UNIVERSITY OF WEST LONDON

Electrical theory

Electrical and electronic engineering

Electrical theory assignment

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13/04/2018

Abstract

In this assignment, two different circuits will be tested. it will be required to calculate the voltage and current of each resistor for both circuits. for the first, the calculation will be made by using simple circuit law like Ohm's and Kirchhoff's law. But for the second it will be required to use OrCAD simulation practical measurement and for the calculation, because of the two voltage supply, it will be required to use super positioning theorem.

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Introduction

For this assignment, the task was to test two circuits by calculating the voltage and current running across all resistor. By using the theoretical knowledge acquired in class and then to confirm the results by comparing them with OrCAD simulation results, and practical measurements taken from the physical circuit, and then to analyze the results. The aims of this assignment are to test the theoretical and practical knowledge of electrical circuits and related software.

Section A

In this section, the circuit shown in figure 1 will be analyzed and tested. The first task for this section was to compare the value of the resistor by measuring each individual resistor with a Voltmeter and comparing the measured value with the value of the resistor, as shown in table 1. The second task consists of calculating the resistivity of the circuit, the voltage supply, the current running through the circuit and the voltage and current of each resistor, then to confirm the results of the calculation by comparing them with measurements taken from the physical circuit as shown in table 2.

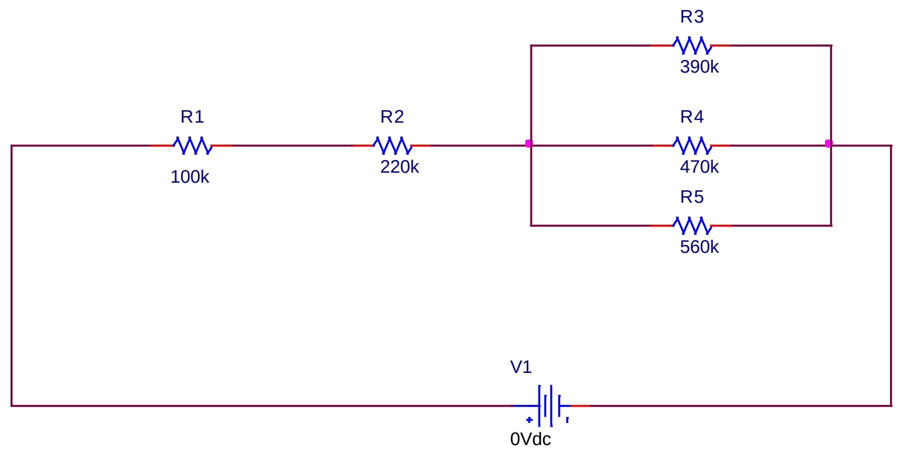

Figure 1

Table 1

Resistor	Nominal resistance	Measured resistance
R1	100Ω	100.1Ω
R2	220Ω	219Ω
R3	390Ω	389Ω
R4	470Ω	467Ω
R5	560Ω	557Ω

Calculation

Total resistance

$$R = R1 + R2 + R_x = 100 + 220 + 154.38 = 474.38\Omega$$

$$R_y = \frac{R3 \times R4}{R3 + R4} = \frac{390 \times 470}{390 + 470} = 213.13\Omega$$
$$R_x = \frac{R_y \times R5}{R_y + R5} = \frac{213.14 \times 560}{213.14 + 560} = 154.38\Omega$$

The total current of the circuit for this calculation an inverse formula of Ohm's law was used

$$I = \frac{V}{R} = 10.5mA$$

The voltage across the resistor here Ohm's law was used for the calculations.

$$VR1 = I \times R1 = 10.5mA \times 100\Omega = 1.05V$$
$$VR2 = I \times R2 = 10.5mA \times 220\Omega = 2.310V$$
$$VR3, VR4, VR5 = I \times R_x = 10.5mA \times 154.38\Omega = 1.621V$$

Current going through the resistor

To calculate the current through the resistors divider formula was used.

$$R_l = \frac{R3 \times R5}{R3 + R5} = \frac{390 \times 560}{390 + 560} = 229.9\Omega$$

$$R_z = \frac{R4 \times R5}{R4 + R5} = \frac{470 \times 560}{470 + 560} = 255.5\Omega$$
$$IR3 = I \times \frac{R_z}{R3 + R_z} = 10.5mA \times \frac{255.5\Omega}{390\Omega + 255.5\Omega} = 4.16mA$$
$$IR4 = I \times \frac{R_l}{R4 + R_l} = 10.5mA \times \frac{229.9\Omega}{470\Omega + 229.9\Omega} = 3.45mA$$
$$IR5 = I \times \frac{R_y}{R5 + R_y} = 10.5mA \times \frac{213.14\Omega}{560\Omega + 213.14\Omega} = 2.89mA$$

Results

Table 2

Components	Measured values	Calculated values
Circuit resistance	473Ω	474.38Ω
Dc supply voltage	5V	5V
circuit current	10mA	10.5mA
VR1	1.04V	1.05V
VR2	2.31V	2.31V
VR2	1.62V	1.621V
VR4	1.62V	1.621V
VR5	1.62V	1.621V
IR1	10mA	10.5mA
IR2	10mA	10.5mA
IR3	4.1mA	4.16mA
IR4	3.4mA	3.45mA
IR5	2.9mA	2.89mA

Analysis

The majority of the measurements conform with calculations. But some results for this circuit differ by a small margin in some cases., this is expected because the calculation is made with optimal base assumptions so they may differ because they don't take in consideration thing that may slightly increase or reduce the conductivity of materials.

Section B

In this section, the task is to use super positioning theorem to calculate the current and voltage of all resistor shown in figure 2, and confirming the calculation results by running the same circuit in OrCAD and doing practical measurements of the circuit. Then compare all the collected results as shown in table 5.

Calculations

The voltage across all resistor with a 5V supply

To calculate the voltage across the resistor the voltage divider formula was used. The formula used to calculate the voltage for R2 and R3 is the same because they are parallel resistors.

$$R_u = \frac{6.8 \times 10}{6.8 + 10} = 4.05\ k\Omega$$
$$R_T = R1 + R_u = 4.7 + 4.05 = 8.75k\Omega$$
$$VR1 = Vs \times \frac{R1}{R1 + R_u} = 5 \times \frac{4.7}{4.7 + 4.05} = 2.7V$$
$$VR2, VR3 = Vs \times \frac{R_u}{R1 + R_u} = 5 \times \frac{4.05}{4.7 + 4.05} = 2.31V$$

Current going through all resistor with a 5V supply.

To calculate the current of the resistor an inverse formula of Ohm's law applied to resistors was used.

$$I = \frac{V}{R_T} = \frac{5}{8.75} = 0.57mA$$
$$IR1 = \frac{VR1}{R1} = \frac{2.7V}{4.7} = 0.57mA$$
$$IR2 = \frac{VR2}{R2} = \frac{2.31V}{6.8} = 0.341mA$$
$$IR3 = \frac{VR3}{R3} = \frac{2.31V}{10} = 0.232mA$$

The voltage across all resistor with a 10V supply.

Here the voltage divider formula was used to calculate the voltage across the resistor. The voltage formula for R1 and R3 is the same because they are two resistors in parallel and have the same voltage.

$$R_x = \frac{R1 \times R3}{R1 + R3} = \frac{4.7 \times 10}{4.7 + 10} = 3.19k\Omega$$

$$R_t = R2 + R_x = 6.8 + 3.19 = 10k\Omega$$
$$VR1, VR3 = Vs \times \frac{R_x}{R_t} = 10 \times \frac{3.19}{10} = 3.19V$$
$$VR2 = Vs \times \frac{R2}{R_t} = 10 \times \frac{6.8}{10} = 6.8V$$

Current going through all resistor with a 10V supply. To calculate the current going through the resistors R1 and R3 the current divider formula was used. For R2 instead was use an inverse formula of Ohm's law.

$$IR2 = I = \frac{Vs}{R_t} = \frac{10}{10} = 1mA$$
$$IR1 = I \times \frac{R3}{R1 + R3} = 1 \times \frac{10}{4.7 + 10} = 0.68mA$$
$$IR3 = I \times \frac{R1}{R3 + R1} = 1 \times \frac{4.7}{10 + 4.7} = 0.32mA$$

Calculation using Super positioning theorem. After calculating the values of current and voltage of all resistor for both voltage sources. The superpositioning theorem calculation and by adding the contribution for each source.

$$VR1 = 3.19V - 2.70V = 0.5V$$
$$VR2 = 6.8V - 2.31V = 4.49V$$
$$VR3 = 3.19V + 2.31V = 5.5V$$

$$IR1 = 0.68mA - 0.57mA = 0.11mA$$
$$IR2 = 1mA - 0.34mA = 0.659mA$$
$$IR3 = 0.232mA + 0.319mA = 0.551mA$$

Calculation Results

Table 3

Component	5V	10V	result
VR1	2.7V	3.19V	0.5V
VR2	2.31V	6.8V	4.49V
VR3	2.31V	3.19V	5.5V
IR1	0.57mA	0.68mA	0.11mA
IR2	0.341mA	1mA	0.659mA
IR3	0.232mA	0.32mA	0.551mA

Simulation

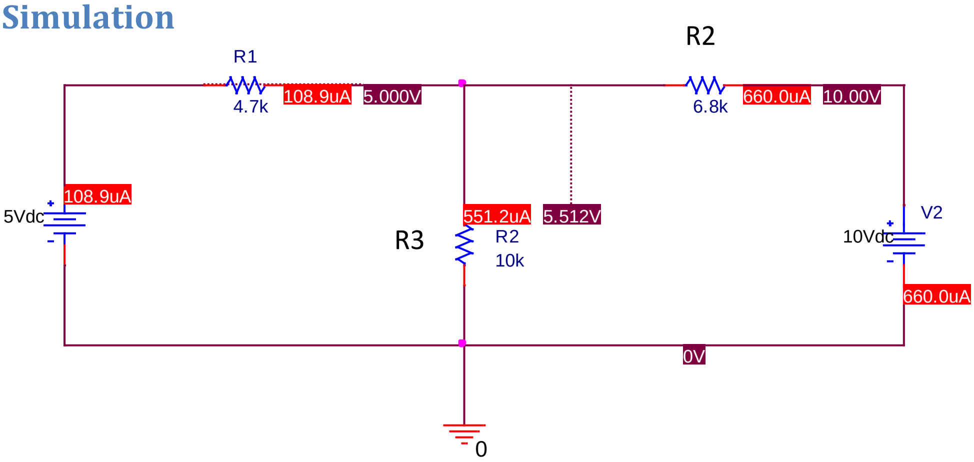

Figure 2

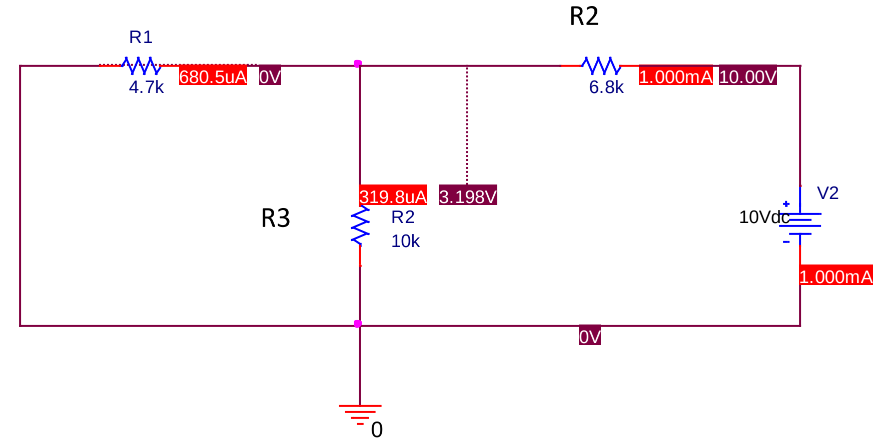

Figure 3

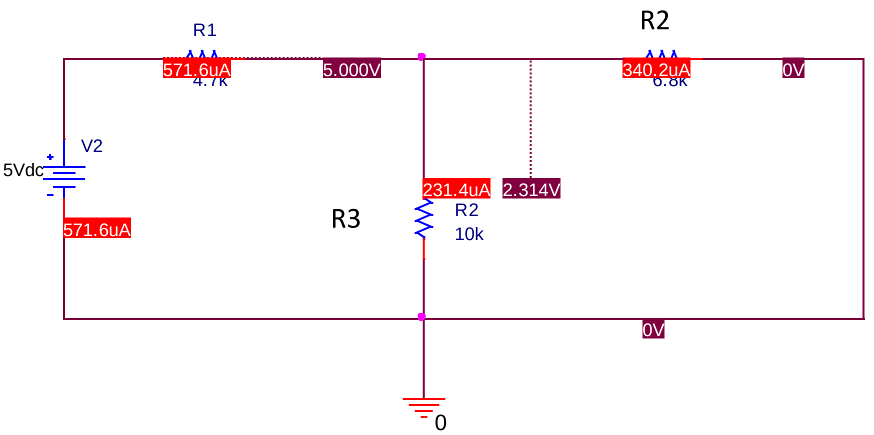

Figure 4

Practical testing results

For the practical testing, it was required to have a physical representation of the circuit used for the calculations so after building it and connecting it to a power supply the measurement was made using a Voltmeter. The measurement for voltage was made by placing the pins so they would be in parallel with the resistor and the measurement for current were made by placing the pin so they were in series with the resistor allowing the current to flow into the Voltmeter.

Table 4

	Measured value 5V	Measured value 10V	Result
VR1	2.67V	3.18V	0.51V
VR2	2.30V	6.78V	4.48V
VR3	2.30V	3.18V	5.48V
IR1	0.56mA	0.670mA	0.11mA
IR2	0.34mA	0.99mA	0.66mA
IR3	0.23mA	0.316mA	0.546mA

Analysis

Table 5

	Calculated results	Simulation results	Experimental results
VR1	0.5V	5V	0.51V
VR2	4.49V	10V	4.48V
VR3	5.5V	5.512V	5.48V
IR1	0.11mA	0.108mA	0.11mA
IR2	0.659mA	0.66mA	0.66mA
IR3	0.551mA	0.551mA	0.546mA

The majority of the results are as expected except VR1 and VR2 voltage results from the simulation. The simulation gives them the same voltage values as the voltage supply even after multiple runs of the simulation the values for VR1 and VR2 wouldn't change. This error was caused by a wrong setup of the voltage measuring settings of the simulation for R1 and R2.