ECE 3251 – Electromechanical Energy Conversion
Lab #5: Iron-Core Transformers

Laboratory Goals
The purpose of this experiment is to familiarize you with the real-world properties of transformers, using the open and short-circuit tests to determine a mathematical model of the transformer. This model will then be used to predict the devices operation under various circumstances and compare it to experimental values obtained.

Lab Procedures:
Wire the experimental transformer as shown below, in a one-to-one configuration.

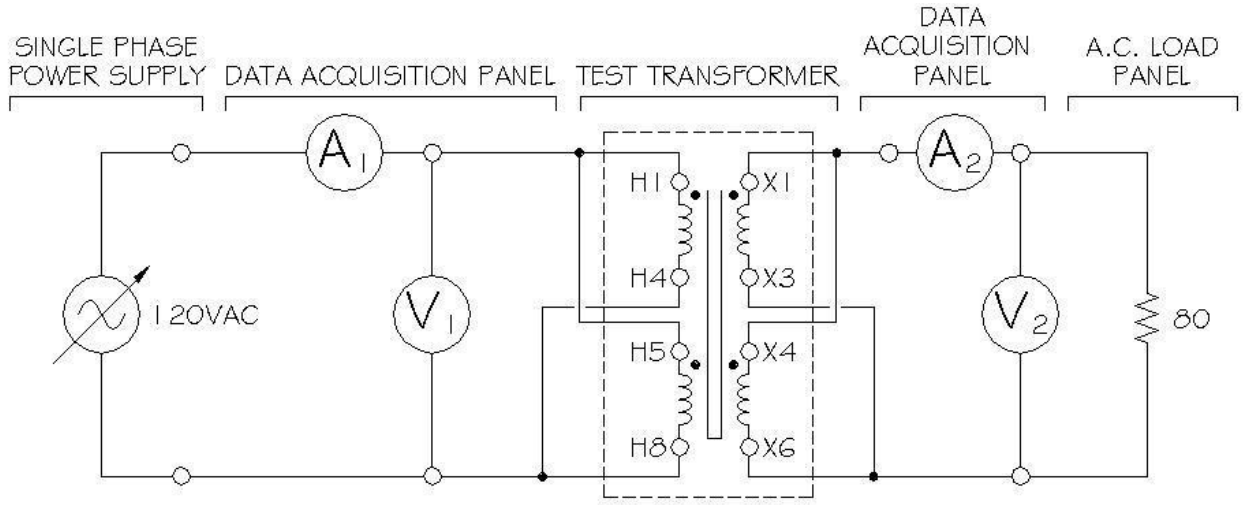

Figure 1 – *Experimental Setup for Open Circuit, Short Circuit, and Loaded Tests of the Laboratory Transformer*

1. **Transformer Rating** – Before turning on the power to the test transformer, calculate the current rating from the given specifications of one main winding of the 600 VA 240/120V transformer. The main windings are X1-X3, X4-X6, H1-H4, H5-H8. Note that both the primary and secondary of each transformer have two windings which must be connected in series for use at 240V or parallel for 120V. The two windings together are rated to carry 600 VA of power. What is the rated current of two windings in parallel? **You must show the instructor or TA the rated current you calculated before running any tests to make sure you do not exceed the rated current.**

2. **Open Circuit Test** – Load the PowerLab program and select Display 3P. Connect the transformer as shown in Figure 1, wiring both the H1-H4 winding and the H5-H8 winding on the primary side, and the X1-X3 and X4-X6 windings on the

secondary side. Perform an open circuit test on the transformer at 60V and 120V using windings H1-H4 to X1-X3 with the Single-Phase Power Supply. (Remember, an open circuit test means that no load is connected to the output.) Measure primary voltage, current, and power, and secondary voltage. What is the expected output voltage? How does it compare with the actual output? Calculate values for the effective core resistance (R_{fe}) and magnetization reactance (X_m).

