<u>ELEN 50 Lab 2 Report</u>

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Part 1 – Resistance in Series and Parallel Connections

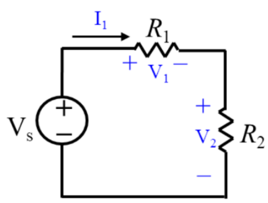


Figure 1 – Resistors in series

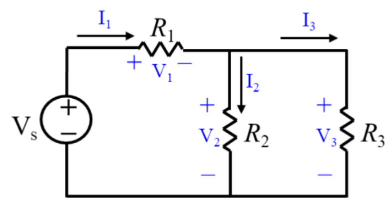


Figure 2 – Resistors in series and parallel

Table 2 - Resistance Values

	R1	R2	R3	R4	R5	R6	
Nominal Values	1.2	2.7	3.3	5.6	10	15	kΩ
Measured Values	1.099	2.709	3.248	5.702	10.46	14.93	kΩ

Table 3 – Currents and Voltages

	I1 (mA)	V1 (V)	V2 (V)
Theoretical values (nominal values of R)	2.564	6.923	3.077
Theoretical values (meas. values of R)	2.632	7.131	2.869
Measured by DMM	2.627	7.115	2.887
Percent Error	-0.19%	-0.22%	0.623%

Compute the ratio of V1 to V2 and the ratio of R1 to R2. How are they related?

V1/V2 = 2.46
R1/R2 = 0.405
V1/V2 = R2/R1   These ratios are proportional

Table 4 – Currents and Voltages

	Current (mA)			Voltage (V)		
	I1	**I2**	**I3**	**V1**	**V2**	**V3**
Theoretical (nominal R)	3.724	2.048	1.676	4.469	5.531	5.531
Theoretical (measured R)	3.722	2.181	1.541	4.090	5.910	5.910
Measured by DMM	3.725	2.184	1.542	4.091	5.913	5.913
Percent Error	0.08%	0.1375%	0.064%	0.024%	0.051%	0.051%

Compute the equivalent resistance of the parallel combination of R3 and R2. How does this explain the values of I1 and V2 in this circuit compared to those measured with the first circuit?

$$Req = \frac{1}{\frac{1}{R3}+\frac{1}{R2}} = \frac{1}{\frac{1}{3.248}+\frac{1}{2.709}} = 1.47k\Omega$$

Both I1 and V2 increased in this circuit compared to the first circuit because this equivalent resistance is greater than R1 which increases the voltage (V=iR).

What is the ratio of I2 to I3? What is the ratio of R2 to R3? How are they related?

$$\frac{I_2}{I_3} = \frac{2.184}{1.542} = 1.4163$$

$$\frac{R_2}{R_3} = \frac{2.709}{3.836} = 0.7062$$

$$\frac{I_3}{I_2} = \frac{1.542}{2.184} = 0.70604$$

These 2 ratios (I2 to I3 and R2 to R3) are inversely proportional.

Now we add R4 in parallel with R2 and R3.

Compute the equivalent resistance Req of R2, R3, and R4. How is the current I1 divided by the three resistors connected in parallel?

The equivalent resistance is $Req = \frac{1}{\frac{1}{R1}+\frac{1}{R2}+\frac{1}{R3}} = \frac{1}{\frac{1}{2.709}+\frac{1}{3.248}+\frac{1}{5.702}} = 1.17\text{k}\Omega$

Current takes the path of least resistance. From the values measured in the table below we observe that R2 has the least resistance and therefore has the most current going throught it. R4 has the greatest resistance and therefore has much less current going through it compared it R3 and R2.

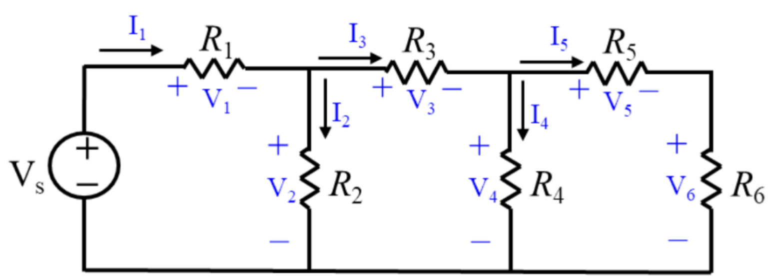
Table 5 – Currents and Voltages

	Current (mA)				**Voltage (V)**			
	I1	**I2**	**I3**	**I4**	**V1**	**V2**	**V3**	**V4**
Theoretical (nominal R)	3.778	2.024	1.656	0.098	4.534	5.466	5.466	5.466
Theoretical (meas. R)	3.783	2.157	1.523	0.102	4.157	5.843	5.843	5.843
Measured	4.27	1.96	1.384	0.093	4.694	5.31	5.31	5.31
Percent Error	12.87%	-9.13%	-9.13%	-8.82%	12.92%	-9.12%	-9.12%	-9.12%

Laboratory Part 2 – Kirchhoff Laws

Table 6 – Currents and Voltages of Voltage Divider Circuit

	Current (mA)					**Voltage**					
	I1	I2	I3	I4	I5	V1	V2	V3	V4	V5	V6
Theoretical (nom.)	3.115	2.319	0.795	0.650	0.416	3.738	6.262	2.624	3.638	1.455	2.183
Theoretical (meas.)	3.209	2.390	0.819	0.669	0.150	3.526	6.474	2.660	3.814	1.571	2.242
DMM Measured	3.209	2.4	0.819	0.668	0.149	3.5	6.482	2.689	3.79	1.561	2.228



3. Write Kirchhoff Current Law (KCL) for each node with the measurements and verify that KCL is satisfied at each node. If there is any discrepancy, recheck the measurements.

Node 1: $I1 - I2 - I3 = 0$

Node 2: $I3 - I4 - I5 = 0$

4. Write Kirchhoff Voltage Law (KVL) for each loop with the measurements, and verify that KVL satisfies each loop. If there is any discrepancy, recheck the measurements.

Loop 1: $-10 + I1 \cdot R1 + I2 \cdot R2 = 0$

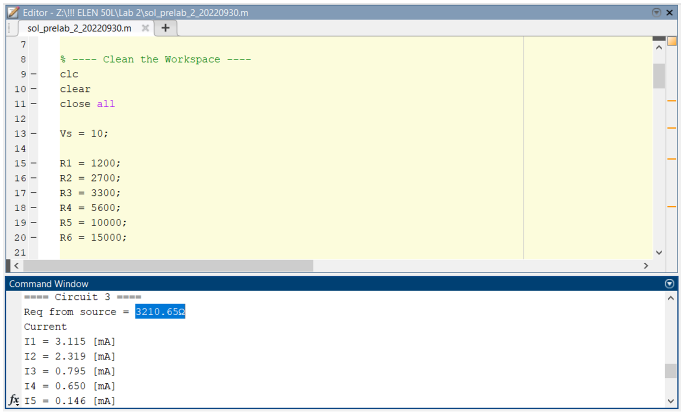
Loop 2: $-I2 \cdot R2 + I3 \cdot R3 + I4 \cdot R4 = 0$

Loop 3: $-I4 \cdot R4 + I5 \cdot (R5 + R6) = 0$

5. Measure the equivalent resistance of the circuit, as shown in Figure 4. Compare it to the theoretical value calculated in the pre-lab.

   Measured using Ohmmeter: 3116.54 Ω

   Theoretical Value: 3210.65 Ω



6. Use the measured value of the voltage VS and the current I1 from Step 2 to calculate the equivalent resistance. Compare this value to the measurement from Step 5.

   Using Ohm's Law:

   Req = Vs/i1

$$\frac{V_s}{I_1} = \frac{10}{3.209 \cdot 10^{-3}} = 3116\,\Omega$$

   It is similar to the measured one from Step 5, which is the equivalent/total resistance.

7. If an unknown resistor value replaced R6, how could you find the value of R6 from the measurement and the calculation method?

   There are 2 methods that can be used to determine the value of R6:

   1. We use the value of V4 and V5 to find V6 using KVL. Then, we can solve for R6 using Ohm's law:

$$-V_4 + V_5 + V_6 = 0$$

$$V_6 = V_4 - V_5$$

$$R6 = \frac{V6}{i5} = \frac{V4 - V5}{i5} = \frac{i4 * R4 - i5 * R5}{i5}$$

      For example using our values:

$$R6 = \frac{i4 * R4 - i5 * R5}{i5} = \frac{0.668 * 5.702 - 0.149 * 10.46}{0.149} * 1000 = 15\ \mathrm{k\Omega}$$

   2. From step 6 (Using Ohm's Law), simply dividing Vs by I1 results in the equivalent/total resistance (Req). Only then, we might be able to find R6 by isolating R6 to the left as per following:

$$\mathrm{Req} = R1 + \frac{1}{\frac{1}{R2} + \frac{1}{R3 + \left(\frac{1}{\frac{1}{R4} + \frac{1}{R5 + R6}}\right)}}$$

and

$$\mathrm{Req} = \frac{V_s}{I_1}$$

$$\frac{V_s}{I_1} = R1 + \frac{1}{\frac{1}{R2} + \frac{1}{R3 + \left(\frac{1}{\frac{1}{R4} + \frac{1}{R5 + R6}}\right)}}$$

Then, I put into an online calculator (Symbolab), since Matlab stated that "Unable to convert to matrix form because the system does not seem to be linear."

$$\frac{10}{3.209\cdot\ 10^{-3}}=1099+\frac{1}{\left(\frac{1}{2709}+\frac{1}{\left(3248+\left(\frac{1}{\left(\frac{1}{5702}+\frac{1}{\left(10460+R_6\right)}\right)}\right)\right)}\right)}$$

Which I got a result like this:

$$R_6 = 14792.02132\ \Omega$$

For Conclusion:

<u>These 2 methods produce similar results.</u>