Mesh and Nodal Analysis

Lab Objectives

1. To identify a circuit that cannot be solved using series/parallel reduction techniques.
2. To determine whether MESH or NODAL analysis is the preferred method to analyze such a circuit.
3. To use MESH or NODAL analysis to solve for voltages and currents in a moderately complex circuit.
4. To use standard circuit analysis and measurement techniques to verify the MESH currents or NODAL voltages in a moderately complex circuit.

Pre-Laboratory Preparation

Prior to your scheduled laboratory meeting time the following items need to be completed. The prelab quiz will be based on this preparation.

1. Carefully review the sections in the text regarding Mesh and Nodal analysis.
2. In Excel create one data table to hold the calculated and <u>measured voltage and current values</u> called out in the circuit shown in fig.1 (the three loop currents and the three node voltages) and another data table to hold the <u>calculated and simulated voltages</u> called out in fig.2 (the three node voltages and V_1 though V_6). Add a row or column in each table to record the % difference between the measured and calculated (or simulated and calculated) values.
3. Use the **Mesh** Analysis technique to <u>neatly</u> analyze the circuit shown in fig. 1. Note the Mesh currents I_1, I_2, and I_3 are shown in the circuit for consistency. Record the <u>calculated</u> voltages V_a, V_b, and V_c and the calculated current values I_1, I_2, and I_3 in your first data table from step 3 (don't forget to leave space for your measured values and % difference). Print this table for use in the lab.
4. Use the **Nodal** Analysis technique to <u>neatly</u> analyze the circuit shown in fig. 2. Note the Nodal voltages V_a, V_b, and V_c are located on the circuit for consistency. Record the <u>calculated</u> node voltages **and** V_1 through V_6 in your second data table from step 3 (don't forget to leave space for your simulated values and % difference). Print this table for use in the lab.

DC Circuits Lab Procedure

1. Build the circuit shown in fig. 1 using good protoboard techniques.
2. Carefully measure the node voltages and loop currents called out in the circuit.
3. Record each measured voltage and current in the first data table you created for the prelab.
4. Perform a % error calculation showing the difference between the measured and calculated values and record these results in your data table. Get your instructor's signature before continuing to step 5.
5. Using Multisim, Capture and simulate the circuit shown in fig. 2.
6. Record the simulated node voltages **and** V_1 through V_6 in the second data table you created for prelab.
7. Perform a % error calculation between the simulated and calculated values, and record these results in your data table.
8. **Get your instructor's signature**. Answer the questions after lab (discuss the answers with your lab partners) and before taking the postlab quiz.

Mesh and Nodal Analysis

Lab Note 1: Mesh Analysis

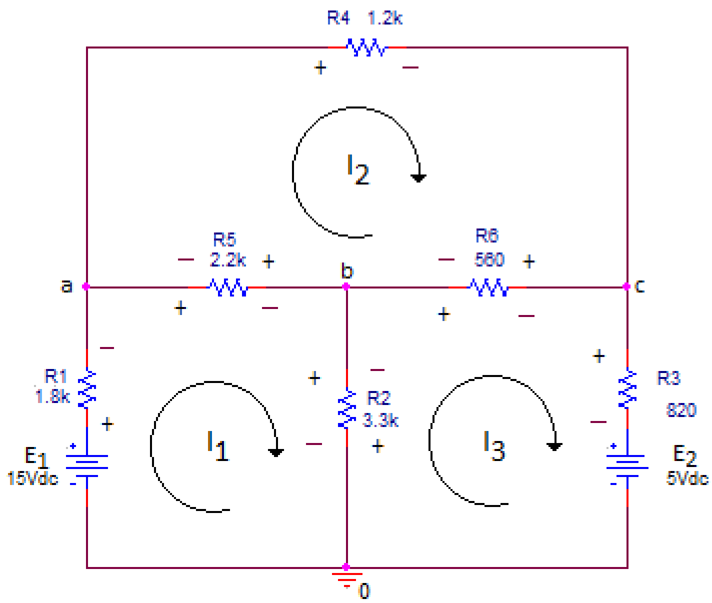

fig. 1

Mesh Analysis uses KVL to create n equations and n unknowns that are solved simultaneously. Note at left, the polarities of the resistor voltages are shown in each Mesh. First lay out the polarities, (already done here) then write down the value of each voltage in the Mesh in terms of the imaginary Mesh Current. Let's start with the I_1 Mesh. The voltage across R_1 is $\mathbf{R_1I_1}$ The voltage across R_5 is $\mathbf{R_5(I_1 - I_2)}$. The voltage across R_2 is $\mathbf{R_2(I_1 – I_3)}$. Now that all the voltages are defined, use KVL to write the KVL equation for the I_1 Mesh: $\mathbf{E_1 = R_1I_1 + R_5(I_1 - I_2) + R_2(I_1 – I_3)}$. Simplify that and you get the I_1 Mesh equation in standard form: $\mathbf{(R_1+R_2+R_5)I_1 - R_5I_2 – R_2I_3 = E_1}$. Note the resistor values and E1 are known values. All that is unknown is the Mesh currents. Now repeat his for the other 2 Meshes and you have 3 equations and 3 unknowns. Solve using your calculator.

