PE 7

Nodal Analysis

(Updated 9/15/2009)

A Practical Exercise Name:__________________ Section: _____________

I. Purpose.

1. Review the concept of voltage subscripts.
2. Introduce the use of two voltage sources in a DC series/parallel circuit.
3. Introduce to the application of nodal analysis in determining multiple unknown node voltages and branch currents in a DC series/parallel circuit.

II. Equipment.

Agilent 34401A Digital Multimeter (DMM)
Agilent E3620A Dual DC Power Supply
Quad Board and Test Leads
560, 1000, 1500, 2000 Ohm resistors

III. Lab Procedure. You must <u>**read**</u> and complete each step.

Step One: Construct a DC series/parallel circuit.

☐ Measure the values of each resistor and record in Table 1.

	560-Ω	1000-Ω	1500-Ω	2000-Ω
Measured Values				

Table 1

☐ On a QUAD board, construct the DC series/parallel circuit in Figure 1. <u>Remember to arrange your circuit so that it will be easy to measure currents I_1, I_2, I_3, I_4, I_5.</u>

☐ Both V1 and V2 channels of your dual power supply will be used in this circuit. Pay close attention to the polarities of the voltage sources in Figure 1.

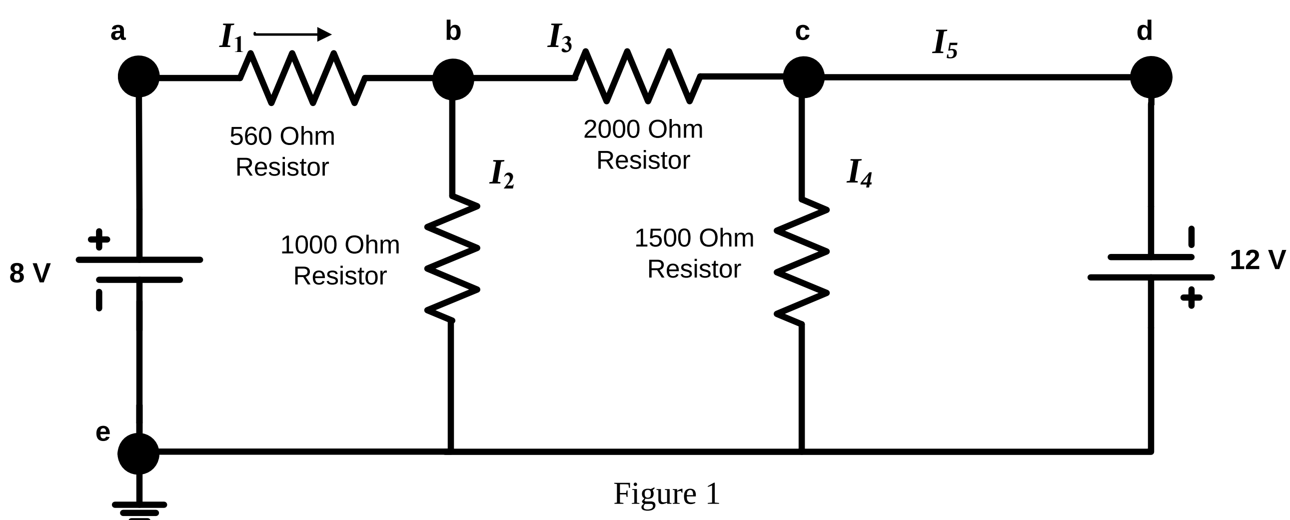

Figure 1

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Step Two: Nodal Analysis.

☐ Identify the voltage at each of the lettered nodes of Figure 1. Write the value or write "UNKNOWN" if this value must be calculated in Table 2.

V_a	V_b	V_c	V_d	V_e

Table 2

☐ Assume a direction for each current I_2 through I_5, and draw the current arrows on Figure 1.

☐ Using these assumed current directions, write the Kirchhoff's Current Law (KCL) equations at node *b*.

KCL @ b → ________________________

☐ Using Ohm's Law and the **measured** values of your resistors, write the equations for the branch currents below in terms of the single-subscript nodal voltages and resistors.

$I_1 =$ ____________________

$I_2 =$ ____________________

$I_3 =$ ____________________

☐ Using KCL equations and the equations for branch currents, write the nodal analysis equation for the voltage at node **b**:

☐ Solve this equation for the voltage at node **b** (showing work below). Write the result in table 3.

Step Three: Calculate branch currents.

☐ Using the predicted values of voltages for each of the lettered nodes in Figure 1 and the measured values of your resistors, calculate the current in each branch using Ohm's law or KCL. Fill in the results in Table 3.

> NOTE:
> **The current calculation is performed "tail to head".** Look at the current arrows you drew on Figure 1, and calculate the voltage across the resistor by subtracting the value at the "head" of the arrow from the value at the "tail". Look at I_1. The tail of the arrow is at V_a and the head of the arrow is at V_b.

$$I_1 = \left(\frac{V_a - V_b}{R_1} \right) = \left(\frac{\qquad}{\qquad} \right) =$$

$$I_2 = \left(\frac{\qquad}{R_2} \right) = \left(\frac{\qquad}{\qquad} \right) =$$

$$I_3 = \left(\frac{\qquad}{R_3} \right) = \left(\frac{\qquad}{\qquad} \right) =$$

$$I_4 = \left(\frac{\qquad}{R_4} \right) = \left(\frac{\qquad}{\qquad} \right) =$$

$$KCL\ @\ \mathrm{c} \rightarrow I_5 =$$

	Predicted values	**Measured values**
$\mathbf{V_b}$		
$\mathbf{I_1}$		
$\mathbf{I_2}$		
$\mathbf{I_3}$		
$\mathbf{I_4}$		
$\mathbf{I_5}$		

Table 3

Step Four: Measure voltages and currents.

- ☐ Measure the voltage at node **b**. Record the results in Table 3.
- ☐ Following the assumed current directions that you recorded on Figure 1, measure each of the currents I_1, I_2, I_3, I_4, I_5. Record the results in Table 3.

NOTE:

Polarity is important. When measuring current flow, the red lead on the DMM goes at the "tail" of the current arrow, and the black lead goes at the "head". For example, measure I_1 by placing the red lead on node **a**, and the black lead at the left end of the 560 ohm resistor. **Don't forget that you have to "break" the circuit to measure this current.** This should give you a positive current value.

- ☐ Does the voltage measured at node **b** match the predicted value? ____________________
- ☐ Does the polarity and values of your predicted and measured currents agree? ______

If your predicted and measured values are different by more then a 0.3 V or 0.3 mA, then you made a mistake. Review your calculations, paying close attention to the polarity of all voltage sources.

If the polarity of your currents was different then predicted, you should double check that you followed the "tail to head" calculation and measurement method. Determining proper polarity when measuring currents is just as important as determining the magnitude of the current.