IC160P-Electrical Systems Around Us

Open-circuit and Short-circuit tests on a single-phase transformer

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1 Objectives 1.

To perform open circuit and short circuit tests on a single-phase power transformer, in order to determine its parameters of the approximate equivalent circuit.

2 Apparatus & Equipment Used

1. Single Phase Autotransformer, Input: 230 V, Output: 0-270 V

2. Transformer: 1 KVA, 230/150 V

3. Wattmeters: 5 A, 250 V, UPF

4. Ammeters: 0-1 A (ac), 0-5 A (ac)

5. Voltmeters: 0-300 V (ac), 0-150 V (ac)

3 Theory

Transformer is a device which transfers electrical energy from one circuit to another without any con ductive coupling between them. The two circuits are magnetically coupled to each other. The magnetic coupling can be modelled in terms of a magnetic circuit, while the electrical power transfer can be mod elled as an equivalent electrical circuit. The magnetic circuit (core) is made up of ferromagnetic material, which is generally electrical (Silicon) steel. In this core, flux circulates and links with the electrical cir cuits placed on it. The electrical circuits are made up of copper windings. In a practical transformer, the magnetic as well as electrical circuits have losses. The losses in the magnetic circuit are called iron losses and those in the windings of transformer are called copper losses. The iron (or core) losses are dependent on the flux in the core and the frequency of operation. Since the value of flux in the core is approximately a function of V /f ratio, and is independent of the load on the transformer, the magnetic losses are approximately constant for a given primary voltage. Copper losses however are load dependent. Generally, the iron losses are very small as compared to the copper losses at rated load. These losses along with other non-ideal effects are modelled in an equivalent circuit of the transformer. An approximate equivalent circuit is given as follows.

Open-circuit Test: In this test, the no-load current and losses are measured. By neglecting the Cu losses at no load, shunt parameters of the transformer equivalent circuit (Rc and Xm as shown in the approximate equivalent circuit) can be calculated.

Short-circuit Test: In this test, secondary side of the transformer is shorted, and rated current is made to flow through the transformer by gradual application of primary voltage. Since the voltage applied is less than the rated value, iron losses are much less as compared to the Cu losses at the rated current. The iron losses are neglected, and thus the series parameters are calculated from the measured values of voltage, current and power input.

These parameters can be used to calculate the efficiency and voltage regulation of transformer at any load condition

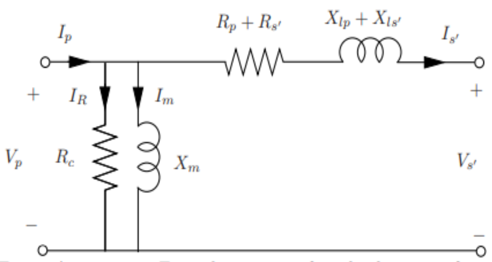

Fig. 1: Approximate Equivalent circuit of single phase transformer

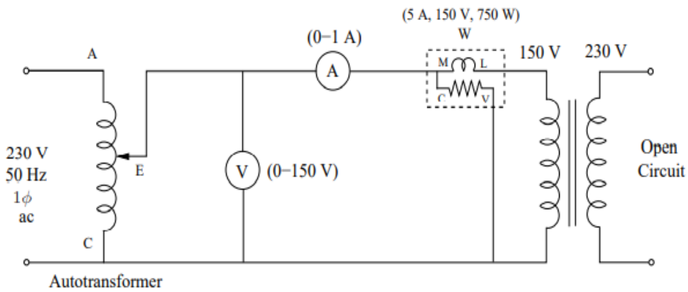

Fig. 2: Circuit diagram for open-circuit test of transformer

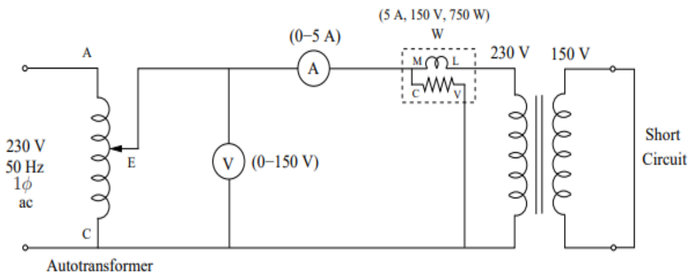

Fig. 3: Circuit diagram for short-circuit test of transformer

4 Procedure

(a)Open-circuit Test: Connect the ammeter, voltmeter and wattmeter in the primary winding of the transformer as shown in Fig. 2. Keep the secondary winding of the transformer open. Energize the primary winding through an auto transformer such that the rated voltage is applied to this winding. The readings of voltmeter, ammeter and wattmeter are as followed:-

Voc (V)	Ioc (A)	Poc (W)
115	0.36	25.75

(b) Short Circuit Test: Connect the ammeter, voltmeter and wattmeter in the primary winding of the transformer as shown in Fig. 3. Short the two terminals of the secondary winding with a shorting link. Energize the primary winding through an auto transformer such that rated current circulates in this winding. The readings of voltmeter, ammeter and wattmeter are as followed:-

Vsc (V)	Isc (A)	Psc (W)
15.81	4.35	30

5 Calculations

1. Open-circuit Test:

$$\mathrm{Zo} = \frac{\mathrm{Voc}}{\mathrm{Ioc}}$$

= 319.44Ω

$$\mathrm{Voc} = \mathrm{I}_R\mathrm{Rc} = \mathrm{ImXm}$$

= 115V

$$\cos\varphi_0 = \frac{\mathrm{Poc}}{\mathrm{VocIoc}}$$

= 0.622

$$I_R = \mathrm{Ioc}\cos\varphi_0$$

= 0.224A

$$\mathrm{Im} = \mathrm{Ioc}\sin\varphi_0$$

= 0.282A

$$\mathrm{Rc} = \mathrm{Voc}/\,\mathrm{I}_R$$

= 513.31Ω

$$\mathrm{Xm} = \mathrm{Voc}/\,\mathrm{Im}$$

= 407.80 Ω

2.Short-circuit Test:

$$\mathrm{Zeq} = \frac{\mathrm{Vsc}}{\mathrm{Isc}}$$

= 3.63 Ω

$$\mathrm{Req} = \frac{\mathrm{Psc}}{\mathrm{Isc}^2}$$

= 1.59Ω

$$\mathrm{Xeq} = \sqrt{\mathrm{Zeq}^2 - \mathrm{Req}^2}$$

= 3.27Ω

6 Questions

1. Why do we perform the Short-circuit test on high-voltage (HV) side?

We perform Short-circuit test on high-voltage (HV) side to minimise the rated current in order to reduce requirement of power supply.

2. What is the meaning of M, L, C, V on the wattmeter terminals?

In Wattmeter, M and L are the two terminals of current coil, positive and negative, respectively and C and V are the two terminals of voltage or pressure coil, positive and negative, respectively.

3. What is the use of autotransformer in this experiment?

Autotransformer is used for adjusting or shifting line voltages as required in experiment.

4. If we performed the SC test on low-voltage (LV) side, what readings should we approximately get?

If SC test on low-voltage(LV) side, readings are as follow:-

Vsc = 7.90V

Isc = 8.71A

Psc = 30W

Req = 13.08Ω

LAB READINGS:

Short

$I = 4.35\ A$

$V = 15.81\ V$

$P = 30\ w$

~~$R_{eq} = 30$~~

$R_{eq} = 1.585\ \Omega$

$Z_{eq} = 3.634\ \Omega$

$X_{eq} = 3.270\ \Omega$

Open

$I_0 = 0.36\ A$

$P = 25.705$

$V = 115\ V$

$\cos\theta = 0.622$

$\theta = 51.54$

$I_e = 0.224$

$I_m = 0.282$

$R_e = 513.33\ \Omega$

$X_m = 407.801\ \Omega$

Amit