<center>**F. Y. B. Tech   2021-22**</center>

Trimester: **Subject:** Basics of Electrical and Electronics Engineering

Name: Krishnaraj Thadesar   **Division   : 9**

Roll No : 109054   **Batch   : I3**

<center>**Experiment No: 9**</center>

Name of the Experiment: Finding Efficiency and regulation of single phase transformer

by using Indirect Loading Method.

Performed on: 17th February 2022

Submitted on: 27th February 2022

Aim: To determine the efficiency and regulation of the transformer by indirect loading (O.C. and S.C. test) of single-phase transformer.

Objective

- To understand the indirect loading test of transformer
- To calculate percentage efficiency
- To calculate percentage regulation

Components and Equipment required

Components	Specifications
Single phase transformer	230/115 V, 50 Hz, 1 kVA
A.C. Voltmeter	0-230 V, 0-150 V
A.C. Ammeter	0-5 A, 0-10 A
Wattmeter	0-750/1500/3000/6000 W

Theory

A transformer is used to transfer electrical energy from one circuit to another at same frequency but at different voltages, depending upon the ratio of the number of turns of primary and secondary winding of the device. Even if the primary voltage applied to the transformer is kept constant, it is observed that secondary terminal voltage varies as the load current is increased. This is because of the voltage drops across resistances and leakage reactance of winding.

Voltage regulation of a transformer is defined as the change in the secondary terminal voltage from NO LOAD to FULL LOAD expressed as the fraction of the NO LOAD voltage, with primary voltage kept constant.

If E_2 = secondary terminal voltage on NO LOAD, volt

V_2 = secondary terminal voltage on LOAD of I amp

I = current flowing through secondary winding

Then, the regulation of Single phase transformer is

$$\% \, regulation = \frac{E_2 - V_2}{E_2} \times 100 \tag{1}$$

Efficiency is defined as the ratio of the power output to power input. Its value is always less than one due to the various losses taking place in the transformer. The losses can be divided into two categories:

1) **Iron or core loss:** This includes the hysteresis and eddy current loss taking place in the iron core. For a fixed frequency and fixed primary voltage, the iron loss remains constant, irrespective of any change in the load current.

2) **Copper loss:** The power loss taking place in the windings of a transformer due to their own resistance is called as copper loss ($I^2 R$). This loss varies according to the load current I.

It is possible to predict the performance of a transformer at various loadings by knowing all the equivalent circuit parameters. These circuit parameters are supplied in terms Open Circuit (OC) and Short Circuit (SC) test data of a transformer. Without actually loading the transformer, these two assessed tests give the test results which are used to determine the equivalent circuit parameters. By these parameters, we can easily predetermine the efficiency and regulation of the transformer at any power factor condition as well as at any load condition. This method of finding the parameters of a transformer is called as an indirect loading method.

Open circuit test (No load test):

