MARINE INSTITUTE

Electrotechnology 1100

Experiment 4
Parallel Circuits - Kirchhoff's Current Law

SAMPLE CALCULATIONS:

Using your own data, provide one worked sample of each formula used in this Lab.

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$$

Table 4-2, Step A4

$$R_T = \frac{V_T}{I_T}$$

Table 4-3, Step B4

$$I_T = I_1 + I_2 + I_3 + I_4$$

Table 4-3, Step B10

BASIC INFORMATION

A parallel circuit is defined as a circuit where components are connected so that the current has more than one possible path. Since there are multiple paths, the current can be different through each component, which means the total current will increase. This implies that the circuit's total resistance has decreased.

The rules for parallel circuits gives the formula for total resistance in a parallel circuit as:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$$

Kirchhoff's Current Law (KCL) states the algebraic sum of all currents entering and leaving a junction is zero. For a parallel circuit, this means:

$$I_T = I_1 + I_2 + I_3 + ...$$

This Experiment will attempt to prove these relationships.

OBJECTIVES:

When you have completed this experiment, you should be able to:

- Measure the total resistance of a parallel circuit.
- Measure the total voltage of a parallel circuit.
- Measure the total current of a parallel circuit.
- Verify the total resistance of a parallel circuit by Ohm's law.
- Measure the branch currents of a parallel circuit.
- Verify Kirchhoff's Voltage Law.

EQUIPMENT & MATERIALS REQUIRED:

Power Supply:	0-60/70V dc.
Instruments:	Analog Ohmmeter.
	Analog Voltmeter.
	Analog Milliammeter.
Resistors:	1000Ω.
	1200Ω.
	2200Ω.
	3300Ω.
Miscellaneous:	Orange board.
	3 Black Alligator Clip to Banana Plug test leads.
	3 Red Alligator Clip to Banana Plug test leads.
	Quick clips.

WHAT YOU SHOULD KNOW

In the previous Experiments, pictorial drawings were used in conjunction with schematic diagrams to help you become familiar with the Lab equipment and connect up your circuits. Typically, Experiments just use schematic diagrams.

So from this point, we will use schematic diagrams. If you need to, you can always go back and look at the earlier Experiments.

But at times, pictorial diagrams will be used to accelerate learning.

PROCEDURE:

PART A: Total Resistance of Parallel Resistors.

A1. Measure the actual resistance of your resistors with your analog ohmmeter and record the results in Table 4-1.

A2. Calculate the total resistance, using the **MEASURED** values of resistance from Table 4-1 and Formula 1, and enter the value in Table 4-2.

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots \qquad \textit{Formula 1.}$$

TIP

If you have 545.4Ω for your calculated R_T, odds are that you did not follow Step A2.

A3. Connect R_1 and R_2 in parallel as shown in the Figure 4-1. Measure the total resistance across the combination and record in Table 4-2.

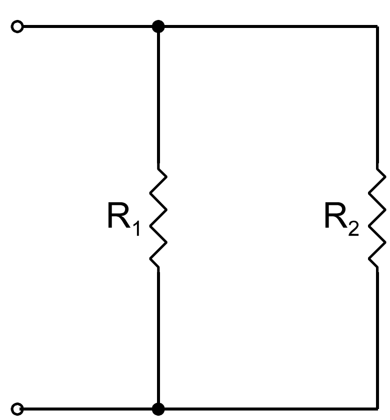


Figure 4-1

A4. Connect the circuit shown below in Figure 4-2.

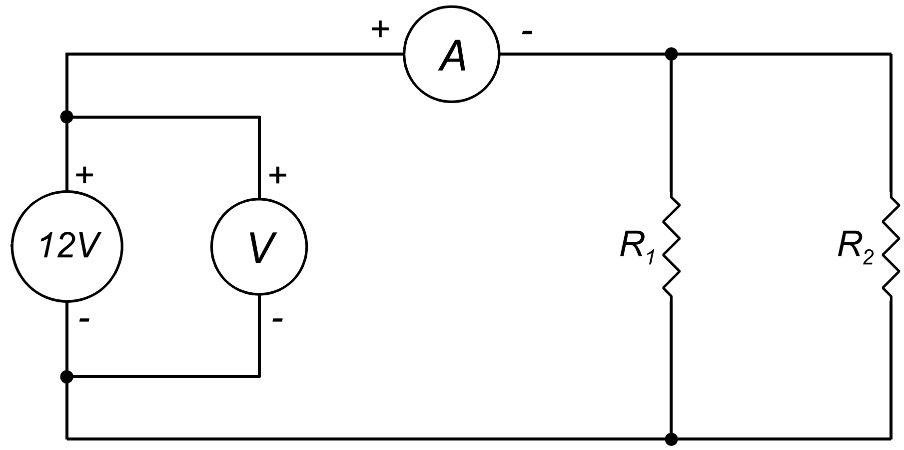


Figure 4-2

A5. Turn on the power supply.

A6. Adjust the voltage to 12V using the voltmeter. Record the value in Table 4-2.

A7. Measure the current using the ammeter. Record the value in Table 4-2.

Start off on the 50mA scale. Get an approximate reading to select a scale. Decrease the scale to obtain an accurate reading. Remember, the more deflection on an analog scale, the greater the accuracy.

> **TIP**
>
> Do not read voltage and current off of the power supply (≈20% error).
>
> Use Voltmeter and Ammeter to measure Voltage and Current!

A8. Use Ohm's Law (Formula 2) and calculate the total resistance of the series circuit from the measured values of voltage and current and record in Table 4-2.

$$R_T = \frac{V_T}{I_T} \qquad \textit{Formula 2.}$$

A9. Turn off the power supply.

A10. Repeat Steps A2-A9 for the other parallel combinations of Table 4-2.

A11. **Have a demonstrator check your results before disconnecting the circuit.**

PART B: Kirchhoff's Voltage Law.

B1. Connect the circuit shown in Figure 4-3.

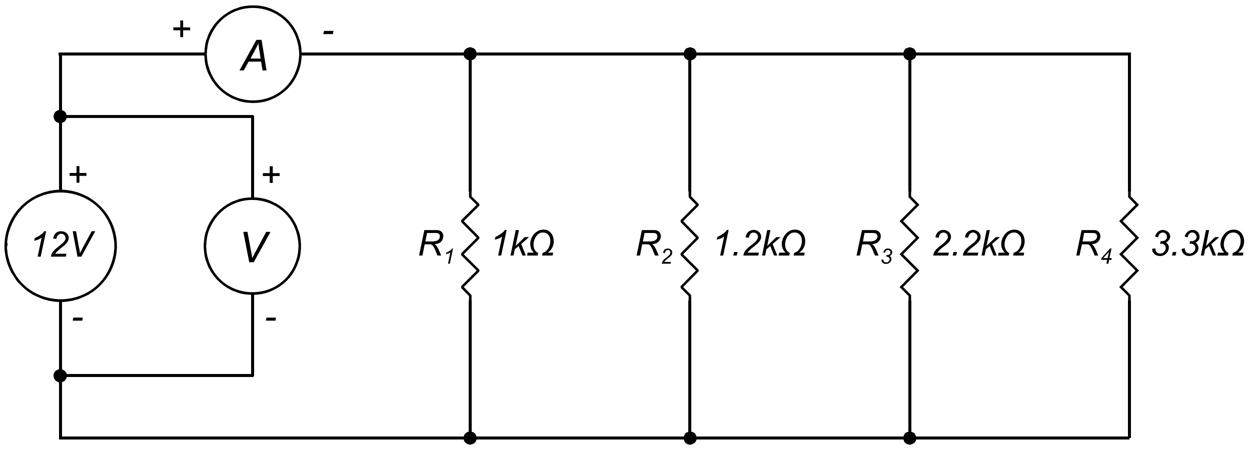


Figure 4-3

B2. Using the total resistance from Table 4-2 for Combination 3, calculate the current using Ohm's Law and record the value in Table 4-3.

B3. Calculate the branch current for each resistor using the **MEASURED** values from Table 4-1 and Ohm's Law and record the values in Table 4-3.

B4. Turn on the power supply.

B5. Adjust the voltage to 12V using the voltmeter. Record the value in Table 4-3.

B6. Measure the total current using the ammeter. Record the value in Table 4-3.

B7. Turn off the power supply and move the ammeter to measure the branch current of each of the resistors. Figures 4-4 and 4-5, show you how to connect the ammeter to measure I_1.

You have to break the circuit to insert the ammeter. Remember to reconnect the resistor when you move to another resistor.

