

## Lab #2: Circuits with Series and Parallel Resistors

### I. Objectives

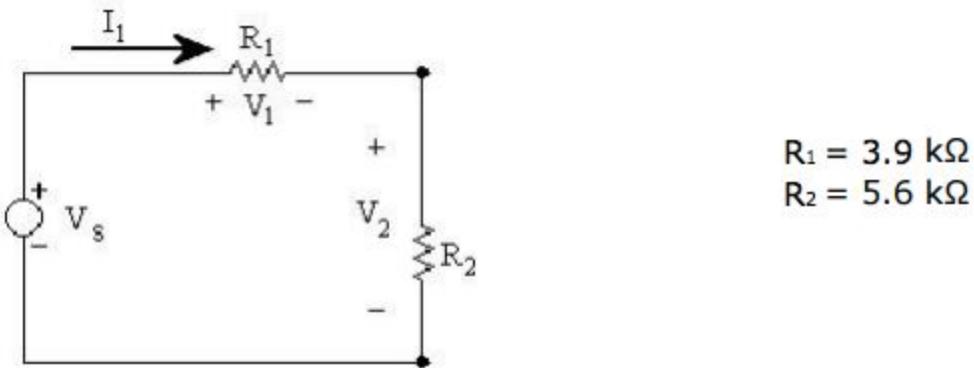
- A. To learn about circuits with series and parallel resistors
- B. Learn how to use the ELVIS board and software

### II. Laboratory Procedure

#### PART 1:

##### Step 1:

Set up the given circuit.



##### Step 2:

$$I_1 = 0.00210\text{A}$$

$$V_1 = 8.1836\text{V}$$

$$V_2 = 11.806\text{V}$$

$$R_1 = 3.8993\text{k }\Omega$$

$$R_2 = 5.6244\text{k }\Omega$$

##### Step 3:

	Voltage V1	Voltage V2	Current I1
Measured	8.1836V	11.806V	0.00210A
Calculated	8.21 V	11.7894 V	0.002105 A
Percentage Difference	-0.322%	-0.141%	0.238%

Step 4:

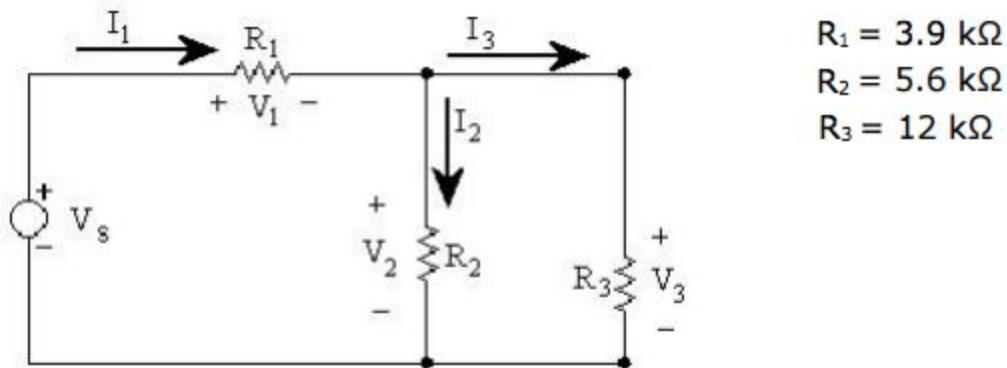
Ideal Ratio of V1 to V2: 39/56

Ideal Ratio of R1 to R2: 39/56

The ratios are the same because resistor 1 and resistor 2 share the same current.

Step 5:

Set up the given circuit.



Step 6:

	Voltage 1	Voltage 2	Voltage 3	Current I1	Current I2	Current I3
Measured	10.087V	9.902V	9.903V	0.00258A	0.00175A	0.00082A
Calculated	10.11 V	9.89 V	9.89 V	0.00259 A	0.001767 A	8.245e(-4) A
Percentage Difference	0.227%	-0.121%	-0.131%	0.386%	0.962%	0.545%

R3 Resistance Value: 11.929kΩ

Step 7:

Equivalent Resistance of R2 and R3: 3818.18 Ohms

Since the equivalent resistance is lower than R2 in the first circuit, hence I1 is higher in the second circuit, and V2 is lower in the second circuit.

Step 8:

Ideal Ratio of I2 to I3: 2.143

Ideal Ratio of R2 to R3: 0.4666

The ratio of I2 to I3 and the ratio of R2 to R3 is inverse.

Step 9:  $R_4 = 1.1898\text{k}\Omega$

Step 10:

	V1	V2	V3	V4	I1	I2	I3	I4
Measured	16.205 V	3.788V	3.7902 V	3.7889 V	0.00417 A	0.00067 A	0.00032 A	0.00318 A
Calculated	16.2 V	3.794 V	3.794 V	3.794 V	0.00416 A	$6.735e(-4)$ A	$3.16e(-4)$ A	0.003162 A
Percentage Difference	-0.0309 %	0.158%	0.100%	0.134%	-0.240%	0.520%	-1.27%	-0.632%

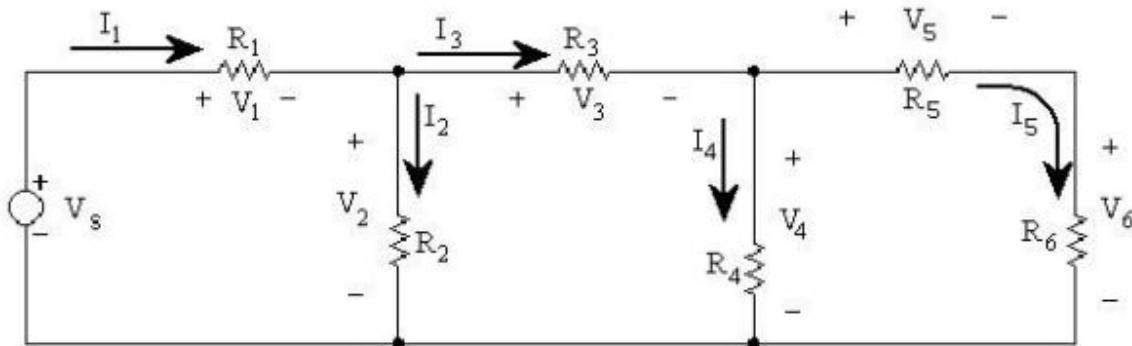
Equivalent Resistance of  $R_2$ ,  $R_3$  and  $R_4$ :  $0.9074\text{k}\Omega$

The current  $I_1$  is divided among the three resistors in parallel, the resistor with higher resistance receives less current, while the resistor with lower resistance receives higher current, because the voltage across each resistor is the same.

## Part 2:

Step 1:

Set up the given circuit.



$$\begin{aligned} R_1 &= 1.2 \text{ k}\Omega, R_2 = 5.6 \text{ k}\Omega, R_3 = 3.9 \text{ k}\Omega, \\ R_4 &= 4.7 \text{ k}\Omega, R_5 = 2.2 \text{ k}\Omega, R_6 = 1.0 \text{ k}\Omega \end{aligned}$$

Step 2:

	Vs	V1	V2	V3	V4	V5	V6
Measured	19.988V	5.8940V	14.094V	9.502V	4.5930V	3.155V	1.4384V
Calculated	20 V	5.9258 V	14.074 V	9.464 V	4.60962 V	3.1817 V	1.446 V
Percentage Difference	0.06%	0.537%	-0.142%	-0.402%	0.361%	0.839%	0.553%

	I1	I2	I3	I4	I5
Measured	0.00495A	0.00251A	0.00244A	0.00099A	0.00146A
Calculated	0.00494 A	0.0025132 A	0.002427 A	9.807716e-4 A	0.001446 A
Percentage Difference	-0.202%	0.127%	-0.536%	-0.941%	-0.968%

Step 3:

KCL:

$$I_1 = I_2 + I_3$$

$$I_1 = 0.00495 = 0.00251 + 0.00244 \text{ (matches)}$$

$$I_3 = I_4 + I_5$$

$$I_3 = 0.00244A = 0.00099 + 0.00146 \text{ (matches)}$$

$$I_1 = I_2 + I_4 + I_5$$

$$I_1 = 0.00495 = 0.00251 + 0.00099 + 0.00146 \text{ (matches)}$$

Step 4:

KVL:

In loop a,

$$V_s - V_1 - V_2 = 0$$

$$20 - 5.8940 - 14.094 = 0.012$$

In loop b,

$$V_s - V_1 - V_3 - V_4 = 0$$

$$20 - 5.8940 - 9.502 - 4.5930 = 0.011$$

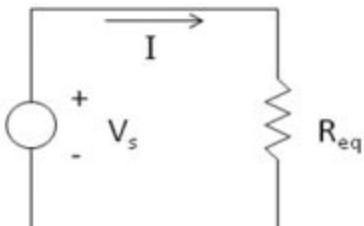
In loop c,

$$V_s - V_1 - V_3 - V_5 - V_6 = 0$$

$$20 - 5.8940 - 9.502 - 3.155 - 1.4383 = 0.0107$$

### Step 5:

Ideal Equivalent Resistance: 4050.04 Ohms



### Step 6:

Measured Equivalent Resistance: 4035.9 Ohms

Calculated Equivalent Resistance:  $V_s/I_1 = 19.988V/0.00495A = 4037.98$  Ohms

The calculated equivalent resistance is a little lower than the ideal equivalent resistance, about 0.30% lower.

### Step 7:

How to find  $R_6$ :

Measurement: Use the Ohm meter to measure  $R_6$  to find the unknown resistance value.

Calculation: Reuse the equivalent resistance formula to track back to  $R_6$ . Use  $V_s = 20$ .

## **III. Observation and Analysis**

From the theory, we know that resistors have same current when they are in series, and they have same voltage when they are in parallel. Today we were mainly measuring the voltage and current of corresponding resistors and trying to find the relationship among these data.

I notice that actually building a circuit and measuring the data, especially current is way harder than simply drawing them on paper, because you need to be careful that you connect the resistors in the way that they are supposed to be, and when measuring the current, you need to put the Amp meter in series with the resistors, which mean you need to somehow break your current circuit and rebuild it, and break it again when measuring the next resistor.

## **IV. Questions**

All questions through the lab are answered in order in the procedure.

## **V. Conclusions**

Through using the ELVIS board, we learned a lot about circuits with series and parallel resistors. We also learned about how to use the software for the ELVIS board, like measuring the current, voltage, and resistance. Furthermore, we were able to calculate percentage differences with our calculated and measured values.