Lab Report for EE202 Circuit Analysis

Laboratory 2

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1 Introduction

This lab aims to determine the current through a specific resistor and the voltage across its nodes using Thevenin's and Norton's theorems and superposition, based on circuit measurements under short-circuit and open-circuit conditions.

1.1 Preliminary Work

1.1.1 Pre Task 1

To determine the Thevenin and Norton of the circuit shown in **Figure 1.**, below steps are followed:
To find R_{eq}:

1. **Short the voltage source** by replacing it with a wire.
2. **Remove** R_3 to analyze the circuit without it.
3. **Find** R_{eq} by simplifying the resistor network.

Following these steps, the circuit in **Figure 2** is obtained. In this configuration, R_1 and R_5 are in parallel, as well as R_2 and R_4. The equivalent resistance, R_{eq}, is calculated as:

$$R_{eq} = R_{(1,5)} + R_{(2,4)}$$

where:

$$R_{(1,5)} = \frac{R_1 R_5}{R_1 + R_5} = \frac{4.7\text{k}\Omega \times 1\text{k}\Omega}{4.7\text{k}\Omega + 1\text{k}\Omega}$$

$$R_{(2,4)} = \frac{R_2 R_4}{R_2 + R_4} = \frac{3.3\text{k}\Omega \times 6.8\text{k}\Omega}{3.3\text{k}\Omega + 6.8\text{k}\Omega}$$

Thus, the total equivalent resistance simplifies to:

$$R_{eq} = \frac{4.7 \times 1}{4.7 + 1}\text{k}\Omega + \frac{3.3 \times 6.8}{3.3 + 6.8}\text{k}\Omega$$

$$R_{eq} \approx \frac{4.7}{5.7}\text{k}\Omega + \frac{22.44}{10.1}\text{k}\Omega$$

$$R_{eq} \approx 0.824\text{k}\Omega + 2.22\text{k}\Omega$$

$$R_{eq} \approx 3.04\text{k}\Omega$$

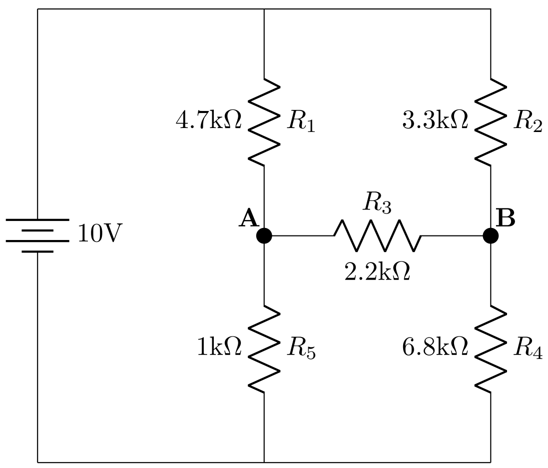

Figure 1: Original Circuit Diagram

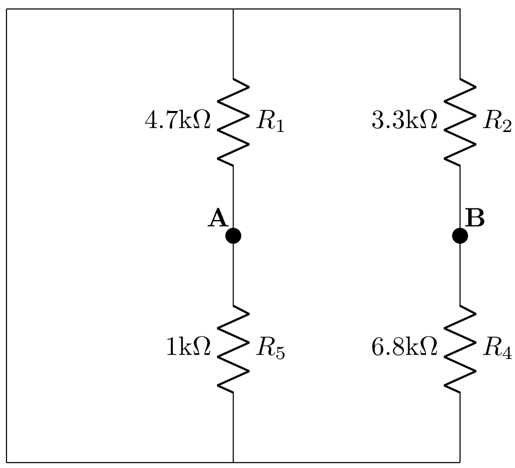

Figure 2: Circuit for Finding R_{eq}

To determine the voltage across nodes A and B ($V_A - V_B$), **the voltage divider rule** is applied:

$$V_A = V_{\text{source}} \times \frac{R_5}{R_1 + R_5}$$

$$V_B = V_{\text{source}} \times \frac{R_4}{R_2 + R_4}$$

Substituting the given values:

$$V_A = 10V \times \frac{1\text{k}\Omega}{4.7\text{k}\Omega + 1\text{k}\Omega}$$

$$V_B = 10V \times \frac{6.8\text{k}\Omega}{3.3\text{k}\Omega + 6.8\text{k}\Omega}$$

