Circuit Theory and Electronics Fundamentals

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First laboratoy report

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1 Introduction

In this laboratory assignment we pretend to study a circuit containing two tension sources V, two current sources I and six resistors distributed R in four elementary meshes.The circuit can be seen in Figure **??**.

In this report we start by analysing in theory the circuit (section **??**).In Section **??**, the circuit is analysed by simulation, and the results are compared to the theoretical results obtained in Section **??**. At the end of this report we make a final conclusion to sumarise what was made along this laboratory (Section **??**).

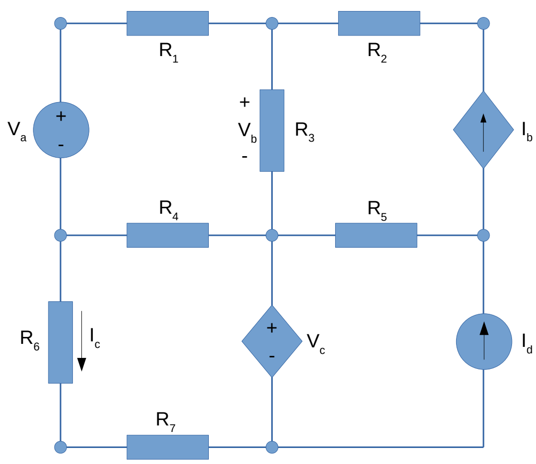

Figure 1: Circuit analysed.

2 Theoretical Analysis

In order to make our theoretical analysis we made use of two well-known methods, Mesh Method and Nodal Method, since its use allow us to make a system of equations that determine our theoretical values.

2.1 Mesh Method

By using the Mesh Method we introduce currents that circulate in the meshes of the circuit as shown in Figure **??**, and then evaluate the circuit based on the new currents.

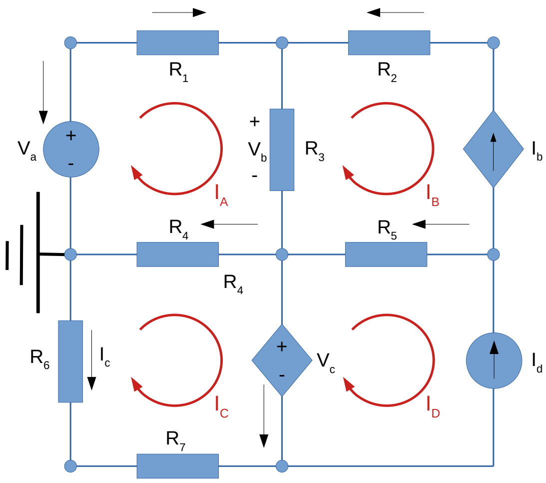

Figure 2: Circuit analysed with mesh currents.

After identifying the mesh currents, we used the Kirchhoff Voltage Law (KVL) in the left meshes (Mesh α and Mesh δ).

$$V_a = R_1 I_a + V_\beta + R_4(I_\alpha - I_\delta); \tag{1}$$

$$R_6 I_\delta + R_4(I_\delta + V_\delta + R_7 I_\delta = 0; \tag{2}$$

Besides that we know: $I_b = I_\beta, I_d = -I_\gamma, I_c = -I_\delta$

At this point we have 5 equations with 8 unknown variables $(I_\alpha, I_\beta, I_\delta, I_b, I_c, I_d, V_\beta, V_\delta)$.

It is required 3 more equations that add more information in order to get the same number of unkonwn variables and equations.

$$V_\delta = K_\delta I_\delta \tag{3}$$

$$I_\beta = K_\beta V_\beta \tag{4}$$

$$V_\beta = R_3(I_a - I_b) \tag{5}$$

The solution to this linear system of equations is determined by Octave:

Variables	Value [A or V]
I_A	1.067284e-03
I_B	1.118444e-03
I_C	0.000000e+00
I_D	-1.019408e-03
@V_b	-1.541489e-01
@V_c	-0.000000e+00
I_b	-1.118444e-03
I_c	-0.000000e+00

Table 1: Variables in the Mesh Method. A variable preceded by @ is of type *current* and expressed in Ampere; other variables are of type *voltage* and expressed in Volt.

2.2 Nodal Method

In this subsection we make use of the other method (Nodal Method) to determinate the values of current and voltage by finding first all the knots in the circuit, as made in Figure **??**.

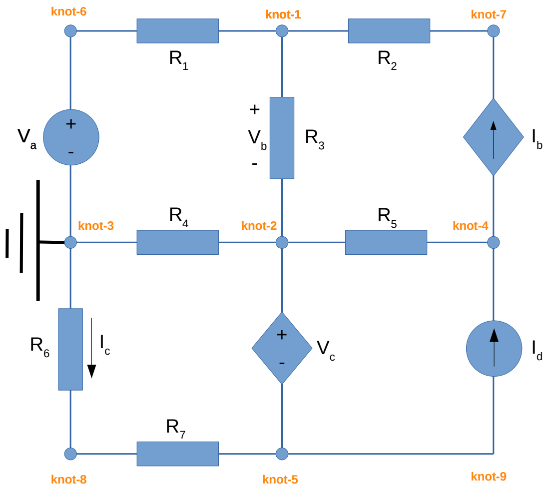

Figure 3: Circuit analysed with nodal voltages.

After finding all the knots we apply KCL (Kirchhoff Current Law) to all the knots except knots 2, 3, 5 and 6 because they are connected to tension sources. Notice that as a reference to the potencial in knot i we use (v_i).

$$\frac{v_6 - v_1}{R_1} + \frac{v_7 - v_1}{R_2} = \frac{V_b}{R_3}; \tag{6}$$

$$I_\beta = \frac{v_7 - v_1}{R_2}; \tag{7}$$

$$I_\gamma = \frac{v_4 - v_2}{R_5} + I_\beta; \tag{8}$$

$$I_\delta = \frac{v_8 - v_5}{R_7}; \tag{9}$$

We also know that:

$$V_\alpha = v_6 - v_3; \tag{10}$$

$$V_\beta = v_1 - v_2. \tag{11}$$

$$V_\delta = v_2 - v_5. \tag{12}$$

And we have the same equations determinated using Meshes Method:

$$V_\beta = K_\beta I_\beta \tag{13}$$

$$V_\delta = K_\delta I_\delta \tag{14}$$

Using Ohm's Law, we find the relation:

$$I_c = \frac{v_3 - v_8}{R_6}. \tag{15}$$

At this point we have 10 equations and 12 unkown variables, so we need 2 more equations that add the information that we need to determinate our final linear system of equations. We can establish:

$$v_2 = 0. \tag{16}$$

Then, by continuity of the current in the tension sources we have:

$$I_c + \frac{v_6 - v_1}{R_1} = \frac{v_2 - v_3}{R_4}. \tag{17}$$

The solution to this linear system of equations is determined by Octave:

Name	Value [A or V]
V_1	3.878423e-05
V_2	1.110223e-16
V_3	-2.255973e-13
V_4	1.890796e+01
V_5	7.105387e-01
V_6	5.230611e+00
V_7	-1.074709e+01
V_8	6.239231e-01
V_b	3.878423e-05
V_c	-7.105387e-01
I_b	-5.155393e-03
I_c	-8.618601e-05

Table 2: Variables in the Nodal Method. A variable preceded by @ is of type *current* and expressed in Ampere; other variables are of type *voltage* and expressed in Volt.

Simulations analysis

2.3 Operation Point analysis

Table **??** shows the simulated operating point results for the circuit under analysis.

Name	Value [A or V]
@gb[i]	-2.92076e-04
@id[current]	1.019408e-03
@r1[i]	2.787154e-04
@r2[i]	2.920757e-04
@r3[i]	-1.33603e-05
@r4[i]	-1.23752e-03
@r5[i]	-1.31148e-03
@r6[i]	9.588061e-04
@r7[i]	9.588061e-04
v(1)	4.947829e+00
v(2)	4.988084e+00
v(3)	0.000000e+00
v(4)	9.004000e+00
v(5)	-2.91655e+00
v(6)	5.230611e+00
v(7)	4.338957e+00
v(8)	-1.95296e+00

Table 3: Operating point. A variable preceded by @ is of type *current* and expressed in Ampere; other variables are of type *voltage* and expressed in Volt.

3 Conclusion

In this laboratory assignment our focus was to study two Methods (Nodal Method and Meshes Method) in order to compare the results calculated by these methods (theoretical results) to the given ones by our circuit simulator (simulator results). By comparing them we can see that these methods are, in this case, well aplied in result of a situation that puts the possibility to calculate our variables using equations that use these two principles. In sum,the use of these methods is a theoretical way of having precise results to unknown variables, but this is only possible because of the simplicity of this circuit. In a more complex circuit using these methods may not be as practical.