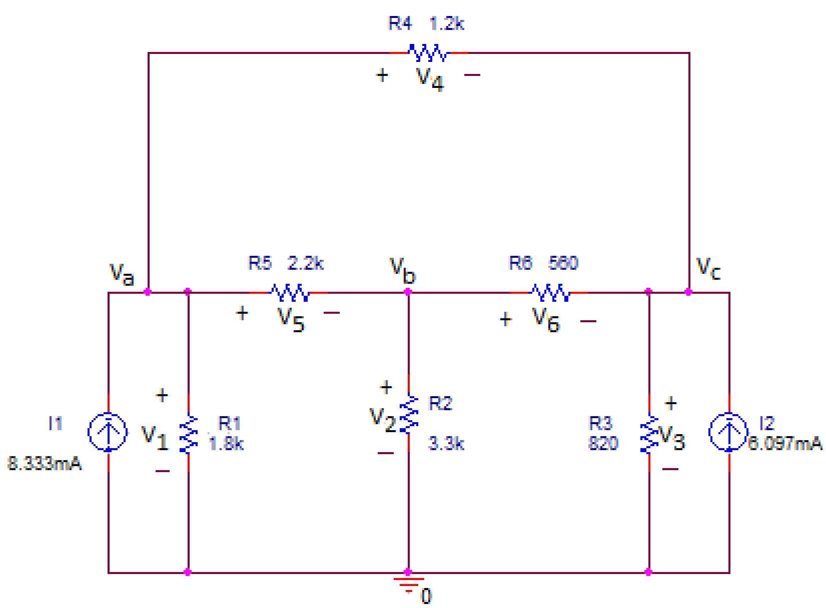

fig. 2

Note the circuit at left is the same circuit as fig.1 with the (practical) voltage sources changed to (practical) current sources. The voltages across the resistors R_2, R_4, R_5 and R_6 should be the same as in the Mesh analysis. Note that the voltages across R_1 and R_3 will not be the same as in the Mesh example because they were changed in the source conversion. When simulating this circuit, you'll "measure" the node voltages Va, Vb, and Vc and compare with your calculated values.

Have your lab work signed off. Work not bearing a signoff from your instructor or lab assistant will not be accepted for a grade.

Answer the questions that follow after your lab period and before you take the post-lab quiz.

Mesh and Nodal Analysis

Questions:

1. **After Lab:** Did any of your error calculations exceed 5%? If so, what are some possible causes for these errors? Explain.

2. **After Lab:** Using your laboratory measurements and standard circuit analysis techniques, verify that the loop current I_1 that you measured in fig. 1 is correct (Hint: think KVL).

Post Lab Requirements and app notes

After lab and after completing your submission packet, **during a time specified by your lab instructor**, take the post-lab quiz. You may use your prelab, lab work and data as references.

Submit your completed documentation at the beginning of next week's lab before you take that week's prelab quiz. Your team's submission package will be graded and returned with comments. **Submit ONLY the following (stapled together and in the following order) 4 pages:**

1) Your team cover sheet, completely filled in by EACH team member and with instructor signatures, one per team.
2) The schematic and your completed data table for fig. 1 on one page, showing calculated and measured values as well as % error calculations, one per team.
3) The schematic and completed data table for fig. 2, on one page, showing calculated and simulated values as well as % error calculations, one per team.
4) The answers to questions 1 and 2, answered neatly and thoughtfully on this page or restated and answered on a separate page, one per team.

Lab Note 2: Equivalence revisited

When Engineers describe 2 circuits, or circuit segments as being ***equivalent***, what they mean is that the 2 circuits react in the same way at 2 specific points. Between the points, the circuits may look very different, but whatever is attached to the 2 points, will cause exactly the same reaction. This is why you can convert a voltage source to a current source (or visa-versa) and have the resulting two circuits be *equivalent*. At the 2 points of interest, when you connect a load, the same thing happens for either circuit. Look at the circuits in fig. 1 and fig. 2. Notice that the voltages at points a, b, and c, relative to ground, in each circuit are the same. That's because the voltage sources E1 and E2 were converted to equivalent current sources. Even though the circuits are configured differently, the *response* to the two *equivalent* circuit segments is identical.

Remember, equivalent doesn't mean equal, it means equivalent. Like a dollar bill and 4 quarters for example, not equal, but equivalent.

Mesh and Nodal Analysis

Team Name and Lab Section:...

Team Members Present (printed)

First Name, Last Name	Role This Lab	RIT Program

TEAM LABORATORY GRADE

(All work complete, legible and properly organized. Both schematics and data tables included, accurate, properly annotated and titled. Q1 and Q2 answered accurately and clearly. Both signoffs in place, no missing or extraneous information.

Instructor Signature, MESH (Calc/Meas) _____	**/15**
Schematic/Data Table	**/10**
Instructor Signature, NODAL (Calc/Sim) _____	**/15**
Schematic/Data Table	**/10**
Questions	**/10**

Final Team Grade	**/60**

Instructor comments: