Efficiency & Regulations Of Single Phase Transformer

Exp. No: **Date:**

Aim: Determination of the efficiency and regulation of a single phase transformer by conducting (a) Open circuit test
(b) Short circuit test

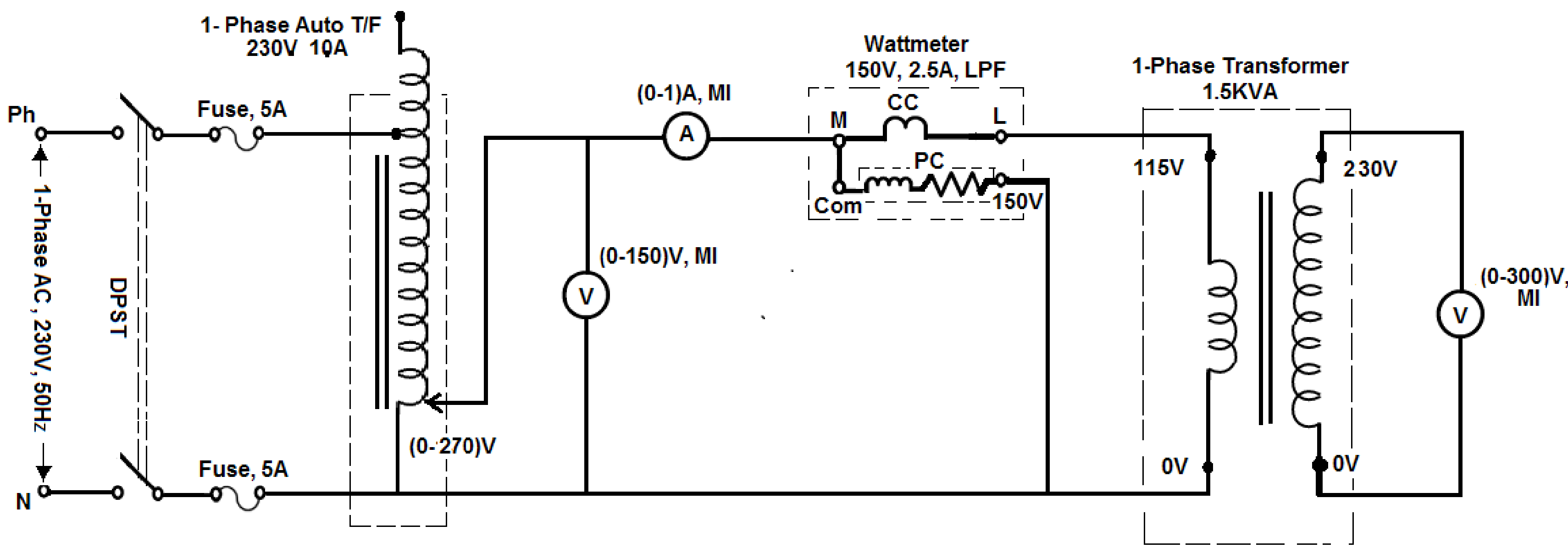
Open circuit test

Apparatus required:

S.No	Name of the equipment	Range/ Specification	Type	Quantity
1	Voltmeter	(0-150) V	MI	1
2	Voltmeter	(0-300) V	MI	1
3	Ammeter	(0-1) A	MI	1
4	Wattmeter	300V, 5A,LPF	Electro-dynamic	1
5	1- Phase Auto Transformer	I/P:1-ϕ, 230V O/P: (0-270)V,10A	Core type	1
6	1-Phase Transformer	1.5KVA, 115V/230V	Core type, Air cooled	1
7	Connecting wires	1.5sq.mm	copper	Required

Procedure:

1. Connect the circuit as per the circuit diagram.
2. Switch ON the 1-phase supply by closing DPST switch. Increase the input voltage by turning the auto transformer knob in clock wise direction up to rated primary voltage**(V_1)** of the 1-phase transformer(Low Voltage winding).
3. Tabulate the readings of no load current**(I_0)**, input power**(W_0)**, primary**(V_1)** & secondary**(V_2)** voltages in the tabular column.



Circuit Diagram for Open Circuit test

Tabular column:

S.No	Primary Voltage **(V_1)** On L.V Side	No load current **(I_0)**	Input Power **(W_0)**	Secondary Voltage (**V_2**) On H.V Side

Theoretical calculations:

Iron losses $W_0 = V_1 I_0 Cos\, \phi_0$ *Watts*

The No load shunt parameters are calculated from the OC test as

The No load power factor $Cos\, \phi_0 = W/ (V_1 I_0)$

The No load compponent currents are determined as

Magnetizing component of No load current, $I_\mu = I_0 Sin\, \phi_0$

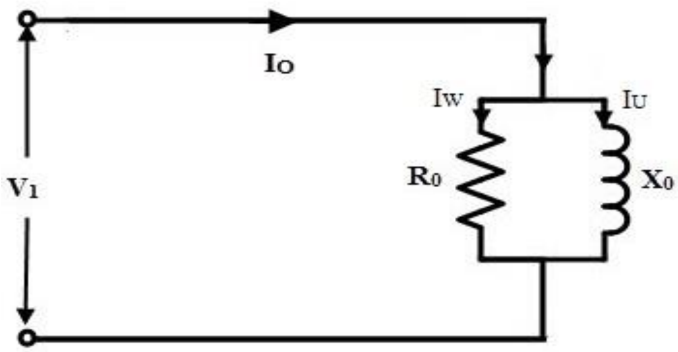
Amps

Working OR core loss component of No load current, $I_W = I_0 Cos\, \phi_0$ *Amps*

Primary No load current $I_0 = \sqrt{(I_\mu^2 + I_W^2)}$ *Amps*

Magnetizing branch reactance $X_0 = V_1/ I_\mu$ *Ohms*

Resistance repreenting core loss$R_0 = V_1/ I_W$ *Ohms*



Precautions:

1. All the connections should be tight.
2. Initially keep the output voltage of the autotransformer to zero.

Short circuit test

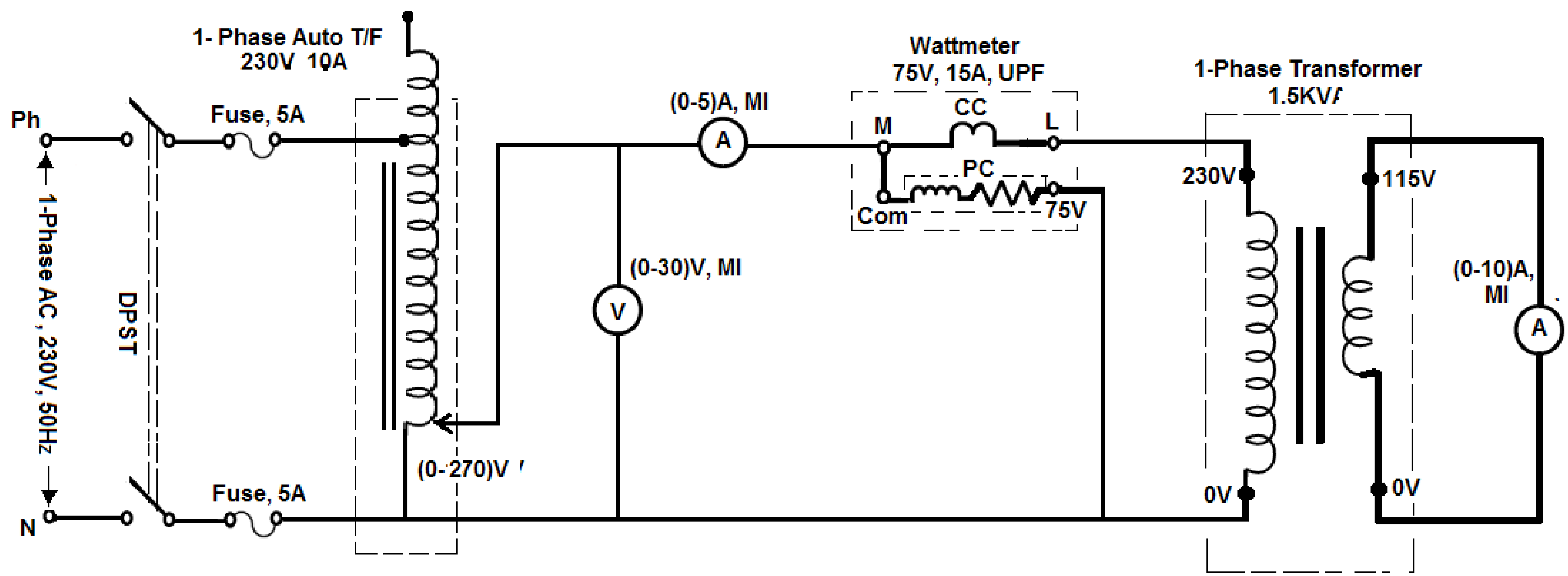
Apparatus required:

S.No	Name of the equipment	Range/ Specification	Type	Quantity
1	Voltmeter	(0-30) V	MI	1
2	Ammeter	(0-10) A	MI	1
3	Ammeter	(0-20) A	MI	1
4	Wattmeter	75V, 15A,UPF	Electro-dynamic	1
5	1- Phase Auto-Transformer	I/P: 1-ϕ, 230V O/P: (0-270)V,10A	Core type	1
6	1-Phase Transformer	1.5KVA, 115V/230V	Core type, Air cooled	1
7	Connecting wires	1.5sq.mm	copper	Required

Procedure:

1. Connect the circuit as per the circuit Diagram.
2. Initially keep the output voltage of autotransformer at zero position.
3. Switch ON the circuit, Increase the output voltage of the autotransformer up to the rated primary current of the 1-Phase transformer.
4. Note down the values of the input voltage (**V_{SC}**) high voltage winding, input current on HV Side**(I_2)**, power**(W_{SC})** and the Current on LV Side **(I_1)** in table.
5. Complete equivalent circuits of the transformer referred to both H.V. & L.V. side.

6. Efficiency of the Transformer at 25%, 50%, 75%, & 100% of the fullload **current** at unity p.f.
7. Full load regulation at power factor of (a) 1.0 (b) 0.8 lagging and (c) 0.8 leading.
8. A graph showing efficiency at unity p.f. against load current at rated voltage.
9. The maximum efficiency at the load (at unity p.f.) at which the maximum efficiency has occurred from the graph.



Circuit Diagram for Short Circuit test

Tabular column:

S.No	Voltage (***V_{SC}***) On H.V Side	Current On H.V Side **(*I_2*)**	Input Power **(*W_{SC}*)**	Current **(*I_1*)** On L.V Side

Theoretical calculations:

W_{sc} = Full load copper losses

Form the test results we determine the series branch parameters of an equivalent circuit

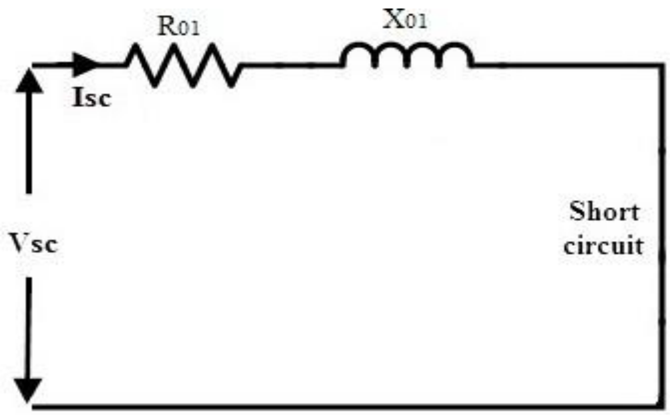
Equivalent resistance referred to HV side, $R_{01} = W_{sc} / I_{sc}^2$

Equivalent impedance referred to HV side, $Z_{01} = V_{sc} / I_{sc}$

Equivalent leakage reactance referred to HV side, $X_{01} = \sqrt{(Z_{01}^2 - R_{01}^2)}$

And also short circuit power factor, $Cos\ \Phi_{sc} = W_{sc} / V_{sc} I_{sc}$

The equivalent circuit obtained from this test is shown below.



Efficiency:

$$Efficiency,\ \eta = \frac{Power\ output\ in\ KW}{Power\ input\ in\ KW}$$

$$Efficiency,\ \eta = \frac{Power\ output\ in\ KW}{(Power\ output\ in\ KW + Copper\ loss + Core\ loss)}$$

The core loss Pcore remains constant from no load to full load as the flux in the core remains constant. And the copper losses are depend on the square of the current. As the winding current varies from no load to full load, copper losses are also get varied.

Consider that the ***KVA*** rating of the transformer is ***S***,

A fraction of the load is ***X*** and

The power factor of the load is ***Cos Φ***. Then

The output power in $KW = X\ S\ Cos\ \Phi$

Suppose the copper loss at full load is P_{cu} (since X =1),

Then copper loss at x per unit loading = $X^2 P_{cu}$

Therefore the efficiency of the transformer is

Efficiency, $\eta = \frac{(XSCos\ \Phi)}{(XSCos\ \Phi + X^2 Pcu + Pcore)}$

In the above efficiency equation, the core or iron losses and full load copper losses are found by OC and SC tests.

<u>Table for efficiency at a fraction of the load and power factor:</u>

Cos Φ / X	0.2	0.4	0.6	0.8
¼ OR 25 % 0f the full load				
½ OR 50 % 0f the full load				
¾ OR 75 % 0f the full load				
1 OR 100 % 0f the full load				

Regulation:

Percentage voltage regulation, $\%R = \frac{(E2 - V2)}{V2} *100$

The expression of voltage regulation in terms voltage drops is given asType equation here.

$$\%R = \frac{(I_1 R_{01} \cos \Phi \pm I_1 X_{01} \sin \Phi)}{V_1} *100$$

From the SC test data we can find out the regulation of a transformer. The positive sign is used for lagging power factor and negative sign is used for leading power factor

Graph

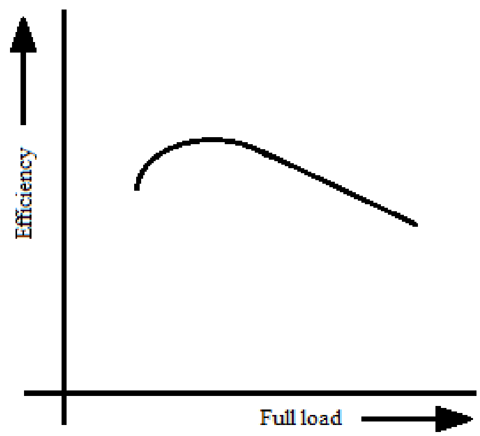


Table for Regulation at a fraction of the load and power factor:

Cos Φ / X	0.2	0.4	0.6	0.8
¼ th OR 25 % 0f the full load				
½ th OR 50 % 0f the full load				
¾ th OR 75 % 0f the full load				
1 OR 100 % 0f the full load				

Precautions:

1. All the connections should be tight.
2. Initially keep the output voltage of the autotransformer to zero.

Result: