# GOVT CO-ED POLYTECHNIC

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**LAB MANUAL**

Branch : Electrical Engineering

Year & Semester : 2nd Year / 3rd Semester

*2024363(024) – DC Machines & Transformers (Lab)*

## EXPERIMENT No. 01

## AIM:- TO STUDY OF THE CONSTRUCTIONAL DETAILS OF TRANSFORMERS.

**Construction:**

Basically a transformer consists of two inductive windings and a laminated steel core. The coils are insulated from each other as well as from the steel core.

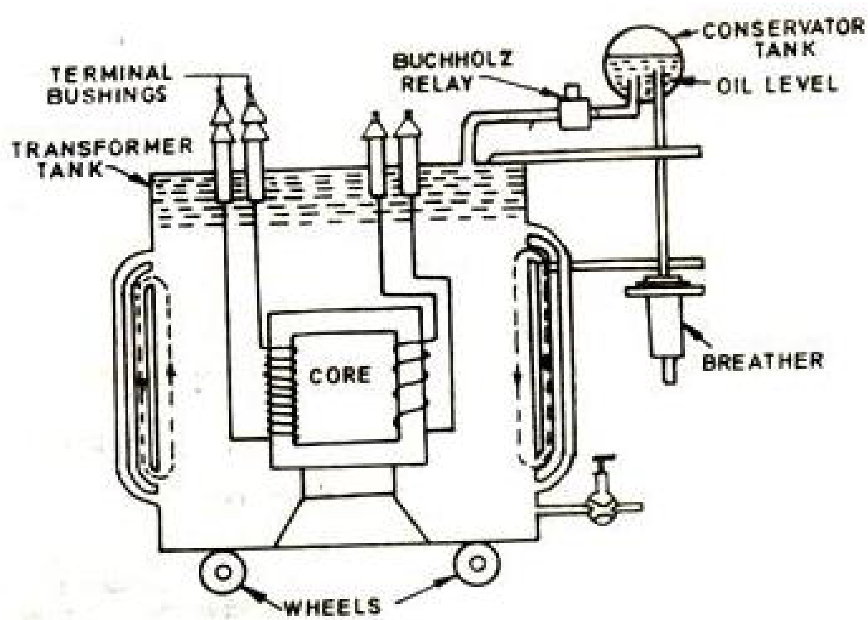



Fig 1.1: Detailed construction of transformer

A transformer may also consist of a container for winding and core assembly (called as tank), suitable bushings to take over the terminals, oil conservator to provide oil in the transformer tank for cooling purposes etc. The figure at left illustrates the basic construction of a transformer.

Transformer laminated steel sheet shapes in all types of transformers, core is constructed by assembling (stacking) laminated sheets of steel, with minimum air-gap between them (to achieve continuous magnetic path).

The steel used is having high silicon content and sometimes heat treated, to provide high permeability and low hysteresis loss. Laminated sheets of steel are used to reduce eddy current loss. The sheets are cut in the shape as E, I and L.

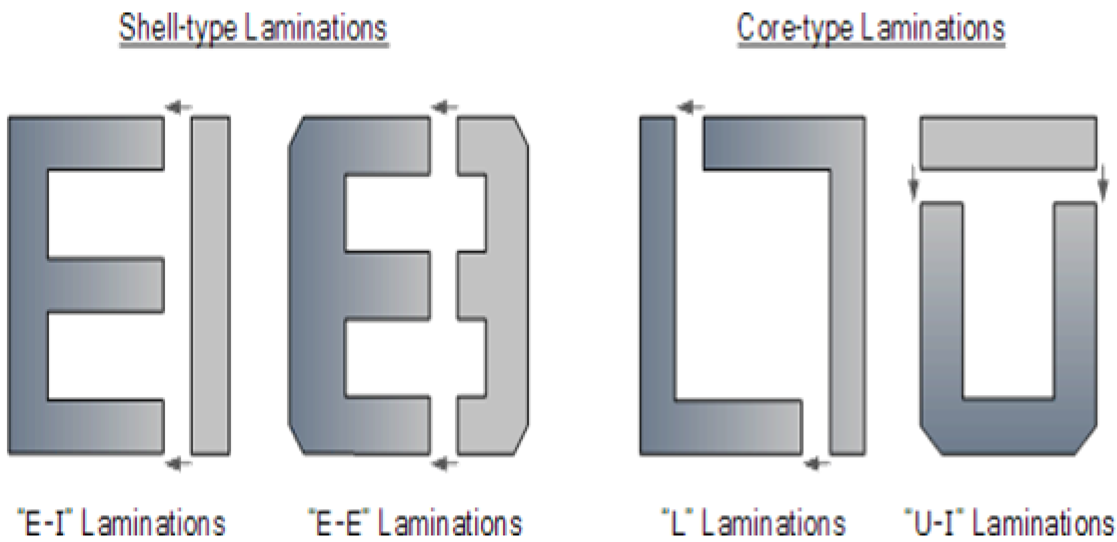


Fig 1.2 Different types of laminations

To avoid high reluctance at joints, laminations are stacked by alternating the sides of joint. That is, if joints of first sheet assembly are at front face, the joints of following assemble are kept at back face.

**CORE**

The core acts as support to the winding in the transformer. It also provides a low reluctance path to the flow of magnetic flux. It is made of laminated soft iron core in order to reduce eddy current loss and Hysteresis loss. The composition of a transformer core depends on such as factors voltage, current, and frequency.

The diameter of the transformer core is directly proportional to copper loss and is inversely proportional to iron loss. If the diameter of the core is decreased, the weight of the steel in the core is reduced, which leads to less core loss of the transformer and the copper loss increase. When the diameter of the core is increased, the vise-versa occurs.

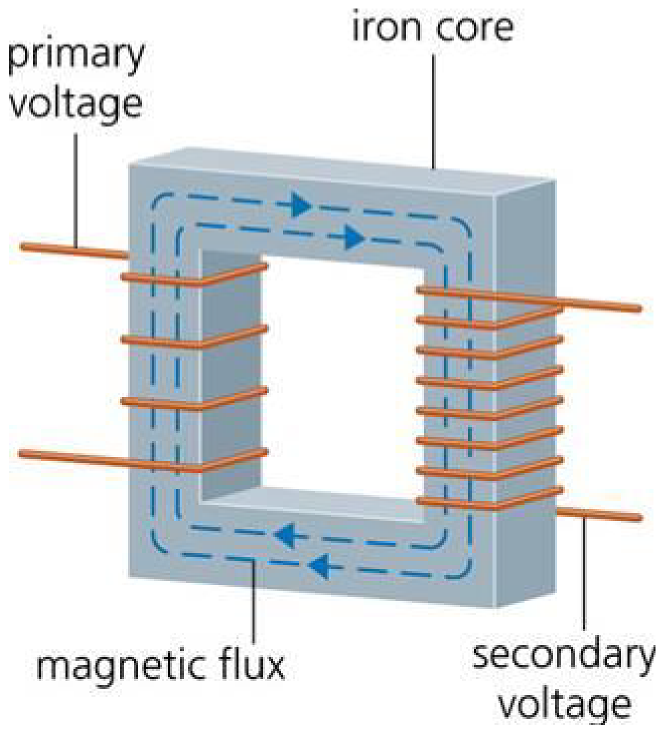



Fig 1.3: Main parts of transformer

**WINDING** Two sets of winding are made over the transformer core and are insulated from each other. Winding consists of several turns of copper conductors bundled together, and connected in series. Winding can be classified in two different ways: 1) Based on the input and output supply 2) Based on the voltage range **Within the input/output supply classification, winding are further categorized:** Primary winding - These are the winding to which the input voltage is applied. Secondary winding - These are the winding to which the output voltage is applied. **Within the voltage range classification, winding are further categorized:** ⌚ High voltage winding - It is made of copper conductor. The number of turns made shall be the multiple of the number of turns in the low voltage winding. The conductor used will be thinner than that of the low voltage winding. ⌚ Low voltage winding - It consists of fewer number of turns than the high voltage winding. It is made of thick copper conductors. This is because the current in the low voltage winding is higher than that of high voltage winding. Input supply to the transformers can be applied from either low voltage (LV) or high voltage (HV) winding based on the requirement.

**CONSERVATOR** The conservator conserves the transformer oil. It is an airtight, metallic, cylindrical drum that is fitted above the transformer. The conservator tank is vented to the atmosphere at the top, and the normal oil level is approximately in the middle of the conservator to allow the oil to expand and contract as the temperature varies. The conservator is connected to the main tank inside the transformer, which is completely filled with transformer oil through a pipeline.

**BREATHER** The breather controls the moisture level in the transformer. Moisture can arise when temperature variations cause expansion and contraction of the insulating oil, which then causes the pressure to change inside the conservator. Pressure changes are balanced by a flow of atmospheric air in and out of the conservator, which is how moisture can enter the system. If the insulating oil encounters moisture, it can affect the paper insulation or may even lead to internal faults. Therefore, it is necessary that the air entering the tank is moisture-free. The transformer's breather is a cylindrical container that is filled with silica gel. When the atmospheric air passes through the silica gel of the breather, the air's moisture is absorbed by the silica crystals. The breather acts like an air filter for the transformer and controls the moisture level inside a transformer. It is connected to the end of breather pipe.

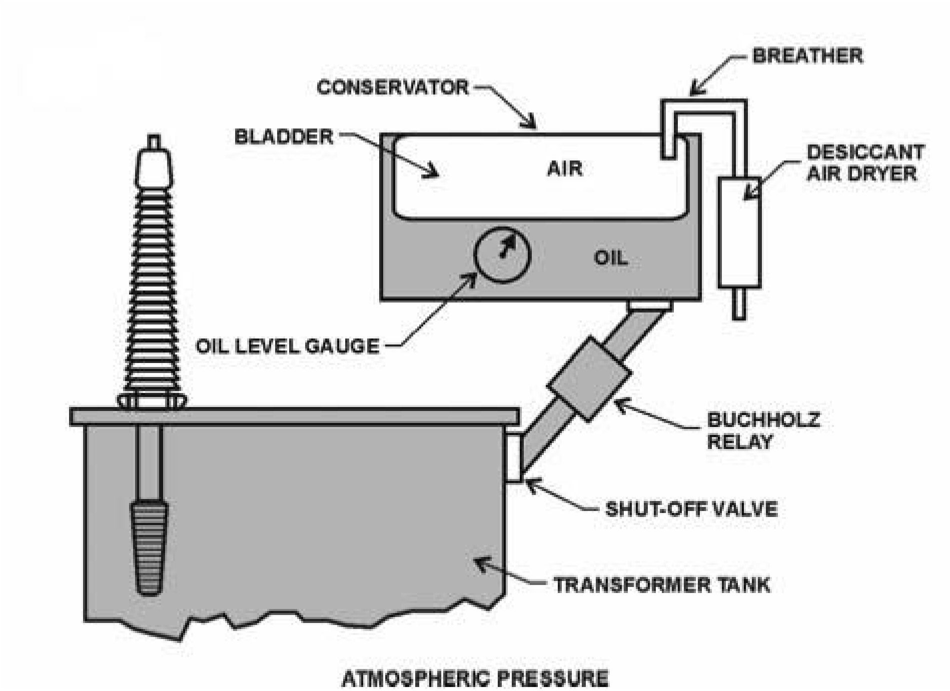



Fig 1.4: Conservator arrangement

**TAP CHANGER** The output voltage of transformer varies according to its input voltage and the load. During loaded conditions, the voltage on the output terminal decreases, whereas during off-load conditions the output voltage increases. In order to balance the voltage variations, tap changers are used. Tap changers can be either on-load tap changers or off-load tap changers. In an on-load tap changer, the tapping can be changed without isolating the transformer from the supply. In an off-load tap changer, it is done after disconnecting the transformer. Automatic tap changers are also available.

