ELG3311: Electric Machines and Power Systems
LABORATORY

LAB 2: TRANSFORMER EQUIVALENT CIRCUIT

1. OBJECTIVE
The objective of this experiment is to determine the parameters of an equivalent circuit for a single-phase transformer.

2. BACKGROUND
The transformer equivalent circuit is very useful for calculating voltage regulation and efficiency for a given load condition. Parameters of the equivalent circuit are obtained by carrying out the open circuit and short circuit tests on the transformer in question. For further information, refer to Chapter 3 of the textbook.

3. EQUIPMENT

Single-phase transformer,	250 VA, 120/240V, 60Hz
AC Voltmeter,	0-300V,
AC Ammeter,	0-5A,
DC Ammeters,	0-10A,
Variac,	0-135V.
Wattmeter.	

4. PREPARATORY WORK
Compute the following, using the simplified equivalent circuit shown in Figure 1.

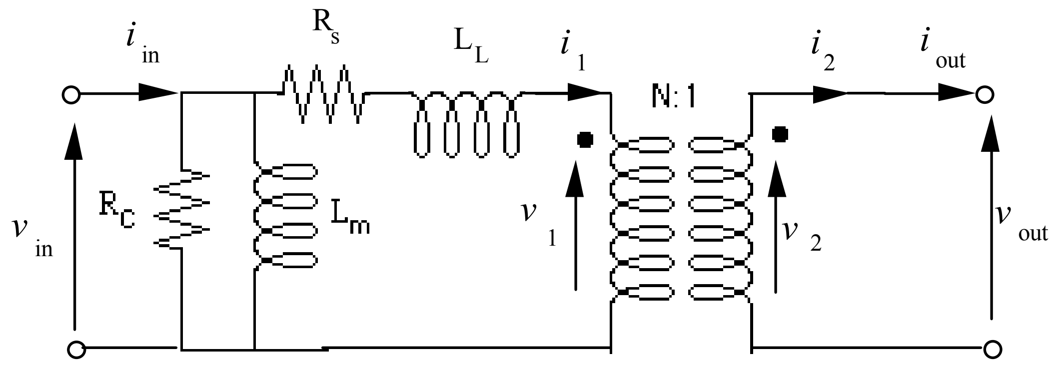

Figure 1. Simplified Equivalent Circuit for a power transformer

Assume the ratings and parameters as given below.

Voltamperes = 280 VA, 60 Hz

Voltage Ratio = 100/50 = 2

Secondary Voltage, V_s = 50 V

Equivalent Series Impedance, $R_s + jX_s = 4.0 + j3.0$

Core Loss Resistance, $R_c = \infty$

Magnetizing Reactance, $X_m = j5000$

Load Impedance, $Z_L = 8 + j6$ ohms

The load is connected to the secondary winding of the transformer.

- Calculate the voltage required at the input to produce 50V at the output.

- Calculate the input current.

- Calculate the total power loss within the transformer.

- Calculate the efficiency of operation with the above load.

- Calculate the voltage regulation for the above load.

5. PROCEDURE

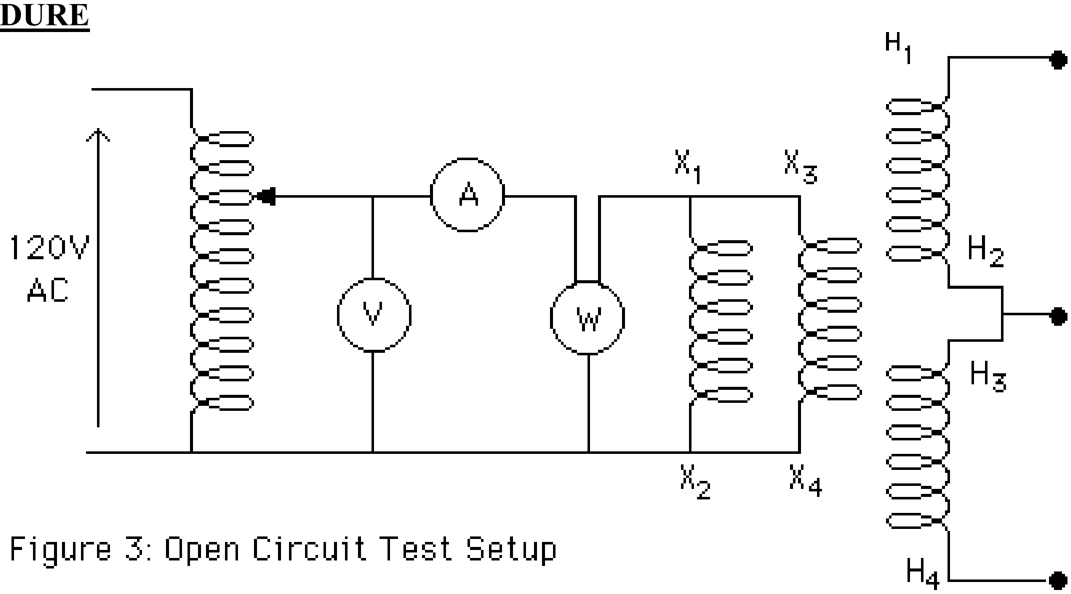

Figure 3: Open Circuit Test Setup

5.1 Open Circuit Test

Connect the circuit as shown in Figure 2 using the low voltage winding for power input and leaving the high voltage winding open circuited.

Set the supply voltage to the rated value of 120V.

Measure the input current and power and switch off the power supply.

Measure and record the values of the following parameters, with the low voltage winding energized.

V_{oc} =

I_{oc} =

P_{oc} =

Calculate the following values referred to the low voltage side;

$$\theta_{oc} = \cos^{-1}\left(\frac{P_{oc}}{V_{oc}I_{oc}}\right) =$$

$$R_c = \frac{V^2{}_{oc}}{P_{oc}} =$$

$$X_m = \frac{R_c}{\mathrm{Tan}\theta_{oc}} =$$

Convert R_c and X_m to the high voltage side values using, N, the nominal turns ratio given on the transformer nameplate. Where:

$$N = \frac{\text{Rated Voltage on the HV side}}{\text{Rated Voltage on the LV side}} =$$

$$(R_c)_{HV} = N^2(R_c)_{LV}$$

$$(X_m)_{HV} = N^2(X_m)_{LV}$$

and the subscripts HV and LV indicate high voltage side and low voltage side values respectively.

5.2 Short Circuit Test

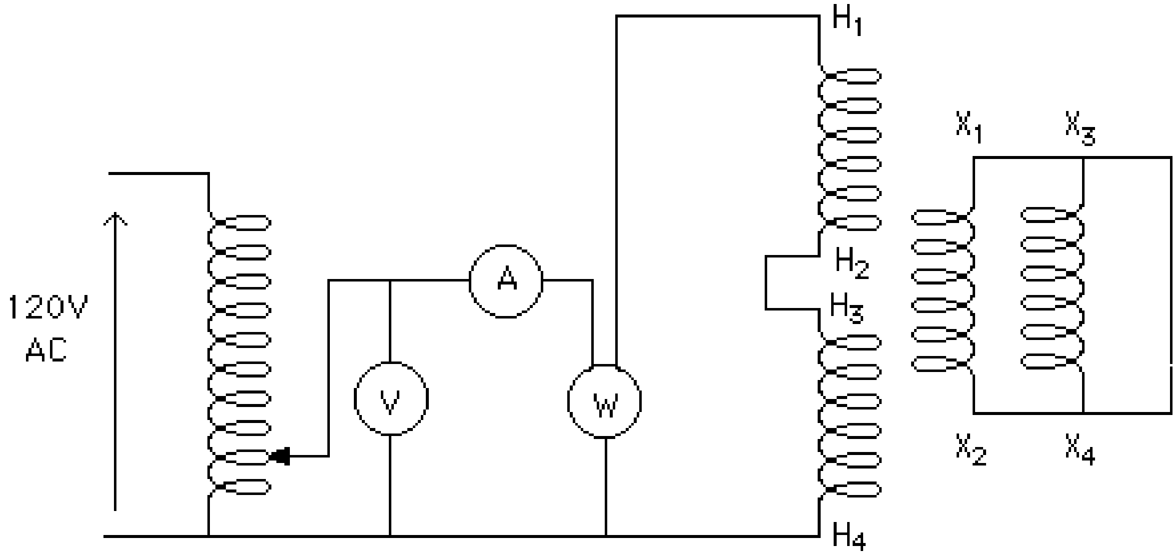

Figure 3: Short Circuit Test Setup

This test calls for extreme care since it can damage the transformer quite easily. Connect the high voltage winding on the transformer to the variable AC source, as shown in Figure 3. Short circuit the low voltage windings.

Apply a very small voltage to the energized winding and note the resulting input current. Increase the voltage just enough to get rated input current. Note the input voltage, input current and power, then switch off the power supply.

Measure and record the following parameters with the high voltage winding energized;

V_{sc} =

I_{sc} =

P_{sc} =

Calculate the following values referred to the high voltage side;

$$\theta_{sc} = \cos^{-1}\left(\frac{P_{sc}}{V_{sc}I_{sc}}\right) =$$

$$R_s = \frac{P_{sc}}{I^2_{sc}} =$$

$$X_s = R_s \ \mathrm{Tan}\theta_{sc} =$$

5.3 DC Resistance Test

This test serves as a check on the value of R_s .

Apply a small DC voltage to the high voltage winding allowing no more than 5 amps of current. Measure the current in the winding and the voltage across it.

$$R_{DC} = \frac{\text{Voltage}}{\text{Current}} =$$ for the high voltage side.

Repeat the measurement with the two low voltage windings connected in parallel.
Equivalent DC resistance referred to the high voltage side will be:

$$R_{DC} = (R_{DC})_{HV} + N^2(R_{DC})_{LV} =$$

6. RESULTS AND CALCULATIONS

Using the test results, calculate the efficiency and voltage regulation for the following cases:

- Full load, unity power factor.
- Full load, 0.8 lagging power factor.
- Full load, 0.8 leading power factor.