Kirchhoff's Current Law Updated 30 AUG 2016

A Practical Exercise Name:__________________ Section: ______________

I. Purpose.

1. Review voltage subscript notation
2. Introduce the construction of a DC parallel circuit.
3. Introduce voltage across parallel elements.
4. Introduce the calculation of total resistance of resistive elements connected in parallel.
5. Introduce the application of Kirchhoff's Current Law in the analysis of a DC parallel circuit.

II. Equipment.

Keysight 34450A Digital Multimeter (DMM)
Agilent E3620A Dual DC Power Supply
560 Ohm, 1000 Ohm, 220 Ohm resistor

III. Pre-lab calculations. Show all work.

Step One: Determine total current I_{TOT} for the circuit of Figure 1.

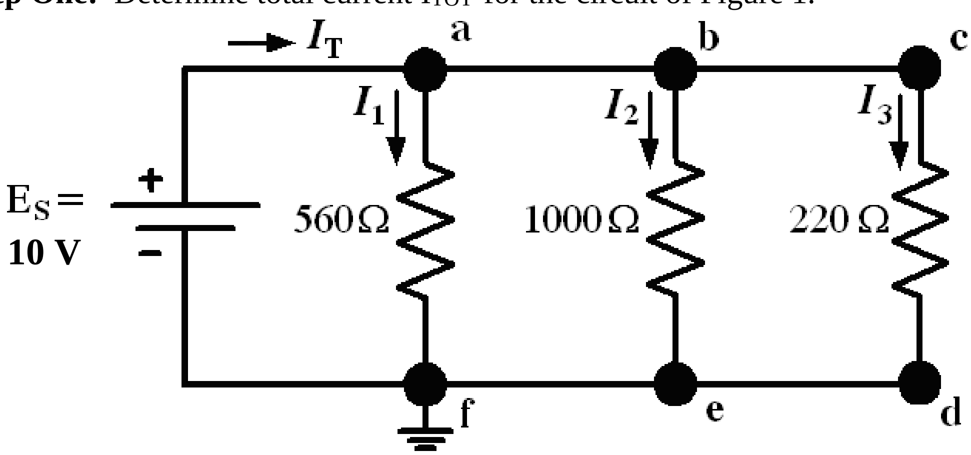

Figure 1

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

$R_{EQ(calculated)}$ = __________

☐ Calculate the total current I_T.

$I_{T(calculated)}$ = __________

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Step Two: Branch Current Calculations

Use Ohm's Law to calculate the current down each branch.

$$I_x = \left(\frac{E_S}{R_x}\right)$$

I_X is the current through $\mathbf{R_X}$. Use nominal (expected) values of resistances.

$$I_1 = \left(\frac{E_S}{R_1}\right) = \left(\frac{\quad}{\quad}\right) =$$ **I_1=** ______________

$$I_2 = \left(\frac{E_S}{R_2}\right) = \left(\frac{\quad}{\quad}\right) =$$ **I_2=** ______________

$$I_3 = \left(\frac{E_S}{R_3}\right) = \left(\frac{\quad}{\quad}\right) =$$ **I_3=** ______________

Now use the Current Divider Rule to calculate the current values.

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.

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

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

- ☐ Calculate the branch currents using the current divider rule, based upon your calculated values of I_T and R_{EQ}, and the nominal resistor values.

$$I_1 = I_T\left(\frac{R_{EQ}}{R_1}\right) = \left(\frac{\quad}{\quad}\right) =$$ **I_1=** ______________

$$I_2 = I_T\left(\frac{R_{EQ}}{R_2}\right) = \left(\frac{\quad}{\quad}\right) =$$ **I_2=** ______________

$$I_3 = I_T\left(\frac{R_{EQ}}{R_3}\right) = \left(\frac{\quad}{\quad}\right) =$$ **I_3=** ______________

Step Three: Verify Kirchhoff's Current Law (KCL).

Verify KCL by summing up the branch currents and comparing to the predicted total current from step one.

$$\sum I_{\text{entering node}} = \sum I_{\text{leaveing node}}$$
$$I_T = I_1 + I_2 + I_3$$
$$\_\_\_\_\_\_\_\_\_\_ = \_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_ = \_\_\_\_\_\_\_\_\_\_$$

How closely does the sum of currents entering the node match the sum leaving?

Exact__________ **Very close__________** **Very Different_________**

Step Four: Instructor or lab assistant verification that pre-lab calculations are complete.

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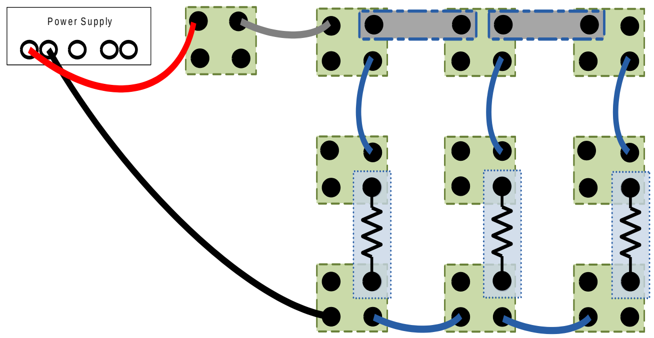
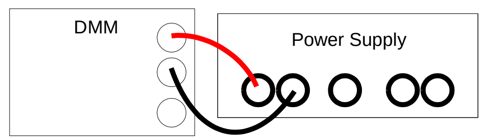
IV. Lab Procedure. Time Required: 40 minutes. **Check-off each step as you complete it.**

Step One: Construct a DC parallel circuit.

