Electric Circuits I

Laboratory 5 – Node Voltage, Mesh Current, and Superposition

Objective:

- Calculate and measure the node voltages using Node-Voltage Analysis and Mesh-Current Analysis.
- Obtain the total response by using the principle of superposition.

I. Equipment:

- DC Power Supply (Keysight EDU36311A)
- Digital Multimeter (Keysight EDU34450A)
- Breadboard for connecting resistors.
- 7 resistors between 1kΩ to 20kΩ.

II. Background & Theory

Node voltage and *mesh current* analyses are standard techniques in simulating complex networks for voltages at nodes or currents going through elements. The node voltage analysis relies on the Kirchhoff Current Law (KCL), in which the sum of all current at a particular node is zero. On the other hand, the mesh current analysis is based on the Kirchhoff Voltage Law (KVL), where the sum of voltages in a close path is zero.

In some cases where there are many active sources in a circuit, particularly active AC sources with different frequencies, applying the node voltage or mesh current analyses is not apparent. Isolating each active source for a response is an alternative to overcome the complexity of AC sources. Isolating each active source is the foundation of the Principle of Superposition. According to the Principle of Superposition, the total response (voltage or current) is the sum of the individual responses caused by each active source.

III. Prelab Assignment:

The prelab assignments should be completed and submitted to Camino before the lab section.

A. Part 1 – Node Voltage and Mesh Current Analyses

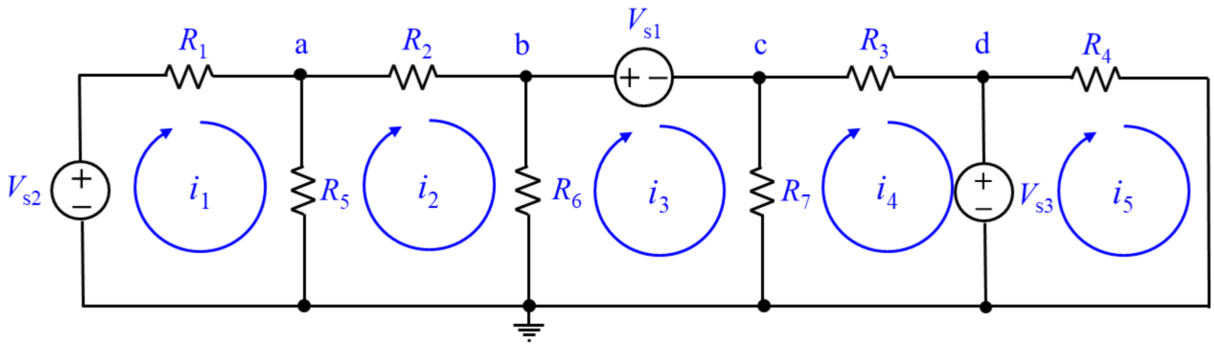

Figure 1 – Node Voltage and Mesh Current Analyses

Table 1 – Standard Resistor Values (K = * 1e3, M = *1e6)

1.0	5.6	33	160	820	3.9K	20K	100K	510K	2.7M
1.1	6.2	36	180	910	4.3K	22K	110K	560K	3M
1.2	6.8	39	200	1K	4.7K	24K	120K	620K	3.3M
1.3	7.5	43	220	1.1K	5.1K	27K	130K	680K	3.6M
1.5	8.2	47	240	1.2K	5.6K	30K	150K	750K	3.9M
1.6	9.1	51	270	1.3K	6.2K	33K	160K	820K	4.3M
1.8	10	56	300	1.5K	6.6K	36K	180K	910K	4.7M
2.0	11	62	330	1.6K	7.5K	39K	200K	1M	5.1M
2.2	12	68	360	1.8K	8.2K	43K	220K	1.1M	5.6M
2.4	13	75	390	2K	9.1K	47K	240K	1.2M	6.2M
2.7	15	82	430	2.2K	10K	51K	270K	1.3M	6.8M
3.0	16	91	470	2.4K	11K	56K	300K	1.5M	7.5M
3.3	18	100	510	2.7K	12K	62K	330K	1.6M	8.2M
3.6	20	110	560	3K	13K	68K	360K	1.8M	9.1M
3.9	22	120	620	3.2K	15K	75K	390K	2M	10M
4.3	24	130	680	3.3K	16K	82K	430K	2.2M	15M
4.7	27	150	750	3.6K	18K	91K	470K	2.4M	22M
5.1	30								

1. Select 7 resistors (R_1 to R_7) from the standard resistor values in **Table 1** between 1kΩ to 20kΩ, label them and save them for later use.
2. Create a MATLAB script with V_{s1} = 4V, V_{s2} = 10V, and V_{s2} = 12V:
   a. Calculate the circuit's node voltages (Va, Vb, Vc, and Vd) in **Figure 1** using the node voltage analysis.
   b. Calculate the mesh currents (i_1, i_2, i_3, i_4, and i_5) of the circuit in **Figure 1** using the mesh current analysis. From the results of the mesh currents, calculate the node voltages (V_a, V_b, V_c, and V_d).

B. Part 2 – Principle of Superposition

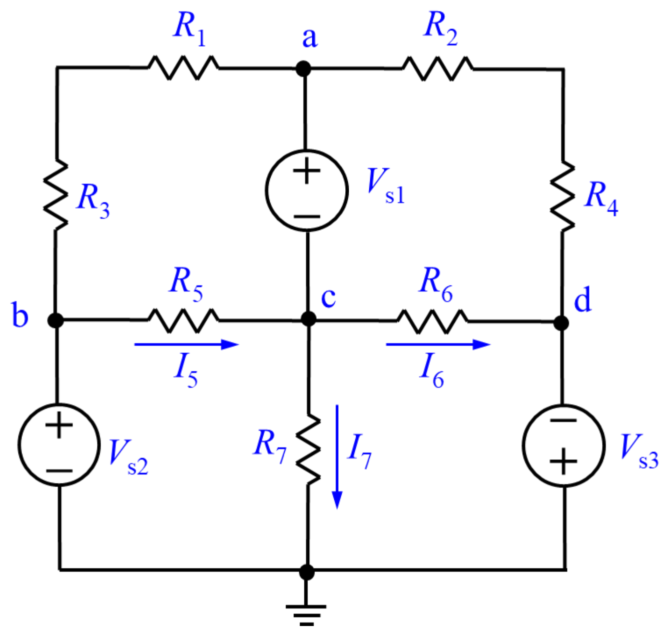

Figure 2 – Circuit to verify Principle of Superposition

1. Create a MATLAB script with V_{s1} = 4V, V_{s2} = 10V, and V_{s3} = 12V to calculate the currents I_5, I_6, and I_7 in **Figure 2** using the principle of superposition.
2. From the results of the currents, calculate the node voltage V_c.

IV. Laboratory Part 1 – Node Voltage and Mesh Current Analyses

Verify the results of MATLAB scripts of your prelab assignment with the TA before working on the lab procedures.

1. Use the digital multimeter to measure 7 resistors chosen in the prelab assignments. Record their measured values in **Table 2** below.

Table 2 – Resistance Values

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	
Nominal Values								kΩ
Measured Values								kΩ

2. Recalculate the theoretical voltages and currents for the prelab **Parts 1** and **2** with the measured values of resistors.

3. Build the circuit in **Figure 1** with V_{s1} = 4V, V_{s2} = 10V, and V_{s2} = 12V. Measure the node voltages, record them in **Table 3**, and compare them with the results from the node voltage analysis.

Table 3 – Node Voltage Analysis

	Theoretical (Meas. *R*) (V)	Measured (V)	Percent Error
V_a			
V_b			
V_c			
V_d			

4. Measure the node voltages and currents, record them in **Table 4**, and compare them with the results from the mesh current analysis. *Note that Ohm Law defines the measured current* i_1 : $i_1 = V_{R1}/R_1$ *(meas.), and the theoretical voltage* V_a *is calculated from the mesh current:* $V_a = R_5(i_1 - i_2)$.

Table 4 – Mesh Current Analysis

	Theoretical (Meas. *R*) (V)	Measured (V)	Percent Error
i_1			
i_2			
i_3			
i_4			
i_5			
V_a			
V_b			
V_c			
V_d			

5. If there are any discrepancies, explain them.

V. Laboratory Part 2 – Principle of Superposition

1. Build the circuit in **Figure 2** with V_{s1} = 4V, V_{s2} = 10V, and V_{s3} = 12V. We will use the principle of superposition to measure the currents I_5, I_6, and I_7.

2. With the active source V_{s1}, zero other independent sources, measure voltages and currents. Record all measurements in **Table 5**. *Note that the measured current* $I_{5,Vs1}$ *is defined by Ohm Law:*

$$I_{5,V_{s1}} = \frac{V_b - V_c}{R_5}$$

Table 5 – Measured Currents and Voltage

	Theoretical (With Meas. *R*)	Measured	Percent Error
$I_{5,Vs1}$			
$I_{6,Vs1}$			
$I_{7,Vs1}$			
$V_{c,Vs1}$			

3. With the active source V_{s2}, zero other independent sources, measure voltages and currents. Record all measurements in **Table 6**.

Table 6 – Measured Currents and Voltage

	Theoretical (With Meas. *R*)	Measured	Percent Error
$I_{5,Vs2}$			
$I_{6,Vs2}$			
$I_{7,Vs2}$			
$V_{c,Vs2}$			

4. With the active source V_{s3}, zero other independent sources, measure voltages and currents. Record all measurements in **Table 7**.

Table 7 – Measured Currents and Voltage

	Theoretical (With Meas. *R*)	Measured	Percent Error
$I_{5,Vs3}$			
$I_{6,Vs3}$			
$I_{7,Vs3}$			
$V_{c,Vs3}$			

5. Determine the total response for the measured currents I_5, I_6, I_7, and V_c in the previous steps

Table 8 – Measured Currents and Voltage

	Theoretical (With Meas. *R*)	Measured	Percent Error
I_5			
I_6			
I_7			
V_c			

6. If there are any discrepancies, explain them.

Make sure to check off with the TA before leaving the lab section.

VI. Laboratory Report:

Include the measurements, computations, and answers to questions from the laboratory procedure. Clearly label all steps.