The purpose of the open-circuit test is to determine the no-load current and losses of the transformer because of which their no-load parameter is determined. This test is performed on the primary winding of the transformer. The wattmeter, ammeter, and the voltage are connected to their primary winding. The nominal rated voltage is supplied to their primary winding with the help of the ac source. The secondary winding of the transformer is kept open and the voltmeter is connected to their terminal. This voltmeter measures the secondary induced voltage. As the secondary of the transformer is open the no-load current flows through the primary winding. The value of no-load current is very small as compared to the full rated current. The copper loss occurs only on the primary winding of the transformer because the secondary winding is open. The reading of the wattmeter only represents the core and iron losses. The core loss of the transformer is same for all types of loads. The OC test arrangement of a transformer is shown in below figure.
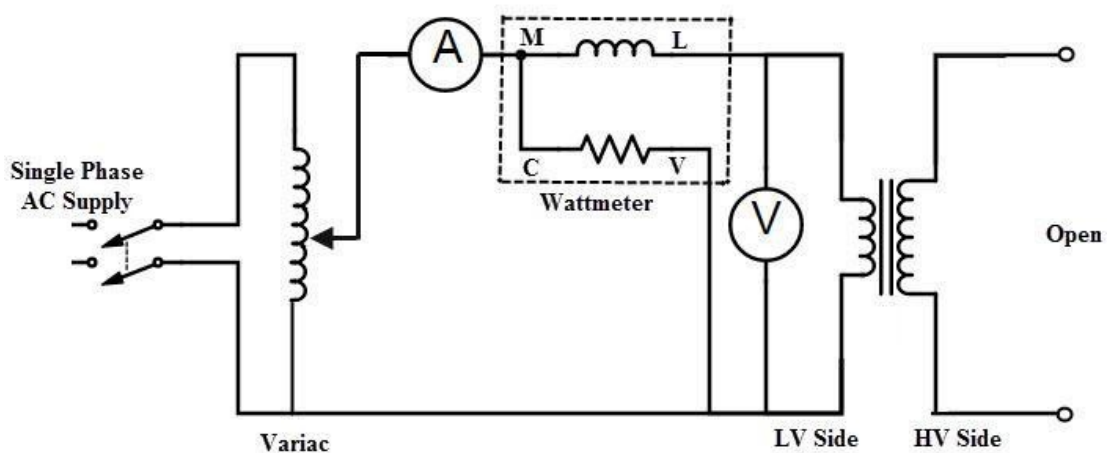
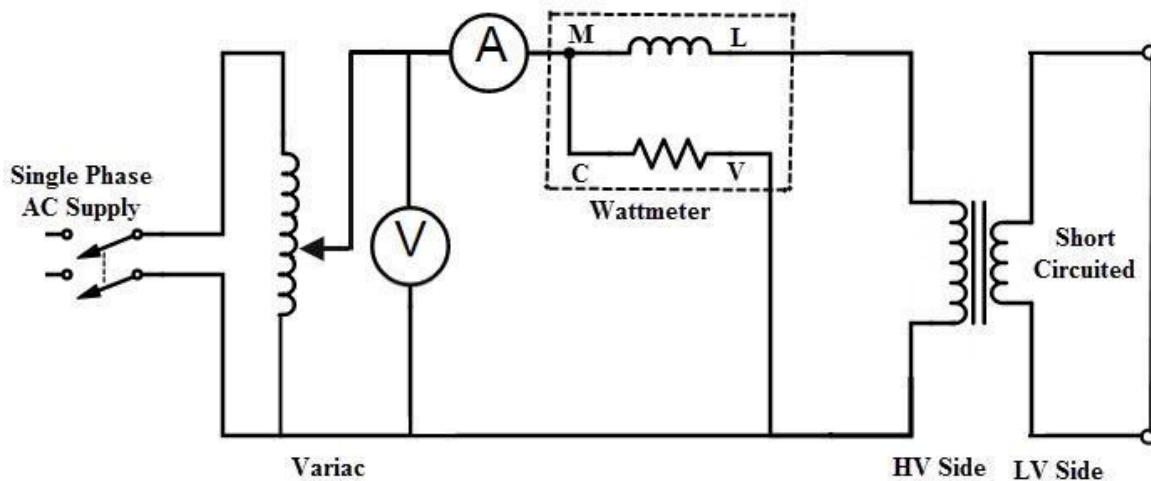**Fig. 1: Circuit diagram for open circuit (no load) test on transformer**

Short circuit test :
The short circuit test is performed for determining the below mentioned parameters of the transformer.

1. It determines the copper loss occurs on the full load. The copper loss is used for finding the efficiency of the transformer.
2. The equivalent resistance, impedance, and leakage reactance are known by the short circuit test.

The short circuit test is performed on the secondary or high voltage winding of the transformer. The measuring instrument like wattmeter, voltmeter, and ammeter are connected to the high voltage winding of the transformer. Their secondary winding is short circuited by the help of thick strip or ammeter which is connected to their terminal. The low voltage source is connected across the secondary winding because of which the full load current flows from both the secondary and the primary winding of the transformer. The full load current is measured by the ammeter connected across their secondary winding.

The low voltage source is applied across the secondary winding which is approximately 5 to 10% of the normal rated voltage. The flux is set up in the core of the transformer. The magnitude of the flux is small as compared to the normal flux. The iron loss of the transformer depends on the flux. It is less occur in the short circuit test because of the low value of flux. The reading of the wattmeter only determines the copper loss occur on their windings. The voltmeter measures the voltage applied to their high voltage winding. The secondary current induces in the transformer because of the applied voltage.

Fig. 2: Circuit diagram for short circuit test on transformer

Observation Table:

Open circuit test (No load test):

P_{oc} (Watt)	I_{oc} (Amp)	V_{oc} (Volt)
50	0.9	230

Short circuit test:

P_{sc} (Watt)	I_{sc} (Amp)	V_{sc} (Volt)
37.5	4.5	11

Procedure:

1. Make the proper connection by clicking the node as instructed below. If the wire is misplaced, click the node number to detach the nodes wire.
2. Then click autotransformer to get the change in all meter.
3. Then click add to table button to get the reading of over open circuit transformer.

Poc (Watt)	Ioc (A)	Voc (V)
50	0.9	230
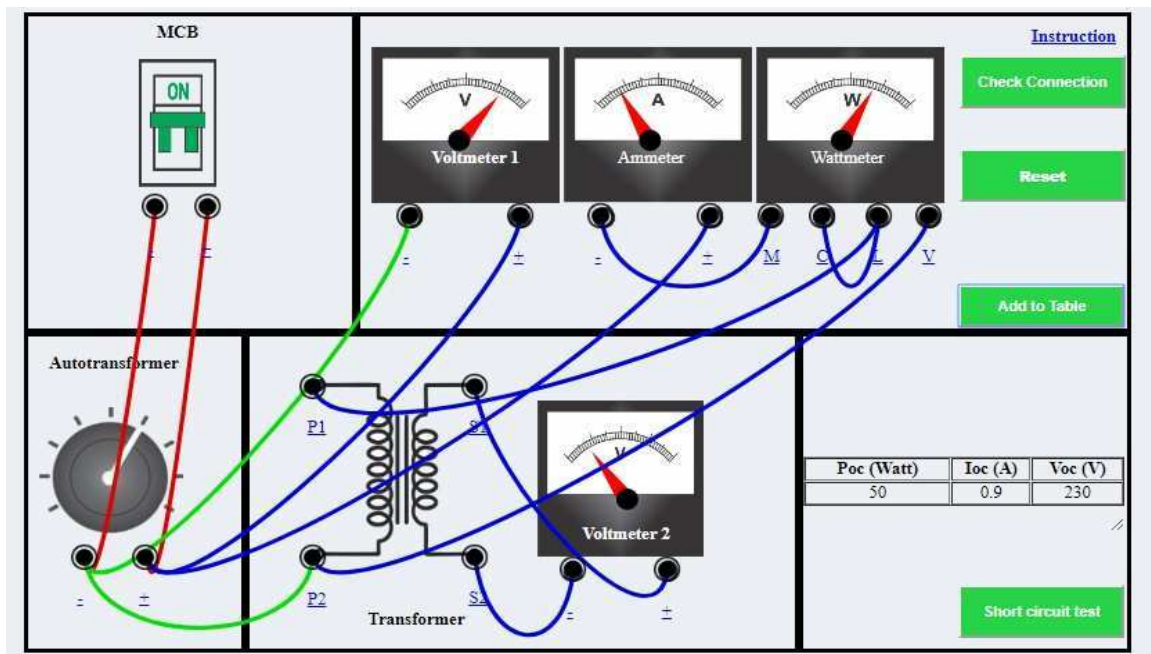
4. Then we have done open circuit transformer test. Then click short button for short circuit transformer test.
5. Make the proper connection by clicking the node as instructed below. If the wire is misplaced, click the node number to detach the nodes wire.

