Lecture-36
OC and SC Test

Lecture delivered by:

Topics

- Determination of Parameters of Circuit Model of Transformer (O.C and S.C Test)
- Voltage Regulation
- Transformer Efficiency

Objectives

At the end of this lecture, student will be able to:

- Explain the need of Open Circuit (OC) and Short Circuit (SC) tests
- Conduct Open Circuit (OC) and Short Circuit (SC) tests
- Compute parameters of equivalent circuit and voltage regulation from the tests results

Tests conducted on a transformer

- Open Circuit test
- Short Circuit test
- Sumpner’s or Back-to-Back test
- Polarity test

In this lecture we will discuss the OC and SC tests only.

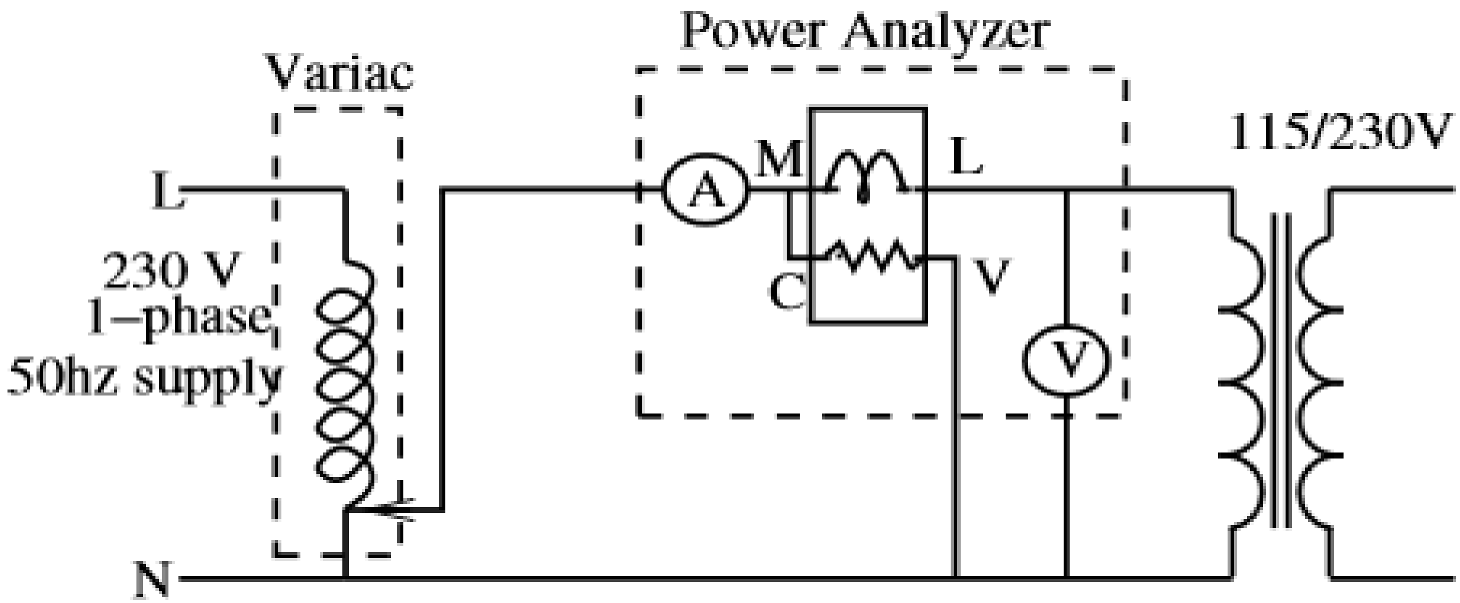
Open circuit and Short circuit tests

Purpose of conducting these tests are:

i. To determine the parameters of the equivalent circuit

ii. To pre-determine the voltage regulation and efficiency at any given load.