Solving for each:

$$V_A = 10V \times \frac{1}{5.7} = 10V \times 0.175 = 1.75V$$

$$V_B = 10V \times \frac{6.8}{10.1} = 10V \times 0.673 = 6.73V$$

Finally, the voltage difference across nodes A and B is:

$$V_{AB} = V_A - V_B = 1.75V - 6.73V = -4.98V$$

Since the result is negative, it means that node B is at a higher potential than node A.

$$|V_{th}| = 4.98V$$

The Norton current is given by:

$$I_N = \frac{V_{th}}{R_{th}} = \frac{4.98V}{3.04k\Omega}$$

$$I_N = \frac{4.98}{3040}A \approx 1.64mA$$

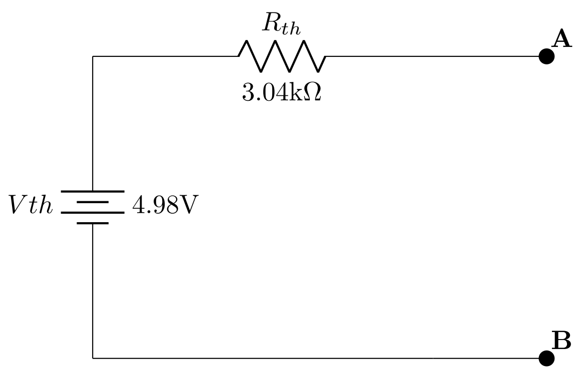

Figure 3: Thevenin Equivalent Circuit

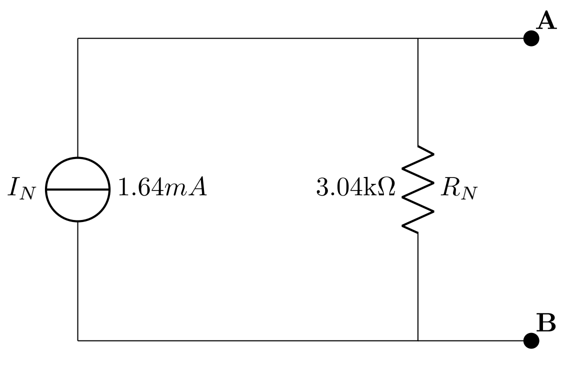

Figure 4: Norton Equivalent Circuit

1.1.2 Pre Task 2

To determine the current through resistor R_4 in **Figure 5**, the Superposition Theorem is applied by considering each independent source separately. The steps are as follows:

- **Step 1: Considering 10V only**

  When the 5V source is turned off by replacing it with a short circuit, the circuit simplifies as shown in **Figure 6**.

  Since R_1 is in parallel with the entire circuit, it does not affect the current through R_4. The circuit simplifies to R_4 and R_2 in parallel, in series with R_3.

  Find Parallel Resistance R_p

  $$R_p = \frac{R_4 R_2}{R_4 + R_2} = \frac{(4.7k\Omega)(2.2k\Omega)}{4.7k\Omega + 2.2k\Omega} = 1.5k\Omega$$

  Find Total Resistance

  $$R_{\text{total}} = R_p + R_3 = 1.5k\Omega + 10k\Omega = 11.5k\Omega$$

  Find Total Current

  $$I_{\text{total}} = \frac{V}{R_{\text{total}}} = \frac{10V}{11.5k\Omega} = 0.870mA$$

  Use Current Division to Find I_4

  $$I_4 = I_{\text{total}} \times \frac{R_2}{R_4 + R_2} = 0.870mA \times \frac{2.2}{6.9} = 0.278mA$$

  Thus, the current through R_4 is:

  $$I_4 = 0.278 \text{ mA}$$

- **Step 2: Considering 5V only**

  When the 10V source is turned off by replacing it with a short circuit, the circuit simplifies as shown in **Figure 7**.