Use your calculations in Step B3 to select the appropriate range for the ammeter. Between 10mA-25mA, use 25mA scale. Between 5mA-10mA, use 10mA scale. Less than 5mA, use 5mA. If $\approx$10mA (maximum of a range), use the 25mA scale (next larger scale) to see if the actual measurement is above or below 10mA. If below 10mA, switch to the 10mA scale to improve accuracy. More deflection equals greater accuracy on an analog meter.

B8. Turn on the power supply and measure the branch current of each of the resistors using the ammeter. Record the values in Table 4-3. Repeat Steps B7 and B8 for the other resistors.

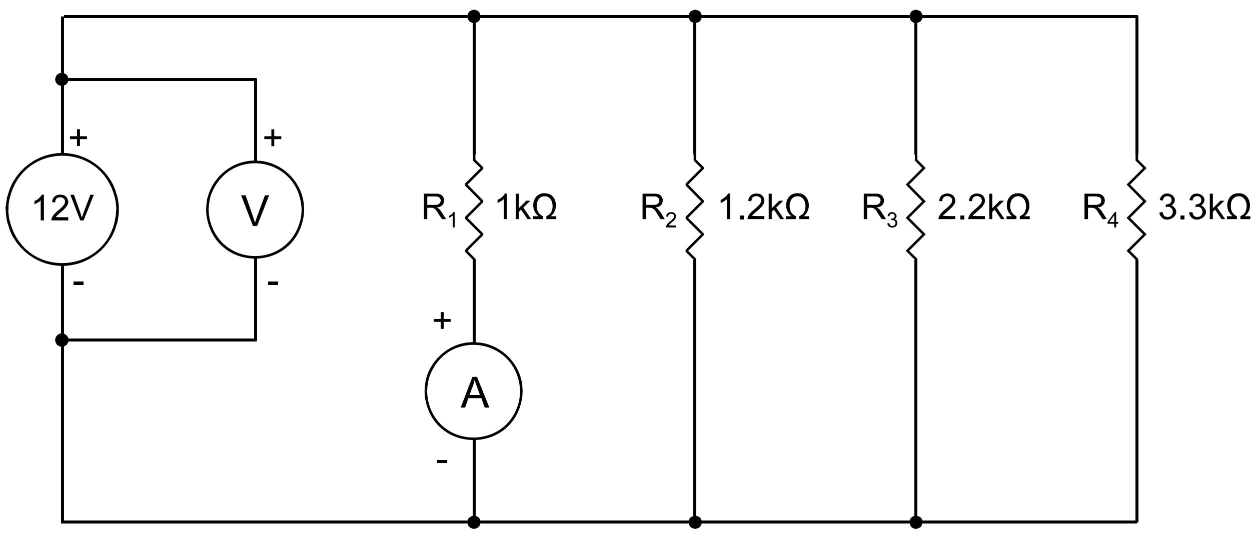
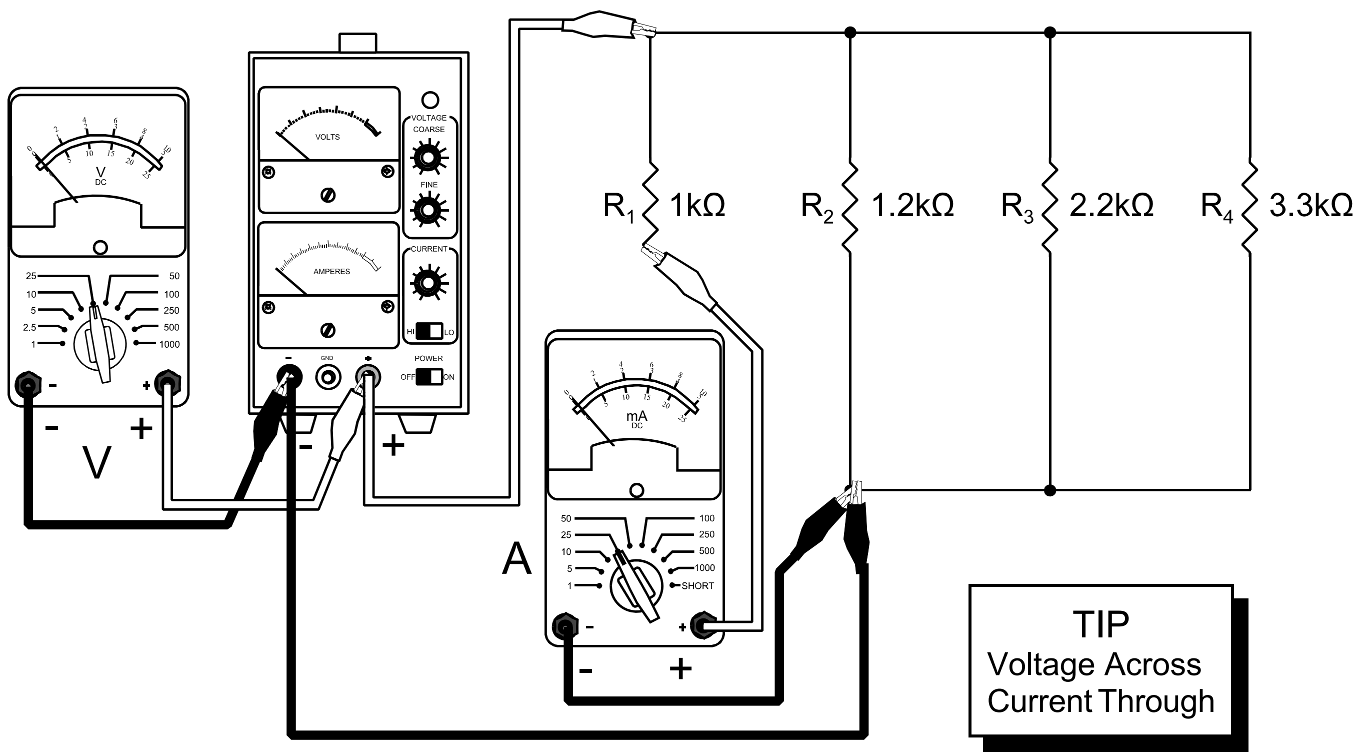


