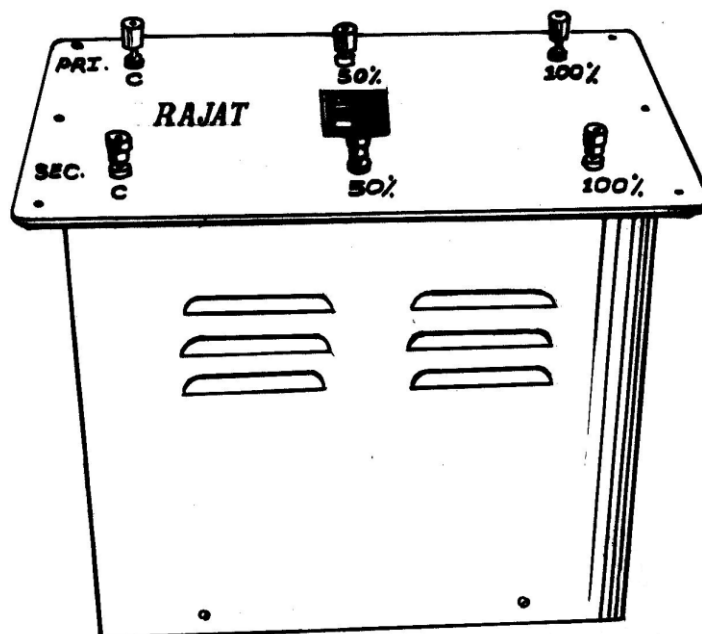




# RAJAT



## TECHNICAL MANUAL FOR O.C. & S.C. TEST ON 1 PHASE TRANSFORMER



Manufactured by :

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## OPEN-CIRCUIT AND SHORT-CIRCUIT TESTS ON TRANSFORMER

- AIM :**
- (a) To perform open circuit test on single phase transformer.
  - (b) To perform short circuit test on the same transformer
  - (c) Calculate the complete parameters of the equipment circuit of this transformer
  - (d) Calculate the efficiency at 1/4, 1/2, 3/4<sup>th</sup> full load and 1.25 times full load and plot the efficiency curve Vs load. Take the operating power factor as 0.85 lagging.
  - (e) Calculation the regulation at full load and at the following power factor (i) 0.85 lagging (ii) unity (iii) 0.85 leading.

### MACHINE REQUIRED

Single Phase Transformer 1 KVA 230/230V with Tappings at 50% & 86.6% Naturally Air Cooled Copper Double wound, Shell type. The transformer will be housed in MS sheet box enclosure with rubber footings. All the terminals of primary & secondary shall be brought over to bakelite sheet fitted on top of the box through insulated terminals. 'RAJAT' make. **Our Transformers have efficiency more than 90%.**

### CONTROL PANEL FOR EXPERIMENT

Fitted on bakelite sheet enclosed in almirah type ms box with lock & handle arrangement suitable for table mounting.

- |    |   |       |
|----|---|-------|
| 1. | MI Voltmeter 96 x 96 mm Sq 0-300V   | 1 No. |
| 2. | MI Voltmeter 96 x 96 mm Sq 0-30V  | 1 No. |
| 3. | MI Ammeter 96 x 96 mm Sq 0-10A  | 1 No. |
| 4. | MI Ammeter 96 x 96 mm Sq 0-1A   | 1 No. |
| 5. | Single Phase Single Element Dynamo type Wattmeter<br>2.5/5 Amp, 75/150/300V Portable UPF type | 1 No. |
| 6. | Single Phase Single Element Dynamo type Wattmeter<br>1/2 Amp, 75/150/300V Portable LPF type   | 1 No. |
| 7. | Single Phase Variac Air Cooled 0-270V,  | 1 No. |

### **THEORY :**

#### **Open Circuit Test :**

In this test low voltage winding (primary) is connected to a supply of normal voltage and frequency (as per the rating of transformer) and the high voltage winding (secondary) is left open as shown in fig. The primary winding draws very low current hardly 3 to 5 percentage of full load current (may be upto 10% for very small rating transformer used for laboratory purpose) under this condition. As such copper losses in the primary winding will be negligible. Thus mainly iron losses occur in the transformer under no load or open circuit condition, which are indicated by the wattmeter connected in the circuit.

Hence, total iron losses =  $W_0$  (Reading of Wattmeter)

From the observation of this test, the parameters  $R_0$  and  $X_m$  of the parallel branch of the equivalent circuit can also be calculated, following the steps given below :

Power drawn,  $W_0 = V_0 I_0 \cos \phi_0$

$$\text{Thus, no load power factor, } \cos \phi_0 = \frac{W_0}{V_0 I_0}$$

Core loss component of no load current,  $I_w = I_0 \cos \phi_0$

And, magnetising component of no load current,  $I_m = I_0 \sin \phi_0$

$$\text{Equivalent resistance representing the core loss, } R_0 = \frac{V}{I_w}$$

$$\text{Magnetising reactance representing the magnetising current, } X_0 = \frac{V}{I_m}$$

### Short Circuit Test :

In this test, low voltage winding is short circuited and a low voltage hardly 5 to 8 percent 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 occurring in the transformer under this condition is negligible, because of very low applied voltage. Hence the total losses occurring under short circuit are mainly the copper losses of both the winding, which are indicated by the wattmeter connected in the circuit as shown in fig. 'B'.

Thus total full load copper losses =  $W_{sc}$  (reading of wattmeter)

The equivalent resistance  $R_{eq}$  and reactance  $X_{eq}$  referred to a particular winding can also be calculated from the observation of this test, following the steps given below.

$$\text{Equivalent resistance referred to H.V. winding, } R_{eq} = \frac{W_{sc}}{I_{sc}^2}$$

$$\text{Also, equivalent impedance referred to H.V. winding, } Z_{eq} = \frac{V_{sc}}{I_{sc}}$$

$$\text{Thus the equivalent reactance referred to H.V. winding } X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2}$$

**PERFORMANCE CALCULATIONS :**

Complete performance of the transformer can be calculated based on the above observation of open-circuit and short-circuit test following the steps given by,

**1. Efficiency at different loads :**

(a) Efficiency at full load :

$$\text{Total losses at full load} = W_0 + W_{sc}$$

Let the full load output power of the transformer in KVA be  $P_0$

$$\text{Then percentage efficiency at full load, } \eta_t = \frac{P_0 \times 1000 \times \cos \phi}{P_0 \times 1000 \times \cos \phi + W_0 + W_{sc}} \times 100$$

(b) Efficiency at half the full load :

Iron losses at half the full load =  $W_0$  (constant)

$$\text{Total copper losses at half the full load} = \left(\frac{1}{2}\right)^2 W_{sc} = \frac{1}{4} W_{sc}$$

$$\text{Output power at half full load} = \frac{1}{2} P_0 \text{ KVA}$$

Thus, percentage efficiency at half the full load,

$$\eta_{1/2f} = \frac{1/2 P_0 \times 1000 \times \cos \phi}{1/2 P_0 \times 1000 \times \cos \phi + W_0 + 1/4 W_{sc}} \times 100$$

In a similar manner, efficiency at order loads can be found out and the efficiency Vs output power curve can be plotted.

**2. Equivalent circuit :**

All the parameters of the approximate equivalent circuit has been calculated above. Thus an approximate equivalent circuit of the transformer can be drawn with these value of parameters marked on it. The equivalent circuit can be solved easily for estimating the performance like terminal voltage across the secondary etc.

**3. Regulation :**

Regulation of the transformer can now be calculated based on the parameters of the equivalent circuit, using the approximate formula given below.

$$\text{Percentage Regulation} = \frac{I (R_{eq} \cos \phi \pm X_{eq} \sin \phi)}{V} \times 100$$

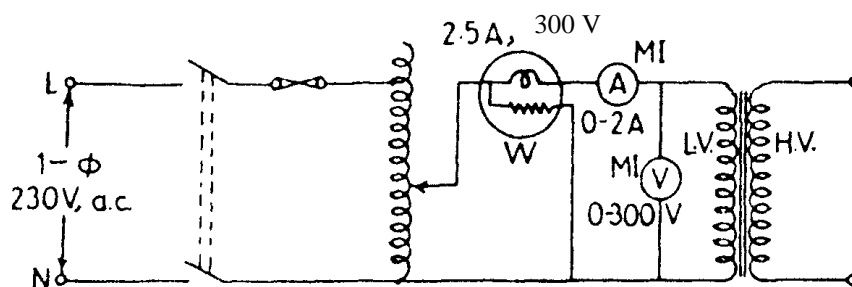
Where,  $I$  – rated current of the winding referred to which  $R_{eq}$  and  $X_{eq}$  have been calculated.

$V$  – Voltage of that winding.

$\cos \phi$  – Power factor at which regulation is to be calculated.

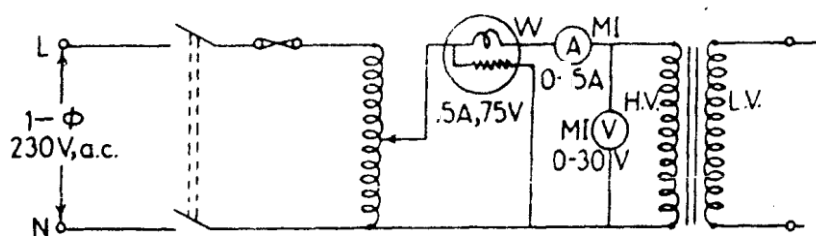
**CIRCUIT DIAGRAM :**

Fig ‘A’ shows the circuit diagram to perform the no load test at rated voltage of the transformer. Ammeter, voltmeter and wattmeter have been connected in the circuit to measure, no load current, rated voltage applied and the no load power drawn by the transformer respectively.



*Fig ‘A’ – Open circuit test on transformer.*

Fig ‘B’ shows the circuit diagram to perform the short circuit test at a reduce voltage, such that the current flowing in the windings is of rated full load value. As such a single phase variac has been included in the circuit. Ammeter, wattmeter connected in the circuit measure, full load short circuit current, power drawn under this condition and the reduced voltage applied to the winding of the transformer respectively.



*Fig ‘B’ – Short circuit test on transformer.*

**PROCEDURE :**

(a) **Open Circuit Test :**

1. Connect the circuit as per fig ‘A’.
2. Ensure that the setting of the variac is at low output voltage.
3. Switch on the supply and adjust rated voltage across the transformer circuit.

4. Record no load current, voltage applied and no load power, corresponding to the rated voltage of the transformer winding.
5. Switch-off the AC supply.

**(b) Short Circuit Test :**

1. Connect the circuit as per fig 'B' for conducting short circuit test.
2. Adjust the setting of the variac, so that the output voltage is zero.
3. Switch on the AC supply to the circuit.
4. Increase the voltage applied slowly, till the current in the windings of the transformer is full load rated value.
5. Record, short circuit current, corresponding applied voltage and power with full load current flowing under short circuit conditions.
6. Switch off the AC supply.

**OBSERVATIONS** : May be tabulated as follows.

S. No.	No Load Test			Short Circuit Test		
	$V_0$	$I_0$	$W_0$	$V_{sc}$	$I_{sc}$	$W_{sc}$

**CALCULATION** - May be tabulated as follows.

S. No.	$\cos \phi_0$	$I_0$	$W_0$	$R_0$	$X_m$	$R_{eq}$	$X_{eq}$	Load	$\eta$	Regulation

## **WORKING OF CONTROL PANEL**

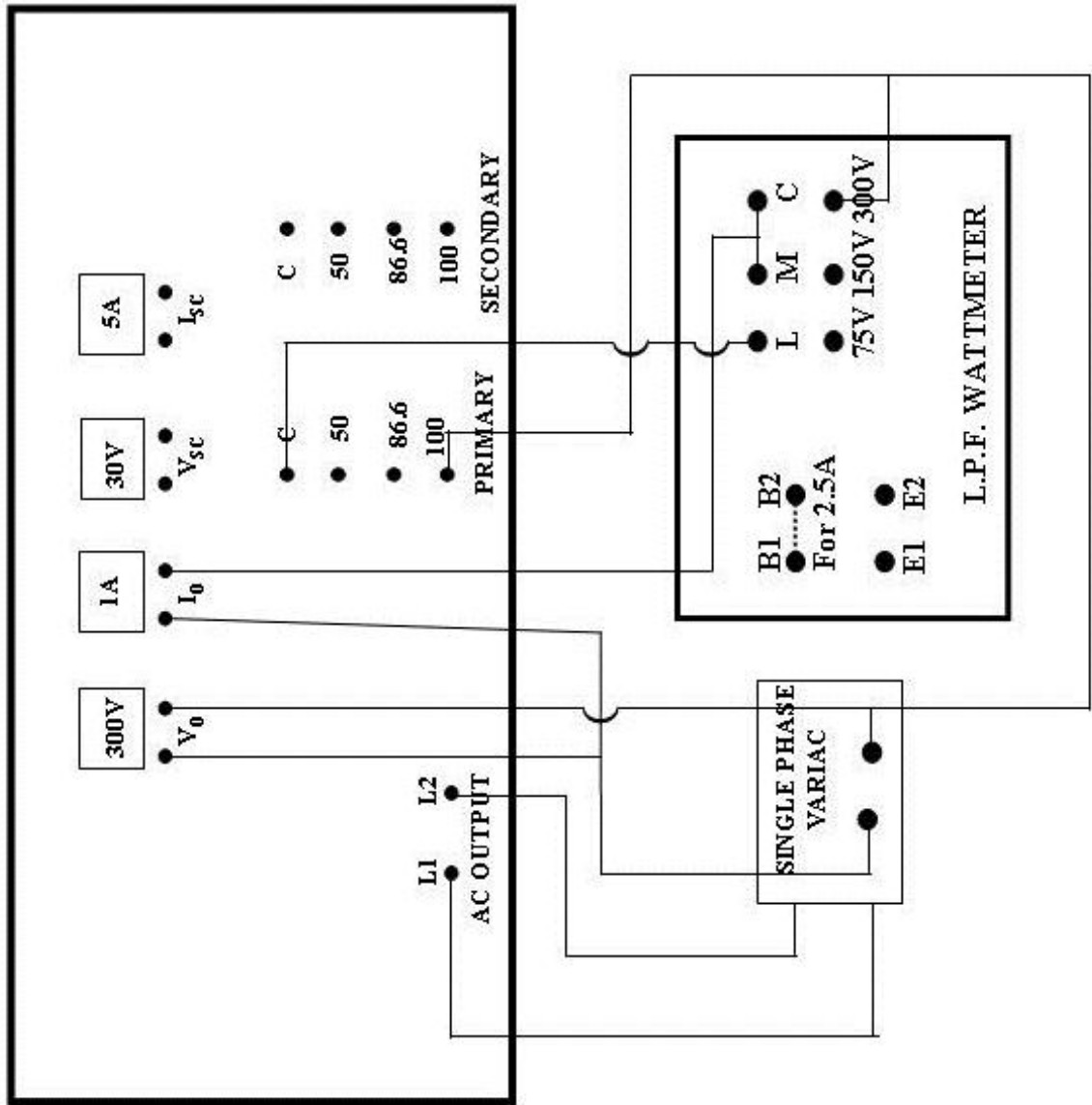
### **FOR OPEN CIRCUIT TEST**

1. Connect the circuit as per attached panel layout diagram for single phase transformer O.C. test.
2. Connect the AC input terminals through Variac on panel.
3. Connect the transformer terminals C and 100% on primary side to terminals marked PRIMARY on panel and the SECONDARY should be left open.
4. Now connect the various instruments i.e. voltmeter, ammeter and wattmeter required for open circuit test as per above figure.
5. Ensure that the setting of the variac is at low output voltage.
6. Switch on the supply and adjust rated voltage across the transformer circuit.
7. Record no load current, voltage applied and no load power, corresponding to the rated voltage of the transformer winding.
8. Switch-off the AC supply.

### **FOR SHORT CIRCUIT TEST**

1. Connect the AC input terminals through Variac on panel.
2. Connect the transformer terminals C and 100% on primary side to terminals marked PRIMARY on panel and short the secondary terminals on transformer plate.
3. Now connect the various instruments i.e. voltmeter, ammeter and wattmeter required for short circuit test as per above figure.
4. Ensure that the setting of the variac is at low output voltage.
5. Switch on the supply and increase the voltage across voltmeter 0-30 volt till the rated current (i.e. full load current as per nameplate date) is indicated on ammeter 0-5 A on primary side.
6. Record short circuit current, corresponding voltage applied and power with full load current flowing under short circuit conditions.
7. Switch-off the AC supply.
8. Tabulate the readings as given below.

**PANEL LAYOUT FOR SINGLE PHASE TRANSFORMER (O.C. TEST)**





**PANEL LAYOUT FOR SINGLE PHASE TRANSFORMER (S.C. TEST)**

