

BASIC TRANSFORMER CHARACTERISTICS



Objectives

In these projects you will connect circuits that will illustrate the concepts of step-up and step-down transformer actions.

In completing these projects, you will connect circuits, make measurements, perform calculations, draw conclusions, and be able to answer questions about the following items relative to transformers:

- Transformer turns ratios
- Transformer voltage ratios
- Transformer current ratios
- The relationship of transformer impedances to turns and/or voltage ratios

Project/Topic Correlation Information

PROJECT	TEXT CHAPTER	SECTION	RELATED TEXT TOPIC(S)
45 Turns, Voltage, and Current Ratios	16	16-5	Important Transformer Ratios
46 Turns Ratios Versus Impedance Ratios	16	16-5	Impedance Ratio

Basic Transformer Characteristics

Turns, Voltage, and Current Ratios

PROJECT

45

Name: _____ Date: _____

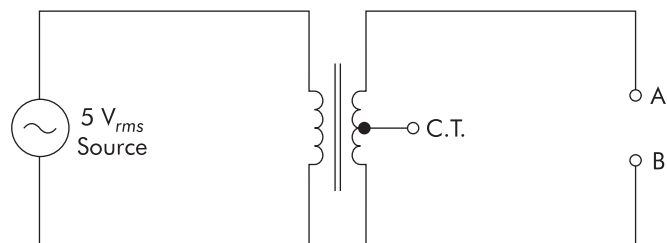


FIGURE 45-1 12.6-V center-tapped step-down transformer

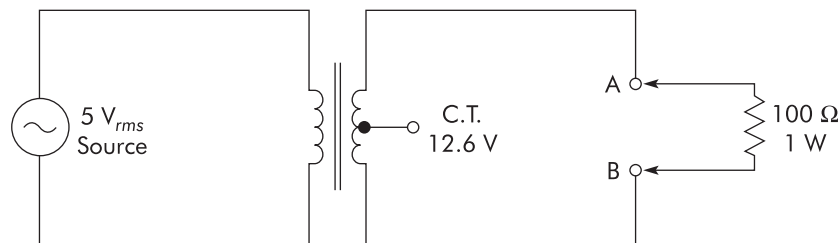


FIGURE 45-2 Loaded transformer

PROJECT PURPOSE To demonstrate the relationships of turns ratios, voltage ratios, and current ratios in transformers by circuit measurements and observations.

- PARTS NEEDED**
- | | |
|--|------------------------------------|
| <input type="checkbox"/> DMM | <input type="checkbox"/> CIS |
| <input type="checkbox"/> Low voltage source | <input type="checkbox"/> Resistors |
| <input type="checkbox"/> 12.6 V C.T. step-down transformer | 100 Ω, 1 W |

SPECIAL NOTE:

Transformers may be used to “step-up” or “step-down” voltages. If it were possible to have 100% efficiency, all of the power in the primary would be transferred to the secondary. If this were true, then the product of V and I in the secondary would equal the product of V and I in the primary, and the current step-up or step-down ratio would be inverse to the voltage step-up or step-down ratio in order for the $V \times I$ products to be the same.

To illustrate the concepts of basic transformer action, we want you to assume 100% efficiency of the transformers used for any calculations you are required to perform.

STOP **Caution!** When working with HIGH VOLTAGE, use all the safety procedures relative to working with high voltage.

PROCEDURE

1. Obtain a 12.6-volt transformer and connect the circuit shown in Figure 45-1.
2. Use a voltmeter and measure the voltage present on the primary and on the secondary.

▲ OBSERVATION Primary $V =$ _____ V.
 Secondary $V =$ _____ V.

▲ CONCLUSION The primary-to-secondary voltage ratio is _____.
 The secondary-to-primary voltage ratio is _____.
 What is the N_S/N_P turns ratio? _____. Are the voltage and turns ratios the same? _____.

3. Connect a 100- Ω , 1-W resistor between points A and B as shown in Figure 45-2. Use Ohm's Law to determine the secondary current.