  Note that the only differences between the circuits in **Figure 6** and **Figure 7** are the battery voltage and its polarity. As a result, the current through R_4 in the second case is given by:

  $$I_4^{(5V)} = -\frac{I_4^{(10V)}}{2}$$

  Substituting $I_4^{(10V)} = 0.278$ mA:

  $$I_4^{(5V)} = -\frac{0.278}{2} \text{ mA} = -0.139 \text{ mA}$$

  Thus, the total current through R_4 using superposition is:

  $$I_4 = I_4^{(10V)} + I_4^{(5V)} = 0.278 \text{ mA} - 0.139 \text{ mA} = 0.139 \text{ mA}$$

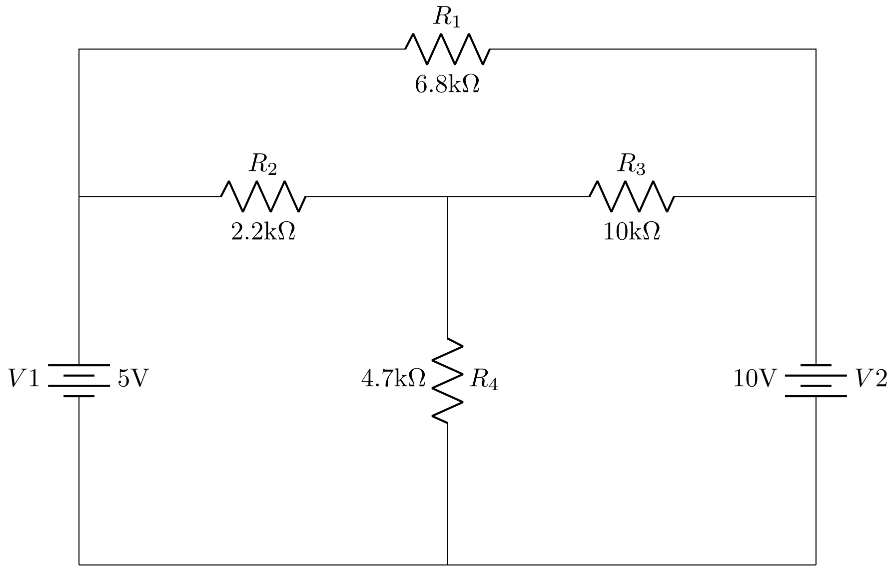

Figure 5: Original Circuit

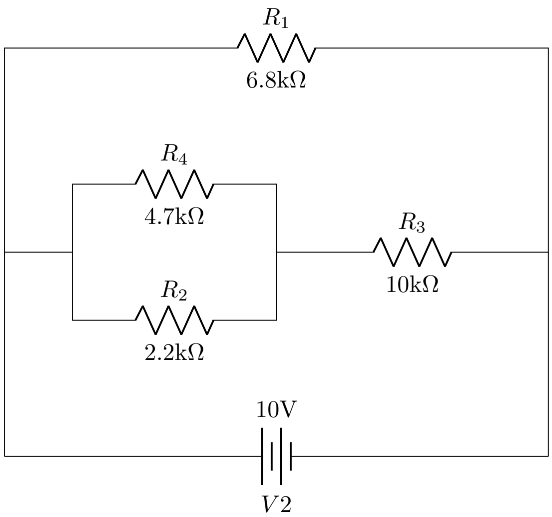

Figure 6: Circuit with Only 10V Source

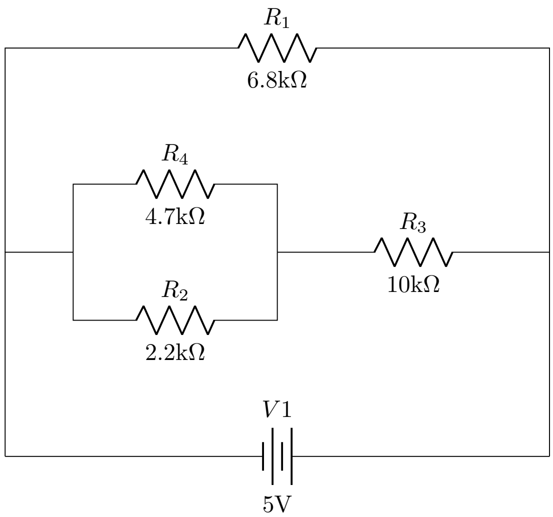

Figure 7: Circuit with Only 5V Source