Northeast Community College
Diversified Manufacturing Technology

Complex (Compound) Circuits

PURPOSE:

This lab activity provides experience in constructing and measuring complex circuits.

DISCUSSION:

In a series circuit, there is only one path for current to flow. There is no limit to the number of components that make up the circuit, but, based upon Ohm's law, the more components connected in series the lower the current flowing through the circuit.

A simple parallel circuit is composed of two or more branches. Each branch will have a current determined by the amount of resistance in the branch. The sum of the branch current will be equal to the source current. The source voltage will be the same through each branch.

As you know, electrical circuits do not come in neat little packages but rather a combination of series and parallel circuits. To solve a compound circuit you have to break the circuit down into manageable units, series and parallel. The problem lies in determining which part is series and which part is parallel. Once determined, the rules for series circuits apply to the series portion of the circuit and the rules for parallel circuits apply to the parallel portion. One rule to bear in mind is to always solve for parallel circuits first.

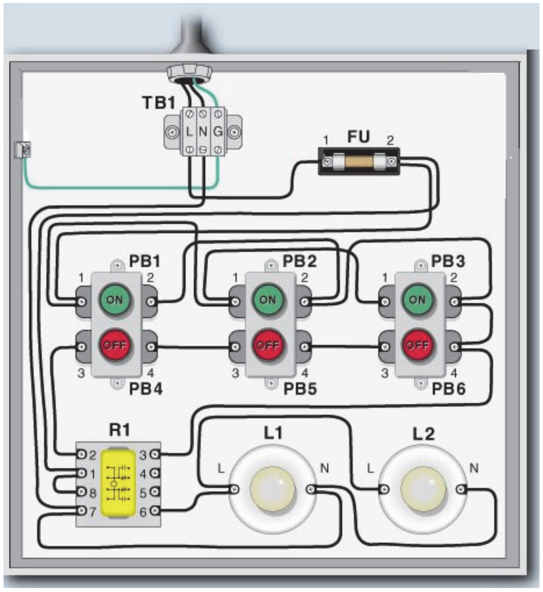

Figure 8-1
Source: http://www.supershareware.com/preview/basic-electrical-troubleshooting.html

If you look at the pictorial view of a circuit (Figure 8-1) you likely recognize the many components. But can you determine which components are in series and which are in parallel? It is much easier to make this determination looking at a schematic of the system. With practice you will become more at ease at identifying and solving complex circuits.

PROCEDURE:

1. Study the circuit in Figure 8-2 and predict the answers to the following questions based upon your experiences with series and parallel circuits.

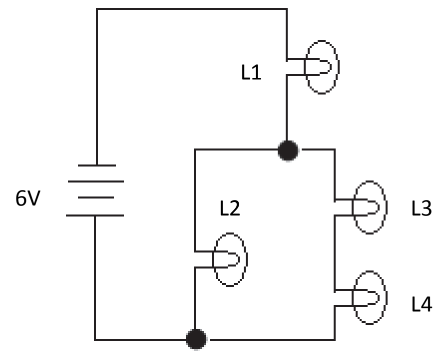

Figure 8-2

   a. Are lamps L1 and L2 in series or parallel? ____________________

   b. Are lamps L3 and L4 in series or parallel? ____________________

   c. Are lamps L2 and L3/L4 in series or parallel? _________________

   d. Which lamp(s) will be the brightest? ____________________

   e. Which lamp(s) will be the dimmest? ____________________

2. Now construct the circuit in Figure 8-2 using the PHET Circuit Construction Kit to check your answers to questions 1(d) and 1(e) and answer the following questions. Again think in terms of your experience with series and parallel circuits. The circuit should appear as shown in Figure 8-3. (http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc).
   Insert Figure 8-3 from PHET

   a. Why is L1 brighter than L2?

   b. Why is L2 brighter than L3 or L4?

   c. Why is the brilliancy of L3 and L4 equal?

3. Again study Figure 8-2 and predict what will happen to the brightness of the lamps when lamp 1 (L1) burns out or is removed from the socket.

   a. Did L2 get brighter or dimmer?

   b. Did L3 and L4 get brighter or dimmer?

