UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE
Department of Electrical and Computer Engineering

EXPERIMENT 8 – NETWORK ANALYSIS

OBJECTIVES

The purpose of this experiment is to mathematically analyze a circuit using different methods and to check their validity against measured data.

MATERIALS/EQUIPMENT NEEDED

Digital Multimeter
DC Power Supply
Resistors: 470Ω, 1kΩ (2), 5.1kΩ, 10kΩ

INTRODUCTION

The ability to analyze complex circuits is a necessary skill for design engineers. Four useful tools for network analysis are described in this laboratory. The methods that are going to be used are

- Kirchhoff's laws
- Mesh-Current Method
- Node-Voltage Method
- Superposition

Kirchhoff's Voltage Law (KVL): Kirchhoff's voltage-law states that the algebraic sum of voltages around any closed loop must be equal to zero. A common convention is to add up the voltages systematic in clockwise movement around the loop. A positive sign is assigned to the voltage across an element if the (+) side of the voltage is encountered first, and a negative sign if the (-) side is encountered first. Mathematically we have

$$\sum_{n=1}^{N} V_n = 0$$

where N is the total number of elements in the loop and V_n is the n^{th} voltage in the loop.

Kirchhoff's Current Law (KCL): Kirchhoff's current-law states that the algebraic sum of currents entering a node must be equal to zero. A common convention is to assign a positive sign to a current that is entering the node and a negative sign to a current that is leaving the node. Mathematically we have

$$\sum_{n=1}^{N} I_n = 0$$

where N is the total number of currents entering the node and I_n is the n^{th} current.

Mesh-Current Analysis: Analysis by mesh currents consists of defining the currents around the individual meshes as independent variables followed by the application of Kirchoff's voltage law around each mesh to obtain the desired system of equations to solve for the currents. The number of equations obtained is dependent on the number of meshes in the circuit. All the currents and voltages in the circuit can then be obtained using the mesh currents. The following outlines the procedure when using this method;

1. Label each mesh of the circuit with a mesh current, going in the clockwise direction.
2. Write KVL equations for each mesh. Expressing each voltage in terms of one or more mesh currents.
3. Solve the resulting system of equations with mesh currents as independent variables. This will give you all the mesh current values.
4. If you are asked to find a voltage or another current you can use Ohm's law or Kirchoff's laws to do it.

Node-Voltage Analysis: Analysis by node voltages consists of defining the voltage at each node as independent variables (one of which is selected as the reference) followed by the application of Kirchoff's current law on each node (except the reference node) to obtain the desired system of equations to solve for the node voltages. The number of equations obtained is one less than the number of nodes in the circuit. All the currents and voltages in the circuit can then be obtained using the node voltages. The following outlines the procedure when using this method;

1. Select the reference node (usually ground).
2. Label the remaining of the node.
3. Write KCL equations for each node (excluding the reference node). Expressing each current in terms of one or more node voltages.
4. Solve the resulting system of equations with node voltages as independent variables. This will give you all the node voltage values.
5. If you are asked to find a voltage or another current you can use Ohm's law or Kirchoff's laws to do it.

Superposition: Superposition is a process for calculating currents and/or voltages for a component in a circuit that has more than one source. Contributions to a particular current or voltage are calculate separately for each source and then algebraically added to give the final value. The method of superposition is valid only for linearly related quantities, and for example, is not an acceptable method for the calculation of power, a quantity proportional to the square of current or voltage. The following outlines the procedure when using this method;

1. Turn-off all sources except one by replacing a short-circuit for voltage sources and an open-circuit for current sources.
2. Apply any convenient analysis method to solve for the currents and/or voltages with that one source acting alone.
3. Repeat the process until all sources in the original circuit have been used.
4. The actual current and/or voltage for any one resistor will be the algebraic sum of the currents and/or voltages found on each case for that particular resistor.

