# Single-Phase Power Transformers

**MANUAL OBJECTIVE**

When you have completed this manual, you will be familiar with the operation of single-phase power transformers. You will be able to discuss what the turns, current, and voltage ratios of a power transformer are, and how to calculate them. You will be able to determine the polarity of the windings of a power transformer, and know how to connect transformer windings in series-aiding, in series-opposing, and in parallel. You will be familiar with the different power losses occurring in a power transformer, as well as with the transformer efficiency and voltage regulation. You will be able to determine the power rating of a power transformer, and know the effects of the operating frequency on the power rating. Finally, you will also know what an autotransformer is, and what its operating characteristics are.

**DISCUSSION OUTLINE**

The Discussion of Fundamentals covers the following points:

- Introduction to single-phase power transformers

**DISCUSSION OF FUNDAMENTALS**

## Introduction to single-phase power transformers

Power transformers are magnetically operated devices that are used to change voltage, current, and impedance values in ac circuits. In its simplest form, a power transformer consists of two coils of wire wound around a common core of ferromagnetic material, such as iron. One coil is called the **primary winding** while the other is called the **secondary winding**. The primary winding is the power input winding of the transformer and corresponds to the side that is connected to the ac power source. The secondary winding corresponds to the side that is connected to the load and is physically and electrically isolated from the primary winding. Since power transformers are bidirectional devices, both windings can either be the primary winding or the secondary winding, depending on the direction of the power transfer in the transformer.

When ac current supplied by an ac power source flows through the primary winding of a power transformer, a varying magnetic flux is created in the iron core. This varying magnetic flux produces a varying magnetic field through the secondary winding of the power transformer. This varying magnetic field then induces a voltage across the secondary winding of the transformer, which causes current to flow from the secondary winding to the load connected to the transformer. Power has thus been transferred from the primary winding of the transformer to the secondary winding through electromagnetic induction only, which means that there is no electric contact between the primary and the secondary windings. Therefore, power transformers not only perform ac power conversion but also electrically isolate the ac power source from the load. Electrical isolation is a very important feature of power transformers that makes them very difficult to replace in certain applications.

In certain power transformers, the primary winding actually consists of two or more individual windings. These windings can be connected in series or in parallel to form a single primary winding that is connected to an ac power source. Similarly, the secondary winding of certain transformers actually consists of several individual windings. These windings can be connected in series or in parallel to form a single secondary winding that is connected to a load. These windings can also be connected individually to supply ac power to different loads.

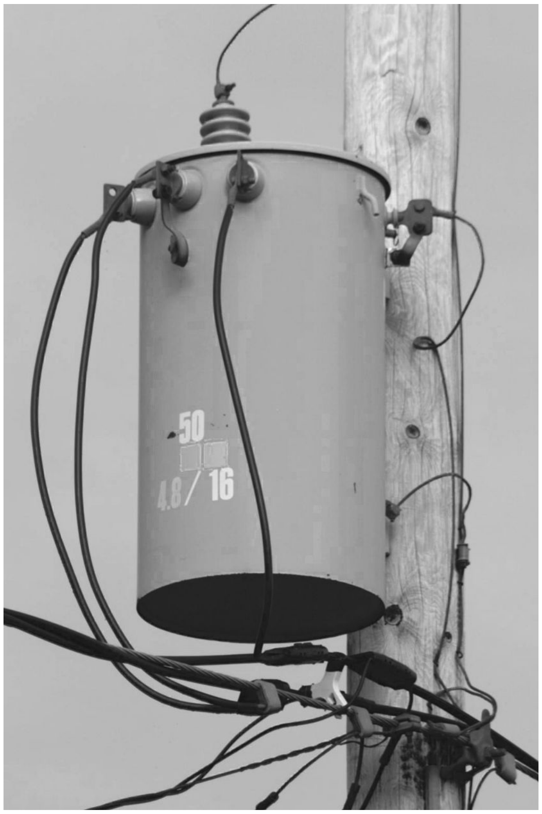


**Figure 1. Power transformers are often used in power distribution lines.**

# Exercise 1

## Voltage and Current Ratios

**EXERCISE OBJECTIVE**

When you have completed this exercise, you will know the relationships between the turns, voltage, and current ratios of a power transformer. You will be familiar with the different characteristics of step-up and step-down power transformers. You will also know how to determine in practice the voltage and current ratios of a power transformer.

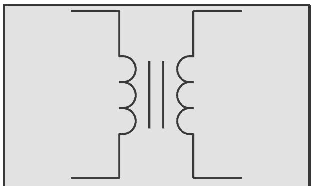
**DISCUSSION OUTLINE**

The Discussion of this exercise covers the following points:

- Transformer voltage and current ratios
- Step-up and step-down transformers
- Determining the voltage and current ratios of a transformer

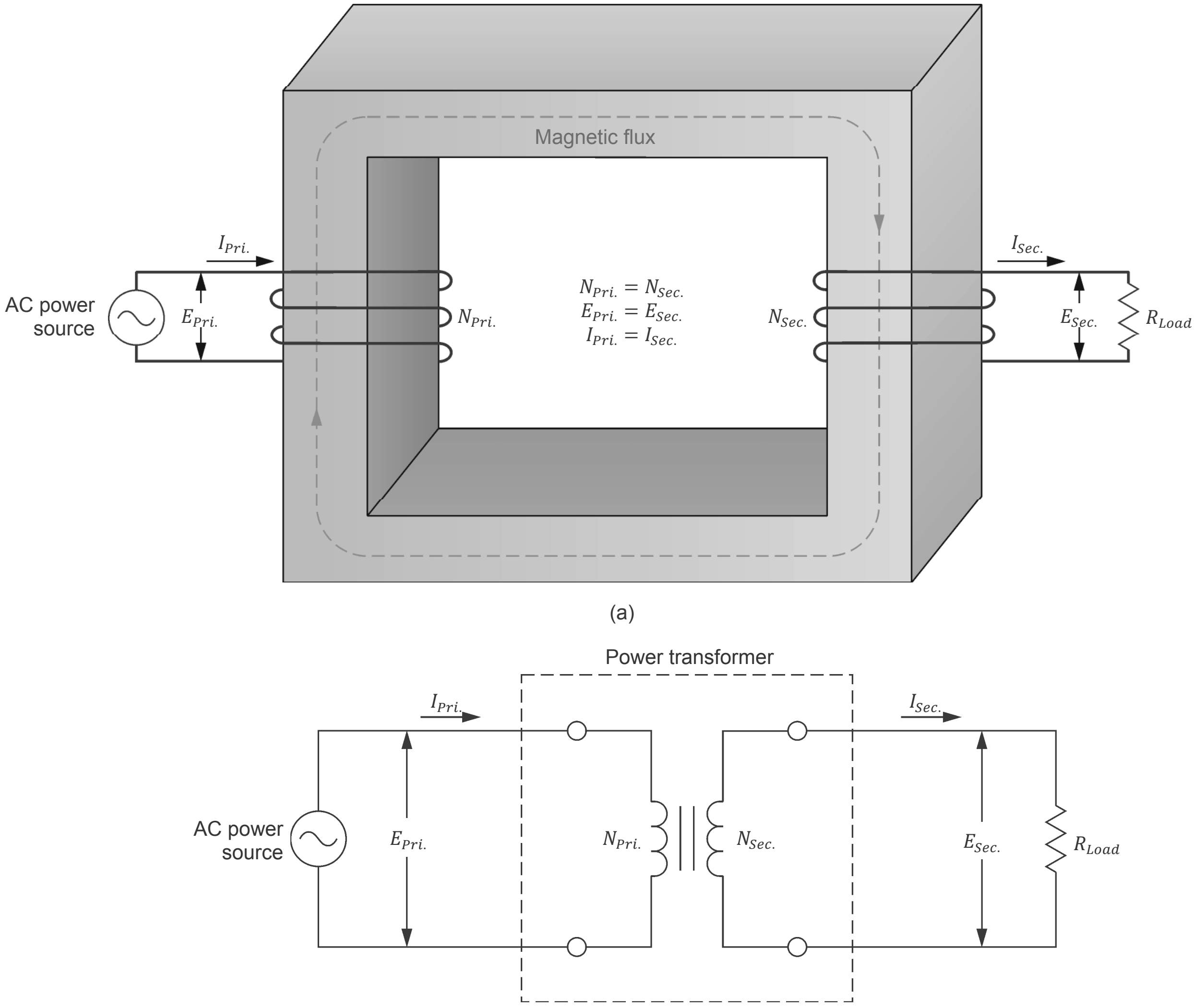
**DISCUSSION**

### Transformer voltage and current ratios



Schematic symbol
of a power transformer

As mentioned in the introduction, power transformers have a primary winding and a secondary winding. The ratio between the number of turns of wire in the primary winding ($N_{Pri.}$) and the number of turns of wire in the secondary winding ($N_{Sec.}$) is called the **turns ratio**. This ratio sets the relationship between the input and output values of the transformer and thus, determines the basic characteristics of the transformer. Figure 2a shows a single-phase power transformer having a turns ratio $N_{Pri.}/N_{Sec.}$ of 1:1 connected to a single-phase ac power source and a resistive load. Figure 2b represents the circuit diagram of the setup shown in Figure 2a.



(a)

(b)

**Figure 2. Power transformer with a turns ratio of 1:1.**

The ratio between the voltage across the primary winding and the voltage across the secondary winding of a power transformer is directly proportional to the transformer turns ratio $N_{Pri.}/N_{Sec.}$ as indicated in the following equation:

$$\frac{E_{Pri.}}{E_{Sec.}} = \frac{N_{Pri.}}{N_{Sec.}} \tag{1}$$

where $E_{Pri.}$ is the voltage across the primary winding of the transformer, expressed in volts (V).

$E_{Sec.}$ is the voltage across the secondary winding of the transformer, expressed in volts (V).

$N_{Pri.}$ is the number of turns in the primary winding of the transformer.

$N_{Sec.}$ is the number of turns in the secondary winding of the transformer.

The voltage across the secondary winding of a transformer can thus be calculated using the following equation:

$$E_{Sec.} = \frac{E_{Pri.} \times N_{Sec.}}{N_{Pri.}} \tag{2}$$

Conversely, the ratio between the current flowing in the primary winding and the current flowing in the secondary winding of a power transformer is inversely proportional to the transformer turns ratio $N_{Pri.}/N_{Sec.}$ as indicated in the following equation:

$$\frac{I_{Pri.}}{I_{Sec.}} = \frac{N_{Sec.}}{N_{Pri.}} \tag{3}$$

where $I_{Pri.}$ is the current flowing in the primary winding of the transformer, expressed in amperes (A).
$I_{Sec.}$ is the current flowing in the secondary winding of the transformer, expressed in amperes (A).

The current flowing in the secondary winding of a transformer can thus be calculated using the following equation:

$$I_{Sec.} = \frac{I_{Pri.} \times N_{Pri.}}{N_{Sec.}} \tag{4}$$

As you can see, the ratio between the voltage across the primary winding of a transformer and the voltage across the secondary winding is equal to $N_{Pri.}/N_{Sec.}$. Conversely, the ratio between the current flowing in the primary winding of a transformer and the current flowing in the secondary winding is equal to the inverse of the turns ratio, i.e., $N_{Sec.}/N_{Pri.}$.

Power transformers are highly efficient devices. Because of this, the voltage and current measured at the secondary winding of a transformer are virtually equal to the values that can be predicted using the voltage and current measured at the primary windings and the transformer **voltage ratio** and **current ratio**. Similarly, the apparent power at the secondary winding of a transformer is virtually equal to apparent power supplied to the primary winding of the transformer. This is true regardless of whether the primary and secondary windings are made of a single winding or of several windings. In other words, the total apparent power at the windings forming the secondary winding of a transformer is virtually equal to the total apparent power at the windings forming the primary winding.

## Step-up and step-down transformers

Depending on its turns ratio, a power transformer can either be a **step-up transformer** or a **step-down transformer**. In step-up transformers, the number of turns in the transformer primary winding is lower than the number of turns in the secondary winding, as is illustrated in Figure 3. Consequently, step-up transformers increase the voltage from the primary winding to the secondary winding, hence the name. Conversely, step-up transformers decrease the current from the primary winding to the secondary winding.

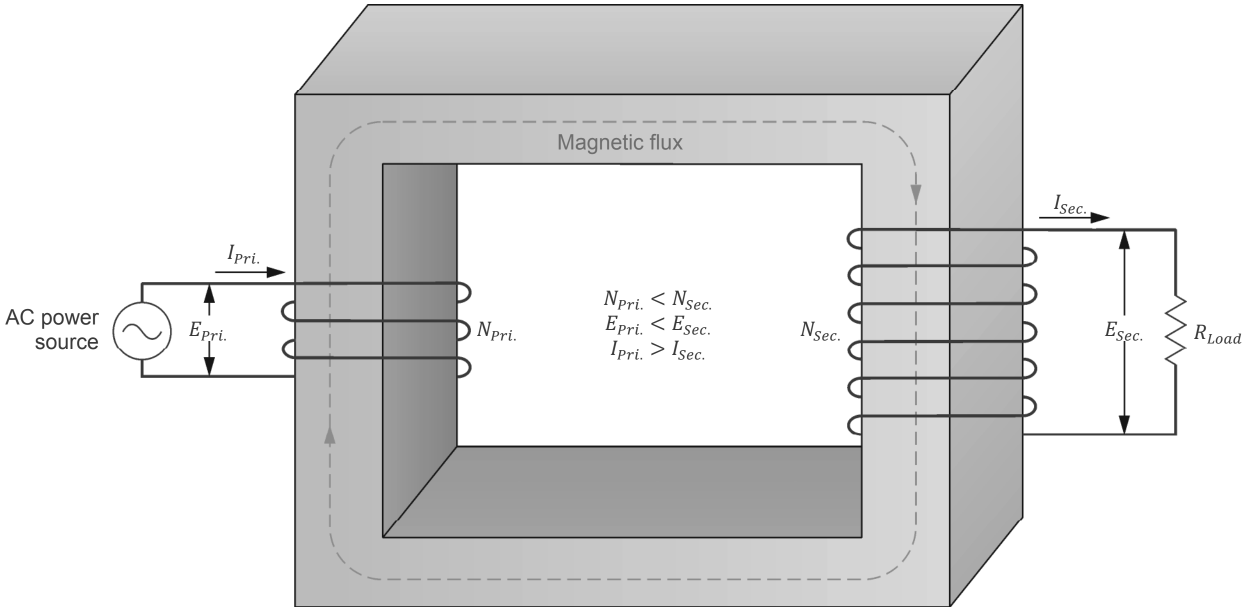


**Figure 3. Step-up power transformer.**

In step-down transformers, the number of turns in the transformer primary winding is higher than the number of turns in the secondary winding, as is illustrated in Figure 4. Consequently, step-down transformers decrease the voltage from the primary winding to the secondary winding, hence the name. Conversely, step-down transformers increase the current from the primary winding to the secondary winding.

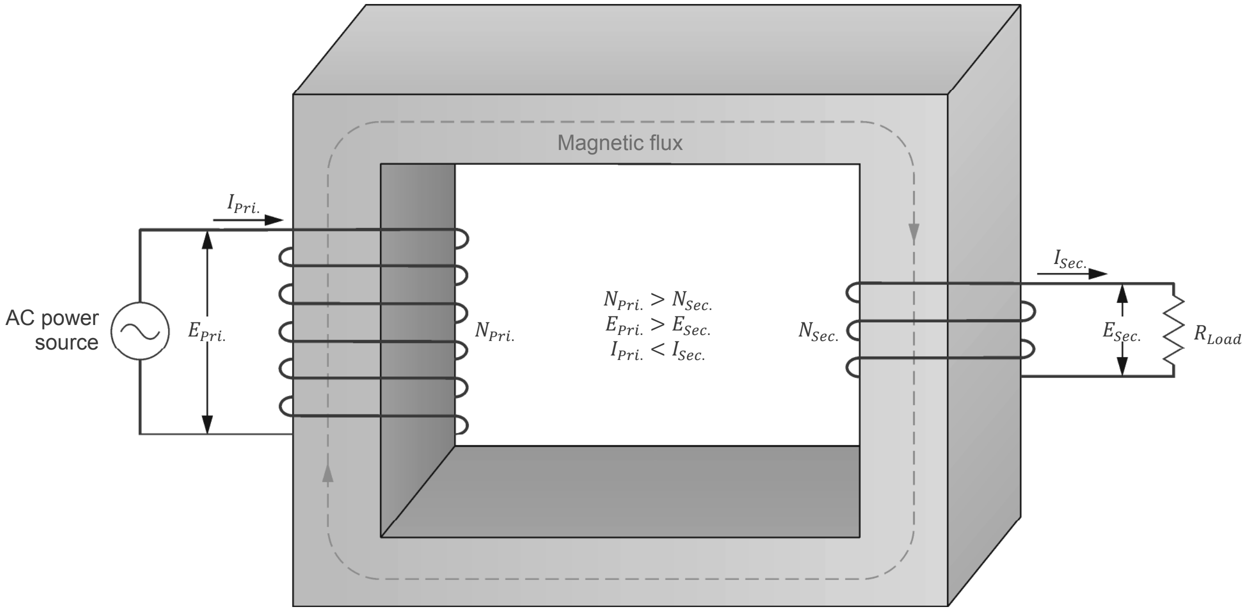


**Figure 4. Step-down power transformer.**

Power transformers are bidirectional devices. This means that power in a transformer can flow from the primary winding to the secondary winding or from the secondary winding to the primary winding. When power flows from the secondary winding to the primary winding of a step-up transformer, this transformer in fact behaves as a step-down transformer as the voltage supplied to the load (i.e., the primary voltage) is lower than the ac source voltage (i.e., the secondary voltage). Conversely, when power flows from the secondary winding to the primary winding of a step-down transformer, this transformer in fact behaves as a step-up transformer as the voltage supplied to the load (i.e., the primary voltage) is higher than the ac source voltage (i.e., the secondary voltage). For example, if the ac power source connected to the primary winding of the step-up transformer in Figure 3 is connected to the secondary winding instead, the transformer operates as a step-down transformer. The resulting circuit diagram is shown in Figure 5. The inverse is true for the step-down transformer in Figure 4, i.e., if the ac power source is connected to the secondary winding instead of the primary winding, the transformer operates as a step-up transformer.

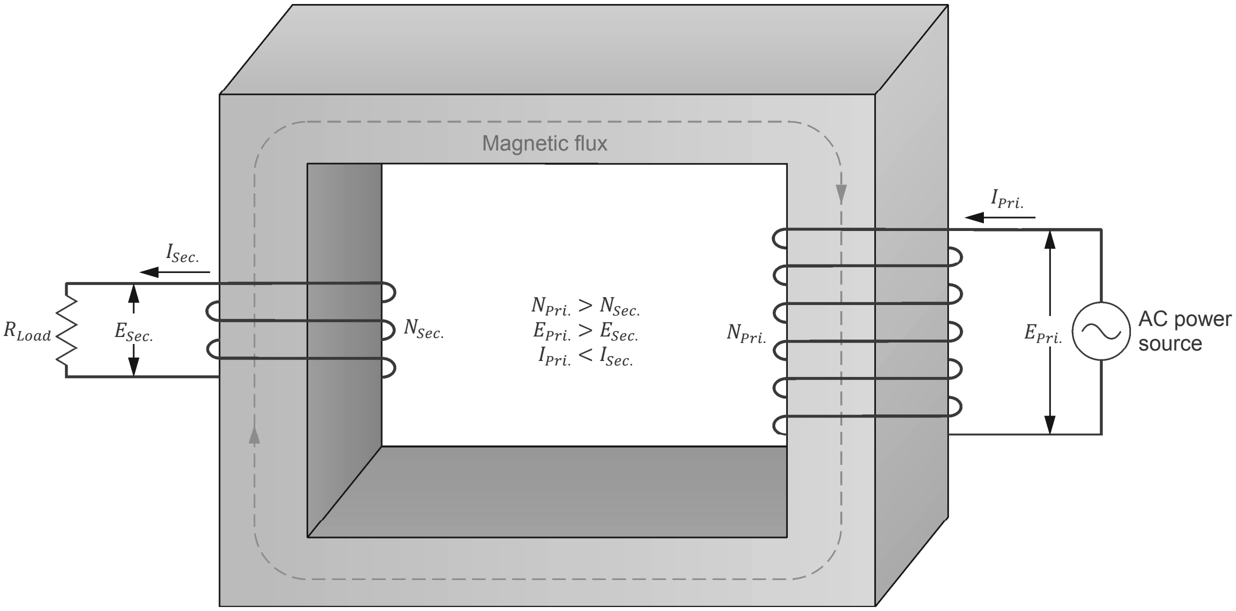


**Figure 5. Step-up transformer of Figure 3 converted into a step-down transformer by connecting the ac power source to what is usually the secondary winding.**

## Determining the voltage and current ratios of a transformer

Determining the voltage ratio of a power transformer is simple. When no load is connected to the secondary winding of the transformer, only the small exciting current necessary to create the magnetic flux inside the transformer flows in the primary winding of the transformer (the transformer exciting current is discussed later in this manual). The transformer losses are thus at a minimum and the ratio of the primary voltage to the secondary voltage is equal to the transformer turns ratio. The transformer voltage (turns) ratio can be found by measuring with a voltmeter the voltage across the secondary winding (without load) of the transformer when nominal voltage is applied to the primary winding.

Determining the current ratio of a transformer can be achieved through a number of methods. The safest method in order to avoid damaging the transformer is to connect the transformer to a resistive load, and to connect two ammeters to the circuit in order to measure the current flowing in the primary winding and in the secondary winding. Nominal voltage is then applied across the primary winding and the load resistance is adjusted so that the current flowing in the secondary winding is close to the nominal value. The transformer current ratio is equal to the ratio of the current flowing in the primary winding to the current flowing in the secondary winding.

## PROCEDURE OUTLINE

The Procedure is divided into the following sections:

- Set up and connections
- Primary and secondary windings of the Transformer module
- Electrical isolation between the primary and secondary windings
- Voltage induction across the windings of a transformer
- Step-up transformer
- Step-down transformer (OPTIONAL)

## PROCEDURE

**WARNING**

High voltages are present in this laboratory exercise. Do not make or modify any banana jack connections with the power on unless otherwise specified.

### Set up and connections

*In this section, you will set up the equipment to study the operation of a power transformer.*

**1.** Refer to the Equipment Utilization Chart in Appendix A to obtain the list of equipment required to perform this exercise.

Install the required equipment in the Workstation.

**2.** Make sure that the main power switch on the Four-Quadrant Dynamometer/Power Supply is set to the O (off) position, then connect its *Power Input* to an ac power wall outlet.

Connect the *Power Input* of the Data Acquisition and Control Interface to a 24 V ac power supply. Turn the 24 V ac power supply on.

**3.** Connect the USB port of the Data Acquisition and Control Interface to a USB port of the host computer.

Connect the USB port of the Four-Quadrant Dynamometer/Power Supply to a USB port of the host computer.

**4.** Turn the Four-Quadrant Dynamometer/Power Supply on, then set the *Operating Mode* switch to *Power Supply*. This setting allows the Four-Quadrant Dynamometer/Power Supply to operate as a power supply.

**5.** Turn the host computer on, then start the LVDAC-EMS software.

In the Module Selector window, make sure that the Data Acquisition and Control Interface and the Four-Quadrant Dynamometer/Power Supply are detected. Make sure that the *Computer-Based Instrumentation* function for the Data Acquisition and Control Interface is selected. Also, select the network voltage and frequency that correspond to the voltage and frequency of your local ac power network, then click the *OK* button to close the Module Selector window.

## Primary and secondary windings of the Transformer module

*In this section, you will observe the transformer module and notice the ratings of the transformer windings.*

**6.** Observe the front panel of the Transformer module (Model 8353). Notice that the power transformer in the module can be used as a step-up transformer. In this case, the two 24 V – 5 A windings form the primary winding and are connected to the ac power source. The two 120 V - 1 A windings form the secondary winding and can be connected to a single load or to two separate loads.

Conversely, the power transformer in the Transformer module can also be used as a step-down transformer. In this case, the two 120 V - 1 A windings form the primary winding and are connected to the ac power source. The two 24 V – 5 A windings form the secondary winding and can be connected to a single load or to two separate loads.

## Electrical isolation between the primary and secondary windings

*In this section, you will use an ohmmeter to verify that a power transformer provides isolation between its primary and secondary windings.*

**7.** Using an ohmmeter, verify that terminals 1, 2, 3, and 4 of the primary winding of the power transformer in the Transformer module are all isolated from terminals 5, 6, 7, and 8 of the secondary winding.

Does this confirm that a power transformer provides electrical isolation between its primary and secondary windings?

☐ Yes ☐ No

## Voltage induction across the windings of a transformer

*In this section, you will calculate the voltages induced across the various windings of the Transformer module when a voltage of 24 V is applied to winding 1-2. You will set up the equipment to measure the voltage across each winding of the Transformer module. You will apply a voltage of 24 V to winding 1-2, and measure the voltages induced across each other windings. You will compare the measured voltages with the calculated voltages. You will then calculate the voltages induced across the various windings of the Transformer module when a voltage of 100 V is applied to winding 5-6. You will apply a voltage of 100 V to winding 5-6, and measure the voltages induced across each other windings. Finally, you will compare the measured voltages with the calculated voltages.*

From now on, the Transformer module will be referred to simply as the power transformer or transformer.

**8.** The number of turns in each of the two 24 V – 5 A windings of the power transformer in the Transformer module is 57 turns. The number of turns in each of the two 120 V – 1 A windings of the transformer is 285 turns. The number of turns in each winding of the transformer is important in order to calculate the transformer turns ratio, which in turn determines the transformer voltage and current ratios.

**9.** Using the number of turns in each winding of the power transformer provided in the previous step, determine the voltage induced across windings 3-4, 5-6, and 7-8 of the transformer when a voltage of 24 V is applied to winding 1-2.

Voltage $E_{3-4}$ across winding 3-4 = _______ V

Voltage $E_{5-6}$ across winding 5-6 = _______ V

Voltage $E_{7-8}$ across winding 7-8 = _______ V

**10.** Connect the equipment as shown in Figure 6.

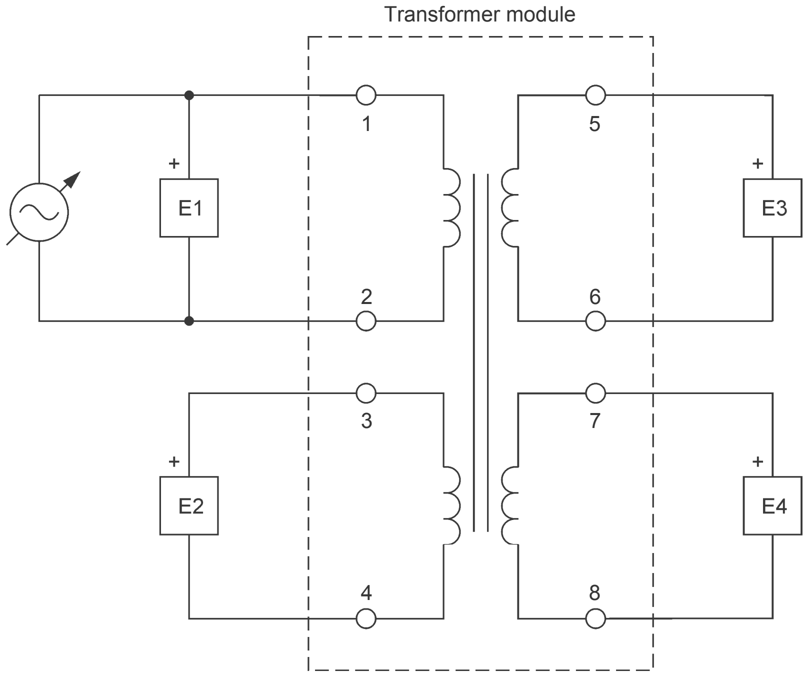


**Figure 6. Circuit for measuring the voltage induced across each winding of the transformer when the ac power source is connected to winding 1-2.**

**11.** In LVDAC-EMS, open the Four-Quadrant Dynamometer/Power Supply window, then make the following settings:

- Set the *Function* parameter to *AC Power Source*.
- Set the *Voltage* parameter to 24 V.
- Set the *Frequency* parameter to the frequency of your local ac power network.
- Start the *AC Power Source*.

**12.** In LVDAC-EMS, open the Metering window. Make the required settings in order to measure the rms values (ac) of voltage $E_{1-2}$ across winding 1-2, voltage $E_{3-4}$ across winding 3-4, voltage $E_{5-6}$ across winding 5-6, and voltage $E_{7-8}$ across winding 7-8 (inputs *E1*, *E2*, *E3*, and *E4*, respectively).

**13.** In the Four-Quadrant Dynamometer/Power Supply window, readjust the *Voltage* parameter so that the voltage $E_{1-2}$ across winding 1-2 indicated in the Metering window is as close as possible to 24 V.

In the Metering window, measure the voltage across each winding of the transformer (except the one to which the ac power source is connected). Record the values below.

Voltage $E_{3-4}$ across winding 3-4 = _______ V

Voltage $E_{5-6}$ across winding 5-6 = _______ V

Voltage $E_{7-8}$ across winding 7-8 = _______ V

Compare the voltages measured across the windings of the transformer to the voltages you calculated in step 9. Are the values virtually equal?

☐ Yes ☐ No

**14.** In the Four-Quadrant Dynamometer/Power Supply window, stop the *AC Power Source*.

**15.** Using the number of turns in each winding of the transformer, determine the voltage induced across windings 1-2, 3-4, and 7-8 of the power transformer when a voltage of 100 V is applied to winding 5-6.

Voltage $E_{1-2}$ across winding 1-2 = _______ V

Voltage $E_{3-4}$ across winding 3-4 = _______ V

Voltage $E_{7-8}$ across winding 7-8 = _______ V

**16.** Connect the equipment as shown in Figure 7.

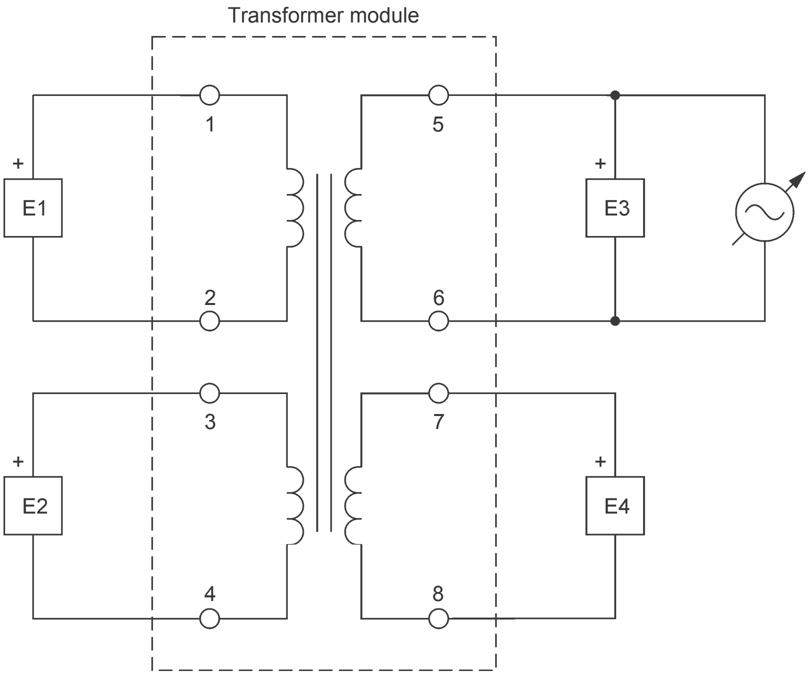


**Figure 7. Circuit for measuring the voltage induced across each winding of the transformer when the ac power source is connected to winding 5-6.**

**17.** In the Four-Quadrant Dynamometer/Power Supply window, set the *Voltage* parameter to 100 V, then start the *AC Power Source*. Readjust the *Voltage* parameter so that the voltage $E_{5-6}$ across winding 5-6 indicated in the Metering window is as close as possible to 100 V.

In the Metering window, measure the voltage across each winding of the transformer (except the one to which the ac power source is connected). Record the values below.

Voltage $E_{1-2}$ across winding 1-2 = _______ V

Voltage $E_{3-4}$ across winding 3-4 = _______ V

Voltage $E_{7-8}$ across winding 7-8 = _______ V

Compare the voltage measured across the windings of the transformer to the voltages you calculated in step 15. Are the values virtually equal?

☐ Yes ☐ No

Do the above manipulations confirm the relationship between the turns ratio and the voltage ratio?

☐ Yes ☐ No

**18.** In the Four-Quadrant Dynamometer/Power Supply window, stop the *AC Power Source*.

### Step-up transformer

*In this section, you will set up a circuit containing a step-up transformer connected to a resistive load, and calculate the step-up transformer turns ratio. You will start the ac power source. You will measure the transformer primary and secondary voltages (with the load resistance set to infinite), and calculate the transformer voltage ratio. You will compare the transformer voltage ratio with the calculated turns ratio, and confirm that the transformer currently operates as a step-up transformer. You will then set the resistance of the resistive load to 120 Ω. You will measure the transformer primary and secondary currents, and calculate the transformer current ratio. Finally, you will measure the step-up transformer apparent power at the primary and secondary, and confirm that both values are virtually equal.*

**19.** Set up the 120 VA step-up transformer shown in Figure 8.

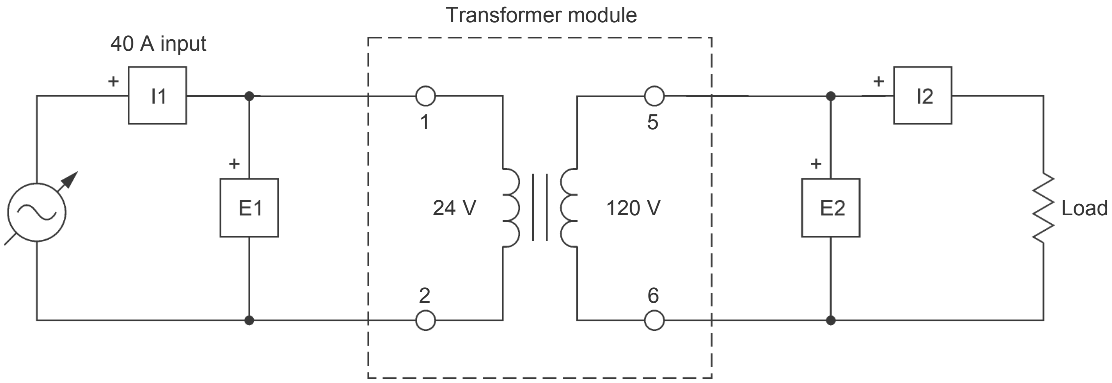


**Figure 8. 120 VA step-up transformer connected to a resistive load.**

In LVDAC-EMS, set the *Range* setting of current input *I1* to high.

**20.** Make the necessary switch settings on the Resistive Load so that the resistance value of the resistive load is infinite.

**21.** Calculate the turns ratio of the step-up transformer you set up in the previous step.

Step-up transformer turns ratio = _______

**22.** In the Metering window, make the required settings in order to measure the rms values (ac) of the power transformer primary voltage $E_{Pri.}$ and current $I_{Pri.}$ (inputs *E1* and *I1*, respectively), as well as the transformer secondary voltage $E_{Sec.}$ and current $I_{Sec.}$ (inputs *E2* and *I2*, respectively). Set two other meters to measure the transformer apparent power $S_{Pri.}$ at the primary and apparent power $S_{Sec.}$ at the secondary (from inputs *E1* and *I1*, and inputs *E2* and *I2*, respectively).

**23.** In the Four-Quadrant Dynamometer/Power Supply window, set the *Voltage* parameter to 24 V, then start the *AC Power Source*. Readjust the *Voltage* parameter so that the transformer primary voltage $E_{Pri.}$ indicated in the Metering window is as close as possible to 24 V.

In the Metering window, temporarily set the meter measuring the transformer primary current so that it displays dc current values. Then, in the Four-Quadrant Dynamometer/Power Supply window, adjust the *DC Offset Correction* parameter so that the dc current flowing in the transformer primary winding is as close as possible to 0 A. Once this is done, set the meter measuring the transformer primary current so that it displays ac current values.

*Adjusting the* DC Offset Correction *parameter of the ac power source ensures that virtually no dc current is supplied to the power transformer. This adjustment is required because dc current negatively affects the operation of power transformers.*

**24.** In the Metering window, measure the step-up transformer primary and secondary voltages. Record the values below.

Step-up transformer primary voltage $E_{Pri.} =$ _______ V

Step-up transformer secondary voltage $E_{Sec.} =$ _______ V

Using the step-up transformer primary and secondary voltages you just recorded, calculate the transformer voltage ratio.

Step-up transformer voltage ratio = _______

**25.** Is the step-up transformer voltage ratio you recorded in the previous step coherent with the transformer turns ratio you calculated in step 21?

☐ Yes ☐ No

Considering the transformer primary and secondary voltages you recorded in the previous step, can you conclude that the transformer currently operates as a step-up transformer? Explain briefly.

**26.** On the Resistive Load, make the necessary switch settings in order to obtain a resistive load value $R_{Load}$ of 120 Ω.

**27.** In the Four-Quadrant Dynamometer/Power Supply window, readjust the *Voltage* parameter so that the transformer primary voltage $E_{Pri.}$ indicated in the Metering window is as close as possible to 24 V. The current flowing in the secondary winding should now be close to the nominal current (1 A).

**28.** In the Metering window, measure the step-up transformer primary and secondary currents. Record the values below.

Step-up transformer primary current $I_{Pri.}$ = _______ A

Step-up transformer secondary current $I_{Sec.}$ = _______ A

Using the step-up transformer primary and secondary currents you just recorded, calculate the transformer current ratio.

Step-up transformer current ratio = _______

**29.** Is the step-up transformer current ratio you recorded in the previous step the inverse of the transformer turns ratio you calculated in step 21 and the transformer voltage ratio you recorded in step 24?

☐ Yes ☐ No

**30.** In the Metering window, measure the step-up transformer apparent power $S_{Pri.}$ at the primary and apparent power $S_{Sec.}$ at the secondary. Record the values below.

Apparent power $S_{Pri.}$ at the primary = _______ VA

Apparent power $S_{Sec.}$ at the secondary = _______ VA

Is the apparent power $S_{Sec.}$ at the secondary of the step-up transformer close to the apparent power $S_{Pri.}$ at the primary?

☐ Yes ☐ No

**31.** In the Four-Quadrant Dynamometer/Power Supply window, stop the *AC Power Source*.

## Step-down transformer (OPTIONAL)

*This section is optional as it requires the use of the load resistors available in the Wind Turbine Generator/Controller module. These low-resistance load resistors are necessary to ensure that the current flowing in the primary winding of the step-down transformer is significant (in relation to the transformer nominal current).*

Omit this section

*In this section, you will set up a circuit containing a step-down transformer connected to a resistive load, and calculate the step-down transformer turns ratio. You will start the ac power source. You will measure the transformer primary and secondary voltages (with the load resistance set to infinite), and calculate the transformer voltage ratio. You will compare the transformer voltage ratio with the calculated turns ratio, and confirm that the transformer currently operates as a step-down transformer. You will then set the resistance of the resistive load to 5 Ω. You will measure the transformer primary and secondary currents, and calculate the transformer current ratio. Finally, you will measure the step-down transformer apparent power values at the primary and secondary, and confirm that both values are virtually equal.*

**32.** Set-up the 120 VA step-down transformer shown in Figure 9. Do not connect the resistive load, i.e., the load resistors of the Wind Turbine Generator/Controller module, to the circuit for the moment. The load resistance at the transformer secondary is thus infinite.

Omit this section

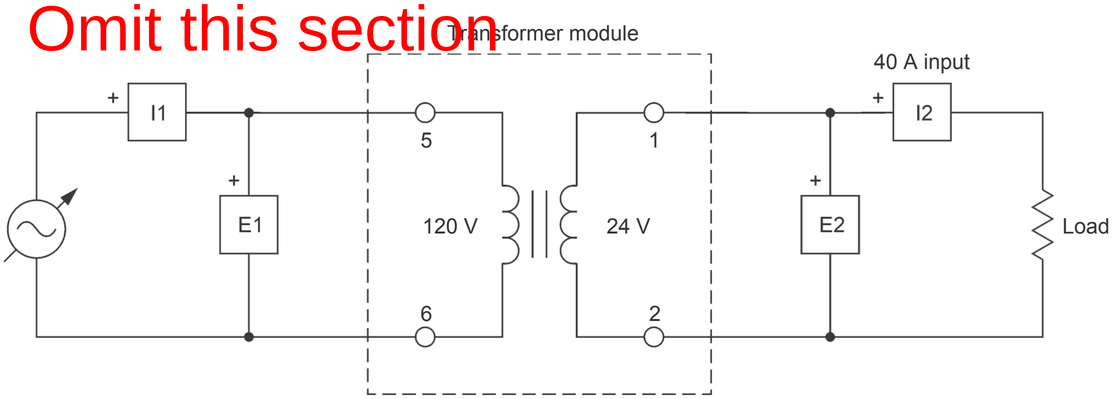


**Figure 9. 120 VA step-down transformer connected to the low-resistance load available in the Wind Turbine Generator/Controller module.**

In LVDAC-EMS, set the *Range* setting of current input *I1* to low, and the *Range* setting of current input *I2* to high.

Omit this section

**33.** Calculate the turns ratio of the step-down transformer you set up in the previous step.

Step-down transformer turns ratio = _______

**34.** In the Four-Quadrant Dynamometer/Power Supply window, set the *Voltage* parameter to 100 V, then start the *AC Power Source*. Readjust the *Voltage* parameter so that the transformer primary voltage $E_{Pri.}$ indicated in the Metering window is as close as possible to 100 V.

*It is possible that you may not be able to set the transformer primary voltage $E_{Pri.}$ indicated in the Metering window to 100 V because you have reached the voltage limit of the Four-Quadrant Dynamometer/Power Supply. If so, simply set the* Voltage *parameter to the highest possible value before proceeding to the next step.*

Omit this section

**35.** In the Metering window, measure the step-down transformer primary and secondary voltages. Record the values below.

Step-down transformer primary voltage $E_{Pri.}$ = _______ V

Step-down transformer secondary voltage $E_{Sec.}$ = _______ V

Using the step-down transformer primary and secondary voltages you just recorded, calculate the transformer voltage ratio.

Step-down transformer voltage ratio = _______

Omit this section

**36.** Is the step-down transformer voltage ratio you recorded in the previous step coherent with the transformer turns ratio you calculated in step 33?

☐ Yes ☐ No

Considering the transformer primary and secondary voltages you recorded in the previous step, can you conclude that the transformer currently operates as a step-down transformer? Explain briefly.

**37.** In the Four-Quadrant Dynamometer/Power Supply window, stop the *AC Power Source*.

On the Wind Turbine Generator/Controller module, connect all three 15 Ω load resistors in parallel. Then, connect the resulting 5 Ω resistive load to the circuit, as shown in Figure 9.

Omit this section

In the Four-Quadrant Dynamometer/Power Supply window, start the *AC Power Source*. Adjust the *Voltage* parameter so that the transformer primary voltage $E_{Pri.}$ indicated in the Metering window is as close as possible to 100 V.

*It is possible that you may not be able to set the transformer primary voltage $E_{Pri.}$ indicated in the Metering window to 100 V because you have reached the voltage limit of the Four-Quadrant Dynamometer/Power Supply. If so, simply set the* Voltage *parameter to the highest possible value before proceeding to the next step.*

**38.** In the Metering window, measure the step-down transformer primary and secondary currents. Record the values below.

Omit this section

Step-down transformer primary current $I_{Pri.}$ = _______ A

Step-down transformer secondary current $I_{Sec.}$ = _______ A

Using the step-down transformer primary and secondary currents you just recorded, calculate the transformer current ratio.

Step-down transformer current ratio = _______

**39.** Is the step-down transformer current ratio you recorded in the previous step the inverse of the transformer voltage ratio you calculated in step 33 and the transformer voltage ratio you recorded in step 35?

☐ Yes ☐ No

**40.** In the Metering window, measure the step-down transformer apparent power $S_{Pri.}$ at the primary and apparent power $S_{Sec.}$ at the secondary. Record the apparent power values below.

Omit this section

Apparent power $S_{Pri.}$ at the primary = _______ VA

Apparent power $S_{Sec.}$ at the secondary = _______ VA

Is the apparent power $S_{Sec.}$ at the secondary of the step-down transformer close to the apparent power $S_{Pri.}$ at the primary?

☐ Yes ☐ No

**41.** From the observations you have made so far, can you conclude that power transformers are bidirectional devices? Explain briefly.

Can a single power transformer operate either as a step-up or a step-down transformer? Explain briefly.

Omit this section

**42.** In the Four-Quadrant Dynamometer/Power Supply window, stop the *AC Power Source*.

**43.** Close LVDAC-EMS, then turn off all the equipment. Disconnect all leads and return them to their storage location.

## CONCLUSION

In this exercise, you learned what the relationships between the turns, voltage, and current ratios of a power transformer are. You familiarized yourself with the different characteristics of step-up and step-down transformers. You also learned how to determine in practice the voltage and current ratios of a power transformer.

## REVIEW QUESTIONS

1. A power transformer has 125 turns of wire in one of its windings, and 375 turns of wire in the other. What is the transformer turns ratio when it is used as a step-up transformer? What is the transformer turns ratio when it is used as a step-down transformer?

2. A step-up transformer connected to a resistive load has 300 turns of wire in the primary winding and 1000 turns of wire in the secondary winding. Determine the amount of current $I_{Sec.}$ flowing in the secondary winding of the transformer when a current $I_{Pri.}$ of 3 A flows in the primary winding.

3. Is it possible for a single power transformer to operate at one time as a step-up transformer and at another time as a step-down transformer? Explain why.

4. A step-down transformer has 480 turns of wire in the primary winding and 120 turns of wire in the secondary winding. Determine the voltage across the primary winding of the transformer when a voltage of 60 V is measured across the secondary winding of the transformer.

5. A voltage of 60 V is measured across the primary winding of a step-up transformer while a voltage of 300 V is measured across the secondary winding. Knowing that a current of 2.5 A flows in the primary winding of the transformer, calculate the current flowing in the secondary winding.