4. You can design your PHET circuit as shown in Figure 8-4 to test your predictions. You can simulate this by setting the lamp resistance to zero. Do not forget to reset the lamp to the original resistance with finished with the question.

    a. Did your predictions match the simulation?

5. Again study Figure 8-2 and predict what will happen to the brightness of the lamps when lamp 2 (L2) burns out or is removed from the socket.

    a. Did L1 get brighter or dimmer?

    b. Did L3 and L4 get brighter or dimmer?

    c. Explain why L1 and L3 changed as they did when L2 was removed from service.

6. Design your PHET circuit as shown in Figure 8-5 to test your predictions to questions 5(a) and 5(b).

7. Using Figure 8-2 as your circuit, predict the answers to the following questions regarding how the various components will react when Lamp 3 (L3) or Lamp 4 (L4) is burned out or removed from their sockets.

    a. If L3 burns out, will L2 get brighter or dimmer?

    b. If L4 burns out, will L2 get brighter or dimmer?

    c. Why did L1 get brighter when either L3 or L4 is burned out?

8.
    a. Why did L3 get brighter when L4 is burned out?

9. Use your PHET circuit to test your predictions.

10. Look at the complex circuit identified in Figure 8-6. Because it is a complex circuit you will need to break it down into pieces in which you can manage. Begin by visualizing how Figure 8-6 could be reduced to an equivalent circuit containing two parallel resistors.

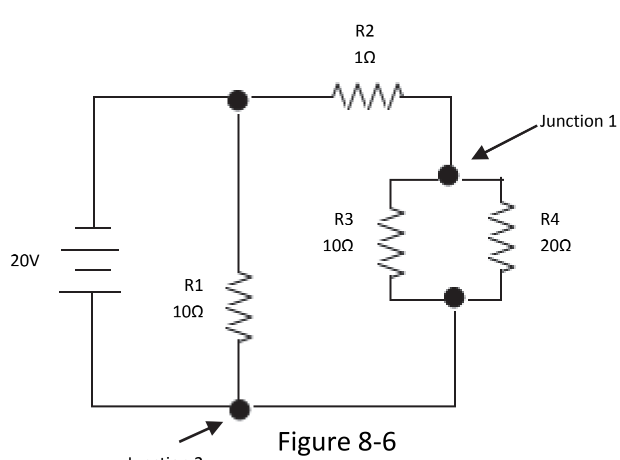

Figure 8-6

a. Using the image, calculate the total resistance of the two parallel resistors. _________

b. Will the total resistance (RT) be greater than or less than 10Ω?

11. Using the total resistance calculated in 9(a), visualize resistors R3 and R4 as a single resistor and call it R5. Your circuit should now resemble Figure 8-7.

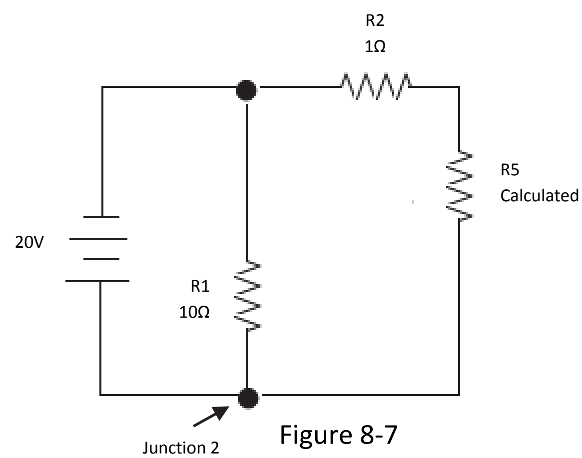

Figure 8-7

12. Look at the complex circuit identified in Figure 8-7. Because it is still a complex circuit you will need to break it down into pieces in which you can manage. Begin by visualizing how Figure 8-7 could be reduced to an equivalent circuit containing two parallel resistors.

    a. Using the image, calculate the total resistance of the two parallel resistors. _________

13. Using the total resistance calculated in 11(a), visualize resistors R1 and R5 as a single resistor and call it R6. Your circuit should now resemble Figure 8-8. Notice you now have a simple series circuit. You could reduce Figure 8-8 one additional time to simplify the circuit even further as shown in Figure 8-9 by summing the two resistors.