PRELAB

1. For the circuit in Figure 8-1, use mesh analysis to calculate the mesh currents. Call your currents I_A, I_B, and I_C. Record these currents (magnitude and direction) in Table 8-2.
2. Having determined all mesh currents, calculate the current through (magnitude & direction) and the voltage across (magnitude & polarity) for each resistor. Record these values in the Tables 8-3 and 8-4 respectively.
3. Write and solve node voltage equations for the circuit of Figure 8-1, and then, solve for the current through (magnitude and direction) and the voltage across (magnitude and polarity) for each resistor. Record these values in Tables 8-3 and 8-4 respectively.
4. For the circuit of Figure 8-1 use superposition to calculate the current through and voltage across R2 (the resistor of interest). It is not required to do calculations for any resistor other than R2. Record the values in Tables 8-3 and 8-4 respectively.
5. Perform a computer simulation of the circuit using PSpice or Multisim, and use the results to find the current through (magnitude and direction) and the voltage across (magnitude and polarity) for each resistor. Record these values in Tables 8-3 and 8-4. Create a screenshot of the simulation showing the results, and include it in your prelab.

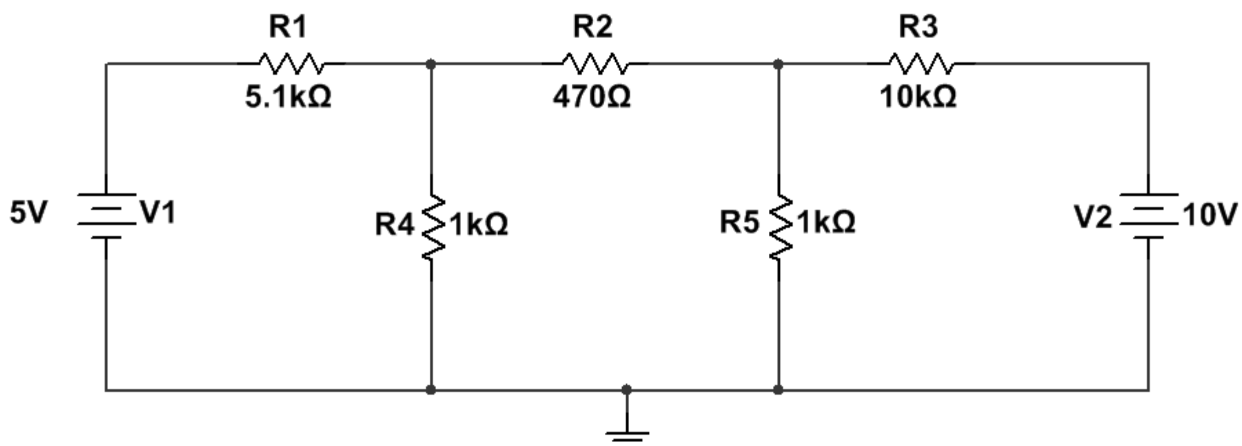

Figure 8-1 Circuit for testing

PROCEDURE

1. Select and measure resistors for your circuit (see Figure 8-1). Record the measured and color-code values in Table 8-1.
2. Build the circuit and turn on the power supplies.
3. Measure the voltage across each resistor in your circuit, and record the values in Table 8-3. Show the proper polarity for each voltage on Figure 8-1. Now, using these measured voltages, calculate the current through each resistor. Record the values in Table 8-4 and show the proper directions on Figure 8-1.
4. Measure the "mesh" currents I_A, I_B, and I_C. Record these measured currents (magnitude and direction) in Table 8-2.

DATA/OBSERVATIONS

Table 8-1: Resistors Values

Resistance	Measured (Ω)	Color Code (Ω)	Error (%)
R_1			
R_2			
R_3			
R_4			
R_5			

Table 8-2: Mesh Currents

Current	Measured (A)	Calculated (A)	Error (%)
I_A			
I_B			
I_C			

Table 8-3: Resistors Voltages

	Measured	Mesh Method	Nodal Analysis	Superposition	Simulation
V_{R1}					
V_{R2}					
V_{R3}					
V_{R4}					
V_{R5}					

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Table 8-4: Resistors Current

	Measured	Mesh Method	Nodal Analysis	Superposition	Simulation
I_{R1}					
I_{R2}					
I_{R3}					
I_{R4}					
I_{R5}					

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POST-LAB

1. From the data obtained in this experiment, calculations and simulations; discuss on the validity of Mesh Analysis, Nodal Analysis, and superposition.

Be sure to include all items from the post-lab exercise above in your written lab report.