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Date: October 19, 2019
Professor Steven Gillette

Abstract
In this lab, I worked with a the 120V/24V transformer, lab transformer, some magnet wire and a digital multimeter to experiment with how magnet wire windings create differing voltages between the primary and secondary coils.

Learning Objectives

- Identify the primary components of an AC transformer
- Calculate transformer turns required to meet output specifications
- Measure the effect of transformer primary and secondary turns on voltage output
- Use a multi-wound secondary to create various voltage outputs

Notes:

1. Took all voltage measurements relative to ground (unless otherwise stated)
2. Recorded relevant measurements and calculation results in data tables
3. Recorded all measured values on the circuit schematics
4. Used all available precision in calculations, rounded off answers to 3 significant figures

Materials

Quantity	Description
1	Digital multimeter (DMM)
1	Digital oscilloscope
1 each	Wire cutter, X-ACTO knife, #1 Phillips head screwdriver
1	120V / 24V transformer
1	Lab transformer
1 Spool	Magnet wire

Procedure –Transformer Turns Ratio

1. Disassembled the lab transformer. Left the primary winding intact.
2. Wound 25 turns of magnet wire to one side of the secondary spool. Kept an accurate count of the number of turns added. Left at least 6” of leads for later connections to circuits and the DMM. Threaded these secondary windings through one hole of the transformer plastic thimble.
3. Used an X-ACTO knife to strip the ends of the secondary winding to reveal clean copper. Used these points for voltage measurements.
4. Reassembled the entire transformer before connecting the transformer to power.

5. Connected the primary side of the lab transformer to the secondary of the 120V/24V transformer (center tap and one side.)

Validated 12V from transformer as found and expected.

6. Turned the 120V/24V transformer on. ***Measured and recorded*** V_P (primary RMS voltage) and V_S (secondary RMS voltage.)

V_p = 13.47V
Vs = 3.2V

7. ***Calculated and recorded*** the number of primary turns using the Transformer Turns Ratio (Voltage) formula. Round the number to the nearest whole number and used it for the N_P variable for the remaining lab activities.

$$\alpha = \frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\frac{3.20V}{13.47V} = \frac{25}{N_p}$$

$$0.238 = \frac{25}{N_p}$$

$$N_p(0.238) = 25$$

$$N_p = \frac{25}{0.238}$$

$$N_p = 105.04$$

$$N_p = 105$$

Transformer Turns Ratio				
Expected N_P	Expected α_1	Measured V_P	Measured V_S	Measured N_S
105.0	0.238	13.5	3.20	25.0

Procedure – Multi-Secondary Transformer (voltage)

8. ***Calculated and recorded*** the number of turns required on the secondary to create a 1.10:1 step-up ratio. Used the Transformer Turns Ratio (Voltage) formula.

$$1.10 = \frac{N_{S1}}{105}$$

$$105 * 1.10 = N_{S1}$$

$$115.5 = N_{S1}$$

$$N_{s1} = 115.5$$

Expected N_P	Design α_1	Expected N_{S1}
105.0	1.10	115.50

9. Added a second winding to the other side of the same secondary to create a transformer with both 1.10:1 step up and 0.25:1 step down ratios. Threaded these secondary windings through the opposite hole of the transformer plastic thimble.

$$0.25 = \frac{N_{S2}}{105}$$

$$105 * 0.25 = N_{S2}$$

$$26.25 = N_{S2}$$

$$N_{s2} = 26.25$$

Expected N_P	Design α_2	Expected N_{S2}
105.0	0.25	26.25

10. Reassembled the transformer before applying power. Connected the lab transformer primary to the 120V/24V transformer secondary as before.

11. ***Calculated and recorded*** the expected RMS voltage outputs for the two new transformer secondary windings using the Transformer Turns Ratio (Voltage) formula.

$$V_{S1} = \frac{115.5 * 13.5}{105}$$

$$V_{S1} = \frac{1559.25}{105}$$

$$V_{S1} = 14.85V$$

$$V_{S2} = \frac{26.25 * 13.5}{105}$$

$$V_{S2} = \frac{354.375}{105}$$

$$V_{S2} = 3.375V$$

12. ***Measured and recorded*** the actual RMS voltage outputs (V_{S1} & V_{S2}) of the two new transformer secondary windings. Compared the expected and measured voltage values using the % Error formula.