▲ OBSERVATION $V_R =$ _____ V.

▲ CONCLUSION $I = V/R$
 $I =$ _____ A.

Is the secondary current the same as the current through the load R ? _____.

4. Use the previously determined voltage ratio from above and calculate the primary-to-secondary current ratio.

▲ OBSERVATION $V_P:V_S =$ _____.
 $I_P:I_S =$ _____.

▲ CONCLUSION The current ratio is the _____ of the voltage ratio.
 Using the secondary current previously determined in Figure 45-2, step 3, and the current ratio just calculated, what is the approximate primary current value?
 _____ A.

Basic Transformer Characteristics

Turns Ratios Versus Impedance Ratios

PROJECT

46

Name: _____ Date: _____

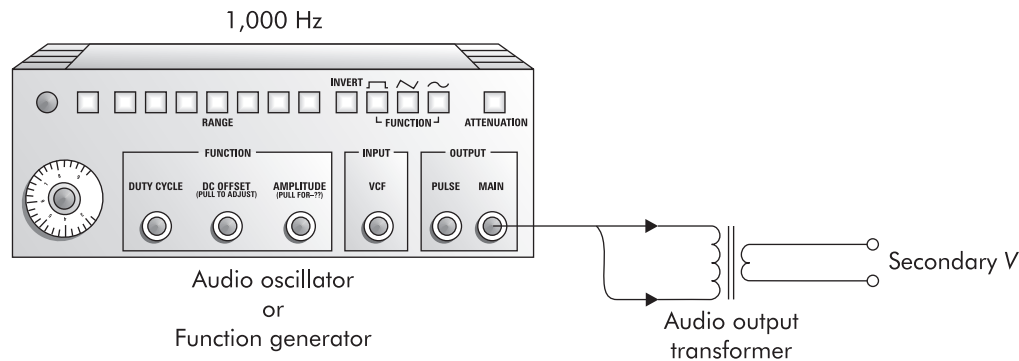


FIGURE 46-1

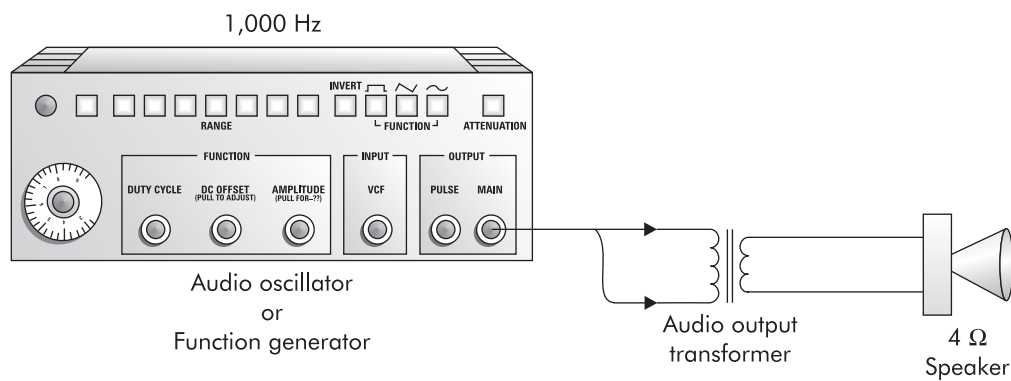


FIGURE 46-2 Optional circuit

PROJECT PURPOSE To demonstrate that the impedance ratio of a transformer is related to the square of the turns ratio.

- PARTS NEEDED**
- | | |
|---|---|
| <input type="checkbox"/> DMM | <input type="checkbox"/> CIS |
| <input type="checkbox"/> Function generator or audio oscillator | <input type="checkbox"/> Audio output transformer |
| | <input type="checkbox"/> 4-Ω speaker |

SPECIAL NOTE:

The impedance ratio of a transformer is related to the square of the turns ratio. This project will let you determine the turns ratio of a transformer, then theoretically determine the impedance ratio. Once this has been determined, you or your instructor will compare your results with the catalog specifications for the transformer you used. You can then see how closely your measurements and calculations correlate with the transformer specifications.

PROCEDURE

1. Obtain an audio output transformer and connect a circuit similar to that shown in Figure 46-1.
2. Apply a 1,000-Hz signal at a 3–5 V voltage level to the transformer primary. Measure the secondary voltage with an appropriate measuring instrument.

▲ OBSERVATION Voltage applied to the primary is _____ V.

Measured voltage on secondary is _____ V.

▲ CONCLUSION The N_p/N_s ratio must be about _____ :1.

Using the formula $Z_p/Z_s = N_p^2/N_s^2$, the primary-to-secondary impedance ratio is _____ :1.

3. Assume that the secondary load is going to be 4 ohms. Using the impedance ratio previously calculated, compute the nominal impedance of the circuit that should be connected to the primary of the output transformer.

▲ OBSERVATION Nominal Z calculated = _____ Ω .

▲ CONCLUSION Using the catalog parameters for the transformer, the primary-to-secondary Z ratio is _____ :1.

Does the impedance ratio you measured and calculated via voltage measurements reasonably agree with the catalog specifications for the transformer? _____.

What might cause any differences? _____
_____.

Optional Step

4. Connect a 4- Ω speaker to the secondary, Figure 46-2. Measure the voltages and determine the Z ratio.

▲ OBSERVATION Primary V = _____ V. Calculated turns ratio = _____.

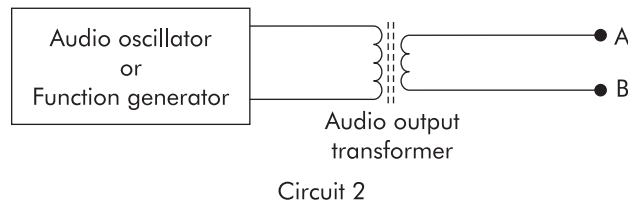
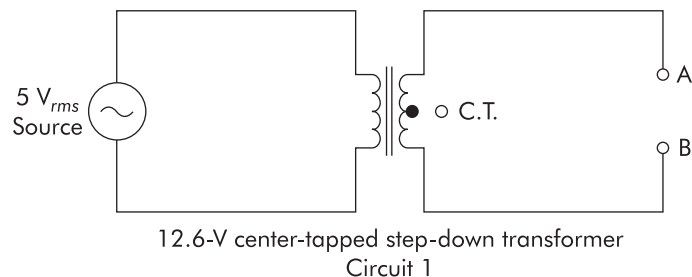
Secondary V = _____ V. Calculated Z ratio = _____.

▲ CONCLUSION Does this measured and calculated Z ratio more closely match the transformer specifications? _____.

Story Behind the Numbers

Basic Transformer Characteristics

Name: _____ Date: _____



Procedure

1. Obtain a 12.6-V transformer and connect Circuit 1 as shown.
2. Use a DMM and measure the voltage present at the primary and at the secondary (with no load connected to the secondary). Record readings on the Data Table, as appropriate.
3. Calculate the primary-to-secondary *voltage ratio* and log results on the Data Table.
4. Determine the approximate primary-to-secondary *turns ratio* and log results on the Data Table.
5. Connect a 100- Ω , 1-W resistor as a load across the secondary at points A and B.
6. Measure the voltage across the 100- Ω resistor and, by using Ohm's Law, calculate the secondary current with the load.
7. Using the previously determined voltage ratio, determine the primary-to-secondary *current ratio* and log results on the Data Table.
8. From your previous steps, determine the approximated primary current.
9. Using normal precautionary measures, temporarily remove voltage applied to the primary. Insert one DMM in the *current measuring function* and measure the primary current. Insert a second DMM to measure the

secondary current with the 100- Ω load. Record these measured currents on the Data Table, as appropriate.

10. Connect Circuit 2 as shown.
11. Apply a 3-V 1,000-Hz signal to the primary. Measure the secondary voltage (unloaded) and record the value on the Data Table, as indicated.
12. From your measurements, calculate and fill in the values for the primary-to-secondary turns ratio. From that data, determine the primary-to-secondary impedance ratio (Z_P/Z_S).
13. After completing the Data Table, answer the Analysis Questions and develop a brief Technical Lab Report to complete the project.

Data Table

Component and Parameter I.D.'s	Measured Values	Calculated Values
Circuit 1, primary V		—
Circuit 1, secondary V		—
P-S voltage ratio	—	
V_{R_L} @ points A–B		—
I secondary w/100 Ω	—	
P-S current ratio	—	
Approx. I primary current	—	
I measured, primary		—
I measured, secondary		—
Circuit 2, secondary V		—
P-S turns ratio	—	
P-S Z ratio, calculated	—	

Analysis Questions

NOTE Answers to these Analysis Questions should be clearly numbered and documented on separate sheets of paper with your name and the date at the top of each page. These answer sheets are to be turned in with the rest of the project documentation, as appropriate.

1. Describe how the voltage ratio and current ratio of a transformer are related.
2. For this project, are we using the transformer in Circuit 1 as a step-up or a step-down transformer? Describe how this transformer might be used in the opposite way.

3. What percentage of transformer efficiency was assumed in determining the various transformer ratios from your voltage measurements?
4. By observing the parameters spelled out for transformers in an electronics parts catalog, list the electrical parameters you think are important when considering replacement of a transformer in an electronic circuit that is similar to the transformer used in project Circuit 1.
5. By observing the parameters spelled out for transformers in an electronics parts catalog, list the electrical parameters you think are important when considering replacement of a transformer in an electronic circuit that is similar to the transformer used in project Circuit 2.
6. For the transformer used in Circuit 2, assume that the secondary load is going to be 4 ohms. Using the impedance ratio previously calculated, compute the nominal impedance of the circuit that should be connected to the primary of the audio transformer.

Technical Lab Report

Write a brief technical lab report summarizing the technical facts learned from this project. The report should be organized to provide the following:

1. An introductory paragraph describing the type of circuit being analyzed and the key parameters that will be discussed relating to this circuit.
2. A section describing the most important characteristics of this type of circuit that were shown via the collected data in the tables and graphs.
3. Any special facts or characteristics about this type of circuit that were highlighted in answering the Analysis Questions.
4. A practical example of how the information learned in this project might help you in operating, troubleshooting, error analysis, or adjusting a circuit of this type in your home setting, in your training program setting, or in a job setting in the real world.
5. A summary statement listing the most positive aspects of the project and any parts of the project that were difficult because of equipment problems or unclear instructions. Include areas that might be improved.

Summary

Basic Transformer Characteristics

Name: _____ Date: _____

Answer the following questions with “T” for true and “F” for false. (Put your answer in the appropriate blank.)

1. A transformer's voltage and current ratios are inverse. _____
2. The impedance ratio of a transformer is related to the square root of the turns ratio. _____
3. If a transformer has a 3:1 turns ratio (secondary-to-primary) and a primary impedance of 5,000 ohms, the load impedance on the secondary should be 45,000 ohms to affect a proper impedance match. _____
4. If a transformer's turns ratio is doubled, the related impedance ratio will quadruple. _____
5. A transformer with a secondary-to-primary turns ratio of 10:1 will have a secondary voltage of 50 volts with 0.5 volts applied to its primary. _____
6. If a transformer's current ratio is 1:3, then the related voltage ratio will be 1:3. _____
7. If a transformer's voltage ratio is doubled, its related current ratio will halve. _____
8. If the turns on a transformer secondary are doubled, the impedance of the secondary will be four times as great as the original impedance. _____
9. Transformer efficiency is typically 100%. _____
10. The voltage across a transformer secondary will be higher when it is “unloaded” as compared to when it is supplying current to a load. _____

