EXPERIMENT NO 8

TESTS ON SINGLE PHASE TRANSFORMER

PARTH JOHRI
2K20/B17/33

Aim: To determine the efficiency and regulation of a single phase transformer by conducting

(a) Open Circuit test

(b) Short Circuit test

Apparatus required :-

Connecting wires, breadboard , resistors , inductor ,

AC source , etc.

Theory:-

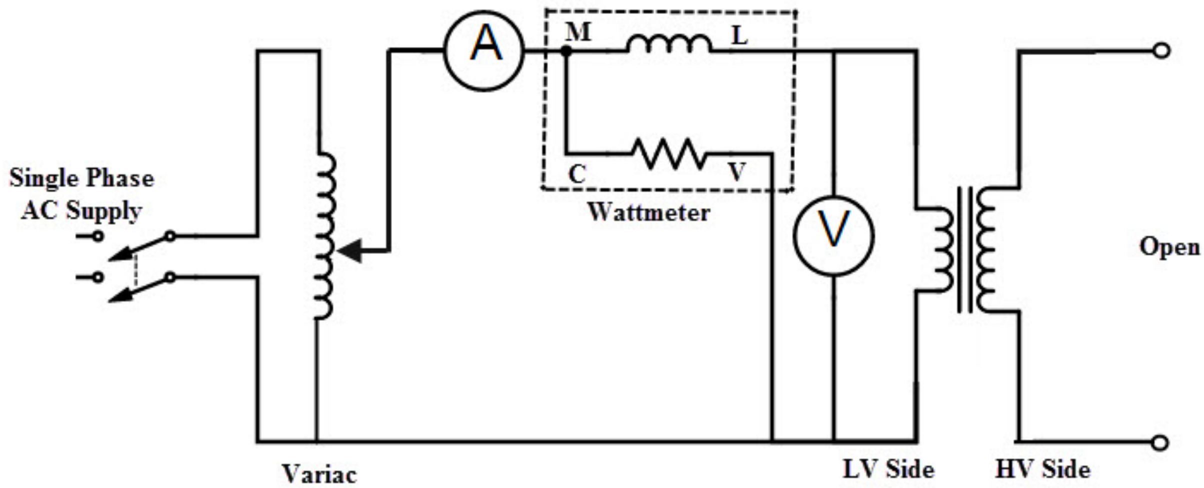
Open Circuit or No Load Test on Transformer

This test is performed to find out the shunt or no load branch parameters of equivalent circuit of a transformer. This test results the iron losses and no load current values, thereby we can determine the no load branch parameters with simple calculations.

As the name itself indicates, secondary side load terminals of the transformer are kept open and the input voltage is applied on the other side. Since this test is carried out by without placing any load, this test is also named as no load test.

The OC test is carried out by connecting LV side (as primary) of the transformer to the AC supply through variac, ammeter and wattmeter instruments. The secondary side or HV side terminals are left open and in some cases a voltmeter is connected across it to measure the secondary voltage.

The primary side voltmeter reads the applied voltage to the transformer, ammeter reads the no load current, wattmeter gives the input power and the variac used to vary the voltage applied to transformer so that rated voltage is applied at rated frequency. The OC test arrangement of a transformer is shown in below figure.



When the single phase supply is given to the transformer, the rated value of the primary voltage is adjusted by varying the variac. At this rated voltage, the ammeter and wattmeter readings are to be taken. From this test, we get rated voltage Vo, input or no load current Io and input power Wo.

As we know that when the transformer is on no load, the no load current or primary current is very small, typically 3 to 5 percent of the rated current value. Thus, the copper loss in the primary winding is negligible. In OC test, transformer is operated at rated voltage at rated frequency so the maximum will be the flux in the core. Since the iron or core losses are at rated voltage, the power input is drawn to supply the iron losses by the transformer under no load.

$$W_o = \text{Iron losses}$$

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

$$\text{The no load power factor, } \cos \Phi_o = W_o/V_oI_o$$

Once the power factor is obtained, the no load component currents are determined as

$$\text{Magnetizing component of no load current, } I_m = I_o \sin \Phi_o$$

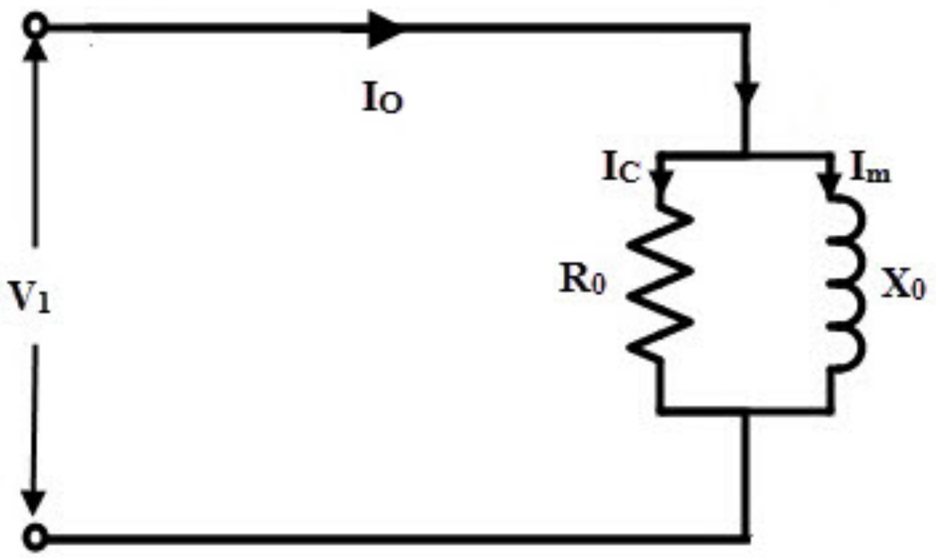
$$\text{Core loss component of no load current, } I_m = I_o \cos \Phi_o$$

$$\text{Then, the magnetizing branch reactance, } X_o = V_o / I_m$$

Resistance representing core loss, $R_o = V_o / I_c$

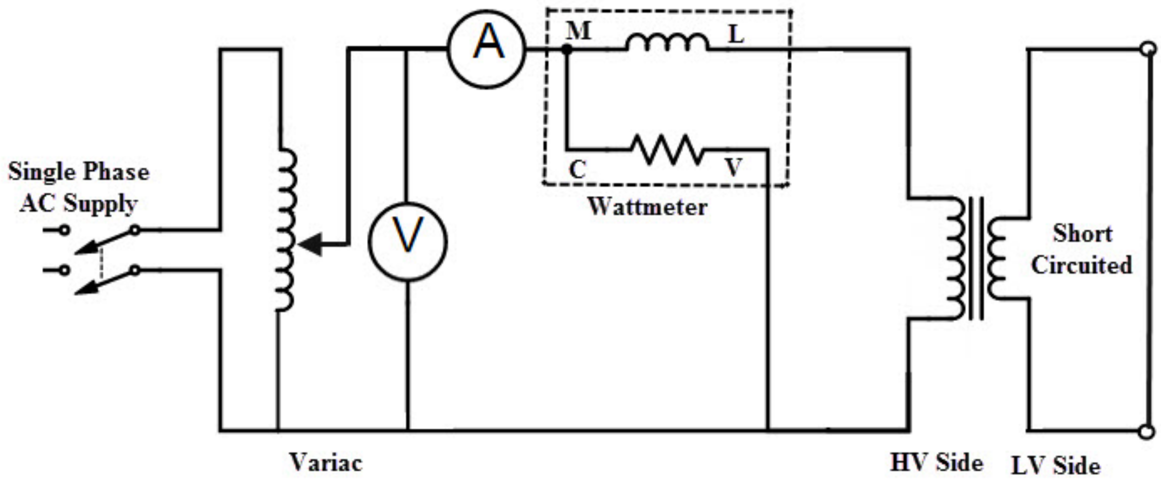
When the transformer is operating on no load, the current drawn by the shunt or parallel parameters is very small about 2 to 5 percent of the rated current. Thus, a low current will flow through the circuit during OC test. In order to be readable by the instruments, the measurements of voltage, current and power must be performed in the low voltage side.

And also, low range current coils and low range ammeter must be selected. The power factor of the transformer on no load is too low which is typically below 0.5 . So in order work with this low value, a LPF watt meter is selected. The equivalent circuit obtained by the OC test is shown below.



Short Circuit Test on Transformer

This test is performed to find series branch parameters of an equivalent circuit such as equivalent impedance (Z_{o1} or Z_{o2}), total winding resistance (R_{o1} or R_{o2}), and total leakage reactance (X_{o1} or X_{o2}). Also, it is possible to determine copper losses at any desired load and total voltage drop of the transformer referred to primary or secondary. In this test, usually LV winding is shorted by a thick wire. And the other side, i.e. HV side this test is conducted.



In this test, the primary or HV winding is connected to the AC supply source through voltmeter, ammeter, wattmeter and a variac as shown in figure. This test is also called as reduced voltage test or low voltage test. This is because as the secondary winding is short circuited, at rated voltage the transformer draws a very large current due to its very small winding resistance.

Such high current can cause the overheating and also burning of the transformer. Thus, to limit the high current, the primary winding must be energized with a low voltage which is just enough to produce the rated current in the transformer primary.

The SC test is conducted on HV side due to the two main reasons. The first one is, the SC test conducted by applying rated current and the HV side rated current is much less than the LV side. Therefore, the rated current is easily achieved at HV side (due to the low current value) as compared to the LV side.

On the other hand, if we short the HV terminals by connecting measuring instrument on LV side, voltage in the secondary is zero. Therefore, the current flow through HV side is very high (as VA rating is constant) compared to the LV side and hence it will cause to burn the transformer.

During this test, by varying the variac slowly, we apply a low voltage to the primary typically 5 to 10 percent of the rated voltage to cause a rated current to flow in both primary and secondary windings that we can observe on ammeter reading (some cases secondary is shorted through an ammeter). At this rated current, we are to record the voltmeter (V_{sc}), ammeter (I_{sc}) and wattmeter (W_{sc}) readings.

In this test, the current flow is rated value and hence no load current is very small and is 3 to 5% percent of rated current. In other words, the voltage applied to the primary winding is very low, thereby the flux level in the core is very small. In turn there is negligible core loss. Therefore, the no load shunt branch is considered as absent in equivalent circuit of this test as core loss is negligible.

As the iron or core losses are function of voltage, these losses are very small. Therefore the wattmeter reading shows the power loss or I_2 R loss equal to the full load copper losses of the whole transformer.

W_{sc} = Full load copper losses

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

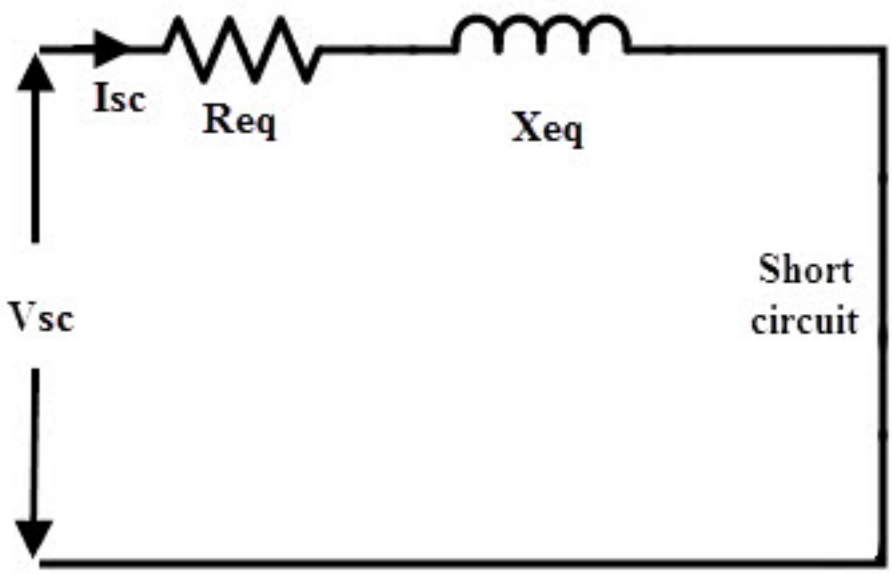
Equivalent resistance referred to HV side, R01 = W_{sc}/ I_{sc}^2

Equivalent impedance referred to HV side, Z01 = V_{sc} / I_{sc}

Equivalent leakage reactance referred to HV side, X01 = $\sqrt{(Z^2 01 – R^2 01)}$

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.



It should be noted that, before parameters calculation, one must aware in which side (primary or secondary) the test reading being recorded. Suppose if the transformer is step-up transformer, then we carry out the SC test on secondary side (HV side) while primary or low voltage side is shorted.

In such case we get the parameters referred to the secondary from calculations such as R02, X02 and Z02. If it is a step-down transformer, we get the parameter values as R01, X01 and Z01 because the meters are connected to the HV side of the primary.

From the OC test we get, shunt branch parameters referred to the LV side and from SC test we get series branch parameters referred to HV side. Therefore, for a meaningful equivalent circuit, all the parameters must be referred to the one particular side. The explanation regarding this transformation is explained in equivalent circuit of the transformer topic in our earlier articles.

Calculation of Efficiency from O.C. and S.C. Tests

As we have seen that, the practical transformer has two types of major losses namely copper and core losses. The temperature of the transformer rises due to these losses which are dissipated as heat. Due to these losses, input power drawn by the primary no longer equal to the output delivered at secondary. Therefore, the efficiency of the transformer is given as

Efficiency, η = Power output in KW/ Power input in KW

= Power output in KW/ (Power output in KW + Losses)

= Power output in KW/ (Power output in KW + Copper loss + Core loss)

We have discussed that, 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 = xSCos Φ

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

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

Therefore the **efficiency** of the transformer is

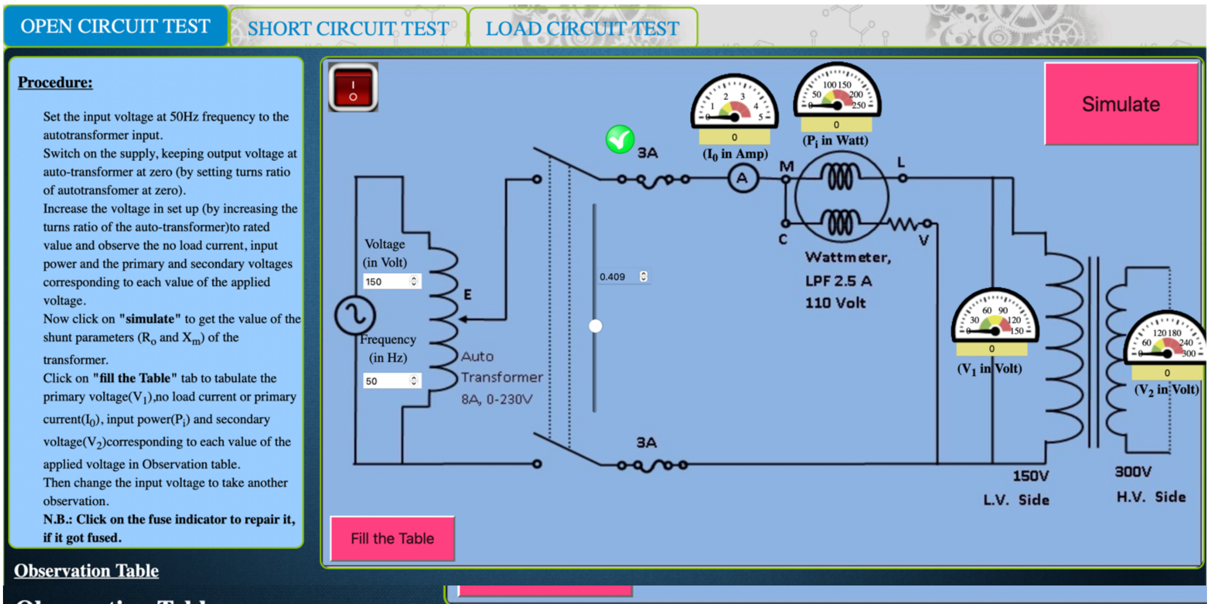
Efficiency,

$$\eta = xSCos\ \Phi / (x_S\ Cos\ \Phi + x^2\ Px_{cu} + Px_{core})$$

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

OBSERVATION TABLE

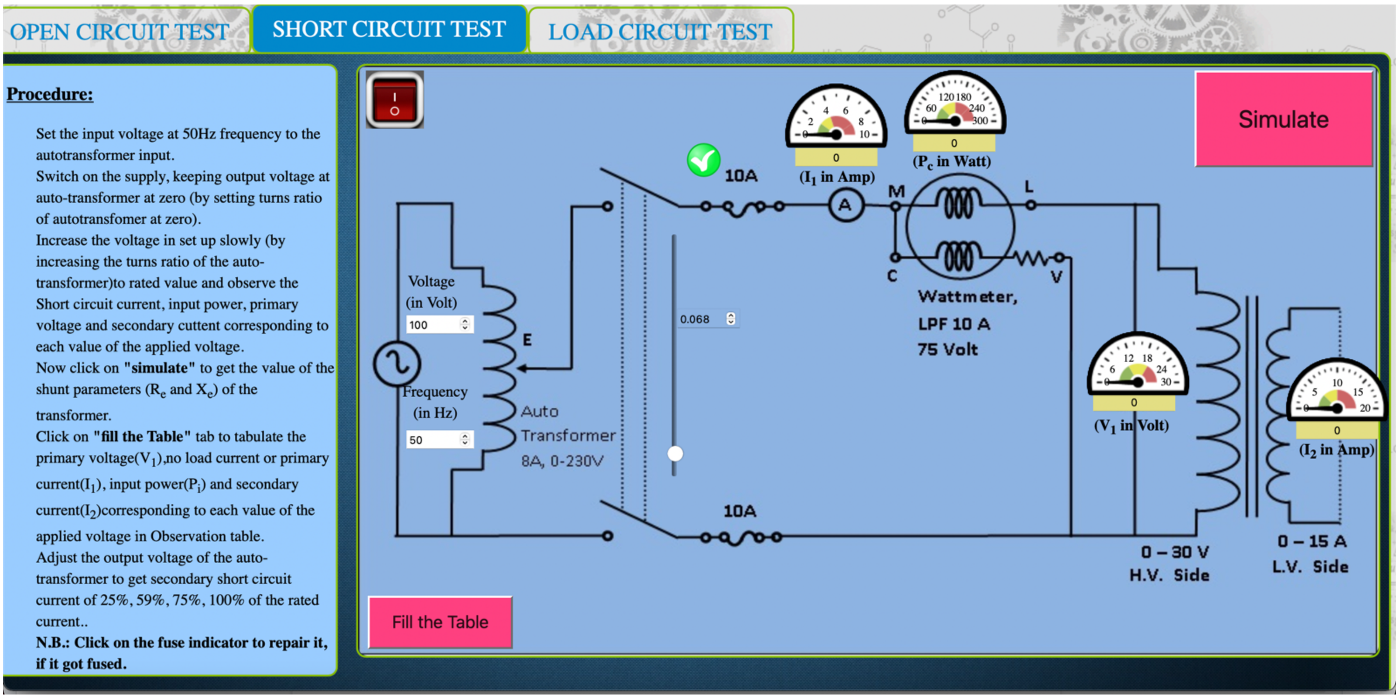
OPEN CIRCUIT TEST



Observation Table

Serial no. of Observation	Primary Voltage V_1 (L.V. Side)	Primary Current I_0 (Amp)	Input Power P_i (Watt)	Secondary Volatge V_2 (H.V.Side)
1st	150.00	1.5699	36.074	307.50
2nd	132.15	1.3831	28.000	270.91
3rd	104.70	1.0958	17.576	214.63
4th	77.850	0.81478	9.7170	159.59
5th	61.350	0.64209	6.0346	125.77

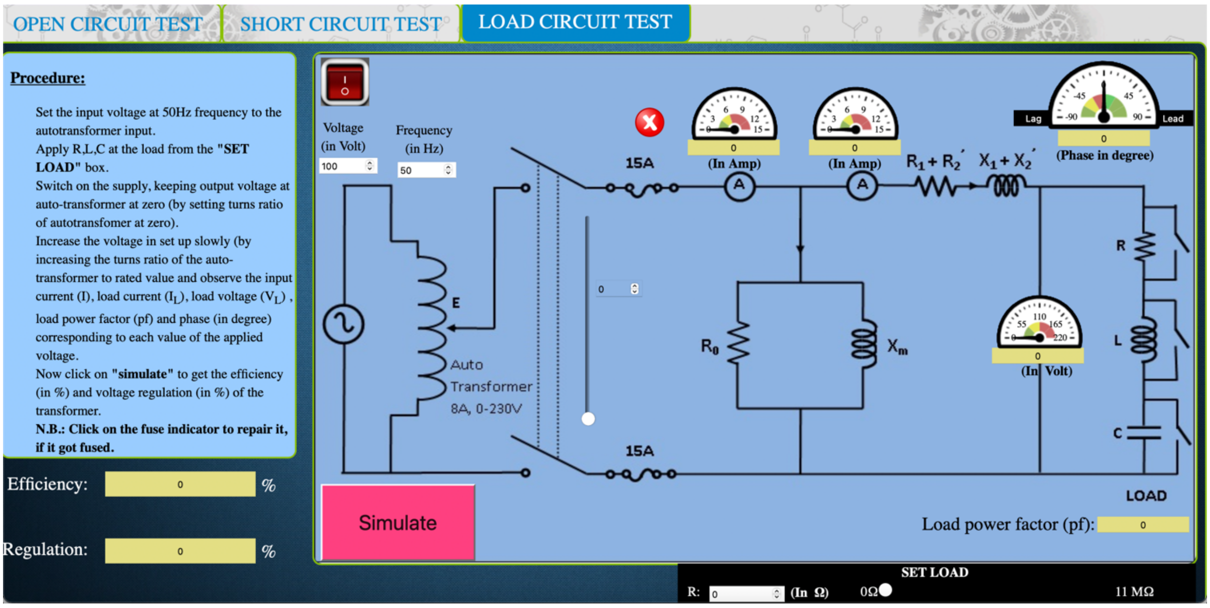
SHORT CIRCUIT TEST



Observation Table

Serial no. of Observation	Primary Voltage V_1 (H.V. Side)	Primary Current I_1 (Amp)	Input Power P_c (Watt)	Secondary Current I_2 (L.V.Side)
1st	22.7	9.6333629893	104.309091112	19.266725978
2nd	15.299999999	6.4929715302	47.386355524	12.985943060
3rd	11.5	4.8803380782	26.771094528	9.7606761565
4th	10.6	4.4983985765	22.744802882	8.9967971530
5th	6.8000000000	2.8857651245	9.3602677580	5.77153024911

LOAD CIRCUIT TEST



This test was not feasible on the vlab because of the fuse , it was not working

RESULT/CONCLUSION

THE **EFFICIENCY** AND **REGULATION** OF A **SINGLE PHASE TRANSFORMER** BY CONDUCTING

a) OPEN CIRCUIT TEST

b) SHORT CIRCUIT TEST

HAS BEEN DETERMINED BY USING THIS EXPERIMENT