Open-circuit Test



- O.C Test is usually conducted on L.V side
- O.C Test is used to find

  (i) No load loss or core loss

  (ii) No load current I_o which is helpful in finding G_o(or R_o) and B_o (or X_o)

Open-circuit Test Cont...

$$\text{Core loss} = W_{oc}$$

$$= V_0 I_0 \cos\varphi_0$$

$$\cos\varphi_0 = \frac{W_{oc}}{V_0 I_0}$$

$$I_c \text{ or } I_w = I_0 \cos\varphi_0$$

$$I_m \text{ or } I_\mu = I_0 \sin\varphi_0 = \sqrt{I_0^2 - I_w^2}$$

$$I_0 = V_0 Y_0; \quad \therefore Y_o = \frac{I_0}{V_0}$$

$$W_{oc} = V_0^2 G_0;$$

$$\therefore \text{conductance} \quad G_0 = \frac{W_{oc}}{V_0^2}$$

$$\& \quad \text{susceptance} \quad B_0 = \sqrt{Y_0^2 - G_0^2}$$

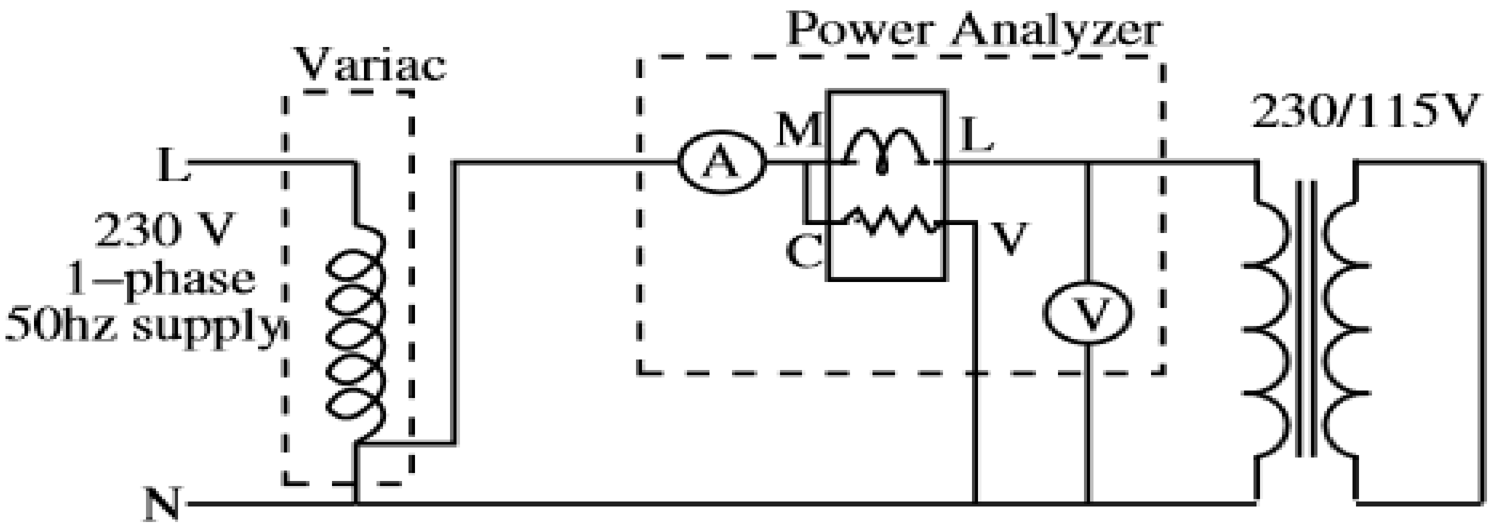
$$R_o = \frac{V_o}{I_w}$$

$$X_o = \frac{V_o}{I\mu}$$

$$G_o = \frac{I_w}{V_o}$$

$$B_o = \frac{I\mu}{V_o}$$

Short-circuit Test

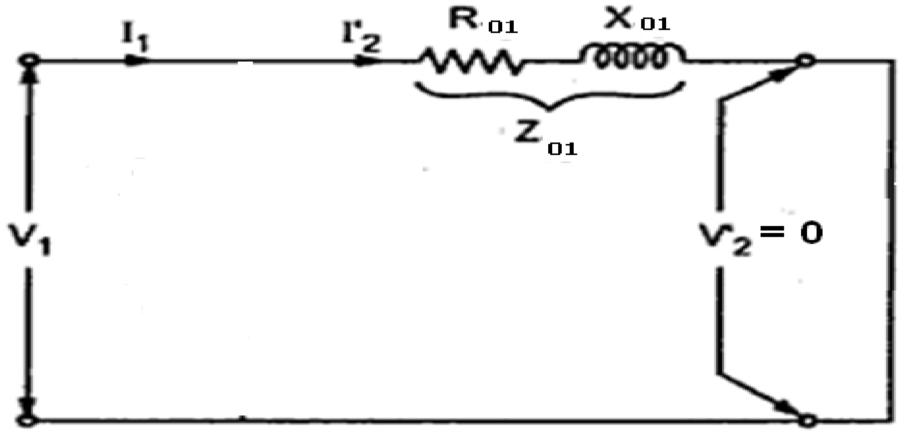


- S.C Test is usually conducted on H.V side
- S.C Test is used to find

  (i) Full load copper loss – to pre determine the efficiency

  (ii) Z_{01} or Z_{02}; X_{01} or X_{02}; R_{01} or R_{02} - to predetermine the voltage regulation

Short-circuit Test Cont..



$$\text{Full load cu loss} = \mathrm{W_{sc}} = I_{sc}^{2} R_{01}$$

$$\mathrm{R_{01}} = \frac{\mathrm{W_{sc}}}{I_{sc}^{2}}$$

$$Z_{01} = \frac{V_{sc}}{I_{sc}}$$

$$\therefore \mathrm{X_{01}} = \sqrt{Z_{01}^{2} - R_{01}^{2}}$$

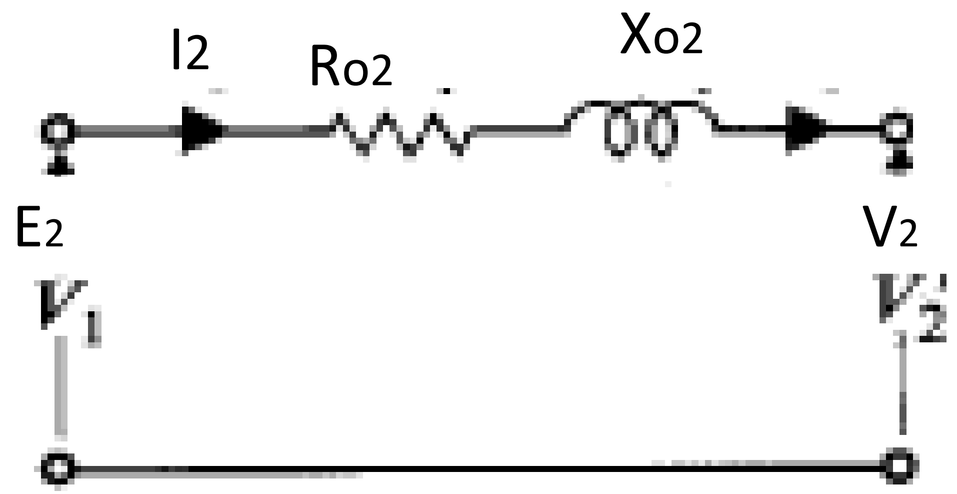
Voltage Regulation of a Transformer

- Voltage regulation of a transformer is defined as the change in secondary terminal voltage from no- load to full-load expressed as a secondary rated voltage with primary applied voltage held constant.

$$\text{Voltage regulation} = \frac{\text{no-load voltage} - \text{full-load voltage}}{\text{no-load voltage}}$$

