PE
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# Parallel Circuits, Kirchhoff's Current Law, and Current Divider Rule

Updated 5 Jun 09

*A Practical Exercise* Name:_____ Section: _____

## I. Purpose.

1. Review voltage subscript notation and the measurement of voltages as designated by their subscripts.
2. Introduce the concept of elements that are connected in parallel.
3. Introduce the construction of a DC parallel circuit.
4. Introduce voltage across parallel elements.
5. Introduce the calculation of total resistance of resistive elements connected in parallel.
6. Introduce the application of Kirchhoff's Current Law in the analysis of a DC parallel circuit.
7. Introduce the application of the Current Divider Rule in the analysis of a DC parallel circuit.

## II. Equipment.

**Agilent 34401A** Digital Multimeter (DMM)
**Agilent E3620A** Dual DC Power Supply
Quad Board and Test Leads
560 Ohm resistor
1000 Ohm resistor
220 Ohm resistor

## III. Preparation.

Review procedures for measuring resistance, voltage, and current.

## IV. Lab Procedure.

**Step One:** Construct a DC parallel circuit.

☐ On a QUAD board construct the DC parallel circuit in figure 1. Notice the suggested spacing of the layout allows you to easily measure current through each parallel branch without rebuilding your circuit following each measurement.

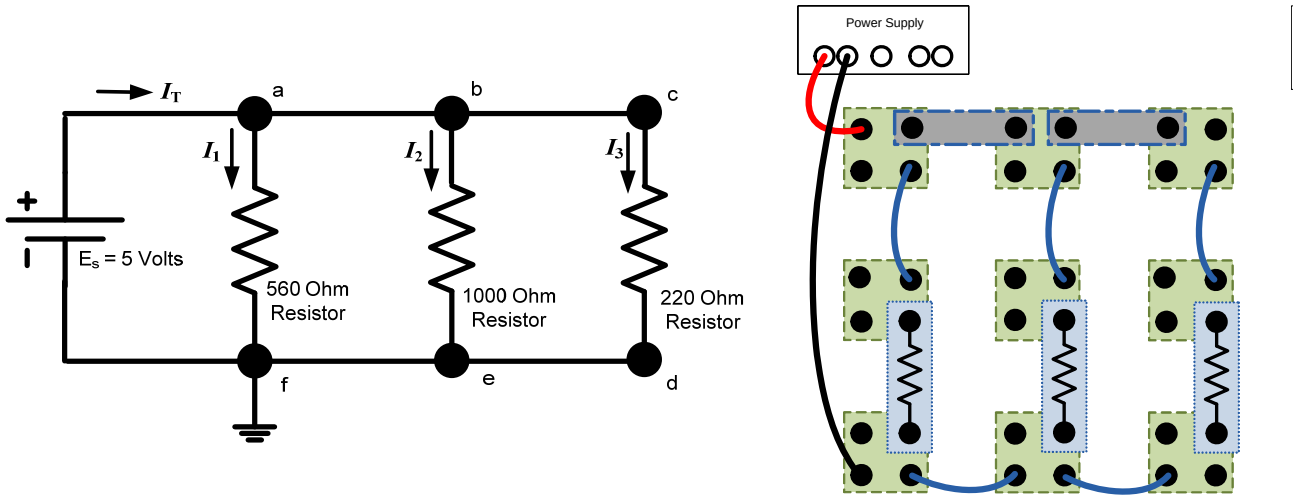


Figure 1

**Step Two:** Verify voltages of parallel elements and Kirchhoff's current law.

Elements or branches are said to be connected in parallel when they have exactly two nodes in common, and therefore voltages across all parallel elements in a circuit will be the same. Kirchhoff's current law states that the summation of currents entering a node is equal to the summation of currents leaving that node.

☐ Measure the voltages and currents indicated in the table below.

Remember the current that you wish to measure must pass through the DMM. It may be difficult to visualize how to measure the current through each resistor. Figure 2 depicts the measurement of current through the 2200 ohm resistor. Use this figure as a guide for your other current measurements.