	V_{S1}	V_{S2}
Expected	**14.85**	**3.37**
Measured	14.13	3.40
% Error	**-4.8%**	**1.0%**

13. Stripped the secondary windings from the lab transformer. Showed the clean lab transformer to the instructor for signature.

Formulas

% Error

$$\%Error = \frac{measured - \exp ected}{\exp ected} x100\%$$

Where;
%Error = % change between measured and expected values
measured = a value taken from direct measurement
expected = a value taken from component or process specifications

Transformer Turns Ratio (Voltage)

$$\alpha = \frac{V_S}{V_P} = \frac{N_S}{N_P}$$

Where;
α = transformation ratio
V_S = secondary voltage
V_P = primary voltage
N_S = number of secondary turns
N_P = number of primary turns

Transformer Turns Ratio (Current)

$$\alpha = \frac{I_P}{I_S} = \frac{N_S}{N_P}$$

Where;
α = transformation ratio
I_S = secondary current
I_P = primary current
N_S = number of secondary turns
N_P = number of primary turns

Critical Thinking

1. What is the primary current of a transformer whose primary voltage is 120V with a secondary supplying 240V @ 100mA?

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\frac{I_p}{I_s} = \frac{N_s}{N_p}$$

$$\frac{120V}{240V} = \frac{N_s}{N_p}$$

$$\frac{120V}{240V} = 0.5$$

$$\frac{I_p}{100mA} = 0.5$$

$$I_p = 0.5 * 100mA$$

$$I_p = 50mA$$

2. What is the secondary voltage of a transformer with a turns ratio of 1:5 and a primary voltage of 120V?

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\frac{V_s}{120V} = 0.2$$

$$V_s = 0.2 * 120V$$

$$V_s = 24V$$

3. What is the turns ratio for a transformer with a primary voltage of 120V and secondary voltage of 12V?

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\alpha = \frac{N_s}{N_p}$$

$$\frac{12V}{120V} = \alpha$$

$$0.1 = \alpha$$

$$\alpha = 0.1 \; or \; 1:10$$

4. What is the turns ratio for a transformer with a primary current of 120mA and secondary current of 6mA?

$$\frac{I_p}{I_s} = \frac{N_s}{N_p}$$

$$\alpha = \frac{N_s}{N_p}$$

$$\frac{120mA}{6mA} = \alpha$$

$$20 = \alpha$$

$$\alpha = 20 \; or \; 20:1$$

Conclusion

This lab was an exciting examination of how induction works to leverage electromagnetic fields to convey electricity from one coil to another and how the coil windings, creating increased and decreased magnetic fields affect the conveyance of the electricity into various voltages and currents. The examination of inverse relationship in the current changes also with voltage changes from the primary to secondary windings provides insight for future circuit analysis and design. Lastly, the lab in class showed an interesting difference between the audible resonance the transformers were making as the alternating current flowed through its cycles from positive to negative and back again when the transformer was energized.

Appendix A – Signature and Lab Notes

SIERRA COLLEGE	MECH 10 - Lab 12 Transformers	Mechatronics *Real Skills Real Jobs*
Name Cayce Barnes		10/15/19

Learning Objectives

- Identify the primary components of an AC transformer
- Calculate transformer turns required to meet output specifications
- Measure the effect of transformer primary and secondary turns on voltage output
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Notes:

1. Take all voltage measurements relative to ground (unless otherwise stated)
2. Record relevant measurements and calculation results in data tables
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4. Use all available precision in calculations, round off answers to 3 significant figures

Materials

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1	Digital oscilloscope
1 each	Wire cutter, Exacto knife, #1 Phillips head screwdriver
1	120V / 24V transformer
1	Lab transformer
1 Spool	Magnet wire