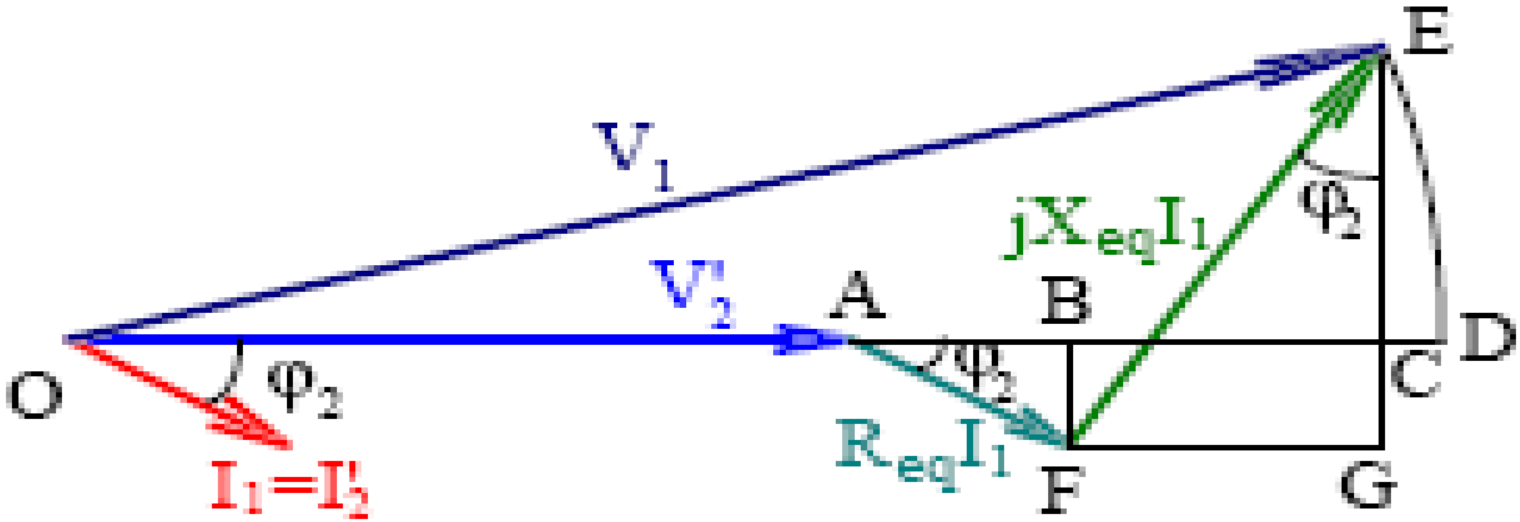
Voltage Regulation of a Transformer Cont..

- The voltage regulation of a transformer can be obtained from its approximate equivalent circuit referred to primary or secondary windings.



Approximate equivalent circuit referred to secondary

Voltage Regulation of a Transformer Cont..



Phasor Diagram

$$E_2 = OC = OA+AB+BC \text{ (or FG)}$$
$$= OA+AF\cos\phi_2 + EG\sin\phi_2$$
$$= V_2 + I_2 R_{o2}\cos\phi_2 + I_2 X_{o2}\sin\phi_2$$

Voltage Regulation of a Transformer Cont..

- Voltage drop in the secondary terminal voltage

$$E_2 - V_2 = I_2 R_{o2} \cos\phi_2 + I_2 X_{o2} \sin\phi_2$$

- Voltage drop in the secondary terminal voltage for any load power factor.

$$E_2 - V_2 = I_2 R_{o2} \cos\phi_2 \pm I_2 X_{o2} \sin\phi_2$$

Where +ve sign for lagging power factor load

-ve sign for leading power factor load

- Similarly the voltage drop as referred to primary is

$$E_1 - V_1 = I_1 R_{o1} \cos\phi_2 \pm I_1 X_{o1} \sin\phi_2$$

Voltage Regulation Based on Phasor's

In terms of secondary values

$$\%\ \text{regulation} = \frac{{}_0V_2 - V_2}{{}_0V_2} = \frac{I_2 R_{02}\cos\phi_2 \pm I_2 X_{02}\sin\phi_2}{{}_0V_2}$$

where '+' for lagging and '-' for leading

In terms of primary values

$$\%\ \text{regulation} = \frac{V_1 - V_2^{'}}{V_1} = \frac{I_1 R_{01}\cos\phi_1 \pm I_1 X_{01}\sin\phi_1}{V_1}$$

where '+' for lagging and '-' for leading

Transformer Efficiency

Transformer efficiency is defined as (applies to motors, generators and transformers):

$$\eta = \frac{P_{out}}{P_{in}} \times 100\%$$

$$\eta = \frac{P_{out}}{P_{out} + P_{loss}} \times 100\%$$

Types of losses incurred in a transformer:

Copper I^2R losses

Hysteresis losses

Eddy current losses

Therefore, for a transformer, efficiency may be calculated using the following:

$$\eta = \frac{V_S I_S \cos\theta}{P_{Cu} + P_{core} + V_S I_S \cos\theta} x100\%$$

Summary

- Open-circuit and short-circuit tests are used to determine equivalent circuit parameters. By conducting these tests efficiency and voltage regulation can be predetermined at any load.