Psc (Watt)	Isc (A)	Vsc (Volt)
37.5	4.5	11
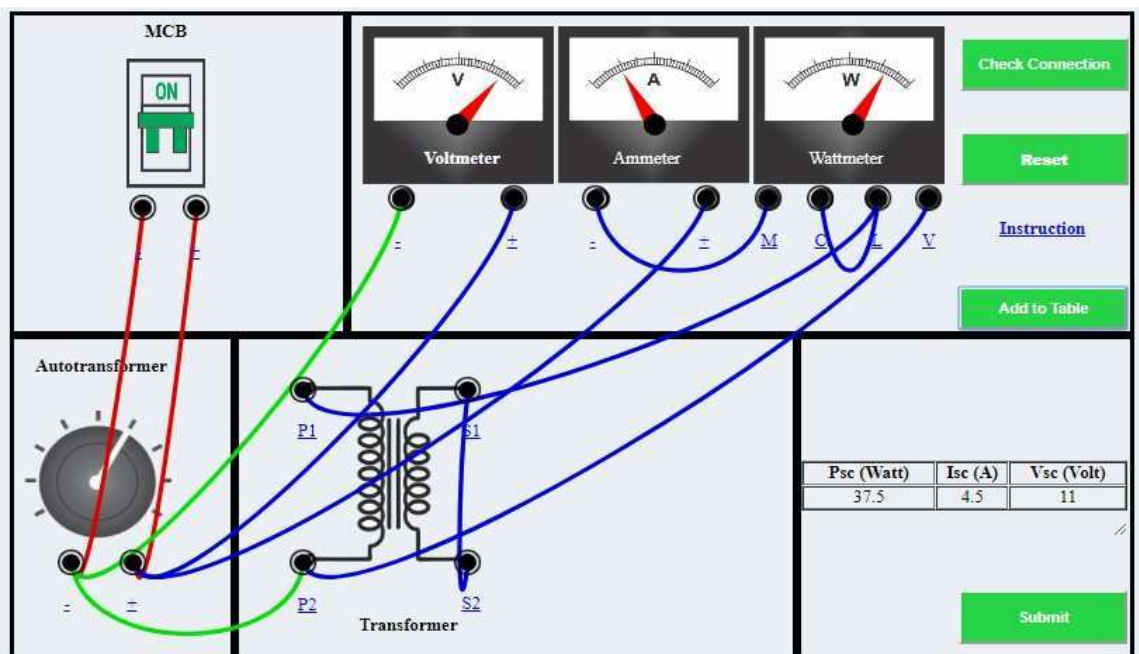
6. Then click check button to check connection is correct or not.
7. Then click add to table button to get the reading of over short circuit transformer.
8. Then we have done short circuit transformer test. Then click submit button for get result.
9. Then we have the result in diagram form. We also print the result by click on print button.

Result:

% Loading	Load power factor	% Regulation	% Efficiency
Full load	0.866	1.576	90.82

Conclusion: Efficiency and regulation of single phase transformer was found.

Post-Lab Questions:

1. Define efficiency of the transformer and state the factors affecting.
2. Define and explain the regulation of the transformer.
3. Discuss the losses that occur during open circuit and short circuit tests.
4. How is regulation related to the load current?

Calculations

→ Efficiency is calculated from short circuit test and open circuit tests

1. ## Efficiency on Full load

$$\eta_{FL} = \frac{\text{Full load } S \times P.F}{\text{full load } S \cdot (PF) + P_{OC} + P_{SC}} \times 100.$$

where, $S =$ Full load KVA rating $= 1\, KVA$

$$= 1000 \, W.$$

$P.F = $ load power factor $= 0.866$.

$P_{OC} = $ Input power on open circuit Test

$$= 50 \, V$$

$P_{SC} = $ Input power on short circuit Tests

$$= 37.5 \, W$$

$$\eta = \left(\frac{1000 \times 0.866}{(1000 \times 0.866) + 50 + 37.5} \right) \times 100$$

$$\eta_{FL} = 90.82$$

%. Regulation :

$$\text{Regulation} = \frac{V_{sc} \cos (\phi_c \pm \phi_2)}{V_1} \times 100.$$

$\cos \phi_c$ = power factor on short circuit.

$$= \frac{P_{sc}}{I_{sc} \times V_{sc}} = \frac{37.5}{4.5 \times 11}, \quad \phi_e = 40.75$$

$\cos \phi_2$ = Load Power Factor = 0.866

V_1 = 230 V = primary Applied voltage

I_{sc} = Primary current

$\phi_2 = 30$

$$\text{%. Regulation} = \frac{11 \times \cos (40.75 \pm 30)}{230} \times 100$$

Since ϕ_2 is lagging, we have to take it as positive.

$$= 1.576$$

25/02/22

BEEE Experiment 9

Post Lab Questions

Q.1 Define efficiency of transformer and state the factors affecting it.

