Lab 6 Series - Parallel dc Circuits

Name ______________________________ **Section** ______

PURPOSE

To experimentally demonstrate the characteristics and laws associated with direct current series-parallel circuits.

EQUIPMENT

LAB SUPPLIED PARTS SERIAL NUMBERS

DC power supply ____________________

DMM ____________________

PARTS KIT PARTS

Resistors a 2.2 kΩ, 3.3 kΩ, a 4.7 kΩ and two 1kΩ ¼ watt
Set of meter leads
Set of clip to clip jumper leads

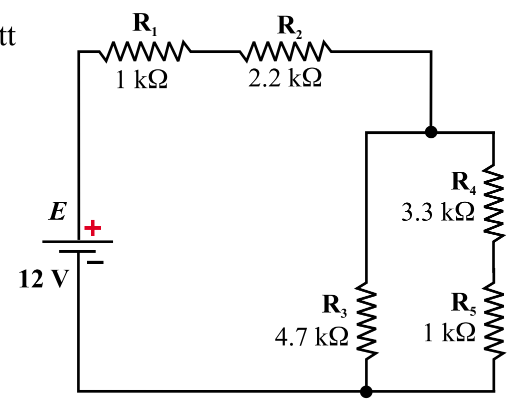

Fig 1 Series - Parallel Circuit

INTRODUCTION

The principles used to analyze series and parallel circuits are also utilized to analyze basic series-parallel circuits. These principles are used to simplify the portions of the circuit that are purely parallel or purely series. The equation for the equivalent resistance of Figure #1 is:

$$R_T = R_1 + R_2 + (R_3 \,\|(R_4 + R_5))$$

Inserting an Open Circuit Example 1

In Figure 2, an open circuit has been inserted as shown. The current through the resistor R_3 drops to zero.

The equivalent circuit not longer contains a parallel combination.

The equivalent circuit is shown to the right. As you can see, it is a series circuit. The equation for the equivalent resistance is:

$$R_T = R_1 + R_2 + R_4 + R_5$$

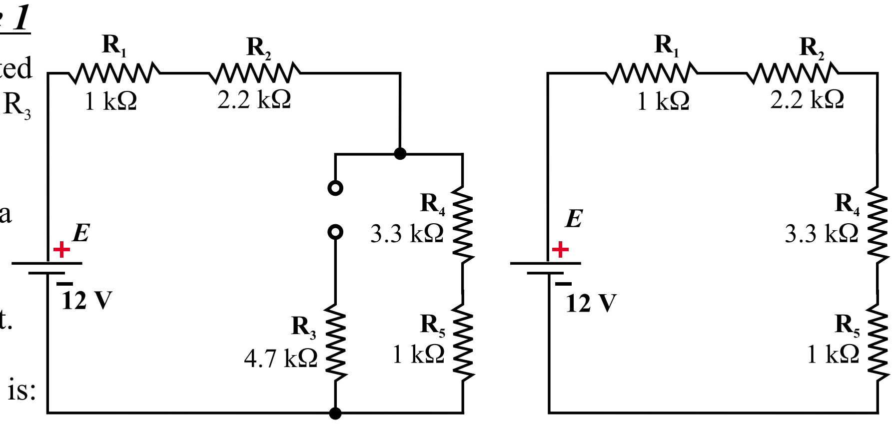

Fig 2 Inserted Open Circuit <u>equals</u> This equivalent Circuit

Inserting an Open Circuit Example 2

In Figure 3, an open circuit has been inserted in the series section of the circuit as shown. The current through ***the entire circuit will drop to zero.***

The equivalent circuit is an open circuit as shown

$$R_T = \infty$$

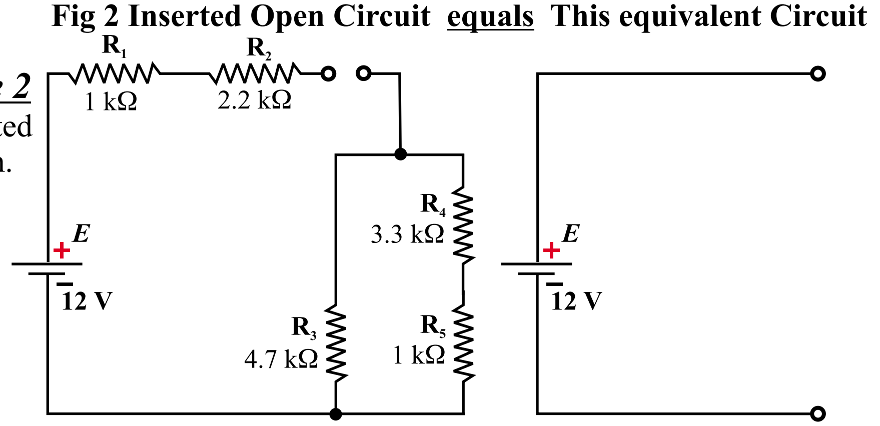

Fig 3 Inserted Open Circuit <u>equals</u> This equivalent Circuit

Inserting Short Circuit Sererio 1

In Figure 3(a), a short circuit has been placed around R_2. Note that R_2 is in the ***series section*** of this circuit.

R_2 now acts as a wire with zero resistance and is "shorted out". We can replace it with a wire as shown in Figure 3(b).

Note that the new circuit simply has R_2 replaced with a wire.

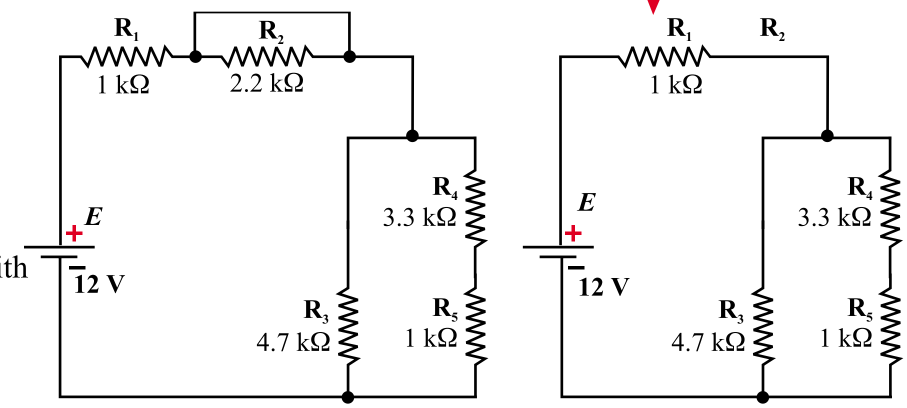

Fig 3a Inserted Short Circuit <u>equals</u> 3b This Circuit

Inserting Short Circuit Senerio 2

In Figure 4(a), a short circuit has been placed around R_3. Note that R_3 is in the ***parallel section*** of this circuit.

R_3 now acts as a wire with zero resistance and is "shorted out" by replacing it with a wire.

We know that most of the current will always follow the path of least resistance. In this case the left leg of the parallel section of the circuit has a resistance of zero.

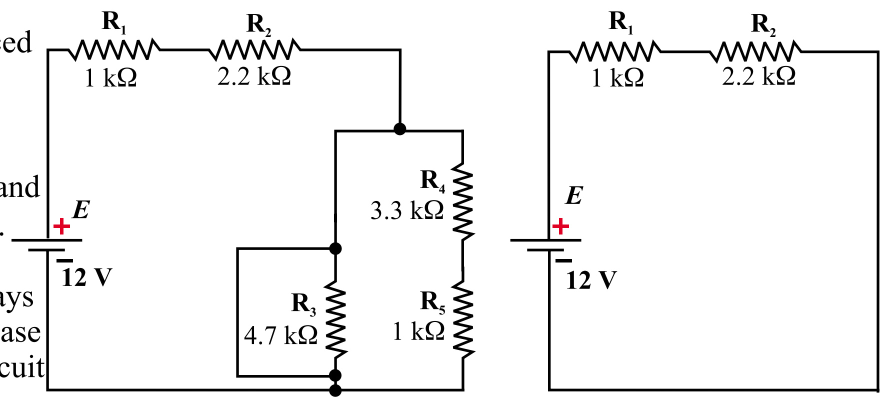

Fig 4a Inserted Short Circuit <u>equals</u> 4b This Circuit

Therefore all of the current will follow the path of zero resistance. This gives us the circuit shown in 4(b)

Power in a Resistive Circuit

The total power into a resistive dc circuit is equal to the sum of the power dissipated in the individual resistive components.

$$\mathbf{P_{supply} = P_1 + P_2 + P_3 + \ldots P_N}$$

Procedure

1) Use the nominal values of the resistors shown in Figure 5 to calculate and record the equivalent circuit resistance and the total circuit current. ***Show your work***

Note that this the same circuit as shown in Figure 1 without the power supply.

We know that the equation for this circuit is:

$$\mathbf{R_T = R_1 + R_2 + (R_3 \,||\, (R_4 + R_5))}$$

Use the procedure that follows:

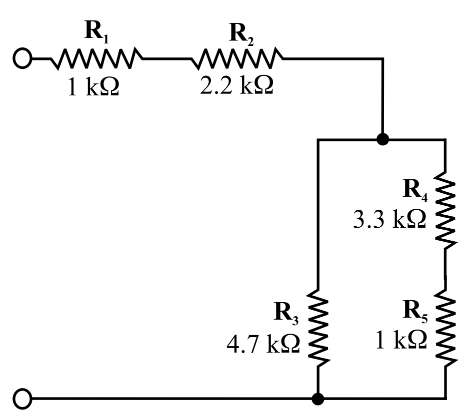

Fig 5 Series - Parallel Circuit

Finding R_T

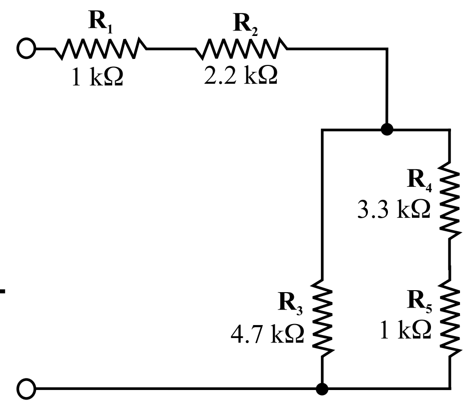

Fig 5 Series - Parallel Circuit

Solve the parallel part of the equation first.

$$\mathbf{R_T = R_1 + R_2 + R_3 + (R_3 \,||\, (R_4 + R_5))}$$

a) Find $R_4 + R_5$ ____________

b) Find **the equivalent parallel resistance** R_3 || a) above ____________

c) Find R_T
Add $R_1 + R_2$ + **the equivalent parallel resistance** ____________

2) Build the circuit shown in Figure 5.
Use the DMM to measure the t***otal resistance*** of the circuit.
Why should it be within 5% of the value you calculated.?

Measured R_T ______________________

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3) Add the power supply as shown in Figure 6. Set it for 12 V and then measure the circuit current.

Measured I_T ______________________

4) Calculate the circuit current using Ohm's law using the value of R_T that you found above. ***Show your work.***

Calculated I_T ______________________

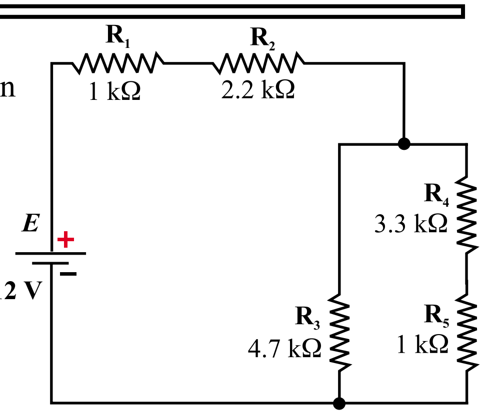

Fig 6 Series - Parallel Circuit

Power in a Series Parallel Circuit

1) Make sure that the power supply is set for 12 V. Once the voltage has been set, to not change the power supply controls for the remainder of the lab.

2) Measure the voltage and current for each of the resistors in the network record these values in Table 3 below.

3) Use the measured values of current and voltage to calculate and record the power dissipated in each of the resistors.

Table 3 Measured Resistor Current and Voltage

Resistor	Current	Voltage	Power
R_1	$I_1 =$	$V_1 =$	$P_1 =$
R_2	$I_2 =$	$V_2 =$	$P_2 =$
R_3	$I_3 =$	$V_3 =$	$P_3 =$
R_4	$I_4 =$	$V_4 =$	$P_4 =$
R_5	$I_5 =$	$V_5 =$	$P_5 =$

Power in a Series Parallel Circuit

4) Use the supply voltage and current to calculate the power delivered to the circuit. ($E\ I_T$)

5) Calculate the total power dissipated by adding the individual resistor powers shown in Table 3.

Power drawn from supply (from 4) ________________

Power dissipated in all the resistors (from 5) ________________

How does the power delivered compared to the total power dissipated ? ________________________

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Inserting an Open Circuit Example 1

1) Insert the open circuit into your circuit as shown in Figure 7. This is the same circuit that a shown in Figure 2.

2) Calculate the total resistance of the circuit and record it below.

3) Calculate the total resistance of the circuit and record it below.

Calculated R_T ____________________

Measured R_T ____________________

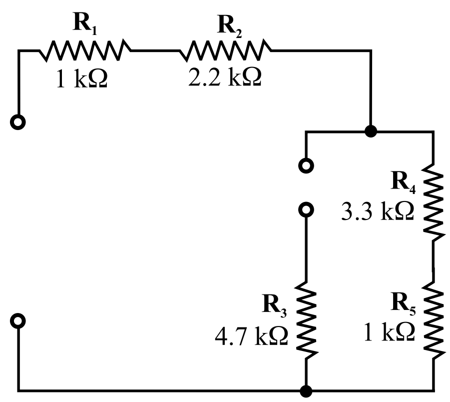

Fig 7 Insert this open circuit

Inserting an Open Circuit Example 2

1) Insert the open circuit into your circuit as shown in Figure 8.

2) Calculate the total resistance of the circuit and record it below.

3) Calculate the total resistance of the circuit and record it below.

Calculated R_T ____________________

Measured R_T ____________________

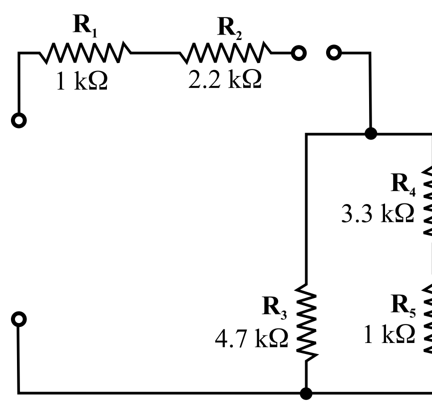

Fig 8 Insert this Open Circuit

Inserting Short Circuit Example 1

1) Insert the short circuit into your circuit as shown in Figure 9.

2) Calculate the total resistance of the circuit and record it below.

3) Calculate the total resistance of the circuit and record it below.

Calculated R_T ____________________

Measured R_T ____________________

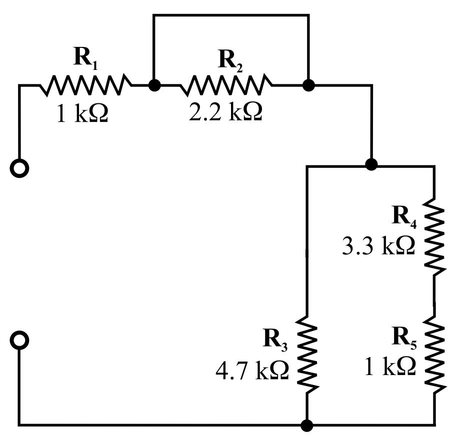

Fig 9 Insert this Short Circuit

Inserting Short Circuit Example 2

1) Insert the short circuit into your circuit as shown in Figure10.

2) Calculate the total resistance of the circuit and record it below.

3) Calculate the total resistance of the circuit and record it below.

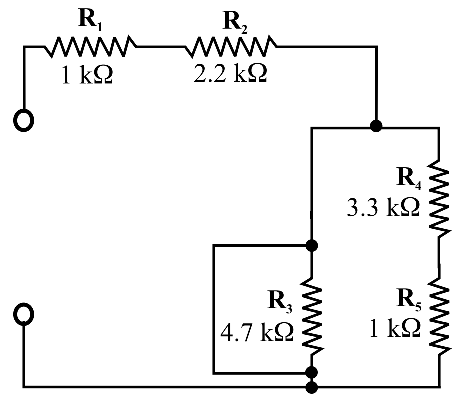

Fig 10 Insert this Short Ciruit

Calculated R_T ______________________

Measured R_T ______________________

Electronic Workbench

1) Use Electronics Workbench to simulate the circuit shown in Figure #1. All the resistor currents and voltages can be measured by putting three ammeters and five voltmeters in the circuit. Make sure the meters are connected using the correct polarity. The thicker border on the meter indicates the negative side.

2) Modify the circuit description to show your name and section number. Print out the description and the circuit showing the meter readings.
Staple the printout as the last page of this lab and hand it in.

3) Record the currents and voltages in Table 2.

4) Use the current and voltage values from Table 2 to calculate and record the power dissipated in each of the resistors. Show a sample calculation below the table. Use the supply voltage and total current to calculate the power delivered (P_{SUPPLY}). Also calculate the total power dissipated (P_T) by adding all the individual resistor powers in table #1.

Table 2 Workbench Resistor Current and Voltage Values

Resistor	Current	Voltage	Power
R_1	I_1 =	V_1 =	P_1 =
R_2	I_2 =	V_2 =	P_2 =
R_3	I_3 =	V_3 =	P_3 =
R_4	I_4 =	V_4 =	P_4 =
R_5	I_5 =	V_5 =	P_5 =