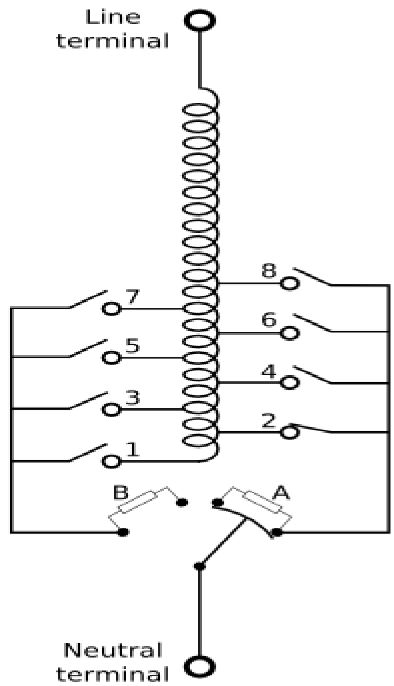



Fig 1.5: Schematic arrangement of tap changer

**COOLING TUBES** Cooling tubes are used to cool the transformer oil. The transformer oil is circulated through the cooling tubes. The circulation of the oil may either be natural or forced. In natural circulation, when the temperature of the oil raises the hot oil naturally rises to the top and the cold oil sinks downward. Thus the oil naturally circulates through the tubes. In forced circulation, an external pump is used to circulate the oil.

**EXPLOSION VENT** The explosion vent is used to expel boiling oil in the transformer during heavy internal faults in order to avoid the explosion of the transformer. During heavy faults, the oil rushes out of the vent. The level of the explosion vent is normally maintained above the level of the conservatory tank.

**BUCHHOLZ RELAY** The Buchholz Relay is a protective device container housed over the connecting pipe from the main tank to the conservator tank. It is used to sense the faults occurring inside the transformer. It is a simple relay that is operated by the gases emitted during the decomposition of transformer oil during internal faults. It helps in sensing and protecting the transformer from internal faults.

## EXPERIMENT No. 02

**AIM- TO THE STUDY OF POLARITY TEST ON A 1-PHASE TRASFORMER**

**Apparatus:**

| S.NO | NAME | RANGE | TYPE | QUANTITY |
|---|---|---|---|---|
| 1 | Voltmeter | (0-30)V | MI | 1NO |
| 2 | Ammeter | (0-10)A | MI | 1NO |
| 3 | 1-Phases Transformer | 2 KVA, 115/230 | - | 1NO |
| 4 | Connecting wires | (0-20)A | - | |

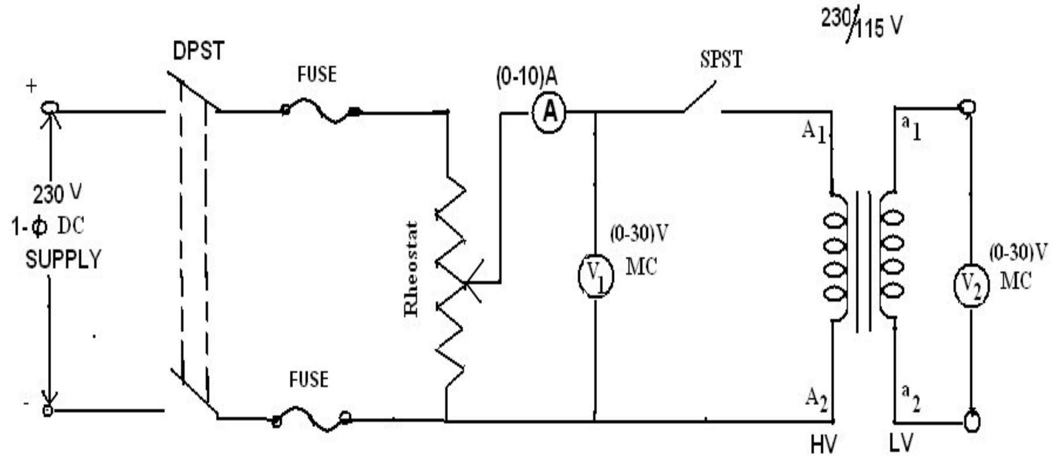
**Name plate details:**

**Transformer Specifications:**
**Transformer Rating :( in KVA) ____**
**Winding Details:**
**LV (in Volts): _______**
**LV side current:_____**
**HV (in Volts): ______**
**HV side Current:____**
**Type (Shell/Core):___**

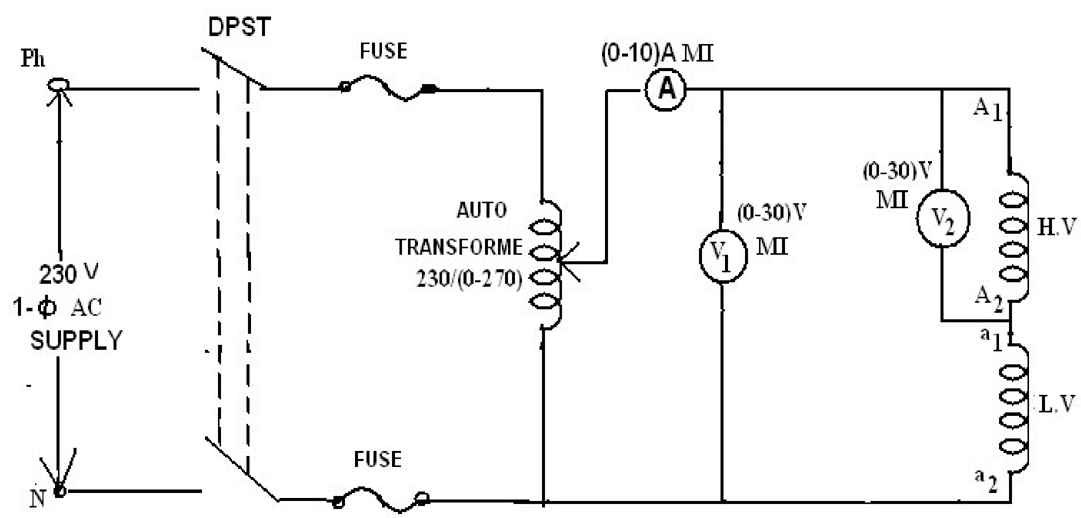
**Auto transformer Specifications:**
**Input Voltage (in Volts):____________**
**Output Voltage (in Volts): ________**
**frequency (in Hz):________________**
**Current rating (in Amp):___**

**Theory:**
**----To be written---**

**Circuit diagram:**
**A) For D.C Supply:**




**B) For A.C Supply:**




**Procedure:**

**For D.C. Supply:**

1. Make the connection as per circuit diagram
2. By varying the potential divider set the input voltage to 10 V.
3. Close the SPST switch and observe the deflection in voltmeter $V_2$
4. If the direction of pointer in $V_2$ is positive then $A_1$ is positive with respective $A_2$ and also $a_1$ is positive with respective $a_2$.

5. If the direction of pointer in $V_2$ is negative then change the polarity on either side.

**For A.C. Supply:**

1. Make the connections as per the circuit diagram.
2. Apply 20V, by varying auto transformer.
3. Observer $V_1$ & $V_2$.
4. If $V_2$ is less than $V_1$ then assumed polarity in circuit1 is correct otherwise polarity is opposite.

**Result:**

For given transformer polarity test is performed.

## EXPERIMENT No. 03

**AIM- To perform open circuit and short circuit test on a single phase transformer and to pre-determine**
**the efficiency, regulation and equivalent circuit of the transformer.**

**APPARATUS REQUIRED;**

| S.NO | NAME | RANGE | TYPE | QUANTIT Y |
|---|---|---|---|---|
| 1 | Voltmeters | (0-300)V<br>(0-150)V | MI<br>MI | 1 NO<br>1 NO |
| 2 | Ammeters | (0-2)A<br>(0-20)A | MI<br>MI | 1 NO<br>1 NO |
| 3 | Wattmeter | (0-150)V LPF<br>(0-2.5)A | Dynamo type | 1 NO |
| 4 | Wattmeter | (0-150)V UPF<br>(0-10)A | Dynamo type | 1 NO |
| 5 | Connecting Wires | (0-20)A | ***** | Required |

**CIRCUIT DIAGRAM:**

**Open Circuit Test:**

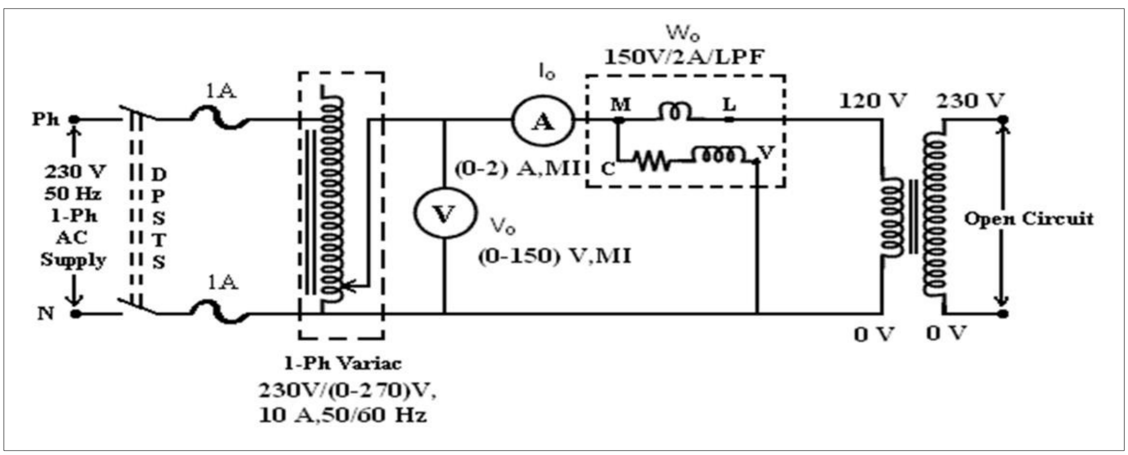



Fig 3.1: Circuit for open circuit test

*Name Plate Details:*

KVA rating :

LV Side Voltage :

HV Side Voltage :
Frequency :
Number of Phases :
Type of Construction :

*Short Circuit:*

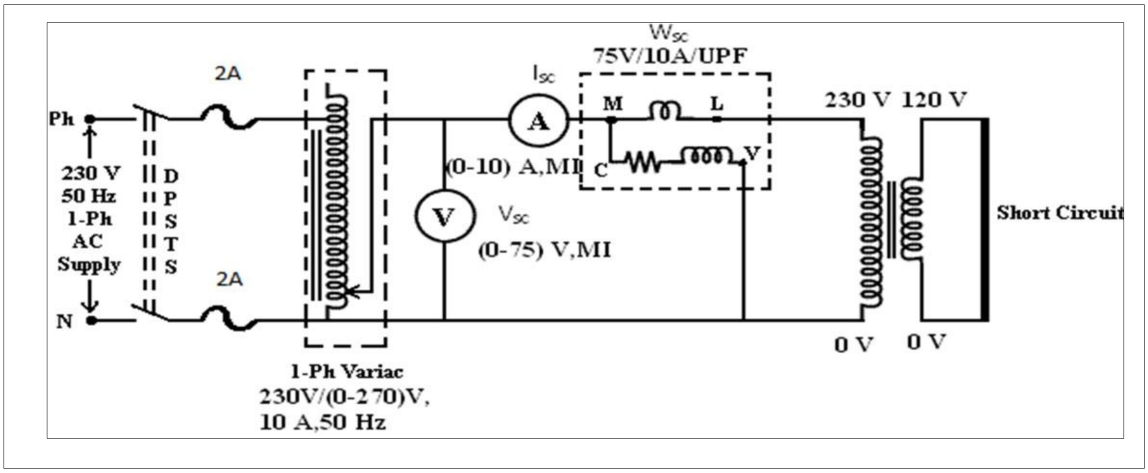



Fig 3.2: Circuit diagram for short circuit test

**OBSERVATIONS:**

**OC Test:**

| 1<br>$V_o$ (V) | 1<br>$I_o$ (A) | Wo = W x M.F (W) |
|---|---|---|
| | | |

**SC Test:**

| $V_{SC}$ (V) | $I_{SC}$ (A) | $W_{SC}$ = W x M.F (W) |
|---|---|---|
| | | |

Where

M. F. = Multiplication factor = $VI \cos \phi / FSD$

FSD = Full scale divisions

**PRECAUTIONS:**

1. Avoid loose and wrong connections.
2. All knife switches should be open initially.
3. Single phase variac should be at minimum potential position initially.
4. Readings are taken without parallax error.

**PROCEDURE:**

**For OC Test:**

1. Connect the circuit as per fig 3.1.
2. Observe all precautions and close the DPST Switch.
3. Apply the rated voltage by increasing variac output gradually.
4. Note down the readings of all the meters.

**For SC Test:**

1. Connect the circuit as per fig 3.2.
2. Observe all precautions and close the DPST Switch.
3. Apply the rated current by increasing variac output gradually.
4. Note down the readings of all the meters.

**MODEL CALCULATIONS:**

Let the transformer be the step-down

transformer Primary is H. V. side.Secondary

is L. V. side

$K = V_2/V_1$ = Transformation ratio

**OC TEST CALCULATIONS:**

$\cos \phi_0 = W_o/(V_o^1 I$

$^1)$ $\sin^2\phi_0 = (1- \cos$

$\phi\ ^2)$ $\sin\phi_0 =$

$I_w^1 = I_0^1 \cos \phi_0$

$I_\mu^1 = I_0^1 \sin \phi_0$

$R_0^1 = V_0^1 / I_w^1$

$X^1_0 = V^1_0 \quad ^1_\mu$

$R_0 = \quad _0$

$R^1 \quad _0/K^2$

$X_0 =$

$X^1 / K^2 \ I_0 =$

$I_0{}^1 * K$

$I_W =$

$I_w{}^1 * K \ I_\mu =$

$I_\mu{}^1 * K$

**SC TEST CALCULATIONS:**

**CALCULATIONS TO FIND EFFICIENCY:**

**For reading 1:- 10% of full load and at Unity Power factor**

Copper losses = $W_{sc}$ x (10% of Full

Load)$^2$ where $W_{SC}$ = full – load cupper

losses Constant losses = $W_0$

Output = 10% of kVA x cos ϕ

Input = output + Cu. Loss + constant loss=

$$\% \ efficiency = \frac{Output}{Input} \ x \ 100 =$$

**CALCULATIONS TO FIND REGULATION:**

**For reading 1: for full load 0.1 pf lag**

$$\% \ \mathrm{Re}\,gulation = \frac{I_2 R_{02} \cos\phi \pm I_2 X_{02} \sin\phi}{V_2} \ \mathbf{x} \ 100$$

'+' for lagging power factor

'-' for leading power factors

**Efficiency at different loads and P.f's:**

**cos $\phi_2$ = 0.707 Lag**

| *S.No.* | *Load* | *Cu. loss (W)* | *Output (W)* | *Input (W)* | *% •* |
|---|---|---|---|---|---|
| | | | | | |

**cos $\phi_1$ = Unity pf**

| S.No | Load | Cu. loss (W) | Output (W) | Input (W) | % • |
|---|---|---|---|---|---|
| | | | | | |

**Regulation at different power factors:**

| Lagging Pf | | | Leading Pf | | |
|---|---|---|---|---|---|
| S.No. | P.F. | % Reg. | S.No. | P. F. | % Reg. |
| | | | | | |
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**MODEL GRAPHS:**

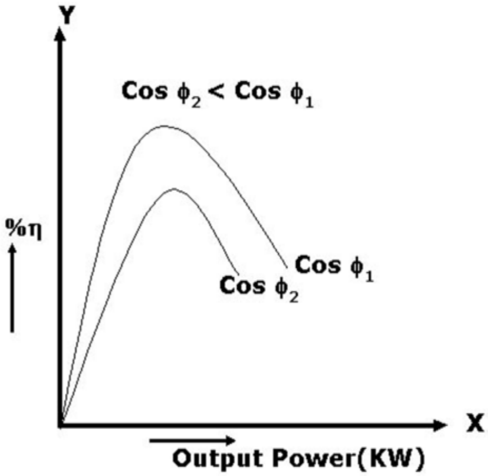



Fig 3.3: Plot of % efficiency Vs output

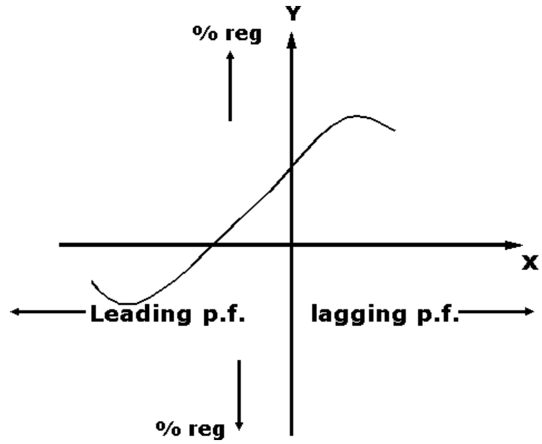



Fig 3.4: Plot of % regulation Vs power factor

*EQUIVALENT CIRCUIT:*

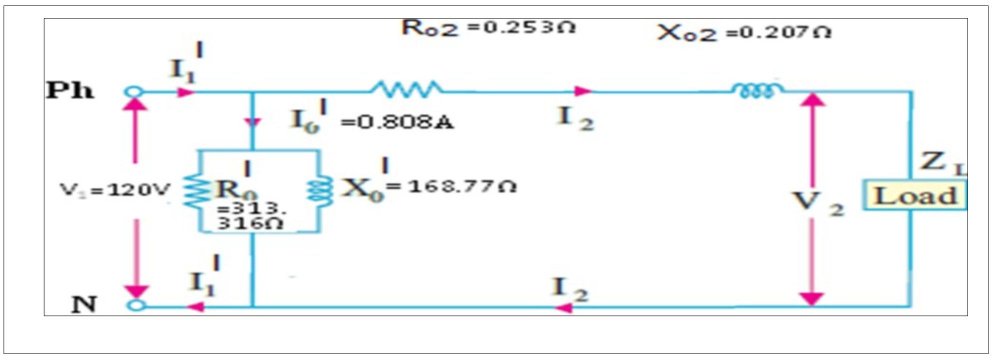



Fig 3.5: Equivalent circuit referred to LV side

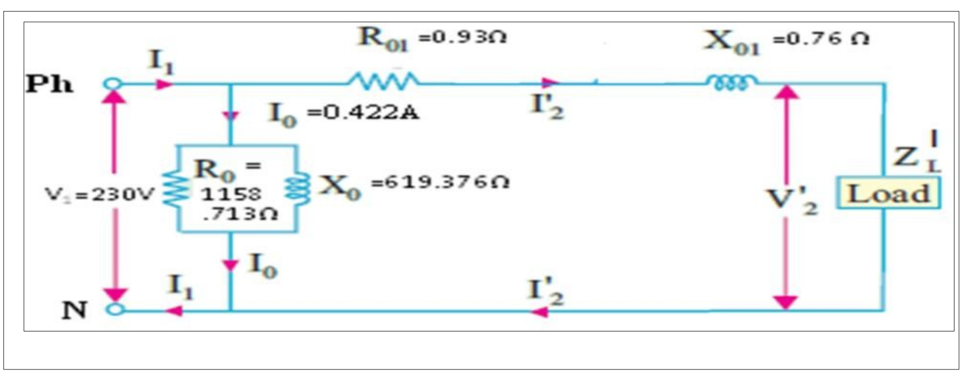



Fig 3.6: Equivalent circuit referred to HV side

**Result:**

## EXPERIMENT No. 04

## AIM- TO THE STUDY OF LOAD TEST ON A SINGLE PHASE TRANSFORMER.

**APPARATUS REQUIRED:**

| S.No. | Apparatus | Range | Type | Quantity |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**NAME PLATE DETAILS:**

KVA rating :

LV Side Voltage :

HV Side Voltage :

Frequency :

Number of Phases :

Type of Construction :

**PRECAUTIONS:**

1. Auto Transformer should be in minimum position.
2. The AC supply is given and removed from the transformer under no load condition.

**PROCEDURE:**

1. Connections are made as per the Fig 5.1.
2. After checking the no load condition, minimum position of auto transformer and DPST switch is closed.
3. Ammeter, Voltmeter and Wattmeter readings on both primary side and secondary sides are noted.
4. The load is increased and for each load, Voltmeter, Ammeter and Wattmeter readings on both primary and secondary sides are noted.
5. Again no load condition is obtained and DPST switch is opened.

