

LabQuest
23

Series and Parallel Circuits

Components in an electrical circuit are in *series* when they are connected one after the other, so that the same current flows through both of them. Components are in *parallel* when they are in alternate branches of a circuit. Series and parallel circuits function differently. You may have noticed the differences in electrical circuits you use. When using some decorative holiday light circuits, if one lamp is removed, the whole string of lamps goes off. These lamps are in series. When a light bulb is removed in your house, the other lights stay on. Household wiring is normally in parallel.

You can monitor these circuits using a Current Probe and a Differential Voltage Probe, and see how they operate. One goal of this experiment is to study circuits made up of two resistors in series or parallel. You can then use Ohm's law to determine the equivalent resistance of the two resistors.

OBJECTIVES

- To study current flow in series and parallel circuits.
- To study voltages in series and parallel circuits.
- Use Ohm's law to calculate equivalent resistance of series and parallel circuits.

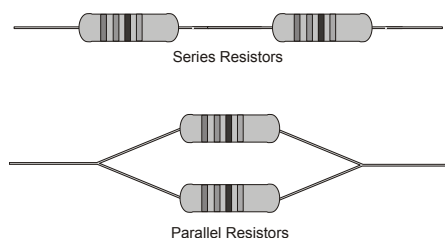


Figure 1

MATERIAL

LabQuest	two 10 Ω resistors
LabQuest App	two 51 Ω resistors
two Vernier Current Probes and	two 68 Ω resistors
one Vernier Differential Voltage Probe	momentary-contact switch
low-voltage DC power supply	connecting wires

PRELIMINARY QUESTIONS

1. Using what you know about electricity, hypothesize about how series resistors would affect current flow. What would you expect the effective resistance of two identical resistors in series to be, compared to the resistance of a single resistor?

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2. Using what you know about electricity, hypothesize about how parallel resistors would affect current flow. What would you expect the effective resistance of two identical resistors in parallel to be, compared to the resistance of one alone?
3. For each of the three resistor values you are using, note the *tolerance* rating. Tolerance is a percent rating, showing how much the actual resistance could vary from the labeled value. This value is labeled on the resistor or indicated with a color code. Calculate the range of resistance values that fall in this tolerance range.

PROCEDURE

Part I Series Circuits

1. Connect the Current Probe and the Differential Voltage Probe to LabQuest and choose New from the File menu. If you have older sensors that do not auto-ID, manually set up the sensors.
2. You need to zero both probes with no current flowing and with no voltage applied.
 - a. Connect the black and red clips together for this step only.
 - b. With no current flowing and with no voltage applied, wait for the readings on the screen to stabilize. Choose Zero ► All Sensors from the Sensors menu. The readings for both sensors should be close to zero.
3. If you have an adjustable power supply, set it at 3.0 V.
4. Check to see that Switch 1, located below the batteries, is set to 3.0 V if you are using the batteries or to External if you are using an external power supply. Connect the series circuit shown in Figure 2 using the 10 Ω resistors for resistor 1 and resistor 2. Notice the Differential Voltage Probe is used to measure the voltage applied to both resistors. The red terminal of the Current Probe should be toward the + terminal of the power supply.
5. You can take readings from the screen at any time. To test your circuit, press on the switch (Switch 3) to complete the circuit; hold for several seconds. Both current and voltage readings should increase. If they do not, recheck your circuit.
6. Press on the switch to complete the circuit again and read the current (I) and total voltage (V_{TOT}). Record the values in the data table.
7. Connect the leads of the Differential Voltage Probe across resistor 1. Press on the switch to complete the circuit and read this voltage (V_1). Record this value in the data table.
8. Connect the leads of the Differential Voltage Probe across resistor 2. Press on the switch to complete the circuit and read this voltage (V_2). Record this value in the data table.
9. Repeat Steps 5–8 with a 51 Ω resistor substituted for resistor 2.
10. Repeat Steps 5–8 with a 51 Ω resistor used for both resistor 1 and resistor 2.

