ECE 370
POWER & ENERGY SYSTEMS

EXPERIMENT 3 & 4
DEVELOPMENT OF A TWO WINDING POWER TRANSFORMER EQUIVALENT CIRCUIT

Objective

The objectives of this laboratory experiment are summarized below:

1. Develop a test procedure for deriving the equivalent circuit of a single-phase two-winding transformer.
2. Gain an understanding of the concept of modeling a single-phase two-winding transformer as an equivalent electrical circuit.
3. Measure the efficiency and voltage regulation of a single-phase two-winding transformer.
4. Gain an understanding of the effect of load magnitude and power factor on the efficiency and voltage regulation of a single-phase two-winding transformer.

Pre - Lab

The objective of this pre-lab is to develop a computer program that will calculate the "approximate" equivalent circuit for a single-phase two-winding transformer. The input data consists of the following:

1. The kVA rating.
2. The voltage rating of the primary winding.
3. The nominal power factor of the load.
4. The results of the open-circuit and short-circuit tests.
5. The DC resistance of the primary winding.

The program must output the following information:

1. The approximate equivalent circuit parameters.
2. Percent voltage regulation and efficiency (two graphs) vs kVA loading, as the load is varied from zero to 200% full-load, while pf and load voltage are held constant.

Develop a *Matlab or Maple* computer program which performs the calculation of the approximate equivalent circuit of a single-phase two-winding transformer, as shown in Figure 1, from the open-circuit and short circuit tests.

The values following Figure 1 should be used as an approximation of the transformer test data to debug your program.

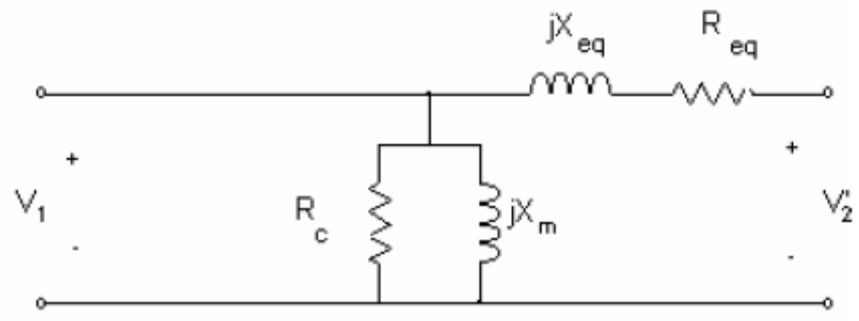

Figure 1. *Approximate Equivalent Circuit of a Single-Phase Two-Winding Transformer.*

Open-Circuit Test: V = 120 V, I = 0.042 A, P = 3.28 W, R_1 = 3.3 Ω(measured)

Short-Circuit Test: V = 6.9 V, I = 1.0 A, P = 6.8 W

Check the results of your computer program with your hand calculations. However, note that the hand calculation is only a checking process. The analytical results are those obtained from the computer program, which must use the approximate equivalent circuit.

Procedure

Read the specification sheet for Model T-100-3A transformer of Figure 2, and pay attention to the ratings of this transformer. Document the ratings (V, I, and S) of the transformer for the configuration of Figure 3.

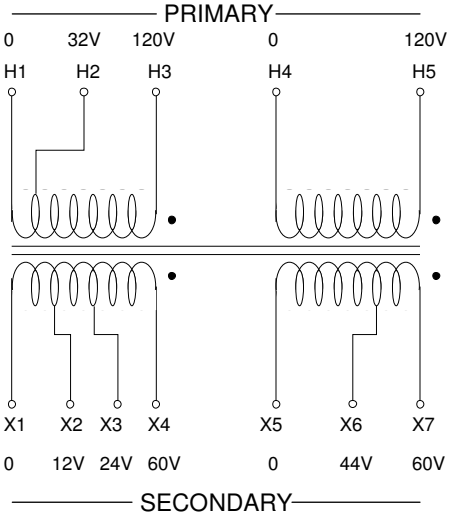

Figure 2. *Model T-100-3A Transformer.*

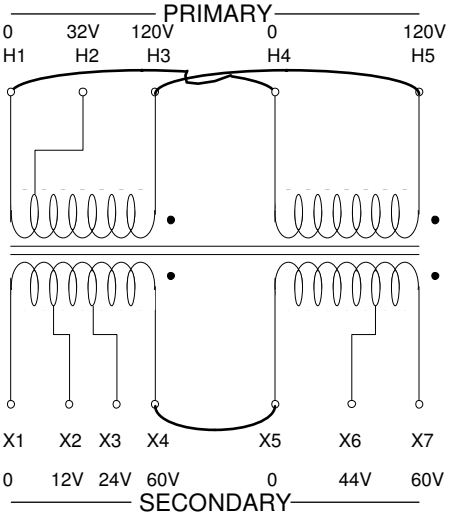

Figure 3. *Configuration for Finding Transformer Ratings.*

Proceed with the following steps:

1. Use the 2.0 A fuse box between the voltage source and the transformer, as shown in Figure 4.

2. Connect the Yokogawa digital meter for measurement of the circuit voltage, current, and power. Connect one channel to the primary (marked H) of the transformer, and another channel to the secondary (marked X) of the transformer. This connection was used in Experiment 1, so you should be able to refer to your laboratory notebook for guidance.