3. **Short Circuit Test** –Perform a short circuit test for approximately 50% and 100% of **rated current**. **Be sure to turn the voltage all the way to zero before energizing the circuit.** (A short circuit test requires that the output from the secondary be short circuited.) The current will increase **very** quickly as you turn up the voltage. **Do not exceed the current rating of the windings**. The maximum voltage should be on the order of 3V. Measure primary voltage, current, and power, and secondary current. Compare the measured secondary current with that expected of an ideal transformer. Calculate values for the effective copper resistance (R_{cu}) and leakage reactance (X_L).

4. **Efficiency and Voltage Regulation** – Connect the 80Ω resistor to the output of the transformer. At both 60V and 120V, measure the voltage, current, and power of both the primary and secondary. How does the power factor of the primary and secondary compare? Repeat this measurement for a load of 40Ω (two 80Ω resistors in parallel). Calculate the efficiency and voltage regulation for all of the data taken.

5. **Transformers with RC Load** – Repeat measurements as in step 4, loading the transformer with the 80Ω resistor in parallel with the 30μF capacitor. Measure the voltage, current, and power in the primary and secondary.

6. **Tapping the Transformer** – The transformer windings contains taps which allow a variety of voltage ratios to be obtained. How would you connect the transformer to get the following voltage transformations: 6/240, 60/240, and 120/240? Hint: Observe the taps on the winding diagram on the transformer. Draw the circuit with the appropriate connections, voltages and currents. Ask your instructor about connecting the circuit. Wire up the different configurations and check to see that the voltages are what you expect.

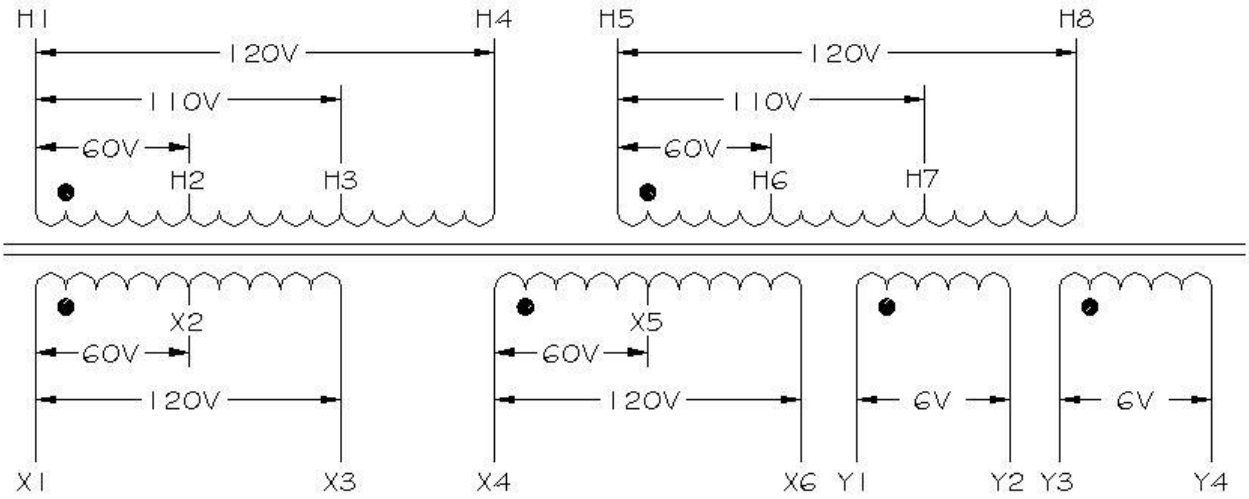

Figure 2 - *Experimental Transformer Schematic*

Grading

- Formal report: Organization, neatness, clear writing, proper formatting of graphs, figures, tables, etc. (15 points)
- Lab Participation: Contributions from each lab partner are fairly distributed and documented (10 points)
- Introduction: What is the purpose of this lab? (5 points)
- Procedures: Brief account of the steps to obtain results, including calculated transformer current rating (15 points)
- Results: Measurements and calculations for each lab step (40 points)
    - Open circuit test (8 points)
    - Short circuit test (8 points)
    - Efficiency and voltage regulation with resistive load (8 points)
    - Efficiency and voltage regulation with RC load (8 points)
    - Alternate transformer taps (8 points)
- Conclusions: Analysis and explanation of data (15 points)