→ efficiency of a transformer :

$$n = \frac{output\ power}{input\ power}$$

→ It is termed as the ratio of the power output to the power input.

⊛ Factors

① Heating effect of current in a coil :

Power is lost as heat I^2R, so higher the resistance, and higher the current, lower becomes the output power and efficiency.

② Effect of ~~eddy~~ induced eddy current.

eddy currents are generated in the iron core when magnetic field fluctuates.

③ Energy used in magnetization and demagnetization of Iron core. This heats it up wasting energy

④ Flux leakage from Primary coil.

Q.2. Define and explain the regulation of a transformer.

→ The measure of how well a transformer can maintain a constant secondary voltage given a constant primary voltage and wide variance in the value of load current is called as Regulation of transformer.

If V_1 is primary, secondary voltage on no load will be

$$\left(V_1 \times \frac{N_2}{N_1} \right)$$

on full load,

$$V_2 = V_c \times \left(\frac{\cancel{+} N_1}{N_2} \right)$$

$$\% \text{ Voltage Regulation} = \frac{V_1 - V_2}{V_1} \overset{(100)}{=} \left(\frac{V_{no\,load} - V_{full\,load}}{V(full\,load)} \right)$$

Q.3 Discuss the losses that occur during open circuit and short circuit losses.

→ **Open circuit:**

This test is done to determine no load current and losses of transformer because of which this no load parameter is determined.

losses

→ core losses and iron losses. They are constant
~~losses~~ losses
These include losses by hysteresis and Eddy
currents.

2. **Short circuit losses**

→ copper loss and impedance losses are
found. This test is done to find the
equivalent resistance, impedance and leakages.
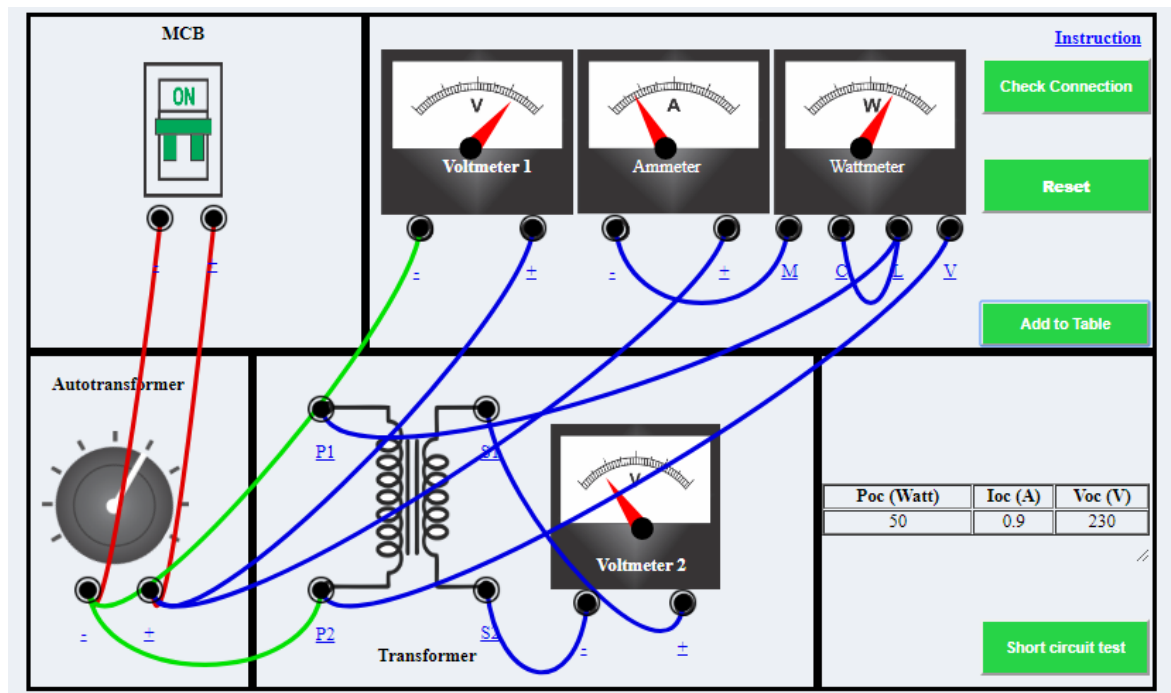
Q(4). How is regulation related to load current?