3. Connect the wiring of the single-phase two-winding transformer, as shown in Figure 4.

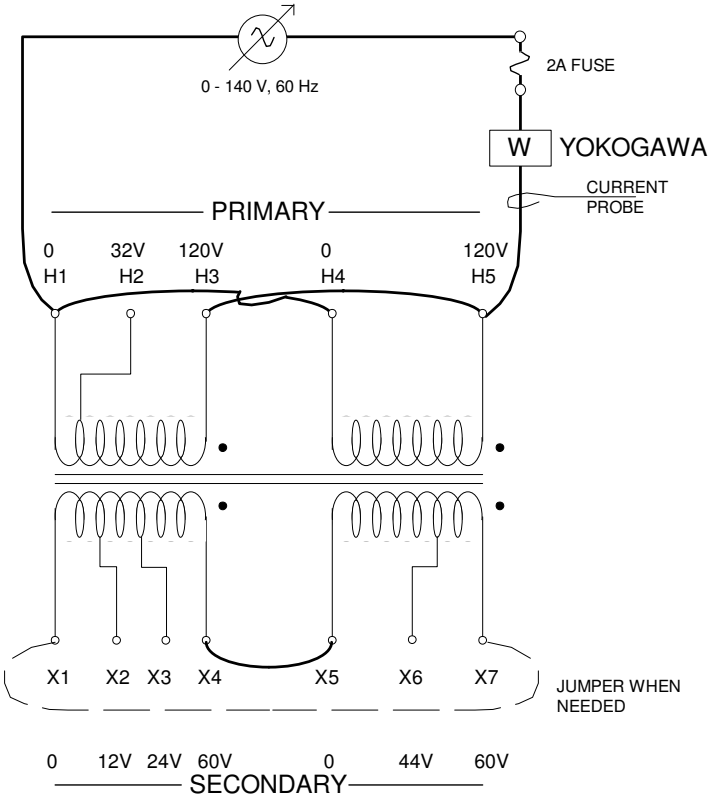

Figure 4. *Transformer Connections for Step #3.*

4. Perform the open-circuit test by leaving the jumper (shown by dashed lines) out. With the power supply set at 120 V (rms), and no load on the transformer, record the Yokogawa readings of the voltage, current, and the active power.

5. Observe the input current wave shape on the oscilloscope with a source voltage of 120 V. Repeat this observation with a source voltage of 90 V and 130 V. Use the CompactFlash Card to save this trace of the current, then print it.

6. Perform the short-circuit test by turning the power supply down to zero volts, and placing the jumper between terminals X1 and X7. *Be sure that your connection is correct.* **Slowly** increase the supply voltage until the current display indicates 1.0 ampere (rated current). Record the Yokogawa readings of the voltage, current, and active power.

7. Measure the dc resistance of the primary and secondary windings with the Fluke multimeter. Utilize the results of the open-circuit and short-circuit tests to obtain the parameters of the transformer equivalent circuit with use of your computer program.

8. Perform the voltage regulation and efficiency measurements under various load conditions, as shown in Figure 5.

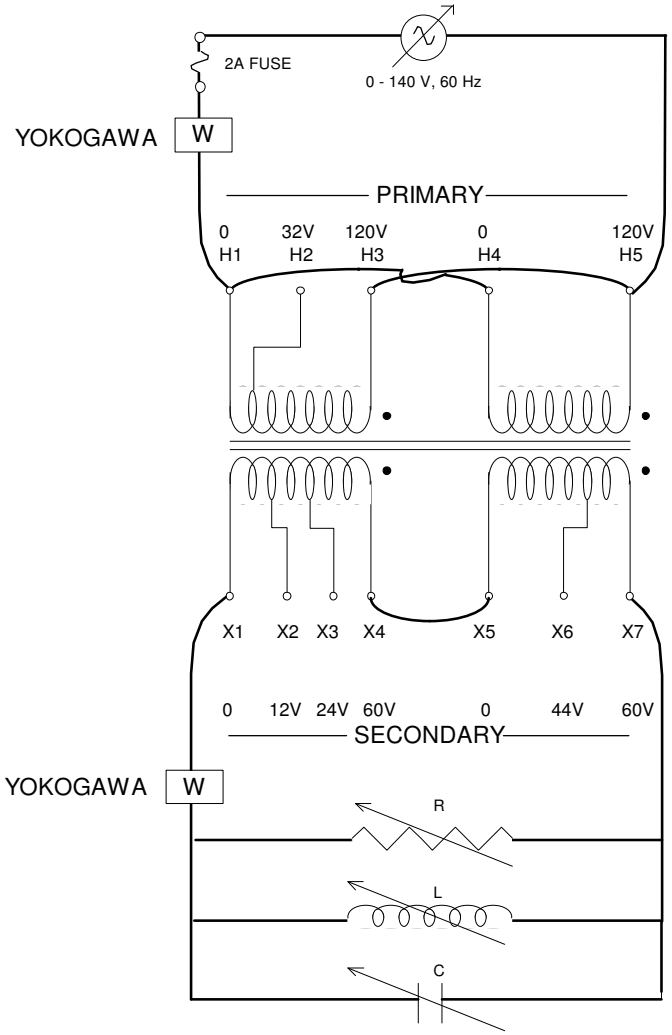

Figure 5. *Transformer Connections for Step #8.*

Maintain a voltage of 120 V on the ***secondary terminals*** *of the transformer for all load conditions*. Take readings for various load configurations, and do not exceed the rated current of 1.0 ampere.
Keeping the power factor constant, take readings for three (3) lagging power factor loads; repeat for three (3) unity power factor loads, and three (3) leading power factor loads. Compare the measured values with the computed results by your computer program.

Documentation
The experiment should be documented in your lab notebook in a lab log format. Your documentation should be complete and clear, so you would be able to write a formal report based on the logged information.

The computer-based calculations of the voltage regulation and efficiency are your analytical results. The laboratory measurement of the voltage regulation and efficiency are your experimental results. There will be a discrepancy between your analytical and experimental results. The discrepancies should be described and explained.