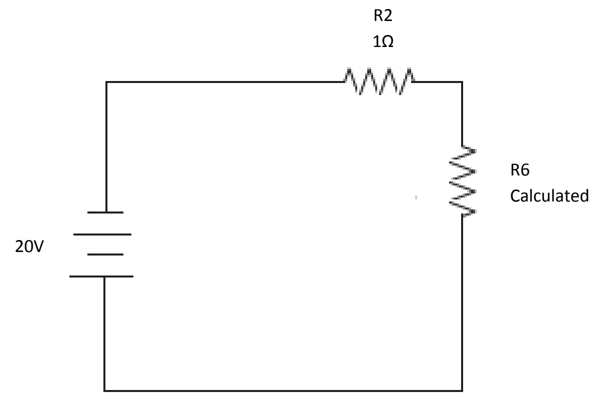

Figure 8-8

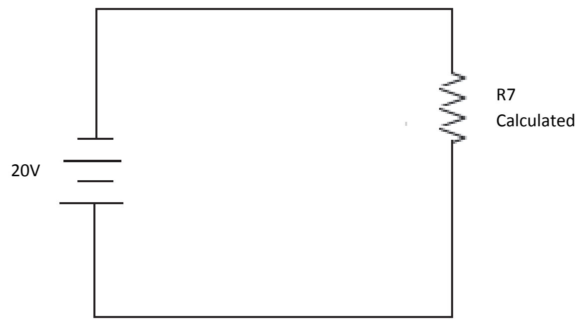

Figure 8-9

14. Now that you have simplified the complex circuit, determine the voltage through R1, R2, R4 and the total voltage (V_{RT}) of the circuit. Also determine the current through R1, R2, R3, R4, and the total circuit current (I_{RT}) by applying Ohm's law and your knowledge of series and parallel circuits. Note: it might be easiest to set up a table.

V_{RT} _______________ I_{RT}_______________

V_{R1} _______________ I_{R1}_______________

V_{R2} _______________ I_{R2}_______________

V_{R4} _______________ I_{R3}_______________

I_{R4}_______________

15. Upon completing your calculations for 15, construct Figure 8-6 using the PHET Circuit Construction Kit. Using the voltmeter and the non-contact ammeter compare the results you obtained from the simulation to those you calculated in question 15. If they are difference you need to check your math.

16. Using the circuit in which you constructed in step 16 answer the following questions.

    a. What is the voltage between junction 1 and junction 2? Check your answer by connected the voltmeter between the two junctions.

b. Does the current entering junction 1 equal the current leaving junction 1? ___________

c. Would removing R1 from the circuit change the value of the current passing through R3? ______________. Temporarily remove R1 and verify your answer by measuring the current through R3. Reset R1 when you are finished with this question.

d. Would removing R4 from the circuit change the value of the current passing through R1? ______________. Temporarily remove R4 and verify your answer by measuring the current through R1.

e. Does removing R4 change the current through R2? ____________ Reset R4 when you are finished with this question.

f. If a 100Ω resistor were added in parallel with R4, what would happen to the voltage across R2? ____________.

Resources:

1. Super Shareware.com (n.d.). Basic Electrical-Troubleshooting.

2. University of Colorado Boulder (n.d.). PhET - Circuit Construction Kit.

   Founded in 2002 by Nobel Laureate Carl Wieman, the PhET Interactive Simulations project at the University of Colorado Boulder creates free interactive math and science simulations. PhET sims are based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery.

3. Grant Statement

   This document was developed as part of Trade Adjustment Assistance Community College and Career Training (TAACCCT) Grant Program Round 2 Grant, Innovations Moving People to Achieve Certified Training (IMPACT): TC-23752-12-60-A-31.