Procedure –Transformer Turns Ratio

1. Disassemble the lab transformer. Leave the primary winding intact.
2. Wind 25 turns of magnet wire to one side of the secondary spool. Keep an accurate count of the number of turns added. Leave at least 6" of leads for later connections to circuits and the DMM. Thread these secondary windings through one hole of the transformer plastic thimble. Remember their location!
3. Use an Exacto knife to strip the ends of the secondary winding to reveal clean copper. Use these points for voltage measurements.
4. Reassemble the entire transformer before connecting the transformer to power.
5. Connect the primary side of the lab transformer to the secondary of the 120V/24V transformer (center tap and one side.) 12✓
6. Turn on the 120V/24V transformer. ***Measure and record*** V_P (primary RMS voltage) and V_S (secondary RMS voltage.)
7. ***Calculate and record*** the number of primary turns using the Transformer Turns Ratio (Voltage) formula. Round the number

V_p 13.47✓
V_s 3.20✓

$\frac{3.20}{13.47} = .238$

$.238 = \frac{25}{N_p}$

$N_p(.238) = 25$

$N_p = \frac{25}{.238} = 105.04$

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to the nearest whole number and use it for the N_P variable for the remaining lab activities. $N_p = 105$

Procedure – Multi-Secondary Transformer (voltage)

8. ***Calculate and record*** the number of turns required on the secondary to create a 1.10:1 step-up ratio. Use the Transformer Turns Ratio (Voltage) formula. $N_s = 115.5$
9. Add a second winding to the other side of the same secondary to create a transformer with both 1.10:1 step up and 0.25:1 step down ratios. Thread these secondary windings through the opposite hole of the transformer plastic thimble. Remember their location!
10. Reassemble the transformer before applying power. Connect the lab transformer primary to the 120V/24V transformer secondary as before.
11. ***Calculate and record*** the expected RMS voltage outputs for the two new transformer secondary windings using the Transformer Turns Ratio (Voltage) formula.
12. ***Measure and record*** the actual RMS voltage outputs (V_{S1} & V_{S2}) of the two new transformer secondary windings. Compare the expected and measured voltage values using the % Error formula.
13. Strip the secondary windings from your lab transformer. Show your clean lab transformer to the instructor or lab technician for signature. SDJ

Formulas

% Error

$$\%Error = \frac{measured - expected}{expected} x100\%$$

Where;
%Error = % change between measured and expected values
measured = a value taken from direct measurement
expected = a value taken from component or process specifications

Transformer Turns Ratio (Voltage)

$$\alpha = \frac{V_S}{V_P} = \frac{N_S}{N_P}$$

Where;
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V_S = secondary voltage
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Transformer Turns Ratio (Current)

$$\alpha = \frac{I_P}{I_S} = \frac{N_S}{N_P}$$

Where;
α = transformation ratio
I_S = secondary current
I_P = primary current
N_S = number of secondary turns
N_P = number of primary turns

Critical Thinking

1. What is the primary current of a transformer whose primary voltage is 120V with a secondary supplying 240V @ 100mA?

Grading Criteria

		Points Possible	Points Earned
Documentation	Abstract, introduction, experiment, data results, conclusions, attachments, clarity, spelling, grammar	**10**	
Transformer Turns Ratio	Primary and secondary voltages measured and recorded in data table	**5**	
	Primary turns calculated accurately and recorded in data table	**5**	
Multi-Secondary Transformer (Voltage)	Secondary turns calculated and accurate	**5**	
	Expected voltage outputs calculated and accurate	**5**	
	Measured voltage outputs recorded and compared to expected value	**5**	
Conclusions	Questions answered completely & accurately. State conclusions drawn and lessons learned from the lab	**10**	
On-time submittal	Lab report is submitted in accordance with the assignment due date as posted on Canvas	**5**	
	Total	**55**	

Lab Report Format

Abstract - a summary and high-level overview of the lab and its results
Introduction - State the objectives of the laboratory and list the equipment required
Experiment - Describe the procedure used to carry out the lab
Data Results - list data taken in table or graphical format where appropriate
Conclusion - State the conclusions drawn and lessons learned from the laboratory activities. Answer any questions found within the lab procedure.
Attachments – grading criteria, verification signatures, circuit diagrams, lab procedures & notes