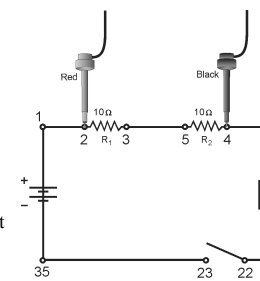


Figure 2

Series and Parallel Circuits

Part II Parallel circuits

- Connect the parallel circuit shown in Figure 3 using $51\ \Omega$ resistors for both resistor 1 and resistor 2. As in the previous circuit, the Differential Voltage Probe is used to measure the voltage applied to both resistors. The red terminal of the Current Probe should be toward the + terminal of the power supply. The Current Probe is used to measure the total current in the circuit.
- As in Part I, you can take readings from the screen at any time. To test your circuit, press on the switch to complete the circuit; hold for several seconds. Both current and voltage readings should increase. If they do not, recheck your circuit.
- Press the switch to complete the circuit again and read the total current (I) and total voltage (V_{TOT}). Record the values in the data table.
- Connect the leads of the Differential Voltage Probe across resistor 1. Press on the switch to complete the circuit and read the voltage (V_1) across resistor 1. Record this value in the data table.
- Connect the leads of the Differential Voltage Probe across resistor 2. Press on the switch to complete the circuit and read the voltage (V_2) across resistor 2. Record this value in the data table.
- Repeat Steps 11–15 with a $68\ \Omega$ resistor substituted for resistor 2.
- Repeat Steps 11–15 with a $68\ \Omega$ resistor used for both resistor 1 and resistor 2.

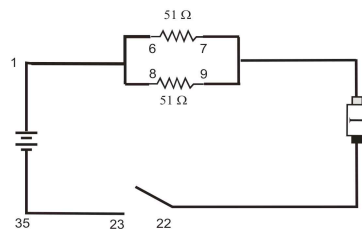


Figure 3

Part III Currents in Series and Parallel circuits

- For Part III of the experiment, you will use two Current Probes. Disconnect the Differential Voltage Probe and connect a second Current Probe. Select OK.
- You need to zero both probes with no current flowing. When the readings on the screen stabilize, choose Zero ► All Sensors from the Sensors menu. The readings for both sensors should be close to zero.
- Connect the series circuit shown in Figure 4 using the $10\ \Omega$ resistor and the $51\ \Omega$ resistor. The Current Probes will measure the current flowing through the two resistors. The red terminal of each Current Probe should be toward the + terminal of the power supply.
- For this part of the experiment you will monitor the current through each of two resistors. Note that the two resistors are not the same. What do you expect for the two currents? Will they be the same or different?

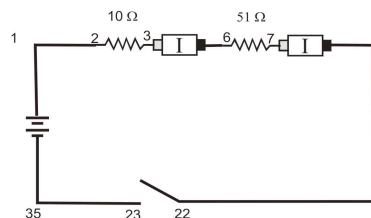


Figure 4

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- Press on the switch to complete the circuit, holding for several seconds. The power supply should still be set for 3.0 V. Record the currents in the data table.
- Connect the parallel circuit as shown in Figure 5 using the $51\ \Omega$ resistor and the $68\ \Omega$ resistor. The two Current Probes will measure the current through each resistor individually. The red terminal of each Current Probe should be toward the + terminal of the power supply.
- Before you make any measurements, predict the currents through the two resistors. Will they be the same or different? Note that the two resistors are not identical in this parallel circuit.
- Press on the switch to complete the circuit, holding for several seconds. Record the currents in the data table.

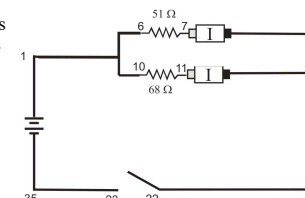


Figure 5

DATA TABLE ANALYSIS

- Examine the results of Part I. What is the relationship between the three voltage readings: V_1 , V_2 , and V_{TOT} ?
- Using the measurements you have made above and your knowledge of Ohm's law, calculate the equivalent resistance (R_{eq}) of the circuit for each of the three series circuits you tested.
- Study the equivalent resistance readings for the series circuits. Can you come up with a rule for the equivalent resistance (R_{eq}) of a series circuit with two resistors?
- For each of the three series circuits, compare the experimental results with the resistance calculated using your rule. In evaluating your results, consider the tolerance of each resistor by using the minimum and maximum values in your calculations.
- Using the measurements you have made above and your knowledge of Ohm's law, calculate the equivalent resistance (R_{eq}) of the circuit for each of the three parallel circuits you tested.
- Study the equivalent resistance readings for the parallel circuits. Devise a rule for the equivalent resistance of a parallel circuit of two resistors.
- Examine the results of Part II. What do you notice about the relationship between the three voltage readings V_1 , V_2 , and V_{TOT} in parallel circuits.
- What did you discover about the current flow in a series circuit in Part III?
- What did you discover about the current flow in a parallel circuit in Part III?
- If the two measured currents in your parallel circuit were not the same, which resistor had the larger current going through it? Why?

EXTENSION

- Try this experiment using three resistors in series and in parallel.