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



☐ Set the DC power supply to 10 volts. Verify the output of the power supply is accurate by measuring it with a DMM and adjusting the voltage as necessary.



NOTE: **You should always use a DMM when adjusting the settings on the power supply. The DMM provides a more accurate reading then the power supply's meter.**

Step Two: Verify voltages of parallel elements.

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.

☐ Measure the voltage drop across the voltage source and across each parallel branch.

$\mathbf{E_S}$= 9.99V

$\mathbf{V_{af}}$= 9.99V

$\mathbf{V_{be}}$= 9.99V

$\mathbf{V_{cd}}$= 9.99V

How closely do all the measured voltages match?

Exact_______ **Very close** X_______ **Very Different**_______

Why? VDR, Different current, same voltage drop, 3 different circuits...

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Step Three: Measure total and branch currents. Verify Kirchhoff's Current Law.

☐ Measure the total current and the current through each branch.

Remember the <u>current that you wish to measure must pass through the DMM</u>. This means you must insert an "OPEN" in the circuit, and measure current with the DMM wired into that opening. Figure 2 shows the measurement of the I_3 current through the 220 ohm resistor.

CAUTION:
IF YOU GET A YELLOW OVERLOAD LIGHT ON THE POWER SUPPLY, IT MEANS THAT YOU HAVE SHORTED ACROSS THE POWER SUPPLY WITH THE DMM.

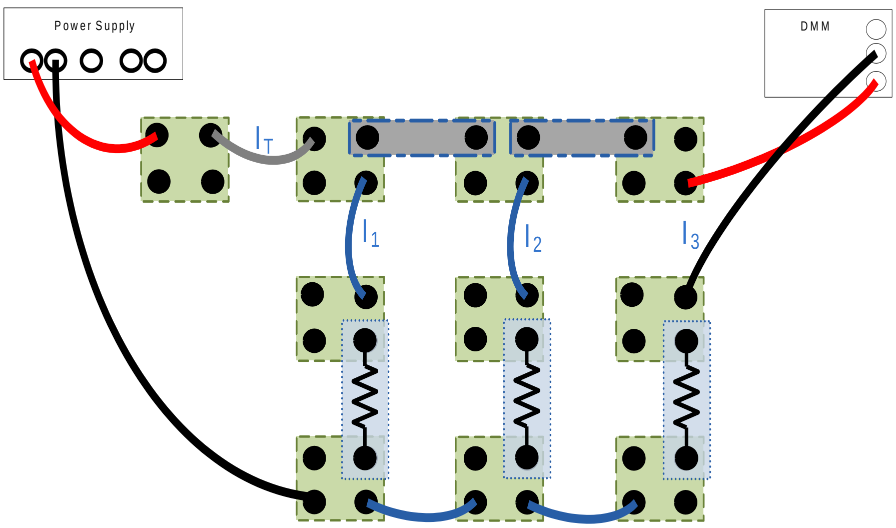

Figure 2

I_T= 73.3mA ____

I_1= 17.81mA ____

I_2= 9.9mA ____

I_3= 45.6mA ____

How closely do the measured branch currents match the predicted values from step two of the pre-lab calculations? <u>If they are substantially different, then you need to check your measurements or calculations for errors, and seek assistance from your instructor.</u>

Exact__________ **Very close** X__________ **Very Different**__________

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

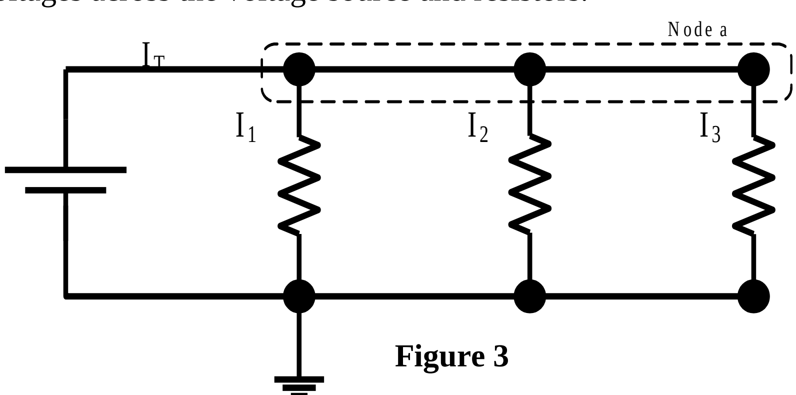

Figure 3

Kirchoff's Current Law

Kirchhoff's current law states that the summation of currents entering a node is equal to the summation of currents leaving that node.

☐ Verify Kirchhoff's Current Law for Node a in the above figure (calculations are required).

$$\sum I_{\text{entering node}} = \sum I_{\text{leaving node}}$$

$$I_T = I_1 + I_2 + I_3$$

73.3mA ______ = 9.9mA ______ + 45.6mA ______ + 17.81mA ______ = 73.31mA ______

How closely does the sum of currents entering the node match the sum leaving?

Exact__________ **Very close**X__________ **Very Different**__________

Step Four: Resistors in parallel.

☐ Measure the equivalent resistance $\boldsymbol{R}_{\mathbf{EQ}}$, as seen by the source. <u>Ensure that you disconnect the power supply</u> before measuring the resistance.

$\boldsymbol{R}_{\mathbf{EQ(measured)}}$ = 136 __________

How closely does the measured equivalent resistance match the predicted value from step one of the pre-lab calculations?

Exact__________ **Very close**x__________ **Very Different**__________

For this parallel circuit, how does the size of $\boldsymbol{R}_{\mathbf{EQ}}$ compare with the sizes of the other resistors in the circuit?

Larger__________ **Smaller**X__________ **Same**__________

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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