delta Connection:**

1. Connections are made as per the circuit diagram.
2. Ensure load on the transformer is in OFF position and position of the auto transformer knob at its zero position.
3. Then switch ON the supply.
4. Slowly go on varying the auto transformer knob until the voltmeter shows the rated voltage on the transformer.
5. Then gradually apply load on the transformer and at each step note down the readings.
6. Bring load on the transformers to zero position.
7. Switch OFF the supply.

CALCULATION:

$$\% \ \eta = \frac{\text{Output power}}{\text{Input power}} = \frac{V_2 \ I_2}{V_1 \ I_1} \times 100 =$$

$$\% \ \text{Regulation} = \frac{V_{02} \ - \ V_2}{V_{02}} \times 100 =$$

PROCEDURE:

II.   **Open-Delta Connection:**

1. Connections are made as per the circuit diagram.
2. Ensure load on the transformer is in OFF position and position of the auto transformer knob at its zero position.
3. Then switch ON the supply.
4. Slowly go on varying the auto transformer knob until the voltmeter shows the rated voltage on the transformer.
5. Then gradually apply load on the transformer and at each step note down the readings.
6. Bring load on the transformers to zero position.
7. Switch OFF the supply.

TABULATION:(OPEN–DELTA CONNECTION)

S.no	Primary side		Secondary side		% η	% R
	V_1 in volts	I_1 in Amps	V_2 in Volts	I_2 in Amps		
1						
2						

CALCULATION:

$$\% \, \eta = \frac{\text{Output power}}{\text{Input power}} = \frac{V_2 \; I_2}{V_1 \; I_1} \times 100 =$$

$$\% \, \text{Regulation} = \frac{V_{02} - V_2}{V_{02}} * 100 =$$

CONCLUSION:

VIVA VOCE

CIRCUIT DIAGRAM:
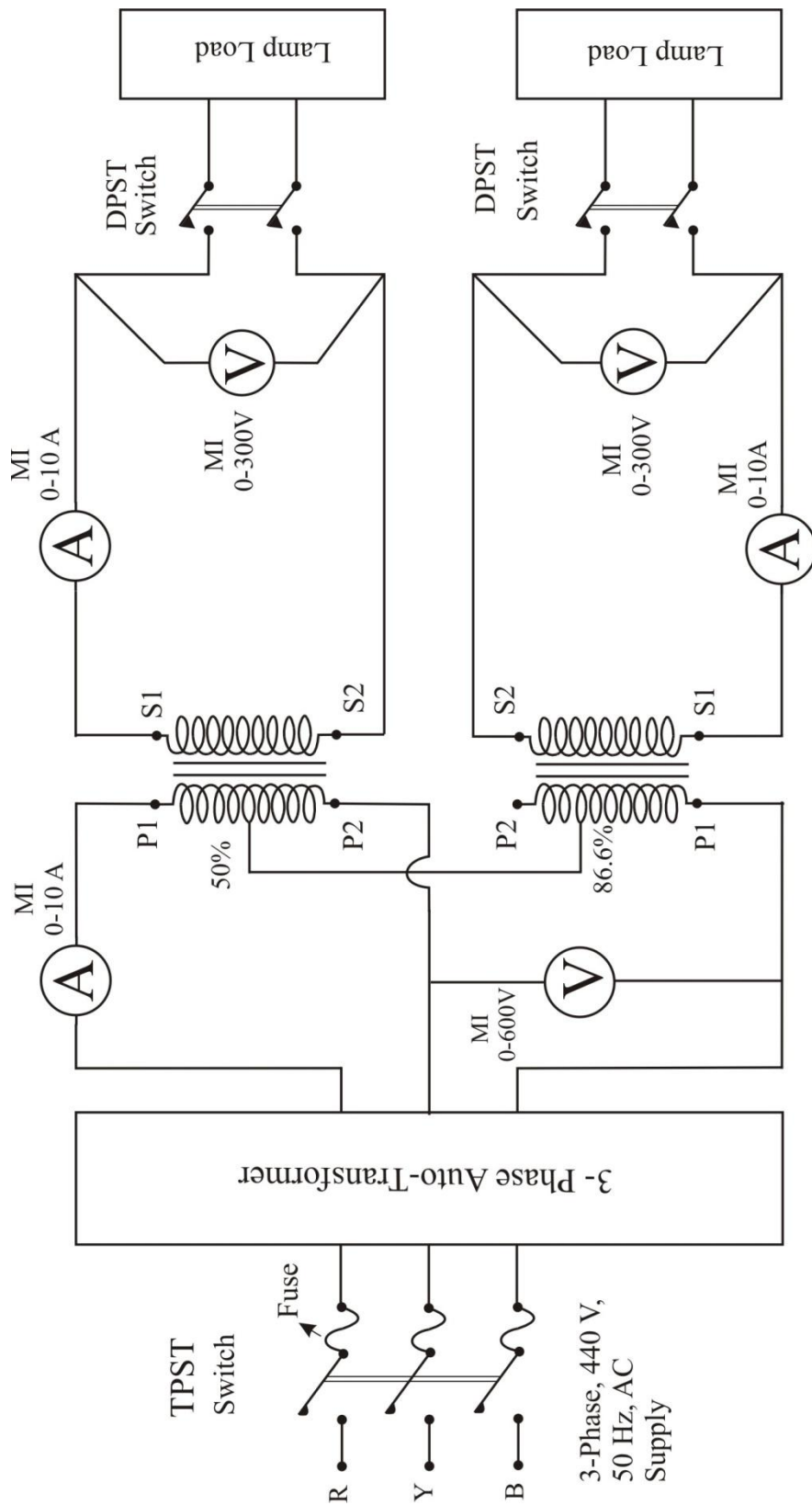
EXPT.NO.6   **DATE:**
   SCOTT CONNECTION WITH BALANCED AND UNBALANCED LOADS

AIM: To determine the load shared by two transformers when they are connected in scott .

APPARATUS REQUIRED:

S.no	Particulars	Range	Quantity
1	Voltmeter	MI 0-300/600V	3 Nos
2	Ammeter	MI 0-10	3 Nos
3	3-ϕ Auto transformer	415V/0-440V	1 Nos
4	Single phase transformers	1KVA, 230V/230V, Single phase, 50Hz	2 Nos
5	Connecting wires	--	Few

THEORY:

The Scott connection is the most common method of connecting two single phase transformers to perform the 3-ϕ to 2-ϕ conversion and vice-versa. The two transformers are connected electrically but not magnetically, one transformer is called main transformer and other is auxiliary or teaser transformer. The main transformer is having 50% tapping and auxiliary transformer is having 86.6% tapping.

   One end of primary winding of the auxiliary transformer is connected to the centre tapping provided on the primary winding of the main transformer with equal number of turns on.

   The voltage per turn is same in primary of both main & teaser transformer with equal number of turn on secondary on both the transformer. The secondary voltage will be equal in magnitude which results in symmetrical & phase system.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Ensure load on the transformer is in OFF position & position of the auto transformer knob at its zero.
3. Switch ON the single phase AC supply.
4. Slowly go on varying the autotransformer until the voltmeter shows on primary the rated (86.6%) voltage of the transformer.
5. Then close the load switch & gradually apply the balanced load on the transformer & at each step note all the meter readings.
6. Repeat the above by applying the unbalanced load on the transformer & note down the meter readings.
7. Bring load on the transformers to zero position & auto transformer knob to zero position.
8. Switch OFF the supply.

TABULATION:

FOR BALANCED LOAD:

S.no	Current I_1 Amps	Current I_{L1} Amps	Current I_{L2} Amps	Voltage V_1 Volts	Voltage V_2 Volts	Lamp load In Watts
1.						
2.						
3.						
4.						

FOR UNBALANCED LOAD:

S.no	Current I_1 Amps	Current I_{L1} Amps	Current I_{L2} Amps	Voltage V_1 Volts	Voltage V_2 Volts	Lamp load In Watts
1.						
2.						
3.						
4.						

CALCULATION:

CONCLUSION:

VIVA VOCE
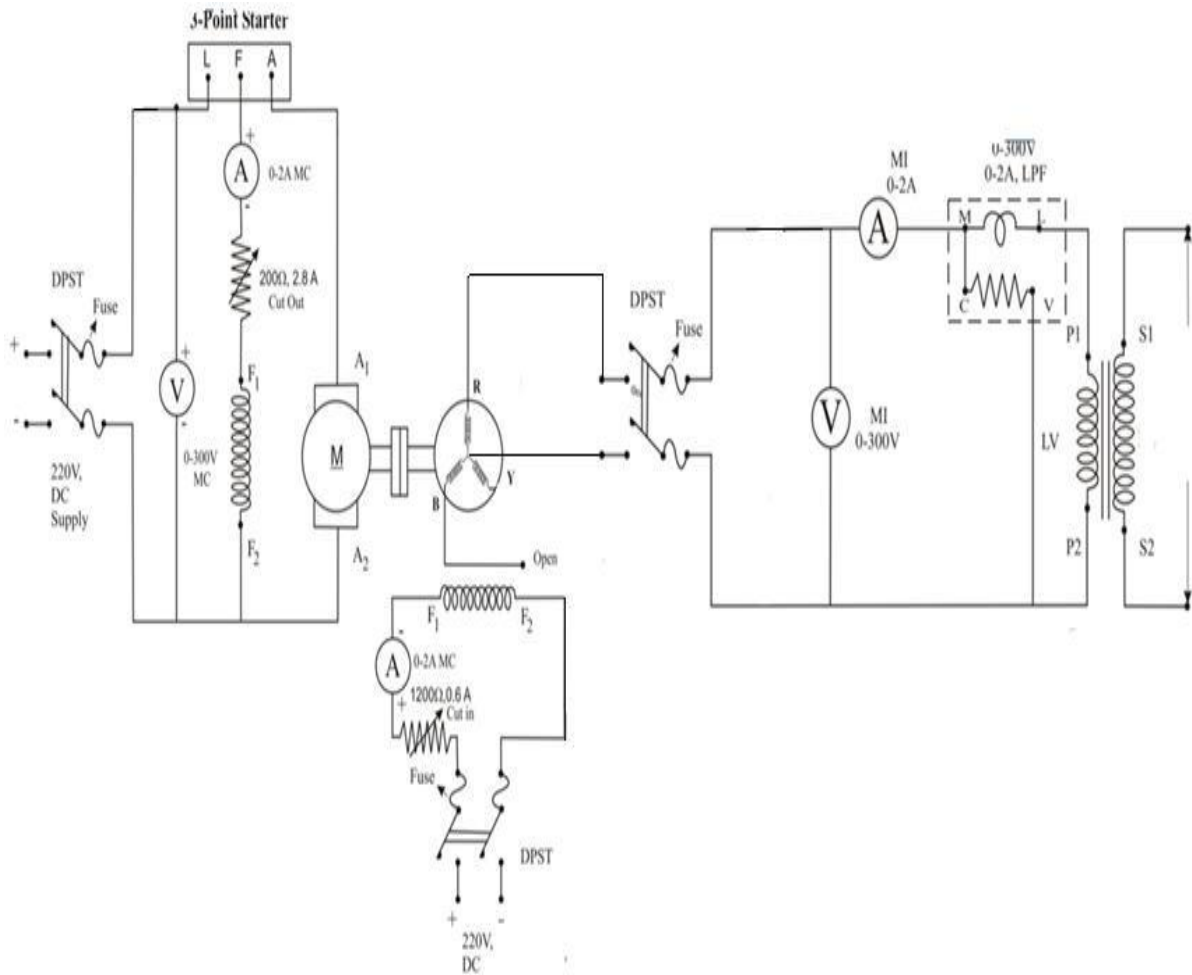
NATURE OF GRAPH:
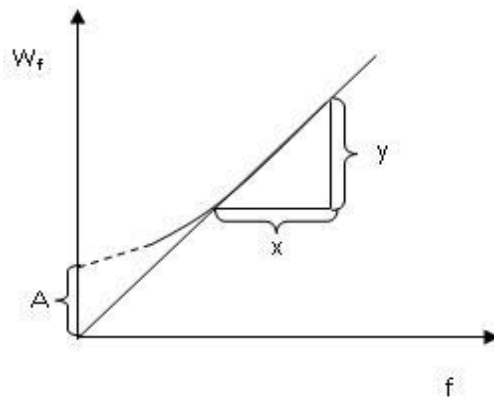
EXPT.NO.7   **DATE:**
SEPARATION OF HYSTERESIS AND EDDY CURRENT LOSSES IN SINGLE PHASE TRANSFORMER.

AIM: To separate the eddy current loss and hysteresis loss from the iron loss of single phase transformer.

APPARATUS REQUIRED:

S.no	Particulars	Range	Quantity
1	Rheostat	1250Ω , 0.8A	
2	Wattmeter	300 V, 5A	
3	Ammeter	(0-2) A	
5	Voltmeter	(0-300) V	
7	Connecting Wires	--	--
8	Transformers	1KVA, 230V/115V Single phase, 50Hz	1 Nos
9	DC Motor coupled with alternator	--	
10	Connecting wires	--	Few

THEORY:

   *Refer: 1) Theory and performance of Electrical Machines, by J.B. Gupta.

   2) A Text book of Electrical Technology, by B.L. Theraja & A.K. Theraja.

PROCEDURE:

1. Connections are given as per the circuit diagram.
2. Supply is given by closing the DPST switch.
3. The DC motor is started by using the 3 point starter and brought to rated speed by adjusting its field rheostat.
4. By varying the alternator field rheostat gradually the rated primary voltage is applied to the transformer.
5. The frequency is varied by varying the motor field rheostat and the readings of frequency are noted and the speed is also measured by using the tachometer.
6. The above procedure is repeated for different frequencies and the readings are tabulated.
7. The motor is switched off by opening the DPST switch after bringing all the rheostats to the initial position

TABULATION:

S.no	Speed in RPM	Frequency in HZ	Voltage V (volts)	Wattmeter reading (Watts)	Iron loss W_i(watts)	W_i/f Joules
1						
2						
3						
4						
5						
6						
7						
8						

FORMULAE USED:

1. Frequency, $f = (P*N_s) / 120$ in Hz P = No.of Poles & Ns = Synchronous speed in rpm.

2. Hysteresis Loss $W_h = A * f$ in Watts A = Constant (obtained from graph)

3. Eddy Current Loss $W_e = B * f^2$ in Watts B = Constant (slope of the tangent drawn to the curve)

4. Iron Loss $W_i = W_h + W_e$ in Watts $W_i / f = A + (B * f)$

Here the Constant A is distance from the origin to the point where the line cuts the Y-axis in the graph between W_i / f and frequency f. The Constant B is $\Delta(W_i / f) / \Delta f$

CALCULATIONS:

CONCLUSION:

VIVA VOCE

CIRCUIT DIAGRAM:

a) For OC Test:

OBSERVATION:

For Motor				For Alternator		
Voltage	:	_____V		Voltage	:	_____V
Current	:	_____Amps.		Current	:	_____Amps.
Power	:	_____KW/HP		Power	:	_____KVA/KW
Speed	:	_____rpm		Speed	:	_____rpm

TABULATION:

a) **For OC Test :**

Sl.no	I_f in Amps	V_{OC} in Volts
1		
2		
3		
4		
5		
6		
7		
8		

EXPT.NO.8   DATE:

VOLTAGE REGULATION OF AN ALTERNATOR BY EMF AND MMF METHODS.

AIM: Determination of regulation of an alternator by EMF method or synchronous impedance method and MMF method or ampere turn method.

APPARATUS REQUIRED:

S.no	Particulars	Range	Quantity
1	Voltmeter	0-300V MC	1 No
2	Voltmeter	0-600V MI	1 No
3	Ammeter	0-2A MC	2 No
4	Ammeter	0-10A MI	1 No
5	Rheostat	200Ω/2.8A	1 No
6	Rheostat	1200Ω/0.6A	1 No
7	Tachometer	--	1 No
8	Connecting wires	--	Few

THEORY:

The KVA ratings of commercial alternators are very high (ex: 500MVA). So, it's not convenient to determine voltage regulation by direct loading. Therefore we have to determine voltage regulation by indirect methods. These methods require very small power as compared to direct loading method. The EMF and MMF methods are indirect methods.

In EMF method, we are determining the armature resistance Ra and synchronous impedance

$$Z_s = \frac{\text{Open circuit voltage}}{\text{short circuit current}}$$

For some selected value of field current I_f. Then we are finding synchronous reactance $X_s = \sqrt{X_s^2 - R_a^2}$. Once know about R_a and X_s draw the phasor diagram for any load and any power factor.

Taking I_a as reference phasor, then I_aR_a drop is in phase with I_a while $I_a X_s$ leads I_a by 90º. The phaser sum of V, I_aR_a and I_aX_s gives the no load emf E_0.
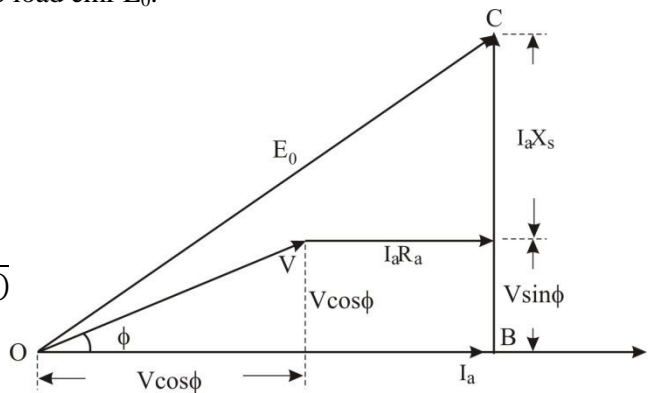
$E_0 = \sqrt{(OB)^2 + (BC)^2}$

Where OB= $V\cos\phi + I_aR_a$
           BC= $V\sin\phi + I_aX_s$

$\therefore E_0 = \sqrt{(V\cos\phi + IaRa)^2 + (V\sin\phi + IaXs)}$

$\therefore \% Voltage\ regulation = \frac{E_0 - V}{V} \times 100$

The main drawback of this method is its approximate method. The reason is the combined effect of X_L (armature reactance) and X_{AR} (reactance of armature reaction) is measured on short circuit. Since current in this condition is almost lagging 90º, the armature reaction will produce its worst demagnetizing effect. This method gives value higher than the value obtained from the actual load test for this reason it is called pessimistic method.

CIRCUIT DIAGRAM:

b) For SC Test:
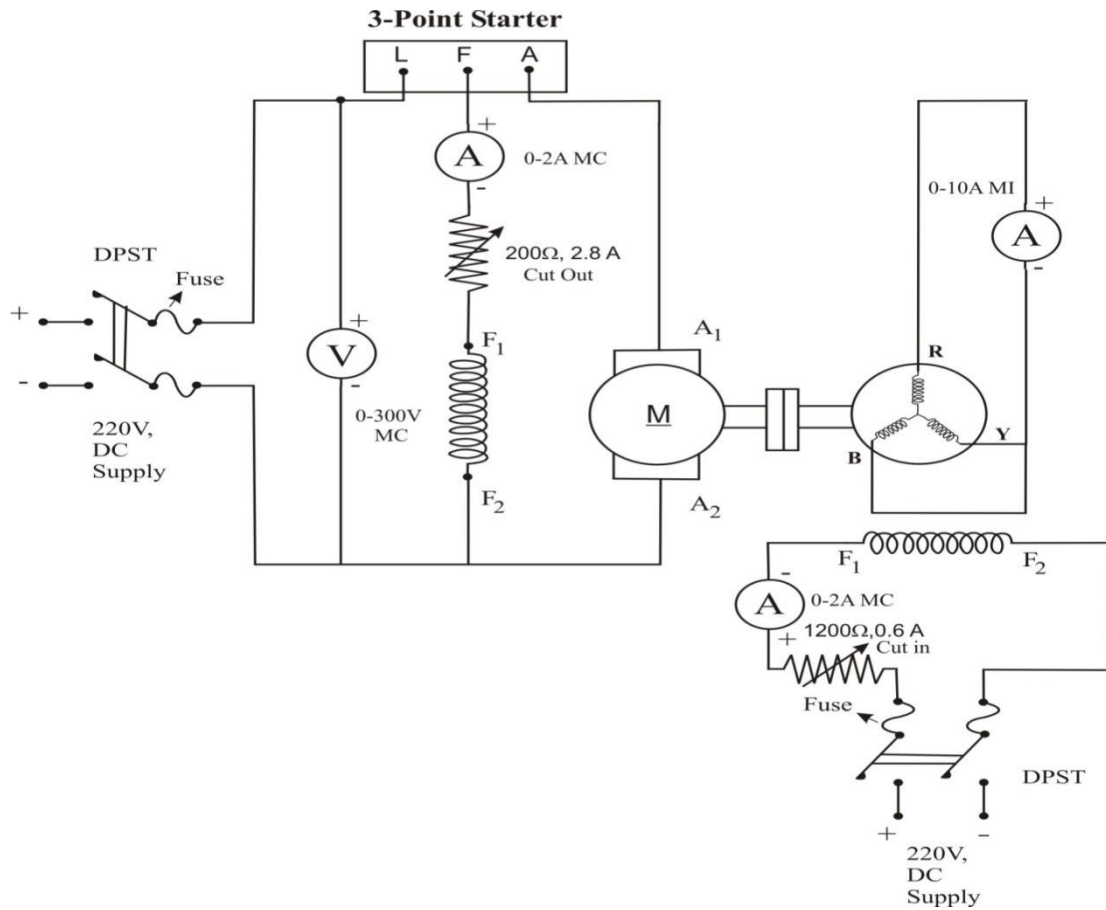
TABULATION:

b) **For SC Test :**

Sl.no	I_{SC} in Amps	I_f in Amps
1		

In MMF method it is assumed that the armature leakage reactance to be additional armature reaction neglecting armature resistance, this method assumes that change in terminal pd on load is due to entirely armature reaction. Same tests (OCC and SC) required for this test also, but interpretation of result only is different.

i) Suppose the alternator is supplying full load current at normal voltage V and ZPF lagging. Then dc field amp-turn required will be those needed to produce normal voltage 'V' Let OA= field AT required to produce the normal voltage 'V' at no load OB_1= field AT required to neutralize the armature reaction, then total field AT required are phasor sum of OA and OB, The OA can be found from OCC and OB_1 can be determined from SCC.

ii)   At full load current of ZPF lead the armature AT are unchanged, since they aid the main field, less field AT is required to produce the given emf

Total field AT, $AB_2=A_0-B_2O$

B_2O=field AT required to neutralize armature reaction. Here A_0 is determined from OCC and B_2O from SCC.

iii)Between zero lagging and zero leading power factors, the armature mmf rotates through 180º
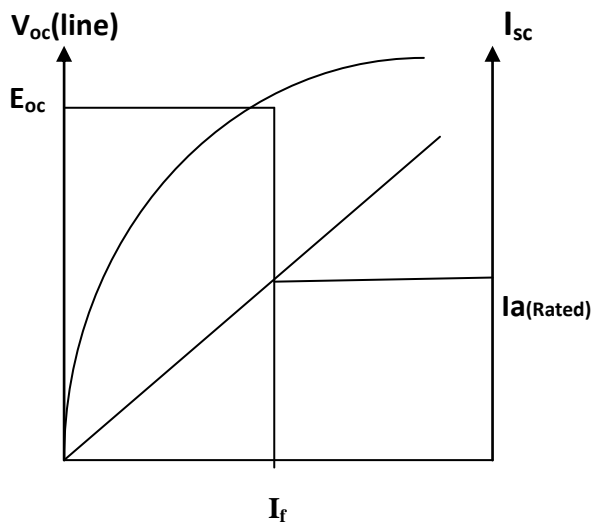At UPF armature reaction is cross magnetizing only. Therefore OB_3 is drawn perpendicular to AO No AB_3 shows the required AT in magnitude and direction.
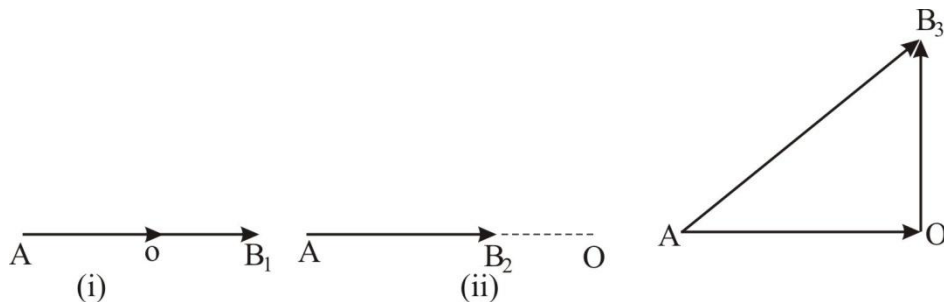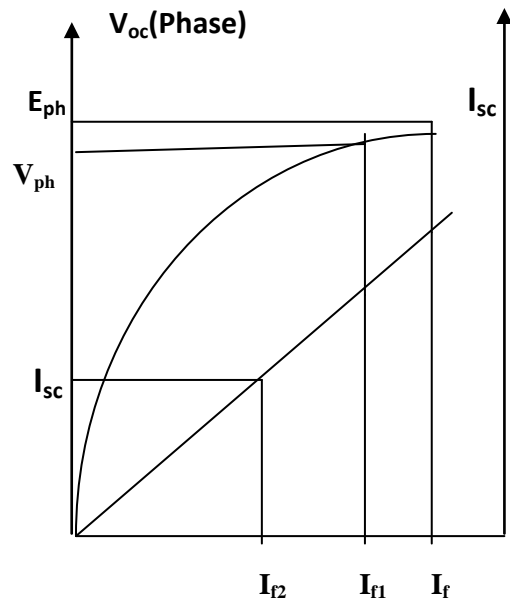

This method gives a regulation lower than actual performance of machine. For this reason it is known as optimistic method.

NATURE OF GRAPH   b) For MMF method

a) For EMF method

PROCEDURE:

A) **Open Circuit Test:**

1. Connections are made as per the circuit diagram.
2. Keep the field rheostat of alternator in cut in position 1200 Ω /0.6A and field Rheostat of motor 200 Ω /2.8A in cut out position.
3. Switch 'ON' the supply by closing the DPST switch.
4. Start the motor with the help of 3-point starter and gradually cut in the field rheostat step-by step to bring motor to the rated speed of alternator.
5. Excite the field of alternator by closing the DPST switch.
6. Go on varying the 1200Ω rheostat and build up the rated voltage across the armature terminals of alternator in steps and at each step note down the reading of voltage across armature and corresponding field current.
7. Reduce current to Zero. And open the DPST switch.
8. Bring all rheostats to original position and switch 'OFF' the supply.

B) **Short Circuit Test:**

1. Connections are made as per the circuit diagram.
2. Keep the field rheostat of alternator in cut in position 1200 Ω /0.6A and field Rheostat of motor (200 Ω /2.8A) in cut out position.
3. Switch 'ON' the supply by closing the DPST switch.
4. Start the motor with the help of 3-point starter and gradually cut in the field rheostat step-by step to bring motor to the rated speed of alternator.
5. Excite the field of alternator by closing the DPST switch.
6. Go on varying the 1200Ω rheostat and build up the rated voltage across the armature terminals of alternator in steps and at each step note down the reading of voltage across armature and corresponding field current.
7. Then note down the reading of field current and also short circuit current.
8. Bring all rheostats to original position and switch 'OFF' the supply.

CALCULATATION:

For EMF method:

Armature resistance between R & B =_____Ω

=

=_____Ω

From the graph:

Synchronous impedance $Z_s = \dfrac{E_{OC}}{I_{SC}}$ =

=_____Ω

Synchronous reactance per phase X$_s$ = $\sqrt{(Z_S)^2 - (Ra^2)}$

$$X_s = \sqrt{(\underline{\quad})^2 - (\underline{\quad})^2}$$

$$X_{s =}\underline{\qquad}\Omega$$

Regulation of an alternator at different power factor can be calculated as follows.

$$E_0 = \sqrt{(Vph\ cos\varphi + Ia\ Ra)^2 + (Vph\ sin\varphi \pm Ia\ Xs)^2}$$

Where $V_{ph} = \dfrac{V_L}{\sqrt{3}} = \underline{\qquad} = \underline{\qquad} V$

Case I: At 0.8 power factor Lagging:

$$E_a = \sqrt{(Vph\ cos\varphi + Ia\ Ra)^2 + (V\ sin\varphi + Ia\ Xs)^2}$$

$$=$$

$$=\underline{\qquad\qquad}$$

Voltage Regulation= $\dfrac{E_0 - Vph}{Vph} \times 100$

$$=\underline{\qquad\qquad} X\ 100$$

$$=\underline{\qquad\qquad}$$

Case II: At 0.8 power factor Leading:

$$E_a = \sqrt{(Vph\ cos\varphi + Ia\ Ra)^2 + (V\ sin\varphi - Ia\ Xs)^2}$$

$$=$$

$$=\underline{\qquad\qquad}$$

Voltage Regulation= $\dfrac{E_0 - Vph}{Vph} \times 100$

$$=\underline{\qquad\qquad} X\ 100$$

$$=\underline{\qquad\qquad}$$

Case III: At Unity power factor:

$$E_a = \sqrt{(Vph\ + Ia\ Ra)^2 + (Ia\ Xs)^2}$$

$$=$$

$$=\underline{\qquad\qquad}$$

Voltage Regulation= $\dfrac{E_0 - Vph}{Vph} \times 100$

$$=\underline{\qquad\qquad} X\ 100$$

= _____

For MMF Method:

Armature resistance = R_a = _____ Ω

V_{oc} /phase = $\frac{V}{\sqrt{3}}$ =

E_{oc} = V_{oc} / phase + I_{sc} R_a cosφ

  =

  =

From graph I_{f1} = _____ I_{f2} = _____

I_f^2 = (I_{f1} + I_{f2}sinφ)^2 + (I_{f2}cosφ)^2 ------- lagging p.f for I_f find $E_{ph(lag)}$ from graph

I_f^2 = (I_{f1} - I_{f2}sinφ)^2 + (I_{f2}cosφ)^2 ------- leading p.f for I_f find $E_{ph(lead)}$ from graph

I_f^2 = (I_{f1})^2 + (I_{f2})^2 ------- Unity p.f for I_f find $E_{ph(upf)}$ from graph

For I_f from graph calculate E_{ph}

Voltage Regulation = (E_{ph}-V_{ph})/ V_{ph} *100

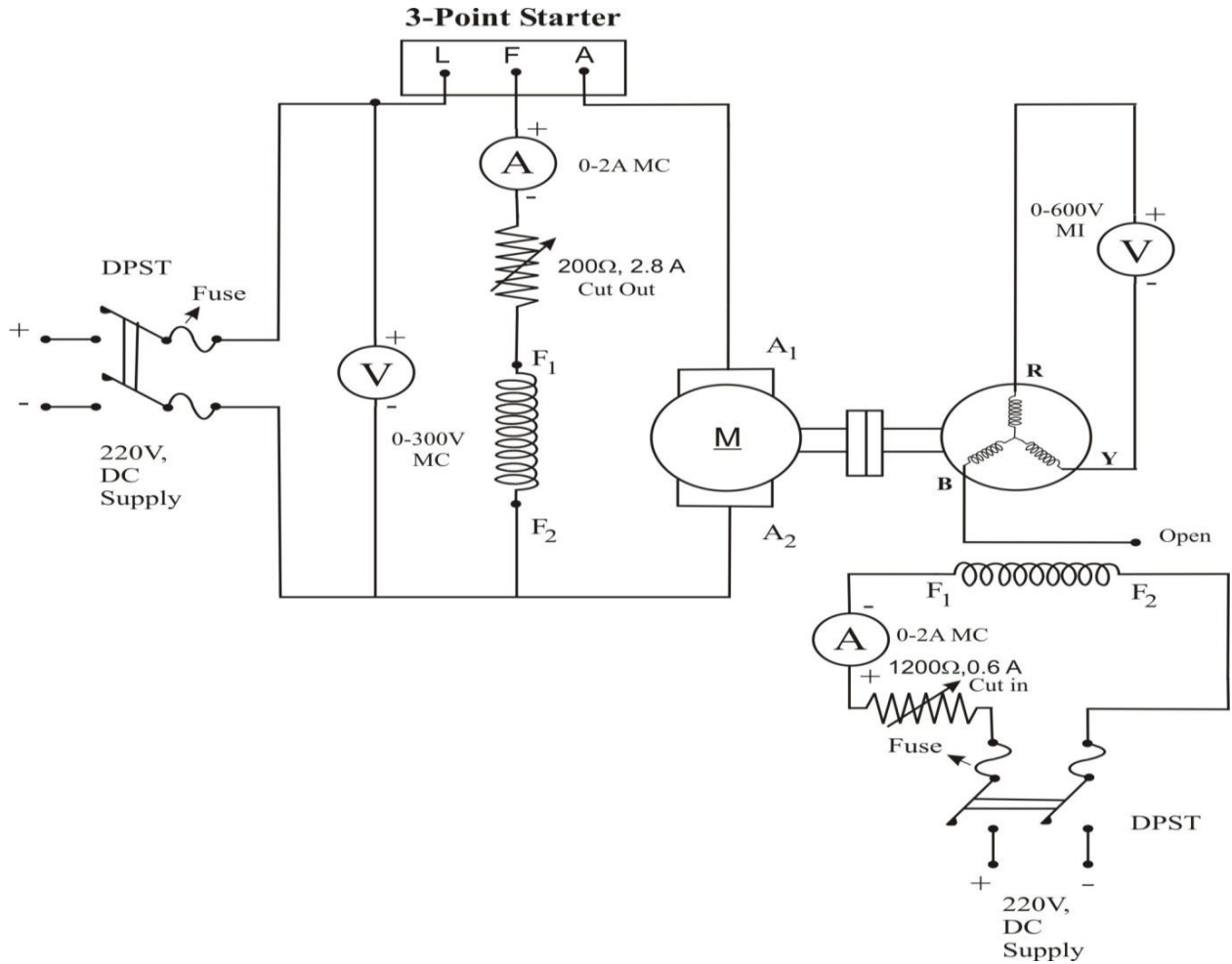Regulation of an alternator at different power factor can be determined as follows.

CALCULATIONS:

CONCLUSION

VIVA VOCE:

CIRCUIT DIAGRAM:

b) <u>For OC Test:</u>

OBSERVATION:

For Motor			For Alternator		
Voltage	:	_____V	Voltage	:	_____V
Current	:	_____Amps.	Current	:	_____Amps.
Power	:	_____KW/HP	Power	:	_____KVA/KW
Speed	:	_____rpm	Speed	:	_____rpm

TABULATION:

a) **For OC Test :**

Sl.no	I_f in Amps	V_{OC} in Volts
1		
2		
3		
4		
5		
6		
7		
8		

EXPT.NO.9   DATE:

REGULATION OF ALTERNATOR BY ZPF METHOD

**AIM:** To determine the regulation of an alternator by potier triangle ZPF method.

APPARATUS REQUIRED:

S.no	Particulars	Range	Quantity
1	Voltmeter	0-300V (MC)	01 No
2	Voltmeter	0-600V (MI)	01 No
3	Ammeter	0-2A (MC)	01 No
4	Ammeter	0-10A (MI)	01 No
5	Rheostat	200Ω/2.8A	01 No
6	Rheostat	1200Ω/0.6A	01 No
7	Connecting wires	--	Few

THEORY:

      The regulation obtained by MMF and EMF methods is based on the total synchronous reactance (The sum of reactance due to armature leakage flux and due to armature reaction effect) This method is based on the separation of reactance due to leakage flux and that due to armature reaction flux. Therefore, it is more accurate method.

      Regulation by this method, the data required are i) Effective resistance of armature winding ii) Open circuit characteristic iii) Field current to circulate full load current in the stator iv) Zero power factor full load voltage characteristics- a curve between terminal voltage and excitation while machine is being run on synchronous speed and delivering full load current at zero power factor.A machine is run at synchronous speed by prime mover. A purely inductive load is connected across the armature terminals and the excitation is raised so as to cause flow of full load armature current. The value of reactance is increased in such a way that the excitation current is adjusted to a value that causes full load rated armature current. The armature terminal voltages are varied from 125% to 25% of rated voltage in steps, maintaining speed and rated armature current constant throughout the test. The curve is drawn between terminal voltage and excitation current, gives the zero power factor lagging characteristics. There is a definite relationship between zero power factor lagging characteristics and an open circuit characteristics of an alternator. The ZPF characteristic curve is of exactly of same shape as the OCC but it is shifted vertically downward by leakage reactance drop IX_L and horizontally by the armature reaction MMF.

NATURE OF GRAPH
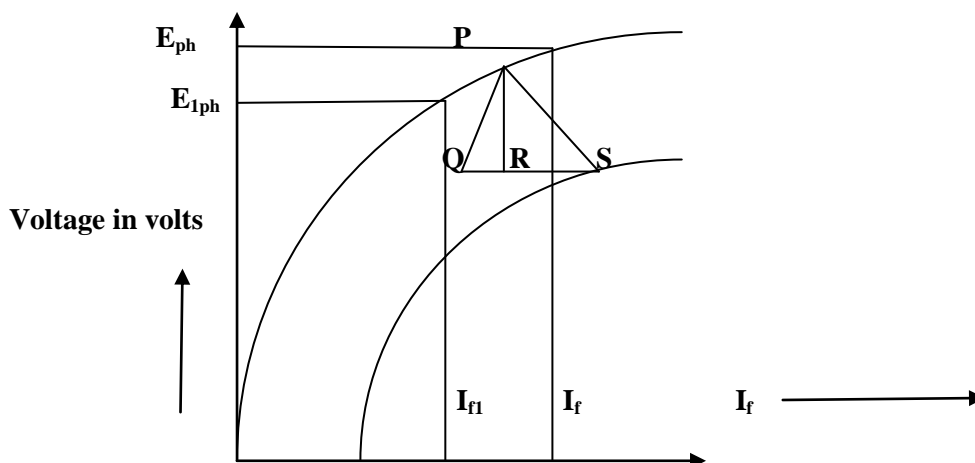
CIRCUIT DIAGRAM:

b) For SC Test:
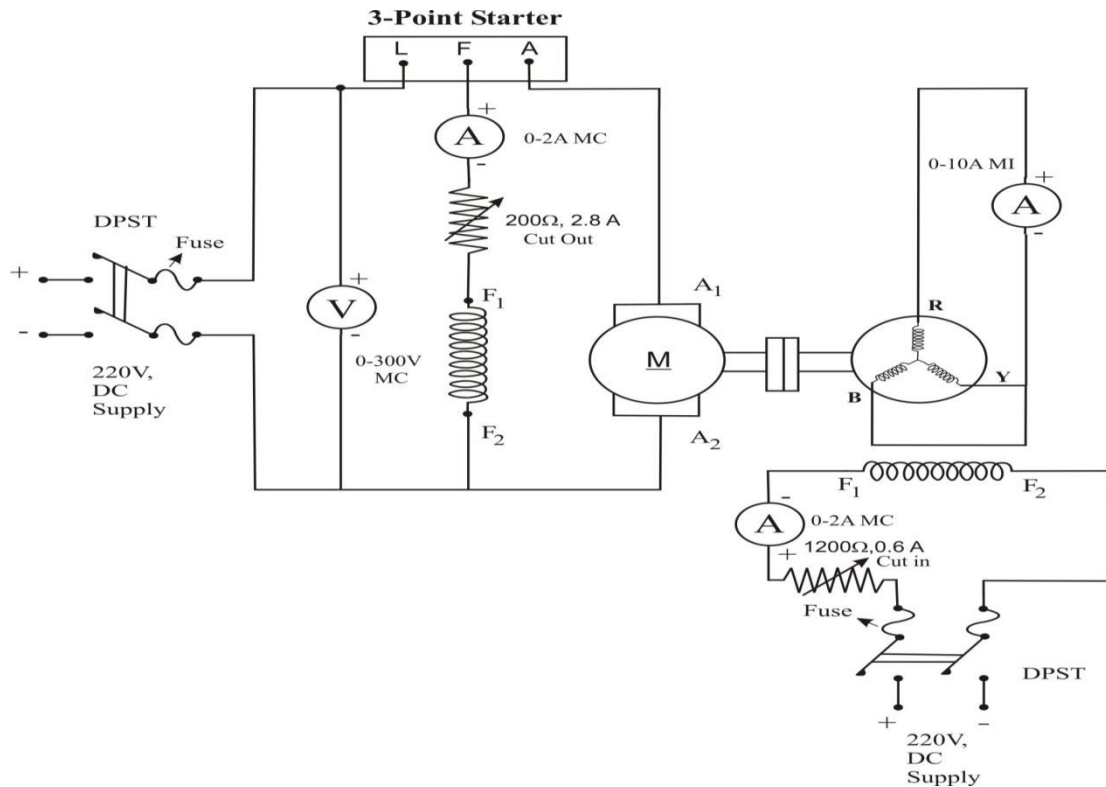
TABULATION:

b) **For SC Test :**

Sl.no	I_{SC} in Amps	I_f in Amps
1		

PROCEDURE:

A) **Open Circuit Test:**
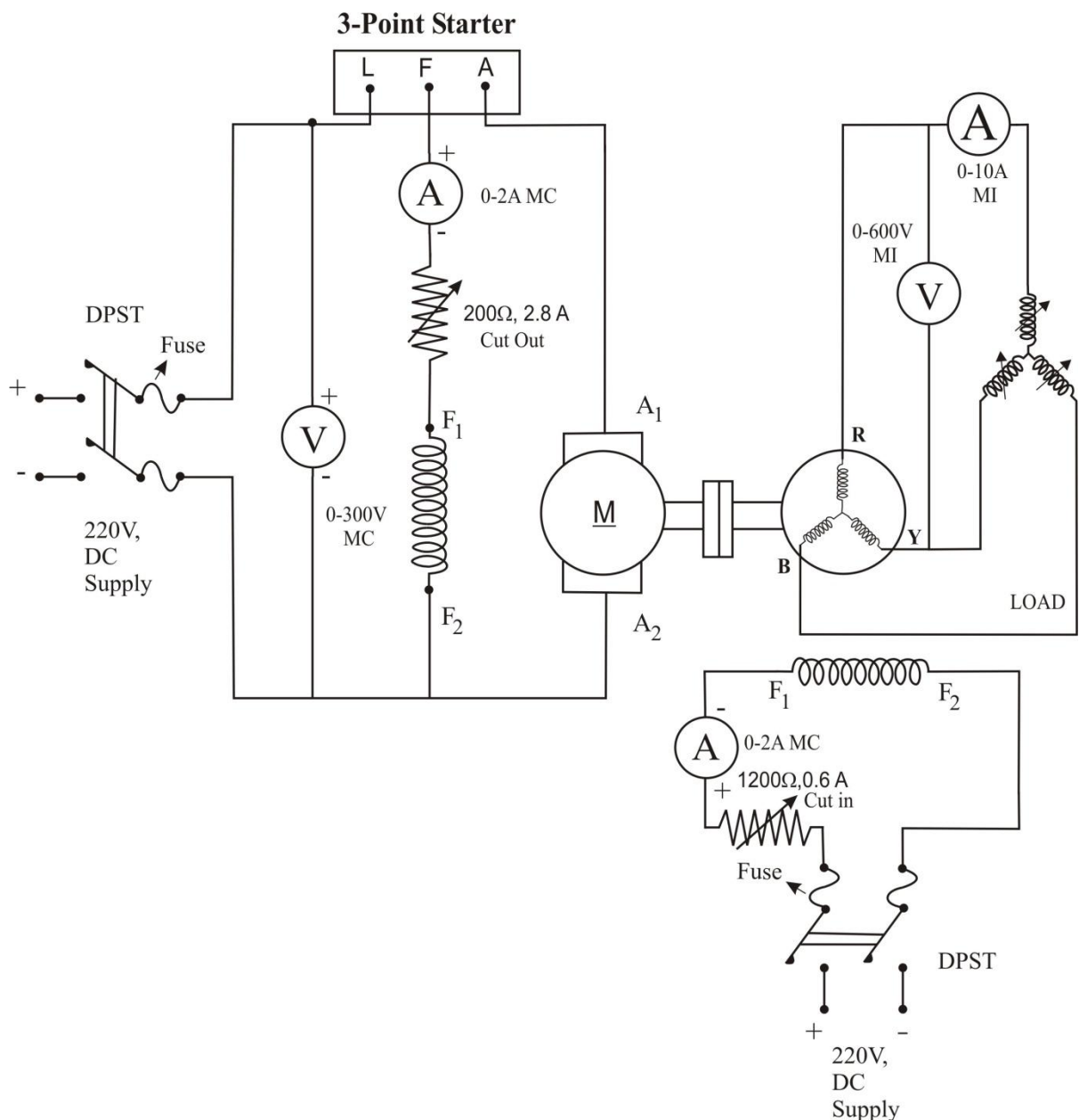
1. Connections are made as per the circuit diagram.
2. Keep the field rheostat of alternator in cut in position 1200 Ω /0.6A and field Rheostat of motor 200 Ω /2.8A in cut out position.
3. Switch 'ON' the supply by closing the DPST switch.
4. Start the motor with the help of 3-point starter and gradually cut in the field rheostat step-by step to bring motor to the rated speed of alternator.
5. Excite the field of alternator by closing the DPST switch.
6. Go on varying the 1200Ω rheostat and build up the rated voltage across the armature terminals of alternator in steps and at each step note down the reading of voltage across armature and corresponding field current.
7. Reduce current to Zero. And open the DPST switch.
8. Bring all rheostats to original position and switch 'OFF' the supply.

B) Short Circuit Test:

1. Connections are made as per the circuit diagram.
2. Keep the field rheostat of alternator in cut in position 1200 Ω /0.6A and field Rheostat of motor (200 Ω /2.8A) in cut out position.
3. Switch 'ON' the supply by closing the DPST switch.
4. Start the motor with the help of 3-point starter and gradually cut in the field rheostat step-by step to bring motor to the rated speed of alternator.
5. Excite the field of alternator by closing the DPST switch.
6. Go on varying the 1200Ω rheostat and build up the rated voltage across the armature terminals of alternator in steps and at each step note down the reading of voltage across armature and corresponding field current.
7. Then note down the reading of field current and also short circuit current.
8. Bring all rheostats to original position and switch 'OFF' the supply.

CIRCUIT DIAGRAM:

C) For ZPF Test:

TABULATION:
   a) **For ZPF Test:**

Sl.no	I_f in Amps	Terminal Voltage V
1		

C) Zero Power Factor Method:

1. Connections are made as per the circuit diagram.
2. Keep the field rheostat of an alternator in cut-in position (1200Ω/0.6A).and rheostat (200Ω/2.8A) of motor in cut out position.
3. Switch ON the power supply, by closing the DPST switch.
4. Start the motor with the help of 3 point starter and gradually cut in the field rheostat step by step to bring the motor to rated speed.
5. Excite the field of alternator by closing the DPST switch.
6. With the zero reactance load vary the excitation current of the alternator until the generated voltage reaches rated value.
7. Slowly vary the reactance load in steps until the rated armature current and note down the values of excitation.
8. Bring all rheostats to their original position and switch OFF the supply.

CALCULATIONS:

From potier triangle PQR, the armature leakage reactance drop is L(RS)
$I_{ph}*X_{Lph}= L(RS)*scale$

Case 1)
 Find $(E_{1ph})^2=(V_{ph}cos\Phi)^2+(V_{ph}sin\Phi+ I_{ph}*X_{Lph})^2$
From OCC corresponding I_{f1} is calculated
   From potier triangle ,field current balancing armature reaction is L(PS)
   $I_{f2}=L(PS)*Scale$
    Add I_{f1} & I_{f2} to get I_f
   Find
   $I_f^2=(I_{f1}+ I_{f2}sin\varphi)^2+(I_{f2}cos\varphi)^2$------- lagging p.f
   $I_f^2=(I_{f1}- I_{f2}sin\varphi)^2+(I_{f2}cos\varphi)^2$------- leading p.f
   $I_f^2=(I_{f1})^2+(I_{f2})^2$------- Unity p.f
   For I_f from graph calculate E_{ph}
   Voltage Regulation=$(E_{ph}-V_{ph})/ V_{ph}$ *100

CALCULATIONS:

CONCLUSION:
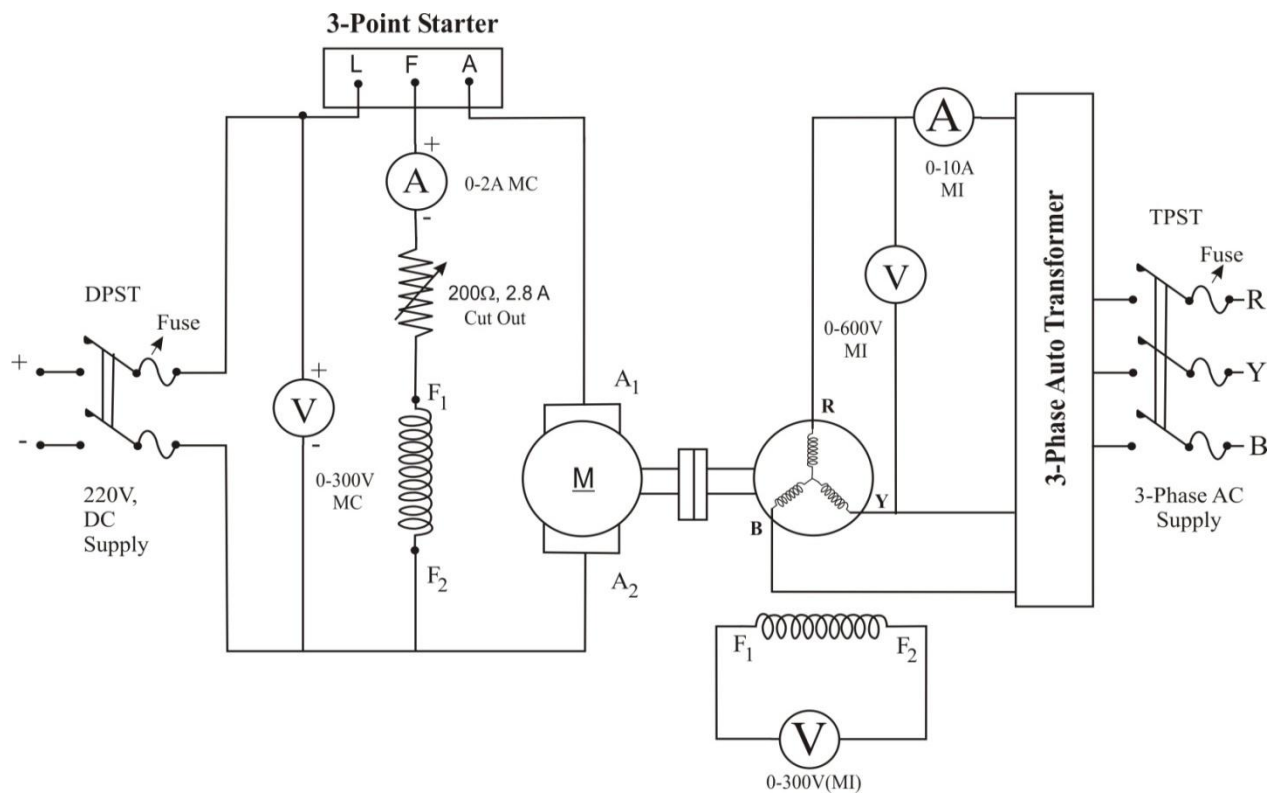
VIVA VOCE:

CIRCUIT DIAGRAM:

3-Point Starter

OBSERVATION:

	For Motor			For Alternator	
Voltage	:	_____V	Voltage	:	_____V
Current	:	_____Amps.	Current	:	_____Amps.
Power	:	_____KW/HP	Power	:	_____KVA/KW
Speed	:	_____rpm	Speed	:	_____rpm
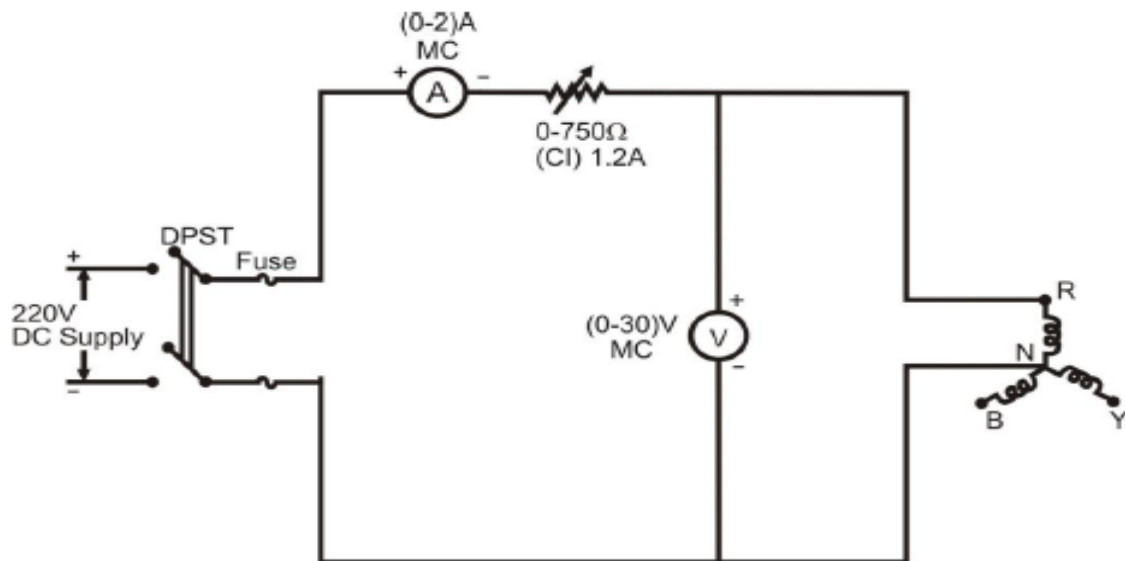
DETERMINATION OF ARMATURE RESISTANCE.

EXPT.NO.10   **DATE:**

SLIP TEST – MEASUREMENT OF DIRECT AND QUADRATURE AXIS REACTANCE AND PREDETERMINATION OF REGULATION OF SALIENT POLE SYNCHRONOUS MACHINES.

AIM: Determination of component of direct axis reactance (X_d) and quadrature component of reactance (X_q) of salient pole generator & Regulation.

APPARATUS REQUIRED:

| S.no	Particulars	Range	Quantity
1	Voltmeter	0-300V (MI)	2 Nos
2	Voltmeter	0-300V (MC)	1 No
3	Voltmeter	0-600V (MI)	1 No
4	Ammeter	0-2A (MC)	1 No
5	Ammeter	0-10A (MI)	1 No
6	Rheostat	200Ω,2.8A	1 No
7	3-φ auto transformer	415V/0-440V,10A	1 No
6	Tachometer	--	1 No
7	Connecting wires	--	Few

THEORY:

A salient pole synchronous machine has non uniform air gap, due to which its reactance varies with rotor position. Thus salient pole machine possesses two axis of geometric symmetry i) field pole axis, or d-axis or direct axis ii) Axis passing through the centers of interpolar space called the quadrature axis or q-axis. Where as in cylindrical rotor machine only one axis of symmetry (Pole axis or d-axis) in salient pole machines X_q= 0.6 to 0.7 times X_d. Where as in cylindrical rotor machine X_d= X_q.

The value of X_d and X_q are determined by applying balanced reduced voltage say V volts to an excited machine at a speed little less than synchronous speed (The slip is less than 1%).
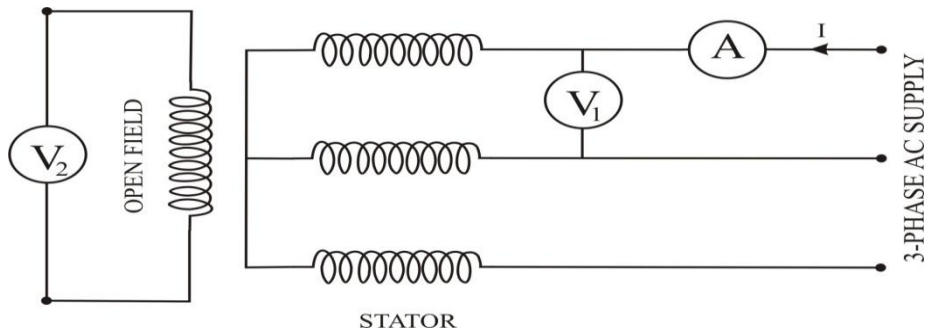
TABULATION:

Sl.No	V_{max} in Volts	V_{min} in Volts	I_{max} in Amps	I_{min} in Amps	X_d	X_q	%Regulation	
							0.8(lag)	0.8(Lead)

CALCULATIONS:

Determination of Stator Resistance (R_a)

a. Connections are made as shown in the circuit diagram (9.b).

b. By keeping rheostat in cut-in position the supply switch (S_1) is closed. Rheostat is adjusted to any value of current (say 1A)

c. All the meter readings are noted down.

d. The supply switch (S_1) is opened.

NOTE: Field of the alternator is kept opened.

Calculation

V = Rated phase Voltage, Volt

I = Rated current, Ampere.

X_d = Vmax / Imin =............... Ω

X_q = Vmin / Imax =............... Ω

For 0.8 p.f lagging

$Cos\Phi = 0.8$

$Sin\Phi = 0.6$

Therefore $\Phi = 36.86$

$tan\theta = (V \sin \Phi \pm I X_q) / (V \cos \Phi + I R_a)$ (Note: + $\rightarrow$ lag , - $\rightarrow$ lead)

$\theta = tan_{-1} ((V \sin \Phi \pm I X_q) / (V \cos \Phi + I R_a))$

Therefore $\alpha = \theta - \Phi$

Therefore

E_o/phase = (V cos α $\pm$ I_d .X_d + I_q. R_a) Volt

Where I_q = I cos θ

I_d = I sin θ

Therefore

Regulation %R=$(E_0-V/V)*100$

The applied voltage to armature, armature current and voltage induced in the field winding are measured by oscillographs. Due to voltage V applied to the stator terminals a current I will flow causing a stator mmf. This stator mmf moves slowly, relative to the poles and induces an emf in the field circuit in the similar fashion to that of rotor in an Induction motor at slip frequency. The effect will be that the stator mmf will move slowly relative to the poles. The physical poles and the armature reaction mmf are alternately in phase and out, the change occurring at slip frequency. When the axis of pole and axis of armature reaction mmf wave coincide the armature mmf acts through the field magnetic circuit. The voltage applied to the armature is then equal to drop caused by direct component of armature reaction and leakage reactance. When the armature reaction mmf is in quadrature with the field poles the applied voltage is equal to the leakage reaction drop plus the equivalent voltage drop of cross magnetizing field component. From the oscillograph record:

$$X_d = \frac{Maximum \quad voltage}{Minimum \quad current}$$

$$X_q = \frac{Minimum \quad voltage}{Maximum \quad current}$$
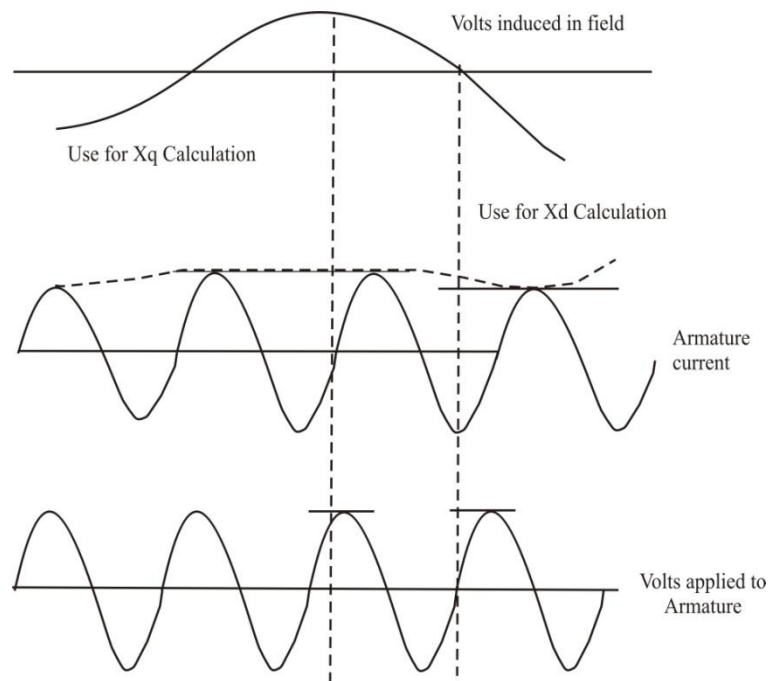
PROCEDURE:

1. Connections are made as per the circuit diagram.

2. Keep the field rheostat (200Ω, 2.8A) in Cut-out position and auto transformer at zero value. Keep the field of an alternator as open circuited.

3. Switch ON the power supply to DC motor by closing DPST switch.

4. Start the motor with the help of 3-point starter and gradually cut in the field rheostat step by step to bring the motor to its speed less than synchronous.

5. Switch ON the 3-phase power supply to auto transformer, gradually increase the voltage to the armature winding of an alternator up to about 25% of the rated value.

6. Note down the max and min value of voltage in rotor and armature current.

7. Bring all the rheostats to their original position and switch OFF the supply.

CONCLUSION:

VIVA VOCE:

CIRCUIT DIAGRAM:
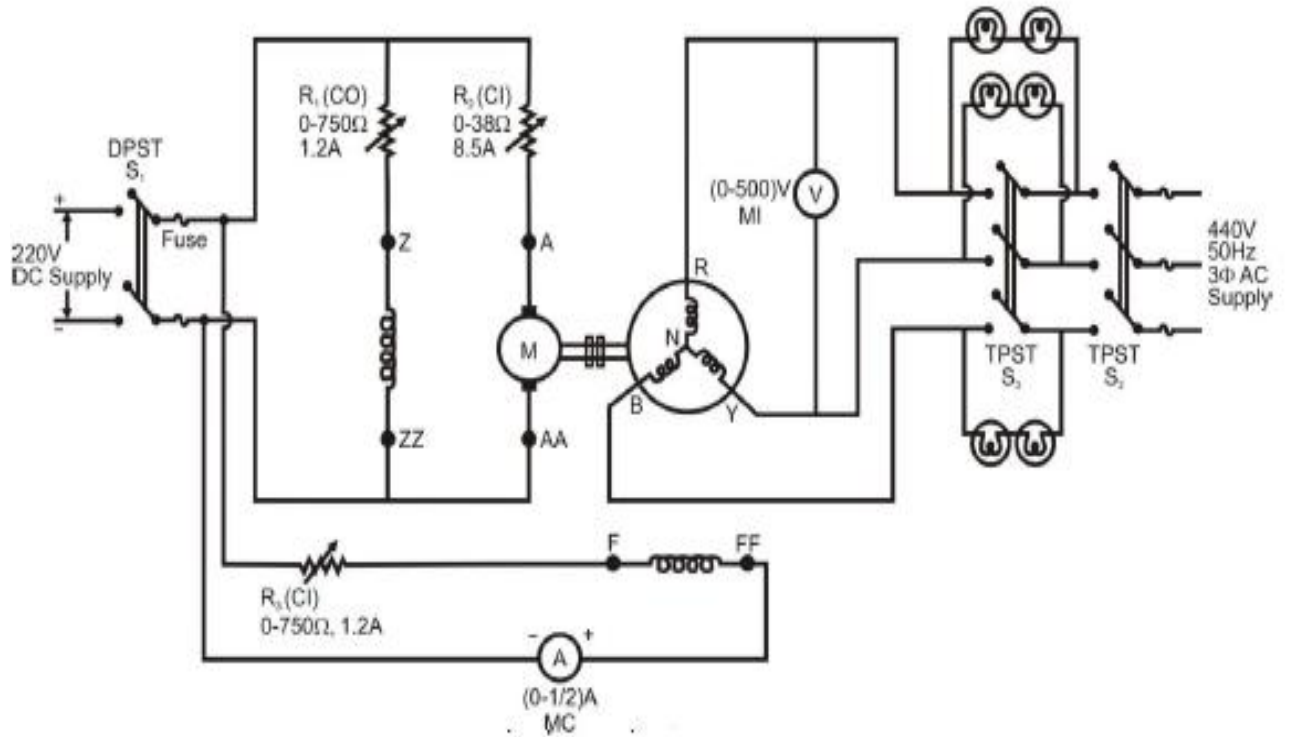
SYNCHRONIZATION OF ALTERNATOR TO INFINITE BUS BAR

OBSERVATION:

For Motor			For Alternator		
Voltage	:	_____V	Voltage	:	_____V
Current	:	_____Amps.	Current	:	_____Amps.
Power	:	_____KW/HP	Power	:	_____KVA/KW
Speed	:	_____rpm	Speed	:	_____rpm

EXPT NO 11   **DATE:**
SYNCHRONIZATION & PERFORMANCE OF SYNCHRONOUS GENERATOR CONNECTED TO INFINITE BUS, UNDER CONSTANT POWER AND VARIABLE EXCITATION & VICE - VERSA.

AIM: To operate the Alternator on
- Infinite Bus.
- Constant Power and Variable Excitation.
- Variable Excitation and Constant Power.

APPARATUS REQUIRED:

S.no	Particulars	Range	Quantity
1	Voltmeter	0 – 500 V (MI)	2 Nos
5	Ammeter	Ammeters 0-1/2A MC 0-5/10A MI	1 No
6	Rheostat	0-750Ω,1.2A(2) 0-38Ω,8.5A(1)	2+1 No
7	Wattmeter	10/20A,0 – 600 V LPF	2 No
6	Tachometer	--	1 No
7	Connecting wires	--	Few

PROCEDURE
a. Operation on Infinite Bus Bar
1. Connections are made as shown in the circuit diagram (4.a)
2. Keeping the rheostat **R1** in the field circuit of motor in **cut-out** position, the rheostat **R2** in the armature circuit of motor and the rheostat **R3** in the field circuit of alternator in **cut-in** positions, the bus bar switch **(S2)** and synchronizing switch (**S3**) in **open** positions, the supply switch **(S1)** is closed.
3. The motor is brought to the synchronous speed of the alternator by gradually cutting out the rheostat R2 and cutting in the rheostat R1, if necessary. By gradually cutting out the rheostat R3, the alternator voltage is built-up to the bus bar voltage.
4. Now, bus bar switch (S2) is closed, and the phase sequence is verified. For correct phase sequence, all the lamps will flicker simultaneously. Otherwise, they flicker alternately. If they flicker alternatively, the bus bar voltage switch is opened and any two terminals of the bus bar supply are interchanged.
5. Repeat step number 2, 3 and 4.
6. By varying the rheostats R1, R2 and R3 the dark period of the lamps are obtained.
7. When all the lamps are in dark condition, the synchronization switch S3 is closed and now the alternator is connected in parallel with the bus bar.
8. Switches (S3) and (S2) are opened; all the rheostats are brought back to their respective initial positions, and supply switch (S1) is opened.

CIRCUIT DIAGRAM:
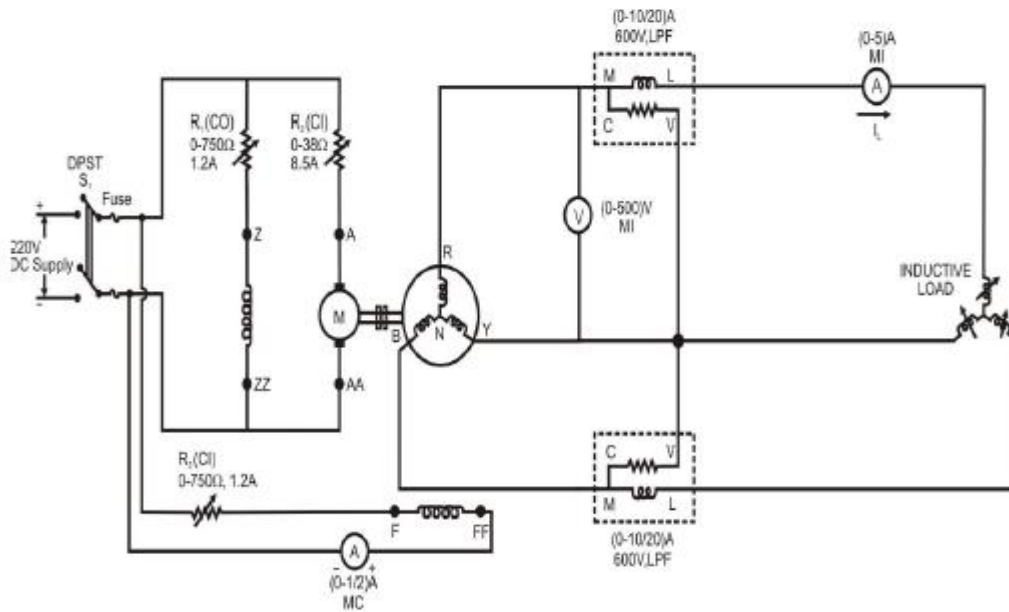
CONSTANT POWER - VARIABLE EXCITATION & VICE-VERSA

b. Constant Power - Variable Excitation Operation
1. Connections are made as shown in the circuit diagram (4.b)
2. Follow the procedure steps 2, 3.
3. By gradually cutting out the rheostat R3, the alternator voltage is built-up to its rated voltage.
4. Apply load gradually.
5. Vary generator excitation (R3) to keep wattmeter readings constant (Total Power).
6. Tabulate the readings.
7. Bring back the load to zero, reduce the excitation to a normal value and all rheostats are brought back to respective initial positions & supply switch (S1) is opened.

c. Constant Excitation - Variable Power Operation
1. Connections are made as shown in the circuit diagram (4.b)
2. Follow the procedure steps 2, 3.
3. By gradually cutting out the rheostat R3, the alternator voltage is built-up to its rated voltage.
4. Apply load in steps & note down all meter readings (Excitation should be constant By adjusting the speed of the Motor).
5. Bring back the load to zero, reduce the excitation to a normal value and all Rheostats are brought back to respective initial positions & supply switch (S1) is opened.

TABULAR COLUMN

1. Constant Power - Variable Excitation Operation

Sl. No.	If(A)	Power(W1+W2)	Speed (RPM)	Voltage (V)	IL (A)

2. Constant Excitation - Variable Power Operation

Sl. No.	If(A)	Power(W1+W2)	Speed (RPM)	Voltage (V)	IL (A)

CALCULATIONS:

CONCLUSION:

VIVA VOCE:

VIVA VOCE:

EXPT NO 12   **DATE:**
POWER ANGLE CURVE OF SYNCHRONOUS GENERATOR

AIM: **TO STUDY THE POWER ANGLE CURVE OF SYNCHRONOUS GENERATOR**

APPARATUS REQUIRED:

SN	Particulars	Range	Type	Quantity
1	Voltmeters	0-30V	MC	01
		0-500V	MI	01
2	Ammeters	0-10/20A	MI	01
		0-1/2A	MC	01
3	Rheostats	0-750 ohm, 1.2A	-	02
		0-38 ohm, 8.5A		01
4	Tachometer	-	-	01

PROCEDURE

    a. **Open circuit test**

        1. Connections are made as shown in the circuit diagram 13.a

        2. Keeping the rheostat R1 in the field circuit of motor in cut-out position, the rheostat R2 in the armature circuit of the motor and the rheostat R3 in the field of the alternator in cut-in positions and TPST (S2) in open position, the supply switch (S1) is closed

        3. The motor is brought to synchronous speed by cutting out the rheostat R2 and then by cutting in the rheostat R1, if necessary.

        4. By gradually cutting out the rheostat R3, the readings of ammeter (A1, 0-2A) and voltmeter (V) are noted down.

        5. The above step is continued until voltmeter reads about 1.25 times the rated voltage of the alternator.

    b. **Short circuit test**

    1. The rheostat R3 is brought to its initial position (cut-in) and TPST (S2) is closed.

    2. By gradually cutting out the rheostat R3, reading of the ammeter (A2, 0-10/20A) is adjusted to the rated current of the alternator and the corresponding field current (A1) is noted down.

3. All the rheostats are brought back to their respective initial positions, TPST switch(S2) and supply switch (S1) are opened.
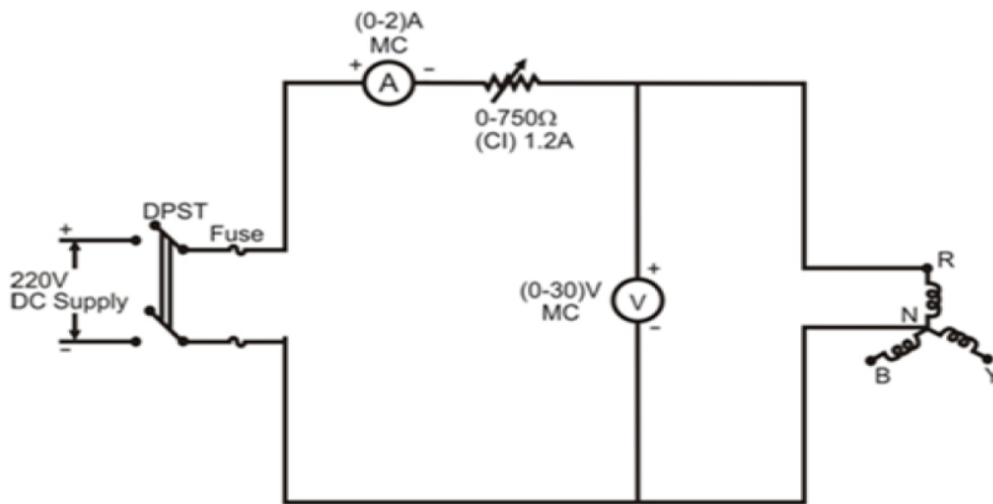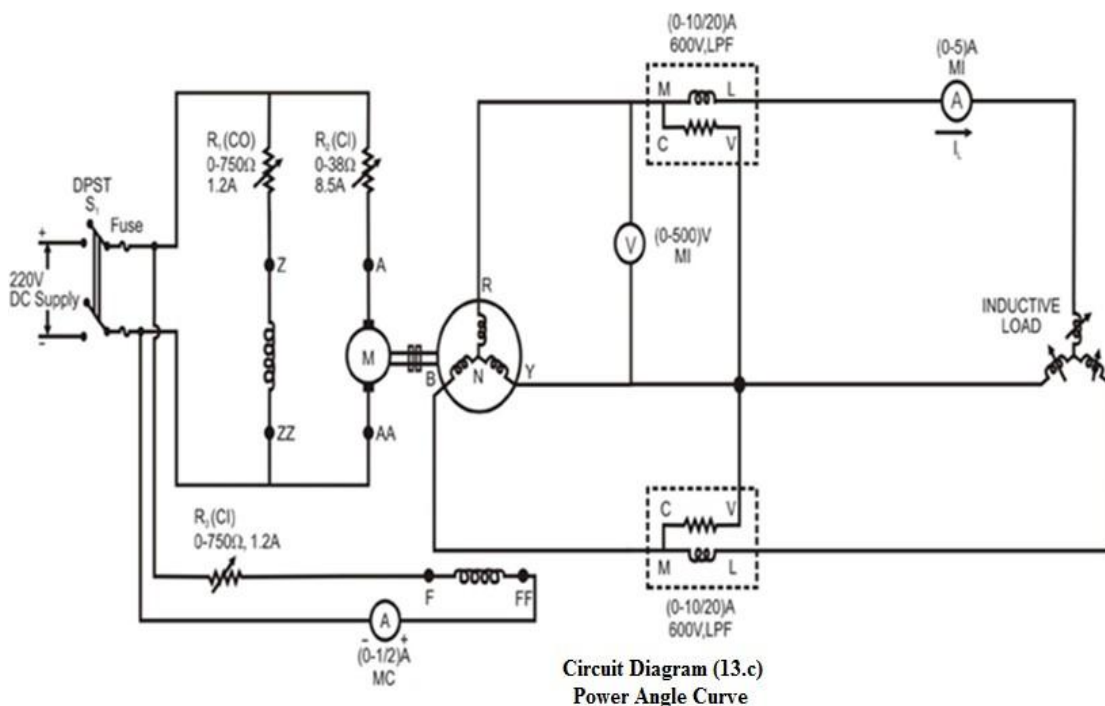

Fig. Determination of armature resistance

Determination of Stator Resistance of Alternator (R_a)

Sl.No	V (Volts)	I (Ampere)	Resistance $R_{DC} = V/I$ Ω	Resistance $R_{AC} = 1.5*R_{DC}$

Circuit Diagram (13.c)
Power Angle Curve

Determination of Armature Resistance (R_a) by V-I Method

1. Connections are made as shown in the circuit diagram (13.b)
2. Keeping the rheostat in cut-in position, the supply switch (S_1) is closed,
   Rheostat is adjusted to any value of current (say 1A) and the readings
   of ammeter and voltmeter are noted down.
3. The supply switch (S_1) is opened.
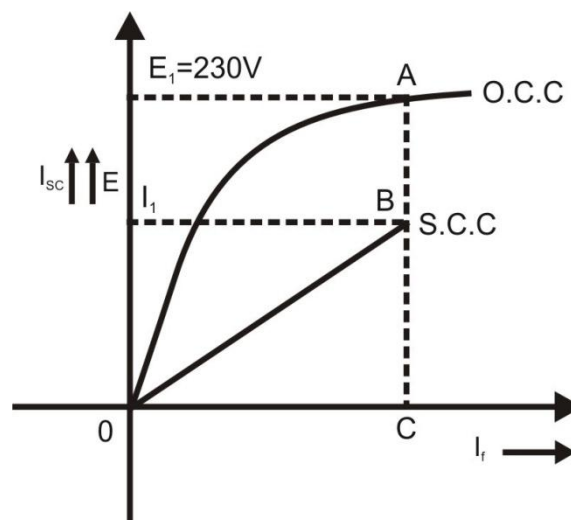
Power angle curve

1. Connections are made as shown in the circuit diagram (13.c)
2. Follow the procedure steps 2, 3 of procedure (a).
3. By gradually cutting out the rheostat R3, the alternator voltage is built-up to its rated voltage.
4. Apply load in steps & note down all meter readings (Excitation should be constant by adjusting the speed of the Motor).
5. Bring back the load to zero, reduce the excitation to a normal value and all rheostats are brought back to respective initial positions & supply switch (S1) is opened.
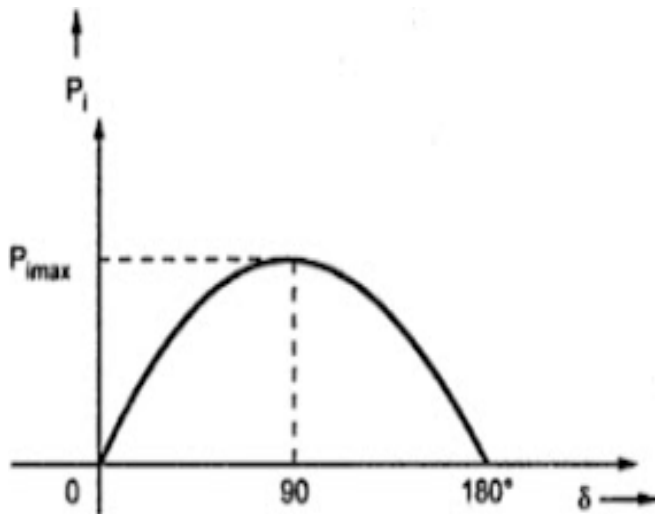
CALCULATION

EMF Method

1. Draw OCC and SCC for suitable scales as shown in model graph no (1).
2. Mark a point A on the OCC corresponding to the rated voltage and draw a Perpendicular so that it cuts SCC line at a point B and X-axis at point C.
3. Corresponding to point A, E1 is the open circuit voltage per phase, and BC is the Short circuit current.
4. Therefore Synchronous impedance per phase Z_s = E1/I1Ω (If Constant) Synchronous reactance per phase $X_s = \sqrt{Z_s^2 - R_a^2}\ \Omega$

Model Graph

Sl. No.	If (Amps)	Ia (Amps)	W1 x K1 (Watt)	W2 x K2 (Watt)	N (rpm)	|V| (Volts)	|E| (Volts)	P = W1 + W2 (Watt)	δ Degree

Model Graph

CONCLUSION:

VIVA VOCE:

VIVA VOCE:

VIVA VOCE of all experiments..

Note: Write down the viva voce related to all experiments in the page provided at the end of respective experiment.

1. Define Transformer?
2. Mention different classifications of Transformer?
3. Give the constructional details of the core & winding part of the transformer,
4. Compare core type & shell type transformers.
5. Power transformer are designed to give good
    a. all day efficiency b) power efficiency
6. Distribution transformer are designed to give good
    a. all day efficiency b) power efficiency
7. Transformer is "Constant flux Machine" True/False, Justify
8. Give the classification of transformers in details.
9. Draw the phasor diagram for single phase transformer considering,
    a. Resistive Load b) Inductive Load c) Capacitive Load
10. Draw the Exact & approximate Equivalent Electric Circuit of single phase transformer
11. What do you mean by the term "Voltage Regulation of Transformer?
12. Give the expression for the Voltage regulation in terms of approximate voltage drop.
13. Give the condition for maximum power efficiency of the transformer, Use the condition to decide the KVA load to be applied on the transformer to give maximum efficiency.
14. Give the comparison between Power efficiency & Energy efficiency.
15. Give the importance of Energy efficiency in case of Distribution Transformer & that of Power efficiency in case of Power transformer.
16. Mention & justify the conditions for parallel operation of the transformers.
17. Write the expressions for power shared by two unequal voltage ratios transformer.
18. What is zero voltage regulation, Give the condition for the same?
19. What do you mean by Testing of transformers, why is it required?
20. Give the comparison between OC, SC & Back to Back Test.
21. What do you mean by predetermination of Efficiency & Regulation of transformers?
22. Give the procedural details of finding efficiency & regulation of the transformers at different load condition.
23. Write the voltage current relationships at primary & secondary of star Delta transformer.
24. Mention the applications where 2-phase supply is required, Explain how 3-phase to 2-phase conversion is achieved in case of Scott connection.
25. How are alternators classified?
26. Name the types of alternator based on their rotor construction.
27. Why do cylindrical alternators operate wth steam turbines?
28. Which type of synchronous generators are used in hydro-electric plants and why?
29. What are the advantages of salient pole type construction used for synchronous machines?
30. Why is stator core of alternator laminated?
31. How does electrical degree differ from mechanical degree?
32. What is distributed winding?
33. Why short pitch s preferred over full pitch winding?

34. Define winding factor.
35. Why alternators rated in KVA and not in MW?
36. What are the causes of changes in voltage in alternators when loaded?
37. What you meant by armature reaction in alternators/
38. What is meant by synchronous impedance of a alternator?
39. What you mean by synchronous reactance ?
40. What is meant by load angle of an alternator?
41. Upon what factor does load angle depend?
42. Define the terminal voltage of alternator.
43. What is the necessesity for predetermination of voltage regulation?
44. How synchronous impedance is calculated from OCC and SCC?
45. Why is EMF method called as pessimistic method?
46. In what way does ampere turn method differ from emf method?
47. State the conditions to be satisfied before connecting two alternators in parallel.
48. How synchronous cope is used for synchronizing alternators?
49. List the factors that affect the load sharing in parallel operating generators?
50. How the change in excitation does affect the load sharing?
51. What is meant by infinite bus bars?
52. Why MMF method is called as optimistic method?
53. Why is the resistance of field winding of a d.c shunt generator kept low?
54. What will happen if a d.c machine is operated below the rated speed?
55. What do you understand by the external characteristics of a d.c generator?
56. What you mean by V and inverted V curve of synchronous motor.