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# 1. Verification of Ohms Law , KVL and KCL

**Aim:**

To verify Ohm's law, KCL and KVL for the given Circuit Diagrams.

**Apparatus Required:**

| S.No | Apparatus | Range | Quantity |
|---|---|---|---|
| 1. | DC voltage source | 0-20V | 1 No. |
| 2. | Resistor | 1KΩ,220KΩ,33KΩ | 3 No. |
| 3. | Ammeter | 0 - 200mA | 1 No. |
| 4. | Voltmeter | 0 - 20V | 1 No. |
| 5. | Connecting wires | | Required. |

**Theory:**

**Ohm's Law:**

Ohm's law states that, "At constant temperature current flowing through the conductor is directly proportional to the potential difference existing between the two ends of the conductor. i.e.,

$$V \propto I$$
$$V = \text{Constant} * I$$

Where
V is the potential difference across the conductor in volts,
I is the current flowing through the conductor in amps

The constant of proportionality = R

Where R is the resistance of the conductor in Ohms.

**Circuit Diagram:**

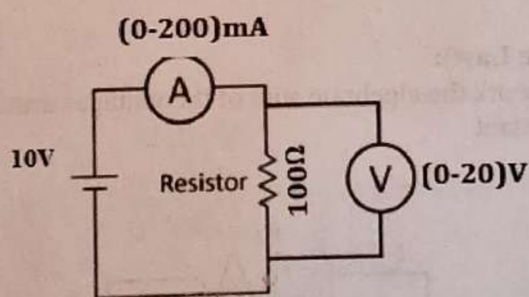



**Fig.1**

**Procedure:**

1. Connect the circuit as shown as in figure 1 with $R_1$
2. Adjust the voltage in steps of 3 volts from 0-20V
3. Record the measured voltage and current in each steps
4. Repeat steps2 and 3 for $R_2$
5. Plot the V – I Characteristics of $R_1$ and $R_2$

**Observations:**

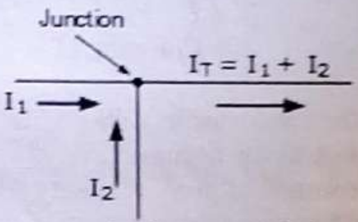
| S.No | Source Voltage (Volts) | $R_1$ (Ohms) | I (mA) | |
|---|---|---|---|---|
| | | | Calculated(V/R) | Measured |
| 1 | 10V | 100Ω | 0.1A | 0.1A |
| 2 | 20V | 100Ω | 0.2A | 0.2A |
| 3 | 5V | 100Ω | 0.05A | 0.05A |
| 4 | 15V | 100Ω | 0.15A | 0.15A |
| | | | | |

## 1. KCL(Kirchoff'sCurrent Law):

Kirchoff's Current Law states that the sum of the currents flowing towards a node is equal to the sum of current flowing away from that node. i.e in any network, the algebraic sum of currents in all the branches meeting at a node is zero.

$$\Sigma I = 0$$

This idea by Kirchhoff is commonly known as the **Conservation of Charge** , as the current is conserved around the junction with no loss of current.



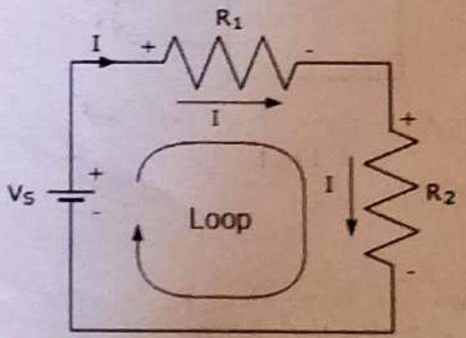

Here in this simple single junction example, the current $I_T$ leaving the junction is the algebraic sum of the two currents, $I_1$and $I_2$ entering the same junction. That is $I_T = I_1 + I_2$.

Note that we could also write this alternatively as the algebraic sum of: $I_T - (I_1 + I_2) = 0$.

## 2. KVL(Kirchoff's Voltage Law):

In any linear, bilateral network the algebraic sum of the voltages around any closed path or closed circuit isalways zero at any instant

**A Single Circuit Loop**




Kirchhoff's voltage law states that the algebraic sum of the potential differences in any loop must be equal to zero as: $\Sigma V = 0$. Since the two resistors, $R_1$ and $R_2$ are wired together in a series connection; they are both part of the same loop so the same current must flow through each resistor.

Thus the voltage drop across resistor, $R_1 = I*R_1$ and the voltage drop across resistor, $R_2 = I*R_2$ giving by KVL:

$$V_S + (-IR_1) + (-IR_2) = 0$$

$$\therefore V_S = IR_1 + IR_2$$

$$V_S = I(R_1 + R_2)$$

$$V_S = IR_T$$

$$\text{Where: } R_T = R_1 + R_2$$

We can see that applying Kirchhoff's Voltage Law to this single closed loop produces the formula for the equivalent or total resistance in the series circuit and we can expand on this to find the values of the voltage drops around the loop.

$$R_T = R_1 + R_2$$

$$I = \frac{V_S}{R_T} = \frac{V_S}{R_1 + R_2}$$

$$V_{R1} = IR_1 = V_S\left(\frac{R_1}{R_1 + R_2}\right)$$

$$V_{R2} = IR_2 = V_S\left(\frac{R_2}{R_1 + R_2}\right)$$

**Circuit Diagram:**

1. **KCL (Kirchoff's Current Law):**

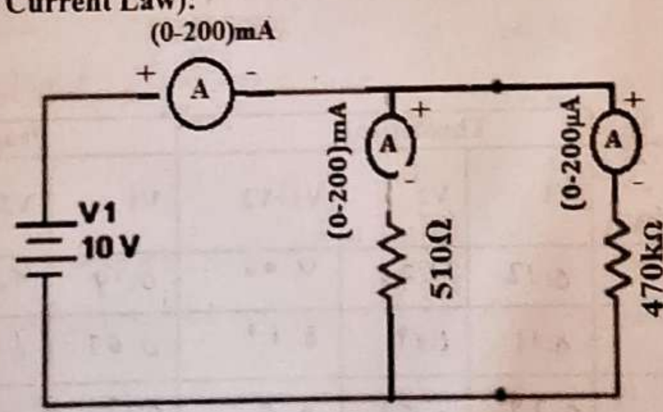



Figure 2

KCL

1) $I_1 = V/R = 5/510 \times 10^{-3} = 9.8\,mA$

2) $I_1 = \frac{10}{510} \times 10^{-3} = 19\,mA$

3) $I_1 = \frac{15}{510} \times 10^{-3} = 29\,mA$

$I_2 = \frac{5}{470} \times 10^{-3} = 10.4\,mA$

$I_2 = \frac{10}{470} \times 10^{-3} = 23.4\,mA$

$I_2 = \frac{15}{470} \times 10^{-3} = 31.2\,mA$

**Result:** successfully verified ohm's law KVL, KCL and calculated the current theoretical and practical values and also calculated the voltage theoretical & practical values

## 5. Load Test on Single Phase Transformer (Calculate Efficiency and Regulation)

**Aim:**

To calculate Efficiency and regulation of Single phase transformer by conducting load test on Single phase transformer

**Apparatus Required:**

| S.No | Apparatus | Range | Quantity |
|---|---|---|---|
| 1. | Single phase transformer | | 1 No |
| 2. | 2 Single phase variac | 0-230v | 1 No |
| 3. | Ammeter | 0-2 A | 1 No |
| 4. | Ammeter | 0-20 A | 1 No |
| 5. | Voltmeter | 0-300 V | 1 No |
| 6. | U.P.F. type Wattmeter | 0-3.0 KW | 2 Nos |
| 7. | Connecting wires | | Required |

**Transformer Ratings :**

Power:2 KVA,

Primary/Secondary :230/415 Volts,8.69/4.82 Amps.