Figure 4-4



TIP
Voltage Across
Current Through

Figure 4-5

B9. Calculate Kirchhoff's Current Law for the parallel circuit using Formula 3 and your measurements, and record this data in Table 4-3.

$$I_T = I_1 + I_2 + I_3 + I_4 \qquad \textit{Formula 3.}$$

B10. **Have a demonstrator check your results before disconnecting the circuit.**

B11. Disconnect your circuit and return all equipment to it's proper place.

RESULTS:

Table 4-1 Measured Resistances

Coded Value	1kΩ	1.2kΩ	2.2kΩ	3.3kΩ
Measured Value				

Table 4-2 Total Resistance of Parallel Circuits

	R_1	R_2	R_3	R_4	R_T (Ω) calc	R_T (Ω) meas	V_T (V) meas	I (mA) meas	R_T (Ω) calc
1	1kΩ	1.2kΩ							
2	1kΩ	1.2kΩ	2.2kΩ						
3	1kΩ	1.2kΩ	2.2kΩ	3.3kΩ					
4	1.2kΩ	2.2kΩ	3.3kΩ						
5	2.2kΩ	3.3kΩ							
Step					A2	A3	A6	A7	A8

Table 4-3 Kirchhoff's Current Law

	V_T (V)	I_T (mA)	I_1 (mA)	I_2 (mA)	I_3 (mA)	I_4 (mA)	I_T (mA)
calc	12						
Step		B2	B3				
meas							
Step	B5	B6	B8				B9

QUESTIONS:

1. What is the relationship between branch or parallel resistors and total resistance of resistors in parallel? Write the relationship as a mathematical formula.

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2. Direct measurement measures the value directly, while indirect measurement derives the value from other measurements. Consider your results for the total resistance in Steps A2, A3 and A8 of Table 4-2.

Which of these are direct or indirect measurements? What impact does indirect measurement have on possible sources of error as compared to direct measurement?

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3. What effect does increasing the number of resistors in parallel have on the total resistance? Refer to your measurements to support your answer.

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4. What effect does increasing the number of resistors in parallel have on the total current? Refer to your measurements to support your answer.

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5. What is the relationship between branch currents and total current in a parallel circuit? Express this relationship as a mathematical expression.

Does your results from Steps B6 and B9 confirm this relationship? Explain any discrepancies.

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As preparation for next week's lab, you can complete Table 5-1 in Experiment 5 (p49). See Step 1 (p48).

Calculation Checkpoints:
$R_T = 1801\Omega$, $V_3 = 7.23V$, $I_6 = 4.01mA$

Although it may seem easiest to get the answers from another student, this is a prime opportunity to get help to understand a key course concept. If you attempt the circuit and bring your workings to the Lab, it is typically easy for demonstrators to help you get to the next level of understanding.