# 1.VERIFICATION OF KVL AND KCL

**Aim:-** To Verify KVL and KCL theoretically and practically.

**Apparatus:**

| S.NO | NAME OF THE EQUIPMENT | RANGE | TYPE | QUANTITY |
|---|---|---|---|---|
| 1. | KVL & KCL Trainer kit | | | 1 |
| 2. | Voltmeter | (0-20)V | MC | 3 |
| 3. | RPS | (0-30)V/2A | | 1 |
| 4. | Ammeter | (0-200)mA | MC | 4 |
| 5. | Connecting wires | | | as per need |

**Theory:** KCL AND KVL are used to solve the electrical network, which are not solved by the simple electrical formula.

KCL: It states that in any electrical network the algebric sum of currents meeting at a point is zero. Consider the case of few conductors meeting at a point A in the fig. Assuming incoming currents to be positive and the outgoing currents to be negative.$I1+(-I2)+(-I3)+I4+(-I5)=0$

Incoming current=outgoing current.

KVL:It states that the algebric sum of product of current and resistance in each of the conductors in any closed path in a network plus the algebric sum of the e.m.f. in the closed path is zero.

**Procedure:**

KVL:- (1) Set the rheostats to given resistance values with the multimeter.

(2) Make connections as for circuit diagram

(3) Verify the connections by the lab instructor.

(4) Switch on the DC supply

(5) Note down all meter readings, the sum of VI, V2 and V3 must be equal to the Vs.