→ Load current and regulation are related
through load regulation expression. It
is the capability of a transformer to
maintain a constant current current level
on the output channel of a power supply.

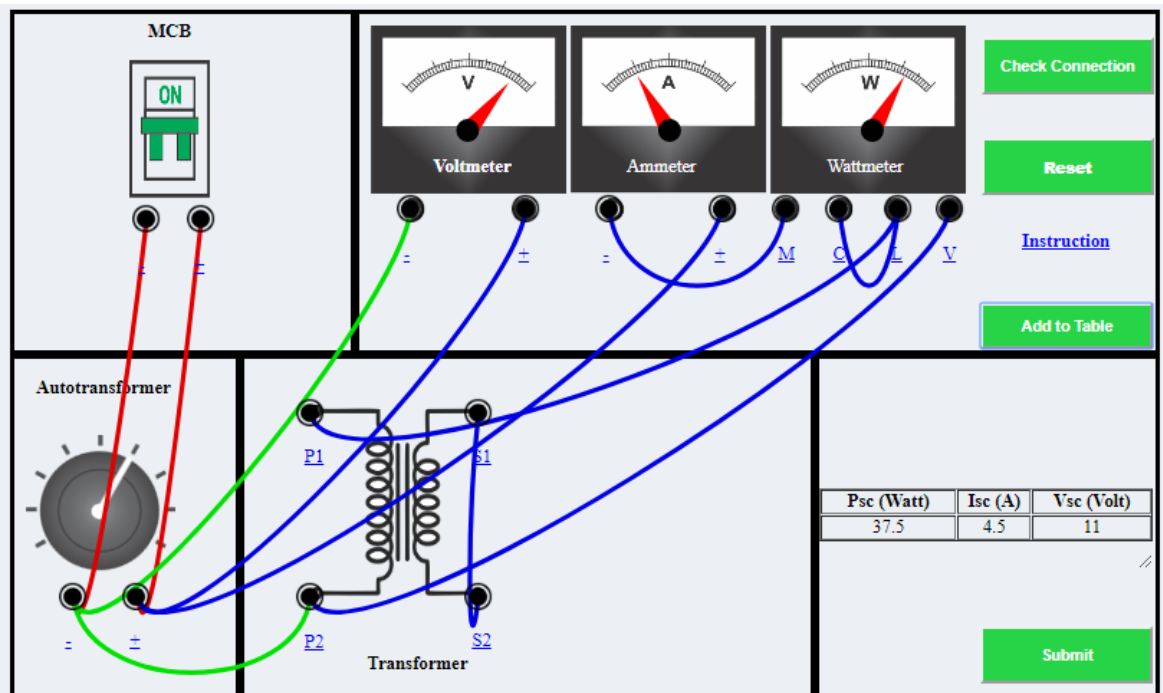$$\boxed{Regulation'} = \frac{V_{sc} \cos(\phi_e \pm \phi_2)}{V_1} \times 100$$

$$\text{But } \boxed{\cos\phi_e = \frac{P_{sc}}{\underline{I_{sc}} \times V_{sc}}}$$

Determination of Transformer equivalent circuit from Open Circuit and Short Circuit Test.

1. Open Circuit Test

Poc (Watt)	Ioc (A)	Voc (V)
50	0.9	230

2. Short Circuit Test

Psc (Watt)	Isc (A)	Vsc (Volt)
37.5	4.5	11

Determination of Transformer equivalent circuit from Open Circuit and Short Circuit Test.

Equivalent Circuit diagram of transformer

0.407 ohm	0.349 ohm		1.85 ohm	1.59 ohm
R1 2	X1 2		R2' 2	X2' 2

1150 ohm
Ri 2

287.5 ohm
Xm