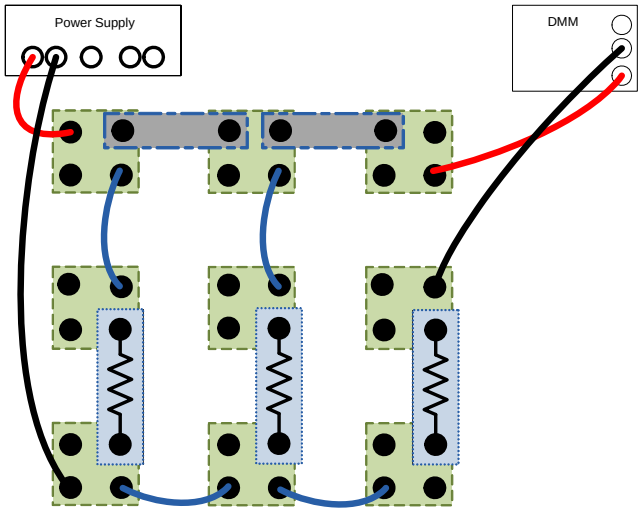


Figure 2

| | **Measured voltage values** | | **Measured current values** |
|---|---|---|---|
| $\mathbf{E_s}$ | | $\boldsymbol{I_T}$ | |
| $\mathbf{V_{af}}$ | | $\boldsymbol{I_1}$ | |
| $\mathbf{V_{be}}$ | | $\boldsymbol{I_2}$ | |
| $\mathbf{V_{cd}}$ | | $\boldsymbol{I_3}$ | |

Are your measured DC voltage values the same? _____

Why? _____

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☐ Indicate in Figure 3 the direction of the DC currents in all branches and the polarity of the DC voltages across the voltage source and resistors.

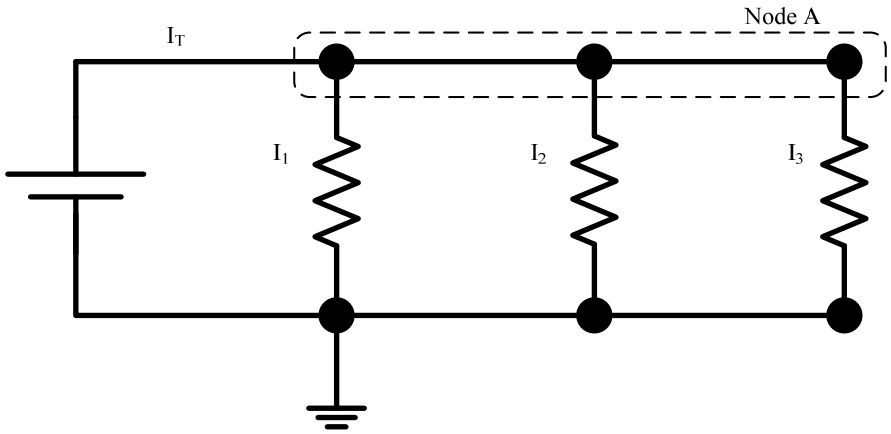


Figure 3

☐ Verify Kirchhoff's Current Law for Node A in the above figure.

$$\Sigma\, I_{\text{entering node}} = \Sigma\, I_{\text{leaving node}}$$

$$\Sigma \_\_\_\_\_ = \Sigma \_\_\_\_\_$$

Do your measured DC current values verify KCL? _____

**Step Three:** Resistors in parallel.

☐ Calculate the equivalent resistance, $R_{EQ}$, as seen by the source.

$$R_{EQ(calculated)} = \_\_\_\_\_$$

☐ Measure the equivalent reistance $R_{EQ}$, as seen by the source. Ensure that you disconnect the power supply before measuring the resistance.

$$R_{EQ(measured)} = \_\_\_\_\_$$

For this parallel circuit, how does the size of $R_{EQ}$ compare with the sizes of the other resistors in the circuit? _____

If the same resistors were connected in series, would they have a greater equivalent resistance than the equivalent resistance of this parallel circuit? _____

**Step Four:** Current Divider Rule.

The current divider rule can be used to determine how current entering a node is split between the various parallel resistors connected to the node.

$$I_x = I_T \left( \frac{R_{EQ}}{R_x} \right)$$

$\boldsymbol{I_X}$ is the current through $\mathbf{R_X}$, $\mathbf{R_{EQ}}$ is the total resistance of parallel resistors, and $\boldsymbol{I_T}$ is the total source current entering the parallel circuit.

☐ Calculate the branch currents using the current divider rule, based upon your measured values of $\boldsymbol{I_T}$ and $\boldsymbol{R_{EQ}}$, and the given resistor values.

$$I_1 = I_T \left( \frac{R_{EQ}}{R_1} \right) = \qquad \left( \text{———} \right) =$$

$$I_2 = I_T \left( \frac{R_{EQ}}{R_2} \right) = \qquad \left( \text{———} \right) =$$

$$I_3 = I_T \left( \frac{R_{EQ}}{R_3} \right) = \qquad \left( \text{———} \right) =$$

For this parallel circuit, how does the measured value of branch currents compared to the calculated values? _____

From this practical exercise, what observation can we make about the relative values of resistance and the current flow through resistors? (Think of the phrase, “the path of least resistance”.) _____

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