Student's Name: Date:

Introduction to Circuit Analysis Laboratory

Lab Experiment 7

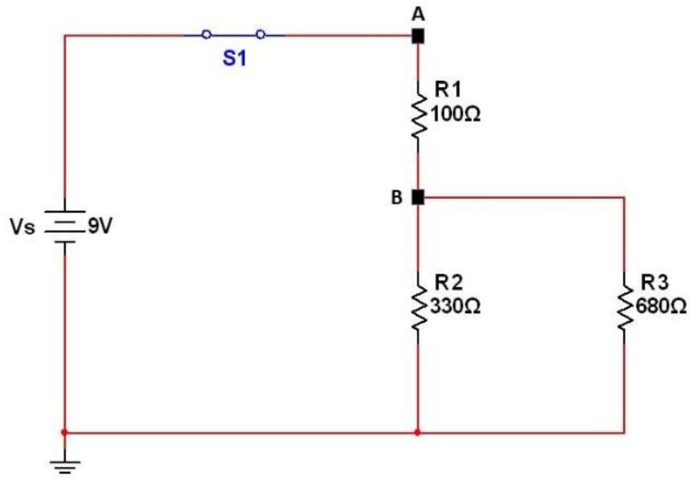
Series-Parallel Circuits and In-circuit resistance measurement

Series-Parallel Circuits

Most practical circuits in electronics are made up combinations of both series and parallel circuits. These circuits are made up of all sorts of components such as resistors, capacitors, inductors, diodes, transistors and integrated circuits. Such a circuit, where the components are not strictly in series or in parallel, is called series-parallel circuit. There is no real world application for a series-parallel circuit made up of only resistors. In this lab however, we investigate series-parallel circuits made up of only resistors to learn about such circuits. The concepts we investigate here can then be applied to real world circuits. In this experiment, we will investigate a series-parallel circuit. The voltages and the currents in the circuit will be measured and then compared to the expected values.

Remember that you can only combine resistors that are in series or resistors that are in parallel. Series resistors add. Resistors in parallel can be combined using either the conductance method or the "product over sum" method (two resistors at a time). The conductance method, you remember, is easier to use with the calculator. Two resistors may be recognized to be in series if they have one node in common and nothing else is connected to that node, it means that the node has a degree of two. Resistors may be recognized to be in parallel, if they are connected between the same two nodes. If two resistors are neither in series nor in parallel, they cannot be combined. Only resistors in series or in parallel can be combined.

Circuit 7.1 shows a series-parallel circuit. Note that R_1 cannot be combined with either R_2 or R_3; R_1 is neither in series nor in parallel with either $R_{2.}$ However, R_2 is in parallel with $R_{3,}$ because they are connected between the same two nodes (node B and ground).



Circuit 7.1 Series-Parallel Resistivity Circuit

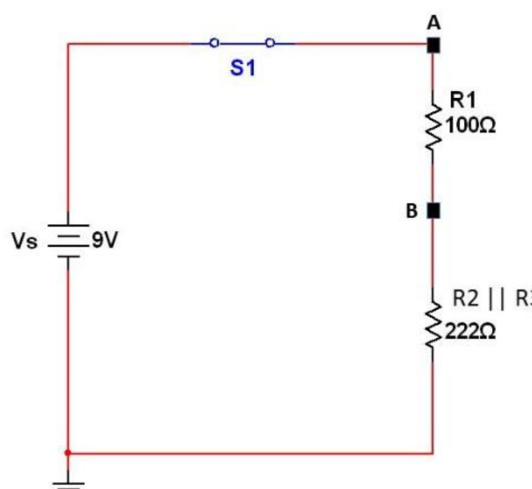
The equivalent combination of $R_2//R_3$ is easily found by using the equation the reciprocal of total conductance formula

$$R_2||R_3 = \frac{1}{\left(\frac{1}{R_2} + \frac{1}{R_3}\right)} = \frac{1}{\left(\frac{1}{330\Omega} + \frac{1}{680\Omega}\right)} = 222\Omega$$

You can also use the special formula, product over the sum, for two resistors connected in parallel

$$R_2||R_3 = \frac{(R_2 \times R_3)}{(R_2 + R_3)} = \frac{(330\Omega \times 680\Omega)}{(330\Omega + 680\Omega)} = 222\Omega$$

This parallel combination can now be seen to be in series with the 100Ω resistor R_1.