## CIRCUIT DIAGRAM OF KVL:-

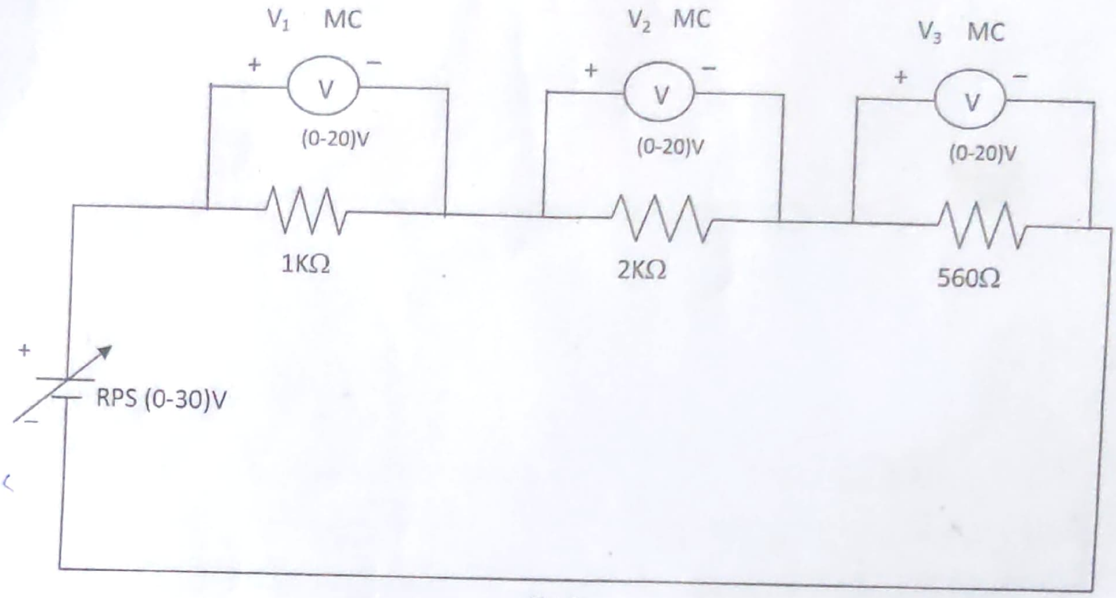



Fig-1

## CIRCUIT DIAGRAM OF KCL:-

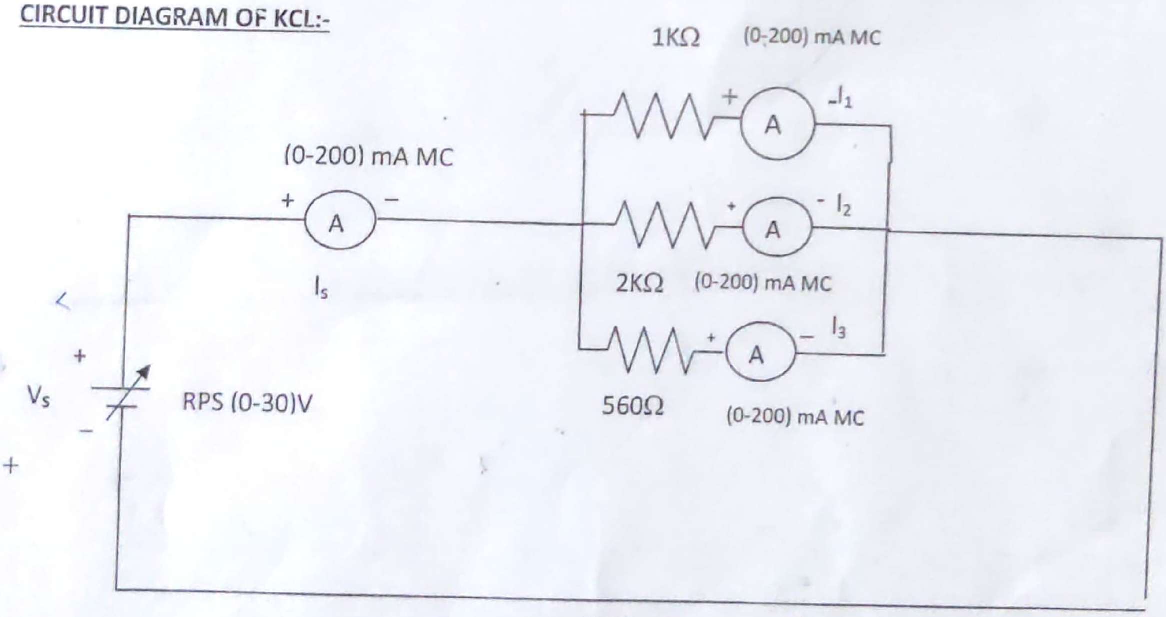



Fig-2

KCL:- (1) Set the rheostats to given resistance values with the multimeter.

(2) Make connections as for circuit diagram

(3) Verify the connections by the lab instructor.

(4) Switch on the DC supply

(5) Note down all meter readings, the sum of $I_1$, $I_2$ & $I_3$ must be equal to $I_S$.

**Observations:**

FOR KVL

| S.NO. | THEORETICAL VALUES | | | | PRACTICAL VALUES | | | |
|---|---|---|---|---|---|---|---|---|
| | $V_S$ | $V_1$ | $V_2$ | $V_3$ | $V_S$ | $V_1$ | $V_2$ | $V_3$ |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

FOR KCL

| S.NO. | THEORETICAL VALUES | | | | PRACTICAL VALUES | | | |
|---|---|---|---|---|---|---|---|---|
| | $I_S$ | $I_1$ | $I_2$ | $I_3$ | $I_S$ | $I_1$ | $I_2$ | $I_3$ |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

**Calculations:-**

KVL-Total resistance of the circuit **Req** =R1+R2+R3 Ω

Total current of the circuit I= Vs÷R -- Amp

Voltage drop in resistance **R1** is **V1** = **I** × **R1**-------Volts.

Voltage drop in resistance **R2** is **V2** = **I** × **R2**-------Volts.

Voltage drop in resistance **R3** is **V3** = **I** × **R3**-------Volts.

Now Supply voltage **Vs= V1+V2+V3**

**KCL-** **R1, R2** and **R3** resistances are in parallel so effective resistance

**1/Req =1/ R1+1/R2+1/R3-** Ω.

Total current of the circuit **I** = **Vs÷Req** -- Amp.

Current through **R1** resistance **I1** = **Vs/R1**

Current through **R2** resistance **I2** = **Vs/R2**

Current through **R3** resistance **I3** = **Vs/R3**

Total current Is = I1+I2+I3

## Precautions :

1.All connections should be tight and correct.
2.Switch off the supply when not in use.
3.Reading should be taken carefully.

## Result:-

## Viva questions:

1 What is the statement of Kirchhoff's first law?
2. Kirchoff's second law is related to what?
3. What is the internal resistance of the ideal voltage source?
4. What is higher, the terminal voltage or the emf?
5. What is the internal resistance of the current source ideally?
6. What is the active network?
7. What is the bilateral network?
8. What is the difference between a node and a branch?
9. What is the non-linear circuit?

# 2. SUPERPOSITION THEOREM

**Aim:** To Verify Superposition theorem theoretically and practically.

## Apparatus:

| S.NO. | NAME OF THE EQUIPMENT | RANGE | TYPE | QUANTITY |
|---|---|---|---|---|
| 1. | Regulated DC power supply | (0 – 30 V) / 2A | DC | 2 |
| 2 | Ammeter | ( 0 – 20)mA | MC | 1 |
| 3 | Superposition Theorem Trainer kit | | | |
| 5 | Connecting wires | | | As per need |

## Superposition theorem

## Circuit Diagram:

When both sources are acting

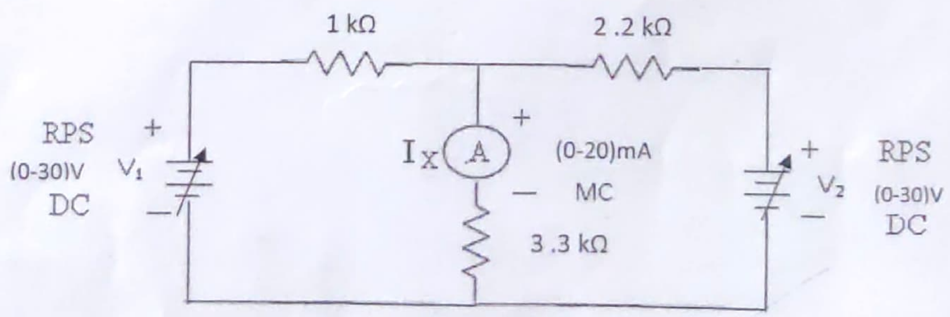



FIG (1)