**CIRCUIT DIAGRAM:**

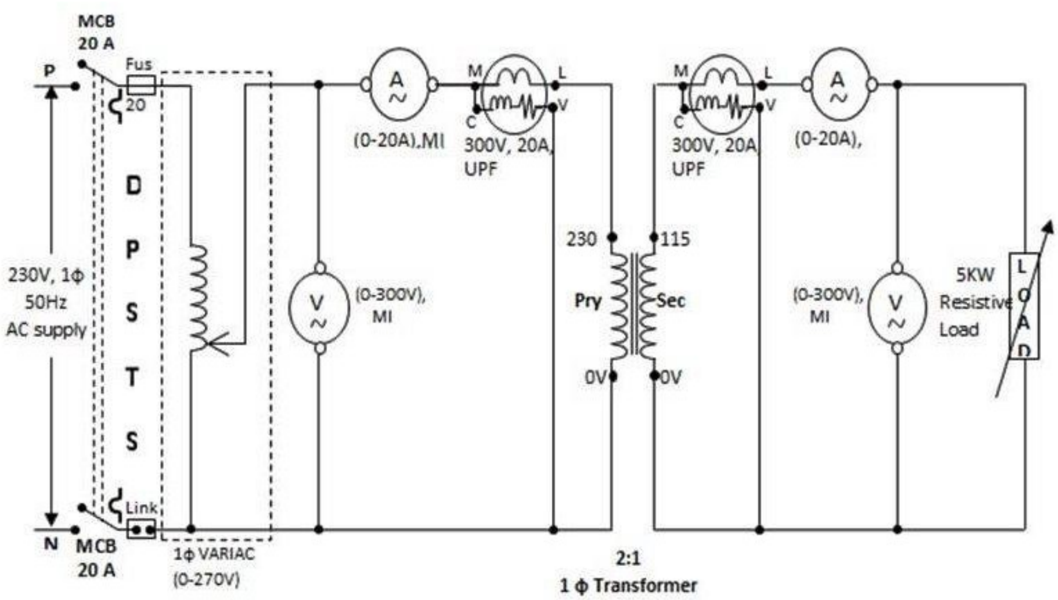



Fig 5.1: Circuit diagram for load test

*TABULAR COLUMN:*

| S.No. | Input Voltage (v1) | Input Power W1 x MF | Output Voltage (v2) | Output current (I2) | Output Power W2 x MF | % Efficiency | % Regulation |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |

**FORMULAE:**

Output Power = $W_2$ x Multiplication factor

Input Power = $W_1$ x Multiplication factor

% efficiency = (output power in watts / Input power in watts) $X \; 100$

% Re$gulation$ = {(No load voltage – full load voltage)/ No load voltage} $X$ 100

**Model Graph:**

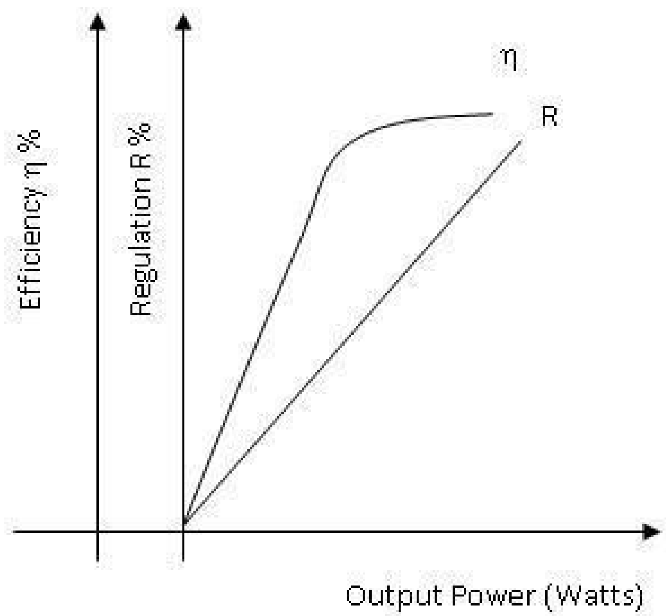



Fig 5.2: Efficiency and regulation characteristics

**RESULT:**

# EXPERIMENT No.05

## AIM- TO STUDY THE PARALLEL OPERATION OF TWO SINGLE PHASE TRANSFORMERS.

*APPARATUS:*

| S.No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**CIRCUIT DIAGRAM:**

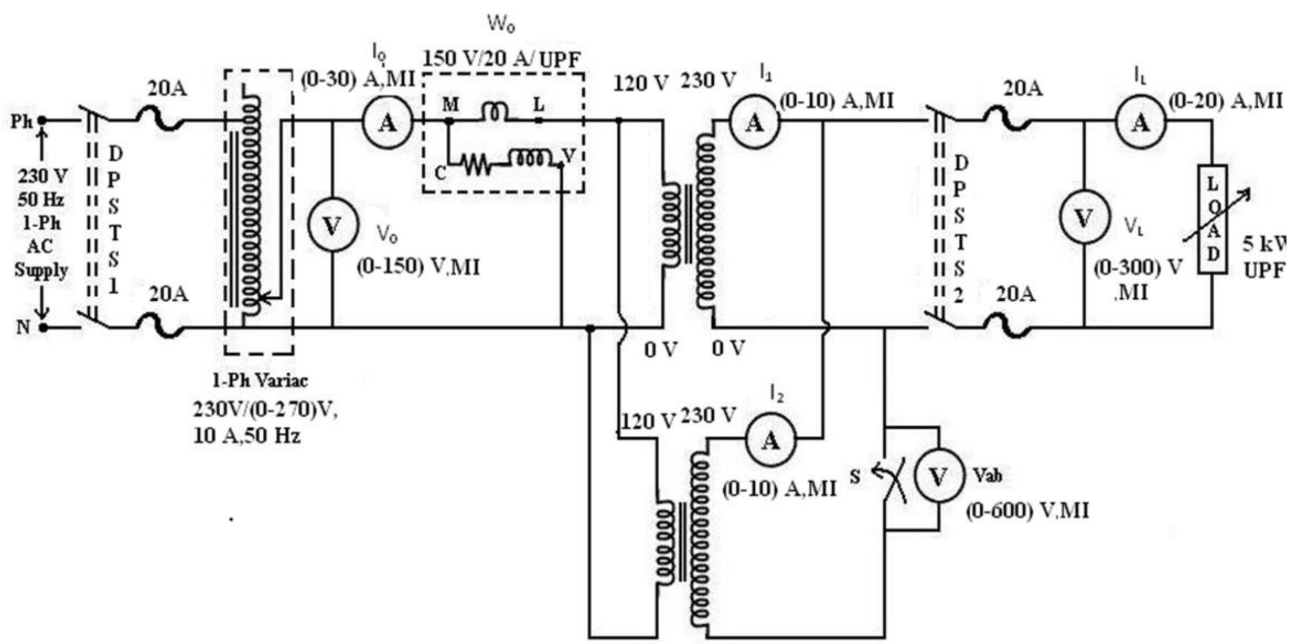



Fig 7.1: Circuit diagram for parallel operation

**NAME PLATE DETAILS:**

KVA rating :

LV Side Voltage :

HV Side Voltage :

Frequency :

Number of Phases :
Type of Construction :

**PRECAUTIONS:**

1. Keep all knife switches open initially.
2. Initially load should be off position.
3. Single phase variac should be minimum potential position initially.
4. Take meter readings without parallax error.

**PROCEDURE:**

1. Make the connections as per the fig 7.1.
2. Observe the precautions and close DPST Switch 1.
3. Vary the variac up to rated lv voltage of transformers. Observe the reading of voltmeter 'Vab', If Vab is zero close the SPST switch. Otherwise inter change secondary terminals of either transformer 1or 2.
4. Close the DPST switch 2 after reading of voltmeter, Vab is zero and note down the readings of all meters.
5. Vary the load in steps up to rated current and note down all meters reading in each step.

**TABULAR COLUMN:**

| S.No. | Vo (V) | Io(A) | Wo (W) | $V_L$ (V) | $I_1$ (A) | $I_2$ (A) | $I_L$ (A) | % $\eta$ | %Reg. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

**MODEL GRAPH:**

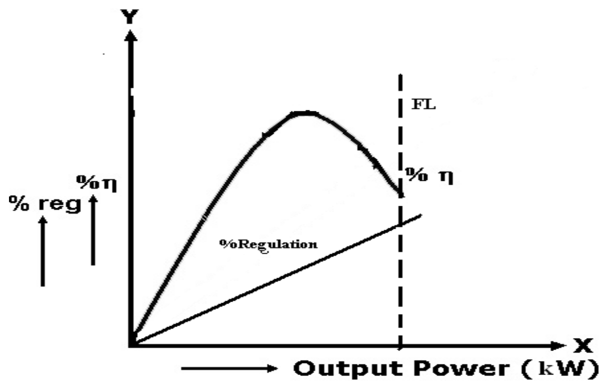



Fig 7.2: Efficiency and regulation characteristics

**MODEL CALCULATIONS:**

**Reading No.:**

$$\% \text{ efficiency} = (\text{output power in watts / Input power in watts}) \; X \; 100$$

$$((V_L * I_L)/Wo X100$$

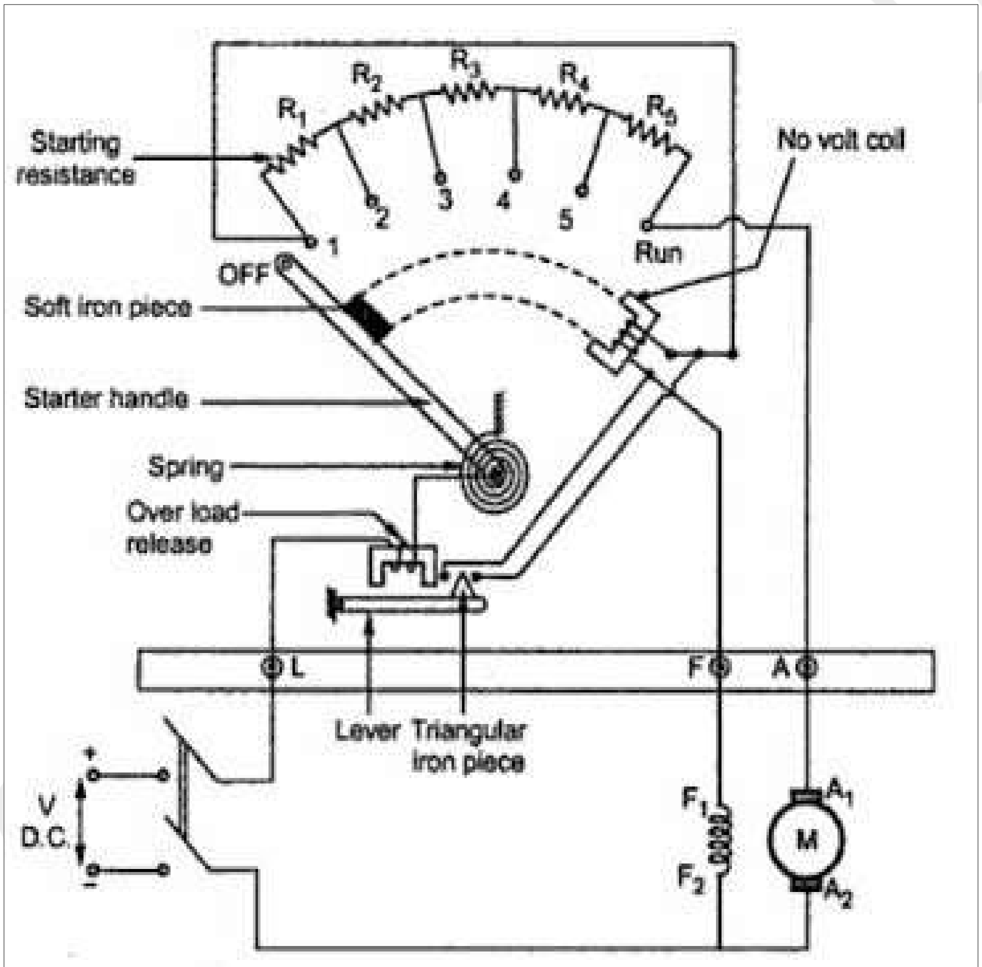
$$\% \text{ Regulation} = \{(\text{No load voltage} - \text{full load voltage}) / \text{ No load voltage}\} \; X \; 100$$

**RESULT:**

EXPERIMENT No. 06

**AIM – TO THE STUDY OF STARTERS USED FOR DC MACHINES.**

## CIRCUIT DIAGRAM:




Three Point Starter

## THEORY: -

Necessity of Starter: The current drawn by the motor armature is given by the equation

$$Ia = (V - Eb)/Ra$$

When a DC Motor is at rest there is no back emf developed in the armature. If now full supply voltage is applied across stationary armature, it will draw very large current because armature resistance is relatively small. This excessive current will damage commutator and brushes. To avoid this, a resistance is introduced in series with armature which limits starting current to safe value.

A mechanism which adds resistance during starting only is known as starter. There are two types of starters which are commonly used for DC shunt motor

1) 3-point starter -
2) 4 point starter

## 3- POINT STARTER

Three point starter is shown in the figure. The three point starter has three external points

1) L : To be connected to line (Mains)
2) F : To be connected to field and
3) A : To be connected to the armature.

Working: When arm touches the stud no. 1 full starting resistance gets connected in the armature circuit. The starting current taken by the armature is limited as

$$I_a = V /(R_a+R_s)$$

As the arm is further moved, the starting resistance is gradually cut off till the arm reaches to the last stud. Mean while the motor speed gradually increases which gradually increases . When arm reaches to last stud, full $Eb$ is developed which keep current to safe value and now no starting resistance is required.

The arm is attached with soft iron piece S. When the arm is moved to the last stud, this iron piece is attracted and held by an electromagnet called HOLD-ON coil.

The arm is supported with spring. When the motor is disconnected from the supply, this spring brings the arm back to the first stud. Three point starter is incorporated with two protective parts namely

1) HOLD ON Coil(Low Voltage or No Voltage release)
2) Over load relay.

## HOLD ON Coil

It is an electromagnet. It has two functions

i) It holds the arm in normal working of motor.

ii) It releases the arm during abnormal conditions and thereby protects the motor.

### Over Load Relay

As the load on the motor increases, it takes more and more current. Under over load condition, the current taken by the motor is very large. To protect the motor from this large current Over Load Relay is used.

It is an electromagnet. It is designed in such a way that, it produces sufficient magnetic force under over load condition only. Due to this force it attracts bar below it. When this bar is lifted, the triangular portion on its one side short circuit the HOLD-ON Coil. The HOLD-ON Coil gets deenergized and releases arm and hence motor is protected.

## Drawback of Three Point Starter:

As this starter has only three points for external connection, the field winding and hold on coil are connected in series. When a flux control method is used to control this motor, due to addition of resistance in field circuit, the current through it reduces. This reduced current may not be sufficient to produce magnetic force by hold on coil to hold the arm. This may release the arm back to the off position.

The disadvantage of three point starter is corrected in four point starter by providing fourth point. This point is useful for separating the connections of HOLD-ON Coil and field winding.

## RESULT:

Hence studied the working of starters used for DC Shunt motor.

## VIVA QUESTIONS:

1) What is the necessity of starter in a d.c. motor?
2) List the starters used for DC series Motor and DC Shunt Motor.
3) What is the function of Hold On coil?
4) What is the function of Over Load relay?
5) What is the limitation of Three point starter?

**EXPERIMENT NO.-07**

**AIM- To Determine The Magnetization Characteristic (O.C.C) Of The Given DC Shunt Generator And To Find Out The Critical Field Resistance And Critical Speed.**

## Apparatus Required:-

| S.NO | NAME | RANGE | TYPE | QUANTITY |
|---|---|---|---|---|
| 1 | Voltmeter | (0 - 300)V | MC | 2NO |
| 2 | Ammeter | (0 – 2.5)A | MC | 1NO |
| 3 | Rheostat | 400Ω, 1.2A | Wire wound | 2NO |
| 4 | Tachometer | (0-10,000)rpm | Digital | 1NO |
| 5 | Connecting wires | (0-20)A | - | Required |

**Name plate details:-**

**Motor** **Generator**

Voltage - 220V Voltage - 220V

Current -19A Current -13.6A

Speed - 1500 rpm Speed - 1500 rpm

Power - 5HP Power -

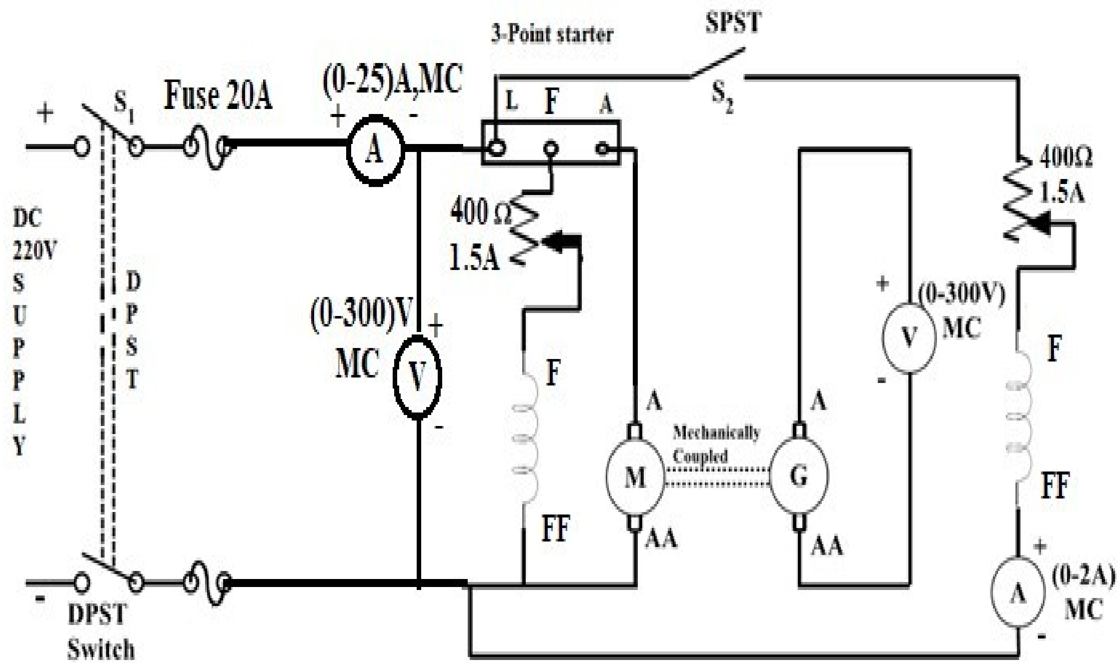
3KW Excitation type –shunt

Excitation

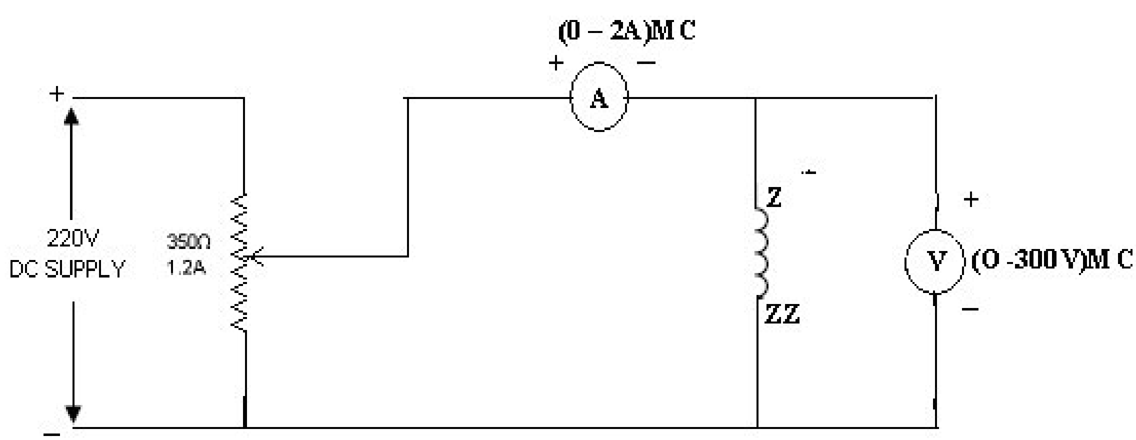
type - shunt

## Circuit diagram:-

### Circuit diagram for OCC :




## Circuit diagram for finding field resistance:




**Theory:**

----To be written---

## Procedure:

1. Make the connections as per the circuit diagram.
2. Initially keep the motor field rheostat in minimum resistance position and

Generator field rheostat maximum resistance position.

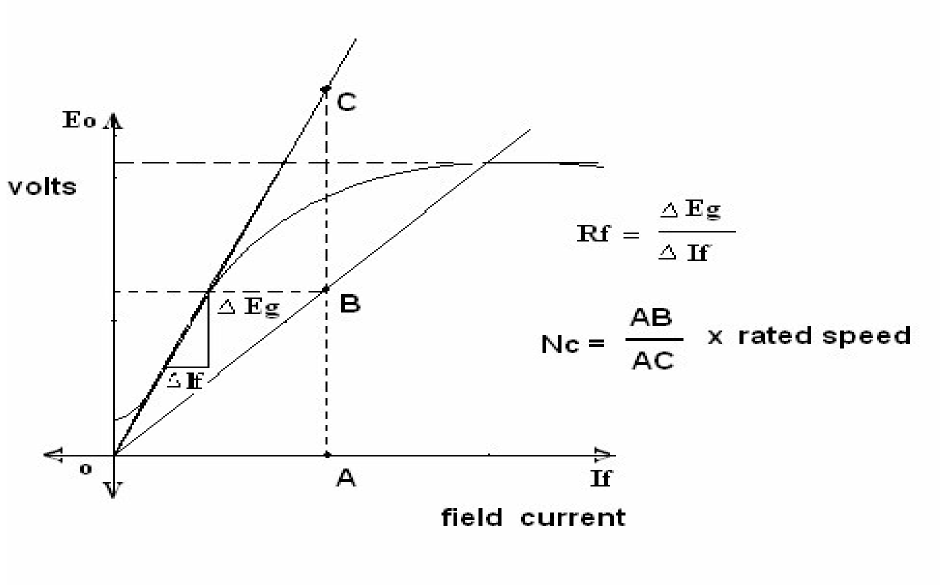
3. Give the supply by closing DPST switch and start the motor with the help of 3- point starter.
4. Adjust the motor field rheostat till the rated speed is obtained.
5. Give the supply to the generator circuit.
6. Vary the generator field rheostat in steps to get field current and measure open circuit voltage at each step.
7. Repeat step no. 6 till we get 120% of rated voltage.
8. Decrease the field current in steps and note down the open circuit voltages
9. Switch off the supply by opening the DPST switch

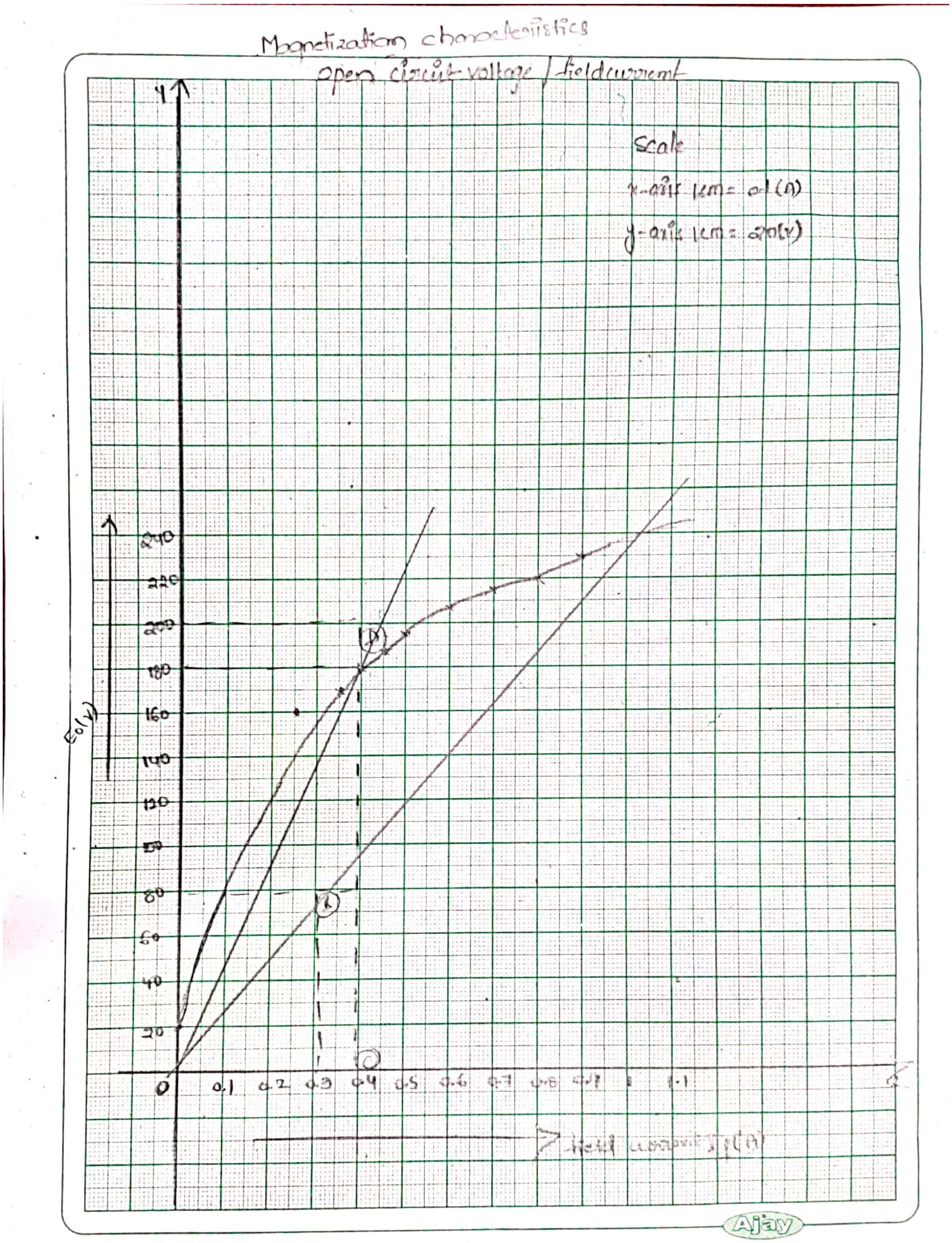
## Tabular column:-

| $I_f$ (amp) | $E_0$ (volts) |
|---|---|
| 0 | 20 |
| 0.35 | 170 |
| 0.4 | 180 |
| 0.45 | 182 |
| 0.5 | 192 |
| 0.6 | 202 |
| 0.7 | 212 |
| 0.8 | 220 |
| 0.9 | 231 |

**Calculations:-**

## Model graph:-


Eo
volts
C
B
A
o
If
field current
△ Eg
△ If
Rf = △ Eg / △ If
Nc = AB / AC x rated speed




**From the graphs,**

The critical field resistance = slope of the line

$R_c = \Delta E_o / \Delta I_f$ ohms

$N_C = (AB/AC)*N$

Where $N_C$ = critical speed

N = Speed at given O.C.C

## Result: -

The magnetization characteristic (O.C.C) of the given DC shunt generator are determined and hence field resistance and critical field resistance are calculated.

## Viva voce

1. What is the principle involved in the operation of generator?
2. Define critical field resistance?
3. Define critical speed?
4. What are the types of generators?
5. What are the causes of failures of excitation?

**EXPERIMENT No.-08**

**AIM-** To Determine The Internal And External Characteristic Of a D.C Shunt Generator By Conducting Load Test On It.

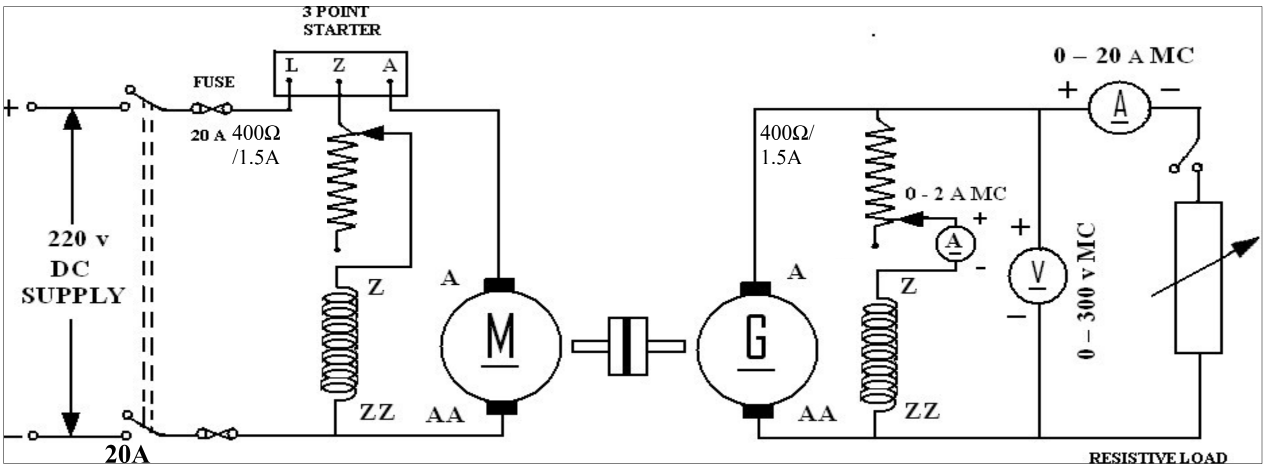
**Apparatus Required:-**

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

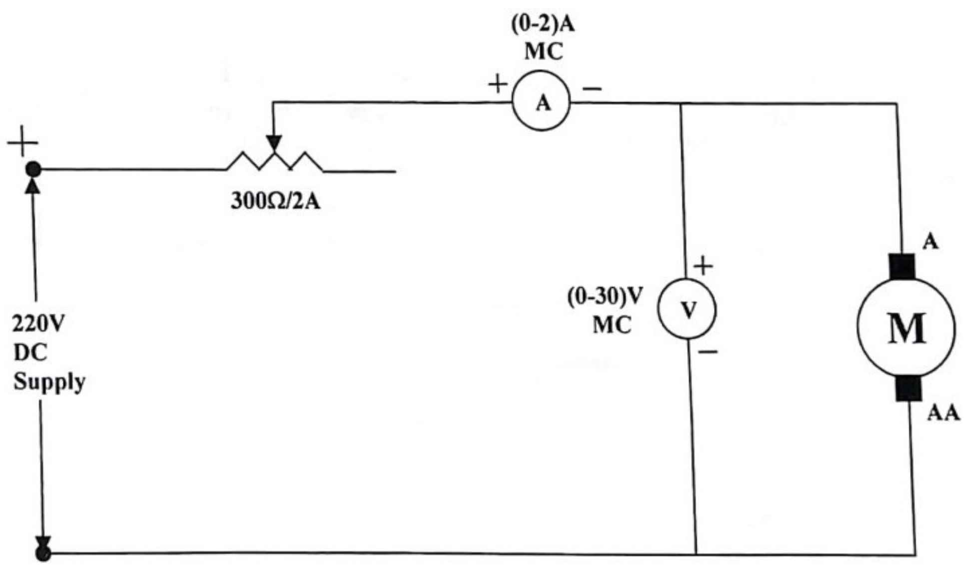
**Nameplate details**:-

| **Motor** | **Generator** |
|---|---|
| Voltage - 220V | Voltage - 220V |
| Current -19A | Current -13.6A |
| Speed - 1500 rpm | Speed - 1500 |
| rpm Excitation types –shunt | Excitation |
| type – shunt | |

## Circuit diagram:-




**To measure armature resistance:-**




## Theory:-

----To be written---

## Procedure:-

1. Make the connections as per the circuit diagram.
2. Initially keep the motor field rheostat at minimum resistance position and generator field rheostat at maximum resistance position.
3. Give the dc supply to the circuit and start the motor with the help starter.
4. Bring the motor to rated speed by varying the field rheostat in the motor circuit.
5. Adjust the generator voltage to the rated value by using generator field rheostat.
6. Apply resistive load in steps and note down the values of terminal voltage, load current and field current.
7. Increase the load till rated current is obtained.

## To determine Armature resistance:-

1. Connect the circuit as per the circuit diagram.
2. Switch on dc supply.
3 .Increase the load and note down the voltage and current.

| V(volts) | I(amp) | $R_a$= (V/I) (ohms) |
|---|---|---|
| | | |

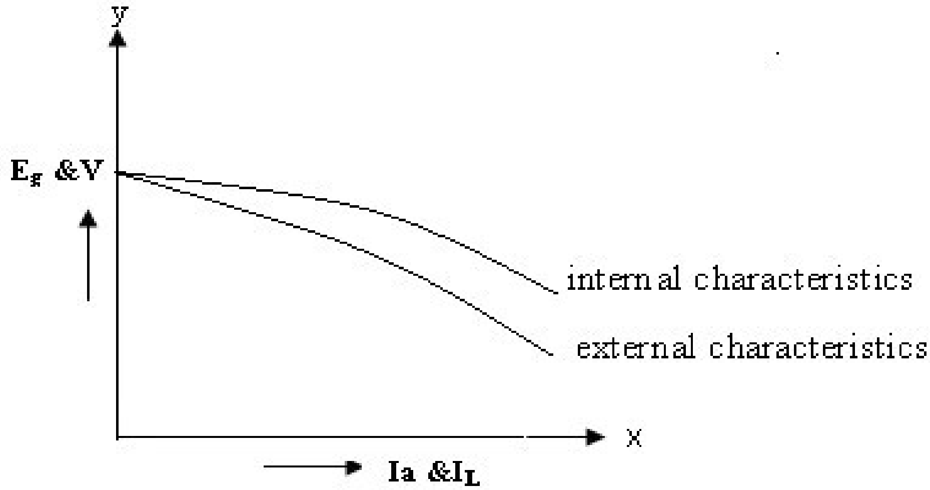
**Tabular columns:-**

Table1

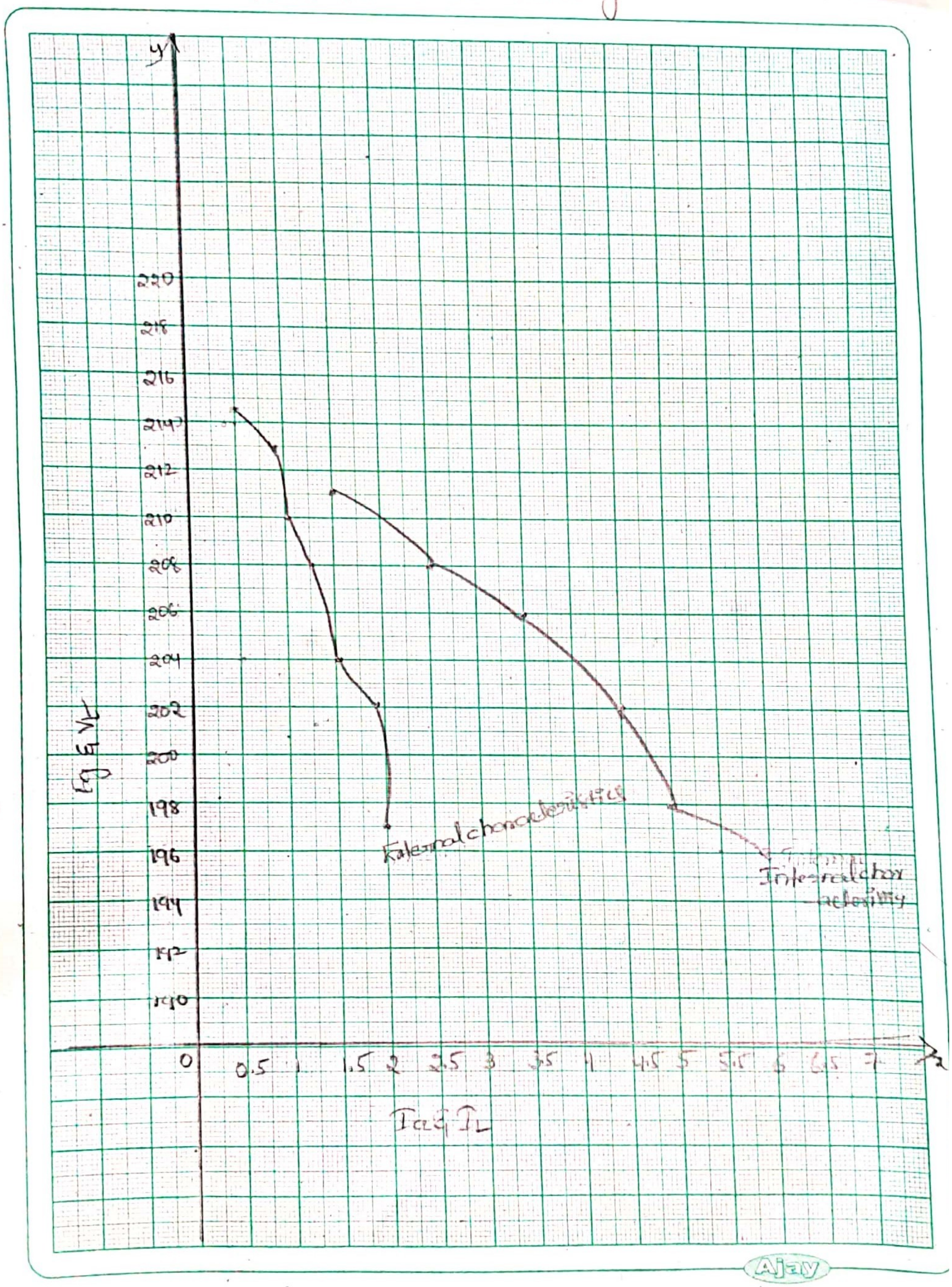
| Terminal Voltage (Volts) | Load Current ($I_L$) | Field Current ($I_f$) | $Ia = I_L + I_f$ (amp) | $E_g = V + IaR_a$ (volts) |
|---|---|---|---|---|
| 214.7 | 0.4 | 0.5 | 0.9 | 215.65 |
| 211.8 | 1.5 | 0.9 | 2.4 | 213.5 |
| 208.6 | 2.5 | 1 | 3.5 | 210.5 |
| 206.1 | 3.5 | 1.2 | 4.7 | 208.38 |
| 202 | 4.5 | 1.5 | 6 | 204.85 |
| 198.5 | 5 | 1.5 | 6.5 | 201.35 |
| 194.1 | 6.5 | 2 | 8.5 | 197.9 |
| 191.1 | 7.5 | 2 | 9.5 | 194.9 |

**Table2: Armature Resistance**

## **Model graph:-**


y
Eg &V
internal characteristics
external characteristics
X
Ia &IL

Load test on dc shunt generator



**<u>Result</u>: -**

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

## Viva voce

1. What is the condition for maximum efficiency?
2. What is the difference between cumulative and differential compound motor?
3. What is torque?
4. What is back Emf?
5. What are the applications of dc shunt motors?

**EXPERIMENT No.-09**

**AIM -To Perform Load Test On A DC Series Generator**

***NAME PLATE DETAILS:***

**Motor**

| | |
|---|---|
| Voltage | |
| Current | |
| Output | |
| Speed | |

**Generator**

| | |
|---|---|
| Voltage | |
| Current | |
| Output | |
| Speed | |

**CIRCUIT DIAGRAM:**

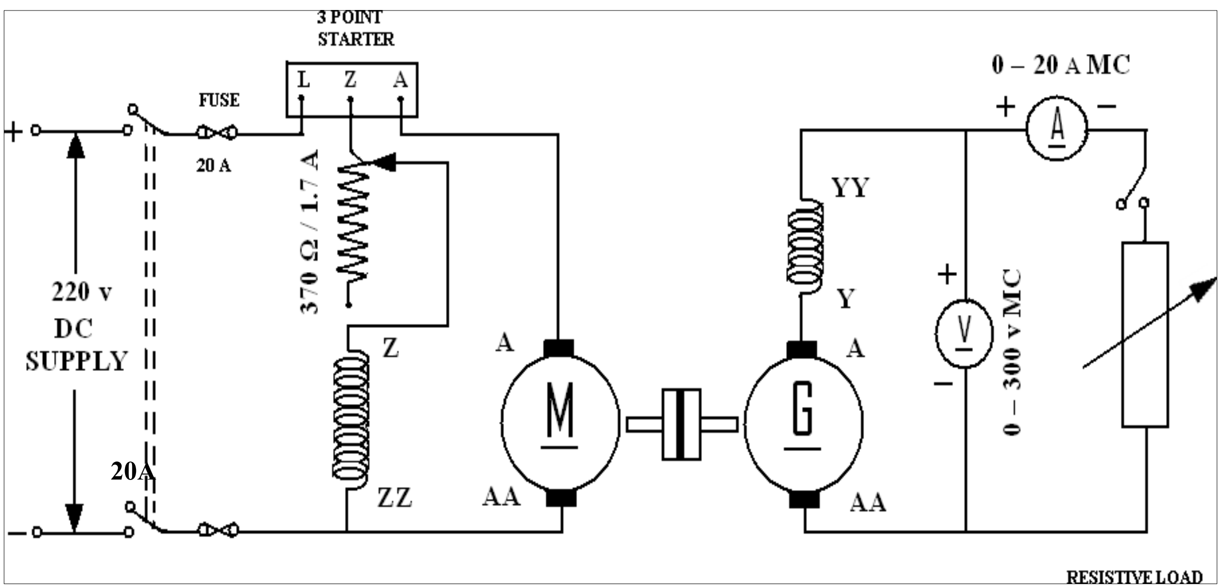



**Fig - 3.1 DC Shunt Motor - Series Generator Set**

**APPARATUS:**

| S.No. | Item | Type | Range | Quantity |
|---|---|---|---|---|
| 1 | Ammeter | | | |
| 2 | Voltmeter | | | |
| 3 | Rheostat | | | |
| 4 | Tachometer | | | |
| 5 | Connecting wires | | | |

**PROCEDURE:**

1. Choose the proper ranges of meters after noting the name plate details of the given machine and make the connections as per the circuit diagram.
2. Keeping the motor field resistance minimum and the generator output terminals are open circuited, give supply and start the motor - generator set.
3. Adjust the speed of the MG Set to the rated speed of the generator using the motor field rheostat ($R_f$)
4. Note down the voltage due to residual magnetism on no load.
5. Run the DC series generator under rated load conditions and note down the terminal voltage and load current by removing the loads slowly. ( but not no-load condition)
6. Measure the generator armature resistance $R_a$ by drop method.
7. Calculate the generated emf E at each load from the relation, $E_g = V + I(R_a + R_{Se})$.
8. Draw the external characteristic, $V_T$ vs. $I_L$ and the internal characteristic, $E_g$ Vs $I_a$ on the same graph sheet.

**TABULAR COLUMN:**

| S. NO. | $I_L$(Amp) | $V_T$(Volt) | $E_g = (V_T + I_L(R_a + R_S))$ |
|---|---|---|---|
| **1.** | | | |
| **2.** | | | |

**MODEL GRAPH:**

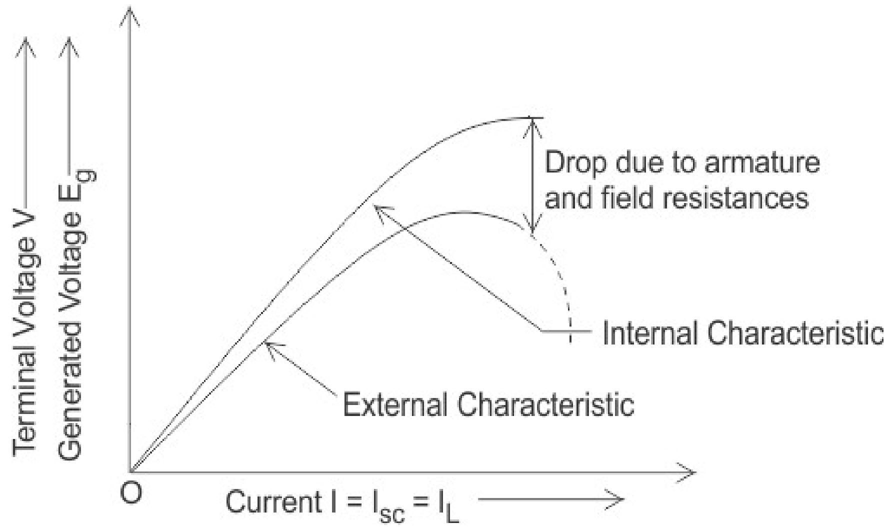



**Fig - 3.2 Internal and External Characteristics of DC series generator**

**PRECAUTIONS:**

1. Don't switch on the supply without any load.
2. Avoid parallax errors and loose connections.

**RESULT:**

**PRE LAB VIVA QUESTIONS:**

1. What are the applications of DC series generator?
2. To conduct the test on DC series generator, can we use any other prime mover other than DC shunt motor?
3. Why DC series motor should not start without any load?
4. State the applications of the series generator.
5. State voltage builds up conditions of a series generator.

***POST LAB VIVA QUESTIONS:***

1. In what way does the series generator differ fundamentally from shunt generator?
2. Why does a series generator have rising characteristics?

3. Why the series generators will only built up when load switch is on?
4. Why the series generator used as voltage booster in transmission system?

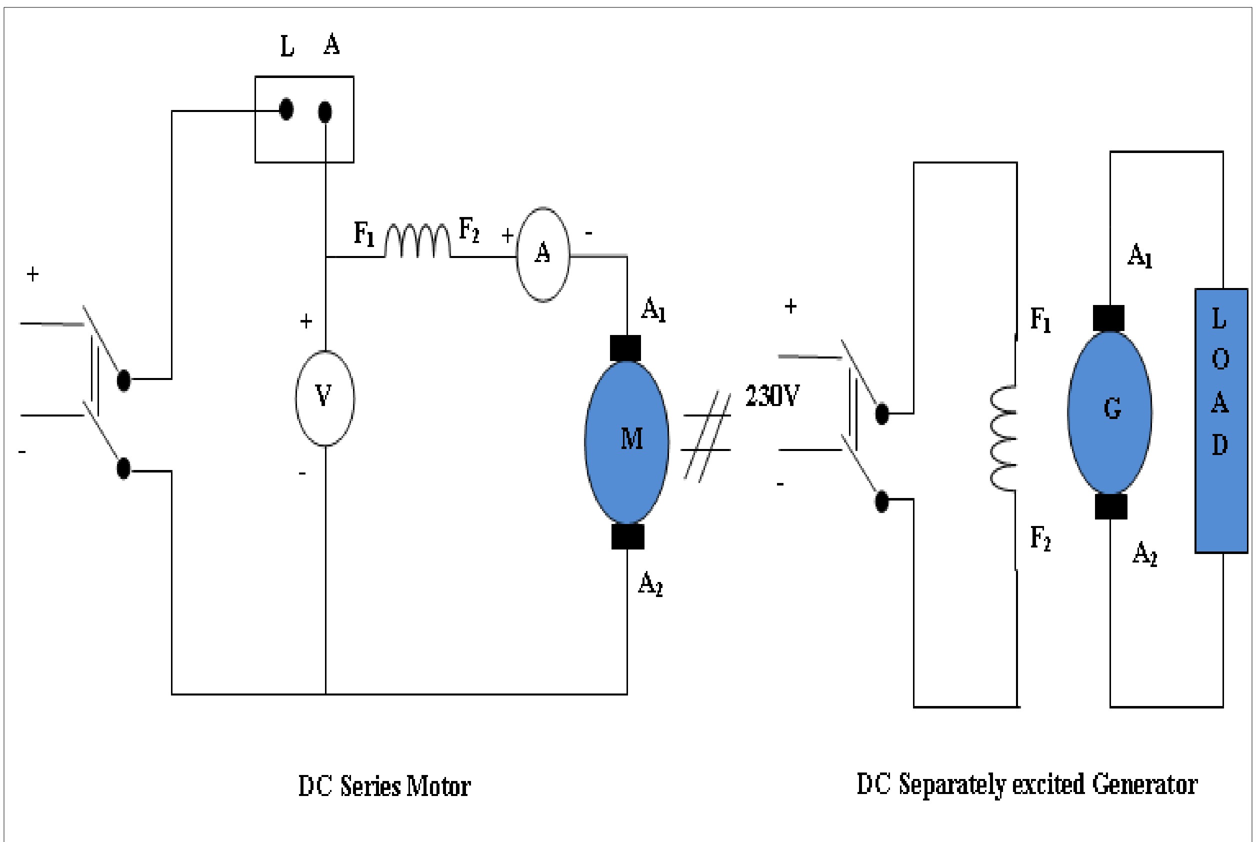
**EXPERIMENT No.-10**

**AIM – To The Study Of Measurement of speed of DC series Motor as a function of the load (Load test on DC Series Motor)**

## EQUIPEMENTS:

1) DC series Motor coupled with DC Generator.
2) Ammeter.
3) Voltmeter.
4) Lamp Load.
5) Tachometer.

## CIRCUIT DIAGRAM:



## THEORY:

The characteristics of DC Motor are nothing but the performance of that motor. The application of motor for a specific work is decided by it's characteristics. For a DC Motor there are three types of characteristics.

1) Torque-Armature current characteristics($T_a/I_a$)

This characteristic is also known as electrical characteristic. We know that torque is directly proportional to the product of armature current and field flux, $T_a$ a ϕ.$I_a$. In DC series motors, field winding is connected in series with the armature, i.e. $I_a = I_f$. Therefore, before magnetic saturation of the field, flux ϕ is directly proportional to Ia. Hence, beforemagnetic saturation Ta α $Ia^2$. Therefore, the Ta-Ia curve is parabola for smaller values of Ia.

After magnetic saturation of the field poles, flux ϕ is independent of armature current Ia. Therefore, the torque varies proportionally to Ia only, T a Ia.Therefore, after magnetic saturation, Ta-Ia curve becomes a straight line.

2) In DC series motors, (prior to magnetic saturation) torque increases as the square of armature current, these motors are used where high starting torque is required Speed-Armature current characteristics($N/I_a$) We know the relation, N a $E_b$/ϕ

For small load current (and hence for small armature current) change in back emf Eb is small and it may be neglected. Hence, for small currents speed is inversely proportional to ϕ. As we know, flux is directly proportional to Ia, speed is inversely proportional to Ia. Therefore, when armature current is very small the speed becomes dangerously high. That is **why a series motor should never be started without some mechanical load**.

But, at heavy loads, armature current Ia is large. And hence, speed is low which results in decreased back emf Eb. Due to decreased Eb, more armature current is allowed.

3) Speed-Armature Torque characteristics($N/T_a$)

This characteristic is also called as **mechanical characteristic**. From the above two **characteristics of DC series motor**, it can be found that when speed is high, torque is low and vice versa.

## PROCEDURE:

1) Make the connection as per the circuit diagram.
2) Switch on the loading resistance on the generator terminals because series motor should not be run on no load.
3) Start the DC series motor with the help of starter. Generator will act as a load on the motor.
4) Apply rated voltage to the motor.
5) Increase the load on the DC generator step by step.
6) Record speed & current drawn by Motor.
7) Plot graphs: N Vs $I_a$, $T_a$ Vs $I_a$, N Vs $T_a$

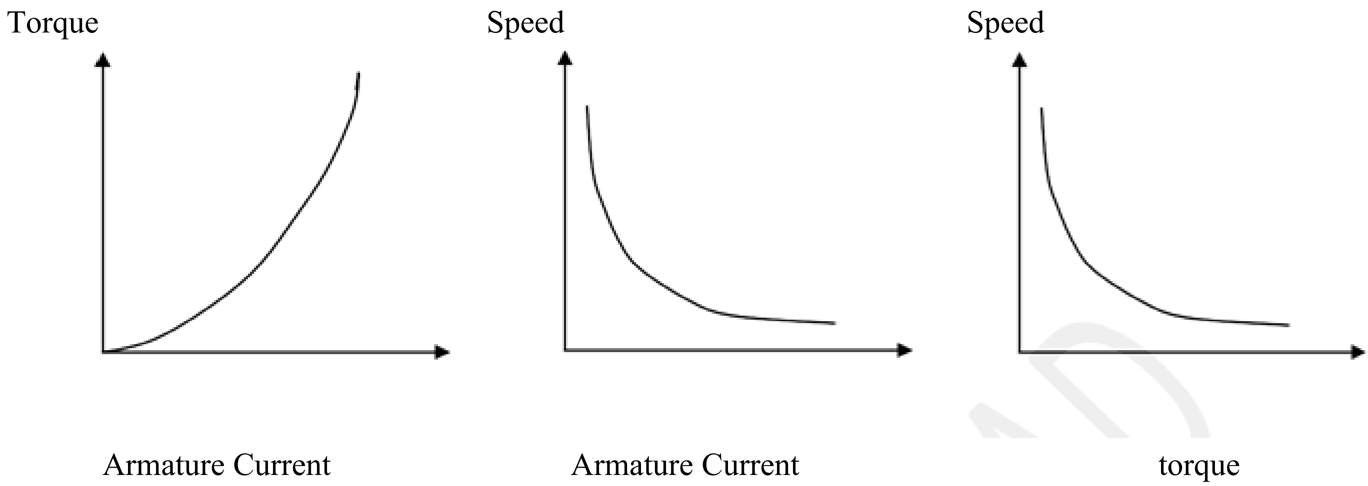
## OBSERVATIONS:

1) Motor applied voltage =---------V.
2) Armature resistance=------------Ω

OBSERVATION TABLE:

| Sr.No. | N(rpm) | $I_a$(Amp) | $E_b = V - I_a R_a$ | $T_a = \frac{9.55 E_b I_a}{N}$ |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |

**Graph:**




## CONCLUSION:

It is observed that, with increase in load,

1) Speed of DC Series motor decreases.
2) Torque of DC series motor increases, the characteristics gives parabola before saturation & straight line after saturation.

## VIVA QUESTIONS:

1) What are the different characteristics of DC Motor?
2) Why is a d.c. series motor used to start heavy loads?
3) Why the D.C. series motor is not operated at zero or light loads?
4) What is the chief advantage of a d.c. series motor?
5) What are the applications of DC Series motor.