# SESHADRIRAO GUDLAVALLERU ENGINEERING COLLEGE

## SESHADRIRAO KNOWLEDGE VILLAGE :: GUDLAVALLERU

## DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

**NAME :**

**ROLL No. :**

**LAB NAME :**

**YEAR & SECTION :**

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**SESHADRIRAO GUDLAVALLERU ENGINEERING COLLEGE**
**SESHADRIRAO KNOWLEDGE VILLAGE::GUDLAVALLERU**
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

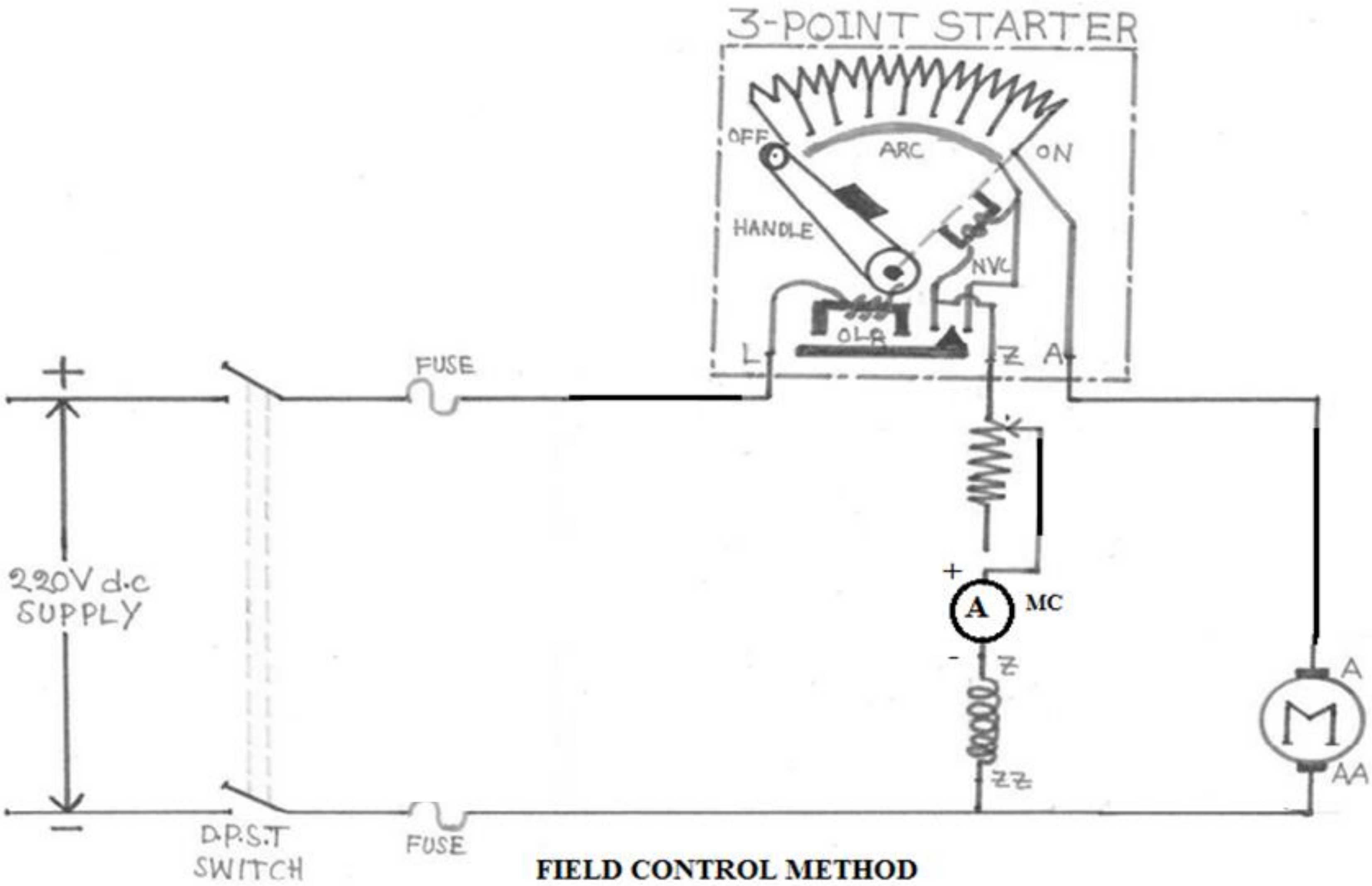
**DC MACHINES AND TRANSFORMERS LAB**

**List of the experiments:**

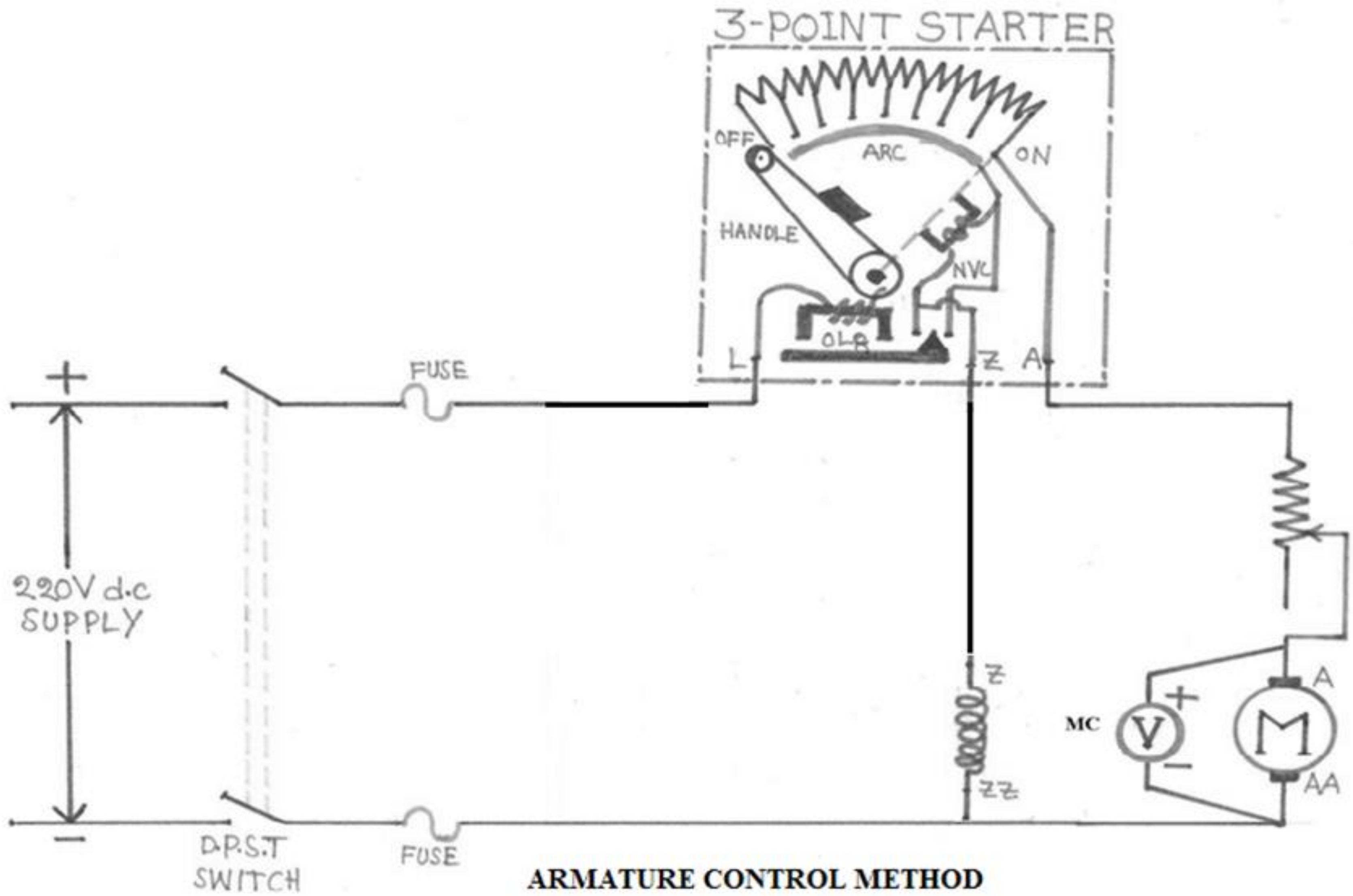
***Any 10 of the following experiments are to be conducted:***

1. Speed control of DC shunt motor by Field Current and Armature Voltage Control.
2. Brake test on DC shunt motor
3. Swinburne’s test - Predetermination of efficiencies as DC Generator and Motor.
4. Hopkinson’s teston DC shunt Machines.
5. Load test on DC compound generator
6. Load test on DC shunt generator
7. Fields test on DC series machines
8. Brake test on DC compound motor
9. OC & SC tests on single phase transformer.
10. Sumpner’s test on single phase transformer.
11. Scott connection of transformers.
12. Parallel operation of Single - phase Transformers.
13. Separation of core losses of a single - phase Transformer.

# SPEED CONTROL OF DC SHUNT MOTOR




**FIELD CONTROL METHOD**




**ARMATURE CONTROL METHOD**

**Exp.No.:** **Date:**

**Aim**: a) To study the speed control of DC shunt motor below the normal speed by armature resistance control method and to plot armature voltage Vs speed characteristic.

b) To study the speed control of DC shunt motor above the normal speed by field control method and to plot field current Vs speed characteristic.

## Name-plate Details:

## Apparatus:

| S. No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MC | | |
| 2. | Ammeter | MC | | |
| 3. | Rheostat | WW | | |
| 4. | Rheostat | WW | | |
| 5. | Tachometer | DGT | | |

## Theory:

The back emf for a D.C motor is given by

$$\text{Back emf, } E_b = \frac{P\Phi NZ}{60A}$$

The number of poles P, the armature conductors Z and the number of parallel paths A are constant for a particular machine. Thus the speed of the D.C motor is given by,

$$\text{Speed of the motor, } N = K\frac{E_b}{\Phi} = K\frac{V - I_a R_a}{\Phi}$$

The equation for the speed of the motor clearly indicates the following,

(i) Speed of the D.C motor can be controlled below the normal range of speed by varying the resistance in the armature circuit included in the form of a rheostat as a variable resistance (armature control).

(ii) Speed of the D.C motor can be controlled above the normal range speed by decreasing the flux φ i.e. by decreasing the current in the field circuit by including an external resistance in the form of a rheostat as variable resistance (field control).

## 1. Armature control method:

Let the external resistance in the armature circuit of a D.C shunt motor be R ohms, then the speed equation modifies to,

$$N = k\frac{V - I_a(R_a + R)}{\Phi} rpm$$

Hence the speed of the motor decreases with an increase in the value of external resistance R. Thus reduced speeds lower than the no load speed can be obtained by this method. However, there is an excessive wastage of power in the additional resistance, which lowers the efficiency of the motor considerably.

## 2. Field control method:

The speed of the D.C motor can be increased beyond the no load speed by inserting an external resistance in the shunt field circuit. The current in the external resistance is very low, hence the losses occurring in the additional resistance is quite small.

## Procedure:

### ➢ Armature Control Method:

1. The connections are made as per the circuit diagram.
2. The motor is started with the help of a 3-point starter.
3. The no-load readings are taken.
4. By varying the rheostat in Armature circuit gradually in steps the readings of Voltmeter and Speed are noted down.
5. The graph is drawn between Armature Voltage($V_a$) and Speed(N).

### ➢ Field Control Method:

1. The connections are made per the circuit diagram.
2. The motor is started with the help of a 3-point starter.
3. The no-load readings are taken.
4. By varying the rheostat in Field circuit gradually in steps the readings of Ammeter and Speed are noted down.
5. The graph is drawn between Field Current($I_f$) and Speed(N).

## Tabular Form:

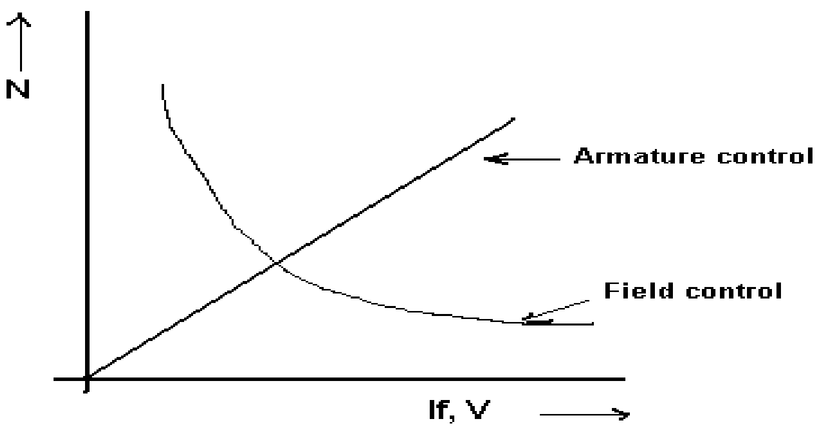
- **Armature Control Method:**

| S. No. | Voltage (V) | Speed (rpm) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |

- **Field Control Method:**

| S. No. | Current (A) | Speed (rpm) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |

## Model Graph:



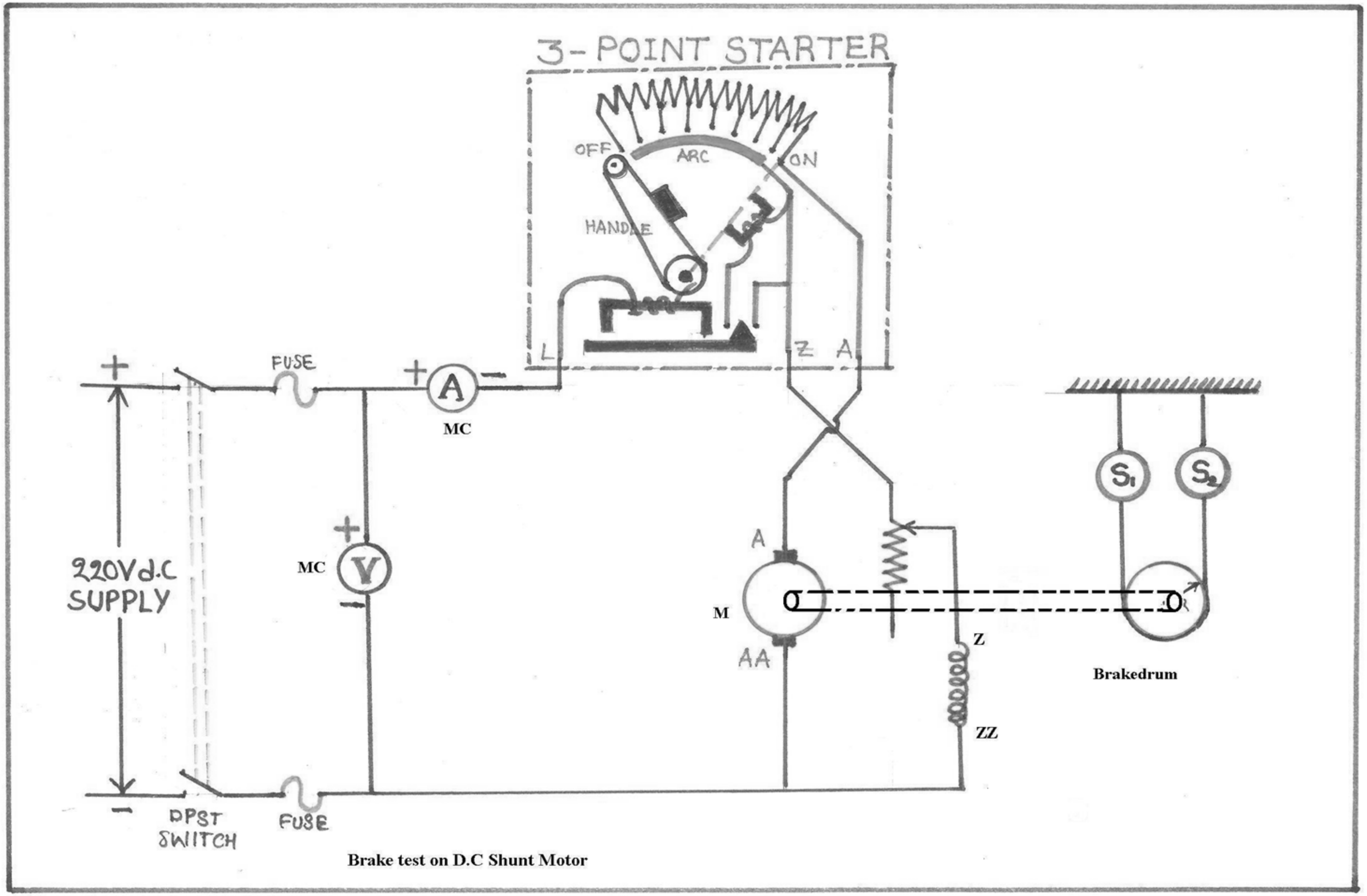

## Precautions:

1. Connections should be made carefully.
2. Readings should be taken without any parallax error.

## Result:

# BRAKE TEST ON

# DC SHUNT MOTOR




Brake test on D.C Shunt Motor

**Exp.No.:** **Date:**

**Aim:** To conduct brake test on DC shunt motor and to draw its characteristics.

## Name-plate Details:

## Apparatus:

| S. No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MC | (0-300v) | 1 |
| 2. | Ammeter | MC | (0-20A) | 1 |
| 3. | Rheostat | WW | 296Ω/2.8A | 1 |
| 4. | Tachometer | DGT | 0-10000 | 1 |

