

## Experiment: Series and Parallel Circuits

### OBJECTIVES

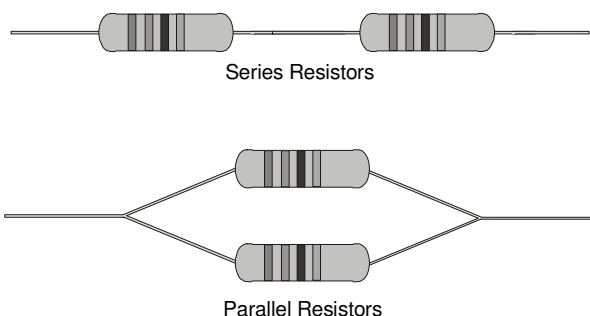
- To study current flow and voltages in series and parallel circuits.
- To use Ohm's law to calculate equivalent resistance of series and parallel circuits.

### MATERIALS

- |                                  |                              |
|----------------------------------|------------------------------|
| • Windows PC                     | • two 10- $\Omega$ resistors |
| • LabPro Interface               | • two 50- $\Omega$ resistors |
| • Logger <i>Pro</i>              | • two 68- $\Omega$ resistors |
| • Current & Voltage Probe System | • momentary-contact switch   |
| • low-voltage DC power supply    | • connecting wires           |

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 burns out, the whole string of lamps goes off. These lamps are in series. When a light bulb burns out in your house, the other lights stay on. Household wiring is normally in parallel.

You can monitor these circuits using a Current and Voltage Probe System and see how they operate. The goal of this experiment is to study circuits made up of two resistors in series or parallel.



### PRELIMINARY QUESTIONS


1. How do series resistors affect current flow? What would you expect the effective resistance of two equal resistors in series to be, compared to the resistance of a single resistor?
2. How do parallel resistors affect current flow? What would you expect the effective resistance of two equal 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.

Labeled resistor value ( $\Omega$ )	Tolerance (%)	Minimum resistance ( $\Omega$ )	Maximum resistance ( $\Omega$ )

## PROCEDURE

### Part I Series Circuits

1. Connect Voltage Probe to CH 1 on the LabPro Interface. Connect Current Probe to CH 2. If you have an adjustable power supply, set it at 3 V.
2. Prepare the computer for data collection by opening the experiment file "23a Series Parallel Circ". Current and voltage readings will be displayed in a Meter window.
3. Connect together the two voltage leads (red and black) of the Voltage Probe then zero both probes with no current flowing and with no voltage applied.
4. Connect the series circuit shown in Figure 1 using 10- $\Omega$  resistors for  $R_1$  and  $R_2$ . Notice the 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. For this part of the experiment, you do not even have to click on the  button. You can take readings from the Meter window at any time. To test your circuit, briefly press on the switch to complete the circuit. Both current and voltage readings should increase. If they do not, recheck your circuit.

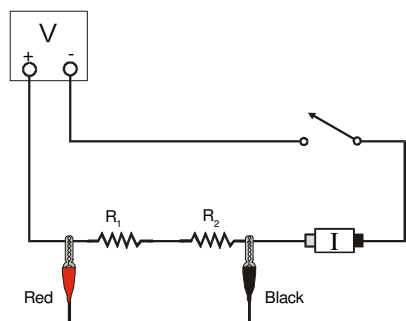


Figure 1

Part I: Series circuits							
	$R_1$ ( $\Omega$ )	$R_2$ ( $\Omega$ )	$I$ (A)	$V_1$ (V)	$V_2$ (V)	$R_{eq}$ ( $\Omega$ )	$V_{TOT}$ (V)
1	10	10					
2	10	50					
3	50	50					

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 Voltage Probe across  $R_1$ . 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 Voltage Probe across  $R_2$ . 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 50- $\Omega$  resistor substituted for  $R_2$ .
10. Repeat Steps 5 – 8 with a 50- $\Omega$  resistor used for both  $R_1$  and  $R_2$ .

### ANALYSIS

1. Examine the results of Part I. What is the relationship between the three voltage readings:  $V_1$ ,  $V_2$ , and  $V_{TOT}$ ?
2. Calculate the equivalent resistance ( $R_{eq}$ ) of the circuit for each of the three series circuits you tested.
3. For each of the three series circuits, calculate  $R_{eq}$  using the resistance color code values. Compare the calculated and experimental  $R_{eq}$  values. *Be sure to consider the tolerance of each resistor by using the minimum and maximum values in your calculations.*

### Part II Parallel circuits

1. Connect the parallel circuit shown below using 50- $\Omega$  resistors for both  $R_1$  and  $R_2$ . As in the previous circuit, the Voltage Probe is used to measure the voltage applied to both resistors. The Current Probe is used to measure the total current in the circuit.

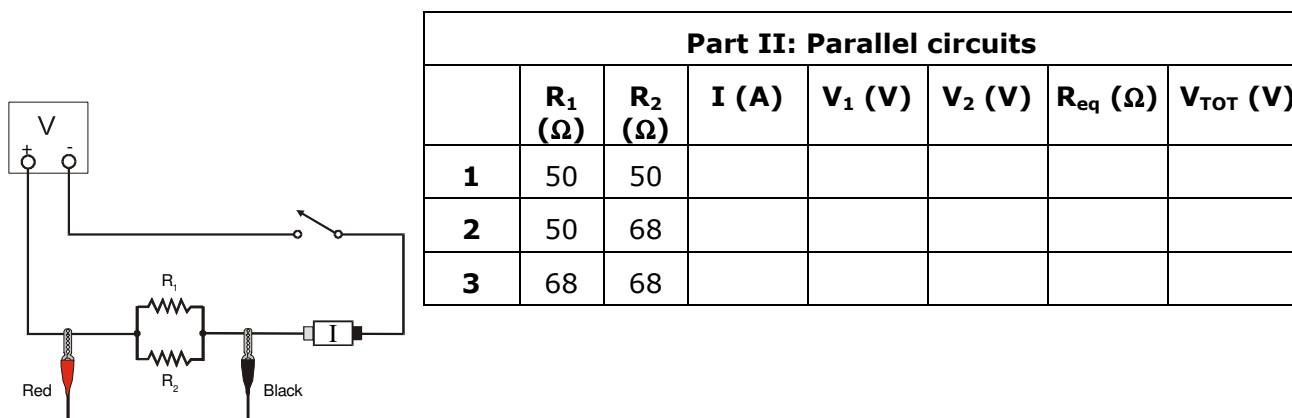


Figure 3

2. As in Part I, you can take readings from the Meter window at any time. To test your circuit, briefly press on the switch to complete the circuit. Both current and voltage readings should increase. If they do not, recheck your circuit.

3. 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.
4. Connect the leads of the 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.
5. Connect the leads of the 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.
6. Repeat Steps 1 – 5 with a  $68\text{-}\Omega$  resistor substituted for resistor 2.
7. Repeat Steps 1 – 1 with a  $68\text{-}\Omega$  resistor used for both resistor 1 and resistor 2.

### **Analysis (Part II)**

1. Using the measurements 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. Record your calculations in the table above.
2. For each of the three parallel circuits, calculate  $R_{eq}$  using the resistance color code values. Compare the calculated and experimental  $R_{eq}$  values. *Be sure to consider the tolerance of each resistor by using the minimum and maximum values in your calculations.*
3. 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?

### **Part III Currents in Series and Parallel circuits**

1. For Part III of the experiment, you will use two Current Probes. Open the experiment file "23b Series Parallel Circ". Two graphs of current vs. time are displayed. The vertical axis of both graphs has current scaled from  $-0.6$  to  $+0.6$  A. The horizontal axis of both graphs has time scaled from 0 to 10 s.
2. Disconnect the Voltage Probe from the CH 1 port of the LabPro Interface and plug in a second Current Probe.
3. With nothing connected to either probe, zero the current probes. This adjusts the current reading to zero with no current flowing.

4. Connect the series circuit shown in Figure 4 using the 10- $\Omega$  resistor and the 50- $\Omega$  resistor. The Current Probes will measure the current flowing into and out of the two resistors. The red terminal of each Current Probe should be toward the + terminal of the power supply.

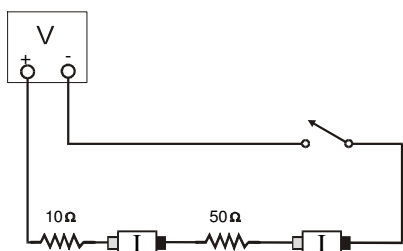






Figure 4

Part III: Currents (series)				
	$R_1$ ( $\Omega$ )	$R_2$ ( $\Omega$ )	$I_1$ (A)	$I_2$ (A)
1	10	50		
2	50	68		

5. For this part of the experiment, you will record a graph of the current vs. time for each probe. You will start the graphs with the switch open, close the switch for a few seconds, and then release the switch.
6. Click on the  button, wait a second or two, then press on the switch to complete the circuit. Release the switch just before the graph is completed.
7. Select the region of the graph where the switch was on by dragging the cursor over it. Click on the Statistics button, , and record the average current in the data table. Determine the average current in the second graph following the same procedure.
8. Connect the parallel circuit as shown in Figure 5 using the 50- $\Omega$  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.
9. Before you make any measurements, sketch your prediction of the current vs. time graphs for each Current Probe in this configuration. Assume that you start with the switch open as before, close it for several seconds, and then open it. Note that the two resistors are not identical in this parallel circuit.
10. Click on the  button and wait a second or two. Then press on the switch to complete the circuit. Release the switch just before the graph is completed.
11. Select the region of the graph where the switch was on by dragging the cursor over it. Click on the Statistics button, , and record the average current in the data table. Determine the average current in the second graph following the same procedure.

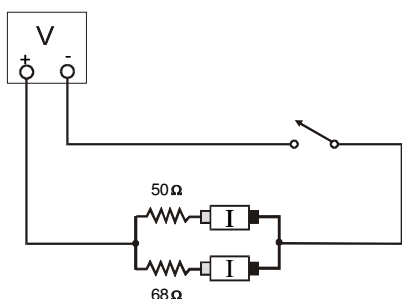


Figure 5

Part III: Currents (parallel)				
	$R_1$ ( $\Omega$ )	$R_2$ ( $\Omega$ )	$I_1$ (A)	$I_2$ (A)
1	10	50		
2	50	68		

---

**Analysis (Part III)**

1. What did you discover about the current flow in a series circuit in Part III?
  
  
  
  
  
  
  
  
  
  
2. What did you discover about the current flow in a parallel circuit in Part III?
  
  
  
  
  
  
  
  
  
  
3. Note that the two measured currents in your parallel circuit were not the same. Which resistor had the larger current going through it? Why?