When $V_2$ source acting alone

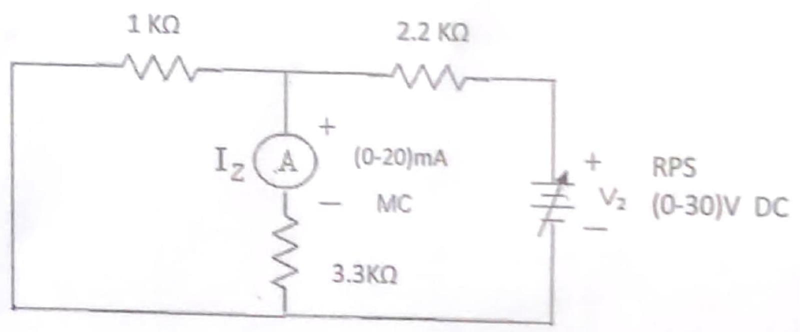



FIG (2)

When $V_1$ source acting alone

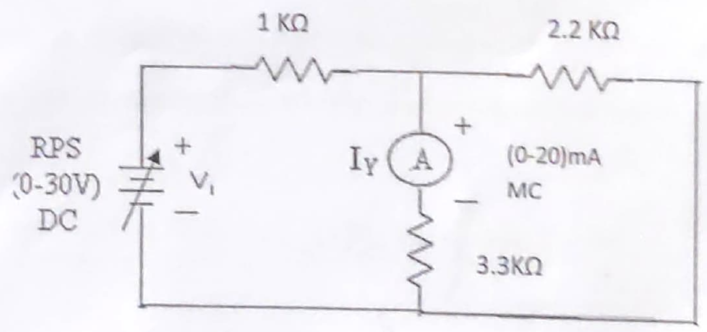



FIG (3)

## Theorem Statement:

In any linear bilateral network containing two or more energy sources the response at any element is equivalent to the algebraic sum of the responses caused by the individual sources.

## Procedure:

1. Connect the circuit as shown in fig (1)
2. Current through 50Ω resistor is noted as $I_x$ by applying both the voltages $V_1 = 10V$and $V_2=15V$ through RPS.
3. Make the supply voltage$V_2$ short circuited and apply$V_1$ through RPS as shown in fig (3) and note down the current through 50Ω resistor as $I_Y$.
4. Make the supply voltage$V_1$ short circuited and apply $V_2$ through RPS as shown in fig (2) and note down the current through 50Ω resistor as $I_Z$
5. Now verify $I_X = I_Y + I_Z$ theoretically and practically which proves Superposition Theorem
6. Repeat the above procedure for $V_1$= 15V, $V_2$= 20V and $V_1$= 20V, $V_2$= 25V.

## Observations:

When both the sources are acting i.e., fig (1)

| S:NO | $V_1$ (V) | $V_2$ (V) | Theoretical $I_X$ (mA) | Practical $I_X$ (mA) |
|---|---|---|---|---|
| 1 | 2 V | 4 V | | |
| 2 | 6 V | 8 V | | |
| 3 | 10 V | 12 V | | |

When $V_2$ source alone is acting i.e., fig (3)

| S:NO | $V_1$ (V) | $V_2$ (V) | Theoretical $I_Z$ (mA) | Practical $I_Z$ (mA) |
|---|---|---|---|---|
| 1 | 0 V | 4 V | | |
| 2 | 0 V | 8 V | | |
| 3 | 0 V | 12 V | | |

When $V_1$ source alone is acting i.e., fig (2)

| S:NO | $V_1$ (V) | $V_2$ (V) | Theoretical $I_Y$ (mA) | Practical $I_Y$ (mA) |
|---|---|---|---|---|
| 1 | 2 V | 0 V | | |
| 2 | 6 V | 0 V | | |
| 3 | 10 V | 0 V | | |

## Precautions:

1. Avoid making loose connections.
2. Readings should be taken carefully without parallax error.
3. Avoid series connection of voltmeters and parallel connection ammeters.

## Result:

2. ## Viva questions:

1.Superposition theorem is not applicable for?

2.What are the applications of Superposition of theorem?

3.What is an active, linear, bilateral network?

4.Superposition theorem is not applicable for?

5.State Reciprocity theorem?

6.What is an active, linear, bilateral network?

7.Mesh analysis based on which laws?

8.Nodal analysis based on which laws?

9.Applications of reciprocity theorem?

10.Reciprocity theorem applicable for?

P= VI

# 3. Maximum Power Transfer Theorem

**Aim:** To verify maximum power transfer theorem.

**Apparatus:**

| S.NO. | NAME OF THE EQUIPMENT | RANGE | TYPE | QUANTITY |
|---|---|---|---|---|
| 1 | Regulated DC Power Supply | (0 – 30 V)/2A | DC | 1 |
| 2 | Decade resistance box | | | 2 |
| 3 | Ammeter | (0-100) mA | MC | 1 |
| 4 | Maximum Power Transfer Theorem Trainer kit | | | 1 |
| 5 | Connecting wires | | | as per need |

**Circuit Diagram:**

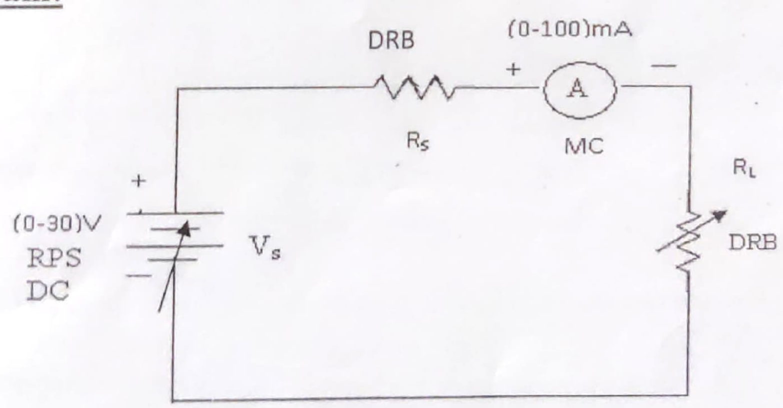
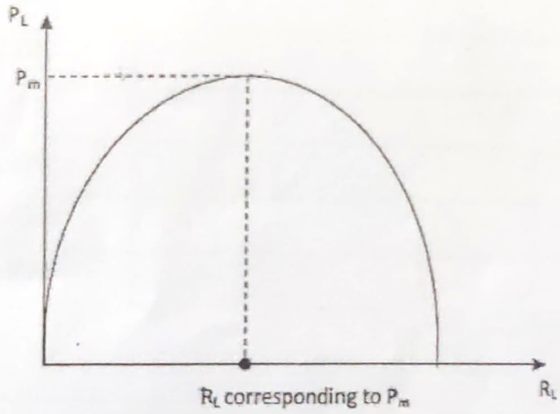



FIG (1)

## Theorem Statement:

It states that the maximum power is transferred from the source to the load, when the load resistance is equal to the source resistance.

## Model Graph:




## Procedure:

1. Make the connections as shown in fig (1)
2. Apply constant voltage of 20 V through RPS
3. Fix $R_S$= 1KΩ through DRB 1 and note down readings of ammeter ($I_L$)
4. By varying the value of $R_L$ from 500Ω to 2KΩ in regular intervals note down the readings in the ammeter as $I_L$
5. Calculate the power by $P=I_L^2R_L$
6. Plot the curve between $R_L$ vs $P_L$
7. Verify that the power transferred is maximum at $R_S$= RL.
8. Repeat the above said procedure from step 2 to step 7 by fixing $R_S$=2KΩ and verify maximum power transfer theorem.

## Observations:

When $R_s = 1\ K\Omega$

| S.No | $R_L$ ($\Omega$) | Theoretical values | | Practical values | |
|---|---|---|---|---|---|
| | | $I_L$ (mA) | $P=I_L^2R_L$ (mWatt) | $I_L$ (mA) | $P=I_L^2R_L$ (mWatts) |
| 1. | 200 | | | | |
| 2. | 400 | | | | |
| 3. | 600 | | | | |
| 4. | 800 | | | | |
| 5. | 1000 | | | | |
| 6. | 1200 | | | | |
| 7. | 1400 | | | | |
| 8. | 1600 | | | | |
| 9. | 1800 | | | | |
| 10. | 2000 | | | | |

When $R_s = 2\ K\Omega$

| S.No | $R_L$ ($\Omega$) | Theoretical values | | Practical values | |
|---|---|---|---|---|---|
| | | $I_L$ (mA) | $P=I_L^2R_L$ (mWatts) | $I_L$ (mA) | $P=I_L^2R_L$ (mWatts) |
| 1. | 400 | | | | |
| 2. | 800 | | | | |
| 3. | 1200 | | | | |
| 4. | 1600 | | | | |
| 5. | 2000 | | | | |
| 6. | 2400 | | | | |
| 7. | 2800 | | | | |
| 8. | 3200 | | | | |
| 9. | 3600 | | | | |
| 10. | 4000 | | | | |

## Model Calculations:

## Precautions:

1. Avoid making loose connections.
2. Readings should be taken carefully without parallax error.
3. Avoid series connection of voltmeters and parallel connection of ammeters
4. All the meters and components are handled with care.

## Result:

### Viva Questions:

1 .What is load matching?
2. What is max power transfer formula?
3. What is the field of application of this theorem?
4. What is electric network?
5. What is necessary to know the polarity of voltage drop across a resistance?
6. What is the reason that terminal voltage is less than emf?
7. What is the resistance of ideal voltage source?
8. When will the power extracted from a circuit is maximum?
9. How is the ammeter connected in circuit?
10 .To find the voltage drop across a resistance, where should the voltmeter be connected?

# 4. THEVENIN'S THEOREMS

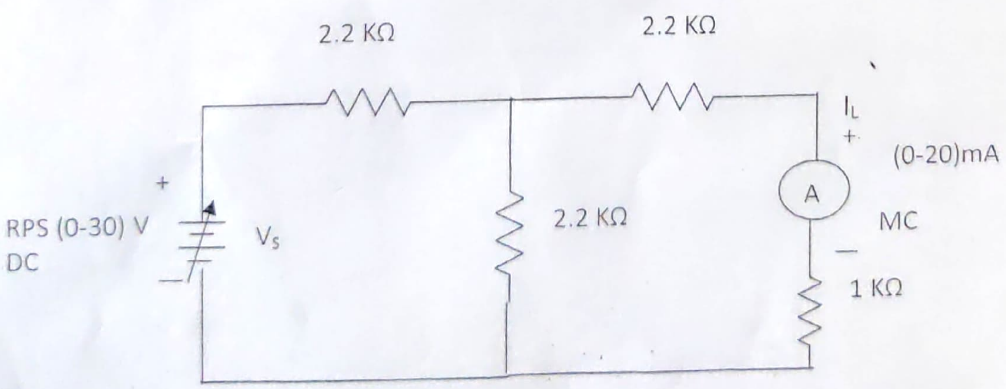
**Aim:** To verify Thevenins theorem theoretically and practically.

**Apparatus:**

| S.NO. | NAME OF THE EQUIPMENT | RANGE | TYPE | QUANTITY |
|---|---|---|---|---|
| 1 | Regulated Power Supply | (0 – 30 V) / 2A | DC | 1 |
| 2 | Ammeter | (0-50) mA | MC | 1 |
| 3 | Ammeter | (0-100) mA | MC | 1 |
| 4 | Voltmeter | (0-25) V | MC | 1 |
| 5 | Resistors | 50Ω, 100Ω,50Ω | | each 1 |
| 6 | Digital Multimeter | | | 1 |
| 7 | Decade Resistance Box | | | 2 |
| 8 | Connecting wires | | | As per need |

**Thevenin's Theorem:**

**Circuit Diagram:**



## To find out $V_{th}$

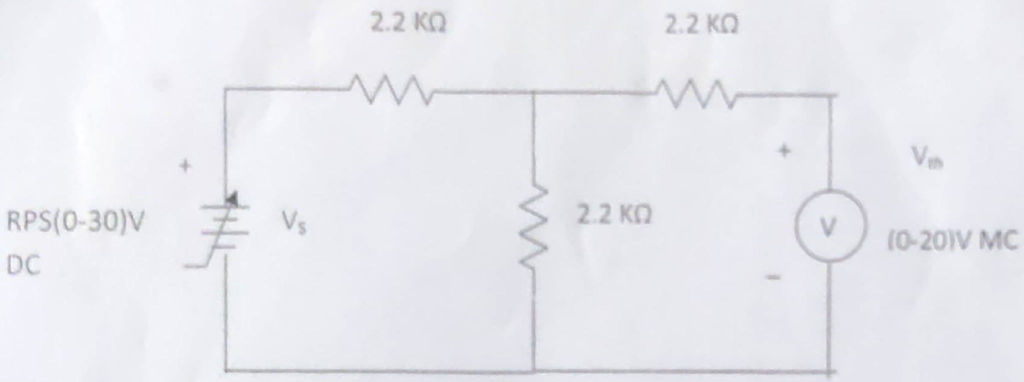



FIG (2)

## To find out $R_{Th}$

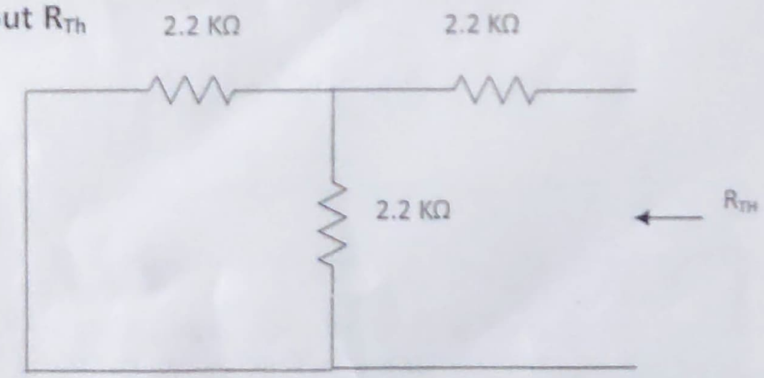
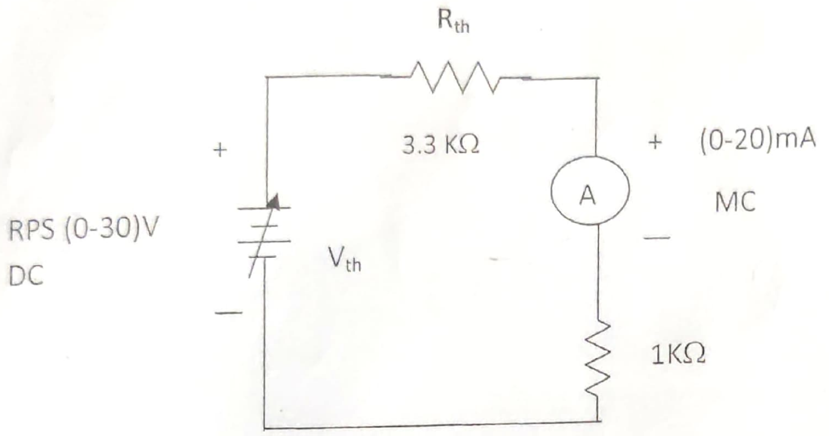



FIG (3)

## Thevenin's Equivalent Circuit




## Theorem Statement:

Any two terminal linear bilateral network containing of energy sources and impedances can be replaced with an equivalent circuit consisting of voltage source $V_{th}$ in series with an impedance, $Z_{th}$, where $V_{th}$ is the open circuit voltage between the load terminals and $Z_{th}$ is the impedance measured between the terminals with all the energy sources replaced by their internal impedances.

## Procedure:

1. Connections are made as per the circuit shown in fig (1).
2. Apply 20V to the circuit and note down the current $I_L$ flowing through the load.
3. Connect the circuit as shown in fig (2) by removing the load resistance. Apply DC supply through RPS and note down the reading of voltmeter as $V_{th}$.
4. Connect the circuit as shown in fig ( 3) ,measure the effective resistance $R_{th}$, with the help of a multimeter, by replacing the source voltage with short circuit.
5. Form the Thevenin's equivalent circuit as shown fig (4) note down the load current $I_L^1$.
6. Check the currents $I_L$ and $I_L^1$ which should be equal theoretically and practically.
7. Repeat the above procedure for different source voltages.

## Tabular column:

| Vs (V) | Theoretical values | | | | Practical values | | | |
|---|---|---|---|---|---|---|---|---|
| | $I_L$ (mA) | $V_{th}$ (V) | $R_{th}$ Ω | $I_L^1$ (mA) | $I_L$ (mA) | $V_{th}$ (V) | $R_{th}$ Ω | $I_L^1$ (mA) |
| 3 V | | | | | | | | |
| 6V | | | | | | | | |
| 9 V | | | | | | | | |

## Model Calculations:

## Precautions:

1. Avoid making loose connections.

2. Readings should be taken carefully without parallax error.

3. Avoid series connection of voltmeters and parallel connection ammeters

## Result:

## Viva Questions:

1. State Thevenin's theorem?
2. State Norton's theorem?
3. State Maximum Power Transfer theorem?
4. Give the applications of MPTT.
5. What is an active, linear, bilateral network?
6. Give an example for active and bilateral elements?
7. Define thevenins voltage and how can you calculate it?
8. Define the thevenins resistance and how can you calculate it?
9. Define the Nortons current and how can you calculate it?
10. Define the Nortons resistance and how can you calculate?

# 10. O.C AND S.C TESTS ON A SINGLE PHASE TRANSFORMER

**Aim:** To conduct OC and SC tests on single phase transformer, to find the equivalent circuit parameters and pre-determine the regulation and efficiency of the transformer.

**Apparatus:**

| SL.NO | NAME OF THE EQUIPMENT | RANGE | TYPE | QUANTITY |
|---|---|---|---|---|
| 1. | Ammeter | (0-20)A | MI | 1 |
| 2. | Ammeter | (0-2)A | MI | 1 |
| 3. | Voltmeter | (0-300)V | MI | 1 |
| 4. | Voltmeter | (0-30)V | MI | 1 |
| 5. | Wattmeter | 300V,5A | LPF | 1 |
| 6. | Wattmeter | 30V,20A | UPF | 1 |
| 7. | 1-Φ Transformer | 3kVA,115/230V | 1-Φ | 1 |
| 8. | 1-Φ Auto Transformer | 0-230V / 270V, 8A | 1-Φ | 1 |
| 9. | Connecting wires | | | As per need |

**Name plate details:**

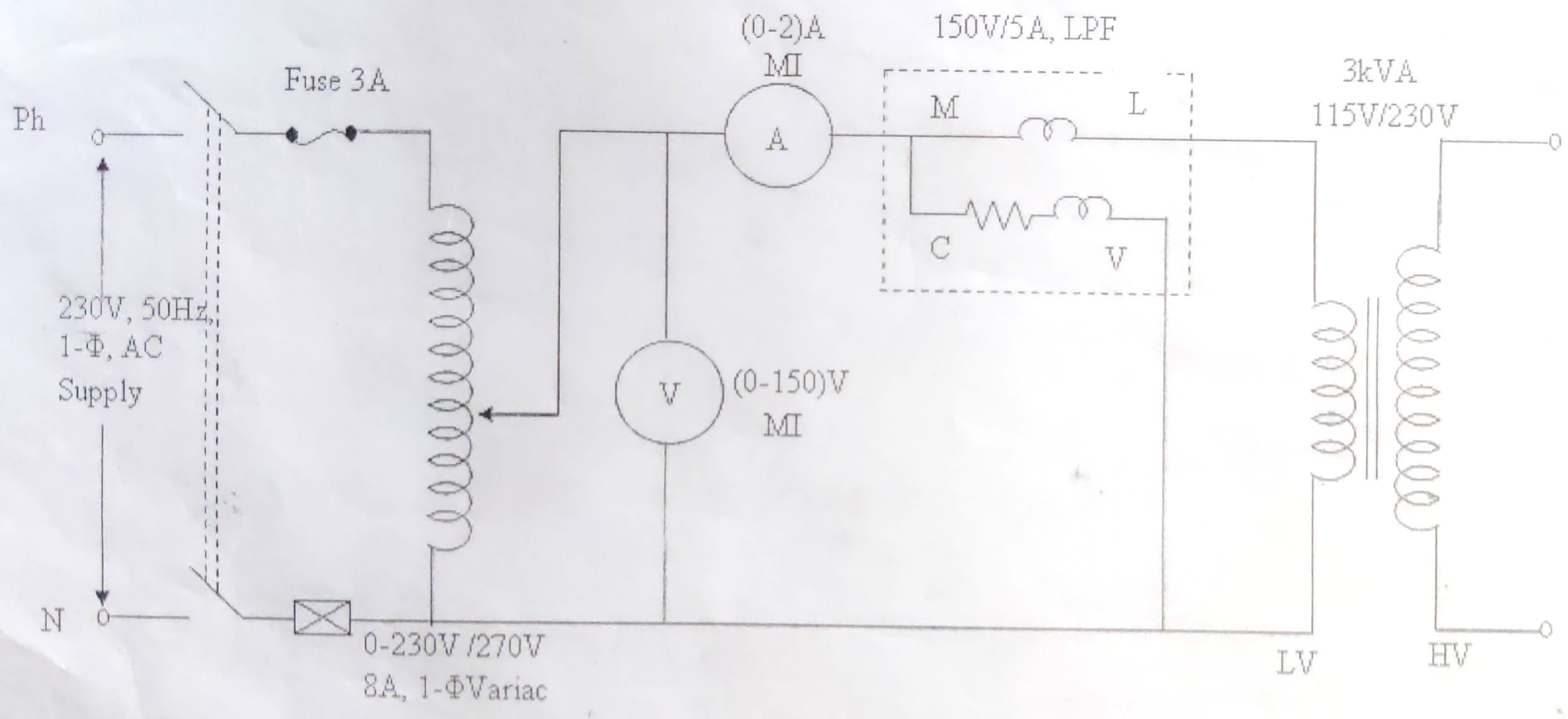
| | |
|---|---|
| Voltage Ratio = | 220/110V |
| Full load Current | =13.6A |
| VA RATING= | 3KVA |

**Theory**: Transformer is a static device which transfers electrical power from one circuit to another circuit either by step up or step down the voltage with corresponding decrease increase in the current, without changing the frequency.

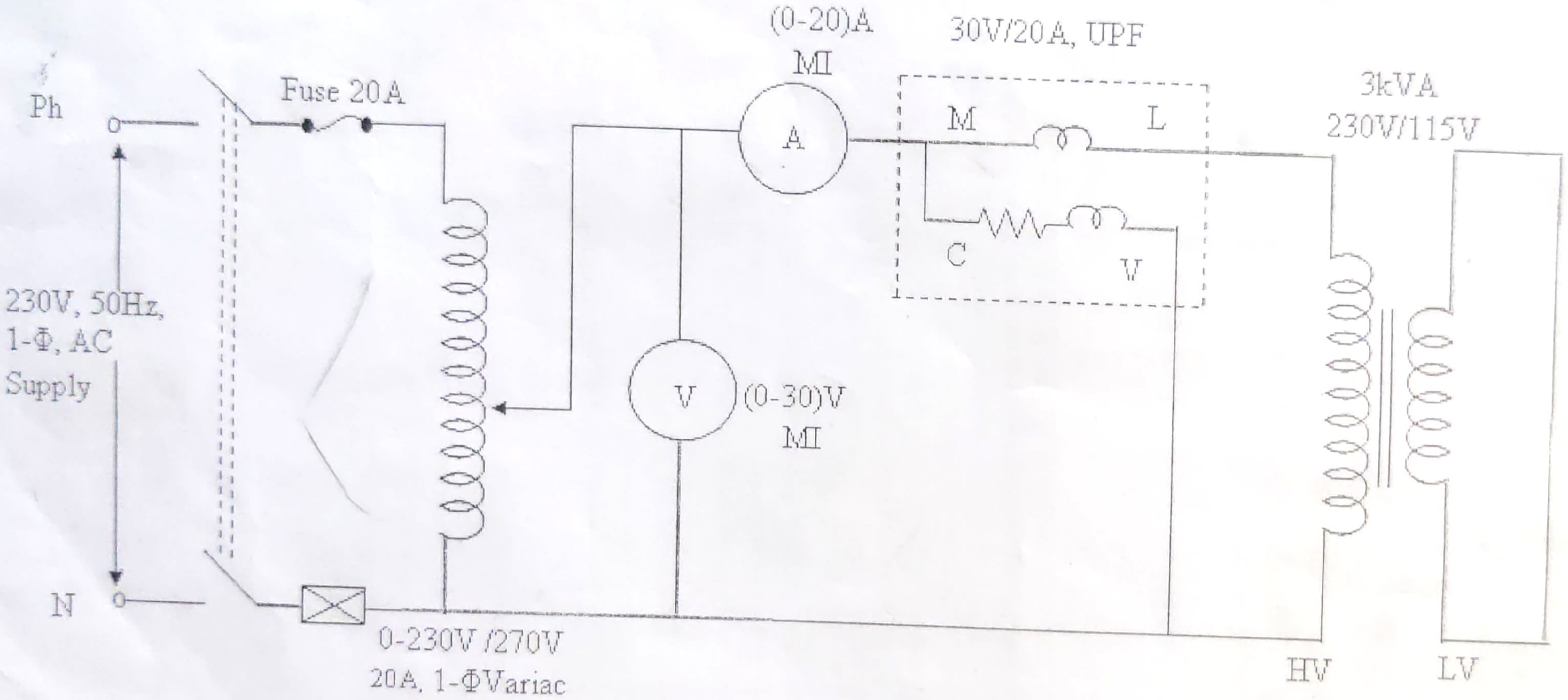
OC Test

The main aim of this test is to determine the Iron losses & No- load current of the T/F which is

## CIRCUIT DIAGRAM FOR OPEN CIRCUIT TEST

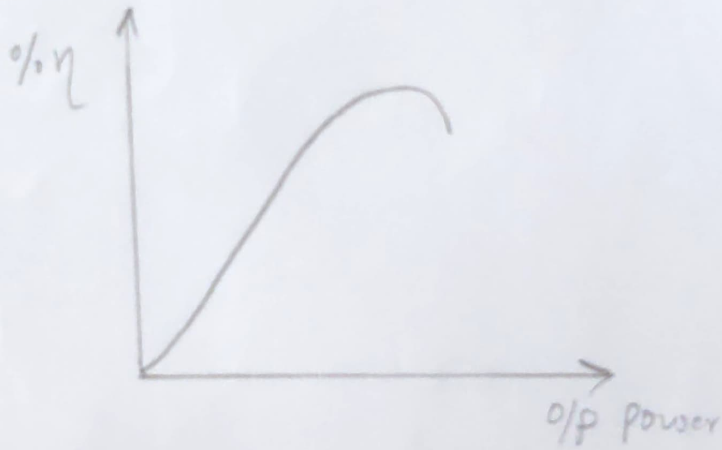


## CIRCUIT DIAGRAM FOR SHORT CIRCUIT TEST



| Load | x | output | % Efficiency |
|---|---|---|---|
| 1/4 load | 1/4 | | |
| 1/2 load | 1/2 | | |
| 3/4 load | 3/4 | | |
| full load | 1 | | |

⇒ Model graph:




Output = $x$ * KVA rating * $\cos\phi$

where $x$ is a fraction of load

$$\%\eta = \frac{\text{output}}{\text{input}} \times 100 \Rightarrow \frac{\text{output}}{\text{output} + \text{losses}} \times 100$$

$$\%\eta = \frac{x * \text{KVA rating} * \cos\phi}{x * \text{KVA rating} * \cos\phi + W_0 + x^2 * W_{sc}}$$

helpful in finding $R_0$ & $X_0$. In this test generally supply will be given to primary and secondary kept open. Since secondary is opened a small current (magnetizing current will flow and it will be 5 to 10% of full load current. The wattmeter connected in primary will give directly the Iron losses (core losses).

SC Test:

The main aim of this test is to determine the full load copper losses which are helpful in finding the $R_{01}$, $X_{01}$, $Z_{01}$, efficiency and regulation of the T/F. Generally low voltage side will be short circuited and supply will be given to high voltage side & it will be of 5-10% of the rated voltage. The wattmeter connected in primary will give directly the full load copper losses of the T/F.

## Procedure:

### OC TEST:

1. All the connections are done as per the circuit diagram of OC test.
2. By using the single phase variac apply rated voltage to the LV side.
3. At this rated voltage, note down the readings of voltmeter as '$V_0$', ammeter as '$I_0$' and wattmeter as '$W_0$' readings.
4. Here the ammeter indicates no load current and wattmeter indicates core losses.
5. From these readings calculate no load power factor $\cos\Phi_0$, $R_0$ and $X_0$.

### SC TEST:

1. All the connections are done as per the circuit diagram of SC test.
2. By using the single phase variac apply rated current to the HV side.
3. At this rated current, note down the readings of voltmeter as '$V_{SC}$', ammeter as '$I_{SC}$' and wattmeter as '$W_{SC}$' readings.
4. Here the ammeter indicates full load current and wattmeter indicates full load copper losses.
5. From these readings calculate $Z_{SC}$, $R_{01}$ and $X_{01}$.
6. Now calculate the efficiency and regulation of the transformer at different loads and power factor respectively.
7. Now draw the equivalent circuit of the transformer referred to primary side i.e., L.V side.

## Tabular column:

| | Voltage $V_0$ (V) | Current $I_0$ (A) | Wattmeter $W_0$ (W) |
|---|---|---|---|
| OC TEST | 115 | 1.75 | 42 |

| | Voltage $V_{SC}$ (V) | Current $I_{SC}$ (A) | Wattmeter $W_{SC}$ (W) |
|---|---|---|---|
| SC TEST | 11.6 | 13A | 80 |

2. Take the readings without parallax error.
3. Do not exceed the rated current of Transformer.

## Result:

## Viva questions:

1. How are the meter ratings selected for O.C and S.C tests?
2. Why is the O.C test conducted on the l.v side of the transformer and S.C test on h.v side?
3. What are the losses measured in an O.C test?
4. What are the losses measured in an S.C test?
5. What is the condition for maximum efficiency in a transformer?
6. What is meant by 'regulation' of a transformer?
7. Is a high or low value of regulation preferred? Why?
8. How can the parameters on one side of the transformer be transferred to the other side?