## Theory:

The load test on a D.C motor is performed to obtain its various performance characteristics including efficiency. The motor can be loaded by a belt and pulley arrangement as shown in Fig(1). If $W_1$ and $W_2$ are the tensions in Kg indicated by the two spring balances provided on the two sides of the belt, then the load torque on the motor is given by,

Load torque, $T = (W_1 + W_2) \times r$ Kg – m

Then, the mechanical power output of the motor,

$$P_m = \frac{2\pi NT}{60 \times 0.102} \text{ watts}$$

Power input to the motor, $P_i = V \times I$ watts

Hence, efficiency of the motor, $\eta = \frac{P_m}{P_i} \times 100\,\%$

Where, r – radius of the pulley in meter

N – speed of the motor in rpm

V – voltage applied to the motor

I – input current drawn by the motor

The speed of the D.C motor is given by the following expression, Speed of rotation, $N = k\frac{V - I_a R_a}{\Phi}$

Where the applied voltage V is constant, more over the flux Φ is nearly constant for shunt motor. Thus the speed of the D.C shunt motor will decrease as the load on the motor increases, because of the increase in the armature voltage drop, $I_a R_a$. The drop in speed from no load to full load operation is hardly 4 to 5% of the rated speed, as such D.C shunt motor is regarded as constant speed motor for all practical purposes.

## Procedure:

1. Connect the circuit as per the circuit diagram.
2. Give the supply to the circuit by closing the DPST switch.
3. Start the motor with the help of a 3-poinrt starter.
4. Note down the voltage and current readings for no-load condition.
5. Apply the load gradually & note down the readings of voltmeter, ammeter & tachometer.
6. Each time note down the readings of $S_1$ & $S_2$.
7. Calculate the output power, input power and efficiency.
8. Repeat the procedure until the ammeter reads full load current.

### Tabular Form:

| S. No. | Voltage (V) | Current (A) | Speed (rpm) | Weights | | | Torque = 9.81*R*($S_1$~$S_2$) | Input = V *I | Output = 2ΠNT / 60 | η = Output / Input * 100 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $S_1$ | $S_2$ | $S_1$~$S_2$ | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
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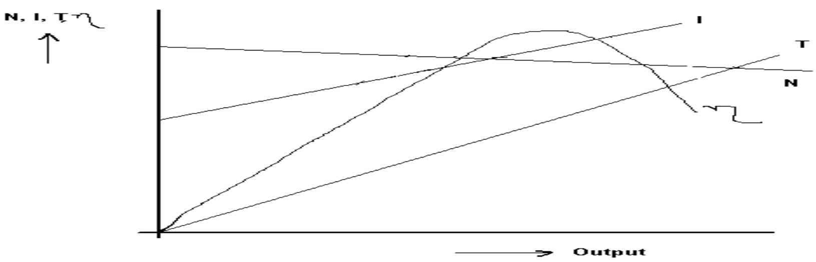
**Note:** R – Radius of Brake Drum

## Model Graph:

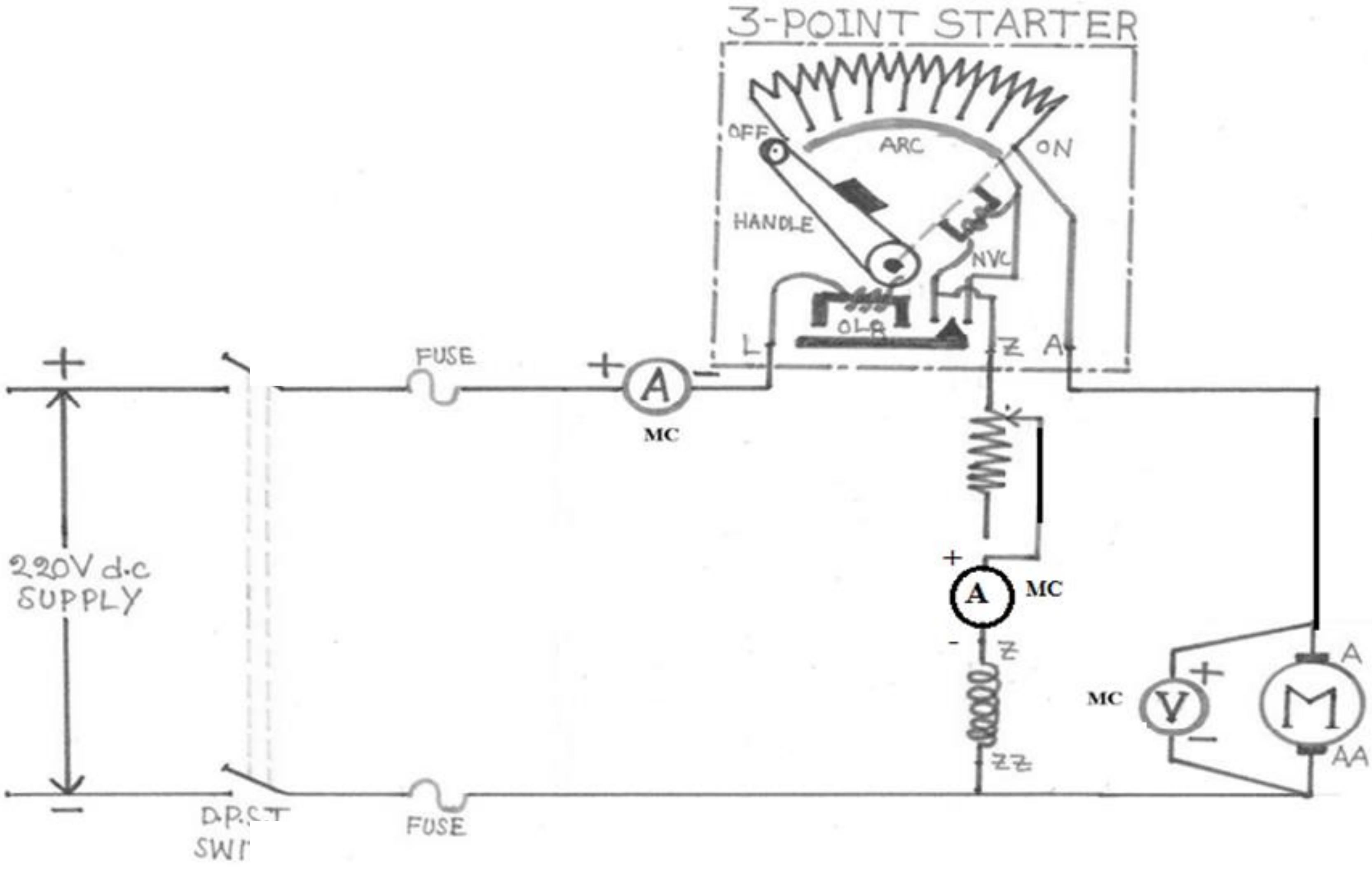


## Precautions:

1. Load must be applied gradually, but not suddenly.
2. Load should be removed before switching of the motor.

## Result:

# SWINBURNE'S TEST ON DC SHUNT MOTOR


3-POINT STARTER
OFF
ARC
ON
HANDLE
NVC
OLR
L
Z
A
FUSE
MC
220V d.c
SUPPLY
MC
Z
ZZ
MC
A
AA
FUSE
D.P.S.T
SWI

**Exp.No.:** **Date:**

**Aim:** To predetermine the efficiency of a DC shunt machine as a motor and as a generator by conducting Swinburne's test.

## Name Plate Details:

## Apparatus:

| S. No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MC | | |
| 2. | Voltmeter | MC | | |
| 3. | Ammeter | MC | | |
| 4. | Ammeter | MC | | |
| 5. | Rheostat | WW | | |
| 6. | Rheostat | WW | | |
| 7. | Tachometer | DGT | | |

## Theory:

Swinburne's test is an indirect method (without loading) for finding out the efficiency of D.C machine. Various losses occurring in a D.C machine can be classified as (i) constant losses and (ii) variable losses. Variable losses are directly proportional to the square of armature current or approximately the load current, where as constant losses are independent of load conditions.

In this method, constant losses are determined experimentally by operating the D.C machine as motor running at no load. Variable losses which occur on load are calculated from the known specifications of the machine.

## Procedure:

1. The circuit is connected as per the circuit diagram.
2. Supply is given to the motor and the motor is started with the help of a 3-point starter.
3. The speed of the motor is adjusted to its rated value with the help of a shunt field rheostat.
4. The line current, armature voltage, shunt field current and speed are noted at no-load.
5. The resistance of the armature is measured with the help of ammeter voltmeter method.

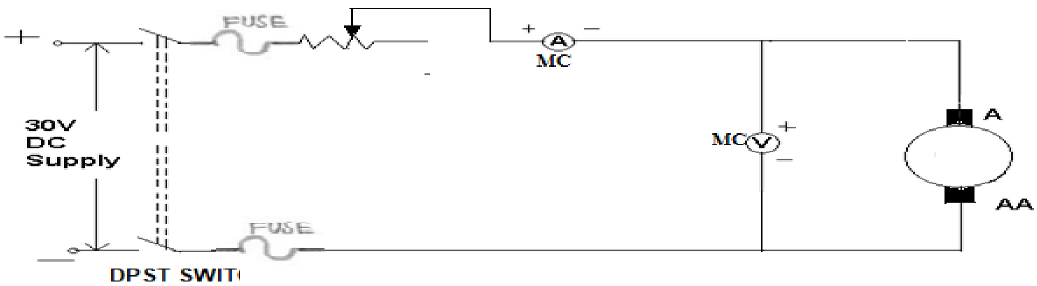
## Tabular Form:

| S. No. | Voltage (V) | Line Current ($I_{L0}$) | Field Current ($I_f$) | Speed (rpm) |
|---|---|---|---|---|
| 1 | | | | |

Constant losses = No. load input – No load armature Cu. Loss

$$= VI_{LO} - (I_{LO} - I_f)^2 R_a$$

## Test to find armature resistance $R_a$:




## Procedure:

1. 30V D.C supply is given to the circuit.
2. The rheostat is varried in suitable steps and the ammeter & voltmeter readings are note down.
3. Armature resistance is calculated.

## Tabular Form:

| S. No. | Voltage across armature ($V_a$) | Armature current ($I_a$) | Armature resistance ($R_a$) |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

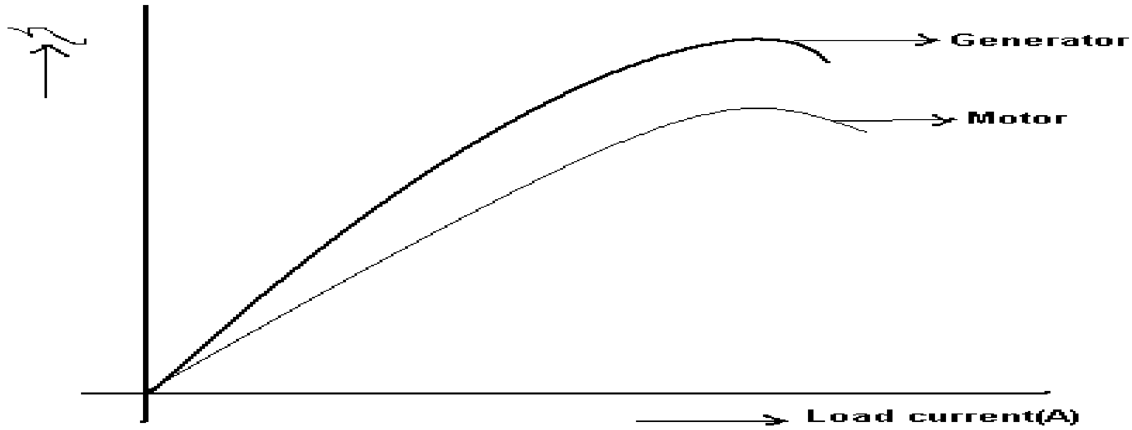
## Generator:

| S.No | Voltage (V) | Load Current ($I_L$) | Output ($V*I_L$) | Constant Losses ($W_c$) | Arm. Cu. Loss ($I_a^2*R_a$) | Total losses= Wc+ $I_a^2*R_a$ | Input= output+losses | η = Output / Input * 100 |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |

## Motor:

| S.No | Voltage (V) | Load Current ($I_L$) | Input ($V*I_L$) | Constant Losses ($W_c$) | Arm. Cu. Loss ($I_a^2*R_a$) | Total losses= Wc+ $I_a^2*R_a$ | Output= Input – losses | η = Output / Input * 100 |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |

**Model Graph**:

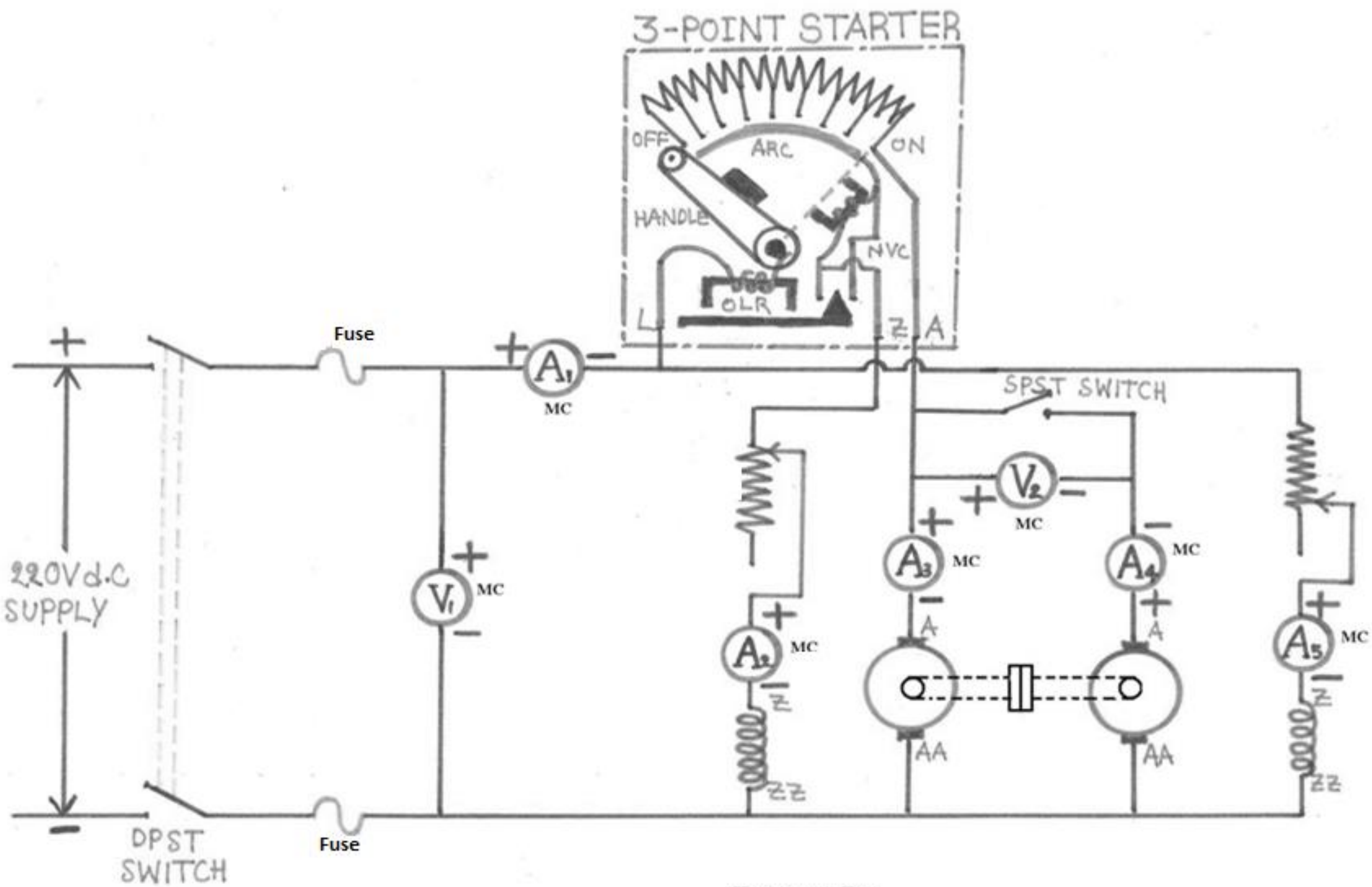



**Precautions**:

1. Connections must be made carefully & very tight.
2. All the meter readings should be taken without parallax error.

**Result**:

# HOPKINSON'S TEST




Hopkinson's Test

**Exp.No.:** **Date:**

**Aim:** To find out the efficiency of a DC motor & generator by conducting Hopkinson's test.

## Name Plate Details:

## Apparatus:

| S. No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MC | | |
| 2. | Ammeter | MC | | |
| 3. | Ammeter | MC | | |
| 4. | Rheostat | WW | | |
| 5. | Rheostat | WW | | |
| 6. | Switch | SPST | | |

## Theory:

The efficiency of the DC machine can be accurately determined by the regenerative method, normally known as Hopkinson's test. This test overcomes the drawback of Swinburne's test, which does not take into account of the stray load losses occurring in DC machines under loaded conditions. As such the efficiency, calculated by Swinburne's test is comparatively higher than the actual one. Hopkinson's test needs two identical DC machines coupled mechanically and connected electrically as shown in the figure. One of the machines is operated as motor, driving the other machine as a generator. The output power of the generator is fed to the motor. Thus the power drawn from the supply is only to overcome the losses of both the machines. By varying the field currents of generator and motor, any desired load can be adjusted on these two machines.

## Procedure:

1. All the connections are made as per the circuit diagram.
2. Motor is started with the help of a 3-point starter.
3. The speed of the motor is adjusted to rated speed by adjusting the shunt field rheostat of the motor.
4. The generator excitation is increased with the help of generator field rheostat until voltmeter connected across the armatures of both generator and motor gives zero deflection.
5. The SPST switch is closed at this condition & all the meter readings are noted.
6. The generator excitation is changed such that the generator armature current increases gradually & the readings of all the meters are tabulated for different loads.

## Tabular Form:

| S. No. | Voltmeter $V_1$ | Ammeter $A_{1(IL)}$ | Ammeter $A_{2(Ifm)}$ | Ammeter $A_{3(Iam)}$ | Ammeter $A_{4(Iag)}$ | Ammeter $A_{5(Ifg)}$ |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

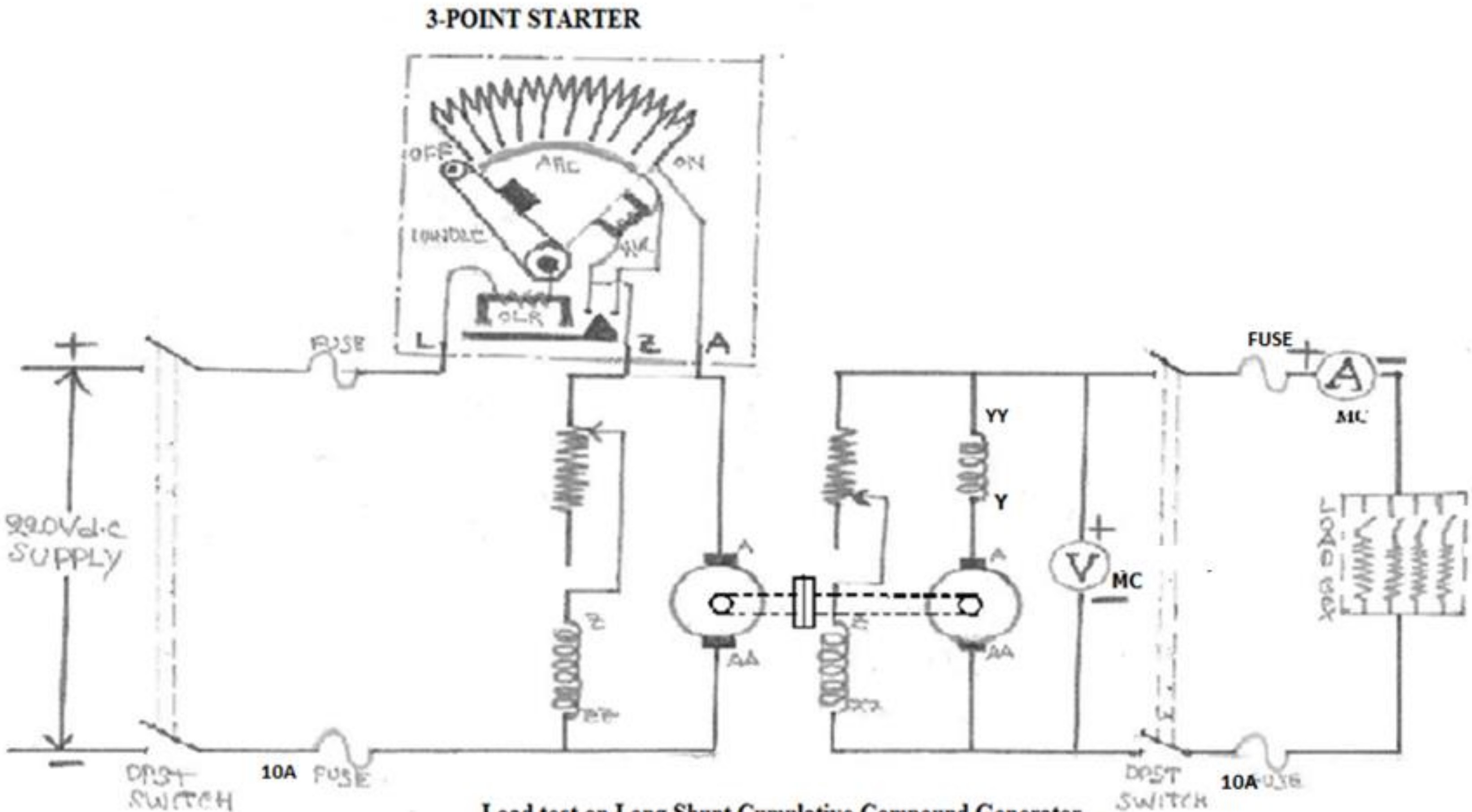
| S.No | Input of Motor $V(I_2+I_3)$ | Motor Armature Cu. Loss $I_3^2R_a$ | Motor Shunt Field Losses | Stray Losses $(W_3)$ | Stray Losses Per machine | Total Losses Of Motor | Armature Cu. Losses Of generator | Shunt field Cu. Loss of generator | Total Losses Of Generator | Output of Generator | η of Generator | η of Motor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |

## Precautions:

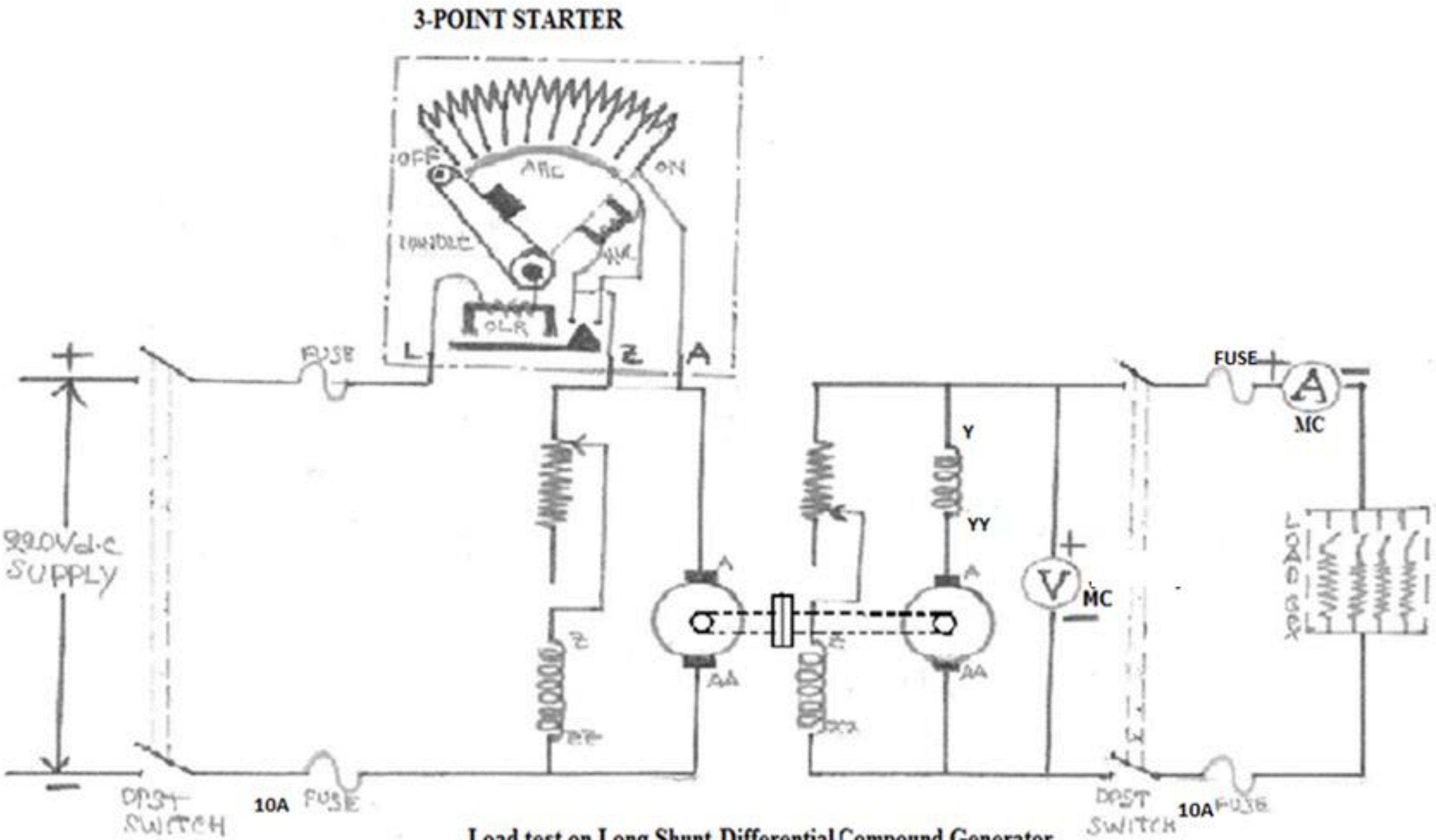
1. The two machines should be identical.
2. The SPST switch should be in open condition at the starting of the experiment. It should be closed, when the voltmeter across it reads zero.
3. The motor field regulator should be in minimum resistance position & the generator field regulator should be in the maximum resistance position.

## Result:

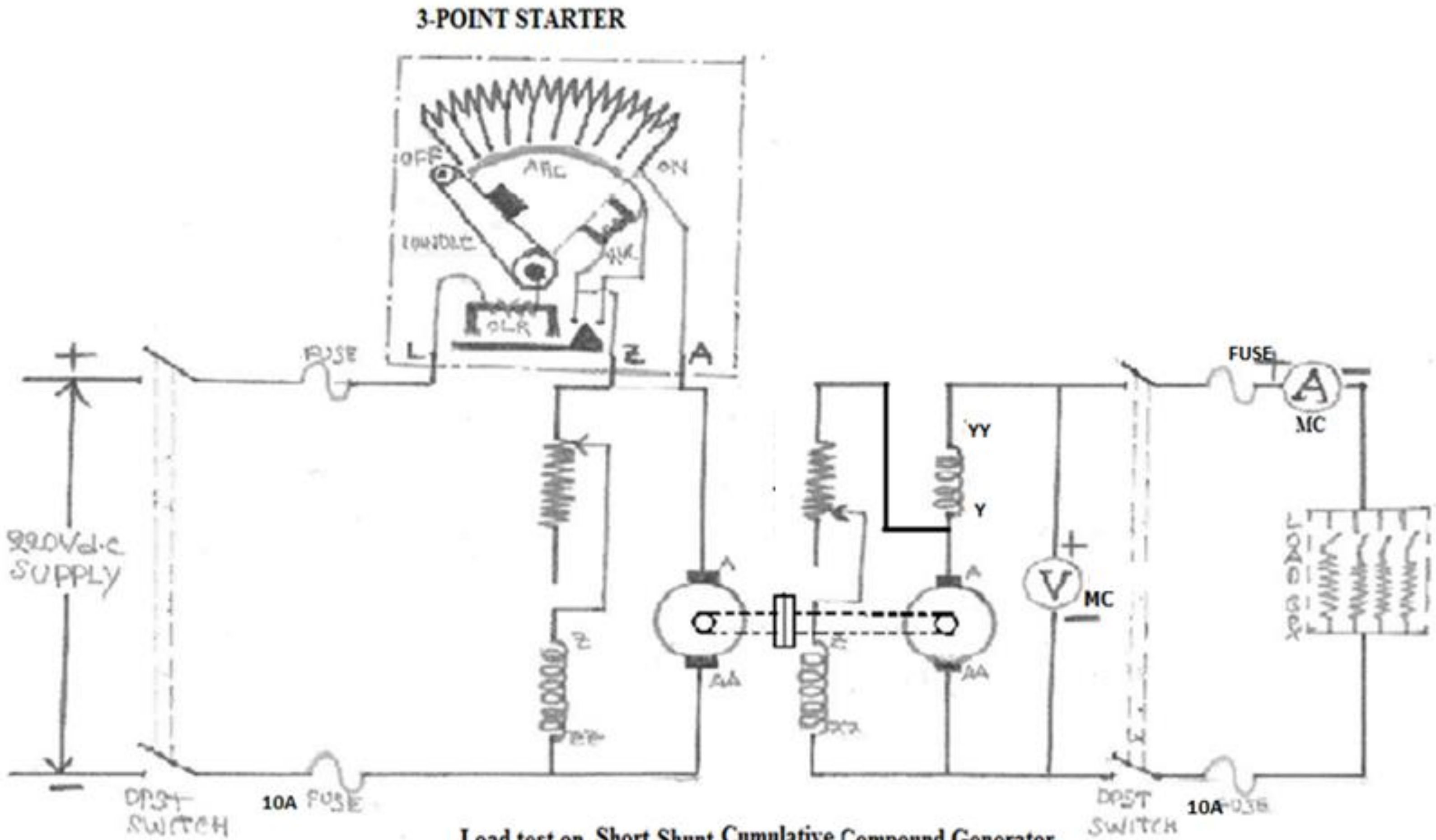
# LOAD TEST ON DC COMPOUND GENERATOR



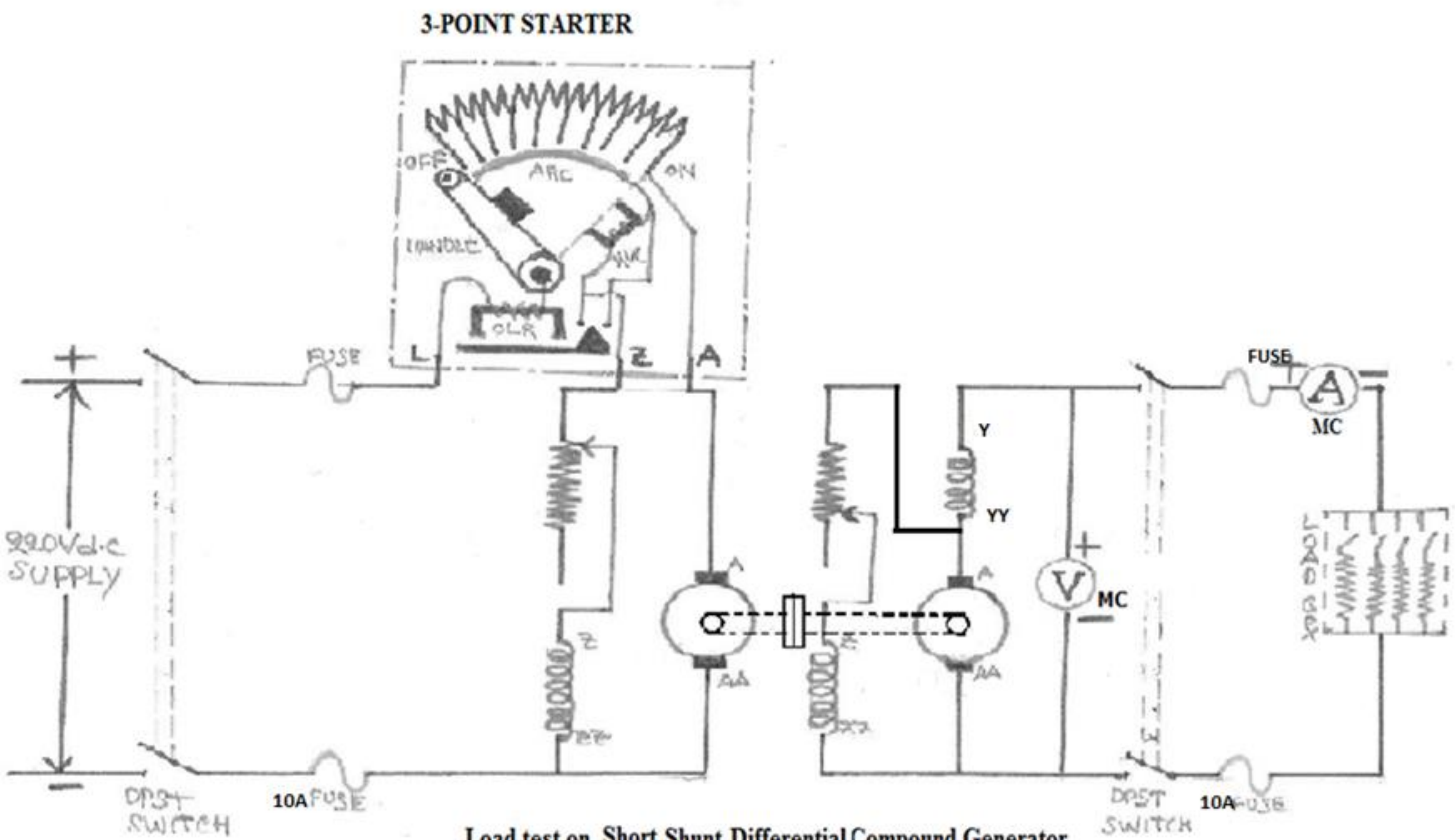

Load test on Long Shunt Cumulative Compound Generator




Load test on Long Shunt Differential Compound Generator




Load test on Short Shunt Cumulative Compound Generator




Load test on Short Shunt Differential Compound Generator

**Exp.No.:** **Date:**

**Aim:** To obtain the load characteristics of a DC compound generator with long shunt and short shunt connections, when the machine is cumulatively and differentially compounded.

## Name Plate Details:

## Apparatus:

| S. No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MC | | |
| 2. | Ammeter | MC | | |
| 3. | Rheostat | WW | | |
| 4. | Rheostat | WW | | |
| 5. | Load Box | Res | | |

## Theory:

The terminal voltage drop of the D.C shunt generator with load makes this type of D.C generator undesirable where constancy of voltage is necessary. A substantial constant voltage in the terminal may be achieved when both the series and shunt field coils are present. Shunt field acts as the main field and the series field either helps or opposes this shunt field. When both the fields help each other, the generator is called cumulative type and while they opposes each other, it is differential type. Thus by controlling the series field ampere-turns, it is possible to get a number of load characteristics.

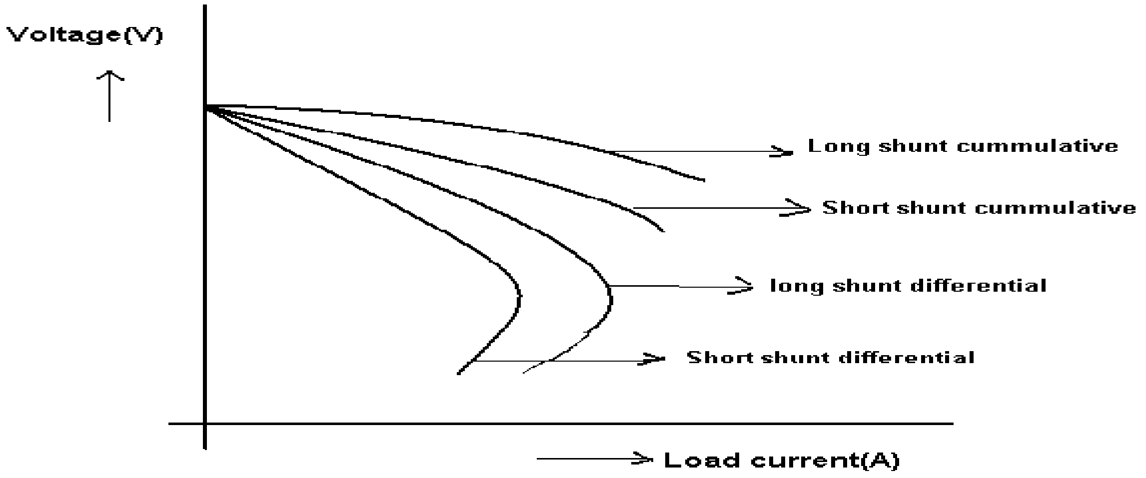
## Procedure:

1. All the connections are made as per the circuit diagram.
2. Supply is given to the DC shunt motor and it is started with the help of a 3-point starter.
3. The speed of the motor is adjusted to rated speed of D.C compound generator by adjusting the shunt field rheostat of motor.
4. The generator is allowed to build up its rated voltage by adjusting the generator shunt field rheostat.
5. The generator is loaded step by step with the help of loading rheostat. For each step, the terminal voltage and load current are noted.
6. The generator is loaded up to its full load current.
7. The above procedure is repeated for long shunt cumulative, long shunt differential, short shunt cumulative & short shunt differential connections.

## Tabular Form:

| S. No. | Long Shunt Cumulative | | Long Shunt Differential | | Short Shunt Cumulative | | Short Shunt Differential | |
|---|---|---|---|---|---|---|---|---|
| | Voltage | Current | Voltage | Current | Voltage | Current | Voltage | Current |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |

**Model Graph**:



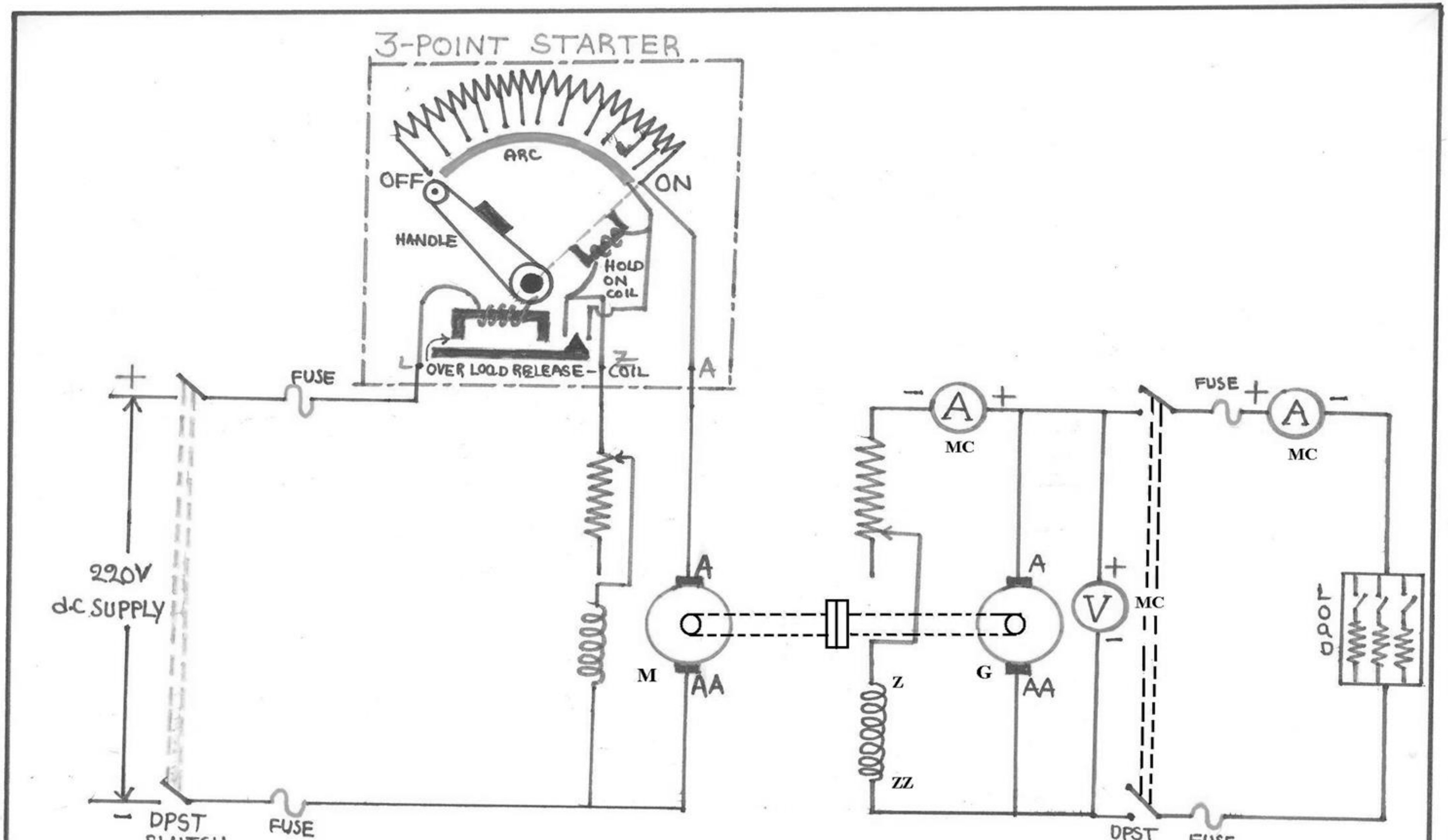

## Precautions:

1. All the connections are made tightly.
2. Readings should be taken without parallax error.

## Result:

# LOAD TEST ON

# DC SHUNT GENERATOR




Load Test on D.C Shunt Generator

**Exp.No.:** **Date:**

**Aim**: To determine the internal & external characteristics of DC shunt generator by actually loading it.

## Name-plate Details:

## Apparatus:

| S. No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MC | | |
| 2. | Ammeter | MC | | |
| 4. | Ammeter | MC | | |
| 5. | Rheostat | WW | | |
| 6. | Rheostat | WW | | |

## Theory:

If a DC shunt generator is loaded, after building up to its rated voltage then its terminal voltage will drop. This drop, in fact, increases if load current increases. But this type of terminal drop is undesirable for a specified service. The external characteristic of a generator represent the graphical relationship between the terminal voltage and the load current, the generator being operated at constant rated speed and with the same excitation as under the no load conditions. The nature of this characteristic depends upon the following factors.

- Voltage drop in the armature winding, interpole and compensating windings.
- Voltage drop at the brush contact
- Voltage drop due to armature reaction.

External characteristic of the generator indicates the fall in the terminal voltage as the load on the generator increases. External characteristic of a shunt generator is more drooping compared to that of separately excited generator.

The internal characteristic of D.C shunt generator can be obtained by adding the voltage drop in the armature winding($I_aR_a$) to the external characteristic plotted experimentally

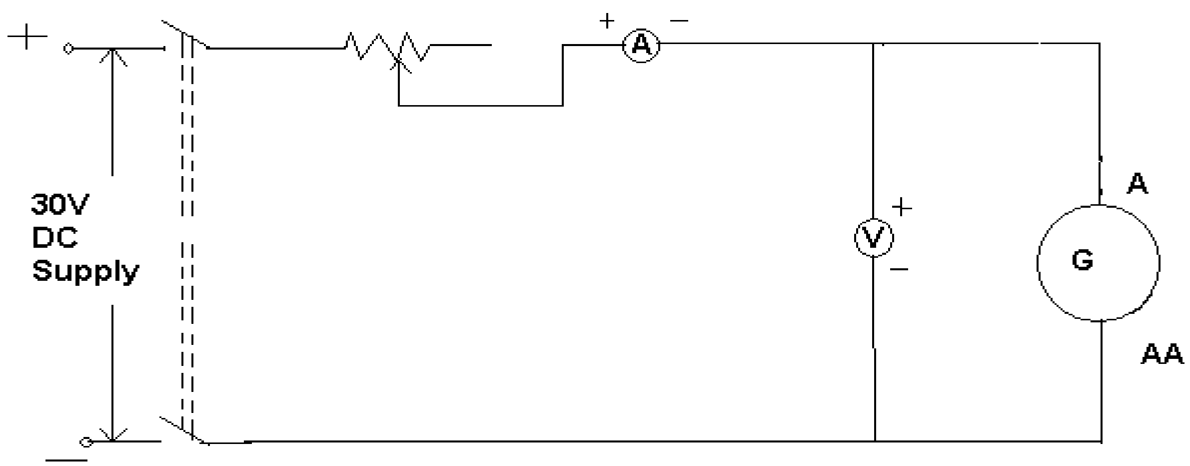
## Procedure:

1. All the connections are made as per the circuit diagram.
2. The supply is given and the motor is started with the help of a 3 – point starter. The speed of the motor is adjusted to that of the rated speed by varying motor field rheostat.
3. The terminal voltage of the generator is brought to the rated voltage by varying generator field rheostat.
4. The generator is loaded step by step with the help of a load resistance, for each step the speed of the generator was kept constant and for each step terminal voltage, load current & field current is noted.
5. The armature resistance ($R_a$) of generator is measured by ammeter – voltmeter method.
6. Induced EMF was calculated by adding $I_aR_a$ drop to the terminal voltage.

## Tabular Form:

| S. No. | Terminal Voltage (V) | Armature Current ($I_a$) | Load Current ($I_L$) | Field current $I_a$ - $I_L$ | Generated voltage $E_g = V + I_aR_a$ |
|---|---|---|---|---|---|
| | | | | | |

## Test to find armature resistance $R_a$:



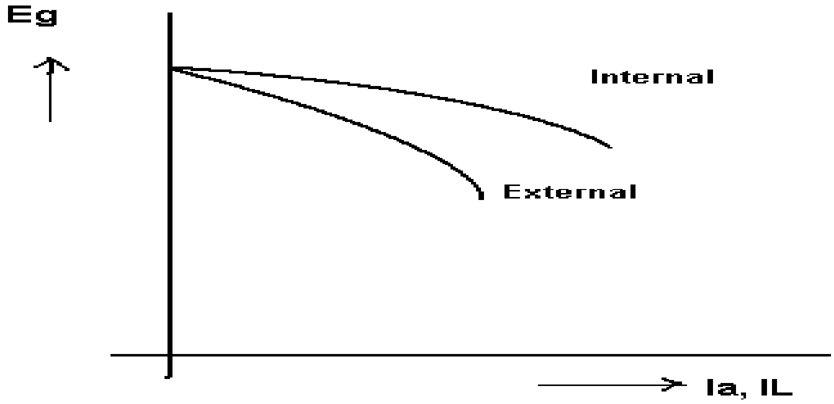

## Procedure:

1. Apply 30V D.C supply
2. Vary the rheostat in suitable steps and note down the ammeter & voltmeter readings
3. Find armature resistance

## Tabular Form:

| S. No. | Voltage across armature ($V_a$) | Armature current ($I_a$) | Armature resistance ($R_a$) |
|---|---|---|---|
| | | | |

**Model Graph:**

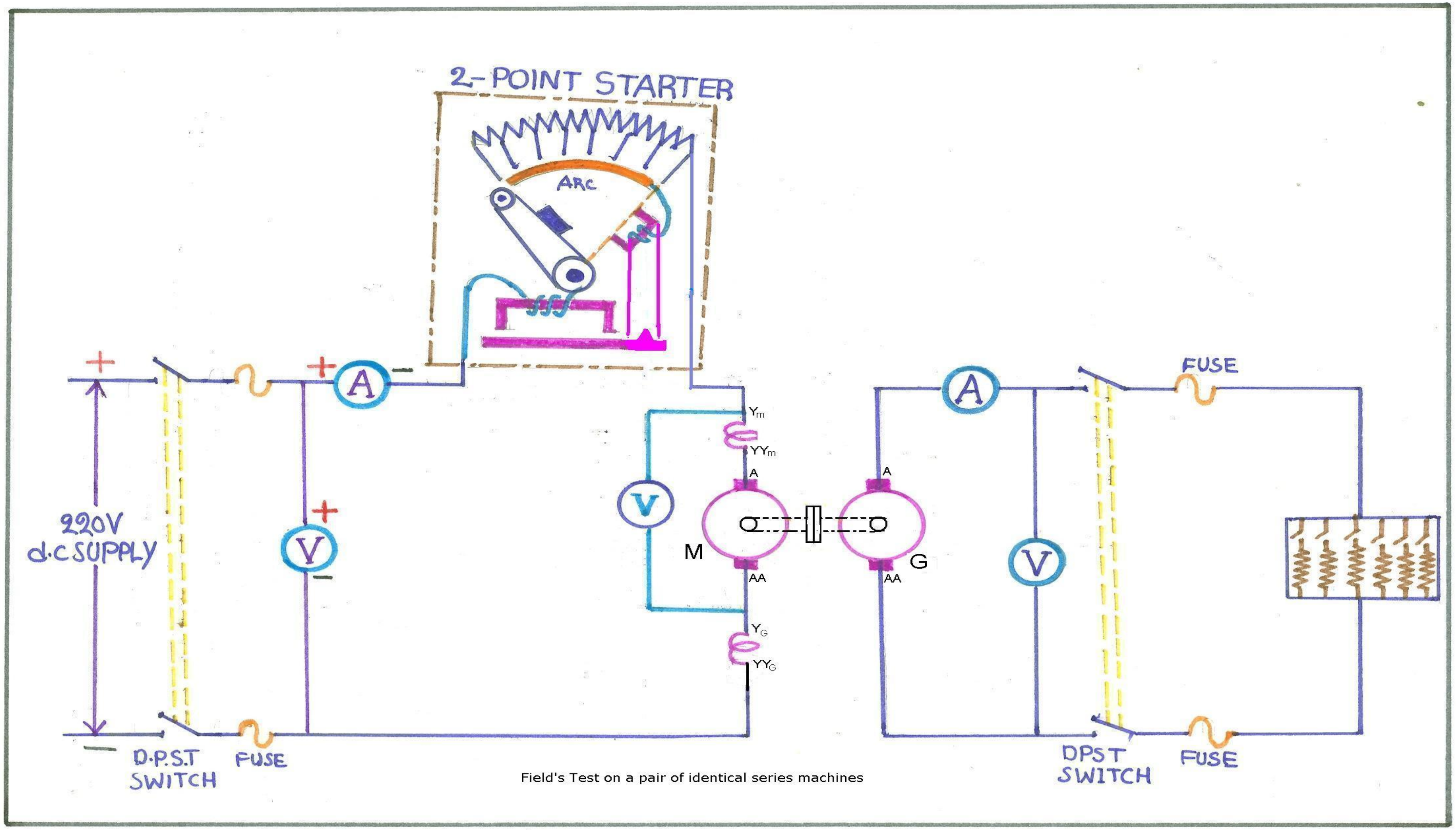



## Precautions:

1. All the connections are made tightly.
2. Speed of the generator is maintained constant throughout the experiment.
3. Readings should be taken without parallax error.

## Result:

# FIELD'S TEST ON DC SERIES MACHINE




Field's Test on a pair of identical series machines

**Exp.No.:** **Date:**

**Aim:** To conduct field's test on two identical DC series machines and to find out the efficiency of each machine.

## Name-plate Details:

## Apparatus:

| S. No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MC | (0-300v) | 3 |
| 2. | Ammeter | MC | (0-20A) | 2 |
| 3. | Rheostat | TWW | 296Ω/2.8A | 1 |

## Theory:

Series motors which are mainly used for traction work are easily available in pairs. The two machines are coupled mechanically. One machine runs as a motor and drives generator whose output is wasted in a variable load. Iron and friction losses of two machines are made equal by joining the series field winding of the generator in the motor armature circuit so that both machines are equally excited and by running them at equal speed. Load resistance is varied till the motor current reaches its Full-load value indicated by ammeter. After this adjustment for full-load current, different ammeter and voltmeter readings are noted.

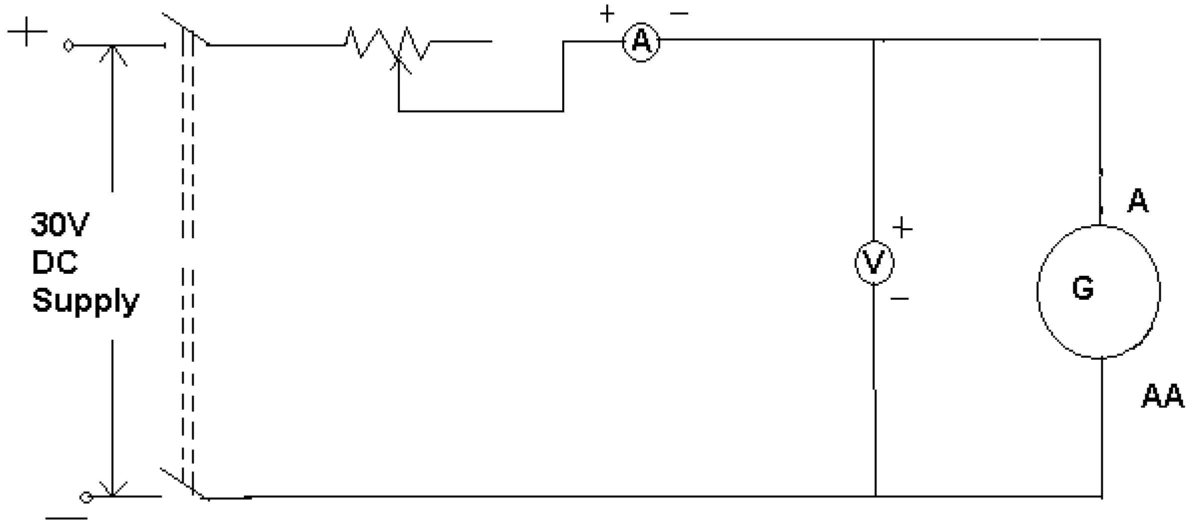
## Procedure:

1. All the connections are made as per the circuit diagram.
2. Keep the load rheostat at suitable value on generator side before starting the motor.
3. Series motor is started with the help, of a 2-point starter.
4. Load is increased until full load value is obtained and corresponding readings are noted.
5. Stray losses for each machine are calculated.
6. For 30V DC supply, armature resistance & series resistance of machines will be measured.
7. Then the efficiency of each machine is evaluated.

## Tabular Form:

| S. No. | Voltage (V) | Motor Current ($I_m$) | Terminal(V) (vg) | Generator current(Ig) |
|---|---|---|---|---|
| | | | | |

## Test to find armature resistance $R_a$:




## Procedure:

1. Apply 30V D.C supply
2. Vary the rheostat in suitable steps and note down the ammeter & voltmeter readings
3. Find armature resistance

**Tabular Form**:

| S. No. | Voltage across armature ($V_a$) | Armature current ($I_a$) | Armature resistance ($R_a$) |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

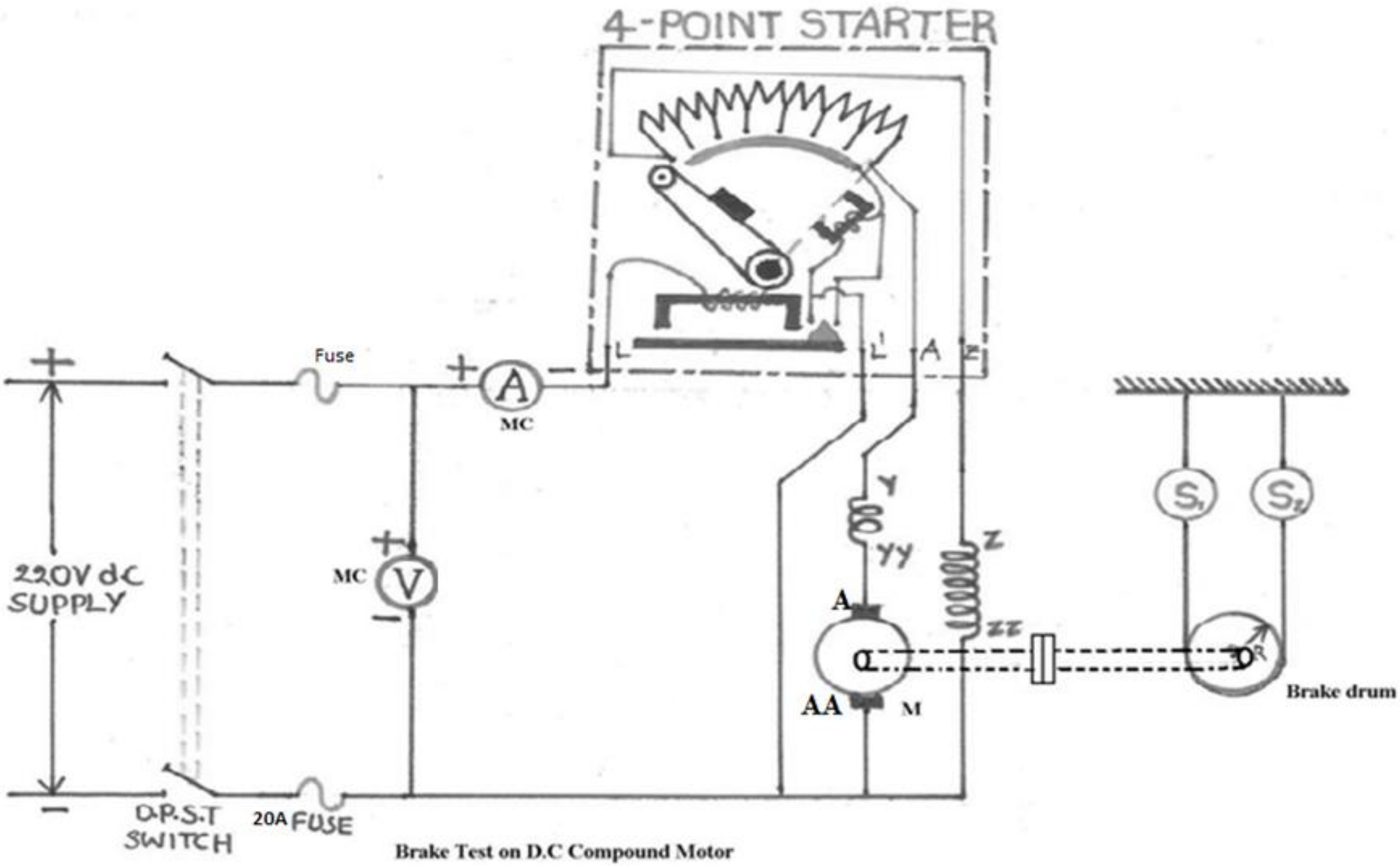
**Ra=**

## Precautions:

1. There should not be any loose connections.
2. There should be some load on the generator at the time of starting.
3. There should be no parallax error while taking the readings.

## Result:

# BRAKE TEST ON DC COMPOUND MOTOR




Brake Test on D.C Compound Motor

**Exp.No.:** **Date:**

**Aim:** To conduct brake test on DC compound motor & draw its performance characteristics.

## Name-plate Details:

## Apparatus:

| S. No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MC | | |
| 2. | Ammeter | MC | | |
| 3. | Tachometer | DGT | | |

## Theory:

Brake test is a direct method and consists of applying a brake to a water-cooled pulley mounted on the motor shaft. The brake band is fixed with the help of wooden blocks gripping the pulley. The motor is run and the load on the motor is adjusted till it carries its full load current. This simple brake test can be used for small motors only, because in case of large motors, it is difficult to dissipate the large amount of heat generated at the brake.

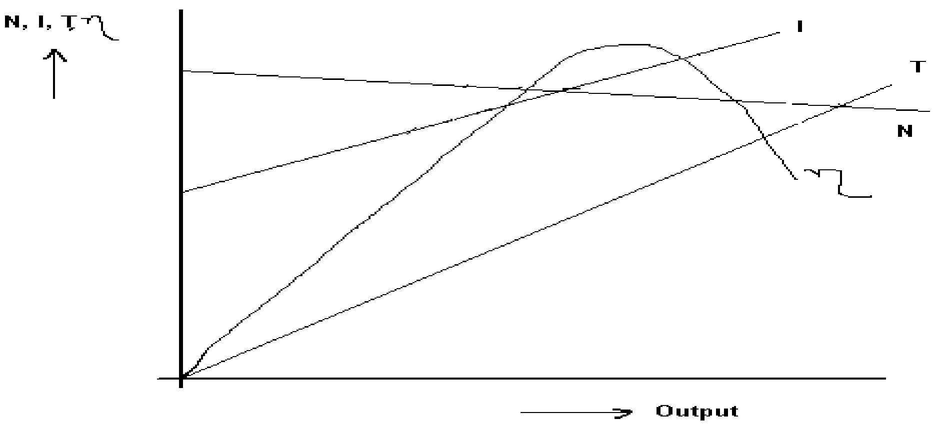
## Procedure:

1. The circuit is connected as per the circuit diagram.
2. The supply is given to the circuit by closing the DPST switch.
3. The motor is started with the help of a 4-point starter.
4. The readings of voltage & current are noted down for no-load.
5. The load is applied gradually and at each time S1, S2, Ammeter reading, Voltmeter reading and speed are noted down.
6. Each time the readings of $S_1$ & $S_2$ are noted down.
7. The load is varied until the Ammeter readings the full load current.
8. The torque, output power, input power and efficiency are calculated.

## Tabular Form:

| S. No. | Voltage (V) | Current (A) | Speed (rpm) | Weights | | | Torque = 9.81*R*($S_1$~$S_2$) | Input = V *I | Output = 2ΠNT / 60 | η = Output / Input * 100 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $S_1$ | $S_2$ | $S_1$~$S_2$ | | | | |
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |

## Model Graph:

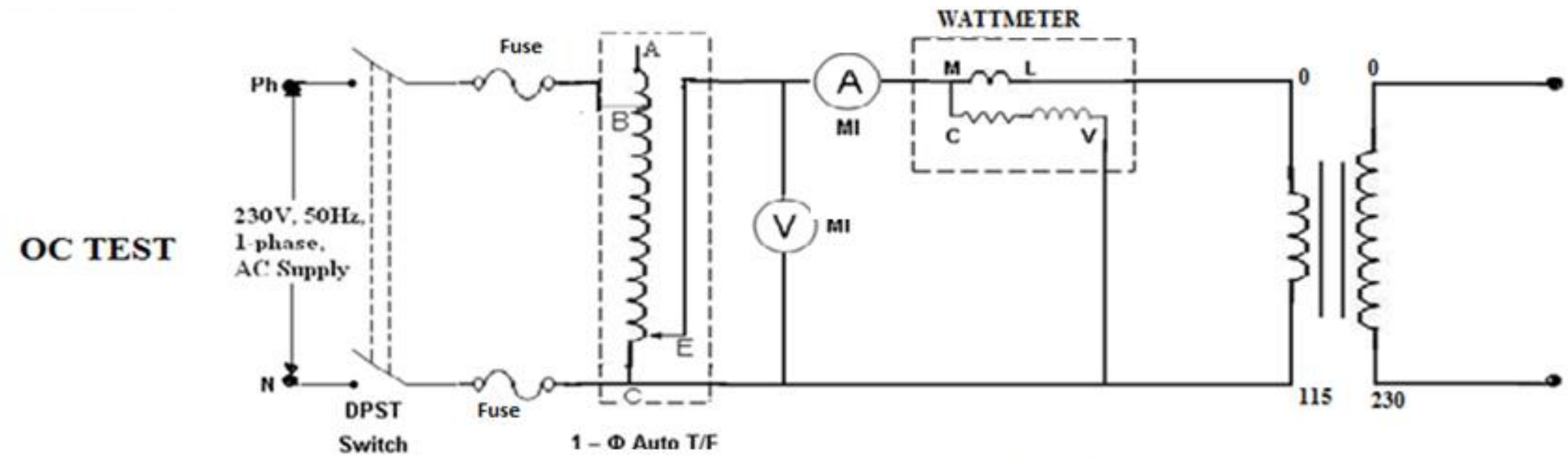


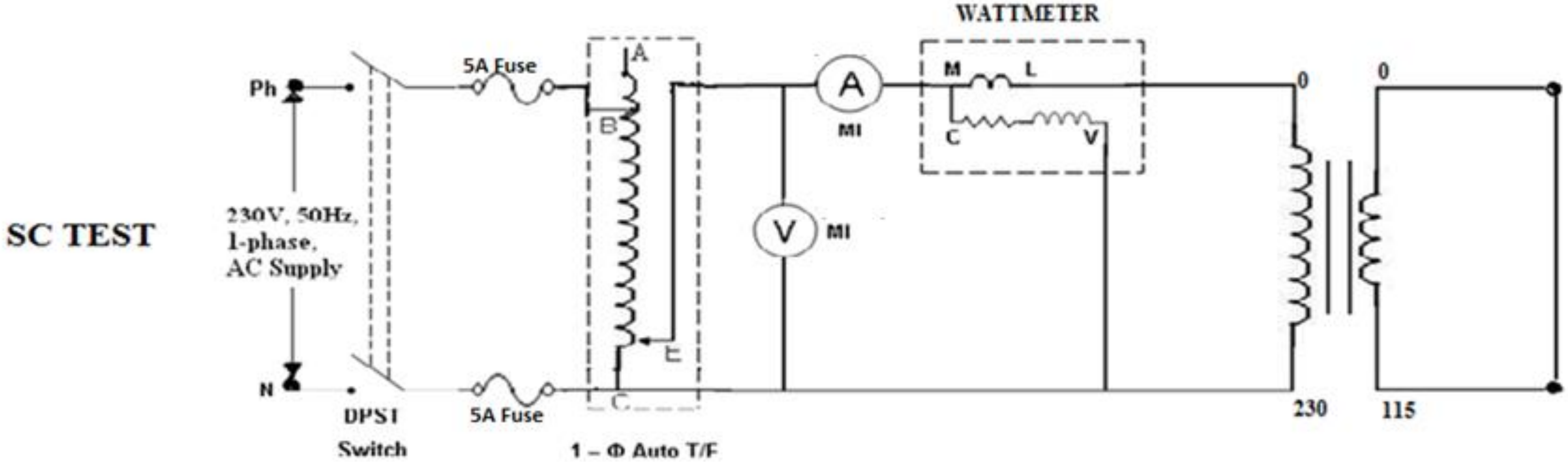

## Precautions:

1. Load should be applied gradually, but not suddenly.
2. Load should be removed before switching off the motor.

## Result:

# OPEN CIRCUIT AND SHORT CIRCUIT TEST ON SINGLE PHASE TRANSFORMER


OC TEST
WATTMETER
Fuse
Ph
A
B
E
C
M
L
C
V
A
MI
V
MI
230V, 50Hz,
1-phase,
AC Supply
N
DPST
Switch
Fuse
1 – Φ Auto T/F
0
0
115
230


SC TEST
WATTMETER
5A Fuse
Ph
A
B
E
C
M
L
C
V
A
MI
V
MI
230V, 50Hz,
1-phase,
AC Supply
N
DPST
Switch
5A Fuse
1 – Φ Auto T/F
0
0
230
115

**Exp.No.:** **Date:**

**Aim:** To predetermine the Efficiency and Regulation of a given single phase transformer by conducting the Open Circuit test and Short Circuit test and also to draw its Equivalent circuit.

## Apparatus:

| S. No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MI | | |
| 2. | Voltmeter | MI | | |
| 3. | Ammeter | MI | | |
| 4. | Ammeter | MI | | |
| 5. | Wattmeter | Dynamometer | | |
| 6. | Wattmeter | Dynamometer | | |
| 7. | Auto Transformer | 1 – Φ | | |

## Theory:

**OC-test:-**In this test low voltage winding is connected to the supply of normal voltage and frequency and the high voltage winding is left open. The primary winding draws very low current hardly 3 to 5% of full load current under this condition .As such copper loss in the primary winding will be negligible. Thus mainly iron losses will occur in the transformer under no load or open circuit condition, which are indicated by the wattmeter reading connected in the circuit.

**SC-test**: - In this test low voltage winding in short circuited and a low voltage hardly 10 to 20% of the rated voltage of the high voltage winding is applied to this winding. This test is performed at rated current flowing in both the windings. Iron losses occur in the transformer under this condition are negligible, because of very low applied voltage. Hence the total losses occur under short circuit are mainly copper losses of both the windings, which are indicated by wattmeter connected in the circuit.

Normally it is conducted at the HV side but if it is conducted on the LV side voltage would be very less and current will be very high so there is a possibility of damage for the windings.

# Formulae:

## Equivalent Circuit

### Open Circuit Test:

1. No Load Power Factor ($Cos\Phi_0$) = $\frac{W_o}{V_1 I_o}$ =28/115x1.3=0.1872lag

   Where, $W_o$ - Open Circuit Power in Watts=28w

   $V_1$ - Open Circuit Voltage in Volts=115v

   $I_o$ - Open Circuit Current in Amps=1.3A

2. Magnetizing component of No load current, $I_m = I_o \sin\Phi_o$=1.277A
3. Working component of No load current, $I_w = I_o \cos\Phi_o$=0.2434A
4. Core loss resistance, $R_o = \frac{V_1}{I_w}\Omega$=472.47Ω
5. Magnetizing Reactance, $X_o = \frac{V_1}{I_m}\Omega$=90.05Ω

### Short Circuit Test:

6. Equivalent impedance referred to HV side ($Z_{02}$) = $\frac{V_{sc}}{I_{sc}}\Omega$=13.7/8.6=1.59Ω

   Where, $V_{sc}$ – Voltage applied to circulate rated current

   $I_{sc}$ – short circuit current

7. Equivalent resistance referred to HV side ($R_{02}$)= $\frac{W_{sc}}{I_{sc}^2}\Omega$=1.48Ω

   Where, $W_{sc}$ – Short circuit Power in Watts

8. Equivalent reactance refereed to HV side ($X_{02}$) = $\sqrt{(Z_{02}^2 - R_{02}^2)}\Omega$=0.58Ω
9. Transformation ratio (K) = $V_2 / V_1$=230/115=2

   Where $V_1$ – primary voltage

   $V_2$ – secondary voltage

10. Equivalent resistance referred to LV side ($R_{01}$) = $\frac{R_{02}}{K^2}\Omega$=0.37Ω

10. Equivalent reactance referred to LV side ($X_{01}$) = $\frac{X_{02}}{K^2}\Omega$=0.145Ω

### Efficiency & Regulation:

11. Output power = (x × KVA × cosΦ) in watts.

    Where, x - Fraction of load

    KVA - power rating of Transformer

    CosΦ- Power Factor

12. Copper loss = ($x^2 \times W_{sc}$) in watts.

    Where, $W_{sc}$ – Copper Loss in Short Circuit Condition

13. Total Loss = (Cu Loss + Iron Loss) in watts
14. Efficiency = $\frac{Outputpower}{Outputpower + totallosses} \times 100\%$
15. Regulation = $\frac{x \times I_2 (R_{02}\cos\Phi + X_{02}\sin\Phi)}{V_{02}} \times 100$

## Procedure:

**Open Circuit Test:**

1. Connections are given as per the circuit diagram.
2. The DPST switch on the primary side is closed.
3. The auto-transformer is adjusted to energize the transformer with the rated primary voltage on the LV side.
4. The voltmeter, wattmeter and ammeter readings are noted down at no-load condition.
5. The auto-transformer is brought to its initial position.
6. The supply is switched off.

**Short-Circuit Test:**

1. Connections are given as per the circuit diagram.
2. The DPST switch on the primary side is closed.
3. The auto-transformer is slowly increased till rated current flows in the HV winding.
4. The voltmeter, ammeter and wattmeter readings are noted down.
5. The auto-transformer is brought to its initial position.
6. The supply is switched off.

## Tabular Form for OC & SC Test on 1- Φ transformer:

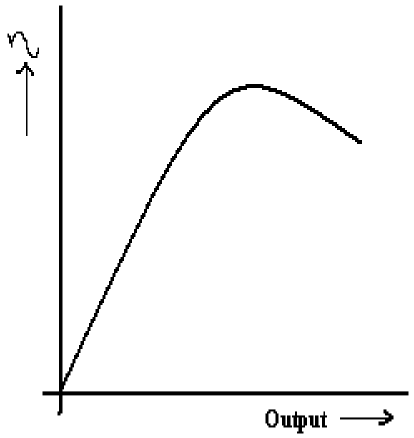
| S. No. | Open Circuit Primary Current ($I_o$) | Open Circuit Primary Voltage ($V_1$) | Open Circuit Power ($W_{oc}$) |
|---|---|---|---|
| 1 | | | |

| S. No. | Short Circuit Primary Current ($I_{sc}$) | Short Circuit Primary Voltage ($V_{sc}$) | Short Circuit Power ($W_{sc}$) |
|---|---|---|---|
| 1 | | | |

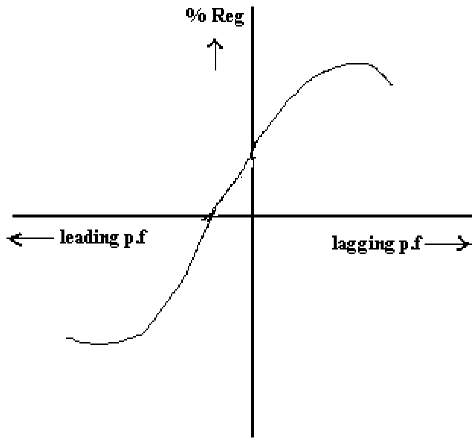
## Model Graph:

The graphs are drawn as

Efficiency Vs Output power




Regulation Vs Power factor




## Resultant Tabulation to find out the Efficiency

Core (or) Iron loss ($W_o$) = KVA rating of transformer =

Short Circuit Current ($I_{sc}$) = Short Circuit Power ($W_{sc}$) =

| Fraction of load (x) | CosΦ = 1 | CosΦ = 0.8 | CosΦ = 0.6 | CosΦ = 0.4 | CosΦ = 0.2 |
|---|---|---|---|---|---|
| 1/4 | | | | | |
| 1/2 | | | | | |
| 3/4 | | | | | |
| 1 | | | | | |

## Resultant Tabulation to find out the Regulation

$I_{sc}$ = $R_{02}$ = $X_{02}$ = $V_{02}$ =

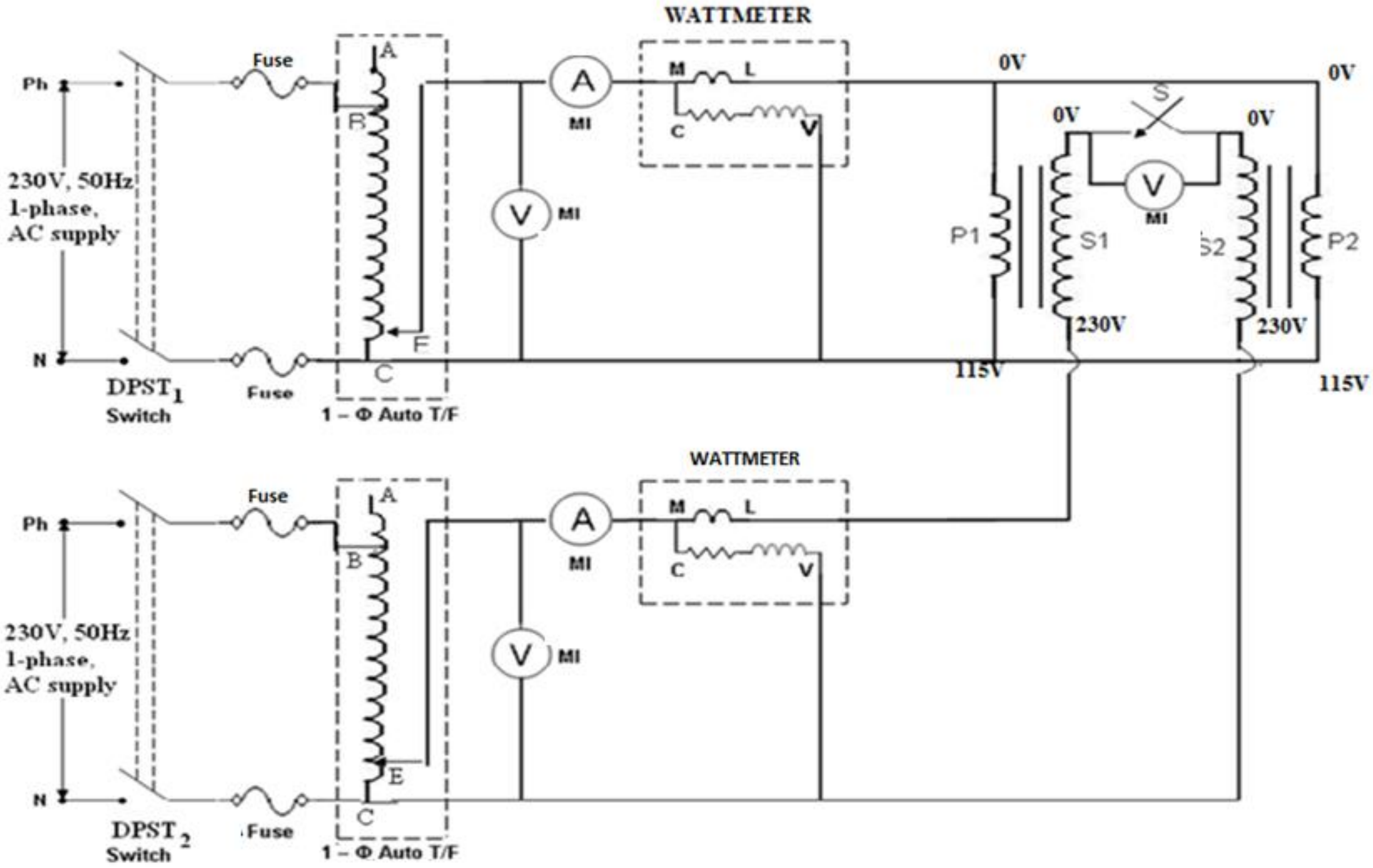
| Cos Φ | Full load | | ¾load | | ½load | | ¼ load | |
|---|---|---|---|---|---|---|---|---|
| | Lag | lead | lag | lead | lag | lead | lag | lead |
| 0.2 | | | | | | | | |
| 0.4 | | | | | | | | |
| 0.6 | | | | | | | | |
| 0.8 | | | | | | | | |
| 1 | | | | | | | | |

## Precautions:

1. At the time of starting auto transformer should be at minimum voltage position.
2. High voltage and low voltage sides of the transformer should be properly used as primary and secondary with respect to the experiments.

## Result:

# SUMPNER'S TEST ON A PAIR OF SINGLE PHASE TRANSFORMERS


WATTMETER
Fuse
A
B
F
C
Ph
N
230V, 50Hz 1-phase, AC supply
DPST1 Switch
Fuse
1 – Φ Auto T/F
A
MI
V
MI
M
L
C
V
0V
0V
0V
0V
S
V
MI
P1
S1
S2
P2
230V
230V
115V
115V
WATTMETER
Fuse
A
B
E
C
Ph
N
230V, 50Hz 1-phase, AC supply
DPST2 Switch
Fuse
1 – Φ Auto T/F
A
MI
V
MI
M
L
C
V

**Exp.No.:** **Date:**

**Aim:** To predetermine the Efficiency and Regulation of a given single phase transformer by conducting the Sumpner's test and also to draw its Equivalent circuit.

## Apparatus:

| S.No | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MI | | |
| 2. | Voltmeter | MI | | |
| 3. | Voltmeter | MI | | |
| 4. | Ammeter | MI | | |
| 5. | Ammeter | MI | | |
| 6. | Wattmeter | Dynamometer | | |
| 7. | Wattmeter | Dynamometer | | |
| 8. | Auto Transformer | 1 – Φ | | |
| 9. | SPST Switch | - | | |
| 10. | Transformer | 1 – Φ | | |

## THEORY:

This test needs two identical transformers. The primary windings of these transformers are connected in parallel and supplied at rated voltage and frequency, while the two secondaries are connected in phase opposition as shown in the circuit diagram. Thus the voltage across the two secondaries is zero, when the primary windings are energized. As such, this test is also called back to back test. In this test iron losses occur in the core and full load copper losses occur in the windings of the two transformers. Currents flowing in the two secondaries are rated full load currents of the transformer. Thus heat run test can be conducted on the transformers without actually loading them and hence steady-state temperature –rise on the transformers can be estimated. The current drawn by the primaries is twice the no load current of each transformer. The wattmeter $W_1$ connected in the circuit of the primaries measure the total core losses of both the transformers.

Thus the iron losses of each transformer = $W_o/2$

Where, $W_o$ is the reading of the wattmeter, $W_1$, when rated voltage is applied to the primaries of the transformers.

Similarly, wattmeter $W_2$, connected in the secondary circuit measures the total full load copper losses of the two transformers.

Hence, full load copper losses of each transformer = $W_{sc}/2$

Where, $W_{sc}$ is the reading of wattmeter $W_2$ when the full load current is flowing in the secondary circuit. A low voltage, hardly 8 to 10% of the rated value is applied across the secondaries for full load current to flow.

# Formulae:

## Equivalent Circuit:

### Open Circuit Test:

1. No Load Power Factor ($\cos\Phi_0$) = $\dfrac{W_o}{V_1 I_o}$

   Where, $W_o$ - Open Circuit Power in Watts
   $V_1$ - Open Circuit Voltage in Volts
   $I_o$ - Open Circuit Current in Amps.

2. Magnetizing component of No load current, $I_m = I_o \sin\Phi_o$
3. Working component of No load current, $I_w = I_o \cos\Phi_o$
4. Core loss resistance, $R_o = \dfrac{V_1}{I_w}\,\Omega$
5. Magnetizing Reactance, $X_o = \dfrac{V_{sc}}{I_{sc}}\,\Omega$

**Short Circuit Test:**

6. Equivalent impedance referred to HV side ($Z_{02}$) = $\dfrac{V_{sc}}{I_{sc}}\,\Omega$
7. Equivalent resistance referred to HV side ($R_{02}$) = $\dfrac{W_{sc}}{I_{sc}^{\,2}}\,\Omega$

   Where, $W_{sc}$ – Short circuit Power in Watts

8. Equivalent reactance refereed to HV side ($X_{02}$) = $\sqrt{(Z_{02}^{\,2} - R_{02}^{\,2})}\,\Omega$
9. Transformation ratio (K) = $V_2 / V_1$

   Where $V_1$ – primary voltage
   $V_2$ – Secondary voltage

10. Equivalent resistance referred to LV side ($R_{01}$) = $\dfrac{R_{02}}{K^2}\,\Omega$
11. Equivalent reactance referred to LV side ($X_{01}$) = $\dfrac{X_{02}}{K^2}\,\Omega$

**Efficiency & Regulation:**

12. Output power = ($X \times KVA \times \cos\Phi$) in watts.

    Where, X - Fraction of load
    KVA - power rating of Transformer
    $\cos\Phi$- Power Factor

13. Copper loss = ($X^2 \times W_{sc}$) in watts.

    Where, $W_{sc}$ – Copper Loss in Short Circuit Condition

14. Total Loss = (Cu Loss + Iron Loss) in Watts
15. Efficiency = $\dfrac{Outputpower}{Outputpower + totallosses} \times 100\%$
16. Regulation = $\dfrac{X \times I_2 (R_{02}\cos\Phi \pm X_{02}\sin\Phi)}{V_{02}} \times 100$

    Where, $V_{02}$ – No Load Voltage on HV side
    + For lagging - for leading

## Procedure:

1. Connections are given as per the circuit diagram.
2. The $DPST_1$ switch on the primary side is closed.
3. The auto-transformer1 is adjusted to energize the transformer with rated primary voltage on the LV side, when the $DPST_2$ switch is open.
4. The HV sides of the transformers are so connected that their polarities are in phase opposition to each other by confirming zero voltage across switch S.
5. Then by closing the SPST Swich the auto-transformer2 is adjusted to apply the rated current at the HV side of the transformer and all the meter readings are noted down.
6. After observing all the readings the auto-transformer2 and auto-transformer1 are brought to their initial position respectively and the supply is switched off.

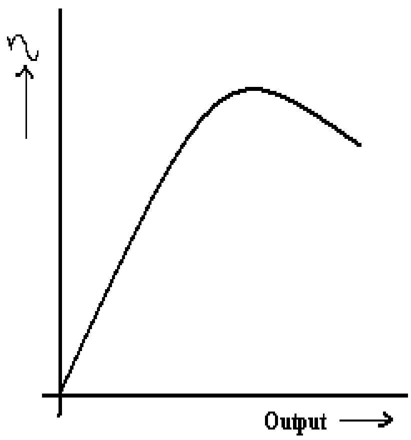
### Tabulation for Sumpner's test:

| S.No | No Load Current ($I_o$) | Open Circuit Primary Voltage ($V_1$) | No load Power ($W_o$) | Short Circuit Current ($I_{sc}$) | Short Circuit Voltage ($V_{sc}$) | Short Circuit Power ($W_{sc}$) |
|---|---|---|---|---|---|---|
| | | | | | | |

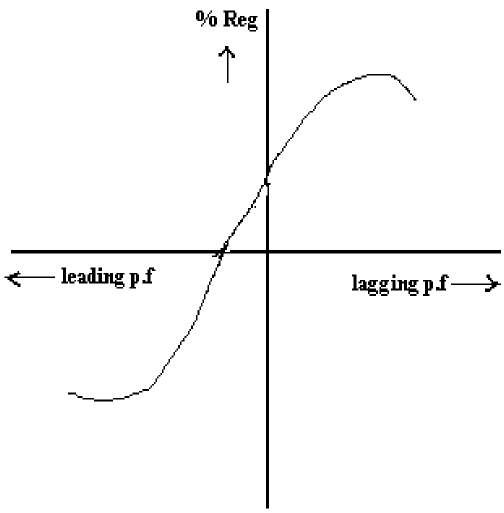
## Model Graph:

The graphs are drawn for

Efficiency Vs Output power




Regulation Vs Power factor




### Resultant Tabulation to find out the Efficiency

Core (or) Iron loss ($W_o$) = KVA rating of transformer =

Short Circuit Current ($I_{sc}$) = Short Circuit Power ($W_{sc}$) =

| Fraction of load (x) | CosΦ = 0.2 | CosΦ = 0.4 | CosΦ = 0.6 | CosΦ = 0.8 | CosΦ = 1 |
|---|---|---|---|---|---|
| 1/4 | | | | | |
| 1/2 | | | | | |
| 3/4 | | | | | |
| 1 | | | | | |

## Resultant Tabulation to find out the Regulation

$I_{sc}$ = $R_{02}$ = $X_{02}$ = $V_{02}$ =

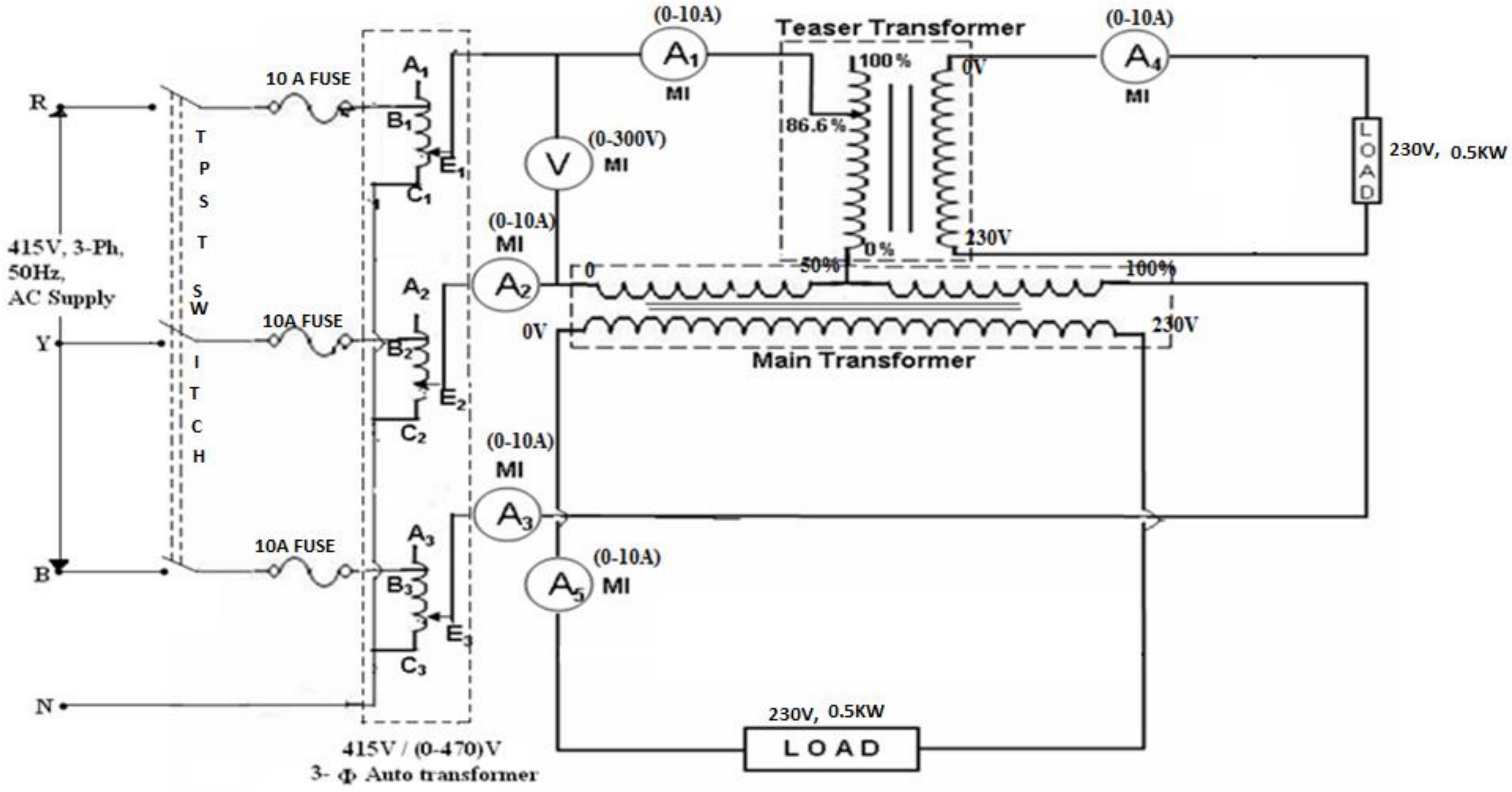
| Cos Φ | ¼ load | | ½ load | | ¾ load | | Full load | |
|---|---|---|---|---|---|---|---|---|
| | Lag | lead | lag | lead | lag | lead | lag | lead |
| 0.2 | | | | | | | | |
| 0.4 | | | | | | | | |
| 0.6 | | | | | | | | |
| 0.8 | | | | | | | | |
| 1 | | | | | | | | |

## Precautions:

1. Two identical transformers should be used for this back to back test.
2. The SPST switch should be kept open till the voltage across it is brought to zero.

## Result:

# SCOTT CONNECTION OF TRANSFORMERS



(0-10A)
Teaser Transformer
(0-10A)
10 A FUSE
R
T P S T S W I T C H
(0-300V)
MI
100%
0V
86.6%
230V, 0.5KW
415V, 3-Ph,
50Hz,
AC Supply
(0-10A)
MI
0%
230V
50%
100%
0
10A FUSE
Y
0V
230V
Main Transformer
(0-10A)
MI
10A FUSE
B
(0-10A)
MI
N
230V, 0.5KW
LOAD
415V / (0-470)V
3- Φ Auto transformer

**Exp.No.:** **Date:**

**Aim:** To convert the three phase supply into two single phase supplies by the method of Scott connection and to verify the following criteria:

1. Teaser transformer primary has √3/2 times the turns of main primary. But volt/turn is the same. Their secondaries have the same turns, which results in equal secondary voltages.
2. If main primary has N1 turns and main secondary has N2 turns, then main transformer ratio is N2/N1. However, the transformation ratio of teaser will be equal to 1.15 times of the transformation ratio of main.
3. If the load is balanced on one side, it is balanced on the other side as well.
4. Under balanced load condition, main transformer rating is 15% grater than that of the teaser.
5. The currents in either of the two halves of the main primary are the vector sum of $KI_{2M}$ and $KI_{2T}$ (or 0.5 $I_{2T}$).

**Apparatus:**

| S. No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MI | (0-300V) | 1 |
| 2. | Ammeter | MI | (0-10A) | 5 |
| 3. | 1-Φ Load | Resistive | 230V/0.5KW | 2 |
| 4. | 3-Φ Auto Transformer | - | 415V/(0-470V) | 1 |
| 5. | Tapped Transformer | | 2KVA | 2 |

**Theory:**

Three phase to two phase conversion or vice versa is essential under the following circumstances

(i) To supply power to two phase electric furnaces.

(ii) To supply power to two phase apparatus from a three phase source

(iii) To interlink three phase system and two phase systems.

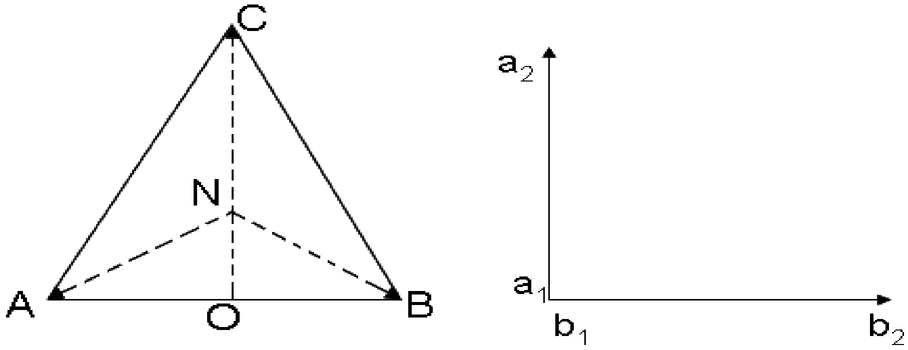
(iv) To supply power to three phase apparatus from a two phase source.

The common type of connection which can achieve the above conversion is normally called Scott – connection.

Two single phase transformers of identical rating with suitable tappings provided on both are required for Scott connection. The two transformers used for this conversion must have the following tappings on their primary windings.

Transformer A – 50% tapping and is called the main transformer.

Transformer B – 86.6% tapping and is called the teaser transformer.




(a) Primary Voltages (b) Secondary Voltages

**Fig: Phasor diagram for Scott connection**

The voltage across the primary, CO of the teaser transformer will be 86.6% of the voltage across the primary AB of the main transformer. The neutral point of the three phase system will be on the teaser transformer such that the voltage between O and N is 28.8% of the applied voltage. Thus the neutral point divided the teaser primary winding, CO in the ratio 1:2.

The voltages across the two secondaries $a_1a_2$ and $b_1b_2$ should be same in magnitude but in phase quadrature, which may be verified experimentally by recording the voltage across the two secondaries $V_{a1a2}$, $V_{b1b2}$ and the voltage across $a_2b_2$ with $a_1$ and $b_1$ connected together. The voltage $V_{a1a2}$ and $V_{b1b2}$ will be in phased quadrature, if the following relationship holds well between the three voltages.

$$V_{a2b2} = \sqrt{(V^2_{a1a2} + V^2_{b1b2})}$$

The behaviour of the above circuit can be studied experimentally, under the following different conditions of loading.

(i) Equal loading on the two secondaries at unity power factor:

If the two secondaries of main and teaser transformers carry equal currents at unity power factor (resistive load), the current flowing in the primary windings on three phase side will also will be equal and that too at unity power factor. This fact may be verified experimentally.

## Formulae:

1. $N_{1T} = \sqrt{3}/2N_{1M}$
2. $V_{ST} = V_{SM}$
3. $K_T = 1.15\ K_M$; where $K_M = N_{2M}/N_{1M}$, $K_T = N_{2T}/N_{1T}$
   Also $K_M = V_{SM}/V_{PM}$; $K_T=V_{ST}/V_{PT}$
4. If $I_{SM} = I_{ST}$, Then $I_R = I_Y = I_B$
5. Under balanced condition KVA (Main) = 15%KVA (Teaser)
6. $I_Y = I_B = \sqrt{(KI_{2M})^2 + (0.58KI_{2T})^2}$ where $0.58KI_{2T} = 0.5I_{1T}$
7. $I_{1T}=I_R$

**Note:** $N_{1T}$ – Number of primary turns in teaser transformer
$N_{1M}$ – Number of primary turns in main transformer
$V_{ST}$ – Secondary voltage of teaser transformer in volts
$V_{SM}$ - Secondary voltage of Main transformer in volts

$K_T$ – Transformation ratio of teaser transformer
$K_M$ – Transformation ratio of main transformer
$I_{SM}$ – Current at the secondary of the main transformer in amps
$I_{ST}$ – Current at the secondary of the teaser transformer in amps
$I_R$, $I_Y$, $I_B$ – Current drawn from the three phase source in amps
$I_{1M}$ – Current in main primary in amps
$I_{2M}$ – Current in main secondary in amps
$I_{1T}$ – Current in teaser primary in amps
$I_{2T}$ – Current in teaser secondary in amps

## Procedure:

1. Connections are made as per the circuit diagram.
2. 3 – Φ Auto transformer is kept at minimum voltage position. The rated three phase supply is given at the 86.6% of the teaser transformer, 0% and 100% of the main transformer by adjusting the auto transformer.
3. The two secondaries of the transformers are loaded with separate loads and all the meter readings are noted down. (The balanced load condition is maintained).
4. Transformers are loaded upto rated current.
5. The above procedure is repeated for unbalanced load condition.
6. The criteria for the Scott connection are verified using the formulae.

## Observations:

**(i) When only main transformer is loaded**

| Practical | | | | | Theoretical | |
|---|---|---|---|---|---|---|
| $I_1$ ($I_R$) | $I_2$ ($I_Y$) | $I_3$($I_B$) | $I_4$ ($I_{2T}$) | $I_5$ ($I_{2M}$) | $I_1$ ($I_R$) | $I_2$ ($I_Y$=$I_B$) |
| | | | | | | |
| | | | | | | |
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**(ii) When only teaser transformer is loaded**

| Practical | | | | | Theoretical | |
|---|---|---|---|---|---|---|
| $I_1$ ($I_R$) | $I_2$ ($I_Y$) | $I_3$($I_B$) | $I_4$ ($I_{2T}$) | $I_5$ ($I_{2M}$) | $I_1$ ($I_R$) | $I_2$ ($I_Y$=$I_B$) |
| | | | | | | |
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**(iii) When both transformers are loaded equally**

| Practical | | | | | Theoretical | |
|---|---|---|---|---|---|---|
| $I_1$ ($I_R$) | $I_2$ ($I_Y$) | $I_3$($I_B$) | $I_4$ ($I_{2T}$) | $I_5$ ($I_{2M}$) | $I_1$ ($I_R$) | $I_2$ ($I_Y$=$I_B$) |
| | | | | | | |
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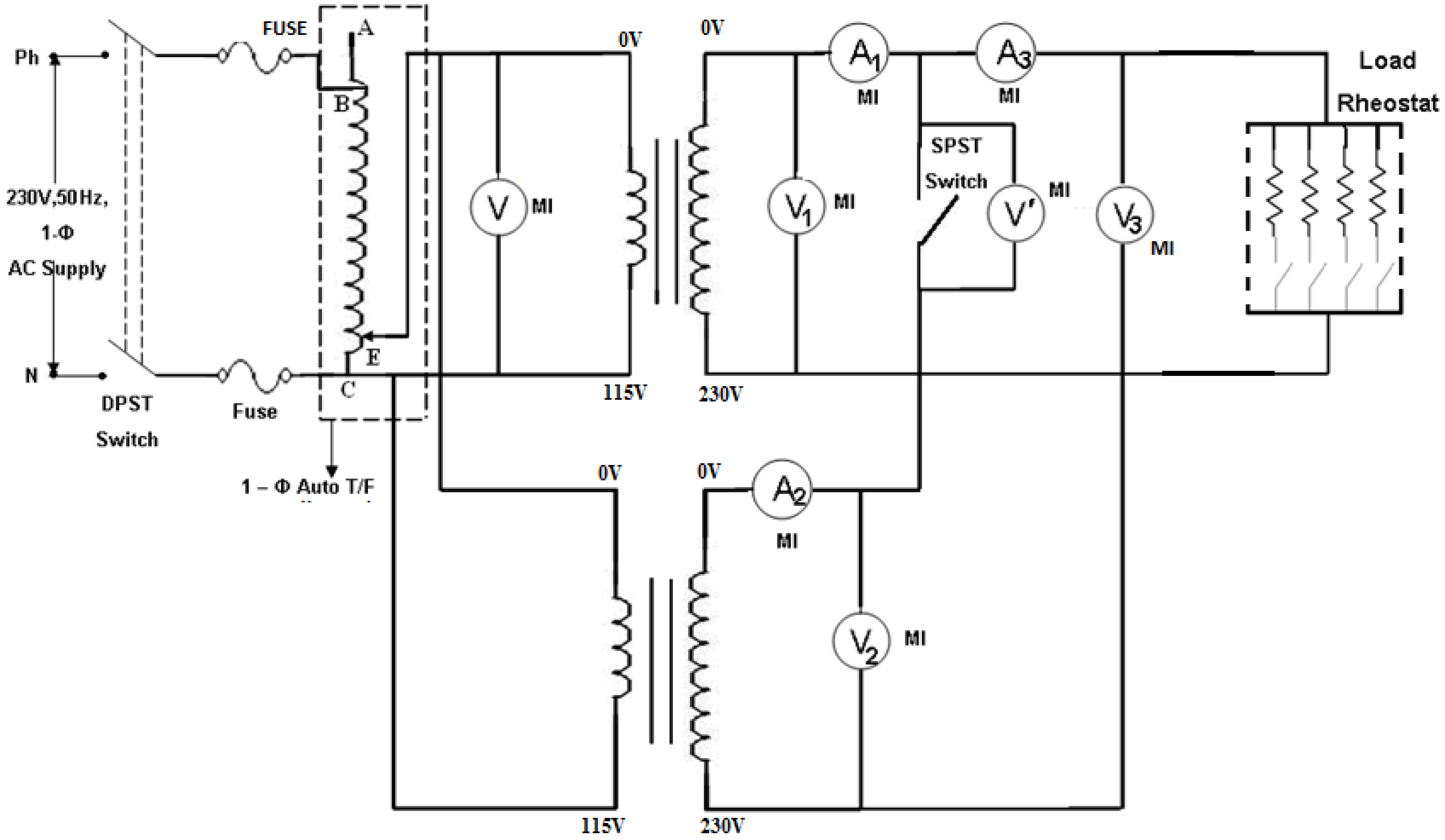
| | | | | | | |

## Precaution:

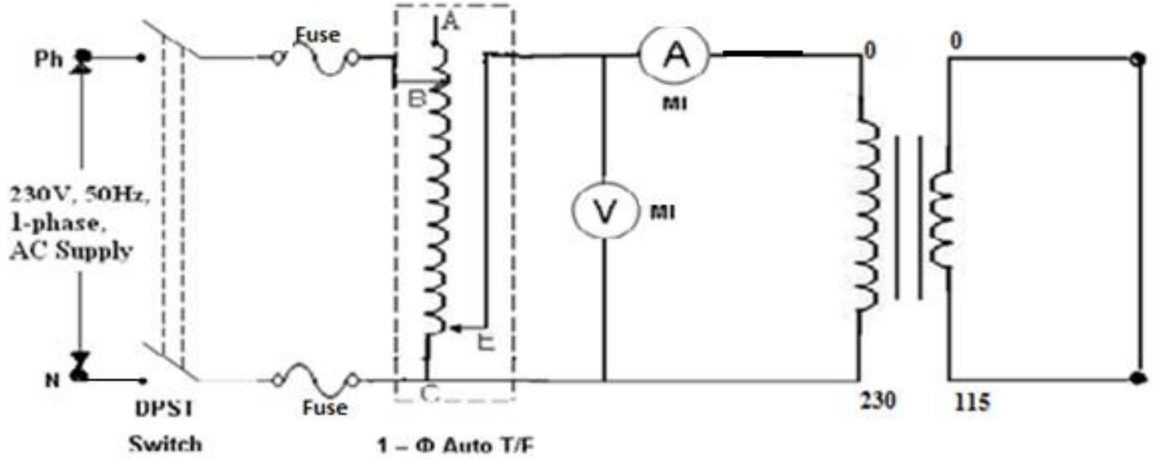
1. Scott connection should be performed with two transformers tapped at 50% and 86.6%.
2. In case of two single phase conversion from three phases, the neutrals of the secondary sides should be tied up. (**Note:** Two phase in not equal to two single phase).

## Result:

# PARALLEL OPERATION OF SINGLE PHASE TRANSFORMERS


Ph
N
230V,50Hz,
1-Φ
AC Supply
DPST
Switch
FUSE
Fuse
A
B
C
E
1 – Φ Auto T/F
V
MI
0V
115V
0V
230V
A1
MI
A3
MI
V1
MI
SPST
Switch
V'
MI
V3
MI
Load
Rheostat
0V
115V
0V
230V
A2
MI
V2
MI

**Circuit Diagram of S.C. Test**



**Exp.No.:** **Date:**

**Aim:** To obtain the load sharing of two 1-Φ Transformers when they are parallel to each other across a common load.

## Apparatus:

| S. No. | Apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1. | Voltmeter | MI | | |
| 2. | Voltmeter | MI | | |
| 3. | Voltmeter | MI | | |
| 3. | Ammeter | MI | | |
| 4. | Ammeter | MI | | |
| 5. | Loading Resistance | 1 - Φ | | |
| 6. | Auto Transformer | - | | |
| 7. | SPST Switch | - | | |

## Theory:-

For supplying a load in excess of the rating of an existing transformer, a second transformer may be connected in parallel with it as shown in the circuit diagram. It is seen that primary windings are connected to the supply and secondary windings are connected to the load. In connecting two or more than two transformers in parallel, it is essential that their terminals of similar polarities are joined to the same terminals. If this is not done, the two e.m.f s induced in the secondaries which are paralleled with incorrect polarities, will act together in the local secondary circuit even when supplying no load and will hence produce the equivalent of a dead short circuit.

There are certain definite conditions which must be satisfied in order to avoid any local circulating currents and to ensure that the transformers share the common load in proportion to their KVA ratings. The conditions are:

1. Primary windings of the transformers should be suitable for the supply system voltage and frequency.
2. The transformers should be properly connected with regard to polarity.
3. The voltage ratings of both primaries and secondaries should be identical. In other words, the transformers should have the same turn ratio i.e., transformation ratio.
4. The percentage impedances should be equal in magnitude and have the same X/R ratio in order to avoid circulating currents and operation at different power factors.
5. With transformers having different KVA ratings, the equivalent impedances should be inversely proportional to the individual KVA rating if the circulating currents are to be avoided.

## Procedure:

1. Connections are made as per circuit diagram.
2. DPST Switch is closed and supply is given to the circuit.
3. By applying rated voltage using dimmerstat the reading in the voltmeter across the SPST switch is observed. If it shows zero deflection the transformer is connected to correct polarities.
4. After observing this zero deflection in the voltmeter SPST switch is closed.
5. By varying the load using a loading rheostat gradually the readings of three ammeters and three voltmeters are noted for each step.
6. The S.C. test circuit is connected on the transformer to calculate the impedances of each Transformer. The rated current is applied after the connections are made and the ammeter and voltmeter readings are noted down.
7. S1, S2 are calculated after tabulating the readings.
8. Theoretical values of S1 and S2 are calculated using the formula given below.

$$S_1 = \frac{S_3 \times Z2}{Z_1 + Z_2} \qquad S_2 = \frac{S_3 \times Z_1}{Z_1 + Z_2}$$

9. Theoretical and practical values are compared.

**SC Test:**

**For T/F-1:**

| V(v) | I(A) | $Z_1(\Omega)$ |
|---|---|---|
| | | |

**For T/F-2:**

| V(v) | I(A) | $Z_2(\Omega)$ |
|---|---|---|
| | | |

**Tabular form:**

| S. No. | $V_1$ | $V_2$ | $V_3$ | $I_1$ | $I_2$ | $I_3$ | $S_1 = V_1I_1$ | $S_2 = V_2I_2$ | $S_3 = V_3I_3$ | $S_1$ | $S_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
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## Precautions:

1. Connections should be made tightly.
2. Readings should be noted without parallax error.

## Result: