Lab 3
Kirchhoff's Current Law

A. Background

In 1845, a German physicist Gustav Robert Kirchhoff stated two rules regarding the behavior of electrical circuits. The first rule, known as Kirchhoff's Current Law (KCL), is about the currents entering and exiting a node (junction). KCL states that "sum of all currents entering and the sum of all currents leaving a node must be equal".

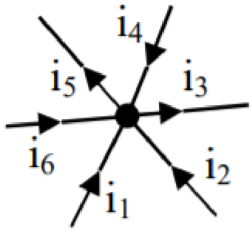


Fig. 3.1.

Consider the above node given in Fig. 3.1.

Currents entering the node = $\{i_1, i_2, i_4, i_6\}$
Currents leaving the node = $\{i_3, i_5\}$

Therefore, KCL states that:

$$i_1 + i_2 + i_4 + i_6 = i_3 + i_5$$

Current Divider:

Consider the circuitry given in Fig. 3.2.

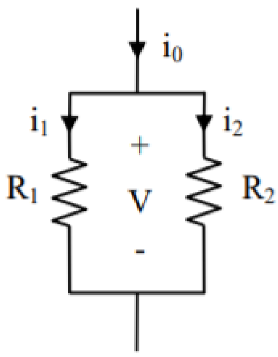


Fig. 3.2.

For the upper node, i_0 is the entering current and i_1 and i_2 are the leaving currents. Then,

$$i_0 = i_1 + i_2$$

The voltage drops over the resistors are equal, then,

$$R_1 i_1 = R_2 i_2$$

Solving the above two equations simultaneously, the branch currents i_1 and i_2 can be expressed in terms of the incoming total current i_0 as:

$$i_1 = \frac{R_2}{R_1+R_2} i_0 \qquad i_2 = \frac{R_1}{R_1+R_2} i_0 \qquad \&$$

B. Experimental Work

B.1. Current Divider & KCL

Consider the circuit given in Fig. 3.3.

1) Use OrCAD/PSpice to find the currents i_0, i_1, i_2, i_3 and i_4 by performing bias point analysis.
2) Set up the given circuit on a breadboard and measure the currents i_0, i_1, i_2, i_3 and i_4.
   i_0 = 0,00098mA
   i_1 = 0,00041mA
   i_2 = 0,00055mA
   i_3 = 0,00023mA
   i_4 = 0,00082mA
3) Express the currents i_1 and i_2 in terms of the current i_0, using current division rule. Similarly express the currents i_3 and i_4 in terms of the current i_0, using the current division rule. Calculate the currents i_0, i_1, i_2, i_3 and i_4, and verify KCL at all nodes.

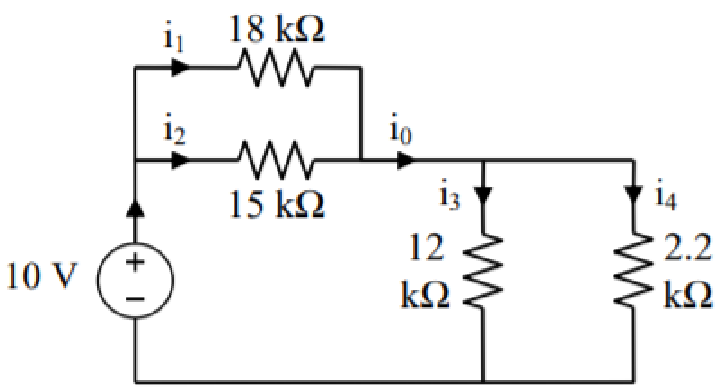
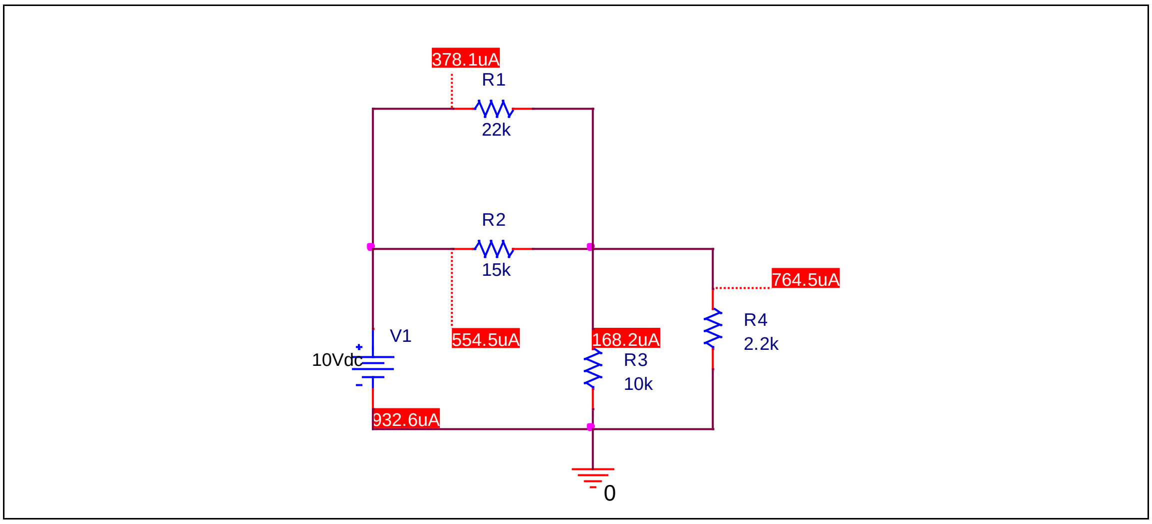


Fig. 3.3. Current Divider Circuit

i. Circuit Schematic & Simulation Output (i_0, i_1, i_2, i_3 and i_4*)*



ii. Hand Calculations (Q3)

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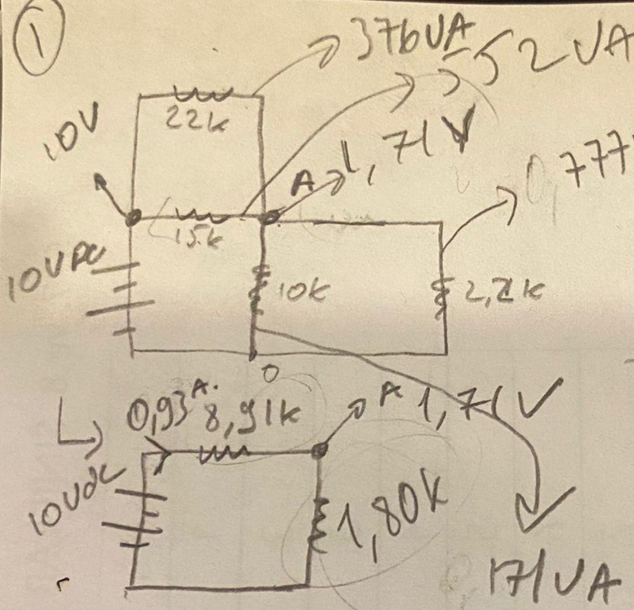


$I = \frac{V}{\Omega}$

$\frac{1}{22k} + \frac{1}{15k} =$

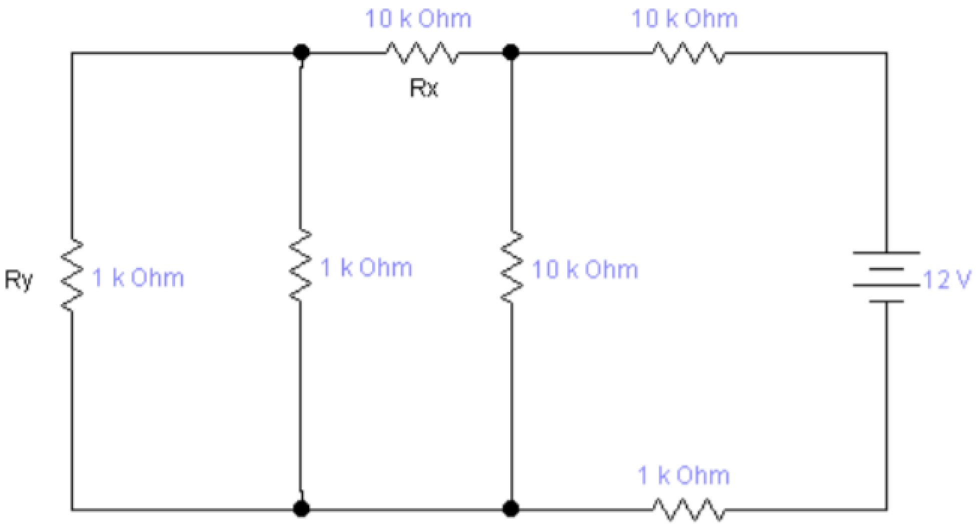
(15) (22)

$\frac{15+22}{330} = \frac{37}{330} = 8{,}91k\Omega$

$\frac{1}{10k} + \frac{1}{2{,}2k} = \frac{2{,}2+10}{22k} = \frac{12{,}2}{22k}$

(2,2) (10)

$\frac{10}{10{,}73k} = \boxed{0{,}93\,A}$ 1,80k



B.2.

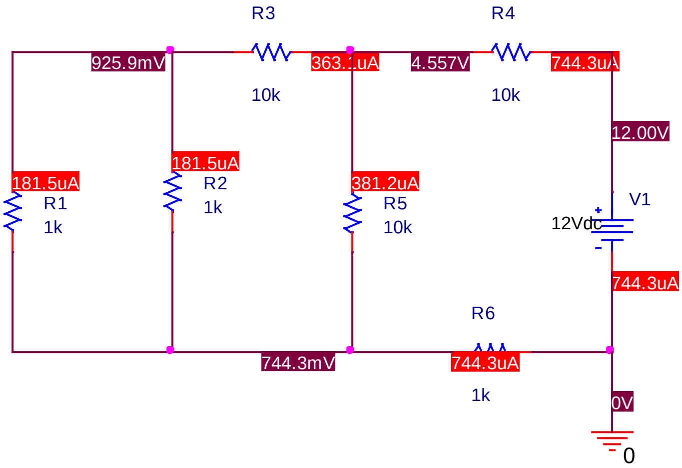
Equivalent Resistance

Consider the circuit given in Fig. 3.4.

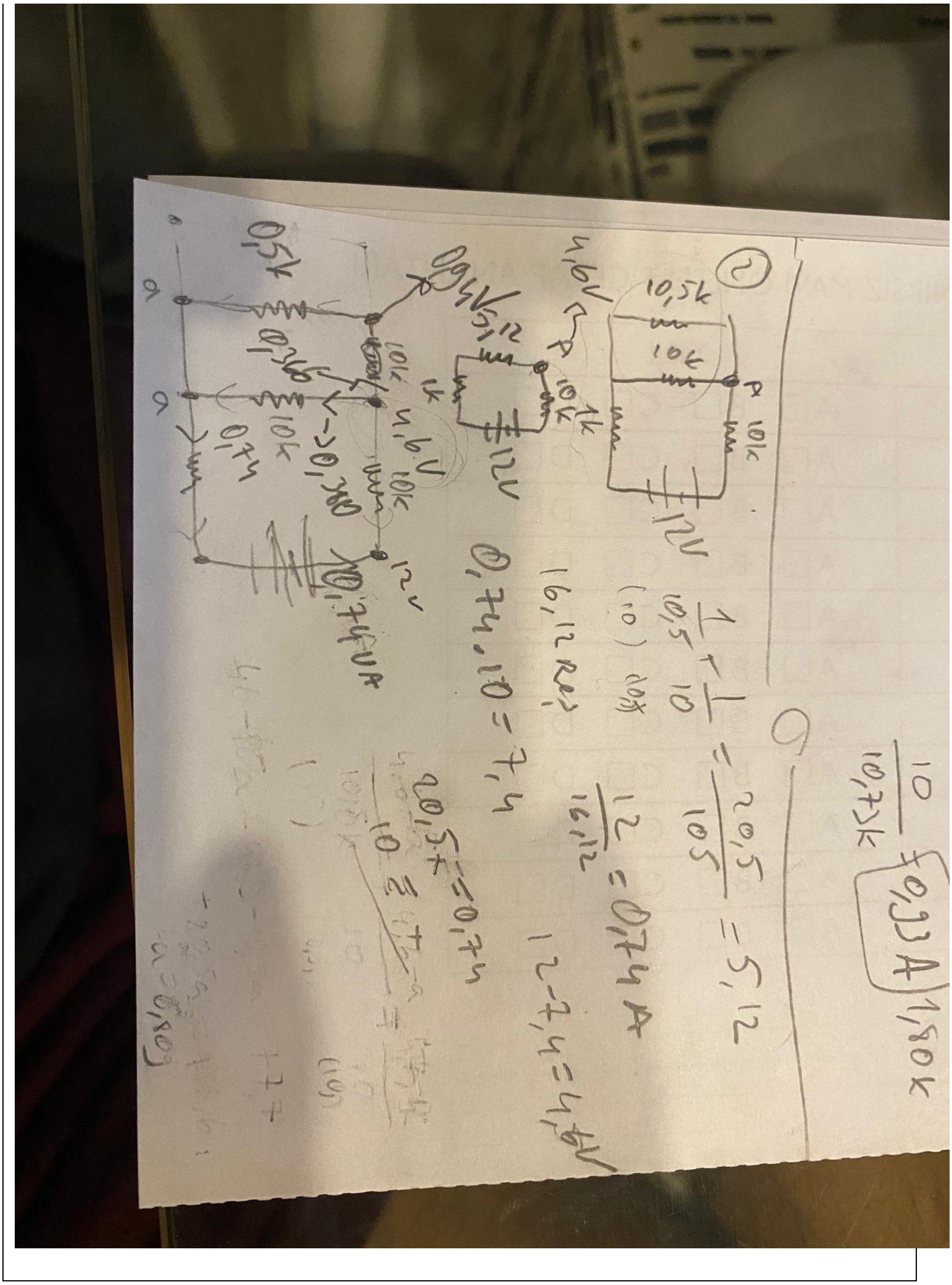
1) Simulate the circuit in OrCAD/PSpice and find the current flowing through the 12V voltage source.
2) Calculate the equivalent resistance seen from the terminals of voltage source.
3) How can you measure the equivalent resistor experimentally? What is the measured equivalent resistor?

Fig. 3.4. A simple resistive circuit

iii. Circuit Schematic & Simulation Output (The current flowing through 12V voltage source)



iv. *Hand Calculations (Calculate the equivalent resistance seen from the terminals of voltage source) 16*



10/10,73k = 0,93 A
1/10,5 + 1/10 = 20,5/105 = 5,12
12/16,12 = 0,74 A
0,74 . 10 = 7,4
12-7,4=4,6V