Pre-Lab
Due before performing the experiment.

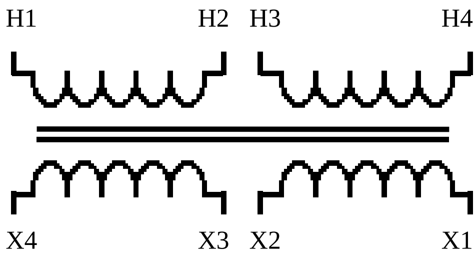
1. Given a voltage ratio described as "X to Y," what is the turns ratio, a? What are the corresponding rated voltages of the primary and secondary windings? (All answers should be in terms of X and Y.)

Given the nameplate information answer the questions below:

<u>Nameplate Information:</u>

Rated Power: 5 KVA
Rated Voltage: 120/240: 120/240
Rated Frequency: 60 Hz

H Windings Primary
X Windings Secondary



(Note: all ratings above apply to the *entire* transformer, which consists of four separate windings, which can be configured in different series and parallel combinations. In the voltage ratings, the colon (:), not the backslashes (/), separate the primary voltages from the secondary voltages.)

2. What is the rated voltage of a single "H" winding?
   What is the rated voltage of a single "X" winding?

3. What is the rated power of a single "H" winding?
   What is the rated power of a single "X" winding?

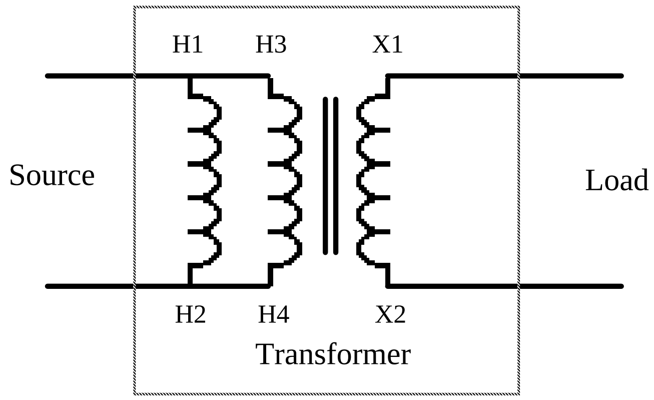
4. What is the rated current of a single "H" winding?
   What is the rated current of a single "X" winding?

5. Draw how the primary windings should be connected for 240 V; be sure to label all the winding terminals. What is the current rating for this connection?

6. How would you connect the windings given above to create a step-up transformer? Answer by drawing the transformer and labeling all of the terminals. What is the turns ratio for this particular transformer?

7. How would you connect the windings given above to create a step-down transformer? Answer by drawing the transformer and labeling all of the terminals. What is the turns ratio for this particular transformer?

8. Given the following connection answer the questions below:



a. What are the rated voltages and currents of the primary and the secondary windings (considered independently)?

b. With this particular connection can the rated power for the primary side be supported by the secondary side? If not why and how could the transformer be changed to supported rated power without changing the voltage characteristics of the set-up.

Lab 3: Transformer Experiment

Below are the instructions for Lab 3. This lab will give experimental results for a real transformer. It is meant to familiarize you with the basic characteristics of a transformer. All the theory needed for this experiment should be available to you in the textbook accompanying this lab.

Objectives:

The first part of this lab is concerned with determining the element parameters of the equivalent circuit model of the transformer. Short circuit, open circuit and load circuit tests will be applied to determine these parameters. The viability of the model can then be checked against the results of a load test. Efficiency and voltage regulation can then be determined from the data.

The second part of the lab is an introduction to three-phase connections using three single-phase transformers. Delta-delta, delta-wye and wye-delta connections will be made and the voltage results compared to the expected theoretical results.

Load, Open and Short Circuit Tests

Before starting each test make sure that the Professor or the TA has looked over your circuit. Before you start, make sure you know what measurements are required and create a data table to record your results.

1. Load Test.

Connect the transformer for 120:120 V operation using **only** one primary and one secondary winding. For the load test you want to obtain 10 to 12 data points over the range of **0 to 120% of the rated load** for this particular transformer set-up; take readings in approximately 10% steps of the rated load. Readings in steps of 2 A are sufficient. For this test you want to record the following data:

Load Test Data

Vp (Volts)	Ip (Amps)	Wp (Watts)	Vs (Volts)	Is (Amps)	Ws (Watts)

2. Open Circuit Test.

This test will give you the core loss parameters for the transformer. Take readings from **0 to 130% of the rated voltage** in approximately 10% steps; the rated voltage is 120 V (130% is 156 V). For this test you want to record the following data.
Note: For this test you need to take a complete set of readings for one of the three transformers.

Open Circuit Data

Vp (Volts)	Ip (Amps)	Wp (Watts)	Vs (Volts)	Is (Amps)	Ws (Watts)

3. Short Circuit Test.

This test will give you the winding resistance loss parameters for the transformer. Take readings from **0 to 120% of the rated current** in approximately 10% steps; steps of 2 A are sufficient. Remember that the current will increase rapidly so 2 A steps will be difficult to obtain. Do not spend too much time trying to obtain exactly 2 A steps; this is not as important as obtaining a number of readings over the range of current rating. **Careful, you will notice that since this is a short circuit only a small voltage is required to reach the rated current!** For this test you want to record the following data:

Short Circuit Data

Vp (Volts)	Ip (Amps)	Wp (Watts)	Vs (Volts)	Is (Amps)	Ws (Watts)

Three PhaseTransformer Connections

This experiment is the introduction to three phase transformer connections. This part of the experiment is designed to show how delta and wye connections are properly made. It is important to label how you propose to connect "H" and "X" windings in order to understand how a three-phase transformer is properly phased. Choose one alternate configuration, I or II, to test.

Always turn off the power, return your auto transformer to the 0% setting and open your visible disconnect switch before changing your circuit!

4. Delta – Wye Transformer (Alternate I)

a. Connect the primary windings into a delta as shown in Figure 1 below. After checking with the professor or TA to make sure the circuit is properly connected, increase the voltage to its rated value. Measure the voltage magnitudes for each of the secondary windings. Remember that the secondary voltages are from X1-X4 since all secondary windings should have a jumper cable from X2-X3.

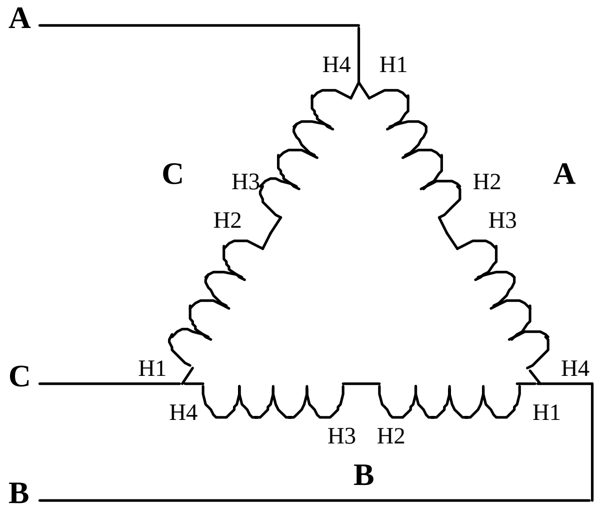


Figure 1

b. First, connect two of the secondary windings as shown in Figure 2 below. Turn on the power and take the primary side voltage up to its rated value. Now measure the voltage across the open-delta secondary side. Explain why the voltage is what you measured in the conclusion of the report.

c. Second, connect the third secondary winding as shown in Figure 3 below. **Do not close the delta!** What should the voltage be at this open end? Measure this open terminal voltage and explain your results in the conclusion of the report.

d. Third, connect two of the secondary windings as shown in Figure 4 below. Turn on the power and take the primary side up to approximately 1/2 rated voltage (why do we want to do this rather than take the primary voltage up to rated?). Measure the voltage between the open terminals and explain your results in the conclusion.

e. Fourth, connect the third secondary winding as shown in Figure 5 below. Turn on the power and take the primary side up to approximately 1/2 rated voltage. Measure all three open ended voltages and explain results in the conclusion.

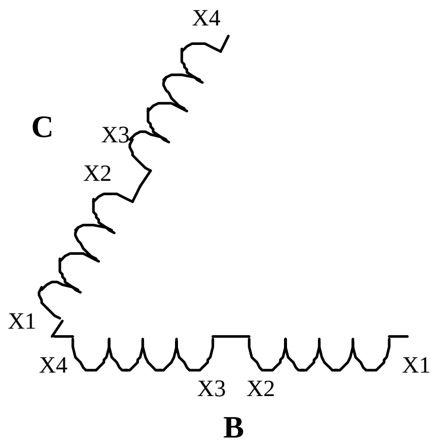


Figure 2

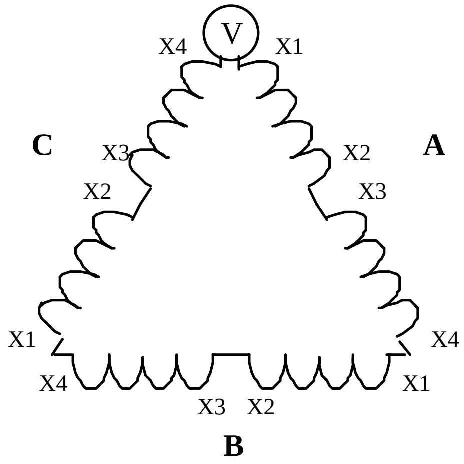


Figure 3

Note: V circled is a voltage meter and does not indicate an electrical connection between the two points.

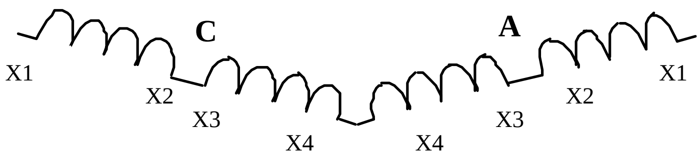


Figure 4

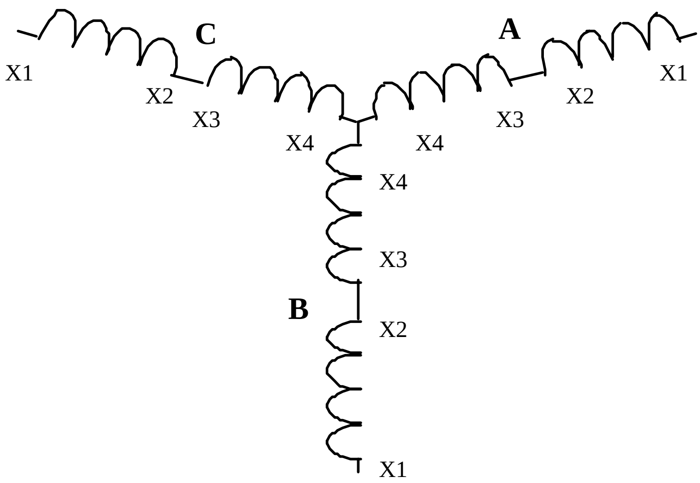


Figure 5

5. Wye-Delta Transformer (Alternate II)

a. Connect the primary windings into a wye as shown in Figure 6 below. After checking with the professor or TA to make sure the circuit is properly connected, take the voltage up to rated. Measure the magnitudes of the voltages of each of the secondary windings. Remember that the secondary voltages are from X1-X4 since all secondary windings should have a jumper cable from X2-X3.

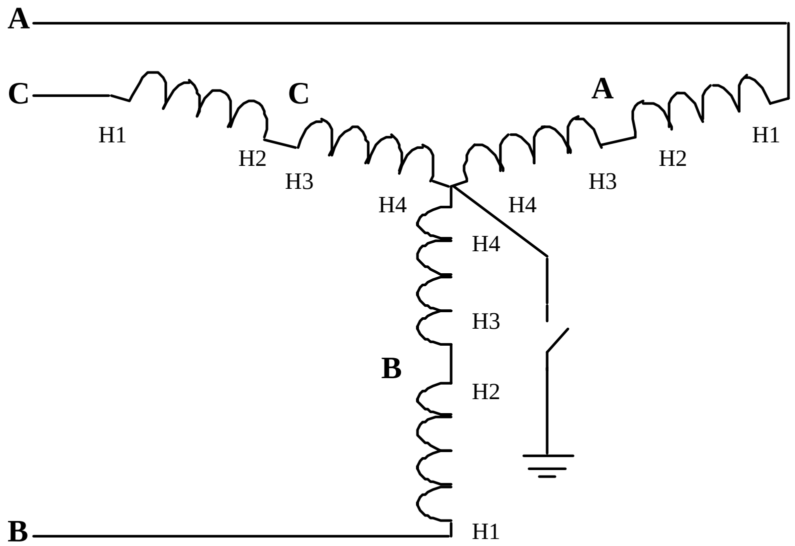


Figure 6

b. Connect the secondary windings into a delta as shown in Figure 3 above; **make sure to leave the delta open!** After checking with the professor or TA make sure the circuit is properly connected, take the voltage up to rated. Measure the open-ended voltage.

c. Now close the switch to ground. Take the primary voltage up to rated and measure the open-ended voltage of the secondary side. Why is this reading lower than in part b?

d. Turn off the power and switch the end connections of one of the windings on the secondary side. Measure the open-end voltage and explain your results in the conclusion.

e. Remove the switch to neutral and close the open end of the secondary delta with the ammeter supplied. Measure the current on the secondary side with the primary voltage at rated. Explain this current.

Lab Report

Draw a schematic of all connections used in the experiment and label all the windings.

Supply for the parts above:

1. Load Test

- Calculate voltage regulation in percent for rated load at unity power factor.
- Calculate voltage regulation in percent for rated load at 0.85 power factor (using data calculated from parts 2 and 3 below).
- Calculate efficiency at all the load points taken for unity power factor.
- Plot Secondary Voltage vs. Secondary Current.
- Plot Efficiency vs. Load Current.

2. Open Circuit Test

- Calculate appropriate transformer model parameters.
- Plot Amperes vs. Input Voltage.
- Plot Watts vs. Input Voltage.

3. Short Circuit Test

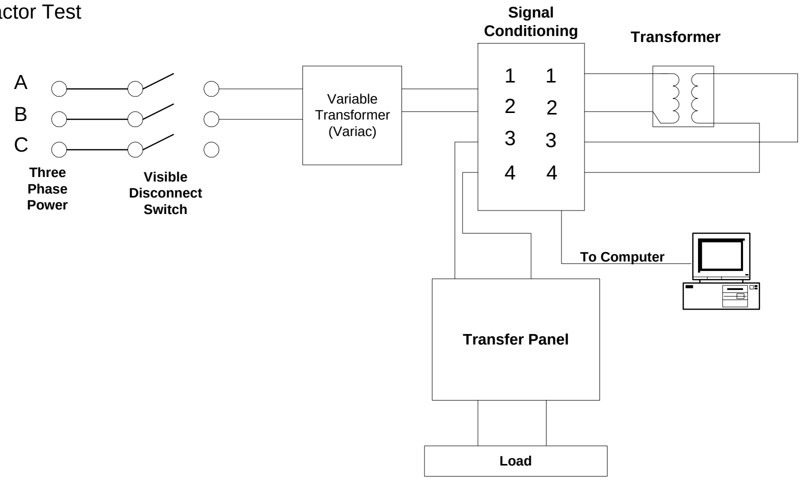
- Calculate appropriate transformer model parameters.
- Plot Amperes vs. Voltage.
- Plot Watts vs. Voltage.
- Plot Impedance vs. Voltage.

4. **Draw the equivalent transformer model** labeled with the calculated parameters determined in this lab.

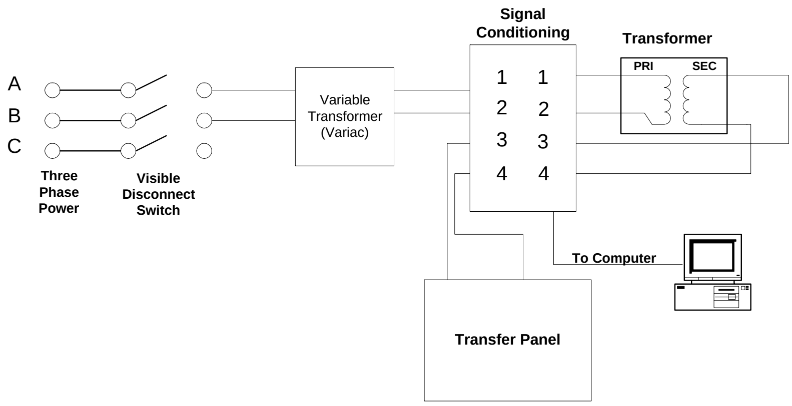
5. Three Phase Transformer Connections:

Supply answers to the questions posed above. Draw the theoretically expected primary and secondary phasor diagrams for all of the different connections tried. (Make sure to indicate label each phase with its letter and magnitude, and indicate the degrees of each angle in your diagrams.)

1. Load Test
2. Power Factor Test



3.Open Circuit Test



4. Short Circuit Test