This laboratory provides the opportunity to demonstrate the characteristics of a transformer and to verify the equations governing them.

1) Pre-lab Assignment (Use the pre-lab worksheet on the following page.)

The transformer used in this experiment resides in a module of the Lab-Volt units and has multiple windings.

As shown in the figure many of the windings are tapped. The numerical values on the windings can be used to deduce the turn ratios. For example, the winding between terminals 1 and 2 is labeled 120 V and the winding between terminal 5 and 9 is labeled 60 V. Hence, applying an ac voltage to terminal 1 and 2 would produce half as much voltage across terminals 5 and 9 and one could conclude that the turns ratio between the primary (1-2) and that portion of the secondary (5-9) is 2:1.

In the case of a tapped winding, the total voltage across two terminals is the sum of all voltages enclosed between the two terminals. For instance, the voltage between terminals 5 and 6 when 120 V is applied to the primary is 60+60=120 V.

**Computations:** With 30 V\textsubscript{rms} applied across terminals 1 and 2,

a) Compute the expected voltage across terminals 3 and 4.

b) Compute the turns ratio between the primary (1-2) and secondary (3-4). Express the answer as an irreducible ratio of integers.

c) Compute the expected voltage across terminals 7 and 8.

d) Calculate the turns ratio between primary (1-2) and secondary (7-8).
II) Laboratory experiments

This experiment will use modules in the Lab-Volt unit mounted in the rack next to your lab bench. This unit is capable of generating lethal voltages; thus, some safety precautions are essential.

- All connections will be made with the power turned off.
- When changing the wiring, the unit will first be turned off, the changes made, and then the unit can be turned back on.
- Two jumper wires may not be spliced to form a longer one.

For this laboratory, the two Fluke 8010 Multimeters will be used to measure ac voltage and current because they measure true rms values.

*Circuit A*

1) Select a 300||600-\(\Omega\) load resistor from the Variable Resistance Module by flipping the appropriate two toggle switches up. Measure the value of the combined resistor by plugging a multimeter into the corresponding terminals of the module. Compute the % deviation from nominal.

2) The source voltage is generated by the variable AC voltage source located in the lower left corner of the rack. The voltage source will be taken across terminals 4 and N. Turn the voltage adjustment knob fully counterclockwise to set zero volts.

3) With the power off, wire up circuit A with a Fluke multimeter as an ammeter placed in the line between the voltage source and terminal 1. Use the mA input. Make certain that the ac mode has been selected.

4) Connect the other Fluke multimeter across terminals 1 and 2 to prepare to measure the voltage of the primary. Make certain that the ac mode has been selected.

5) Double check the wiring and then turn on the circuit breaker on the variable AC supply. Turn the adjustment knob slowly clockwise until 30 V\textsubscript{rms} is read on the Fluke multimeter.

6) Record the primary voltage and current as measured by the multimeters. Compute the apparent power entering the transformer as the product \(VI\), and then calculate the magnitude of the input impedance by taking the quotient \(\frac{V}{I}\).
7) **Turn off the power**, but do not change the setting of the voltage adjustment knob. Remove the ammeter and connect the voltage source directly to terminal 1 of the transformer.

8) Disconnect the load and then reconnect it with a Fluke multimeter as an ammeter in between terminal 3 and the load to prepare to measure the load current.

9) Connect the other Fluke multimeter so that it can measure the voltage across the load.

10) After double checking the wiring, turn on the power at the voltage source using the circuit breaker without disturbing the adjustment knob.

11) Measure and record the load current and voltage. Compute the apparent power in the load as $VI$ and the load impedance as $V^2/I$.

12) Turn the voltage adjustment fully counterclockwise to zero, and **turn off the power** with the circuit breaker.

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Circuit B

1) From the Variable Resistance Module select another 300-$\Omega$ resistor for use in the primary by flipping the appropriate toggle switch. Measure the value of this resistor by plugging a multimeter into the corresponding terminals of the module. Compute the % deviation from nominal.

2) With the **power off** and wire up circuit B with one Fluke multimeter as an ammeter connected in the line between the voltage source and the 300-$\Omega$ series resistor so that the primary current can be measured.

3) Connect the other Fluke multimeter directly across the voltage source to monitor its voltage.

4) After double checking the wiring, turn on the circuit breaker on the variable AC supply. Turn the voltage adjustment knob slowly clockwise until 50 V$_{\text{rms}}$ is read on the Fluke multimeter.

5) Measure and record the primary current with the other Fluke multimeter.

6) **Turn off the power** without touching the voltage adjustment knob. Change the connection of the voltage multimeter so that it measures the voltage across the primary (terminals 1 and 2).

7) Turn the power back on and measure the primary voltage.
8) **Turn off the power** without touching the voltage adjustment knob. Change the connection of the voltage multimeter so that it will be able to measure the voltage across the load.

9) Change the connections of other multimeter so that it is set up to measure the current through the load.

10) Turn the power back on without and measure the load voltage and current.

11) Turn the voltage adjustment knob fully counterclockwise to zero, and **turn off the power** with the circuit breaker.

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**Circuit C**

1) **With the power off**, wire up circuit C with a Fluke multimeter as an ammeter placed in the line between the voltage source and terminal 1 to prepare to measure the primary current. Use the mA input.

2) Connect the other Fluke multimeter across terminals 1 and 2 to set up to measure the voltage of the primary. Make certain that the ac mode has been selected.

3) Double check the wiring and then turn on the circuit breaker on the variable AC supply. Turn the adjustment knob slowly clockwise until 30 V rms is read on the Fluke multimeter.

4) Record the primary voltage and current as measured by the multimeters. Compute the apparent power entering the transformer as the product $VI$, and then calculate the magnitude of the input impedance by taking the quotient $V/I$.

5) **Turn off the power**, but do not change the setting of the voltage adjustment knob. Remove the ammeter and connect the voltage source directly to terminal 1 of the transformer.

6) Disconnect the load and then reconnect it with a Fluke multimeter as an ammeter in between terminal 7 and the load to prepare to measure the load current.

7) Connect the other Fluke multimeter so that it can measure the voltage across the load.

8) After double checking the wiring, turn on the power at the voltage source.

9) Measure and record the load current and voltage. Compute the apparent power in the load as $VI$ and the load impedance as $V/I$.

10) Turn the voltage adjustment fully counterclockwise to zero, and **turn off the power** with the circuit breaker.
III) Lab Report

The lab report should be in standard format and include the following specific items:

1) Purpose
2) Model numbers of all test equipment used
3) Block diagrams of test setups
4) Circuit schematics for A, B, and C with component values shown.
5) Written test procedure
6) Computed turns ratio of the transformers (from pre-lab).
7) Nominal versus measured resistor values with %deviation.

For every measured voltage and current that is put into the report, a corresponding theoretical value computed by analyzing the transformer circuit must also be given and a percent error computed.

For each circuit give:

8) Measured primary voltage and current.
9) Measured load voltage and current.
10) Power dissipated in the resistor ($P_L$) computed from the load current. Use the measured value of the resistance.
11) Apparent power entering the primary ($P_1$) calculated from the voltage and current measurements.
12) Estimate of the power lost by dissipation in the transformer as $P_1 - P_L$.
13) Computed transmission efficiency as $\eta = P_L/P_1*100\%$.
14) Impedance of the load calculated from voltage and current measurements. Compare with measured value of resistance.
15) Impedance looking into the primary of the transformer calculated from voltage and current measurements. Compare with theoretical calculation using the load resistance and the transformer turns ratio.
16) Conclusion