**Theory:**

A transformer is a static apparatus used to transform a.c. electrical power from one voltage to another voltage. It works on the principle of mutual induction.In a transformer there are two windings primary winding & secondary winding. Both these windings are having their internal resistance & leakage current. When the transformer is loaded there will be voltage drop in the transformer due to the resistance & reactance of the windings.When the secondary winding of the transformer is completed through a load an voltage V is applied to the primary winding ,the transformer is said to operate under load condition.

Under this condition transformer copper loss increase with increase in current, due to that efficiency changes. At half load efficiency is reaches to maximum, it gradually decreases when further load increases. This is because at half load Cu loss is less and iron loss is also less, but below half load iron loss will be more which results in less efficiency. This situation happens when transformer is distribution transformer.

When load increase beyond half load Cu loss will increase which again reduces the efficiency. This test is performed to determine the efficiency and regulation of a transformer at different load conditions.

REGULATION: If E0 is the load voltage of the secondary side & V, is the terminal voltage of the secondary side.When it is loaded: Then,

E0 – V = Voltage drop in the transformer when it is loaded.

=Change in the terminal voltage of the transformer when it is loaded.

**Circuit Diagram:**

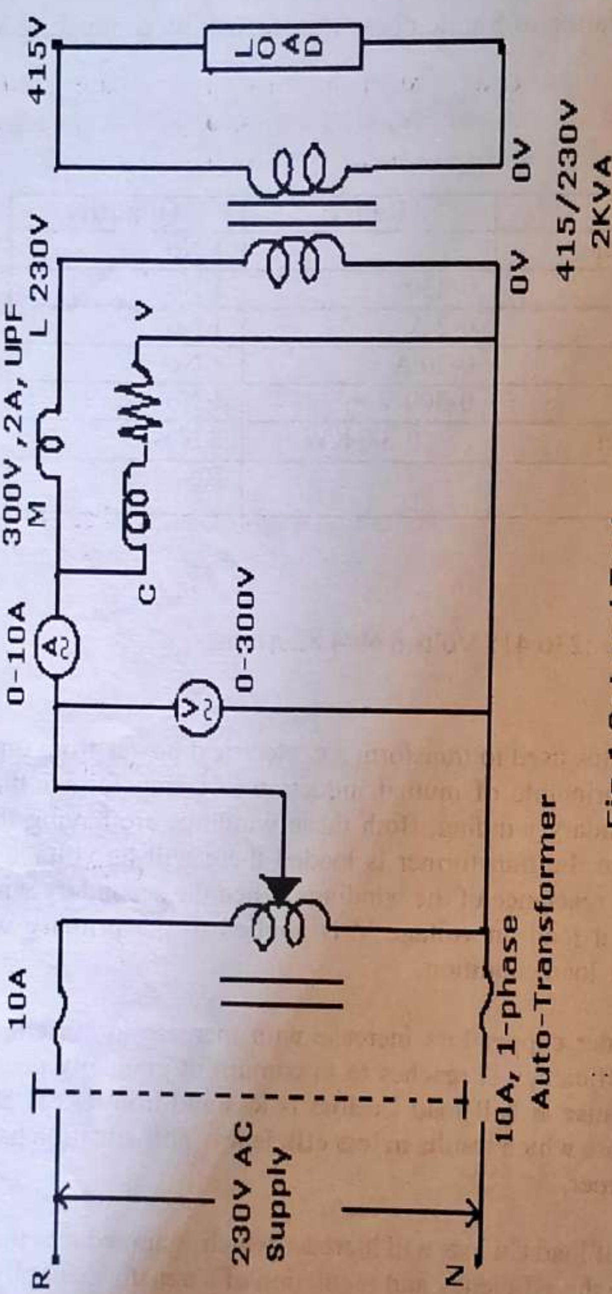



Fig.1.3: Load Test

Voltage regulation of a transformer is the ratio of change in the terminal voltage of the secondary from no load to load condition.
To its rated voltage, at a particular load current.

i.e % Regulation = $\frac{E0 - V}{V \text{ rated}} \times 100$

As the load current increases, the voltage drop in the transformer windings also increases & hence the voltage regulation increases. The Regulation of a transformer should not more than 8%. In a transformer lower percentage regulation is a better regulation.

**EFFICIENCY:**

The ratio of output power to the input power of a transformer is called the efficiency of the transformer up to certain amount of load, efficiency increases with the increases in load and the onward slightly decreases.

$$\text{EFFICIENCY} = \frac{\text{OUTPUT}}{\text{INPUT}} = \frac{V2\ I2\ \text{COS}\Phi}{\text{IN PUT POWER}}$$

The above formula shows that efficiency depends not on the value of load current, but also on the power factor (COSΦ) of the load current.If the load is purely resistive, the power factor i.e. cosΦ =1.

$$\text{EFFICIENCY} = \frac{V2\ I2}{\text{IN PUT POWER}}$$

The efficiency of a transformer is generally more. Compared to other rotation machines, as it is a static apparatus, involving no frictional losses. Generally efficiency of a good transformer is more than 90% at full load.
A load test is performed in the laboratory to check its performance before it is actually used on site.For getting the values of regulation & efficiency at different power factor, the different types of loads that is inductive or capacitive load should be used.

**Formula Used:**

$\%\eta = (W_2 / W_1)*100$

$\%reg = \{(V_{rated} - V_2) / V_{rated}\} * 100$

**Procedure:**

1. Connect the circuit diagram such that the supply on LV side and load on HV side as shown in the fig
2. Gradually increase the voltage using auto transformer till the voltmeter reads the rated voltage, 230v on LV side and also record the voltage on HV side.
3. Maintain the voltage V to be constant for all loads.
4. Switch on the load switches one by one and record the ammeter, voltmeter and wattmeter readings. (The load current should not be exceed the rated current,4.82A.)
5. Switch off the supply and set the auto-transformer at zero position.

**Observations:**

| S.No | Primary | | | Secondary | | | %η | % reg |
|---|---|---|---|---|---|---|---|---|
| | $V_1$ (Volt) | $I_1$ (Amp) | $W_1$ (kW) | $V_2$ (Volt) | $I_2$ (Amps) | $W_2$ (kW) | | |
| 1 | 230 | 0.47 | 0.04 | 413 | 0 | 0 | 0 | 0 |
| 2 | 230 | 0.5 | 0.31 | 402 | 0.61 | 0.28 | 90.32 | 2.18 |
| 3 | 230 | 2.64 | 0.5 | 400 | 1.3 | 0.56 | 112 | 3.61 |
| 4 | 230 | 3.4 | 0.80 | 392 | 1.98 | 0.82 | 95.39 | 5.54 |
| | | | | | | | | |

**Calculations:**

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

$$\%\,reg = \left(\frac{V_{nl} - V_2}{V_{rated}}\right) \times 100$$

$$\eta_1 = \frac{0}{0.04} \times 100 = 0\%$$

$$\%\,reg_1 = \frac{415-425}{415} \times 100 = 0$$

$$\eta_2 = \frac{0.28}{0.31} \times 100 = 90.32\%$$

$$\%\,reg_2 = \frac{425-402}{415} \times 100 = 2.18$$

$$\eta_3 = \frac{0.56}{0.5} \times 100 = 112\%$$

$$\%\,reg_3 = \frac{415-400}{415} \times 100 = 3.61\%$$

$$\eta_4 = \frac{0.82}{0.86} \times 100 = 95.34\%$$

$$\%\,reg_4 = \frac{425-392}{415} \times 100 = 5.54\%$$

**Result:** Efficiency & regulation of single phase transformer conducting load test is performed

## 6. Three Phase Transformer: Verification of Relationship between Voltages and Currents (Star-Delta, Delta-Delta, Delta-star, Star-Star)

**Aim:**
To verify the relationship between voltages and currents in a three phase transformer for Star Delta Connection

**Apparatus Required:**

| S. No | Apparatus | Range | Quantity |
|---|---|---|---|
| 1. | 3 Phase Auto transformer | | 1 No |
| 2. | Ammeter | 0-20 A | 2 Nos |
| 3. | Voltmeter | 0-300 V | 2 Nos |
| 4. | Resistive Load | | Suitable |
| 5. | 1 Φ Transformer | 1KVA, 230/415V | 3 Nos |
| 6. | Connecting wires | | Required |

**Theory:**
In this type of transformer connection, then primary is connected in star fashion while the secondary is connected in delta fashion as shown in the Figure 1 below.

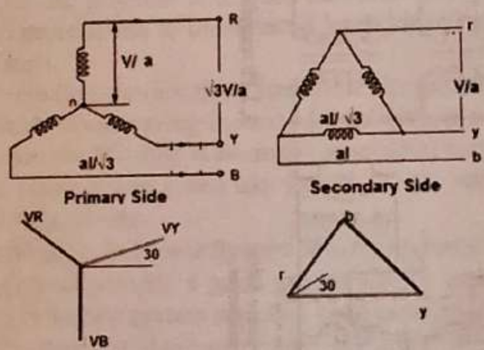



Figure 1 – Transformer Connection – Star-Delta

The voltages on primary and secondary sides can be represented on the phasor diagram as shown in the ***Figure 2*** below.

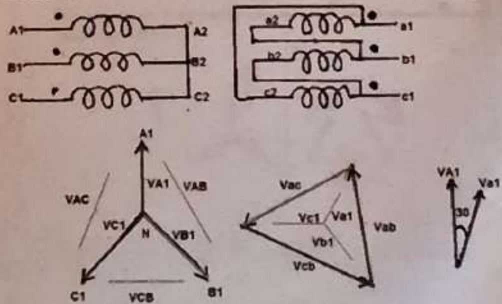
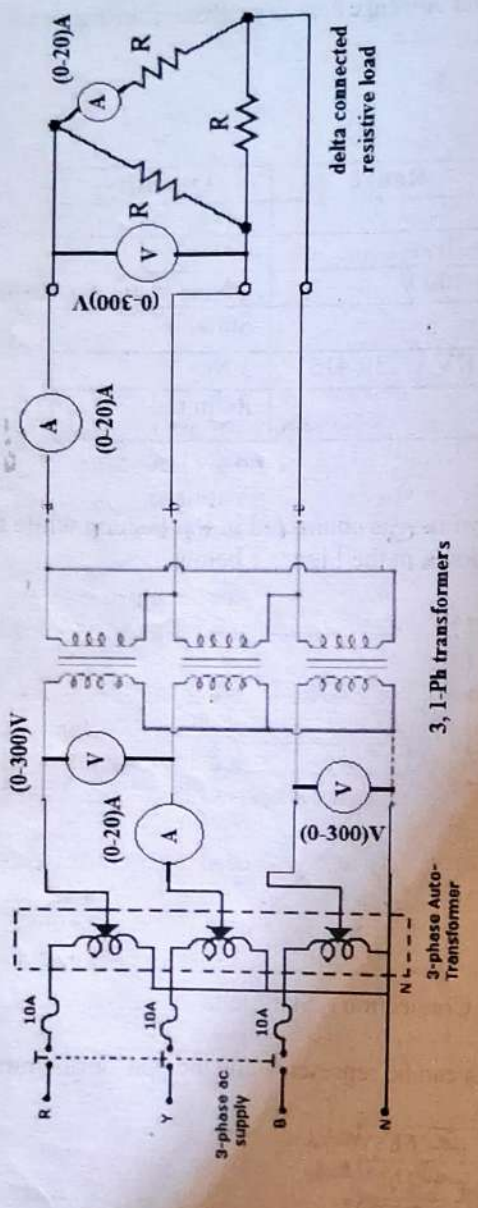



Figure 2 – Phasor diagram with voltages on primary and secondary sides

**Circuit Diagram:**



Key points

**As Primary in Star connected:**

Line voltage on Primary side = √3 X Phase voltage on Primary side. So

Phase voltage on Primary side = Line voltage on Primary side / √3

Now Transformation Ration (K) = Secondary Phase Voltage / Primary Phase Voltage

Secondary Phase Voltage = K X Primary Phase Voltage.

**As Secondary in delta connected:**

Line voltage on Secondary side = Phase voltage on Secondary side.

Secondary Phase Voltage = K X Primary Phase Voltage.

=K X (Line voltage on Primary side / √3)

Secondary Phase Voltage = (K/ √3 ) X Line voltage on Primary side.

There is s +30 Degree or -30 Degree Phase Shift between Secondary Phase Voltage to Primary Phase Voltage

**Advantages of Star Delta Connection:**

1. The primary side is star connected. Hence fewer numbers of turns are required. This makes the connection economical for large high voltage step down power transformers.
2. The neutral available on the primary can be earthed to avoid distortion.
3. The neutral point allows both types of loads (single phase or three phases) to be met.
4. Large unbalanced loads can be handled satisfactory.
5. The Y-D connection has no problem with third harmonic components due to circulating currents inD. It is also more stable to unbalanced loads since the D partially redistributes any imbalance that occurs.
6. The delta connected winding carries third harmonic current due to which potential of neutral point is stabilized. Some saving in cost of insulation is achieved if HV side is star connected. But in practice the HV side is normally connected in delta so that the three phase loads like motors and single phase loads like lighting loads can be supplied by LV side using three phase four wire system.
7. **As Grounding Transformer**: In Power System Mostly grounded Y- Δ transformer is used for no other purpose than to provide a good ground source in ungrounded Delta system. Take, for example, a distribution system supplied by Δ connected (i.e., ungrounded) power source.If it is required to connect phase-to-ground loads to this system a grounding bank is connected to the system, as shown in Figure 3 below:

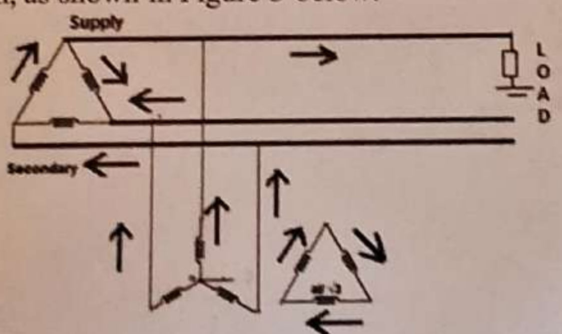



Figure 3 – Y-D Grounding transformer

8. This system a grounding bank is connected to the system, as shown in Figure 3. Note that the connected winding is not connected to any external circuit in Figure 3.
9. With a load current equal to 3 times i, each phase of the grounded Y winding provides the same current i, with the -connected secondary winding of the grounding bank providing the ampere-turns required to cancel the ampere-turns of the primary winding.

**Procedure:**

1. Connect the Circuit as per circuit diagram.
2. Adjust the Auto transformer till it reaches 230V and measure primary and secondary voltages and currents.
3. Repeat the above step for different input voltages
4. Note down the values of phase(voltages and currents) and line(voltages and Currents)
5. Compare the measured values with theoretical values.

**Observations:**

| S.No | Primary | | | | Secondary | | | |
|---|---|---|---|---|---|---|---|---|
| | Phase | | Line | | Phase | | Line | |
| | I | V | I | V | I | V | I | V |
| 1 | 2.34 | 237 | 234 | 392 | 1.16 | 426 | 0.60 | 428 |
| 2 | 4.38 | 236 | 4.38 | 379 | 1.29 | 409 | 2.26 | 366 |

**Calculations:**

**Result:** Verification of relationship b/w voltage and current has been verified

## 7 Measurement of Active and Reactive Power in a balanced Three-phase circuit

**Aim:**

To measure active and reactive power using 2-wattmeters for balanced loads in a 3- phase circuit.

**Apparatus Required:**

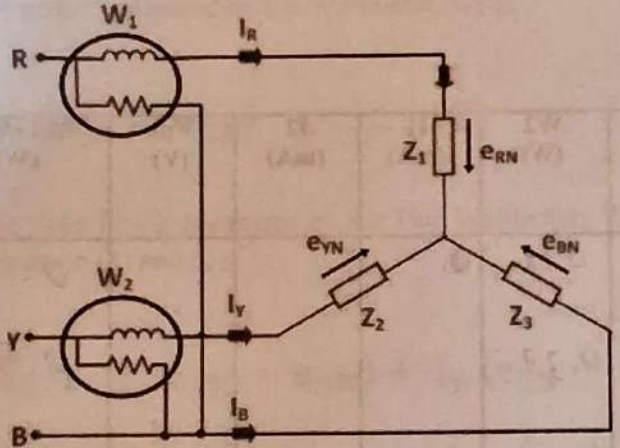
| S. No | Apparatus | Range | Quantity |
|---|---|---|---|
| 1. | 3 Phase Auto transformer | | 1 No |
| 2. | Ammeter | 0-20 A | 2 Nos |
| 3. | Voltmeter | 0-300 V | 2 Nos |
| 4. | Resistive Load | | Suitable |
| 5. | 1 Φ Transformer | 1KVA, 230/415V | 3 Nos |
| 6. | Connecting wires | | Required |

**Theory:**

In a 3-phase, 3-wire system, power can be measured using two wattmeter's for balance loads. This can be verified by measuring the powerconsumed in each phase. In this circuit, the pressures coils are connected between two phasesuch that one of the line is coinciding for both the meters.

$P_1 + P_2 = 3\, V_{Ph} I_{Ph} COS\phi$

Power factor $Cos\phi = Cos\ (tan^{-1}\ \sqrt{3}\ ((P_1 - P_2)/\ (P1 + P_2)))$




Considering the above figure (A) in which Two Wattmeter $W_1$ and $W_2$ are connected, the instantaneous current through the current coil of Wattmeter, $W_1$ is given by the

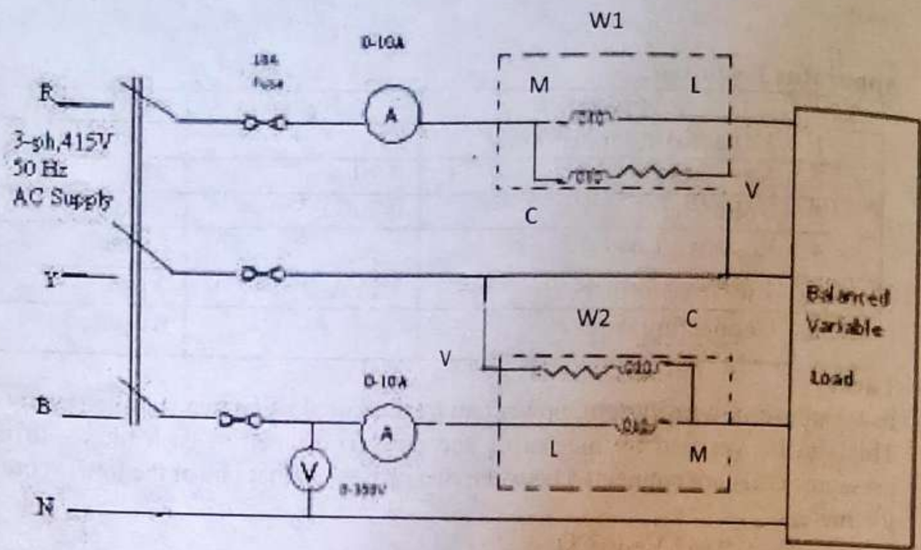
$W_1 = i_R$ iown

below.

Instantaneous potential difference across the potential coil of Wattmeter, $W_1$ is given as

$$W_1 = e_{RN} - e_{BN}$$

**Circuit Diagram:**




**Observations:**

| TYPE OF LOAD | W1 (W) | W2 (W) | I1 (mA) | I2 (mA) | Vph (V) | W1+W2 (W) | P (KW) |
|---|---|---|---|---|---|---|---|
| 1) | 0.18 | 0.18 | [illegible]. | | | 0.36 | 0.62 |
| 2) | 0.37 | 0.37 | | | | 0.74 | 1.23 |

Instantaneous power measured by the Wattmeter, $W_1$ is

$$W_1 = i_R\,(e_{RN} - e_{BN}) \;\ldots\ldots\ldots (1)$$

The instantaneous current through the current coil of Wattmeter, $W_2$ is given by the equation

$$W_2 = i_Y$$

Instantaneous potential difference across the potential coil of Wattmeter, $W_2$ is given as

$$W_2 = e_{YN} - e_{BN}$$

Instantaneous power measured by the Wattmeter, $W_2$ is

$$W_2 = i_Y\,(e_{YN} - e_{BN}) \;\ldots\ldots\ldots (2)$$

Therefore, the Total Power Measured by the Two Wattmeters $W_1$ and $W_2$ will be obtained by adding the equation (1) and (2).

$$W_1 + W_2 = i_R\,(e_{RN} - e_{BN}) + i_Y\,(e_{YN} - e_{BN})$$

$$W_1 + W_2 = i_R e_{RN} + i_Y e_{YN} - e_{BN}\,(i_R + i_Y) \quad \text{or}$$

$$W_1 + W_2 = i_R e_{RN} + i_Y e_{YN} + i_B e_{BN} \qquad (\text{i.e. } i_R + i_Y + i_B = 0)$$

$$W_1 + W_2 = P$$

Where P – the total power absorbed in the three loads at any instant.

**Calculations:**

load 1 = $W = W_1 + W_2$

$= 0.18 + 0.18$

$= 0.36$

$P = \sqrt{3}\ W$

$= \sqrt{3}\ (0.36)$

$= 0.62$

load 2 ; $W = W_1 + W_2$

$= 0.37 + 0.37$

$W = 0.74$

$P = \sqrt{3}\ W$

$= \sqrt{3}\ (0.74)$

$= 1.23$

**Result:** Measurement of active a passive power in a balanced three phase circuit is verified

# 8. Torque Speed Characteristics of DC Shunt Motor

**Aim:**

To obtain Torque ~ Speed characteristics of a DC shunt motor by performing brake test

**Name Plate Details:**

Power = 5.0 hp; Field voltage = 220 volts
Armature voltage = 220 volts; Field current = 1.0 amps
Armature current = 19.0 amps; Field Winding = shunt
Speed = 1500 rpm

**Apparatus Required:**

| S.No | Apparatus | Range | Quantity |
|---|---|---|---|
| 1. | DC Voltmeter | 0-300V | 1 No |
| 2. | DC Ammeter | 0-20A | 1 No |
| 3. | DC Ammeter | 0-2A | 1 No |
| 4. | Variable rheostat | 0-200Ω | kNo |
| 5. | Speed Indicator | 0-2000rpm | 1 No |
| 6. | Spring Balance | 0-10Kg | 2 Nos |
| 7. | Connecting wires | | Required |

**Theory:**

This is a direct method of testing a dc machine. It is a simple method of measuring motor output, speed ar efficiency etc., at different load conditions. A rope is wound round the pulley and its two ends are attached to tv spring balances $S_1$ and $S_2$.The tensions provided by the spring balances $S_1$ and $S_2$ are $T_1$ and $T_2$. The tension of t rope can be adjusted with the help of swivels. The force acting tangentially on the pulley is equal to the differen between the readings of the two spring balances in Kg - force.

The induced voltage $E_b = V - I_a R_a$ and $E_b = K\Phi N$

Where V = applied voltage; $I_a$ = armature current; $R_a$ = armature resistance.

Total power input to the motor $P_{in}$ = field circuit power + Armature power

$= V_f I_f + V_a I_a$

If „r" is the radius of the pulley, then torque at the pulley is given by

$$T_{shaft} = 9.81(T_1 \sim T_2)\, r = 1.5(T_1 \sim T_2) \text{ N-m}$$

Motor output power $P_{out} = T_{shaft} * \omega = 1.5(T_1 \sim T_2) 2 N \cdot /60$

$$\%Efficiency = P_{out} / P_{in} * 100$$

A dc shunt motor rotates due to the torque developed in the armature when the armature and field termi are connected to the dc supply. The direction of rotation can be explained with help of Fleming"s left hand princ A counter emf or back emf ($E_b$) is induced in the armature conductors while the armature (rotor) rotating ir magnetic field. The direction of the induced emf can be explained with the help of Fleming"s right hand prin and Lenz"s law. The direction this induced emf is such that it opposes the applied voltage (V). This induced e also called as back emf $E_b$.

The equation of the motor is $V = E_b + I_a R_a$ Where

$E_b = (\cdot ZN/60)*(P/A)$ ; $I_a = (V_a \cdot E_b) / R$

The value of „$E_b$" is zero while starting the motor. Hence, the voltage across the armature has to be inc gradually. The power developed in the rotor (armature) $= E_b I_a = T\omega$

Where $\omega = 2\Pi N / 60$ is the angular velocity of the pulley, in rad/sec.

In a dc motor $T \alpha \Phi I_a$, Where Φ= Flux produced by the shunt field per pole

$I_a$= Armature current



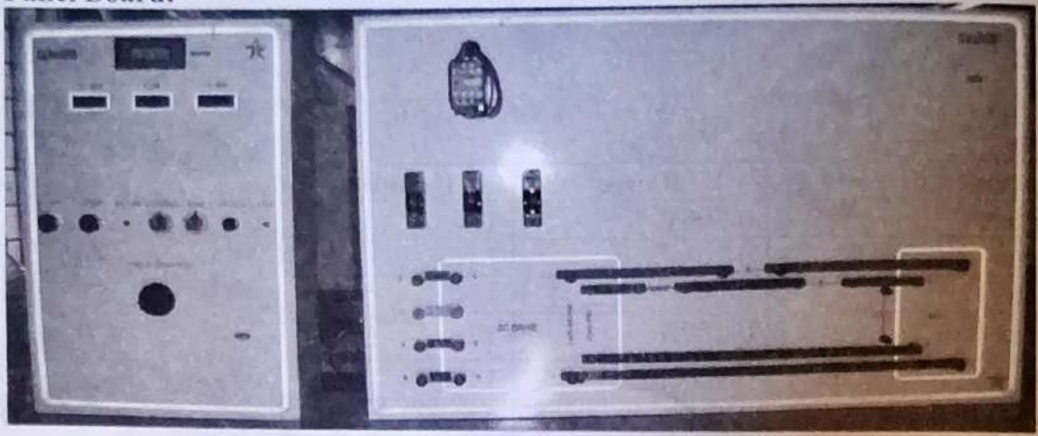
~~The torque developed in the motor is opposed by the torques due to~~

(a) Friction and windage
(b) Eddy currents and hysteresis and
(c) Mechanical load connected at the shaft.

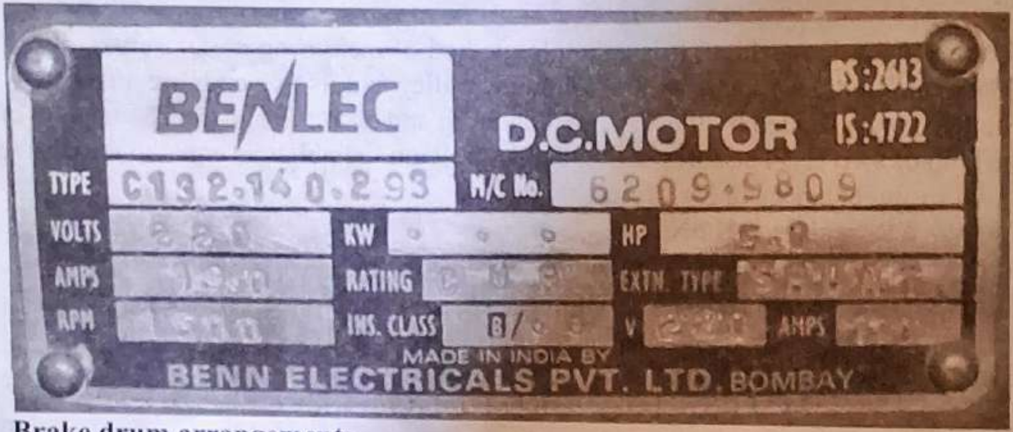
***Torque ~ Speed:***

With increase in load, $I_a$ and $T_a$ increase since the shunt field $\Phi$ is constant. The fall in speed is very small as the $I_aR_a$ drop is very small compared to V. In a dc shunt motor $N \alpha E_b$ / ·

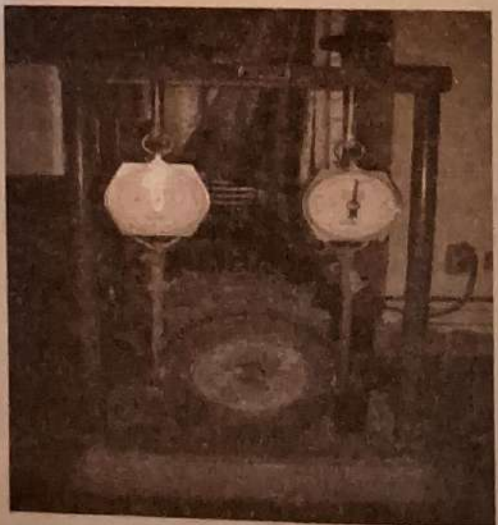
**Panel Board:**



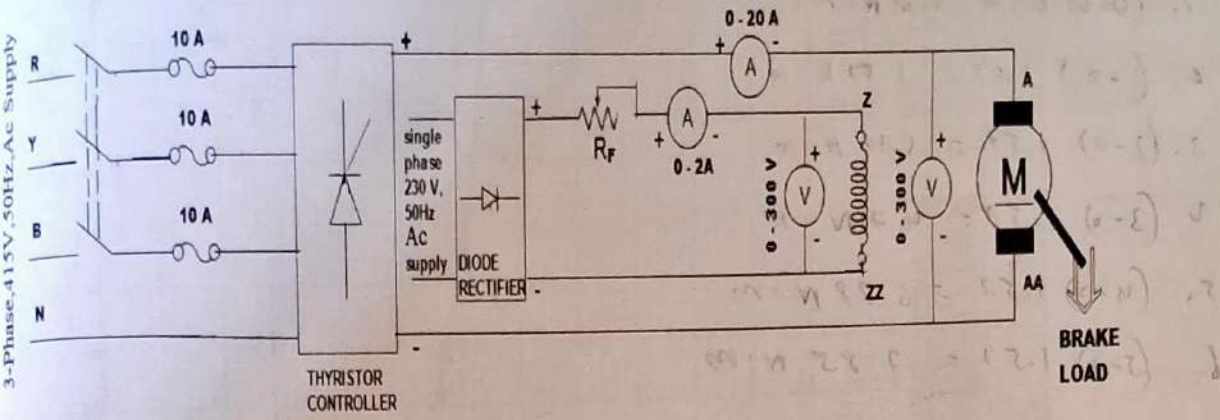
**Name Plate Details:**




**Brake drum arrangement:**



Circuit diagram:




**Procedure:**

1. Note down the name plate details.
2. Keep the dc drive potentiometers and field control rheostat at minimum resistance position.
3. Loosen the rope on the brake drum and put some water inside the rim of the brake drum.
4. Connect the circuit as shown in the circuit diagram.
5. Switch on the motor and adjust the potentiometers till the armature attains the rated voltage and increase the field rheostat till the motor attains the rated speed.
6. Record the readings of the instruments at no-load condition.
7. Gradually, increase the load on the brake drum and record the readings as per the given table.
8. Do not exceed the armature current more than its rated value.
9. Gradually, reduce the load and switch off the supply.
10. Maintain Constant armature voltage and constant field current during the total experiment.

**Calculations:**

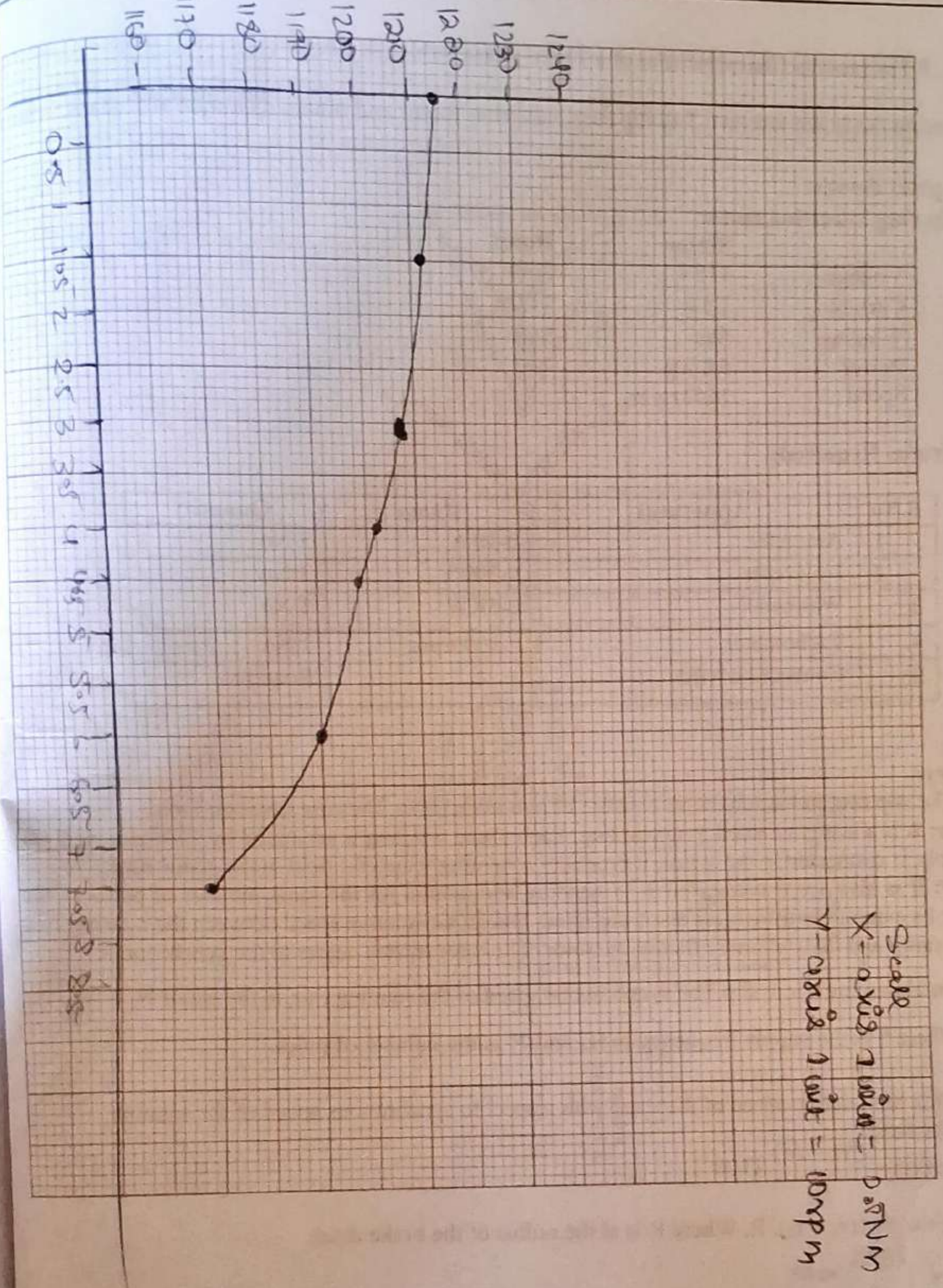
| S. No | Voltage | Current | N | $T_1$ | $T_2$ | Torque |
|---|---|---|---|---|---|---|
| 1 | 220 | 1.15 | 1240 | 0 | 0 | 0 |
| 2 | 220 | 2.9 | 1237 | 1 | 0 | 1.57 |
| 3 | 220 | 3.4 | 1239 | 2 | 0 | 3.14 |
| 4 | 220 | 4.85 | 1221 | 3 | 0 | 4.71 |
| 5 | 220 | 5.99 | 1203 | 4 | 0 | 6.28 |
| 6 | 220 | 7.65 | 1190 | 5 | 0 | 7.85 |

Torque = $(T_1 - T_2)$ 1.57 N·m

1. (0-0) 1.57 = 0 N·m
2. (1-0) 1.57 = 1.57 N·m
3. (2-0) 1.57 = 3.14 N·m
4. (3-0) 1.57 = 4.71 N·m
5. (4-0) 1.57 = 6.28 N·m
6. (5-0) 1.57 = 7.85 N·m

**Conclusions:**

- The shunt motor speed regulation is small from no load to full load.
- Speed ~ Torque characteristic is not linear but has some drooping due to demagnetization.




**Result:** T The Torque speed characteristics of DC shunt motor are successfully compared

## 9 Torque-Slip Characteristics of a Three-phase Induction Motor

**Aim:**

To perform the brake test on a 3-ϕ slip ring induction motor and obtain its torque slip characteristics

**Nameplate details:**

**AC slip ring induction motor**

| | **Stator** | **Rotor** |
|---|---|---|
| Voltage | 415V | 200v |
| Current | 7.5A | 11.0A |
| Winding | Star | Star |
| Power | 5.0 h.p | |
| Speed | 1440 r.p.m | |

**Apparatus Required:**

| S.No | Apparatus | Range | Quantity |
|---|---|---|---|
| 1. | Ammeter | 0-10 A | 1 No |
| 2 | Voltmeter | 0-300 V | 1 No |
| 3. | Wattmeter | 0-5KW | 1 No |
| 4. | Tachometer | 0-9999rpm | 1 No |
| 5. | Connecting wires | | Required |

**Theory:**

The slip ring induction motor consists of two main parts. They are stator and rotor.

**Stator:** It is a star connected 3- ϕ winding. Each phase winding is separated by $120^0$ electrical, 3- ϕ supply is connected to the stator, it produces a rotating magnetic field in the stator core.

**Rotor:** It is also a star connected 3- ϕ winding and wound for the same number of poles as the stator. Its external terminals are short-circuited. Due to the relative speed between the rotating flux in the stator and the stationary flux in the rotor. The rotor rotates nearer to the synchronous speed maintaining a low slip.The synchronous speed of the rotating flux in the stator $N_s = \frac{120f}{P}$

Where 'f is the supply frequency in Hz and 'P' is the number of poles.

**Slip** : It is the relative speed of the rotor with respect to synchronous speed of the rotating magnetic field.

Percent Slip $= \frac{(Ns - N)}{Ns} X100$

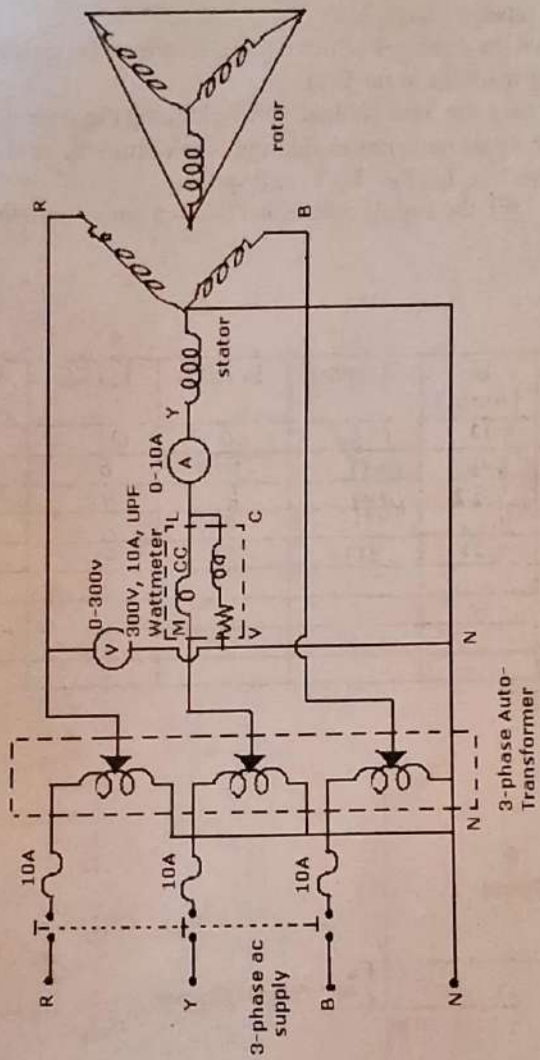
Torque $\tau = 9.81(\tau_1 - \tau_2)$. R, Where R is at the radius of the brake drum.

Output $= \frac{2\pi N\tau}{60}$ *watts*

$\%\eta = \frac{output}{input} x100$

Power factor $= \cos\phi = \frac{Pph}{Vph.Iph}$ (Where '$P_{ph}$' is the input power per phase)

**Circuit Diagram:**



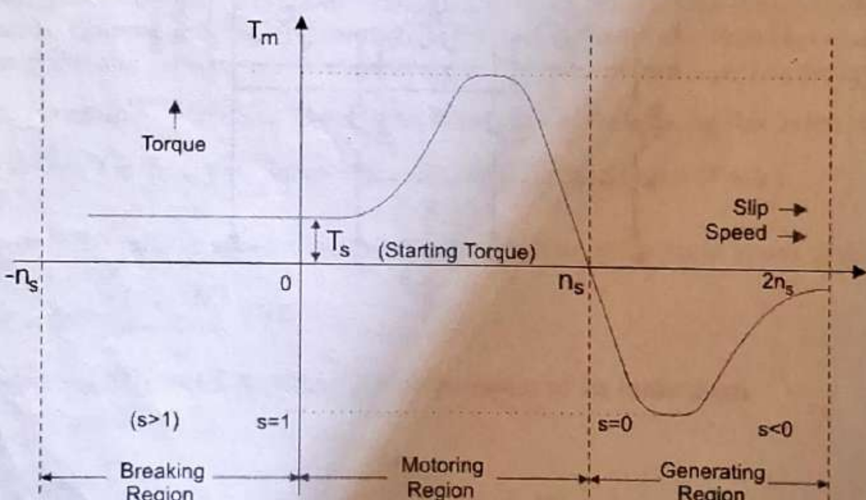
**Procedure:**

1. Connect the circuit diagram as shown in fig.
2. Keep the 3-ф auto transformer at zero voltage position.
3. Loosen the rope on the brake drum and set the tension meters at zero position.
4. Switch - ON the motor and increase the auto - transformer gradually till the voltmeter reads the rated phase voltage 230V.
5. Note down the readings of the voltmeter, ammeter, tachometer, spring balances and wattmeter readings at no-load.
6. Now increase the load gradually by tightening the rope till the ammeter reads the rated current. Pour some water in side the break drum for cooling.
7. Note down $V_{ph}$, $I_{ph}$, $P_{ph}$, $T_1$, $T_2$ and speed.
8. Switch – OFF the supply and adjust the 3-ф auto - transformer at zero position.

**Observations :**

| S.No | $V_{Ph}$ (Volt) | $I_{Ph}$ (Amps) | N (rpm) | $T_1$ (KG) | $T_2$ (KG) | $\tau = 1.5*(T_1\ \ T_2)$ N- m | % Slip |
|---|---|---|---|---|---|---|---|
| 1 | 230 | 3.17 | 1460 | 0 | 0 | 0 | 0 |
| 2 | 230 | 3.46 | 1455 | 3 | 0 | 4.5 | 0.3424 |
| 3 | 230 | 4.22 | 1442 | 6 | 0 | 9.0 | 1.0951 |
| 4 | 230 | 4.91 | 1432 | 9 | 0 | 13.5 | 1.9178 |
| 5 | 230 | 6.22 | 1412 | 12 | 0 | 18.0 | 3.2976 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

**Model Graph:**




**Torque Slip Curve for Three Phase Induction Motor**

**Calculations:**

① $T = 1.5(0-0)$
$= 0$

② $T = 1.5(T_1 - T_2)$
$= 1.5(3-0)$
$= 4.5$ N-m

③ $T = 1.5(6-0)$
$= 9.0$ N-m

④ $T = 1.5(9-0)$
$= 13.5$ N-m

⑤ $T = 1.5(12-0)$
$= 18.0$ N-m

slip

① $\frac{1460-1460}{1460} \times 100 = 0$

② $\frac{1460-1435}{1460} \times 100 = 0.342\%$

③ $\frac{1460-1444}{1460} \times 100 = 1.095\%$

④ $\frac{1460-1432}{1460} \times 100 = 1.917\%$

⑤ $\frac{1460-1412}{1460} \times 100 = 3.287\%$

**Result:** slip - torque characteristics is not linear

## 10: No-Load Characteristics of a Three-phase Alternator

**Aim:**

To plot No load charecteristics of Three phase alternator.

**Apparatus Required:**

| S.No | Apparatus | Range | Quantity |
|---|---|---|---|
| 1. | Dc Voltmeter | 0 - 300 V | 1 No |
| 2. | DC Ammeter | 0 - 10 amps | 1 No |
| 3. | DC Ammeter | 0 - 2 amps | 2 Nos |
| 4. | AC Ammeter | 0 - 10 amps | 1 No |
| 5. | Ac Voltmeter | 0 - 300 V | 1 No |
| 6. | Tachometer | 0 - 2000 rpm | 1 No |
| 7. | Connecting wires | | Required |

**Motor Ratings:**

**DC Motor**

Voltage : 220V
Current : 19 Amps
Power: 3.7 KW

**Alternator**

Voltage: 415 V
current: 5 Amps
Power: 3.5 KVA
Speed: 1500 rpm

**Theory:**

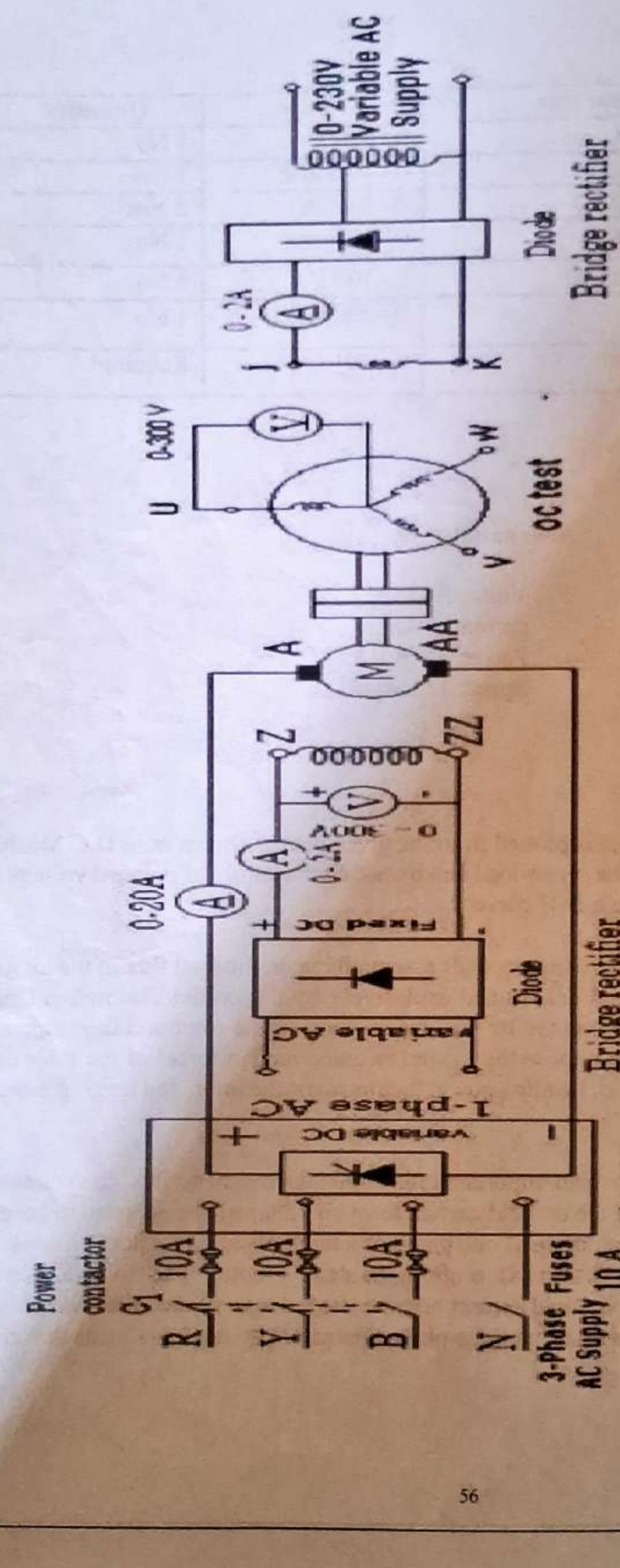
**O.C.C:**

Open Circuit Characteristics is plotted from the given data as shown as in D.C Machines, this is plotted by running the machine on no-load and by noting the values of induced voltage and field excitation current. It is just like a B-H curve.

The output voltage of an alternator depends essentially upon the total flux in the air gap. At no load, this flux is established and determined exclusively by the dc field excitation.Under load, however, the air gap flux is determined by the ampere-turns of the rotor and the ampere-turns of the stator. The latter may aid or oppose the MMF (magneto motive force) of the rotor depending upon the power factor of the load. Leading power factors assist the rotor, and lagging power factors oppose it.

Because the stator MMF has such an important effect upon the magnetic flux, the voltage regulation of alternators is quite poor, and the dc field current must continuously be adjusted to keep the voltage constant under variable load conditions.If one phase of a three-phase alternator is heavily loaded, its voltage will decrease due to the IR and IXL drops in the stator winding. This voltage drop cannot be compensated by modifying the dc field current because the voltages of the other two phases will also be changed. Therefore, it is essential that three-phase alternators do not have loads that are badly unbalanced.

**Circuit diagram:**

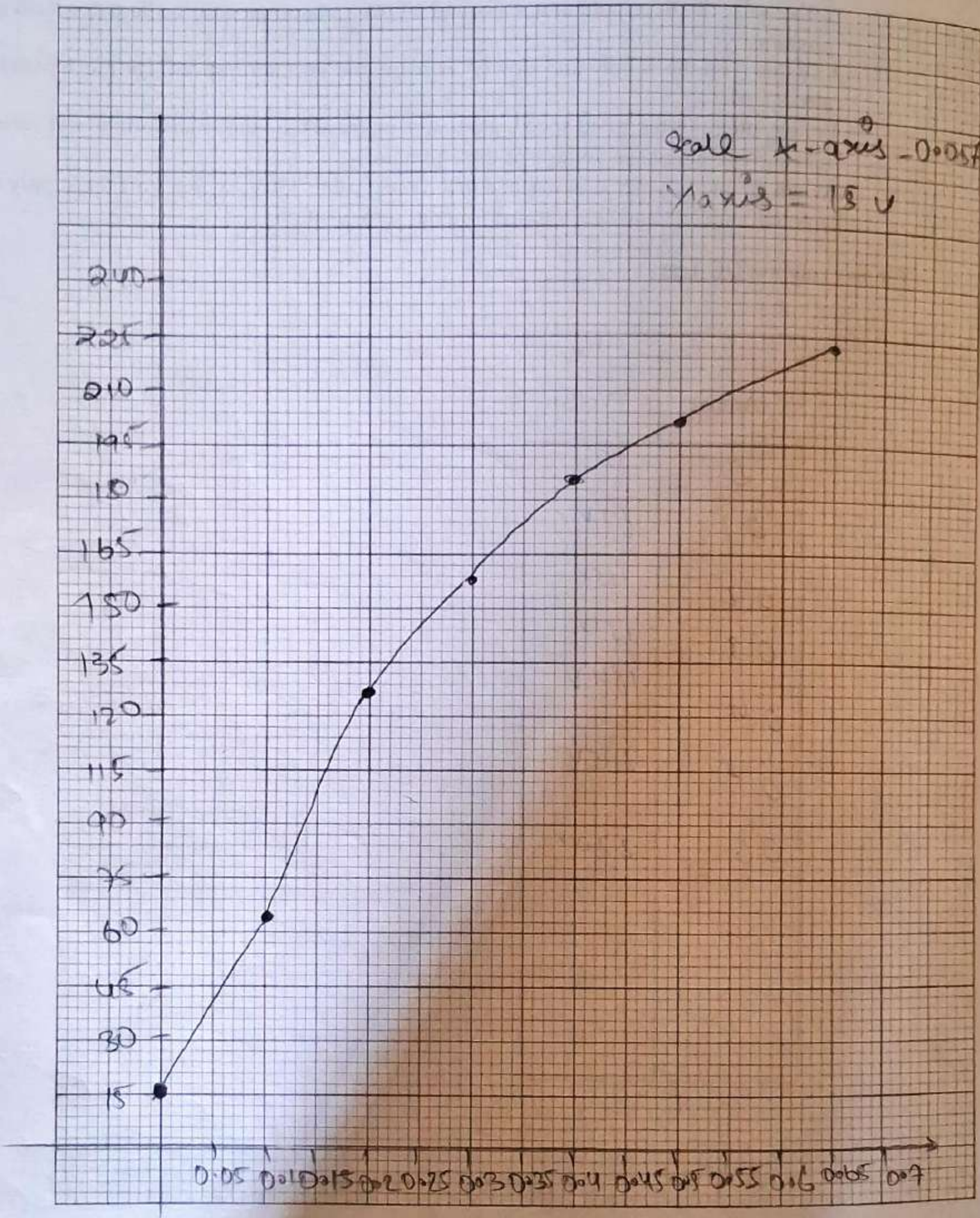


**Procedure:**

1. Connect the circuit as shown in the figure for O.C. Test.
2. Keep the dc drive potentiometers and auto - transformer of the alternator field at zero position.
3. Switch - on the supply and slowly increase, the dc motor speed, (prime mover) to its rated speed.
4. After attaining the rated speed, gradually increase the auto -transformer and record the field current and phase voltage of the alternator.
5. When the phase voltage is reached to the rated value 230V, switch - off the supply and keep the potentiometers and auto - transformer at zero position

**Tabular column: OC Test**

| $I_f$ (Amps) | $E_{oc}$ (Volts) |
|---|---|
| 0 | 15 |
| 0.1 | 65V |
| 0.2 | 115V |
| 0.3 | 155V |
| 0.4 | 184V |
| 0.5 | 205V |
| 0.6 | 220V |
| | |




**Result:** NO load characteristics of phase alternator is plotted successfully