Circuit 7.1A – Equivalent Circuit from Circuit 7.1 (R2 || R3)

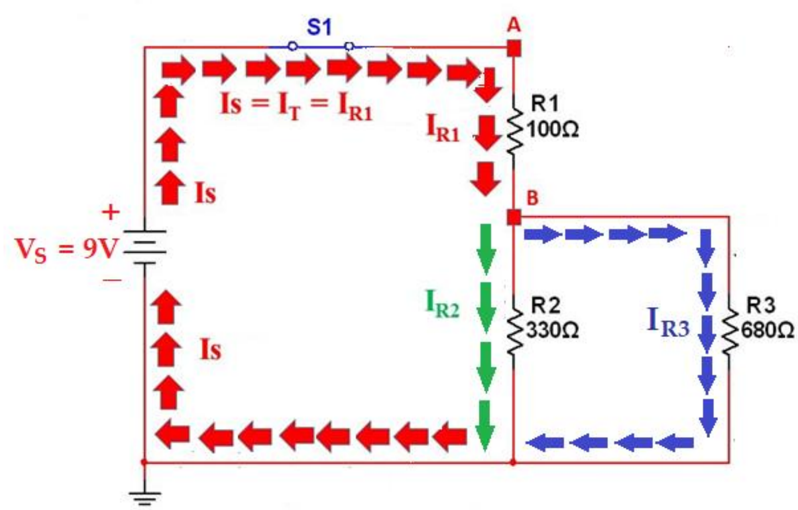
The total resistance can be calculates as follows:

$$R_T = R_1 + (R_2 // R_3) = 100 + 222 = 322\Omega$$

The 9V power supply therefore "sees" 322Ω. Ohm's Law allows us to predict the total current.

$$I_T = \frac{V_T}{R_T} = \frac{9}{322} = 0.028A = 28mA$$

About the current distribution in Circuit 7.1, you can note since the positive of the voltage source is connected in series with R1, the current through R1 is the same as the voltage source. At node B, the current source or current coming out from R1 divides in two path. Check Circuit 7.2 for reference.



Circuit 7.2 – Current distribution for Circuit 7.1

Appendix

$$\% \, \boldsymbol{difference} = \left(\frac{\textbf{Calculated value} - \textbf{Measured value}}{\textbf{Calculated value}}\right) \times \mathbf{100\%}$$

Formula 7.1 – Percentage of difference formula

Laboratory Experiment

Part 1 – Resistance Measurement in a Series-Parallel Circuit

1. Obtain a protoboard, jumper wires, and 100 Ω, 330 Ω, and 680 Ω resistors from your component kit.
2. Build Circuit 7.1 into your protoboard, but don't make the connection to voltage source yet.
3. Measure total resistance of Circuit 7.1 as shown in Figure 7.1. Record your measurement in Table 7.1. Do not forget the unit.

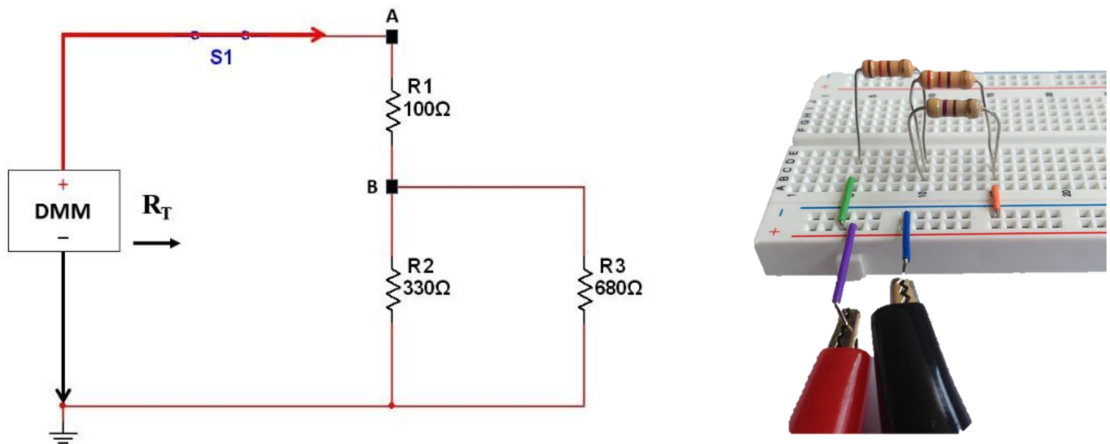


Figure 7.1 – Total resistance measurement using a DMM

4. Calculate the total resistance and the percentage of difference between your calculated and measured total resistance and record your result in Table 7.1

Show calculations here:

	Calculated R_T	**Measured R_T**	**% of difference**
Total Resistance R_T			

Table 7.1 – Total Resistance Analysis in a Series-Parallel Circuit, Circuit 7.1

Part 2 – Current Analysis in a Series-Parallel Circuit

5. Turn ON the power supply and it to 9 V. Connect the power supply in Figure 7.1 to power and complete Circuit 7.1
6. Set up the DMM and Circuit 7.1 to measure current. Remember to break one terminal open of the element to be measured and place the DMM in series or between the open terminals.
7. Measure the current through each element in Circuit 7.1 and record the measurements in Table 7.2. Remember that you MUST turn OFF or disconnected the power supply first before making changes to the circuit.
8. Calculate the current through each resistor and voltage source in Circuit 7.1. Record calculation in Table 7.2
9. Find the percentage of difference between the measured and calculated current. Record the result in Table 7.2

	Current through voltage source, Is	**Current Through $R_1 = 100\Omega$**	**Current Through $R_2 = 330\Omega$**	**Current Through $R_3 = 680\Omega$**	**Does KCL Hold? (Yes/No)**
Measured Value					
Calculated Value					
% Difference					

Table 7.2 Current Analysis in a Series-Parallel Circuit, Circuit 7.1

Part 3 – Voltage Analysis in a Series-Parallel Circuit

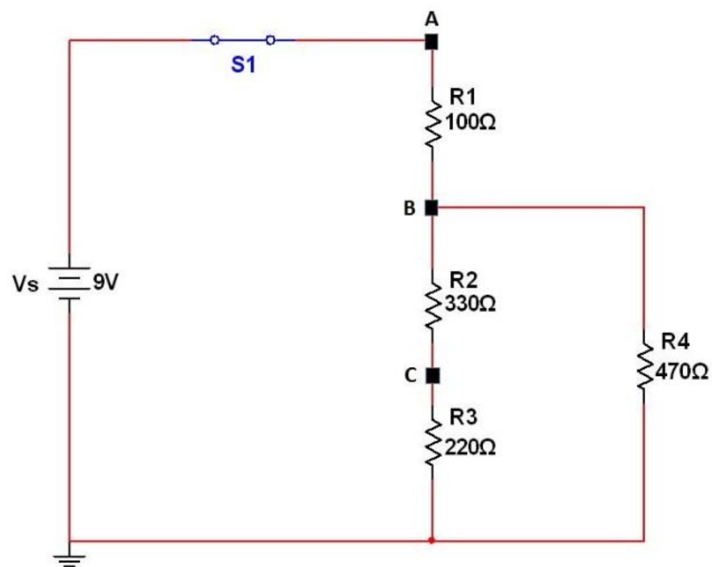
10. Set the DMM and Circuit 7.1 to measure voltage.
11. Measure the voltage across each resistor and voltage source. Record the measured value in Table 7.3
12. Calculate the voltage across each resistor and voltage source in Circuit 7.1. Record calculation in Table 7.3
13. Find the percentage of difference between the measured and calculated voltage. Record the result in Table 7.3.

14. Turn OFF the power supply, disassemble the circuit and place your component in their respective kit. Proceed with Circuit 7.2

	Voltage Source, Vs	**Voltage across $R_1 = 100\Omega$**	**Voltage across $R_2 = 330\Omega$**	**Voltage across $R_3 = 680\Omega$**	**Does KVL Hold? (Yes/No)**
Measured Value					
Calculated Value					
% Difference					

Table 7.3 Voltage Analysis in a Series-Parallel Circuit, Circuit 7.1

Part 4 – Resistance, Voltage, and Current Analysis in a Series-Parallel Circuit



Circuit 7.2 – Series-Parallel Resistivity Circuit

15. Obtain resistors: 100 Ω, 330 Ω, 220 Ω, and 470 Ω
16. Build Circuit 7.2 into your protoboard, but don't make the connection to voltage source yet.

17. Measure total resistance for Circuit 7.2. Record your measurement in Table 7.4. Do not forget to include the unit.
18. Calculate the total resistance and the percentage of difference between your calculated and measured total resistance. Record calculations in Table 7.4

	Calculated R_T	**Measured R_T**	**% difference**
Total Resistance, R_T			

Table 7.4 – Total Resistance Analysis in a Series-Parallel Circuit, Circuit 7.2

Part 5 - Current Analysis in a Series-Parallel Circuit

19. Turn ON the power supply and set it to 9 V. Connect the power supply to complete Circuit 7.2
20. Set the DMM and prepare Circuit 7.2 to measure current. Remember to break one terminal open of the element to be measured and place the DMM in series or between the open terminals.
21. Measure the current through each element in Circuit 7.2 and record the measured value in Table 7.5. Remember that you MUST turn OFF or disconnected the power supply first before making changes to the circuit.

	Current through voltage source, Is	**Current Through $R_1 = 100\Omega$**	**Current Through $R_2 = 330\Omega$**	**Current Through $R_3 = 220\Omega$**	**Current Through $R_4 = 470\Omega$**
Measured Value					
Calculated Value					
% Difference					

Table 7.5 Current Analysis in a Series-Parallel Circuit, Circuit 7.2

22. Calculate the current through each resistor and voltage source in Circuit 7.3. Record calculation in Table 7.5.
23. Find the percentage of difference between the measured and calculated current. Record the result in Table 7.5.

Show calculations here:

Part 6 - Voltage Analysis in a Series-Parallel Circuit

24. Set DMM and prepare Circuit 7.2 to measure voltage.
25. Measure the voltage across each resistor and voltage source. Record the measured value in Table 7.6
26. Calculate the voltage across each resistor and voltage source in Circuit 7.2. Record calculation in Table 7.6
27. Find the percentage of difference between the measured and calculated voltage. Record the result in Table 7.6

	Voltage Source, Vs	**Voltage across $R_1 = 100\Omega$**	**Voltage across $R_2 = 330\Omega$**	**Voltage across $R_3 = 220\Omega$**	**Voltage across $R_4 = 470\Omega$**
Measured Value					
Calculated Value					
% Difference					

Table 7.6 Voltage Analysis in a Series-Parallel Circuit, Circuit 7.2

28. Turn OFF the power supply, disassemble the circuit and place your component in their respective kit.

Questions

1. A student built Circuit 7.1 and measured the voltage through each resistor. The student measured 9 V for all three resistors. What was the mistake that the student made? Explain your answer.
2. A student built Circuit 7.2 and measured the total resistance using a DMM. The recorded total resistance was around 101 Ω. What was the mistake that the student made? What should the student do to measure total resistance correctly? Explain your answer.
3. For Circuit 7.2, if a student measured the current through R_1, R_2, and R_3 and found that they were the same current. Just by observation, how can you justify that the measured currents are wrong?

Answers:

Student's Signature:______________ Lab Instructor's Signature_______________Date: _______

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